4.0 – Elements of an MHRA

The elements of the MHRA approach used in the case studies are established and published by MISHC (www.mishc.uq.edu.au). During these studies, MISHC personnel assisted NIOSH in conducting the MHRA. Training on the MHRA process was given to participants when possible. A risk assessment scope and the potential team participants were most often identified during these training sessions.

4.1 – Risk Assessment Design (Scoping)

The risk assessment design or scope is best defined prior to the MHRA exercise. Major hazards to be discussed, decisions on risk assessment team membership, and time allotment for the activity are best addressed with a scoping document. This document provides an opportunity to break down the MHRA process into reviewable parts containing the following information:

1. An objective statement that identifies potential major hazards of interest to the mining operation,
2. The boundaries of the mining system or work process,
3. The risk analysis methods and risk assessment tools,
4. The names of potential team members,
5. The time and dates of the MHRA,
6. The location of the MHRA,
7. Determination of the potential data requirements, i.e. in-house safety statistics, MSHA data related to the hazard(s), and similar assessments from the MIRMgate website (www.mirmgate.com),
8. The use of experts from outside the mining operation, and
9. The types of documents that will be produced.

4.2 – Risk Assessment Team

A fundamental part of an MHRA is the risk assessment team. This team must include an appropriate cross-section of knowledgeable persons familiar with the hazards to be investigated (*Figure 9*). The team must be capable of identifying all relevant hazards, unwanted events and possible controls. The process leader is the facilitator who has the appropriate qualifications, knowledge and experience. The facilitator is responsible for following a quality risk assessment process designed to meet the risk assessment scope and is responsible for making sure the team and the process remain focused on a quality output. It is important for the facilitator to act as a teacher and coach without dominating the discussion while making sure to avoid conflict and imbalance in involvement of team members. Open ended questions are often used to elicit participation from the group.

It is also important to consider non-management/labor entities for team participation. Miners responsible for performing tasks that are part of the work processes under review can validate information and provide insight, perspective and ideas that are invaluable to a quality output. These team members are also helpful in communicating adherence to existing prevention controls and recovery measures and in embracing changes brought about by the application of new ideas.

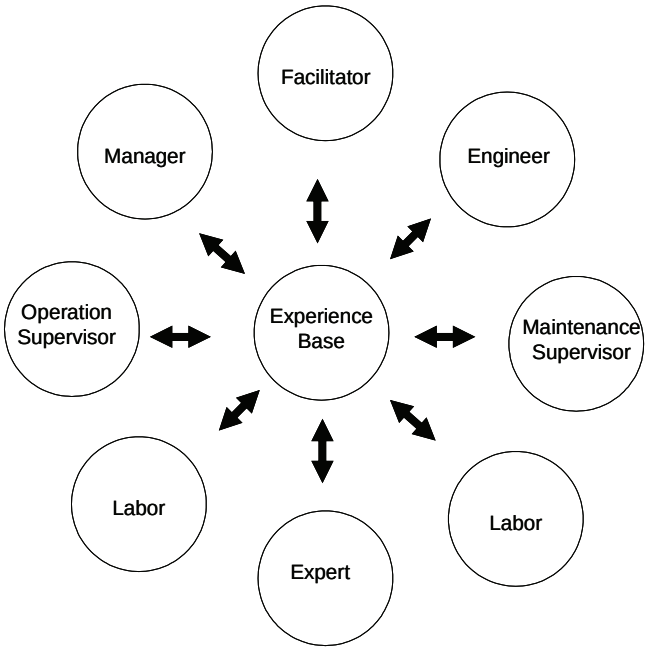

Figure 9 - Example MHRA team structure (MISHC, 2007).

The individuals assigned to the MHRA should fully dedicate their time to this effort during the assessment. It is very important for team members to receive instruction on the MHRA approach prior to the risk assessment. The time allotted for the MHRA should be determined by the complexity of the topic. A focused topic could be done in one day, while more complex topics or a site-wide MHRA could take 3 to 5 days. The venue for the activity is also important. The location should be quiet, free from disruptions, with tables set in a U-shaped pattern to promote discussions and equality among members.

4.3 – Risk Assessment

Five basic steps make up the MHRA process:

1. Identify and characterize major potential mining hazards,
2. Rank potential unwanted events,
3. Determine important existing prevention controls and recovery measures,
4. Identify new prevention controls and recovery measures, and
5. Discuss implementation, monitoring and auditing issues.

