Commissioner for
Resources Safety & Health

Risk assessment education resource

Mining Safety and Health Advisory Committee

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Acknowledgement

The Mining Safety and Health Advisory Committee would like to acknowledge the important contribution of Ms Carmel Bofinger and The University of Queensland Sustainable Minerals Institute in the development of this resource.

Version history

Version	Date	Description of change	Approved by
1	21 March 2023	Initial version	MSHAC Chair

Contents

Figures

Tables

1. Introduction

This resource was developed to assist companies and sites to complete effective risk assessments that provide information to make good decisions about risk management. The risk management framework used in the resource is consistent with *ISO 31000:2018—Risk Management*.

The resource covers the following areas:

- Section 2—Starting point for all risk assessments

  Section 2 introduces the important points common to every risk assessment that should be considered and understood before a risk assessment is started. It includes how risk management links to the safety and health management system.

- Section 3—Steps in any risk assessment

  Section 3 outlines the steps that need to be completed for any risk assessment irrespective of the risk assessment technique used. It provides guidance on why the step is needed and what constitutes good or poor practice.

- Section 4—Common techniques for operational risk assessments

  Different risk assessment techniques can be used depending on why the risk assessment is being completed. Section 4 covers two of the most common tools used for operational risk assessments—the *workplace risk assessment and control* (WRAC) technique and the *bowtie analysis*. It also considers the relationship between the WRAC and the bowtie.

- Section 5—Controls and control effectiveness

  Section 5 considers controls. Controls give an acceptable level of risk. This section includes what we define as a control and how important it is to also consider how effectively the control is implemented and continues to work.

- Section 6—Major hazards and critical controls

  Major hazards are those that have the potential to cause fatalities or other catastrophic consequences. Section 6 covers the identification of major hazards and the critical control identification, implementation, assurance and verification process.

- Section 7—Example templates

  Example templates are provided for
  - a risk register
  - issue/work process risk assessment
  - bowties using Excel, Word or Visio
  - critical control performance criteria.

- Section 8—Example risk assessment for vehicle/mobile plant interactions

  This section uses the management of vehicle/mobile plant interactions as an example of risk assessment and management processes. It covers from the risk being initially identified in the site risk register as a major hazard through the development of the bowtie and the identification of the critical controls and the development of an example of performance criteria. It is included as a practical example to demonstrate the processes discussed in the other sections.

- Section 9—Definitions

  The final section provides definitions of the important terms used in this resource.

Throughout this resource, these tip boxes are used to identify important points.

2. Starting point for all risk assessments

The *ISO 31000:2018—Risk Management* standard outlines the requirements for the effective management of risks. This resource focuses on the completion of the risk assessment that sits at the heart of the risk management framework as shown in Figure 1.

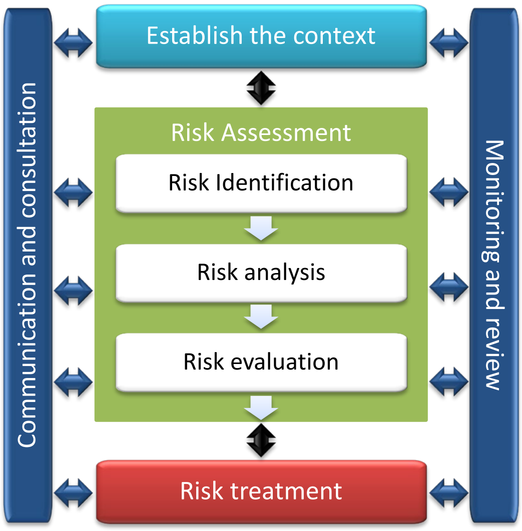

Figure 1 Risk management process

No matter what tool or processes is used, there are some important points common to every risk assessment. Before the risk assessment is started, it is important to understand the following:

- Why is the risk assessment being completed?
- What output is needed from the risk assessment?
- Who needs to be included in the risk assessment team?

It is also important to consider if a risk assessment is the most appropriate process to use to make a decision. Sometimes other processes may be more suitable—for example, a report from an expert—or may need to be completed before the risk assessment is started. This could be in the form of additional information needed about:

- the magnitude of the hazard being considered
- how the hazard is released and any uncertainty
- the type and magnitude of consequences being considered.

Expert advice may need to be obtained before the risk assessment is completed.

2.1. Why is the risk assessment being completed?

There are many reasons why a risk assessment is undertaken.

If the reason the risk assessment is being completed is not clear and understood—it should not be started.

This is the objective of the risk assessment.

A risk assessment will give information to make decisions about the matter that is the subject of the risk assessment. For example, the risk assessment may be completed to:

- identify the hazards and risks associated with a general work process—for example, working at height—to make sure the risks associated with it are well controlled and managed
- ensure an individual task can be completed safely—this would need to consider the steps in the tasks, the hazards associated with the steps and the controls needed
- make a decision between two different work options.

2.2. What output is needed from the risk assessment?

The output from the risk assessment needs to link to the objective and something needs to be done with the information that comes from the completion of the risk assessment.

The output needed from the risk assessment should be identified before the risk assessment starts. Some examples of outputs from risk assessments include:

- a report outlining whether the risk is acceptable and any actions needed to make a risk acceptable if it was found to not be at an acceptable level
- a list of controls that need to be in place before work commences
- the development of a work procedure
- the development of a risk register.

Something needs to be done with the results of a risk assessment. It should not just be a paper exercise.

2.3. Who needs to be involved?

The risk assessment team provides the knowledge and understanding of the work or subject being considered and the associated hazards and risks. The composition of the risk assessment team must be considered carefully. The team must be familiar with the topic.

The members of the risk assessment team should be recorded on the risk assessment.

2.4. Linking the risk assessment with the safety and health management system

There are different levels of risk assessment needed to address the different reasons for completing a risk assessment. These can be considered as four levels and they are supported by the risk management system within the safety and health management system. The four layers are shown in Figure 2.

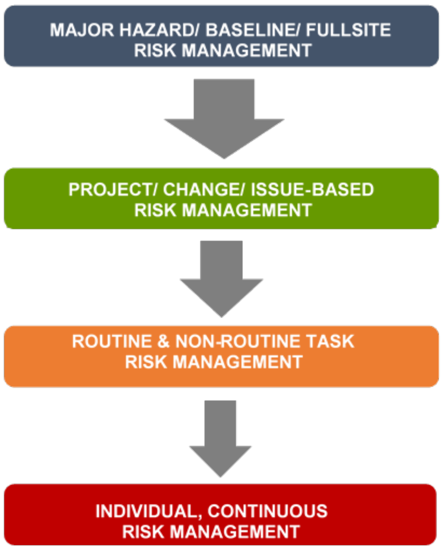

Figure 2 Four-layer risk management model

Table 1 outlines the basic requirements for each level. Further information on the WRAC and bowtie risk assessment techniques is included in the following sections.

Table 1 Risk assessment levels in safety and health management systems

Level	Common risk assessment techniques	Why	When	Who By
Level 1—Major hazard/baseline/ full site	WRAC	To establish site risk register To identify major hazards and material risks	Annually or as required by changes to operations	Management and relevant cross section of workforce
	Bowtie	To further analyse major hazards to ensure risk management and control		Relevant cross section of workforce including managers and supervisors External expertise if appropriate
Level 2—Project/change/ issue based	WRAC	To analyse risks present due to projects, changes or new issues	As required by site or company or due to changes. When a task is too complex to be covered by a task-based risk assessment (e.g. JSA)	Team members with relevant knowledge and experience External expertise if appropriate
Level 3—Routine and non-routine task management	WRAC	To analyse the risks associated with a process or task	To allow the development of safe operating procedures/work procedures and the development of safe work method statements (SWMs) or safe work instructions (SWIs)	Team members with relevant knowledge and experience
	Job safety analysis (JSA)/job hazard analysis (JHA)	To identify hazards associated with a task and ensure adequate and effective controls are in place	Prior to the start of a task if there is no work procedure or work instruction or whenever conditions associated with the task change	Supervisor and team members who will be completing the task
Level 4—Individual, continuous	Individual risk assessment e.g. Take 5, SLAM	To identify hazards associated with the work or in the work area and controls needed	Prior to the start of work or if the work or conditions change	Individuals performing work

As part of the management of risks there are additional parts of the safety and health management system that are linked to the type of hazards and high-risk activities. These include documented company or site standards, procedures and requirements for permits to be completed. Some examples of these activities and the links to standards and permits are shown in Table 2.

Table 2 Links to safety and health management systems

High-risk activity	Standard/procedures	Permit
Working at heights	Working at heights	Working at heights
Confined space work	Confined space	Confined space entry permit and rescue plan
Electrical	Electrical safety	High voltage electrical work permit Electrical work permit for testing and fault finding
Cranes, slings and lifting	Lifting and cranage	High-risk crane work permit
Isolation	Isolation Standard	May be required

3. Steps in any risk assessment

In any risk assessment, it is important to look beyond the boundaries of a single operation to identify good practice. This could be outside your organisation or in another industry.

