The key reference for this module is the BPEM booklet Environmental Risk Management.

Learning Objectives of Notes

Refer booklet: Section: 1.2

Learning Objectives

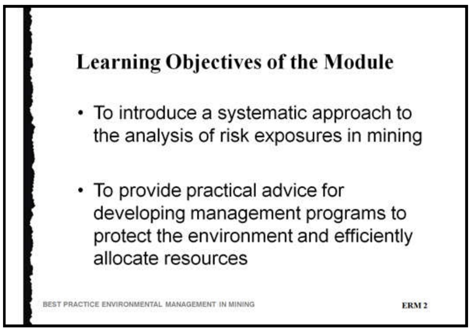
By the end of the session the participants should be able to:

- Describe the concept of environmental risk management;
- Systematically apply policies, procedures and practices relevant to hazard identification;
- Identify the consequences of the known hazards;
- Estimate the risk levels (quantitatively or qualitatively);
- Assess those levels of risk against relevant criteria and objectives; and
- Make decisions to minimise the identified risks.

This module uses a broad definition of '**environment**' which encompasses not only the natural or biophysical environment but also human health and community values.

Risk management is an essential part of overall environmental management in mining operations.

A structured and systematic approach to risk management enables environmental protection measures to be well targeted rather than either excessive or inadequate.



TIPS

Definitions of key terms used in this module can be found in the *Glossary* in **Volume 1 of this kit.**

More information about risk management can be obtained in the *Australian/New Zealand Standard 4360:1995 Risk Management.*

See the Standards Australia website: http://www.standards.com.au

What is ERM? (i)

Refer booklet: Section: 1.3

Since the 1960s, there has been increasing recognition of the importance of environmental impacts. This had led to progressive introduction of regulatory requirements for the protection of the environment.

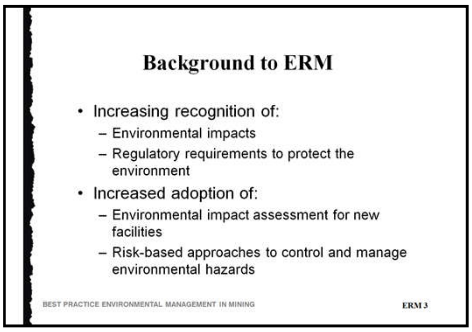
Early environmental protection measures tended to be limited to pollution control and followed a prescriptive regulatory approach.

This has evolved into a performance-based approach which uses environmental auditing and emphasises risk-based approaches to control and manage environmental hazards.

The potential for causing environmental harm has implications for the mine operator and for the directors and officials who may be held legally liable.

The possibility of unintended adverse environmental outcomes cannot always be eliminated. Therefore we need a way to judge:

- The severity and likelihood of those outcomes;
- The suitability and cost-effectiveness of control measures; and
- The acceptability of the risk which remains after available control measures have been implemented.



TIPS

Exercise 1

Risk management uses a range of technical terms (jargon). The next slide includes a list of terms used in the *Environmental Risk Management* **booklet.**

Ask the small groups to discuss and try to reach definitions of the following terms:

- **Hazard**
- **Risk**
- **Consequences**
- **Likelihood**
- **Frequency**
- **Probability**

Ask the groups to record their definitions on large sheets of paper. Post the sheets around the room, and compare them with the definitions given in the notes to the next slide. These definitions are also given in Handout 1.

Try to reach agreement that the definitions on the handout will be used during the training session. These definitions are derived from the BPEM booklet *Environmental Risk Management.*

This is an important step to ensure that further discussions will be focused and based on common understanding.

The key reference for this module is the BPEM booklet Environmental Risk Management.

What is ERM? (ii)

Refer booklet: Section: 1.4

Environment - All aspects of the biophysical environment; human health and well being and community values. Emphasis should be placed on ecologically sustainable development.

Hazard - A source of potential harm or a situation with a potential for harm.

Harm - Any damage to people, property or the biophysical, social or cultural environment.

Risk - Risk has two dimensions: the *consequences* of an event and the *likelihood* of those consequences being realised. If hazard denotes a potential cause of harm, then risk describes the likelihood that harm will occur.

Consequence(s) - The intermediate or final outcome(s) of an event or situation.

Likelihood - This is a qualitative term commonly used to describe both frequency and probability.

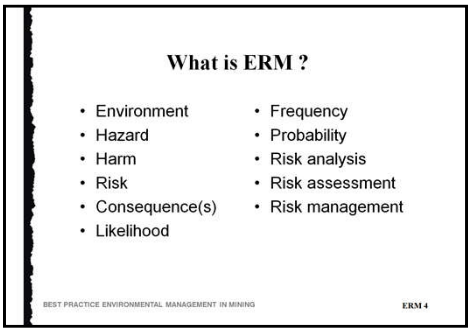
Frequency - The number of occurrences of a defined event in a given time (i.e. the rate).

Probability - The likelihood of an outcome measured by the ratio of the specific outcome to the total number of possible outcomes. Expressed as a number from 0 to 1 where 0 indicates an impossible outcome and 1 indicates that an outcome is certain.

Risk analysis - Systematic use of available data to identify hazards and estimate the likelihood and consequences of those hazards being realised.

Risk assessment - Evaluation of the results of risk analysis against criteria or objectives to determine the acceptability of risks and to determine management priorities.

Risk management - Application of policies, procedures and practices to the identification of hazards; analysing the consequences and likelihoods associated with those hazards; estimating risk levels; assessing those levels of risk against relevant criteria and objectives and making decisions and acting to reduce risk levels.



TIPS

ERM is an essential aspect of sustainable development. The concept of sustainability is explored in detail in the *Overview* module in Volume 1.

The definitions given here are those used in the accompanying *Environmental Risk Management* booklet.

Note that risk analysis and risk assessment are two different processes. The differences are discussed in detail on page 17 of the *Environmental Risk Management* booklet.

Distribute Handout 1 to participants.

Exercise 3

- **Pose the question: What do you understand about the meaning of environmental risk management?**
- **Perceptions of what ERM means may be influenced by the different backgrounds and training of individuals in the group.**
- **This exercise may be conducted as a brainstorming exercise involving the entire class or as small 'buzz groups'. If using small group work, then Worksheet 1 may be used as a handout to allow participants to record their responses.**
- **Advice on how to conduct group work is provided in the *General Trainers' Guide* in Volume 1.**

Everyday Risks

Comparative Risk

This table lists some of the common risks that people are exposed to in everyday life.

The figures given in the table are the frequency of death as a result of the risk per million person years (i.e the rate).

Example: The frequency of death from a smoking-related illness is 5000 deaths per every million smokers per year. The probability of death as a result of smoking, would therefore be 0.005.

Use this table to explore perceptions of risk. Most people accept some risks more readily than others. For example, smokers voluntarily expose themselves to a high risk of illness and death.

The perception of many people is that air travel carries a higher risk than travel by car. The slide shows that statistically the converse is true. Many people consider that flying is more risky than driving a car because they have no control over or responsibility for the aeroplane, or because they are less familiar with how an aeroplane works compared to a car.

