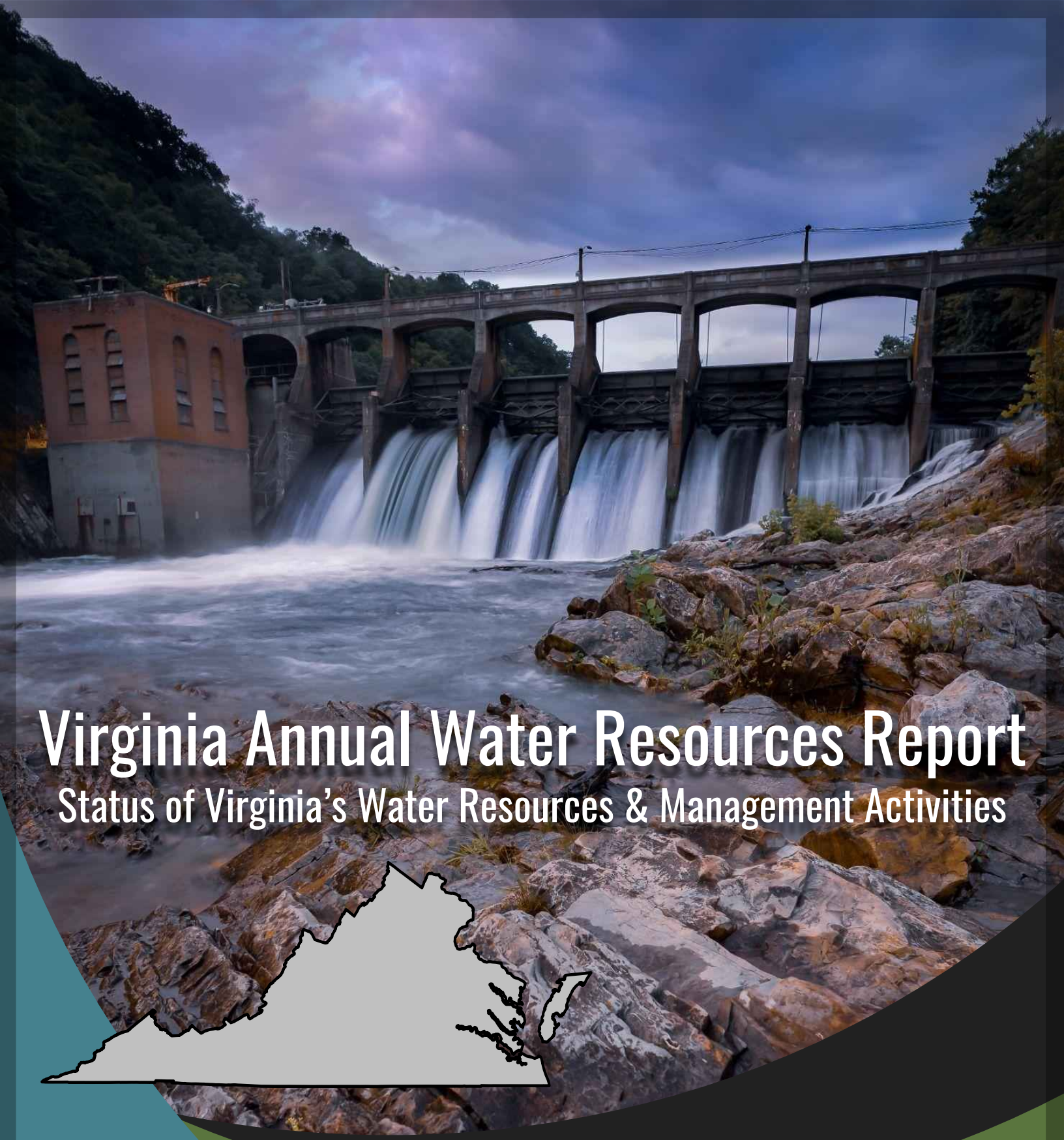

Virginia Annual Water Resources Report

Status of Virginia's Water Resources & Management Activities

Virginia Department of Environmental Quality

Commonwealth of Virginia

January 2022

DEQ
Virginia Department of Environmental Quality

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Acronyms

BGD: Billion Gallons per Day
BGY: Billion Gallons per Year
CSO: Consent Special Order
DEQ: Virginia Department of Environmental Quality
DL: Delivery
FERC: Federal Energy Regulatory Commission
GPD: Gallons per Day
GW: Groundwater
GWCP: Groundwater Characterization Program
GWMA: Groundwater Management Area
HRSD: Hampton Roads Sanitation District
HUC: Hydrologic Unit Code
JPA: Joint Permit Application
MGD: Million Gallons per Day
NOV: Notice of Violation
NPDES: National Pollutant Discharge Elimination System
NWIS: USGS National Water Information System
OWS: Office of Water Supply
PDC: Planning District Commission
PWS: Public Water System
RL: Release
SD: System Delivery
SR: System Release
SW: Surface Water
SWCB or Board: State Water Control Board
SWIFT: Sustainable Water Initiative for Tomorrow
SWIP: Surface Water Investigations Program
TAC: Technical Advisory Committee
TMDL: Total Maximum Daily Load
USACE: United States Army Corps of Engineers
USEPA: United States Environmental Protection Agency
USGS: United States Geological Survey
VDH: Virginia Department of Health
VGIN: Virginia Geographic Information Network
VMRC: Virginia Marine Resources Commission
VWP: Virginia Water Protection (Permit Program)
WL: Withdrawal
WSP: Water Supply Plan
WTP: Water Treatment Plant
WUDR: USGS Water Use Data and Research Program
WWTP: Waste Water Treatment Plant

Executive Summary

The Virginia Annual Water Resources Report (Annual Report) is submitted in October of each year to the Governor and the Virginia General Assembly in accordance with § 62.1-44.40 of the Code of Virginia. The current Annual Report focuses on water quantity and supply, summarizing reported water withdrawals for the 2020 calendar year, identifying water withdrawal trends, and providing an update on the Commonwealth's water resources management activities. The Annual Report also serves as a status report on activities associated with the State Water Resources Plan between five year updates. The Draft 2020 State Water Resources Plan was released for public comment in June 2021.

Water quality issues are addressed in the most recent biennial Water Quality Assessment Integrated Report, published by the Virginia Department of Environmental Quality (DEQ).

Chapter 1 provides an overview of water resource management activities and outcomes during 2020. This chapter discusses several DEQ programs including water withdrawal permitting and compliance, water supply planning and analysis, groundwater characterization, surface water investigations, and drought assessment and response.

Chapter 2 provides a detailed summary of all water withdrawal reporting data during the 2020 calendar year. Reported information is organized by water source and use type.

Chapter 3 provides an overview of water withdrawal reporting trends from 2016-2020, and allows for direct comparison of 2020 withdrawals to the last five years. Information is organized based on water source, use type, and permit status.

Chapter 4 identifies new, continuing, and future priorities, challenges, or other topics of specific interest in terms of water resources management at DEQ. These include updates on new legislative or regulatory actions, programmatic goals and achievements, and other items.

In addition to the main chapters, the report includes several appendices that provide: detailed information on reported use for each category (Appendix 1), the top 20 largest reported withdrawals in 2020 (Appendix 2), reported use by locality (Appendix 3), an overview of Virginia's water resources and climate by the numbers (Appendix 4), and some additional information on water transfers (Appendix 5).

Summary of 2020 Water Withdrawals and Recent Trends:

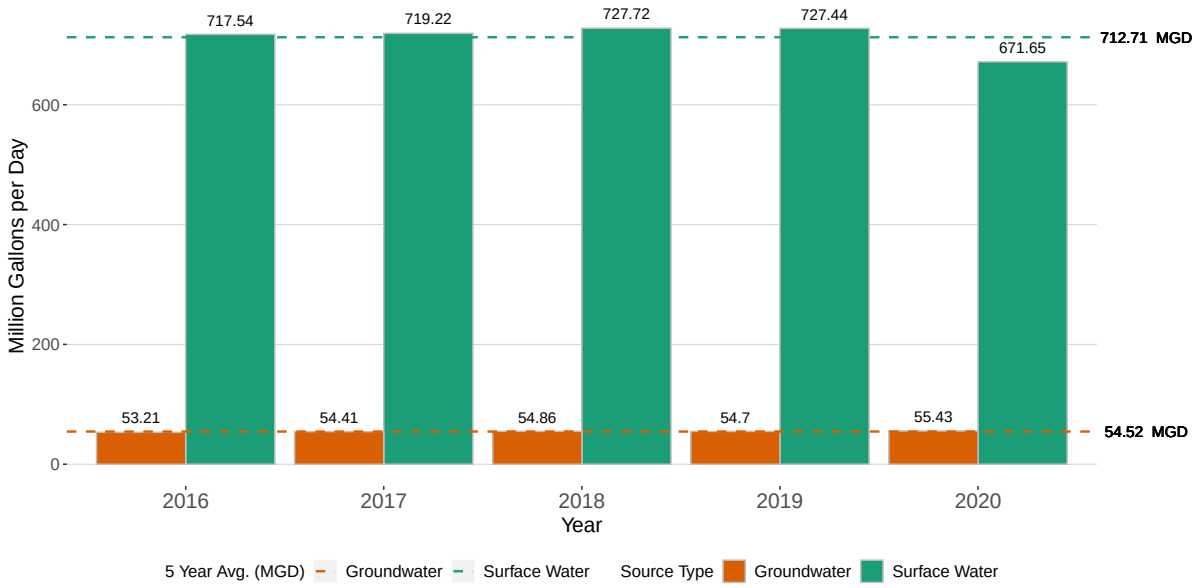
In calendar year 2020, 1,225 facilities reported water withdrawals to DEQ. The total volume of reported withdrawals from all water use categories (including fossil-fuel and nuclear power generation) was approximately 5.68 billion gallons per day. Dominion's North Anna and Surry Nuclear Power Stations made up 3.8 billion gallons per day of that total, although these facilities are also largely non-consumptive in that the water withdrawn is returned to the source with minimal loss. Water withdrawals related to nuclear, fossil fuel, and other power generation facilities are addressed in the power generation section in Appendix 1. When excluding withdrawals for power generation, the total volume of reported withdrawals for all other categories was approximately 1.18 billion gallons per day, a decrease of approximately 4% when compared to the five-year average. Table 1 includes a summary of reported water withdrawals for the past five years by water use and source type when excluding power generation.

Table 1: Summary of Virginia Water Withdrawals by Use Category and Source Type 2016 - 2020 (MGD) Excluding Power Generation

Category	2016	2017	2018	2019	2020	5 Year Avg.	% Change 2020 to Avg.
Groundwater							
Agricultural	0.67	0.70	0.80	1.22	1.31	0.940	39.4
Commercial	5.46	5.37	4.32	4.96	3.99	4.820	-17.2
Irrigation	1.86	1.65	1.74	2.01	1.93	1.840	4.9
Manufacturing	56.10	57.54	60.57	57.76	58.02	58.000	0.0
Mining	17.34	15.54	18.04	17.57	19.62	17.620	11.4
Public Water Sup.	53.21	54.41	54.86	54.70	55.43	54.520	1.7
Surface Water							
Agricultural	33.64	30.59	32.70	30.98	29.73	31.530	-5.7
Commercial	10.41	9.52	7.98	9.91	6.33	8.830	-28.3
Irrigation	20.40	18.59	12.89	20.12	15.76	17.550	-10.2
Manufacturing	312.23	324.45	304.17	293.49	301.92	307.250	-1.7
Mining	15.48	13.66	16.84	13.74	15.62	15.070	3.6
Public Water Sup.	717.54	719.22	727.72	727.44	671.65	712.710	-5.8
Total (GW + SW)							
Agricultural	34.31	31.29	33.50	32.20	31.04	32.470	-4.4
Commercial	15.87	14.89	12.30	14.87	10.32	13.650	-24.4
Irrigation	22.26	20.24	14.63	22.13	17.69	19.390	-8.8
Manufacturing	368.33	381.99	364.74	351.25	359.94	365.250	-1.5
Mining	32.82	29.20	34.88	31.31	35.24	32.690	7.8
Public Water Sup.	770.75	773.63	782.58	782.14	727.08	767.240	-5.2
Total							
Total Groundwater	134.64	135.21	140.33	138.22	140.30	137.740	1.9
Total Surface Water	1109.70	1116.03	1102.30	1095.68	1041.01	1092.940	-4.8
Total (GW + SW)	**1244.34**	**1251.24**	**1242.63**	**1233.90**	**1181.31**	**1230.684**	**-4.0**

The major trend in reported use was one of reducing demands. In 2020 reported use for municipal water demand decreased by 5.2% compared to the five year average. The trend in public water supply withdrawals over the last five years can be seen in Figure 1. Reported withdrawals for commercial use declined by 24.4% compared to the five year average. These reductions may be the result of social and economic impacts from COVID-19 and associated mitigation measures. In contrast, groundwater demands for agricultural use grew by nearly 40% in 2020, in large part due to recently permitted facilities on the Eastern Shore reporting withdrawals for a full calendar year for the first time.

Figure 1: 2016-2020 Public Water Supply Water Withdrawals by Source Type



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Surface water withdrawals accounted for approximately 88% of total withdrawal volumes in 2020 (excluding withdrawals for power generation), which is consistent with the proportion of reported use over the previous five years. Public water supply was the largest use type for surface water withdrawals with 671 million gallons per day (MGD) withdrawn in 2020. Surface water withdrawals for public water supply declined by 5.8% compared to the five year average, a more than 40 MGD reduction. Reported decreases from public water suppliers were consistent statewide with most major suppliers reporting the lowest withdrawals in recent years. As noted, impacts from COVID-19 likely contributed to this reduction as demand from non-residential (commercial & industrial) customers served by public water suppliers was impacted by COVID-19 mitigation requiring some closures and reduced operations. The year 2020 was also one of the wettest years on record which reduces withdrawals necessary for commercial or residential irrigation. The largest surface water withdrawals by volume occurred within the City of Richmond, Hampton Roads, Northern Virginia, and within Giles County. Total reported surface water withdrawals declined by 4.8% when compared to the five-year average. Figure 2 shows the total surface water withdrawals by locality.

Groundwater withdrawals accounted for approximately 12% of total reported withdrawals in 2020 with 140.3 MGD reported to DEQ. Manufacturing & industrial use remained the largest total withdrawal category for groundwater with 58.0 MGD reported to DEQ in 2020, which is comparable to the five year average. In 2020, groundwater withdrawals for agricultural use showed the largest reported increase of any category, with a 39.4% increase compared to the five-year average. As noted above, this is largely because 2020 was the first year that many newly permitted poultry farms reported an entire year of withdrawals to DEQ. Reported groundwater withdrawals for commercial users decreased by more than 17% in 2020, the largest reduction observed over the five year period. Similar to reductions in surface water demands reported by municipal suppliers, impacts from COVID-19 combined with a wetter than average year may have influenced the reduction in demands statewide. Figure 3 shows the total groundwater withdrawals by county. The largest groundwater withdrawals by volume occurred in the Coastal Plain (Isle of Wight and King Williams counties) and along the Valley and Ridge, particularly in the Shenandoah Valley and Giles County. Total reported groundwater withdrawals increased by approximately 1.9% compared to the five-year average.

Figure 2: 2020 Surface Water Withdrawals by Locality

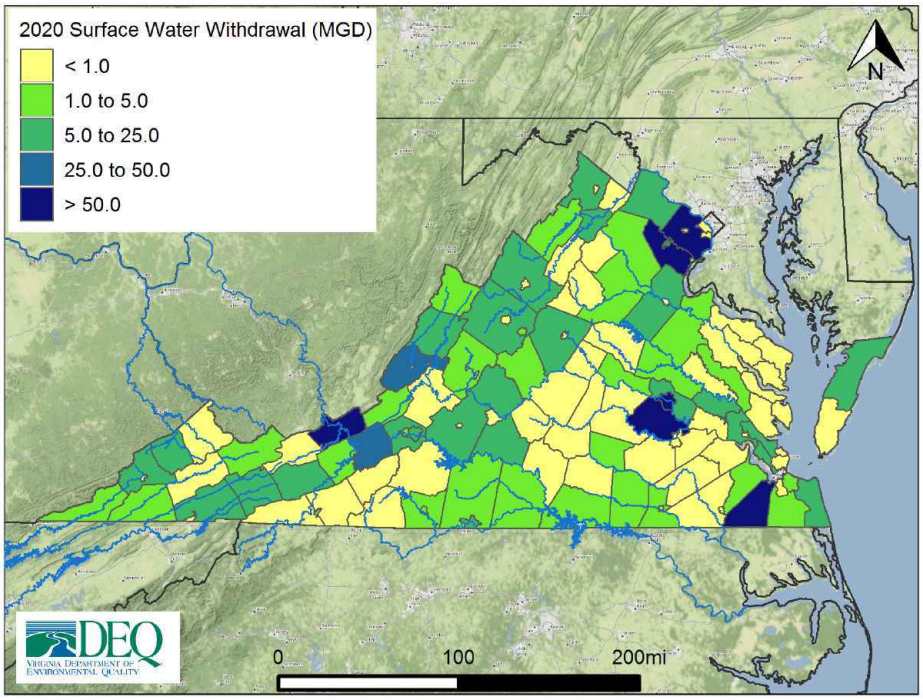
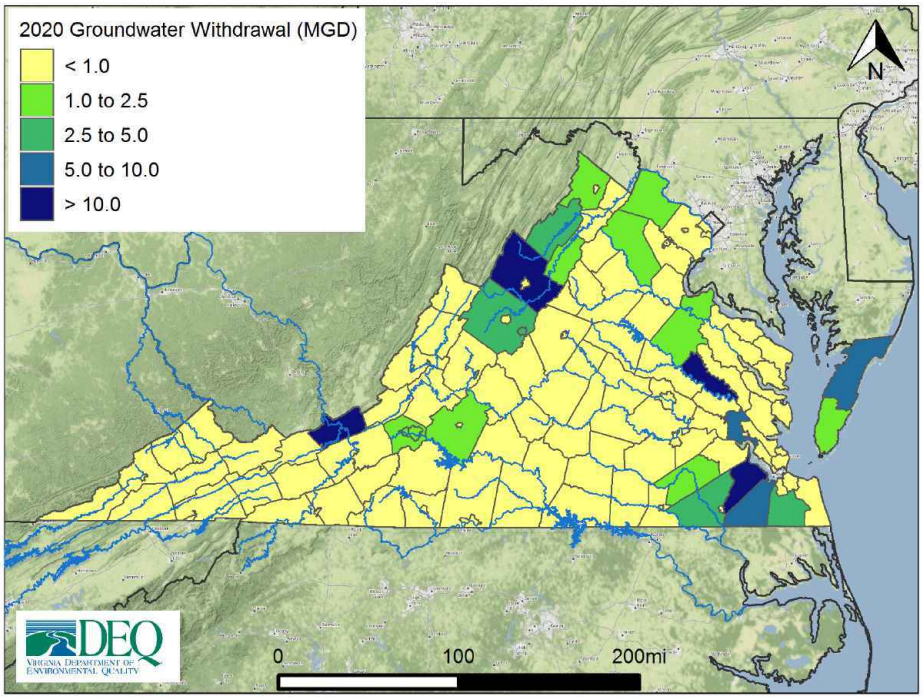


Figure 3: 2020 Groundwater Withdrawals by Locality



In 2020, groundwater and surface water withdrawals not subject to any permitting requirements ("unpermitted withdrawals") represent approximately 72% of the total reported withdrawals in Virginia, and 15 of the top 20 reported withdrawals were from facilities not required to have a permit.

For groundwater withdrawals, that includes withdrawals located outside of current groundwater management areas (GWMA), the Eastern Virginia and Eastern Shore GWMAs, or withdrawal volumes below the permitting threshold. While 50.9% of reported groundwater withdrawals were located within a GWMA and were associated with a permit, it is important to note that cumulative impacts from large users and domestic/private well users outside of current GWMAs present unique water resource management challenges due to the limited groundwater studies in these areas. Some of the largest groundwater withdrawals occur within the Shenandoah Valley and in Giles County which are outside of the current GWMAs.

For surface water users, unpermitted withdrawals include all users that are exempt from from VWP permit requirements per Va.Code § 62.1-44.15:22 B, whether due to the size of the withdrawal, date on which the withdrawal began, or other exemptions. Approximately 75% of all surface water withdrawn in Virginia is associated with unpermitted users, which has remained largely consistent across reporting years. Unpermitted surface water users reported more than 780 MGD in withdrawals during 2020 when excluding power generation.

For both groundwater and surface water withdrawals, there may be some instances of users who may require a permit but have not yet obtained one. DEQ works to identify such users each year as resources allow.

State Water Resources Plan:

The Draft 2020 State Water Resources Plan (State Plan), was released for public comment on June 28, 2021, and the final version is expected in Winter 2021. The 2020 State Plan as a whole builds upon the 2015 State Plan with significant refinement of nearly every aspect of the original including: updated water demand projections, withdrawal/discharge data, improved spatial information, more robust cumulative impact analysis modeling, and three climate change scenarios. As a result of improved data sets and spatial information, each major river basin was able to be further subdivided into smaller watersheds. This provides a more detailed and locally meaningful picture of water resource availability across the Commonwealth. These analyses will provide a wealth of information that can be utilized by localities, water users, and the state for future planning and management decisions.

Water Resoures Priorities and Challenges:

The following section summarizes several of the water resource management priorities, challenges, or other topics of specific interest that are discussed in more detail in Chapter 4. These include updates on new legislative or regulatory actions, programmatic goals and achievements, and other items. As this year's report aligns closely with the release of the Draft 2020 State Plan, many of the items discussed below are also addressed in the 2020 State Plan and informed by the analysis completed during its development.

Climate Change and Resource Planning: The 2020 State Plan includes a series of climate change scenarios that simulate how streamflow may respond to various meteorological conditions based on predictions of the best available global climate models. The results show a range of possibilities that Virginia must prepare for including the potential for more severe droughts. Temperature increases observed over the last 30 years have already led to increased evaporation throughout Virginia and future increases in temperature will further increase evaporation. Although climate change will likely mean increased total precipitation, this additional evaporation means future droughts may be more severe than those experienced in the past. In the context of water resource management, it will become increasingly important that water supply planning

occur at a scale that facilitates a regional evaluation of sources and demand, as well as evaluating regional opportunities for diversifying sources, developing storage, and building interconnections and redundancy where possible among neighboring systems. Additionally, developing a process for incorporating the evaluation of climate change into existing management programs including water withdrawal permitting and water supply plan development and review is increasingly necessary.

Addressing Unpermitted and Unreported Water Use: Evaluating and addressing impacts from water users that are statutorily exempt from the requirement to obtain a withdrawal permit, or otherwise unpermitted, continues to be a challenge in managing both surface water and groundwater. Approximately 75% of surface water and 49% of groundwater is unpermitted or exempt pursuant to current statutes. The 2020 State Plan includes an exempt user surface water withdrawal scenario that evaluates the most conservative, or maximum possible, demand for such users. To summarize the results from this analysis, when evaluated cumulatively, and even in some cases individually, the maximum possible exempt demands are not sustainable in many parts of Virginia during drought conditions regularly experienced today; the potential for worsening droughts in response to climate change will only exacerbate this issue. A fair and equitable process to incorporate the evaluation of potential exempt demands into the VWP permit application review process needs to be developed to avoid over allocation of available surface water resources.

The proportion of groundwater that is unpermitted, while smaller than surface water, is more challenging to estimate and incorporate into water resource management as withdrawals from residential or private domestic wells are not required to report withdrawals as they fall under the reporting threshold. Particularly in the groundwater management areas, continuing to improve estimates of domestic use remains a key goal given the increasing demands on the aquifer system by the growing population of homeowners with individual wells. Additionally, groundwater use outside of declared groundwater management areas does not require a withdrawal permit. Significant groundwater demands occur throughout these areas including within the Shenandoah Valley and Giles County. New investment in regional and local groundwater studies in these fractured rock aquifers is necessary to understand where resources challenges may occur.

Eastern Virginia Groundwater Management Area: One of the long-term water resource management challenges in Virginia is the historic over allocation of groundwater from the Coastal Plain aquifer system in the Eastern Virginia GWMA, particularly from the Potomac Aquifer. A long-term decline in water levels required DEQ to develop new permit limits that resulted in a reduction of 52% in the total permitted withdrawals in the Eastern Virginia GWMA. DEQ expects that with these reductions, as well as the development and implementation of the Hampton Roads Sanitation District's (HRSD) Sustainable Water Initiative for Tomorrow Project (SWIFT), aquifer water levels will improve over the course of the next decade. The 2020 State Plan includes a new groundwater modeling scenario that incorporates the proposed SWIFT injections. The scenario shows promising reductions in the number of critical cells in the Potomac Aquifer, particularly in areas south of the James River, although many unknowns remain regarding the rate and extent that injections will impact water levels in the aquifer system.

Although there is reason for cautious optimism, groundwater levels in confined aquifers can take years to respond to changes in pumping or injections. During this time, continued challenges in issuing both new and existing permits in some parts of the Eastern Virginia GWMA are expected. Potentially impacted localities include those along the fall-line such as King William, Caroline, Henrico, and Prince George counties, and those in and around the existing cone of depression located at International Paper's Franklin Mill, which includes parts of the counties of Sussex, Southampton, and (western) Isle of Wight, as well as the City of Franklin. As water levels stabilize and even recover, there will continue to be a need for localities and water users to develop regional planning relationships that support interconnections and cooperative development of alternatives to groundwater in areas where critical cells continue to be a concern. Continued improvements in implementation of water conservation and leak detection is also necessary, as addressing excessive water use and water loss is one of the major tools for reducing demands on groundwater.

Evaluating Tidal Fresh Surface Water Withdrawals: Groundwater limitations in the Coastal Plain region have led water users to consider alternatives that they previously considered to be cost prohibitive.

Recently, several applications for the construction of tidal fresh surface water withdrawal intakes in the Appomattox and Rappahannock rivers have been received and are under review by DEQ. VWP permits authorizing the construction of intakes in tidal fresh sections of the Pamunkey and Chickahominy rivers have been issued, but the intakes have yet to be constructed. DEQ's non-tidal model was not designed to model water quality changes in a tidal system. Given the growing interest in tidal freshwater withdrawals, developing an in-house model to evaluate water quality impacts from upstream withdrawals would allow evaluations comparable to those completed for non-tidal projects. The Chesapeake Bay tidal model is already in use at DEQ for development of Total Maximum Daily Loads (TMDLs), and may provide an important foundation for accomplishing this task. Additional funding would be required to support this development.

