COMMONWEALTH of VIRGINIA

DEPARTMENT OF ENVIRONMENTAL QUALITY
Street address: 629 East Main Street, Richmond, Virginia 23219
Mailing address: P.O. Box 1105, Richmond, Virginia 23218
www.deq.virginia.gov

Molly Joseph Ward
Secretary of Natural Resources

David K. Paylor
Director

(804) 698-4000
1-800-592-5482

To: The Honorable Terence R. McAuliffe

Members of the General Assembly

From: David K. Paylor

Date: September 26, 2017

Subject: Status of Virginia's Water Resources: A Report on Virginia's Water Resources Management Activities (2017)

In accordance with § 62.1-44.40 of the *Code of Virginia* and on behalf of the State Water Control Board, I am pleased to provide you with the 2017 report "Status of Virginia's Water Resources: A Report on Virginia's Water Resources Management Activities." The purpose of this report is to provide a summary of the status of the Commonwealth's water resource supply. The report also provides a summary of DEQ's water supply and resource planning accomplishments for the year.

This report is being made available on DEQ's website at:
http://www.deq.virginia.gov/LawsRegulations/ReportstotheGeneralAssembly.aspx.

If you have any questions concerning this report or would like a hard copy of this report, please contact Brandon Bull, Water Policy Manager, at (804) 698-4092.

A REPORT TO

THE HONORABLE TERENCE R. MCAULIFFE, 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 2017

PAGE LEFT INTENTIONALLY BLANK

TABLE OF CONTENTS

FIGURES

TABLES

ACRONYMS

AG: Agriculture
CAG: Citizen Advisory Group
CWS: Community Water System
DEQ: Department of Environmental Quality
DL: Delivery
DMME: Department of Mines, Minerals, and Energy
DMTF: Drought Monitoring Task Force
GIS: Geographic Information System
GPD: Gallons per Day
GPM: Gallons per Minute
GW: Groundwater
GWMA: Groundwater Management Area
JPA: Joint Permit Application
MAN: Manufacturing
MGD: Million Gallons per Day
NWIS: USGS National Water Information System
OWS: Office of Water Supply
PDC: Planning District Commission
PWS: Public Water System
RL: Release
RAP: Regulatory Advisory Panel
SD: System Delivery
SR: System Release
SW: Surface Water
SWCB or Board: State Water Control Board
SWIP: Surface Water Investigations Program
SWMA: Surface Water Management Area
SWRP or Plan: State Water Resources Plan
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
VMRC: Virginia Marine Resources Commission
VWP: Virginia Water Protection (Permit Program)
VWUDS: Virginia Water Use Data System
WL: Withdrawal
WTP: Water Treatment Plant
WWR: Water Withdrawal Reporting (Regulation)

EXCUTIVE 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 2016 calendar year, discussing water withdrawal trends, and providing an update on the Commonwealth's water resources management activities. The Annual Report also serves as a status report concerning the State Water Resources Plan between five year planning updates.

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

State Water Resources Plan

The State Water Resources Plan was finalized and released to the public in October 2015. The State Water Resources Plan identified some potential areas of concern as well as challenges for future water resources management and recommendations for action.

Data analysis of local data conducted during development of the State Water Resources Plan predicted a net increase of approximately 32% in mean daily water demand over the planning period, indicating that an estimated 450 MGD of additional water will be needed to meet projected 2040 demands.

Cumulative impact analyses have indicated that projected surface water withdrawal increases may result in negative impacts during future drought situations, particularly within the James, Potomac-Shenandoah, and York River basins. These areas are prioritized for planning discussions regarding required updates to their local water supply plans (required by December 2018).

Comparison of annual water withdrawals reported under the regulatory reporting requirement with water use estimates from the water supply plans indicates that water withdrawals from several categories may be under-reported. This has led to increased efforts to improve reporting which were initially targeted at golf courses and the agricultural community. Outreach to other water use categories will be conducted over the next couple of years. Additional information is obtained through the private water well registration program, which enables DEQ and VDH to receive water well completion reports. As of December 31, 2016, 2,538 water well completion reports have been submitted online through the private water well registration program, with approximately 80% of the reported wells located in a designated GWMA.

Coastal Plain Aquifer System

While the Virginia Coastal Plain Groundwater Initiative has been successful in reducing permitted withdrawals from the costal plain aquifer system by about 50%, additional work needs to be done to ensure the availability of the aquifer system as a reliable water source for the future. Some short-term groundwater level recovery has been seen south of the James River since the reduction in water withdrawals by International Paper in 2011, increased use by the plant since then and others who have unused permitted amounts has resulted in a leveling off of the groundwater level improvements. DEQ is continuing to work with permitted 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.

At the direction of the General Assembly, the Joint Legislative Audit and Review Commission published its report titled "Effectiveness of Virginia's Water Resource Planning and Management" in October 2016. The report confirmed DEQ's findings that available groundwater supplies in the Eastern Virginia GWMA were insufficient to meet the demands of current and future groundwater users. In addition, the report validated DEQ's utilization of the VA Hydro-GW model as an appropriate tool to predict the sustainability of groundwater in eastern Virginia.

The Eastern Virginia Groundwater Management Advisory Committee, established pursuant to Va. Code § 62.1-256.1, to assist the State Water Commission and DEQ in "developing, revising, and implementing a management strategy for groundwater in the Eastern Virginia Groundwater Management Area," held meetings during March, April, May, June, and July 2017. The committee presented its recommendations to the State Water Commission and the DEQ Director on August 4, 2017. The DEQ Director will issue a report responding to the Committee's recommendations by November 1, 2017 pursuant to Va. Code § 62.1-256.1 C. Information about the activities of the Committee is posted on the DEQ Eastern Virginia Groundwater Management Advisory Committee webpage.

Water Withdrawals

Water withdrawals were reported in January 2017 by over 1,300 facilities for calendar year 2016. Compared to the five-year (2012-2016) average, the total volume of reported withdrawals from all water use categories (including power generation) decreased by approximately 4%. However, the total volume of reported withdrawals increased by 1% excluding the power generation use categories.

Surface water withdrawals had a higher proportion of the total water withdrawal volume by source type in 2016, which is comparable to 2012 through 2015. Surface water withdrawals also accounted for approximately 89% of total withdrawal volumes in 2016 (excluding withdrawals for power generation), which is equivalent to previous years.

Analysis of the spatial distribution of 2016 water withdrawals in Virginia indicates that, as in previous years, the largest groundwater withdrawals by volume predominantly occurred in the Coastal Plain, Eastern Shore, and Shenandoah Valley regions.

Withdrawals for Public Water Supply and for Manufacturing were again the largest sources of withdrawals for 2016 and for the average of the previous five-year period. Manufacturing makes up the highest proportion of groundwater withdrawals, whereas public water supply use accounts for the greatest proportion surface water withdrawals by volume.

I. INTRODUCTION

The waters of Virginia are among the state's most treasured resources. 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.

DEQ coordinates the management of water quantity and supply across the Commonwealth of Virginia through five programs: Water Supply Planning, Water Withdrawal Permitting and Compliance, Groundwater Characterization, Environmental Data and Analysis, 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 II. 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 focusses on water quantity and supply, summarizing reported (including permitted) water withdrawals for the 2016 calendar year, discussing water withdrawal trends, and providing an update on the Commonwealth's water resources management activities. The 2016 annual water withdrawals were reported to DEQ in January 2017, 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 2017 water year [1] (Appendix 1). The Annual Report also serves as a status report concerning the State Water Resources Plan between five year planning updates.

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

II. 2016 WATER RESOURCES MANAGEMENT UPDATES

Although Virginia historically has enjoyed plentiful water resources relative to demand, the growth of the Commonwealth's economy and population continues to present a challenge for maintaining both the quality and quantity of these resources for the duration of typical water supply planning periods. The state's water resources are used for a variety of important and sometimes competing in-stream and off-stream uses. Over the past decade, increased demand and competition for water have established a greater sense of urgency in Virginia's approach to resource management to avoid problems over the long term. 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.

[1] The U.S. Geological Survey 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, 2017 is called the "2017 water year."

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.

At the direction of the General Assembly, the Joint Legislative Audit and Review Commission published its report titled "Effectiveness of Virginia's Water Resource Planning and Management" in October 2016. The report was presented to the State Water Commission on November 30, 2016, and confirmed DEQ's findings that available groundwater supplies in the Eastern Virginia GWMA were insufficient to meet the demands of current and future groundwater users. In addition, the report validated DEQ's utilization of the VA Hydro-GW model as an appropriate tool to predict the sustainability of groundwater in eastern Virginia.

The Eastern Virginia Groundwater Management Advisory Committee, established pursuant to Va. Code § 62.1-256.1, to assist the State Water Commission and DEQ in "developing, revising, and implementing a management strategy for groundwater in the Eastern Virginia Groundwater Management Area," held meetings during March, April, May, June, and July 2017. The committee presented its recommendations to the State Water Commission and the DEQ Director on August 4, 2017. The DEQ Director will issue a report responding to the Committee's recommendations by November 1, 2017 pursuant to Va. Code § 62.1-256.1 C. The DEQ Eastern Virginia Groundwater Management Advisory Committee webpage provides additional information.

The following sections briefly discuss the various DEQ programs involved in water resources planning and management (Water Supply Planning and Reporting, Water Withdrawal Permitting and Compliance, Groundwater Characterization, Drought Assessment and Response, Surface Water Investigations, and Environmental Data and Analysis) as well as updates for 2016. The DEQ Water Supply and Water Quantity webpage provides additional information.

Water Supply Planning

Although Virginia has been managing water resources and supply in some form since 1927, the drought of 1999-2002 led to a change in management philosophy. When the drought peaked in late August 2002, wildfire indices were at record levels, streamflows had reached record lows, a majority of agricultural counties had applied for Federal disaster designation, thousands of individual private wells had failed, and several public water supply systems were on the brink of failure. Following this experience, the General Assembly amended the Code of Virginia to require the establishment of a "comprehensive water supply planning process" [2] to ensure the availability of safe drinking water, to protect all other beneficial uses[3] of the Commonwealth's water resources, and to encourage development of alternative water sources.

The Local and Regional Water Supply Planning Regulation[4] 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

[2] § 62.1-44.38:1, *Code of Virginia*.

[3] The term "beneficial uses" is defined in § 62.1-44.3 of the *Code of Virginia* as "both instream and offstream uses. Instream beneficial uses include, but are not limited to, the protection of fish and wildlife resources and habitat, maintenance of waste assimilation, recreation, navigation, and cultural and aesthetic values. The preservation of instream flows for purposes of the protection of navigation, maintenance of waste assimilation capacity, the protection of fish and wildlife resources and habitat, recreation, cultural and aesthetic values is an instream beneficial use of Virginia's waters. Offstream beneficial uses include, but are not limited to, domestic (including public water supply), agricultural uses, electric power generation, commercial, and industrial uses."

[4] 9VAC25-780-10 et seq.

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 State Water Resources Plan, which staff began developing concurrent with the plan review process. Completed in draft form in late 2014, the Plan was released for public comment in April 2015. The final Plan was published in October 2015.

The State Water Resources Plan was the first of its kind in Virginia and is the primary planning mechanism for achieving sustainable water supplies for the future. The document provides a statewide look at information provided by local and regional water supply plans, and the results of a cumulative impact analysis conducted using data from the plans and water withdrawal data submitted by individual users under the Water Withdrawl Reporting Regulation.[5] The Plan also describes major water supply challenges facing the Commonwealth through 2040 and makes recommendations for addressing those challenges. A summary of the challenges and recommendations is provided in Chapter V.

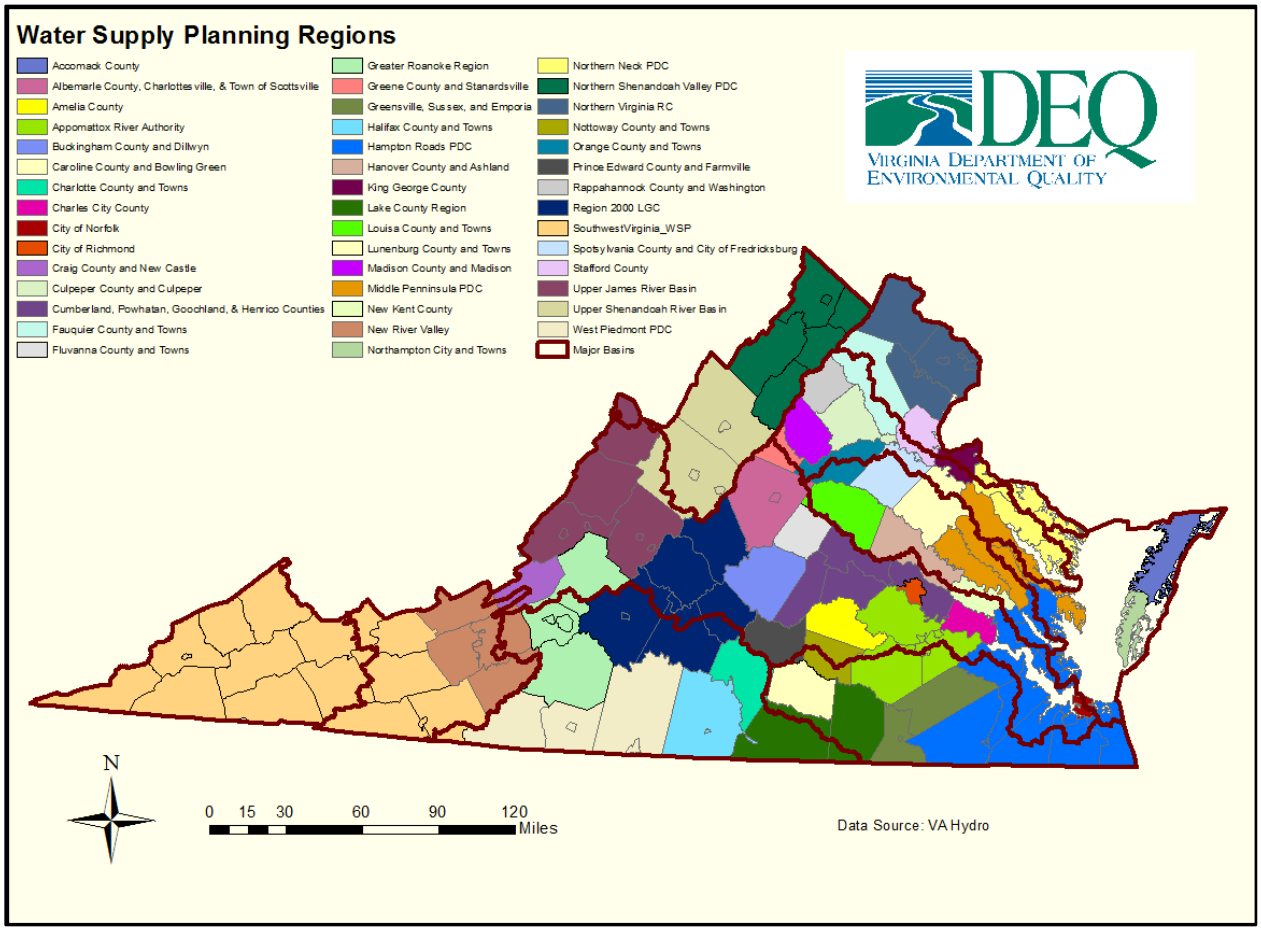


Figure 1: Water supply planning regions according to 2011 submittals with major river basins

The Plan will be updated every five years following updates or resubmittals of the local and regional water supply plans. The next update will begin in 2018. The Plan is accessible through DEQ's website and will be subject to incremental revision as DEQ, localities, and other stakeholders provide input

[5] 9VAC25-200-10 et seq.

through ongoing water supply planning efforts. It is anticipated that information provided by localities via a web-based, interactive platform will provide 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.

