2023 Annual Water Resources Report

Joint Legislative Oversight Commission on State Water Resources
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Prepared by the

West Virginia Department of Environmental Protection
Division of Water and Waste Management
Water Use Section

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Water Resources Protection and Management Overview

The Water Resources Protection and Management Act (WV Code §22-26*)* was passed into law in 2004. The Act recognized the need to protect and conserve the water resources of the state and directed the West Virginia Department of Environmental Protection (WVDEP) to develop a State Water Resources Management Plan. WVDEP formed the Water Use Section in 2008 to initiate a comprehensive review of the state's water resources. The State Water Resources Management Plan was published in 2013 and adopted by the Legislature in 2014. The Water Use Section has continued to implement the provisions and recommendations within the Act and Plan with several ongoing programs, projects, and studies in support of WVDEP's responsibility for the state's waters. This annual report is submitted to the Joint Legislative Oversight Commission on State Water Resources in accordance with WV Code §22-26-8(e).

2022 – 2023 Water Resources Availability

The following section relies on national datasets and related analyses from various federal agencies with data source specifics referenced accordingly in figures below. Going back to the late 19th century, average annual rainfall in West Virginia has been approximately 45 inches. Total annual precipitation has been highly variable with a slight increase over the long record period (126 years and counting), with the driest in the early 1930s and late 1960s and the wettest since 2015 (Figure 1). More specifically, the driest consecutive 5-year interval was 1962–1966, averaging 39.6 inches per year, and the wettest was 2016–2020, averaging 51.9 inches. Total statewide precipitation was slightly higher in 2022 at 49.37 inches (compared to 42.58 inches in 2021). Although Charleston, West Virginia precipitation totals were below normal amounts throughout all of 2021 except for a brief period in March, they were also above normal in 2022 (Figure 2).

In general, temperatures in West Virginia have risen 1 degree Fahrenheit since the beginning of the 20th century. This change in temperature will affect both the number and intensity of extreme precipitation events with more potential for flooding and drought. Winter and spring precipitation amounts are projected to increase, as well as the number and intensity of extreme precipitation events, creating an increased risk of flooding. Naturally occurring droughts are projected to be more intense in the future due to temperature-caused increases in the rate of soil moisture loss during dry spells. Less snowpack affects both surface water runoff and groundwater infiltration. Warmer temperatures cause more surface water to evaporate and plants to require more water so there is less to seep into the ground to replenish aquifers. The speed of heavy rains from extreme downpours also do not support the typically more gradual aquifer recharge from lighter and longer rain events.

West Virginia experiences a wide array of extreme weather, including tornadoes, thunderstorms, snowstorms, hurricane remnants, and flooding. Flooding, caused by extreme precipitation over the rugged topography, is the costliest and most severe natural hazard for the state. The Central Appalachian Mountains run through the eastern portions of the state, creating a disparity in precipitation. As typical, 2022 precipitation was greatest in the high mountains west of the continental divide (over 70 inches observed) and lowest in the rain shadow from those same mountains (just under 30 inches in some spots) in the Eastern Panhandle (Figure 3). Although 5 of the top 10 wettest years on record have occurred since 2000, intermittent drought conditions can and still occur between periods of extreme precipitation.

Groundwater recharge is typically between 15-18% of annual precipitation. The U.S. Geological Survey (USGS) Ber-0445 station is a 154 feet deep well in an unconfined aquifer in Berkeley County, West Virginia where groundwater levels have been recorded since 1970 and continually monitored since 2006 with measurements ranging from a high of 20.09 feet in September 2018 to a low of 68.45 feet in December 1969. In 2022, the groundwater levels were highest on May 9th at 40.32 feet and lowest on November 10th at 55.64 feet (Figure 4a). As of August 7, 2023 at this location, the groundwater level was 55.42 feet below land surface which is much below normal (>=5-10 percentile) based on 47 years of data (Figure 4b).

Nationally, the annual runoff in the rivers and streams during water year 2022 (8.97 inches) was slightly lower than the long-term (1930–2022) mean annual runoff of 9.39 inches for the contiguous United States. However during the water year 2022 (October 1, 2021-September 30, 2022), annual mean streamflow in West Virginia was normal (Figure 5). West Virginia seasonal characteristics compared to streamflows for water years 1930-2022 ranked Autumn (October-December 2021) streamflow below normal while Summer (July-September 2022) streamflow in West Virginia ranked above normal.

West Virginia started 2022 with moderate drought conditions (D1) in the first part of January, April through May and again in the first half of November (Figure 6a). There were abnormally dry (D0) conditions in West Virginia for a good part of 2022. February, the second half of August and first half of October were the only months with no drought and dryness. There have been no severe drought conditions (D2) since October 2019 and no extreme drought conditions (D3) since September 2010 (Figure 6b). A resource is https://www.drought.gov/states/west-virginia where the US Drought Monitor map is updated each Thursday to show the location and intensity of drought and dryness at various levels across the country. This website also provides a state based snapshot summary of drought related information as well as an email alert system. A number of physical indicators are important for monitoring drought, such as precipitation, temperature, streamflow, and soil moisture conditions, all of which are available also on this website.

Large Quantity User Water Withdrawals

Any person that withdraws more than 300,000 gallons in 30 days from state's waters – except for farm use – and any person that bottles water for resale regardless of quantity withdrawn is considered a Large Quantity User (LQU) per the Water Resources Protection and Management Act. These LQUs use the WVDEP Electronic Submission System (ESS) to report their withdrawals annually to the Water Use Section. LQU surveys are collected between January 1 and March 31 of the year following water withdrawal; the Water Use Section will receive 2023 reports beginning January 1, 2024. The Water Use Section has been collecting LQU information since 2006 and monitoring trends in water use. The Water Use Section shares water withdrawal data with research partners including state universities and the USGS.

The LQU data represents our best insight into water use throughout West Virginia but is by no means definitive. The Water Use Section does not collect any water withdrawal information on users below the LQU threshold; the cumulative impact of such withdrawals is unknown. For existing LQUs, as with

any user-input dataset, the opportunity for error or omission exists. The Water Use Section conducts limited audits and field visits to verify reported information and register new LQUs.

Annual Data and Trends

In 2022, 326 LQUs reported withdrawing over 614 billion gallons of water (Table 1). Additionally, 10 hydroelectric facilities report more than 234 trillion gallons withdrawn. Total withdrawal from West Virginia water resources decreased (4.3%) from 2021 to 2022. Thermoelectric operations continue to be the largest water use sector overall excluding hydroelectric. The chemical and public water supply users continue to round out the top 3 in total quantity at over 125 billion and 62 billion gallons in 2022, respectively. The mining and recreation industry use increased by almost 20% in 2022 as the Covid-19 pandemic ended.

WVDEP Water Use Category	LQUs	Total 2022 Withdrawal (Gallons)	Category %	% Change from 2021
Agriculture/aquaculture	12	8,007,907,629	1.30%	-5.27%
Chemical	12	125,115,951,895	20.37%	-11.91%
Industrial	17	12,798,607,849	2.08%	-17.32%
Mining	66	13,527,095,464	2.20%	18.86%
Oil & Gas	14	3,212,283,274	0.52%	-10.85%
Petroleum	1	303,478,334	0.05%	4.44%
Public water supply	169	62,857,451,729	10.23%	3.92%
Recreation	22	1,122,240,686	0.18%	19.97%
Thermoelectric (coal)	10	386,531,287,514	62.93%	-2.89%
Timber	3	784,106,590	0.13%	-13.89%
TOTAL	**326**	**614,260,410,964**	**100.00%**	**-4.26%**
Hydroelectric	10	234,716,322,984,805		

Table 1. Total 2022 water withdrawals from the LQU database (WVDEP).

Most LQUs continue to withdraw from the surface (95.3%) with only 4.7% using groundwater (Table 2). Thermoelectric (coal) continues to use the most surface water with over 385 billion gallons in 2022. The public water supply remains the single largest user of groundwater with over 12 billion gallons used, followed by the chemical and mining sectors. Groundwater use is concentrated in the alluvium along the Ohio River, southern coalfields, and karst aquifer systems of eastern West Virginia (Figure 7).

