SME Society for Mining, Metallurgy & Exploration | SUMMERXCHANGE

Access to the SUMMERXCHANGE technical program becomes available July 19, 2022. Watch and learn at your convenience this summer with full availability to presentations and sessions through the end of September.

Live Virtual Keynote

Tuesday, July 19 | 10 am MT
Workforce - The Paradigm Shift | Live Panel

Moderators: Jill Nelson, Managing Founder, and Anita Bertisen, Brooks & Nelson
Recruiting Students for the Future: Sarah Lizarraga, Outreach Coordinator, Colorado School of Mines
Women and Workforce: Nicholas Hendren, HR Manager, Newmont
Millennial Impact: Sean McDonald, Senior Construction Engineer
Remote Work: Best Practices and Insights: Carl Burkhalter, Partner, New Fields
Leaderships Role in Workplace Well-being: Joline Lenz, Talent Sleuth, Brooks & Nelson

Industries struggled with significant workforce changes during COVID, including increased employment attrition and workforce frustration and dissatisfaction. Attracting and retaining top talent remains high on companies list of priorities, however resignations have been trending up. While this spike has decreased, there is high demand for talent across industries. Mining is above the national average in job openings at 7.4%. With this increasing need for talent, how do we attract and retain talent?

It is even more concerning that organizations experience a talent drain by employee populations that hurt the most: and more women than men showed a dramatic increase in resignations compared to the pandemic-ridden year 2020. Additionally, more experienced employees are rethinking their work situation. All of this impacts businesses ability to sustain its performance as well as progressing with increasingly public diversity goals.

COVID also significantly accelerated the momentum towards remote work opportunities. Our now flexible work world remains as a desirable job feature for millions, which is a tectonic change in where, when and how Americans work. Per this McKinsey study, over 58% of working America has the opportunity to work at least one day a week from home. That is 92 million people. Eighty-seven percent of the people offered work place flexibility take it. More men are offered this (61%) than women (52%). The opportunity to

work from home can be a deciding factor in hiring.

Join a panel discussion of professionals who are on the front lines of the evolving workforce and moving the needle in recruitment and retention for mining.

Recorded Presentations

- **MINEXCHANGE 2022 Keynote Session:**

  The Undiplomatic Truth: Mining Missing the Mark on Securing Popular Support
  Ambassador Todd Chapman, International Business Consultant

  Ambassador Chapman will review how international governments and local communities are demanding more of mine operators and the increasing complexities associated with securing the social license necessary to ensure uninterrupted operations of mining sites. Drawing on his 30 years of diplomatic experience, most recently as U.S. Ambassador to Brazil and Ecuador, he will share his experiences working with governments, indigenous communities, environmental activists, and mining companies to seek profitable outcomes for all.

  The Power of Purpose (Robert E. Murray Innovation Lecture)
  George Hemingway, Managing Partner, Stratalis

  George is considered one of the leading futurists in the mining industry, having delivered over 100 keynotes on uncertainty, innovation and the future at venues ranging from the World Mining Congress to S&P Global, from NASA to the Pentagon and at leading universities and organizations worldwide. His work in Techno-Economic and futures modeling for Mining has won awards for Innovation in 2019 and 2020, and he has been named a top-10 leader in mining technology.

- **Signature Lectures:**

  Health & Safety Division Breakfast: Mining's Social License in an ESG World
  Hugh Thatcher, Thatcher Company

  Dreyer Lecture: Navigating the Hurricane of the Junior Resource Market in the Search of Ore Deposits
  Jeff Pontius, Geologist

  Over the past four decades the business of exploration and discovery has changed in many ways. The discussion that follows will examine the shift in the discovery process from internally funded, production company groups to that of the emerging, public market funded, junior explorer. The transfer of exploration leadership to the junior sector has been facilitated by the availability of public market financial resources at a time in the commodity/ business cycle that saw traditional production companies reduce long-term exploration funding. These two dynamics worked in unison to empower the junior sector as a significant new discovery vehicle for future mining projects. The producer strategy of outsourcing discovery to the junior sector is driven by risk reduction and the idea that buying assets, post-discovery will be more cost effective. Although the fiscal momentum over the past couple decades has swung in the favor of the junior explorer, the path to technical and fiscal success for this group is extremely difficult as it navigates public market, stakeholder and commodity cycle demands.

