

**DSC3F**

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# TAILINGS DAMS

## Table of Contents

Item	Page
1. Introduction .....	2
2. DSC Tailings Dams Safety Goal & Key Requirements .....	2
3. Background .....	5
4. DSC Considerations.....	6
5. Documentation .....	15
6. References.....	16
D19 Form      DSC Intermediate Report Requirements .....	17

## 1. INTRODUCTION

The normal requirements of the NSW Dams Safety Committee (DSC) are set out in its guidance sheets with its principal guidance sheet, *DSC Background, Functions and Operations - DSC1A*, outlining the DSC's general operations and authority.

The DSC continues to give critical consideration to the unique characteristics of tailings dams. Dam owners, and their professional advisers, have full responsibility to determine, and take appropriate actions to ensure the ongoing safety of their tailings dams. However, the DSC also has a responsibility to promote best practices in this area by drawing owners' attention to any DSC requirements (see Section 2.2) for the processes and procedures involved, as well as providing guidance, on general issues or findings, that may assist owners in this regard.

This Guidance Sheet supersedes DSC19, and has been prepared to outline and clarify dam safety management practices which the DSC expects prescribed tailings dam owners will have in place for compliance with the normal requirements of the DSC.

In this regard, the DSC has had significant input to, and has adopted in principle, the 2003 Australian National Committee on Large Dam's (ANCOLD) *Guidelines on Dam Safety Management – August 2003* and the ANCOLD *Guidelines on Tailings Dams – May 2012* as its requirements for dam owners. Consequently, it is the DSC's policy that dam owners should normally comply with these ANCOLD guidelines (and their terminology) unless otherwise indicated in this sheet.

The sheet applies to all dams in NSW that store waste materials from mining / industrial operations (e.g. tailings dams, process dams, power generation ash dams). It does not apply to mine water supply dams or sewerage ponds which would be considered as conventional dams in terms of DSC requirements.

The DSC Tailings Dams Safety Goal and Key Requirements (Section 2) at the start of the sheet are a summary - the whole sheet is to be read for a proper understanding of DSC considerations on tailings and ash dams.

## 2. DSC TAILINGS DAMS SAFETY GOALS & KEY REQUIREMENTS

### 2.1 DSC Tailings Dams Safety Goals

The primary goal of the DSC, relevant to this Guidance Sheet, is that all prescribed NSW tailings dam owners apply appropriate dam safety management practices to their dams using a risk management approach in line with a whole of Government approach to public safety.

Another goal is that risks to community interests from the potential for dam failure are tolerable, the owner's determination in this regard being satisfactory to the DSC. This requires that the risks are detected, identified and assessed, that they are reduced, when necessary, as soon as reasonably practicable and in a way that best

serves community interests, and that they are kept under review throughout the life cycle of the dams.

It is for each dam owner to determine how these goals, including DSC requirements, (see Section 2.2) will be achieved and to demonstrate that the goal has been achieved, or will be achieved following safety improvements. The following sections of this sheet aim to provide guidance to assist dam owners in the achievement of the DSC goals.

## 2.2 DSC Key Requirements

This section summarises the DSC requirements outlined in this sheet.

### 4. DSC CONSIDERATIONS

In prescribing a dam under the Act, the DSC requires the owner to make an assessment of the Consequence Category of the dam refer DSC's Guidance Sheet on '*Consequence Categories for Dams*' (DSC3A) for a detailed explanation (s4.1).

Owners of all prescribed tailings dams are to comply with the provisions of the pertinent design chapters of the ANCOLD *Guidelines on Dams Safety Management – August 2003*, and ANCOLD *Guidelines on Tailings Dams – May 2012*, except where differing requirements have been specified by the DSC (refer DSC3F & DSC3G).

Dams that routinely pond water against the embankment must be designed as water retaining structures (s4.2.1).

The DSC normally requires that tailings dams have an emergency spillway or some other reliable and robust method of managing floods.

Owners are required to meet, in full, the provisions of the DSC's Guidance Sheet on *Acceptable Flood Capacity for Dams - DSC3B* (s4.2.2).

Owners are required to meet in full the provisions of the DSC's Guidance Sheet on *Acceptable Earthquake Capacity for Dams - DSC3C* (s4.2.3).

Designers should ensure tailings dams are designed to be stable throughout their life and the DSC requires evidence of these stability capabilities for its consideration at the design review stage (s4.2.4).

Particular attention should be given to minimising the risks of piping of tailings dams through appropriate design controls (e.g. layout, filters). Further, designers proposing dams to be constructed by end-dumping methods, or by use of run-of-mine material, should ensure that appropriate dam design configurations are employed to minimise piping (e.g. thicker sections, zoning layout etc) and deleterious settlement effects (s4.2.6).

Particular attention should be paid to the DSC's requirement for all significant and higher consequence category tailings dams, which store liquids against their embankments, to have fully intercepting filters or their equivalent (e.g. very wide designed transition zone) (s4.2.7).

Particular care should be taken at the design stage to minimise the risk of piping around any conduits required to transfer materials into and out of tailings dams (s4.2.8).

