A REPORT TO

THE HONORABLE RALPH S. NORTHAM, GOVERNOR,

AND

THE GENERAL ASSEMBLY OF VIRGINIA

STATUS OF VIRGINIA'S WATER RESOURCES

A REPORT ON VIRGINIA'S WATER RESOURCES MANAGEMENT ACTIVITIES

Virginia Department of Environmental Quality
COMMONWEALTH OF VIRGINIA

OCTOBER 2020

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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
TMDL: Total Maximum Daily Load
USACE: United States Army Corps of Engineers
USEPA: U.S. 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: Water Use Data and Research Program (USGS)
WWTP: Waste Water Treatment Plant

Executive Summary

The Report on Virginia's Water Resources Management Activities (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 focuses on water quantity and supply, summarizing reported water withdrawals for the 2019 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 next State Water Resources Plan is expected to be published in 2020.

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

State Water Resources Plan

The State Water Resources Plan (State Plan), finalized and released to the public in October 2015, identified potential areas of water availability concern within the state as well as challenges for future water resources management and recommendations for action. An update on several of these challenges is provided in Chapter 4 of this report. In 2019, DEQ began development of the 2020 State Plan. This included significant organization and review of data, as well as development of new and improved systems and techniques to support existing cumulative impact modeling. The 2020 State Plan as a whole will build upon the 2015 State Plan with significant refinement of nearly every aspect of the original including: updated water demand projections and water withdrawal/discharge data, improved spatial information on withdrawals and discharges, more robust cumulative impact analysis modeling, and three climate change scenarios. Additionally, each major river basin has been further subdivided into minor basins for modeling and analysis purposes, with the end result being a higher resolution product that will provide a more detailed and localized picture 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.

Data analysis conducted during the 2020 State Plan development predicts a net increase of approximately 20% in daily water demands between 2020 and 2040. This highlights the importance of evaluating water supply statewide and determining where current supplies may be insufficient, one of the major objectives of the State Plan. The next step in the State Plan development process is conducting outreach to stakeholders to solicit input on other content that may be beneficial in informing future planning processes. In 2023, new local and regional Water Supply Plans are required to be submitted. The State Plan will provide a critical resource to support these efforts, allowing planning decisions to be based on a public repository of the most current water use data, water use projections, and state of the art resource modeling evaluations for both surface water and groundwater within Virginia.

Coastal Plain Aquifer Systems

DEQ continues to work with permitted groundwater withdrawal facilities within the Eastern Virginia and Eastern Shore Groundwater Management Areas to decrease withdrawals, increase system efficiencies, identify alternate sources of water, and to investigate other innovative ways to increase supplies in order to maintain groundwater productivity and availability over the next fifty years and beyond. Nevertheless the capacity to issue or reissue permits in some areas of the Coastal Plain, particularly around large industrial or municipal withdrawals, remains limited. Applicants seeking a groundwater withdrawal from confined coastal plain aquifers must justify their need for high-quality groundwater over other available alternative sources such as surface water, reuse, or lower-quality groundwater from other aquifers, including the surficial aquifer. Many of the largest groundwater users have recently made significant reductions in their permit limits as they work towards available alternatives. However, as population grows throughout the Commonwealth each year, new demands are added to the aquifer systems in turn. In particular, individual private self-supplied groundwater withdrawals that are largely unpermitted continue to grow and potentially offset the progress made in reducing permitted groundwater withdrawals. It is critical to continue efforts to address these and

other unpermitted groundwater withdrawals, as well as to promote and incentivize alternatives, including lower quality groundwater from shallow or unconfined aquifers, through a variety of means. The efforts DEQ is making in these areas are covered in more detail in Chapter 4 of this report. However several examples are discussed in brief in this section.

One of the first hurdles to addressing unpermitted withdrawals is the identification of them. DEQ continued its ongoing efforts to identify, permit, or register unpermitted groundwater withdrawals in 2019. Staff reviewed permit applications for a number of unpermitted groundwater users originally identified through a 2017 outreach initiative. This included a group of 56 poultry facilities in Accomack County. In 2018, the State Water Control Board (SWCB) approved Consent Special Orders (CSOs) for these 56 poultry facilities. The CSOs provided temporary authorization to withdraw groundwater while requiring the submission of a groundwater withdrawal permit application, metering, and reporting of water use. Throughout 2019, DEQ worked with these facilities to complete the permitting process and permits were approved by the State Water Control Board for 45 of the original 56 facilities in December, 2019. The remaining facilities were determined to be operating below the permit threshold requirement or to have discontinued operation. DEQ continues to process applications from several other facilities identified during these outreach efforts, including schools, universities, and crop irrigation facilities.

Evaluating the use of lower quality groundwater from shallow aquifers or the unconfined surficial aquifer (commonly known as the water table) in lieu of higher quality groundwater from confined aquifers remains a key requirement in any application for a Groundwater Withdrawal Permit. In many areas of the Commonwealth, the surficial aquifer can provide a viable alternative and due to its higher recharge rate is less susceptible to overuse. DEQ is currently working to implement two pieces of legislation enacted following the 2019 and 2020 General Assembly sessions which are intended to increase use of the surficial aquifer (2019 Va. Acts Ch. 755 and 2020 Va. Acts Ch. 670). See Chapter 4 for more details on these bills.

Groundwater withdrawal reductions are not the only method to address the resource issue. The Hampton Roads Sanitation District's (HRSD) Sustainable Water Initiative for Tomorrow (SWIFT) project proposes to reverse groundwater declines through direct injection of highly treated water into the Potomac Aquifer. As of summer of 2020, the SWIFT water treatment project has successfully injected 328 million gallons of treated water into the Potomac Aquifer, with plans to expand the project by constructing additional injection facilities. However, as the project is still in the pilot phase, the ultimate benefits of large-scale injection may not be known for a decade or more. DEQ continues to consult with and support HRSD; the pursuit of this project and others like it is another key recommendation made by the Eastern Virginia Groundwater Management Advisory Committee.

Water Withdrawals

In calendar year 2019, 1,249 facilities reported water withdrawals. The total volume of reported withdrawals from all water use categories (including fossil-fuel and nuclear power generation) was approximately 5.72 billion gallons. When excluding withdrawals for power generation, the total volume of reported withdrawals was approximately 1.23 billion gallons per day, a decrease of approximately 0.4% when compared to the five-year average. Note that withdrawals associated with power generation are often excluded throughout this report as they are largely non-consumptive (the withdrawal is discharged back to the same source at near the same quantity). Nuclear and fossil fuel power plants make up the majority of users within this category, and are addressed separately in the Power Generation section in Appendix 4.

Surface water withdrawals accounted for approximately 89% of total withdrawal volumes in 2019 (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 of surface water withdrawals with 727.31 MGD withdrawn. Irrigation facilities reported the largest increase (5.5%) in surface water withdrawal reporting when compared to the five-year average. The largest surface water withdrawals by volume occurred within the Richmond, Hampton Roads, and Washington D.C. metro areas, and within Giles County. Total reported surface water withdrawals declined when compared to the five-year average, decreasing by 1%.

Groundwater withdrawals accounted for approximately 11% of total withdrawal volumes in 2019 with 139.26 MGD withdrawn. Manufacturing & industrial uses continued to report the largest total withdrawal of groundwater statewide in 2019 (57.73 MGD), an 1.8% increase compared to the five-year average. In 2019, groundwater withdrawals for agricultural uses showed the largest reported increase of any category, with a 56.2% increase in groundwater withdrawals compared to the five-year average. This is largely the result of the increased reporting from poultry operations on the Eastern Shore discussed above. Analysis of the spatial distribution of 2019 groundwater withdrawals show the largest groundwater withdrawals by volume occurred in the Coastal Plain and along the Valley and Ridge, particularly in the Shenandoah Valley and Giles County. Total reported groundwater withdrawals increased by approximately 3.9% compared to the five-year average, largely driven by the increases in reporting from newly permitted agricultural facilities on the Eastern Shore.

In 2019, unpermitted withdrawals represented approximately 72% of the total reported withdrawals in Virginia. The majority of reported groundwater withdrawals (52%) are from users operating under a Groundwater Withdrawal Permit. This is consistent with the 2018 result but represents an increase of 8% from the percentage of total groundwater withdrawals originating from permitted users in 2016 (44%). Approximately 75% of the total surface water withdrawn in Virginia is associated with unpermitted users, which has remained largely consistent across reporting years.

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 discharge data is critical to the operation of all DEQ water supply programs. Details regarding each program area are provided in Chapter 1. The DEQ Water Supply and Water Quantity webpage provides additional information.

The Report on Virginia's Water Resources Management Activities (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 2019 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 2019 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.

[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 "2019 water year."

1 2019 Water Resources Management Updates

The Commonwealth of Virginia has for decades enjoyed a robust economy and an increasing population drawn by the many opportunities the State offers. 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, 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.

DEQ's mission is "to protect and enhance Virginia's environment, and promote the health and well-being of the citizens of the Commonwealth." To that end, DEQ works to identify, quantify, and manage current and future risks to the availability and productivity of Virginia's water resources.

Chapter 4 of this report, Water Resource Challenges and Priorities, provides an overview of several "hot topics" in water resource management including new legislation, research, and other developments. Additionally, this section covers several key resource challenges and updates on how DEQ is working to address those challenges.

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 2019. The DEQ Water Supply and Quantity webpage provides additional information on these programs.

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 (Figure 1) for consistency with the regulations, completing the compliance evaluation process with the issuance of final compliance determinations to all planning partners in late 2013.

The water supply plans formed the basis of the 2015 State Water Resources Plan (State Plan), which staff began developing concurrent with the plan review process. Published in October 2015, the State Plan was the first of its kind in Virginia and is the primary planning mechanism for achieving sustainable water supplies for the future. It includes the results of a cumulative impact analysis conducted using data from the plans and water withdrawal data submitted by individual users under the Water Withdrawal Reporting Regulation[3]. The State Plan also describes supply challenges facing the Commonwealth through 2040 and makes recommendations for addressing those challenges. The State Plan is updated every five years following reviews or resubmittals of the local and regional water supply plans

DEQ is currently developing the 2020 version of the State Plan with publication expected in late 2020. In 2018, all localities in Virginia: 38 cities, 95 counties, and 190 towns (323 in total), reviewed their water supply plans and addressed compliance conditions by the required five year review deadline. The information submitted by localities in 2018 is being used to prepare the State Plan Update. In addition, the 2020 State

[2] 9VAC25-780-10 et seq.
[3] 9VAC25-200-10 et seq.

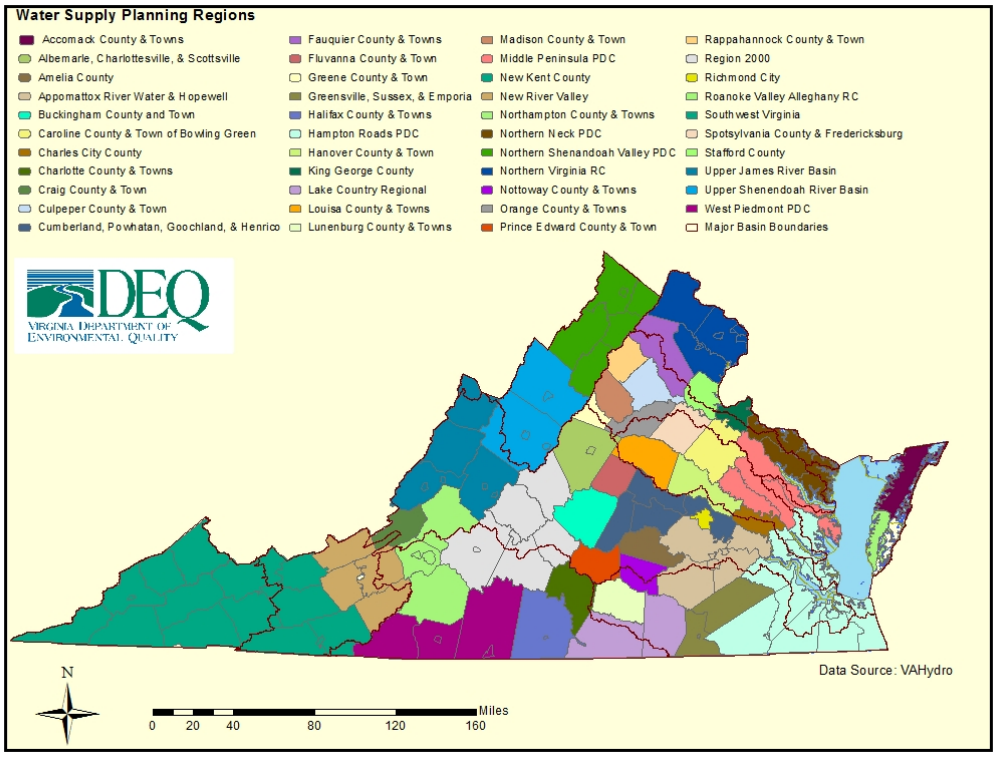

Figure 1: Water Supply Planning Regions according to 2011 submittals, with major river basins delineated

Plan will include enhanced cumulative impact analysis modeling conducted at the minor basin level[4], as well as detailed summaries for each of the 21 minor basins on existing sources, demand projections, water use trends, and modeling results.

The State Plan is accessible through DEQ's website and is subject to periodic revision as DEQ, localities, and other stakeholders provide information through ongoing water supply planning efforts. Information provided by localities via VAHydro, a web-based, interactive platform, provides the basis for more efficient data collection and analysis, which in turn, will continue to improve DEQ's understanding of the Commonwealth's water resources and any associated management risks. 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 2). The goal for VAHydro is to give localities and regional stakeholders the ability to use up-to-date water supply planning data to inform decision making in every day local and regional water management efforts.

DEQ staff have continued working in cooperation with the United States Geological Survey (USGS) and the Virginia Tech Department of Biological Systems Engineering on several cooperative science projects that will inform DEQ's cumulative impact analysis modeling. The primary focus of the past two years has centered on developing a method to relate widely available hydrologic and ecological monitoring data. DEQ's approach combines state planning and reporting databases, multiple river and habitat models, and biometric assessment of fish and benthic monitoring data to develop a more geo-spatially specific understanding of the

[4]The nine major river basins within Virginia are further divided into 21 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.

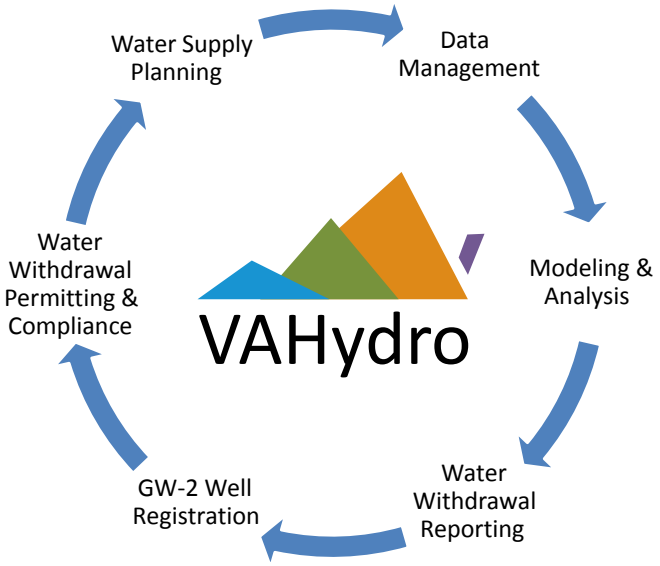

Figure 2: Modules within VAHydro

relative risk to aquatic life resulting from surface water withdrawals in Virginia. Two professional papers outlining project methods, results and potential management implications were accepted for publication in the Journal of the American Water Resources Association.

A second project has focused on consumptive use data transfer and analysis, funded by a grant from the USGS Water Use Data and Research (WUDR) Program and DEQ's ongoing collaboration with Virginia Tech. Primary objectives include the development of a suite of tools to transfer data on water withdrawal, discharge, and consumptive use between the National Pollutant Discharge Elimination System (NPDES), VAHydro, and USGS National Water Information System (NWIS) databases. This project was completed in June of 2020. DEQ uses this data to analyze trends in consumptive use over time and across different user categories, and to develop predictive models of consumptive use for categories of use for which limited data on consumptive use is available. This information was integrated into the cumulative impact modeling associated with the 2020 State Plan to better account for consumptive use. This information is critical to create an accurate surface water budget and to determine water availability in different locations across the Commonwealth.

The DEQ partnership with Virginia Tech also developed an automated "hydrologic analysis toolkit" to perform model error analysis (MEA), and complete cumulative impacts analysis (CIA) for use in permitting and water supply planning throughout Virginia. In 2019-2020 DEQ applied the hydrologic analysis toolkit for modeling several water supply scenarios (including current 2020 and future 2040 conditions) in preparation for the 2020 State Plan. Three climate change model scenarios were received from the USGS modeling team in the fall of 2019. These three scenarios were chosen to represent an upper, lower, and medium range of likely changes to the water budget based on the best available down-scaled global climate models. A review of climate change model scenarios using the model accuracy toolkit has been completed, with results to be presented in the 2020 State Plan.

Additional water supply modeling enhancements developed over the past year include an expanded modeling time span, as well as higher resolution water withdrawal intake locations for water supply planning. The 2020 model is built on a rainfall-temperature-runoff (RTR) time-series which runs from January 1, 1984 to

December 31, 2014 in the Chesapeake Bay watershed drainage, a significant advancement over the previous model time span January 1, 1984 to December 31, 2005. Extensive efforts by DEQ staff were undertaken over the past year to integrated water supply planning datasets with annual reporting and permitting components in VAHydro. This resulted in improved spatial accuracy of withdrawal locations, which allows DEQ to analyze current and projected impacts in HUC10 sub-watersheds, a 10 fold increase in resolution over analyses in the 2015 State Plan. These efforts also facilitated modeling monthly use patterns based on historical reported data. These data integration efforts will continue going forward, ensuring localities will have the most up to date reporting data to use in their assessment of current demands, and projection of future trends in water use.

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 2019 data are provided in Appendices 3 and 4.

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 2019. Livestock producers with permits for animal waste management were contacted and registered for reporting if their water withdrawals are estimated to meet or exceed the reporting threshold. Additionally, outreach to industry stakeholders resulted in an additional 25 poultry facilities that will be contacted and registered to report annual water withdrawals. 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[5], Virginia manages groundwater through a permit program regulating the withdrawal of groundwater in certain areas designated as Groundwater Management Areas (GWMA). Currently, there are two GWMAs in the state (Figure 3). The Eastern Virginia GWMA comprises all areas east of Interstate 95 and west of the Chesapeake Bay and Atlantic 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.

[5]Va. Code § 62.1-254 et seq.

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[6]. 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 withdrawals, overlapping cones of depression[7], and declining water levels in the Coastal Plain aquifer system led the SWCB to expand[8] 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[9] 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 11 of the existing user applicants did not require permits since the facilities' withdrawals remained under the 300,000 gallon per month level. Existing agency resources allowed for the issuance of 32 existing user permits in 2015, 22 existing user permits in 2016, 22 existing user permits in 2017, and 26 existing user permits during 2018. Five additional existing user permits were issued during 2019 resulting in a total of 107 permits issued. Three 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 107 issued existing user permits is approximately 2.54 billion gallons per year (BGY), which equates to an annualized average daily withdrawal rate of 6.95 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 June 5, 2020, administers a total of 370 groundwater withdrawal permits, including those issued to existing users. These users are authorized to withdraw a combined total of approximately 46.3 BGY, which equates to an annual average withdrawal rate of 127 MGD. Since the beginning of 2019, a total of 62 groundwater withdrawal permits have been issued. Of these, three were reissuances of previously permitted facilities within the boundaries of the original Eastern Virginia GWMA. A complete list of all active groundwater permits can be found at Groundwater Withdrawal Permitting (GWP) Program and Active Permits.

The Virginia Coastal Plain Groundwater Initiative was developed in response to an ongoing and long-term decline of groundwater levels, and growing concerns about land subsidence and salt water intrusion in the confined Coastal Plain aquifer system. In order to achieve the goal of protecting the aquifer system and providing for current and future water needs for the Commonwealth, DEQ identified and negotiated potential reductions in water withdrawals with the largest 14 groundwater users in the Eastern Virginia GWMA, which, if implemented could begin stabilizing the groundwater level declines in the confined aquifers. Combined, these users represented approximately 80% of all permitted groundwater withdrawals within the Eastern Virginia GWMA. New permits were issued to all 14 users that, over their 10-year permit term, reduce their combined, non-drought maximum annual permitted withdrawal volumes by approximately 52%.

[6] Va. Code §§ 62.1-44.15:20 through 62.1-44.15:23.1.

[7] "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.

[8] 9VAC25-600-20.

[9] 9VAC25-610-10 et seq.