3.1. Setting the scope

The first step in any risk assessment should be to define the scope of the assessment. This scope will identify what is to be included in the risk assessment and, equally importantly, what is not to be included in the risk assessment. Clearly defining the scope also allows a review of the risk assessment after it is completed to check that everything in the scope was included and nothing outside of the scope is included.

An example of a simple scope for vehicle interactions is shown in Table 9.

3.2. Completing the risk assessment

Table 3 includes the next steps for any risk assessment. It includes examples of *good practice* to be used and *poor practice* to be avoided to ensure a good result from the risk assessment.

The quality of the risk assessment greatly depends on:

- identifying and understanding the hazards
- identifying the unwanted events and assessing the risks.

Table 3 Steps in a risk assessment

Risk assessment step	Purpose of the step	Good practice	Poor practice
Identify the risk	• To understand the hazards • Identify the unwanted events associated with the hazards	Break down a system/process into steps to: • Identify the type, nature and magnitude of the hazards. • To identify what, why and how the unwanted event associated with the hazard can occur.	• Not considering the full range of potential hazards associated with the issue or not having information available about the nature and magnitude of a hazard and continuing the risk assessment. • Considering the hazard rather than the unwanted event resulting from release of the hazard.
Analyse the risk	• To develop an understanding of the risk in terms of – likelihood and consequence – to prioritise the risks based on matrix used. • Identify the controls that affect the likelihood or consequence of the unwanted event.	• Using definitions of likelihood and consequence that are consistent with the reason the risk assessment is being undertaken. For the WRAC analysis, both likelihood and consequence are considered. For the Bowtie, only consequence is usually considered as explained in Section 6.1. • Defining what is acceptable to be considered as a control. The Hierarchy of Control is a good model to include. This should include whether the controls are adequate and how effective the identified control is. Only effective controls will change the likelihood or consequence and therefore the risk rating. Control effectiveness should be checked. Deciding whether controls are adequate can be subjective – these need to be checked.	• Definitions used for likelihood and consequence not understood or appropriate to the risk issue. All members of the team not using consistent definitions. • Team is not concerned with type of controls or the adequacy or effectiveness of the controls. Controls are not clearly identified e.g. Procedure 21 is listed as a control with no further identification or recognition that this is documentation and not a control. The team assume that controls are working
Evaluate the risk	Evaluate the risk using the risk acceptability criteria or identify the level of risk indicating a priority risk to make a decision if risks are acceptable, unacceptable or need to reduce to an ALARA level.	Risk evaluation attempts to define what the estimated risk actually means to people concerned with or affected by the risk Risk acceptance criteria are the limits above which a risk will not be tolerated. Qualitative risk assessments focus the discussion on the higher priority risks. Risk acceptability will be determined by the type and effectiveness of the controls.	No acceptable risk standard exists. The acceptability of risk is defined solely by where the risk sits on the risk matrix. Type and effectiveness of controls is not considered.

Risk assessment step	Purpose of the step	Good practice	Poor practice
Treat the risk	When an unacceptable risk remains after existing control are considered, new controls are needed to make the risk acceptable	All unacceptable risks are addressed with improved existing or new controls to ensure the risk is managed or the work is not undertaken. Accountability is assigned for the implementation of the improved or new controls with a timeframe for implemented. Management approval is provided or the reason for not going ahead with the new controls is communicated. The new controls are checked to confirm they provide the anticipated level of protection.	No accountability or check to see if additional controls are implemented and if they provide the level of protection anticipated The risk is re-assessed on the basis of identified but unimplemented controls. This gives a perception of the level of risk that is not current.
Non-consensus items	Risk assessments are completed by a team. Where the team is unable to agree on any part of the risk assessment, these items need to be noted and referred to management by the risk facilitator. As examples, these areas could include the risk rating or the effectiveness of controls.	Non-consensus items and the management decisions relevant to the items are reported. A template for the reporting of non-consensus items is shown below.	Non-consensus items are not recorded or are ignored.

Non-consensus report

Risk Issue	Reason for non-consensus	Referred to	Management decision	Actioned by

4. Common techniques for operational risk assessments

The principles and steps previously discussed are common for any risk assessment. Different risk assessment techniques are used for different reasons depending on why the risk assessment is being completed. The two most common tools used in the resources industry are:

- Workplace risk assessment and control (WRAC)—A WRAC is a team based, proactive or pre-event risk assessment completed to ensure that risks are understood and controlled to an acceptable level. A WRAC is a qualitative risk assessment method that allows the understanding of risks and identifies the priority of the risks using a risk matrix that considers the likelihood of the event occurring and the consequences should the event occur. A number of risks can be included in each WRAC.
- Bowtie analysis—A bowtie risk analysis is also team based and focusses on a single unwanted event associated with an uncontrolled hazard. It is used to understand and manage the risks that are of greatest concern—the major or principal hazards. The bowtie diagram is used to demonstrate that hazards and unwanted events are being controlled, and that there is a direct link between the preventative controls and the causes of the unwanted events, and also a direct link between the mitigating controls and the consequences of the unwanted event. Bowtie diagrams can also be used as an effective tool to communicate risks and show where controls act.

These are two very different techniques and are used for different purposes. Details and examples of each of these risk assessment techniques are shown in Sections 4.1 and 4.2.

4.1. Workplace risk assessment and control

The WRAC can be used for many purposes from developing a company or site risk register to understanding the risks associated with work processes. There are a number of steps that need to be completed to ensure a *good* risk assessment result.

The questions asked in Section 2 need to be answered for a WRAC. The reason for completing the risk assessment and the output required need to be clear. A team needs to be selected that has the knowledge and skills required.

4.1.1. Definitions for consequence and likelihood

The WRAC analyses and prioritises the risks based on the consequence and likelihood. Therefore, there needs to be clear definitions of likelihood and consequence that are understandable by the team and are used consistently throughout the risk assessment. It is also important to be clear if the current controls and the control effectiveness are considered in determining the level of consequence and likelihood.

The risk assessment could consider a number of different consequences such as:

- most likely consequence
- maximum possible or maximum foreseeable consequence
- maximum reasonable consequence.

There is no right or wrong definition of consequence. It needs to relate to the reason for completing the risk assessment and this is why the reason for the risk assessment must be clear before it starts. For example:

- A risk assessment to identify major hazards at a site might consider the maximum possible or maximum foreseeable consequence without considering the current controls. The objective may be to identify what can kill people.
- A risk assessment to identify the current risk posed by a work process might consider the maximum reasonable consequences considering the current controls and how effective they are. This would provide an understanding of how well managed the risks are and the risk level faced with controls in place.

The likelihood can refer to the likelihood of:

- the unwanted event occurring—for example, someone falling from height
- the consequences occurring—for example, someone dying from falling from height.

These are different likelihoods that will result in different risk ratings.

The most important thing to remember is whichever definitions are used, they are used consistently throughout the risk assessment by the whole team. This is the only way the risks can then be successfully prioritised.

4.1.2. Risk assessment matrix

The risk assessment matrix is a crucial tool in risk management for two reasons:

1. Prioritisation of risks.

> *All risks aren't equal. A risk matrix allows prioritisation of the most severe risks the company/site faces. By color-coding these risks in a risk assessment matrix, personnel can identify the most pressing threats and manage them.*

2. Targeted strategy for managing risks.

> *The risk matrix enables personnel to develop targeted strategies for managing high risk events.*

These risks have the biggest impact and can pose the greatest losses and are often identified as major or catastrophic risks. They are discussed further in Section 5.

The risk matrix can give two values depending on the reason for the risk assessment. It can identify the *inherent* risk—i.e. the risk with no controls—and the *current* risk—i.e. the risk with the current controls in place and effective. It is not good practice to re-evaluate the risk after *proposed* or *new* controls are identified. These need to be in place and proved to be effective before the risk level changes.

There are different types of risk matrixes. One example of a risk matrix is shown in Table 4.

Table 4 Example risk matrix

	Consequence				
Likelihood	**1 Minor**	**2 Low**	**3 Medium**	**4 High**	**5 Major**
5—Almost certain	Medium	Significant	Significant	High	High
4—Likely	Medium	Medium	Significant	High	High
3—Possible	Low	Medium	Significant	Significant	High
2—Unlikely	Low	Low	Medium	Significant	Significant
1—Rare	Low	Low	Medium	Medium	Significant

Depending on the level of risk identified, different actions and higher level of approval may be needed before work commences or continues.

It is important to understand that not all risks will be LOW and GREEN.

Some risks may be higher but will be well managed and therefore acceptable. An example of the actions taken based on the risk rating is shown in Table 5.