Technical Session Content Capture (30+ presentations - audio and slides)

- **Coal & Energy: Automation and Innovation in Mine Production Operations**

  A Discussion of the Design and Development of an Intrinsically Safe Drone for Underground Coal Mining Applications

Pedram Roghanchi, Assistant Professor, New Mexico Institute of Mining & Technology

This study discusses the challenges in developing an intrinsically safe drone platform for underground coal mining applications. Our team is currently working on a research project to design a permissible propulsion system for a multi-rotor drone. The Mine Safety and Health Administration has not developed specific guidance for testing and approval of a flying vehicle. Therefore, the design of an intrinsically safe drone should be based on the general MSHA's guidelines and the requirements for the intrinsic safety level for Class1-Division1 and Class2-Division1 classifications. The design of a permissible propulsion system must include a systematic feasibility study on the drone platform sizing to ensure the flyability of such design. An intrinsically safe machine is usually much heavier than its non-intrinsically safe counterpart. Increasing the weight of a drone drastically decreases its efficiency. Therefore, the two main challenges in designing an intrinsically safe drone for indoor applications are (1) to demonstrate the permissibility and intrinsic safety of the vehicle and (2) to design a propulsion system that provides sufficient lifting power and reasonable flight time.

Development of Shuttle Car Autonomous Docking with a Continuous Miner Using 3-D Depth Cameras

Joseph Sottile, Professor, University of Kentucky and Sibley Miller, University of Kentucky

In recent years, a great deal of effort has been put into automating mining equipment with the goal of improving worker health and safety and increasing mine productivity. Significant progress has been made in automating mining equipment such as load-haul-dumps and drills in underground environments where global positioning systems are unavailable. This paper addresses automating the task of positioning the shuttle car (SC) under the continuous miner (CM) coal-discharge conveyor during cutting and loading operations. A stereo depth camera is mounted on the SC. Machine learning based algorithms are applied on the camera's output to identify the CM discharge conveyor and segment the scene into various regions such as roof, ribs, and personnel. This information is used to plan the shuttle car path to the CM discharge conveyor. The approach currently uses a 1/6th scale continuous miner and shuttle car in an appropriately scaled mock mine.

Concepts for the Development of an Autonomous Roof Bolting Module for Enhancing Miner Safety

Steven Schafrik, University of Kentucky; and Anastasia Xenaki, Mining Engineer, University of Kentucky

Equipment operators, especially, roof bolter operators are often exposed to dangerous conditions. This research is developing an automated process within the roof bolting cycle removing humans from hazardous environments. The study focuses on the concept of the development of a robotic assembly capable of carrying out the entire sequence of roof bolting operations in a full or partial autonomous manner. A bolting module has been set up with programmable hydraulic controls and connected to an industrial robot to develop and demonstrate this automation methodology. Computer simulations enable the control and motion of the hydraulic system, the drill steel, roof bolts, and resin cartridges. Various considerations for calibration-diagnostics and a self-monitoring system have been incorporated. The autonomous system is supervised by a human-machine interface enabling manual approval of the tasks and overriding of the system in the event of unpredicted or unsafe actions.

Developing a Semi-Autonomous Shuttle Car: Performance of a Lab-Scale Prototype

Vasileios Androulakis, University of Kentucky

Delegating hazardous tasks from humans to machines can be critical for improving personnel safety and mine productivity. Integrating autonomous vehicles in the mining cycle is undoubtedly a necessity for the mining industry of the future. Employing autonomous solutions in the multi-disciplinary field of mining engineering is a cutting-edge trend of the last few decades.

