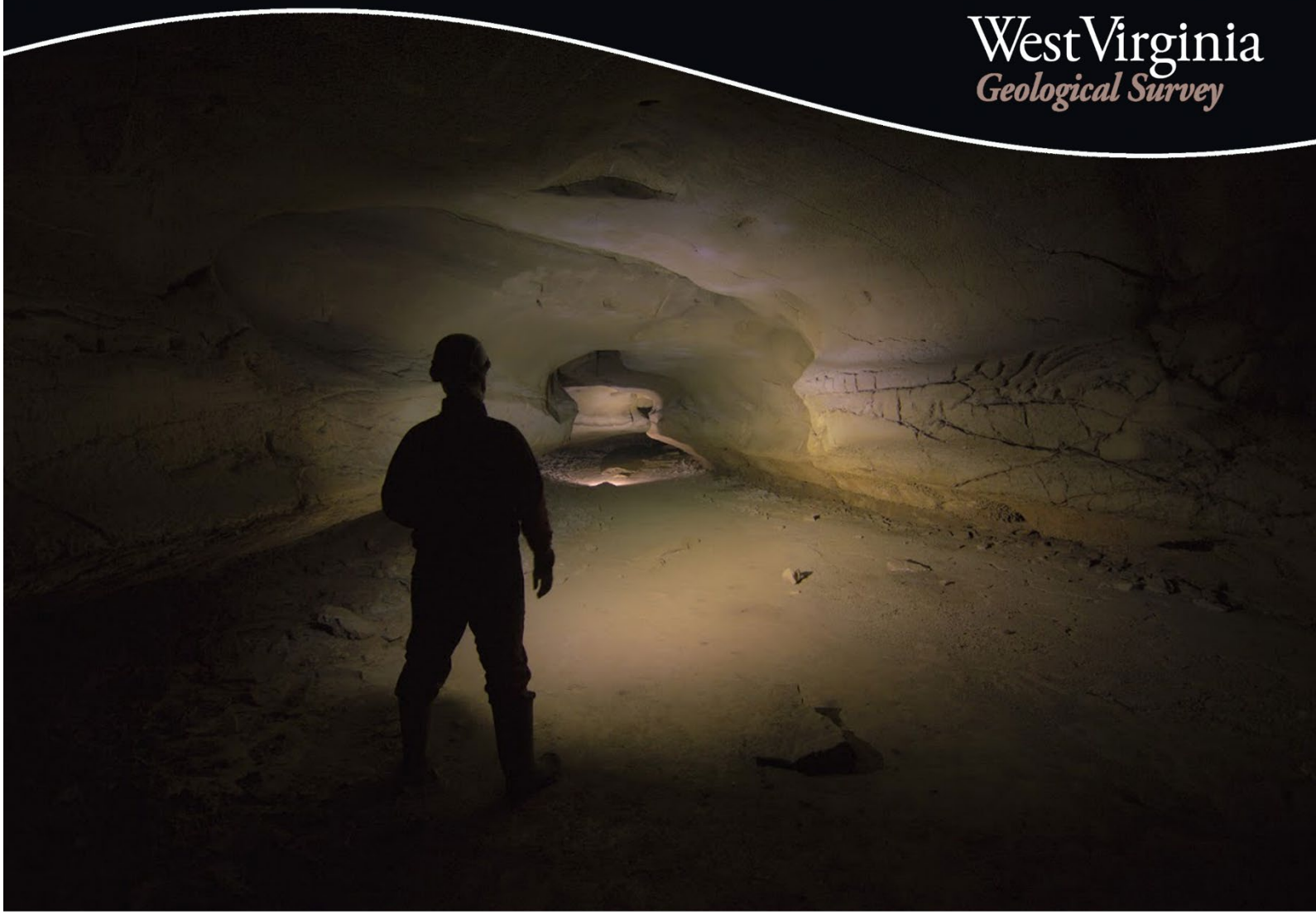
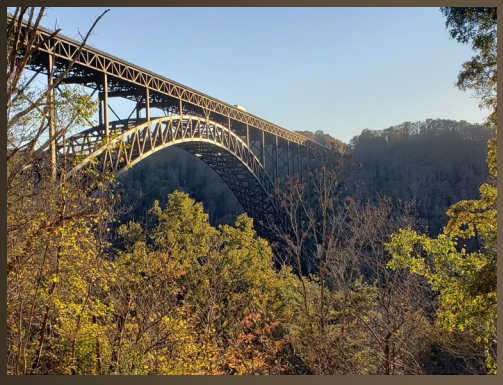
West Virginia
Geological Survey



2020 ANNUAL REPORT



West Virginia

WEST VIRGINIA

Cover Photos

Top: Poor Farm Cave, Pocahontas County
(Photo by WVGES Geologist J.W. Perkins)

Inset: New River Gorge Bridge, Fayette County
(Photo by WVGES Geologist J.W. Perkins)

A misty morning at Mont Chateau, home of the
West Virginia Geological and Economic Survey

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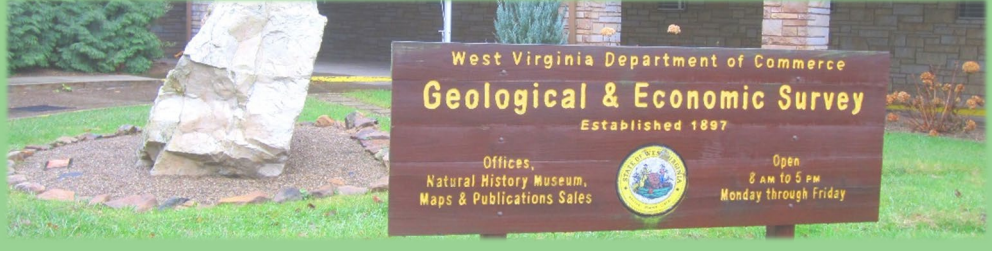
WVGES
West Virginia Geological and Economic Survey

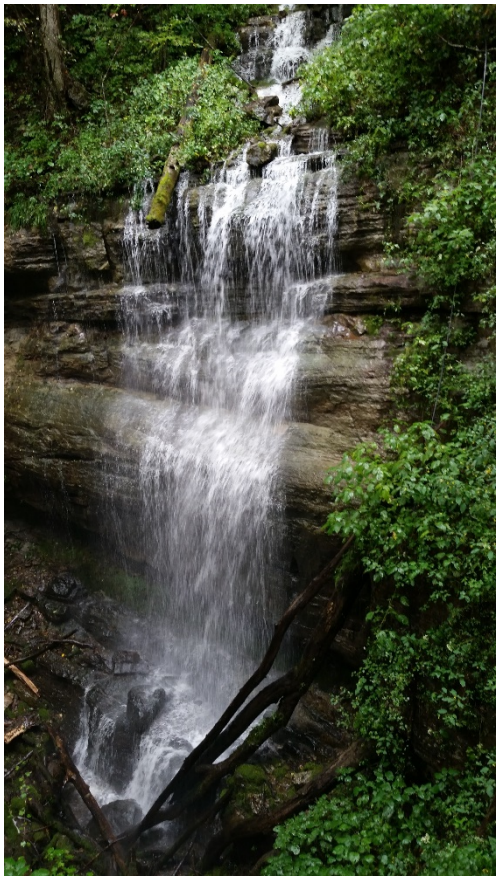


Sign at WVGES office

EXECUTIVE SUMMARY

B. Mitchel Blake, Jr., Ph.D., Director and State Geologist

The Mission of the West Virginia Geological and Economic Survey is to conduct long-term, independent and unbiased analysis of the geological resources of the state, especially coal, oil, and gas, and to provide expertise, information, and scientific knowledge to the citizens of West Virginia regarding geological resources and the environment through direct contact, publications, and web-based applications.



I am pleased to present this report on the WV Geological and Economic Survey's (WVGES) efforts to support the citizens of West Virginia. As I sit here at my desk during late fall, I am struck by how fast things can change in a few months. The current fiscal year started well enough. Other than temporary discussions about budget cuts early in the year, things moved along well. Field work continued, investigations on using mine pools for pump storage or geothermal energy production began, and our normal work continued, as discussed by the various Managers in this report. Coal production was down, as were natural gas prices, but the State's economy performed well. State revenues stabilized, relieving downward pressures on WVGES' budget and allowing us to continue to provide much needed maintenance to Mont Chateau, the Survey's spectacular home. Besides continuing routine painting and repairs, we saw our vulnerable electrical lines buried as well as newly installed fiber optic lines! No more power interruptions due to trees inconveniently falling across the lines.

The only existential danger the WVGES faced this year is what I termed the "Boomer Bust." Approximately 30% of WVGES staff was planning to retire between October, 2019 and late 2020. The Survey has lost approximately 400 years of institutional knowledge in approximately two years. This includes myself as I am planning on retiring at the end of 2020. With all that, I think now is a good time to list some of the Agency's accomplishments for the past four years. This is not to show what a great director I am, rather to demonstrate what a great staff the WVGES has and all the value-added benefits the Agency brings to all the citizens of the State. While the following seems long, it is not, by any means, comprehensive. As I say farewell after 42 years, I wish the WVGES and all the citizens of West Virginia the best and to say what a pleasure and honor it has been to serve for so long.

Fault in the Alderson Limestone along Route 39, Pocahontas County

Project-specific research includes over $432,850 in Federal funding and $491,150 in private industry or nonprofit funding to conduct directed research at no additional cost to the taxpayers of West Virginia. Project highlights over the past four years include:

- The Virgin Hyperloop Certification Center study determined the geologic and geographic feasibility of various proposed sites for developing this cutting-edge mode of transportation
- Appalachian Storage Hub Study identified geologically feasible locations for safe and accessible ethane storage; completed for the Benedum Foundation and 13 industry partners (AEP, Antero, Blue Racer, Charleston Area Alliance, Chevron, Dominion, EQT, First Energy, Mountaineer NGL Storage, Noble Energy, Southwestern, XTO Energy, and WVONGA).
- Earth MRI Critical Mineral Reconnaissance identified potential sources of critical minerals, especially rare earths; funded by United States Geological Survey (USGS)
- Mine Pool Geothermal Study mapped the availability of water-flooded mines to serve as low-carbon energy sources; produced for the WV Office of Energy
- Broadband POWER Grant identified Broadband availability in 10 coal-impacted counties (Boone, Clay, Lincoln, Logan, McDowell, Mingo, Nicholas, Wayne, Webster, Wyoming); in conjunction with the Development Office
- STATEMAP Bedrock Mapping projects furthered geologic mapping in the state, partially funded by the USGS
- The State GIS Coordinator (WVGES) assisted the Secretary of State's Office on the Geo-Enabled Elections project in conjunction with WVGES personnel.
- The State GIS Coordinator (WVGES) was instrumental in advancing the acquisition of State-wide, high resolution elevation data (LiDAR) through the USGS and FEMA

Coal research includes the ongoing collection and integration of mine maps and data from industry and sister agencies, such as Miners Health, Safety and Training, but also includes new and novel research into the potential for critical mineral enrichment in Pennsylvanian coal measures. Coal Program highlights include:

- Coal FIRST research grant (2020) designed to deploy modular coal-fired power generation with onsite Carbon Capture Utilization and Storage capabilities.
- Mine Pool Geothermal Study (2019)
- U.S. Department of Energy Rare Earth Element Feedstock Characterization Study (2018)
- Ongoing Coalbed Mapping Program data compilation and conversion
- High-resolution scanning of large-format historical mine maps in partnership with WV Office of Miner's Health, Safety and Training
- Brokered a cooperative work agreement between WVGIS Tech Center and WV Property Tax Division to develop a novel and low-cost procedure to capture mineral parcel polygons
- Worked with industry representatives to advance new underground mine projects

Stony Gap Standstone, Trout Quadrangle

Natural Gas and Petroleum research utilizes data and knowledge gained from the unprecedented rise of Appalachian shale gas exploration and production and distributes information via the WVGES website to a variety of stakeholders and members of the public. Oil and Gas Program highlights include:

- Physical samples (rock core and drill cuttings) requested by the agency and submitted in compliance with **WV Code 22-6-22**. Recent acquisitions (2020) include the first Utica/Point Pleasant core samples from the active drilling fairway
- Natural Gas Liquids (NGL) Resource Assessment Desktop Study (2018)
- Appalachian Storage Hub Project (2017)
- Conasauga Shale Research Consortium (2019-present)
- Tracking of Marcellus, Utica, "Upper Devonian" and Rogersville shale drilling activity
- Maintenance of the Oil and Gas Wells database, interactive mapping applications and "Pipeline" data portal

Non-fuel resource research leverages knowledge gained from bedrock mapping and subsurface exploration studies to investigate alternate sources of energy for the Mountain State. Research projects include:

- Mine Pool Geothermal Project (2020)
  - *Explored potential for pump storage in areas with stacked mine voids; expanded a 2012 mine pool study to identify mined area prospects for low-temperature geothermal resources. Funded by the WV Office of Energy in conjunction with U.S. DOE*
- Deep Direct-Use Geothermal project (2019)
  - *Evaluated potential use of the Tuscarora Sandstone as a low-temperature geothermal reservoir for the WVU Evansdale Campus. Funded by U.S. DOE*
- Earth MRI Critical Mineral Reconnaissance (2020)
  - *Geochemical reconnaissance study to evaluate critical mineral potential of clay-rich strata associated with coal beds. Eight-state cooperative coordinated by WVGES and funded by the USGS*

Environmental concerns are addressed in a variety of research topics, including bedrock mapping in areas of known karst and investigation of Carbon Capture, Utilization, and Storage potential in the Appalachian basin.

