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 2019

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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 2018 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 will 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, identifies potential areas of water availability concern within the state as well as challenges for future water resources management and recommendations for action. The 2020 State Water Resources Plan Update is currently under development.

Data analysis conducted for the 2015 State Plan predicts a net increase of approximately 32% in mean daily water demand over the planning period, indicating that an estimated 450 million gallons per day (MGD) of additional water supply will be needed to meet projected 2040 water demands. State Plan related activities conducted by DEQ during 2018 focused on facilitating the five-year review of the local and regional water supply plans, as required by the Local and Regional Water Supply Planning Regulation (9VAC25-780). Localities across the state used the VA Hydro database's Water Supply Planning module to meet their five-year plan review requirements and deadlines. Localities use VA Hydro to edit, analyze, and submit their water supply plan data in near real time. As of January 2019, all 323 localities (38 cities, 95 counties, and 190 towns) in Virginia successfully completed the required five-year review and submitted all data required under the Local and Regional Water Supply Planning Regulation.

The 2015 State Plan also identifies gaps in water withdrawal reporting as a challenge for water resources management. In 2018, three farms, one data center, and one public water system were newly registered to report their water withdrawals. Additional information is obtained through the private water well registration program, which enables DEQ and the Virginia Department of Health (VDH) to receive water well completion reports as wells are constructed inside of the Groundwater Management Areas. As of July 2019, over 6,374 water well completion reports have been submitted online to VA Hydro, including an additional 1,520 wells added in 2018.

Coastal Plain Aquifer Systems

Population growth and development throughout the Coastal Plain and the Eastern Shore add new demands on the aquifer systems annually. In particular, individual private self-supplied groundwater withdrawals continue to grow and represent an incremental loss in the progress made in reducing the largest permitted withdrawal. DEQ is working to address unpermitted groundwater withdrawals through a variety of means.

DEQ continues to evaluate opportunities to implement the Eastern Virginia Groundwater Management Advisory Committee's recommendations to address resources and unpermitted withdrawals. One of those recommendations supports the ongoing work to develop procedures to address new requirements pursuant to § 62.1-259.1 of the Code of Virginia (2018 Va. Acts Ch. 427), which requires developers of subdivisions with 30 or more plots with individual wells to complete a technical evaluation prior to plat approval. Developers must adhere to the well construction and source recommendations made by DEQ or they must record a mitigation plan in the subdivision plat. DEQ expects to publish guidance outlining the procedures for the technical evaluation process by the end of 2019. That effort will require outreach to localities within the groundwater management areas. There were no requests for technical evaluations in 2018.

DEQ continued its ongoing efforts to identify, permit, or register unpermitted groundwater withdrawals in 2018. Staff reviewed permit applications for a number of unpermitted groundwater users originally identified through the 2017 Compliance Assistance Framework outreach initiative. This includes a group of 56 poultry facilities in Accomack County. In 2018, the State Water Control Board (SWCB) approved Consent Special Orders (CSO's) for these 56 poultry farms. The CSO's provide temporary authorization to withdraw 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 44 of the original 56 are moving forward with draft permits. The draft permits will be reviewed by the State Water Control Board by the end of 2019.

DEQ continues to work with permitted groundwater withdrawal facilities to decrease net withdrawals, increase efficiency, 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 50 years and beyond. Groundwater availability in some areas of the Coastal Plain, particularly around large industrial or municipal withdrawals, leaves no excess supply, which limits the ability for DEQ to issue permits. New or expanding withdrawals from the Potomac Aquifer must also be limited; recent permit reductions were made by DEQ to improve long-term groundwater availability. In all cases, permit 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.

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) continues working to reverse groundwater declines through direct injection of highly treated water into the Potomac Aquifer. As of May 2019, SWIFT has successfully injected 100 million gallons of treated water into the Potomac Aquifer, at its pilot facility in Nansemond. Going forward HRSD aims to develop additional facilities through 2030 to increase the recharge capacity to 100 MGD. 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.

Water Withdrawals

In calendar year 2018, 1,605 facilities reported water withdrawals. Compared to the recent five-year (2014-2018) average, the total volume of reported withdrawals from all water use categories (including fossil-fuel and nuclear power generation) was approximately 5.9 billion gallons, an approximately 8% decrease compared to the five-year average. When excluding withdrawals for power generation, the total volume of reported withdrawals was approximately 1.24 billion gallons, an increase of approximately 1% when compared to the five-year average.

Surface water withdrawals accounted for approximately 89% of total withdrawal volumes in 2018 (excluding withdrawals for power generation), which is similar to the previous five years. Public water supply was the largest use type for surface water withdrawals at 719.5 MGD. Mining facilities reported the largest increase (18%) in surface water withdrawal reporting when compared to the five-year average. Analysis of the spatial distribution of 2018 surface water withdrawals show that 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 remained consistent with the five-year average, increasing by less than .1%.

Groundwater withdrawals accounted for approximately 11% of total withdrawal volumes in 2018 at 142 MGD. Manufacturing continued to be the largest use type of groundwater in 2018 at 59.46 MGD, around a 5% increase compared to the five-year average. Additionally in 2018, groundwater withdrawals for mining operations reported the highest withdrawals in five years at 18.04 MGD, a 16% increase compared to the five-year average. Analysis of the spatial distribution of 2018 groundwater withdrawals show the largest groundwater withdrawals by volume occurred in the Coastal Plain and along the Valley and Ridge, in

particular the Shenandoah Valley and Giles County. Total reported groundwater withdrawals increased by approximately 7% compared to the five year average of 132.3 MGD. Increased permitting and identification of unreported groundwater withdrawals across Virginia show increased demands placed on groundwater availability, especially in the Groundwater Management Areas.

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 hundreds of 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 focuses on water quantity and supply, summarizing reported (including permitted) water withdrawals for the 2018 calendar year, discussing water withdrawal trends, and providing an update on the Commonwealth's water resources management activities. The 2018 annual water withdrawals were reported to DEQ in January 2019, then processed, analyzed, and formatted for presentation in the current Annual Report. 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 2018 Water Resources Management Updates

The growth of the Commonwealth's economy and population continues to present a challenge for maintaining both the quality and quantity of water resources for the duration of water supply planning periods. The state's water resources are used for a variety of in-stream and off-stream beneficial uses. Increased demand, resource availability, and competition for water have established a greater sense of urgency in Virginia's approach to resource management. 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 productivity and availability of Virginia's water resources.

The DEQ Director issued a final report to the Governor in response to the Eastern Virginia Groundwater Management Advisory Committee's recommendations on November 1, 2017 pursuant to § 62.1-256.1(C) of the Code of Virginia. The report, found on the Eastern Virginia Groundwater Management Advisory Committee website, provides additional information on committee actions and recommendations.

On Tuesday, November 13, 2018, DEQ held its second groundwater stakeholder forum in Chesapeake, Virginia. At this meeting, DEQ invited and met with industry stakeholders and the public to provide updates and to discuss the state of groundwater resources in the Eastern Virginia Groundwater Management Area (GWMA) and the Eastern Shore GWMA. Updates were provided on trends of groundwater availability, legislative actions, permitting, and water supply planning efforts within both management areas. DEQ continues to pursue implementation of the Advisory Committee's recommendations through efforts such as the development of procedures to address the new requirements pursuant to § 62.1-259.1 of the Code of Virginia (2018 Va. Acts Ch. 427), which requires developers of subdivisions with 30 or more plots with individual wells to complete a technical evaluation prior to plat approval.
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 for 2018. The DEQ Water Supply and Quantity webpage provides additional information.

1.1 Water Supply Planning and Analysis

The Local and Regional Water Supply Planning Regulation[2] requires 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 packages 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 major water supply challenges facing the Commonwealth through 2040 and makes recommendations for addressing those challenges.

The State Plan will be updated every five years following reviews or resubmittals of the local and regional water supply plans. In 2018, all localities in Virginia: 38 cities, 95 counties, and 190 towns (323 in total),

[2] 9VAC 25-780-10 et seq.
[3] 9VAC 25-200-10 et seq.

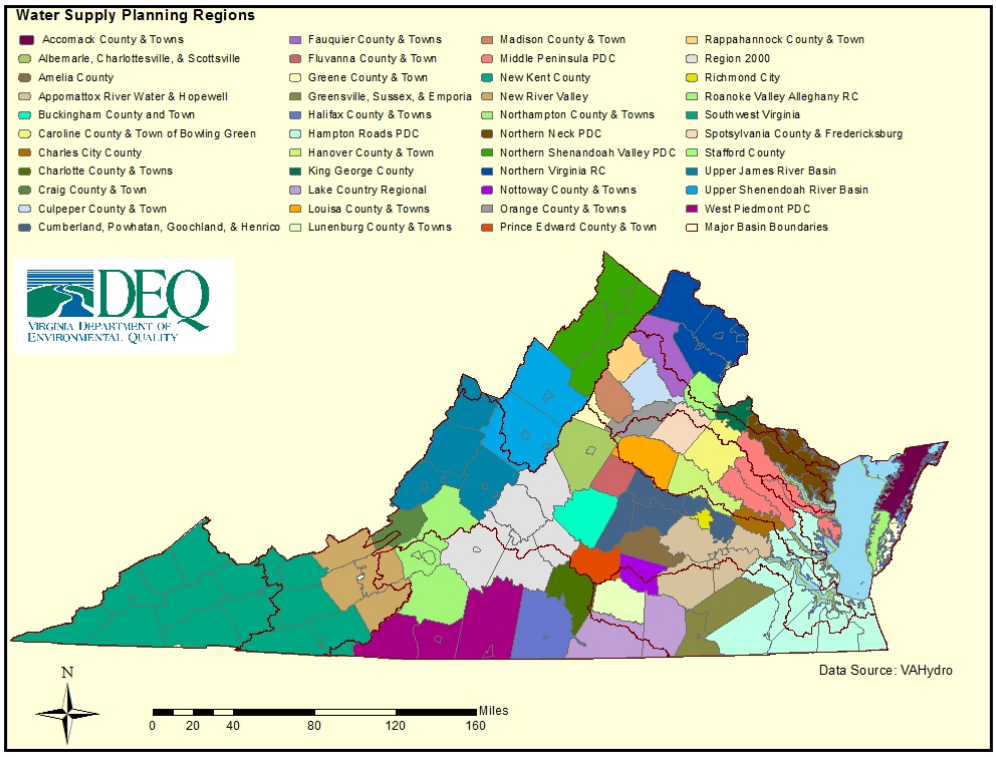

Figure 1: Water Supply Planning Regions according to 2011 submittals, with major river basins delineated

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 a 2020 update to the State Plan.

The State Plan is accessible through DEQ's website and is subject to incremental revision as DEQ, localities, and other stakeholders provide input through ongoing water supply planning efforts. Information provided by localities via VA Hydro, 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. VA Hydro is designed to ultimately 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). Development of VA Hydro by DEQ has allowed 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 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. The primary focus of the past two years has centered on developing an instream flow framework for widely available hydrologic and ecological monitoring data. DEQ has taken an approach that 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 relative risk to aquatic life resulting from surface water withdrawals in Virginia. Two professional manuscripts outlining project methods, results and potential management implications are currently in the final stages of development and are expected to be published by the end of 2019.

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), VA Hydro, and USGS National Water Information System (NWIS) databases. DEQ plans to leverage this data to analyze trends in consumptive use over time and across different user categories, and to develop predictive models of consumptive use for missing time periods and users. This information is critical to create an accurate surface water budget and to determine water availability in different locations across the Commonwealth.

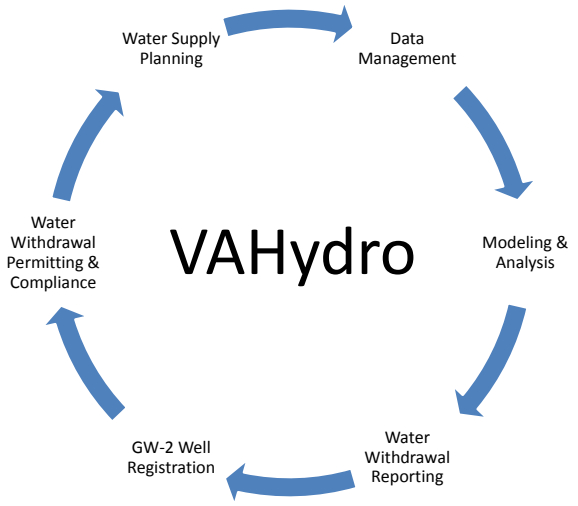

Figure 2: VA Hydro Diagram

The DEQ partnership with Virginia Tech 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 2018-2019 DEQ performed a model error analysis of the raw output from Chesapeake Bay model segments that flowed outside of the Chesapeake Bay (aka the "Southern Rivers"). No prior review of model accuracy had been performed in the southern rivers, the review provided crucial validation of the models capabilities in the Big Sandy, Chowan, Clinch-Powell, Holston, New River, Roanoke and Yadkin basins. The analysis was conducted for all segments that had long term USGS gauges, and found that over 80% of model segments had a simulated mean annual flow within +/-5% of observed flow. This result was consistent with prior review of the Chesapeake Bay Program Phase 5.3.2 model for those segments flowing into the Chesapeake Bay.

The model also had very good fit with drought year mean flow, and 90 day low flow during the drought of record. Periods less than 30 days had higher error rates, and future efforts will be focused on improving simulations of extreme low flows. A preliminary analysis of the enhanced VA Hydro model simulation showed that the reservoir operations models improved model fit, particularly during low flows, and that inaccuracy in withdrawal estimates in the Bay Model input decks was responsible for errors in a small number of areas in the southern rivers. As a result, DEQ, Virginia Tech, USGS, and the Chesapeake Bay Program modeling team will collaborate on updating surface water withdrawal input decks, and operation rules simulation for all Virginia rivers in 2019-2020.

The first of three climate change model scenarios were received from the Chesapeake Bay Program modeling team and the two remaining scenarios will be received in the fall of 2019. These three scenarios will be chosen to represent an upper and lower 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 is currently underway, with results to be presented in the 2020 State Plan Update.

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 VA Hydro data system that allows reporters to enter withdrawal data on a monthly basis, mail in reporting is also accepted. VA Hydro stores withdrawal data as far back as 1982 and categorizes water withdrawals by water use types: agriculture, commercial, irrigation, manufacturing, 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 subtype (reservoir, spring, stream, or well). Analyses of the reported 2018 data are provided in Appendices III and IV.

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 VA Hydro 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 decision making and water supply planning efforts. The effectiveness of the Commonwealth's water resource management depends on the comprehensiveness and accuracy of this self-reported withdrawal information.

Efforts to improve water withdrawal reporting within agricultural communities continued in 2018. Livestock producers with permits for animal waste management are being contacted and registered for reporting if their water withdrawals are estimated to meet or exceed the reporting threshold. In 2018, three farms were registered to report non-irrigation water withdrawals for a total of 30 farms registered through DEQ's outreach efforts. 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. These outreach efforts continue to increase DEQ's understanding of water withdrawals across Virginia, and improve modeling and water supply planning initiatives.

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[4], 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.

[4] 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[5]. 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[6], and declining water levels in the Coastal Plain aquifer system led the SWCB to expand[7] 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[8] provided for the issuance of groundwater withdrawal permits to existing users in the additional areas accompanied the expansion, effective January 1, 2014. 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 33 existing user permits in 2015, 23 existing user permits in 2016, 22 existing user permits in 2017,and 22 existing user permits during 2018. Four additional existing user permits were issued during the first quarter of 2019, resulting in a total of 104 permits issued. Four existing user applications remain pending. It was also determined that three applicants needed 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 104 issued existing user permits is approximately 2.5 billion gallons per year (BGY), which equates to an annualized average daily withdrawal rate of 6.83 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 August 31, 2019, administers a total of 333 groundwater withdrawal permits, including those issued to existing users. These permits are authorized to withdraw a combined total of approximately 46.5 BGY, which equates to an annual average withdrawal rate of 127.4 MGD. Since the beginning of 2018, a total of 39 permits have been issued (Figure 3). Of these, 10 were reissuances of previously permitted facilities within the boundaries of the original Eastern Virginia GWMA.

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%.

In 2018, a Consent Special Order (CSO) was executed for 56 poultry facilities. After DEQ review, two facilities demonstrated that they did not withdrawal more than 300,000 gallons per month, and did not

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

[6] "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.

[7] 9VAC 25-600-20.

[8] 9VAC 25-610-10 et seq.

