




Mine Waste and Geotechnical Engineering Division

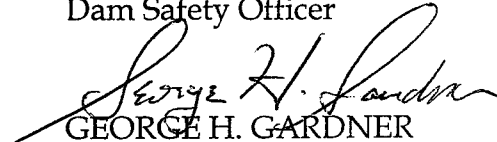
September 21, 2006

MEMORANDUM FOR IRVING McCRAE

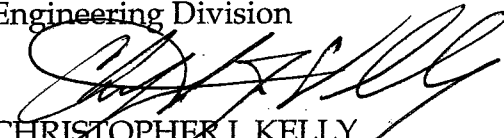
Contracting Officer, Acquisitions Management Division  
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THROUGH:

  
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Dam Safety Officer

  
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FROM:

  
CHRISTOPHER J. KELLY  
Civil Engineer, Mine Waste and Geotechnical  
Engineering Division

SUBJECT:

Summary of Electrical Resistivity Geophysical Void Detection  
Demonstration by D'Appolonia Engineering Division of  
Ground Technology, Incorporated, Mine Void Detection Project  
Account Number B2532538, MSHA RFP No. J53R1011

D'Appolonia Engineering Division of Ground Technology (D'Appolonia) has recently fulfilled their contract to demonstrate the use of electrical resistivity and time domain electromagnetic (TDEM) geophysical methods to detect underground mine voids along the perimeter of a coal waste impoundment. As the Contracting Officer's Technical Representative (COTR) for the electrical resistivity portion of the contract, I was responsible for overseeing the electrical resistivity demonstration on behalf of the Contracting Officer. This work was performed under account number B2532538 in connection with MSHA RFP No. J53R1011. This memorandum is intended to provide a general summary of the electrical resistivity demonstration and a discussion of the final results. The details of the TDEM portion of the contract will be discussed in a separate memorandum.

## DEMONSTRATION SUMMARY

The objective of the electrical resistivity portion of the contract was to demonstrate the use of the electrical resistivity geophysical method to detect the presence of underground mine voids along the perimeter of a coal waste impoundment. Knowledge regarding the location and extent of the voids created by adjacent underground mine workings is critical in evaluating an impoundment's breakthrough potential (i.e., the potential for impounded coal waste slurry or water to break through natural or constructed barriers between the impoundment pool and the mine workings). The electrical resistivity demonstration was conducted at Pine Ridge Coal Company's Lots Branch Impoundment, MSHA I.D. No. 1211-WV04-00020-01, where the Lewiston Coal Seam outcrops on the perimeter of the impoundment and abandoned mine workings in the seam intersect the outcrop in several locations.

The fundamental concept employed by the electrical resistivity geophysical method is that mine voids can be identified by the difference in their response to induced electrical currents relative to that of the surrounding subsurface material. The electrical resistivity method is a surface-based method that involves deploying arrays of electrodes on the surface of the ground above suspected void locations. The effectiveness of the method is influenced by several factors including the size of the voids, the depth of the voids (or the distance of the voids from the electrodes), and the electrical properties of the voids compared to those of the surrounding subsurface material.

Activities performed under the contract included: information gathering and work plan development; electrical resistivity surveys; data analyses; exploratory drilling and mine void imaging; and final report preparation. The project kickoff meeting took place in November 2004. The meeting was followed by information gathering and work plan development. The work plan was submitted in April 2005 and electrical resistivity surveys were conducted in May 2005. Data from the surveys was then analyzed and exploratory drilling and mine void imaging were conducted in September 2005. A draft of the final report was submitted for peer review in January 2006. Review comments were forwarded and the final report was submitted in July 2006.

## DISCUSSION OF RESULTS

The underground mine voids along the perimeter of the Lots Branch Impoundment are the result of abandoned mine workings in the Lewiston Coal Seam. The seam outcrops on the perimeter of the impoundment and workings in the seam intersect the outcrop in several locations. The workings range in size from 4 to 6 feet high and 15 to 25 feet wide. The depth of the surveyed workings ranged from 40 to 60 feet depending on the local topography. Flooded workings represented the best opportunity for detection due to the low resistivity (high conductivity) of acidic mine water. However, according to

the contractor, the possibility also existed for dry workings to be detected based on the conversely high resistivity (low conductivity) of dry coal. Electrical resistivity surveys were performed along the impoundment perimeter and exploratory drilling was used to verify the results of the surveys. The information obtained by drilling was augmented in certain locations by downhole laser imaging performed by Workhorse Technologies, Inc., a subcontractor.

The results of the electrical resistivity demonstration indicate that this method is most effective in detecting relatively shallow mine voids that contain a significant amount of water. Detection of damp or dry voids is possible; however, the results appear to be too subtle to interpret with sufficient confidence for informed decision making. The results also appear to be influenced by large deposits of coal refuse, steep terrain, and elevated levels of heat and humidity in the voids. One notable innovation from the demonstration was the experimental deployment of an electrical resistivity survey line in the actual outcrop of the coal seam. The outcrop survey, which was conducted in an attempt to determine the width of the coal barrier, identified a strong resistive anomaly in an area previously identified as being unmined coal. Subsequent downhole laser imaging of the area identified the anomaly as unmapped mine workings located very near the face of the outcrop. This result suggests that the deployment of electrical resistivity survey lines in the coal seam outcrop may be useful in identifying voids located near the outcrop face.

## CONCLUSION

The effectiveness of the electrical resistivity geophysical method appears to be largely dependent on the particular application. The method appears to be most useful in detecting shallow, flooded mine voids in uncomplicated terrain.

While not a method for detecting voids, the downhole laser imaging performed by Workhorse Technologies, Inc., proved to be an extremely effective tool for increasing the amount of information obtainable from a single borehole. Once a void has been located and accessed with a borehole, downhole laser imaging can be used to determine the dimensions, orientation, and interior condition of the void up to several hundred feet. Use of downhole laser imaging is restricted to air-filled or partially air-filled voids; however, Workhorse Technologies, Inc. also has a very effective downhole sonar imaging technology for use in flooded mine voids which was demonstrated under other void detection demonstration project contracts.

Please contact us at 412-386-4470 or 412-386-6929 if there are any questions regarding this memorandum.

cc: D. Chirdon - General Eng., TS