At the design stage, the DSC requires designers to specifically outline all designer requirements for operation and response actions that must be met to ensure the ongoing safety of the dam. Criteria are to be highlighted in the Operation and Maintenance Manual prepared for each tailings dam (s4.2.10).

The DSC has identified several particularly critical issues that require an appropriate minimum standard of design (and operation) to satisfy the DSC's requirements for upstream / centre lift tailings dams (s4.2.11).

The DSC requires dam designers to be integrally involved during the construction of tailings dams and to approve any design changes made during construction. This involvement is to be signed off formally by the Owner's representative in a Construction Certificate to be provided to the DSC at the end of each stage, and conclusion, of construction. Work-As-Executed Drawings and a Construction Report are to be provided to the DSC at the same time (s4.3).

Owners of all prescribed tailings dams are required to meet, in full, the provisions of the DSC's Guidance Sheets DSC2F, DSC2G and DSC3G. These requirements apply with the qualifications outlined in Section 4.4. The O&M Manual should specify all requirements for operators and the minimum level of operator training with alternatives (e.g. consultant assistance) whenever these levels are not available. Operation and Maintenance Manuals for tailings dams are to be updated at least every two years with the updated copies forwarded to the DSC for its information.

The DSC requires a Dam Safety Emergency Plan (DSEP), in conjunction with appropriate emergency authority planning, to be prepared for prescribed tailings dams where non-itinerant persons could be at risk. The DSC requires a modified DSEP to be prepared for all other prescribed tailings dams (refer DSC2G for details). DSEPs are to be forwarded to the DSC for its consideration before commissioning of tailings dams (s4.4).

Owners of all prescribed dams are required to meet in full the provisions of the DSC's Guidance Sheet on Requirements for *Surveillance Reports - DSC2C* and align with the reporting/inspection frequencies outlined in Table 10 of the *ANCOLD Guidelines on Tailings Dams – May 2012*. The DSC requires all prescribed dam owners to submit the results of their comprehensive inspections in Surveillance Reports to the DSC.

Due to the normally dynamic nature of tailings dams, the DSC requires the owners of tailings dams to submit the results of their intermediate inspections in reports for the DSC's consideration (s4.5). For dams requiring Type 1 and 2 Surveillance Reports, these intermediate reports should be prepared by a suitably qualified engineer, and cover the review requirements for Surveillance Reports (see attached DSC Form D19 for report checklist). Owners of other prescribed tailings dams are to submit their intermediate reports in the format of Type 3 Surveillance Reports (s4.5).

Incident Reports of any events threatening dam safety, including their inspection, assessment and remedial action / control details, are to be forwarded at the earliest opportunity for the DSC's consideration (s4.5).

Dam owners are required to advise the DSC of their long-term strategies at the initial design stage for the dam to enable assessment of the long term feasibility of design options. Dam owners are also required to submit their final decommissioning proposal for the DSC's consideration prior to implementing their decommissioning processes (refer Section 4.6 for detailed DSC requirements).

## 5. DOCUMENTATION

The DSC's normal requirements as to the substance and timing of information required by the DSC, and the responses to be expected from the DSC, are set out in the Committee's Guidance Sheet on *Documentation and Information Flow over Dam Life Cycle - DSC2B*. Rehabilitation Strategy Plans are to be submitted at the design stage to enable determination of the long term feasibility of design options. Management Plans are to be submitted at the design stage for upstream or centre lift construction tailings dams to ensure designer requirements are appropriately incorporated for these types of dams.

## 3. BACKGROUND

The DSC has statutory functions under the Dam Safety Act, 1978 and the Mining Act, 1992 to ensure that all prescribed dams do not impose an unacceptable level of danger to downstream residents and property or to adversely affect the public welfare and environment. In this respect, the DSC considers that nearly all tailings dams, because of their size, design, or the nature of the materials they store, can pose a significant threat to the community and the environment and are therefore subject to DSC requirements.

In preparing its normal requirements for tailings dams, as set out in this Guidance Sheet, the DSC has adopted, as its basic requirements, the guiding principles set out in the *ANCOLD Guidelines on Dam Safety Management - 2003*. However it notes that there are a number of unique issues associated with tailings dams, including:

- The presence of other regulators, and instruments, such as the Department of Primary Industries, the Department of Environment and Climate Change and the Clean Waters Act;
- The dynamic nature of the mining industry where mining infrastructure may have a short design life at any given site and that the purpose, and geometry, of tailings dams can change over the life of the project. Further, it is understood that there can be a high rate of turnover of personnel compared to more conventional water supply dams;
- The sites are often in isolated areas suggesting a low impact on persons and property. However the dams can be involved in complex mineral extraction processes that may have a major impact on water quality in addition to the normal hazards of uncontrolled discharge; and
- The short term nature of the industry obliges the owner to ensure timely submission of information to the DSC. It is essential that all owners of tailings dams rigorously comply with DSC requirements in terms of detail and timing to allow the DSC to undertake its commitment to review the submissions within its scheduled meeting program.

