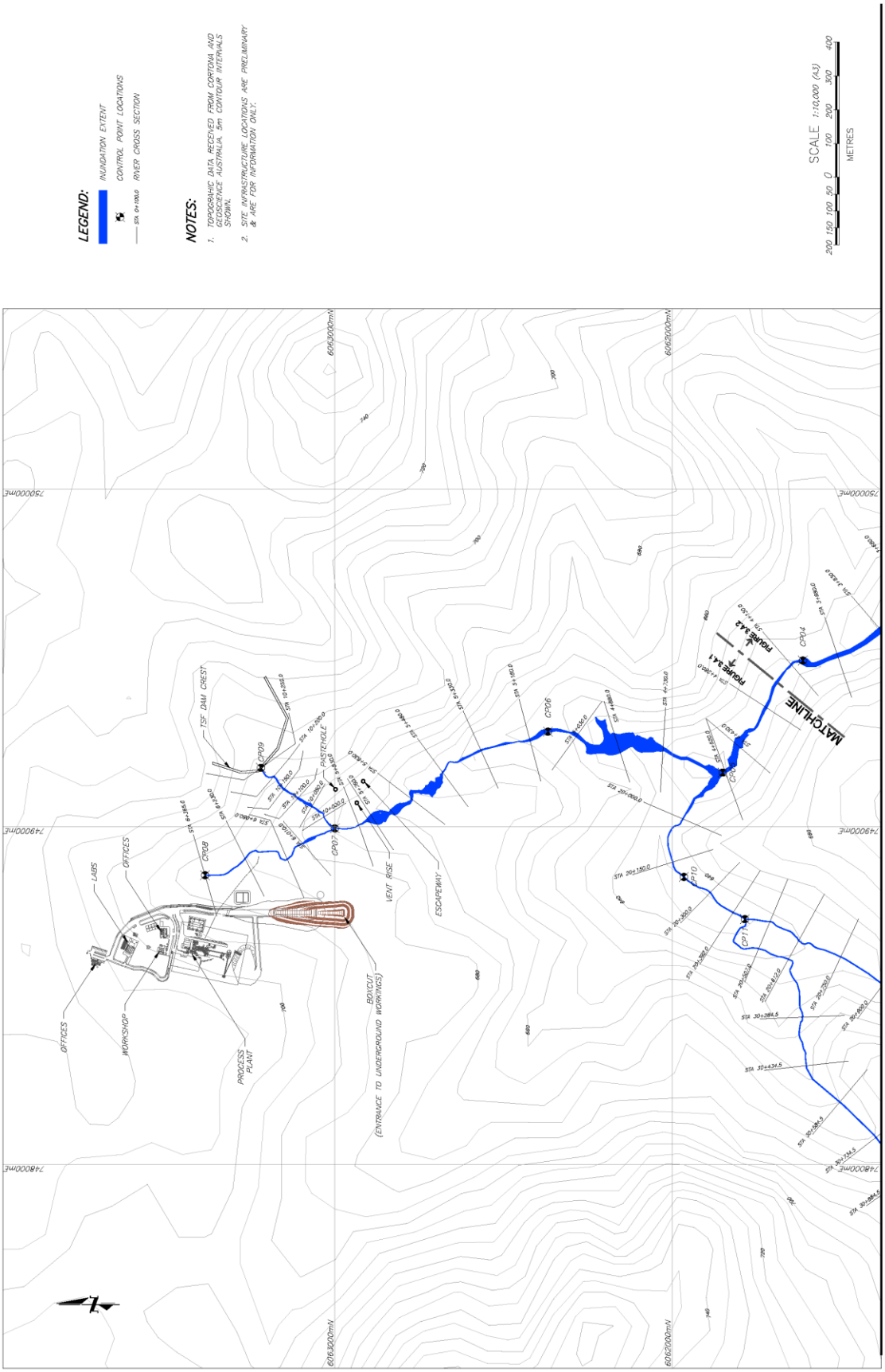
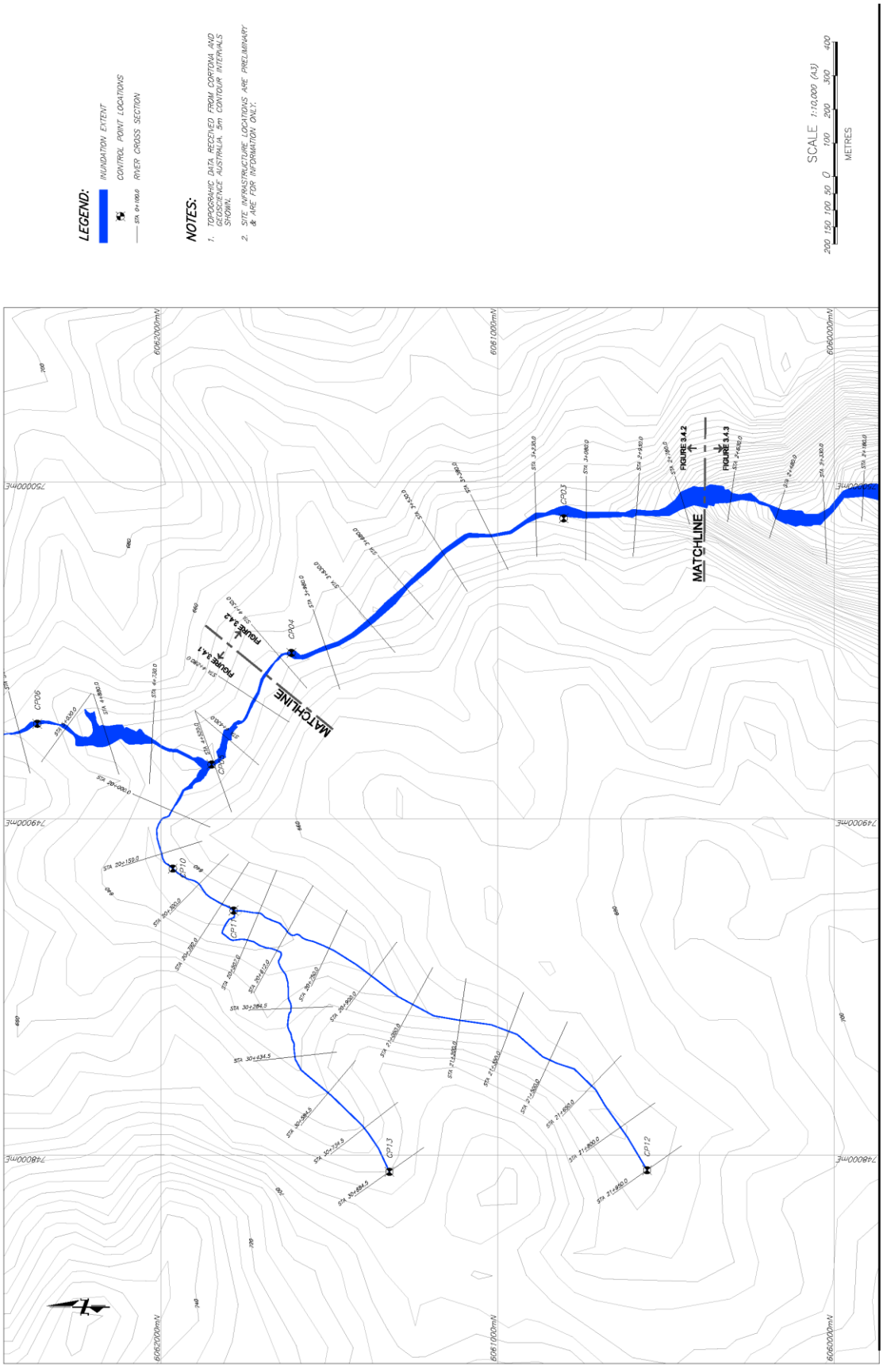


