GUIDELINES ON UNDERTAKING CONSEQUENCE CATEGORY ASSESSMENTS FOR DAMS

A guide to assist in determining a consequence category for a dam

December 2015

Tasmania

Department of Primary Industries, Parks, Water and Environment

TABLE OF CONTENTS

TABLE OF CONTENTS 2

Preface 3

1. Introduction 4
   - 1.1 Background 4
   - 1.2 Purpose of these Guidelines 4
   - 1.3 Limitations 4
   - 1.4 Regulations and Legislation 5
   - 1.5 Reporting 5
   - 1.6 Competence Class 5
   - 1.7 A discussion on geography as a basis for the assessment of the Consequence Category 6
2. Consequence Category Assessment 7
   - 2.1 ANCOLD Consequence Category Guidelines 7
   - 2.2 Population at Risk (PAR) Analyses 8
   - 2.3 Potential for Loss of Life (PLL) Analyses 9
   - 2.4 Dam Breach Time 10
   - 2.5 Dwellings 10
   - 2.6 Roads Downstream of a Dam 10
   - 2.7 PLL and Filters 13
   - 2.8 Mapping Features below a Dam 13
   - 2.9 Flood Assessment Level 14
   - 2.10 Multiple Dams on a Catchment 15
   - 2.11 Tailings Dam 16
   - 2.12 Small Dams 16
3. Further Information 17
4. ANCOLD Publications 17

Preface

The *Water Management (Safety of Dams) Regulations 2015* allow for all Australian National Committee on Large Dams (ANCOLD) Guidelines when assessing matters related to dam works and dams safety.

In particular, the current ANCOLD Guidelines *"Guidelines on the Assessment of Consequence Categories"* October 2012 (ANCOLD's Consequence Category Guidelines), provides essential information for practitioners when assessing consequence categories for dams.

Although ANCOLD's Consequence Category Guidelines are extensive in themselves, they present a more generic outline that is focussed at a broader level to inform the undertaking of assessments in regards to dam safety matters nationally. Each state is unique and has their own unique requirements, including dam safety legislation or frameworks, in addition to having unique and different physical settings, including geographical characteristics and topography, geological types, climate and socio-economic scenarios. This has necessitated the development of more specific guidelines on assessing dam safety and Consequence Category for dams in Tasmania.

ANCOLD's Consequence Category Guidelines still remain the basis for undertaking Consequence Category assessments for dams in Tasmania, and should be used as the primary guideline in undertaking such activities. The purpose of these guidelines is to supplement ANCOLD's Consequence Category guidelines where there is a shortfall on assessing dam safety matters that are more specific to Tasmania.

In addition, these guidelines aim to establish a greater degree of consistency in the way Consequence Category assessments are undertaken, both between dams and between consultants undertaking these assessments.

Whilst Tasmania has a diversity of dams including large hydroelectric dams, large mine tailings dams, all types of rural irrigation and water supply dams and sewerage treatment dams, these guidelines are intended to mostly apply to rural irrigation and water supply dams with Consequence Categories of up to High C/High B. These dams represent over 90% of all dams in Tasmania.

1. Introduction

1.1 Background

Tasmania is unique in the sense that it has approximately 1% of the land mass of Australia but receives approximately 11% of all water. The impact of this concentration can be seen by the approximately 16,000 dams across the state. These include large hydroelectric dams, large mine tailings dams, large and small rural irrigation and water supply dams, waste water and sewerage treatment dams, weirs, levees etc. that all come under the *Water Management Act 1999*.

Of these 16,000 dams, approximately 9,000 of these are registered by the Tasmanian Government on the Water Information Management System (WIMS). The remaining dams are either small dams or were constructed before any legislation required dams to be registered and as such many do not have a current consequence category assigned.

In addition, the assessment of the hazard /consequence category has evolved over the years from a three tier classification (Low, Significant and High) to the seven tier category system that is in place today (Very Low, Low, Significant, High C, B, A and Extreme).

Note: *All relevant ANCOLD Guidelines and these Guidelines are specified under the Water Management (Safety of Dams) Regulations 2015 and therefore are a legislative document. They are also open at any time for comments from dam practitioners who work in the industry.*

1.2 Purpose of these Guidelines

These guidelines, in conjunction with the ANCOLD Publication *"Guidelines on the Consequence Category for Dams"* 2012 are provided to assist consultants and engineers working in the dams and the water industry to prepare Consequence Category assessments to meet the requirements of the Department of Primary Industries, Parks, Water and Environment (DPIPWE).