- **Coal & Energy: Accessing Capital in the Ever-Changing Energy Landscape**

  Social Challenges for Coal in Raising Capital

  John Craynon, Teaching Assistant Professor, West Virginia University

  The continued focus globally on reducing carbon emissions and addressing climate change has created high social barriers for funding operations that focus on fossil energy, particularly coal operations. However, there are possible approaches to address the social challenges for coal in raising capital for new and expanding operations. Many of those approaches involve making a full life-cycle analysis for the entire operation and supply chain.

  Energy Industry Trends Impacting Transactions, Financings and Restructings

  Rick Reeves, KCR Capital, LLC

  This presentation will provide an update of the landscape and market for raising capital as the energy industry adapts to a new political landscape with respect to source of electricity generation. It will start with a brief overview of competing energy sources including coal, natural gas and renewables. It will also discuss recent developments in the coal as well as natural gas industry both nationally and internationally that are relevant for financing at the mine and corporate level. The discussion will focus on financing alternatives for a mature industry and explore possible alternatives or scenarios that could create upside for the industry and facilitate raising capital.

- **Environmental: Environmental Policy and Regulation**

  Status of Waters of the U.S. in the Arid West

  Brian Lindenlaub, Vice President, WestLand Resources, Inc

  The definition of waters of the U.S. (WOTUS) remains an enduring source of confusion and debate for mine projects, particularly in the arid west. The presence of WOTUS can significantly impact permitting timelines and compliance obligations for mine projects. Three administrations in a row have attempted to clarify the definition of WOTUS and a fourth has announced yet another change. Despite the advertised clarity, the result has been persistent uncertainty for the mining community. In light of the ever-shifting political landscape, we provide a brief review of WOTUS history and a discussion of the current and potential future status of WOTUS in the arid west.

  Implications of Operating in an Environmental Justice Community

  Alma Feldpausch, Principal Health Scientist, Ramboll US Consulting

  The U.S. Environmental Protection Agency (USEPA) established the Office of Environmental Justice following the creation of Executive Order 12898 in 1992 with the intent of reducing environmental and health disparities for low income and people of color and improving overall environmental quality. Since then, USEPA has endeavored to meet the challenge of addressing environmental and health disparities. The current U.S. administration is elevating environmental justice issues by increasing investments in disproportionately impacted communities identified using USEPA's EJScreen tool. Similar

investments are being seen at the state and local levels. With increased public participation, pressure from investors and other stakeholders, and initiatives pushing the regulated community to account for cumulative impacts or meet lower risk thresholds, managing mining operations, meeting regulatory obligations, and maintaining a social license to operate is becoming increasingly dynamic and complex. In this talk, we explore the implications of changes in policy and regulations on mining in environmental justice communities.

Real-Time Monitoring and Data Management of a NEPA Draft EIS Public Comment Period
Jessica Joyner, Project Manager, Brown and Caldwell

As part of the United States Forest Service's National Environmental Policy Act (NEPA) process, the public has the opportunity to comment on proposed project alternatives and impacts assessed in a draft environmental impact statement (EIS). Past comment periods have focused on community outreach efforts to gather proposed project support prior to the comment period. To create a real-time collaborative process, Brown and Caldwell (BC) combined efforts with its client to develop a series of tools for data capture, data analytics, and communication that included tailored status reports. BC's use of a shared platform provided the client with 24/7 access to the nearly 10,000 letters over a 75-day period and instantaneous feedback on the effectiveness of public outreach efforts. Early indications of public concern allowed for immediate adjustments to planning and agency interactions. The use of real-time monitoring and data management of a NEPA draft EIS public comment period enables multiple departments of the proponent to collaborate and improve respective strategies, ultimately leading to an improved project with overwhelming public support.