4.3.1 – Identify and Characterize Major Potential Mining Hazards

The first step is to identify all relevant hazards or possible problems that could lead to a potential multiple fatality event. If the list is incomplete, the risk assessment will be inadequate. The types of hazard that should be identified are best thought of as uncontrolled releases of energy that have the potential to cause significant harm (Standards Australia, 2004). The energy approach is used to think about what could go wrong specifically at a mining operation. If an accident can be thought of as an uncontrolled release of energy, then it follows that the risk of an accident is higher when the energy is large. An exact measure of energy is not needed, only

recognition that it can do serious harm. Potential energies inherent in many mines are contained within the roof and rib of the underground mine, the highwall of the surface mine, the chemical energy in toxic or explosive gases, and the fluid energy of water above or adjacent to the mine workings. The process of mining also brings large-scale energy into the mining environment, i.e. the mechanical energy in mobile and processing equipment, the shocking energy in electrical equipment, the air and hydraulic pressure in fluid systems, etc. Energy that is not completely controlled leads to some level of risk, depending on the likelihood of release and the consequences should the energy be released. When the unwanted release occurs, it can cause serious injuries. *Table 10* is used to list typical sources of energy and to characterize their possible locations and magnitudes.

Table 10 - Categorizing the location and magnitude of the worst hazards using the energy approach.

Hazard (Energy approach)	Location	Magnitude (worst case)

4.3.2 – Rank Potential Unwanted Events

After a comprehensive list of hazards is identified and characterized, a broad-brush risk assessment tool such as the WRAC or PHA is used to risk rank the potential unwanted events. Depending on the topic, the individual hazards should be broken down using a process mapping technique or by the geographic location within the mine. For each step in the work process or for each geographic location within the mine, a likelihood of occurrence and a consequence for each potential hazard are determined. It should be noted that in some MHRA case studies, likelihood is ignored because the consequences of the unwanted event are deemed significant. For all field studies, a qualitative risk ranking procedure is used, integrating some variation of the risk matrix shown in *Table 2*. At the conclusion of this step, the team has successfully ranked the risk. The highest rank risks are almost always unacceptable and the lowest rank risks are often acceptable.

4.3.3 – Determine Important Existing Prevention Controls and Recovery Measures

Additional risk assessment tools are used to help determine what prevention controls and recovery measures are currently being used. In most cases, the BTA or the work process flow chart are excellent tools to conduct detailed analysis of the highest ranked risks. At the end of this step, a detailed list of all existing prevention controls and recovery measures for the hazard in question are documented so they can be monitored and audited on some regular basis.

4.3.4 - Identify New Prevention Controls and Recovery Measures

The same process that identifies existing prevention controls and recovery measures is used to identify new prevention controls and recovery measures. This is a crucial step since it potentially produces a list of actions to be investigated that are capable of further reduction of risks at an underground mine site. It is important for management to consider the merits of each

new idea suggested by the risk assessment team. Typically, these new ideas are presented in the form of an action plan.

4.3.5 - Discuss Implementation, Monitoring and Auditing issues

A document is produced at the conclusion of the MHRA that focuses on a description of the hazards examined, the ranks of the potential risks, and a summary of both existing and new prevention controls and recovery measures. The document does not rank the new ideas nor should it attempt to define a specific course of action or recommend a specific design solution for management. A post-risk assessment presentation by the team to management is made to gain acceptance and understanding of the MHRA outcomes. Two key responses from management are needed. First, management needs to make sure that all existing prevention controls and recovery measures identified by the risk assessment team are monitored, audited, or investigated to ensure that unacceptable risks are controlled. Second, all suggested new ideas should be, at a minimum, investigated.

4.4 – Effectiveness of Controls

The important output of the risk assessment team is the list of existing and new controls. Assessing the quality of this output can only be accomplished when the effectiveness of these controls is understood. In this study, the controls were categorized using a hierarchy framework (*Table 11*) used by MISHC personnel. When a hazard is eliminated, the risks associated with the hazard are also eliminated. This should always be the first action of the risk assessment team – to investigate how to eliminate the hazard. However, this is usually difficult to do, since a hazard can owe its origin to many different factors. Some of these factors are poorly understood, while others may represent a condition of business that is perceived to be difficult to change.

Table 11 - Control categories based on risk reduction effectiveness.

