Understanding Victorian Local Government Authority Dams and Retarding Basins

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The Department of Environment, Land, Water and Planning (DELWP) has a regulatory role for the safety of dams under the Water Act 1989 (Act) and is the control agency for dam related emergencies.

Local Government in Victoria is divided up between 79 Local Government Authorities (LGAs), each responsible for administering local infrastructure and community services such as roads, drainage, parks etc. Current records indicate that 42 of the 79 LGAs own or manage up to 435 dams and retarding basins.

Many of these assets, which include a mix of old water supply dams, ornamental lakes and retarding basins, have been accumulated by LGAs over many years as a result of asset transfers and conversions, land development projects, flood mitigation programs and opportunistic acquisitions by the transfer of land.

DELWP engaged GHD to assist and provide advice to the LGAs to significantly improve and update knowledge on LGA dams and retarding basins. The objective of this project is to ascertain where the State's LGA dams and retarding basins are located, what risks they might pose to communities and infrastructure, what to consider during emergency management planning and response, and to provide owners with the essential management tools and procedures to effectively manage these assets, if these are not in place already.

The outcome of this project was to support LGAs to improve management of their dams and retarding basins. It aimed to do this by assisting LGAs with the development of basic dam safety programs that will enable LGAs to more effectively manage their portfolios of dams and retarding basins in terms of ongoing maintenance, dam surveillance and emergency planning and response, and demonstrate due care.

This project had a number of key challenges. These included the requirement to process and assess a large number of sites within a small timeframe whilst achieving good value for money, without compromising DELWP's objectives. A number of efficient methods were adopted during this project particularly during the initial data gathering process, identifying those dams which needed to be inspected based on embankment heights, reservoir capacity and consequences, rapid preliminary assessment of consequences, the development of effective templates for the site inspections, and a method of applying qualitative risk assessments, applicable to the majority of the dams, allowing a consistent assessment of the status of each dam and dam safety documentation.

The methods discussed (although developed specifically for the Victorian LGA dams portfolio) provide a sound basis for a screening tool to assess a large number of smaller dams in an efficient manner and quickly identify higher consequence category dams requiring attention. This method could easily be modified and adapted to be applied to similar portfolios of dams.

Keywords: dam safety, local government authorities, surveillance, consequences, risk, documentation, small dams

1.0 Introduction

The Minister for Water has powers under the Act to regulate the construction, operation and safety of dams in Victoria. These powers apply to dams owned and managed by public entities such as water corporations, Local Government Authorities (LGAs), Parks Victoria, and private dams owned by farmers and commercial entities.

To help administer these powers, the minister is supported by the Risk and Resilience Team in the Water and Catchment Group in DELWP, which has regulatory responsibilities for dam safety. DELWP regulates dam safety in Victoria and is also the control agency for all dam safety emergency incidents under the Emergency Management Manual of Victoria.

Available estimates indicate that there are over 455,000 dams throughout Victoria (SKM, 2012), the vast majority of which are very small. Dam safety regulation focuses on a small subset of dams which, because of their size and location, warrant a higher level of surveillance and oversight.

DELWP is currently working to regulate LGA dams and retarding basins, most of which have a recreational, aesthetic and firefighting secondary purpose. This paper details the key stages of work undertaken by GHD who were engaged by DELWP to significantly improve and update knowledge on LGA dams and retarding basins.

2.0 Local Government Authority Dams and Retarding Basins

2.1 General

In Victoria, dams and retarding basins are primarily under the control of the following bodies:

- Water corporations;
- Private owners;
- Parks Victoria;
- DELWP; and
- Local government.

The focus of this paper is the dams and retarding basins under the control of local government authorities in Victoria.

2.2 DELWP LGA Regions

DELWP has split the state into six regions, as shown in Figure 1. Within the six regions, there are 79 LGAs, each responsible for administering local infrastructure and community services such as roads, drainage, parks etc.

Figure 1: DELWP Regions

GHD were engaged by DELWP to implement a LGA dam safety program for four out of the six regions, namely:

- Hume;
- Loddon Mallee;
- Port Phillip; and
- Grampians.

Within these four regions, there were 42 identified LGAs that own or manage dams and retarding basins.

The dam safety program for the two other regions within Victoria, namely Barwon South West and Gippsland, is being completed by Southern Rural Water. The program for these two regions was in progress at the time of this paper.

2.3 Dams and Retarding Basins

Records indicate that a number of the LGAs own or manage dams and retarding basins. Many of these assets, which include a mix of old water supply dams, ornamental lakes and retarding basins, have been accumulated by LGAs over many years as a result of asset transfers and conversions, land development projects, flood mitigation programs and opportunistic acquisitions by the transfer of land.

Of the 42 LGAs identified within the four regions included in the GHD program, there were 435 dams and retarding basins identified for consideration.

The estimated maximum embankment height at this sites ranged from 0 (below ground) to 12 metres with storage capacities recorded up to 1000 ML. These limits have not been confirmed with site specific survey data but provide an indication of the range of storage sizes that Councils are responsible for.

The age of the dams and retarding basins also varies considerably with the construction date ranging from 1860 to 2016.

Majority of the dams consisted of earthen embankments with less than 1% of sites having a different recorded construction type such as concrete gravity and concrete faced rockfill.

3.0 Our Approach to a Large-Scale Project

3.1 Objectives

The objectives of this project, referred to as the 2017 LGA Dam Safety Program, were to:

- ascertain where the State's LGA dams and retarding basins were located;
- what risks they might pose to communities and infrastructure;
- what to consider during emergency management planning and response; and
- whether the owners had the essential management tools and procedures in place to effectively manage these assets.

The outcome of this project was to develop a statewide LGA dams database and support LGAs to improve management of their dams and retarding basins. It aimed to do this by assisting LGAs with the development of basic dam safety programs that would enable LGAs to more effectively manage their portfolios of dams and retarding basins in terms of ongoing maintenance, dam surveillance and emergency planning and response, and demonstrate due care.