The combination of these two documents represents the recommended approach to be used to assess Consequence Categories for dams in Tasmania. These guidelines also represent the ongoing development and evolution of established practices by the Department, in consultation with industry, through the dam approval process to better suit conditions in Tasmania.

The assessment process detailed in these guidelines applies to mostly rural irrigation and water supply dams with consequence categories of up to High C/High B. The process can also apply to larger and higher consequence category dams, such as larger Hydro Electric dams or mine tailings dams, however it is recommended that these more critical dams should be rigorously assessed on their own merit, using a comprehensive flood model.

1.3 Limitations

These guidelines provide advice on the minimum standard for consequence categories assessments acceptable to the Department. The Department reserves the right to review and request more information on an assessment if it is deemed necessary.

Please note *that the Department will reject an assessment report that is ambiguous or not clear and succinct in meaning and/or use a combination of methods such as a PLL or PAR analyses.*

1.4 Regulations and Legislation

The primary Acts and Regulations that are relevant to dam safety in Tasmania are:

- *Water Management Act 1999; and*
- *Water Management (Safety of Dams) Regulations 2015.*

The *Water Management (Safety of Dams) Regulations 2015* require the following:

- *Dam works and related activities, including the preparation of Consequence Categories, must be undertaken in accordance with the relevant provisions of guidelines issued by the Australian National Committee on Large Dams (ANCOLD).*
- *The person/s preparing specific activities including dam safety reviews or Consequence Category assessments and pre-construction reports must meet the prescribed competence level for an individual or expert team.*

1.5 Reporting

The format of the report must cover the aspects of the assessment as per Section 2 of the guidelines. If the submitted report does not meet the basic requirements of the guidelines the report will be returned to the dam owner for revision.

These requirements are consistent for any consequence category assessment undertaken (including proposed or existing dams).

Where an assessment report has been submitted and reviewed, a fee, in accordance with the regulations will be charged for the time spent reviewing the report. As a minimum, a fee of $90.60 (FY2015-16) for each half hour assessing the report will be charged.

1.6 Competence Class

In undertaking Consequence Category Assessments for dams, the *Water Management (Safety of Dams) Regulations 2015* specify the competence class required by a person.
Table 1 below indicates the competence class required.

Table 1 – Competence class for consequence category assessments for dams

Dam height (m)	Consequence Category						
	Very Low	Low	Significant	High C	High B	High A	Extreme
is less than 10m	Class 2 or authorised safety reviewer	Class 2 or authorised safety reviewer	Class 2	Class 1	Expert team	Expert team	Expert team
is 10m or more but not more than 25m	Class 2 or authorised safety reviewer	Class 2	Class 1	Class 1	Expert team	Expert team	Expert team
is more than 25m	Class 2 or authorised safety reviewer	Expert team	Expert team	Expert team	Expert team	Expert team	Expert team

1.7 A discussion on geography as a basis for the assessment of the Consequence Category

Within Tasmania there are 48 defined catchments. All catchments have at least one major river system such as the Welcome, Detention, Mersey, Meander, Macquarie, North and South Esk, Tamar and Derwent Rivers. These major river systems are mostly dendritic in nature where secondary tributaries tend to drain sub-perpendicular to the major rivers.

An example of this is the north of the state, where within the major catchments the main river channel tends to be orientated in a north-south direction, flowing down from the highland areas to Bass Strait. Smaller tributaries tend to trend in an east-west direction, joining these rivers. These smaller drainage systems or creeks are where the majority of the rural dams are situated.

Major highways tend to run perpendicular to major rivers and cross them with mostly expansive bridge crossings. A good example of this is the Bass Highway (A1) and Tasman Highway (A3) in the north of state, which extend in an east west direction, crossing the major rivers.

The lower volume rural roads, which are mostly local government owned roads, tend not to cross major river systems. In the north of the state, these rural roads tend to be orientated in a north south direction parallel to major rivers and cross over the smaller tributaries. These crossings could be anything from a large bridge to a single barrel culvert. Because most rural dams sit above these secondary roads with limited crossings, the traffic on these roads present the most common risks in a breach of a dam, rather than the major highways with their large river crossings.

