



**PUBLIC CONSULTATION DRAFT**

# Dams Safety Regulation 2019

Regulatory Impact Statement

*Prepared for  
NSW Department of Industry  
May 2019*

---

The Centre for International Economics is a private economic research agency that provides professional, independent and timely analysis of international and domestic events and policies.

The CIE's professional staff arrange, undertake and publish commissioned economic research and analysis for industry, corporations, governments, international agencies and individuals.

© Centre for International Economics 2019

This work is copyright. Individuals, agencies and corporations wishing to reproduce this material should contact the Centre for International Economics at one of the following addresses.

**CANBERRA**

Centre for International Economics  
Ground Floor, 11 Lancaster Place  
Majura Park

Canberra ACT 2609  
GPO Box 2203  
Canberra ACT Australia 2601

Telephone +61 2 6245 7800  
Facsimile +61 2 6245 7888  
Email [cie@TheCIE.com.au](mailto:cie@TheCIE.com.au)  
Website [www.TheCIE.com.au](http://www.TheCIE.com.au)

**SYDNEY**

Centre for International Economics  
Level 7, 8 Spring Street  
Sydney NSW 2000

Telephone +61 2 9250 0800  
Email [ciesyd@TheCIE.com.au](mailto:ciesyd@TheCIE.com.au)  
Website [www.TheCIE.com.au](http://www.TheCIE.com.au)

**DISCLAIMER**

While the CIE endeavours to provide reliable analysis and believes the material it presents is accurate, it will not be liable for any party acting on such information.

## *Contents*

<b>Executive summary</b>	<b>1</b>
Background and introduction	1
The need for government action	1
Objectives	2
Options	3
Cost-benefit analysis	4
Conclusions	4
<b>1 Background and introduction</b>	<b>6</b>
Dams safety in NSW	6
Requirement for a Regulatory Impact Statement	7
This report	8
<b>2 The need for government action</b>	<b>10</b>
The role of dam safety regulation	10
Overview of current regulatory framework	11
Issues with the current regulatory framework	13
Estimating the size of the problem	20
<b>3 Objectives and options</b>	<b>32</b>
Objectives of the reform	32
Options under consideration	32
<b>4 Impacts</b>	<b>36</b>
Approach to assessing impacts	36
Key changes under the proposed regulations	36
Impacts of the proposed changes	40
<b>5 Cost benefit analysis</b>	<b>47</b>
Summary of CBA results	47
Approach to the CBA	47
Estimated cost of proposed changes	48
Benefits of proposed changes to regulatory framework	59
Sensitivity analysis	61
<b>6 Conclusion</b>	<b>64</b>
<b>A Summary of changes to regulatory framework</b>	<b>66</b>
<b>B Approach to estimating the expected cost of dam failure in NSW</b>	<b>71</b>

## **C List of dams modified for safety upgrading 73**

### **BOXES, CHARTS AND TABLES**

1	Cost-benefit analysis - summary	4
1.1	Prescribed dams by ownership and assessed risk level	6
1.2	RIS requirements under the SLA	7
1.3	Better Regulation Principles	8
2.1	Establishing a monetary value for human safety outcomes	14
2.2	Dams Safety Committee social risk requirements for existing dams	16
2.3	Expected costs of dam failure in NSW	21
2.4	Composition of expected cost from dam failure	22
2.5	Causes of dam failures in the US Significant Incident Reporting Database	24
2.6	Risk of dam failure due to inadequate surveillance and maintenance	25
2.7	Expected costs of dam failure in NSW due to inadequate surveillance and maintenance practices	25
2.8	Expected benefits of reducing risk	28
2.9	Potential over-investment under current regulatory framework	30
3.1	Current and proposed dams safety regulatory frameworks	33
4.1	Proposed societal risk criteria for existing dams	40
4.2	Summary of impacts for key changes	41
4.3	Can a 'gross disproportionality factor' be justified?	43
5.1	Cost-benefit analysis - summary	47
5.2	Estimated costs of proposed changes	49
5.3	Government costs of current and proposed regulatory frameworks	50
5.4	Present value of government costs	50
5.5	Cost to update operations and maintenance plan	50
5.6	Cost to dam owners from increased update frequency of O&M plans	51
5.7	Proposed change to required frequency of emergency exercises	51
5.8	Cost to dam owners to conduct emergency exercises	52
5.9	Change in cost from increased frequency of emergency exercises	52
5.10	Cost to dam owners from increased frequency of assessment	53
5.11	Preliminary estimate of cost to establish and annually review ISO 55000 system	54
5.12	Cost to prepare ISO 55001 asset management system	54
5.13	Estimate of annual cost to implement and maintain asset management system	55
5.14	Annual cost to implement and maintain asset management system	55
5.15	Estimated cost to conduct risk review	55
5.16	Change in cost to dam owners from proposed requirements for risk review	56
5.17	Estimated cost to prepare annual report	57
5.18	Cost to dam owners to prepare annual reports	57

5.19	Cost to prepare O&M for dam owners without a current plan	58
5.20	Preliminary cost estimate to prepare an emergency plan	59
5.21	Impact of extrapolations on cost estimates	62
5.22	Net benefits/costs under various	63
A.1	Summary of changes to the Dams Safety Act	66
A.2	Summary of changes from <i>Dams Safety Regulation 2019</i>	66
A.3	Summary of changes from <i>Dams Safety Standards 2019</i>	68
B.1	Prescribed dams by risk rating	71
C.1	Dams modified for safety upgrading since 2001 (excluding tailings dams)	73



## *Executive summary*

### ***Background and introduction***

Following an Independent Review of the *Dams Safety Act 1978* and the Dams Safety Committee in 2013, new dams safety legislation — the *Dams Safety Act 2015* — received assent in September 2015. However, the new Act will not become fully operational until the supporting regulations have been made. Under the Subordinate Legislation Act 1989 all new regulations require a Regulatory Impact Statement (RIS).

This report is a RIS for the proposed *Dams Safety Regulations 2019*. However, as the proposed regulations will trigger the commencement of the new Act, the RIS covers the new regulatory framework more broadly.

### ***The need for government action***

Dam failures can impose significant costs on the community, including economic, social and environmental costs. Although dam owners may bear significant costs associated with dam failure, there may be an incentive to under-invest in dam safety without explicit dam safety regulation.

### ***Issues with the current regulatory framework***

The Independent Review of the *Dams Safety Act 1978* and the Dams Safety Committee (and various other analyses) have identified a number of issues with the existing regulatory framework, including:

- a bias towards over-investment in dam safety
- potential conflicts of interest from having large dam owners representatives on the Dams Safety Committee (DSC)
- lack of ability to enforce the existing regulations
- a low priority on ongoing management and emergency response.

### ***Estimating the size of the problem***

#### *The expected cost of dam failures in NSW*

Although the historical social and environmental costs of dam failures have been low in NSW, the risk of a dam failure with potentially catastrophic consequences remains. One way to quantify the ‘size of the problem’ is to estimate the ‘expected costs’ of dam failure (i.e. the cost of dam failure multiplied by the probability of that event occurring).

- Based on information provided by the Department of Industry (based mostly on flood and earthquake modelling), the total expected cost of dam failure (due mostly to extreme weather events) is estimated at around **\$4.27 million per year**. This includes only the cost of human fatalities and downstream property damage and should be considered an indicative estimate only. Most of these expected costs relate to the small number of dams that remain above the ‘limit of tolerability’.
- In addition, there may be some additional risk of dam failure due to inadequate maintenance and surveillance practices. These risks are unknown for prescribed dams in NSW, but based on estimated global averages, the expected cost could be in the order of **\$2.2 million per year**.

### *Over-investment in dam safety*

The extent to which there would be over-investment in dam safety in the period ahead is not known. We estimated the potential for over-investment under the current regulatory framework using two different approaches.

- The first approach was based on extrapolating from WaterNSW’s dam safety upgrade plans under the current regulatory framework, assuming that all of this investment would be ‘inefficient’ (i.e. the costs would outweigh the benefits). This approach reflects a view among some stakeholders that dam owners (encouraged by the DSC) would continue to invest in dam safety upgrades until the risks of dam failure are considered negligible, despite limited safety benefits from doing so. Under this approach, the costs of dam safety upgrades in the period ahead could exceed the safety benefits by up to **\$470 million**.
- The second approach inferred the potential for over-investment through an analysis of how the application of a ‘gross disproportionality factor’ in a formal CBA could distort investment decisions.
  - This analysis suggests that once below the ‘limit of tolerability’, the benefits of reducing risk to a level considered negligible are modest. This implies that there are likely to be few dam safety upgrade opportunities that would achieve a net benefit in a formal CBA, even when a gross disproportionality factor is applied.
  - This analysis suggests that the costs of dam safety upgrades in the period ahead could exceed the safety benefits by only around **\$21 million**.
  - This finding is consistent with one view encountered that there would be relatively little investment in dam safety upgrades under the existing regulatory framework in the period ahead.

## **Objectives**

The specified objectives of the Dams Safety Act 2015 are:

- to ensure that any risks that may arise in relation to dams (including any risks to public safety and to environmental and economic assets) are of a level that is acceptable to the community
- to promote transparency in regulating dams safety



- to encourage proper and efficient management in matters relating to dams safety, and
- to encourage the application of risk management and the principles of cost-benefit analysis in relation to dams safety.

The goals of the reforms are to:

- remove the existing incentives for dam owners to overinvest in dam safety
- remove the potential conflict of interest resulting from dam owners on the board of the DSC
- improve the ability of the regulator to enforce the existing regulations
- improve the practice of dam owners relating to ongoing safety management and emergency response.

## *Options*

There are two options under consideration.

- 1 **The current regulatory framework** — although the Dams Safety Act 2015 has already been enacted, it would not become fully operational until the associated regulations have been made. As such, with no further government action, the regulatory framework set out in the Dams Safety Act 1978 would continue to apply.
- 2 **The proposed regulations** — the Dams Safety Regulations 2019 would trigger the commencement of the new regulatory framework, including the Dams Safety Act 2015 (that has already received assent), the regulations themselves, standards and guidelines (many of which are yet to be finalised).

Key changes under proposed regulations (relative to the current regulatory framework, which is used as a baseline) include the following.

- Changes to regulatory requirements for dam owners (including: more frequent updating of operations and maintenance plans for some dam owners; more frequent emergency exercises; more frequent consequence category assessments for some dam owners; ISO 55001-compliant asset management systems; new requirements for dam design, construction, commissioning and de-commissioning; risk reviews following non-trivial changes; and annual reports).
- Enforceable standards and greater focus on compliance (including: legislated management requirements on dam owners; fines for non-compliance; and an audit program implemented by Dams Safety NSW).
- Change to the risk management framework — dams below the ‘limit of tolerability’ will need to reduce risk ‘so far as is reasonably practicable’ (SFAIRP), rather than ‘as low as reasonably practicable’ (ALARP) as is currently the case. In practical terms, dam owners will no longer need to apply a ‘gross disproportionality factor’ when considering potential dam safety upgrades.

## Cost-benefit analysis

Based on the best available (albeit limited) information, indicative costs and benefits of the proposed changes to the regulatory framework are shown in table 1. The wide range reflects uncertainty around the cost and particularly the benefit estimates.

The benefit estimates depend critically on the assumption around the extent of over-investment (i.e. investment where the costs outweigh the safety and other benefits) under the existing regulatory framework in the period ahead (i.e. the baseline).

### 1 Cost-benefit analysis - summary

	Low	High
	\$ million	\$ million
<b>Benefits</b>		
Reduced over-investment	21.0	472.3
Reduced risk of dam failure due to inadequate management	16.4	16.4
<b>Total benefits</b>	<b>37.4</b>	<b>488.7</b>
<b>Costs</b>		
Costs to dam owner from new regulatory requirements	99.2	186.5
Costs to dam owners from improved compliance	4.5	4.5
Additional costs to the NSW Government	16.2	16.2
<b>Total costs</b>	<b>119.9</b>	<b>207.2</b>
<b>Net benefit/costs</b>	<b>- 82.5</b>	<b>281.5</b>

Note: Costs and benefits are presented in net present value terms over ten years, using a discount rate of 7 per cent.

Source: CIE estimates.

## Conclusions

Consistent with the recommendations of the Independent Review of the Dams Safety Act 1978 and the DSC, the new regulatory framework:

- ensures that dam owners (rather than the regulator) carry primary responsibility for dam safety decisions
- establishes enforceable standards and refocuses the regulator on compliance and enforcement and gives the regulator stronger mechanisms to compel dam owners to comply with the safety standards
- removes the explicit bias towards disproportionate investment in infrastructure to achieve limited safety benefits.

The overall CBA results depend critically on the assumption around the extent of over-investment in dam safety under the current regulatory framework in the period ahead. Although both baseline scenarios considered are broadly plausible, the scenario with a significant level of over-investment is on balance, considered more likely. This baseline scenario is consistent with:

- direct evidence of future dam safety upgrade plans under the existing regulatory framework (for WaterNSW), and
- observations from stakeholders that there is limited use of formal CBA in dam safety decision and many dam owners interpret the ALARP principle as needing to reduce risk to a level considered negligible.

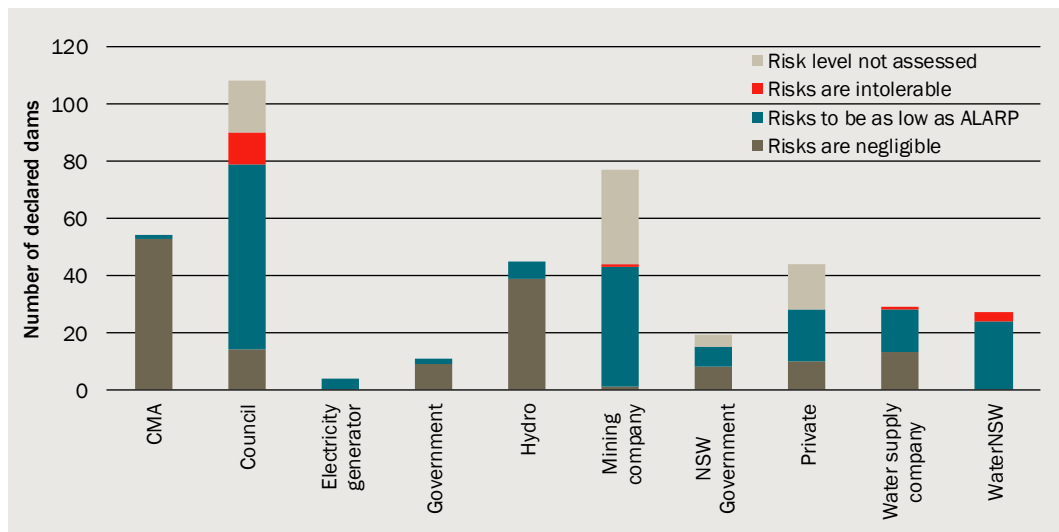
Under this scenario, the benefits of the proposed changes to the regulatory framework would significantly outweigh the costs.

# 1 Background and introduction

## Dams safety in NSW

As of July 2018, there were 408 dams in NSW that were prescribed by the DSC under the Dams Safety Act 1978. These dams have a wide variety of ownership, including state-owned water corporations (59), power generation companies (39), local councils (152), and mining companies (115)<sup>1</sup> and are identified by the Dams Safety Committee on the basis that a dam failure would “threaten lives or have significant economic impacts or have significant environmental damage”.

### 1.1 Prescribed dams by ownership and assessed risk level



Data source: Dams Safety Committee.

Dams regulated under the Act vary in size and include very large dams, such as Warragamba dam (2,030,000 ML) and Eucumbene Dam (4,800,000 ML), as well as a significant number of relatively small dams (there are 11 dams with less than 5 ML capacity). The Dams Safety Act covers both water and tailings dams, which are used to store the by-products of mining operations.

The regulatory framework is designed to ensure that prescribed dams remain safe. The Dams Safety Act 1978 establishes the DSC and authorises it to regulate the operation of dams in NSW. The DSC is also responsible for regulating mining activity below and around dams. The DSC is empowered with various enabling functions under the Mining Act 1992 to fulfil this role.

<sup>1</sup> NSW Dams Safety Committee Annual Report 2017/18 – Appendix A.

### ***Review of the Dams Safety Act and Dams Safety Committee***

Following concerns raised by Independent Pricing and Regulatory Tribunal of NSW (IPART) in 2010,<sup>2</sup> and the NSW Commission of Audit in 2012,<sup>3</sup> that the existing regulatory system was not operating efficiently with evidence of disproportionate investment in dams safety for limited safety gains, the NSW government announced a review of the Dams Safety Act and the DSC. This review was conducted in 2013 by KPMG and included consultation with key stakeholders with NSW dam owners. This review made 14 recommendations to the NSW Government about how best to improve the safety regulation of dams.

### ***The Dams Safety Act 2015 and supporting regulations***

Based on the recommendations of the KPMG review, new dams safety legislation, the Dams Safety Act 2015, received assent in September 2015. The second reading speech stated that:

...the bill will modernise the regulatory framework for dam safety in NSW and ensure that the Act reflects the outcomes of the review of the dam safety regime conducted in 2013.

Although the new Act received assent in 2015, it will not become fully operational until the supporting regulations have been made. In the meantime, the arrangements under the Dams Safety Act 1978 remain in force.

### ***Requirement for a Regulatory Impact Statement***

The *Subordinate Legislation Act 1989* (SLA) requires that a regulatory impact statement (RIS) must be prepared before regulations are made. The matters that must be included in a RIS are outlined in box 1.2.

#### **1.2 RIS requirements under the SLA**

A regulatory impact statement must include the following matters:

- A statement of the objectives sought to be achieved and the reasons for them.
- An identification of the alternative options by which those objectives can be achieved (whether wholly or substantially).
- An assessment of the costs and benefits of the proposed statutory rule (this includes economic and social benefits and costs). Wherever possible, costs and benefits should be quantified. If quantification is not possible, the anticipated impacts of the proposed action and of each alternative should be stated and presented in a way that permits a comparison of the costs and benefits.

<sup>2</sup> Independent Pricing and Regulatory Tribunal (2010), Review of the productivity performance of state-owned corporations – Volume 4 – State Water Corporation.

<sup>3</sup> NSW Commission of Audit (2010), Final report on Government expenditure, 4 May.

- An assessment of the costs and benefits of each alternative option to the making of the statutory rule (including the option of not proceeding with any action), including the costs and benefits relating to resource allocation, administration and compliance.
- An assessment as to which of the alternative options involves the greatest net benefit or the least net cost to the community.
- A statement of the consultation program to be undertaken.

This process is simply a formal framework to help policy-makers think through the impacts of regulatory proposals in a disciplined and comprehensive way. This helps to ensure that policy decisions are based on best practice regulatory principles (see box 1.3) and the best available evidence, resulting in better policy outcomes for the community.

### 1.3 Better Regulation Principles<sup>4</sup>

**Principle 1:** The need for government action should be established. Government action should only occur where it is in the public interest, that is, where the benefits outweigh the costs.

**Principle 2:** The objective of government action should be clear.

**Principle 3:** The impact of government action should be properly understood by considering the costs and benefits (using all available data) of a range of options, including non-regulatory options.

**Principle 4:** Government action should be effective and proportional.

**Principle 5:** Consultation with business and the community should inform regulatory development.

**Principle 6:** The simplification, repeal, reform or consolidation of existing regulation should be considered.

**Principle 7:** Regulation should be periodically reviewed, and if necessary reformed to ensure its continued efficiency and effectiveness.

