

# West Virginia Geological and Economic Survey

# ANNUAL REPORT

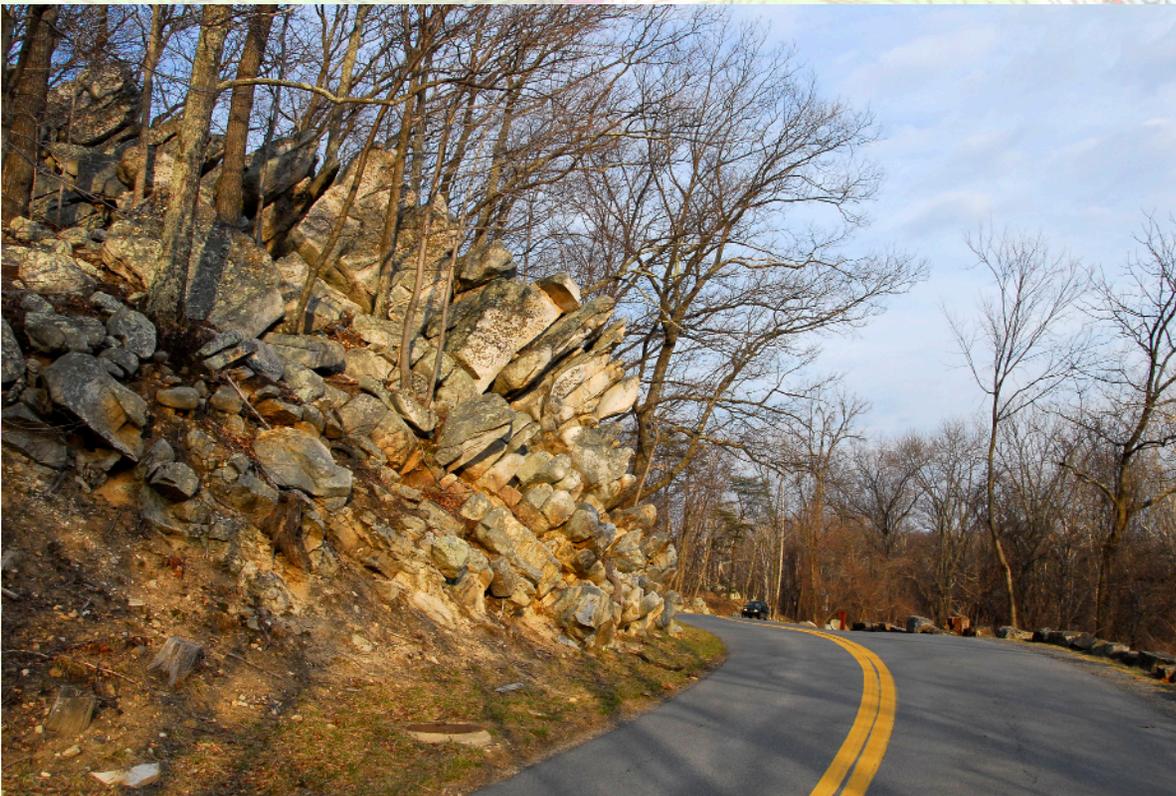
**Fiscal Year 2007**



**STATE OF WEST VIRGINIA**  
Joe Manchin III, *Governor*

**BUREAU OF COMMERCE**  
Kelley Goes, *Secretary*

**GEOLOGICAL & ECONOMIC SURVEY**  
Michael Ed. Hohn, *Director and State Geologist*



**WEST VIRGINIA GEOLOGICAL AND ECONOMIC SURVEY**  
**Principal Staff Directory and Points of Contact**  
**January 2008**

|  |                              |
|--|------------------------------|
| Director and State Geologist               | <i>Michael Ed. Hohn</i>      |
| Deputy Director Finance and Administration | <i>John D. May</i>           |
| Chief Geologist                            | <i>Douglas G. Patchen</i>    |
| GIS Program and Statewide GIS Coordinator  | <i>Vacant</i>                |
| <br>                                       |                              |
| Coal Resources                             | <i>Mitch Blake</i>           |
| Geoscience Education                       | <i>Thomas E. Repine, Jr.</i> |
| Mapping                                    | <i>Ronald R. McDowell</i>    |
| Oil and Gas Resources                      | <i>Katharine L. Avary</i>    |
| Water Issues and Geologic Hazards          | <i>Jane S. McColloch</i>     |
| Computing Services and Publications        | <i>Mary C. Behling</i>       |
| Earth Science Information Center           | <i>Paul R. Liston</i>        |
| Public Service                             | <i>Kenneth C. Ashton</i>     |
| Publication Sales                          | <i>Michael A. Kirk</i>       |

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**Hours:** 8:00 am to 5:00 pm Monday through Friday (closed holidays)

**Cover Photo:** Northeast dipping beds of Oriskany sandstone near entrance to Cacapon Resort State Park.

## THE WEST VIRGINIA GEOLOGICAL AND ECONOMIC SURVEY

The mission of the Geological and Economic Survey is to make available timely, responsive, unbiased, and credible geoscience information to promote thoughtful public policy; to help create prosperity; and to maintain a high level of environmental quality, economic opportunity, and quality of life for all West Virginians. We accomplish this mission through research, data collection, and service. This annual report for fiscal year 2006-7 summarizes accomplishments in every aspect of our mission.

We provide information to the public through our website, e-mail, phone, letter, or in person. Our website continues to receive more hits every year as we increase its content. Interactive maps, databases, and downloadable files accessible via our website have largely replaced traditional paper publications. We continue to scan our legacy paper publications for distribution in digital form. Many of our maps have been scanned or digitized either in-house as part of our geologic mapping program, or by the Geographic Information System Technical Center at West Virginia University. One of our goals in 2008 is to roll out a new website framework with improved design and organization and even more information.

We typically receive requests for information from:

- Mineral property owners, businesses, and state agencies using our data and maps to understand property valuation issues and assist in filing mineral appraisal forms.
- Coal companies and resource consultants seeking information on available coal resources, geology, and quality.
- Geologists with oil and gas companies reading our reports and perusing our databases to identify potential resources.
- Home buyers seeing if property is underlain by coal or a mine.
- Property owners wanting information about the potential for hydrocarbon resources under their property.
- Homeowners asking questions about the seriousness of earth movement on their property and whether it might threaten their home.

Our outreach efforts include technical presentations at professional meetings, displays at trade shows, guiding field trips, talks at our state parks, and education-related activities. We are very excited about the revised and

rewritten series of the Geology of State Parks Bulletins, originally published in the 1950's with black and white photographs. New versions reflect discoveries in geology over the past fifty years, and figures will now be in color, thanks to the professional services of the new Marketing and Communications Division within the Department of Commerce.

Providing accurate information to the public, businesses, and government requires a strong research program. Before data can be gathered, examined, and served out, we must know what data are most important and how to carry out an appropriate analysis. As an example, the section of this report on our coal program includes a summary of an ongoing study of stratigraphic correlation in coal-bearing units in the state. These studies provide the geologist with the knowledge needed to correctly match coals from different locations and therefore for accurately predicting available coal.

Our goals for the 2007-8 fiscal year include: continue mapping of the state's eastern panhandle, an area of challenging geology, geography, and in many areas significant economic and population growth; convert all published maps and publications to digital format; upgrade computer operations; improve on-line availability of geologic databases; complete coal resource calculations in additional counties; identify and digitize all areas of past mining; and complete digital conversion of 70% of existing logs from oil and gas wells.

Challenges we face in making progress on these goals include:

- High rate of personnel turnover. With increases in energy prices, we have increasing difficulty in attracting and retaining talented employees with the salaries that we can offer.
- Impending retirements by senior geologists. Geological understanding results from an accumulation of knowledge. Senior geologists have reached their greatest effectiveness in proposing projects for research, obtaining funding from external sources, executing effective and timely research, providing accurate information to the public, and knowing where to obtain such information.
- Obsolete core and sample storage. An important part of current and future geological research and service is the collection of well cores and samples we have gathered over the years, many donated by companies, others



resulting from our coring activities. Our storage building, almost filled to capacity, is approaching fifty years of age, and is showing its years. We have been forced to convert a garage and retrofit an abandoned sewage treatment plant into core storage for numerous coal bed methane exploration cores being donated by industry. At best these facilities are inadequate and do not provide space to work on the samples.

- With the move of West Virginia University's Geology and Geography Department to Brooks Hall during the summer of 2007, we have lost laboratory space and no longer have basic coal analytical capabilities. This loss will affect our work for years to come.

In a self-study conducted in the 2006-7 fiscal year, we identified professional development as a critical goal that cuts across all activities of our agency. Through a number of initiatives, we hope to attract scientists to our agency, increase our rate of employee retention, and maintain a high level of service and research even while a significant proportion of senior staff retires.

The following sections summarize accomplishments in our three geological programs: coal, oil and gas, and general geosciences. I would like to also recognize the Information Services Program, which partners with the geological groups in accomplishing many of our goals for providing information to the public through publications and the internet and for providing computing support. In addition, a summary of activities is included for the GIS Technical Center, which we fund in part.

Michael Hohn  
Director and  
State Geologist

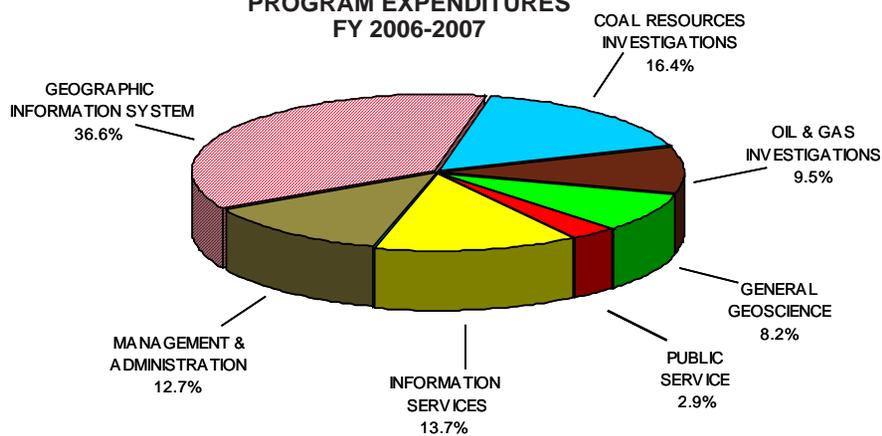


# FINANCIAL INFORMATION

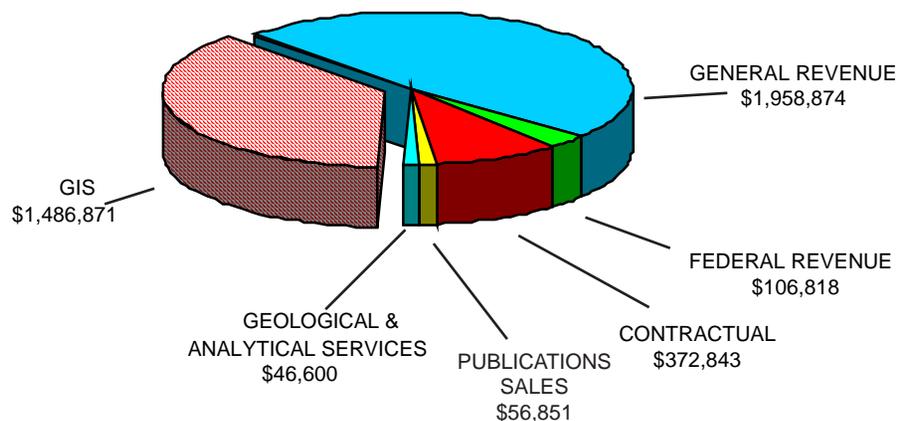
## FUNDING OVERVIEW

The Geological & Economic Survey encompasses seven major programs (Fig. 1) that are supported through a combination of State, Federal and other funding sources (Fig. 2). In addition to funding for basic operations from General Revenue appropriations, the agency is supported by funds dedicated to specific areas of research from supplemental General Revenue, Federal cooperative agreements, contracts and revenue-generating operations.

**Figure 1  
PROGRAM EXPENDITURES  
FY 2006-2007**



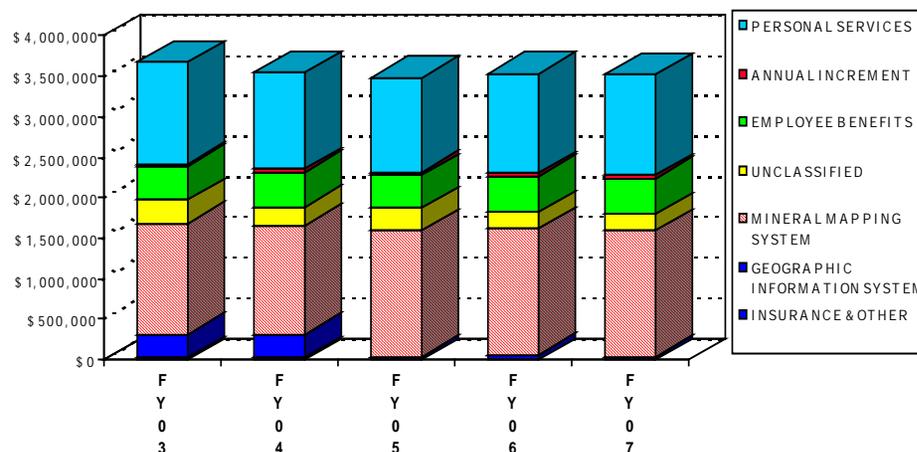
**Figure 2  
EXPENDITURES BY SOURCE OF FUNDING  
FY 2006-2007**



## GENERAL REVENUE

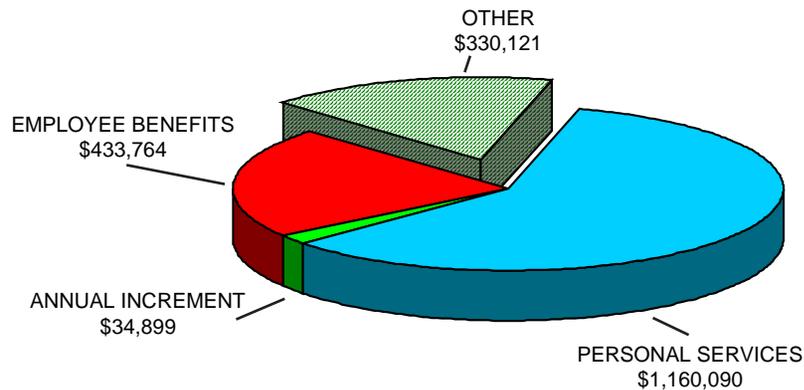
Most agency funding is provided through General Revenue appropriations. In FY 2006-2007, approximately 57% of General Revenue was dedicated to support agency operations, with the balance funding the State-wide Geographic Information System (GIS). In comparison to other funding sources, General Revenue has remained relatively stable, decreasing by only 3.5% in the past 5 years (Fig. 3).