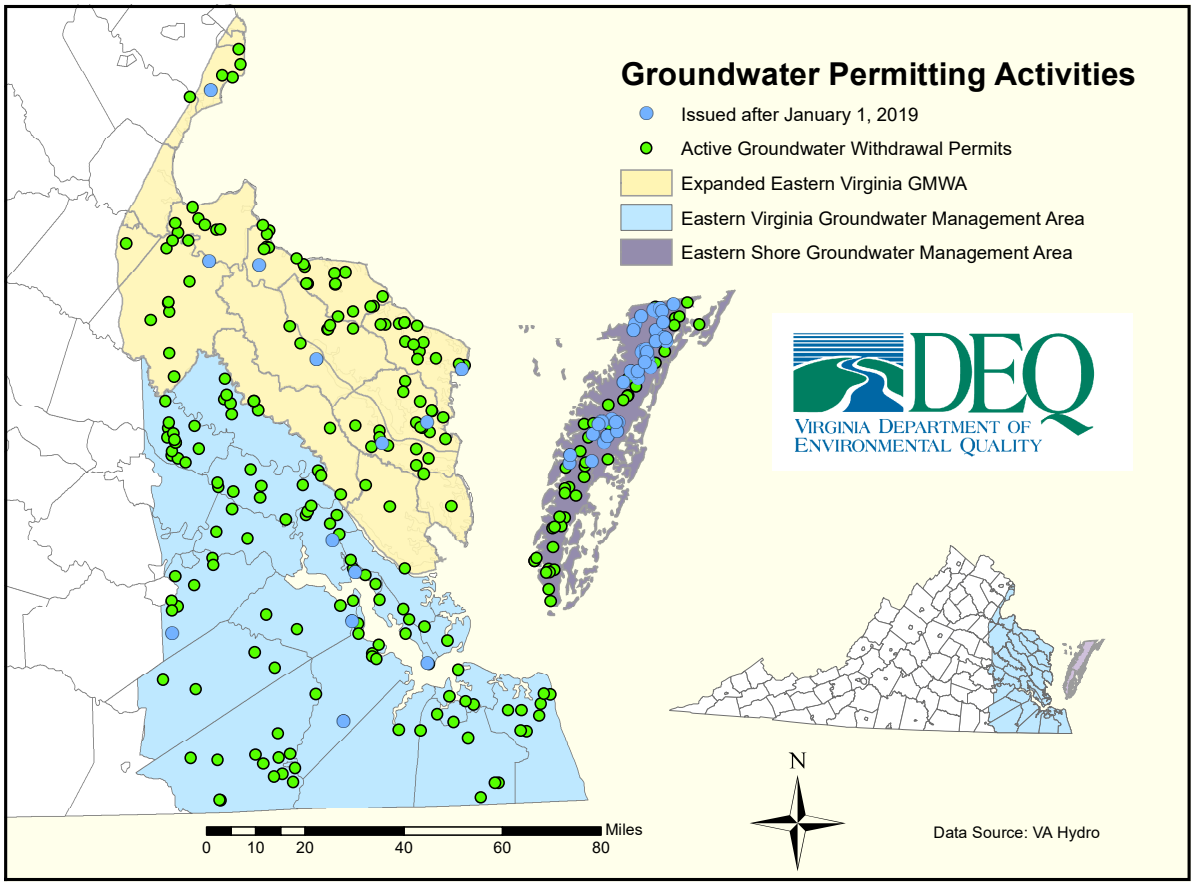

Figure 3: 2019 Groundwater Withdrawal Permitting Activities

In 2018, a Consent Special Order (CSO) was executed for 56 poultry facilities. After DEQ review, two facilities demonstrated that they did not withdraw more than 300,000 gallons per month, and did not require a groundwater withdrawal permit. The remaining 54 poultry facilities were required by the CSO to install well meters and report monthly groundwater withdrawals while applying for groundwater withdrawal permits. On April 30, 2019, 54 poultry facilities received draft groundwater permits, but only 48 chose to continue with the application process. Four of the facilities received Notice of Violations (NOV) for failing to comply with the requirements of the CSO. Three of the facilities were notified that DEQ had withdrawn the tentative decision to issue a groundwater withdrawal permit, and after an informal fact finding hearing, the permit applications were denied. Final issuance of the remaining 45 permit applications were reviewed and approved by the State Water Control Board on December 13, 2019, and issued on December 18, 2019. The State Water Control Board required inclusion of a special condition in each of the 45 groundwater withdrawal permits to conduct an alternative source investigation of the surficial (Columbia) aquifer to evaluate whether it can provide all or part of the water supply needs for the permitted facility in the future.

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 4 illustrates 2019 VWP surface water withdrawal permitting activities, including permits issued since January 2019. Currently, DEQ administers 111 VWP permits for surface water withdrawals. These permits are authorized to withdraw a combined total of 785 MGD.

Over the next five years, a significant undertaking for the Withdrawal Permitting program will be to process Virginia Water Protection Permit applications for a large number of hydroelectric power facilities that are already 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 must apply for a 401 Certification. A 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 [10]. 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 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.

[10] 9VAC25-210-340

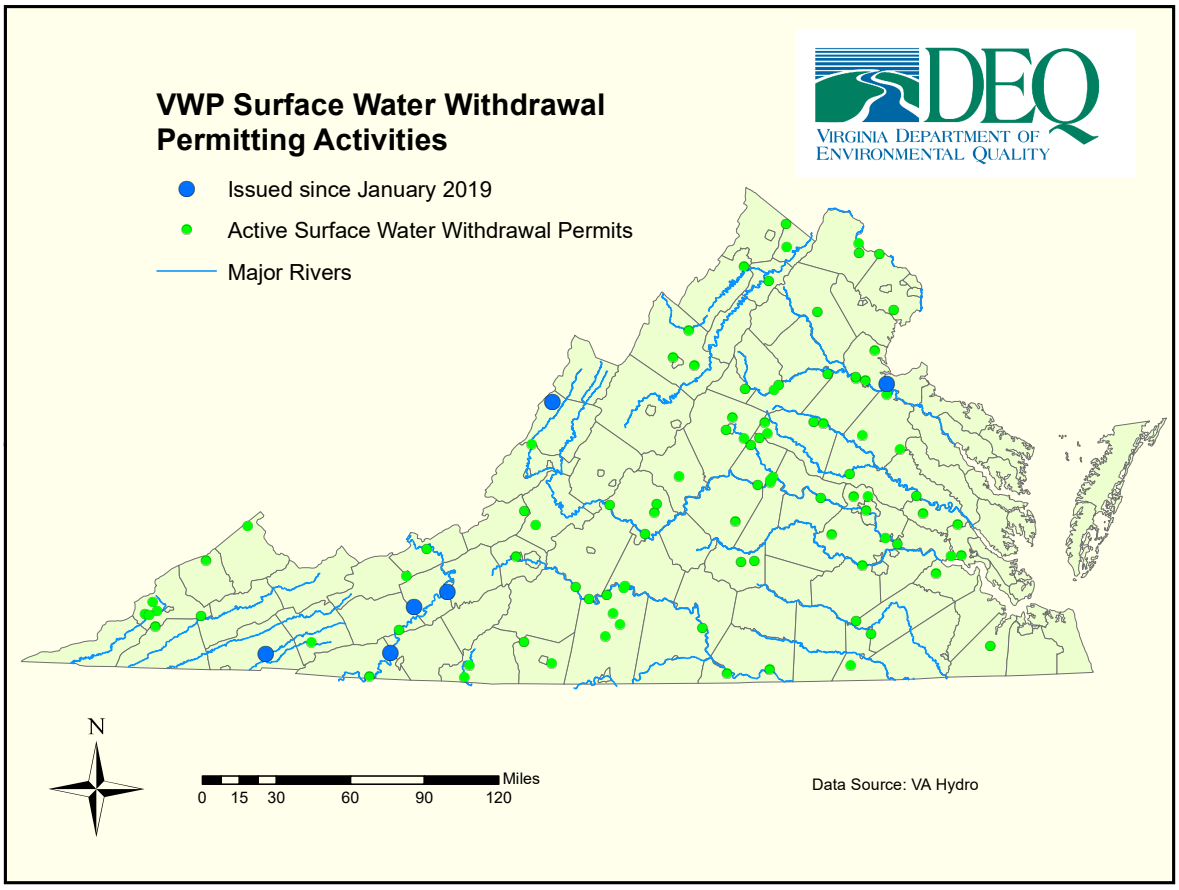

Figure 4: 2019 Surface Water Withdrawal Permitting Activities

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, 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 2019, 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 "upconing," 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.

In addition to chloride trend well monitoring, groundwater sampling was conducted prior to the initiation of groundwater level data collection at several new State Observation Wells in the Middle Peninsula and at Colonial Williamsburg to help characterize the geochemical conditions in the monitored portions of the aquifers. Spot sampling of several wells was conducted in the Virginia Southside Piedmont in order to improve the density of ambient groundwater sample coverage in the region. Additional sampling was also conducted

in the Culpeper Mesozoic Basin - a regional geologic feature comprised of sedimentary and volcanic rock that occupies substantial portions of Loudoun, Prince William, Fauquier, and Culpeper counties. Sampling in the Basin was conducted in support of an ongoing USGS groundwater study in Fauquier County.

Groundwater resource investigations were conducted in the fractured rock aquifer portion of the state to better understand the complexities associated with the flow and storage of groundwater in fractured rock settings. During the 2019 calendar year, particular emphasis was placed on collection and analysis of borehole data from the Culpeper Mesozoic Basin in Fauquier County as part of a larger, ongoing study being conducted by the USGS to characterize the groundwater resources in the County. Groundwater permeability and storage within the Culpeper Basin is higher than in the surrounding crystalline Piedmont rocks, and therefore makes the Culpeper Basin a favorable target for groundwater use. There was also a continuation of study in northern Fauquier County for the purpose of characterizing and describing borehole hydrogeologic conditions in the fractured crystalline rocks that are currently relied upon by several municipalities in the county. A better understanding of groundwater storage and availability in these complex geologic settings is needed to sustainably manage the resource and to help ensure water availability for a growing population. Borehole geophysical logging and hydraulic testing was also conducted to the west of the Blue Ridge in Glasgow, Churchville, and Seawright Springs to collect data on the depth of circulation and distribution of hydraulic head in clastic and karst aquifers in the Valley and Ridge. 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 2019, staff expanded the Real-Time State Observation Well Network, one existing multi-aquifer groundwater level observation station and two additional groundwater level observation wells in the Middle Peninsula were incorporated into the Real-Time State Observation Well Network. These wells were originally drilled as part of the West Point paper mill groundwater level monitoring network and were recently outfitted with automated levels monitoring and satellite telemetry equipment for incorporation into the state-wide network. Prior to equipment installation, the wells were inspected with a borehole video camera and hydraulically tested and sampled to evaluate aquifer connectivity and geochemical conditions in the aquifer. Conversion of these wells to a real-time data collection platform will provide a better understanding of groundwater trends in the vicinity of a major groundwater withdrawal center that has regional effects on groundwater gradients in the Coastal Plain.

In 2019 Groundwater Characterization staff completed a compilation of legacy and modern data on the characteristics of natural spring resources throughout the Commonwealth of Virginia. Most of the work on the dataset in 2019 related to the systematic improvement of springhead locational accuracies and the careful meshing of smaller external datasets into the statewide database. Late in 2019, a final geodatabase was established connecting the locations of approximately 1,640 springs with roughly 5,900 field measurement events, and 2,900 laboratory water quality sampling events. A publication about the spatial and temporal characteristics of groundwater discharges from springs throughout the state is in process.

GWCP staff continued to play an active role in data collection efforts associated with the Mountain Valley and Atlantic Coast Pipelines. Staff played an important role in the maintenance of federally operated real-time ambient water quality monitoring stations during the federal government shutdown and were also proactive in spring sampling along the Atlantic Coast Pipeline corridor in order to ascertain pre-construction groundwater quality conditions.

A two year cooperative effort with the USGS to characterize the hydrogeology of Virginia's Eastern Shore was completed in 2019. An improved understanding of the hydrogeology of the Eastern Shore is currently required to refine groundwater management strategies associated with sustainable groundwater withdrawal rates as well as regional contaminant fate and transport predictions (including saltwater intrusion). A large component of the research associated with describing the hydrogeology of the Eastern shore is associated with the delineation and hydrologic description of ancient paleochannels (remnants of ancient river beds) that transect the subsurface of the Eastern Shore. These paleochannels are important because they are thought to significantly influence storage and movement within the regional groundwater system. Well

cuttings description and interpretation and geophysical borehole log interpretation in the study area helped to delineate the regional hydrostratigraphy. A revised hydrogeologic framework of the Virginia Eastern Shore was published in December of 2019 by the United States Geological Survey, and was co-authored by DEQ Groundwater Characterization staff. The report, Hydrogeologic Framework of the Virginia Eastern Shore, is a major revision of the hydrostratigraphy, permeability, and regional groundwater chloride distribution of the Virginia Eastern Shore. Information in the new framework will be used to revise an existing regional groundwater flow model, and to assist with groundwater withdrawal and management decisions pertaining to agricultural and municipal groundwater demands.

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.

Assistance for the SWIFT pilot underground injection well project is ongoing. On-site cuttings collection and description at the Hampton Roads Sanitation District Virginia Initiative Plant injection wells was conducted to identify formations, contacts, and aquifers to assist with injection well design.

DEQ staff worked with local well drillers to collect and evaluate video and pump test drawdown data to assess the efficacy of various well development techniques. Effective well development seeks to maximize pumping well efficiency and communication with the aquifer through the screened interval of the constructed well. Improved well efficiency manifests as lower rates of pump wear, lower power consumption, and higher well yields. Findings of the study were presented at the annual Virginia Water Well Association Winter Symposium.

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 5 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 2019, multiple groundwater monitoring wells were evaluated in the Richmond Metro Area, the City of Suffolk, and the Middle Peninsula.

DEQ Groundwater Characterization Geologists continue to routinely provide technical assistance to citizens, academic, and governmental entities throughout the Commonwealth. Of note, assistance was provided to academic and intra-agency personnel regarding contaminant migration and mitigation in karst, and the occurrence of anthropogenic influences on groundwater quality in karst terrain in the Valley and Ridge. DEQ expertise on Coastal Plain hydrostratigraphy was provided to consultants, academia, and intra agency personnel to help answer questions relating to local contaminant issues, microbial propagation in flooded wells, and the correlation of hydrostratigraphic units in the Mid-Atlantic. Throughout the year, DEQ staff were asked to speak on the occurrence and availability of groundwater to a variety of organizations including municipal and county governments, Virginia Department of Health, Virginia Tech, the Virginia Water Well Association, and the Virginia Master Naturalists.

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 (Figure 5). 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.

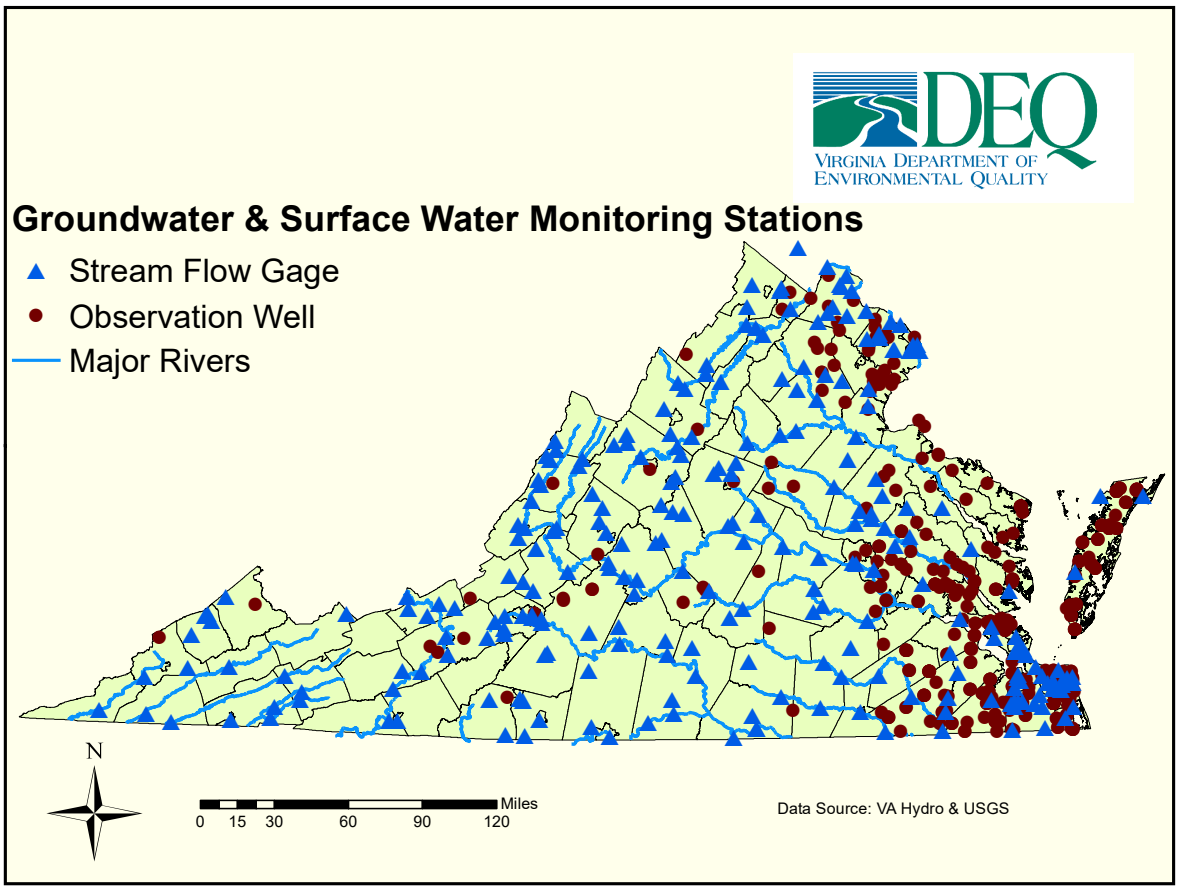

Figure 5: Groundwater and Surface Water Monitoring Stations

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.

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.

During late August and September 2019 very dry conditions spread across all of Virginia. By the beginning of October 2019, this "Flash Drought" resulted in a Drought Watch advisory being declared throughout all portions of the Commonwealth on October 11, 2019. Normal precipitation returned in mid-October, and the statewide Drought Watch advisory was lifted at the beginning of November. Periods of generally dry weather (December 2019 and March 2020) alternated with normal to wet conditions (January-February and April 2020) during the winter and spring of 2019-2020. As of August 2020, precipitation for the water year beginning October 1, 2019 was in the normal range for the eastern half of the Commonwealth and well above normal across the western half of Virginia. Consequently, other drought indicators (stream flows, groundwater levels, and reservoir storage) were in the normal range. As of September 1, 2020, most drought indicators were above normal to normal range and no drought watches were in effect. DEQ provides an drought indicator map that is updated daily and can be viewed online at Current Drought Conditions in Virginia.

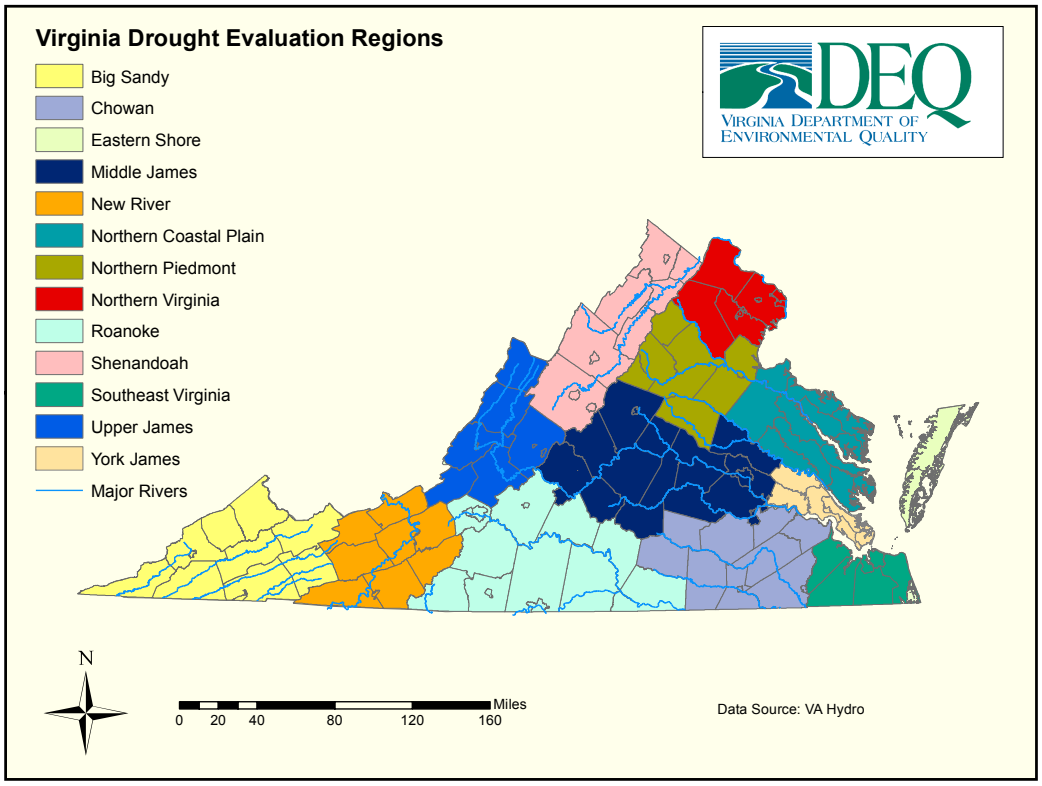

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Figure 6: Drought Evaluation Regions

2 Summary of 2019 Water Withdrawals

A total of 1,249 facilities reported water withdrawals for the calendar year 2019. This total is a reduction compared to previous years' reports as in the past the total number of individual reporting users was presented rather than the number of individual reporting facilities (some facilities have multiple active online users reporting through the VAHydro system). This improvement in the facility total does not 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 5.72 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 2019 withdrawals totaled over 1.23 BGD[11]. Compared to the five-year reported average (2015-2019), total reported 2019 withdrawals from all water use categories decreased by approximately 0.4% 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. "Mining" includes water withdrawn for the excavation, processing, and removal of bulk products such as coal, rock, sand, and gravel. "Manufacturing" facilities include 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 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 2. Discussion of 2019 reported water withdrawals by source type, distribution across the state, and water use category occurs on subsequent pages of Chapters 2 and 3 with additional detail provided in the appendices as follows:

[11] 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-see pg. 52, Power Generation Water Withdrawals. These 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 3 provides a list of the top 20 non-power generating water withdrawals ranked by the amount of their 2019 reported withdrawals.