Decarbonization Strategies for Miners
Ron Miller, Principal, Reliant Energy Solutions LLC

Lowering our globe's emissions is a major effort as we move toward a future net-zero-carbon environment, and will require significant investment in new low-carbon infrastructure, along with key market incentives to change. The mining industry will play a key part in this transformation, requiring expertise in both energy and emissions. Key elements of the decarbonization strategy are: energy data, emissions reporting method, governance, decarbonization project generation and drivers, the MACC, electrification, and the decarbonization checklist. For a zero carbon future, it will be key for mining leaders to understand decarbonization, anticipate technological changes, and implement new business methods and processes to remain good stewards of the environment.

- **Environmental: Mine Water Management**

Making Informed Operational Decisions for Water Management at a Remote Legacy Mine Using a Probabilistic Water Balance Model
Dale Kolstad, Vice President, Barr Engineering Co.

Operators are often challenged with the management of water throughout the life cycle of a mine. High water levels can lead to physical or chemical instability of water-retaining structures. Operators need to predict changes in water levels to make timely operational decisions and plan for contingencies, particularly in remote legacy mines. A closed mine in northern Canada with no permanent on-site personnel had a simple water balance model that was effective for decades to inform annual water treatment operations. In recent years the region has experienced more precipitation and higher water levels, triggering emergency response activities and putting a strain on treatment campaigns. A calibrated probabilistic model was used to provide enhanced prediction capabilities and to identify key sensitivities in the water balance for monitoring. A several year case study shows the

value that this modeling tool provided for mobilizing personnel and performing response actions, particularly the inclusion of probability paired with forecasted pond water levels. Annual drawdown targets were subsequently established which provided more certainty in scheduling of annual treatment operations.

Geochemical Model to Predict Aquifer Restoration Following Low pH In-Situ Uranium Recovery

Kathryn Johnson, Senior Geochemist, Barr Engineering Co.

Demonstrating aquifer restoration is an essential component of regulatory approval needed to mine uranium, copper, and other minerals by in-situ recovery (ISR). A PHREEQC geochemical model provided a useful means of forecasting the time for restoration and predicting future groundwater quality following low pH mining at Strata Energy's Ross ISR Project in northeast Wyoming. The model simulated groundwater quality at three phases of the process: at the end of mining; during restoration; and post- restoration. The model utilized the one-dimensional reactive transport and dual porosity features of PHREEQC. Mineral surface ion-exchange, dissolution/precipitation reactions, and adsorption processes were simulated to estimate water quality as the pH was shifted from circumneutral to acidic and back to neutral during restoration. The model results showed that cost-effective management of mine water could meet regulatory requirements. Additionally, the model was used to interpret results from a field trial and inform operational decisions. The predictive approach and geochemical understanding developed have application in assessing aquifer restoration for other ISR projects.

Wetbud: A Constructed Wetlands Design Tool

Caroline Gerwig, Student

Creating constructed wetlands is often a key part of mining infrastructure to remove heavy metals and contaminants from mining wastewaters. Constructed wetlands are relatively low cost in construction and maintenance in comparison to traditional wastewater treatment plants, provided there is sufficient land access for them to be used. This makes them an attractive option for mines needing to reduce acid mine drainage so that wastewaters can meet EPA regulations to be released into the environment. Wetbud is a design tool for wetland creation. In wetland water budgeting, there is a wide variation in water budgeting approaches across various agencies and consultants. Wetbud offers a variety of water budget calculation options including the Penman-Monteith method, Thornthwaite equation, and a user-defined series for calculation of evapotranspiration. The program includes 130 preloaded weather stations for user calibration to site conditions. Wetbud allows users to design an appropriate constructed wetland to meet the water filtration needs of their mining operation.

Impacts Assessment to Wetlands During Mine Development – Looking Beyond Drawdowns

Vikas Tandon, Lead Environmental Scientist, Foth Infrastructure & Environment, LLC

Mine operators and regulatory agencies are often required to predict and document impacts to wetlands associated with dewatering during open pit and underground mine operations. This is typically done by predicting drawdowns in groundwater caused by dewatering and establishing a not to exceed threshold and followed by implementing a monitoring program. Modeling at a mid-western US mining site indicates other criteria besides drawdown may serve as complimentary indicators of mine dewatering impacts. These include projected and measured changes in 1) groundwater flux to wetlands, and 2) the recharge/discharge relationship between wetlands and surrounding groundwater.