3.2 Scope of Work

The scope of work completed for this project included the following key components:

1. Initial desktop review, which included:
    a) Confirmation of the location of all assets included in the Dams Database maintained by DELWP (based on available information and past surveys).
    b) Identification of the height of the embankment at each site (data either provided by the Council or estimated from survey data provided by DELWP).
    c) If the site had an estimated height greater than 1 m, development of an inundation zone associated with a 'dam crest flood (DCF)' failure.
    d) Identification of whether the site has an expected Population at Risk (PAR) within the inundation zone.

For the sites that had an estimated height greater than 1 m, an expected PAR and no records of recent 'intermediate level' dam safety inspections, the following additional tasks were completed:

2. 'Intermediate Level' Dam Safety Inspections in accordance with the ANCOLD Guidelines on Dam Safety Management (2003b).
3. 'Initial Level' consequence assessment in accordance with the ANCOLD Guidelines on Consequence Categories (2012).
4. Qualitative risk assessment in accordance with the ANCOLD Guidelines on Risk Assessment (2003a).
5. Preparation of a Dam Safety and Assessment Report in accordance with the ANCOLD Guidelines on Dam Safety Management (2003b).
6. Preparation of a Surveillance and Maintenance Plan in accordance with the ANCOLD Guidelines on Dam Safety Management (2003b).
7. Preparation of a Dam Safety Emergency Plan, based on the DELWP template for LGA Dams.

The methodology and results relating to the assessment of consequence and risk are detailed below.

ANCOLD Guidelines were used as the basis for developing the methodology for this project. ANCOLD provide the advice that although the guidelines are typically applicable to larger dams, the use when assessing smaller dams may be appropriate. Other references were considered however it is evident that there appears to be an absence of other suitable guidelines specific to smaller dams. Of note, ANCOLD is currently developing a guideline for Design, Construction, Operation and Maintenance for Retarding Basins, which will address specific issues associated with Wetlands and Retarding Basins etc.

3.3 Assessment of Consequences

As outlined in the ANCOLD Guidelines on the Consequence Categories for Dams (2012), a consequence assessment is carried out to assign a dam a 'Consequence Category' by collecting information about the consequences of a potential dambreak and identifying the severity of these consequences. Consequence Categories provide a useful basis for determining dam safety management requirements, which include:

- Dam Safety surveillance;
- Dam Safety inspections;
- Operation and maintenance;
- Dam Safety emergency management; and
- Remedial and upgrade works.

The 'initial' level consequence assessment was carried out by mapping the downstream inundation extent using a GIS-based approach developed specifically for this project. The GIS routine steps through the following process:

- From the embankment, project a line starting at half the embankment height downstream at a slope equal to the ground slope at the dam, until it intersects a major waterway.
- Buffer the line from Point 1 above in a horizontal fashion in both directions until it intersects the ground surface.
- Iteratively truncate the downstream extent created above to match the volume of the flood extent to the volume of the reservoir.

This methodology produced a consistent and feasible result for the majority of the dams, however there were a small number of dams which needed to be reassessed on a case-by-case basis. The estimates for PAR was also presented as a range in accordance with the ranges applied to assign consequence categories (i.e. PAR 10-100) rather than a singular value due to the limitations and expected level of accuracy associated with this method.

The VicMap 10 metre and 20 metre digital terrain models were widely adopted as the base terrain for this assessment, but where made available, LiDAR data was also used (this was more common for the urban dams and/or retarding basins).

The inundation maps were used to estimate the PAR. The PAR includes all people who would be directly exposed to flood waters assuming they took no action to evacuate.

PAR estimates were compared against aerial imagery and considered for selected sites where dam safety inspections were carried out to assess whether they may be over or under estimated.

It was assumed that the severity of damage and loss would be driven by economical losses due to damage to properties rather than other considerations like impact to dam owner's business, health and social impacts and environmental impacts. To simplify this further, the severity of damage and loss was assigned as Minor where the PAR was <100 and Medium where the PAR was >100.

3.4 Qualitative Risk Assessments

3.4.1 General

A framework for Qualitative Risk Assessment (QRA), represented by a 5 x 5 matrix as shown in Table 1 was used as a framework for the purposes of delivering the 2017 LGA Dam Safety Program.

Table 1 DELWP qualitative risk matrix for dams and retarding basins

Likelihood / Condition Rating	ANCOLD Consequence Category				
	Very Low (1)	Low (2)	Significant (3)	High A,B,C (4)	Extreme (5)
Very Likely (5)	Medium	Significant	Significant	High	High
Likely (4)	Medium	Medium	Significant	High	High

Likelihood / Condition Rating	ANCOLD Consequence Category				
	Very Low (1)	Low (2)	Significant (3)	High A,B,C (4)	Extreme (5)
Possible (3)	Low	Medium	Medium	Significant	High
Unlikely (2)	Low	Low	Medium	Medium	Significant
Rare (1)	Low	Low	Low	Medium	Significant

In simple words, risk is quantified by (i) the likelihood of dam failure; and (ii) the consequences due to the dam failure. As shown in the risk matrix in Table 1, consequences are to be classified in accordance with ANCOLD Guidelines on Consequence Category for Dams (2012). The methodology for classification of consequences has already been discussed in this paper in the previous Section. This Section describes the methodology for rating the likelihood of dam failure.

Table 2 summarises a list of condition descriptors proposed by DELWP to be used by GHD as part of the 2017 LGA Dam Safety Program for rating the likelihood of an embankment dam failure due to (i) internal erosion and piping; (ii) scour erosion by flood overtop, or spillway failure; and (iii) deformation and instability of the dam embankment. Based on Table 2, further condition descriptors were developed to aid assessment of the likelihood of failure due to four major embankment failure modes, namely:

1. Internal erosion and piping.
2. Flood overtop.
3. Embankment slope instability.
4. Non-performance of spillway and/or floodway erosion.