Generally, tailings dams have a reasonable safety record. However, records indicate, on average, one or two major failures each year throughout the world. In addition, there are many recorded

instances of tailings dam failures which have caused a substantial impact on the community in terms of loss of life, property and major damage to the environment. Some recent examples are summarised in Table 1 below:

**TABLE 1 - SOME RECENT TAILINGS DAM INCIDENTS**

DATE	LOCATION	INCIDENT	IMPACTS
Oct. 2010	Hungary	Dam failure	Destroyed village, 9 people killed, high pH material contaminated long section of river
Dec. 2008	Kentucky, USA	Dam failure	Destroyed 4 houses, contaminated 3km of river
April 2006	Shanglou, China	Dam failure	Buried 9 houses, cyanide contaminated 5km of river
April 2005	Mississippi, USA	Flood failure	65,000m <sup>3</sup> of acidic water released
Sept. 2004	Florida, USA	Flood failure	230,000m <sup>3</sup> of acidic water released
Oct. 2003	Quinta, Chile	Dam failure	50,000 tonnes of tailings flowed 20km
Aug. 2002	Phillipines	Flood failure	Village flooded, 250 people evacuated
Nov. 2001	Singleton, NSW	Piping event	Flow stemmed before dam failure
Oct. 2001	Guangxi, China	Dam failure	115 people killed, 100 houses destroyed
June 2001	Minas Gerais, Brazil	Dam failure	Tailings flowed 6km and 5 people killed

#### 4. DSC CONSIDERATIONS

The generally dynamic and unique nature of tailings dams requires the DSC to keep a closer than usual audit overview of their performance. This audit process takes into account, amongst other issues, the following matters during the life of these dams.

##### 4.1 Consequence Assessment

In prescribing a dam under the Act, the DSC requires the owner to make an assessment of the Consequence Category of the dam, that is, the seriousness and magnitude of the adverse consequence that would arise if the dam failed. Dam owners are referred to the DSC's Guidance Sheet on *Consequence Categories for Dams - DSC3A* for a detailed explanation of the DSC's requirements in this regard. These DSC requirements align closely with the 2012 update (yet to be released) of the ANCOLD *Guidelines on the Assessment of Consequences of Dam Failure - May 2000*.

However, both the DSC and ANCOLD (clause 2.6 of its updated Guidelines) recognise the difficulties in quantitatively determining the environmental consequences of dam failure and hence the appropriate Consequence Category determination for tailings dams. To provide preliminary assistance in this regard, the DSC has amplified Table 3 of the ANCOLD Guidelines in Table 2.

## TABLE 2 - CONSEQUENCE CATEGORIES ASSESSMENT

(Adapted from the ANCOLD Consequence Guidelines Table 3 - the worst case of the three inputs - PAR, Receiving Environment and Severity of Damage and Loss- determines the Consequence Category)

Population at Risk-PAR	Receiving Environment	Severity of Damage or Loss			
		Minor (Benign Solid/Liquid)	Medium (Saline Liquid / Unsightly Solid)	Major (Acid Tailings)	Catastrophic (Highly Reactive/Toxic Tailings)
<1	Remote / Degraded	Very Low	Low	Significant	High C
≥1-10	Rural / Productive	Significant <sup>2</sup>	Significant <sup>2</sup>	High C	High B
>10-100	Urban / Sensitive	High C	High C	High B	High A
>100-1000		(Note 1)	High B	High A	Extreme
>1000			(Note1)	Extreme	Extreme

### Notes:

- 1 "Minor" damage and loss would be unlikely when the PAR exceeds 1000.
- 2 Change to at least *High C* where the loss of non-itinerant lives is reasonably likely.
- 3 See Sections 2.6 & 1.6 of ANCOLD Consequence Guidelines for explanation of the range of *High* Consequence Categories.
- 4 The PAR is to be the total PAR.

In view of the unique nature of tailings dams, the DSC will, in general, be conservative in making its preliminary considerations of consequence assessments for these dams unless comprehensive, specialised studies are provided by owners.

The DSC recommends that dam owners obtain a specialised evaluation of the environmental consequences of dam failure, particularly where toxic tailings or liquids are stored, with consideration given to increasing the dam's Consequence Category in these cases. This evaluation may require consultants with an understanding of the nature of the stored materials and the sensitivity of the downstream environment, working with a dams engineer proficient in dam break studies.

Dam owners should note that the DSC relies on the integrity and expertise of the owner or the consultant, but will judge each submission on a case-by-case merit according to the detail and accuracy of the information supplied.

Further, the DSC will also place some emphasis on the dynamic nature of the industry and the possibility that the Consequence Category can change over the mining operation's life. For example, the Consequence Category of a coal mine's dam can change according to the proximity of mining operations, or due to changes in operational practices in the placement of tailings (e.g. from paste to wet tailings).

## 4.2 Design

### 4.2.1 General

Owners of all prescribed tailings dams are to comply with the provisions of the pertinent design chapters of the *ANCOLD Guidelines on Dam Safety Management - August 2003*, and *ANCOLD Guidelines on Tailings Dams - May 2012*, except where differing requirements have been specified by the DSC (refer DSC3F & DSC3G).

