Emergency Preparedness for Tailings Dams

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Over the last few years tailings dams have come under increased scrutiny, partly due to two highly publicised TSF failures in South America, but also because of several other incidents in Australia and elsewhere in the world. As investors came under pressure to positively impact the projects they financed, the Global Industry Standard on Tailings Management (GISTM) was released in August 2020.

Topic 5 of GISTM, "Emergency response and long-term recovery", comprises Principle 13: "Prepare for emergency response to tailings facility failures" and Principle 14: "Prepare for long-term recovery in the event of catastrophic failure". The topic further introduces the term "Emergency Preparedness and Response Plan" (EPRP).

This paper explains what the term "Emergency Preparedness" means and how the owner/operator of a mine can achieve it. The paper also delivers a concept for long-term recovery planning

Keywords: *tailings, emergency preparedness, emergency response, governance, GISTM, long-term recovery*

Introduction

Practitioners in the mining industry generally appreciate that, although unlikely, a significant incident or the catastrophic failure of a Tailings Storage Facility (TSF) must always be considered plausible. In response, a great deal of effort is invested in robust design approaches, control of construction, responsible operation and maintenance and ongoing surveillance. However, if catastrophic failures are plausible scenarios, the site owner needs to be prepared for them.

Topic 5 of the Global Industry Standard on Tailings Management (GISTM), "Emergency response and long-term recovery", comprises two principles. Principle 13 requires TSF owners to "Prepare for emergency response to tailings facility failures" and Principle 14 requires them to "Prepare for long-term recovery in the event of catastrophic failure".

In essence, Topic 5 is about creating Emergency Preparedness and having a conceptual plan for recovery and restoration after a "catastrophic failure". This paper explains how to achieve these goals.

Let's start with Emergency Preparedness. What is it?

"The objective of emergency preparedness is to ensure that the strategic direction and required building blocks for an eventual emergency response are in place." (United Nations Human Rights Council)

Emergency Preparedness is the ability to meet and mitigate the impact of an emergency. In most countries, with some minor variations in wording, an emergency is defined as "an event, actual or imminent, which endangers or threatens to endanger life, property or the environment, and which requires a significant coordinated response." (Emergency Management Australia, 1998)

The next question is of course: How does an organisation create Emergency Preparedness?

The answer is: Functional Emergency Preparedness for the unlikely event of a TSF failure comprises three main components:

- ORGANISATION – A suitable Emergency Management and Emergency Response Organisation
- PLAN – An understandable plan to guide the operation
- COMPETENCY – Capability to execute an Emergency Response

Emergency Response is the tactical response to mitigate the impact of an emergency, whilst Emergency Management is "the organisation and management of resources for dealing with all aspects of emergencies." (United Nations International Strategy for Disaster Reduction, 2009)

Considering some of the recent catastrophic TSF failures, such as the Brumadinho incident where approximately 270 to 310 people were killed, it may be reasonable to ask whether there is anything to be gained by emergency preparedness?

A recent paper titled "Modelling the Brumadinho tailings dam failure, the subsequent loss of life and how it could have been reduced" (Lumbroso, D. et al. 2021) concludes that, in a modelled case, very similar to the actual failure geography, a warning given five minutes before the dam failed could have reduced the number of fatalities by between 200 and 270 and a warning received 15 minutes before the failure could have reduced the number of deaths to zero. This assumes that the monitoring systems can detect imminent failure, the decision is made to disseminate the warning signal, and evacuees are familiar with the warning signal and know how, and to where to evacuate.

The following sections examine the three components in the Emergency Preparedness: Organisation, Plan, and Competency. To be able to correlate these three elements to a realistic dimensioning scenario, a dam break study is required.

The dam break study *"based on credible flow failure"* is used to form the Emergency Management Organisation, develop the Emergency Response Plan and achieve the required Competency.

Requirement 13.1 of the Global Industry Standard on Tailings Management states that owners must make sure that their emergency preparedness is designed and implemented using "best practices and emergency response expertise." (International Council on Mining and Metals, 2020)

Organisation

The role of an Emergency Response Organisation is to execute the emergency response, based on strategic and tactical decisions by the Emergency Management Organisation. To deliver a functional emergency response the Emergency Management Organisation needs to understand the capabilities and limitations of the Emergency Response Organisation.

