C8.2 TOLERABLE RISK CRITERIA

a) Loss of Life criteria

As discussed in Section C3.5, the regulator is the appropriate authority to set standards for tolerable risk which may relate not only to perceived safety in relation to other risks, but also to government policy. Implementation of a tolerable risk level has implications to the community at large, both in terms of relative risks or safety, but also in terms of economic impact.

Table C9: Individual Loss of Life Risk Criteria. (Leroi *et al.,* 2005)

Organisation	Industry	Description	Risk/annum	Reference
Health and Safety Executive, United Kingdom	Land use planning around industries	Broadly acceptable risk. Tolerable limit	10^{-6}/annum, public and workers 10^{-4}/annum public(1) 10^{-3}/annum workers	HSE (2001)
Netherlands Ministry of Housing	Land use planning for industries	Tolerable limit (2)	10^{-5}/annum, existing installation 10^{-6}/annum, proposed installation	Netherlands Ministry of housing (1989), Ale (2001), Vrijling *et a*l. (1998)
Department of Urban Affairs and Planning, NSW, Australia	Land use planning for hazardous industries	"acceptable" (tolerable) limits (2)	$5x10^{-7}$/annum hospitals, schools, childcare facilities, old age housing 10^{-6}/annum residential, hotels, motels $5x10^{-6}$/annum commercial developments 10^{-5}/annum sporting complexes	
Australian National Committee on Large Dams	Dams	Tolerable limit	10^{-4}/annum existing dam, public most at risk subject to ALARP 10^{-5}/annum new dam or major augmentation, public most at risk, subject to ALARP.	ANCOLD (2003)
Australian Geomechanics Society guidelines for landslide risk management	Landslides (from engineered and natural slopes)	Suggested tolerable limit	10^{-4}/annum public most at risk, existing slope 10^{-5}/annum, public most at risk, new slope	AGS (2000)
Hong Kong Special Administrative Region Government	Landslides from natural slopes	Tolerable limit	10^{-4}/annum public most at risk, existing slope. 10^{-5}/annum public most at risk, new slope	Ho et al. (2000), ERM (1998), Reeves *et al*. (1999)
Iceland ministry for the environment hazard zoning	Avalanches and landslides	"acceptable" (tolerable) limit	$3x10^{-5}$/annum residential, schools, day care centres, hospitals, community centres. 10^{-4}/annum commercial buildings $5x10^{-5}$ recreational homes(3)	Iceland Ministry for the environment (2000), Arnalds *et al.* (2002)
Roads and Traffic Authority, NSW Australia	Highway landslide risk	Implied tolerable risk	10^{-3}/annum(4)	Stewart *et al*. (2002), RTA (2001)

Notes:

(1) But for new developments HSE (2004) "advises against giving planning permission where individual risks are > 10^{-5}/annum".

(2) Based on a temporal spatial probability of 1.0.

(3) Assumes temporal spatial probability of 0.75 for residential, 0.4 commercial, 0.05 recreational.

(4) Best estimate of societal risk for one person killed, top risk ranking. If slope ranks in this range action is taken to reduce risks within a short period. For the second ranking, societal risk is 10^{-4}/annum, and slope is put on priority remediation list.

Table C9 summarises published individual loss of life risk criteria. An overview of the issues in relation to Loss of Life criteria are discussed in Leroi *et al.* (2005).

It is important to distinguish between "acceptable risks" and "tolerable risks".

Tolerable Risks are risks within a range that society can live with so as to secure certain benefits. It is a range of risk regarded as non-negligible and needing to be kept under review and reduced further if possible.

Acceptable Risks are risks which everyone affected is prepared to accept. Action to further reduce such risk is usually not required unless reasonably practicable measures are available at low cost in terms of money, time and effort.

Most organisations listed in Table C9 have adopted Tolerable Risk as the measure to gauge risk. This is because there is a trade-off between the benefits and cost of risk mitigation, and the costs to achieve acceptable risk levels are often high. The Australian National Committee on Large Dams (ANCOLD) has adopted tolerable risk criteria for assessing risks posed by dams. This decision was reached after extensive consultation locally and internationally and after seeking legal opinion.