Assessment of the likelihood of dam failure was based on:

- Observed conditions of the dam based on the inspection carried out as described in this Paper;
- Observed design features (or information where available);
- Where no data or drawings existed, assumed conditions based on experience with similar dams, the age of the dam, known uses of the dam when constructed; and
- Our understanding of the dam safety surveillance and monitoring program in place, based on discussions with the Council.

Table 2 Likelihood / condition descriptors proposed by DELWP

Likelihood	Condition descriptor
Very Likely (5)	Heavy woody vegetation, spillway filled or blocked, evidence of piping, sink holes, severe settlement, upstream beaching erosion, severe cracking, heavily corroded outlet works
Likely (4)	Significant woody vegetation, spillway appears undersized or partially blocked, some surface erosion, settlement evident, moderate cracking
Possible (3)	Generally good grass cover with some woody vegetation, unlined clear spillway, minor settlement or cracking, may have zoned embankment, no filters, outlet works functional
Unlikely (2)	Good vegetation cover, some minor erosion and cracking, lined spillway with some defects, visual surveillance program, zoned embankment, may have filters
Rare (1)	Well maintained grass cover, full drainage and filters, lined spillway off embankment, monitoring instrumentation, surveillance program, outlet works fully operational

The following sections describe the various condition descriptors used for rating the likelihood of each of the four key failure modes, and how they would affect the safety of an earthen dam. A rating between one and five is assigned to each descriptor, with a rating of five representing the most unfavourable condition and a rating of one representing the most favourable condition. These ratings were then assessed together to assign an overall rating for the likelihood of dam failure for the storage.

It should be emphasised that the ratings are not quantitative and should not be compared against different categories. Specifically, a rating of 5 for one category does not 'equal' a rating of 5 in another in relation to likelihood of the dam failing. These numbers are used to rate conditions within a category independently.

It is noted that the potential failure modes associated with concrete dams are different to those assessed for embankment dams. Condition descriptors used to determine the likelihood of failure for concrete dams were prepared and utilised as part of the 2017 LGA Dam Safety Program however due to the small percentage of sites that this impacted, it has not been included in this Paper.

It should also be noted that the results of this assessment do not necessarily mean the dam is near failure but highlights the urgency for which improved dam safety practices and/or modifications to the dam are required.

3.4.2 Condition descriptors based on the observed condition of an embankment dam

Vegetation

When trees and woody plants are allowed to grow on embankment dams, they can hinder safety inspections and can interfere with safe operation. Trees can damage the structure of an earthen dam and result in failure of dam in the following ways.

- Growth and penetration of tree roots into an embankment dam can open cracks through which piping erosion can take place.
- Fallen trees because of strong wind or when the trees die may result in big holes/depressions in the embankment dam, which can lead to slope instability. It may shorten the seepage gradient and trigger piping erosion through the embankment.
- Fallen trees may result in local depressions along the embankment crest and increase the likelihood of flood overtopping through the depressions.
- Roots of dead trees within the embankment will decay resulting in voids and preferential seepage paths along which piping erosion may occur.

By contrast, a healthy, dense stand of low-growing grass on embankment dams is a desirable condition and should be encouraged. An embankment without grass cover may be subjected to gully erosion caused by surface runoff.

Therefore, a rating of 5 (most unfavourable) is to be assigned to situations when a lot of trees and woody plants grow within one metre of the embankment crest. A rating of 1 (most favourable) is to be assigned to embankments covered with dense, short growing grass.

Desiccation cracks

Cracks caused by desiccation in the top part of an embankment dam may form preferential seepage paths when the storage level rises above the tips of the cracks. Desiccation cracks usually occur in a random pattern. The cracks can be fine and very localised. The most unfavourable condition is when the cracks are wide and continuous in a transverse direction across the width of the embankment crest. When continuous transverse cracks are wider than 5 mm, the likelihood of seepage-induced erosion (i.e. piping erosion) initiating along the cracks are high.

A rating of 5 is to be assigned to embankments with wide (> 5 mm) desiccation cracks continuous through the width of *the embankment crest, and a rating of 1 is to be assigned to embankments with no observable desiccation cracks.*

Longitudinal/diagonal cracks

Longitudinal and diagonal cracks are indicators that part of the embankment is slipping or beginning to slip down the slope. A minor slope slip will leave a scarp along the top edge of the slip.

The most unfavourable condition, to be assigned a rating of 5, is when a longitudinal crack or scarp is observed on the upstream slope of the embankment. It may suggest that a relatively deep-seated slope failure is developing with the upper part of the slip surface daylighting on the upstream slope. When water level rises and drowns the longitudinal crack, water entering the crack may further destabilise the potential slipping mass.

A rating of 1 is to be assigned to embankments with no observable longitudinal cracks.

Signs of piping/internal erosion

Any signs of previous piping erosion in the embankment may suggest that piping erosion may be reactivated when the water level is high enough. Signs which suggest piping erosion might have occurred or still progressing include but not limited to:

- Sinkholes. Most dangerous sinkholes are those found on the upstream slope which might be drowned when water level is high.
- Sand boils at the downstream toe. It is a sign of high groundwater pressure at the downstream toe, and the presence of some preferential seepage paths through the dam foundation.
- Leakage through the downstream slope or toe. This is an indication of flow through some relatively permeable zones or cracks within the embankment.
- Vortex observed in the reservoir. This is an indication of a major leak through the floor of the reservoir, and there is a chance that the leakage path might be through the embankment.

A rating of 5 should be assigned to the embankment if the above signs are observed. A rating of 1 should be applied if none of the above signs is observed.

Outlet works and conduits (if applicable)

There have been many Reported incidents of piping along conduits through an embankment dam leading to dam failure. Piping along a conduit can occur due to the following reasons:

- Poor compaction around a conduit results in a preferential seepage path along which piping erosion can occur.
- Piping into a deteriorating conduit through opened pipe joints or cracks in the conduit.
- Leakage from a pressurised conduit resulting in erosion of earth materials along the conduit.