Knight Piésold CONSULTING



Ref: PE801-00139/08
Figure 3.4.2
Rev: 0

CORTONA RESOURCES LIMITED
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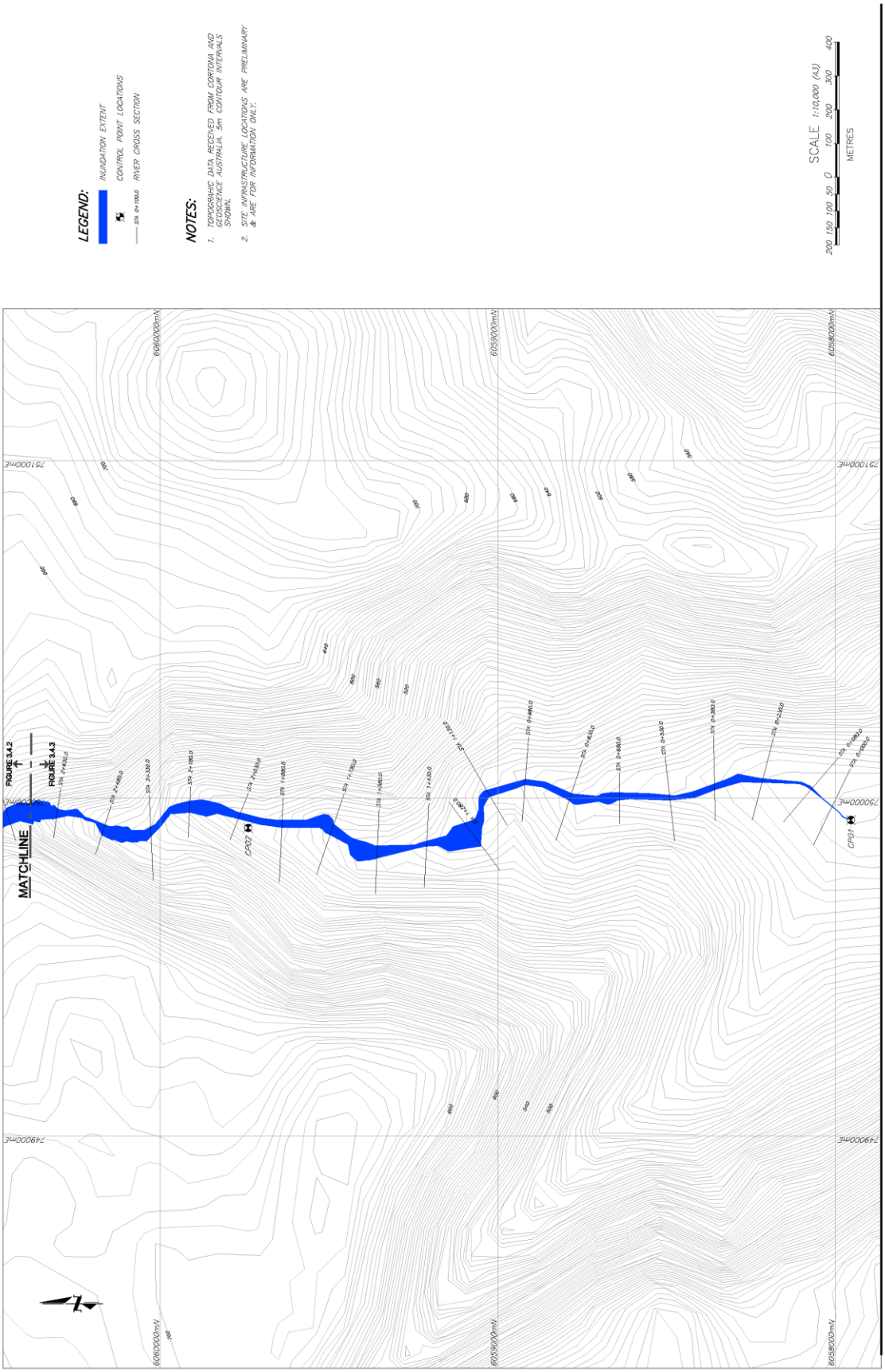
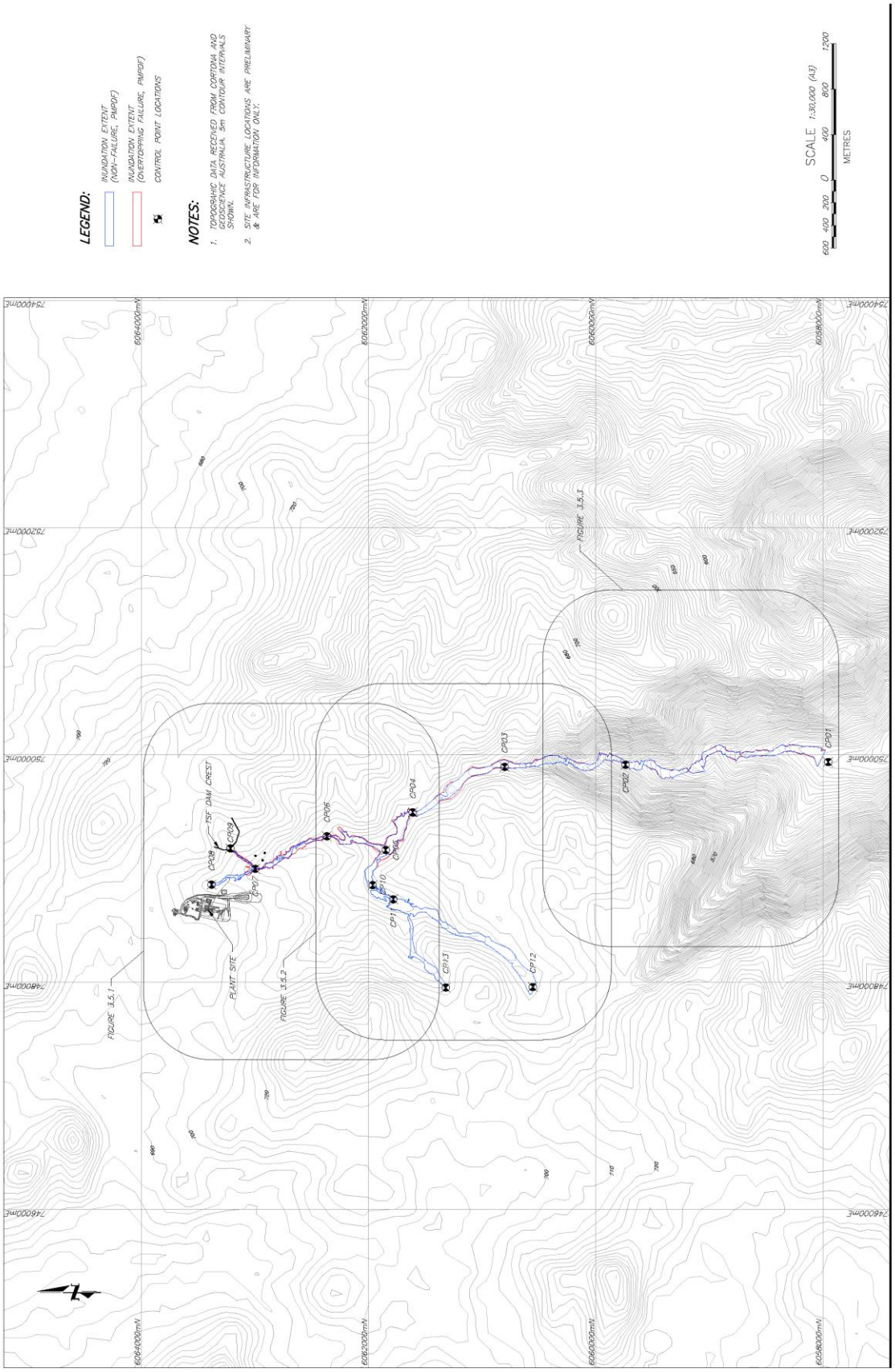
INUNDATION DETAIL MAP 2 (OVERTOPPING FAILURE, SUNNY DAY)

Knight Piésold CONSULTING



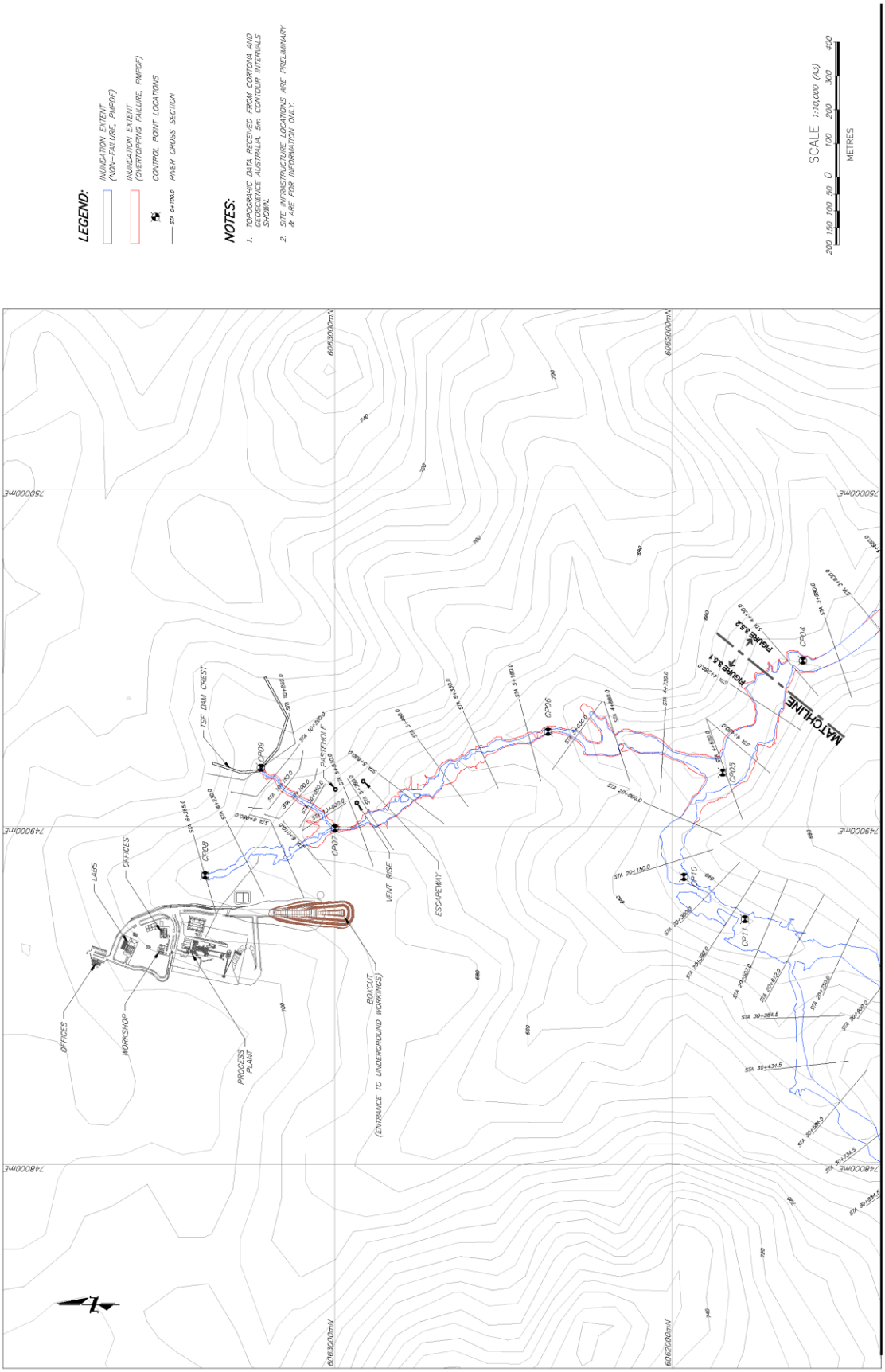
Knight Piésold CONSULTING



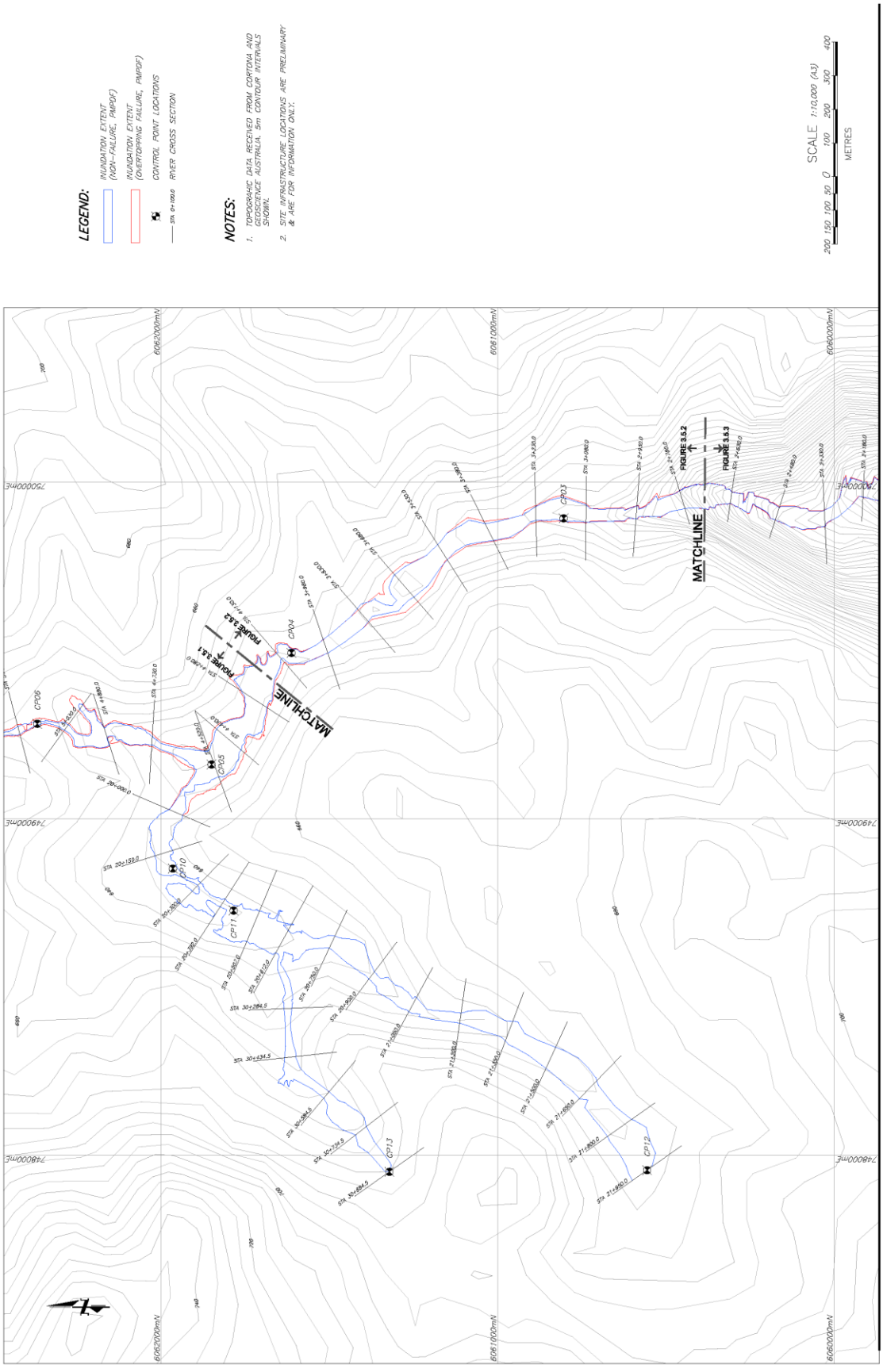
CORTONA RESOURCES LIMITED
DARGUES REEF GOLD PROJECT
INUNDATION KEY MAP (COMPARISON OF FAILURE AND NON-FAILURE DURING PMPDF)