Risk perceptions can be very important in forming community opinions about a mining operation.

Compare these data with rate of work-related fatalities to workers in the various high risk industries in Australia.

Deaths per million person years	
Fishermen	1170
Forestry and logging labourers	1160
Mining	
Drilling plant operators	720
Mining labourers	660
Truck drivers	410
Operators of earthmoving machinery	390

(National Occupational Health and Safety Commission (1998))

Everyday Risks

(Source ANSTO 1989)

Risk	Chances of fatality per million person years
Smoking (20 cigarettes a day)	5000
Drinking alcohol	360
Travelling by:	
• motor vehicle	145
• Train	30
• Aeroplane	10
Cancers from all causes	1800
Fires and accidental burns	10
Cataclysmic storms and storm flood	0.2
Lightning strike	0.1
Meteorite	0.001

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TIPS

Reference for figures on slide: Australian Nuclear Science and Technology Organisation (ANSTO), 1989, ***Risks to individuals in NSW and Australia as a whole*****.**

Exercise 3

Ask the group to discuss why people have the perceptions they do about the relative risks of the activities shown on the slide.

What could be done to reduce the disparity of the perception of risk and the actual levels of risk shown for the different activities?

Encourage a discussion of the difference between voluntary and imposed risks. Sandman and Miller provide useful guidance on risk perception including the important idea of community outrage. Johnson, Sandman, and Miller (2001) *Testing the Role of Technical Information in Public Risk Perception* http://www.psandman.com/articles/johnson1.htm

- **How does the risk of death from working in mining compare with the "everyday risks".**
- **What are the risks of death for mine workers in your country or at your mine?**
- **What risks are posed for people who may be affected by activities at the mine?**
- **Are risks to neighbours voluntary or imposed? How will this influence their perception of risk?**

Lead in to next slide:

Ask the groups to brainstorm the hazards associated with mining. Ask them to generate a list of the impacts that may result from mining activities at you site.

Either record the responses on a white board, or ask the groups to write their responses on large sheets of paper and post these around the room. Then reveal the next slide.

The key reference for this module is the BPEM booklet Environmental Risk Management.

Environmental Hazards in Mining

Refer booklet: Section 2.4.2

This slide lists some of the hazards associated with mining.

There are often links and interactions between hazards. A single incident may result in a range of negative impacts.

For example, ground subsidence may cause a dam to fail. This may then result in release of tailings.

Other typical hazards that may be found at mine sites include:

- Subsidence;
- Radioactive tailings;
- Saline or other contaminated waters from mine workings;
- Disruption of surface or groundwater flows (including diversion or collection for use);
- Storage and handling of explosives and intentional or unintended explosions;
- Introduction of weeds or plant, animal or human diseases;
- Processing, storage, handling and transport of mined or processed material which can result in fire, explosion, spillage, dust;
- Containment and service structures including tailings dams, pipelines, and conveyor belts; and
- Mechanical failure such as burst pipes.

TIPS

Show this slide after the group discussion. Many of the hazards shown on the overhead will be on the list contributed by the participants.

If you have used large sheets of paper for recording responses, keep them on display for the rest of the training session. You can refer to them during the following discussions.

Principles of ERM (i)

Refer booklet: Section 1.5

Taking a risk management approach recognises that **uncertainty** is a fact of operations, business, nature and natural hazards and the 'real world' in general.

Uncertainty can be derived from, or be associated with, any aspect of a system.

Examples:

- Unintended spillage of a hazardous material;
- Inevitable events whose frequency and intensity are uncertain, such as earthquakes; and
- Intended actions such as emissions to air which have consequent health effects.

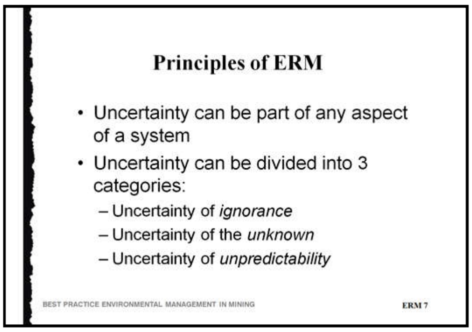
Uncertainty can be divided into **3 categories** which have been called the uncertainty of ignorance, the uncertainty of the unknown and the uncertainty of unpredictability.

The **uncertainty of ignorance** exists because the hazards and risks have not been investigated - you don't know because you didn't ask.

The **uncertainty of the unknown** exists because of the limits to our knowledge. The ***precautionary principle*** or ***approach*** is important in dealing with this type of uncertainty.

The **uncertainty of unpredictability** is due to inherent unpredictability such as weather and earthquakes.

For any aspect of a system the **overall uncertainty** may be a product of all these types.



TIPS

The Precautionary Approach is discussed in detail in the Overview module.

Exercise 4

Small group work may be used for this exercise.

Appendix 1 of the *Environmental Risk Management* **booklet discusses the uncertainties associated with tailings dams.**

Ask participants to identify hazards associated with tailings dams that are familiar to them.

They should identify:

- **Activities or operations;**
- **Possible initiating events;**
- **Possible consequences; and**
- **Available safeguards associated with tailings dams.**

You may wish to discuss an example or two from Appendix 1 of the *Environmental Risk Management* **booklet to help the groups get started.**

There are several case studies included on the CD ROM relevant to tailings dams. These could also be used here.

Allocate a set time period of 15 to 20 minutes for participants to work through the exercise. Participants can work individually or in small groups of 5 or 6 people. Participants should record their answers on Worksheet 2.

At the conclusion of the allocated time bring the class back together and discuss the group responses.

Principles of ERM (ii)

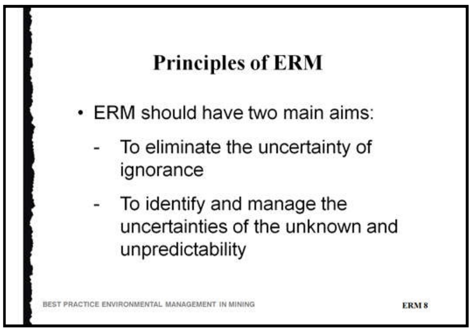
Refer to booklet: Section 1.5

A comprehensive risk analysis cannot predict the timing and magnitude of all possible events. However, there should be sufficient knowledge to:

- Eliminate some hazards;
- Minimise the likelihood of the hazardous event occurring; and/or
- Minimise and manage adverse outcomes.

Risk analysis should include the risk and consequences of low probability catastrophic events.

Both on-site and off-site hazards should be considered.



TIPS

An example might be how to manage variable climatic data - i.e. keep plenty of freeboard available in tailings dams to allow for large rain events.

Use the following case study as an illustration.

The Arcturus Dam in Zimbabwe stored tailings from its gold mining operation in an upstream dam constructed of tailings. In January 1978 the seasonal total rainfall was above average. Following continuous rain over several days the freeboard capacity of the dam was exceeded. A 55 m wide breach suddenly developed, releasing a flow slide of tailings, that blocked and contaminating a public waterway. A local village was damaged, one child killed, and another injured.

