Slide 1: Title Slide

Good Morning. It is my pleasure to participate in this Underground Mine Mapping Benchmarking Workshop, and to provide you with an update on the status of MSHA's void detection demonstration projects.

I have passed around a copy of the presentation, which contains more detail than I will have time to cover this morning. So please read over it at your convenience, and if you have any questions, please see me or Dr. Kelvin Wu

Slide 2: High Profile Incidents

We are all of course aware of the most prominent events – impoundment breakthroughs and mine inundations which led to this mine mapping and void detection initiative.

We had four very significant incidents where large volumes of coal processing waste broke through inadequate barriers of soil and rock passed through mines and discharged into adjacent watersheds

And then of course the infamous mine inundation and dramatic rescue at Quecreek Mine

These major problems share one element in common. They were all the result of either unavailable, incomplete, or inaccurate mine maps or inadequate characterization of the subsurface conditions above the mines.

Slide 3: Impoundment Problem

This shows the impoundment breakthrough problem in general. The question is, of course, do we actually have the barrier here that we expect, and is the quality of the soil and rock sufficient to prevent a breakthrough.

Slide 4: Martin County Overview

The Martin County breakthrough, the largest of these, resulted in the release of more than 300 million gallons of coal waste

Slide 5: Martin County Breakthrough

The processing waste broke through an inadequate barrier in the back of a refuse impoundment, passed through an unoccupied area of an active mine and discharged from two locations as depicted by these arrows.

Slide 6: Martin County Discharge at South Mains

The waste emerged at the South Mains Portal

Slide 7: Martin County Discharge at No. 2 North Belt Entry

And the No. 2 North Belt entry

Slide 8: Martin County Damage

This is typical of the environmental and property damage experienced downstream.

Slide 9: Martin County Damage

The effects were felt as far as 100 miles downstream through the Tug Fork of the Big Sandy River, and all of the way to the Ohio River

Slide 10: Martin County Public Outcry

There was the expected public outcry

Slide 11: Extent of Abandoned Mines in Appalachia

This is of course by no means an isolated situation. There are nearly 300,000 abandoned coal mines in the Appalachians, distributed as shown here.

Slide 12: Impoundments over Mines

There are 220 existing coal-mining related impoundments built over or adjacent to coal mine workings.

One of the biggest problems is to determine the extent of mining. In many instances, mine maps have proven not to be accurate, particularly in the final cut near the outcrop.

Slide 13: Congressional Study

As a result of the Martin County Breakthrough, Congress funded a study through the National Academy of Science, National Research Council, Committee on Coal Waste Impoundments. The committee ultimately wrote a report – Coal Waste Impoundments: Risks, Responses and Alternatives. Many of you have seen this report.

Slide 14: NRC Recommendation

One of the recommendations included in the report is shown here:

Among various other things, the council recommended that demonstration projects using modern geophysical techniques be funded and that results be widely conveyed to the mining industry and to government regulatory personnel through workshops and continuing education. And that is what we are doing now.

Slide 15: Quecreek Group

Shortly thereafter the Quecreek Inundation occurred.

Slide 16: Quecreek Map

The mine cut into flooded workings which were not depicted on the available mine map.

Slide 17: Quecreek Flooded Portal

The mine filled with water

Slide 18: Quecreek Trapped Miners

9 miners narrowly escaped while 9 others remained trapped for 72 hours.

Slide 19: Quecreek Rescue

And of course the dramatic rescue which ensued.

Slide 20: Inundation Statistics

This was a dramatic example of a very frequent problem.

From 1995-2002 mine operators had reported 181 mine inundation, 107 of which were unplanned cut-throughs resulting in water inundation.

Slide 21: Congressional Funding

Congress appropriated 10M to the MSHA budget to address this problem.
3.9 went to mine mapping and 6.1 to void detection demonstration projects

Slide 22: RFP

MSHA issued a request for proposals (RFP as shown here)

Slide 23: Demonstration Projects Workflow

This slide represents the detailed screening and selection process that we went through. I would especially like to point out here that each proposal was reviewed by a team of expert reviewers, generally including a representative of the COE Geophysics Branch and a recognized University Professor of Geophysics.

Slide 24: Response to RFP

We had an overwhelming response – 58 different proposals from 23 sources covering the technologies shown here.

Slide 25: Projects Underway

Of these, we selected 14 projects covering a wide range of seismic, electrical, and electromagnetic methods. These projects are now underway, and range from about 10-50% complete.

Slide 26: Surface Seismic Reflection projects

We have two demonstrations of surface seismic reflection, a technique that has been widely used in the oil and gas exploration industry to image depths from 50 to several thousand feet.

Slide 27: Surface Seismic Illustration

Seismic energy is generated at the ground surface, and reflected when the interface of zones with different seismic properties are encountered. By recording these reflected waves using geophones, and evaluating the data, the subsurface conditions can be profiled.

Slide 28: Blackhawk GeoServices - Test Layout

Here we see, the array of geophone and source locations marked out on the ground

Slide 29: Blackhawk GeoServices – Geophone

An installed geophone, embedded in the ground

Slide 30 Blackhawk GeoServices - Vibroseis

The seismic source – in this case a vibroseis device which excites the ground over a range of frequencies.

Slide 31 LM Gochioco Impact Hammer

Or in this case, a hydraulic and mechanical impact hammer that strikes a steel plate on the ground.

Slide 32 Blackhawk GeoServices Data Record

And the seismic reflection data being recorded.

Slide 33: Borehole Seismic Tomography Projects

These two projects will demonstrate borehole seismic tomography

Slide 34: Borehole Seismic Tomography Illustration

This method uses guided waves passing through a coal seam, generated in one borehole and measured using geophones or hydrophones in other boreholes.