Most major mining companies have an Existing Emergency Management Organisation, with emergency management or incident management teams. This organisation should be dimensioned for management of all major emergencies on a site, hence also management of a response to a potential catastrophic TSF failure. The organisation should be built on a reputable Incident Management System, e. g. AIIMS, NIMS, ICS or a similar.

However, there is one complicating factor. A catastrophic TSF failure may affect areas outside of the mine lease, and in some cases have an impact on the surrounding community, where the local emergency authorities will be providing emergency response. For these cases a plan for coordination with the organisation/s responsible for these external areas needs to be in place (refer to section on Coordination below).

Timing of activation of this organisation is often well described for a broad variety of emergencies, and available in the company's escalation process for incidents and emergencies. This system should be used also for potential emergencies emanating from a TSF failure (refer to section on Escalation below).

Plan

Overview

As indicated in Figure 1, the Emergency Response Plan (ERP) provides guidance on mitigating the impact of an emergency and defines how to develop and maintain the capability to do so. Prevention of emergencies through operation, maintenance and surveillance is addressed separately in the Operations, Maintenance and Surveillance (OMS) Manual.

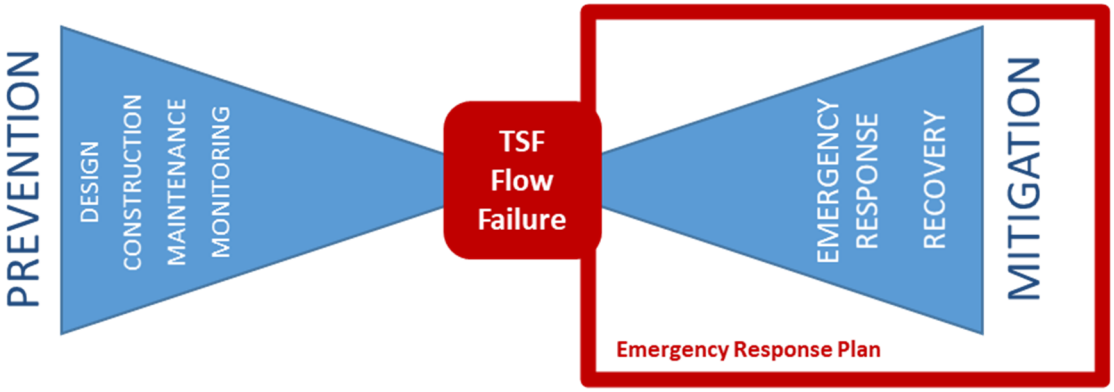

Figure 1: The Emergency Response Plan should describe the response to the effects of an emergency

The ERP needs to be written in such a way that the organisation can use it both for training and capability building, as well as using it to guide the execution of an emergency response operation. The owner needs to engage with relevant public sector agencies, local government, and the emergency services in the planning process.

The following sections describe the structure of a good ERP.

Introduction

This chapter describes the purpose and scope of the ERP and identifies the target audience. Normally the ERP is written for the Site Manager, the supporting emergency management team and the emergency response team, but it can also be used in parts to coordinate an operation with external resources, authorities and organisations.

The introduction explains the location of the site and provides a brief description of the site layout with aerial views of the relevant infrastructure. It also briefly conveys an understanding of the purpose of the TSF as well as the associated hazard.

A glossary of terms should be included that aligns with the legal framework of the country and region where the operation is located and the professional standards and guidelines for emergency response and management.

Conditions in the TSF operation

The Operations, Maintenance and Surveillance (OMS) Manual typically describes the operational conditions of the TSF that are illustrated in Figure 2. These conditions should be connected to the ERP and the same or similar terminology used.