## *This report*

This report is a draft Regulatory Impact Statement (RIS) for the proposed Dams Safety Regulations 2019. As regulations would trigger the full commencement of the Dams Safety Act 2015, the analysis covers the reforms to regulatory framework more broadly (including the Dams Safety Act of 2015, as well as the associated regulations and standards. The remainder of this report is structured as follows:

---

<sup>4</sup> NSW Government, *NSW Guide to Better Regulation*, October 2016, p. 6.

- Chapter 2 presents the need for government action including issues identified with the current regulatory framework and an estimate of the size of the problem
- Chapter 3 outlines the objectives of and options for change
- Chapter 4 outlines the impacts of the proposed changes to the regulatory framework
- Chapter 5 is the cost benefit analysis of the impacts
- Chapter 6 concludes.

## 2 *The need for government action*

### *The role of dam safety regulation*

Dam failures can impose significant costs on the community, including economic, social and environmental costs. The costs from dam failure could include the following:<sup>5</sup>

- Costs associated with downstream flooding, including:
  - the loss of human life
  - property damage
  - environmental damage (and/or restoration costs)
  - the costs associated with emergency response
  - displaced economic activity from flooding.
- The loss of the benefits provided by the dam itself — this would depend on the purpose of the dam, but could include:
  - urban water supply
  - irrigation
  - power generation
  - flood mitigation
  - recreational benefits.
- The cost of repairing or rebuilding the dam.

In the event of a dam failure, the dam owner would bear a significant cost and therefore have a strong incentive to ensure that dams do not fail.

- Dam owners would bear the cost of replacing the dam and/or some of the costs associated with the loss of benefits provided by the dam (consumers of these services would also bear a cost).
- Dam owners also have a ‘duty of care’ to downstream communities and as such, may be found liable for damages in the event of a dam failure under common law.

Nevertheless, without explicit dam safety regulation there may be an incentive for dam owners to ‘under-invest’ in dam safety, particularly where:

- dam owners do not bear to full cost of a dam failure, or would not be able to meet the associated liability (i.e. there are external costs imposed on downstream communities)
- the dam owner has a different preference for risk than downstream communities.

Given the potentially high costs to the community from a dam failure, dam safety is regulated in NSW. Safety regulation is not unusual in industries that are associated with

---

<sup>5</sup> US Department of Homeland Security, *Dams Sector: Estimating Economic Consequences for Dam Failure Scenarios*, September 2011.



high risks to life and property. The value of a system to ensure dam safety can be highlighted by considering examples of dam failures — and the associated loss of life and property destruction — that have occurred outside of Australia. A particularly notable example is the recent (January 2019) Brumadinho dam disaster in Brazil in which at least 150 people were killed following the failure of a tailings dam owned by the Vale mining company. In contrast, Australia has relatively few incidents of dam failure, and no loss of life due to dam failure since 1929.<sup>6</sup> While this strong safety record may not be entirely attributable to dam safety regulations, they are surely a contributing factor.

### *Overview of current regulatory framework*

The regulatory framework for dam safety in NSW is established under the *Dams Safety Act 1978*. This Act establishes a regulator (the DSC) and grants this regulatory body relatively broad authority to interpret this role. For instance, the 2013 review of the Act noted that:

The Act establishes the powers of the DSC to allow it to “formulate measures to ensure the safety of dams”. It does not, however, define “safety” or specify how “safety” should be achieved. Rather, the DSC defines how it will achieve its objectives and refines this process over time as its understanding of risks to dam safety develops.

This regulatory design means that most of the functional details of dam safety regulation in NSW are not found in regulations under the Act but rather in ‘Guidance Sheets’ published by the DSC. These guidance sheets also directly reference ANCOLD safety guidelines, which are therefore another key component of the regulatory framework in NSW. Finally, in the event of dam failures owners can be liable for damages under common law. Discussion conducted with dam owners suggests that this common law liability is a significant consideration in dam safety decisions and so this must also be considered as part of the regulatory environment.

### *The NSW Dams Safety Committee*

The NSW Dams Safety Committee is comprised of 9 part-time members, including:

- a person nominated by Snowy Hydro Limited
- a person nominated by the portfolio Minister under the State Owned Corporations Act 1989 for the electricity generators that are State owned corporations under that Act
- a person nominated by the Sydney Catchment Authority constituted under the Sydney Water Catchment Management Act 1998
- a person nominated by State Water Corporation constituted under the State Water Corporation Act 2004
- a person nominated by the Hunter Water Corporation referred to in the Hunter Water Board (Corporatisation) Act 1991

---

<sup>6</sup> KPMG 2013, Review of the Dams Safety Act 1978 and Dams Safety Committee, Final report, page 87.

- a person nominated by the Minister administering the Public Works Act 1912
- 2 persons nominated by the Federal Council of the Institution of Engineers, Australia
- a person nominated by the Minister administering the Mining Act 1992.

In addition, the Committee is assisted by seven staff (full time equivalent), who are mostly employed by the NSW Department of Industry.

The 2013 review of the Dams Safety Act identifies four key roles of the DSC:

- identifying prescribed dams
- setting safety standards
- monitoring dam surveillance by dam owners
- approval of mining activities in notification areas.

In addition, the DSC provides significant assistance to dam owners in complying with the safety regulations, particularly to smaller dam owners (such as local councils). The review also noted that the DSC had a relatively high degree of discretion in making determinations as to whether a dam met an appropriate safety standard.

The DSC receives around \$1.4 million of funding annually from the NSW government.<sup>7</sup> Of this funding, the majority (\$1.1 million in 2018) is provided in-kind in the form of wages to Department of Industry staff working for the DSC. In addition, the wages of Committee Members are funded by their employer which represents a significant in-kind contribution to the operation of the DSC.

### ***Dams Safety Committee Guidance Sheets***

The NSW DSC has published 22 Guidance Sheets that provide advice to dam owners on how to comply with the Dams Safety Act of 1978. These Guidance Sheets include both risk-based and standards-based components. The DSC has relative discretion to change these guidance sheets. However, since the introduction of the new set of guidance sheets in June 2010, there have been relatively few changes made.<sup>8</sup>

The DSC also notes that the Guidance sheets can be over-ruled where it is appropriate to do so.

The DSC's overriding policy to determine appropriate dam safety arrangements in any particular case on the merits of the case. Where owners believe that a departure from the DSC's normal requirements is warranted, they should submit substantiated proposals for the DSC's consideration (Dams Safety Committee Guidance Sheet DSC1A)

However, this process is at the full discretion of the DSC.

---

<sup>7</sup> NSW Dams Safety Committee Annual Report 2017/18, p. 56.

<sup>8</sup> A list of changes to the guidance sheets is available at:  
[http://www.damsafety.nsw.gov.au/DSC/Download/Info\\_Sheets\\_PDF/Amendments/Amendments%20to%20Guidance%20Sheets.pdf](http://www.damsafety.nsw.gov.au/DSC/Download/Info_Sheets_PDF/Amendments/Amendments%20to%20Guidance%20Sheets.pdf)

### *ANCOLD guidelines*

In developing and implementing dam safety, the DSC draws heavily on guidelines developed by ANCOLD (the Australian National Committee on Large Dams). ANCOLD describes itself as a non-government organisation dedicated to sharing professional information and knowledge on the design construction, maintenance and impact of large dams.

The DSC Guidelines also directly reference ANCOLD Guidelines in several situations which creates a situation in which ‘changes to the ANCOLD guidelines, over which the New South Wales Government has no control, are translated into the New South Wales regulatory system without the filter of normal regulatory impact assessment processes’.<sup>9</sup>

### *Issues with the current regulatory framework*

The following issues with the current regulatory framework have been identified.

#### *Over-investment in dam safety*

The most consistent criticism raised over the existing system of dam safety regulation is that it results in dam owners ‘overinvesting in dam safety’. Or, put another way, some dam safety investments required by the existing regulations would not pass a well-designed cost-benefit analysis. Some such criticism includes:

To meet the Act’s requirements, very small reductions in risk are being achieved at a disproportionate cost that is not consistent with safety cost/benefit trade-offs in other industries (NSW Commission of Audit (2010), Final report on Government expenditure, p. 233.)

Evidence provided on a commercial in confidence basis has indicated that there is evidence of some larger dams overinvesting in safety (KPMG 2013, Review of the Dams Safety Act 1978 and Dams Safety Committee, p.55)

There appeared to be a limited focus on applying cost-benefit analysis to identify the most efficient dam safety risk reduction options (Mr Anthony Robert, Minister for Industry, Energy and Resources, Dam Safety Bill 2015 Second Reading).

To understand how the existing system encourages dam owners to overinvest in safety measures, it is necessary to understand how the costs incurred by dam owners and risks (to life and property) are generally weighed up in regulatory impact assessments, and then examine how they are weighed up under the existing dam safety regulatory framework.

#### *Best practice approaches to balancing costs against risks to human life*

Projects to improve the safety of a dam typically involve an upfront financial cost incurred by the dam owner (which in some cases may be passed onto users of the services provided), along with a benefit associated with a lower risk of dam failure. This benefit

---

<sup>9</sup> (Mr Anthony Robert, Minister for Industry, Energy and Resources, Dam Safety Bill 2015 Second Reading).

includes both a reduced risk of property damage and a reduced risk of the loss of human life.

Cost-benefit analysis (CBA) is a tool commonly used to systematically weigh up the costs and benefits of various choices, including all economic, social and environmental costs and benefits. Ideally, additional investment in dam safety would proceed only where the total benefit to society was greater than the total cost.

Balancing financial costs against human safety involves establishing a monetary value for lives saved.

### 2.1 Establishing a monetary value for human safety outcomes

A key concept in establishing a monetary value for lives lost is the value of a statistical life (VSL). This concept is based on the value that individuals are observed to place on a small reduction in the risk of (their own) death. The use of VSL in CBAs of public safety programs is not an attempt to place a normative 'value' on a human life. Rather, it encourages a level of investment on public safety goods that reflects the preferences towards risk observed elsewhere in society.

A related concept is the value of a life year (VLY), which refers to the notional value that an individual places on each additional year of life. The two concepts are related because the VSL should reflect the discounted value of expected future life years. This implies that the VSL will vary depending on age (and other factors), since younger individuals would be expected to have more life years ahead of them. VSL is usually assumed to refer to the life of a young adult with at least 40 years of life ahead of them.

Valuing the benefits of a reduced loss of human life is conceptually difficult task, but many approaches have been developed, including:

- estimating the willingness to pay of consumer to purchase products (such as airbags) that reduce the risk of risk or injury
- estimating the higher wages that must be paid to attract staff to hazardous industries
- direct survey methods that ask people how much they would be willing to pay to prolong their life.

In regulatory impact analysis, the Australian Government Office of Best Practice Regulation (OBPR) currently recommends using: a VSL of \$4.35 million (in 2014 dollars), which is around \$4.5 million in 2018 dollar terms.<sup>10</sup> This estimate was based on a review of relevant research and international guidelines.<sup>11</sup> Although the *NSW Government Guide to Cost-Benefit Analysis* does not recommend a specific VSL for use in CBA, the Australian Government recommendation has been widely adopted. In

<sup>10</sup> Office of Best Practice Regulation 2014, Best Practice Regulation Guidance Note: Value of a statistical life

<sup>11</sup> See Abelson (2008).

particular, the Department of Industry's Cost Benefit Analysis Guiding Principles for the Safe and Secure Water Program refers to the Australian Government's recommended value.<sup>12</sup>

The application of these guidelines implies that investment in additional dam safety should proceed where the benefits in present value terms (including the reduced risk to human life where a human life saved is valued at around \$4.5 million) outweigh the costs (also in present value terms). An alternative way of expressing this is that additional investment in dam safety should proceed where the cost of saving a statistical life is less than around \$4.5 million.

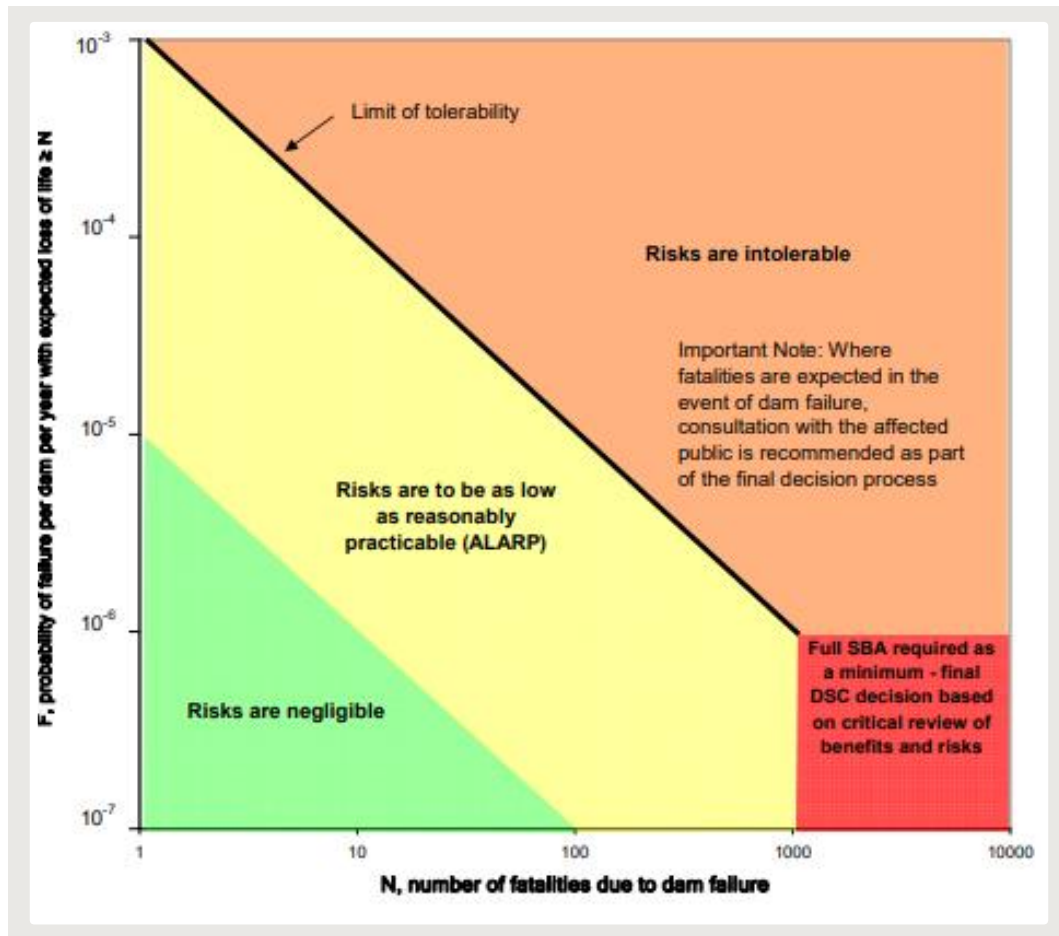
*Current approach to balancing costs against the risks to human safety*

Dam safety management decisions under the existing regulatory framework are a mixture of a standards-based approach and a risk-based approach and dam owners can typically choose whether to follow the deterministic or risk-based approach (section 4 of DSC2D Demonstration of Safety for Dams). This combined framework is best understood with reference to the risk diagram published by the Dams Safety Committee. In this framework, the x-axis shows the number of potential fatalities that would occur in the event of a dam failure, and the y-axis shows the estimated probability of a dam failure in any given year.

---

<sup>12</sup> NSW Department of Industry 2018, Safe and Secure Water Program: Cost Benefit Analysis Guiding Principles, p. 6.

## 2.2 Dams Safety Committee social risk requirements for existing dams



Data source: Dams Safety Committee Infosheet DSC1B: Background to DSC Risk Policy Context.

An existing dam is represented as a point on this diagram.

- For dams that lie above the limit of tolerability (i.e. the orange area), the risks are considered intolerable and the dam owner must reduce risk to move the dam below the limit of tolerability, regardless of the cost of doing so (except in exceptional circumstances).
- For dams that lie in the yellow area, the dam owner must continue to reduce risks to a level that is As Low As is Reasonably Practicable (ALARP).
- For dams in the green area, 'the DCS regards this negligible level of risk as so low that it is not worth search for further reduction, though any obvious inexpensive precautions would be taken' (DSC Guidance Sheet DSC1B, p.6).

In determining whether the risks associated with a dam are 'As Low as Reasonably Practical' the DSC will consider a variety of factors, including:

- the disproportion between the sacrifice (money, time, trouble and effort) in making the safety improvement and the risk reduction that it achieved
- the level of risk in relation to the limit of tolerability and the negligible risk level
- the cost-effectiveness of safety improvement options

- any relevant recognised good practice
- societal concerns as revealed by the owner's or proponent's consultation with the community and other stakeholders (Dams Safety Committee Guidance Sheet DSC1B, p.7).

In order to satisfy the first of these points, dam owners are required to apply a 'gross disproportionality factor' when evaluating investments. This is a scaling factor applied to the risks associated with the potential loss of life that increases the benefits of a safety upgrade included in a cost-benefit analysis. The use of a disproportionality factor in risk assessments is referred to in sub-section 6.18 of DSC2D Demonstration of safety for Dams, June 2010:

For societal risk, disproportion can be judged by comparison of the cost to save a statistical life (CSSL) value for any improvement option with Table 8.6 or Table 8.7 of ANCOLD (2003b) or the interpolated value....

...The DSC will not accept a case based on CSSL alone as a demonstration that risks are ALARP.

The values of the disproportionality factor recommended in the ANCOLD guidelines range from 3 (where risks are just above the broadly acceptable risk level) to 10 (where risks are just below the level of tolerability). In other words, the disproportionality factor inflates the value of safety by a factor of between 3 and 10 before being compared to the cost of a project.

- The application of a 'gross disproportionality factor' of 3 implies that each human life saved would be valued at around \$13.5 million (i.e. 3 x \$4.5 million) in a CBA of a proposed dam safety upgrade.
- The application of a gross disproportionality factor of 10 implies that each human life saved would be valued at around \$45 million (i.e. 10 x \$4.5 million) in a CBA of a proposed dam safety upgrade.

By contrast, the NSW Government has determined that \$4.5 million an appropriate value for the VSL in regulatory impact analysis. The gross disproportionality factor may therefore encourage 'over-investment' in dam safety.

#### *Dam owners defaulting towards deterministic standards*

As discussed earlier, dam safety regulations are based on a mixture of standards-based approach and a risk-based approach in which a dam owner has the choice between achieving full compliance with deterministic standards or conducting a risk assessment to show that risks have been lowered where practical.

In principle, having two options is good policy design.<sup>13</sup> As full risk assessments are costly to conduct, it may be optimal in many situations to build to a standard that is known to be safe and thereby avoid the cost of conducting a full risk assessment. (This is

---

<sup>13</sup> The survey of dam owners conducted for the KPMG review found that 89% of dam owners thought that a mixture of prescriptive and risk-based regulation was the best regulatory approach (KPMG, 2013, Review of the Dams Safety Act 1978 and Dams Safety Committee, Final report, p. 56).



particularly important for smaller operators with a lower risk dam). It should also be noted that the two-tier system is a significant improvement over the previous system in which deterministic standards were required for all dams. Indeed, a significant motivating factor behind the 2006 reform 'Risk Management Policy Framework for Dam Safety' was to avoid situations where a deterministic standard would require a large capital outlay for very little benefit.