Ref: PE801-00139/08
Figure 3.5
Rev: 0

Knight Piésold CONSULTING



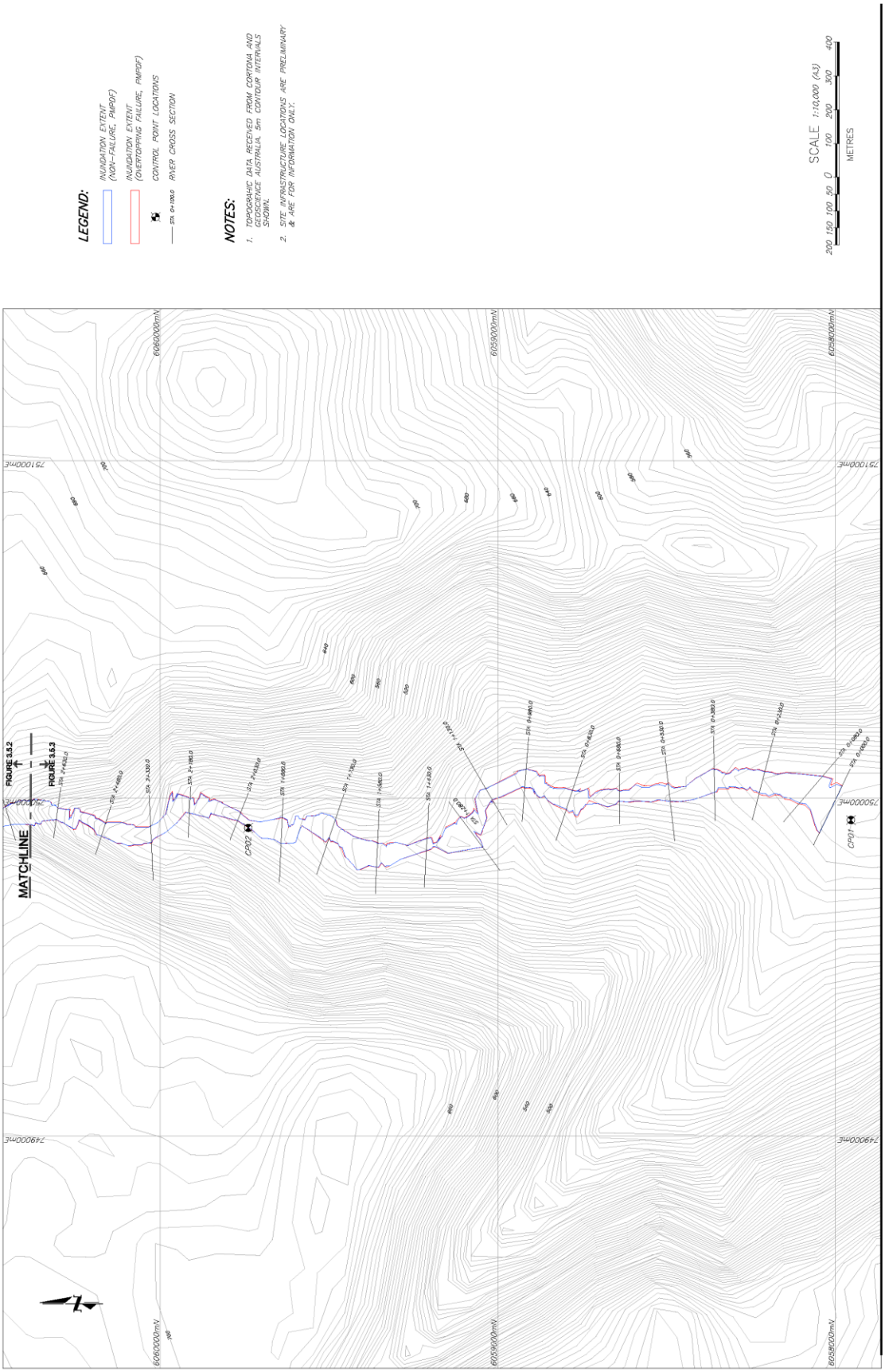
Knight Piésold CONSULTING



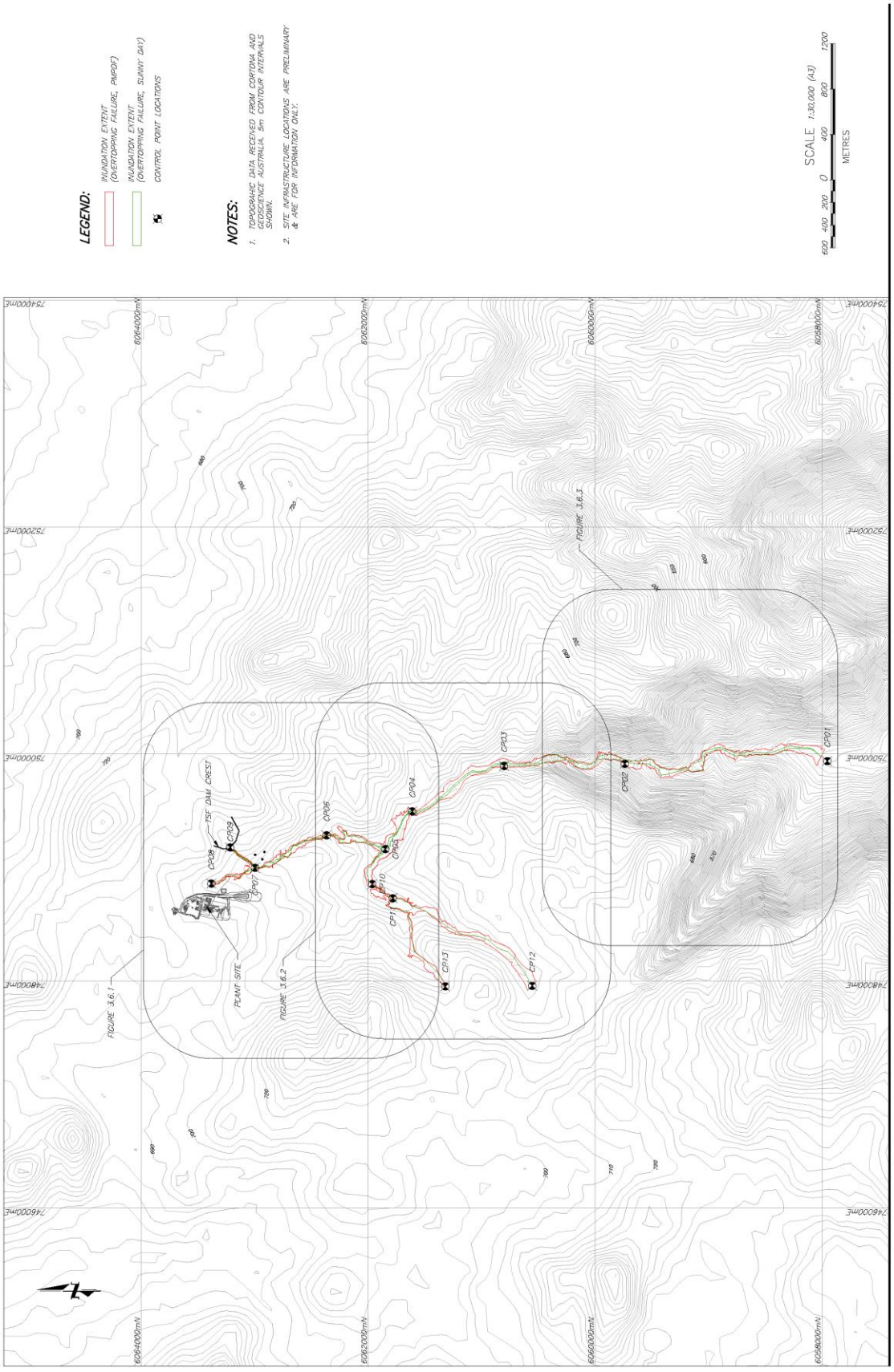
CORTONA RESOURCES LIMITED
DARGUES REEF GOLD PROJECT
INUNDATION DETAIL MAP 2 (COMPARISON OF FAILURE AND NON-FAILURE DURING PMPDF)