Dams that routinely pond water against the embankment must be designed as water retaining structures.

The DSC has identified in the following sub-sections particular issues that should be considered by owners in their design submissions to the DSC (refer DSC2B for documentation details).

### 4.2.2 Flood Capacity

The DSC normally requires that tailings dams have an emergency spillway or some other reliable and robust method of managing floods. Pumps are not considered reliable especially as it can be difficult to account for movement of the decant pond. Gravity decants are more reliable, but need to be generously sized in order to account for the possibility of blockage. The reliability and capacity of any diversion bunds are to be taken into consideration when determining flood capacity of tailings dams.

Owners of all prescribed tailings dams are required to meet, in full, the provisions of the DSC's Guidance Sheet on *Acceptable Flood Capacity for Dams - DSC3B*. These requirements are in line with the *ANCOLD Guidelines on Selection of Acceptable Flood Capacity for Dams - 2000*, which have been adopted, in principle, by the DSC. However, tailings dams have operational issues that require a range of operational flood criteria, in addition to overall flood capability as follows (summarised in Table 3):

**Beach Freeboard.** For upstream and centre lift tailings dams without internal filters, it is crucial to control the phreatic surface level against the upstream face of these dams to minimise their piping risks and maximise stability. This is achieved by placing tailings against the upstream face of these types of dams and maximising the distance between the tailings pond and the embankment. A minimum beach freeboard is specified for these dams. This is defined as the vertical distance between the top of the tailings, abutting the upstream face of the dam, and the tailings pond level, which will contain the rainfall volume of a 72 hour storm (AEP as in Table 3) after inflow of a 1 in 100 AEP, 72 hour rainfall event on top of normal operating pond level;

**Pond Recovery Time.** The Operational Pond Limit is the maximum extent of the pond under normal operating conditions. During heavy rainfall it would be expected that this limit would be exceeded, and procedures and facilities should be available that will allow recovery of the pond level, formed by the inflow of a 1 in 100 AEP, 72 hour rainfall event, back to the Operational Pond Limit within a specified period;

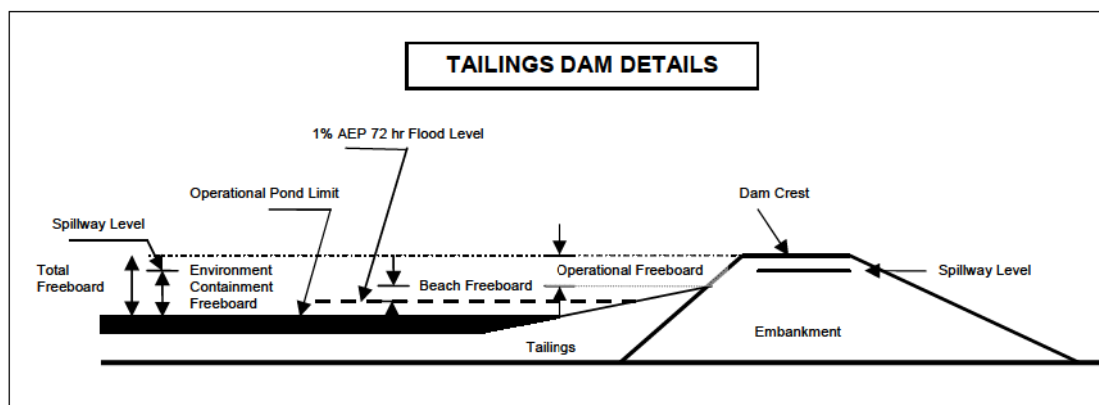
**Operational Freeboard.** This is the vertical distance between the top of the tailings and the adjacent embankment crest. A minimum operational freeboard is normally specified to minimise the potential for backflow and overtopping as a result of tailings mounding at discharge points (usually superseded by environmental containment freeboard);



**Environmental Containment Freeboard.** This is the vertical distance between the Operational Pond Limit and the spillway crest level. It is designed to maximise the containment of stored wastes and minimise the number and size of potentially damaging outflows during flood events over the life of a tailings dam. This freeboard is normally set to contain the rainfall volume produced by a 72 hour storm of a certain AEP, without spilling (Note: this is discussed similarly in Section 5.1.3 of the ANCOLD *Guidelines on Tailings Dams – May 2012* relating to dam spill consequence category). Usually the Department of Environment and Climate Change will give its requirements for individual tailings dams but indicative AEPs for 72 hour storms are listed in Table 3; and

**Total Freeboard.** This is the vertical distance between the Operational Pond Limit and the crest of the dam, and represents the capacity of the dam to pass an extreme storm by combination of storage and spillway discharge, and prevent overtopping of the dam. The requirement for total freeboard is specified in line with all other prescribed dams, and relates to the Consequence Category for the tailings dam.

Illustrative representations of these freeboard criteria are set out in the following diagram.



