OSM SERVICE SHARES TECHNOLOGY NATIONWIDE[1]

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TIPS –Technical Innovation and Professional Services – Brings advanced scientific and engineering capabilities to coal regulatory and reclamation agencies

Abstract. The U.S. Office of Surface Mining's Technical Innovation, and Professional Services (TIPS) is a service developed by an innovative group of employees at the Office of Surface Mining. In cooperation with State and Tribal regulatory and reclamation agencies, as well as Office of Surface Mining offices nationwide, TIPS provides the latest off-the-shelf scientific and engineering software and hardware tools for Federal, State, and Tribal experts to do their job faster and more efficiently. Since its inception in 1988, it has expanded to serve 700 desktops at 96 locations nationwide.

The tools provided consist of off-the-shelf software and technology used commonly for scientific and engineering applications by the Mining Industry. With the Industry regulators at the State and Federal level using the very same tools, exchange of information is facilitated and the regulatory and reclamation processes are expedited. Through a system of license sharing TIPS is able to provide expensive software to 700 desktops nationwide at the cost of only a few licenses. By making the technology tools available to more people directly at their desktop, usage has grown from 56 licenses in use each business day in 2001 to more than 85 licenses used each business day in 2002. TIPS also provides full, no-cost training to its customers at three training centers in Pittsburgh, PA; Alton, IL; and Denver, CO.

Additional Key Words: Remote sensing, site planning, environmental design, site inventory, site analysis, GPS, GIS, photogrammetry, aerial photography, satellite imagery, LIDAR.

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[1]Paper was presented at the 2003 National Meeting of the American Society of Mining and Reclamation and the 9th Billings Land Reclamation Symposium, Billings MT, June 3-6, 2003. Published by ASMR, 3134 Montavesta Rd., Lexington, KY 40502.

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Proceedings America Society of Mining and Reclamation, 2003 pp 311-324
DOI: 10.21000/JASMR03010311

https://doi.org/10.21000/JASMR03010311

Manuscript

A lone airplane soars steadily over a Pennsylvania coalfield. A beam of invisible laser-light scans the terrain below sculpting an exact replica of the mine topography in digital form.

A group of Hopi Indians on horseback traverses sandstone canyons near a coal mine in Northeastern Arizona. They carry backpacks with Global Positioning System devices that receive signals off satellites 1,100 miles overhead to map their exact location.

Both of these cases have something in common. They are using technology provided by the Office of Surface Mining's Technical Innovation and Professional Services (TIPS) Team.

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Interior's Office of Surface Mining regulates coal mining and helps to reclaim land devastated by past mining. The agency also provides funding and oversight for State and Tribal agencies to carry out the mandates of the Surface Mining Control and Reclamation Act of 1977. In the mid 1980's, many of these agencies were requesting funds to buy computer equipment and software to help evaluate coal mining and reclamation issues. A few far-sighted individuals at the Office of Surface Mining saw this as an opportunity – an opportunity to ensure that every coal-regulatory and reclamation agency was using the same tools to conduct their technical business. This was especially valuable to some smaller agencies that could not afford such technology. With the same tools these agencies would be able to exchange critical technical data, and the Surface Mining Control and Reclamation Act would be administered more uniformly nationwide. It also allowed for a large federal purchase of equipment, resulting in considerable cost savings. The result was the formation of TIPS in 1988.

