NSW Resources Regulator
Department of Regional NSW

Mine Planning

and its relationship with slope stability & blasting

Small Mines Roadshow 2023

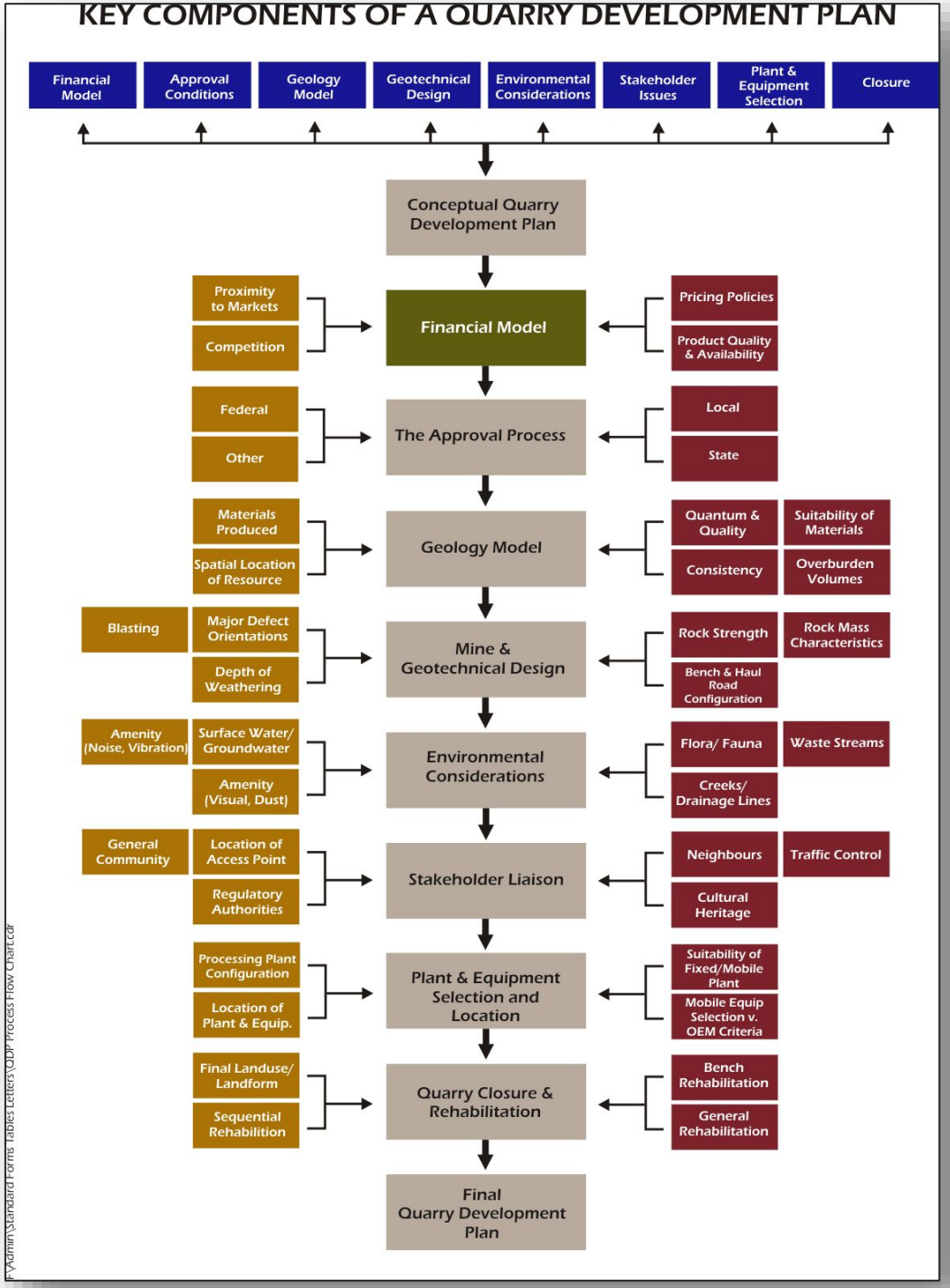
February to March 2023

Presentation covers...

- Mine planning lifecycle
- Consequences of poor planning
- Legislation requirements
- Mine design criteria and information
- Ground or Strata failure (PHMP)
- Slope stability incidents
- Planned assessment results
- Blasting and the mine plan
- Take home messages and questions

Mine planning...

- Financial Model
- Approval Process
- Geology Model
- Geotechnical Design
- Environmental considerations
- Stakeholder Liaison
- Plant & Equipment Selection
- Quarry Closure Plan
- Review Process



A quarry begins to close the day it opens !

Decisions made during the mine planning and development phase – and even earlier, during the exploration phase – have profound effects on the ultimate closure plan, production outputs and costs, and on the going **safe and efficient** operation of the site.

WE NEED TO GET OUR PLANNING RIGHT !


DANGER
OPEN PIT
FOOT
PROTECTION
MUST BE WORN
IN THIS AREA

Consequences of poor mine (pit) planning ? ...

Consequences of poor mine (pit) planning... (some examples)

- **Safety**
- Increased risk to workers and visitors
- Poor access to benches and production areas (roads too steep and narrow)
- Poorly aligned haul roads (switch backs)
- Unstable highwalls (above and below)
- Ground and strata failure (minor and major)
- Increased blasting hazards (flyrock)
- Managing oversize (transport & crushing)
- Can lead to production pressures and shortcuts being taken !

- **Financial**
- Lower annual productivity
- Reduced internal efficiencies (workforce #'s up)
- Inefficient haulage routes
- Double handling (side casting)
- Contamination of products
- Isolation of resource
- Managing oversize ($$$)
- Unable to meet development consent conditions
- Unable to meet market demands (products)
- Increased rehabilitation costs

What does the legislation say?

Survey plans and Mine plans - *Work Health and Safety (Mines and Petroleum Sites) Regulation 2022 (Part 6, section 116 – 122)*

- A survey plan is required for an underground mine, a coal mine, a petroleum site or a mine determined by the regulator to require one
- A survey plan is also required for a mine, other than an underground mine or coal mine, if the mine operator determines a survey plan is necessary E.g a risk assessment

Must be prepared by a registered ‘mine surveyor’

Mine Plan – (most in the room will require a ‘mine plan’ not a ‘survey plan’)

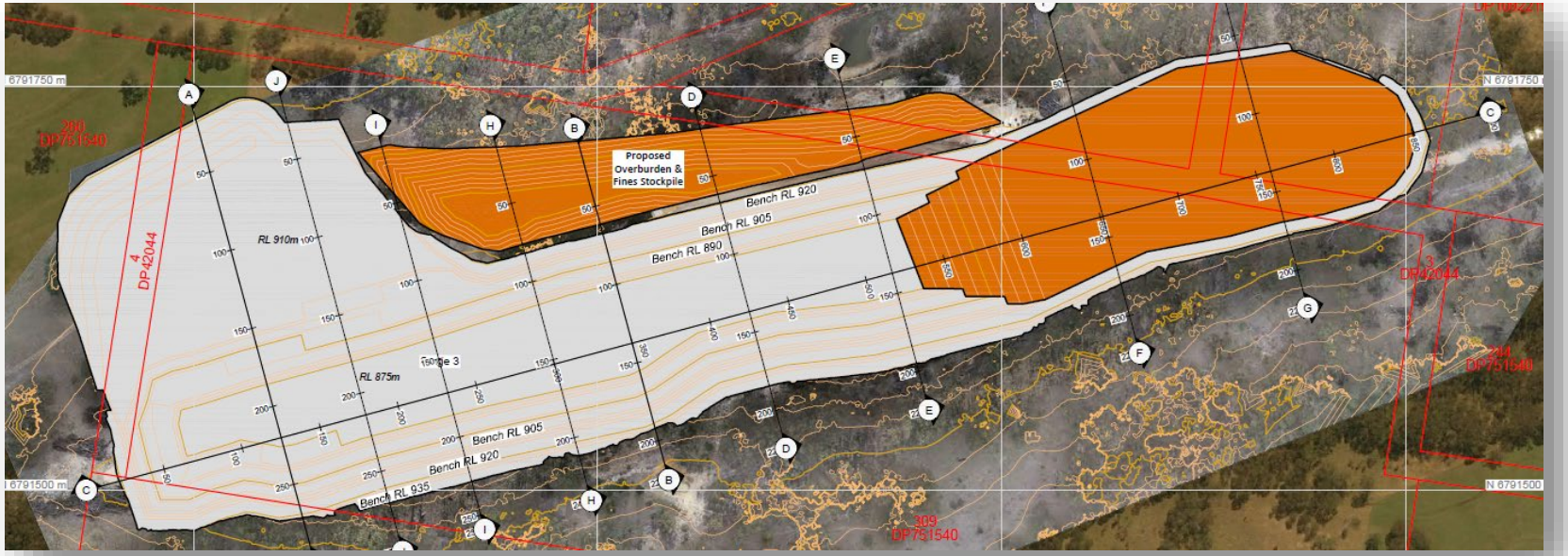
- **Must be prepared by a competent person**

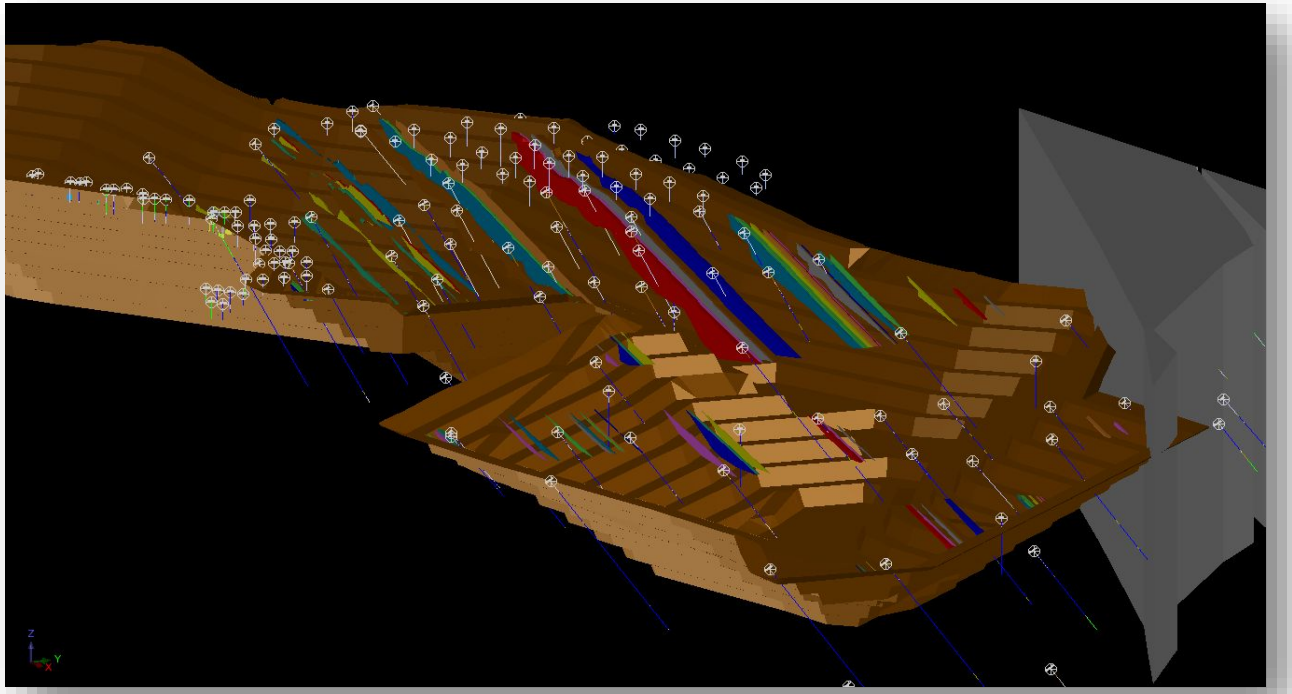
- **Must show the following if present at the mine**
  - Proposed workings of the mine
  - Existing workings of the mine, including disused workings
  - Other disused workings that are attached to, or near, the mine
  - The location or estimated location of the boundary of adjacent workings or geological structures

- **Plan must be reviewed every 12 months**

Mine Plan

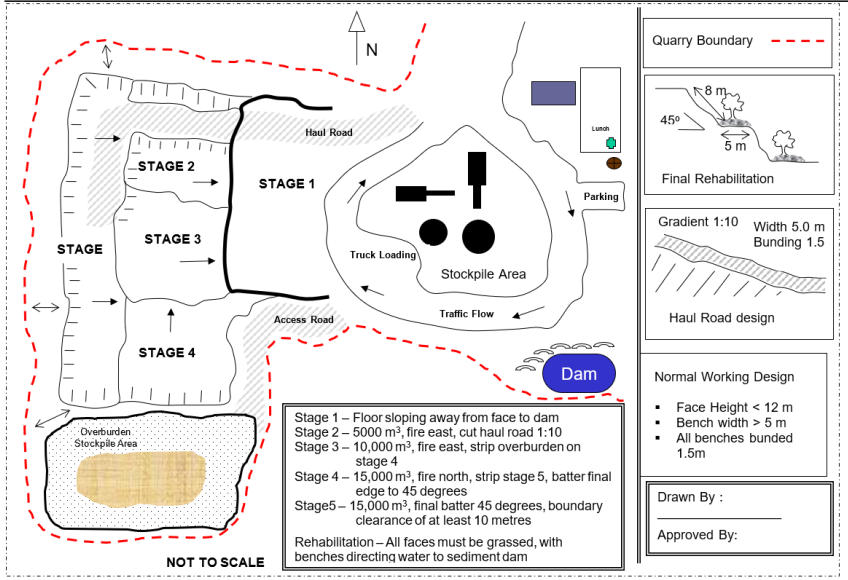
Paper vs Electronic





FORM 20A - EXAMPLE

Example of Mine Plan

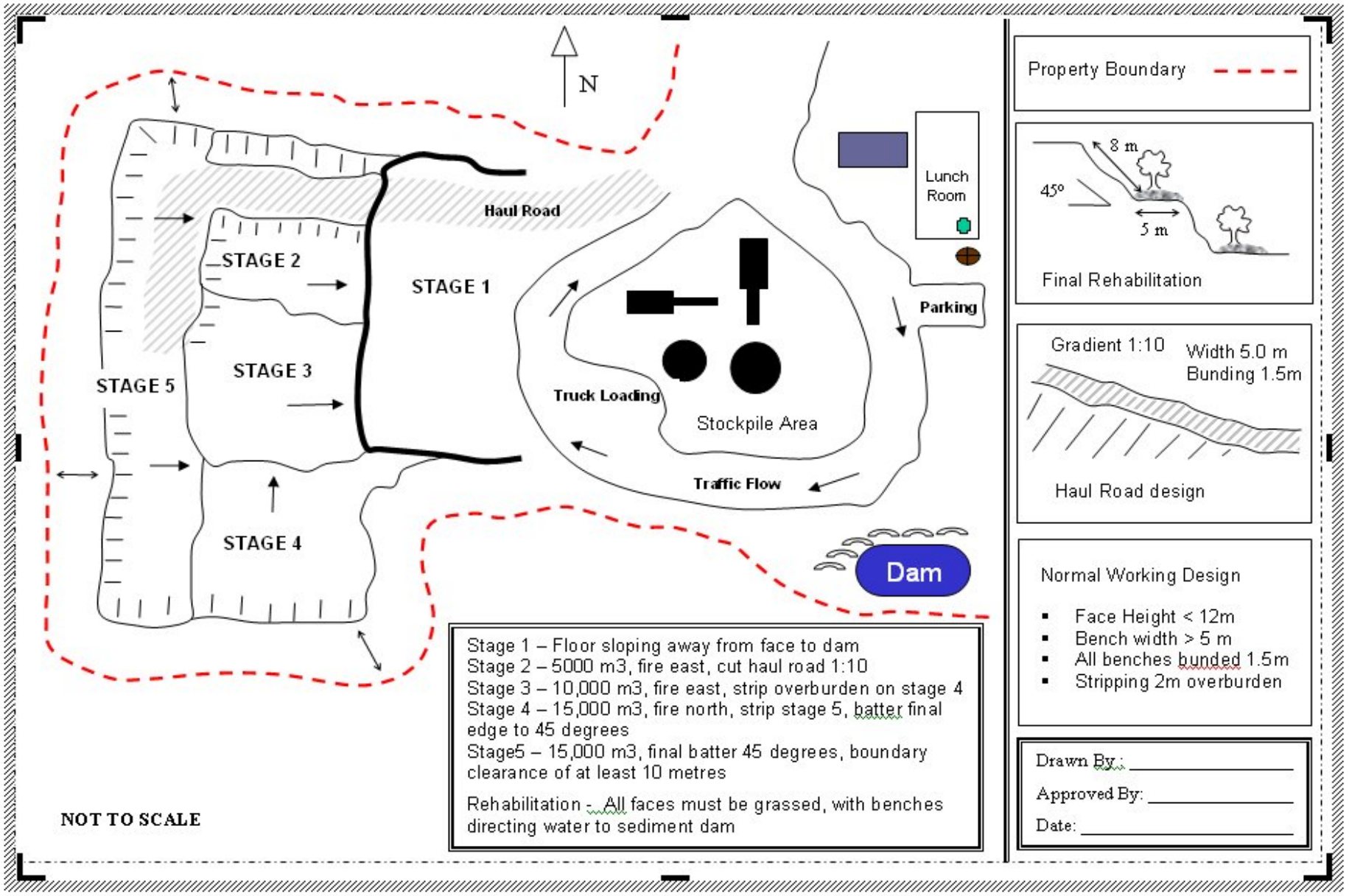


Stage 1 – Floor sloping away from face to dam
Stage 2 – 5000 m³, fire east, cut haul road 1:10
Stage 3 – 10,000 m³, fire east, strip overburden on stage 4
Stage 4 – 15,000 m³, fire north, strip stage 5, batter final edge to 45 degrees
Stage5 – 15,000 m³, final batter 45 degrees, boundary clearance of at least 10 metres

Rehabilitation – All faces must be grassed, with benches directing water to sediment dam

Doc: 20.0 Mine Planning	Approver:	Date:	Program 20 - 7

Example of Mine Plan

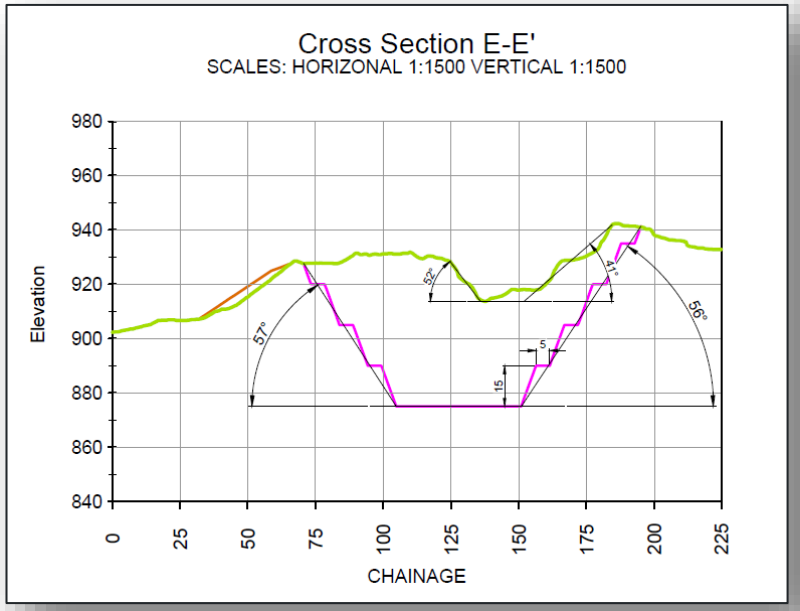


Smaller Mines

- Sequencing
- Haul roads
- Parking
- Boundary
- Traffic flow
- Mining criteria
- Rehab requirements
- Sign off

(not all mandatory)

How did you determine your operating parameters and mine design criteria ?

