

# Harvey Water Supply System: Safety Standards & Compliance

Paper 1 of 4 relating to aspects of dam safety  
and cost allocation, provided as input to the  
Inquiry into Harvey Water Bulk Water Pricing

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**ACIL Tasman**

Economics Policy Strategy

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# Executive Summary and Conclusions

## Context & Purpose

This is the first of a series of four papers prepared by ACIL Tasman and commissioned by the Economic Regulation Authority of Western Australia – in relation to the current Inquiry into Harvey Water Pricing.

The Authority's October Issues Paper identified as a key issue the treatment of the proposed cost of dam upgrade worked designed by Water Corporation to allow the eight relevant dams to comply with the latest Australian National Committee on Large Dams (ANCOLD) Safety Guidelines – with these works being costed at around \$130m. This figure is very much in excess of the expectations that applied at the time the Bulk Water Service Agreement was negotiated in 1996, and treatment of these costs in the way envisaged in that Agreement would have major implications for the bulk water price.

ANCOLD compliance is not required by regulation in WA, though several other Australian jurisdictions do require compliance with these Guidelines or with relatively modest modifications to the Guidelines. Dam owners do, however, have a responsibility to be able to demonstrate sound risk management, given the risks of dam failure, especially as a result of extreme, but credible, floods – with risks to lives and property. Customers of the dam owners also have a strong interest in sound risk management – because dam failure could have substantial ramifications for their regions and associated populations, for their assets and for their ability to conduct their water-dependent businesses.

This paper focuses on the question of appropriate investment in safety for these assets – whether in the form of compliance with the ANCOLD Guidelines, or through some other soundly based risk management process. The other three papers in the series are concerned more with the question of how the costs of delivering appropriate safety outcomes should be shared across the community.

The papers are concerned with relevant principles and with how they might be applied in the present setting. Earlier work, led by Marsden Jacob Associates for Harvey Water, involved much more detailed probing of the specific empirics of the proposed program of works and the implications for pricing and affordability. It dealt also with many of the issues raised in this present paper, though there have since been revisions to ANCOLD Guidelines, significant upgrade works have been undertaken and there is now a longer history with the current extreme drought. The Authority has commissioned

Marsden Jacob to review and update key aspects of this earlier work relevant to the current deliberations, including application of the strategy and cost allocation questions raised in these papers. The empirical content of this paper, as it relates to specifics of the dam safety program, needs to be interpreted as illustrative of principles and their application and is preliminary only, since it is based largely on now dated studies. It will be important that it be reviewed in the light of the update that is being prepared.

## **Key Features of ANCOLD Guidelines**

- Compliance is not compulsory in WA, provided that sound risk management can otherwise be demonstrated – but active departure from the Guidelines in a way that increases risks could be a dangerous strategy for a dam owner in the event of failure.
- The drafters of the Guidelines (and of their ‘inspiration’ via the Health & Safety Executive (HSE) in the UK) fully recognise that the recommended process has serious, and potentially high cost, implications, relative to a more broadly based and systematic approach to managing risks across the community, led by Government.
  - The Guidelines are seen as a ‘second best’ response to society’s demands for adequate safety management.
- The Guidelines are not fully prescriptive and in fact leave very substantial discretion for large variations in the response – by either or both of dam owners and governments – to the Guidelines while still being compliant.
  - The Guidelines set out a process for assessing risks and provide Guidance as to which risks might be judged to be unacceptable.
  - They require the development of a strategy to move towards tolerable levels of risk for each dam, and to assess whether the costs of delivering even greater risk reduction would be reasonably justified.
  - A business moving towards these outcomes at a justifiable pace can be compliant, even if the dams do not yet fall within the tolerable risk guidance.
- Conceptually, the level of tolerable risk is defined independently of the costs of getting to this point – exceeding these risk levels are seen as intolerable, irrespective of costs. However:
  - The Guidelines do allow for the exercise of ‘exceptional circumstances’ provisions by government, where these are characterised as involving costs that are ‘grossly disproportionate to benefits’; and
  - Different levels of tolerable risk are accepted for upgrading existing assets vs building new assets – which implicitly embodies some form of risk/reward trade-off.
- Once a risk has been deemed tolerable, it is still necessary to probe whether further reductions in risk could be delivered, using an As Low As

Reasonably Possible (ALARP) criterion, which is essentially a benefit cost criterion, though with an apparent leaning, given the way the principle is discussed in the Guidelines, towards doing the works unless the costs grossly exceed the benefits.

- This is a departure from the more conventional net benefit test.
- The actually levels of risk deemed to be intolerable (barring exceptional circumstances) – for either the most at risk individual (the individual risk test), or for the wider community at risk (the societal risk test) – have been based on substantial research and consultation but remain essentially arbitrary.
  - No single individual faces a risk greater than 1:1000 of death from dam failure in any one year – broadly consistent with the background mortality risk for the individuals at lowest risk in the community.
  - The expected (risk weighted) number of fatalities in any one year must not exceed 1:1000 for an established dam (1:10000 for a new or augmented dam).
- In assessing these risks, fatalities in the event of failure are to be compared to fatalities in the event of non-failure, to derive the incremental risk.
  - This seems somewhat odd as a concept. More natural might be comparison of fatalities in the event of failure to fatalities without the dam being present – since it is the presence of a dam with a risk of failure that is of concern.
  - Taking this alternative view, would allow the societal test to be assessed inclusive of any lives saved as a result of the dam being present during normal floods – flood mitigation services. The current test appears not to allow for these offsetting benefits in reduced risks to society.
- ANCOLD applies dam-by-dam.
  - It is permissible, and clearly sensible, to plan the timing of works across the whole portfolio owned by the business, so the highest returning activities across the portfolio are undertaken first.
  - However, the process must result in all dams ultimately complying with the limits, even if greater safety at lower cost could be achieved by shifting some dams in the portfolio to comfortably exceed these safety requirements, and allowing others to fall slightly short of the requirements.
  - Again, the exceptional circumstances provisions might allow some variance in this.
- Exercise of the exceptional circumstances provisions needs to be done by a government or statutory dam safety regulator – not by the dam owner.
  - This creates some difficulties in a state where there is no regulatory requirement compliance.
    - … There is no dam safety regulator to issue an exemption.

- ... What is the meaning and legal significance of a Government declaring ‘exemption’ from provisions that it does not require in the first place.
- The exceptional circumstances clauses appear more relevant where safety requirements are regulated.
- Whether a dam safety program is compliant or not may depend on form of ownership of the assets.
  - Water Corporation, with its substantial financial capacity and portfolio diversity, may need to move faster (and therefore incur higher costs in present value terms) than would other forms of ownership.
  - Water Corporation probably faces strong incentives to ensure it is compliant, if necessary through over-engineering or overly fast response, while facing relatively weak commercial sanctions as a result of over-costing the needed works – assuming these costs will largely be passed forward to customers or back in the form of a CSO adjustment.

## **Does ANCOLD offer good value for money?**

The risk assessment processes recommended by ANCOLD appear, in the main, to be very good – embodying sound risk principles and a healthy and documented understanding of limitations. There are specific details – notably the dam-by-dam as opposed to portfolio risk focus and the comparison of dam failure to no dam failure (as opposed to dam failure to no dam) risks that may result in excessively costly strategies for the level of safety delivered being developed.

Of potentially greater concern are the implications of the cost-independent ‘tolerable risk’ limits on a dam-by-dam basis. This is not about the risk assessment process, but rather about the guidance given in respect of response to identified risks.

These concerns can, in principle, be handled through the exercise of the exceptional circumstances provisions of ANCOLD – ANCOLD would seem to allow for an interpretation all the way through to a full net benefit test in which incremental expenditures on dam safety would need to be justified on the basis of incremental benefits at least equal to incremental costs. However, as was noted above, the wording of the Guidelines could encourage expenditures somewhat in excess of this.

Pending access to updated information from the Marsden Jacob review, we have revisited the earlier work done by Marsden Jacob for Harvey Water, and by David Bowles in his portfolio assessment, for Water Corporation, of the optimal sequencing of works.

These 2001 and 2003 figures strongly suggest that the program as developed then contained very substantial outlays whose value for money should be seriously questioned. Some of the then proposed works appeared to offer, at low cost, substantial improvements in safety. About half the safety gains appeared to be available from about 3 per cent of the budget, and about 85 per cent of the gains from about a third of the budget.

However, the last \$90m (about 70% of the package of measures considered) appeared to offer safety reductions that could be described as grossly disproportionate to costs, with an implied cost per fatality avoided of the order of \$65m.

- This is approximately 30 times the guidance recommended by the Department of Health and Aging, in its guidelines for public health sector interventions, and the implicit values reflected in pharmaceutical approval processes.
- It is about 250 times the cost per fatality avoided, estimated in the 2001 National Road Safety Strategy (Australian Transport Council, 2001), for expenditure targeted on road accident 'black spots', and over 25 times the equivalent cost for safety improvements through general investments in better roads.
- It is of the order of 15-20 times the implicit *values of a fatality prevented* cited in the HES Guidelines referred to earlier, that in turn drew on UK Treasury Guidelines for assessing infrastructure risks, with broadly analogous figures being given in analogous guidelines in Commonwealth and State jurisdictions in Australia.

It is understandable that very large failure, with potentially large loss of life, could reasonably involve greater conservatism in respect of risk – and this concept is built into ANCOLD, with special treatment of potential risks involving more than 100 fatalities. Similar psychology is evident in the difference in response to a single plane crash compared to the cumulative annual road toll that is much greater. Large single calamities tend to provoke demands for greater safety. Also individuals are more willing to accept risks they can control, or opt out of, than ones imposed – for example by a dam being built. Some judgment is needed, but the fatality risks for the eight dams appear, individually, to be of the scale of normal to car/bus accidents than the high end scale of single incident fatalities.

Unless a very different picture emerges from the revised program of dam works, it seems likely that at least part of the remaining program, still of the order of \$130m, would entail poor value for money if the other reasons for complying with ANCOLD could be met.



## Alternative approaches

A number of alternatives have been explored. Other papers in this series, and the parallel work being done by Marsden Jacob, may well point to opportunities to develop an ANCOLD-compliant budget that is substantially less than that now on the table – especially if the means can be found to allow sensible and effective exercise of the exceptional circumstances provisions.

One way would be to have more explicit regulation of dam safety, underscored by ANCOLD principles or a minor variant (such as has been done with the Dam Safety Committee in NSW). This would deliver a much sounder basis for exercising exceptional circumstances provisions and could allow subsequent expansion to include a wider range of assets.

The information required by the risk assessment processes under ANCOLD constitutes much of what is needed to sensibly address these exceptional circumstances.

It is clear that application of normal ANCOLD Guidelines (without exceptional circumstances) could have very different cost implications – at least through the implied timing of works – depending on the nature of the ownership of the dam assets. The earlier Marsden Jacob work explored the implications of the dams being owned (or being treated as being owned) by Harvey Water, and concluded that this could allow for a significant reduction in compliance costs. This does not mean that the higher costs can be avoided by Water Corporation except through divestment – but the implications of this for cost sharing are explored in Paper 2 in this series.