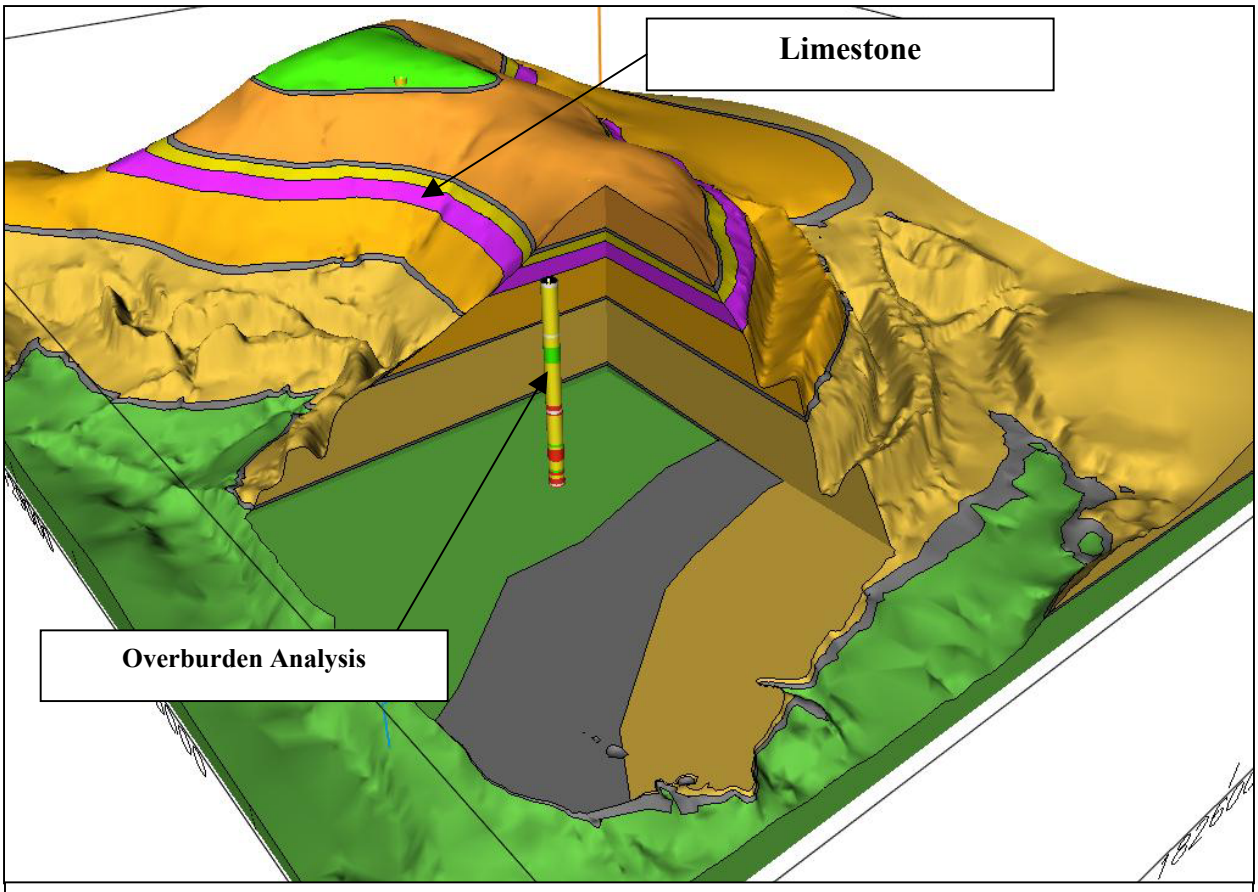

Figure 1. The Pennsylvania Department of Environmental Protection used earthVision modeling software from TIPS to help clean up acid mine drainage from this area near the Dent's Run watershed in rural Northern Pennsylvania. Not published.

The service evolves with the technology

When TIPS began, it consisted of a single 386 DOS-based computer with modem, digitizer, plotter, and printer with scientific modeling software shared at a central location in each of 28 office locations in 24 states. Over the years, this setup has now grown to advanced scientific and engineering modeling software available to all regulatory and reclamation staff directly at their desktop computers at 96 office locations nationwide. Scientists and engineers use 20 different modeling and analytical software programs from such companies as ESRI, AutoDesk, Dynamic Graphics, and Carlson Software to create maps, calculate material volumes, predict subsidence and water pollution, evaluate statistics, model ground-water, and even create three-dimensional images of mining effects below the earth's surface (An example of subsurface modeling by a TIPS customer is shown in Figure 1). A system of license sharing developed in cooperation with

each software developer allows TIPS to distribute costly scientific and engineering applications to 700 desktops nationwide at a fraction of the cost of buying individual licenses for each user. This kind of innovation allows TIPS to provide more technical tools to more of the technical specialists that need them.

TIPS Core Software	
ArcGIS and Extensions (GIS)	**AquaChem** (Water-quality analysis)
AQTESOLV (Analysis of aquifer data)	**ArcView** (GIS)
AutoCAD/AutoDesk Map (Computer-aided drafting)	**Blast Log Evaluation Program** (Blasting analysis)
EarthVision (Create 3-D earth models)	**ERDAS** (remote-sensing analysis software)
Galena (Slope stability analysis)	**GMS** (Ground-water modeling system)
Geochemist's Workbench (Water-quality analysis)	**Groundwater Vistas** (Ground-water modeling)
Planimeter (Calculate acreage from maps)	**HEC-RAS** (Surface-water modeling)
StatGraphics (Statistical analysis)	**Pathfinder Office** (GPS)
Surface Deformation Prediction System (Subsidence modeling)	**SEDCAD** (Surface-water modeling)
StratiFact (Correlate lithology from drill holes)	**SurvCADD** (Mapping and 3-D modeling)

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Training is the most sought after commodity

Technology tools are not the only commodities provided by TIPS. TIPS also provides expert support and a full schedule of training classes for each of the software programs. Team members develop custom classes in each software application. They draw from real-life mining examples and their own experience to tailor the training to the type of work the students will be doing after class is over. This customized training for coal regulatory and reclamation customers is much more cost effective than general vendor-provided training.