The DSC's minimum and indicative guidelines for these flood criteria are set out in Table 3:

**TABLE 3 - TAILINGS DAM FLOOD CRITERIA**

Consequence Category	Low	Significant	High C	High B	High A / Extreme
Beach Freeboard (AEP-72hr storm) – min	1	10 <sup>-1</sup>	10 <sup>-2</sup>	10 <sup>-3</sup>	10 <sup>-4</sup>
Pond Recovery Time (days) – max	14	14	7	7	7
Operational Freeboard (mm) – min	300	300	500	500	500
Environmental Freeboard (AEP-72 hr) – indicative	1	10 <sup>-1</sup>	10 <sup>-2</sup>	10 <sup>-3</sup>	10 <sup>-4</sup>
Total Freeboard (AEP-critical duration)-min	10 <sup>-3</sup>	10 <sup>-4</sup>	10 <sup>-5</sup>	10 <sup>-6</sup>	10 <sup>-7</sup>

#### 4.2.3 Seismic Capacity

Owners of all prescribed tailings dams are required to meet in full the provisions of the DSC's Guidance Sheet on *Acceptable Earthquake Capacity for Dams - DSC3C*. However, tailings can be susceptible to liquefaction under seismic loading and, in particular, tailings dams which rely on tailings for support, should be carefully assessed for their seismic stability. In addition, foundations under tailings dams should be examined closely for liquefaction potential (refer Section 6.6(1) of *ANCOLD Guidelines for Design of Dams for Earthquakes – 1998* and Section 6.1.5 of *ANCOLD Guidelines on Tailings Dams – May 2012* for further information).

#### 4.2.4 Stability

Designers should ensure tailings dams are designed to be stable throughout their life from construction, through commissioning and operation, and ultimately their final decommissioned state. The DSC requires evidence of these stability capabilities for its consideration at the design review stage including, in particular, any operational rules required by the designer to ensure dam stability (refer Table 8 of *ANCOLD Guidelines on Tailings Dams – May 2012* for initial guidance in this area and noting construction safety factors do not apply to operational conditions).

#### 4.2.5 Foundations

The DSC has outlined some general design considerations for dam foundations in its Guidance Sheet on *General Dam Safety Considerations - DSC3G*. Particular consideration should be taken in foundation preparation design where the functionality of the tailings dam relies on a drained (e.g. subsoil drain, wellpoints) or impermeable (e.g. clay liner, cut-off) foundation.

#### 4.2.6 Earthworks

The DSC has outlined some general earthworks design considerations in its Guidance Sheet on *General Dam Safety Considerations - DSC3G*. Particular attention should be given to minimising the risks of piping of tailings dams through appropriate design controls (e.g. layout, filters). Further, designers proposing dams to be constructed by end-dumping methods, or by use of run-of-mine material, should ensure that appropriate dam design configurations are employed to minimise piping (e.g. thicker sections, zoning layout etc) and deleterious settlement effects.

#### 4.2.7 Seepage Control (Filters/Drains)

The DSC has outlined some general seepage control design considerations in its Guidance Sheet on *General Dam Safety Considerations - DSC3G*. Particular attention should be paid to the DSC's requirement for all significant and higher consequence category tailings dams, which store liquids against their embankments, to have fully intercepting filters.

#### 4.2.8 Conduits

The DSC has outlined some general design considerations for placement of conduits in its Guidance Sheet on *General Dam Safety Considerations - DSC3G*. Particular care should be taken at the design stage to minimise the risk of piping around any conduits required to transfer materials into and out of tailings dams.

#### 4.2.9 Erosion Control

Designers are to consider appropriate long-term erosion control measures to protect embankments from the effects of waves and rainfall runoff.

#### 4.2.10 Operational Requirements

At the design stage, the DSC requires designers to specifically outline all designer requirements for operation and response actions that must be met to ensure the ongoing safety of the dam. Criteria for mechanical and electrical works (including pumps) should also be specified and align with the considerations set out in the DSC's Guidance Sheet on *General Dam Safety Considerations - DSC3G*. Designers' operational requirements are to be highlighted in the Operation and Maintenance Manual prepared for each tailings dam.

#### 4.2.11 Upstream / Centre Lift Tailings Dams

While upstream tailings dams can be the cheapest method of construction, they require the highest level of operator skill and owner diligence in order to maintain their stability. They also need to be subject to strict design and operational constraints to ensure their ongoing safety (see Sections 7.7 and 7.8 of *ANCOLD Guidelines on Tailings Dams – May 2012* for further discussion). The DSC has identified several particularly critical issues, which require an appropriate minimum standard of design (and operation) to satisfy the DSC's requirements for this type of dam, as follows:

- A separate geotechnical report should be prepared;
- Results of a flownet analysis, detailing all assumptions, should be undertaken;
- Operating pond levels and trigger levels, which signal “unsafe” phreatic surfaces, should be determined and documented;
- Tailings discharge requirements for safe operation of the dam should be established;
- A planned, and safe maximum, rate of rise of the dam should be determined;
- Design parameters, values and requirements for seepage control, should be assessed and documented;
- Specifications for surveillance (including monitoring instrumentation) should be determined and outlined; and
- A conceptual rehabilitation plan should be prepared.