Appendix 4 provides detailed withdrawal information by major water use category, including fossil fuel and nuclear power generation water withdrawals, and excluding hydropower.

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 the Report.

2.1 Water Withdrawals by Source Type

In 2019, water withdrawals for non-power generation totaled approximately 1.23 BGD with surface water sources (streams, reservoirs, and springs) the predominant source type. The total reported non-power generation withdrawals decreased by approximately 0.4% when compared to the five-year average of 1.24 BGD. Surface water withdrawals accounted for approximately 89% of total withdrawals in 2019 at 1.1 BGD, when excluding power generation. Pumping of groundwater wells accounted for the remaining 11%, at 139.3 MGD. Reported groundwater withdrawals increased by approximately 3.9% compared to the five-year average, whereas reported surface water withdrawals decreased by 1%, when compared to the five-year average. The reduction in surface water is largely due to decreases in use from manufacturing and agriculture users in 2019. More information on the breakdown between source types as it applies to each category of use can be found in Appendix 4.

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 7. Of the 133 counties and cities reporting water withdrawals, 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 2019 with 21.8 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 10% of 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.

Users in King William County reported the second largest groundwater withdrawal amounts in 2019, with 17.46 MGD. WestRock's West Point paper manufacturing facility withdrew 96% of the countywide groundwater reported in 2019, approximately 16.8 MGD. The WestRock West Point system is currently permitted by DEQ and remained within permitted withdrawal limits as set by its Groundwater Withdrawal Permit.

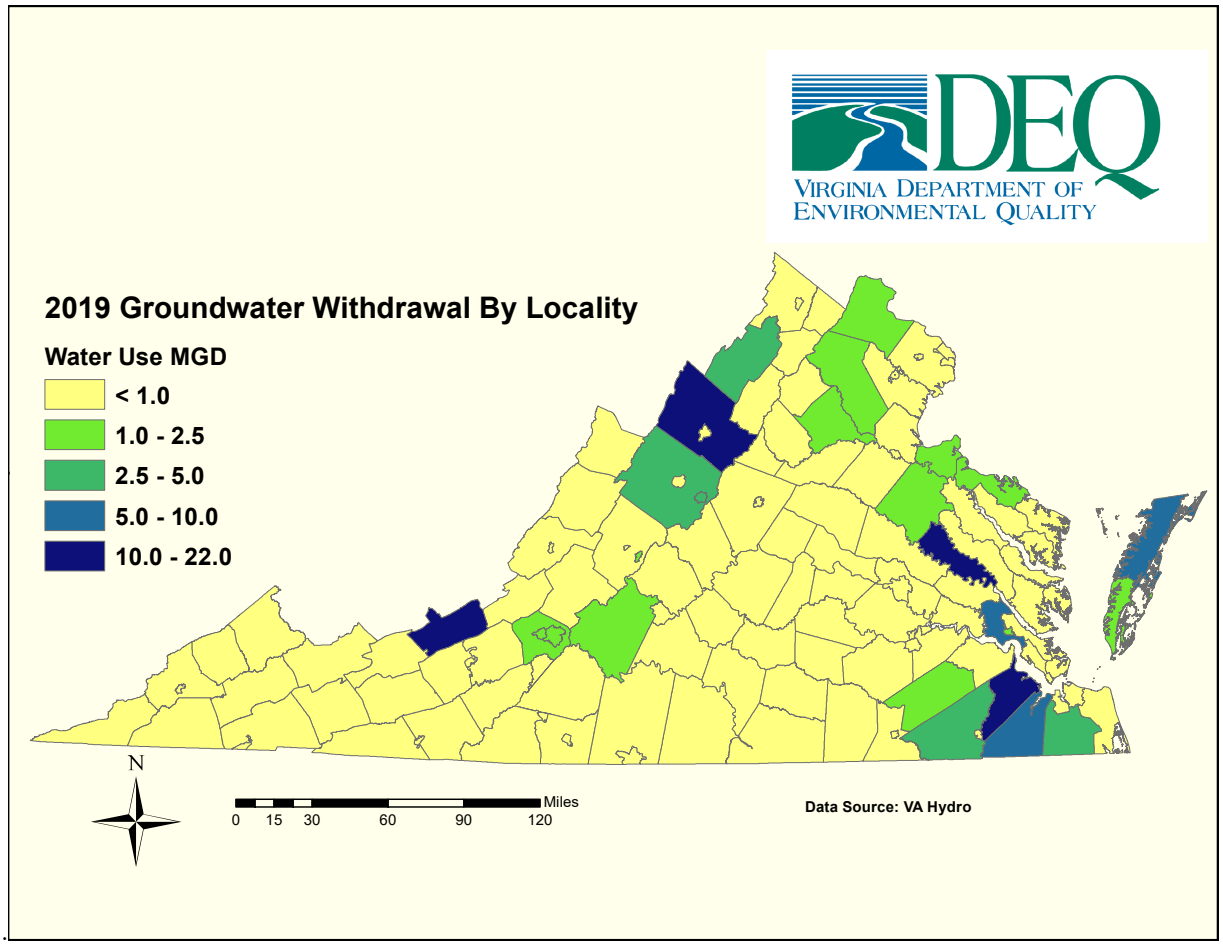

Figure 7: 2019 Total Groundwater Withdrawals By Locality

Users within Isle of Wight County reported approximately 14.61 MGD in groundwater withdrawals in 2019. The International Paper Company Franklin Mill was the primary user of groundwater in the county with

11.9 MGD reported in 2019. 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 14.4 MGD. Merck and Company, a manufacturing facility, reported the largest single groundwater withdrawal within Rockingham County, approximately 5.7 MGD in 2019. 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 2.73 MGD. Additional towns within the county, including Dayton, Grottoes, and Timberville, all reported moderate groundwater withdrawals for public water supplies in 2019.

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 8). 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. Surface water withdrawals are concentrated most densely within the James River, Potomac-Shenandoah River, and New River basins; these three basins comprise approximately 75% of the statewide total surface water withdrawal. Withdrawals for public water supply represent 66.4% of the total surface water withdrawals in the Commonwealth.

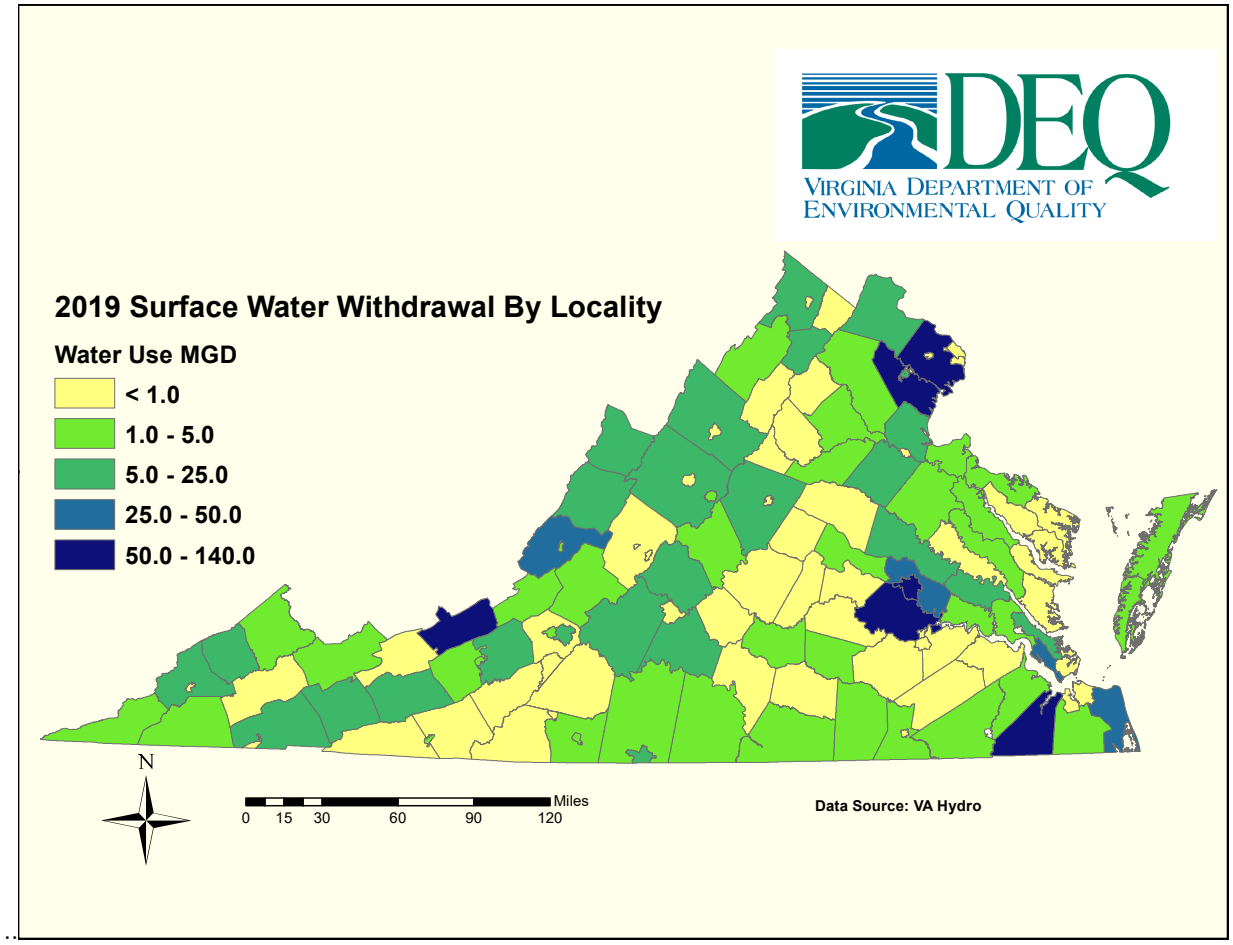

Figure 8: 2019 Total Surface Water Withdrawals by Locality

The largest reported surface water withdrawals occurred within the City of Hopewell, City of Suffolk, and Fairfax County. The City of Hopewell reported the largest surface water withdrawal volume for any locality in 2019, with 138.8 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 104 MGD or 9% of the total surface water withdrawals reported in the Commonwealth. Virginia American Water, a major public water supply for the region reported 22.5 MGD in 2019, slightly more than its reported five-year average, which can be found in Table 4. Finally the WestRock Hopewell plant reported 12.3 MGD in surface water withdrawals in 2019. No other facilities in Hopewell reported surface water withdrawals in 2019.

The City of Suffolk was the second highest reporting locality in 2019 with 95.61 MGD in surface water withdrawals. The Western Branch Reservoir was the largest source of surface water in the city with 75.11 MGD reported by the City of Norfolk, which owns and operates an intake on the reservoir and provides public water supply throughout the region. Additional intakes for public water supply located within the City of Suffolk included Lake Prince, that is owned and operated by the City of Norfolk, and the City of Portsmouth's Lake Kilby intake. Lesser withdrawals were reported by golf courses and crop irrigation facilities.

Fairfax County's proximity to a highly populated urban center results in significant withdrawals from surface water sources to meet public water supply demands. Total reported surface water withdrawals in 2019 equalled 90.88 MGD. The largest withdrawal (90.07 MGD) was reported by Fairfax Water from the Potomac River. 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 87.7 MGD in surface water withdrawals in 2019. 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 2019, 35.18 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 23.38 MGD, and the AdvanSix Plant reported 15.43 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 also supports several large scale industrial users within the county.

The variable spatial distributions of 2019 total withdrawals, as depicted in (Figure 9), 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 2019. The top three highest total withdrawal amounts reported within a locality were in the City of Hopewell, the City of Suffolk, and Fairfax County. Large facilities or singular withdrawals, such as for public water supply or manufacturing operations, often dominate within a locality. The reported water withdrawal amounts for each locality in the Commonwealth can be found in Appendix 5.

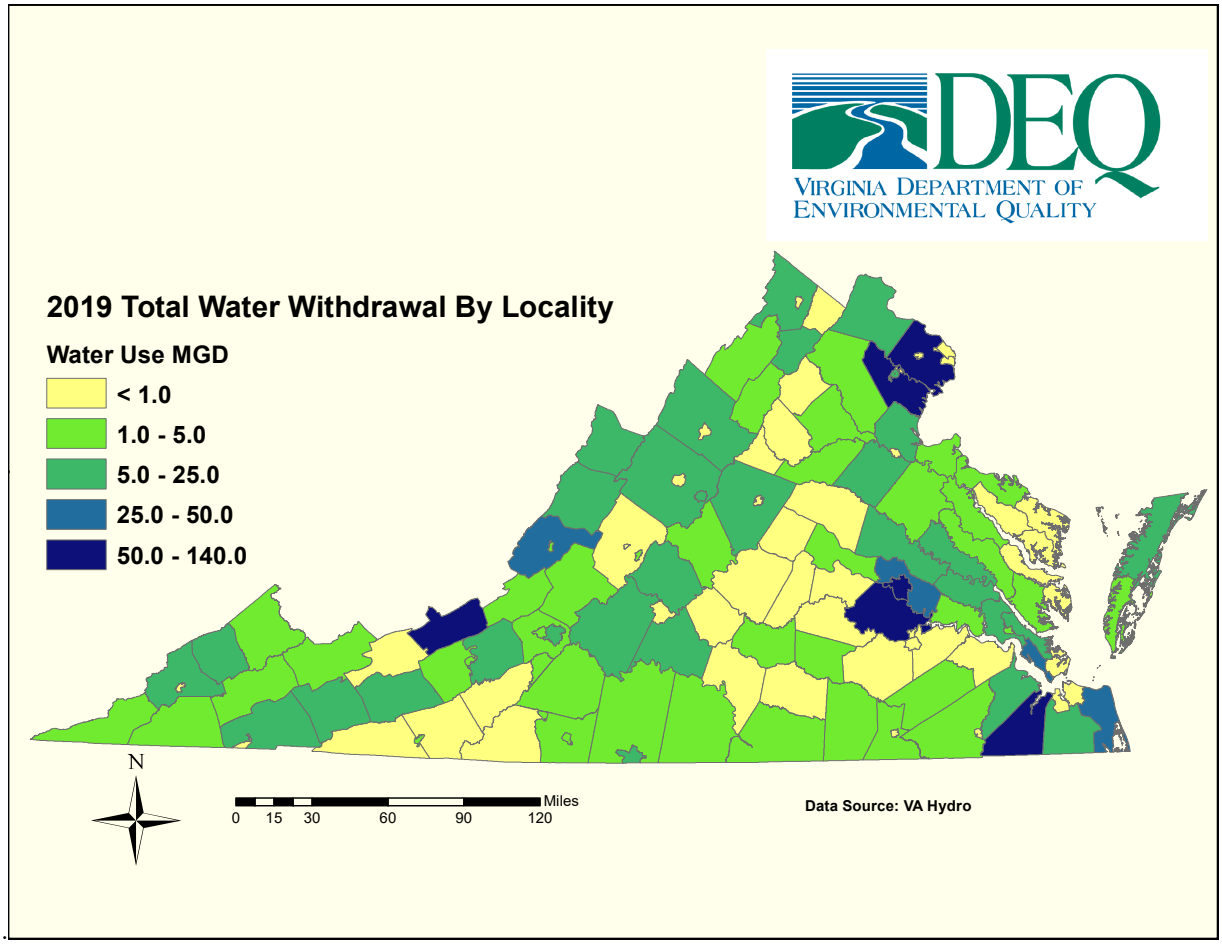

Figure 9: 2019 Total Water Withdrawals By Locality

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 2015-2019 are provided by source type for each category for comparison, excluding Power Generation (Nuclear Power and Fossil Fuel Power) in Figures 10 and 11. 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 2019 withdrawal totals. This allows for direct comparisons between 2019 withdrawal totals and the 2015-2019 averages of total withdrawals.

Groundwater withdrawals increased in 2019 as compared to the five year average across all categories except commercial, which decreased 2.4%. 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 56.2% 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.

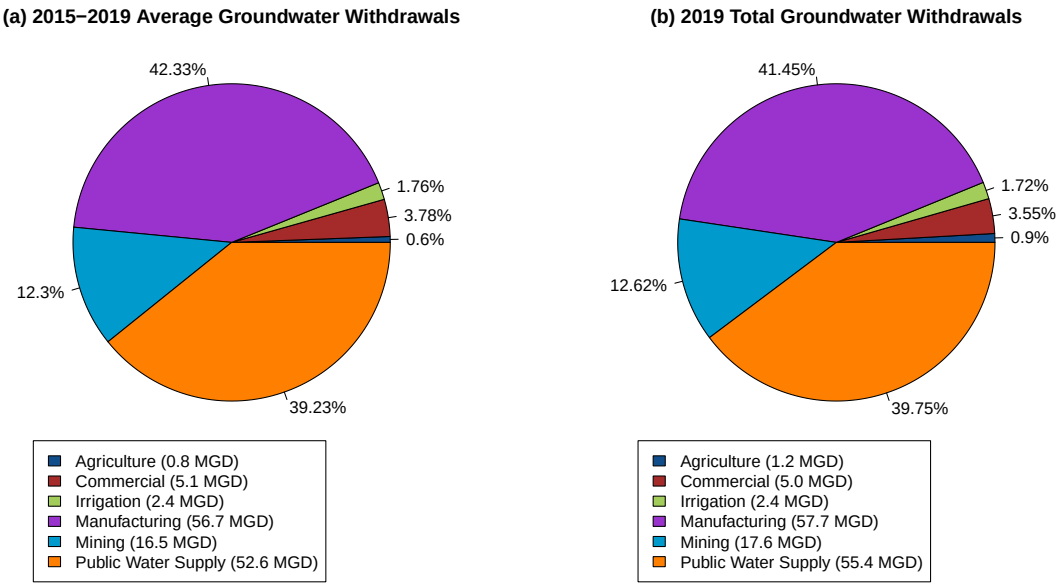

Figure 10: Groundwater Withdrawals, 2015-2019 Average and 2019 Total

Public Water Supply and Manufacturing were once again the largest water withdrawal categories in 2019, which is consistent with the average of the previous five-year period. Manufacturing makes up the highest proportion of groundwater withdrawals (41.45%), whereas Public Water Supply accounts for the greatest proportion of surface water withdrawals (66.38%) (Figure 11). 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 2019. 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 2019 decreased by 0.4% compared to the five-year average as seen in Figure 12. The reported decrease in total water withdrawals was driven by a 5.4% decrease in surface water withdrawals by manufacturing users. However, continued increases in withdrawals from other use categories, such as public water supply, indicates a continued need to evaluate water sources to meet short and long term demands. Water supply planning and permitting staff continue to work collaboratively to identify available sources and alternatives for water users between regional partners and across Virginia.