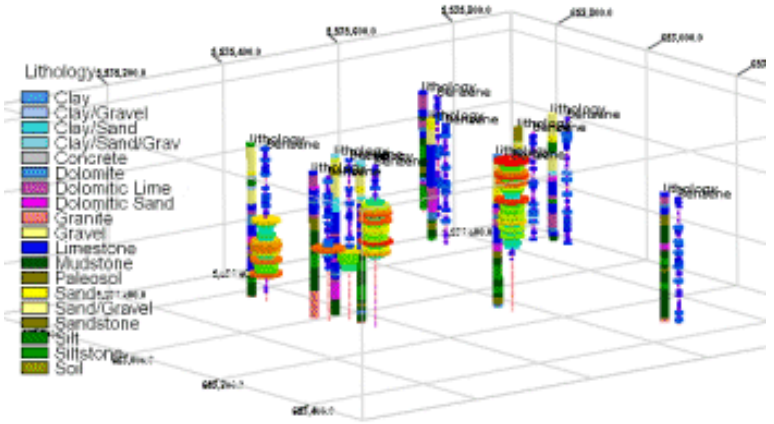


DOCUMENTATION REVIEW - Control PC1.2 – Mine Design

Objective: *The mine design minimises the likelihood of ground or strata failure.*

Expected control supports	Assessment outcome
CDA - 0201 - PC1.2 - 05 Identified ground stability data is used to produce mine designs and operating parameters.	☐ Verify that the mine plan and operating parameters have been determined considering the identified ground conditions. *Refer to requirements of Clause 123 of WHS (MPS) Regs.* *These may include:* o *Pit boundary.* o *Dump area location and capacity.* o *Smooth wall blasting.* o *Wall angles.* o *Berm widths.* o *Wall heights* o *Dump material composition.* o *Dump height.* o *Dump edge slope.* o *Drainage requirements.*
Evidence/Observation/Comment:	

Geotech information - data



"... and we can save 700 lira by not taking soil tests..."

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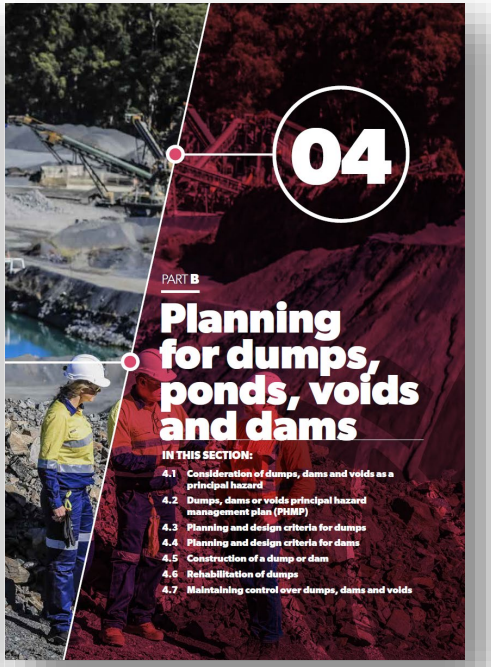
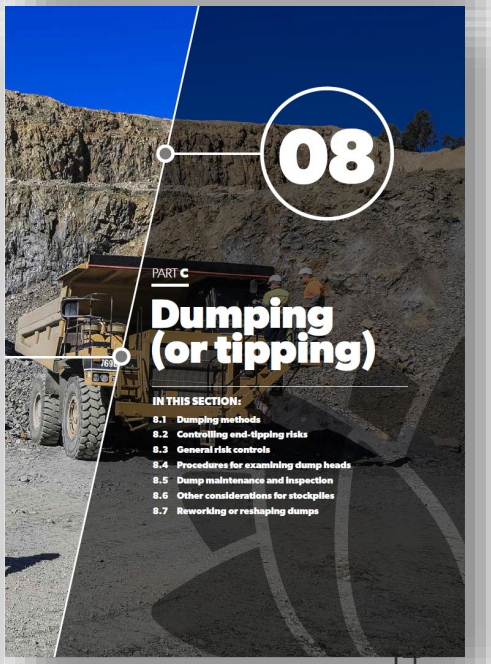
Health and Safety at Quarries Guide





Example of detail in the Guide

Table 2 provides a list of typical issues that are commonly considered during a risk assessment or field investigation regarding actual, or the potential of, ground instability.

PARAMETER	CONSIDERATIONS
Slope type	Active or inactive
Slope geometry	Overall slope height, slope angle, bench height, bench slope angle, bench width
Engineering Characteristics	Rock or soil, structurally controlled, variable alteration or materials present, material or discontinuity shear strength parameters
Proximity of existing infrastructure	Property or services adjacent to both crest and toe of slope, both external and located on site
Proximity of workers	Vulnerability, location relative to potential failure
Proximity of general public	Proximity of public access, roads, footpaths, walkways and so on
Failure mechanism	Planar, wedge, toppling, rotational, liquefaction, toe bulge crest damage
Speed of failure	Rapid (flows, rockfall), slow (rotational), very slow (rotational)
Water (surface water and groundwater)	Visible signs of seepage or discharge, pore pressures behind high walls, prevention of detrimental effects by effective surface water management, and limiting uncontrolled
Recent history of failure	History of instability (type, location and so on), visible signs of active or previous failure (bulging of slope surfaces and so on)
Frequency and size of rockfall	The size of the rockfall and ejection or roll out distance (i.e. distance ejected off the batter and potentially down the slope)

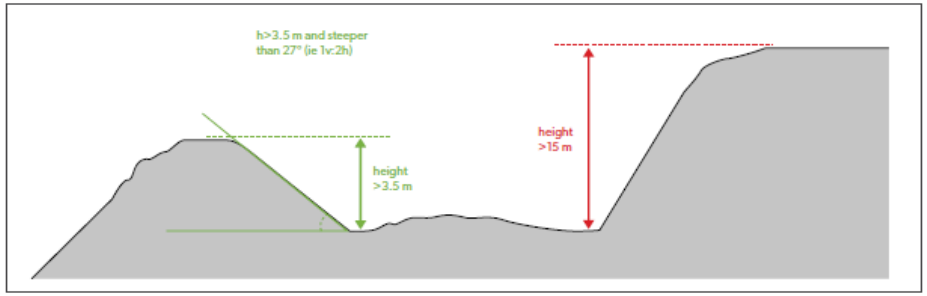


Figure 5: 'Soils and very weak rock' guidance

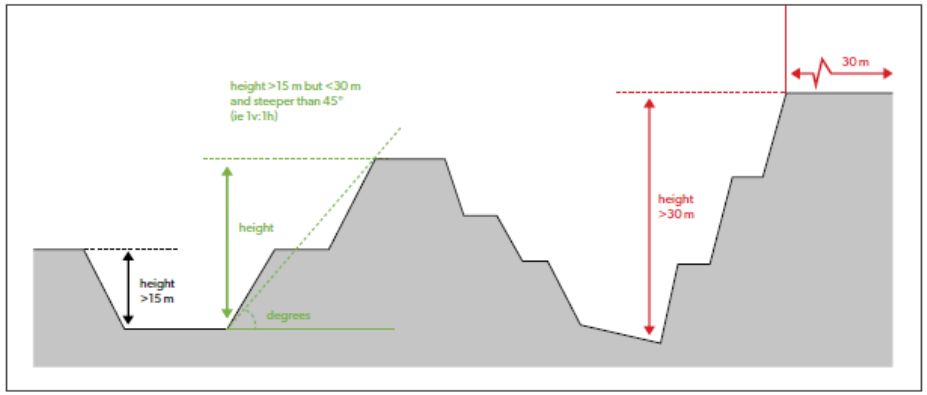
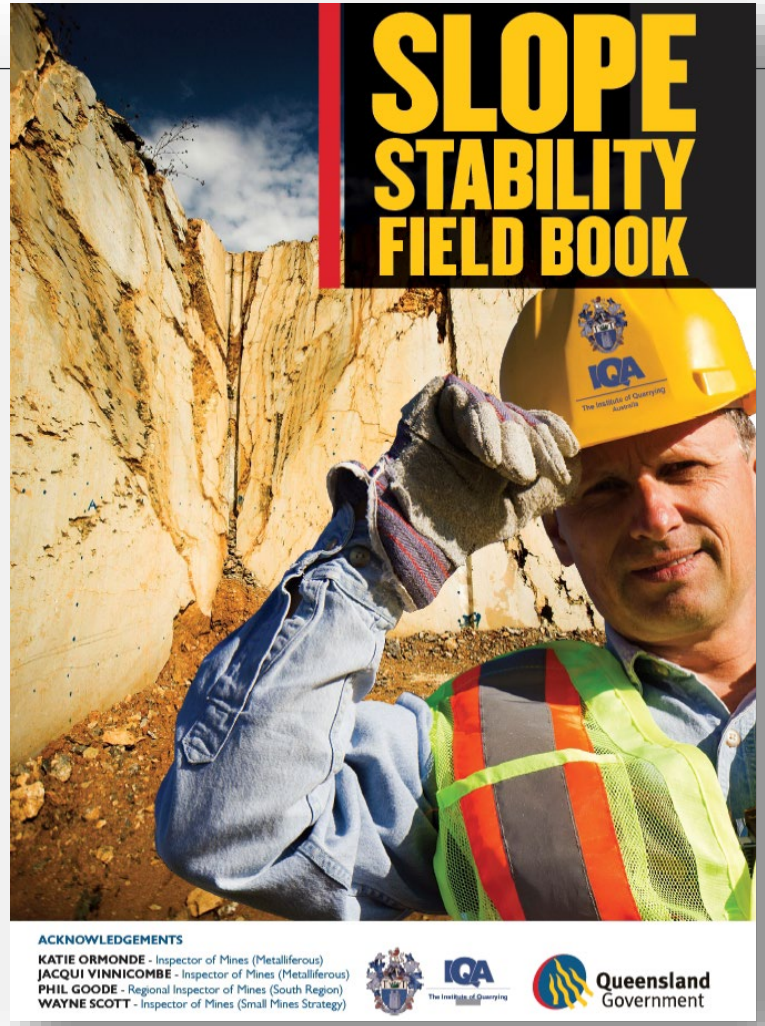
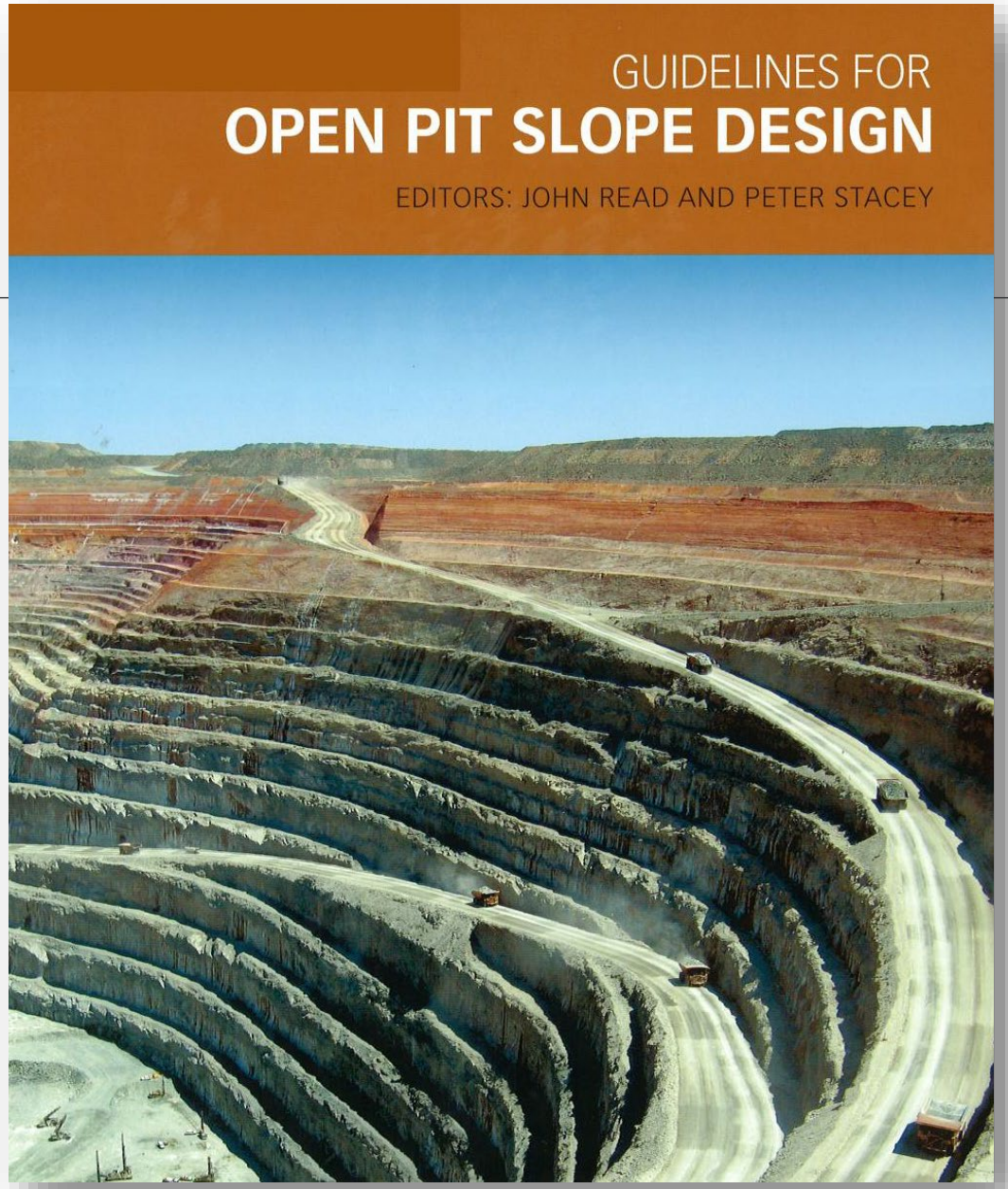