Introduction

The citizens of the Commonwealth are able to enjoy more than 100,000 miles of non-tidal streams and rivers, 248 publicly-owned lakes, about 236,000 acres of tidal and coastal wetlands, about 808,000 acres of freshwater wetlands, 120 miles of Atlantic Ocean coastline, and more than 2,800 square miles of estuaries. In addition to the publicly-owned lakes, there are numerous small, privately-owned lakes and ponds distributed throughout the state. Statewide, rainfall averages are close to 43 inches per year, and the total combined flow of all freshwater streams is estimated at about 22.5 billion gallons per day (BGD).

DEQ coordinates the management of water quantity and supply across the Commonwealth of Virginia through four programs: Water Supply Planning and Analysis, Water Withdrawal Permitting and Compliance, Groundwater Characterization, and Drought Assessment and Response. DEQ's Surface Water Investigations Program also supports water resources management because the collection and evaluation of surface water flow data is critical to the operation of all DEQ water supply programs. Details regarding each program area are provided in Chapter 1.

The Annual Water Resources Report (Annual Report) is submitted in October of each year to the Governor and the Virginia General Assembly in accordance with § 62.1-44.40 of the Code of Virginia. The Annual Report provides an overview of reported (including permitted and unpermitted) water withdrawals and water use trends for the 2020 calendar year and a summary of water resources management activities within the Commonwealth of Virginia. The Annual Report also includes summaries of current climatologic conditions and available hydrologic information for the Commonwealth as a whole for the 2020 water year.[1] The Annual Report also serves as a status report concerning the State Water Resources Plan between five year planning reviews.

Water quality issues are addressed in the most recent biennial Water Quality Assessment Integrated Report, published by DEQ and available on the DEQ website.

Annual Water Resources Report cover photo by Trevor Lawson, 2021.

[1]The USGS uses the term "water year" in reports that deal with surface-water supply, defining it as the 12-month period of October 1, for any given year through September 30, of the following year. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. Thus, the year ending September 30, 2019 is called the"2020 water year."

1 2020 Water Resources Management Updates

The Commonwealth of Virginia has for decades enjoyed a robust economy and an increasing population drawn by the many opportunities available to its residents. However, an increasing population and a growing economy can present challenges for managing water resources. The state's water resources are shared and support a variety of beneficial uses including in-stream uses such as recreation, navigation, habitat for wildlife, and the aesthetic value of rivers and streams, as well as off-stream uses such as supplying drinking water, agricultural, commercial, or industrial facilities. Increasing demands coupled with limited resource availability and competition for water highlight the importance of active management of Virginia's water resources. This means placing a greater emphasis on collaboration with planning partners and permittees to find cost-effective solutions that conserve the Commonwealth's water resources and ensure their ability to support all beneficial uses into the future, particularly during periods of drought.

DEQ's mission is "to protect and enhance Virginia's environment, and promote the health and well-being of the citizens of the Commonwealth." State law determines how this mission is to be fulfilled with respect to water resources. More information on the statutes and regulations related to water resources management can be found on the DEQ website. The following sections briefly discuss the various DEQ programs involved in water resources planning and management (Water Supply Planning and Analysis, Water Withdrawal Permitting and Compliance, Groundwater Characterization, Drought Assessment and Response, and Surface Water Investigations) as well as updates on the work done by each program in 2020.

Chapter 4 of this report, Water Resource Challenges and Priorities, provides an overview of current and future program priorities in water resource management such as regulatory or statutory changes, program initiatives, and other developments. Additionally, this section covers several key resource challenges and updates on how DEQ is working to address those challenges.

1.1 Water Supply Planning and Analysis

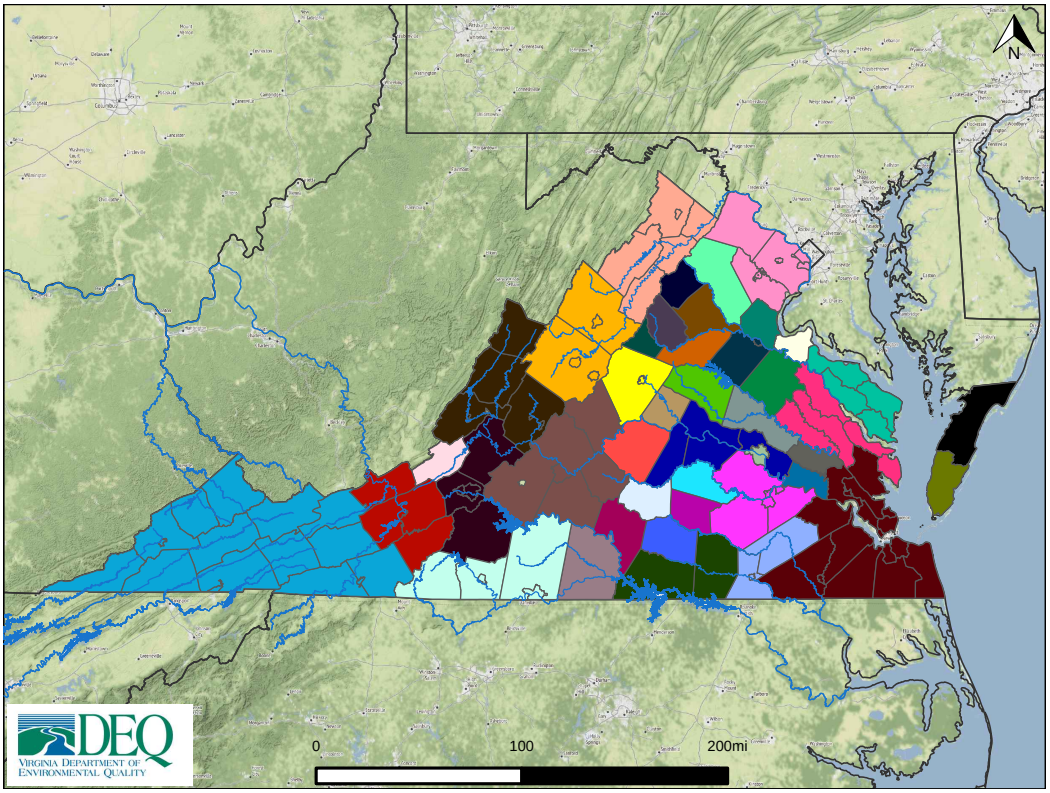
The Local and Regional Water Supply Planning Regulation[2] requires periodic development of local, regional, and state water supply plans describing, among other things, environmental resources, existing and anticipated water sources, and existing and projected water use and demand. Local and regional planning partners submitted their plans to DEQ no later than November 2011, depending upon statutory requirements. Following submission, staff reviewed all 48 plans (see Figure 4 for planning programs) for consistency with the regulations, completing the compliance evaluation process with the issuance of final compliance determinations to all planning partners in late 2013. In 2018, all 323 localities in Virginia reviewed their water supply plans and addressed compliance conditions by the required five year review deadline.

Legislation enacted following the 2020 General Assembly Session (2020 Va. Acts Ch. 1105) requires the State Water Control Board (SWCB) to adopt regulations designating regional planning areas based primarily on river basins, to encourage the development of cross-jurisdictional water supply projects, and to estimate the risk that each locality and region in the Commonwealth will experience water supply shortfalls. This law also directs localities to participate in cross-jurisdictional, coordinated water resource planning, and to develop a single water supply plan for each regional planning area. A Notice of Intended Regulatory Action (NOIRA) was published June 7, 2021 and the comment period ran through July 22, 2021. A Regulatory Advisory Panel (RAP) made up of a variety of stakeholders will be used to develop recommended regulation amendments for SWCB consideration through the collaborative approach of regulatory negotiation and consensus.

This regulatory process will result in the most significant change to the Local and Regional Water Supply Planning Regulation since its promulgation. It will also likely impact the process and requirements for the upcoming 2023 planning cycle during which all water supply plans are currently due to be updated. DEQ will provide additional information on how this action may impact requirements for water supply plans as the regulatory process progresses. More information on the program and the ongoing regulatory process can be found on the DEQ website.

[2] 9VAC25-780.

Figure 4: Water Supply Planning Programs According to 2011 Submittals



- Accomack County + Towns Regional WSP
- Albemarle County, City of Charlottesville, Town of Scottsville Regional Water Supply Plan
- Amelia County Water Supply Plan (LOCAL PLAN)
- Appomattox River Water Authority (ARWA) + Hopewell Regional WSP
- Buckingham County & Town of Dillwyn Regional Plan
- Caroline County & the Town of Bowling Green Regional WSP
- Charles City County (LOCAL PLAN)
- Charlotte County Regional WSP
- Craig County–Town of New Castle Regional WSP
- Culpeper County + Town Regional WSP
- Cumberland, Goochland, Henrico, and Powhatan Counties Water Supply Plans
- Fauquier County Regional Water Supply Plan
- Fluvanna County + Town of Columbia Regional WSP
- Greene County + Stanardsville Regional WSP
- Greensville, Sussex, Emporia Regional Water Supply Plan
- Halifax County and Towns
- Hampton Roads Planning District Commission (HRPDC) Regional WSP
- Hanover County & Town of Ashland Regional
- King George County WSP (LOCAL PLAN)
- Lake Country Regional WSP
- Louisa County and Towns
- Lunenburg County + Towns Regional WSP
- Madison County + Town Regional WSP
- Middle Peninsula Regional Water Supply Plan
- New Kent County WSP (LOCAL)
- New River Valley WSP
- Northampton County + Towns Regional WSP
- Northern Neck Regional WSP
- Northern Shenandoah Regional WSP
- Northern Virginia Regional Water Supply Plan
- Nottoway County and Towns
- Orange County Regional Water Supply Plan
- Prince Edward County and Town of Farmville Water Supply Plan
- Rappahannock County + Town of Washington WSP
- Region 2000 Regional Water Supply Plan
- Richmond, City of (LOCAL PLAN)
- Roanoke Valley Alleghany Regional Commission Regional WSP
- Southwest VA Regional Water Supply Plan
- Spotsylvania County and City of Fredericksburg Regional Water Supply Plan
- Stafford County Water Supply Plan (LOCAL PLAN)
- Upper James River Basin WSP
- Upper Shenandoah Regional WSP
- West Piedmont Planning District Commission Regional Water Supply Plan

1.1.1 Virginia State Water Resources Plan

The water supply plans and other water use reporting and source data collected by DEQ form the basis of the Virginia State Water Resources Plan (State Plan). The first iteration of the State Plan was published in October 2015 and was the first of its kind in Virginia. It includes the results of a cumulative impact analysis (CIA) conducted using data from the plans and water withdrawal data submitted by individual users under the Water Withdrawal Reporting Regulation.[3] The 2015 State Plan also described water supply challenges facing the Commonwealth through 2040 and made general recommendations for addressing those challenges.

DEQ has completed development of the Draft 2020 State Plan. The draft was made available for public comment on June 28, 2021 with comments accepted through August 13, 2021. The draft 2020 State Plan includes updated demand and source information, improved discharge data, and enhanced cumulative impact analysis modeling including new metrics and scenarios, including the first ever climate change CIA scenarios. Analysis was also conducted at a more localized scale.[4] The draft State Plan includes detailed summaries for each of the 20 minor basins on existing sources, demand projections, water use trends, and modeling results.

1.1.2 VAHydro and Data Development and Analysis

Data used in the State Plan such as locality provided demand and source data, annual withdrawal reporting, and withdrawal permit reporting is collected via VAHydro, a web-based, interactive platform, that provides the basis for more efficient data collection and analysis. VAHydro is designed to link modules pertaining to water withdrawal permitting, water supply planning, water withdrawal reporting, groundwater well registration, and drought monitoring/modeling of both surface water and groundwater (Figure 5). The goal for VAHydro is to give DEQ staff, as well as localities, water users, and regional stakeholders, the ability to use up-to-date water use data to inform decision making in every day local and regional water management efforts.

In 2020, DEQ staff completed a multi-year collaboration with the United States Geological Survey (USGS) and the Virginia Tech Department of Biological Systems Engineering. The primary focus of the past several years centered on developing a methodology for characterizing relations between widely available hydrologic and ecological monitoring data. The framework DEQ developed, known as "elfgen", combines data on reported water withdrawals, multiple river and habitat models, and biometric assessment of fish and benthic monitoring data to facilitate a more geo-spatially specific understanding of the relative risk to aquatic life resulting from surface water withdrawals in Virginia. Two professional papers outlining project methods, results, and potential management implications were published in the Journal of the American Water Resources Association (JAWRA).[5] [6]

In 2020, Virginia Tech and DEQ also completed a long-term project to improve estimates of consumptive use in Virginia, as well as to develop a suite of tools to transfer data on water withdrawals, discharges, and consumptive use between the National Pollutant Discharge Elimination System (NPDES), VAHydro, and USGS National Water Information System (NWIS) databases. This project was funded by a USGS WUDR grant and a paper summarizing the results is currently pending publication in the Journal of Water Resources Planning and Management. This research was also integrated into the cumulative impact modeling associated with the draft 2020 State Plan to better account for consumptive use. Evaluating consumptive use is critical for creating an accurate surface water budget and determining water availability in different locations across the Commonwealth.

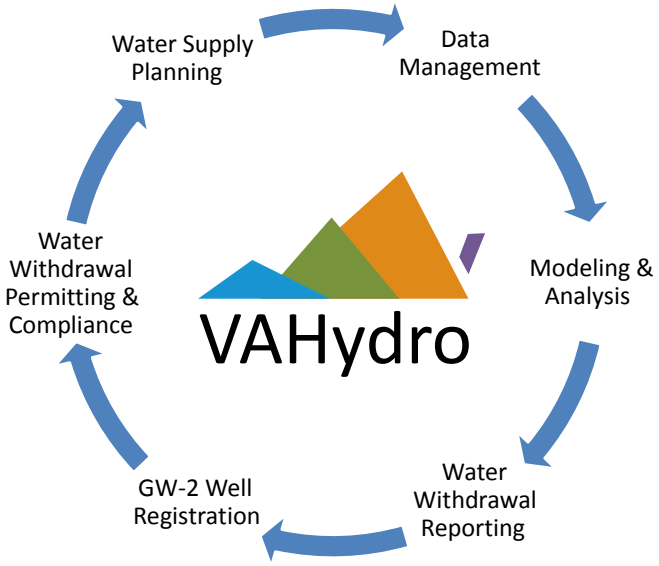
[3] 9VAC25-200.

[4] The nine major river basins within Virginia are further divided into 20 minor basins to provide a higher resolution, more localized scope for analysis. Minor basins are generally delineated around significant tributaries to the major river (for instance, Shenandoah Minor Basin is a tributary to the Potomac-Shenandoah Major Basin), or by physical characteristics of the area geography. For instance, the James River Basin is subdivided by the Upper James, Middle James, and Lower James minor basins, which are located in the Ridge and Valley, Piedmont, and Coastal Plain geographical regions of Virginia respectively.

[5] Kleiner et al. - DOI: https://doi.org/10.1111/1752-1688.12876.

[6] Rapp et al. - DOI: https://doi.org/10.1111/1752-1688.12876.

Figure 5: Modules within VAHydro



A USGS WUDR grant award was also received by DEQ in 2020 based on a proposal to develop better estimates of agricultural water use. This project is also being completed in cooperation with the Virginia Tech Department of Biological Systems Engineering. Primary objectives for this project include the development of a set of coefficients to estimate unreported agricultural water withdrawals at the county level based on irrigation data from USDA and literature crop water requirements, the generation of monthly total irrigation withdrawal timeseries for major agricultural counties in Virginia, and an estimation of a range of total irrigation withdrawals under different meteorological scenarios (e.g. average year conditions, moderate drought conditions, and extreme drought conditions). One of the major challenges localities had when preparing water supply plans was collecting information on water use from agricultural water users, and the majority of the plans have limited estimates for agricultural water use. Agricultural water use is also under reported, although DEQ continues to work to engage with agricultural communities to improve awareness of reporting requirements annually. This project helps address these gaps by improving estimates of water used for irrigation at the county level using USDA Agricultural Census data and DEQ water withdrawal reporting data.

In cooperation with the Virginia Institute of Marine Science (VIMS) working closely with the Virginia Department of Health (VDH), DEQ is overseeing a project titled "Assessing vulnerability of private wells to flooding." This project, funded by 106 Disaster Mitigation supplemental funding, focuses on identifying the growing risk for contamination of drinking water aquifers from rising sea level and increasing coastal storm strength. The primary goals of this project include the development of a digital database of private wells for the study area (Virginia's Northern Neck - Northumberland and Lancaster counties), the establishment of flood probability zones based on tide records and sea level rise projections, the mapping of well locations to assess potential flood risk through the year 2100, and the development of database guidance and analytical protocols for extending analysis to additional localities. This project will result in a geo-referenced database that may be used to identify areas of highest risk, with the ability to interface with the latest models of aquifers and groundwater resources.

1.2 Water Withdrawal Reporting

The Water Withdrawal Reporting Regulation requires the annual reporting of monthly water withdrawals (surface water and groundwater) of volumes greater than an average of 10,000 gallons per day (GPD) during the month, or one million gallons per month for crop irrigation. The regulation allows the submission of metered and estimated water withdrawal information. DEQ offers electronic reporting using the VAHydro data system that allows reporters to enter withdrawal data on a monthly basis, mail in reporting is also accepted. VAHydro stores withdrawal data as far back as 1982 and categorizes water withdrawals by water use types: agriculture, commercial, irrigation, manufacturing & industrial, mining, fossil fuel power, hydropower, nuclear power, and public water supply. The database also categorizes withdrawals by water source (groundwater, surface water, or transfer) and source sub-type (reservoir, spring, stream, or well). Analyses of the reported 2020 data are provided in Chapters 2 and 3, and in more detail in Appendices 1, 2, and 3.

Annual water withdrawal reporting is one of the most important data sources for DEQ. Reporting of water withdrawals allows for informed modeling and planning decisions related to the Commonwealth's future water demands and availability. Reported water withdrawals are linked through VAHydro to the water supply modeling system, which enables staff to prepare up-to-date and accurate water budgets and conduct cumulative impact analyses in support of permit decisions and water supply planning efforts. Withdrawal data is also used by other programs within DEQ, other agencies, and the public. The effectiveness of the Commonwealth's water resource management depends on the comprehensiveness and accuracy of this self-reported withdrawal information.

Each year DEQ works to increase the number and quality of withdrawal reports. A particular focus in the last few years has been agricultural water users. Efforts to improve water withdrawal reporting within agricultural communities continued in 2020. Livestock producers with permits for animal waste management were contacted and registered for reporting if their water withdrawals were estimated to meet or exceed the reporting threshold. Additionally, outreach to industry stakeholders resulted in additional poultry facilities that staff expect to register to report annual water withdrawals beginning in 2021. Outreach to users in other water use categories, including but not limited to data centers, public and private educational institutions, and vineyards will be conducted over the next couple of years as resources allow. Outreach efforts and increased reporting continue to increase DEQ's understanding of water withdrawals across Virginia, improving water supply planning initiatives across the Commonwealth.

1.3 Water Withdrawal Permitting and Compliance

This program administers the permitting and related compliance and reporting activities required by statutes aimed at the management and protection of groundwater and surface water resources. Under the Ground Water Management Act of 1992[7], Virginia manages groundwater through a permit program regulating the withdrawal of groundwater in certain areas designated as Groundwater Management Areas (GWMAs). Currently, there are two GWMAs in the state. The Eastern Virginia GWMA comprises areas east of Interstate 95 and west of the Chesapeake Bay and Atlantic Ocean coast. The Eastern Shore GWMA includes Accomack and Northampton counties. Any person or entity located within a declared GWMA must obtain a groundwater withdrawal permit to withdraw 300,000 gallons or more of groundwater in any one month.

[7] § 62.1-254 et seq. of the Code of Virginia.

Projects involving surface water withdrawals from state waters and related permanent structures are permitted under the Virginia Water Protection (VWP) Permit Program Regulation as provided by Article 2.2 of the State Water Control Law[8]. DEQ issues VWP Individual permits for such impacts through use of the Joint Permit Application (JPA) process.

1.4 Groundwater Withdrawal Permitting

Between 2009-2013, growing concerns over increased water use by new or expanding groundwater withdrawals, overlapping cones of depression[9], and declining water levels in the Coastal Plain aquifer system led the SWCB to expand[10] the Eastern Virginia GWMA to include all of the Coastal Plain east of Interstate 95 in order to ensure comprehensive management of the aquifer system. Modifications to the Groundwater Withdrawal Regulations[11] provided for the issuance of groundwater withdrawal permits to existing users in the expanded areas. Permit applications were received from 122 existing users during 2014 as a result of the Eastern Virginia GWMA expansion. Through evaluation of the applications, it was determined that 15 of the existing user applicants did not require permits.

Since 2015, 102 existing user permits have been issued. Two existing user applications remain pending. Three applicants were determined to need new/expanded permits since the level of use for each exceeds the historic use amounts documented in the application. The total maximum annual groundwater withdrawal volume authorized for the 102 issued existing user permits is approximately 2.41 billion gallons per year (BGY), which equates to an annualized average daily withdrawal rate of 6.60 MGD.

Groundwater withdrawal permit applications for new or expanded withdrawals in a GWMA are evaluated to determine impacts of the proposed permit on the groundwater resource. The evaluation determines the area of impact, the potential for a proposed withdrawal to cause salt water intrusion, and assesses the impact of the combined drawdown from all existing lawful withdrawals. Existing lawful withdrawals include those permits issued under historic use conditions and current new or expanded use permits, as well as users that withdraw less than 300,000 gallons per month.

DEQ, as of September 1, 2021, administers a total of 367 groundwater withdrawal permits, including those issued to existing users. These users are authorized to withdraw a combined total of approximately 41.5 BGY, which equates to an annual average withdrawal rate of 113.9 MGD. Since the beginning of 2020, a total of 23 groundwater withdrawal permits have been issued. Of these, ten were reissuances of previously permitted facilities within the boundaries of the original Eastern Virginia GWMA. Figure 6 provides a spatial overview of groundwater withdrawal permitting activities in Virginia. A complete list of all active groundwater permits is available upon request.

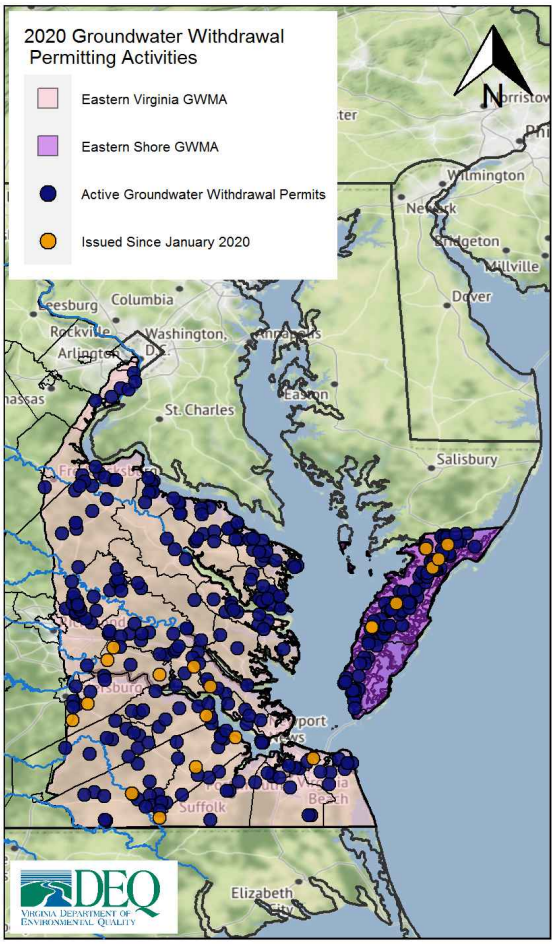
[8] §§ 62.1-44.15:20 through 62.1-44.15:23.1 of the Code of Virginia.

[9] "Cone of depression" means a localized reduction, or depression, of groundwater levels in an aquifer typically associated with increased rates of pumping. Groundwater levels are lowest at the point of withdrawal, creating a concentric cone around the pumping center. The reduction may sometimes lead to issues of land subsidence due to compaction of sediments as a result of reduced groundwater in pore spaces.

[10] 9VAC25-600-20.

[11] 9VAC25-610.

Figure 6: 2020 Groundwater Withdrawal Permitting Activities



1.5 Surface Water Withdrawal Permitting

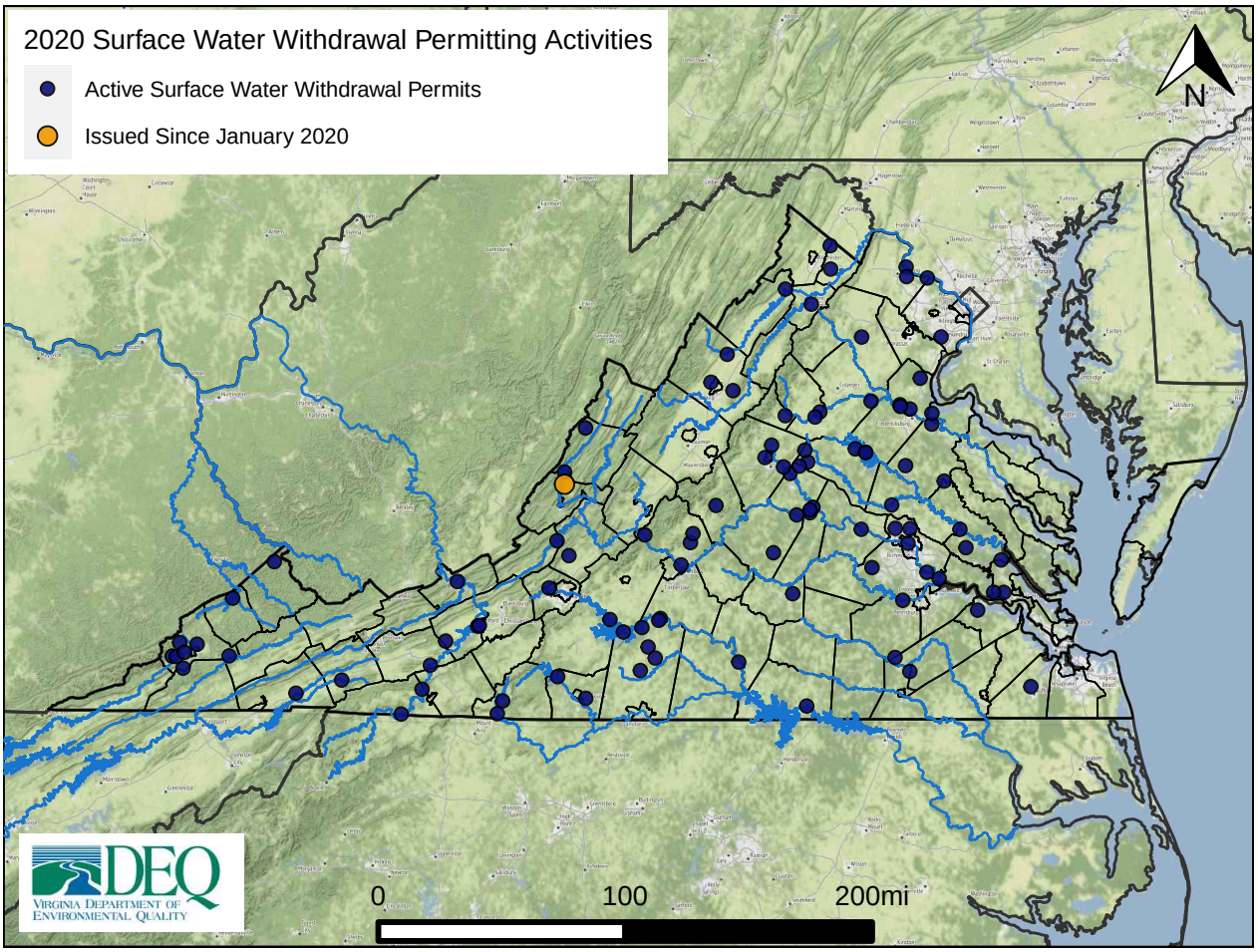
Application for a surface water withdrawal permit is made through the submittal of a JPA to DEQ, the Virginia Marine Resources Commission (VMRC), and the U.S. Army Corps of Engineers (USACE). DEQ's evaluation of surface water withdrawal permit applications includes an in-depth analysis of the applicant's water demand and a cumulative impact analysis of the project to determine potential impacts on existing in-stream and off-stream beneficial uses. To conduct these analyses, DEQ uses an operational hydrologic model to determine the cumulative impacts to aquatic life, water quality, recreation, and down stream water availability for existing intakes.