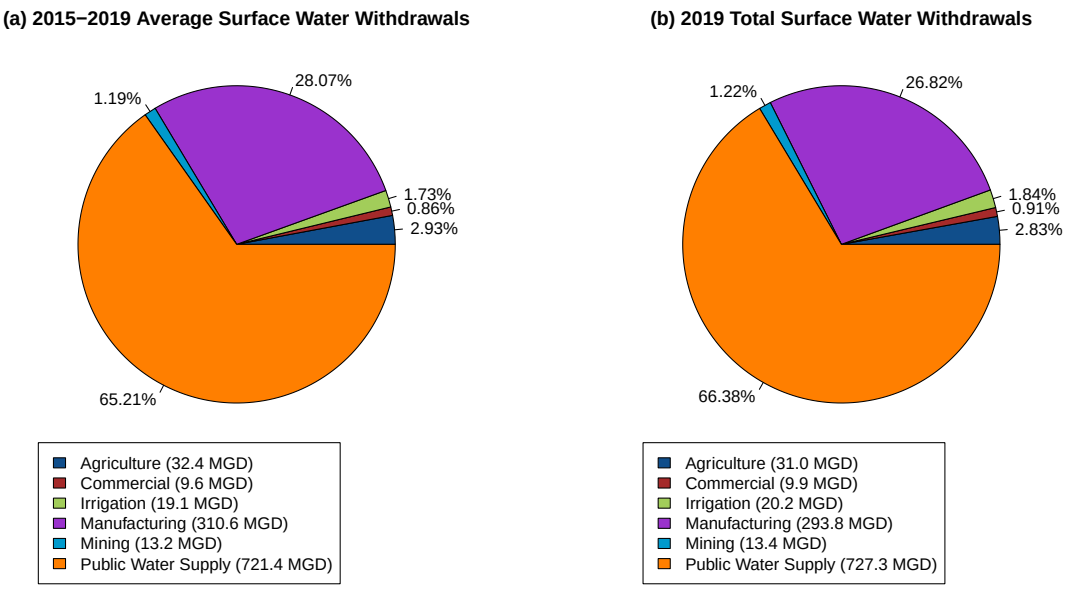

Figure 11: Surface Water Withdrawals, 2015-2019 Average and 2019 Total

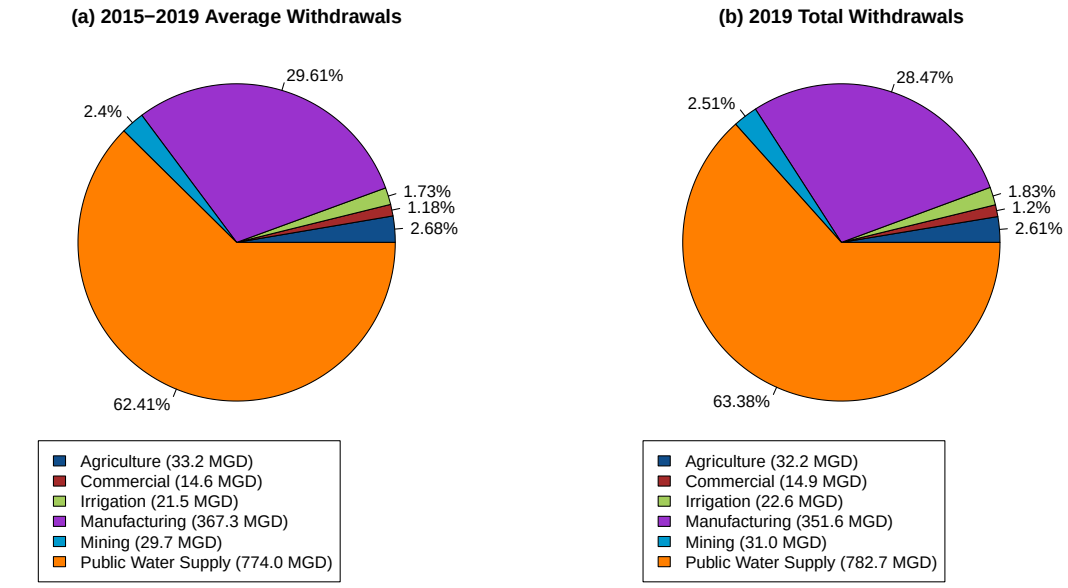

Figure 12: Groundwater + Surface Water Withdrawals, 2015-2019 Average and 2019 Total

Appendix 4 provides additional information for each water use category, including tables and graphs comparing 2019 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.

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 us. "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. 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. 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.

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[12]. 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 and 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 4.

"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[13]. 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 Power Generation Water Withdrawals, Appendix 4).

[12]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.]

[13]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: 2015-2019

Water withdrawals reported to VAHydro from 2015-2019 are represented in Table 1. Total 2019 water withdrawals reported for non-power generation decreased approximately 0.4% compared to the five-year average (2015-2019)[14]. The 2019 reported withdrawals from groundwater sources increased approximately 3.9% 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 2019 was largely the result of new agricultural facilities registered and reporting withdrawals through water supply planning and permitting efforts, including the 45 poultry operations that were issued groundwater withdrawal permits on the Eastern Shore in 2019. However, increases in agricultural and irrigation withdrawals were likely also driven by the occurrence of dry conditions and the "flash drought" which occurred in 2019. Increased groundwater withdrawals reported within the mining use category largely resulted from increased quarry dewatering from two major Kimballton mine operations in Giles County.

Municipal groundwater withdrawals increased by 5.3% 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 use is the only category that experienced a decrease (2.4%) in groundwater withdrawals when compared to the five year average. However, this is largely driven by higher than normal use in years 2016 and 2017, as 2019 withdrawals were similar to those reported in 2015 and 2018. As such the decrease does not appear to be part of a larger trend.

Total reported surface water withdrawals in 2019 decreased by 1.0% compared to the five-year average. This decrease was primarily due to decreases in the agricultural and manufacturing categories of 4.3% and 5.4% respectively. The top five surface water users within the agricultural category are all fish hatcheries. Each reported minor decreases in withdrawals compared to the five-year average, and these decreases in combination are the primary driver of the reduction in withdrawals for this category. The decrease in surface water withdrawals associated with manufacturing was largely driven by reduced withdrawals from two large chemical plants located in Chesterfield County. Increased surface water withdrawals were reported for the commercial, irrigation, mining, and public water supply use categories. Increases in withdrawals for irrigation (5.5%) are likely due to the dry conditions associated with the flash drought in 2019 requiring more supplemental irrigation.

Increased surface water withdrawals from the two Kimballton mine operations in Giles County contributed to a 1.3% increase in mining withdrawals as compared to the five-year average. As observed in Table 1, incremental increases in surface water withdrawals for public water supply have been consistent from 2015-2017. A significant increase of 8.5 MGD was seen between 2017 and 2018, and 2019 withdrawals were comparable to the total recorded in 2018. This indicates that this large increase may be evidence of an increasing trend, one that is largely driven by population growth in large metropolitan areas.

[14] Figure percentages are rounded

Table 1: Summary of Virginia Water Withdrawals by Use Category and Source Type 2015 - 2019 (MGD)

Category	2015	2016	2017	2018	2019	5 Year Avg.	% Change 2019 to Avg.
Groundwater							
Agricultural	0.53	0.69	0.73	0.82	1.25	0.80	56.2
Commercial	4.96	5.48	5.37	4.60	4.95	5.07	-2.4
Irrigation	2.82	2.27	2.09	2.20	2.40	2.36	1.7
Manufacturing	57.78	50.41	57.52	60.21	57.73	56.73	1.8
Mining	13.98	17.34	15.53	18.04	17.57	16.49	6.5
Public Water	48.73	49.52	54.54	54.72	55.36	52.57	5.3
Surface Water							
Agricultural	33.91	33.64	30.64	32.70	30.98	32.37	-4.3
Commercial	9.81	10.41	9.59	8.06	9.92	9.56	3.8
Irrigation	23.70	20.33	18.48	12.88	20.17	19.11	5.5
Manufacturing	312.03	314.74	326.31	305.88	293.84	310.56	-5.4
Mining	12.79	12.98	11.80	15.12	13.38	13.21	1.3
Public Water	715.38	717.54	719.22	727.72	727.31	721.43	0.8
Total (GW + SW)							
Agricultural	34.44	34.33	31.37	33.52	32.23	33.18	-2.9
Commercial	14.77	15.89	14.96	12.66	14.87	14.63	1.6
Irrigation	26.52	22.60	20.57	15.08	22.57	21.47	5.1
Manufacturing	369.81	365.15	383.83	366.09	351.57	367.29	-4.3
Mining	26.77	30.32	27.33	33.16	30.95	29.71	4.2
Public Water	764.11	767.06	773.76	782.44	782.67	774.01	1.1
Total							
Total Groundwater	128.80	125.71	135.78	140.59	139.26	134.02	3.9
Total Surface Water	1107.62	1109.64	1116.04	1102.36	1095.60	1106.24	-1.0
Total (GW + SW)	**1236.42**	**1235.35**	**1251.82**	**1242.95**	**1234.86**	**1240.28**	**-0.4**

3.1 2019 Permitted and Unpermitted (Excluded) Withdrawals

The following tables demonstrate the difference between reported withdrawals from users that hold a surface or groundwater permit, and unpermitted withdrawals. Table 2 displays the reported total withdrawals for both permitted and unpermitted users by source type for 2019. Unpermitted surface water withdrawals includes withdrawals that have reported to the DEQ that they are excluded from VWP permitting requirements pursuant to 9VAC25-210-310. Unpermitted groundwater withdrawals are those not regulated by the groundwater withdrawal permitting program. 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. Currently, the unpermitted groundwater withdrawals total also includes three facilities that have applied for Existing User Groundwater Withdrawal Permits and are located inside the Eastern Virginia Groundwater Management Area. These applications remain in review.

In 2019, unpermitted withdrawals represented approximately 72% of the total reported withdrawals in Virginia. The majority of reported groundwater withdrawals (52%) are from users operating under a Groundwater Withdrawal Permit. This is consistent with the 2018 result but represents an increase of 8% from the percentage of total groundwater withdrawals originating from permitted users in 2016 (44%). Approximately 75% of the total surface water withdrawn in Virginia is associated with unpermitted users, which has remained largely consistent across reporting years.

Table 2: 2019 Permitted and Unpermitted (Excluded) Withdrawals (MGD)

Withdrawal Type	2019 Withdrawal Amount	% of Total
Groundwater		
Permitted	72.18	51.81
Unpermitted	67.13	48.19
Surface Water		
Permitted	276.61	25.25
Unpermitted	818.99	74.75
Total (GW + SW)		
Permitted	348.79	28.24
Unpermitted	886.12	71.76

Table 3 disaggregates the reported permitted and unpermitted water withdrawals by use category, and shows the percent composition of each withdrawal category in 2019.

In 2019, a total of 139.26 MGD in groundwater withdrawals were reported (excluding power generation). Manufacturing withdrawals, both permitted and unpermitted, were the largest percentage of the total reported groundwater in 2019 at approximately 41.5%, with 15% of the total from unpermitted manufacturing. The unpermitted portion is generally made up of manufacturing/industrial facilities that rely on groundwater outside of the groundwater management areas. Withdrawals for public water supply were the second largest contributor to total groundwater withdrawals in 2019. Approximately 40% of all groundwater withdrawals reported in 2019 were used for public water supply needs, with 18% associated with unpermitted public water supply facilities. Unpermitted public water supply facilities are generally made up of those outside the management areas. 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 the supply is inside a GWMA or an area with existing resource concerns.

As with groundwater, surface water withdrawals in 2019 were dominated by withdrawals associated with manufacturing and public water supply facilities, with the two categories making up approximately 93% of total surface water withdrawals. Manufacturing facilities comprised 26.8% of all surface water withdrawals, with 25.4% unpermitted. Withdrawals for public water supply comprised 66% of total surface water withdrawals. Within the public water supply category, 42.8% were 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 both for DEQ and water users across the state. 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: 2019 Permitted and Unpermitted (Excluded) By Use Type Withdrawals (MGD)

Use Type	Withdrawal Type	2019 Withdrawal Amount	% of Total
Groundwater			
	Unpermitted	0.21	0.15
Agriculture	Permitted	1.04	0.75
	Unpermitted	1.80	1.29
Commercial	Permitted	3.15	2.26
	Unpermitted	1.01	0.73
Irrigation	Permitted	1.42	1.02
	Unpermitted	21.23	15.24
Manufacturing	Permitted	36.51	26.21
	Unpermitted	17.56	12.61
Mining	Permitted	0.01	0.01
	Unpermitted	25.32	18.18
Public Water Supply	Permitted	30.04	21.56
Total Groundwater		**139.26**	**100.00**
Surface Water			
	Unpermitted	30.55	2.79
Agriculture	Permitted	0.43	0.04
	Unpermitted	8.03	0.73
Commercial	Permitted	1.89	0.17
	Unpermitted	18.61	1.70
Irrigation	Permitted	1.56	0.14
	Unpermitted	278.99	25.46
Manufacturing	Permitted	14.86	1.36
	Unpermitted	13.34	1.22
Mining	Permitted	0.04	0.00
	Unpermitted	469.48	42.85
Public Water Supply	Permitted	257.83	23.53
Total Surface Water		**1095.60**	**100.00**

Unreported unpermitted withdrawals are not represented in either Table 2 or 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 2015, over 6,000 wells have been registered; 1,279 wells were registered electronically with DEQ in 2019 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 and outreach to 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 panning efforts. More details on how DEQ continues to address this challenge can be found in Chapter 4.

4 Water Resource Challenges And Priorities

4.1 Water Resources Management in Virginia: Hot Topics

The following section identifies new and continuing topics of specific interest in Water Resources Management. These include new legislative or regulatory actions, updates on programmatic goals and achievements, and other items.

DEQ continues to work to identify unpermitted groundwater withdrawals, and where appropriate, provide compliance assistance for users who are required to obtain a permit but were unaware of the regulatory requirements. One major focus area for these efforts in 2019 has been on the Eastern Shore:

- DEQ has made significant progress in addressing the large number of previously unpermitted groundwater withdrawals associated with poultry facilities on the Eastern Shore. A large number of new poultry facilities were constructed in Accomack County in the last five years. In 2019, 45 groundwater withdrawal permits were issued to both new and existing poultry facilities within the county. The permits limit groundwater withdrawals and require quarterly reporting, as well as investigation of alternative sources. These permits will allow both a better understanding of impacts to the resource and provide mechanisms for mitigating that impact.

DEQ continues to work with permitted groundwater facilities to decrease net withdrawals, to identify alternative sources of water, and to investigate other innovative ways to increase supplies in order to maintain groundwater productivity and availability over the next 50 years.

- 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 Groundwater Management Area. In 2019, DEQ published a Notice of Intended Regulatory Action (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 has convened a Regulatory Advisory Panel (RAP) and the RAP meetings are ongoing. Once complete, the new general permit regulation will include the establishment of permit terms, withdrawal limitations, reporting requirements, and other elements necessary to permit withdrawals through this new general permit framework.

- Legislation enacted following the 2020 General Assembly Session (2020 Va. Acts Ch. 670) will prohibit construction of wells for non-agricultural irrigation in aquifers other than the surficial, unless DEQ determines the surficial aquifer is inadequate to meet the proposed beneficial use, once the SWCB adopts a general permit for regulation of irrigation withdrawals. DEQ expects to begin this regulatory process in late 2020 and will solicit public comment beginning with a NOIRA.

- Groundwater withdrawal reductions are not the only method to address the resource issue. The Hampton Roads Sanitation District's (HRSD) Sustainable Water Initiative for Tomorrow (SWIFT) project continues working to reverse groundwater declines through direct injection of highly treated water into the Potomac Aquifer. As of the summer of 2020, the SWIFT water treatment project has successfully injected 328 million gallons of treated water into the Potomac Aquifer, with plans to expand the project by constructing additional injection facilities throughout the Hampton Roads area. However, as SWIFT is still in the pilot phase, the ultimate benefits of large-scale injection may not be known for a decade or more.

DEQ continues to manage the Water Supply Planning program with several significant endeavours on the horizon.

- Legislation enacted following the 2020 General Assembly Session (2020 Va. Acts Ch. 1105) directs the State Water Control Board to estimate the risk that each locality and region in the Commonwealth will experience water supply shortfalls, to encourage the development of cross-jurisdictional water supply projects, and to adopt regulations designating regional planning areas based primarily on river basins. The bill 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. DEQ expects to begin the regulatory process with a Notice of Intended Regulatory Action in the Fall of 2020.

- 9VAC25-780-50 of the Administrative Code requires localities to review, revise, and resubmit water supply plans every 10 years. As the original plans were submitted in 2013, the new local and regional plans will be required in 2023. DEQ expects to begin outreach to localities in preparation for this undertaking as early as 2021. These efforts will benefit from the publication of the 2020 State Water Resources Plan, which will include a significant amount of information that will assist localities in their planning at both a regional and local scale. DEQ is currently organizing a series of presentations on the results of the cumulative impact analyses for stakeholders. A formal public comment period will be offered in the winter of 2020 to solicit feedback on the draft Plan.

DEQ is concerned about users that report significant water loss. Based on information provided by localities pursuant to the Local and Regional Water Supply Planning Regulation, there are many localities in Virginia reporting significant water loss. Some localities could not account for as much as 25 percent of their potable water supplies, which significantly exceeds the best practice goal of water loss of no more than 10 percent. These high levels of water loss raise concerns about the efficiency and effectiveness of public water use.

4.2 Long-term Priorities and Challenges Identified in the State Water Resources Plan

The State Water Resources Plan identifies challenges for future water resources management and provides recommendations for action. The first State Plan was published in 2015. The 2020 State Plan is currently in development. However, many of the challenges identified in the 2015 State Plan continue to be a factor. Since the plan was published new challenges have also arisen and are also addressed here.

- Challenge: Understanding the Impact of Unpermitted Water Withdrawals.

  DEQ continues to collaborate with VDH to estimate the number of unpermitted private wells in the Eastern Virginia GWMA. VDH reports that approximately 275,000 to 300,000 homes are served by private wells in the Eastern Virginia GWMA. In 2019, 1,279 GW-2 Uniform Water Well Completion Form were submitted electronically to DEQ. Most new wells are for private/residential purposes and will be below the threshold requiring a permit. In many cases, subdivisions are constructed with individual wells and supply systems for each house to avoid exceeding the permit threshold. DEQ collaborated with the Virginia Institute of Marine Science to seek federal funding to pilot a method that identified legacy wells in two counties within the Eastern Virginia GWMA.

  With respect to surface water withdrawals, the majority remain excluded from permitting requirements pursuant to Section 62.1-44.15:22 of the Code of Virginia and 9VAC25-210-310. As these withdrawals are not permitted, they lack permit limits, flow-by requirements, and other means to assess and mitigate impacts that are typically in place for permitted withdrawals. As a result, it is a particular challenge to understand and estimate the impact of these withdrawals on downstream beneficial uses. However, DEQ has developed a methodology to address this challenge and the resulting data is being incorporated into the 2020 State Plan.

  Surface water withdrawals associated with agricultural operations are also historically more likely to be unpermitted than not. Many of these withdrawals are excluded from permitting requirements because they fall below the threshold volume of 1,000,000 gallons in any month for non-tidal streams,

or 60,000,000 gallons in any month for tidal streams[15]. However, even smaller scale agricultural withdrawals can have a significant impact on the resource, particularly if located in headwaters or minor streams. One challenge is that there is very limited water use data for many agricultural users in the state which makes quantifying impacts challenging. DEQ has tentatively been approved for federal funding from the USGS Water Use Data Research Program to support a project to improve estimates of agricultural water use. This project will help address a critical information gap which can then be fed into resource modeling, which in turn is used by both the state and localities for water supply planning purposes.

- Challenge: Gaps in Water Withdrawal Reporting, Differences in Reporting Thresholds between the Local and Regional Water Supply Planning Regulation and the Water Withdrawal Reporting Regulation, and Lack of Adequate Data.

  The data gaps in withdrawal reporting have prompted a systematic approach to improve reporting of annual withdrawals, which initially focused on golf courses with the current focus on the agricultural community. This is largely due to the aforementioned gaps in water use data for agricultural users, which remains a critical data gap for planning purposes. As a result of the work done by the Withdrawal Permitting Program, 45 poultry facilities will begin quarterly reporting as a result of the issuance of their groundwater withdrawal permits. This represents a significant increase in water use reporting for agricultural use on the Eastern Shore. Additionally, DEQ received a list of poultry facilities located outside of groundwater management areas that will be contacted to begin reporting. Notably, poultry facilities historically maintained limited water use information, so these data will also be useful in future efforts to better estimate water use for poultry facilities statewide.

- Challenge: Quantifying Current and Future Risks to Groundwater Availability Outside of Current Groundwater Management Areas.

  Groundwater resource investigations continued in 2019 in the fractured rock aquifer portion of the state to better understand the complexities associated with the flow and storage of groundwater in fractured rock settings. During the 2019 calendar year, DEQ continued the collection and analysis of hydrogeologic data from the granitic and meta-sedimentary rocks in northern Fauquier County as part of a larger, ongoing study being conducted by the USGS to characterize the groundwater resources in the county. In the Valley and Ridge portion of Virginia, a hydrogeologic study was conducted to characterize the seasonal component of groundwater storage and movement within the Staunton-Pulaski Thrust Sheet – a regionally significant geologic structure in the Great Valley. After publication, this work was continued through long term aquifer characterization studies at a state observation well in Rockbridge County (SOW 063). Regional studies are critical to understanding these fractured rock systems, as flow and storage can vary significantly across even modest distances. DEQ continues to be contacted by concerned citizens in Prince William and Stafford counties regarding groundwater well problems.[16]

- Challenge: Managing Groundwater Use in Groundwater Management Areas.

