CREATING NATIONAL COAL MINING GEOSPATIAL DATA STANDARDS

Bill Card[1] L. Keith Evans, Len Meyer

Abstract. Recent history has demonstrated a regrettable, sometimes fatal relationship between mining related disasters and continued use of poor quality paper-based mapping information. Movement from paper to digital geospatial data describing past, present, and proposed coal mining operations will provide significant benefits to government agencies, business interests, and the public when planning land use activities in the northern and southern West Virginia coal fields. Benefits include improved regulation of active coal mining operations, more successful reclamation of abandoned mine lands, better public policy at local, state, and national levels, and potentially saving lives during mining related emergencies. In September 2005, the Office of Surface Mining (OSM) established the National Coal Mining Geospatial Committee (NCMGC) to promote the use of geospatial technology for implementing the Surface Mining Control and Reclamation Act of 1977 (SMCRA). The NCMGC is supported by OSM's Technical Innovation and Professional Services (TIPS) program and operates as a partnership between OSM and the states. Committee members represent the geospatial technology interests of the states, tribes, and OSM offices. SMCRA organizations with representation in the NCMGC include the Interstate Mining Compact Commission (IMCC), National Association of Abandoned Mine Lands Programs (NAAMLP), and the Western Interstate Energy Board (WIEB). In June 2006, the NCMGC hosted the first National Meeting of SMCRA Geospatial Data Stewards in Denver, CO. Each steward is designated by each his or her state/tribe regulatory and/or AML program to represent their geospatial technology interests and provide national coordination. Meeting accomplishments included identifying local needs for advancing the use of geospatial data; identifying goals within organizations to obtain and use geospatial data; and identifying NCMGC activities at a national level to advance the use of geospatial technology in SMCRA organizations. The stewards approved a recommendation from NCMGC to develop the first two national coal mining data layers: surface coal mining boundaries and underground coal mining boundaries. The stewards also approved the formation of a work group, the Coal Mining Spatial Data Standards ASTM Task Group, to develop voluntary standards for the initial two layers. Paralleling development of the first two data standards in time, the NCMGC began work on a coal mining spatial data infrastructure to manage selected coal mining datasets shared by each participating state/tribe. This infrastructure will assemble these data into national datasets for use in SMCRA business processes and distribution to the nation.

Additional Key Words: landuse, coal mining, surface coal mining, underground coal mining, spatial data, mining fatality

---

[1]Bill Card is GIS Coordinator at U.S. Department of the Interior's Office of Surface Mining in Knoxville, TN, 37902. L. Keith Evans is the Manager of TAGIS Unit, Information Technology Office at the West Virginia Department of Environmental Protection in Charleston, WV, 25703. Len Meier is Chief of Program and Technology Support Branch, U.S Department of the Interior's Office of Surface Mining in Alton, IL, 37902.

Introduction

The Mine Improvement and New Emergency Response Act of 2006, also known as the MINER Act, was signed by President George W. Bush on June 15, 2006. This legislation was called by MHSA *"the most significant mine safety legislation in 30 years, amends the Mine Safety and Health Act of 1977 and contains a number of provisions to improve safety and health in America's mines."*

While the MINER Act is significant mine safety legislation, it failed to consider the role played in recent mining disasters by inaccurate paper maps. This situation represents a complete disconnect between the new legislation and a major factor leading to recent mining related disasters.

Role of inaccurate paper maps in recent mining disasters

The information that follows was compiled to demonstrate the irrefutable cause-and-effect relationship between dependency on inaccurate mapping and limited survey control in recent national mining disasters. In some instances inaccurate mapping was a direct cause of an emergency. On other occasions it was a significant impediment to rescue operations. Survey control could likewise be characterized as both cause of an incident and as impeding rescue operations.

Martin County, Kentucky slurry impoundment failure

On Oct. 11, 2000 the nation's largest coal slurry spill occurred at the Martin County Coal Company in Inez, Kentucky. The EPA called the Inez spill the worst environmental catastrophe in the history of the Eastern United States. Far more extensive in damage than the widely known 1989 Exxon Valdez oil spill off the coast of Alaska, the Martin County Coal slurry spill dumped an estimated 306 million gallons of toxic sludge down 100 miles of waterways. The MHSA report issued October 17, 2001 points to inaccurate mapping as the principal cause of this environmental disaster.