**Figure 3  
GENERAL REVENUE APPROPRIATIONS  
FY 2002-2006**

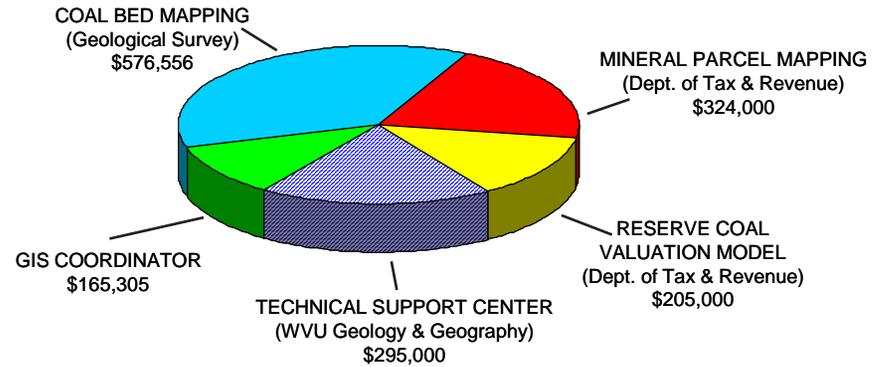


As the Geological Survey is a human resources-intensive agency, most of its non-Geographic Information System (GIS) General Revenue appropriations underwrite the costs of Personal Services, Annual Increments and Employee Benefits. In FY 2006-2007, Personal Services-related expenditures accounted for 83% of all non-GIS General Revenue expenditures (Fig. 4), with the remaining funds applied to operational expenses.

**Figure 4**  
**GENERAL REVENUE EXPENDITURES**  
**(Exclusive of GIS Appropriations)**



**Figure 5**  
**ALLOCATION OF GIS APPROPRIATIONS**  
**(\$1,561,250)**



Year-end expiring appropriations (unexpended balances that are returned to the State's General fund) totaled \$25,423; an amount resulting from contractual reimbursements for personal services, employee benefits and indirect costs.

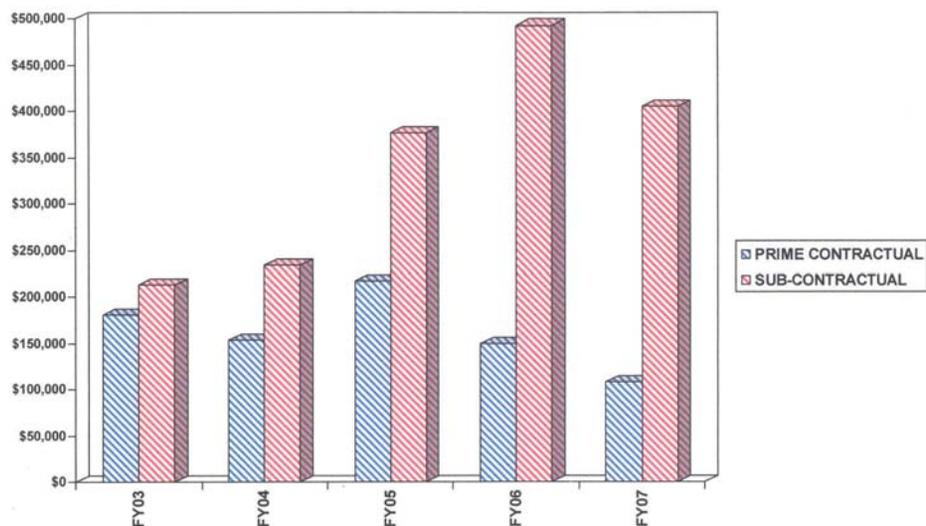
Expenditures for the Geographic Information System accounted for approximately 43% of total General Revenue outlays in FY 2006-2007. The Geological Survey serves as the lead and fiscal control agent in this joint program with the Department of Tax & Revenue and the West Virginia University Department of Geology & Geography. Approximately two thirds of GIS appropriations are passed through to the other cooperating State agencies. The remaining one third is allocated to the Geological Survey's participating

GIS research group, the Coal Bed Mapping Project. FY 2006-2007 General Revenue funding (Mineral Mapping appropriation) totaling \$1,565,861 was allocated for GIS participating agencies as shown in Figure 5.

**FEDERAL PROGRAMS**

Direct Federal funding for cooperative agreements with the US Dept. of Interior's US Geological Survey (USGS) has decreased over the past 5-year period. In contrast, sub-contractual funding for US Dept of Energy (DOE) and the US Department of Labor contracts has risen over the same period (Fig. 6).

**Figure 6  
FEDERAL FUNDS RECEIPTS**



Publication sales products include maps, books, reports and other agency documents reproduced on a variety of media (photo static, black line & well-log copies, microfilm, CDs, etc.). FY 2006-2007 net sales receipts totaled \$42,710; a decrease of 16% from the prior year.

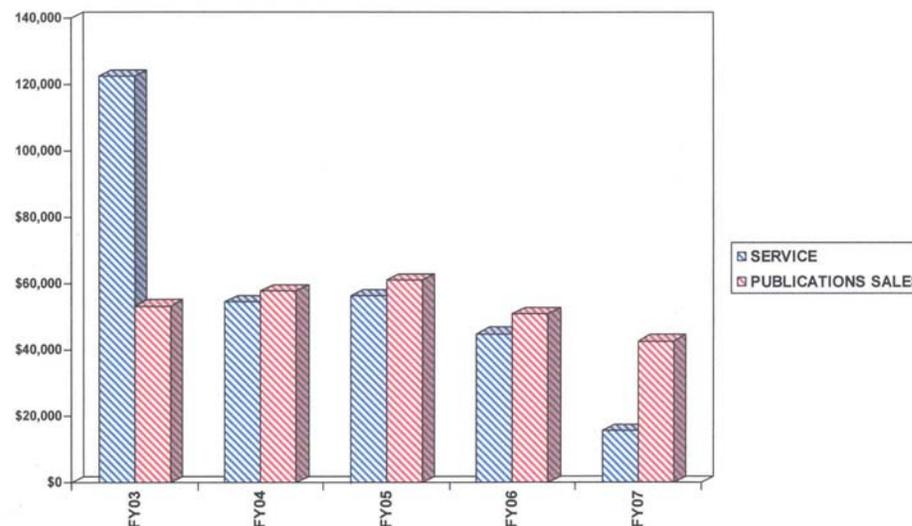
The establishment of equitable fees to be charged to users for geological services has facilitated recovery of incremental costs associated with the performance of services. FY 2006-2007 service fees collected totaled \$15,562; a decrease of 65% from the prior year.

While it is anticipated that the USGS programs will be continued at present levels of funding, a significant funding reduction for US DOE's Fossil Fuels program in the FY 2008 Federal budget currently under consideration in Congress would result in a loss of up to 89% of sub-contractual receipts to the Geological Survey. As a consequence, the Geological Survey would forgo annual reimbursements for salaries, benefits and indirect costs of approximately \$150,000.

**SALES REVENUES**

Funds have been generated through the sales of publications and geologic services (Fig. 7). Sufficient balances of sales receipts are maintained to defray agency operational costs associated with these revenue-producing activities.

**Figure 7  
SALES REVENUES**



**WEST VIRGINIA GEOLOGICAL AND ECONOMIC SURVEY**  
**Consolidated Statement of Expenditures**  
**For the Period July 1, 2006 through June 30, 2007**

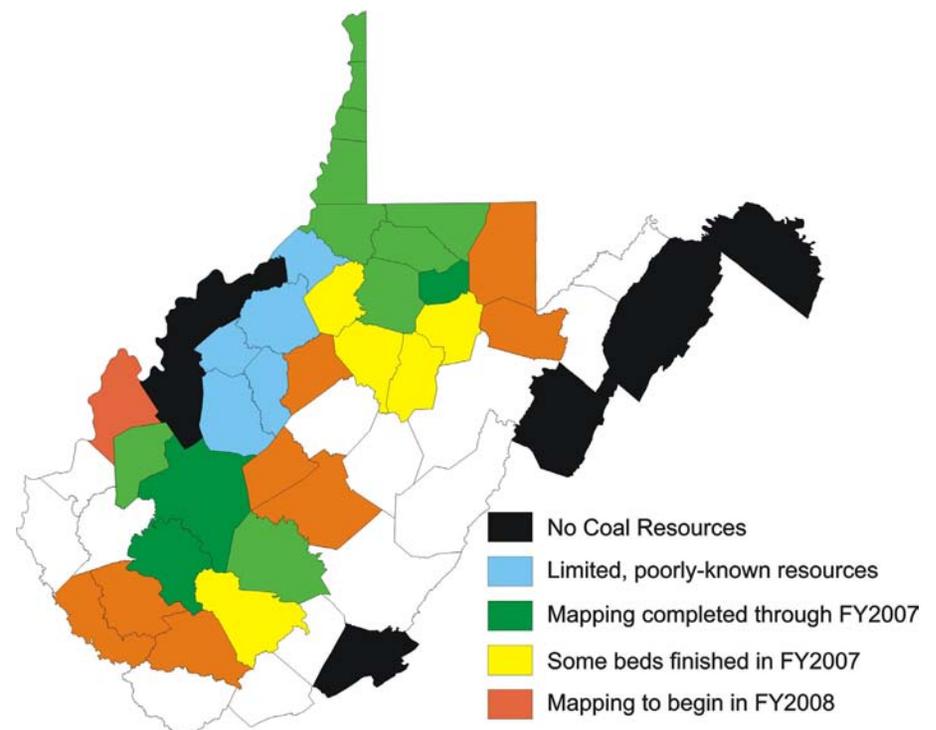
|                                  | <u>Total</u>               | <u>Agency<br/>General<br/>Revenue</u> | <u>GIS<br/>General<br/>Revenue</u> | <u>Approp.<br/>Special<br/>Revenue</u> | <u>Other<br/>Special<br/>Revenue</u> | <u>Approp.<br/>Federal<br/>Revenue</u> |
|----------------------------------|----------------------------|---------------------------------------|------------------------------------|--|--------------------------------------|--|
| Personal Services                | \$ 1,898,227               | \$ 1,160,090                          | \$ 425,699                         | \$ 11,444                              | \$ 258,025                           | \$ 42,969                              |
| Personal Services Reimbursements | 249,563                    |                                       | 249,563                            |  |                                      |  |
| Annual Increment                 | 42,209                     | 34,899                                | 4,962                              | 524                                    | 1,824                                |  |
| Insurance & Retirement Fee       | 18,502                     | 8,152                                 | 6,483                              | 132                                    | 3,035                                | 700                                    |
| Matching FICA                    | 159,497                    | 84,677                                | 50,165                             | 2,010                                  | 19,396                               | 3,249                                  |
| Public Employees Insurance       | 346,104                    | 181,931                               | 117,354                            | 2,955                                  | 40,010                               | 3,854                                  |
| Workers' Compensation            | 58,376                     | 27,388                                | 18,738                             | 959                                    | 9,138                                | 2,153                                  |
| Retirement Benefits              | 225,246                    | 120,201                               | 71,129                             | 2,832                                  | 27,272                               | 3,812                                  |
| PEIA Transfer                    | 18,188                     | 11,415                                | 4,412                              | 266                                    | 2,095                                |  |
| Office Expense                   | 3,525                      | 2,794                                 | 286                                | 194                                    | 165                                  | 86                                     |
| Printing & Binding               | 2,138                      | 1,721                                 | 417                                |  |                                      |  |
| Building Rental                  | 8,279                      | 1,134                                 | 7,145                              |  |                                      |  |
| Utilities                        | 32,066                     | 30,334                                | 335                                | 1,397                                  |                                      |  |
| Telecommunications               | 15,587                     | 14,445                                | 1,142                              |  |                                      |  |
| Contractual                      | 448,033                    | 43,434                                | 399,599                            |  | 5,000                                |  |
| Travel                           | 83,344                     | 20,515                                | 41,603                             | 13,257                                 | 1,409                                | 6,560                                  |
| Computer Services                | 11,882                     | 8,187                                 | 1,759                              | 841                                    | 545                                  | 550                                    |
| Vehicle Rental                   | 11,937                     | 7,611                                 | 1,932                              |  |                                      | 2,394                                  |
| Machine Rental                   | 17,709                     | 16,779                                | 558                                | 372                                    |                                      |  |
| Association Dues                 | 650                        | 300                                   | 350                                |  |                                      |  |
| Insurance Premiums               | 33,752                     | 33,752                                |                                    |  |                                      |  |
| Household Supplies               | 649                        | 413                                   | 30                                 |  |                                      | 206                                    |
| Advertising & Promotional        | 1,261                      | 772                                   |                                    |  | 489                                  |  |
| Vehicle Expense                  | 12,068                     | 9,091                                 | 1,345                              |  |                                      | 1,632                                  |
| Research Expense                 | 18,269                     | 11,279                                | 234                                | 468                                    | 1,179                                | 5,109                                  |
| Maintenance Contracts            | 117,488                    | 60,364                                | 45,297                             | 556                                    | 6,896                                | 4,375                                  |
| Merchandise For Resale           | 3,308                      |                                       |                                    |  | 3,308                                |  |
| Cellular Charges                 | 1,178                      | 1,178                                 |                                    |  |                                      |  |
| Hospitality                      | 834                        | 834                                   |                                    |  |                                      |  |
| Miscellaneous                    | 188                        | 188                                   |                                    |  |                                      |  |
| Training & Development           | 13,775                     | 8,163                                 |                                    |  | 5,612                                |  |
| Postal & Freight                 | 2,797                      | 1,534                                 | 29                                 |  | 1,102                                | 132                                    |
| Computer Supplies                | 62,267                     | 29,641                                | 7,299                              | 6,366                                  | 11,424                               | 7,537                                  |
| Miscellaneous Equipment          | 13,386                     | 9,285                                 | 2,568                              |  | 1,346                                | 187                                    |
| Bank Costs                       | 631                        |                                       |                                    |  | 631                                  |  |
| Office Equipment Repairs         | 57                         |                                       |                                    |  |                                      | 57                                     |
| Research Equipment Repairs       | 2,302                      | 1,252                                 |                                    |  |                                      | 1,050                                  |
| Household Equipment Repairs      | 630                        | 603                                   |                                    | 27                                     |                                      |  |
| Building Repairs & Alterations   | 78                         | 78                                    |                                    |  |                                      |  |
| Vehicle Repairs                  | 2,161                      | 311                                   |                                    |  |                                      | 1,850                                  |
| Ground Improvements              | 737                        | 737                                   |                                    |  |                                      |  |
| Other Repairs & Alterations      | 263                        | 263                                   |                                    |  |                                      |  |
| Office Equipment                 | 7,466                      |                                       | 5,466                              | 2,000                                  |                                      |  |
| Research Equipment               | 9,599                      | 9,599                                 |                                    |  |                                      |  |
| Computer Equipment               | 24,502                     | 3,530                                 | 20,972                             |  |                                      |  |
| Computer Software                | 5,375                      |                                       |                                    |  | 5,375                                |  |
| Indirect Cost Reimbursement      | <u>42,774</u>              |                                       |                                    | <u>24,418</u>                          | <u>18,356</u>                        |  |
| <b>Total</b>                     | <b><u>\$ 4,028,857</u></b> | <b><u>\$ 1,958,874</u></b>            | <b><u>\$ 1,486,871</u></b>         | <b><u>\$ 46,600</u></b>                | <b><u>\$ 429,694</u></b>             | <b><u>\$ 106,818</u></b>               |