Source: ICOLD and UNEP (2001) *Tailings Dams: Risk of Dangerous Occurrences. Lessons learnt from practical experiences*

What meteorological data should be used to guard against such an incident?

Suggest strategies that could have been used to reduce the risk of this incident.

Principles of ERM (iii)

Refer booklet: Section 1.5

Best practice principles for ERM

- **Commitment and a formalised, structured approach** - ERM cannot be effective without real commitment from the organisation starting with senior management.
- **Covering all operations and the whole life cycle of the mine** - ERM should cover all the mining and associated operations, including transport. The risk management process should include all stages of the mining process, from concept to closure, monitoring and management in the post-mining stage.
- **Sound risk analysis** - The quality of decisions or actions taken to reduce risk depend on the quality of the analyses on which they are based. Analyses must be comprehensive and rigorous. The scope must be well-defined to ensure that target hazards are analysed cost-effectively and comprehensively.
- **Integration with overall risk, mine, and environmental management** - If ERM is in its own separate compartment, it is unlikely to be ranked as highly as it should be against other regulatory compliance and business interests of the mining operation. Neither is it likely to be given the priority it deserves in the organisation's environmental policy and community relations objectives.

  Risk management needs to be integrated with overall management of the facility and organisation. ERM also needs to be closely integrated with the environmental management systems. Failure to do so may have implications for future operational costs.
- **Ongoing** - The risk management process should be an on-going commitment, not a single exercise as mining operations undergo continual change. As the facility or operations change it is highly likely that new hazards will develop.

TIPS

The principles of best practice and their importance in mining is explored in detail by the *Overview* training module. See the *Environmental Management Systems* module and booklet for a detailed discussion of a systematic approach to management.

Risk assessment is an ongoing process. For example, a risk identified during an audit might lead to a full risk study and result in new strategies being adopted.

Case study: The importance of including mine closure when carrying out risk assessment is illustrated by an incident at the Marga copper mine in Chile. An abandoned cross-valley dam had a decant structure but no abandonment spillway. Overtopping failure occurred due to insufficient decant capacity for routing stream flows through the impoundment.

Source: ICOLD and UNEP (2001) *Tailings Dams: Risk of Dangerous Occurrences. Lessons learnt from practical experiences*

How could ERM at planning stage have affected this outcome?

Principles of ERM (iv)

Refer booklet: Section 1.6

Mining operations, if not managed effectively, have significant potential to cause environmental harm.

Mining can never have zero environmental impact. There is always some uncertainty about the probability of events and about the type and extent of of possible adverse effects.

ERM helps to contain environmental risk within acceptable limits. It also helps to ensure that management measures, controls and regulatory requirements do not impose unnecessary or inappropriate cost burdens.

ERM is well established in some industries but relatively new in the mining industry.

The scope, objectives and application of implementing ERM in the mining industry varies widely. In many instances its application has been significantly below best practice in other industries, such as the chemical and nuclear industries. This offers a significant opportunity for improvement.

Regulatory requirements are, in part, driving the move towards ERM in the mining industry.

However, there is also an increasing awareness that a risk-based approach to managing the relevant issues can be a powerful tool in ensuring cost-effectiveness of environmental management, thus protecting the operation's bottom line.

TIPS

Review the regulatory requirements governing your mining operation. What requirements are imposed for risk assessment for mining development or expansion?

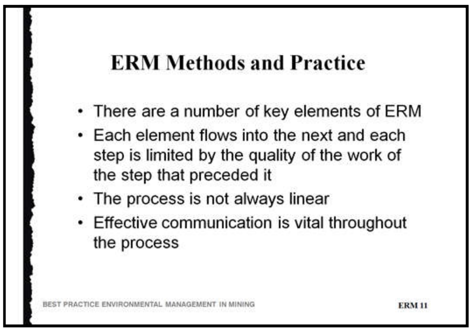
Principles of ERM (v)

Refer booklet: Section 2.1

The following slides introduce the basic elements of ERM.

There are a number of points which should be remembered as we go through this process:

- Each element flows into the next. The downstream analysis, assessment or management of environmental risks is constrained by the quality and depth of work that preceded it. This directly affects the validity and efficacy of all stages of the ERM process.
- The process shown in the diagram on **Handout 2** (see Tips) is a simplified diagram of what usually happens. In practice, initial analysis may be less than linear and some stages can overlap or be carried out in parallel.
- Effective communication between those undertaking the studies and those running the facility is vital throughout the process.
- Within this framework, different approaches and methods are possible but each of the elements needs to be carried out.
- It is beneficial to start risk analysis as early as possible when planning a new development or when modifying existing operations.
- There is value in ensuring that ERM covers both strategic and operational aspects. Both the big picture and the detail are important to a sound ERM.



TIPS

Give Handout 2 to the class to help guide them through the elements of environmental risk management. By providing each member of the group with a copy of the diagram they can make their own notes and can refer to the process as you move through the following slides.

This diagram is a reproduction of Figure 1 in the *Environmental Risk Management* **Booklet.**

You may also find Figure 2 in the booklet, "The 7C's of Risk Management" useful in illustrating the components of effective risk management.

Defining the Scope (i)

Refer booklet: Section 2.2

It is particularly important, when starting any ERM process, to pay careful attention to defining the scope of the entity to be covered and the objectives of the exercise.

The ERM process may be initiated by regulatory requirements, by an incident, or by recognition that a critical issue needs resolving.

Depending on its purpose and objectives, the exercise may extend across several operations or be limited to a single mining operation or a single division of the operation.

Operationally, the ERM exercise might be confined to a primary extractive operation or extend to downstream processing and transport-related activities.

ERM may be confined to a particular mining phase or it may cover the life cycle of the mine.

It is also possible that the specific ERM exercise might be confined to a particular hazard or consequence.

When the ERM exercise is limited to a part of an operation or facility, it is necessary to establish the organisational and operational context of the entity to be managed and to define its boundaries.

TIPS

Setting the scope of an ERM exercise is essential its for success.

The scope of risk analysis may include off site activities. For example, transport accidents have caused severe environmental damage. In 1998 in Kyrgyzstan, a truck transporting cyanide to a gold mine plunged off a bridge. About 1800 kg of sodium cyanide were spilled into a river upstream of several villages. Within days hundreds, possibly thousands of people sought treatment at medical clinics. (UNEP (2000) *TransAPELL Guidance for Dangerous Goods Transport Emergency Planning in a Local Community).*

Defining the Scope (ii)

Refer booklet: Section 2.3

There may be a need for a number of separate studies within an ERM exercise.

The careful scoping of these studies is an important issue.

There may be time and resource constraints for particular studies. The scope and methods chosen need to match those constraints.

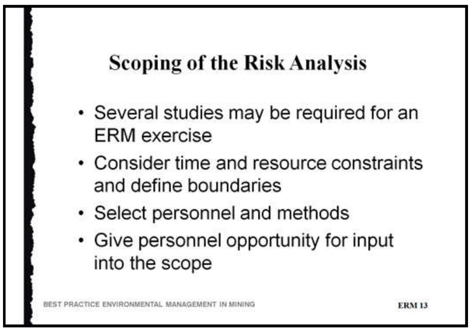
We should remember that limiting the study will affect the quality and value of the results.