"The investigation of the spill shows that ***the protective barrier between an underground mine and the Martin County coal-waste impoundment was far thinner than regulators thought****.* ***Map information*** *Martin County Coal Co. gave the state in seeking a permit to expand the impoundment* ***showed*** *a barrier of about 70 feet (21 m) between the bottom of the impoundment and the mine. However, … the* ***barrier was*** *apparently* ***less than 10 feet*** *(3 m) thick."*

Quecreek Pennsylvania mining accident

During the emergency the primary mechanism for working with maps was paper (Figure 1 below). In our digital information age, dependence on paper maps that have no way to be easily tested against other mapping information to check for inaccuracies impedes the rescue effort and could cause unnecessary fatalities.

Figure 1: Governor of Pennsylvania et. al. study a paper map during Quecreek rescue.

Fortunately for the nine men involved, everyone remembers Quecreek because of the rescue effort was successful. The perception is that paper maps saved the day allowing rescuers to accurately locate and drill the rescue shaft used to free the trapped men. Unfortunately for workers trapped after Quecreek, most people never learned or quickly forgot why the Pennsylvania mine became inundated July 24, 2002.

The United States Mine Safety and Health Administration issued a report July 24, 2006 citing faulty maps as a cause for the Quecreek Mine disaster in June 2002, trapping nine miners for 4 days. According to the MHSA's Quecreek accident report, *"The primary cause of the water inundation was the use of an undated and uncertified mine map of the Harrison No.2 mine. "* See also Faulty Maps to Blame for Quecreek Mine Disaster. The MSHA report states *"The root cause of the accident was the unavailability of a certified final mine map for Harrison No.2 mine in the State of Pennsylvania's mine map repository."* While that is certainly true, the lack of any ability to see "Harrison No.2 mine workings overlaid on the Quecreek #1 mine map" more accurately describes the limitations of operating with paper that really created the situation at Quecreek.

Requirements for survey ground control in Pennsylvania prior to Quecreek were basically similar to what the authors believe exists today in most coal mining states. Underground maps are referenced to a group of ground control points typically clustered together near the face up of the mine. As a result of delays encountered in surveying the location to drill a rescue shaft during the successful Quecreek rescue, Pennsylvania passed reform legislation requiring survey control at one mile intervals along the axis of active underground mining operations. The lack of similar legislation in West Virginia impacted attempts to rescue miners trapped in the Sago mine approximately three and a half years later.

Sago Disaster

March 14, 2006 International Coal Group's press release proposed lightning as the source of the energy for ignition at Sago. Potential paths for the electricity into the sealed area were listed including … *"through the gas well casing and through the ground, or through the network of gas well lines on the surface and into the ground."* While this mechanism for ignition at Sago remains unconfirmed, this potential of this being the cause of this incident underlines the importance of having all oil and gas well casings and pipelines in the vicinity of coal mining operations located with a high degree of accuracy. Likewise, oil and gas exploration and transmission workers need to know when their activities may be impacted by surface or subsurface mining activities and its associated infrastructure. With the increasing national demand for energy, it is a certainty that buffering distances between these two industries' field operations will diminish over time.

Black Castle Strip Mine Fatality

On February 1, 2006, a bulldozer operator was killed at the Elk Run Coal Co.'s Black Castle strip mine in Drawdy, WV (Figure 2 below). The 58-year old bulldozer operator with 15 years experience was fatally injured due to an ignition of natural gas. As the bulldozer operator was developing a drill bench, the blade of the machine contacted and ruptured a 16-inch low-pressure, high-volume natural gas line which immediately burst into flames.

Figure 2: February 1, 2006 Boone County, WV a front-end loader operator was killed removing material above a coal seam when his loader bucket penetrated a buried 20" high pressure natural gas transmission line.

In the **DESCRIPTION OF THE ACCIDENT** section of MHSA's report about the fatal accident, the statement is made that *"Vira told Moss to stay 100 feet away from the gas line. Neither Vira nor Moss knew the exact location of the gas line."* Clearly lack of knowledge of the precise location of the pipe line was the primary cause of this mining fatality.