Due to the above reasons, a rating of 5 is to be assigned to an embankment with an embedded conduit which is inoperable, badly deteriorated, or might have partly broken within the embankment. A rating of 1 is to be assigned to an embankment with fully operational outlet works which do not pass through the embankment dam. Where an outlet was unable to be located but was expected to exist given the history of the reservoir (i.e. old water supply dam), a rating of 5 was assigned due to lack of information.

Movements

When the reservoir level rises, overtopping of the dam will start at the lowest spot on the dam crest. Concentration of the flow through the low spot will result in high flow velocity that may initiate a breach (notch) by scour erosion. Continuous flow through the initial breach will then quickly widen and deepen the notch as the breach progresses. Localised low spots possibly caused by settlement or surface erosion should, therefore, be avoided in an embankment dam to prevent concentration of flow through the low spots when overtopping occurs.

A rating of 5 is to be assigned to a dam with severe settlement observed on the crest and slopes. A rating of 1 is to be applied to a dam with uniform crest and slope surfaces having no obvious sign of settlement.

Surface erosion

When the embankment slopes are progressively undermined by wave and rainwater erosion, they become less stable.

A rating of 5 is to be assigned to a dam whose upstream slope has been severely undermined by wave erosion, and severe gully erosion by surface runoff is observed in other parts of the dam. A rating of 1 is to be applied to a dam where there is no obvious surface erosion.

Spillway (if applicable)

The main function of a spillway is to release flood water from a reservoir to limit the rise in water level to avoid overtopping of the embankment dam. Therefore, a spillway should be maintained free from blockage so that its flood discharge capacity will not be hampered.

A rating of 5 is to be assigned to dams whose spillway channel is severely blocked by heavy vegetation or debris. A rating of 1 is to be applied to dams whose spillway channel is clear of vegetation or debris.

3.4.3 Condition descriptors based on the design features of an embankment dam

Slope gradient

Embankments with steep slopes are likely to have slope instability problems. From experience, earth embankment slopes flatter than 3 (horizontal): 1 (vertical) usually have adequate safety margin against slope failure.

A rating of 5 is to be assigned to dams whose slope gradients are steeper than 1 (horizontal): 1 (vertical), and a rating of 1 is to be assigned to dams whose slope gradients are flatter than 4 (horizontal): 1 (vertical).

Embankment zoning and foundation

Embankments with full height chimney filters and complete foundation cut-off to bedrock level have good performance records in terms of their resistance against internal erosion and piping. On the contrary, homogeneous embankments constructed on permeable foundations with no seepage cut-off into the foundation are vulnerable to internal erosion and piping.

Therefore, a rating of 5 is to be assigned to homogeneous embankments without downstream filters, and which might have poorly compacted zones within the body of the embankment and permeable zones through the dam foundation. A rating of 1 is to be applied to zoned embankments with downstream filter constructed to the crest of the embankment and have complete seepage cut-off in the foundation constructed down to impermeable bedrock.

Crest width and protection

Applying a capping layer of fine gravels or bitumen-gravel to the crest of an embankment dam will protect the top part of the embankment from desiccation cracking. The capping layer will also add some resistance against scouring erosion in case the embankment is overtopped.

The width of the embankment crest will affect the likelihood of piping in the upper part of the embankment as the seepage gradient through cracks is lower if the embankment crest is wider. A wider crest also means that the likelihood of having continuous transverse cracks through the width of the crest will also be smaller.

When an embankment is overtopped, scouring erosion will initiate at the downstream edge of the embankment as the flow starts to accelerate down the slope. The scour erosion will work its way back towards the upstream edge of the dam crest to form an erosion channel and initiate a dam breach (notch). It will take a longer time to form the initial breach if the embankment has a wide crest.

Therefore, a rating of 5 is to be assigned to embankments with a narrow crest (< 2 m) without paving to protect the crest materials against desiccation. A rating of 1 is to be applied to embankments with a crest width wider than 3 m, with the crest sealed or covered with concrete pavement.

Flood capacity

The flood capacity is defined, in simple terms, as the storm event that will bring the water level to the dam crest level. The flood capacity of a dam in terms of its Annual Exceedance Probability (AEP), therefore, is a good indicator of the likelihood of flood overtopping.

A rating of 5 is to be assigned to dams whose flood capacity is more frequent or equal to 1:50 AEP, and a rating of 1 is to be assigned to dams whose flood capacity is less frequent than 1:10,000 AEP.

Spillway lining (if applicable)

A spillway channel should have sufficient resistance against scour erosion when it operates, otherwise collapse of the channel side walls and backward scour erosion of the spillway channel may adversely affect the safety of the embankment dam. A properly designed spillway should have stable channel floor and side walls which are resistant to scour erosion, otherwise the channel floor and the sides should be protected by lining.

A rating of 5 is to be assigned to a dam whose spillway is unlined, susceptible to scour erosion, has unstable side slopes and the potential to divert flows to the embankment toe causing damage to the embankment. A rating of 1 is to be assigned if the spillway is located far away from the embankment, or the likelihood of scour erosion of the spillway channel is negligible.

Spillway discharge (if applicable)

If a spillway discharges flood water at or close to the toe of the embankment dam, and there is no energy dissipator to reduce the flow velocity, there is a chance that the flood discharge will cause scour erosion at the downstream toe of the embankment. Scour erosion may also occur along the embankment toe if it is part of the floodway, or flood water discharged into the river course is backed up to the toe of the embankment.

A rating of 5 is to be assigned for situations when flood discharge through the spillway is likely to cause scour erosion at the downstream toe of the embankment. A rating of 1 is to be assigned if the spillway is located far away from the embankment and any flood discharge from the reservoir will not cause scour erosion at the downstream toe of the embankment.

Spillway training walls (if applicable)

The interface between a spillway training wall and the embankment dam is a vulnerable spot for piping erosion to initiate because of the following reasons:

- The soil porosity at the interface is higher than the porosity within the soil mass making the interface a preferential seepage path.
- Deflection of the training wall may leave a gap between the buried face of the training wall and the backfill materials allowing water to seep through the gap.
- Settlement of the embankment materials may cause a separation of the backfill materials from the training wall.
- At some dams, the top of the training wall may be lower than the embankment crest level so that the upper part of the embankment above the top of the training wall may be subjected to scouring erosion when the water level is higher than the top of the training wall.