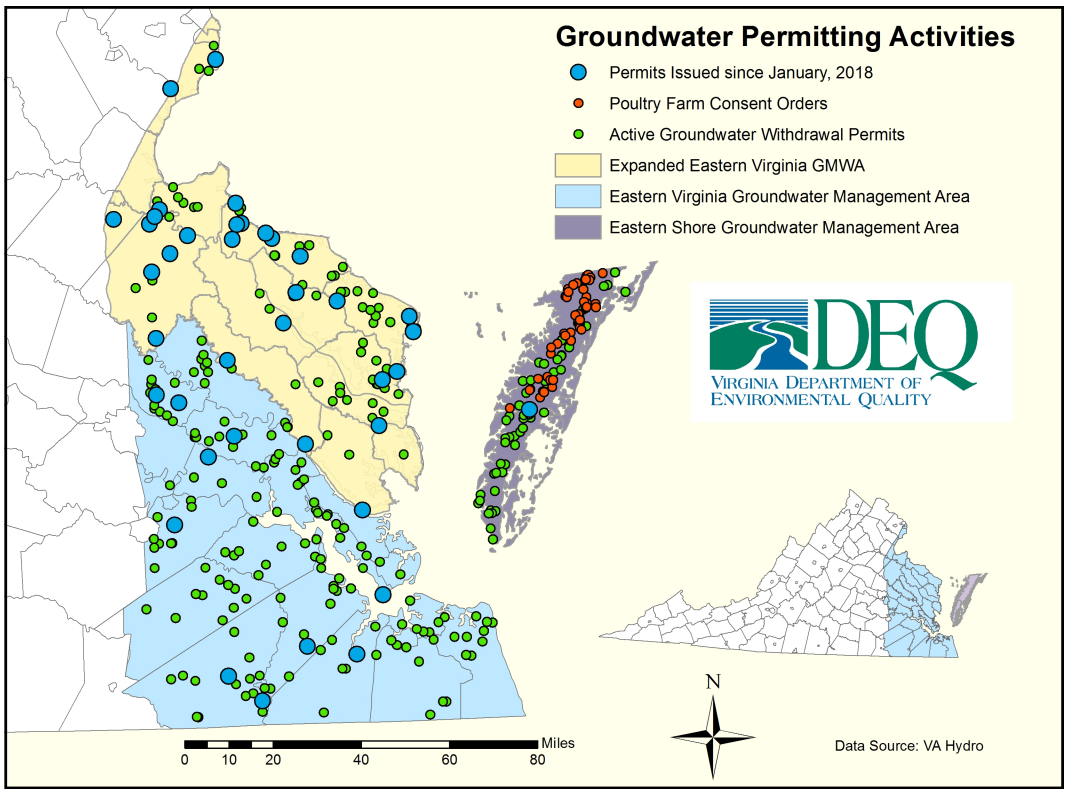

Figure 3: 2018 Groundwater Withdrawal Permitting Activities

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 30th, 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. The facilities were notified that the Department has withdrawn the tentative decision to issue a groundwater withdrawal permit, and is considering denial of the applications. Final action on the remaining 44 permits will be reviewed by the State Water Control Board by the end of 2019.

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 2018 VWP surface water withdrawal permitting activities, including permits issued since January 2018. Currently, DEQ administers 104 VWP permits for surface water withdrawals. These permits are authorized to withdraw a combined total of approximately 172 BGY (471 MGD annual average).

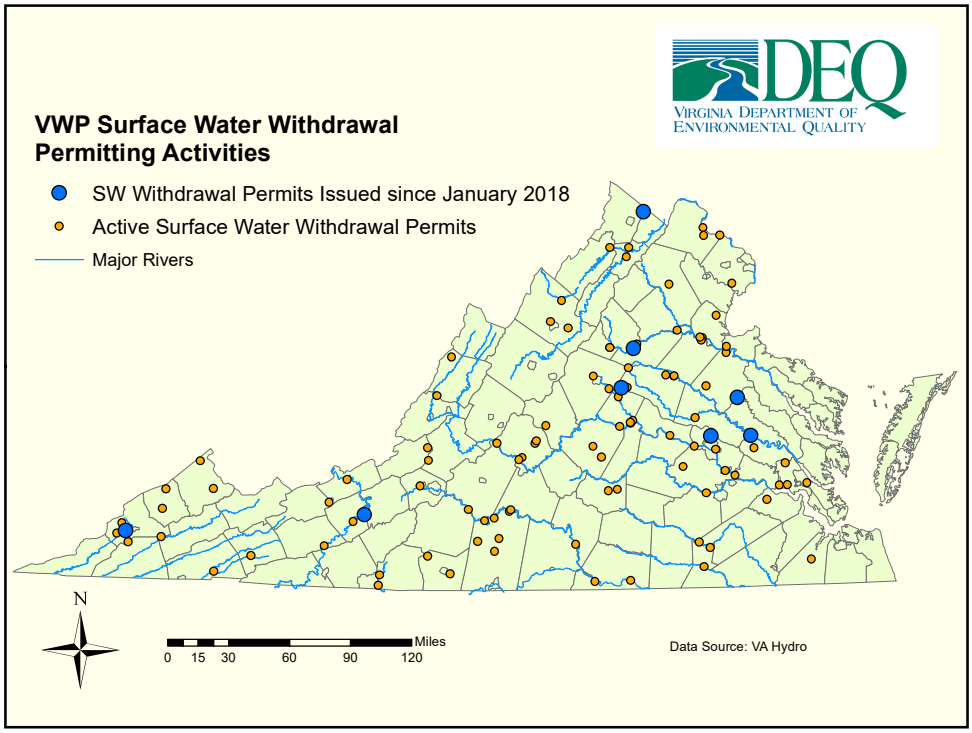

Figure 4: 2018 Surface Water Withdrawal Permitting Activities

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 state-wide 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 2018, 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.

Additional groundwater sampling was conducted in 2018 at multiple sites to characterize the pre-injection groundwater chemistry in the Potomac Aquifer near the Hampton Roads Service District (HRSD) Williamsburg Waste Water Treatment Plant (WWTP). The Williamsburg WWTP is the location of one of four test sites the HRSD is establishing to study the feasibility of using treated wastewater to increase hydrostatic pressures in the Potomac Aquifer in order to counteract pressure reductions associated with long term groundwater withdrawals. Knowledge of pre-injection groundwater chemistry is important for assessing potential changes in groundwater geochemical conditions associated with the injection and dispersion of chemically engineered water into a confined groundwater system. Additional groundwater samples were taken from several state observation wells to collect data on trace metals and major ionic concentrations in data deficient portions of the Coastal Plain Aquifer system. Emphasis was placed on collecting geochemical

data from the Piney Point Aquifer – a significant source of potable groundwater in portions of the Virginia Coastal Plain that can in places serve to reduce withdrawal demands on the heavily utilized Potomac Aquifer.

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 2018 calendar year, particular emphasis was placed on 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. The northern portion of Fauquier County is under significant development pressure owing to its proximity to Interstate 66 and the Washington D.C. metro area, and is currently striving to meet current water demands. A better understanding of groundwater storage and availability in this complex geologic setting is needed to sustainably manage the resource and to help ensure water availability for a growing population. A county wide synoptic water level inventory was also planned and conducted with the USGS in 2018 to better understand the distribution of groundwater levels near the larger pumping centers within the Fauquier County Service Districts.

In the Valley and Ridge portion of Virginia, considerable time was devoted in 2018 to the review of the route and construction for both the Mountain Valley Pipeline and Atlantic Coast Pipeline. Due to the high permeability of limestone (karst) in many portions of the Valley and Ridge, much of the review process was focused on the provision and interpretation of hydrogeologic data to effectively communicate the need for avoidance of sensitive areas and municipal water systems during pipeline construction, and to help develop proper mitigation plans in the event of contamination. Staff advised on the selection of injection and sampling sites for dye trace testing that helped to document subsurface groundwater flow paths throughout several karst areas crossed by pipeline routes, assisted with erosion and sediment control training for pipeline inspectors, and provided technical guidance to other DEQ staff regarding karst groundwater issues. Also in the Valley and Ridge portion of Virginia, a hydrogeologic study was conducted to characterize the seasonality of groundwater storage and movement within the Staunton-Pulaski Thrust Sheet – a regionally significant geologic structure in the Great Valley. Findings of the study were published and presented in April 2018 at the Third Appalachian Karst Symposium held in Shepherdstown, West Virginia.[9]

A two year cooperative effort with the USGS to characterize the hydrogeology of Virginia's Eastern Shore is ongoing. 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. The final published report of this work will also serve as the basis for revising the hydrostratigraphy in the Eastern Shore groundwater flow model. The Eastern Shore report is currently in peer review and is expected to be published by the end of 2019.

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 and well cuttings description and logging. Insight gained through borehole and cuttings analysis helps to ensure well screen placement in accordance with groundwater withdrawal permit conditions and optimizes screen placement within the permitted section of the aquifer. A process and review of groundwater sample data and geochemical trends was also conducted for the City of Chesapeake to provide guidance on placement of monitoring wells associated with aquifer storage and salt water intrusion monitoring for the Western Branch Well Field.

[9]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.

Assistance for the SWIFT pilot underground injection well project is ongoing. On-site cuttings collection and description at the Williamsburg and Newport News WWTP injection wells was conducted to identify formations, contacts, and aquifers to assist with injection well design.

In 2018, DEQ staff provided technical support to Newport News in the construction and instrumentation of the Lee Hall chloride well monitoring station. The station was required under the groundwater withdrawal permit conditions for the facility. Due to the increased potential for chloride movement at the site, groundwater level and quarterly geochemical sample data will be used to monitor long-term chloride concentration trends in the Newport News area. Geochemical data from this station will also be used to monitor for potential changes in groundwater chemistry associated with wastewater injection at the HRSD Williamsburg WWTP.

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 256 monitoring wells in the network exceed 30 years of age and are in need of repair, maintenance, or replacement/abandonment. Over time, observation 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 2018, multiple groundwater monitoring wells were evaluated in the City of Suffolk and the Middle and Virginia Peninsulas.

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.

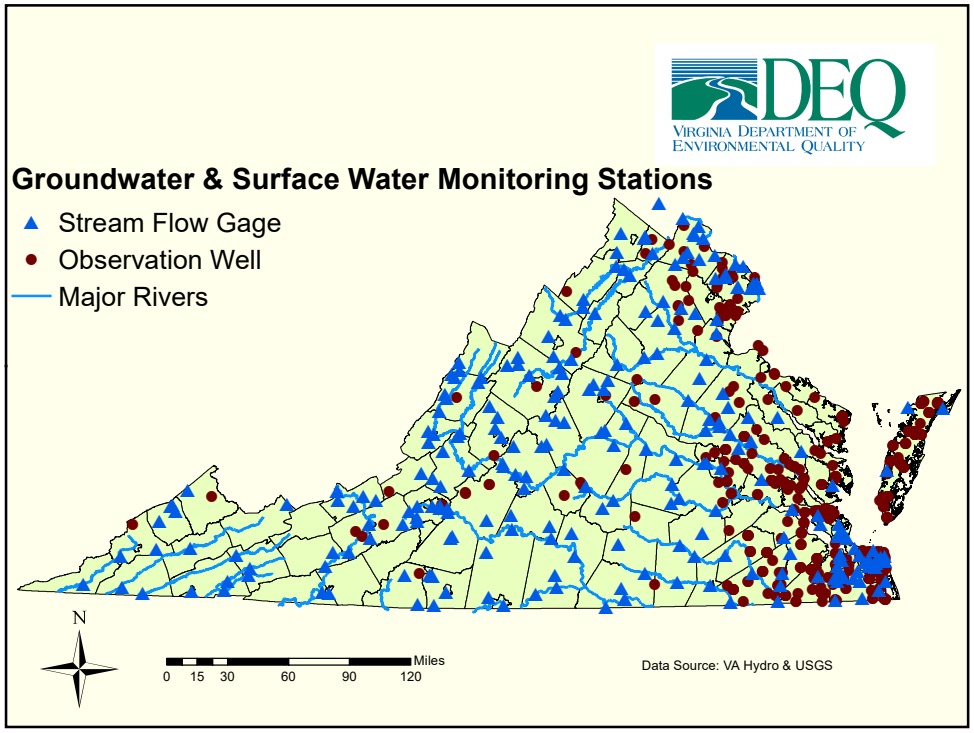

Figure 5: Groundwater and Surface Water Monitoring Stations

SWIP field personnel collect and process data from a network of 68 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 a drier than normal 2017-2018 winter season, a drought watch was in effect across much of northern, central, and parts of south-central Virginia. However, the watch was lifted in the Shenandoah and Upper James regions (Figure 6) during the early spring after normal rainfall returned to those areas. Wet conditions occurred throughout the rest of the Commonwealth during May 2018, and in June 2018 the watch was lifted for all remaining drought evaluation regions. Subsequently, precipitation fell at near or even above record levels all across Virginia throughout the remainder of 2018. The spring of 2019 brought a return to normal rainfall levels, but relatively dry conditions prevailed during the summer months. As of September 1, 2019, however, most drought indicators were in the 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.

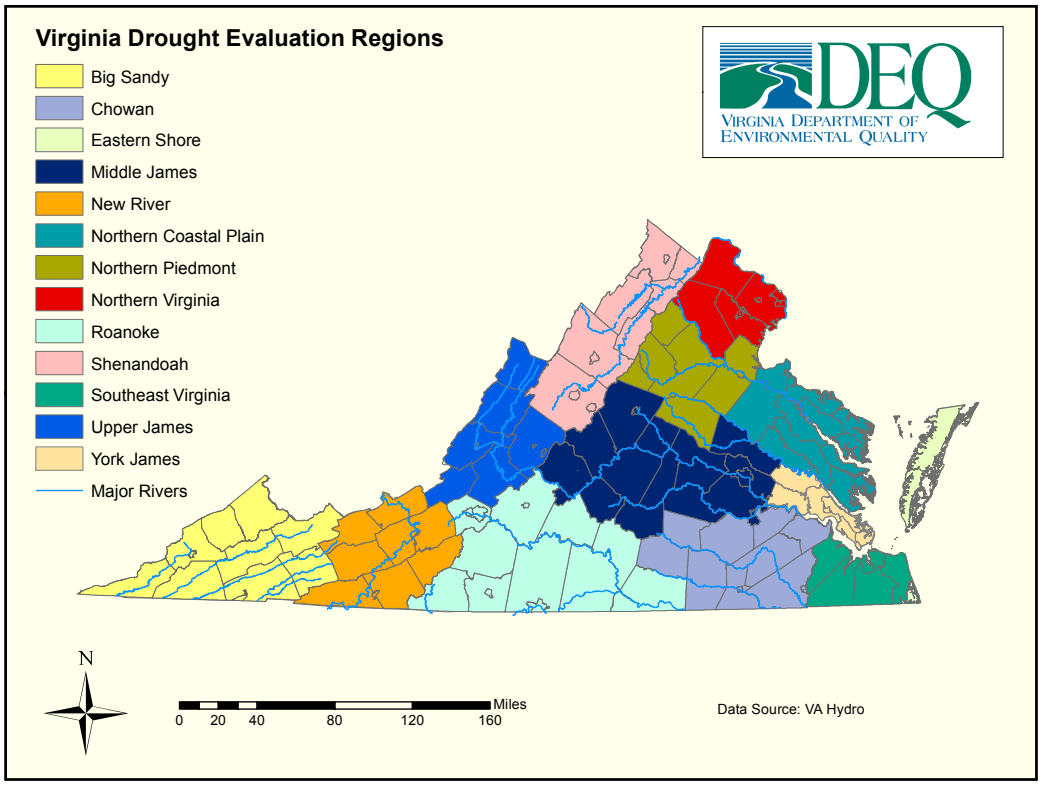

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Figure 6: Drought Evaluation Regions

2 Summary of 2018 Water Withdrawals

A total of 1,605 facilities reported water withdrawals for the calendar year 2018. Reported withdrawals were approximately 5.9 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 2018 withdrawals totaled over 1.24 BGD.[10] Compared to the five-year reported average (2014-2018), total reported 2018 withdrawals from all water use categories increased by approximately 1% when excluding power generation withdrawals.

VA Hydro 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 VA Hydro.

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 stored in VA Hydro is provided in Appendix 2. General descriptions of 2018 water withdrawals by source type, distribution across the state, and water use category occurs on subsequent pages with additional detail provided in the appendices as follows:

Appendix 3 provides a list of the top 20 non-power generating water withdrawals ranked by the amount of their actual 2018 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.

2.1 Water Withdrawals by Source Type

In 2018 the water withdrawals for non-power generation totaled approximately 1244 MGD with surface water sources (streams, reservoirs, and springs) as the predominant source type. The total reported non-power generation withdrawals increased by approximately 1% when compared to the five-year average of 1234 MGD. Surface water withdrawals accounted for approximately 89% of total withdrawals in 2018 at 1102 MGD, when excluding power generation. Pumping of groundwater wells accounted for the remaining 11%, at 142 MGD. Reported groundwater withdrawals increased by approximately 7% compared to the five year average, whereas reported surface water withdrawals increased by less than 1%, when compared to the five-year average.

[10] Withdrawal volumes reported to VA Hydro 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. 49, Power Generation Water Withdrawals. These flows are exempted from the reporting requirement and are generally not reported to VA Hydro. 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.