It is important to note that this death had no relationship whatsoever to OSM's federal mining industry oversight partner MSHA.

Aracoma Disaster

A June 17, 2006 article written by Dennis B. Roddy and Steve Twedt in Pittsburgh's Post-Gazette brought to light mapping issues with attempted rescue activities at Aracoma Coal Co.'s Alma No. 1 Mine after the Jan. 19th accident that claimed the lives of two West Virginia miners. Ellery Hatfield and Donald I. Bragg became lost in the dense smoke and suffocated. In testimony given to an attorney representing the widow of Mr. Hatfield, Timmy Paul Morgan gave a statement that rescue team members complained that the map they were given to search for the missing men was inaccurate, showing doors and stoppings in places they did not exist. While inaccurate mapping was not a factor in causing this tragedy, the rescue operation was clearly impeded by poor geospatial information and the continued use of last century's technology for locational information analysis, paper maps.

The Office of Surface Mining (OSM) and the state and tribal coal mining regulatory authorities (SRAs) implementing the Surface Mining Control and Reclamation Act of 1977 (SMCRA) regularly make decisions and perform actions in controlling the potential environmental impacts of surface coal mining operations. The majority of these actions consider the proximity of the proposed or existing coal mining operation to potentially affected adjacent areas and resources. Historically, these regulatory actions have been supported through the use of paper maps containing geographic features describing the coal mining operation and adjacent areas of interest.

Since 1988, the Technical Innovation and Professional Services (TIPS) program of OSM has promoted the use of Commercial-off-the-Shelf (COTS) computer software applications by the SRAs to model the potential impacts of coal mining operations. In recent years, these scientific software applications allowed coal mining features shown on mining operations maps to be converted (automated) to digital format for use in computer mapping applications. The resulting digital geospatial features can now be stored in standardized geographic databases for reuse in multiple ways. For many reasons, efforts have been in progress within individual SRAs to digitally acquire and use coal mining geospatial features in many of their SMCRA business processes.

In 2005, OSM initiated a new national effort to promote the standardized use of geospatial technology within the entire SMCRA community (Card and Meier, 2007),

National Coordination of Coal Mining Geospatial Activities

At the TIPS Steering Committee meeting held in St. Louis on May 3-5, 2005, the TIPS Steering Committee and OSM Director Jeff Jarrett concurred on the formation of a National Coal Mining Geospatial Committee (NCMGC). The NCMGC was established in late FY 2005 to promote the use of geospatial technology for implementing SMCRA. The NCMGC is supported by TIPS and operates as a partnership between OSM and the states authorized to implement SMCRA.

Committee members represent the geospatial technology interests of the states, tribes, and OSM offices. SMCRA organizations with representation in the NCMGC include the Interstate Mining Compact Commission (IMCC), National Association of Abandoned Mine Lands Programs (NAAMLP), and the Western Interstate Energy Board (WIEB).
The NCMGC will develop a national strategy for implementing and promoting the use of geospatial technology within the SMCRA community; provide solutions to problems affecting implementation of enterprise Geographic Information System (GIS) within OSM; and identify geospatial activities, policies, standards, and products that will increase the effectiveness and efficiencies of organizations working on SMCRA-related projects on a national scale. The committee will assess the need for geospatial resources to support all regulatory aspects of mining and reclamation activities and the availability of geospatial information, systems, and expertise. The committee will evaluate the gap between the requirements, information holdings, system capabilities and expertise; identify critical geospatial tools and services for federal, state, and tribal managers and staff; facilitate improved interoperability and sharing of geospatial resources; and will help to coordinate federal geospatial resources and initiatives relevant to national requirements.

Specifically, the committee will examine SMCRA business processes for application of geospatial technology, and facilitate sharing of geospatial technologies to support implementation of SMCRA. The committee will recommend guidance in reengineering business processes across the SMCRA community to gain efficiency and benefit from today's geospatial automation technology. The overall objective of the committee is to ensure that scientifically sound geospatial data, spatial information products, technology applications, and services are provided in an efficient and cost effective manner to the SMCRA user community for use in minimizing risk and improving regulatory decision-making relevant to surface coal mining and reclamation operations.

