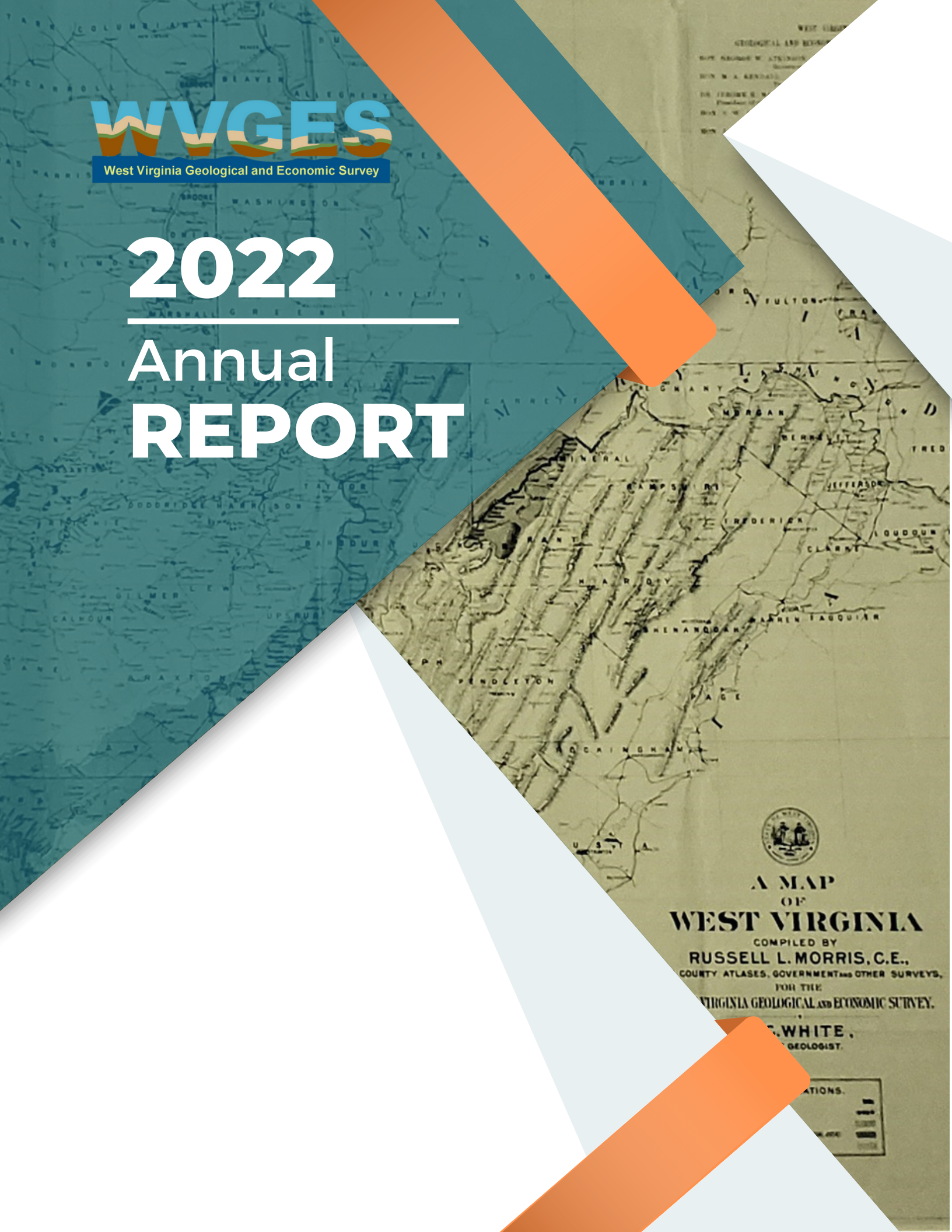
WVGES

West Virginia Geological and Economic Survey

2022 Annual REPORT



Cover Photo

The West Virginia Geological and Economic Survey's first publication, "A Map of West Virginia Compiled by Russell L. Morris, C.E., from County Atlases, Government, and Other Surveys," which went on sale in 1899 for 50 cents.

Photo courtesy of Shane Leiggi

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WVGES
West Virginia Geological and Economic Survey

EXECUTIVE SUMMARY

Jessica P. Moore, Director and State Geologist

Once again, I am pleased to report on a busy and productive year at the West Virginia Geological and Economic Survey (WVGES). Fiscal Year 2022 also happens to coincide with the 125th anniversary of the agency, which was created by an act of the West Virginia Legislature in 1897. This milestone year has been punctuated by several significant scientific discoveries, including the May 2022 discovery of a skull of West Virginia's State Fossil, the giant ground sloth, *Megalonyx jeffersonii*, by a hunter in Putnam County as well as the sampling and radiometric age dating of an intrusive igneous dike in a cave near Cass that may represent one of the youngest igneous intrusions identified on the east coast. These are just two of the exciting developments we cannot wait to share with you in this year's Annual Report.

As I am certain other state geologists have done during major events in the agency's history, I wonder what our first State Geologist, Dr. Israel Charles (or "I.C.") White, would think about our progress. His brilliant mind and early efforts built a solid foundation for the agency, and the work he and his crew of geoscientists performed in the early years remains relevant and useful to this day. Furthermore, in addition to the prolific technical prowess of his geologic work, his writings' prescience is remarkable. Take this, for example, an excerpt from the "Conference of the Governors of the United States" convened by President Theodore Roosevelt in 1908 on the topic of waste of domestic resources:

> *What account can we have as a nation give of our stewardship of such vast fuel treasures? Have we carefully conserved them, using only what was necessary in our domestic and industrial life, and transmitted the remainder like prudent husbandmen, unimpaired to succeeding generations? Or have we greatly depleted this priceless heritage of power, and comfort, and source of worldwide influence, by critical criminal waste and wanton destruction? The answer should bring a blush of shame to every patriotic American; for not content with destroying our magnificent forests, the only fuel and supply of carbon known to our forefathers, we are with ruthless hands and regardless of the future applying both torch and bomb to the vastly greater resources of this precious carbon which provident Nature had stored for our use in the buried forest of the distant past. The wildest anarchist determined to destroy and overturn the foundations of government could not act in a more irrational and thoughtless manner than have our people in permitting such fearful destruction of the various sources of our power and greatness.*

The entire address can be found on our website, WVGES Mission, Information, and History (wvnet.edu). It's worth a read.

I am also thankful for the foresight of Colonel Paul Price, the state geologist from 1934 to 1969, who invested time and resources into a collection of photographs of Survey activities. Many of these images appear throughout the FY22 Annual Report and record a rich and vivid history of our investigations.

Now, on to the future.

The Infrastructure Investment and Jobs Act, colloquially known as the Bipartisan Infrastructure Law, became Public Law 117-58 on November 15, 2021. This monumental federal investment in infrastructure and economic development includes significant funding for geoscience research, with substantial increases to several U.S. Geological Survey programs that fund work performed by state surveys. Notable among these increases is an additional $320 million dollars for the U.S. Geological Survey Earth MRI Program to identify domestic sources of critical minerals and an additional $25 million dollars for its National Geological and Geophysical Data Preservation Program, which makes funds available to states for modernization and preservation efforts. Additional funds from the Bipartisan Infrastructure Law will be directed toward economic development in coal and energy communities impacted by the closure of coal-fired power plants, invested in carbon capture and storage research through the Department of Energy. Funds will also be utilized for the identification and plugging of orphaned and abandoned wells, which remains a major liability for many states in the Appalachian basin, including West Virginia.

The increase in federal research funding presents a tremendous opportunity to advance our knowledge of West Virginia's geology and will enable our researchers to perform work that would not otherwise be possible. However, this unique opportunity also presents challenges and necessitates careful project management, administration, and accounting of funds. Fortunately, the WVGES has a highly capable Administrative staff trained and ready for the work ahead, including a recipient of the 2022 Shining Star Award for the Department of Commerce.

I hope you enjoy this summary of activities performed in Fiscal Year 2022. The work performed by the Coal, Oil and Gas, and Geoscience programs is often collaborative, so this work will be organized into project descriptions rather than program-by-program summaries. In addition, updates are included from the office of the State GIS Coordinator, the state Property Tax Division and the West Virginia GIS Tech Center.

125 Years of Geological Research & Public Service

When created by the state legislature on February 26, 1897, the West Virginia Geological Survey's goals were directed by a five-person commission which included the governor, state treasurer, commissioner of agriculture, WVU president, and the WV Agricultural Experiment Station director. This commission established that the Survey was to investigate the state's geological and physical resources; make the investigation results quickly available to the public; and provide topographic, geologic, and other maps and publications.

Under Dr. I.C. White's leadership, Survey employees determined true meridians; conducted general structural geology and stratigraphy research; participated in a water gauging project on all of the principal rivers with the U.S. Geological Survey (USGS), and published economic geology studies on coal, oil, gas, limestone, sandstones, clays, and brines. The Survey further completed 29 county geological reports covering all 55 counties, and in cooperation with the USGS, finished a complete set of 15-minute topographic maps of the entire state. We were the first state to accomplish this task.

After the unexpected death of Dr. White in 1927, the Survey went through a period of reduced activity because of leadership turnover and the Great Depression. The agency experienced four different state geologists during those 7 years: David B. Reger, Cassius McCarl Lemley, Rietz C. Tucker, and James D. Sisler. When the Great Depression struck in 1929, the Survey's budget was cut and WVGES stopped field investigations and hiring personnel.

In 1935, Dr. Paul H. Price was named the Survey's director, and its new direction included two main goals: 1) intensive studies of the physical and chemical properties of the state's natural resources, and 2) improving the Survey's facilities. Up to this point, offices, laboratories, and depository for cores and well cuttings were located in different buildings on the WVU campus. Price understood that new tools, techniques, and laboratory equipment all located in one facility were vital to doing this research.

Top: WVGES's first headquarters on the grounds of I.C. White's Morgantown home, Cherryhurst, on Willey Street.

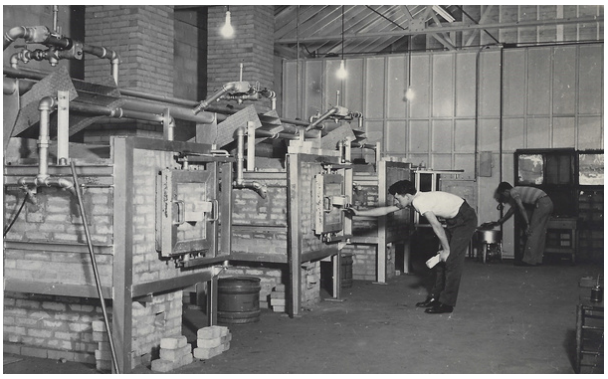
Bottom: Survey employee inspecting a coal seam near a mine opening in Barbour County in 1918.

