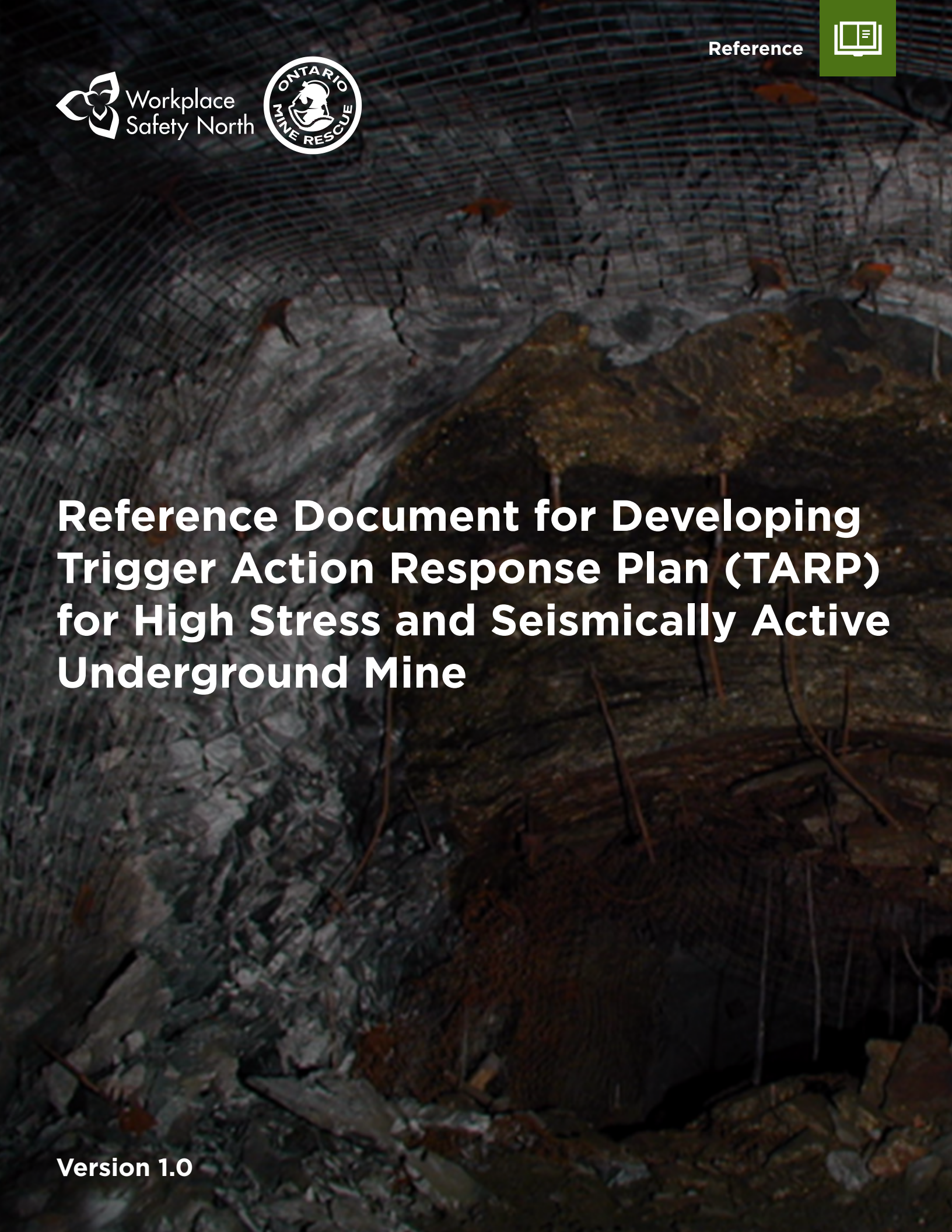
Reference



Reference Document for Developing Trigger Action Response Plan (TARP) for High Stress and Seismically Active Underground Mine

Version 1.0

Reference Document for Developing Trigger Action Response Plan (TARP) for High Stress and Seismically Active Underground Mine

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Table of Contents

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List of Figures

Reference Document for Developing Trigger Action Response Plan (TARP) for High Stress and Seismically Active Underground Mine

List of Tables

Reference Document for Developing Trigger Action Response Plan (TARP) for High Stress and Seismically Active Underground Mine

Notes:

1. Introduction

Seismic activity is now the leading killer in Ontario's underground mines. Between 2000 and 2023, fatal injuries related to ground control have shifted dramatically. As shown in Figure 1.1, the primary cause of death has moved away from traditional falls of ground and towards seismic events like rockbursts and strainbursts. While the overall number of fatalities has declined, the nature of the risk has changed. Of the seven ground control-related fatalities recorded during this period, five – or 71 per cent – were linked with seismic activity, while only two, or 29 per cent were due to falls of ground. A detailed breakdown of these incidents is provided in Table 1.1.

Workplace Safety North (WSN) and WSN's Ground Control Technical Advisory Committee (GC TAC) have taken note of the shift in what's causing fatal ground control incidents underground. With Ontario underground mines getting deeper and facing more intense stress conditions, seismic hazards like rockbursts and strainbursts are becoming more common – and more dangerous. That's why WSN is developed a 'Trigger Action Response Plan (TARP)' tailored for high-stress, seismically active mines. The goal is simple; help mines recognize early warning signs and take action before something goes wrong. It's a proactive step to keep workers safe and prevent serious incidents before they happen.

WSN and WSN's GC TAC recognize individual companies must develop health and safety policies and programs, that comply with legislation, which apply to their workplaces. The information in this material is a guide to help develop those policies and programs.

Everyone who works underground must be aware of, and trained in, how to identify seismic and ground control-related hazards. They must also be able to implement controls to reduce the risks. This document will help you learn to recognize the clues that a hazard could be developing. It is essential for you to become a trained observer of the conditions around you as you work.

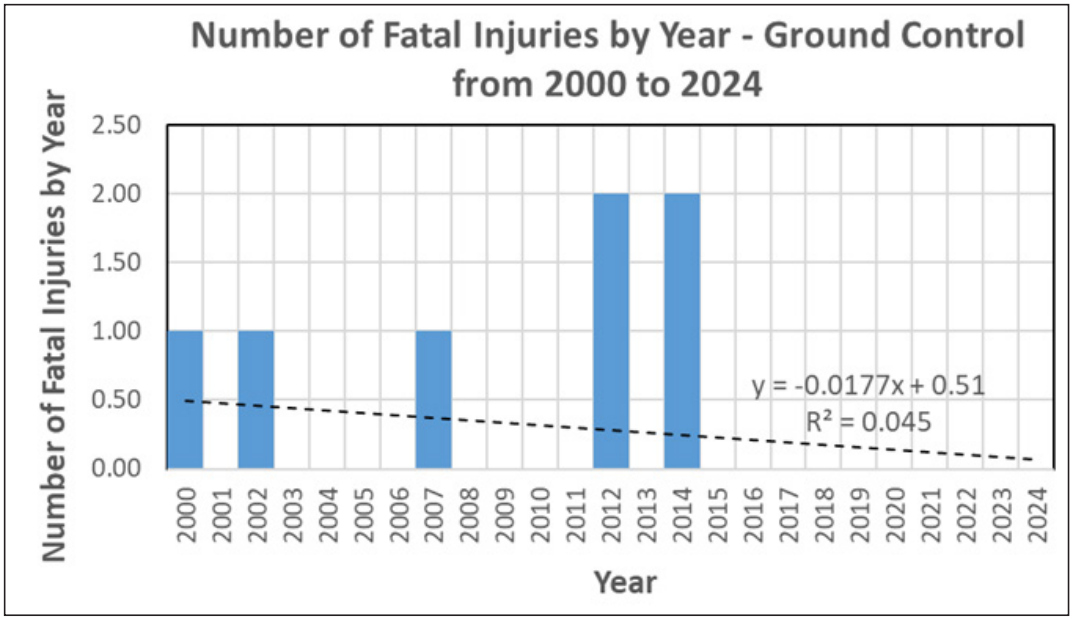


Figure 1.1 - Ontario ground control related fatal injuries 2000-2023.

Table 1.1 - Summary of Ontario mines fatal injuries for falls of ground and rockbursts from 2000-2024.

Year of Incident	Description of Incident
2000	A worker was struck by a rockfall caused by a rockburst that displaced 20 tons (gold mine).
2002	A worker was struck by loose while operating a scooptram in an open stope (gold mine).
2007	A worker was struck by a piece of rock while in a raise (mine contractor at a gold mine).
2012 (January)	A worker was struck by displaced material from a development face (nickel mine).
2012 (April)	A worker was struck by a piece of rock while loading a development round (gold mine).
2014	Two workers were struck by shotcrete and rock, following a seismic event (nickel mine).

2. Scope of the Reference Document

The information in this document is a guide to help Ontario underground mining operations develop a trigger action response plan (TARP) for high stress, abnormal seismic conditions, and other seismic hazards as a part of a written Seismic Risk Management Program (SRMP). This is as per Section 71.1 of Regulation 854 Mines and Mining Plants, which came into effect in September, 2023.

This document serves as a reference for assessing high stress and seismic hazards and preparing TARPs to manage the risks to an acceptable level. It follows the same process of assessing ground control-related hazards described in the WSN's and WSN's GC TAC document 'Reference Document for Preparing Risk Assessment and Management Program of Ground Control Hazards,' published in 2021, which is posted on WSN's website as a resource

https://www.workplacesafetynorth.ca/en/resource/preparing-risk-assessment-and-management-program-ground-control-hazards-reference-document).

The development of TARPs for high stress, abnormal seismic conditions, and seismicity hazards also supplements the requirements under sections 5.1, 5.2 and 5.3 of Regulation 854 Mines and Mining Plants, that came into effect on January 1, 2017.

WSN's and WSN's GC TAC also published 'Best Practices for Assessing Ground Control Hazards in the Workplace,' available on WSN's website https://workplacesafetynorth.ca/en/resource/best-practices-assessing-ground-control-hazards-workplace). Underground mine workers can reference the information, photographs, and illustrations in the document to help in recognizing ground control issues.

3. Objective

This document provides a process to prepare TARPs for mining activities, including instrumentation for ground movement and seismic monitoring where seismic risks are encountered in underground hard rock mines.

It also provides a quantification of risk involved by generating color-coded categories indicating alert-levels ratings and their meanings. Each operation preparing a TARP needs to provide site-specific descriptions depending on the level of seismic risks encountered at their workplace. TARPs preparation is intended to prevent unwanted events (UEs) from happening.

A process flowchart is provided to help ground control personnel to achieve:

- A basis for decision-making, planning, and implementation of controls
- Better identification of opportunities and threats associated with seismic risks
- Proactive seismic risk management
- More effective allocation and use of resources
- Improved seismic risks management and reduced loss and cost
- Compliance with legislation.

Section 8 of this document provides example TARPs prepared for specific mining activities.

4. Definition of Terms

- **TARP** – Trigger Action Response Plan.
- **Rockburst or Strainburst** – rock mass damage or damage to an excavation that occurs in a sudden or violent manner associated with a seismic event.
- **Seismic event** – a dynamic stress wave caused by the energy released from a sudden or violent fracture or deformation of a rockmass.
- **Seismic risk** – the likelihood that a given area of the mine will be adversely affected by a seismic hazard, such as rockburst, leading to an injury or other unwanted event.
- **Seismic hazard** – the likelihood of the occurrence of seismic events of a certain magnitude.
- **Abnormal seismic conditions** – are conditions that are unusual or statistically different from what is considered normal (for example: subtle, and nonlinear patterns from previous experience, increased/diminished frequency rates, unusual high- or low-magnitude events, etc.) background levels of seismic activity.
- **Normal condition** – a condition in ground control that is typical, ordinary, usual, or what is expected based on design, ground reaction, or failure mechanisms.
- **Adverse condition** – a condition in ground control that may result in negative or harmful effects to personnel, and damage to equipment and infrastructure.

5. Suggested Process for Preparing a Trigger Action Response Plan (TARP)

When seismic activity or unusual ground movement is detected – especially in high-stress underground hard rock mines – it's critical to have a plan in place. That's where a Trigger Action Response Plan (TARP) comes in. Developing a TARP for these situations should be part of a broader risk management strategy, based on the framework outlined in the AS/NZS 4360:2004 – Risk Management standard. Figure 5.1 shows a modified version of that model adapted to fit with the needs of this document. Table 5.1 walks through a general process.

5.1 Communication and Consultation

Communication and consultation are essential to the process of seismic risk management. They should be considered at each step of the process summarized in Figure 5.1. The intent of preparing TARPs is to develop a process of communication and consultation to ensure the organization and stakeholders are informed.

The concept of risk communication is generally defined as an interactive process of exchanging information and opinion in high stress and seismically active underground mines, involving multiple messages about the nature of risk and managing the risk (Adapted from the National Research Council, 1989. Improving risk communication. National Academy Press. Washington D.C.). Inappropriate communication can lead to poor risk management.

Consultation can be described as a process of informed communication within the organization and its stakeholders on seismic issues prior to deciding or determining actions to be taken on a particular seismic issue.

5.2 Establishing Context

Before developing a TARP for falls of ground or rockbursts, it's important to first establish the context – in other words, define the environment and conditions where these risks are being managed. This step sets the foundation for the entire risk management process. It helps clarify what types of hazards are being addressed, what triggers are relevant, and how far the response plan needs to go. The scope defined here will guide how the rest of the TARP is developed and applied underground.

5.3 Risk Identification

This step seeks to identify 'what can happen, where and when,' and 'why and how it can happen.'

5.3.1 'What can happen, where and when?'

The aim is to generate a list of sources of falls of ground and seismic risks and events that affect the achievement of the objective identified in the context.

5.3.2 'Why and how can it happen?'