Each new or re-issuance permit application is modeled to evaluate any potential impact to beneficial uses downstream of the withdrawal site. Staff uses the output of this analysis to inform the permit determination and to develop appropriate limits on withdrawal volumes and minimum in-stream flow conditions if a permit is issued. Figure 7 illustrates VWP surface water withdrawal permitting activities, including permits issued since January 2020. Currently, DEQ administers 100 VWP permits for surface water withdrawals. These permits are authorized to withdraw a combined total of 413 MGD.

Over the next five years, a significant undertaking for the Water Withdrawal Permitting program will be to process VWP permit applications for a large number of hydroelectric power facilities that are or will be applying for Federal Energy Regulatory Commission (FERC) relicensure as their 30 year licenses expire. Any applicant for a federal license or permit to conduct an activity which may result in a discharge to navigable waters must apply for a Section 401 Certification. A Section 401 Certification is a statement from the state that there is reasonable assurance that the facility will comply with the Clean Water Act and any state established water quality standards. The DEQ VWP Permit Program serves as the Commonwealth's issuing authority for Section 401 Certifications for FERC licenses as established by the VWP Regulation.[12] Ten of the twenty two regulated hydroelectric facilities in Virginia are currently undergoing or will be initiating the relicensing process with FERC and DEQ within the next five years, resulting in an increase in VWP permit applications overall. The VWP permitting process for these facilities will incorporate current scientific framework and regulatory requirements, which are more robust than those in place during the original Section 401 Certification issuance processes. Previous certifications generally required only a minimum release from the facility downstream. Once issued, current VWP permits provide enhanced data collection, instream flow management during droughts or low flow events, and better protections for instream beneficial uses, especially in regions where multiple hydroelectric facilities are located on the same river.

[12] 9VAC25-210-340.

Figure 7: 2020 Surface Water Withdrawal Permitting Activities



1.6 Groundwater Characterization

The Ambient Groundwater Quality Program was established to characterize the quality of groundwater throughout the Commonwealth of Virginia. In 2013, the Groundwater Characterization Program (GWCP) added a minimal capacity to collect groundwater quality data which has improved the ability of the program to execute its mission. DEQ resources allow for the collection and analysis of no more than 40 groundwater samples statewide each year. As described in the Ambient Groundwater Quality Monitoring Strategy (available upon request), the program establishes a groundwater quality baseline across the state, identifies areas of potential groundwater quality concern, and monitors the changes in groundwater quality over time as resources allow. In 2020, the Ambient Groundwater Quality Program continued to focus on the collection of groundwater samples from wells in the trend well network. Trend wells were selected for sampling on a quarterly basis to monitor both for saltwater "up coning," the transient upwelling of salty groundwater that can occur in response to the local removal of non-saline groundwater by supply wells, and the more regional phenomena known as salt water intrusion in the Coastal Plain Aquifer System.

Groundwater resource investigations were conducted in the Piedmont, Blue Ridge, and Valley and Ridge to better understand the complexities associated with the flow and storage of groundwater in fractured rock aquifers. During the 2020 calendar year, particular emphasis was placed on the evaluation of borehole geophysical and aquifer test data in the vicinity of Marshall, Virginia in Northern Fauquier County. Results from this analysis indicated that fractures associated with ductile shear deformation can act as zones that

preferentially concentrate and access groundwater stored in a variably fractured and relatively undeformed crystalline rock "matrix", and support earlier observations previously made by hydrogeologists working in the southern Blue Ridge. Because this style of shear deformation occurs throughout the Blue Ridge and Piedmont, it is theorized that this conceptual understanding of aquifer storage may be applicable in multiple areas of the State. Results from the study are currently in final editorial review and are anticipated for publication in Hydrogeology Journal in late summer or fall of 2021.

Additional borehole geophysical data collection efforts focused on the potential of mafic intrusive rocks as preferential drilling targets in otherwise poorly fractured formations, and on the characterization of hydrogeologic conditions in the actively developing area of the Central Virginia Piedmont in the vicinity of Lake Anna. A deep borehole investigation was also conducted near Augusta Springs to better define the stratigraphy in this structurally complex area. Data acquired from borehole logging is used to describe local hydrogeologic conditions in the vicinity of the wellbore and can also be used in aggregate with other log data to describe aquifer systems in a more regional scope.

In 2020, staff expanded the Real-Time State Observation Well Network to include the addition of four groundwater research stations. A multi aquifer groundwater research station was constructed near the West Point paper mill to monitor the vertical distribution of hydraulic pressures within the Coastal Plan aquifer system. This station was the last phase of a multi-year effort to improve the temporal and spatial resolution of water level data in the vicinity of the paper mill - a major groundwater withdrawal center that has regional effects on the groundwater gradients in the Coastal Plain. An additional multi-aquifer groundwater level observation station was completed at the Western Branch water treatment plant in the City of Chesapeake to monitor groundwater pressures associated with the injection of treated water into the Potomac Aquifer. Two additional observation wells were completed in the Piney Point Aquifer in New Kent and Gloucester counties. The Piney Point Aquifer is an important and regional source of potable water in the Middle Peninsula and Northern Neck.

GWCP staff continued to play an active advisory role in the Mountain Valley Pipeline project. Staff conducted multiple closure plan reviews for portions of the Atlantic Coast Pipeline and continued to serve as a point of contact for individuals and municipalities with groundwater related questions and concerns associated with construction of the Mountain Valley Pipeline.

DEQ staff provided technical support to multiple groundwater withdrawal permit applicants in the Eastern Virginia and Eastern Shore Groundwater Management Areas through borehole geophysical log interpretation, description of well cuttings, and logging. Insight gained through borehole and cuttings analysis helps to ensure well screen placement in accordance with groundwater withdrawal permit conditions and optimizes screen placement within the permitted section of the aquifer.

A monitoring well assessment and maintenance initiative has been started by DEQ to evaluate the integrity of existing groundwater monitoring wells to ensure that measured groundwater levels are representative of hydraulic conditions in the aquifer. This is a critical need as more than 50% of the 270 monitoring wells in the network exceed 30 years of age and are in need of repair, maintenance, or replacement/abandonment. Figure 8 displays all the monitoring wells currently in operation in Virginia. Over time, monitoring wells can lose connection to the aquifer through siltation, development of mineral encrustation, or growth of bacterial mats. A prioritized quarterly implementation schedule has been developed to help guide well evaluation efforts as resources allow. In 2020, multiple groundwater monitoring wells were evaluated in the Middle Peninsula.

A recent initiative has begun to improve the accuracy of reported water level elevations in observation wells that are maintained in the statewide USGS/DEQ observation well network. Datums of all monitoring points will be shifted from NGVD 29 to NGVD 88 and will be leveled to an accuracy of 0.05 m in order to maintain consistency throughout the network. The elevations of many wells within the network were estimated from topographic maps and may be off by several feet from the true elevation. This stringent leveling process occurs as new wells are constructed and old wells are evaluated for structural integrity. Optimizing the

vertical precision of groundwater elevations in the Coastal Plain is becoming increasingly important for evaluating the relation between groundwater levels and sea level rise.

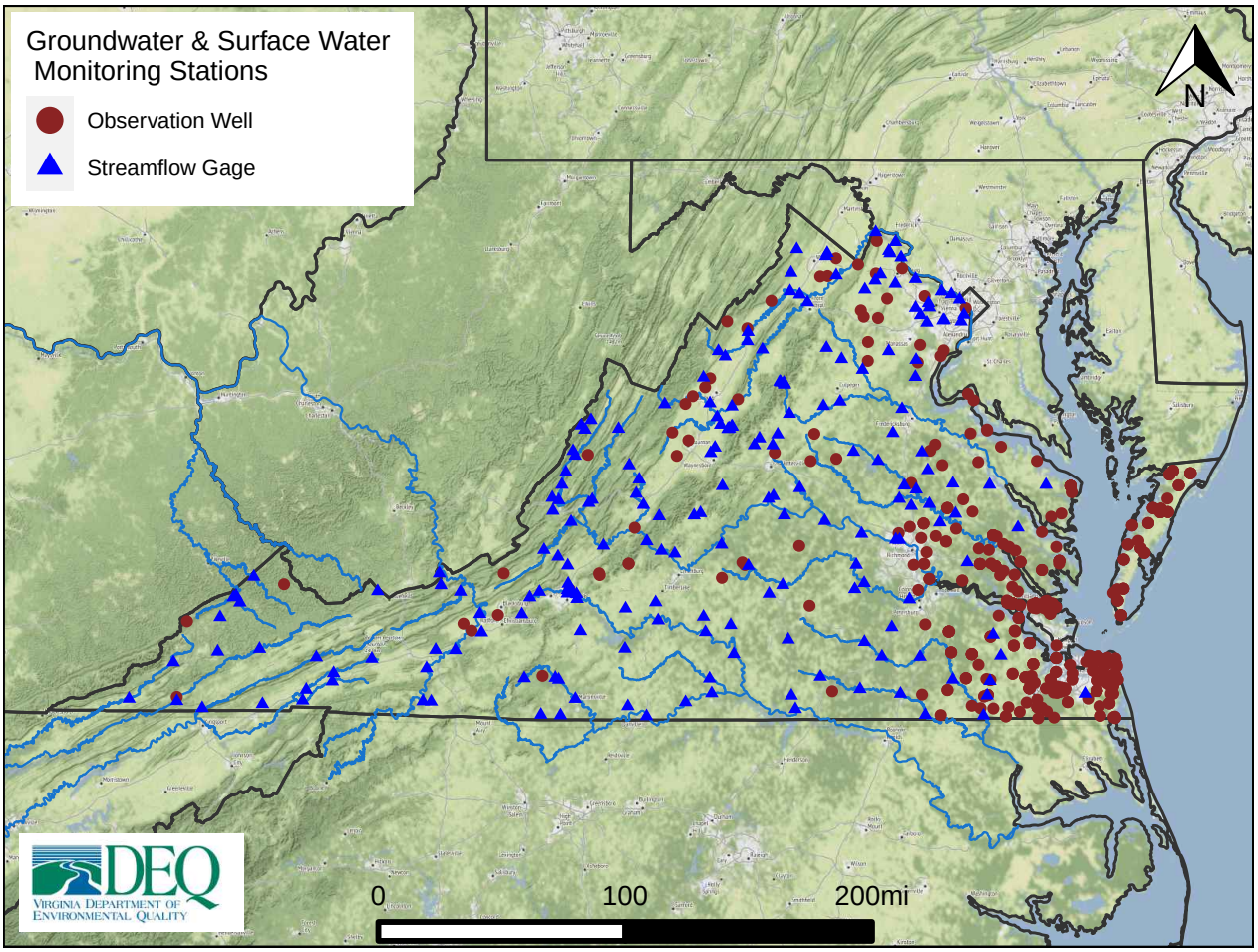
DEQ geologists continue to provide technical assistance to citizens, academic, and governmental entities throughout the Commonwealth. In addition to the provision of routine technical assistance, DEQ staff developed virtual groundwater courses as part of an educational outreach program facilitated by the Virginia Water Well Association, and as part of the Virginia Water Treatment Plant Short Course curriculum - an annual training event for water works operators that is sponsored and organized by Virginia Tech and the Virginia Department of Health.

1.7 Surface Water Investigations

DEQ's Surface Water Investigations Program (SWIP) and the USGS National Streamflow Information Program are the primary entities responsible for collecting surface hydrologic data in Virginia. Their collaboration provides a comprehensive picture of real-time and historical hydrologic conditions in the Commonwealth. The SWIP mission is the systematic collection of reliable hydrologic data concerning the quantity of surface water in the Commonwealth, using the same standards and procedures as the USGS. Virginia is currently the only state partnering with the USGS on the collection of real-time streamflow data where state-collected data are incorporated directly into the USGS database. Data accuracy, attained through use of state-of-the-art equipment and personnel training in USGS methods, is the key to maintaining this unique partnership.
SWIP field personnel added a new surface water monitoring station in 2019 and collected and processed data from the network of 69 surface water discharge monitoring stations on a six to eight week schedule, or more frequently in times of drought or flood. Monitoring often occurs in extreme conditions such as low and high water, and involves the servicing of sensitive equipment, maintaining permanent gauging stations, and measuring streamflow ("discharge"). The data obtained from each surface water discharge monitoring station is continually measured and uploaded into the USGS National Water Information System (NWIS) database where it is accessible by citizens, localities, and state and federal agencies for water supply planning, emergency management response planning, water withdrawal permitting, and natural resource management purposes. Development of and access to this data is essential for the successful planning and management of the Commonwealth's water resources.

Figure 8 provides a spatial overview of active surface water and groundwater monitoring stations in Virginia.

Figure 8: Groundwater and Surface Water Monitoring Stations



1.8 Drought Assessment and Response

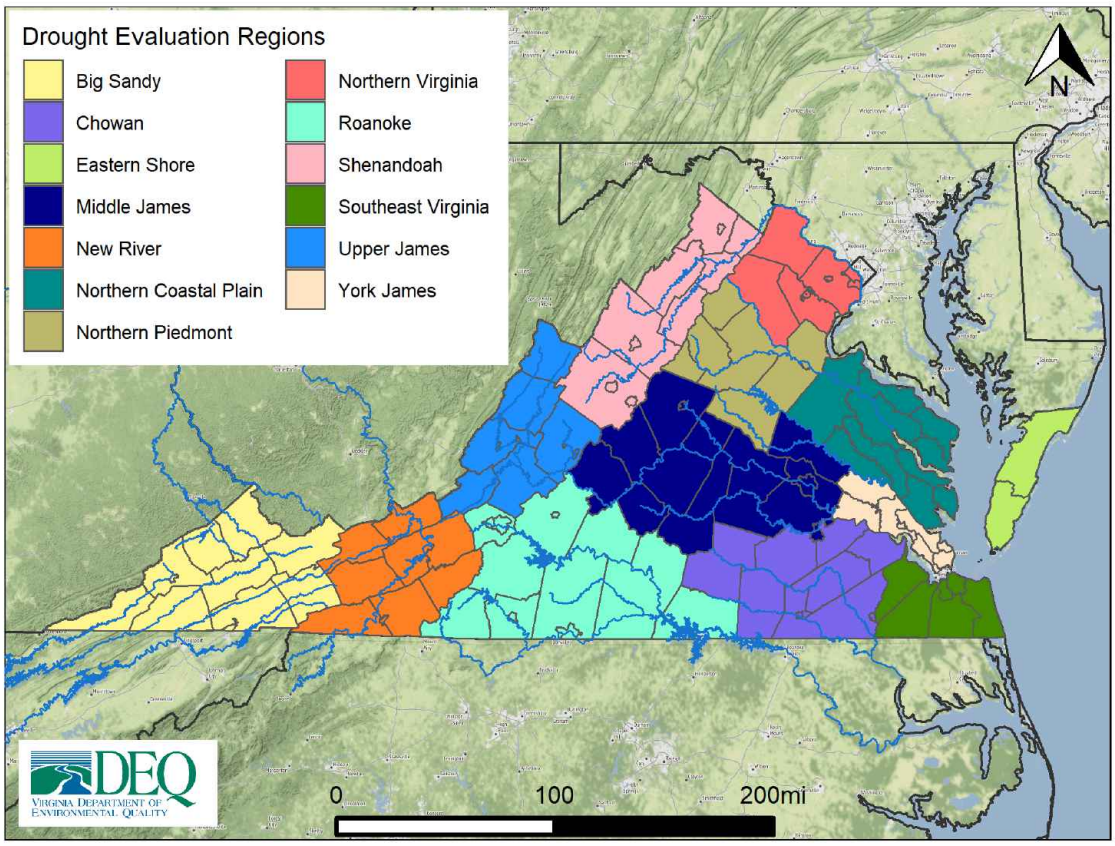
Since the adoption of the Virginia Drought Assessment and Response Plan in 2003, drought watch declarations have been issued for various regions nearly every year, but drought warning declarations have occurred less frequently. A Drought Emergency declaration has not been issued since the 2002 drought.

Normal to above-normal precipitation conditions prevailed throughout most of 2020 in Virginia. Moderate drought conditions existed only during July and early August within parts of the Eastern Shore, Northern Piedmont, and Northern Virginia drought evaluation regions. During 2021, dry conditions returned during the spring, with an exceptionally dry May across much of Virginia. The northwestern half of the Commonwealth was abnormally dry throughout July and much of August. The U.S. Drought Monitor map showed abnormally dry to moderate drought conditions within these areas during June through August. Consequently, stream flow and groundwater level records often indicated lower than normal values during these periods.

As of September 30, 2021, precipitation for the water year beginning October 1, 2020 was near-normal to above-normal throughout Virginia, except for parts of Augusta, Highland and Rockingham counties. Stream flows at most gauging stations and groundwater levels in nearly all Climate Response Network observation wells were within normal levels. Major water supply storage reservoirs maintained water levels within

normal ranges. DEQ provides a drought indicator map that is updated daily and can be viewed online at Current Drought Conditions in Virginia.

Figure 9: Drought Evaluation Regions



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2 Summary of 2020 Water Withdrawals

A total of 1,225 facilities reported water withdrawals for the calendar year 2020. The total number of reporting facilities aligns to previous years' reports. Annual variation in the number of facilities reporting does not greatly affect the volume of water use reported, only the total number of facilities cited in this report annually. It should be noted however that the number of reporting facilities may also vary year to year as facilities cease operation, or in some cases fail to report despite outreach by DEQ. Reported withdrawals were approximately 5.68 BGD for all groundwater and surface water use categories, including the cooling water withdrawals at nuclear and fossil fuel power generation facilities. Excluding power generation, reported 2020 withdrawals totaled over 1.18 BGD.[13] Power generation facilities are the largest withdrawals in Virginia. However, most power generation facilities return the vast majority of their demand to the source; in other words it is not consumed. The following chapters will generally reference water demands excluding power generation in order to more clearly show trends in all other water use categories. Compared to the five-year reported average (2016-2020), total reported 2020 withdrawals from all water use categories decreased by approximately 4.0% when excluding power generation withdrawals.

VAHydro characterizes four water withdrawal source types: streams (including rivers), reservoirs, springs, and wells. Withdrawals from the first three of these sources are considered "surface water withdrawals." Springs discharge groundwater to surface water bodies and would naturally form the headwaters of watercourses as defined by the State Water Control Law and are therefore categorized as surface water, rather than as groundwater. Groundwater withdrawals are typically derived from wells; however, there are a small number of withdrawals from dug farm ponds and quarries that intersect the groundwater table, and which are otherwise unconnected to a watercourse, that are also categorized as groundwater in VAHydro.

Water withdrawals reported to VAHydro are categorized by how, or for what purpose, the water withdrawal is used. Use categories include: Agriculture, Commercial, Fossil Power, Hydropower, Irrigation, Manufacturing, Mining, Nuclear Power, and Public Water Supply. For example, the "Agriculture" category includes water withdrawn for raising livestock, fish farming/hatcheries and general farm use, but is not inclusive of water used for crop irrigation. The "Commercial" category includes water used by golf courses, local and federal installations, hotels, resorts, and correctional centers, among others. The "Irrigation" category includes water used to promote crop growth, including but not limited to tobacco, corn, soybeans, turf grass, and ornamental nursery products. The "Mining" category includes water withdrawn for the excavation, processing, and removal of bulk products such as coal, rock, sand, and gravel. The "Manufacturing" category includes industrial facilities that generally produce goods such as paper mills, food processors, pharmaceutical companies, furniture manufacturing, and concrete plants, among others. "Public Water Supply" includes water withdrawn and treated to produce water for drinking water, and other domestic and residential uses. This category includes both large municipal, or locality owned and operated systems, as well as smaller non-municipal, privately owned water systems. Public Water Supply also includes water that is processed and sold by water suppliers to commercial or institutional facilities that are not self-supplied.

Water withdrawn in the Commonwealth may be used by the withdrawing entity or locality, or it may be "transferred" to another entity or locality. Ideally, the total amount of water reported as released from the transferring facility should equal the total reported as deliveries by the receiving facility. However, in reality, the amounts of reported deliveries are generally significantly less than the amount reported as released. This discrepancy is most likely due to incomplete reporting of deliveries from facilities that purchase water. In order to avoid double counting, this report will generally refer to "water use" as synonymous with "water withdrawn," and any reporting or illustration of water transfers will be clearly marked as "water transferred" or "water purchased." A more detailed explanation of how water transfers are addressed in VAHydro is provided in Appendix 5. Discussion of 2020 reported water withdrawals by source type, distribution across the state, and water use category occurs on subsequent pages of Chapter 2 and 3 with additional detail provided in the appendices as follows:

[13] Withdrawal volumes reported to VAHydro are "gross," rather than "net," and as such do not reflect the amount of water that was ultimately returned to the source water body. Water diverted for hydropower generation is primarily non-consumptive use. Hydroelectric flows are exempted from the reporting requirement and are generally not reported to VAHydro. A significant portion of water diverted for uses in Virginia related to fossil fuel and nuclear power generation is also non-consumptive. For these reasons, the summary of total statewide water withdrawals does not include water withdrawn for power generation.

Appendix 1 provides detailed withdrawal information by major water use category, including fossil fuel and nuclear power generation. Appendix 2 provides a list of the top 20 non-power generating water withdrawals ranked by the amount of their 2020 reported withdrawals. Appendix 3 provides reported water use by locality.

DEQ staff continuously strive to improve the accuracy of reported withdrawal amounts and classification of data within VAHydro through a proactive data quality assurance/quality control process. Improvements in previously published data sets routinely occur due to identification and correction of reporting unit conversion errors, incorrect use classifications, removal of duplicate facilities, and measuring points among other issues. Additionally, facilities occasionally provide updated withdrawal reporting for prior years when errors are identified. As such, minor changes may be noted when comparing current data to prior publications of this Report.

2.1 Water Withdrawals by Source Type

In 2020, water withdrawals for non-power generation totaled approximately 1.18 BGD with surface water sources (streams, reservoirs, and springs) the predominant source type. The total reported non-power generation withdrawals decreased by approximately 4.0% when compared to the five-year average of 1.23 BGD. Surface water withdrawals accounted for approximately 88% of total withdrawals in 2020 with 1.04 BGD reported, when excluding power generation. Pumping of groundwater accounted for the remaining 12%, at 140 MGD. Reported groundwater withdrawals increased by approximately 1.9% compared to the five-year average, whereas reported surface water withdrawals decreased by 4.8%, when compared to the five-year average. The reduction in surface water is largely due to decreases in municipal or public water supply demands. More information on the breakdown between source types as it applies to each category of use can be found in Appendix 1.

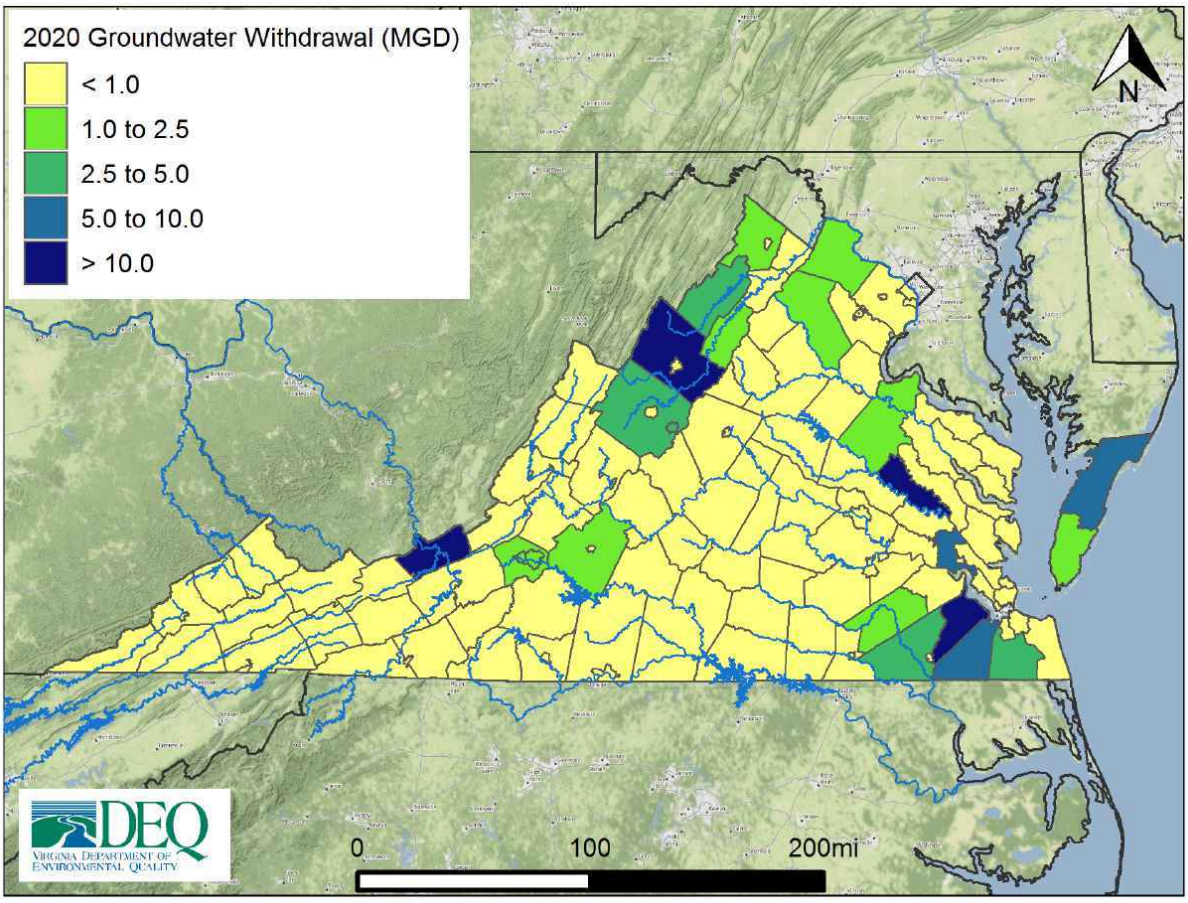
2.2 Water Withdrawals by Location

Surface and groundwater withdrawal amounts are variable and driven by numerous factors including but not limited to: supply availability from groundwater and surface water sources, presence of large users, population, etc. Groundwater withdrawals by locality are shown in Figure 10. The largest reported total groundwater withdrawals were located within Giles, King William, Isle of Wight, and Rockingham counties.