However much the scope of a study is limited, it still needs to deal with the interactions between the different parts of the system and external systems.

During the scoping stage, the methods and personnel for the study should be selected or reviewed.

All personnel who will be responsible for the study and those with a major role in it should have the opportunity to have input into the scope before it is finalised.

The scope, resources, and methods will affect one another. This means that setting the scope of the process may need to be revisited.



TIPS

Ask the group to discuss the factors that should be taken into account when defining the scope of environmental risk management at your operation.

Risk Analysis (i)

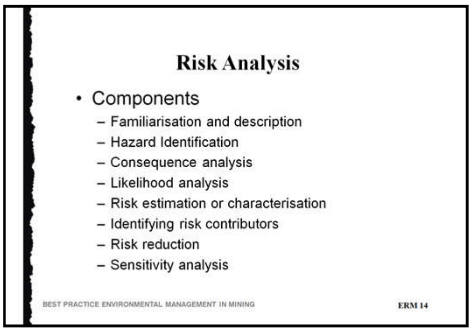
Refer booklet: Section 2.4

Risk analysis consists of a number of elements which are shown on **Handout 2**. Identifying risk contributors and risk reduction options also falls within the analytical process but may be done after or during the assessment stage.

The components are explored in subsequent slides:

- Familiarisation and description;
- Hazard identification;
- Consequence analysis;
- Likelihood analysis;
- Risk estimation or characterisation;
- Identifying risk contributors;
- Identifying opportunities for risk reduction; and
- Sensitivity analysis.

Risk management cannot be better than the analysis on which it is based – if based on good analysis it can still be poor but if the analysis is bad it cannot be good – except by unlikely lucky coincidence.



TIPS

See the *Environmental Management Systems* Booklet and Module for a detailed discussion of the systematic approach to management.

Risk Analysis (ii)

Refer booklet: Section 2.4.1

Becoming familiar with the environmental and operational context of a system and developing a description of it, is a crucial stage of the analysis.

All features of the mining operation and the relevant environmental context need to be fully described.

The extent of the work needed in this stage will depend on how familiar the personnel involved are with the system and the level of detail needed.

The environment considered may extend for a substantial distance off-site. An example of off-site effects could be the impacts of contamination on a river system.

Descriptions should include physical features (layout and equipment) as well as operational practices, organisational structures and responsibilities.

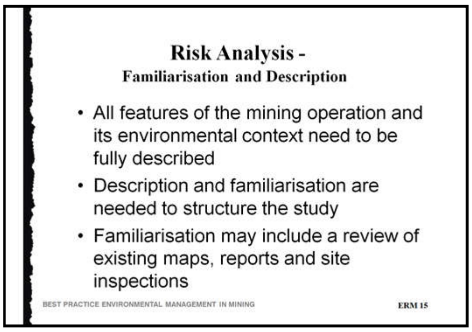
Accurate description is necessary to allow for appropriate structuring of the study. Structure can be based on operational steps in a mining process or around operational areas or equipment systems. It is also appropriate to consider the stages of the mining process.

A logical and systematic structure will ensure that no aspects are overlooked.

Familiarisation is usually based on a review of documentation including drawings and maps, procedures, reports on previous studies, as well as investigations and audit reports. An inspection of the surrounding environment is essential.

The system description must be thorough and comprehensive, within the confines of the scope, or it will not be possible for hazard identification to be complete.

It is important to get these initial stages of the analysis right. They form the foundation on which all else is built.



TIPS

Consider a tour of the mine site to familarise participants with potential on-site and off-site impacts.

Use maps, photographs, and site diagrams as tools for familiarisation with your site or another site chosen for the exercise.

Risk Analysis (iii)

Refer booklet: Section 2.4.2

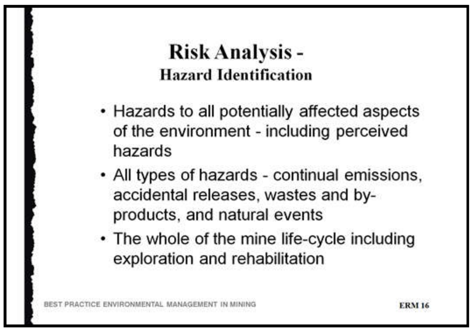
Hazard identification should be a structured process that uncovers all events and circumstances that could lead to significant adverse outcomes.

A structured process works systematically through each element of the operation. For each element consider possible initiating events, possible outcomes and available safeguards.

Consider:

- Hazards (including perceived hazards) to all potentially affected parts of the environment;
- All types of hazards including accidental and intentional release of emissions, waste management, and natural events such as earthquakes or floods;
- The consequences if these events occur;
- Available technical, operational, or organisational safeguards and controls;
- The likelihood or probability of the event or circumstance occurring;
- The likelihood of its translation into significant adverse outcomes if safeguards and controls are used; and
- The whole life-cycle of the mine.

Assume that “what can go wrong will go wrong”! Do not overestimate the effectiveness of a system’s safeguards and controls. Fail-safe mechanisms are not fool proof.



TIPS

You have already carried out a brainstorming exercise for identifying hazards. You may wish to extend this exercise by using the more structured process below.

Exercise 5

Small group work may be useful here.

- **Ask the participants to think about the aspects of the environment that may be affected by the mining operation.**
- **Ask them to list the types of incidents that may occur (example: release of polluting materials) and the aspect of the environment that these incidents will impact such as rivers, local population , air etc.**
- **Participants can use Worksheet 3 to record their responses.**
- **The groups will then report back. Write their responses on the white board or post the sheets of paper with their responses around the room.**
- **Compare their responses with the next slide and lead a discussion on which hazards are relevant to different stages of the mine’s life cycle or operational areas.**

For advice and information on small group work refer to the *General Trainers' Guide* **in Volume 1.**

Risk Analysis (iv)

Refer booklet: Section 2.4.2

Hazard identification processes must be tailored to the specific study. Drawing on as many sources of information as possible will help to ensure that they are comprehensive.

An environmental audit can help to identify hazards. Reports of any previous audits should also be used. An audit should not be the sole source of hazard identification.

Risk analysis is about ensuring that all relevant risk issues are addressed. This includes the perceived risks, issues identified by the community (and workforce), as well as the ‘actual’ or ‘technical’ risks.

At the end of the hazard identification process, the issues that warrant further detailed analysis should be further examined by developing scenarios.

Scenario development involves pulling apart the hazardous event into its separate parts so that the consequences and likelihoods of the components can be analysed.

This can be a powerful tool for identifying weak links. This will be useful later in the analytical process.

Hazard Identification Processes

- Audit-type inspections
- Brainstorming sessions with relevant parties
- Reviews of:
  - Community concerns
  - Licence conditions including compliance and breaches
  - Incidents and previous audits
  - Operating, maintenance and emergency procedures

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TIPS

Exercise 6

In Exercise 5, you posted sheets summarising identified hazards around the room.

Consider these hazards again in the light of licence conditions, results of previous audits or incidents, existing procedures, and community concerns. This is likely to bring more hazards to light. Update the sheets if necessary.

