Vedanta Resources Plc

Sustainability Governance System

Guidance Note GN32

Inflow or Inundation of Liquids

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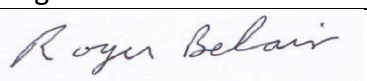
Signature	
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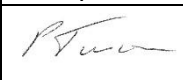
Signature	
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Confidentiality

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1. INTRODUCTION

1.1 Who is this Guidance Note aimed at?

This Guidance Note is aimed at all Vedanta subsidiaries, operations and managed sites with underground mining operations and other business where underground or excavations works may be undertaken, including new acquisitions, and to new and existing employees and contractor employees. This Guidance Note is applicable to the entire operation lifecycle (including exploration and planning, evaluation, operation and closure).

1.2 What is the aim of this Guidance Note?

The aim of this Guidance Note is to outline the company requirements which Vedanta implements in order to ensure that all risks associated with mining operations are eliminated or minimised within an acceptable level.

1.3 What issues does this Guidance Note address?

This Guidance Note presents the framework for the management of prevention of inrush required to avoid untoward incidents within Vedanta operations. The focus of the Guidance Note is on the provision of preferred methods and outcomes rather than being prescriptive whilst at the same time representing a practical "how to" guide for all Vedanta operators.

It is however recognised that the different operations are at different levels of "maturity" with regards to the development of systems to manage the risk associated with prevention of inrush. With this in mind, the Guidance Note includes two approaches:

- *Prescriptive Approach.* This establishes specific requirements that are deemed mandatory and are indicated by the term '**shall**.'
- *Risk Based Approach.* This is less prescriptive and is driven from the site, acknowledging its specific geology, mining methods, equipment, infrastructure and the competency of its personnel.

In reviewing this Guidance Note, the site needs to decide which approach to adopt using competent advisors. Some sites will already have mature systems in place, and it is recommended that a combination of competent internal and external reviewers determines the level at which the site is currently operating. Where a site is deemed mature with competent resources, a risk-based approach is acceptable. Where a site is immature and/or has limited competent resources, the prescriptive approach is to be adopted and Group will require assurance such measures are being implemented.

Those requirements that are associated with '**shall**' statement are mandatory irrespective of site maturity.

1.4 How should this Guidance Note be used?

This Guidance Note is mandatory (as per instructions in Section 1.3 above) and is intended to provide a standard baseline and reflect good practice whilst providing the basis for continual improvement of sustainability issues across the Vedanta business. The need for flexibility at a site is depending upon specific

circumstances or regulatory specific requirements is also recognised. This Guidance Note is not designed to be definitive text, nor is it designed to provide prescriptive methods and procedures for undertaking tasks. In most cases there will also be national and/or local regulatory requirements which address prevention of inrush and sites must ensure that these requirements are identified and complied with.

The guidance has been designed to be applicable for all Vedanta operations. Some references are specific to underground mining operations.

The successful implementation of this Guidance Note is expected to require several years of dedicated commitment from all the Vedanta mining sites depending on their existing maturity and controls.

The following provides guidance on how this may be achieved. This is not a mandatory approach, but an equivalent implementation programme must be designed where the guidance is not followed:

- Prevention of inrush is the responsibility of the Mine Manager who will drive the implementation protocols and is supported by a top line manager with authority to approve new requirements and who will be accountable for successful implementation of the mine plan.
- The mine operates to a mine plan which covers all aspects of the design, planning, scheduling, and implementation, monitoring and reviewing of mining operations in a safe and sustainable manner. The mine plan is not a single fixed plan, but a constantly changing plan, based on dynamic conditions within a mine. Designs, plans, schedules and associated activities change on a continuous basis and all of the changes must be managed, tracked and re-adjusted, as required. Therefore, the system in which the mine plan operates must be robust, flexible, and implementable and have a change management system allowing changes to be managed properly.
- Prevention of inrush is an important part of the mine plan as poor implementation of the mine plan has the potential to have an adverse effect on the controls associated with the prevention of unwanted inrushes.
- Once a system for the mine plan and inrush prevention management is in place, an audit needs to be conducted with competent resources to determine the current status of the site with regard to the elements of this guidance; ideally this will use resources from across Vedanta sites to enable a peer review to be conducted and create a community of practice amongst champions.
- The results of this audit are to be used as the basis of an action plan to implement those aspects that are currently not in place.
- Once this process has been started, an annual progress review will be required to ensure implementation is on track.
- Each site is encouraged to share experiences and build further competencies and internal capacity within the Vedanta Group.