2.2 Water Withdrawals by Location

Of the 127 counties and cities reporting groundwater withdrawals, the largest reported groundwater withdrawals were in Giles, Isle of Wight, King William, and Rockingham counties. In Giles County, Celanse Acetate a major manufacturing facility and the Kimballton mine operations were the primary groundwater withdrawals in the county. Additional withdrawals for public water supply by the Giles County Public Service Authority also contributed to countywide totals. In total, a total combined withdrawal of 21.6 MGD came from within Giles County in 2018. This represents the largest total reported groundwater withdrawals of any locality (county or city) in the Commonwealth. Groundwater withdrawals by locality are shown in Figure 7)

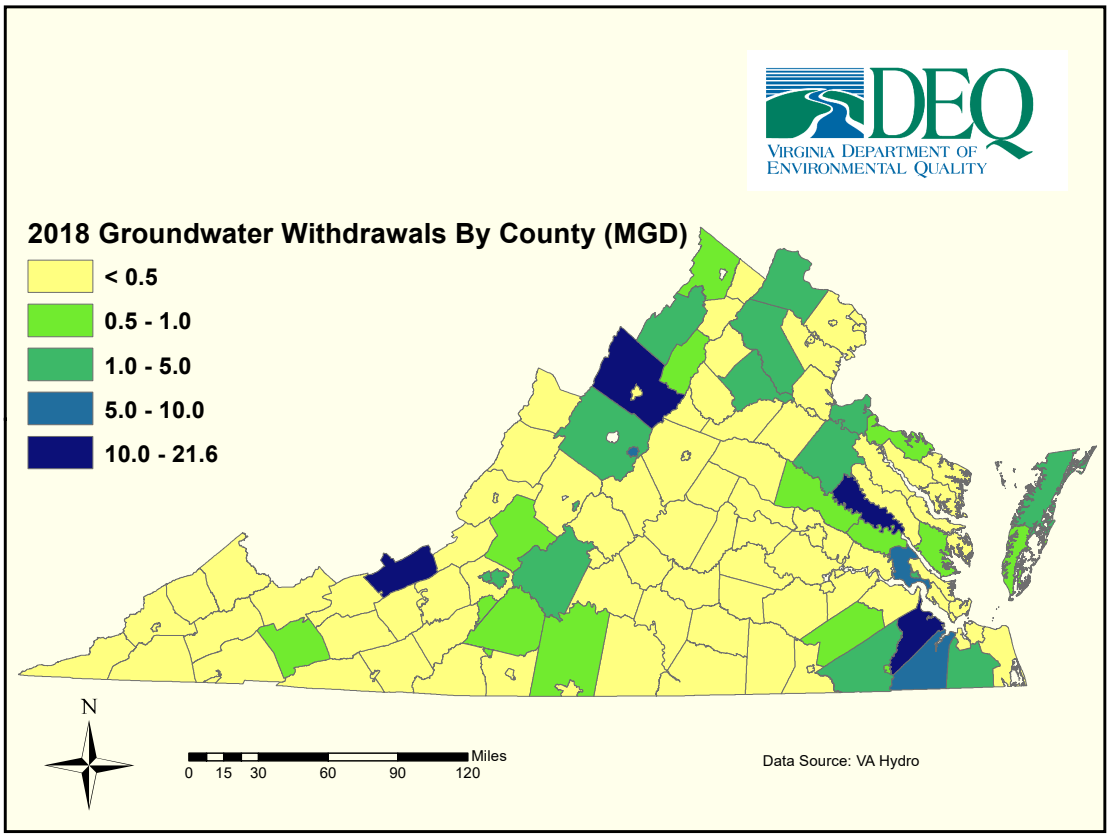

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Figure 7: 2018 Total Groundwater Withdrawals By Locality

Isle of Wight County reported 17.29 MGD of groundwater withdrawals in 2018. Groundwater withdrawals reported by the International Paper Company were the second largest withdrawals reported by manufacturing facilities in 2018, at approximately 14.3 MGD. Smithfield farms and small public water suppliers in the county also reported groundwater withdrawals contributing to the countywide total. All facilities remained within their withdrawal limits as set by their Groundwater Withdrawal Permits.

King William reported a countywide groundwater withdrawal amount of approximately 16.8 MGD in 2018. WestRock's West Point manufacturing facility withdrew 97% of the countywide groundwater reported in 2018, approximately 16.5 MGD. The WestRock West Point system is currently permitted by DEQ and remained within permitted withdrawal limits as set by its Groundwater Withdrawal Permit.

Reported groundwater withdrawals from Rockingham County, within the Shenandoah Valley, totaled approx-

imately 14.5 MGD. Merck and Company, a manufacturing facility, reported the largest single groundwater withdrawal within Rockingham County, approximately 5.8 MGD in 2018.

Surface water withdrawals were distributed widely across the state and were greatest around cities and counties with dense population centers and significant manufacturing/industrial water uses (Figure 8). In addition to public water supply and manufacturing, agriculture and irrigation contribute to the most significant surface water withdrawals in rural counties. Surface water withdrawals are concentrated most densely within the James, Potomac-Shenandoah, and New River basins, comprising approximately 75% of the statewide total surface water withdrawal. Withdrawals for public water supply represent approximately 65% of the total surface water withdrawals in the Commonwealth, an increase of 1.8% of the category's five-year average of reported withdrawals.

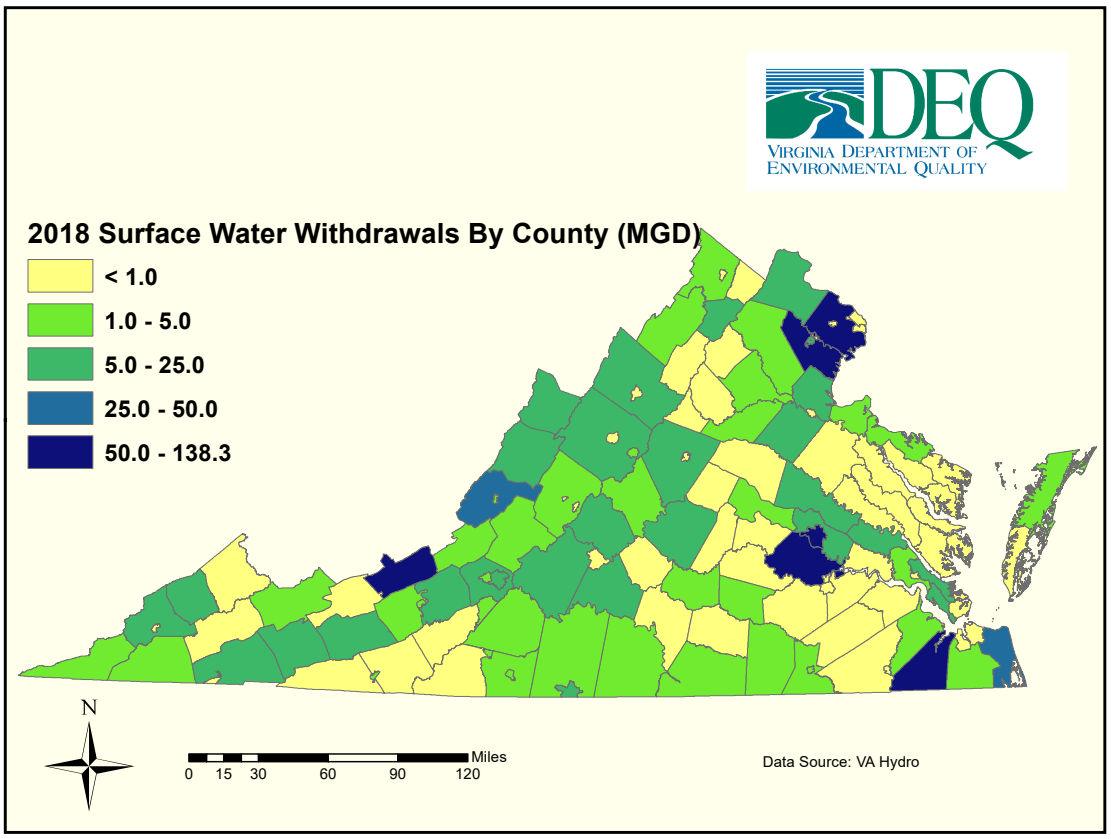

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Figure 8: 2018 Total Surface Water Withdrawals by Locality

Of the 126 counties and cities reporting surface water withdrawals, the largest reported surface water withdrawals occurred within the City of Hopewell and the Counties of Chesterfield and Fairfax. The City of Hopewell reported the largest surface water withdrawal volume for any locality in 2018, at approximately 138.3 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 approximately 102 MGD or 9% of the total surface water withdrawals reported. Virginia American Water, a major public water supply for the region and WestRock a major manufacturing facility contributed with a combined 36 MGD or 3% of total water withdrawals in 2018.

Chesterfield County was the second highest reporting county in 2018 with approximately 95 MGD of reported surface water withdrawals. Similar to the City of Hopewell, 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 for public water supply throughout the region. In 2018, approximately 34 MGD was withdrawn from the reservoir to meet public water supply demands. Additionally, Chesterfield County Utilities withdrew approximately 23 MGD of surface water from Swift Creek Reservoir in 2018. Major manufacturing facilities withdrawing surface water in Chesterfield County include Dupont, reporting withdrawals of approximately 24 MGD from the James River in 2018, and a second AdvanSix facility reporting approximately 25 MGD in withdrawals from the James River. Chesterfield County's location adjacent to the City of Richmond and large surface water sources are drivers of the water withdrawals reported within the county. Population density and manufacturing operations required the surface water withdrawals to meet demands.

Similar to Chesterfield County, Fairfax County's proximity to a highly populated urban center resulted in significant withdrawals from surface water sources to meet public water supply demands. The largest surface water withdrawal in the County was reported by Fairfax Water at approximately 89 MGD from the Potomac River. Fairfax Water serves as the primary water supplier in the region.

The variable spatial distributions of 2018 total withdrawals, groundwater and surface water combined, suggest that withdrawals vary considerably between Virginia's individual localities, with the largest withdrawals occuring within or adjacent to major population centers or regions with large manufacturing facilities. (Figure 9).

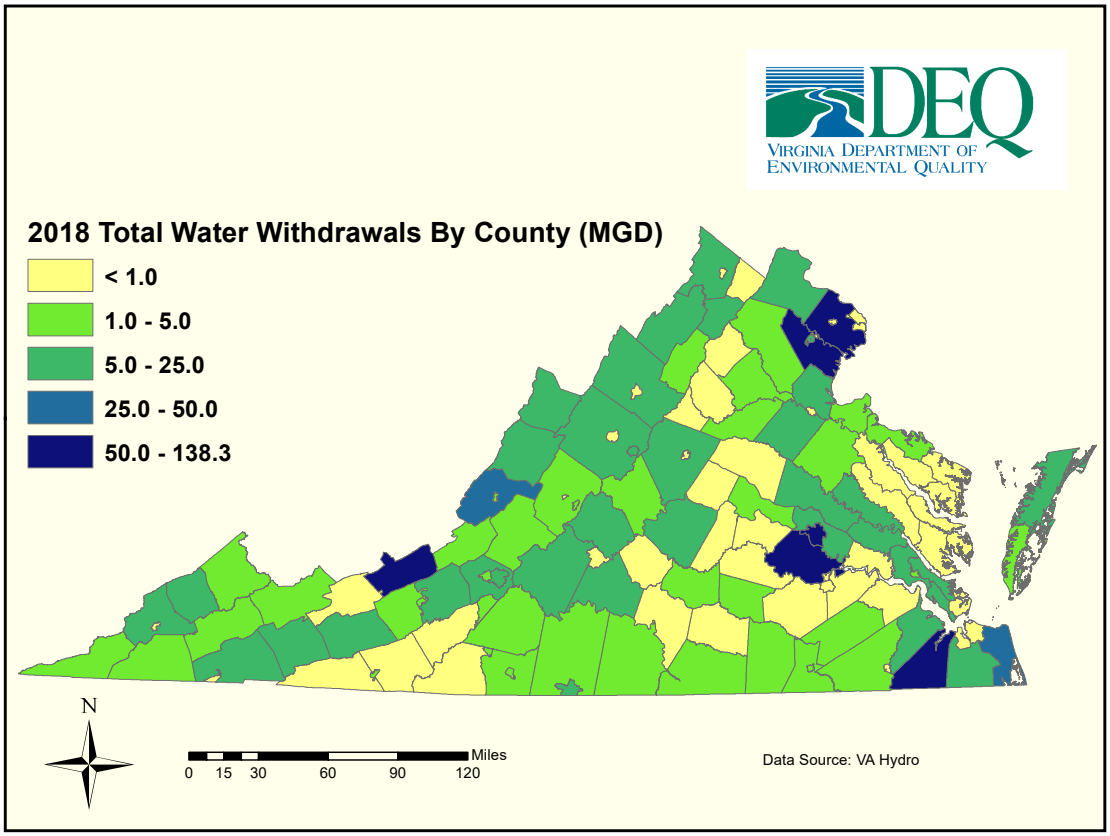

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Figure 9: 2018 Total Water Withdrawals By Locality

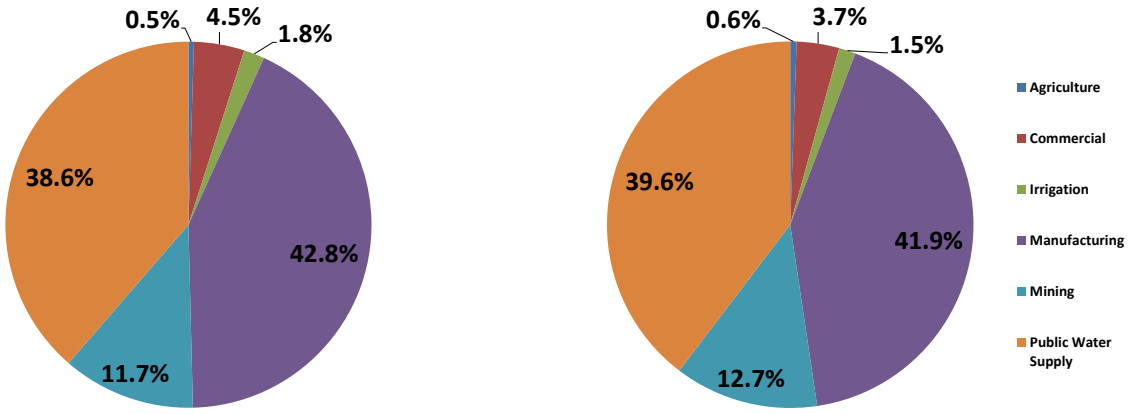
The largest reported withdrawals for groundwater and surface water sources also reported the largest total water withdrawals in 2018, to include; Chesterfield, Hopewell, and Fairfax County. Large facilities or singular withdrawals, such as for public water supply or manufacturing operations, often dominate within a locality. When compared to the five-year average, total 2018 reported withdrawals increased by approximately 10 MGD, or 1%, for all source types. The increased withdrawals reported across Virginia suggest continued long-term growth in water withdrawal amounts from surface and groundwater sources. The reported water withdrawal amounts within individual counties and cities is found in Appendix 5.

2.3 Water Withdrawals by Water Use Category

Throughout 2018-19 DEQ staff continued to improve the accuracy of reported withdrawal amounts and classification of data within VA Hydro through a proactive data quality assurance/quality control process. Improvements in previously published data sets occurred due to the identification of reported unit conversion errors, discovered within the 2014-2017 reported data. The corrected data set results in a less than 1% change in overall total annual withdrawal volumes from 2014-2017. The improved consistency of all data analysis reduces inter-annual variation and greatly improves overall data integrity.

Water withdrawals reported to VA Hydro are categorized by how, or for what purpose, the water withdrawal is used including: 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 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. Public Water Supply also includes water that is processed and sold to commercial or institutional facilities that are not self-supplied.

Water withdrawals can fluctuate from year to year due to weather variability, economic conditions, additional permitting actions, or other factors; therefore, average water withdrawals from 2014-2018 are provided by source type for each category for comparison, excluding Power Generation (Nuclear Power and Fossil Fuel Power) Figures 10a, 10b, 11a and 11b[11]. Average water withdrawals during this five-year period were calculated using the same source type categories (surface water and groundwater) as the 2018 withdrawal totals. This allows for direct comparisons to be made between 2018 withdrawal totals and the 2014-2018 averages of total withdrawals.