To know what might happen, it is necessary to consider possible causes of why and how falls of ground and rockbursts happen; that is, what are the triggering mechanisms. There could be several ways falls of ground and rockburst events can occur. It is important to identify significant causes.

5.4 Risk Analysis

Risk analysis is about developing an understanding of the risk. The understanding is important to provide input into decisions in preparing TARPs. The TARPs need to be developed to appropriately respond to the falls of ground and seismic risks, using the most appropriate and cost-effective risk treatment strategies.

Risk analysis involves consideration of the sources of risk, their benefits and consequences, and the likelihood those consequences may occur. Factors affecting consequences and likelihood may also be identified.

Risk is analyzed by combining consequences and their likelihood. Existing controls should be considered in the analysis process.

5.5 Risk Evaluation

Risk evaluation is intended to make decisions, based on the outcomes of risk analysis, about which falls of ground and seismic risks need to be addressed and prioritized, and prepare TARPs based on identified risk category, that is, normal condition or adverse condition. Risk evaluation involves comparing the level of risk found during the analysis process with established risk category.

In some circumstances, the risk evaluation may lead to a decision to undertake further analysis.

5.6 Risk Treatment

Risk treatment involves identifying the range of options for treating risks, assessing these options, and the preparation and implementation of treatment plans such as TARPs.

Figure 5.1 provides a suggested process of managing seismic risks including the description of the various steps. The suggested process is a modified version of the risk management model to fit with the intent of this reference document. **Table 5.1** summarizes a general process of preparing TARPs. Note that the level of responses is category dependent.

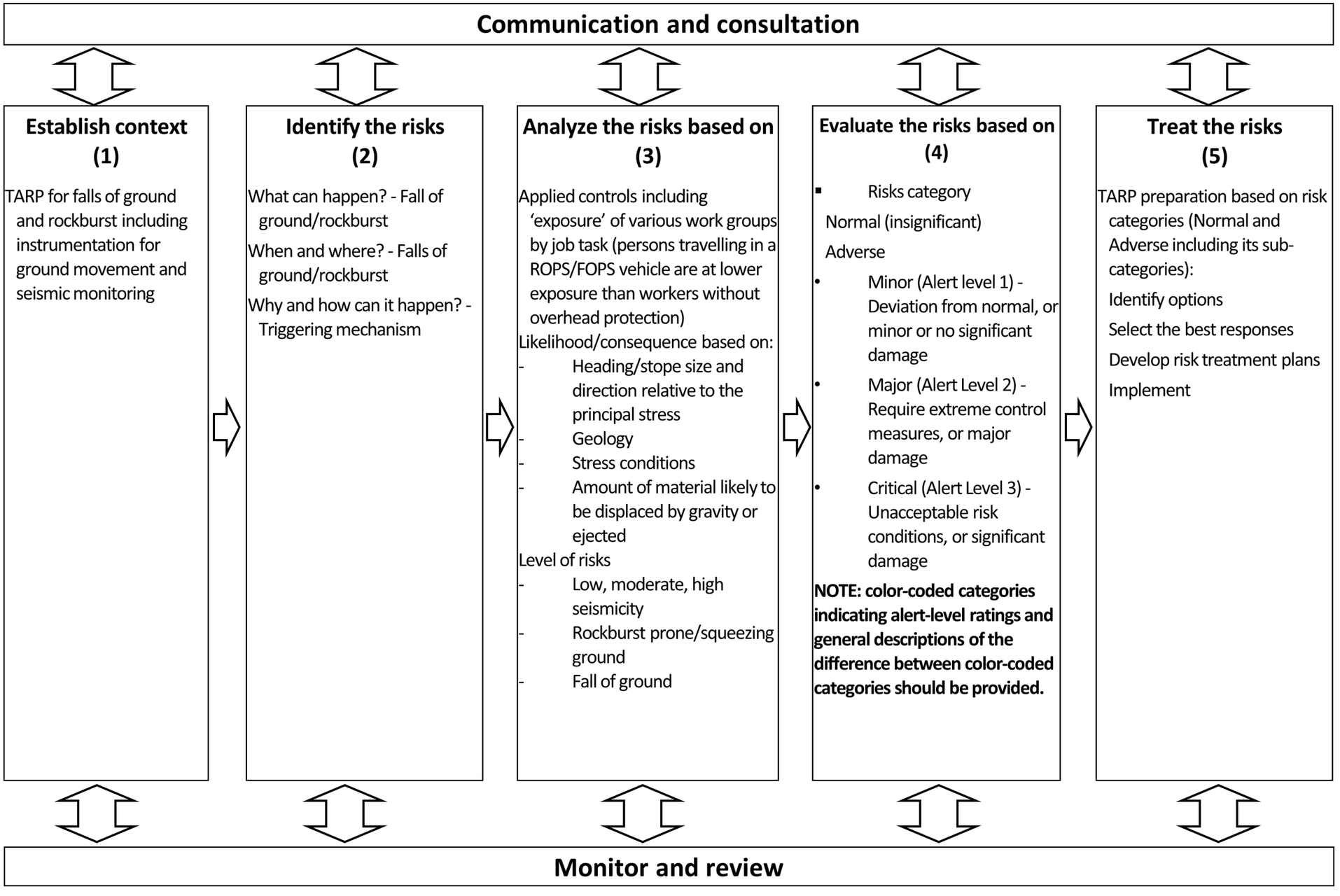


Figure 5.1 - Suggested seismic risks management process (adapted from the AS/NZS 4360:2004 - Risk Management).

Table 5.1 - General process of preparing TARPs.

		Description	Example Conditions				Suggested Targeted/ Trigger Action Plans	Example Responses
			Development Heading	Non-Entry Stope	Instrumentation (Seismic Monitoring System)	Rockburst in an Accessible Workplace Causing Rock Mass or Support Damage		
Normal		Parameters and/or levels of risks are within acceptable level	<5 tons of displaced or ejected materials, no injury, no damage of equipment, others.	<5 tons of displaced or ejected materials, no equipment damage, no displaced materials past the stope brow, others.	Low magnitude events (defined by the mine) not sufficient to cause damage, far field events felt by underground personnel, events occur within a certain distance (defined by the mine)to active workings, others.	<5 tons of displaced materials and fullycontained by ground support system.	Current controls, procedures and practices are appropriate tomaintain risks at an acceptable level.	Dynamic rated support system, equipment with ROPS/FOPS (rollover or falling object protective structure) or automation, area isolation, preventive support maintenance or capacity restoration, others.
Minor (Alert Level 1)		Deviation from normal orminoror no significant damage	>5 tons of displaced or ejected materials causing equipment damage rendering it unfit to use.	>5 tons of displaced or ejected materials causing equipment damage (physical or remotely operated) rendering it unfit for use.	Large magnitude event felt throughout underground workings,multiple events below a definedmagnitude which may cause popping noise in active headings, others.	Large magnitude event felt throughout underground workings, multiple events below a defined magnitude which may cause popping noise in active headings, others.	Requires investigation of causal effects for the changes, which may require increased vigilance and control efforts.	Requires investigation of causal effects for the changes, which may require increased vigilance and control efforts.
Adverse	**Major (Alert Level 2)**	Major damage or require extreme control measures	>5 tons of displaced or ejected materials causing equipment damage rendering it unfit to use for intended purposes or causing minor injury.	Displaced or ejected materials causing injury in an ancillary area. Displaced or ejected materials past a predefined distance from the stope brow, significant overcutfailure into stope, brow failure, uncontrolled caving, others.	Large magnitude events felt throughout underground workings, or multiple events below a defined magnitude which may cause observed damage,local generationof dust, rock fracturing noise, strainbursting or more significant events in development headings causing materials ejection, others.	Multiple events below a defined magnitude, >5 tons of displaced materials causing or not causing equipment damage, or minor injury.	Rectify – requires extreme control measures. May require preparation of an emergency response team.	STOP work, barricade, and immediately evacuate work area, contact supervisor, ground control, supervisorto fill out GC Logbook. In case of equipment damage or injury, restrict scene pending investigation, others.
Critical (Alert Level 3)		Significant damage, or unacceptable risk conditions	Displaced or ejected materials causing serious orfatal injury, loss of access trapping personnel, equipment damage rendering it unfit to use for intended purpose, major infrastructure damage.	Displaced or ejected materials causing major infrastructure damage. Injury due to an ancillary damage within an accessible area.	Results to serious or fatal injury, access and secondary egress to workplaces blocked, large or multiple events below a defined magnitude causing automated emails sent fromseismic systems.	Rockburst causing serious or fatal injury, trapped personnel due to loss of access, major equipment, or infrastructure damage. Multiple events greater than a defined magnitude.	Unacceptable level of risks requiring critical actions and evacuation of personnel. Requires implementation of Emergency Response Plan.	STOP work, fence area, contact supervision (supervisor, superintendent), ground control. Initiate site Emergency Response Plan, applicable portionof Seismic Management Plan

6. Types of Ground Failures in High Stress Seismically Active Hard Rock Underground Mines

How a rock mass fails around an underground opening depends upon the stress conditions and the nature of the rock itself. In deep, high stress environments, the type of failure can vary depending on whether the rock is massive with few joints or heavily jointed. For example, massive rocks with few joints tend to fail in a brittle way – through spalling and slabbing. On the other hand, jointed rock masses often show more ductile failure patterns. Figure 6.1 provides a simplified overview of the common types of failure seen in these conditions, helping to illustrate how different rock structures respond under stress.

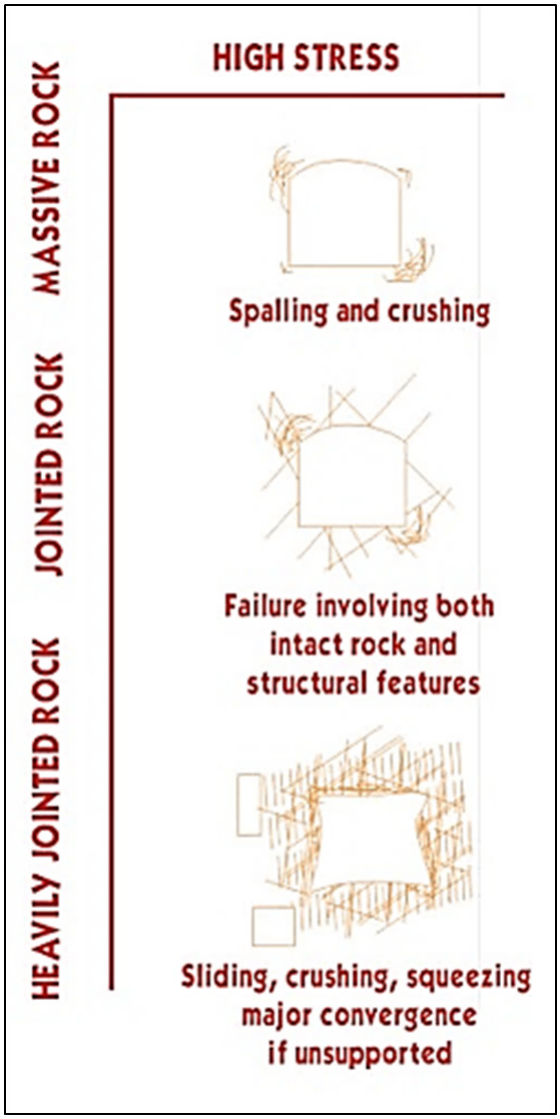


Figure 6.1 – Simplified description of the various types of failures which are commonly observed in underground openings excavated in deep, high stress, massive with few joints, and jointed rock masses *(WSN's Ground Support Manual)*.

Rockbursts present hazards that are particular to hard rock mines. Factors affecting seismicity include: rock characteristics; pre-mining stresses; the presence of geological structures; the amount of material extracted; and mine sequencing.

Figure 6.2 shows damage mechanisms caused by rockbursts. The depth of damage caused by bulking, ejection, and shaking depends on: rock stress levels; rock mass quality; excavation shape; support system design; condition and residual capacity to withstand the induced deformation and load at the time of the event; and the magnitude of the seismic event.