A rating of 5 is to be assigned when a gap is observed between the spillway training wall and the backfill due to deflection of the wall or lateral settlement of the embankment materials behind the wall, or when there are cracks and open lift joints in the training wall which allow water to seep through the training wall and initiate piping erosion at the back of the wall. A rating of 1 is to be assigned if there is no spillway or the spillway is located away from the embankment dam.

3.4.4 Condition descriptors based on the dam safety inspection program in place

A rating of 5 is assigned if no routine surveillance and monitoring program is applied to the dam. A rating of 1 is assigned if the dam has a surveillance and monitoring program in compliance with the requirements of ANCOLD Guidelines on Dam Safety Management (2003b).

4.0 Results

4.1 Assessment of Consequences

Of the 435 sites identified by LGAs within the four regions, 109 sites were assessed as part of the initial desktop review as having an embankment height of greater than 1 m, the potential for PAR in the unlikely event of dam failure and no recent dam safety inspection or report available. The results of the consequence assessments for these 109 sites is summarised in Figure 2 with a further breakdown per region provided in Figure 3.

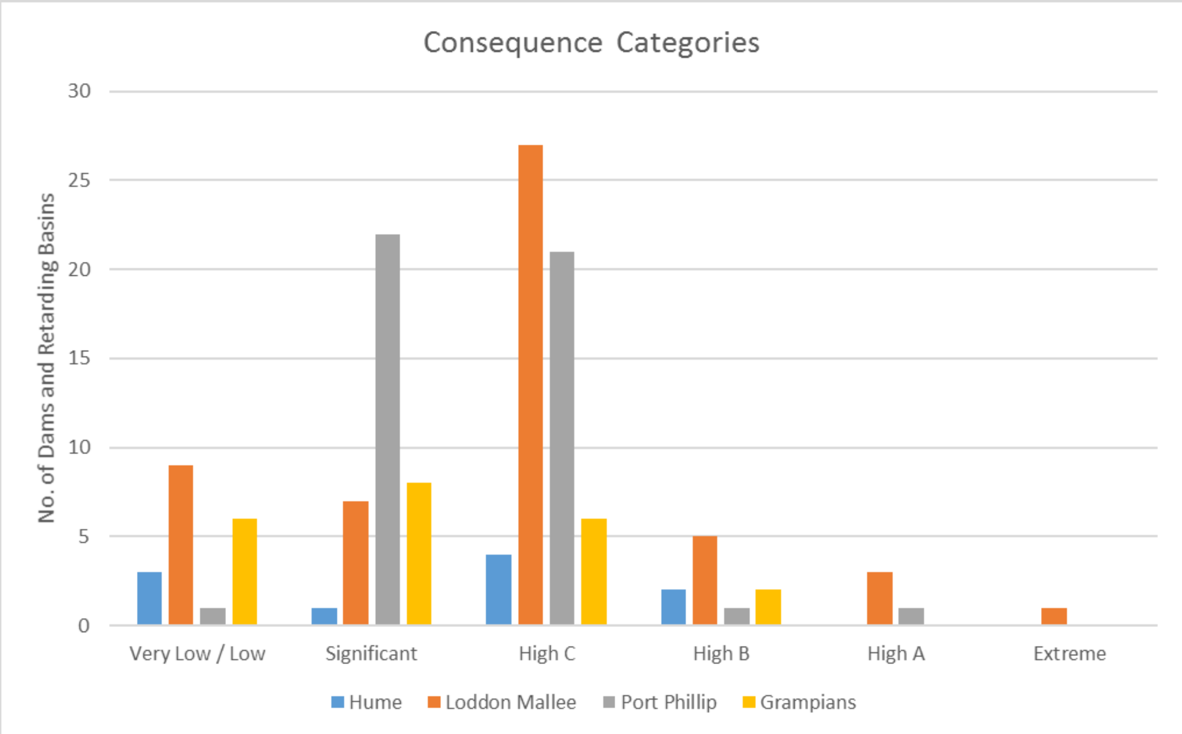

Figure 2: Summary of Consequence Categories

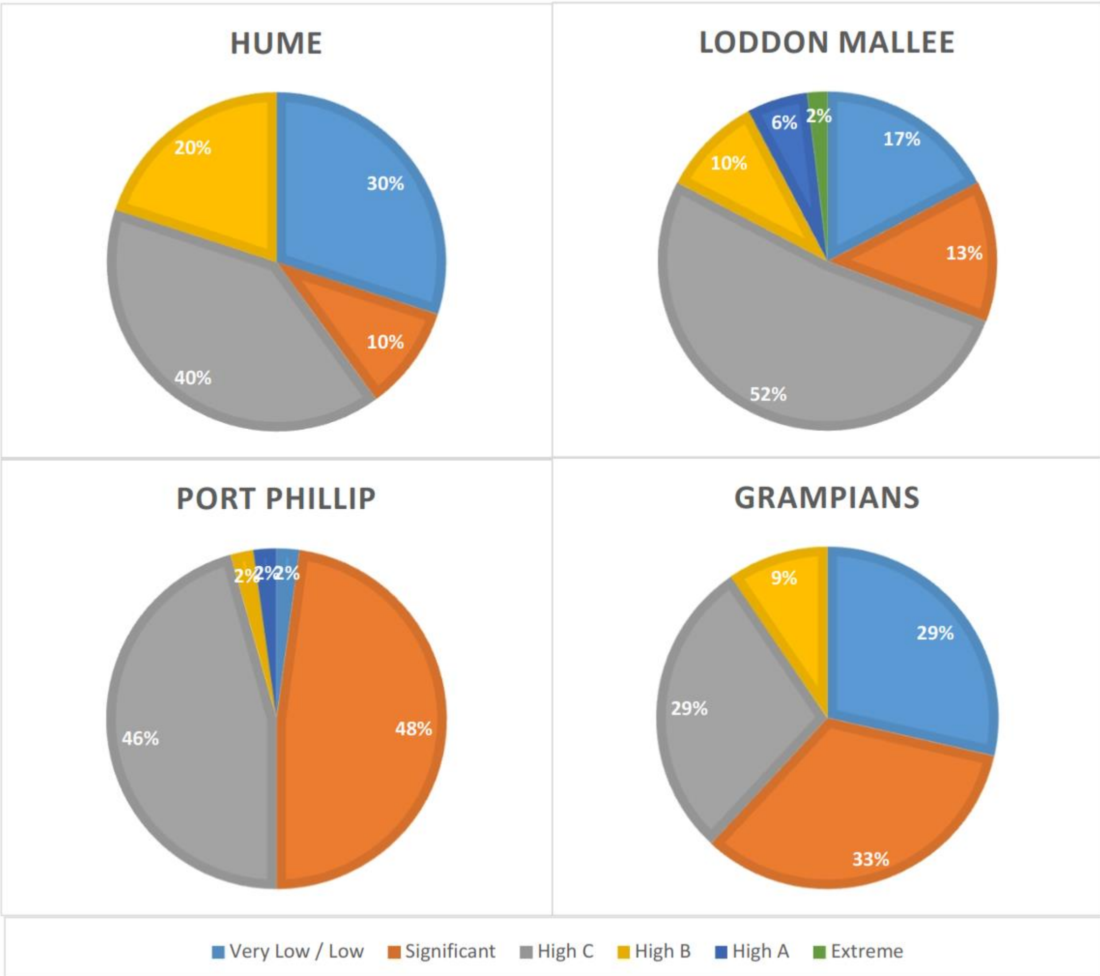

Figure 3: Consequence Categories Per Region

4.2 Qualitative Risk Assessments

The results of the qualitative risk assessments for the 109 selected sites is summarised in Figure 4 with a further breakdown per region provided in Figure 5.