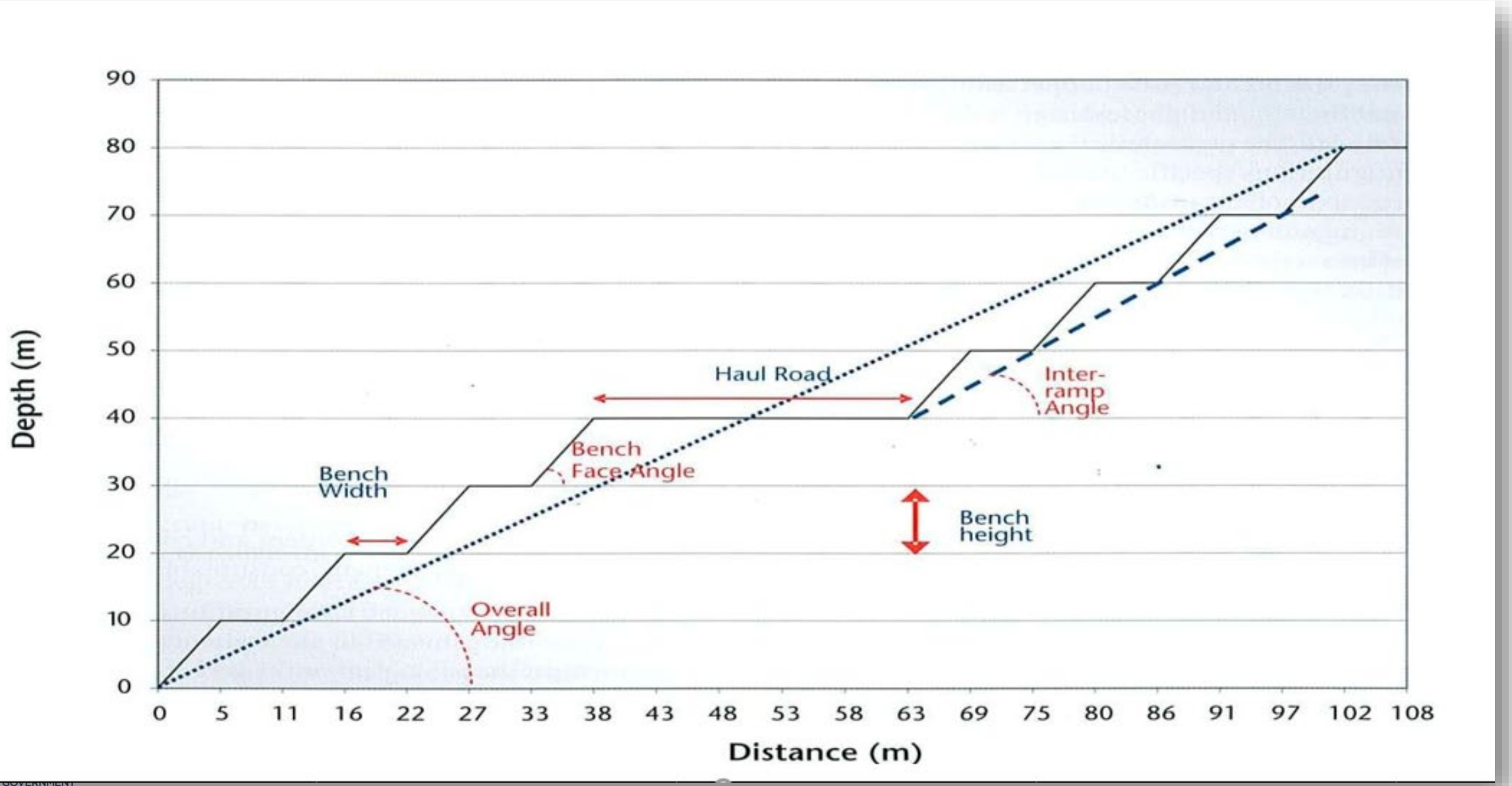
Figure 6: 'Stronger rock' guidance

Other Publications

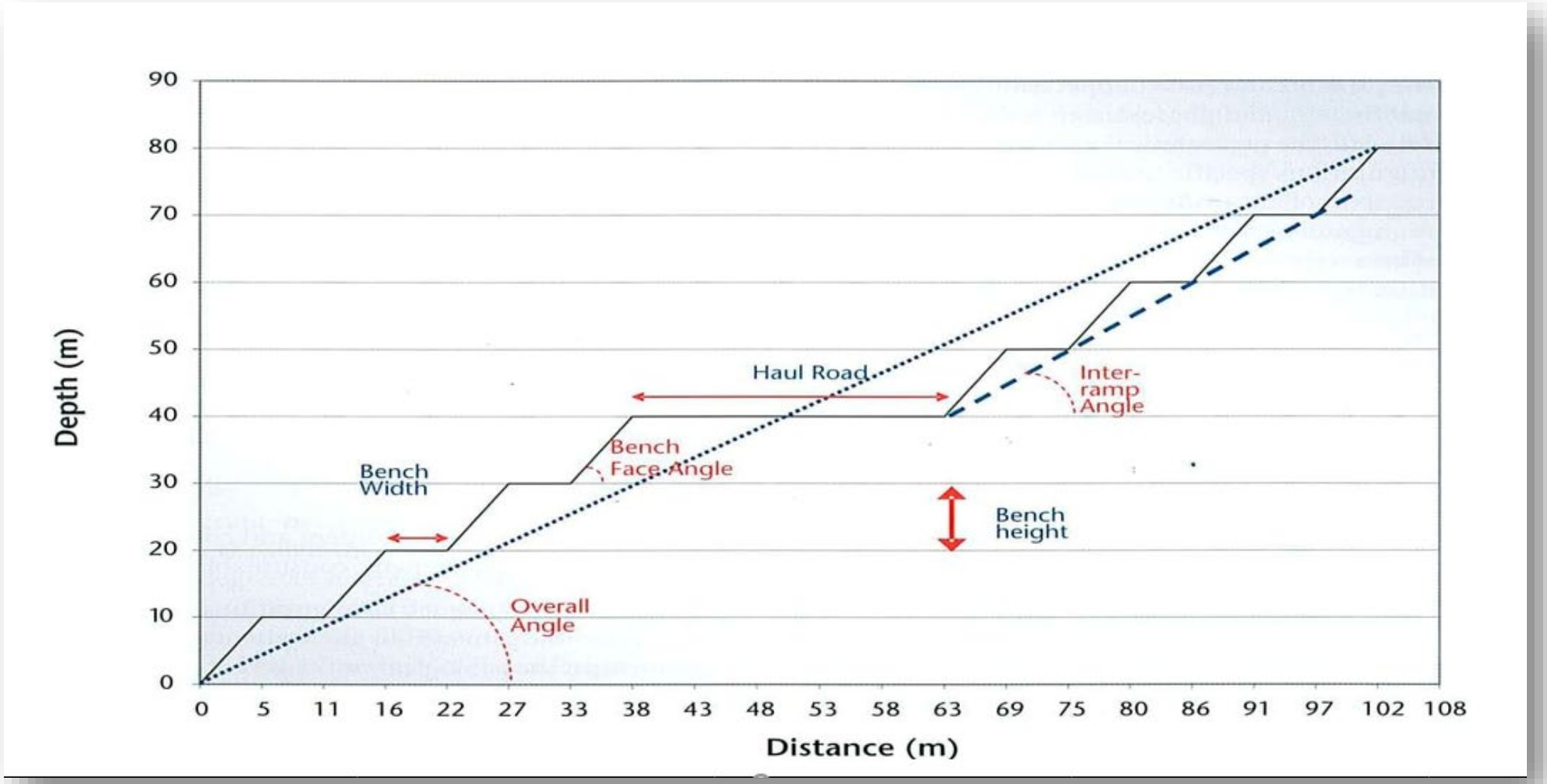




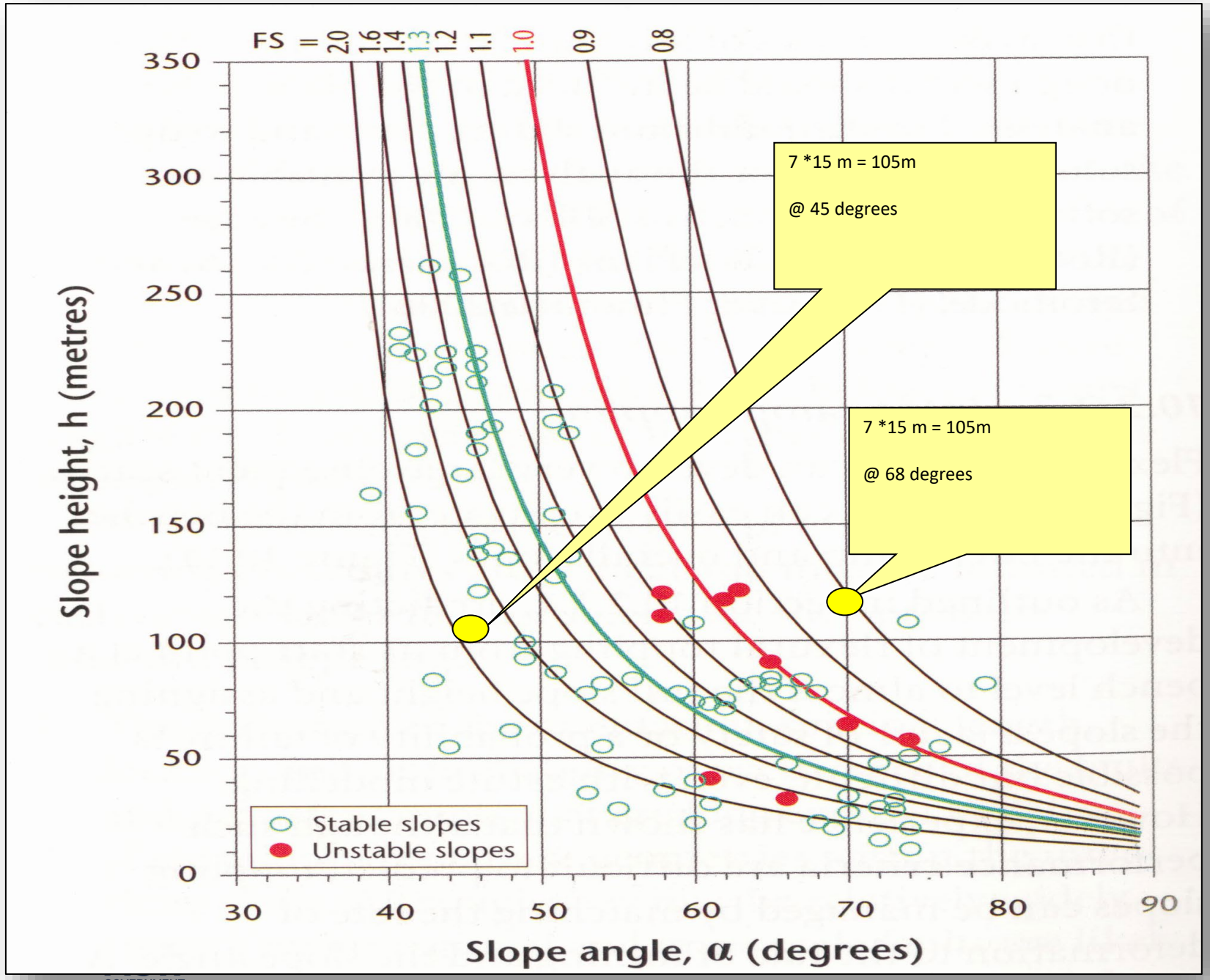
General Definition of Terms

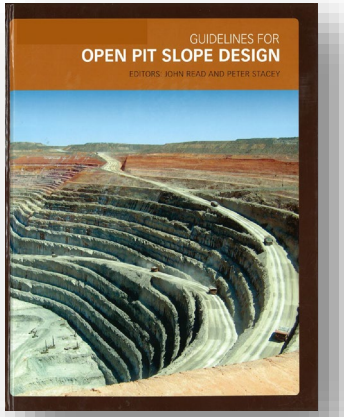


General Definition of Terms

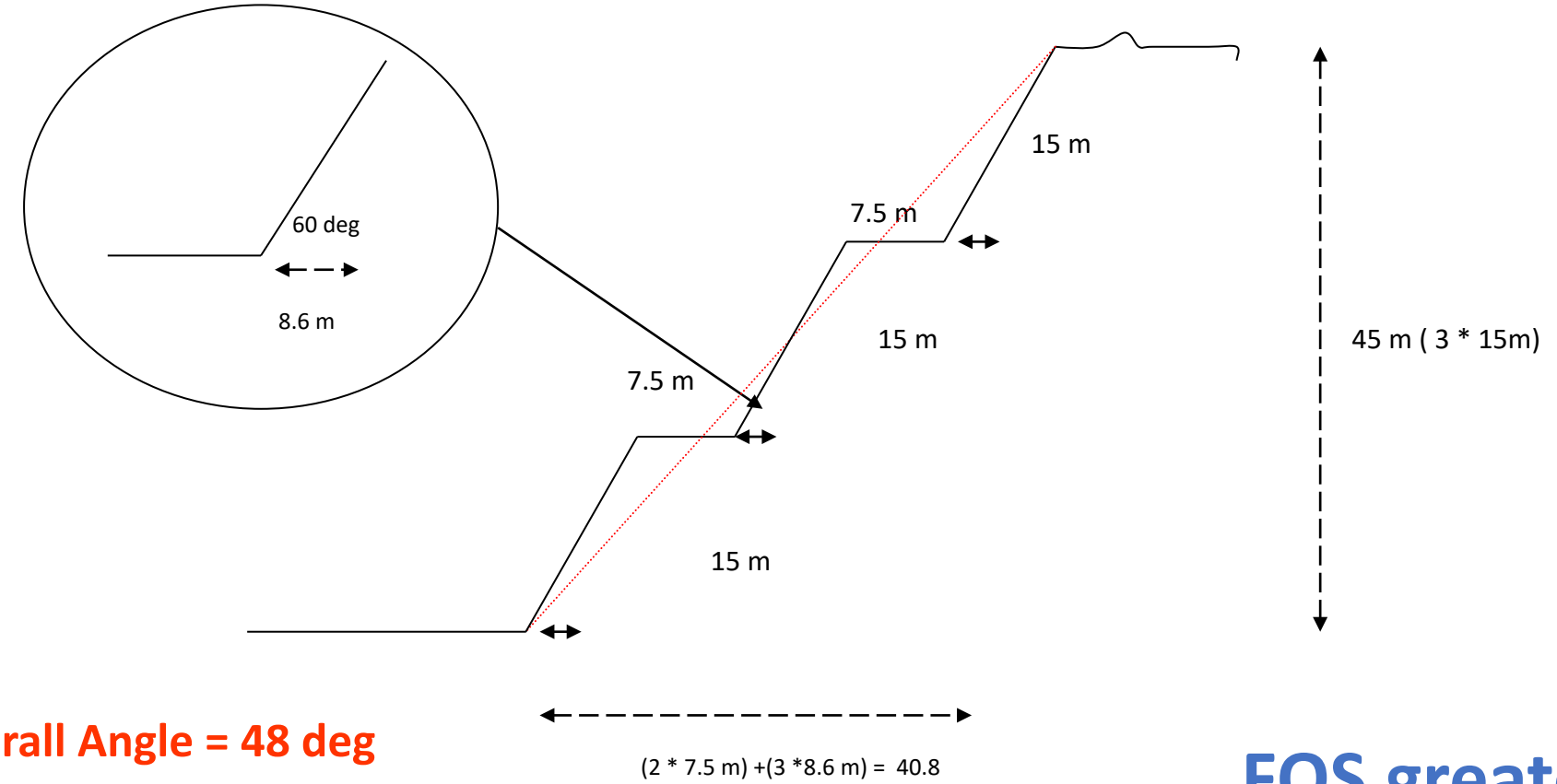


Slope Design





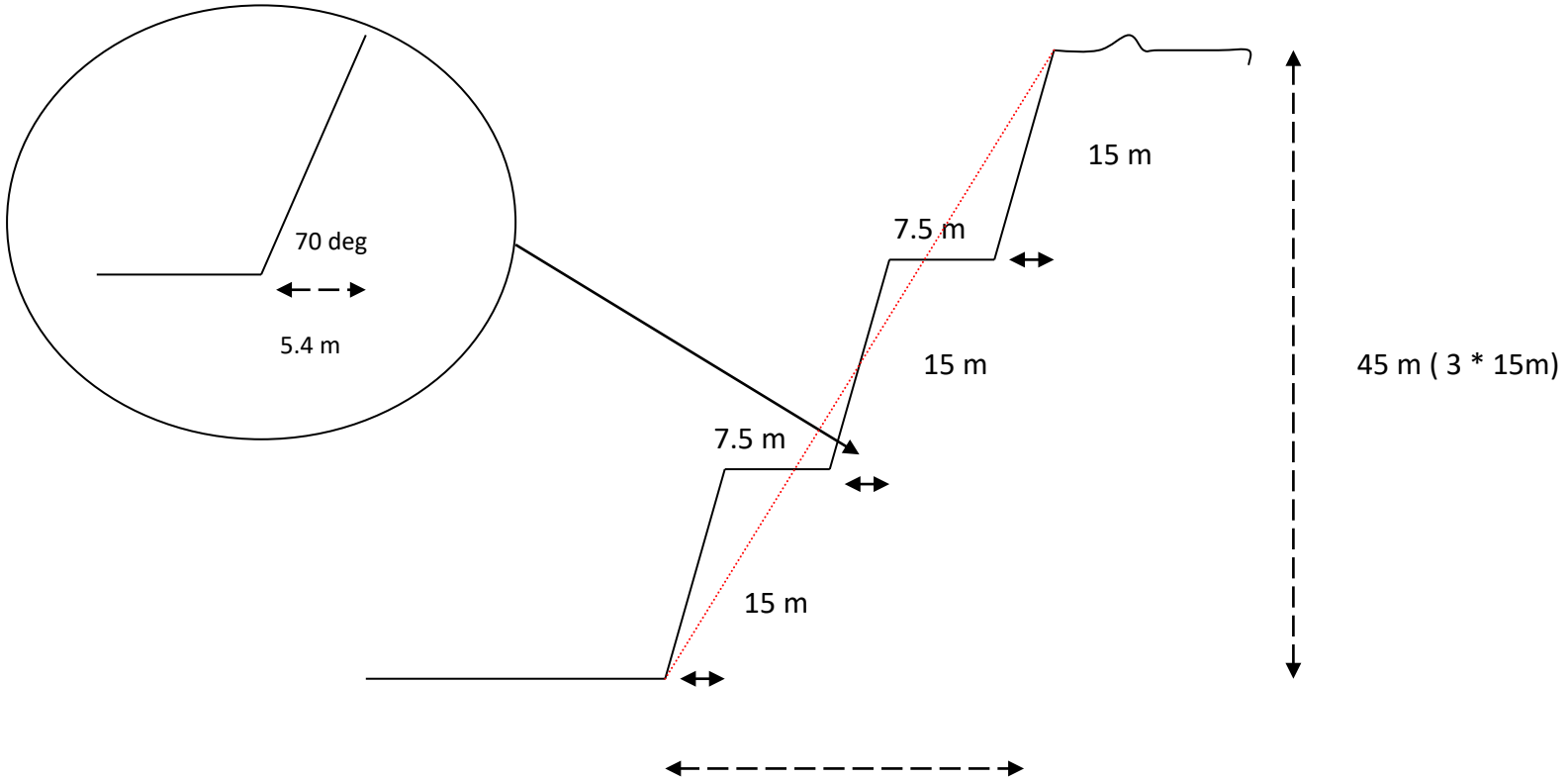
Overall Pit Angle @ 60 degree face



Overall Angle = 48 deg

FOS greater then 2.0

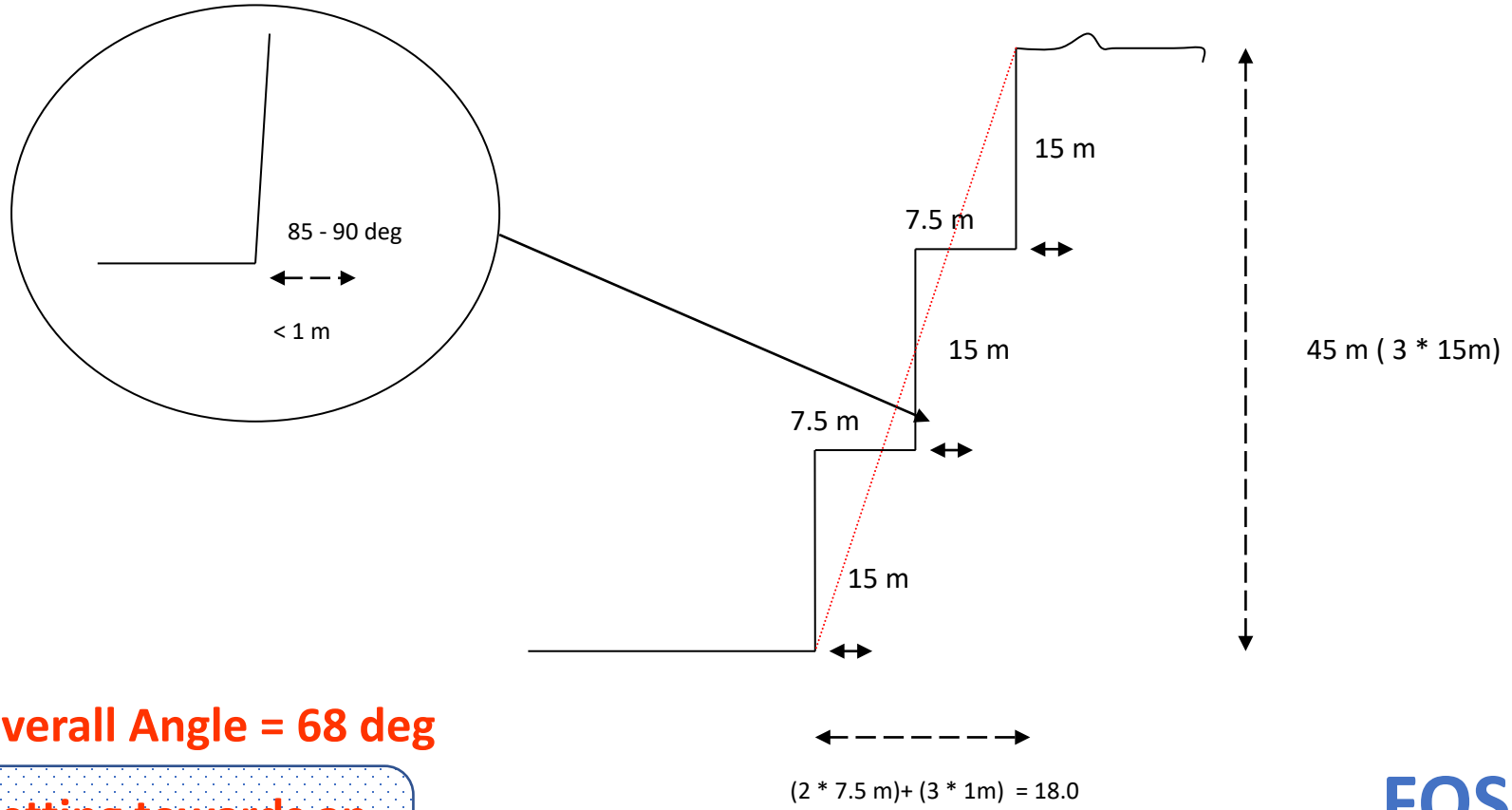
Overall Pit Angle @ 70 degree face



Overall Angle = 55 deg

FOS approx. 1.8

Overall Pit Angle @ 85 -90 degree face



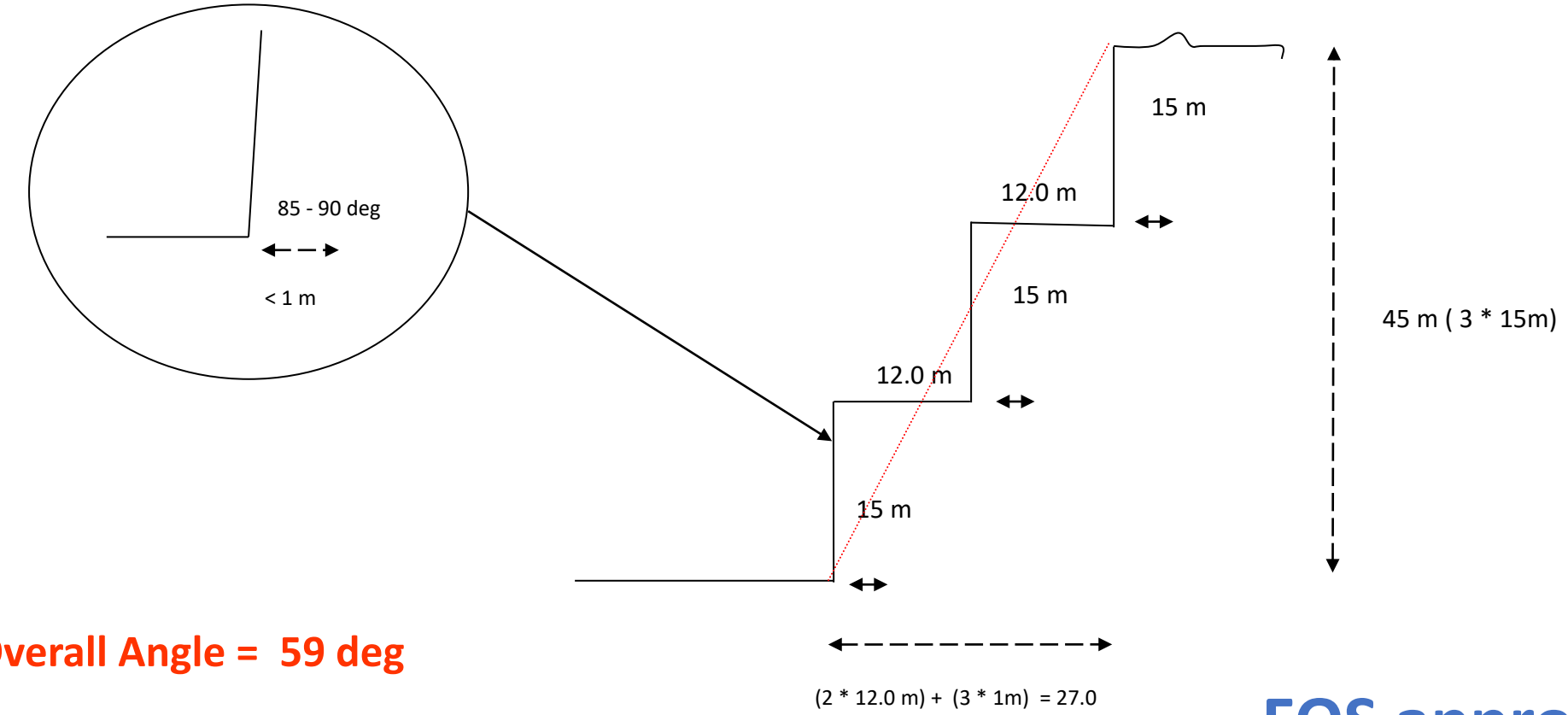
Overall Angle = 68 deg

Getting towards an unstable situation

FOS approx. 1.2

Overall Pit Angle @ 85 -90 degree face

Increase bench width from 7.5m – 12m



Overall Angle = 59 deg

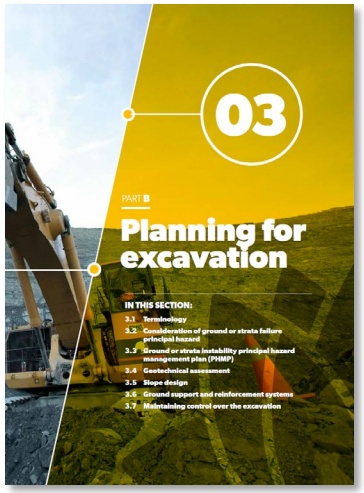
Better result

FOS approx. 1.7

Is Ground or Strata failure a Principal Hazard ?

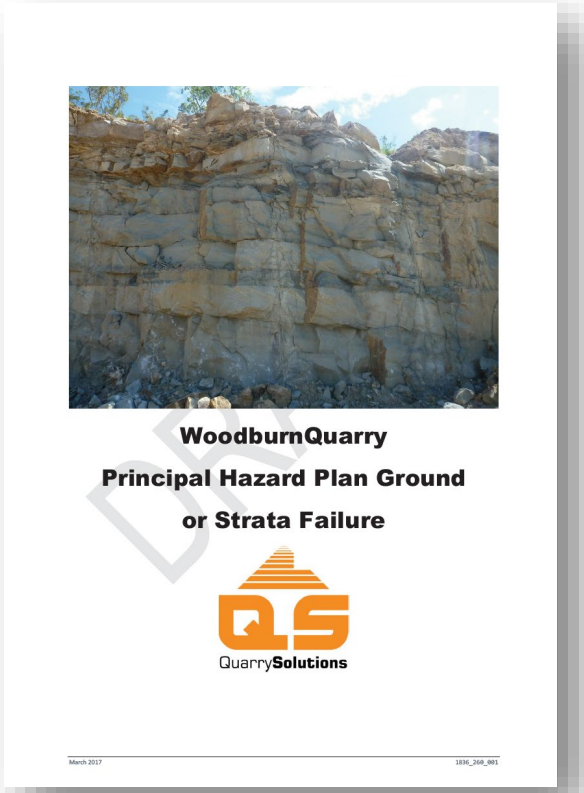
To determine if ground or strata failure is a principal hazard, consider how an excavation might feasibly fail, and the likely consequences of any such failure. The probability of such a failure happening is not relevant in the context of determining a principal hazard.

The consequences depend on the likely scale of the failure (i.e. the size of the failure and the area affected by it) and whether people are likely to be fatally injured.



PHMP and underpinning risk assessment

Stand alone PHMP with underpinning risk assessment – larger sites



RA & PHMP one in the same document – smaller sites

Considerations	Potential hazard	L	C	Risk	Controls used to manage hazard	HoC
Geotechnical attributes	• Failure of highwall due to geological conditions (faults, intrusions, cavities, bedding and jointing) • Failure due to no geotechnical expertise involved with bench design • Failure to identify and monitor cracks forming on a bench or highwall	L3 L3	C2 C3	M8 M13	Make sure, so far as is reasonably practicable • Excavation of faces/slope is adequately designed and benched at miminual intervals • Accredited and licenced qualified shot firer used for blasting of quarries • Monitoring of forming ground cracks on a daily basis whilst quarry is active	1 4
Pit design & layout	• Failure of highwall due to excessive face height • Failure of highwall due to excessive overall slope angle • Failure of highwall due to ineffective bench width • Failure due to location and loadings of waste dumps and haul roads	L3 L3 L3 L4	C2 C2 C3 C3	M8 M8 M13 L17	Make sure, so far as is reasonably practicable • Highwall is benched adequately between 15m - 30 m • Total slope angle is less than 27% • Benches are constructed to a minimum width and inspected daily for any possible failures • Pit layout reduces access to highwall	***1*** ***4*** ***5***
Effects of blasting on structure	• Bench failure due to excessive blast back break • Increased fractured ground due to poor blast management practises	L2	C3	M9	Make sure, so far as is reasonably practicable • Accredited and licenced blasting contractors to be used in quarry • Monitoring of fractured ground is carried out to identify any potential hazards	***4*** ***5***
Matching machinery	• Face not adequately scaled due to mismatch of machinery compatibility • Working in close proximity to highwall due to incompatible machinery	L3 L3	C3 C2	M13 M8	Make sure, so far as is reasonably practicable • Machinery is adequate and fit for purpose • Good blasting practices to ensure good access to materials for machinery • Face height does not exceed the reach of the machinery to be used	***4*** ***5***

Schedule 1 Principal hazard management plans—additional matters to be considered

(Sch 19 model WHS Regs)

Part 1 Mines

1 Ground or strata failure

(1) The following matters must be considered in developing the control measures to manage the risks of ground or strata failure—

(a) the local geological structure,

(b) the local hydrogeological environment, including surface and ground water,

(c) the means by which water may enter the mine, and the procedures for removing water from the mine and the effect that those procedures have on rock stability over time,

(d) the geotechnical characteristics of the rocks and soil, including the effects of time, oxidation and water on rock support and stability,

(e) the timing of installation of ground and strata support for the mine, taking into account the geotechnical conditions and behaviour of the rocks and soil,

(f) the collection, analysis and interpretation of relevant geotechnical data, including the monitoring of openings and excavations,

