Pedestrian-Mobile Equipment Visibility

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Forward

The results of the Mining Health, Safety and Prevention Review (MHSPR) completed in early 2016 identified mobile equipment hazards as one of the main causes of underground injuries and fatalities in Ontario's hard rock mines.

As a result of the review, the Ministry of Labour, Training and Skills Development (MLTSD) – formerly the Ministry of Labour (MOL) – through the Mining Legislative Review Committee (MLRC) in mobile equipment, and in consultation with the Ontario mining industry, and Workplace Safety North (WSN) prepared a series of guidelines and resource materials. These tools can be used by workplace parties to prepare programs, policies and procedures to manage the risk associated with hazards that may arise from the nature of the workplace, and the type or conditions of work, associated with mobile equipment.

These resources are also designed to help workplace parties understand their obligations under the Occupational Health and Safety Act (OHSA) and regulations pertaining to mobile equipment.

On September 4, 2014, the MLTSD issued the Guideline for High Visibility Safety Apparel for Mines and Mining Plants. Resource documents on Vehicle/Mobile Equipment and Visibility Hazards in Mining Workplaces and on Mobile Equipment in Underground Mines were issued on December 31, 2014, and July 17, 2015, respectively.

On January 1, 2017, Sections 5.1, 5.2 and 5.3 of Regulation 854 came into force with new provisions providing the framework for the implementation of risk assessments and management in Ontario's mines and mining plants, including hazards associated with mobile equipment.

This reference document is intended to assist Ontario mining operations in developing their internal programs for traffic management, including conducting risk assessments for mobile equipment hazards and managing the risks associated with the identified hazards.

This document was prepared by the WSN Technical Advisory Committee for Mobile Equipment. WSN gratefully acknowledges the contributions of all members.

WSN Mining Equipment Technical Advisory Committee

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1. Introduction

During the past 25 years, significant improvement has been made in underground mines and surface operations in controlling hazards and reducing incidents that lead to incidents involving mobile equipment. Changes to equipment design, operating procedures, and pedestrian and operator training have all contributed to a safer working environment.

Incidents, however, continue to occur underground and on surface. Mobile equipment has collided with other mobile equipment, clipped pedestrians, and struck fixed hazards, such as stationary equipment and drift walls, as well as fallen into open holes. These incidents have resulted in damaged equipment, lost production, and most significantly, worker injury and loss of life.

From 1996 to 2006, approximately 76 vehicle incidents were voluntarily reported in WSN's mining sector that involved collisions or pedestrians (see **Table 1**). These incidents resulted in 60 medical aid injuries, 15 lost-time injuries, and one death. Visibility may have been a factor in 39 (more than 50 per cent) of incidents, which resulted in 30 medical aid injuries, eight lost time injuries, and one death. Summaries of incidents that may have involved visibility issues are provided in **Appendix 1**.

Table 1 – WSN Mining Sector vehicle incident statistics from 1996-2006.

Type of Injury	Reported Mobile Equipment Incidents	In which visibility may have been a factor
Medical Aid Injuries	60	30
Lost Time Injuries	15	8
Fatalities	1	1
Total	**76**	**39**

From 2010 to 2019, there were 137 mobile equipment lost-time incidents (LTIs), including aircraft, reported as per Canadian Standards Association (CSA) category code (see **Table 2**). **Figure 1** shows the percentage distribution per year for all mining LTIs. The distribution shows that mobile equipment LTIs comprise six to eleven per cent of all mining LTIs during the period.

Table 2 – WSN Mining Sector transportation LTIs from 2010-2019.

CSA Accident Category Code and Description	Number of LTIs, 2010-2019
40 – Transportation accident, UNS	1
41 – Highway accident	25
42 – Non-highway accident, except rail, air, water	97
43 – Pedestrian struck by vehicle, mobile equipment	7
44 – Railway accident	6
46 – Aircraft accident	1
Total	**137**

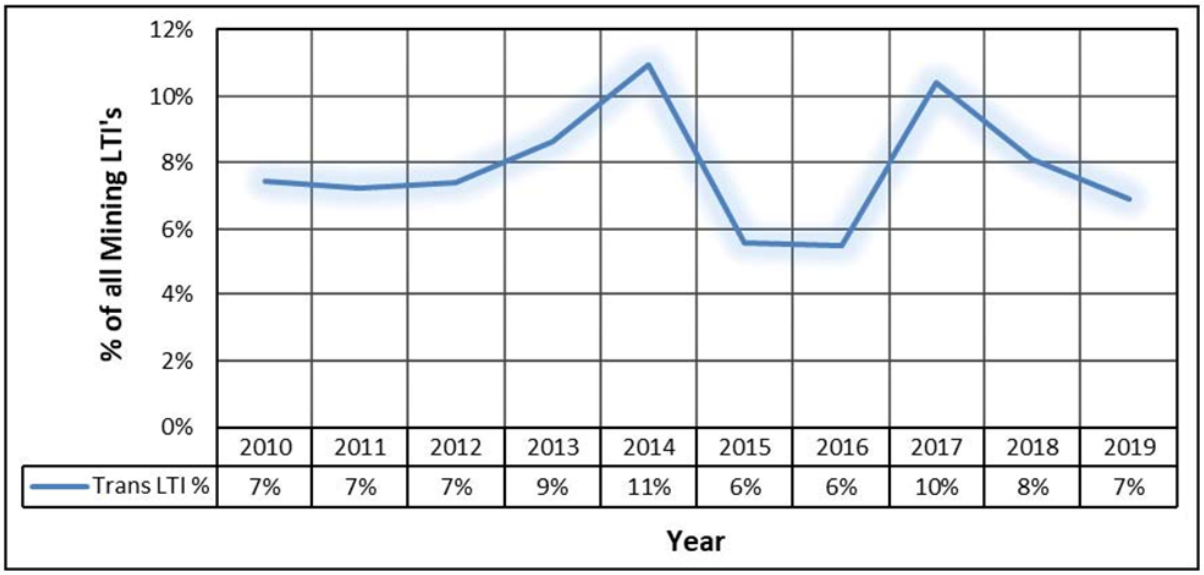

Figure 1 – Percentage distribution per year for all mining LTIs from 2010-2019.

Though the costs in lives and suffering are the most significant in incidents involving mobile equipment, they are not the only costs. Damage to equipment and loss of production are also major costs resulting from mobile equipment incidents, not to mention damaged reputation.

An informal survey of members of the WSN Mining Equipment Technical Advisory Committee (ME TAC) conducted in 2006 indicated that property damage from collisions alone exceeded $5 million a year in Ontario.

Nor do the statistics account for 'near misses,' which did not, save by chance, result in personal injury. Since only a fraction of incidents result in worker injury or death – making them reportable to the Workplace Safety and Insurance Board (WSIB) or the MLTSD – the actual cost of near misses to the mining and aggregates industries may be incalculable.

Visibility and line-of-sight issues have been a focus for the WSN mining sector for many years, establishing the basis for a lengthy relationship with Laurentian University's Centre of Research in Occupational Safety and Health (CROSH), which has conducted significant and valuable research into these issues.

2. Traffic management program

By law, each underground and surface mine operation is required to develop and maintain a written traffic management program.

Section 105.1 (1) of Regulation 854: Mines and Mining Plants specifies that 'An employer at a mine shall, in consultation with the joint health and safety committee or health and safety representative, if any, develop and maintain a written traffic management program.'

(2) The program shall include measures and procedures to,

(a) prevent collisions, of motor vehicles, that may endanger the health and safety of workers by addressing hazards relating to reduced or impeded visibility of motor vehicle operators; and

(b) protect the health and safety of workers and pedestrians who may be endangered by the movement of a motor vehicle.

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

(4) The program shall be reviewed at least annually.

Hazards involving mobile equipment in underground mines and surface mine operations still present themselves despite new laws and changes to equipment design, operating procedures, and pedestrian and operator training implemented for a safer working environment. Hazards include mobile equipment-to-mobile equipment collision, mobile equipment-to-pedestrian collision, clipped pedestrians, and being struck by fixed hazards, such as stationary equipment and drift walls, as well as falling into open holes. These result in damaged equipment, lost production, and most significantly, worker injury and loss of life.

3. Visibility program

As part of the Traffic Management Program required under Section 105.1 of Regulation 854, and as best practice, underground mines and surface operations should develop and maintain a visibility plan to reduce the risk of mobile equipment incidents. A visibility plan is also required under Sections 104 (taillight on the last car of a train), 262. (high visibility apparel in underground workplaces); and 263 (high visibility apparel in surface workplaces) of Regulation 854 (https://www.ontario.ca/laws/regulation/900854).

Visibility refers to how well the human eye can see something. Assessing visibility involves more than whether or not there is a clear line-of-sight between the viewer and an object. While line-of-sight is an objective evaluation, any proper measurement of visibility is subjective because human judgment is involved.

The goal of a visibility plan should not be just to maximize an individual's line-of-sight, but to improve the safety of operators and pedestrians, and reduce the probability of a vehicle incident, by addressing all of the factors that determine visibility. Factors that determine the visibility of an object include:

- **Line-of-sight (LOS)** - Visibility is greater if the view of an object is not physically obstructed.
- **Illumination** - Visibility increases with adequate illumination. Too little or too much illumination will obscure objects or areas of interest.

- **Contrast** - Visibility increases as the contrast, the difference between the luminance of an object and the luminance of its background, increases.
- **Adaptation Level** - Visibility increases with viewing time as the eye adapts to the luminance level of the object and its surrounding area.
- **Observer Age** - The contrast sensitivity (and visual acuity) of a person decreases as he or she ages.
- **Object Size** - The visibility of an object increases as it becomes larger in the observer's field of view.
- **Movement** - Visibility decreases with the movement of the object and/or the observer.
- **Colour Detection** - Visibility increases with the ability to detect colour differences, a factor that depends on genetics and illumination.
- **Visual Acuity** - Visibility is dependent on the individual's ability to resolve distinct objects or fine details with the eye

A visibility plan must meet the minimum requirements set out in various sections and subsections of Regulation 854, Mines and Mining Plants, particularly Part V Haulage.

Resource documents are available from the MLTSD that can be used to assist operation in developing their visibility program. These include the 'Vehicle/Mobile Equipment and Visibility Hazards in Mining Workplaces,' issued on December 31, 2014, and reviewed in January 2017; and the 'Guideline for High Visibility Safety Apparel for Mines and Mining Plants,' issued on September 5, 2014, and last reviewed in May 2016. These resource documents are available online at https://www.ontario.ca/page/traffic-management-programs-mines, and https://www.ontario.ca/page/high-visibility-safety-apparel-mines-and-mining-plants, respectively. respectively. The requirements are referenced in this document, and it is advisable to check the current edition of Regulation 854 to ensure they are still up to date.

4. Risk assessment and management of mobile equipment and pedestrian hazards

Risk assessment and management of mining equipment and pedestrian hazards underground and on the surface should be incorporated in all programs developed and maintained to reduce risk of workers' exposure to mobile equipment/pedestrian hazards.

The programs (traffic management, visibility, and other programs) should begin with a thorough job task analysis on each piece of mobile equipment, with particular attention on risk factors and hazards that could affect mobile-to-mobile equipment and mobile equipment-to-pedestrian interactions, along with visibility. For each hazard, the most effective control measures should be determined and established.

The intent of this section is to promote risk assessment as an inherent part of the operations and not only as a moral or legal obligation. It is intended to promote the use existing standards and guidelines, including the MLTSD guideline 'Risk Assessment and Management for Mines and Mining Plants,' and supplement it with more complete and process-oriented information.

Risk assessments and management processes of hazards associated with mobile equipment and pedestrians are very important as they form an integral part of an occupational health and safety management plan (OHSMP), in general, as well as a traffic management plan (TMP) and a visibility program in particular. The processes help to establish context, and identify, analyse, evaluate, and treat, or control, risks.

- Create awareness of mining equipment/pedestrian hazards and risk:
- Identify who may be at risk (e.g., employees, cleaners, visitors, contractors, the public, etc.);
- Determine whether a control program is required for a particular mining equipment or pedestrian-related hazard;
- Determine if existing control measures are adequate or if more should be done;
- Prevent injuries, especially when the assessment is performed at the design or planning stage;
- Prioritize mining equipment or pedestrian hazards and control measures; and
- Meet legal requirements where applicable.

The content of this reference document is generally based on the risk management model in the AS/NZS 4360:2004 - Risk Management as shown in **Figure 2**.

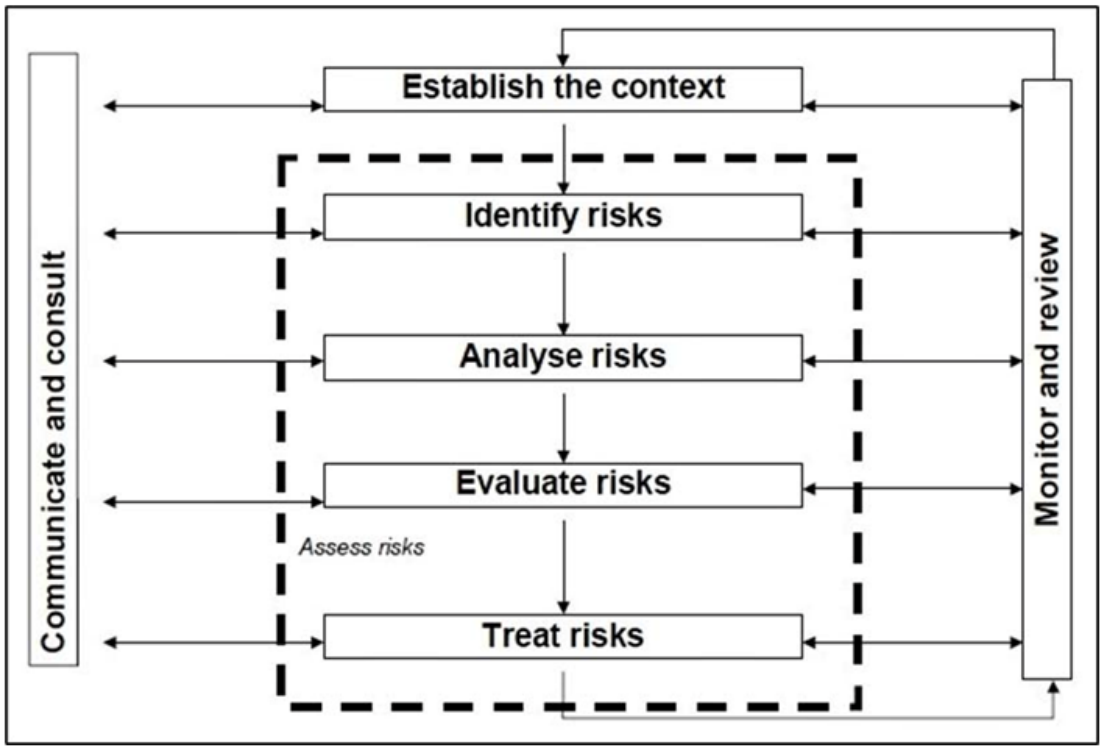

Figure 2 – Risk management process model (Source: AS/NZS 4360:2004).

4.1 Pertinent legislation for risk assessment and management

Sections 5.1, 5.2 and 5.3 of Ontario's Regulations 854 (Mines and Mining Plants) read as follows:

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.

4.2 Risk assessment process of mobile equipment hazards

Risk assessment of mobile equipment/pedestrian-related hazards is a term used to describe the overall process or method of:

- **Mobile equipment hazard identification** – Identify mobile equipment/pedestrian-related hazards and risk factors that have the potential to cause harm to personnel or damage to mine equipment and infrastructures.
- **Risk analysis and evaluation** – Analyse and evaluate the identified risk associated with the mobile equipment/pedestrian hazards and risk factors. Determine the seriousness of the risk and risk/hazard prioritizing or risk ranking.
- **Risk control** – Determine appropriate ways to eliminate the mobile equipment/pedestrian hazard and risk factors, or control the risk if the mobile equipment/pedestrian hazard cannot be eliminated.
- **Risk management and documentation** – Monitor and assess the effectiveness of controls implemented to eliminate mobile equipment/pedestrian hazards and risk factors. Keep records of the assessment process and control actions taken to eliminate hazards in a risk register.

A risk assessment of mobile equipment hazards provides a thorough look at the workplace to identify signs, conditions, situations, processes, and other factors that may cause harm, particularly to people. After identification is established, the likelihood and severity of the risk are analysed and evaluated. Once the hazard has been identified, measures should be investigated and identified to effectively eliminate or control the harm from happening.

4.3 Mobile equipment hazards and risks identification

Note that a HAZARD is something that can cause harm, e.g., being struck by mobile equipment; chemical exposures; working at heights, increasing potential for a fall, noise, stress, etc.; while a RISK is the chance that any hazard will actually cause somebody harm.

The overall goal is to find and document possible mobile equipment/pedestrian hazards that may be present in the workplace. Working as a team in this endeavour is beneficial and should include people familiar with the work area, as well as people who are not: for example, people from a corporate office or a sister company can be part of the team. In this way, both experienced and fresh eyes will conduct the inspection. In either case, the person or team should be competent to conduct the assessment and have good knowledge about the hazard being assessed, any situations that might likely occur, and protective measures appropriate to that hazard or risk.

Table 3 shows a simplified example of a hazard and risk inventory identified in a risk assessment process for a specific task of 'mucking a newly blasted heading using an 8-yard scoop tram'. (Other examples of mobile equipment/pedestrian hazards inventories and risk/hazard registers are shown in **Appendix 2**).

Table 3 – Example hazard and risk inventory identified in a risk assessment process.

Task	Hazard	Risk	Risk Rating	Control
Mucking a newly blasted round using an 8-yard scoop tram	Mobile equipment-to-pedestrian interaction	Injury, fatality, production delays		
	Mobile-to-mobile equipment interaction	Major equipment damage, injury, fatality, production delays		
	Visibility	Equipment damage, injury, fatality, production delays		
	Struck by an object	Injury		
	Slips, trips and falls	Injury		
	Awkward posture and prolonged sitting	Fatigue, back pain, etc.		
	Vibration	White foot finger, whole body vibration syndrome, back pain, etc.		

4.4 Risk assessment method - the means of determining the level of risk

Risk analysis is about developing an understanding of risk. It provides an input to decisions on whether risks need to be treated and the most appropriate and cost-effective strategies to do so. Risk analysis involves consideration of the sources of hazard or risk, their consequences, and the likelihood that these consequences may occur. As such, risk analysis involves different ways of calculating risk considering "how often" (probability or likelihood) and consequences (or severity) of an incident. For methods of assessing mobile equipment/pedestrian hazards, refer to the MLTSD guideline on *Risk Assessment and Management for Mines and Mining Plants* available at https://www.ontario.ca/page/risk-assessment-and-management-mines-and-mining-plants.