- Karst Area Mapping
  - *White Sulphur Springs quadrangle, Greenbrier County (2018), Edray and Hillsboro quadrangles, Pocahontas County (2019) and Denmar, Lobelia and Woodrow quadrangles, Greenbrier, Pocahontas, and Webster Counties (2020)*
- Midwest Regional Carbon Sequestration Partnership (MRCSP) (2003-2019)
  - *Long-standing partnership with Battelle Memorial Institute to evaluate opportunities for Carbon Storage and CO2 enhanced recovery of hydrocarbons from depleted reservoirs. Funded by U.S. Department of Energy*
- Midwest Regional Carbon Initiative (2020)
  - *Follow-on to the MRCSP. Expands study area to include a 21-state region and includes infrastructure analysis and stakeholder engagement activities*
- Geologic Quadrangle mapping:
  - *Parsons and southern portion of Saint George Quadrangle, Tucker County (2017), Kingwood and Terra Alta quadrangles, Preston County*

Sandstone Falls, Hinton, WV

Geologic hazards are a constant threat to the health and safety of West Virginians, and research to characterize these hazards includes:

- Landslide susceptibility studies in conjunction with the WV GIS Tech Center
- Description of underground mining for mine subsidence insurance
- Landslide potential study for a proposed pump-storage project near Davis, WV

All of these tasks would be impossible without ***Spatial Analysis and GIS*** capabilities. Over the past four years, directed GIS research has been conducted in the following areas:

- Geo-Enabled elections for the Secretary of State's Office
- Mineral Parcel Digitization in Conjunction with WV GIS Tech Center
- Appalachian Regional Commission Broadband POWER grant
- Coordination with Broadband Enhancement Council
  - *biannual FCC Form 477 data conversion for multiple years; geographically enabled survey form; conversion of 2014 Broadband data*

Geoscience Education and Outreach activities aim to captivate and inspire future generations of geoscientists in Appalachia and beyond. WVGES publications are utilized by a variety of stakeholders and scientific peers. Recent education and outreach activities include:

- GeoCamp (2018 – present)
  - *High school students from throughout the U.S. can receive scholarship money to attend a geoscience-focused STEM camp outside of Morgantown. Activities include hiking in Coopers Rock, caving, and whitewater rafting. Conducted in conjunction with the U.S. Geological Survey and Adventure WVU.*
- Geologic Transect (2019)
- Geological Society of America and AAPG Field trips along Corridor H and associated WVGES publications, FTG-9 and FTG-10
- Virginia Virtual Field conference (2020)
- Acquisitions and additions to the WVGES mini-museum
  - *Read our 5-star reviews on Google!*
- Seventeen new or revised publications, including Reports of Investigations *RI-34 STATEMAP geochemical data compilation* and *RI-35 Lithostratigraphy of Middle and Upper Devonian Organic-Rich Shales in West Virginia*
- Annual compilation and publication of the Oil and Gas Wells Database

Water sinkpoint near the top of the Union Limestone, Pocahontas County

COVID-19 highlighted the importance of ***Information Technology***, website access and maintenance, and staff connectivity. IT applications are essential and ubiquitous in the geosciences, and WVGES IT staff have made major strides in the past four years, including:

- Developing and expanding remote work capabilities
- Acquiring and putting into operation new desktops and laptops
- Upgrading infrastructure, including a buried fiber optic connection with WVNET
- Advancing processing capabilities for LiDAR datasets
- Updating mining information and providing access to the data through web site and file transfers
- Continuously updating CBMP and Oil and Gas well permit and completion data

Geographic Information Systems Program is responsible for planning, organizing, coordinating and delivering high level Geographic Information Systems (GIS) advice to agencies in state government; it is headed by the State GIS Coordinator, employed by WVGES and based in Charleston.

- The program continues to make headway in a number of critical areas: promoting data sharing between agencies; providing technical assistance to state, county, and local government and the public; and fostering efficient and effective use of the state's geospatial capabilities.
- State GIS Coordinator provided support and gave advice to the Division of Homeland Security, Division of Emergency Management, Department of Environmental Protection, the Water Development Authority, Infrastructure and Jobs Development Council, the National Guard, the WV Intelligence Fusion Center, Hazard Mitigation section, and other state, regional and local agencies in their search for GIS contract services, funding, and GIS application development.
- A feasibility study for the provision of GIS services to communities with less than 5000 inhabitants is underway. This study is derived from the State Senate's Concurrent Senate Resolution 61.
- The WVGES Office of GIS Coordination cohosted GIS conferences, meetings, and other activities around the state.
- The State GIS Coordinator participated in the National Emergency Number Association's (NENA) GIS Data Stewardship for NG9-1-1 Workgroup. The documents developed by this group outline the development of a nationwide address spatial data infrastructure.

Highland Scenic Highway Overlook, Pocahontas County

Preserving the State's Collections happens in many different ways, but special importance is placed on rescuing physical collections at risk of loss and updating paper collections into digital formats for wider distribution. Collection curation projects include:

- National Geological and Geophysical Data Preservation Grant (2017, 2019, 2020)
  - *Effort focused on cataloguing and barcoding oil and gas cuttings and core, photographing physical cores, rescuing physical samples at risk due to loss from poor storage conditions, scanning physical data to digital data and serving these data to the public. Funded by the USGS*
- Industry Data Donations
  - *Thousands of geophysical logs in paper and digital format donated by several major and independent operators; historical well records; physical samples. A large number of coal exploration drill logs donated by industry.*

Our People are WVGES' greatest asset, and staff members work diligently to collect, process, and analyze the State's geological data and distribute information to the public. WVGES has faced the "Boomer Bust," as long-time public servants, representing over 30% staff loss in a little over a year due to retirement. This represents the irreplaceable loss of over 400 years of detailed institutional knowledge. Fortunately, this loss is being mitigated by the recent hiring of several new, highly-educated, and motivated staff members, thereby ensuring the continuation of robust geologic research in the Mountain State.

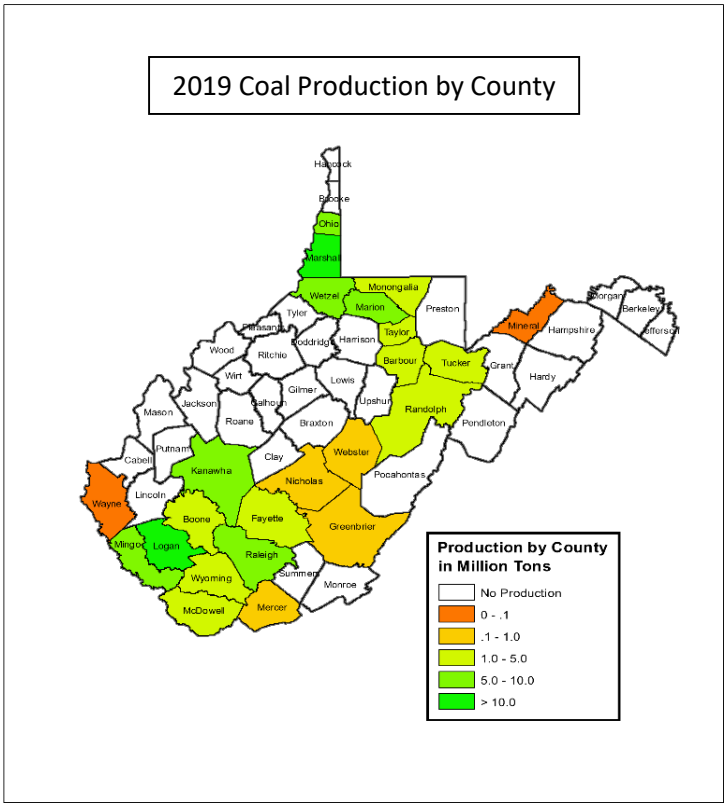
Geologists examine a coal bed in the field

COAL RESOURCES PROGRAM

FY2020 was a year of challenges as well as a year of continued progress for the Coal Program. Retirement of three long time tenured employees in the Coal Program resulted in a loss of over 120 years of institutional knowledge which can never be replaced. The loss of tenured employees punctuated with the challenges of operating during the COVID-19 pandemic created new and difficult hurdles to overcome. Our responsibilities remained the same, even with the challenges presented by remote working and social distancing, and we were still able to accomplish our work thanks to our great IT staff.

Coal Bed Mapping

Coal production in West Virginia continued to decline from a high of 165 million tons in 2008, decreasing to 104 million tons in 2018 and ending at around 100 million tons in 2019. Regardless of reduced mining the importance of a reliable, accurate, and up-to-date database of mined and mineable coal for environmental, safety and property tax valuation purposes is essential. This GIS mapping project provides citizens, businesses and government agencies access to a vast array of coal related data.

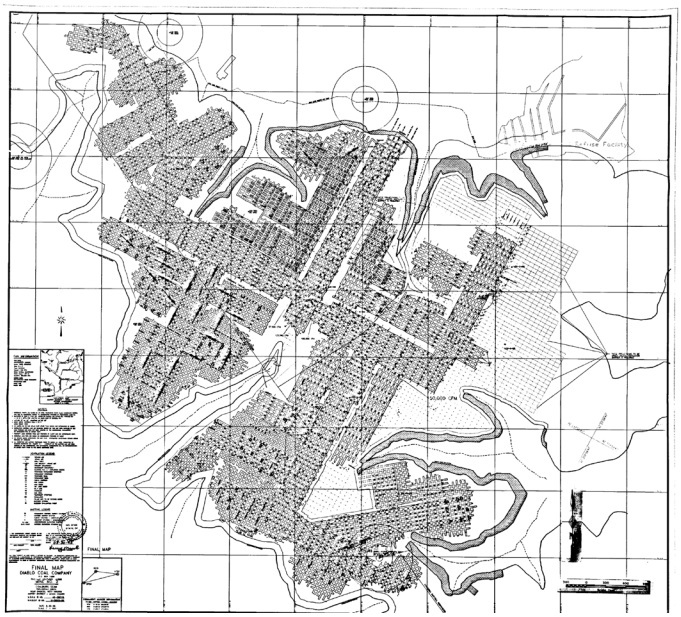


The Coal Bed Mapping Project (CBMP) is a multiyear program working to update and map all mineable coal beds in West Virginia. Various data are incorporated into a GIS-based data model containing mapping of 85 coal seams and associated splits. The feature classes for each coal seam include study area, outcrops, mined and remaining coal differentiated by mining method, structural contours, and associated grids showing total seam thickness, total coal thickness, percent partings, and overburden. All data are served to the public via the Survey's website at:
http://www.wvgs.wvnet.edu/www/coal/cbmp/coalims.html

The majority of the state has been mapped but WVGES constantly receives new data, requiring periodic updates datasets from industry, WV Property Tax Division, and the Office of Miners Health Safety and Training in order to keep current. A few problem areas remain where sparse data do not allow confident correlations but field observation by State Map project mapping should help resolve issues identified by GIS.

Underground Mine Mapping Project

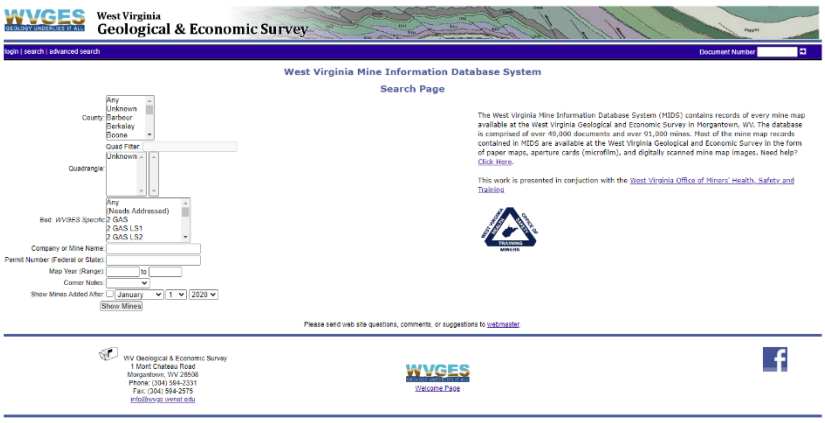
Geologists in the Coal Program continued a cooperative effort with the West Virginia Office of Miners Health, Safety and Training (WVMHS&T) to process new and legacy mine maps collected from various sources including industry archived datasets and private collections. In FY2020 WVGES received 381 new mine maps representing 1801 individual mines. WVMHS&T obtains the maps from various sources including engineering companies, coal companies, and private individuals who possess legacy data.



WVGES continued work to process and enter the over 1300 maps submitted in FY2019 which were completed in FY2020. Many of the new mine maps were already in our system but each map must be examined for new mined areas and new data to add to the CBMP ArcGIS database. Many small portions of existing mines have been added as have several 'new' mines in depleted areas where mine maps have been difficult to collect. These data help to increase the accuracy of the data model and the information is available to public, industry and government to serve and protect miners, land owners and citizens from potential hazards and for more accurate property valuation.