## APPLIED COAL RESOURCES INVESTIGATIONS PROGRAM

**Coal-bed Mapping Project (CBMP)**—The geographic information system (GIS)-based Mineral Lands Mapping Program is a cooperative effort between the Survey, the West Virginia Department of Tax and Revenue, and the West Virginia University (WVU) Department of Geology and Geography. The Department of Tax and Revenue is responsible for creating GIS layers of mineral parcel ownership. WVU is charged with creating various GIS base map layers, or digital line graphs (DLGs). As part of this project, the Survey is conducting a GIS-based inventory of coal in the State. Coal-bed maps include: structural contour maps; outcrop maps; mined area maps by methodology; coal thickness maps; percent parting maps; and coal quality maps. At the end of FY2007, mapping of important coal beds were completed for 13 counties and the majority of 3 additional counties (Figure 1). It is anticipated that coal seam mapping for Barbour, Doddridge, Gilmer, Lewis, Mason, Preston, and Tucker counties will be substantially finished in FY2008. Completed maps were delivered to the Department of Tax and Revenue in early June (2007) and are publicly available on the Survey's web site.

**Mineral property tax related issues**—Mineral property owners, including general public, land companies, consultants, extractive industry, oil and gas industry, and the West Virginia Division of Tax and Revenue (WVDTR), use the basic data and derived map products from the CBMP to understand property valuation issues, assist them in filing required mineral appraisal forms, resolve disputes with or about resource valuation, and to value mineral parcels for taxation purposes. Taxes received based on Survey products are used to fund many important parts of the State's infrastructure, notably the education system.

**Basic Data Collection and Research**—Basic geologic data are continually collected and added to various databases to increase the knowledge base of the Survey. These data include core logs, coal analyses, measured sections of outcrops, highwalls, roadcuts, maps of underground coal mines and data extracted from the maps and a host of other important information. Most data collection throughout the year was associated with the Coal-bed Mapping Project. An interesting part of basic data collecting is the Survey's drilling



**Figure 1. Coal-bed mapping progress as of the end of Fiscal Year 2007.**

program initiated in 1995 as a tool to solve various geologic questions, including acid producing potential, problematic stratigraphic relationships, coal bed methane potential of deep coal beds, and to gather information on the stratigraphic and lithologic distribution of selenium in the Middle Pennsylvanian Kanawha Formation. To date, 17 holes have been drilled by the Survey alone or as part of cooperative research initiatives with industry or other government agencies. Although the Survey did not drill any additional holes in FY2007, access to several industry holes were provided to our coal geologists allowing important research to continue.

**Coal-bed Methane Activities**—Coal-bed methane is an increasingly important energy resource in West Virginia. Coal Programs geologists continue to work cooperatively with various coal companies and natural gas companies, describing the lithologies from coal bed methane exploration drill holes in Barbour, Braxton, and Calhoun counties during FY 2007. These data, coupled with data from oil and gas wells, are providing insights into basin development in previously under-investigated, deeper parts of the Appalachian Basin within the State.

**Coal Quality**—The Coal Program maintains and continually enhances a computerized database of the chemical and physical characteristics of West Virginia coals. The data base currently contains over 35,000 sample analyses and is one of the largest public databases of coal quality information in the nation. Basic coal analyses, washability data and petrography characteristics for the State's coal beds are available by request and trace element data are served through the Survey's web site. This database has proven to be very useful in helping potential customers find the specific West Virginia coal to meet their needs for power generation and to serve as chemical feedstock or as a source for coal to liquid studies. Policy makers often call on the Survey's coal quality expertise to gauge the potential effects of legislation on the State's coal industry. Unfortunately, with the Geology and Geography Department at West Virginia University moving from White Hall to newly renovated Brooks Hall, the Survey's coal analytical laboratories were forced to close due to loss of space. Analytical data will continue to be added to the Survey's coal quality data base obtained from various sources.

**National Coal Resources Data System (NCRDS)**—The Survey's Coal Program has received numerous grants from the U.S. Geological Survey's NCRDS program to contribute West Virginia coal information to the USGS' national computerized coal database. This database is used for a variety of investigations including Coal Availability Studies, but its use is not limited to cooperative federal projects.

Data acquisition, entry into Survey computer databases, and verification by Coal Program personnel are ongoing processes. Non-confidential data are uploaded to the NCRDS periodically. Stratigraphic database work accomplished under

this effort directly benefits the Coal-bed Mapping Project. Coal samples collected by Survey geologists are forwarded to the U.S. Geological Survey for trace element analyses and the results are added to the Survey's coal quality database. Other studies funded by the USGS through the NCRDS coop include selenium investigations, trace elements in coal, distribution of marine beds in Middle Pennsylvanian strata that are used for global correlations, and contributions to an electronic lexicon of geologic names for the United States.

**Underground Mine Mapping Project**—Recognition of the value of underground mine map compilations to mine safety issues, as highlighted by the Quecreek mine accident in Pennsylvania, resulted in closer cooperation and communication between the Survey and the West Virginia Office of Miner's Health, Safety, and Training (MHST). The two agencies formed a partnership and were successful in receiving funding from the U.S. Department of Labor, Mine Safety and Health Administration, to enhance compiling and providing public access to these important data. Funding was received in 2004 and the project is nearing completion. MHST is focusing on collecting and archiving maps of underground mines, while the Survey is compiling the mined areas, by seam, in a geographic information system format.

Mining compilation directly benefits mapping conducted under the Coal-bed Mapping Project. With the exception of Randolph County and a few coal beds from McDowell, Nicholas and Mingo counties, available mine maps from the State have been examined, inventoried and where appropriate, the mine footprint has been digitized and entered into the Survey's comprehensive coal bed GIS. All mine maps and compiled mining by bed are available for examination on the Survey's web site and individual mine map documents can be downloaded by interested parties. It is anticipated that all remaining, currently available maps will be processed during FY 2008.

**Mine subsidence related issues**—Potential home and land buyers require documentation as to whether a property of interest has been undermined or overlies potentially minable coals to evaluate the mine subsidence potential. Homeowners, insurance adjusters, engineering consultants, and government agencies (WV Division of Tax Revenue, WV Department of Environmental



Protection; WV Department of Natural Resources; US Geological Survey) contact us concerning properties experiencing suspected subsidence problems to obtain information on mining and geological conditions of coal under affected property. In addition, mining companies search our mine map data base looking for abandoned mines adjacent to proposed and active mines to forestall Quecreek type disasters. Mined area maps are available, by seam, through direct contact with Survey geologists or can be downloaded from the Survey's web site.

### **General Services and Outreach**

**Visiting Geologist Program**—This popular program, run in cooperation with WVDNR State Parks, allows Survey geologists to visit WV State Parks where they present programs on West Virginia and local geology and lead field trips for park visitors. The Survey has just completed the 15<sup>th</sup> season of this popular program.

**Informational and sales displays**—The WVGES annually exhibits at the West Virginia Hunting and Fishing show in Charleston in January and the West Virginia State Fair in August. The set-up includes an informational exhibit as

well as map and publication sales, making all WV topographic maps and other assorted maps and geological publications available on-site. Another important outreach meeting is the USGS and WVGES' cooperative ESIC program that provides access to various aerial photographs and related products in West Virginia. Paul Liston, the Survey's ESIC Coordinator, provides informational displays mainly on the ESIC products annually at the Industrial Expo and West Virginia Surveyor's Convention, both in Charleston. In addition, the Survey sponsors a rock and mineral show that draws over 1,000 attendees annually (1172 in 2006).

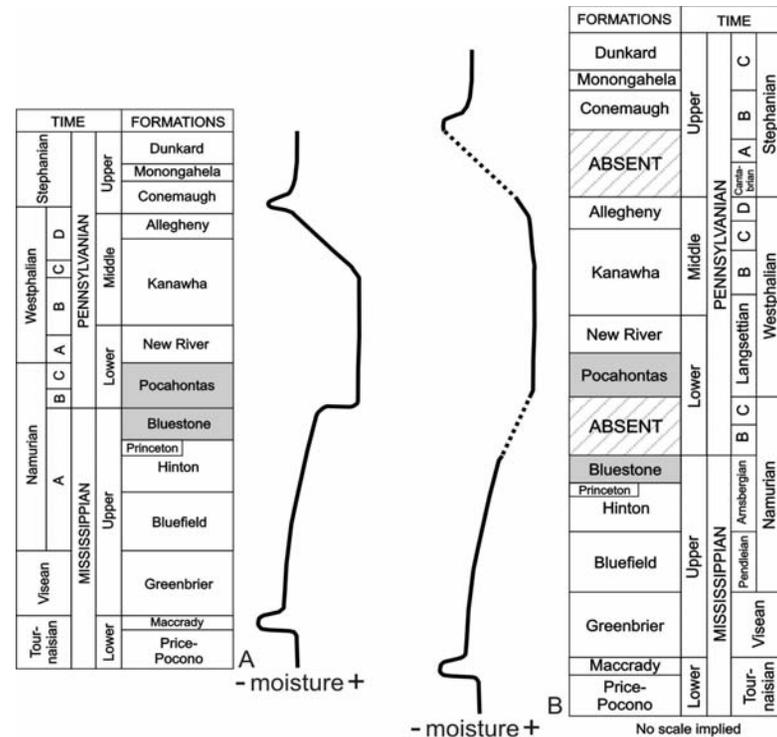
**Informational Meetings**—The Survey routinely host various small to medium sized meetings that target a diverse clientele. These meetings are as diverse as the ESRI Northern WV Users Group meeting, two regional benchmarking workshops on mine maps (participants from AL, CO, IL, IN, KY, ND, NM, NY, OH, TN, VA, WV), and regional meetings for professional societies such as GSA and AAPG. Through the Petroleum Technology Transfer Council program, a joint USDOE/industry sponsored program, the Survey co-sponsored workshops, a website, and an online newsletter to provide information on new technology to oil and gas producers through out the 7 state Appalachian Region.



## SPECIAL REPORT: ANCIENT CLIMATE CHANGE AND SEA LEVEL

**Comparison of Mid-Carboniferous Floras**—Geologist Mitch Blake is participating in a National Science Foundation (NSF)-funded research project to compare mid-Carboniferous fossil plant collections available from eastern Europe and North America to address questions relevant to vegetation responses during onset of a major glacial interval. Since the Carboniferous is the last time in geologic history when there were extensive equatorial rain forests during an ice age, findings of this study are being compared with vegetative patterns of change during the Pleistocene. It is hoped these comparisons will provide insights into the impacts of climate change on vegetation distributions. Mitch presented the results of his part of the study at the annual meeting of the Geological Society of America in Salt Lake City in October, 2005 and Philadelphia in October, 2006. The October, 2005 presentation has been accepted for publication and Mitch is currently preparing the 2006 presentation for publication.

Besides the benefits of increased understanding of vegetative evolution and distribution patterns during the Carboniferous, the work provides the opportunity to heighten public awareness of the severity of climatic oscillations recorded during an earlier period of earth's geologic history and the implications for the present day. W.H. Gillespie, paleobotanist, is also a cooperating scientist on the project. Lead investigators are Dr. H.W. Pfefferkorn of the University of Pennsylvania and Dr. R. Gastaldo, Colby College. Below are several interpretations of paleoclimate changes that occurred during the Carboniferous. The curve on the left is an older interpretation based on suggestions of continuous deposition during the late Mississippian and Pennsylvanian in the Appalachian region. The curve on the right is a reinterpretation of the rapidity of climate change and discontinuous nature of sedimentation that resulted from the identification, using plant fossils, of a substantial hiatus across the Mississippian-Pennsylvanian boundary.