Staff provides outreach and technical assistance to all localities and planning regions to ensure compliance conditions are addressed by the five year review deadline of 2018. Initial outreach was prioritized in those areas where shortfalls were projected based on the projected water demand information and analyses in the Plan. As of August 2017, the following localities have satisfied their outstanding compliance items: Blacksburg, Christiansburg, Danville, Greensville County, Martinsville, New Kent County, Nottoway County, and Patrick County. The City of Emporia had no outstanding items.

The review of water supply plans revealed several sectors of water users were identified as not reporting annual withdrawals as required (see the 'Water Withdrawal Reporting' section below). Reported withdrawals serve as the basis for understanding which water uses are sustained from a particular source and which may be supported in the future. Also, calculating and reporting annual withdrawals assists with planning for future water needs in terms of growth or expansion. This data gap is identified in many final compliance documents as a condition that must be addressed. These sectors include golf courses, the agricultural community, small private community water systems, and others. To assist localities in meeting compliance conditions regarding the reporting of withdrawals, staff initiated outreach efforts to golf courses and the agricultural community. Additional sectors will be researched as resources allow.

Water Withdrawal Reporting

The Water Withdrawal Reporting Regulation requires the annual reporting of monthly water withdrawals (surface water and groundwater withdrawals) 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. DEQ offers electronic reporting into the VA Hydro data system, an interactive database that allows operators to enter withdrawal data on a monthly basis throughout the year and to view withdrawal reporting information from previous years. The VA Hydro data system 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 source (groundwater or surface water) and source sub-type (reservoir, spring, stream, or well). Analyses of the submitted data is provided in Chapters III and IV.

The collection of water use data through water withdrawal reporting enables appropriate planning for the Commonwealth's future water needs. Automatically linked to the water supply modeling system, the water use reporting database 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.

Efforts to improve water withdrawal reporting within the agricultural communities were continued in 2016. 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 2016, 20 farms were registered to report non-irrigation water withdrawals. Outreach to other water use categories, including but not limited to nurseries, sod farms, public and private educational institutions, and vineyards will be conducted over the next couple of years.

Water Withdrawal Permitting and Compliance

Under the Ground Water Management Act of 1992, 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 2). The Eastern Virginia GWMA comprises all areas east of Interstate 95. 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.

Projects involving surface water withdrawals from state waters and related permanent structures are permitted under the Virginia Water Protection (VWP) Permit Program Regulation[6] as directed by Article 2.2 of the State Water Control Law. DEQ issues VWP Individual permits for such impacts through use of the Joint Permit Application process.

Groundwater Withdrawal Permitting

Enacted to address declining water levels in the confined aquifer system caused by increased industrial usage of groundwater, the Groundwater Act of 1973 recognized the duty of the State Water Control Board to manage groundwater resources and establish GWMAs. In 1976, the Eastern Virginia GWMA, comprising most of the Coastal Plain Physiographic Province (Figure 2), and the Eastern Shore GWMA were designated in response to increasing stresses on the resource. Amendments to the Act in 1986 added municipal water supplies as a regulated beneficial use and created a permitting threshold of 300,000 gallons per month. The Ground Water Management Act of 1992[7] removed a permittee's guaranteed right to withdraw at maximum daily values year-round on a continuous basis, and added agriculture as a regulated beneficial use.

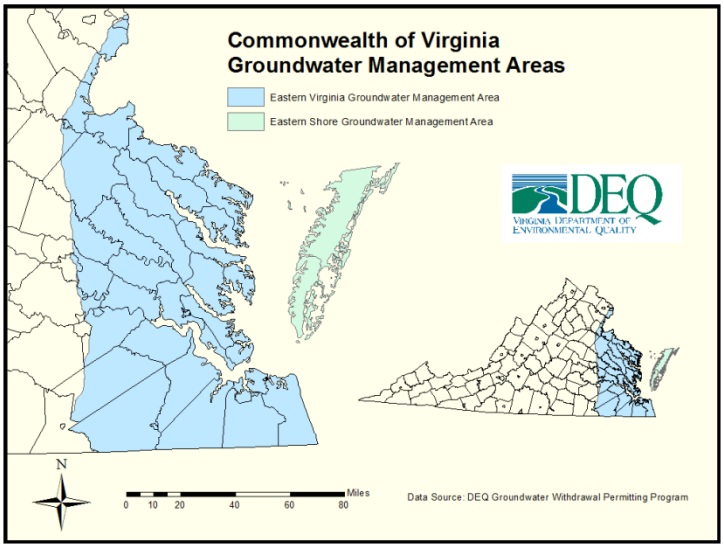


Figure 2: Virginia Groundwater Management Areas

Between 2009-2013, growing concerns over increased water use by new or expanding withdrawals, overlapping cones of depression,[8] and declining water levels in the Coastal Plain aquifer system led the Board to consider expanding[9] the Eastern Virginia GWMA to include all of the Coastal Plain east of I-95 in order to ensure comprehensive management of the aquifer system. Modifications to the

[6] 9VAC25-210-10 et seq.
[7] § 62.1-254 et seq., *Code of Virginia*.
[8] "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.
[9] 9VAC25-600-20, effective January 1, 2014, and Figure 2.

Groundwater Withdrawal Regulations[10] accompanied the expansion, effective January 1, 2014, codified the criteria for the declaration of GWMAs and for the issuance of groundwater withdrawal permits to withdrawers of groundwater in excess of 300,000 gallons per month in a declared GWMA. Over 100 existing user permit applications were received during 2014 as a result of the Eastern Virginia GWMA expansion. A total of 33 Existing User Groundwater Permits were issued in 2015 and an additioanl 22 Existing User Groundwater Permits were issued in 2016. Of the 55 permits issued, 34 facilities elected to prepare and submit a Water Conservation and Management Plan, which exceeds the current requirements of the permitting process.

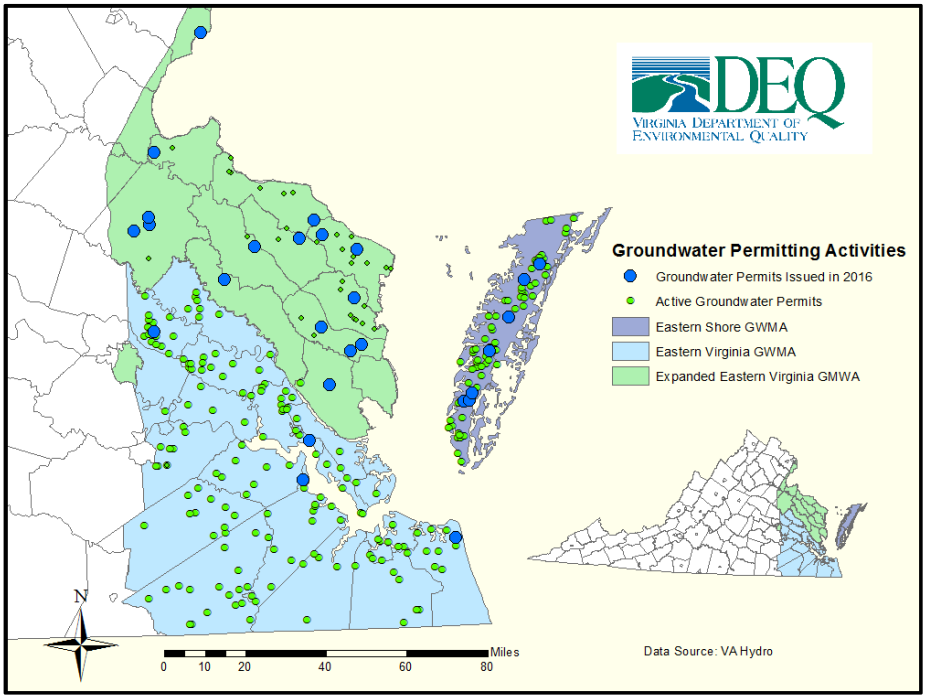


Figure 3: 2016 Virginia groundwater withdrawal permitting activities

Groundwater withdrawal permit applications for new or expanded (increase to existing withdrawal) 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 weighs 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 (Figure 3).

DEQ staff meets with all prospective permit applicants to discuss the permitting process, administrative requirements, and technical requirements prior to application submission. Technical evaluations of impacts and resource sustainability are conducted by groundwater modeling contractors working closely with staff on proposed withdrawals. This ongoing collaborative effort enables program staff to provide technical support to applicants through review and comment on all proposals for field data collection in support of permit development.

The Virginia Coastal Plain Groundwater Initiative was developed in response to ongoing and long-term decline of groundwater levels, head loss, and growing concerns about land subsidence and salt water intrusion into the 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 discussed potential reductions in water withdrawals with the largest 14 groundwater users, which, if implemented could begin stabilizing the groundwater level declines in the aquifer. Combined, these users represented approximately 87% of all groundwater withdrawals within the GWMA. The Initiative continued in 2016 and 2017 with progress made in establishing permit reductions with all of the top 14

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

facilities. The overall reduction in permitted volume is as much as 52%; however, several individual facilities have permitted reductions of greater than 65%. The total permitted volume allocated from the Coastal Plain aquifer system has been decreased by 77 MGD. To date, DEQ has issued permits for 13 of the top 14 groundwater users.

Surface Water Withdrawal Permitting

DEQ manages and permits surface water projects that withdraw greater than 10,000 GPD or one million gallons in a single month for agricultural use from state waters such as non-tidal streams, lakes, and reservoirs under the VWP Permit Program.[11] VWP permits are required for withdrawals in tidal streams that are greater than 2 MGD, or 60 million gallons per month for agricultural use. Withdrawal projects may be exempt from the VWP permit program if they meet any of the exclusion criteria specified in the regulations.[12] VWP surface water withdrawal permits function as the vehicle for Section 401 Certification, as required by the Clean Water Act.[13]

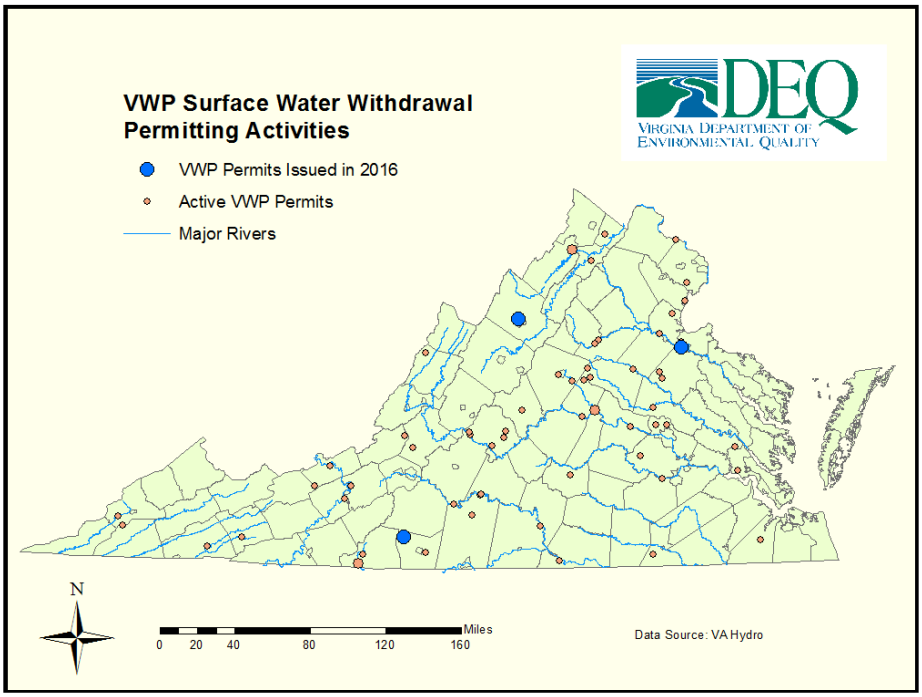


Figure 4: 2016 Virginia Water Protection Permit activities for surface water withdrawals

Application for a surface water withdrawal permit is made through the submittal of a Joint Permit Application (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 beneficial uses. To conduct these analyses, staff continues to develop and maintain an operational hydrologic model, which collates data on all streams and large impoundments in the Commonwealth. Each new or reissuance 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 withdrawal limits and flow-by rates if a permit is issued. Figure 4 illustrates 2016 VWP surface water withdrawal permitting activities, including permit issuances and modifications.