"The people are what really make TIPS unique," says TIPS Chief Billie Clark from his office in Denver. "Sure we have some computer specialists, and their contribution is critical to our success, but the majority of the team are scientists and engineers that knew the regulatory and reclamation work before TIPS even started. They knew the issues that the technology could

solve, and therefore how to apply the technology. They made TIPS effective as soon as it left the gate."

The Team includes members from all three of the Office of Surface Mining's major regional centers in Pittsburgh, PA; Alton, IL; and Denver, CO. Also included are members from the Knoxville Field Office in Tennessee.

The demand for training has outpaced team resources from the very first day. "There are only so many people on the team," says Team Training Manager Robert Welsh. "They weren't hired as instructors, they were hired for their knowledge and expertise. The teaching grew out of a need to train people in how to use the software for a very specialized purpose – surface mine reclamation."

"As our students become proficient in use of the software in reclamation, we impose upon the best ones to become teachers," says Robert. "Thankfully, many have accepted. Today nearly half of the instructors for TIPS courses are state employees. They know how short staffed we are, and they share a commitment to the program."

During the past year, TIPS trained 500 students in 59 classes. Through a contract for eight on-line Geographic Information System courses from ESRI's Virtual Campus, e-training became available for the first time in 2002 and 114 students have already taken the on-line classes.

No agency is required to use TIPS. Participation is voluntary and the Federal government as part of the TIPS budget underwrites all software, equipment, and training costs. Participation is limited to Federal, State, and Tribal agencies that carry out the functions of the Surface Mining Control and Reclamation Act.

A variety of tools for a variety of uses

Coal mine inspectors use TIPS technology tools to precisely locate mine facilities and areas in relation to permit areas, and to perform comprehensive inspections over a greater area in less time. Satellite and air photos provide a tool to quickly evaluate vegetation success and to locate areas of greater erosion. Global Positioning System technology can be combined with mapping software on laptop computers for inspectors to use interactively while at a mine site.

With TIPS, reclamation specialists design the most effective post-mining landscapes using precise volumes of earth material, preventing erosion and minimizing landslides.

Mining impacts on both ground and surface water can be modeled and what-if scenarios created and evaluated. Statistical tools help validate water-quality analyses and other software can help detect the source of contaminants in water samples.

Each software program provided by TIPS to its customers is selected under two basic criteria. 1) It must be suitable for the task. Each software program must be capable of performing the scientific or engineering task for which it was selected in an accurate and intuitive manner. 2) The program must be compatible with existing software in use by the mining industry and other federal and state agencies. One of the fundamental tenets of TIPS is to promote electronic exchange of data between agencies and the mining industry.

TIPS GIS is Adapted to Surface Mining Applications

TIPS has selected the suite of Geographic Information Systems (GIS) software from the Environmental Systems Research Institute (ESRI) as its standard for GIS software. A GIS can portray the total picture of pre-and post-mining environmental conditions and monitoring of regulated activities is easier. Well-informed decisions about proper waste rock and soil handling and storage are possible and ensure that proper drainage is preserved and sensitive plants, animals, and water are protected. With GIS software, natural features and man-made activities can be mapped and characterized (attributed) for comparison and interrelationship analyses (Environmental Systems Research Institute, 1994). For example, a map of wildlife areas can be combined with a map of vegetation species to see which kind of plants the wildlife prefer (Figure 2). With this information post-mining land use can be better planned with more successful results. This example is a fundamental capability of any GIS software. TIPS has chosen the ESRI suite because it is the most widely used GIS software by the mining industry and other agencies. This fosters electronic exchange of data between agencies and the mining industry resulting in technical reviews completed faster and more thoroughly

.Most of the TIPS state and tribal partners, and all OSM offices use the ESRI ArcGIS and ArcView software to create and manage GIS databases and to produce GIS maps. ArcGIS (and extensions - Spatial Analyst, 3-D Analyst, Geostatistical Analyst, ArcPress, ArcScan, and COGO) is distributed to all of the participating agencies and is licensed using FLEX*lm* from Macrovision™. TIPS users have access to ArcView through the KeyServer® License Manager produced by Sassafras Software.