Mine Information Database System

The WVGES Mine Information Database System (MIDS) houses publicly accessible information collected from mine maps in our database. These data include mine name, company name, permit number, map year, plus location data including latitude and longitude, county and quadrangle. Currently the MIDS database contains nearly 50,000 documents representing over 91,000 mines. WVGES encourages comments and mine map submissions from the public to improve the database. MIDS can be accessed on the WVGES website at http://www.wvgs.wvnet.edu/www/mids/main.php

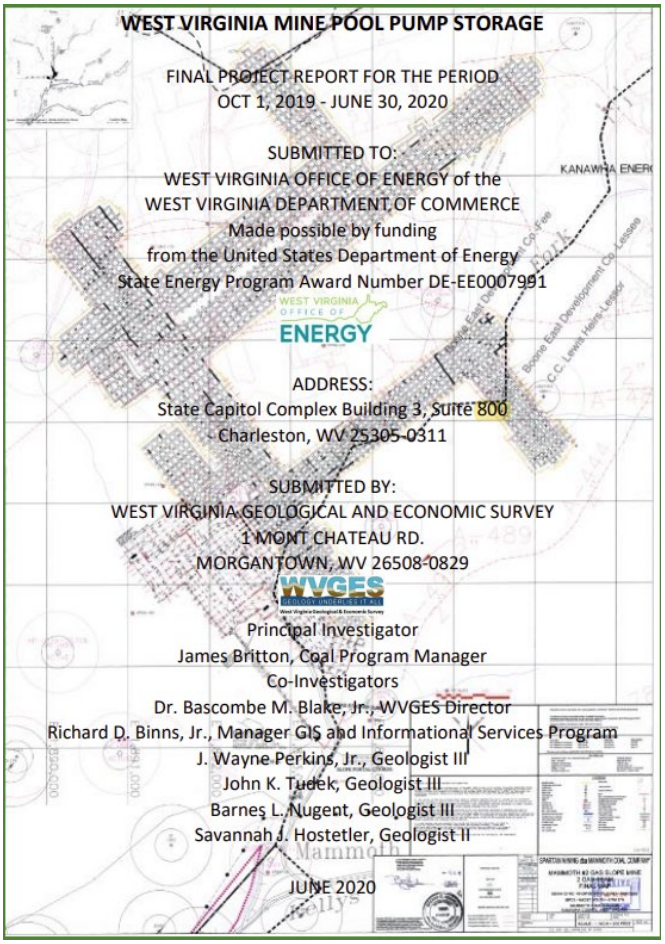


Coal Bed Chemistry Database

The CBMP Coal Bed Chemistry Database provides non-confidential coal analyses of West Virginia coal samples to interested users. The database consists of coal analysis records from both industry donations and decades of WVGES coal sampling. The database houses coal analyses, accessory minerals, and Rare Earth Element (REE) data. In addition, the WVGES archives a large collection of processed coal samples from around the state, many of which have been reanalyzed for current projects. The database, in its current form is not accessible to the public but inquiries can be made to the WVGES Coal Program to conduct focused searches. Past users include industry, researchers, graduate students and other interested people.

Mine Pool Project

The WVGES was contracted by the West Virginia Office of Energy (WVOE) through a grant from the United States Department of Energy State Energy Program for a six-month study to examine the State's water-filled underground mines to identify possible candidates for pump storage opportunities. A shift in energy production away from carbon-based fuels and toward renewables appears to be the direction that the US market will take. Pump storage facilities have the potential to provide opportunities to enhance the capabilities of the national electric grid while being environmentally responsible in lowering the nation's overall carbon footprint by utilizing a virtually free, previously overlooked, untapped energy source.



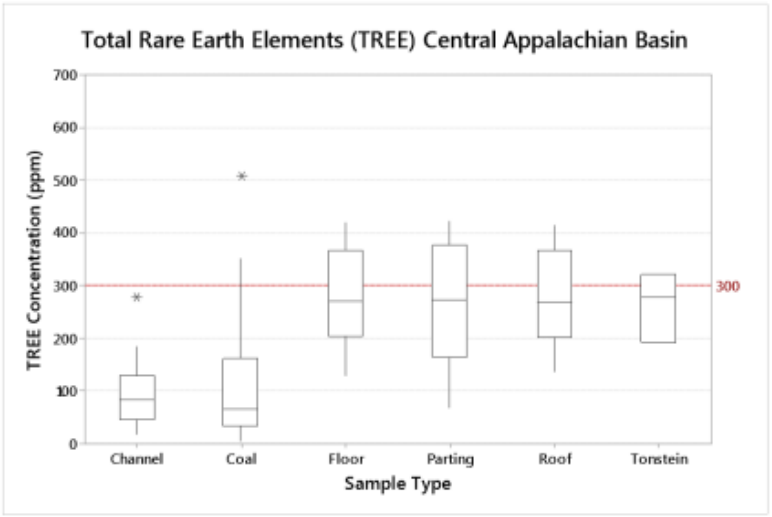
Pump storage power generation is accomplished via a two-reservoir (abandoned mine) configuration with the reservoirs sited at different elevations. Electricity is generated via a turbine driven by water released from the upper reservoir into a lower reservoir. Water is pumped into the upper reservoir during low-demand, low-cost times using surplus electricity in the grid and released to generate power during peak demand, higher rate times.

The WVGES identified thirteen possible mine pairs which met all criteria. The selections are a mixture of drift, slope and shaft 'target' mines paired with a mixture of upper reservoir mines or surface reservoir(s). However, WVGES recommends a more viable use of West Virginia water-filled underground mines: utility scale geothermal energy. The extensive amount of mining spread across the state possesses significant potential for geothermal heating and cooling systems to be utilized by industry, government and private properties. The large thermal mass of mine waters can serve as an excellent source of utility scale geothermal energy. An additional benefit of geothermal heating and cooling requires the circulation of a fraction of the water needed to generate electricity resulting in much less to no erosion of the mine infrastructure; thereby preserving the longevity of the mine roof and floor.

A geodatabase of all incorporated town polygons in the state and a selection of industrial sites was buffered and overlain on the CBMP mine map database. Spreadsheets of the resultant data were formatted alphabetically by municipality paired with 2010 census population data and all underlying mining. The report is available here: http://www.wvgs.wvnet.edu/www/coop_rpts/reports/West_Virginia_Mine_Pool_Pump_Storage-WVGES_2020.pdf

Critical Mineral Exploration

The paradigm shift in energy—a decrease in coal combustion for power generation, increase in natural gas-fired power plants, and growing public demand for renewable energy sources presents a unique challenge for West Virginia. Despite the tremendous abundance of natural gas, there is yet to be a gas-fired power plant in the state, and coal-fired plants continue to be shuttered. Where does this leave West Virginia in the energy game? One surprising development comes in the form of critical minerals. These minerals, as defined by Federal Executive Order 13817, include 31 elements, oxides, or mineral compounds that are used in modern technological applications, including renewable energy sources, communications devices, household products, and defense tools. A majority of the critical minerals come from non-domestic sources, which has significant economic and security implications.



TetraTech, 2018

Occurrence by Seam (Strata Only)

	Number	%
Waynesburg (Way)	1	2%
Sewickley (Sew)	1	2%
Pittsburgh (Pitt)	4	6%
Mahoning	1	2%
Upper Freeport (UF)	5	8%
Lower Freeport (LF)	3	5%
Middle Kittanning (MK)	11	17%
Lower Kittanning (LK)	**30**	**48%**
Clarion (Cl)	1	2%
Brookville (Br)	5	8%
Mercer	1	2%
	63	100%

Occurrence by County (Strata Only)

	Number	%
Barbour	11	17%
Centre	**9**	**14%**
Clearfield	**9**	**14%**
Clinton	**16**	**25%**
Fayette	1	2%
Forrest	1	2%
Marshall	2	3%
Monongalia	6	10%
Somerset	2	3%
Webster	5	8%
Westmoreland	1	2%
	63	100 %

WVGES is involved in several initiatives to identify critical mineral sources in the Mountain State, and current research centers on the Pennsylvanian coal measures. That's right, coal--or, more specifically, the rocks surrounding the coal. A feedstock identification project conducted by WVGES in FY2018 in conjunction with the U.S. Department of Energy and TetraTech showed that while the coal itself has generally low enrichment levels of critical minerals (with the exception of certain coal beds that contain high levels of volcanic ash), the clay-rich seat rock, partings, and roof materials showed higher levels of enrichment. Given this information, in FY2020 WVGES proposed and was awarded $125,000 from the USGS to study these clay-rich materials as part of the Earth Mapping Resources Initiative, or Earth MRI. The Earth MRI project uses a mineral systems approach to define areas of enrichment, and the mineral systems that are prospective for rare earth elements in coal can be formed over broad areas. As part of the project, WVGES will spearhead a 2-year geochemical reconnaissance study of Pennsylvanian coal measures over an eight state region (Maryland, Pennsylvania, Ohio, West Virginia, Kentucky, Indiana, Illinois, and Iowa). A link to the project description can be found at: Earth MRI Funds Critical Minerals Projects in West Virginia (usgs.gov) Earth MRI Funds Critical Minerals Projects in West Virginia (usgs.gov). https://www.usgs.gov/news/earth-mri-funds-critical-minerals-projects-west-virginia. Stay tuned for future results.

State Park Sandbox Program

WVGES staff in partnership with West Virginia State Parks built three "Augmented Reality Sandbox" units which were placed at various State Parks, the first of which is in operation at Blackwater Falls State Park. These special sandboxes are similar to the existing sandbox located in the WVGES museum. These displays are hands-on exhibits that combine a common sandbox, 3D measuring cameras, high resolution projector and visualization applications created by researchers at the University of California at Davis. These displays project topographic lines onto the "mountains" and "valleys" that users create by molding the sand. They also model hydrologic processes by allowing users to in effect make it rain over their sculpted landscape. It is a powerful teaching tool that allows users to better understand topographic maps and geomorphology.

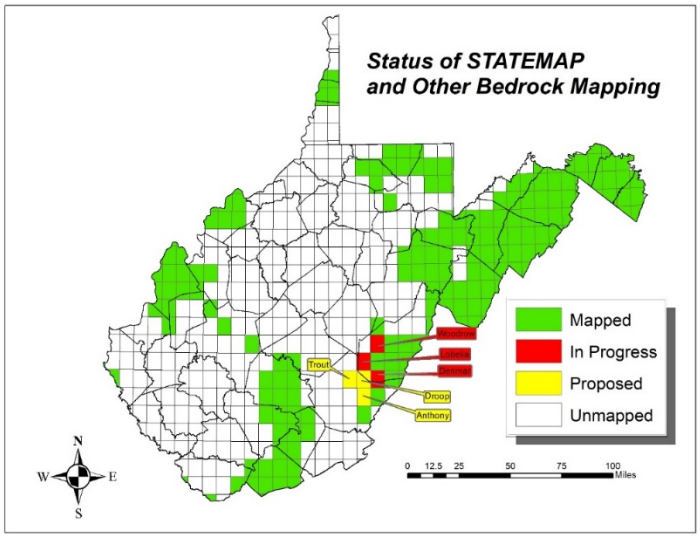
The Augmented Reality Sandbox: A computer projector overlays an interactive topographic map onto sand. By modifying the sand, visitors learn how geomorphologic processes change a landscape and how that landscape is represented on a topographic map

Cross-section drawing

GEOSCIENCE AND MAPPING PROGRAM

Geologic Mapping

One of the cornerstone products a state geological survey produces to further the geological knowledge of the state are bedrock geologic maps. These maps provide direct evidence of the rocks at the surface. WVGES has maintained a constant geologic mapping operation that includes the direct acquisition of new geological information through field data collection, examination of high-resolution digital imagery, and geochemical analysis of rock samples, in addition to the compilation of new and legacy data into digital format. WVGES typically maps 1:24,000-scale quadrangles. A list of priorities are used to determine present and future mapping. These priorities include areas adjacent to present mapping, an increase in population, highway and pipeline corridors, and carbonate outcrops with karst potential and known caves.



Currently, WVGES geologists are mapping in southeastern West Virginia, primarily in Greenbrier and Pocahontas Counties where, as part of these bedrock-mapping projects, geologists are endeavoring to map the constituent formations of the Greenbrier Group limestones that create the karst terrain so prevalent in this region.

Understanding karst systems is key to understanding groundwater flow and the potential effects of oil and gas drilling and other industrial construction through karst terrains.

Acquisition of new geological data is carried out under the STATEMAP program funded jointly by the USGS and WVGES. During Fiscal Year 2020, WVGES geologists conducted field work on the Denmar, Lobelia, and Woodrow 7.5-minute quadrangles in Pocahontas, Greenbrier, and Webster Counties, West Virginia, shown in red on the map above. Published as WVGES Open File Reports, these geologic quadrangles will be available as paper maps, PDF files, and geographic information systems (GIS) geodatabases. WVGES typically provided these map deliverables and associated data to the USGS on May 15 each year. However, due to the impacts of COVID-19, WVGES requested and received a no-cost extension to July 31st, 2020 to complete all tasks proposed. COVID-19 impacted the ability to conduct field work and work in-office to construct the final versions of the maps and databases.

In August 2019, the STATEMAP Advisory Committee met to evaluate new potential areas to map within West Virginia for the upcoming STATEMAP cycle. This committee includes individuals from mining and oil & gas industries, government officials at the state and local levels, and individuals from several universities. Feedback from the committee was integrated into the WVGES proposal to the USGS and in November 2019, WVGES submitted a proposal. Partial funding was received in March 2019 to map the Anthony, Droop, and Trout quadrangles in Greenbrier and Pocahontas Counties (shown in yellow on the map).