However, following the risk-based approach is (by design) a subjective process. For instance, the ANCOLD Guidelines on Risk Assessment state that 'Judgment that Risks are ALARP is not an exercise in mathematics' and that 'the final decision may take into account wider political and equity considerations as to whether costs are grossly disproportionate to benefits'

This has resulted in concerns that in practice the risk-based approach is too difficult to get approved by the DSC. For instance, a key finding of the KPMG review of the Dams Safety Act was that:

There is a lack of transparency for dam owners with regard to DSC decisions that require capital expenditure to reduce the risk of dam failure to 'as low as reasonably possible'

State Water also suggested that:

The lack of an endpoint defined in economic/risk and engineering terms results in continued dam safety investment, pursuing ever diminishing benefits at ever increasing costs. This will continue until 'engineering standards-based assessments' are met (State Water (2013) Submission to the Review of the Dams Safety Act, p. 3).

If the risk-based approach is impractical to use, or if the DSC use their discretion to rule out some risk-based approaches, then the system essentially reverts back to a standards-based approach. This may be of particular concern if the standards are set at a conservative level, which is currently the case for some standards. For instance:

For flood capacity, which is the main driver for dam safety improvement, the DSC deterministic standards are set out in table 5.1 of DSC3B Acceptable Flood Capacity for Dams 2010. The safety levels in that table are at the conservative (safer and more costly) end of the range set out in table 8.1 of ANCOLD, 2000, Guidelines on Selection of Acceptable Flood Capacity for Dams. (Leonard McDonald (2013), Submission on the Review of Dams Safety Act 1978, p. 2).

To the extent that dam owners are unable to implement a risk management approach to determining safety management, this represents a significant issue with the existing regulatory system.

### ***Potential conflicts of interest from having large dams represented on the board of the Dams Safety Committee***

Another critique of the existing regulatory framework is that the DSC is comprised primarily of owners of large NSW dams, and this creates a potential conflict of interest when making decisions relating to safety. For instance, the 2013 review concluded:

Membership of the regulator should not include representatives of dam owners, as is currently the case. This would avoid real or perceived conflicts of interest generated by a regulator that



are comprised in part by the industry it regulates (KPMG 2013, Review of the Dams Safety Act 1978 and Dams Safety Committee, p.4)

Good practice regulatory principles would suggest that having an independent regulator would be better than the existing set-up.

### ***Lack of ability to enforce the existing regulations***

Another concern raised regarding the current regulatory system is that the DSC has limited powers to enforce the existing regulations. Under the existing regulatory system:

If the DSC considers that a prescribed dam is unsafe or may become unsafe, it may give notice under section 18 of the Act requiring the dam owner to take actions necessary to ensure the dam's safety...

...The Act also allows the DSC, in the event that the dam owner does not respond to the section 18 notice, to enforce the notice by either imposing a penalty for violations – under a state of emergency – undertaking remedial work on behalf of dam owners. (KPMG Review of the Dams Safety Act 1978 and Dams Safety Committee, p. 16)

There is mixed evidence as to whether the current level of fines is sufficient to allow the DSC to enforce the Dams Safety Act. On the one hand, the maximum fine that can be levied by the DSC is \$1100, which is relatively trivial in comparison to the large capital expenses that can be incurred.

On the other hand, the CIE has been told that giving notice under section 18 is an effective incentive for dam owners to make changes due to the public perception (dam owners don't want to be known as an unsafe dam owner) and legal (being a non-compliant dam is likely to be interpreted by a court as a basis for liability in the event of a dam failure). Moreover, as noted above the Act also allows for the DSC to undertake remedial work on behalf of dam owners in the event of an emergency.

The DSC appears to issue section 18 notices relatively infrequently. DSC Annual Reports refer to three Section 18 notices being issued (in 2009/10, 2010/11 and 2011/12).

### ***A low priority on ongoing management and emergency response***

In recent decades, dam operators in NSW have been required by the DSC to undertake a significant program of safety related capital investment. This was largely in response to an improvement in the technical understanding of flood events which revealed that existing dams were less safe than previously understood.

However, this program of capital investment is now largely completed, and consultation has suggested that the largest improvements in dam safety going forward are likely to come from improved operational practices and emergency response protocols.

For example, the DSC has reported that close to 20 per cent of prescribed dams currently have a surveillance report outstanding.

## *Estimating the size of the problem*

### *Dam safety incidents in NSW*

There have been relatively few dam safety incidents in NSW under the current regulatory framework. The KPMG review noted that there had been three dam failures in NSW since the Dams Safety Act commenced in 1978, with no fatalities.<sup>14</sup> This included the following dam failures.

- The Oaky River hydro-electricity dam near Armidale, failed due to flood overtopping when its flood gates did not operate properly following torrential rain in February 2013.<sup>15</sup> However, the dam had a Low Consequence Category (confirmed in the actual dambreak), so there was no loss of life and only minor environmental damage.<sup>16</sup>
- In 1999, one of two inflatable rubber dams fitted to the spillway crest of the Lyell hydro-electricity dam near Lithgow ruptured without warning and deflated instantaneously resulting in an uncontrolled discharge of 6000 ML over five days.<sup>17</sup> This caused the river to rise by 2.5 metres about 40 minutes after the rupture. The Dam Safety Emergency Plan was activated, which facilitated the timely evacuation of campers downstream.<sup>18</sup>
- More recently (i.e. subsequent to the KPMG review), there was a limited breakthrough of a tailings dam embankment at the Cadia goldmine near Orange in March 2018.<sup>19</sup> However, the breakthrough was fully contained within an adjacent tailings dam, so there was no environmental damage and no loss of life. There were significant costs associated with disruptions to production; however, these costs were borne by the dam owner (Newcrest Mining), rather than the community more broadly.

In addition to these dam failures, DSC Annual Reports refer to two significant tailings dam safety incidents during the 2001-02 financial year, where failure was averted by early detection of the problems.<sup>20</sup>

### *The expected cost of dam failures in NSW*

Although the historical social and environmental costs of dam failures have been low in NSW, the risk of a dam failure with potentially catastrophic consequences remains. One

<sup>14</sup> KPMG, Review of the Dams Safety Act 1978 and Dams Safety Committee, Final Report, p. 87.

<sup>15</sup> Dams Safety Committee, Annual Report 2012-13, p. 3.

<sup>16</sup> Dams Safety Committee, Annual Report 2012-13, p. 24.

<sup>17</sup> Delta Electricity, Lyell Dam 5-Yearly Surveillance Report, p. 18.

<sup>18</sup> Dams Safety Committee, Annual Report 2017-18, p. 32.

<sup>19</sup> Newcrest Mining Limited, Market Release, [http://www.newcrest.com.au/media/market\\_releases/2018/Market\\_Release\\_12\\_03\\_2018.pdf](http://www.newcrest.com.au/media/market_releases/2018/Market_Release_12_03_2018.pdf), accessed 20 March 2019.

<sup>20</sup> Dams Safety Committee, Annual Report 2001/02, p. 5.

way to quantify the ‘size of the problem’ is to estimate the ‘expected number of fatalities’ and the associated ‘expected costs’ of dam failure. The expected cost of a dam failure can be estimated by multiplying the cost imposed on the community in the event of a dam failure by the probability of that event occurring.

The Department of Industry has provided estimates of the probability of dam failure and the potential number of fatalities in the event of a dam failure (based on flood modelling) for 347 prescribed dams. The level of analysis used to produce these estimates varies and estimating extreme events and the number of fatalities in the event of such events is inherently uncertain.

Nevertheless, based on this information we estimate (see appendix B for details of the approach used):

- the expected number of annual fatalities from dam failure in NSW
- the expected annual human safety costs from dam failure in NSW
- expected annual downstream property damage from dam failure
- the total annual expected cost of dam failure in NSW.

For the 73 prescribed dams where a risk assessment had not been completed, we base our estimates on the average of the prescribed dams of the same type and in the same consequence category for which the relevant information is available. As such, these estimates are treated as indicative only.

This information suggests that the expected number of fatalities from dam failure in NSW is around 0.66 per year and the total expected cost is around \$4.27 million per year (table 2.3).

### 2.3 Expected costs of dam failure in NSW

	Number of dams	Expected number of fatalities	Expected human safety costs	Expected property damage	Total expected costs
	No.	No. per year	\$ per year	\$ per year	\$ per year
Orange	16	0.4152	1.87	0.82	2.69
Yellow	184	0.0239	0.11	0.04	0.15
Green	147	0.0003	0.00	0.00	0.00
Not assessed <sup>a</sup>	73	0.2227	1.00	0.43	1.43
<b>Total</b>	<b>420</b>	<b>0.6620</b>	<b>2.98</b>	<b>1.29</b>	<b>4.27</b>

<sup>a</sup> Estimates based on the average of prescribed dams in the same consequence category and the same type for which the relevant information was available.

Source: NSW Department of Industry, CIE.

These estimates include only the cost of human fatalities and downstream property damage. Other costs could also be significant.

- The environmental costs of dam failure can be irreversible.
  - Environmental costs of dam failure are likely to be highest for tailings dams which contain mine waste, which can include toxic substances, such as arsenic, cyanide and heavy metals. The release of these materials into river systems increases

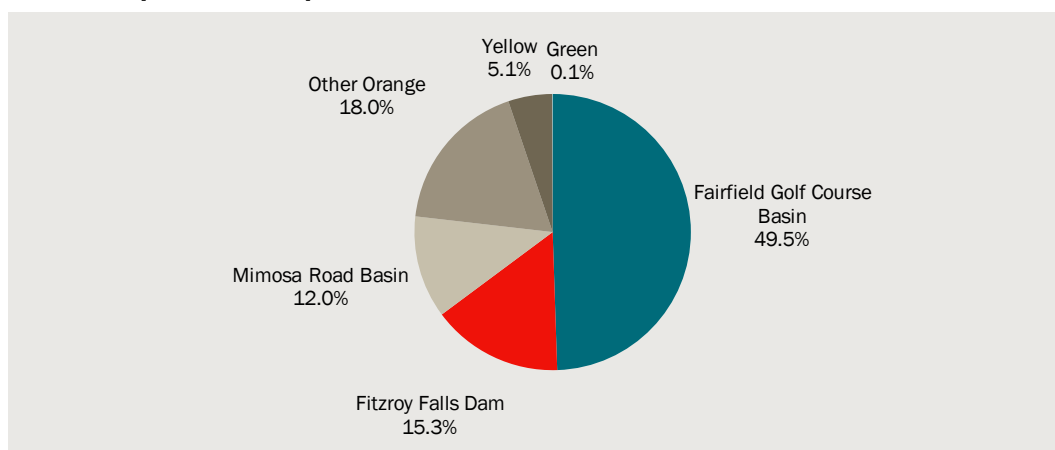
concentrations of contaminants for many years. These contaminants are a threat to human health and the environment.<sup>21</sup>

- The cost of the failure of water retention dams could include the loss of endangered flora and fauna species due to flooding.
- The loss of benefits from the dam could also be large, particularly where the dam provides essential services, such as urban water supply (e.g. if a large urban water supply dam failed, the cost and/or inconvenience of supplying water to users would be large).
- The cost of repairing or rebuilding the dam could also be significant, depending on the extent of the damage.

As these costs are likely to vary significantly across dams based on a range of dam-specific factors, it has not been possible to quantify them.

Of the prescribed dams that have been assessed (i.e. excluding the dams that have not been assessed where the estimates are based on the average of assessed dams of the same consequence category and type), around 95 per cent of the expected costs relate to the small number of dams that remain above the limit of tolerability (i.e. the orange area). A more detailed analysis shows that around 75 per cent of the total statewide expected cost relates to just three dams (Fairfield Golf Course Basin, Fitzroy Falls and Mimosa Road Basin), with almost half of the total expected cost relating to the Fairfield Golf Course Basin (chart 2.4).

#### 2.4 Composition of expected cost from dam failure



Data source: NSW Department of Industry, CIE.

#### *The expected cost of dam failure due to inadequate surveillance and maintenance*

The risk estimates discussed above are mostly based on flood (and earthquake) modelling and do not take into account the possibility of dam failure due to poor surveillance and maintenance practices. The US Association of State Dam Officials identifies ‘Inadequate

<sup>21</sup> HR Wallingford, A review of the risks posed by the failure of tailings dams, January 2019, pp. 10-16.

Maintenance and Upkeep' as one of the five factors most likely to cause a dam failure. However, although this is understood to be a key determinant in dam safety, the aggregate level of risk created by inadequate surveillance and maintenance is not well understood and are therefore difficult to quantify. In NSW, the DSC has limited visibility on the surveillance and maintenance practices of many dam owners.

*Quantifying the risk of dam failure due to inadequate surveillance and maintenance based on international evidence*

The risk of dam failure in NSW due to inadequate surveillance and maintenance practices is unknown. Nevertheless, reviewing the extent to which inadequate maintenance and surveillance practices have contributed to dam failures around the world may provide some insights into these risks in NSW.

It should be noted from the outset that this type of exercise has significant limitations.

- It can be difficult to determine whether a particular safety incident is a result of poor surveillance and maintenance practices. Many dam failures are due to the interaction of multiple factors. For instance, if minor seepage occurred but was not identified in surveillance reports, which then contributes to a dam failure in a period of heavy rain, it is unclear whether the dam should be attributed to the seepage, the lack of surveillance or the weather event. The interaction between different failure factors is discussed further in Horstedt et al (2008)<sup>22</sup> and Irfan (2015).<sup>23</sup> Where a dam failure has multiple contributing factors, attributing the failure of a dam to a single cause is often subjective, and this calculation is reliant on whether previous researchers have done this in a reliable way.
- The likelihood of failure due to a lack of maintenance and surveillance is likely to vary significantly between countries and over time. As such, global failure rates may not be reflective of the current risks in NSW.

The best long-term data source of dam failures is the Significant Incidence Reporting Database that is maintained by the US Association of Dam Safety Officials. The database includes dam failure as well as non-failure events, which are events that required attention and without intervention would likely have resulted in dam failure.

Imbrogno (2014)<sup>24</sup> identifies 337 dam incidents, of which 265 occurred after 2008. A summary of the causes of dam safety incidents found in the database is presented in table 2.5. This table lists the primary cause of each incident, and so each incidence is associated with a single cause.

<sup>22</sup> Norstedt, U. Rollenhagen, C and Evenus, P. (2008) *Considering Human factors in dam safety*. Hydro Review Worldwide.

<sup>23</sup> Irfan, A. (2015) Human Factors in Dam Failures, ASDSO paper on Lessons Learned, accessed from [https://damfailures.org/wp-content/uploads/2015/07/106\\_Human-Factors-in-Dam-Failures.pdf](https://damfailures.org/wp-content/uploads/2015/07/106_Human-Factors-in-Dam-Failures.pdf).

<sup>24</sup> Imbrogno, D. 2014, Analysis of Dam Failures and Development of a Dam Safety Evaluation Program, Thesis Presented in Partial Fulfillment of the Requirements for the Degree Master of Science in the Graduate School of The Ohio State University.

## 2.5 Causes of dam failures in the US Significant Incident Reporting Database

	Non-failure	Failure	Total	Share of dam failures	Share of total incidents
	No.	No.	No.		Per cent
<b>Enabling causes</b>					
Overtopping	29	32	61	27.8	21.9
Seepage and piping	10	25	35	21.7	12.5
Spillway deficiency	11	12	23	10.4	8.2
Instability	9	10	19	8.7	6.8
<b>Triggering causes</b>					
Extreme weather event	91	27	118	23.5	42.3
Deterioration or poor condition	10	5	15	4.3	5.4
Equipment or human error	2	2	4	1.7	1.4
Animal activity or vegetation	2	2	4	1.7	1.4
<b>Overall total</b>	<b>164</b>	<b>115</b>	<b>279</b>	<b>100.0</b>	<b>100.0</b>

Note: 58 incidents do not have a cause in the SIR database.

Source: Imbrogno 2014

Of those identified, the following causes are potentially related to inadequate surveillance and/or maintenance practices:

- seepage and piping
- deterioration or poor condition
- equipment or human error
- animal activity or vegetation.

Based on the information presented above, around 30 per cent of dam failures and 20 per cent of all incidents were a result of these causes.

Davies (2001)<sup>25</sup> estimated that:

- the global rate of failure of tailings dams is between 1:700 and 1:1750 in any year
- the global rate of failure of water-retaining dams is 1:10,000 in any year.

Putting this information together, we can infer the risk of dam failure due to inadequate surveillance and/or maintenance practices globally (table 2.6).

<sup>25</sup> Davies, M., 2001. *Impounded mine tailings: What are the failures telling us?* Can. Min. Metall. Bull. 94, 53-59.

## 2.6 Risk of dam failure due to inadequate surveillance and maintenance

	Assumed risk of failure	Proportion due to maintenance/surveillance	Total risk (expected dam failures per year)
Water retaining dams	0.00010	30	0.00003
Tailings dams	0.00100	30	0.00030

Source: CIE estimates.

### *Estimating the annual expected damage from maintenance and surveillance related dam failures*

If the average risk of dam failure due to inadequate surveillance or maintenance practices globally applied to each prescribed dam in NSW, this would imply an expected annual cost of around \$2.18 million in addition to the expected costs of dam failure to flooding (and to a lesser extent earthquake) events estimated above (table 2.7).

## 2.7 Expected costs of dam failure in NSW due to inadequate surveillance and maintenance practices

	Number of dams		Expected number of fatalities	Expected human safety costs	Expected property damage	Total expected costs
	No.	No. per year		\$ per year	\$ per year	\$ per year
Orange	16	0.4152		0.16	0.07	0.23
Yellow	184	0.0239		1.15	0.52	1.67
Green	147	0.0003		0.16	0.07	0.23
Not assessed	73	0.2227		0.04	0.02	0.06
<b>Total</b>	<b>420</b>	<b>0.6620</b>		<b>1.51</b>	<b>0.68</b>	<b>2.18</b>

Note: Estimates based on global estimates of the average risk of failure due to inadequate maintenance and surveillance practices.

Source: NSW Department of Industry, CIE.

As above, these estimates are indicative only.

- The estimate assumes that the risk of dam failure to inadequate maintenance and surveillance practices in NSW reflects the global average. However, these risks may be lower in NSW, compared to the global average (which includes many developing countries).
- The estimates apply the global average risk equally to all prescribed dams in NSW. However, it is likely that owners of dams with a higher consequence of failure would have in place better surveillance and maintenance practices and therefore have a lower risk of failure. Therefore, applying the global average evenly to all dams may overstate the expected cost.

### *Potential over-investment in dam safety*

There has been considerable investment in dam safety over the past 10-20 years. The DSC Annual Report lists 49 dams that have been upgraded since 2001 (excluding tailings dams) (see appendix C).



The total amount spent on dam safety upgrades over this period is not known, but publicly available information suggests it has been significant. In particular, WaterNSW has reportedly spent around \$420 million over the past 10 years on a safety risk reduction program on its rural water supply assets.<sup>26</sup> However, based on the information available, it is difficult to identify the extent to which past investment in dam safety could be considered ‘over-investment’ (i.e. the extent to which the cost of the upgrades exceeded the benefits).

Under the current regulatory framework, future ‘over-investment’ in dam safety could occur as follows.

