

**The United States Department of Health and Human Services
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health (NIOSH)
Mine Safety and Health Research Advisory Committee (MSHRAC)**

Spring Meeting
NIOSH Mining Program
Spokane, Washington
Hybrid in-person and Zoom, open to the public
Wednesday, May 24, 2023

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Summary Proceedings

The spring 2023 meeting of the National Institute for Occupational Safety and Health (NIOSH) Mine Safety and Health Research Advisory Committee (MSHRAC) was convened at the Spokane Mining Research Division offices, Spokane, Washington, and via Zoom on Wednesday, May 24, at 8:30 a.m. PDT, Kyle Zimmer, Jr., Chair, presiding. The meeting was also open to the public by video teleconference.

Attendees

Members Present In-Person or Via Zoom

Kyle Zimmer, Jr., International Union of Operating Engineers; Chair

Kristina Behringer, M.D.

Ronald Bowersox, United Mine Workers of America

Andrea Brickey, South Dakota School of Mines and Technology

Tom Duffy, United Steelworkers of America

Marifran Mattson, Purdue University

Elizabeth “Libby” Prichard, National Stone, Sand & Gravel Association

Steven Schafrik, University of Kentucky

Matt Stewart, R. T. Vanderbilt Holding Company, Inc.

Ex Officio Members Present

Melanie Calhoun, Mine Safety and Health Administration, Ex Officio

Giovanna Biscontin, National Science Foundation, Ex Officio

Invited Non-Members Present (In-Person or Virtually)

NIOSH Office of the Director (OD)

John Howard, NIOSH Director

George Luxbacher, Designated Federal Official, NIOSH Deputy Associate Director for Mining

Pauline Benjamin, NIOSH OD

Bob Randolph, NIOSH OD Mining Program

NIOSH Spokane Staff

Doug Johns, Director, NIOSH Spokane Mining Research Division Director

Cara Halldin, NIOSH Spokane Mining Research Division Deputy Director

Tim Bauerle

Joe Bourgeois

Brianna Eiter

Heather Lawson

Carol Nixon

David Parks

Gerald Poplin

Tashina Robinson

Kristin Yeoman

NIOSH Pittsburgh Staff

Steven Sawyer Jr., NIOSH Pittsburgh Mining Research Division Director

Carin Kosmoski, NIOSH Pittsburgh Mining Research Division Deputy Director

Other Invited Guests

Christopher Williamson, Assistant Secretary for Mine Safety and Health Administration, U.S. Department of Labor

Todd Moore, CONSOL Energy (Membership Nomination Pending)

Members Unable to Attend

Aubrey Miller, National Institutes of Health, Ex Officio

DFO Introductions, Announcements, Roll Call

Dr. George Luxbacher

Deputy Associate Director for Mining

**National Institute for Occupational Safety and Health
Centers for Disease Control and Prevention**

The meeting opened with a slide of Dr. Jessica Kogel, the Associate Director for Mining for NIOSH and the Director of the Office of Mine Safety and Health Research (OMSHR) from 2015 through 2022, who passed away on January 25, 2023. Chair Zimmer asked for a moment of silence to honor her memory.

Dr. Luxbacher, as the Designated Federal Official for the Committee, after commenting on Dr. Kogel's significant contributions to the NIOSH Mining Program, then called to order the open session of the spring 2023 meeting of NIOSH MSHRAC at 8:30 am Pacific Daylight Time (PDT) on Wednesday, May 24, at the Spokane Mining Research Division offices, Spokane, Washington and via Zoom. A roll call of all MSHRAC members confirmed that a quorum was present. The roll was also called following each break and lunch to ensure that a quorum was maintained. A quorum was maintained throughout the day.

No conflicts of interest (COIs) were declared. Committee members were instructed that if a conflict of interest came up at any time during the meeting, they were to declare that conflict and recuse themselves from any discussion or voting on that matter.

Members of the public on Zoom were notified that they would only be able to listen to the meeting, not comment or ask questions, until the Public Comment period, scheduled at the end of the presentations, although questions could be submitted online via the Zoom chat feature at any time, to be addressed during the Public Comment period.

Dr. Luxbacher welcomed everyone and briefly reviewed the structure and history of MSHRAC, initially established in 1969; this meeting is the 90th NIOSH meeting of MSHRAC, now in its 53rd year. This is only the third meeting held at Spokane, with the earlier meetings in 1999 (then the Spokane Research Laboratory) and 2016. He then reviewed the agenda for the meeting.

Chair Remarks, Approval of Minutes

Mr. Zimmer, MSHRAC Chair, welcomed the Committee members. Mr. Zimmer then asked for an approval of the minutes from the prior meeting. Mr. Bowersox made the motion, seconded by Dr. Brickley. The floor was opened for discussion and the motion was then approved. Mr. Zimmer then introduced Dr. Howard for his remarks.

NIOSH Director's Remarks

Dr. John Howard, MD

Director

**National Institute for Occupational Safety and Health
Centers for Disease Control and Prevention**

Dr. Howard thanked the members of the Committee for their service on MSHRAC and expressed his appreciation to both the Committee and the Mining Program leadership and staff. He then reviewed the Fiscal Year 2023 approved budget for NIOSH, which included an additional \$4 million for the Mining Program. The President's budget request for FY24 is at the FY23 level, although the request also formally proposes an average of a 5.2% pay increase for federal civilian employees, which is an unfunded mandate. Dr. Howard then discussed the search for an Associate Director for Mining and the progress on the development of the NIOSH Underground Mine Safety and Health Research Laboratory near Mace, WV. He then concluded and asked if there were any questions. Chair Zimmer reinforced the value of incorporating joint labor and management perspectives in the design of the Mace facility.

Report from the Deputy Associate Director for Mining

Dr. George Luxbacher
Deputy Associate Director for Mining
National Institute for Occupational Safety and Health
Centers for Disease Control and Prevention

With the absence of an Associate Director for Mining, Dr. Luxbacher presented a brief update on the Mining Program. The current head count for the program is 171, compared to an authorized level of 270; the fiscal year budget is only sufficient to adequately support the existing head count. The project portfolio has also been reduced over the years to match the available resources in both manpower and discretionary funding.

He then discussed the FY23 budget allocation for the Mining Program, explaining the funds allocated by Congress to expand grant opportunities to universities with graduate programs in mining and explosives engineering to fund additional research initiatives in automation, robotics, and intelligent mining systems as well as the directive by Congress that “CDC is also urged to increase support for research on exposure assessment, behavioral science, and mental health in the mining industry.”