In March, 2020, additional funding was made available by the USGS under a supplemental STATEMAP funding announcement. WVGES proposed numerous tasks under this supplemental announcement and received 100% of the requested funds in May, 2020. Funds were requested to prepare previously published WVGES maps in a new USGS database structure called the Geologic Map Schema (GeMS). WVGES requested and received funding for training associated with the GeMS format and integrating a GeMS workflow into the maps and GIS databases created by the WVGES for submittal to USGS. Furthermore, WVGES proposed and received funds to integrate the statewide geologic map's lines and polygons into GeMS format as well as update all WVGES maps into the catalog of publications for the USGS. Finally, WVGES received funds under the supplemental grant to edge-match previously published geologic maps and, if needed, to field check the discrepancies identified.

As technology for mapping in the field continuously evolves and changes WVGES mappers employ new techniques, hardware, and methods to collect and utilize digital data in the field. WVGES has been standardizing data collection by individual mappers using handheld mapping units and by developing forms in which to enter the data. Geologists are able to load digital imagery into the devices and work is completed in the office prior to examining the map area to more economically identify areas on which to focus. Along with human observation, using high-resolution LiDAR imagery to identify previously hidden landforms, built-in GPS technology, sample collection, and field photography, mappers are able to acquire and integrate data in a more systematic manner.

To keep abreast of the latest trends and advances in methodology, technology, and tools in geologic mapping, members of the WVGES attended several meetings, workshops, and conferences. Due to COVID-19, most of these events were held virtually. These included the Geologic Mapping Forum and the Digital Mapping Techniques (June, 2020), hosted by the USGS, and corresponding workshops. Both of these are primarily attended by state and federal geologic mappers and GIS professionals. Presentations included information on collection of data in the field, integrating newly acquired data with legacy data, and building geologic databases and maps.

Geochemical Analysis

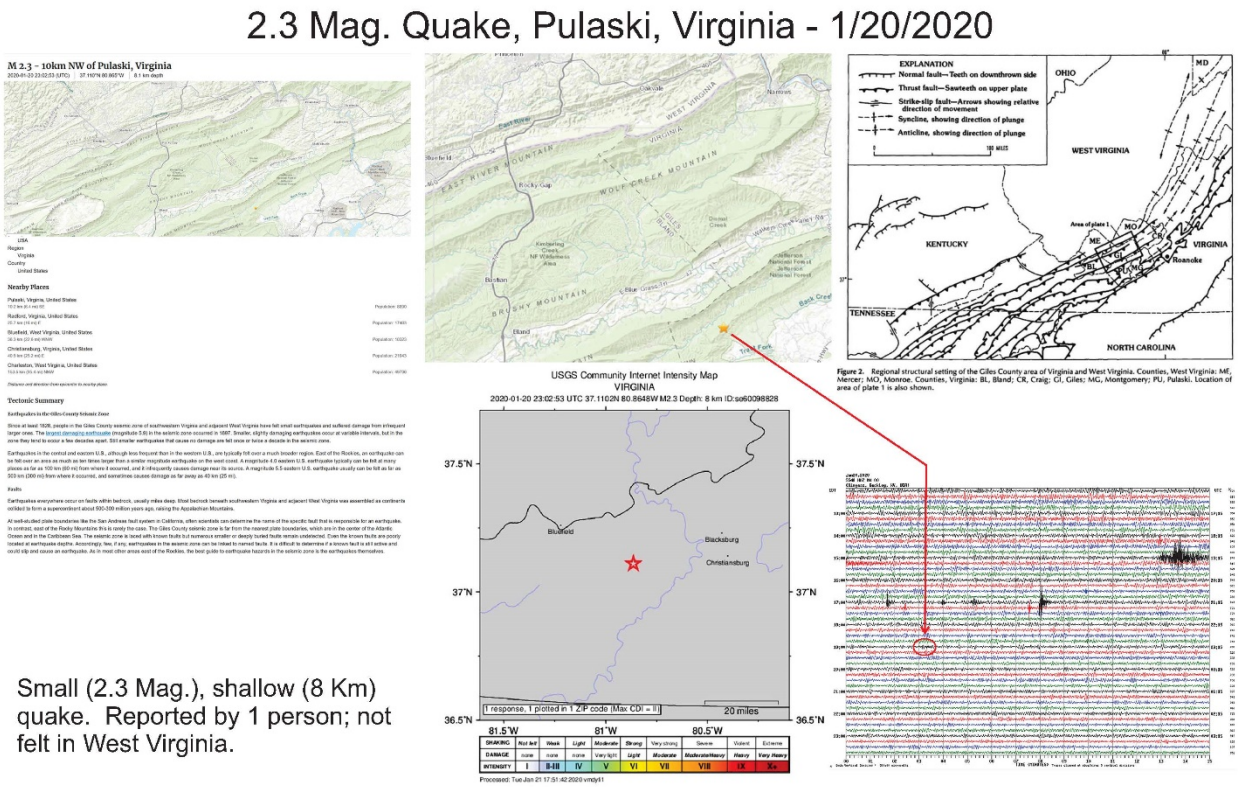
WVGES has established a statewide stratigraphic geochemical database and analyses for 5 new rock samples were added to the existing database during this fiscal year bringing the total number of samples up to 1,157. Existing data cover West Virginia rock units ranging in age from Precambrian through Pennsylvanian. The geochemical database is available as a GIS layer that can be combined with other maps of West Virginia for use in environmental and economic assessments of the near-surface bedrock of a particular geographic location.

Geothermal Resources

In previous fiscal years, the reservoir characteristics of the Silurian Tuscarora Sandstone were investigated to help determine its suitability as an alternative energy source as part of a U. S. Department of Energy project. A presentation by a WVGES representative summarizing those results was made at the Eastern Section AAPG meeting held in Columbus, OH in November 2019.

Seismic Monitoring

WVGES maintains a permanent seismic-monitoring station at its office in Morgantown linked with five other seismic-monitoring stations overseen by the USGS operating in the state. While no earthquakes occurred in West Virginia during the fiscal year, several smaller quakes were recorded by the West Virginia seismic network from the portions of neighboring states adjacent to WV's border. Summaries of these earthquakes in Ohio, Pennsylvania, and Virginia, as well as large (≥ 6.0 magnitude) earthquakes from around the world are posted on the WVGES website at:
www.wvgs.wvnet.edu/www/earthquakes/seismic.html

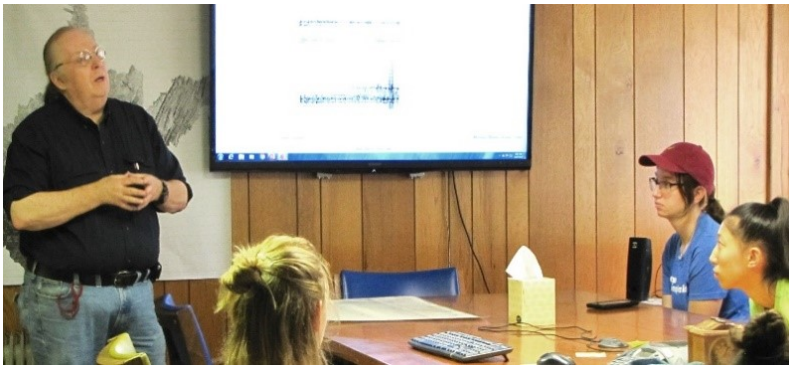


Small (2.3 Mag.), shallow (8 Km) quake. Reported by 1 person; not felt in West Virginia.

GeoEducation and Outreach Activities

An overreaching goal of the WVGES is to disburse the geological information pertaining to West Virginia to a wide audience. Therefore, geoscience personnel consistently provide geologic information to the state in many different outreach capacities. Beyond professional research and project work, the WVGES responds to inquiries from government officials or entities (state, local, and federal), industry, academia, and the public at large. Prior to COVID-19 restrictions, WVGES personnel physically visited sites, schools, and universities to provide information, respond to questions, career development, and present work. Subjects include, but are not limited to, rock identification, earthquakes, landslides, water-well contamination, radon risk potential, and career development.

In FY2019, WVGES geologists, in partnership with the USGS and West Virginia University's Adventure WV Outdoor Education Center, conducted a week-long summer GeoCamp for high school students interested in science, technology, engineering, and math activities focusing on the earth sciences (GEOSTEM). Mini-classes hosted by WVGES geologists in the classroom and in the field included earthquakes, orienteering, fossil collecting, mapping, caving, a geologic whitewater rafting trip, a geologic field trip to Seneca Rocks, Judy Gap, Canaan Valley, and Blackwater Falls, a bicycle trail ride along reclaimed mined areas, a geocaching trip to Coopers Rock State Forest, and discussions about acid-mine drainage, mining processes, and earthquakes. WVGES geologists were planning to do this again in 2020, but due to COVID-19 this valuable program was cancelled for this year.



WVGES was able to maintain the popular "Visiting Geologist" program where, in cooperation with the West Virginia Division of Natural Resources, WVGES staff visited selected state parks to give evening presentations on state and local geology and then, on the next morning, guide participants on a field trip hike showcasing the local park geology.

In October, 2019, a WVGES geologist presented material at the West Virginia Science Teachers Association (WVSTA). Geology has recently been added to the educational milestones in the public school system and specifically as part of 9th grade science. To aid teachers in gathering geological knowledge and material a WVGES representative offered a "What can the WVGES do for you?" presentation followed by a Q&A session. The goal was to showcase the educational materials the WVGES provides (http://www.wvgs.wvnet.edu/www/geoeduc/geoeduc.htm) to K-12 teachers and students but also to gather information to plan for the future of developing GeoEducational material for West Virginia.

Data Preservation: Curating the State's Rock and Data Collection

WVGES maintains a sample repository containing over 28,000 linear feet of core collected as part of oil & gas and coal exploration plus cuttings samples from thousands of wells and/or boreholes, as well as hundreds of samples collected during geological fieldwork by the agency. WVGES curates these physical samples at auxiliary storage facilities in Morgantown and this collection represents the most comprehensive group of rock-core and well-cuttings samples in West Virginia. Many of these samples are decades old and were collected from locations that are no longer accessible. However, requests for access to these samples by industry, federal government, and academia are common and many times legacy samples are of new interest as scientists develop new analytical techniques and make new discoveries, which make the WVGES collection that much more relevant since it is publicly accessible. Additionally, if outside researchers sample the collection, results and analyses are required to be submitted to the state and WVGES is able to collect advanced analytical data sets at no cost to the taxpayer.

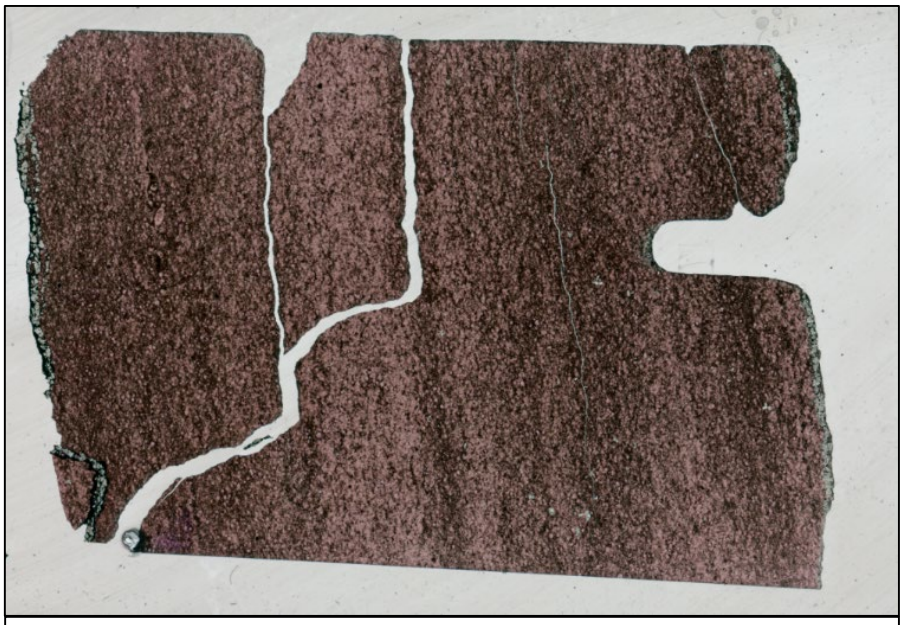


Figure: Thin section photograph of a sample of Marcellus Shale from Harrison County, West Virginia. Depth of sample is 7,206 feet. Thin section is ~2 inches long and ~one inch high.

However, the large and irregular collection is difficult to both catalogue and curate. In support of this and other tasks, WVGES received funding from the USGS National Geological and Geophysical Data Preservation Program to continue our work preserving and updating this collection. WVGES's goal is to continue efforts to develop a modern, comprehensive, web-accessible catalog of WVGES core and well cuttings collections via barcode technology. Additionally, through this funding WVGES is re-boxing core and well cuttings samples that are in damaged, deteriorating, or improperly sized core and well cuttings boxes and cataloging these samples when finished.

WVGES also received funding to purchase new heavy-duty shelving to both expand and replace shelving that has lost integrity. Also, to make data more available to the public WVGES is photographing cores and thin-sections. Thin sections (see image above) are very thin slices of rock that can be examined under the microscope to determine the makeup of the rock, cement, and pore space.