WVDEP Water Use Category	Surface Water WD (Gallons)	Category % of SW	Groundwater WD (Gallons)	Category % of GW
Agriculture/aquaculture	7,790,075,229	1.33%	217,832,400	0.76%
Chemical	116,040,580,511	19.82%	9,075,371,384	31.50%
Industrial	12,108,274,386	2.07%	690,333,463	2.40%
Mining	8,207,454,246	1.40%	5,319,641,218	18.47%
Oil & Gas	3,103,995,033	0.53%	108,288,241	0.38%
Petroleum	1,752,828	0.00%	301,725,506	1.05%
Public water supply	50,684,573,064	8.66%	12,172,878,665	42.26%
Recreation	803,668,776	0.14%	318,571,910	1.11%
Thermoelectric (coal)	385,939,996,835	65.92%	591,290,679	2.05%
Timber	773,638,788	0.13%	10,467,802	0.04%
SUB TOTAL	585,454,009,696	100.00%	28,806,401,268	100.00%
Breakdown % of Total WD	**95.31%**		**4.69%**	
Hydroelectric	234,716,322,984,805			

Table 2. Breakdown of surface water and groundwater 2022 withdrawal data (WVDEP).

The 2022 estimate for water consumption is approximately 45.4% of the total statewide water withdrawal (Table 3) which is slightly more than 2021's 44.9% (Figure 8).

WVDEP Water Use Category	2022 Total Gallons Withdrawal	New Consumptive Coefficient	2022 Calculated Gallons Consumed	Category % of Consumed
Agriculture/aquaculture	8,007,907,629	0.03	240,237,229	0.09%
Chemical	125,115,951,895	0.12	15,013,914,227	5.39%
Industrial	12,798,607,849	0.59	7,551,178,631	2.71%

Mining	13,527,095,464	0.48	6,493,005,823	2.33%
Oil & Gas	3,212,283,274	1	3,212,283,274	1.15%
Petroleum	303,478,334	0.16	48,556,533	0.02%
Public water supply	62,857,451,729	0.15	9,428,617,759	3.39%
Recreation	1,122,240,686	0.41	460,118,681	0.17%
Thermoelectric (coal)	386,531,287,514	0.61	235,784,085,384	84.65%
Timber	784,106,590	0.39	305,801,570	0.11%
SUB TOTAL	**614,260,410,964**		**278,537,799,112**	**100.00%**
			% of Consumption **45.36%**	
Hydroelectric	234,716,322,984,805			

Table 3. Current consumption coefficients applied to 2022 withdrawal data (WVDEP).

Total monthly water withdrawals are generally highest in the summer and winter (Figure 9) and this trend was relatively remarkable in 2022 data. Energy demands during these times of the year increase the need for thermoelectric water withdrawals. These seasons are also peak for public supply water withdrawals – likely owing to burst pipes in winter and increased outdoor water use in the summer. The recreation water use sector also has a substantial increase in wintertime water use, driven by snowmaking at ski resorts. The summer's higher demand for water coincides with the typically lowest water levels of the year throughout West Virginia.

Oil and Gas Water Management Plans

The Water Use Section of the WVDEP is responsible for the processing, analysis, and approval of operator-submitted water management plans. Pursuant to WV Code §22-6A-7 and the Horizontal Well Development Rule 35CSR8, natural gas operators developing horizontal wells that use water more than 210,000 gallons during any 30-day period, shall submit a Water Management Plan as part of the well work permit application. H6A well work permit applicants must identify all potential water sources with the inclusion of a Water Management Plan along with their horizontal well permit application. The WVDEP evaluates each proposed water source (surface water, groundwater, purchased water, or recycled frac water) for suitability based on a variety of considerations.

For Fiscal Year 2022, the Water Use Section received and reviewed all individual Water Management Plans associated with WV Code §22-6A well work, including new pad-level plans and existing Water Management Plan modifications, all relating to the planned withdrawal of surface and groundwater used in horizontal well drilling operations. The actual volume of water used in these operations is captured by the LQU program.

Water Resources Research

To carry out mandates from the Water Resources Protection and Management Act, the Water Use Section has routinely collaborated on research initiatives with various state, federal, and nonprofit partners. These projects support the data and informational needs of the Water Use Section to understand, protect, and conserve state water resources. Previous projects have included stream gauge statistical analysis, water budgets, water consumption, and water infrastructure. The Water Use Section current projects are described below.

Abandoned Underground Coal Mine Aquifers

The Water Use Section has been involved in many projects to determine the location, quantity, quality, and sustainability of water within Abandoned Underground Coal Mine Aquifers (AUCMA), also known as Mine Pools. Several municipalities and public service districts in southern West Virginia obtain their water supply from groundwater in mine pools and there has been additional interest in putting these accessible water resources to beneficial use. In 2012, WVDEP collaborated with the West Virginia Geological and Economic Survey (WVGES) to map the extent of potential mine pools (Figure 10). Since then, we have worked with the USGS to obtain data from more than 770 water samples from 294 mines. The WVDEP Water Use section received the final Groundwater Quality in Abandoned Underground Coal Mine Aquifers report in the fall 2023 from the USGS.

Monroe County Hydrogeologic Assessment

Since 2017, the USGS has been working on a Hydrogeologic Framework Assessment of Monroe County. The objective of this study is to develop aquifer maps useful for active management of the groundwater resources in Monroe County. Interpretive maps inclusive of aquifer boundaries, water table elevations, and dye-trace results will provide additional insights into sources of groundwater and groundwater flow paths. Aquifer mapping is intended to advance the conceptual understanding of the interconnectedness between the groundwater system and activities at the land surface. This investigation will establish a baseline of aquifer status for fractured-rock aquifers in Monroe County, West Virginia. This project is anticipated to be complete by winter 2024 and will be used to better understand, manage, and protect ground-water resources of Monroe County. The inventory of aquifer conditions in Monroe County provided by this study will be important for assessment of source waters to public supplies where regional geologic structure may significantly influence the understanding of areas contributing to localized withdrawals. Data collected as part of this study have transfer potential to similar karst aquifers elsewhere in the Appalachian Plateaus and Valley and Ridge Physiographic Provinces within the Appalachian Mountain Region.

Geophysical Groundwater Well Logging

The Water Use Section and the USGS have continued a collaborative five-year project to assess geophysical and hydrologic properties of groundwater wells throughout West Virginia. The data from this project will be used to characterize the complex and various types of aquifers within the state through a better understanding of the bedding planes, joints, faults, and other fractures through which most of our groundwater flows or is stored. This research will increase knowledge of the depth and location of these water bearing features throughout the state.

All the fieldwork for the project was completed by September 30, 2019, with over 120 well logs containing geological and hydrological data (Figure 11). The USGS final report and data models were anticipated in spring 2022, however due to staffing issues and other high priority local projects such as perfluoroalkyl and polyfluoroalkyl substances (PFAS), completion of this project is now planned for spring 2024. Although aspects of the study are time consuming and manpower intensive, the borehole geophysics data collected for this project are the only mechanism which allow a detailed characterization of the fracture-controlled bedrock aquifers upon which so many residents and commercial and industrial entities rely as a primary source of water. Results of the study will aid in future assessment and management of groundwater resources within the state.

Water Stress and Critical Planning Areas

The Water Resources Protection and Management Act directs WVDEP to "establish criteria for designation of critical water planning areas comprising any significant hydrologic unit where existing or future demands exceed or threaten to exceed the safe yield of available water resources." Previous work by the Water Use Section has shown that on an annual level the state enjoys abundant water resources. However, there is potential for water stress on smaller spatial or temporal scales so additional research in this area is being pursued.

Initiated in fall 2019, the 2022 report on Quantifying Water Security in West Virginia and the Potomac River Basin by Eric Sjostedt, Michael Strager and Nicolas Zegre is based on master's thesis work at West Virginia University (WVU). The thesis included two studies to provide insight into water resources management in West Virginia. The first study compared existing water use data in West Virginia to identify strengths and limitations of current water resource accounting practices with recommendations on how to improve water security. It determined the LQU water use dataset made up 73% of all USGS water use, implying it does a good job of representing large-scale water users in West Virginia. Overall, the greatest differences between the USGS and LQU datasets came from the Thermoelectric and Agriculture water use sectors, with 31% and 29.9%, respectively. Due to the lack of mandatory reporting from aquaculture, agriculture, irrigation, livestock, and poultry water use sectors under LQU, the million gallons/year shown in the LQU dataset are only estimated from the voluntarily reported data and are not representative of the actual total water use of these agricultural water uses for the state. Insight into water use below 300,000 gallons, including domestic water supply estimates would also benefit LQU data. The Water Use section will continue to consider these improvement suggestions in better understanding contemporary water use to support the development of sustainable management of water resources for both quantity and quality. The second study identified West Virginia as a vital headwater state in the Gulf of Mexico drainage basin from the Ohio and Mississippi Rivers as well as to the Potomac River. It included a community-scale water tower model of the Potomac River basin that showed the impact of hinterland high-elevation forested land cover on the Washington DC metropolitan area source water.