Dr. Luxbacher briefly reviewed the status of the extramural contracts and grants program, followed by an overview of the NIOSH Underground Mine Safety & Health Research Laboratory in Mace, WV. Dr. Howard had suggested that the Committee consider forming a workgroup to provide feedback on the Mace facility and he reviewed a possible scope of work for the Committee’s consideration.

At the conclusion of his presentation, Dr. Luxbacher asked if there were any questions. Mr. Stewart asked if there was a particular discipline in which there was a shortage; Dr. Luxbacher, Dr. Johns, and Dr. Sawyer responded, noting that industrial hygiene, behavioral science, and mining-related positions have been difficult to fill. Mr. Stewart then asked about funding for the Coal Workers’ Health Surveillance Program Mobile Medical Unit as directed by Congress; Dr. Luxbacher noted that NIOSH had identified available funds outside the Mining Program to address that request.

Chair Zimmer then called upon Christopher J. Williamson to address the Committee, since Mine Safety and Health Administration (MSHA) has an ex officio seat on the Committee and Mr. Williamson was present with the MSHA representative.

Comments from the Assistant Secretary Labor; Mine Safety and Health

Administration (MSHA)
Christopher J. Williamson
Assistant Secretary of Labor
Mine Safety and Health Administration
U.S. Department of Labor

Assistant Secretary Williamson thanked the Committee for the opportunity to speak and highlighted the interactions between MSHA and NIOSH. He discussed the high number of fatalities that have occurred already this year and the steps both MSHA and industry are taking to address this, including the first annual Stand Down to Save Lives campaign and an increased frequency of safety and health alerts. Work also continues on a new silica rulemaking.

SMRD Overview

Dr. Doug Johns
Director, Spokane Mining Research Division
National Institute for Occupational Safety and Health
Centers for Disease Control and Prevention

Dr. Johns introduced himself as the Director of the Spokane Mining Research Division, thanked the MSHRAC panel for their work and his staff for their preparation for the meeting, and welcomed all in attendance to Spokane. He provided an overview of the Division’s major research program areas: Geomechanics, Automation and Emerging Technology, and Miner Health. Dr. Johns noted that, while the Division’s foundational research programs in ground control and seismicity and stability in underground metal mines remained of vital

importance in SMRD's research portfolio, the Division has worked diligently over the past several years to expand the scope of research in mining automation and miners' health. He then presented a slide with the NIOSH Mining Program's strategic goals and noted that he shared these with his Division several times each year to remind them of the importance of their work.

Dr. Johns described a recent visit to the Spokane Mining Research Division by the CDC Director, Dr. Rochelle Walensky, and noted that Dr. Walensky was clearly interested in SMRD's research and impressed by the depth and breadth of the Division's work. During an All Hands meeting with employees from NIOSH's Spokane Mining Research Division and Western States Division (also based in Spokane), she noted that "the work you do saves lives." Acknowledging Dr. Jessica Kogel as a strong supporter of Spokane, Dr. Johns noted that at the beginning of his tenure as Director of SMRD in 2019, the plan for SMRD was to grow to 60 FTE. The Division has experienced significant growth since it was established in 2015, but recent increases in costs along with flat funding has required the Division to begin to shrink through attrition. Dr. Johns noted that the work of the Division has support in Congress, and the Division received a targeted increase in its budget as a result of language included in the 2023 Omnibus Appropriations bill. Funding for FY24 is uncertain, but the Division has been able to move ahead in filling its most critical hiring needs. Dr. Johns ended his presentation by providing an overview of the agenda, noting that the Committee would be hearing directly from the Division's researchers using a mix of traditional PowerPoint presentations and more hands-on presentations in the laboratories. Dr. Johns responded to a question from the panel on staffing needs, after which Mr. Zimmer thanked him for his presentation.

Overview of the Miner Health Program

Dr. Gerald Poplin

Branch Chief, Miner Health Branch, Spokane Mining Research Division

National Institute for Occupational Safety and Health

Centers for Disease Control and Prevention

Dr. Poplin introduced himself as an epidemiologist and Chief of the Spokane Mining Research Division's Miner Health Branch, yet emphasized that the planned discussion of the Miner Health Program (MHP) is inclusive of both the Spokane and Pittsburgh Mining Research Divisions, in addition to relevant research in NIOSH. Dr. Poplin initially took time to recognize and pay tribute to Dr. Jessica Kogel, who conceived of and initiated the Miner Health Program in a strategic and inclusive manner, and who was responsible for its current good standing and involvement from across the mining community. Using language extracted from the 1970 Occupational Safety and Health Act, Dr. Poplin explained the need for the MHP in that occupational health standards often present problems differently from occupational safety problems and thus often require a different approach and perspective.

A brief timeline of the MHP was provided, demonstrating the strategic and progressive involvement of mining community partners, including individual and group meetings that directly helped inform the development of a 10-year Strategic Agenda that is currently available online to the public. The Agenda was described to have complementary details on the background, need, and development of the MHP and its three core components: Research, Community Engagement, and Evaluation. While Dr. Poplin noted the research goals and objectives for the MHP can be found directly in the Agenda, he provided additional emphasis on the intention for formal evaluation of the Program in order to measure short- and long-term impacts in a meaningful way that would inform sensible changes to the Program and improve communication and transparency to the mining community.

A new website for the MHP was highlighted as a new medium for informing the community of recent activities, new research, and opportunities to engage, most notably the Miner Health Partnership that was formally established by NIOSH in 2021 as a mechanism for direct engagement with community members outside NIOSH. Dr. Poplin noted recent indicators of the Miner Health Program's recognition as a sought-after source for health and wellbeing information. In the last year, researchers from the MHP had been (1) invited to speak at the National Academies of Science on the health considerations with respect to the Future of Mining; (2) asked to coordinate and facilitate a panel discussion on mental health in mining during the annual conference of

the Society for Mining, Metallurgy & Exploration (SME); (3) collaborate with the MSHA in developing resources for workplace guidance on opioid misuse; and (4) an invitation to provide a keynote address and panel discussion during the health and safety stream of the World Mining Congress.

In concluding remarks, Dr. Poplin reemphasized the interest in soliciting continued engagement from the mining community, noting an upcoming virtual meeting of the Miner Health Partnership on June 15. Lastly, in response to conversation between committee members on the increasing awareness and need for research and resources to support workplace mental health, Dr. Poplin noted the request to facilitate a mental health session at the SME annual conference was partly in response to growing interests and requests from younger members of SME, indicating a likely area of emphasis for the future mining workforce.