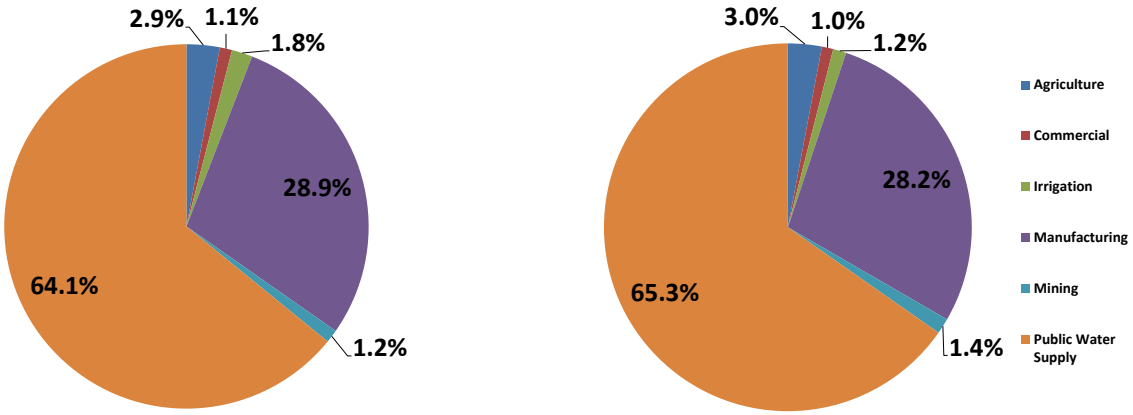


(a) 2014-2018 Average Groundwater Withdrawals

(b) 2018 Total Groundwater Withdrawals

Figure 10: Groundwater Withdrawals Average and Totals

[11] Figure percentages are rounded to nearest whole number

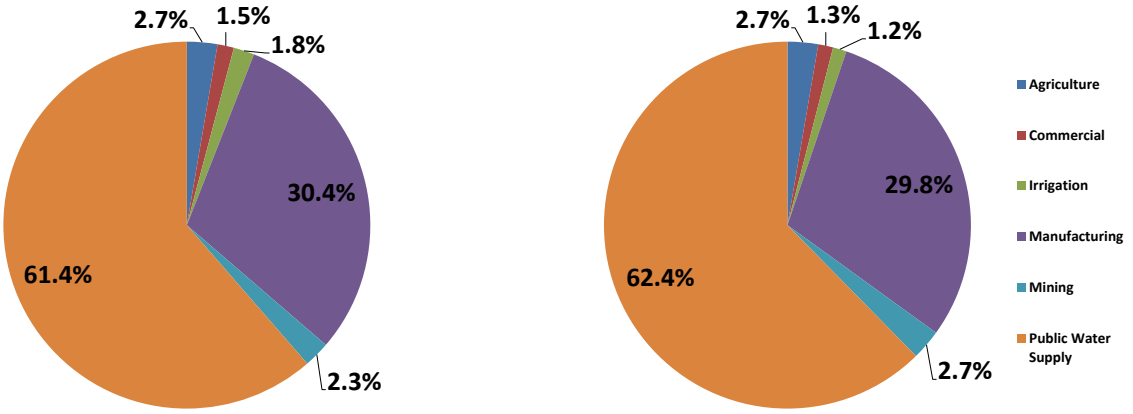


(a) 2014-2018 Average Surface Water Withdrawals

(b) 2018 Total Surface Water Withdrawals

Figure 11: Surface Water Withdrawals Average and Totals

Public Water Supply and Manufacturing were once again the largest water withdrawal categories in 2018, as for the average of the previous five-year period (Figures 12a and 12b)[12]. Manufacturing makes up the highest proportion of groundwater withdrawals (41.9%) whereas Public Water Supply accounts for the greatest surface water withdrawals (65.3%). Withdrawals for Agriculture, Irrigation, Mining, and Commercial uses made up lesser, but still significant, portions of the totals. Agricultural use, both the Irrigation and Agriculture categories, tends to be largely driven by surface water withdrawals (97%) while mining and commercial use is more evenly distributed between surface water and groundwater sources.



(a) 2014-2018 Average Withdrawals

(b) 2018 Total Withdrawals

Figure 12: Total Water Withdrawals

While the total amount of reported water withdrawals in 2018 are consistent with the five-year average, increases in withdrawals from key use categories, such as public water supply, indicates continued stress on water sources to supply such demands. Withdrawals for groundwater and surface water sources showed increases of approximately 1.2% compared to the five-year average for public water supply. Water supply planning and permitting staff continue to work collaboratively to identify available sources and alternatives for public water supply between regional partners and across Virginia.

[12]Figure percentages are rounded to nearest whole number

Appendix 4 provides additional information for each water use category, including tables and graphs comparing 2018 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 use. "Consumptive water use" refers to that portion of a water withdrawal that is not returned to the source due to, for example, 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. It is also noted that 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, estimates of human consumptive use (domestic self-supplied and public water supplied) made by the USGS for Virginia were approximately 58% of annual withdrawal volumes (excluding power generation).[13] Without specific information about the types and distribution of end users, estimates of consumptive use from public water supply withdrawals can be uncertain.

"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 can lose a significant percentage of total water withdrawn to evaporation.[14] 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).

[13] 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.]

[14] 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: 2014-2018

Water withdrawals reported to VA Hydro from 2014-2018 are represented in (Table 1)[15]. Total 2018 water withdrawals reported for non-power generation increased approximately 1% compared to the five-year average (2014-2018). The 2018 reported withdrawals from groundwater sources increased approximately 7% when compared to the five-year average, with the agriculture and mining categories showing the largest percent increase. Increased groundwater withdrawals from agriculture use types during 2018 was the result of increased agricultural facilities registered through water supply planning efforts and identification of agricultural operations on the Eastern Shore, including the poultry operations that have applied for a groundwater withdrawal permits. Additional groundwater withdrawals reported from the mining use category, resulted from increased quarry dewatering from two major Kimballton mine operations in Giles County. The greatest reduction in total reported water withdrawals is shown in the irrigation use category. With historic rainfall occurring across much of Virginia in 2018, demand to irrigate crops was reduced and commonly communicated with DEQ staff during the annual reporting of water withdrawals.

Total reported surface water withdrawals in 2018 remained static increasing by less than 0.1% from the five-year average. However, increased surface water withdrawals were reported for the mining, public water supply, and agriculture use categories. Similar to reported groundwater withdrawals, increased surface water withdrawals from the two Kimballton mine operations in Giles County resulted in and 18% increase in mining withdrawals as compared to the five-year average. Additionally, withdrawals reported for public water supply in 2018 were the highest reported in five years. As observed in Table 1, incremental increases in surface water withdrawals for public water supply have occurred over the past five years.

Source Type	Category	2014	2015	2016	2017	2018	5 Year Avg.	% Change 2018 to Avg.
Groundwater	Agricultural	0.66	0.51	0.59	0.64	0.80	0.64	25.0
	Commercial	6.19	5.78	6.14	6.06	5.32	5.90	-9.8
	Irrigation	2.68	2.84	2.35	2.15	2.09	2.42	-13.6
	Manufacturing	57.87	58.06	50.47	57.59	59.46	56.69	4.9
	Mining	12.80	13.98	17.34	15.53	18.04	15.54	16.1
	Public Water Supply	48.90	47.94	48.93	53.62	56.31	51.14	10.1
Surface Water	Agricultural	31.79	33.81	33.22	30.68	32.70	32.44	0.8
	Commercial	11.50	12.08	13.35	12.00	11.06	12.00	-7.8
	Irrigation	26.03	23.54	20.19	18.37	12.81	20.190	-36.6
	Manufacturing	311.24	316.90	319.81	330.88	310.96	317.96	-2.2
	Mining	11.04	12.94	13.00	11.81	15.12	12.78	18.3
	Public Water Supply	686.23	704.13	708.75	713.94	719.54	706.52	1.8
Total (GW + SW)	Agricultural	32.45	34.32	33.81	31.32	33.50	33.08	1.3
	Commercial	17.69	17.86	19.49	18.06	16.38	17.90	-8.5
	Irrigation	28.71	26.38	22.54	20.52	14.90	22.61	-34.1
	Manufacturing	369.11	374.96	370.28	388.47	370.42	374.65	-1.1
	Mining	23.84	26.92	30.34	27.34	33.16	28.32	17.1
	Public Water Supply	735.13	752.07	757.68	767.56	775.85	757.66	2.4
	Total Groundwater	129.10	129.11	125.82	135.59	142.02	132.33	7.3
	Total Surface Water	1077.83	1103.40	1108.32	1117.68	1102.19	1101.89	0.0
	Total (GW + SW)	**1206.93**	**1232.51**	**1234.14**	**1253.27**	**1244.21**	**1234.21**	**0.8**

Table 1: Summary of Virginia Water Withdrawals by Use Category and Source Type, 2014-2018 (MGD)

[15] Figure percentages are rounded

3.1 2018 Permitted and Unpermitted (Excluded) Withdrawals

The following tables demonstrate the difference between the 2018 reported permitted and unpermitted withdrawals. Table 2 displays the aggregate reported total withdrawals by source type for 2018. Unpermitted surface water withdrawals listed in Table 2 represent withdrawals reported to the DEQ that are excluded from the VWP permitting requirements. Unpermitted groundwater withdrawals are generally those not regulated by the groundwater withdrawal permitting program (located west of Interstate-95, outside of the GWMAs). Currently, the unpermitted groundwater withdrawals total includes five existing users located inside the GWMA. Three of the users are in the expanded GWMA with applications submitted for a permit, and the remaining two existing users are in the final stages of the groundwater withdrawal permitting process. Unpermitted withdrawals represented approximately 73% of the total reported withdrawals in 2018, with surface water withdrawals as the primary water source type reporting a total of 839.8 MGD in 2018.

Source Type	Withdrawal Type	2018 Withdrawal Amount	% of Total 2018 Withdrawals By Source Type
Groundwater	Permitted	67.83	48
	Unpermitted	74.18	52
Surface Water	Permitted	262.42	24
	Unpermitted	839.78	76
Total Withdrawals	Permitted	298.5	27
	Unpermitted	909.6	73

Table 2: 2018 Permitted and Unpermitted (Excluded) Withdrawals (MGD)

Table 3 disaggregates the reported permitted and unpermitted water withdrawals by use category, and shows the percent composition of each withdrawal in 2018.

In 2018, 142 MGD of groundwater withdrawals was reported (excludes power generation). Manufacturing withdrawals, both permitted and unpermitted, were the largest percentage of the total reported groundwater in 2018 at approximately 42%. Withdrawals for public water supply were the second largest contributor to total groundwater withdrawals in 2018. Approximately 40% of all groundwater withdrawals reported in 2018 were used for public water supply needs. DEQ staff continue to work with manufacturing and public water suppliers who rely on groundwater to identify water conservation measures and alternatives sources when available, especially when the supply is inside a GWMA.

Similar to reported groundwater withdrawals, surface water withdrawals in 2018 were predominately for manufacturing and public water supply. Manufacturing facilities comprised 28.2% of all surface water withdrawals, with approximately 26% of these withdrawals being unpermitted as shown in Table 3. Public water supply dominated the reported surface water withdrawals in 2018 with over 65% of total surface water withdrawals being used for public water supply. Within the public water supply category, nearly 44% of surface water withdrawals were unpermitted.

Source Type	Withdrawal Type	2018 Withdrawal Amount	% of Total 2018 Withdrawals
Groundwater			
Agriculture	Permitted	0.61	0.4
	Unpermitted	0.2	0.1
Commercial	Permitted	3.17	2.2
	Unpermitted	2.15	1.5
Irrigation	Permitted	1.19	0.8
	Unpermitted	0.9	0.6
Manufacturing & Industrial	Permitted	38.39	27.0
	Unpermitted	21.07	14.8
Mining	Permitted	0.03	0.0
	Unpermitted	18.00	12.7
Public Water Supply	Permitted	30.08	21.7
	Unpermitted	25.51	18.0
Total Groundwater		**142.02**	**100.0**
Surface Water			
Agriculture	Permitted	0.00	0.0
	Unpermitted	32.70	3.0
Commercial	Permitted	2.5	0.2
	Unpermitted	8.57	0.8
Irrigation	Permitted	2.2	0.2
	Unpermitted	10.60	1.0
Manufacturing & Industrial	Permitted	21.45	1.9
	Unpermitted	289.5	26.3
Mining	Permitted	0.05	0.0
	Unpermitted	15.08	1.4
Public Water Supply	Permitted	236.22	21.4
	Unpermitted	483.32	43.9
Total Surface Water		**1102.19**	**100.0**

Table 3: 2018 Permitted and Unpermitted (Excluded) By Use Type Withdrawals (MGD)

Unreported unpermitted withdrawals are not represented in either Tables 2 or 3, however unreported withdrawals are of interest to DEQ. This type of withdrawal represents water withdrawals that do not exceed an

average withdrawal of 10,000 gallons per day in any single month, and therefore do not meet DEQ reporting requirements. 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 with 1,520 wells registered in 2018. Though water withdrawal data is not collected with the groundwater well completion reports, the increase in private wells likely results in increase groundwater withdrawals and overall water use. The understanding of unreported unpermitted withdrawals is essential to ensure that the water resource management gains from permitting and permit reductions are not lost due to those unpermitted withdrawals.

4 Water Resource Challenges And Priorities

4.1 Water Resources Management in Virginia: Hot Topics

DEQ worked extensively throughout 2017-2018 to increase outreach to unpermitted groundwater users, and where appropriate, provide compliance assistance for those who required a permit but were unaware of the regulatory requirements.

- On the Eastern Shore, DEQ continues to address the large number of unpermitted groundwater withdrawals associated with poultry farming operations. The industry has expanded over the last few years, with a significant number of new facilities located in Accomack County. In 2018, Consent Special Orders (CSO) were executed for 56 poultry facilities. After DEQ review, two facilities demonstrated that they did not use more than 300,000 gallons per month, and did not require a groundwater withdrawal permit. On April 30th, 2019, 54 poultry facilities received draft groundwater permits, but only 48 chose to continue with the application process and authorize a public comment and public hearing notice that was published May 24, 2019. Final action on the remaining 44 permit applications is pending review by the State Water Control Board.

- DEQ is looking for ways to implement the Eastern Virginia Groundwater Management Advisory Committee's recommendations to address resources and unpermitted withdrawals. One of those recommendations supports the ongoing work to develop procedures to address new requirements pursuant to § 62.1-259.1 of the Code of Virginia (2018 Va. Acts Ch. 427), which requires developers of subdivisions with 30 or more plots on individual wells to complete a technical evaluation prior to plat approval. Developers must adhere to the well construction and source recommendations made by DEQ based on the technical evaluation or they must record a mitigation plan in the subdivision plat. DEQ expects to finalize and implement the procedures for the subdivision technical evaluation process by the end of 2019. That effort will require significant outreach to localities within the groundwater management areas. There were no requests for technical evaluations in 2018.

DEQ continues to work with permitted groundwater facilities to decrease net withdrawals, to 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 50 years.

- Senate Bill 1599 (2019 Va. Acts Ch. 755), added § 62.1-262.1 to the Code of Virginia, which directs the SWCB to adopt regulations providing incentives for the withdrawal of water from the surficial aquifer, rather than the deep aquifer, in the Eastern Shore Groundwater Management Area. DEQ drafted a Notice of Intended Regulatory Action (NOIRA), which is in Executive Review[16] to start the process to amend the Groundwater Withdrawal Regulations to establish the framework for the issuance of a general permit under the Groundwater Withdrawal Regulation for withdrawals from the surficial aquifer in the Eastern Shore GWMA. The new general permit regulation will include the establishment of permit terms, withdrawal limitations, and reporting requirements necessary to permit withdrawals.

- 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) continues working to reverse groundwater declines through direct injection of highly treated water into the Potomac Aquifer. As of May 2019, the SWIFT water treatment project has successfully injected 100 million gallons of treated water into the Potomac Aquifer. Going forward HRSD aims to develop additional facilities through 2030 to increase the recharge capacity to 100 MGD. 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.

[16] Virginia Regulatory Town Hall: https://townhall.virginia.gov/L/ViewAction.cfm?actionid=5341

- In 2018, surface water withdrawals reported by VWP permitted users amounted to approximately 264 MGD and surface water withdrawals reported from excluded (unpermitted) users amounted to approximately 838 MGD. A comparison of reported withdrawals with water use estimates from the approved local and regional water supply plans indicates that unpermitted water withdrawals from several categories may be under reported. Additionally, unpermitted surface water withdrawals cause additional uncertainty when estimating available water supply during drought events, basins where water withdrawal activities are concentrated, or where water availability is stressed.

- There has been a large increase in the number of hydroelectric power facilities applying for relicensing as their 30 year licenses with the Federal Energy Regulatory Commission (FERC) expire. Any applicant for a federal license or permit to conduct an activity which may result in a discharge must apply for and be issued a 401 Certification stating 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.[17] Eighteen of the 22 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 permits. The relicensing process and expiration of the previous 401 Certifications is allowing the DEQ to apply the current scientific and regulatory framework to the facilities that was absent during the original 401 Certification issuance. 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.

4.2 Long-term Priorities Identified in State Water Resources Plan

The State Water Resources Plan identifies challenges for future water resources management and provides recommendations for action. Progress in addressing these challenges and implementing the recommendations includes the following:

- 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 2018, 1,520 new private wells were permitted by VDH for construction in the GWMA. Based on estimated usage by use type (irrigation, drinking water, etc.), additional unpermitted groundwater demands of approximately 1 MGD per year are anticipated. As discussed in prior sections, a recent response to this challenge is the subdivision technical evaluation process, spurred by § 62.1-259.1 of the Code of Virginia (2018 Va. Acts Ch. 427). The technical evaluation enables DEQ to make resource recommendations for subdivisions with individual wells and provides additional data on water use for such developments.

- 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 and continued with the agricultural community. Outreach to users in other water use categories, such as data centers, public and private educational institutions, and vineyards will be conducted over the next couple of years as resources allow. In 2018, three additional farms were registered to report withdrawals, contributing to a total of 30 farms registered to date through DEQ's outreach efforts.

[17] 9VAC 25-210-340

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

  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 2018 calendar year, particular emphasis was placed on 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.[18]

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

  DEQ obtained USGS grant funding to improve consumptive use data analysis, transfer, and export. DEQ, along with the USGS and Virginia Tech are studying consumptive use trends and predictive model development to better understand and track impacts of water transfers. This information is critical to create an accurate surface water budget and to determine water supply availability in different locations across the Commonwealth.

- Challenge: Understanding Stream Water Quality/Ecology.