The BPEM booklet *Environmental Auditing* **provides useful advice on this tool for hazard identification.**

Risk Analysis (v)

Refer booklet: Section: 2.4.3

Analysing consequences encompasses not just the end outcomes but also the steps leading to the outcomes.

For each element, it may be necessary to consider several aspects. These may include magnitude, extent, severity and duration.

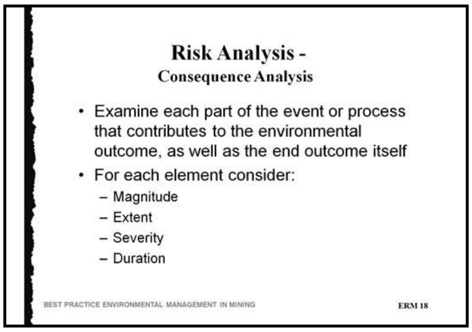
Consequence analysis is always a mixture of quantitative and qualitative considerations. Some components can be measured or estimated with relative precision. For others you may need to rely on qualitative analysis.

Given uncertainties and limits to knowledge, the precautionary approach should be observed. See the *Overview* module for a discussion of this approach.

Worst-case scenarios are often used to test the limits of potential impacts. If worst case assumptions indicate no serious potential for significant impacts, then no further analysis is needed for that particular issue.

Analysis may call for a wide range of information inputs such as meteorological, geological hydrological, ecological and chemical data. Some of these data sets will also include information relevant to the likelihood analysis.

Collecting this information may take considerable time. In some cases the data may not be available. In these cases, primary investigations and surveys may be required. In some cases it may be possible to proceed by working around missing data by using conservative assumptions and applying the precautionary principle while data collection is undertaken.



TIPS

Exercise 7 - Case Study

The Trainer may wish to introduce a case study here to help the participants to understand consequence analysis.

A case study and suggested questions are presented on Worksheets 4 and 4a which can be given to participants to read and record their responses to the questions. The exercise may be conducted as small group work or individually.

Set a time limit of 10 to 15 minutes for participants to complete the exercise.

After the elapsed time bring the class back together and lead a discussion based on the responses of each group.

You may choose to use other case studies included on the CD ROM, or to develop your own site-specific case study.

Risk Analysis (vi)

Refer booklet: Section 2.4.4

Likelihood analysis is covered in Slides 19 and 20.

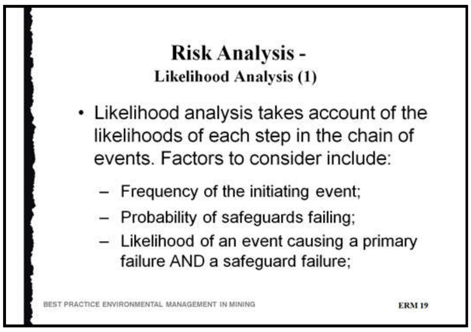
Likelihood analysis includes the likelihoods for each step in the chain of events.

One tool used in likelihood analysis is a logic tree. Logic trees have various forms. The most commonly used analytical method is a fault or event tree. See Appendix 2 and 3 in the booklet.

These trees provide a strategy for sorting out the interrelationships between steps in an event. Sometimes quantitative analysis is possible, as illustrated in Appendix 3 of the booklet.

Even if quantitative data are not available, logic trees can be used to clarify thinking about the factors that contribute to an event.

Detailed quantitative analysis deconstructs the whole system into its component parts and looks at each part in turn. This allows deeper analysis and testing of sensitivity to changes in inputs and assumptions.



TIPS

Appendices 2 and 3 in the booklet illustrate the use of fault and event trees in risk analysis. This can be downloaded from the Best Practice Environmental Management in Mining website:

http://www.ea.gov.au/industry/sustainable/mining/bpem.html

Risk Analysis (vii)

Refer booklet: Section 2.4.4

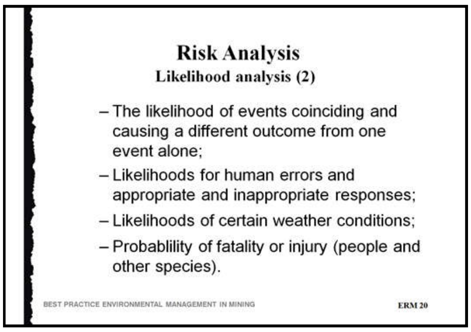
Data sources for likelihood analysis can be many and varied.

There are well-established databases for items such as equipment components (such as pumps and valves) based on industrial experience.

In other cases, data may not be available and may have to be compiled by manipulating or extrapolating data. Drawing on the experience of facility personnel may provide useful inputs.

Questionnaires, interviews and group sessions can help to gather information. The knowledge of experienced personnel can be a valuable tool.

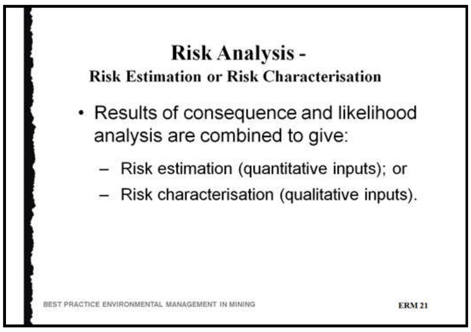
The focus in likelihood analysis is on particular variable components, not on the overall incident or outcome likelihoods. People generally give more accurate and consistent responses if they are asked about component likelihoods than for outcomes as a whole.



TIPS

Exercise 8

Use a logic tree to carry out a likelihood analysis on a scenario that is familiar to the participants. This could be similar to the logic trees found in Appendix 2 and 3 in the booklet. The exercise will be most meaningful if you construct your own scenario based on a part of your own mine.



Risk Analysis (viii)

Refer booklet: Section 2.4.5

Risk estimation can be used when the analysis has a substantial quantitative component.

Risk estimates are commonly expressed as the chances per year of the defined outcome. For example, the result could be a one in a million chance per year of a fatality at a specified location.

There are many ways of expressing quantified risk estimates. The denominator could be based on time (per month or year), output (per tonne of product or export dollar earned), or human exposure (per person employed).

Sometimes the relevant measure may be probability within the lifetime of the operation. This could apply to outcomes such as catastrophic events, destruction of sensitive ecosystems, or the introduction of an unstoppable exotic species.

Risk Characterisation is usually applied when the work is substantially qualitative.

Qualitative outputs may be described by rankings such as very low to extreme risk.

Numerical scores are sometimes derived by adding or multiplying the consequence and likelihood scores.

When a risk analysis has been completed, there are many ways to communicate the results. These include risk contours, societal risk curves, or tables of risk contributors. Combining a written description of the risk analysis process with graphs or tables is usually the most informative. Descriptions should include key assumptions and limitations, and interpret the meaning of the results.

Risk Analysis (ix)

Refer booklet: Sections 2.4.6 and 2.4.7

One of the most useful outputs of estimating risk is the identification of the parts of the system that contribute most to risk.

This provides an opportunity to rank matters for action and to identify cost-effective risk management measures.