Table 5 Risk measures

Risk level	Risk measures
High	Immediate action required Identify and implement controls to manage risks Highest level of management needs to be involved
Significant	Immediate action required Identify and implement controls to manage risks Senior site management needs to be involved
Medium	Implement control to manage risks Responsibility must be defined
Low	Implement controls as required Manage by routine processes

4.1.3. Descriptors used in risk matrix

Table 4 shows a 5x5 matrix—there are five levels of consequence and five levels of likelihood. Other matrixes may have additional levels of consequence. Some multinational companies have seven levels of consequence with the original five applying to site operations and the top two applying at corporate level.

It is important that the descriptors for both likelihood and consequence match the type of risks being considered. These can vary depending on the risks.

Likelihood descriptors

There are a number of ways to express likelihood. This can be in terms of timeframe of occurrence, history of occurrence or probability of event occurring. An example of the different descriptors used for likelihood is shown in Table 6. It is important that it is clear if the likelihood refers to the unwanted event occurring or the consequence of the unwanted event occurring.

Table 6 Example of likelihood descriptors

Likelihood level	Description
Almost certain	Could occur several times a year Could be expected to occur during a project >80% likely to occur
Likely	Could occur within a 1 year Could easily occur during a project 60%-80% likely to occur
Possible	Could occur in a 1 – 2 year period Occurred in a small number of projects 30%-60% likely to occur
Unlikely	Could occur in a 2 – 5 year timeframe Known to have happened in industry 5%-30 % likely to occur
Rare	Could occur in > 5 year timeframe Has not occurred but could <5% likely to occur

Consequence descriptors

The descriptors used for consequence will vary depending on the type of consequence considered. For example, the risk assessment may be considering safety, health, environment, community, reputation, legal or other factors such as financial or productivity consequences.

An example of the different descriptors used for consequence is shown in Table 7.

Table 7 Example of consequence descriptors

Severity level	Safety	Health	Environment	Community	Legal/regulatory
5 Major	Fatality or significant permanent disabling injury	Fatality or significant life shortening effects	Destruction of important habitat, species or natural environment Regulatory significant	Widespread community unrest and/or adverse national/international media coverage	Significant prosecution action
4 High	Serious injury resulting in permanent disabling injury	Exposure resulting in life-impacting health effects	Extensive and measurable medium-term impact on habitat, species or natural environment	Community alarm at regional level and adverse local/regional media coverage	Formal, higher-level intervention Regulatory investigation or prosecution
3 Medium	Lost time injury or requiring non-emergency hospitalisation	Significant adverse health effect needing medical treatment or management	Localised medium-term impact on habitat, species or natural environment	Co-ordinated community concern at a local level and limited local media coverage	Formal intervention at site but unlikely to escalate if complied with
2 Low	Treatment by a medical professional No lost time	Some functional impairment needing treatment	Localised short-term impact on habitat, species or natural environment	A cluster of complaints and local media interest	Limited intervention e.g. field report
1 Minor	First aid injury	Limited or no effect on ability to function	No discernible impact on habitat, species or natural environment	Isolated compliant from local individual	No penalising actions and intervention limited to observation

4.1.4. WRAC templates

Because WRACs can be used for a number of different purposes, different information will be included, and this may need different templates. For example, a WRAC can be used to:

- develop a risk register
- assess a project or issue
- assess a work process.

Example templates are shown in Section 7.

4.2. Bowtie

A bowtie risk analysis considers a single unwanted event and is used to focus on the controls and the control strategy.

A bowtie also requires the questions from Section 2 to be answered. The reason for completing the risk assessment and the output required need to be clear. A team needs to be selected that has the knowledge and skills required. However, a bowtie does not usually consider the likelihood of the unwanted event occurring. It focusses on the high consequence events that can occur.

A bowtie analysis is of most use in the following situations:

- More detail is needed about the causes and consequences of a risk than is contained in a risk register—for example, for major hazards.
- The focus is on identifying controls, control effectiveness and control gaps and ensuring that each pathway has appropriate and adequate controls.
- The overall control strategy needs to be confirmed.
- Where a picture may be much clearer than text, or a simple diagram is required to communicate the range of causes and consequences and the associated controls.

4.2.1. Components of a bowtie

As shown in Figure 3, a bowtie—named after its shape—contains six main elements:

1. Hazard—as with any risk assessment, a bowtie analysis starts with the hazard.
2. Unwanted event—the next step is to define the unwanted event that forms the knot of the bowtie. This is when control is initially lost over the hazard.
3. Causes—these lead to the unwanted event occurring and can cover a range of causes—for example, people, equipment, work environment, or organisational or system issues.
4. Consequences—these result from the unwanted event. There can be more than one consequence for each unwanted event—for example, health and safety, environment, legal or reputational.

5. Preventive controls—preventive controls act to either prevent the causes occurring or, if they do, to not result in a loss of control i.e. the unwanted event.
6. Mitigating controls—mitigating controls make sure that if the unwanted event occurs, it does not result in the consequences and/or they mitigate the impact.

Figure 3 was developed using one of the software programs available. While a number of these are available, bowties can also be developed using Excel, Visio or Word. Other example bowtie templates using Excel and Word are shown as Figure 8 and Figure 9.

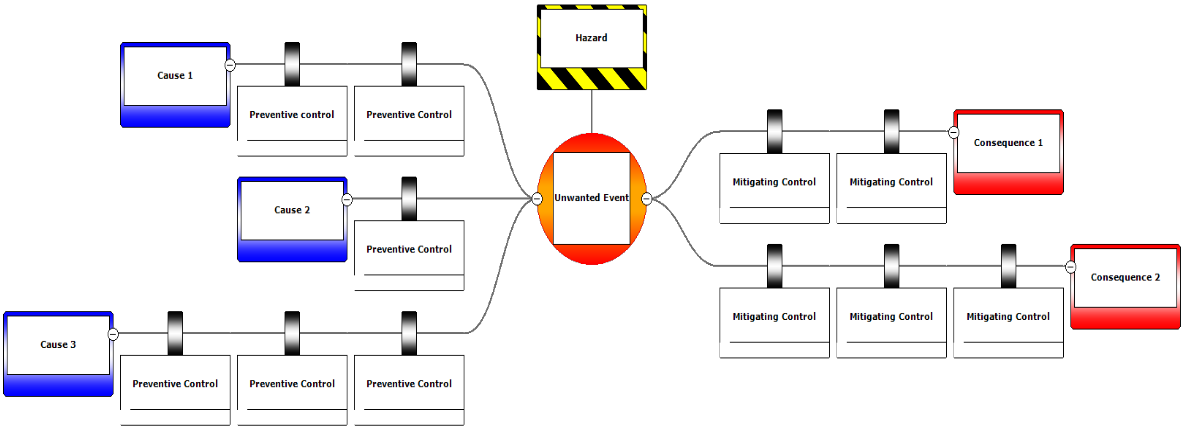

Figure 3 Parts of a bowtie

4.3. Relationship between WRAC and bowtie

Both WRAC and bowties can be completed for different reasons. However, there can be a close relationship between a WRAC and a bowtie. A WRAC can be used to identify major or principal hazards and associated unwanted events, usually based on the level of consequence without considering the controls. These are often defined in terms of potential fatalities—either multiple or single fatalities. These are the risks where the consequence level is so high, that the risk must be controlled even when the likelihood of the unwanted event occurring is very low. A bowtie can then be used to ensure there are adequate and effective individual controls and a good overall control strategy. This is part of the treatment of the major hazards as shown in Table 1.

The following steps outline the direct connections:

1. Use the WRAC—perhaps in the form of the site register—to identify the high consequence risks to be examined in the bow tie analysis. Bow tie analysis is of most use for risks that have high consequences.
2. List the causes of the associated unwanted event on the left and the consequences of the risk on the right, using material from the WRAC where possible.
3. List the existing and required controls for the causes—preventive controls—and the controls for the consequences—mitigating controls. These may have already been identified in the WRAC. Ensure they meet the definition of a control.

5. Controls and control effectiveness

As the focus of risk management is on the controls, it is important to clearly define what is acceptable as a control.

Many companies use the International Council on Mining and Metals (ICMM) definition of a control taken from the *Health and Safety Critical Control Management Good Practice Guide* as shown in Figure 4.[1]

Using this definition means that policies, standards, procedures and other documents are not controls. They may identify the controls needed but they are not controls themselves. It also means that some of the systems used are not controls—for example, the training system or some monitoring or inspection systems.

This does not mean they are unimportant. These documents and systems are important as part of the control management system. They may be support systems for the controls that ensure the controls remain effective or they may be verification processes to check on the condition and effectiveness of the control.

The relationship between these support and verification systems and the controls is shown in Figure 5. Together they make up the control management system.