- **Mining & Exploration: Geosciences: Geology: Making the Grade - Operational Practices for Improving Grade Control**

  Improvement of Productivity Through Mine to Mill Reconciliation
  Abani Samal, Principal, GeoGlobal LLC

  The model to mine to mill (M3) reconciliation process is a way to learn about the reasons for the success that the mine operation celebrated or, any concern of low productivity. Generally, mining is an integrated operation that includes exploration, mining (extraction), processing, and metallurgy where metals are extracted. Success in annual production may be due to many reasons such as a good mine plan based on a nearly robust resource/ reserve model; execution of mine-plan in the operation supported by reliable laboratory services and disciplined work-culture led by a competent workforce. A detailed M3 reconciliation process leads to finding out the rooms for improvements at various levels. It's an excellent way to identify various nodes of the operation contributing to meeting or exceeding production targets. A healthy operation conducts the reconciliation at a regular time interval. This presentation is meant to start a healthy discussion on the reconciliation process as a tool for improving productivity in a mining operation.

  An Operational Tool to Adjust Ore Polygons for Blast Movement
  Seshadri S. Kanchibotla, Director, Seshat Consultants Pty Ltd

  During blasting, the rock breaks and moves but standard grade control practices do not adjust the ore waste boundaries to cater for blast movement. The material movement resulting from blasting may result in mischaracterization of grade boundaries resulting in ore loss and dilution. Las Bambas operations of MMG Peru, realized the economic impact of blast induced ore loss and dilution. They use limited blast movement monitors (BMMs) to estimate blast movement and adjust post blast ore polygons. Polygon adjustments based on few blast movement measurements has limitations for everyday application. This paper discusses the advantages of disadvantages of current blast monitoring and modelling techniques and introduces an operational tool to estimate ore polygon movements for different blast designs and confinement conditions. Simulations from a proprietary discrete element model and site monitoring data from highspeed videos, blast movement monitors and muck pile surveys are used to calibrate the tool. Blast movement estimates from the site-specific tool have been compared against the estimates from BMM's for several production blasts and results were quite promising.

- **Mining & Exploration: Management: Mine Financing & Investing**

  Digital and Technological Trends Enabling Supply Chain Transparency and How this Could Impact Mine Finance and Projects
  Ishaan Kapoor, University of Utah

  Modern markets of mineral commodities are a complex network of explorers, developers, and financiers. These networks can be formal and/or informal structures based on regional geology, the strength of governing institutions, commodity type, and a variety of other economic drivers. Many critical minerals have underground, or informal markets driven by bad actors and/or desperation, which drive human rights violations, environmental degradation, and economic disruption. As there is significant diversity in approaches to mineral development and a market shift toward "green" technology, many manufacturers are insisting on "certified" or sustainably sourced raw materials. Investments funds are pushing ESG incentives for the extractive industries and digital tools, such as blockchain-enabled technology, are being deployed to enhance supply chain transparency and sustainability. A review of these technology trends in this area is

provided as well as, potential implications on ESG reporting in mine finance.

- **Mining & Exploration: Management: Sustainable Development Across the Entire Mining Value Chain**

  Building a Global Community: The Creation of the Global GeoForum
  Mackenzie Sorensen, Senior Mineralogist, Rio Tinto

  Feeling connected and informed is a major problem among employees of large global mining companies. Even more strained are the opportunites for development and global sharing of innovations and access to information that can improve the workforce. Enter the global GeoForum- Rio Tinto's first interconnected, multidisciplinary, biannual, internal conference that seeks to connect geoscientists from across the world and create a more innovative and informed workforce. The GeoForum helps give internal opportunites for employees of all skill levels to report on their work and findings, as well as learn and network from others around the globe, creating opportunites for networking that might not have been available previously. The Geoforum is open to anyone, targeting geoscientists who range in careers from exploration to closure, covering hydrology, environmental, finance, production, and geomet- to name a few, and includes all commodities.To date, we have had four GeoForums, starting in 2019, and going global in 2021. In addition to the conference itself, we are working on creating more mentoring and networking opportunities for our global workforce as well.