Giles County reported the highest withdrawal of groundwater in 2020 with 24.1 MGD. Celanese Acetate, a major manufacturing facility, and the Kimballton Mine operations were the primary users of groundwater in the county, reporting over 90% of total groundwater withdrawals in the county. The Giles County Public Service Authority reported the remaining total groundwater withdrawals. Giles County is one of the few localities that relies primarily on groundwater to supply major users and public water supply west of the Coastal Plain. Located in the fractured rock portion of the state, groundwater availability is generally less consistent but can be highly productive along fractures. As these withdrawals are not located in a GWMA, they are not required to obtain a groundwater withdrawal permit.

Users in King William County reported the second largest groundwater withdrawal amounts in 2020, with 16.8 MGD. WestRock's West Point paper manufacturing facility withdrew 96% of the countywide groundwater reported in 2020, approximately 16.1 MGD. The WestRock West Point system is currently permitted by DEQ and remained within permitted withdrawal limits as set by its Groundwater Withdrawal Permit.

Figure 10: 2020 Groundwater Withdrawals by Locality



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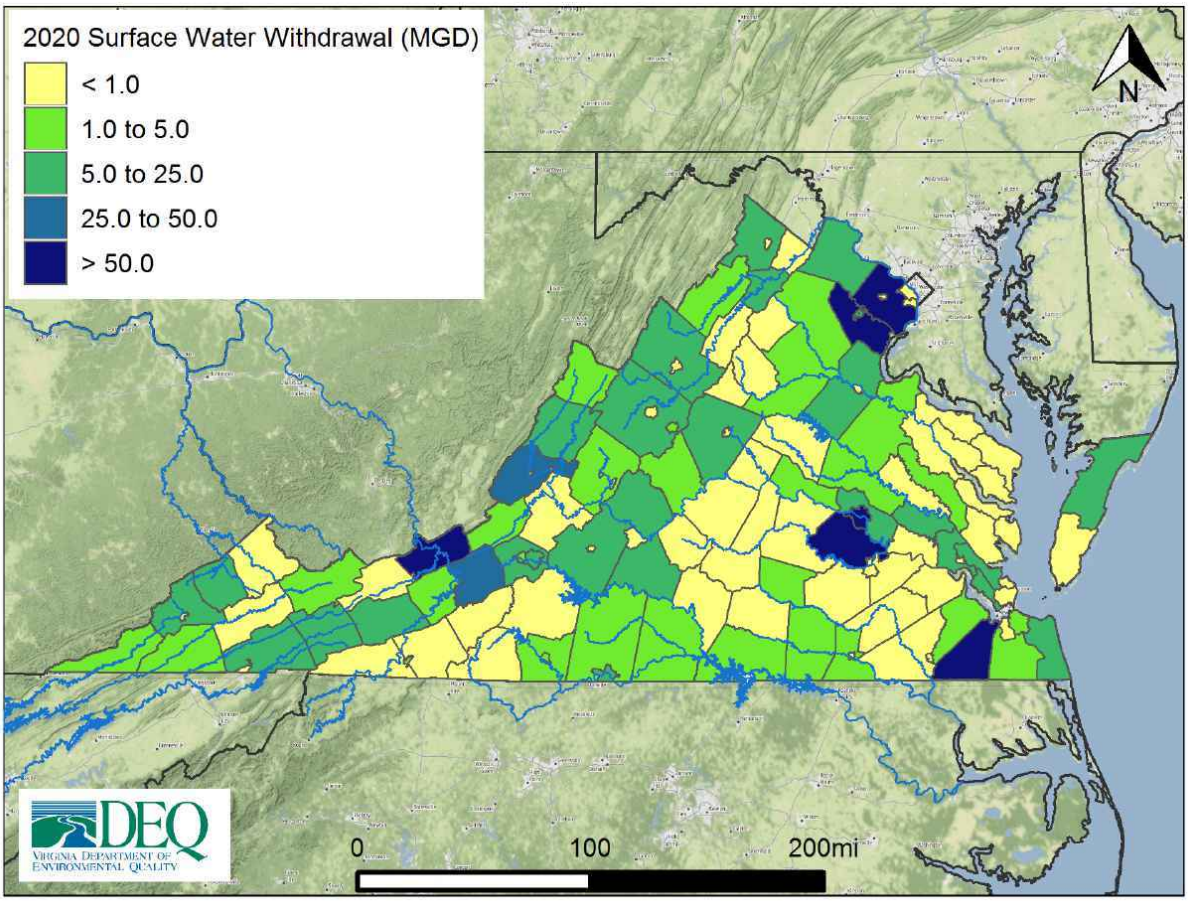
Users within Isle of Wight County reported approximately 15.9 MGD in groundwater withdrawals in 2020. The International Paper Company Franklin Mill was the primary user of groundwater in the county with

13.3 MGD reported in 2020. Additional withdrawals from Smithfield farms and small public water suppliers in the county also reported groundwater use contributing to the countywide total. All facilities remained within their withdrawal limits as set by their Groundwater Withdrawal Permits.

In the Shenandoah Valley, reported groundwater withdrawals from Rockingham County totaled approximately 14.8 MGD. Merck and Company, a manufacturing facility, reported the largest single groundwater withdrawal within Rockingham County, approximately 5.7 MGD in 2020. Additionally, Rockingham County's Three Springs Service area that supplies municipal water reported its greatest withdrawal of groundwater since it began reporting in 1982 with 2.8 MGD. Additional towns within the county, including Dayton, Grottoes, and Timberville, all reported groundwater withdrawals similar to their five year average for public water supplies in 2020. As these withdrawals are not located in a GWMA, they are not required to obtain a groundwater withdrawal permit.

Surface water withdrawals were distributed widely across the state and were greatest around cities and counties with dense population centers and significant manufacturing water uses (Figure 11). In addition to public water supply and manufacturing uses, agriculture and irrigation are significant contributions to surface water withdrawals and are commonly located in more rural counties. Over 63% or approximately 665 MGD of surface water withdrawals are located within ten localities, withdrawal by locality is provided in Table 21. Additionally, withdrawals for public water supply represent 64.5% of the total surface water withdrawals in the Commonwealth.

Figure 11: 2020 Surface Water Withdrawals by Locality



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The largest reported surface water withdrawals occurred within the City of Hopewell, Fairfax County, and Chesterfield County. The City of Hopewell reported the largest surface water withdrawal volume for any locality in 2020, with 131.2 MGD. Three major facilities located within Hopewell contributed to the total withdrawal amount. AdvanSix Resins, a major manufacturing facility, was the single largest reported surface water withdrawal in the Commonwealth with 99.1 MGD or approximately 9% of the total surface water withdrawals reported in the Commonwealth. Virginia American Water, a major public water supply for the region reported 21.4 MGD in 2020, slightly less than its reported five-year average, which can be found in Table 20. Finally the WestRock Hopewell plant reported 10.6 MGD in surface water withdrawals in 2020, which is the lowest reported withdrawal on record for this facility.

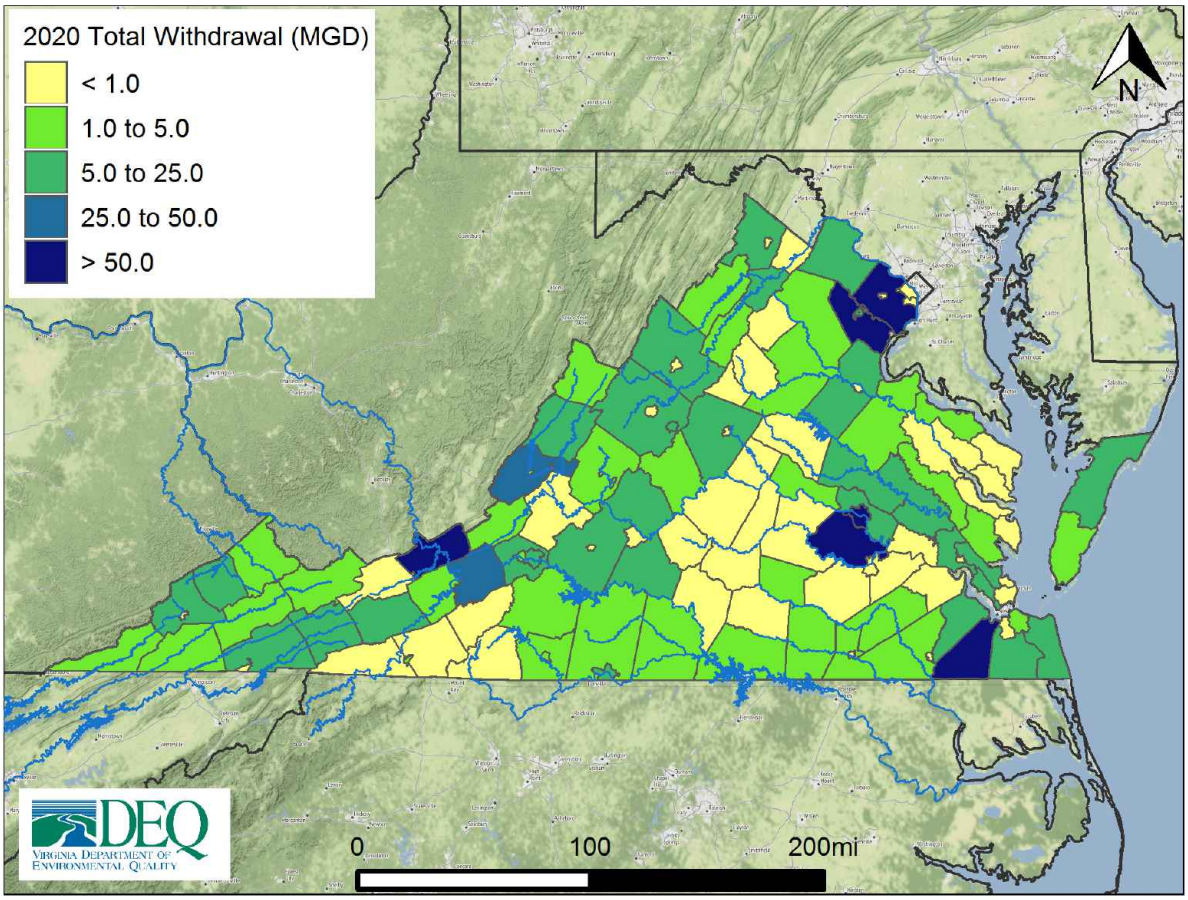
Fairfax County was the second highest reporting locality in 2020 with 89.8 MGD in surface water withdrawals. Fairfax County is primarily urban/suburban and relies on several surface water sources to meet public water supply demands. The largest withdrawal was reported by Fairfax Water's Potomac River intake with 89.3 MGD reported in 2020. Fairfax Water serves as the primary water supplier in the region. Additional withdrawals from other users were reported for golf course irrigation and manufacturing/industrial uses.

Similar to Fairfax County, Chesterfield County reported 85.1 MGD in surface water withdrawals in 2020. Public water supply and major manufacturing facilities were the primary withdrawal use types in the county. Public water supplies within Chesterfield include the Appomattox River Water Authority, which withdraws surface water from the Chesdin Reservoir. In 2020, 35.2 MGD was withdrawn from the reservoir to meet public water supply demands. Major manufacturing/industrial facilities are the other primary user of surface water in Chesterfield County. The Dupont Spruance Plant reported the lowest surface water withdrawal since the early 1990s with 23.0 MGD. Similarly the AdvanSix Plant reported the lowest withdrawal since 2015 with 16.0 MGD, both users withdraw from the James River. Chesterfield County's location adjacent to the City of Richmond and large surface water sources results in large demands for public water supply and several large industrial users within the county.

The variable spatial distributions of 2020 total withdrawals, as depicted in (Figure 12), suggest that withdrawals vary considerably between Virginia's individual localities, with the largest withdrawals occurring within or adjacent to major population centers or regions with large manufacturing facilities.

The localities with the largest reported withdrawals for groundwater and surface water sources also reported the largest total water withdrawals in 2020. The top three highest total withdrawal amounts reported were in the City of Hopewell, Fairfax County, and the City of Suffolk. Large facilities or singular withdrawals, such as for public water supply or manufacturing operations, were the primary contributors to largest reported withdrawals in these localities. The City of Suffolk reported 88.4 MGD in total demands, with greater groundwater demands than Chesterfield County that results in greater total demands. The reported water withdrawal amounts for each locality in the Commonwealth can be found in Appendix 3.

Figure 12: 2020 Total Water Withdrawals By Locality



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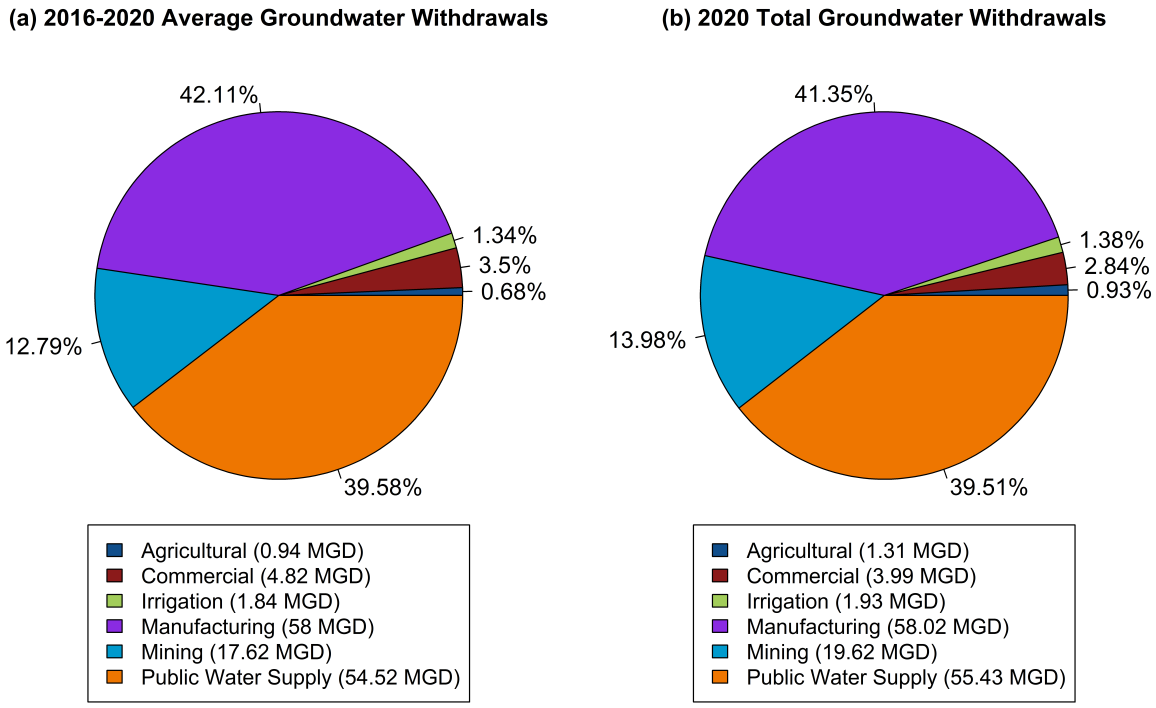
2.3 Water Withdrawals by Water Use Category

Water withdrawals can fluctuate from year to year due to weather variability, economic conditions, permitting actions, or other factors; therefore, average water withdrawals from 2016-2020 are provided by source type for each category for comparison, excluding Power Generation (Nuclear Power and Fossil Fuel Power) in Figures 13 and 14. Power related withdrawals are not included in these figures as they are generally non-consumptive. Average water withdrawals during this five-year period were calculated using the same source type categories (surface water and groundwater) as the 2020 withdrawal totals. This allows for direct comparisons between 2020 withdrawal totals and the 2016-2020 averages of total withdrawals.

Groundwater withdrawals increased in 2020 compared to the five year average across all categories except commercial, which decreased 17.2%, and manufacturing, which equalled the five year average. This is consistent with current trends in total groundwater withdrawals which increased consistently over the past five years. Agricultural withdrawals reported the largest increase compared to the five year average with a 39.4% increase, which is largely linked to both DEQ's outreach and permitting efforts to ensure that poultry facilities on the Eastern Shore are reporting their groundwater withdrawals and an increase in poultry facilities on the Eastern Shore.

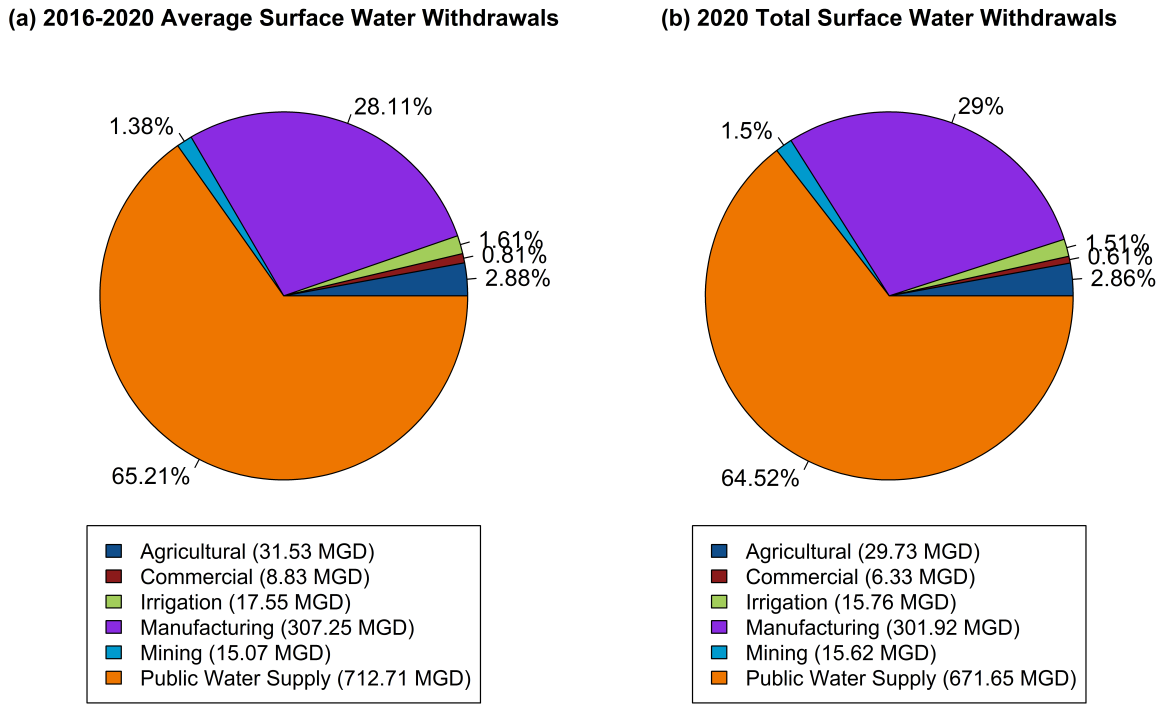
Figure 13: Groundwater Withdrawals, 2016-2020 Average and 2020 Total



Public Water Supply and Manufacturing were the largest water withdrawal categories in 2020, which is consistent with the average of the previous five-year period. Manufacturing makes up the highest proportion of groundwater withdrawals (41.35%), whereas Public Water Supply accounts for the greatest proportion of surface water withdrawals (64.5%) (Figure 14). Withdrawals for Agriculture, Irrigation, Mining, and Commercial uses made up lesser, but still significant, portions of the totals. Note that all use categories remain predominately reliant upon surface water withdrawals, with the exception of mining operations, which withdrew more groundwater than surface water in 2020. Most groundwater withdrawals associated with mining are associated with dewatering of rock quarries or sand/gravel mines.

The total amount of reported water withdrawals in 2020 decreased by 4% compared to the five-year average as seen in Table 2 and shown by use category in Figure 15. The reported decrease in total water withdrawals

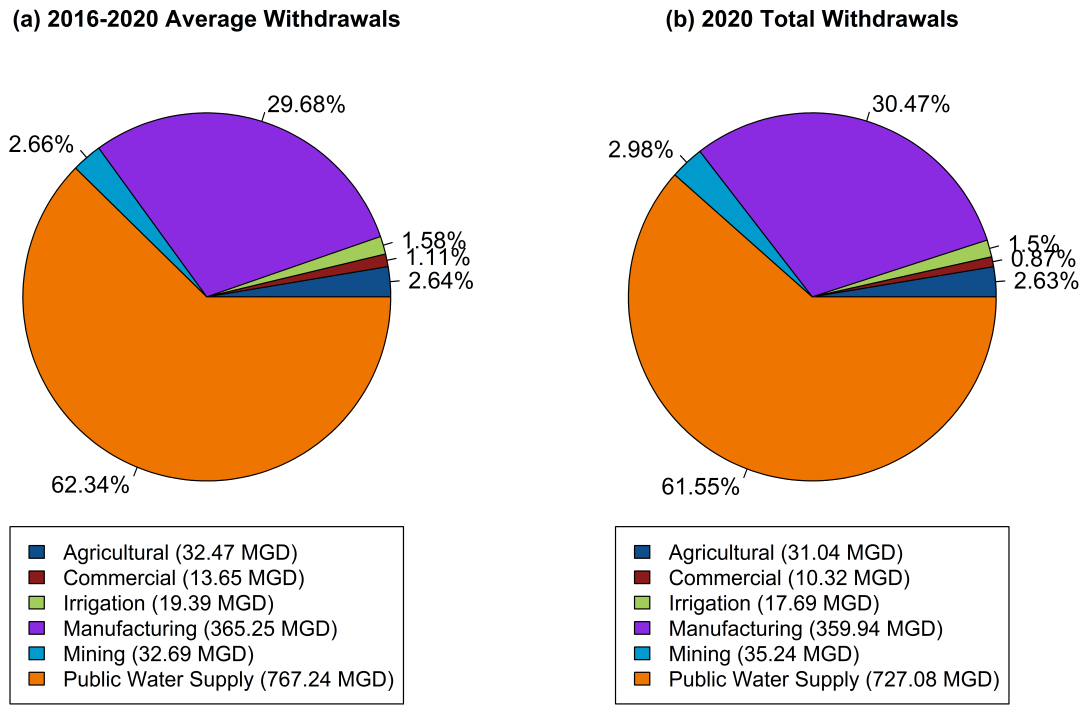
Figure 14: Surface Water Withdrawals, 2016-2020 Average and 2020 Total



was primarily driven by decreases in surface water withdrawals by public water suppliers. Reported surface water demands for many public water supplies were the lowest over the five year period of comparison. Reductions in public water supply demands were consistent statewide. The unique circumstances resulting from COVID-19 likely reduced demands from public water supply service areas and transitioned the use to primarily serving residential customers. With a more than 40 MGD reduction compared to the five year average, reported surface water withdrawals for public water supply were a significant driver in the 4% reduction in overall demands. Another factor that may have contributed to this reduction is that 2020 was wetter than average, which reduces demand for commercial and residential irrigation, which is served by public water supplies in many areas.

Appendix 1 provides additional information for each water use category, including tables and graphs comparing 2020 withdrawals with the five-year average and annual withdrawal trends for each use category. The top water users within each category are identified, including maps demonstrating the spatial distribution and magnitude of withdrawals across the Commonwealth.

Figure 15: Groundwater + Surface Water Withdrawals, 2016-2020 Average and 2020 Total



2.4 Consumptive vs. Non-consumptive Use of Water

A portion of all water withdrawn from groundwater or surface water sources is "consumed", or becomes unavailable for further use. "Consumptive water use" refers to that portion of a water withdrawal that is not returned to the source due to evapotranspiration, domestic use, incorporation into products or crops, or diversion from the source basin. The percentage of water consumed by agricultural, commercial, manufacturing, and mining facilities varies widely, depending on the specific use, product, or process at each facility. For example, most of the water withdrawn for agricultural irrigation is consumed by evapotranspiration and incorporation into the irrigated crop. Similarly, domestic consumptive use can vary significantly depending upon whether wastewater is discharged (i.e., returned) to the source stream, discharged to a stream within the same water basin, or discharged to a stream in another water basin. Domestic consumptive use in public water supplies can vary significantly depending upon the amount of lawn irrigation and/or outdoor watering employed by consumers. Weather patterns and seasonal variations can also affect domestic consumptive use. Age of infrastructure can also affect consumptive use as older water systems tend to experience more leaks leading to infiltration rather than return to the source.

In 2015, USGS published estimates of consumptive use associated with domestic self-supplied and public water supplies for each state. USGS estimated approximately 58% of annual withdrawal volumes (excluding power generation) in Virginia are consumptive. [14] Without specific information about the types and distribution of end users, estimates of consumptive use from public water supply withdrawals include significant uncertainty. However, this publication provided an excellent foundation for a extensive evaluation of consumptive use in Virginia that was conducted between 2018 - 2020 by DEQ in cooperation with Virginia Tech and USGS. More specifics on this effort to quantify Virginia's consumptive use are discussed in Chapter 1.

"Non-consumptive" water use is characterized by water that remains in, or is immediately returned to, the location in a stream or aquifer from which it was withdrawn with little or no water loss. Most non-consumptive water use involves some level of consumptive loss. Power generation withdrawals are often referred to as "non-consumptive," due to their relatively low rate of consumptive loss when compared to other categories. At thermoelectric power plants, the type of cooling system in use determines the relative amount of consumptive use. For example, "once-through" cooling systems return most of the diverted water to the original source, causing a relatively insignificant amount of consumptive use. In contrast, "closed-loop" cooling systems re-circulate diverted water through wet cooling towers and consume a significant percentage of total water withdrawn through evaporation.[15] In Virginia, the thermoelectric power plants with the five largest water withdrawals employ once-through cooling systems. Other plants, with smaller water withdrawals, use wet cooling tower systems and may have relatively greater consumptive losses. Hydropower plants are also exempt from reporting due to their low consumptive use (see Appendix 1 for more on Power Generation Water Withdrawals).