Because many States have limited budgets, they can't afford to pay for much GIS training. TIPS fills this gap by offering instructor-led classes in ArcView, ArcGis, and ArcGIS Spatial Analyst. These courses are customized to provide students with exercises that use actual mining data and examples. TIPS also pays for eight of ESRI's on-line courses on topics ranging from

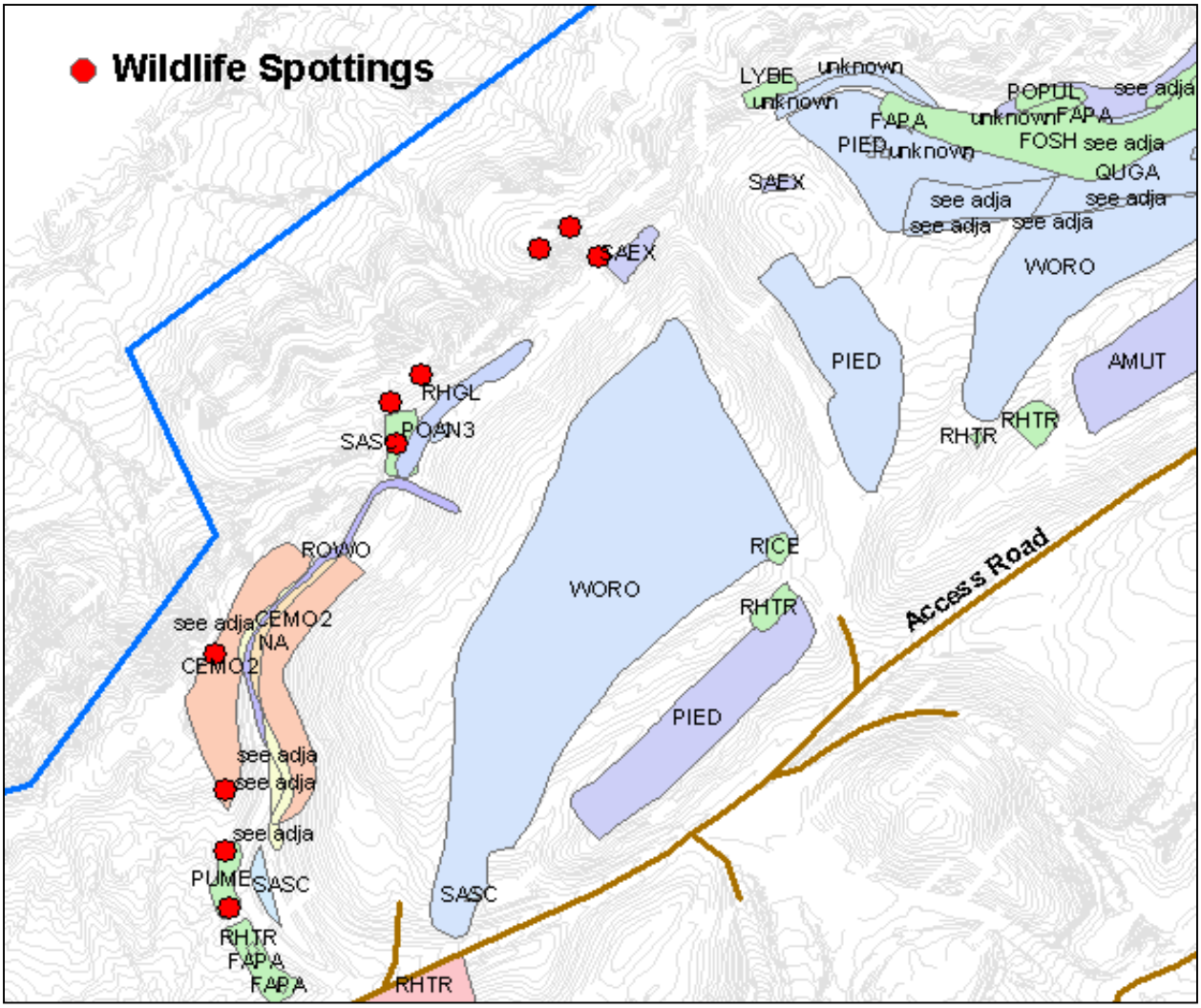

Figure 2: This GIS map shows wildlife areas relative to seedling planting areas. From McKinley Mine permit application data, New Mexico. Not published.

Visual Basic programming to Metadata compliance. Over the past year, TIPS trained 229 students in GIS and provided the opportunity for tribal and state personnel to receive this otherwise expensive training at no cost to them. TIPS customers frequently consult with the GIS instructors and software managers to solve problems with software, hardware, and application problems so they can get their work done with fewer headaches. Chances are someone on the TIPS GIS team has already "been there and done that!"