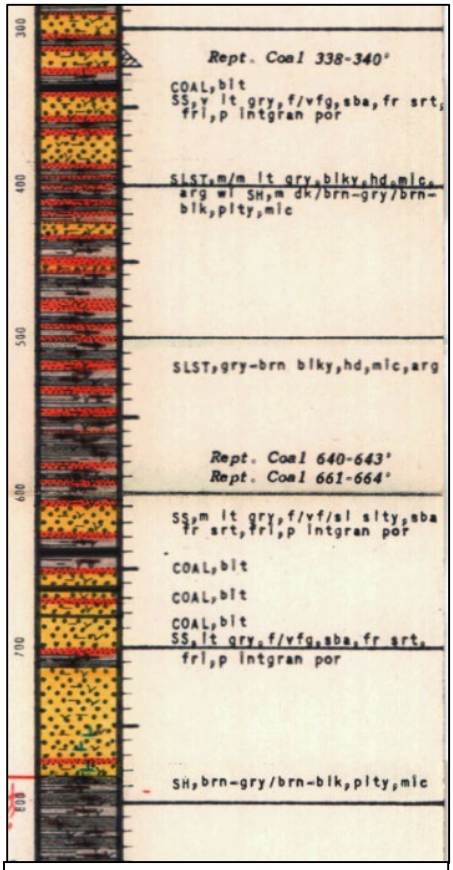


Figure: Example of a portion of the scanned, hand-colored log from a well in Nicholas Co, WV.

Finally, through this funding WVGES is scanning a collection of hand-colored well logs that only exist in paper format. Any digital products from this work are being made available via the WVGES website (see the left image).

A second component of WVGES work being conducted using funds received from the USGS National Geological and Geophysical Data Preservation Program is part of the USGS Earth Mapping Resources Initiative (Earth MRI) and focused on identification and compilation of historical and modern data to aid in the development of geologic models for critical mineral enrichment. This work has two goals: to tabulate the data contained in the literature and to spatially locate historical field sites. Proposed work has been focused on WVGES publications, WVGES County Geologic Reports, academic work, and a modern dataset collected by the U.S. Department of Energy. This dataset includes a total of 1,139 samples from 44 of the 55 counties in West Virginia. The geochemical data were collected from 1907 to 2018 and are varied; major oxides are reported for a minimum of 2 to a maximum of 1,028 samples while trace elements are reported for a much smaller number of samples (15 to 124). Rare earth element volumes are reported for 124 samples.

In addition to conducting this work, a representative from WVGES presented the type of work, workflow, and details of the WVGES Data Preservation ongoing project to peers from the USGS and other states participating in the USGS Data Preservation Program in September 2019 in Golden, Colorado. From this presentation and workshop, ideas were exchanged with other state geological survey representatives on common goals, challenges, and techniques to preserve samples and data, and methods to distribute those data to the public.

Log and Data Donations

As exploration companies enter and exit the Appalachian basin and assets change hands, the preservation of data and samples is of heightened importance, a task which commonly falls to a geological survey. The WVGES is fortunate to have fostered relationships with industry partners and stakeholders, and many of those relationships run deep.

As Director Blake mentioned in his opening column, the “Boomer Bust” has significant reverberations in the geoscience community. A generation of men and women are preparing to leave or have exited the profession into retirement, many of whom have amassed significant personal collections of records, maps, and geophysical logs. Some of the donations received in FY2020 include:

- A comprehensive set of farm-line and property maps from a region spanning from northern WV into the southern coal fields, donated by Ed Rothman.
- A comprehensive set of well logs donated by Tom White (of Haney and White) from several counties across the state
- A set of deep well logs and associated well data, donated by EQT Corporation.
- Well logs and historical documents, donated by CNX Gas

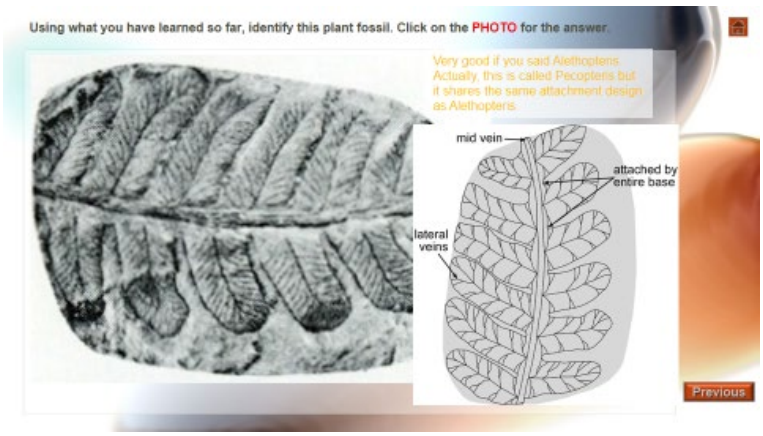
These donations are in addition to a major industry donation of geophysical logs in FY2018, in both paper and digital format. Assimilation of this data into existing file systems is a significant task, and has turned into a Survey-wide effort as stay-at-home orders went into effect in March of 2020. Staff loaded boxes of logs into their cars, and from the safety of their homes conducted the inventory, scanning and digital data entry of thousands of wireline logs. The scale of this task is large; it could take (and has taken) multiple years to process such a large donation under normal circumstances, but is work that requires no special equipment or software and can be easily accomplished by a variety of staff members. A small silver lining, perhaps, for these very strange times.

The State's "rock collection" also grew during FY2020, both through industry donation and legislative request. The Horizontal Well Act of 2012 granted WVGES the authority to request cores and drill cuttings from operators. Storage space is always an issue--our facilities are near-capacity and not climate-controlled, but it is imperative that physical material be preserved for current and future research. This year, WVGES requested and received not one, but two cores from the Utica/Point Pleasant in Marshall County. To say that this information increases public-domain data density is an understatement; prior to this acquisition, the state held only one core that captured this geologic interval, and it is located outside of the main productive fairway. We are thankful to the West Virginia Legislature for their foresight in the addition of the legislation to the Horizontal Well Act, as well as to the companies operating in the basin for their timely correspondence and compliance. These assets form the cornerstone of a modern collection that records a momentous period in Appalachian oil and gas exploration.

While physical materials are integral to all aspects of geological research, modern software applications are also essential to assimilate, analyze, and map disparate datasets. These software packages are often designed for industry applications, and their acquisition can be financially challenging for government organizations. Through the generosity of the IHS Markit University Grant Program, WVGES received networked software licenses for both the seismic data interpretation Kingdom® software as well as the subsurface mapping program, Petra™. Together, these network licenses are valued at more than $750,000.00. WVGES would like to extend our deepest gratitude to IHS Markit for this generous award, which enables our geoscientists to develop analysis skills that not only keep them current when compared to peer groups, but also enable them to interpret, map, and package data that can be used by a variety of stakeholders, at no additional cost to the taxpayers of West Virginia.

Geoscience Education Web Page

WVGES continues to host a vast amount of digital content on our website, http://www.wvgs.wvnet.edu/www/geoeduc/geoeduc.htm, providing K-12 teachers with products designed for their classroom use. New content has been added to this website and more content is being developed.

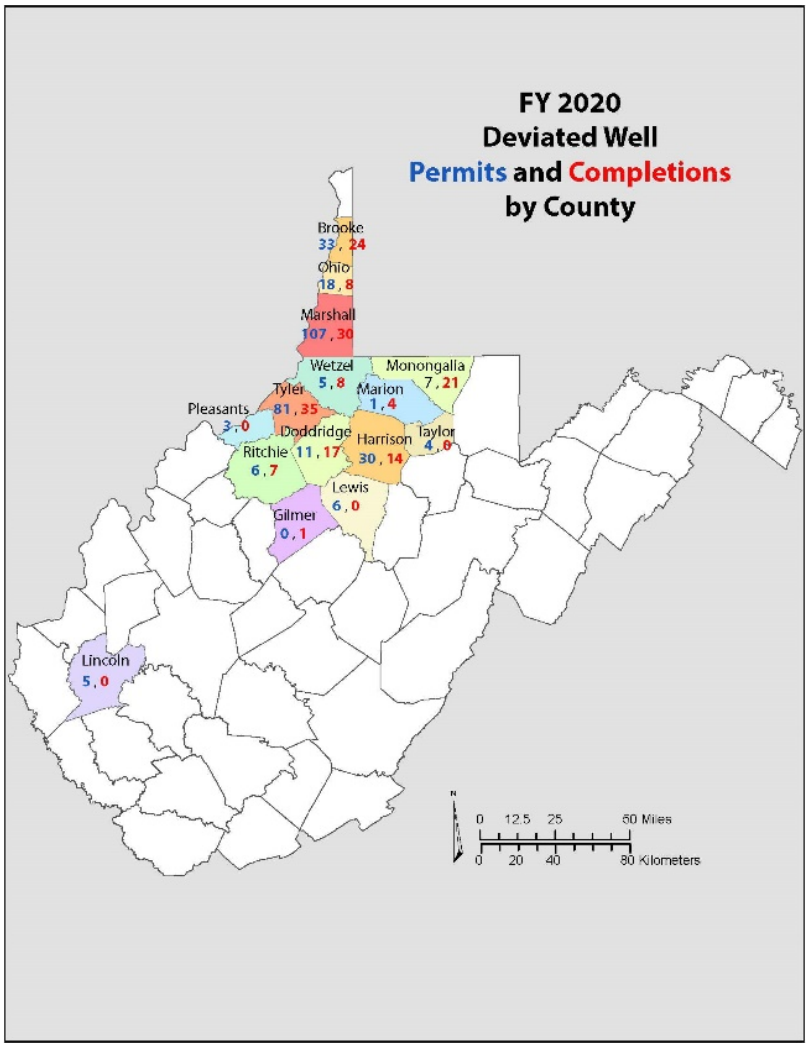


The Taggard Formation in Pocahontas County

OIL AND GAS PROGRAM

Oil and Gas Drilling Trends

Fiscal year 2020 marked a year of a slower pace in the oil and gas industry. This slowdown, just as all other aspects of daily life, was exacerbated by the COVID-19 crisis. Well site work ground to a halt (U.S. rig counts dropped by 70%) and suddenly, the already-present downturn in the oil and gas industry took another precipitous dip. The number of permitted wells in FY2020 decreased approximately 30% from the previous fiscal year; 317 deviated wells were permitted, down from 461 in FY2019. The Marcellus is still the major drilling target and accounts for 80% of the total, with 255 wells permitted to be drilled. The Utica Point/Pleasant is the second major target, with 55 permits issued in FY2020. Plans to develop the Marcellus have a wider geography, albeit within the discrete northern and northwestern drilling fairway. Tyler County is the most heavily permitted (81), followed by Marshall (54), Brooke (33) and Harrison (30). The Utica/Point Pleasant permits are located almost exclusively in Marshall County (53 of 55 permits).

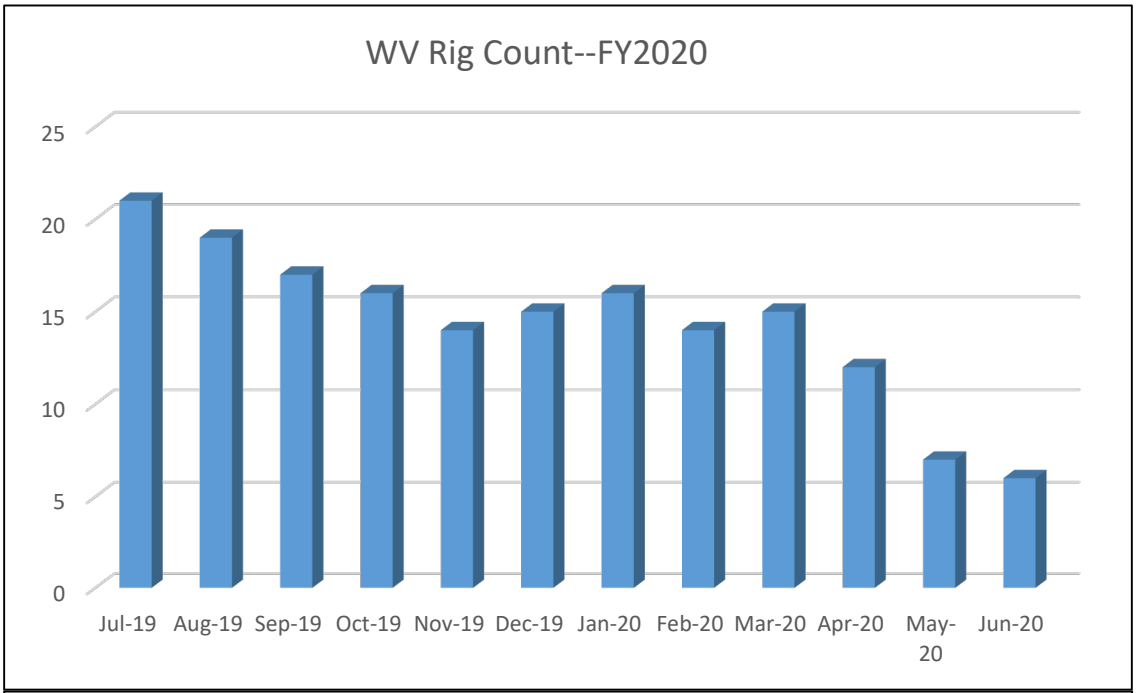


Other deviated well targets lag far behind the Marcellus and Utica/Point Pleasant. Five wells were permitted in the Griffithsville waterflood operation in Lincoln County, two horizontal oil wells each were permitted in the conventional Price Formation and Weir sand, and one in the Speechley sand. One well was permitted to be drilled in the Upper Devonian Geneseo/Burket shale.

The number of wells completed in FY2020 also decreased from the previous year, but not as markedly as the number of permitted wells. Well completions numbered 167 over the course of the fiscal year, down from 198 in FY2019. Of these wells, more than 95% were completed in the Marcellus Formation (160). Approximate lateral length (calculated from subtracting reported Total Vertical Depth from Total Measured Depth) ranged from ~5877 ft. to ~18,608 ft., with an average of 11,633 ft. Completion stages ranged from 13 to 126. Tyler County is again the nexus of Marcellus drilling, with 35 completions, followed closely by Marshall (25), Brooke (24), and Monongalia (21).