At the conclusion of Dr. Poplin's presentation, Mr. Duffy, noting that the mental health struggle in mining is real, shared information about an individual employed at one of the biggest quarries in Connecticut (represented by the United Steelworkers of America [USW]) who had committed suicide earlier that day and the labor management collaboration that immediately stepped in to assist. He emphasized how important the work the Miner Health Branch is to both labor and management. Mr. Stewart then thanked Dr. Poplin for coming to Johns Hopkins to talk about miner health.

Building an Evidence-Based Framework for Improving Miners' Health

Ms. Tashina Robinson

Research Epidemiologist, Miner Health Branch, Spokane Mining Research Division

National Institute for Occupational Safety and Health

Centers for Disease Control and Prevention

Ms. Robinson introduced herself as a research epidemiologist at the Spokane Mining Research Division, primarily working on the Evidence-Based Framework for Improving Miners' Health (EBF) project. She started her presentation by stating the primary research question of the EBF project is to determine the health status of miners, but she elaborated that this question has largely been unanswered due to the underreporting of miner illnesses and lack of knowledge of overall health status and exposures of miners. She then discussed needing data for health surveillance and the data sources that were evaluated through the project (19 in total). The datasets included clinical data, compliance data, and survey data. The data inventory process was extensive, and several datasets were rejected. Some reasons for rejection included not having industry or occupational data, not collecting data finely enough to identify miners, and not having enough miners to analyze. Six datasets in total emerged as applicable to miners' health. She then discussed the accomplishments of the EBF project over the past five years using these datasets. These accomplishments included a total of six scientific manuscripts and reports, with three still in progress at the time of the presentation, as well as a Miner Health Program website.

A myriad of health concerns for miners were identified through this research using the datasets: hypertension (high blood pressure), cardiac disease, mental distress and suicide, hearing loss, lung disease, silica exposure, pain, and musculoskeletal disorders. Ms. Robinson also noted challenges and limitations that emerged from the datasets, including imprecise estimates, small sample size, worker health design, generalizability, and the ability to study rare outcomes. She identified several research gaps for the future include studying miner subpopulations, different subsectors and commodities, chemical and physical hazards, and incorporating GIS data. Substance use and mental health, fatigue, and heat are also priority topics for future study.

Ms. Robinson then led into discussing the next project, which will be shifting to systematize the framework in more of a classic surveillance program style approach. Ms. Robinson will be leading the next project, starting in fiscal year 2024. Similar to the EBF project, the next project will identify data sources and priority hazards and conditions and conduct analyses. In addition, this new project will also explore and evaluate methods to communicate the research. Ms. Robinson ended her presentation by asking how the project can increase dissemination of results and how the committee would like to see results shared.

Ms. Robinson and Dr. Gerald Poplin responded to questions about fatigue and creating health metrics tools for mining sites to track health scores for miners over time. Dr. Steve Sawyer and Dr. Luxbacher responded to a question on the status of the Pittsburgh Mining Health Division miner survey effort status. In closing, Ms. Robinson and Dr. Luxbacher responded to a suggestion on using the MSHA phone app to disseminate health information.

Mining Applications of Novel Interventions for Fatigue: Evaluating Safety Toolkits

Dr. Timothy Bauerle

Research Behavioral Scientist, Miner Health Branch, Spokane Mining Research Division

National Institute for Occupational Safety and Health

Centers for Disease Control and Prevention

Dr. Bauerle introduced himself as a research behavioral scientist specializing in occupational health psychology and went on to describe the Fatigue Project. The primary objective of the project is to equip operators with the knowledge and skills to choose, implement, and evaluate effective fatigue mitigation strategies, allowing workers to be well-rested, alert, and prepared for their shifts. Dr. Bauerle acknowledged that circumstances had changed since his last address to the group in November 2019, primarily due to the impact of COVID-19. Adjusting to these challenges, the project team with Dr. Bauerle at the lead decided to consolidate existing and innovative data to develop an intervention framework. The goal of this framework was to combine feasible strategies for mid-level mine occupational health and safety managers, enabling them to create action plans to manage fatigue risk within their specific sites.

There are four key tasks involved in this endeavor. First, the team conducted a needs assessment to gather industry input and identify the unique impact of fatigue on the community and the gaps that need to be addressed. Second, the team undertook the challenging task of synthesizing the vast amount of fatigue-related literature. This process involves analyzing existing recommendations, conducting systematic reviews, meta-analyses, and distilling information applicable to the mining industry. Third, Dr. Bauerle acknowledged the lack of precise data capturing the extent of fatigue in mining. Therefore, the team aimed to utilize existing data and determine what additional research is necessary to answer critical questions. Finally, the team would consolidate all the obtained information and formulate reasonable approaches into an intervention framework to combat fatigue within the mining industry.

Providing an update on the project's progress, Dr. Bauerle shared that interviews for the needs assessment were completed and an umbrella review—a review of reviews—is underway to synthesize the wealth of information from authoritative articles. The team has also identified various public datasets to aid in their analyses, which were approximately 60% complete. Additionally, the team has started developing the intervention framework document. Furthermore, Dr. Bauerle described the ways in which the team shared its findings to-date through diverse channels, such as peer-reviewed publications, discussions with trade groups, NIOSH Science Blogs, and forthcoming contributions to an SME Safety Book chapter. Looking ahead, Dr. Bauerle outlined potential future directions for the project, including implementing the approaches identified in the intervention framework as well as gathering field data on fatigue detection technologies. In conclusion, Dr. Bauerle expressed his appreciation and invited questions from the audience, and he received a number of various questions from the audience.

One question was regarding the nuanced differences between burnout and fatigue, with Dr. Bauerle clarifying that burnout represents (in part) compounded fatigue over time. The participant went on to clarify that fatigue detection technologies are being implemented in some of the operations they knew, but that underlying issues such as long schedules and short staffing issues were not being addressed. Another participant asked about sleep apnea being an issue. Various questions evolved into a conversation about shift duration and rotation regarding work-related fatigue risk and workers' preferences for different schedules allowing for more or less flexibility. A question was posed to Mr. Williamson about the fatigue-related information MSHA collected after a safety-related incident. This prompted a larger discussion on what information is collected in a root cause analysis or becomes written in a report or citations, such as shift or working hours. Dr. Bauerle commented, mentioning a study which used MSHA data and found an association between the number of hours into a shift that an injury occurred and the severity of that injury. Mr. Zimmer thanked Dr. Bauerle for his presentation and for answering questions.