In his 1936 report, he urgently pleaded for permanent housing, and he and his staff devoted much effort to planning for and acquiring the new facility. Finally in 1942, the Survey and the WVU Geology Department moved into occupy half of the new Mineral Industries Building.

Top Left: Dr. Paul Price, WVGES director and state geologist, making an address at the Monroe County, WV-Alleghany County, VA border monument dedication in 1959.

Bottom Left: Artist's rendering of the Mineral Industries Building on the downtown campus of WVU (now. I.C. White Hall).

Bottom Right: The kiln room at the Mineral Industries Building.



After the construction of the Mineral Industries Building (now I.C. White Hall), the Survey shifted its research to secondary recovery of oil and natural gas. Experienced petroleum geologist, Oscar Haught, prepared many structural maps and authored publications describing oil and gas possibilities by county. Additionally, the Survey maintained a well sample library with more than 4.5 million feet of cuttings from approximately 2,200 wells. The specimens from the well sample library were available for study by industry experts, scientists, and the public.

In addition, the Survey began a new cooperative topographic mapping program with the USGS in 1955. The updated project was for complete state coverage with a more detailed set of 7.5 minute quadrangles. Other projects included a new state geologic map; shaded relief map; base map; mineral resources and mineral industries map; three editions of oil and gas maps; and limestone map. Toward the end of Price's time as director, the Survey formed the Geologic Data Section to tackle putting the agency's geologic data into digital form for computer processing.

During the 1970s, the Survey enlarged its scope with detailed statewide coal studies, land use mapping, remote sensing, sophisticated analytical capabilities, and computerized data processing. Agency staff more than doubled in size due to the demand caused by the nation's critical energy situation as well as environmental problems. Under Robert Erwin's directorship, geologic information was increasingly applied as a part of land-use planning, water resource management, building construction, transportation and utility facilities planning, and waste disposal safety. These expansive projects made the agency quickly outgrow its space at I.C. White Hall. As a result, the Survey relocated to the former Mont Chateau State Park facilities on Cheat Lake in 1978.

Important accomplishments during this period included computerizing the agency's oil and gas data, the creation of the Mineral Producers Directory, and the end of the USGS cooperative 7.5 minute topographic mapping project. New projects involved the Coal Resources and Pollution Potential Program which addressed environmental, health, safety, and economic problems of the industry, and the USGS Land Use Data Analysis Program which created the first statewide map to describe land use patterns. At the end of Erwin's tenure, the Survey finally released the West Virginia Gazetteer of Physical and Cultural Place Names in 1988.

Geologic Data Section Head, Mary C. Behling, revising a statistical application program on coal data (LEFT) and Survey geochemist, John Renton (RIGHT).

Budget cuts in the late 1980s caused staff reductions and restructuring to maximize research, mapping, service, education, and data acquisition. To decrease the impact of the budget shortfall, WVGES found funding from non-state sources, increased publication prices, and began to charge for service requests to better support the agency. The Survey marched forward with fully computerizing its geoscience and service functions as well as embarking on innovative research and educational outreach projects.

The Survey in the 1990s saw the beginning of two new long-term cooperative mapping projects. The first was the USGS-supported geologic mapping project now known as STATEMAP. The second partnered WVGES with WVU and the WV Department of Tax & Revenue for the Mineral Lands Mapping Program. This program developed several layers of mapping information of coal resources, coal ownership, and digital line graphs. These two initiatives led to the creation of the Office of GIS Coordination under the umbrella of the Survey.

Additionally, an expanded emphasis on public service and education created the Earth Science Information Center (ESIC) and Rock Camp. The ESIC maintained aerial photographs and maps that were accessible to the public and industry. In contrast, Rock Camp was a 12-day intensive summer geology program for WV science teachers. Over 160 teachers participated in the graduate credit geology course short course and field trips in the first three years of the program.

Studies of Devonian shale and the development of the Atlas of Major Appalachian Gas Plays and "pipeline" databases in the mid-1990s were the forerunners to the research WVGES conducted on the Marcellus, Utica, and Rogersville shale reservoirs in the 2000s. This research expanded the exploration and development of these fields by the oil and gas industry. In addition, the increased hydrocarbons produced by this latest oil and gas boom further led the Survey to investigate sources for carbon capture and storage with the Midwest Regional Carbon Sequestration Partnership.

WV school teachers on a field trip as a part of WVGES's Rock Camp 2003 (LEFT). John Saucer and Sarah Gooding with the WVGES display at the 2002 GIS Forum (RIGHT).

Since their first use of GIS technologies back in 1994, WVGES further applied GIS as well as high-resolution LiDAR imagery for the Coal Bed Mapping and geologic mapping programs. The increased use of digital technologies made the Survey realize the importance of preserving historical data sets in addition to incorporating modern data. In response, WVGES began cataloguing and barcoding oil and gas cuttings and core, photographing physical cores, rescuing physical samples at of loss due to poor storage conditions through the USGS National Geological & Geophysical Data Preservation Grant. Furthermore, WVGES has kept pace on scientific research into energy sustainability and resources. The agency has focused studies on coal measures and associated strata to increase our understanding on potential rare Earth elements (REEs) as well as geothermal energy production possibilities.

As WVGES prepares to enter its 126th year, we will continue our proud tradition of geologic research and public service for many more years to come.

New Geothermal Test Well at WVU

West Virginia University continues to investigate utilization of deep geothermal resources for the energy demands of its Evansdale Campus, which was designed to run on electricity and steam produced from waste coal and generated at the WVU Physical Plant on Beechurst Avenue in Morgantown. The WVU Board of Governors voted in 2020 to switch to a natural gas feedstock as a cost-saving measure, and local utility Mon Power opted for a buyout of its remaining contracted electricity, so the plant now supplies only steam to both WVU campuses. It is slated to close in 2027, and the university is actively researching alternative ways to offset the energy load of its facilities. Following a 2019 study to characterize the geothermal potential of a low-temperature anomaly identified from a national survey with an approximate temperature of 100 degrees F at a depth of 10,000 feet beneath Morgantown, WVU will receive 7.5 million dollars to drill a deep stratigraphic test well to a proposed total depth of 15,000 feet. Core samples will be taken from several intervals along the wellbore, including from the shallower Devonian and Silurian sections, to investigate the potential for other applications, such as subsurface storage of CO2 or geothermal brines. Drilling is slated to start in early 2023, and WVGES will participate in the analytical work following sample retrieval.

21st Century Power Plant (21CPP) Initiative Research Grant

- This ongoing project will deploy modular coal-fired power generation, utilizing waste coal and biomass as feedstocks, with on-site Carbon Capture Utilization and Storage capabilities.
- Funding is from the U.S. Department of Energy. Research will be conducted by Battelle Memorial Institute, Carbon Solutions, LLC, and both the Pennsylvania and West Virginia geological surveys in conjunction with industry partner Consol Energy.
- In FY22, the project team evaluated multiple formations for potential CO2 injection using deep geophysical logs and regional two-dimensional (2D) seismic lines. Site-specific locations and their most prospective geological formations were proposed for further investigation.

Coalbed Mapping Program (CBMP)

The CBMP is tasked with creating an accurate and up-to-date Geographic Information Systems (GIS) database of mined and remaining coal for environmental, safety and tax purposes.

As new data are obtained from industry and other contributors, the database and maps of West Virginia's 84 mineable coal seams and splits are updated to improve the overall data model. CBMP utilizes an Oracle database of coal elevations and thickness data with nearly 188,000 points. Over 37,000 of these points are detailed drill holes, 246 of which were added in FY22. An additional 9,800 thickness or elevation points were collected from scanned mine maps.

The State Tax Department uses CBMP to accurately and equitably value properties for tax assessment.

Shape files of coal mine location, mining type, coal thickness, elevation, and percent parting grids, mined and remaining areas and overburden information are created from the CBMP database for easy online access.

Data are free and easily accessible to everyone on the WVGES website at http://www.wvgs.wvnet.edu/www/coal/cbmp/coalims.html

Underground Mine Mapping Project

- Continue to process new and legacy mine maps collected from various sources including industry archived datasets and private collections. Several paper maps were collected that are much higher quality than existing scanned images. These were scanned and added to the data set. Paper copies are archived when possible.
- The project received 51 new mine maps representing 136 individual mines in FY22. Each mine map was examined to see if it resides in our system. If new mined areas are identified, they and any associated data are entered into the data model.
- Large-format historical mine maps are scanned to create high-resolution digital images.
- The database contains various snapshots in time of mined areas. The clearest and most complete maps are used to create a mine footprint. Commonly, the footprint of a large mine complex is composed of a mosaic of many smaller images.
- Many small areas were added to existing mine footprints along with several 'new' mines in depleted areas where mine maps have been difficult to collect.
- The CBMP continues to increase the accuracy of the data model. As more data are added, a clearer understanding of the depositional environment associated with the coal seam comes into focus.

- This information is made available to the public, industry, and government to inform companies, landowners, and citizens about potential hazards while allowing more accurate equitable property valuation.
- The CBMP works in cooperation with the West Virginia Office of Miners Health, Safety and Training.

Mine Information Database System (MIDS)

MIDS houses publicly accessible information collected from mine maps including mine name, company name, mined seam, county and quad and various notes with a link to download most scanned mine maps images.

The database contains 49,899 documents representing 91,564 mines.

WVGES encourages comments and mine-map submissions from the public to improve our database. If you have a mine map that you would like to donate or allow us to scan or if you see an error in our database, please contact us at info@wvgs.wvnet.edu

MIDS is accessible from the WVGES website at http://www.wvgs.wvnet.edu/www/mids/main.php

Coal Bed Mapping Project Chemistry Database

The database contains coal analyses, accessory minerals, and critical mineral data, including Rare Earth Elements, and many other types of information for most coals in West Virginia.

It includes a large archive of physical samples, many of which have been reanalyzed for recent critical minerals projects.

The database provides non-confidential laboratory analyses of coal samples from industry donations and decades of WVGES sample collection.

The first iteration of a publicly accessible data search engine has been created. It contains critical minerals and rare earth elemental data and is available at WVGS Coal Sample Records (wvnet.edu).

Banded coal specimen from Bolt Mountain, Route 99 in WV. Photographed by Geologist Bethany Royce.