- Dams currently above the limit of tolerability (i.e. in the orange area) must reduce risk to move below the limit of tolerability regardless of cost. This could potentially mean that some dam owners incur costs that outweigh any safety benefits (where safety benefits are valued using standard values used in regulatory impact assessment).
- Dams below the limit of tolerability, but above the threshold where risks are considered negligible (i.e. in the yellow area) must apply the ALARP principle. In discussions with various stakeholders, we encountered various views on how the ALARP principle is applied in practice.
  - Some dam owners appear to apply a ‘gross disproportionality factor’ within a formal CBA framework to inform decisions on whether a safety upgrade is warranted. As discussed above, the application of a gross disproportionality factor could lead to over-investment in dam safety.
  - Rather than formally applying a gross disproportionality factor in a CBA context, other dam owners interpret their regulatory obligations under the ALARP principle as ultimately needing to reduce risk to the point considered negligible (i.e. reach the green area). Under this interpretation, the only difference between intolerable risks (i.e. the orange area) and the area where the ALARP principle applies (i.e. the yellow area) is the urgency of reducing risk.

#### *Estimating the net cost of over-investment in dam safety*

One approach to estimating the net cost of future over-investment in dam safety under the existing regulatory framework would be based on:

- future investment plans under the existing regulatory framework
- **less:** the safety (and other) benefits of these investment (in present value terms over the life of the dam).

#### *Future investment plans*

Future investment plans under the current regulatory framework are not known for most prescribed dams. However, there is some publicly available evidence to suggest that there

---

<sup>26</sup> Aither, *WaterNSW rural bulk water services expenditure review: A review of capital and operating expenditure*, A final report prepared for the Independent Pricing and Regulatory Tribunal of NSW, February 2017, p. 50.



could be significant investment in dam safety under the current regulatory framework in the period ahead.

In particular, a review of WaterNSW's capital and operating expenditure for IPART's rural bulk water services review reported that WaterNSW has forecast a number of large projects from 2021-22 onwards, with average annual expenditure of \$34.5 million (to 2025-26) to comply with existing regulatory requirements.<sup>27</sup> If this level of expenditure continued beyond the determination period, this would amount to spending of around \$345 million over the next ten years (or around **\$259 million** in present value terms, using a discount rate of 7 per cent). The review noted that the need for these projects is directly linked to current dam safety regulation, which would be reviewed once the regulatory changes are finalised.<sup>28</sup>

Note that this estimate applies only to dams owned by WaterNSW used to provide rural bulk water services. WaterNSW owns 40 dams in total, around 10 per cent of all prescribed dams. That said, WaterNSW owns most of the larger dams in NSW, so the investment estimates above is likely to represent a disproportionate share of the total investment over the next ten years.

The bias towards over-investment in the current regulatory framework could affect all dams: currently above the limit of tolerability; and those currently subject to the ALARP principle (i.e. those currently in the yellow area). Of the dams with relevant information available, we estimate that those owned by WaterNSW would account for around 48 per cent of total construction costs (based on a rough estimate using the relationship between cost per ML and the reservoir capacity established in Petheram and McMahon (2019)<sup>29</sup>). This implies that the total investment across all dam owners could be in the order of **\$534 million** in present value terms over ten years (using discount rate of 7 per cent).

#### *Future safety benefits*

The future safety benefits of the investments estimated above are not known. However, the benefits of all dams reducing risk to a level considered negligible can be estimated from available information and represents an upper bound estimate of the potential safety benefits from further dam safety upgrades.

Reducing the risk of failure for all dams to a negligible level includes the following.

- For dams currently above the limit of tolerability (i.e. the orange area):
  - reducing the risk of dam failure to the limit of tolerability

---

<sup>27</sup> Aither, *WaterNSW rural bulk water services expenditure review: A review of capital and operating expenditure*, A final report prepared for the Independent Pricing and Regulatory Tribunal of NSW, February 2017, p. 63.

<sup>28</sup> Aither, *WaterNSW rural bulk water services expenditure review: A review of capital and operating expenditure*, A final report prepared for the Independent Pricing and Regulatory Tribunal of NSW, February 2017, p. 63.

<sup>29</sup> See Petheram, C. and McMahon, T.A. 2019, "Dams, dam costs and damnable cost overruns, *Journal of Hydrology*, p. 6.

- subsequently reducing the risk of dam failure from the limit of tolerability to a level where risks are considered negligible (i.e. the green area).
- For dams currently below the limit of tolerability (i.e. the yellow area), reducing risk to a level considered negligible (table 2.8).

Using a VSL of around \$4.5 million (as recommended by Australian Government Guidelines and widely adopted in NSW), a dam on the ‘limit of tolerability’ implies an expected cost to the community from loss of human life of around \$4500 per year or around \$66 500 in present value terms (assuming a 50 year period and using the NSW Government’s preferred discount rate of 7 per cent). Including the cost of property damage, the expected cost from dam failure at the limit of tolerability increases to around \$5500 to \$6550 per year (around \$81 000 to \$96 000 in present value terms).

The benefit of reducing the risk of all dams to the threshold where risks are considered negligible is estimated at around \$4.2 million per year or around \$62.7 million in present value terms over 50 years (using a discount rate of 7 per cent). As the limit of tolerability is relatively conservative, around 90 per cent of the total expected cost to the community from dam failures could be avoided through reducing dams that are above the limit of tolerability to the limit of tolerability (excluding dams that have not had a risk assessment). For dams at or below the limit of tolerability, the benefits of reducing risk to the threshold where risk is considered negligible are generally relatively modest.

## 2.8 Expected benefits of reducing risk

	Annual reduction in expected costs	Net present value	Share of total
	\$ million	\$ million	Per cent
<b>Rated dams</b>			
Orange: to LT	2.59	38.28	61.04
Orange: LT to RN	0.10	1.41	2.25
Yellow: to RN	0.13	1.99	3.17
<b>Total - rated dams</b>	<b>2.82</b>	<b>41.68</b>	<b>66.47</b>
<b>Unrated dams</b>			
Orange: to LT	1.04	15.33	24.45
Orange: LT to RN	0.39	5.69	9.07
Yellow: to RN	0.00	0.00	0.00
<b>Total - unrated dams</b>	<b>1.42</b>	<b>21.03</b>	<b>33.53</b>
<b>Total</b>	<b>4.25</b>	<b>62.71</b>	<b>100.00</b>

<sup>a</sup> Over ten years, using a discount rate of 7 per cent.

Note: LT is an abbreviation for Limit of Tolerability. RN refers to the threshold where risks are considered negligible.

Source: CIE estimates based on information provided by the NSW Department of Industry.

### *Net cost of future over-investment*

The limited evidence available suggests the following.

- Investment in dam safety could be significant over the next ten years (approximately \$534 million in present value terms, using a discount rate of 7 per cent, based on WaterNSW investment plans).
- The benefits from all prescribed dams reducing the risk of dam failure to the threshold where risk is considered negligible would be relatively modest at around \$4.25 million per year. Assuming all dams have a future life of 50 years, the benefit would be around \$62.7 million in present value terms (using a discount rate of 7 per cent).
- This implies that the net cost of future over-investment in dam safety over the next ten years could be in the order of \$470 million.

*Estimating the impact of applying a gross disproportionality factor on investment decisions*

An alternative approach to estimating the potential for over-investment in dam safety is to estimate the extent to which the application of a 'gross disproportionality factor' in a formal CBA could distort investment decisions. This approach implies the use of CBA to make decisions on safety upgrades. However, the use and quality of CBAs in the decision-making process appears variable. Further, CBA is only one factor taken into account.

- There may be significant uncertainty around CBA estimates, which means that dam owners (and in some cases regulators) may err on the side of caution.
- Dam owners have a 'duty of care' to downstream communities and could exceed the minimum standards required by regulation to protect themselves from legal liability in the event of a dam failure. One view was that the courts may decide that complying with the regulatory framework (good rather than best practice) may not be sufficient to avoid legal liability in the event of a dam failure (although this is yet to be tested in the courts).

Future investment in dam safety would be considered 'efficient' where the benefits (estimated using the recommended VSL of \$4.5 million) from the investment outweigh the costs. From the benefit estimates presented above, we can infer the maximum amount that could be efficiently invested in dam safety (such that the risk of all prescribed dams in NSW is considered negligible) in the period ahead could be around **\$63 million**.

As above, this estimate is indicative only.

- There may be significant uncertainty around the probability of dam failure and the potential loss of life in the event of dam failure.
- These estimates could also change over time due to:
  - further studies to more rigorously estimate the probability of dam failure (particularly for those dams where a full risk assessment has not been undertaken)
  - improved techniques for estimating the probability of dam failure and the potential loss of life in the event of a dam failure
  - future downstream development that increases the potential loss of life in the event of a dam failure.

Nevertheless, this estimate implies that investment in excess of this amount could potentially be inefficient. However, it is not necessarily the case that investment at or below \$63 million is efficient; investment in safety upgrades totalling \$63 million could only be justified if the risk of failure for all dams was reduced to a level considered negligible.

To provide a high-level indication of the extent to which the application of a gross disproportionality factor could lead to over-investment in dam safety, we compare: the above estimate of the maximum 'efficient' investment in dam safety; to an estimate of the maximum investment that could potentially be justified under the current regulatory framework (which would reflect an estimate of the potential benefits with a gross disproportionality factor applied to the expected loss of human life).

Based on ANCOLD Guidelines, the gross disproportionality factor should range between 3 and 10, depending on the risk. Our estimates are based on a linear scale, where:

- a gross disproportionality factor of 10 applies at the limit of tolerability, and
- a gross disproportionality factor of 3 applies at the threshold, below which risks are considered negligible.

Note that the gross disproportionality factor applies only to dams below the limit of tolerability and above the threshold at which risks are considered negligible. As dams above the limit of tolerability must reduce risk to a level below the limit of tolerability regardless of costs, there is effectively no upper limit on the potential for over-investment. That said, given the relatively high expected cost for some dams above the limit of tolerability, the benefits of dam safety upgrades are also likely to be significantly higher.

The potential over-investment as a result of applying a gross disproportionality factor is estimated at around \$42 million (table 2.9).

## 2.9 Potential over-investment under current regulatory framework

	Estimated annual reduction in expected costs applying GDF	Maximum investment under current regulatory framework	Maximum efficient investment	Potential over-investment
	\$ million	\$ million	\$ million	\$ million
<b>Rated dams</b>				
Orange: LT to RN	0.74	10.88	1.41	9.47
Yellow: to RN	0.66	9.81	1.99	7.82
<b>Total - rated dams</b>	<b>1.40</b>	<b>20.69</b>	<b>3.40</b>	<b>17.29</b>
<b>Unrated dams</b>				
Orange: LT to RN	2.06	30.39	5.69	24.71
Yellow: to RN	0.00	0.00	0.00	0.00
<b>Total - unrated dams</b>	<b>2.06</b>	<b>30.39</b>	<b>5.69</b>	<b>24.71</b>
<b>Total</b>	<b>3.46</b>	<b>51.08</b>	<b>9.09</b>	<b>42.00</b>

<sup>a</sup> Over ten years, using a discount rate of 7 per cent.

Note: LT is an abbreviation for Limit of Tolerability. RN refers to the threshold where risks are considered negligible.

Source: CIE estimates based on information provided by the NSW Department of Industry.

The above estimates imply that all investment justified as a result of applying the gross disproportionality is right on the upper limit of being accepted. It is possible that some investments fall somewhere between the upper limit without the gross disproportionality factor applied and the upper limit with the gross disproportionality applied. To account for this, it may be more defensible to halve this estimate, implying a reduction in over-investment of around **\$21 million**.

That said, this approach based on the formal application of a gross disproportionality factor produces much lower estimates of the potential for over-investment under the current regulatory framework, compared to the approach outlined above. This is consistent with one view encountered that:

- there is likely to be significantly less investment in dam safety upgrades in the period ahead, compared to the previous 10-20 years, reflecting the fact that most dams have successfully reduced risk below the limit of tolerability (or will do so in the near future), and
- once below the limit of tolerability, there are unlikely to be many safety upgrade options, where the costs would outweigh the benefits, even if a gross disproportionality factor is applied.

### 3 *Objectives and options*

#### *Objectives of the reform*

The specified objectives of the Dams Safety Act 2015 are:

- to ensure that any risks that may arise in relation to dams (including any risks to public safety and to environmental and economic assets) are of a level that is acceptable to the community
- to promote transparency in regulating dams safety
- to encourage proper and efficient management in matters relating to dams safety
- to encourage the application of risk management and the principles of cost benefit analysis in relation to dams safety.

The goals of the reforms relate directly to the issues with the existing regulatory structure identified in chapter 2. These specific goals are to:

- remove the existing incentives for dam owners to overinvest in dam safety
- remove the potential conflict of interest resulting from dam owners on the board of the DSC
- improve the ability of the regulator to enforce the existing regulations
- improve the practice of dam owners relating to ongoing safety management and emergency response.

#### *Options under consideration*

The NSW Government *Guide to Better Regulation* requires that multiple options are considered, including the status quo.<sup>30</sup>

The options under consideration are as follows.

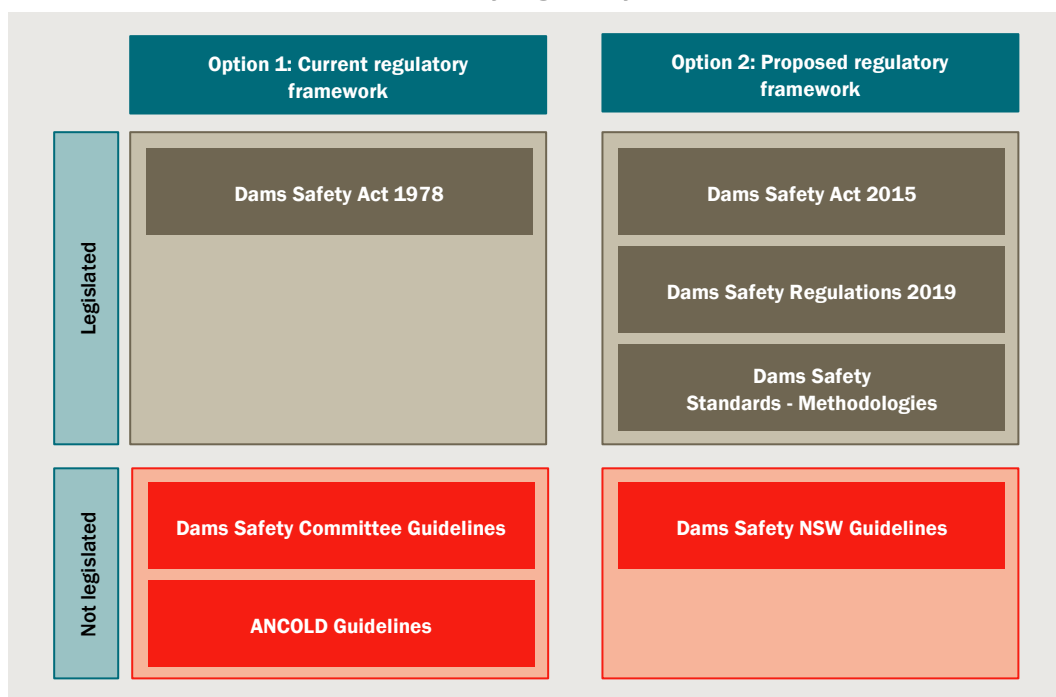
- 1 Continuing with the current regulatory framework (i.e. the status quo) which is based on the Dams Safety Act of 1978 and implemented by the DSC. This option also includes the continued use of DSC Guidelines and ANCOLD Guidelines.
- 2 The proposed regulatory framework developed by the Interim Dams Safety Committee. This is based on the Dams Safety Act of 2015, along with legislated regulation and standards.

A comparison between the two options is presented in chart 3.1 and described below.

---

<sup>30</sup> NSW Government, NSW Guide to Better Regulation, October 2016, p 12.

### 3.1 Current and proposed dams safety regulatory frameworks



Data source: Dam Safety NSW.

#### ***Option 1: Continuing with the current regulatory framework***

Option 1 is to maintain the status quo, which is understood to be a continuation of the Dams Safety Act 1978, administered by the DSC and implemented through the existing system of guidance sheets and ANCOLD Guidelines (this system is described in detail in Chapter 2).

Although the Dams Safety Act 2015 has already been enacted, it will not become fully operational until the associated regulations have been made. As such, with no further government action, the regulatory framework set out in the Dams Safety Act 1978 would continue to apply.

#### ***Option 2: Proposed regulatory framework***

Option 2 is to adopt the new regulatory framework. This includes:

- The Dams Safety Act (2015), which will replace the existing Act (i.e. the Dams Safety Act 1978) once the associated regulations have been made
- Regulations and standards created under the Dams Safety Act (2015), which largely replace the guidance sheets published by the DSC.
- *Dams Safety Standards – Methodologies* — the methodologies that dam owners will need to use for assessments required under the Standards will be published separately in the Government Gazette
- Supporting guidelines (such as cost benefit analysis guidelines –not yet published)

Although this RIS relates specifically to the Dams Safety Regulations 2019, as noted above the already enacted Dams Safety Act 2015 will not become operational until the regulations have been made. As such, the impact of making the regulations includes making the Dams Safety Act 2015 operational.

#### *Dams Safety Act 2015*

The Dams Safety Act of 2015 (the 2015 Act) is the legislative instrument that enables the new regulatory framework (including the Regulations, the proposed Standards and the supporting guidelines). The 2015 Act also provides the legal authority for the creation of Dams Safety NSW.

The 2015 Act also contains several specific provisions pertaining to how Dams Safety is to be regulated in NSW. These include:

- requiring a cost benefit analysis be performed whenever regulation is changed under the Act
- powers for Dams Safety NSW to stop work and intervene where safety is at risk
- penalties that can be levied on dam owners where they don't comply with the Act or the regulations
- specific restrictions
- the power to impose a levy on dam owners to fund the operations of Dam Safety NSW (note that at the present time, the NSW Government is not proposing to impose a levy).

#### *Proposed Dams Safety Regulation 2019*

The proposed Dams Safety Regulation 2019 sit below the 2015 Act in the regulatory hierarchy. The regulations:

- determine which dams should be declared and how these dams should be classified
- require dam owners to prepare and regularly update maintenance plans
- require dam owners to prepare and regularly update emergency plans (and to provide a copy of these plans to Dams Safety NSW, the SES)
- require dam owners to conduct emergency exercises
- require dam owners to maintain records of all important documentation.

#### *Proposed Dam Safety Standards 2019*

The proposed standards sit below both the 2015 Act and the 2019 Regulations in the regulatory hierarchy. The Safety Standards detail the specific technical requirements that must be complied with by dam owners. The standards cover:

- the requirement for dam owners to notify Dams Safety NSW of any proposed change in the configuration of a dam



- the requirement for dam owners to maintain a safety management system in compliance with AS ISO 550001 2014 Asset Management – Management Systems, including maintaining a manual in compliance with this standard
- the requirement for any organisation carrying out design, construction, commissioning or decommissioning work to have established a quality management system in compliance with AS IOS 9001:2016
- the framework for determining whether risk has been lowered So Far as Is Reasonably Practical (SFAIRP)
- a requirement to undertake a risk review at intervals no greater than five years
- increase in the frequency for which a dam with a significant consequence category must undertake a safety review
- dam owners' annual report requirements.

#### *Supporting guidelines*

The 2015 Act provides specifies that one of the functions of Dam Safety NSW is to develop guidelines to ensure the safety of dams. While these have not yet been drafted, they are expected to include specific guidance on how to perform cost-benefit analysis to satisfy assess investment decisions.