In addition to the WVU project, the USGS is currently drafting a proposal for a Jefferson and Berkeley County water-use study and development of a predictive groundwater flow model. The Water Use Section will continue to work together on local projects and studies to improve our understanding of water stress throughout the state and, if needed, support the designation of critical planning areas. It is important to use data to spatially inform where water use could potentially expand and/or it should

be curtailed to minimize negative impacts.

Online Water Resources Information

In cooperation with WVDEP's Technical Applications and GIS Unit (TAGIS) group, the Water Use Section maintains a suite of internet-based tools that display water resources management data in online Geographic Information Systems (GIS). The Water Resources Management Mapping Tool acts as a clearinghouse for all manner of data relevant to water management, including LQU withdrawals, watershed delineations, karst, monitoring wells, springs, mine pools, NPDES, geology, and more. The tool is available at: http://tagis.dep.wv.gov/WVWaterPlan/ TAGIS and the Water Use Section also maintain a Water Withdrawal Guidance Tool. Developed in 2009, this tool helps direct potential water withdrawals towards only those surface waters with sufficient flow. The Section is currently investigating improvements to this tool, including the incorporation of groundwater resources, stream ecology, and higher spatial resolutions. The tool is available at https://tagis.dep.wv.gov/wwts/.

The Water Use Section continues to utilize available national resources. The USGS Groundwater and Streamflow Information Program also recently updated their internet interface to better share their surface and groundwater gaging and monitoring network data to support improved water resources management statewide. There is also potential to develop more helpful applications upon request. For example and without WVDEP request or funding, USGS most recently provided a report and tool based on WV Public Water System Drought Risk at https://rconnect.usgs.gov/wv-surface-withdrawals/. Similarly, the USGS provided the Virginia and WV Groundwater Levels and Trends tool https://rconnect.usgs.gov/vawv-groundwater/.

USGS WaterWatch has multiple existing real time user friendly applications for current streamflow, flood, drought, past flow and animation. They also have an Archive of Streamflow Maps and a Streamflow Map Animation for the US applications. The State Dashboard application shows all available data in an extremely user-friendly format (https://waterwatch.usgs.gov/index.php?st=wv&id=wwsa4state&full=1&ct=wwsa4state). StreamStats v4.17.0 (https://streamstats.usgs.gov/ss/) provides access to an assortment of GIS analytical tools that are useful for water-resources planning and management, and for engineering and design purposes. The explanation and metadata provided throughout these web applications is also thorough.

Water Resources: Plans and Priorities

The Water Use Section is developing future projects and plans to support our continued efforts to improve water resources management, data collection, and analysis consistent with the Water Resources Protection and Management Act. The Water Use Section continues to discuss with the USGS and other research entities on a variety of potential proposals to enhance water quantity data and use. All current projects are also encouraged to include recommendations for future pursuits within their findings.

Upgrade Data Entry and Management

The Water Use Section continues to collaborate with other groups within WVDEP's Division of Water and Waste Management (DWWM) and the WV Business Technology Office to develop new data entry and data management programs. Feedback on the current ESS remains mixed and data entry error rates for LQU approaches 40%. The Section is pursuing a system with a new interface to improve the user experience, reduce errors, and provide better data analytics to Water Use Section staff. The new system and data migration project is currently in progress and targets to be in production for the 2024 reporting season.

Water Resources Program Needs

Nationally, the USGS stream gaging network is a multipurpose network that comprises more than 10,000 stream gages. The stream gages are primarily operated and maintained by the USGS, but most are funded in partnership with one or more of about 1,800 Federal, State, Tribal, regional, and local partners. This unique cooperation results in nationally consistent and impartial data that also aids local decision making. The shared costs result in the operation of far more stream gages than would be possible if financed solely by USGS appropriations, which provide approximately than one-third of the needed funding. These partnerships also enable fixed costs (such as costs associated with data storage and delivery infrastructure) to be broadly distributed, resulting in more economical stream-gaging information for all. It encompasses several smaller networks that produce specific information or support specific needs. The data are quality assured and served online-most in near real time-to meet many diverse needs. Data users include emergency responders, water managers, environmental and transportation agencies, universities, utilities, recreational enthusiasts, and consulting firms. Specific uses of the data include the following:

- planning, forecasting, and warning about floods and droughts;
- managing water rights and transboundary water issues;
- operating waterways for power production and navigation;
- monitoring environmental conditions to protect aquatic habitats;
- describing impacts to streamflow from changing land and water uses;
- assessing water quality and regulating pollutant discharges;
- determining if streams are safe for recreational activities; and,
- designing reservoirs, roads, bridges, drinking water and wastewater facilities.

Locally, the Water Use Section is deeply reliant upon these federal resources. The Water Use Section uses stream gauges to generate thresholds for water management plans under the Horizontal Well Control Act. Similarly, the Water Use Section's Water Withdrawal Guidance Tool fetches data from the stream gauge servers to provide recommendations for withdrawals across the state. The Water Use Section has other requirements under the Water Resources Protection and Management Act, including a surface water inventory, estimating safe yield/water budget, identifying potential problems with water availability, monitoring detrimental low-flow conditions, and assessing/projecting public water supply capabilities. Many of these duties are heavily dependent, if not entirely contingent, upon the stream gauge and groundwater level monitoring network for understanding the supply of water throughout West Virginia.

The Water Use Section respectfully requests the continued support from the Legislature and all concerned state agencies regarding funding and cost-sharing solutions for the 183 stream gauges and 19 groundwater level monitoring wells in the local network managed by the USGS (Figure 12). Like in other states, the West Virginia streamgage network primary funding partners are: West Virginia; U.S. Army Corps of Engineers; USGS; and, Energy and water companies. Following the June 2016 floods, network partners worked with the *Joint Legislative Committee on Flooding* to expand the network by 39 monitoring locations, improve operational efficiency and information access, and stabilize funding through a line item in the annual state budget administered through the WV Emergency Management Division. Network expansion cost $1.1 million and was shared between the State and USGS: $340,000 and $760,000, respectively. This was a tremendous accomplishment to commit at the top state level to annually supporting USGS gages and the data produced and utilized locally. Prior to the line item, multiple state and federal agencies had to individually determine each year how to financially support key resources for their daily work which was inefficient and risky.

Although the total network costs for 2024 are about $2.5 million, the operational cost for the network shared by multiple funding partners does continue to change over time. In 2020 and 2021, the West Virginia line-item portion was $800,000. Although able to operate within the FY2022 budget of $820,000, a funding partner loss and increase to overall costs due to pandemic resulted in the state FY2023 cost being $891,780. WVDEP paid the additional $71,780 difference to prevent any local gages from being discontinued and ensure continuity of data. Where the current state FY2024 budget remained at $820,000 again, there was another shortfall of $118,000 which had to be again covered by state agency participants (WVDEP, West Virginia Department of Transportation Division of Highways, Department of Health and Human Resources, Division of Natural Resources, and Conservation Agency) to prevent a reduction in network activities that would jeopardize data quality and continuity. We have learned it is as important at the state level to build in periodic small cost increases since funding partners share operational costs for the network through the line item commitment. Another complication is although the other funding partners' cumulative costs have also increased to $1,033,550 the USGS portion mandated by Congress has remained $575,230 since 2023. The anticipated costs for state FY2025 are $965,000. The West Virginia Stream Gaging Council will continue to communicate priorities and plan the state budget appropriately as it has since 2005. The recent total funding history is as follows:

Fiscal Year	West Virginia	USGS	Other	Total Annual Funding
2020	$800,000	$560,234	$827,730	$2,187,964
2021	$800,000	$561,765	$846,740	$2,208,505
2022	$820,000	$562,800	$892,880	$2,275,680
2023	$891,780	$575,230	$952,090	$2,419,100
2024	$938,000	$575,230	$984,333	$2,497,563
2025	*$965,000*	*$575,230*	*$1,033,550*	*$2,573,780*

Table 4. WV Stream Gaging Network Cost.