The HSE Guidelines are strikingly similar in their framework to those of ANCOLD – which is no coincidence – though the general guidance does appear to allow for a significantly higher acceptable societal risk than do the ANCOLD Guidelines – with a 1:5000 chance of 50 or more people being killed, which is nominally a ten times greater risk than would be allowed under ANCOLD. The HSE Guidelines are more generic (non-dam specific) and the specific requirements for Australian dam safety have been subjected to extensive consultation, but the discrepancy here is significant and could have large cost implications. The evidence from the Bowles portfolio risk assessment of most of the upgrade budget being directed at achieving the last little bit of improved safety is highly relevant here.

ANCOLD Guidelines allow for portfolio-based planning of an implementation strategy but require, ultimately, dam-by-dam compliance. An alternative approach would be to work with the portfolio of eight dams and explore least cost ways of delivering, across the set of dams, the same level of safety improvement as is implied by the ANCOLD process (or a lower

reduction if the government should accept this). In effect, this would involve treating the collection of dams as a single asset, once the tolerable safety target had been determined under ANCOLD guidelines, and developing a least cost response over all the assets. Again the evidence of rapidly diminishing returns on some single-dam investments suggests there could be large cost savings from this approach.

A further variant would be to treat the collection of eight dams as a single asset for purposes of applying the ANCOLD Guidelines. This might imply a different safety target, as well as allowing for a lower cost way of reaching the target.

More generally, expanding the portfolio of assets to include non-dam assets could reveal large opportunities for achieving the same or greater levels of community safety reduction – even in the SW region – at lower cost. This would require a commitment from government.

## **Implications**

Some of these possibilities require a policy position extending well beyond the reach of the current Inquiry. The Authority will have to determine how far it is prepared to go in taking into account these issues. Subsequent papers in this series are highly relevant – dealing with interrelated issues of the allocation of costs and with the efficient level of costs.

Probably the most straightforward position on safety requirements would be one that looks to the applying the exceptional circumstances provisions based on review of the proposed program of works from the perspective of the diminishing returns on incremental investment. The indicative data now available, that is being updated, suggests scope for large and justifiable cost reductions here if the legal and governance concerns of Water Corporation can be managed. Applied dam-by-dam, these cost savings would involve a small increase in risks relative to those proposed under the program.

Even greater savings could almost certainly be achieved through an 8-dam portfolio approach to delivering the same level of safety as would be implied under the dam-by-dam exceptional circumstances approach. However, some of these savings could be used to restore the original safety targets, while still almost certainly allowing larger cost savings than under the dam-by-dam approach.

The wider portfolio warrants serious consideration in the medium term.

The Authority can probably look either at pushing to create the conditions in which these cost savings are readily achievable, or look under its cost sharing



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principles at whether a smaller percentage of the currently proposed costs should be attributed to bulk water users because of these opportunities for substantial cost avoidance. The latter approach may create commercial incentives to explore a change in ownership arrangements.

# 1 Purpose

This is one of four short and inter-related papers prepared by ACIL Tasman at the request of ERA, to provide input to its Inquiry in Harvey Water Bulk Water Pricing. All three papers are heavily concerned with different, but interrelated, aspects of the appropriate form and timing of investment in improved dam safety for purposes of assessing supply costs, and of the appropriate basis for allocating such costs across stakeholders.

More specifically, the four papers cover:

1. Issues that arise in considering whether it appropriate for the full costs of complying with the ANCOLD dam safety requirements should be assumed, for price determination purposes; and
  - if alternative approaches to safety might be considered, what form these might take.
2. The basis on which the costs of meeting dam safety targets should be shared across stakeholders;
3. Whether the current arrangements, including the approach taken in striking the Bulk Water Service Agreement (BWSA) entail a subsidy for Harvey Water and the possible relevance of this for cost allocation.
4. Review of the value of benefits recreational users derive from the dams, as possible input to the cost sharing arrangements.

These four papers are not independent of each other. Decisions taken on which costs to take into account in price determination – and why – have implications for both equitable and efficient cost sharing. Whether there is a subsidy depends heavily on the regulatory pricing framework used, and the attitude taken to restrictions on uses of the water beyond the current user base. The questions addressed in each paper do not lend themselves to the provision of a uniquely ‘correct’ answer – scope for substantial discretion exists and it is important that the different choices add up to a package of decisions that is sensible.

These papers are being prepared in parallel with work being undertaken by Marden Jacob Associates (MJA), focusing on specific aspects of the dams being considered. A balanced strategy will need to take into account both the issues and principles set out in the four papers, and the specific empirical insights to emerge from the MJA work. We have coordinated our work with MJA – who have previously undertaken significant relevant work<sup>1</sup>.

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<sup>1</sup> Marsden Jacob Associates (2003) and Marsden, Jacob *et al* (2005)

## 2 Background

The Issues Paper prepared by ERA sets out the main points of relevant background. Selected features of special relevance are summarised here.

Water Corporation built, owns and operates 8 dams in SW WA. They were originally constructed when Water Corporation was the regional water distributor, for which it also built and owned distribution assets. In 1996, the distribution assets were transferred to South West Irrigation Asset Cooperative, and Water Corporation entered into a Bulk Water Supply Agreement (BWSA) with the South West Irrigation Management Cooperative, now trading as Harvey Water.

Water Corporation is a service provider to Harvey Water, providing storage and dam operation services in respect of water where the rights to use are and were effectively vested in Harvey Water – ie, Water Corporation is not selling water to Harvey Water, it is selling water storage management services. Harvey Water has rights to about 150 GL, with trades reducing this to about 136GL by 2009/10.

The BWSA was designed to recover from Harvey Water 85 per cent of the forward costs of the supply services – operating costs and renewals annuity. The 85 per cent emerged from a crude assessment of the mix of benefits between extractive users and other, mainly recreational, users of the facilities centred on the dams. This agreement was struck in a context where there was recognition of need for some expenditure to upgrade dam safety, estimated at that time at around \$17m. Agreement to seek recovery only of forward costs could be viewed as either:

- gifting for the period of the BWSA, the rights to use of the dam, in its then state of repair, to Harvey Water and the recreational users, presumably on the assumption that this value would be non-negative; or
- assessing the value of the dam at the time of the BWSA as nominally zero.

The accounting differences implied by this arrangement – essentially the cost of sunk capital – have been managed via a CSO. Presumably, this CSO has been struck on the basis of historical costs, not a formal ‘market’ or deprival value valuation of the dam at the time of transfer, and the CSO figure is likely to be fairly artificial as a measure of economic subsidy. In 2004/05 this CSO payment was approximately 4 times the recoveries from beneficiaries; some care is needed before assessing the full ‘subsidy’ implications of this.

Historical cost of the dam is not necessarily a good pointer to current asset value, and this is especially likely to be true when a large, then unanticipated contingent liability has since emerged in the form of indicated costs of dam upgrades to comply with safety standards. For a range of other historical

reasons, the current forms of the dam need not be optimised and this too could imply a mismatch between historical cost and current value for purposes of assessing subsidy.

These value and subsidy questions are addressed principally in the third paper in this series. The nature of the decision taken in 1996 in respect of recovery of then sunk costs is also highly relevant to the issues addressed in the second paper – because that decision has almost certainly had significant cost allocation effects already.

The concern with this, the first paper in the series, is with the appropriate level of costs, at least from the perspective of price regulation.

The above \$17m estimate was, we believe, viewed at the time as only indicative and it applied to the costs of complying with the then current 1994 ANCOLD safety standards. These standards have subsequently been adjusted somewhat, with 2003 standards now being current. We assume these changes in safety standards would have some impact on the costs of compliance. However, the fact that much more detailed planning for compliance has led to a dramatically higher estimated cost of works – \$130m as indicated in the Issues Paper – would appear mainly to be attributable to refinements in the risk assessment and more detailed scoping of necessary works.

The revised budget does imply, for reasons developed below, very expensive investments in modest risk reductions. It is appropriate to address both whether such investment is justifiable and, even if so, whether these costs constitute the most appropriate basis for building dam safety compliance costs into bulk water pricing. This paper addresses these two matters.

### **3 Rationale for Dam Safety Standards**

The concept of designing and maintaining infrastructure for acceptable levels of safety would seem quite uncontroversial – and would reasonably be demanded by the community. A proportion of construction costs, and maintenance and operating – and the costs of complying at least with any regulated safety standards are reasonably seen as costs of doing business – including the business of ownership and operation of dam assets. To the extent that these costs are necessarily incurred in the course of delivering services – including dam operation services – it would be normal to expect these costs to be reflected in the price of those services.

Commercial imperatives to invest in safety could come from any or all of:

- Legal requirements as a condition of being allowed to build or own assets;

- Management of risks of legal redress in the event of failure or other event that causes damage;
  - Risks to officers of the company/ownership entity from legal actions by injured parties;
  - Risks to the company/ownership entity itself from legal action by injured parties or by safety regulators.
- Management of market risks that could flow from serious failure in infrastructure.
  - Changes in company/ownership entity cash flows as a result of temporary or permanent loss of assets for a period and the costs of recreating those assets if allowable and commercially justified.
  - Altered customer demands due to resultant perceptions of the company/ownership entity.
- Asset owner values and ethos that may well place added emphasis on safety, especially if this does not erode competitiveness.

WA has no regulated safety standards for dams, so that the first principle is not directly applicable, though other regulation – such as occupational health and safety regulation – would result in some safety requirements being met. The lack of regulated requirements could be expected to place increased emphasis on the second principle – demonstrable compliance with regulated standards could well go a long way towards managing the legal risks. In the absence of a regulated requirement, the demands to manage these risks will tend to favour demonstration of commitment to what might reasonably be seen as industry standards or industry best practice – providing evidence of not skimping on safety or of being negligent in this area.

From an Australian dam perspective, it is hard to go past the ANCOLD Guidelines, or one of the regulated implementations of these guidelines, as the prevailing standard for such demonstration purposes. Dam owners who fail to comply with the guidelines almost certainly create risks in respect of legal exposure and there would also be legitimate market risk concerns to be addressed.

It does not follow from this that compliance with the ANCOLD Guidelines results in the best overall use of community resources and this does raise interesting question for an economic regulator. Should an economic regulator allow costs to be passed through that are not required by regulation if they would not pass a ‘net benefit test’ – an assessment that that form of expenditure involves a reasonable use of resources taking into account alternatives?

Certainly before ‘rubber stamping’ the pass through of a set of budgeted costs, it is appropriate to look in some detail at the question of what ANCOLD



compliance means, at the value offered in relation to the costs proposed, and at alternatives. In fact, it may well be that the bigger issue is what is meant by ANCOLD compliance and whether the proposed costs are necessary in order to achieve compliance.