Efforts to update and improve the Surface Water Withdrawal Permitting language within the VWP regulatory framework were continued during 2016. Proposed revisions were certified by the Attorney

[11] §§ 62.1-44.15.20 and 62.1-44.15.22, *Code of Virginia*, and 9VAC25-210-10 et seq.
[12] 9VAC25-210-60.B
[13] 33 U.S.C. § 1251 et seq.

General and approved by the State Water Control Board and Governor. The revisions became effective on August 2, 2016.

GROUNDWATER CHARACTERIZATION

DEQ established the Groundwater Characterization Program in response to negative impacts experienced by many localities, businesses, and domestic well users during the drought of 2002 and the need for more information about groundwater for state and local water supply planning. The program protects Virginia's environment and promotes the health and well-being of its citizens by collecting, evaluating, and interpreting technical information necessary to manage groundwater resources of the Commonwealth. Staff also participates in outreach and educational opportunities in order to increase public awareness of the wide range of issues affecting Virginia's water resources. Finally, staff manages the Ambient Groundwater Quality Monitoring Program, to characterize the quality of groundwater throughout the Commonwealth of Virginia. As described in the *Ambient Groundwater Quality Monitoring Strategy*,[14] 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. Figure 6 depicts the locations of surface and groundwater monitoring stations maintained by both USGS and DEQ staff.

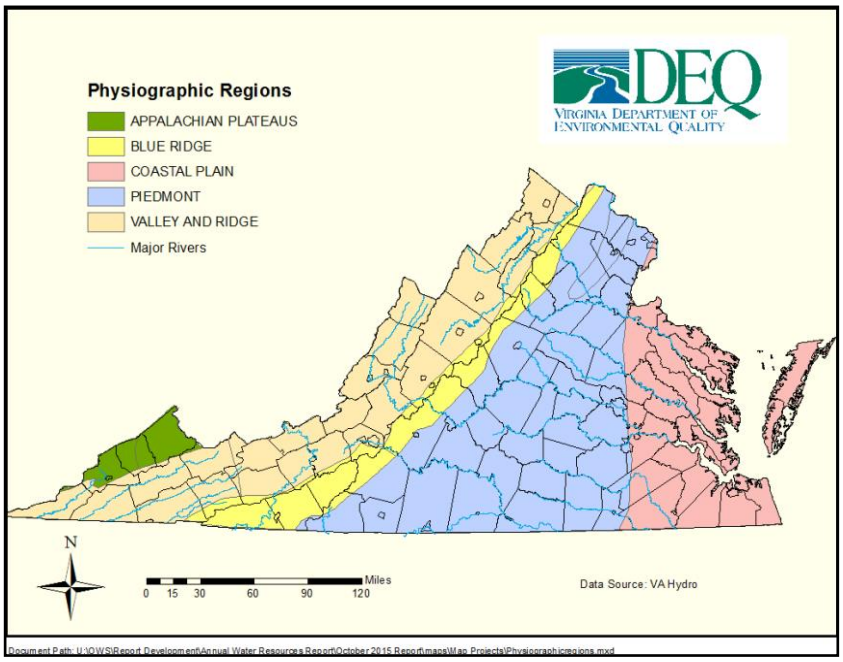


Figure 5: Virginia's Physiographic Provinces

In 2016, 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 for salt water "upconing," the transient upwelling of salty groundwater that can occur in response to the local removal of non-saline groundwater by supply wells in the Coastal Plain aquifer system. Trend wells were also sampled on a quarterly basis to document chloride concentrations in portions of the Coastal Plain aquifer system that may be vulnerable to upward migration of the fresh water/salt water interface, or the more regional phenomena known as salt water intrusion. Focused sampling was also conducted in the Coastal Plain aquifer system overlying the Taylorsville Early Mesozoic Basin. Sampling in the regional aquifer system overlying the Taylorsville Basin was conducted in order to describe the natural chemical composition of groundwater within these aquifers and to develop an inventory of baseline groundwater quality data.

[14] DEQ, 2013, *Ambient Groundwater Quality Monitoring Strategy, Final – November 2013*, 88 p.

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 2016 calendar year, particular emphasis was placed on collection and analysis of hydrogeologic data from multiple groundwater production wells and springs in the central portion of the Great Valley for the purpose of describing the hydrogeologic significance and structure of the Staunton/Pulaski Fault System near Harrisonburg Virginia, which is an area of the Great Valley with actively increasing demands for groundwater. In the Piedmont portion of the Commonwealth, DEQ assisted the USGS and Fauquier County with data collection and analysis of hydrogeologic data as part of a five-year study intended to inventory and describe county-wide groundwater resources and availability. Outside of the town of Warrenton, Fauquier County relies exclusively on groundwater to meet all water demands and development pressures in this region are requiring expansion of infrastructure and additional development of the resource. Initial data collection efforts are focused on describing groundwater movement and availability in the Catoctin Formation, which comprises roughly one-third of the county's geology.

A cooperative effort with the USGS to characterize the hydrogeology of the Piney Point aquifer initiated in 2013 to facilitate sound management of the Coastal Plain aquifer system was published in 2017. Improved information on the Piney Point aquifer is needed to effectively plan for a sustainable water supply. Wells in the Piney Point aquifer in rural areas widely yield from 10 to 50 GPM, whereas larger residential and municipal wells in developed urban and suburban areas yield as much as 400 GPM. Pump test, continuous core, borehole geophysical, and water levels data collected and compiled by DEQ and USGS staff for characterizing the Piney Point Aquifer were summarized in a USGS publication entitled, "*Hydrogeologic Framework and Hydrologic Conditions of the Piney Point Aquifer in Virginia*."

In May of 2016, cuttings were collected and described during the construction of the Hampton Roads Sanitation District's Sustainable Water Initiative for Tomorrow (SWIFT) pilot underground injection well. Because the Nansemond site is located within the outer rim of the Chesapeake Bay impact crater, collection and description of borehole cuttings were needed to evaluate the potential for hydrogeologic uncertainties or discontinuities that may be present as a result of crater structure. Cuttings and descriptions were used to help refine the hydrogeologic framework at this location and help guide construction and development of the injection well.

In the late Summer and early Fall of 2016, development of two new groundwater monitoring stations began in the southeast portion of the Coastal Plain. Placement of these nested wells will help provide groundwater level data needed to continuously refine the Coastal Plain groundwater model used to assist with the issuance of groundwater withdrawal permits. Specifically the groundwater monitoring station near Wakefield, Virginia will be used to monitor and further calibrate modeled groundwater levels near a critical model cell in the overall groundwater model; this model cell is currently showing rapidly declining groundwater levels that need to be corroborated with data from nearby groundwater level measurements from dedicated observation wells. A groundwater monitoring station in the Town of Smithfield, Virginia was initiated to monitor a known cone of depression in the Potomac Aquifer that increases the potential for local salt water intrusion associated with groundwater withdrawals occurring in the Town of Smithfield. In both cases, groundwater monitoring stations required extraction and description of continuous core, drilling of deep geophysical boreholes into the Potomac Aquifer to allow delineation of aquifers from resultant borehole geophysical logs, and subsequent construction of nested observation wells for monitoring groundwater levels in the stratified Coastal Plain aquifer system. The groundwater research station near Wakefield has been completed and construction of the wells at the Smithfield Groundwater Research Station is currently underway.

A monitoring well assessment and maintenance initiative has been started by the Groundwater Characterization Program to evaluate the integrity of existing groundwater research stations to insure that measured groundwater levels are representative of hydraulic conditions in the aquifer. 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 evaluation efforts. To date, groundwater level monitoring stations have been evaluated at Fentress, Newport News Park, and Western Branch Community Center.

Surface Water Investigations

DEQ's Surface Water Investigations Program (SWIP) and the USGS National Streamflow Information Program are the primary entities responsible for collecting hydrologic data in Virginia (Figure 6). 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.

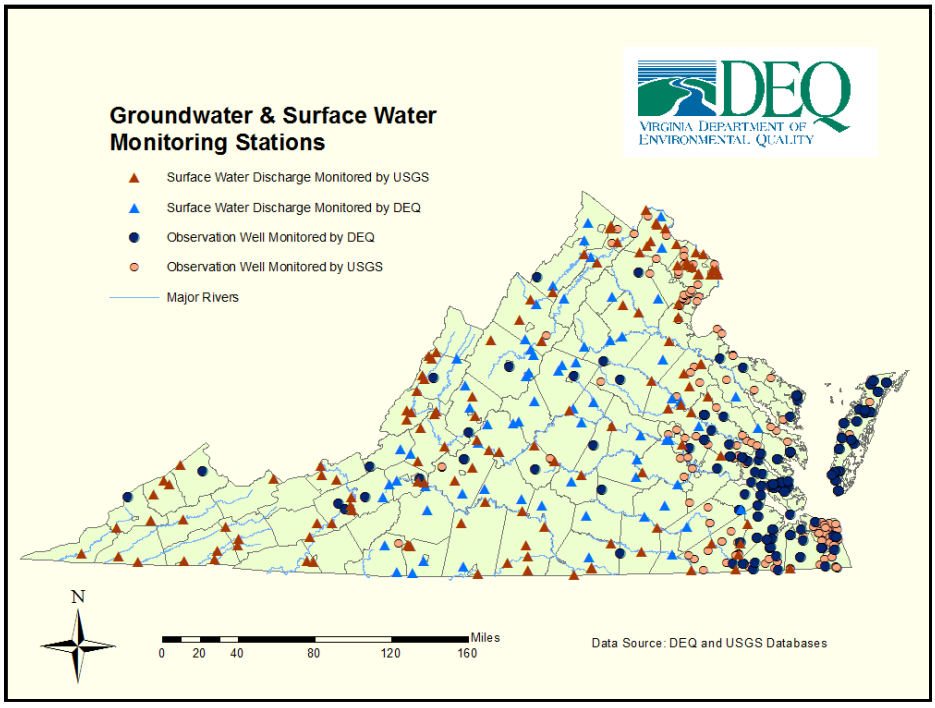


Figure 6: Location of groundwater and surface water monitoring stations. Monitoring at all of the USGS sites is performed by the USGS under contract for DEQ.

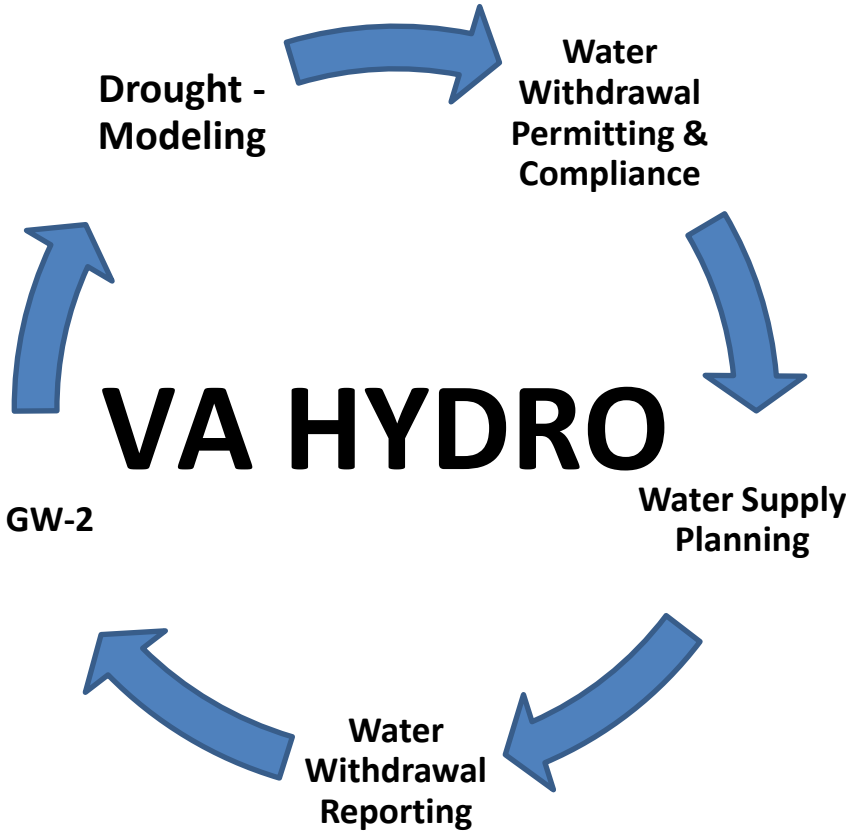
SWIP field personnel monitor and process data from a network of 68 surface water discharge monitoring stations on a six to eight week schedule, or more frequently in times of drought or flood. Monitoring often occurs in extreme conditions such as low and high water, and involves the servicing of sensitive equipment, maintaining permanent gauging stations, and measuring streamflow ("discharge"). The data collected 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.

In addition to managing the network of surface water discharge monitoring stations, SWIP field personnel perform site specific stream flow measurements to support DEQ TMDL development and permitting programs.

In 2016, over 600 discharge measurements were made by DEQ personnel for the USGS gauging station network. Stream depth, width, and velocity are measured in the waterway in the vicinity of the gauging station to determine discharge. These data are then input into the online USGS current conditions database for Virginia data related to streamflow for floods, droughts, permitting withdrawals and discharges, future water planning, and recreational usage. The USGS requires that these measurements be analyzed and processed within 48 hours of being read, which ensures the webpage is as up to date as soon possible for use by the Drought Monitoring Task Force (DMTF) and other entities dependent upon the accuracy of this resource for analysis.

Environmental Data and Analysis

DEQ continues to develop VA Hydro, an integrated water supply modeling and analysis tool designed to ultimately link modules pertaining to water withdrawal permitting, water supply planning, water withdrawal reporting, GW-2 well registration, and drought monitoring/modeling (of both surface water and groundwater).



Calendar year 2016 initiatives related to VA Hydro included the development of the Water Supply Planning module to be used as a pilot project for target localities to update their Water Supply Plans, the full integration of the legacy water withdrawal reporting database (VWUDS) into VA Hydro, the

completion of a Drought module, and continued analysis of the flow ecology metrics project in collaboration with Virginia Tech and USGS.