This is easier to do by looking at the parts of the system rather than the whole.

When combined with cost information, the various risk management options can be ranked in order of cost-effectiveness.

Opportunities for risk reduction can be found throughout the analysis.

When assessing risk reduction opportunities consider:

- Eliminating the hazard (e.g.using a non-hazardous process chemical rather than a hazardous one);
- Reduction of potential consequences (e.g. adding safeguards); and
- Reduction of likelihoods (e.g.increasing maintenance or other safeguards).

Take a broad view and try to consider changes to operational details and safeguards as well as changes to basics such as location of facilities and modes of transport for products.

Risk reduction can often be achieved at little cost, and can, in some cases, lead to substantial operational or capital cost savings. This is especially true when ERM is initiated early in the planning process for a facility.

Risk Analysis -
Identifying Risk Contributors and Opportunities for Risk Reduction

- Identify the parts of the system that make the largest contribution to risk
- This provides the opportunity to rank matters for action and to identify the opportunities for cost-effective risk management measures

BEST PRACTICE ENVIRONMENTAL MANAGEMENT IN MINING ERM 22

TIPS

An environmental aspects register can affect perceptions about the importance of issues at a mine.

An environmental aspects register is compiled by reviewing all activities conducted at a mine, together with other considerations such as possible climatic events.

Each item on the register is ranked in terms of its likelihood and consequence to produce an overall risk ranking.

If a number of issues, such as handling and transport of hazardous materials, generation of acid rock drainage, and management of emissions in water from tailings are identified as high priority, these issues become most deserving of limited site resources.

Other issues can be assigned resources according to their risk ranking.

The exercise may change the perceptions of site management about the relative importance of issues. This may result in some issues attracting increased attention while others are subsequently regarded as less important.

Risk Analysis (x)

Refer booklet: Sections 2.4.8 and 2.4.9

As our knowledge may be limited, we may need to make assumptions during an analysis. This means using estimated or assumed values for some variables during the consequence and likelihood analysis.

If we use conservative estimates, we are unlikely to underestimate the risk. However it is important to test how changing these estimates affects the analysis. This process starts during hazard identification and continues through the analysis.

Sensitivity analysis is most beneficial when using a qualitative approach. It is generally less worthwhile when a quantitative approach is used.

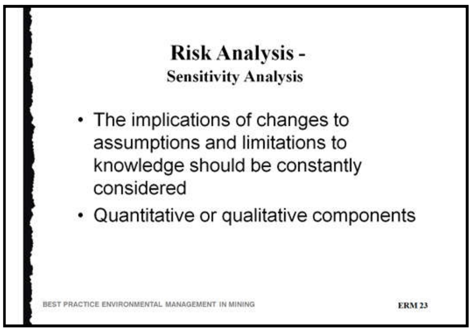
Risk analysis will generally include both **qualitative** and **quantitative** components.

Quantitative analysis generally provides greater opportunities for risk management as it is more precise and generally forces a more rigorous analysis. However care must be taken not to have a blind belief in the numerical results generated since these outputs may be based on assumptions and incomplete information.

Qualitative analysis also suffers from assumptions and generalisation. The outputs can never be better than the quality of the inputs. Qualitative outputs are estimates, not statements of fact.

Wholly qualitative analysis can be used to identify and rank some of the more obvious issues but should not be used at the level of excluding hazards.

Environmental risk analysis is multidisciplinary. Depending on the type and scope, an exercise may require inputs from many different individuals and disciplines. Some of the necessary expertise may be available from within the mining organisation. However, some outside resources may be needed for a specific technical issue or for risk assessment.



TIPS

An example of a typical qualitative ranking system is shown by Mount Isa Mines' incident ranking categories. These categories are:

- ***Category 1* – Minor non-conformance – no environmental impact**
- ***Category 2* – Minor incident – minimal potential for environmental impacts outside the immediate area.**
- ***Category 3* – Moderate incident – moderate, localised environmental impact, possibly off MIM managed areas.**
- ***Category 4* – Major incident – significant medium term effect, possibly off MIM managed areas.**
- ***Category 5* – Catastrophic incident – potentially serious consequences and long term impact.**

Source: *MIM, 2000 Environmental Report*. **To download the report from the Internet go to:**

www.mim.com.au/environment.html

Risk Assessment

Refer Booklet: Sections 2.5.1 to 2.5.3

Responses to risk can include accepting the risk, eliminating the hazard or avoiding the risk, reducing the consequences, reducing the likelihood, and risk transfer.

Defining a framework of criteria or objectives can help provide a rational basis for evaluating the responses.

Criteria identification

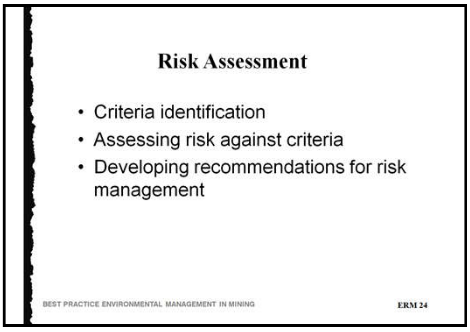
- Since it is not possible to eliminate all risk, some level of risk must be regarded as acceptable or tolerable.
- How much risk is acceptable depends on the benefits that flow from the risk-generating activity.
- Appropriate criteria may be based on regulatory requirements, company policy, and national or international standards. Alternatively they can be identified through case-by-case research. Criteria should cover issues such as human fatality or injury, property damage, and harm to the biophysical environment.

Assessing risk against criteria

- Assessment compares risk results with risk criteria or environmental protection objectives.
- If risk levels do not meet the defined criteria you may need to review and refine the analysis process.

Developing recommendations

- Make recommendations at each stage of the analysis. At the risk assessment stage, effects or interactions of all the recommendations must be assessed against compliance with the criteria.
- During this stage you may need to identify further changes to the existing or proposed operations.
- You may decide that some of the recommendations are not needed or are not cost-effective.



TIPS

Examples of criteria for risk to the biophysical environment:

- **Industrial developments should not be close to sensitive natural environmental areas if the effects of the likely accidental emissions may threaten the long-term viability of the ecosystem or any species within it.**
- **Industrial developments should not be sited close to sensitive natural environmental areas if the likelihood of impacts that may threaten the long-term viability of the ecosystem or any species within it is not substantially lower than the background level of threat to the ecosystem.**

Source: NSW Department of Urban Affairs and Planning; Hazardous Industry and Planning Advisory Paper No. 4, *Risk Criteria for Land Use Safety Planning.*

Each country is likely to have established regulatory criteria such as various air, water and soil concentration standards or health risk criteria.

If these are not available, it may be necessary to access documents from other countries as a guide. Some of these are listed in the booklet. Australian examples include the ANZECC *Australia and New Zealand Guidelines for Fresh and Marine Water Quality* **and the National Environment Protection Council** *Assessment of Site Contamination.* **See** *References and Further Reading* **in Volume 1. Many of these documents are available at no charge on the internet.**

Risk Treatment (i)

Refer booklet: Section 2.6

The term **treatment** is used here to mean action taken to eliminate, minimise or monitor risk. Sometimes this is called **management**. The term **risk treatment** is used to avoid confusion with the concept risk management that refers to the overall ERM process. Whichever term is used, treatment or management is a continuing part of ERM once the initial risk analysis and assessment processes have been completed.