[14] Dieter, C.A., Maupin, M.A., Caldwell, R.R., Harris, M.A., Ivahnenko, T.I., Lovelace, J.K., Barber, N.L., and Linsey, K.S., 2018, *Estimated use of water in the United States in 2015*: U.S. Geological Survey Circular 1441, 65 p., https://doi.org/10.3133/cir1441. [Supersedes USGS Open-File Report 2017–1131.]

[15] Diehl, T.H., Harris, M.A., Murphy, J.C., Hutson, S.S., and Ladd, D.E., 2013, *Methods for estimating water consumption for thermoelectric power plants in the United States*: U.S. Geological Survey Scientific Investigations Report 2013–5188, 78 p.

3 Water Withdrawal Trends: 2016-2020

Total reported water withdrawals for all use categories including power generation were approximately 5.68 BGD in 2020. This is a 6.2% decrease from the five year average of 6.06 BGD. Power generation decreased 6.8% compared to the five year average, which was due in large part to deactivation in coal and natural gas plants, including Yorktown Power Station, Chesterfield Power Station, and Possom Point Power Station. More details on power generation withdrawals from 2016-2020 can be found in Appendix 1 Table 18. The remainder of this chapter will discuss water withdrawals excluding power generation.

Water withdrawals reported to VAHydro from 2016-2020 for all use categories excluding power generation are represented in Table 2. Total reported 2020 water withdrawals decreased approximately 4.0% compared to the five-year average (2016-2020).[16] The 2020 reported withdrawals from groundwater sources increased approximately 1.9% when compared to the five-year average, with the agriculture and mining categories showing the largest percent increases. Increased groundwater withdrawals from agriculture use categories during 2020 was largely the result of new agricultural facilities registered and reporting withdrawals through both water supply planning and withdrawal permitting efforts, including continued increases from poultry operations on the Eastern Shore, some of which began operation in 2020. Increased groundwater withdrawals reported within the mining use category largely resulted from increased quarry dewatering from two major Kimballton mine operations in Giles County.

Public water supply groundwater withdrawals increased by 1.7% as compared to the five year average, and the overall trend indicates consistent increases in groundwater use for this category year after year. This is consistent with continuing population increases in many parts of Virginia, which increases demand for public water supplies. Many smaller public water supplies as well as those located in areas with limited access to surface water continue to rely on groundwater to meet their needs. Commercial water use is the only category that experienced a decrease in groundwater withdrawals when compared to the five year average. The 17.2% decrease is likely due to decreased commercial activity during the COVID-19 pandemic.

Total reported surface water withdrawals in 2019 decreased by 4.8% compared to the five-year average. This decrease was primarily due to decreases in the commercial and irrigation categories of 28.3% and 10.2% respectively, as well as a substantial decrease by volume (40 MGD reduction from five year average) in the public water supply category. The decrease in surface water withdrawals for public water supply and commercial use is likely due to mitigation measures associated with the COVID-19 pandemic, as well as reduced commercial and residential irrigation supplied by water systems due to above average precipitation. The decrease in withdrawals for irrigation is likely also a result of above average precipitation in 2020 leading to less supplemental irrigation from surface water sources. The only category experiencing an increase in surface water withdrawals is mining (3.6%). The above average precipitation in 2020 may have led to increased quarry dewatering.

As observed in Table 2, an overall increasing trend in surface water withdrawals for public water supply has been consistent from 2016-2019, and was interrupted in 2020. While the increasing trend in past years is likely driven by population growth in large metropolitan areas, the decrease in 2020 by 5.8% is not likely indicative of a reversal of that trend, but rather a pause as a result of COVID-19 mitigation.

[16] Figure percentages are rounded.

Table 2: Summary of Virginia Water Withdrawals by Use Category and Source Type 2016 - 2020 (MGD) Excluding Power Generation

Category	2016	2017	2018	2019	2020	5 Year Avg.	% Change 2020 to Avg.
Groundwater							
Agricultural	0.67	0.70	0.80	1.22	1.31	0.940	39.4
Commercial	5.46	5.37	4.32	4.96	3.99	4.820	-17.2
Irrigation	1.86	1.65	1.74	2.01	1.93	1.840	4.9
Manufacturing	56.10	57.54	60.57	57.76	58.02	58.000	0.0
Mining	17.34	15.54	18.04	17.57	19.62	17.620	11.4
Public Water Sup.	53.21	54.41	54.86	54.70	55.43	54.520	1.7
Surface Water							
Agricultural	33.64	30.59	32.70	30.98	29.73	31.530	-5.7
Commercial	10.41	9.52	7.98	9.91	6.33	8.830	-28.3
Irrigation	20.40	18.59	12.89	20.12	15.76	17.550	-10.2
Manufacturing	312.23	324.45	304.17	293.49	301.92	307.250	-1.7
Mining	15.48	13.66	16.84	13.74	15.62	15.070	3.6
Public Water Sup.	717.54	719.22	727.72	727.44	671.65	712.710	-5.8
Total (GW + SW)							
Agricultural	34.31	31.29	33.50	32.20	31.04	32.470	-4.4
Commercial	15.87	14.89	12.30	14.87	10.32	13.650	-24.4
Irrigation	22.26	20.24	14.63	22.13	17.69	19.390	-8.8
Manufacturing	368.33	381.99	364.74	351.25	359.94	365.250	-1.5
Mining	32.82	29.20	34.88	31.31	35.24	32.690	7.8
Public Water Sup.	770.75	773.63	782.58	782.14	727.08	767.240	-5.2
Total							
Total Groundwater	134.64	135.21	140.33	138.22	140.30	137.740	1.9
Total Surface Water	1109.70	1116.03	1102.30	1095.68	1041.01	1092.940	-4.8
Total (GW + SW)	**1244.34**	**1251.24**	**1242.63**	**1233.90**	**1181.31**	**1230.684**	**-4.0**

3.1 2020 Permitted and Unpermitted (Excluded) Withdrawals

The following tables demonstrate the difference between reported withdrawals from users that hold a VWP surface water withdrawal or groundwater withdrawal permit, and reported withdrawals from unpermitted facilities. Table 3 displays the reported total withdrawals for both permitted and unpermitted users by use and source type for 2020. Unpermitted surface water withdrawals includes withdrawals that are excluded from VWP permitting requirements pursuant to §62.1-44.15:22 of the Code of Virginia or 9VAC25-210-310, which includes exclusions related to the size, age, and purpose of the withdrawal. Unpermitted groundwater withdrawals are those not required to obtain a groundwater withdrawal permit under the Ground Water Management Act of 1992. These include withdrawals located outside of a groundwater management area or those that withdraw less than 300,000 gallons in any month or are otherwise excluded pursuant to 9VAC25-610-50.

In 2020, unpermitted withdrawals represented approximately 72% of the total reported withdrawals in Virginia. The majority of reported groundwater withdrawals (51%) are from users operating under a Groundwater Withdrawal Permit. This is consistent with the 2019 and 2018 results. Approximately 75% of the total surface water withdrawn in Virginia is associated with unpermitted users, which has remained largely consistent across reporting years. Of the top 20 reported withdrawals in 2020, 15 are from facilities that are unpermitted.

In 2020, a total of 140.30 MGD in groundwater withdrawals were reported (excluding power generation). Manufacturing withdrawals made up 41.3% of total reported groundwater withdrawals in 2020 with 15.0% of the total from unpermitted manufacturing. These percentages are consistent with 2019. The largest unpermitted groundwater withdrawals are for manufacturing/industrial facilities that rely on groundwater outside of the GWMAs, as well as for mining facilities which report groundwater withdrawals associated with sand and gravel mine dewatering. Withdrawals for public water supply were the second largest contributor to total groundwater withdrawals in 2020. Approximately 39.5% of all groundwater withdrawals reported in 2019 were used for public water supply needs, with 18.7% associated with unpermitted public water supply facilities. These percentages are also consistent with 2019. Unpermitted public water supply facilities are almost entirely made up of those located outside GWMAs. DEQ staff continue to work with manufacturing and public water suppliers who rely on groundwater to identify water conservation measures and alternative sources when available, especially when located inside a GWMA or an area with existing resource concerns. Note that groundwater withdrawals for domestic and private well use are not included in the reported use totals, as such use falls below the reporting threshold and is not required to be reported to DEQ. This use can be significant in areas with large populations outside of service areas and is neither permitted nor reported.

As with groundwater, surface water withdrawals in 2020 were dominated by withdrawals associated with manufacturing and public water supply facilities, with the two categories making up approximately 93.5% of total surface water withdrawals. Manufacturing facilities comprised 29.0% of all surface water withdrawals, with 27.8% unpermitted. Withdrawals for public water supply comprised 64.5% of total surface water withdrawals, with 41.3% unpermitted. As noted previously, three quarters of surface water withdrawals are unpermitted. Unpermitted withdrawals, whether groundwater or surface water, continue to present a significant challenge for management of the resource. More information on measures DEQ is taking to better evaluate the impacts from unpermitted users is provided in Chapter 4 of this report.

Table 3: 2020 Permitted and Unpermitted (Excluded) By Use Type Withdrawals (MGD)

	2020 Withdrawal Amount		**% of Total**	
Use Type	**Unpermitted**	**Permitted**	**Unpermitted**	**Permitted**
Groundwater				
Agriculture	0.19	1.12	0.14	0.80
Commercial	1.18	2.81	0.84	2.00
Irrigation	0.63	1.36	0.45	0.97
Manufacturing	21.00	37.03	14.96	26.38
Mining	19.62	0.00	13.98	0.00
Public Water Supply	26.23	29.20	18.69	20.80
Total Groundwater	**68.85**	**71.52**	**49.06**	**50.95**
Surface Water				
Agriculture	29.41	0.32	2.83	0.03
Commercial	5.00	1.33	0.48	0.13
Irrigation	14.79	0.97	1.42	0.09
Manufacturing	288.86	13.06	27.75	1.25
Mining	15.51	0.12	1.49	0.01
Public Water Supply	430.01	241.64	41.31	23.21
Total Surface Water	**783.58**	**257.44**	**75.28**	**24.72**

Unreported unpermitted withdrawals are not represented in Table 3, however unreported withdrawals are of interest to DEQ. These withdrawals consist primarily of those that do not exceed the reporting thresholds for their use type as stated in 9VAC25-200-30. However, trends in increased private groundwater well completion reports received by DEQ and VDH point to an increase in private groundwater well construction. Since 2016, over 7,000 wells have been registered; 1,481 wells were registered electronically with DEQ in 2020 alone. Note that wells may also be registered via submission of a hard copy uniform water well completion form (GW-2) and this total does not include those. Though water withdrawal data is not collected with the groundwater well completion reports, the increase in private well construction can be viewed as a metric for evaluating increasing unreported and unpermitted groundwater withdrawals. Unreported and unpermitted withdrawals also includes users who may be withdrawing above the thresholds requiring reporting but are not in compliance with the regulation. Identification of such users is an ongoing effort for DEQ. Further developing an understanding of the extent and impacts associated with unreported unpermitted withdrawals is essential to maintaining the water resource management gains achieved through both permitting and water supply planning efforts. More details on how DEQ continues to address this challenge can be found in Chapter 4.

4 Water Resource Priorities and Challenges

The following section identifies new, continuing, and future priorities, challenges, or other topics of specific interest in terms of water resources management at DEQ. These include updates on new legislative or regulatory actions, programmatic goals and achievements, and other items. Publication of the 2020 Annual Water Resources Report will align closely with publication of the 2020 Virginia State Water Resources Plan (State Plan). The priorities identified in this chapter are consistent with those raised in the Draft 2020 State Plan, which was released for public comment on June 28, 2021, and available on the DEQ website through August 13, 2021. Final publication of the 2020 State Plan is expected in Winter of 2021.

4.1 Climate Change and Resource Planning

The scientific consensus is that worldwide climate is changing in response to greenhouse gas emissions. Climate modeling has been completed by the United States Geological Survey (USGS) and the Chesapeake Bay Program to better understand how these changes may impact the Commonwealth of Virginia. Global climate models nearly unanimously project Virginia to have continued increases in temperature over the next century; the extent of those increases depends primarily on the magnitude of greenhouse gas emissions. Drought in Virginia is driven largely by the difference between annual precipitation and evaporation. Extreme droughts in most Virginia streams are the result of a combination of low precipitation during winter, which leads to depleted base flows, combined with low summer precipitation and/or high summer evaporation. Temperature increases observed over the last 30 years have already caused increased evaporation throughout Virginia. Although climate change will likely mean increased total precipitation, this additional evaporation means future droughts may be more severe than those experienced in the past.

The 2020 State Plan includes a series of climate change scenarios that simulate how streamflow may respond to various meteorological conditions that are within a reasonable bound based on predictions of the best available global climate models. More detail on these scenarios can be found in the 2020 State Plan. These scenarios represent the initial effort by DEQ to address climate uncertainty related to surface water resources. DEQ is currently working to expand the capability to do this type of analysis beyond the Chesapeake Bay watershed to include areas in Virginia that do not drain to the Chesapeake Bay (often called the "Southern Rivers").

In the context of resource management and water supply planning, most climate models suggest an overall increase in precipitation; however, these models also suggest more severe drought periods due to increasing evaporation, and potential for periods of decreased precipitation despite the overall trend. Even if such periods are rare, it is increasingly important that water supply planning occurs at a scale that facilitates a regional evaluation of sources and demand, as well as evaluating regional opportunities for diversifying sources, developing storage, and building interconnections and redundancy where possible among neighboring systems. Additionally, developing a process for incorporating the evaluation of climate change into existing management programs, including water withdrawal permitting and water supply plan development and review is increasingly necessary.

4.2 Addressing Unpermitted and Unreported Water Use

Evaluating and addressing impacts from water users that are statutorily exempt from the requirement to obtain a VWP surface water or groundwater withdrawal permit, or otherwise unpermitted, continues to be a challenge in managing both surface water and groundwater. Reported surface water withdrawals not subject to permitting requirements made up approximately 75% of total reported surface water withdrawals in 2020 (see Figure 3). Exempt in this context means a surface water facility that is exempt pursuant to the criteria in § 62.1-44.15:22B of the Code of Virginia. One of the challenges in evaluating impacts from exempt surface water users is the multiple types of data cited to support exempt demand amounts ranging from the capacity of the intake to the safe yield of the source. There is considerable variation across these values for any given facility, and this variation only increases when evaluating the cumulative impact of a stream with multiple exempt users. The Draft 2020 State Plan includes an exempt user surface water withdrawal scenario that

evaluates the most conservative, or maximum possible, demand for such users to illustrate the potential implications based on claimed exemptions. However, DEQ does not agree that the maximum values used in this scenario represent an allocation for, or the expectation of, a future withdrawal of that volume; nor does DEQ concede that any particular exempt user is necessarily entitled to withdraw any particular maximum value used in this scenario.

To summarize the results from this analysis, when evaluated cumulatively, and even in some cases individually, the maximum possible exempt demands are not sustainable in many parts of Virginia during drought conditions regularly experienced today; the potential for worsening droughts in response to climate change would only exacerbate this issue. If facilities were to operate at the maximum possible exempt demand, issuance of VWP applications for new withdrawals would be unlikely or even impossible in portions of every major river basin in Virginia due to unacceptable impacts to downstream beneficial uses, which includes existing water users, aquatic life, and the maintenance of water quality. Based on these results, a process to incorporate the evaluation of potentially exempt demands into the VWP permit application review process needs to be developed.

The proportion of groundwater use that is exempt from permitting, or otherwise unpermitted, although smaller in absolute terms than exempt surface water demands, is more difficult to estimate since much of it comes from domestic or private wells with no requirement to report withdrawals. There are few exemptions from the requirement to obtain a permit for groundwater withdrawals in a declared groundwater management area, and therefore those that are considered unpermitted are generally either very small users such as domestic/residential wells, or facilities that do withdraw enough groundwater to require a permit but have not obtained one. Particularly in the groundwater management areas, continuing to improve estimates of domestic use remains a key goal given the increasing demands on the aquifer system by the growing population of homeowners with individual wells. Additionally, groundwater use outside of declared groundwater management areas does not require a withdrawal permit.

As with surface water withdrawals, DEQ continues to identify groundwater users that meet the withdrawal permitting threshold, but do not have a withdrawal permit. Bringing such withdrawals into compliance with the regulations remains a DEQ priority.

Another ongoing priority is evaluating and addressing unreported use below the regulatory threshold requiring withdrawal reporting (domestic or private well use for instance), and use above the regulatory threshold that is nonetheless not currently being reported. As discussed in Chapter 1, DEQ staff conduct compliance activities annually to identify users who meet the threshold for annual withdrawal reporting as well as to contact users who have previously reported but have failed to do so consistently. The extent of this outreach is highly dependant on available staff resources each year and must be balanced against other program responsibilities. In addition, DEQ works to address known gaps in this data through projects like the 2020-2021 USGS WUDR Grant project to develop estimates of unreported agricultural water use in Virginia (discussed in more detail in Chapter 1).

DEQ has contracted with the USGS to improve estimates of historic domestic and private groundwater use to inform the total pumping used for groundwater modeling scenarios. The most recent estimate was published 12 years ago in 2008. An update on the status of these efforts is included in the following Program Funding section. The groundwater scenarios completed for the 2020 State Plan represent an additional approach in estimating domestic and private well use based on water supply plan projections that account for the local expectations of growth. The results of those scenarios show that projected increases in unpermitted groundwater use in the Eastern Virginia GWMA could reduce groundwater levels in confined aquifers like the Potomac and Aquia aquifers below the critical threshold at which groundwater permits cannot be issued or reissued in some areas. DEQ also continues to collect private well construction information that provides important context for domestic groundwater use trends statewide. These data are used by USGS/DEQ to refine domestic use estimates. The most recent estimate [17] of domestic groundwater withdrawals from

[17] Pope, J.P., McFarland, E.R., and Banks, R.B., 2008, Private domestic-well characteristics and the distribution of domestic withdrawals among aquifers in the Virginia Coastal Plain: U.S. Geological Survey Scientific Investigations Report 2007–5250, 47 p. (available online at http://pubs.water.usgs.gov/sir2007-5250).

confined aquifer systems in the Coastal Plain was more than 30 MGD, or almost half the volume (66 MGD) of the reported groundwater withdrawals associated with permitted facilities referenced in the 2019-2020 Virginia Coastal Plain Model Report.[18] As Virginia's population continues to grow, it will be important to update estimates for this type of use to better inform cumulative impacts to Coastal Plain aquifers from domestic and permitted withdrawals.

Annual withdrawal reporting is one of the most critical water related datasets available to DEQ, other resources agencies and stakeholders, and the public. It forms the foundation for evaluating both water use in Virginia as well as the potential impact of withdrawals on the resource.

4.3 Eastern Virginia Groundwater Management Area

One of the long-term water resource management challenges in Virginia is the historic over allocation of groundwater from the Coastal Plain aquifer system in the Eastern Virginia GWMA, particularly from the Potomac Aquifer. A long-term decline in water levels in the Potomac and other aquifers required DEQ to develop new permit limits that resulted in a 52% reduction for the largest permitted users in the Coastal Plain aquifer system. Most public water supplies have also noted reductions in the average use per connection over time as conservation technologies improve and consumers become more water conscious. Water levels in the Potomac and other aquifers in the Coastal Plain have stabilized in some areas where use has dropped and may continue to improve over the course of the next decade. Yet even with reductions in permit limits, both public water supply demands and domestic or private well use will continue to increase where population does; in many urban/suburban parts of Virginia that are already largely developed, much of the growth is occurring outside of existing service areas and will be supplied by individual wells. New cumulative impact groundwater simulations included in the 2020 State Plan use water supply plan projections to estimate the impacts of increasing domestic use through 2040 (in combination with permitted use); the results identified areas of the Potomac, Aquia, and Piney Point aquifers where water levels are simulated to fall below the critical surface[19], and the simulations suggested if demands increase as projected by localities, water levels would begin to decline once more.

Despite water levels stabilizing in some parts of the Eastern Virginia GWMA, DEQ expects continued challenges in issuing both new and existing permits where water levels are simulated near or below the critical surface in some parts of the Eastern Virginia GWMA, particularly in localities along the fall-line such as King William, Henrico, and Prince George counties, as well as near the existing cone of depression by International Paper's Franklin Mill, including the counties of Sussex, Southampton, and (western) Isle of Wight, as well as the City of Franklin. In addition, with the expansion of the Eastern Virginia GWMA in 2014 to include the remaining counties east of interstate 95 (including the Northern Neck and Middle Peninsula), facilities in this area received existing user permits that did not require modeling of their effect on the aquifer system during their initial application. These facilities will begin applying for reissuance of their groundwater withdrawal permits as early as 2025 and their withdrawals will be evaluated to ensure compliance with the technical criteria for permit issuance. There is the potential for challenges in reissuing permits in these areas, particularly in localities along the fall-line where aquifer thickness and depth is limited, including King George and Caroline counties.

As groundwater levels can take years to respond to changes in pumping, adaptive management strategies and frequent evaluations of water level trends are necessary. However, recent successes in reducing permitted use and ongoing demonstrations of aquifer injection through Hampton Roads Sanitation District's (HRSD) Sustainable Water Initiative for Tomorrow Project (SWIFT) pilot program offer reasons for cautious optimism. A pilot injection well at HRSD's SWIFT Research Center is providing field data on how injections impact pressure in the Potomac and overlying aquifers.[20] The center currently collects data from observation wells and from an extensometer operated by USGS which measures changes in land elevation in response

[18] Virginia Coastal Plain Model (VAHydroGW-VCPM) 2019-2020 Annual Simulation of Potentiometric Groundwater Surface Elevations of Reported and Total Permitted Use.

[19] The critical surface is defined as 80% of the distance between the land surface and the top of the aquifer in use.

[20] https://www.hrsd.com/swift/about

to the injection. These data are critical to evaluating model results and calibrating the model with respect to the simulation of the proposed injections. The 2020 State Plan includes a new groundwater modeling scenario that incorporates the proposed SWIFT injection sites. The scenario shows potential reductions in the number of critical cells in the Potomac Aquifer, particularly in areas south of the James River, although there remain many unknowns regarding the rate and extent that injections will impact water levels in the aquifer system.

Recent legislation (discussed in more detail in the Recent and Ongoing Legislative and Regulatory Actions section) paves the way for the first general permits from the surficial aquifer (water table) for groundwater withdrawals in the Eastern Virginia and Eastern Shore GWMAs for irrigation and agricultural use respectively. These general permits will offer a streamlined permit process and are intended to increase withdrawals from the surficial (water table) aquifer, which recharges more readily, and thereby reduce withdrawals from confined aquifers. Withdrawals from confined aquifers such as the Potomac Aquifer cannot be permitted under these general permits given the technical criteria that must be evaluated for withdrawals from a confined aquifer.

In summary, there are several management strategies in process that will work in concert to address this long-term challenge. However, there will likely continue to be a need for localities and water users to develop regional planning relationships that support interconnections and cooperative development of alternatives to groundwater in areas where critical cells continue to be a concern. Continued improvements in implementation of water conservation and leak detection is also necessary, as addressing excessive water use and water loss is one of the major tools for reducing demands on groundwater.

4.4 Eastern Shore Groundwater Management Area

Hydrogeology on the Eastern Shore is often characterized through the analogy of a freshwater lens, representing the freshwater aquifers like the Upper, Middle, and Lower Yorktown-Eastover aquifers, as well the surficial (water table) aquifer, that sit atop groundwater that is substantially higher in chlorides, with the Chesapeake Bay to the west and the Atlantic Ocean to the east. Groundwater simulations on the Eastern Shore evaluate both impacts to water levels and changes in chloride concentration. Historically, challenges in issuing groundwater withdrawal permits as a result of critical cells has not been a major factor on the Eastern Shore. Total permitted demands on the Eastern Shore are far lower than in the Eastern Virginia GMWA, and demand projections in local water supply plans for Accomack and Northampton counties suggest only minor increases in demand. However, recent increases in agricultural irrigation, poultry facilities, and processing plants have resulted in areas where groundwater levels are simulated near the critical surface, and in some cases permitted facilities have had to adjust proposed limits to meet the technical criteria for permit issuance.

This suggests that in addition to existing concerns related to salt-water intrusion in localities located near the coast like the towns of Cape Charles and Chincoteague, violations of the 80% drawdown criteria are possible if demands continue to increase, particularly in the vicinity of the two poultry processing plants which are the largest groundwater users in the Eastern Shore GWMA. Agricultural facilities already use the surficial (water table) aquifer to meet some of their demands, and this is the primary alternative to the confined aquifers. As noted in the Recent and Ongoing Legislative and Regulatory Actions section, a general permit is currently under development to incentivize use of the surficial (water table) aquifer for applicable uses. Recently issued groundwater withdrawal permits on the Eastern Shore typically include conditions requiring evaluation of the surficial (water table) aquifer to determine if part or all of a facility's use can be met through it.

In 2019, an update to the Hydrogeologic Framework of the Virginia Eastern Shore, a joint effort between USGS and DEQ was published.[21] This report updated the prior hydrogeologic framework that was published in 1994, and includes significant improvements in our understanding of the saltwater-fresh water interface,

[21] McFarland, E.R., and Beach, T.A., 2019, Hydrogeologic framework of the Virginia Eastern Shore: U.S. Geological Survey Scientific Investigations Report 2019–5093, 26 p., 13 pl., https://doi.org/10.3133/sir20195093.

and the location and effect of paleochannels on aquifer flow patterns and well yields. This work was made possible by data collected through the groundwater withdrawal permit program and is being used as the basis for a new groundwater model. The new groundwater model is currently under development and is expected to be completed in the next biennium.

4.5 Evaluating Impacts to Aquatic Life from Surface Water Withdrawals

In managing water resources to protect all beneficial uses, the expectation has been that DEQ use the most current science and best available evaluation methods when reviewing project impacts. Chapter 1 provides updates on two DEQ publications[22] [23] in The Journal of American Water Resources Association related to evaluating impacts on species richness as a result of changes in flow, and the decision support tool: the elfgen R package (https://github.com/HARPgroup/elfgen). The 2020 State Plan includes significantly more detail on this research and the initial application of the tool using water supply demand scenarios to evaluate impacts to species richness as a result of increasing demands. The tool will allow for project scale evaluation of potential aquatic impacts to become more common as they can be completed at less cost to applicants than traditional methods such as Instream Flow Incremental Methodology. A process for incorporating elfgen into other water resource evaluations including the review of VWP surface water withdrawal applications is necessary to ensure DEQ can continue to make use of the best available methods for these kinds of evaluations.