  Informed decision making requires robust means of assessing potential risk to fish and benthos resulting from human consumptive water use. Through an ongoing collaboration with the Virginia Tech Department of Biological Systems Engineering and the USGS Virginia and West Virginia Water Science Center, DEQ developed a new instream flow framework for rapid generation and optimization of flow-ecology relations. The objective was to generate Ecological Limit Functions from species-flow relations to quantify potential species richness response to flow alteration and compare results to currently accepted streamflow management guidelines. The project found that flow-ecology relations were watershed specific, and absolute richness change 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% of HUC 10s showed richness decreases of one or more species resulting from a 20% flow reduction. While absolute richness change was consistent across stream sizes within a HUC, percent richness change was found to be stream size dependent. Percent richness change was compared to percent habitat change using Instream Flow Incremental Methodology models. Although predicted habitat loss was greater than predicted richness change, 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 effort has resulted in two manuscripts outlining the methodology and potential management implications of implementing this new framework for water resource management activities including permitting, water supply planning and restoration ecology (Manuscripts currently under review by the Journal of the American Water Resources Association).

[18] 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.

- Challenge: Public Education and Outreach.

  In 2018, DEQ held over 40 outreach events with localities to provide training in the use of VA Hydro as a water supply planning tool. Localities across the state used the VA Hydro database's Water Supply Planning module to meet the five-year plan review deadline. Localities use VA Hydro to edit, analyze, and submit their water supply plan data in real time. As of January 2019, all 323 localities (38 cities, 95 counties, and 190 towns) in Virginia successfully completed the required five-year review and submitted all data required under the Local and Regional Water Supply Planning Regulation. The information submitted by localities is being used to prepare the 2020 update to the State Water Resources Plan.

4.3 Investment Challenges for Water Resources Management

Continued financial investment is necessary for program development and implementation, and improved local government and public participation as DEQ strives to effectively manage 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 256 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 required in order to ensure that water levels in the observation wells accurately represent the hydrostatic pressures in the aquifer. As resources allow, DEQ is evaluating wells based on a prioritized quarterly schedule. Resources are 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 2019 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. 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 unit is approximately $3,200 per unit.

- 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 data, DEQ SWIP staff must continue to receive state of the art training on the use of USGS' sophisticated data management system.

- 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 Water Resources Plan implementation and long-term maintenance. A recurring comment from local and regional entities is that for the State Plan process to reach its full potential, funding to support local water supply planning efforts is essential to maintain long-term data gathering and planning.

- 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 US 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.[19] DEQ determined that 42 chloride upconing 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.

- Improvements are needed in the way the transfer of water is tracked, both within systems and between entities. 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 in the success of monitoring land subsidence. At least one additional extensometer will need to be installed in the region that is thought to be most vulnerable to movement as a result of ongoing groundwater withdrawals. The Eastern Virginia Groundwater Management Advisory Committee identified West Point, Virginia as a potential location of a new extensometer. DEQ's groundwater model estimates nearly a foot of subsidence has occurred near West Point since 1910.

[19] 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.

Appendix 1: Water Resources Information and Climactic Conditions

State Population
(2010 census) – 8,001,025
(2018 U.S. Census Bureau estimate) – 8,517,685

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
hline 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 12, 2019, precipitation totals for the 2019 water year (October 1, 2018 through September 30, 2019) were generally above normal. However, rainfall amounts were below normal during the summer months across large portions of Virginia, resulting in the spread of abnormally dry conditions across nearly 40% of the Commonwealth. 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 VA Hydro'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 VA Hydro 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 VA Hydro as "releases" to outside customers and "deliveries" of water from another outside customer.

Currently, not all water transfers are consistently reported to VA Hydro, 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 2018 (Excluding Power Generation)

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

Facility	City/County	Type	Major Source	5 Year Avg.	2018 Withdrawal Amount	Category
AdvanSix Resins & Chemicals LLC: Hopewell Plant **	Hopewell	SW	James River	103.8	102.4	Manufacturing
Fairfax Water: Corbalis WTP**	Fairfax County	SW	Potomac River	89.2	88.8	Municipal
City of Norfolk: Western Branch Reservoir**	Suffolk	SW	Western Branch Reservoir	63.9	73.0	Municipal
City of Richmond: Richmond WTP**	Richmond City	SW	James River	64.6	62.9	Municipal
Fairfax Water: Griffith WTP**	Prince William	SW	Occoquan Reservoir	65.3	62.3	Municipal
Celanese Acetate: Celaco Plant**	Giles	SW/GW	New River & 5 Wells	56.2	57.2	Manufacturing
WestRock Virginia Corporation: Covington Plant**	Alleghany	SW/GW	Jackson River & 2 Wells	39.1	37.4	Manufacturing
Appomattox River Water Authority: Chesdin Reservoir WTP*	Chesterfield	SW	Chesdin Reservoir	31.9	33.8	Municipal
City of Virginia Beach Service Area**	Virginia Beach	SW	Lake Gaston & Stumpy Lake	24.3	29.0	Municipal
AdvanSix Resins & Chemicals LLC: Chesterfield Plant**	Chesterfield	SW	James River	16.0	24.7	Manufacturing
Henrico County WTP*	Henrico	SW	James River	23.7	24.6	Municipal
Dupont E I De Nemours & Co: Spruance Plant**	Chesterfield	SW	James River	29.3	24.4	Manufacturing
Virginia American Water: Hopewell District**	Hopewell	SW	Appomattox River	20.4	23.3	Municipal
City of Newport News: Lee Hall WTP**	Newport News	SW	Lee Hall Reservoir	22.5	21.8	Municipal
City of Newport News: Harwood's Mill WTP**	York	SW	Harwood's Mill Reservoir	18.6	18.9	Municipal
City of Portsmouth: Lake Kilby WTP*	Suffolk	SW/GW	Lake Kilby, Meade, & Price & 5 Wells	31.6	17.1	Municipal
International Paper Company: Franklin Mill*	Isle of Wight	SW/GW	Blackwater River & 12 Wells	12.7	16.6	Manufacturing
WestRock CP, LLC: West Point Water System*	King William	GW	15 Wells	19.2	16.6	Industrial
United States Government: Radford Ammunitions WTP**	Montgomery	SW	New River	18.8	15.0	Manufacturing
GP Big Island, LLC: Big Island WTP**	Bedford County	SW	James River	14.1	14.7	Manufacturing

Table 4: Top 20 Reported Water Withdrawals in 2018 Excluding Power Generation (MGD)

Appendix 4: Water Withdrawals By Use Category

Water withdrawals reported annually to VA Hydro 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 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 of two to three page fact sheets for each water use category, containing information regarding withdrawals reported for 2018, including the following:

- A map depicting withdrawal point locations for each category, scaled by the magnitude of the 2018 reported annual withdrawal rate of individual facilities;
- A bar graph illustrating the reported quantity withdrawn for each category between 2014 and 2018, 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 2014 and 2018 in terms of an annual average rate by source type (groundwater or surface water); and
- A table listing facilities reporting the largest withdrawals for 2018, facility location, water source, reported 2018 annual withdrawal rate, and the average annual withdrawal rate for the five-year period from 2014 to 2018.

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, reported withdrawals for this category are mostly incomplete and 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 2018 groundwater and surface water withdrawals for agricultural purposes statewide. The majority of water withdrawn for agricultural use is obtained from surface waters (Figure 14), primarily springs located in western Virginia. These springs support fish farms and hatcheries. Reported 2018 surface water withdrawals for agriculture withdrawals from surface water sources increased by 0.42 MGD to 33.5 MGD, as compared to the five-year average (Figure 14). Although surface water is the primary source, the majority of farms reporting agriculture withdrawals make use of groundwater sources. Reported groundwater withdrawals increased by 0.16 MGD to 0.8 MGD, when compared to the five-year average. Groundwater withdrawals for agriculture are anticipated to increase over time with increased reporting from poultry farms on Virginia's Eastern Shore. The five facilities reporting the greatest withdrawals for agriculture in 2018 are listed in Table 6. Water withdrawals from agriculture make up around 3% of all reported 2018 non-power generation withdrawals in Virginia.

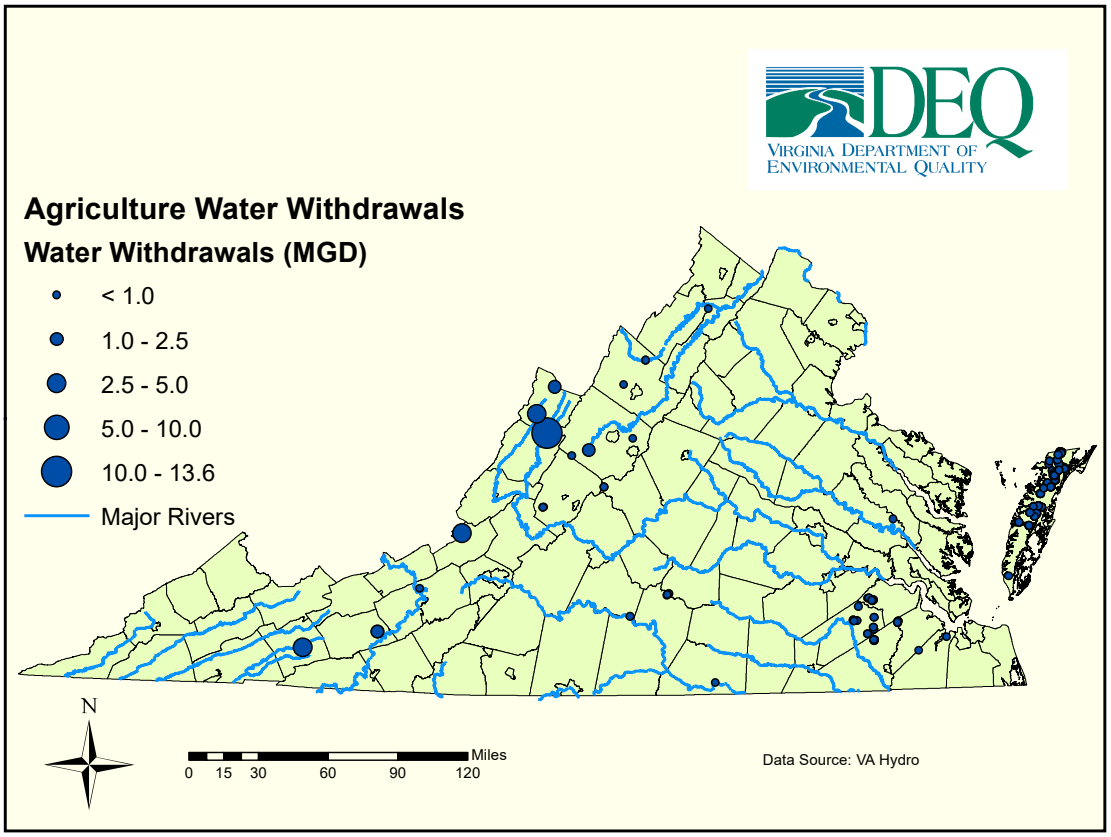


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Figure 13: 2018 Agriculture (Non-Irrigation) Water Withdrawals by Withdrawal Point Location

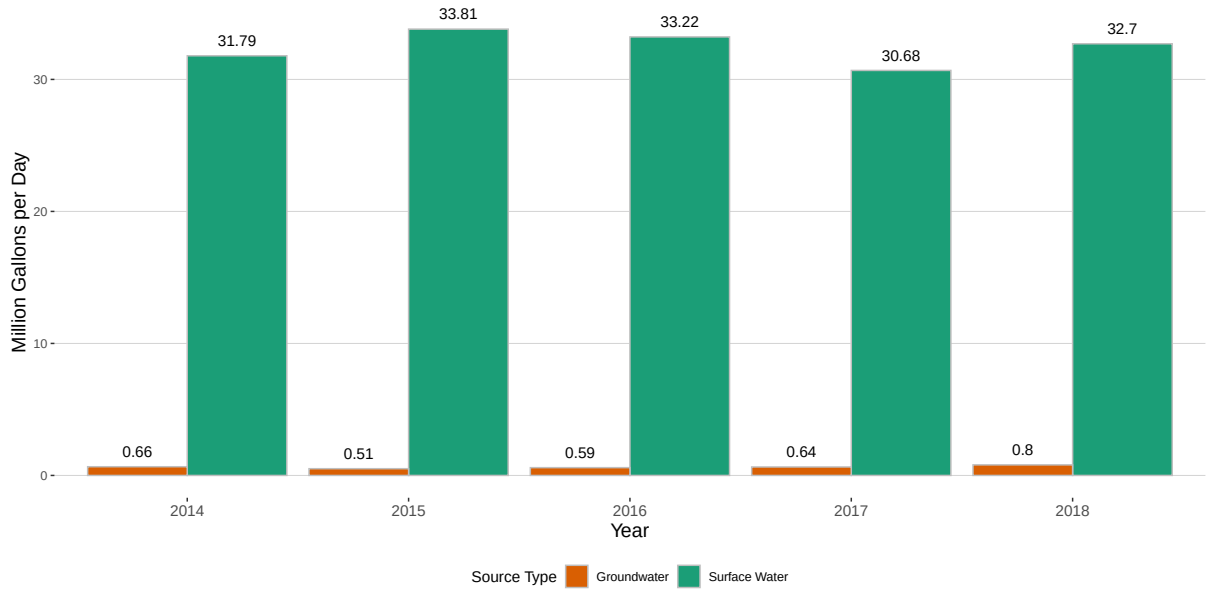

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Figure 14: 2014-2018 Agriculture Water Withdrawals by Source Type

Source Type	2014	2015	2016	2017	2018	5 Year Avg.	% Change 2018 to Avg.
Groundwater	0.66	0.51	0.59	0.64	0.8	0.64	25.0
Surface Water	31.79	33.81	33.22	30.68	32.7	32.44	0.8
Total (GW + SW)	**32.45**	**34.32**	**33.81**	**31.32**	**33.5**	**33.08**	**1.3**

Table 5: 2014-2018 Agriculture Water Withdrawals by Source Type (MGD)

Facility	Locality	Type	Major Source	5 Year Avg.	2018 Withdrawal
Commonwealth of Virginia: Coursey Spring Fisheries	Bath	SW	Coursey Spring	12.3	13.63
Commonwealth of Virginia: Paint Bank Fish Cultural Station	Craig	SW	Pain Bank Branch	3.34	3.57
Commonwealth of Virginia: Marion Fish Cultural Station	Smyth	SW	Staleys Creek	3.25	3.37
Commonwealth of Virginia: Wytheville Fish Hatchery	Wythe	SW	Boiling and West Springs	3.27	3.26
Laurel Hill Trout Farm-South Monterey	Highland	SW	Blue Spring	3.27	3.12

Table 6: Highest Reported Agriculture Withdrawals in 2018 (MGD)

Irrigation (Agricultural) Water Withdrawals

Irrigation withdrawals promote growth in agricultural crops such as corn, soybeans, turf grass, and nursery products. Figure 15 illustrates the distribution of reported 2018 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 2018 total irrigation withdrawals (Figure 16). The majority of the reported groundwater withdrawals for irrigation are from "dug" ponds or groundwater filled reservoirs in Accomack and Northampton counties on the Eastern Shore. Because these ponds do not have a direct connection with a perennial stream they are categorized in VA Hydro as groundwater sources. There are no major transfers of water for irrigation, so water withdrawal figures also represent water use. Reported water withdrawals for irrigation in 2018 are approximately 7.7 MGD less than the reported five-year average (Table 7). The decrease may be a result of the wet growing season experienced in many areas of the state in 2018. As with previous years, most large-scale irrigation facilities are located in the northern Coastal Plain and on the Eastern Shore. The five facilities reporting the greatest withdrawals for irrigation in 2018 are listed in Table 8. Water withdrawals from irrigation make up about 1% of all non-power generation withdrawals in Virginia.