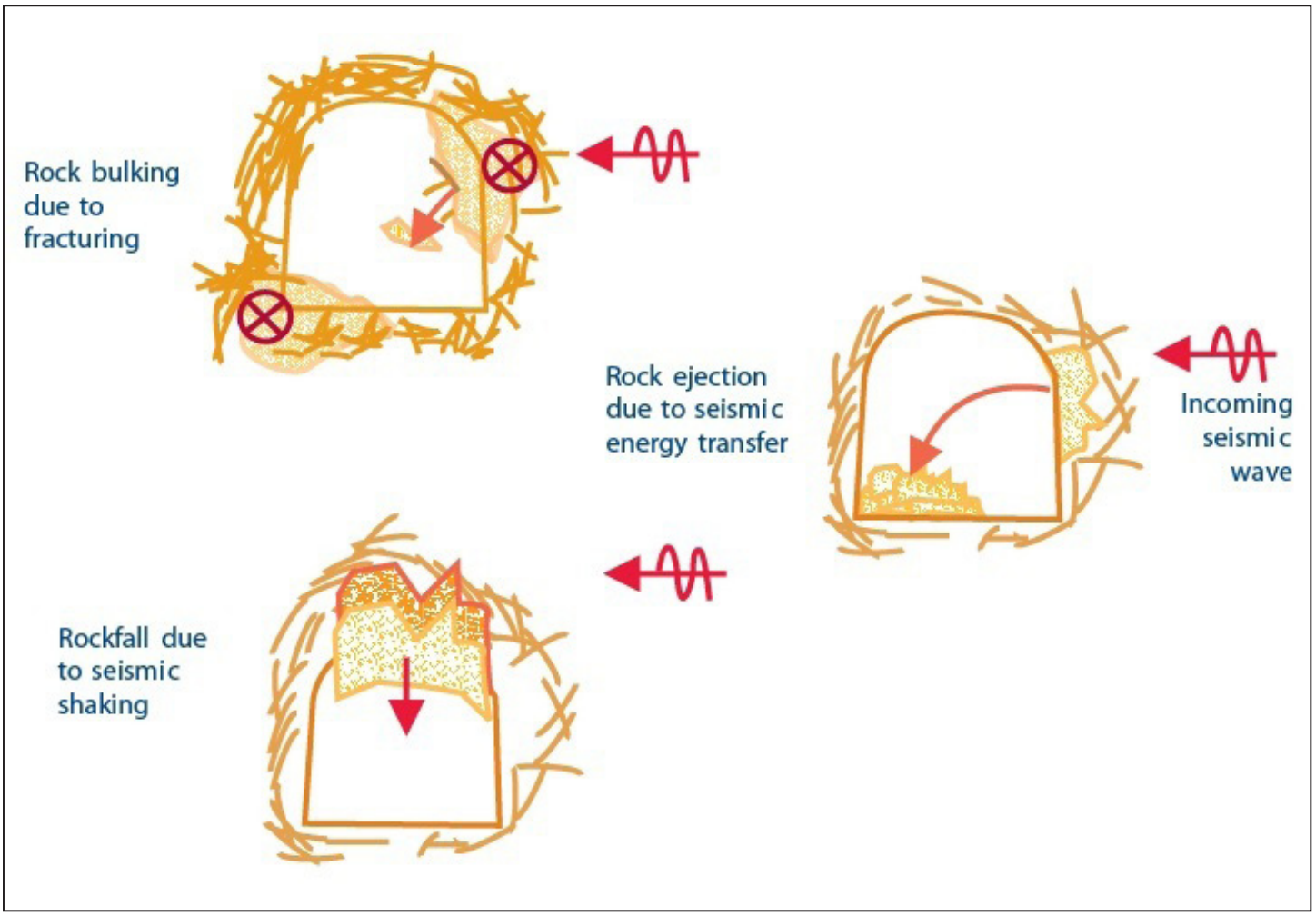


Figure 6.2 - Rockburst damage mechanism *(after CAMIRO, 1995)*.

7. Recognizing Ground Control Hazards or Changing Ground Conditions

7.1 Things to Check

7.1.1 Digital scan and numerical modeling analysis in high stress ground conditions

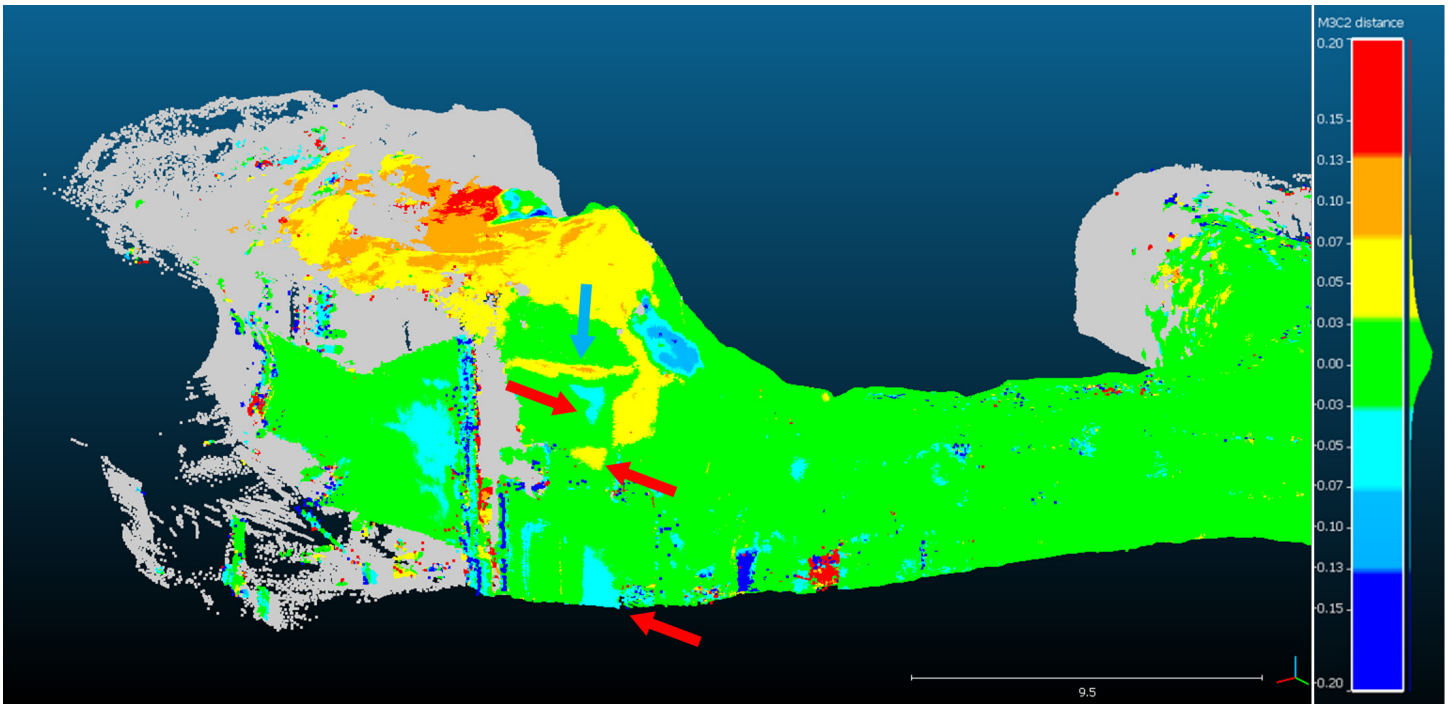


Figure 7.1 – Zeb deformation results, looking north at XXXXXX chamber. Access development shows no signs of deformation or damage exceeding 3 cm. The back of the XXXXXX chamber generally shows closure in excess of 3 cm, with local zones near the north side of the access drift showing up to 20 cm of deformation. The bulkhead and door show up to 7 cm of deformation (in and out) at arrows, and the lintel (blue arrow) has moved up to 10 cm.

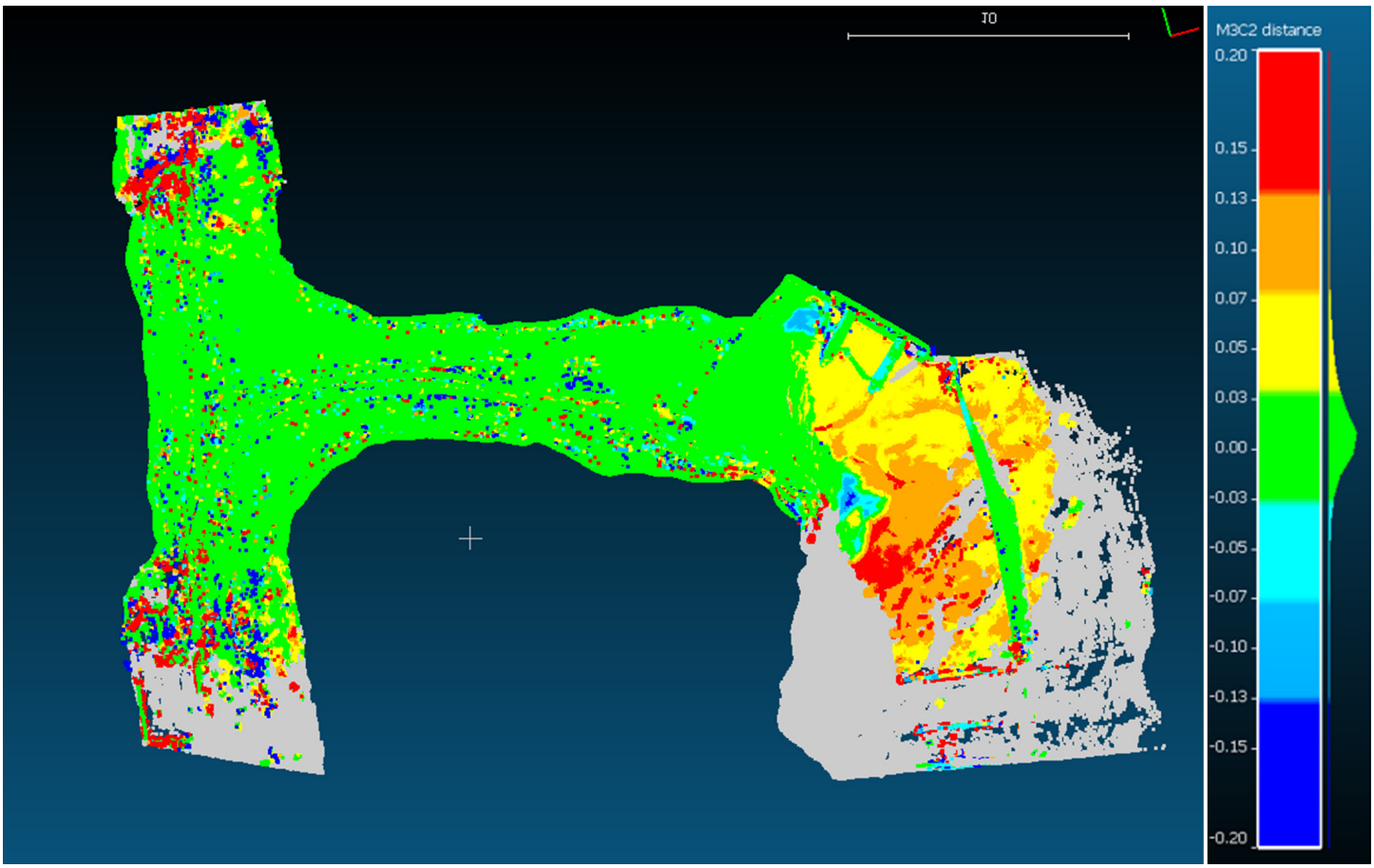
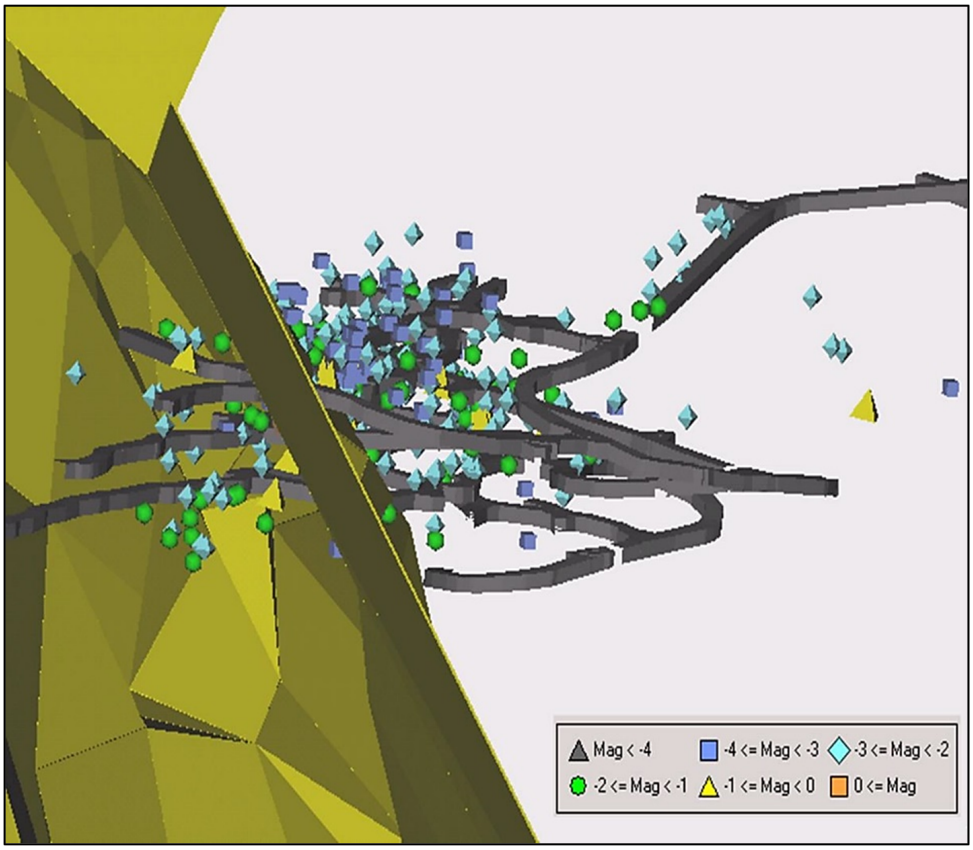
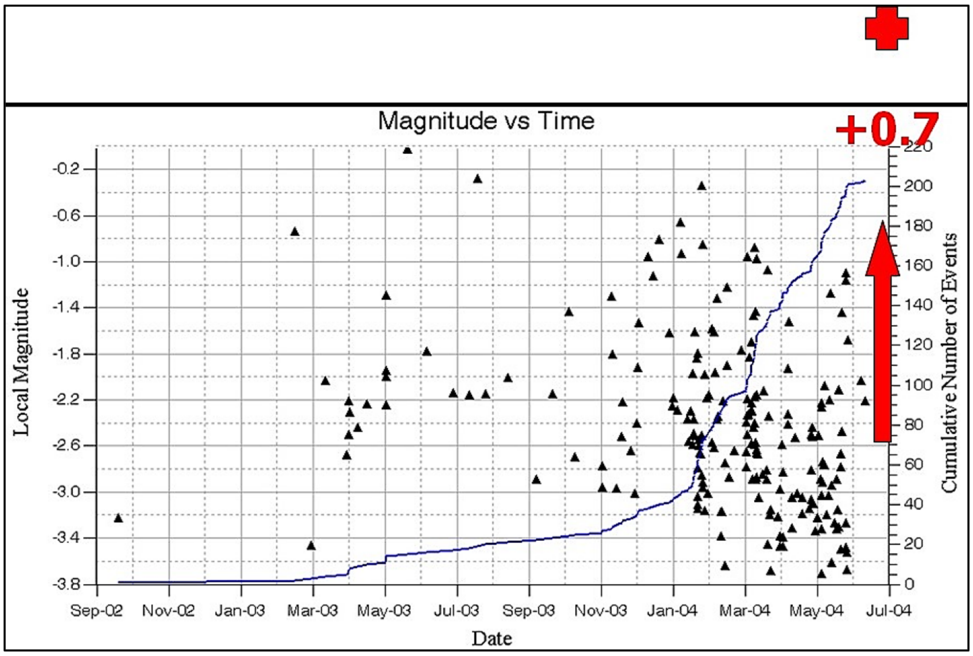


Figure 7.2 - Plan view of deformation of the back of XXXXXX chamber. Note extensive areas showing more than 3 cm of deformation (sagging), with some areas having over 13 cm of deformation, which exceeds the capacity of the support system. Gray areas have no comparison data. The green "line" is the side of mechanical equipment within the scan volume.