4.6 Evaluating Tidal Fresh Surface Water Withdrawals

Groundwater limitations in the Coastal Plain region have led water users to consider alternatives that they previously considered to be cost prohibitive. Recently, several applications for the construction of tidal fresh surface water withdrawal intakes in the Appomattox and Rappahannock rivers have been received and are under review by DEQ. VWP permits authorizing the construction of intakes in tidal fresh sections of the Pamunkey and Chickahominy rivers have been issued, but the intakes have yet to be constructed. The water quality in a tidal system is dynamic and the amount of available freshwater can improve or reduce local water quality. Reducing freshwater inflows into a tidal system can shift the location where low salinity and high salinity water combine further upstream. Sea-level rise associated with climate change is also a significant potential driver of changes water quality in these areas.

Recent water supply permit applications in tidal fresh zones have employed custom-developed high resolution adaptations of the tidal model developed for use in the Chesapeake Bay TMDL model and also the James River tidal fresh TMDL models. These high resolution tidal models were linked to water supply models, and provided insight into cumulative impacts of freshwater diversions in these zones, the potential cumulative effects of sea level rise, and the compounding effect of climate change. Development of dynamically resegmentable models for the Chesapeake Bay and its tributaries is also ongoing, resulting in river segment sizes better suited for local scale models. Integrating these new tidal-fresh models into VAHydro to evaluate suitability of tidal fresh water sources and the impacts of freshwater diversion on tidal water quality would allow evaluations comparable to those completed for non-tidal projects. Additional funding would be required to support this development. In addition, developing a process for both modeling and evaluating tidal fresh withdrawal projects will be necessary to ensure a consistent and clear application review process

[22] Kleiner et al. - DOI: https://doi.org/10.1111/1752-1688.12876.
[23] Rapp et al. - DOI:https://doi.org/10.1111/1752-1688.12876.

4.7 Recent and Ongoing Legislative and Regulatory Actions

DEQ is currently coordinating several regulatory actions related to water resources management in response to legislation passed by the General Assembly. A summary of each action and the current status is provided below:

- Legislation enacted following the 2021 General Assembly Special Session I (2021 Special Session I Va. Acts Ch. 100) will improve the efficiency and effectiveness of water use by requiring all applications for Virginia Water Protection (VWP) permits for surface water withdrawals and Ground Water Withdrawal permits to include: 1) a water auditing plan and 2) a leak detection and repair plan that satisfy the requirements in regulations to be adopted by the State Water Control Board. These plans would also, once approved, be incorporated by reference as conditions in the permit. DEQ is beginning the regulatory process to implement the provisions of this bill.

- Legislation enacted following the 2021 General Assembly Special Session (2021 Special Session I Va. Acts Ch. 275) directs DEQ to convene a working group for the purpose of developing a schedule of annual maintenance fees for certain water withdrawal permits. A working group was convened for this purpose and a report will be submitted to the Governor and General Assembly that includes a summary of the working group's discussions and recommendations for a schedule of annual maintenance fees that shall, at a minimum, be sufficient to reflect no less than 40% of the direct costs required for the development, administration, compliance, and enforcement of such permits.

- Legislation enacted following the 2020 General Assembly Session (2020 Va. Acts Ch. 1105) requires the SWCB to adopt regulations designating regional planning areas based primarily on river basins, to encourage the development of cross-jurisdictional water supply projects, and to estimate the risk that each locality and region in the Commonwealth will experience water supply shortfalls. This law also directs localities to participate in cross-jurisdictional, coordinated water resource planning, and to develop a single water supply plan for each regional planning area. A Notice of Intended Regulatory Action (NOIRA) was published June 7, 2021 and the comment period continued through July 22, 2021. A Regulatory Advisory Panel (RAP) made up of a variety of stakeholders is currently meeting and will be used to develop recommended regulation amendments for SWCB consideration through the collaborative approach of regulatory negotiation and consensus.

- Legislation enacted following the 2020 General Assembly Session (2020 Va. Acts Ch. 670) prohibits construction of wells for non-agricultural irrigation in aquifers other than the surficial (water table) aquifer, unless DEQ determines this aquifer is inadequate to meet the proposed beneficial use, once the SWCB adopts a general permit for regulation of withdrawals from the surficial aquifer. DEQ published a NOIRA on November 23, 2020 and the public comment period closed on December 23, 2020. A Technical Advisory Committee (TAC) was formed to develop amendments to 9VAC25-610 (Groundwater Withdrawal Regulations). The final TAC meeting was held on June 22, 2021. The proposed regulation will be presented to the SWCB, and if approved, an additional public comment period will follow.

- Legislation enacted following the 2019 General Assembly Session (2019 Va. Acts Ch. 755) directed the SWCB to adopt regulations providing incentives, such as an expedited general permit process, for the withdrawal of groundwater from the surficial aquifer, rather than the confined aquifer, in the Eastern Shore GWMA. In 2019 DEQ published a NOIRA to establish the framework for the issuance of a general permit for withdrawals from the surficial aquifer in the Eastern Shore GWMA. A comment period ran from November 11, 2019 through January 6, 2020. DEQ convened a RAP and developed regulations which will be considered by the SWCB. The new general permit regulation includes the establishment of permit terms, withdrawal limitations, reporting requirements, and other elements necessary to permit withdrawals through this new general permit framework.

4.8 Program Funding

DEQ's responsibilities and authorities in terms of managing water supply are complex and increasingly intensive. Continued financial investment is necessary for program development and implementation in order to allow for proactive and responsive management. Likewise, investment in the science that underpins data driven management decisions is necessary to maintain currency with the changing world. Finally, focus and investment is needed to continue the outreach and engagement that drives improved local government and public participation in the effective management of Virginia's water resources for current and future generations.

Investment in regional water supply program implementation is necessary to build long-term local government stewardship of local and regional water resources. A secure source of funding for planning grants to local governments is a fundamental element to the success of plan implementation and long-term maintenance. A recurring comment from local and regional programs is that for the statewide planning process to reach its full potential, funding to support water supply planning efforts is essential to maintain long-term data gathering and planning. As a result of 2020 Va Acts Ch. 1105, planning areas will change ahead of the upcoming planning cycle which may impact existing planning relationships, and form new ones. Funding for local governments may become more necessary as a result.

Appendix 1: Water Withdrawals By Use Category

Water withdrawals reported annually to VAHydro are grouped into the following categories:

- Public Water Supply
- Agriculture
- Irrigation
- Commercial
- Mining
- Manufacturing
- Power Generation

The "Public Water Supply" category includes water withdrawn and treated to produce water for drinking water, and other domestic and residential uses. It also includes water that is processed and sold to commercial or institutional facilities that are not self-supplied. The "Agriculture" category includes water withdrawn for raising livestock, fish farming/hatcheries and general farm use, but is not inclusive of water used for crop irrigation. The "Irrigation" category includes water used to promote crop growth, including but not limited to tobacco, corn, soybeans, turf grass, and nursery products. The "Commercial" category includes water used by golf courses, local and federal installations, hotels, resorts, and correctional centers, among others. The "Mining" category includes water withdrawn for the excavation, processing, and removal of bulk products such as coal, rock, sand, and gravel. The "Manufacturing" category includes industrial facilities that generally produce goods such as paper mills, food processors, pharmaceutical companies, furniture manufacturing, and concrete plants, among others.

The "Power Generation" category includes water withdrawn for Fossil Fuel Power and Nuclear Power. Withdrawals or diversions of water for Hydroelectric power (Hydropower) generation are nearly all non-consumptive and are exempt from the annual water withdrawal reporting requirements. As a result, a detailed description for Hydropower is not included; however, a brief discussion of consumptive use of water is provided in Chapter 2.

Appendix 1 is divided into sections for each water use category that contain information regarding withdrawals reported for 2020, including the following:

- A table that lists reported withdrawals for the five-year period between 2016 and 2020 in terms of an annual average rate by source type (groundwater or surface water)
- A table listing facilities reporting the largest withdrawals for 2020, facility location, water source, reported 2020 annual withdrawal rate, and the average annual withdrawal rate for the five-year period from 2016 to 2020
- A map depicting withdrawal point locations for each category, scaled by the magnitude of the 2020 reported annual withdrawal rate of individual measuring points (wells and surface water intakes)
- A bar graph illustrating the reported quantity withdrawn for each source type (groundwater or surface water) between 2016 and 2020, as well as the withdrawal amounts relative to the five-year average

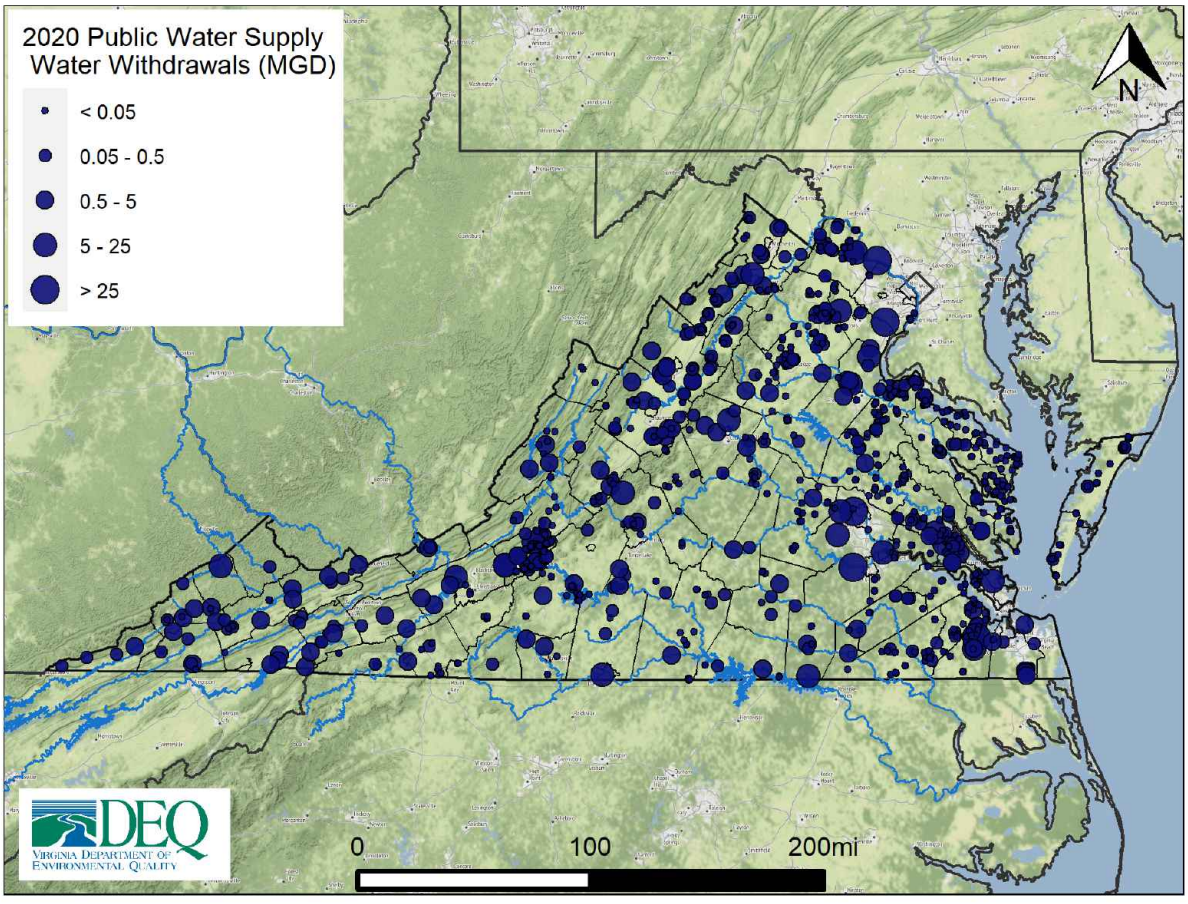
The public water supply water withdrawal totals do not include water withdrawn by individuals from private or domestic wells, as those withdrawals are not required to be reported. The total only represents the water withdrawn by public or private community water systems.

Public Water Supply Water Withdrawals

Water withdrawals for public water supply are primarily delivered to domestic users by both municipal (public) and private community water systems; however, significant volumes are also delivered to commercial and industrial customers by water suppliers. Deliveries to specific users are generally not reported to DEQ; therefore, the reported withdrawals for public water supply do not differentiate between the categories of end users.

While the greatest number of reporting public water systems are small systems that use groundwater (over 80%), the majority of the population in Virginia is served by large surface water systems with extensive service areas. The largest public water supply withdrawals are located within or near population centers such as the Washington D.C., Richmond, Hampton Roads, and Roanoke metropolitan areas. The largest public water supply purchases are located in the same areas, where water purveyors with large reservoirs or river withdrawals are able to supply both the majority of the population within their localities as well as in some cases neighboring localities. Smaller public water supply systems are spread throughout the state serving small towns or communities (Figure 16).

Figure 16: All 2020 Public Water Supply Water Withdrawals by Withdrawal Point Location



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Surface water is the major source of water for public water supply in terms of the overall quantities used. Surface water supplied 92% of the total 2020 public water supply withdrawals in Virginia (Figure 17). Reported 2020 water withdrawals for public water supply decreased by 5.2% when compared to the average of the previous five years (Table 4). A major contributor to this overall decrease is a 5.8% decrease in public water supply surface water withdrawals. In previous years, the overall use has shown an increasing trend. However, the decrease in 2020 could be attributed to temporary closures and other mitigation strategies due to the COVID-19 pandemic. Table 5 lists the ten facilities that reported the largest public water supply withdrawals in 2020. They include large public water suppliers such as Fairfax Water, City of Richmond, City of Norfolk, and the Appomattox River Water Authority. Water withdrawals for public water supply make up 63.4% of all non-power generation withdrawals in Virginia.

Table 6 displays information supplied by VDH regarding the number of public water supply waterworks by type and the total population served by all such systems.

Figure 17: 2016-2020 Public Water Supply Water Withdrawals by Source Type

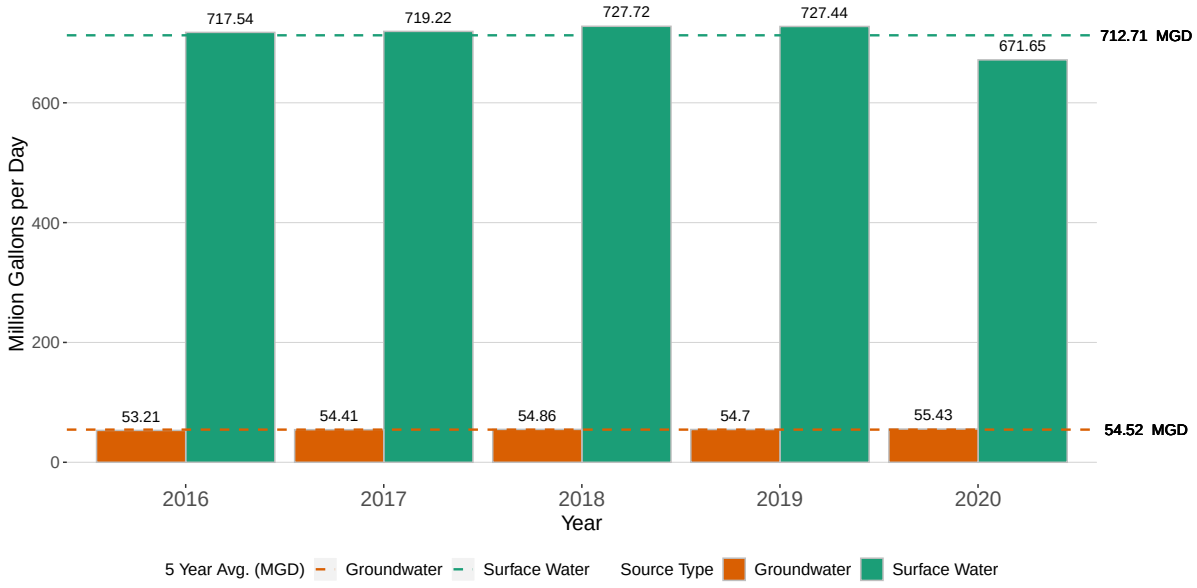

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Table 4: 2016 - 2020 Public Water Supply Water Withdrawals by Source Type (MGD)

Source Type	2016	2017	2018	2019	2020	5 Year Avg.	% Change 2020 to Avg.
Groundwater	53.21	54.41	54.86	54.70	55.43	54.52	1.7
Surface Water	717.54	719.22	727.72	727.44	671.65	712.71	-5.8
Total (GW + SW)	**770.75**	**773.63**	**782.58**	**782.14**	**727.08**	**767.24**	**-5.2**

Table 5: Highest Reported Public Water Supply Withdrawals in 2020 (MGD)

Facility	Locality	Type	Major Source	5 Year Avg.	2020 Withdrawal
Fairfax Water: Corbalis WTP	Fairfax County	SW		90.1	89.3
City of Richmond WTP	City of Richmond	SW		65.5	67.2
City of Norfolk: Western Branch Reservoir	City of Suffolk	SW		70.7	64.2
Fairfax Water: Griffith WTP	Prince William County	SW		63.8	59.2
Appomattox River Water Authority: Chesdin Reservoir WTP	Chesterfield County	SW		33.6	35.2
Henrico County WTP & Service Area	Henrico County	SW		24.6	23.7
Virginia American Water: Hopewell District	City of Hopewell	SW		21.7	21.4
City of Newport News: Harwood's Mill WTP	York County	SW		17.9	17.0
City of Portsmouth: Lake Kilby WTP	City of Suffolk	SW/GW		17.2	16.8
City of Virginia Beach Service Area	City of Virginia Beach	SW		24.7	14.6

Table 6: Number of Public Water Supply Systems and Population Served in 2020

Category	Community Water Systems	Nontransient Noncommunity Water Systems	Transient Noncommunity Water Systems	Total
Number of Systems	1,083	499	1,193	2,775
Population Served	7,139,589	273,244	192,350	7,605,183

Agriculture (Non-Irrigation) Water Withdrawals

Withdrawals for Agriculture include the non-irrigation withdrawals from livestock, poultry, and fish farms. Information concerning Irrigation withdrawals associated with agriculture are provided in the "Irrigation (Agricultural) Water Withdrawals" section below. Figure 18 illustrates the distribution of reported 2020 groundwater and surface water withdrawals for agricultural purposes statewide. The majority of water withdrawn for agricultural use is obtained from surface water (Figure 19), primarily via springs located in western Virginia. Although springs originate from underground, they are considered surface water as they are generally only withdrawn once they reach the surface. These springs primarily support fish farms and hatcheries, including those operated by the Department of Wildlife Resources. Reported 2020 surface water withdrawals for agriculture uses decreased by 5.7% compared to the five-year average, with 29.73 MGD in total withdrawals reported (Table 7).

Although surface water is the primary source by volume, the majority of farms reporting agriculture withdrawals make use of groundwater sources as well. Groundwater is generally used as a supplement for surface water during droughts or during high-flows where turbidity or water quality issues can limit use of surface water. Reported groundwater withdrawals increased by 39.4% when compared to the five-year average. This significant increase was the result of increased groundwater reporting from a large group of existing and new poultry facilities located on the Eastern Shore that were identified through outreach efforts in 2019. Reported groundwater withdrawals among this group have continued to increase into 2020 as facilities that completed construction in 2019 began operation in 2020. As discussed previously, outreach to agricultural users continues, which may lead to more reporters being identified and registered. The five facilities reporting the largest withdrawals for agriculture use in 2020 are fish hatcheries; they are listed in Table 8. In total, surface water and groundwater withdrawals from agriculture make up 2.63% of all reported 2020 non-power generation withdrawals in Virginia.

Table 7: 2016 - 2020 Agriculture Water Withdrawals by Source Type (MGD)

Source Type	2016	2017	2018	2019	2020	5 Year Avg.	% Change 2020 to Avg.
Groundwater	0.67	0.70	0.8	1.22	1.31	0.94	39.4
Surface Water	33.64	30.59	32.7	30.98	29.73	31.53	-5.7
Total (GW + SW)	**34.31**	**31.29**	**33.5**	**32.20**	**31.04**	**32.47**	**-4.4**

Table 8: Highest Reported Agriculture Withdrawals in 2020 (MGD)

Facility	Locality	Type	Major Source	5 Year Avg.	2020 Withdrawal
Commonwealth of Virginia: Coursey Spring Fisheries	Bath County	SW		12.4	12.2
Commonwealth of Virginia: Paint Bank Fish Cultural Station	Craig County	SW		3.5	3.8
Commonwealth of Virginia: Wytheville Fish Hatchery	Wythe County	SW/GW		3.2	3.3
Commonwealth of Virginia: Marion Fish Cultural Station	Smyth County	SW		3.3	3.2
Laurel Hill Trout Farm-South Monterey	Highland County	SW		3.7	2.7

Figure 18: All 2020 Agriculture (Non-Irrigation) Water Withdrawals by Withdrawal Point Location

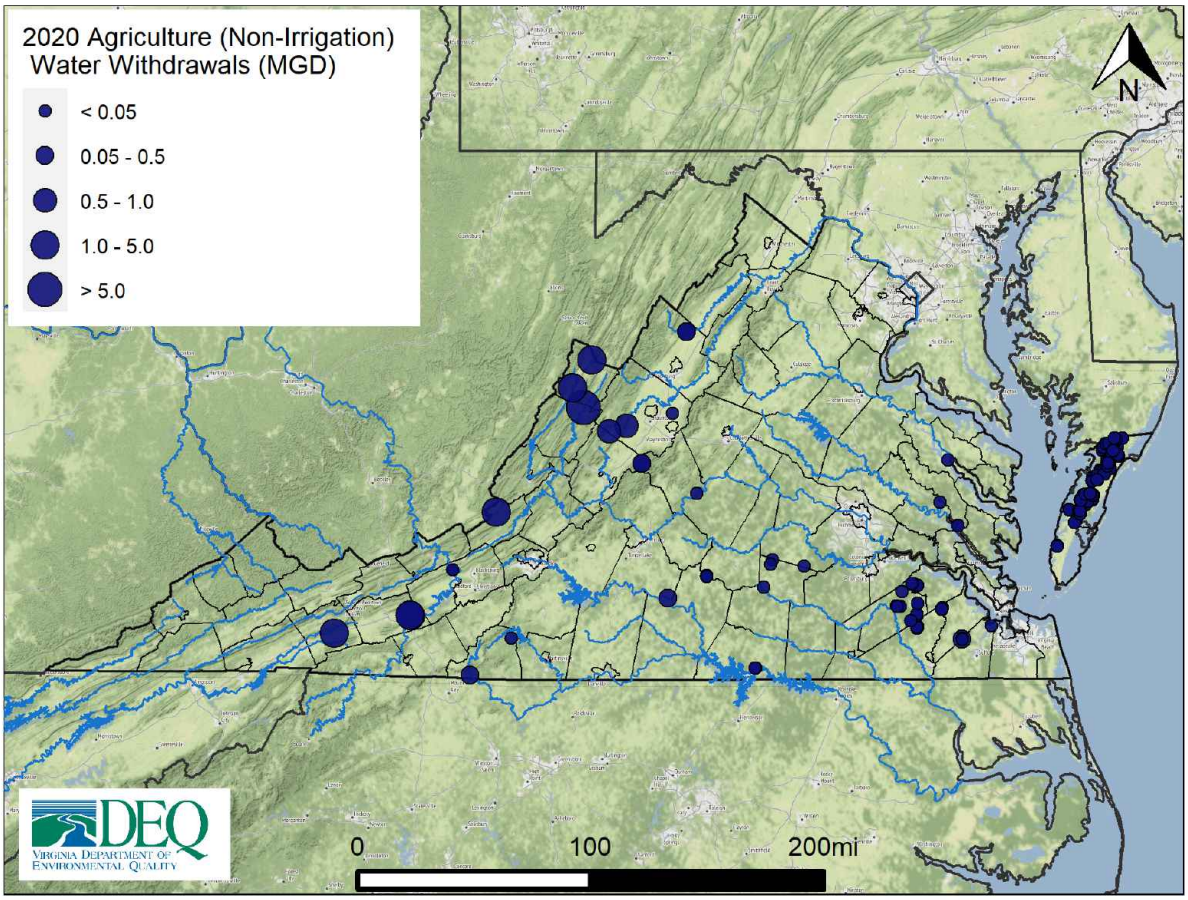

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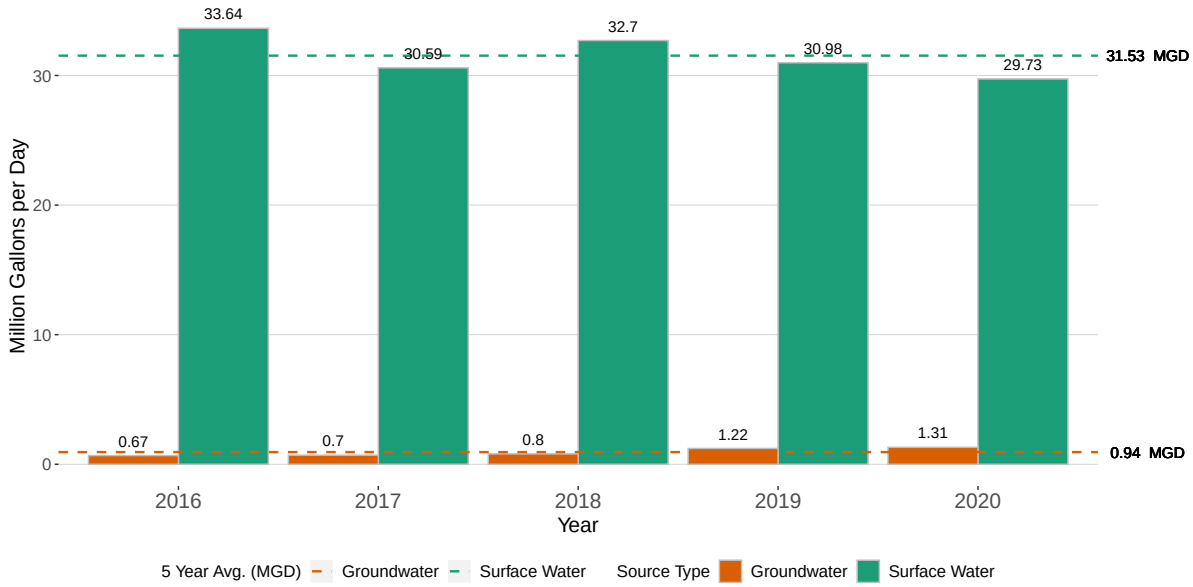
Figure 19: 2016-2020 Agriculture Water Withdrawals by Source Type



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Irrigation (Agricultural) Water Withdrawals

Irrigation withdrawals promote growth in agricultural crops such as corn, soybeans, sod, and nursery products. Figure 20 illustrates the distribution of reported 2020 groundwater and surface water withdrawals for irrigation purposes statewide. Surface water continues to be the major water source type for irrigation, representing about 89% of 2020 total irrigation withdrawals (Figure 21). The majority of the reported withdrawals for irrigation are located in the heavily agrarian communities in Accomack and Northampton counties on the Eastern Shore. Many of these facilities rely on a combination of wells and "dug ponds", which are shallow ponds used to store groundwater as well as rainwater for irrigation. Because these ponds do not have a direct connection with a perennial stream they are categorized in VAHydro as groundwater sources. There are no major transfers of water for irrigation, so water withdrawal figures also represent direct water use.