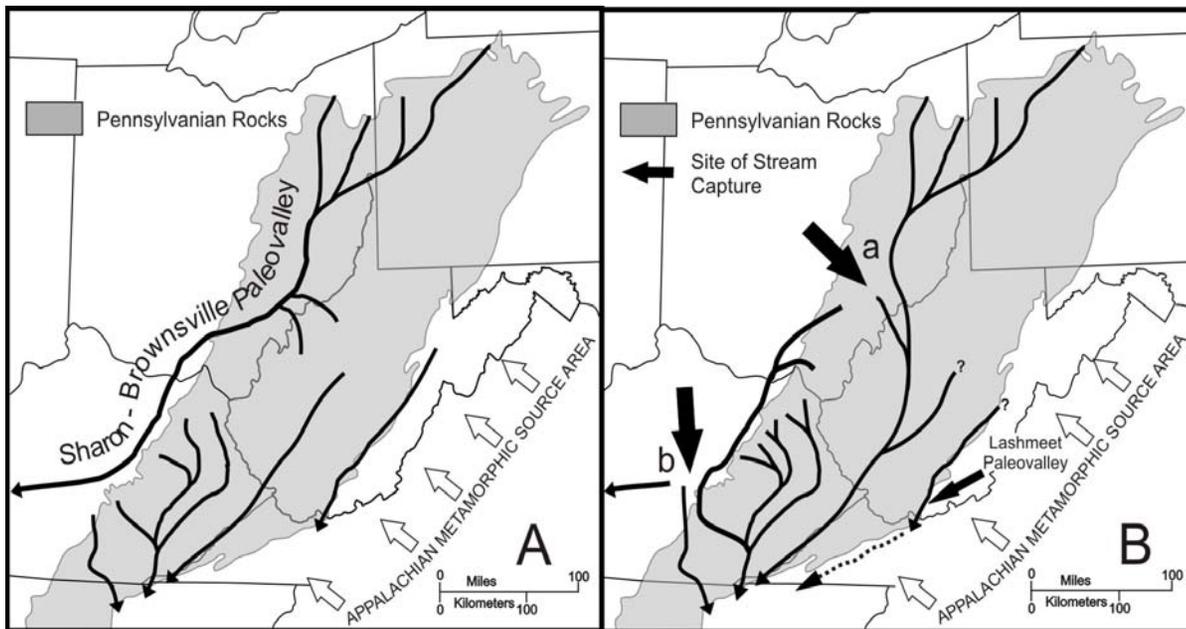
**Figure 2. Paleomoisture curve for the Carboniferous of the Appalachian region. The left curve assumes a conformable Mississippian-Pennsylvanian boundary and postulates a geologically instantaneous climate change from semi-arid/monsoonal to the tropical everwet climate of the Early Pennsylvanian. The curve on the right reinterprets the paleomoisture curve, in light of the substantial unconformity associated with the mid-Carboniferous eustatic event.**

**Deciphering the Mid-Carboniferous eustatic event in the central Appalachian region, in: Resolving the Late Paleozoic Ice Age in time and space (Geological Society of America Special Paper)**

A prominent unconformity, present across shallow shelf areas of the Euramerican paleoequatorial basins, is used to demark the boundary between the Mississippian and Pennsylvanian (Miss-Penn) subsystems. This unconformity, the mid-Carboniferous eustatic event (MCEE), is generally attributed to a major glacio-eustatic sea-level fall. Although a Miss-Penn unconformity is recognized throughout most of the Appalachian region, the record of the MCEE in the structurally deepest part of the basin has been controversial. Based on early reports suggesting the most complete Pennsylvanian section is present in southern West Virginia, various conceptual depositional models postulated continuous sedimentation between the youngest Mississippian Bluestone Formation and the oldest Pennsylvanian Pocahontas Formation. In contrast, tabular-erosion models envisioned axial drainage systems that evolved in response to changing basin dynamics (Figure 3 below). These models predicted a Miss-Penn unconformity. All these models suffered from a lack of biostratigraphic control.

The presence of a sub-Pocahontas paleovalley, herein named the Lashmeet paleovalley, has been confirmed in southern West Virginia. The Lashmeet paleovalley was incised over 35 m into Bluestone strata and filled by lithic sands derived from the Appalachian orogen to the northeast and east (Figure 4, page 11). The polygenetic Green Valley paleosol complex marks the Bluestone-Pocahontas contact on associated interflues. Together, these features indicate a substantial period of subaerial exposure and argue strongly in favor of a Mississippian-Pennsylvanian unconformity. Paleontologic data from the Bluestone Formation, including marine invertebrates and conodonts from the marine Bramwell Member and paleofloral data, support a late, but not latest Arnsbergian age assignment. Marine fossils are not known from the Pocahontas Formation, but macrofloral and palynomorph taxa support a Langsettian age for most of the Pocahontas (Figure 5, page 12).

The sum of biostratigraphic, sedimentologic and paleogeographic data support the presence of an Early Pennsylvanian (middle to late Namurian) disconformity in the Appalachian basin that corresponds to the MCEE.



**Figure 3. Paleogeography of latest Mississippian (map A) and earliest Pennsylvanian (map B) fluvial drainage systems.**

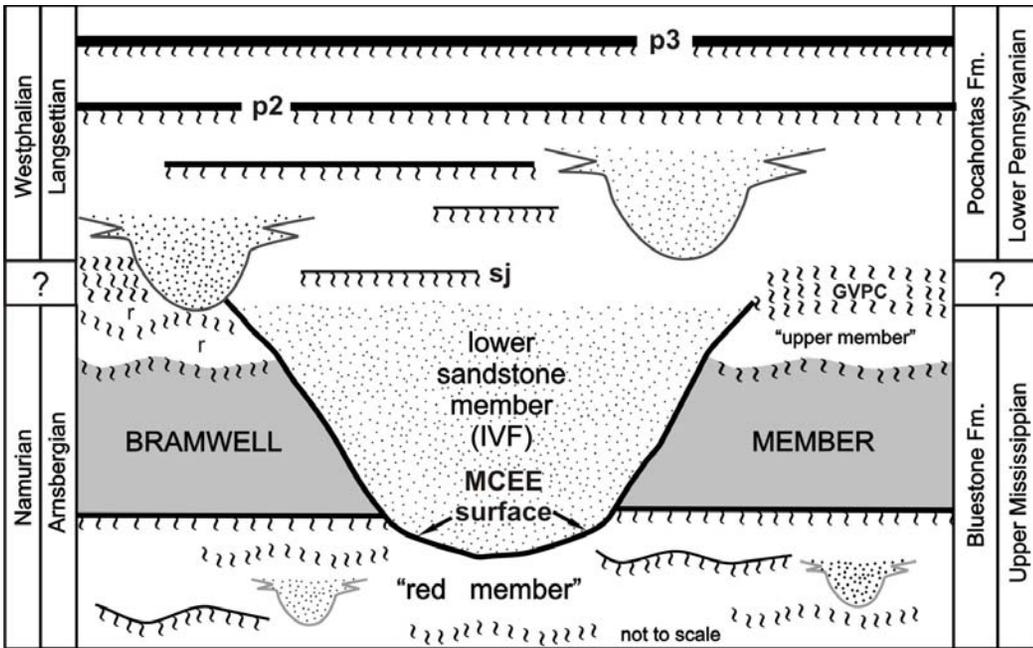
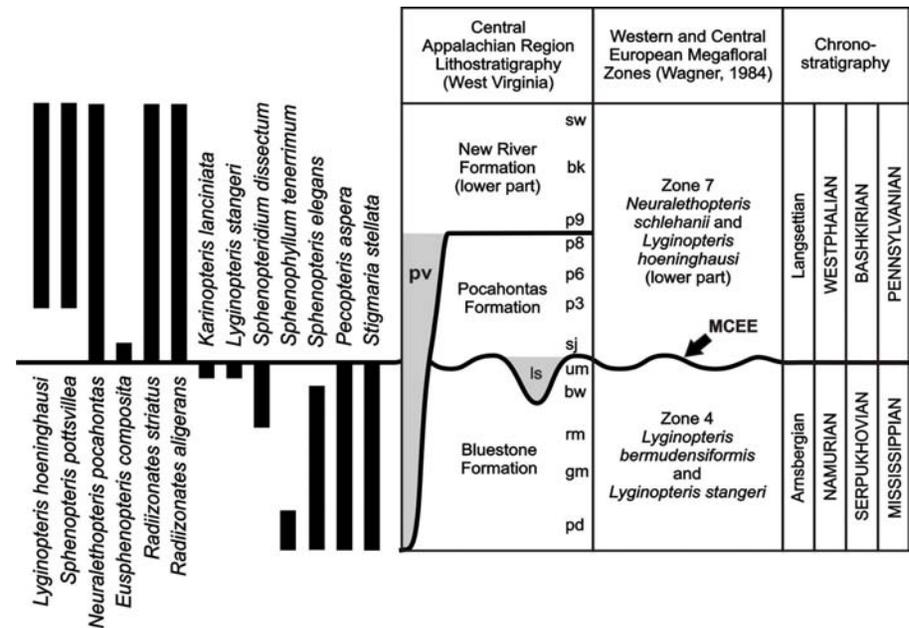


Figure 4. General model of the Mississippian-Pennsylvanian unconformity in southern West Virginia. The lower sandstone member fills the Lashmeet paleovalley that was incised into the Late Mississippian (Serpukhovian) landscape during the mid-Carboniferous eustatic event (MCEE). The polygenetic nature of the GVPC precludes a precise age assignment. Abbreviations listed in Fig. 5.

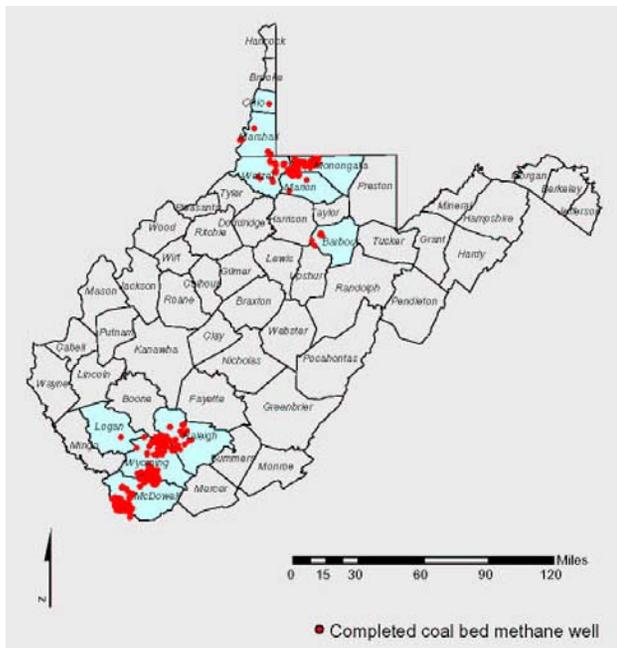
Figure 5. Ranges of selected paleofloral species showing nearly complete taxonomic turnover across the Bluestone-Pocahontas formation contact, herein correlated with the mid-Carboniferous eustatic event (MCEE). Macrofloral data are from Mitch Blake's work and palynomorph data were provided by Cortland Eble (Kentucky Geological Survey). Bluestone Formation: Pd-Pride Member; gm-gray member; rm-red member; bw-Bramwell Member; um-upper member; Pocahontas Formation: ls-lower sandstone member of Englund, 1968; sj-Squire Jim coal; p3-Pocahontas #3 coal; p6-Pocahontas #6 coal; p8-Pocahontas #8 coal; New River Formation: pv-Pineville Sandstone; p9-Pocahontas #9 coal; bk-Beckley coal; sw-Sewell coal. Stratigraphy as used by West Virginia Geological and Economic Survey. Not to scale.



## Coalbed Methane

Coal bed methane (cbm) production and drilling has continued to increase. As of September 2006, records for over 725 wells had been received by the WVGES (Figure 1). Production continues to increase as well, with calendar year 2006 production totaling nearly 19 billion cubic feet (Bcf) of gas (Figure 2). Most of the activity to date has been in southern and northern West Virginia; however, in the spring of 2006, several wells were permitted in Clay County in addition to more wells in Barbour County. Production includes post-mining gob gas or coal mine methane, pre-mining de-gasification of coals using a multilateral horizontal drilling system, vertical fractured wells, and simple horizontal wells. The WVGES website has available downloadable files containing data for individual CBM wells.

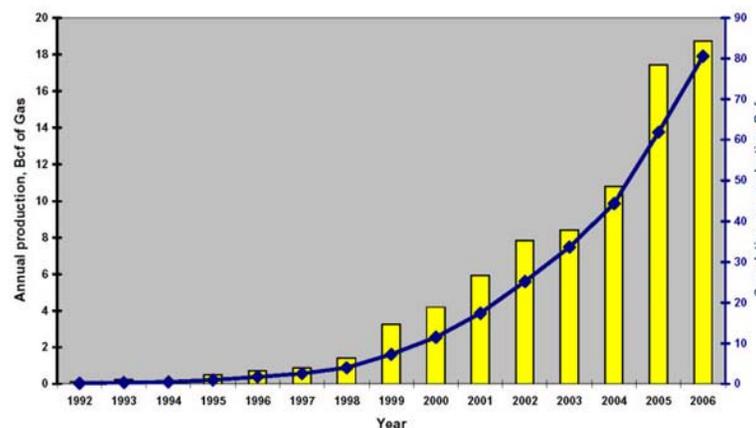
**Figure 1. West Virginia Coal Bed Methane Wells.**



## Trenton-Black River

The WVGES completed work on a 2 year contract with the U.S. Department of Energy to create a regional play book for the Trenton-Black River limestones in the Appalachian Basin. Although nearly 300 wells were permitted to these zones in West Virginia from 1999 through 2004, only about

## West Virginia CBM Gas Production



**Figure 2. Annual and Cumulative CBM production for WV; total 80.6 Bcf of gas; 2006 production >18.7 Bcf.**

10% of the permitted wells were drilled. Cumulative production from the WV wells is about 10.1 Bcf through 2005. Even with this additional deep drilling, there are still large parts of West Virginia that are not well-explored at depths below a few thousand feet. The final product of this study, a play book for the Trenton-Black River in the Appalachian Basin, is now available on a DVD from the U.S. Department of Energy (DOE). An article highlighting the study appeared in the DOE/Gas Technology Institute's Gas Tips magazine.

<http://www.netl.doe.gov/technologies/oil-gas/publications/GasTIPS/GasTIPS-Summer06.pdf>

## Devonian Shales

Recent developments in shales in other basins have inspired renewed interest in West Virginia's Devonian shales, both the traditional Lower Huron and Rhinestreet shales in southwestern West Virginia as well as the deeper Marcellus Shale in other parts of the State. New horizontal drilling and well stimulation technologies have helped to encourage new drilling and evaluation programs in these shales. A PTTC workshop on Devonian shales was well-received and a proposal for a new Devonian shale research consortium was presented at this workshop by D.G. Patchen.

A cooperative project supported by the U.S. Geological Survey to update summary Devonian shale production data contained in an earlier study performed for the Gas Research Institute (now the Gas Technology Institute) was initiated.