NCMGC Accomplishments in FY 2006

The FY 2006 accomplishments include holding the first meeting to plan work activities; determining geospatial technology development status among all SMCRA organizations; establishing a Geospatial Data Steward within each SMCRA organization; conducting the first National Meeting of SMCRA Geospatial Data Stewards; identifying geospatial technology development needs of SMCRA organizations for FY 2007; establishing a Coal Mining Spatial Data Standards ASTM Task Group from Geospatial Data Stewards offering to help develop voluntary standards for exchanging coal mining spatial data; conducting the first meeting of this task group at ASTM headquarters; obtaining vendor software training for a few qualified Geospatial Data Stewards in managing coal mining geospatial data in an enterprise environment; and successful first steps in a "proof of concept" effort to develop a geospatial infrastructure to exchange selected coal mining spatial datasets between two networked servers inside OSM's Wide Area Network (WAN). These activities of the NCMGC support the goals of the President's Management Agenda in the expansion of e-Government to reduce redundancy; facilitate horizontal (cross-federal) and vertical (federal, state and local) information sharing; establish a direct relationship between IT and mission/program performance to support citizen-centered,

customer-focused government; and maximize IT investments to better achieve mission outcomes.

NCMGC Activities Planned in FY 2007

In FY 2007, the NCMGC will continue efforts to promote the use of geospatial technology to meet the business needs of SMCRA organizations. Activities anticipated in FY 2007 include a planning meeting to review and implement recommendations from the first National Meeting of SMCRA Geospatial Data Stewards; briefings to OSM management and SMCRA organizations on the accomplishments and progress of the NCMGC in its activities; holding three meetings of the Coal Mining Spatial Data Standards ASTM Task Group to develop voluntary spatial data standards for the first two coal mining spatial data sets of national interest: surface coal mining boundaries and underground coal mining boundaries; sending additional qualified personnel to attend vendor software training in managing coal mining geospatial data in an enterprise environment; continuing development work on a geospatial infrastructure to exchange selected coal mining spatial datasets among networked servers outside OSM's WAN; recruiting state regulatory programs to participate in this geospatial infrastructure; conducting an outreach program by giving presentations about NCMGC activities at national meetings of SMCRA organizations; exploring participation with the Mine Safety and Health Administration (MSHA); and establishing a planning sub-committee to begin preparations for an FY 08 National Meeting of SMCRA Geospatial Data Stewards with a theme of "Integrating GIS into SMCRA Business Processes".

Establishing Geospatial Data Stewards

The NCMGC hosted the first National Meeting of SMCRA Geospatial Data Stewards at the Warwick Hotel in Denver, CO on June 27-28, 2006. Benny R. Wampler, Deputy Director of the Virginia Department of Mines, Minerals, and Energy, delivered the keynote address on "Coal Mining Datasets of National Significance".

During this two-day meeting attended by 44 participants, geospatial data stewards from 18 approved state regulatory programs and 7 OSM offices worked through issues affecting the coal mining spatial data interests of their respective offices. Topics discussed during the meeting included promoting the use of geospatial data in coal mining, results of a recent geospatial technology development questionnaire distributed among SMCRA programs, establishing voluntary standards for coal mining geospatial data, working with the coal industry to exchange coal mining spatial data, activities and accomplishments of the NCMGC in FY 06, establishing an electronic infrastructure to share coal mining geospatial data, and vendor software training for highly specialized SRA staff.

The geospatial data stewards participated in a live panel discussion on the first day of the meeting and a business networking session on the second day. During the business networking session, geospatial data stewards first identified needs, goals, and expectations and then established

priorities. Working with the geospatial data stewards were representatives from the MSHA, Peabody Western Coal Company, Environmental Systems Research Institute (ESRI), and the American Society of Testing Materials (ASTM) International. More information about the meeting can be found at http://www.tips.osmre.gov/NCMGC/NCMGC_Meeting_2006.asp .