The remainder of this Guidance Note is structured as follows:

- Section 2 – Overall Management Approach
- Section 3 – Identification of potential inrushes
- Section 4 – Risk Management
- Section 5 – Safe Operating Procedures

- Section 6 – Safety Systems
- Section 7 – Preventive measures
- Section 8 – Training and Competency
- Section 9 - Monitoring and review

2. OVERALL MANAGEMENT APPROACH

The management of prevention of unwanted inrushes into the mine is a critical aspect of the mine management approach to safety, as an inrush has the potential to have catastrophic consequences. Inrushes can be the result of a water, backfill, mud or other fluid. Inrushes are either caused by failures of control systems such as barricades, new unanticipated sources of water or mud, or failures to systems such as dewatering.

On specific type of inrush is called a mud rush. Mud rushes can and have posed a major hazard to safety in underground mining.
Mud rushes are sudden inflows of mud from draw points or other underground openings. The rapidity of the mud inflow is such that escape of personnel in its path is most unlikely, with terrible consequences for safety. Mud rushes are also directly responsible for severe damage to infrastructure. Considerable violence, in the form of an air blast, is often associated with a mud rush. Such an air blast event can be the cause of accidents and severe damage to mine infrastructure.

Inrush prevention must be managed through control processes, education and training of employees and fit for purpose equipment and technology. This should include:

- Design by 'competent' persons
- Fit for purpose structures and equipment
- A risk assessment process which identifies all of the potential risks and implements appropriate control systems
- Appropriate Standards, procedures and systems
- Training of persons whose work affects the potential for inrush
- Regular review of all systems associated with inrush prevention

2.1. Risk Register

A Risk Register shall be set up to identify all risks associated with inrush prevention activities, evaluate the likelihood and severity of each rick and determine a control or set of controls to ensure that the risk is removed or minimised.

2.2. Training

An appropriate training programme shall be in place for all mine workers, with specific training for each task that has been outlined within a SOP. Training can be either field based, classroom based or a combination

of both. Training shall be carried out by qualified trainers, either internal or external and all training shall be recorded.
In some cases, training certificates shall be either presented to the recipient or placed on their file.

2.3. External review

The activities associated with inrush prevention shall be reviewed by an external person or group at least once per year to evaluate the level of compliance with the Guidance and Standard. This can be carried out by either an external consultancy group or by a peer review group from within the business entity.

2.4. Competent persons

Competency is a very important element in mining as people are often working alone in potentially hazardous situations. It is therefore very important that 'competent persons' are appointed to key roles.

The definition of a "Competent Person" is somebody that has the experience, skills and knowledge to recognize a hazard and the authority to put suitable and sufficient controls in place to prevent a negative outcome as a result of the hazard.

An Authorized Person is a person assigned by mine management to perform a specific type of duty or duties or to be at a specific location or locations in the mine, who is trained and has demonstrated the ability to perform such duty or duties safely and effectively.

While many people are authorised to carry out a specific task, others may not be authorised to correct a problem when they observe one. Many will report a problem to their supervisor, who should have the authority to correct it.

However, in some cases a supervisor may not be competent in the specific role to be able to make the correct adjustment, implement a change or stop a process. It is therefore very important that mine management distinguishes between competent persons and authorised persons to ensure that there are enough numbers of both in key positions.

The mine department shall appoint key persons as competent persons, within their speciality in the mine, and ensure that they could recognise how a process should operate, advice when it is not being completed in a satisfactory manner and stop the process if deemed unsafe.

Key persons working in areas directly associated with inrush potential shall be specifically trained on emergency procedures, so that any breaches in the integrity of inrush prevention systems can be managed and alerted in a timely manner.

3. IDENTIFICATION OF POTENTIAL INRUSHES

Inrushes in mines can come from several sources.

Water sources such as aquifers, rivers and lakes can result in sudden surges of water into a mine. While groundwater recharge is somewhat predictable, sudden surges can result from water breeches of barricades, dams, geology features, etc. Water inrushes can also result from pump, pipeline, mechanical or electrical failures and can be very problematic if the appropriate backup is not in place. Mines that have significant water ingress or are close to aquifers or water sources, shall engage external experts to carry out hydrogeological and hydrology studies to ensure that there is a good understanding of the potential for inrushes.

Mud rushes can be caused by several reasons, such as wet ore or waste suddenly flowing dynamically out of control as a result of mucking a stope or from mud within geology structures flowing dynamically out of control. In both cases effective management and system controls can greatly reduce the likelihood of such an occurrence and the understanding, monitoring and control of water within mining areas such as stopes is key to this. Water release drainage holes, open brows, overflow pipes and instrumentation all help to manage this risk. Mine planning must take into consideration potential water ingress into areas where mucking operations can cause an inrush.

