# Geotechnical considerations underground audit Site: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

# Date conducted:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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| 1 Mine planning and design |
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| **Point** | **Standard** | **Standard met** | **Comments** |
| 1.1 | The design life of the mine and economic limits of the ore body have been determined. |  |  |
| 1.2 | Mine management has a documented LOM design. |  |  |
| 1.3 | Senior mine management has demonstrated a clear understanding and commitment to address the geotechnical issues in underground mining using sound geotechnical engineering practice. |  |  |
| 1.4 | A set of development planning and design guidelines have been drawn up to provide general guidance in mine planning and design. |  |  |
| 1.5 | Mine management has established a "geotechnical model of the mine". |  |  |
| 1.6 | The designed number, types, operating life and dimensions of all openings have been based on a suitable "geotechnical model of the mine". |  |  |
| 1.7 | The number, types, design life, dimensions, orientation and spacing of all pillars have been determined by geotechnical methods. |  |  |
| 1.8 | Geotechnical domains are used to divide the rock mass into volumes of similar expected ground behaviour. |  |  |
| 1.9 | A justifiable design criteria exists for mining beneath / near surface water or water-filled mine workings according to the ground conditions, the mine plan and size of openings and mine access. |  |  |
| 1.10 | The mine uses a formalised approach for the design of rock support and reinforcement (RSAR) for all types of mine openings in all geotechnical domains. |  |  |
| 1.11 | The mine has developed a ground control management plan (GCMP) relevant to the local ground conditions and mining strategies |  |  |
| 1.12 | The mining method, design and positioning of mine infrastructure have taken into consideration the long term stability/viability of nearby tenements and any surface features. |  |  |

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| 2 Development and maintenance of geotechnical model |
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| **Point** | **Standard** | **Standard met** | **Comments** |
| 2.1 | The range of geological structure (planes of weakness) within the proximity of the mine have been defined, given geotechnical qualification and kept up to date in a suitable structural database. |  |  |
| 2.2 | Geotechnical mapping is being carried out on a regular basis in all 'active' and accessible mine voids. |  |  |
| 2.3 | The pre-mining rock stress magnitude and orientation in the mine has been quantified and is updated at suitable intervals commensurate with the rate of mining. |  |  |
| 2.4 | The rock mass strength and deformation characteristics within each geotechnical domain in the mine have been quantified and engineering properties understood. |  |  |
| 2.5 | Local hydrogeology has been quantified and ongoing measures taken to verify these assumptions. |  |  |
| 2.6 | Geotechnical diamond drill core logging is used as a tool for ongoing confirmation of mine-wide geological/structural models in conjunction with scan-line and area mapping models. |  |  |
| 2.7 | A comprehensive database is maintained that includes all geotechnical data (e.g. rock mass properties) relevant to the local geological and mining characteristics. |  |  |
| 2.8 | A hazard map for existing and future areas of the mine has been developed. |  |  |
| 2.9 | A formal numerical modelling ”philosophy” has been developed and numerical model/s exists for the mine, taking into account the nature of the mine, the geotechnical conditions and perceived hazards. |  |  |

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| 3 Operations – mining control |
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| **Point** | **Standard** | **Standard met** | **Comments** |
| 3.1 | A system is in place which ensures that short, medium and long term planning and scheduling are compatible with one another and reviewed concurrently. |  |  |
| 3.2 | Mine design drawings are signed off by the underground manager and all relevant geology, surveying and engineering professionals. |  |  |
| 3.3 | Mine planning and design meetings are held monthly or more frequently. |  |  |
| 3.4 | Mine planning and design matters are regularly discussed with the underground workforce. |  |  |
| 3.5 | For recoverable pillars, an appropriate pillar recovery plan exists and is implemented. |  |  |
| 3.6 | The mine has a formalised, clear definition of "unsupported ground" and has derived a formal protocol with respect to persons working near these areas. |  |  |
| 3.7 | The mine has established tolerance limits / trigger points for mine planning/scheduling and trigger-action-response plans relevant to major geotechnical hazards. |  |  |
| 3.8 | The mine has formalised procedures for preventing inadvertent access to vertical openings and unsupported ground - as required. |  |  |
| 3.9 | Appropriate strategies/designs have been developed and implemented to maintain safe working conditions when working near unsupported ground and portal access via open pits - as required |  |  |
| 3.10 | Waste dumping procedures (surface and underground) have been developed to take into account the full range of materials being dumped and ground/surface water conditions in all areas at both the tip head and toe of the dumping points. |  |  |