Opioid Resources Awareness Pilot

Dr. Carole Nixon

**Health Scientist, Miner Health Branch, Spokane Mining Research Division
National Institute for Occupational Safety and Health
Centers for Disease Control and Prevention**

Dr. Nixon introduced herself as a Health Science Evaluator and Principal Investigator for the pilot project, Tailoring Opioid Awareness Training Resources for the Mining Industry. She described the project as a collaboration with MSHA to address the high rates of opioid use, misuse, and overdose experienced by mine workers by tailoring workplace prevention resources to the unique needs of the mining industry, including an opioid awareness training curriculum for mine workers and a prevention resource guide for operators. MSHA is overseeing the content development while NIOSH has taken the lead on engaging the mining community for feedback to inform MSHA's resources development.

Given the short timeline for the project, Dr. Nixon stated that the project is leveraging internal and external collaborations (e.g., Total Worker Health Centers of Excellence) as well as existing structures and opportunities to interact with mining community members. These included the Miner Health Partnership whose members expressed support for the formation of a opioids working group, site visits, and conferences. Dr. Nixon described seven working sessions that were conducted in January and February 2023, characteristics of the 21 participants, and the qualitative analysis of feedback. Draft reports have been shared with MSHA as well as the working group. She also provided examples of themes that have emerged from the analysis—for example, less than half of participants representing operations perceive opioids as a problem and most operators do not use comprehensive data to understand worker opioid-related outcomes. Overreliance on drug testing data may contribute to misperceptions of opioid use and misuse among workers. This also weakens management awareness of negative outcomes and subsequent support for prevention efforts. She presented data from the construction industry that supports proactive prevention given five suicide and fourteen overdose fatalities for each work-related fatal incident. In a related theme, none of the participants indicated that they were using any procedural model to guide their planning and implementation of health promotion and prevention, which often contributed to oversight of needs assessment and identification of helpful sources of data (e.g., Employee Assistance Programs or EAPs). Dr Nixon concluded by describing the use of the feedback by MSHA to tailor resources in the upcoming months and the Miner Health Program's use of the feedback to inform upcoming site visits and development of further research and evaluation efforts.

Chair Zimmer thanked Dr. Nixon for NIOSH's work and called for questions. Dr. Behringer asked about evidence of education about and use of Narcan. Dr. Nixon noted one working group member who had promoted Narcan's use, although this was met with resistance. Discussion of Narcan is growing given its recent over-the-counter approval by the FDA. There is a current working group in construction looking at developing a model Narcan policy. Mr. Zimmer added that he has seen more willingness on the owner and operator side to include Narcan in their policies and training. Another participant added that NIOSH's Total Worker Health Program offers resources on the topic.

Assistant Secretary Williamson reaffirmed the importance of this topic and MSHA's ongoing work in this area and recognized MSHA's staff for their hard work. He also emphasized the efforts of MSHA's Miner Health Matters campaign and Total Worker Health as "umbrella" organizing paradigms, and he stated that the most important piece is just talking about these things and making them topics that can be discussed in the workplace to remove some of the stigma that may be associated with these topics.

Identify and Characterize Health Hazards Associated with Stone, Sand and Gravel Mining Processing (Pilot)

Dr. Brianna Eiter

**Team Lead, Health Surveillance Assessment and Intervention Team, Miner Health Branch,
Spokane Mining Research Division
National Institute for Occupational Safety and Health
Centers for Disease Control and Prevention**

Dr. Eiter introduced herself as team lead for the Health Surveillance Assessment and Intervention team in the Miner Health Branch and project lead for the pilot project. She started off reminding the Committee that hazard recognition is a critically important skill to mine worker safety and health but that there is limited research focused on hazard recognition as it relates to health hazards. Therefore, it is unclear whether workers perceive, recognize, and understand health hazards in the same way they do safety hazards. Dr. Eiter indicated the project team is conducting several tasks to better understand health hazard recognition: a retrospective examination of previous data sources, previous data collection efforts, and the research materials that were developed in support of those efforts; an assessment of Mine Safety and Health Administration incident, injury, and fatality data; and a mapping review to identify gaps in the evidence base to better understand whether and how health hazards have been studied in the context of worker hazard recognition. Dr. Eiter reported that the project team has had opportunities to present the project at government and mining industry conferences and has plans to publish journal articles in the future. She also indicated that findings from this pilot project are being used to inform a second pilot project that will encompass research related to fatigue, mental health, substance use/misuse, hazard recognition, and risk management. The goal of the future pilot project is to move beyond the siloed focus of the impact of individual risks, exposures, and adverse outcomes for mine workers to identify where and how fatigue, substance use/misuse, and health hazard recognition and risk management intersect. Dr. Eiter indicated that she looks forward to providing an update on this work at a future MSHRAC meeting and thanked the Committee for their time.

Unconventional Monitoring and Design for Mine Stability in Sedimentary Rock

Ms. Heather Lawson

**Physical Scientist, Miner Safety Branch, Spokane Mining Research Division
National Institute for Occupational Safety and Health
Centers for Disease Control and Prevention**

The overarching goal of this project is to develop, field test, and/or modify tools, as needed, for use by mine operators for the proactive monitoring and anticipation of ground deterioration. Ms. Lawson indicated that the team is taking a three-pronged approach to meet this objective.

- The first goal is to explore, develop, or modify novel tools and approaches for the anticipation of ground deterioration.
- The second goal is to evaluate the potential of geochemical markers as early risk indicators for dynamic failure events in coal, particularly with respect to gas outbursting.
- The third goal is to enhance the accessibility of routine seismic monitoring for underground mines operating in sedimentary deposits by reducing barriers to use such as cost, ease of use, and practicality.

Among this project's accomplishments, first, one long-term network has been successfully established at a partner mine. This network provides near-real time monitoring to mine operators through an easy-to-use web interface, and it directly contributes to the third objective of enhancing accessibility to routine seismic monitoring. Second, a temporary deployment of a distributed acoustic sensing (or DAS) system has been performed at a second, deep and seismically active partner mine. DAS systems have several advantages over traditional seismic data collection systems in terms of both density of data and possibly correlation with dynamic failure events. This accomplishment helps to streamline seismic data collection by improving data quality and practicality. Third, a machine learning approach has been successfully applied to a large database containing information regarding coal properties, geochemical and petrographic composition, and in situ dynamic failure status. The goal of this effort was to develop a model that would consistently anticipate

dynamic failure status as a function of the coal's properties and characteristics. Findings indicated that the factors that most consistently correlated with dynamic failure status were sulfur content, oxygen content, Van Krevelen ratio, and vitrinite reflectance.