Control Category Based on Hierarchy Framework	Major Control Issues	Potential for Human Error	Risk Reduction Effectiveness
Eliminate Hazard (EH)	Economic/strategic	Doesn't exist	Complete
Minimize/Substitute Hazard (MH)	Engineering	Human error plays a minor role	High
Physical Barriers (PB)			
Warning Devices (WD)	Assessing	Human error is possible	Medium
Procedures (P)	Administrative and work processes	Human error can play an important role	Low
Personnel Skills and Training (PST)			

If it is not possible to eliminate the hazard, attempts must be made to mitigate the potential effects of the hazard. Mitigation consists of actions to minimize the hazards (MH), most often with engineering methods, or to implement physical barriers (PB) capable of separating the hazard from the worker or the work process. Warning devices (WD) are often used to assess the performance of engineering controls (MH) and physical barriers (PB) or to prompt a change in administrative or work processes. Controls that are largely focused on operational and work process issues consist of procedures (P) and personnel skills and training (PST). Procedures (P) can often rely on the personnel skills and training (PST) of the worker. The reliance on worker behavior increases the potential for human error and reduces the risk reduction effectiveness when compared to mitigation efforts (*Table 11*). If controls fail to prevent the unwanted event or are not possible, then the hazard is tacitly tolerated and recovery measures are put into place to

minimize losses. It is then appropriate to consider the hazard as a real threat and not just a potential threat. Recovery measures can include all control categories listed in *Table 11*.

Analyses of the ten case studies presented in this report require an evaluation of the controls identified by the risk assessment teams. These controls are the principal output of the MHRA. To accommodate this analysis, every identified control was assigned to one of the categories listed in *Table 11*. The characteristics of each category are given below:

Eliminate Hazard (EH) – The characteristics of this category are self-evident – elimination of the hazard under consideration. This can also be done with changes in equipment, changes to the mining process or method, or changes in the location of the hazard which eliminate personnel exposure.

Minimize or Substitue Hazard (MH) – The characteristics of this category consist mainly of engineering controls, i.e., improved ventilation, fire fighting equipment, backup systems, fire suppression systems, use of an event simulator, enhanced information about the hazard, improved construction / drilling / exploration techniques, electrical component performance characteristics and fault protection, designing to standards, improved equipment (values, brakes, tubing, etc.), available medical and rescue teams, etc.

Physical Barriers (PB) – The characteristics of this category are focused on physical barriers that separate the hazard from the worker, i.e., roof rock reinforcement, equipment skirting and guarding, sealing, rock dusting, refuge chambers, shielding, barriers, walls, special containers, heat wraps, self-rescuers, personal protective gear, etc.

Warning Devices (WD) – This category is primarily concerned with systems that monitor environmental / equipment conditions, i.e., gas monitors, PEDs, sampling pumps, gages, extensometers, tags, indicators, microseismic monitors, bag samples, alarms, sirens, certain kinds of communication systems, etc.

Procedures (P) – The characteristics of this category concentrate on processes conducted by workers and management, i.e., policies, inspections, checks, documentation, methods, roles, definition, restrictions, audits, purchases, investigations, standards, trigger action response plans (TARP), duties, work orders, updates specifications, process requirements, etc.

Personnel Skills and Training (PST) – The characteristics of this category center on training needs, personnel needs, required competency, testing, estimate consequences, reinforcing skills, mentoring, communication, expertise, behavior controls, operator errors, operator sensors, inspection quality, observation of conditions, introductions, clarification, etc.

An MHRA risk assessment team should strive for the high end of the hierarchy of controls. Some attempt must be made to at least consider how the hazard might be eliminated. This is often most easily accomplished in the early stages of a mining project's life cycle. Most often,

the controls identified during the MHRA attempt to mitigate the hazard or to tolerate the hazard by putting into place recovery measures that will minimize losses. The team should be cautious of an over-reliance on warning devices that require manual readings, administrative procedures, and the personnel skills and training of the work force. In general, an MHRA should strive to go beyond the standards and regulations requirements for mining.

4.5 – Audit and Review

After an MHRA, a re-assessment of the site's hazards and an evaluation of the implemented risk mitigation program should be done on a regular basis by skilled and experienced personnel. It is also appropriate to audit and review the MHRA when rapid changes occur in some relevant work process or operational factor, i.e. design, construction, etc. In these cases, the audit and review can focus on the part or condition that is actually undergoing the change. An audit and review should, at minimum, determine the status of the risk management plan and make recommendations for improving potential deficiencies in the plan. Tools, such as a risk register, are sometimes used to help with auditing and reviewing important controls at a mining operation.