Through VA Hydro, DEQ continues to expand on the external reporting capabilities of stakeholders. Annual water withdrawal reporters utilized VA Hydro to submit their 2016 water withdrawals to DEQ. This transitioned the annual reporting process away from a standalone, legacy database and into the integrated program database. In total, 654 annual water withdrawal reporting users submitted their data through VA Hydro for the 2016 reporting period, covering 1,303 active facilities.

During 2016, DEQ and Virginia Department of Health (VDH) staff continued to work together on activities related to the private water well registration program. Well drillers are able to use VA Hydro in order to submit Water Well Completion Reports to both DEQ and VDH simultaneously. As of December 31, 2016, 2,538 water well completion records have been submitted online via VA Hydro.

Office of Water Supply modeling staff have continued working in cooperation with the Virginia Tech Department of Biological Systems Engineering and the USGS on a collaborative project to characterize the relationships between aquatic species metrics and streamflow. This project consists of foundational hydro-ecological analyses and the development of modeling approaches for describing the potential effects of flow reductions from consumptive water withdrawals on fish and benthic macroinvertebrate communities. Professional peer reviewed papers outlining the modeling methodology, initial findings, and potential management implications are currently under development.

Drought Assessment and Response

Planning for conservation during water shortages allows all users to share the responsibility for the resource. Drought monitoring, assessment, and response protocols in the Commonwealth of Virginia follow the procedures described by the Virginia Drought Assessment and Response Plan.[15] DEQ coordinates drought monitoring activities through the Drought Monitoring Task Force (DMTF), as required by the Drought Assessment and Response Plan (2003).

The DMTF is an interagency group of technical representatives from state and federal agencies[16] responsible for monitoring natural resource conditions and the effects of drought on various segments of society. The DMTF meets regularly to assess hydrologic conditions and make recommendations to the Commonwealth Drought Coordinator regarding drought status. After each meeting, the DMTF releases Drought Status Reports summarizing drought conditions in the Commonwealth. DEQ also maintains an online drought webpage that displays the status of a series of drought indicators across 13 Drought Evaluation Regions (Figure 7). The status of three of the four indicator types (precipitation deficit, streamflows, and groundwater levels) is updated daily. The fourth indicator, reservoir storage, is updated monthly, or more frequently depending upon drought conditions.

[15] Virginia Drought Response Technical Advisory Committee, 2003, *Virginia Drought Assessment and Response Plan*, 22 p.
[16] State agencies with active representation on the DMTF include the departments of Game and Inland Fisheries, Agriculture and Consumer Services, Emergency Management, Forestry, and Health. Federal agencies include the National Weather Service, USACE, Department of Agriculture, and the USGS.

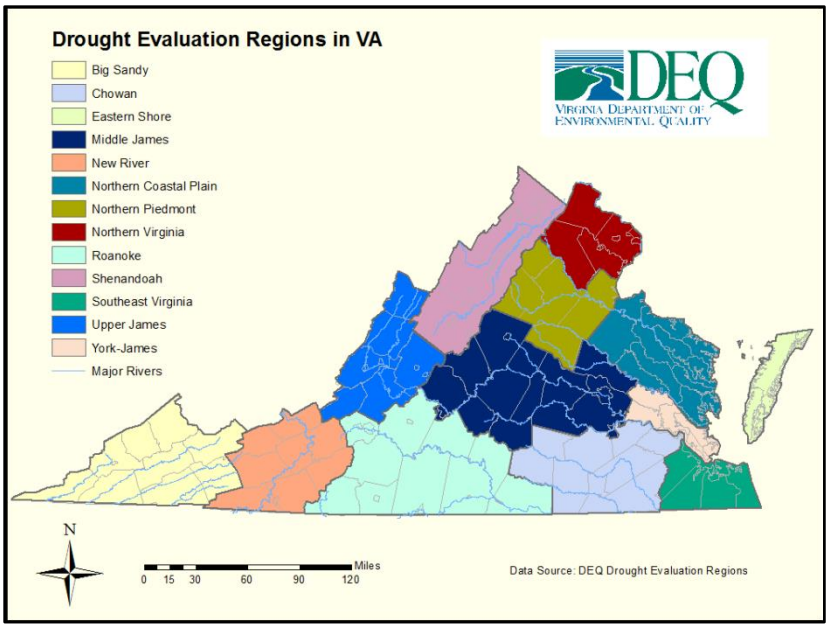


Figure 7: Drought Evaluation Regions

The Virginia Drought Coordinator issues drought stage declarations for one or more drought evaluation regions based upon the recommendations of the DMTF. Stage declarations range from Watch to Warning to Emergency depending upon the severity of drought conditions. Declarations of drought watch and warning stages are announced by DEQ via press releases, email blasts and/or direct phone calls to local governments and planning district commissions, and notifications on the DEQ webpage. These stages are meant to raise local and regional awareness of drought conditions and focus on voluntary water use restrictions. A drought emergency, when called for, involves mandatory water use restrictions and is declared by the Governor via executive order.

Since the adoption of the Drought Assessment and Response Plan in 2003, watch declarations have been issued for various regions nearly every year but warning declarations have occurred less frequently. A Drought Emergency declaration has not occurred since the 2002 drought. The most recent drought watch declaration was issued for the Northern Virginia and Northern Piedmont drought evaluation regions on March 22, 2017. Most of northern and central Virginia experienced a drier than normal 2016-2017 winter season. Below normal winter precipitation results in less groundwater recharge, and because groundwater provides baseflow to streams during the normally dry late summer and early fall months when flow in streams is naturally low, less than normal groundwater levels can impact surface water availability during July, August or September. The watch declaration for the Northern Virginia region was lifted on June 21, 2017 due to above normal rainfall and subsequent increases in regional groundwater levels. To date, the watch declaration for the Northern Piedmont region is still in effect.

III. SUMMARY OF 2016 WATER WITHDRAWALS

A total of 654 VA Hydro users reported their annual water withdrawals to DEQ covering 1,303 active facilities during calendar year 2016. Reported withdrawals were approximately 6.6 billion GPD for all groundwater and surface water use categories, including cooling water at nuclear and fossil fuel power generation facilities. Excluding power generation, reported 2016 withdrawals totaled over 1.2 billion GPD.[17] Compared to 2015, total reported withdrawals from all water use categories increased by 1% when excluding power generation withdrawals.

[17] 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 use is essentially non-consumptive use. These flows are exempted from the reporting requirement and are generally not reported to VA Hydro. A significant portion of

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[18] 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/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 2016 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 2016 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.

Water Withdrawals by Source Type

Water withdrawals for non-power generation uses totaled approximately 1,242 MGD and predominantly occurred from surface water sources (streams, reservoirs, and springs). The total reported 2016 non-power generation withdrawal s was about 1% higher than the 2015 total of 1,230 MGD. Pumping of groundwater wells totaled 139 MGD. Surface water withdrawals accounted for 89% of total withdrawals in 2016 at 1,104 MGD when excluding power generation. Groundwater increased 5 MGD and surface water increased 8 MGD from 2015 totals.

Water Withdrawals by Location

Analysis of the spatial distribution of 2016 water withdrawals in Virginia indicates that as in previous years, the largest groundwater withdrawals predominantly occurred in the Coastal Plain, Eastern Shore, and Shenandoah Valley regions (Figure 8). The largest volumes of groundwater were produced from karstic limestone formations in the Shenandoah Valley, within the Valley and Ridge physiographic province, and from aquifers within the Coastal Plain province. Shallow aquifers on the Eastern Shore (part of the Coastal Plain aquifer system) also produce significant quantities of groundwater. Reported use by permitted groundwater withdrawals from locations within GWMAs totaled about 60.2 MGD for 2016, or 44% of all groundwater withdrawals in the Commonwealth. Permitted groundwater withdrawals within GWMAs represented 47% of all groundwater withdrawals in 2015. Manufacturing

---

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.

[18] § 62.1-104, *Code of Virginia*.

and public water supply withdrawals comprise about 85% of all actual groundwater withdrawals in Virginia

Surface water withdrawals were distributed widely across the state and were greatest around cities and counties serving as significant population centers (Figure 9). Irrigation and agriculture account for the most significant withdrawals in rural counties. Surface water withdrawals are concentrated within the James, Potomac-Shenandoah, and New River basins, comprising approximately 75% of the statewide total surface water withdrawal. Public Water Supply use represents 65% of total surface water withdrawals in the Commonwealth, which is a 4% decrease in Public Water Supply use from 2015.

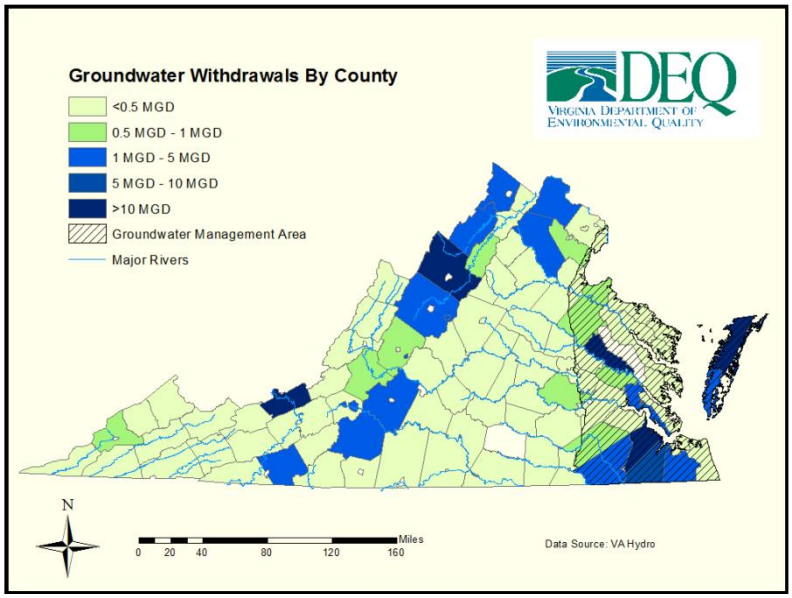


Figure 8: Groundwater withdrawals within County

The variable spatial distributions of groundwater and surface water withdrawals suggest that withdrawals also vary considerably between Virginia's major surface water basins (Figure 10) and physiographic provinces (Figure 11). Reported water withdrawals by county are included in Appendix 5.

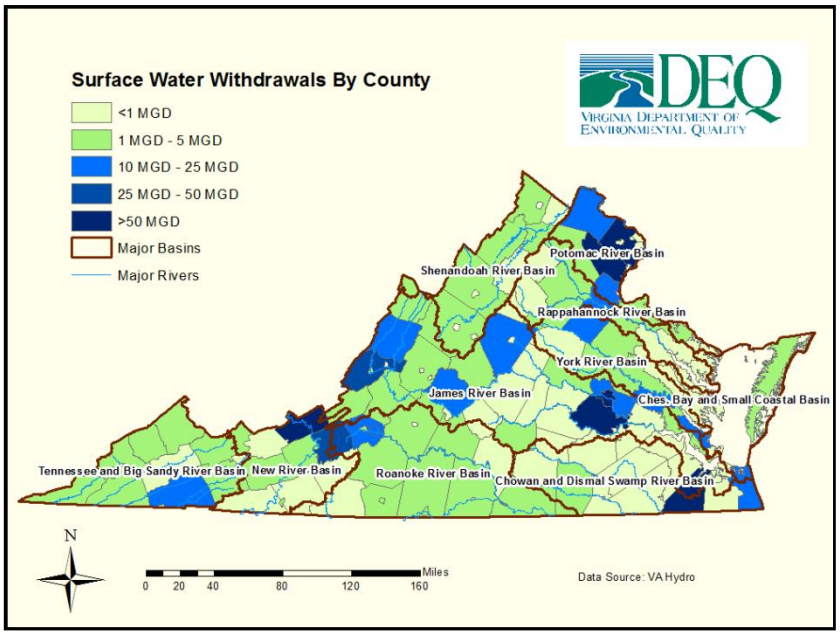


Figure 9: Surface water withdrawals within County

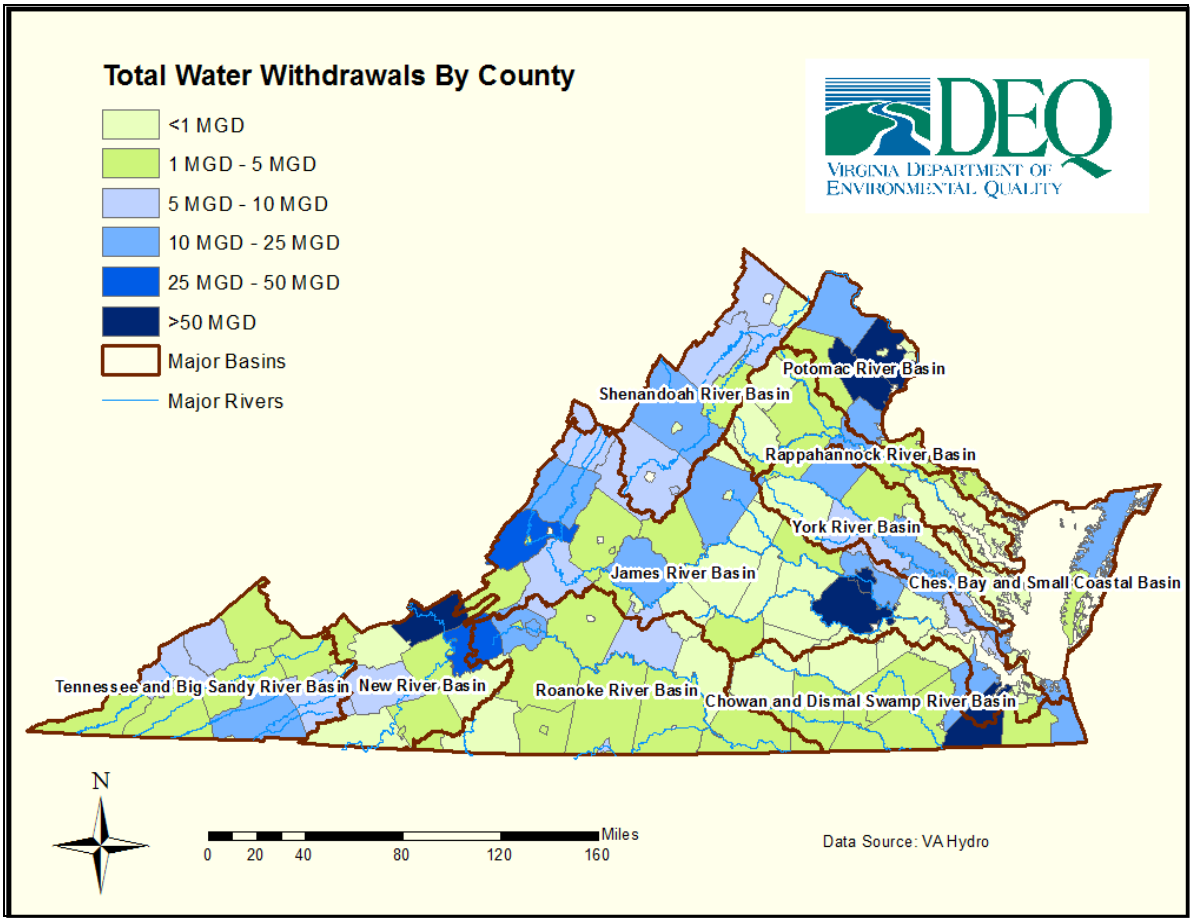


Figure 10: Total (groundwater plus surface water) withdrawals within County and river basin

