The following was presented at DMT'11
(May 22-25, 2011).

The contents are provisional and will be
superseded by a paper in the
DMT'11 Proceedings.

See also earlier Proceedings (1997-2010)
http://ngmdb.usgs.gov/info/dmt/

West Virginia Mine Pool Atlas - A Work in Progress

Jane S. McColloch, Richard D. Binns, Jr., Bascombe M. Blake, Jr., and Gayle H. McColloch, Jr.
West Virginia Geological and Economic Survey

West Virginia Mine Pool Atlas Project—A Work in Progress

Introduction

West Virginia is considered to be a well-watered state, receiving more than 50 inches of precipitation per year. However, much of the water that falls onto West Virginia leaves the state by way of its many streams. The remainder infiltrates the ground surface, but only a small amount of this water provides recharge to ground-water aquifers. One currently underutilized and often overlooked source of stored ground water is abandoned coal mines (Figure 1). In order to develop an understanding of the potential of this water source for development, the West Virginia Geologic Survey (WVGES) is in the process of building a dynamic, interactive GIS to portray the location of mine pools that could provide large volumes of water for various private, public, and industrial uses. The GIS will provide tools to estimate mine pool volumes, and available existing water quality data will be tied to appropriate mine water sources in West Virginia.

This GIS will be updated as new mining and water quality data becomes available. It will be used to produce PDF reports of mine pools by seam, the estimated volume of water contained in each mine pool, and available water quality data. Maps and statistics about each mine pool will be presented in the PDF report, and it will include seam and mining information available from the WVGES Coal Bed Mapping Program (CBMP) at the time the study is conducted. Figure 2 shows the status of work being conducted by CBMP (B.M. Blake, unpub. data, 2011).

Project Overview

Currently available CBMP data is being used to determine which seams have mine pools capable of supplying large quantities of ground water. Underground mining has taken place in 69 of 73 of the West Virginia's mineable coals, and information about underground mining in these seams is being incorporated in this GIS. Mine polygons of approximately 9,500 underground mines have been digitized from mine maps (Figure 3). In addition, a cropline, a structure contour of the elevation of the base of the coal seam, coal seam elevation raster data, and an isopach have been created for each coal seam. GIS analytical tools have been developed to assist in determining the position of each mine with respect to drainage (above, near, or below), the relative amount of potential ground-water flooding (not flooded, partially flooded, or flooded), and direction of ground-water flow. In the second stage of the project, water quality data from other state government agencies will be tied to specific mine pools, where available. Maps and statistics about each mine pool will be presented in the PDF report, and it will include seam and mining information available from the WVGES CBMP at the time the study is conducted.

The project consists of the following tasks:

- Conducting a regional evaluation of each coal seam to determine which parts of the seam are above major drainage, near major drainage, and below major drainage.
- Calculating the estimated mine pool volume of each seam assuming an average thickness based on WVGES CBMP GIS data and an extraction rate determined by the mining patterns.
- Identifying, collecting, and compiling water quality data for selected major coal seams from several sources, as availability, time, and funding permits.
- Linking water quality data to GIS layer.
- Preparing maps of each mine pool for the PDF report.
- Developing a map template for the PDF report.

Regional Evaluation

As this study is ongoing, the focus of this presentation is the regional evaluation of each coal seam using WVGES CBMP GIS data layers and models. The GIS data layers for each seam include underground mine polygons, coal boundaries (croplines), and a structure contour of the elevation of the base of the coal seam (Figure 4). In addition to visual analysis of GIS data layers, models were developed to aid in determining ground-water flow direction and mine position relative to drainage.

The Watershed model to determine groundwater flow direction is an ArcMap geoprocessing model which uses the Spatial Analyst Hydrology toolset to convert the Coal Bed Mapping coal seam elevation raster data into predictive hydrologic flow direction and flow accumulation rasters. From these generated datasets the model outputs generalized "stream" features which can be used to help predict the movement of groundwater through the mine voids and whether or not flow direction is toward the coal outcrop. Model output for the Sewell coal seam on the Fayetteville 7.5-minute quadrangle are shown in Figure 5.