Reported water withdrawals for irrigation in 2020 were 8.8% less than the five year average (Table 9). The decreased withdrawals may be a result of well above average annual precipitation in 2020 leading to less additional irrigation to supplement crops. As with previous years, most large-scale irrigation facilities are located in the Coastal Plain, the Eastern Shore, and Shenandoah Valley. The five facilities reporting the greatest withdrawals for irrigation in 2020 are listed in Table 10. Water withdrawals from irrigation make up 1.5% of all non-power generation withdrawals in Virginia for 2020 and in total accounted for 17.7 MGD withdrawn.

Figure 20: All 2020 Irrigation (Agricultural) Water Withdrawals by Withdrawal Point Location

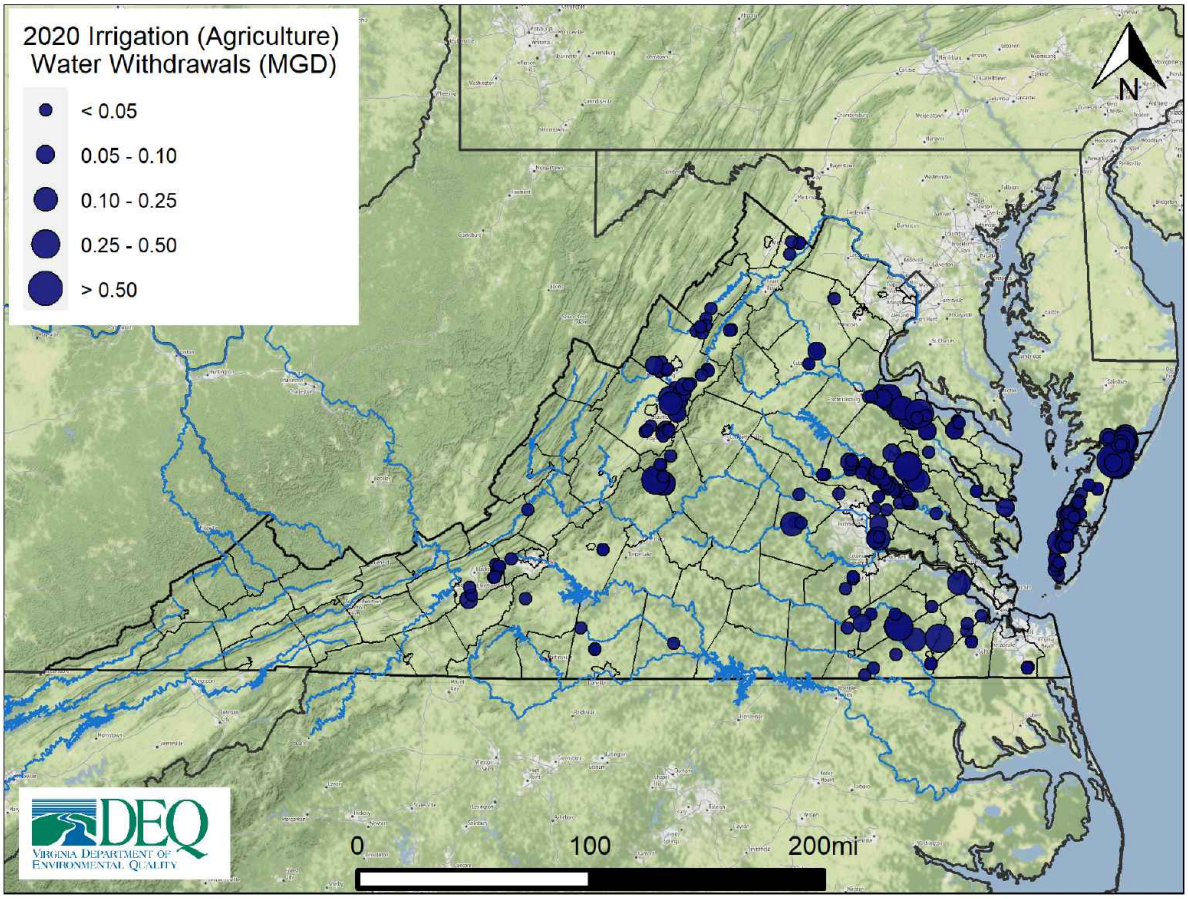

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Figure 21: 2016-2020 Irrigation Water Withdrawals by Source Type

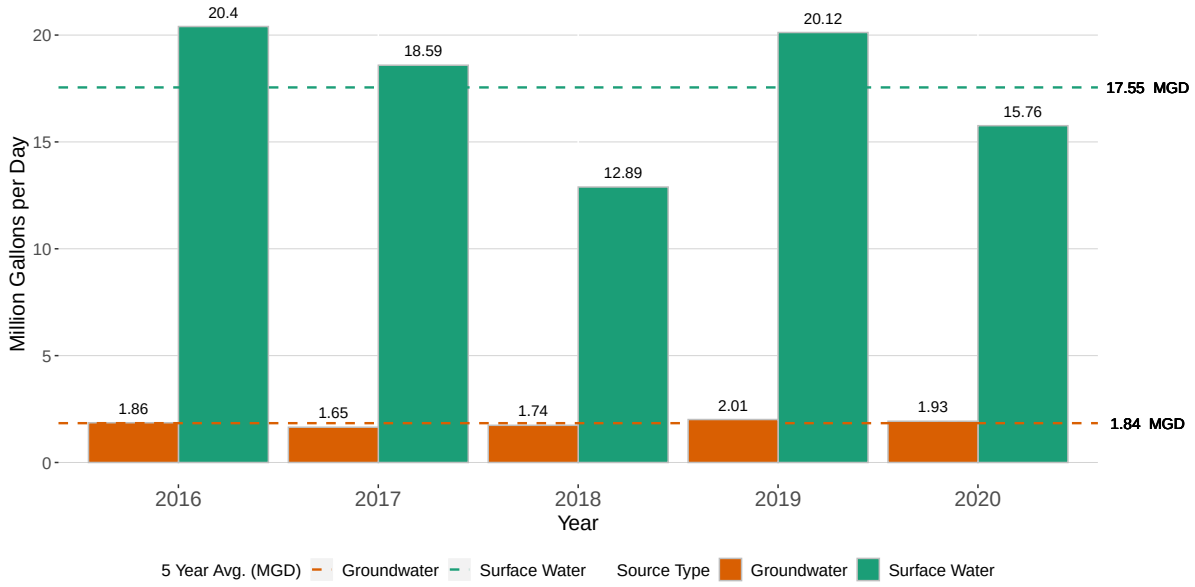

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Table 9: 2016 - 2020 Irrigation Water Withdrawals by Source Type (MGD)

Source Type	2016	2017	2018	2019	2020	5 Year Avg.	% Change 2020 to Avg.
Groundwater	1.86	1.65	1.74	2.01	1.93	1.84	4.9
Surface Water	20.40	18.59	12.89	20.12	15.76	17.55	-10.2
Total (GW + SW)	**22.26**	**20.24**	**14.63**	**22.13**	**17.69**	**19.39**	**-8.8**

Table 10: Highest Reported Irrigation Withdrawals in 2020 (MGD)

Facility	Locality	Type	Major Source	5 Year Avg.	2020 Withdrawal
Arbuckle Farms	Accomack County	SW		2.6	3.3
Dublin Farms Inc.	Accomack County	SW		1.7	2.0
Glenwood Farms	King and Queen County	SW		0.9	1.0
Saunders Brothers, Inc.	Nelson County	SW/GW		1.0	1.0
Garland Gray Forestry Center	Sussex County	SW/GW		0.5	0.8

Commercial Water Withdrawals

Commercial operations include golf courses, universities, hotels, resorts, among others. Figure 22 illustrates the distribution of reported 2020 groundwater and surface water withdrawals for commercial purposes, which are located predominantly near population centers. Reported commercial withdrawals continue to show majority reliance on surface water sources driven largely by golf course and resort irrigation and grounds keeping, as well as for snow making (Figure 23). Reported commercial water withdrawals decreased by 24.4% compared to the five year average (Table 11). The decreased withdrawals may be a result of decreased use of commercial facilities during 2020 due to the COVID-19 pandemic. The five facilities reporting the largest 2020 water withdrawals for commercial operations are listed in Table 12. Water withdrawals from commercial activities make up 0.9% of all non-power generation withdrawals in Virginia.

Figure 22: All 2020 Commercial Water Withdrawals by Withdrawal Point Location

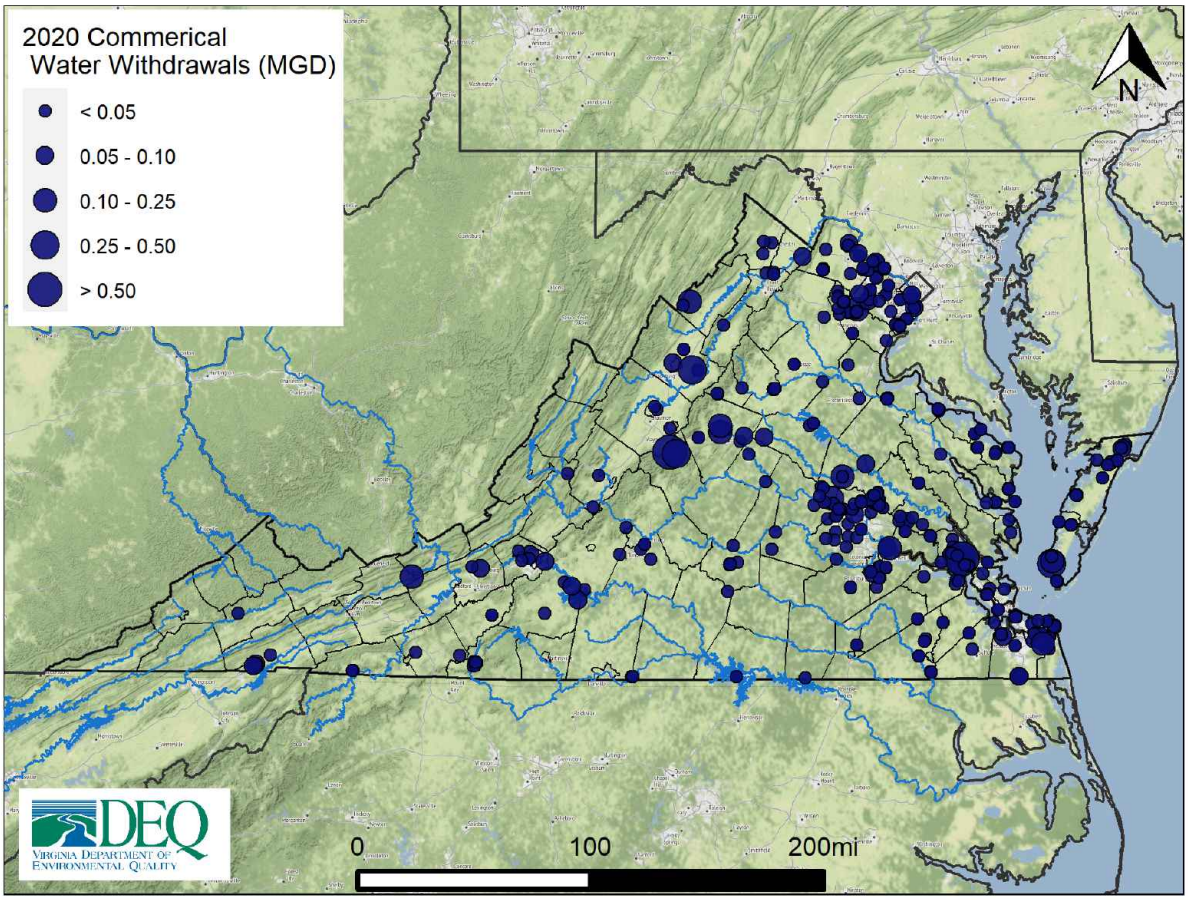

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Table 11: 2016 - 2020 Commercial Water Withdrawals by Source Type (MGD)

Source Type	2016	2017	2018	2019	2020	5 Year Avg.	% Change 2020 to Avg.
Groundwater	5.46	5.37	4.32	4.96	3.99	4.82	-17.2
Surface Water	10.41	9.52	7.98	9.91	6.33	8.83	-28.3
Total (GW + SW)	**15.87**	**14.89**	**12.30**	**14.87**	**10.32**	**13.65**	**-24.4**

Figure 23: 2016-2020 Commercial Water Withdrawals by Source Type

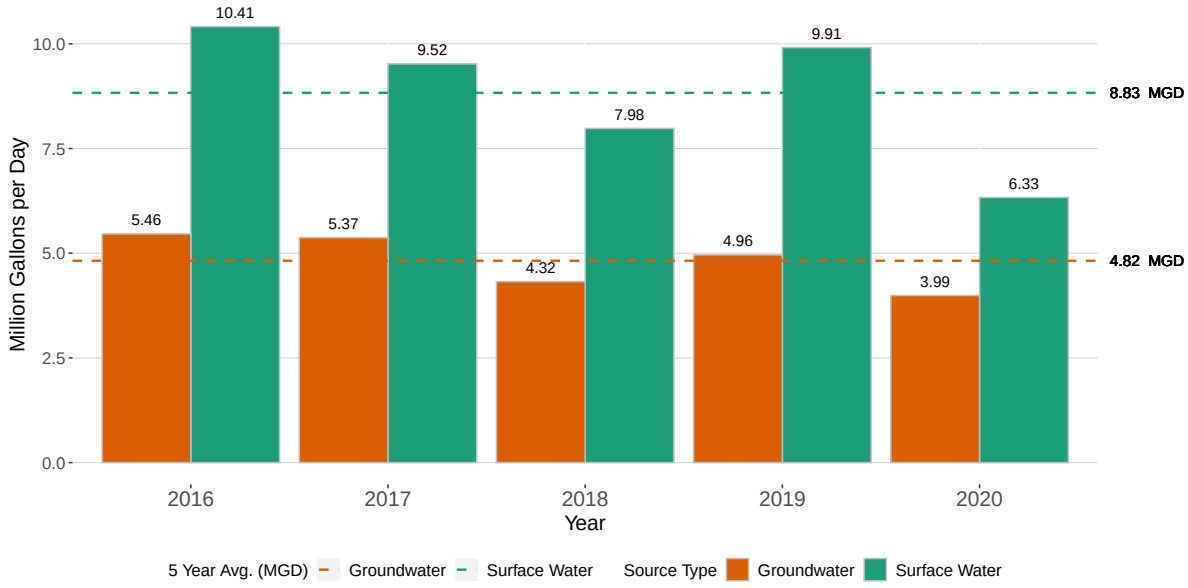

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Table 12: Highest Reported Commercial Withdrawals in 2020 (MGD)

Facility	Locality	Type	Major Source	5 Year Avg.	2020 Withdrawal
Colonial Williamsburg	City of Williamsburg	GW		1.0	0.9
Lake Monacan-Stoney Creek (Wintergreen)	Nelson County	SW		0.9	0.8
Bay Creek Resort & Club	Northampton County	SW		0.5	0.5
Virginia Beach National Golf Course	City of Virginia Beach	SW/GW		0.1	0.3
Massanutten Resort Surface Water Withdrawal Project	Rockingham County	SW		0.3	0.3

Mining Water Withdrawals

Mining includes operations such as sand, rock, and coal mining. Figure 24 illustrates the distribution of reported 2020 groundwater and surface water withdrawals for mining purposes statewide. The majority of stone and sand mining facilities are located along the Interstate 95 corridor. Additional stone and coal mining withdrawals are located in southwestern Virginia. In 2020, the majority of reported withdrawals for mining continued to be from groundwater sources (Figure 25). This is largely due to the dewatering of the water table that must be completed for many types of mining, which is done through wells constructed in the water table. Such withdrawals are reported under groundwater withdrawals. Total reported water withdrawals for mining purposes in 2020 increased by 7.8% as compared to the five-year average (Table 13). The increase in 2020 over the five-year average was largely due to increases from the top five water users. The five facilities reporting the largest 2020 mining withdrawals are listed in Table 14. Water withdrawals from mining operations are 3.0% of all non-power generation withdrawals in Virginia.

Figure 24: All 2020 Mining Water Withdrawals by Withdrawal Point Location

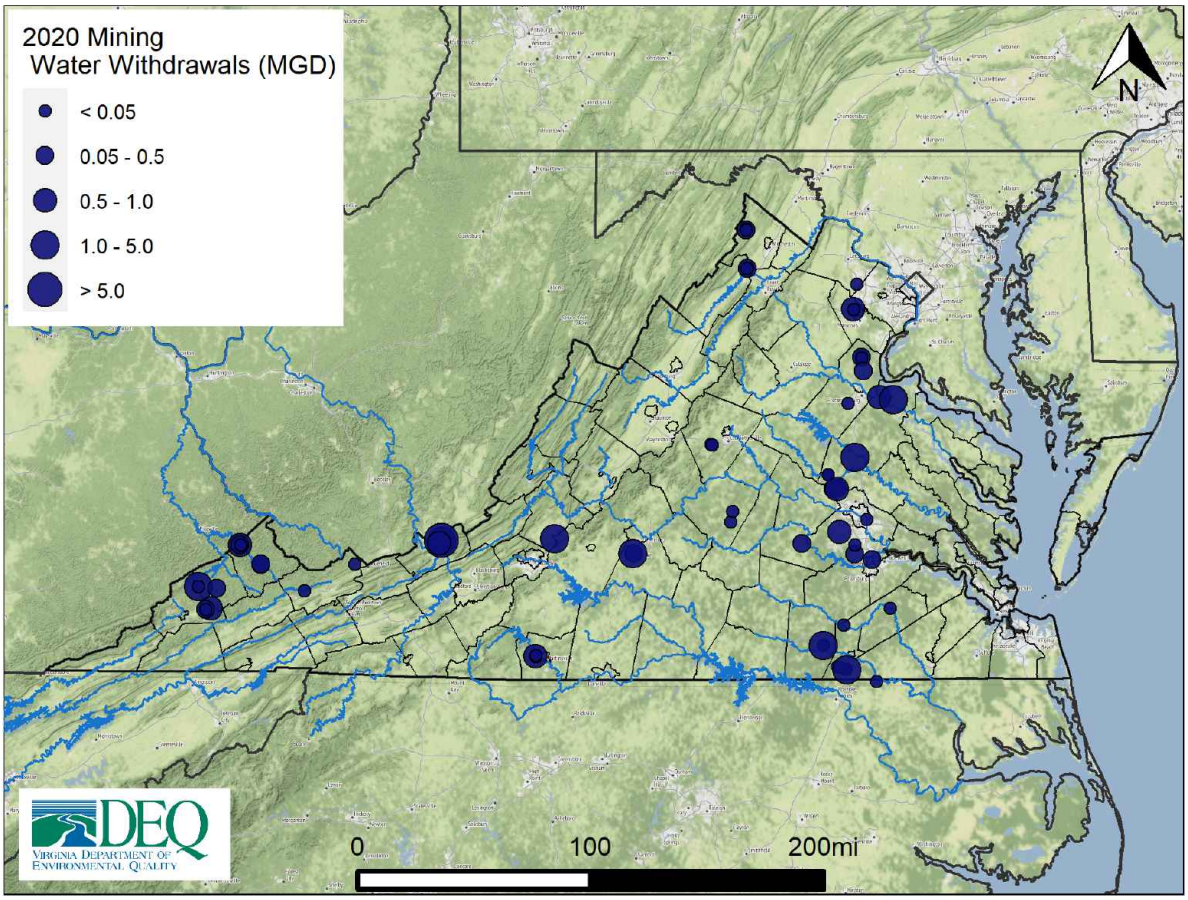

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Figure 25: 2016-2020 Mining Water Withdrawals by Source Type

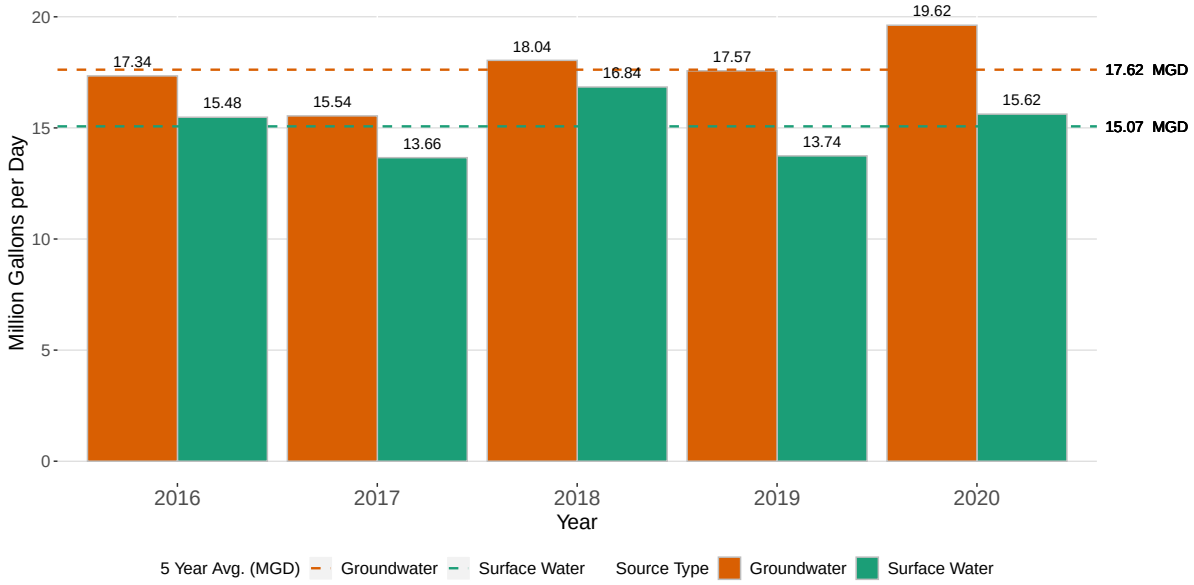

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Table 13: 2016 - 2020 Mining Water Withdrawals by Source Type (MGD)

Source Type	2016	2017	2018	2019	2020	5 Year Avg.	% Change 2020 to Avg.
Groundwater	17.34	15.54	18.04	17.57	19.62	17.62	11.4
Surface Water	15.48	13.66	16.84	13.74	15.62	15.07	3.6
Total (GW + SW)	**32.82**	**29.20**	**34.88**	**31.31**	**35.24**	**32.69**	**7.8**

Table 14: Highest Reported Mining Withdrawals in 2020 (MGD)

Facility	Locality	Type	Major Source	5 Year Avg.	2020 Withdrawal
Lhoist North America: Kimballton Plant 1	Giles County	GW		10.0	12.5
Lhoist North America: Kimballton Plant 2	Giles County	SW/GW		5.6	5.1
Boxley Materials: Blue Ridge Plant	Town of Bedford	GW		2.0	2.1
Vulcan Construction Materials: Lawrenceville Quarry	Brunswick County	SW/GW		1.3	1.7
Doswell Quarry	Hanover County	SW		1.1	1.4

Manufacturing Water Withdrawals

The manufacturing use category includes industrial operations such as chemical and plastics manufacturing, paper mills, food processors, and other industrial withdrawals. Water withdrawals reported in 2020 for manufacturing purposes are spread throughout much of Virginia (Figure 26) as such facilities can be found in both rural and urban areas. The major determining factor for siting manufacturing facilities is access to sufficient quantity and quality of water, whether it be groundwater or surface water. Clusters of large-scale manufacturing withdrawals occur in the Middle James River Basin around the City of Richmond, as well as in the New and the Upper James river basins. Facilities that rely on groundwater are generally located in the Coastal Plain with wells constructed in the productive Potomac Aquifer or along productive fractures in the Western region of the State. All of the locations with large surface water withdrawals are situated on or near major rivers to facilitate water supply.

Figure 26: All 2020 Manufacturing Water Withdrawals by Withdrawal Point Location

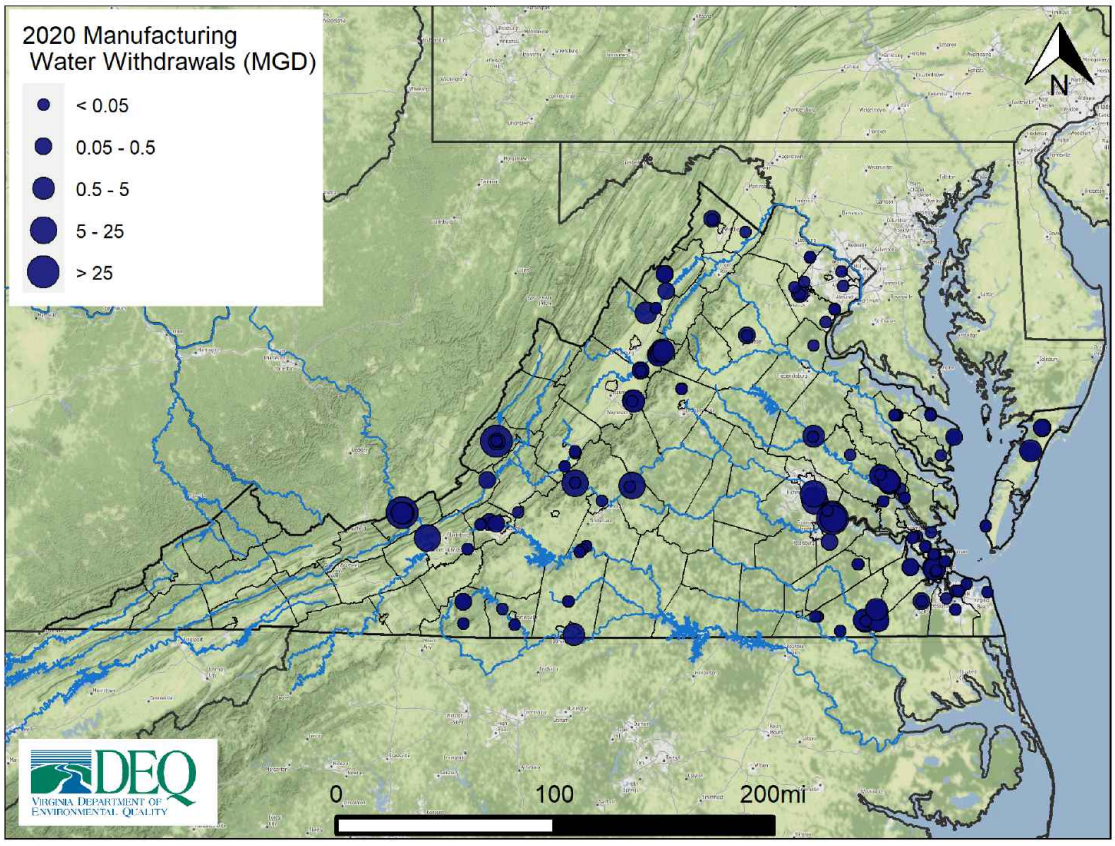

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Figure 27 illustrates the source distribution and annual changes in statewide totals of groundwater and surface water withdrawals for manufacturing from 2016-2020. Reported 2020 withdrawals decreased by 1.5% as compared to the five year average, shown in Table 15. While surface water withdrawals did increase from 2019 to 2020, the overall 5-year trend is a decrease in manufacturing surface water withdrawals. Surface water is the predominate water source type for manufacturing, accounting for approximately 84% of supply in 2020. Water withdrawals from manufacturing users account for 28.47% of all non-power generation withdrawals in Virginia. Table 16 lists the five facilities reporting the largest groundwater withdrawals associated with this category in 2020 and Table 17 lists the facilities reporting the largest surface water withdrawals associated with this category in 2020.