The Water Use Section along with other WVDEP program staff continue to participate in the quarterly stream gaging council meetings to support continued cooperation and prioritization of statewide water resources data maintenance and development where possible.

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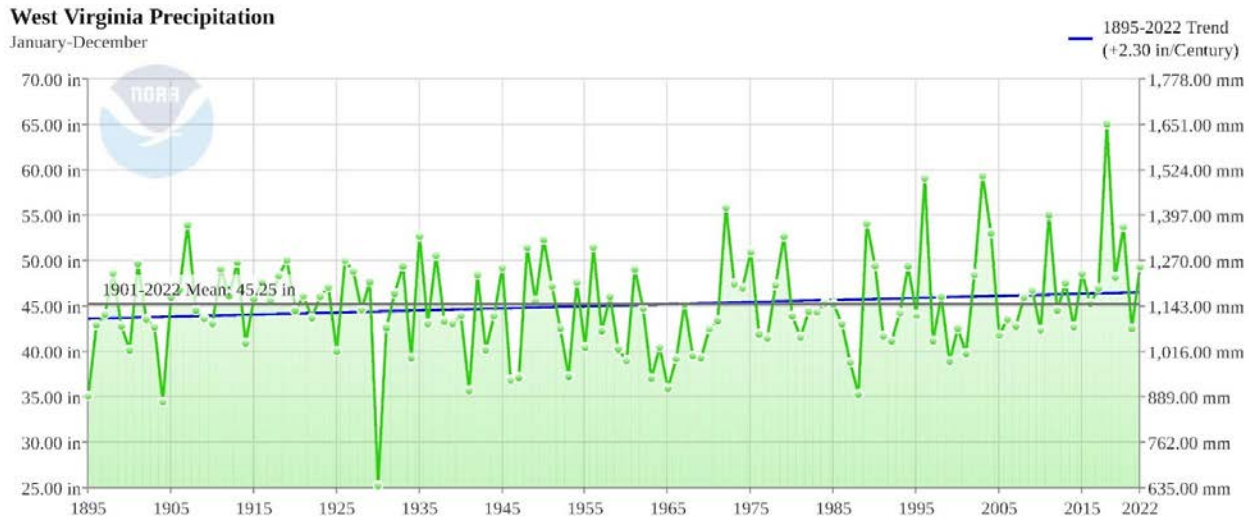

Figure 1. WV's annual precipitation from 1895 - 2022 (from National Oceanic and Atmospheric Administration). Blue line in 2022 is 49.37 inches.

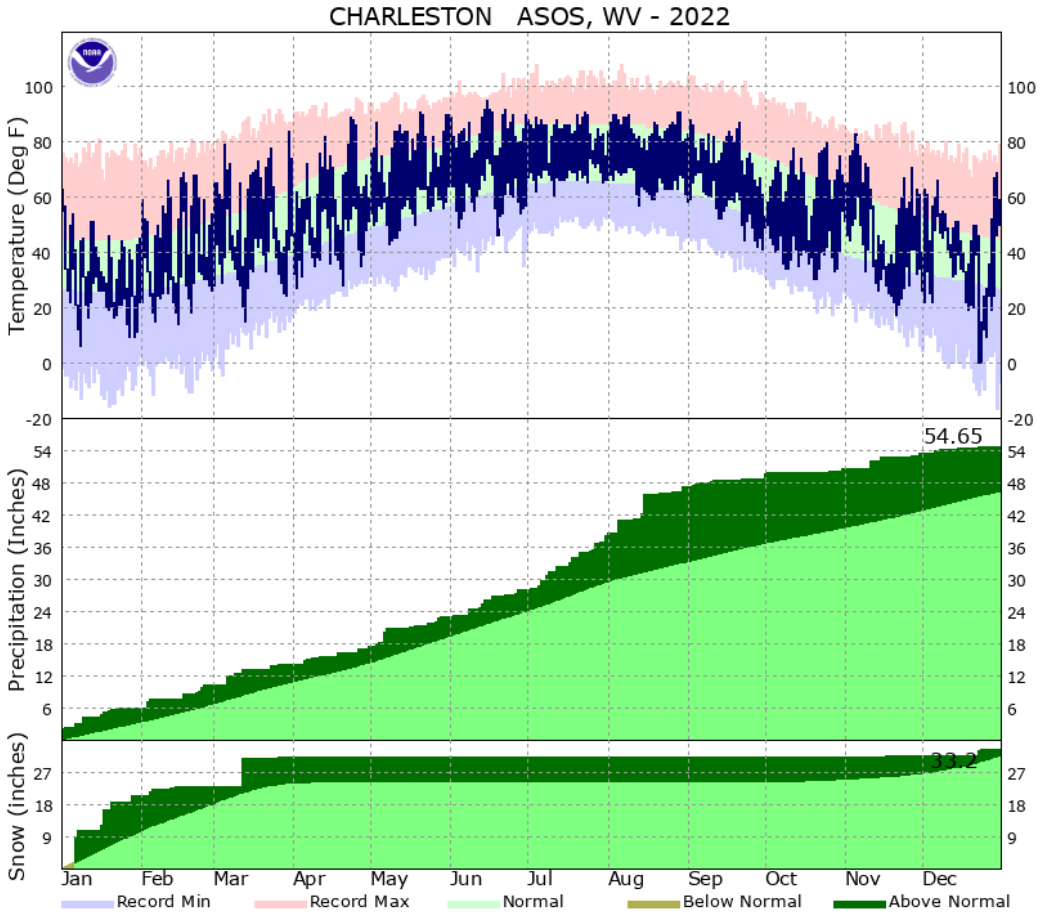

Figure 2. Climate data for Charleston, WV from January - December 2022 (from National Weather Service).

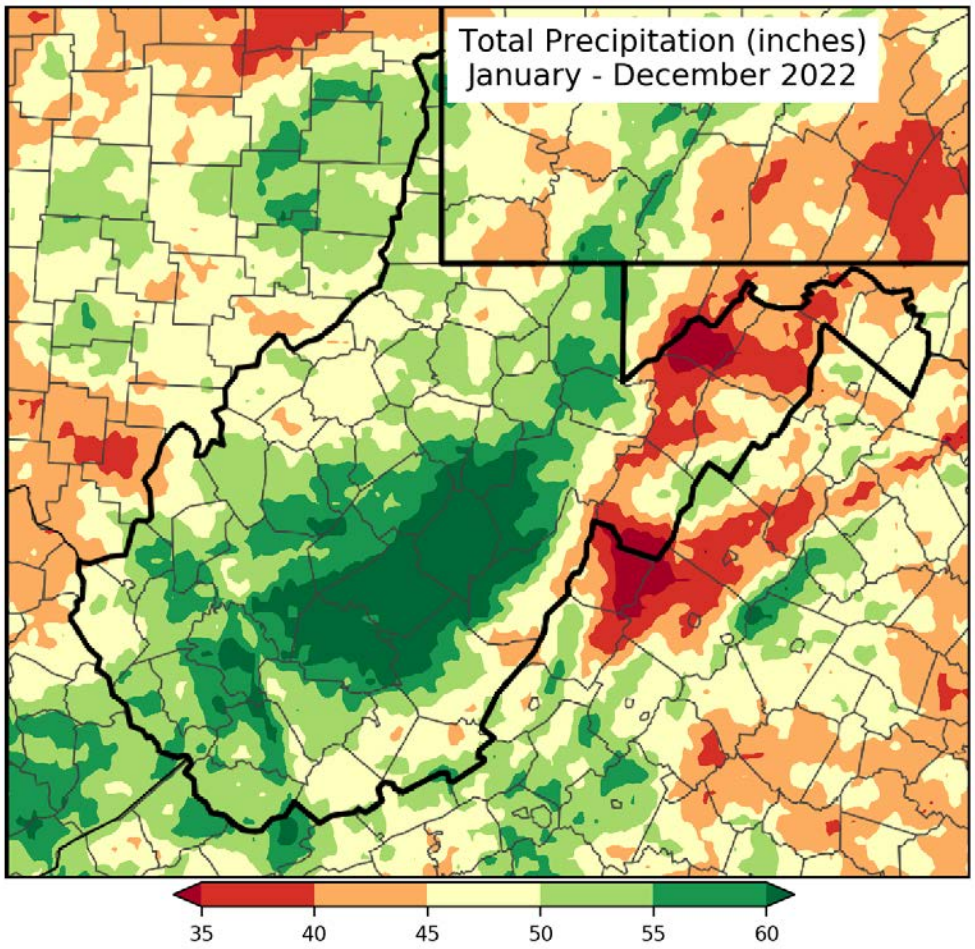

Figure 3. Total 2022 Precipitation (from Northeast Regional Climate Center).