(g) any natural or induced seismic activity,

(h) the equipment and procedures used to record, interpret and analyse data from the monitoring of seismic activity,

(i) the location and loadings from existing or proposed mine infrastructure such as waste dumps, tailings storage, haul roads and mine facilities,

(j) any previously excavated or abandoned workings,

(k) the proposed and existing mining operations, including the nature and number of excavations, the number and size of permanent or temporary voids or openings, backfilling of m

(l) the proposed blasting activities (including the design, control and monitoring of each blast),

(m) the design, layout, operation, construction and maintenance of any dump, stockpile or emplacement area at the mine, including any open cut dumps or stockpiles,

(n) the filling requirements for mined areas and the material to be used as fill,

(o) the stability of any slopes,

(p) the size and geometry of the mine's openings,

(q) the use of appropriate equipment and procedures for scaling,

(r) the design, installation and quality of rock support and reinforcement,

(s) the need to monitor areas at or around the mine where control measures are in place for the principal hazard of ground or strata failure,

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WHS (MPS)Reg 2022 Schedule 1

Ready made prompt list

Subject Matter Experts – (when) ?

As a guide:

> Simple operations (e.g. shallow depth, soft material with faces less than 3.5 m, or competent rock with faces less than 15 m). A competent person should determine if the face design is safe, adequate benching is in place, or arrange for a geotechnical assessment. Assessments should be in writing, dated and signed with a review period established.

> Complex operations (e.g. individual faces exceeding 15 m, overall excavation depth exceeding 30 m, fractured rock, disturbed geological structure) will require a geotechnical assessment by a competent person.

A geotechnical assessment should be completed where:

> the height of any individual face is more than 15 m

> in the case of 'soils and highly weathered or friable rock' where the height of any part of an excavation is more than 3.5 m and the overall slope angle is steeper than 2 horizontal to 1 vertical (27° to the horizontal) (see Figure 4)

> the bottom of the excavation is more than 30 metres below any surrounding land within 30 metres of the edge of the excavation (i.e. the excavation is more than 30 metres deep, allowing for any nearby higher ground) (see Figure 5).

> Complex operations (e.g. individual faces exceeding 15 m, overall excavation depth exceeding 30 m, fractured rock, disturbed geological structure) will require a geotechnical assessment by a competent person.

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Bench 3	Description / Comment				
Drainage	Acceptable				
Stability	Large undercut unstable wedge at northern end of bench. Could impact existing haul ramp. Batter angles over-steepened or undercut in parts. Loose blocks and wedges perched precariously on batter.				
Deformation	Minor in parts				
Crest Cracking	Yes, extensive in weathered rock sections				
Modes of Failure	Rock wedge slide and flexural toppling along jointing and bedding. Block topple and fall from loose rocks on batter and over steepened or undercut batters.				
Batter Angle	70-90°	Bench Width	1-20 m	Bench Height	10-25 m
General Condition	○ Bench widths in north are narrow, particularly in southern section (< 1.5 m). ○ Bench heights are too high in northern and eastern sections. ○ Bench in north is segmented due to slope failures (refer Bench 1 above). Bench widths are narrow in southern section (< 1.5 m). This poses a safety risk as there are limited escape routes in an emergency. ○ Batter slope angles are over steepened in places.				
Photo	Unstable large wedge directly above main haul ramp with bulging in rock column near toe. 				
Unmitigated Risk	High				
Risk Mitigation	○ Implement a no stop zone and maintain bund at toe of slope. ○ Reduce batter angle in over-steepened sections. Increase bench width in southern section. ○ Buffer and toe restraint bunds are needed between road and batter slope to reduce risk of rock impacting vehicles and personnel. ○ Buttress with fill rock undercuts and bulging to provide wedge toe support. ○ Planning of future works adjacent to the unstable wedges is to include methodologies for safe wedge removal, e.g., excavation towards the wedges and then safe wedge removal from or above (rather than from below).				