The WestRock West Point Mill Water system was the largest groundwater user reporting 16.1 MGD in groundwater withdrawals in 2020, a slight decrease when compared to the five year average. International

Paper's Franklin Mill reported use of 13.3 MGD in groundwater withdrawals is consistent with the five year average. Celanese Acetate reported 2020 withdrawals of 5.9 MGD, an increase of 1 MGD from the five year average of 4.9 MGD. Merck & Co's Elkton Plant reported 5.7 MGD in groundwater withdrawals in 2020, a slight decrease when compared to the five year average. The LYCRA Company in Waynesboro continues to report increased withdrawals since resuming withdrawals from a previously inactive well in 2017, with a total groundwater withdrawal of 3.8 MGD in 2020.

The AdvanSix Hopewell Plant was the largest reported surface water withdrawal with a 2020 reported withdrawal of 99.1 MGD. This is a decrease compared to the 5 year average of 102.5 and compared to 2019. The Hopewell Plant is the largest reported surface water withdrawal in the Commonwealth when excluding power generation facilities. The Celco Plant in Giles County was the second largest manufacturing surface water withdrawal reporting 53.5 MGD, an increase of 1 MGD when compared to the five year average. The Celco Plant is a unique facility as it reports some of the highest groundwater and surface water withdrawals of its category. WestRock's Covington Plant withdrawals were slightly above the 5 year average with 37.6 MGD compared to the average of 37.5 MGD. The Radford Army Ammunition Plant withdrew 24.0 MGD in 2020, a 6.1 MGD increase over the average, and the highest withdrawal in 10 years. The DuPont Spruance Plant was the only facility in the top 5 with a significant decrease: 22.8 MGD in 2020, compared to 26.4 MGD 5 year average.

Figure 27: 2016-2020 Manufacturing Water Withdrawals by Source Type

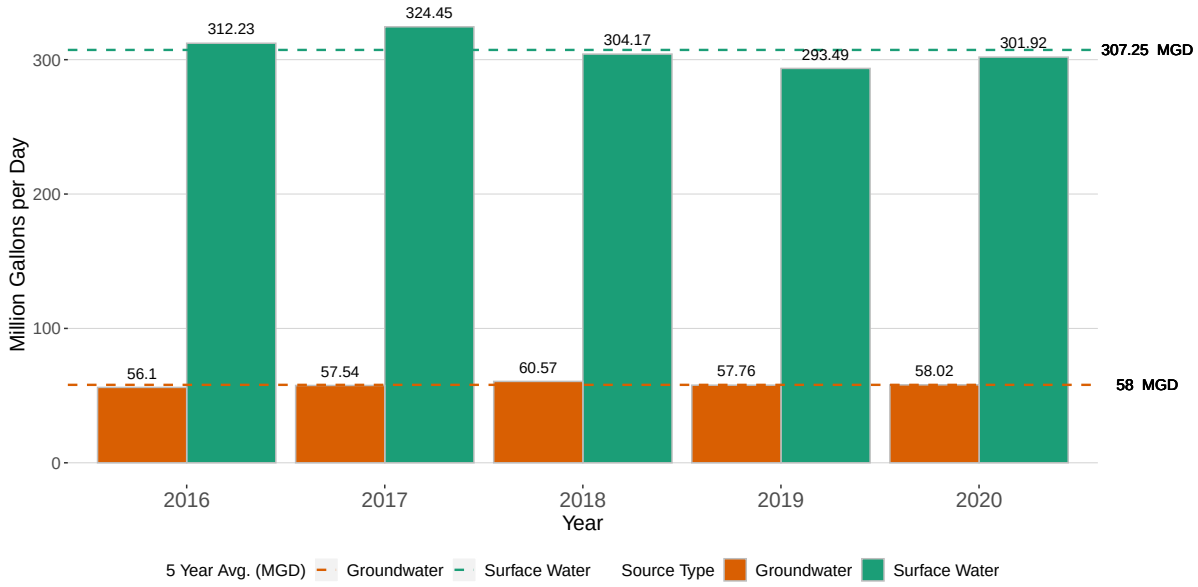

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Table 15: 2016 - 2020 Manufacturing and Industrial Water Withdrawals by Source Type (MGD)

Source Type	2016	2017	2018	2019	2020	5 Year Avg.	% Change 2020 to Avg.
Groundwater	56.10	57.54	60.57	57.76	58.02	58.00	0.0
Surface Water	312.23	324.45	304.17	293.49	301.92	307.25	-1.7
Total (GW + SW)	**368.33**	**381.99**	**364.74**	**351.25**	**359.94**	**365.25**	**-1.5**

Table 16: Highest Reported Manufacturing and Industrial Groundwater Withdrawals in 2020 (MGD)

Facility	Locality	Type	Major Source	5 Year Avg.	2020 Withdrawal
WestRock CP, LLC: West Point Mill Water System	King William County	GW		16.9	16.1
International Paper: Franklin Virginia Mill	Isle of Wight County	GW		13.3	13.3
Celanese Acetate LLC: Celco Plant	Giles County	GW		4.9	5.9
Merck & Co: Elkton Plant	Rockingham County	GW		5.8	5.7
The LYCRA Company: Waynesboro Plant	City of Waynesboro	GW		3.4	3.8

Table 17: Highest Reported Manufacturing and Industrial Surface Water Withdrawals in 2020 (MGD)

Facility	Locality	Type	Major Source	5 Year Avg.	2020 Withdrawal
AdvanSix Resins & Chemicals: Hopewell Plant	City of Hopewell	SW		102.5	99.1
Celco Plant	Giles County	SW		52.5	53.5
Covington Plant WestRock	Alleghany County	SW		37.5	37.6
Radford Army Ammunition Plant	Montgomery County	SW		17.9	24.0
DuPont: Spruance Plant	Chesterfield County	SW		26.4	22.8

Power Generation Water Withdrawals

Water withdrawals for power generation are treated separately than other use types, because most of the water diverted for these purposes is used non-consumptively (see Chapter 2 for a description of non-consumptive water use). Additionally, water diverted for hydropower electric generation is exempted from reporting and is nearly all non-consumptive use; therefore, these flows are generally not reported to the VAHydro database.

The largest power generation facilities are located in central and eastern Virginia, including two nuclear-power generating plants located in Louisa and Surry counties (Figure 28). Groundwater withdrawals reported by power generation facilities in 2020 remain insignificant compared to surface water withdrawals, which is consistent with historical trends (Figure 29). Total power generation withdrawals in 2020 decreased by 6.8% as compared to the five-year average (Table 18). This is largely due to several large fossil power facilities being deactivated or put into cold storage in 2019. Surface water and groundwater withdrawals totaled 4,500 MGD in 2020, which was the third consecutive year of withdrawals under 5,000 MGD. The five power generation facilities with the highest reported withdrawals are listed in Table 19.

Figure 28: All 2020 Power Generation Water Withdrawals by Withdrawal Point Location

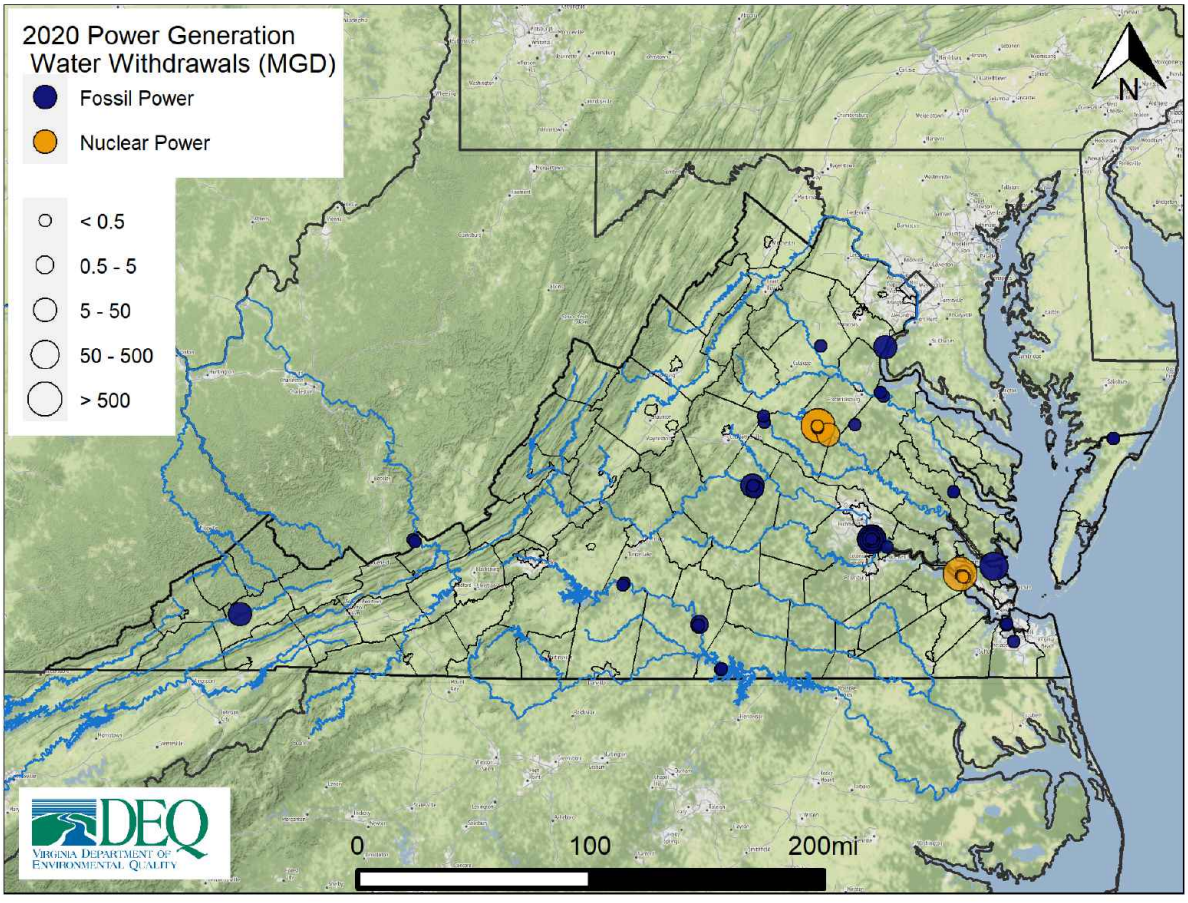

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Figure 29: 2016-2020 Power Generation Water Withdrawals by Source Type

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Table 18: 2016 - 2020 Power Generation Water Withdrawals by Source Type (MGD)

Power Type	2016	2017	2018	2019	2020	5 Year Avg.	% Change 2020 to Avg.
Groundwater							
Fossil	0.07	0.09	0.12	0.07	0.07	0.080	-12.5
Nuclear	0.36	0.32	0.38	0.37	0.35	0.360	-2.8
Total Groundwater	0.43	0.41	0.50	0.44	0.42	0.440	-4.5
Surface Water							
Fossil	1348.99	1102.08	1012.39	752.18	635.84	970.300	-34.5
Nuclear	4021.44	3951.16	3705.29	3739.35	3863.89	3856.230	0.2
Total Surface Water	5370.43	5053.24	4717.68	4491.53	4499.73	4826.530	-6.8
Total (GW + SW)	**5370.86**	**5053.65**	**4718.18**	**4491.97**	**4500.15**	**4826.962**	**-6.8**

Table 19: Highest Reported Power Generation Withdrawals in 2020 (MGD)

Facility	Locality	Type	Major Source	5 Year Avg.	2020 Withdrawal
Surry Power Station	Surry County	SW/GW		1988.3	1955.6
North Anna Nuclear Power Plant	Louisa County	SW/GW		1868.3	1908.6
Chesterfield Power Station	Chesterfield	SW		590.6	415.8
Yorktown Fossil Power Plant	York County	SW		261.6	153.6
Possum Point Power Station	Prince William County	SW		88.4	48.6

Appendix 2: Top 20 Reported Water Withdrawals in 2020 (Excluding Power Generation)

SW: Surface Water, GW: Groundwater, *Permitted Withdrawal, **Unpermitted Withdrawal

Table 20: Top 20 Reported Water Withdrawals in 2020 Excluding Power Generation (MGD)

Facility	Locality	Type	Major Source	5 Year Avg.	2020 Withdrawal	Category
AdvanSix Resins & Chemicals: Hopewell Plant**	City of Hopewell	SW		102.5	99.1	Manufacturing
Fairfax Water: Corbalis WTP**	Fairfax County	SW		90.1	89.3	Municipal
City of Richmond WTP**	City of Richmond	SW		65.5	67.2	Municipal
City of Norfolk Western Branch Reservoir**	City of Suffolk	SW		70.7	64.2	Municipal
Celanese Acetate: Celco Plant**	Giles County	SW/GW		57.4	59.4	Manufacturing
Fairfax Water: Griffith WTP**	Prince William County	SW		63.8	59.2	Municipal
WestRock Virginia Corporation: Covington Plant**	Alleghany County	SW/GW		37.8	38.1	Manufacturing
Appomattox River Water Authority: Chesdin Reservoir WTP*	Chesterfield County	SW		33.6	35.2	Municipal
Radford Army Ammunition Plant**	Montgomery County	SW		17.9	24.0	Manufacturing
Henrico County WTP and Service Area	Henrico County	SW		24.6	23.7	Municipal
Dupont E I De Nemours & Co: Spruance Plant**	Chesterfield County	SW/GW		26.5	23.0	Manufacturing
Virginia American Water: Hopewell District**	City of Hopewell	SW		21.7	21.4	Municipal
City of Newport News: Harwood's Mill WTP**	York County	SW		17.9	17.0	Municipal
City of Portsmouth: Lake Kilby WTP*	City of Suffolk	SW/GW		17.2	16.8	Municipal
WestRock CP LLC: West Point Mill Water System*	King William County	GW		16.9	16.1	Manufacturing
AdvanSix Resins & Chemicals: Chesterfield Plant**	Chesterfield County	SW		20.1	16.0	Manufacturing
International Paper Company: Franklin Virginia Mill*	Isle of Wight County	SW/GW		15.6	15.7	Manufacturing
Georgia-Pacific Big Island WTP**	Town of Bedford	SW/GW		14.6	15.2	Manufacturing
City of Virginia Beach Service Area**	City of Virginia Beach	SW		24.7	14.6	Municipal
City of Manassas WTP**	City of Manassas	SW		12.7	13.2	Municipal

Appendix 3: Water Withdrawals Within Localities in 2020 (MGD) (Excluding Power Generation)

Table 21, shown below, lists the reported water withdrawals, both permitted and unpermitted, that occurred in 2020 within individual localities.

Table 21: Water Withdrawals Within Localities in 2020 (MGD)

Locality	GW Withdrawal	SW Withdrawal	GW + SW Total	% of Total Withdrawal
Accomack	5.19	5.60	10.79	0.91
Albemarle	0.06	10.36	10.42	0.88
Alexandria City	0.00	0.00	0.00	0.00
Alleghany	0.47	38.91	39.38	3.33
Amelia	0.23	0.11	0.34	0.03
Amherst	0.00	18.09	18.10	1.53
Appomattox	0.00	0.00	0.00	0.00
Arlington	0.01	0.07	0.08	0.01
Augusta	3.23	6.59	9.82	0.83
Bath	0.15	13.04	13.19	1.12
Bedford	2.19	17.86	20.05	1.70
Bedford Town	0.00	0.00	0.00	0.00
Bland	0.06	0.17	0.23	0.02
Botetourt	0.69	0.10	0.79	0.07
Bristol City	0.00	0.00	0.00	0.00
Brunswick	0.03	2.67	2.70	0.23
Buchanan	0.27	0.91	1.17	0.10
Buckingham	0.00	0.39	0.39	0.03
Buena Vista City	1.20	0.02	1.23	0.10
Campbell	0.08	6.22	6.30	0.53
Caroline	1.34	1.85	3.19	0.27
Carroll	0.18	0.30	0.48	0.04
Charles City	0.06	0.54	0.60	0.05
Charlotte	0.15	0.10	0.25	0.02
Charlottesville City	0.00	0.00	0.00	0.00
Chesapeake City	3.70	2.93	6.63	0.56
Chesterfield	0.44	85.16	85.60	7.25
Clarke	0.06	0.61	0.67	0.06
Clifton Forge City	0.00	0.00	0.00	0.00
Colonial Heights City	0.00	0.00	0.00	0.00
Covington City	0.00	2.79	2.79	0.24
Craig	0.08	3.96	4.04	0.34
Culpeper	0.95	1.65	2.60	0.22
Cumberland	0.01	0.04	0.05	0.00
Danville City	0.00	5.18	5.18	0.44
Dickenson	0.11	6.33	6.43	0.54
Dinwiddie	0.03	0.15	0.18	0.02
Emporia City	0.00	0.91	0.91	0.08
Essex	0.32	0.59	0.92	0.08
Fairfax	0.20	89.84	90.04	7.62
Fairfax City	0.01	0.01	0.02	0.00

Falls Church City	0.00	0.00	0.00	0.00
Fauquier	1.81	1.18	2.99	0.25
Floyd	0.10	0.09	0.20	0.02
Fluvanna	0.14	0.70	0.84	0.07
Franklin	0.15	0.94	1.09	0.09
Franklin City	0.90	0.00	0.90	0.08
Frederick	1.66	5.67	7.34	0.62
Fredericksburg City	0.00	0.01	0.01	0.00
Galax City	0.00	1.72	1.72	0.15
Giles	24.10	54.06	78.17	6.62
Gloucester	0.65	0.69	1.34	0.11
Goochland	0.09	2.10	2.20	0.19
Grayson	0.15	0.05	0.20	0.02
Greene	0.02	0.69	0.71	0.06
Greensville	0.03	4.40	4.43	0.37
Halifax	0.10	1.72	1.82	0.15
Hampton City	0.02	0.01	0.03	0.00
Hanover	0.67	4.86	5.53	0.47
Harrisonburg City	0.00	0.05	0.05	0.00
Henrico	0.01	24.11	24.11	2.04
Henry	0.01	3.75	3.77	0.32
Highland	0.05	4.41	4.47	0.38
Hopewell City	0.00	131.23	131.23	11.11
Isle of Wight	15.89	2.85	18.74	1.59
James City	5.17	9.21	14.38	1.22
King George	1.38	1.56	2.94	0.25
King William	16.77	0.50	17.27	1.46
King and Queen	0.01	1.10	1.11	0.09
Lancaster	0.42	0.00	0.42	0.04
Lee	0.00	2.42	2.42	0.20
Lexington City	0.00	0.00	0.00	0.00
Loudoun	1.49	13.19	14.68	1.24
Louisa	0.20	0.42	0.62	0.05
Lunenburg	0.00	0.58	0.58	0.05
Lynchburg City	0.01	0.00	0.01	0.00
Madison	0.04	0.08	0.13	0.01
Manassas City	0.29	13.17	13.46	1.14
Manassas Park City	0.00	0.00	0.00	0.00
Martinsville City	0.00	1.72	1.72	0.15
Mathews	0.01	0.00	0.01	0.00
Mecklenburg	0.12	1.75	1.87	0.16
Middlesex	0.23	0.09	0.32	0.03
Montgomery	0.14	30.54	30.68	2.60
Nelson	0.12	2.60	2.72	0.23
New Kent	0.86	8.05	8.91	0.75
Newport News City	0.15	6.46	6.61	0.56
Norfolk City	0.04	1.84	1.88	0.16
Northampton	1.15	0.94	2.09	0.18
Northumberland	0.32	0.02	0.35	0.03
Norton City	0.00	0.75	0.75	0.06

Nottoway	0.04	1.01	1.06	0.09
Orange	0.03	1.88	1.91	0.16
Page	1.02	0.78	1.79	0.15
Patrick	0.09	0.71	0.80	0.07
Petersburg City	0.00	0.01	0.01	0.00
Pittsylvania	0.00	1.50	1.50	0.13
Poquoson City	0.00	0.00	0.00	0.00
Portsmouth City	0.13	0.00	0.13	0.01
Powhatan	0.09	0.09	0.18	0.02
Prince Edward	0.05	0.90	0.95	0.08
Prince George	0.25	0.19	0.44	0.04
Prince William	0.33	60.92	61.24	5.18
Pulaski	0.00	4.65	4.65	0.39
Radford City	0.00	2.89	2.89	0.24
Rappahannock	0.03	0.00	0.03	0.00
Richmond County	0.31	0.00	0.31	0.03
Richmond City	0.17	67.27	67.44	5.71
Roanoke	1.21	13.28	14.49	1.23
Roanoke City	1.12	12.30	13.41	1.14
Rockbridge	0.31	1.30	1.60	0.14
Rockingham	14.76	9.16	23.92	2.02
Russell	0.49	0.59	1.08	0.09
Salem City	1.62	2.25	3.88	0.33
Scott	0.08	1.23	1.32	0.11
Shenandoah	2.99	1.82	4.81	0.41
Smyth	0.78	5.70	6.48	0.55
South Boston City	0.00	0.00	0.00	0.00
Southampton	3.21	0.24	3.45	0.29
Spotsylvania	0.19	12.23	12.41	1.05
Stafford	0.00	14.80	14.80	1.25
Staunton City	0.00	0.00	0.00	0.00
Suffolk City	5.14	83.35	88.49	7.49
Surry	0.24	0.15	0.39	0.03
Sussex	1.00	0.83	1.83	0.16
Tazewell	0.00	4.54	4.54	0.38
Virginia Beach City	0.39	14.75	15.14	1.28
Warren	0.12	7.80	7.92	0.67
Washington	0.09	9.41	9.50	0.80
Waynesboro City	4.86	1.29	6.15	0.52
Westmoreland	0.94	0.70	1.64	0.14
Williamsburg City	0.96	0.00	0.96	0.08
Winchester City	0.00	0.00	0.00	0.00
Wise	0.00	6.59	6.60	0.56
Wythe	0.00	8.22	8.23	0.70
York	0.33	19.31	19.64	1.66
Total	**140.37**	**1040.99**	**1181.37**	**100.00**

Appendix 4: Water Resources Information and Climactic Conditions

State Population
(2010 census) – 8,001,025
(2020 Weldon Cooper Center Estimate[24]) – 8,586,967

State Surface Area – 42,775 square miles (39,490 sq. miles total land area, 3,285 sq. miles inland waters)

Major River Basins (with Current Estimates of Annual Mean River Flow):
- Tennessee-Big Sandy (4,132 sq. miles, 3,225 MGD)
- Albemarle Sound-Chowan River (4,252 sq. miles, 1,748 MGD)
- James (10,236 square miles, 5,501 MGD)
- New (3,068 square miles, 3,304 MGD)
- Rappahannock (2,714 square miles, 1,100 MGD)
- Roanoke (6,274 square miles, 5,120 MGD)
- Shenandoah (3,041 sq. miles, 1,797 MGD)
- Chesapeake Bay-Small Coastal (3,157 sq. miles, 97 MGD)
- York (2,669 square miles, 1,060 MGD)

Total Non-tidal River/Stream Miles - 100,927 (This estimate represents mileage determined by the USGS National Hydrography Dataset)

Publicly-Owned Lakes and Reservoirs
There are 248 publicly-owned lakes in the Commonwealth:

Larger than 5,000 acres -	5	109,838 acres
Smaller than 5,000 acres -	243	52,392 acres
Total -	248	162,230 acres

Additionally, hundreds of small privately-owned lakes and ponds are distributed throughout the state.

Freshwater Wetlands - 808,000 acres

Tidal and Coastal Wetlands - 236,900 acres

Estuary (excluding small coastal areas) - 2,308 sq. miles

Atlantic Ocean Coastline - 120 Miles

Statewide Average Annual Rainfall – 44.3 inches

Average Freshwater Discharge of All Rivers - Approximately 22,850 MGD

Average Freshwater Discharge into the Chesapeake Bay – Approximately 9,500 MGD

Climatic Conditions: As of September 30, 2021, precipitation for the water year beginning October 1, 2020 was near-normal to above-normal throughout Virginia, except for parts of Augusta, Highland and Rockingham counties. Stream flows at most gauging stations and groundwater levels in nearly all Climate Response Network observation wells were within normal levels. Major water supply storage reservoirs maintained water levels within normal ranges.

[24]University of Virginia Weldon Cooper Center, Demographic Research Group. (2020). Virginia Population Estimates. Retrieved from https://demographics.coopercenter.org/virginia-population-estimates.

Appendix 5: Water Transfers

Water use is tracked in VAHydro's Water Withdrawal Reporting module by recording different actions, identified as follows:

- WL = Withdrawal
- RL = Release
- DL = Delivery
- SR = System Release
- SD = System Delivery

In general, withdrawals from a water source (groundwater or surface water) account for the largest portion of a locality's actual water use. Water can also be transferred, or sold, both within a water system and between water purveyors and water users. "System release" and "system delivery" records established in VAHydro refer to situations where both the water treatment plant and the service area are owned and operated by the same waterworks entity. System release records contain data regarding the amounts of water released from a water treatment facility to a service area within a particular water system. System delivery records contain data about water received within a particular service area from, for example, a water treatment plant. Water is generally "released from" or, sold to, a water treatment plant, and "delivered to," or purchased by, a service area, or water distribution system.

In addition to system releases and system deliveries within their own water treatment and distribution systems, some entities report the sale or purchase of water to/from a customer outside of their own system as well as system releases and deliveries. These transactions are established in VAHydro as "releases" to outside customers and "deliveries" of water from another outside customer.

Currently, not all water transfers are consistently reported to VAHydro, in part because many systems lack the technology necessary to track water transfers that closely. For example, in several instances, there are localities that have reported water releases (RL), but there are no corresponding records indicating the water has been received and used by another locality (DL) or entity. Some entities reportedly sell water (RL), but have no reported means of receiving water (WL, DL, or SR). Improvements in the way DEQ tracks the transfer of water, both within systems and between entities, are important to understanding the extent of water loss due to aging infrastructure, as an example, or other factors and can have a significant impact on water resource planning.