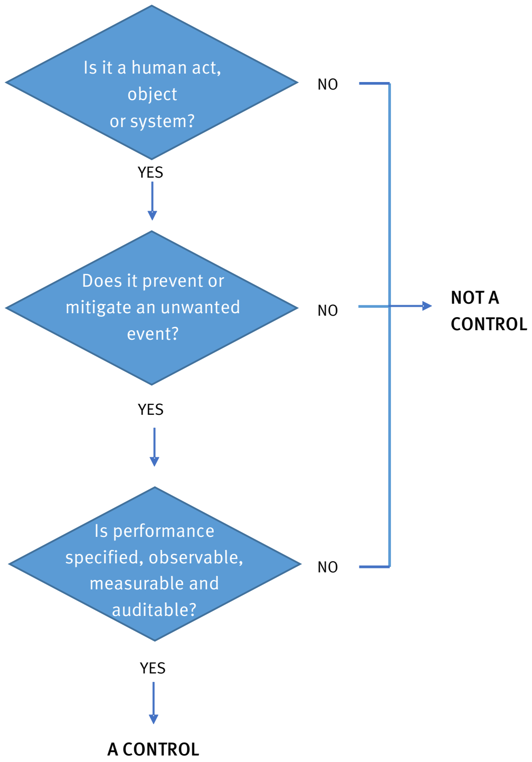

Figure 4 International Council on Mining and Metals definition of a control

[1] https://www.icmm.com/en-gb/guidance/health-safety/2015/ccm-good-practice-guide

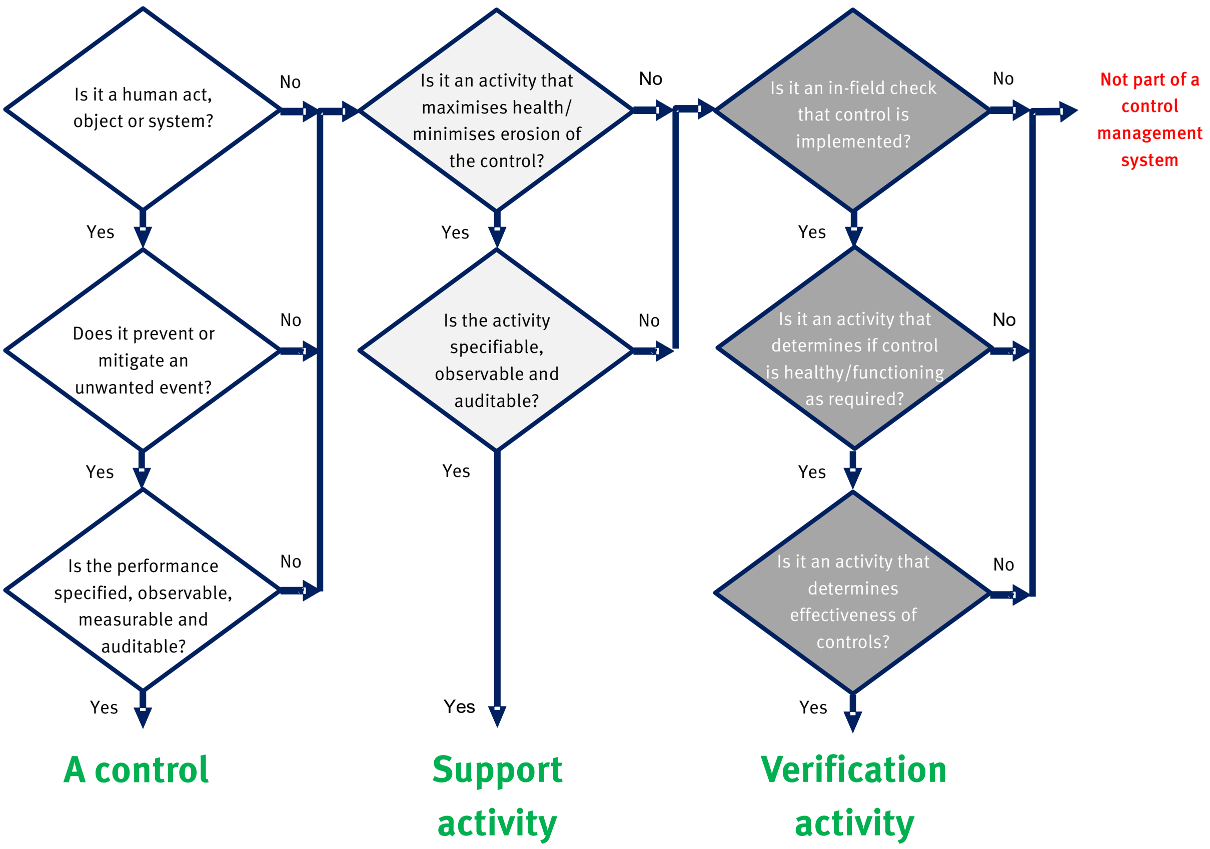

Figure 5 Control management system

In addition to identifying the controls, the effectiveness of the controls must also be considered.

The following actions will assist in determining the effectiveness of the controls.

- Assess the effectiveness of each control, by asking, “Is it designed well (should it work)?” and “Is it implemented well (does it work)?”
- Identify options for improving existing controls, to improve their effectiveness or to fill gaps. This may include additional monitoring and more frequent review.
- Look for gap where there are inadequate or no controls.

6. Major hazards and critical controls

6.1. Major hazards and catastrophic risks

Major hazards or catastrophic risks are defined as those that have the potential to result in one or more fatalities. The number of fatalities used to define this level of risk varies across organisations from a single fatality to multiple fatalities. These are sometimes also identified in legislation or by organisations.

When considering the risk associated with major hazards, focus on the consequences that are at the highest level.

The likelihood of the event leading to the fatalities may be low but, as the consequences are so high, we need to ensure these risks continue to be well managed even if they occur infrequently.

6.2. Critical controls

Critical controls are identified when the consequences of an unwanted event can lead to fatalities or other catastrophic consequences. These are called different names by different organisations—for example, catastrophic risks, material unwanted events, major hazards. It is important for the organisation/site to set the level of consequence for the use of critical controls.

The definition of a critical control and how it is selected remains a challenge. The flowchart shown in the ICMM *Health and Safety Critical Control Management Good Practice Guide* uses the following questions to assist in determining if a control is critical:

- Is the control crucial to preventing the event or minimising the consequences of the event? If yes, consider if a critical control.
- Is it the only control, or is it backed up by another control in the event the first fails? If the only control, consider if a critical control.
- Would its absence or failure significantly increase the risk despite the existence of the other controls? If yes, consider if a critical control.
- Does it address multiple causes or mitigate multiple consequences of the material unwanted event? If yes, consider if a critical control.

Critical controls are the most important and effective controls used to manage major hazards and require additional checks and verification to ensure they are working as expected and when needed.

There is no guideline that prescribes the number of critical controls needed. It is possible to have too few or too many. The problem with too few is that the risk may not be most effectively managed. The problem with too many is that the workload associated with the critical control management system may be so great that the system becomes unmanageable and unsustainable. Again, the risk may not be effectively managed.

6.3. Critical control assurance and verification

Most importantly, critical controls are the controls that get an extra level of focus. This includes identifying the things that impact on their effectiveness and how they can fail—the erosion factors. There are also additional verification processes and reporting requirements.

Critical control performance criteria and verification processes are closely linked. Some companies combine these into a single document. Others have separate performance criteria and verification tools.

6.3.1. Critical control performance criteria

Critical controls need to be managed and the first steps in this process include:

- Defining the objective of the critical control—What is it meant to do?
- Defining the performance requirements—How is it meant to act?
- Identifying activities and factors that impact on control performance—The factors that support performance or erode performance—erosion factors. These will be different for acts, objects and systems. Understanding how a control can fail and what influences that is important if the assurance and verification processes are to be effective.
- Defining the control assurance management plan and verification or checking activities.
- Defining the triggers for stopping or changing operation based on the critical control performance.

Together, these provide the performance and reporting criteria needed.

Unless the details of the critical control are clearly defined, it is not possible to ensure the control is functional, available, reliable and effective.

The performance criteria need to be:

- specific for the critical control and site requirements
- measurable
- appropriate for the objective of the critical control
- realistic within the operating environment.

If the performance criteria are not defined well, it will result in varying understanding of what is an effective control. For example— the performance criteria defines that vehicles must maintain a *suitable* separation distance rather than a defined distance. A suitable distance may be different for different people. Performance criteria need to be objective and not subjective or open to interpretation.

The final step in defining the performance criteria is determining the triggers for stopping or changing operation based on the critical control performance. This step involves pulling up the management system for the critical control to determine what has gone wrong. It is not simply stopping a task—although that may be a trigger for identifying that the critical control is not working—it involves checking the whole system to see why the critical control is not performing to the required standard.

Clearly determining these *stop points* is vital for a successful system. The triggers must be clear, otherwise people may not stop.

There are particular challenges with defining the performance requirements and activities when we consider acts as controls. Objects are much simpler to define and monitor. For example, it is a simple process to check if a pump is in place and pumping at the required rate. However, determining if acts are being completed correctly and in a timely manner by people who are competent to complete those acts is more complex. Considering the erosion factors influencing acts as controls can help to better identity the performance criteria.