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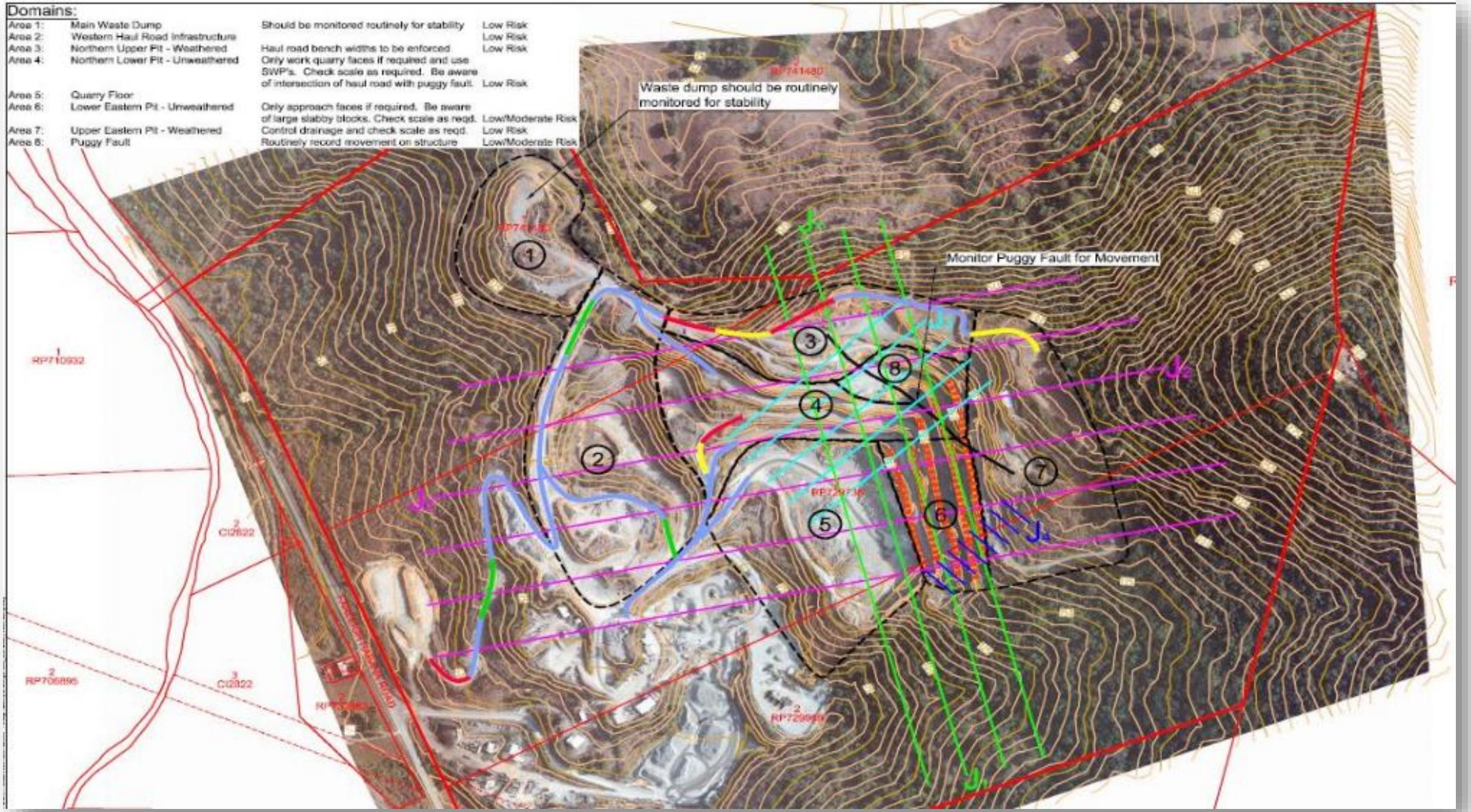
External reports

(initial and on going)

Pictorial view of risk assessment


Domains:
Area 1: Main Waste Dump
Area 2: Western Haul Road Infrastructure
Area 3: Northern Upper Pit - Weathered
Area 4: Northern Lower Pit - Unweathered
Area 5: Quarry Floor
Area 6: Lower Eastern Pit - Unweathered
Area 7: Upper Eastern Pit - Weathered
Area 8: Puggy Fault
Should be monitored routinely for stability Low Risk
Low Risk
Haul road bench widths to be enforced Low Risk
Only work quarry faces if required and use SWP's. Check scale as required. Be aware of intersection of haul road with puggy fault. Low Risk
Only approach faces if required. Be aware of large slabby blocks. Check scale as reqd. Low/Moderate Risk
Control drainage and check scale as reqd. Low Risk
Routinely record movement on structure Low/Moderate Risk
Waste dump should be routinely monitored for stability
Monitor Puggy Fault for Movement
RP710932
RP706896
CI2822
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3
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7
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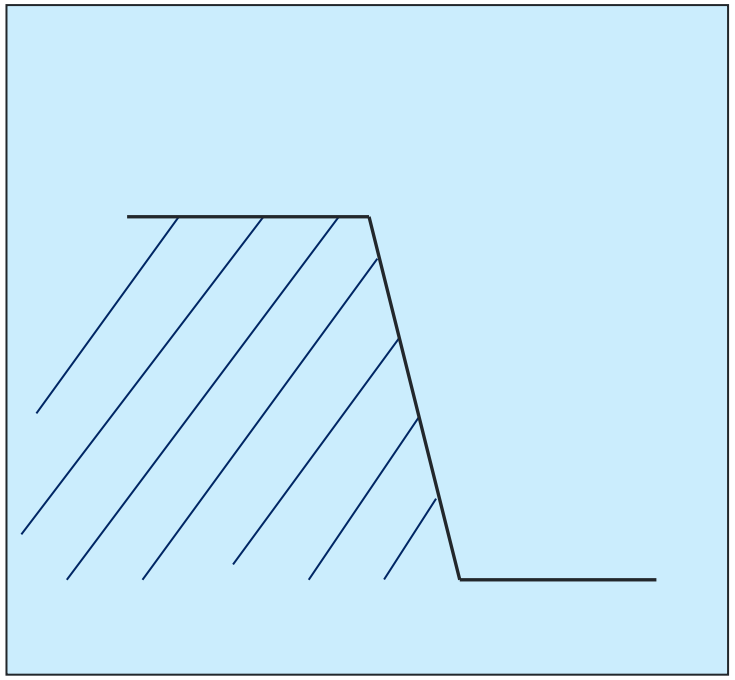
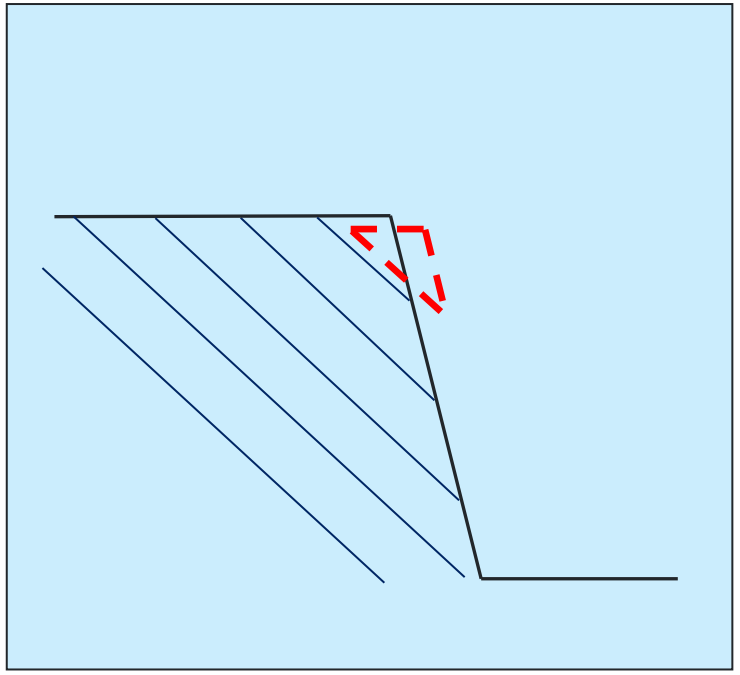
Bedding and face orientation

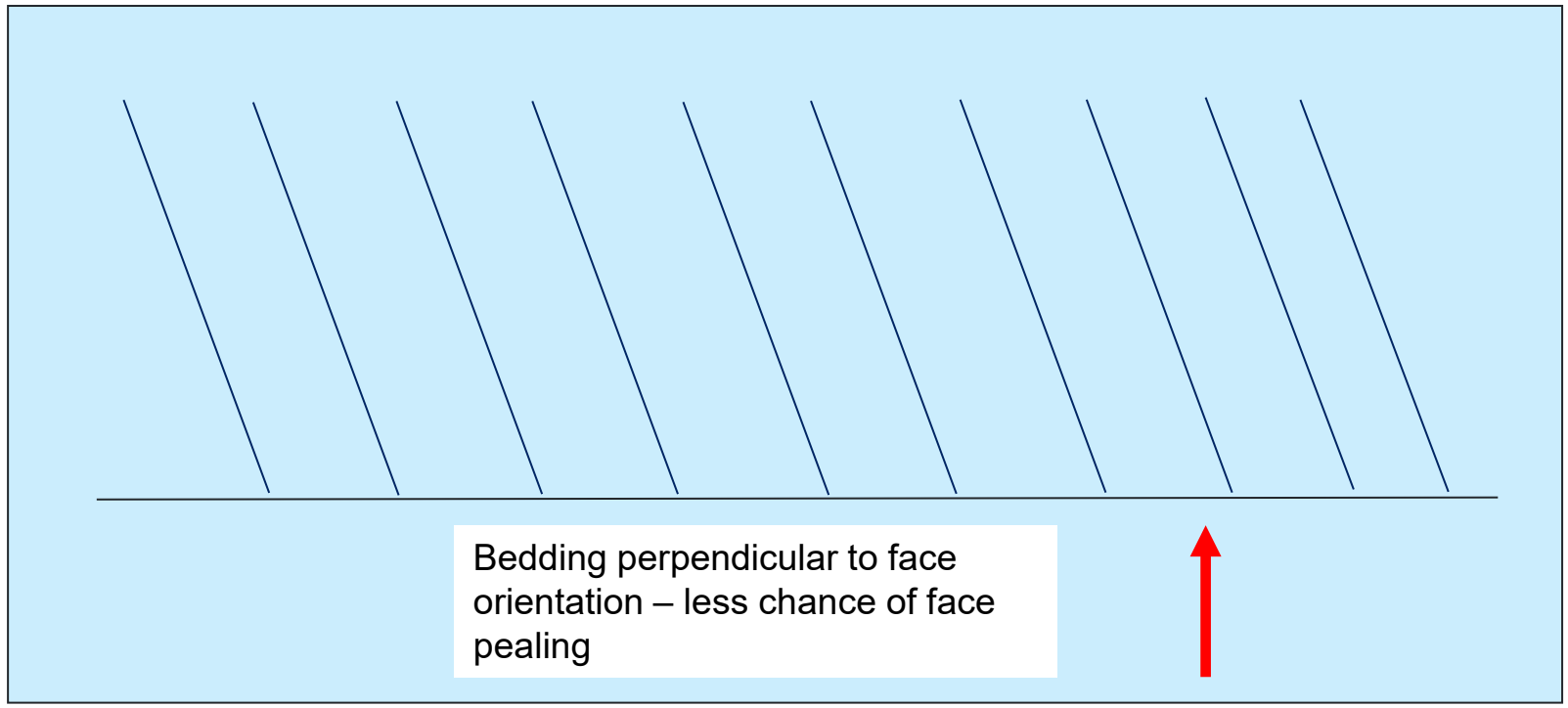


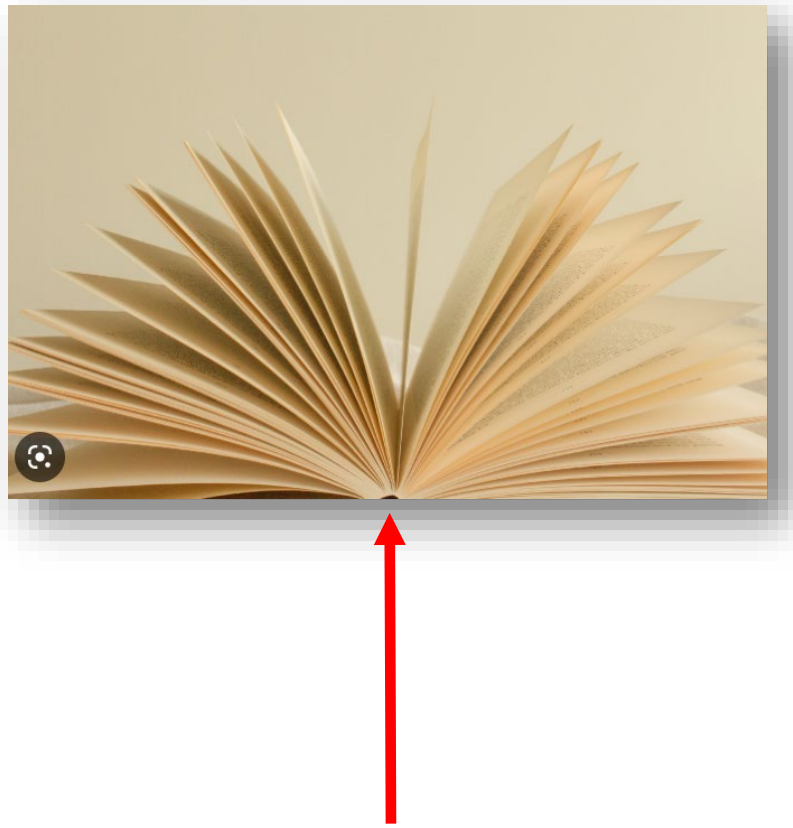
Side elevation – bedding dipping into the face



Side elevation – bedding dipping out of the face

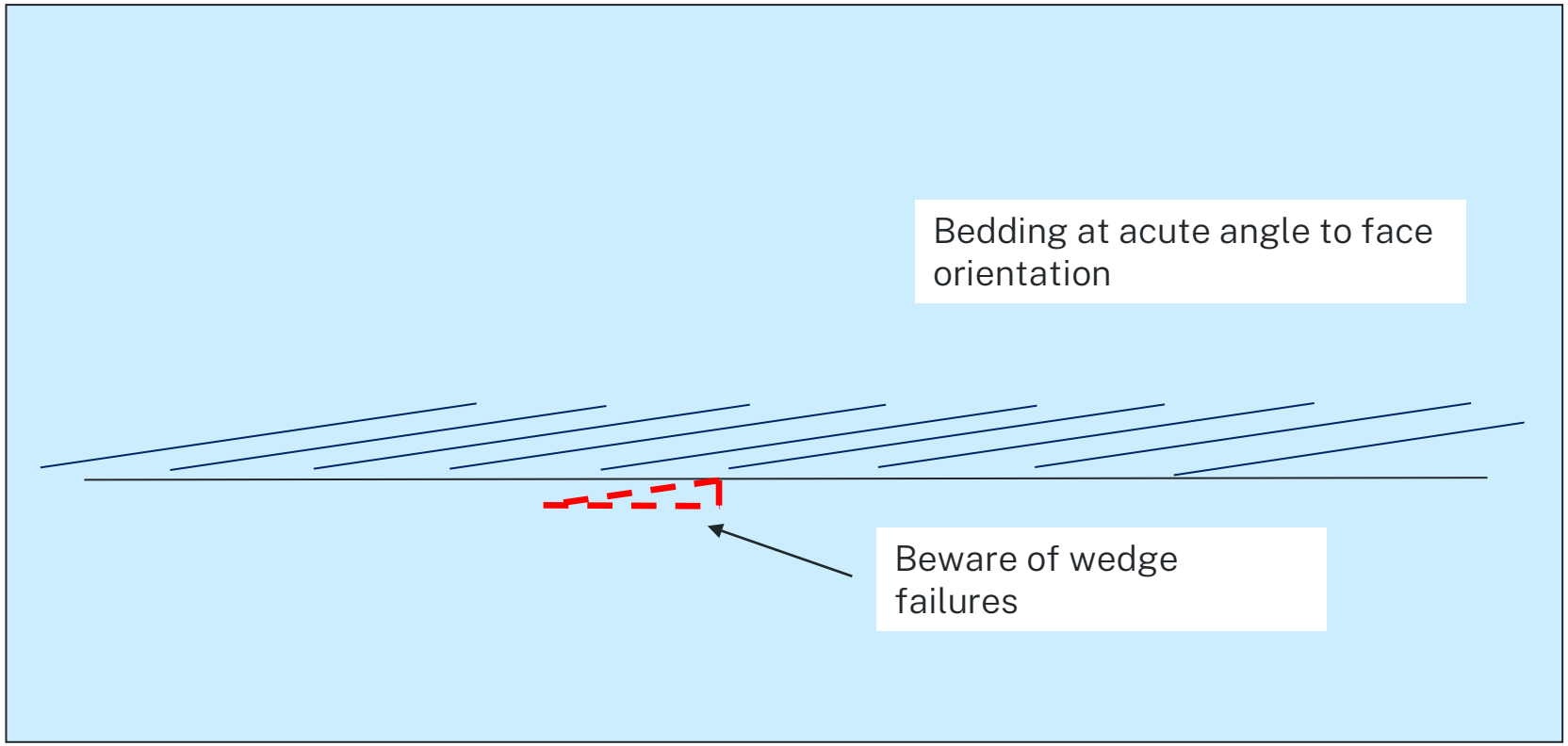
Bedding perpendicular to the face





Plan view of Quarry face

Bedding at acute angle



Plan view of Quarry face

In Pit (local) geological structures

- Bedding running at an acute angle to face
- Major fault cuts through entire deposit

2022 – severe weather

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SAFETY BULLETIN

DATE: 14 MARCH 2022

Impacts of severe weather on slope stability

This safety bulletin provides safety advice for the NSW mining industry.

Background

Large parts of New South Wales have experienced significant rainfall over the past several days.

Severe weather events can disrupt mining operations as well as impact safe access and egress from mines. This safety bulletin serves as a reminder to people conducting a business or undertaking as a mine operator or contractor, to consider the risks posed by significant rainfall impacting slope stability of excavations, quarry benches, dumps and other structures.

Hazards

Prolonged rainfall can saturate soils, cause pooling on surfaces, lubrication of faults and cause erosion of roads and ramps. This can impact the safety of workers and safe access and egress to and from mine working areas.

Recommendations

Mine operators should monitor conditions and identify areas where the potential exists for slopes to fail. Areas which have potential to fail must be managed to ensure that workers are not impacted if a slope failure occurs. Monitor highwalls and benches for cracking, fretting and any other signs of movement. Ensure that drains are functioning correctly so that flood water cannot pool on the surface of highwalls, benches and dumps. Keep workers and equipment away from areas where stability has been compromised by recent rainfall.

NOTE: Please ensure all relevant people in your organisation receive a copy of this safety bulletin and are informed of its content and recommendations. This safety bulletin should be processed in a systematic manner through the mine's information and communication process. It should also be placed in the mine's common area, such as your notice board where appropriate.