In addition, these major catchments tend to be longer than they are wide, with the major of rivers running down the centre. Most secondary tributaries that discharge into these major rivers are relatively short as a result with, as discussed above, rural secondary roads tending to cross them perpendicular to the stream.

As most rural dams are either adjacent to or on one of these tributaries, they are generally situated within a maximum distance of 5km from one of the larger river systems.

This often results in a constraint to the extent of assessment required for many dams, as within 5km the impact of a dam failure should be mitigated by the increased capacity of the major river in the catchment.

Dwellings also may be impacted on along these tributary systems because of the smaller flood attenuation potential of these streams. This needs to be taken into consideration during the assessment, but once again most dwellings adjacent to major river systems will be situated above the major flood line or the 1 in 50 year flood level.

2. Consequence Category Assessment

2.1 ANCOLD Consequence Category Guidelines

The ANCOLD Publication *"Guidelines on the Consequence Category for Dams"* 2012 provides limited detail on methods of assessing risks downstream of a dam. The purpose of these guidelines is to provide additional detail to inform the consideration of risks by engineers and consultants within Tasmania.

The following relevant parts of ANCOLD's Consequence Category Guidelines and are presented here for information:

> *The categories used in these guidelines are based on the severity of the potential damage and loss, in conjunction with either the Population at Risk (PAR) or Potential Loss of Life (PLL).*

This means that either a PAR or PLL analyses can be used to determine the consequence category. However, the ANCOLD Consequence Category Guidelines also recommends to limit all Consequence Category assessments to PAR Analyses and to only use a PLL where the person undertaking the assessment is very experienced. These differing assessments are discussed in further detail below.

It should also be noted that ANCOLD's Consequence Category Guidelines also discusses that it would be expected that if a PLL is undertaken following an initial PAR assessment that:

> *It is not the intention of these guidelines that a consequence assessment using PLL and Table 4 would provide a category level any lower or higher than an assessment using a dam break PAR and Table 3. Considerable and defendable judgement is required should this situation arise and the category assigned for both sunny day and flood failure would be dependent on the circumstances and information related to that particular dam.*
>
> *There are uncertainties associated with any level of assessment and particularly for an assessment based on PLL. The practitioner should be able to ensure sound and repeatable judgement is used in the assessment process and the determination of the Consequence Category.*

The ANCOLD Consequence Category Guidelines also provides clear guidance under what situation *"sunny day"* and *"flood failure"* conditions should be used. It is the expectation of the Department that this guidance will be followed in the assessment of all consequence categories.

2.2 Population at Risk (PAR) Analysis

The following summary of a PAR analysis is provided from ANCOLD's Consequence Category Guidelines:

> *The PAR includes all those persons who would be directly exposed to flood waters assuming they took no action to evacuate.*
>
> *For the purpose of these guidelines, the criteria used to determine those people who could be discounted from the Dam break PAR are:*
>
> - *PAR exposed to pre-dam break flood waters where the product of the Depth (D) and Velocity (V) is greater than 0.6 m^2/s. In determining this value of DV, D max should not exceed 1.2 m or V max should not exceed 1.5 m/s at the point of reference.*
> - *PAR who have had conclusively adequate warning (at least 12 hours) of the event or have been subject to pre-dam break flooding for a period of at least 12 hours and are within an area which is covered by a demonstrably effective and reliable emergency flood planning arrangement.*

The above can be used in assessing both PAR and PLL and is discussed further below.

Table 2 below, from ANCOLD's Consequence Category Guidelines, provides details of the Consequence Category of a dam based on PAR.

Table 2 – Consequence Category of a dam based on PAR (Table 3 in the Guidelines)

Population at Risk	**Severity of Damage and Loss**			
	Minor	**Medium**	**Major**	**Catastrophic**
<1	**Very Low**	**Low**	**Significant**	**High C**
≥1 to 10	**Significant** ***(Note 2)***	**Significant** ***(Note 2)***	**High C**	**High B**
>10 to 100	**High C**	**High C**	**High B**	**High A**
>100 to 1,000	**(Note 1)**	**High B**	**High A**	**Extreme**
>1,000		**(Note 1)**	**Extreme**	**Extreme**

Note 1: *With a PAR in excess of 100, it is unlikely Damage will be minor. Similarly with a PAR in excess of 1,000 it is unlikely Damage will be classified as Medium.*

Note 2: *Change to "High C" where there is the potential of one or more lives being lost*

2.3 Potential for Loss of Life (PLL) Analysis

The Department does not have any preference on whether a PAR or PLL analysis is used when determining a consequence category, however, as discussed above, the two methodologies are discrete and terminology should not be confused (for example if a PAR analysis is undertaken the discussion in the report cannot reference a PLL without undertaking further investigations).