WV Coals and Critical Minerals

Could the nation's (and, closer to home, Appalachia's) historical problem with coal waste help pave the way for our energy future? That's the question the U.S. Department of Energy's Mineral Sustainability Program aims to answer through its Carbon Ore, Critical Minerals, and Rare Earths (CORE-CM) funding opportunities, which were awarded to 13 multidisciplinary teams located in coal basins throughout the United States. Researchers from WVGES, West Virginia University, Virginia Tech and the University of Kentucky received an award for the Mid-Appalachian Carbon Ore and Rare Earths (MAPP-CORE) initiative, which will characterize critical mineral concentration and distribution in several legacy waste streams, including acid mine drainage, coal fly ash and gob piles. In addition, the coal and carbon-rich waste materials (aka "carbon ore") will be evaluated for use in advanced materials and manufacturing. Research performed by WVGES will include a basinal analysis of the resource performed by calculating mined and remaining coal for major seams in Kentucky, Virginia, West Virginia, and western Pennsylvania, performing a desktop study of elemental composition and concentrations of critical minerals (several of which have been identified in previous studies), and location and volumetric assessment of waste impoundments and ash ponds.

The location and assessment of legacy waste impoundments presents several unique challenges: older refuse piles have been re-vegetated and are difficult to locate using aerial photography, but were sorted using more rudimentary techniques, leaving behind significant volumes of higher quality coal along with rare earth element-bearing clays in the discarded floor and partings. Newer impoundments, especially those constructed after federal regulations were instituted in the late 1970s, are highly engineered structures that were not designed to be disassembled but contain large volumes of materials, often have supporting data and information available from regulatory agencies and are easier to locate and access.

Critical Minerals, as defined by Federal Executive Order 13817, include 31 elements, oxides or mineral compounds 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 for the country.

The Earth MRI project uses a mineral systems approach to define areas of enrichment, and the mineral systems potentially containing rare earth elements (REEs).

Earth (Mapping Resources Initiative) MRI for Critical Minerals

In FY21, WVGES was awarded $125,000 from the U.S. Geological Survey to coordinate a geochemical reconnaissance study across an eight- state region.

The study aims to evaluate the critical mineral potential of clay-rich strata associated with coal beds. The clay-rich material is often discarded during the mining process and could potentially be processed for beneficial reuse.

The goal of the study is to identify potential sources of critical minerals, especially rare earth elements, but also other critical mineral resources such as lithium.

Work focuses on the Pennsylvanian-aged coal measures, which were deposited in an equatorial climate with humid, ever-wet conditions creating laterite deposits similar to those being mined in China today.

The study will conclude in June of 2023, but preliminary data can be accessed at the following link: [Earth MRI Funds Critical Minerals Project in West Virginia (usgs.gov)]

Unidentified WVGES staff examining saltpeter hoppers in Organ Cave, Greenbrier County.

Maintaining WVGES' Sample Repository

This collection represents the most comprehensive group of geological samples in West Virginia. WVGES maintains over 28,000 linear feet of core from coal, oil and gas exploration, cuttings samples from thousands of wells and boreholes, and hundreds of samples collected during fieldwork by agency geologists. Housing, cataloguing, curating, and updating this large, complex, and irregular collection is difficult and space is always an issue. Our facilities are near-capacity and not all climate-controlled, and it is imperative that physical material be preserved for current and future research. As oil, gas, and coal companies downsize their operations in Appalachia, elimination of sample storage space is often one of the first cost-saving measures adopted. Many of these companies have longstanding relationships with WVGES and frequently offer to donate sample material rather than see it disposed of and/or destroyed. Cores and cuttings can also be requested by WVGES via legislative authority outlined in WV Code 22-6-22. Additionally, results and analyses from outside researchers must be submitted to WVGES resulting in advanced analytical data sets at no cost to the taxpayer.

In addition to the requests outlined in WV Code, WVGES accepts donations of geologic material and data from individuals, industry, and academia. WVGES, in turn, makes access to these collections public. Preserving data and samples has heightened importance as exploration companies enter and exit the basin with assets continually changing hands. WVGES seeks to maintain and foster deep relationships with industry partners and stakeholders. Additionally, as a generation of geoscientists and engineers retire, many have contributed personal collections of records, maps, and geophysical logs. Over the past fiscal year WVGES received three significant core collections from Berkshire Hathaway Energies Eastern Gas Transmission and Storage, EQT, and TC Energy. In addition to geological samples, WVGES received a large collection of maps and data from the family of Philip Martin, who worked in the oil & gas industry and later as a geologic consultant. WVGES appreciates these donations and has already incorporated these samples into current research.

Left: WVGES's agency truck and core drilling rig.

Right: Core testing at site of National Radio Astronomy Observatory, Green Bank, WV.

Donations of Software

The IHS Markit University Grant Program generously donated networked software licenses for both the seismic data interpretation Kingdom® software, as well as the subsurface mapping program Petra™

- These modern software applications are essential to assimilate, analyze, and map disparate datasets.
- They enable WVGES to develop analysis skills and keep current with other state geological surveys.
- This software allows WVGES to interpret, map, and package data used by a variety of stakeholders.
- Their acquisition can be financially challenging for government organizations.
- These donated network licenses are valued at more than $750,000, a generous award at no cost to the taxpayers of West Virginia, and an amount WVGES would be unable to afford.

National Geological and Geophysical Data Preservation Program Grant (NGGDPP)

WVGES utilized funding from the U.S. Geological Survey National Geological and Geophysical Data Preservation Program (NGGDPP) to rescue and preserve at-risk scientific data while also making those data publicly available in modern formats. The U.S. Geological Survey NGGDP program requires and evaluates submitted proposals each year and, if approved, provides funding on a yearly project basis. WVGES has successfully been awarded funding multiple times, successfully completed a project in April 2022 and was most recently awarded a year of funding that began in May 2022.

FY22 Completed Data Preservation Project

In FY22 WVGES completed multipronged data preservation activities that included six components. These projects included processing of recently donated oil & gas well logs, re-boxing oil and gas cores that were at risk due to inadequate containment and storage, developing an interactive map of bedrock geology in West Virginia, scanning a collection of aerial photos taken after the 1985 flood, creating an inventory of critical minerals samples and geochemical data in West Virginia, and photographing coal exploration cores recently used for critical minerals sampling and analysis. WVGES's goal is to make this information more accessible for analysis and distribution to stakeholders.

The first of the Data Preservation projects included the processing of thousands of oil & gas logs donated to the state from industry partners.

These well logs are useful in mapping and analyzing the rocks below the surface. WVGES processed over 3,000 digital logs and were able to add over 2,300 digital logs to our collection. WVGES had previously only had 100-200 digital logs available and this effort increased availability tenfold. Additionally, WVGES scanned over 2,000 paper logs and added those to the collection. All of these logs are freely available on a per-well basis for download on the WVGES website.

Second, through the NGGDPP program, WVGES utilized awarded funds to purchase specialized boxes to store oil & gas cores. These cores had been donated to the state by industry partners and are extremely expensive to collect. Therefore, WVGES curates the state's collection of oil & gas cores. This curation requires labor-intensive efforts to properly maintain and store the collection. In the latest period of performance WVGES re-boxed 1,030 feet of core from deteriorating boxes into new boxes. Cores from Hardy, Kanawha, and Roane counties were re-boxed. Cores from Hardy County were collected to determine geomechanical properties for dam construction and flood protection efforts. The cores from Roane County were selected because they contained rock intervals previously examined for natural gas liquids storage as well as karst potential. The core from Kanawha County contained material over a known oil & gas interval.

A primary mission of WVGES is to produce maps of the bedrock geology at the surface in West Virginia. This has been a task of the WVGES since its inception and WVGES is constantly updating the maps available for use, whether due to new information, data, technology, geographical coverage or other factors. However, WVGES did not have a public-facing interactive map for users to examine bedrock geology in the state. Assisted by NGGDPP funds and expertise of WVGES geologists and GIS professionals, an interactive map was constructed and will be made available on the WVGES website. This map includes geology at different scales, names of available maps, and earthquake and landslide information.

WVGES houses a large collection of aerial photographs that cover the state from different time periods. WVGES discovered a collection of unscanned photographs in our holdings and recently cataloged the set of aerial photographs collected for the agency after a devastating flood in 1985. The flight lines were flown to follow the channel of the Potomac River and tributaries where the most severe flooding occurred. A total of 511 images were scanned and are now available.

In support of a nationwide effort by the U.S. Geological Survey's Earth Mineral Resources Initiative and other critical mineral research efforts in the Appalachian basin, WVGES proposed compilation of a comprehensive inventory and modern database of WV legacy coal samples and chemistry data. This effort modernized a substantial coal chemistry database containing greater than 10,000 samples, the majority of which were collected from exploratory drilling or during active underground mining operations. This database was previously compiled in numerous tabular and document files, in unsupported formats, and was not linked to information on sample availability. The availability of this information greatly enhances the public accessibility of WVGES critical minerals data.

Under previous NGGDPP projects WVGES has photographed approximately 3,000 feet from 22 cores from oil and gas operations. In this period of performance WVGES began the process of photographing a core that has been examined and sampled for critical minerals research. The core photographed, the Mylan Park core in Monongalia County, WV (306-061), is the most extensive core through the coal measures held in the State's collection. The core begins at a depth of 63 feet and is continuous to a depth of 2,525 feet. The total footage of 2,462 feet is stored in 275 total boxes of either 8- or 10-foot intervals. These core photos are available for viewing on the WVGES website.

Current WVGES NGGDPP Project

WVGES capitalized on changes in the usage of funds permitted in the NGGDPP program announcement in FY22. Support for infrastructure improvements was added and WVGES requested funds to build a storage facility for the state's core, cuttings, and geological samples collection. In addition to the storage facility, WVGES requested funds to curate crushed coal samples that were in deteriorating conditions. Finally, WVGES proposed to continue photographing cores through the coal measures that have been utilized for critical minerals research. The WVGES proposal was funded in full and work began in May 2022.

As mentioned above WVGES curates a large collection of geological samples from oil & gas operations, coal exploration, geologic mapping, and other activities. Storage space for physical material at both WVGES headquarters and existing offsite locations is inadequate and the amount of core material donated or requested continues to increase. WVGES has been successful in growing the collection and storing the material but had to utilize spaces not originally designed for core storage. This new 30 x 40' steel frame building will alleviate some of the space issues.

WVGES has a decades-long history of curating samples collected from coal mining operations and the WVGES coal sample repository holds over 10,500 samples. Additionally, as coal mines close, the subsurface locations where the samples were collected are inaccessible; mines are either flooded post-closure, abandoned and permanently sealed, or are designed to collapse as the longwall mining proceeds through the seam. Therefore, these materials form a representative sample set that cannot be replicated. WVGES is in the process of preserving these samples in plastic containers that will securely store the geological samples and provide a more easily accessible collection. Additionally, WVGES will be photographing more cores that extend through the coal measures and have been used in critical minerals research.