4.5 Determining acceptable level of risk

As risk analysis involves the determination of the magnitude, amount, or size of the hazard, as well as the potential consequences to provide risk ratings, each operation should decide if the level of risks related to an identified hazard are acceptable. Deciding on risk acceptability involves initially determining the risk acceptance criteria. This is followed by the process of reviewing the hazard or risk, establishing the relevant risks with controls in place, and deciding whether the relevant risks are –or can be – reduced to an acceptable level.

Risk acceptance criteria are the limits above which an operation will not tolerate risk associated with identified mobile equipment/pedestrian hazards. These criteria must be defined for each type of risk to be assessed. Risk acceptance criteria should be established for the following types of risks:

- **Personnel risk** – fatality or critical injury.
- **Risk of property damage** – equipment or infrastructure.
- **Economic risk** – loss of production or property.

For a rational reduction of risk related to mobile equipment/pedestrian hazards, such as those identified in **Table 3**, it is necessary to establish a risk acceptance criterion. Without a generally agreed-upon criterion, it may not be possible to find the balance between safety in terms of risk reduction and costs to the operation. Most importantly, in the case of mobile equipment/pedestrian hazards, the safety level depends on the workplace condition and location, awareness and skill set of workers, and whether workers follow safe work practices, (including following prescribed procedures and using appropriate equipment and accessories). For example, for the hazards identified in **Table 3**, if the location of the task is in a sensitive area, (i.e., high traffic location), the risk class or rating should be considered to be high.

Risk acceptance criteria are also used to derive the appropriate controls, which are conducted prior to the acceptance limit being breached. This would allow for either the reassessment of the risk level based on better information, a detailed evaluation of any damage, or for the timely repair or replacement of a degraded component.

Acceptance criteria are defined for each consequence category. They can be based on previous experience, design requirements, workplace practices, national and provincial legislation, or corporate or operation risk tolerance. The acceptance criteria for a work cycle or function may be 'broken down' into acceptance criteria for the performance of the individual task comprising the work cycle.

4.5.1 The 'as low as reasonably practicable' (ALARP) or 'as low as reasonably achievable' (ALARA) principle

The acceptance criteria for injuries (fatalities and critical injuries) related to mobile equipment/pedestrian incidents can also be based on two principles:

- The individual injury risk, fatal or critical, shall be approximately the same as typical for other occupational hazards.
- The frequency of incidents with several fatalities, such as the societal fatality risk, shall not exceed a level defined as unconditionally unacceptable, and moreover, the general concept of managing risk to 'as low as reasonably practicable' (ALARP) or 'as low as reasonably achievable' (ALARA) shall be applied. **Figure 3** illustrates the principle of the ALARP or ALARA acceptance criterion (adapted from Trbojevic 2002).

The ALARP or ALARA argument is based on using cost-benefit analysis to argue that it is acceptable to reduce safety standards, provided that reducing the risk has to be less costly than the consequence

if an incident occurs. The use of the ALARP or ALARA principle may be interpreted as satisfying a requirement to keep the risk level "as low as possible," provided the ALARP or ALARA evaluations are extensively documented. In the ALARP or ALARA region (see **Figure 3**), the risk is tolerable only if risk reduction is impracticable or if its cost is grossly disproportionate to the improvement gained.

The common way to determine what is practicable is to use cost-benefit evaluations as a basis for the decision on whether certain risk reducing measures should be implemented. A risk may not be justified in any ordinary circumstance if it is higher than the 'upper tolerable limit'. The 'upper tolerable limit' is usually defined, whereas the 'lower tolerable limit' may sometimes be left undefined. This will not prohibit effective use of the approach, as it implies that ALARP or ALARA evaluations of risk-reducing measures will always be required. The ALARP or ALARA principle used for risk acceptance is applicable to risks regarding personnel, the environment or workplace, and assets.

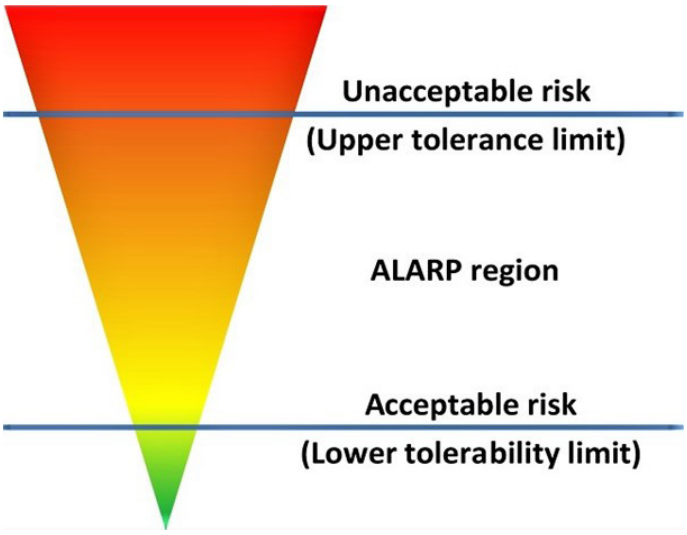

Figure 3 – Principle of the ALARP acceptance criterion (adapted from Trbojevic 2002).

4.6 Control measures

After priorities are established, the organization can decide on ways to control each specific hazard. Control measures may include pro-active and reactive methods.

Control measures can be considered as the barriers between the inherent mobile equipment/pedestrian hazards of an operation. It can also be thought of as the realization of an unwanted incident as a result of the hazards, and, ultimately, the harm that may be caused to people, property, and the economy in the event of the unwanted incident.

Controls can be identified as part of the hazard identification process. For an existing operation, a range of these measures would be readily identified as both existing measures and possible alternatives.

The assessment of the effect of the measures on the hazard/outcomes must be determined for each hazard and outcome. The record for this can be maintained in a risk register and reviewed annually as required by the legislation or periodically at agreed-upon intervals.

4.6.1 Proactive control measures

Proactive control measures can also be considered as elimination of and prevention of the hazard. The following recommendations are intended to assist the mining and aggregates industries to reduce the risk of incidents involving mobile equipment/pedestrians by developing traffic management and visibility programs in the following six (6) general categories:

1. Underground mine design.
2. Surface site design.
3. Equipment design.
4. Traffic control.
5. Operator/pedestrian considerations.
6. Training.

Each category is addressed and discussed in **Section 5** of this document.

4.6.2 Reactive control measures

Reactive control measures can also be considered to be reduction and mitigation of consequences. Examples include:

- Provision of fresh air base underground.
- Emergency planning.
- Permits to work.
- Others.

4.7 Risk management and documentation

4.7.1 Hazard/risk register development

The objective of creating a risk or hazard register is to prepare a document that lists, outlines, and prioritizes the mobile equipment/pedestrian-related risks/hazards in an operation or organization. It is a document intended to communicate and monitor the current status of priority risks on the site. Communication is the primary intent of the risk register.

The risk register should be regularly reviewed for changes in exposure over time and possibly for better understanding of the hazards and consequences (hazards change, methods change, etc.).

The inputs to a risk or hazard register may come from a wide variety of sources, including:

- Major hazards from risk analysis studies.
- Information from accident or incident investigations or from external sources.
- Information developed through management of change.
- Health and safety hazards forms, including:
  - Incident reports.
  - Hazard reports.
  - Job safety analyses (JSAs).
  - Audit reports.
  - Inspection reports.
  - Reviews.

Potential data for the hazards/risks register is developed using a risk matrix (qualitative, quantitative, or quantitative/qualitative method), which may include records of hazards rated as extreme, high, or moderate-level risks. However, low or negligible risks are expected to be recorded, tracked, and resolved by local management systems. Note that a key part of the hazard/risk register is hazard/risk tracking and close out mechanisms. **Figure 4** shows a hazard/risk register data flow (source: NMISHRAG, Version 4, January 2005).

An important deliverable from a hazard/risk report is a critical control activities list that summarizes activities required to control each identified hazard, which include:

- A list of control measures and performance measures.
- Engineering changes.
- Organizational and/or procedural control.
- Training and competency assurances.
- Recovery measures.

All control activities in the hazard/risk register should be assigned as individual responsibilities to be completed within an appropriate time frame. **Table 4** presents an example of a simple risk register using an identified hazard for the task of 'Mucking a newly blasted round using an 8-yard scoop tram'. The risk assessment was conducted using the risk matrix in the MLTSD guideline on 'Risk Assessment and Management for Mines and Mining Plants', available at https://www.ontario.ca/page/risk-assessment-and-management-mines-and-mining-plants. Using the principle of the ALARP or ALARA acceptance criterion shown in **Figure 3**, the level of risks related to the identified hazard or risk falls under the ALARP or ALARA region.

In identifying the implementation of a better control to prevent an incident from occurring or to minimize consequences if it were to occur, an operation should refer to **Subsection 4.7.2.2** (Managing control measures) of this document to ensure proper implementation and management of controls.

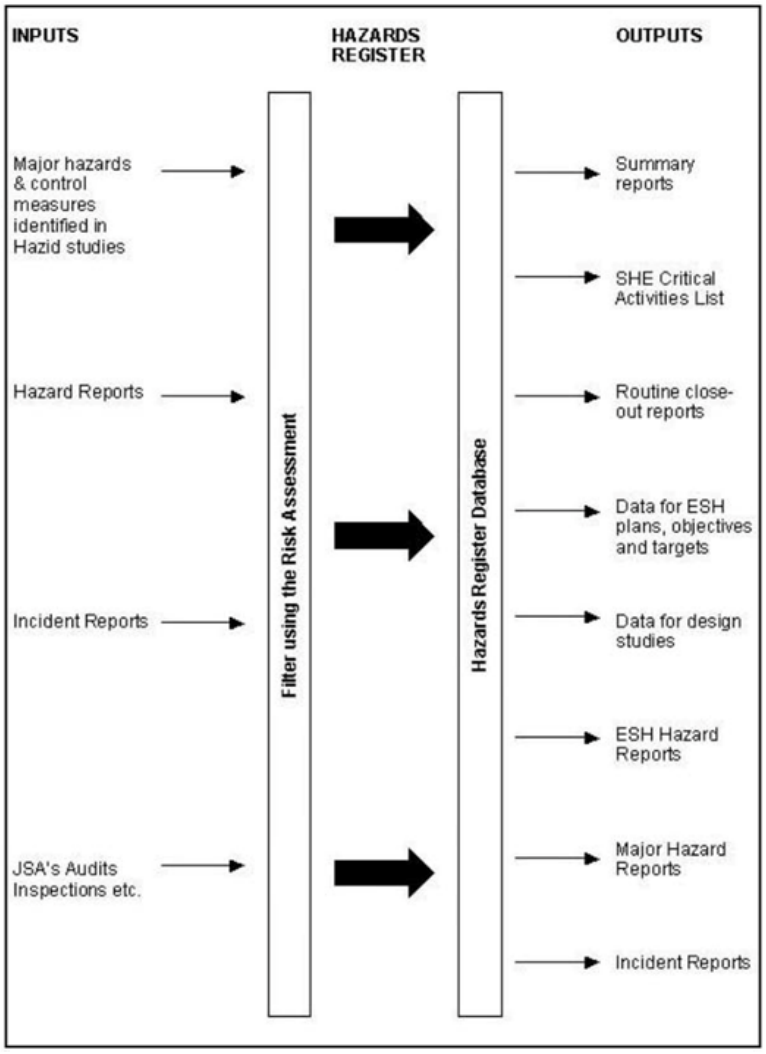

Figure 4 – Hazard/risk register data flow (source: NMISHRAG, Version 4, January 2005).

4.7.2 Risk management

Subsection 5.1(1) of Regulation 854 specifies that the purpose of risk assessment is to identify, assess and manage hazards, including potential hazards. Once hazards have been identified and assessed, risk management involves the ongoing monitoring and adjustment of controls that have been adopted for mitigating the risk associated with a health and safety hazard.

4.7.2.1 Root-cause analysis of priority mobile equipment/pedestrian hazards

Root-cause analysis of priority hazards is a proactive way of clearly identifying the underlying reason for an unwanted event and the mitigating controls for each hazard.

Table 4 – Example simplified risk register for an identified hazard and the associated risks based on a risk assessment using a quantitative risk analysis matrix.

Task	Hazard	Risk	Existing Controls	Risk Analysis			Preventative Measures	Responsibility	Comp. Date
				L	C	RR			
Mucking a newly blasted round using an 8-yard scoop tram	Mobile equipment-to-pedestrian interaction	Injury, fatality, production delays	• Use of prescribed high visibility apparel • Use of RFID tracking • Use of safety strobe or rotating beacon light to indicate present of worker in the area • Communication between worker and operator on the presence of the worker in the area • Using correct mobile equipment operating procedures during mucking/tramming • Operator performing perimeter check as required • Awareness training of workers and operators regarding traffic management and visibility	3	4	12	Ensure the following are performed by workers and operators commencing work: • Check for dirty/worn retro-reflective materials that may provide lower visibility • Check tracking and safety strobe/beacon light are operational • Workers to communicate with mobile equipment operator when entering a workplace to indicate presence • Conduct perimeter check as required	Worker Operator Supervisor	Daily

L – Likelihood; C – Consequence; RR – Risk rating

Note that the table is only provided as an example and does not reflect any input from actual mining operations.

Priority hazards, determined through the risk ranking of all mobile equipment/pedestrian hazards that were identified during a risk assessment, can be put through root-cause analysis. If a qualitative risk matrix had been used in the risk analysis and results have shown a number of priority hazards, the most acceptable methods for identifying priority hazards are as follows (source: *MLTSD Risk Assessment and Management for Mines and Mining Plants*):

- Any hazard that could result in an event that has been assigned a critical level of risk should be considered to be a priority hazard.
- If no hazards that could result in events have been identified as having a critical level of risk, hazards that are in the top-ranking risk events (i.e., at least the top five) should be considered as priority hazards.
- Hazards that have resulted in fatalities at the mine or mining plant in the past should be considered as priority hazards.

There are several types of root-cause analyses that are available for use. Some of the common methods utilized in the Ontario mining sector are (according to the MLTSD Risk Assessment and Management for Mines and Mining Plants):

- Bow-tie analysis;
- Failure mode and effects analysis;
- Fault tree analysis;
- Fish bone (i.e., the Ishikawa) analysis; and
- Pareto analysis.

An example of a root-cause analysis of a priority hazard identified in the MLTSD risk-ranking process for the mining sector, conducted in 2014, is discussed on the next page. The 'fish bone' approach of root-cause analysis was conducted on a mobile equipment/pedestrian priority hazard with the risk statement: 'Motor vehicle contacts workers'.

The root-cause analysis was conducted by peer-recognized subject matter experts (SMEs) from various mining operations (representing employers), labour groups (representing workers), health and safety associations (HSAs), and the MLTSD.

The 'fish bone' analysis identifies tiered (primary, secondary, tertiary, and quaternary) causal factors through an open, transparent, and collaborative process. The causal factors were ranked and prioritized by the SMEs from employer and worker groups. SMEs from HSAs and the MLTSD did not vote. **Figure 5** shows the 'fish bone' diagram that lists primary causal factors. **Table 5** summarizes the top ten (10) primary causal factors and examples of identified controls for each causal factor.

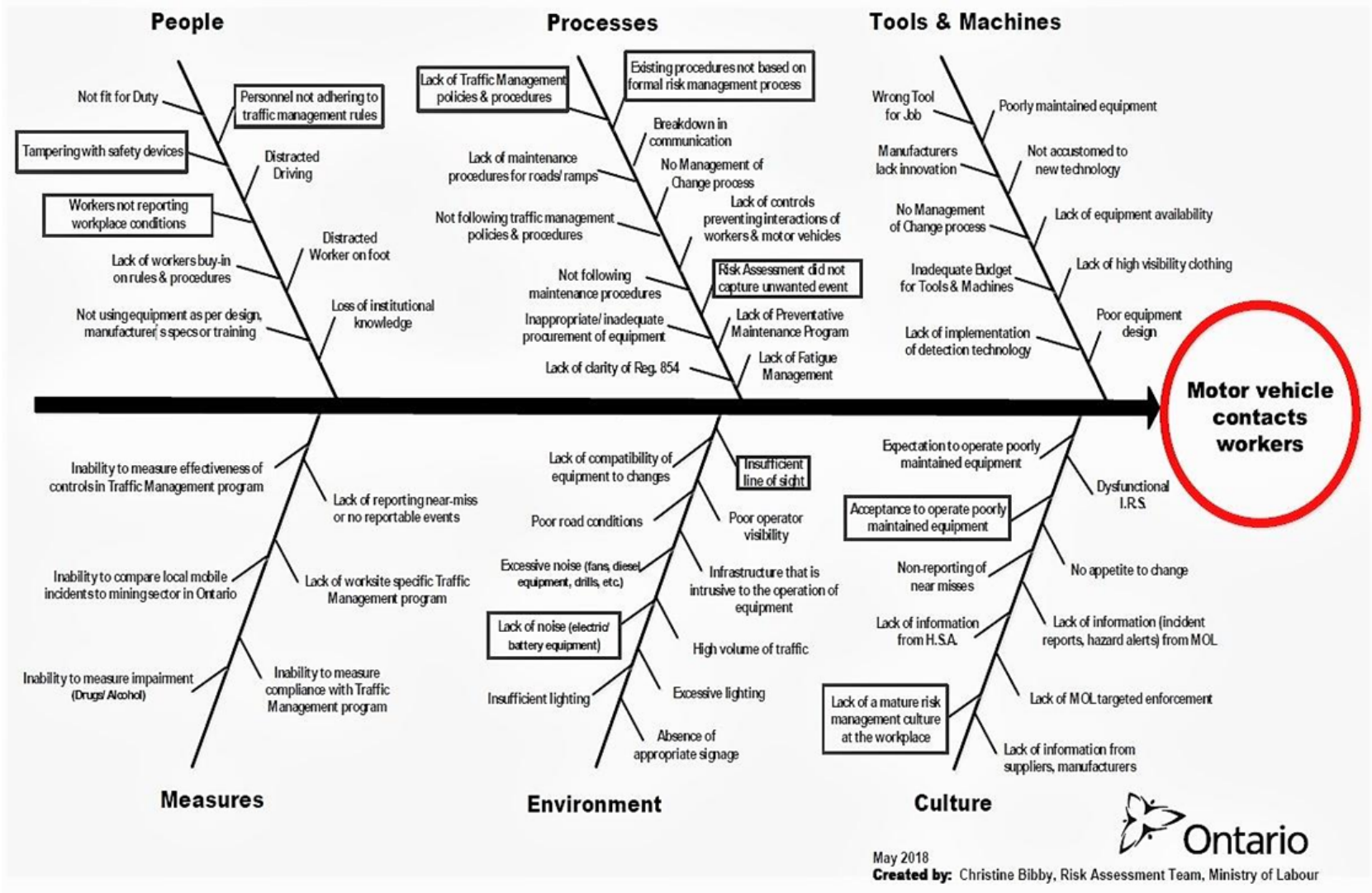

Figure 5 – 'Fish bone' diagram for the primary causal factors (Source: MLTSD).