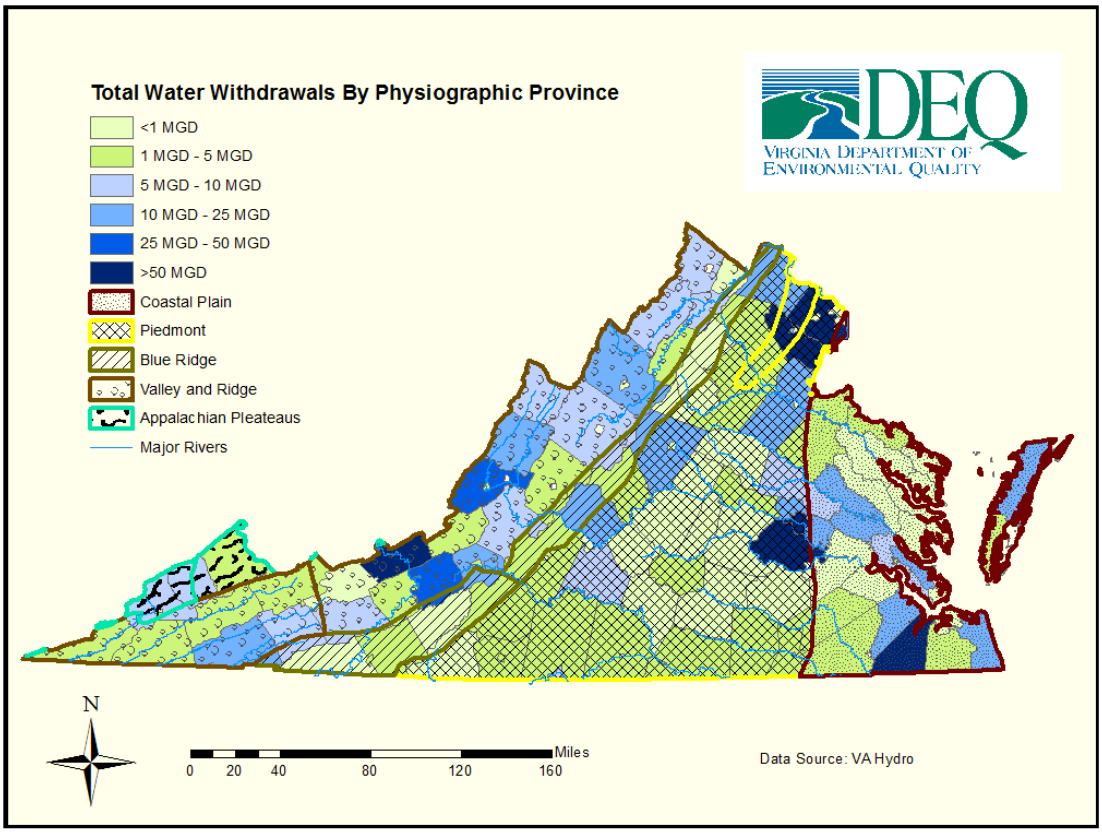


Figure 11: Total (groundwater plus surface water) withdrawals within County and physiographic province

Water Withdrawals by Water Use Category

Water withdrawals reported to VA Hydro are categorized by how, or for what purpose, the water withdrawal is used: Agriculture, Commercial, Fossil Power, Hydropower, Irrigation, Manufacturing, Mining, Nuclear Power, Public Water Supply, and Other uses. The "Agriculture" category includes water withdrawn for raising livestock, and for fish farming and hatcheries. The "Commercial" category includes water used by golf courses, local and federal institutions, hotels, resorts, and correctional centers, among others. The "Irrigation" category includes water used to promote crop growth, including but not limited to tobacco, corn, soybeans, turf grass, and ornamental nursery products. The "Other" category contains a small number of facilities for which the water use does not fit into one of the previously mentioned categories, such as short term infrastructure development.

Water withdrawals can fluctuate from year to year due to weather variability and economic or other factors; therefore, average water withdrawals from 2012-2016 are provided by source type for each category for comparison, excluding Power Generation (Nuclear Power and Fossil Fuel Power) (Figures 12 and 13). Average water withdrawals during this five-year period were calculated using the same source type categories (surface water and groundwater) as the 2016 withdrawal totals. This allows for direct comparisons to be made between 2016 withdrawal totals and the 2012-2016 averages. Little difference is apparent between the pairs of charts comparing groundwater, surface water, and total withdrawals between 2016 and the 2012-2016 periods.

Withdrawals for Public Water Supply and for Manufacturing were again the largest for 2016 and for the average of the previous five-year period. Manufacturing makes up the highest proportion of groundwater withdrawals whereas Public Water Supply use accounts for the greatest surface water withdrawals. Pumping for Agriculture, Irrigation, Mining, and Commercial uses made up lesser, but still significant, portions of the totals. Agriculture use tends to be largely driven by surface water withdrawals (98%) while irrigation and commercial use is more evenly distributed between surface water and groundwater.

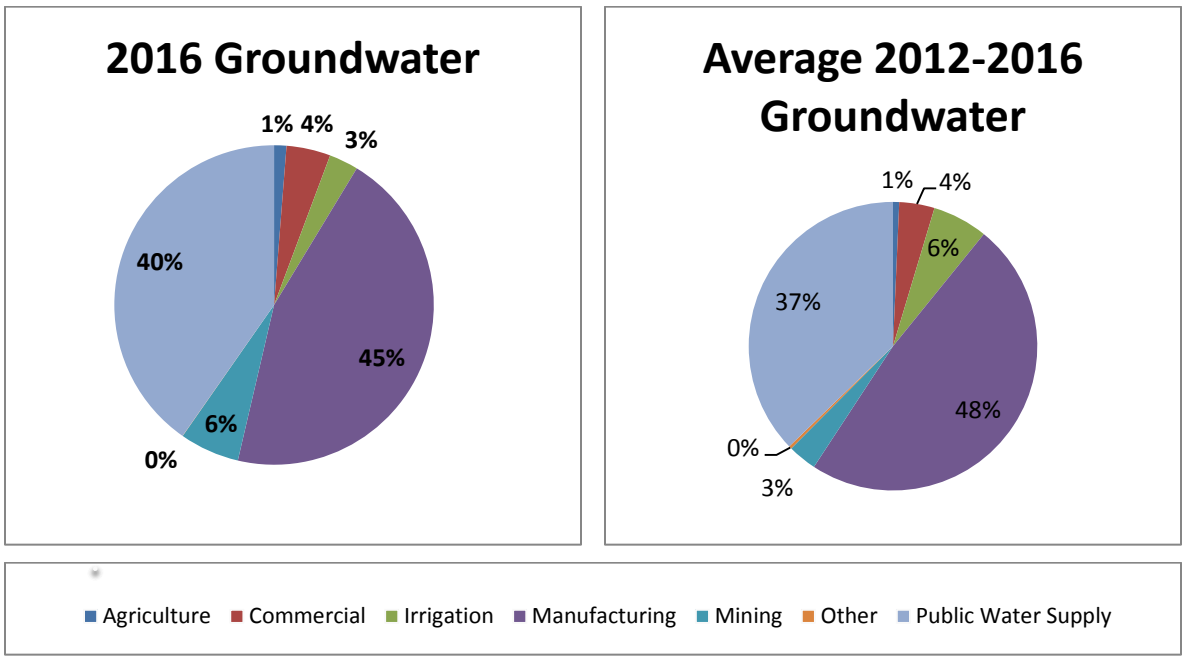


Figure 12: Groundwater withdrawals by use category for 2016 and the 2012-2016 average

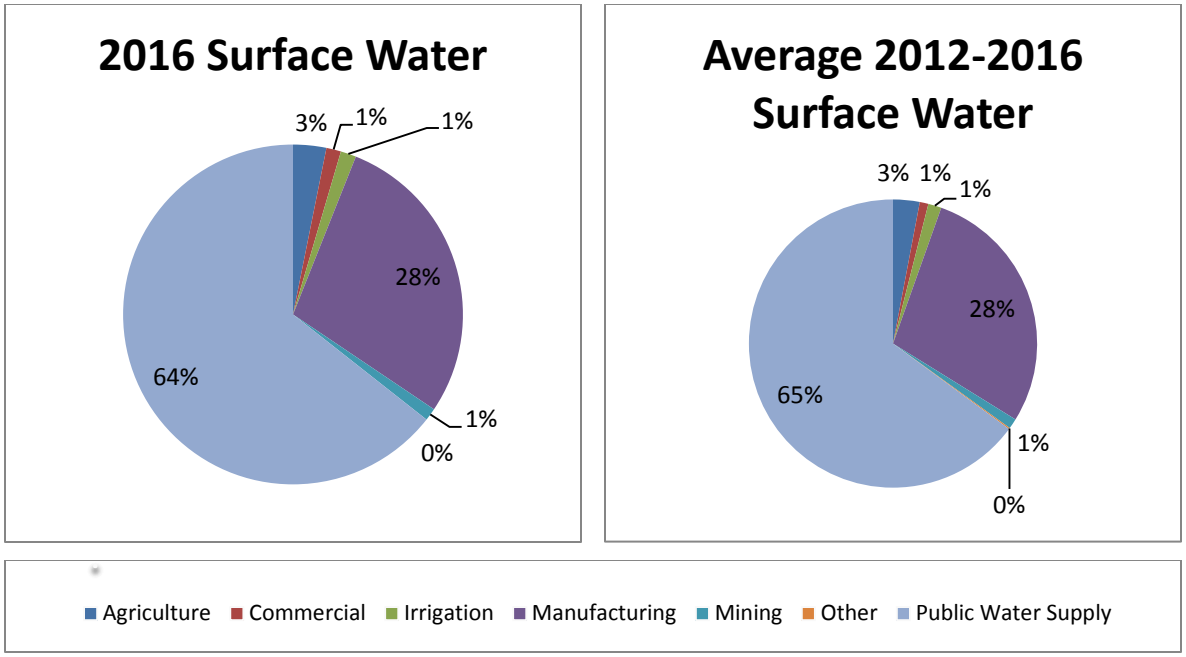


Figure 13: Surface water withdrawals by use category for 2016 and the 2012-2016 average

Similarly to 2015, the proportions of 2016 water use totals by category are comparable with the reported 2010 water use by category contained in the State Water Resources Plan (Figures 14 and 15). The Community Water Systems (CWS) category in the State Water Resources Plan can be compared to the Public Water Supply category in the Annual Report. Likewise, Agricultural use totals in the Plan are comparable to the sum of withdrawals from the VA Hydro Agriculture plus Irrigation categories, and the total use from the Large Self-Supplied User category in the Plan is comparable to the sum of the withdrawals from the remaining VA Hydro categories.