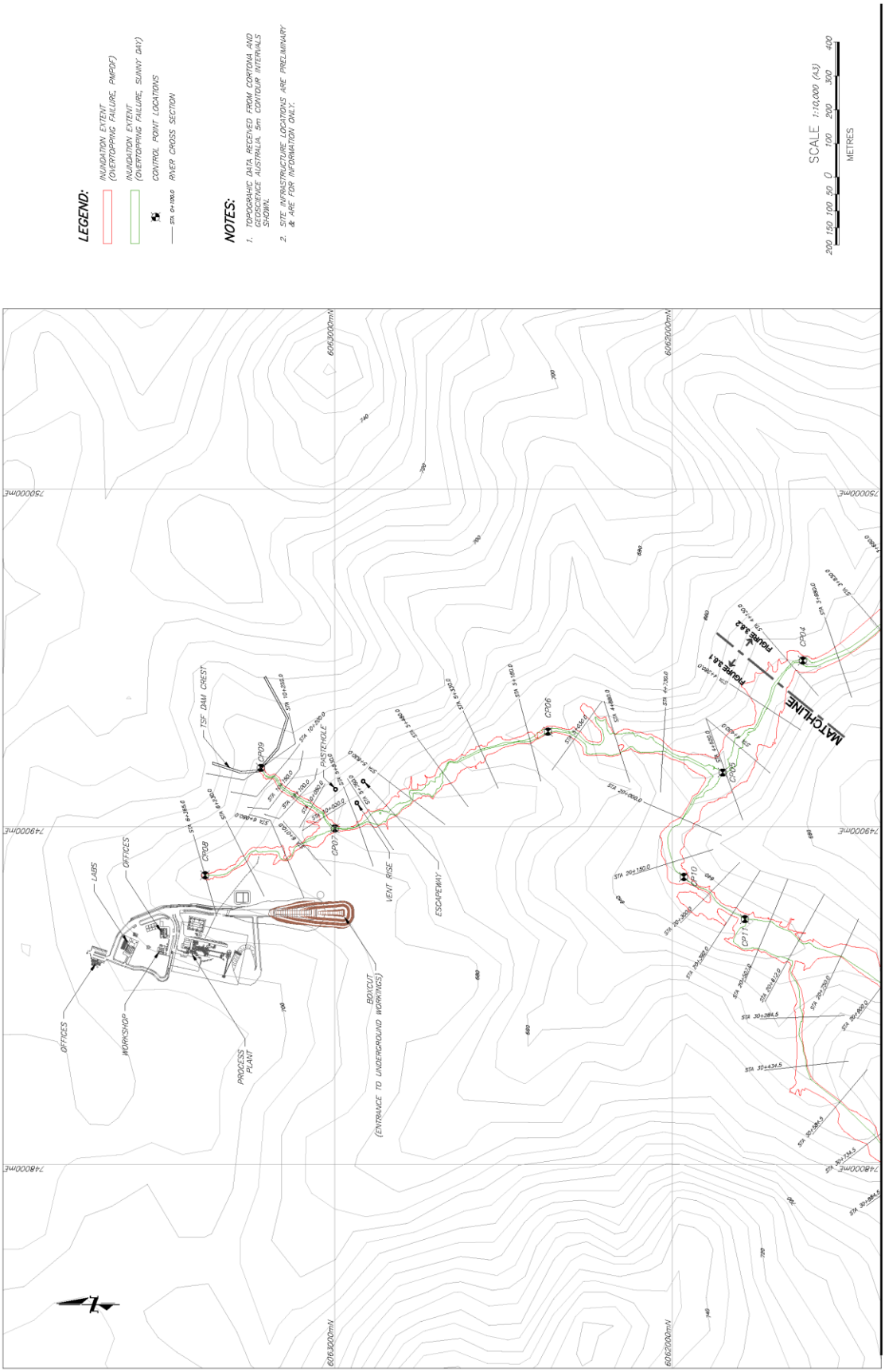
Ref: PE801-00139/08
Figure 3.5.2
Rev: 0

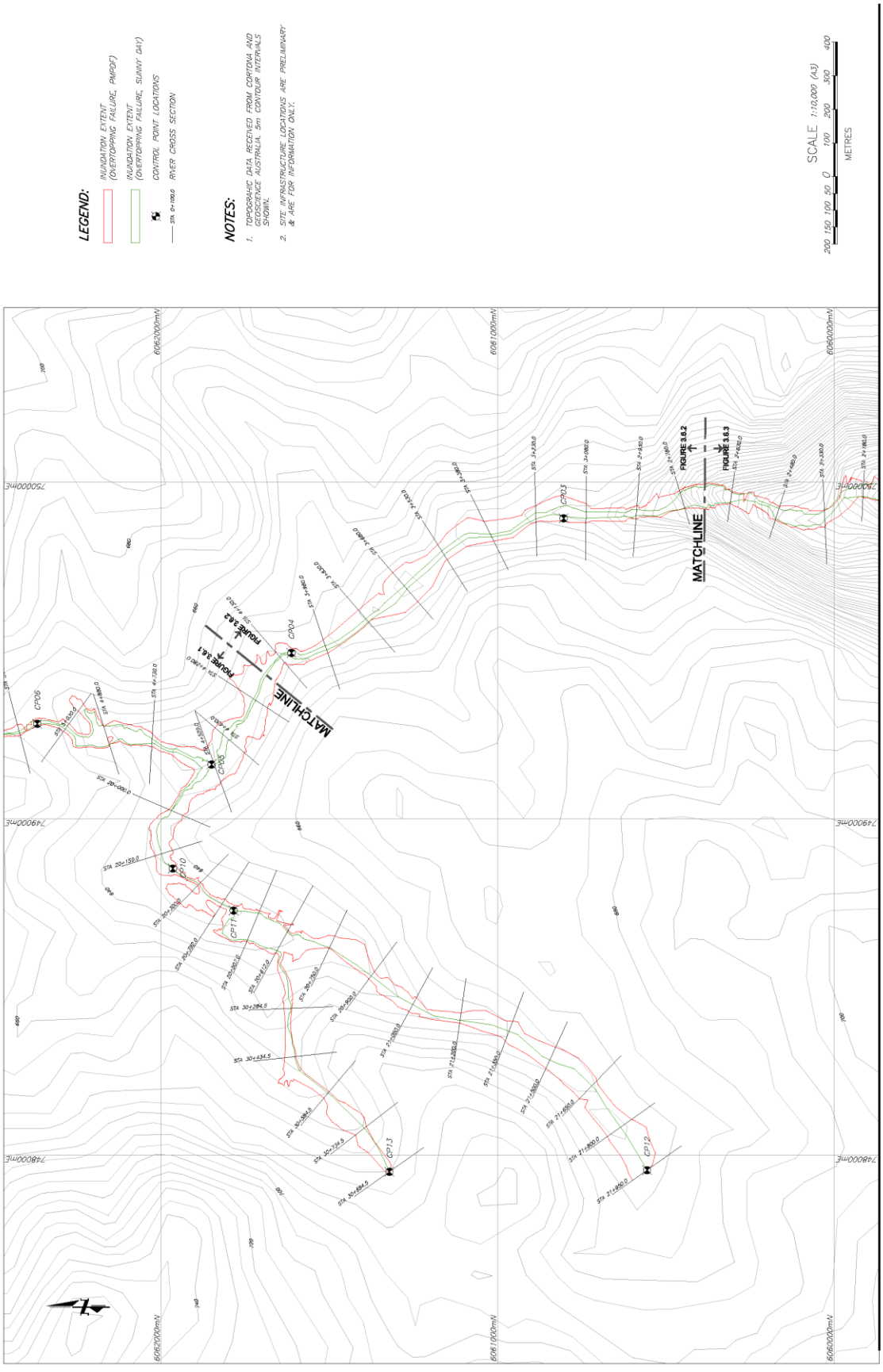
Knight Piésold CONSULTING



Knight Piésold CONSULTING


LEGEND:
INUNDATION EXTENT (OVERTOPPING FAILURE, PMPDF)
INUNDATION EXTENT (OVERTOPPING FAILURE, SUNNY DAY)
CONTROL POINT LOCATIONS
NOTES:
1. TOPOGRAPHIC DATA RECEIVED FROM CORTONA AND GEOSCIENCE AUSTRALIA, 5m CONTOUR INTERVALS SHOWN.
2. SITE INFRASTRUCTURE LOCATIONS ARE PRELIMINARY & ARE FOR INFORMATION ONLY.
SCALE 1:30,000 (A1)
600 400 200 0 400 800 1200
METRES
TSF DAM CREST
PLANT SITE
FIGURE 3.6.1
FIGURE 3.6.2
FIGURE 3.6.3
CP01
CP02
CP03
CP04
CP05
CP06
CP07
CP08
CP09
CP10
CP11
CP12
CP13
CORTONA RESOURCES LIMITED
DARGUES REEF GOLD PROJECT
INUNDATION KEY MAP (COMPARISON OF OVERTOPPING FAILURE DURING PMPDF AND SUNNY DAY)
Knight Piésold CONSULTING
Ref: PE801-00139/08
Figure 3.6
Rev: 0