Backfill, such as paste, has the potential for inrush due to pipeline, barricade or geological failures and also due to liquefaction. The design of the backfill system must be carried out by a 'competent' person with backfill expertise. Installation, operation, monitoring and management must be carried out with controls at all key points in the system. A review system shall be in place to identify any deviations from design or changes to the working environment. Backfill barricades will typically have instrumentation installed to test backfill levels, curing and water levels. Pipeline checks may be required to ensure blockages are managed.

Geology mud rushes can result from failures in geological structures, often in areas where there are karstic features, significant infilled jointing or soft porous rock. A high level of understanding of the regional geology is required to ensure that this risk is mitigated.

Analysis of historic events, the following sources of mud which has been involved in mud rush occurrences have been identified:

- Readily weatherable materials such as shale and kimberlite, which occur in the ore and country rocks;
- Tailings impoundments which are located on surface above or adjacent to mine workings;
- Backfill placed in underground stopes for support or disposal purposes;
- In the case of box holes and rock passes, any fines, from whatever source, which can form "sticky" material.

Four elements are required for a mud rush to occur:

- Potential mud-forming materials must be present;

- Water must be present;
- A disturbance of the mud, in the form of drawing or other mining activity, must occur;
- Discharge points must be present through which the mud can enter the mine workings.

Evidence from mud rush occurrences suggests that all four elements must be present at once for a mud rush to occur.

Fuel inrushes are more likely to be of lower volume than water or backfill as the limitations are controlled by tank size, pipeline length and the installation of safety features such as valves, etc., but the consequence can be significant. The design of a fuel system in a mine must be carried out by a 'competent' person with the requisite expertise, with regular checks in place.

Blasting in a mine can result in damage to the natural or built environment in a mine and as such, there must be a good communication system between departments such as mining, geology, mine planning, maintenance and safety. Blasting has the potential to open a water source suddenly and create a major problem very quickly. Therefore, the risk must be reviewed on an ongoing basis and controls put in place. Blasting into an unknown water feature or a geological feature that is connected to a water source can create a sudden inrush, which may not be identified until the start of the following shift, due to ventilation clearance times required.

Controls will include a review process of the mine plans between the mine department, geology, planning, geotechnical, maintenance and safety, on a regular basis to ensure all departments are aware the potential of an inrush. Controls may include advance probe drilling, review of hydrogeological studies on a regular basis, instrumentation to measure water levels locally.

All major inrush risks must be identified through a thorough risk management process. Controls will be based on the risk level to ensure that each risk is mitigated to a level where it can at least be proactively managed. The levels of control associated with inrushes may require fast action due to the speed at which an inrush can cause harm and damage. This may require immediate engagement of the Emergency Response Plan and as such those persons directly engaged in tasks that have potential for inrush, shall be trained on the Emergency Response Plan.

Understanding Mud-rush Mechanisms

There is no single mechanism for the occurrence of mud-rushes in mines. Mud-rushes can be classified as external mud-rushes or internal mud-rushes.

- External mud-rushes result from mud generated externally by the deposition of tailings and by the production of mine backfills from metallurgical plants. Inrushes of material from slope failures are also classified under this heading. External mud-rushes are those in which the mud is produced externally to the physical underground environment.

- Internal mud-rushes involve mud produced by the comminution of shale or other clay-forming country rocks, and clay mineral rich ores, within the cave muckpile. Fines which accumulate as a result of the mining process are also involved in the internal process. Mixed mud forming materials are also grouped in this category - even though some material is formed outside the underground environment, owing to drawdown, this material mixes with internal mud.

External mud-rushes

External mud-rushes are produced from three main sources:

- Inrush of tailings or slimes: the inflow of tailings or slimes can occur directly or indirectly as a result of dam wall rupture, from which the material can flow unaided towards a shaft, adit or open bench, resulting in an inrush of tailings underground.
- Failure of placed backfill in underground massive stopes: this type of failure could occur due to the placement of poor quality backfill, during the filling if a drawpoint bulkhead ruptures, and once the fill has been placed.
- Mud rushes due to open pit slope failures: in cases in which underground mining of an orebody has been preceded by open pit mining, the influx of mud into the workings is due to the failure of an open cut slope directly above open stope, open bench or fissure mine drawpoints, resulting in the inrush of slope material to the underground workings via the drawpoints.