As a fourth accomplishment, this project research has established a repeatable, systematic, and effective methodology for dynamic failure data analysis, which is intended to be applied to a second database of laboratory-induced dynamic failure events. Comparison between the two analyses will help to clarify whether the variables identified thus far are artifacts of the depositional setting, or if instead they impact the inherent capacity of the coal to retain energy prior to failure, independent of geologic setting. If the latter, then this finding would contribute to the objective of evaluating geochemical markers as early indicators of dynamic failure risk.

As part of this project, innovative numerical modeling solutions and studies have been developed. These include a method for more realistic modeling of movement along fault surfaces, possible validation of the correlative relationships seen in the team's geochemical studies with respect to dynamic failure behavior, and further development of the user-friendly modeling software UT3PC, developed in conjunction with the University of Utah. The development of these approaches and tools will enhance the ability to more accurately model real-world ground movement problems, while also relying less on empirical foundations that may not have been derived from similar environments.

Future projected work includes using satellite-based subsidence monitoring, field testing of two unconventional ground penetrating radar tools, application of machine learning to data generated from laboratory-induced dynamic failure events (as opposed to in situ events), additional laboratory tests to measure gas desorption rates and composition during failure, and publication of the project team's Framework for Induced Seismicity, which is a library of algorithms for use in the analysis and interpretation of seismic data.

Mr. Stewart asked if there was interest in doing work on potash or salt and received an affirmative answer from Ms. Lawson.

Highwall Safety

Dr. Josef Bourgeois

**Mining Engineer, Miner Safety Branch, Spokane Mining Research Division
National Institute for Occupational Safety and Health
Centers for Disease Control and Prevention**

Dr. Bourgeois introduced himself as a Mining Engineer and Co-PI on the Highwall Safety project which runs from 2021 to 2026. He started the presentation by outlining the two specific aims of the project. He explained that the first specific aim focuses on updating rockfall catch-bench design guidelines through empirical rockfall testing at open pit mines. He noted that current design guidelines are outdated and incorporate only bench height when calculating catch-bench width in open pit mines. There is strong industry support for this specific aim.

Dr. Bourgeois then explained that the second specific aim focuses on advancement in slope monitoring capabilities through raising awareness about current technologies that exist for slope monitoring. This specific aim was requested to be added to this project during the development of the project proposal by external reviewers.

Next, Dr. Bourgeois listed the up-to-date major accomplishments according to each specific aim of the project, including the following:

- development of an in-house suite of synthetic molds/rocks and acquirement of equipment necessary to conduct rockfall testing at mines;
- conducting of rockfall testing at three mines and quarries in Washington, Idaho, and Nevada;
- presenting two papers at the Slope Stability Conference 2022 in Tucson, Arizona;
- establishing industry support to develop a slope instability database in collaboration with the Geotechnical Center of Excellence; and
- establishing an InSAR monitoring contract with SkyGeo to back-analyze slope failures in Nevada and test early detection capabilities.

Dr. Bourgeois then listed the future work needed to accomplish the planned impacts, including development of MOUs with additional mining companies to continue the rockfall program in as many different bench configurations as possible throughout the remaining duration of the project; refinement of drone data acquisition and processing methods; full construction of a slope instability database through acquiring slope failure data and application of machine learning to better predict failure modes, and development of a NIOSH-sponsored Partnership focusing on slope monitoring methods. Dr. Bourgeois ended the presentation by showing a highlight video reel of rockfall testing that has occurred so far in the project as well as listed current collaborators on the project.

There were three questions after the presentation. The first was from Mr. Zimmer asking what the synthetic rocks are made of, to which Dr. Bourgeois replied 5,000 PSI early strength concrete. The second question came from Dr. Biscontin asking if any progress has been made on modeling the rockfall testing and if the data would be available if people wanted to test their own numerical methods, to which Dr. Bourgeois replied that the team has a publication coming out in Mining, Metallurgy & Exploration outlining rockfall testing using RocFall 2D using the same bench/rock configurations that are being tested in the field for calibration purposes. Additionally, Dr. Bourgeois stated that he would be interested in talking further with Dr. Biscontin regarding the modeling aspect of rockfall testing. The third question came from Dr. Luxbacher asking if there was any update on instrumenting the synthetic rocks for runout analysis using equipment designed by the University of Nevada, Reno, to which Dr. Bourgeois replied that the instruments had recently been completed and they will be installed into some of the larger synthetic rocks for testing later in the summer of 2023.

Evaluation of Methods to Inform Development of a Near-Real-Time Monitor for Measuring and Reducing RCS Exposures in Non-Coal Mines

Dr. David Parks

Mechanical Engineer, Miner Health Branch, Spokane Mining Research Division

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Dr. Parks presented the research project aimed at the development of a real-time silica monitor in the SMRD industrial hygiene lab so that the laboratory tools used by the project could be readily referred to and explained. An overview of the current methods for quantifying respirable crystalline silica was provided and the current state of the art in terms of real-time dust monitors was discussed. This led into a discussion of the infrared spectroscopy-based method for quantifying silica with a benchtop Fourier transform infrared (FT-IR) spectrometer. Several alternative infrared spectroscopy techniques were also explained and their merits in terms of being more portable, cheap, and robust were described. Dr. Parks specifically described non-dispersive infrared spectrometers and diffraction grating spectrometers, each of these being inferior in terms of resolution and optical throughput to the FT-IR, but having the redeeming characteristics of being smaller, cheaper, and possessing no moving parts. The ongoing collaboration with industry partners aimed at implementing infrared spectroscopy both by way of diffraction grating and non-dispersive infrared spectrometers was described.