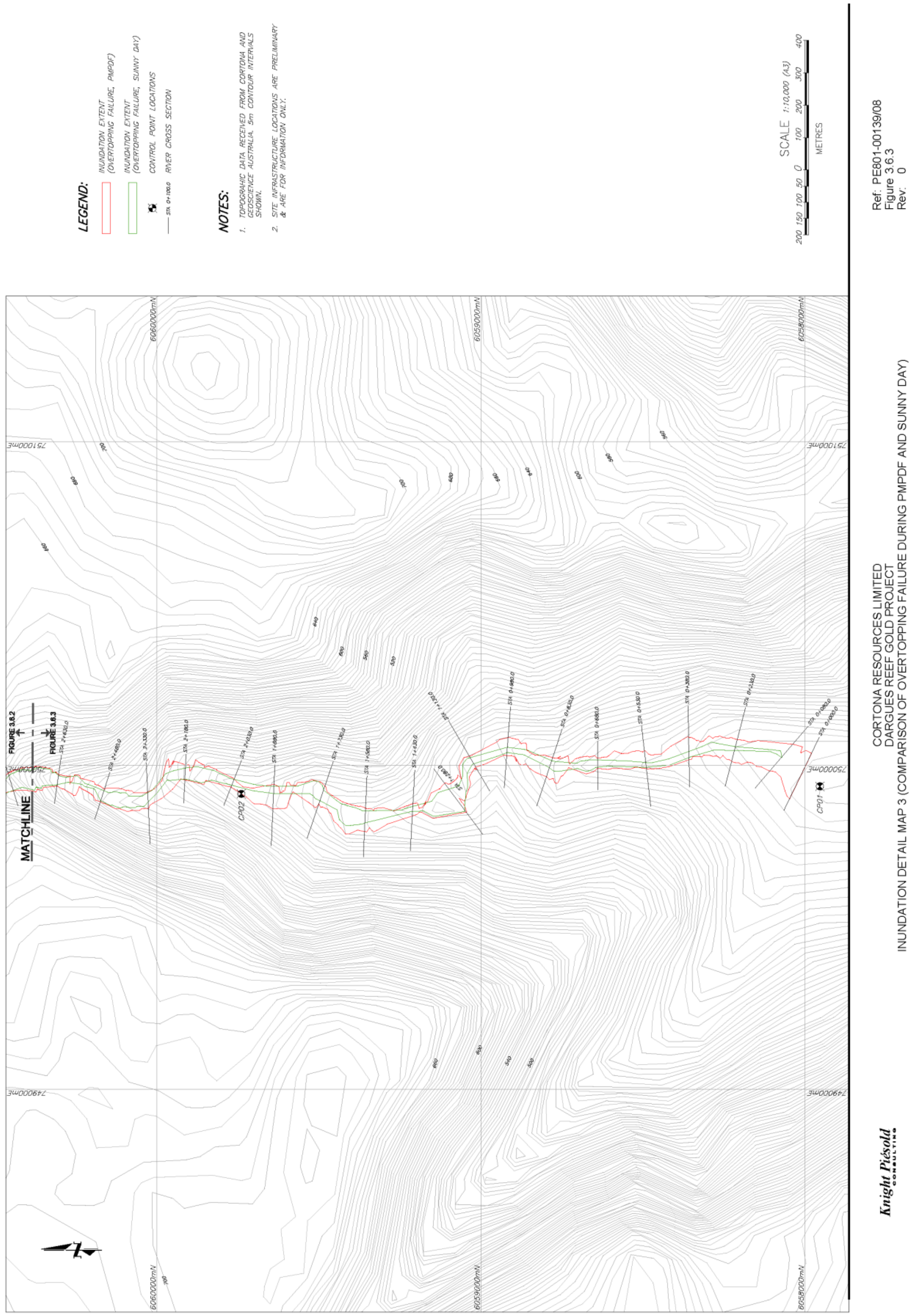

LEGEND:
INUNDATION EXTENT (OVERTOPPING FAILURE, PMPDF)
INUNDATION EXTENT (OVERTOPPING FAILURE, SUNNY DAY)
CONTROL POINT LOCATIONS
STA 0+100.0 RIVER CROSS SECTION
NOTES:
1. TOPOGRAPHIC DATA RECEIVED FROM CORTONA AND GEOSCIENCE AUSTRALIA. 5m CONTOUR INTERVALS SHOWN.
2. SITE INFRASTRUCTURE LOCATIONS ARE PRELIMINARY & ARE FOR INFORMATION ONLY.
SCALE 1:10,000 (A3)
200 150 100 50 0 100 200 300 400
METRES
CORTONA RESOURCES LIMITED
DARGUES REEF GOLD PROJECT
INUNDATION DETAIL MAP 1 (COMPARISON OF OVERTOPPING FAILURE DURING PMPDF AND SUNNY DAY)
Ref: PE601-00139/08
Figure 3.6.1
Rev: 0
Knight Piésold
CONSULTING
MATCHLINE
FIGURE 3.6.2
FIGURE 3.6.1
TSF DAM CREST
PASTEHOLE
CP09
CP08
CP07
CP06
CP05
CP04
CP10
CP11
LABS
OFFICES
WORKSHOP
PROCESS PLANT
VENT RISE
ESCAPEWAY
BOXCUT
(ENTRANCE TO UNDERGROUND WORKINGS)
6063000mN
6062000mN
6061000mN
750000mE
749000mE
748000mE

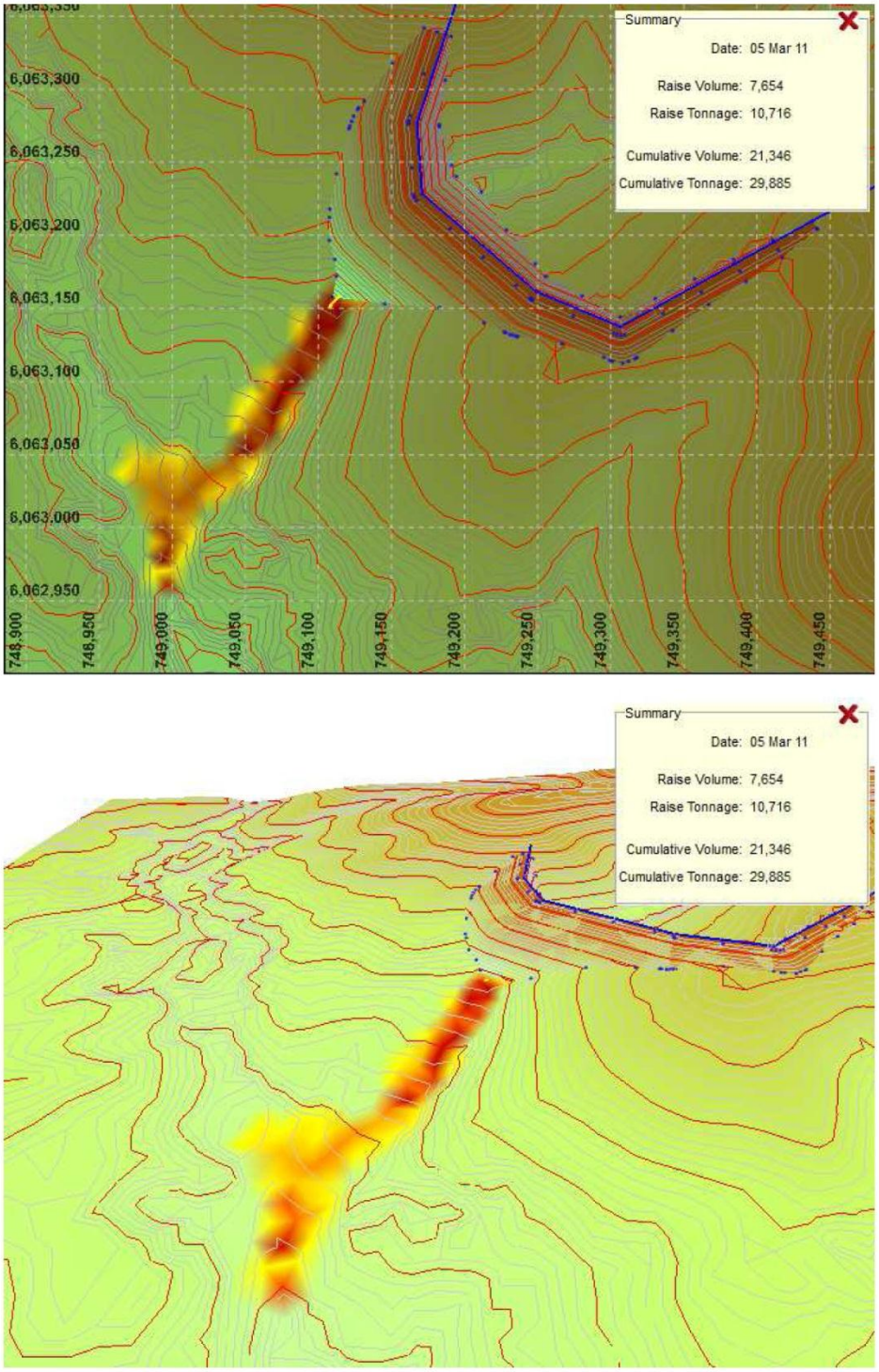


CORTONA RESOURCES LIMITED
DARGUES REEF GOLD PROJECT
INUNDATION DETAIL MAP 2 (COMPARISON OF OVERTOPPING FAILURE DURING PMPDF AND SUNNY DAY)

Ref: PE801-00139/08
Figure 3.6.2
Rev: 0

Knight Piésold CONSULTING


LEGEND:
INUNDATION EXTENT (OVERTOPPING FAILURE, PMPDF)
INUNDATION EXTENT (OVERTOPPING FAILURE, SUNNY DAY)
CONTROL POINT LOCATIONS
RIVER CROSS SECTION
NOTES:
1. TOPOGRAHIC DATA RECEIVED FROM CORTONA AND GEOSCIENCE AUSTRALIA. 5m CONTOUR INTERVALS SHOWN.
2. SITE INFRASTRUCTURE LOCATIONS ARE PRELIMINARY & ARE FOR INFORMATION ONLY.
SCALE 1:10,000 (A3)
METRES
MATCHLINE
FIGURE 3.6.2
FIGURE 3.6.3
CP01
CP02
CORTONA RESOURCES LIMITED
DARGUES REEF GOLD PROJECT
INUNDATION DETAIL MAP 3 (COMPARISON OF OVERTOPPING FAILURE DURING PMPDF AND SUNNY DAY)
Ref: PE801-00139/08
Figure 3.6.3
Rev: 0
Knight Piésold



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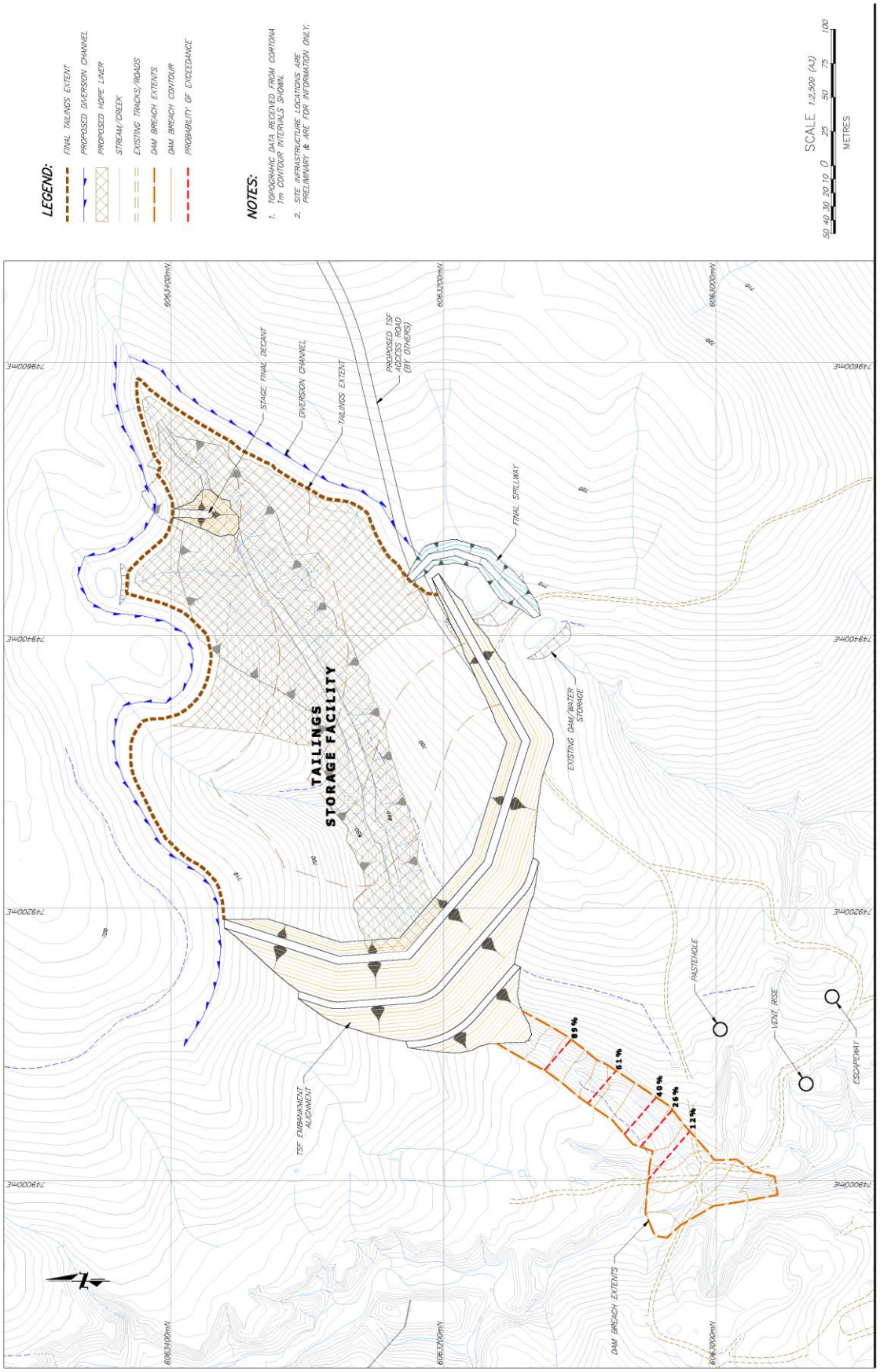
DARGUES REEF GOLD PROJECT
EMBANKMENT TAILINGS BREACH ANALYSIS
RIFT 2D AND 3D OUTPUT