Cass Cave Research

In late 2020, it was brought to the attention of WVGES geologists that a basaltic igneous intrusion within Cass Cave, Pocahontas County, had been dated to an age of 27 million years old (unpublished data), which would make it the youngest known volcanic activity on the east coast by about 10 million years, and is also at least 15 miles from any other known intrusion. As a discovery of this magnitude could add a new chapter to the volcanic history of the Eastern United States, plans were made to obtain an additional sample and determine if the first age was correct or if the weathering of the rock could have obscured the true age. Upon obtaining landowner permission to access the cave, a sampling trip was executed in January of 2021 consisting of one WVGES geologist and a number of experienced-caver volunteers.

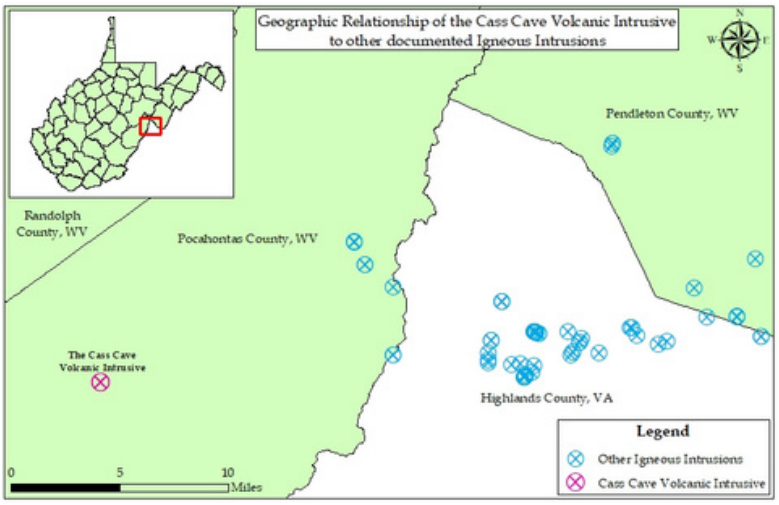


Photo courtesy of Ryan Maurer

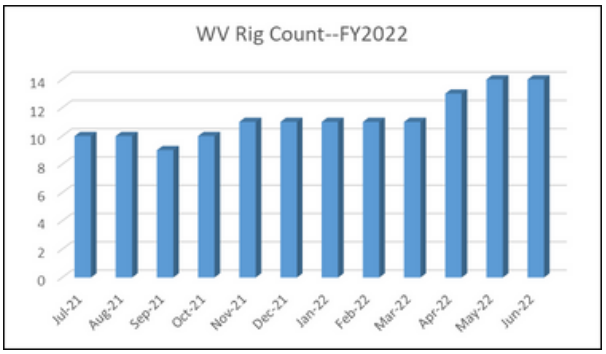
The trip yielded enough sample to allow for the creation of thin sections to confirm that the mineralogy is indeed basaltic, to conduct trace geochemistry to compare against previously documented basaltic intrusions and Argon-Argon radiometric dating. The U.S. Geological Survey offered to partner with the WVGES in obtaining the Argon-Argon radiometric dates. Preliminary results, obtained in August 2022, show that the original numbers appear to be correct. Further studies are necessary to confirm that the Cass Cave sample is statistically differentiable from the older igneous intrusions in the region and to ensure that the data presented are accurate. This study is currently ongoing as a partnership between the WVGES and the U.S. Geological Survey.

Community & Stakeholder Support for Preservation of Geologic Samples

For the first time in many years, Congress accepted applications for Congressionally Delegated Spending (CDS) requests, also known as earmarks. These requests reflect spending needs not necessarily included in Federal funding language but applicable under existing programs. WVGES was fortunate to be included in CDS requests from the offices of Senator Capito and Senator Manchin for the construction of a new core building to be constructed at Mont Chateau. Unfortunately, Congressional budget negotiations stalled, precluding implementation of the spending requests, but the agency is incredibly grateful for the support of our Congressional delegation.

Oil and Gas

The OIL & GAS PROGRAM is responsible for reseach into current oil and gas trends, fields, and evaluating specific horizons using well logs, cores, and associated samples and data. Managing physical samples as well as database curation allows requests from researchers, industry, and governments to be easily accommodated. Historical documents and legacy samples are of new interest as scientific advances are made.



Oil and Gas drilling trends increased dramatically. In West Virginia the number of permitted wells in FY22 increased 40% from the previous fiscal year.

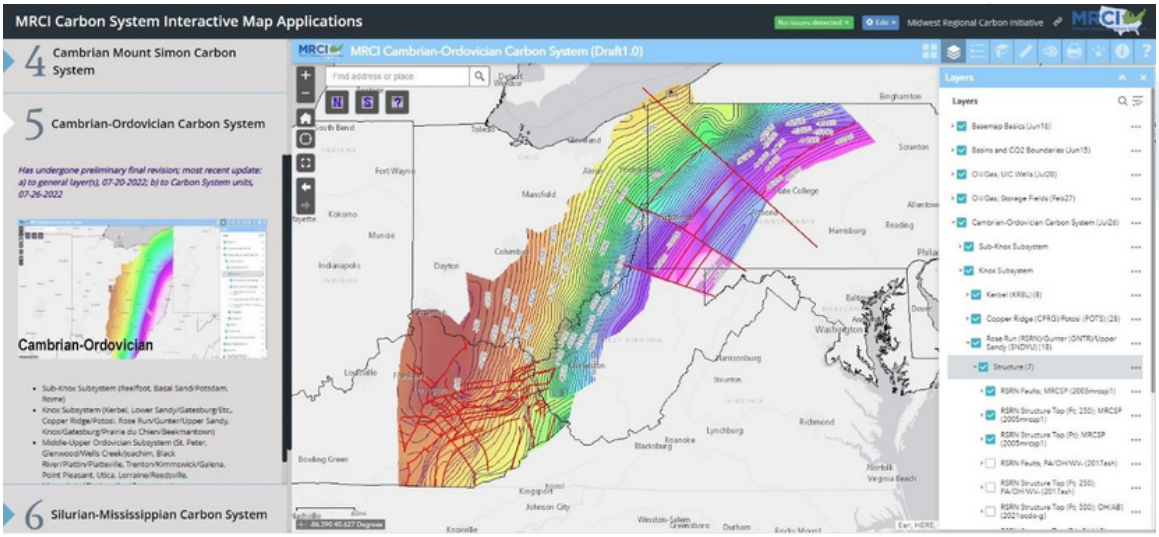
- 271 deviated wells were permitted, up from 193 in FY21.
- Marshall County has the most permits (68), followed by Wetzel (57), and Tyler (42).
- The Marcellus is still the primary drilling target and accounts for 86% of the total drilling permits, with 233 wells permitted to be drilled. Marshall and Wetzel counties account for the majority of Marcellus activity.
- The Utica Point/Pleasant is the second major target, with 28 permits issued in FY22.
- The permits for wells targeting the Utica/Point Pleasant are located primarily in Marshall County (22 of 28 permits).

Conasauga Shale Research Consortium (CSRC) Project

WVGES participated in a multistate project with government, industry, and academic partners to examine the Rogersville Shale as an emerging unconventional oil and gas play in West Virginia and Kentucky. This almost 2-year project was funded by the U.S. Department of Energy and WVGES worked with the University of Kentucky-Kentucky Geological Survey, West Virginia University, Hay Exploration, and Schlumberger. The project was intended to have two phases of which the first was completed. Phase I included the evaluation of the Rogersville Shale, located 11,000 to 16,000 feet below the surface (deeper than the Utica-Point Pleasant shale interval), while Phase II was to drill a well and collect new data in the Rogersville Shale. Phase I was completed using existing and new well data. Since the Rogersville Shale is so deep, the number of wells penetrating this interval is relatively small (<20 in West Virginia). However, new modern datasets were contributed by industry partners (Cabot Oil & Gas, EQT, and Chesapeake Energy) from recent test wells. In particular Cabot Oil & Gas contributed a large collection of material from a well in Putnam County, WV. WVGES, and its partners improved correlation and mapping of the Rogersville Shale as well as analyzing samples from multiple cores and cuttings. A core from this interval from a well in Wayne County, WV, held in the WVGES collection, indicates elevated total organic carbon (TOC), used as an indicator for potential hydrocarbons. This project began shortly before COVID lockdowns, which hampered both data transfer and the economic viability of drilling a deep test science well as part of Phase II. Financing of the well was unsuccessful and therefore the project was terminated before Phase II began. While a new well was not drilled, WVGES increased knowledge of the Rogersville Shale and obtained modern well datasets that may not have been available without this project. Information on the project and a link to the final report can be found at https://netl.doe.gov/node/9374.

Midwest Regional Carbon Initiative, Carbon Dioxide (CO_2) Research

- This project continues the work of the multi-decadal Midwest Regional Carbon Sequestration Partnership by combining forces with the Midwest Geologic Carbon Storage program in cooperation with state geological surveys and other stakeholders from 21 statesin the Atlantic and Midwest regions.
- The goal of the project is leveraging knowledge gained through hydrocarbon exploration to identify reservoirs amenable to carbon capture utilization and storage (CCUS).
- Reservoir evaluation will be accomplished by defining regional carbon storage systems, constructing detailed geologic models, and packaging technical results in the form of searchable databases, maps, and web pages.
- Over 600 geologic layers were aggregated into a preliminary “Interactive Map” during FY22, with future work focused on refining map data and adding well log data reference locations.



- Targets in the Appalachian Basin include shallow depleted oil fields for enhanced hydrocarbon recovery and eventual CO2 storage via CO2 flood, deep saline reservoirs, or a combination of both for “stacked” storage.
- The project is funded by the U.S. Department of Energy in long-standing partnership with Battelle Memorial Institute.

Geologic Mapping and the STATEMAP and U.S. Geoframework Program

A cornerstone of research conducted at WVGES is bedrock geologic mapping. While mapping has been ongoing since the Survey’s inception, WVGES has conducted mapping in conjunction with the U.S. Geological Survey’s STATEMAP Program since the early 1990s. This program is a part of the National Cooperative Geologic Mapping Program and partial funding is secured through the National Geologic Mapping Act. The program is a partnership between the U.S. Geological Survey, the Association of State Geologists, and State Geological Surveys. Funding is a 1:1 match between WVGES and the U.S. Geological Survey. WVGES has proudly been able to expand the program in West Virginia and is currently mapping more areas than in prior years.