The planned testing of a prototype non-dispersive spectrometer-based monitor developed under a BAA contract was also mentioned. This prototype monitor was described as including an integrated pump and collection filter in addition to the infrared components. As such, this monitor potentially represents the first portable infrared monitor aimed at the quantification of respirable crystalline silica. Since it is an infrared-based device, it is hoped that the frequent recalibrations required when utilizing existing portable dust monitors can be eliminated. However, Dr. Parks noted that interfering minerals will likely affect the accuracy of this monitor. As such, it was explained that a collection of a diverse set of mine dust samples will be needed to test the monitor in the worst-case scenario wherein other mineral species exhibit similar infrared absorbance to that of quartz. This issue will be addressed by adding additional infrared channels to allow for correction of the interference from non-quartz minerals.

There was a robust question and answer period in the lab discussing interferences and the need for a portable unit. Dr. Luxbacher described some of the extramural contracts that are underway to develop a portable silica monitor using several technologies.

Managing Ground Support for Long-Term Stability in Underground Mines

Mr. David Sweet, Mining Engineer

Ms. Casey Stazick, Materials Engineer

Mr. Joseph (Brad) Seymour, Mining Engineer

Mr. Tyler Emery, Branch Chief, Miner Safety Branch, Spokane Mining Research Division

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The project was introduced by David Sweet and Casey Stazick, the co-leads for the project, Managing Ground Support for Long-Term Stability in Underground Mines. There are four specific aims to the project:

- Squeezing ground research—quantifying ground support performance in low rock quality squeezing ground conditions, with the aim of developing predictive guidelines as to when rehabilitation is required. SMRD is partnering with Montana Tech University on this research.
- Corrosion—characterizing different corrosion processes and the influence they have on the performance of the ground support. Long-term experiments are underway at the Eagle Mine in Northern Michigan and the Galena Mine in Idaho’s Silver Valley, and further work is planned in Arizona.
- Backfill—researching what engineering properties are required for backfill and what safety spans can be used for different stope designs. Montana Tech is assisting with paste backfill studies, and other mines (Lucky Friday and Eagle mines) are actively participating in other aspects of the research.
- Seismicity—using models and dynamic shear box testing work, developing an understanding of different methods for viewing the energy balance and energy transfer in underground mines.

Mr. Emery presented in a lab setting on the NIOSH High Energy High Displacement (HEHD) machine and associated research. He first described the intended purpose of the machine, which is to test whole ground support systems as opposed to individual elements of the ground support system. One of his examples was the difference of the testing using the HEHD in comparison to an ASTM three-point panel test which only tests the shotcrete’s strength, but not the bolts and mesh.

Next, Mr. Emery walked the committee through the progression of the research and evolution of the utilization of the machine. During this time, a live test was started in the HEHD machine and while he spoke the machine went through the process of testing chain link mesh, as during a research project. Mr. Emery pointed out some notable applied research for direct use by miners and inspectors, such as measuring the crack width of shotcrete to determine if the shotcrete is still useful or if it has reached its capacity. Next, Mr. Emery discussed how different ground support combinations were tested in the HEHD and the impact it had for mine operators in answering questions as to truly the best combination. He also showed how the research pointed to the importance of macro synthetic fibers in shotcrete to assist in ground support safety. He went on to discuss how the same research also helped geotechnical engineers to advocate at mines because sometimes operations have a hard time accepting change and need to see definitive research such as this.

Finally, Mr. Emery finished his presentation by showing charts on the synthetic meshes that were tested recently and noted that these meshes can offer a lot of benefits to the traditional steel meshes, such as corrosion resistance.

Questions and answers posed by the Committee to Mr. Emery and Mr. Sweet follow.

- How far can the ram be extended on the HEHD? Up to 24 inches.
- *What is the weight on the synthetic meshing?* Three different types of mesh have been tested. One type was almost as heavy as the chain link; it was very bulky, but it was the highest-performing mesh and performed better than chain link in that test. Lighter ones did not perform quite as well. Meshes were sourced from civil works geotechnical companies and one was specifically designed for the kind of high dynamic ground found in hard rock mining.
- *Did the mesh used incorporate fibers?* A lot of this work has been with synthetic fibers, and the project research is moving towards hybrid systems with both steel and synthetic fibers.
- *Are the synthetics impacted at all by humidity or the presence of water, long-term water saturation, etc.?* It depends on the type. Synthetics designed for civil geotechnical applications are not impacted. Synthetics for dynamic ground had nylon banding through them that would have some degradation over time.

- *What about basalt fibers?* Basalt fiber is just basalt rock that is melted down and extruded into a fiber. It's a more sustainable approach to creating materials and is now being introduced in geotextiles that are coming out. The geogrids required for ground support for mining are by far the heaviest duty available and different from that used in general civil construction.

The tour continued into the corrosion lab where Ms. Stazick showed the Committee examples of corroded ground support from partner mines and the potentiostat (an electronic instrument that controls the voltage between two or more electrodes) used for electrochemical testing to understand mine support corrosion rates. The Committee also saw the current long-term corrosion lab test focusing on electrical isolation for mine support experiencing galvanic corrosion with the rock mass. Ms. Stazick discussed how many variables contributing to corrosion have been documented but pointed out that the way they work together in a corrosion setting is still unknown. Committee questions related to metal coatings and detection of corroded bolts underground were answered by Ms. Stazick.

The last lab tour stop was with Mr. Seymour, who discussed the multiple types of backfill testing that occur at SMRD. He described the standard UCS tests that mines perform to get the geomechanical properties of their backfill, the ASTM standards that are referenced, and the variety of materials that often make up the fill. He explained that the project team is trying to create a standardized process matched with performance data to improve the quality control standards in the industry. He showed samples with different ductility that are being tested to investigate its relationship to tensile strength. After a tensile strength test was run for the Committee, he then gave a short PowerPoint presentation of the compressive strength of differently sized cylinders, some with different additives, for QA/QC and tensile strength research. Committee questions about binders such as flyash and slag were answered, which concluded the part of the tour related to the project, Managing Ground Support for Long-Term Stability in Underground Mines.

Evaluating and Developing Emerging Technologies to Improve Conveyor System Safety

Assured Autonomy Supervisory Intervention System Technology (Pilot Completed)

Dr. Michael McNinch

Mechanical Engineer, Miner Safety Branch, Spokane Mining Research Division

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Michael McNinch presented on behalf of the Automation and Technology Team for the pilot project, Assured Autonomy Supervisory Intervention System Technology (AASIST), and the wrap-up of the project, Evaluating and Developing Emerging Technologies to Improve Conveyor Safety (Conveyor Safety). Mr. McNinch presented safety monitoring research done during the Conveyor Safety project in which remote monitoring of equipment precluded maintenance personnel from having to put themselves in potentially hazardous situations. This included an overview of a pilot Industrial Internet of Things (IIoT) installation at a partnering cement batch plant belonging to Central Pre-Mix in Spokane Valley, WA. Mr. McNinch indicated that this research, as well as other work, led the team to conclude that the application of emerging technology that would best benefit the health and safety of miners would be the development of Machine Situational Awareness (MSA). He defined MSA as the ability of a piece of equipment to monitor its environment, identify emerging hazards, and act to prevent injury. This led to the proposition of the AASIST pilot project and the MSA full project proposal.