Table 5 – Top 10 primary causal factors and examples of controls.

#	Top 10 Primary Causal Factors	Example of Controls for Each Causal Factor
1.	Existing procedures not based on a formal risk assessment process	• Have a formal risk management framework for the development of operational procedures (e.g., job safety analysis, failure mode and effect analysis, etc.). • Formal framework to review old/outdated procedures using risk management process in consultation with JHSC/HSR.
2.	Acceptance to operate poorly-maintained equipment	• Ensure maintenance programs exist in all workplaces. • Have all personnel understand cost implications on poorly operated/maintained equipment.
3.	Lack of a mature risk management culture at the workplace	• Educate and involve all workplace parties in the power and the fundamentals of risk assessment and management. • Train people on risk management facilitation.
4.	People tampering with safety devices (e.g., Bypass whisker switch)	• Engineering out ability to tamper (make it tamper-proof). • Zero-tolerance on such activities by worker or supervisor (everyone).
5.	Insufficient line of sight	• Consider "line of sight" in mine/road/building design. • Integrate proximity detection technologies (e.g., using artificial intelligence).
6.	Lack of noise (electric or battery equipment)	• Traffic management program should take into consideration hazards associated with equipment that do not generate a lot of noise. • Proximity detection in specific areas.
7.	Risk assessment did not capture unwanted risks	• "Real-life" validation of residual risk and controls by the end-user. • Training in risk assessment and hazard identification.
8.	Personnel not adhering to traffic management rules	• Develop a risk-based traffic management plan. • Communication and monitoring of the traffic management plan to personnel.
9.	Personnel not reporting workplace conditions (i.e., hazards & near-misses	• Functioning IRS that encourages reporting. • Proper training in hazard/near-miss identification.
10.	Lack of traffic management policies & procedures	• Have a formal risk management framework for the development of traffic management policies and procedures. • Understand the expectations of a traffic management program (e.g., MLTSD guideline).

Note: The control list is not in any order of priority.

4.7.2.2 Managing control measures

Following a risk assessment exercise and once the mobile equipment/pedestrian hazards or risks are known (provided the organization had identified ways to control each hazard), the next step is to ensure that controls are effectively implemented and are performing efficiently.

The International Council on Mining and Minerals (ICMM) developed the guidance document titled 'Health and Safety Critical Control Management' in 2015, which was designed to support the principle of continual improvement. The document provides practical guidance on preventing the most serious types of health and safety incidents, which can be referred to as unwanted events (UEs).

The approach described in this document is called critical control management (CCM), as it provides guidance on how to identify and manage critical controls. However, the method is applicable to any control implementation intended to prevent the occurrence of a serious incident or minimize the consequences if a serious incident will occur.

The CCM program consists of nine (9) steps, including six (6) steps for planning the program and three (3) steps for implementation (ICMM 2015), as shown in **Figure 6**. The first six (6) steps follow a similar process of hazards/risks identification, risk analysis and prioritization, and control identification as described in the previous sections. It also follows the overall risk management process flowchart shown in **Figure 2**.

This section discusses the implementation and management of controls as applied to mobile equipment/pedestrian hazards, including critical controls, if defined. **Table 6** summarizes the steps and target outcomes for accountability and control implementation and management process, adopted from the ICMM guidance document.

4.7.2.3 Measuring impact of control initiatives for ground control hazards/risks

Methods to measure the degree to which control initiatives for ground related hazards are functioning as expected can be based on both lagging and leading indicators. Lagging indicators are based on incident statistics that provide information on the frequency of relevant major events and, possibly, the resulting consequences. A more prominent lagging indicator may be found in the frequency of incidents related to ground control hazards. Frequency trends of incidents pre- and post-control implementation can be captured and compared.

Leading indicators, on the other hand, can be found in reports from control verification activities. Verification reports contain information summarizing the performance status of the control versus defined expectations. Well-defined and well-executed verification activities could yield control efficiency in quantified format (either in percentage or scale format). **Figure 7** shows an example of basic time lagging and leading indicators for two (2) selected controls specified in **Table 4** (Use of RFID tracking; and Awareness training of workers and operators regarding traffic management and visibility) to prevent the occurrence of a hazard (mobile equipment-to-pedestrian interaction) or

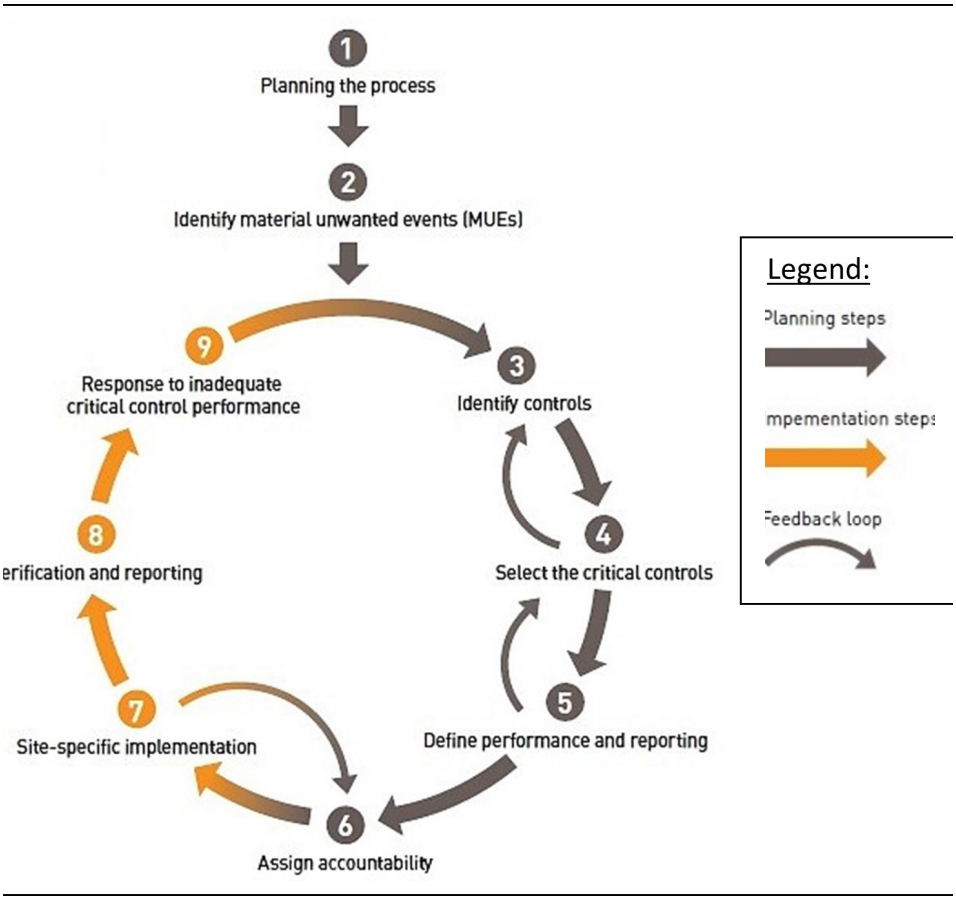

Figure 6 – The critical control management process (source: ICMM 2015).

Table 6 – Target outcome for each step for the implementation and management process of controls for mobile equipment/pedestrian hazards (adapted from ICMM 2015).

STEP	TARGET OUTCOME
Assigning accountability (Step 6 in **Figure 6**)	A list of individuals who will be responsible and accountable for the implementation of controls for each of the identified mobile equipment/pedestrian hazards/risks and verification of activity must be assigned. A verification and reporting plan are required to verify and report on the efficacy of each control.
Implementation (Step 7 in **Figure 6**)	The implementation strategy for controls for each mobile equipment/ pedestrian hazard/risk, along with verification processes and reporting plans, must be defined.
Verification and reporting (Step 8 in **Figure 6**)	Implement verification activities and report on the process. Define and report on the status of each control.

minimize the consequence if an incident occurs. Note that the data used in the graph are assumed values of lagging and leading indicators.

The performance indicator shows an example of continuous improvement of controls over time, resulting in the decrease in injury associated with the type of hazard being managed.

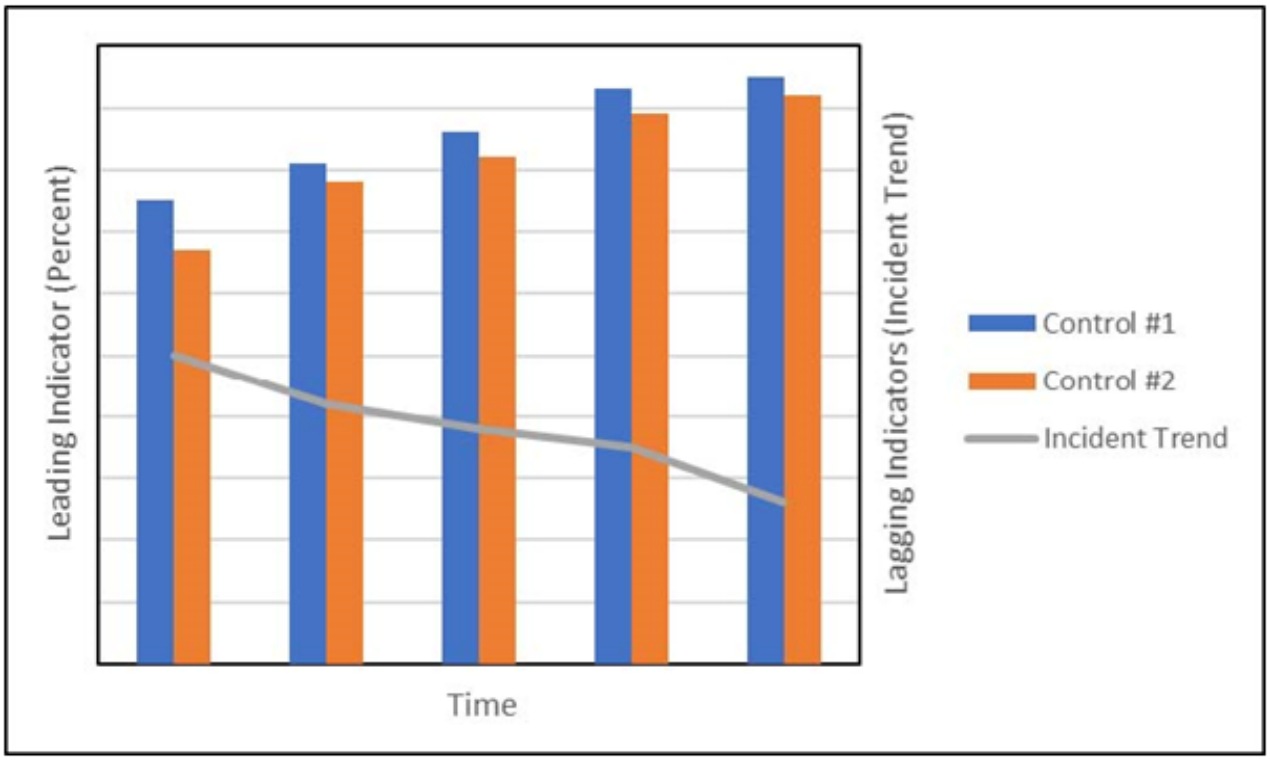

Figure 7 – Example of lagging and leading indicators for two (2) controls implemented to prevent the occurrence of a serious incident or minimize the consequences if a serious incident from mobile equipment-to-pedestrian interaction occurs.

Figure 8 illustrates a guide from the United Kingdom Health and Safety Executive (UK HSE), 2006, on 'Developing process safety indicators' focusing on "risk control systems," which can be adapted for **Subsection 4.7.2.2** (Managing control measures) of this document.

The guide document recommends regular review of the entire risk assessment and management process and system in order to identify the degree to which the initiative is being implemented and operated to expectations.

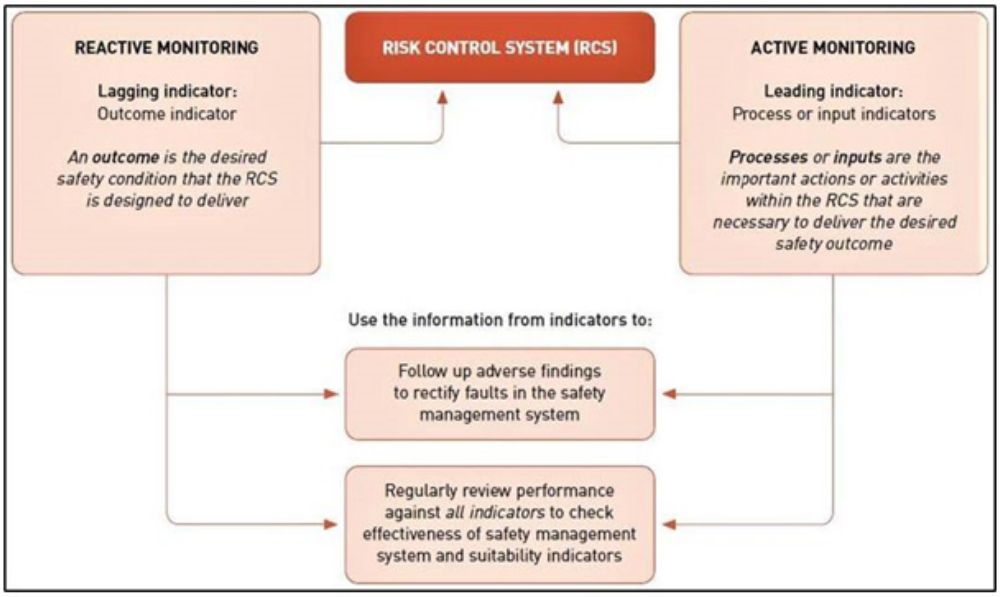

Figure 8 – Illustration of 'Dual assurance – leading and lagging indicators measuring performance of each control system' (source: UK HSE, 2006).

5. Categories for developing traffic management and visibility programs

5.1 Underground mine design

Environment plays a significant role in creating conditions that permit people to see and be seen. Environmental conditions in an underground mine pose special challenges — most notably but not limited to poor lighting — that restrict and impair vision and increase the risk of incidents. Improved underground mine design, not just for new mines but existing mines as they further develop, can address many of these challenges.

5.1.1 Safety bays

- **Section 114** of Regulation 854 states that:

  (1) A safety station shall consist of a recess in the wall of a haulageway that shall be,

  (a) at least,
  i. 0.6 metre (2 ft.) in depth, in addition to any existing clearance between the vehicle and the wall,
  ii. two metres (6.6 ft.) in height, and
  iii. 1.5 metres (5 ft.) in length;
  (b) plainly marked; and
  (c) clean and free of obstruction.

- It is suggested that the floor of a safety bay be about 0.45 metre (1.5 ft.) above the floor of the drift. As many drifts are eventually used as main haulageways, the 0.45 metre (1.5 ft.) clearance will permit a roadbed of this depth, still providing good access to the safety bay.
- All safety bays should be well marked, both at their locations and on all approaches to their location. Retroreflective signs hung in mid-span of drift are effective as they are visible down the drift from the safety bay.
- It is important to discuss the location, size, designation, and rules for safety bays during orientation sessions with each visitor and each new employee.

5.1.2 Haulageways

- **Section 112** of Regulation 854 states that:

  A haulageway used by motor vehicles, other than motor vehicles running on rails, shall,

  (a) except where pedestrian traffic is effectively prevented, be at least 1.5 metres (5 ft.) wider than the maximum width of a motor vehicle using the haulageway; and
  (b) where it is regularly used by pedestrians and it is less than two metres (6.6 ft.) wider than the maximum width of a motor vehicle using the haulageway, have safety stations as prescribed in Section 114 at intervals not exceeding 30 metres (114 ft.).

- **Section 113** of Regulation 854 states that:

  Except in an underground mine with a low clearance roof in which equipment designed to be operated herein is used, a haulageway used by a motor vehicle shall have sufficient clearance below the roof, support or overhead installations to enable the operator of a motor vehicle to sit erect at all times.

- **Subsection 117** (1) of Regulation 854 states that:

  Where, on surface at a mine or mining plant, the clearance between the sides of a train or motor vehicle and the wall of a building or other structure is less than 500 millimetres, the location shall be plainly marked showing the danger.

- Low-clearance hazards, such as a pipe, fan, or ventilation tubing, should be clearly marked with a retroreflective warning sign that indicates the clearance height of the hazard from the floor of the drift.
- Recognizing that there are problems associated with mining long radius curves in underground haulageways, it is recommended that to optimize pedestrian visibility, horizontal curves have as long a radius as possible.
- To optimize the effectiveness of equipment headlights and taillights, it is recommended that the change from a horizontal haulageway to a ramp be as gradual as possible (i.e., a low, steady grade). A proposed design is shown in **Appendix 3**.

- Intersections should occur only on level straightaways.
- Large convex mirrors may be used to improve line-of-sight on ramps, horizontal curves, intersections, and other areas with blind spots.
- Proper road maintenance is important toward preventing incidents. A machine operator cannot see properly if he or she is bouncing about or is continually on the lookout for washouts and fallen rocks.
- Wherever possible, proper parking areas should be incorporated into the mine design.

5.1.3 Turnarounds

- There are no regulations concerning turnarounds.
- When in the vicinity of a loading area, pedestrians sometimes use turnarounds as a safety bay. It is recommended that:
  - Turnarounds never be used by pedestrians as safety bays;
  - A safety bay be located in the vicinity of each turnaround (a suggested location is shown in **Appendix 4**); and
  - Safety bays should never be used for storage.

5.1.4 Draw points and loading points

- Pedestrian access to draw/loading points used by manual, automated or remote operations should be restricted and enforced.

5.1.5 Dumping areas

- Section 118 of Regulation 854 states that:

  (1) When material is dumped from a vehicle that is occupied by a person, the dump point shall include features designed to prevent the vehicle from going over a bank, over a bench or into a raise or other open hole.

  (2) In an underground mine, the features referred to in subsection (1) shall not include the use of a ridge of material.
- All dumping points (and specifically, all barriers) should be well-lit in a manner that prevents glare to reduce fall hazards posed by open holes.
- All dumping points (and specifically, all barriers) should be marked with appropriate signage that identifies the hazard (i.e., 'Danger: Open Hole').

- Ore and waste dump points should be controlled with a door to prevent dust from contaminating the air and reducing visibility. In addition, there may be a need to provide traffic control if more than one vehicle is dumping at the same point.
- Where a dump point is under the control of an operator, there should be dump/no-dump lights.

5.1.6 Ambient lighting and noise

Subsection 262 (1) of Regulation 854 states that:

> Effective illumination by means of stationary lighting shall be provided in an underground mine,
>
> (a) at all active shaft stations and shaft conveyance landings where workers are required to travel or work; and
>
> (b) where the nature of the equipment or the operation may create a hazard due to insufficient illumination.