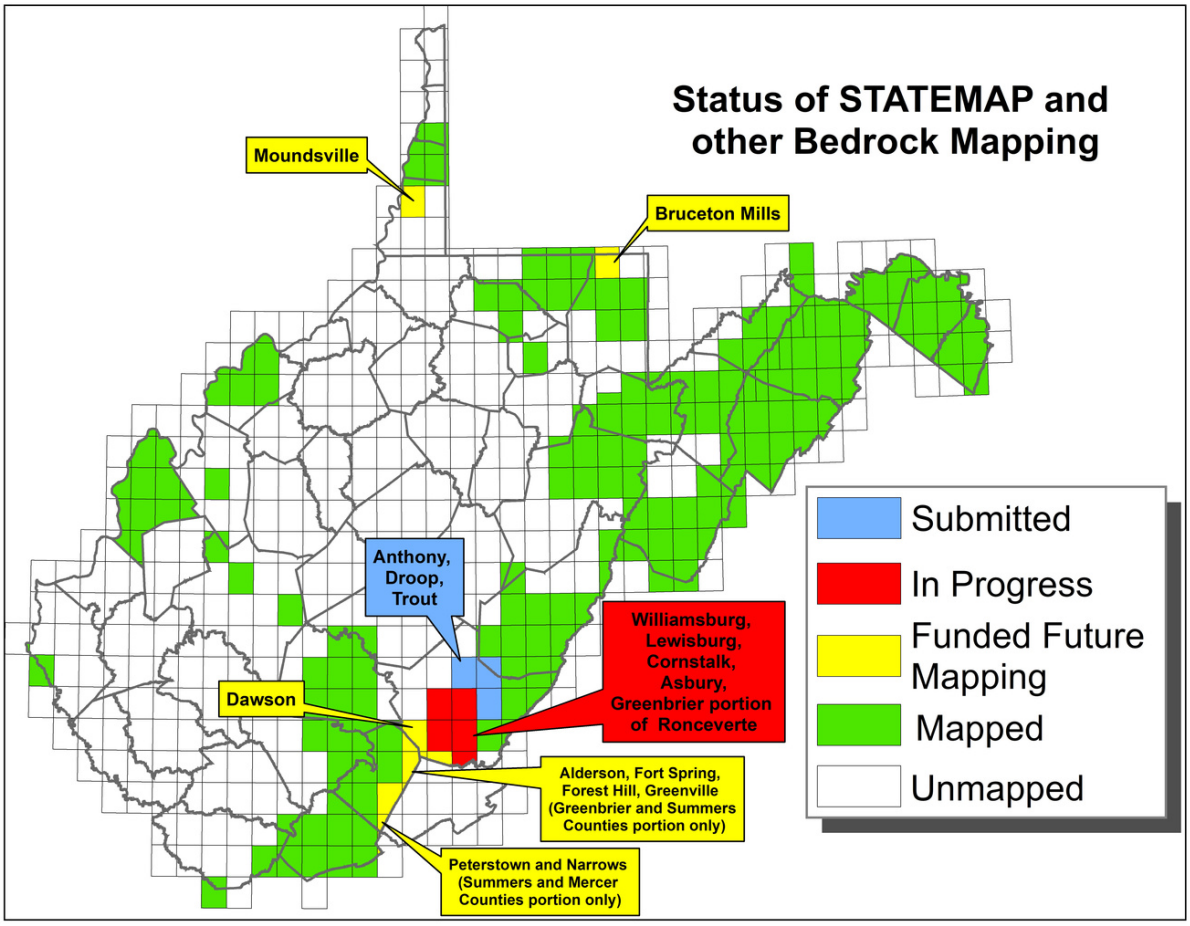
The STATEMAP program had operated on a one-year period of performance and WVGES had been working on a June 1 to May 31 cycle. COVID continued to disrupt timelines through FY21 & 22. WVGES had received a no-cost extension in FY21 which moved both our deliverable date to July 31, 2021 and our expected start date in FY22 to August 1. WVGES delivered FY21 maps on time (July 31, 2021), however, delays in the U.S. Geological Survey’s grant office due to prior-year COVID disruptions caused a delay in the FY22 WVGES award start date to mid-September.

Maps and reports for the Anthony, Droop, and Trout quadrangles in Greenbrier and Pocahontas counties were delivered to the U.S. Geological

Survey STATEMAP program in July 2021 and published as WVGES Open File Reports. They are available as paper maps, PDF files, and geographic information systems (GIS) geodatabases. Additionally, a new component, the U.S. Geoframework Initiative, works towards seamless 2D and 3D mapping for the nation. Under this component, WVGES has been working to update databases and correct edge-matching issues across map boundaries.

The program announcement from the STATEMAP program was released in October 2021 and the annual meeting of the STATEMAP Advisory Committee, a group of industry, academia, and government professionals, was held virtually in November 2021. WVGES personnel presented proposed mapping areas in West Virginia. Meeting attendance was robust and resulted in delineation of new priority areas to map.

Changes to the STATEMAP program announcement allowed for proposed projects over a two-year timeframe rather than the previous one year period of performance. WVGES utilized this change and proposed new geologic mapping in multiple areas of the state in a proposal submitted to the U.S. Geological Survey in December 2021. A total of 8 full quadrangles and 7 partial quadrangles was proposed in Grant, Greenbrier, Marshall, Mercer, Pendleton, Preston, Pocahontas, Randolph, Summers, and Taylor counties.



Field work was conducted for bedrock mapping on the Asbury, Cornstalk, Lewisburg, Williamsburg and the portion of the Ronceverte quadrangle in Greenbrier County, shown in red on the map above. Maps will be completed and delivered in FY23. Additional funding was requested to improve previously published geologic maps by edge-matching, digital database updates, addressing geologically difficult problem areas via focused field work, and using newly available LiDAR imagery. Additionally, under the U.S. Geoframework Initiative, WVGES is working to build seamless, edge-matched 1:24,000 geology organized by 1:100,000 sheets. The first product will be the WV portion of the Hagerstown 100k map in the eastern panhandle. Finally, WVGES is working to convert geologic map databases to the newly required U.S. Geological Survey's Geologic Map Schema (GeMS) digital map database format. This database format has many complexities and will be mandatory for all future map submissions to the U.S. Geological Survey.

Notification of partial funding was received in April 2022 to proceed with mapping in three different areas of the state with a September 2022 start date. This includes the Dawson quadrangle and portions of Alderson, Forest Hill, Fort Spring, Greenville, Peterstown, and Narrows quadrangles in Greenbrier, Mercer, and Summers counties (shown in yellow on the map). These projects will connect recent mapping with previous mapping conducted in the New River Gorge funded by the National Park Service. A second map area in Preston County includes the Bruceton Mills and Brandonville quadrangles as well as the WV portion of the Friendsville quadrangle. This will complete mapping in the Morgantown 1:100,000 scale sheet. A third map area in Marshall County will include the mapping of the Moundsville and Majorsville quadrangles. This is the first mapping that WVGES has conducted in the northern panhandle in over a decade.

Geoscience Education and Outreach Activities

- WVGES conducts multiple outreach activities with the goal of captivating and inspiring future generations of geoscientists in Appalachia and beyond.
- The Visiting Geologist Program includes an evening lecture and a morning hike at select state parks. Cacapon Resort, Canaan Valley, Twin Falls, Balckwater Falls, and Tygart Lake State Parks were visited this year.

WVGES geologist, Ken Ashton, leading a Visiting Geologist program at Blackwater Falls State Park.

WVGES Museum

- Adjustments were made to the space between the displays in the main gallery and upper floor to make the space more ADA compliant.
- Staff improved the labeling and exhibit text for the *Megalonyx jeffersonii* (Jefferson's ground sloth) and minerals displays.
- The history of Mont Chateau exhibit was redesigned.
- Visitation Statistics
  - Over 200 visitors total
  - 51% were in-state visitors and 49% were out of state visitors
  - We had visitors from as far away as New York, New Jersey, Tennessee, Alabama, Michigan, Illinois, Arizona, London, UK, and Australia.

Main gallery of the WVGES Museum at Mont Chateau Research Center

WVGES exhibit at the WV Mountain State Forest Festival in October 1939.

Geoscience and Mapping Program

WVGES continues to create new 1:24,000-scale bedrock geologic maps. These foundational products provide an understanding of the rocks present at the surface and an idea of the rocks below the surface. Mapping of karst areas remains a high priority for understanding groundwater flow and potential hazards. WVGES is currently mapping areas in Greenbrier County, WV in FY22.

WVGES Field Trips

Geology is a field of study requiring field observations to train personnel. As one retired Survey geologist stated, 'The best geologist is the one who has seen the most rocks'. To that end, WVGES conducted three field trips for Survey staff in FY22.

West Virginia contains a wealth of outcrops, road cuts and quarries which can be used to understand earth dynamics of the deep past. Field observations are used to interpret lithology, depositional environments, paleo climatic conditions, structural geologic trends and prehistoric biota.

The first field trip, led by Dr. Ronald McDowell, visited primarily older rock units in east-central West Virginia. The trip included stops in Randolph, Pendleton and Pocahontas counties in West Virginia and Highland County, Virginia to observe rocks ranging in age from Eocene to Silurian.

Dr. McDowell spent much of his career at WVGES participating in STATEMAP projects. His years of experience and expertise differentiating and identifying individual rock units, as well as understanding the dynamic processes involved in the accumulation of these rocks was put on display during this trip.

Outcrop exposure of the new Coalfields Expressway in Beckley, WV. Photo courtesy of Geologist Bethany Royce

The second field trip was led by Dr. B. Mitchell Blake (former WVGES Director), looking specifically at the Mauch Chunk formation in southern WV. Stops were conducted in Greenbrier, Summers, Raleigh and Mercer counties.

This trip was important because several WVGES staff are or will be actively working on STATEMAP grants, which are federally matched funding grants to map geologic units on individual quadrangles within the state. Most of the new mapping will contain portions of the Mauch Chunk formation, which can be difficult to differentiate into its individual named units. Dr. Blake spent years working in these rocks, which included several STATEMAP projects as well as his Ph.D. dissertation. During this field trip, each unit within the Mauch Chuck formation was visited, and observations of how to differentiate individual units was shared.

The third field trip, also led by Dr. Blake, included stops in Braxton, Nicholas, Fayette, Raleigh, Wyoming and Mingo counties looking specifically at the West Virginia coal measures. The majority of Dr. Blake's career has been spent working in the West Virginia

coal fields. His encyclopedic knowledge of coal stratigraphy coupled with his world renowned expertise in paleobotany (plant fossils) was shared.

This coal-orientation field trip included several newly hired staff members unfamiliar with coal seams in the field. Using earlier published field trip guides, the route followed RT 19 south from the I-79 split, to Beckley. From there the group moved west along RT 99 across Bolt Mountain which has over 2,000 feet of continuous section of the Lower and Middle Kanawha formation and lower Allegheny formation. The final portion of the trip took place on the King Coal Highway near Red Jacket, West Virginia.