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| 4 Operations – performance monitoring |
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| **Point** | **Standard** | **Standard met** | **Comments** |
| 4.1 | The mine has formally established monitoring requirements for all potential geotechnical hazards. |  |  |
| 4.2 | The mine has established tolerance limits / trigger points for all forms of geotechnical performance monitoring and has formalised appropriate trigger-action-response plans. |  |  |
| 4.3 | There are regular geotechnical inspections of the as-mined conditions of the relevant mine RSAR, openings and their surroundings. |  |  |
| 4.4 | An on-going photographic record of important geotechnical events, with written notes of observations, is maintained and regularly updated. |  |  |
| 4.5 | Absolute and/or incremental rock stress measurement techniques are used where appropriate. |  |  |
| 4.6 | Appropriate surveying techniques are used to monitor as-mined void and pillar geometry. |  |  |
| 4.7 | Displacement monitoring instrumentation is used as and where appropriate. |  |  |
| 4.8 | Appropriate seismic monitoring is undertaken where potential exists for rockburst activity to damage mine openings and/or the RSAR systems in the mine. |  |  |
| 4.9 | The installed seismic monitoring system is capable of detecting, processing and displaying a representative sample of the range of seismic events occurring in real time - including during power outages. |  |  |
| 4.10 | The seismic system is capable of providing coverage to all areas of the mine that persons work for the full range of events used to determine the performance of the mine. |  |  |
| 4.11 | The results from all forms of monitoring have been used to assess trends of movement or seismic activity. |  |  |
| 4.12 | ALL forms of monitoring results (underground and where applicable surface) and interpretations are regularly communicated to the workforce. |  |  |

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| 5 Operations – rock support and reinforcement (RSAR) |
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| **Point** | **Standard** | **Standard met** | **Comments** |
| 5.1 | Load capacity of the individual elements (anchorage, bar or tendon and surface restraint) are appropriately matched to prevent premature failure of any one component for various modes of failure. |  |  |
| 5.2 | The mining cycle has been adapted to the ground conditions to take into account the effect of time dependent behaviour of the rock mass and LOM void design. |  |  |
| 5.3 | A technical specification exists for all the RSAR systems in use, taking into consideration design and performance requirements. |  |  |
| 5.4 | The mine possesses, and enforces formal standard work procedures for installation of all the various types of RSAR in use at the mine. |  |  |
| 5.5 | The storage and handling of rock support and reinforcement elements is such that deterioration with time is minimised. |  |  |
| 5.6 | The drill hole orientation is appropriate for the excavation geometry and expected ground/block movement. |  |  |
| 5.7 | All components to be encapsulated in resin or cement grout are clean and free of deleterious materials. |  |  |
| 5.8 | Records are kept that fully grouted elements are actually fully grouted. |  |  |
| 5.9 | Retensioning of relevant anchor rock reinforcement is carried out and/or records are kept to verify that retensioning is not required. |  |  |
| 5.10 | RSAR is protected against corrosion for the design life of the opening. |  |  |
| 5.11 | The mine has formalised procedures to ensure that the quality control of resins and grouts (including shotcrete and fibrecrete) satisfy design requirements at all times. |  |  |
| 5.12 | All equipment used for cementitious applications, pressurising swellex-type bolts and tensioning is maintained on a regular basis. |  |  |
| 5.13 | Shotcrete/fibrecrete thickness testing is regularly undertaken to ensure that the specified thickness has been applied. |  |  |
| 5.14 | Regular load versus displacement testing is conducted for all types of rock reinforcement used in the mine. |  |  |
| 5.15 | The equipment being used to install the rock support and reinforcement has formal confirmation that it is suitable for that purpose from both installation safety and quality assurance perspectives. |  |  |