- In addition to shaft stations and shaft conveyance landings, the following underground areas should be well-illuminated in a manner that prevents glare:
  - Crushers.
  - Rock breakers.
  - Dump points at ore passes and waste passes.
  - Refuge stations.
  - Any location where pedestrian traffic density is high.
- The book titled *The Lighting of Underground Mines* by Donald A. Trotter (1982) may be useful to assist in the design of underground lighting.
- Intersections underground are particularly hazardous for pedestrians. In most mines, the lights from mobile equipment warn pedestrians of approaching equipment near an intersection. Similarly, lights – both cap lamp and equipment – are used in many production areas to communicate the proximity between pedestrians and machines and between machines. Since fixed lighting at these points could diminish visibility by reducing the contrast created by cap lamps and equipment lights, fixed lighting should not be installed at intersections or at other haulageways regularly used by mobile equipment.
- In some locations with substantial pedestrian traffic, permanent fixed lighting may provide added safety for pedestrians from tripping and falling, among other hazards. A thorough risk assessment should be done in these locations to ensure that fixed lighting does not create a comparable or greater hazard from mobile equipment for pedestrians.
- The transition from a well-illuminated area to a non-illuminated area or from a non-illuminated area to a well-illuminated area (such as at the entrance of a ramp or an adit) should be as gradual as possible to allow workers' vision time to adjust to the change in light level. Such transition areas should be kept clear of possible hazards, such as parked vehicles.

- The transition between illuminated and non-illuminated areas cannot be achieved by increasing the space between light fixtures: it should be achieved through wattage control, such as the gradual decrease/increase in the wattage of the fixtures.
- In addition to intersections and haulageways that are over-lit, the risk of pedestrian/machine collision is increased in areas where the noise level is high (i.e., pedestrians may not hear oncoming equipment). Ventilation fans are often a source of high noise levels. It is recommended that fans used to ventilate underground service shops be insulated or located outside the shop area.

5.1.7 Ventilation

Section 266 of Regulation 854 states that:

> Where dust or other material is likely to cause a hazard by becoming airborne, the dust, or other material, shall be removed with a minimum of delay by,
>
> (a) vacuuming;
> (b) wet sweeping;
> (c) wet shovelling; or
> (d) other suitable means.

- Ventilation in the mine, and specifically wherever mobile equipment will be used, should be designed and maintained to provide fresh air while removing dust, diesel fumes and fog as quickly and effectively as possible, while meeting regulatory requirements.
- Fog is not an uncommon visibility hazard in underground mines. If traffic controls are not adequate to ensure safe operations, it may be necessary to add a heat source at the lower end of a foggy area. Experimentation may be necessary to determine the best location.
- Retroreflective lines or lamps on the walls may help equipment operators navigate correctly through foggy conditions.
- Dust control measures should be used on any ramp where ventilation and/or vehicle traffic may cause dust to fly up and impair visibility.

5.1.8 Storage

- Adequate underground storage should be provided in designated areas so that ramps, haulageways and operating areas are clear of storage items that may impede a mobile equipment operator's line of sight.
- Storage and utility areas should not be located in poor-visibility or hazardous locations, such as on ramps or close to corners. Workers accessing such areas should not be expected to stop their vehicles on a ramp or close to a corner.

5.1.9 Remote operations

- The WSN Mining Equipment Technical Advisory Committee prepared guidelines for mobile equipment remote control to address the safety concerns of remote mobile equipment operation, including visibility issues concerning the operator, mobile equipment, and pedestrians.
- These guidelines should be considered as a supplement to this visibility guideline and a component of a visibility program.

5.2 Surface mine design

Surface mines also pose their own unique challenges in creating environmental conditions conducive to allowing workers and mobile equipment operators to see and be seen. As much as possible, pedestrians and mobile equipment should be isolated from each other. Though effective visibility design measures focus mainly on haulageways, other measures, including dumping, stockpiling, lighting, and dust control can improve visibility.

5.2.1 Haulageways

- **Section 113** of Regulation 854:

  Refer to **Subsection 5.1.2** (Haulageways).

- **Section 116** of Regulation 854 states that:

  (1) Haulage roads on surface shall be designed, constructed, and maintained to,

  (a) minimize hazards from the slipping or skidding of vehicles;
  (b) enable vehicles to pass each other safely; and
  (c) avoid steep grades wherever practical.

  (2) The open side of a ramp haulage road in a surface mine shall be provided with a suitable protective barrier.

  (3) Every haulage road on surface shall be kept in good repair.

- **Section 117** of Regulation 854

  Refer to **Subsection 5.1.2** (Haulageways).

- Surface haulage roads should be wide enough for safe passage. Where practical, they should be one-way.
- Single-lane haulage roads with two-way traffic should have turnouts or a system to prevent vehicles or heavy equipment from meeting on the road.
- Surface haulage roads should be designed to eliminate or reduce intersections, while giving operators as wide a field of vision as possible along the entire route.

- Intersections should occur only on unobstructed, level straightaways.
- Any intersection in which the operator's vision is restricted should be controlled by signage and/or stop lights.
- When possible, traffic segregation should be used to separate pedestrians, light vehicles, and production vehicles.
- Proper road maintenance is important in preventing incidents. A machine operator cannot see properly if he or she is bouncing about or is continually on the lookout for potholes.
- Wherever possible, proper parking areas should be incorporated into the design.
- Where practical, a plan view drawing for the entire site should be posted and updated whenever any major change is made to structures, stockpiles, or roadways. Aerial photographs may be used to identify characteristics of the site.

5.2.2 Dumping areas

- **Section 118** of Regulation 854:

  Refer to **Subsection 5.1.5** (Dumping area).
- All dumping points (and specifically, all barriers) should be well-lit in a manner that prevents glare to reduce the fall hazard posed by open holes.
- All dumping points (and specifically, all barriers) should be posted with appropriate signage that identifies the hazard, i.e., 'Danger: Open Hole').

5.2.3 Stockpile areas

- A document prepared by WSN industry experts for the mining sector, titled 'WSN Recommended Practices for Working Safely Around Stockpiles', is available as a resource for addressing the safety concerns of working around stockpiles, including visibility issues. These guidelines should be considered as a supplement to this visibility guideline and a component of a visibility program. The resource document is available online at https://www.workplacesafetynorth.ca/sites/default/files/resources/Mining-Working-Safely-Around-Stockpiles-Workplace-Safety-North.pdf.

5.2.4 Ambient lighting, dust, extreme weather

- **Section 266** of Regulation 854:

  Refer to **Subsection 5.1.7** (Ventilation).

- **Subsection 263(1)** of Regulation 854 states that:

  Effective illumination appropriate for the task shall be provided at all workplaces on the surface, including,

  (a) in those areas adjacent to the workplace where workers are required to travel; and

  (b) in those circumstances where the nature of the equipment or the operation may create a hazard to a worker due to insufficient lighting.

- Surface operations should incorporate a watering system or road treatment as part of a larger dust abatement program to reduce and minimize dust levels, thereby improving operator visibility.
- Surface operations should develop operating standards and procedures to control increased hazards created by extreme weather conditions, including fog, heavy rain, hail, snow, high winds, and excessively wet conditions.

5.3 Equipment design/considerations

Improving the design of mobile equipment may offer the single greatest opportunity for reducing line-of-sight and visibility hazards in underground mine and surface operations.

Significant progress has been made in design and technology since the use of such equipment became more widespread almost 20 years ago. However, much remains to be done, not only by equipment manufacturers, but by companies purchasing equipment.

5.3.1 Purchasing and pre-commissioning

- Line-of-sight comparisons should be part of tender documents for all vehicle and mobile equipment purchases. In the event of a supplier not providing line-of-sight documents, third-party line-of-sight evaluations may be available if the potential purchaser has the equipment or a computer-assisted design (CAD) drawing of it. See **Appendix 5** for more information.
- For custom-designed machines, every effort should be made by both the purchaser and the manufacturer to maximize the line-of-sight from the operator's location. Consider innovative measures such as smaller, low-profile hybrid drives and horizontal or included radiators, as well as the redesign of standard features, such as:

  - Falling object protection.
  - Rollover protection.
  - The operator's compartment.
  - Bucket teeth.
  - The bucket/box.
  - Fire extinguishers.

- The remote control interface.
- Air conditioning equipment.
- Air filters.
- The exhaust system.
- Any other feature that may, through size and/or location, interfere with the operator's line of sight.

- All customizations should also be assessed to ensure they do not create other non-visibility related hazards.
- The Canadian Standards Association (CSA) Standard M424 suite includes standards for the design of operator control stations. Designers and purchasers of equipment should refer to this standard.
- Designers of surface and underground bucket-equipped equipment should be aware of how the machine bucket, both loaded and empty, will affect operator visibility. The base of the bucket should be as long as possible for load capacity without compromising other design requirements.
- Mobile equipment sould be painted in a single, high-visibility colour. Dark colours and two-tone paint patterns render vehicles less visible. Extensive research by Stephen Solomon, conducted for the National Safety Council in the United States, indicates that the most visible colour for vehicles under any condition is lime yellow, followed by pure yellow, and then white.

5.3.2 Modifying equipment

- When possible, mine operators should modify existing equipment (enumerated previously in **Section 3**) to improve the operator's line of sight and equipment visibility.
- When adding features or to upgrade existing mobile equipment, mine operators should avoid or minimize features (enumerated previously in **Section 3**) that restrict the operator's line of sight.

5.3.3 Cab ergonomics

- Operators regularly shift not only their eyes and head to improve their lines of sight and visibility: they also move their backs and whole bodies, and they may even stand from their seated position to get a better view. Line-of-sight improvements can reduce the risk of back injury and musculoskeletal disorders (MSDs) for operators.
- A machine operator's visibility is usually improved if he or she is facing the direction in which the machine is travelling. It is also less physically strenuous for the operator, as this improvement reduces the frequency of needing to turn one's neck. Designers and purchasers of underground trucks should consider having the operator's seat facing the direction of most travel.

5.3.4 Headlights/taillights

- **Subsection 105(1)** of Regulation 854 states that:

  When in use, a motor vehicle, other than a motor vehicle running on rails, shall,

  (c) subject to subsection (2), have headlines and taillights

- **Subsection 182(2)** of Regulation 854 states that:

  Non-rail-bound diesel-powered equipment that is first used in an underground mine after June 1, 1995 must meet the requirements set out in CSA Standard M424.2-M90 "Non-Rail-Bound Diesel-Powered Machines for use in Non-Gassy Underground Mines" excluding the requirements in sections 4.5, 5.3 and 5.4 of that document.

- According to the CSA Standard M424 suite, which includes standards for lighting:
  - Each machine shall be equipped with two or more white lighting units, with each circuit protected against overload and short-circuit by a device located close to the power source. The lighting units shall be permanently attached and directed to illuminate the roadway in each direction of travel. Each lighting unit shall produce illumination equivalent to or greater than that provided by a 60 W incandescent sealed lighting unit as described in SAE (Society of Automotive Engineers) Standard J598.
  - Red or amber reflective material shall be attached to both ends of each machine. The minimum area of red or amber reflective material attached to each end of a machine shall be 460 cm^2.
- All vehicles should be equipped with adequate and good-quality backup lights and red taillights.
- All vehicles should be equipped with adequate and good-quality brake lights that activate automatically.
- To assist operators in orienting their machines in a haulageway, vehicles should be equipped with adequate and good-quality lights that point forward and down.
- Lighting brackets should not obstruct operator visibility.
- Equipment that is not equipped with a lighting system should be provided with a temporary headlight system when being used for transport.
- One of the simplest and most powerful ways of optimizing illumination from headlights and taillights is to routinely clean them.

5.3.5 Hazard lights

- **Section 131** of Regulation 854 states that:

A motor vehicle when transporting explosives on the surface at a mine or plant shall,

(b) be conspicuously marked by red signals or flags easily visible from front, rear, and both sides;

- **Subsection 135(1)** of Regulation 854 states that:

  Where explosives are transported underground by means of a motor vehicle or a train,

  (e) the motor vehicle or train shall display and operate a flashing red light whenever explosives are being transported

- Flashing red hazard lights should be reserved exclusively to indicate explosive hazards. All other flashing hazard lights should project other colours, such as amber, white, or blue-green.
- Hazard/warning lights should have the ability to be independently operated while the vehicle or equipment's master switch is in the 'off' position.
- In surface mines, all low-profile vehicles should be equipped with buggy (warning) whips topped with warning flags and/or lights that extend high enough above grade level to be clearly visible when in the vicinity of high-profile vehicles.
- Pneumatically powered mobile equipment (e.g., Long Tom drills, cavos) and any other mobile equipment that is not furnished with a lighting system should be equipped with a temporary lighting system when being transported.
- Oversized loads exceeding the width and/or length of the mobile equipment used to transport them should be marked with a temporary lighting system to alert pedestrians and other mobile equipment operators to the increased hazard.
- Recent studies by the Transportation Research Institute at the University of Michigan have shown that blue-green light is highly visible in low- and no-light situations, and that blue light, when used in combination with other coloured lights (e.g., red, yellow, and white) increases the visibility of emergency warning lights. For more information, consult the publication titled *Effects of Warning Lamps on Pedestrian Visibility and Driver Behavior*, from April 2007, by Michael J. Flanagan.
- Consideration should be given to using blue warning lights to supplement red and yellow lights on mobile equipment. Blue lights should not be used on their own, especially on surface vehicles, as they can be washed out under strong ambient light conditions.

5.3.6 Reflectors

Subsection 105(1) of Regulation 854 states that:

When in use, a motor vehicle, other than a motor vehicle running on rails, shall,

(j) except when used in an underground mine, have lights or reflectors that show the width

of the vehicle to a person in the path of its direction of travel.

- According to the CSA Standard M424 suite:

  "Red or amber reflective tape shall be attached to both ends of each machine. The minimum area of red or amber reflective material attached to each end of a machine shall be 460 square centimeters."

- Reflective tape should outline the perimeter of each machine on the front, back, and sides to indicate not only the location of mobile equipment, but also its size. Incomplete coverage is discouraged as an intermittent pattern may contribute to a camouflage effect, disguising the size and location of the machine.
- On mobile equipment with doors, reflective tape should be placed on the inside edge as well as inside of each door to help alert operators to an open door.
- It is recommended that crystal or diamond-grade reflective tape, which has 10 times the reflective candlepower of engineer-grade tape, be used on all mobile equipment. Crystal or diamond-grade school bus reflective tape (DOT, SOLAS, Rail Car) may be better suited for some needs.
- Operators should place portable reflective markers on overhanging sections of machines when they are transported (e.g., booms on drills).

5.3.7 Windows/windshields

- **Subsection 105(5)** of Regulation 854 states that:

  The windshield and windows of the cab of a motor vehicle shall consist of safety glass and be maintained so as to provide unobstructed vision.

- The windshields/windows of a cab should be maximized to provide operators with the greatest possible unobstructed view.
- Mobile equipment with windows/windshields should be equipped with working powered wipers and washer fluid reservoirs.
- Mobile equipment with enclosed cabs should be equipped with working defogging/defrosting devices to keep the interior of the windows clear of fog or frost.
- Mobile equipment for use in underground mines should not be equipped with tinted windows or windshields.
- One of the most obvious ways of optimizing visibility is to routinely clean windows and windshields.

5.3.8 Mirrors

- **Subsection 105(4)** of Regulation 854 states that:

  Except when the motor vehicle is used in an underground mine, a rear-view mirror shall be installed in the motor vehicle where the view to the rear of the operator is limited.

- Surface mobile equipment and underground mobile equipment (where practical) should be equipped with adequate and good-quality adjustable mirror systems to provide a line of sight into blind spots. Distortions of distances should be minimized.

- Mirror systems may incorporate good-quality convex mirrors that widen an operator's line of sight but that also distort the field of vision. Operators should be made aware of the distortion by a warning placed on each mirror.

5.3.9 Audible/visible warning systems

- **Subsection 105(3)** of Regulation 854 states that:

  Where the view of the operator of a motor vehicle in the direction of its travel is limited,

  (a) the vehicle shall be equipped with an audible or visible alarm that will warn a worker who may be endangered by the movement of the vehicle; and

  (b) the alarm shall be activated before the vehicle is put in motion.

- Though the regulation does not set a standard for the audibility or volume of the alarm, U.S. standards require that backup alarms be audible at a distance of approximately 61 metres (200 ft.).

- Audible alarms should be positioned on equipment to optimize their performance.

5.3.10 Collision avoidance systems

- A wide variety of devices that may be categorized as collision avoidance systems have been introduced and marketed in recent years to industries in which visibility involving large mobile equipment is a safety concern. They include:

  - **Radar systems** that transmit a radio signal and receive a return signal, reflected off objects within the range of the transmitted signal;
  - **Sonar systems** that transmit pulsed sound waves and receive echoes, reflected off objects within the range of the transmitted pulse;
  - **Infrared proximity sensors** that transmit an invisible infrared light beam and detect reflections from nearby objects within the range of the transmitted beam;

- **Magnetic field tag-based systems** that use magnetic field generating tags, worn by workers or attached to vehicles and stationary objects while tag detectors are installed on mobile equipment;
- **Radio frequency identification (RFID) systems** that use a low-frequency, or microwave tags that are worn by workers or are attached to vehicles and stationary objects while radiowave detectors are installed on mobile equipment;
- **Global positioning systems**, available only for surface operations, that incorporate a collision avoidance process into a GPS tracking service;
- **Ultra wide band (UWB)**: a shortrange radio frequency technology for wireless communication that can be leveraged to detect people, devices, and assets, used to transmit data between devices through radio waves with short nanosecond pulses over an ultrawide range of frequencies;
- **Light detection and ranging (LiDar)** that uses lasers to ping off objects and return to the source of the laser, measuring distance by timing travel, or flight, of the light pulse; or
- **Halo system technology** that uses a combination of LED lights to form a perimeter around mobile equipment.

Collision avoidance systems are rapidly gaining popularity, and the technology is changing frequently. The above examples are some of the technologies that are currently available. The National Institute for Occupational Health and Safety (NIOSH) in the United States has evaluated some of these available devices. Their evaluations are available in the publication titled *Recommendations for Evaluating and Implementing Proximity Warning Systems on Surface Mining Equipment*, June 2007, by T. Ruff.

One of the study's findings indicates that an effective proximity warning system requires multiple technologies that combine obstacle detection and alarm functions with the ability to make a visual check of a blind area. The study recommends that any device be installed and evaluated under actual operating conditions before conclusions are made about reliable detection areas, false alarm rates, and overall effectiveness. The study also recommends that any such system by used to complement – and not replace – proper visibility procedures.

- Backing cameras that are mounted on the rear of machinery with a monitor mounted next to the operator provide a view of an area otherwise out of the operator's line of sight. Though backup cameras provide an additional measure of safety, they do not substitute or spotters.
- Thermal imaging cameras with monitors mounted next to the operator can help drivers see farther in low light, fog, dust, and smoky conditions. These may also be positioned to help cover areas that would otherwise be out of the operator's line of sight. The camera detects differences in temperature so that warm objects (e.g., workers, engines) are a lighter shade than cooler objects.

