Deficiency Management Context

The introduction of ñdangerousò and ñpronenessò classifications into the dam safety regime has been driven from the regulatory perspective of defining thresholds for the application of particular powers to mitigate public hazard exposure. From an owneròs perspective, the same matter is addressed through the deficiency management system (DMS) that forms an important element of the dam safety assurance programme (DSAP). From this perspective, ñdangerousò and ñpronenessò are just two examples of deficiencies that need to be addressed with appropriate degrees of urgency. It is important that the regulatory framework that is put in place does not become misaligned with the owners deficiency management system, as it is the proactive DMS that NZSOLD wishes to encourage in the first instance, with the regulatory intervention only being called upon in the absence of an effective DMS.

Prone Thresholds

Risk based Approach

To follow a risk based approach in establishing prone thresholds requires making some assumptions regarding the consequences of failure. Consequences of failure are theoretically captured in the Potential Impact Classification (PIC) rating, but there are some limitations in the use of the current PIC framework for this purpose.

One issue is the relatively low threshold that is set for the High PIC category. Two dams can have an identical High PIC rating despite the Population at Risk (PAR) associated with these structures being significantly different. However, given that generally the larger dams with the significant PAR are owned by the larger corporateòs and are subject to reasonable scrutiny, it is highly unlikely that they will fall into the prone category. Therefore in practical terms, we are only focusing on the smaller dams with low PAR and therefore can discount this limitation at present.

For the purposes of the following approach we have made this assumption

A further issue is the matter of the potential differences in interpretation of *"likely to fail"* vs *"not meeting current design criteria"* approach to the assessment of thresholds. In an environment where the failure modes are very well understood, it is practical to adopt the *"likely to fail"* definition, as this can be reasonably well quantified. However, where there is limited knowledge on actual failure mechanisms (such a might apply to say concrete arch dams), we have generally had to rely on the *"not meeting current design criteria"* approach to quantify the position. As current design criteria have inbuilt safety factors or margins to failure included, the two approaches have differing quantitative probability thresholds for the same level of community exposure. As a starting position, we have adopted the *"not meeting current design criteria"* approach when deriving the suggested proneness thresholds, as this method is seen to be more generally applicable, particularly in light of the potential sites that may fall within this regulatory category.

However, during the application of a prone dam policy, the proposed thresholds are intended only be used as a first order test in the process of establishing whether a dam is prone or otherwise. To establish a case where a specific failure mechanism would result in dam failure under such a threshold condition will in most cases require further detailed second order analysis to be carried out by suitably qualified professionals.

Earthquake Threshold

The only similar precedent we have for a prone threshold under New Zealand Law is the thresholds that apply to buildings. The adopted legislation for Earthquake Prone Buildings has a trigger level of 33% of that required for new buildings. According to the New Zealand Society of Earthquake Engineering this trigger level represents about 10 to 20 times the risk of earthquake damage and collapse of a new building that meets current design requirements. (Note: risk in this context refers to the likelihood or probability of experiencing the consequences in a given period of time ï typically an annual exposure probability basis is used).

Considering the above assumptions and precedent, and recognising that the high PIC dams that may be ŗproneò will be those with a PAR that is not too far above the high PIC threshold, it is proposed that the Earthquake Prone threshold for a high PIC dams should be similarly based; namely on an annual exceedence probability (AEP) level of 10 to 20 times the current design standards for the lower end of the high PIC range.

A similar approach is proposed for setting the threshold for a medium PIC dam.

This approach allows an assessment of the net risk exposure to the community to be determined for cases where ŗpronenessò generates additional exposure. The additional exposure may continue over a period in the order of say 10 to 15 years while remediation is undertaken. Comparing the cumulative exposure to the community over the life of a dam meeting current standards with one that is ŕearthquake proneò for a portion of its life while remediation is undertaken (say 10 to 15 years), reveals that the proposed prone threshold equates to approximately twice the cumulative exposure. NZSOLD considers this to be a rational and transparent risk based approach to determining the threshold for proneness.

Flood Prone Threshold

The second issue is the method of deriving a threshold for vulnerability to floods and the relativity to the earthquake prone threshold discussed above.

If the process described above for establishing EQ proneness thresholds is accepted, NZSOLD argues that a parallel process should logically apply to setting flood proneness thresholds. That is, the adoption of suitable AEP values in both High and Medium PIC categories based upon the lower end of the respective current design standards.

This approach differs from the previously discussed Q_{100} flood peak multiplier system.

The reason for the multiplier system in the first place was to enable a simple estimate of whether a dam was "dangerous". In the case of prone dams, this matter of simplicity is not such an issue, as it warrants the analysis being carried out by a suitably qualified professional who will be aware of "state of the art" methodologies to derive the flow for the proposed threshold event. Guidance on these matters may be covered by the NZSOLD guidelines.

Considering the above assumptions and precedent, it is proposed that the Flood Prone threshold for a high PIC dams should in terms of an AEP, be based on the design standards for the lower end of the high PIC range and the trigger level based on 10 to 20 times the risk of flood damage and collapse of a new dam that meets current design requirements.