Slide 35: Blackhawk GeoServices Cased Borehole

This is one of a series of strategically placed cased boreholes.

Slide 36: Blackhawk GeoServices Airgun

Seismic energy is generated with an airgun

Slide 37: Blackhawk GeoServices Geophones

And measured in all of the other boreholes with geophones

Slide 38: Blackhawk GeoServices Data Acquisition

And the data is acquired for processing.

Slide 39: Edgar Mine, Army Tunnel

Colorado School of Mines is doing a similar test in their Edgar Experimental Mine – an old Silver Mine. This mine was used extensively as part of the Korean Tunnel Detection Project and they will use the existing boreholes from the surface.

Slide 40: VSP Illustration

A variation of this method is Vertical Seismic Profiling. In this case, seismic energy is generated at the surface and reflections are measured in a borehole. The advantage here is that recorded waves do not pass through the surface soils which have a tendency to filter out the desired high-frequency component of the record.

Slide 41: VSP Project

This demonstration project is being conducted by LM Gochioco and Associates.

Slide 42: LM Gochioco Hydrophones

Here are the hydrophones being inserted into a cased borehole

Slide 43: LM Gochioco Impulse Hammer

The ground being struck radially at various locations.

Slide 44: LM Gochioco Data Acquisition

And the data being acquired for later processing.

Slide 45: ISS Projects

We sponsored demonstrations involving variations of inseam seismic reflection technology

Penn State is testing at anthracite and bituminous coal mines in pennsylvania and at a trona mine in Wyoming using sources and receivers in the mine.

LM Gochioco will do a similar test at bituminous coal mines in Ohio and Virginia.

Marshall Miller is using a source and receivers at a surface outcrop.

And ***Wright State University*** is attempting to evaluate seismic signals generated by the continuous miner during the mining process by measuring secondary waves at the ground surface.

Slide 46: ISS Illustration

This is a general illustration of tests conducted from within the mine. Seismic energy is generated using a blasting cap or small explosive charge in one location and the reflected signal is measured with geophones in another.

Slide 47: PSU Anthracite Mine

Here are geophones mounted in the coal rib in an anthracite mine.

Slide 48: PSU Trona Mine

And at a Soda Ash Mine.

Slide 49: PSU Data Collection

And the reflected waveforms being recorded.

Slide 50: Marshall Miller Illustration

This is from Marshall Millers project. The source (explosion) and receivers (geophones) are all at the surface outcrop

Slide 51: Marshall Miller Maps

And they are looking in two locations, one for air-filled voids and one at water-filled. They expect good results up to 1000 feet away with a precision of about 30 feet.

Slide 52: Wright State Map

Wright State University is measuring the secondary waves generated at the ground surface by a continuous miner underground, as it approaches an abandoned mine during the regular mining process.

Slide 53 Wright State Layout

Here is the geophone layout

Slide 54 : Wright State 3-Component Geophone

A 3-component geophone embedded in the ground surface

Slide 55: Wright State Data Acquisition

And Professor Hauser doing the data acquisition

Slide 56:Electrical Resistivity Illustration

A more conventional near-surface geophysical method is Electrical Resistivity,

Current is induced within the ground, and the electrical potential between two electrodes is measured along survey lines to determine variations or anomalies in the resistance of subsurface layers which could be indicative of mine voids, at shallow depths.

Slide 57: Electrical Resistivity Project

We are sponsoring one demonstration of this technology.

Slide 58: Lots Branch Aerial

In an area of uncertain mining near a coal seam outcrop around an impoundment.

Slide 59: Electrical Resistivity Photo and Explanation

Here you a survey line of electrodes, with a simple explanation.

Slide 60: TDEM and Radar Illustration

Time Domain Electromagnetics and Radar Methods involves transmitting electromagnetic waves into the ground and measuring those secondary waves that are reflected back as a result of differences in the dielectric, magnetic, and conductive properties in the subsurface.

Slide 61: TDEM and Radar Methods

We are sponsoring two projects using electromagnetic and radar methods

Slide 62: Lot's Branch Aerial

The D'Appolonia demonstration will be at the Lot's Branch Impoundment. The same site as for the electrical resistivity.

Slide 63: TDEM Photo and Explanation

Here is a shot of the transmitter and receivers. With this setup the antennas are laid out on the ground surface. Again with a simple explanation.

Slide 64: Stolar EM Gradiometer Transmitter

Stolar Research Corporation has developed a system called the Electromagnetic Gradiometer where the transmitter…

Slide 65: Stolar EM Gradiometer Receiver

And receivers are moved simultaneously along the ground surface to profile the ground beneath in real-time.

Slide 66:CSM Crosshole Radar

Colorado School of mines will deploy the electromagnetic transmitters and receivers in boreholes in a crosshole tomographic mode.

Slide 67: CSM Edgar Mine

They will again use the existing boreholes at the Edgar Experimental Mine, Army Tunnel and run this demonstration the same way as their crosswell seismic demonstration.

Slide 68: LAR Illustration

A somewhat different approach is to move the transmitter and receivers to the mine face in the look-ahead mode to again detect differences in the dielectric properties of coal and mine voids for a distance of 20 – 70 feet, as a last line of defense against an accidental cut-through.. The ultimate goal would be to have a machine mounted system.

Slide 69: LAR Project

MSHA is sponsoring the development of a hand-held unit, with the hopes that if the technology proves viable, the developer will invest additional funds to make it machine-worthy. They have already developed a similar device for measuring and controlling the mining horizon. Work on this project up to this time has been primarily development and modifying equipment.

Slide 70: MSHA Slide

And that is a very cursory overview of the work that we are doing. If anyone would like additional details, talk to me or Dr. Wu over the next couple of days and we can provide you with any additional information or details which you may want.