GPS at TIPS gets to the Point

The satellite-based Global Positioning System (GPS) has revolutionized the way surface coal mining field inspectors, permitting staff, and technicians collect and use spatial data. Many surface coal mines cover in excess of 30,000 acres and just knowing where you are on the permit can be difficult. With GPS technology, precise positioning on such vast expanses is possible. TIPS is supporting State, Tribal and OSM customers with rugged state of the art GPS equipment and training. Currently, TIPS supports GPS units from handheld recreational grade to dual-frequency survey grade systems and everywhere in between. Most units that have been purchased and deployed to TIPS customers are mid-grade handheld and backpack real-time or post-processed differential correction capable units. Typically, TIPS users require accuracies of around 1 meter to do their jobs. The GPS units are easy to use, rugged, and support the complex attribute collection that is necessary to document the information needed for regulatory enforcement. The real-time correction capability is very useful to users that want to navigate to a specific place on the mine site and verify an elevation or confirm that mining is occurring where it is permitted.

TIPS GPS training is structured into four classes that cover topics from the introductory to advanced, all geared towards The Surface Mining Act requirements and Abandoned Mine Lands applications. In addition to providing hardware, software, and training, TIPS GPS experts help users with their problems and, when necessary, provide on-site consultation and project assistance. TIPS can also provide high accuracy, geodetic grade surveying using a real-time kinematic GPS total station (Shown in Figure 3). This unit is available for checkout to States, Tribes and other OSM offices and provides a level of accuracy that is necessary for photogrammetric control, surveying, and boundary retracement.

Mobile Computing goes to the Active Mine Site

A recent development in geotechnology is the integration of maps and data with real-time GPS positioning. Besides the primary application of allowing inspectors to field verify information provided by the mining companies the inspectors can collect new information using real-time GPS logging. The ability to add detailed attributes right in the field means that nothing is forgotten later and the background maps and images allow inspectors to verify the accuracy of their collected GPS data.

Figure 3: TIPS team member Kyle Bohnenstiehl surveys pond elevation in Tennessee with the GPS Total Station. A valley fill of removed mine overburden is in the background.

Although still in the research and development phase, TIPS has deployed 10 such systems to the field. Several systems are being tested and range from handheld, supercharged Personal Data Assistant (PDA) devices to fully sunlight readable, ruggedized tablet computers all linked with real-time differentially corrected GPS units. Eventually, TIPS envisions that field inspectors, engineers, and technical staff will supplement, if not replace, their clipboards, paper maps and rangefinders with this amazing technology.

A Top Down View Promotes Greater Efficiency

Remote sensing using aerial and satellite imagery is having a major impact on the way some TIPS customers do business. Surface coal mining regulators and reclamation specialists have always appreciated the benefits of aerial photography but it is simply too costly to use routinely. Off-the-shelf data (like Digital Orthophotoquads) are frequently old and may lack the needed resolution. With the advent of powerful desktop computers, user-friendly software, and several new high-resolution satellites, TIPS customers are lining up to use remote sensing technology. Focusing on one-meter or better satellite imagery, TIPS has pilot projects with state personnel in Pennsylvania, Virginia, West Virginia, Kentucky, and Tennessee. In the West, TIPS is providing high-resolution imagery on a quarterly basis to inspectors, permitting staff, management, states, tribes, and other federal agencies for mines in Arizona, New Mexico, and Washington.

Along with providing imagery and conducting pilot studies, TIPS is providing training, software, and hardware support to customers based upon the ERDAS Imagine Photogrammetry suite of software (ERDAS, Inc., 1999). Two week-long training sessions are planned for 2003 and will cover processing of satellite and aerial imagery into high-resolution digital elevation models and orthophotos. In addition, because much of the satellite imagery TIPS acquires is in stereo, advanced photogrammetric mensuration and 3-D GIS digitizing tools and techniques are being provided. TIPS remote sensing is truly state of the art, and has been recognized nationally, on several occasions for the early adoption of this technology.