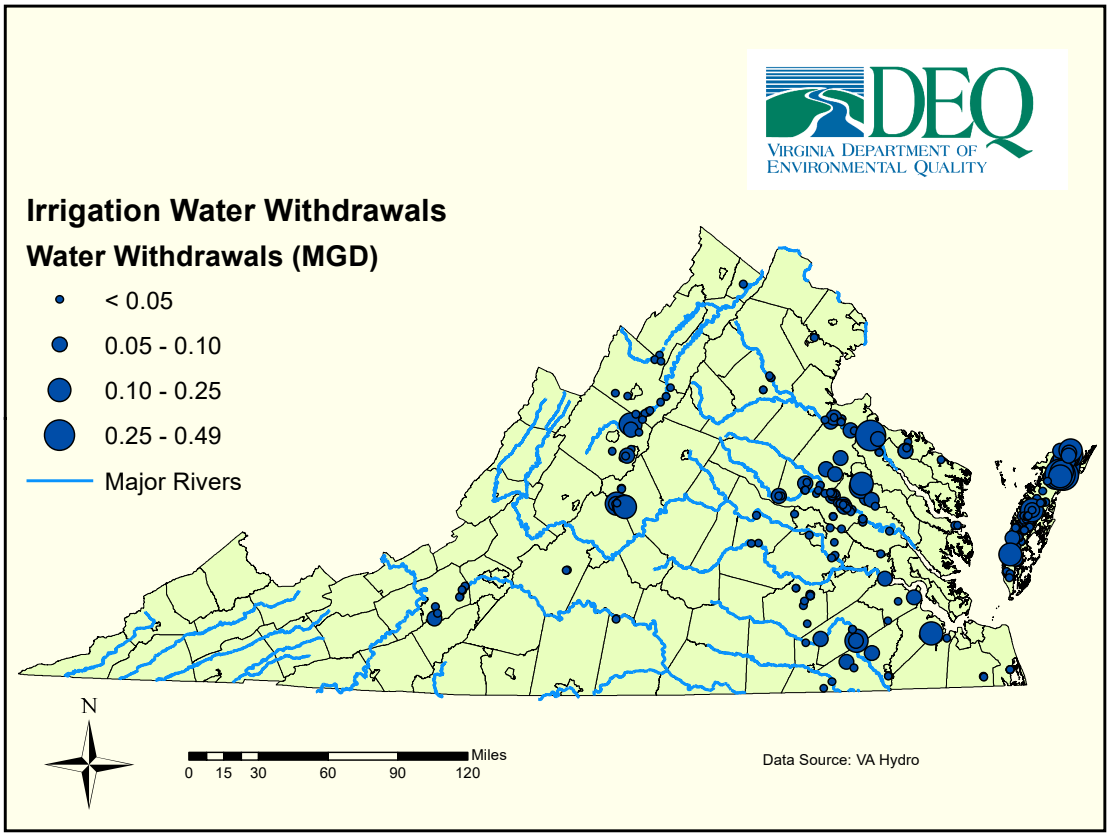

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Figure 15: 2018 Irrigation (Agricultural) Water Withdrawals by Withdrawal Point Location

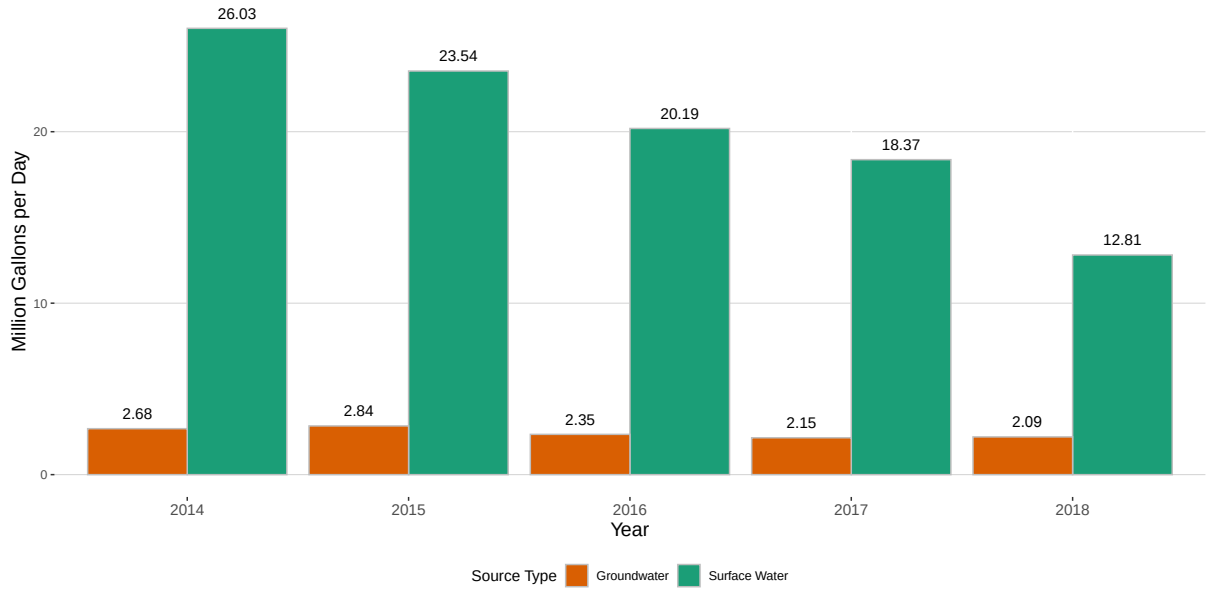

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Figure 16: 2014-2018 Irrigation Water Withdrawals by Source Type

Source Type	2014	2015	2016	2017	2018	5 Year Avg.	% Change 2018 to Avg.
Groundwater	2.68	2.84	2.35	2.15	2.09	2.42	-13.6
Surface Water	26.03	23.54	20.19	18.37	12.81	20.19	-36.6
Total (GW + SW)	**28.71**	**26.38**	**22.54**	**20.52**	**14.90**	**22.61**	**-34.1**

Table 7: 2014-2018 Irrigation Water Withdrawals by Source Type (MGD)

Facility	Locality	Type	Major Source	5 Year Avg.	2018 Withdrawal
Arbuckle Farms	Accomack	GW	6 Dug Ponds	4.12	2.30
Dublin Farms, Inc.	Accomack	SW/GW	13 Farm Ponds, 1 Dug Pond	1.81	1.64
Saunders Brothers, Inc.	Nelson	SW/GW	Tye River, Allen Creek, Farm Ponds, and Two Wells	0.73	0.63
Glenwood Farms	King and Queen	SW	Chapel Creek and Ponds	0.66	0.57
Eagle Tree Farms	Westmoreland	SW	Rappahannock & Peedee Creek	0.72	0.50

Table 8: Highest Reported Irrigation Withdrawals in 2018 (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 2018 groundwater and surface water withdrawals for commercial purposes, located predominantly near population centers. Reported commercial withdrawals from surface water sources were almost double those reported from groundwater sources (Figure 18). Reported commercial water withdrawals continued to fall again in 2018, decreasing by 8.5% when compared to the five-year average (Table 18). The five facilities reporting the largest 2018 water withdrawals for commercial operations are listed in Table 10. Water withdrawals from commercial activities make up about 1% of all non-power generation withdrawals in Virginia.

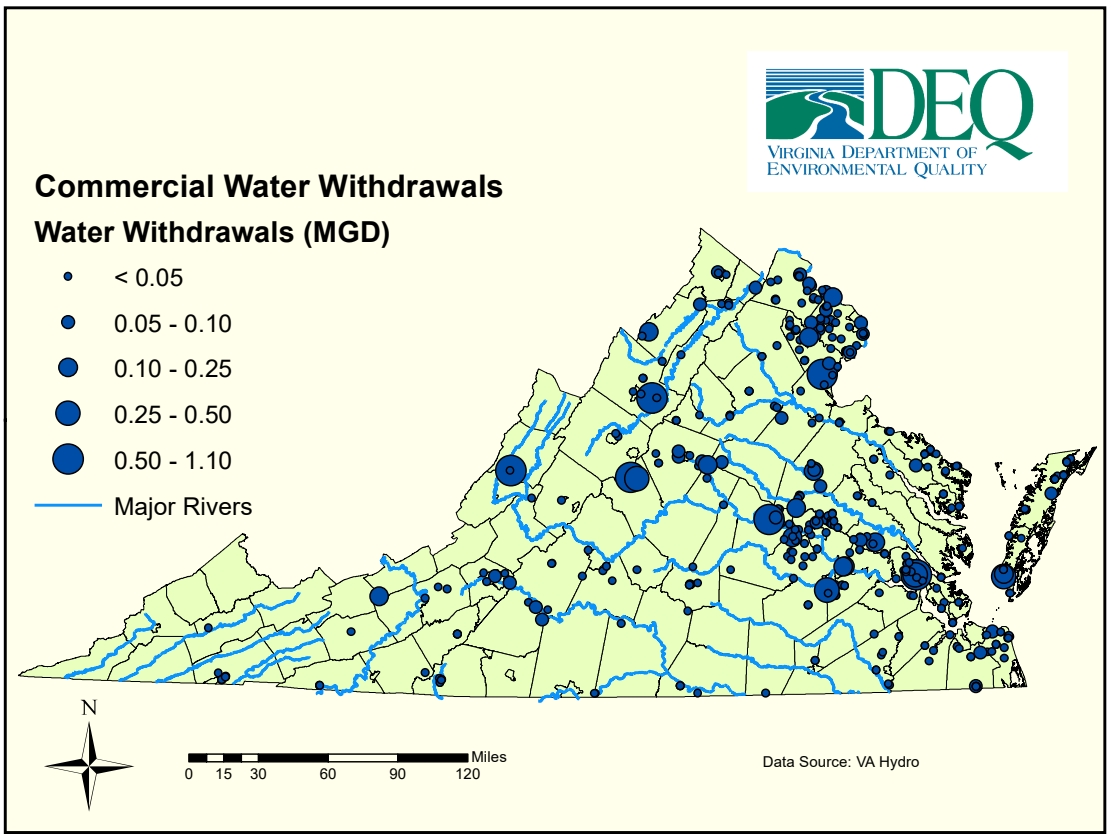

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Figure 17: 2018 Commercial Water Withdrawals by Withdrawal Point Location

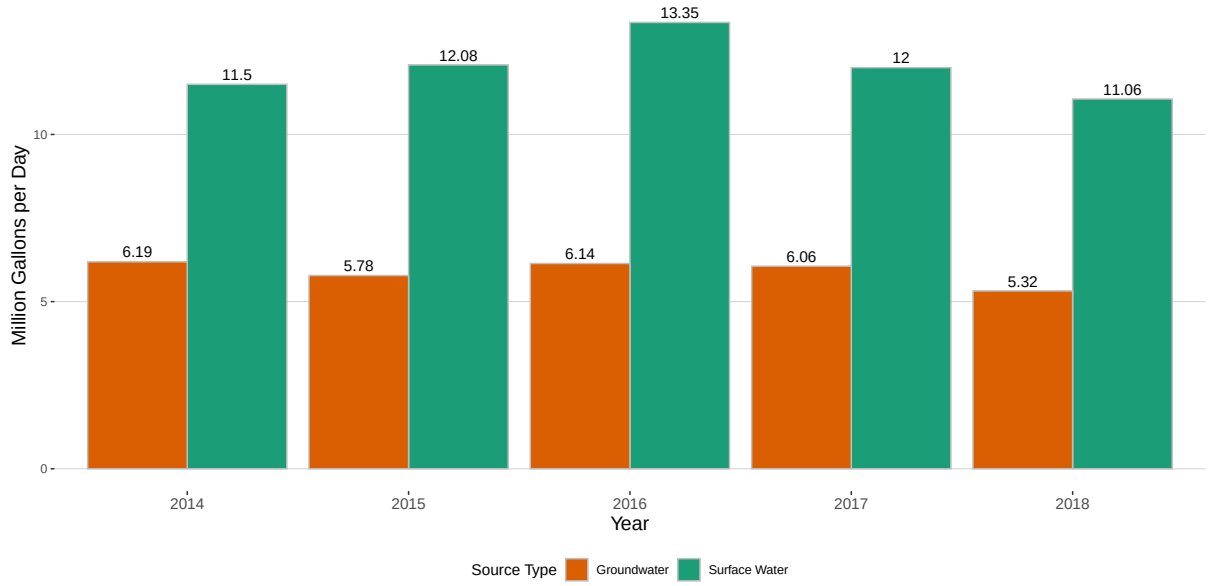

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Figure 18: 2014-2018 Commercial Water Withdrawals by Source Type

Source Type	2014	2015	2016	2017	2018	5 Year Avg.	% Change 2018 to Avg.
Groundwater	6.19	5.78	6.14	6.06	5.32	5.9	-9.8
Surface Water	11.50	12.08	13.35	12.00	11.06	12.0	-7.8
Total (GW + SW)	**17.69**	**17.86**	**19.49**	**18.06**	**16.38**	**17.9**	**-8.5**

Table 9: 2014-2018 Commercial Water Withdrawals by Source Type (MGD)

Facility	Locality	Type	Major Source	5 Year Avg.	2018 Withdrawal
Colonial Williamsburg Hotel	Williamsburg	GW	3 Wells	1.21	1.12
US Government: Post Camp WTP	Prince William	SW	Breckenridge Reservoir	1.01	1.10
Homestead Water Company	Bath	SW	3 Springs	0.37	0.85
Wintergreen Partners, Inc	Nelson	SW	Lake Monocan	0.97	0.84
Massanutten Resort	Rockingham	SW	Quail Run & Lakes	0.12	0.63

Table 10: Highest Reported Commercial Water Withdrawals in 2018 (MGD)

Mining Water Withdrawals

Mining includes operations such as sand, rock, and coal mining. Figure (Figure 19) illustrates the distribution of reported 2018 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 the Appalachian Basin in southwestern Virginia. In 2018, the reported withdrawals for mining continued to be predominantly (54%) from groundwater sources (Figure 19) Total reported water withdrawals for mining purposes in 2018 increased by 4.8 MGD as compared to the five-year average (Table 11). Because there are no major transfers of water for mining purposes, the water withdrawals also represent water use. The five facilities reporting the largest 2018 mining withdrawals are listed in Table 12. Water withdrawals from mining make up about 3% of all non-power generation withdrawals in Virginia.

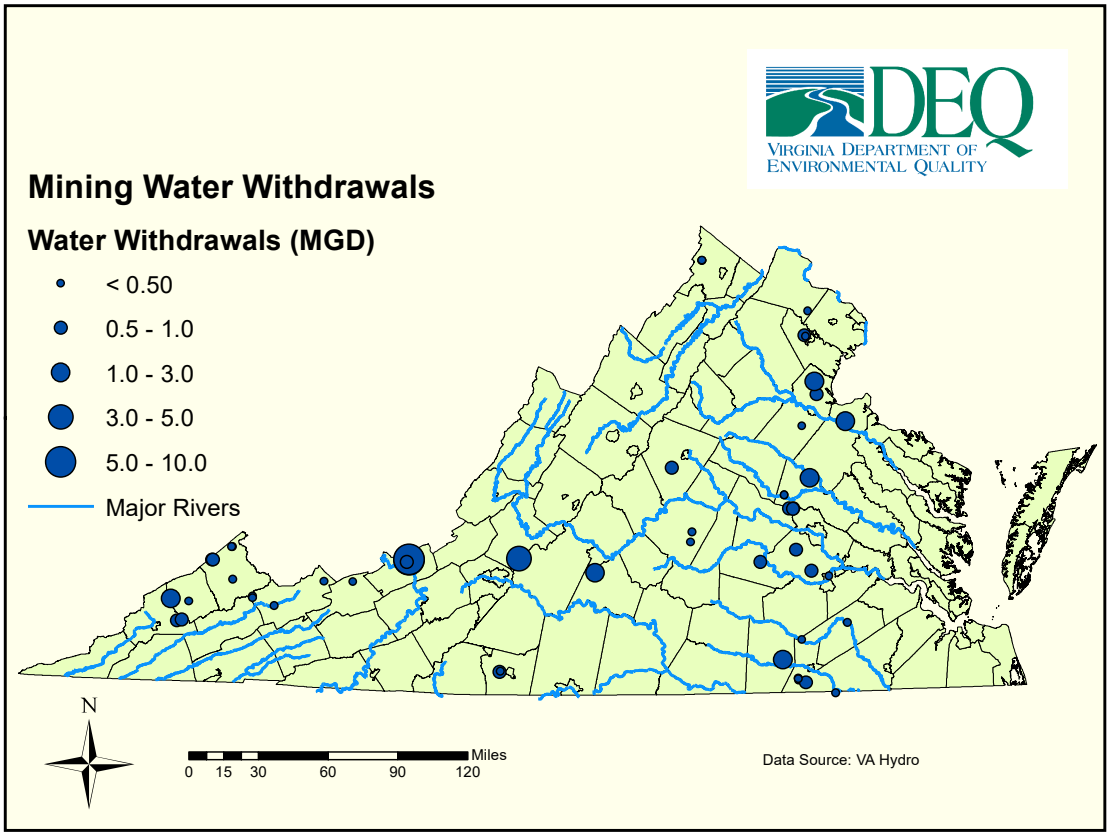

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Figure 19: 2018 Mining Water Withdrawals by Withdrawal Point Location

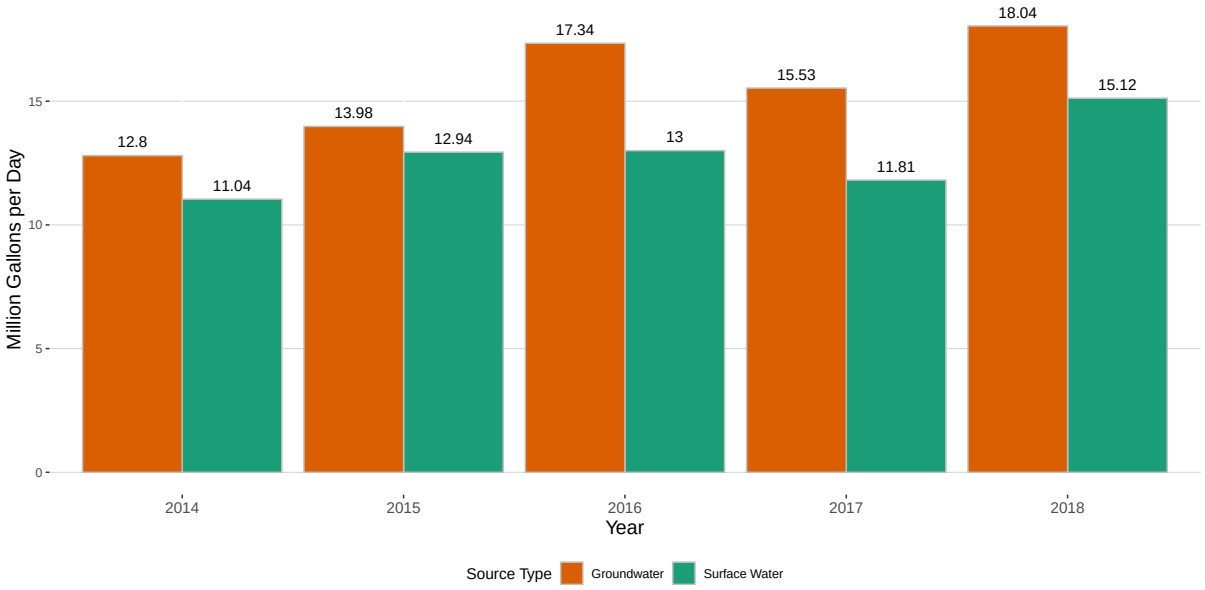

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Figure 20: 2014-2018 Mining Water Withdrawals by Source Type

Source Type	2014	2015	2016	2017	2018	5 Year Avg.	% Change 2018 to Avg.
Groundwater	12.80	13.98	17.34	15.53	18.04	15.54	16.1
Surface Water	11.04	12.94	13.00	11.81	15.12	12.78	18.3
Total (GW + SW)	**23.84**	**26.92**	**30.34**	**27.34**	**33.16**	**28.32**	**17.1**

Table 11: 2014-2018 Mining Water Withdrawals by Source Type (MGD)

Facility	Locality	Type	Major Source	5 Year Avg.	2018 Withdrawal
Lhoist North America: Kimballton Plant 1	Giles	GW	Quarry and Spring	9.36	10.19
Lhoist North America: Kimballton Plant 2	Giles	SW/GW	Stony Creek and Quarry Well	4.79	5.86
Boxley Materials:Blue Ridge Plant	Bedford	SW	Quarry	1.79	2.04
Mid-Atlantic Materials: Sand/Gravel	King George	SW	Rappahannock River	0.77	1.55
Vulcan Construction Materials	Brunswick	SW/GW	Quarry	0.85	1.45

Table 12: Highest Reported Mining Water Withdrawals in 2018 (MGD)

Manufacturing and Industrial Water Withdrawals

Manufacturing and Industrial includes operations such as chemical and plastics manufacturing, paper mills, food processors, drug companies, furniture, and concrete companies. Water withdrawals reported in 2018 for manufacturing and industrial purposes are spread throughout much of Virginia (Figure 21). Clusters of large-scale withdrawals occur in the Middle James River basin around Richmond City, as well as in the New River and the Upper James River basins. All of the locations with large withdrawals are situated on or near major rivers to facilitate water supply.