### Technology Transfer

The Appalachian Region Petroleum Technology Transfer Council (PTTC) continued to provide timely workshops on a variety of topics to a broad range of attendees. Funding for this program from the U. S. Department of Energy was zeroed out in early 2007, so considerable effort was expended to identify other sources of funding and implement a new model for the program. Since its inception in 1996, the Appalachian Region PTTC has hosted over 100 workshops with over 5,000 registrants, maintained a website including an interactive mapping capability for key wells, produced a newsletter, and provided technical expertise to many independent oil and gas producers throughout the Appalachian Basin. Workshop topics during this year included hydraulic fracturing, acquisitions and divestitures, explosives safety, reservoir engineering for geologists, hydrothermal dolomites, well log interpretation, and Devonian Shale plays

### Carbon Dioxide Sequestration

West Virginia has the potential for storage or sequestration of carbon dioxide in various zones below the surface (Figure 3). The WVGES is part of the geologic sequestration team for the Midwest Regional Carbon Sequestration Partnership (MRSCP). The MRSCP is one of seven regional partnerships established by the U.S. Department of Energy. Battelle Memorial Labs in Columbus, Ohio is the prime contractor for the MRSCP. The Ohio Geological Survey is the lead agency for the geologic sequestration team. As part of the Phase 1 MRSCP efforts, a large amount of basic geologic data was compiled at a regional scale in digital form. Many of these data had not previously been compiled in such a way; these data are useful for applications beyond identifying zones with potential for geologic carbon sequestration. The data can be used for oil and gas exploration and an improved understanding

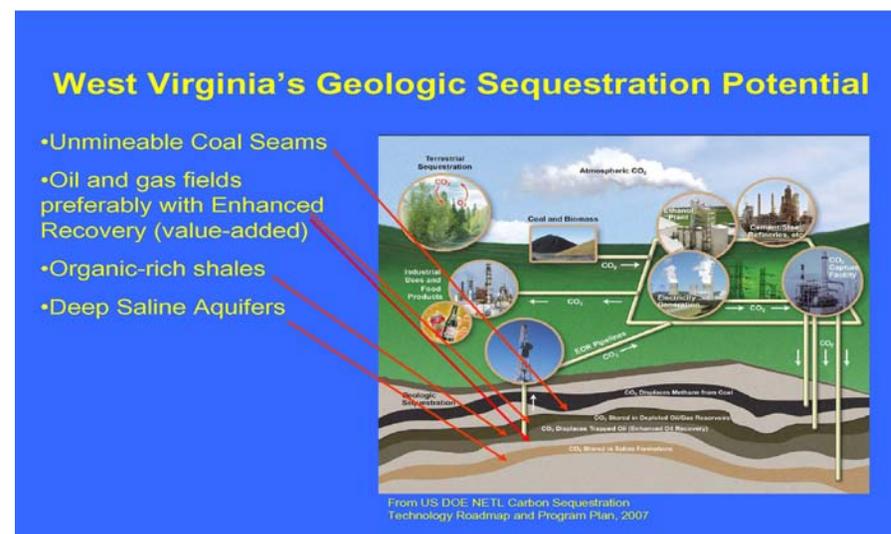


Figure 3.

of subsurface geology. During the year, work continued on Phase 2, which includes more detailed characterization of selected intervals identified during Phase 1, as well as some pilot tests throughout the region. West Virginia oil and gas well data were compiled in the area of a pilot test well drilled at the R. E. Burger power plant, south of Wheeling, in Belmont County, Ohio.

K.L. Avary worked with Jeff Herholdt of the West Virginia Development Office to provide data on potential carbon sequestration zones to various companies evaluating potential West Virginia locations.

Douglas Patchen is serving on a task force to examine issues associated with regulations and permitting for potential CO<sub>2</sub> sequestration activities. This task force organized by the Interstate Oil and Gas Compact Commission is supported by the U.S. DOE. The goal is to produce a set of model regulations which can be modified to fit a particular state's needs. The IOGCC formally approved the report during their May 2007 meeting and distributed it to the appropriate state regulatory agencies.

## Improving the Availability and Delivery of Critical Information for Tight Gas Resource Development in the Appalachian Basin

This three-year U.S. DOE-sponsored project, begun in fall 2005 in cooperation with the Pennsylvania Geological Survey, will provide ready public access to well-specific and region-wide data and interpretations of those regional data. The project will allow gas producers to advance their understanding of the nature of six significant, regional, tight gas accumulations in the central Appalachian Basin. The improved understanding of these reservoirs will enable expanded resource recoverability through more cost-effective exploration of new areas, and more efficient infill drilling and recompletion programs in existing fields.

This project will provide easier access to scanned wireline logs, digitized wireline logs, production data, core analysis reports, digital photographs of cores, scanned maps and cross-sections, and related data on tight gas plays through an interactive website. Wireline logs are being scanned and database entries are being updated for use in system queries.

Two main objectives to this project are:

*Collect a broad range of data* and information in public records and published sources and convert it to digital format. The work concentrates on the Lower Mississippian/Upper Devonian Berea/Murrysville play and the Upper Devonian Venango, Bradford, and Elk plays in Pennsylvania and West Virginia, the Lower Silurian "Clinton"/Medina play in Pennsylvania, and the Lower Silurian Tuscarora Sandstone play in West Virginia. Scanning of wireline logs, digitizing of logs, database updates, data quality assessment, digital core photography and digital conversion of relevant maps are currently on-going.

*Design and implement an on-line, interactive digital and geospatial website* that consolidates a broad range of existing information about tight gas reservoirs, and has the potential to be extended to any tight gas reservoir in the future. This website will include scanned images of logs, photomicrographs of thin-sections, digital photographs of core slabs, selected basic well data,

and digital regional maps and cross-sections. Development of this website is underway.

## Zero Emissions Research and Technology (ZERT)

Researchers at Montana State University created a DOE-funded ZERT Center to develop a comprehensive approach to the measurement, monitoring, migration and risk assessment of geological sequestration of carbon dioxide. This approach includes fundamental studies of geophysical and geochemical investigations of CO<sub>2</sub> with formation waters and reservoir lithologies, and development of new monitoring methods, as well as strategic use of suites of methods, parameterization of potential leakage/seepage mechanisms and assessment of reservoirs relevant to these mechanisms.

Montana State assembled a research team consisting of scientists from Los Alamos National Laboratory, Lawrence Livermore National Laboratory, and West Virginia University, among others. The WVU team includes members from the National Energy Technology Laboratory, the West Virginia Geological and Economic Survey, and the Departments of Petroleum & Natural Gas Engineering, Civil & Environmental Engineering, and Geology & Geography. The task assigned to the WVU Research team is to determine the feasibility of sequestering carbon dioxide in Appalachian coal beds.

The WVU-NETL-WVGES researchers organized their effort into four subtasks: computational modeling and visualization; determination of key physical data; a structural integrity investigation; risk assessment; and a cost effectiveness investigation. Drs. Thomas Wilson and Douglas Patchen are cooperating on the first part of the structural integrity subtask, which is to conduct geophysical monitoring and subsurface characterization of storage and seal intervals. Part two of this subtask, structural integrity modeling, is being conducted by Dr. Hema Siriwardane.

Initially, geophysical studies, subsurface characterization and structural integrity modeling were focused on the coal-bearing interval overlying the Granny Creek oil field in Clay County. However, during 2006 we explored the potential of collaborative efforts with a gas company and a large coal company that produces natural gas from coal beds. Although the gas company declined our offer, eventually we were able to enter into an agreement with the coal company to conduct MMV-related research activities associated with their enhanced CBM project that will involve injection of CO<sub>2</sub>.

Consol Energy has drilled multiple horizontal laterals in the Pittsburgh and Upper Freeport coals in Marshall County. Some of the laterals will become production wells, whereas others will serve as CO<sub>2</sub> injection wells. Consol plans to produce natural gas from both coals, and to inject CO<sub>2</sub> into the Upper Freeport coal, which will not be mined. Once ECBM from the Upper Freeport ceases, the injected CO<sub>2</sub> will remain as a long-term sequestration project.

The WVU research team, of which WVGES is a partner, will conduct characterization studies of the reservoir, develop computational models and predict the structural integrity of the CO<sub>2</sub> storage reservoir. The research team also will develop and implement field methods to monitor possible CO<sub>2</sub> emissions from the site.

Field studies planned for the 2007-2008 contract year include the drilling, logging and coring of three observation wells through the Upper Freeport coal; drilling 30 shallow wells in which to install tiltmeters; drilling three shallow water wells to monitor drinking water quality from subsurface aquifers; and collecting water from streams to monitor surface water quality. Background data in each of these areas will be collected prior to injection of CO<sub>2</sub>. Monitoring will continue throughout the injection period.

In addition, 2-D surface seismic data will be collected over the injection laterals to assist in the subsurface geophysical characterization of the sequestration site.

### **Digital Conversion of Maps**

The WVGES contracted the WV GIS Technical Center to scan, georeference and digitize several WVGES published maps that are useful for many applications including oil and gas exploration. These maps at the 1:250,000 scale are the Aeromagnetic Map, the Landsat Linear Features Map, the Fracture Trends in the Allegheny Plateau, and the Bouger Gravity Map. The 1:500,000 scale maps of Structural Countours on the top of the Ordovician and the top of the Newburg were also converted.

A series of landslide maps at the 1:24,000 scale were scanned and georeferenced.

The digital files for these maps are available from the GIS Technical Center website. K.L. Avary coordinated this effort.

### **Support for Graduate Student Research**

Proposals were solicited from graduate students for support for thesis or dissertation research in West Virginia. Proposals from 3 students were selected for funding. The projects were “Cyclic Sedimentation in the Pride Shale and Implications for Appalachian Basin Geometry and ITCZ Migration in the late Paleozoic,” “Stratigraphic and Facies Heterogeneity within the Princeton Formation,” and “Inference of Base Level and Paleoclimatic Fluctuations in an Upper Mississippian Fluvial Succession.” K.L. Avary coordinated this process and served as the point of contact with the students.

### **Basic Oil and Gas Data**

As part of the WVGES mission to archive and make available basic data on the State’s mineral resources, work continued on the Oil and Gas database. Scanning of plats and well records continued during the year using the new photocopy/scanner machine. In addition, scanning of wireline logs continued, supported largely with funding from the U.S. Department of Energy.

A large donation of cores from the old U.S. Bureau of Mines Reservoir Evaluation Program was moved to the WVGES core and sample library. A broken water faucet caused extensive damage to the laboratory portion of the core and sample warehouse, necessitating replacement of ceiling and wall panels by a contractor. Lou Curkendall assisted in the repair efforts.

Several hundred well logs were obtained from the WVU Geology and Geography Department prior to the department’s move to Brooks Hall.

### **Research Partnership to Secure Energy for America**

The new DOE-funded Research Partnership to Secure Energy for America was up and running in FY 2007. To promote this new organization and the opportunities for Appalachian producers and research entities to become involved with them, RPSEA requested that we organize and host an Oil & Gas Forum in February at NRCCE. Our role was to invite speakers, develop the technical program, advertise the forum to attract attendees from industry, and prepare a summary evaluation.

We also agreed to assist RPSEA by serving on one of their Advisory Boards, specifically for the Small Producer Program. The duties of our representative will include reading and grading all proposals submitted under this plan, meeting with the entire Board to recommend which proposals should be funded, and assisting RPSEA with writing future Requests for Proposals that fit the needs of Appalachian producers.

### **Outreach**

- K.L. Avary and R.R. McDowell supervised a summer intern from Concord University.
- K.L. Avary served as faculty advisor for the West Virginia University American Association of Petroleum Geologists Student Chapter.
- K.L. Avary and R.R. McDowell conducted a field trip in Pendleton and Highland counties for a group of oil and gas industry geologists interested in Devonian shales.
- K.L. Avary wrote a brief article for the “One Delegate’s Voice” column in The Delegates’ Voice, newsletter of the American Association of Petroleum Geologists House of Delegates.
- K.L. Avary wrote an article on “West Virginia’s Oil and Natural Gas Reserves: Present and Future” for a special issue of The State Journal coordinated by the West Virginia Oil and Natural Gas Association.
- D.G. Patchen continued to participate in the Visiting Geologist Program of the AAPG.

## GENERAL GEOSCIENCE PROGRAM

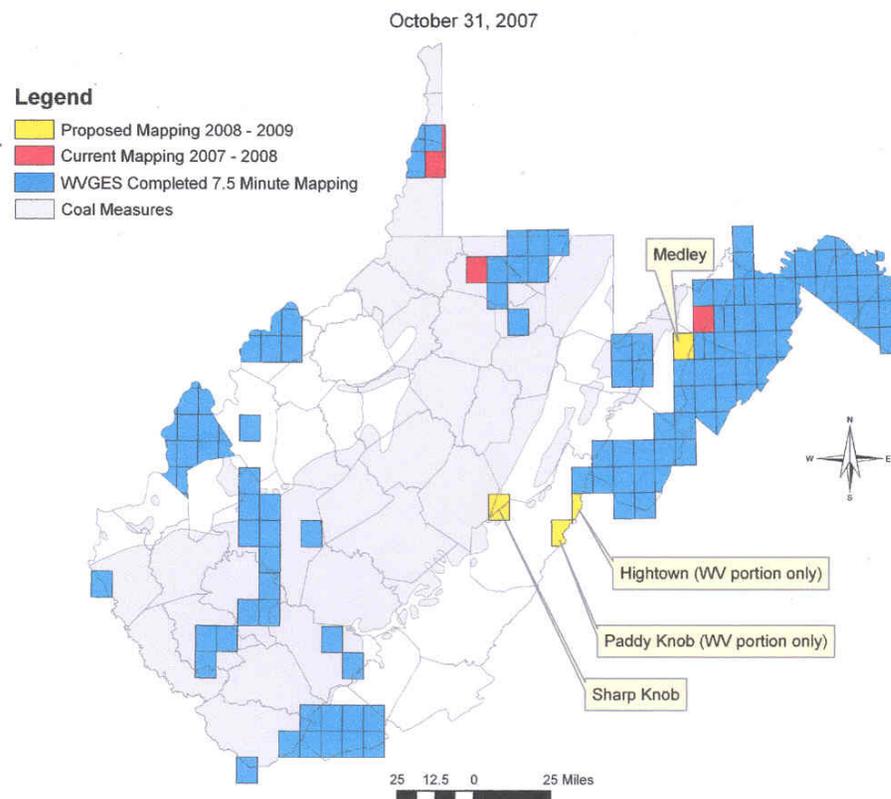
The General Geoscience Program includes: Advanced Geoscience Research, Economic Minerals Geoscience, Environmental Geoscience, Geologic Mapping, and Geoscience Education.

### Geologic Mapping

A primary activity of the General Geoscience Program is geologic mapping and the creation of new 7.5-minute geologic quadrangle maps. Status of mapping is shown in Figure 1. During FY 2006-2007, mapping efforts were carried out in the eastern panhandle, in the northern panhandle, and in north-central West Virginia as part of U.S. Geological Survey's annually-funded, competitive grant STATEMAP Program. The purpose of the STATEMAP Program is to produce high-quality, 7.5-minute quadrangle maps of West Virginia's geology. Completed mapping projects for FY 2006-2007 were submitted in July. Two mapping projects were proposed and successfully funded for 2007-2008, and work commenced on three new quadrangles.