Mr. McNinch then introduced sensors, processing hardware, and software that the team had developed to test candidate MSA methods researched during the pilot. He demonstrated a basic target tracking algorithm that fused lidar and camera data to identify his position near a conveyor. Mr. McNinch stated that there were three critical components for an assured autonomy supervisory system: (1) the ability to perceive the relevant environment by merging robust sensor data to create a time-based digital twin that identifies objects and their motion, (2) a probability processing engine that projects object movement in the environment and calculates the likelihood and cost of interaction, and (3) an alternate futures evaluation package that identifies the lowest risk (based on probability and cost) course of action that the equipment can implement. Mr. McNinch and the Committee discussed the difficulty and importance of mining/OEM partnerships for the success and ultimate implementation of the framework.

Coexistence and Safety of Wireless Systems in Mining

Mr. Ronald Jacksha; Electronics Technician

Carl Sunderman, Electrical Engineer

Miner Safety Branch, Spokane Mining Research Division

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Mr. Jacksha introduced himself as the Principal Investigator of the Coexistence and Safety of Wireless Systems in Mining project. Mr. Jacksha stated wireless coexistence is basically the ability of wireless devices and systems to function satisfactorily in the presence of other wireless devices and systems, adding that it is a subset of electromagnetic interference. He explained that it's like groups of people talking in a restaurant—everyone is trying to be polite and follow rules of etiquette, but there can still be problems with individuals understanding each other. Mr. Jacksha then stated the Institute of Electrical and Electronic Engineer (IEEE) definition of coexistence—the ability of one wireless system to perform a task in a given shared environment where other systems in that environment have an ability to perform their tasks and might or might not be using the same setup rules.

Mr. Jacksha presented a wireless coexistence case study involving 5G cellular towers near airports impacting the ability of aircraft RADAR altimeters to provide accurate data on a landing approach. He emphasized in this case both the cellular and airline industries were following appropriate regulations (rules) but there were still problems leading to the need to redesign the altimeters.

In response to a question from the Committee if there is really a problem given that wireless has been around forever, Mr. Jacksha explained that the medical sector started seeing wireless coexistence issues 15 or 20 years ago. He stressed that based on these issues, the Food and Drug Administration (FDA), the National Institute of Standards and Technology (NIST), and the Federal Communications Commission (FCC) partnered to come up with guidelines on how to evaluate for coexistence in the medical device sector. Mr. Jacksha stated that the FDA now mandates coexistence analysis for all wireless medical devices. He further added that the available frequency spectrum is becoming increasingly crowded and that other industries are exploring more efficient ways to utilize the available spectrum.

Regarding wireless coexistence issues in mining, Mr. Jacksha mentioned indications are that problems are already occurring, but they may not be attributed to coexistence. He added that when a coexistence issue occurs, an injury or fatality is a concern; that coexistence issues can be very time consuming and expensive to troubleshoot; and that mining companies may be hesitant to adopt systems based on the concerns.

Mr. Jacksha then outlined NIOSH's research approach to ensure safe wireless coexistence in mining. He said NIOSH was collaborating with the NIST to ultimately provide stakeholders with guidelines and recommendations to define acceptable wireless system performance and to proactively determine the probability of wireless systems to coexist. Mr. Jacksha finally mentioned that NIOSH will be developing additional guidelines and recommendations for development of mine-site-wide wireless system documentation.

Mr. Sunderman was then introduced to provide a demonstration of a coexistence failure involving a wireless emergency stop (e-stop) and a handheld radio. He first demonstrated the normal operation of the e-stop in that, upon initiating an emergency stop, a strobe light activated which simulated a piece of equipment being shut down. Mr. Sunderman then reset the e-stop and used an instrument to produce an interference signal similar to that of a handheld radio. This interference signal caused the e-stop circuit to generate a nuisance false-trip by activating the strobe light even though an emergency stop had not been initiated. Mr. Sunderman went on to show the radio frequency shielded enclosure lab where in-depth testing is being performed.

The comments and questions from the Committee were primarily related to traditional electromagnetic interference (EMI)-related issues in mining and Mr. Jacksha and Mr. Sunderman acknowledged there will always be EMI concerns in mining. Comments directly related to wireless coexistence generally conveyed a sense of the perceived importance and support of the research effort.

Predicting the Impact of Heat Strain on Cognitive Functions in Miners

Dr. Kristin Yeoman,

Medical Officer, Miner Health Branch, Spokane Mining Research Division

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Dr. Yeoman introduced herself as an epidemiologist with NIOSH. She provided an overview of the environmental chamber and SMRD's heat stress research. She outlined the reasons that NIOSH is studying heat stress: (1) Heat stress is a growing issue in mining as mines extend to hotter, deeper levels and as surface mines are exposed to increasingly frequent and severe heat waves; and (2) Injuries are an important consequence of heat exposure among workers, likely related to cognitive changes, psychomotor changes, fatigue, and other factors.

Because cognitive changes from heat exposure can lead to various adverse outcomes, including injuries, SMRD's research aims to answer the following questions:

1. Who is most at risk for heat-related cognitive changes (i.e., describe how individual variability impacts workers' responses to heat stress)?
2. When do cognitive changes begin to happen?
3. Is it possible to predict when these changes will occur?

Dr. Yeoman described a dual-arm study designed to answer these questions, with both an environmental chamber and field component. The environmental chamber study will recruit 30 workers to perform moderate exercise both at room temperature and under hot conditions. Physiological monitoring will occur throughout, and a chest strap for heart rate and an ingestible capsule for core body temperature monitoring were demonstrated. During the study, when core body temperature reaches pre-specified thresholds, participants will be administered cognitive tests, and investigators will compare the results of cognitive tests conducted in hot conditions with those conducted at room temperature.