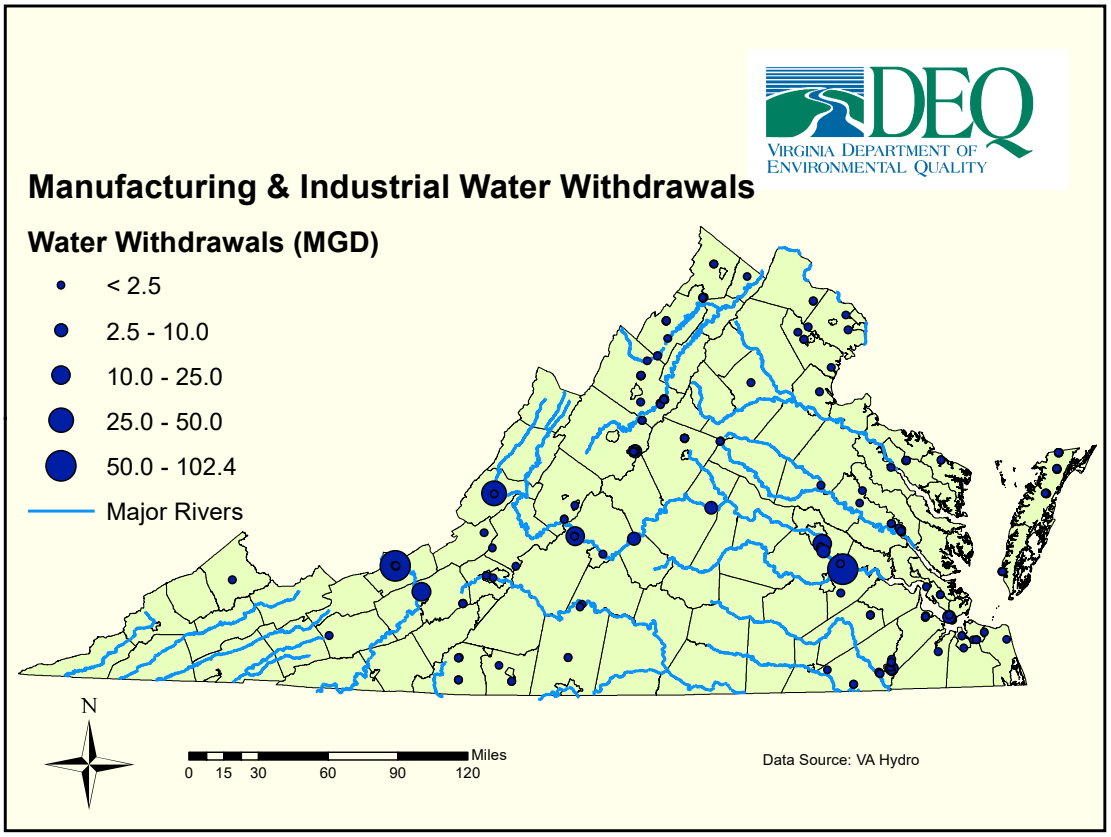

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Figure 21: 2018 Manufacturing and Industrial Water Withdrawals by Withdrawal Point Location

Figure 22 illustrates the source distribution and annual changes in statewide totals of groundwater and surface water withdrawals for manufacturing and industrial from 2014-2018. Reported 2018 withdrawals decreased by 4.2 MGD as compared to the average of the previous five years, shown in Table 13. Surface water is the predominate water source type for manufacturing, accounting for about 84% of the total withdrawals in 2018. There are no major transfers of water reported for manufacturing purposes, so the water withdrawals generally represent water use. Table 14 lists the five facilities reporting the greatest groundwater withdrawals in 2018 and Table 15 lists the facilities reporting the greatest surface water withdrawals in 2018. Water withdrawals from manufacturing and industrial users make up about 30% of all non-power generation withdrawals in Virginia.

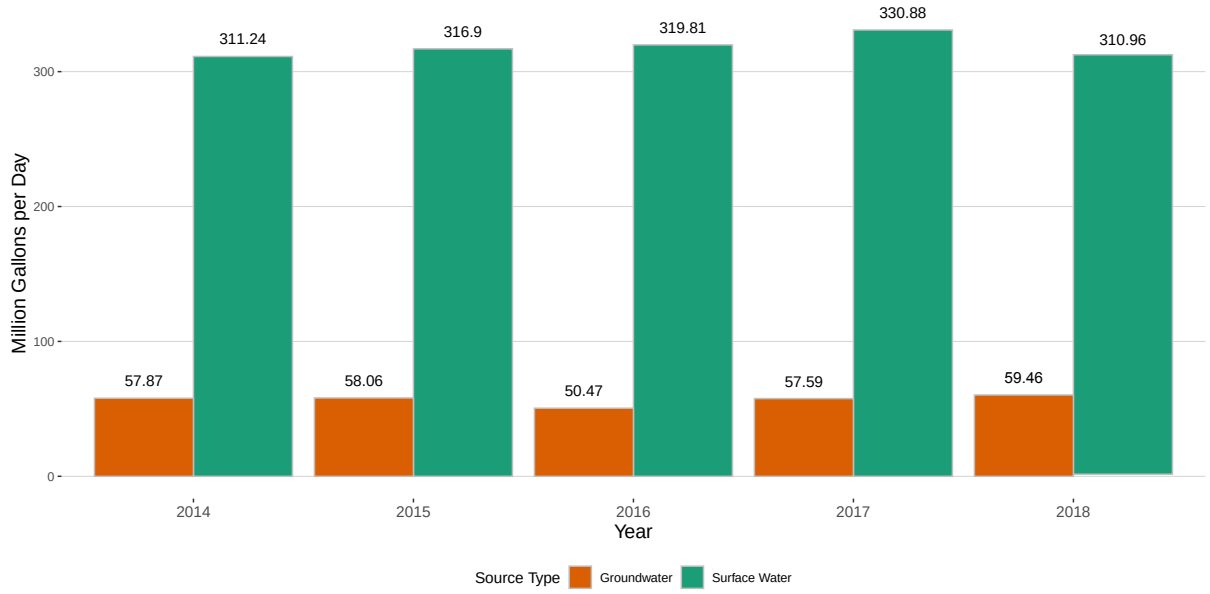

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Figure 22: 2014-2018 Manufacturing and Industrial Water Withdrawals by Source Type

Source Type	2014	2015	2016	2017	2018	5 Year Avg.	% Change 2018 to Avg.
Groundwater	57.87	58.06	50.47	57.59	59.46	56.69	4.9
Surface Water	311.24	316.90	319.81	330.88	310.96	317.96	-2.2
Total (GW + SW)	**369.11**	**374.96**	**370.28**	**388.47**	**370.42**	**374.65**	**-1.1**

Table 13: 2014-2018 Manufacturing and Industrial Water Withdrawals by Source Type (MGD)

Facility	Locality	Type	Major Source	5 Year Avg.	2018 Withdrawal
WestRock CP, LLC: West Point Mill Water System	King William	GW	14 Wells	19.18	16.56
International Paper: Franklin Plant	Isle of Wight	GW	12 Wells	10.89	14.32
Merck & Co: Elkton Plant	Rockingham	GW	11 Wells	6.61	5.81
Celanse: Celco Plant	Giles	GW	5 Wells	4.00	5.81
The LYCRA Company: Waynesboro Plant	Waynesboro	GW	3 Wells	2.86	4.69

Table 14: Highest Reported Manufacturing and Industrial Groundwater Withdrawals in 2018 (MGD)

Significant increases in groundwater withdrawals compared to the five-year average from International Paper and the LYCRA Company's Waynesboro Plant are shown in Table 14, International Paper withdraws groundwater from a series of 12 wells, distributing their withdrawals more evenly across groundwater sources as compared to the LYCRA Company in Waynesboro which withdraws groundwater from three wells. Over 1.5 BG of additional groundwater was withdrawn from one LYCRA well that was put back in operation in 2017, resulting in an approximately 64% increase in groundwater withdrawals at the facility in 2018.

In 2018, the top reported surface water withdrawals for manufacturing and industrial uses remained consistent with the facilities five-year average (Table 15), with AdvanSix Resins Chesterfield Plant as the outlier. The Chesterfield Plant's James River intake is currently excluded from the DEQ VWP conditions, and reported a surface water withdrawal of approximately 54% in 2018 when compared to the current five-year average.

Facility	Locality	Type	Major Source	5 Year Avg.	2018 Withdrawal
AdvanSix Resins & Chemicals LLC: Hopewell Plant	Hopewell	SW	James River	103.78	102.39
Celanese Acetate LLC: Celco Plant	Giles	SW	New River	51.92	52.09
WestRock Virginia: Covington Plant	Alleghany	SW	Jackson River	39.07	37.27
AdvanSix Resins & Chemicals LLC: Chesterfield Plant	Chesterfield	SW	James River	16.04	24.65
DuPont E I De Nemours: Spruance Plant	Chesterfield	SW	James River	29.27	24.43

Table 15: Highest Reported Manufacturing and Industrial Surface Water Withdrawals in 2018 (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. 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 is served by larger surface water systems. 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 sell water to their neighbors. Smaller public water supply purveyors are scattered throughout the rest of the state (Figure 23).

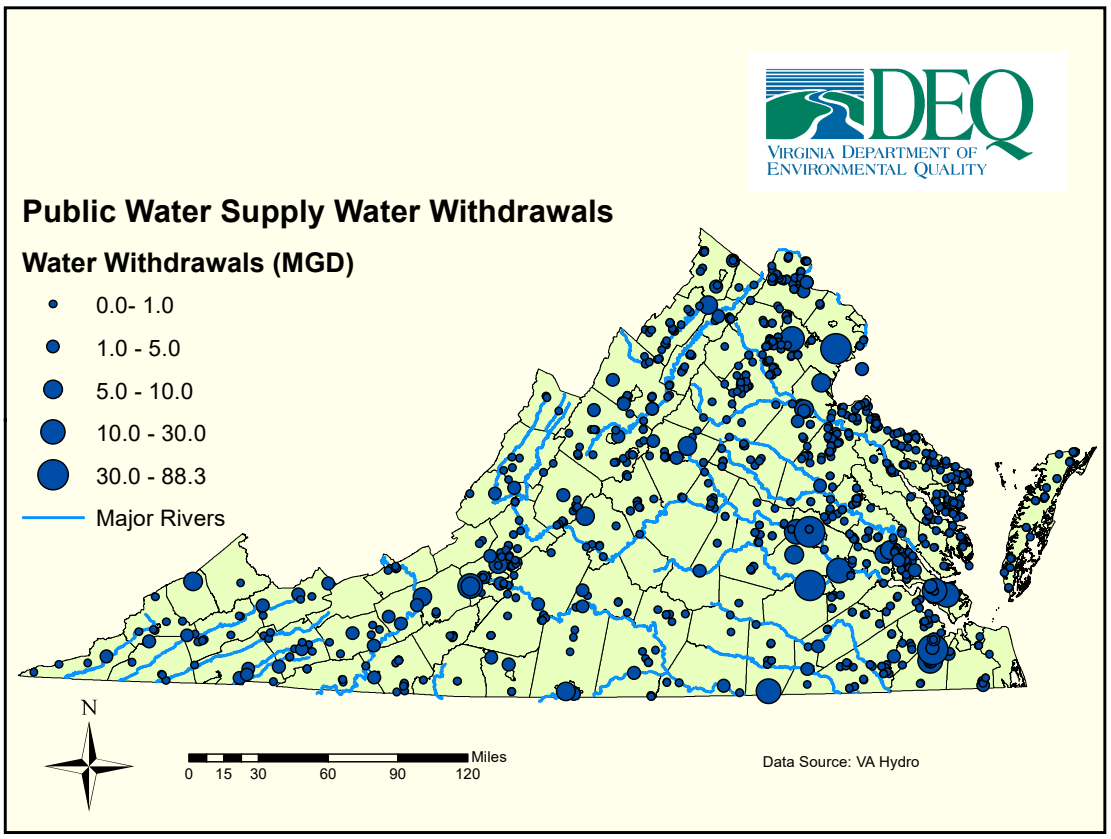

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Figure 23: 2018 Public Water Supply Water Withdrawals by Withdrawal Point Location

Reported 2018 water withdrawals for public water supply increased by 2% when compared to the average of the previous five years (Table 16). 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 2018 public water supply withdrawals in Virginia.(Figure 24). Table 17 lists the ten facilities that reported the greatest rates of public water supply withdrawal in 2018. Water withdrawals for public water supply make up approximately 62% of all non-power generation withdrawals in Virginia.

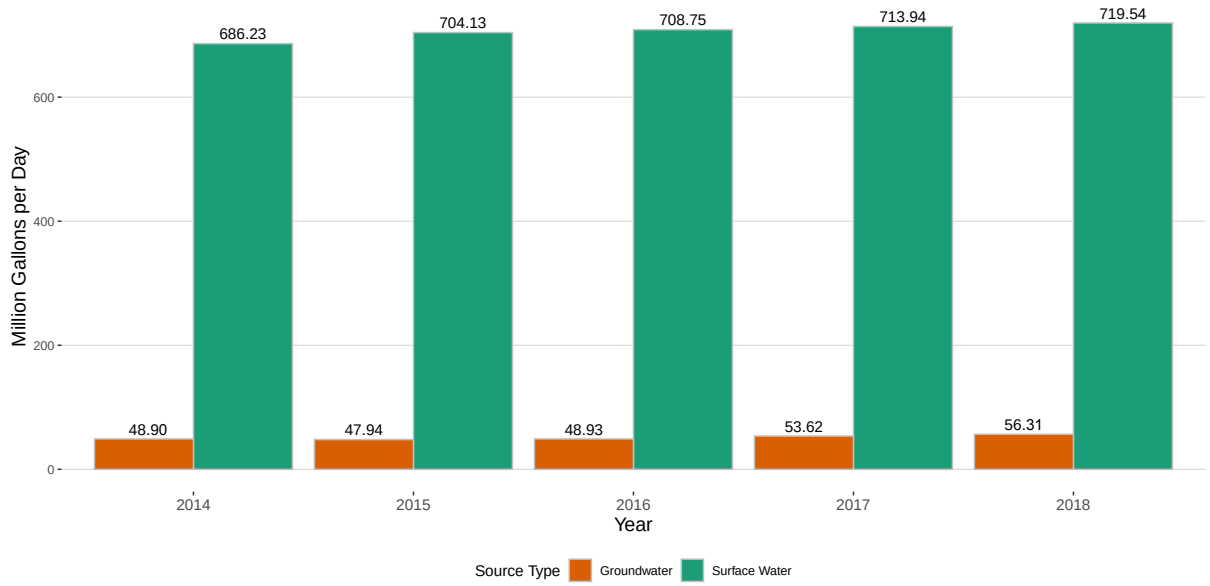

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Figure 24: 2014-2018 Public Water Supply Water Withdrawals by Source Type

Source Type	2014	2015	2016	2017	2018	5 Year Avg.	% Change 2018 to Avg.
Groundwater	48.90	47.94	48.93	53.62	56.31	51.14	10.1
Surface Water	686.23	704.13	708.75	713.94	719.54	706.52	1.8
Total (GW + SW)	**735.13**	**752.07**	**757.68**	**767.56**	**775.85**	**757.66**	**2.4**

Table 16: 2014-2018 Public Water Supply Water Withdrawals by Source Type (MGD)

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).