- In recent years, there has been increased use of global positioning system technology in surface mining operations. This has been, principally, to monitor and control navigation and operations. Some systems include alarms when two or more GPS-equipped vehicles are within a pre-set distance of each other. Such systems should be installed and evaluated under actual operating conditions before any conclusion is made about reliability and effectiveness. Any such system should be used to complement – not replace – proper visbility procedures.
- The HASARD (Hazardous Area Signaling and Ranging Device) system was developed in the late 1990s and early 2000s by NIOSH. It is designed to reduce the risks of working around continuous mining equipment used in coal mining. HASARD alerts miners carrying a personal alarm device when they are within monitoring and warning range of heavy equipment; it even shuts down the equipment when they are within stop range. The device has been continuously tested on mining machines in U.S. coal mines and is now commercially available. NIOSH has not developed a similar device for other mining operations.
- When collision avoidance devices are introduced to an underground or surface operation, equipment operators should be fully trained in their proper use, maintenance, and limitations. Care should be taken to ensure such devices do not become distractions or replace safe operating procedures.

5.3.11 Equipment maintenance

- **Subsection 105(7)** of Regulation 854 states that:

  A procedure for the testing, maintenance and inspection of each motor vehicle shall be adopted and the procedure shall,

  (a) schedule the testing of brakes, steering, lighting, and other safety components prior to initial use of the motor vehicle for the shift;
  (b) schedule the motor vehicle for routine inspection and maintenance, taking into consideration the recommendations of the manufacturer and the conditions of use;
  (c) itemize the tests to be carried out following maintenance work and before first use of the motor vehicle;
  (d) provide a record of the testing, maintenance, inspection, and testing that has been carried out; and
  (e) provide for the testing, maintenance, and inspections to be performed by competent persons.

- **Subsection 119 (10)** of Regulation 854 states that:

  Before a motor vehicle is first put into service, the following systems shall be tested by a competent person for proper operation:

1. Service brake.
2. Emergency brake.
3. Parking brake.
4. Steering.
5. Warning devices.
6. Lighting.

- Where proximity warning devices, such as radar, sonar, RFID, or others are used, procedures should be developed to ensure they are adequately maintained and working properly.
- Regardless of how insignificant the problem may be (e.g., a rattle under the seat, an intermittent flashing dash light), any minor fault that may distract an operator from the safe operation of the equipment should be repaired before the equipment is used.
- Simple routine maintenance – washing windows, lights, mirrors, reflective areas; filling washer reservoirs; replacing torn/worn reflective material –will contribute to improved visibility.
- Advances in technology for collision avoidance, safety management systems, and visibility improvement, should be monitored and reviewed to determine whether new technology should be implemented.

5.4 Traffic control procedures

In addition to road design crews, municipalities and the provincial Ministry of Transportation address visibility issues on public roadways by using traffic control procedures, including traffic laws, parking regulations, signage, and lights.

Underground and surface mining operations should use traffic control procedures to address their unique visibility issues. As much as possible, these procedures should be identical or similar to the broader public traffic control procedures presented in the Highway Traffic Act.

- **Subsection 105(1)** of Regulation 854 states that:

  When in use, a motor vehicle, other than a motor vehicle running on rails, shall,

  (k) where the motor vehicle is to be operated in reverse and the operator or another person may be endangered thereby, be operated only when another worker is stationed to direct and warn the operator of any hazard to himself or another person

- **Subsection 105(6)** of regulation 854 states that:

  Where motor vehicles that restrict the view of the operator because of size or design are used, procedures to control and govern the movement of such vehicles, other vehicles and pedestrians shall be established.

- **Section 105.1** of Regulation 854 states that:

(1) An employer at a mine shall, in consultation with the joint health and safety committee or health and safety representative, if any, develop and maintain a written traffic management program.

(2) The program shall include measures and procedures to,

(a) prevent collisions, of motor vehicles, that may endanger the health and safety of workers by addressing hazards relating to reduced or impeded visibility of motor vehicle operators; and
(b) protect the health and safety of workers and pedestrians who may be endangered by the movement of a motor vehicle.

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

(4) The program shall be reviewed at least annually.

- **Section 106** of Regulation 854 states that:

(1) Where a motor vehicle is operated on a grade or ramp, traffic control procedures shall be established including provision for the control of emergency situations.

(2) Where a motor vehicle is disabled or parked in the travelled portion of a roadway, a warning to approaching traffic shall be provided by,

(a) flashing lights;
(b) flares;
(c) reflectors;
(d) lamps; or
(e) a worker suitably equipped to be readily seen, who directs traffic approaching the area.

(3) In the operation of a motor vehicle in an underground mine,

(a) the maximum load to be carried;
(b) the maximum speed; and
(c) the gear selection to be used,

on a grade or ramp shall be established and made known to the operator by the supervisor in charge of the mine.

- Some form of emergency warning devices or markers should be readily available to mobile equipment operators in the event of a breakdown or accident.
- Warning devices or markers should be placed at a distance that will give other equipment operators adequate time and distance to react safely to the hazard.

- The manager of an underground mine or surface operation should set and post maximum gear and/or maximum speed limits for all haulageways and roadways. These limits must be made known to all vehicle operators.
- Each underground mine should develop a procedure regarding right-of-way. This statement of right-of-way, while not limited to the following, should address factors such as production versus service equipment; size of equipment; up-ramp or down-ramp; and other traffic control areas.
- Each surface operation should develop a procedure regarding right-of-way in operating areas. This statement of right-of-way, while not limited to the following, should address factors such as production versus service equipment; size of equipment, and other traffic control issues. It is recommended that pedestrians not be permitted in operating areas.
- When vehicles and mobile equipment encounter pedestrians, they should be stopped until the pedestrians have cleared the operating area or moved into a safe location, such as a safety bay.
- Where radio traffic control is used to direct the flow of mobile equipment, each communication should be two-way and confirmed to ensure the parties hear and understand the communication.
- Multi-channel radio systems should be used to reduce distractions for mobile equipment operators while improving clarity of communications. Different work areas or levels can be assigned a specific frequency for traffic control, while another frequency can be set aside for necessary but non-traffic related communication.
- Where radio traffic control is used, a special alarm term or code should be in place to immediately stop all vehicles. All operators should be aware of and be authorized to use the term or code. No operator should be allowed to move again until his or her entire operating area has undergone a visual check.
- All mobile equipment operators will maintain a minimum of 31 metres (100 ft.) of separation from other mobile equipment, especially while travelling in haulageways and roadways.
- At the end of the shift or for other extended periods of shutdown, vehicles should be parked in approved, designated areas, according to clear procedures that allow for:
    - Safe parking distances,
    - Isolation from pedestrians, and/or
    - Easy and safe operator access and egress.
- Vehicles parked for shorter periods of time or broken down in traffic areas should be marked with a strobe light or reflective pole. Small vehicles should not be parked or stopped near operating large equipment. They should never be parked or stopped in the blind spot of large equipment.

- A procedure should be developed and implemented to address pedestrian work assignments and mechanical failures on ramps and in travel areas, ensuring the safety of all personnel and equipment.
- Disabled vehicles in traffic areas should be towed to a maintenance area as soon as possible.
- Where traffic signage to indicate speed limits, traffic hazards, and other factors is required, the signage should conform in content and design to the standards in the Manual of Uniform Traffic Control Devices (MUTCD), used by the U.S. Department of Transport and by provincial highway authorities in Canada.
- All signage should be maintained in clean and readable condition at all times. It should also be in a visible location, at an appropriate distance – one that gives vehicle operators and pedestrians sufficient time to react – from the hazard or control point.

5.5 Operator/pedestrian safety considerations

For pedestrians and equipment operators, improving visibility is a joint effort requiring the former to make every effort to be visible and the latter to make every effort to see. Failure to make every effort possible could lead to an incident. Operation/pedestrian safety considerations, both underground and in surface mining operations, include proper personal protective equipment (PPE), proper attitude, and good communication.

5.5.1 Personal protective equipment (PPE)

- **Section 262** of Regulation 854 states that:

  (2) Every worker in an underground mine shall wear,

  (a) high visibility safety apparel that makes the worker visible to others in the workplace and that meets the requirements set out in subsection (3); and
  (b) retro-reflective material applied to the front, back and sides of head gear.

  (3) High visibility safety apparel must meet the following requirements:

  1. It shall be made of fluorescent or bright-coloured background material.
  2. It shall have retro-reflective striping that,

  i. is located on the outside of the garment,
  ii. measures at least 50 mm in width,
  iii. completely encircles the waist, each arm, and each leg below the knee,
  iv. is arranged in two vertical lines on the front of the garment, extending over the shoulders and down to the waist, and
  v. is arranged in the form of an "X" on the back of the garment, extending from the shoulders and down to the waist.

(4) All high visibility safety apparel and all retro-reflective material on head gear must be maintained in good condition so that they adequately visually identify a worker.

A guideline prepared by MLTSD on 'High Visibility Safety Apparel for Mines and Mining Plants' addresses safety concerns for workers who must be visible to equipment operators in conditions with reduced visibility. The guideline is available online at https://www.ontario.ca/page/high-visibility-safety-apparel-mines-and-mining-plants.

- **Section 263** of Regulation 854 states that:

  (2) Subject to subsection (3), between sunset and sunrise, every worker shall wear retroreflective material on headgear and outer clothing that enables the worker to be seen.

  (a) high visibility safety apparel that makes the worker visible to others in the workplace and that meet the requirements set out in subsection 262 (3); and

  (b) retro-reflective material applied to the front, back and sides of head gear.

  (3) A worker is not required to comply with subsection (2) if the worker is in a booth, vehicle cab or another protective enclosure or if a work area is provided with fixed lighting that enables the worker to be seen.

  (4) All visibility safety apparel and all retro-reflective material on head gear must be maintained in good condition so that they adequately visually identify a worker.

- Tear-away retroreflective vests, as a minimum, may be used by visitors at a surface operation, but not for workers. The vests can become a loose clothing hazard when oil and grease are attracted to the velcro closures, making them ineffective.
- The Canadian Standards Association has established standards (CSA Z96) for high visibility safety apparel under different lighting conditions. The standards are useful in both underground and surface mining operations.
- Entire outer (visible) work clothing must be of a single, high visibility colour — fluorescent red, orange-red, or yellow-green. Dark colours (blue) render personnel less visible.
- Often, in low-light situations, the first and last sight an equipment operator has of a pedestrian is his or her hard hat. Hard hats should be of a single, high visibility colour (yellow, white) with appropriate retroreflective material that makes the wearer visible from any angle. Glow-in-the-dark hard hats and/or hard hats equipped with a one-inch-wide retroreflective band that completely encircles the helmet should be considered.
- Retroreflective material on outer clothing and headgear should be maintained in good condition, and washed, repaired, or replaced when necessary.

- When underground, cap lamps should be worn on the hard hat to increase pedestrian visibility. The lamp should be removed only to attract a vehicle operator's attention. The lamp should not be flashed in a vehicle operator's eyes. It should be returned to the hard hat when signaling is complete.
- Equipment operators in surface operations should wear quality, polarized sunglasses to reduce glare and improve vision in brightly sunlit conditions.
- Operators who wear sunglasses should remove them when lighting conditions change due to dusk or heavy cloud cover, or when they enter a darker environment, such as a shop or underground mine.

5.5.2 Staying alert

- Attitude is important. Operators and pedestrians should be encouraged to make safety their highest priority, and to stay focused on the job at hand. Mental distractions and frustrations can lead to incidents.
- Physical distractions should be remedied as quickly as possible. Cell phone use, review of drawings or note taking should only be done in safe locations. Operators should use cell phone only when their equipment is stationary and in a safe location.
- Equipment operators should be of good health. They should not be fatigued, use medication that may cause drowsiness or loss of coordination, or consume other drugs or alcohol.
- Equipment operators should continually assess the safety of their actions, and never move a machine if pedestrians or vehicles are too close. They should wait until the operating area is clear.
- Equipment operators with limited lines of sight (blind spots) should walk around their vehicle immediately prior to starting operation or resuming operation following any break. It is suggested that operators be required to place wheel chocks on both sides of their vehicles immediately after stopping to ensure that they walk around their vehicle before restarting.
- Pedestrians should take every precaution to ensure operators can see them at all times while remaining alert to the hazard of placing themselves in danger when the operator's attention is elsewhere. Conversely, vehicle operators should not move unless they feel they have the attention of other workers in the area.
- There is technology available to assist with detecting and monitoring the alertness of the operator, examining fatigue and distraction, smoking, electronic device usage, etc.

5.5.3 Restricted areas

- Areas restricted to pedestrian workers should include remote and automated or unmanned equipment areas, haulageways, and maintenance and service work areas in haulageways.

Restricted areas should have appropriate signage to identify the hazard, using one or more of the following:

- Chains.
- Flashing lights.
- Fencing.
- Barricades.

5.5.4 Communications

- It is recommended that all equipment operators be assigned control of the physical area in which they operate, and that all other personnel, including drivers of light vehicles, be required to communicate their intentions to enter the area. Two-way confirmed communication should be established when entering and exiting the area.
- During a start-of-shift briefing, operators should be advised of any pedestrian work assignments to be undertaken in their operating area during their shift. Operators should also be kept informed of any changes in work assignments in the operating area during the shift.
- If an operator has been advised of personnel working in their assigned area, they should locate the person(s) prior to beginning operations and notify them of the planned work.
- In a start-of-shift briefing, underground personnel should be advised of all restricted areas, especially recent changes to them, and should be kept informed of any changes in restricted areas that occur during the shift.
- A procedure should be established to ensure surface staff going underground and all visitors going underground are informed of restricted areas.
- Pedestrians working in areas used by mobile equipment should use warning devices (e.g., reflective barriers, battery operated strobe lights, reflective sticks) on either side of their working area to warn and prevent inadvertent entry of equipment.
- To assist with communication, pedestrians should pass equipment operators on the operator side of the equipment whenever possible.
- Wherever feasible, a spotter should be used to help operators back up heavy machinery and equipment with limited lines of sight. The spotter should stand well away from the equipment but in clear view of the operator. Spotters should be used:
  - In noisy and/or congested areas,
  - Whenever backward movement is hazardous, or
  - Whenever the operator's line-of-sight is obstructed.
- A simple code of cap lamp signals can help pedestrians and vehicle and equipment operators communicate with each other. Standard underground communication signals using the cap lamp are included in the sketch in **Appendix 6**.

- Pedestrians and passengers should approach and withdraw from mobile equipment at a right angle (or as close as possible) to avoid stepping in a blind spot to the operator or to be hidden from the view of other equipment operators.

5.5.5 Direction of travel

- Whenever possible, mobile equipment operators should orient their vehicles to proceed in the direction with the largest possible field of vision.

5.6 Training

No single measure is as important in reducing the number and likelihood of incidents as training workers. Pedestrians and equipment operators, through training, learn to recognize, assess, and control workplace hazards before an incident can occur.

- **Subsection 105(1)** of Regulation 854 states that:

  When in use, a motor vehicle other than a motor vehicle running on rails shall:

  (e) except for purposes of training or testing be operated by a competent person

- Visibility/line-of-sight information, procedures and guidelines should be incorporated into regular training programs for all contractors and employees, and in particular, all new workers.
- Operator and worker training, as well as new worker orientation, should include specific visibility and travel risks that will be encountered within the environment in which they will be working.
- Individuals should be trained in the traffic management program.
- Pedestrians should be continually trained to use their eyes and ears, and to use safety bays and lamp signals appropriately. There should be no assumption that employees automatically know or remember visibility policies and procedures.
- Training courses, materials, and information specific to line-of-sight/visibility issues may be accessed through the Centre for Research in Occupational Safety and Health (CROSH) at Laurentian University and from Workplace Safety North.
- Operators should be continually trained in the proper use of emergency warning devices/markers and in the procedures to follow in the event of a mechanical failure.
- Where audible warning systems, proximity warning systems, backing cameras, thermal imaging cameras, RFID and other devices are used to increase safety and help prevent potential incidents, all employees should be trained in their use. Specifically, operators should be aware of any adjustments and/or controls that could make the system more effective, while pedestrians should be aware of the standards and limitations of any system in use.

RESEARCH-RELATED ACTIVITIES

Line of Sight and Mobile Equipment Accident Prevention (ongoing) includes the following:

- 'Using visibility tools in Classic JACK to assess line-of-sight issues associated with the operation of mobile equipment' International Journal of Human Factors Modelling and Simulation (2010)
- 'Implications of articulating machinery on operator line of sight and efficacy of camera-based proximity detection systems' (2017)

Proximity detection systems, such as a video system designed to provide a 360-degree view around a machine, have been implemented to improve available lines of sight for the operator. The work points to the need to integrate proximity detection systems at the design, build, and manufacturing stages and to consider proper policy and procedures that would address the gains and limitations of the systems prior to implementation.

Publications of the research are available online at the Centre for Research in Occupational Safety and Health (CROSH) at Laurentian University website: https://crosh.ca/research/publications/.

'Factors influencing load-haul-dump operator line of sight in underground mining' (2004):

Line-of-sight evaluations were conducted on 11 different LHD models. Results indicated blind spots were caused by cab posts, vehicle lights, and light brackets. Line-of-sight impairments were caused by wheel well covers, buckets, fire extinguishers, light posts, radiator covers, booms, radio remote boxes, elevated engine profiles, and air intake cylinders. Results of this study have been used to conduct awareness campaigns within the Ontario mining industry and to suggest vehicle design modifications to LHD manufacturers.

'Development of Products to Transfer Line-of-sight and Mobile Equipment Knowledge to Industry and Educational Institutions' (2007):

In previous projects, researchers at Sudbury's Laurentian University have studied visibility/ line-of-sight issues in the operation of mobile mining equipment since 1999. Researchers have now developed various training modules and user guides, including a computer game, to help industry and training institutes educate current workers of the knowledge gained in these projects, increasing the profile of workplace safety. A summary of the research is available on the Workplace Safety and Insurance Board's website: www.wsib.ca.

'Recommendations for Evaluating and Implementing Proximity Warning Systems on Surface Mining Equipment' (2007):

Researchers at the National Institute for Occupational Safety and Health, Spokane Research Laboratory, studied technology and methods that could reduce visibility-related incidents involving surface mining equipment.

Several technologies designed for detecting obstacles in blind areas and providing a warning to the operator were evaluated. These proximity warning systems included radar, sonar, GPS, radio transceiver tags, and combinations of radar and cameras. A summary of test results is presented in this study, as well as guidance on effective proximity warning technology, installation and maintenance considerations, and recommendations for effective implementation. Visit https://www.cdc.gov/niosh/mining/works/coversheet202.html for more information.

'Effects of Warning Lamps on Pedestrian Visibility and Driver Behavior – Interim report of work on Non-Blinding Emergency Vehicle Lighting' (2007):

Researchers from the Transportation Research Institute at the University of Michigan, under contract to the Society of Automotive Engineers, conducted research on non-blinding emergency vehicle warning lighting systems. These studies include efforts related to the effects and how to mitigate motorist disorientation caused by the day and nighttime use of emergency warning lights (including issues of lighting colour and visibility issues. Visit https://www.sae.org/standardsdev/tsb/cooperative/nblighting.pdf for more information.