The ICMM *Health and Safety Critical Control Management Good Practice Guide* includes examples of performance criteria templates. Example templates for the development of critical control performance criteria are included in Section 7. It is important that each organisation/site develops templates that account for the unique circumstances of that site and provide meaningful information for their use.

6.3.2. Critical control verifications

After the performance requirements have been determined for each critical control, the site needs to develop the verification materials, tools and processes that are needed to confirm the performance criteria are met. This is where the extra verification steps for critical controls are designed.

The verification processes may be in the form of:

- checklists
- interviews with operators
- maintenance completion details
- safety observations
- in-field inspections
- other suitable processes.

In addition to the processes needed, the frequency of the verification processes must be determined. These need to be at a frequency that is meaningful for the benefit of the verification process to be realised. For example, if a verification process related to a review of calibration records and the calibrations are done monthly, it could be appropriate to verify the completeness of the records every three months. The scheduling and accountabilities for these assurance and verification activities must be defined. The frontline assurance processes are often already in place and included in procedures. The verification processes may need to be developed in addition to what is already in place.

Where possible, information that is already being gathered should be used for verifications. It is not always necessary to put additional activities in place.

An example of verification tasks for a critical control for essential safety components for vehicles is shown in Table 8.

Table 8 Example critical control verification tasks

Critical control verification task	Task details	By whom	How often
Infield observation of vehicle pre-start	Observe a minimum of 2 operators completing pre-start vehicle checks. Confirm all critical safety components are included ie brakes, steering	All site supervisors	1 every month
Infield observation of vehicles conducting brake tests before entering underground	Observe a minimum of 2 operators conducting brake tests on vehicles before entering underground. The brake test involves the operator engaging the brake and coming to a complete stop at the stop sign. The equipment should not move forward	All site supervisors	1 every month
Review of completion of checks and service of braking and steering system	Verify that checks and maintenance for brake and steering systems have been completed as per the schedule	Superintendent Mobile Maintenance	Quarterly

It is also important to remember that the assurance and verification processes can be modified in terms of detail and scheduling as more is learned about the factors affecting the performance of the critical control. If limitations are found with the critical control during the initial assurance or verification checks, the frequency of checking might be increased and vice-versa if the control is found to be operating well whenever checked.

Examples of critical control performance standards and verification information for vehicle interactions is included in Section 8.

7. Example templates

7.1. Risk register template

An example of a basic risk register is shown in Figure 6. The objective of the risk register is to identify and assess all the risks at a site to determine the most significant risks and where additional work/controls needs to be done.

Additional information and columns can be added as required.

- Risk identification
  - Work area—divides the site into work areas to ensure full coverage.
  - Hazard—includes the identification of all hazards in the area.
  - Unwanted event—identifies how the hazard can result in an unwanted event occurring.
- Risk analysis
  - Maximum foreseeable consequence—the different types of consequences to be considered and the level of consequence without considering the current controls. This allows the identification of the major or principal hazards with the most serious consequences. These major hazards should have further analysis completed to ensure they are, and remain, managed to an acceptable level either through a bowtie analysis or a more detailed WRAC analysis. For the risk register, different types of risks might be considered or, if it is only a health and safety register, only health and safety would be considered.
  - Current controls—the controls in place now. For the risk register, clarification of what is acceptable as a control is needed. It should be confirmed if the act, object or system definition is to be used or if a broader definition of control is acceptable at the risk register level.
  - Control effectiveness—how effective these controls are in terms of design, implementation and maintenance. This may be the view of the team during the risk assessment and should be verified.
  - Rating likelihood, consequence and risk using the risk matrix.
- Risk acceptability—is the risk at an acceptable level given the current controls and the control effectiveness? This should also consider ALARA. A risk does not need to be *low* to be acceptable if the risk is well managed through the current controls.
- If the risk is not acceptable—what additional controls or actions are needed? These need to have accountability assigned to ensure they are completed.

Figure 6 Example of risk register template

1—Risk identification			2—Risk analysis											3—Risk evaluation	4—Risk treatment
Work area	Hazard or risk element	Unwanted event	Maximum foreseeable consequence						Current controls	Control effectiveness				Risk acceptability	Actions to be taken
			Health and safety	Environment	Community	Reputation	Legal	Financial			Likelihood rating	Consequence rating	Current risk rating		

7.2. Issue/work process template

Figure 7 is an example of a basic work process risk assessment. The objective is to have a more detailed understanding of the risks associated with a particular work area or process.

Additional information and columns can be added as required:

- Risk identification
  - Hazard/unwanted event—identifies the hazard and the associated unwanted event.
  - Consequences to be considered—a range of different consequence at different levels could be included.
  - Cause—why the unwanted event or consequences can occur—for example, it could be because of systems, people, work environment, weather etc.
- Risk analysis
  - Current controls—the controls in place now. For this risk assessment, the controls must be linked to the causes. At this level of risk assessment, the act, object or system definition should be used.
  - Control effectiveness—how effective these controls are in terms of design, implementation and maintenance. This may be the view of the team during the risk assessment and should be verified.
  - Rating likelihood, consequence and risk using the risk matrix.
- Risk acceptability—Is the risk at an acceptable level given the current controls and the control effectiveness?
- If the risk is not acceptable—What additional controls or actions are needed? These need to have accountability assigned to ensure they are completed.

1—Risk identification			2—Risk analysis					3—Risk evaluation	4—Risk treatment
Hazard/ unwanted event	Consequences to be considered	Cause	Controls	Control effectiveness	Likelihood rating	Consequence rating	Current risk rating	Risk acceptability	Actions to be taken

Figure 7 Example of work process risk assessment template

7.3. Bowtie template

As the focus of the bowtie is on the controls, it is important to clearly define what is acceptable as a control before starting the analysis.

Figure 8 is an example of a bowtie developed using Excel. It contains the six elements of the bowtie and all the information required is present. This template does not line the controls along the causal or consequence pathways and it does not give a pictorial representation of the risk.

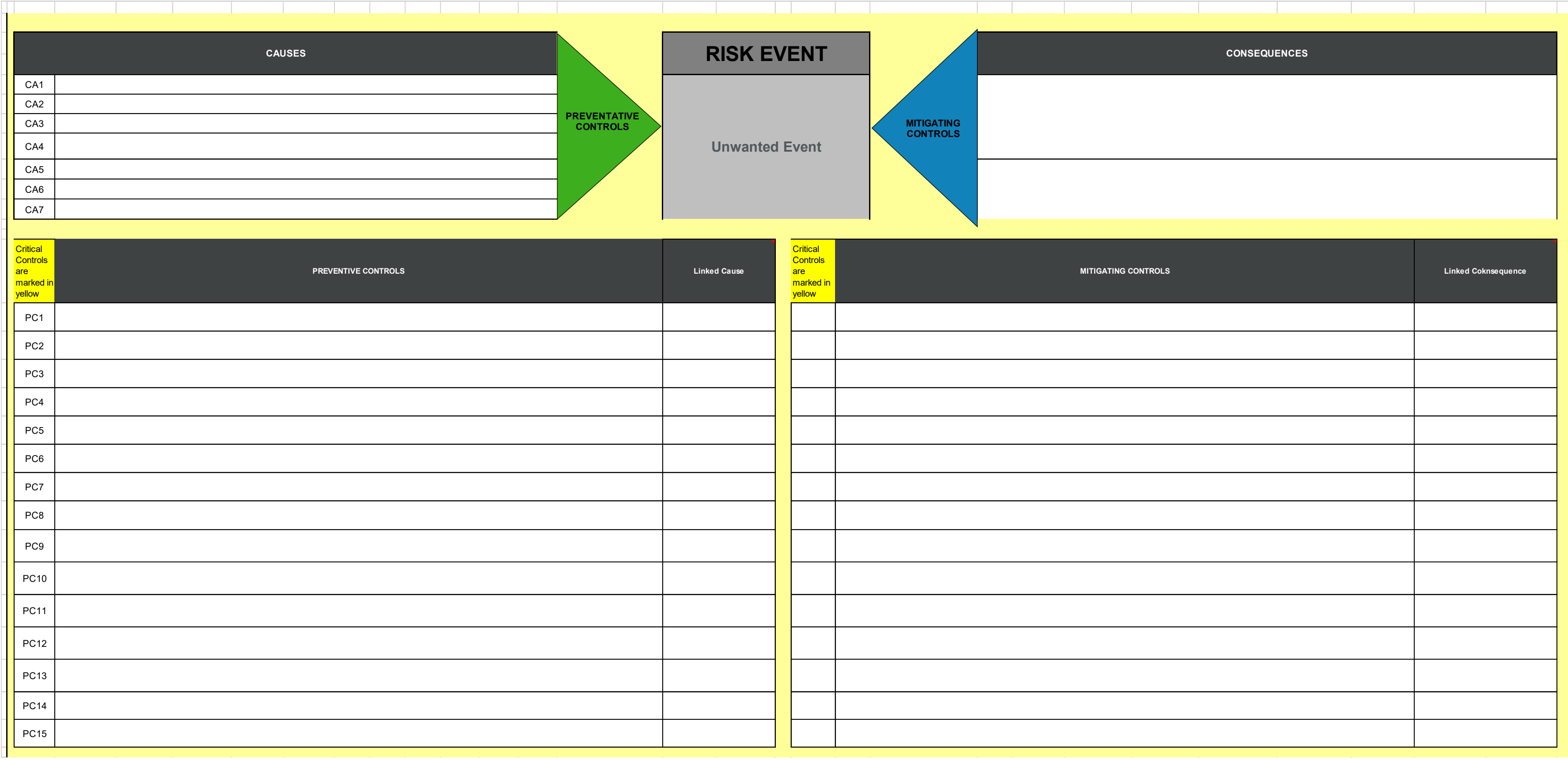

Figure 8 Bowtie template using Excel

Figure 9 shows a bowtie developed using the drawing capacity of Word or Visio. It is relatively simple to construct and shows the links between the causes and preventative controls, and also the links between the consequence and mitigating controls.