## 4 Key features of ANCOLD Guidelines

### 4.1 General features

A number of points need to be clearly recognised up front in relation to the ANCOLD Guidelines:

- There are just that – guidelines, without regulatory force.
  - Most jurisdictions in Australia have moved or are moving to create regulatory requirements for compliance with guidelines that bear close analogy to ANCOLD.
  - This is not true of WA.
- ANCOLD is about a *process* for managing risks, heavily weighted towards risks to personal safety rather than property damage – not about the specific status of the dams at a single point in time.
  - Ownership of a dam with a high likelihood of failure does not, in itself, imply failure to comply. Compliance could flow from:
    - … Low risks in the event of failure – either because few people risk being in the path of a flood, or because of early warning systems that would allow them to be moved out of danger; and/or
    - … Establishment of processes that would, in ‘reasonable time’ move the dam to a safety status that would be considered acceptable for the longer term.
  - Viewed from another perspective, ANCOLD compliance could involve a ‘transition path’ with a risk-weighted level of risk that is acceptable over the longer term – and this could allow continuance with safety levels in the short term that would not be acceptable indefinitely.
- ANCOLD formally applies to each individual dam, even where multiple dams are under the one ownership and/or a wider array of assets with safety considerations is under one ownership.
  - Practical implementation of ANCOLD would, realistically, need to take a wider portfolio perspective and to factor in considerations of financial capacity etc, across all operations – but in general this approach could be expected only to influence the timing of activities undertaken for each dam.
  - This point still means that whether safety upgrade plans for a dam are ANCOLD compliant or not may well depend on who owns the dam, though the guidelines involve a high level of subjectivity in



relation to compliance provide there is a sound plan to move towards ‘acceptable’ risk levels.

- The guidelines for risk assessment appear in general to be extremely well thought through, practical and appropriate;
  - This is a statement about process, about the questions raised and the methods suggested for addressing the questions – as opposed to the specific guidance as to what risks are acceptable, where there is great subjectivity and specific efficiency concerns developed later.

The ANCOLD Guidelines themselves recognise that they offer a ‘rough justice’ approach to dealing with societal risks, where the ideal treatment would be very different, and that there remains substantial subjectivity. A couple of quotes from the 2003 Guidelines on Risk Assessment (G10-1) are informative:

“Risk assessment typically requires tolerable risk policies and criteria. ... It is the responsibility of the dam owner to ensure that policies and criteria, and to endorse them. It is the dam owner who must decide what risks are tolerable, provided any regulatory and legal requirements are met and proper account is taken of political constraints, community expectations and recognized good practice.

“Ideally, tolerable community risks, especially life safety risks, would be determined by society, or by governments or their regulators acting on behalf of society, with risks from dams balanced against all other forms of societal risk, such as risks from the process industries, disease, crime and transportation – society would decide where best to direct its resources in reducing risks to life. HSE (1995) states specifically that government should decide what risks are tolerable. In reality, there are no mechanisms for systematic societal choices in setting an overall framework for tolerability of risk across all industries and activities. Outrage at risk levels, or at rare disasters, is the usual political mechanism for keeping risks within tolerable bounds, and for maintaining a crude consistency between industries and activities.

“...Where there is no explicit government requirement, and no dam safety regulator, the owner must set tolerable risk policies and criteria for both community and business risks. In relation to community risks, the owner would need to have regard to such aspects as national guidelines, practice across the dams and other industries, legal considerations and community expectations.”

## 4.2 Four key principles

The ANCOLD Guidelines are based heavily around 3 principles, all of which need to be satisfied – unless a fourth ‘exceptional circumstances’ principle is involved.

- **The individual risk guideline**
  - “for existing dams, an individual risk to the person or group which is most at risk, that is higher than  $10^{-4}$  per annum is unacceptable except in exceptional circumstances.” For new dams or major augmentations the corresponding figure has been set at  $10^{-5}$ .

- Effectively, this implies that no one individual should face an increment of risk from an existing dam due to the dam of greater than a 1 per cent chance of being killed in 100 years – broadly consistent with the background level of risk of people at least risk of single year death in society (which happens to be girls around 12 years of age).
- **The societal risk guideline**
  - A loss of life (LOL), attributable to the failure, that exceeds  $10^{-3}$  – one death per thousand years – is unacceptable except in exceptional circumstances.
    - … Note that the guidelines are clear (G8-4) that it is the *additional* deaths, over and above those that would have arisen in any case *even had the dam not failed*, that is relevant<sup>2</sup>.
  - The greater the number of lives at risk from failure, the lower the tolerance for failure probability – with a doubling of numbers halving the tolerable failure probability.
  - Where the LOL exceeds 100, special conditions apply – but this is not considered relevant to any of the dams being considered by the present inquiry.
  - The Guidelines clearly state, under their “f,N” principle (G8-8 and G10-1) that the LOL to be used should be the expected loss of life across the set of plausible failure events – risk weighted for the likelihood of these events occurring.
    - … This is not the same as the maximum possible loss of life and would allow, for example, for probability weighting for day/night risks, for seasonal variations in numbers of campers etc below the dam etc.
- **The ALARP principle**
  - Levels of safety even greater than these ‘limits of tolerability’ should be achieved unless it is not reasonably practical to do so – the risks should be **As Low As Reasonably Practical** (ALARP).
  - In broad terms, ALARP suggests that, once tolerable risk has been achieved, additional investments in safety can be subject to some form of cost benefit assessment, though the guidelines (G10-1) suggest, rather than benefits needing to exceed costs, that benefits should not fall grossly below costs, quoting from HSE:
    - … “Risk is tolerable only if risk reduction is impracticable or if its cost is grossly disproportionate to the improvement gained (HSE, 1992)”
    - … “Residual risk is tolerable only if further risk reduction is impracticable or requires action that is grossly disproportionate in

<sup>2</sup> This measure of incremental risk is not intuitively obvious as the ‘right’ measure to use – risks over and above those in the absence of the dam seems more natural. This distinction is discussed in more detail in Section 4.3.3 below.

- time, trouble and effort to the reduction in risk achieved (HSE, 1999a)” This later wording has dropped explicit recognition of cost, relying instead on an implicit notion of opportunity cost.
- HSE (2001a) more explicitly asserts that there is a need to weigh the achievable risk reduction against the sacrifice involved. This language lacks the ‘grossly disproportionate’ connotations of the earlier references, but leaves a wide area for discretion.
  - These references to HSE guidelines are explicit in the ANCOLD Guidelines, and indeed the HSE process appears to have been drawn on heavily by those framing and revising the ANCOLD Guidelines.
  - We return to the HSE Guidelines in more detail in Section 4.3 below.
- **The exceptional circumstances principle**
    - The Guidelines do not explicitly recognise a separate ‘exceptional circumstances principle’ – they embody it as an ‘out clause’ in the other three principles.
      - … However, it deserves comparable status to the others for reasons flagged below.
    - “The decision that there are *exceptional circumstances* that justify risks higher than the *limit* is to be made by government or its regulators, and would normally be based on the benefit to society of the facility, despite its risks. It is for the government or its agents to weigh such considerations that involve public safety.” (G10-1)
    - This seems to embody a net benefit test into this principle. In principle, it offers a lot of room to move.
    - In WA, where the ANCOLD principles do not have any regulatory force, the concept of the WA Government exercising the exceptional circumstances provisions is a slightly curious one – what would they be exempting the owners from? – but not an absurd one.
      - … If there is a net benefit case for not requiring the normal ANCOLD safety standards, and the asset owners are concerned for their liability in unilaterally declaring the risk acceptable, then a government determination might help to support a more cost effective strategy.
      - … Exactly how much support this would offer to a defence case in the event of legal action following failure, is not entirely clear. Certainly it could not harm – but it seems unlikely that the legal case would be prosecuted entirely in *ex ante* community net benefit terms.

### 4.3 Some comments on the principles

There is a lot of arbitrariness in these principles, in their scope and in the tolerability limits set. This is not intended as a strong criticism. Not even individuals, let alone communities, are consistent in their approach to risk or in

the response, including political response, to adverse outcomes. The group that fashioned the ACARP principles recognised this and tried to weave a path through quite inconsistent practice across different industries and activities.

However, in considering whether high compliance costs are justified, it is worth noting some special consequences of these arrangements:

#### **4.3.1 Compound risks**

The dam-specific orientation creates some anomalous situations. Consider a situation where an individual lives at the junction of two dammed rivers and his individual risk from failure of either dam has been assessed at just below 1:1000 – this appears to satisfy the individual risk criterion. Unfortunately, this individual is exposed to a risk of just under 2:1000 from dam failure. If this risk arose from a single dam, it would be unacceptable, but spread across two dams it becomes acceptable. What if someone were to propose a single large dam, as a replacement for the 2 small dams, and could demonstrate a small reduction in dam failure risk to the individual and substantial wider benefits. The proposal would fail the individual risk criterion, presumably to the detriment of all.

This appears to hold whether the two dams are under the same or different ownership. In theory at least, the guidelines could favour the roll out of a higher risk and lower benefit dam strategy.

None of the dams under consideration seem relevant to this application of the individual risk criterion, but a variant arises in relation to societal risk. It would be quite plausible for the collection of eight dams in the region to satisfy the societal risk criterion if assessed as a block, but for several individual dams to fail the criterion. If the 8 dams are in common ownership, as part of a total supply system, why is it appropriate to look at their societal risks on a case-by-case as opposed to a whole of portfolio, basis? Again it would be easy to produce examples where the effect of this structure would be to encourage a more dangerous and less beneficial dam system.

In theory, this argument could be taken further – to apply across all Water Corporation dams for example – with the likelihood that it would be much cheaper to satisfy a societal risk criterion across the portfolio than on a dam-by-dam basis.

We note that Marsden Jacob *et al* (2003) raised the concept of an even wider portfolio approach to dam safety risk – alongside other government-owned infrastructure. This is consistent with the concepts set out in HSE (1995) and quoted earlier, as a ‘first best’ approach to these safety trade-off issues.

The fact that taking a wider view of the set of assets to which ANCOLD principles apply could produce both greater safety and greater wider benefits does suggest that this is a relevant consideration for ERA in weighing which compliance costs are justifiable and efficient.

It needs to be stressed though that one reason why the guidelines tend to focus on single assets is because legal processes in the event of failure will focus on individual assets. Company, and company officer risks, may require such an orientation for a strong defence in the event of failure – even if a rational societal approach in advance of any failure would suggest the strategy is excessively costly and, possibly, excessively dangerous. The overall outcome remains quite anomalous.

#### **4.3.2 Differentiation between retrofit and new dams**

The individual and societal risk principles appear to ignore costs – costs are viewed as only relevant in the ALARP setting, where tolerable risk is already achieved or is to be achieved. Why then do the individual and societal risk criteria distinguish between retrofit and new dam tolerable safety and allow existing dams to exceed the tolerable risk standards for new dams?

It certainly seems likely that it will be more costly to retrofit a substantial safety improvement than to design that level of safety into a new dam. In a cost-benefit setting this would probably favour higher safety standards for new than established dams. But the tolerable risk levels are presented as arising outside the cost-benefit framework.

This suggests a grey area. It could raise interesting issues were there a proposal to substantially augment an existing dam. ANCOLD Guidelines would require that the augmentation deliver safety standards an order of magnitude higher than those tolerable for the existing dam. What if it was only cost effective to deliver half that order of magnitude improvement – presumably the augmentation would not proceed, and the result would be lower safety and lower other benefits from the augmentation.

The same greyness does raise the question of whether lower safety levels for existing dams would be justified if the costs of complying with the letter of the individual and societal risk principles would have been very high.

Within the ANCOLD guidelines the only way to allow this would be through exercise of the exceptional circumstances provisions in the guidelines. We return to these below. However, the implicit nod given by the Guidelines to some concession to higher costs of works, even within these individual and societal (as opposed to ALARP) principles does seem to offer some support

for reasonable consideration being given to some cost sensitivity, even in relation to these two principles.

