MINING NEAR PRESCRIBED DAMS
MINING APPLICATIONS

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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.

One of the DSC’s main functions is the surveillance of mining within the Notification Area of any Prescribed Dam in NSW (see DSC4A for definitions) to ensure the safety of the Prescribed Dam and the security of its stored water. The DSC has defined Notification Areas around all prescribed dams and storages which it considers may be affected by mining. Prior to the commencement of mining within a Notification Area, mining companies must obtain the consent of the Minister administering the Mining Act. The DSC advises the Minister on the extent and type of mining to be permitted, and on any special conditions which should apply. Accordingly this Guidance Sheet, supersedes DSC33, June 1998, and is provided to indicate which aspects the DSC will consider before making recommendations on a mining application, and provides guidance on the extent and type of mining which the DSC may recommend to the Minister.

Companion guidance sheets indicate:

- definitions, and administrative procedures involved in obtaining consent for mining within Notification Areas (DSC4A) and includes details of the types of supporting material to be included with an application;
- some guidelines on the types of monitoring conditions normally recommended by the DSC to the Minister (DSC4C). These guidelines are an indication only as variations will occur as a result of local conditions; and
- some guidelines on preparing a contingency plan for mining under stored waters (DSC4D).

The DSC Mining Safety Goal and Key Requirements (Section 2) are a summary - the whole sheet is to be read for a proper understanding of DSC considerations on mining applications near prescribed dams.

2. DSC MINING SAFETY GOAL & KEY REQUIREMENTS

2.1 DSC Mining Safety Goal

The primary goal of the DSC, relevant to this sheet, is that mining risks to prescribed dams and their storages are demonstrated to be tolerable, with all these risks:

- Identified and assessed;
- Reduced as low as reasonably practicable (ALARP), and as soon as reasonable practicable, in a way that best serves community interests; and
- Kept under review throughout the life cycle of the mining operations.
The following sections of this sheet aim to provide direction and guidance to assist mining companies in achieving the DSC’s goal.

2.2 DSC Key Requirements

This section summarises the DSC requirements outlined in this sheet.

3. GENERAL APPROACH

The DSC will permit mining around or under dams and storages where it can be demonstrated to its satisfaction that mining will not have a significant adverse affect on the safety of the dam or the security of the stored waters.

4. LIMITS ON MINING NEAR DAMS

Each mining application is assessed on its merits and there are no pre-determined limits on the extent or type of mining.

5. MINING APPLICATION REQUIREMENTS

The fundamental requirement is for the applicant to demonstrate that mining will not have a significant adverse affect on the safety of the dam or the security of the stored waters.

A risk assessment can be useful for any application.

All applications should include an assessment of the geology and discuss its influence on the potential for mining impacts.

For all applications (particularly underground workings), predictions of surface ground movements are required and are critical to the decision to permit mining or not.

A mining schedule must be provided.

The DSC requires that applicants develop a contingency plan for mining applications adjacent to major water supply dams.

Applicant’s need to develop a plan for mine closure.

Applicants are required to submit a proposal for managing and monitoring the area with their application.

Applicant’s need to confirm to the DSC that arrangements are in place such that the dam owner will restore the safety of the dam if it is compromised by mining.

6. PRESENTATION OF THE MINING APPLICATION

All mining applications must include a summary report with sufficient information to allow the DSC to form its own opinion on the impact of the proposed mining.
• Mining will not reduce the safety of a dam to a level below its current requirements. Specifically an appropriate margin of safety based on the importance of the dam, its design and construction, and its Consequence Category (see DSC3A for definitions), will need to be incorporated into any approval; and

• Loss of stored waters will be within tolerable limits. The importance of the storage will determine the margin of safety required for any proposed mining.

Further research into the effects of mining beneath stored waters is encouraged by the DSC with the objective of achieving more efficient use of resources, consistent with safeguarding community interests and the existing investment in storage facilities.