Mining Above/Below Drainage GIS models were developed to indicate probable mine pools in relation to major drainage and perennial drainage elevations. The major drainage elevation model was generated by assigning USGS 7.5 minute elevations to points selected from National Hydrography Dataset (NHD) perennial streams located within hydrological features digitized as having an area. The resolution of this DEM was generated to 10 meters to match the coal bed mapping seam elevation raster data. The coal elevation DEM is subtracted from the major drainage DEM to indicate regions of the coal seam that lie above and below major drainage, this result is overlaid with the mine footprint polygons to obtain the final GIS layer of mines and parts of mines potentially flooded. The Perennial drainage elevation model was generated by assigning USGS 7.5 minute elevations to points selected from NHD perennial streams of hydrologic features digitized as lines. Examples of both models are shown in Figures 6 and 7.

The Sewell coal seam was selected to assess the Mining Above/Below Drainage GIS models because it has been extensively mined by underground methods in southern West Virginia as shown in Figure 8. Coal and mining information for the Sewell seam including mine polygons, coal cropline, structure contour of the base of this coal, and scanned images of mine maps (WVGES, 2011) were visually examined to establish which areas have adequate data available to determine the position of each mine relative to major drainage (above, near, or below) and to determine the potential for each mine to be partially or totally filled with ground water. Of the 884 documented mines in this seam, 472 are located in areas in which cropline, structure contour, and seam elevation raster data are available to provide input to the models.

Visual structure contour/cropline examination of underground mines indicates 431 mines are above drainage, 24 are near drainage, and 17 are below drainage. Nineteen of the near drainage mines and 250 of the above drainage mines are potentially partially flooded. Three of the near drainage mines and all 17 below drainage mines are potentially totally flooded. The potentially totally flooded mines range in area from 1.7 to 4,587.4 acres and jointly occupy approximately 33,361 acres.

The effectiveness of the Mining Above/Below Drainage GIS models was tested by comparing the results of the visual structure contour/cropline examination of underground mines to the GIS model output for 472 mines in the Sewell coal seam located in Nicholas, Fayette, Greenbrier, Raleigh, and northeastern Wyoming counties. The results are shown in Table 1.

Field work being conducted for geologic mapping of the Fayetteville 7.5-minute topographic quadrangle has verified locations of a few mine discharges within the New River Gorge near Fayetteville, WV (Figures 9, 10, 11, and 12).

Summary and Conclusions

As indicated by the visual structure contour/cropline examination of the 472 underground mines in the Sewell seam, underground mines located below or near drainage have the greatest potential to provide large quantities of water. The downdip areas of some of the large mines located above drainage may also be potential sources of ground water.

The comparison of structure contour/cropline examination to Mining Above/Below Drainage GIS models shows the structure contour/cropline examination is the most effective method of identifying areas and potential extents of flooding in mines. The perennial drainage model is a fairly good predictive tool, but it is most effective in identifying potential flooding below drainage. The major drainage model proved ineffective in predicting potential mine flooding.

References Cited

West Virginia Geological and Economic Survey, 2010a, West Virginia Coal Bed Mapping: http://ims.wvgs.wvnet.edu/All_Coal/viewer. htm (accessed May 20, 2011).
———2010b, Sewell coal: http://ims.wvgs.wvnet.edu/sew/viewer.htm (accessed May 20, 2011).
———2011, West Virginia Mine Map Repository: http://downloads.wvgs.wvnet.edu/minemaps/ (accessed May 20, 2011).

Acknowledgments

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Figure 1. Water discharging from a powerhole in the downdip end of the Summerlee mine in the Sewell coal emerges from a pipe at Dempsey, WV, where the water is treated. The mine is approximately 340 feet below the surface at this location. (photo by G.H. McColloch)

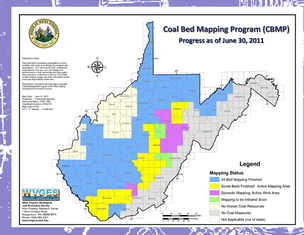

Figure 2. Status of coal bed mapping in West Virginia by the WVGES Coal bed Mapping Program projected to June 30, 2011 (B.M. Blake, unpub. data, 2011).

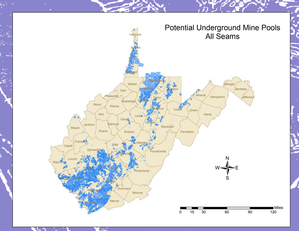

Figure 3. The footprints of all documented underground mines in West Virginia coal seams delineates the areas of potential mine pools in the state (WVGES, 2010a).