'Comparison of operator line-of-sight (LOS) assessment techniques: Evaluation of an underground load-haul dump (LHD) mobile mining vehicle' (2007):

The line of sight (LOS) for underground mobile equipment research is a result of the numerous fatalities and injuries that occur in the mining industry that are related to poor operator LOS. The visibility assessment methods were used to prepare guidelines for the mining industry to assess current and potential designs.

Appendix 1 – Summary of incidents

Ontario Mining Industry Reported Traumatic Injuries 1992 - 2006
UG Mobile Equipment - Visibility may have been a factor

DATE	08/31/1992
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Struck by Objects, NEC
SOURCE	LHD Vehicle
EQUIPMENT 1	Rockbolt (incl. Accessories)
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Knee
IMMEDIATE CAUSE 1	Congestion / Restricted Action
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	WHILE DIRECTING SCOOPTRAM OPERATOR TO PICK UP BUNDLE OF REBARS INJUREDS KNEE WAS SQUEEZED BETWEEN THE BUCKET & REBARS.WORKING IN CLOSE QUARTERS:POOR LIGHTING:NOT ATTENTIVE TO HAZARDS.

DATE	09/23/1992
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Conductors / Electric Cable
EQUIPMENT 1	LHD Vehicle
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Neck
IMMEDIATE CAUSE 1	Failure to Secure / Make Safe
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	Preventative Action, NEC
ACCIDENT DESCRIPTION	WHILE MUCKING WASTE THE SCOOPTRAM BUCKET CAUGHT A CABLES & PULLED THEM DOWN STRIKING INJURED ON THE HEAD.DID NOT REMOVE THE CABLE.

DATE	10/06/1992
CLAIM STATUS	Lost Time
ACCIDENT TYPE	Struck by Objects, NEC
SOURCE	LHD Vehicle
EQUIPMENT 1	
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Hips / Groin (incl. Pelvis / Pelvic Organs)
IMMEDIATE CAUSE 1	Taking an Improper Position for Task
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	INJURED STATES THAT WHILE ATTEMPTING TO WALK BETWEEN THE WALL & THE SCOOPTRAM THE REAR OF THE SCOOPTRAM LIFTED & ARTICULATED STRIKING INJURED.WALKING BESIDE WORKING SCOOPTRAM.

DATE	12/01/1992
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Collision with Moving Vehicle
SOURCE	LHD Vehicle
EQUIPMENT 1	
NATURE OF INJURY 1	Fracture
BODY PART 1	Lower Leg
IMMEDIATE CAUSE 1	Taking an Improper Position for Task
BASIC CAUSE 1	Improper Motivation
PREVENTATIVE ACTION 1	None Reported
ACCIDENT DESCRIPTION	WHILE PICKING UP A VENTILATION TUBE & PLACING IT IN THE SCOOPTRAM BUCKET INJURED WAS STRUCK BY THE EDGE OF THE BUCKET .SIGNALLED TO MOVE AHEAD BUT THEN STEPPED IN FRONT: HASTE MAY HAVE CLOUDED JUDEGEMENT.

DATE	01/07/1993
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Struck by Objects, NEC
SOURCE	Mucking Machine
EQUIPMENT 1	Rail Muck Car
NATURE OF INJURY 1	Contusion / Bruise (Intact Skin Surface)
BODY PART 1	Elbow
IMMEDIATE CAUSE 1	Failure to Warn / Poor Communication
BASIC CAUSE 1	Improper Motivation
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	WORKER WALKING BETWEEN MUCK MACHINE AND MUCK CAR WAS STRUCK BY MUCK MACHINE AND PINNED AGAINST CAR.FAILURE TO WARN OPERATOR OF HIS MOVEMENT:IMPROPER MOTIVATION.

DATE	04/12/1993
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Metal Items, NEC
EQUIPMENT 1	Haulage Truck
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Neck
IMMEDIATE CAUSE 1	Congestion / Restricted Action
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	WHILE BACKING UP THE HAULAGE TRUCK INJURED STRUCK HIS HEAD ON THE VENTILATION PIPE.PIPE IS LOW.

All information in this table has been drawn from WSN's legacy database, now managed by WSN.

Ontario Mining Industry Reported Traumatic Injuries 1992 - 2006
UG Mobile Equipment - Visibility may have been a factor

DATE	06/07/1993
CLAIM STATUS	Lost Time
ACCIDENT TYPE	Struck by Objects, NEC
SOURCE	LHD Vehicle
EQUIPMENT 1	Floor / Wall of Mine
NATURE OF INJURY 1	Cut / Laceration
BODY PART 1	Lower Leg
IMMEDIATE CAUSE 1	Failure to Warn / Poor Communication
BASIC CAUSE 1	Improper Motivation
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	INJURED WAS STANDING AT THE CORNER OF WASTE PASS DRIFT WHEN OPERATOR BACKED UP THE SCOOPTRAM STRIKING INJURED.INJURED STANDING ON WRONG SIDE OF SCOOPTRAM:RESTRICTED AREA:IMPROPER MOTIVATION.

DATE	01/12/1994
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Fan (Any Type)
EQUIPMENT 1	LHD Vehicle
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Knee
IMMEDIATE CAUSE 1	Defective / Hazardous Tools, Equipment or Material
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	WHILE MUCKING THE SCOOPTRAM CANOPY HIT THE FAN CAUSING IT TO FALL HITTING INJURED.FAN NOT PROPERLY INSTALLED:NOT ENOUGH CLEARANCE.

DATE	01/12/1994
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Struck by Objects, NEC
SOURCE	Flatbed / Pipe / Boom Truck
EQUIPMENT 1	
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Foot (Not Ankle or Toes)
IMMEDIATE CAUSE 1	Taking an Improper Position for Task
BASIC CAUSE 1	Inadequate Capability
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	INJURED WAS LIFTING THE VENTILATION CURTAIN SO PARTNER COULD DRIVE BOOMTRUCK THROUGH & WHEN HE DID HE RAN OVER INJURED'S FOOT.STANDING TO CLOSE:INJURED MISJUDGED DISTANCE.

DATE	10/19/1994
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	NEC
EQUIPMENT 1	Explosives Truck / Anfoloader
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Multiple Parts (More than 2 Parts)
IMMEDIATE CAUSE 1	Congestion / Restricted Action
BASIC CAUSE 1	Inadequate Engineering / Design
PREVENTATIVE ACTION 1	Design to Eliminate / Reduce Hazard
ACCIDENT DESCRIPTION	WHILE OPERATING POWDER TRUCK BACKWARDS PAST THE NEW VENTILATION MAT THE BACK OF THE TRUCK HIT THE MAT CAUSING IT TO BOUNCE BACK STRIKING INJURED. CONGESTED AREA: INADEQUATE STANDARDS.

DATE	11/27/1994
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Collision with Standing Vehicle / Object
SOURCE	LHD Vehicle
EQUIPMENT 1	Floor / Wall of Mine
NATURE OF INJURY 1	Contusion / Bruise (Intact Skin Surface)
BODY PART 1	Chest (incl. Ribs / Sternum)
IMMEDIATE CAUSE 1	Substandard Housekeeping
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	AFTER FILLING THE BUCKET INJURED WAS MOVING AHEAD HE STRUCK THE WALL WITH THE SCOOPTRAM CAUSING INJURED TO BE THROWN AGAINST THE SHIFT LEVER.ROUGH ROADWAY.

DATE	12/05/1994
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Collision with Standing Vehicle / Object
SOURCE	Scissor Lift
EQUIPMENT 1	Scissor Lift
NATURE OF INJURY 1	Contusion / Bruise (Intact Skin Surface)
BODY PART 1	Chest (incl. Ribs / Sternum)
IMMEDIATE CAUSE 1	Using Equipment / Material Improperly
BASIC CAUSE 1	Improper Motivation
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	INJURED WAS BACKING UP DOWN THE RAMP TO LET A JEEP GO BY WHEN HIS SCISSOR LIFT HIT THE WALL THROWING HIM AGAINST THE CONTROLS & THE CANOPY.BACK UP LIGHTS NOT ON:INJURED WAS FRUSTRATED.

All information in this table has been drawn from WSN's legacy database, now managed by WSN.

Ontario Mining Industry Reported Traumatic Injuries 1992 - 2006
UG Mobile Equipment - Visibility may have been a factor

DATE	01/31/1995
CLAIM STATUS	Lost Time
ACCIDENT TYPE	Collision with Standing Vehicle / Object
SOURCE	Bulldozer
EQUIPMENT 1	Piping
NATURE OF INJURY 1	Contusion / Bruise (Intact Skin Surface)
BODY PART 1	Abdomen (incl. Internal Organs)
IMMEDIATE CAUSE 1	Using Equipment / Material Improperly
BASIC CAUSE 1	Lack of Knowledge
PREVENTATIVE ACTION 1	Design to Eliminate / Reduce Hazard
ACCIDENT DESCRIPTION	INJURED WAS BACKING UP THE BULLDOZER THE ROLL BAR CAUGHT A PIPE BENDING IT & PINNING HIM IN THE SEAT.DID NOT INSURE HE HAD ADEQUATE CLEARANCE:OPERATOR UNAWARE OF HAZARD.

DATE	03/23/1995
CLAIM STATUS	Lost Time
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Fork-Lift
EQUIPMENT 1	Rail Timber Truck / Flat Car
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Lower Leg
IMMEDIATE CAUSE 1	Taking an Improper Position for Task
BASIC CAUSE 1	Inadequate Engineering / Design
PREVENTATIVE ACTION 1	Preventative Action, NEC
ACCIDENT DESCRIPTION	WHILE MOVING THE FORKLIFT INJURED'S LEG WAS CAUGHT BETWEEN THE FORKLIFT & THE TIMBER TRUCK.THE TRUCK IN THE DRIFT CREATED LIMITED CLEARANCE:DESIGN OF FORKLIFT LEAVES LEG & KNEE EXPOSED.

DATE	04/08/1995
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Collision with Standing Vehicle / Object
SOURCE	LHD Vehicle
EQUIPMENT 1	Loose
NATURE OF INJURY 1	Multiple Injuries (More than 2)
BODY PART 1	Back (incl. Spine / Spinal Cord)
IMMEDIATE CAUSE 1	Operating at Improper Speed
BASIC CAUSE 1	Inadequate Maintenance
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	WHILE DRIVING THE SCOOPTRAM DOWN THE RAMP THE SCOOPTRAM HIT THE WALL CAUSING A LOOSE TO FALL BEHIND THE SEAT BENDING THE SEAT & SQUEEZING INJURED.OPERATING TOO FAST:RUT IN ROAD.

DATE	05/12/1995
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Metal Items, NEC
EQUIPMENT 1	LHD Vehicle
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Neck
IMMEDIATE CAUSE 1	Failure to Secure / Make Safe
BASIC CAUSE 1	Wear and Tear
PREVENTATIVE ACTION 1	Design to Eliminate / Reduce Hazard
ACCIDENT DESCRIPTION	WHILE OPERATING THE SCOOPTRAM IN THE DRIFT INJURED HIT HIS HEAD ON A ROCKBOLT STRAP.THE STRAP WAS HANGING BY A BOLT.

DATE	08/24/1995
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Tractor / Powered Towing Vehicle
EQUIPMENT 1	Ventilation Tubing
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Multiple Parts (More than 2 Parts)
IMMEDIATE CAUSE 1	Failure to Secure / Make Safe
BASIC CAUSE 1	Inadequate Maintenance
PREVENTATIVE ACTION 1	Repair / Clean-Up
ACCIDENT DESCRIPTION	WHILE TRYING TO PASS UNDER THE VENTILATION TUBING INJURED WAS CAUGHT & PULLED OUT OF THE SEAT STRETCHING INJURED BACKWARDS ACROSS THE REAR OF THE TRACTOR WITH HIS FOOT CAUGHT UNDER THE BRAKE.

DATE	09/06/1995
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Struck by Objects, NEC
SOURCE	Rockbolt (incl. Accessories)
EQUIPMENT 1	LHD Vehicle
NATURE OF INJURY 1	Cut / Laceration
BODY PART 1	Nose (incl. Nasal Passages / Sense of Smell
IMMEDIATE CAUSE 1	Inadequate Guards / Barriers
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	WHILE MUCKING INJURED STRUCK A ROCKBOLT WITH THE SCOOPTRAM BUCKET CAUSING THE SHELL TO FLY OFF & HIT INJURED.NO GUARD ON SCOOPTRAM.

All information in this table has been drawn from WSN's legacy database, now managed by WSN.

Ontario Mining Industry Reported Traumatic Injuries 1992 - 2006
UG Mobile Equipment - Visibility may have been a factor

DATE	11/30/1995
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Ventilation Tubing
EQUIPMENT 1	Fork-Lift
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Multiple Parts (More than 2 Parts)
IMMEDIATE CAUSE 1	Congestion / Restricted Action
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	Design to Elimnate / Reduce Hazard
ACCIDENT DESCRIPTION	WHILE OPERATING THE FORKLIFT INJURED STRUCK HIS HEAD ON A VENTILATION PIPE THEN HE SLID FORWARD & STRUCK HIS KNEES ON THE DASH.LOW VENTILATION PIPE.

DATE	12/27/1995
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Piping
EQUIPMENT 1	Haulage Truck
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Back (incl. Spine / Spinal Cord)
IMMEDIATE CAUSE 1	Congestion / Restricted Action
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	Design to Eliminate / Reduce Hazard
ACCIDENT DESCRIPTION	WHILE MOVING THE HAULAGE TRUCK INJURED WAS LOOKED BACK AS HE TURNED TO LOOK FORWARD HIS HEAD STRUCK A PIPE.LOW PIPES: LARGE TRUCK:CONFINED AREA.

DATE	02/26/1996
CLAIM STATUS	Lost Time
ACCIDENT TYPE	Collision with Standing Vehicle / Object
SOURCE	LHD Vehicle
EQUIPMENT 1	LHD Vehicle
NATURE OF INJURY 1	Fracture
BODY PART 1	Arm, NEC
IMMEDIATE CAUSE 1	No Response Given
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	INJURED WAS OPERATING THE SCOOPTRAM WHEN HE RAN INTO THE WALL.HITTING HIS ARM ON THE DASH & CAUSING A LOOSE TO FALL STRIKING HIM.USING SCOOPTRAM TO GO CHECK BLAST.

DATE	03/28/1996
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Vehicles, NEC
EQUIPMENT 1	Floor / Wall of Mine
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Head, NEC
IMMEDIATE CAUSE 1	No Response Given
BASIC CAUSE 1	Lack of Knowledge
PREVENTATIVE ACTION 1	None Reported
ACCIDENT DESCRIPTION	WHILE GOING UP THE RAMP THE VEHICLE STRUCK THE WALL CAUSING THE CAB TO BREAK SQUEEZING DOWN STRIKING INJURED.POOR DRIVING ON PART OF DRIVER:BACK & WALL LOW:INEXPERIENCED DRIVER.

DATE	08/02/1996
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Struck by Objects, NEC
SOURCE	Percussion Drill Rod
EQUIPMENT 1	LHD Vehicle
NATURE OF INJURY 1	Contusion / Bruise (Intact Skin Surface)
BODY PART 1	Leg, NEC
IMMEDIATE CAUSE 1	Failure to Secure / Make Safe
BASIC CAUSE 1	Lack of Skill
PREVENTATIVE ACTION 1	None Reported
ACCIDENT DESCRIPTION	WHILE BACKING UP A TRACTOR A DRILL STEEL THAT WAS STICKING OUT WAS STRUCK BY A SCOOPTRAM & HIT INJURED.PROTRUDING STEEL:IMPROPERLY PLACED STEEL:LACK OF SKILL:INADEQUATE WORK STANDARDS.

DATE	09/06/1996
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Collision with Standing Vehicle / Object
SOURCE	LHD Vehicle
EQUIPMENT 1	Floor / Wall of Mine
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Chest (incl. Ribs / Sternum)
IMMEDIATE CAUSE 1	Hazardous Environmental Gases / Fumes / Dust
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	WHILE TRAVELLING IN THE DRIFT INJURED HIT THE WALL WITH THE SCOOPTRAM.FOGGY & DUSTY AREA.

DATE	09/16/1996
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Buildings / Structures, NEC
EQUIPMENT 1	Vehicles, NEC
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Neck
IMMEDIATE CAUSE 1	No Response Given
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	Preventative Action, NEC
ACCIDENT DESCRIPTION	WHILE BACKING THE KUBOTA THROUGH THE VENTILATION DOOR INJURED STRUCK HIS HEAD ON THE DOOR FRAME.INJURED DID NOT BEND OVER ENOUGH.

DATE	02/09/1997
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Vehicles, NEC
EQUIPMENT 1	Floor / Wall of Mine
NATURE OF INJURY 1	Contusion / Bruise (Intact Skin Surface)
BODY PART 1	Skull
IMMEDIATE CAUSE 1	No Response Given
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	WHILE BACKING UP THE JEEP IT HIT THE WALL CAUSING INJURED TO HIT THE ROLL BAR.

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Ontario Mining Industry Reported Traumatic Injuries 1992 - 2006
UG Mobile Equipment - Visibility may have been a factor

DATE	02/11/1997
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Floor / Wall of Mine
EQUIPMENT 1	Tractor / Powered Towing Vehicle
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Trunk, NEC
IMMEDIATE CAUSE 1	Using Equipment / Material Improperly
BASIC CAUSE 1	Improper Motivation
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	WHILE RIDING ON A TRACTOR THE OPERATOR WAS TOO CLOSE TO THE WALL THE OTHER GUY TOOK HIS HAND OFF THE RAILING & LOST HIS BALANCE HE GRABBED INJURED PULLING HIM OFF THE TRACTOR.

DATE	05/02/1997
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Struck by Objects, NEC
SOURCE	Tractor / Powered Towing Vehicle
EQUIPMENT 1	
NATURE OF INJURY 1	Contusion / Bruise (Intact Skin Surface)
BODY PART 1	Foot (Not Ankle or Toes)
IMMEDIATE CAUSE 1	No Response Given
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	None Reported
ACCIDENT DESCRIPTION	INJURED WAS MOVING SUPPLIES WHEN HE WAS STRUCK BY KABOTA BUCKET ON HIS FOOT.

DATE	02/09/1998
CLAIM STATUS	Fatal
ACCIDENT TYPE	Struck by Objects, NEC
SOURCE	LHD Vehicle
EQUIPMENT 1	Tractor / Powered Towing Vehicle
NATURE OF INJURY 1	Multiple Injuries (More than 2)
BODY PART 1	Multiple Parts (More than 2 Parts)
IMMEDIATE CAUSE 1	Operating at Improper Speed
BASIC CAUSE 1	Inadequate Capability
PREVENTATIVE ACTION 1	Preventative Action, NEC
ACCIDENT DESCRIPTION	INJURED WAS STANDING BESIDE THE TRACTOR WHEN HE WAS HIT BY A SCOOPTRAM.WORKER OPERATING SCOOPTRAM AT AN IMPROPER SPEED:CONGESTED AREA:NOISE EXPOSURE:POOR ILUMINATION:INCOMPLETE PROCEDURES.