Developing Coal Mining Spatial Data Standards

At the National Meeting of SMCRA Geospatial Data Stewards, the NCMGC announced plans and requested volunteers to develop voluntary standards for the exchange of coal mining spatial data among the states, tribes, OSM offices, coal mining industry, and the public. Developing these standards will help advance the use of geospatial technology for implementing SMCRA.

On August 2, initial selections from among the volunteers were made to establish the Coal Mining Spatial Data Standards ASTM Task Group. The task group consists of representatives from the state regulatory programs, OSM offices, the Mine Safety and Health Administration (MSHA), coal industry (National Mining Association), and the general public.

Daniel Kestner and Tom Galya will co-chair the task group and provide coordination and leadership. Joe Ritchey, a qualified professional facilitator knowledgeable and experienced in development of voluntary standards under American Society of Testing Materials (ASTM) guidelines, will provide technical support. Julie Maitra will provide coordination with the Federal Geographic Data Committee (FGDC) as the task group works on establishing an ASTM standard. Current members of the Coal Mining Spatial Data Standards ASTM Task Group are listed in Table 1 below.

Name	State/OSM Affiliation
Alan Wilhelm	OSM, Western Region Office
Arielle Feitelson	OSM Appalachian Region Office
Bruce Johnson	North Dakota Public Service Commission
Daniel Kestner (Co-chair)	Virginia Department of Mines, Minerals and Energy
Darrell Trent	Peabody Coal Company
Jo Gault	OSM, Knoxville Field Office
Joe Ritchey (Facilitator)	ASTM International
Kathy Rossmann	Ohio Division of Mineral Resources Management
Mike Shank	West Virginia Department of Environmental Protection
Robert Hughes	Luzerne (PA) Conservation District
Sandin Phillipson	Mine Safety and Health Administration

Tom Galya (Co-chair)	OSM, Charleston Field Office

Table 1: Members of the Coal Mining Spatial Data Standards ASTM Task Group.

The first task group meeting was held September 20-21, 2006 at ASTM International Headquarters near Philadelphia, PA. At this meeting, group members learned how the ASTM methodology works for developing voluntary national standards for geospatial data. The task group began the process to develop standards for the first two national coal mining spatial data sets – surface coal mining boundaries and underground coal mining boundaries – which will be assembled and periodically updated from existing data sets already in use within each of the various regulatory programs in differing formats. The task group also began to identify and work on many issues to define the content, scope, geometry, attributes, and other characteristics of these first two national coal mining spatial data sets.

When voluntary standards have been established for these first two coal mining spatial data sets, review and comment will be requested from all interested parties. As requirements are met for establishing ASTM standards for these two spatial data sets, requirements to establish FGDC standards will also be accomplished.

In FY 07, three additional team meetings are planned for various locations in the U.S to continue work on this task. Meetings are planned for Costa Mesa, CA on January 30, Newport, VA in June, and Salt Lake City, UT in September. In future years, development of additional national layers of coal mining spatial data will be considered. These additional layers may include geologic sampling locations and their chemical attributes, surface- and ground-water sampling locations and their associated water quality attributes, bond release areas, abandoned mined land areas, or other data layers determined by the task group to be of national interest.

Creating a Coal Mining Spatial Data Infrastructure

Following the National Meeting of SMCRA Geospatial Data Stewards, OSM began internal discussions to determine how to develop a coal mining geospatial infrastructure to collect, store, manage, use, and distribute selected coal mining spatial data from among all participating SMCRA organizations. At the SRA level, two elements are critical to implementation. First, SMCRA Geospatial Data Stewards must adopt the data standards developed by the Coal Mining Spatial Data Standards ASTM Task Group and apply them to applicable coal mining spatial data used within their respective SMCRA organizations. Second, the SMCRA Geospatial Data Stewards must use a Relational Database Management System (RDBMS) such as Microsoft SQL Server or Oracle to store their data and also manage it with a spatial data management system such as ESRI's ArcSDE.