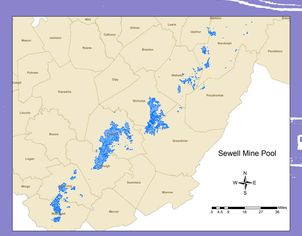

Figure 8. Footprints of all documented underground mines in the Sewell coal seam of the Pennsylvanian New River Formation (WVGES, 2010b).

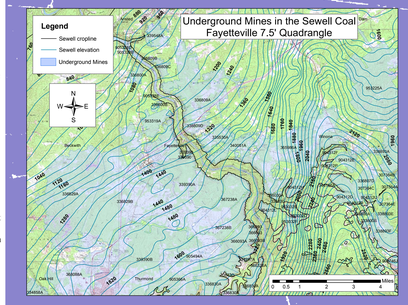

Figure 4. Extent of underground mines in the Sewell coal seam on the Fayetteville 7.5-minute topographic quadrangle and surrounding area.

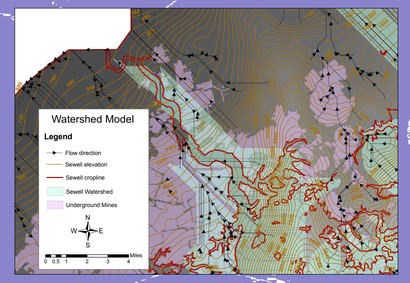

Figure 5. Watershed model of the Sewell coal seam on the Fayetteville 7.5-minute topographic quadrangle and surrounding area.

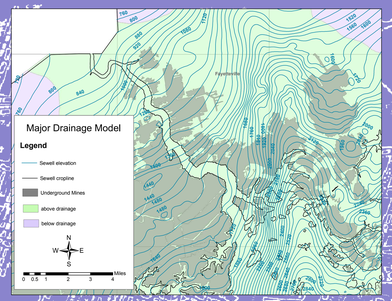

Figure 6. Major Drainage Mining Above/Below Drainage GIS model of the Sewell coal seam on the Fayetteville 7.5-minute topographic quadrangle and surrounding area.

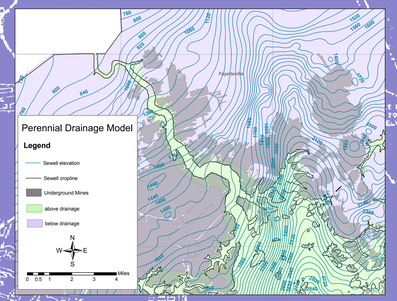

Figure 7. Perennial Drainage Mining Above/Below Drainage GIS model of the Sewell coal seam on the Fayetteville 7.5-minute topographic quadrangle and surrounding area.

Mine position relative to drainage/extent of probable groundwater flooding		METHOD		
		Structure Contour/Cropline examination	Perennial drainage model	Major drainage model
Mines above drainage	not flooded	181	265	428
	partially flooded	250	118	2
	flooded	0	48	1
Mines near drainage	not flooded	2	0	23
	partially flooded	19	15	1
	flooded	3	9	0
Mines below drainage	not flooded	0	0	12
	partially flooded	0	0	4
	flooded	17	17	1
Total Mines		472	472	472

Table 1. Comparison of structure contour/cropline examination to the major and perennial Mining Above/Below Drainage GIS models for determining mine position with respect to drainage and extent of probable ground-water flooding for underground mines in the Sewell coal seam.

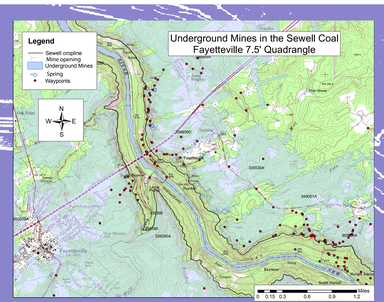

Figure 9. The locations of mine openings and mine water discharges were among waypoints recorded during the process of geologic field mapping.

Figure 10. Mine water discharges from a trough built into an opening in the Ames Mine in the New River Gorge east of Fayetteville, WV. (photo by G.H. McColloch)

Figure 11. Mine water discharges through an earthen seal of a undocumented mine opening in the Sewell coal west of the Dubree No. 4 mine near the site of Nuttallburg in the New River Gorge. The location of this photo is approximately 415 yards west of the location of the photo in Figure 12. (photo by G.H. McColloch)

Figure 12. An opening in the Dubree No. 4 mine in the Sewell coal near the site of Nuttallburg in the New River Gorge near Fayetteville, WV, has no water emerging from it. The grate over the mine opening provides access for bats.