PE801-00139
Figure 4.1


LEGEND:
FINAL TAILINGS EXTENT
PROPOSED DIVERSION CHANNEL
PROPOSED HDPE LINER
STREAM/CREEK
EXISTING TRACKS/ROADS
DAM BREACH EXTENTS
DAM BREACH CONTOUR
PROBABILITY OF EXCEEDANCE
NOTES:
1. TOPOGRAPHIC DATA RECEIVED FROM CORTONA 1m CONTOUR INTERVALS SHOWN.
2. SITE INFRASTRUCTURE LOCATIONS ARE PRELIMINARY & ARE FOR INFORMATION ONLY.
SCALE 1:2,500 (A3)
50 40 30 20 10 0 25 50 75 100
METRES
Ref: PE801-00139/08
Figure 4.2
Rev: 0
TAILINGS STORAGE FACILITY
STAGE FINAL DECANT
DIVERSION CHANNEL
TAILINGS EXTENT
PROPOSED TSF ACCESS ROAD (BY OTHERS)
FINAL SPILLWAY
EXISTING DAM/WATER STORAGE
TSF EMBANKMENT ALIGNMENT
DAM BREACH EXTENTS
89%
61%
40%
26%
13%
PASTEHOLE
VENT RISE
ESCAPEWAY
6083400mN
6083200mN
6083000mN
749600mE
749400mE
749200mE
749000mE
DARGUES REEF GOLD PROJECT
EMBANKMENT TAILINGS BREACH ANALYSIS
VICK METHOD
Knight Piésold CONSULTING

APPENDIX A

New South Wales Dams Safety Committee Guidelines:

DSC3A – Consequence Categories for Dams and

DSC3F – Tailings Dams

Knight Piésold CONSULTING

Dams Safety Committee
NEW SOUTH WALES

DSC3A June 2010

CONSEQUENCE CATEGORIES FOR DAMS

Table of Contents

1.0 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 consequences of dam failure in determining whether to prescribe dams, and in setting the requirements relating to the safety management of dams in NSW.

Dam owners, and their professional advisers, have full responsibility to determine, and take appropriate dam safety management action relative to, the potential failure consequences of their dams. However, the DSC also has a responsibility to promote best practices in the classification of dam failure consequences by drawing owners' attention to any DSC requirements (see Section 2.2) for the processes and procedures involved, as well as providing guidance and assistance to owners on general issues or findings in this area.

The DSC Consequence Category Goals 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 determination of consequence categories for dams.

2.0 DSC CONSEQUENCE CATEGORY GOALS & KEY REQUIREMENTS

2.1 DSC Consequence Category Goals

The DSC's primary goal in relation to this sheet is that all NSW dams are appropriately and consistently classified as to their dam failure consequence categories to enable the DSC to determine their need for prescription and the level of safety management they are to receive. Another goal is that this dam failure consequence information may inform the level of safety a dam requires under the risk management approach (see DSC1B and DSC2D) being progressively implemented by NSW prescribed dam owners, in line with a whole of Government approach to public safety in NSW.

2.2 DSC Key Requirements

This section summarises the DSC requirements outlined in this sheet.

4.0 DEFINITION

The term *hazard category*, formerly used as a rating of dam failure consequences, is replaced by the new term *consequence category*.

A prescribed dam owner shall undertake regular reviews of a dam's failure consequences (usually as part of Surveillance Report requirements - see DSC2C) and shall inform the DSC promptly of any significant changes, which are determined.

5.0 TYPES OF CONSEQUENCE CATEGORIES

Two types of dam failure are recognised for the purposes of determining a dam's Consequence Category, as follows:

- failures that occur without any attendant natural flooding, giving rise to the 'Sunny Day' Consequence Category (SDCC); and
- failures that occur in association with a natural flood, giving rise to the Flood Consequence Category (FCC replaces IFHC – *incremental flood hazard category* - in ANCOLD guidelines published before May 2000).

DSC is proposing a two tier system of consequence rating. Where *probable loss of life (PLL)* figures have not yet been estimated, an owner can base a tentative consequence category on PAR as in Table 2 of this sheet. Where PLL figures are available, the consequence category is to be based on PLL as in Table 1 of this sheet. The Table 1 rating has primacy and will override any rating based on Table 2.

6.0 USES OF CONSEQUENCE CATEGORY

The higher of the SDCC or FCC, is used to determine the need for prescription of, and Surveillance Reporting for, a dam, with SDCC usually used for determination of surveillance frequency.

Under the standards-based approach, the SDCC is normally used to determine design standards for seismic stability and the FCC is used in order to determine the flood capacity required for a prescribed dam. All other design requirements, (e.g. internal erosion, conduit security etc) usually involve consideration of the dam's SDCC.

7.0 PROCEDURES FOR ASSIGNING CONSEQUENCE CATEGORIES

Where the reliable assessment of consequences involves specialist knowledge, the DSC requires that appropriate specialists be employed in the consequence classification.

Consequence categories are classified as one of seven levels as follows:-

Extreme, High A, High B, High C, Significant, Low, Very Low

Under the Table 2 system, because PAR may not always be a good indicator of the potential for loss of life, the DSC requires the assessor to comment on the potential for loss of life (total and incremental) in addition to providing the total and pre-dambreak flood PAR figures.

In determining the PLL and PAR, account is to be taken of itinerant as well as non-itinerant populations (see note 7, Table 2). The separate PAR values for the itinerant and non-itinerant populations are to be provided to the DSC.

The "damages and losses" categories in the ANCOLD guidelines should be treated as advisory only.

The DSC will consider, on a case by case basis, any proposal by a dam owner to reduce the Consequence Category on the basis of the dam having a "thick" profile (i.e. has a wide crest or non-liquefiable contents).

3.0 BACKGROUND

This guidance sheet supersedes DSC13 and has been prepared to outline and clarify the processes and procedures the DSC considers necessary for classification of the failure consequence categories of NSW dams. In this regard, the DSC has had significant input to, and has adopted with qualifications the publication of the Australian National Committee on Large Dams (ANCOLD) *Guidelines on Assessment of the Consequences of Dam Failure* (May 2000). Consequently, it is the DSC's policy that dam

owners should comply with these ANCOLD Guidelines unless otherwise indicated in this or other DSC guidance sheets.

DSC3A applies to all dams in NSW. However, on the basis of a dam's consequence categories, determined in accordance with this sheet, the DSC decides whether that dam should be prescribed under the NSW *Dams Safety Act, 1978* and come under the DSC's regulatory oversight. Generally, the DSC prescribes, and sets requirements for, those dams storing water or other liquefiable materials that pose a significant potential threat to the interests of the community (including environmental effects).

4.0 DEFINITION

The term "hazard" has been used by ANCOLD (and dam owners world-wide through ICOLD - Internal Commission on Large Dams) over several decades to refer to the scale of potential dam failure consequences. However, in risk analysis it is understood to mean "that which has the potential for harm" and for dams it would refer to the threat or event which could cause a dam failure. The term "Consequence Category" has now been adopted by ANCOLD and the DSC for the classification of potential impacts resulting from a dam failure.

The DSC assigns "Consequence Categories" to a dam according to the seriousness, and magnitude, of the adverse consequences affecting the community's interests, including environmental effects, which could be expected to result from that dam's failure. In assigning such consequence categories, no account is taken of the likelihood of dam failure. Thus a dam which meets the highest safety standards, and which therefore is extremely unlikely to fail, can have a *HIGH* Consequence Category.

In addition, it should be noted that the consequence categories for a dam can vary with time due to such things as changes in downstream development or modifications to the dam. Therefore, a prescribed dam owner shall undertake regular reviews of a dam's failure consequences (usually as part of Surveillance Report requirements - see DSC2C) and shall inform the DSC promptly of any significant changes, which are determined.

5.0 TYPES OF CONSEQUENCE CATEGORIES

5.1 The Basic Distinction

Many dams have failed throughout the world, often with disastrous consequences. A small number of large dams have failed, or partially failed, in Australia but only one of those failures involved loss of life (Briesis Dam, Tasmania, 1929).

Natural flooding is the cause of considerable devastation and even loss of life from time to time. However, it has been recognised internationally that dam owners should not be accountable for the consequences of natural flooding which passes through their dam without dam failure (however, see Sub-section 5.4).

Therefore two types of dam failure are recognised for the purposes of determining a dam's Consequence Category, as follows:

- failures that occur without any attendant natural flooding, giving rise to the 'Sunny Day' Consequence Category (SDCC); and
- failures that occur in association with a natural flood, giving rise to the Flood Consequence Category (FCC replaces IFHC – *incremental flood hazard category* - in ANCOLD guidelines published before May 2000).

Note that it is quite possible for a dam to have a *HIGH SDCC* but a *LOW FCC* (e.g. concrete dams that overtop and 'drown out' in floods) or conversely, it is possible for the dam to have a *LOW SDCC* but a *HIGH FCC* (e.g. retarding basins).

5.2 Two Tier Consequence Rating System

ANCOLD has based consequence categories on *population at risk (PAR)* as a worst case proxy for loss of life but the DSC is concerned that this may underestimate the FCC for dams (if incremental PAR is used) or may result in costly safety improvements (especially if the PAR is located a long way downstream of the dam). To deal with this reality, DSC is proposing a two tier system of consequence rating.

Where *probable loss of life (PLL)* figures have not yet been estimated, an owner can base a tentative consequence category on PAR as in Table 2 of this sheet. Where PLL figures are available, the consequence category is to be based on PLL as in Table 1 of this sheet. The Table 1 rating has primacy and will override any rating based on Table 2. In particular cases, the DSC may require that consequence categories be classified according to Table 1.

5.3 Sunny Day Consequence Category (SDCC)

The SDCC should, in principle, be based upon the "worst case" consequences resulting from the most unfavourable failure circumstances of a dam, at a time when flows in the stream on which the dam is situated, are "normal" (i.e. non-flood flows). These consequences include potential loss of life, as well as damage to property, services and environmental values that are directly attributable to dam failure.

The cause of dam failure could be such things as slope instability, internal erosion, or due to seismic loading (e.g. sliding or foundation / embankment liquefaction).

5.4 Flood Consequence Category (FCC)

The FCC should, in principle, be based upon the consequences that result from the most unfavourable failure circumstances of a dam during a flood and which are attributable to the failure of the dam.