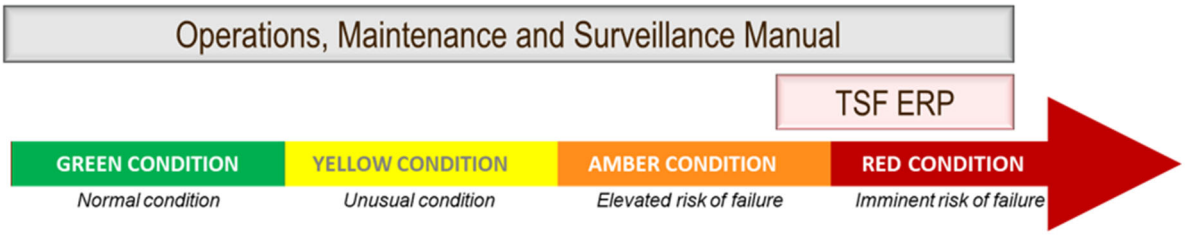

Figure 2: Conditions in a TSF operation and the relationship between ERP and OMS Manual

Roles and responsibilities

This chapter describes the chain of command applicable to:

- Daily Operations of the Site and the TSF
- Emergency management and response pertaining to a catastrophic TSF failure (this must be fully aligned with the operation's emergency management plan or equivalent)

Clear and simple organograms should be presented.

Emergency Identification and Incident Classification

Organisations should use the same definition of the term "emergency" as the legislation of the state where the operation is located.

An incident is "an unplanned event with potential of leading to harm" *(*AS/NZS 4801:2001). The owner/operator likely has a system for classification of all incidents, not only TSF incidents. In many cases this "Incident Classification System" is based on a risk management system. The same classification system should preferably be applied for all incidents in the company.

Not all incidents become emergencies, but all emergencies begin as an incident.

Emergency Trigger Points

This chapter describes, in tangible and simple terms, what are the emergency trigger points, i.e., conditions that define the transition to an operational condition that entails an immediate risk of failure (refer to Figure 2). This transition would drive a decision to invoke the ERP. The emergency trigger points are descriptors of when the ERP and the corresponding management organisation should be operational (refer to Figure 3) and should be identical in both the ERP and the OMS. Most organisations are not operational the moment they are activated. It is therefore prudent to activate ahead of the emergency trigger point.

The emergency trigger points should be clearly defined and measurable. Besides emergency trigger points there might be a need to describe indications to undertake an urgent and targeted inspection. If this inspection identifies an emergency trigger point, ERP activation follows.

The term Trigger Action Response Plan (TARP) is a generic term for a described set of actions to be executed in response to the operation reaching a specified point or condition. A TARP defines the minimum set of actions required, in response to a deviation from normal operating conditions. A TARP is not to be confused with an ERP. One of the actions in a TARP may be to activate the ERP and emergency management organisation.

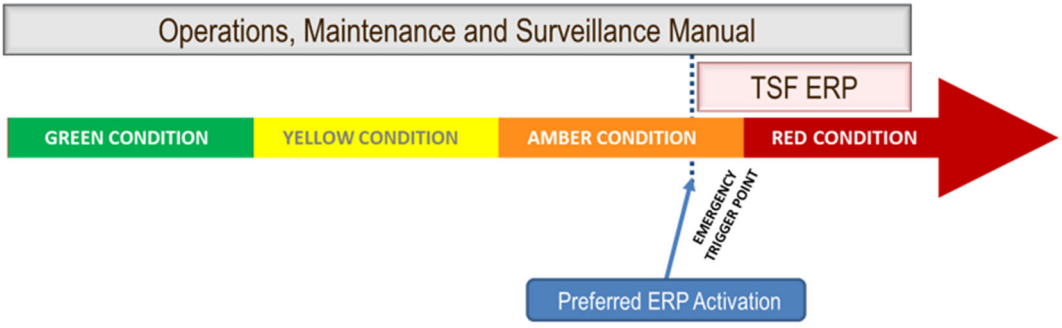

Figure 3: Emergency trigger point and timing of ERP activation

Escalation

Following detection of a trigger point and incident classification, the site owner escalates the incident as per its standing order for escalation and emergency response.

The principle of prudent over-reaction and rapid de-escalation applies when considering the level of escalation. It is easier and usually more effective to scale down an initial over-reaction than it is to gain control of an overwhelming situation exacerbated by a late, or insufficient, response. The escalation process should be clearly described in the ERP.

Consequence

The potential outflow of water and tailings from a catastrophic TSF failure can be described in four dimensions: length, width, depth, and time. Variations in time to breach and time to inundation at a specific location might warrant a plan containing several different scenarios. Further information is provided in the section on Inundation Maps below.