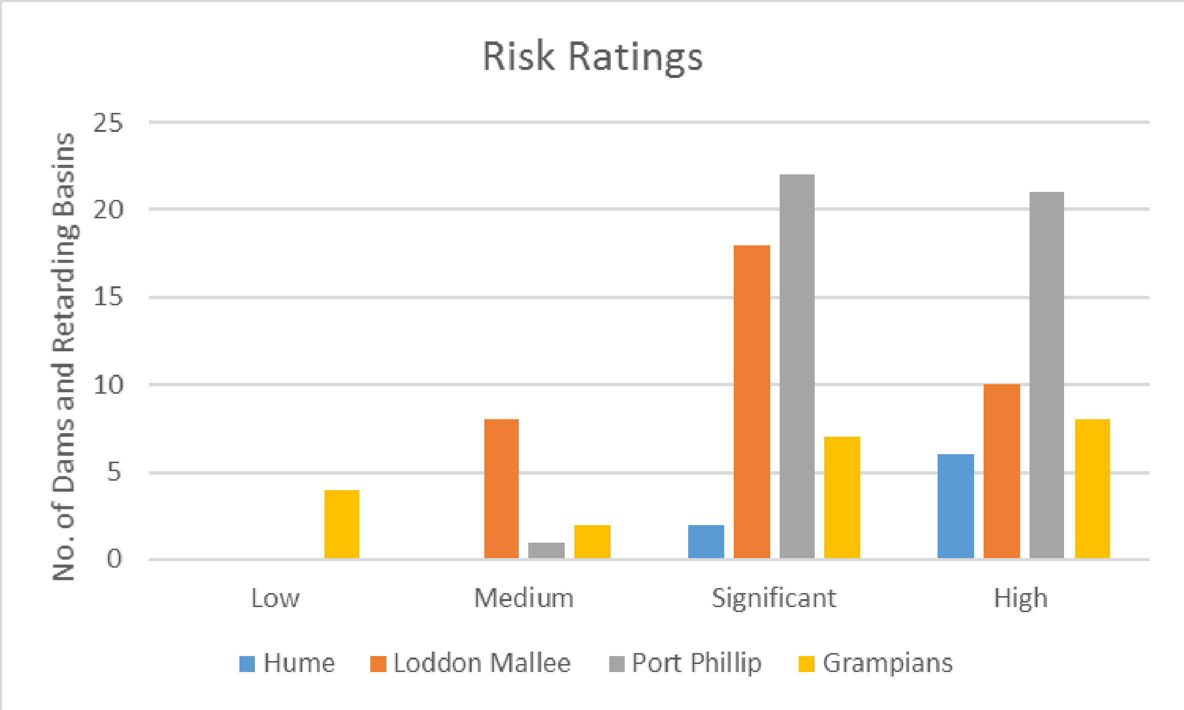

Figure 4: Summary of Risk Ratings

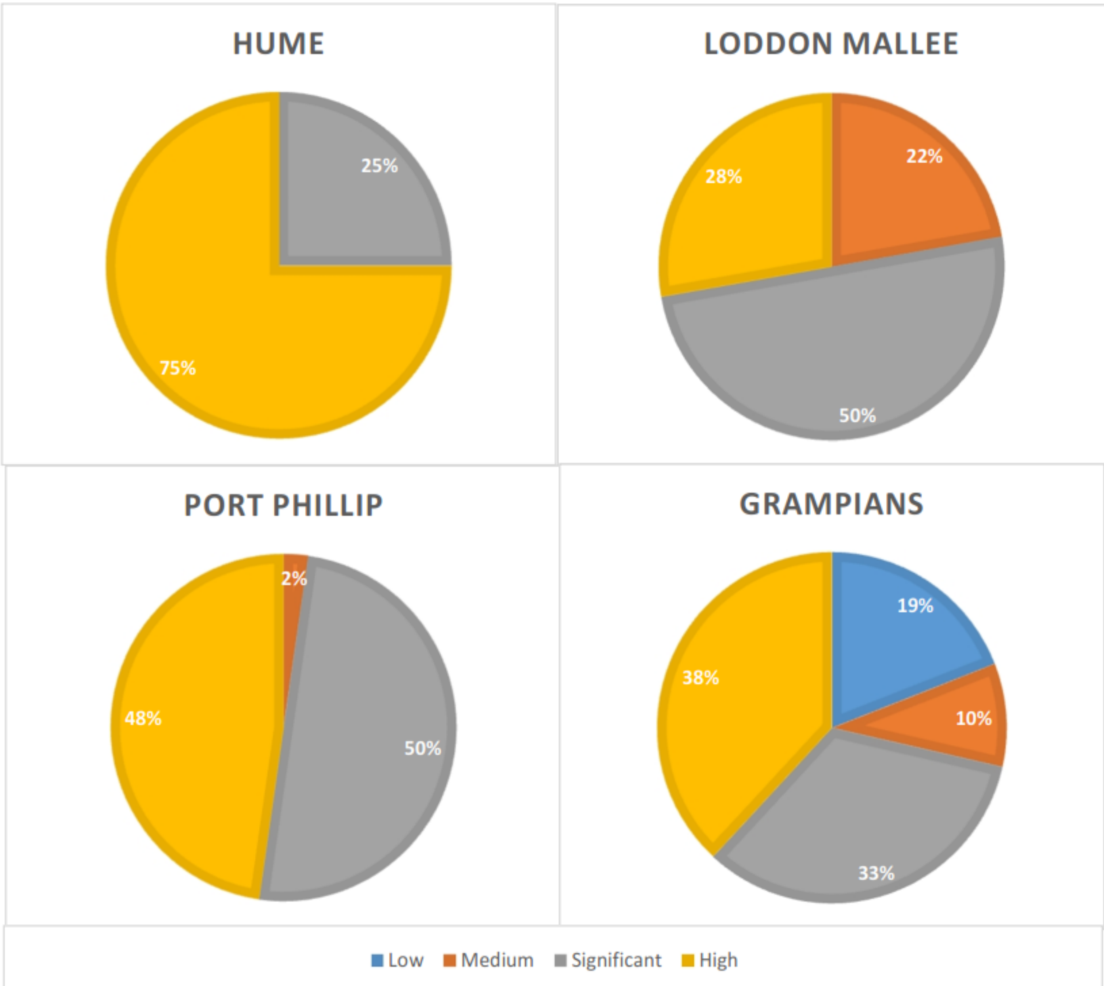

Figure 5: Risk Ratings per Region

The failure modes driving the risk ratings (i.e. failure modes with an assigned rating of 5) of the 103 selected sites that are embankment dams are illustrated in Figure 6 with a further breakdown per region provided in Figure 7.