Other projects in Oklahoma and Colorado are using high accuracy Light Detection and Ranging (LIDAR) data to map Abandoned Mine Land (AML) sites at 2-foot contours. In Pennsylvania's anthracite region, natural color aerial photography and the GPS Total Station were used to generate 5-foot contours and 1-foot orthoimagery for an area covering 100,000

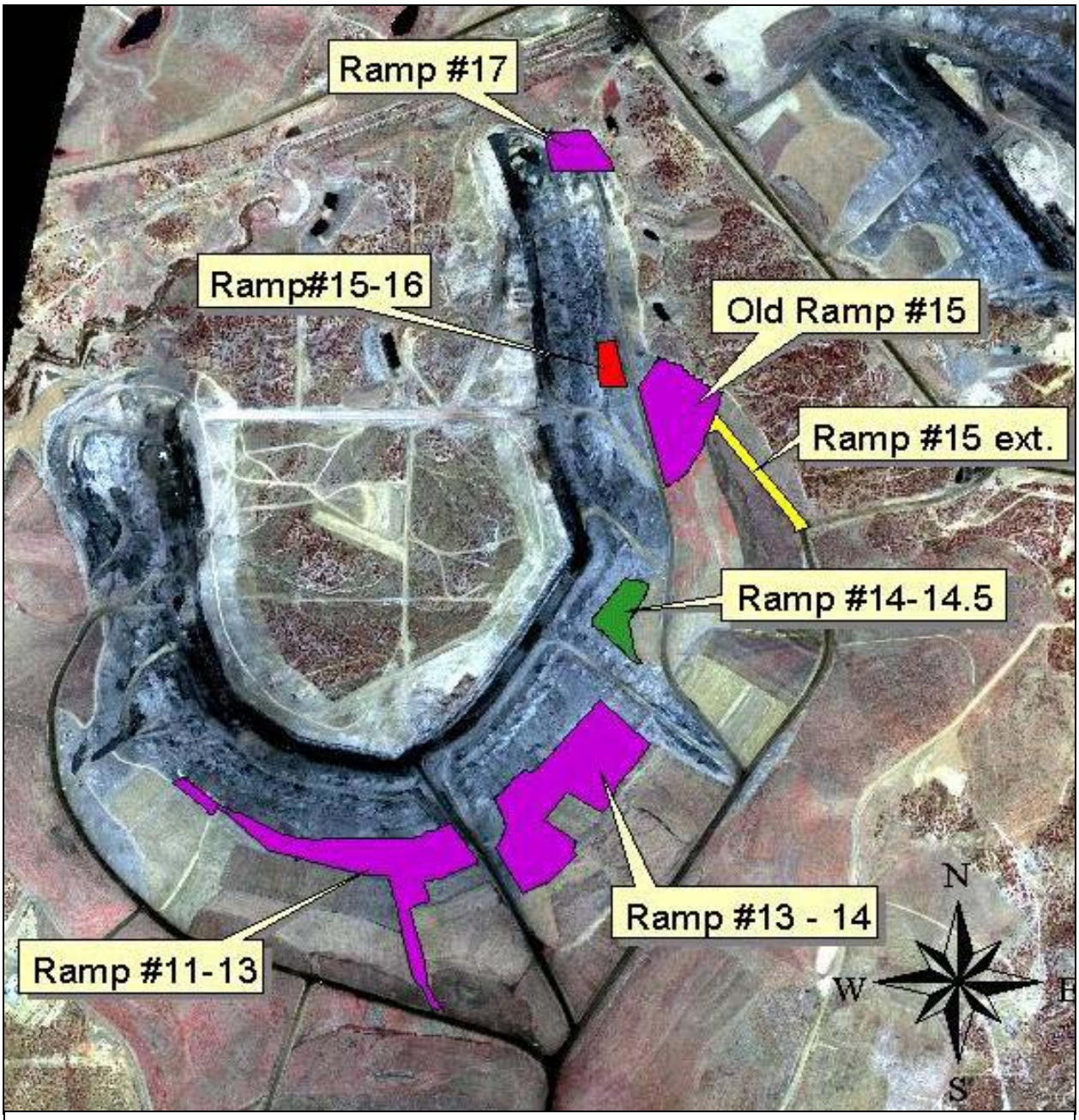

Figure 4: At a mine in Northern Arizona satellite photography is used to map the coal-pit reclamation areas. From Black Mesa Mine permit application data. Not published.

acres. In Figure 4 you see how satellite imagery helps to map reclamation areas near a mine pit. In the near future, TIPS will evaluate new cost effective strategies for providing engineering grade topographic information using 0.61m satellite imagery from the Quickbird satellite operated by DigitalGlobe. TIPS will also begin offering photogrammetric scanning for state, tribal, and OSM customers to help reduce the costs of their photogrammetric projects and

encourage the widespread adoption of this exciting technology. Overall, TIPS is hoping to leverage the recent technological advances in photogrammetry hardware and software so that the technology is more accessible and more affordable for its customers.