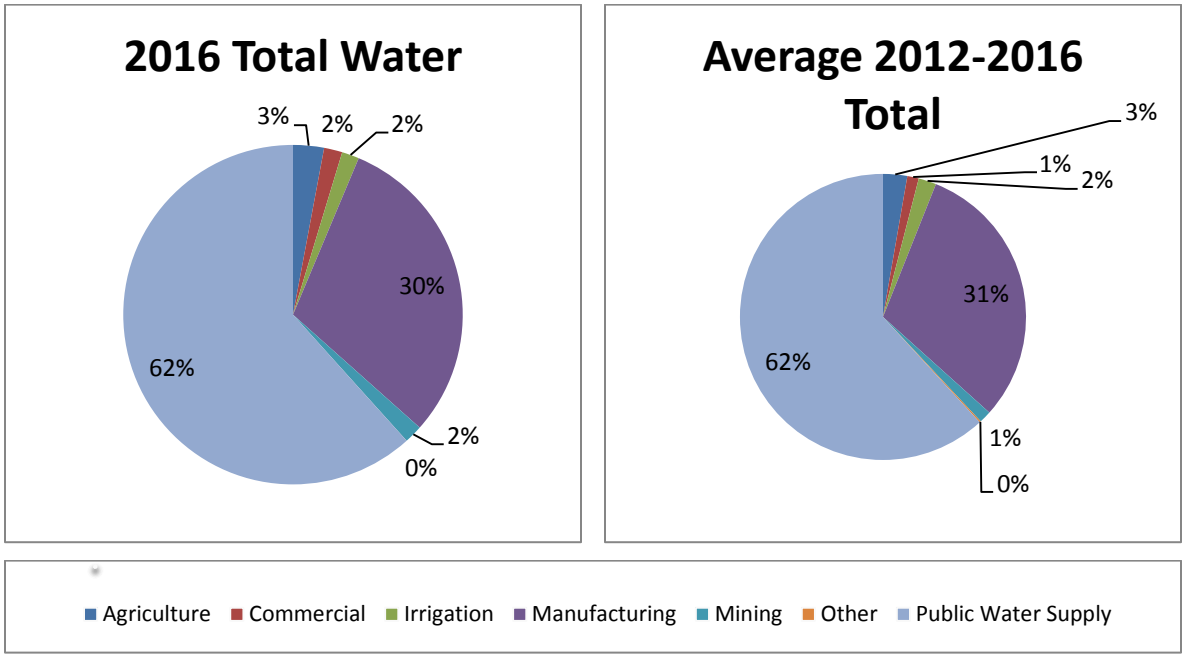


Figure 14: Total water withdrawals by use category for 2016 and the 2012-2016 average

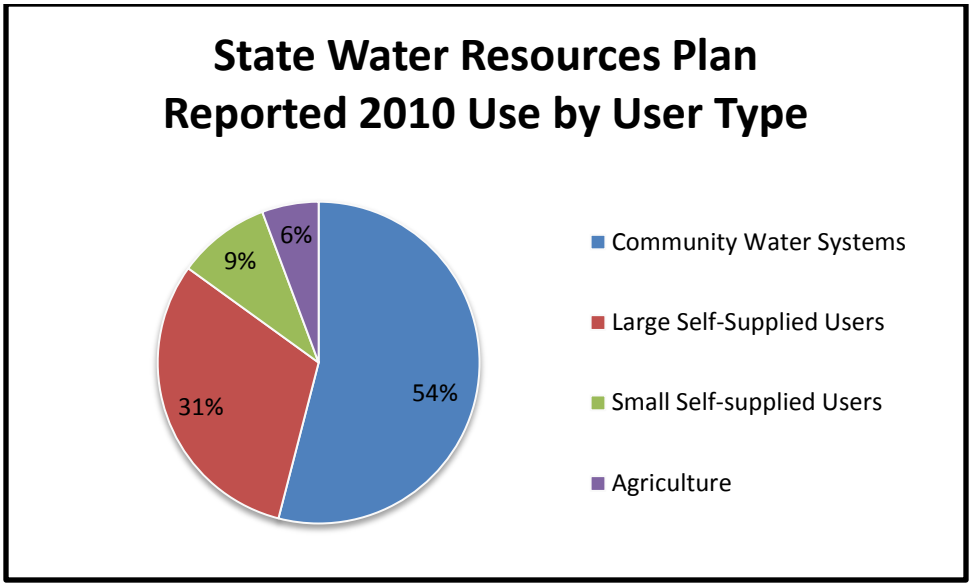


Figure 15: 2010 Water Use by Type as Reported in the State Water Resources Plan

The percentages of 2010 statewide water use by Plan user category are similar to the withdrawal percentages by category obtained from the VA Hydro database.[19] The main difference between the two compilations is the Small Self-Supplied User category identified in the Plan. This category includes small users who would generally fall beneath the reporting threshold for annual water withdrawal reporting (300,000 gallons/month) and are not captured in VA Hydro. As a result, Public Water Supply is a larger percentage of the total withdrawals (Figure 14) than that represented by the Community Water System category (Figure 15).

Appendix 4 provides additional information on each water use category. These fact sheets contain tables and graphs comparing 2016 withdrawals with the five-year average and annual withdrawal trends (2012-2016) for each use category. The top water users within each category are identified as well. In order to demonstrate the spatial distribution and magnitude of withdrawals, maps are included in the use category fact sheets.

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.

[19] Adapted from Figure 4-7 of the *State Water Resources Plan*, 2015.

Weather patterns and seasonal variations can also affect domestic consumptive use. In 1995, estimates of domestic consumptive use made by the USGS for Virginia were approximately ten percent of annual withdrawal volumes.[20] Without specific information about the types and distribution of end users, estimates of consumptive use from public water supply withdrawals can be very 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.[21] 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. Hydro power plants are also exempt from reporting due to their low consumptive use (see Power Generation Water Withdrawal fact sheet, Appendix 4).

IV. WATER WITHDRAWAL TRENDS: 2012-2016

Total withdrawals reported to VA Hydro have been fairly stable since 2012 (Table 1). Total 2016 reported non-power generation withdrawals were approximately 12 MGD greater than those reported for 2015 and about 1% higher than the five-year average between 2012-2016. Because withdrawals remained relatively consistent from the five-year average and 2015 totals, there were not major differences in 2016 withdrawals. The highest relative change in reported withdrawal rate comes from the commercial sector. Manufacturing experienced the largest increase in withdrawals, approximately 12 MGD from 2015 to 2016. Commercial withdrawals continued to increase in 2016, which is partially a result of increased reporting from an outreach effort by DEQ to reach golf courses and other commercial water users that did not previously report water withdrawals to VA Hydro.

Surface water withdrawals for agricultural purposes have increased slightly each year since 2012. These steady increases are due, in part, to increases at the Commonwealth of Virginia Coursey Spring Fish Hatchery in Bath County, where withdrawals increased from an annual average of 6.2 MGD in 2010 to 12.24 MGD in 2016. Withdrawals for irrigation from both surface and groundwater sources have fluctuated significantly from year to year, since 2011. For example, surface water irrigation withdrawals dropped by nearly 40% (18.2 MGD to 11.0 MGD) between 2012 and 2013, and then increased by nearly 90%, to 20.8 MGD, in 2014. Irrigation surface water and groundwater withdrawals were 30 MGD in 2014 but have decreased to 20.3 MGD in 2016. The reasons for these fluctuations may include annual weather variations, different water needs from crop rotations, and uneven reporting of withdrawals by irrigation facilities from year to year. Mining withdrawals tend to undergo similar variations between each year. Groundwater withdrawals for mining almost doubled from 2015 due to a quarry dewatering well being used by the largest mining category water user. Additional detail concerning water withdrawal trends by water use category can be found in Appendix 4.

[20] Solley, Wayne B., 1998, *Estimated use of water in the United States in 1995*: U.S. Geological Survey Circular 1200, 71 p.
[21] 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., http://dx.doi.org/10.3133/sir20135188.

	Category	2012 MGD	2013 MGD	2014 MGD	2015 MGD	2016 MGD	Avg. 2012-2016 MGD	2016 Diff. from Average MGD	2016 % Diff. from Average
Groundwater	Agriculture	0.6	0.6	0.5	1.2	1.7	0.9	0.8	84%
	Commercial	4.8	5.0	5.2	5.7	6.2	5.4	0.8	15%
	Irrigation	11.9	8.4	9.2	8.5	4.1	8.4	-4.3	-51%
	Manufacturing	63.4	67.5	66.6	68.7	62.3	65.7	-3.4	-5%
	Mining	2.3	3.4	3.1	4.8	8.4	4.4	4.0	91%
	Other	0.7	0.7	0.7	0.1	0.0	0.4	-0.4	-93%
	Power	0.5	0.3	0.7	0.06	0.45	0.4	0.0	12%
	Public Water Supply	52.7	50.0	49.1	45.1	55.8	50.5	5.3	10%
	Total (GW)	**136.8**	**135.8**	**135.1**	**134.1**	**139.0**	**136.2**	**2.8**	**2%**
Surface Water	Agriculture	29.9	31.9	32.0	33.8	34.5	32.4	2.1	7%
	Commercial	6.8	7.1	10.2	13.2	15.3	10.5	4.8	45%
	Irrigation	18.2	11.0	20.8	14.6	16.2	16.2	0.0	0%
	Manufacturing	322.7	311.7	305.8	291.8	310.6	308.5	2.1	1%
	Mining	12.0	12.7	11.1	12.9	13.0	12.3	0.7	5%
	Other	2.2	2.2	2.2	1.1	0.0	1.5	-1.5	-100%
	Power	5872	5844	5764	5328	5370.11	5635.6	-265.5	-5%
	Public Water Supply	699.8	690.3	702.6	728.6	714.1	707.1	7.0	1%
	Total (SW)	**6964**	**6911**	**6849**	**6424**	**6474**	**6724.2**	**-250.3**	**-4%**
Total (GW + SW)	Agriculture	30.5	32.5	32.5	35.0	36.3	33.4	2.9	9%
	Commercial	11.6	12.1	15.4	18.9	21.4	15.9	5.6	35%
	Irrigation	30.2	19.3	30.0	23.1	20.3	24.6	-4.3	-17%
	Manufacturing	386.1	379.2	372.4	360.6	372.9	374.2	-1.3	0%
	Mining	14.3	16.1	14.2	17.6	21.4	16.7	4.7	28%
	Other	2.8	2.9	2.9	1.2	0.0	1.9	-1.9	-98%
	Power	5873	5844	5765	5328	5371	5636.0	-265.5	-5%
	Public Water Supply	752.4	740.3	751.7	773.7	769.9	757.6	12.3	2%
	Total (GW + SW)	**7100**	**7047**	**6984**	**6558**	**6613**	**6860.3**	**-247.5**	**-4%**

Table 1: Summary of Virginia water withdrawals by use category and source type, 2012-2016

2016 Permitted and Unpermitted (Excluded) Withdrawals

The following tables demonstrate the difference between 2016 reported permitted withdrawals and 2016 reported unpermitted (i.e. excluded from permitting requirements) withdrawals. Table 2 displays the aggregrate reported total withdrawals by water source type. Unpermitted withdrawals represent all withdrawals reported to VA Hydro that are not regulated by the VWP or GWP permitting programs. In general, unpermitted withdrawals are higher than permitted withdrawals in Virginia. 75% of reported

water withdrawals are unpermitted, which is largely driven by unpermitted surface water withdrawals. The percentage trends of 2016 unpermitted and permitted water withdrawals remain consistent with the values from the 2015 Annual Water Resources Report. Table 3 disaggregates the permitted and unpermitted reported water withdrawals by use category.

Unreported unpermitted withdrawals are also of interest to DEQ. This type of withdrawal represents water users that do not exceed an average daily withdrawal of 10,000 gallons per day in any single month, and therefore, do not have to report to DEQ. However, trends in water well completion reports received by DEQ and VDH point to an increase in private well construction. Though water use data is not associated with the water well completion reports, the increase in private wells likely results in increases to overall water use. The importance of understanding unreported unpermitted withdrawals is essential to ensure that water resource management gains from permitting and permit reductions are not lost due to those unpermitted withdrawals.

		2016 MGD	% of Total 2016 MGD
Groundwater			
	Permitted Withdrawals (In GWMA)	60.2	44%
	Unpermitted Withdrawals	77.66	56%
Surface Water			
	Permitted Withdrawals	248.9	23%
	Unpermitted Withdrawals	854.7	77%
Total Withdrawals			
	Permitted Withdrawals	309.2	25%
	Unpermitted Withdrawals	932.4	75%

Table 2: Summary of Virginia permitted and unpermitted withdrawals reported as of August 2017 by source type in 2016 (excluding the Other category)

Groundwater		**2016 MGD**	**% of Total 2016 MGD**
Agriculture	Permitted Withdrawals	1.6	1.2%
Agriculture	Unpermitted Withdrawals	0.016	0.0%
Commercial	Permitted Withdrawals	3.2	2.3%
Commercial	Unpermitted Withdrawals	3	2.2%
Irrigation	Permitted Withdrawals	0	0.0%
Irrigation	Unpermitted Withdrawals	4	2.9%
Manufacturing	Permitted Withdrawals	28.3	20.4%
Manufacturing	Unpermitted Withdrawals	27.7	20.0%
Mining	Permitted Withdrawals	0	0.0%
Mining	Unpermitted Withdrawals	8.4	6.1%
Public Water Supply	Permitted Withdrawals	20.3	14.7%
Public Water Supply	Unpermitted Withdrawals	35.4	25.6%
Surface Water		**2016 MGD**	**% of Total 2016 MGD**

Agriculture	Permitted Withdrawals	0	0.0%
Agriculture	Unpermitted Withdrawals	33.21	3.0%
Commercial	Permitted Withdrawals	2.5	0.2%
Commercial	Unpermitted Withdrawals	12.3	1.1%
Irrigation	Permitted Withdrawals	0.3	0.0%
Irrigation	Unpermitted Withdrawals	15.8	1.4%
Manufacturing	Permitted Withdrawals	0	0.0%
Manufacturing	Unpermitted Withdrawals	310.6	28.4%
Mining	Permitted Withdrawals	0.02	0.0%
Mining	Unpermitted Withdrawals	13	1.2%
Public Water Supply	Permitted Withdrawals	246.1	22.5%
Public Water Supply	Unpermitted Withdrawals	468.2	41.9%

Table 3: Summary of Virginia permitted and unpermitted withdrawals reported as of August 2017 by use and source type in 2016 (excluding the Other category)

V. FUTURE CHALLENGES AND PRIORTIES

Effect of Current Withdrawals on Future Water Supply

- While the Virginia Coastal Plain Groundwater Initiative has been successful in reducing permitted withdrawals from the Potomac Aquifer by about 50%, additional work needs to be done to ensure the availability of the Coastal Plain aquifer system as a reliable water source for the future. DEQ is continuing to work with permitted 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.

- VWP permitted withdrawals in 2016 amounted to approximately 249 MGD and known excluded (unpermitted) surface water withdrawals amounted to approximately 845 MGD. However, not all surface water withdrawals are currently reported to VA Hydro, due in part to exclusions from the reporting requirements. A comparison of reported withdrawals with water use estimates from the water supply plans indicates that water withdrawals from several categories may be under-reported. Lack of information regarding water withdrawal rates causes additional uncertainty when making estimates of available water supply during drought events or in surface water basins where water withdrawal activities are concentrated.