New dams should have either a suitably permeable foundation or an upstream drainage blanket. If this requirement is not met for existing dams then the Operational Pond Limit should be determined by flownet analyses based on measured permeability values. In the absence of a flownet analysis, or underdrainage system, the DSC will require that the operational pond not approach closer to the embankment than a distance which is 10 times the height of the embankment.

Flood handling capabilities of these types of tailings dams are particularly crucial for their long term safe operation and they should meet the criteria specified in Table 3.

The rate of rise of an upstream or centre-lift dam should not exceed 5 m per year. Proposals to exceed this rate should consider a total stress stability analysis and must incorporate additional monitoring aimed at fully understanding the pore pressures being developed in the dam.

### 4.3 Construction

Owners of all prescribed tailings dams are required to comply with the provisions of the pertinent chapters of the *ANCOLD Guidelines on Dam Safety Management – August 2003*, and *ANCOLD Guidelines on Tailings Dams – May 2012* which have been adopted by the DSC.

The DSC requires dam designers to be integrally involved during the construction of tailings dams and to approve any design changes made during construction. This involvement is to be signed off formally by the Owner's representative in a Construction Certificate to be provided to the DSC at the end of each stage, and conclusion, of construction. Work-As-Executed Drawings and a Construction Report are to be provided to the DSC at the same time (refer pertinent sections of DSC Guidance Sheets DSC2A, DSC2B and DSC3G for details).

### 4.4 Operation, Maintenance and Emergency Management

Owners of all prescribed tailings dams are generally required to meet, in full, the provisions of the DSC's Guidance Sheets DSC2F, DSC2G and DSC3G. These requirements are in line with the pertinent chapters of the *ANCOLD Guidelines on Dam Safety Management – August 2003*, and *ANCOLD Guidelines on Tailings Dams – May 2012*, which have been adopted by the DSC, subject to the following qualifications:

- Since operational rules are important for the ongoing safety of tailings dams, an Operation and Maintenance (O&M) Manual is to be compiled, normally prior to commissioning of a tailings dam. The exception to this requirement is for upstream and centre lift construction tailings dams where, as a minimum, the Operational Management Section of the Manual is to be forwarded at the design stage for DSC consideration. This action is required for these types of dams as design operational rules are crucial to their ongoing safety;
- Operational Management Plans within the O&M Manual should specifically highlight all designer requirements for operation and response actions that must be met to ensure the ongoing safety of the dam. The O&M Manual should specify all requirements for operators and the minimum level of operator training with alternatives (e.g. consultant assistance) whenever these levels are not available;
- Operation and Maintenance Manuals for tailings dams are to be updated at least every two years with the updated copies forwarded to the DSC for its information;
- The DSC requires a Dam Safety Emergency Plan (DSEP) to be prepared for prescribed tailings dams where non-itinerant persons could be at risk. The DSEP is to include an appropriate dambreak study with the conservative assumption of liquid tailings flow in the event of dam failure (refer DSC2G for details);
- The DSC requires a modified DSEP to be prepared for all other prescribed tailings dams (refer DSC2G for details);

- DSEPs are to emphasise planning and strategies to minimise dam failure impacts on the surrounding environment. DSEPs are to be forwarded to the DSC for its consideration before commissioning of tailings dams. DSEPs are to be updated annually with pertinent update sections forwarded to the DSC for its information.

#### 4.5 Surveillance

Owners of all prescribed dams are required to meet in full the provisions of the DSC's Guidance Sheet on *Surveillance Reports for Dams - DSC2C*. These requirements are in line with the pertinent chapters of the ANCOLD *Guidelines on Dam Safety Management - August 2003*, which have been adopted by the DSC. They recommend that dam owners undertake comprehensive inspections on initial dam filling, and thence on a regular basis, with intermediate inspections undertaken usually on an annual basis. Routine inspection and monitoring of the dam is to be undertaken by trained staff, with overall DSC surveillance requirements as set out in Table 4, which is adapted from the ANCOLD *Dam Safety Management Guidelines – August 2003*. Note that the frequency of comprehensive inspections for High and Extreme Consequence Category dams is 2 yearly, in accordance with the ANCOLD *Guidelines on Tailings Dams – May 2012*.

**TABLE 4 - TAILINGS DAM SURVEILLANCE CRITERIA**

Sunny Day Consequence Category	Low	Significant	High C	High B	High A / Extreme
Comprehensive Inspections	5yr	5yr	2yr	2yr	2yr
Intermediate Inspections	2yr	Annual	Annual	Annual	Annual
Routine Inspections	Monthly	Weekly	Tri- weekly	Daily to Tri-weekly	Daily
Rainfall	Monthly	Weekly	Tri- weekly	Daily to Tri-weekly	Daily
Pond Level	Monthly	Weekly	Tri- weekly	Daily to Tri-weekly	Daily
Seepage – rate	Monthly	Weekly	Tri- weekly	Daily to Tri-weekly	Daily
Seepage - chemistry analysis		Consider	Annual	Annual	Annual
Pore Pressure	Consider	3 Monthly	Monthly	Monthly	Monthly
Surface Survey <sup>1</sup>	Consider	2yr	Annual	Annual	Annual

**Note 1** For compacted dams on solid foundations - (more frequent survey required for lightly compacted dams and dams on compressible foundations).