A similar approach is proposed for setting the threshold for a medium PIC dam.

The cumulative community exposure check over the dam life as described above for earthquake proneness applies equally to this flood proneness threshold determination.

Applying the above risk based rationale to the definition of proneness thresholds generates the suggested values shown in figure 1 overleaf.

Summary Regulatory Category Thresholds

The following figure illustrates the suggested thresholds for the two regulatory categories of ĩDangerousò and ĩEarthquake or Flood Proneò in a risk matrix context encompassing the full range of compliance status that might be addressed in the deficiency management portion of dam safety assurance programmes.

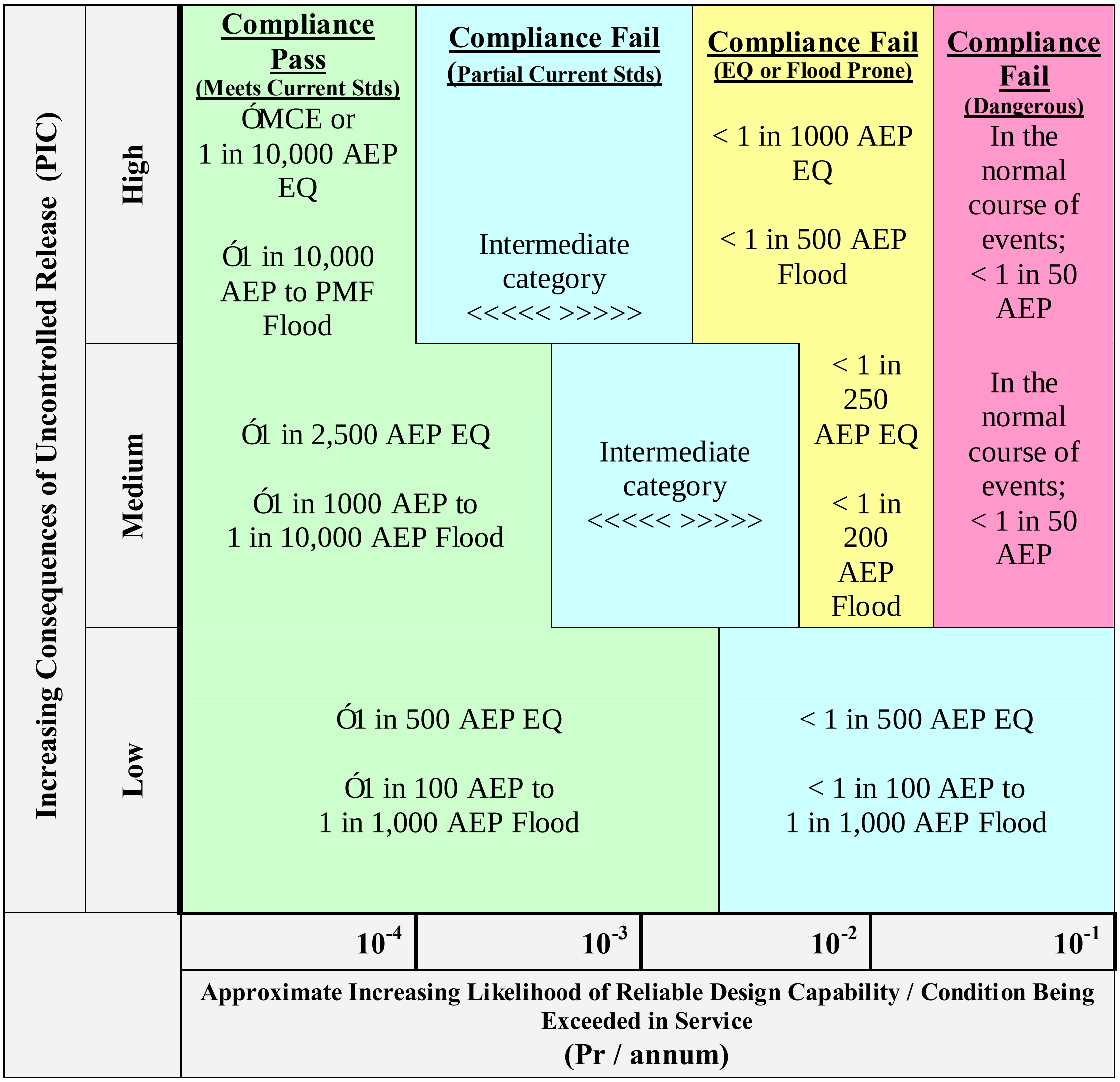

Figure 1. Schematic risk matrix representation of regulatory category thresholds (Mulvihill & Walsh 2008, modified from Lilley & Walsh 2007)

[AEP; Annual Exceedence Probability]

NOTE: During the application of a prone dam policy, the proposed thresholds should only be used as a first order test in the process of establishing whether a dam is prone or otherwise. To establish a case where a specific failure mechanism would result in dam failure under such a threshold condition will in most cases require further detailed second order analysis to be carried out by suitably qualified professionals.