- Analysis of local data conducted during development of the State Water Resources Plan predicted a net increase of approximately 32% in mean daily water demand over the planning period, indicating that an estimated 450 MGD of additional water will be needed to meet projected 2040 demands. Seventy-seven percent of the projected 2040 average daily demand is expected to be met by surface water resources, with the remaining 23% of total 2040 demand anticipated to come from groundwater resources. Cumulative impact analyses have indicated that these projected surface water withdrawal increases may result in potential negative impacts during future drought situations, particularly within the James, Potomac-Shenandoah, and York River basins.[22]

- Nearly 97% of the total projected 2040 surface water demand is proposed to come from approximately 25% of the stream reaches evaluated. With 16% of streams predicted to see a greater

[22] *State Water Resources Plan*, Figure 4-11 and Table 5-10.

than five percent reduction in Drought of Record streamflows due to projected increases in upstream benefical uses, there is a high probability that new management approaches and/or infrastructure will be required to maintain safe yields (the maximum amount of water available during a drought of record) at current levels. Systems that already have new storage, or are planning to build new storage in the short term, will probably have adequate reserves to meet the predicted reduced drought in-stream flows. However, systems without storage, or with demands that are nearing existing safe yield, will face challenges as the cumulative demands on streams increases. In addition, with the majority of Virginia's future demand concentrated on so few surface water resources, the availability of accurate data will become essential to ensure accurate modeling.[23]

Long-term Priorities Identified in the State Water Resources Plan

The State Water Resources Plan identified 12 challenges for future water resources management and provided recommendations for action. A number of the 2016 activities described in Chapter II above were focused on gathering, storing, and analyzing data in order to improve water resource management for the Commonwealth. Progress in addressing the challenges and implementing the recommendations includes the following:

- Collaborated with VDH to estimate the number of unpermitted private wells in the Eastern Virginia GWMA. VDH reported that approximately 275,000 to 300,000 homes are served by private wells in the Eastern Virginia GWMA. It was also estimated that approximately 1,500 new private wells are permitted annually 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.

- Contacted all golf courses within the Commonwealth (325) with regards to annual water withdrawal reporting requirements. This effort resulted in an additional 125 golf courses registerd to report withdrawals annually.

- Deployed a pilot project for localities to use VA Hydro as a water supply planning tool and to satisfy reporting requirements. This included a hands-on training session for pilot users (Augusta County Service Authority, Caroline County, Hampton Roads Planning District Commission, and Rockingham County);

- Successfully obtained USGS grant funding to improve consumptive use data anaylsis, transfer, and export. DEQ has partnered with USGS and Virginia Tech to perform consumptive use trend analysis and predicitive model development;

- Continued collaboration with USGS and Virginia Tech to evaluate streamflow metrics to improve cumulative impact analyses for surface water withdrawals;

- Continued collection of groundwater samples in order to monitor for salt water "upconing," the upwelling of salty groundwater that can occur in response to the local removal of non-saline groundwater by water wells in the Coastal Plain aquifer system;

- Presented to 13 planning district commissions and their associated member localities, 33 planning regions, the Virginia Local Government Managers Association, and the Natural Bridge Soil and Water Conservation District. As a result of these meetings, seven localities are in full compliance with their

[23] Ibid., Chapter 5.

water supply planning conditions and nine localities are in the process of finalzing full compliance with their conditions; and

- Participated in the Eastern Virginia Groundwater Management Advisory Committee and associated subcommittees. This Committee was formed to assist the State Water Commission and DEQ in developing, revising, and implementing a management strategy for groundwater in the Eastern Virginia GWMA.

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:

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

- 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 to support surface water flow and groundwater level data collection and analysis is essential to accurately quantify and manage the Commonwealth's water resources. Such surface and groundwater data are an integral part of many DEQ programs including numerous permitting programs, establishment of Total Maximum Daily Loads (TMDL), water supply planning, and overall water resource characterization; therefore, continued local, state, and federal investment in these stations is critical.

- Maintenance and rehabilitation of wells in the statewide groundwater level monitoring network will be a priority for the near future. There are approximately 300 wells in the network managed by both DEQ and USGS. Aging well infrastructure associated with many of the wells in the network will require a case-by-case evaluation of well integrity and subsequent well rehabilitation (if needed) in order to insure that hydrostatic pressures in the aquifer continue to be accurately represented by the water level in the observation well.

- As part of the effort to monitor chloride concentrations in the Coastal Plain aquifer system, 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 (USGS Scientific Investigations Report 2015-5117). Securing additional funding for the installation of new chloride monitoring wells will be a major factor in starting this monitoring program.

- In order to maintain Virginia's cooperative agreement between DEQ and the USGS for the collection of real-time streamflow data, DEQ staff must continue to receive state of the art training provided by USGS and the necessary equipment to maintain the existing gauging station network. Continued

training for use of USGS' recently-implemented sophisticated data management system remains an emphasis for SWIP staff.

- Improvements are needed in the way the transfer of water is tracked, both within systems and between entities. This information is important to understanding the extent of water loss due to inter or intra-basin transfers or other factors and can have a significant impact on water resource planning.

- As part of the effort to monitor land subsidence in the Coastal Plain, 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. Securing additional funding for the installation, operation, and maintenance of new or existing extensomenters will be a major factor in the success of monitoring land subsidence.

- 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 also estimated that by 2016 unregulated use increased to 39 MGD since the publication of the report. Securing additional funding to update the unregulated use methodology will be a significant factor in the success of ongoing groundwater modeling efforts.

APPENDIX 1: WATER RESOURCES INFORMATION AND CLIMATIC CONDITIONS

State Population (2010 census) – 8,001,025
(2014 U.S. Census Bureau estimate) – 8.3 million

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

Major River Basins (with Current Estimates of Annual Mean River Flow):

Tennessee-Big Sandy (4,132 sq. miles, 2,986 MGD)

Albemarle Sound-Chowan River (4,220 sq. miles, 1,724 MGD)

James (10,265 square miles, 5,437 MGD)

New (3,068 square miles, 3,229 MGD)

Rappahannock (2,712 square miles, 1,085 MGD)

Roanoke (6,393 square miles, 4,955 MGD)

Potomac-Shenandoah (5,681 sq. miles, 1,842 MGD)

Chesapeake Bay-Small Coastal (3,592 sq. miles, 97 MGD)

York (2,674 square miles, 1,053 MGD)

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

Publicly-Owned Lakes and Reservoirs

There are 248 publicly-owned lakes in the Commonwealth:

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

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

Freshwater Wetlands - 808,000 acres

Tidal and Coastal Wetlands - 236,900 acres

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

Atlantic Ocean Coastline - 120 Miles

Statewide Average Annual Rainfall – 42.9 inches

Average Freshwater Discharge of All Rivers - Approximately 22.5 billion gallons per day

Average Freshwater Discharge into the Chesapeake Bay – Approximately 9.5 billion gallons per day

Climatic Conditions: As of August 10, 2017, the 2017 water year (October 1, 2016 through September 30, 2017) precipitation totals and drought indicators varied across Virginia, depending upon location. Precipitation totals throughout the Commonwealth were below normal throughout the first six months of the water year, followed by wetter than normal conditions during the spring in most areas. Normal to dry conditions returned during late June and early July. The driest areas were within central Virginia, where a Drought Watch declaration was issued for the Northern Piedmont drought evaluation region in March, 2017. Portions of the middle and lower James River basin and the Chowan and York River basins were abnormally dry. Stream flows and groundwater levels in Climate Response Network observation wells were below normal in central Virginia and parts of eastern Virginia, but within normal levels elsewhere. Water supply storage reservoirs throughout the Commonwealth maintained water levels within or above normal ranges throughout the water year.

APPENDIX 2: WATER TRANSFERS IN THE VA HYDRO DATABASE

Water use is tracked in the VWUDS database 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 the VA Hydro database 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 the VA Hydro database as "releases" to outside customers and "deliveries" of water from another outside customer.

Currently, not all water transfers are consistently reported to the VA Hydro database, 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 WATER WITHDRAWAL SYSTEMS IN 2016 (excluding power generation)

Facility	City/County	Type	Major Source	Avg. MGD	2016 MGD	Category
Honeywell International: Hopewell Plant	Hopewell	SW	James River	105.78	96.21	Manufacturing
Fairfax Water Authority: Potomac River WTP	Fairfax	SW	Potomac River	90.68	94.56	Municipal
Norfolk: Western Branch Reservoir	Suffolk	SW	Western Branch Reservoir	60.56	68.39	Municipal
Fairfax Water Authority: Occoquan Reservoir	Prince William	SW	Occoquan Reservoir	63.48	68.14	Municipal
City of Richmond: Richmond WTP	Richmond, City	SW	James River	62.90	66.28	Municipal
Celanese Acetate LLC: Celco Plant	Giles	SW	New River	52.77	56.51	Manufacturing
WestRock Virginia: Covington Plant	Alleghany	SW	Jackson River	38.64	38.44	Manufacturing
DuPont E I De Nemours: Spruance Plant	Chesterfield	SW	James River	29.64	34.63	Manufacturing
Portsmouth: Lake Kilby WTP	Suffolk	SW/ GW	Lake Kilby, Meade & 6 wells	24.71	33.5	Municipal
Appomattox River Water Authority: Chesdin Reservoir WTP	Chesterfield	SW	Chesdin Reservoir	31.54	31.26	Municipal
Henrico County: Henrico County WTP	Henrico	SW	James River	25.382	23.99	Municipal
Newport News: Lee Hall WTP & ROF	Newport News	SW	Lee Hall Reservoir	23.66	22.68	Municipal
Virginia American Water: Hopewell District	Hopewell	SW	Appomattox River	20.62	20.37	Municipal
Virginia Beach: Virginia Beach Service Area	Virginia Beach	SW	Lake Gaston	24.09	19.47	Municipal
Honeywell Resins & Chemicals: Chesterfield Plant	Chesterfield	SW	James River	13.5	19.28	Manufacturing
Newport News: Harwood's Mill WTP	York	SW	Harwood's Mill Reservoir	19.53	17.88	Municipal
US Government: Radford Ammunitions Water Treatment Plant	Montgomery	SW	New River	21.27	17.29	Manufacturing
WestRock CP, LLC: West Point Mill Water System	King William	GW	14 Wells	18.63	16.13	Manufacturing
GP Big Island, LLC: Georgia-Pacific Big Island WTP	Bedford	SW	James River	13.51	13.85	Manufacturing
City of Manassas: Manassas Service Area	Manassas	SW	Lake Manassas	13.03	13.69	Municipal

AG: Agriculture; GW: Groundwater; MAN: Manufacturing; PWS: Public Water Supply; SW: Surface Water

Table 4: Top 20 Water Withdrawal Systems in 2016

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
- Other

The "Agriculture" category includes water withdrawn for raising livestock, and for fish farming and hatcheries, 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. It also includes water that is processed and sold to commercial or institutional facilities that are not self-supplied. The "Other" category contains a small number of facilities for which water use does not fit into one of the previously mentioned categories.

Appendix 4 is divided into sections, or two to four page fact sheets for most categories, each containing information regarding withdrawals reported for 2016, including the following:

- A map depicting withdrawal point locations for each category, scaled by the magnitude of the 2016 reported annual withdrawal rate of individual facilities;
- A bar graph illustrating the reported quantity withdrawn for each category between 2012 and 2016, as well as the relative amounts by source type (groundwater or surface water);
- A table that lists withdrawals for 2012-2016 in terms of an annual average rate by source type (groundwater or surface water); and
- A table listing facilities reporting the largest withdrawals for 2016, facility location, water source, reported 2016 annual withdrawal rate, and the average annual withdrawal rate for the 2012-2016 period.

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 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 III. 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 operations such as commodity farms, fish farms, and hatcheries. Information concerning Irrigation withdrawals associated with agriculture and other uses is provided on the Irrigation Water Withdrawals fact sheet. Figure 16 illustrates the distribution of reported 2016 groundwater and surface water withdrawals for agricultural purposes statewide. The majority of water withdrawn for agricultural uses is obtained from springs located in western Virginia and nearly all is withdrawn from surface waters (Figure 17 and Table 5). Groundwater withdrawals increased 40% from 2015 to 2016, though it is only a 0.5 MGD total change in withdrawals. Agricultural withdrawals from springs have increased steadily over the past five years (Table 5) due, in part, to greater withdrawals at the Commonwealth of Virginia owned fishery operations, where withdrawals continue to increase from their five-year average (Table 6). Groundwater is pumped at lower rates for livestock production in southeastern Virginia. Water withdrawals from agriculture make up about 2% of all reported non-power generation withdrawals in Virginia.