Facility	Locality	Type	Major Source	5 Year Avg.	2018 Withdrawal
Fairfax Water: Corbalis WTP	Fairfax	SW	Potomac River	89.22	88.83
Norfolk: Western Branch	Suffolk	SW	Western Branch Reservoir	63.86	72.95
City of Richmond: Richmond WTP	Richmond, City	SW	James River	64.56	62.90
Fairfax Water Authority: Griffith WTP	Prince William	SW	Occoquan Reservoir	65.25	62.28
Appomattox River Water Authority: Chesdin Reservoir WTP	Chesterfield	SW	Chesdin Reservoir	31.85	33.79
Virginia Beach	Virginia Beach	SW	Lake Gaston	24.26	29.01
Henrico County: Henrico County WTP	Henrico	SW	James River	23.68	24.55
Virginia American Water: Hopewell District	Hopewell	SW	Appomattox River	20.37	23.30
Newport News: Lee Hall WTP	Newport News	SW	Lee Hall Reservoir	22.49	21.83
Newport News: Harwood's Mill WTP	Newport News	SW	Harwood's Mill Reservoir	18.61	18.91

Table 17: Highest Reported Public Water Supply Water Withdrawals in 2018 (MGD)

Category	Community Water Systems	Nontransient Noncommunity Water Systems	Transient Noncommunity Water Systems	Total
Number of Systems	1,119	522	1,226	2,867
Population Served	-	-	-	7,515,211

Table 18: Number of Public Water Supply Systems and Population Served 2018

Power Generation Water Withdrawals

Withdrawals for power generation are treated separately because most of the water diverted for these purposes is used non-consumptively (see Chapter 2 for a description of non-consumptive water use). Withdrawals during 2018 by nuclear and fossil fuel power generating plants are listed below. Water diverted for hydropower use is exempted from reporting and is nearly all non-consumptive use; therefore, these flows are generally not reported to the VA Hydro database.

Most of the large fossil-fuel facilities are located in central or eastern Virginia. Two nuclear-power generating plants are located in Louisa and Surry counties (Figure 25). Groundwater withdrawals by power generators in 2018 were insignificant compared to surface water withdrawals, which is true historically as well (Figure 26). Total power generation withdrawals in 2018 decreased by 10% as compared to the five-year average (Table 19). Surface water and groundwater withdrawals totaled 4,711.6 MGD in 2018. The five power generation facilities with the highest reported withdrawals are listed in Table 20.

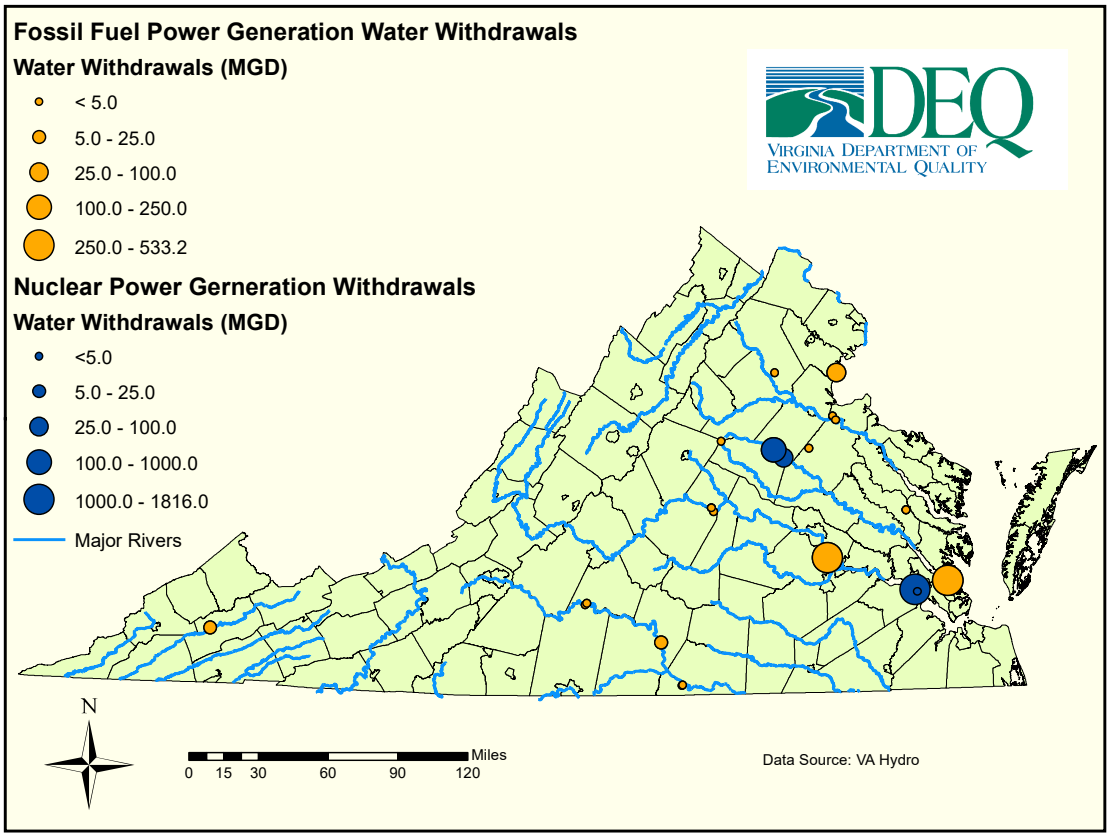

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Figure 25: 2018 Power Generation Water Withdrawals by Withdrawal Point Location

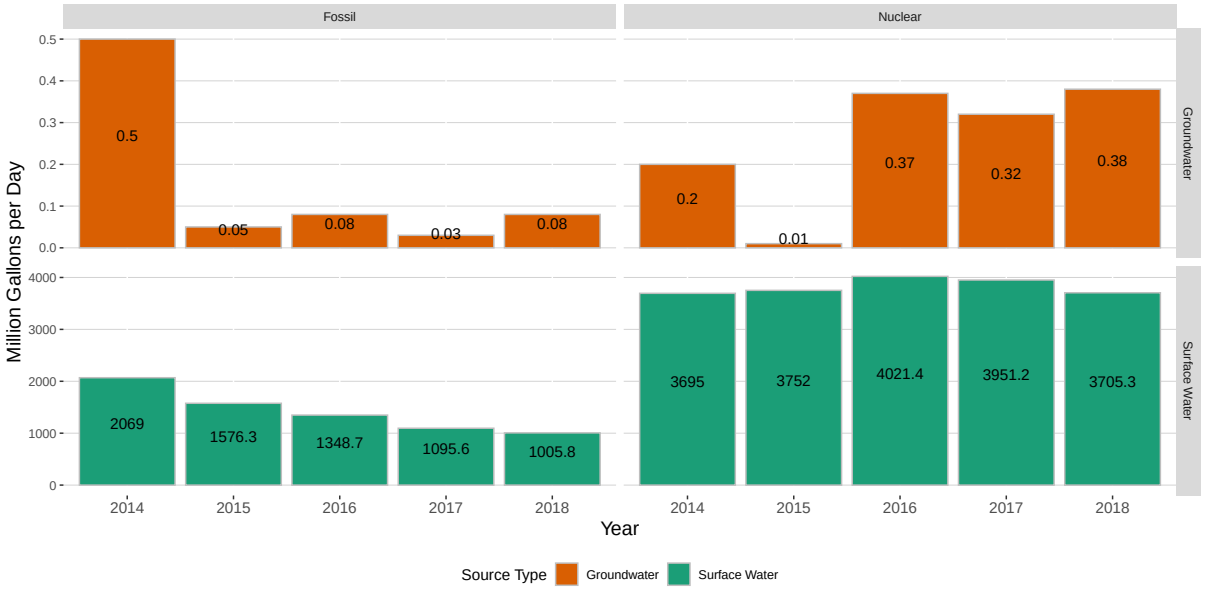

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Figure 26: 2014-2018 Power Generation Water Withdrawals by Source Type

Source Type	Power Type	2014	2015	2016	2017	2018	5 Year Avg.	% Change 5-year Avg. to 2018
GW	Fossil	0.5	0.05	0.08	0.03	0.08	0.15	-45.3
	Nuclear	0.2	0.01	0.37	0.32	0.38	0.26	48.4
	Total (GW)	0.7	0.06	0.45	0.35	0.46	0.40	14.1
SW	Fossil	2069.0	1576.3	1348.7	1095.6	1005.8	1419.1	-29.1
	Nuclear	3695.0	3752.0	4021.4	3951.2	3705.3	3825.0	-3.1
	Total (SW)	5764.0	5328.3	5370.1	5046.8	4711.1	5244.1	-10.2
Total GW + SW		**5764.7**	**5328.3**	**5370.6**	**5047.2**	**4711.6**	**5244.5**	**-10.2**

Table 19: 2014-2018 Power Generation Water Withdrawals by Source Type (MGD)

Facility	Locality	Type	Major Source	5 Year Avg.	2018 Withdrawal
Dominion Generation: North Anna Nuclear Power Plant	Louisa	SW	Lake Anna	1833.4	1889.1
Dominion Generation: Surry Nuclear Power Plant	Surry	SW	James River	2004.6	1816.6
Dominion Generation: Chesterfield Power Station	Chesterfield	SW	James River	805.7	534.4
Dominion Generation: Yorktown Fossil Power Plant	York	SW	York River	413.6	358.8
Dominion Generation: Possum Point Power Plant	Prince William	SW	Potomac River	161.2	95.8

Table 20: Highest Reported Power Generation Water Withdrawals in 2018 (MGD)

Appendix 5: Water Withdrawals Within Localities in 2018 (MGD) (Excluding Power Generation)

Table 21, shown below, lists the reported water withdrawals, both permitted and unpermitted, that occurred in 2018 within individual localities. Note: Approximately 30 MGD of uncategorized water withdrawals are not represented in the table below.

Locality	GW Withdrawal	SW Withdrawal	GW + SW Total	% of Total Withdrawal
Accomack	4.140	4.31	8.450	0.7
Albemarle	0.140	11.49	11.630	1.0
Alexandria	0.000	0.00	0.000	0.0
Alleghany	0.173	38.39	38.563	3.2
Amelia	0.160	0.21	0.370	0.0
Amherst	0.005	17.36	17.365	1.4
Appomattox	0.000	0.01	0.010	0.0
Arlington	0.012	0.06	0.072	0.0
Augusta	3.110	6.67	9.780	0.8
Bath	0.128	14.68	14.808	1.2
Bedford	2.079	17.45	19.529	1.6
Bland	0.033	0.13	0.163	0.0
Botetourt	0.780	2.36	3.140	0.3
Bristol	0.001	0.00	0.001	0.0
Brunswick	0.028	2.36	2.388	0.2
Buchanan	0.310	0.79	1.100	0.1
Buckingham	0.000	6.93	6.930	0.6
Buena Vista	1.244	0.02	1.264	0.1
Campbell	0.075	6.24	6.315	0.5
Caroline	1.400	0.63	2.030	0.2
Carroll	0.242	0.33	0.572	0.0
Charles City	0.070	0.73	0.800	0.1
Charlotte	0.136	0.11	0.246	0.0
Charlottesville	0.000	0.01	0.010	0.0
Chesapeake	3.099	2.27	5.369	0.4
Chesterfield	0.293	95.42	95.713	7.9
Clarke	0.000	0.56	0.560	0.0
Colonial Heights	0.000	0.00	0.000	0.0
Covington	0.000	2.53	2.530	0.2
Craig	0.101	3.66	3.761	0.3
Culpeper	1.113	1.63	2.743	0.2
Cumberland	0.034	0.05	0.084	0.0
Danville	0.000	5.17	5.170	0.4
Dickenson	0.102	6.80	6.902	0.6
Dinwiddie	0.032	0.36	0.392	0.0
Emporia	0.000	1.08	1.080	0.1
Essex	0.366	0.23	0.596	0.0
Fairfax City	0.000	0.01	0.010	0.0
Fairfax County	0.260	89.65	89.910	7.4
Falls Church	0.000	0.00	0.000	0.0
Fauquier	1.829	1.30	3.129	0.3
Floyd	0.112	0.10	0.212	0.0

Fluvanna	0.129	0.75	0.879	0.1
Franklin City	0.804	0.00	0.804	0.1
Franklin County	0.690	1.01	1.700	0.1
Frederick	0.947	4.12	5.067	0.4
Fredericksburg	0.000	0.01	0.010	0.0
Galax	0.000	1.78	1.780	0.1
Giles	21.607	52.67	74.277	6.1
Gloucester	0.592	0.00	0.592	0.0
Goochland	0.060	2.01	2.070	0.2
Grayson	0.150	0.06	0.210	0.0
Greene	0.019	0.60	0.619	0.1
Greensville	0.025	2.20	2.225	0.2
Halifax	0.153	1.78	1.933	0.2
Hampton	0.000	0.01	0.010	0.0
Hanover	0.673	5.57	6.243	0.5
Harrisonburg	0.000	0.03	0.030	0.0
Henrico	0.039	24.83	24.869	2.1
Henry	0.013	3.73	3.743	0.3
Highland	0.079	5.23	5.309	0.4
Hopewell	0.000	138.29	138.290	11.4
Isle of Wight	17.297	2.48	19.777	1.6
James City	5.365	2.77	8.135	0.7
King and Queen	0.010	0.61	0.620	0.1
King George	1.167	1.66	2.827	0.2
King William	16.788	0.51	17.298	1.4
Lancaster	0.441	0.04	0.481	0.0
Lee	0.000	2.30	2.300	0.2
Lexington	0.000	0.00	0.000	0.0
Loudoun	1.360	9.81	11.170	0.9
Louisa	0.310	0.40	0.710	0.1
Lunenburg	0.000	0.55	0.550	0.0
Lynchburg	0.018	0.41	0.428	0.0
Madison	0.049	0.09	0.139	0.0
Manassas	0.298	11.69	11.988	1.0
Manassas Park	0.000	0.01	0.010	0.0
Martinsville	0.000	2.03	2.030	0.2
Mathews	0.013	0.00	0.013	0.0
Mecklenburg	0.125	1.95	2.075	0.2
Middlesex	0.216	0.02	0.236	0.0
Montgomery	0.125	22.12	22.245	1.8
Nelson	0.105	2.24	2.345	0.2
New Kent	0.752	16.21	16.962	1.4
Newport News	0.181	6.04	6.221	0.5
Norfolk	0.040	0.18	0.220	0.0
Northampton	0.819	0.85	1.669	0.1
Northumberland	0.242	0.01	0.252	0.0
Norton	0.000	0.76	0.760	0.1
Nottoway	0.000	1.05	1.050	0.1
Orange	0.022	1.79	1.812	0.1
Page	0.980	0.85	1.830	0.2

Patrick	0.167	0.47	0.637	0.1
Petersburg	0.431	0.02	0.451	0.0
Pittsylvania	0.973	2.11	3.083	0.3
Poquoson	0.000	0.00	0.000	0.0
Portsmouth	0.098	0.00	0.098	0.0
Powhatan	0.112	0.14	0.252	0.0
Prince Edward	0.102	1.10	1.202	0.1
Prince George	0.310	0.07	0.380	0.0
Prince William	0.380	64.21	64.590	5.3
Pulaski	0.000	4.33	4.330	0.4
Radford	0.000	2.85	2.850	0.2
Rappahannock	0.033	0.00	0.033	0.0
Richmond	0.192	63.01	63.202	5.2
Richmond County	0.301	0.00	0.301	0.0
Roanoke City	1.507	12.59	14.097	1.2
Roanoke County	0.025	15.36	15.385	1.3
Rockbridge	0.355	1.45	1.805	0.1
Rockingham	14.504	9.54	24.044	2.0
Russell	0.363	0.74	1.103	0.1
Salem	1.568	3.06	4.628	0.4
Scott	0.073	1.10	1.173	0.1
Shenandoah	2.930	3.08	6.010	0.5
Smyth	0.941	6.37	7.311	0.6
Southampton	3.530	0.45	3.980	0.3
Spotsylvania	0.209	11.20	11.409	0.9
Stafford	0.004	14.98	14.984	1.2
Staunton	0.000	0.00	0.000	0.0
Suffolk	6.397	87.71	94.107	7.8
Surry	0.223	0.08	0.303	0.0
Sussex	0.989	0.31	1.299	0.1
Tazewell	0.021	4.77	4.791	0.4
Virginia Beach	0.149	29.04	29.189	2.4
Warren	0.104	9.44	9.544	0.8
Washington	0.078	10.31	10.388	0.9
Waynesboro	5.894	1.20	7.094	0.6
Westmoreland	0.880	1.14	2.025	0.2
Williamsburg	1.130	0.00	1.130	0.1
Winchester	0.000	0.00	0.000	0.0
Wise	0.004	6.72	6.724	0.6
Wythe	0.202	7.62	7.822	0.6
York	0.400	18.91	19.310	1.6
Total	**139.890**	**1071.68**	**1211.574**	**100.0**

Table 21: Water Withdrawals Within Localities in 2018 (MGD)