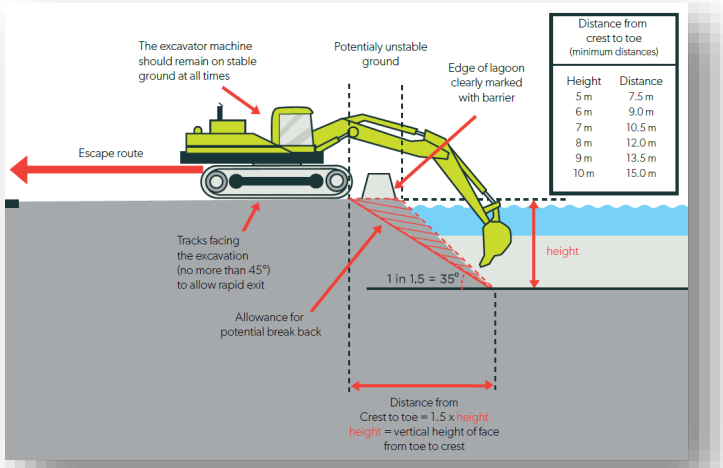
January 2023

- Currently being investigated by external geotech (likely to be geology contact)
- Establish failure mode
- Revise mine plan
- Implement action plan

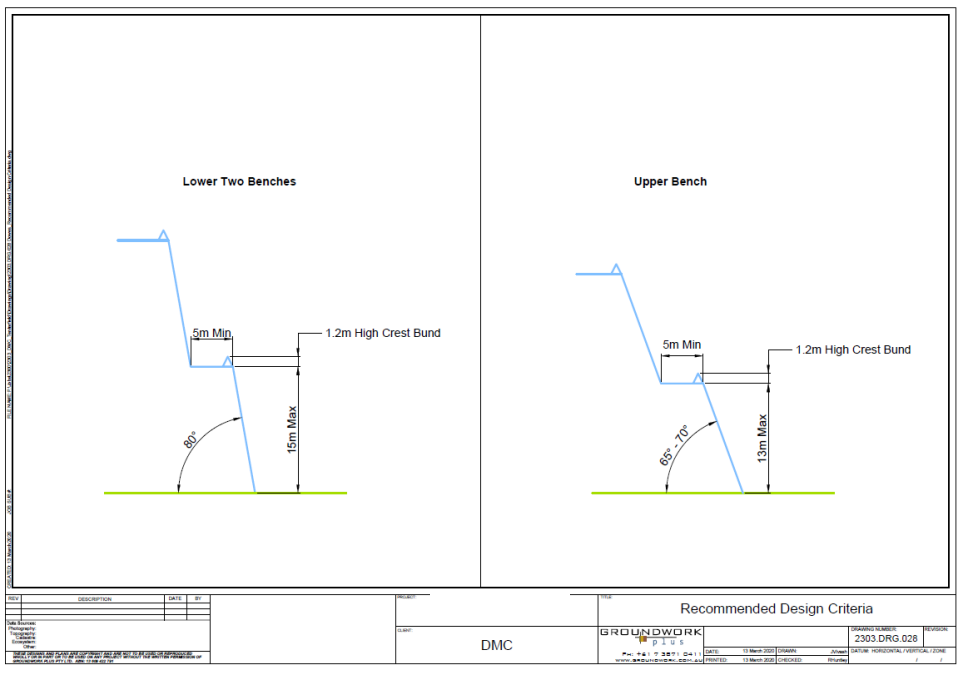
Doesn’t have to be hard rock ! (circa 2004)

Can be under the water ! (circa 2001)

- Change of mining method
- Undercut the working area
- No systematic approach
- No edge protection



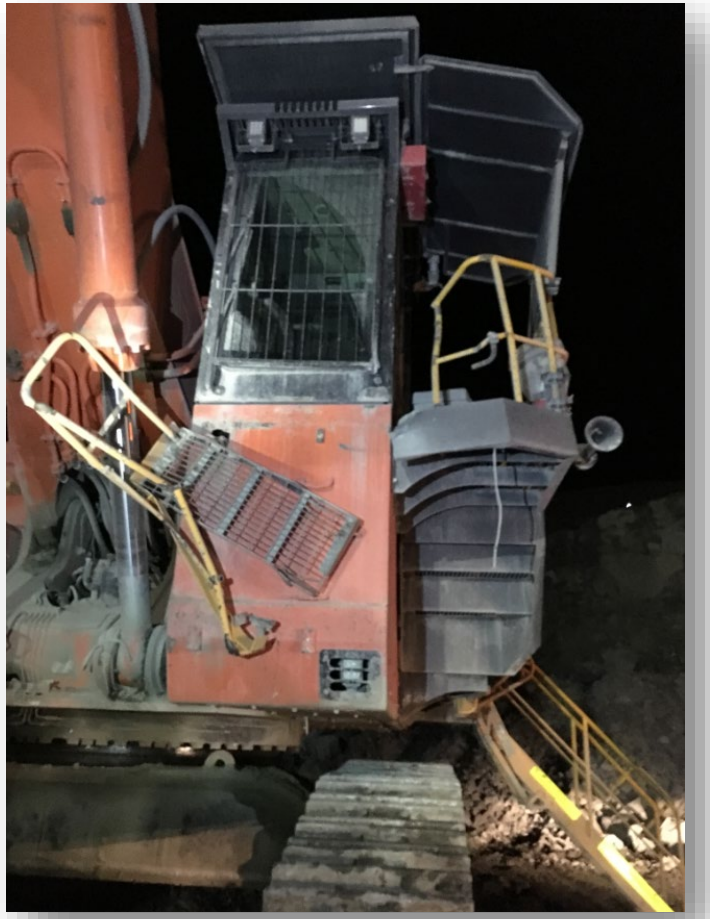
Catch bund design ?



Working near faces !

Stockpile extraction at small site ！

Can happen to excavators ?



- Fit for purpose equipment
- Correct and agreed setup
- Workers trained in slope stability awareness
- Scaling practices in place
- Inspection systems in place

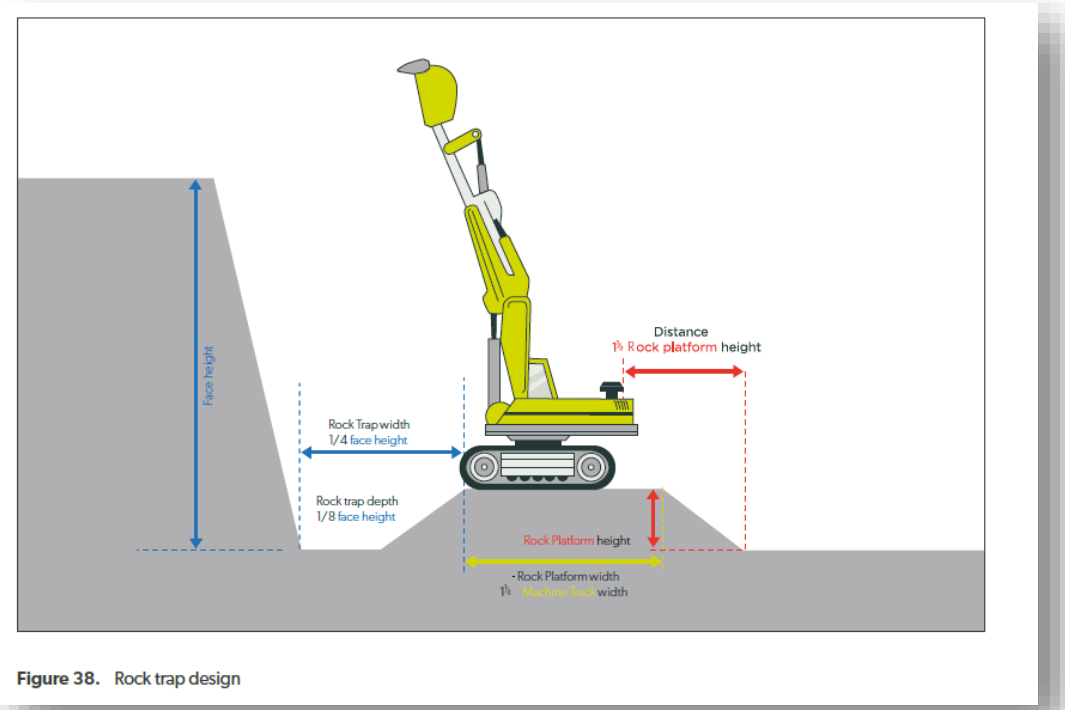
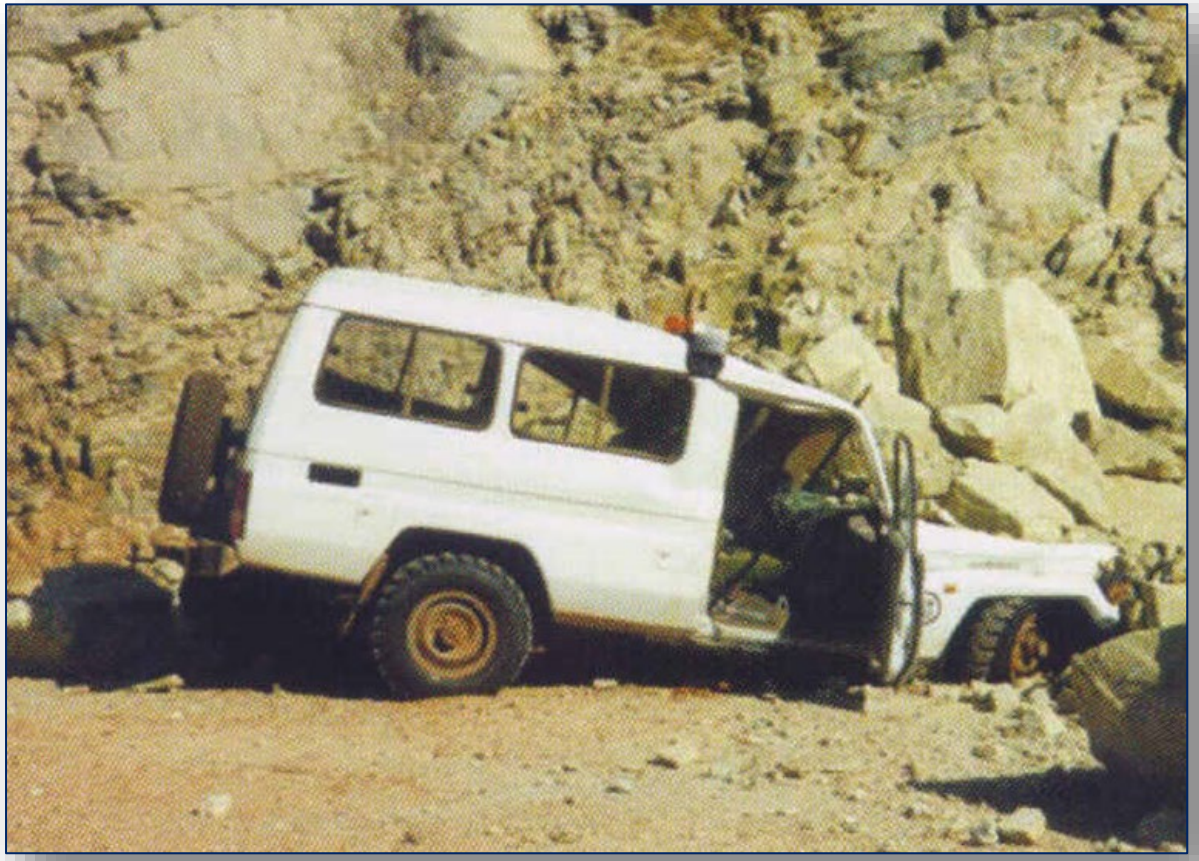


Figure 38. Rock trap design

Separating people and parking locations !

Separate people from the ground or strata hazard

- Indicators of potential failure are identified and people are subsequently protected from areas of risk.



Safety Alert 2020

NSW GOVERNMENT

NSW Resources Regulator

SAFETY BULLETIN

DATE: FEBRUARY 2020

Failure of highwalls, low walls and dumps

This safety bulletin provides safety advice for the NSW mining industry.

Issue

Several incidents have been reported recently where people and equipment have been exposed to significant health and safety risks as a result of highwalls, low walls and dumps failing.

Circumstances

These types of failures can occur at any time in open cut mines and quarries.

Incidents reported to the NSW Resources Regulator show the frequency of this type of incident increases significantly during and post wet weather events.

Figure 1 Recent highwall failure February 2020

SAFETY BULLETIN

NSW Resources Regulator

Figure 2 Recent highwall failure January 2020

Recommendations

NSW GOVERNMENT

Safety Bulletin - recommendations

1. **Installation and maintenance of water drainage** to prevent pooling of water
2. **Pumps are installed and operational** where required, prior to wet weather events
3. Thorough **inspections are completed by supervisors** prior to and during mining operations (results are recorded and communicated)
4. **Increase frequency of inspections** of highwalls and dumps during wet weather
5. **Workers to monitor conditions** in work areas
6. **Scaling of walls** to be completed during excavation
6. **Avoid working near, or parking vehicles** and equipment under, or on edge of highwalls during and post weather events
7. **Geotechnical assessments** are completed by qualified people and regular reports are provided to workers
8. Where possible **consider use of drones** to inspect wall conditions
9. **Access is available above and below** walls and dumps to allow inspections to be conducted
10. **Access is restricted to high risk areas** (e.g. dykes, faulted areas) until hazards are identified and controlled

Dump construction

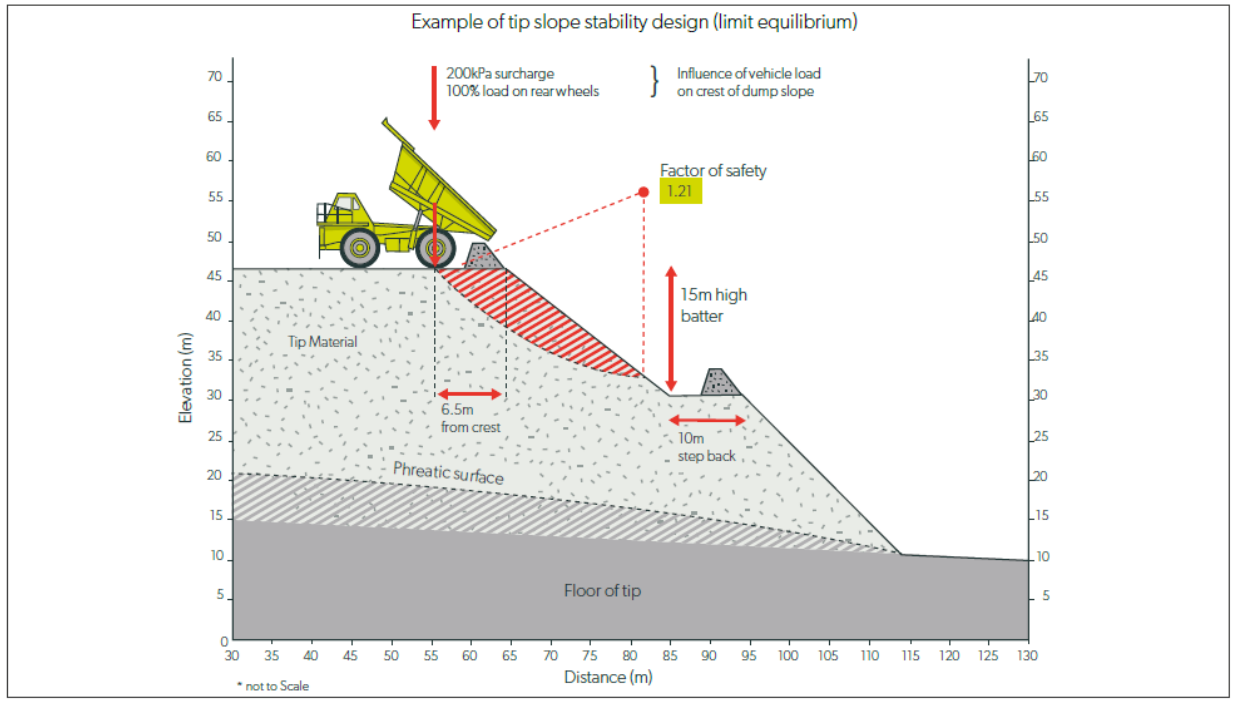


Figure 39. Example of tip slope stability design (limit equilibrium)

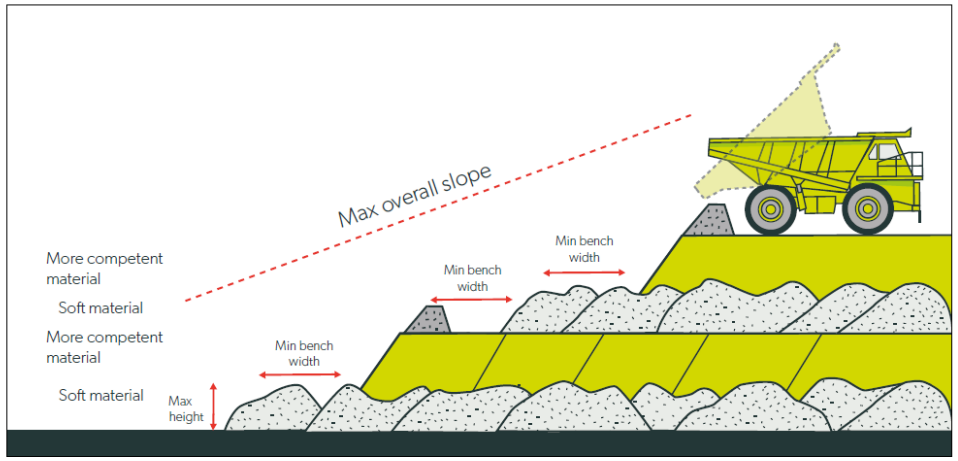


Figure 40. Example dump construction method for mixed material (mattressing)

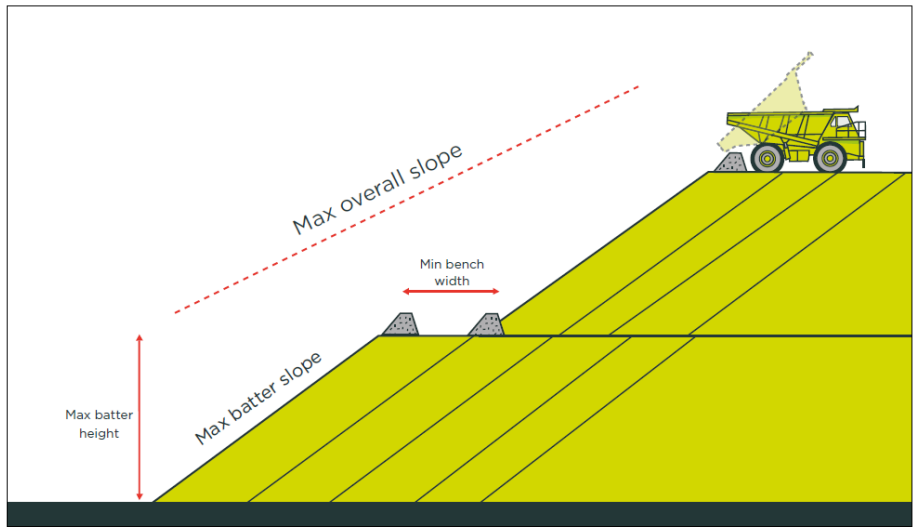


Figure 41. Example dump construction method for competent material

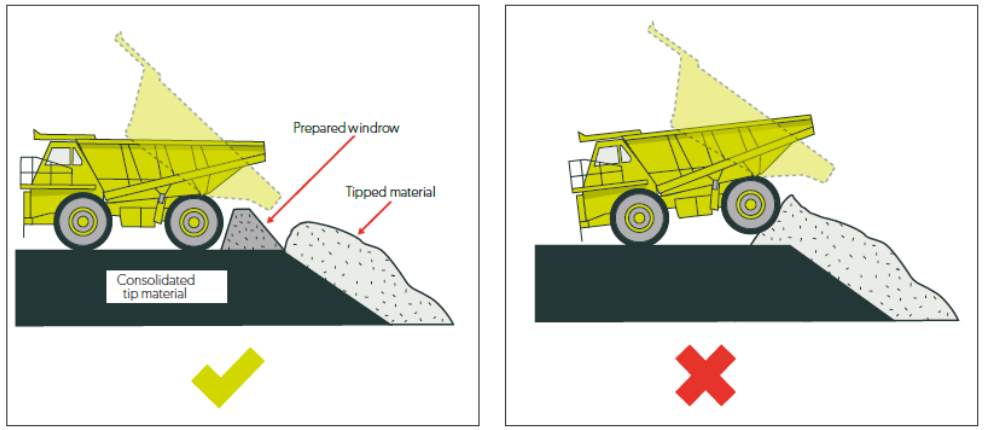


Figure 43. Approaching tip point windrow

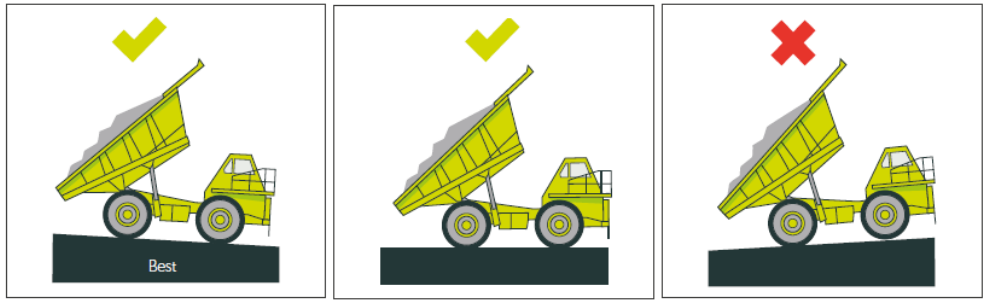


Figure 45. Dump on level ground with a slight uphill gradient

Dump to design

- Factors which affect dump stability are identified, dumps are correctly constructed, and dumps are inspected and monitored for compliance.