After due consideration of these factors and taking account of the criteria which were included in AGS (2000, 2002) AGS suggests that **for most development in existing urban areas criteria based on Tolerable Risks levels are applicable because of the trade-off between the risks, the benefits of development and the cost of risk mitigation. The recommended Tolerable loss of life risk values for the person most at risk for different situations are shown in Table 1 of the Practice Note.**

It is recommended that risks be assessed only for the person most at risk, and not for the average person as suggested in AGS (2000, 2002). ANCOLD (2003) reported that the person most at risk always controlled, and that average risks were difficult to define and determine.

The recommended values are higher for existing slopes than for new slopes. This is in keeping with ANCOLD (2003) and general literature on risk tolerability which indicates that persons tolerate risks from existing hazards more than for newly constructed ones. Where development modifies an existing slope, the "new slope" criteria should be applied in accordance with the definitions given for the situation in Table 1 of the Practice Note.

Regulators may decide to apply "acceptable risk" criteria for high consequence cases, such as schools, hospitals and emergency services in recognition of the importance of these structures and as a way of covering societal risk concerns. This is also reflected in the recommended criteria for property loss for different Importance Levels of structures below.

The community may tolerate higher risks from natural hazards than man made hazards (IUGS 1997). Such a consideration by the regulator may result in some natural hazards being tolerated in the face of exceptional expenditure to reduce the risk to tolerable levels. An example of this may be the risks associated with boulder falls from natural cliff lines in a bush reserve adjacent to existing residential development. If the regulator and potentially affected owners were not aware of the circumstances then prior to the LRA they would have been "uninformed". Adoption of such tolerable risks should be made on the basis of an appropriate LRA and assessment of the risk mitigation options.

It is recognised that the recommended criteria are higher than required by NSW Department of Planning (2002) However, their criteria are applied to development such as chemical plants which can be sited in areas where the low risks can be achieved. Urban development is within designated areas, the land owner has no option but to develop (if practical) so the trade-off between risk levels, cost of development and risk mitigation have to be considered. This is a similar situation to dams and is part of the reason ANCOLD have adopted tolerable risk criteria.

Societal Risk may be measured against the ANCOLD (2003) recommended values as given in Figure 4 of Leroi *et al.* (2005). Reference should be made to ANCOLD (2003) when carrying out such assessments.

For special cases of work place related risks, such as in mining and tunnelling, and/or for short term stability in construction sites, then work-place safety requirements will control and those criteria might govern.

b) Loss of Property Criteria

Acceptable (or tolerable) values for Risk to Property are rarely quoted in literature.

Lee and Jones (2004) considers evaluation of such risk in economic terms by evaluating economic indicators such as the Benefit-to-Cost Ratio, Net Present Value and Incremental Benefit-to-Cost Ratio. This allows comparison of alternative risk management strategies. Application of a decision rule allows selection of the most cost effective management option. Various methodologies for evaluation are detailed in Lee and Jones (2004) and are too lengthy to repeat here. Such methods should be investigated for larger projects or where a variety of stabilisation options are possible.

The issue of what might be an acceptable value for risk to property has been subject to considerable discussion following publication of the Pittwater Council Draft policy in 2003. This policy required a Low Risk to property using the qualitative terminology given in Appendix G of AGS (2000).

Discussion of whether this risk criterion should be modified and whether it is in accordance with community expectations was progressed by consideration of the annualised cost of damage to property as discussed in Appendix CC.