  Managing groundwater in Virginia continues to present new opportunities and challenges. With respect to the Eastern Virginia Groundwater Management Area, some areas continue to show stabilizing water levels in response to the reductions in permit limits negotiated with many of the largest groundwater users. However, as population continues to increase, thereby also increasing demand on groundwater, further reductions may be necessary to sustain these gains and to ensure availability of groundwater into the future. Reductions in withdrawals are generally accomplished through the pursuit and development of alternative sources, often at significant cost to the user. At the same time, development continues on the HRSD SWIFT project which seeks to increase pressure in the aquifer system through injection.

[15] 9VAC25-210-310.A.4

[16] Maynard, Joel P. and White, Brad A. 2018, 'Packer Testing and Borehole Geophysical Characterization of Observation Wells in a Vertically Integrated Karst Aquifer in Augusta County, Virginia', paper presented to the Third Annual Appalachian Karst Symposium, Shepherdstown, West Virginia, April 2018.

This project if realized at scale would also come at significant expense. In 2019 through 2020, DEQ worked with HRSD and VDH on the permitting of the first large scale injection project at the James River Plant.

Legislation enacted following the 2020 General Assembly Session (2020 Va. Acts Ch. 805) reestablishes the Eastern Virginia Groundwater Management Advisory Committee. This committee, along with the Eastern Shore Groundwater Committee, offer excellent opportunities to engage stakeholders in addressing the complexity of managing groundwater in the two groundwater management areas. DEQ looks forward to the work that will be completed in these committees.

- Challenge: Understanding the Impact of Consumptive Use on Water Supply.

  In 2018, DEQ obtained federal grant funding for a two year project to develop consumptive use data and analysis tools, as well as to improve transfer and export of withdrawal and discharge data to allow wider access to these datasets. In 2019, the data development and analysis portions of this project were completed. DEQ, along with the USGS and Virginia Tech studied consumptive use trends and predictive model development to better understand and track impacts of consumptive use as well as inter-basin transfers of water. This information has allowed DEQ to create a more robust surface water budget that accounts for consumptive use trends for specific facilities. The products of this project are already being integrated into cumulative impact modeling efforts that inform work in both the Water Supply Planning and Water Withdrawal Permitting programs. The result of these efforts will also be incorporated into the next iteration of the State Plan, allowing localities to better evaluate how consumptive use affects water availability on both regional and local scales.

- Challenge: Understanding Stream Water Quality/Ecology.

  Informed decision-making requires practical, data-driven means of assessing potential risk to fish and benthic macroinvertebrates resulting from human consumptive water use. Through a collaboration with the Virginia Tech Department of Biological Systems Engineering and the USGS Virginia and West Virginia Water Science Center, DEQ has developed a new instream flow framework for rapid generation and optimization of flow-ecology relations (elfgen). Current streamflow management guidelines were developed using extensive Instream Flow Incremental Methodology (IFIM) studies. IFIM describes the field method for creating detailed habitat-streamflow models. These traditional habitat-based instream flow management approaches are often time and cost prohibitive. This was a primary driver to develop a new framework of analytical methods and best practices to reduce the cost of flow-ecology analysis by integrating widely available hydrologic and ecological datasets. Ecological limit function (ELF) models are used to describe the upper limit of increasing biodiversity with increasing stream size. The primary outcome of this study is a decision support tool for ELF generation and analysis in the form of the elfgen R package (available on GitHub: https://github.com/HARPgroup/elfgen). The findings and the elfgen tool developed provide a consistent framework for ELF analysis and can be used to quantify potential species richness response to human consumptive water use.

  The project found that flow-ecology relations were watershed specific, and species richness changes resulting from flow reduction varied based on sample sets derived from hydrologic unit classifications of different sizes (from HUC 6 large major river basins, to smaller HUC 8 and HUC 10 local scale watersheds). Ten percent of HUC 8s and 25 percent of HUC 10s showed richness decreases of one or more species resulting from a 20 percent flow reduction. While absolute richness change was consistent across various sized streams within a HUC, percent richness change was found to be stream size dependent. Streams with smaller mean annual flow were shown to have an increased potential risk of species loss resulting from equivalent flow reductions. Percent richness change was evaluated with percent habitat change using IFIM models to compare elfgen results to currently accepted streamflow management guidelines. Predicted habitat loss was shown to be greater than predicted richness change, however the magnitude of change increased in a similar manner as stream size decreased. Species richness loss rates varied between different watersheds, which could allow water supply management decisions to be made locally based on the predicted richness change and stream size response from a given flow reduction.

This instream flow modeling effort has resulted in two professional papers outlining the methodology behind the elfgen framework and potential management implications of implementing this new approach for water resource management activities including permitting, water supply planning, and restoration ecology. The approach builds on current instream flow management strategies, and facilitates the use of existing large state-wide datasets, which may offer an improved understanding of aquatic life risk variability due to factors such as geographic location, stream size and local scale. These papers were nationally peer reviewed and accepted for publication in the Journal of the American Water resources Association. Publication is expected by the end of 2020.

- Challenge: Federal Changes to 401 Certification Procedures.

  In August of 2019, EPA issued a Notice of Proposed Rulemaking (NOPR) proposing significant changes to section 401 regulations that may affect the VWP Permitting Program. On June 1, 2020, EPA released its final rule, which will become effective 60 days after its publication in the Federal Register. Federal Permitting agencies such as FERC and the U.S. Army Corps of Engineers will need to review and possibly amend their associated regulatory programs. While it is beyond the scope of this report to discuss this rule in detail, the changes will likely present significant challenges to the withdrawal permitting program. DEQ continues to evaluate the potential impacts from this rule.

4.3 Investment Challenges for Water Resources Management

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 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. Identified investment challenges include:

- Additional resources are needed to fund staffing, maintenance, rehabilitation, and abandonment of wells in the statewide groundwater level monitoring network and more staff are needed to perform this critical work. More than 50% of the 270 DEQ maintained monitoring wells are over 30 years of age and need attention. A case-by-case evaluation of well integrity and subsequent well rehabilitation needs is in progress. Each well must be reviewed to ensure water levels accurately represent the hydrostatic pressures in the aquifer. A prioritized quarterly implementation schedule has been developed to help guide well evaluation efforts as resources allow. In 2019, multiple groundwater monitoring wells were evaluated in the Richmond Metro Area, the City of Suffolk, and the Middle Peninsula. Resources are also needed to fund the proper abandonment of existing monitoring wells that are compromised, posing a threat to the general public and groundwater quality. These wells, until properly abandoned, are a potential liability issue for the Commonwealth. DEQ has not abandoned any wells in the network as of fall of 2020 due to limited staff and resources.

- In 2018, DEQ was notified by the National Oceanic and Atmospheric Administration (NOAA) that the satellite used to transmit real-time groundwater quality data to the existing database was being updated with improved software. As a result of the improved system, 31 of the 55 "Sat Links" used to transmit data will need to be replaced over the next five years. As of August 2020, 25 Sat Links remain to be replaced. In order to ensure consistency in data collection and water quality/levels across Virginia, increased funding is critical to ensure the continuation of data collection. The estimated cost to replace a single Sat Link is approximately $3,200 per unit. DEQ has applied for federal funding from EPA to assist in purchasing this equipment.

- The numbers of long-term monitoring stations for surface water flow, groundwater levels, and groundwater quality have not kept pace with identified resource management needs. Sustained funding and continued local, state, and federal investment in these stations is critical. At current funding levels, it is difficult to add to or maintain the network of stations and additional staff are needed. The

data collected by stations aides to accurately quantify and support many DEQ activities including numerous permitting programs, establishment of Total Maximum Daily Loads (TMDL), water supply planning, and overall water resource management in the Commonwealth. In order to maintain Virginia's cooperative agreement between DEQ and the USGS for the collection of real-time streamflow and groundwater data, DEQ staff must continue to receive state of the art training on the use of USGS data management system and techniques.

- The Eastern Virginia Groundwater Management Advisory Committee noted that an updated unregulated use estimation methodology is necessary to more accurately quantify and manage the Commonwealth's water resources. DEQ's groundwater model currently uses an estimate of 29 MGD for "unregulated use" based on a methodology developed by the USGS and published in 2008. DEQ estimates that by 2016 unregulated use increased to 39 MGD. The success of ongoing groundwater modeling efforts is dependent on securing additional funds to update the unregulated use methodology.

- 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 State Plan implementation and long-term maintenance. A recurring comment from local and regional entities is that for the statewide planning process to reach its full potential, funding to support local water supply planning efforts is essential to maintain long-term data gathering and planning. Localities will need to submit updated Water Supply Plans in 2023 and funding would promote further investment and participation in the planning process.

- DEQ efforts to monitor chloride concentrations in the Coastal Plain aquifer system identified 81 wells at higher-risk for producing groundwater with chloride concentrations over U.S. EPA standards of 250 mg/L. Additional monitoring wells will need to be drilled in order to sample in the portions of the system that are thought to be most vulnerable to "up-coning" or the landward movement of the freshwater/saltwater interface. Prioritization of new monitoring well locations will be guided by the cooperatively prepared USGS chloride monitoring strategy funded by DEQ.[17] DEQ determined that 42 chloride up-coning monitoring wells and 11 lateral intrusion monitoring wells are needed to fully implement the strategy. Securing additional funding for the installation of new chloride monitoring wells will be a major factor in starting this monitoring program and DEQ's ability to understand groundwater quality across the Coastal Plain. In 2018, Newport News installed the first dedicated chloride monitoring well, State Observation Well 244, at Lee Hall. This well represents the first of many that are needed to fully monitor for changes in chloride concentrations in the Coastal Plain aquifer system.

- Improvements are needed in the way the transfer of water is tracked, both within systems and between localities. This information is used by DEQ to understand the extent of water loss due to inter and intra-basin transfers, aging infrastructure needs, and calculate water balances across the State. In order to improve water supply planning efforts greater reporting of transfers and funding of outreach is needed to understand transfers of water occurring in Virginia and improve modeling capabilities.

- As part of the effort to monitor land subsidence in the Coastal Plain, securing additional funding for the operation, and maintenance of existing extensometers will be a major factor. Two extensometers were originally constructed in Suffolk and in Franklin. However, the extensometers were taken offline in 1995 and only recently rehabilitated in 2016 by USGS. The Eastern Virginia Groundwater Management Advisory Committee identified West Point, Virginia as a potential location of a new extensometer, which would allow measurements in one of the areas most vulnerable to subsidence. DEQ's groundwater model estimates nearly a foot of subsidence has occurred near West Point since 1910. Notably, since the

[17] McFarland, E.R., 2015, A conceptual framework and monitoring strategy for movement of saltwater in the Coastal Plain aquifer system of Virginia: U.S. Geological Survey Scientific Investigations Report 2015–5117.

Committee made this recommendation, an extensometer was installed in a cooperative effort between USGS and Hampton Roads Sanitation District at the Nansemond Wastewater Treatment Facility. While this extensometer could potentially measure further land subsidence, it's primary function is to monitor the response to the injection of groundwater at the SWIFT research site. As these injections increase aquifer pressure in the Potomac Aquifer, changes in rates of subsidence are expected. Securing funding for maintaining and potentially expanding the extensometer network will ensure Virginia is collecting the data needed to accurately monitor subsidence.

Appendix 1: Water Resources Information and Climactic Conditions

State Population
(2010 census) – 8,001,025
(2019 Weldon Cooper Center Estimate) – 8,535,519

State Surface Area – 42,775 square miles (39,493 sq. miles total land area, 3,282 sq. miles inland waters)

Major River Basins (with Current Estimates of Annual Mean River Flow):
- Tennessee-Big Sandy (4,132 sq. miles, 2,986 MGD)
- Albemarle Sound-Chowan River (4,220 sq. miles, 1,724 MGD)
- James (10,265 square miles, 5,437 MGD)
- New (3,068 square miles, 3,229 MGD)
- Rappahannock (2,712 square miles, 1,085 MGD)
- Roanoke (6,393 square miles, 4,955 MGD)
- Potomac-Shenandoah (5,681 sq. miles, 1,842 MGD)
- Chesapeake Bay-Small Coastal (3,592 sq. miles, 97 MGD)
- York (2,674 square miles, 1,053 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 – 42.9 inches

Average Freshwater Discharge of All Rivers - Approximately 22.5 BGD

Average Freshwater Discharge into the Chesapeake Bay – Approximately 9.5 BGD

Climatic Conditions: As of September 1, 2020, precipitation totals for the 2020 water year (October 1, 2019 through September 30, 2020) were generally above normal. Stream flows at most gaging stations and groundwater levels in the majority of Climate Response Network observation wells remained within normal levels. Levels at major water supply storage reservoirs maintained water levels within normal ranges.

Appendix 2: 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 is also 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.

Appendix 3: Top 20 Reported Water Withdrawals in 2019 (Excluding Power Generation)

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

Facility	Locality	Type	Major Source	5 Year Avg.	2019 Withdrawal	Category
AdvanSix Resins Chemicals LLC: Hopewell Plant**	Hopewell City	SW	James River	102.8	104.0	Manufacturing
Fairfax Water: Corbalis WTP**	Fairfax	SW	Potomac River	90.2	90.1	Municipal
City of Norfolk Western Branch Reservoir**	Suffolk City	SW	Western Branch Reservoir	69.6	75.1	Municipal
City of Richmond WTP**	Richmond City	SW	James River	65.3	66.0	Municipal
Fairfax Water: Griffith WTP**	Prince William	SW	Occoquan Reservoir	65.3	62.0	Municipal
Celanese Accetate: Celco Plant**	Giles	SW/GW	New River & 5 Wells	56.8	59.9	Manufacturing
WestRock Virginia Corporation: Covington Plant**	Alleghany	SW/GW	Jackson River & 2 Wells	38.2	36.9	Manufacturing
Appomattox River Water Authority: Chesdin Reservoir WTP*	Chesterfield	SW	Chesdin Reservoir	32.9	35.2	Municipal
City of Virginia Beach Service Area**	City of Virginia Beach	SW	Lake Gaston & Stumpy Lake	26.5	32.2	Municipal
Henrico County WTP & Service Area*	Henrico	SW	James River	23.9	25.6	Municipal
Dupont E I De Nemours &Co: Spruance Plant**	Chesterfield	SW	James River	27.6	23.6	Manufacturing
Virginia American Water: Hopewell District**	Hopewell City	SW	Appomattox River	21.5	22.5	Municipal
Newport News Waterworks: Lee Hall WTP**	City of Newport News	SW	Lee Hall Reservoir	22.2	22.1	Municipal
City of Newport News: Harwood's Mill WTP**	York	SW	Harwood's Mill Reservoir	18.2	18.2	Municipal
City of Portsmouth: Lake Kilby WTP*	Suffolk City	SW/GW	Lakes Kilby, Meade, & Price & 5 Wells	17.6	17.2	Municipal
WestRock CP LLC: West Point Mill Water System*	King William	GW	15 Wells	17.7	16.8	Manufacturing
AdvanSix Resins & Chemicals: Chesterfield Plant**	Chesterfield	SW	James River	19.4	15.4	Manufacturing
Georgia-Pacific Big Island WTP**	Bedford	SW/GW	James River & 4 Wells	14.4	15.0	Manufacturing
International Paper Company: Franklin Virginia Mill*	Isle of Wight	SW/GW	Blackwater River & 12 Wells	13.5	14.4	Manufacturing
Western VA Water Authority City of Roanoke Service Area**	Roanoke City	SW/GW	Carvins Cove Reservoir, Crystal Spring, & 4 Wells	14.1	13.8	Municipal

Table 4: Top 20 Reported Water Withdrawals in 2019 Excluding Power Generation (MGD)

Appendix 4: Water Withdrawals By Use Category

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

- Agriculture
- Commercial
- Fossil Fuel Power
- Hydropower
- Irrigation
- Manufacturing
- Mining
- Nuclear Power
- Public Water Supply

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 nursery products. "Mining" includes water withdrawn for the excavation, processing, and removal of bulk products such as coal, rock, sand, and gravel. "Manufacturing" facilities include industrial facilities including 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. It also includes water that is processed and sold to commercial or institutional facilities that are not self-supplied.

Appendix 4 is divided into sections for each water use category that contain information regarding withdrawals reported for 2019, including the following:

- A map depicting withdrawal point locations for each category, scaled by the magnitude of the 2019 reported annual withdrawal rate of individual facilities;
- A bar graph illustrating the reported quantity withdrawn for each category between 2015 and 2019, as well as the relative amounts by source type (groundwater or surface water);
- A table that lists reported withdrawals for the five-year period between 2015 and 2019 in terms of an annual average rate by source type (groundwater or surface water); and
- A table listing facilities reporting the largest withdrawals for 2019, facility location, water source, reported 2019 annual withdrawal rate, and the average annual withdrawal rate for the five-year period from 2015 to 2019.

Several major transfers of water occur for public water supply; therefore, the total water used for public water supply by locality includes the water withdrawals in that locality, as well as water transferred into that locality from elsewhere, minus any water sold to other localities. The public water supply water withdrawal totals do not include water withdrawn by individuals from private wells, as those withdrawals are not required to be reported. The total only represents the water withdrawn by public or private community water systems. Additional information concerning water transfers can be found in Appendix 2.

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 discussion of Consumptive Use of Water is provided in Chapter 2. Fossil Fuel Power and Nuclear Power are combined as one section entitled Power Generation Water Withdrawals.

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 on the Irrigation Water Withdrawals fact sheet. Figure 13 illustrates the distribution of reported 2019 groundwater and surface water withdrawals for agricultural purposes statewide. The majority of water withdrawn for agricultural use is obtained from surface water (Figure 14), 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 2019 surface water withdrawals for agriculture uses decreased by 4.3% compared to the five-year average, with 30.98 MGD in total withdrawals reported (Table 5).

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 56.2% 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. Reported groundwater withdrawals among this group are anticipated to continue to increase as a portion of these facilities only completed construction in 2019 and began operation in 2020. As discussed previously, outreach to agricultural users continues and as more reporters are identified and registered, the trend of increasing use in this category is expected to continue. The five facilities reporting the largest withdrawals for agriculture use in 2019 are fish hatcheries; they are listed in Table 6. Water withdrawals from agriculture make up 2.61% of all reported 2019 non-power generation withdrawals in Virginia.