If a PLL analysis is undertaken, then this should use a more comprehensive flood model (such as the intermediate or comprehensive flood modelling approach discussed below), including the use of a flood modelling program such as HEC-Ras.

The following is discussed in the ANCOLD Consequence Category Guidelines:

> *The ANCOLD guidelines on Risk Assessment require that an estimate be made of the number of potential fatalities that would result from a dam failure. No currently available procedure is available that can accurately predict the number of fatalities resulting from a dam failure.*
>
> *However, a range of empirical methods have been developed in recent times to estimate the potential loss of life resulting from a dam failure event. The 2003 ANCOLD Guidelines on Risk Assessment recommended that, of the techniques available at that time, the model developed by Graham (1999) is considered the most suitable of the empirical approaches. For the purpose of these guidelines, this approach is still considered the most suitable of the currently available methods.*
>
> *Personnel who are highly experienced in loss of life assessments are required to undertake, or at least closely supervise, the assessment process. It is also a requirement that an experienced Engineer who has significant experience in dam break analyses be involved in the dam break analyses.*

Table 3 provides details of the Consequence Category of a Dam based on the Potential Loss of Life and is presented below detailed in ANCOLD’s Consequence Category Guidelines.

Table 3: Consequence Category of a Dam based on the Potential Loss of Life (Table 4 in the Guidelines)

Loss of Life (PLL)	Severity of Damage and Loss			
	Minor	Medium	Major	Catastrophic
<0.1	Very Low	Low	Significant	High C
≥0.1 to 1	Significant	Significant	High C	High B
>1 to 5	(Note 1)	High C	High B	High A
>5 to 50		High A	High A	Extreme
>50		(Note 1)	Extreme	Extreme

Note 1: *With a PLL equal to or greater than one (1), it is unlikely Damage will be minor. Similarly with a PLL in excess of 50 it is unlikely Damage will be classified as Medium.*

2.4 Dam Breach Time

A breach of a dam may take as long as a number of years, or as little time as 15 minutes, to develop. This is dependent on a range of factors including the dam type; quality of construction and soil types (especially if the soil the dam is built out of is either sodic or dispersive).

Given that most dams that do breach, do so on first filling, it is recommended that as a general rule a 15 minute breach time be adopted when determining a Consequence Category. In undertaking any time analysis of a dam break, a hydrograph should be developed based on a Gumbel type probability distribution curve over the selected dam breach time.

2.5 Dwellings

For the purpose of an assessment of Consequence Category using these guidelines, a dwelling is a fixed place and includes residences or houses, schools, sheds or other structures that are occupied for some time on any given day, and therefore has a fixed population for a certain period of that day. The average population per residence in Australia is 2.6 (figures from the ABS 2009-2010 year book for 2006).

The assessment of risks to dwellings are generally quite straight forward as they are either in the flood zone or not in the flood zone, with the person undertaking the assessment required to clearly demonstrate this.

For PLL analyses, the level of flood water above the floor of the house (with 300mm viewed as a critical level) would need to be determined to allow for assessment of risks to people with limited mobility (for example older people or young children in the house).

However, most houses are built above the 1 in 50 year flood line, mitigating many of these risks. If the dwelling is also built along a major river system, a flood from a breach of a reasonably sized dam would most likely have little incremental impact in both a Flood and Sunny Day failure scenario due to the extensive flood plains of the river absorbing any flood from a dam breach.

However, houses adjacent to smaller tributaries could quite possibly be impacted from a flood from a breach of a dam due to the limited flood attenuation in these streams, with this needing to be assessed on a case by case basis.

2.6 Roads Downstream of a Dam

In Tasmania, there are many public roads ranging from major highways to gravel roads that may service a single property. The roads that are mostly at risk in a breach of a dam are the larger rural through roads that cross over tributaries of major rivers and major highways that cross over a minor tributary.