7.1.2 Seismic responses to mining



Abnormal level of seismicity in a development heading



Seismic data analysis and interpretation

Figure 7.3 - Abnormal seismic activity.

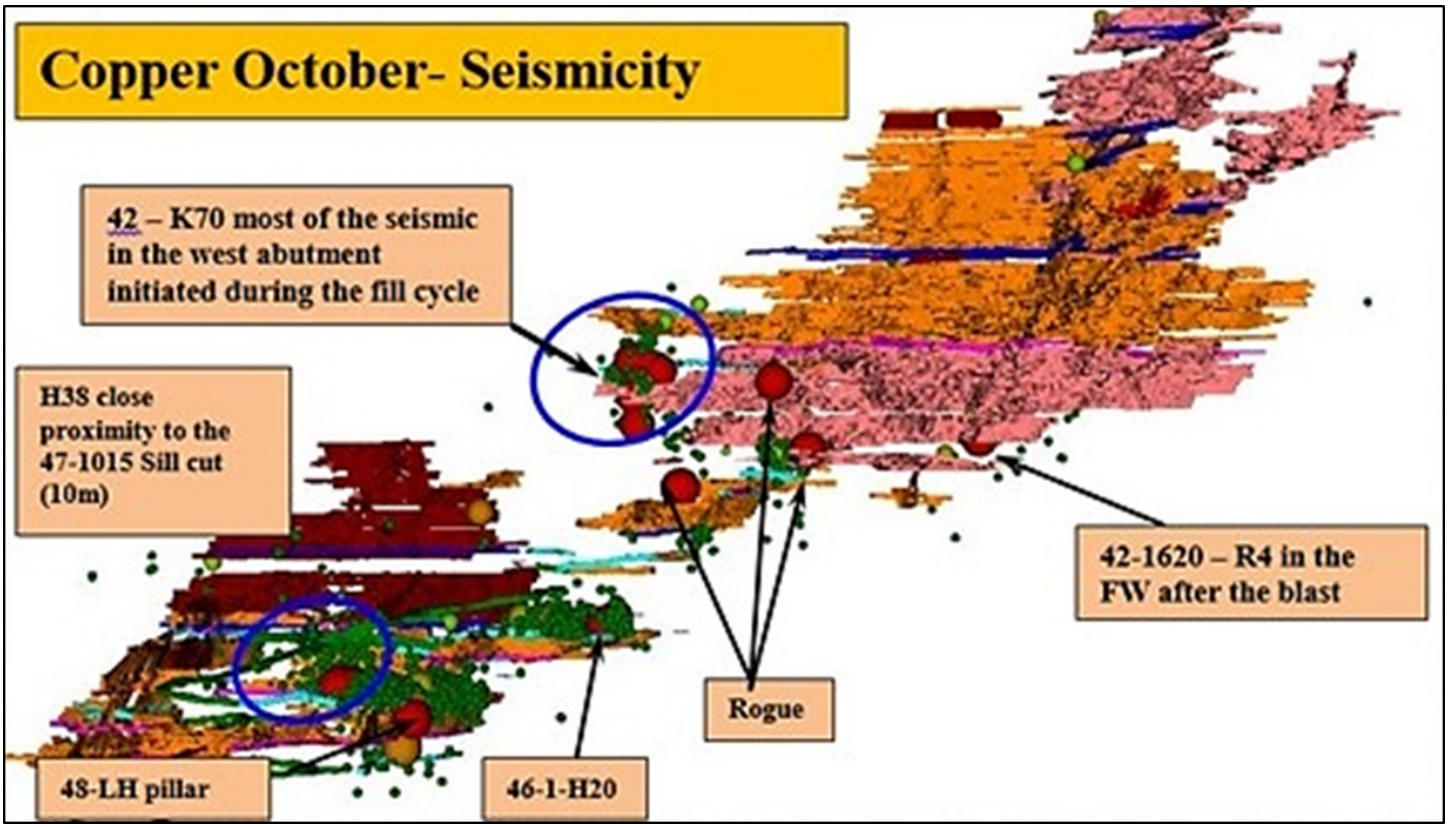


Figure 7.4 - Large seismic events.

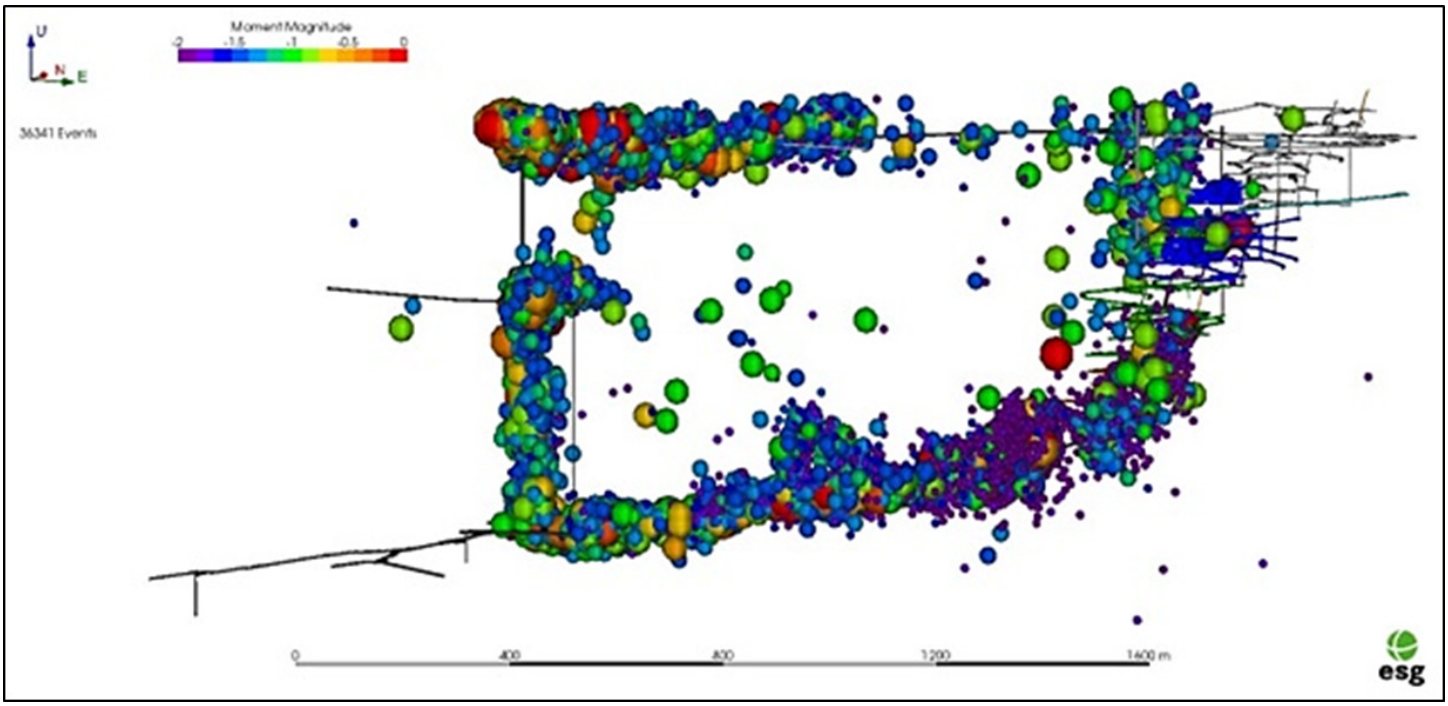


Figure 7.5 - Other seismic conditions.

7.1.3 Ground reactions to minig in high stress ground

Figure 7.6 - Deformation of headings.

Figure 7.7 - Deterioration or change in shape pillars (such as hourglass shape with fracturing and plate-like pieces).

Figure 7.8 - Plate-like peices or flakes of rock - stress fracturing.

8. Example Trigger Action Response Plans (TARPs)

Table 8.1 provides examples of TARPs.

Trigger Level	Acceptability of Current Level of Risk	Acceptability of Current Level of Risk
Normal	Normal Operating Standards/Procedures adequate to deal with potential hazards. Risk is within Acceptable Limits	Routine Communication Methods and normal Operating Processes apply
Level 1 - Alert/Investigate	Risk indicator has deviated from "normal" resulting in need for Investigation. Additional controls likely required to manage risk.	Ground Control must be notified, in addition to Supervision. Increased frequency of reporting of status/change is required.
Level 2 - High Alert/ Rectify	Risk requires high level of control. Area must be barricaded, or other controls put in place to manage elevated risk exposure	Significant hazard requiring Ground Control and Operations to investigate and develop remediation plan/stop work
Level 3 - Critical/STOP	Unacceptable risk. Area/Site shutdown/evacuation may be required. Crisis Management Team involvement required.	Area/Level Site notification required. May require escalation to Zinc Crisis Management

FHP Protocol	Aspect	Trigger	Level	Magnitude or Observation	Primary Actions	Time Line	Increasing Actions	Time Line	Site Crisis Management Action	Time Line	Zinc Crisis Management Action	Time Line
Protocol #5 Ground/Strata Failure	**Fall of Ground in an Accessible Underground Workplace**	**Fall of Ground Within Development of Rehab heading from Unsupported Ground**	**Normal**	<5 tonnes of material	Isolate area, contact Supervisor	Immediate	Fill out Ground Control Log in CPCR. Install support as directed by Supervisor if capable and can be done safely, or escalate to Level 1.	End of Shift	No action required	N/A	No Action Required	N/A
			Level 1	>5 but <50 tonnes, no damage which renders equipment unfit for use, no injury	**STOP** work, barricade area, notify Supervisor. Fill out Ground Control Logbook and request inspection	Immediate	Ground Control and Operations determine remediation plan (scaling, extra support)	Before work resumes	Determine if HPRI. Un-supported ground is typically classified as non entry. Should not pose risk to personnel.	End of Shift	If HPRI follow procedure	Per HPRI process
			Level 2	>50 tonnes, damage renders equipment unusable for intended purpose, minor injury	**STOP** work, barricade area, notify Supervisor. Fill out Ground Control Logbook and request inspection	Immediate	Ground Control to report Fall of Ground to MLITSD. Ground Control and Operations determine remediation plan.	48 hours to report	Safety and Operations determine if HPRI warranted.	End of Shift	If HPRI follow procedure	Per HPRI process
			Level 3	Serious/fatal Injury, loss of access trapping personnel, major infrastructure damage	**STOP.** Fence area. Contact CPCR, Incident Commander, Supervisor, Superintendent, Ground Control	Immediate	Initiate Emergency Response Plan. Ensure personnel affected are evacuated/ receive medical treatment as necessary. Fence affected areas as required.	Immediate	As stated in Emergency Response Plan. Safety and perations determine if HPRI warranted. Unlikely to occur as unsupported ground deemed to be nonentry.	Immediate	As stated in Emergency Response Plan/Zinc Crisis Management Plan	Per Zinc CMP
		Fall of Ground in Travel way, Ramp, Shop, Hoistroom, or other Workplace from Supported Ground (Access not normally restricted)	**Normal**	Small loose falling through screen, wall/ back material which can be safely scaled	Standard Workplace Inspection, deal with loose through normal workplace check scaling	Immediate	If check scaling not sufficient, escalate to Level 1.	Same shift	No action required	N/A	No action required	N/A
			Level 1	<1 tonne of loose, no or minor equipment damage (broken headlight) which does not prevent normal use. No injuries.	**CAUTION.** Scale area if safe to do so. Fill out Ground Control Logbook. If in a travel way or other area where personnel must travel or work within 2m of the location of the Fall of Ground, barricade and notify Supervisor.	Immediate	Fence if use of main travel way compromised. Contact CPCR if second means of egress affected. Ground Control to inspect and prepare rehab plan and risk assessment.	Same shift	Notify Incident Commander. Modify normal activity or stop work if second means of egress affected. Risk Assessment to define barricading requirements.	N/A	No action required	N/A
			Level 2	>1 tonne of loose, or damage renders equipment unusable, minor injury	**STOP.** Barricade area, contact Supervisor/Ground Control, fill out Ground Control Logbook in CPCR.	Immediate	>50 ts or equip. damage, Ground Control report to MLITSD as appropriate, and within 48 hrs. Ground Control and Operations determine remediation plan	Beofre work resumes	Determine if HPRI. Modify normal activity or stop work if second means of egress affected. Risk Assessment to define barricading requirements.	Before work resumes	If HPRI follow procedure	Per HPRI process
			Level 3	Fall of ground results in serious/ fatal Injury, loss of access trapping personnel, major infrastructure or equipment damage	**STOP.** Fence area. Contact CPCR, Incident Commander, Supervisor, Superintendent, Ground Control	Immediate	Initiate Emergency Response Plan. Ensure personnel affected are evacuated/receive medical treatment as necessary. Fence affected areas as required. If fatal/serious injury or equipment damage, Ground Control to report to MLITSD regardless of tonnage.	Immediate	As stated in Emergency Response Plan	Immediate	As stated in Emergency Response Plan/Zinc Crisis Management Plan	Per Zinc CMP