  Using the Sustainable Livelihoods Framework to Understand Artisanal and Small-Scale Mining in Colombia
  Alejandro Delgado-Jimenez, PhD Student, Colorado School of Mines

  This research applies the sustainable livelihood framework (SLF) to understand the activities of artisanal and small-scale gold mining (ASGM) in a municipality in Colombia. ASGM is a critical livelihood in the rural global south, where few alternative economic opportunities exist; however, ASGM often operates on or near large-scale mining concessions and conflicts between the two sectors are common. The sustainable livelihoods framework (SLF) is suitable for large-scale mining companies to improve their relationships with ASGM and identify methods for coexistence among the two sectors. The SLF allows us to examine various forms of capital available to or held by miners and how these forms of capital intersect with policies, institutions, and processes to influence the vulnerability of ASGM livelihoods. The application of the SLF to the ASGM context can indicate to what extent proposed interventions can contribute to the sustainability of ASGM livelihoods and better coexistence strategies.

  The Permitting and Public Relations of Controversial Projects in Mining
  Madison Akers, Grad. Mining Engineer, Northern Star Resources

  Modern mining, especially developing new mines, consistently faces controversy so a quality public relations (PR) program for mining companies may improve society’s impression of the mining industry. Two case studies were selected based on the type of public controversy they face to demonstrate how pervasive permitting issues are in industry. Both Pebble Mine, owned by Northern Dynasty Minerals (NDM), and Black Butte, owned by Sandfire Resources America Inc (SRA), experienced difficulties with their water permitting due to potential risks their mine developments posed to local fish populations. The local history, mine setting, prevalent culture groups, technology development, and intercultural communication competence (ICC) of these two projects will be discussed. The mining industry needs to evaluate its ICC skills since ICC directly determines the effectiveness of PR. Based on Barna’s Stumbling Blocks for intercultural communication, methods for improving the mining industry’s PR will be suggested in the

hope of easing the permitting process for future mines by developing ICC.

5.7 Magnitude Earthquake and the Kennecott Tailings Storage Facility
Eva Hover, Hydrologist, Rio Tinto

On March 18, 2020, a 5.7 magnitude earthquake shook the Salt Lake Valley. The epicenter of the earthquake was located near the northeast corner of the South Impoundment of the Rio Tinto Kennecott Tailings Storage Facility (RTK TSF). Over the course of the successive months, over 2,500 additional aftershocks were felt in the area surrounding the 10,000 acre impoundment. Immediately following the initial earthquake and additional aftershocks, theab team of RTK TSF Geotechnical Engineers as well as qualified internal and external site representatives preformed in field inspections once deemed safe to do so. Drones were used after the initial earthquake to help determine safe access for field investigations of geotechnically sensitive areas. In addition to field inspections, the substantial amount of geotechnical monitoring equipment installed throughout the currently operational North Impoundment and no longer operating South Impoundment were monitored extensively. This instrumentation includes piezometers to monitor pore pressures, inclinometers to measure subsurface displacement, and accelerometers to measure earthquake acceleration.

- **MPD: MPD Plenary Session**

  The Journey…and the Lessons
  Kathleen Altman, Consultant, Chair of SME Council of Education

  Robert H. Richards Award Recipient and Lecturer

- **Tailings: Technological Advancements**

  Site-Specific Approach for Developing Profiles of Critical State Soil Mechanics Parameters in Mine Tailings Deposits
  Jason Harvey, Geotechnical Engineer, Barr Engineering Co