Of course, the principle of ‘grandfathering’ some existing assets in the event of new regulation – exempting existing assets from the need for some or all of the compliance costs – is not unique to dams. It has commonly been the case with car safety design features – where new cars have been required to install extra features – such as airbags – but retrofit has not been needed. We would expect that in most cases this has involved the application of some form of ALARP principle, alongside possible consideration of affordability. The obvious difference with the ANCOLD principles is the fact that they appear not to be using any such principles in reaching this position, though it seems highly likely that they are implicit.

The main question this gives rise to then is the meaning of tolerable risk outside of something like an ALARP principle. If a tolerable risk threshold can be amended on cost grounds, then in what sense is the tolerable risk threshold different from the ALARP approach? It is easy to see pragmatic reasons for the guidelines having settled on a ‘rule of thumb’ for dealing with tolerability – but this does not mean that the consequences need be accepted if the costs would be very high. This could underpin a case for invoking either the exceptional circumstances clauses or for looking beyond ANCOLD for guidance.

### **4.3.3 Credit for lives saved**

As was noted earlier, the guidelines allow for correction of LOL in the event of failure for LOL in the event of non-failure. A 1:1,000,000 flood may well be a dangerous thing, even in the dam does not fail. The guidelines focus on the incremental loss of life.

This appears a little curious – focusing on the risk of failure rather than the risks posed by the dam in its state of repair. They are quite different concepts. If I build and own a dam, and it fails, I might have legal problems, financial problems and a conscience to deal with – justifying some preemptive risk management. What however, if the dam is built in part because of the scope it offers to reduce flood risks, possibly extending to saving lives – where a 1:50 year flood might otherwise pose a substantial risk to communities. What if the same dam offers a small increment in LOL in the event of a 1:100,000 flood, but regularly (every 50 years or so) saves lives as a result of its flood function and the net effect is fewer drownings, on average, than if the dam were not there. Would the dam safety risk be intolerable.

Under the societal risk principle it may well be – unless the exceptional circumstance provision is invoked. The principle allows no credit for lives



saved and, indeed, by comparing the failure event to non-failure in the face of the same flood it seems to be imposing a particularly high burden on the dam owner. If the dam failure would be indistinguishable from the no dam outcome, it is hard to see why the dam safety should be less tolerable than not having the dam – and again it would be easy to envisage circumstances in which the outcome could be less safety and less benefits from the water, with no offsetting upside.

Circumstances like this, were they to arise, would seem to provide a reasonably solid basis for considering the exceptional circumstances provisions.

#### 4.3.4 Safety outcomes are a function of ownership structure

Who owns the dams can have very substantial implications for what needs to be done, and when, in order to be able to argue that the Guidelines are being complied with.

A particular version of this argument has been developed by Marsden Jacob *et al* (2003). They note that the 1996 Cabinet Submission stated:

“The proposed bulk water price ... is based on irrigation farmers paying on the same basis that they would pay if they owned the assets.”

The authors then go on to explore the likely implications of the response to the ANCOLD Guidelines if this principle were extended – with the safety upgrade costs being determined on the same basis as would result if the assets were owned by the irrigation farmers or Harvey Water. They conclude that a very different timing and lower compliance cost response would be possible. This is because Harvey Water would face very different financial and affordability constraints, and could legitimately develop its compliant risk management response within these constraints.

The nature of the ownership would have implications for any legal liabilities of office holders, in particular Directors. The very different spread of the portfolio of assets could encourage a different response strategy. Harvey Water would be far more directly accountable to the irrigators for any decisions it were to take and would have a fundamentally different set of business risks to be managed.

This analysis appears still highly relevant. There is no decision to base the dam safety planning on an ‘as if they owned the assets’ principle but it does highlight another quite arbitrary feature of the Guidelines. Applying such a principle would not, we expect, remove legal liability from Water Corporation or its Directors; we expect that they would be judged for compliance within the terms dictated by the structure of Water Corporation. The ERA Issues

Paper did flag the possibility that the interests of efficiency might be served by a formal shift in ownership.

The above does not imply that Water Corporation ownership is inefficient. It might be that a financially restrained ANCOLD compliance by Harvey Water would be inefficient. What it does highlight is these differences. If it were to be the case that current ownership arrangements are encouraging a form of compliance that would perform poorly on net benefit grounds relative to that offered by different ownership – and this does seem plausible for reasons further developed below – then there is a real issue here in relation to the nature of ownership.

It may, of course, be possible that instruments other than a change of ownership – including regulation for safety standards different from ANCOLD or invocation of exceptional circumstances provisions within ANCOLD, could also deliver the efficiency improvement.

## **5 Value for money**

The above discussion is all about principles, not empirics. It does suggest that there is little that is sacred about the detail of ANCOLD Guidelines in a WA setting – other than its de facto status as a standard that might have some weight in a legal setting. However, it also highlights that the Guidelines actually offer a lot of scope for the exercise of discretion based on cost effectiveness criteria – by the government in the case of the individual and societal risk tolerances and by the asset owner in the application of the ALARP principle.

The relevance of all this depends on whether application of the default approach to ANCOLD would appear likely to fail on cost effectiveness grounds. There are, of course, two sides to a cost effectiveness assessment – costs and benefits – and some comments are relevant on both.

### **5.1 Cost considerations**

The costs of complying with ANCOLD are not firmly fixed. The ERA Issues Paper attributes to Water Corporation a most recent estimate of \$128m, up from the \$16-18m notionally estimated in 1996. The earlier discussion suggests this figure could be altered in a number of ways:

- Normal review, revised modelling based on new data and techniques, design and costing.
- Revised timing, and possibly form, of works through a change in ownership or the adoption of a different portfolio of assets for planning purposes.



- Critical review of key assumptions built into the current planning, including LOL estimates.
- Clarification of the issues of offsets for the value of lives (and damage) saved as a result of flood mitigation services from the dams.
- Possible consideration of alternative operating patterns that may alter upgrade costs.

We understand that Marsden Jacob have been commissioned by the Authority to review and update some of their past work, and to provide specific input into some of these possibilities.

## 5.2 Benefit considerations

As was noted above, the ANCOLD Guidelines are heavily loaded towards avoiding deaths, presumably with an assumption that this is likely also to help avoid injuries. Thorough risk assessment within the guidelines will also involve reporting – presumably with the view of assisting management of – other risks, including:

- Monetary and financial losses, distinguished between the dam owners business losses and losses to the wider society.
  - This could clearly include damage to assets downstream of the dam and loss of access to future water services as a result of loss of the dam.
- ‘Incommensurable impacts’, taken to include a range of, mainly moderately tangible environmental, impacts where reasonable quantification of impacts in physical, but not financial terms is possible.
  - For example<sup>3</sup>, loss of 30 platypus and associated habitat, lasting into medium term; or 3,000 people at risk from disease in the town, lasting a short while.
- ‘Intangible impacts’, where even incommensurable quantification is difficult
  - For example, grief of 500 near relatives of victims and 3,000 more distant relatives and friends, trauma, reputational damage for the owner, fear of judicial inquiry.

It seems likely that satisfying the central risk of death standards would go a long way towards rendering these other risks tolerable – though this implicitly assumes that tolerability of risk to lives and tolerability of risks to property etc are separate concepts that should each be satisfied independently. If on the other hand there is some concept of tolerable combinations of different forms of risk – lives, trauma, damage etc – with lower levels on one dimension allowing for higher levels on another, then this assumption would not hold. If

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<sup>3</sup> Drawn from Attachment J of ANCOLD Guidelines on Risk Assessment (2003)

such trade-offs were consistent with limits of tolerability, then it is hard to see how to avoid application of cost-benefit principles even to the determination of these limits.

We note that the Guidelines do not require formal valuation of incommensurable and intangible risks, even though in many cases methods do exist for at least indicative valuation. Given the effective exclusion of these benefits from the formal guidance on tolerability (though not from the responsibility non owners to weigh these effects), this is understandable – and the Guidelines certainly do not preclude formal valuation in support of this weighing process.

In what follows, we focus on risks of death.

### 5.3 Diminishing returns and implications

As was asserted in Section 3, there is no controversy about the need to build and operate dams for safety. However, like most investments in capability or safety, it could be expected that a law of diminishing returns would apply – that after the early and relatively cheap improvements in safety, the level of extra safety delivered per extra dollar of investment in safety would fall.

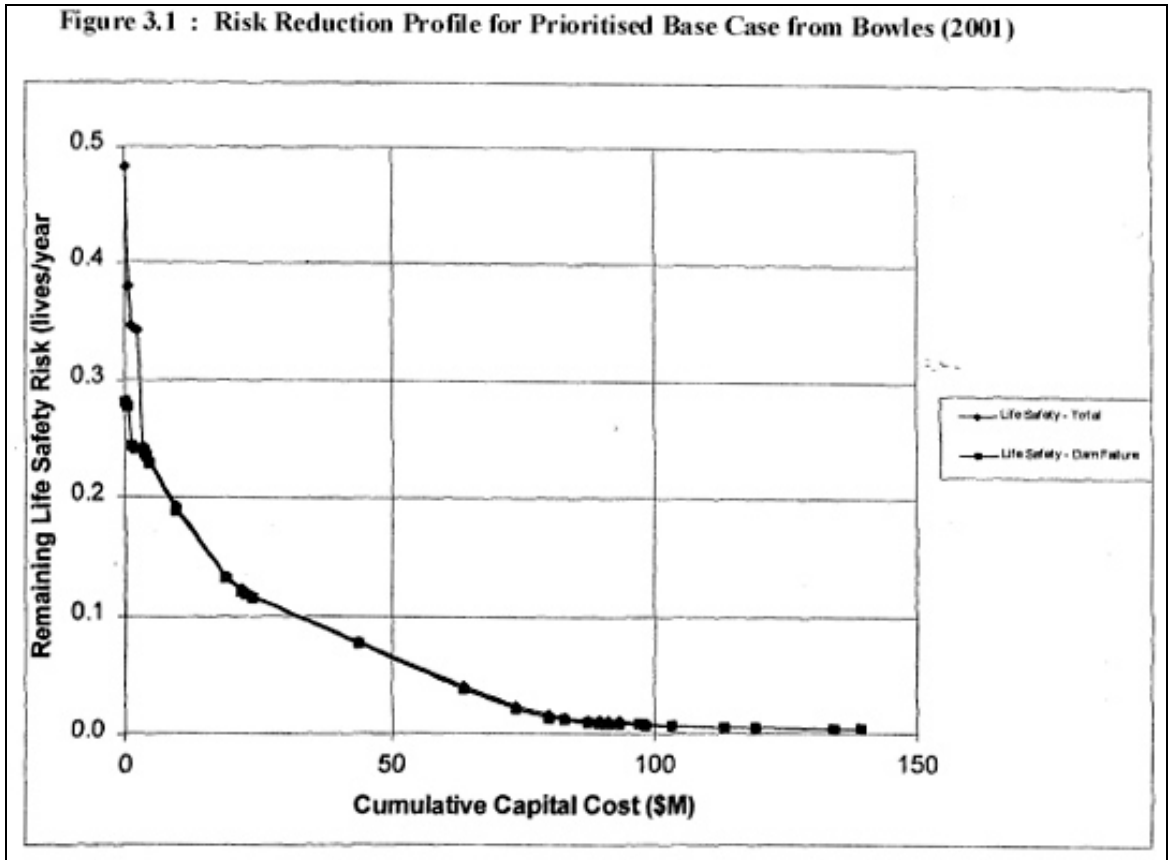
Evidence in favour of this proposition was reported by Marsden Jacob (2003), citing an earlier study by Bowles, who undertook a portfolio risk assessment of the South-West dams for Water Corporation. We understand that Marsden Jacob are now reviewing the empirics of the proposed works program, but it is useful, in the meantime, to review that earlier evidence.

