2022 ICARD Conference

RGS/Deswik/Geosystems- Short Course Overview

Topics

Mine planning; characterization; designing, managing, and closing mine waste facilities; and economics of AMD management

Course Title

Integrated mine planning to minimise AMD and improve mine closure outcomes

Lead Presenters

Greg Maddocks, PhD, Principal Hydrogeochemist, RGS Environmental Consultants Pty Ltd. Greg has over 20 years' experience in the mining sector in planning and design, geochemistry and developing rehabilitation and mine closure plans for mine waste storage facilities and final voids. He has a wealth of experience in presenting technical information in a concise format to a variety of audiences including short courses and international conferences such as ICARD.

Matt Landers, Principal Geochemist, RGS Environmental Consultants Pty Ltd. Matt has over 15 years' experience in management, development, implementation and delivery of geochemical programs for mining and energy industries. Matt specializes in the hydro-geochemical characterization of mine waste and development of solutions for mine waste and water management for projects from concept through to Closure. Matt also has extensive experience in constructing hydro-geochemical models for the assessment of mine landforms and water quality.

Ainsley Ferrier, Technical Product Manager – Enviro Tools, Deswik Mining Consultants (Australia) Pty Ltd. Ainsley is a mining engineer with over 20 years' experience in the open cut coal industry in mine planning and production roles, before pivoting to a role in software product management. The main impetus for this move is her passionate belief that integrating better mine water and rehabilitation planning into all levels of mine design planning improves post-mining outcomes and delivers greater project value.

André Stengl, Principal Mining Consultant, Deswik Mining Consultants (Australia). Andre has 20 years of technical planning knowledge in surface and underground mining sectors, mostly in Australia and North America. His diverse experience in mine design, scheduling and landform closure helps steer Deswik integrated software development, challenge culture paradigms and maintain a positive trajectory for best-practice planning in the industry.

Nick Anderson, Product Manager, Deswik Mining Consultants (Australia) Pty Ltd. Nick is a geologist with over 20 years working in geoscience and technology in the Oil and Gas and Mining industry. Nick has helped Deswik to bring to life multiple mine geology workflows including geological mapping, sampling and grade control modelling. Nick is passionate about helping Deswik create software tools that make geoscience tasks as

simple and powerful as possible for Deswik's users, allowing geologists to focus on the value of their deliverables.

Amanda Forbes, Senior Mining Consultant, Deswik Mining Consultants (Australia) Pty Ltd. Amanda has over 15 years of industry experience as a mining engineer in the open pit metals industry. During her time at Deswik, Amanda has contributed to and developed several integrated mining and closure models. Amanda has a passion for integrating mine planning sequences and closure requirements to improve closure outcomes, minimize costs and improve communication around life of asset strategies.

Michael Milczarek, is Program Director, GeoSystems Analysis Inc. and has 30 years' experience in developing, implementing, and managing vadose zone and hydrogeologic studies and has actively managed or participated in numerous mine closure characterization, design and monitoring programs and is responsible for designing and overseeing over a dozen long-term cover performance evaluation projects. Mike has authored or co-authored 20 referred articles on cover systems and mine closure and has also given technical workshops on the characterization, design and monitoring of mine waste cover systems.

Course Length

The short course will comprise two four-hour sessions held over two days. Each session will comprise pre-recorded PPT presentations with a live question and answer component for participants and presenters at the end of each session. The pre-recorded PPT presentations will be made available to registered participants in advance of the actual workshop date to allow questions to be sent and collated prior to the short course.

Objectives

The objectives of the short course are to familiarize participants with current leading developments and practices in integrated mine planning and designing for closure that aim in part reduce the risk of AMD and improve mine closure outcomes for rehabilitation.

Description

The purpose of the course is to provide participants with a clear understanding of how the mining industry now has the tools to couple geochemical, physical, hydraulic and soil fertility data with a GBM and integrate these within mine planning reduce the long-term risk of AMD and improve both operational and mine closure outcomes.

The course will be presented in two sessions by RGS/Deswik/Geosystems personnel who have introduced and applied these tools at mine sites mining various commodities around the world.

Session 1 provides a strategic analysis of what integrated mine planning and designing for closure is at a corporate level, and what this means to the people working on smaller discrete technical packages of work that occur multiple time horizons.