4. LIMITS ON MINING NEAR DAMS

Approvals to mine in Notification Areas are issued subject to conditions recommended by the DSC which may limit the extent and type of mining, specify a particular layout or may stipulate a monitoring program or other project to be undertaken. Each mining application is assessed on its merits and there are no pre-determined limits on the extent or type of mining. However, it is unlikely that an applicant will be able to demonstrate that the following mining would be within tolerable limits for a major water supply dam (particularly a concrete dam):

• Uncontrolled extraction (e.g. full-sized longwalls) within 1.7x depth of cover of the dam structure;
• Any mining within 1.2x depth of cover of the dam structure;
• Mining under the stored waters with less than 60 m depth of cover;
• Secondary extraction (e.g. longwalls or pillar extraction) under the stored waters with less than 120 m depth of cover; or
• Uncontrolled extraction under the stored waters.

5. MINING APPLICATION REQUIREMENTS

The fundamental requirement is for the applicant to demonstrate that mining will not have a significant adverse affect on the safety of the dam or the security of the stored waters.

The effort required for an application will depend on the importance of the dam or storage being protected and the likelihood of mining impacts. Applicants are responsible for the content and for generally managing the application process. Applicants should develop an outline of an application and submit this to the DSC at an early stage.

Preparing an application to mine near a major water supply dam structure or storage is not a trivial matter. Applicants are required to comprehensively assess the risks to a dam or its storage reservoir as the result of mining. Successful applications tend to be scientific, rigorous, and supported by facts. They require inputs from a
multidisciplinary team. They may require a significant lead time, of the order of 12 months or more. Following are discussions of typical elements in an application.

5.1 Risk Assessment - optional

A risk assessment can be useful for any application. It may assist in:

- Assessing the viability of a proposal;
- Planning the investigations to be undertaken as part of the application, and determining the relative importance of these investigations; and
- Greater understanding of the impact of mining on the dam or stored water.

An assessment should be done at an early stage. For mining near a major dam it would be expected that the initial assessment would be incomplete as a result of insufficient information. However the assessment process will generate a list of aspects that require further investigations. When these are complete a final risk assessment can be undertaken.

Appendix A discusses an application approach from a risk assessment perspective.

5.2 Geological / Hydro-geological model – for all applications

All applications should include an assessment of the geology and discuss its influence on the potential for mining impacts. Where the mining may impact a major water supply storage, geology and hydrogeology play a critical role and should be given a suitable priority. Geology can influence:

- The stability of the workings;
- The development of the goaf and other sub-surface impacts;
- Subsidence and other surface ground movements; and
- Groundwater flow paths.

Structural geological features may have a strong influence on the performance of the mining operation and hydro-geological regime, and consequently are a major focus of the investigations.

The most credible models will be based on inspections of all the available sources: surface, underground, and boreholes. In particular the combination of surface and underground mapping may permit an assessment of the likelihood that structural features are continuous from the surface to the workings.

The highest level of detail would be required for any high risk applications, and medium risk applications that may impact on valuable stored water. These applications should integrate all available relevant data, such as:

- General surface mapping to determine contacts between geological units, overall structure, domains, structural fabric, etc;
- Lineament analyses;
• Satellite and airborne geophysical data;
• Detailed surface mapping in the vicinity of significant structural
geological features or areas of uncertainty;
• Data from boreholes, including lithology, structure, piezometric
data, and the results from permeability testing;
• Data from existing workings nearby; and
• In-situ stress measurements.

This data will provide important inputs to the necessary hydro-
geological modelling to predict mining effects on the groundwater
regime and the source and magnitude of potential inflows to the
mining operation.

As it integrates a number of data sources, care is required when
presenting the geological/hydro-geological model. The primary
document will be a series of plans and cross sections which aim to
summarise this information, supported by explanatory notes. An
appendix containing all the source documents should also be
provided.

5.3 Ground
movement
predictions –
for all
applications

For all applications (particularly underground workings),
predictions of surface ground movements are required and are
critical to the decision to permit mining or not. Accurately predicting
ground movements at points in valleys and remote from mining,
where movements may be small, is difficult. Both these situations
are relevant to the impact of mining on major dam structures, and
the former is also relevant to the impact of mining on stored water.
The prediction of ground movements should consider:

• Large Scale Movements: These usually occur over the mine
workings and in the immediate vicinity of the workings, perhaps
defined by an angle of draw to 20 mm of vertical movement
(which is the common criterion in NSW). Angles of draw vary
significantly, but an average of 26.5 degrees from vertical at the
underground edge of an extraction is often adopted in NSW. In
this realm “normal” or “systematic” mining induced subsidence
and strain occur.