Bowles worked with the components developed by Water Corporation *at that time*, but analysed the incremental impact of expanding the program across successive components – effectively ‘picking the low hanging fruit’ first up, and then, within technical constraints, working out through decreasingly effective add-ons.

The curve was based on 30 components analysed by Bowles. The chart shows the cumulative reduction in assessed *average annual risk to life* associated with the accumulation of these measures, reflected in the cost of the program of works. Note that the total for all components is of the order still being suggested for the dam safety program. This is the full program as proposed by Water Corporation – and currently subject to review by Marsden Jacob.



Figure 3.1 : Risk Reduction Profile for Prioritised Base Case from Bowles (2001)



What is striking is the rate of early decline depicted in the chart. A total package of about \$140m was assessed as delivering a saving of approximately 0.5 lives per annum, across all dams in the system.

- It seems likely from the chart that half of those gains would have been obtainable for outlays of the order of \$5m – ie, about 3 per cent of budget could buy about 50% of the risk reduction.
  - It is likely that that many of these measures, or variations on them, have now been implemented as part of the package of works already rolled out, implying a much low starting risk.
- About 85 per cent of the gains could be obtained for about a third of the budget.
- The remaining 15 per cent of the gains – involving a saving of about 0.07 lives per annum – would appear to absorb the remaining \$90m of the budget – an implied cost per life saved per annum of about \$1.3b, or an implied through life cost (at 5% discount) of about \$65m.

Normal economic principles (but not ANCOLD Guidelines) and analysis would suggest that you move out along this diminishing returns curve until the marginal return on moving further falls below the opportunity cost of doing so – till a better use can be found for the funds. This opportunity cost could be viewed as investment in other safety measures, or investment in other ways

deemed to offer a greater return than the best of the available investments in safety. As we have noted, the ANCOLD Guidelines pay no formal attention to the cost side of meeting safety standards until at least its ‘tolerable’ level of safety has been achieved. These diminishing returns suggest that the last bit of additional safety could come at a very high cost – including a very high cost to safety defined more widely.

## 5.4 Returns on investment in safety

One measure of value for money in safety investment is that of cost per statistical life saved (CPSLS).

The notion of what it might be worth spending to save a statistical life is common in the literature concerned with investments in safety. A statistical life is not the same as a life. Some unwilling to attach a value to a human life may quite happily and voluntarily engage in a dangerous sport, drive while tired or duck across the road between traffic. Each of these decisions involves a risk to life and an implicit judgment that the rewards of the activities justify the risks. Risk to life is implicitly valued by most people several times a day. Studies of willingness to accept risks – either through revealed behaviour of survey methods, can be used to indicate the value individuals or society attach to a risk to life. If a 1:10,000 risk (roughly the risk of the average person being killed in a car accident each year) is valued at, say \$200, then the value of a statistical life (VOSL) implied by this is  $\$100 \times 10,000$ , or \$2m.

Not everyone is comfortable with this concept, but the fact is that we all deal implicitly with such valuation in managing our day-to-day lives. Governments do the same. Presumably requiring full racing harness seat belts and fireproof coveralls for all occupants of vehicles could deliver better safety outcomes – but is not required by governments nor, in the main, voluntarily installed by car owners. The trade-off, in amenity and cost, is unacceptable – yet standard seat belts are widely accepted. There is a notion of safety improvements that justify their costs and of ones that do not. There is no great consistency in this, but there is a basis in weighing benefits against costs.

The Health and Safety Executive (2001) in the UK recognises the equivalent concept of value in preventing a fatality (VPF), a concept recognised in HM Treasury Guidelines (that have an affinity with similar guidelines in WA and other state and Federal jurisdictions in Australia) – where a base figure is recommended for purposes of cost-benefit analysis. This figure was £1m in 2001.

The NSW Dam Safety Committee (2004) clearly recognises that “the aim of regulation is tolerable risk, not zero risk”. Practical process in grappling with these safety matters requires acceptance of this reality.

CPSLS avoids the troubling appearance of ‘valuation of life’/‘affordable safety’ connotations of VOSL, at the expense of providing only a basis for comparing alternative investments in safety – it does not offer a standard of justifiable cost. For any proposed investment, it is possible to calculate the number of statistical lives it is likely to save over its life, and to work out the cost over the life of the investment, and from this to infer the CPSLS. In reality, costs and lives saved are spread over time and the standard tools of discounting are generally applied, but this does not cut across the concept – it simply recognises the opportunity cost of resources. If two proposals are on the table, one with a much higher CPSLS than the other, it would be appropriate to query a decision to invest in the high CPSLS initiative and not the low one.

Returning now to the above analyses of incremental costs, this last figure of \$65m/life saved is an estimate of CPSLS from the last \$90m of the proposed (in 2001) dam upgrade program. In relation to other government interventions to improve safety, it would be fair to say that the figure is large. In relation to mainstream estimates of VOSL it would be fair to say this figure looks very high and unlikely to be justified in a VOSL framework.

The corresponding CPSLS figure in relation to the entire 2001 budget of \$140m is \$14m – a much lower figure that taps the early gains, and reflects very low CPSLS from the early initiatives, offset by the very expensive gains from the later initiatives.

To provide a firmer context for weighing these dam safety initiatives, consider some analogous figures and rules of thumb, which are presented as illustrative only:

- The National Road Safety Strategy, issued by the Council of Australian Transport Ministers in 2001, cites figures supporting a CPSLS, again calculated at a 5% discount rate, as follows:
  - From general investment in road improvements – \$2.5m
  - From investment targeted at ‘black spots’ – \$0.25m
- The Federal Department of Health and Aging has published guidelines for assessing environmental health interventions, including guidance for the conduct of cost-benefit assessments involving differences in risk of death and morbidity (enHealth, 2003, Volume 1).
  - The *guidelines* support, based on assessment of a wide range of studies, an indicative figure for the average value of a statistical life in Australia of \$2.5m;
    - … suggesting that public health measures with a CPSLS greater than \$2.5m would not be deemed cost effective under these guidelines (unless justified by other injury and damage benefits, that could be significant for dams, as they would be for car accidents etc).



- As was mentioned earlier, UK Treasury guidelines for infrastructure cost benefit assessments specify an indicative value for a prevented fatality of £1m, which is broadly consistent with the above Health and Aging figure.
- A Monash University Centre for Health Program Evaluation assessment (George, Harris and Mitchell, 1999) of the consistency of Australian pharmaceuticals approval processes across the period 1991-1996 concluded that the implicit cost effectiveness threshold for most PBAC approvals was in the range of \$37,000 to \$69,000 per life year saved.
  - Even with adjustment for inflation this figure is likely to be comparable to, but somewhat under, the value of a statistical life year included in the above Department of Health and Aging Guidelines – of \$150,000. This suggests an implicit value of a statistical life underpinning these decisions of the order of \$2m.
- The Bowles analysis cited above discusses estimates of CPSLS, calculated for the 3 stages of works identified for Waroona Dam – but it seems possible, from the material cited, that the figures have applied a formula based on statistical lives saved *per annum*. In respect of monitoring, the two measures may be approximately identical – if the monitoring costs are annual – but they are tabulated as capital costs so there is some confusion that may be resolved in the related work now being done by Marsden Jacob, whose earlier drafting around the Bowles analysis has been used below. Subject to any revision here, and using a 5 per cent discount rate, it would appear that:
  - Monitoring has a CPSLS of about \$0.4m if the Bowles costs are annual, otherwise about \$8m;
  - Phase 1 works have a CPSLS of about \$0.4m
  - Phase 2 works (occupying about 60 per cent of the budget) involve a CPSLS \$65m as above – though in this case the Phase 2 works only accounted for about 60 per cent of the budget, not the 85 per cent suggested across all the dams.
    - … The more marginal components of Phase 2 would have a CPSL that is very much higher again.
- The ERA Issues Paper cites road safety, with an indicator figure of a 1:12,330 chance of being killed in a car accident each year in WA.
  - This risk this lines up fairly well with the 1:10,000 tolerability level built into the societal guidelines.
  - On the other hand, it involves much higher individual risk (as defined by ANCOLD) than for dams – if the average person faces a 1:12,330 chance of being killed, then I would expect a young male with a drinking problem and a ‘souped up’ old model car to face a much greater individual risk – along with any passengers.
  - If you were the only WA person at risk from a just tolerable dam, then the risk the dam poses would be broadly comparable to the likelihood



of being killed in a car accident if your car accident risk is average for WA.

- ... But if you lived in the Northern Territory, you appear to accept a risk of death in a car accident that is 3 times as great, still on the assumption that your risk is average – and very much higher again if you are in a high risk group!

Implementation of ANCOLD Guidelines – at least without invocation of the exceptional circumstances clauses – seems likely therefore to involve, at least in relation to the higher cost/lower effectiveness elements of the necessary investment package:

- A need to invest to reduce to ‘tolerable’ levels, risks that are clearly tolerated in other parts of our everyday lives, both in voluntary risks and in imposed risks.
- Costs per unit of risk reduction that are many times greater than those available from alternative safety initiatives that have not been required.
- Costs per statistical life saved that imply a value of statistical life that is dramatically greater than that suggested by other studies and by other government guidelines.

It is clear from discussions, and from references in the documents, that the drafters of the ANCOLD Guidelines appreciate these apparent anomalies. The Guidelines are deliberately highly conservative. It does not follow that they imply a sound balance in the use of community resources.

It is very easy to understand a high level of caution in respect of risks of truly cataclysmic dam failure. A dam upstream of a major urban centre, where failure could result in the loss of tens or hundreds of thousands of lives, would be seen by many as fundamentally different. The failure of such a dam could have a truly devastating impact right across society, and extending for many years into the future. The dams under consideration in this inquiry are not of this type. Worst case scenarios, at least after the ‘low hanging fruit’ safety upgrades have been performed, involve risks to life more on the scale of a major bus accident (or less) – and it is likely that bus safety could be improved at much lower cost than could the last increment of dam safety needed for normal (non-exceptional circumstances) compliance with ANCOLD Guidelines.

Indeed, it is probably that investment in improving road black spots in the Harvey Water district could improve safety in the region by far more, or far more cost effectively, than could be done with the high cost/low effectiveness elements in the safety package. This position clearly needs to be reviewed when the Marsden Jacob work on revising the empirics is available – but it

seems likely that the broad picture will remain if the budget remains in the vicinity of \$130m.

## 5.5 “Non-product measures of risk”

The nature of dam failure risk in Australia is different in nature from, for example, State-level car accident fatality risks. Major dam failure in Australia is virtually unheard of – though the same is far from true of some other countries such as the US<sup>4</sup>.

In any one year, the chances of even one significant dam failing, and of any lives being lost from dam failure, in Australia – let alone in WA or in the South-West Irrigation region – is tiny.