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| 6 Operations – management of unstable rock |
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| **Point** | **Standard** | **Standard met** | **Comments** |
| 6.1 | The mine has developed and enforces a scaling policy to be adopted in each area within the mine. |  |  |
| 6.2 | The mine has developed and enforces a standard work procedure for all forms of scaling used in the mine. |  |  |
| 6.3 | The mine conducts on-going regular checks for scaling / rehabilitation requirements of all main access ways. |  |  |
| 6.4 | Records are kept of all scaling / rehabilitation required and these records are placed into a suitable database for future reference. |  |  |
| 6.5 | The mine has a standard specification for scaling bars and other forms of scaling equipment (e.g. mechanised scaling units and work platforms). |  |  |
| 6.6 | The mine has established trigger points for acceptable limits of issues such as tested load capacity or visual degradation (e.g. "bagging" of mesh, "popped" plates etc) of the installed RSAR system. |  |  |
| 6.7 | The mine has developed and enforces a standard work procedure (SWP) for removal of loose rock (as required) that is considered too hazardous to be scaled or removed by normal methods. |  |  |
| 6.8 | Where appropriate, additional illumination is available and used while the scaling or checking is in progress. |  |  |

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| 7 Operations – drill and blast |
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| **Point** | **Standard** | **Standard met** | **Comments** |
| 7.1 | The mine has developed and enforces standard design procedures for drilling and blasting in rises and development. |  |  |
| 7.2 | The mine has developed and enforces standard design procedures for drilling and blasting in stopes. |  |  |
| 7.3 | A standard drilling and blasting pattern exists for all forms of blasting (and is always available to end users) for each geotechnical domain. |  |  |
| 7.4 | The drilling and blasting crew(s) understand the importance of correct drilling and blasting work procedures. |  |  |
| 7.5 | All drilling equipment can deliver required hole parallelism at appropriate gradients and operators are capable of achieving this. |  |  |
| 7.6 | The mine implements blast strategies to minimise blast damage to the perimeter of all excavations in all geotechnical domains and ensures that these strategies (e.g. modified perimeter blasting) are followed rigorously underground. |  |  |
| 7.7 | Overbreak at the excavation perimeters is monitored. |  |  |
| 7.8 | A system exists to correct mining techniques where excess overbreak is encountered. |  |  |
| 7.9 | The mine uses appropriate blast monitoring techniques in development, rises and stopes to verify blasting performance on a regular basis. |  |  |
| 7.10 | Blasting in the immediate vicinity of stopes that contain wet fill is not permitted. |  |  |

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| 8 Design conformation – back analysis |
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| **Point** | **Standard** | **Standard met** | **Comments** |
| 8.1 | The mine has conducted back-analyses/comparisons of as-mined void geometry (Section 4) to justify the mine's short term design and planning strategies. |  |  |
| 8.2 | The mine has conducted back-analyses/comparisons of as-mined performance monitoring (Section 4) against existing numerical or empirical design criteria to validate existing geotechnical models and justify the mine's short-term design and planning strategies. |  |  |
| 8.3 | The mine has conducted back-analyses/comparisons of the as-installed performance of RSAR (Section 4 and 7) against mine site design criteria to validate existing geotechnical models and justify the mine's RSAR short term design strategies. |  |  |
| 8.4 | Methods exist to confirm that existing assumptions for the potential for corrosion/degradation of the RSAR system, cement products and other relevant mine infrastructure can be expected to remain appropriate in all areas of a potentially changing hydrogeological environment. |  |  |
| 8.5 | A procedure exists to ensure that formal records of any changes in the geotechnical model (resulting from back analysis/confirmation processes) are maintained. |  |  |
| 8.6 | Back analysis / design confirmation data is used to verify that the existing geotechnical models and mine design / planning methods can be expected to remain appropriate for LOM designs. |  |  |

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| 9 Training and competency |
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| **Point** | **Standard** | **Standard met** | **Comments** |
| 9.1 | The workforce receives on the job training and ongoing competency assessment of issues covering rock fall hazards in the underground workplace. |  |  |
| 9.2 | The workforce receives on the job training and ongoing competency assessment of issues covering general ground awareness when working near vertical openings, and other areas of unsupported ground. |  |  |
| 9.3 | The workforce receives on the job training and ongoing competency assessment of issues covering the importance of the correct drilling and blasting work procedures. |  |  |
| 9.4 | The workforce receives on the job training and ongoing competency assessment of issues covering general ground awareness with respect to assessing scaling requirements and safe scaling practices |  |  |
| 9.5 | The workforce receives on the job training and ongoing competency assessment of issues covering the importance of the correct RSAR installation procedures. |  |  |

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