GOVERNMENT

Instability or movement in dumps and stockpiles can cause serious harm. To minimise this risk, actively manage dumps and stockpile, and have robust procedures in place.

This section describes:

> common risks from dumps, stockpiles dumps and tipping materials and ways to control them

> procedures for inspecting tip heads and tip condition.

Incidents can occur for various reasons when dumping. These reasons are unsafe dump head conditions, unsafe dumping practices or a combination of the two.

Some unsafe dump point conditions include:

> **No windrow or restraint, or an inadequate windrow or restraint.** This makes the edge location difficult to judge, offers inadequate restraint to keep a vehicle from going over the edge.

> **A windrow that is too narrow at the base.** This allows the heavy loading of the truck to get so close to the edge of the dump that the edge material may not be strong enough to support the weight.

> **An edge of a dump that has been weakened** because the dump has been loaded out at the toe and over steepened. Edge material may not be able to support the truck weight and its own weight. A portion of the windrow may have fallen away, reducing the windrow's capability to provide restraint.

> **An edge of a dump that has been undercut.** Overhanging conditions can be created especially when the dump material is frozen, or has sat for an extended period.

> **Cracks, settlement, or a slide near the edge of the dump.** The edge may be unstable and may not support the additional truck weight.

> **A soft area near the edge of the dump** may cause tyres to sink in and the truck to tip over as it attempts to dump.

> **A dump that runs downgrade to the windrow.** Gives drivers less control while backing and can soften the dump area from poor drainage.

> **A dump that's placed on a soft or weak foundation.** As the dump gets larger, the slope may become unstable due to the foundation giving way underneath.

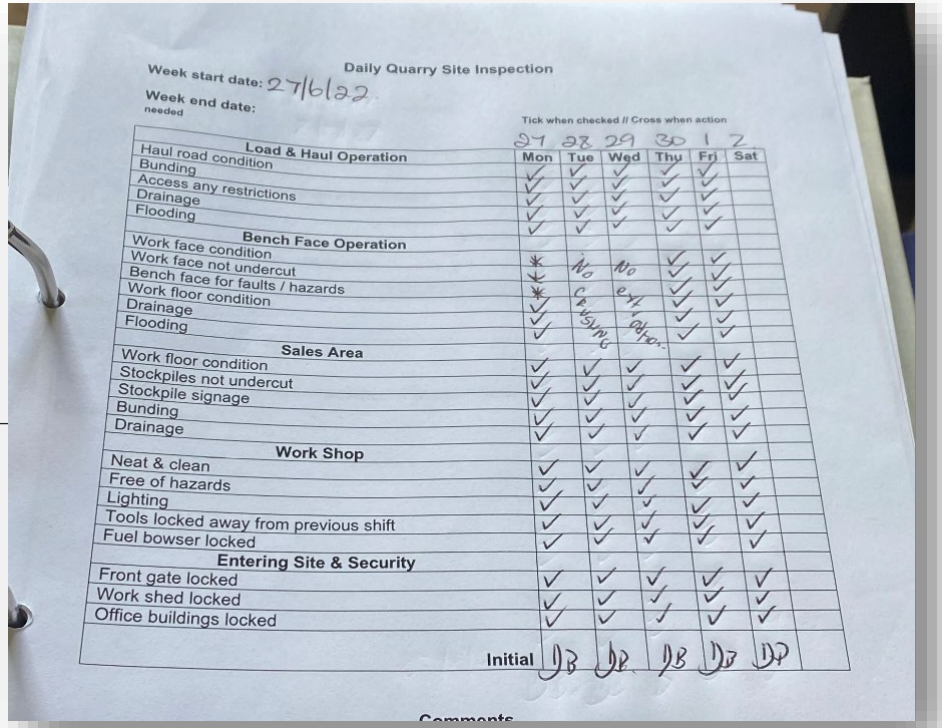
> **Inadequate lighting for night operations,** or poor visibility during inclement weather. Makes driver judgements, and detection of unsafe conditions, more difficult.

> **Inadequate clearance** between equipment and overhead power lines. Two particular concerns are that truck trays are raised at dump points, and as dumps get larger the clearance may become reduced.

> **Congestion around the dump head** where dump trucks or other mobile machinery congregate and crowd the dump head due to operational delays or unplanned events.

Inspections – (pit, face, dumps stockpiles)

Inspection (by who)	Frequency
Extraction team	Daily (prior to work)
Supervisor	Daily
Quarry Manager	Routinely
Internal professionals	As required
External Subject Matter Expert	As required (annually)



Daily Quarry Site Inspection

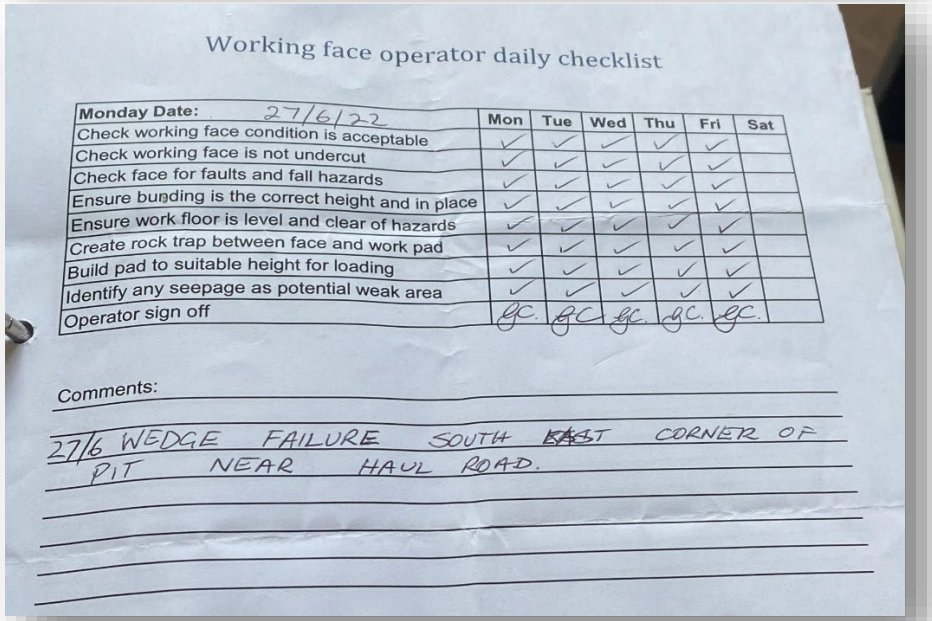
Week start date: 27/6/22

Week end date:

Tick when checked // Cross when action needed

	27 Mon	28 Tue	29 Wed	30 Thu	1 Fri	2 Sat
Load & Haul Operation						
Haul road condition	✓	✓	✓	✓	✓	
Bunding	✓	✓	✓	✓	✓	
Access any restrictions	✓	✓	✓	✓	✓	
Drainage	✓	✓	✓	✓	✓	
Flooding	✓	✓	✓	✓	✓	
Bench Face Operation						
Work face condition	✳	No	No	✓	✓	
Work face not undercut	✳			✓	✓	
Bench face for faults / hazards	✳	Crushing	excavation	✓	✓	
Work floor condition	✓			✓	✓	
Drainage	✓			✓	✓	
Flooding	✓			✓	✓	
Sales Area						
Work floor condition	✓	✓	✓	✓	✓	
Stockpiles not undercut	✓	✓	✓	✓	✓	
Stockpile signage	✓	✓	✓	✓	✓	
Bunding	✓	✓	✓	✓	✓	
Drainage	✓	✓	✓	✓	✓	
Work Shop						
Neat & clean	✓	✓	✓	✓	✓	
Free of hazards	✓	✓	✓	✓	✓	
Lighting	✓	✓	✓	✓	✓	
Tools locked away from previous shift	✓	✓	✓	✓	✓	
Fuel bowser locked	✓	✓	✓	✓	✓	
Entering Site & Security						
Front gate locked	✓	✓	✓	✓	✓	
Work shed locked	✓	✓	✓	✓	✓	
Office buildings locked	✓	✓	✓	✓	✓	
Initial	JB	JB	JB	JB	JB	

Comments



Working face operator daily checklist

Monday Date: 27/6/22	Mon	Tue	Wed	Thu	Fri	Sat
Check working face condition is acceptable	✓	✓	✓	✓	✓	
Check working face is not undercut	✓	✓	✓	✓	✓	
Check face for faults and fall hazards	✓	✓	✓	✓	✓	
Ensure bunding is the correct height and in place	✓	✓	✓	✓	✓	
Ensure work floor is level and clear of hazards	✓	✓	✓	✓	✓	
Create rock trap between face and work pad	✓	✓	✓	✓	✓	
Build pad to suitable height for loading	✓	✓	✓	✓	✓	
Identify any seepage as potential weak area	✓	✓	✓	✓	✓	
Operator sign off	GC	GC	GC	GC	GC	

Comments:

27/6 WEDGE FAILURE SOUTH ~~EAST~~ CORNER OF PIT NEAR HAUL ROAD.

Slope stability inspections can extend to ongoing monitoring…

- visual inspection
- surface extensometers and crack monitoring
- Manual survey
- Real time GPS stations with prisms
- radar
- micro-seismic monitoring
- monitoring of groundwater pressure.
- Use of a drone

Planned assessment results

Fact sheet – Ground or strata failure – small mines

NSW GOVERNMENT

NSW Resources Regulator

FACT SHEET

Assessment program - Ground or strata failure – slope stability

Small mines

January 2022

The principal mining hazard of ground or strata failure can occur through various mechanisms at surface mining operations. This can therefore potentially place workers at risk if not controlled effectively. The management of slope stability is a key mechanism within this process and should be assessed both individually and cumulatively with other hazards.

The Resources Regulator is commencing a program of planned inspections and targeted assessments at small mines focussing on the critical controls associated with slope stability. The assessments will be focussed on the following criteria:

Mine design

- Ground stability risks are assessed and controlled within the mine design and mine operating parameters.

Water management

- Controls for risks to ground or strata from water damage are implemented.

FACT SHEET
Ground or Strata Failure –Slope Stability
Small Mines

NSW Resources Regulator

Dump to design

- Factors which affect dump stability are identified, dumps are correctly constructed, and dumps are inspected and monitored for compliance.

Excavate to design

- Walls are excavated to design and cleared of loose material.

Drilling and blasting practices

- Execution of drill and blast practices are completed to designed specifications.

Separate people from the ground or strata hazard

- Indicators of potential failure are identified and people are subsequently protected from areas of risk.

FACT SHEET
Ground or Strata Failure –Slope Stability
Small Mines

NSW Resources Regulator

Operator protection

- Plant design provides a barrier for falling objects and also prevents workers from being crushed in a rollover event.

Considerations

Mine operators should consider the above criteria as a minimum, ensuring such information is included within their principal hazard management plans and associated documentation. Following investigations into strata failure incidents within the mining industry, it was evident that non-compliance to these key control measures contributed to incident outcomes, which caused both severe and fatal injuries to workers. When identifying and implementing control measures, mines are also reminded to follow the hierarchy of controls to ensure health and safety risks are minimised so far as is reasonably practicable.

Other relevant safety alerts and bulletins published by the NSW Resources Regulator:

DATE PUBLISHED	REFERENCE	TITLE
February 2020	SB20-01	Failure of highwalls
August 2019	SB19-09	Lack of bunding on accessible edges
December 2018	SA18-13	Dangerous incident involving excavator on edge of highwall
July 2018	SA18-09	Drill rig breaches highwall windrow
July 2018	SB18-11	Windrow management and demarcation
March 2017	SB17-03	Rocks breach catch bund
January 2017	SB17-01	Industry reports more truck rollover incidents
November 2014	IIR14-06	Track mounted excavator tip over

DOC21/1088805

Ground or Strata failure consolidated report findings…

Throughout the inspection program, there were several examples where sites could demonstrate a good application in controlling the principal hazard of ground or strata failure – slope stability.

Improvement areas were also identified and discussed with the sites during the assessments for managing their ground or strata hazards.

- **Areas for improvement:**
- Documentation **not relevant, site specific** or up to date
- Excavations **not meeting design criteria** or mine plan
- Lack of understanding to **inspect blast hole logs** and anomalies
- **Water management practices** not documented and regularly inspected

Ground or Strata failure consolidated report findings...continued !

- **Equipment setup up procedures** adjacent to geological structures not documented
- **Inspections not routinely** completed
- **Absence of awareness training** for workers and supervisors
- Disconnect between **blast management plan and mine plan** (reliance on contractors)
- **Non reporting** of ground and strata failures to the Regulator

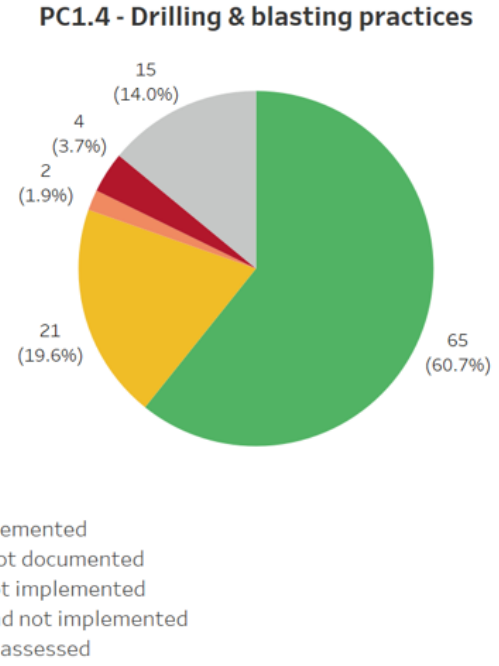
Drilling and Blasting practices

FIELD VERIFICATION - Control PC1.4 – Drilling and blasting practices

Objective: *Achieve stable wall conditions.*

Expected control supports	Rating	Assessment outcome / comments
CIA - 0201 - PC1.4 - 02; **CIA - 0201 - PC1.4 - 03;** **CIA - 0201 - PC1.4 - 06;** **CIA - 0201 - PC1.4 - 08** Confirm that quarry manager/supervisor can explain the key features of the drill plan. *Key features could include:* • *Pre-splitting or trim shot detail.* • *Formation of benches* • *Drill hole* 1. *Correct location* 2. *Correct angle* 3. *Correct depth* • *Maintaining hole logs*	4 3 2 1	
CIA - 0201 - PC1.4 - 07 Confirm that information relevant to the blast design is recorded in the hole logs. *Relevant information may include:* • *Deviation from planned hole location or angle.* • *Holes drilled short of planned length.* • *Broken ground or voids encountered*	4 3 2 1	
CIA - 0201 - PC1.4 - 09 Confirm that the blast holes have been checked prior to loading for anomalies such as water in the holes, collapsed or blocked holes. *Relevant information may include:* • *Check loading records from most recent blast*	4 3 2 1	

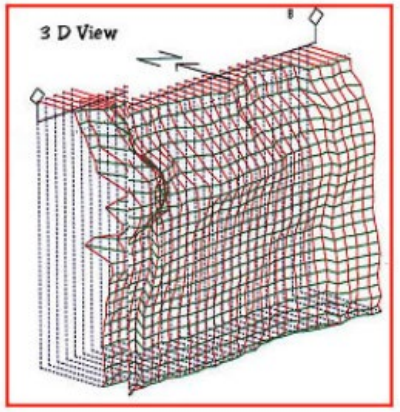
Figure 8. Overall assessment findings ratings for critical control – PC1.4 Drilling & blasting practices (total 107 findings)

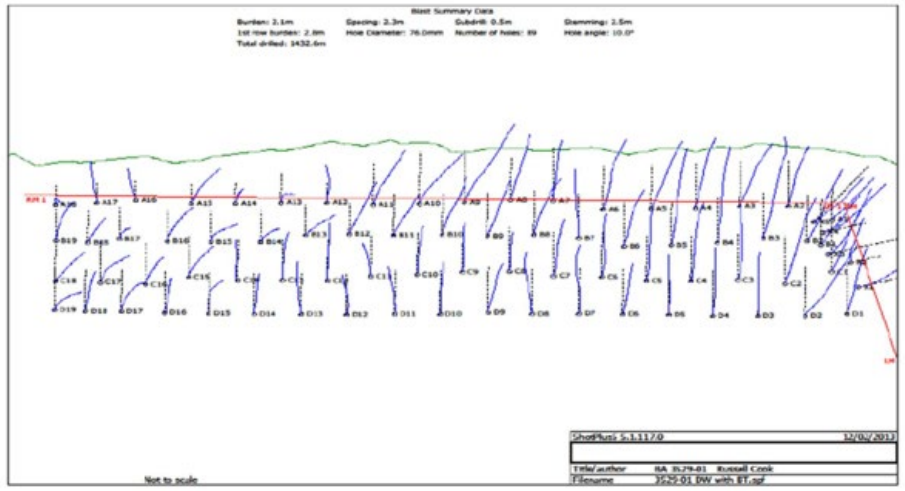


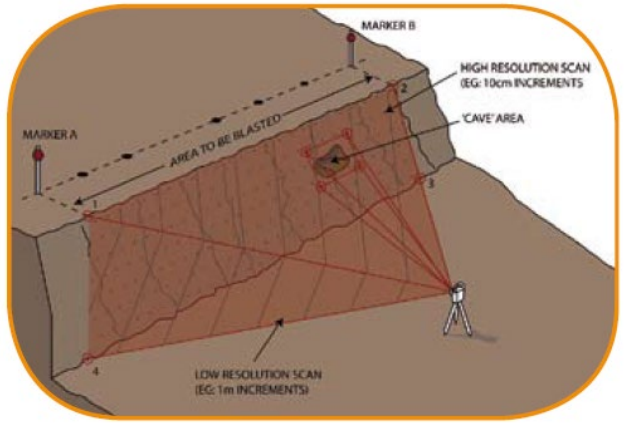
Disconnect between **blast management plan (design)** and **mine plan** (reliance on contractors) ?