Therefore a quantitative risk analysis has been developed based on the amount of vehicular traffic on a road and an assumed dam breach time of 15 minutes as discussed above.

Determining the PAR from a Road Downstream of a Dam

The basis for the method used by DPIPWE is by estimating the Annual Average Daily Traffic (AADT) Volume on a road. This is defined as the average daily traffic volume determined over a year, which can vary both seasonally and over the course of the day, but is averaged over a year to give a daily average.

There are a number of ways of obtaining the AADT volume. Some data can be obtained from local government authorities or is published in a similar manner to the major highways and can be found in the following publication:

> *"State of our Roads 2014"* Department of State Growth Tasmania Government 2014

For an initial assessment of roads with lower traffic volumes, estimated AADT volumes can be found using the following methods:

- Using satellite imagery the AADT volume can be roughly estimated by tracing a road down past where the road crosses the stream the dam is situated on and do a physical count of all the activities there. This may include counting dwellings and allowing for two vehicle trips per day / per dwelling in the count. Land use also needs to be considered; such as forest plantations which will have logging trucks and farming enterprises will have agricultural equipment operating, as well as the potential for itinerant movements such as tourist activity.
- To confirm the above count, it is good practice to spend a couple of hours at the dam site and count the number of vehicles on the road, which can be done while undertaking other activities at the dam site.

When the estimated AADT volume is obtained the itinerant PAR for a road is determined by the average number of vehicles that would use that section of road over a 15 minute dam breach time.

If it is determined that on average there is one or more vehicles within this 15 minute dam breach time (an AADT Volume of 100 vehicle or more per day), then a PAR is established, if there is less than one vehicle then there is a PAR of less than 1.

For example, in most cases the vehicle would have two passengers or a PAR of 2 or as defined within ANCOLD's Consequence Category Guidelines, a PAR of ≥1 and <10. Based on a severity of damage and loss of minor, this results in the dam being assessed with a Consequence Category of Significant. However this does not automatically mean that there is a potential for loss of life, given the meaning of PAR in ANCOLD's Consequence Category Guidelines:

> *The PAR includes all those persons who would be directly exposed to flood waters assuming they took no action to evacuate.*

The above does not take into account the actual road crossing type which may be a large bridge or a set of road culverts. As discussed above, major highways crossing major rivers generally have very expansive crossing, however, in some cases where there are minor streams this could be a set of road culverts which may present a greater risk to the population.

An example of this method is the assessment undertaken for a 9m high dam, with a capacity of 94 ML. The land downstream of this dam is used mainly for forestry operations, but also includes a number of small hobby farms. There were also 19 dwellings (counted from satellite imagery) that are accessed by the road downstream of the crossing the dam sits above.

Including logging vehicles, recreational 4 wheel drive vehicles which use the road to access the Tarkine area and vehicles accessing the dwellings, it was estimated that the AADT volume would be less than 100 vehicles per day (70), giving a PAR of less than 1.

This was confirmed up by a Department staff member who attended the dam site and counted nine vehicles over a three hour time period (an AADT Volume of 72).

The assessed PAR of less than 1, with a damage and loss severity of medium (due to the – economic value of water in the dam), resulted in a Consequence Category of Low being confirmed for the dam.

Determining where there is Potential for Loss of Life

To have a PLL due to a road there must be a PAR in the first place. If there are no people exposed to a flood then there is no potential loss of life.

As discussed in the Consequence Category guidelines below, assessing this:

> *Road users represent a special category of itinerants. The risks posed to vehicle traffic arise from two possible hazards:*
>
> *1 Being present in the flood inundation zone at the time that the dam break flood wave passes through.*
>
> *2 Driving into the flooded area after the flood wave passes through.*

The points are discussed in more detail below:

For the first point above, to determine if there is PLL and to confirm the PAR, the actual road crossing needs to be taken into consideration and how much of a flood from a dam breach would overtop the road. For the PLL analyses, an estimate of the velocity of flow also needs to be undertaken, which can be derived using an estimate of stream friction factor and slope of the stream that is upstream of a road (Manning Equation).

High velocity combined with a considerable depth of flow (VxD) over a road could cause considerable damage to any vehicle and occupants caught in it, therefore a high potential for loss of life. The velocity times depth concept is discussed in ANCOLD's Consequence Category Guidelines, but a depth of 1m or greater over a road has been accepted by the Department is an accepted rule of thumb regarding where a PLL is likely.