The consequences to be taken into account would be similar to those for the SDCC case but would include consideration of the dambreak wave front effect on the areas inundated before failure, as well as the additional areas of inundation after failure. For assessment of the FCC it would be important to consider the qualitative differences between dambreak floods and the natural floods that are routed through the spillway. Dambreak floods can carry large debris and sediment loads, sometimes have steep wave fronts and rise very rapidly. They are typically larger than any

natural flood ever experienced over geologic time and consequently they scour soil materials to bedrock in some places and deposit massive sediment fans in other places.

In assessing the FCC, the cause of dam failure would typically be flood related. Examples of such causes are overtopping of an embankment dam or stability failure of a concrete gravity dam due to high flood surcharge levels. However a dam could suffer a piping or other type of failure that may also be associated with sunny day conditions, during a flood. Any potential failure mode during a flood should be considered in assigning the FCC.

Incremental consequences of failure are determined by examining the consequences that would result without dam failure, and the consequences that would result from the same flood event with dam failure, for a range of floods up to the Probable Maximum Flood (PMF). The differences between these two sets of consequences for a particular flood magnitude would be the incremental consequences; that is, those directly attributable to the dam failure, for that flood condition.

It is necessary to undertake sufficient flood magnitude and consequence assessments to be able to reasonably identify the flood magnitude that would produce the most severe incremental consequences. The requirement to compare the *failure* and *no failure* consequences still holds where the dam can safely pass the PMF. The maximum differential impact between the *"with failure"* and *"without failure"* cases, over the full range of possible flood magnitudes, would be the basis for assignment of the FCC on an incremental consequences basis.

With regard to the clearly rational concept of incremental consequences, the assessor should be mindful that, in the aftermath of a dam failure, it might not be a simple matter to distinguish between the consequences directly attributable to the dam failure, and the flooding consequences from the flood event which caused the dam's failure. For this and other reasons, the DSC requires owners to provide estimates of both incremental and total consequences (PLL or PAR as the proxy for loss of life) to assist the DSC to make a determination of the FCC for a dam.

Determination of the FCC requires preparation of inundation maps for:

(i) Flooding with the dam intact for a range of floods up to the PMF;

(ii) Flooding from dam failure for the same range of floods.

The number of flood discharge states to be considered for inundation mapping will depend on the required rigour and detail for the purpose in hand, but as a minimum should be two, the estimated flood capacity (see the definition in the last paragraph of this sub-section) of the dam, and the PMF. Where there have not yet being analyses to estimate the flood capacity, the default position could be the DCF (*Dam Crest Flood* – see ANCOLD *Guidelines on Selection of Acceptable Flood Capacity for Dams*, March 2000).

However, the aim is to strike a balance between two competing needs of:

- limiting the number of breach analyses, dambreak analyses and consequence assessments in view of the high costs involved; and
- reliably identifying the flood condition with the worst incremental consequences.

For example, if an embankment dam would be prone to a piping failure at a flood considerably less than the DCF, the incremental consequences at that lesser flood could be appreciably worse than the incremental consequences at the DCF.

The owner is to demonstrate to the DSC that sufficient analysis has been undertaken to reliably identify the flood case with the worst incremental consequences.

A dam's flood capacity is usually not known as a single flood value but is recognised to be within an estimated range of flood magnitudes. For the DSC's purposes, the flood capacity is to be taken as the maximum flood condition for which the owner's engineer(s) is prepared to certify that the dam is safe.

6.0 USES OF CONSEQUENCE CATEGORIES

Sunny Day and Flood Consequence Categories are used for three important purposes:

(i) To determine whether a dam should be prescribed under the NSW Dams Safety Act (see DSC1A) – Table 2 or Table 1 system, the latter to take precedence;

(ii) To provide guidance on setting the level and frequency of surveillance and reporting that is appropriate for a prescribed dam (see DSC1A, DSC2A & DSC2C) – Table 2 or Table 1 system, the latter to take precedence;

(iii) To determine the design standards (level of safety and review frequency) that a prescribed dam is to meet under the standards-based approach (see DSC2D, DSC3B & DSC3C) – Table 1 system only.

The higher of the SDCC or FCC, is used to determine the need for prescription of a dam and type of Surveillance Report required. SDCC is usually used for determination of the frequency of a dam's routine surveillance (i.e. inspection and monitoring).

Under the standards - based approach, the SDCC is normally used to determine design standards for seismic stability where failure, if it occurred, would most likely take place at a time of normal stream flow. However critical design loadings may rarely involve a seismic loading combined with a moderate long-duration (months) flood event.

Under the standards - based approach, the FCC is used (sometimes in conjunction with an examination of Base Safety Condition - see DSC3B) in order to determine the flood capacity required for a prescribed dam.

All other design requirements (e.g. internal erosion security, conduit security etc), usually involve consideration of the dam's SDCC.

7.0 PROCEDURES FOR ASSIGNING CONSEQUENCE CATEGORIES

7.1. Consequence Categories are a function of the Magnitude of Adverse Consequences

Consequence Categories depend on the nature and severity of adverse consequences. Whilst SDCC and FCC are measured differently, the procedure for assigning a consequence category in terms of adverse consequences is identical.

7.2 Degree of Rigour in Assigning Consequence Categories

In some cases the *order of* scale of consequences of dam failure is so obvious that a conclusive assignment of a consequence category can be made by inspection (for example, if the PAR must clearly be in the tens of thousands and is located not far downstream of a large dam).

Usually however, a conclusive assessment would require dambreak analyses (refer ICOLD 1998, *Dam Break Flood Analysis - Review and Recommendations* - Bulletin No.111), preparation of inundation maps, surveys of dwelling floor levels, identification of the numbers, ages and health status of persons at risk and consideration of warning times, escape routes and the like. Similarly the impact of loss of storage on the community, and the environmental effects of dam failure may require detailed assessment.

Where the reliable classification of consequences involves specialist knowledge, the DSC requires that the appropriate specialists be employed in the consequence assessment [examples are environmental scientists, heritage scientists and economists].

Initially, consequence categories may sometimes be conservatively assigned on the basis of judgments made by experienced dam engineers. Such classifications should always be regarded as tentative and subject to revision on the basis of any future assessment(s). These judged classifications cannot be used to decide on required safety levels unless there is no non-itinerant PAR.

7.3 Consequence Categories

Consequence Categories represent a continuum that extends from minimal consequences at the low end to catastrophic consequences for a broad community at the high end. However, for practical purposes, consequence categories are classified as one of seven levels as follows:-

Extreme, High A, High B, High C, Significant, Low, Very Low

7.4 Assignment of Consequence Categories

Procedures for assessing the consequences of dam failure and the classification of the associated consequence category under the Table 2 system are outlined in the ANCOLD *Guidelines on*

Assessment of the Consequences of Dam Failure, May 2000. The DSC has adopted these Guidelines, with qualifications as in this sheet, to assist dam owners in providing information for the DSC to make an initial [Table 2] determination on the consequence categories for a dam.

The same procedure will apply under the Table 1 system, except that the estimated incremental PLL will be used instead of the PAR. The DSC will use the Table 1 consequence ratings as a conclusive basis for assignment of consequence categories.

In assessing consequences, the following important aspects should be noted:

- The DSC's charter relates only to protection of the community's interests, including protection of the environment. Consequently, the DSC takes no account of a dam owner's private or business risks in assessing a dam's Consequence Categories.
- According to the purpose at hand, assessors should consider whether they need to take into account existing or future planned developments, downstream of dams, in their estimation of dam failure consequences. For example, in assessing the existing safety status of a dam the usual basis would be existing development. In deciding on the needed level of safety improvement, it would often be appropriate to consider the projected future development. The DSC is to be told whether consequences are based on existing or future developments, and the reasons for the chosen basis.
- For the DSC's purposes, the definition of the *population at risk (PAR)*, as defined in the Glossary of the May 2000 ANCOLD Guidelines, is amended to read: *All those who would be significantly exposed to floodwaters within the natural flood, or dambreak zone, if they took no action to evacuate*. This change allows for the estimation of the PAR for natural flooding (without dam failure).
- Under the Table 2 system, because PAR may not always be a good indicator of the potential for loss of life, the DSC requires the assessor to comment on the potential for loss of life (total and incremental) in addition to providing the total and pre-dambreak flood PAR figures.
- Application of the method of Graham (Graham, W J, 1999, *A Procedure for Estimating Loss of Life Caused by Dam Failure*, DSO-99-06, U.S. Department of the Interior, Bureau of Reclamation, Denver, Colorado) could be used as the basis for PLL figures. Other recognised methods for estimation of PLL could be submitted for the consideration of the DSC.
- In determining the PLL and PAR, and for assessing the potential for loss of life, account is to be taken of itinerant as well as non-itinerant populations (see note 7, Table 2). The separate PAR values for the itinerant and non-itinerant populations are to be provided to the DSC.

- The "damages and losses" categories in the ANCOLD Guidelines should be treated as advisory only and more detailed assessments may be required in particular circumstances, particularly for environmental consequences (see Sub-section 7.5). This is noted in the last paragraph of Section 2.7 of the Guidelines in relation to dams in sensitive natural environmental areas, where no, or limited, PAR exist. In addition, the DSC gives particular guidance on the consequence assessment of tailings dams in its guidance sheet on *Tailings Dams (DSC3F).* Where a dam stores something other than clean water reference should be made to that document.
- To reflect the DSC's requirements, Table 3 of the ANCOLD Guidelines has been modified as in the following Table 2. The main departures from the ANCOLD Guidelines are:
  - The PAR groupings have been altered slightly to provide a full continuum, and reflect the fact that the PAR is not necessarily an integer.
  - Notes 4 & 5 have been amended to clarify the influence of the potential for loss of life in assigning a consequence category.
  - Clarification is made of assessment of the PAR (see Note 7).
- The DSC will consider, on a case by case basis, any proposal by a dam owner to reduce the Consequence Category on the basis of the dam having a "thick" profile (i.e. has a wide crest or non-liquefiable contents). The owner will be expected however to develop this case with full consideration of the geometry, dam materials, nature of stored substances, phreatic surface, storage volume of the dam and estimated peak outflow discharge.

TABLE 1

CONSEQUENCE CATEGORIES BASED ON PROBABLE LOSS OF LIFE [PLL]

Probable Loss of Life (PLL) *(Note 4)*	Severity of Damage and Loss			
	Negligible	**Minor**	**Medium**	**Major**
0	Very Low	Very Low	Low	Significant
<1	High C	High C	High C	High B
1 to 10	(Note 1)	High B (Note 2)	High B	High A
10 to 100			High A (Note 3)	High A
>100				Extreme

Note 1: With a PLL of more than 1 non-itinerant people, it is unlikely that the severity of damage and loss will be "Negligible".

Note 2: "Minor" damage and loss unlikely when the PLL exceeds 5 non-itinerant people.

Note 3: "Medium" damage and loss unlikely when the PLL exceeds 50.