FHP Protocol	Aspect	Trigger	Level	Magnitude or Observation	Primary Actions	Time Line	Increasing Actions	Time Line	Site Crisis Management Action	Time Line	Zinc Crisis Management Action	Time Line
Protocol #5 Ground/Strata Failure	**Fall of Ground in an Accessible Underground Workplace**	**Fall of Ground or Rockburst in an Open Stope, Ventilation Raise, or other Nonentry area. Potential for ancillary damage in Accessible areas.**	**Normal**	<5 tonnes, no equipment damage, no spill out past brow	Supervisor to inspect and evaluate. If any concern regarding run of material, concussion blast	Same day	If increased seismic activity, Ground Control to review and restrict access if not already in place	Same Shift	No action required	N/A	No Action Required	N/A
			Level 1	>50 tonnes (FOG) or >5 tonnes (Burst) or damage renders equipment unfit for use, including equipment operated remotely from a safe location.	**STOP.** Barricade area, contact Supervisor/Ground Control, fill out Ground Control Logbook in CPCR.	Immediate	Ground Control inspect remotely with drone, and report to MOLITSD as required. Equipment to be checked by Maintenance before return to normal use. Scan to be reviewed for additional risks. Ground Inspection Report to be prepared	48 hours	Notify Mine Manager and applicable Superintendent. No Crisis Management action required.	48 hours	No Action Required	N/A
			Level 2	Ejection of material >5m from brow, significant overcut failure into open void, brow failure, uncontrolled caving, in addition to Level 1 criteria, or minor injury in an Ancillary area	**STOP.** Barricade area, contact Supervisor/Ground Control, fill out Ground Control Logbook in CPCR.	Immediate	Ground Control inspect remotely with drone. Report to MLITSD as required. Install additional barricades as required if risk of caving to other levels. Ground Inspection Report to be prepared. Develop action plan that may include remote backfilling if caving severe. Review implications to Short Term and LOM plans.	Before work resumes	Notify Mine Manager and applicable Superintendent, and Manager of Technical Services. Safety and Operations determine if HPRI warranted.	48 hours	If HPRI follow procedure	Per HPRI process
			Level 3	Major infrastructure damage. Possible injury due to ancillary damage within an accessible area.	**STOP.** Barricade area. Contact CPCR, Incident Commander, Supervisor, Superintendent, Ground Control, and execute all appropriate Steps from Level 2	Immediate	Initiate Emergency Response Plan. Initiate applicable portions of Seismic Management Plan. Ensure personnel affected are evacuated/ receive medical treatment. Fence affected areas as required per Ground Control.	Immediate	As stated in Emergency Response Plan. Safety and Operations determine if HPRI warranted. Depending on severity, may need to invoke Zinc Crisis Management Plan.	Immediate	As stated in Emergency Response Plan/Zinc Crisis Management Plan	Per Zinc CMP

FHP Protocol	Aspect	Trigger	Level	Magnitude or Observation	Primary Actions	Time Line	Increasing Actions	Time Line	Site Crisis Management Action	Time Line	Zinc Crisis Management Action	Time Line
Protocol #5 Ground/Strata Failure	**Fall of Ground in an Accessible Underground Workplace**	**Fall of Ground or Rockburst in an Open Stope, Ventilation Raise, or other Nonentry area. Potential for ancillary damage in Accessible areas.**	**Normal**	<5 tonnes, no equipment damage, no spill out past brow	Supervisor to inspect and evaluate. If any concern regarding run of material, concussion blast	Same day	If increased seismic activity, Ground Control to review and restrict access if not already in place	Same Shift	No action required	N/A	No Action Required	N/A
			Level 1	>50 tonnes (FOG) or >5 tonnes (Burst) or damage renders equipment unfit for use, including equipment operated remotely from a safe location.	**STOP.** Barricade area, contact Supervisor/Ground Control, fill out Ground Control Logbook in CPCR.	Immediate	Ground Control inspect remotely with drone, and report to MOLITSD as required. Equipment to be checked by Maintenance before return to normal use. Scan to be reviewed for additional risks. Ground Inspection Report to be prepared	48 hours	Notify Mine Manager and applicable Superintendent. No Crisis Management action required.	48 hours	No Action Required	N/A
			Level 2	Ejection of material >5m from brow, significant overcut failure into open void, brow failure, uncontrolled caving, in addition to Level 1 criteria, or minor injury in an Ancillary area	**STOP.** Barricade area, contact Supervisor/Ground Control, fill out Ground Control Logbook in CPCR.	Immediate	Ground Control inspect remotely with drone. Report to MLITSD as required. Install additional barricades as required if risk of caving to other levels. Ground Inspection Report to be prepared. Develop action plan that may include remote backfilling if caving severe. Review implications to Short Term and LOM plans.	Before work resumes	Notify Mine Manager and applicable Superintendent, and Manager of Technical Services. Safety and Operations determine if HPRI warranted.	48 hours	If HPRI follow procedure	Per HPRI process
			Level 3	Major infrastructure damage. Possible injury due to ancillary damage within an accessible area.	**STOP.** Barricade area. Contact CPCR, Incident Commander, Supervisor, Superintendent, Ground Control, and execute all appropriate Steps from Level 2	Immediate	Initiate Emergency Response Plan. Initiate applicable portions of Seismic Management Plan. Ensure personnel affected are evacuated/ receive medical treatment. Fence affected areas as required per Ground Control.	Immediate	As stated in Emergency Response Plan. Safety and Operations determine if HPRI warranted. Depending on severity, may need to invoke Zinc Crisis Management Plan.	Immediate	As stated in Emergency Response Plan/Zinc Crisis Management Plan	Per Zinc CMP

FHP Protocol	Aspect	Trigger	Level	Magnitude or Observation	Primary Actions	Time Line	Increasing Actions	Time Line	Site Crisis Management Action	Time Line	Zinc Crisis Management Action	Time Line
Protocol #5 Ground/Strata Failure	**Random seismic activity with or without initial report of damage**	**Random large event remote from workings (note for comparison Stope slot blasts ~ MN 1, Stope final blasts ~MN 1.5 to 2. Both usually can be felt on surface). Largest historic events MN 3.8 which caused extensive damage on multiple levels. Smallest historic event to trigger damage ~ MN 0 if in very close proximity to workings, and support system is not capable of withstanding deformation and shock loading.**	**Normal**	Far field event felt by one or more persons underground, or felt on surface within central blast time. Event not within 50 m of workings, or not sufficient in terms of magnitude to cause damage. Random event or multiple events below a ML -1 or MN 0.5 in close proximity to accessible areas	Contact CPCR to determine event magnitude and location. If in zone with current seismic restriction, or within area isolated for a Longhole Production blast, contact Supervisor to ensure area remains isolated. Contact Ground control to confirm if real event, location and magnitude. EMAIL alert sent to CPCR and Ground Control for SGM events >0.8 ML and microseismic events >1.5 ML to avoid false alarms.	Immediate	CPCR and or Ground Control to post event information in TEAMS including location and magnitude, and to advise if any areas are to be closed. Supervisor to be provided instructions by Ground Control for areas which require barricades, if there is to be an exploratory inspection, etc. depending on location and magnitude. Ground Control to inspect/document, scan, per normal protocols.	Before work resumes	If damage noted - escalate to Level 1 and follow response in the "Rockburst" section above.	As required	No Action Required	N/A
			Level 1	Large magnitude event felt on surface and/or throughout underground workings during shift. Random event or multiple events below a ML - 0.5 or MN 1 causing spalling, spitting or popping in an active development area.	**STOP.** Follow the process from "Normal" above. EMAIL alert sent to CPCR and Ground Control for SGM events >0.8 ML and microseismic events >1.5 ML to avoid false alarms. Contact Supervisor. Underground personnel to check surroundings, and ensure area has not been damaged locally. Check TEAMS for further information from CPCR or Ground Control. Ground Control to provide clear instructions on areas which require barricades.	Immediate	If any damage noted, follow instructions for Rockburst above. Also ensure damage is documented in the Ground Control Logbook in CPCR. If any concern regarding location or status of personnel, institute evacuation per Emergency Response Plan after consultation with Ground Control. If active development heading is experiencing events which are causing local ground instability, fence heading and enter in Ground Control Logbook in CPCR and request Ground Control to inspect. May require a change to support systems, methods, etc. based on level of deformation (see LIDAR)	Before work resumes	Barricaded areas require clearance from Ground Control (Approved Seismic Re-entry Permit) before inspecting by Supervisor and/ or Ground Control. If damage sufficient to trigger reporting to MLITSD, Ground Control to follow instructions from "Rockburst" above. Safety and Operations to determine if HPRI warranted.	As required	If HPRI follow procedures	Per HPRI process
			Level 2	As above but with observed damage, local dusting out, sounds of additional failure, secondary FOG. Random event or multiple events below a ML 0.5 or MN 2. Local strain bursting causing ejection or more significant seismic activity in a development heading.	**STOP.** Check surroundings, evacuate area if safe to do so, barricade off affected/damaged area at a safe location. Contact Supervisor. Check TEAMS for further information from CPCR or Ground Control. Ground Control to provide clear instructions on areas which require barricades.	Immediate	If any damage noted, follow instructions for Rockburst above. If any concern regarding location or status of personnel, institute evacuation per Emergency Response Plan after consultation with Ground Control. Some Refuge Stations or routes of travel may need to be barricaded. Fill out Ground Control Log in CPCR.	Before work resumes	Safety and Operations determine if HPRI required. Ground Control and Operations to follow standard protocols to inspect/document, scan, assess, and institute a remediation plan if required. Ground Control to provide information to Supervisors/ Crews regarding event, damage, etc. as information comes available. No Zinc Crisis Management response required.	Communicate preliminary information before next Shift goes UG.	Determine if mine wide communication required. If required follow HPRI procedure	Per HPRI process
			Level 3	Serious injury, access to workplaces or second means of egress blocked, ML > 0.5 or Moment magnitude >MN 2, multiple automated emails from Seismic System. Refer to site Emergency Response plan	**STOP.** Fence area. Contact CPCR, Incident Commander, Supervisor, Superintendent, Ground Control	Immediate	Initiate Emergency Response Plan. Initiate applicable portions of Seismic Management Plan. Ensure personnel affected are evacuated/ receive medical treatment. Fence affected areas as required per Ground Control.	Immediate	As stated in Emergency Response Plan. Safety and Operations determine if HPRI warranted. Depending on severity, may need to invoke Zinc Crisis Management Plan.	Immediate	As stated in Emergency Response Plan/Zinc Crisis Management Plan	Per Zinc CMP

FHP Protocol	Aspect	Trigger	Level	Magnitude or Observation	Primary Actions	Time Line	Increasing Actions	Time Line	Site Crisis Management Action	Time Line	Zinc Crisis Management Action	Time Line
Protocol #5 Ground/Strata Failure	**Inadequate ground support capacity - Applicable to any accessible underground work place**	**Damaged or compromised ground support which may pose an additional risk due to remote seismic event, or change in loading conditions resulting in a fall of ground.**	**Normal**	Minimal to no damage, no safety hazard	Daily workplace inspection. Spot job observations, Development, Rehab, and CCV audits.	Same shift	If warranted based on local conditions or worker concern, Supervisor to fill out Ground Control Logbook	End of shift	No action required	N/A	No Action Required	N/A
			Level 1	Damaged/protruding or heavily corroded screen, bent bolt plates, fly rock damage, shotcrete cracking and loose...	Report damage to Supervisor. Supervisor to enter in Ground Control Log in CPCR. If in an active development heading, install new support to meet design standard. If in a travel way, or not in an area undergoing active rehabilitation, **STOP** and fence area.	Same shift	Fill in Ground Control Log in CPCR. Ground Control to inspect, scan and develop rehabilitation plan based on deformation >2 and less than 7.5 cm. Ground Control to complete risk assessment and determine criticality. Pending the risk assessment, area to remain fenced until repaired.	72 hours	Ground Control to issue rehabilitation plan within 5 days. Production Engineering to schedule and Operations to execute work. Ground Control to inspect when notified rehabilitation completed. Pending risk assessment, may remain barricaded until rehab complete. No set time line as a result. No Crisis Management action required.	See cell to left	No Action Required	N/A
			Level 2	Multiple plates bending, bolts broken or nuts popped off, badly bulging screen, excessive corrosion, fractured and failed shotcrete, failed shotcrete arches, steel sets, cable bolts, etc.	**STOP.** Barricade area. Contact supervisor, fill out Ground Control Logbook in CPCR. Ground Control to inspect and develop action plan in conjunction with Operations and Scheduling.	Immediate	Ground Control to inspect, scan and develop rehabilitation plan based on deformation >7.5 cm. Ground Control to complete risk assessment and determine criticality. Pending the risk assessment, area to remain fenced until repaired.	Area to be rehabilitated prior to any other assigned work	Ground Control to issue rehabilitation plan within 5 days. Production Engineering to schedule and Operations to execute work. Ground Control to inspect when notified rehabilitation completed. Pending risk assessment, may remain barricaded until rehab complete. No set time line as a result. No Crisis Management action required.	Rehabilitate Area prior to any other assigned work	No Action Required	N/A
			Level 3	Failure of ground support system, leading to significant damage to excavation or workplace rendering it unsafe to enter. See Rockburst or Fall of Ground above for other responses.	**STOP.** Fence area. Contact CPCR, Incident Commander, Supervisor, Superintendent, Ground Control, depending on nature of event, and impact to personnel and Operations.	Immediate	Initiate Emergency response plan if required due to injury or trapped personnel. Ground Control to inspect and develop action plan in conjunction with Operations to repair or abandon the area, depending on severity. Determine if damaged or compromised ground support was a root cause or contributed to the failure.	Area to be rehabilitated prior to any other assigned work if safe to do so	As stated in Emergency Response Plan. Safety and Operations determine if HPRI warranted. Depending on severity, may need to invoke Zinc Crisis Management Plan.	As required	As stated in Emergency Response Plan/Zinc Crisis Management Plan	Per Zinc CMP