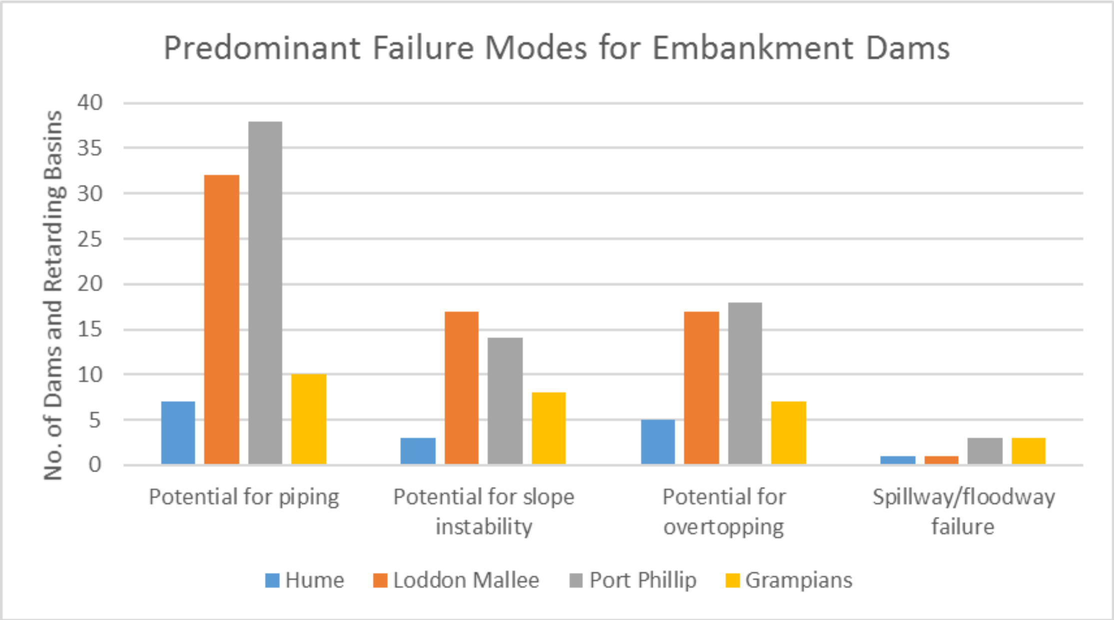

Figure 6: Summary of Predominant Failure Modes for Embankment Dams

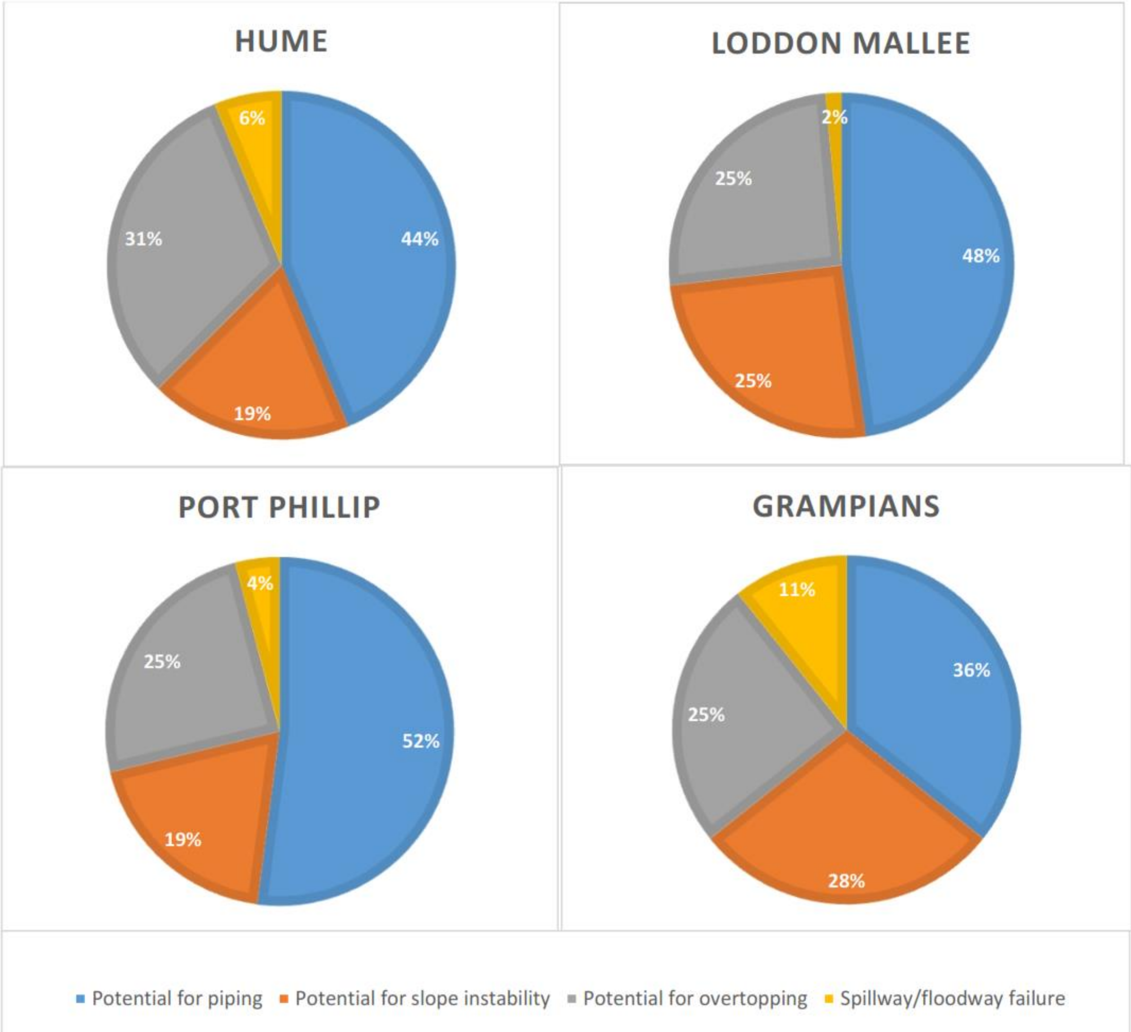

Figure 7: Predominant Failure Modes per Region for Embankment Dams

5.0 Summary

The approach taken to delivering the 2017 LGA Dam Safety Program was efficient, allowing DELWP to identify key dams and retarding basins that are expected to pose the greatest consequence and risk.

At the commencement of this project, DELWP had 435 sites identified under the control of 42 LGAs within four DELWP regions. The desktop review enabled the shortlisting of 109 sites (<25%) that warranted further investigation.

Adding to the 21 sites with prior consequence assessments, the review identified that of a total of 130 sites, there is:

- Less than 4% had a consequence category of Extreme or High A
- 8% had a consequence category of High B
- 45% had a consequence category of High C
- 29% had a consequence category of Significant; and
- Less than 15% had a consequence category of Low or Very Low

Of the 109 sites selected for a qualitative risk assessment, the review of risk identified that there is:

- 45 sites had a High risk rating
- 49 sites had a Significant rating
- 11 sites had a Medium rating
- 4 sites had a Low rating

Although the findings of this program cannot be considered definitive, overall, the 2017 Dam Safety program was able to narrow down the 435 sites to 45 sites that are assessed to pose a High risk in terms of consequences and likelihood of failure. Further effort in developing dam safety programs can now be prioritised for these dams by their respective owners.

The program also delivered a database, summarising information on the dams which could assist DELWP during emergency management. LGAs also received dam safety documentation to aid them in the ongoing management of these assets.

6.0 Outcomes and Benefits