Table 5: 2015 - 2019 Agriculture Water Withdrawals by Source Type (MGD)

Source Type	2015	2016	2017	2018	2019	5 Year Avg.	% Change 2019 to Avg.
Groundwater	0.53	0.69	0.73	0.82	1.25	0.80	56.2
Surface Water	33.91	33.64	30.64	32.70	30.98	32.37	-4.3
Total (GW + SW)	**34.44**	**34.33**	**31.37**	**33.52**	**32.23**	**33.18**	**-2.9**

Table 6: Highest Reported Agriculture Withdrawals in 2019 (MGD)

Facility	Locality	Type	Major Source	5 Year Avg.	2019 Withdrawal
Commonwealth of Virginia: Coursey Spring Fisheries	Bath	SW	Coursey Spring	12.6	12.4
Laurel Hill Trout Farm-South Monterey	Highland	SW	Blue Spring	3.9	3.7
Commonwealth of Virginia: Paint Bank Fish Cultural Station.	Craig	SW	Paint Bank Branch	3.5	3.3
Commonwealth of Virginia: Marion Fish Cultural Station	Smyth	SW	Staleys Creek	3.4	3.3
Commonwealth of Virginia: Wytheville Fish Hatchery	Wythe	SW/GW	Boiling and West Springs	3.2	3.1

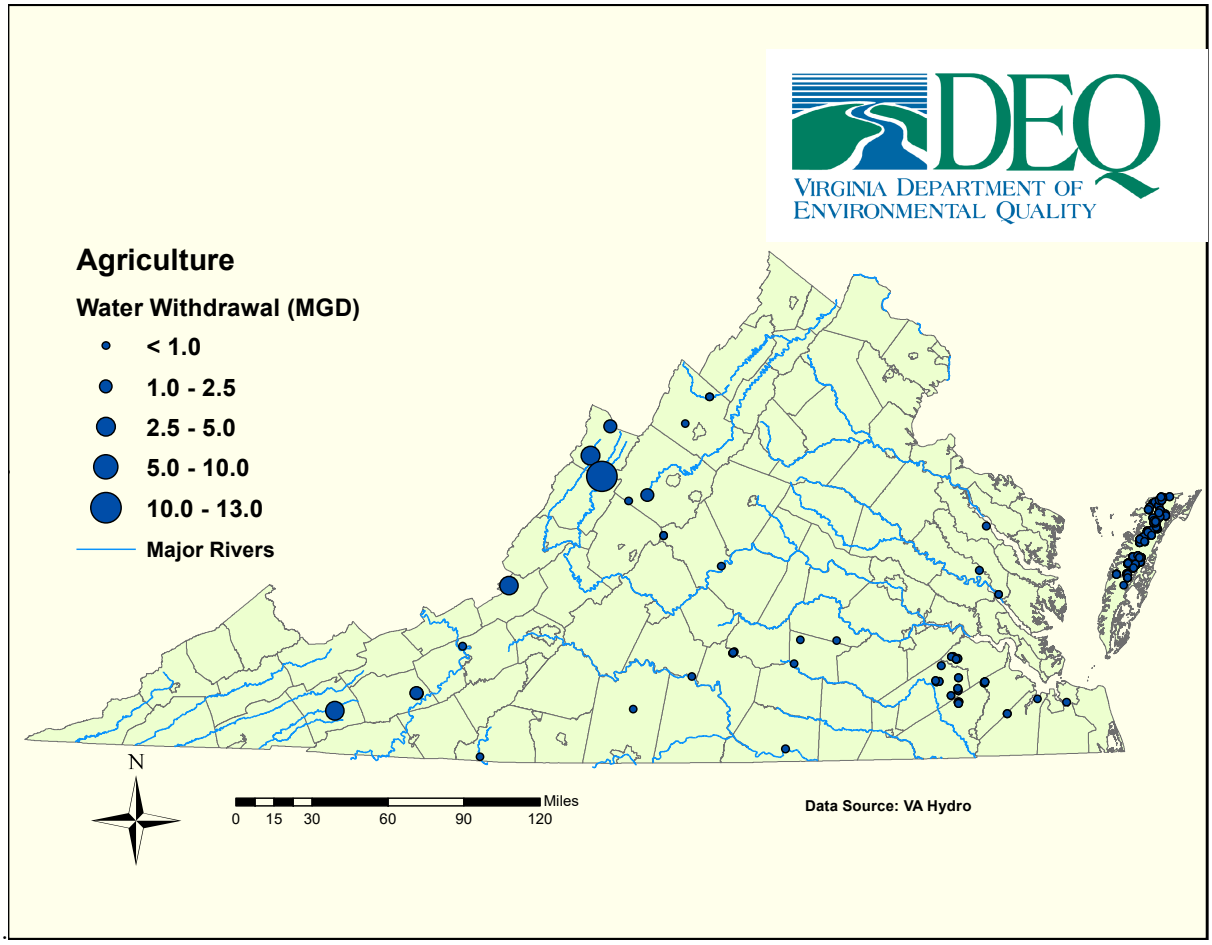

Figure 13: All 2019 Agriculture (Non-Irrigation) Water Withdrawals by Withdrawal Point Location

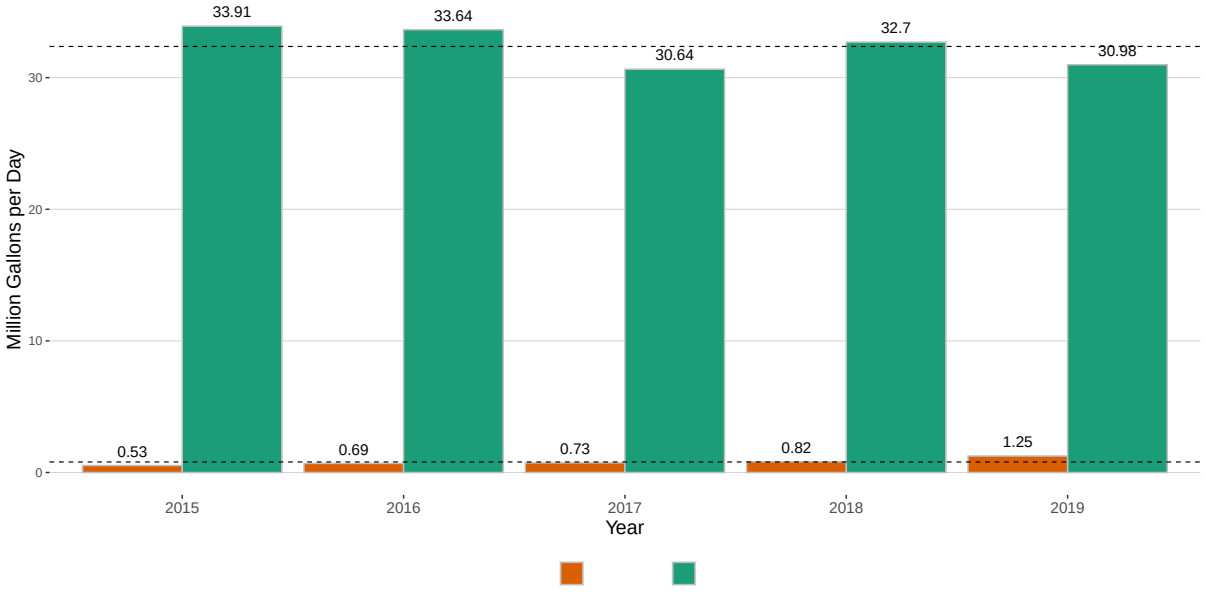

Figure 14: 2015-2019 Agriculture Water Withdrawals by Source Type

Irrigation (Agricultural) Water Withdrawals

Irrigation withdrawals promote growth in agricultural crops such as corn, soybeans, sod, and nursery products. Figure 15 illustrates the distribution of reported 2019 groundwater and surface water withdrawals for irrigation purposes statewide. Surface water continues to be the major water source type for irrigation, representing about 86% of 2019 total irrigation withdrawals (Figure 16). The majority of the reported groundwater 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 2019 were 5.1% greater than the five year average (Table 7). The increased withdrawals may be a result of drier conditions that occurred in August-October, requiring additional irrigation to supplement crops. By the end of October a "Flash Drought" resulted in drought watch advisories being declared across Virginia. The dry conditions experienced across the state increased reliance on irrigated water sources as rainfall was limited over extended periods of time. As with previous years, most large-scale irrigation facilities are located in the northern Coastal Plain, the Eastern Shore, and Shenandoah Valley. The five facilities reporting the greatest withdrawals for irrigation in 2019 are listed in Table 8. Water withdrawals from irrigation make up 1.83% of all non-power generation withdrawals in Virginia for 2019 and in total accounted for 22.6 MGD withdrawn.

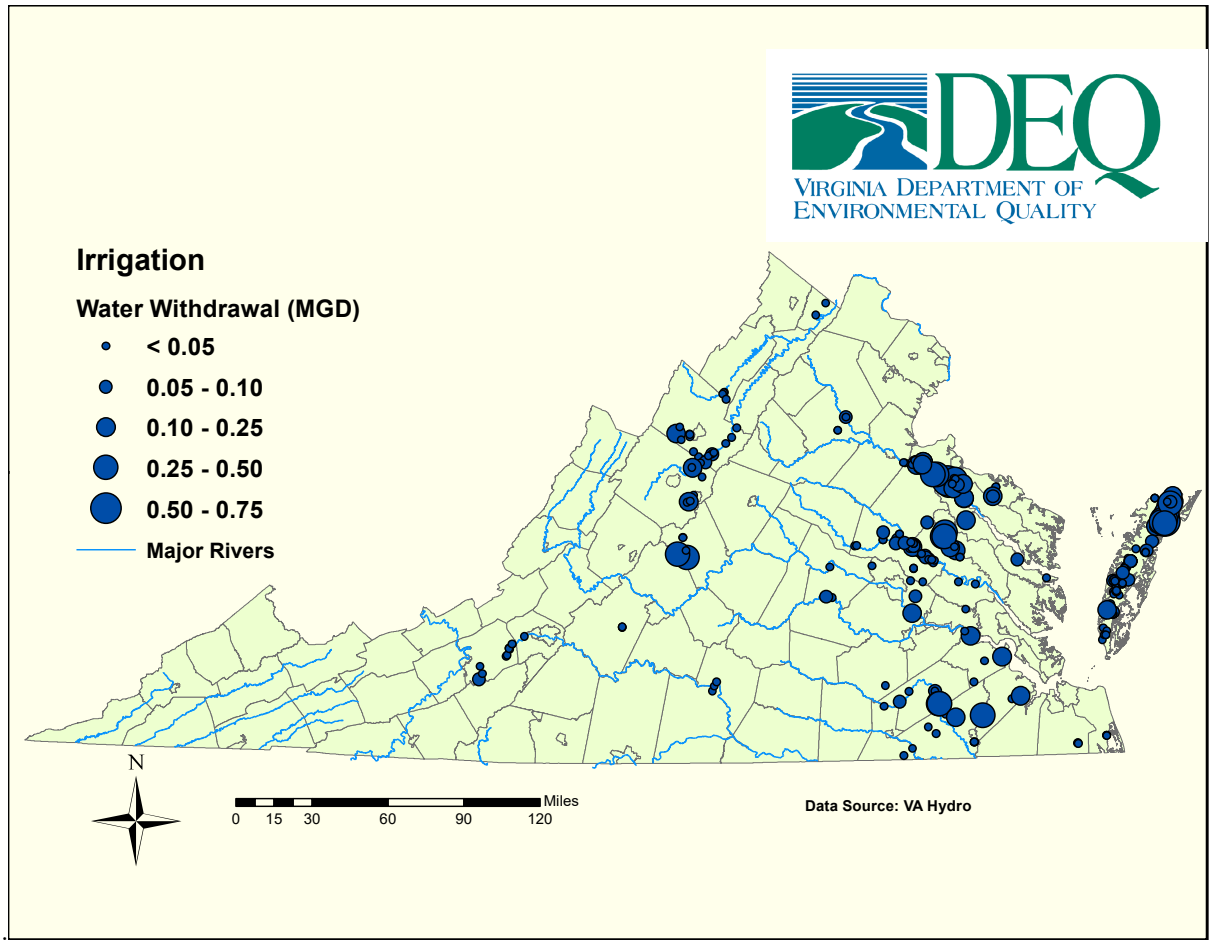

Figure 15: All 2019 Irrigation (Agricultural) Water Withdrawals by Withdrawal Point Location

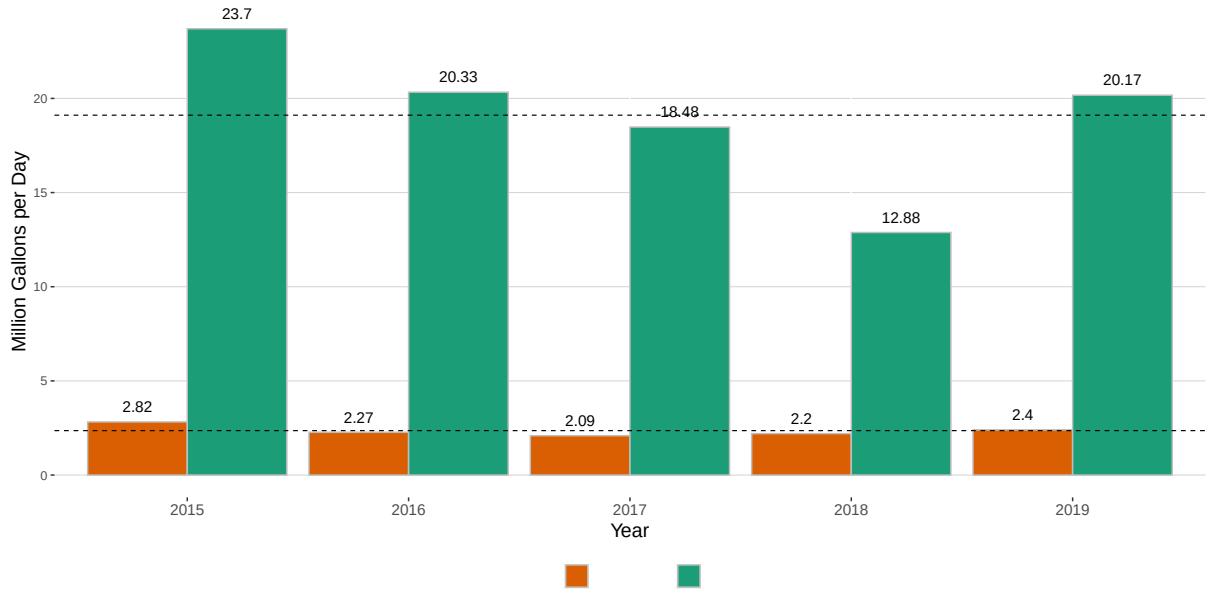

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Figure 16: 2015-2019 Irrigation Water Withdrawals by Source Type

Source Type	2015	2016	2017	2018	2019	5 Year Avg.	% Change 2019 to Avg.
Groundwater	2.82	2.27	2.09	2.20	2.40	2.36	1.7
Surface Water	23.70	20.33	18.48	12.88	20.17	19.11	5.5
Total (GW + SW)	**26.52**	**22.60**	**20.57**	**15.08**	**22.57**	**21.47**	**5.1**

Table 7: 2015-2019 Irrigation Water Withdrawals by Source Type (MGD)

Facility	Locality	Type	Major Source	5 Year Avg.	2019 Withdrawal
Arbuckle Farms	Accomack	SW	6 Ponds	3.2	2.7
Dublin Farms Inc.	Accomack	SW	14 Ponds	1.8	1.8
Saunders Brothers, Inc.	Nelson	SW/GW	Tye River, Allen Creek, Ponds, and Two Groundwater Well	0.9	1.3
Glenwood Farms	King and Queen	SW	Chapel Creek and Ponds	0.8	1.2
Cloverfield Farm	Essex	SW	Rappahannock River and 2 Ponds	0.6	1.0

Table 8: Highest Reported Irrigation Withdrawals in 2019 (MGD)

Commercial Water Withdrawals

Commercial operations include golf courses, local and federal installations, hotels, resorts, and correctional centers, among others. Figure 17 illustrates the distribution of reported 2019 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 snow making (Figure 18). Reported commercial water withdrawals increased by 1.6% compared to the five year average; however groundwater withdrawals associated with commercial facilities dropped by 2.4% as compared to the five year average (Table 9). The five facilities reporting the largest 2019 water withdrawals for commercial operations are listed in Table 10. Water withdrawals from commercial activities make up 1.2% of all non-power generation withdrawals in Virginia.

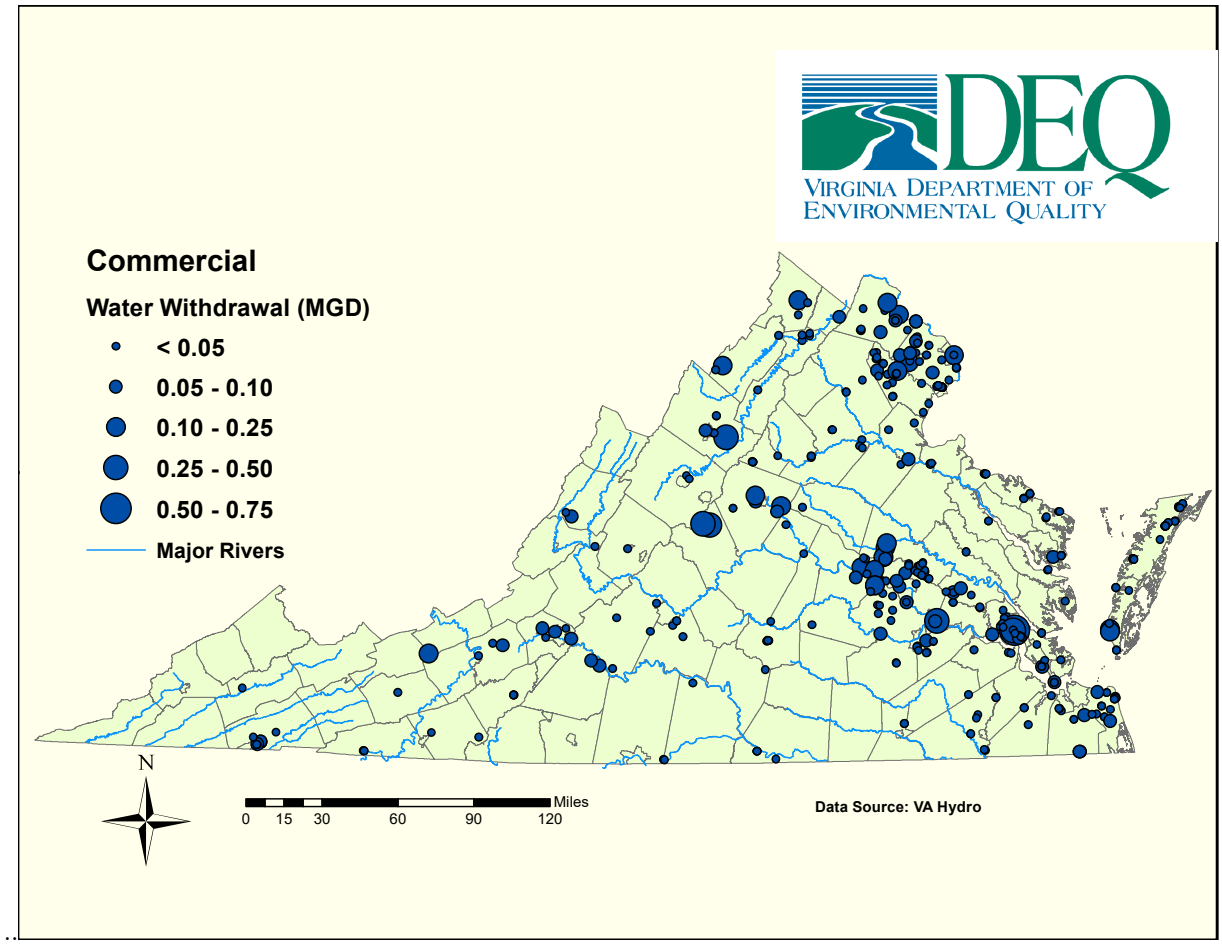

Figure 17: All 2019 Commercial Water Withdrawals by Withdrawal Point Location

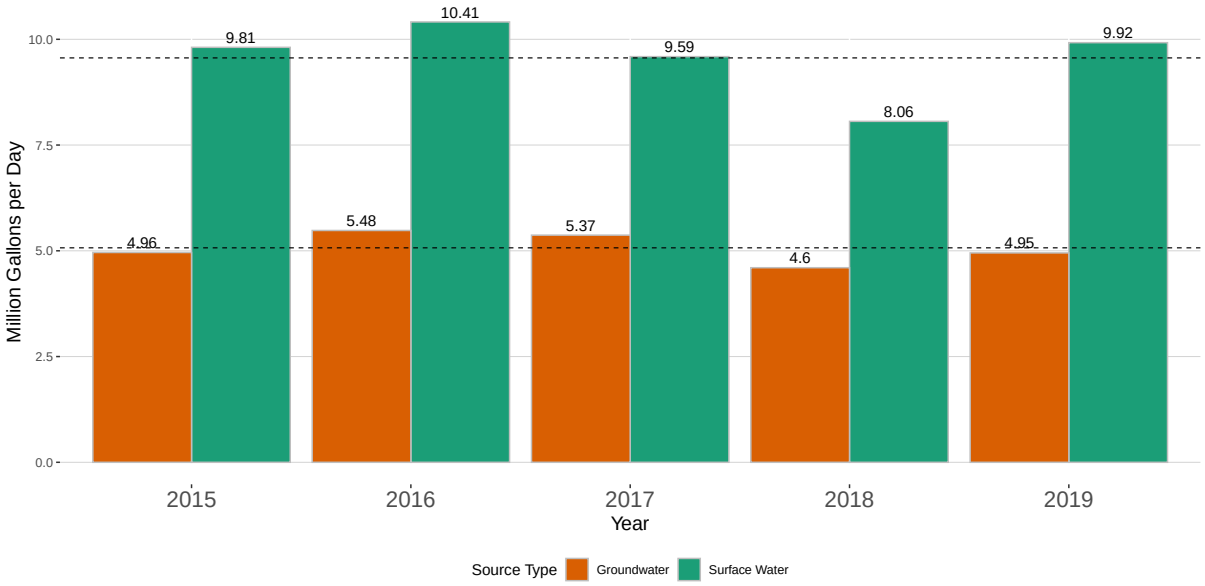

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Figure 18: 2015-2019 Commercial Water Withdrawals by Source Type

Source Type	2015	2016	2017	2018	2019	5 Year Avg.	% Change 2019 to Avg.
Groundwater	4.96	5.48	5.37	4.60	4.95	5.07	-2.4
Surface Water	9.81	10.41	9.59	8.06	9.92	9.56	3.8
Total (GW + SW)	**14.77**	**15.89**	**14.96**	**12.66**	**14.87**	**14.63**	**1.6**

Table 9: 2015-2019 Commercial Water Withdrawals by Source Type (MGD)

Facility	Locality	Type	Major Source	5 Year Avg.	2019 Withdrawal
Colonial Williamsburg	Williamsburg	GW	3 Wells	1.1	1.0
Lake Monacan-Stoney Creek (Wintergreen)	Nelson	SW	Lake Monocan	0.9	0.8
Port Tobacco	Charles City	SW	James River and Dredge Pond	0.2	0.5
Bay Creek Resort & Club	Northampton	SW	2 Lakes	0.7	0.4
Massanutten Resort	Rockingham	SW	Quail Run, Woodstone Lake, and Painters Pond	0.3	0.3

Table 10: Highest Reported Commercial Withdrawals in 2019 (MGD)

Mining Water Withdrawals

Mining includes operations such as sand, rock, and coal mining. Figure (Figure 19) illustrates the distribution of reported 2019 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 2019, the reported withdrawals for mining continued to be predominantly from groundwater sources (Figure 19). This is largely due to the dewatering that must be completed for many types of mining. Such withdrawals are reported under groundwater withdrawals. Total reported water withdrawals for mining purposes in 2019 increased by 4.2% as compared to the five-year average (Table 11). Increases observed in 2019 were largely due to increases in withdrawals from the largest water users, with the top five users all reporting withdrawals over their five year average. Because there are no major transfers of water for mining purposes, the water withdrawals also represent direct water use. The five facilities reporting the largest 2019 mining withdrawals are listed in Table 12. Water withdrawals from mining operations are 2.51% of all non-power generation withdrawals in Virginia.