Environmental Concerns and Hazards

One of the main public services WVGES provides through the Coal Bed Mapping Program is locating and describing underground mining for mine subsidence insurance for homeowners throughout the state.

- Increasing the understanding of groundwater flow and the potential effects of oil and gas drilling and other industrial construction in the karst terrains of Greenbrier and Pocahontas counties through bedrock mapping as part of the STATEMAP grant.
- Investigating carbon capture, utilization, and storage potential, as discussed under the Midwest Regional Carbon Initiative.
- Studying landslide susceptibility in conjunction with the WV GIS Tech Center, discussed later in this report.
- Monitoring seismicity in the state through a permanent monitoring station at the WVGES Mont Chateau office, part of a Seismic-Monitoring Network of six statewide seismic-monitoring stations overseen by the U.S. Geological Survey, including:
- Reporting one earthquake in West Virginia during FY22 (1.9 magnitude).
- Recording smaller earthquakes in neighboring states with the WV Seismic Network.
- U.S. Geological Survey completed repairs on the main seismic station housed at the Mont Chateau office, as well as completing repairs at two other regional stations.
- Posting earthquake information on the WVGES website at http://www.wvgs.wvnet.edu/www/earthquakes/seismic.html

Information Services

Applications

- Redesigned the WV Geothermal Interactive map and migrated the map service from a legacy interactive map server (ArcIMS).
- Automated coal seam and coal mining spatial data request form and implemented cloud-based data delivery access.
- Updated all oil & gas wells in West Virginia, including Marcellus Formation and Utica Shale Plays data.
- Updated Lithostratigraphy of Middle and Upper Devonian Organic-Rich Shales online publication.
- Updated West Virginia Underground and Surface Mining interactive mapping layers.
- Incorporated the expansion of the Coal Bed Mapping Project data holdings.
- Added additional Giga pan imagery to the Geologic Transect across WV online story map.
- And others, see http://ims.wvgs.wvnet.edu

Website Numbers

Website – 1,513,832 website visits: 21,305,053 page views, over 3,000 webpages

Service Requests – Staff responded to 804 requests for information

Facebook Page – 66 total posts, 35,097 total reach

Hardware and Software Support for Office and Field

Activities included:

- Upgrading and streamlining the digital data backup and archiving system with the installation of a Dell PowerVault tape drive/library with capacity to store 12 to 30 TB of data on a single LTO8 tape.
- Launching an enterprise level geologic database based on the national U.S. Geolgocial Survey GeMS data model providing, for the first time, a comprehensive dataset of all previous geologic mapping projects.
- Using latest release of state-wide 1-meter high-resolution LiDAR imagery on desktop workstations as well as mobile mapping devices along with direct observation to identify previously hidden landforms.

- Continuing to advance processing capabilities for extremely large, high-resolution imagery (LiDAR) datasets.
- Providing support for staff who are virtually attending meetings, workshops, and conferences, including the Geologic Mapping Forum, Digital Mapping Techniques, and corresponding workshops with other state and federal geologic mappers and GIS professionals.
- Presenting and learning best practices for the collection of data in the field, integrating newly acquired data with legacy data, and building geologic databases and maps.
- Helping mappers employ new techniques, hardware, and methods to collect and utilize digital data in the field.
- Standardizing data collection with handheld mapping units and developing data-entry forms using built-in GPS technology and field photography, allowing mappers to acquire and integrate data in a more systematic manner.

Geologists use tablets to digitally record data in the field.

New Publications in FY22

MAP-WV42 Bedrock Geology of the Elkins Area, West Virginia: Elkins, Junior, Beverly East and Beverly West 7.5-minute Quadrangles: B. L. Nugent, E. Moser, R. J. Johnson, J. Q. Britton, J. S. Chapman, J. W. Perkins, G. W. Daft, Jr., D. Jones, J. M. Horner, Digital Cartography by S.E. Gooding, 2021, 1:24,000 scale, 2 pages, 60"x 42" and 42”x 42”. Full color map shows geology and structure, strike/dip. Second page includes text, legend, and cross sections. Scan available and files for GIS.

OF-2001 Bedrock Geologic Map of the Droop 7.5’ Quadrangle, Pocahontas and Greenbrier Counties, West Virginia, J.W. Perkins, J.K. Tudek, D.L. Spurgeon, S.E. El-Ashkar, S.J. Hostetler, S.R. Brown, R.T. Toth, L.A. Woodward, C. Lindsay; Digital Cartography by S.E. Gooding, 2022, 1:24,000 scale, full color map shows geology and structure, strike/dip. Map layout includes legend, cross sections and stratigraphic column. Text in booklet. Files for GIS available.

OF-2002 Bedrock Geologic Map of the Trout 7.5’ Quadrangle, Greenbrier County, West Virginia, J.K. Tudek, S.J. Hostetler, E.C. Rhenberg, D.L. Spurgeon; Digital Cartography by S.E. Gooding, 2022, 1:24,000 scale, full color map shows geology and structure, strike/dip. Map layout includes legend, cross sections and stratigraphic column. Text in booklet. Files for GIS available.

OF-2003 Bedrock Geologic Map of the Anthony 7.5' Quadrangle, Greenbrier County, West Virginia, S.R. Brown, G.D.M. Andrews, J.W. Perkins, S.E. Gooding; Digital Cartography by S.E. Gooding, 2022, 1:24,000 scale, full color map shows geology and structure, strike/dip. Map layout includes legend, cross sections and stratigraphic column. Text in booklet. Files for GIS available.

AR-2021 – Annual Report: Fiscal Year 2021

RI-34 Stratigraphic Geochemical Database for Portions of Pendleton County, West Virginia, and Adjacent Virginia Counties, annual update

DDS-5 WVGES Oil and Gas Well Data for West Virginia, annual update

ED-A Publications, Maps, and Services of the West Virginia Geological and Economic Survey, annual update

Facility Maintenance

- Replaced decking boards on Activities Building deck.
- Purchased a new heat pump/AC unit for the Director's Suite.
- Removed old metal buildings from property that had fallen into disrepair.
- Replaced the roof on the Main Building, Activities Building and Garage storage building.
- Replaced Gutters and downspouts on Main Building.
- Smaller projects:
  - Fixed a sewage line issue.
  - Replaced several pieces of equipment due to an electrical surge.
  - Built a portable XRF tool mounting bracket for lab use.
  - Replaced hot water tank in Activities Building.
  - Began renovation of Activities Building basement and interior painting

Equal Employment Opportunity

The agency has undertaken major initiatives to achieve pay equity among similarly classified and experienced professionals regardless of race, religion, gender, sexual orientation, national origin, age, or disability. However, a major issue within our recruiting efforts continues to be that the agency operates within an outdated pay scale that does not attract those, including females and minorities, within the Geoscience field. This includes new graduates, as they have learned they can secure more lucrative positions within the private sector. Although we are making great strides to increase pay and put an end to pay inequality, budgetary constraints remain. We will

continue to devote a serious and sustained effort to educate the community through our outreach programs. By increasing knowledge and awareness of the Geosciences through our presence within these programs we can aspire to also reach a greater diversity of people, thereby creating a greater diversity in the candidates who wish to fill vacant positions. As an agency we will also continue to internally and externally disseminate the affirmative action policy and plan.

Professional Development and Presentations to Government Agencies and Scientific Conferences

Professional Conference/Paper Paper (with presentation given by C. Smith, AHS--Advanced Hydrocarbon Stratigraphy)

Smith, C., Pool, S., Dinterman, P., Moore, J., Vance, T., Smith, T., Gordon, P., and Smith, M., "Evaluating the liquids potential and distribution of West Virginia's Marcellus liquids fairway," URTeC-5540, Unconventional Resources Technology Conference, Houston, TX, July 26-28, 2021.

Journal Paper

Carney, B.J., Boswell, R., and Pool, S., "New assessment suggests substantial Appalachian shale gas resources," Oil & Gas Journal, November 1, 2021.

GSA Joint SE-NC meeting in Cincinatti, OH April 7th-8th, 2022

Title: "Filling in the gaps, not just with CO2, but with more data; Examining the Gordon Sandstone in the Jacksonburg-Stringtown Field, West Virginia Using New Permeability and XRF Data."
Authors: Bethany Royce, Jessica Moore, Ronald McDowell, Philip Dinterman

Cohosted and presented at conferences, meetings, and other activities around the state

- WV Association of Geospatial Professionals annual GIS meeting
- WV Information Technology Council
- E911 Council
- WV Association of Professional Surveyors
- Geographical Information Systems Certification Institute Board of Directors
- National States Geographic Information Council (NSGIC) Leadership Group
- NSGIC's NextGen 911, county working groups

Awards

During the Public Service Recognition Ceremony, an exceptional employee from each Department with under 20 years of service is recognized with the "Shining Star" Award. Hanna Law, WVGES' Administrative Services Manager, received the award on May 3rd.

Photo courtesy of WV Department of Arts, Culture & History

West Virginia
Office of GIS Coordination

The Office of the State Geographic Information System (GIS) Coordinator

This program is responsible for planning, organizing, coordinating and delivering high level Geographic Information System (GIS) advice to agencies in state government.

Encouraging and Coordinating GIS data sharing among agencies

- Fostering efficient and effective use of the state's geospatial capabilities and enhancing data sharing and exchange among state and local agencies.
- Providing technical assistance to state, county, and local government agencies as well as the public in their search for GIS contract services, funding, and GIS application development.
- Including 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 others.
- Consulted on a statewide trail map with the Development Office.
- Consulted on the hosted Statewide Addressing and Mapping System on the WVGISTC web servers in support of the WV Emergency Management Division.
- Advised on continued development and updating the Flood Assessment Structure Tool with FEMA's National Hazard Modeling Team.
- Provided direction on the WV Flood Tool, used by floodplain managers and FEMA personnel.
- Continued to provide input or statewide multi-hazard risk assessments for 287 communities in West Virginia to supplement local hazard mitigation plans.
- Provided technical advisory services to the state geospatial community, fielding numerous calls and emails regarding GIS data and applications.
- Educating those organizations that have yet to embrace GIS technology.
- Initiated a series of meetings with the GIS Steering Committee on the review and update of the GIS Strategic Plan.
- Participated in the organization of the biannual state GIS user group conference hosted by WV Association of Geospatial Professionals.