TIPS Software Helps Pennsylvania During Quecreek Mine Accident

Last July when nine miners were trapped 240 feet below the surface in a flooded mine shaft, Pennsylvania staff with the Bureaus of Mining and Reclamation (BMR) and Abandoned Mine Reclamation (BAMR) used TIPS software to prepare informational maps for the public. Mike DiMatteo of BMR, a TIPS instructor and steering committee member, used EarthVision to customize existing mine data on file and prepare a three-dimensional model that showed the interaction of surface topography, geology and coal seams; the locations of the rescue and air shafts, and the abandoned Saxman mine workings which flooded into the Quecreek mine when

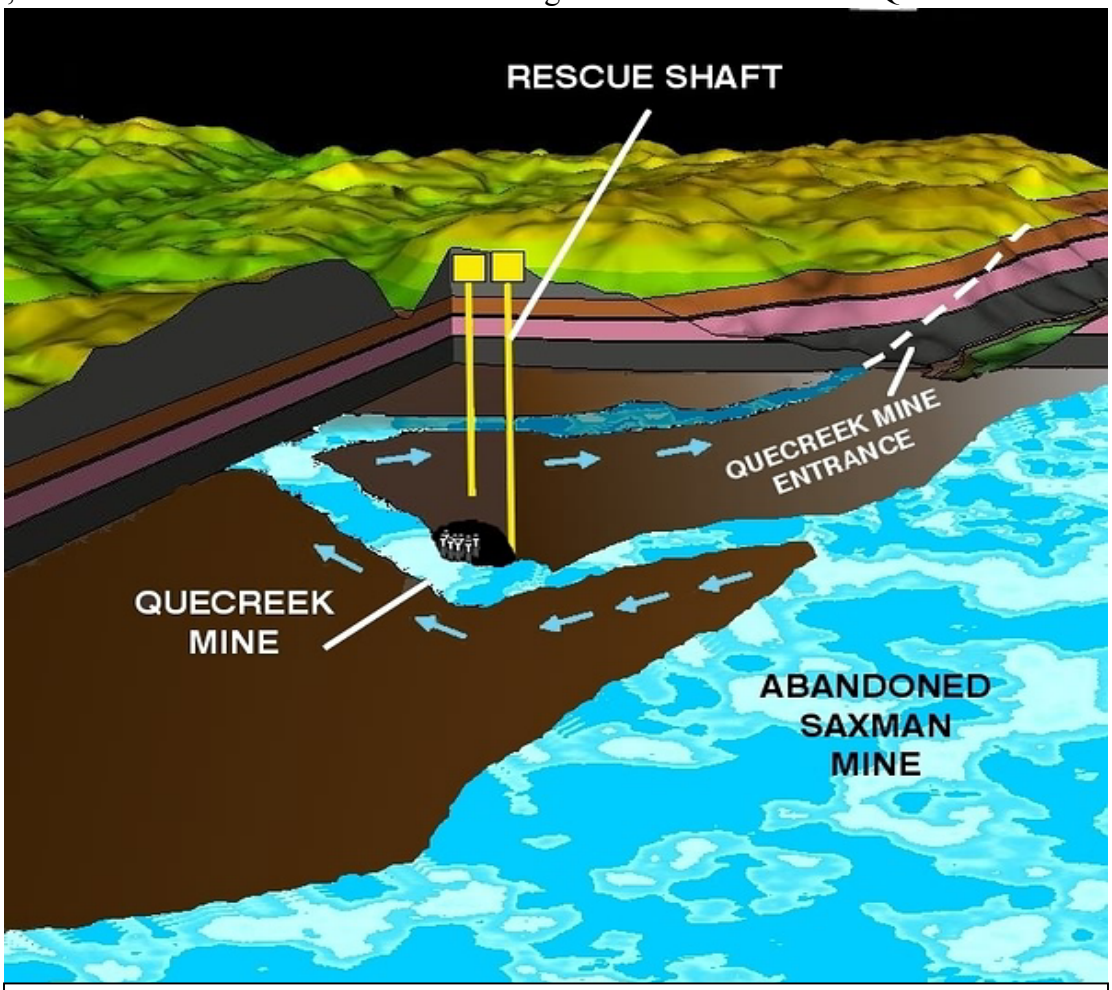

Figure 5: Earthvision 6.0 was used to prepare this 3-D perspective view of the Quecreek Mine accident. Courtesy of Mike DiMatteo PA-DEP. Not published.

the barrier between the mines was breached. Mike provided the 3-D illustration to Bureau artists who added graphics showing the water and trapped men to create a very effective map illustrating the miners' situation.

Meanwhile, at the BAMR offices, Jeremy Monn was digitizing the Quecreek and abandoned Saxman mine boundaries from available mine maps and Brian Bradley, a TIPS ArcView instructor, was creating a location map. Their combined efforts showed on a USGS basemap, where the men were trapped in the mine in relation to nearby roads and towns. Jeremy and Brian used ArcMap and ArcView software distributed by TIPS to do this, and produced a very informative map that was not only published on the DEP website, but was also widely distributed to the media and rescue officials.