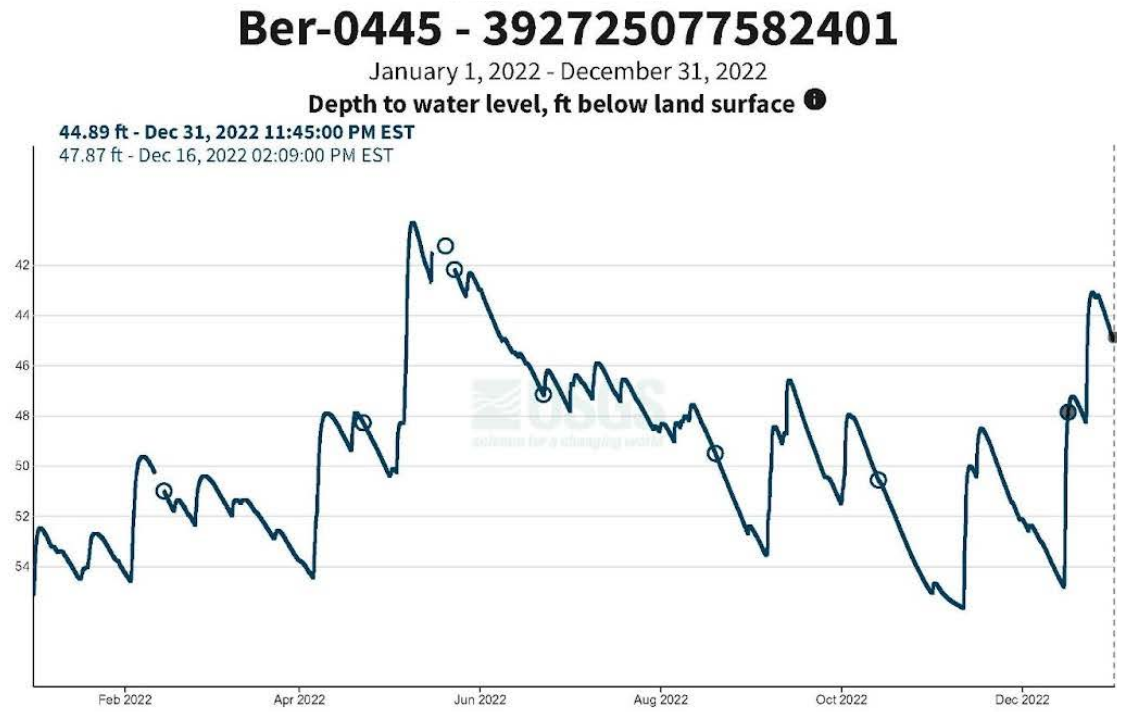

Figure 4a. Groundwater levels 2022 in Martinsburg, WV (from USGS).

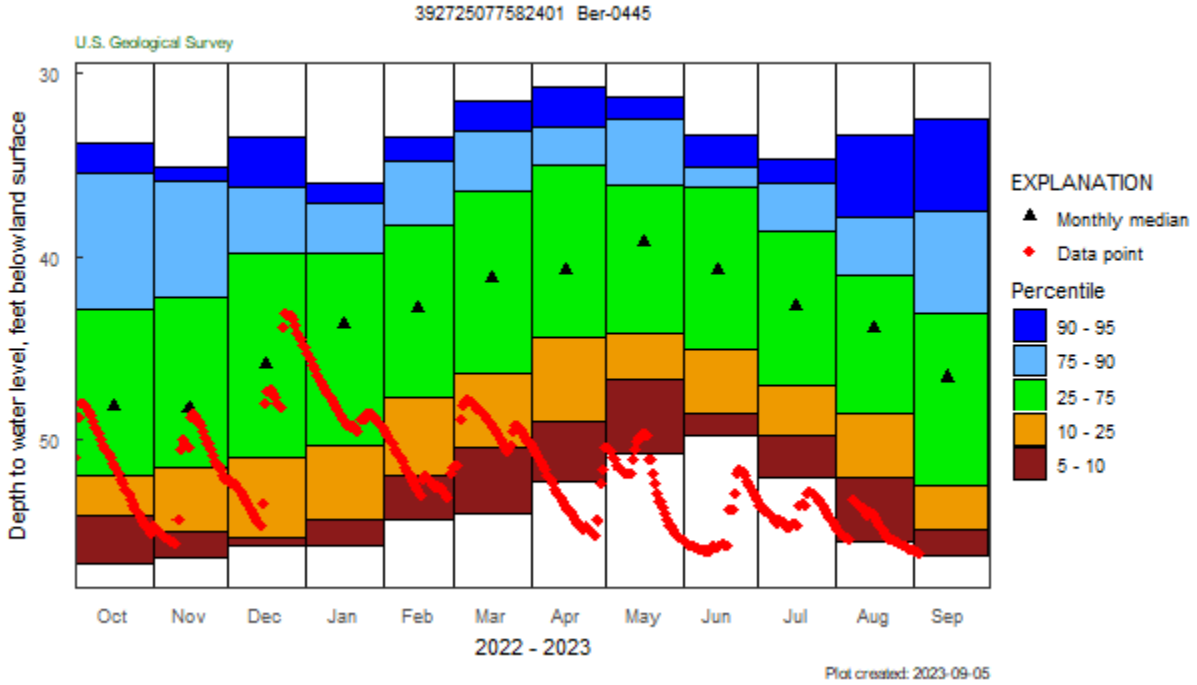

Figure 4b. Recent groundwater level statistics (from USGS).

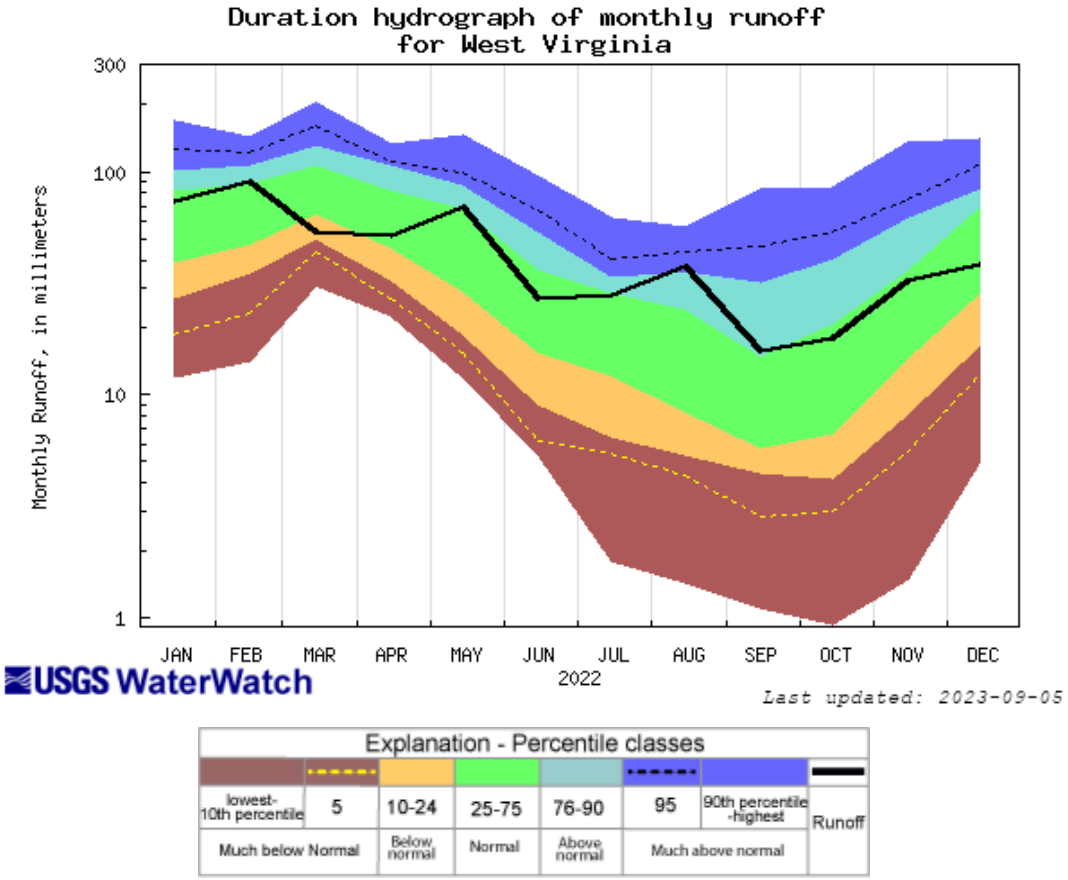

Figure 5a. WV 2022 monthly hydrograph. Note logarithmic scale (from USGS).