Internal mud-rushes

- The mud is formed internally during drawdown of the waste capping above the orebody. Mixed mud rushes are included in this classification, due to the mixing of internally and externally generated mud materials within the muckpile. The proposed internal mud-rush mechanisms are given below.
- Muckpile/waste capping mud-rushes: is where an open pit mining was succeeded by underground cave mining and is conceptually applicable to other operations as well.
- Secondary waste capping/muckpile mud-rush mechanisms: the above mechanism may be regarded as a "major" mechanism. However, there are two other secondary internal mud-rush mechanisms. These are, firstly, rapid muckpile compaction, which can be seen as the mechanism responsible for mud pocket discharge; and reduced muckpile/waste capping drainage

Mixed mud-rushes can be ascribed to the creation of mud from a combination of sources namely:

- The deposition of tailings above the mine waste cap;
- Sloughing of open cut sidewalls;
- Comminution of muckpile remnant ores and wastes.

Mud-rush mechanisms from boxholes and passes are straightforward. The "sticky" material formed from the fines and water adheres to the sides of the boxhole or pass, and to the box or chute structure. This restriction impedes the flow of material and causes further agglomeration and ultimately a blockage. In addition, sticky

material particles may adhere together to form, effectively, much larger particles. These may be large enough to lead to hang-ups in boxholes and passes.

Once a blockage or hang-up has occurred, rock, further fines and water accumulate above the restriction, providing a driving force for a mud-rush, which occurs when the chute is opened.

Trigger Mechanisms and Warning Signs

As can be deduced from the above, only two possible mud-rush triggers exist — disturbance and water. This is because these two factors control the discharge process of the mud-rush. Disturbance creates the conditions necessary to allow free mud discharge, and water acts as a mobilizing force for the mud, either by changing the material properties of the mud, or by applying a pressure, due to an increasing head of water.

Disturbance

Disturbance as a mud rush trigger can take several forms:

Excavation of slopes or stopes in mud forming materials: this is self-explanatory in that, if unstable slopes or stopes are developed in weak and/or weathered rocks and soils, which, in the presence of water, can flow or fail, then a mud-rush can occur. In the case of slopes, the following are considered as potential warning signs for mud ingresses:

- Incorrect or no design of slope angles in weak/weathered materials;
- Poor slope drainage, resulting in a sudden rise in the phreatic surface;
- Lack of maintenance of slope drainage measures, resulting in increases in water quantity and water pressure in the slope;
- The alteration of the mine pit geometry, resulting in a change of slope confining stresses and an increase in ravelling;
- Removal of a slope ore protection pillar in an open benching system, resulting in the exposure of weak zones in the slope;
- The undercutting of the slope toe, resulting in an unstable slope geometry.

In the case of underground stopes, the following are considered to be warning signs for mud rushes:

- The poor design of stope, back, crown pillars and sidewalls;
- The collapse of open stope rib pillars leading to back/crown pillar failure and surface subsidence;
- The ingress of groundwater into the stope, weakening the rock mass.

Disturbance due to drawdown of the cave muckpile: there is a correlation between isolated draw and mud-rush occurrence. The main danger associated with isolated draw is the high rates of extraction from drawpoints. This results in an increased possibility of mud rushes due to the fact that dilution from the mud-bearing waste cap enters the draw column sooner. Also, larger quantities of waste can be drawn from diluted drawpoints before they are closed, resulting in dilution cut-off of reserves from adjacent drawpoints. In essence, these heavily extracted drawpoints act as mud pocket pathways to the operation

levels. As draw rates increase, the fines are normally extracted from the draw column first, leaving a honeycomb of rock arches and an increased possibility of mud pocket discharge due to rapid draw column compaction.

With regard to draw trigger mechanisms, the following conditions must be fulfilled:

- A condition of isolated draw must exist on operational levels;
- 30% of drawpoints must be overdrawn (beyond the allocated drawpoint reserves);
- Operational drawpoints must have draw rates much higher than common practice (typically 1.5m/day). For example, sublevel cave draw rates of 8m/day are favourable for mud ingress.

It should be noted that these draw rates are probably only applicable to SLC mining. In block cave mining, due to the fragmentation requirement, draw rates in the region of 200mm/day are considered normal. However, isolated draw conditions can still occur in block caving and the danger of mud ingress due to excessive over extraction still exists.

From the above it is apparent that, for mud ingress to occur, isolated drawpoints must be extracted in excess of the allocated reserves. It therefore follows that non-interactive draw conditions are a warning sign of mud-rushes in caving operations. Isolated draw conditions can occur due to poor draw discipline (drawpoints deliberately over pulled), or due to poor layout design. Even though instances of poor draw discipline do occur at most operations, experience indicates that uniform drawdown is generally achieved at most profitable caves, unless waste cap mining is economic.