• Far-Field Movements: These are predominantly horizontal
movements which increasingly dominate the total ground
movements further away from the “limit” of the Large Scale
Movements. The DSC is aware of cases where they have been
recorded up to 1.5 km from mine workings.

• Response of the site: Ground movements (Large Scale and
Far-Field) may be modified locally by the characteristics of the
site. Valleys in particular are known to sometimes respond to
ground movements in a different manner to relatively flat ground.
Geological features can also modify the locally recorded
movements.

• Response of the structure: Dams in particular tend to be long
structures, and may therefore be more susceptible to certain
ground movements. The nature of the dam will also contribute to
its response. For example, rigid construction (e.g. concrete) will
be more susceptible to concentration of strain at discrete points
than flexible construction, such as earth or rockfill. For applications relating to open cut mining, blasting predictions will be required on the maximum likely peak particle velocities and accelerations at critical points on the dam, together with the prediction of the impacts of these blasting effects.

5.4 Mining Schedule – for all applications

It is usual for applicants to have a concern over the timing of approvals. Communicating this to the DSC will help reduce the risk of delays, as will allowing sufficient time for the DSC’s review.

A mining schedule must be provided which shows the proposed timing for:

- Each panel or area applied for;
- The long-term (i.e. beyond the current application) mining program;
- Proposed delivery dates for any additional supporting information.

Delivery of documents needs to be coordinated with the DSC’s cycle of review and meetings.

5.5 Contingency Plan – for mining under or near stored waters

The DSC’s decisions are based on the best information available to it, and it takes considerable care in making these decisions. However the nature of mining is such that unexpected conditions are not uncommon. Given the possibility of serious consequences occurring in the event of encountering these conditions, the DSC requires that applicants develop a contingency plan for mining applications adjacent to major water supply dams and recommends them for other applications near stored waters. These plans may be associated with the potential for damage of the dam structure or an Inrush Control Management Plan aimed at minimising loss of stored water in the event that a major connection from the workings to the storage develops (see DSC4D for discussion on the preparation of contingency plans). These plans may cover particular areas of mining, and/or the overall mining application, depending on site conditions.

5.6 Closure Plan

The life of a typical major water supply dam is probably about an order of magnitude greater than a typical mining operation. The dam and storage need to remain in a safe condition for a very long time after mining has ceased. Applicants need to develop a plan for mine closure which takes into account:

- The need for stabilisation or sealing of the workings in order to achieve acceptable levels of risk in the long-term;
- The likelihood that deterioration of the workings after completion will lead to additional mining impacts; and
- The combined effect of any future mining together with that applied for.
Closure plans are particularly important where layouts are used which provide some support to the strata, (e.g. first workings or partial extraction layouts) as these have components which can deteriorate or fail over a long period. They are also important for applications that are close to the limit of tolerable risk.

Applicants must consider all possible post mining failure scenarios, demonstrate that there are feasible technical solutions to these and that they have the capacity to implement one. It may be difficult to fully develop these plans at the outset, so it may be appropriate to plan to review the performance of the workings at the completion of mining in an area. If appropriate, the DSC will arrange to have a suitable security deposit held to ensure that resources are available for the review and any required works before closure is finalised.

5.7 Management and Monitoring Proposal – for all applications

All approvals are subject to some form of monitoring (see DSC4C for details of typical DSC requirements). Applicants are required to submit a proposal for managing and monitoring the area with their application.

5.8 Agreement with the dam owner – for all applications

In the event that the safety of a dam structure is reduced below tolerable levels, or that unacceptable leakage is occurring from a storage, and the DSC decides that it is necessary to issue a notice under the Dams Safety Act to ensure the safety of the dam, this notice is likely to be issued to the dam owner. This situation arises partly because the owner remains responsible for safety of the dam, even when the safety is reduced as a result of the actions by others. It is also due to the need to issue notices that are enforceable, and certain actions relating to the repair of a dam or storage may not be enforceable when imposed on a person other than the owner of the dam as they may require, for example, the cooperation of the dam owner.