Four case studies will be presented to demonstrate how integrated planning and designing for closure can be applied to provide better technical, social, financial and closure outcomes.

Session 2 supports Session 1 and will describe mine material characterization techniques and detail how the geochemical, physical, hydraulic and erosion properties of mine materials are acquired, interpreted and used to develop criteria for incorporation into geoenvironmental block models (GBM).

Material balances are used to develop cover and final landform designs which are subsequently evaluated using (amongst others) unsaturated flow modelling, drain down modelling and hydrogeochemical water quality modelling.

Some of the case studies in Session 1 will be re-visited to illustrate how the performance of final landforms can be assessed.

Sunday 18 September 2022

Session 1:

Integrated mine planning and designing for closure – strategic analysis – focal points on waste rock management

1.1 (RGS: Greg Maddocks): Industry standards and guidelines (20 minutes).

- What is integrated mine closure planning and designing for closure, what is in the toolkit, and is good practice guidance (INAP 2019, ICMM 2019) being implemented to minimise AMD production?
- Are beneficial outcomes being achieved for mine waste management from integrated mine closure planning and designing for closure, how do poor design outcomes impact water (MCA, 2014, ICMM, 2021), and are risks to water considered significant to the sector (EY, 2021).
- If successful outcomes are not being achieved where are the flaws in these processes and what can we do to improve environmental and social governance?

1.2 (Deswik: Nick Anderson): A technical toolkit – geoenvironmental block models (30 minutes).

- Understanding the characterization of ore and waste in a mine during production is essential for Ore Control process to make the most profitable decisions at dig time. Material characterization for waste and landform construction is critical in building landforms that consider the optimal geochemical, soil fertility and physical characteristics.
- Building a geo-environmental block model that characterizes ore, low grade ore and waste that have soil fertility, geochemical and physical attributes appended to each block in the block model. Dig blocks are then designed to incorporate the desired characterization and account for practical mining constraints, such as mining direction and minimum mining widths. Characterization dig blocks are then used to determine where the material will be moved to.
- The data can be used to verify that a WRD is built to design **Ernest Henry Mine case study Evolution Mining.**

1.3 (Deswik: Ainsley Ferrier): A social engagement toolkit – landform haulage schedules and the social license (30 minutes).

- As part of the 2017 Environmental Impact Statement, Glencore's McArthur River Mine (MRM) constructed an integrated LoA model depicting the mining sequence and all subsequent closure activities.
- The model included quarry and borrow pit mining to achieve closure designs, the complex WRSF sequencing, in-pit dumping, stockpile sizing and reclamation as well as the TSF construction during operations, reprocessing of tailings and the final placement of tailings in-pit. The simulation was released to the public to convey the projected mining and closure sequence as well as the final landform surface. **McArthur River Mine case study, Glencore Zinc**

1.4 (Deswik: Andre Stengl): A financial toolkit – the financial upside of mine waste) (30 minutes).

- Pulling a holistic mine and closure plan together should be supported with a detailed economic model using variable costs rather than fixed unit costs. As a mine moves toward the closure phase, real costs rather than NPV should be used to evaluate the impact of final mining and dumping without discounting closure costs.
- Understanding waste rock types as a commodity and placing a value on their suitability for mine planning can drive strategy and remove risk by improving operational performance as well as satisfying closure requirements. Placing a value on waste means identifying its potential application(s), then prioritizing or constraining it during scheduling.
- Building an inclusive plan challenges, assumptions, breaks down planning silos, engages co-reliant departments and often reveals hidden opportunities.

Case Study - Pan-American Silver

- The study was designed to consider variable mining & closure costs to confirm high-level assumptions from the co-reliant strategy:
    - Construction of new leach pad facility on steep terrain to process additional ore.
    - Mined open pit waste to be used to build a large rock structure (base pad).
    - Reshaping of base bad before leach ore stacking (geotechnical constraint).
- The study concluded that the additional haulage cost to build the base pad cancelled out the revenue from the marginal ore that would be processed at the end of mine life. The optimisation of ore feed processing revealed that the leach pad crusher would not send marginal ore to the base pad based on the result being cost neutral (base pad was built for no reason!).
- A secondary finding was that the reduced waste inventory in the pit (result of upgrading waste to ore) slowed the rate of waste delivery to build the base pad (dynamic landform haulage modelling) and this resulted in delays for commissioning the base pad and therefore a risk to continual processing.
- Finally, the geotechnical constraint for reshaping the base pad early brought forward closure costs that contributed to a higher operating cost and therefore a higher cut-off grade than originally assumed.