On the hand, the chances that there will be no fatalities on the road is even tinier; given the number of cars, and the risks per car, car accidents are effectively a statistical certainty. They are accepted as a fact of life, safe in the knowledge that the same statistics tend to mean the road toll in any one year will not rise far above expectations any more than it will fall far below. A sustained upwards trend might provoke a reaction, and the general downwards trend over many years has been applauded, but this setting of inevitable deaths promotes acceptability of risk in a way that need not arise for very rare risks that people have not already factored into their expectations.

The truth is that every year more people are killed on WA roads than is envisaged from even the worst dam failures countenanced in planning the safety program. Numerous, ‘inevitable’ deaths on this basis are likely to be more acceptable – just as they are more acceptable than a single large plane crash that kills a fraction of numbers in the annual road toll. Plane crashes are not outside boundaries of understanding, but have a rarity and scale of single incident death likely to provoke a different societal reaction. This variance in attitude to risks is sometimes described as irrational – but that really means little more than that societal attitudes do not comfortably fit relative simple models of values.

Given these variations, there can be useful information contained in a more detailed description of pairs of possible outcomes and measures of likelihood than is contained in a risk weighted ‘expected’ impact. Reporting these pairs, as opposed to reporting their product or summed product, is sometimes

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<sup>4</sup> There were several significant dam failures in the US in the 1970s and 1980s, including, in 1972 two major failures (in South Dakota and West Virginia), killing a total of 262 people. These failures appear to have been a major driver behind the Government response, including early identification of 2,900 ‘unsafe’ dams, and the progressive development of dam safety guidelines, inspection systems and requirements. See report by Building Research Establishment (2002), Appendix E.



referred to as providing ‘non-product measures of risk’. They can certainly be valuable in identifying possible high consequence-low probability elements hidden with an expected value and this may allow for consideration of the strategic implications of any such events. Unless the consequences are very large, this is unlikely to have implications for normal cost-benefit analysis but may have implications for the weighing of possible political costs, that may well prove relevant to any exercise of exceptional circumstances provisions by government.

Further discussion of variable attitudes to different types of risks of this form is contained in HSE (2001).

## **6 Departure from ANCOLD**

The above assessments do, in our opinion, lend strong support to the view – recognised also by the ANCOLD Guidelines – that better community safety outcomes are likely to be achievable via departure from the letter of the ‘normal’ interpretation of the guidelines. This could be done in one of two ways:

- Working within the ANCOLD Guidelines, while exploiting the flexibility that pervades these guidelines, to limit the extent of investment that would perform poorly if assessed as safety investment relative to other accepted risk contexts.
  - In part, this could involve considering alternative ownership models, or procedures that would allow the development and timing of more cost effective dam safety plans;
    - … for example, through application of the ‘as if they owned the assets principle’, through careful review of the LOL estimates and of their relationship to expected lives lost in the event of failure, through careful consideration of the ‘no failure’ risks and consideration of whether application of a ‘no dam’ counterfactual would be defensible and would have significant implications.
    - … These possibilities are being examined in more detail by Marsden Jacob.
  - It could also involve invoking the exceptional circumstances clauses to remove the absolute imperative to move safety into the ANCOLD tolerable region – effectively extending the ALARP principle into this region and interpreting very high CPSLS initiatives as failing the ALARP test.
    - … This seems entirely feasible, though some care may be needed to address the legal concerns of Water Corporation if the assets are to remain with Water Corporation.

- ... At its simplest level, this might involve recognising a CPSLS above which some form of exemption on the basis of exceptional circumstances might normally apply.
- Moving to recognise an alternative approach.
  - Minor adaptation of ANCOLD Guidelines would seem relatively straightforward – and this approach has been adopted by several other Australian jurisdictions.
  - A major shift to reject these Guidelines, that have established a *de facto* standard, should probably be done cautiously – and might best be done within the context of WA taking a more formal, regulatory approach to dam safety.
  - It is also appropriate to recognise that the risk assessment process documented by ANCOLD looks particularly well thought through and in this form, and in the somewhat adapted implementation format being used by other jurisdictions, provides what appears to be an excellent framework for planning for sound risk management.
  - ... Our assessment above relates to specific aspects of the framework where parameters, recognised by ANCOLD as fairly arbitrary, have consequences that suggest blind compliance may involve substantial costs to the community.

The Australian National Committee on Large Dams has worked closely with the International Commission on Large Dams (ICOLD) in developing both ICOLD Guidelines and their Australian interpretation as ANCOLD Guidelines. Other jurisdictions have developed their own variants.

There appears to be a trend towards systematic risk assessment, as espoused by ANCOLD, and we believe this is sensible – it would seem a retrograde step to move back to a pure engineering standards approach for example, that could be expected to result in over-engineering of smaller, more remote dams and that could well allow for under-engineering of some major dams.

The broad concept seems sound and consistent with wider modern approaches to risk management – including modern approaches to accounting for risk in economic investment planning settings. The concerns, as highlighted above, that the Guidelines may encourage expenditures that are out of kilter with revealed standards elsewhere in society, and expenditures that would have difficulty passing a net benefit test, stem from specific aspects of the detail of the approach.

These details refer to the way that a cost-independent ‘intolerable risk’ region is defined, the application of the risk concepts, including risk tolerability dam by dam as opposed to across a portfolio of assets with collective risks to be managed, and some specifics – such as assessment of risks relative to a ‘no failure’ alternative rather than a no dam alternative.

There is some evidence of formal portfolio assessment methods being used selectively, but these appear to have been more ways of prioritising works across a set of dams than ways to allow for long-term departure from dam-specific guidelines and standards. In this sense, these examples differ from the portfolio concept suggested in the early work by Marsden Jacob (2003), which is discussed further below – and that has significant attraction as a generalisation of the ANCOLD Guidelines.

Building Research Institute (2002, Attachment E) provides a summary of approaches then taken to dam safety in 6 countries (Australia, Canada, Germany, Portugal, US and UK).

Development of these approaches has drawn from wider experience. ANCOLD has explicitly recognised the role played by the evolving guidelines developed by the Health and Safety Executive in the UK, safety practices in Holland, BC Hydro in Canada and the Institute for Dam Safety Risk Management in Utah USA (where David Bowles, cited above and part of the Marsden Jacob team for the 2003 review, is based).

## **6.1 Regulatory process for WA**

Almost a generic strategy, in that it could work with a range of risk management processes and standards, is the possibility of WA following other Australian jurisdictions and introducing a formal regulatory base for dam safety.

NSW, through its Dam Safety Committee and its involvement in ANCOLD and ICOLD processes, has taken a lead role in relation to shaping and interpreting the ANCOLD Guidelines within a practical regulatory context and implementing and running an assessment and regulatory process to ensure compliance. Most other jurisdictions are following a broadly analogous path – establish formal requirements for risk assessment and risk management planning and providing formal guidance on government expectations. In all cases, these expectations are based around ANCOLD processes.

Water Corporation is a government-owned entity and the dominant owner of larger dams in WA. The reality, borne out by experience, is that, in the absence of formal regulatory standards, Water Corporation would – for good governance reasons – seek to base its dam risk planning around ANCOLD standards. It may well be that WA concluded that formal regulation was not necessary – at least if ANCOLD compliance was to be accepted as appropriate.

This position would seem particularly strong if the ANCOLD requirements were strictly formulaic – if they specified what needed to be done and when, with little discretion as to the determination of acceptable risk, estimation

processes and timing of works. A non-regulatory approach could probably work well in delivering compliance.

It does not, of course, follow from this that the compliance would represent an efficient use of community resources, or that the investments in safety would be cost-justifiable – all of the earlier discussion and evidence of some poor cost-effectiveness would remain relevant to the appropriateness of the requirements in a WA setting. However, the policy process could be expected to work and to avoid the need for another layer of administration and associated costs.

Beyond (and in part because of) these issues of efficiency, this approach would not resolve the problems of an economic pricing regulator. Without a formal Government position that ANCOLD is a requirement, and given the arguments that full compliance may not be an efficient use of community resources or the most effective way to improve community safety, it would still not be possible to argue that the costs of compliance correctly reflect the true commercial market cost of doing business. However, as long as the ANCOLD requirements were quite formulaic – eliminating scope for arguing about the efficient costs of compliance – then it is likely that a resolution by a pricing regulator would be a lot easier.

The high level of subjectivity and discretion actually built into the Guidelines does mean that the outcomes from the non-regulatory approach may, in fact, differ in important ways from what would arise under a regulatory approach. The earlier discussion shows that there is a lot of discretion as to timing – though possibly less for Water Corporation with a large and diversely-based capacity to pay than might be the case for a smaller dam owner – and also scope for discretion as to the level of acceptable risk. However, natural incentives within Water Corporation are likely to discourage significant exercise of discretion as to the level of acceptable risk – and this could be read as consistent with ANCOLD, where departures from indicated maximum levels of normally acceptable risks, using the exceptional circumstances provisions of ANCOLD, are recognised as being decisions that should be taken by government or a regulator – not by owners.

For Water Corporation, the apparent scope for passing these compliance costs forward to Harvey Water and other customers, and possibly back to the Government via CSO payments, does suggest that they see clearly the major benefits of complying unambiguously with ANCOLD, but may see relatively few of the costs. Even if the compliance costs push bulk water costs to a point where current demands fall off, then there may well be value to Water Corporation in any water so freed – and the compliance costs for dam safety

may prove far more affordable for urban customers than for irrigators<sup>5</sup>. These incentives may be problematic in seeking an efficient response even within ANCOLD Guidelines – especially if, as seems plausible, the efficient response might be significantly less costly under alternative ownership structures.

This last point is a potentially complicated one for an economic regulator – what position should it take if Water Corporation truly faces high compliance costs, but these would be a lot lower under an alternative ownership structure. Does it allow the higher costs to be passed through? Does it consider seeking alternative ownership (flagged in a sense in the Issues Paper)? Does it allow only those costs that would arise under a least cost ownership structure to be passed through, leaving Water Corporation (or its owner) to wear the costs of retaining that ownership structure? These matters are addressed in more detail in Paper 2 in this series, as they link strongly into appropriate cost sharing arrangements.

Formal regulation for ANCOLD compliance, or for compliance with analogous arrangements, would remove some of the uncertainty for a regulator, and would clarify certain costs as being necessary costs of the business of dam ownership. For the above reasons, it would not eliminate this uncertainty, and it still seems likely that incentives in developing a dam safety program would, if anything, lean towards over- rather than under-estimating the least cost approach to compliance – both because Water Corporation probably does have to incur higher costs and because it faces added incentives to err on the side of caution, especially in relation to potential legal risks, with somewhat limited market disciplines to contain such an emphasis.

Regulation for more formulaic dam safety requirements (reducing the discretion) could further reduce the uncertainty – but not obviously in ways that would encourage a more efficient approach to resource use and investments in safety in WA. Any requirements that apply dam-by-dam can be expected to constrain the scope for delivering least cost.

What formal regulation could do is establish a much clearer, and sounder, basis for either the exercise of the exceptional circumstances clauses (with weight behind any such determinations that could reduce Water Corporation's understandable concerns for legal and business risk management).