Note 4: The PLL is to be estimated by the methods of Graham, WJ, 1999, A Procedure for Estimating Loss of Life Caused by Dam Failure, DSO-99-06, US Department of the Interior, Bureau of Reclamation, Denver, Colorado or another recognised method approved by the DSC. Because of the computational methods followed in estimating PLL, it is possible to have a notional PLL, which is less than 1.0 or a PLL greater than 1.0 which is not an integer. Given a particular dam failure scenario (which has its own probability), a PLL less than 1.0 is to be interpreted as the probability of the loss of one life. Thus a PLL of 0.1 would be interpreted as a probability of 1 in 10 that a life would be lost, given the failure scenario. A PLL greater than 1.0 should be rounded to the nearest integer.

TABLE 2

CONSEQUENCE CATEGORIES BASED ON POPULATION AT RISK [PAR]

Adapted from ANCOLD *Guidelines on Assessment of the Consequences of Dam Failure, Table 3.*

(Notes 1, 2, 3 and 6 are similar to the ANCOLD guidelines but Notes 4 and 5 have been modified and Note 7 is new.)

Population at Risk (PAR) *(Note 7)*	Severity of Damage and Loss			
	Negligible	**Minor**	**Medium**	**Major**
<1	Very Low	Very Low	Low	Significant
1 to 10	Low (Notes 1, 4 & 5)	Low (Notes 4 & 5)	Significant (Note 5)	High C (Note 6)
10 to 100	(Note 1)	Significant (Notes 2 & 5)	High C (Note 6)	High B (Note 6)
100 to 1000		(Note 2)	High A (Note 6)	High A (Note 6)
>1000			(Note 3)	Extreme

Note 1: With a PAR of 5 or more people, it is unlikely that the severity of damage and loss will be "Negligible".

Note 2: "Minor" damage and loss unlikely when the PAR exceeds 10.

Note 3: "Medium" damage and loss unlikely when the PAR exceeds 1000.

Note 4: Change to Significant where the loss of itinerant lives is reasonably likely, given dam failure.

Note 5: Change to at least High C where the loss of non-itinerant lives is reasonably likely, given dam failure.

Note 6: Refer Section 2.7 and 1.6 of the ANCOLD *Guidelines on Assessment of the Consequences of Dam Failure* for explanation of the range of High Consequence Categories.

Note 7: The PAR is to be the total PAR occupying the full extent of the dambreak affected zone (including that area affected by natural flooding prior to dambreak) immediately prior to the onset of flooding. The contribution to PAR of non-itinerants (i.e. regular occupants of dwellings, schools, hospitals, commercial and industrial premises and other permanent places of occupation) shall be the largest total population that is exposed at the one time on a regular basis. To allow for the variable exposure of itinerants, the contribution to PAR of such populations shall be computed on the basis of exposure factors. Where low exposure factors are applied to few itinerants, it is possible to have a notional PAR, which is less than 1.0.

7.5 DSC Changes to ANCOLD's Environmental Consequence Assessment Criteria

The DSC has had concerns expressed about the fairly generic nature of the criteria used in the tables, in Appendix D of the ANCOLD *Guidelines on Assessment of the Consequences of Dam Failure*, for assessing environmental related consequences of dam failure. Acting on these concerns, the DSC has developed and trialled a more consistent and robust approach for consideration of the natural environment and cultural heritage issues. It believes the proposed changes to be more user-friendly and replaces subjective assessments with more quantitative assessments.

The following tables are offered as DSC guidance. In addition, the "natural environment" section of Table 2 of the ANCOLD Guideline (which is not attached) should be made the same as the DSC's new Appendix D explanation table.

APPENDIX A

DSC AMENDMENTS TO ANCOLD CONSEQUENCE GUIDELINES Appendix D

DATA ASSEMBLY AT LEVELS OF ASSESSMENT

Type of Data	Assessment Level		
	Initial	Intermediate	Comprehensive
Environmental	General information from topographic and ortho-photo maps[1].	• General information from topographic and ortho-photo maps[1]. • Reviews of government data-bases[2].	• Professional advice. • Professional surveys[3]. • Formal environmental impact assessment[4].

Explanatory notes for environmental

1	Topographic and ortho-photo maps provide good information on environmentally sensitive areas including: • Areas of native vegetation • Historic Sites • Landform features that may have natural heritage values. • National Parks • Wetlands
2	Government Departments maintain databases on endangered species and heritage items.
3	Surveys of vegetation, animals (including aquatic species), indigenous and non-indigenous heritage items.
4	Formalised impact assessment should follow established state or national processes, such as the NSW Government's "IS and EIS required?" Best Practice Guidelines for Part 5 of the Environmental Planning and Assessment Act 1979. An alternative is to carry out a qualitative risk assessment on environmental impacts.

Selection of the severity of damage and loss

3. SOCIAL

Type	Negligible	Minor	Medium	Major
Loss of cultural heritage[1].	No expected physical damage to heritage items.	Significant physical damage to item(s) of local heritage[2].	Significant physical damage to item(s) of state heritage[3].	Significant physical damage to item(s) of National or World heritage[4].

Explanatory notes for social

Loss of Cultural Heritage	1. Cultural heritage include items of value to indigenous or non-indigenous communities, such as historic and archaeological sites, places and buildings that may be damaged or destroyed. When assessing cultural heritage, consideration should be given to the business risks and liabilities for which the organisation may be held responsible.
	2. Information available on local environmental plans available from local government.
	3. Information available from State government heritage databases (e.g. NSW State Heritage Register on www.heritage.nsw.gov.au and the Aboriginal Sites Register).
	4. Information available from the Federal Government via www.ea.gov.au, which provides the National Heritage List and a list of World Heritage sites within Australia.

✪ **Selection of the severity of damage and loss**

4. NATURAL ENVIRONMENT

Where a dam stores something other than clean water reference should also be made to Guidance Sheet DSC3H Tailings Dams.

Type	Negligible	Minor	Medium	Major
Area of impact[1]	< 0.1 km^2	0.1 km^2 to 1 km^2	1 km^2 to 10 km^2	> 10 km^2
Duration of impact[2]	< 1 month	1 month to 3 years	3 year to 10 years	> 10 years
Impacts on conservation value	Physical damage limited to areas that are extensively cleared of vegetation[3].	Limited physical damage to: A. item(s) of local[4] and state natural heritage[5] B. native vegetation within state recognised forestry, aquatic and conservation reserves[5], or recognised habitat corridors, wetlands or fish breeding areas[5].	Significant physical damage to areas A & B. Limited physical damage to: C. item(s) of National or World natural heritage[5]. D. native vegetation within national parks[5], recognised wilderness areas[3], RAMSAR wetlands[6] and nationally protected aquatic reserves[6].	Extensive damage to areas A & B. Significant physical damage to areas C & D.
Impacts on plants and animal habitat	Impact in extensively cleared or disturbed areas[7].	Loss of habitat for protected native species[5].	Significant loss of habitat for regionally or state-listed rare or endangered species[5].	Significant loss of habitat for national rare or endangered species[6].
Riverine landscape processes	No changes expected to river channel post inundation.	Localised impacts in river connectivity expected.	Some cutoffs expected.	Significant change in river course expected.

Explanatory notes for natural environment

1	Land inundated by dam failure, exclusive of land that is prone to inundation by natural flooding.
2	The removal of topsoil from flood plains and erosion of waterways may cause a long term scar. Habitats may take a long time to recover as areas of debris and gravel may prevent regrowth.
3	Information available from topographic maps.
4	Information available on local environmental plans available from local government.
5	Information available from state government departments on natural heritage, conservation reserves, endangered species, etc.
6	Information available from the Federal Government via www.ea.gov.au, with information on nationally protected natural heritage, World Heritage sites within Australia, nationally and internationally protected endangered species etc.
7	It is acknowledged that agricultural use is not an empirical measure of soil fertility.

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TAILINGS DAMS

Table of Contents

1.0 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 - 2003* and the ANCOLD *Guidelines on Tailings Dam Design, Construction and Operation - October 1999* (currently being updated) 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.

2.0 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.

4.0 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 Dam Design, Construction and Operation – 1999*, 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 *Surveillance Reports for Dams - DSC2C*. 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).

5.0 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.

3.0 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
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^3 of acidic water released
Sept. 2004	Florida, USA	Flood failure	230,000m^3 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

4.0 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 ANCOLD *Guidelines on the Assessment of Consequences of Dam Failure - May 2000*.

However, both the DSC and ANCOLD (clause 2.7 of its 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			
		Negligible (Benign Liquid)	Minor (Benign Solid)	Medium (Saline Liquid / Unsightly Solid)	Major (Acid / Toxic Tailings)
<1	Remote / Degraded	Very Low	Very Low	Low	Significant
1-10	Rural / Productive	Low[1,4]	Low[4,5]	Significant[5]	High C[6]
10-100	Urban / Sensitive	(Note 1)	Significant[2,5]	High C[6]	High B[6]
100-1000			(Note 2)	High A[6]	High A[6]
>1000				(Note3)	Extreme[6]

Notes (summary-see full notes under Table 2 in DSC3A):

1 With a PAR of 5 or more, it is unlikely that the severity of damage and loss will be "Negligible."
2 "Minor" damage and loss would be unlikely when the PAR exceeds 10.
3 "Medium" damage and loss would be unlikely when the PAR exceeds 1000.
4 Change to *Significant* where the loss of itinerant lives is reasonably likely.
5 Change to at least *High C* where the loss of non-itinerant lives is reasonably likely.
6 See Sections 2.7 & 1.6 of ANCOLD Guidelines for explanation of the range of *High* Consequence Categories.
7 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 Dam Design, Construction and Operation - 1999*, 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;

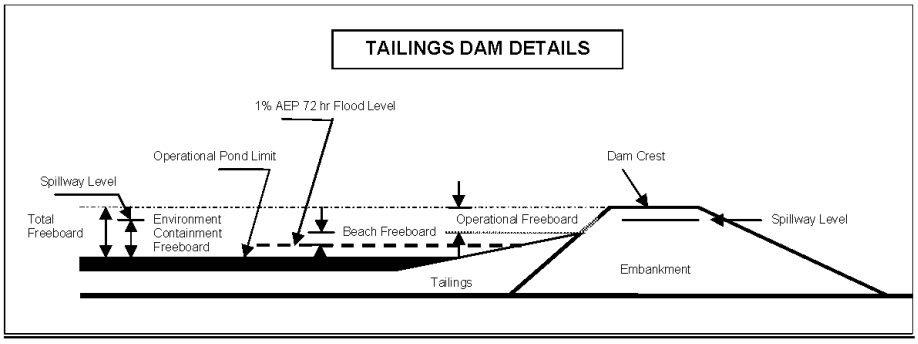
Pond Recovery Time. The Operational Pond Limit is the maximum extent of the pond under normal operating conditions. During heavy rainfall it would be expected that this limit would be exceeded, and procedures and facilities should be available that will allow recovery of the pond level, formed by the 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. 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^{-1}	10^{-2}	10^{-3}	10^{-4}
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^{-1}	10^{-2}	10^{-3}	10^{-4}
Total Freeboard (AEP-critical duration)-min	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}

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 6.6(1) of ANCOLD *Guidelines for Design of Dams for Earthquakes - 1998*).

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 6.5 of ANCOLD *Guidelines on Tailings Dam Design, Construction and Operation - 1999* 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.