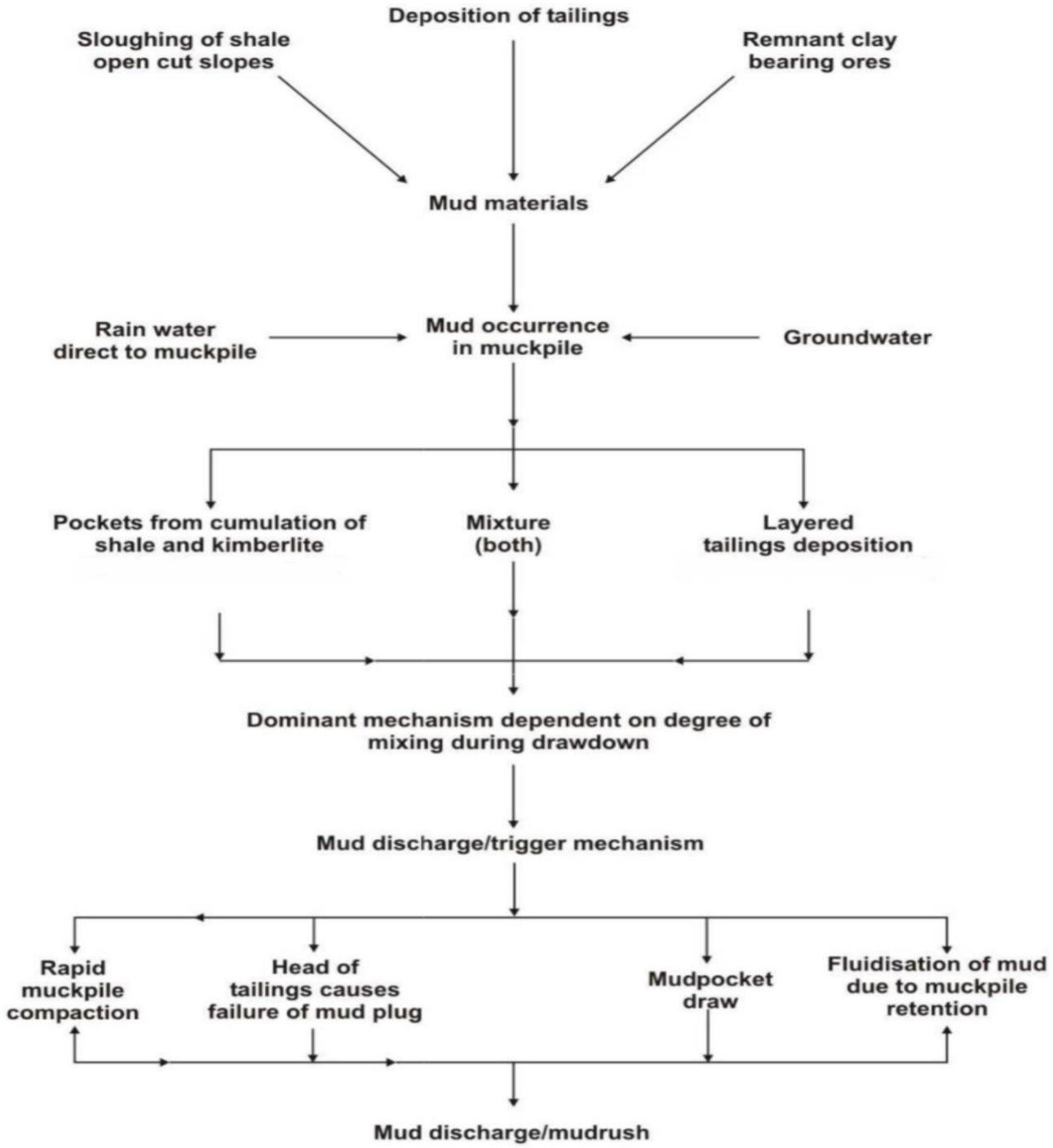
Non-interactive draw normally begins when drawpoints or drifts are lost due to the following:

- Ground control problems requiring drift repairs;
- Ground control problems due to excessive action blasting (blasting for drawpoint hang-up clearance);
- The formation of crown pillars, bridges or banks due to poor blast design and practice. This is non-extraction of the full fan profile, which results in remnant pillars remaining in the fan blast geometry;
- Destruction of drifts by point loading due to poor action work;
- Destruction of drifts or drawpoints due to stress loading from remnants left on previously mined levels;
- Drawpoints lost due to non-mining of areas where there has been a mud occurrence or where mud pockets are suspected.

The result of the initial loss of drawpoints or drifts is that, if the level or block tonnage is not reduced, then the remaining drifts and drawpoints will be extracted above their natural capacity. The usual result is that ore fragmentation size reporting to drawpoints increases. Consequently, the frequency with which action blasting of drawpoints (to clear hang-ups) is conducted also increases. This causes additional drawpoints to be lost due to blast damage. Again, if the call is maintained, the remaining drawpoints are

extracted above their natural capacity and the process is repeated until excessive dilution of ore reserves occurs or the block is lost due to mud ingress.