Through read-only access to selected coal mining spatial data in the SMCRA organization's ArcSDE geodatabase, an automated process from a centralized server within OSM's Wide Area Network (WAN) will download the selected spatial data, re-project the data from a local coordinate system to a national coordinate system and perform other data adjustments as may be required, and aggregate it with data from other SMCRA organizations into a single national

dataset for each selected theme. By using an automated process, no resource requirements will be imposed by OSM on participating SMCRA organizations to collect, process, or upload "stale" coal mining spatial data to OSM, and resource requirements on OSM will be minimized. Coal mining spatial data uploaded through the automated process will be the highest quality, most reliable, and latest available data from the authoritative data source, the SMCRA organization creating and managing the data on a daily basis for their respective area. In this manner, selected coal mining spatial data from all participating SMCRA organizations will be combined to form national datasets appropriate for internal use by OSM and for distribution to the public via Internet map server applications and/or data services to Geospatial One Stop (GOS), the National Map, and other means as appropriate without additional human resource commitments by the participating SMCRA organizations.

Many problems will need to be overcome during development of a national coal mining spatial data infrastructure. Potential problems include but are not limited to inability of small SRA programs to adequately participate due to resource issues; possible resistance to participation by SRA's; state and federal mandated Information Technology (IT) requirements adversely affecting infrastructure development; IT security issues; unanticipated difficulties within OSM in collecting, managing, and developing applications for national datasets; spatial data metadata documentation; stewardship of authoritative spatial data; data liability and confidentiality concerns; and funding for infrastructure development. All of these problems appear to have manageable solutions.

An initial meeting of the Coal Mining Spatial Data Infrastructure team on June 29 and teleconferences of September 5 and November 7 provided opportunities for team members to identify issues, discuss possible solutions, and develop plans to prototype a spatial data infrastructure. An implementation plan consisting of two phases was selected. In Phase 1, a "proof-of-concept" pilot project to exchange coal mining spatial data between at least two ArcSDE servers at remote locations within OSM's WAN would be attempted. In Phase 2, a similar effort would be made to exchange selected coal mining spatial data between an ArcSDE server inside OSM's WAN and one or more ArcSDE servers located outside the OSM WAN at a SRA.

The Phase 1 attempt was successfully conducted on August 3. Prior to this attempt, a user account with read-only permission was established on an ArcSDE server located at an OSM office in Knoxville, TN to allow access through the Internet from another ArcSDE server located at an OSM office in Denver, CO. In Phase 1, a GIS specialist in Denver manually executed a script written in ArcGIS Model Builder to automate the entire process of logging onto the ArcSDE servers in Knoxville and Denver from a workstation, downloading previously selected data from both servers, closing connections, reprojecting four datasets from different coordinate systems to a single national coordinate system, and merging them into a single dataset. In this test, 891 surface coal mining polygon boundaries and attributes of Tennessee were combined with 8 surface coal mining polygon boundaries and attributes representing 4 surface coal mining operations located on Indian tribal lands in Arizona and New Mexico. This entire process required less than a minute for completion.

Prior to attempting Phase 2, numerous requirements must be met. In Phase 2, GIS personnel within selected SMCRA organizations will be contacted to allow access and downloading of selected coal mining spatial data located on ArcSDE servers within state organizations operating outside OSM's WAN. OSM may be required to establish interconnection agreements with the SMCRA organizations, provide business plan documentation to OSM's Chief Information Officer (CIO), and adequately address potential issues relative to security. An automation procedure similar to that used in Phase 1 will be employed. New technologies, such as ESRI's Data Interoperability Kit, Feature Manipulation Engine, and ArcGIS Server 9.2 will be evaluated. Phase 2 is planned for May of 2007.