Criteria group	Critical control	Control support number	Criteria Text	Enforcement action		Grand Total
				Concern (s23)	Contravention (s191)	
PC1.4	Drilling & blasting practices	02	CIA - 0201 - PC1.4 - 03; CIA - 0201 - PC1.4 - 06; CIA - 0201 - PC1.4 - 08 Confirm that quarry manager/supervisor can explain the key features of the drill plan.	2	4	6
		07	Confirm that information relevant to the blast design is recorded in the hole logs.	4	5	9
		09	Confirm that the blast holes have been checked prior to loading for anomalies such as water in the holes, collapsed or blocked holes.	6	6	12

Lack of understanding to **inspect blast hole logs** and anomalies ? **(Laser profile)**

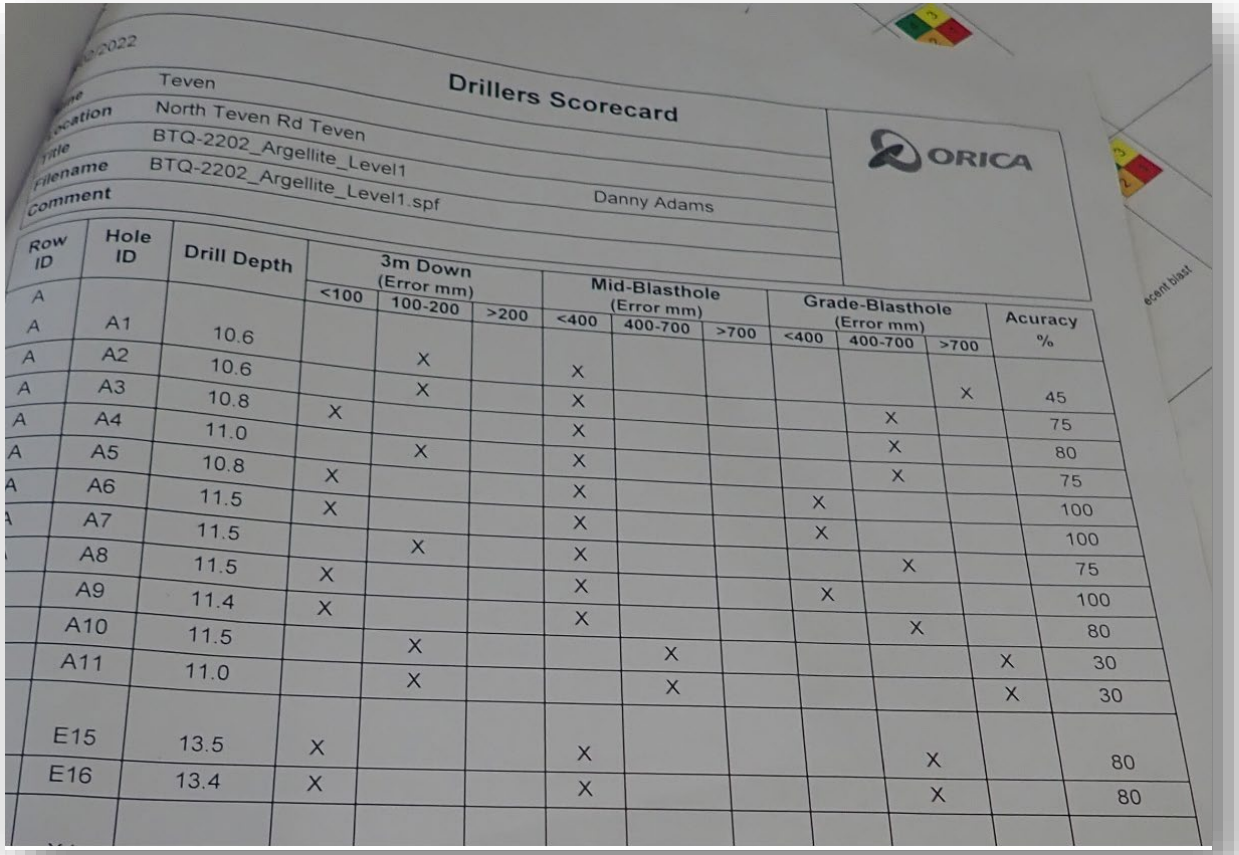






Face survey showing scan area and hole markers

...and Bore Tracking



Drillers Scorecard

ORICA

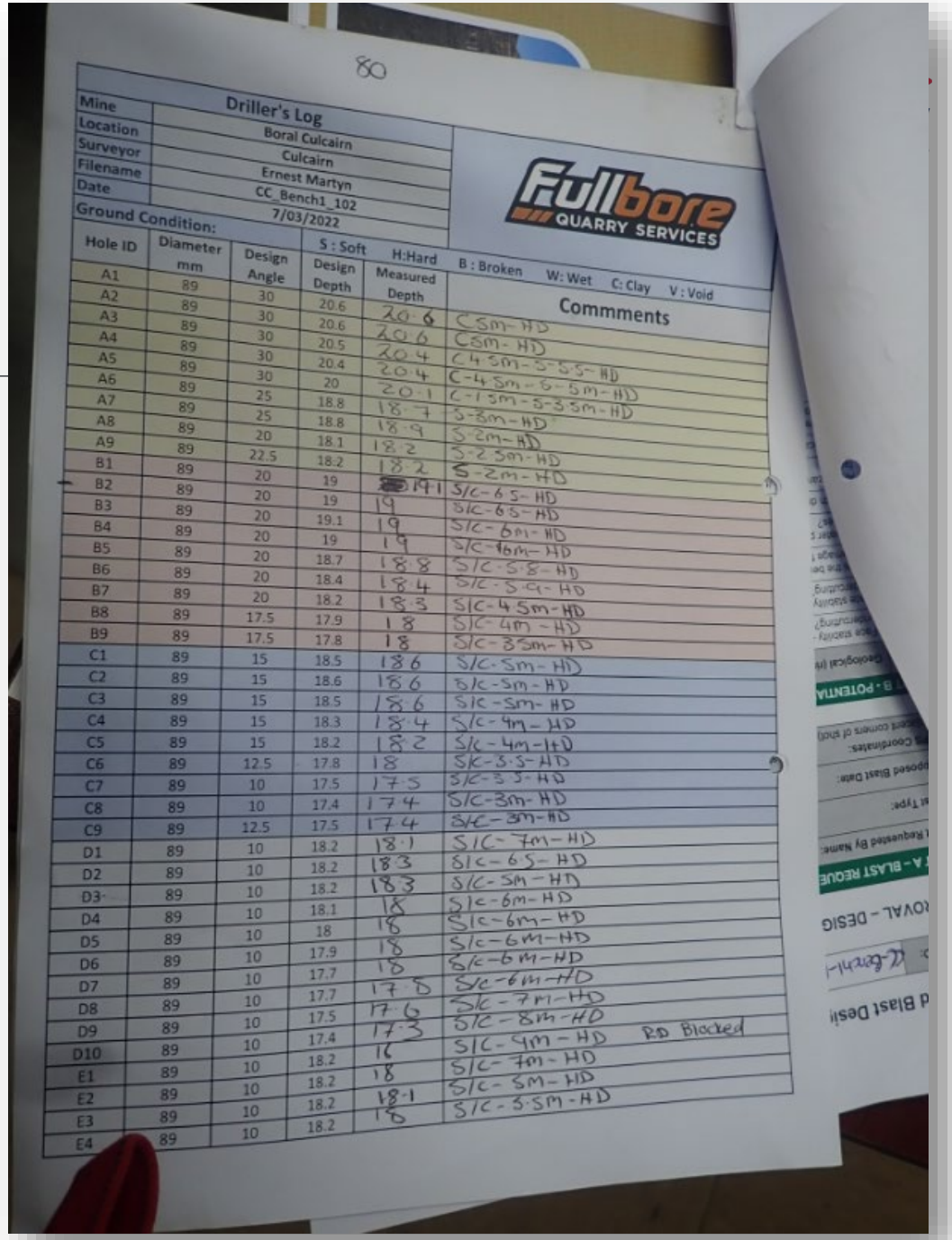
Location	Teven
Title	North Teven Rd Teven
Filename	BTQ-2202_Argellite_Level1
Comment	BTQ-2202_Argellite_Level1.spf
	Danny Adams

Row ID	Hole ID	Drill Depth	3m Down (Error mm)			Mid-Blasthole (Error mm)			Grade-Blasthole (Error mm)			Acuracy %
			<100	100-200	>200	<400	400-700	>700	<400	400-700	>700	
A												
A	A1	10.6		X		X					X	45
A	A2	10.6		X		X				X		75
A	A3	10.8	X			X				X		80
A	A4	11.0		X		X				X		75
A	A5	10.8	X			X			X			100
A	A6	11.5	X			X			X			100
A	A7	11.5		X		X				X		75
	A8	11.5	X			X			X			100
	A9	11.4	X			X				X		80
	A10	11.5		X			X				X	30
	A11	11.0		X			X				X	30
	E15	13.5	X			X				X		80
	E16	13.4	X			X				X		80

Drill logs

- Correct starting location
- Correct depth
- Correct inclination
- Any geological anomalies
- Any water intersection
- Correct loading amounts

Talk to the driller and shotfirer

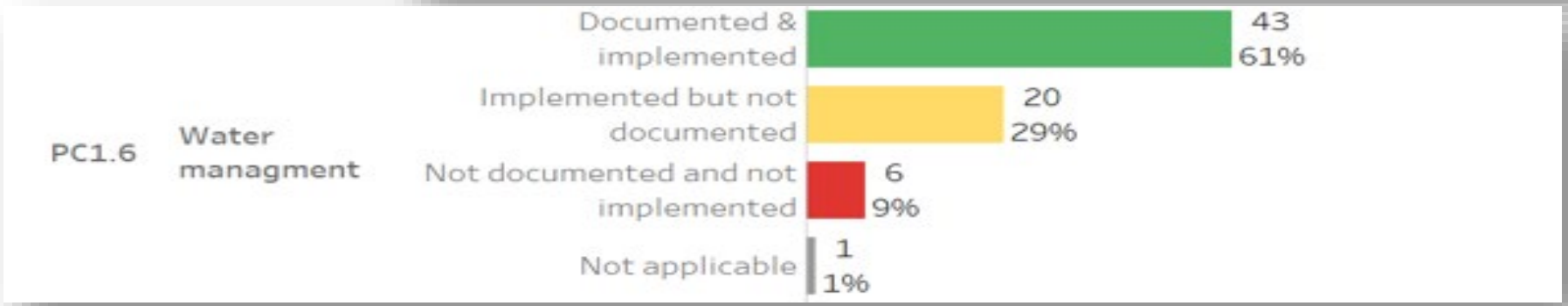


Bench Access – think ahead !

FIELD VERIFICATION - Control PC1.6 – Water Management

Objective: *Water is diverted or removed to prevent ground or strata failure.*

Expected control supports	Rating	Assessment outcome / comments
Select a sample of nominated water management controls identified in the SMS related to ground or strata failure. *Controls may include:* • *Ground water bores and associated pumping and level monitoring.* • *Sub horizontal drainage holes in walls.* • *Run off diversion and drainage.* • *Pit pumping arrangements for removing pooled water.*		
CIA - 0201 - PC1.6 - 02 Confirm the nominated water management controls are implemented to the specified design.	4 3 2 1	
CIA - 0201 - PC1.6 - 03 Confirm the nominated inspection and monitoring arrangements are in place. *These may include.* • *Rain levels.* • *Ground water levels – piezometers.* • *Maintenance and inspection of water management controls.* • *Water pooling at dump bases* • *Drains in place free from silt.*	4 3 2 1	



NSW GOVERNMENT

Check sheet

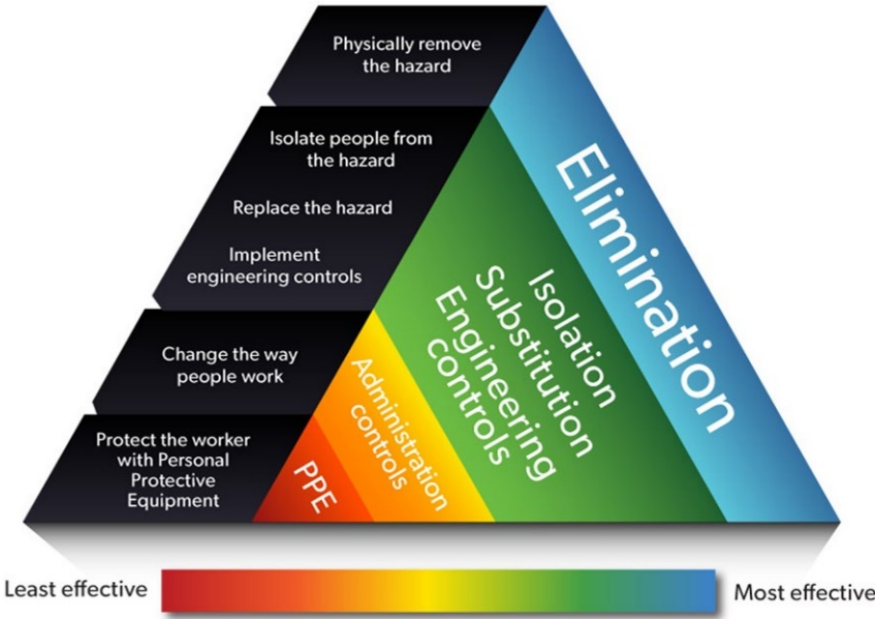
MINE PLANNING - SELF ASSESSMENT

(this document does not guarantee compliance and should be used as a guidance tool only)

		Yes/No
Approval Conditions:	1. Do you have a current copy of your development consent & conditions?	
	2. Do you regularly review compliance with these conditions?	
	3. Does your team understand your consent condition requirements?	
	4. Have you considered drafting a development consent conditions map?	
Geology:	1. Do you have an up-to-date geological map including reserves?	
	2. Does your map distinguish between various quarry products?	
	3. Is your drilling data catalogued and stored for future use?	
	4. Is geological assessment an integral component of your on going mine planning?	
Geotechnical Design Criteria:	1. Have you considered geotechnical criteria in your pit design?	
	2. Have you identified areas where additional geotechnical controls are needed?	
	3. Have you considered drafting a risk rated geotechnical plan of your site?	
	4. Do you have design criteria and inspection checklists to ensure compliance?	
Haul Roads :	1. Do you have a documented haul road design guideline?	
	2. Have you considered and documented haul road locations (short & long term)?	
	3. Do you have scheduled haul road maintenance and inspection systems?	
	4. Do you have a traffic management plan for your site?	
Blast & Environment :	1. Are your environmental conditions understood by your team?	
	2. Have you considered the preparation of an environmental conditions map?	
	3. Do your blasting procedures include environmental conditions and an exclusion zone?	
	4. Are your inspection, monitoring & recording systems for environmental matters documented?	
Rehabilitation & Closure:	1. Do you have a progressive "live" quarry rehabilitation plan in place?	
	2. Have you been progressively completing rehabilitation in accordance with the plan?	
	3. Do your inspection and monitoring programs include your completed rehabilitation?	
	4. Are you planning financially to honour your agreed rehabilitation obligations?	
Stakeholders :	1. Have you imbedded agreed consultation processes in each of your programs ?	
	2. Are you being proactive in your stakeholder dealings?	
	3. Are you scheduling and managing internal and external reviews in a systematic manner?	
	4. Is there a continuous improvement requirement in each of your programs?	

"All mine planning programs include stakeholder engagement - remember to manage it proactively"

Take home messages...



- Ensure your mine plan is current and displayed
- Discuss with your supervisors and team
- Understand your mine design criteria
- Revisit your PHMP for ground or strata failure
- Review your DA consent conditions and display
- Discuss with your blasting contractor your mine plan requirements
- Provide your workers with slope stability awareness training
- Make sure your inspections are happening !

Any questions ?