Annualised cost of property damage is a useful benchmark for comparison of different hazards. However, adoption of a dollar value based on a cost equivalent to an insurance policy premium is only considered to be appropriate where such policies can be obtained. Where insurance cannot be obtained (which unfortunately is currently the case across Australia), then experience shows that most informed home owners are likely to be risk averse as a result of appreciation of the consequences at a family or personal level, almost regardless of the likelihood of the event. This risk aversion suggests that Low Risk to Property is an appropriate recommendation for acceptable risk to the regulator for domestic dwellings which are of Importance Level 2 (as defined in the BCA, refer to Practice Note Appendix A). Alternative levels are risk are considered reasonable for structures of other Importance Levels as shown in Table C10

Table C10: AGS suggested Acceptable qualitative risk to property criteria.

Importance Level of Structure (1)	Suggested Upper Limit of Acceptable Qualitative Risk Property (2)	
	Existing Slope (3) / Existing Development (4)	New Constructed Slope (5) / New Development (6) / Existing Landslide (7)
1	Moderate	Moderate
2	Low	Low
3	Low	Low
4	Very Low	Very Low

Notes:

1. Refer to Appendix A, Practice Note
2. Based on Appendix C, Practice Note
3. "Existing Slopes" in this context are slopes that are not part of a recognizable landslide and have demonstrated non-failure performance over at least several seasons or events of extended adverse weather, usually being a period of at least 10 to 20 years.
4. "Existing Development" includes existing structures, and slopes that have been modified by cut and fill, that are not located on or part of a recognizable landslide and have demonstrated non-failure performance over at least several seasons or events of extended adverse weather, usually being a period of at least 10 to 20 years.
5. "New Constructed Slope" includes any change to existing slopes by cut or fill or changes to existing slopes by new stabilisation works (including replacement of existing retaining walls or replacement of existing stabilisation measures, such as rock bolts or catch fences).
6. "New Development" includes any new structure or change to an existing slope or structure. Where changes to an existing structure or slope result in any cut or fill of less than 1.0 m vertical height from the toe to the crest and this change does not increase the risk, then the Existing Slope / Existing Structure criterion may be adopted. Where changes to an existing structure do not increase the building footprint or do not result in an overall change in footing loads, then the Existing Development criterion may be adopted.
7. "Existing Landslides" have been considered likely to require remedial works and hence would become a New Constructed Slope and require the lower risk. Even where remedial works are not required per se, it would be reasonable expectation of the public for a known landslide to be assessed to the lower risk category as a matter of "public safety".

Tolerable risk levels would be one class higher (for example Moderate where Low is acceptable). Consideration should be given by regulators to adopting Tolerable risk to property for Existing Slope and Existing Development situations in a similar vein to the recommended differentiation for risk to life.

C9 RISK MANAGEMENT

C9.1 RISK MITIGATION PRINCIPLES

The principal aim of the risk mitigation measures should be to reduce risk, to engineer out uncertainty in the risk and to provide a level of risk satisfying community expectations through the regulator's criteria once properly implemented.

Not all options for risk control methods will be feasible or appropriate for each project/ circumstance.

The issue of whether residual risk (after implementation of risk mitigation measures) is tolerable or acceptable (as appropriate) should take into account the ALARP principle. ANCOLD (2003) defines ALARP (As Low As Reasonably Practicable) principle as "that principle which states that risks, lower than the limit of tolerability, are tolerable only if risk reduction is impracticable or if its cost is grossly disproportionate (depending on level of risk) to the improvement gained." Note that ANCOLD (2003) adopts tolerable risk criteria; where an acceptable risk criterion is adopted, then "acceptable" would replace "tolerable" in that definition. Putting this principle in another way, if risk can be reasonably and cost effectively reduced further than the acceptability criterion, then the additional risk mitigation measures should be adopted also.

Risk control measures are likely to require on-going maintenance in most, if not all, instances.

Detailed specification of the design, construction and maintenance criteria for each risk treatment measure should be appropriately specified or addressed. Feedback is essential throughout the design and construction process to enable re-evaluation of the assessment as appropriate.

C9.2 SITE SPECIFIC DEVELOPMENT CONDITIONS

Site specific development conditions need to be determined such that risk levels are reduced to satisfy the regulator's criteria. They need to take into account uncertainties and limitations of design and construction.