Senior Research Geologist R.R. McDowell, Geologist and Program Head K.L. Avary, and Geologists J.Q. Britton, J. E. Lewis, and P. J. Hunt completed the open-file geologic maps of the Milam and Cow Knob (Pendleton County, WV-Rockingham County, VA) 7.5-minute quadrangles. These maps lie astride the West Virginia-Virginia border and WVGES geologists mapped the Virginia portion of both quadrangles as part of a cooperative agreement with the Virginia Division of Mines and Mineral Resources. Cooperating geologists S.L. Dean and B.R. Kulander completed mapping of the Headsville (Mineral and Hampshire counties) 7.5-minute quadrangle and began mapping the Burlington (Mineral and Hampshire counties) 7.5-minute quadrangle. Geologist G.H. McColloch, Jr. and Geologist/Hydrogeologist J.S. McColloch completed the open-file geologic maps of the West Virginia parts of the Wheeling (Ohio and Marshall counties) and Tiltonsville and Bethany (Ohio and Brooke counties) 7.5-minute quadrangles and began mapping the Mannington (Monongalia and Marion counties), the Valley Grove (Ohio and Marshall counties, WV and Washington County, PA) and the Pennsylvania portion of the Bethany 7.5-minute quadrangles. Mapping the Pennsylvania portion of the Bethany and Valley Grove quadrangles is part of a cooperative agreement with the Pennsylvania Bureau of Topographic and Geologic Survey.

Completed maps and accompanying text and cross section(s) are initially available as an open-file report. Maps of the bedrock geology and other relevant themes are then produced for the final publication. The open-file reports are the first step in becoming formal publications in the Survey's newly developed digital production facility. These projects also produce digital GIS data sets and maps conforming to newly adopted Association of American State Geologists guidelines.



**Figure 1. Status of 1:24,000 geologic mapping by West Virginia Geological and Economic Survey as of October 31, 2007.**

## Other Mapping-Related Projects

• **Digital GIS Map Products Project**—This ongoing, long-term project produces geographic information system (GIS) data sets and digital maps of all West Virginia geologic quadrangles mapped under the federal 1:24,000-scale STATEMAP Project and other mapping projects. Other West Virginia quadrangles mapped under other projects are also slated to be digitized and converted into GIS layers to create a complete digital collection of all geologic mapping at 1:24,000-scale in West Virginia. Line work for all maps is digitized at a scale of 1:24,000. Once this work is completed, attributes are assigned to geologic contacts, faults, and bedding orientations, thus completing the process of providing detailed data for inclusion in West Virginia’s growing 1:24,000-scale GIS database. This digital map conversion process results in Digital Geological Open-File Map Products that include:

1. GIS shapefiles for layers included in the data model. Layers are named according to feature type and the USGS 7.5-minute topographic quadrangles from which they are drawn.
2. Hardcopy plots of geologic maps when requested by customer.
3. ArcMap map documents (.mxd files) and layer rendering files (.lyr files) are included for the convenience of customers that also use ESRI software, when possible. Not all digitized open-file maps have reached the stage of being published in ArcMap. Some map documents contain fully published map layouts; others only contain cartographically rendered GIS layers.
4. Georeferenced scanned images of USGS topo maps used as the base maps for some quadrangles, when available.
5. Georeferenced scanned images of original geological open-file maps, cross sections, and other source material that may accompany that quadrangle.
6. Open-File Report of Investigations documents that accompanied the original paper map (in Microsoft Word or Adobe PDF format), where possible.
7. A README document containing procedures, metadata, and the GIS data model used by WVGES.

To date, 18 data sets, which include 31 quadrangles, have been completed.

- **Full-Color Map Compilation**—This project produces full-color geologic map publications from recent STATEMAP projects. Maps of 19 quadrangles are currently available.
- **Derivative Map Project**—Geologic data and other information to develop derivative maps are used to aid in the visualization of geologic hazards and other environmentally related aspects in the areas where digital geologic map data are available from the Digital GIS Map Products Project.
- **Digital Archiving Project**—Legacy maps are scanned for preservation and for use with other GIS datasets. Scanning of 156 legacy 7.5-minute USGS Open-File Landslide and Related Feature maps was completed. Scanning and processing of 25 legacy 7.5-minute 24K WVGES Open-File Geologic maps, cross sections, and other documents was completed, and several of these were also georeferenced.
- **USGS Winchester 100K Map Project**—This project provided quality assurance and quality control of the digitized GIS files for 28 West Virginia 7.5-minute geologic quadrangles submitted to USGS for inclusion in the Winchester 100K Map.

## Geoscience Education

Geoscience education is another major component of the General Geoscience Program, and it is nearly half-way through its second decade of providing professional development “teacher experiences” to West Virginia’s kindergarten through 12th-grade (K-12) science teachers. The cumulative number of provided “teacher experiences” since 1992 now exceeds 8,000. (One professional development “teacher experience” represents outreach and assistance in the form of a time-intensive workshop, field trip, professional presentation and/or publication opportunity for a single teacher.) These contacts have resulted in the indirect transfer of Survey and geological knowledge awareness to more than 200,000 classroom students in all 55

counties. Outreach to a broader audience has been accomplished, to date, by the completion of 24 peer-reviewed publications and numerous professional presentations. In 2006, the 12<sup>th</sup> I.C. White Earth Science Educator was awarded.

The program's goals are to increase awareness of earth science in general, the Geological and Economic Survey in particular, and to create a better understanding of the role geology plays in our state's past, present, and future. Using teachers as a vehicle to reach young citizens, the Survey's work and products are only one step removed from general public use. To

accomplish these goals, educators are trained and provided experiences that can be translated into classroom-useful activities and lessons. The Geoscience Education Program cooperated with Fairmont State University and the Educator Resource Center at the NASA IV and V Facility to provide 56 teachers with a series of Project GLOBE workshops funded by the West Virginia Higher Education Policy Commission. Another group of 18 teachers were provided with training on fossils and dinosaurs through a co-operative program with the Carnegie Museum. These projects were a direct result of Geoscience Education Program general revenue funding which provided matching funds available to secure the grant.



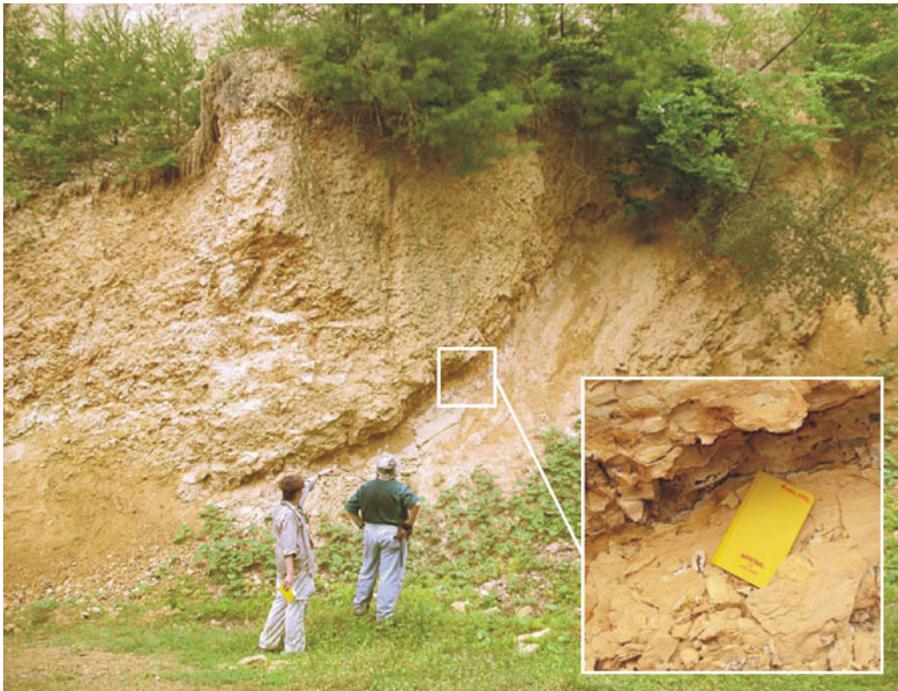
**Sandstones and shales of the Greene Formation of the Dunkard Group are exposed in large excavations during the construction phase of the new Highland Complex near Triadelphia in Ohio County. These outcrops have since been leveled, and fast food restaurants now occupy the area.**



**A landslide partially blocks the Short Creek Road north of Clinton in Ohio County. The area is underlain by rocks of the Monongahela Formation.**

## Data Collection

Activities associated with the General Geoscience Program's service and research require continuous collection and analysis of significant amounts and types of data. Databases for limestone, springs, geochemical analyses of rock samples, maps, and geographic information are maintained. Additional information and materials are available for nonfuel minerals, geologic hazards, map information, and a host of other topics that fall within the expertise of the program.



(Above) WVGES geologists examine an unusual claystone layer at the base of the Devonian Shriver Chert south of Dorcas, WV. Inset shows a closeup of the same layer. Chemical analysis of this unit suggests that it contains volcanic ash.  
*(Photo by Paula Waggy)*

## Service

The General Geoscience Program responds to service requests from industry, government, the general public, and academia. As the responsibilities of the program are to address all geologic and geographic matters not directly related to West Virginia's fossil-fuel resources, the scope of service activities is quite diverse. These areas of expertise fall into these general categories:

- Economic Minerals (limestone, dolomite, sandstone, sand and gravel, clay and shale, salt, peat, etc.).
- Environmental Geology (flood hazards, landslides, karst geology, radon, seismicity, etc.).
- Water (ground- and surface-water hydrology, water resources, water supply, water quality, water use, springs, etc.).
- Geoscience Education (teacher experiences and related topics).



(Right) WVGES geologists examine an exposure of Devonian Oriskany Sandstone south of Dorcas, WV in Grant County. The Oriskany here is fractured but has been recemented with quartz. *(Photo by Paula Waggy)*

## Geographic Information System (GIS) Program

The West Virginia GIS Technical Center provides focus, direction and leadership to users of geographic information systems (GIS), digital mapping and remote sensing within the State of West Virginia. The WV GIS Technical Center (WVGISTC) was established under Executive Order No. 4-93 in November 1993, which specified that the Technical Center should provide technical support services to support the development and operation of GIS in West Virginia.

Objectives of the Center are to reduce the duplication of GIS data development efforts among organizations; disseminate GIS spatial data, Web map services, mapping applications, and other geographic information free-of-charge through the Internet; coordinate acquisition of new data additions to the West Virginia Spatial Data Infrastructure; assist with strategic planning, development and implementation of GIS and mapping guidelines statewide; provide advisory services and training programs in GIS; and conduct research and provide education towards improvement of geographic information technologies in West Virginia.

### Build and Disseminate State's Spatial Data Infrastructure

The WVGISTC supports digital data conversion, data development, and coordination with federal geospatial data initiatives, statewide mapping programs, and local (county, municipal) data producers. Data clearinghouse at <http://wvgis.wvu.edu//data/data.php>

**SAMB Base Layer Development:** Center collaborates with the Statewide Addressing and Mapping Board (SAMB), USGS, and other partners to create a value-added, high resolution 1:4800-scale digital base map for West Virginia. Elevation, transportation, streams and administrative map layers benefit mapping in the entire state community; government, private and non-profit.

### National Hydrology Dataset (NHD)

- Initiated development of an attributed, linear referenced, 1:4800-scale local resolution hydrography data set for two 8-digit watersheds: Upper Guyandotte (05070101) and Gauley (05050005).

- Validated completeness of 1:4800-scale hydrographic geometry derived from the SAMB project and posted this new stream geographic database on the State Data Clearinghouse.
- Cooperated with USGS and WVU Natural Resources Analysis Center to develop new NHD geo-conflation tools.
- Attended and presented progress and results at the NHD Stewardship conference in April 2007 at Denver, Colorado.
- Received funding from the USGS through Great Lakes-Northern Forest Cooperative Ecosystems Studies Unit.

### National Elevation Dataset

- A value-added statewide grid elevation dataset originating from the SAMB project was made publicly available via file download and Web map services. West Virginia is the first state in the Nation to have complete statewide coverage of 1/9 arc-second (3-meter) resolution digital elevation data as part of the USGS National Elevation Dataset (NED). This accomplishment is a major milestone in the ongoing development of new high resolution datasets for the State of West Virginia and for the Nation, and directly supports the vision of the National Spatial Data Infrastructure (NSDI).
- Created statewide 20-foot contours from the 3-meter grid elevation dataset. Available via FTP download or Web map service.

**Flood Hazard Mapping:** WVGISTC is responsible for the DFIRM (Digital Flood Insurance Rate Map) conversion of 14 counties in northern and eastern West Virginia under FEMA Cooperating Technical Partner (CTP) Agreement No. EMP-2006-GR-3825. In cooperation with FEMA and flood map modernization contractors, WVGISTC created digital flood insurance rate maps to assist in the implementation of a statewide digital flood-mapping program.

**Mass Evacuation Mapping Project:** The WV Department of Military Affairs and Public Safety is funding a project to develop a suite of modeling and simulation tools for the future situational awareness capability and improved preparedness and consequence management capabilities based on realistic estimates of potential impacts of a mass evacuation on the State. The West Virginia GIS Technical Center provided GIS technical support for coordination

meetings with project leaders and participants from WVU, WVAGP, WV Dept of Military Affairs and Public Safety, Johns Hopkins University, and All Hazards Consortium. Determined preliminary assessment of key GIS datasets for mass evacuation mapping. This has involved contacting numerous agencies, including FEMA, Red Cross, West Virginia State Police, WV DMAPS, WV Dept. of Administration, WV Dept. of Education, WV Dept. of Agriculture, WV National Guard, and other agencies.

**Map West Virginia (WV Geographic Information Network):** “MapWV” is a public gateway to online mapping resources in the Mountain State. MapWV comprises Internet services: online map viewers, web mapping services, metadata catalogs, and FTP downloadable services. <http://www.mapwv.gov/>

**Internet Map Service Development:** The WVGISTC assists the Department of Health and Human Resources (DHHR), the Department of Natural Resources, the State Historic Preservation Office (SHPO), the State Flood Insurance Program Coordinator, and other state agencies to create Internet databases and mapping systems for intra-agency and public use.