The second point is particularly relevant on major highways where there is a considerable traffic volume, say an AADT volume of 5,000 vehicles or more. During the flood, it is unlikely that the first vehicles approaching the scene would have time to pull up and would enter the flood area. Subsequent vehicles would also enter until a point was reached that vehicles coming behind would see what was happening and eventually pull over.

This could mean three or four vehicles traveling in each direction which would result in a PAR of ≥ 10 but it is unlikely that it would be greater than 100. In such a case, there is a high probability that it would result in at least one fatality, or possibly more and combined with a severity of damage and loss of medium (for larger dams) would result in a consequence category of High C.

An example of this assessment approach is that of a proposed dam which was proposed to have a height of 11m and a capacity of nearly 200ML.

This dam is situated on a watercourse approximately 50m upstream from a major highway, with the stream flowing under the highway through two, 1000mm diameter road culverts. At the road crossing the highway is elevated about 3m above the bed of the stream. The highway at this point has an AADT volume of greater than 5,000 vehicles.

In analysing the road it is assumed that in a 15 minute dam breach the water would back up behind the highway and flow over the highway. The soils at the dam site are also highly dispersive so a 15 minute dam breach time on first substantial filling is not unreasonable, and also leading to the potential blocking of the culverts.

In this case due to the AADT Volume, over the 15 minute dam breach time there is the potential for 50 vehicles to be impacted on. It is assumed that four vehicles will be going in either directions and with two people per vehicle that is a PAR of 16.

Based on a PAR of ≥ 10 and < 100 this would give the dam a category of High C, justifying further analysis to consider any PLL

Analysis of the dam break indicated that the flow across the highway would also be at least 1m, with little water flowing through the culverts.

Of the 16 individuals at risk, this would indicate that there is potential for at least one fatality, giving a PLL of ≥ 1, resulting in a Consequence Category of High C (without allowing for the assessment of additional risks from dwellings or smaller rural roads).

It should also be noted that when undertaking field investigations, the assessment of sighting distance should not be taken into consideration due to the fact that the dam may breach at night and the driver of a vehicle may not see the flood until they drive into it.

2.7 PLL and Filters

When a Consequence Category assessment has shown that there is a high potential for loss of life in breach of a dam, the Department will need to consider the need for the requirement for a filter as part of the approval process.

Given this, it is recommended that the inclusion of a filter should be considered for the dam in a pre-construction and design report, to increase protection of the dam against piping failure or internal erosion.

2.8 Any filter design provided must comply with the methodologies developed by Sherard and Dunnigan of the United States Soil Conservation Services (US SCS) or what is considered modern dam filter design. Mapping Features below a Dam

The ANCOLD Consequence Category Guidelines has the following table which suggests the distance downstream a flood from a breach of a dam should be mapped:

Storage (ML)	Intervals Between Sections (Total Distance)
Greater than 2,000	1 kilometre (up to 60 kilometres)
200 to 2,000	0.5 to 1 kilometre (up to 20 kilometres)
Up to 200	Not greater than 0.5 kilometre (up to 5 kilometres)

Using satellite imagery, map everything downstream of a dam including all roads and dwellings, places where people may congregate (parks) and features of significance such as wetland and railway lines.

Usually it is only roads and dwellings that are present. This should be undertaken until a major river system, lake or sea that would absorb a flood from an upstream dam breach is encountered and as discussed above, due to topographic influences, this is rarely further than 5km within Tasmania.

2.9 Flood Assessment Level

ANCOLD's Consequence Category Guidelines discuss three levels for flood assessment:

1. *Flood Assessment - Initial level;*
2. *Flood Assessment - Intermediate Level; and,*
3. *Flood Assessment - Comprehensive Level.*

For assessment of dams in Tasmania these are discussed in further detail below.