Boxholes and passes: in the case of boxholes and passes, the disturbance is the opening of the chute.



4. RISK MANAGEMENT

The site shall maintain a Risk Register for the mine which includes all aspects of Prevention of Inrush relating to the mining operation and its personnel. Risk assessment associated with Prevention of Inrush shall

consider the natural environment, consisting of regional and structural geology, water sources, weather variations, construction around the mine. In addition, the risk assessment shall consider all aspects of design, installation, management and monitoring of all potential sources of inrush, including but not limited to water, backfill, mud sources, large quantities of fuel and other potential sources.

A Prevention of Inrush hazard identification and risk assessment process, including the development of a Risk Register, should identify all major foreseeable events that could impact on the mining operation and its personnel. This will require input and advice from operational groups and subject matter experts, such as geologists, geotechnical engineers, hydrogeologists and hydrologists. The process shall follow the risk assessment process as defined in the risk management guidance note.

5. SAFE OPERATING PROCEDURES (SOP)

Safe operating procedures (SOP) are required for all tasks that are carried out in a mine. This includes those to be identified in the risk register. A rule of thumb is that a mine should have between thirty and sixty SOPs for mining operations alone, excluding maintenance, technical services and safety.

5.1. Definition of a SOP

A SOP is a written document that provides step-by-step instructions on how to safely perform a task or activity. A SOP includes elements of hazards and risks associated the health and safety of the people associated with the task.

5.2. Selection process for SOPs

The mine management team shall decide the list of appropriate tasks that require a SOP. Typically, for Prevention of Inrush, major tasks such as probe drilling, barricade inspection, pump maintenance, testing of back-up power sources are selected. However, each mine will have variations of each task above and will need several SOPs to cover the full requirement. These may be tasks such as backfill barricade construction, which may require use of specific materials, testing, installation of instrumentation, etc.
Similar sub-groups can be made for all tasks depending on the department which is managing the specific area of the Prevention of Inrush sector. It is essential that all tasks are identified by mining professionals and that input to the SOP is provided by a range of people including mining engineers, geotechnical engineers, geologists, mechanical/maintenance engineers, managers, safety personnel and other stakeholders.

5.3. SOP Structure

A SOP shall contain the following elements

- Scope – outlining the extent of the SOP, from start to finish
- Objective – specifying exactly what task the SOP covers
- Relevant legislation
- General rules – step by step details relevant to completing the task
- Review system – details of SOP owner, and those responsible for reviewing it

- Emergency Response
- Responsibilities of mining roles

5.4. Management of SOP

A SOP shall be completed for a task before the task is in standard use in the mine.

When the SOP has been written, it must then be approved by mine or other departmental management.

The recommended process to be followed is:

- Ensure that the mine management and safety team are familiar with the SOP
- Ensure that the SOP is stored where it can be easily accessed by the mining teams, supervisors and other stakeholders
- Provide a full brief of the SOP to all mine/maintenance supervisors and other stakeholders
- Provide a full training programme to the required personnel and other users on the details of the SOP. This may require 'on the job' and classroom training and should include a questionnaire to ensure that the SOP is fully understood
- Review the SOP on a regular basis or when a change management process takes place that changes any of the elements of the SOP.
- Ensure that the SOP is modified and re-briefed to all stakeholders following any changes
- Record any changes in a controlled system
- Replace any SOPs which are available for stakeholders or are displayed in the mine or related areas

High quality development, management and use of a SOP, including training, will ensure that the specific task can be carried out to a high standard.

6. SAFETY SYSTEMS

The mine management team shall provide a safety system to ensure that the mine and its personnel can operate in a safe and sustainable manner, including some of the following:

Management of water reticulation systems

Monitoring of water ingress systems

Mud-rush from wet ore or waste

Paste Backfill being poured

Safety systems shall be provided as support to mining and other related operations and to ensure that mining can be carried out in a safe and efficient manner.

For the management of Prevention of Inrush, safe systems should include, but not be limited to the following:

1. Access to Hydrogeology and Hydrology experts and studies to gain a full understanding of the regional and local water. This is necessary so that decisions can be made regarding the potential water ingress levels in the mine. Based on this and some related assumptions, a water management system can be designed for specific areas of the mine.
2. The mine shall have a Mine Emergency Flooding Plan, including a written procedure, with designated areas for flooding in an emergency.
3. Storage systems designed for excess water shall have excess capacity of at least 25% more than the anticipated highest levels based on seasonal variations and a built-in safety factor.
4. Water reticulation systems shall not exceed safe working specifications of pipelines, with valves placed at major junctions and at key points in the mine.