FHP Protocol	Aspect	Trigger	Level	Magnitude or Observation	Primary Actions	Time Line	Increasing Actions	Time Line	Site Crisis Management Action	Time Line	Zinc Crisis Management Action	Time Line
Protocol #5 Ground/Strata Failure	**Any accessible underground work place - ground support product quality or installation issue**	**Defective ground support, poor quality of installation, and/or not installed to Standard**	**Normal**	Workplace supported to standard with no issues related to deformation, corrosion, or mechanical damage of support system.	Daily workplace inspection. Spot job observations, Development, Rehab, and CCV audits.	Same shift	If warranted, and ground support installation becomes suspect, if in active heading, STOP fence area and fill out Ground Control Logbook in CPCR. If deficiencies discovered during an Audit, follow normal audit closeout process, repair area and submit necessary documentation.	End of shift	No action required. Escalate to Level 1 if issues noted.	N/A	No Action Required	N/A
			Level 1	Weld strength problems with screen, bolts not torquing, resin expired or not setting, poor screen overlaps, bolting pattern not to standard, shotcrete not applied to standard.	Worker to discuss with Supervisor, implement plan to bring area to standard, e.g. add new bolt, or substitute a different type of tendon if resin or hole size issues (If more than two resin based bolts fail to set in the back and cannot be torqued). Fill out Ground Control Logbook in CPCR. Supervisor to do a JTO if necessary and discuss proper installation methods, correct bit size, etc. If larger issue out of control of Crew/Supervisor, institute **STOP.**	Same shift	Fill out Ground Control Logbook. If issue with job execution, train and coach workers as required. If issue with general ground conditions and inability to install the designated support system, if more than 2 resin based bolts in the back in a heading fail to set, install standard or Super Swellex, and report to Supervisor. Ground Control to inspect, review issue and change the design and specify tendon type(s) which can reliably be installed in the given ground conditions.	48 hours	Ground control to perform QC plan/ installation audit, and follow up with Superintendent and Mine Manager. Confirm hole size, resin mixing, swellex pump output pressures, etc. are all to specification. Determine if tendon failure was caused by stress or rock mass failure, and revise support plan/update driving layout or rehab plan accordingly. If material quality issue as received from Supplier, follow up with Procurement. If Worker issue, ensure crews are properly trained. If potential to trigger HPRI, follow HPRI process. No Crisis Management action required.	As required	If HPRI follow procedure	Per HPRI Process
			Level 2	Ground support deficiencies causing immediate hazard, including ungrouted cable bolts or other ground support which could fall from hole, or result in a major fall of ground. Inadequate expansion of inflatable bolts which results in loss of load capacity due to pump failure or improper bit/hole size which is applicable to any friction stabilizer. Manufacturing defect which results in Support System not capable of being installed to standard, or incapable of performance to specification.	**STOP.** Barricade area. Contact supervisor, fill out Ground Control Logbook in CPCR. If cable bolt pulls out of hole during tensioning process (critical control), remove cable from hole. If cable cannot be removed, fish plate over cable so it does not pose an ongoing risk. Ground Control to assess implication of reduced support coverage/capacity, inspect/document and develop action plan in conjunction with Operations. For Supplier quality issue, involve Procurement, Training and Scheduling as appropriate.	Immediate	Ground control to inspect, complete GIR, Install Audit, etc. as appropriate, and develop remediation plan, in accordance with the Level 1 actions above. For defective ground support material, Operations to provide batch or manufacturer's ID number so Ground Control/Procurement can follow up with Supplier. Other areas where the same support system has been installed, or where the same personnel have installed support to be inspected and verify no issues. Fence if any issues discovered. Defective cable bolts to either have alternate tendon installed, or to have additional holes drilled and new cables installed, per instructions from Ground Control.	Before work resumes or same support system is used in another location.	Ground control to perform QC plan/ installation audit, and follow up with Superintendent and Mine Manager. Confirm hole size, resin mixing, swellex pump output pressures, cable bolt grout process, etc. are all to specification. Determine if tendon failure was caused by stress or rock mass failure, and revise support plan/update driving layout or rehab plan accordingly. If material quality issue as received from Supplier, follow up with Procurement. If Worker or procedural issue, ensure crews are properly trained. If potential to trigger HPRI, follow HPRI process. No Crisis Management action required.	As required	If HPRI follow procedure	Per HPRI Process
			Level 3	Failure of ground support system, leading to significant damage to excavation or workplace rendering it unsafe to enter. See Rockburst or Fall of Ground above for other responses.	**STOP.** Fence area. Contact CPCR, Incident Commander, Supervisor, Superintendent, Ground Control, depending on nature of event, and impact to personnel and Operations.	Immediate	Initiate Emergency response plan if required due to injury or trapped personnel. Ground Control to inspect and develop action plan in conjunction with Operations to repair or abandon the area, depending on severity. Determine if inadequate, damaged or compromised ground support was a root cause or contributed to the failure.	Before work resumes	If major support system quality issue, follow up with Supplier and Procurement. If Worker issue, ensure training is provided. If due to condition of rock mass, revise support plan. If potential to trigger HPRI, follow HPRI process. May require notification of other sites which utilize the same material if major Supplier quality issue.	As required	If HPRI follow procedure	Per HPRI Process

FHP Protocol	Aspect	Trigger	Level	Magnitude or Observation	Primary Actions	Time Line	Increasing Actions	Time Line	Site Crisis Management Action	Time Line	Zinc Crisis Management Action	Time Line
Protocol #5 Ground/Strata Failure	**Monitoring Seismic Activity (Critical Control)**	**Components of Seismic Monitoring System, or Site Wide Data Transmission Network are not Functional**	**Normal**	Sensor(s) down within one level in a Mining Block	Paladin Diagnostics monitors system health in real time. Alert from Paladin Diagnostics sent via email to Ground Control and CPCR when failure or out of specification condition detected. CPCR to send Shift Electrician to troubleshoot and restore power or communications.	Same shift	Ground Control to repair if possible, or coordinate repair work with Electrical Maintenance General Foreman if more significant issue. Ground Control to supply UPS, replacement batteries, Paladin monitoring hardware to Electrical department from on site critical spares inventory. Ground Control to procure replacement critical spares from OEM once at minimum inventory.	As required	If work not completed in timely fashion, escalate to Manager of Technical Services and Manager of Maintenance and Engineering as required.	N/A	No Action Required	N/A
			Level 1	Significant portions of system down (multiple components spanning single to multiple Mining Blocks).	Ground control to inform Operations via CPCR. CPCR to immediately dispatch Shift Electrician and if Network issue, to contact Network Specialist. Electrician to contact Ground Control for spare UPS, Batteries, Fibre Optic network switches, Paladin recorders, Seismic system master clock, etc. depending on nature of failure if hot spares not available in CPCR.	ASAP and within 2 days.	Ground Control to contact supplier (support@esgsolutions.com 613-541-0287) as required for OEM equipment issues, and coordinate with IT/Electrical Departments to repair ASAP for power/network issues. Delay high risk production or development blasting in affected area until system integrity is restored.	ASAP	If work not completed in timely fashion, escalate to Manage of Technical Services and Manager of Maintenance and Engineering as required.	N/A	No Action Required	N/A
			Level 2	Entire Seismic System down due to major component failure (Processing PC, Seismic Servers, major Network switch or fiber optic cable failure between 9400 and Surface)	Ground control to inform Operations (Mine Manager, Senior Supervisors, CPCR) system is down, **STOP** work and barricade any high risk areas, allow work in lower risk areas if agreed by Operations Manager. Limit development blasting to low seismic risk areas, and NO Production blasting to be authorized until system integrity is restored. Only autonomous mucking from High Risk Areas with no entry for concussion blasts, etc. due to lack of data.	Immediate	Ground control to contact supplier (support@esgsolutions.com 613-541-0287) as required for OEM equipment issues, and coordinate with IT/Electrical Departments to repair ASAP for power/network/ major component issues. Workers to report any unusual seismic activity to CPCR and Supervisor, vacate working place if seismically active. Limit development blasting to non-critical low risk areas. Defer all Production blasting until system restored. Backup files stored off site at ACG and ESG, as well as in virtual servers if system recovery is required with minimal loss of data.	Immediate	Inform Site Management Team of issues. Site Management Team must agree to limited activity for duration of outage, with additional controls based on scheduled mining activity at time of loss of monitoring system. Live copies of database and processing software available from ESG, ACG, and Offsite Database backups, with no more than one week of lost data as worst case scenario.	N/A	No Action Required	N/A
			Level 3	Entire Seismic System down for extended period (Level 2) and High Risk areas barricaded. Large events reported by multiple workers/ occurring with no ability to process data and verify event magnitude or location.	Multiple persons reporting seismic events from various areas of the Mine. Evacuate personnel to surface. May need to implement Emergency Response Plan if any personnel not accounted for. **STOP** work until monitoring capability is restored.	Immediate	Ground Control to source material and expedite delivery to site if not already available in Critical Spare inventory. IT to assist if any computer or server replacement is required. In short term, may be able to host Seismic processes on existing shared Network or Cloud server, and repurpose PC equipment as necessary. STOP work based on inability to monitor events as reported by workforce, with inability to update risk profile with respect to Mine geometry.	ASAP	Live backup copies of database and processing software available from ESG, ACG, and Offsite Database backups, with no more than one week of lost data as worst case scenario. If all Site activity will be on hold for an extended period of time due to loss of system integrity, may need to inform Zinc Canada of impact on production.	N/A	No Zinc Crisis Management notification required. Notify Zinc Canada/Asset Manager if Production will be negatively impacted.	N/A

FHP Protocol	Aspect	Trigger	Level	Magnitude or Observation	Primary Actions	Time Line	Increasing Actions	Time Line	Site Crisis Management Action	Time Line	Zinc Crisis Management Action	Time Line
Protocol #5 Ground/Strata Failure	**Deformation Monitoring Instrumentation or Processes**	**Ground Movement measured by MPBX or GMM (in the hole instruments) within Accessible Area**	**Normal**	Total displacement between two anchors points <10mm, rate of change constant with time	Normal operating conditions, regular inspections/reporting adequate	On going	If other warning signs such as plate bending, excessive screen bagging escalate to Level 1	As required	No Action Required	N/A	No Action Required	N/A
			Level 1	Total displacement between two anchors points 10 < d < 20mm, rate of change accelerating at <120% of historical rate of change per unit of time	Formal documented inspection of the area, look for signs of support system taking load, plates bending, screen bagging, complete with LIDAR Scan. **STOP** Barricade area if signs of excessive deformation are noted.	5 days	Fill in Ground Control Log in CPCR. Ground Control to inspect, scan and develop rehabilitation plan based on deformation >2 and less than 7.5 cm. Ground Control to complete risk assessment and determine criticality. Pending the risk assessment, area to remain fenced until repaired.	Authorization to resume activity pending investigation/ inspection, and need for repair.	No Action Required	N/A	No Action Required	N/A
			Level 2	Total displacement between two anchors points > 20mm, rate of change accelerating at >120% of historical rate of change per unit of time.	**STOP.** Barricade area. Formal documented inspection, scan, and risk assessment required. Additional support or change in processes likely.	Immediate	Ground Control to inspect, scan and develop rehabilitation plan based on magnitude of deformation >2 and less than 7.5 cm, in accordance with Rock Burst and Support Capacity TARPs. Ground Control to complete risk assessment and determine criticality. Pending the risk assessment, area to remain fenced until repaired, or develop alternate mining plan as required.	Before work resumes	Ground Control to issue rehabilitation plan within 5 days. Production Engineering to schedule and Operations to execute work. Ground Control to inspect when notified rehabilitation completed. Pending risk assessment, may remain barricaded until rehab complete. No set time line as a result. No Crisis Management action required.	N/A	No Action Required	N/A
			Level 3	Total displacement between two anchors >30mm. Rate of change accelerating at >150% of historic rate of change per unit of time. Areal deformation in excess of 7.5 cm per LIDAR scans.	**STOP.** Barricade area. Ground control to perform full documented inspection , scan and risk assessment. Non Routine Hazardous task assessment required. Rehab plan required, or area needs to be abandoned and permanently isolated.	Immediate	Initiate Emergency response plan if required due to injury or trapped personnel. Ground Control to inspect and develop action plan in conjunction with Operations to repair or abandon the area, depending on severity.	Area to be rehabilitated prior to any other assigned work if safe to do so.	Safety and Operations determine if HPRI warranted, however since hazard typically identified prior to an incident, likely not required. Adjust Mine Production schedule and LOM plan as warranted.	As required	If HPRI follow procedure	Per HPRI process