**DNR Trout Stream Web Application**

- Public access project with custom interface for Trout Streams in WV
- Housing and serving of project for the coming fiscal year and expected beyond

**DHHR Secure Internet Mapping Application**

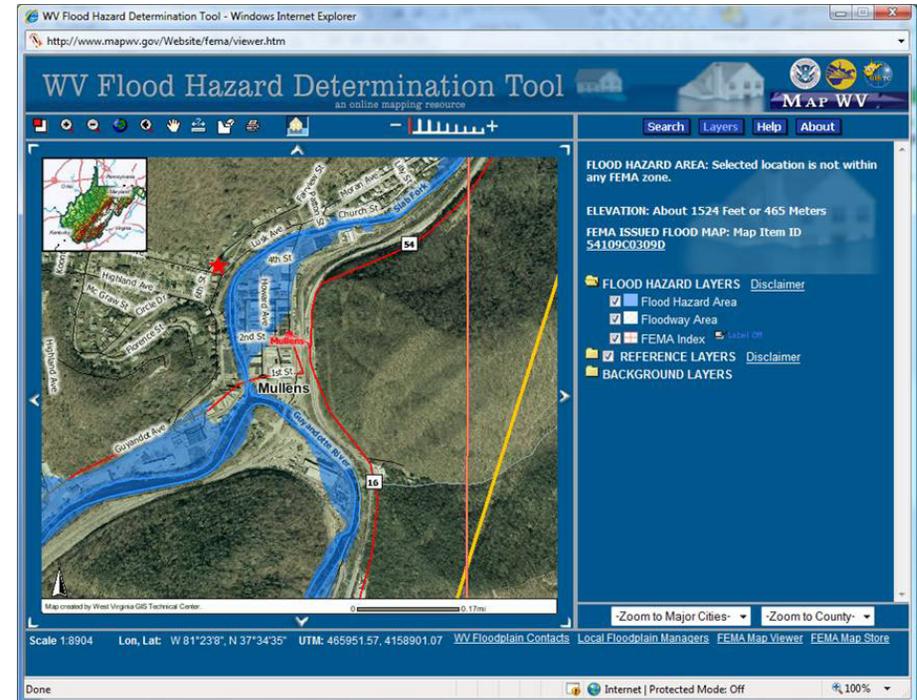
- Creation of secure access to service water areas
- Housing and serving of the project in the coming fiscal year
- Organize and Coordinate the NHD users community for comments and concerns of the current NHD and future Local Res NHD for West Virginia

**SHPO Internet Mapping Application:** Created a prototype Internet mapping application for cultural and archeological resources of the State Historic Preservation Office.

**WV Flood Determination Tool** (Figure 1): Funded by FEMA and the State National Flood Insurance Program Coordinator, this Internet mapping

application allows the public to locate their property and ascertain if they are within or in proximity of any identified flood hazard areas. It provides the user the ability to identify an elevation value at any geographic location using the new statewide high-resolution elevation data which has an accuracy of plus or minus 10 vertical feet. It incorporates the best available reference mapping layers such as the new statewide color orthophotos. For counties where modern digital flood maps are available, it links users to FEMA’s flood insurance rate map library.

**Grade School Internet Mapping Application:** The WVGISTC created a statewide grade school Internet mapping application utilizing Google maps and Web map hosted on WVGISTC map servers.



**Figure 1. The Flood Hazard Determination Tool, an online mapping application, determines if a resident lives in a flood hazard area. WVGISTC created this application for FEMA and the WV NFIP Coordinator. This application is receiving national acclaim from FEMA.**

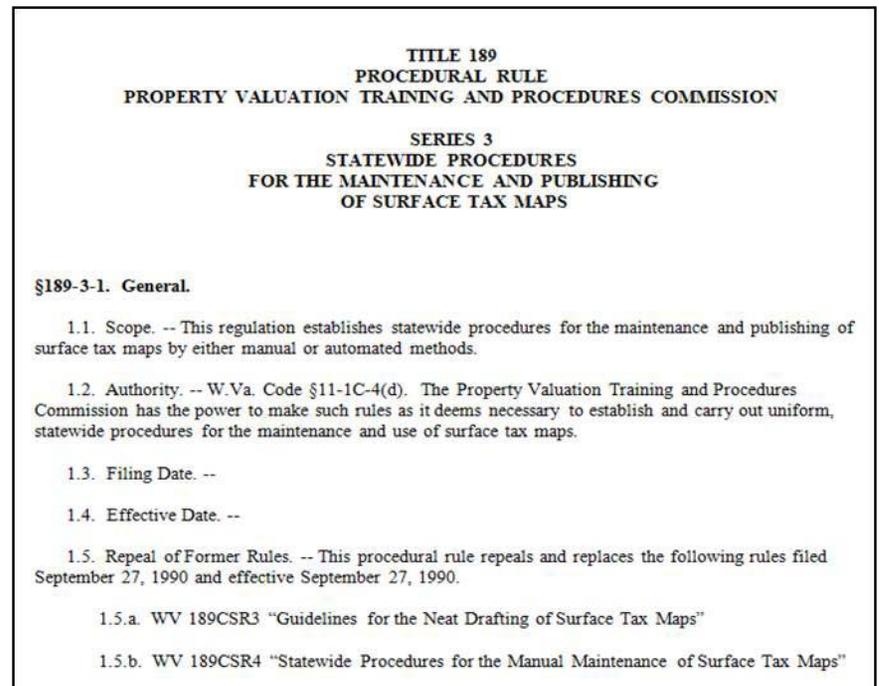
**Strategic Planning:** The WVGISTC assists with strategic planning, development, and implementation of statewide GIS. Coordinates with state, federal, local government and private sector entities to define, refine, and implement the GIS Coordinating Council and State GIS Strategic Plan.

- As part of the Fifty States Initiative, WVGISTC and other state partners received a cooperative assistance program grant from the Federal Geographic Data Committee to create a new GIS coordinating body for West Virginia . This new coordinating body, named the WV Association of Geospatial Professionals (WVAGP), approved bylaws and elected officers in March 2007. WVAGP is interdependent from other coordinating bodies and provides a broad-level representation to include the private sector, academia, and all levels of government.
- WVGISTC and other state partners have begun working on creating a State GIS Plan to replace the 1993 GIS Development plan.
- WVGISTC was the primary drafter of procedural and legislative tax map rules that were approved in May 2007 by the WV Property Valuation Training and Procedures Commission (Figure 2).

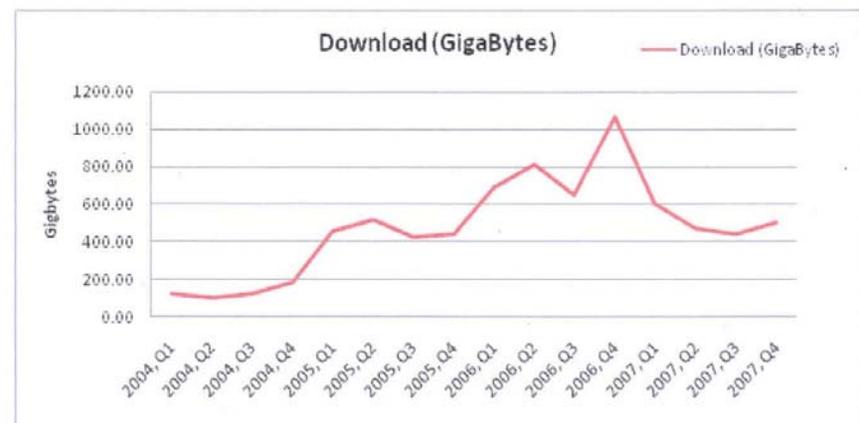
**Technical Support Services:** The WVGISTC provides outreach, educational and training support, and advisory services to the citizens, government agencies, non-profit organizations, and businesses of West Virginia in the area of GIS and related spatial data handling technologies.

**The State Data Clearinghouse** has 250 GIS data sets valued at more than \$50 million dollars. Over 1000 average unique visits/day, 126,124 total unique visitor/year, 1.4 million visitors since 2004, representing a doubling in the average number of visitors /day; total visitors has grown 20% per quarter for last 2 years. 7 Terabytes of data, comprising 2 million files, downloaded since 2004 (Figure 3), and 1.3 Terabytes of data reside on FTP and map servers.

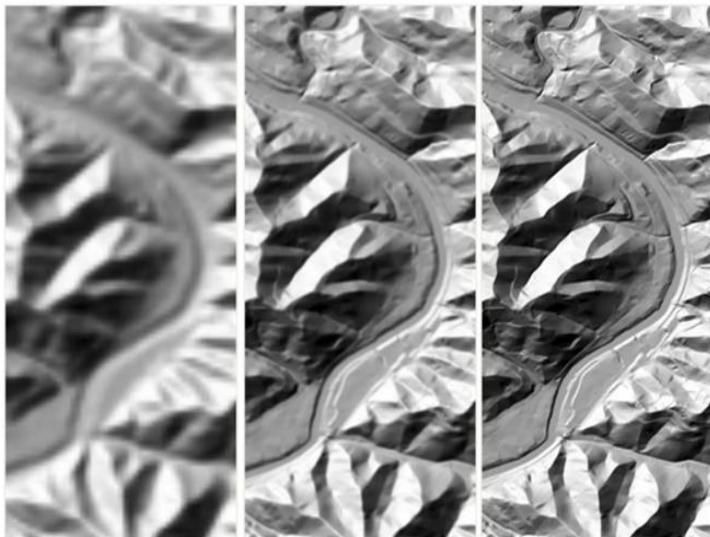
**The MapWV.gov Portal** has been visited by nearly a quarter million people since its inception in early 2006. There have been over 400 average unique visits/day, 60,000 total unique visitor / year, and 270,000 visitors since 2004, representing a 50% increase in average number of unique visitors/day. A gateway to 10 Internet state mapping application, over 30 Web map services allow users to connect to “live” map data.



**Figure 2. Revised tax map standard drafted by WVGISTC for the Property Valuation Training and Procedures.**



**Figure 3. Download of map files in Gigabytes from State Data Clearinghouse.**



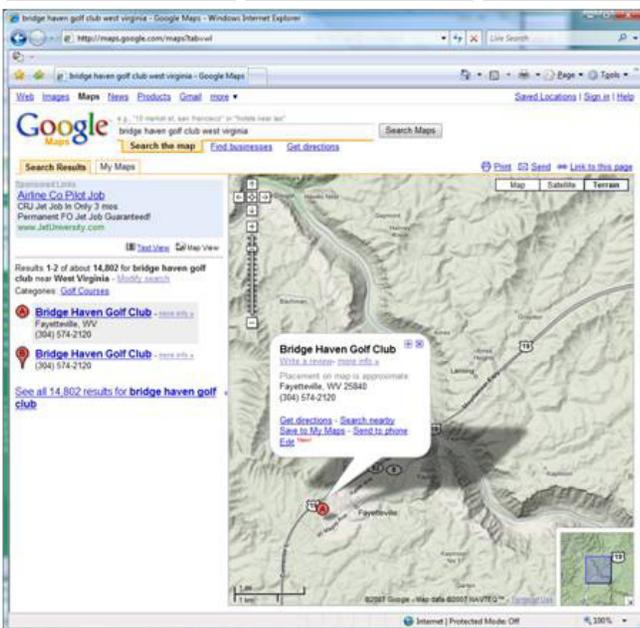
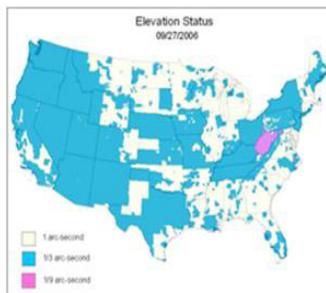
1-arc-second  
(30 meters)

1/3-arc-second  
(10 meters)

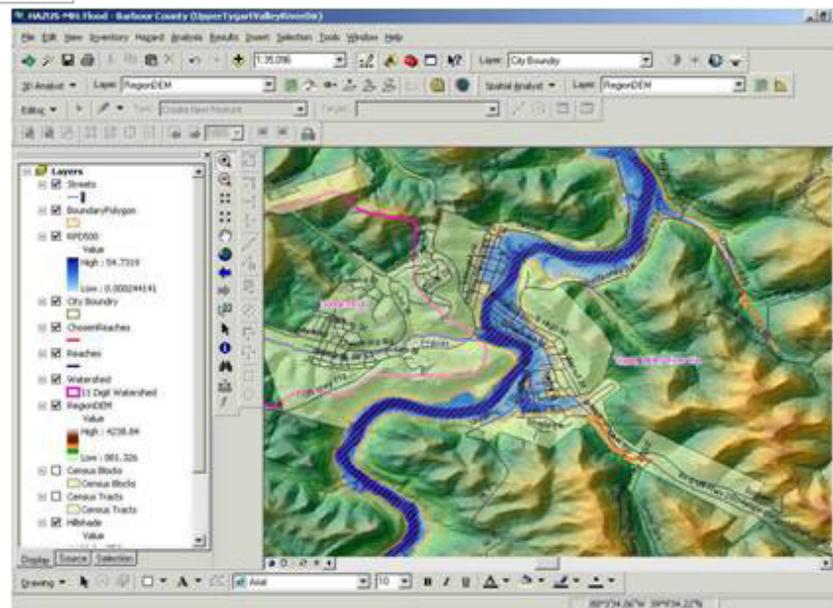
1/9-arc-second  
(3 meters)



WV is the first state in the nation to incorporate high-resolution elevation data into National Elevation Dataset



Data products and applications resulting from the statewide, high-resolution elevation data created by WVGISTC and other partners.



## PUBLICATIONS

- Blake, B. M. J.** (2006). Macrofloral evidence for an unconformity at the Mid-Carboniferous boundary in the Central Appalachian Basin. **Geological Society of America Abstracts with Programs**, vol. 38, n. 7, p. 317.
- Blake, Bascombe M. Jr**, and **Beuthin, Jack D.**, in press. Deciphering the Mid-Carboniferous eustatic event in the central Appalachian region, in: Resolving the Late Paleozoic Ice Age in time and space, C. R. Fielding, T. D. Frank, and J. L. Isbell (eds.), **Geological Society of America Special Paper**.
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- McDowell, R. R., K. L. Avary, J. E. Lewis, J. Q. Britton, P. J. Hunt, P. J. Waggy, and M. E. Ganak, M.**, 2007, Preliminary Bedrock Map of the Milam Quadrangle: West Virginia Geological and Economic Survey Open File Report, OF-0602, 1:24,000 scale.
- McDowell, R. R., K. L. Avary, J. E. Lewis, J. Q. Britton, P. J. Hunt, P. J. Waggy, and M. E. Ganak, M.**, 2007, Preliminary Bedrock Map of the Cow Knob Quadrangle: West Virginia Geological and Economic Survey Open File Report, OF-0603, 1:24,000 scale.
- Patchen, Douglas G.**, 2006, Trenton-Black River Play Overview, Research Summary and Resource Assessment: **American Association of Petroleum Geologists Eastern Section Annual Meeting Program and Abstracts**, p. 15.
- Ryder, Robert T; Swezey, Christopher S; Trippi, Michael H; Lentz, Erika E; Avary, K Lee; Harper, John A; Kappel, William M; Rea, Ronald G.**, 2007, In search of a Silurian total petroleum system in the Appalachian Basin of New York, Ohio, Pennsylvania, and West Virginia,: **U. S. Geological Survey Open-File Report** , OF 2007-1003, 78 pp.
- Stocks, L.**, 2007, A Spatio-Temporal Examination of Land Use Change and Sinkhole Development in an Urbanizing Karst Watershed of West Virginia: 1984-2004. (abstract): **Geological Society of America Abstracts with Programs**, vol. 39, no. 3, p. 4.
- Stocks, L.**, 2007, Image-Object Analysis for Sinkhole Inventory: **Papers of the Applied Geography Conferences**, vol. 30, pp. 447-456

## PRESENTATIONS

**K.L. Avary** gave a presentation on West Virginia Coal Bed Methane drilling and production activity at the North American Coalbed Methane Forum.