  Critical state soil mechanics (CSSM) has become increasingly integrated in the characterization of mine tailings deposits; however, practical application of CSSM has been problematic in mine tailings. Estimation of the in-situ state parameter from cone penetration testing (CPT) based correlations involves considerable uncertainty, and universally applying laboratory-derived CSSM parameters (λ and Γ) from only a few samples may not sufficiently characterize highly variable mine tailings. In this paper, the authors present an analytical and statistical approach to characterize a mine tailings deposit using site-specific laboratory and in-situ testing data to develop estimated profiles of CSSM parameters that more reliably capture the material variability. CPT is used to capture near-continuous profiles of the in-situ response, and index properties from adjacent boreholes are used to associate CPT responses with CSSM parameters derived in the laboratory and interpolated as needed. In so doing, profiles of CSSM parameters can be combined with other site-specific data to estimate profiles of in-situ state parameter and undrained shear strength with less generality and uncertainty.

  Tailings Draindown Estimates: Implementation and Considerations
  Nick Rocco, Geotechnical Engineer, Newfields

  Implementation of post-closure draindown estimates for tailings facilities are important predictive tools to for reclamation planning and often influence jurisdictional bonding. Simplified estimates of draindown have been proposed in the past, but it is clear that simplified methods are not able to capture many of the operational and material parameters that influence robust draindown estimates. This paper will discuss an iterative

approach that relies on an unsaturated flow model to predict draindown rates and an associated pond inventory water balance that tracks inputs into the pond system, solution volumes, active evaporation, and recirculation. Specific design criteria such as climate, facility geometry, material properties, and initial conditions, as well as active closure operational considerations that can be used to influence the draindown estimates will be discussed. Concepts presented will be valuable for closure planning and to guide analytical analyses that support tailings draindown estimates.

Inherent Uncertainties in Determining Breach Parameters Utilized in Numerical Tailings Dam Breach

Mark Walden, NewFields Mining Design and Technical Services

The 2019 Brumadinho dam failure incident in Brazil, has influenced many mining industry regulators to reassess their requirements for the numerical modelling of tailings dam failure. A dam breach analysis that meets the requirements of industry standard, typically begins with identification of credible failure modes and the estimation of the total volume of tailings and water contained within the facility at the time of the breach. The volume of released tailings can then be determined considering the appropriate angle of repose or available empirical equations. Subsequently, the breach hydrograph can be developed using the released volume of tailings and embankment materials. The following technical paper aims to provide guidance on how to address a wide array of uncertainties inherent in determination of breach parameters and breach flow hydrograph. The common methodologies utilized in breach parameters estimation are reviewed and the pros and cons of available methods are listed. The procedure suggested in this article will help practitioners make a risk-based decision on choosing the most appropriate matrix of breach parameters utilized in numerical dam breach modelling.

Thickening 101 - Putting Theory Into Practice

Todd Wisdom and Geoff Seale, Patterson Cooke

Tailings thickening remains a relatively misunderstood process with many attributing it to ‘anecdotal’ science and ‘bucket’ chemistry. Tailings thickening is typically at the end of the process and consequently the last unit operation considered during both design and operations. When operating well, thickeners are ignored and left to run independently with minimal supervision. However, when operating poorly, there is a lack of basic understanding and remedial actions to solve issues are reactionary rather than proactively addressing shortcomings. This paper aims to clarify many aspects surrounding the thickener process. Topics will range from test work methods, coagulant and flocculant basics, feed system importance, rake mechanism design and thickener operational control philosophy. Industry ‘rules of thumb’ for thickener types, applications, sizing practices, design aspects, and troubleshooting techniques will be discussed. This paper will improve understanding so that thickeners are no longer a ‘black box’, and operators will be more self-reliant and less dependent on supplier participation.