It is important to integrate the treatment phase of ERM with overall risk, environmental, and mine management.

Accepting risk

- Once a risk is known, a company or regulatory authority may decide that the risk is acceptable. If so, no action is needed to reduce it. It may decide to respond to a hazard by including it in a monitoring program or in emergency response plans. Acceptance of risk is regarded as a management measure when a risk is known, understood and accepted.

Risk reduction or minimisation

- There are 3 components of risk reduction:
  - *Eliminating the hazard* by not proceeding with the risk generating activity or by changing the way an activity is carried out.
  - *Reducing consequences* by giving attention to the size and severity of an event or by limiting impacts of an event. Examples include building smaller dams, using less hazardous materials, developing emergency response procedures and clean-up programs.
  - *Reducing likelihood* by making systems more reliable. This may be done by improving training, maintenance, monitoring and planning, or by installing new or larger capacity equipment. Likelihood can also be reduced by putting in place safeguards and emergency response procedures.

TIPS

Examples:

Accepting Risk **– Airborne particles smaller than 10 micrometres in size (PM$_{10}$) are small enough to penetrate deep into the lungs causing health problems.**

Standards are established by Environment Protection Agencies which set limits on particulate emissions. Standards establish a level of acceptable risk. For example the current Victorian EPA one day standard for PM$_{10}$ is 50 micrograms per cubic metre.

Emergency response plans should include all known risks. A useful planning tool is UNEP's Awareness and Preparedness for Emergencies at Local Level (APELL) program. See *Technical Report No 41 APELL for Mining: Guidance for the Mining Industry in Raising Awareness and Preparedness for Emergencies at Local Level.* Available at http://www.uneptie.org/pc/apell/index.html

Risk Reduction **– Passive smoking (exposure of non-smokers to other people's cigarette smoke) has been shown to increase the risk of developing lung cancer. This is an identified risk. As a treatment, smoking has been banned in some public spaces in Australia such as restaurants, offices, and some sporting venues. The effect is a reduction in exposure to cigarette smoke which reduces the risk.**

Risk Treatment (ii)

Refer booklet: Section 2.6.3 and 2.6.7

Risk Transfer

- Risk transfer describes arrangements that shift responsibility for potential outcomes of hazards.
- Risk transfer does not change the likelihood or consequences, just who bears the responsibility.
- Risk transfer is used where consequences are mostly financial or where legal liability can be transferred.
- Insurance is a common form of risk transfer. However there are non-transferable penalties for a company including fines, bad publicity or even imprisonment of executives or staff.

Emergency and contingency planning

- Emergency plans covering all environmental hazards should be integrated into the ERM program.
- Emergency planning should include provisions for incident reporting and investigation.

Monitoring

- ERM requires monitoring of environmental performance and the performance of safeguards.
- A monitoring program can detect emerging problems or impacts and provide opportunities to correct them.

Auditing

- Environmental auditing is essential to the ERM process. It is not sufficient to rely on a one-off analysis, as circumstances will change. Auditing can identify changes that may affect risk.
- Auditing needs to address the implementation of any recommendations of the risk analysis and the findings of previous audits, monitoring programs, and performance assessments as they relate to risk-affected aspects of the mining operation.

Risk management program or system

- Continuing ERM should be incorporated into a structured environmental management system.
- This system must identify roles and responsibilities and action plans to reduce risks.

TIPS

Monitoring in the wider environmental management context is covered in the *Environmental Monitoring and Performance* **booklet.**

Environmental auditing is covered in more detail in the *Environmental Auditing* **booklet in the Best Practice Environmental Management in Mining series. See Volume 1 for information on how to obtain this booklet.**

Risk management must include emergency response planning. A useful guide has been published by UNEP (2001) *Technical Report No 41 APELL for Mining Guidance for the Mining Industry in Raising Awareness and Preparedness for Emergencies at Local Level.* **It is available at:** http://www.uneptie.org/pc/apell/index.html

Communication and Consultation (i)

Refer booklet: Section 2.7

Communication and consultation cane be very challenging parts of the ERM process. However, putting effort into this process is usually worth it. Effective risk communication should be a two-way process. It is about listening to what interested parties have to say about their concerns, and providing them with clear and accessible information on the results of risk analyses and the ERM process.

Risk communication is an integral part of ERM. It should cover the entire life cycle of the mine. Communication should involve accessing the knowledge and concerns of outsiders, understanding their perspectives, and providing them with information held by the company.

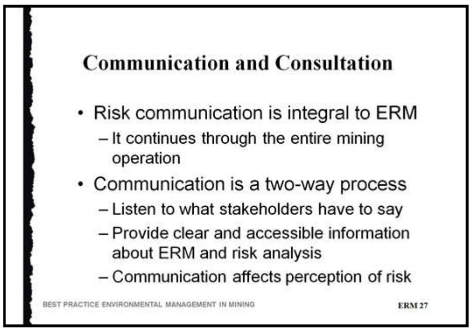
This same two-way process is needed for company personnel. They have had experience that gives them a different outlook on hazards of the mining operation. Their familiarity with the mining process may lead them to underestimate risks. Appropriate training for all relevant personnel is essential.

Good communication will help to reduce problems encountered when personnel or members of the community develop unrealistic perceptions of risk. These perceptions may magnify or underestimate the scientific estimate of risk. Risk perception of the community should not be discounted.

Community risk perception can be influenced more by the "outrage" factor than by technical risk assessment. Good communication helps to reduce the outrage factor.

Risks that frighten and anger people have a high "outrage" factor. Risks with high outrage factors are less acceptable to communities, even if they rate low in terms of their technical risk assessment.

Factors that increase outrage include unfamiliarity, involuntary exposure, dread, and memorability.



TIPS

Sandman argues that "Risk communication ought to be multi-directional rather than one-directional, a debate instead of a lecture."

See Sandman (1987) *Risk Communication: Facing Public Outrage* **for a discussion of outrage:**
http://www.psandman.com/articles/facing.htm

Exercise 9

Topic for Discussion

Stakeholders or interested parties include more than just the shareholders!

Who are the interested parties in the activities at your minesite?

Ask the groups to develop lists of interested parties. Encourage them to think as widely as possible.

Use the inputs from the small groups to develop a table of interested parties and the reasons for their interest.

Communication and Consultation (ii)

Refer booklet: Section 2.7

Different stakeholders may have varying perceptions of the risks posed by a mining operation. Perceived risk may differ widely from the estimated risk.

Appropriate management measures cannot be developed without an understanding of perceived risk. The risk analysis is not complete without this input.

Perceived risk may encompass concepts such as fairness, trustworthiness of the organisation controlling the risk-generating activity, and familiarity.

