UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

National Coal Resource Assessment Methodology: Comparison of Resource Calculation Methods by Two Geographic Information Systems (GIS)

by

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Introduction

This brief report documents a test of resource calculation methodologies that are available for use in the National Coal Resource Assessment project. Previous USGS resource estimation studies generally used USGS software called GARNET (Graphic Analysis of Resources using Numerical Evaluation Techniques) developed by the National Coal Resources Data System (NCRDS). When this software was replaced with GRASS [Geographic Resource Analysis Support System; U.S.Army Corps. of Engineers Research Laboratory (USACERL, 1993)], extensive comparisons of resource calculations between GRASS and GARNET were performed. For the National Coal Resource Assessment, newer software was available, including Earthvision* (Dynamic Graphics, 1997) and ARC/INFO* (ESRI, 1998).

This study compares resource calculations for the Pittsburgh coal bed in Monongalia County, West Virginia that were generated by two geographic information systems (GIS): a raster-based GIS (GRASS) and a vector-based GIS (ARC/INFO) . The studies were done nearly two years apart, but originated from the same set of coal thickness data (originally obtained from NCRDS and stored in StratiFact*; GRG Corp, 1996). The components required to complete a coal resource assessment according to criteria established by Wood and others (1983) include: coal thickness, rank, areal extent, overburden thickness, reliability categories and mined areas. Only original resources are compared (although remaining resources were calculated by both systems), because the mined area extent was revised between the times of the two studies.

GRASS System (1996)

The resource calculation performed in GRASS began with a 238 point x,y,z file (where z was coal thickness [100's of feet]) searched from the StratiFact database to generate an isopach raster for the county. The implemented version of GRASS is integer only, although floating point versions exist. The z-values were stored as 100's of feet in order to maintain the existing data precision and the tonnage factor was adjusted accordingly. (Note that grid, raster, and surface are the same entity and used interchangeably in this report). The x,y locations were converted to UTM (zone 17) from the latitudes and longitudes stored in StratiFact. Also from the database, 887 points with elevation of the Pittsburgh coal (in feet) were used to generate a structure contour surface on the top of the coal bed. USGS Digital Elevation Models of 1:250,000 scale were imported to GRASS to create a topographic surface for the county and converted to units of feet. The raster subtraction of the topography and structure grids yielded an estimation of overburden thickness in feet. Vector files of mined areas and outcrop were also available (from ARC/INFO) and were converted to raster format by labeling the inside of the polygons. Isopach and structure grids were generated using a 50-meter cell size and all rasters were sampled so that cells directly overlaid each other for the analysis. Reliability circles around the thickness points were generated using 402, 1207, and 4828 meters as the radii (Wood and others, 1983) and then converted to raster format. The resource calculation program in GRASS was written by a USGS contractor and added to GRASS's public domain software. A conversion factor of .00445 short tons per foot-meter square was used to convert the volume calculated from thickness in 100's of feet and area in square meters (Wood and others, 1983).

ARC/INFO System (1998)

The ARC/INFO resource calculation was conducted over a four-state area (not just Monongalia county), but the resources for the county were extracted from the larger study for this report. The number of thickness values used to create the isopach surface exceeded 4,500 and approximately 7,000 points were used to generate the structure contour on the top of the Pittsburgh coal. The latitudes and longitudes were converted to Albers Equal Area projection coordinates prior to gridding. Isopach and structure surfaces were generated in Interactive Surface Modeling (ISM, a precursor to Earthvision; Dynamic Graphics, 1991) using 300 meter cells and units of feet. The grids were contoured and the resulting line files imported to ARC/INFO as polygons. The values attributed to the polygons were halfway between the bounding contour lines, i.e. a polygon bounded by contour lines of 1.17 feet (14 inches) and 2.34 feet (28 inches) had the value of 1.755 feet. An overburden thickness surface was created in GRASS from an imported digital elevation model (compiled in ARC from both 1:100,000 and 1:250,000 scales) and the imported structure contour grid from ISM. This surface was contoured and the lines exported to ARC. Reliability circles were generated in ARC as had been done in the GRASS study. The resulting coverages (plus the mined areas) were unioned together, a process that joins all the attributes of the polygons in each coverage into the final coverage of polygons. Tonnages were calculated in each of the resulting 26,618 polygons by multiplying the area of the polygon times the thickness value of the polygon (which was half of the bounding contour lines, equally spaced at 1.17 foot intervals) times the tonnage factor of 0.445 short tons per foot-square meter. Approximately 1400 polygons occur within Monongalia County, made more complex by the addition of the mined areas (Appendix 1).