The DSC requires all prescribed dam owners to submit the results of their comprehensive inspections in Surveillance Reports to the DSC (refer DSC2C for details). For water supply dams, the DSC does not require the submission of intermediate reports and they are usually incorporated into the normal Surveillance Reports for dams. However, due to the normally dynamic nature of tailings dams, the DSC requires the owners of tailings dams to submit the results of their intermediate inspections in reports for the DSC's consideration.

For dams requiring Type 1 and 2 Surveillance Reports, these intermediate reports should be prepared by a suitably qualified engineer, and cover the same surveillance issues addressed in five yearly Surveillance Reports, including updates on operations and programming, but need not be as detailed (e.g. not include a long-term review of surveillance data) as the review requirements for

Surveillance Reports (see attached DSC Form D19 for report checklist). Owners of other prescribed tailings dams are to submit their intermediate inspection reports in the format of Type 3 Surveillance Reports.

The following specific issues should be considered and reported to the DSC, where appropriate:

- Groundwater monitoring with special emphasis on the environmental impacts of the tailings dam on groundwater;
- Seepage monitoring, both visual observations and seepage measurement is required as a minimum; and
- Chemical analysis of seepage water with reference to changing chemical and
- physical characteristics of the flow.

In view of the short term nature of mining operations, it is essential that dam owners conform to the report process and the required deadlines for submissions. Failure to do so could result in delays of approvals to proceed with construction and operational activities, with consequent interruptions to the mining operation.

In ensuring effective surveillance of tailings dams, the owners are required to select suitable operational staff and arrange for their training in the areas of dam safety management with regular refresher courses to keep operators up to date with current practices. As part of that training, operators should be capable of recognising abnormal conditions and circumstances that could affect the safety of their dams and be able to institute appropriate actions including when to call for more expert assistance.

Incident Reports of any events threatening dam safety, including their inspection, assessment and remedial action / control details, are to be forwarded at the earliest opportunity for the DSC's consideration (refer DSC2A for details).

#### 4.6 Decommissioning

The decommissioning of tailings dams raises issues that are not faced in the decommissioning of other dams. The DSC notes that it is often necessary to undertake site rehabilitation and long term monitoring of decommissioned dams. Dam owners are required to advise the DSC of their strategies in this regard at the initial design stage for the dam to enable assessment of the long term feasibility of design options. Dam owners are also required to submit their final decommissioning proposal for the DSC's consideration prior to implementing their decommissioning processes.

In particular, the DSC requires, as a minimum, consideration of the following issues in decommissioning a tailings dam:

- Protection of its long term stability;
- The potential for erosion of an embankment, especially if it has been an upstream construction with a low quality material on the exposed face;

- Its flood capacity with consideration of provision for changes in future standards and the long term loss of holding capacity;
- Advice on its ongoing effects on the surrounding environment and long term controls to minimise these effects;
- Advice on the proposal for its long term monitoring and the role of the Department of Primary Industries in this respect; and
- Advice on when the dam can be de-prescribed, in the owner's opinion.

Dam owners are advised that the DSC will maintain prescription of any dam, and place its normal dam safety obligations on the dam owner, until such stage that the decommissioning process has guaranteed that the dam imposes minimal safety risks to life and the surrounding environment, whereupon the DSC will de-prescribe the dam.

## 5. DOCUMENTATION

The DSC's normal requirements as to the substance and timing of information required by the DSC, and the responses to be expected from the DSC, are set out in the DSC's Guidance Sheet on *Documentation and Information Flow over Dam Life Cycle - DSC2B*. These requirements apply for all tailings dams with the following qualifications:

- Incident Reports of any events threatening dam safety, including their inspection, assessment and remedial action / control details, are to be forwarded at the earliest opportunity for the DSC's consideration (refer DSC2A for details);
- Due to the usually dynamic nature of tailings dams, the DSC requires the owners of these dams to submit the results of their intermediate inspections in reports for the DSC's consideration. These reports should cover the same surveillance issues addressed in comprehensive Surveillance Reports, and include updates on operations and programming, but need not be as detailed as Surveillance Reports (refer sub-section 4.5 and Form D19 checklist). They should also include an updated DSC D8 Form to update the DSC on pertinent owner contact details;
- The DSC also has some concerns about the issue of ownership of tailings dams. Submissions should state clearly "Who is the owner?" and "What is their relationship to the land owner or leaseholder?" In this context, the term "owner" has its usual legal sense, and does not have the meaning defined in the *Dams Safety Act 1978*. There should also be advice on the corporate structure clearly outlining the responsibilities for the management of the dams. Any changes in the detail of these arrangements should be advised to the DSC immediately;
- Rehabilitation Strategy Plans are to be submitted at the design stage to enable determination of the long term feasibility of design options;

- Management Plans are to be submitted at the design stage for upstream or centre lift construction tailings dams to ensure designer requirements are appropriately incorporated for these types of dams; and
- Operational Management Plans are to be included in the Operations and Maintenance Manual for the dam.