Using Coal Mining Geospatial Data

Within the various SMCRA organizations, managers have struggled with demands to modernize business processes, improve efficiency, and produce higher quality work products in a budget-constrained environment with limited resources. A key factor affecting these demands is the high but hidden cost of managing paper information products such as narrative reports, tables of environmental data, and maps. Historically, SMCRA organizations have required that mining companies provide these information products with every permit action involving considerable quantities of paper at great expense in order to conduct analyses supporting regulatory decisions affecting surface coal mining operations. Extracting features shown on coal mining operation maps with their associated attributes for storage and management in a Geographic Information System (GIS) allows access, analysis, and reuse of this data by modern software applications. This is a significant technological advancement in processing data contained in the information product most resistant to conversion to "intelligent data" – paper maps. With this development, opportunities now exist for re-engineering SMCRA business processes to employ automation to improve efficiency, and use of scientific software mapping applications to conduct better analyses resulting in higher quality work products.
In the modern SRA working environment, a spatial data infrastructure which uses data storage structures in a client-server architecture will promote acquisition of new spatial data from the mining industry in a digital format; aid in conversion of existing paper-based maps to digital format through scanning and digitizing; support the business processes of the organization through the use of scientific software to display, query, and map coal mining spatial data at desktop workstations; provide spatial data for use by mobile computing devices equipped with Global Positioning System (GPS) technology at coal mining operations; support Electronic Permitting (EP) initiatives; and establish a foundation for On-Line Analytical Processing (OLAP). OLAP allows users to query summarized, multidimensional data; apply relevant business logic; retrieve information; and produce fast, consistent, and accurate information products that support decision-making in applications without manual data manipulation. A brief description of how OLAP applies to geospatial data can be found on-line at http://www.esri.com/news/arcuser/0206/olap1of2.html.

For many reasons, SMCRA organizations will require coal mining spatial data infrastructures which support the present operational needs of their organizations and provide an adequate foundation to meet future challenges. At the SRA, these infrastructures will be used in the

management of day-to-day activities related to technical review of coal mining permit applications and inspection of coal mining operations. At OSM, coal mining spatial data collected from SRA infrastructures and aggregated into national datasets will be used to help implement the nation's coal mining laws and regulations, promote better understanding of the potential impacts of surface coal mining operations, detect and identify problems, and provide new opportunities in the assignment of resources to resolve potential environmental issues.

These national datasets may consist of coal mining features such as surface coal mining boundaries, underground coal mining boundaries, coal haul roads, critical earth fill structures, sediment basins, geologic drill holes, surface- and groundwater monitoring locations, and other coal mining features determined to be of national interest. Sharing and using these datasets nationally provides access to valuable natural resource information otherwise stored in paper files within the various SRA program offices and subject to future loss. OSM intends to make these national coal mining spatial datasets available to the public through Internet mapping services, registration with Geospatial One Stop (GOS), publication on the National Map, and other media as appropriate.

Benefits to the Nation

Digital geospatial data describing past, present, and proposed coal mining operations can provide significant benefits to government agencies, business interests, and the public when planning land use activities in coal-bearing areas of the nation. These benefits will include improved regulation of active coal mining operations, more successful reclamation of abandoned mine lands, and better public policy at local, state, and national levels.

Improved Regulation of Active Coal Mining Operations

Aggregation of SRA coal mining spatial datasets into a small collection of coal mining spatial data themes of national significance provides an opportunity for OSM to use these new data sources to better understand and more efficiently work with individual SRA's on issues of local importance. For the first time, OSM will have near real-time access to coal mining spatial data accurately describing location, boundaries, spatial extent, and important attributes of significant coal mining features of all coal mining operations in the United States. These data can be used to enhance OSM's administrative capabilities by being able to locate, identify, and conduct reviews of permitted coal mining operations. Information products derived from this data can be used to help determine and verify on a state, regional, or national basis acres under permit and acres reclaimed in various phases of bond release: support or replace current methods of obtaining information for OSM's Annual Report; and answer other "state of the land regarding SMCRA" questions in near real-time.

Creation and use of national coal mining spatial datasets by OSM will support better cooperative efforts among government organizations working in new ways such as regional hydrologic investigations of subterranean water flow among interconnected underground coal mine workings, studies of potential mine blowout locations, acid mine drainage, and underground subsidence planning and investigation. Use of these data to support traditional "oversight

inspections" conducted by OSM of state regulatory activities may result in reallocation of human resources by OSM from random inspections to focus on geographically-defined "problem areas" to help SRA's better implement SMCRA.

More Successful Reclamation of Abandoned Mine Lands

SMCRA organizations manage the reclamation of lands mined for coal and abandoned prior to passage of the Act through funding provided by OSM. When reclaimed, these lands support higher and better land uses. However, certain types of reclaimed coal mine features present limitations to future land uses. These include former coal refuse piles, mine spoil areas, slurry impoundments, and underground coal mines with a high potential for subsidence.