In an emergency quick action may be required. Clearly matters such as the roles of the various parties, access rights in the event of an emergency, the responsibility for costs and the like should be discussed and agreed in broad terms before an emergency occurs. Accordingly, applicant’s need to confirm to the DSC that arrangements are in place such that the dam owner will restore the safety of the dam if it is compromised by mining. There are no requirements on the arrangements to be made; this is left to the dam owner and mining company to negotiate. However the usual method of satisfying this requirement is by the provision of a written agreement between the mining company and the dam owner which convinces the DSC that the dam will be expeditiously repaired in the event that unacceptable mining induced damage occurs.

Note that the DSC’s role, and the approval for mining in the notification area, only relates to dam safety issues. Matters such as cosmetic damage to a dam or the cost of lost storage to the dam owner, are not dam safety issues. However the loss of access to a critical water supply as a result of damage to a dam is a dam safety issue.
6. PRESENTATION OF THE MINING APPLICATION

All mining applications must include a summary report with sufficient information to allow the DSC to form its own opinion on the impact of the proposed mining. The report should include all appropriate data and analyses, an assessment of the risk of the mining proposed and a statement by the applicant on their view of the impact of the application on the safety of the dam and its stored waters.

Applicants should note:

- It is a good investment to put resources into effectively presenting applications to reduce the time taken for review by the DSC and reduce the number of queries from the DSC;
- Analysis and interpretation of data is essential and simply supplying data is not acceptable;
- The supporting data is required to be submitted. The DSC does not believe that the interaction between mining impacts and dams or stored waters is well understood. As a result, the DSC will carefully review relevant details and, where appropriate, will form its own opinion on the facts; and
- A summary report is required which:
  - Summarises the application and guides the reader through the supporting documentation;
  - Integrates all the data, analyses and predictions;
  - Conclusively clarifies the mining impacts;
  - States the applicants assessment of the risks to the dam and stored waters;
  - Provides a peer review of the report for important applications;
  - Summarises any monitoring or contingency plans; and
  - Proposes a timeframe for review and approval that aligns with the mining operation’s timeframe.
APPENDIX A
RISK ASSESSMENT

A1 Introduction

A risk assessment can be useful for any application. It may assist in:

- Assessing the viability of a proposal;
- Planning the investigations to be undertaken as part of the application, and determining the relative importance of these investigations; and
- Understanding the impact of mining on the dam or stored water.

An assessment should be done at an early stage. For mining near a major dam it would be expected that the initial assessment would be incomplete as a result of insufficient information. However the assessment process will generate a list of areas that require further investigations. When these are complete a final risk assessment can be undertaken. Readers are referred to AS4360:2004 “Risk Assessment” and HB 436:2004 “Risk Assessment Guidelines” by Standards Australia for further background.

A2 Process

The generic risk assessment process can be summarised in the following steps:

1. Determine tolerable limits.
2. Identify mining hazards and impacts.
3. Determine the consequences.
4. Determine the likelihood.
5. Estimate the risk.
6. Evaluate the risks, are they tolerable?
7. Treat the risks to reduce them below tolerable limits.

These steps are discussed below in relation to assessing the impact of mining on dams and the potential for loss of stored waters. Each case will have unique aspects which need to be considered. At each stage it is critical to have experienced persons involved in discussions, as well as the stakeholders.

A2.1 Tolerable Limits

Setting these limits requires a discussion with stakeholders. At a minimum the DSC and the dam owner should be involved in this process. The objective is to maintain the safety of the dam structure and storage within tolerable limits.

A2.2 Risk Identification

A comprehensive risk identification needs to be undertaken. It is useful to do this in a structured way. One approach is to consider impacts generated by mining which might affect the safety of a dam. These impacts are the sources of hazard, which are triggered by mining.
Focussing on the safety of dams and protection of stored waters, impacts from mining might be categorised as:

- Large Scale Subsidence (see section “Ground movements” in main document);
- Far-Field Movements (see section “Ground movements” in main document);
- Response of the site (see section “Ground movements” in main document);
- Response of the structure (see section “Ground movements” in main document);
- Vibration due to blasting;
- Creation of open cut voids and potential highwall instability;
- Changes in permeability due to vertical and horizontal fracturing and collapse of strata, or opening of pre-existing fractures;
- Opening of a drainage point or conduit;
- Changes to the stress regime, leading to changes in permeability; and
- Changes to groundwater levels.