Discussion

The following table shows the comparison of original Pittsburgh resources in millions of short tons as calculated by the two techniques. ARC/INFO and GRASS results have been compiled into categories of overburden (OVB) and coal thickness (THK). All the numbers have been rounded off to millions of short tons. Although the resource tonnages have shifted thickness and overburden categories (largely because of the difference in the number of data values used to create the coal surfaces), the totals for the county are very similar (differing by about 1 percent). In 1913 the West Virginia Geological and Economic Survey made a resource estimation for the Pittsburgh coal bed in Monongalia County (Hennen and others) that was 1507.1 million short tons, by assuming a constant thickness of 7 feet for the bed in the county. This estimate differs from the ARC/INFO estimate by about 11 percent. Graphic representations of each resource study are shown in Appendix 1 [1].

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[1]*Use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Table 1. Comparison of original Pittsburgh resources for Monongalia County in millions of short tons.

Categories							
OVB (ft)	**0-200**		**200-1000**		**>1000**		
THK (ft)	**1.17-2.34**	**>2.34**	**1.17-2.34**	**>2.34**	**1.17-2.34**	**>2.34**	
GRASS							
Total	0	232.1	0.2	1321.9	0	170.5	
Grand Total							1724.7
ARC							
Total	0	185.3	0.6	1148.0	0	378.0	
Grand Total							1712.0

References

Dynamic Graphics, Inc., 1991, Interactive Surface Modeling, v. 7.1.

Dynamic Graphics, Inc., 1997, Earthvision, v. 4.

ESRI- Environmental Systems Research Institute, Inc., 1998, ARC/INFO, v. 7.1.1

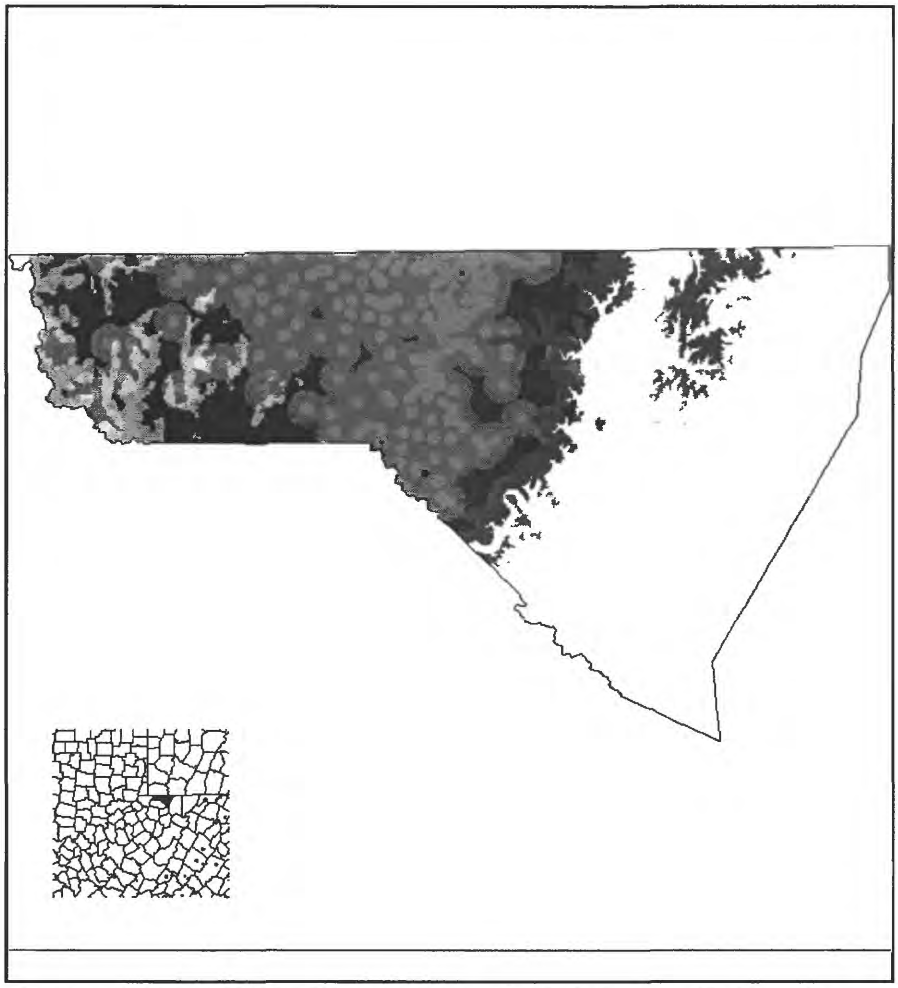
GRG Corp., 1996, StratiFact, v. 4.5.