Reclaimed coal refuse piles, mine spoil areas, and slurry impoundments should not be built upon for many years unless special construction methods are used. During reclamation, these materials may be covered by only two to four feet of earth to provide adequate depth for plant growth. Reclaimed coal mining areas may be difficult for the public to recognize without prior training or experience. These coal mining areas will continue consolidating over time and may be structurally unstable without earth compaction methods.

In home and building construction, excavations for basements and foundations may also expose toxic and acidic coal mine wastes resulting in loss of reclamation and construction damage. Structures built in these areas may also be susceptible to accumulation of CO_2 and other coal mine gases. If basements and crawl spaces are excavated into recently mined and reclaimed mine spoil, CO_2 may fill the completed structure to concentrations which can cause injury or death to the occupants if not properly ventilated. Abandoned underground coal mines near the surface may be susceptible to subsidence, causing very serious structural damage as room-and-pillar mining areas collapse many years after abandonment. The OSM AML inventory only identifies areas where abandoned mines have already subsided, causing damage to existing structures, and not those locations in which abandoned coal mines may yet subside in the future. Prior public knowledge of the location of former coal mining areas is required to adequately plan for construction in these areas and address potential problems.

Better Public Availability of Coal Mining Spatial Data

Dissemination of coal mining spatial data to the nation provides opportunities for others outside the SMCRA community to benefit from state and federal coal mining spatial data resources. In the future, these data may help inform the public about the extent and potential impacts of existing and proposed surface and underground coal mining operations, reduce the amount of new construction on abandoned mine sites, help reduce the growth of the AML inventory by public awareness of the location of abandoned coal mines, support MSHA responses to underground coal mine emergencies, assist the USGS in their efforts to estimate remaining coal reserves (Tewalt et al., 2001), help update surface land use and geologic information for improved environmental impact assessments, and enhance the utility and relevance of the approximately 134,000 underground mine map images contained in the National Mine Map Repository managed by OSM by providing a "geographic footprint" which can be used as a spatial index to the location of the map image.

Recent legislation in Virginia may someday be perceived as the first State initiative tying mining activities to Community Right to Know. In 2006 the Commonwealth passed House Bill 1562 requiring that, for the sale of new dwellings the builder or owner (if the builder is not the owner), must disclose to the purchaser whether the builder or owner has any knowledge of (i) whether mining operations had previously been conducted on the property or (ii) the presence of abandoned mines, shafts, or pits.

Acknowledgements

The activities described in this paper could not have been accomplished without the supporting efforts of the 42 SMCRA Geospatial Data Stewards in various SMCRA organizations of the United States, members of the NCMGC, Coal Mining Spatial Data Standards ASTM Task Group, Coal Mining Spatial Data Infrastructure Team, and OSM senior management. Funding for all geospatial activities of the NCMGC is provided by OSM's Technical Innovation and Professional Services (TIPS) program.

Literature Cited

Card, Bill and Meier, Len, 2007, National Meeting of the American Society of Mining and Reclamation, 30 Years of SMCRA and Beyond, June 2-7, Gillette WY Barnhisel (ed) published by ASMR, 3134 Montavesta Rd., Lexington, KY 40502.

Meier, L.M. 2006. National Coal Mining Geospatial Committee and AML Reclamation Programs: Digital Data to Reduce the AML Inventory and Protect the Public. *In* Proc. 2006 National Association of Abandoned Mine Land Programs 28th Annual Conference, (Billings, MT, Sept. 25-27, 2006) Montana Department of Environmental Quality, Remediation Division, Helena.

Tewalt, S.J., Ruppert, L.F., Bragg, L.J., Carlton, R.W., Brezinski, D.K., Wallack, R.N., and Butler, D.T., 2001, Chapter C—A digital resource model of the Upper Pennsylvanian Pittsburgh coal bed, Monongahela Group, northern Appalachian Basin coal region. *In* Northern and Central Appalachian Basin Coal Regions Assessment Team, 2000 resource assessment of selected coal beds and zones in the northern and central Appalachian Basin coal regions: U.S. Geological Survey Professional Paper 1625–C, CD-ROM, version 1.0.