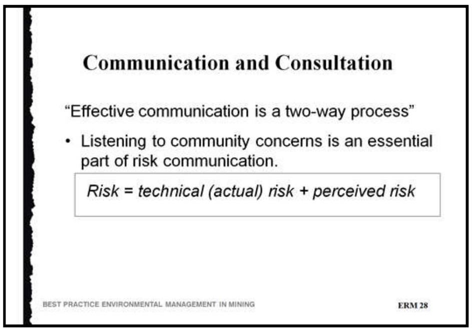
The **technical** definition of risk may be too narrow. It may need to be redefined to include both technical (estimated or actual) risk and perceived risk.

In this way perceived risk is treated with respect, and management processes are designed to recognise and accept risk perception.

Perceived risk may be strongly influenced by what Sandman describes as “outrage factors”. He argues that perceived risks are increased by exposures that are:

- Coerced rather than voluntary;
- Industrial rather than natural;
- Dreaded rather than not dreaded;
- Unfamiliar rather than familiar;
- Controlled by others rather than by those at risk;
- In the hands of the untrustworthy rather than trustworthy sources; and
- Managed in ways that are unresponsive rather than responsive.
  (Sandman 1987, updated, 2001)

The latter two outrage factors can be decreased by good communication and consultation practices.



TIPS

The ICME Newsletter Volume 7: No 2 has two useful articles on risk communication: *Risk and Trust in Communications* **by V.T.Covello and** *Devoting Adequate Resources tor Risk Communication the Risk Management of Chemicals* **by W.Leiss.**

The BPEM booklet *Community Consultation and Involvement* **is a resource for developing positive relationships with the community.**

See the articles by Sandman listed in the *References and Further Reading* **section.**

Communication and Consultation (iii)

Refer to Section 4 (p 20) *APELL for Mining*

"APELL" stands for Awareness and Preparedness for Emergencies at Local Level. APELL was developed by the United Nations Environment Program in partnership with governments, communities, and industry associations.

The APELL process can be summarised in 10 steps:

1. Identify emergency response participants and establish their roles, resources and concerns.
2. Evaluate the risks and hazards that may result in emergency situations in the community and define options for risk reduction.
3. Have participants review their own emergency plan, including communications to ensure a fully to a coordinated response.
4. Identify the required response tasks not covered by existing plans.
5. Match tasks to resources available from the identified participants.
6. Make changes necessary to improve existing emergency plans, integrate them into an overall community plan and gain agreement.
7. Write out the integrated community plan and obtain endorsement and relevant approvals for it.
8. Communicate final version of integrated plan to participating groups and ensure that all emergency responders are trained.
9. Establish procedures for periodic testing, review and updating of the plan.
10. Communicate the integrated plan to the general community.

TIPS

APELL for Mining: Guidance for the Mining Industry in Raising Awareness and Preparedness for Emergencies at Local Level (Technical Report No 41) **can be downloaded from:** http://www.uneptie.org/pc/apell/index.html

The key reference for this module is the BPEM booklet Environmental Risk Management.

ERM and the Mining Cycle

Refer booklet: Sections 3.1 to 3.7

ERM should be applied to all phases of the mining cycle. Some issues for each phase are listed here. You should consider other issues that may be specific to your site.

Planning and concept development

Considering hazards and risk management issues early can help to avoid costly problems and delays. Issues to be considered include:

- Location and layout of mine facilities; there may be areas that are too sensitive for mining to be acceptable; and
- Processing facilities and choice of mining method (open cut or underground mining).

Exploration

- Potential to introduce or spread pest plants and animals; and
- Disturbance and destruction of habitat.

Approval processes including Environmental Impact Assessment (EIA)

Sometimes a number of important issues are not covered in the EIA process, these may include:

- Transport;
- Remote processing operations;
- Issues of sustainable development; and
- Whole of mining-cycle issues.

Development and construction

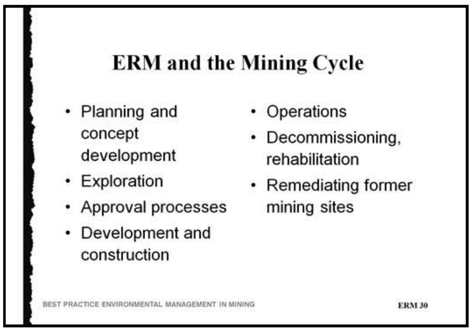
Major modifications or demolition activities.

Operations

This will depend on the type of mining activity and must be considered.

Mine closure and rehabilitation

- Contamination of land, or surface or ground water;
- Soil erosion and siltation; and
- Weed invasion.



TIPS

Exercise 10

It may be valuable at this stage to ask the participants to break up into small discussion groups.

- **Ask the groups to identify environmental risk issues that are applicable at each stage of the mining cycle.**
- **Groups can record their responses on Worksheet 5.**
- **Depending on the type of mining activity you are involved in the group responses may include some of the issues identified in the Notes column.**

Other booklets in the Best Practice Environmental Management in Mining series may be helpful. Of particular relevance are:

- *Mine Planning for Environment Protection*
- *Onshore Minerals and Petroleum Exploration*
- *Environmental Impact Assessment*
- *Environmental Management Systems*
- *Rehabilitation and Revegetation*

These are available from the Environment Australia website. See Volume 1 for details.

Risk Management and the Future

Refer booklet: Section 4

Given environmental awareness and regulation trends and growing global environment pressures, it is highly likely that requirements for a high standard of environmental management will increase.

In the future, ERM will play a bigger role in the environmental management of mining than it does today.

Performance-based regulatory requirements will encourage the use of ERM. Current trends that make directors, managers and workers personally liable for environmental incidents should result in an increased use of risk analysis to demonstrate due diligence if incidents occur.

Greater experience with using ERM in mining will promote further development and refinement of ERM tools including developing and standardising risk criteria.

There may be moves towards accreditation of consultants and others who assess risk and audit environmental hazards.

Longer term perspectives and issues such as greenhouse gas issues and climate change are likely to become major factors in ERM.

Overall it would seem that ERM will grow in importance and that there will be significant benefits in heading down this path sooner rather than later.

Risk Management and the Future

- ERM will play a bigger role in mine management in the future as environmental management standards develop.
- Why?
  - Growing environmental awareness
  - Regulation requirements
  - Growing global environmental pressures

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TIPS

The Trainer may wish to explore one or more case studies at this point.. If using small group work allocate each group one or two questions to examine. After a set time period of 10 to 15 minutes ask each group to contribute their answers to the class as a whole during discussion.

You may use any of the case studies described in the *Environmental Risk Management* **booklet or you may construct your own case study relevant to your mining operation.**

Example questions for the class may include:

- **What environmental hazards can be identified in this case study?**
- **What are the potential environmental consequences of these hazards?**
- **Include consequences that may occur both on and off the mine site.**
- **How should the risk be assessed?**
- **How should risk be treated in each case?**
- **What would be an appropriate management plan in each case?**
- **How should the success of the proposed management plan be monitored?**
- **Who in your organisation is responsible for risk management?**
- **How are decisions about risk management communicated in your organisation?**
- **How do advanced companies communicate about risk management?**

Ask participant to use Worksheet 6 to record their responses.

Feedback

Use the feedback form in the *General Trainers' Guide* **to record reactions of the group.**