**K.L. Avary** gave a presentation on West Virginia Coal Bed Methane drilling and production activity to the Appalachian Geological Society.

**K.L. Avary** gave a presentation on West Virginia Coal Bed Methane drilling and production activity to a class in the Petroleum and Natural Gas Engineering Department at West Virginia University.

**M.C. Behling** gave a presentation on “Developing an Efficient Data Delivery System for Tight Gas Plays in the Appalachian Basin” at a RPSEA oil and gas forum.

**M.C. Behling** gave a presentation on “Delivering Critical Information on Appalachian Basin Tight Gas Plays to Producers” at a meeting of the Appalachian Geological Society.

**M.C. Behling** gave a presentation on “The LogScan Model: A New Approach for Delivering West Virginia’s Data” at the PTTC workshop on “The Digital Revolution: Archive, Organize, Deliver.”

**G.H. McColloch** and **J.S. McColloch** gave a presentation on “Importance of Historical Elevation Data” at the Digital Mapping Techniques’07 Workshop.

**J.S. McColloch** gave a presentation about WV Geological and Economic Survey’s information relevant to source water protection at the 2006 West Virginia Rural Water Association’s 21<sup>st</sup> Annual Canaan Valley Training and Technical Conference.

**R. R. McDowell** gave a presentation, “Ichnofossils” for the Geology Department at the University of Pennsylvania – Johnstown.

**L. Stocks** gave three presentations: “Digitizing Abandoned Coal Mines and Capturing Geologic Data,” at the 2006 West Virginia Regional Mine Map Workshop; “Using ArcGIS to Capture Abandoned Coal Mines,” at the 2006 Southeast Division of the American Association of Geographers Meeting; and “A Spatio-Temporal Analysis of Land Use/ Land Cover Change and Sinkhole Development in an Urbanizing Karst Watershed of West Virginia: 1984-2004,” at the 2007 Geological Society of America Joint North-Central/ South-Central Annual Meeting.

## AWARDS, ELECTIONS, and APPOINTMENTS

- **K.L. Avary** served on the Honors and Awards Committee of the Eastern Section AAPG and served as Chair of the Committee.
- **K.L. Avary** attended the annual AAPG meeting in Long Beach, CA to participate in committee and section business meetings.
- **K.L. Avary** is a member of the AAPG Student Job Fair, Professional Women in Earth Sciences (PROWESS), and AAPG Committee Oversight committees.
- **K.L. Avary** attended the AAPG Leadership Conference in Tulsa, OK.
- **K.L. Avary** is the Eastern Section AAPG Advisory Council Representative and serves as Advisory Council Recording Secretary. Her term ended June 30, 2006 and she chaired a nominating committee to identify candidates for the next Advisory Council Representative from the Eastern Section of AAPG..
- **K.L. Avary** is the delegate elected to represent the Appalachian Geological Society and **D.G. Patchen** is the delegate elected to represent the Pittsburgh Association of Petroleum Geologists in the AAPG House of Delegates.
- **K.L. Avary** served as the Eastern Section representative on the House of Delegates Resolutions Committee. **D. G. Patchen** served as the Eastern Section representative on the House of Delegates Nominations Committee.
- **K.L. Avary** serves on the West Virginia Coal Bed Methane Review Board.
- **K.L. Avary** became an Associate Editor for the AAPG Bulletin E & P notes.
- **M.C. Behling** represents Department of Commerce agencies on the State Information Technology Council. She also serves as secretary of the State's Statewide Internet Group.
- **M.E. Hohn** served as Publications Committee Chair for the International Association for Mathematical Geology.
- **G.H. McColloch** served as Chairman of the AAPG Energy Minerals Division Honors and Awards Committee.
- **G.H. McColloch** served on the North American Geologic Map Data Model (NADM) Steering Committee. The NADM Steering Committee sponsors and facilitates cooperative development of digital infrastructure for geologic map databases, and it works on behalf of the sponsoring agencies to develop products and ideas that can be adapted as agency standards for geologic map databases.
- **G.H. McColloch** served as a member of the joint USGS/AASG Data Capture Working Group. This committee is charged with helping to promote more efficient and useful methods for digital mapping and GIS analysis.
- **G.H. McColloch** helped AAPG GIS Products Committee georeference and start extracting GIS data layers from a global tectonic map in an Adobe Illustrator file donated by Albert Bally, Emeritus Professor, Rice University.
- **G.H. McColloch** reviewed a map entitled: "An Overburden Thickness Model for Lac de Gras and Aylmer Lake, Northwest Territories, Canada" for the on-line Journal of Maps.
- **J.S. McColloch** served as American Association of Petroleum Geologists (AAPG) Division of Environmental Geosciences President 2006-2007 and as an *ex officio* member of the AAPG Advisory Council. She serves on the West Virginia Source Water Assessment/Wellhead Protection Program Review and Liaison Committee and the Appalachian States Coalition for Geological Hazards in Transportation Committee.
- **D.G. Patchen** is the President-Elect for the AAPG Energy Minerals Division. Also, he is chair of the AAPG Domestic Sections Committee
- **D.G. Patchen** represents West Virginia on the Potential Gas Committee, a group funded by the American Gas Association and company donations. He also serves as the Appalachian Basin Chairman for the Potential Gas Committee. During the year, the Potential Gas Committee released a new report which contains estimates of the nation's remaining gas resources and reserves. During the current year, the Appalachian Basin committee reviewed the data for the basin and updated the resources and reserves data for the Trenton-Black River, based on the results of the DOE-funded study.
- **T.R. Repine, Jr.** served as NAGT Eastern Section President 2006 and host for the annual section meeting in Parkersburg. He is an adjunct faculty member at WVU and Fairmont State. He served on the State's Eisenhower Committee to select Presidential Award Teachers.

**WEST VIRGINIA GEOLOGICAL AND ECONOMIC SURVEY STAFF — Fiscal Year 2007**

Michael Ed. Hohn, Ph.D. .... Director and State Geologist  
 John D. May, M.B.A. .... Deputy Director Finance and Administration  
 Craig A. Neidig, M.S.\*\* .....Statewide Coordinator  
 Douglas G. Patchen, Ph.D. .... Geologist V

**ADMINISTRATIVE AND FACILITIES MAINTENANCE**

Gloria J. Rowan, B.S. .... Administrative Service Manager  
 Charles P. Bowman .....Production Assistant  
 Linda C. Carlier ..... Administrative Assistant  
 Louis W. Curkendall .....Maintenance Man  
 Michael A. Kirk, B.S. ....Publication Sales Manager  
 Judith A. Sparks ..... Receptionist/Director’s Secretary

**APPLIED COAL RESOURCES INVESTIGATIONS**

Nick Fedorko III, M.S.\*\* .....Coal Geologist and Manager  
 Bascombe M. Blake, Jr., M.S. ....Coal Geologist and Manager  
 David E. Anderson, B.S.\*\* .....Geologist I  
 Kenneth C. Ashton, B.S. ....Coal Geologist  
 Tayrn A. Bell, B.A. ....GIS Technician  
 James Q. Britton, M.S. ....Geologist IV  
 Michael T. Clifford, M.S. ....GIS Technician  
 William C. Grady, M.S. ....Microscopist  
 Robert J. Johnson, B.S. ....Geologist III  
 David A. Jones, B.S. ....Geologist III  
 Ronald D. Lane, M.S.\*\* .....GIS Technician  
 Paul R. Liston, A.A. ....Engineering Technician/Surveyor  
 Edward I. Loud, B.S. ....Coal Geologist  
 Steven W. McClelland, M.S.\*\* .....Coal Geologist and Manager  
 Darren McConnell, B.S.\* .....Geologist I  
 Barnes L. Nugent, M.S. ....Geologist IV  
 Ledrew Stocks, Jr., M.S.\* .....GIS Technician  
 Jennifer L. Stump, B.S.\* .....Geologist I

**GENERAL GEOSCIENCE**

Ronald R. McDowell, Ph.D. .... Manager and Senior Research Geologist

**Geologic Mapping**

Paula Hunt, M.S. .... Geologist III  
 Ledrew Stocks, Jr., M.S. .... Geologist II

**Environmental Geology**

Jane S. McColloch, M.S., R.P.G. ....Hydrogeologist

**Geoscience Education**

Thomas E. Repine, Jr., Ed.D., R.P.G. ....Education Specialist and Manager

**INFORMATION SERVICES**

Mary C. Behling, M.S. .... Geologist and Manager  
 Susan C. Anderton, B.S.\*\* .....GIS Technician  
 John M. Bocan, B.S. .... GIS Programmer/Analyst I  
 Cheryle A. Boggs, B.S. ....GIS Technician  
 Charles H. Gover, Jr., B.S.\*\* .....Editor  
 Sarah E. Gooding, B.S. ....Geologist I  
 Samatha J. Hawkins, B.S. ....GIS Technician  
 Susan C. Kite, B.S. ....Data Analyst  
 Jeffrey M. Marion, B.S. ....GIS Technician  
 Tara R. Miller, B.A.\* .....Data Analyst I  
 Steven A. Munro, M.S. .... Network Administrator  
 John T. Saucer, B.S. ....Database Administrator  
 Betty L. Schleger ..... Editorial Assistant  
 Susan E. Pool, B.S. ....GIS Programmer/Analyst II

**GIS PROGRAM**

Richard D. Binns, Jr., M.S. ....GIS Database Administrator II  
 John M. Bocan, B.S.\* ..... GIS Programmer/Analyst I  
 Todd Bowman, B.S. ....GIS Technician I  
 Misty L. Cawthern, B.S.\*\* ..... Geologist I  
 Leigh A. Cielensky .....Executive Secretary  
 Gary W. Daft, Jr., B.S. ....Geologist I

\*Transferred within program during year

\*\*Left during year

Sarah E. Gooding, B.S.\* ..... Geologist I  
 Nathan T. Heilmann, B.S. .... Geologist I  
 James M. Horner, B.S. .... Geologist I  
 Robert J. Johnson, B.S.\* ..... Geologist III  
 David A. Jones, B.S.\* ..... Geologist II  
 Tara R. Miller, B.A. .... Geologist I  
 John T. Snider, B.S. .... GIS Programmer/Analyst II  
 Jeanne M. Sutton, B.S. .... Geologist II  
 Brian J. Walker, M.A.\*\* ..... Assistant Editor

**APPLIED OIL AND GAS RESOURCES INVESTIGATIONS**

Katherine L. Avary, M.S. .... Petroleum Geologist and Manager  
 Patricia J. Johns ..... Records Manager  
 J. Eric Lewis, B.S. .... Geologist III  
 Gayle H. McColloch, Jr., M.S., R.P.G. .... Geologist IV

**COOPERATING PERSONNEL**

Robert E. Behling, Ph.D. .... Geologist  
 E. Ray Garton ..... Geologist/Curator  
 William H. Gillespie, M.S. .... Geologist  
 Thomas W. Kammer, Ph.D. .... Paleontologist  
 J. Steven Kite, Ph.D. .... Geologist  
 Philip A. Martin, M.S. .... Geologist  
 Ronald L. Martino, Ph.D. .... Geologist

**PART-TIME EMPLOYEES**

Edwin K. Berry, M.S. .... Geoscience Education  
 Alison L. Behling\*\* ..... Applied Oil and Gas Resources Investigations  
 John D. Beuthin, Ph.D. .... Applied Coal Resources Investigations  
 Jeffrey P. Brusoe\*\* ..... Computing Services  
 Mary Sue Burns, B.S. .... Geoscience Education  
 Stuart L. Dean, Ph.D. .... Applied Geoscience Research  
 Richard J. Diecchio, Ph.D. .... Applied Oil and Gas Resources Investigations  
 Megan Ganak ..... General Geoscience

Debra A. Hemler, Ph.D. .... Geoscience Education  
 Joshua K. Hull\*\* ..... Applied Coal Resources  
 James Ross Kite, B.A. .... Applied Oil and Gas Resources Investigations  
 Byron R. Kulander, Ph.D.\*\* ..... Applied Geoscience Research  
 Marie A. Patchen\*\* ..... Applied Coal Resources Investigations  
 John J. Renton, Ph.D. .... Applied Coal Resources Investigations  
 Adam Simms\*\* ..... Applied Geoscience Research  
 Paula J. Waggy, M.S. .... Geoscience Education  
 Karen A. Walton ..... Applied Coal Resources Investigations

**DIGITAL LINE GRAPH DEVELOPMENT PROJECT  
 West Virginia University Department of Geology and Geography**

Trevor Harris, Ph.D. .... Co-director  
 Gregory Elmes, Ph.D. .... Co-director  
 Kurt Donaldson ..... Senior Research Coordinator  
 Eric Hopkins ..... GIS Analyst  
 Kevin R. Kuhn ..... GIS Analyst  
 Frank LaFone ..... Senior Internet Coordinator  
 Evan Fedorko ..... GIS Analyst

**MINERAL PARCEL MAPPING PROJECT  
 West Virginia Property Tax Division, GIS Development Unit**

Yi-Ning Chen ..... GIS Manager  
 David Bailey ..... Tax Map Technician—Field  
 Robert Barker ..... Tax Map Technician—Office  
 Randy Butler ..... Tax Map Technician—Field  
 Mary Gray ..... Gis Programmer/Analyst  
 Robert Hardman ..... Tax Map Technician—Field  
 Diane Leadmon ..... GIS Unit Office Assistant  
 Leo Muncy ..... Tax Map Technician—Field  
 Norbert Netzel ..... Tax Map Technician—Field  
 Ron Oxley ..... Tax Map Technician—Field  
 Craig Wanless ..... Tax Map Technician—Field  
 John Wright ..... Tax Map Technician—Field

\*Transferred within program during year

\*\*Left during year



(Left) Brooke, Jackson, and Preston County teachers enrolled in a Rock-Camp/GLOBE workshop, hosted by the National Radio Astronomy Observatory, take field notes while interpreting the sequence of geologic events in a highway roadcut in Pocahontas County.



(Right) Teachers and 8th grade students from Brooke County trying to decipher the Pottsville Sandstone of Coopers Rock State Forest with the assistance of the WVGES Education Specialist.



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