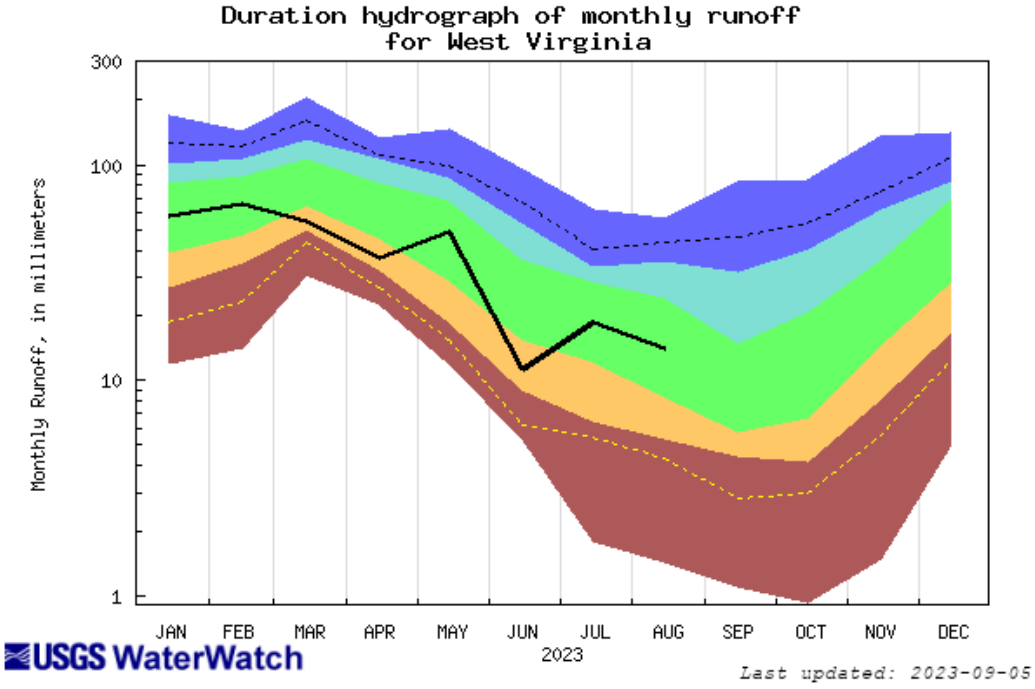

Figure 5b. WV 2023 monthly hydrograph. Note logarithmic scale (from USGS).

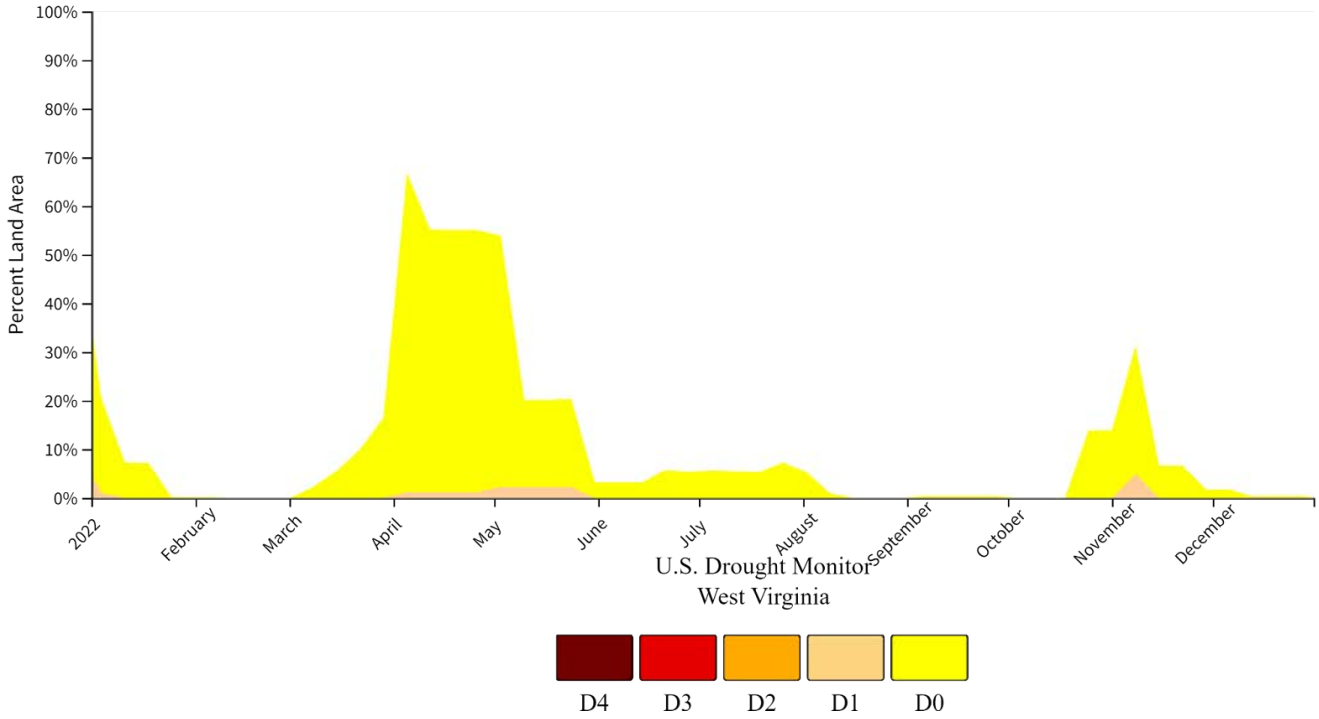

Figure 6a. Drought conditions in WV in 2022 (from US Drought Monitor).