Strategy for an Emergency Response

Without a strategy set for an emergency response, efforts often become and remain reactive. Having a strategy defined before arriving at actions will help with maintaining focus of the operation. At the same time, immediate actions commonly need to be carried out whilst the strategic intent is developed (see Figure 4).

The strategy must be established considering dam break study outputs and balanced against the emergency response capability of the response organisation both at the site and in the surrounding community.

The strategy is, early in the emergency operation, developed into a Strategic Intent which communicates the objective of the operation, the basic steps required to reach the objective and a brief description of the "end state". This is initially the most important task for whoever oversees the Emergency Management.

Based on the Strategic Intent a Plan Inventory for the emergency response operation is developed in the Emergency Management organisation, detailing what plans are needed, by when they need to be ready to launch, and who is responsible for developing them.

Following this, necessary plans are adjusted or developed and set into action, i.e., implemented.

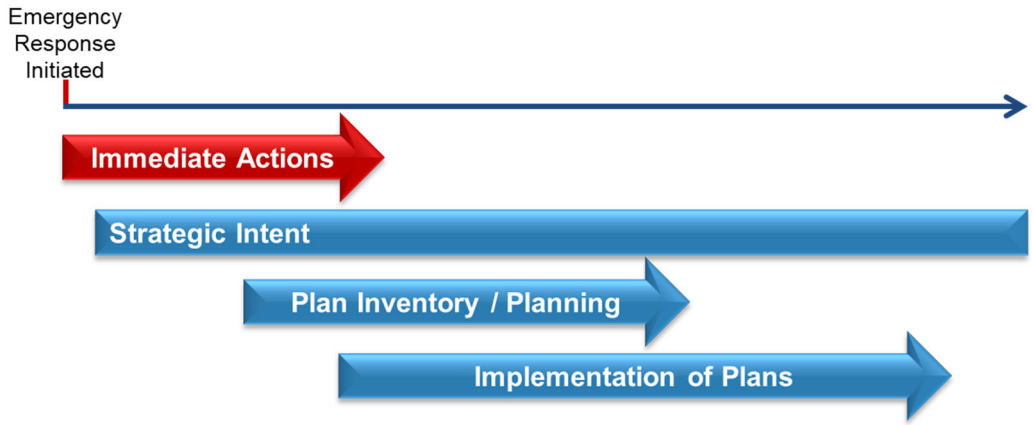

Figure 4: Immediate actions vs proactive planning

Tactical Plans

Alert for self-evacuation, evacuation, rescue, and similar efforts are tactical plans and should be based on the strategy included in the ERP and the Strategic Intent developed at start of the operation. Some of these tactical plans may be built on Standard Operating Procedures (SOP) and are the outcome of decisions made by people experienced and trained in Emergency Response and Emergency Management.

Evacuation of areas outside of the site may be subject to legal requirements for the evacuation decision and execution, from authorities or external emergency services. If there is unacceptable danger in delay of such decision, evacuation sometimes must be executed without the legal instruments in place.

If a TSF failure is likely to develop differently in time and geography it is important to prepare the tactical plans for foreseeable variations. Hence the ERP might contain alternatives for actual or imminent failure as well as one or many alternatives for more slow progressing failure types, such as gradual overfilling due to rain, decant failures or a combination of the two. See also the section on Inundation Maps below.

Notification and Warnings

This chapter in the plan should specify who will be notified, in what order, and what message will be used. Determining these details requires an understanding for the receivers' need for information and further use of that information. Pre-approved notification texts, included in the ERP, with applicable inundation maps are preferred.

A pre-scripted message is especially important when initiating coordination of the emergency authorities and other external stakeholders in the emergency operation.

If there are specific systems that should be used during the communication process, this should be included in the ERP. All such special systems, such as radio, sirens, SMS broadcast, etc must be subject to regular and frequent testing and the intended recipients are to be informed of their expected actions.

Coordination

Coordination is "The bringing together of organisations and elements to ensure an effective response". (Emergency Management Australia, 1998)

If a catastrophic TSF failure is expected to impact areas outside of the site, a concept for coordination with the organisation/s responsible for these external areas needs to be in place. The coordination organisation should be described in the ERP (preferably using an organogram) and should be prepared and trained (refer to Figure 5).