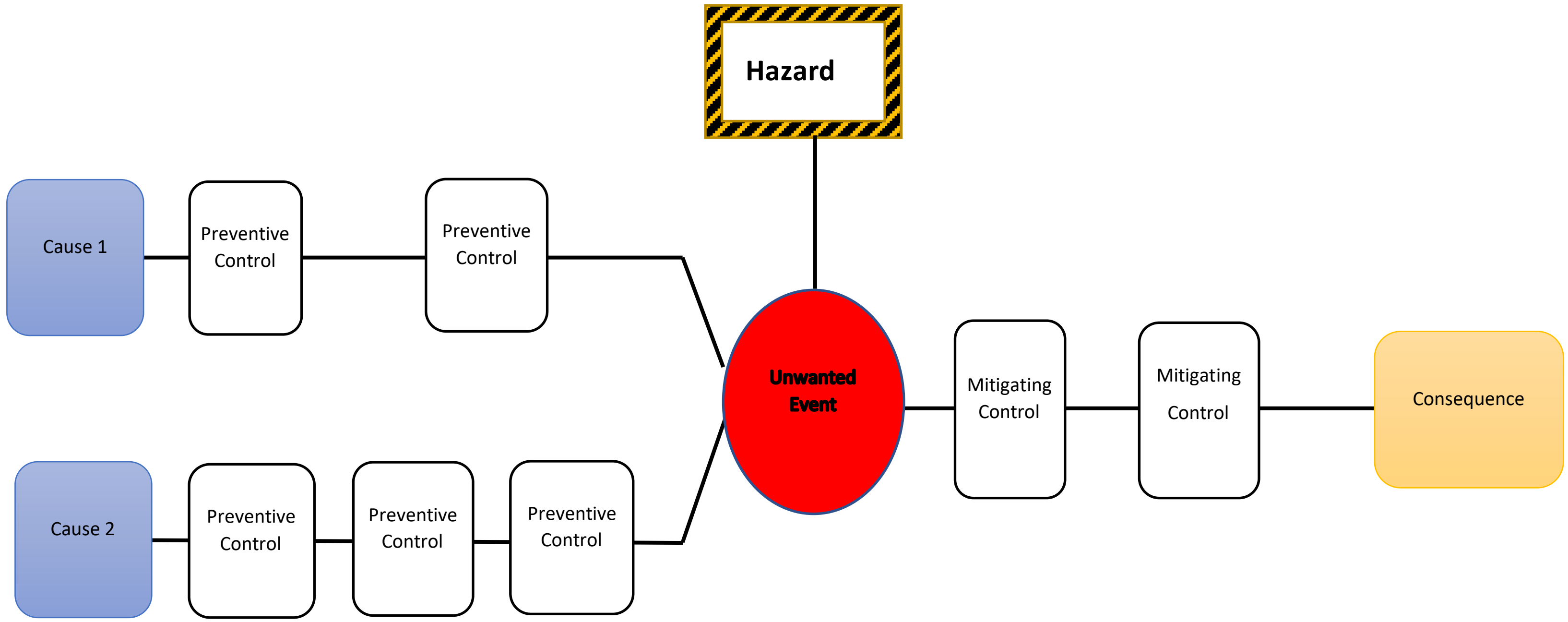

Figure 9 Bowtie template using Word

7.4. Critical control performance criteria templates

Figure 10 and Figure 11 are examples of critical control performance criteria templates. Figure 10 is based on the ICMM template. Figure 11 is modified to suit the requirements of a site.

Example 1 based on the ICMM template

Critical control	Group risk owner	Site risk owner	Site critical control owner

Objective of critical control

Performance specification	Frontline monitoring tasks			Verification activities		
What is the performance specification of the control?	*What are the planned tasks to address the performance specification? (frontline monitoring)*	*By whom?*	*How often?*	*What activities are needed to verify the planned tasks are being done correctly—at the right time and to a set level of quality? (we do what we say)*	*By whom?*	*How often?*

Erosion factors	Control support tasks			Verification activities		
What can cause the control to fail or erode over time?	*What are the planned tasks to address the performance specification?*	*By whom?*	*How often?*	*What activities are needed to verify the planned tasks are being done correctly—at the right time and to a set level of quality? (we do what we say)*	*By whom?*	*How often?*

Criteria for pulling up critical control system

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Figure 10 Example of a critical control performance criteria based on the ICMM template

Example 2 Combining control specification, monitoring and verification information

<table>
<tr><td colspan="3">1. What is the unwanted event?</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">2. Name of the control</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">3. What are the specific objectives of the control related to the unwanted event?
• Include a description of good/ideal control performance.</td></tr>
<tr><td colspan="3">Objective:

Good/ideal performance:</td></tr>
<tr><td colspan="3">4. Erosion factors—What are the escalation factors that could cause this control to fail or lessen its effectiveness over time?</td></tr>
<tr><td>Plant/equipment</td><td>People</td><td>Processes</td></tr>
<tr><td>•</td><td>•</td><td>•</td></tr>
<tr><td colspan="3">5. Support activity</td></tr>
<tr><td>Maintenance</td><td>Training</td><td>Other</td></tr>
<tr><td>•</td><td>•</td><td></td></tr>
<tr><td colspan="3">6. Control monitoring requirements</td></tr>
<tr><td>Supervisor checks</td><td>Answer</td><td>Comments and actions</td></tr>
<tr><td></td><td>☐ Yes
☐ No
☐ Not applicable</td><td></td></tr>
<tr><td></td><td>☐ Yes
☐ No
☐ Not applicable</td><td></td></tr>
<tr><td></td><td>☐ Yes
☐ No
☐ Not applicable</td><td></td></tr>
<tr><td>Manager verifications</td><td>Answer</td><td>Comments and actions</td></tr>
<tr><td></td><td>☐ Yes
☐ No
☐ Not applicable</td><td></td></tr>
<tr><td></td><td>☐ Yes
☐ No
☐ Not applicable</td><td></td></tr>
<tr><td></td><td>☐ Yes
☐ No
☐ Not applicable</td><td></td></tr>
<tr><td></td><td>☐ Yes
☐ No
☐ Not applicable</td><td>Control effectiveness =</td></tr>
</table>

Figure 11 Example of a critical control performance criteria combining control specification, monitoring and verification information

8. Example risk assessment for vehicle/mobile plant interactions

8.1. Scope of risk issue

Table 9 outlines the scope of the issue to be considered. This is an example and should be modified to suit company/site operations and conditions.

Table 9 Scope for risk issue

Risk title: Mobile equipment/vehicle collision, rollover or impacts person

	In-scope	Out-of-scope
People	All people in vehicles/mobile plant or pedestrians: • Site personnel • Site employed contractors and sub-contractors • Visitors to site • Escorted delivery drivers or other delivery drivers to operational areas	• Delivery drivers to non-operational areas
Locations	All areas on the mine lease: • Underground operations • Surface mining operations • Travel roads • Processing plant • Other surface areas e.g. – workshops – warehouses – offices	• Public travel roads • Interactions with rail network • Travel for exploration will be covered by remote and isolated work risk assessments
Equipment/ plant	All mobile plant and vehicles on the mine lease, operational areas and processing plant e.g. • Light/medium vehicles (LMV) • Heavy vehicles (HME/HV) • Ancillary equipment e.g. trailers, lighting plants, drill rigs, sleds/skids • Cranes moving to and from position of lifting • Forklifts • EWP moving to area of operation. Safety critical components including e.g. • Brakes • Steering • Lights • Windscreen and wipers • Flashing lights/Whips on LV • 2 way radio—handheld and in vehicle	• Cranes during lifting operations (covered by separate risk assessment) • Delivery vehicles condition when not accessing operational areas • Tyres and rims will be included in separate risk assessment

Activities	• Operation of vehicles/mobile equipment on-site either on surface or underground operational areas or travel roads • Vehicles moving in/out of workshop/stores • Pedestrians moving around site	• Lifting operations (covered by separate risk assessment) • Travel in company vehicles off site • Travelling during environmental testing/monitoring on remote/informal tracks • Travelling during exploration

Scenarios	• Vehicle/vehicle interactions e.g.
	  – LV/LV
	  – HME/HME
	  – LV/HME
	• Vehicle/infrastructure interactions
	• Pedestrian/vehicle interactions
	• Single vehicle unplanned movement/collision/rollover
		• Uncontrolled release of stored energy during maintenance of vehicles e.g. hydraulics, jacks
		• Mobile plant traveling over edge or into a body of water. This will be covered in tips ponds and voids risk assessment
		• Fall of ground hitting/obstructing vehicle. This will be covered in fall of ground risk assessment
		• Ground subsidence
		• Loading of trucks/or movement of loads is not considered
		• Deliberate reckless behaviour or deliberate non-compliance with site requirements is not considered

Consequences	• Fatality/fatalities—vehicle occupants or pedestrians	• Fire resulting after an accident e.g. bushfire • Fatality of occupant due to fire caused by accident on board the vehicle (covered by separate risk assessment)

8.2. Site risk register entry

Table 10 demonstrates how the risk issue could appear in the risk register. It is identified as a high risk when the maximum foreseeable consequence is considered and this indicates it needs further analysis irrespective of what the risk rating is when current controls and control effectiveness is considered.