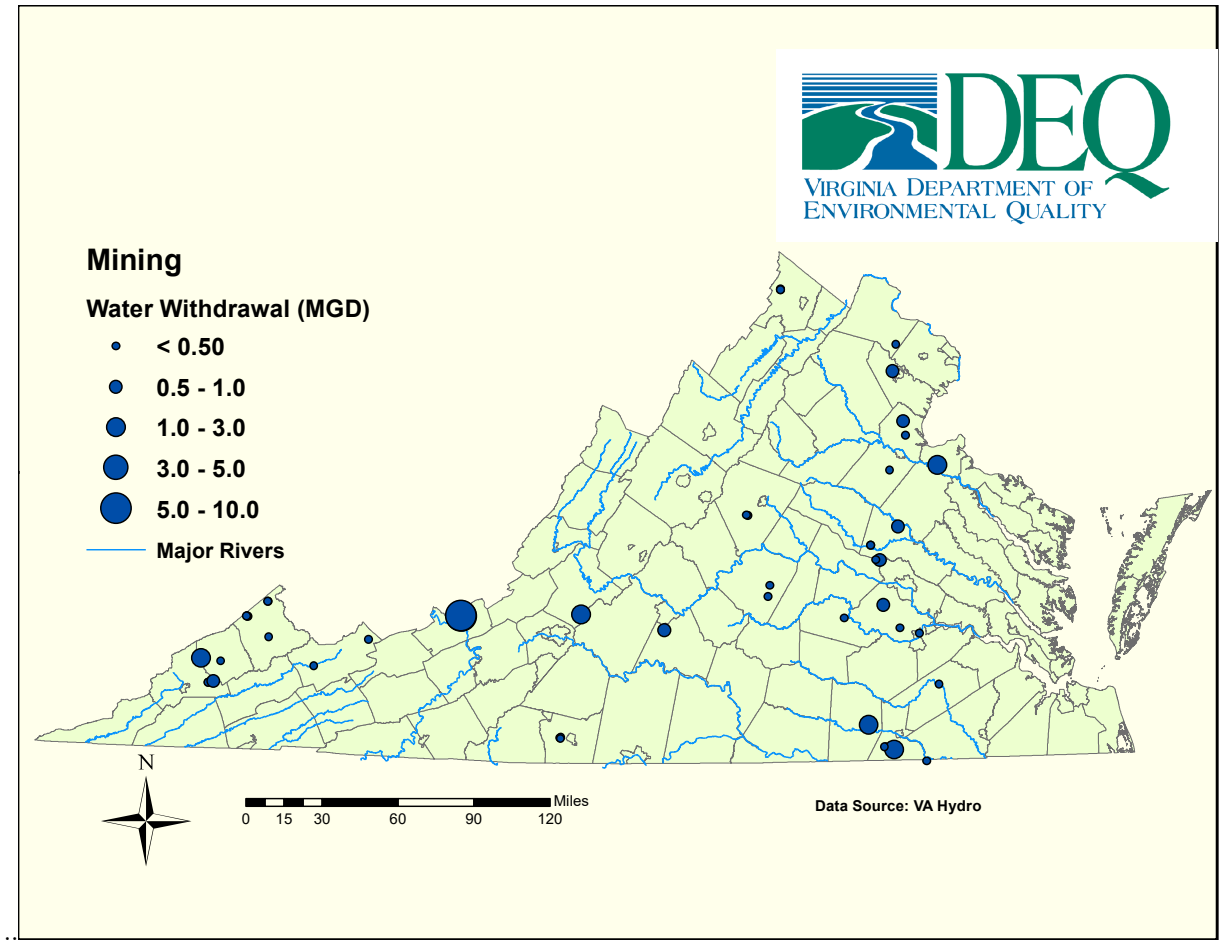

Figure 19: All 2019 Mining Water Withdrawals by Withdrawal Point Location

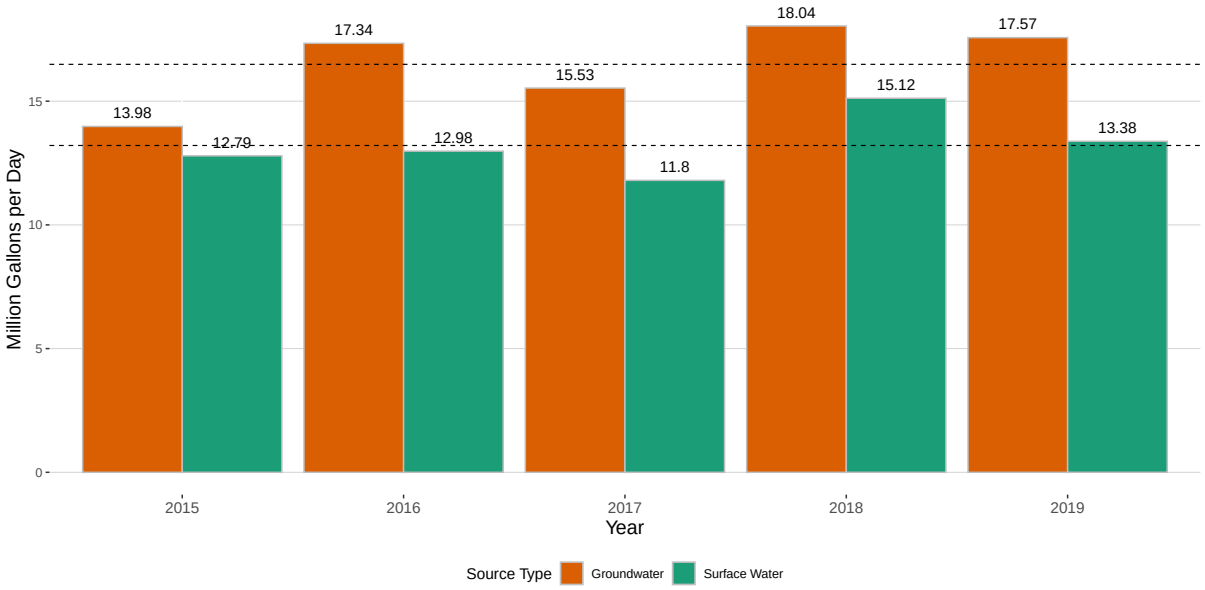

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Figure 20: 2015-2019 Mining Water Withdrawals by Source Type

Source Type	2015	2016	2017	2018	2019	5 Year Avg.	% Change 2019 to Avg.
Groundwater	13.98	17.34	15.53	18.04	17.57	16.49	6.5
Surface Water	12.79	12.98	11.80	15.12	13.38	13.21	1.3
Total (GW + SW)	**26.77**	**30.32**	**27.33**	**33.16**	**30.95**	**29.71**	**4.2**

Table 11: 2015-2019 Mining Water Withdrawals by Source Type (MGD)

Facility	Locality	Type	Major Source	5 Year Avg.	2019 Withdrawal
Lhoist North America: Kimballton Plant 1	Giles	GW	Quarry and Spring	9.4	9.7
Lhoist North America: Kimballton Plant 2	Giles	SW/GW	Stoney Creek and Quarry Well	5.0	5.9
Boxley Materials: Blue Ridge Plant	Bedford	GW	Quarry	1.9	2.0
Vulcan Construction Materials: Lawrenceville Quarry	Brunswick	SW/GW	Quarry	1.2	1.6
Mid-Atlantic Materials Rappahannock Farms Sand & Gravel	King George	SW	Rappahannock River	1.3	1.4

Table 12: Highest Reported Mining Withdrawals in 2019 (MGD)

Manufacturing Water Withdrawals

The Manufacturing use category includes industrial operations such as chemical and plastics manufacturing, paper mills, food processors, drug companies, furniture, and industrial withdrawals. Water withdrawals reported in 2019 for manufacturing purposes are spread throughout much of Virginia (Figure 21) 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 River 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.

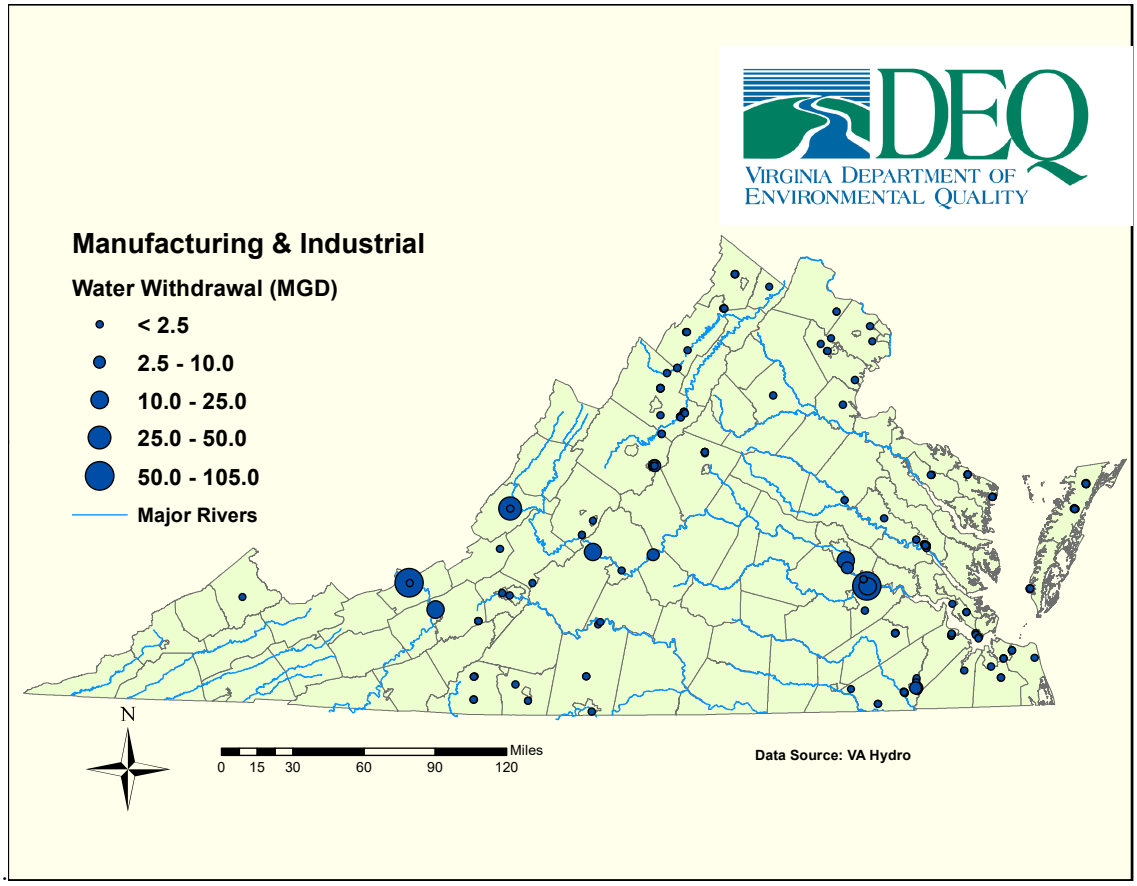

Figure 21: All 2019 Manufacturing Water Withdrawals by Withdrawal Point Location

Figure 22 illustrates the source distribution and annual changes in statewide totals of groundwater and surface water withdrawals for manufacturing from 2015-2019. Reported 2019 withdrawals decreased by 4.3% as compared to the five year average, shown in Table 13. This is largely driven by a 5.4% decrease in surface water withdrawals for manufacturing. Surface water is the predominate water source type for manufacturing, accounting for approximately 80% of supply in 2019. There are no major transfers of water reported for manufacturing purposes, so the water withdrawals generally represent direct water use. Water withdrawals from manufacturing users account for 28.47% of all non-power generation withdrawals in Virginia. Table 14 lists the five facilities reporting the largest groundwater withdrawals associated with this category in 2019 and Table 15 lists the facilities reporting the largest surface water withdrawals associated with this category in 2019.

The WestRock West Point Mill Water system was the largest groundwater user reporting 16.8 MGD in groundwater withdrawals in 2019, a slight decrease when compared to the five year average. International Paper's Franklin Mill reported 11.9 MGD in groundwater withdrawals, a slight increase in withdrawal compared to the five year average. Celanese Acetate reported the largest increase in groundwater withdrawals compared to their five year average, with 5.8 MGD reported in 2019 compared to a five year average of 4.6 MGD. The LYCRA Company in Waynesboro continues to report increased withdrawals since resuming withdrawals from a previously inactive well in 2017; an additional 0.7 MGD of groundwater withdrawal was reported in 2019. Note that three of the largest manufacturing groundwater withdrawals occur outside of current groundwater management areas.

Table 15, shows the highest reporting surface water withdrawals for manufacturing uses in 2019. The AdvanSix Hopewell Plant was the largest reported surface water withdrawal with a 2019 amount of 104 MGD, an increase of 1.2 MGD compared to the five year average. The Hopewell Plant is the largest reported surface water withdrawal in the Commonwealth when excluding power generation facilities. Celanese Acetate in Giles County was the second largest surface water withdrawal reporting 54.0 MGD, an increase of 1.7 MGD when compared to the five year average. Celanese Accetate is a unique facility as it reports some of the highest groundwater and surface water withdrawals. The Covington Westrock, Dupont Spruance Plant, and AdvanSix Resin Chesterfield Plant all reported significant reductions in reported surface water withdrawals compared to their five year average.

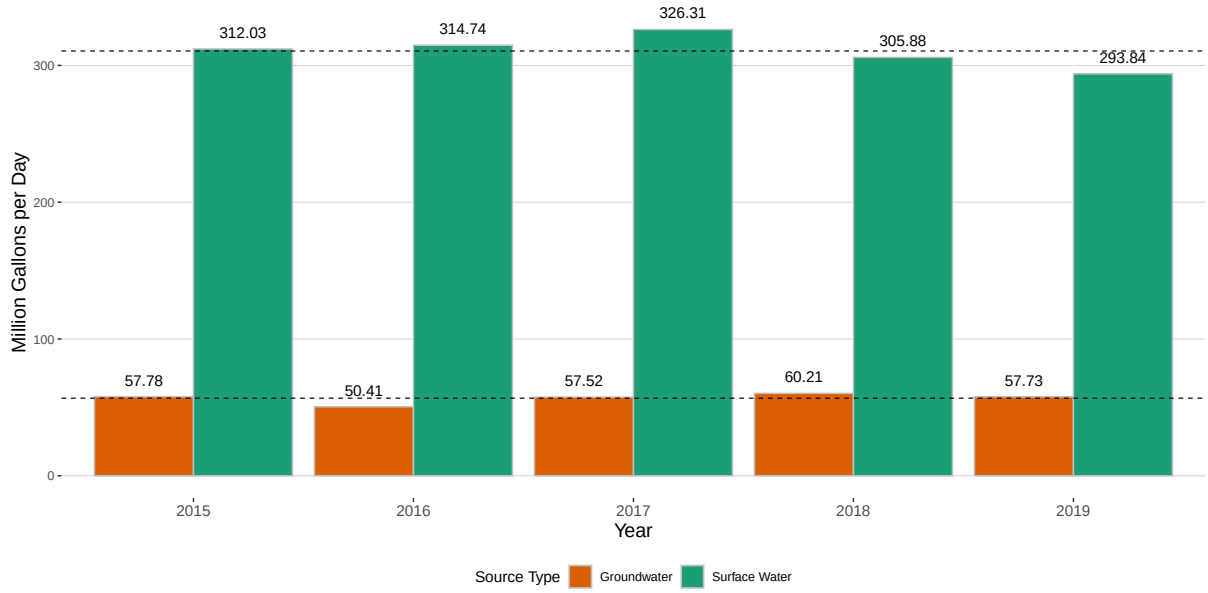

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Figure 22: 2015-2019 Manufacturing Water Withdrawals by Source Type

Source Type	2015	2016	2017	2018	2019	5 Year Avg.	% Change 2019 to Avg.
Groundwater	57.78	50.41	57.52	60.21	57.73	56.73	1.8
Surface Water	312.03	314.74	326.31	305.88	293.84	310.56	-5.4
Total (GW + SW)	**369.81**	**365.15**	**383.83**	**366.09**	**351.57**	**367.29**	**-4.3**

Table 13: 2015-2019 Manufacturing Water Withdrawals by Source Type (MGD)

Facility	Locality	Type	Major Source	5 Year Avg.	2019 Withdrawal
WestRock CP, LLC: West Point Mill Water System	King William	GW	14 Wells	17.7	16.8
International Paper: Franklin Virginia Mill	Isle of Wight	GW	12 Wells	11.4	11.9
Celanese Acetate LLC: Celco Plant	Giles	GW	5 Wells	4.6	5.8
Merck & Co: Elkton Plant	Rockingham	GW	11 Wells	6.1	5.7
The LYCRA Company: Waynesboro Plant	Waynesboro City	GW	3 Wells	3.1	3.8

Table 14: Highest Reported Manufacturing Groundwater Withdrawals in 2019 (MGD)

Facility	Locality	Type	Major Source	5 Year Avg.	2019 Withdrawal
AdvanSix Resins & Chemicals LLC: Hopewell Plant	Hopewell City	SW	James River	102.8	104.0
Celanese Acetate LLC: Celco Plant	Giles	SW	New River	52.3	54.0
Covington Plant Westrock	Alleghany	SW	Jackson River	37.9	36.7
DuPont: Spruance Plant	Chesterfield	SW	James River	27.5	23.4
AdvanSix Resins & Chemicals LLC: Chesterfield Plant	Chesterfield	SW	James River	19.4	15.4

Table 15: Highest Reported Manufacturing Surface Water Withdrawals in 2019 (MGD)

Public Water Supply Water Withdrawals

Water withdrawals for public water supply are primarily delivered to domestic users by both municipal (public) and private water purveyors; 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 public water purveyors reporting 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 purveyors are spread throughout the state serving small towns or communities (Figure 23).