## 4 *Impacts*

### ***Approach to assessing impacts***

This RIS relates specifically to the *Dams Safety Regulations 2019*. However, as discussed above, the Dams Safety Act 2015 will not become fully operational until the regulations are in place. One of the key impacts of the regulations is therefore to bring the Dams Safety Act 2015 into operation.

The RIS is therefore effectively assessing the impacts of implementing the proposed regulatory framework in its entirety against a baseline of maintaining the existing regulatory framework (see chart 3.1 above).

That is, the RIS assesses the impact of the proposed *changes* to the regulation of dam safety. Key changes include:

- legislated regulations and standards
- establishment of Dams Safety NSW Guidelines which will incorporate to a large degree information provided in the existing DSC Guidelines and the ANCOLD Guidelines, with additional information as required such as the Cost Benefit Analysis guidelines currently being developed.

The Dam Safety NSW Guidelines are yet to be finalised. Hence the impacts from these supporting guidelines are not explicitly included in this analysis. The DSC Guidelines and the ANCOLD Guidelines are not legislated but are a component of the current regulatory regime and establish current practice for dam owners. As such these two sets of guidelines are included in existing regulatory framework against which the changes due to the proposed regulatory framework are assessed against.

### ***Key changes under the proposed regulations***

The changes to the regulatory framework include both:

- specific changes to the regulatory requirements that apply to dam owners
- greater focus on compliance.

These changes are summarised below. Further details of the proposed changes are provided in appendix B.

### ***Changes to regulatory requirements***

Specific changes to the regulatory requirements that apply to dam owners include the following.

- Operations and Maintenance Plans (O&M Plans) — owners of declared dams with a consequence category of either Extreme or High, will be required to update their Operations and Maintenance Plan annually, rather than every five years, as is currently required
- Increased frequency of emergency exercises to be carried out by dam owner
- Increased frequency of consequence category assessment for dams within Significant consequence category
- Asset management system adhering to ISO 55001 is required for all declared dam owners
- Requirements for dam design, construction, commissioning and decommissioning management system requirements
- Risk reviews to be carried out following any non-trivial change
- Dam owners must provide an annual report

The Dams Safety Act 2015 also provides for the introduction of a Dams Safety Levy to fund Dams Safety NSW's regulatory activities, where the details would be specified in regulations. However, the NSW Government is not proposing to specify a levy in the regulations at the present time. Any future decision to implement a levy would presumably be subject to a separate RIS.

#### *Operations and Maintenance Plans*

The proposed regulations require compliance operations and maintenance (O&M) plans to be in place and to be updated annually. Currently the DSC guidelines recommends O&M plans are updated at least every five years.

There is uncertainty regarding how many dam owners currently have a compliant O&M plan because the DSC does not currently require dam owners to submit their O&M. Dam owners are likely to fall into one of the following categories:

- have an existing compliant O&M plan in place
- have an informal operations and maintenance plan that requires formalisation into a compliant O&M plan
- do not have a compliant operations and maintenance plan.

#### *Consequence category assessments*

Dams with a consequence category of 'significant', the frequency with which a dam owner must re-assess the dam's consequence category will be increased.

- Under the proposed regulatory framework, a dam consequence category assessment must be carried out at least every 15 years.
- This compares to the requirement of not exceeding 20 years.

### *Increased frequency of updating emergency plans*

Under the proposed regulatory framework, emergency plans must be updated more frequently for some dams. Emergency plans must be updated within one month for dams which meet any of the following circumstances:

- emergency management arrangement changes
- significant change to the population risk or potential loss of life
- change to the consequence category of the dam.

There will also be a minor reduction in administration requirements with dam owners only required to provide an electronic copy of the emergency plan, when updated, to Dams Safety NSW, the SES and the State Emergency Operations Centre. A paper copy will no longer be required.

### *Increased frequency of emergency exercises*

The key changes under the proposed regulatory framework with respect to emergency plans are:

- an increase in frequency of emergency exercises:
  - exercises to be conducted with dam owner operations staff at least once every two years (rather than at least once every 5 years), and
  - exercises to be conducted with other agencies identified in the emergency plan (at the very least SES) at least once every 5 years for declared dams with consequence class above High

Based on discussions with stakeholders, the majority of dam owners have provided the DSC with an emergency plan. For this analysis, we assume an emergency plan is in place for all declared dams.

### *Risk reviews*

Currently a risk review must be carried out whenever the owner considers that a review is needed, but as a minimum whenever the DSC determines it is required (DSC Guidelines DSC 1B). Based on consultation, risk reviews are conducted by dam owners once every 10 years, on average.

The proposed regulatory framework makes the following changes:

- dam owners must conduct a risk review at intervals not greater than 5 years
- dam owners must prepare a risk review report that shows that:
  - dam safety risks are below the limit of tolerability. If the safety risks are not below the limit of tolerability, then the report must be provided to Dams Safety NSW who may direct the dam owner to take specific steps to ensure that the societal risk rating is reduced to the limit of tolerability or lower
  - once below the limit of tolerability that dam safety risks that have been identified in the risk review have been minimised SFAIRP.

### *General dam safety management system requirements*

The proposed regulatory framework requires all declared dam owners to undertake the following new requirements:

- establish, implement, and maintain a dam safety management system in the manner prescribed by all of the requirements of the AS ISO 55001
- prepare and maintain an electronic copy of a dam safety management system manual which addresses all the requirements of the AS ISO 55001
- dam owner must take into account the Dam Safety NSW guidelines and ANCOLD guidelines into account when preparing its dam safety management system
- dam owner must carry annual review of the dam safety management system, and/or as soon as practicable after any non-trivial change occurs in relation to the design, operation and maintenance of the dam.

### *Safety reviews*

Safety reviews must be carried out at least once every 15 years, instead of the current requirement of once every 20 years, for dams with a consequence category of significant.

### *Annual report*

Dam owners must prepare an annual report in the form approved by the Chief Executive Officer of Dams Safety NSW and a copy of the annual report must be provided to Dams Safety NSW.

### *Greater focus on compliance*

Under the proposed regulatory framework, there will be an increased focus on dam management and compliance and enforcement, including the following measures.

- The management requirements imposed on dam owners will be legislated (rather than specified in guidelines as is currently the case) and are therefore enforceable.
- Fines for non-compliance (which will be specified in the regulations) will be increased significantly to encourage better compliance.
- Dams Safety NSW will implement an audit program, under which a proportion of declared dams will be audited every year.

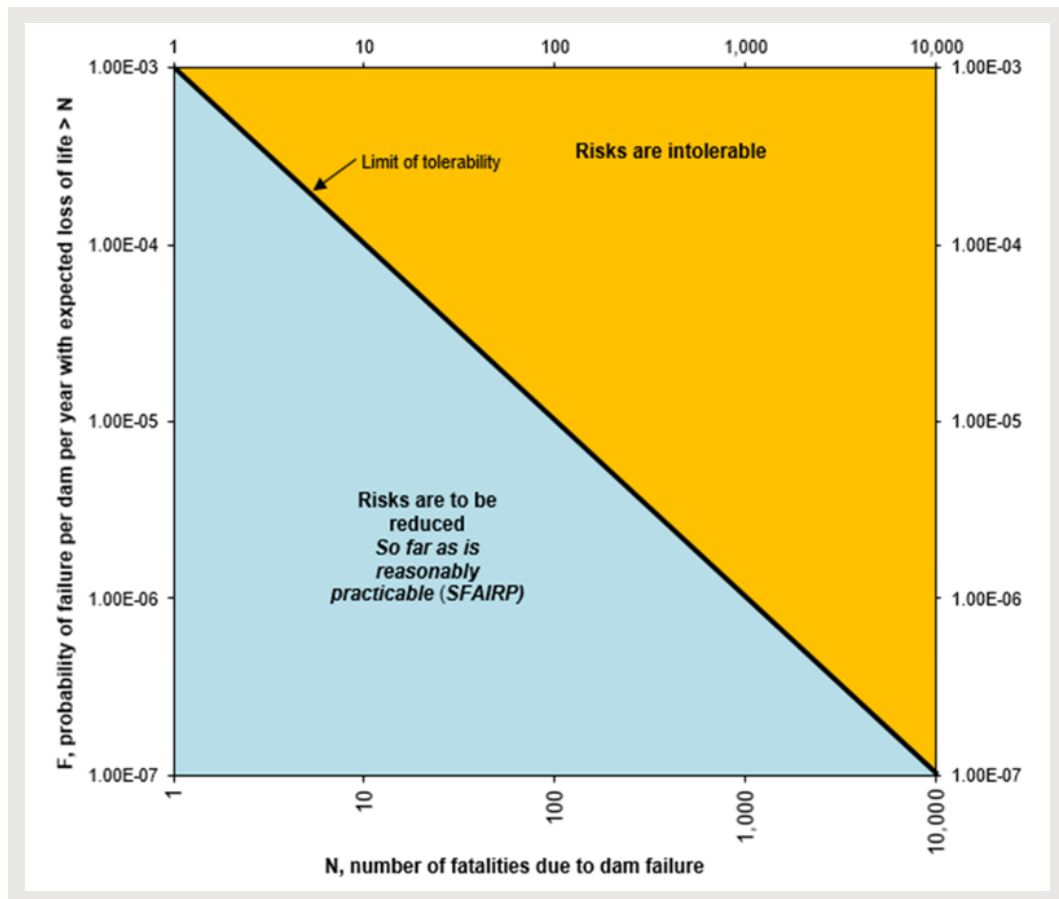
### *Change to the risk management framework*

A key change is a new risk management framework (chart 4.1). Under the proposed regulatory framework:

- The limit of tolerability has not changed. However, dams above this threshold will need to report this to Dams Safety NSW who may direct the dam owner to reduce the risk of dam failure to below the limit of tolerability.
- Dams below the limit of tolerability must reduce risk 'so far as is reasonably practicable' (SFAIRP), rather than ALARP as is currently the case.

- There is no threshold where risks are considered negligible.

#### 4.1 Proposed societal risk criteria for existing dams



Data source: NSW Department of Industry.

### *Impacts of the proposed changes*

The impacts (costs and benefits) of the proposed changes are summarised in table 4.2 and could include:

- change in government costs — in particular:
  - increased costs associated with the audit program
  - reduced costs associated with removing some regulatory functions
- increased administrative costs to dam owners
- reduced over-investment in dam safety — this will:
  - reduce costs for dam owners
  - result in slightly higher risks to the community
- reduced risk of dam failure due to poor management
- improved operational performance for some dams.

## 4.2 Summary of impacts for key changes

Change	Potential benefits	Costs
<b>Changes from current regulatory requirements</b>		
Increased frequency to update O&M plan for declared dams of Extreme or High consequence class	<ul style="list-style-type: none"> <li>▪ Reduced risk of dam failure</li> </ul>	<ul style="list-style-type: none"> <li>▪ Increased cost to dam owners</li> </ul>
Increased frequency of emergency exercises to be carried out by dam owner	<ul style="list-style-type: none"> <li>▪ Reduced consequence in the event of a dam failure</li> </ul>	<ul style="list-style-type: none"> <li>▪ Increased cost to dam owners</li> </ul>
Increased frequency of consequence category assessment for dams within Significant consequence category	<ul style="list-style-type: none"> <li>▪ Reduced risk of dam failure</li> </ul>	<ul style="list-style-type: none"> <li>▪ Increased cost to dam owners</li> </ul>
Asset management system adhering to ISO 55001 is required for all declared dam owners	<ul style="list-style-type: none"> <li>▪ Improved operational performance</li> <li>▪ Reduction in costs to dam owners if cost efficiencies are achieved</li> <li>▪ Reduced risk of dam failure</li> </ul>	<ul style="list-style-type: none"> <li>▪ Increased cost to dam owners to implement asset management system</li> </ul>
Risk management based on SFAIRP instead of the current ALARP framework and requirements for risk review	<ul style="list-style-type: none"> <li>▪ Reduced over-investment resulting in:               <ul style="list-style-type: none"> <li>– lower costs to dam owners</li> <li>– offset by slightly higher risk of dam failure.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>▪ Increased cost to dam owners to demonstrate risks have been minimised SFAIRP</li> <li>▪ Increased cost to dam owners if frequency of risk review increases from current practice</li> </ul>
Risk reviews to be carried out following any non-trivial change	<ul style="list-style-type: none"> <li>▪ Reduced risk of dam failure</li> </ul>	<ul style="list-style-type: none"> <li>▪ Increased cost to dam owners</li> </ul>
Safety review	<ul style="list-style-type: none"> <li>▪ Reduced risk of dam failure</li> </ul>	<ul style="list-style-type: none"> <li>▪ Increased cost to dam owners</li> </ul>
Requirements for dam design, construction, commissioning and decommissioning management system requirements	<ul style="list-style-type: none"> <li>▪ Reduced risk of dam failure</li> <li>▪ Improved operational performance</li> </ul>	<ul style="list-style-type: none"> <li>▪ Increased cost to dam owners</li> </ul>
Dam owners must provide an annual report	<ul style="list-style-type: none"> <li>▪ Reduced risk of dam failure</li> </ul>	<ul style="list-style-type: none"> <li>▪ Increased cost to dam owners</li> </ul>
<b>Changes through improved enforcement</b>		
Operations and maintenance (O&M) plans	<ul style="list-style-type: none"> <li>▪ Reduced risk of dam failure</li> <li>▪ Improved operational performance</li> </ul>	<ul style="list-style-type: none"> <li>▪ Increased cost to dam owners which do not currently have compliant O&amp;M plan</li> <li>▪ Higher costs for the NSW Government</li> </ul>
Emergency plan	<ul style="list-style-type: none"> <li>▪ Reduced risk of dam failure</li> <li>▪ Improved operational performance</li> </ul>	<ul style="list-style-type: none"> <li>▪ Increased cost to dam owners which do not currently have compliant emergency plan</li> <li>▪ Higher costs for the NSW Government</li> </ul>

Source: CIE.

### ***Change in government costs***

Under the proposed regulatory framework, the NSW Government will bear the costs associated with the audit program run by Dams Safety NSW. Although the Dams Safety Act 2015 provides for a levy to fund these costs (i.e. pass the costs onto dam owners), the NSW Government is not proposing to implement a levy at the present time.

These new costs will be partly offset by some cost savings through reducing the regulatory functions currently undertaken by the DSC.

### ***Increased costs incurred by dam owners***

The proposed changes to the regulatory framework are expected to impose additional costs on dam owners. This will include additional costs from:

- changes to regulatory requirements
- improved enforcement.

#### ***Additional costs from changes to regulatory requirements***

As outlined above, additional costs from changes to regulatory requirements will include costs associated with:

- updating O&M plans more frequently
- more frequent emergency exercises
- implementing and maintaining a dam safety management system
- completing consequence category assessments more frequently
- risk and safety reviews
- preparing annual reports.

#### ***Additional costs from improved enforcement***

In addition to the additional costs from changes to the regulatory requirements, the greater focus on compliance and enforcement is likely to improve compliance with existing regulatory requirements. Dam owners that are not currently complying with existing regulatory requirements will therefore incur some additional costs.

### ***Reduced over-investment in dam safety***

The impact of the change in the risk management framework will depend to a large extent on:

- how dam owners interpret the differences between the requirement to reduce risk SFAIRP, compared to ALARP
- potentially how the courts interpret a dam owners' duty of care to downstream communities.



There appears to be various interpretations of the difference between SFAIRP and ALARP. Differences in the interpretation of SFAIRP will only partly be resolved through guidelines on how the SFAIRP principle should be interpreted (the guidelines are currently in draft form).

In practice, applying the SFAIRP principle means there is no requirement to apply a 'gross disproportionality factor' when considering the need for a dam safety upgrades (see box 4.3 for a discussion on the merits of apply a gross disproportionality factor).

#### 4.3 Can a 'gross disproportionality factor' be justified?

Arguments used to justify the use of a gross disproportionality factor, include the following.

- Different level of aversion to different types of deaths — the ANCOLD Guidelines on Risk Assessment note that there is significant variation in the observed social preference for risk. For example, there are very high costs being paid to avoid the risk of cancer due to exposure to chemicals, and relatively low costs being paid to improve roads to avoid motor vehicle accidents. In effect, the application of a gross disproportionality factor is justified on the basis that some types of death are 'worse' than others, and so more resources should be spent to avoid them.
- Underlying uncertainty in the safety calculations — HSE (2002)<sup>31</sup> refers to the disproportionality factor as 'compensating to some extent for imprecision in the comparison of costs and the benefits'.
- To explicitly bias CBA results in favour of safety — the final rationale for a disproportionality factor is that it is explicitly designed to result in higher levels of safety. For example:
  - The ANCOLD Guidelines on Risk Assessments quote Rimington et. al. 2003 as follows: "It is taken as axiomatic that at all levels of risk there should be some bias in favour of safety, so that for risks above the broadly acceptable level we should be prepared to pay rather more than the estimated value of any increment of risk reduction to achieve it."<sup>32</sup>
  - HSE refers to the disproportion factor as 'the bias on the side of safety'.<sup>33</sup>

Although there is some validity to these observations, it does not necessarily justify the use of a gross disproportionality factor in a CBA.

- The variation across different studies was taken into account when arriving at the recommended VSL for use in regulatory impact analysis and in various government's decisions to adopt this recommendation (including the NSW Government).<sup>34</sup>

<sup>31</sup> Health and Safety Executive (2002), Principles and Guidelines to Assist HSE in its Judgments that Duty -Holders Have Risk as Low as Reasonable Practicable.

<sup>32</sup> (Rimington et al. (2003) quoted in the ANCOLD Guidelines on Risk Assessments)

<sup>33</sup> Health and Safety Executive (2002), Principles and Guidelines to Assist HSE in its Judgments that Duty -Holders Have Risk as Low as Reasonable Practicable.

<sup>34</sup> Abelson, P. 2008, *Establishing a Monetary Value for Lives Saved: Issues and Controversies*, Working papers in cost-benefit analysis, WP 2008-02, Office of Best Practice Regulation.

- There is no particularly compelling argument that suggests that a death by a dam failure is worse than the ‘average’ death envisaged by governments when specifying an appropriate VSL for use in CBA.<sup>35</sup> In particular, the practice of surveying individuals at risk from a dam failure need to be interpreted cautiously and cannot be compared to estimates from VSL studies.
- There is no evidence that the reduction from dam augmentation is being systematically underestimated.<sup>36</sup> Indeed the risks associated with the process of augmenting the dam are not always considered (such as workers dying or dams failing as a result of the upgrade process), suggesting that the underlying bias is likely to go in the opposite direction.

In general, key uncertainties in CBA should be explored through sensitivity testing, rather than through explicitly distorting the CBA results, such as through the application of a gross disproportionality factor. The extent to which risks are not well understood should also factor into decision-making.

To the extent that the application of a gross disproportionality factor contributes to the problem, the proposed changes to the risk management framework could be expected to reduce over-investment in dam safety. This implies a reduction in the cost of dam safety upgrades for dam owners, partly offset by a slightly higher risk of dam failure.

### ***Reduced risk of dam failure from improved management***

The focus of the DSC over the past 10-20 years has been on ensuring that all dams in NSW move below the limit of tolerability. This has largely been achieved; currently, only 15 dams remain above the limit of tolerability and we understand several of these will move below the limit of tolerability in the near future.

To some extent, the new regulatory framework shifts the focus onto dam management through strengthened management requirements and greater focus on compliance. As noted previously up to 30 per cent of dam failures are caused by inadequate surveillance and maintenance practices.