DATE	03/10/1998
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Struck by Objects, NEC
SOURCE	Couplings / Pipe Fittings
EQUIPMENT 1	LHD Vehicle
NATURE OF INJURY 1	Cut / Laceration
BODY PART 1	Head, NEC
IMMEDIATE CAUSE 1	Congestion / Restricted Action
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	Design to Eliminate /Reduce Hazard
ACCIDENT DESCRIPTION	WHILE HAULING MUCK THE SCOOPTRAM CAUGHT THE BULL HOSE THE HEADER BLEW OFF THE AIR PIPE STRIKING INJURED.THE HEADER WAS INSTALLED ON THE CORNER OF THE INTERSECTION.

DATE	02/07/1999
CLAIM STATUS	Lost Time
ACCIDENT TYPE	Struck by Objects, NEC
SOURCE	Mucking Machine
EQUIPMENT 1	Rail Muck Car
NATURE OF INJURY 1	Cut / Laceration
BODY PART 1	Head, NEC
IMMEDIATE CAUSE 1	Failure to Warn / Poor Communication
BASIC CAUSE 1	Lack of Knowledge
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	WHILE INSTALLING A MISSING PIN ON THE GRAMBY MUCK CAR INJURED WAS STRUCK BY THE MUCK MACHINE BUCKET & THEN STRUCK THE CAR.FAILURE TO WARN HIS PARTNER THAT HE WAS ENTERING HIS PATH:WORKING BEHIND MUCK MACHINE:LACK OF COMMUNICATION:LACK OF KNOWLEDGE.

DATE	05/20/1999
CLAIM STATUS	Lost Time
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Fork-Lift
EQUIPMENT 1	Fork-Lift
NATURE OF INJURY 1	Fracture
BODY PART 1	Lower Leg
IMMEDIATE CAUSE 1	Defective / Hazardous Tools, Equipment or Material
BASIC CAUSE 1	Improper Motivation
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	WORKER WAS STRUCK BY A FORKLIFT.BACKUP ALARM ON FORKLIFT NOT WORKING: UNSAFE OPERATING PRACTICE: EQUIPMENT CHECK NOT PROPERLY DONE.

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Ontario Mining Industry Reported Traumatic Injuries 1992 - 2006
UG Mobile Equipment - Visibility may have been a factor

DATE	09/11/1999
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Collision with Standing Vehicle / Object
SOURCE	Grizzly
EQUIPMENT 1	LHD Vehicle
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Neck
IMMEDIATE CAUSE 1	Operating at Improper Speed
BASIC CAUSE 1	Lack of Knowledge
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	INJURED CAME TO THE GRIZZLY TO DUMP & CLEAN OFF THE GRIZZLY WHEN THE BUCKET HIT THE GRIZZLY LIP JARRING HIM HURTING HIS NECK.OPERATING TO FAST:GRIZZZLY FRAME IS WORN:OPERATOR WAS UNAWARE OF PLATE STICKING OUT:INADEQUATE INSPECTION OF GRIZZLY.

DATE	10/14/1999
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Screen (Ground Support)
EQUIPMENT 1	LHD Vehicle
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Neck
IMMEDIATE CAUSE 1	Failure to Secure / Make Safe
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	Preventative Action, NEC
ACCIDENT DESCRIPTION	WHILE OPERATING A SCOOPTRAM A SCREEN WAS CAUGHT ON THE FENDER & TIRE PULLING IT FORWARD & WHEN IT LET GO IT SPRUNG BACK HITTING HIM. SCREEN NOT BOLTED PROPERLY.

DATE	12/13/1999
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Struck by Objects, NEC
SOURCE	Particles / Dust
EQUIPMENT 1	Rocks / Stones
NATURE OF INJURY 1	Scratch / Abrasion / Scratch to Eye
BODY PART 1	Eye(s)
IMMEDIATE CAUSE 1	Hazardous Environmental Gases / Fumes / Dust
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	None Reported
ACCIDENT DESCRIPTION	INJURED WAS MUCKING DRAWPOINT WHEN IT CAME DOWN CREATING DUST IN THE AREA.DUST IN ATMOSPHERE.

DATE	04/16/2000
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Collision with Standing Vehicle / Object
SOURCE	Tractor / Powered Towing Vehicle
EQUIPMENT 1	Bodily Motion, NEC
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Neck
IMMEDIATE CAUSE 1	Using Equipment / Material Improperly
BASIC CAUSE 1	Improper Motivation
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	INJURED WAS BACKING UP THE TRACTOR WHEN IT SLID INTO THE DITCH HITTING THE WALL CAUSING INJURED'S HEAD TO WHIP BACK INJURING HIS NECK. LOST CONTROL OF TRACTOR:INJURED NOT PAYING ATTENTION.

DATE	07/24/2000
CLAIM STATUS	Lost Time
ACCIDENT TYPE	Struck by Objects, NEC
SOURCE	Battery Locomotive
EQUIPMENT 1	
NATURE OF INJURY 1	Multiple Injuries (More than 2)
BODY PART 1	Multiple Parts (More than 2 Parts)
IMMEDIATE CAUSE 1	Failure to Secure / Make Safe
BASIC CAUSE 1	Improper Motivation
PREVENTATIVE ACTION 1	Incorporate Barriers / Safety Devices
ACCIDENT DESCRIPTION	INJURED WAS INSTALLING A BULLHOSE ACROSS THE DRIFT HE WAS CONNECTING IT TO THE DRAIN LINE WHEN HE WAS HIT BY THE TRAIN. THE HORN ON THE MOTOR IS NOT LOUD:THREE FANS & A SCOOPTRAM RUNNING IN THE AREA: VERY POOR TO NO LIGHTRING IN AREA: TIGHT AREA.

DATE	09/24/2000
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Collision with Standing Vehicle / Object
SOURCE	LHD Vehicle
EQUIPMENT 1	Grizzly
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Multiple Parts (More than 2 Parts)
IMMEDIATE CAUSE 1	No Response Given
BASIC CAUSE 1	Inadequate Engineering / Design
PREVENTATIVE ACTION 1	Design to Eliminate / Reduce Hazard
ACCIDENT DESCRIPTION	WHILE MUCKING THE SCOOPTRAM BUCKET HIT A STEEL PLATE ON THE GRIZZLY CAUSING THE SCOOPTRAM TO SUDDENLY STOP CAUSING INJURED TO HIT THE DOOR HANDLE. PROTRUDING DOOR HANDLES.

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Ontario Mining Industry Reported Traumatic Injuries 1992 - 2006
UG Mobile Equipment - Visibility may have been a factor

DATE	10/25/2000
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Rail Muck Car
EQUIPMENT 1	Couplings / Pipe Fittings
NATURE OF INJURY 1	Contusion / Bruise (Intact Skin Surface)
BODY PART 1	Wrist
IMMEDIATE CAUSE 1	Failure to Warn / Poor Communication
BASIC CAUSE 1	Inadequate Tools / Equipment
PREVENTATIVE ACTION 1	Design to Eliminate / Reduce Hazard
ACCIDENT DESCRIPTION	WHILE TRAMMING INJURED HIT A HEADER FALLING OF THE MOTOR CAUSING THE BACK WHEEL OF THE CAR TO RUN ALONG HIS FOREARM. THE DRIFT IS CONFINED: HEADER WAS NOT MARKED: INJURED BRUSHED THE HEADER ON PREVIOUS TRIP & DID NOT MARK:SEAT IS TIGHT FIT FOR A BIG MAN.

DATE	07/18/2001
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Fork-Lift
EQUIPMENT 1	Floor / Wall of Mine
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Wrist
IMMEDIATE CAUSE 1	Taking an Improper Position for Task
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	AFTER DRIVING THE FORKLIFT INTO THE DITCH INJURED WAS TRYING TO DRIVE IT OUT HE HAD HIS HAND ON THE ROLL BAR & CAUGHT IT BETWEEN THE WALL & THE ROLL BAR. IMPROPER PLACEMENT OF HAND.

DATE	07/21/2001
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Personnel Carrier
EQUIPMENT 1	Screen (Ground Support)
NATURE OF INJURY 1	Cut / Laceration
BODY PART 1	Face, NEC
IMMEDIATE CAUSE 1	Defective / Hazardous Tools, Equipment or Material
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	Repair / Clean-Up
ACCIDENT DESCRIPTION	INJURED WAS RIDING IN THE BUS WHEN HE WAS STRUCK IN THE FACE BY A PRODRUDING SCREEN. SCREEN WAS BROKEN BY FALLING LOOSE:LOOSE BROKE SCREEN.

DATE	08/02/2001
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Collision with Standing Vehicle / Object
SOURCE	Tractor / Powered Towing Vehicle
EQUIPMENT 1	Floor / Wall of Mine
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Back (incl. Spine / Spinal Cord)
IMMEDIATE CAUSE 1	Using Equipment / Material Improperly
BASIC CAUSE 1	Inadequate Capability
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	WHEN DRIVING DOWN THE RAMP INJURED STOPPED ON THE LEVEL HE WAS BACKING UP WHEN HE HIT THE WALL.NOT PAYING ATTENTION TO WHAT HE WAS DOING:INADEQUATE CAPABILITY.

DATE	04/04/2002
CLAIM STATUS	Lost Time
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Piping
EQUIPMENT 1	Fork-Lift
NATURE OF INJURY 1	Fracture
BODY PART 1	Leg, NEC
IMMEDIATE CAUSE 1	No Response Given
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	None Reported
ACCIDENT DESCRIPTION	INJURED WAS RIDING IN A FORKLIFT WHEN THE PIPE THAT WAS IN THE PASSENGER AREA CAUGHT THE WALL SCREEN HITTING HIS LEG.

DATE	06/03/2002
CLAIM STATUS	Lost Time
ACCIDENT TYPE	Collision with Standing Vehicle / Object
SOURCE	LHD Vehicle
EQUIPMENT 1	Floor / Wall of Mine
NATURE OF INJURY 1	Multiple Injuries (More than 2)
BODY PART 1	Hand (Not Wrist or Fingers)
IMMEDIATE CAUSE 1	Failure to Secure / Make Safe
BASIC CAUSE 1	Lack of Skill
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	WHILE CLEANING THE DRIFT THE SCREEN CAUGHT INJURED 'S COVERALLS AT THE SHOULDER MOVING HIS ARM & CAUSING HIS HAND TO BE CAUGHT BETWEEN THE SCOOPTRAM & THE WALL.DID NOT CUT DOWN THE SCREEN:DID NOT LEAVE ENOUGH ROOM BETWEEN THE SCOPPTRAM & THE WALL.

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Ontario Mining Industry Reported Traumatic Injuries 1992 - 2006
UG Mobile Equipment - Visibility may have been a factor

DATE	06/24/2002
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Struck by Objects, NEC
SOURCE	Pressure Lines (Hose or Pipe)
EQUIPMENT 1	High Air Pressure
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Chest (incl. Ribs / Sternum)
IMMEDIATE CAUSE 1	Congestion / Restricted Action
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	Preventative Action, NEC
ACCIDENT DESCRIPTION	INJURED WAS DRIVING THE KUBOTA TO THE FACE WHEN HE WAS STRUCK BY A HOSE. BUCKET CAUGHT LOW HANGING HOSE PULLING IT APART.

DATE	07/25/2002
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Lumber
EQUIPMENT 1	Scissor Lift
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Trunk, NEC
IMMEDIATE CAUSE 1	Using Equipment / Material Improperly
BASIC CAUSE 1	Abuse / Misuse
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	INJURED WAS SITTING ON A BOARD SPANNING THE DECK OF THE SCISSOR LIFT GOING TO THE LUNCHROOM WHEN ANOTHER BOARD HIT THE WALL & STRUCK INJURED. USING EQUIPMENT IMPROPERLY:TAKING AN IMPROPER POSITION:ABUSE & MISUSE.

DATE	11/16/2002
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Ventilation Tubing
EQUIPMENT 1	Front End Loader
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Neck
IMMEDIATE CAUSE 1	Congestion / Restricted Action
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	Design to Eliminate / Reduce Hazard
ACCIDENT DESCRIPTION	WHILE DRIVING THE KUBODA INJURED STRUCK HIS HEAD ON A VENTILATION PIPE.LOW PIPE.

DATE	12/18/2002
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Collision with Standing Vehicle / Object
SOURCE	Haulage Truck
EQUIPMENT 1	Bodily Motion, NEC
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Neck
IMMEDIATE CAUSE 1	Substandard Housekeeping
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	Preventative Action, NEC
ACCIDENT DESCRIPTION	WHILE DRIVING THE HAULAGE TRUCK IT HIT THE WALL JARRING INJURED'S NECK & BACK.ROUGH ROADS.

DATE	06/19/2003
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Haulage Truck
EQUIPMENT 1	
NATURE OF INJURY 1	Amputation
BODY PART 1	Finger(s)
IMMEDIATE CAUSE 1	Congestion / Restricted Action
BASIC CAUSE 1	Inadequate Engineering / Design
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	WHILE BACKING UP THE TRUCK HIT THE WALLTHE GAUGE PANEL CAUGHT THE WALL CAUSING IT TO RAISE & SPRING DOWN ON THE TIP OF INJURED'S FINGER.TURN-AROUND AREA WAS NARROW & SHORT: INADEQUATE ENGINEERING.

DATE	01/24/2004
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Ventilation Tubing
EQUIPMENT 1	Front End Loader
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Neck
IMMEDIATE CAUSE 1	Congestion / Restricted Action
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	Design to Eliminate / Reduce Hazard
ACCIDENT DESCRIPTION	INJURED WAS OPERATING A KUBOTA WHEN HIS HARD HAT CAUGHT ON THE VENTILATION PIPE COMPRESSING HIS NECK.LOW VENTILATION PIPE.

DATE	02/19/2004
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Miscellaneous Ground Support
EQUIPMENT 1	LHD Vehicle
NATURE OF INJURY 1	Contusion / Bruise (Intact Skin Surface)
BODY PART 1	Abdomen (incl. Internal Organs)
IMMEDIATE CAUSE 1	Failure to Secure / Make Safe
BASIC CAUSE 1	Improper Motivation
PREVENTATIVE ACTION 1	Design to Eliminate / Reduce Hazard
ACCIDENT DESCRIPTION	INJURED WAS TOWING ANOTHER VEHICLE WHEN HE BACKED INTO A PROTRUDING ROCKBOLT STRAP IT CAME THROUGHT THER CAB HITTING HIM IN THE KIDNEY.FAILURE TO SECURE MAKE SAFE: PROTRUDING STRAP.

All information in this table has been drawn from WSN's legacy database, now managed by WSN.

Ontario Mining Industry Reported Traumatic Injuries 1992 - 2006
UG Mobile Equipment - Visibility may have been a factor

DATE	03/28/2004
CLAIM STATUS	Lost Time
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	LHD Vehicle
EQUIPMENT 1	Floor / Wall of Mine
NATURE OF INJURY 1	Multiple Injuries (More than 2)
BODY PART 1	Multiple Parts (More than 2 Parts)
IMMEDIATE CAUSE 1	Using Equipment / Material Improperly
BASIC CAUSE 1	Lack of Skill
PREVENTATIVE ACTION 1	Preventative Action, NEC
ACCIDENT DESCRIPTION	INJURED WAS OPERATING THE SCOOPTRAM DOWN THE RAMP WHEN IT HIT THE WALL CAUSING THE DOOR TO OPEN DISLODGING INJURED OUT OF THE UNIT THE SCOOPTRAM CONTACTED HIS FOOT AS IT WENT BY.DRIVING TOO CLOSE TO THE WALL:NOT WEARING HIS SEAT BELT.

DATE	04/07/2004
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Screen (Ground Support)
EQUIPMENT 1	Front End Loader
NATURE OF INJURY 1	Multiple Injuries (More than 2)
BODY PART 1	Multiple Parts (More than 2 Parts)
IMMEDIATE CAUSE 1	Defective / Hazardous Tools, Equipment or Material
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	Preventative Action, NEC
ACCIDENT DESCRIPTION	WHILE DRIVING THE KUBOTA INJURED STRUCK HIS HEAD AGAINST A PIECE OF SCREEN.DAMAGED SCREEN.

DATE	06/03/2004
CLAIM STATUS	Lost Time
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Fork-Lift
EQUIPMENT 1	Floor / Wall of Mine
NATURE OF INJURY 1	Cut / Laceration
BODY PART 1	Forearm
IMMEDIATE CAUSE 1	No Response Given
BASIC CAUSE 1	No Response Given
PREVENTATIVE ACTION 1	None Reported
ACCIDENT DESCRIPTION	WHILE BACKING THE FORKLIFT INJURED CAUGHT HIS ARM BETWEEN THE FORKLIFT & THE DRIFT WALL WHEN SCOOPTRAM OPERATER HEARD INJURED SCREAMING ON THE RADIO HE WENT TO ASSIST.

DATE	10/07/2004
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Collision with Standing Vehicle / Object
SOURCE	Fork-Lift
EQUIPMENT 1	Fork-Lift
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Head, NEC
IMMEDIATE CAUSE 1	Using Equipment / Material Improperly
BASIC CAUSE 1	Inadequate Work Standards
PREVENTATIVE ACTION 1	Design to Eliminate / Reduce Hazard
ACCIDENT DESCRIPTION	WHILE OPERATING THE FORKLIFT ONE OF THE FORKS HIT A RAIL CAUSING IT TO STOP SUDDENLY CAUSING INJURED TO HIT HIS HEAD ON THE ROLL BAR & HIS KNEE ON THE CONSOLE.USING EQUIPMENT IMPROPERLY:INADEQUATE WORK STANDARDS.

DATE	03/08/2005
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Collision with Standing Vehicle / Object
SOURCE	Haulage Truck
EQUIPMENT 1	Floor / Wall of Mine
NATURE OF INJURY 1	Cut / Laceration
BODY PART 1	Scalp
IMMEDIATE CAUSE 1	Inadequate Guards / Barriers
BASIC CAUSE 1	Lack of Skill
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	WORKER WAS IN THE PROCESS OF BACKING UP THE HAULAGE TRUCK WHEN HE STRUCK THE WALL THE SUDDEN STOP CAUSED HIM TO STRIKE HIS FOREHEAD AGAINST THE HANDHOLD. INADEQUATE QUARD OR BARRIER:LACK OF SKILL IN BACKING UP THE TRUCK.

DATE	05/19/2005
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Vehicle Accident, NEC
SOURCE	Piping
EQUIPMENT 1	LHD Vehicle
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Neck
IMMEDIATE CAUSE 1	Improper Placement
BASIC CAUSE 1	Improper Motivation
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	WHILE MUCKING ON THE DECLINE WITH A SCOOPTRAM INJURED HIT HIS HEAD ON A PIPE. HUGGING LEFT PILLAR WHEN MUCKING:SITTING TO HIGH ON SEAT:NOT FOLLOWING WORK STANDARDS.