As we noted earlier, the exercise by the WA Government of exceptional circumstances provisions under the current arrangements appears odd and may

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<sup>5</sup> In line with our brief, we have not probed affordability issues in any detail in these three papers. We have considered the work on irrigator affordability done by Marsden Jacob in 2004, and we understand that Marsden Jacob will be addressing the question of the value of the water in alternative uses – with urban supply via Water Corporation being the most likely 'competitive use'.

have muted impact on legal risks, as long as the WA Government is not a party to requiring ANCOLD compliance in the first place. A formal requirement, coupled with a Government-based review and assessment capacity, could underpin a more soundly-based capacity for the exercise of the exceptional circumstances provisions or, in time, for movement to a set of requirements different from ANCOLD. Of course, such arrangements would not be costless.

Of particular interest if WA is to consider a regulatory approach that might differ substantially from the ANCOLD requirements does lie with moving away from a dam-by-dam approach – to cover a wider portfolio of dams or a wider set of assets. This possibility is discussed in more detail in Section ## below.

## **6.2 HSE (UK)**

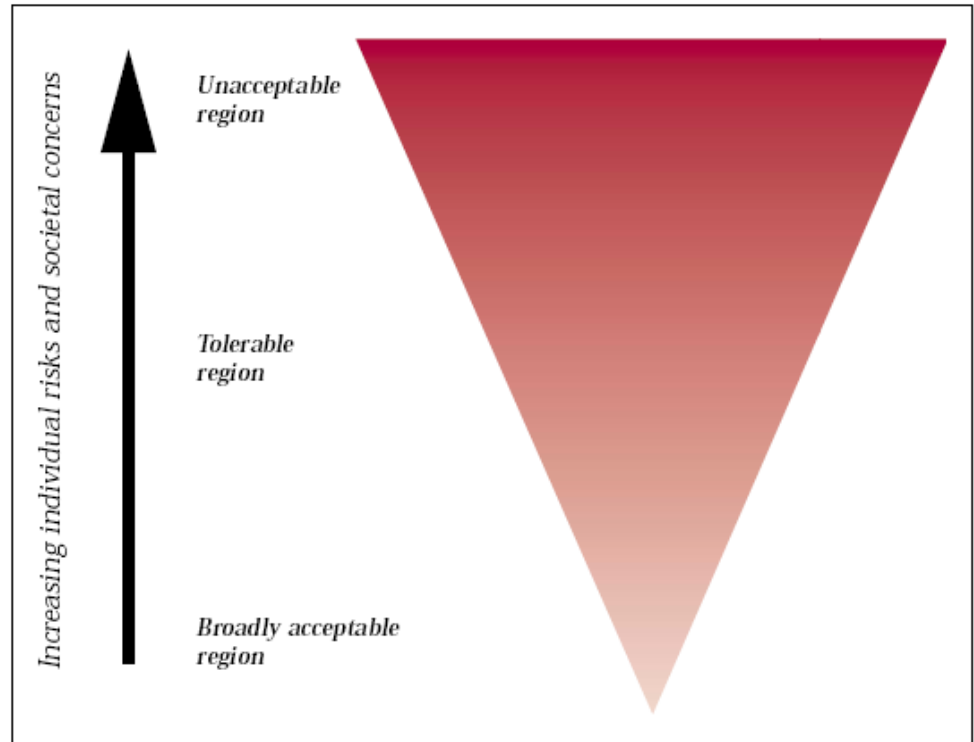
The Health and Safety Executive of the UK has, over the past two decades, made a major investment in developing processes for managing risks to workers and the wider community. These procedures are documented in Health and Safety Executive (2001). It has involved detailed probing of methodologies, attitudes to risk revealed by other studies and by legal precedent (in the UK) and the assembly of a set of procedures for responsible risk assessment across a range of classes of risk. Primary emphasis has been on worker safety, but the resultant guidelines do systematically address risks to the wider community.

The ANCOLD Guidelines, and even more clearly the policies of the NSW Dam Safety Committee, have clearly drawn strongly on the HES framework. NSW Dam Safety Committee (2004) clearly cites the HES framework as a good model for dam safety planning and the ANCOLD Guidelines for Risk Assessment could certainly be interpreted as an application of this framework. In general, the HES material seems very sound. We understand that a further revision of these NSW Guidelines it at an advanced stage of consideration by Government – with these reflecting some further evolution but the same underlying approach and link back into the HSE Guidelines.

The concept of an unacceptable risk region is clear in the HSE framework. It sets out a clear concept of an upper limit on risk, which they see as a limitation of the traditional economic ‘utility-based’ risk planning paradigm:

“...we believe that there are risks that society regards as unacceptable because they entail too high a likelihood that harm will actually occur to those exposed or the consequences are too extreme, however small the likelihood of the risk being realised, to countenance exposure to the hazard

**Figure 1: HSE framework for the tolerability of risk**



Conversion of this concept, as a central tenet of their planning framework, is clear in Figure 1 of the report, which also highlights both the societal and individual dimensions of risk. The HSE commentary that accompanies the Figure is worth repeating for the rationale it displays:

“122 The framework is illustrated in Figure 1. The triangle represents increasing level of ‘risk’ for a particular hazardous activity (measured by the individual risk and societal concerns it engenders) as we move from the bottom of the triangle towards the top. The dark zone at the top represents an unacceptable region. For practical purposes, a particular risk falling into that region is regarded as unacceptable whatever the level of benefits associated with the activity. Any activity or practice giving rise to risks falling in that region would, as a matter of principle, be ruled out unless the activity or practice can be modified to reduce the degree of risk so that it falls in one of the regions below, or there are exceptional reasons for the activity or practice to be retained.

“123 The light zone at the bottom, on the other hand, represents a broadly acceptable region. Risks falling into this region are generally regarded as insignificant and adequately controlled. We, as regulators, would not usually require further action to reduce risks unless reasonably practicable measures are available. The levels of risk characterising this region are comparable to those that people regard as insignificant or trivial in their daily lives. They are typical of the risk from activities that are inherently not very hazardous or from hazardous activities that can be, and are, readily controlled to produce very low risks. Nonetheless, we would take into account that



duty holders must reduce risks wherever it is reasonably practicable to do so or where the law so requires it.

“124 The zone between the unacceptable and broadly acceptable regions is the tolerable region. Risks in that region are typical of the risks from activities that people are prepared to tolerate in order to secure benefits, in the expectation that:

- ✿ “the nature and level of the risks are properly assessed and the results used properly to determine control measures. The assessment of the risks needs to be based on the best available scientific evidence and, where evidence is lacking, on the best available scientific advice;
- ✿ “the residual risks are not unduly high and kept as low as reasonably practicable (the ALARP principle – see Appendix 3); and
- ✿ “the risks are periodically reviewed to ensure that they still meet the ALARP criteria, for example, by ascertaining whether further or new control measures need to be introduced to take into account changes over time, such as new knowledge about the risk or the availability of new techniques for reducing or eliminating risks.

“125 Benefits for which people generally tolerate risks typically include employment, lower cost of production, personal convenience or the maintenance of general social infrastructure such as the production of electricity or the maintenance of food or water supplies.

“126 As such the framework can be seen as essentially applying an equity-based criterion for risks falling in the upper region, while a utility-based criterion predominates for risks falling in the middle and lower regions and technology-based criteria complement the other criteria in all three regions.”

All of this is consistent with the ANCOLD approach, and underpins the corresponding case for recognising an ‘unacceptable risk region’.

It is noteworthy that the HSE report (p51) lists some examples of risks in the UK that have been declared unacceptable and banned as evidence for the unacceptable individual risk region. Most of the examples cited were banned *after* affordable alternatives became available, and might stand better as examples of the informal application of an ALARP principle. The UK banning of people under 18 years of age being employed in some activities involving high exposure to lead is cited as evidence of an unacceptable societal risk. It seems likely the risks involved in these activities would have been very high by Australian dam risk standards.

HSE does provide broad guidance for the tolerability of risks:

- In relation to individual risk and in the context of its review of nuclear plant safety, it proposed a maximum fatality risk for workers of 1:1000 and for the wider public of 1:10,000.
  - This appears consistent with the individual risk criteria in the ANCOLD guidelines.



- In relation to societal risk, it proposes (paragraph 136) that risk of 50 deaths from a single incident should be subject to a single-year likelihood no greater than 1:5,000, with extrapolation for other numbers of fatalities.
  - This appears to be a substantially weaker requirement than that embodied in the ANCOLD Guidelines – where a risk of 50 deaths would imply retrofitting to at least a 1:50,000 standard.
  - HSE recognises the need to factor political and social considerations into final decisions and it would be hard to claim that this indicator figure is the appropriate one to apply to dams in an Australian setting.

As with ANCOLD, these criteria apply to single incident risks for a specific facility – and as such appears to align with a dam-by-dam as opposed to portfolio approach to acceptable risk. The HSE Guidelines would, like ANCOLD, allow planning for an orderly transition over time, but would place a high emphasis on moving out of any single dam intolerable risks. HSE (2001) states that high individual risk and societal concerns may be classified as “unacceptable” risks in that they would be *“regarded as unacceptable whatever the benefits”* unless they can be reduced to be tolerable or *“there are exceptional reasons for the activity or practice to be retained.”*

This could be viewed as an alternative statement of the exceptional circumstances provisions in ANCOLD – and this is presumably not a coincidence. It does, however, mean that the HSE Guidelines also allow for an exceptional circumstances case to override default limits on acceptable risks – and the guidelines clearly indicated that this case could rest heavily on cost-benefit considerations.

As was noted earlier, HSE does refer to UK Treasury Guidelines (\*updated, at HM Treasury, 2005) for guidance on the application of cost-benefit principles to the evaluation of risks. A quote from these guidelines is relevant:

**“4.19** For example, one benchmark in use is derived from research for DfT, which suggests a valuation range for preventing an accidental fatality (VPF) of £1 – 1.5 million (in 2002 prices). This range has also been reviewed in the contexts of rail transport, domestic fires and public fires. Similar values were elicited in these alternative scenarios; it may therefore be appropriate to consider this range in the context of similar scenarios involving accidental and near immediate loss of life. It would not however be appropriate to use this range for a specific, known individual.

“... It (the VPF figure) is based on a well-established ‘value of a statistical life’ (VOSL) used by the Department for Transport, £1.25 million, based on 2002 road traffic data. This value has been used by the Home Office, HSE, Environment Agency, Food Standards Agency and other government bodies. See Annex C for the detailed breakdown of this VPF into its constituent parts. It is important to note that this is not an insurance-based value. The values in this guidance should not in any way be used for insurance or for compensation claims. For the specific road safety values,

and how to up-rate them, see the Department for Transport's Highways Economics Note 1 (HEN1), 2002 at [http://www.dft.gov.uk/stellent/groups/dft\\_rdsafety/documents/page/dft\\_rdsafety\\_026183.hcsp](http://www.dft.gov.uk/stellent/groups/dft_rdsafety/documents/page/dft_rdsafety_026183.hcsp).

See also paragraphs 5.45 - 5.47 in the Green Book, <http://greenbook.treasury.gov.uk/chapter05.htm#adjustments> which discusses the up-rating of values in appraisal more generally. The calculation for up-rating any value in line with GDP is provided, along with the relevant annual data, at [http://www.hm-treasury.gov.uk/economic\\_data\\_and\\_tools/gdp\\_deflators/data\\_gdp\\_index.cfm](http://www.hm-treasury.gov.uk/economic_data_and_tools/gdp_deflators/data_gdp_index.cfm). Research in 1997 concluded that an acceptable range was £0.75 – 1.25 million, or +/- 25% of the central value £1million.. Beattie et al (2001)”

Again, as was noted earlier, these values are broadly in line, but not surprisingly a little above) with Australian Guidance, including the Health and Aging Guidelines that suggest a figure of about \$2m.