Table 10 Example of a risk register entry for vehicle/mobile equipment interactions

Work area	Hazard	Unwanted event	Maximum foreseeable consequence						Controls	Control effectiveness	Likelihood rating	Consequence rating	Risk rating	Risk acceptability	Actions to be taken
			Health and safety	Environment	Community	Reputation	Legal	Financial							
Surface and underground operations	Vehicle or mobile plant interactions	Mobile equipment/vehicle collision, rollover or impacts person	5						Training, competence and behaviour management system provides trained and competent workers						
									Fitness for work program and fatigue management ensure drivers are fit for work						
									Traffic management system is in place and complied with e.g. signage, speed, direction, right of way, overtaking rules						
									LV and HV roadway separation is used						

Work area	Hazard	Unwanted event	Maximum foreseeable consequence						Controls	Control effectiveness	Likelihood rating	Consequence rating	Risk rating	Risk acceptability	Actions to be taken
			Health and safety	Environment	Community	Reputation	Legal	Financial							
									Roads are built and maintained according to specification						
									Pedestrians use dedicated pathways						
									Change management system is used to manage changes to road or traffic system						
									Safety critical features are checked and maintained e.g. brakes, steering						
									Lighting is adequate to ensure good vision						
									Barriers and barricades are in place to prevent access to high-risk areas e.g. near voids, along roadways and parking area						

Work area	Hazard	Unwanted event	Maximum foreseeable consequence						Controls	Control effectiveness	Likelihood rating	Consequence rating	Risk rating	Risk acceptability	Actions to be taken
			Health and safety	Environment	Community	Reputation	Legal	Financial							
									Functional protections fitted in vehicle/mobile equipment as specified e.g. airbags, cargo barriers, ROPS, bullbars, ABS, ANCAP5						
Surface and underground operations	Vehicle or mobile plant interactions	Mobile equipment/ vehicle collision, rollover or impacts person	5						Vehicles/mobile equipment are parked in a stable position in designated parking areas						
									Vehicles and mobile equipment are taken out of service if found defective during pre-start inspections or during operation						
									Vehicles and mobile equipment are stopped during adverse weather						
									Emergency response processes equipment and personnel are available and used.						

8.3. Bowtie analysis

As vehicle/mobile plant interaction was identified as a major hazard with the potential for fatalities, a bowtie analysis would be completed. This identifies the causes of the unwanted event and the different possible consequences. It links the controls identified in the risk register entry with these causes or consequence. It could also identify additional controls either in place or ones needed to be put in place. It allows the adequacy of the control strategy to be determined. If there are gaps along causal or consequence lines, these need to be addressed.

Figure 12 shows an example of a bowtie analysis for vehicle/mobile equipment interactions.

The critical controls identified during this analysis were:

- Physical separation in high-risk areas—for example, separation bunds at parkup areas, intersections, pedestrian separation in admin area.
- Preventative and reactive maintenance is completed as per OEM and site specifications by trained competent personnel.
- Drivers comply with road and traffic management rules and signage—for example, speed, intersections and drive to conditions.
- Seat belts are fitted in vehicles/mobile plant and are functional and worn.
- Emergency response is initiated, first aid, first response fire, ERT, external ER.

Once the critical controls have been identified, the performance criteria for each critical control needs to be developed.

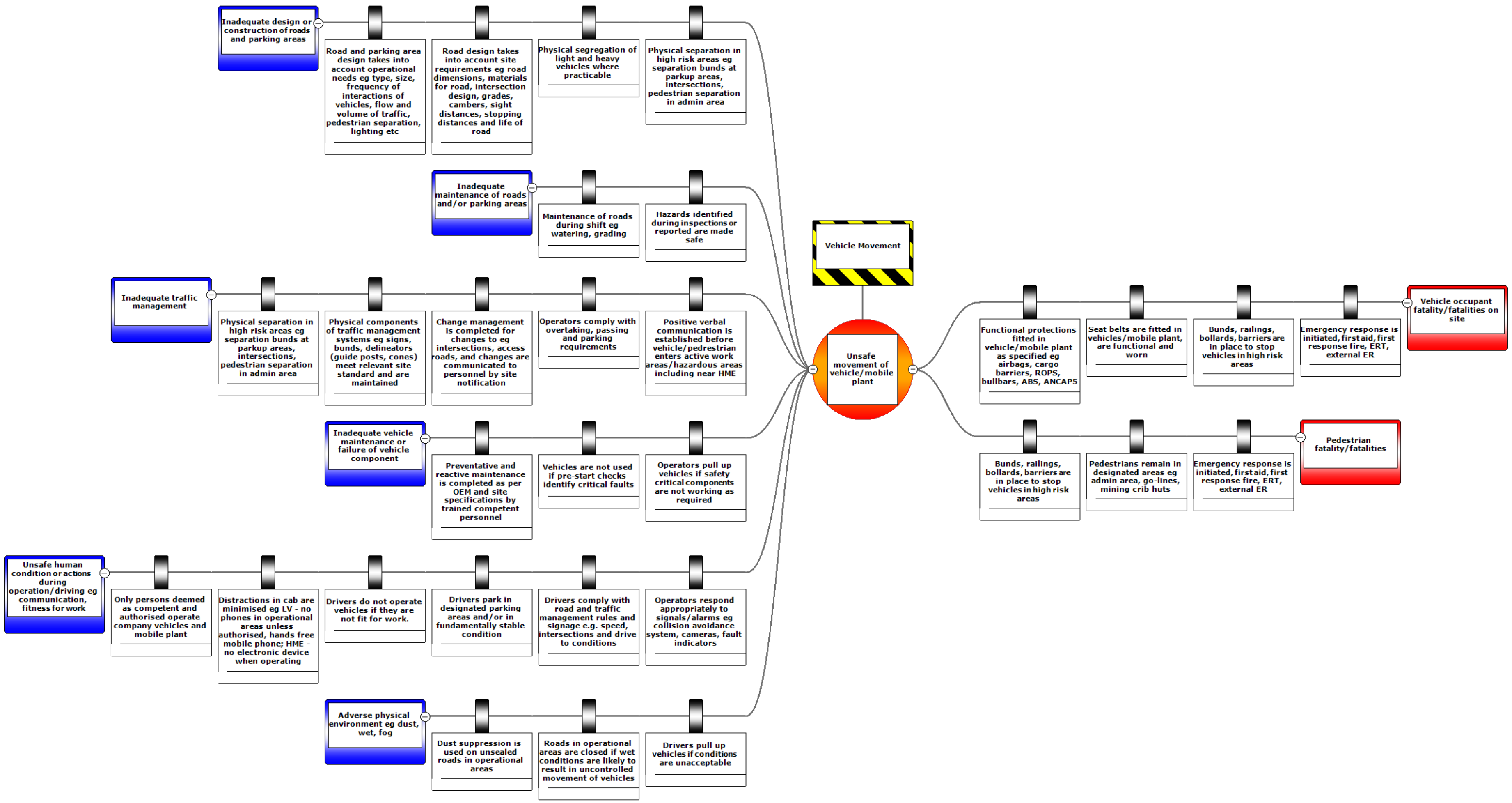

Figure 12 Example bowtie analysis for vehicle interactions

8.4. Critical control performance and verification criteria

Example 1: Single uncontrolled movement of HME or LV due to failure of a safety critical component

Critical control	Group principal hazard owner	Site principal hazard owner	Site critical control owner
Preventative and reactive maintenance is completed as per OEM and site specifications by trained competent personnel		SSE	Operations Manager

Critical control intent
To ensure: • through scheduled preventative maintenance that vehicles are maintained as per OEM and site requirements and are safe for operation. • through reactive maintenance that vehicles are safe for operation. • that qualified personnel complete the maintenance