## 6. REFERENCES

- ANCOLD (Australian National Committee on Large Dams), 1998, *Guidelines for Design of Dams for Earthquake*, August.
- ANCOLD, 2012, *Guidelines on Tailings Dams*, May.
- ANCOLD, 1999, *Guidelines on Tailings Dam Design, Construction and Operation*, October.
- ANCOLD, 2000, *Guidelines on Selection of Acceptable Flood Capacity for Dams*, March.
- ANCOLD, 2000, *Guidelines on Assessment of the Consequences of Dam Failure*, May (being updated in 2012).
- ANCOLD, 2003, *Guidelines on Dam Safety Management*, August.
- ANCOLD, 2003, *Guidelines on Risk Assessment*, October.
- DMEWA (Western Australian Department of Minerals and Energy), 1998, *Guidelines on the Development of an Operating Manual for Tailings Storage*.
- DMEWA, 1999, *Guidelines on the Safe Design and Operating Standards for Tailings Storage*.
- EPA, 1995, *Best Practice Environmental Management In Mining*, 1995
- Fell, MacGregor, and Stapledon, 2004, *Geotechnical Engineering of Dams*, GEED
- ICOLD (International Commission on Large Dams) Bulletin 97, 1994, *Tailings Dams-Design of Drainage-Review and Recommendations*.
- ICOLD Bulletin 98, 1995, *Tailings Dams and Seismicity-Review and Recommendations*.
- ICOLD Bulletin 104, 1996, *Monitoring of Tailings Dams-Review and Recommendations*.
- ICOLD Bulletin 106, 1996, *A Guide to Tailings Dams and Impoundments-Design, Construction, Use and Rehabilitation*.
- ICOLD Bulletin 121: *Tailings Dams Risk of Dangerous Occurrences Lessons learnt from Practical Experiences*
- Mining Association of Canada, 1998, *A Guide to the Management of Tailings Facilities*, September.
- UNEP, 1996, *Environmental and Safety Incidents Concerning Tailings Dams at Mines*.
- Vick, Steven, 1990, *Planning Design and Analysis of Tailings Dams* BiTech Publishers.
- WMC (Western Mining Corporation) *Guidelines for the Design of Tailings Storage Facilities- GL68*, undated.





## TAILINGS DAM - INTERMEDIATE REPORT REQUIREMENTS

### Checklist for owners and consultants preparing Reports

*Please return this form completed with Report*

The following checklist covers the minimum items to be included in Intermediate Reports. Please tick against each item to indicate completion of the item in the Report, and enclose the signed D19 Form with the copy of the Report submitted to the Dams Safety Committee. Please note that Reports which do not address all relevant items may not be accepted.

- Owner to provide cover letter indicating that the owner accepts the report and containing a program to carry out recommendations
- Conclusions (in point form)
- Recommendations (in point form), separate from the Conclusions
- Basic Dam Details – location, type of dam, height, crest length, storage volume, consequence categories, outlet works, spillway type and hydrology, etc
- Inspection
  - Details of inspection – names of inspection team, date, weather conditions, storage level
  - Condition of dam, e.g. evidence of slips, erosion, cracks, sink holes, piping, subsidence, seepage, settlement, movement, misalignment, etc. & history (old, recent or continuing)
  - Condition of Abutments & Foundations – seepages related to the storage, slips, erosion, piping, etc. & history
  - Condition of Spillways – stability, erosion, blockages, movement, etc. & history
  - Condition of Storage Basin & Downstream Areas
  - Condition & operability of inlet & outlet works, spillway works and other mechanical & electrical equipment
- Monitoring
  - Type of instrumentation and frequency of monitoring
  - Comment on monitoring measurements since the previous Report – seepage (rates & quality), pore pressures, groundwater, deformation surveys, rainfall, storage level, etc.
- Comment on compliance of inspection and monitoring procedures with the ANCOLD "Guidelines on Dam Safety Management - 2003".
- Comment on status of O & M Manual and Dam Safety Emergency Plan (DSEP)
- Findings of any reports produced since the previous Report
- Incidents which have occurred since the previous Report and actions taken
- Changes to the dam, operating procedures, developments, management or operating staff since the previous Report and their effect on dam safety.
- Comparison to the previous Report, action taken as a result of that Report's recommendations and any recommendations not carried out.
- Provide information on mining activities close to the dam or storage
- An opinion as to whether the dam is safe in terms of the Committee's requirements
- Signatures of Report writers
- Appendices
  - Dam data sheets - D1 & D8
  - Drawings, e.g. Site, General Arrangement, Cross-Section, Spillway, Outlet Works, etc.
  - Photographs of main aspects of dam taken during the inspection, particularly areas commented on in the Report
  - Monitoring data summary sheets
  - An IBM compatible CD, or equivalent, containing a Microsoft Word format file of the text and a PDF of the entire report including drawings and photos.

Checklist completed by: .....

This Guidance Sheet is one of a series available from our Website at:

<http://www.damsafety.nsw.gov.au>

In order to read this file you need a Portable Document Format (PDF) reader. A free PDF reader is available from <http://www.adobe.com/>

For any further information please contact:

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