Six wells were completed in the Utica/Point Pleasant. Approximate lateral length ranged from ~6226 ft. to ~17,121 ft., and completion stages ranged from 31 to 82. Geographic drilling trends in the Utica/Point Pleasant are again centered on Marshall County; five of the six completions occurred in Marshall County with the sixth in Monongalia County.

In summary, a majority of the activity occured in the rich gas areas in the Marcellus, such as Tyler County, with Utica activity focused in Marshall County. Other, more exploratory drilling, lagged far behind as operators sought to decrease risk in an unstable pricing market.



Source: Baker Hughes

Conasauga Shale Research Consortium (CSRC)

WVGES is part of a U.S. Department of Energy funded project examining the Rogersville Shale as an emerging play in the Appalachian Basin. This is a geological unit deeper than the Utica/Point Pleasant Shale that has the potential to be an unconventional reservoir producing oil and gas. This unit ranges from 11,000-16,000 feet below the surface in West Virginia. Since the Rogersville Shale is so deep below the surface, very few wells have penetrated the interval and little data was available for the Rogersville. WVGES is working with the Kentucky Geological Survey and West Virginia University to study the interval in West Virginia and Kentucky.

WVGES is correlating and mapping this unit in West Virginia using well logs, cores, and associated samples. A core from this interval (pictured right) is held in the WVGES collection indicated elevated total organic carbon (TOC) that is used as an indicator for potential hydrocarbons. This core and others are being examined, sampled, and analyzed for this project. These data are being integrated with similar data in Kentucky to develop a regional picture of the distribution, depth, and potential quality of the reservoir to be developed by industry.

Figure: Example of a box of core containing the Rogersville Shale in a well from Wayne County, West Virginia.

CO2 Research

Exploration of the subsurface is not relegated to the oil and gas industry. Several other projects in the Oil and Gas Program seek to leverage the knowledge gained through hydrocarbon exploration to understand a diverse set of geological problems. Foremost among these is the need to identify reservoirs amenable to carbon capture utilization and storage (CCUS) activities. Carbon neutrality ranks high among corporate goals in response to growing public demand, and many prospective development opportunities in Appalachia and the Midwest require identification of CO2 storage prospects.

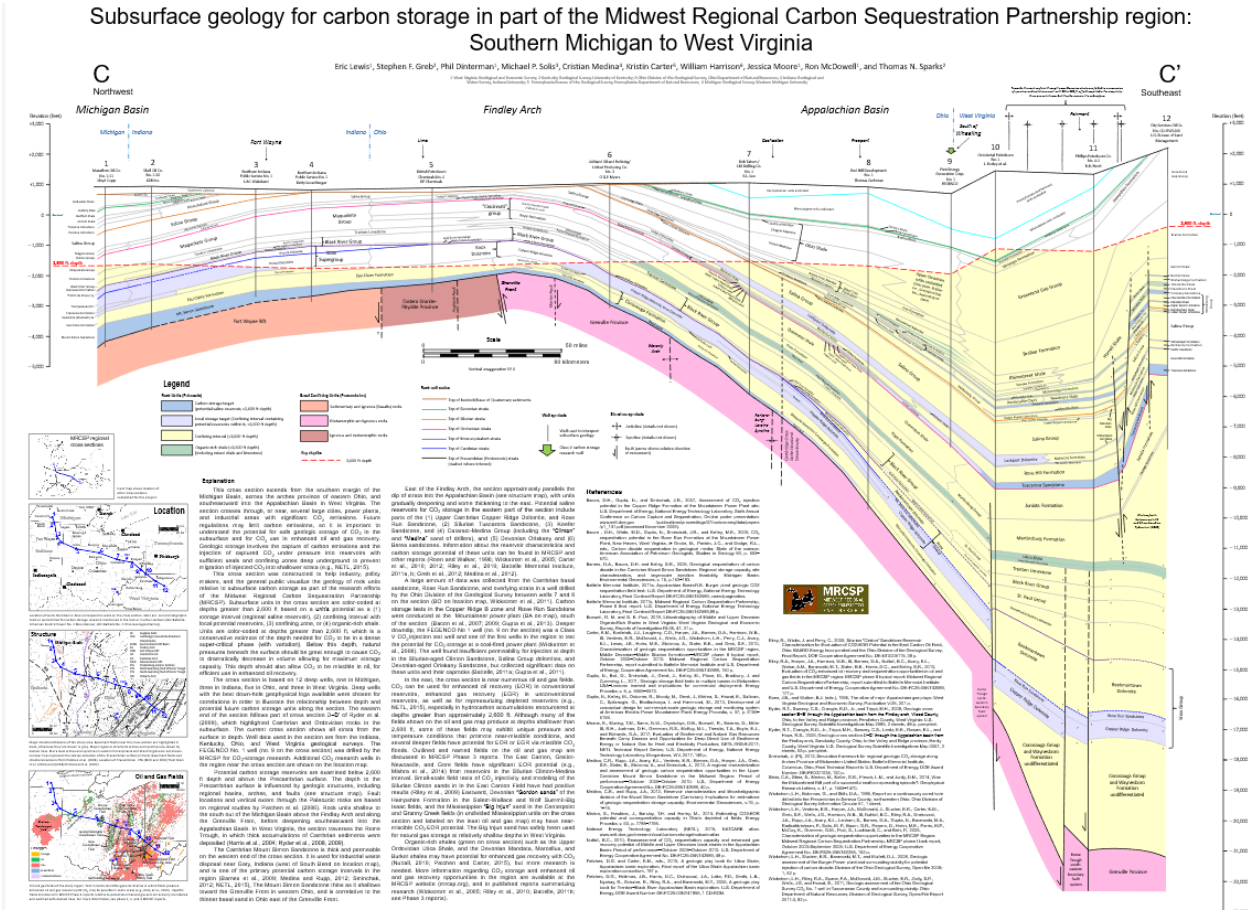
In the Mountain State, CCUS prospects include shallow depleted oil fields that could yield enhanced results (and eventual storage) via CO2 flood, deep-saline reservoirs, or by a combination of both for “stacked” storage. Work to locate, characterize, and rank these prospects has been ongoing for more than 15 years as part of the Midwest Regional Carbon Sequestration Partnership (MRCSP), which concluded its technical scope of work in FY2020. Final products from the project include a Capstone Report that characterizes a broad region from the Michigan Basin to the Appalachian Basin, the Atlantic Coastal Plain and Continental Shelf off the coast of New Jersey, and a set of Topical

Reports. The Appalachian Basin Topical Report covers several major topics including case studies of the Washington-Taylorstown oil field in western Pennsylvania and the Jacksonburg-Stringtown field in Tyler and Wetzel Counties in West Virginia, as well as technical details of many historical oil fields in the tri-state area of Ohio, West Virginia and Pennsylvania. This information is also compiled in a comprehensive database that can be utilized for reservoir characterization and spatial analysis. In addition to the Topical Reports, a set of six regional cross-sections were compiled to illustrate the subsurface geometry and stratigraphy.

The lasting legacy of the MRCSP includes not only the technical work, but the efforts of the technical workers. The Midwest partnership is the only one of the 6 regional CO2 partnerships to have an intact and working "Geoteam" at the end of the program. Fortunately, WVGES staff will continue to have the opportunity to work across geopolitical boundaries with our sibling states on the next phase of CO2 research as part of the Midwest Regional Carbon Initiative, or MRCI. This project will take the technical information collected during MRCSP and utilize it to define broad carbon storage systems, to construct detailed geologic models and simulations, to delineate and construct roadmaps for infrastructure development and policy, and to package technical information for distribution to a widening group of stakeholders. The region of interest has grown, as well, to encompass 21 states across the Atlantic and Midwest.

Topical Report: Regional Cross-Sections

C-C': Michigan, Indiana, Ohio and West Virginia



Olivellites trace fossil, Mauch Chunk Group, Randolph County

INFORMATION SERVICES PROGRAM

The Information Services Program is responsible for the agency's publications, website and feedback presence, network infrastructure and desktop operations, interactive mapping applications, and other programming applications in support of the agency's projects.

- **Web services**
  The following web services provide data to the public:
  - Oil and gas well "pipeline" and "Pipeline-Plus" services
  - Daily update of Excel spreadsheets for Marcellus shale wells and horizontal wells
  - Scanned Well Logs
  - Mine Information Database System (MIDS)
  - Coal Bed Mapping Project
  - Scanned Mine Maps

- **Web-based Interactive Mapping**
  The following mapping applications were completely redeveloped during FY2020:
  - WV Oil and Gas Interactive Map
  - Topographic Map Index

- **Posters and Presentations**
  - Poster: *Constraining Recovery Efficiency via Production Data: Marcellus Play WV*, Authors: Ray Boswell (U.S. DOE/NETL), B.J. Carney (NNE), Susan Pool (WVGES)
  - Presentation: *Constraining Estimates of In-place Resources and Recovery Efficiency using Production Data: An Example from the Marcellus Play in Northern WV*, Authors: Ray Boswell (U.S. DOE/NETL), B.J. Carney (NNE), Susan Pool (WVGES)

Information Services, FY2020

***By the Numbers*:**

Website:

- Over 3,000 static and dynamic web pages
- 934,514 website visits
- 110,136,931 page views

Service Requests:

- Agency staff responded to more than 880 requests for information.

Facebook Page:

- 46 Total Posts
- 19,689 Total Reach
- 2,772 Total Engagement

IT Support and Professional Development

- Program staff expanded programming to develop and enhance project applications, databases, interactive mapping applications, and management of network infrastructure.

- Staff implemented a WIFI mesh network to support field-mapping activities and digital-data migrations between the field and the office. This new network, used in conjunction with field-mapping tablets, allows geologists in the field access to all the resources available to them in the office.

- Services to Agencies: Program staff prepared customized data-analysis files requested by the WV Department of Environmental Protection - Division of Air Quality for their use in the preparation of reports to federal agencies.

- IT staff helped coordinate the 2020 "WV GIS Day at the Legislature," and designed and staffed the agency's display booth.

- Program staff analyzed and processed data for a database and interactive applications for the Broadband Enhancement Council, with special processing of FCC Form 477 data. We participated in an Appalachian Regional Commission POWER Grant to the West Virginia Development Office ascertaining broadband access (especially fiber-optic technologies) for ten southern coalfield counties, in conjunction and cooperation with the Broadband Enhancement Council, the Development Office, and the Division of Highways. Our data analysis and mapping work aided in the development of a web-based hub for broadband-expansion resources in West Virginia. Broadband can help the economic revitalization of these "coal-impacted" counties.

- Program staff serve on the following committees: the State Information Technology Council (representing the Department of Commerce), the WV GIS Steering Committee, and the WV Association of Geospatial Professionals -- Communications Committee and Board of Directors.

New Publications in FY2020

AR-2019 – *Annual Report: Fiscal Year 2019*

OF-1901 – *Bedrock Geologic Map of the Woodrow 7.5' Quadrangle*, West Virginia, by J.K. Tudek, J.W. Perkins, S.J. Hostetler, P.J. Hunt; Digital Cartography by S.E. Gooding

OF-1902 – *Bedrock Geologic Map of the Lobelia 7.5' Quadrangle, West Virginia*, by J.W. Perkins, J.K. Tudek, G.R. Dasher; Digital Cartography by S.E. Gooding

OF-1903 – *Bedrock Geologic Map of the Denmar 7.5' Quadrangle, West Virginia*, by P.J. Hunt, M.S. Burns, S.R. Brown, R.R. McDowell, P.A. Dinterman; Digital Cartography by S.E. Gooding

Publications Updated in FY2020

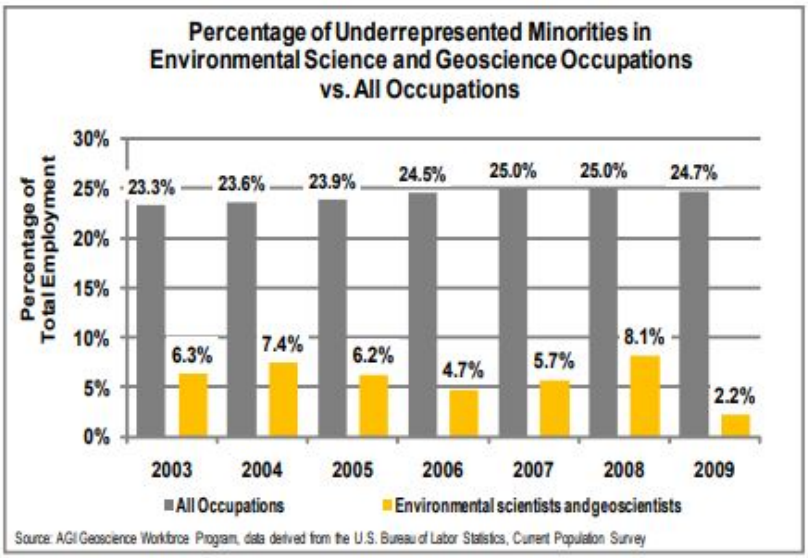
DDS-5 – *WVGES Oil and Gas Well Data for West Virginia*, May 2020

RI-34 – *Stratigraphic Geochemical Database for Portions of West Virginia and Adjacent Virginia Counties*, by R.R. McDowell (compiler); 2020 supplement added

Tributary to Robbins Run, Greenbrier County

EQUAL EMPLOYMENT OPPORTUNITY

The year 2020 brought its own unexpected challenges. The global pandemic closed our building to staff as well as the public and reduced and/or halted our outreach programs due to stricter guidelines and social distancing toward the end of FY2020. These programs were developed to help and encourage members of the community to have a better understanding of the many aspects and disciplines within the Geosciences fields. The direct exposure and increased knowledge help create positive changes in how Geology and related fields are viewed. Even though it is a somewhat antiquated view that Geosciences are predominantly white male fields of work, women and minorities are still under represented in the discipline. However, the pandemic has also created a ripple effect of increase and diversification of candidates. As unemployment rises due to changes and/or closures within other businesses, the agency has a unique opportunity to draw from a more diverse pool of applicants than we have had in previous years. The West Virginia Geological & Economic Survey remains committed to workplace diversity and equality moving into the New Year.