Figure 5: Coordination vs. Command

Checklist

Checklists should be short, sharp and to the point, to serve as a support in the execution of an emergency response operation. They should be written for a specific level in the organisation and should not be generic. Intangible actions should be avoided.

Inundation Maps

The ERP should include inundation maps for the scenarios for which it is written. Inundation maps should be easy to read and understand for all parties that might potentially be involved in a joint emergency response operation. The maps should include the following information:

- Source, i.e., the breach point
- Estimated flooded area and when this flooding can be expected to reach and peak
- Estimated maximum depth of water/mud

Termination and Follow-Up

The ERP should identify who is responsible for evaluating when the emergency is over and subsequently making the decision to terminate the emergency response. An emergency is terminated when there is no longer a threat to people, property, or the environment.

Long-term Recovery Planning

In some circumstances, recovery can be an emergency operation, but more often it is not. At some point in time the emergency response will shift to a recovery operation. Such operations are to be planned just like an emergency response, but with different timescale and targets. The recovery planning process is illustrated in Figure 6.

Early and before the emergency operation is terminated, the TSF owner/operator needs to initiate a Post Incident Impact Assessment. This is an assessment of the damages caused both by the initial emergency but also by the emergency response. The Post Incident Impact Assessment should cover community, environment and company assets and capabilities.

The outcomes of the assessment are:

- Identification of Immediate Actions (potentially)
- Basis for a Strategic Intent for the recovery operation

The Plan Inventory for the recovery operation is developed from the Strategic Intent, detailing what plans are needed, by when they need to be ready to launch, and who is responsible for developing them.

In general, the plans will fall into either of three "Lines of Operation":

- People
- Environment / Assets
- Financial

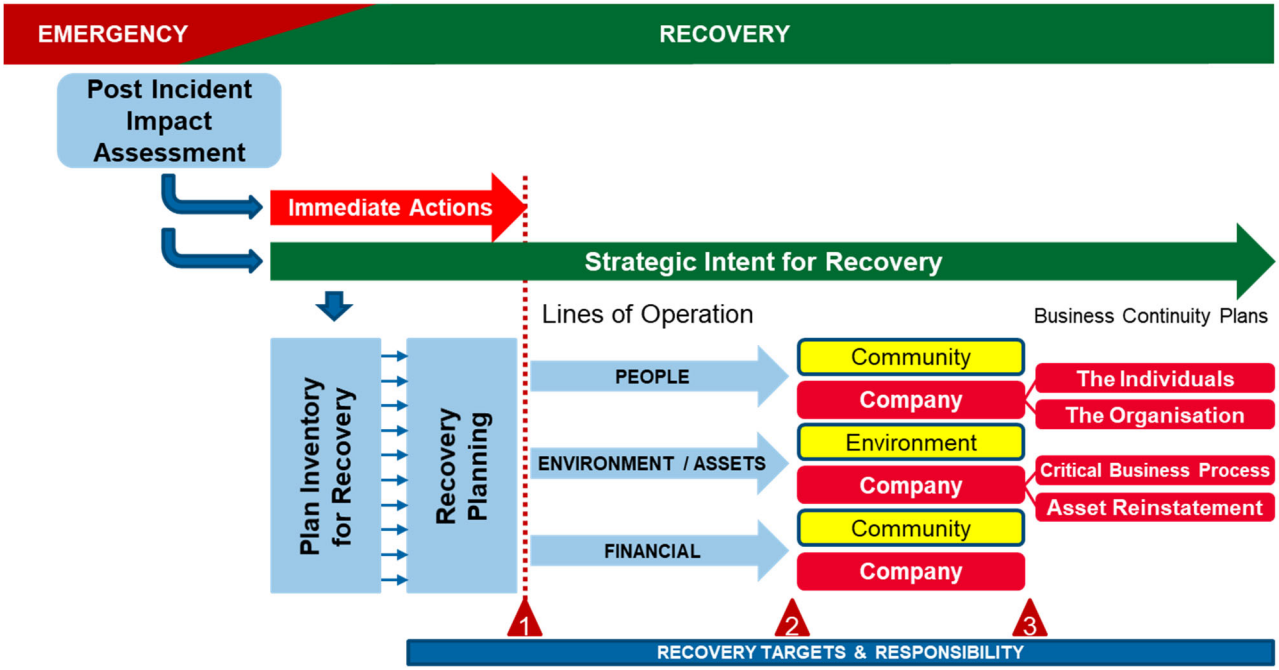

Figure 6: Planning flow for the recovery operation (list of BCPs is not exhaustive)

Each of these categories usually sub-divides into "company" and "community". Recovery Plans following an emergency are often based on the Business Continuity Plan and other existing plans.