FHP Protocol	Aspect	Trigger	Level	Magnitude or Observation	Primary Actions	Time Line	Increasing Actions	Time Line	Site Crisis Management Action	Time Line	Zinc Crisis Management Action	Time Line
Protocol #5 Ground/Strata Failure	**Deformation Monitoring Instrumentation or Processes**	**Areal deformation measured by LIDAR Scans within Accessible Area**	**Normal**	Convergence <5cm between bolts, if bolt plate convergence can be identified <2cm. No compromised support, excessive loose or bagging, no to moderate corrosion.	Normal operating conditions, regular inspections/reporting adequate	On going	If other warning signs such as plate bending, excessive screen bagging escalate to Level 1.	As required	No Action Required	N/A	No Action Required	N/A
			Level 1	Convergence > 7.5 cm between bolts, and if bolt plate convergence can be identified >2cm and <7.5 cm	Formal documented inspection of the area, look for signs of support system taking load, plates bending, screen bagging, complete with LIDAR Scan. **STOP.** Barricade area if signs of excessive deformation or failed ground support tendons are noted. If bolt displacement is near 7.5 cm, support system is at nominal rated capacity to withstand a future seismic event.	immediate	Fill in Ground Control Log in CPCR. Ground Control to inspect, scan and develop rehabilitation plan based on deformation >2 and less than 7.5 cm. Ground Control to complete risk assessment and determine criticality. Pending the risk assessment, area to remain fenced until repaired.	Authorization to resume activity pending investigation/ inspection, and need for repair.	No Action Required	N/A	No Action Required	N/A
			Level 2	7 cm < convergence < 13 cm. Signs of broken bolt heads, broken plates, failed ground support tendons.	**STOP.** Ground support has reached maximum deformation capacity and failure imminent. Install A type barricade. Review LOM use for area and determine if rehab plan to restore support capacity required, or area to be abandoned and alternate mining methods considered. NO entry until repairs are made.	Immediate	Ground Control to inspect/ document, scan and assess damage. If displacement exceeds 7.5 cm STOP. Support capacity degraded to the point excavation will not survive even a moderate seismic event or blast. If access required for LOM or in critical area, shut down until support capacity restored. Institute rehab plan or abandon area as appropriate pending result of risk assessment.	Area to remain barricaded until repairs completed. If area abandoned, permanent barricades required.	Ground Control to issue rehabilitation plan within 5 days. Production Engineering to schedule and Operations to execute work. Ground Control to inspect when notified rehabilitation completed. Pending risk assessment, will remain barricaded until rehab complete. No set time line as a result. No Crisis Management action required.	Immediate	If HPRI follow procedure	Per HPRI process
			Level 3	As a result of excessive deformation, support system fails. Will either result in a fall of ground, or damage due to a seismic event of potentially any magnitude. Normally would be identified and rectified at Level 1 or Level 2.	**STOP.** Fence area. Ground Support system beyond specified deformation capacity. Follow Emergency Plan if applicable. Follow actions from Fall of Ground, Rockburst, or Support Capacity TARPS if incident does not cause injury, affect second means of egress or main travel way.	Immediate	Follow Emergency Plan, Seismic Management Plan, or TARPS from Fall of Ground, Rockburst, or Inadequate Ground Support Capacity	Immediate	As stated in Emergency Response Plan. Safety and Operations determine if HPRI warranted. Depending on severity, may need to invoke Zinc Crisis Management Plan.	As required	As stated in Emergency Response Plan/ Zinc Crisis Management Plan	Per Zinc CMP

FHP Protocol	Aspect	Trigger	Level	Magnitude or Observation	Primary Actions	Time Line	Increasing Actions	Time Line	Site Crisis Management Action	Time Line	Zinc Crisis Management Action	Time Line
Protocol #5 Ground/Strata Failure	**Load Monitoring Instrumentation**	**Smart Cable (load readings on cable bolts)**	**Normal**	<15 tonnes (due to twin cables, <30 t per hole)	Normal operating conditions, regular inspections/reporting adequate	On going	If other warning signs such as plate bending, excessive screen bagging, cable slip or cable unbraiding, escalate to Level 1	As required	No Action Required	N/A	No Action Required	N/A
			Level 1	15< load < 20 tonnes (due to twin cables, <40 tonnes per hole). Cables at up to 80% of ultimate capacity.	**CAUTION.** Formal documented inspection of the area, look for signs of support system taking load, plates bending, screen bagging. If real time monitoring is available on Newtrax, increase reading frequency or change alarm settings.	immediate	Provide rehab layout if required, generally linked to production schedule (e.g. rehab prior to taking nearby stope blast). If critical infrastructure, or long term access required, consider installing additional cable bolts in tandem with the rehabilitation process to restore capacity.	Link to mine schedule	No Action Required	N/A	No Action Required	N/A
			Level 2	20 < load < 25 tonnes (due to twin cables, between 40 and 50 tonnes per hole). Cables in excess of 80% of ultimate capacity.	**STOP.** Barricade the affected area. Assume cables are nearing their ultimate capacity, and any other deleterious conditions such as corrosion or shear could lead to sudden failure. Rehabilitation Plan or Cable Bolt layout required to restore capacity. Alternately, review proposed mining plan and abandon and isolate area if possible.	Immediate	Provide rehab and secondary cable bolt layout or design alternate access and permanently close off heading.	Before work resumes	Ground Control to issue rehabilitation plan within 5 days. Production Engineering to schedule and Operations to execute work. Ground Control to inspect when notified rehabilitation completed. Pending risk assessment, will remain barricaded until rehab complete. No set time line as a result. No Crisis Management action required. Adjust mine production plan as necessary due to lack of access.	Immediate	No Action Required	N/A
			Level 3	>25 tonnes (due to twin cables over 50 tonnes per hole). Cables at or beyond 100% of nominal capacity. No FOS.	**STOP.** Barricade area, bolts may be compromised, or failed, and Fall of Ground imminent, or burst damage likely. Rehab Plan and Cable Bolt layout required to restore capacity. NRHT or HHA risk assessment required. Abandon area and permanently isolate if no other options.	Immediate	Provide rehab and secondary cable bolt layout or design alternate access and close off heading. Provide NRHT assessment, or HHA risk assessment to Supervisor and crew if no other alternative but to maintain the opening. Should not have reached this point as should have been repaired at Level 2.	Before work resumes	See above	Immediate	No Action Required	N/A

FHP Protocol	Aspect	Trigger	Level	Magnitude or Observation	Primary Actions	Time Line	Increasing Actions	Time Line	Site Crisis Management Action	Time Line	Zinc Crisis Management Action	Time Line
Protocol #5 Ground/Strata Failure	**Caving Instrumentation**	**Slough meter/ tell tale triggered, indicating caving in close proximity to accessible work area**	**Normal**	Slough meter/tell tale still intact, instrument fully functional.	Normal operating conditions, regular inspections/reporting adequate - ensure Site Specific Ground Control Logbook is being used.	On going	If other warning signs such as plate bending, excessive screen bagging, sounds of caving, excessive oversize in drawpoint, escalate to Level 1	Immediate	No Action Required	N/A	No Action Required	N/A
			Level 1	Slough meter lowest node point broken but not at critical threshold (e.g. multiple wire loops functional, and still sufficient intact rock between accessible location where personnel are working, and void being monitored)	**CAUTION.** Follow instructions in site specific Ground Control logbook associated with instrument. Formal documented inspection of the area, increase monitoring frequency or establish real time monitoring. CALS or Drone LIDAR scan of caving zone if accessible. Review of remaining solid material vs size of void and potential for cave to breakthrough into accessible area.	immediate	Provide rehab layout if required. Link to production schedule (e.g. rehab prior to taking nearby stope blast). In some situations, may require immediate STOP to mucking to maintain passive support or void to be filled, or modification of mining plan to minimize worker exposure to sudden caving hazard - remote drilling, non entry drill site, etc.	Link to mine schedule	No Action Required	N/A	No Action Required	N/A
			Level 2	Tell tale triggered, additional slough meter wire loops broken approaching critical distance.	**STOP.** Barricade area with A Barricade. Full investigation of area required as per Level 1. NRHT or other HHA risk assessment to determine how to proceed.	Immediate	STOP mucking to maintain passive support. Fill void, or determine safe means to remove equipment. Revise mining plan to allow all work to be done remotely. Remotely recover equipment if necessary.	Before heading is re-opened	Pending Risk Assessment, will remain barricaded until alternate mining plan/procedure/processes established, such as fully remote drilling. Adjust mining plan as required based on lack of access.	Immediate	No Action Required	N/A
			Level 3	Slough meter minimum distance reached. Insufficient sill remaining to work above remaining span.	**STOP.** Immediately abandon area. Install A type barricade(s) at safe location. Any equipment (e.g. Long Hole drill/Raise bore) to remain in place until safe to remove.	Immediate	Initiate ERP if required. Ground Control to inspect and develop action plan in conjunction with Operations to repair or abandon the area, depending on severity.	Before heading is re-opened	Safety and Operations determine if HPRI warranted, however since hazard typically identified prior to an incident, likely not required. Adjust Mine Production schedule and LOM plan as warranted.	As required	If HPRI follow procedure	Per HPRI Process

FHP Protocol	Aspect	Trigger	Level	Magnitude or Observation	Primary Actions	Time Line	Increasing Actions	Time Line	Site Crisis Management Action	Time Line	Zinc Crisis Management Action	Time Line
Protocol #5 Ground/Strata Failure	**General hazard recognition**	**General ground, support, and excavation conditions including geometry of openings and adherence to design**	**Normal**	Area supported to standard, no scaling required, profile normal	Maintain standards	On going	If conditions change, go to Level 1	On going	No Action Required	N/A	No Action Required	N/A
			Level 1	Excessive span, open or pervasive structures, joints or contacts that could create wedge failures, other deterioration including advanced corrosion, floor heave, or drift heading showing signs of stress.	**CAUTION.** Contact Supervisor, verify Ground Control Support Standards or other recommendations on existing Driving Layout or Rehabilitation Plan.	Before end of shift	Barricade area if un-sure. Fill out Ground Control Logbook in CPCR.	As required	No Action Required	N/A	No Action Required	N/A
			Level 2	Open cracks, wedges dilating, plates bending, ground support under load. Any issues with support installation not to specification, not to plan, questionable support performance, etc.	**STOP** Barricade area, Contact Supervisor and Ground Control. Fill out Ground Control Logbook in CPCR. Formal documented inspection of the area, look for signs of support system taking load, plates bending, screen bagging, estimate maximum potential wedge volume/ mass. If real time monitoring is available on Newtrax, increase reading frequency or change alarm settings. LIDAR scan mandatory.	Immediate	Ground Control to inspect/ document, scan and assess damage. If displacement exceeds 7.5 cm STOP. Support capacity degraded to the point excavation will not survive even a moderate seismic event or blast. If access required for LOM or in critical area, shut down until support capacity restored. Institute rehab plan or abandon area as appropriate pending result of risk assessment.	Area to remain barricaded until repairs completed. If area abandoned, permanent barricades required.	Ground Control to issue rehabilitation plan within 5 days. Production Engineering to schedule and Operations to execute work. Ground Control to inspect when notified rehabilitation completed. Pending risk assessment, will remain barricaded until rehab complete. No set time line as a result. No Crisis Management action required.	N/A	No Action Required	N/A
			Level 3	Failure observed, or conditions unsuitable for entry. See Rockburst or Fall of Ground from Accessible Area above if an actual failure of the rock mass has occurred.	**STOP.** Fence area. Contact Ground Control if conditions not suitable for entry. If an actual failure occurs, contact CPCR, Incident Commander, Supervisor, Superintendent, Ground Control as required. If injury or loss of access, initiate Emergency Response Plan as required .	Immediate	Initiate Emergency Response Plan if required. Ensure personnel affected are evacuated/receive medical treatment as necessary. Fence affected areas as required.	Before heading is re-opened	As stated in Emergency Response Plan	Immediate	As stated in Emergency Response Plan/Zinc Crisis Management Plan	Per Zinc CMP

FHP Protocol	Aspect	Trigger	Level	Magnitude or Observation	Primary Actions	Time Line	Increasing Actions	Time Line	Site Crisis Management Action	Time Line	Zinc Crisis Management Action	Time Line
Protocol #5 Ground/Strata Failure	**Backfill stability in Lateral Development (accessible area)**	**Development in fill, or fill removal from existing development**	**Normal**	Good quality fill, normal operating standards sufficient. No issues with support installation, no excessive amounts of suspended paste in roof.	Normal operating conditions, regular inspections and reporting adequate. Follow instructions on Driving Layout or Rehab plan as appropriate.	Ongoing	If fill quality issues, void, free running rubble, or any other unexpected conditions encountered, STOP and escalate to Level 1. Fill out Ground Control Logbook in CPCR. Barricade heading as required.	Immediate	No Action Required	N/A	No Action Required	N/A
			Level 1	Shotcrete not sticking, bolts failing to properly anchor, or causing fill to un-ravel, water percolating / draining from cemented fill	Review operating procedures. Shotcrete needs to be built up gradually in layers. Confirm proper bit size, bolt type, output pressure on Swellex pumps, etc. If no obvious triggers, **STOP.** Barricade heading, contact Supervisor, fill out Ground Control Log in CPCR.	Immediate	Ground Control to inspect, scan and develop rehabilitation plan based on conditions. Ground Control to complete risk assessment and determine criticality. Pending the risk assessment, area to remain fenced until repaired. Normally would require installation of more robust shotcrete arches, or other support system, or change of development design.	72 hours	Ground Control to issue rehabilitation plan within 5 days. Production Engineering to schedule and Operations to execute work. Ground Control to inspect when notified rehabilitation completed. Pending risk assessment, may remain barricaded until rehab complete. No set time line as a result. No Crisis Management action required.	N/A	No Action Required	N/A
			Level 2	Poor quality fill not suitable for mining under/through (collapse of fill after blasting, weak material easily scaled out by hand). Unconsolidated waste present or not removed from area prior to filling. Cannot install support into intact material in perimeter of excavation.	**STOP.** Barricade heading, contact Supervisor, fill out Ground Control Log in CPCR. Good quality fill needs to be drilled and blasted, easy removal of “intact” fill by scoop bucket or free running material is trigger for shutting down area.	Immediate	Ground Control and Engineering to develop revised plan. In worst case may require remote mucking of unconsolidated material and replacement of fill, or change in global design.	Before development resumes	No Action Required	N/A	No Action Required	N/A
			Level 3	Fall of ground results in serious/ fatal Injury, loss of access trapping personnel, local excavation or equipment damage	**STOP.** Fence area. Contact CPCR, Incident Commander, Supervisor, Superintendent, Ground Control	Immediate	Initiate Emergency Response Plan. Ensure personnel affected are evacuated/receive medical treatment as necessary. Fence affected areas as required. Leave heading ‘as is’ pending investigation.	Immediate	As stated in Emergency Response Plan for injury or trapped personnel only as required. If FOG does not result in injury, but causes equipment damage, Ground Control to submit necessary reports to MLITSD.	Immediate	As stated in Emergency Response Plan/ Zinc Crisis Management Plan	Per Zinc CMP