MAINTENANCE

Following many years of budget restrictions, the WVGES was able to complete several small to medium scale renovations and upgrades to the property. After approximately a year of planning, power lines on the property were buried and outdated transformers were replaced with all the old infrastructure removed. This will eliminate intermittent power outages caused by falling trees and branches on the property resulting in incidences like the one in 2018 when a prolonged power outage in January caused by a falling tree shut off all power for several days eliminating heat and nearly cost us the building before power crews could restore the service.

Along with the power upgrade, the WVGES was able to repair a badly weather damaged retaining wall, seal the lower parking lot, improve outside lighting for safety, paint most of the building, complete a landscape beautification project, repair and paint the badly rusted fire escape and complete several other smaller projects. All of these tasks, except the electrical renovations and lot sealing, were completed by Survey maintenance staff plus many general staff volunteers who wish to preserve the historic nature of the property.

Updated sign and landscaping in front of Mont Chateau

HISTORIC PRESERVATION

The Geological Survey has been housed at the former Mont Chateau State Park Lodge since 1977. Many are familiar with the Park but what is not as well-known is the history of the original Mont Chateau Hotel. In the early twentieth century it was the center of social activity in the Morgantown area and attracted visitors from throughout the east. Built in 1894, the hotel, with its grounds, cottages and tennis courts, was a favorite vacation destination for many notable personages, including Thomas A. Edison and General George C. Marshall. From 1915 through 1919 the WVU football team used Mont Chateau as its pre-season training camp and often sequestered there on nights before important home games. In the 1920s the hotel was operated as a summer resort for prominent members of Pittsburgh's Duquesne Club. Purchased by the State in 1955 with the intent of converting it into a State Park, the hotel was destroyed by fire the following year and was replaced by the current building which continued operation as a lodge and restaurant for the next nineteen years.

In recognition of the historic significance of Mont Chateau to the area, research has been initiated to obtain information required for inclusion in an application to place the land, current building and the stone structures of the original resort on the National Register of Historic Places. It is anticipated that formal submission will be made in 2021 to the National Park Service through the West Virginia Historic Preservation Office. A Facebook page has been created (at "Historic Mont Chateau") to promote this effort and to provide information as to the progress of the application process. *(Photos courtesy of the WVU Regional History Center)*

WVGES MINI-MUSEUM

The Survey's Mini-Museum in our office lobby and its associated web pages continue to be an important part of our outreach and educational programs. Museum displays continue to inspire and educate teachers, students, and visitors. The Mini-Museum is currently closed due to COVID-19, but will be reopened under normal business hours as soon as possible. In the meantime, the Mini-Museum can be visited virtually on the website at: http://www.wvgs.wvnet.edu/www/museum/museum.htm.

GEOGRAPHIC INFORMATION SYSTEM PROGRAM

This program is responsible for planning, organizing, coordinating and delivering high level Geographic Information System (GIS) advice to agencies in state government; it is headed by the statewide GIS Coordinator, based in Charleston.

- The program continues to make headway in a number of critical areas: promoting data sharing between agencies; providing technical assistance to state, county, and local government and the public; and fostering efficient and effective use of the state's geospatial capabilities.

- The Coordinator provided support to the Secretary of State's Office on the Geo-Enabled Elections project in conjunction with WVGES personnel. In their search for GIS contract services, funding and GIS application development the Division of Homeland Security, Division of Emergency Management, Department of Environmental Protection, the Water Development Authority (WDA), Infrastructure and Jobs Development Council (IJDC) the National Guard, the WV Intelligence Fusion Center, Hazard Mitigation section, and other state, regional and local agencies also reached out the Coordinator for support.

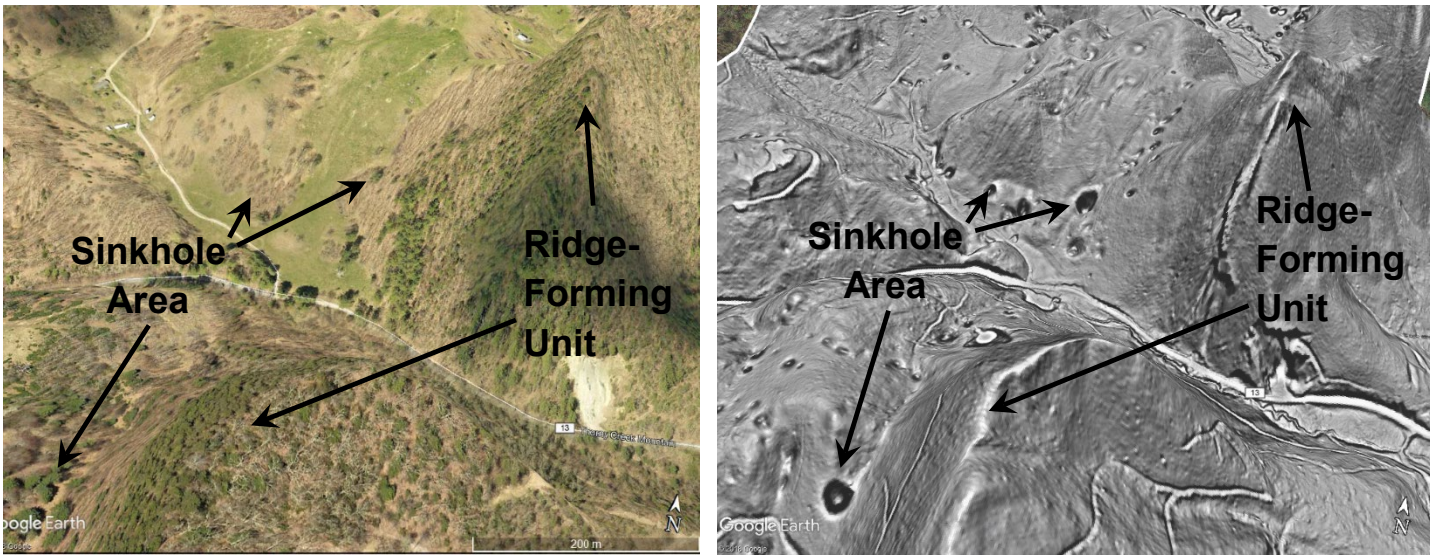
- A feasibility study for the provision of GIS services to communities with less than 5000 inhabitants got underway. This study derived from the State's Concurrent Senate Resolution 61.

- The State GIS Coordinator participated in the National Emergency Number Association's (NENA) GIS Data Stewardship for NG9-1-1 Workgroup. The documents developed by this group outline the development of a nationwide address spatial data infrastructure. The GIS Coordinator also participated in virtual workshops with stakeholders to find ways to acquire statewide LiDAR data under the USGS 3D Elevation Program (3DEP).

- Data exchange protocols to enhance data sharing and exchange between state and local agencies established in the previous years continue to be successful. The protocol began the inclusion of state and locally produced datasets in the GIS Clearinghouse maintained by the WV GIS Technical Center in Morgantown. Of note is the parcel viewer which allows access to parcel information at no cost to the taxpayer.

- Virtual GIS workshops developed and presented in collaboration with the WV Association of Geospatial Professionals, WV GIS Technical Center, Property Tax Division, County Assessors, and 911 directors continue to be popular among GIS professionals. These workshops are designed to inform, train and advise county and local government officials that have GIS programs in the latest technology and at the same time to educate those officials that have not embraced GIS technology in their own organizations. The workshops emphasize inter-agency collaboration and are given at different locations throughout the state.

- The GIS Coordinator attended Virtual sessions and made presentations at the West Virginia Association of Geospatial Professionals (AGP) 2020 GIS meeting and participated in virtual sessions of the Geographical Information Systems Certification Institute (GISCI) Board of Directors, NSGIC Leadership Group, WV Information Technology Council, WV Broadband Deployment Council, E911 Council, WV Association of Professional Surveyors, and NSGIC's NextGen 911 and Broadband workgroups.
- Data-exchange protocols enhancing data sharing among state and local agencies established in previous years continue to be successful and this year state and locally produced datasets were added to the GIS Clearinghouse maintained by the WV GIS Technical Center in Morgantown.



Features not apparent on traditional aerial imagery (left) are visible on recently acquired high-resolution LiDAR (right)

WV GIS TECHNICAL CENTER

The West Virginia GIS Technical Center, located in the Department of Geology and Geography, West Virginia University, provides focus, direction, statewide coordination, and leadership to users of geographic information systems (GIS), digital mapping and remote sensing within the State of West Virginia. The Center was established by Executive Order 4-93 to provide coordination and technical support in the development and operation of GIS for the State. Statewide geospatial activities are coordinated through the WV Office of GIS Coordination, WV Geological and Economic Survey. *Below are selected highlights for GIS Data Development, GIS Map Applications, Web Portals, and GIS Services.*

GIS Data Development

The Center plays a crucial role in not only serving critical spatial data to state users but in updating and integrating local geospatial data within state and national geospatial databases. These data layers are utilized by state agencies, communities, and the general public for applications that include emergency response, risk assessments, economic development, energy resource exploitation and management, transportation, natural resources, community planning, tax assessments, and health studies.

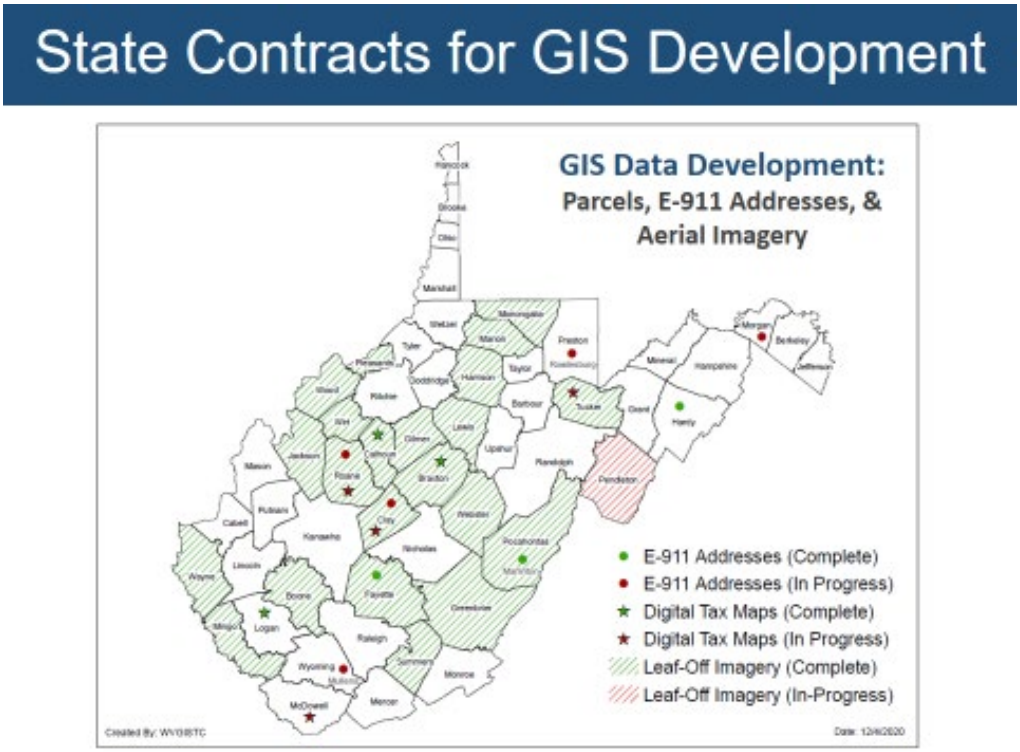


Figure 1: Two statewide GIS contracts through WVU Procurement currently support parcel, address, and aerial imagery data development for multiple communities in West Virginia

This past year the Center focused on the development of the geospatial data layers listed below to enhance the State's Spatial Data Infrastructure. The continued development and publishing of GIS layers through the state clearinghouse node hosted by the Center supports the Mineral Lands Mapping Program and other vital programs in the State that depend on current and accurate mapping layers.

- **Mineral Parcel Mapping:** The Mineral Parcels Map Project is a collaborative effort with the WV Property Tax Division and WV Geological and Economic Survey. This past year the WV GIS Technical Center (WVGISTC) reviewed 46,033 mineral records, mapped 8,353 unique mineral records, and georeferenced 806 well plats. WVGISTC completed mapping records for Marshall and Wirt counties, and progressed in mapping unmapped mineral records for three counties: Ritchie (23%), Doddridge (17%), and Harrison (7%) counties.