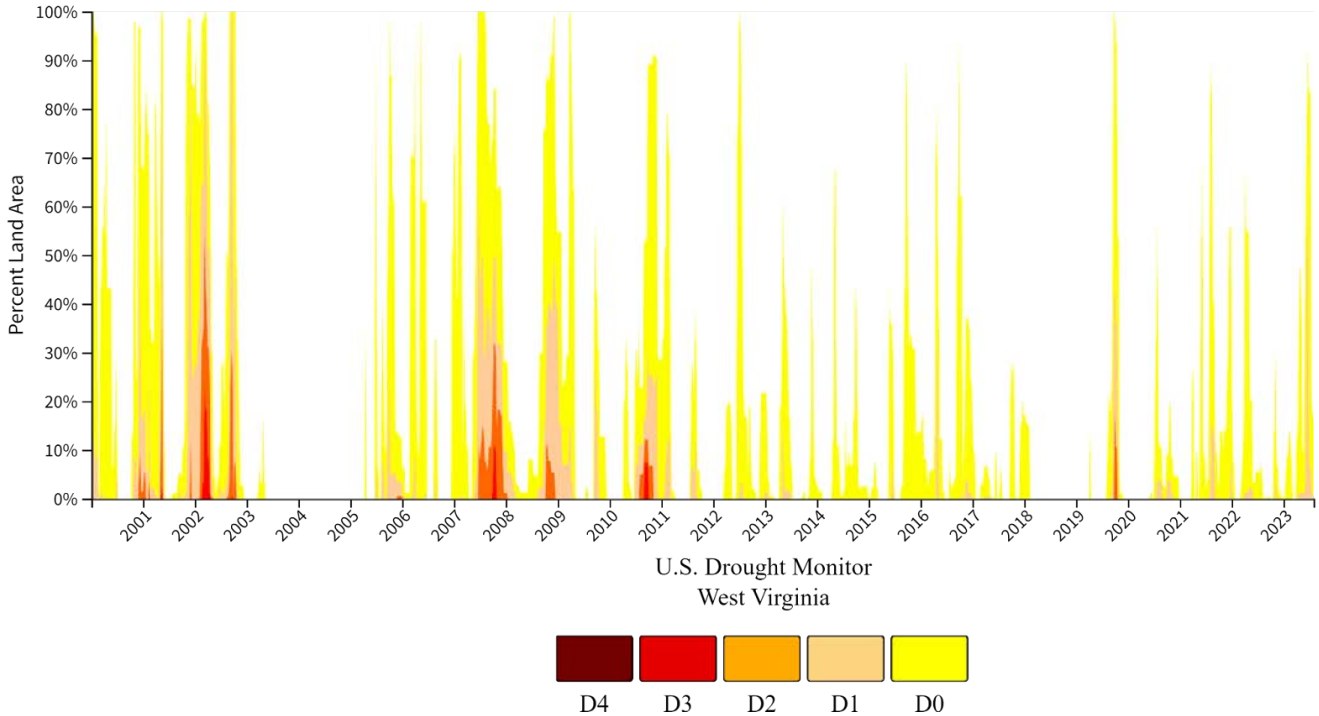

Figure 6b. Drought conditions in WV since 2000 (from US Drought Monitor).

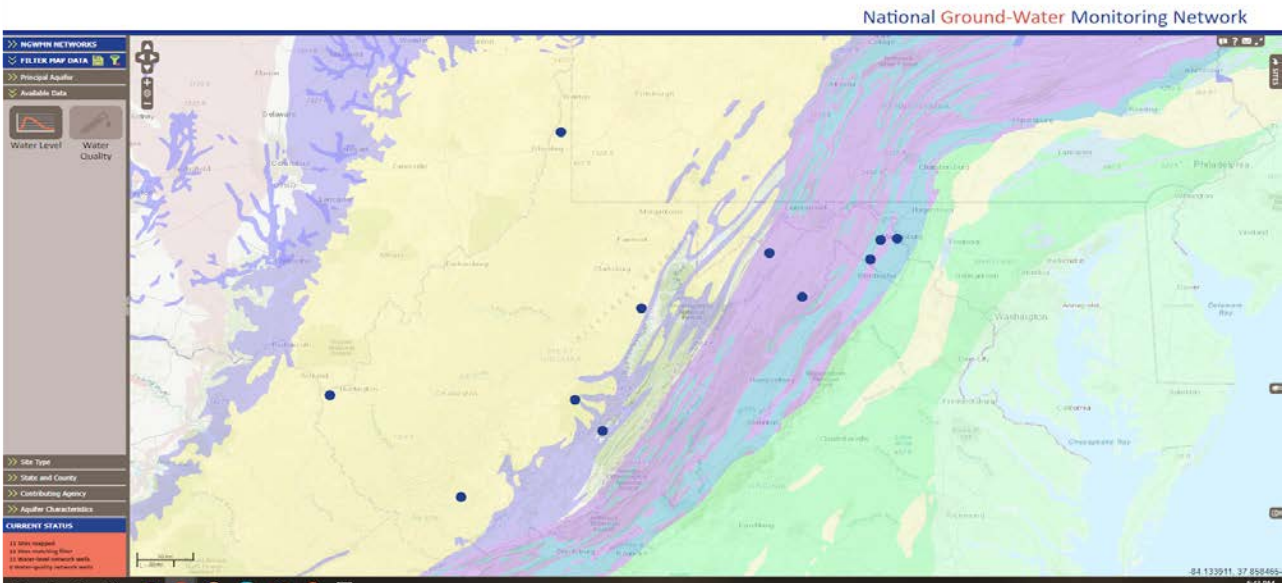

Figure 7. Groundwater use is concentrated in the alluvium along the Ohio River, southern coalfields, and karst aquifer systems of eastern WV (from the National Ground-Water Monitoring Network).

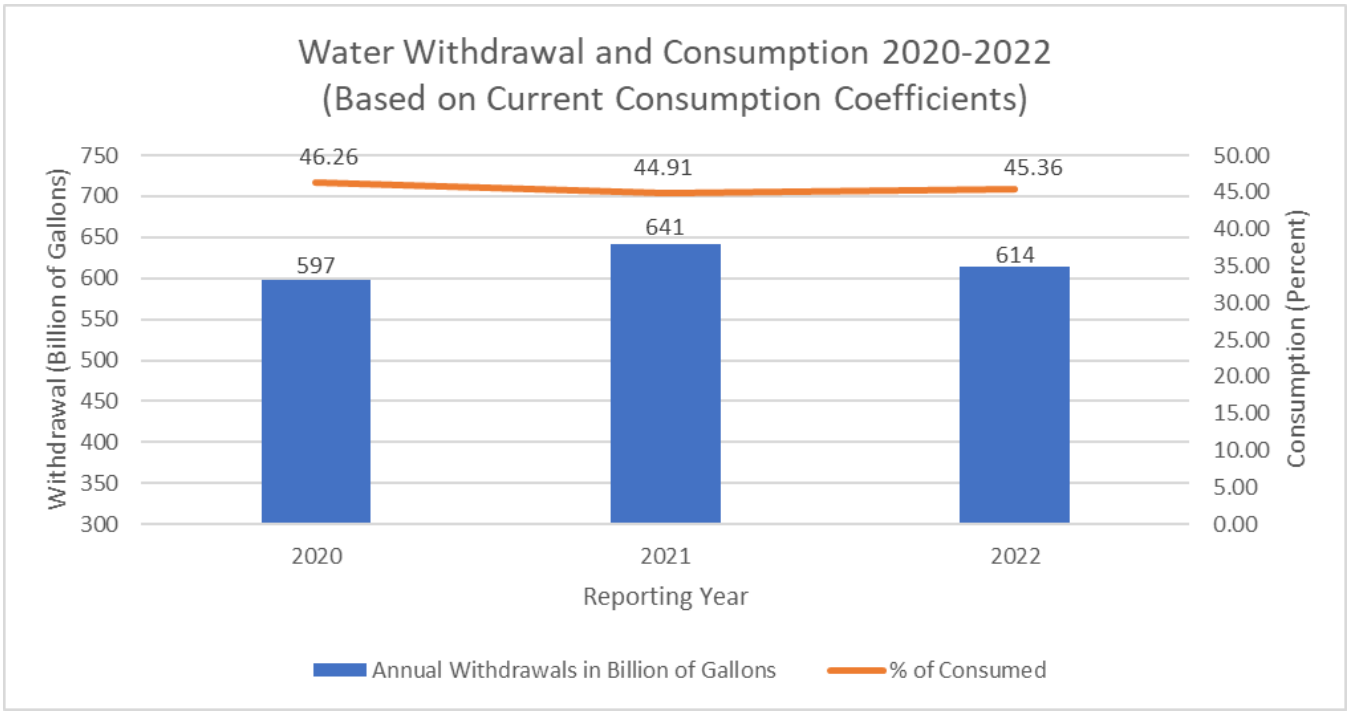

Figure 8. Water withdrawal and consumption 2020-2022 (based on current consumption coefficients).