A greater focus on strengthening dam management requirements and compliance and enforcement is likely to reduce the risk of a dam failure.

---

<sup>35</sup> The Victorian Department of Environment, Land, Water and Planning (2017, Guidance Note on Dam Safety Principles, p.17) notes that while ‘there has been little attention paid to understanding community perceptions of dam risk in Australia. Research uncovered was undertaken by CSIRO some two decades ago showed that when compared to 19 other risks such as traffic accidents, medical error and bushfires, dam failure was the lowest short and longterm concern’.

<sup>36</sup> Although, if this were the case, it would make more sense to conduct sensitivity analysis on the variation in underlying risk, rather than add an arbitrary factor to one part of the decision rule.

### ***Improved organisational performance***

Among the strengthened management requirements is the need to establish a dam safety management system, which must be set out in a dam safety management system manual that complies with Australian Standard AS ISO 55001 (2014). ISO 55001 is the international standard for Asset Management Systems, which was first established in 2014. ISO 55001 is flexible and can be applied to any business. Businesses can voluntarily obtain certification as complying with the standard.

ISO 55001 has some similarities with ISO 9001, the international standard for Quality Management Systems, which was first established in the late 1980s. There are numerous studies that estimate the impact of ISO 9001 certification on a range of measures of business performance, such as return on assets, sales, investment, equity, profit margin, profitability, sales and market share across various countries and industries. The results of these studies are mixed, although a meta-analysis of 42 empirical studies found that ISO 9001 certification does increase financial performance, mainly through increased sales.<sup>37</sup>

By contrast, ISO 55001 was established relatively recently and studies on the impact of ISO 55001 certification on business performance are only now starting to emerge. An early study of this type surveyed experts in asset management in ISO 55001-certified companies (including utilities) in the United Arab Emirates. The study found a statistically significant positive impact of ISO 55001 certification on 21 key performance indicators (KPIs), including:<sup>38</sup>

- production and operative cost reduction
- return on investment or net profit
- reduction of insurance premiums
- increased customer satisfaction
- improved corporate image
- improvement in organisation efficiency
- process and organisation effectiveness
- improvement in the quality, reliability of products/services
- improved documentation, work procedures, policies and registers
- continuous improvement through reduction of mistakes, non-conformity, re-work and non-value added activities
- improved working conditions, health and safety performance
- increased employee motivation and commitment
- increased employee development, education and training
- clear knowledge of tasks responsibilities by employees.

<sup>37</sup> ISO website, <https://www.iso.org/news/2012/10/Ref1665.html>, accessed 31 January 2019.

<sup>38</sup> Imad Alysouf, Maitha Alsuwadi, Sadeque Hamdan and Mohammad Shasuzzamm, 2018, Impact of ISO 55000 on organizational performance: evidence from certified UAE firms, *Total Quality Management and Business Excellence*, p. 11.

This suggests that a potential benefit of the requirement to develop a dam safety management system that complies with ISO 55001 could be improved financial performance through better asset management.

## 5 Cost benefit analysis

### Summary of CBA results

The proposed changes will impose additional costs on dam owners, mostly due to new regulatory requirements. The NSW Government will also incur some additional costs associated with administering the new regulatory framework.

On the other hand, the benefits of the proposed regulatory changes are highly uncertain. The proposed regulatory changes have sought to address the perceived ‘over-investment’ problem, mainly through applying the less stringent SFAIRP principle, rather than ALARP for dams below the limit of tolerability. However, the benefits of these changes over the next ten years are difficult to quantify.

- Under the ‘low scenario’ considered the benefits of the proposed changes would fall short of the costs.
- However, under the ‘high scenario’, the benefits from reduced over-investment in dam safety would significantly exceed the costs.

#### 5.1 Cost-benefit analysis - summary

	Low	High
	\$ million	\$ million
<b>Benefits</b>		
Reduced over-investment	21.0	472.3
Reduced risk of dam failure due to inadequate management	16.4	16.4
<b>Total benefits</b>	<b>37.4</b>	<b>488.7</b>
<b>Costs</b>		
Costs to dam owner from new regulatory requirements	99.2	186.5
Costs to dam owners from improved compliance	4.5	4.5
Additional costs to the NSW Government	16.2	16.2
<b>Total costs</b>	<b>119.9</b>	<b>207.2</b>
<b>Net benefit/costs</b>	<b>- 82.5</b>	<b>281.5</b>

Note: Costs and benefits are presented in net present value terms over ten years, using a discount rate of 7 per cent.

Source: CIE estimates.

### Approach to the CBA

Clause 14(2a) of Part 3 of the *Dams Safety Act 2015* requires a cost benefit analysis be carried out for regulations which prescribe standards for or with respect to any matter

relating to the safety, operation or maintenance of declared dams. Therefore, this RIS includes assessment of the impacts from:

- the proposed reform package including the *Dams Safety Act 2015*, Regulations 2019 and legislated dam safety standards, as well as
- the legislated dam safety standards separately.

Costs and benefits will be estimated in net present value terms over a ten-year period. Future costs and benefits are discounted to present value terms using a real discount rate of 7 per cent, consistent with NSW Treasury CBA guidelines.<sup>39</sup>

Recently there has been significant capital investment in dam safety upgrades, with a focus on shifting dams from above the line of tolerability to below, and also in response to an improvement in the technical understanding of flood events. This program of capital investment is now largely completed with only a few dams remaining above the line of tolerability. The focus for dams safety is now shifting to improved operational and management practices and emergency response protocols. The proposed changes to the regulatory framework reflect this shift through establishing legislative requirements to complete/establish protocols including:

- operations and maintenance plan
- emergency plan
- asset management system in compliance with AS ISO 55001
- risk and safety reviews.

The key aim of these changes is to improve the safety of dams through good management practices. Given the benefits of good management cannot be attributed to one particular safety, management or emergency protocol, it is sensible for this CBA to consider the benefits of good management and systems from the package of reform changes. Below we discuss the benefits of the proposed changes to the regulatory framework as a bundle with the two key benefits being:

- reduced over-investment in dam safety, and
- improved organisational performance.

In terms of costs it is appropriate to quantify the costs for each individual change to the regulatory framework. The costs for each change under the *Dams Safety Regulation 2019* and the *Dams Safety Standards 2019* are detailed and quantified (where possible) below.

### ***Estimated cost of proposed changes***

The costs arising from the proposed changes to the regulatory framework are estimated at between \$134.6 million to \$221.2 million in present value terms over ten years, using a discount rate of 7 per cent (table 5.2).

- These costs are mostly borne by dam owners through new regulatory requirements.

---

<sup>39</sup> NSW Treasury, *NSW Government Guide to Cost-Benefit Analysis*, Policy and Guidelines Paper TPP 17-03, March 2017, p. 15.

- There may also be some additional costs on dam owners due to the greater focus on compliance and enforcement to the extent that some dam owners that are avoiding existing requirements.
- There are also expected to be some additional costs for the NSW Government in administering the new regulatory framework. The Dams Safety Act 2015 allows for these costs to be recovered through a levy; however, the no levy is being proposed at the present time.

## 5.2 Estimated costs of proposed changes

Proposed new requirements	Low	High
	\$ million	\$ million
<b>Cost to dam owners - new regulatory requirements</b>		
Increased frequency to update O&M plans	4.4	4.4
Increased frequency of emergency exercises	13.4	13.4
Increased frequency of assessment of consequence category	1.3	1.3
Requirement to develop AMS in accordance with ISO55001a	2.1	41.6
Requirement to implement and maintain AMSa	28.1	76.0
Requirement for risk review and risk review report	22.0	22.0
Requirement for dam owners to conduct a safety review	1.3	1.3
Requirement for annual report to be prepared and provided to DS NSW	26.5	26.5
<b>Total</b>	<b>99.2</b>	<b>186.5</b>
<b>Cost to dam owners - improved compliance</b>		
Prepare compliant O&M Plans	4.5	4.5
Prepare compliant emergency plans	0.0	0.0
<b>Total</b>	<b>4.5</b>	<b>4.5</b>
<b>Costs to government</b>		
Change to staff costs due to change in responsibilities	16.2	16.2
<b>Total</b>	<b>119.9</b>	<b>207.2</b>

Note: Estimates presented in net present value terms over ten years, using a discount rate of 7 per cent.

Source: CIE estimates.

### *Change to government costs from transfer of DSC to Dams Safety NSW*

The current regulatory framework is administered by the DSC and three sub-committees with a total staff cost of \$1.6 million per year, equivalent to \$12.0 million in present value terms over ten years.

The proposed regulatory framework will be administered by Dams Safety NSW and supporting compliance with an estimated staff cost of \$3.5 million. In addition, there will be an additional \$1 million cost in each of the first two years of operation to cover costs to establish Dams Safety NSW (table 5.3). The present value of government costs under the proposed regulatory framework is \$28.2 million over ten years.

The proposed regulatory framework will increase government costs by \$16.2 million in present value terms over ten years (table 5.4).

### 5.3 Government costs of current and proposed regulatory frameworks

	Current regulatory framework	Proposed regulatory framework
	\$m/year	\$m/year
Annual costs including establishment cost	na	4.5
Annual costs excluding establishment cost	1.6	3.5

Source: Information provided by the Interim Dams Safety Committee.

### 5.4 Present value of government costs

Timeframe of analysis	Current regulatory framework	Proposed regulatory framework	Change
	PV\$m	PV\$m	PV\$m
No. of years			
10	12.0	28.2	16.2

Source: CIE based on information provided by DSC.

## *Dam owner costs from changes to regulatory requirements*

### *More frequent updating of operations and maintenance plans*

The regulations specify that the operations and maintenance plan must be updated annually for all declared dams which are classified at extreme, high or significant consequence class. For declared dams classified at low or very low consequence category, the operations and maintenance plan must be updated at intervals no greater than five years.

The current DSC guidelines recommends O&M plans are updated at least every five years.

The cost to update a plan ranges between \$11 000 and \$15 000, depending on consequence category, for an update frequency of once every 5 years, and between \$4 000 and \$6 000 for annual updates (table 5.5).

### 5.5 Cost to update operations and maintenance plan

Consequence category	Cost to update plan once every 5 years	Cost to update plan annually
	\$	\$
Very low and low	11 000	4 300
Significant	16 000	5 900
High A, B, C	16 000	5 900
Extreme	16 000	5 900

Source: Information provided by stakeholders.



As there is no change in the update frequency for declared dams classified at low, very low and significant consequence class, there is no change in annual cost. The increase in update frequency for consequence categories, high and extreme, increases the total annual cost across all declared dams by \$0.58 million (table 5.6), equivalent to a present value of \$4.4 million over ten years (applying 7 per cent discount rate).

### 5.6 Cost to dam owners from increased update frequency of O&M plans

Consequence category	Number of dams	Annual cost under current regulatory framework	Annual cost under proposed regulatory framework	Change in annual costs
		\$m	\$m	
Very low and low	28	0.06	0.06	0.00
Significant	167	0.53	0.53	0.00
High A, B, C	184	0.59	1.09	0.50
Extreme	32	0.10	0.19	0.09
<b>Total</b>	<b>411</b>	<b>1.29</b>	<b>1.87</b>	<b>0.58</b>

Source: CIE.

#### *Increased frequency of emergency exercises*

The current DSC guidelines requires emergency plans to be reviewed and tested at least every 5 years with SES involvement (section 4.5 DSC 2G). The proposed regulatory framework increases the frequency of emergency exercises for declared dams. The required frequency depends on a dam's risk level (table 5.5)

### 5.7 Proposed change to required frequency of emergency exercises

Consequence category	Frequency of emergency exercise with operations staff		Frequency of emergency exercises with operations staff and other agencies	
	Current	Proposed	Current	Proposed
Very low and low				Not required
Significant	At least every 5 years	At least every 2 years	At least every 5 years	Not required
High A, B, C				At least every 5 years
Extreme				At least every 5 years

Source: Interim Dams Safety Committee.

The cost to dam owners to conduct emergency exercises with operational staff, and also with other agencies is outlined in table 5.8.

Due to limited information on the cost of emergency exercises across different types of dams we have assumed the cost for storage detention and other dams is 50 per cent of the cost to water supply and tailings dams as it is expected there is generally less operational staff required and no loss of production during time spent conducting emergency exercise.

## 5.8 Cost to dam owners to conduct emergency exercises

	Cost per emergency exercise with operations staff	Cost per emergency exercise with operations staff and other agencies
	\$	\$
<b>Water supply and tailings dams</b>		
Very low and low	14 000	26 000
Significant	18 000	49 000
High A, B, C	18 000	49 000
Extreme	18 000	49 000
<b>Storage detention and other dams</b>		
Very low and low	7 000	13 000
Significant	9 000	24 500
High A, B, C	9 000	24 500
Extreme	9 000	24 500

Source: Information provided by stakeholders

The increase in frequency to conduct emergency exercises for declared dams, increases costs to dam owners by \$1.8 million per year (table 5.9), equivalent to a present value of \$13.4 million over ten years (applying 7 per cent discount rate).

## 5.9 Change in cost from increased frequency of emergency exercises

Dam type and consequence category	Number of declared dams	Exercise with operational staff		Exercise with operational staff and other agencies		Total change in cost
		Cost per exercise	Change in annual cost for declared dams	Cost per exercise	Change in annual cost for declared dams	
<b>Water detention</b>						
Very low and low	1	7 000	2 100	13 000	0	2 100
Significant	55	9 000	148 500	24 500	0	148 500
High A, B, C	63	9 000	170 100	24 500	0	170 100
Extreme	1	9 000	2 700	24 500	0	2 700
<b>Water storage/supply</b>						
Very low and low	14	14 000	58 800	26 000	0	58 800
Significant	39	18 000	210 600	49 000	0	210 600
High A, B, C	66	18 000	356 400	49 000	0	356 400
Extreme	22	18 000	118 800	49 000	0	118 800
<b>Tailings dam</b>						
Very low and low	11	14 000	46 200	26 000	0	46 200
Significant	68	18 000	367 200	49 000	0	367 200
High A, B, C	43	18 000	232 200	49 000	0	232 200
Extreme	0	18 000	0	49 000	0	0

Dam type and consequence category	Number of declared dams	Exercise with operational staff		Exercise with operational staff and other agencies		Total change in cost
		Cost per exercise	Change in annual cost for declared dams	Cost per exercise	Change in annual cost for declared dams	
<b>Other</b>						
Very low and low	2	7 000	4 200	13 000	0	4 200
Significant	5	9 000	13 500	24 500	0	13 500
High A, B, C	12	9 000	32 400	24 500	0	32 400
Extreme	9	9 000	24 300	24 500	0	24 300
<b>Total (\$m)</b>						<b>1.8</b>

Source: CIE.

### *Assessment of consequence category of dam*

There are approximately 170 declared dams that have a significant consequence category. Currently declared dams with a significant consequence category are required to re-assess the consequence category once every 20 years under the DSC Guidelines (DSC 2D).

From consultation the average cost to assess the consequence category of a dam is \$60 000.<sup>40</sup> The requirement for declared dams with a 'significant' category to assess its consequence category once every 15 years as opposed to the current requirement of once every 20 years, increases the cost per dam per year by \$1000 or \$167 000 per year across all dams. This is equivalent to a present value of \$1.3 million over ten years (applying 7 per cent discount rate).

### **5.10 Cost to dam owners from increased frequency of assessment**

Dam type	Number of dams declared 'significant'	Cost per assessment	Annual cost with frequency of assessment (1 every 20 years)	Annual cost with frequency of assessment (1 every 15 years)	Change in annual cost across all declared 'significant' dams
	No.	\$	\$/dam	\$/dam	\$
Water detention	55	60 000	3 000	4 000	55 000
Water supply	39	60 000	3 000	4 000	39 000
Tailings dam	68	60 000	3 000	4 000	68 000
Other	5	60 000	3 000	4 000	5 000
<b>Total</b>	<b>167</b>				<b>167 000</b>

Source: CIE.

<sup>40</sup> It is noted that the assessment of consequence category often incorporate hydrology and dam break modelling.

### *Dam safety management system requirements - general*

The requirement to establish, implement and maintain a dams safety management system which meets the requirements of ISO 55001 is a new requirement. However, there are a few dam owners, including the major water utilities which already meet this requirement, for example WaterNSW has in place a AS ISO 55001 management system across its portfolio of 40 dams. Hence, we assume this is a new requirement for 90 per cent of dam owners.

From preliminary consultation we received two estimates of the cost to prepare an asset management system which meets the requirements of ISO 55001. These costs vary substantially, ranging between \$6 000 and \$25 000 for the very low and low consequence categories and between \$6 000 and \$150 000 for the High A and Extreme consequence categories (table 5.11). Given the substantial variation in costs between the two cost estimates, we estimate the cost of this regulatory change for two cost scenarios:

- low cost scenario based on estimate A
- high cost scenario based on estimate B.

It is also important to note these cost estimates were provided by water supply dam owners and may not reflect costs to other dam types such as water storage dams or tailings dams.

#### **5.11 Preliminary estimate of cost to establish and annually review ISO 55000 system**

Consequence category of dam	Estimate A	Estimate B
	\$	\$
Very low and low	5 700	25 000
Significant and High B, C	5 700	112 500
Extreme and High A	5 700	150 000

Source: Information provided by stakeholders.

The total cost across all declared dams to prepare an asset management system which meets the requirements of ISO 55001 ranges between \$2.1 million and \$41.6 million (table 5.12).

#### **5.12 Cost to prepare ISO 55001 asset management system**

Consequence category	Number of dams without ISO 55001	Low cost scenario		High cost scenario	
		Cost per dam	Total cost across dams	Cost per dam	Total cost across dams
		\$	\$m	\$	\$m
Very low and low	25	5 700	0.14	25 000	0.63
Significant and High C, B	291	5 700	1.66	112 500	32.72
High A and Extreme	55	5 700	0.31	150 000	8.24
<b>Total</b>	<b>371</b>		<b>2.11</b>		<b>41.59</b>

Source: CIE based on information provided by stakeholders.

Estimates of the annual cost to implement and maintain the dam safety management system range between \$10 500 and \$29 200 per dam per year (table 5.13).

### 5.13 Estimate of annual cost to implement and maintain asset management system

Consequence category of dam	Estimate A	Estimate B
	\$	\$
Very low and low	10 500	17 200
Significant and High B, C	10 500	29 200
Extreme and High A	10 500	29 200

Source: Information provided by stakeholders.

The total annual cost across all declared dams to implement and maintain the asset management system ranges between \$4.3 million and \$11.7 million (table 5.14). This is equivalent to a present value ranging between \$28.1 million and \$76 million over ten years (applying 7 per cent discount rate).

### 5.14 Annual cost to implement and maintain asset management system

Consequence category	Number of dams	Low cost scenario		High cost scenario	
		Annual cost per dam	Total cost	Annual cost per dam	Total cost
		\$	\$m	\$	\$m
Very low and low	28	10 500	0.29	17 200	0.48
Significant and High C, B	306	10 500	3.21	29 200	8.94
High A and Extreme	77	10 500	0.81	29 200	2.25
<b>Total</b>	<b>411</b>		<b>4.32</b>		<b>11.67</b>

Source: CIE based on information provided by stakeholders.

#### *Risk review and risk review report*

Based on consultation, risk reviews are currently conducted by dam owners once every 10 years, on average. The proposed regulations require a risk review to be conducted at least once every 5 years.