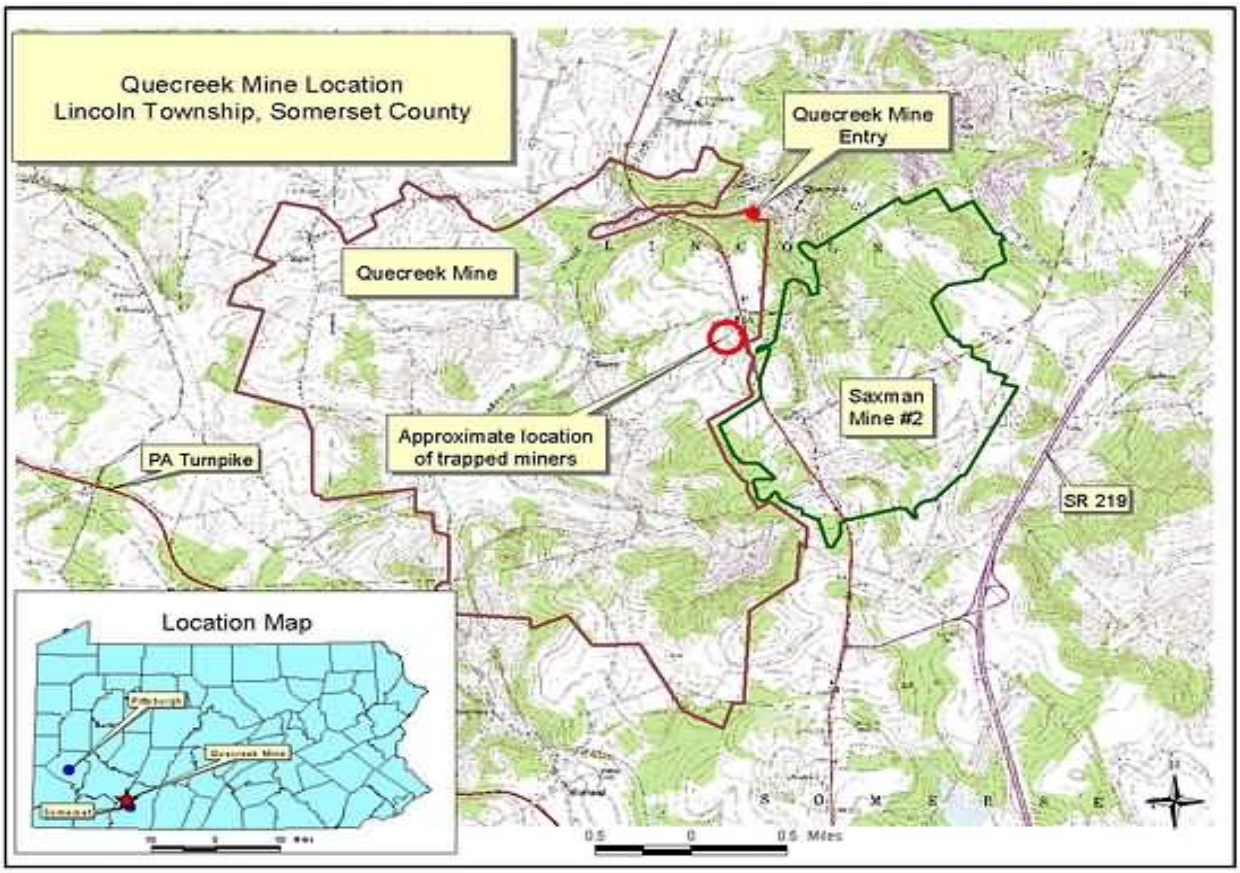

Figure 6: ArcView GIS software was used to prepare this overview map of the Quecreek Mine accident. Courtesy of Brian Bradley PA-DEP. Not published.

TIPS now approaches its 15th year of providing high-technology tools to the federal, state, and tribal agencies that regulate coal mining and reclaim dangerous abandoned mine areas

nationwide. Mine permit review and reclamation design has never been more thorough or accurate since the inception of TIPS. Nor has data been exchanged more efficiently and accurately. It is a tool that federal, state, and tribal authorities nationwide have come to rely upon in increasing numbers.

Further information can be found on the TIPS website at www.tips.osmre.gov or by contacting TIPS Chief, Billie Clark at bclark@osmre.gov or (303) 844-1400 ext. 1495.

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