If any of the dams being considered by this inquiry have budgeted safety costs that are strongly influenced by the societal risk tolerance levels in ANCOLD (as opposed to being driven by individual risk requirements), then it is possible that application of the HSE Guidelines would allow for a significant reduction in costs. However, structurally the HSE Guidelines are little different from those of ANCOLD, and could not claim the authority of detailed development in the context of Australian dams.

## **6.3 Portfolio methods**

The term portfolio risk management can be used in several distinct ways in relation to dam safety planning.

### **6.3.1 Normal usage – ANCOLD compliance**

The main interpretation appears to apply in the context of the owner of a range of dams, each of which is to be managed in a manner consistent with ANCOLD Guidelines. Portfolio risk management is used to develop a sequence of upgrade works, within practical and financial constraints, that ‘optimises’ the improvement in the safety performance of the whole portfolio – as opposed to planning for each dam on a case-by-case basis.

Interpreted this way, portfolio risk management can be part of the implementation strategy for the ANCOLD Guidelines, and we see a lot of merit in this approach. In broad terms, it involves identifying the works needed across all dams to meet acceptable safety standards and determining the optimal sequence – where feasible, undertaking the ‘big bang for the buck’ works first, so that greatest gains are achieved at the least cost early on. This may well mean starting the upgrade for one dam, then moving on to another

and only returning to the first much later. In principle, the concept of an optimal sequence across the portfolio seems well-defined and the approach makes sense – and has clearly gained support.

A number of portfolio risk assessments of this type have been undertaken in Australia and overseas. Water Corporation sought assistance from David Bowles referenced earlier, an international expert in this field, in developing its portfolio response strategy.

Clearly the same approach is applicable, and likely to have merit, in relation to implementation of any set of dam-by-dam risk management guidelines where several dams are held by the one owner.

However, this approach still assumes that compliance with single dam acceptable risks standards will be achieved, in time – the approach may well justify pushing out the delivery for some dams, but it does not alter the ultimate target under the ANCOLD principles.

Of course, such a risk assessment is likely to provide some good insights into the cost effectiveness of some of the initiatives – particularly those ranked late in the program on the basis of the portfolio analysis. This appears to have been the case in the Bowles assessment of these dams – leading to the evidence, reported in Sections 5.3 and 5.4 of some activities with extremely high CPSLS (or equivalently, value per fatality avoided that appears very high by wider community standards.

The portfolio approach would not itself justify deciding not ever to proceed with such activities, but the analysis could well provide the key input to an assessment of whether exceptional circumstances apply.

### **6.3.2 Cost effective portfolio balancing**

Picking up on this last point suggests a generalization of this approach to portfolio risk management that would allow for indefinite deferral of some high-CPSLS activities, on the basis that a greater reduction could be achieved in the portfolio as a whole by moving more deeply into the tolerable region for a dam where the incremental costs of doing so are ‘competitive.

For example, consider the case of two dams. Dam A can be rendered tolerable with an investment of 10m. Dam B can be moved to 95% tolerance for a cost of \$10m, but achieving the last 5% would cost an additional \$30m, and save an average of 0.0001 lives per annum. For \$5m, Dam A could be further upgraded to deliver the same saving of 0.0001 lives per annum.

Strict application of normal ANCOLD Guidelines would require that the \$30m be spent, eventually. The additional \$5m would be subject to dam-

specific ALARP assessment. It would not be allowable to say that the extra reduction in safety required for Dam B will be delivered by improving the safety of Dam A, even though the figures suggest this would be highly cost effective.

A generalized portfolio strategy would open up this possibility – effectively allowing a form of ‘trading’ of risk reduction opportunities across the portfolio, to find the most cost effective way of creating a total portfolio that offers at least tolerable risk to individuals and the community.

As a general proposition, allowing such trading cannot increase the costs of compliance, and is likely to lower the costs of achieving such a requirement. It is certainly conceivable that the cost savings in delivering a given level of risk reduction across the entire portfolio could be very large – and these savings are likely to rise the more diverse is the portfolio.

Marsden Jacob (2003) allude to the potential value in this sort of portfolio approach. In the final section of the body of their report, in considering next steps, they state:

“For the State Government, the report has raised the major issue of how the total portfolio of risks facing the State Government, its agencies and Treasury should be managed. An immediate and particular issue is how capital expenditure should be prioritised. The State Treasurer has already indicated increasing attention to this issue.”

This suggests an even more ambitious approach to portfolio risk manager. It involves not just the dams in SW WA, not just Water Corporation’s portfolio of dams across the State – but rather the total portfolio of risks faced by the State Government. Presumably this includes risks across all its infrastructure assets, and could extend even wider.

In principle, such a broad approach to risk management has considerable appeal and would be consistent with the ‘ideal’ recognised in the ANCOLD Risk Assessment Guidelines (G10-1) and quoted earlier –

“Ideally, tolerable community risks, especially life safety risks, would be determined by society, or by governments or their regulators acting on behalf of society, with risks from dams balanced against all other forms of societal risk, such as risks from the process industries, disease, crime and transportation – society would decide where best to direct its resources in reducing risks to life. HSE (1995) states specifically that government should decide what risks are tolerable.

The above portfolio arguments are relevant – any given level of overall safety improvement could almost certainly be achieved at much lower costs using such a diverse portfolio, relative to an asset-by-asset approach in which each asset needs to meet tolerable risk levels independently of cost. At this level of portfolio diversity, there may be little practical difference for dam safety

between the two portfolio risk approaches. The risks in non-dam infrastructure likely to claim priority over the high cost-low impact activities in the current safety program would probably imply pushing these investments out for many decades, and effectively driving their cost implications close to zero.

However, the two approaches are conceptually quite different. And with a narrower view of the portfolio – for example, the SW dams, or all dams below a certain size and with a maximum loss of life of less than, say, 50 – the differences in outcome could be substantial.

We see considerable merit in allowing some cost effective ‘trading’ across dams and other assets – with the likelihood that this could deliver both greater safety and lower cost if carefully managed. How far the current inquiry processes can push into extending the portfolio beyond the SW dams is not so clear.

It is possible that the analyses undertaken by Bowles for Water Corporation and any updates on these – by Water Corporation or by Marsden Jacob – could provide the basis for assessing the likely implications of moving to this form of cost effective portfolio response across the SW dams.

Note that, unlike the normal portfolio approach above, this approach will probably not comply with the standard guidance of ANCOLD. It would be possible for the analyses done to identify least cost ways of improving safety across the portfolio to be used to underpin application of the exceptional circumstances provisions of ANCOLD – allowing compliance.

However, this would be rather artificial. This form of cost effective portfolio risk management involves breaking away from the tolerable risk concept, as applied to a single dam – and instead would recognise either tolerable or affordable risk in relation to the whole portfolio. It would seem cleaner to recognise that this is a move away from the ANCOLD Guidelines, possibly at the same time creating scope for subsequently adding other assets to the portfolio, and not necessarily dam assets.

While this wider portfolio approach has considerable appeal, it is important that it relies on being willing to breach the single dam tolerable risk standards. There may still be legal and community resistance to this, even though any such move would be reliant on delivering equivalent or greater safety improvements elsewhere. It is likely that the ‘trading’ would be undertaken in respect of activities offering very small individual dam safety improvement at high cost, but careful industry consultation would seem likely to be needed.

## 6.4 Scope for options-based management

Another concept, potentially with very large value, is that of treating the need for dam safety investment as a risk-based investment process. Even if ANCOLD (or any other applicable standards) were fully prescriptive as to thresholds etc, there would be a lot of uncertainty as to the scope of investment needed to comply with the intent of the process. This is even more true, given the discretionary character of the guidelines and the scope for extending them into a portfolio-context.

The fact is that the scope for modelling extreme flood events – while dramatically improved in recent years – is still quite primitive. Some of the limitations are data – even internationally, there is little more than 100-150 years of sound measurements of rainfall and this would introduce serious limitations on modelling 1:10,000 or 1:100,000 year events even if we could safely assume the climate system is stable.

Bring in a climate change trend of uncertain scale, and the fact that most modelling suggests that even with lower average rainfall (which seems likely in the region) there could be greater extreme events, and the level of uncertainty in estimating the key events needing to be designed for is huge.

The earlier evidence in Section 5.3, suggesting rapidly diminishing returns on investment in dam safety, and it seems likely that even modest shifts in the severity or frequency of these extreme events could have large implications for the level of expenditure needed to deliver tolerable risk. This could, in principle, move costs either up or down – but could very plausibly suggest that some of the investments in the current Water Corporation package are inappropriate in either case.

Modern options-based investment theory focuses on the development of robust investment strategy that is less prone to serious error in the level or form of investment as a result of poor data. A central theme that emerges from this approach is an emphasis on building flexibility into the strategy, deferring where possible investment elements that may prove unnecessary or not needed for a long time and actively investing in the creation of more valuable options – better characterisation of the risks and associated optimisation strategy, investment in better information, investment in responses to developing problems with shorter lead times etc.

Presumably, extremely rare droughts will remain impossible to forecast with accuracy, except with very short lead times – safety strategy will require a level of preemptive investment. However ANCOLD allows, and it makes sense under most other approaches to allow, deferral of key works for sensible financial and risk management reasons. This should allow for ANCOLD-



compliant delay on works directed at truly rare events if this will allow better information to be obtained that could point to much sounder strategy, especially if the strategy involves explicit investment in gaining that better information.

Recent ACIL Tasman work on planning optimal responses to extreme drought risks for the Sydney Basin utilised these methods and resulted in commitment to an options-based strategy that allowed for expected cost savings of the order of \$1-\$2b. The long leads times for severe droughts clearer provide greater scope for flexible responses, but key features of that strategy – including investment in better climate change modelling and investment in setting in place options for rolling out large water factory capability in a very short lead time – have some analogy here.

Our impression is that the data are relatively poor, and in some cases may well exhibit systematic bias in relation to any assessment of expected costs and benefits. Provided that strategies are in place to deal with any identified large risks, then sensible structuring of an adaptive response strategy could offer some fairly good economic returns.

This approach should be, in principle, applicable as a layer on top of most of the above safety planning paradigms.

## 7 Concluding comments

A final position on appropriate strategy needs to take into account the cost sharing and efficient cost arguments set out in the other two papers in this series. The parallel work being done by Marsden Jacob Associates may well point to scope for a significant reduction in costs, even within the normal ANCOLD Guidance. Certainly the consideration of alternative ownership arrangements could be expected to suggest a lower cost, raising questions of how any incremental costs should be dealt with in the bulk water determination. These matters are discussed in the other papers.

A radical change in the WA approach to dam safety almost certainly requires a process somewhat wider than this specific Inquiry. This Inquiry should, however, be able to consider whether the exceptional conditions provisions of ANCOLD, and possibly the particular ownership arrangements, imply that the currently proposed program is excessively costly – and if so what this implies for the level of costs reasonably attributable to bulk water users. It may be appropriate to take into account the scope offered by wider portfolio-based safety management to deliver greater efficiencies in the future in considering whether to develop an approach broadly reflective of this philosophy but still exercised within the formal ANCOLD Guidelines.



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