Hennen, R.V., Reger, D.B., and White, I.C., 1913, Marion, Monongalia, and Taylor Counties, West Virginia Geological and Economic Survey, Wheeling , WV, 844 p.

USACERL, 1993, Geographic Resource Analysis Support System (GRASS), v.4.1.2.

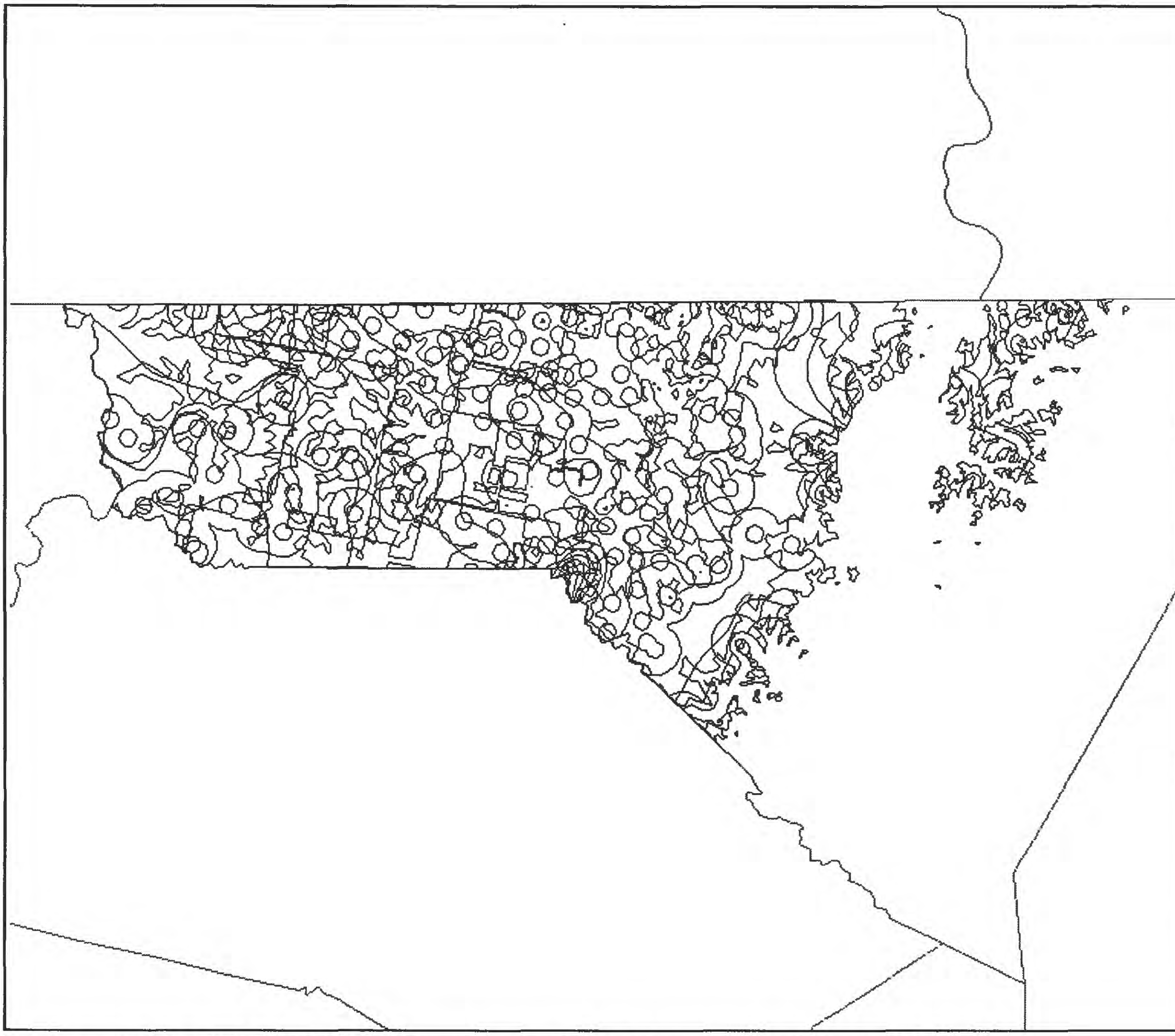
Wood, G.H., Thomas, M.K., Carter, M.D., and Culbertson, W.C., 1983, Coal resource classification system of the U.S. Geological Survey: U.S. Geological Survey Circular 891, 65 p.

APPENDIX 1
GRASS



Representation of GRASS resource raster in Monongalia County, WV.

ARC



Representation of ARC/INFO polygon coverage in Monongalia County, WV.