The field component of the study is observational, where 59 participants will conduct their normal shift activities after ingesting the temperature capsule and wearing the chest strap for physiological monitoring. They will be equipped with a smart phone to allow them to take two assessments during their shift: one at normal body temperature and one at elevated body temperature. The assessments will include brief questions and a cognitive test. NIOSH investigators will receive additional information from the field study. Specifically, NIOSH investigators will obtain a better understanding of the various patterns of heat strain in miners (i.e., how often core body temperatures become elevated during a typical shift, for how long, etc.). This information will help inform future NIOSH heat stress research and ensure that research is relevant to the heat strain patterns commonly seen in the mining industry.

Dr. Yeoman responded to several questions from the Committee. A question was asked regarding whether the field study would include agricultural workers, since they are high risk for heat-related adverse outcomes, but Dr. Yeoman responded that the field study was only focused on miners to allow NIOSH to understand how heat strain specifically affects miners. Another question was asked regarding the type of volunteers being recruited (i.e., older workers, less fit workers, etc.). Dr. Yeoman responded that many studies have focused on young, fit males, which is not representative of the working population. NIOSH will recruit persons aged <55 years of any weight or fitness level, but people with certain conditions will be excluded for safety reasons. NIOSH has a strict safety protocol that is followed to minimize the risk to participants. Another question was asked as to whether investigators control for hydration, and Dr. Yeoman responded that investigators monitor the specific gravity of a urine sample to minimize the risk of dehydration. Finally, a participant asked about targets for physiological monitoring. Dr. Yeoman explained that heart rate will be maintained within age-specific limits for safety reasons, whereas core body temperatures of 38°C and 38.5°C were chosen as thresholds at which cognitive tests will be administered based on national and international guidance recommending that workers' core temperatures not exceed these levels.

Committee Discussion

At the conclusion of the in-laboratory presentations, the Committee reconvened in the conference room for further discussions. Dr. Behringer, participating via Zoom, had several questions that were answered by Dr. Poplin and Dr. Nixon and suggested further areas to include in research, including additional data sources. Mr. Zimmer and Mr. Duffy commented on the importance of doctors querying their patients on the type of work they do. Mr. Stewart asked about the declining number of certified B Readers, and Dr. Johns was able to provide some background on that issue.

Dr. Luxbacher then facilitated a discussion on how the Committee could provide input for the NIOSH Underground Mine Safety and Health Research Laboratory near Mace, WV. The Committee decided to form a Working Group, with Dr. Schafrik and Ms. Prichard volunteering to organize it for Committee approval. Dr. Luxbacher then reviewed the current design layout as depicted in the Environmental Impact Statement and some of the enhancements to the design that had been suggested thus far, answering questions for the Committee.

Fall Meeting Planning

Dr. George Luxbacher
Deputy Associate Director for Mining
National Institute for Occupational Safety and Health
Centers for Disease Control and Prevention

The Committee discussed the dates, location, and format for the next meeting. It was decided that potential dates would be circulated for input. The meeting will include time for the NIOSH Underground Mine Safety and Health Research Laboratory Workgroup to meet as well as a half-day Mining Program update. The National Mine Health and Safety Academy in Beaver, West Virginia, was suggested for the site of that meeting.

At this point the meeting entered the Public Comment period.

Public Comment Period

Chair Zimmer asked if any member of the public attending via Zoom wished to address the Committee; there were no such requests and the Public Comment period was closed.

Adjourn

At the conclusion of the meeting, a motion was made to adjourn, was seconded, and was unanimously approved.

Appendix A - Attendees

Name	Affiliation
Kristina Behringer	Public - Committee Member
Giovanna Biscontin	National Science Foundation
Ron Bowersox	UMWA - Committee Member
Andrea Brickey	South Dakota School Mines & Tech - Committee Member
Melanie Calhoun	MSHA - Ex Officio Member
Tom Duffy	USW - Committee Member
Marifran Mattson	Purdue University - Committee Member
Todd Moore	Consol Energy - Committee Member Pending
Elizabeth (Libby) Pritchard	NSSGA - Committee Member
Steven Schafrik	Univ. of Kentucky - Committee Member
Matthew Stewart	R. T. Vanderbilt - Committee Member
Kyle Zimmer	IUOE - Committee Member (Chair)
Anita Alston	NIOSH-OD
Pauline Benjamin	NIOSH-OD
Kelley Durst	NIOSH-OD
John Howard	NIOSH-OD
George Luxbacher	NIOSH-OD Mining, DFO
M. Berni Metzger	NIOSH-OD Mining
David Snyder	NIOSH-OD Mining
Lisa Steiner	NIOSH-OD Mining
Jonathan Fritz	NIOSH-PMRD
Lydia Kocher	NIOSH-PMRD
Carin Kosmoski	NIOSH-PMRD
Launa Mallett	NIOSH-PMRD
Steven Mischler	NIOSH-PMRD
Mahiyar Nasarwanji	NIOSH-PMRD
Eranda Perera	NIOSH-PMRD
J Drew Potts	NIOSH-PMRD
Stephen Sawyer	NIOSH-PMRD
Jack Trackemas	NIOSH-PMRD
Dave Yantek	NIOSH-PMRD
Allegra Yeley	NIOSH-PMRD
Liming Yuan	NIOSH-PMRD

Chenming Zhou	NIOSH-PMRD
Max Barham	NIOSH-SMRD
Tim Bauerle	NIOSH-SMRD
Josef Bourgeois	NIOSH-SMRD
Brianna Eiter	NIOSH-SMRD
Tyler Emery	NIOSH-SMRD
Bo Hyun	NIOSH-SMRD
Ron Jacksha	NIOSH-SMRD
Doug Johns	NIOSH-SMRD
Mark Larson	NIOSH-SMRD
Heather Lawson	NIOSH-SMRD
Michael McNinch	NIOSH-SMRD
Carol Nixon	NIOSH-SMRD
Gerald Poplin	NIOSH-SMRD
Vaibhav Raj	NIOSH-SMRD
Tanisha Robinson	NIOSH-SMRD
David Sweet	NIOSH-SMRD
Casey Stazick	NIOSH-SMRD
Brad Seymour	NIOSH-SMRD
Samantha Wilson	NIOSH-SMRD
Kristin Yeoman	NIOSH-SMRD
Christopher Williamson	MSHA

I hereby certify that, to the best of my knowledge, the minutes of the May 24, 2023 meeting of the Mine Safety and Health Research Advisory Committee (MSHRAC) are accurate and complete.

Kyle F Zimmer J 10/13/2023

Chair, Mine Safety and Health Research
Advisory Committee