- **Valuation**

Financing Options for Small Mines—What We Learned in Our Senior Design Project

Gates Campbell and Mike Nelson, University of Utah

A senior design project is required by all accredited mining engineering degree programs. Often referred to as the capstone of a student’s education, this project is expected to include all the important components of the preliminary economic assessment of a mineral prospect, including orebody modeling, grade and reserve estimation, selection of

mining and processing methods, preliminary mine design, access and utilities, environmental compliance and reclamation, and financial analysis. In the authors' experience, most senior design projects use a marginal cutoff grade and a discounted cash flow analysis to assess the financial viability of the project under consideration. These analyses usually assume direct sale of the product or products over a range of market prices, and capital financing from corporate reserves or equity investors. Capital and operating costs are estimated using the Mining Cost Service, provided by Western Mine Engineering, Inc. The analysis described here used Lane's method to calculate cutoff grade, and looked at five types of project financing— streaming, offtake, royalty, debt, and equity—and calculated net present value for the mine operation in each case.

Search for Candidates for Sales Comparison Approach in Non-Disclosure States

Fred Pirkle, Gannett Fleming Inc

The search for comparable sales in a non-disclosure state can be daunting. Non-disclosure states record transactions, makes them available to the public but do not list financial terms. How are comparable sales found and how are qualifying comparable sales selected? The subject property is a sand mine in a non-disclosure state. The search for comparable sales candidates is facilitated if there are prior sales. The prior sale must be at the same stage of use as the subject property. In this study the comparable sales search was undertaken by identifying sand mines within about a 15-mile radius, reviewing sales history, and determining the comparable sales candidates' Highest and Best Use at time of sale. Candidates also included properties identified by market knowledge. The candidate transactions must meet the definition of Fair Market Value to be reliable and relevant. Sales data, tax records, loan instruments and other property lists were used in the search as well as deed searches from real estate transactions. Through diligent searches, the sales comparison candidates could be adjusted to provide the Fair Market Value of the subject property.

Net Present Value in Early Stage Technical Studies vs Market Value

William Roscoe, SLR Consulting

Preliminary Economic Assessments (PEA) of gold projects commonly use discount rates of 5%, rarely more than 8%. We have compared the Net Present Value (NPV) in PEAs to (a) the market value of a transaction on the project and (b) the adjusted market capitalizaiton of a junior company for which the project is its major asset. In most cases, there is a significant difference between the NPV and the other two parameters, whiche the transaction value and the market cap are a fraction of the NPV. The differences can be rectified by applying a higher discount rate to bring each project NPV into line with the transaction value or the market cap. We have also compared NPV in Preliminary Feasibility Studies (PFS) with market value and market capitalization of gold projects.

Assessing Diminution in Value in Eminent Domain Proceedings

James Beck, J. M. Beck & Associates

Mineral properties are often subject to eminent domain actions providing for or establishing rights-of-way for highways, utilities, temporary construction easements, etc. Such rights-of-way or easements are typically narrow, linear strips of land (of limited areal extent), and are known as "partial takings". Partial takings, however, often (but not always) result in otherwise unforeseen damage to the "larger parcel" disproportionate to the tons or surface actually taken. The "remainder" can be damaged (or not) or rendered uneconomic, effectively resulting in a diminution in value. Condemnation documents and

condemnor appraisals often fail to recognize the incremental damages that are unique to mining, as well as the manner in which such damages can be realistically quantified. It is incumbent upon the appraiser to identify such damages and opine diminution of value, if any, because the opposing appraiser may fail to do so. The appraiser must possess both minerals expertise, as well as a sufficient command of eminent domain appraisal procedures in order to correctly define the “larger parcel”, “part(s) taken”, and “economic/uneconomic remainders”, and, do so in a compelling manner.

Before and After Valuation

David Falkenstern

While most texts and accepted appraisal practice on the subject dictate that partial acquisitions of mineral properties be valued with the Before and After technique; specifically using royalty income, is it always appropriate? Do different site specific situations necessitate a different appraisal approach to partial acquisitions:

Permitted/active and non-permitted/reserve mineral properties
Acquisition involves part of an eminently mineable section within a well defined mine plan
Separate royalty/mineral owners within the mine
If the partial acquisition is a significant percentage of an active operation
Is royalty income the only damage?
Reserve replacement
New permitting costs
Do juries grasp Before and After?

The goal of this presentation is to present different examples of partial acquisitions and facilitate an open dialog of our appraisal experiences on the subject.