The Strategic Intent for the recovery operation should also identify the Recovery Targets which are the "milestones" at which specific parts of the recovery operation are expected to be completed. These Recovery Targets should be expressed in terms of absolute time.

Responsibility for both plan development and execution should be defined in the Recovery Planning.

Resources and Contacts

Contact details should be provided, preferably on alternative means of communication. Several levels of responsibility should be identified within the plan. This includes the operator; local emergency management and local responders; and state/regional emergency management organisations. Contact lists should be subject to frequent updates and available redundant of internet connections and computers.

If the operation has a functional system for listing contact details, this system can be used, if it has back-up for power and network outage.

Competency

Competency is the capability to apply or use a set of related knowledge, skills, and abilities required to successfully achieve a result or an outcome.

The most important preparation for the successful response to a potential TSF failure is to train the members of the emergency management and emergency response organisation.

The interaction between the owner and other stakeholders will also play an important role in mitigating the effects of a failure. All members of the emergency response and the emergency management organisation should be required to maintain an understanding of, and familiarity with, the ERP for TSF failure.

The owner organisation should, as a minimum, arrange one event to train and test interaction between the owner and other stakeholders relevant to a potential TSF failure, every 3 years, or when change of conditions, plans or personnel so require. Training should be a suitable combination of formal training and scenario-based exercises.

If external resources, such as public sector agencies, first responders, local authorities and institutions are expected to be included in a joint emergency operation, the arrangements for maintaining such a joint operational capability should be described in the ERP. Each of the organisations should maintain its own system for command and control, but the model for coordination before and during an operation needs to be applied (refer to the section on Coordination, above).

Each organisation participating in the joint operation requires its own plan, as a plan is written for a specific target group, with its own organisation, competency, professional language, and needs, in mind. However, the owner/operator should take all reasonable steps to maintain a shared state of readiness for tailings facility credible flow failure scenarios by securing resources and carrying out annual training and exercises.

If a segment of the community is expected to self-evacuate, or undertake any other actions, they need to be informed and trained. As a minimum they should be made aware of what signals are used to initiate the evacuation or action and what actions they are advised to take on receiving such signal.

Evaluation of training events and actual emergencies are important inputs for the review and update process. Responsibility for this process should be described in the ERP.

Conclusions and recommendations

The GISTM uses the term Emergency Preparedness and Response Plan (EPRP). In essence an EPRP is an ERP with the additional declaration of how the owner/operator intends to reach and verify Emergency Preparedness.

Emergency preparedness has three main components:

- ORGANISATION – A suitable Emergency Management and Emergency Response Organisation
- PLAN – An understandable plan to guide the operation
- COMPETENCY – Capability to execute an Emergency Response

If these components are in place, then this constitutes an EPRP and embodies emergency preparedness.

If the owner/operator company has functioning organisation and escalation processes in place for management of emergencies, then they should be applied to TSF emergencies. It would be confusing to have different, classification, emergency response and emergency management organisations for different types of emergencies. Owner/operators should adhere to the legislation and the definitions of the country and state in which they are operating.

If the impact of the emergency following a TSF failure is expected to affect areas or functions outside of the mine lease, the authorities and stakeholders that operate in that area would be involved in execution of an emergency response. It follows that they should also be involved in both planning and capability building.

Each organisation participating in the joint operation needs its own plan, as a plan is written for a specific target group, with its own organisation, competency, professional language, and needs.

A joint operation requires, in contrast to a single organisation operation, a functional concept for coordination.

It is important to use the professional definitions for incident, emergency, crisis, and disaster. Each of these terms has a different meaning.

Emergency management is a specialised discipline and the GISTM states that owners/operators must “use best practices and emergency response expertise”. In practice this means that an experienced professional in emergency management and response should assist owners/operators with planning and capability building.

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