From preliminary consultation we received two estimates of the cost to conduct a risk review. As these costs vary substantially by consequence category we have applied a weighted average cost by consequence category to all declared dams (table 5.15). It is also important to note these cost estimates were provided by water supply dam owners and may not reflect costs to other dam types such as water storage dams or tailings dams.

### 5.15 Estimated cost to conduct risk review

Consequence category	Estimate A	Estimate B	Weighted average <sup>a</sup>
Very low and low	18 200	138 000	40 000
Significant and High A, B, C	29 800	164 000	64 000
Extreme	54 800	207 000	177 000

<sup>a</sup> The weighted average is based on apportioning cost estimates to reflect differences between type of dams as much as possible with limited information.

Source: Information provided by stakeholders.

Based on the data available, the requirement for dam owners to conduct risk reviews at least once every 5 years increases the cost to dam owners by \$2.93 million per year, equivalent to a present value of \$22.0 million over ten years (applying 7 per cent discount rate).

### 5.16 Change in cost to dam owners from proposed requirements for risk review

Consequence category	Number of dams	Cost per risk review	Change in annual cost due to increase in frequency	Total change in cost across dams
	No.	\$/dam	\$/dam	\$m
Very low and low	28	39 982	3 998	0.11
Significant and High A, B, C	351	64 273	6 427	2.26
Extreme	32	176 560	17 656	0.56
<b>Total</b>	<b>411</b>			<b>2.93</b>

Source: CIE.

#### *Dam safety management system requirements – safety review*

This change relates to dams with a significant consequence category. Currently declared dams with a significant consequence category are required to undertake a safety review once every 20 years. The new requirement is for a safety review to be completed at least once in 15 years. In the absence of information on the cost to conduct a safety review, the average cost of \$64 000 to conduct a risk review for a dam with a significant consequence category (table 5.15) is taken as the cost to conduct a safety review. The increased frequency of safety reviews increases the annual cost per dam by \$1 070.

The total annual cost across all declared dams with a significant consequence category is \$0.2 million. This is equivalent to a present value of \$1.3 million over 10 years (applying 7 per cent discount rate).

#### *Dam design, construction, commissioning and decommissioning management system requirements*

The current regulatory framework requires dam owners to submit the design team and dam design to the DSC for approval. This will no longer be required under proposed regulatory framework. Instead dam owners will be required to:

- ensure that any organisation carrying out design, construction, commissioning and decommissioning work has established, implemented and is maintaining a quality management system in the manner prescribed by AS ISO 9001:2015
- dam designs for dams in the extreme or high class must be reviewed and verified and validated by a competent person who is independent of the original design process.

The key impacts of the proposed changes are likely to be:

- reduced time on finalising dam design as designs will no longer have to be sent to the DSC for approval

- change in cost to carry out design, construction, commissioning and decommissioning work
- increase in cost associated with cost of competent person to conduct review of the dam design.

These impacts have not been quantified due to insufficient information on the costs and frequency of processes related to dam design, construction, commissioning and decommissioning. From preliminary consultation, one stakeholder noted the processes for dam design and construction for their declared dams already met the proposed requirements and the key impact of this change is avoided time delay involved with gaining DSC approval for designs.

### *Dam owner's annual report*

Under the proposed regulatory framework, there is a new requirement for dam owners to prepare an annual report and provide a copy to Dams Safety NSW.

From preliminary consultation we received two estimates of the cost to prepare an annual report. As these costs vary we have applied a weighted average cost by consequence category to all declared dams (table 5.17). It is also important to note these cost estimates were provided by water supply dam owners and may not reflect costs to other dam types such as water storage dams or tailings dams.

### 5.17 Estimated cost to prepare annual report

Consequence category	Estimate A	Estimate B	Weighted average
Low and very low	10 000 <sup>a</sup>	8 000	8 400
High and significant	20 000	8 000	8 500
Extreme	45 000	8 000	9 600

<sup>a</sup> This estimate was not provided by the stakeholder but has been estimated by CIE as 50 per cent of the cost for a High/Significant dam to reflect the reduced complexity of preparing an annual report for a low and very low consequence category.

Source: CIE and information provided by stakeholders.

The total annual cost across all declared dams is \$3.5 million. This is equivalent to a present value of \$26.5 million over 10 years (applying 7 per cent discount rate)(table 5.18).

### 5.18 Cost to dam owners to prepare annual reports

Consequence category	Number of dams	Cost per annual report	Total chance in cost across dams
	No.	\$/dam	\$m
Very low and low	28	8 400	0.2
Significant and High A, B, C	351	8 500	3.0
Extreme	32	9 600	0.3
<b>Total</b>	<b>411</b>		<b>3.5</b>

Source: CIE based on information provided by stakeholders.

## *Costs to dam owners from improved compliance and enforcement*

### *Operations and maintenance plans*

The Dams Safety Act 2015 requires mandatory operations and maintenance plans to be prepared and implemented for declared dams with the requirements for these plans specified in the regulations

There is uncertainty regarding how many dam owners currently have a compliant O&M plan because the DSC does not currently require dam owners to submit their O&M. Dam owners are likely to fall into one of the following categories:

- have an existing compliant O&M plan in place
- have an informal operations and maintenance plan that requires formalisation into a compliant O&M plan
- do not have a compliant operations and maintenance plan.

Based on discussions with stakeholders, we assume that 75 per cent of dam owners have a current operations and management plan which is compliant with the new regulations, with the remaining 25 per cent not holding a compliant operations and management plan.

Based on information provided by stakeholders, the cost to prepare an operations and maintenance plan varies between \$40 000 and \$52 000 depending on consequence category and whether the dam has mechanical operations (e.g. water supply dam) (table 5.19).

The estimated total cost for dam owners to prepare an operations and maintenance plan, for owners without a current compliant plan, is \$4.5 million (table 5.19).

### **5.19 Cost to prepare O&M for dam owners without a current plan**

Consequence category and nature of dam's mechanical operations	Number of dams	Assumed number of dams without O&M	Cost to prepare O&M	Total cost across dams
	No.	No.	\$	\$m
<b>Dams with mechanical operations incl. water supply</b>				
Very low and low	14	3.5	41 000	0.1
Significant and High A, B, C	105	26.23	51 500	1.4
Extreme	22	5.5	51 500	0.3
<b>Dams without mechanical operations incl. water detention, tailings and other dams</b>				
Very low and low	14	3.5	30 000	0.1
Significant and High A, B, C	246	61.5	40 500	2.5
Extreme	10	2.5	40 500	0.1
<b>Total</b>	<b>411</b>	<b>102.8</b>		<b>4.5</b>

Source: CIE based on information provided by stakeholders.



### *Requirements for emergency plans for declared dams*

The Dams Safety Act 2015 requires owners of declared dams to prepare and implement an emergency plan.

There is uncertainty regarding how many dam owners currently have a compliant emergency plan. Based on discussions with stakeholders, the majority of dam owners have provided the DSC with an emergency plan. For this analysis, we assume 100 per cent of owners of declared dams currently have a compliant emergency plan.

The cost to prepare an emergency plan is estimated to range between \$25 000 and \$34 000 depending on the consequence category of a dam (table 5.20).<sup>41</sup> Hence if 10 per cent of owners of declared dams do not currently have a compliant emergency plan, the total cost is approximately \$1.4 million for these dam owners to meet the requirement for an emergency plan under the Act.

## **5.20 Preliminary cost estimate to prepare an emergency plan**

Consequence category	Cost to prepare plan
	\$
Very low and low	25 000
Significant and High A, B, C	34 000
Extreme	34 000

Source: CIE based on information provided by stakeholders.

## ***Benefits of proposed changes to regulatory framework***

In general, the benefits of the proposed changes to the regulatory framework are based on obtained figures from a few dam owners and the publicly available information. This may not be representative of all dams in NSW. The estimates provided below should be considered indicative only.

### ***Reduced over-investment in dam safety***

We previously used two alternative approaches to estimate the potential for over-investment in dam safety under the current regulatory framework.

- The first approach effectively assumed that once below the limit of tolerability, dam owners would over time, continue to reduce risk to the point where risks are considered negligible.
  - A review of WaterNSW's capital and operating expenditure suggested that dam safety upgrades costing around \$34.5 million per year could potentially be avoided under a new regulatory framework (although the specific reforms were not known at that time). This implies a potential saving of \$259 million in net present value terms over ten years.

<sup>41</sup> This is a preliminary estimate and is based on the cost to prepare an operations and maintenance plan as information was not received on the cost to prepare an emergency plan.

- Extrapolated across all relevant dams, the potential net savings could potentially be in the order of \$450 million over ten years.
- The second approach was based on a comparison between the maximum investment that could be justified under the current regulatory framework (i.e. applying a gross disproportionality factor), compared with the maximum efficient investment. This approach implied the potential for over-investment of around \$21 million.

If the proposed regulatory framework removes what is in effect a regulatory requirement to over-invest in dam safety, the net benefit could range anywhere between around \$21 million and \$450 million over ten years.

### *Reduced risk of dam failure from improved management*

Based on global risk estimates, we previously estimated an expected cost of dam failure to inadequate management practices could be around \$2.18 million per year or around \$16.38 million in present value terms over ten years (using a discount rate of 7 per cent).

A greater focus on strengthening dam management requirements and compliance and enforcement would reduce these risks, although the extent to which these risks would be reduced is not known. If these risks were eliminated completely (unlikely), the benefits would be around **\$16.38 million** (in present value terms over ten years, using a discount rate of 7 per cent).

### *Improved organisational performance*

As noted above, there is some evidence to suggest that implementation of ISO 55000 can improve the operational performance of businesses. However, to date, there have been no rigorous quantitative studies to indicate the extent to which operational performance would increase.

Nevertheless, asset management systems aligned to ISO 55000 have been implemented by various industries including airports (Geneva's international airport), water suppliers (Scottish Water), hydropower generation (Alpiq) and hospitality (Sodexo). Quantified benefits of implementing an asset management system based on ISO 55 000 include:

- Alpiq Hydro reported benefits from expenditure reductions and increases in value exceeded the costs incurred by a ratio in excess of ten to one. [1]
- Sodexo has demonstrated benefits including operational efficiency gains of 20 per cent, reduction in total operating cost of between 7 per cent and 12 per cent, and increased reliability of asset infrastructure of between 10 per cent and 25 per cent.[2]

---

[1] Alpiq Holding, 2016, *Managing Hydropower Assets: ISO 55000 for performance-based maintenance*, [https://www.alpiq.com/fileadmin/user\\_upload/documents/solutions/asset\\_management/alpiq-oxand-managing\\_hydropower\\_assets\\_en.pdf](https://www.alpiq.com/fileadmin/user_upload/documents/solutions/asset_management/alpiq-oxand-managing_hydropower_assets_en.pdf)

[2] International Organization for Standardization, 2016, *ISO 55001: Sodexo's bottom line*, <https://www.iso.org/news/2016/05/Ref2085.html>

- Downer reported the following benefits from its asset management system at its underground water recycling facility in Victoria: a 47 per cent operational cost saving through improved monitoring and management, improved risk management and reliability resulting in a reduction of reactive work by approximately 40 per cent, and a 41 per cent reliability improvement over 3 years.[3]
- Hunter Water Corporation reportedly achieved the following benefits following implementation of its asset management practices: reduction in operations costs of greater than 40 per cent, reduction in capital expenditure of \$185 million (equivalent to 4 years of planned capital expenditure), and improved level of service to customers.[4]

Benefits from asset management listed above which are relevant to the management of dams are:

- reduction in operating costs ranging between 7 per cent and approximately 50 per cent
- reduction in capital costs
- improved risk management and reliability.

If these types of benefits were realised by dam owners in NSW, the benefits could be substantial. However, these benefits have not been quantified in this regulatory impact statement due to an absence of information on operating and capital costs specific to the management of dams across NSW, and information on the degree to which an asset management system will reduce the risk of dam failure. Furthermore, case studies are not a substitute for a rigorous quantitative study; case studies are likely to be selected where implementation of ISO 55000 has been most successful.

### *Sensitivity analysis*

As noted, there is significant uncertainty around the estimates presented above, particularly the benefit estimates. Much of this uncertainty relates to the extent to which there would be over-investment in dam safety over the next ten years under the current regulatory arrangements. This is reflected in the relatively wide range between the low and high scenarios.

As the high levels of uncertainty are already reflected in the range of cost and benefit estimates presented above, a formal sensitivity analysis (where the sensitivity of the CBA results to alternative input assumptions are tested), is unlikely to add any additional insights.

That said, a potentially important finding in weighing up the costs and benefits of the reforms is that under the 'high scenario' (implying significant over-investment in dam safety in the period ahead), the benefits of the proposed changes would significantly outweigh the costs. Given the importance of this finding, it may add some additional insights to test the robustness of this finding.

---

[3] Downer, *Reliable, efficient and sustainable asset management: ISO 55001 case study*.

[4] Information provided by the Interim Dam Safety Committee, in *Section 1: Introduction to Infrastructure Asset Management*.

The underlying evidence for this finding is WaterNSW's planned investment in dam safety upgrades under the existing regulatory framework. Over the five years to 2025-26, a review of WaterNSW's capital and operating expenditure reported that it was planning to spend around \$34.5 million per year on dam safety upgrades (implying costs of around \$150 million in present value terms, using a discount rate of 7 per cent). This was then extrapolated across the full ten-year regulatory period used for this RIS and across all dams by:

- assuming that level of investment (i.e. \$34.5 million per year) would continue over the full ten year regulatory period; and
- extrapolating up WaterNSW's investment plans across all dams based on estimated construction costs.

The estimated benefits of reducing risk from the current level to the level considered negligible was then subtracted from this cost estimate. We also assumed that all of this investment could be avoided under the new regulatory framework.

In general, the more the direct evidence is 'scaled up' the weaker it becomes. Put another way, the more the CBA relies on direct evidence, the stronger the conclusions that can be drawn.

Table 5.21 presents various estimates of the estimated cost (and net cost) of dam safety upgrades over the period ahead, including:

- estimates based on WaterNSW's planned upgrades (over five years) only and extrapolated across all dams
- estimates based on published planned upgrades (over a five year time horizon) and extrapolated over ten years.

### 5.21 Impact of extrapolations on cost estimates

	WaterNSW only	Extrapolated across all dams
	\$ million	\$million
<b>Estimated cost</b>		
Reported investment only (over 5 years)	151.36	312.31
Extrapolated across ten year regulatory period	259.28	534.99
<b>Estimated net cost</b>		
Reported investment only (over 5 years)	143.43 <sup>a</sup>	249.61 <sup>b</sup>
Extrapolated across ten year regulatory period	251.35 <sup>a</sup>	472.28 <sup>b</sup>

<sup>a</sup> Estimated cost, **less:** the estimated benefits of reducing all dams owned by WaterNSW to a level considered negligible (around \$7.9 million in present value terms over 50 years, using a discount rate of 7 per cent). <sup>b</sup> Estimated cost, **less:** the estimated benefits of reducing all dams to a level considered negligible (around \$62.7 million in present value terms over 50 years, using a discount rate of 7 per cent).

Source: CIE estimates.

Table 5.22 combines each of these scenarios with the high and low cost estimates.

- Under the most conservative scenario (i.e. where the benefits are based only on WaterNSW's planned projects over 5 years and the high cost estimate), the proposed reforms would deliver a net cost.
- On the other hand, under all other scenarios, the reforms are estimated to deliver a net benefit.

## 5.22 Net benefits/costs under various

	Benefits	Costs	Net benefits /cost
	\$ million	\$ million	\$ million
<b>Low cost estimates</b>			
Reported WaterNSW investment only	143.43	119.90	23.53
WaterNSW investment extrapolated over full regulatory period	251.35	119.90	131.45
Reported WaterNSW project extrapolated across all dams	249.61	119.90	129.71
Reported WaterNSW projects extrapolated across full regulatory period and all dam owners	472.28	119.90	352.38
<b>High cost estimates</b>			
Reported WaterNSW projects	143.43	207.20	- 63.77
WaterNSW investment extrapolated over full regulatory period	251.35	207.20	44.15
Reported WaterNSW project extrapolated across all dams	249.61	207.20	42.41
Reported WaterNSW projects extrapolated across full regulatory period and all dam owners	472.28	207.20	265.08

Source: CIE estimates.

This suggests that we do not have sufficient **direct** evidence (i.e. published WaterNSW investment plans over five years) to conclude that the benefits of reduced over-investment would outweigh the costs associated with the reforms. However, the benefits outweigh the costs (even under the high cost scenario) under relatively conservative assumptions to 'scale up' the direct evidence across the full ten-year regulatory period and across all dams. This suggests the conclusion drawn from this analysis (i.e. that the benefits of the reform outweigh the costs) is plausible.

## 6 Conclusion

The proposed Dams Safety Regulation 2019 would trigger the commencement of the new regulatory framework under the Dams Safety Act 2015. This represents a significant change in the way that dam safety is regulated in NSW.

Consistent with the recommendations of the Independent Review of the Dams Safety Act 1978 and the Dams Safety Committee, the new regulatory framework:

- ensures that dam owners (rather than the regulator) carry primary responsibility for dam safety decisions
- establishes enforceable standards and refocuses the regulator on compliance and enforcement with stronger mechanisms to compel dam owners to comply with these safety standards
- removes the explicit bias towards disproportionate investment in infrastructure to achieve limited safety benefits.

Dam owners may bear some higher regulatory costs at the initial stage, particularly those that do not have established asset management systems in place, as major dam owners such as WaterNSW and Sydney Water do. The NSW Government will also bear some additional costs, largely associated with the greater focus on compliance and enforcement. Although these costs can be recovered through a levy under the Dams Safety Act 2015, no levy is being proposed at the present time.

The main benefit of the new regulatory framework is likely to be from reduced over-investment (the benefits from reduced risk of dam failure from inadequate surveillance and maintenance practices and better asset management are either estimated to be relatively modest or unquantifiable). The new regulatory framework would apply the SFAIRP principle to dams below the limit of tolerability, rather than the ALARP principle as is currently the case. This removes the explicit requirement to apply a 'gross disproportionality factor' and therefore addresses the bias towards disproportionate investment in dam safety.

Although in-principle the proposed changes should reduce over-investment, the magnitude of the benefits is uncertain. The benefits of removing the bias towards disproportionate investment in dam safety depend on the extent to which there would be over-investment in the period ahead under the current regulatory framework (i.e. the baseline). This is largely unknown, based on publicly available information and depends on how dam owners (and the DSC) interpret the ALARP principle, as well as their 'duty of care' over downstream communities.

We estimated the potential benefits using two different approaches.

- The first approach implied there would be significant over-investment in dam safety in the period ahead (based on extrapolating from WaterNSW's dam safety upgrade

plans under the current regulatory framework, assuming that this investment would not be required under the new regulatory framework). This approach reflects the view that dam owners (and the DSC) effectively interpret the ALARP principle as needing to ultimately reduce risk to a level considered negligible.

- The second approach inferred potential benefits through an analysis of how the formal application of a ‘gross disproportionality factor’ in CBAs could distort investment decisions and lead to over-investment.
  - Our analysis suggests that once below the ‘limit of tolerability’, the benefits of reducing risk to a level considered negligible are modest. This implies that there are likely to be few dam safety upgrade opportunities that would achieve a net benefit in a formal CBA, even when a gross disproportionality factor is applied.
  - This finding is consistent with one view encountered, that there would be relatively little investment in dam safety upgrades under the existing regulatory framework in the period ahead.
  - This approach suggests that the benefits of the proposed regulatory framework could be modest and fall short of the additional costs imposed on dam owners.