FHP Protocol	Aspect	Trigger	Level	Magnitude or Observation	Primary Actions	Time Line	Increasing Actions	Time Line	Site Crisis Management Action	Time Line	Zinc Crisis Management Action	Time Line
Protocol #5 Ground/Strata Failure	**Unanticipated leakage or failure of any Bulkhead or Dam. Read in conjunction with Water Management Plan and TARPS.**	**Unexpected leak of paste or other material through an Engineered bulkhead, or from other opening connected to the Stope or other location being filled, or failure of any water retaining structure.**	**Normal**	Backfill barricade showing signs of seepage, no visible cracks, pressures not in excess of 18 psi or 125 kPa, cameras functional. No signs of failure of any water retaining structure, no significant leakage, no overtopping or flooding.	Maintain safe distance (low and high pressure barricades) following instructions on Paste Fill Pour Plan, monitor the pour remotely using cameras and pressure transducers on both pipeline and paste bulkhead. Normal operating procedures and inspections sufficient for water management and dewatering infrastructure.	Ongoing	If any signs of plugged line, bulkhead failure, or other leak, immediately shut down pour. Escalate to Level 1. Flush line as soon as possible. If on plug or cap pour with high binder, if distribution line breaks, install flushing header on downhole side of line break and flush from underground as required.	As required and as soon as possible. Continue to flush system as required, and before fill hardens.	Safety and Operations to determine if HPRI. Enter incident in KSS. Perform investigation to determine root cause. If run of material in excess of 1 cubic meter that could have endangered a worker, Ground Control to submit UOR to MLITSD.	N/A	No Action Required	N/A
			Level 1	Paste fill bulkhead pressure in excess of 18 psi or 125 kPa, loss of cameras preventing adequate monitoring of bulkhead pressures. Leakage from any water retaining structure.	**STOP.** Contact Supervisor, stop pour if bulkhead pressure is over 18psi or 125 kPa. Ensure high pressure fences are in place and that no personnel enter area. Fill out Ground Control Log. Berm area as required to prevent leak reaching ore passes, ventilation raises, ramp, or other areas of concern. Fence any other areas where leakage detected.	Immediate	Wait until paste has cured to a minimum of 0.42 MPa (no longer a fluid), re-spray shotcrete if bulkhead issue, install new bulkhead, or seal any other leak as required. Allow 24 hour shotcrete cure time, modify pour plan as required, resume pour. Continue to monitor for leaks per pour plan. If leak from water retaining structure, investigate conditions, modify water consumption, berm and repair as required.	Before resuming pour or allowing Sump to return to high level.	Safety and Operations to determine if HPRI. Enter incident into KSS. Perform investigation to determine root cause. If run of material in excess of 1 cubic meter that could have endangered a worker, Ground Control to submit UOR to MLITSD.	N/A	No Action Required	N/A
			Level 2	Significant fill leakage/bulkhead rupture or other opening into pour area not sealed. Major paste line leak or rupture. Major leakage from water retaining structure or overtopping of any dam, flooding of level, etc.	**STOP.** Contact supervisor, stop pour, fill out Ground Control Log. Berm area as required to prevent spill reaching ore passes, ventilation raises, ramp, or other areas of concern. Fence any other areas where leakage detected. If water has potential to enter shaftor impact conveyances, stop hoisting and institute stop work order if second means of egress not available.	Immediate	Wait until paste has cured to a minimum of 0.42 MPa (no longer a fluid), re-spray shotcrete if bulkhead issue, install new bulkhead, or seal any other leak as required. Allow 24 hour shotcrete cure time, modify pour plan or reassemble paste line as required, resume pour. Continue to monitor for leaks per pour plan. Determine cause of upset condition in dewatering or process water system and rectify.	Before resuming pour, or before resuming normal operations	Safety and Operations to determine if HPRI. Enter incident into KSS. Perform investigation to determine root cause. If run of material in excess of 1 cubic meter that could have endangered a worker, Ground Control to submit UOR to MLITSD.	N/A	No Action Required	N/A
			Level 3	Fill bulkhead failure causing inrush, or failure of any water containing structure which puts main travel way or shaft at risk. Any run of material which results in trapped personnel, injury, or fatality.	**STOP.** Fence area. Contact CPCR, Incident Commander, Supervisor, Superintendent, Ground Control	Immediate	Initiate Emergency Response Plan. Ensure personnel affected are evacuated/receive medical treatment as necessary. Fence affected areas as required. Leave heading 'as is' pending investigation. Operations, Safety and Ground Control to investigate as required.	Immediate	As stated in Emergency Response Plan. Safety and Operations determine if HPRI warranted. Depending on severity, may need to invoke Zinc Crisis Management Plan.	As required	As stated in Emergency Response Plan/ Zinc Crisis Management Plan	Per Zinc CMP

Appendix

Occupational Health and Safety Act and Regulation 854: Mines and Mining Plants Pertaining to Ground Control and Risk Assessment

Seismic Risk Management Program

Regulation 854: Mines and Mining Plants

71.1 (1) An owner of an underground mine shall, in consultation with the joint health and safety committee or health and safety representative, if any, develop and maintain a written seismic risk management program.
(2) The program shall,

(a) set out how areas of the mine that have high levels of seismic risk and activity are to be identified;

(b) include a description or list of the areas of the mine identified under clause (a) and set out mitigation plans for those areas;

(c) set out how micro seismic activity will be monitored in the areas of the mine identified under clause (a) and how frequently that data will be analysed;

(d) include measures and procedures to assess the performance of the system used to monitor micro seismic activity and to maintain the system and its components;

(e) identify the persons responsible for implementing the program, including the persons responsible for responding to seismic events and rockbursts;

(f) set out how seismic events and rockbursts are to be documented and where the documentation will be kept; and

(g) establish a re-entry protocol following seismic events or rockbursts and set out how and when the re-entry protocol applies.

(3) A copy of the program shall be provided to the joint health and safety committee or health and safety representative, if any, and be kept readily available at the mine site.

(4) Subject to subsections (5) and (6), the program shall be reviewed at least annually.

(5) The program shall be reviewed as soon as possible if,

(a) a risk assessment conducted under section 5.1 identifies a new seismic risk;

(b) a measure developed and maintained under section 5.2 in relation to seismic risks fails; or

(c) a mine design prepared and maintained under subsection 6 (1) identifies a new zone or area of the mine that is expected to be seismically active.

(6) If a review is required under subsection (5), the next annual review required by subsection (4) shall be within one year of the date of the review under subsection (5).

(7) For greater certainty, an employer's duty to provide information and instruction to a worker under clause 25 (2) (a) of the Act includes the duty to provide the worker with information and instruction that is appropriate for the worker on the contents of the seismic risk management program.

Risk Assessment and Managing of Hazards

Regulation 854: Mines and Mining Plants

5.1 (1) An employer shall conduct a risk assessment of the workplace for the purpose of identifying, assessing and managing hazards, and potential hazards, that may expose a worker to injury or illness. (2) A risk assessment must take into consideration the nature of the workplace, the type of work, the conditions of work at that workplace and the conditions of work common at similar workplaces.

(3) The results of an assessment must be provided, in writing, to the joint health and safety committee or the health and safety representative, if any.

(4) If no joint health and safety committee or health and safety representative is required at the workplace, the results of an assessment must be communicated to workers at the workplace and provided, in writing, to any worker at the workplace who requests them.

(5) The requirement in subsection (1) to conduct a risk assessment is in addition to any specific assessments required by the Act or any Regulation made under it.

5.2 (1) An employer shall, in consultation with the joint health and safety committee or the health and safety representative, if any, develop and maintain measures to eliminate, where practicable, or to control, where the elimination is impracticable, the hazards, and potential hazards, identified in a risk assessment conducted under subsection 5.1 (1).

(2) The measures referred to in subsection (1) shall be put in writing and shall include each of the following, as applicable and reasonable in the circumstances:

1. Substitution or reduction of a material, thing or process.
2. Engineering controls.
3. Work practices.
4. Industrial hygiene practices.
5. Administrative controls.
6. Personal protective equipment.

(3) Personal protective equipment shall only be used as a measure if the measures referred to in paragraphs 1 to 5 of subsection (2) are not obtainable, are impracticable or do not eliminate or fully control hazards and potential hazards.

5.3 (1) The risk assessment required by section 5.1 must be reviewed as often as necessary and at least annually.

(2) When conducting the review, the employer shall ensure that,

(a) new hazards or new potential hazards are assessed;

(b) existing hazards or potential hazards that have changed are re-assessed; and

(c) the measures required by section 5.2 continue to effectively protect the health and safety of workers.

(3) Subsections 5.1 (3) and (4) and section 5.2 apply with necessary modifications in respect of any new hazards and potential hazards and any existing hazards or potential hazards that have changed.

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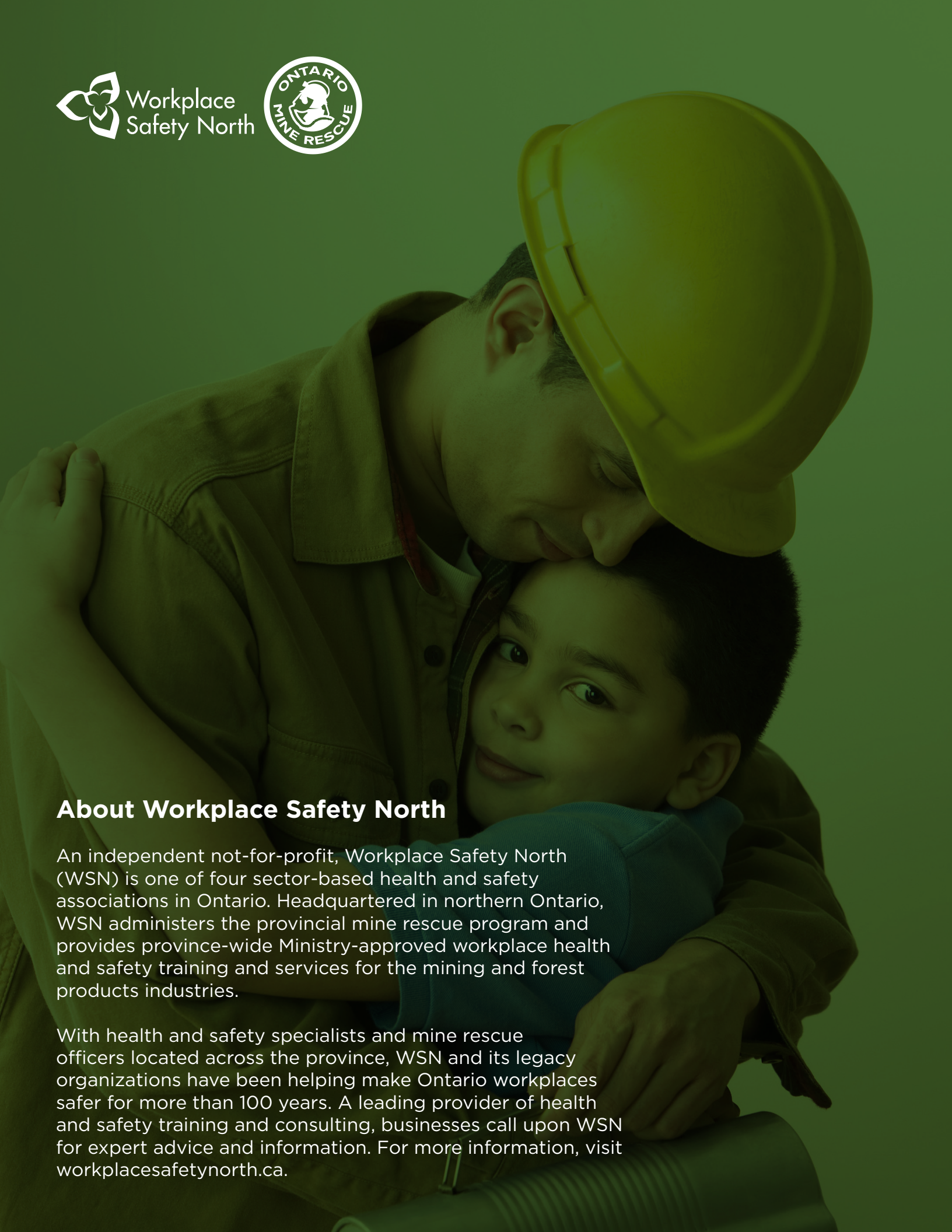

About Workplace Safety North

An independent not-for-profit, Workplace Safety North (WSN) is one of four sector-based health and safety associations in Ontario. Headquartered in northern Ontario, WSN administers the provincial mine rescue program and provides province-wide Ministry-approved workplace health and safety training and services for the mining and forest products industries.

With health and safety specialists and mine rescue officers located across the province, WSN and its legacy organizations have been helping make Ontario workplaces safer for more than 100 years. A leading provider of health and safety training and consulting, businesses call upon WSN for expert advice and information. For more information, visit workplacesafetynorth.ca.