5. There shall be procedures in place for emergency isolation of ruptured pipelines.
6. There shall be maintenance programmes in place for pumping systems and sump management.
7. Each mine shall carry an appropriate number of spare pumps, pipes and associated consumables.
8. Where possible and appropriate, alarm and monitoring systems will be in place in both local and remote areas. Modern systems include warning systems which can be sent to mobile phones for a variety of warning alerts.
9. Mine plans shall be located in key areas for easy access in an emergency. This will be in line with the Emergency Response Standard.
10. Barricades and signage shall be placed in appropriate locations to ensure unauthorised access to high risk areas.
11. Design of mine workings by 'competent' mining engineers to ensure that water ingress is measured, monitored and managed will significantly reduce the likelihood of a mud-rush.
12. Assessment by Geologists, Mining and Geotechnical Engineers to gain a full understanding of the regional and structural geology which may affect water, backfill, mud or other ingress into the mine.
13. Provision of adequate back-up power sources to ensure water pumping in the event of a power failure, for 'wet' mines based on the risk assessment. The risk assessment will consider the level of water ingress, the capacity within the mine to store water, the level of water which may significantly affect infrastructure, production and ultimately the safety of employees.
14. External review of any design, installation and monitoring systems associated with the management of Prevention of Inrush. This may include design and review of
    1. Water reticulation systems
    2. Mining methods
    3. Backfill system design, operations and management
    4. Geology review of Prevention of Inrush
    5. Fuelling systems – capacity and distribution

15. Provision of appropriate monitoring and testing systems to ensure that any inrush is identified promptly, and any problems communicated appropriately.
16. A backfill system shall have systems to manage inrushes including a Mine Emergency Backfill Inrush procedure, and an Emergency Stoppage procedure.
17. Training on Emergency Response procedures for all persons who are involved in the management, operation or monitoring of any areas associated with the potential for inrush. This may include supervisors, drillers, backfill operators, maintenance personnel, control room personnel and others who may be required to act in the event of a system failure.
18. Communications systems are required to ensure that any inrush or potential for inrush that occur is identified and communicated promptly. These systems should include:
    - Telephone, Leaky Feeder system and Hand-held radios
    - Stench gas
    - Control room systems
    - Supervisor checks during shift
    - Shift start briefs
    - Safety and operational briefs
    - Notice boards
19. Review of results from any controls in place to measure, control or otherwise manage systems associated with Prevention of Inrush

7. PREVENTIVE MEASURES

The implementation of preventive measures will reduce the risks of mud rushes. At least the following preventative measures shall be implemented.

7.1. General preventive measures

In mining operations in which backfill is used as regional support such as cut and fill, open stoping, post-filling and postpillar mining operations, fill quality is vital:

- Backfill should be designed according to best current practice
- A backfill quality control programme must be implemented, where acceptability of fill strength is judged according to established concrete practice statistical analysis techniques
- A mine dewatering system and other measures must be implemented to prevent the ingress of groundwater into filled stopes. All mines using backfilling must have a system of preventing fill decantation water from accumulating in stopes and other workings
- Backfill barricades should be designed with a sufficient factor of safety to prevent backfill runaway.

The hazards associated with blockages and hang-ups in chutes, box-holes and rockpasses should be prevented by the following:

- Minimizing the quantity of water that flows into these excavations

- Correct design of box/chute fronts and chute operating systems
- Draining of water from behind box front structures
- Regular removal of pagging from the surface of the box-hole and pass, and from the surfaces of the box or chute front structure
- Regular drawing of material to ensure that the rock column is kept moving and does not consolidate.

At all mud rush prone mines, methods should be in place for the sealing of old workings and abandoned drawpoints from where mud discharge could occur. Methods of slowing or preventing the flow of mud to other operational levels via mud transport excavations, such as shafts, box-holes, passes, haulages, etc, must be determined and implemented.
Special note should be taken of the need to secure those passes and shafts which may facilitate mud flow to operational workings.

7.2. Procedural measures for the prevention of mud-rushes

The first procedural step is to classify mines as mud rush prone or non-mud rush prone operations, based on a risk assessment as indicated above. Should a mine be classified as a mud rush prone mine, the following measures should be implemented:

- The compilation of a code of practice for the prevention of mud rushes. This code of practice should be reviewed independently on an annual basis
- A set of underground mud rush precautions should be compiled and distributed on the mine
- The appointment of a competent person to be responsible for mud rush control
- Mud rush incidents should be recorded in the Vedanta Critical Events and Charting System.