During the early stages of this project, one of the key challenges was to identify a cost-efficient way of processing a lot of sites. The information provided on majority of the identified sites was very limited, with no known dam safety management program and a lack of understanding of the consequences and risks associated with each asset.

This project highlights the benefits of utilising available survey, aerial imagery and GIS software to develop basic data for a large number of sites in a short period of time. Given the high level nature of this type of data collection, there are limitations with accuracy however it gave the project team a very good platform to commence more site specific and detailed assessments.

There were a number of benefits arising from the outcomes of this project however a few are definitely worth emphasising, namely:

- We were able to gain the confidence and co-operation of LGAs. Majority of the LGAs were very supportive and interested in learning more about their assets.
- We established asset ownership of a number of dams. At the commencement of the project, there were a number of sites with unknown ownership and through discussions we were able to raise this issue and discuss whether the sites were the responsibility of Councils, DELWP, private or water corporations. A key benefit of this will be during emergency management situations.
- We initiated discussions and were able to understand risk profiles of LGA dams and retarding basins. DELWP and LGAs are now aware of the risk profiles and which sites require more attention.

- We developed simplistic dam safety management programs, with useful tools and instructions, that LGAs are now able to implement.
- The methods discussed, although developed specifically for the Victorian LGA dams portfolio, provide a sound basis for a screening tool to assess a large number of smaller dams in an efficient manner, quickly identifying higher consequence category dams requiring attention. This method could easily be modified and adapted to be applied to similar portfolios of dams.

7.0 References

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7.1 Acknowledgements

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