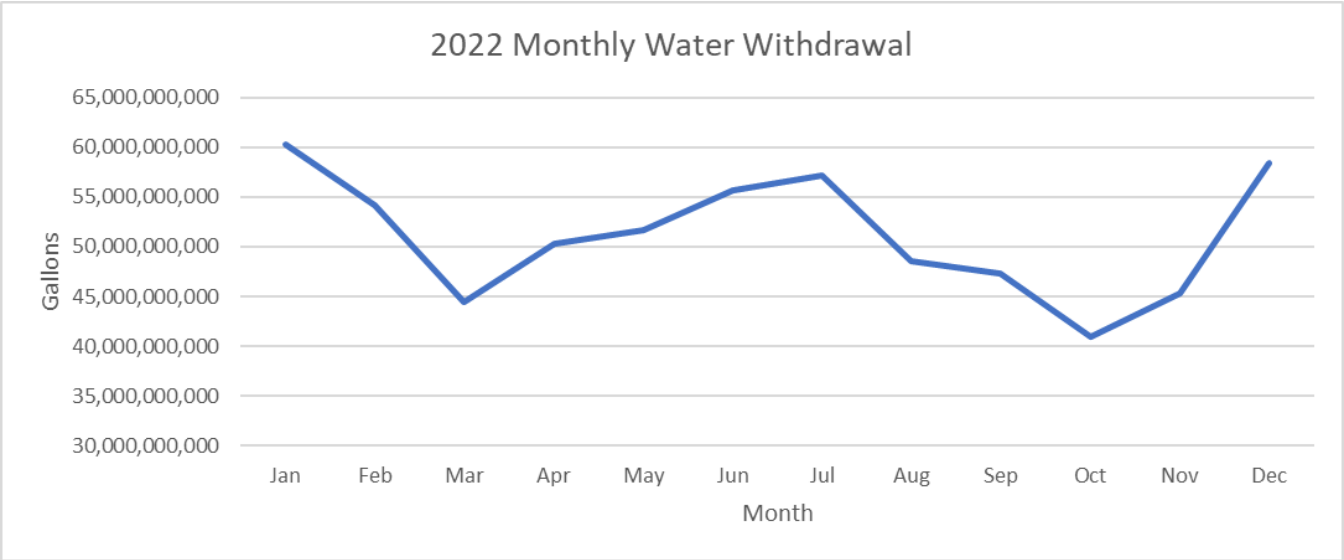

Figure 9. 2022 Monthly trends in total withdrawal from the LQU database (WVDEP).

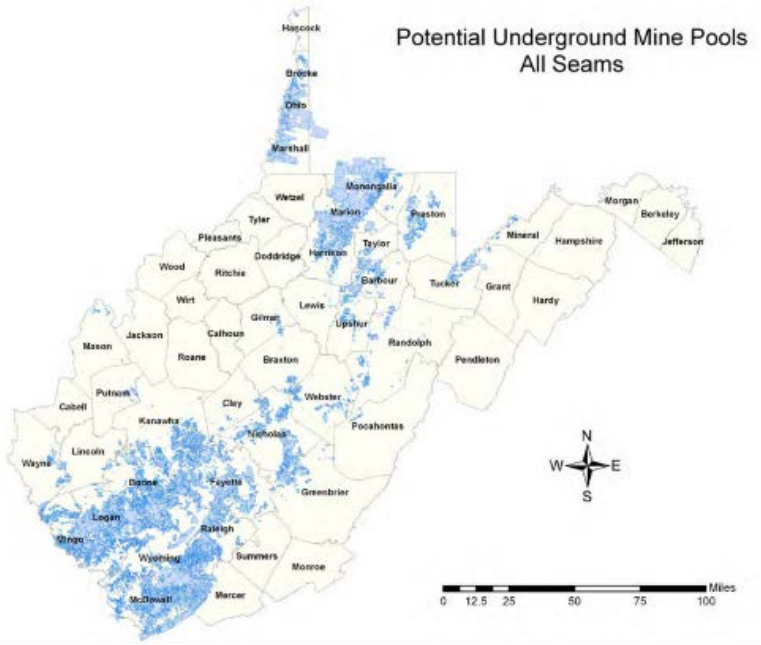

Figure 10. Estimated extent of Abandoned Underground Coal Mine Aquifers (WVGES & WVDEP).

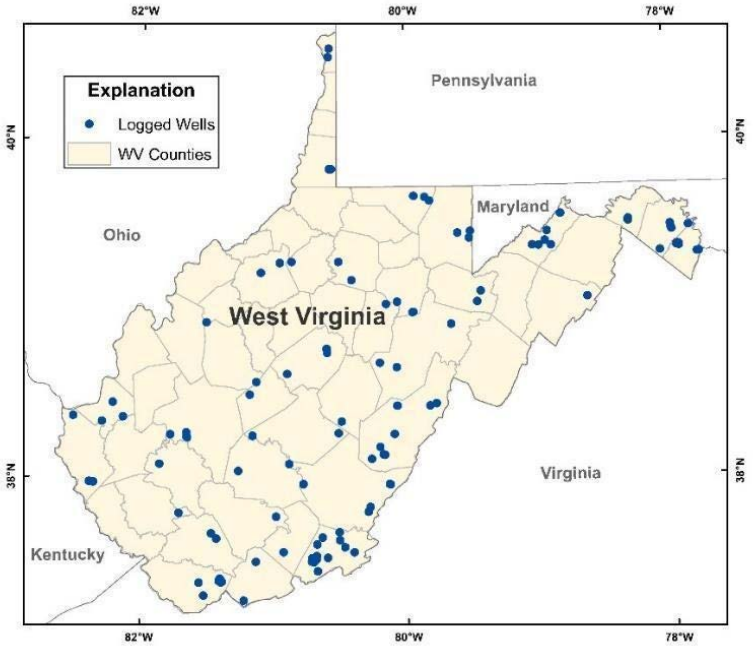

Figure 11. Location of USGS-WVDEP borehole geophysics well logs 2015-2019 (USGS).

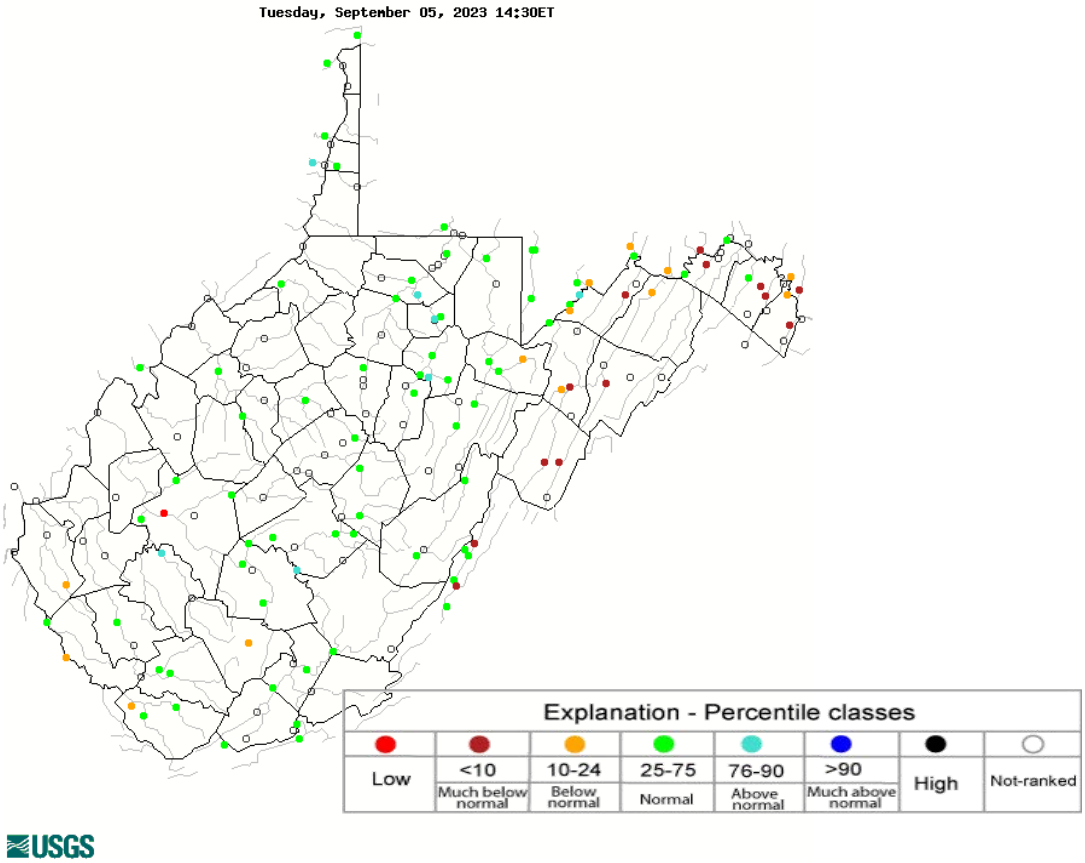

Figure 12. The stream gauge network in WV (from USGS).