Flood Assessment - Initial level

ANCOLD's Consequence Category Guidelines discuss the following:

> *"The Initial Assessment involves a site inspection which could simply be a "windscreen" reconnaissance of the area together with the conservative use of topographic and hydrographic data. Any habitable dwellings as well as major infrastructure such as bridges, roads and railway lines within a height above the stream bed of between one third (1/3) and one half (1/2) of the dam height should be recorded and located on the largest available scaled contour map of the area.*

Using the above the concept *"of between one third (1/3) and one half (1/2) of the dam height*" should be limited to dams where there is one feature downstream of the dam at risk and mostly applies to a road and to a lesser extent, a fixed dwelling. This will give a good idea of how deep a road may be overtopped and will then give a very good indication of the PAR and PLL using the methods described above. This single feature downstream of a dam can be used in developing the Dam Safety Emergency Plan without a detailed survey.

This method should also be used for an initial assessment using satellite imagery where there are a number of features at risk downstream of a dam, after this a more comprehensive flood assessment method should be used.

Flood Assessment – Intermediate Level

Again this should only be used where there are only one or two features at risk in a breach of a dam. ANCOLD's Consequence Category Guidelines discusses the follow:

> *The intermediate assessment uses "normal" depth to estimate maximum flood levels at a section for any given discharge. As such, the technique does not take into account any backwater or significant floodplain effects and therefore should not be used where these effects are expected to be significant in terms of the affected population at risk.*

Flood Assessment- Comprehensive Level

Where there are a number of features downstream of a dam at risk, then a comprehensive flood assessment will need to be undertaken. The area downstream will need to be surveyed and the flood impact modelled using a program such as HEC-Ras. This is required for two purposes:

i To accurately identify all features that are definitely at risk in a breach of a dam; and,

ii To develop the flood polygons that are used by police and emergency management personnel in a dam break emergency.

Where a dam is on a small stream with a limited crossing that flows under a major highway the Department in most cases will request a comprehensive flood assessment using software such as HEC-Ras. This is especially the case where there are also some dwellings nearby.

2.10 Multiple Dams on a Catchment

ANCOLD's Consequence Category Guidelines states where there are multiple dams on a catchment, the consequence category of the dam upstream should be based on the dam downstream.

In Tasmania in the highly fertile volcanic areas, especially in the north there are many catchments with multiple dams on them. One example is Wilsons Creek where there are 25 rural dams on the creek (or tributary). The current Consequence Categories of the dams range from Very Low to High C for dams of a similar type, size and consequence and there is little to distinguish why such a broad range of Consequence Categories exist.

Where there are multiple dams on a catchment, any features of significance at risk downstream of any or all dams should be identified and mapped, and at that point all dams upstream should be taken into consideration when assessing the Consequence Category of the dam in question. In the case of Wilsons Creek, the Bass Highway and the town of Detention are at the extreme end of the catchment, but there are also both dwellings and roads all the way upstream.

The argument is that any upstream dams that are larger than the dam in question will most likely result in the failure of the dam as well. If the dam in question does not absorb the flood and fails, the combined flood wave will most likely fail all of the downstream dams.

This also needs to be taken into consideration when preparing a dam safety emergency plan.

2.11 Tailings Dam

Mine tailings dams, due to their environmental impact especially Acid Mine Drainage, all require the Severity of Damage and Loss to be Catastrophic, based on damage to the environment. When this is combined with an assessed PAR of ≥ 1 and < 10, it will result in a Consequence Category of High B. The majority of tailing dams in Tasmania are either High C (no PAR) or High B (includes a PAR).

2.12 Small Dams

Small dams (less than 5ML) which are in close proximity to a dwelling provide unique challenges. Whilst the dwelling needs to assessed as for a normal assessment of risks in a flood zone, the characteristics of the dam break need to established to understand the momentum of the flood wave and the magnitude of the potential impact.

This is particularly important given that smaller dams that may impact on a dwelling will also tend to be off stream, and as such do not have a defined channel for an assessment of the flood zone.

3. *Further Information*

Enquiries to:

Dam Safety Coordinator

Water Operations Branch

Department of Primary Industries, Parks, Water and Environment

PO Box 46, Kings Meadows TAS 7249

Visit www.dpipwe.tas.gov.au/water/dams/dam-safety or

Call 1 300 368 550 for assistance or

Email Water.Operations@dpipwe.tas.gov.au.

Links:

- The *Water Management (Safety of Dams) Regulations 2015* and the *Water Management Act 1999* are available at:

  http://www.thelaw.tas.gov.au/

4. *ANCOLD Publications*

ANCOLD publications referred to in the Guideline are available from:

ANCOLD http://www.ancold.org.au/