7.3. Compilation of underground mud rush precautions

At every mine where a historical, major mud rush hazard or potential mud rush hazard exists, as determined by a risk assessment, a set of underground mud rush precautions should be compiled. These precautions should be focused on the evacuation and identification of workers in a mud rush hazard area. The following must be included:

- A record book or other means of recording the number and names of personnel working in the hazard area. This book must be kept in a prominent position at the entrance and exit of each area. It must be signed by all personnel entering, working in, visiting and leaving the area. The position should be identified by a flashing light and signs
- A mud rush warning system, consisting of sirens or alarms, should be installed in the hazard area. These alarms must be sounded in the event of a mud rush.
- An evacuation procedure, showing the means of escape from the affected area and the further actions to be taken if deemed prudent.
- A notification procedure to ensure that the responsible officials are informed of the in-rush as quickly as possible.
- A closure procedure for any mine services that may hamper rescue efforts.

Copies of the precautions must be placed at the entrance and exit of all potential in-rush areas. These procedures should be communicated to all personnel concerned, on a monthly basis, at the working place.

8. TRAINING AND COMPETENCY

Training and competency are key areas that are essential for the safe management of the Prevention of Inrushes. The core training requirements include:

8.1. Train all personnel on safety and SOPs

Training of all personnel on the key elements of safety shall start at the induction of a person when starting employment at a mine. Further training must be delivered based on the person's job, experience, expertise and any other relevant factors. Further details on training are discussed in Section 2 – Overall Management Approach.

Typical training programmes will be given for:

- Induction about inrush and mud rush risks
- Emergency response in the event of a inrush and mud rush

Training records should be maintained in the persons file including any assessment criteria and results, certification and results of tests/questionnaires for a period on no less than 24 moths.

8.2. Assess their competency

A high level of competency is required for all areas related to the Prevention of Inrushes and this must be assessed prior to carrying out the related tasks.

8.3. Retraining

Almost training requires that re-training programmes are used as follow-up to ensure that the learnings are embedded, and the standards are maintained.

8.4. Internal and external training

In many cases training can be carried out internally. However, external training should be considered to ensure that safety and operational systems are maintained up to date and to best practice.

8.5. External audits

At regular intervals, external audits shall be used to verify that the learnings from the training and standards are being maintained. External audits can be conducted by either peer groups from within the organisation or by external consultants/auditors. Specific to Prevention of Inrushes, external audits shall be carried out as required through the risk assessment process.

9. MONITORING AND REVIEW

To ensure the effectiveness of controls is maintained at the site, a monitoring and review program shall be implemented that includes inspections, testing and auditing of the systems associated with mining operations. This should cover the effectiveness and limitations of current practices, training and overall mining management systems.

As part of the site's validation process, responsibilities and accountabilities should be clearly defined and assigned and may include independent auditing. The findings of the monitoring and review process should be used to:

- Confirm the recommendations of previous reviews were actioned.
- Confirm responses were appropriate for any mining operations incidents or issues that arose.
- Verify compliance with specifications (e.g. inspection, monitoring, and quality control).
- Confirm site practices comply with the mine standards as set out.

If significant gaps are identified, this should prompt a review of the risk assessment process. Throughout the risk management process, it is vital to ensure that key stakeholders and subject matter experts are consulted where appropriate.

The SBU Head should be able to demonstrate that hazards associated with mining operations are controlled so far as is practicable, with the risk assessment and management process formally documented in the operation's hazard and risk register.

RELATED DOCUMENTATION

A summary of the references and supporting documents relevant to this document is provided in the following table.

Doc. Ref.	Document name
POL 06	HSE Policy
VSS	Vehicles and driving
VSS	Ground Control
VSS13	Emergency Response and Fire Control
VSS15	Explosives and Blasting
VSS17	Hoisting in Shaft
VSS18	Inflow or Inundation of Liquids
VED/CORP/SUST/MS 6	Competency, Training and Awareness
VED/CORP/SUST/TS 10	Safety Management
GN 19	Permit to Work

VED/CORP/SUST/MS 1	Leadership, Responsibilities and Resources
VED/CORP/SUST/MS 9	Documentation and Record Management
VED/CORP/SUST/MS 11	Incident Reporting and Investigation
VED/CORP/SUST/TS 13	Emergency and Crisis Management
VED/CORP/SUST/MS 14	Management Review and Continual Improvement
GN 01	Incident Investigation
GN 07	Risk Assessment
GN 10	PPE
GN 14	Health and Safety Management Systems
VED/CORP/SUST/MS 13	Corrective and Preventive Action Management