State-wide, High-resolution Elevation Data (LiDAR) Acquisition through the USGS and FEMA

- Providing input on areas being flown and processed.
- Providing input on areas being delivered.
- Processing and publishing 2-foot contours from the 2012 FEMA LiDAR-derived elevation data for Morgan and Berkeley counties.
- Advised on quality control, organizing, and publishing all new FEMA-purchased QL2 LiDAR-derived elevation products for West Virginia.
- Consulted on elevation products for download using the WV Elevation Download Tool (www.mapwv.gov/elevation).
- Consulted on generating new statewide elevation and hill shade grids from the best-available elevation sources as published on the State Data Clearinghouse.
- Status Graphic: https://data.wvgis.wvu.edu/pub/RA/_resources/Status/FEMA-purchased_LidarCoverage.pdf
- Part of the US Geological Survey's 3D Elevation Program

Geo-Enabled Elections Project

- Supporting the Secretary of State's Office in their search for GIS contract services, funding, and GIS application development.

National Emergency Number Association's GIS Data Stewardship for Next Generation NG9-1-1 Workgroup

- Helping develop a nationwide address spatial data infrastructure

Collaboration with Division of Emergency Management and County Governments

- Assisted with the design of quality control standards and prompt address data updates dissemination to first responders.

Collaboration with County and Regional Governments

- Assisting county and regional governments in the acquisition of aerial imagery and GIS services.

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 geographic information systems (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 Web Portals, GIS Data Development, GIS Map Applications, and GIS Services.

Web Portals

A core mission of the WV GIS Technical Center is to provide a mechanism to distribute GIS data and products to the public. Two portals serve the means for achieving this goal – MapWV.gov and the WV GIS State Clearinghouse. The WV GIS State Clearinghouse (https://wvgis.wvu.edu) catalogs over 300 unique datasets and 120 web services valued at more than $70 million dollars. MapWV.gov (https://mapwv.gov) provides the public accessible gateway to the wealth of GIS data available in the Clearinghouse. The WVGISTC currently provides over 197 TB of storage space in a virtualized environment configured to maximize availability and access. To continue this mission, the WVGISTC has invested considerably to expand and update this environment with new equipment and capabilities.

MapWV.gov continues to be impressively popular with users, largely due to important functions such as the Parcel Viewer, the Flood Tool, and the recreation tools like Trails Viewer and Hunting and Fishing Tool. In the last year, the average daily page views jumped slightly over 30% to 171,768 compared to 131,841 the year before. However, the number of unique users jumped a considerable 25% to 630,611 unique users this year compared to the previous year's 505,303 unique users. This suggests a significant number of new users are discovering the site's capabilities and tools.

The GIS Data Clearinghouse similarly received an unprecedented jump in traffic, increasing 300% in one quarter alone. Average page views per day jumped considerably from 1,900 to 7,650. Total Unique users increased from 72,000 users to 85,000 users the following year. The availability of the new elevation data from FEMA contributed to the utilization increase.

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 **public** for applications that include emergency response, risk assessments, economic development, energy resource exploitation and management, transportation, natural resources, community planning, tax assessments, health studies, and election management. 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 98,054 mineral records, mapped 78,002 unique mineral records, and georeferenced 765 well plats. WVGISTC progressed in mapping unmapped mineral records for three counties: Ritchie (28%), Doddridge (52%), and Harrison (62%) counties.
- **Highway Plans**: Completed the second phase of scanning 225,000 highway plan sheets to increase to 10,000 the total number of plan books scanned since the project was initiated in 2015. Scanning production increased significantly during this phase in which all the right-of-way and bridge plans were scanned. An interactive map viewer named the Highway Plans Locator (www.mapwv.gov/DOTplans) allows users to locate and view the archival plans.
- **County and Community Boundary Layers**: Updated the county boundary GIS layer with the 2016 Logan-Lincoln county boundary change. The updated community layer of all incorporated and unincorporated jurisdictions was created from U.S. Census incorporated boundaries, 1:24,000- scale USGS topo county boundaries, and local sources. Moreover, these updates additionally enhanced the FEMA community boundary layer to produce more accurate risk assessment products. A total of 268 flood-prone communities that include eight split communities that span over two counties were verified and updated.

- **Public Lands**: Coordinated with the WV Division of Natural Resources and other stakeholders to review and submit state public lands and local parks for submission to the Protected Areas Database of the United States.
- **Recreational Trails:** Maintained and published recreational trails for West Virginia comprised of 4,665 miles of land trails (85% non-motorized; 15% motorized) and 3,346 water trails (63% whitewater and 37% flatwater).

Community GIS Data Development Project

Two state contracts managed by the WV GIS Technical Center were awarded to GIS professional services companies for enhancing aerial imagery, parcel, and addressing data in the state. For West Virginia communities, a total of 45 distinctive data development projects were completed with funding assistance from FEMA's Hazard Mitigation Grant Program to improve leaf-off aerial imagery (30 unique counties; 41 total counties), parcels (7 counties), and E-911 addresses (8 communities). Multiple counties took advantage of the aerial imagery contract by paying for imagery for more than one year, and thus increasing the total data development projects to 56. These data development projects filled GIS data gaps that were preventing West Virginia from achieving detailed hazard identification and quality risk assessments. The total cost of the data development projects was $1,406,528, with the FEMA grant obligated dollars $542,541 and the county cost share 61% or $863,987.

- **Aerial Imagery**: Current and high-resolution aerial imagery is used throughout West Virginia to meet daily business needs and for developing other foundation framework layers to include E-911 addressable structures and parcels. A state contract executed between 2019 and 2022 through WVU Procurement allowed for 41 county leaf-off aerial imagery acquisitions for a total of 18,987 square miles. The total cost share by counties was 85% while the FEMA grant share was $124,478. Only two counties – Clay and Pendleton – could not contribute any cost share. Milestone Accomplished: Replaced the legacy statewide 12-inch resolution WV Sheriffs Association imagery acquired in 2010-12 with county leaf-off imagery that is higher resolution and more current (not older than 5 years). All the counties were collected at 4-inch resolution except for Cabell (3"), Pendleton (6'"), and Randolph (6") counties. County imagery data sets acquired via the contract reside in

the public domain. The best available, leaf-off countywide imagery is mosaicked together and published as a statewide aerial imagery map service. Status Graphic: County Aerial Imagery Year Acquired. Refer to the WV State Aerial Imagery program for more information.

- **Recreational Trails:** Maintained and published recreational trails for West Virginia comprised of 4,665 miles of land trails (85% non-motorized; 15% motorized) and 3,346 water trails (63% whitewater and 37% flatwater).
- **E-911 Addresses**: To update E-911 addresses, eight counties received grant funds of $96,220 with a 39% county cost share. A total of 56,818 E-911 addresses were mapped and verified. E-911 addresses of flood-prone communities such as Marlinton (Pocahontas County), Mullens (Wyoming County), and Rowlesburg (Preston County) were updated. In addition, the community of Rowlesburg was re-addressed. Addressing deficiencies for the counties of Clay, Fayette, Hardy, Morgan, and Pocahontas counties were updated as well. Milestone Accomplished: This project resulted in Morgan County, which had major gaps in its E-911 address mapping, to receive a complete GIS addressing and mapping database. It also provided funding to correct addressing deficiencies for communities devastated by past floods.
- **Digital Parcels**: Seven counties received grant funds of $321,000 with a 22% county cost share to convert paper tax maps to digital. A total of 136,364 parcels were mapped. Milestone Accomplished: In 2004, only five counties in the state had GIS parcels; this grant provided funding to convert all remaining paper tax maps to digital so now all 55 counties maintain and publish tax maps in an electronic GIS format.

GIS LiDAR Elevation Data Development and Products

High quality elevation data is essential for flood and landslide hazard mapping, terrain 3D maps, preliminary engineering assessments, etc. A multi-year effort finished the processing and publishing of all the FEMA-purchased QL2 LiDAR elevation data and products to the WV Flood Tool and WV Property Viewer. This includes the 1-foot contours, 1-meter Digital Elevation Models (DEMs), and Hillshade basemap. The Center also completed the redelineation mapping for all the Zone AE flood zones (1% recurrence interval) using the new FEMA elevation data. The statewide FEMA-purchased LiDAR and derived products are valued at $10 million.

GIS Map Applications

Continued application development and web programming assistance were provided for local and state agencies in support of West Virginia and its citizens. These applications support agencies via e-governance solutions to meet their regulatory and information exchange requirements. (Table 1). This past year, for example, the Center created online applications to support geo-enabled elections that included the WV 2022 Voter Map (www.mapwv.gov/Vote) for the Primary Election on May 10. The Center also updated the WV Elevation Download Tool (www.mapwv.gov/Elevation) to allow users to download the statewide QL2 LiDAR high-resolution elevation products. Web statistics reveal that the most popular web application is the WV Property Viewer, which attracts six times the users than the WV Flood Tool. To assist disadvantaged counties in West Virginia with limited GIS resources, the Center now supports three major local government data producers with GIS technologies to validate and view their spatial data: county clerks (elections), county assessors (parcels), and local E-911 offices (addresses). Additionally, during this fiscal year, the Center began modernizing its applications to JavaScript 4.24 for the WV Property Viewer, WV Flood Tool, SHPO GIS Viewer, and WV Wetlands Functional Assessment Tool.

Table 1: StatewideMap Applications supported by Center

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, Assessors
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
WV Voter Map	A web map application for the public to look up election districts, polling sites, or sample ballots by address (https://www.mapwv.gov/vote)	WV SOS, County Clerks

GIS Voting Applications (Redistricting and Geo-Enabled Elections)

In 2022, West Virginia joined the increasing number of states using geospatial technology to visualize and analyze their voter data in support of geo-enabled elections. This past year the WV GIS Technical Center collaborated with the Secretary of State's office and county clerks to geo-enable the Statewide Voter Registration System (SVRS) to assist with the redistricting of county election geographies and to improve the spatial accuracy of the state's 1.1 million voter registration points.