Performance specification	Frontline monitoring tasks			Verification activities		
What are the planned tasks to address the performance specification? (frontline monitoring)	*What is the performance specification of the control?*	*By Whom?*	*How often?*	*What activities are needed to verify the planned tasks are being done correctly – at the right time and to a set level of quality? (we do what we say)*	*By Whom?*	*How often?*

Performance specification	Frontline monitoring tasks			Verification activities		
Preventative maintenance is completed as scheduled Maintenance takes into account plant availability targets and requirements Check of % planned work completed on schedule Scheduled work ratio – Planned (75%) vs unplanned maintenance (25%) work	Scheduled maintenance checks are completed as planned including: • OEM required maintenance schedules are loading into system For mobile plant • Maintenance triggered by hours of use • Manual allocation of resources and labour • Genuine parts or parts compliant with OEM specifications are available and used For light vehicles • Maintenance triggered by kilometres travelled • Manual allocation of resources and labour Genuine parts or parts compliant with OEM specifications are available and used	*Mining Maintenance Superintendent* *Processing Maintenance Superintendent*	*Monthly* *Monthly*	Operations manager would: • Confirm % of scheduled preventative maintenance completed • Check outstanding work order report • Verify process of scheduling, planning and completing preventative maintenance for 2 pieces of equipment	*Operations Manager*	*Annually*

Performance specification	Frontline monitoring tasks			Verification activities		
• Notification of faults leading to unplanned maintenance to correct faults. • Maintenance completed before vehicles returned to service	• Pre-operational checks completed and faults logged through pre-start app or paper system – For HME – every shift – For LV – every day • Issues identified during operational activities eg breakdown or report from operator. • Maintenance responds when notified – addressing safety issues is prioritised. If not able to be fixed, equipment is placed out of service.	*Crew Supervisor* *HME - Mining Maintenance Superintendent* *LV - Processing Maintenance Superintendent*	*Per shift* *Monthly*	Report run to confirm that pre starts are being completed for HME. Check for one month of data. This allows coverage of 4 crews. Manager to have in field discussion (safety interaction) to: • Confirm that the HME operators can: – Explain the required process for pre-starts and what is required if fault identified during operation • Confirm that a LV operator can: – Explain the required process for pre-starts and what is required if fault identified during operation At least 10% of workers for each crew needs to be interviewed • Confirm % of closure of faults identified during pre-starts or during operation eg confirmation of breakdown work orders	*Operations Manager*	*6-monthly*

Performance specification	Frontline monitoring tasks			Verification activities		
• Trained and qualified maintainers complete work – Site employees or external providers • Specialists skills and training for site employees are identified in the training matrix	Site personnel who work on HMEs need to: • Be qualified (eg mechanic, fitter, HV and auto -electricians) or if in training supervised by qualified person. • Follow safe work instructions (SWI) available for some tasks • Completion of specialist training as identified in training matrix • Have manuals available for equipment Site personnel who work on LVs need to: • Be qualified (eg mechanic, fitter, auto-electricians) or if in training supervised by qualified person. • Completion of specialist training as identified in training matrix • Have manuals available for equipment External providers of maintenance are managed through the contractor management system	*Maintenance supervisor*	*Daily*	Competency currency checking for personnel completing maintenance (10%) Superintendent to have in field discussion (safety interaction) to confirm that persons completing maintenance can demonstrate understanding of maintenance process eg. • Leading hands and supervisors close out work orders • Maintainers complete work and ensure equipment is safe to return to service	*Safety and training superintendent* *Mining and processing maintenance superintendents*	*Annually* *6-monthly*

Erosion factors	Control support tasks			Verification activities		
What can cause the control to fail or erode over time?	*What are the planned tasks to address the performance specification?*	*By whom?*	*How often?*	*What activities are needed to verify the planned tasks are being done correctly – at the right time and to a set level of quality? (we do what we say)*	*By whom?*	*How often?*
Faults are not reported during pre-starts or during operation	• Training in pre-starts as part of induction and training package for HME and LV. • Primary system of reporting faults identified at pre-start is electronic. Paper system is back-up system. Electronic system has auto-notification process • Operator alerts supervisor to faults during operation and supervisor contacts maintenance	*Crew Supervisor*	*Weekly*	• Managers in field interactions (safety interactions as above)	*Operations manager*	*6-monthly*

Criteria for pulling up critical control system

- Single uncontrolled movement of HME or LV due to failure of a safety critical component

Example 2: Single uncontrolled movement of HME or LV due to failure of a safety critical component

1. What is the unwanted event?

Loss of control of vehicle on site.

2. Name of the control

Intersections have traffic lights/signs which drivers comply with.

3. What are the specific objectives of the control related to the unwanted event?
    - Include a description of good/ideal control performance.

Objective:

To ensure prevent collisions at intersections by ensuring drivers follow signals/rules stating which vehicle(s) have 'right of way' and which vehicle(s) have to yield/giveway.

Good/ideal performance:

All road intersections have functional traffic lights or stop or giveway signs installed to be visible 100m from intersection. Intersections also be marked with clear painted line showing drivers where intersection is and where to stop vehicle

4. Erosion factors—What are the escalation factors that could cause this control to fail or lessen its effectiveness over time?

Plant	People	Processes
- No power - Failed lights - Damaged/knocked over	- Failed to notice – distraction - Non-compliance	Hidden/concealed by signs, building etc

5. Support activity

Maintenance	Training	Other
Intersection traffic lights and street lighting maintained so remain fully functional Intersection signs and lines are cleaned and maintained so remain in good condition	Competency based training every 12 months for: - Drivers - Maintainers - Civil engineer	Civil engineer conducts annual review of intersection design, condition and visibility against relevant standards

6. Control monitoring requirements

Supervisor checks	Answer	Comments and actions
Night shift supervisor: Are all intersection lights and signs present, working and visible from 100m?	☐ Yes ☐ No ☐ Not applicable	
All supervisors: Review traffic reports (e.g. IVMS or camera footage) - Are drivers/ vehicles complying to intersection rules?	☐ Yes ☐ No ☐ Not applicable	
All supervisors: Can workers explain what intersections rules are and is their training up-to-date?	☐ Yes ☐ No ☐ Not applicable	

Manager verification questions	Answer	Comments and actions
Do inspection walk-through with supervisors - Are supervisors able to demonstrate correct daily inspection and reporting requirements.	☐ Yes ☐ No ☐ Not applicable	
Do intersection inspection with civil engineer – Is he/she able to describe how intersection compliance check is done and reported?	☐ Yes ☐ No ☐ Not applicable	
Is intersection maintenance up-to-date with no outstanding actions?	☐ Yes ☐ No ☐ Not applicable	
Check traffic reports across site to determine effectiveness of control. Is control effectiveness acceptable?	☐ Yes ☐ No ☐ Not applicable	Control effectiveness =

9. Definitions

Bowtie analysis (BTA)	An analytical method for identifying and reviewing controls intended to prevent or mitigate a specific unwanted event.
Cause	A brief statement of the reason for an unwanted event.
Consequence	The outcome of an event. There may be a range of possible outcomes associated with an event.
Control	An act, object (engineered) or system (combination of act and object) intended to prevent or mitigate an unwanted event.
Critical control	A control that is crucial to preventing the event or mitigating the consequences of the event. The absence or failure of a critical control would significantly increase the risk despite the existence of the other controls. In addition, a control that prevents more than one unwanted event or mitigates more than one consequence is normally classified as critical.
Critical control management (CCM)	A process of managing the risk of material or catastrophic unwanted events that involves a systematic approach to ensure critical controls are in place and effective.
Hazard	Something with the potential for harm. In the context of people, assets or the environment, a hazard is typically any energy source that, if released in an unplanned way, can cause damage.
Material unwanted event (MUE)	An unwanted event where the potential or real consequence exceeds a threshold defined by the company as warranting the highest level of attention (e.g. a high-level health or safety impact).
Likelihood	The chance of something happening.
Mitigating control	A control that eliminates or reduces the consequences of the unwanted event.
Preventing control	A control that reduces the likelihood of an unwanted event occurring.
Risk	The chance of something happening that will have an impact on objectives. It is usually measured in terms of event likelihood and consequences.
Risk register	A risk register is a document that records all the identified risks for a company or site. It enables all risks to be recorded in one location in a consistent format. It usually records the likelihood and consequences associated with a risk and allows the risks to be prioritized to identify the most important risks.
Unwanted event	A description of a situation where the hazard has or could possibly be released in an unplanned way
Verification activities	The process of checking the extent to which the performance requirements set for a critical control are being met in practice. Company safety and health management systems might use a variety of terms for "verification" activities. Common terms include audit, review, monitoring and active monitoring.
Workplace risk assessment and control (WRAC)	An analytical method of risk assessment to prioritise risks based on the likelihood and consequence. This may take into account the controls and control effectiveness.

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