- **E-911 Addresses and Digital Parcels:** A major state contract through WVU Procurement was awarded to a GIS professional services company to assist 15 communities in correcting deficiencies with their E-911 addresses or tax maps. During this reporting year, digital tax map projects were completed for Braxton, Calhoun, and Logan Counties, while E-911 Addressing projects were completed for Fayette, Hardy, and Pocahontas Counties. Status Graphic: GIS Reference Data Development.
https://data.wvgis.wvu.edu/pub/RA/_resources/Status/GISDataDevelopment.pdf

- **Aerial Imagery:** A state contract executed through WVU Procurement allowed for 12 counties to capture spring 2020 leaf-off imagery at four-inch resolution. The best available, leaf-off countywide imagery is mosaicked together and published as a statewide imagery map service. Status Graphic: County Aerial Imagery Year Acquired.
https://data.wvgis.wvu.edu/pub/RA/_resources/Status/CountyImageryYearAcquired.pdf

- **Elevation:** Processed and published 2-foot contours from the 2012 FEMA LiDAR-derived elevation data for Morgan and Berkeley counties Quality checked and organized all new FEMA-purchased QL2 LiDAR-derived elevation products for West Virginia which are downloadable from the WV Elevation Download Tool (www.mapwv.gov/elevation). Created new statewide elevation and hillshade grids from the best available elevation sources and published to the State Data Clearinghouse. The statewide FEMA-purchased LiDAR and derived products are valued at $10 million; the State should receive the final QL2 LiDAR deliveries for the remainder of the State in 2021. Status Graphic: FEMA-Purchased LiDAR Elevation Status.
https://data.wvgis.wvu.edu/pub/RA/_resources/Status/FEMA-purchased_LidarCoverage.pdf

- **Flood-Risk Buildings:** Published to the WV Flood Tool more than 25,000 building-level risk assessments for a 1-percent-annual-chance (or 100-year) flood.

- **Highway Plans:** Scanned nearly 9,000 highway plan sets for an ongoing project with the WV DOT.

- **Recreational Trails:** Inventoried and published recreational trails for West Virginia that include 5,314 miles of land trails and 3,373 miles of blue water/whitewater trails. Customized trails maps were made for several state and local agencies.

- **Public Lands:** Coordinated with the Division of Natural Resources and other stakeholders to update the state public lands and local parks for submission to the Protected Areas Database of the United States.

- **Landslides:** More than 66,000 landslides were mapped from the new LiDAR-derived elevation data of which 1,082 landslides have been field verified. Although most of the landslide types are classified as slides, other landslides mapped include debris flows, rockfalls, lateral spreads, and multiple failures. The landslide incidents mapped from LiDAR-derived digital elevation models are model inputs for creating landslide susceptibility maps for the State.

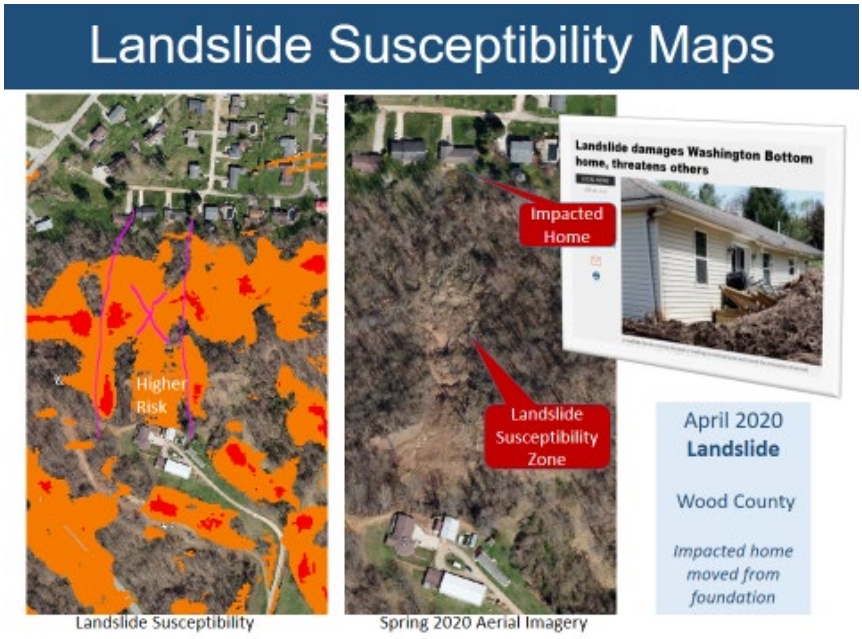


Figure 2: The new FEMA-purchased LiDAR allows for many elevation applications including the mapping of landslide incidents and susceptibility zones (www.mapwv.gov/landslide)

Web Portals

The Center maintains two major web portals to distribute spatial data and information in the State. Presently the **WV GIS State Clearinghouse** (http://wvgis.wvu.edu) catalogs over 300 unique datasets and 120 web services valued at more than $65 million dollars, while **MapWV.gov** (http://mapwv.gov) provides a public gateway to online mapping resources in the Mountain State. These geospatial services are distributed through virtualized servers and storage devices located at the Center with a storage capability of 150 TB. These servers are continuously tuned and configured to attain high-availability performance.

Web usage statistics reveal that MapWV.gov had a significant increase in traffic for FY2020 as web map services continue to grow in popularity. Average page views per day surged from slightly over 50,000 last year to in excess of 85,000 this year. Total page views nearly doubled from 4.6 million to 8.3 million, almost 80% more pages than the previous year. The new WV Property Viewer and Real Estate Assessment Search tools (www.mapwv.gov/property) account for most of this growth. The property and assessment tools have grown in popularity and are used by many organizations in performing multi-county property record searches.

GIS Map Applications

Continued application and web programming assistance was provided for state and federal agencies in support of West Virginia and its citizens. These applications support multiple state agencies via e-governance solutions to meet their regulatory and information exchange requirements. (see Table below). This past year, for example, the Center completed the WV Water Quality Impact Portal (WVWQIP) which provides information about past and current water quality in the 14 counties where most of the active Marcellus Shale gas development has taken place. Additionally, during this fiscal year, the Center modernized desktop applications for the WV Flood Tool, WV Interagency Tool, WV Wetlands Functional Assessment Tool, WV Trail Inventory Viewer, and WV Elevation Download Tool. A new e-governance solution implemented this past year allows for the WV State Auditor's Office to publish weekly its delinquent properties to the WV Property Viewer (www.mapwv.gov/property) with links to the State Auditor's Delinquent Properties Database. The Center also supported federal initiatives for the Marcellus Shale Energy and Environment Laboratory (www.mseel.org) and terrestrial biosphere carbon (www.carbonscapes.org).

APPLICATION	PURPOSE	SPONSOR
WV Elevation & Lidar Download Tool	Download LiDAR, digital elevation models, and contours (www.mapwv.gov/elevation)	WV VIEW
WV Flood Tool	Flood hazard determinations, floodplain management, building-level risk assessments (www.mapwv.gov/flood)	WV DHSEM, FEMA
SHPO Map Viewer	Conduct Cultural Resource Section 106 reviews (www.mapwv.gov/SHPO)	SHPO
Statewide Addressing & Mapping System (SAMS)	Update address sites and road centerlines required for emergency response (www.mapwv.gov/address)	WV DHSEM, E-911 Address Coordinators
WV Hunting and Fishing	Search and identify hunting and fishing adventures (http://www.mapwv.gov/huntfish)	WV DNR
WV Trail Inventory	View publicly accessible recreational trails in the State (http://www.mapwv.gov/trails)	WV DOT
WV Highway Plans Locator	View and download archival highway plans (http://www.mapwv.gov/dotplans)	WV DOT
WV Conservation Interagency Conservation Tool	Determine conservation planning measures for endangered species in support of environmental site evaluations (www.mapwv.gov/ICT)	WV DNR, NRCS
WV Property Viewer & Property Record Search	Search and display property information for entire State (www.mapwv.gov/property). Includes delinquent properties managed by the WV State Auditor's Office.	WV Tax, WV State Auditor
Wetlands Functional Assessment	A standardized tool for assessing wetlands (https://mapwv.gov/wetlands)	WV DEP
WV Water Quality Impact Portal (WVWQIP)	Obtain information about past and current water quality in the 14 Marcellus Shale gas development counties (https://www.mapwv.gov/wvwqip)	WV DEP, EPA

Services

This past year the WV GIS Technical Center continued to assist the WV Geospatial Community with advisory, training, and outreach services. These services are coordinated with the WV Office of GIS Coordination and WV Association of Geospatial Professionals.

- The GIS Technical Center provided GIS Foundations in-person training at the WVU Morgantown campus and the Division of Highways in Charleston. Due to the COVID-19 pandemic, the Center transitioned to remote training for its ArcGIS Pro and ArcGIS Online courses.
- Provided limited mapping support to the WV Development Office for mapping schools in support of fiber deployments. In addition, the Center supported a WV Development Office's request for a statewide trail map that was required for a planning document.
- Supported the WV Emergency Management Division and communities with mapping support for the Statewide Addressing and Mapping System hosted on the Center's servers.
- Coordinated with FEMA's National Hazard Modeling Team on the development of its Flood Assessment Structure Tool (FAST).
- Provided the WV DHHR with address geocoding support for the COVID-19 pandemic emergency.
- Training and outreach services were provided on numerous occasions in support of the WV Flood Tool, an important web application used by floodplain managers and FEMA personnel.
- Continued technical support for statewide multi-hazard risk assessments for 287 communities in West Virginia to supplement local hazard mitigation plans
- Presented on geospatial activities and projects at state and national conferences/webinars.
- Provided technical advisory services to the state geospatial community. The Technical Center responds to an estimated 15 public calls per week from the public and clients regarding GIS data and applications.

Figure 3: The popular WV Property Viewer and Property Search Tool for searching and viewing property records (www.mapwv.gov/property)

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Principal Staff Directory and Points of Contact as of June 2020

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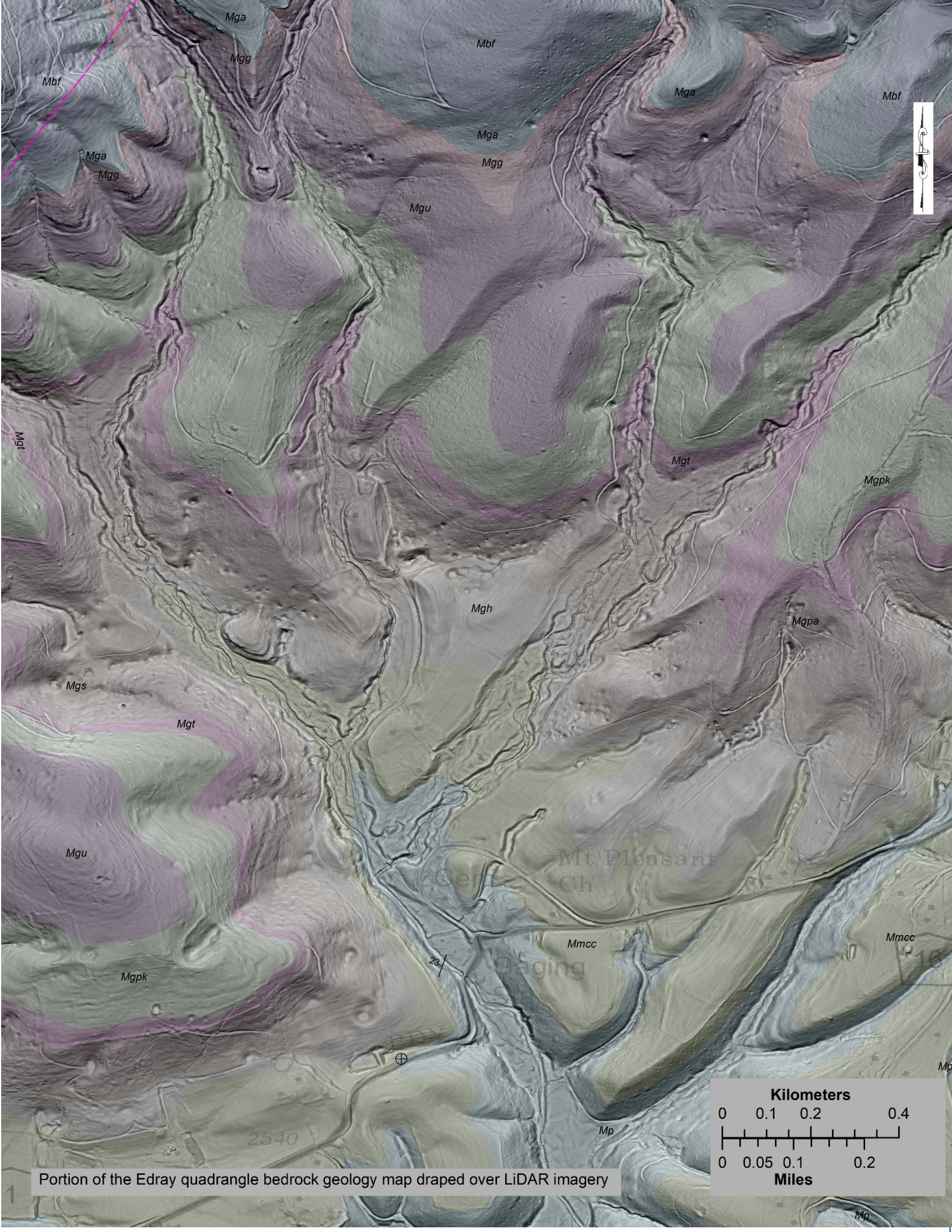

Portion of the Edray quadrangle bedrock geology map draped over LiDAR imagery