1.5 (Deswik: Amanda Forbes): A closure planning toolkit – optimizing rehabilitation for MIM TSF) (30 minutes).

- The IPaDFC allowed MIM to develop a comprehensive rehabilitation plan for the TSF and provided assurance that the proposed cover system design would be effective when constructed using the identified borrow materials. Soil fertility, geochemical and physical analysis work conducted by RGS Environmental (RGS) was integrated into an overburden model which was used in an integrated landform and haulage model.
- The modelling immediately identified a topsoil deficit and the need to potentially dilute the available topsoil with underlying subsoil.

- The model also showed that previous assumptions significantly underestimated the equipment requirements and the time required to construct the TSF cover. The equipment requirements were also highly sensitive to both the dumping strategy and the selected borrow pit locations due to the spatial extents of the TSF.
- Unsaturated zone modelling on the final landform surface showed that cover will shed runoff when constructed using the available borrow material.
- By confirming the material properties of the available soil regolith and rock units and running schedules of the placement work, MIM have ensured that their solution has longevity and will provide a cost effective and environmentally effective outcome. **Mount Isa Mines case study, Glencore**

1.6 (RGS: Greg Maddocks): Integrated planning toolkit – bringing it all together (20 minutes).

- At the domain level, integrated planning and designing for closure to us means:
    - keeping the ICMM big picture outcomes in the back of mind so we do not get caught in a technical, environmental, financial or social (bubble)
    - communicating these broader outcomes to technically focused staff in technical silos
    - working across the technical silos to find the people who have information we need
    - talking to those people and explaining what we are trying to achieve
    - asking the right kind of questions to find data and information we need
    - sharing what we have found, as they would probably find what we have uncovered from other silos to be useful to them
    - presenting and progressively updating what we have done to the group so the bigger integrated mine closure planning picture is always in their collective minds and keeps them moving in the same direction down the funnel to the successful (ICMM) outcome that society is seeking.

Live Questions and Answers (1.5 hours)

Monday 19 September 2022

Session 2:

Mine material properties, geo-environmental block models, covers design considerations and water quality modelling

2.1 (RGS): Mine material properties (20 Minutes) – what materials do you have and how can they be utilized for rehabilitation and Closure?

- Deleterious (e.g. PAF) and beneficial (e.g. NAF, regolith, top soil) mine materials.
- NAF materials include unconsolidated topsoil and subsoil through to competent rock all of which may have specific purpose for closure and rehabilitation.
- Soil fertility, geochemical and physicochemical attributes for each mine material are characterized according to specific tests discussed in this presentation.
- Case study - Mount Isa Mines Glencore Copper

2.2 (RGS): GBM and material balance (20 Minutes) – how much material do you have?

- Develop numerical criteria for mine resource block model/ GBM.
- Generate material balances for each unit and evaluate how they can be effectively incorporated into mine landforms to minimize the risk of environmental harm (e.g. AMD, erosion).
- Case study – McArthur River Mine Glencore Zinc

2.3 (GeoSystems): Physical and hydraulic material properties (30 Minutes)

- Physical and hydraulic property characterization needs.
- Appropriate data collection methods.
- Scaling effects and integration of data.

2.4 (GeoSystems): Water infiltration and drainage modelling (30 minutes)

- Unsaturated flow modelling to assess net infiltration through covers.
- Drain down modelling for heap leach, waste rock and tailings.
- Monitoring tools to assess closure performance
- Trade-off analyses.

2.5 (GeoSystems): Cover system design considerations (30 minutes)

- Climate and post-mining land use drives the complexity of the design.
- Precipitation/evapotranspiration/natural recharge rates.
- Revegetation.
- Erosion and surface water controls.

2.6 (RGS): Mine water modelling (30 Minutes)

- Hydrogeochemical modelling to assess the performance of the final landforms.
- Case studies using reactive transport modelling and development of pit lake water balance/ water quality models (Hazelwood Coal Mine).

Live Questions and Answers (1.5 hour)