A2.3 Consequences

It is likely that damage to a dam or water supply would have consequences on a mining company’s operation. However the risk assessment needs to focus on the consequences to the community of damaging the dam, as this is the basis on which the DSC’s will assess the application.

The consequences might be separated into consequences for a dam structure, and consequences for a storage reservoir.

A2.3.1 Consequences for a dam structure

- Subsidence or settlement, which may reduce freeboard, leading to a reduction in flood capacity and possibly overtopping;
- Changes in slope, causing problems with drains and hydraulic structures. In extreme case instability in the upstream or downstream face due to a steepening of slope;
- Differential movement between the embankment, abutments, spillway, conduits, and other components, possibly leading to physical damage of components, increasing the likelihood of leakage and piping failure, or a failure of particular components (e.g. blocked conduits, burst conduits);
- Differential movement on geological structures present in the foundation;
- Strain concentration, in particular over long structures, leading to cracking and leakage, and potentially piping;
- Dynamic loading, which may result in settlement, liquefaction of foundations or (for tailings dams) of the storage; or
- Changes in groundwater, leading to ground movements or changing the groundwater pressure regime at the dam wall.

A2.3.2 Consequences for a storage reservoir

- Where the overburden is relatively permeable, creation of a drain (the workings) at a level below the stored waters, leading to loss of stored waters; and
Where the overburden is relatively impermeable, impacts on the stored water require the creation of flowpaths, or the enhancement of existing flowpaths. These flowpaths may or may not intersect the workings. Flowpaths may be made up of sub-paths created by:

- Pre-existing permeable beds;
- Pre-existing permeable geological structures: faults, joints, shear zones, dykes, sills, cinder, etc. These may have a substantial vertical component.
- Fracturing, probably with a significant proportion of vertical fractures, immediately above areas of extraction;
- Opening of voids as a result of sagging of strata over areas of extraction;
- Cracking at the surface;
- Uplift or bulging in the bottom of valleys, either pre-existing or as a result of mining, leading to the opening of voids;
- Reduction or increase in stress leading to a change in the permeability of a unit; or
- Man-made voids including old mine workings or exploration drill holes.

Evaluations of the severity of the consequences should take into account:

- Dam failure consequences (defined for all prescribed dams, see DSC3A); and
- The consequence of the loss of the stored waters.

### A2.4 Likelihood

Determinations of likelihood should take into account:

- The probability of sources of risk (e.g. ground movements due to subsidence, vibrations from blasting) being within predictions, and exceeding predictions;
- The probability that the workings may not perform as designed or that the geology is not as theorised (e.g. the probability of pillar failure, or the probability of encountering a major fault);
- The ability of a dam structure to accommodate ground movements. Generous filter zones, conservative design, and flexible components should improve the capability of a dam to withstand ground movements, whereas brittle components such as a concrete core or face, limited or no filter zones, or poor overall design will lead to greater concern for the safety of the structure. Generally earth or rockfill dams are more flexible than concrete dams; and
- The level of detail, or degree of uncertainty in the available data, models, analyses etc.

### A2.5 Estimate the Risk

An appropriate scheme for combining consequence and probability should be adopted. In determining this, applicants should be aware that the DSC will not endorse mining that would reduce the safety of a prescribed dam below tolerable levels.
A2.6 Evaluate the Risks

Risks may be assessed both quantitatively and qualitatively but quantified risks are preferred for assessment, where available, as they can be compared to the tolerable limits. Risks which exceed the limits need treatment to reduce the risks to tolerable limits.

A2.7 Treat the Risks

Risks can be avoided, the likelihood can be reduced, or consequences reduced. For each treatment option the likelihood, consequence and risk should be re-estimated, and the acceptability of the risk re-evaluated.