All information in this table has been drawn from WSN's legacy database, now managed by WSN.

Ontario Mining Industry Reported Traumatic Injuries 1992 - 2006
UG Mobile Equipment - Visibility may have been a factor

DATE	02/21/2006
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Struck by Objects, NEC
SOURCE	Haulage Truck
EQUIPMENT 1	Persons
NATURE OF INJURY 1	Occupational Injury, unspecified
BODY PART 1	Back (incl. Spine / Spinal Cord)
IMMEDIATE CAUSE 1	Inadequate Guards / Barriers
BASIC CAUSE 1	Lack of Knowledge
PREVENTATIVE ACTION 1	Write / Rewrite Procedures
ACCIDENT DESCRIPTION	AFTER ROPPING OFF THE ENTRANCE TO THE FUEL BAY INJURED & PARTNER WERE BOLTING WHEN A TRUCK ENTERED THE FUEL BAY HITTING INJURED WITH THE FRONT TIRE.RED TAPE WAS INADEQUATE:LACK OF KNOWLEDGE:INADEQUATE LEADERSHIP/SUPERVISION: INADEQUATE WORK STANDARDS.

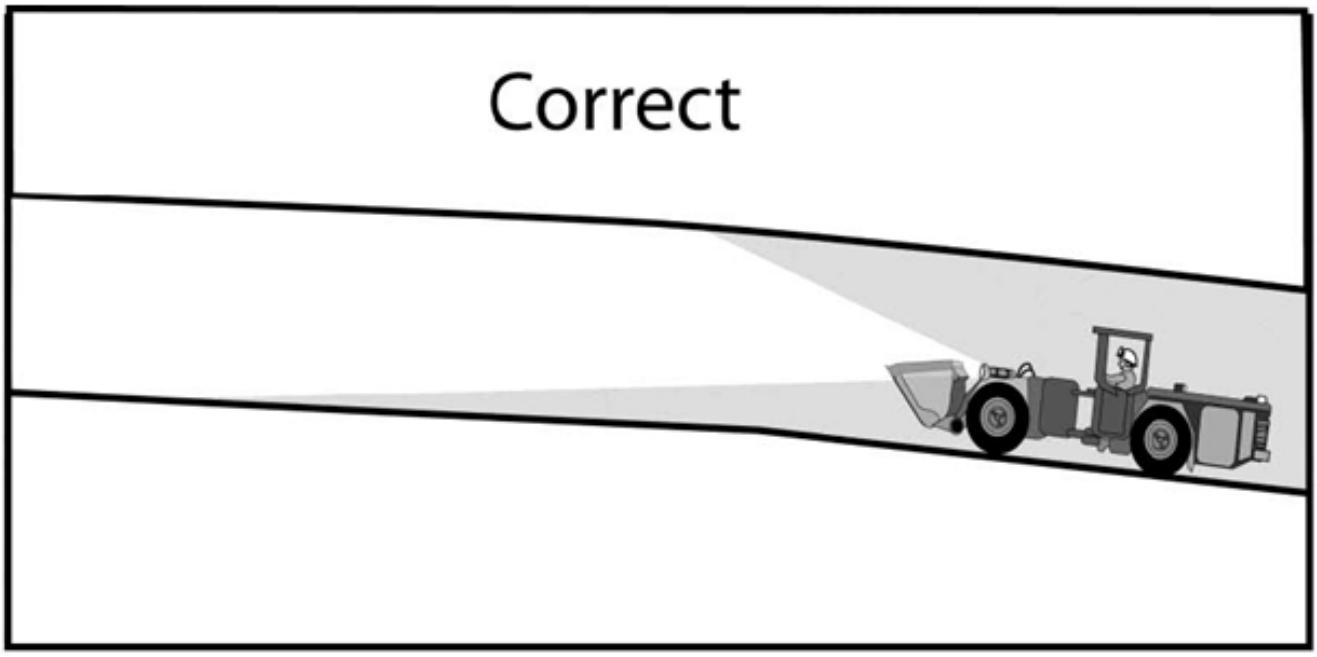
DATE	11/08/2006
CLAIM STATUS	Medical Aid Only
ACCIDENT TYPE	Struck by Objects, NEC
SOURCE	NEC
EQUIPMENT 1	LHD Vehicle
NATURE OF INJURY 1	Contusion / Bruise (Intact Skin Surface)
BODY PART 1	Arm, NEC
IMMEDIATE CAUSE 1	Improper Placement
BASIC CAUSE 1	Inadequate Engineering / Design
PREVENTATIVE ACTION 1	Safety Contact
ACCIDENT DESCRIPTION	WHILE STOPED INJURED WAS SECURING THE BROUSER BASE ON THE FELLS WHEN ANOTHER SCOOPTRAM CAMO DOWN THE RAMP HIT THE BROUSER BAR AT THE END COUNTER LEVELING THE BAR INTO INJURED'S CHEST.LOADING IN A BLIND SPOT:LOADING BAR SO IT WAS STICKING OUT:BUSY AREA.

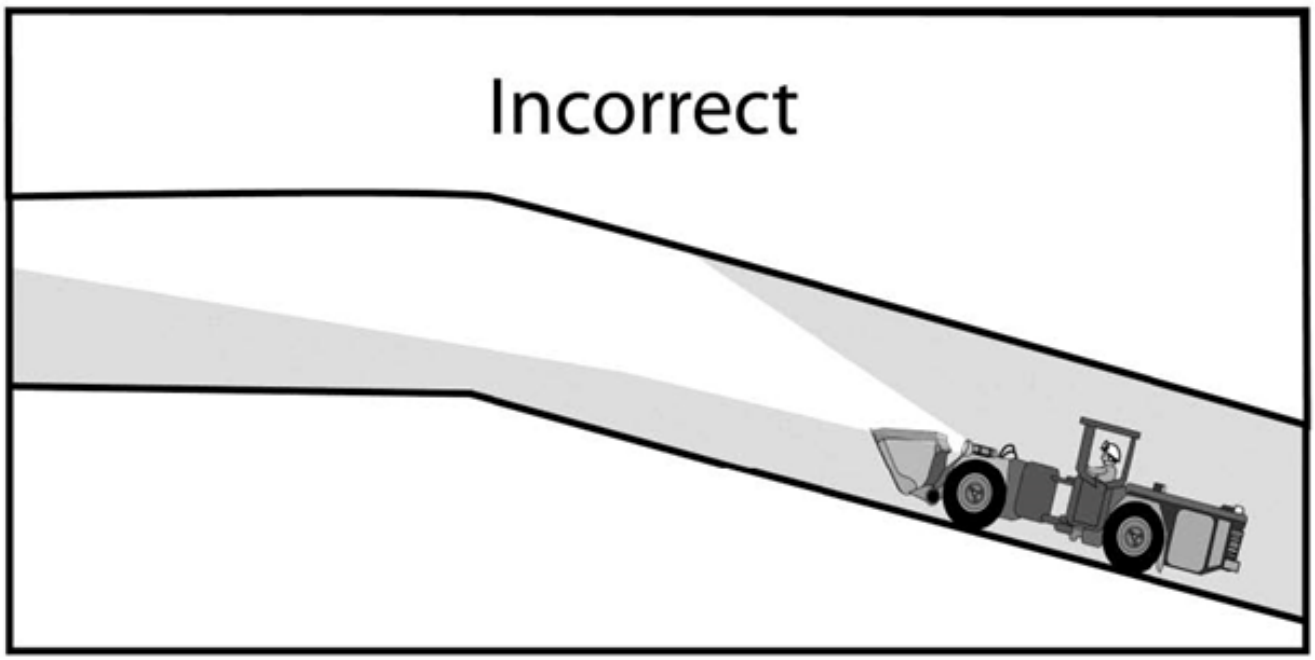
All information in this table has been drawn from WSN's legacy database, now managed by WSN.

Appendix 2 – Sample mobile equipment/pedestrian hazards inventory and risk/hazard register

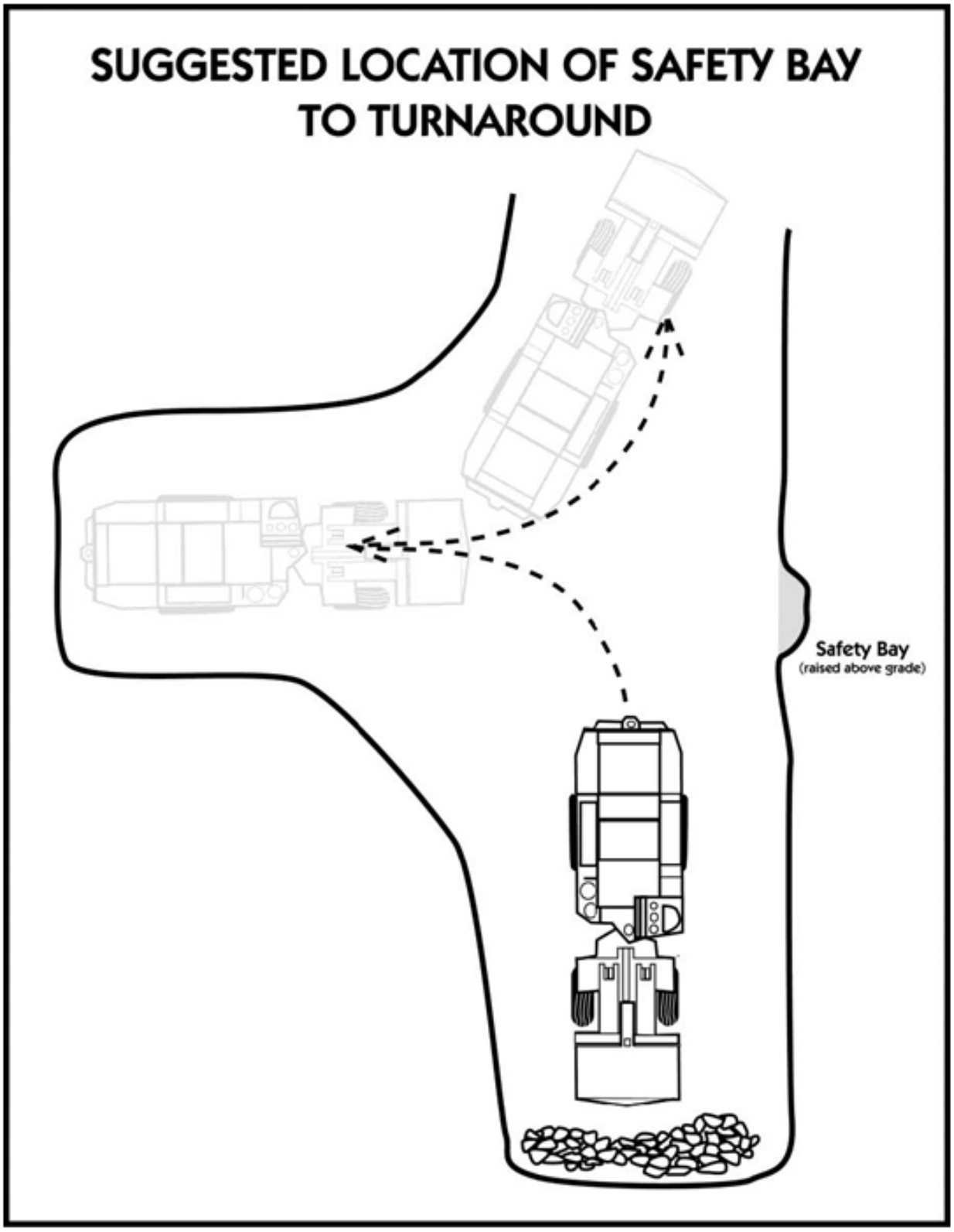
Risk Session Topic: Personal Vehicle Risks								
Activities: means to and from mine sites.		**Team:**			**Rev Date:**			
JOB/TASK DESCRIPTION	HAZARDS / ENERGIES	CONTROLS	RISK ASSESSMENT			TAKE ACTION, MONITOR, REVIEW		NOTES
Description of activity	What are the unwanted events? (Based on Hazards/Energies)	What are the current controls (if any)?	LIKLIEHOOD of an Occurrence	CONSEQUENCES of an Event	ASSESSED RISK	Who is responsible for implementing the control?	Date control was implemented	Opportunities
Driving vehicle	Employee gets into a motor vehicle incident while traveling for work	1. All staff who travel for work regularly, received driver training as needed by certified third party trainer. 2. Employee is expected to follow rules highway traffic act. 3. Follow policies on fatigued driving and night driving. As well as poor driving conditions. Left to the discretion of the staff. 4. Annual review of policies is completed. 5. Automobile safety annually as per policy (note: state policy name). 6. Reminder safety talks, discussions, cultural norms to discuss proper driving. 7. During adverse weather conditions (blizzard, extreme storm, etc.) were expected to wait it out and stay put.	Unlikely	Catastrophic	High			1. Should get phone boosters for vehicles to allow staff to have greater cell coverage. 2. All staff are supposed to carry a spot device. 3. Seasoned field staff bring winter jackets, toques, gloves, snow pants, winter jackets, etc with them.
	Employees vehicle breaks down in remote area exposing worker to vulnerable situation (dangerous people)	1. Call 911 when cell is available.	Rare	Medium	Moderate			
	Employees vehicle breaks down in remote area exposing worker to environmental hazards such as cold conditions.	1. Emergency safety kits which include: blankets, matches, candle, shovels, flashlight, etc. 2. Call 911 when cell is available.	Possible	Medium	High			
	Arrive at a motor vehicle incident and employee gets injury while at the scene.	1. First responder protocol to be followed if deemed necessary (first point, ensure your safety first). 2. Call 911. 3. Traffic control.	Possible	Minimal	Low			
	Motor vehicle collison with animal resulting in injury	1. All staff who travel for work regularly, received driver training as needed by certified third party trainer. 2. Follow policies on fatigued driving and night driving. As well as poor driving conditions. Left to the discretion of the staff. 3. Annual review of policies is completed. 4. Automobile safety annually as per policy (note: state policy name). 5. Reminder safety talks, discussions, cultural norms to discuss proper driving.	Unlikely	Catastrophic	High			
	Employee gets lost while traveling for work	1. GPS or plan travel route via google maps. 2. Smartphone communication to assist where cell coverage is located.	Rare	Medium	Moderate			

Appendix 3 – Vertical curve on ramp





Appendix 4 – Safety bay location at turnaround



Appendix 5 – CS LOS diagram

Computer simulation line-of-sight diagram

Laurentian University has developed a computer simulation line-of-sight assessment method to evaluate the lines of sight of different mobile equipment from point of view of the operator in the cab. The mobile equipment being evaluated in the diagram is placed in a scaled “boxplot” which shows the lighter shaded areas (light grey) as unobstructed lines-of-sight, and the darker shaded areas as obstructed lines-of-sight.

If a two-or three-dimensional drawing is available, Laurentian University can develop a report as a fee for service. Visit https://crosh.ca/ for more information.

Appendix 6 – Suggested cap lamp signals

Examples of common cap lamp signals

When it is necessary for a pedestrian to signal with a cap lamp, the mobile equipment operator should stop the equipment and return the signal. The operator should not move the equipment until the pedestrian signals.

Pedestrians and equipment operators need to follow the signals established by the mine.

Example of common cap lamp signals in underground mines are:

Motion	Meaning
Up and down	Move away from signal
Circular	Move toward signal
Side to side	Stop

Appendix 7 – Related WSN mining sector products

Safe Operation of Remote-Controlled Equipment - Remote controls on mining equipment are intended to remove equipment operators from dangerous situations. However, if not managed well, remote controls can actually cause incidents (and even fatalities). WSN's mining sector guideline, Safe Operation of Remote-Controlled Equipment, is completely updated. It includes sections on:

- procurement,
- commissioning,
- operations,
- maintenance, and
- training,

as well as safe workplace design considerations for specific types of equipment used in a mining environment.

Mobile Mining Equipment Commissioning Checklist – Mobile equipment continues to be a major source of incidents and injuries in Ontario's mines, pits, and quarries. WSN's mining sector technical guideline offers a tool to help control equipment hazards. The Mobile Mining Equipment Commissioning Checklist is intended to help companies improve their initial inspection of new or used mobile machines, making them safer and more reliable when first put into service. This information could also be used when considering purchasing documents, site safety audits and routine preventive maintenance programs.

See and Be Seen: Pedestrian Safety Underground Safety Meeting Package – Every year, incidents occur when pedestrians in underground mines are struck by mobile equipment. Based on WSN's extensive visibility research project for the mining sector, this safety meeting package includes materials to introduce LHD operators and other workers to the hazards related to poor operator visibility.

Underground Mobile Equipment Fires – A fire underground is one of mining's most terrifying hazards. Many of the fires reported underground are related to mobile equipment. Help your workers learn how to prevent those fires with this new set of safety meeting training packages.

Underground Track Haulage Manual - This manual, based on a study of 18 Ontario mines, identifies causes that contribute to the high frequency of track haulage-related incidents while providing information that enables the reader to develop guidelines for future installations or improve existing installations.

Appendix 8 – Collision avoidance device manufacturers

The following is an incomplete list of manufacturers of collision avoidance devices for underground and surface mining operations. The list is intended solely as a starting point for companies considering the use of such devices. A manufacturer's inclusion or exclusion from the list does not reflect an endorsement or otherwise from WSN's mining sector specialists.

Collision Avoidance Safety System by AcuMine Pty Ltd., Sydney, Australia, https://acumine.com/

AMT CAS/CAM - RF by Advanced Mining Technologies, Brisbane, Australia

Becker CAS System by Walter Becker SA, Gauteng, South Africa, https://www.becker-mining.com/

BodyGuard by Orbit Communications Pty Ltd., Ourimbah, NSW, Australia, http://www.orbitcoms.com/

Collision Warning System by Vak Technical Solutions, Beacon Bay, South Africa

Collision Avoidance System by International Mining Technologies, Osborne Park, WA, Australia

GeoSteering TramGuard by Geo Steering Mining Services, Huntsville, AL, USA

Proximity Detection/Collision Avoidance System by Frederick Mining Controls, Huntsville, AL, USA, http://www.frederickmining.com/

J.A.W.S (Jannatec Advanced Warning System) by Jannatec Radio Technologies, Sudbury, ON, https://jannatec.com/

Matrix Miner Monitor by Matrix Design Group, Newburgh, IN, USA

Nautilus Buddy-PDS by Nautilus International, Burnaby, B.C., http://www.nautilus-intl.com/

Northern Light Digital by NL Technologies, Levitt-Safety Ltd., Toronto, ON, https://www.nltinc.com/

Proximity Detection System by Mine Site Technologies, Sudbury, ON

SAFEmine by SAFEmine Ltd., Schwyz, Switzerland, https://hexagonmining.com/