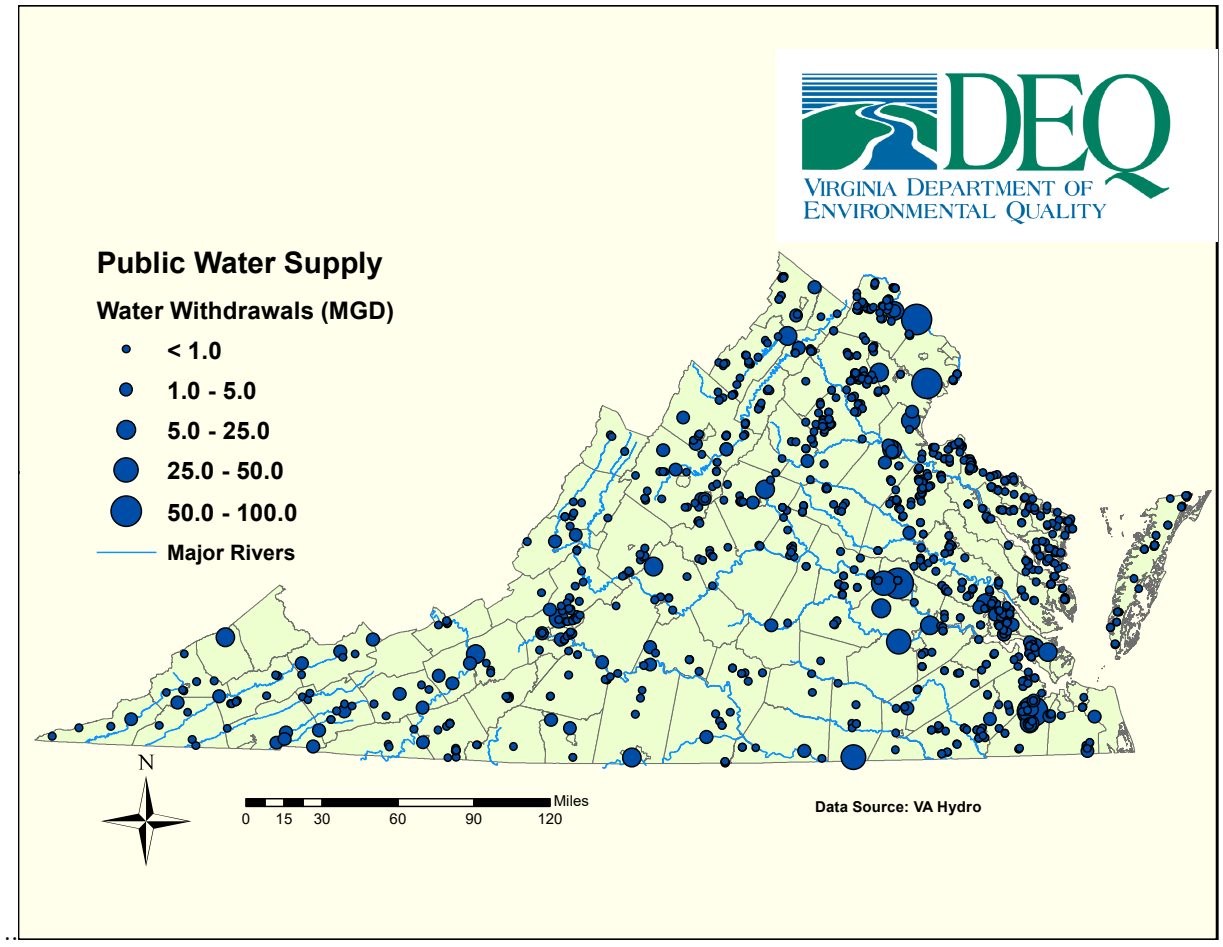

Figure 23: All 2019 Public Water Supply Water Withdrawals by Withdrawal Point Location

Reported 2019 water withdrawals for public water supply increased by 1.1% when compared to the average of the previous five years (Table 16). Over the last five years, withdrawals for public water supply have shown a consistent increasing trend, which is driven by increasing population. As with manufacturing, surface water is the major source of water for public water supply in terms of the overall quantities used. Surface water supplied 93% of the total 2019 public water supply withdrawals in Virginia (Figure 24). Table 17 lists the ten facilities that reported the largest public water supply withdrawals in 2019. They include large public water suppliers such as Fairfax Water, City of Norfolk, City of Richmond, and the Appomattox River Water Authority. Water withdrawals for public water supply make up 63.4% of all non-power generation withdrawals in Virginia.

There are several major transfers of water that occur for public water supply; therefore, the total water used for public water supply in each locality includes the water withdrawals in that locality, as well as water transferred into that locality from elsewhere, minus any water sold to other localities. The public water supply water withdrawal total does not include water withdrawn by individuals from private wells, as those withdrawals are not required to report. The total only represents the water withdrawn by public or private community water systems.

Table 18 displays information from VDH's 2018 Public Drinking Water Annual Compliance Report. The report lists the number of public water supply waterworks by type and the total population served by all of these systems (population served by type of waterworks was not available).

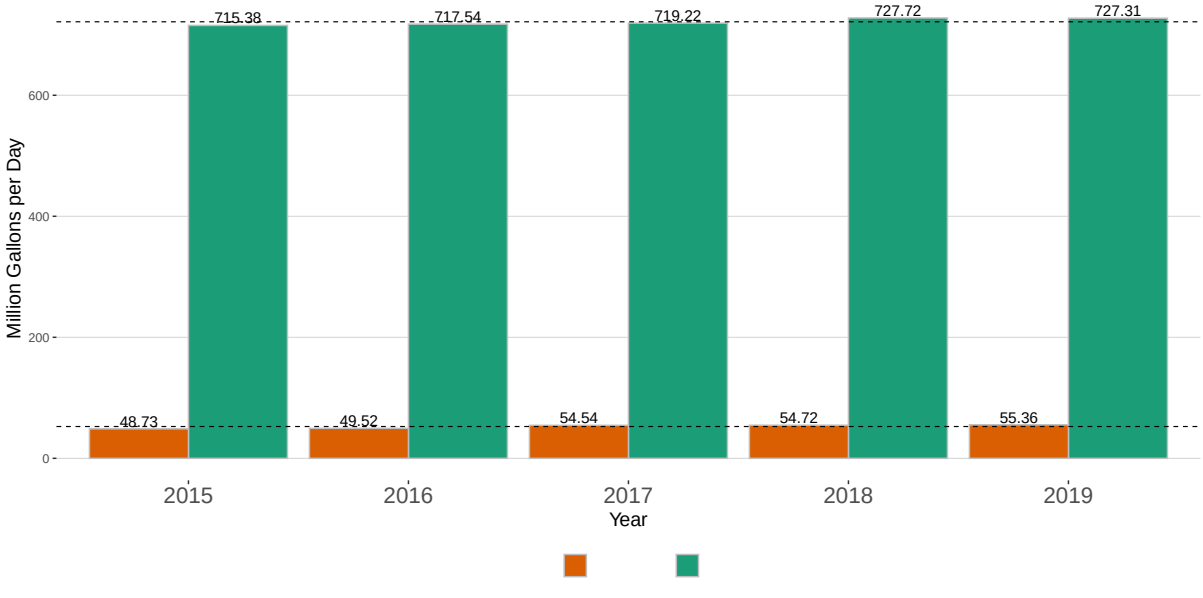

Figure 24: 2015-2019 Public Water Supply Water Withdrawals by Source Type

Source Type	2015	2016	2017	2018	2019	5 Year Avg.	% Change 2019 to Avg.
Groundwater	48.73	49.52	54.54	54.72	55.36	52.57	5.3
Surface Water	715.38	717.54	719.22	727.72	727.31	721.43	0.8
Total (GW + SW)	**764.11**	**767.06**	**773.76**	**782.44**	**782.67**	**774.01**	**1.1**

Table 16: 2015-2019 Public Water Supply Water Withdrawals by Source Type (MGD)

Facility	Locality	Type	Major Source	5 Year Avg.	2019 Withdrawal
Fairfax Water: Corbalis Water Treatment Plant	Fairfax	SW	Potomac River	90.2	90.1
Norfolk: Western Branch	Suffolk City	SW	Western Branch Reservoir	69.6	75.1
City of Richmond Wtp	Richmond City	SW	James River	65.3	66.0
Fairfax Water: Griffith Water Treatment Plant	Prince William	SW	Occoquan Reservoir	65.3	62.0
Appomattox River Water Authority: Chesdin Reservoir WTP	Chesterfield	SW	Chesdin Reservoir	32.9	35.2
Virginia Beach	Virginia Beach City	SW	Lake Gaston	26.5	32.2
Henrico County WTP	Henrico	SW	James River	23.9	25.6
Virginia American Water Hopewell District	Hopewell City	SW	Appomattox River	21.5	22.5
City of Newport News Waterworks Lee Hall WTP	Newport News City	SW/GW	Lee Hall Reservoir	22.2	22.1
City of Newport News Harwood's Mill WTP	York	SW	Harwoods Mill Reservoir	18.2	18.2

Table 17: Highest Reported Public Water Supply Withdrawals in 2019 (MGD)

Category	Community Water Systems	Nontransient Noncommunity Water Systems	Transient Noncommunity Water Systems	Total
Number of Systems	1,088	505	1,201	2,794
Population Served	7,096,695	283,695	192,865	7,573,255

Table 18: Number of Public Water Supply Systems and Population Served in 2019

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 25). Groundwater withdrawals reported by power generation facilities in 2019 were insignificant compared to surface water withdrawals, which is consistent with historical trends (Figure 26). Total power generation withdrawals in 2019 decreased by 10.2% as compared to the five-year average (Table 19). 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 4,492 MGD in 2019, which was the second consecutive year of withdrawals under 5,000 MGD. The five power generation facilities with the highest reported withdrawals are listed in Table 20. These consist of two nuclear power plants and three coal fired power plants.

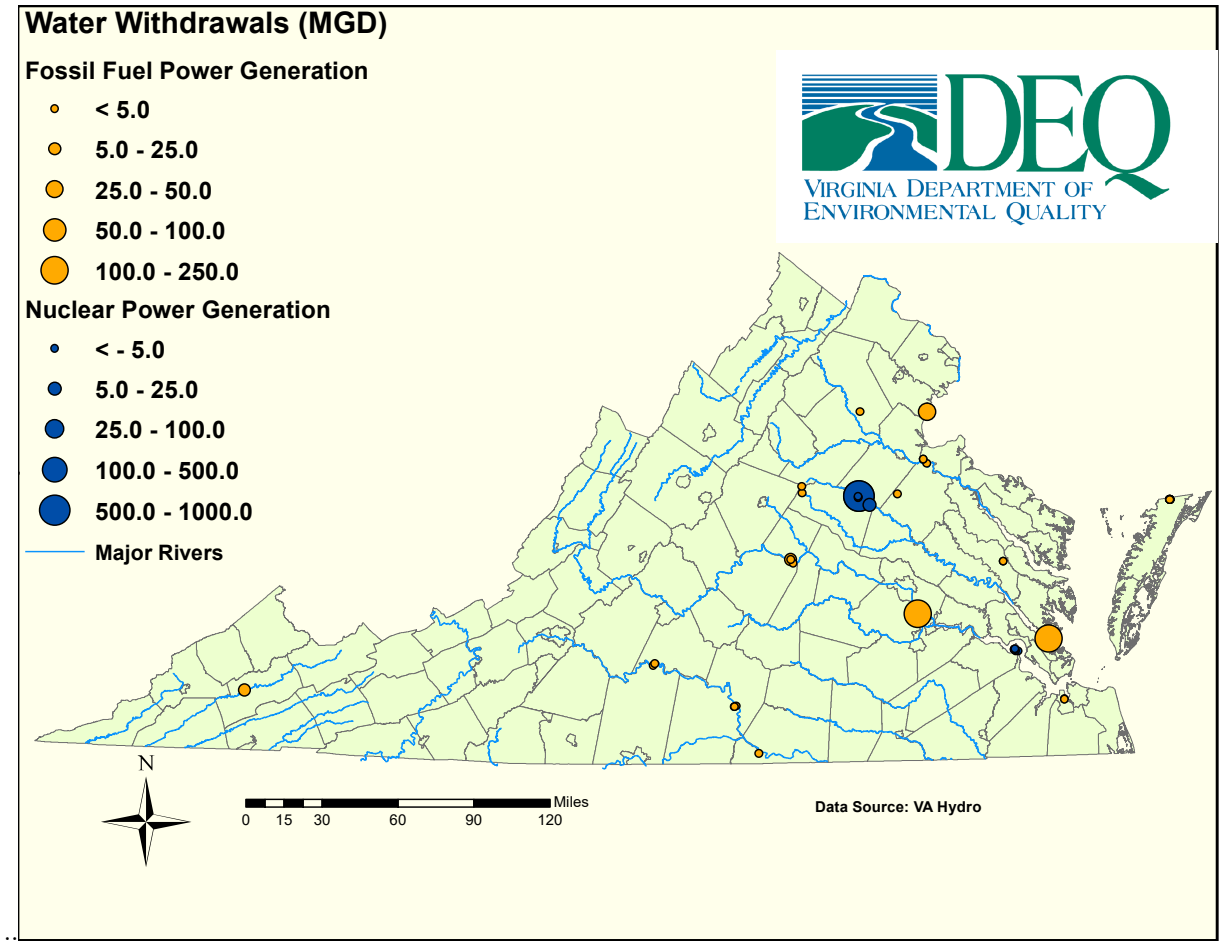

Figure 25: All 2019 Power Generation Water Withdrawals by Withdrawal Point Location

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Figure 26: 2015-2019 Power Generation Water Withdrawals by Source Type

Power Type	2015	2016	2017	2018	2019	5 Year Avg.	% Change 2019 to Avg.
Groundwater							
Fossil	0.30	0.07	0.09	0.12	0.07	0.130	-46.2
Nuclear	0.35	0.36	0.32	0.38	0.37	0.360	2.8
Total Groundwater	0.65	0.43	0.41	0.50	0.44	0.490	-10.2
Surface Water							
Fossil	1583.93	1348.99	1102.08	1012.39	752.18	1159.910	-35.2
Nuclear	3782.24	4021.44	3951.16	3705.29	3739.35	3839.900	-2.6
Total Surface Water	5366.17	5370.43	5053.24	4717.68	4491.53	4999.810	-10.2
Total (GW + SW)	**5366.82**	**5370.86**	**5053.65**	**4718.18**	**4491.97**	**5000.296**	**-10.2**

Table 19: 2015 - 2019 Power Generation Water Withdrawals by Source Type (MGD)

Facility	Locality	Type	Major Source	5 Year Avg.	2019 Withdrawal
Dominion Generation: Surry Power Station	Surry	SW	James River	1968.5	1921.7
Dominion Generation: North Anna Nuclear Power Plant	Louisa	SW	Lake Anna	1871.8	1818.0
Dominion Generation: Chesterfield Power Station	Chesterfield	SW	James River	675.5	459.8
Dominion Generation: Yorktown Fossil Power Plant	York	SW	York River	305.8	240.4
Dominion Generation: Possum Point Power Station	Prince William	SW	Potomac River	122.7	35.3

Table 20: Highest Reported Power Generation Withdrawals in 2019 (MGD)

Appendix 5: Water Withdrawals Within Localities in 2019 (MGD) (Excluding Power Generation)

Table 21, shown below, lists the reported water withdrawals, both permitted and unpermitted, that occurred in 2019 within individual localities.

Locality	GW Withdrawal	SW Withdrawal	GW + SW Total	% of Total Withdrawal
Accomack	5.31	4.97	10.28	0.83
Albemarle	0.14	10.89	11.03	0.89
Alexandria	0.00	0.00	0.00	0.00
Alleghany	0.28	37.84	38.12	3.09
Amelia	0.12	0.25	0.37	0.03
Amherst	0.00	16.88	16.88	1.37
Appomattox	0.00	0.00	0.00	0.00
Arlington	0.02	0.12	0.14	0.01
Augusta	3.14	6.95	10.09	0.82
Bath	0.16	13.54	13.71	1.11
Bedford	2.08	18.06	20.14	1.63
Bland	0.04	0.14	0.18	0.01
Botetourt	0.72	2.34	3.07	0.25
Bristol	0.00	0.00	0.00	0.00
Brunswick	0.03	2.64	2.67	0.22
Buchanan	0.37	1.10	1.47	0.12
Buckingham	0.00	0.37	0.37	0.03
Buena Vista	1.15	0.02	1.17	0.09
Campbell	0.07	6.40	6.47	0.52
Caroline	1.46	1.90	3.36	0.27
Carroll	0.21	0.32	0.53	0.04
Charles City	0.06	1.05	1.11	0.09
Charlotte	0.13	0.12	0.25	0.02
Charlottesville	0.00	0.00	0.00	0.00
Chesapeake	3.36	2.80	6.16	0.50
Chesterfield	0.62	87.76	88.38	7.16
Clarke	0.03	0.59	0.61	0.05
Colonial Heights	0.00	0.00	0.00	0.00
Covington	0.00	2.73	2.73	0.22
Craig	0.10	3.36	3.46	0.28
Culpeper	1.04	1.56	2.61	0.21
Cumberland	0.00	0.06	0.06	0.00
Danville	0.00	5.20	5.20	0.42
Dickenson	0.00	6.18	6.18	0.50
Dinwiddie	0.03	0.38	0.41	0.03
Emporia	0.00	1.00	1.00	0.08
Essex	0.36	1.52	1.88	0.15
Fairfax City	0.01	0.01	0.03	0.00
Fairfax County	0.36	90.89	91.25	7.39
Falls Church	0.00	0.00	0.00	0.00
Fauquier	1.90	1.30	3.20	0.26
Floyd	0.12	0.13	0.25	0.02
Fluvanna	0.15	0.71	0.87	0.07

Franklin City	0.84	0.00	0.84	0.07
Franklin County	0.13	0.90	1.02	0.08
Frederick	0.75	5.10	5.84	0.47
Fredericksburg	0.00	0.02	0.02	0.00
Galax	0.00	1.84	1.84	0.15
Giles	21.80	54.60	76.41	6.19
Gloucester	0.70	0.47	1.18	0.10
Goochland	0.08	2.15	2.23	0.18
Grayson	0.13	0.05	0.18	0.01
Greene	0.02	0.63	0.65	0.05
Greensville	0.06	2.56	2.62	0.21
Halifax	0.10	1.79	1.90	0.15
Hampton	0.00	0.02	0.02	0.00
Hanover	0.69	5.53	6.22	0.50
Harrisonburg	0.00	0.06	0.06	0.00
Henrico	0.01	26.11	26.11	2.11
Henry	0.01	3.83	3.84	0.31
Highland	0.07	5.83	5.90	0.48
Hopewell	0.00	138.82	138.82	11.24
Isle of Wight	14.62	4.32	18.93	1.53
James City	5.61	3.52	9.13	0.74
King and Queen	0.01	1.28	1.29	0.10
King George	1.18	2.03	3.21	0.26
King William	17.46	0.77	18.23	1.48
Lancaster	0.42	0.10	0.52	0.04
Lee	0.00	2.20	2.20	0.18
Lexington	0.00	0.00	0.00	0.00
Loudoun	1.46	15.51	16.97	1.37
Louisa	0.32	0.39	0.71	0.06
Lunenburg	0.00	0.58	0.58	0.05
Lynchburg	0.02	0.10	0.12	0.01
Madison	0.05	0.10	0.16	0.01
Manassas	0.31	11.97	12.28	0.99
Manassas Park	0.00	0.00	0.00	0.00
Martinsville	0.00	1.94	1.94	0.16
Mathews	0.01	0.00	0.01	0.00
Mecklenburg	0.12	1.98	2.10	0.17
Middlesex	0.23	0.10	0.33	0.03
Montgomery	0.15	20.99	21.14	1.71
Nelson	0.14	2.99	3.12	0.25
New Kent	0.88	16.40	17.28	1.40
Newport News	0.30	25.89	26.19	2.12
Norfolk	0.05	0.24	0.29	0.02
Northampton	1.28	1.24	2.52	0.20
Northumberland	0.32	0.03	0.35	0.03
Norton	0.00	0.73	0.73	0.06
Nottoway	0.01	1.05	1.07	0.09
Orange	0.02	1.93	1.96	0.16
Page	0.97	0.82	1.79	0.14
Patrick	0.13	0.83	0.97	0.08

Petersburg	0.05	0.03	0.08	0.01
Pittsylvania	0.02	2.09	2.11	0.17
Poquoson	0.00	0.00	0.00	0.00
Portsmouth	0.17	0.00	0.17	0.01
Powhatan	0.11	0.15	0.27	0.02
Prince Edward	0.08	1.08	1.16	0.09
Prince George	0.34	0.10	0.44	0.04
Prince William	0.44	64.16	64.60	5.23
Pulaski	0.00	4.58	4.58	0.37
Radford	0.00	2.96	2.96	0.24
Rappahannock	0.03	0.00	0.03	0.00
Richmond	0.20	66.19	66.39	5.38
Richmond County	0.27	0.00	0.27	0.02
Roanoke City	1.10	13.18	14.28	1.16
Roanoke County	1.09	0.06	1.15	0.09
Rockbridge	0.40	0.04	0.44	0.04
Rockingham	14.41	10.17	24.58	1.99
Russell	0.44	0.68	1.12	0.09
Salem	1.53	2.99	4.52	0.37
Scott	0.08	1.22	1.30	0.11
Shenandoah	2.81	1.73	4.54	0.37
Smyth	0.77	5.92	6.69	0.54
Southampton	3.40	1.31	4.71	0.38
Spotsylvania	0.29	10.62	10.91	0.88
Stafford	0.00	14.08	14.09	1.14
Staunton	0.00	0.00	0.00	0.00
Suffolk	6.72	95.61	102.33	8.29
Surry	0.23	0.17	0.40	0.03
Sussex	1.02	0.94	1.97	0.16
Tazewell	0.00	4.58	4.58	0.37
Virginia Beach	0.16	32.39	32.56	2.64
Warren	0.17	8.44	8.61	0.70
Washington	0.17	9.82	9.99	0.81
Waynesboro	4.98	1.21	6.18	0.50
Westmoreland	1.14	1.41	2.54	0.21
Williamsburg	1.04	0.00	1.04	0.08
Wincester	0.00	0.00	0.00	0.00
Wise	0.03	6.48	6.51	0.53
Wythe	0.08	7.84	7.92	0.64
York	0.42	20.94	21.36	1.73
Total	**139.26**	**1095.60**	**1234.86**	**100.00**

Table 21: Water Withdrawals Within Localities in 2019 (MGD)