The overall CBA results depend on the assumption around the extent of over-investment in dam safety under the current regulatory framework in the period ahead.

- Under the scenario where there would be significant over-investment in dam safety under the current regulatory framework, the benefits from the proposed regulatory change significantly exceed the additional costs.
- However, under the scenario where there would be limited additional investment in dam safety in the period ahead, the benefits of the proposed regulatory changes would be modest and fall short of the estimated costs.

Although both baseline scenarios are broadly plausible, the scenario with a significant level of over-investment is on balance, considered more likely. This baseline scenario is consistent with:

- direct evidence of future dam safety upgrade plans under the existing regulatory framework (for WaterNSW);
- evidence of some dams investing in dam safety upgrades even when below the limit of tolerability; and
- observations from stakeholders that there is limited use of formal CBA in dam safety decisions and many dam owners interpret the ALARP principle as needing to reduce risk to a level considered negligible.

Under this scenario, the benefits of the proposed changes to the regulatory framework would significantly outweigh the costs.



## A Summary of changes to regulatory framework

### A.1 Summary of changes to the Dams Safety Act

2015 Act	Current Practice
Dams Safety NSW is to consist of 5 members appointed by the Minister and the Chief Executive Officer. Owners of declared dams are not eligible to be a member.	The DSC is comprised of 9 part-time members, with representatives appointed from large dam owners (required by the Act)
Significant increases in the fines that can be levied for violations of the ACT and regulations. (Up to 10,000 penalty units or \$1.1 million)	Fines to not exceed 10 penalty units (\$1100)
The introduction of an objective into the Act	The 1978 has no formal objective
The introduction of a dam Safety levy to fund the ongoing cost of Dam Safety NSW	The DSC is funded through general revenue and in-kind contributions of staff time from dam owners.
New declared dams are gazetted.	New regulated dams must be added to a schedule attached to the Act
A new requirement that changes to the regulation must be analysed using cost-benefit analysis.	No requirement

Source: CIE.

Table A.2 provides a summary of the changes from the *Dams Safety Regulation 2019*. Detailed description of the changes is provided in Appendix A.

### A.2 Summary of changes from Dams Safety Regulation 2019

Proposed regulation framework	Current regulation framework	Changes to current practice
<b>Requirements for operations and maintenance plans for declared dams</b>		
Prepare operations and maintenance plans		
Operations and maintenance plan required and to include content specified by regulation	<ul style="list-style-type: none"> <li>Operations and maintenance plan required by DSC Guidelines</li> </ul>	<ul style="list-style-type: none"> <li>There is no change in principle.</li> <li>However, it is assumed in practice approximately 25 per cent of dam owners do not have a current operations and maintenance plan and will have to prepare a plan or face penalties.</li> </ul>
Update operations and maintenance plans		
Declared dam of Extreme or High consequence class to update O&M plan annually	<ul style="list-style-type: none"> <li>O&amp;M plans required by DSC 3G and DSC 2F.</li> </ul>	<ul style="list-style-type: none"> <li>Increased frequency of update for declared dams of Extreme or High consequence class</li> </ul>
Declared dam of significant, low or very low to update O&M plan at intervals no greater than every five years	<ul style="list-style-type: none"> <li>O&amp;M plans required by DSC 3G and DSC 2F.</li> </ul>	<ul style="list-style-type: none"> <li>No change in practice.</li> </ul>



Proposed regulation framework	Current regulation framework	Changes to current practice
<b>Requirements for emergency plans for declared dams</b>		
<b>Prepare emergency plan</b>		
Emergency plans required and to include content specified by regulation	<ul style="list-style-type: none"> <li>Emergency plan required to be documented and submitted to DSC by DSC 2G.</li> </ul>	<ul style="list-style-type: none"> <li>There is no change in principle.</li> <li>However, in practice approximately 30 per cent of dam owners do not have a current emergency plan and therefore will have to prepare a plan or face penalties.</li> </ul>
<b>Update emergency plan</b>		
Contact details in emergency plans must be updated annually. Remainder of emergency plan must be reviewed and updated at intervals no longer than 5 years (except for circumstances below)	DSC requires emergency plans to be updated annually, with a review and test of plan at least every 5 years (section 4.5 DSC 2G)	No change in principle.
Emergency plans must be updated within 1 month of a specified triggers, including changes to emergency management plans (See Appendix A).	DSC requires emergency plans to be updated annually, with a review and test of plan at least every 5 years (section 4.5 DSC 2G)	Increase in frequency for prescribed dams under the specified circumstances.
<b>Conduct emergency exercises</b>		
Emergency exercises to be carried out by dam owner at least once every two years for all declared dams	<ul style="list-style-type: none"> <li>DSC requires emergency plans to be reviewed and tested at least every 5 years with SES involvement (section 4.5 DSC 2G)</li> </ul>	<ul style="list-style-type: none"> <li>Increase in frequency of emergency exercises</li> </ul>
Emergency exercises to be carried out with other agencies identified in the emergency plan (at the very least SES) at least once every 5 years for declared dams with consequence class above High C.	<ul style="list-style-type: none"> <li>DSC requires emergency plans to be reviewed and tested at least every 5 years with SES involvement (section 4.5 DSC 2G)</li> </ul>	<ul style="list-style-type: none"> <li>No change in principle for declared dams with consequence class above High. However, in practice dam owners may not be adhering to the requirement for testing at least every 5 years and will either incur costs to meet requirement or face penalties.</li> <li>Removal of requirement for declared dams with consequence class less than High.</li> </ul>
<b>Provision of emergency plans and related documents to agencies</b>		
Dam owners to provide an electronic copy of the emergency plan to Dams Safety NSW, the SES and the State Emergency Operations Centre	DSC requires a paper and electronic copy to be provided to DSC, SES, and the State Emergency Operations Centre (DSC 2G S 4.3)	Reduced requirement
<b>Requirement to maintain records relating to safety, operation or maintenance of a declared dam</b>		
Dams owners required to keep records as specified by the regulation.	DSC requires owners of Prescribed dams to have in place an effective long-term archiving system of all important documentation (DSC2B s4.10)	No change in principle, excluding additional requirement to keep records associated with the operation of the safety management system.

Source: CIE based on information provided by Dams Safety NSW.

Table A.3 provides a summary of the changes from the *Dam Safety Standards 2019*. Detailed description of the changes is provided in Appendix A.

### A.3 Summary of changes from *Dams Safety Standards 2019*

Proposed regulation framework	Current regulation framework	Changes to current practice
<b>Assessment of consequence category of a dam</b>		
Dam owner must assess the consequence category of a dam as prescribed by the Standards	Dam owners to assess consequence category	<ul style="list-style-type: none"> <li>No change in principle</li> </ul>
Consequence category assessment must be carried out in the manner prescribed by the Chief Executive Office of Dams Safety NSW	Consequence category assessment to be carried out in line with DSC2B.	<ul style="list-style-type: none"> <li>No change in principle</li> </ul>
Consequence category assessment must be published on the Dams Safety NSW public website	Consequence category assessment is not published on DSC website.	<ul style="list-style-type: none"> <li>New requirement with the methods for assessment published on Dams Safety NSW website</li> </ul>
Dam owner must review a dam's consequence category assessment at intervals not exceeding 15 years	<p>DSC requires a review, which includes a consequence assessment is undertaken:</p> <ul style="list-style-type: none"> <li>every 20 years for declared dams assigned a significant consequence category</li> <li>every 15 years for all other declared dams</li> </ul>	Increase in frequency of review for declared dams with significant consequence category.
<b>Part 4 Dam safety management system requirements</b>		
<b>Division 1 Dam safety management system requirements – general</b>		
Dam owner must establish, implement, and maintain a dam safety management system in the manner prescribed by all of the requirements of Australian Standards AS ISO 550001 2014 Asset Management – Management Systems – Requirements and additional system elements described in Divisions 1, 2, 3 and 4 of this Part of these Standards	<ul style="list-style-type: none"> <li>No requirement under current regulatory framework</li> </ul>	<ul style="list-style-type: none"> <li>New requirement</li> </ul>
<p>The dam safety management system must be set out in a manual which addresses all the requirements of AS ISO 55001 2014 Asset Management – Management Systems – Requirements</p> <p>Dam owners must maintain an electronic copy of the dam safety management system manual</p>	<ul style="list-style-type: none"> <li>No requirement under current regulatory framework</li> </ul>	<ul style="list-style-type: none"> <li>New requirement</li> </ul>
<b>Division 2 Dam safety management system requirements – risk management</b>		
Dam owner must establish, implement and maintain a risk management framework as part of the Dam Safety Management System	The DSC adopts the national standard Risk Management, AS/NZS 4360:2004 which has been superseded by ISO AS 31000:2009.	No change in principle.

Proposed regulation framework	Current regulation framework	Changes to current practice
The risk management framework must include items specified by the Dam Safety Standards 2019, including identifying a hazard identification component.		
So far as is reasonably possible (SFAIRP) applied	As low as reasonably possible (ALARP) applied which incorporates application of disproportionality factors.	Switch to SFAIRP from ALARP Removal of requirement to apply disproportionality factors.
<b>Requirements for Risk Review and Risk Review report</b>		
<p>Dam owners must:</p> <ul style="list-style-type: none"> <li>undertake a risk review at intervals not greater than 5 years</li> <li>demonstrate in a risk review report that actions to address dam safety risks will result in the risks being below the limit of tolerability</li> <li>demonstrate in a risk review report, once below the limit of tolerability, that dam safety risks that have been identified are minimised SFAIRP</li> </ul>	<p>Currently, the safety of a dam is to be reviewed wherever the owner considers that a review is needed, but as a minimum whenever the DSC determines that a review is needed (DSC 1B)</p> <p>The DSC requires that dam owners demonstrate that risks are ALARP (DSC1B).</p>	<p>Unclear if the frequency of review will increase or decrease as currently the frequency of review is determined by the DSC. Dam owners will face an additional cost if the frequency of the review increases, and vice versa.</p> <p>Change from a requirement to demonstrate safety risks are ALARP instead to minimised SFAIRP. There may potentially be an additional cost to dam owners to demonstrate that risks that are below the limit of tolerability have been minimised SFAIRP</p>
<b>Division 3 Dam safety management system requirements – safety review</b>		
Safety reviews must be carried out once every 15 years and/or as soon as practicable after any non-trivial change occurs in relation to the design, operation or maintenance of the dam, ie the consequence category changes	<p>DSC currently requires a safety review is undertaken:</p> <ul style="list-style-type: none"> <li>every 15 years for High and Extreme consequence category and</li> <li>every 20 years for significant consequence category</li> </ul>	Increase in frequency of review for declared dams with significant consequence category
<b>Part 5 Dam design, construction, commissioning and decommissioning management system requirements</b>		
A dam owner must ensure that any organisation carrying out design, construction, commissioning or decommissioning work has an established, implemented and is maintaining a quality management system in the manner proscribed by AS IOS 9001:2015.	<ul style="list-style-type: none"> <li>No requirement under current regulatory framework</li> </ul>	<ul style="list-style-type: none"> <li>New requirements</li> </ul>
For a dam in the Extreme or High class, as part of the quality management system design and construction planning and control component, the dam design must be reviewed and verified and validated by a Competent Person who is independent of the original design process.	<ul style="list-style-type: none"> <li>DSC Guidelines (DSC 2B) requires dam owners to submit the design team to the DSC for approval and the dam designs to the DSC for approval.</li> </ul>	<ul style="list-style-type: none"> <li>Reduced requirement – Dam owners will no longer be required to submit design team and dam designs to the DSC for approval</li> <li>New requirement – Dam owners will be required to have a dam design reviewed, verified and validated by a Competent person.</li> </ul>

Proposed regulation framework	Current regulation framework	Changes to current practice
<b>Part 6 Dam owner's annual report</b>		
Dam owners must provide an annual report in the form approved by the Chief Executive Officer of Dams Safety NSW and a copy of the annual report must be provided to Dams Safety NSW	<ul style="list-style-type: none"> <li>▪ No requirement under current regulatory framework</li> </ul>	<ul style="list-style-type: none"> <li>▪ New requirement</li> </ul>

## *B Approach to estimating the expected cost of dam failure in NSW*

### *Estimating the expected cost of human fatalities*

The Department of Industry has provided estimates of the probability of dam failure and the potential number of fatalities in the event of a dam failure (based on flood modelling) for 347 prescribed dams. The level of analysis used to produce these estimates varies and estimating extreme events and the number of fatalities in the event of such events is inherently uncertain. As such, these estimates are treated as indicative only.

Table **Error! Reference source not found.** shows the number of prescribed dams by risk rating.

#### **B.1 Prescribed dams by risk rating**

	Number of dams	Share of total
	No.	Per cent
Orange	16	3.8
Yellow	184	43.8
Green	147	35.0
Not rated	73	17.4
<b>Total</b>	<b>420</b>	<b>100.0</b>

Source: NSW Department of Industry.

An indicative estimate of the expected number of annual fatalities from dam failure can be estimated by multiplying the estimated probability of dam failure ( $F$ ) by the estimated number of potential fatalities in the event of a dam failure ( $N$ ). Summing across all prescribed dams gives the expected number of fatalities from dam failure in NSW.

Multiplying the expected number of annual fatalities by a VSL of \$4.5 million, which is typically used in regulatory impact analysis (as recommended by the Australian Government and widely adopted in NSW) gives the expected annual cost from the loss of human lives due to dam failure. This can be expressed as:

$$EC_{DF} = \sum_{i=1}^n F_i \cdot N_i \cdot VSL$$

Where:  $EC_{DF}$  is the expected annual cost of dam failure;  $F_i$  is the probability of dam  $i$  failing;  $N_i$  is the potential loss of life in the event of a dam failure;  $VSL$  is the value of a statistical life; and  $n$  is the number of prescribed dams in NSW.

### *Estimating downstream property damage*

In addition to the potential loss of human life, dam failure could also result in significant damage to property in downstream communities.

Analysis by the US Department of Homeland Security (US DHS) found that a statistically significant relationship may exist between population at risk (PAR) and property damage (including damage to buildings and their contents, transportation infrastructure, essential facilities and their contents, utilities, vehicles and agriculture). Based on regression analysis of 54 dam failures, the US DHS found that if PAR increases by 1, property damage can be expected to increase by US\$78 000 (in 2011 dollar terms).<sup>42</sup> Converting to Australian dollars using the average monthly exchange rate since 2010 (around 0.87 based on RBA data) and inflating to 2018 dollar terms (using the national CPI published by the ABS), this suggests that if PAR increases by 1, property damage costs increases by around \$102 200.

Dams Safety NSW provided information on the potential loss of life (PLL) measure, rather than PAR. The relationship between PAR and PLL depends on a range of factors, including flood severity, warning time and other factors; however, the relevant information is not available. Nevertheless, DSC guidance on consequence categories suggests that a reasonable 'rule of thumb' for converting PLL to PAR would involve applying a multiplier of:

- around 10 where PLL is less than 1
- around 20 where PLL is greater than 1.

### *Other costs*

Other costs of dam failure include:

---

<sup>42</sup> US Department of Homeland Security, *Dams Sector: Estimating Economic Consequences for Dam Failure Scenarios*, September 2011, p. 13.

## *C List of dams modified for safety upgrading*

### **C.1 Dams modified for safety upgrading since 2001 (excluding tailings dams)**

Dam	Main safety issue	Year completed	Nature of upgrading
Blowering	Flood	2010	Parapet wall on dam, spillway walls raised
Bulli Upper R'way Basin	Flood	2010	Embankment removed (and basin de-prescribed)
Burrendong	Flood	2011	Dam & saddle dams raised
Cecil Park Basin 3A	Flood/Stability	2008	Spillway enlarged, embankment stabilised
Chaffey	Flood	2011; 2016	Dam raised and auxiliary spillway constructed
Chichester	Flood/Stability	1995; 2004	Dam post-tensioned, abutment stabilised
Chifley	Flood	2001	Dam raised and spillway post-tensioned
Clarrie Hall	Flood	2014	Spillway modification works
Company	Flood	2006	Spillway enlarged, embankment raised
Copeton	Flood	2013	Auxiliary spillway constructed
Daintree Drive Lower	Flood	2013	Spillway capacity increased (and dam de-prescribed)
Daintree Drive Upper	Flood	2013	Spillway capacity increased (and dam de-prescribed)
Emigrant Creek	Flood	2002	Dam post-tensioned, abutments raised
Googong	Flood	1992; 2011	Dam raised, spillway stabilised
Grahamstown	Flood	2001; 2005	Dam core raised, face armoured, spillway upgraded
Green Meadows Basin	Flood	2003	Embankment & crest stabilised, new spillway
Hamilton Valley 5A	Flood	2009	Embankment stabilised
Hume	Stability/Earthquake	1997-2017(staged)	Embankment / south training wall stabilised, associated works
Jerrara Creek	Flood	2015	Dam decommissioned (and de-prescribed)
Jindabyne	Flood	2006; 2010	New spillway and outlets

Dam	Main safety issue	Year completed	Nature of upgrading
Kalingo	Flood	2012	Spillway upgraded
Keepit	Flood	2011	Right abutment spillway & subsidiary wall spillway
Kensington Pond	Flood	2018	Dam augmented/strengthened
Lake Pambulong Basin	Flood	2014	Extra spillway capacity provided (basin de-prescribed)
Mardi	Earthquake/Flood	1991; 2011	Embankment stabilised; spillway & outlet augmented
Moore Creek	Flood	2007	Dam buttressed
Muirfield Golf Club	Flood	2013	Spillway enlarged
Pacific Palms	Flood	2013	Spillway enlarged (and dam de-prescribed)
Petrochilos	Flood	1989; 2006	Spillway upgraded
Prospect	Earthquake	1997; 2014	Upstream dam embankment stabilised
Quipolly Dam	Flood	2013	Dam raised, spillway augmented
Redbank Creek	Flood	2011; 2014	Outlet conduit for minor flood load; dam wall lowered
Rocky Creek	Flood/Piping	2010	Embankment upgrade to resist piping
Rylstone	Flood	2003	Auxiliary embankments removed
Sooley	Flood	2005; 2010	Dam raised & buttressed, new spillways
Split Rock	Flood	2012	Parapet wall modification works completed
Spring Creek	Flood	2011	Bank strengthened and raised, spillway augmented
St Joseph Sch. R Basin	Flood	2001	Bank stabilisation and new spillway
Suma Park	Flood	2016	Auxiliary spillway, dam strengthened / raised, storage raised
Tenterfield	Stability / flood	2018	Dam buttressed
Tilba	Flood/Stability	1997; 2003	Dam wall raised; toe drained
Warragamba	Flood	1990; 2002; 2011	Dam tensioned & raised, auxiliary spillway, gate upgrade
Wentworth Falls	Flood	1993; 2003	Dam raised, spillway augmented
Widemere Det. Basin	Flood	2009	Basin raised, spillway enlarged
Winding Ck 5 Basin	Flood	2011	Parapet wall on embankment



Dam	Main safety issue	Year completed	Nature of upgrading
Wingecarribee	Piping, Flood	2012	Piping upgrade, peat barrier flood protection
Wyangala	Flood	2011	Spillway walls raised
Yellow Pinch	Piping	2013	Downstream filter extension in upper crest section

Source: Dams Safety Committee, Annual Report 2017-18, p. 25.



**THE CENTRE FOR INTERNATIONAL ECONOMICS**  
*www.TheCIE.com.au*