- **GIS Voting Applications**
  - Created two voter applications: the first to provide the voting information to the public;the second a non-public application for both county clerks and state election officials to review and resolve potential voting errors in the state's election data management system (e.g., voter addresses mismatch with election geography assignments).
  - The interactive map voter application leverages GIS technology and is a result of collaboration between the state's 55 counties, their GIS mapping offices and vendors, and the WV GIS Technical Center. Due to redistricting of State Senate and House of Delegates districts by the WV Legislature and magisterial districts by the county commissions, many voting precinct lines were required to be modified which impacted many voters' in-person polling location.
  - The WV Interactive Map for Voting Precincts and Districts (www.mapwv.gov/vote) allows the public to view the most current voter information: voting district maps (precinct, magisterial, state legislative, congressional), sample ballots, and polling site locations (both early voting and Election Day) and directions. A key accomplishment is that West Virginia may be the first state in the nation to create a statewide interactive voter map application for all its 1,675 voting precincts and 195 magisterial districts.
  - Ahead of the Primary Election, the Secretary of State's Office extensively promoted the new voting application on its GoVoteWV.com website and media outlets. "We want to keep voters engaged in the outcome of the redistricting process," [Secretary of State] Warner said. "This interactive map is a foundational tool for voters to find their voting precinct, Magisterial District, House of Delegates District, State Senate District and their Congressional District."
  - On the Primary Election Day of May 10 in West Virginia, the state's best-known broadcaster Hoppy Kercheval commented: "The Secretary of State's Office has a helpful interactive website with lots of voter information. Just go to https://www.mapwv.gov/vote/ enter your address and it will tell you your polling location and have links to sample ballots." After the election Hoppy Kercheval commented about the impact of the state's new interactive voter map: "The

Secretary of State's interactive map and the clerks' efforts to notify voters worked well. Yes, there was some confusion because of the new districts, but most of those problems were easily resolved on Election Day."

- The Center used Esri's ArcGISWeb AppBuilder to create and standardize the voter application for both the desktop and mobile phone platforms.

Statewide Risk Assessment Applications

Leveraging geospatial technologies, the GIS Technical Center completed preliminary risk assessment products focused on flood and landslide hazards for all 55 counties and 231 incorporated communities in West Virginia to supplement local and state hazard mitigation plans. This statewide approach and standardized methodology to multi-hazard risk assessments at the building level for every community in the state and for a geographic area over 24,000 square miles constitutes one of the largest risk assessment studies ever undertaken in the nation. Importantly, the various risk assessment products generated from this grant will benefit future risk reduction plans and projects.

- **Statewide Building Inventories**: Updated the structure-level inventory of all 1.1 million buildings and facilities exposed to multi-hazards. A more detailed inventory was created of 98,000 at-risk structures in the floodplain. Building-level risk assessments for a 1-percent- annual-chance (or 100-year) flood event were published to the WV Flood Tool's RiskMAP View in support of flood reduction efforts. The building inventories include building occupancy and replacement values of every structure in the state.
- **Flood Risk Assessments**: Created site-specific flood risk assessments for 268 flood-prone communities (231 municipalities and 55 unincorporated areas). Referred to as the Total Exposure in Floodplains (TEIF) project. Results are published on the WV Flood Tool's RiskMAP View (www.mapwv.gov/flood) and accessed using the Risk Assessment Product Index. A FEMA Region 3 Resilience Report and the WV Public Broadcasting recently highlighted a successful cost-effective mitigation project whereby the building-level flood risk assessments identified voluntary floodplain buyout properties in McDowell County, WV.

- **Landslide Risk Assessments**: Referred to as the Total Exposure in Areas of Landslides (TEAL), this activity crated landslide incident and susceptibility maps for 55 counties. The landslide risk information is published on both the WV Flood Tool (www.mapwv.gov/Flood) and the WV Landslide Tool (www.mapwv.gov/Landslide). Other states like Maryland have shown interest in the landslide maps and methodology developed by West Virginia. Refer to this resource link for more information about the landslide risk assessments.

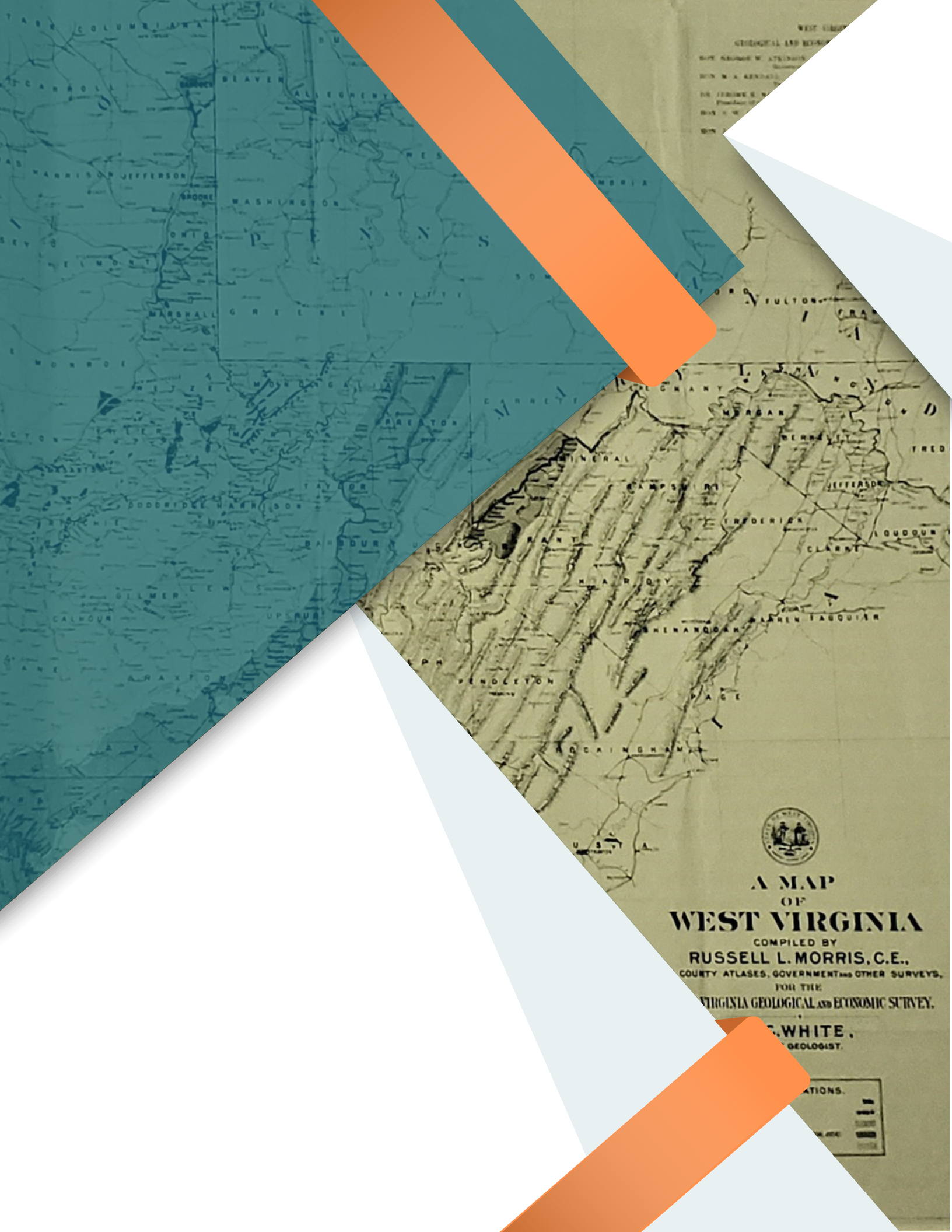
GIS Services

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. Below are highlighted GIS services performed by the Center.

- **Public Technical Support**: Provided technical advisory services to the state geospatial community. The Technical Center responds to an estimated 15 calls per week from the public and clients regarding GIS data and applications. Many calls are received from the public about the WV Property Viewer, the most popular web application hosted by the Center.
- **Presentations and Outreach Services**: Presented on geospatial activities and projects at state and regional conferences/webinars such as the GIS-Transportation Day, WV Association of Floodplain Managers Conference, and FEMA Region III webinars.
- **E-911 Address Support**: Supported the WV Emergency Management Division and various communities with mapping support for the Statewide Addressing and Mapping System hosted on the Center's servers.
- **Address Geocoding and Locator Services**: The Address and Street Locator Services created from the Statewide Addressing and Mapping Database were used extensively by state agencies like the DHHR and the Secretary of State's Office.
- **WV DOT Transportation Conflation Project**: Initiated research on how to update missing road segments in the WV DOT's road network from the E-911 road database or Statewide Addressing and Mapping System (SAMS).

- **Property Tax Parcel Support**: Drafted a minor amendment for the WV Property Valuation Training and Procedures Commission's (PVC) Procedural Rule §189-3 "Statewide Procedures for the Maintenance And Publishing Of Surface Tax Maps" (2009) to have the same annual tax map maintenance and GIS boundary file submission dates, by striking the text in paragraph §189-3- 15 "during the month of April" and replacing with "by February 1st of each year."
- **Redistricting and Election Support**: Supported the Secretaryof State's office and county clerks with redistricting and geo-enabled election services.
- **WV Floodplain Management Support**: Training and outreach services were provided on numerous occasions in support of the WV Flood Tool, an important web application used extensively by floodplain managers and land surveyors.
- **Managed Timberland (MTL) Program**: Provided GIS technical support and consultations for the Forest Management Review Commission during the June Legislative Interims.
- **Execution of Daniel's Law**: In the execution of Daniel's Law (W.Va. Code §5A-8-24) for the "protection of personal information relating to judicial officers, prosecutors, and law enforcement officers," the WV GIS Technical Center coordinated with the WV Emergency Management Division to remove personally identifiable information (PII) of flagged individuals from online public databases controlled by the Center.
- **Potential Redevelopment Property Report**: For the WV Land Stewardship Corporation, which is part of the WV Abandoned Properties Coalition, created a programming script to search 1.4 million property parcels for redevelopment based on the flowing seven criteria: delinquent properties with status "No Bid" or "No Action"; located inside a municipal boundary, qualifying census tract and HUD opportunity zone; minimum lot square footage> 6,000 square feet; parcel does not intersect a flood zone; and median slope < 15 degrees (not steep).
- **Special Project - Land Use Query**: Supported U.S. Senator Manchin's office in identifying large tracts of previously mined lands (50-100 acres) for a specific project. Quote from Senator Manchin's Office Assistant: "Finally got all of those maps downloaded last night and had the chance to look through a few with the index as a guide. That information looks amazing, I can't imagine how you were able to pull everything together in such detail."

- **2022 GIS Strategic Plan**: In support of the WV Office of GIS Coordination, the WV GIS Technical Center was a principal author of the 2022 GIS Strategic Plan. In February, the WVGIS Technical Center presented to the Transportation and Infrastructure Senate Committee of the WV Legislature on the potential for GIS to improve infrastructure in the state. The committee was presented with information on statewide efforts that could potentially help localities, such as a statewide imagery program and a statewide addressing program. The committee inquired as to the current local utilization of GIS and potential future use of GIS to assist communities.


A MAP
OF
WEST VIRGINIA
COMPILED BY
RUSSELL L. MORRIS, C.E.,
COUNTY ATLASES, GOVERNMENT AND OTHER SURVEYS,
FOR THE
VIRGINIA GEOLOGICAL AND ECONOMIC SURVEY.
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