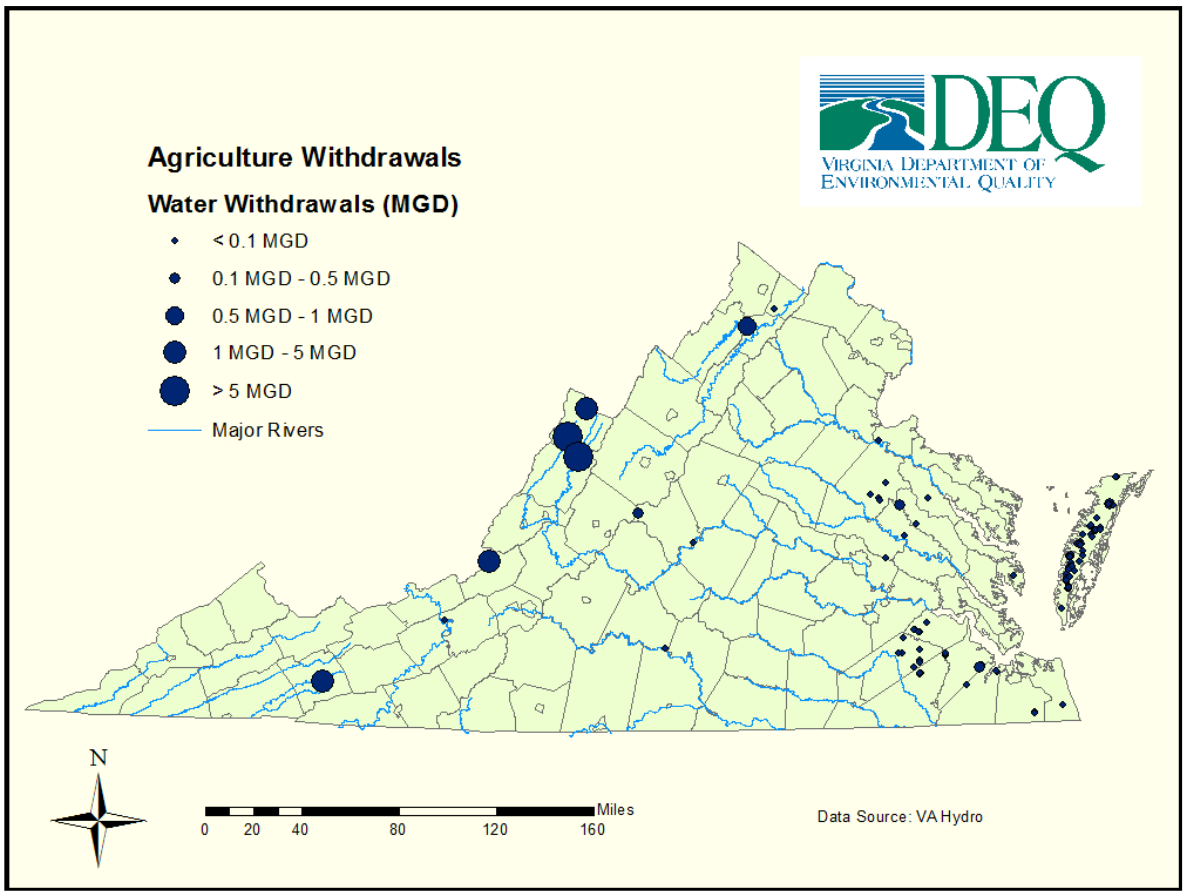


Figure 16: Agricultural (non-irrigation) water withdrawals by withdrawal point location

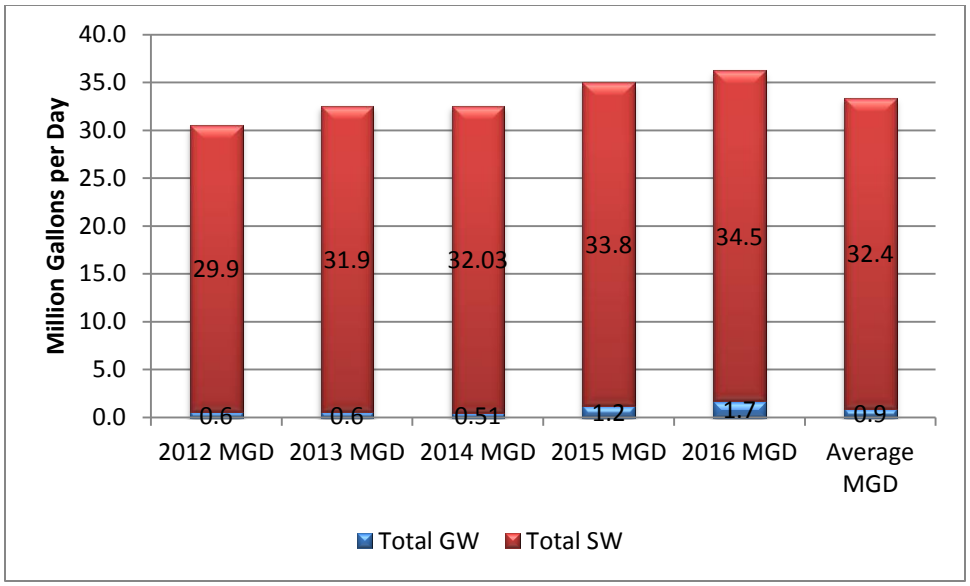


Figure 17: 2012-2016 Agricultural water withdrawals by source type

Source Type	2012 MGD	2013 MGD	2014 MGD	2015 MGD	2016 MGD	Average MGD	Absolute Change (MGD)	% Change
Total GW	0.6	0.6	0.5	1.2	1.7	0.9	0.5	54
Total SW	29.9	31.9	32.0	33.8	34.5	32.4	0.8	2
Total GW + SW	30.5	32.5	32.5	35.0	36.3	33.4	1.3	4

[1] Absolute Change = difference between 2016 water withdrawals and average 2012-2016 water withdrawals
[2]% Change = percent difference in 2016 water withdrawals from average 2012-2016 water withdrawals

Table 5: 2012-2016 Agricultural water withdrawals by source type

Facility	Locality	Type	Major Source	Average MGD	2016 MGD
Commonwealth of Virginia: Coursey Spring Fisheries	Bath	SW	Coursey Spring	10.504	12.24
Virginia Trout Company Inc: Terry Place Plant	Highland	SW	Blue Spring	4.656	5.04
Commonwealth of Virginia: Marion Fish Cultural Station	Smyth	SW	Staleys Creek	3.148	3.46
Commonwealth of Virginia: Paint Bank Fish Cultural Station	Craig	SW	Paint Bank Branch	2.828	3.38
Commonwealth of Virginia: Wytheville Fish Hatchery	Wythe	SW	Boiling and West Springs	3.33	3.25

[1]Average = Average water withdrawals from 2012-2016

Table 6: Top water withdrawals by agricultural (non-irrigation) operations

IRRIGATION WATER WITHDRAWALS

Irrigation withdrawals promote growth in crops such as tobacco, corn, soybeans, turf grass, and ornamental nursery products. Figure 18 illustrates the distribution of reported 2016 groundwater and surface water withdrawals for irrigation purposes statewide. Surface water continues to be the major water source type for irrigation (Figure 19). 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 2016 are 4.3 MGD less than the five-year average from 2012-2016 (Table 7). This is largely due to groundwater withdrawals being 4.4 MGD less than 2015. Surface water withdrawals increased by 1.6 MGD in 2016.

As with previous years, most large-scale irrigation facilities are located in the northern Coastal Plain (Northern Neck) counties and on the Eastern Shore. The five facilities with the greatest withdrawals for irrigation in 2016 are listed in Table 8. Water withdrawals from irrigation make up about 2% of all non-power generation withdrawals in Virginia.

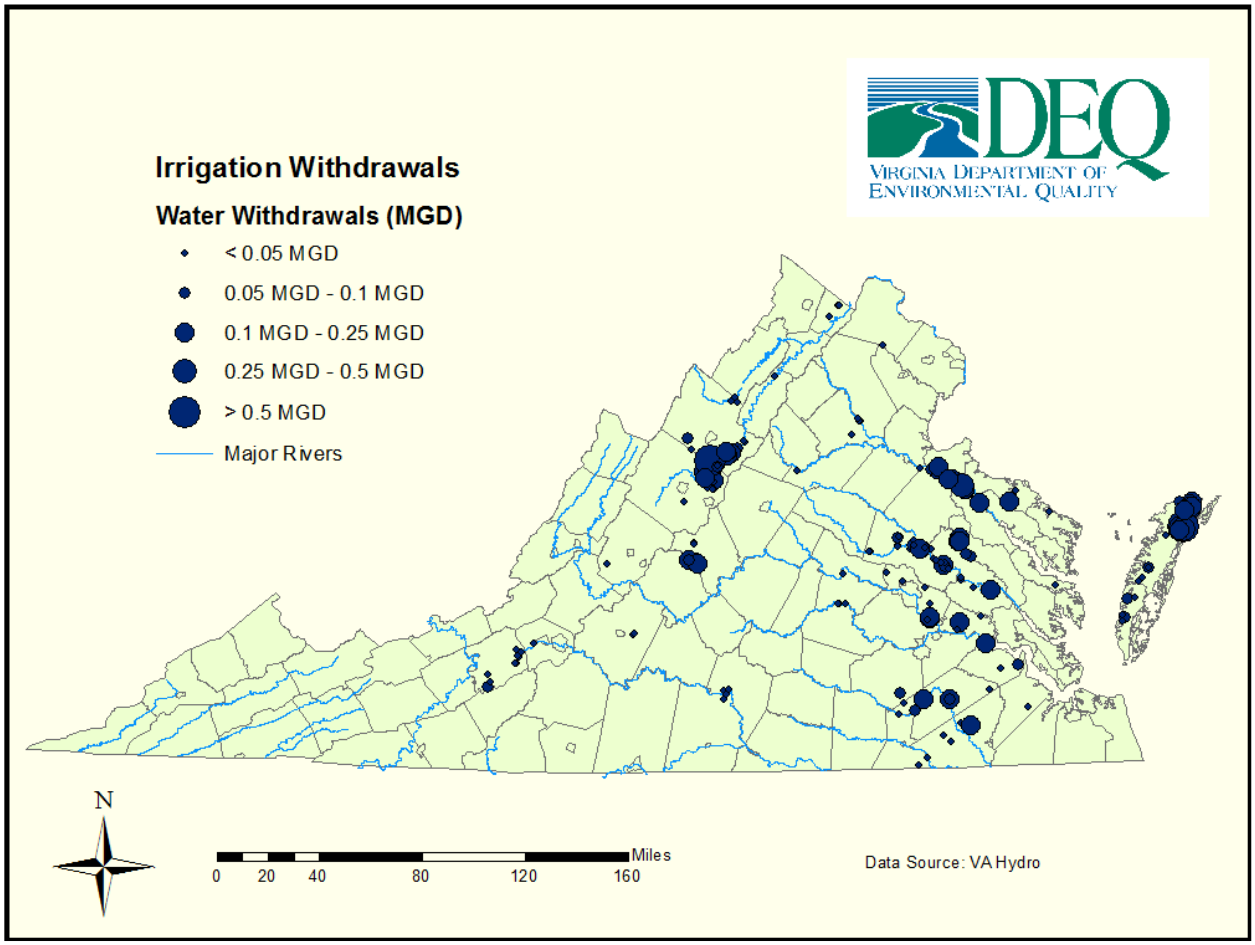


Figure 18: Irrigation (agricultural) water withdrawals by withdrawal point location

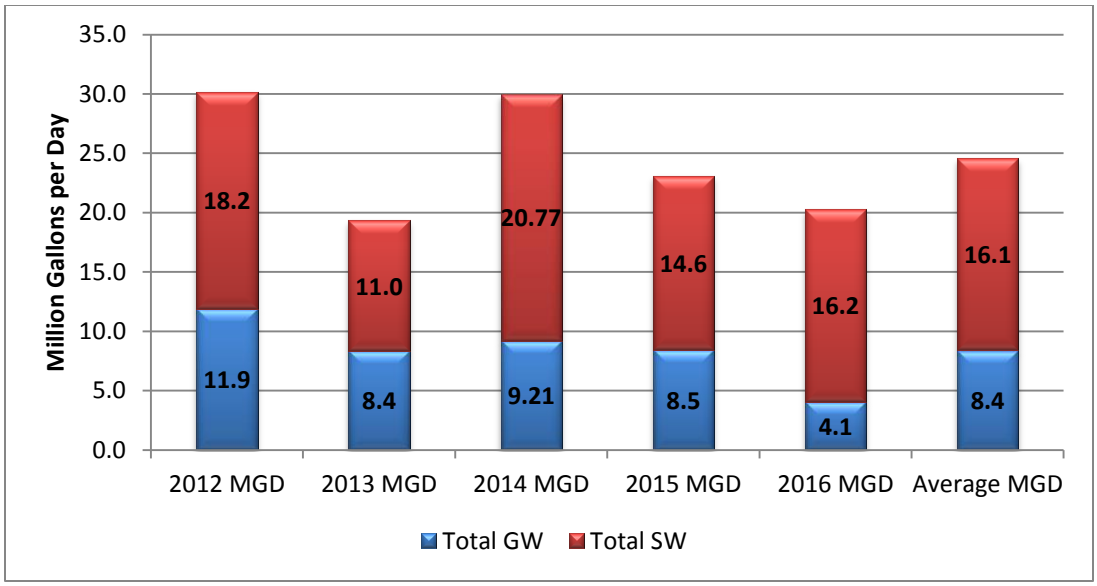


Figure 19: 2012-2016 Irrigation (agricultural) water withdrawals by source type

Source Type	2012 MGD	2013 MGD	2014 MGD	2015 MGD	2016 MGD	Average MGD	Absolute Change (MGD)	% Change
Total GW	11.9	8.4	9.21	8.5	4.1	8.4	4.4	52
Total SW	18.2	11.0	20.77	14.6	16.2	16.1	1.5	9
Total GW + SW	30.2	19.3	30.0	23.1	20.3	24.6	2.8	12

[1]Absolute Change = difference between 2016 water withdrawals and average 2012-2016 water withdrawals
[2]% Change = percent difference in 2016 water withdrawals from average 2012-2016 water withdrawals

Table 7: 2012-2016 Irrigation (agricultural) water withdrawals by source type

Facility	Locality	Type	Major Source	Average MGD	2016 MGD
Robert C Darby and Sons: Arbuckle Farms	Accomack	GW	6 Dug Ponds	5.12	2.37
E Phillip and David L Hickman: Dublin Farms Inc	Accomack	SW/GW	13 Farm Ponds, 1 Dug Pond	2.2	1.77
Gerald W Garber: Cave View Farms	Augusta	SW/GW	North River, Well	1.95	1.95
Saunders Brothers Inc	Nelson	SW/GW	Tye River, Allen Creek, Farm Ponds, and Two Wells	0.66	0.76
Cloverfield Enterprises: Cloverfield Farm	Essex	SW/GW	2 Ponds, Rappahannock River	0.5	0.68

[1]Average = Average water withdrawals from 2012-2016

Table 8: Top water withdrawals for irrigation (agricultural)

COMMERCIAL WATER WITHDRAWALS

Commercial operations include golf courses, local and federal installations, hotels, resorts, and correctional centers, among others. Figure 20 illustrates the distribution of reported 2016 groundwater and surface water withdrawals and transfers for commercial purposes are spread throughout Virginia, predominantly near population centers. Surface water withdrawal totals are typically greater than groundwater withdrawal totals for commercial operations (Figure 21). Reported surface water withdrawals have risen about 2 MGD in each of the past two years whereas reported groundwater withdrawals have remained around 6 MGD. Total water withdrawals for commercial operations in 2016 were about 5 MGD higher than the average withdrawals over the past five years (Table 9). This increase is partly due to increased reporting by golf course facilities. The five facilities reporting the largest 2016 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.

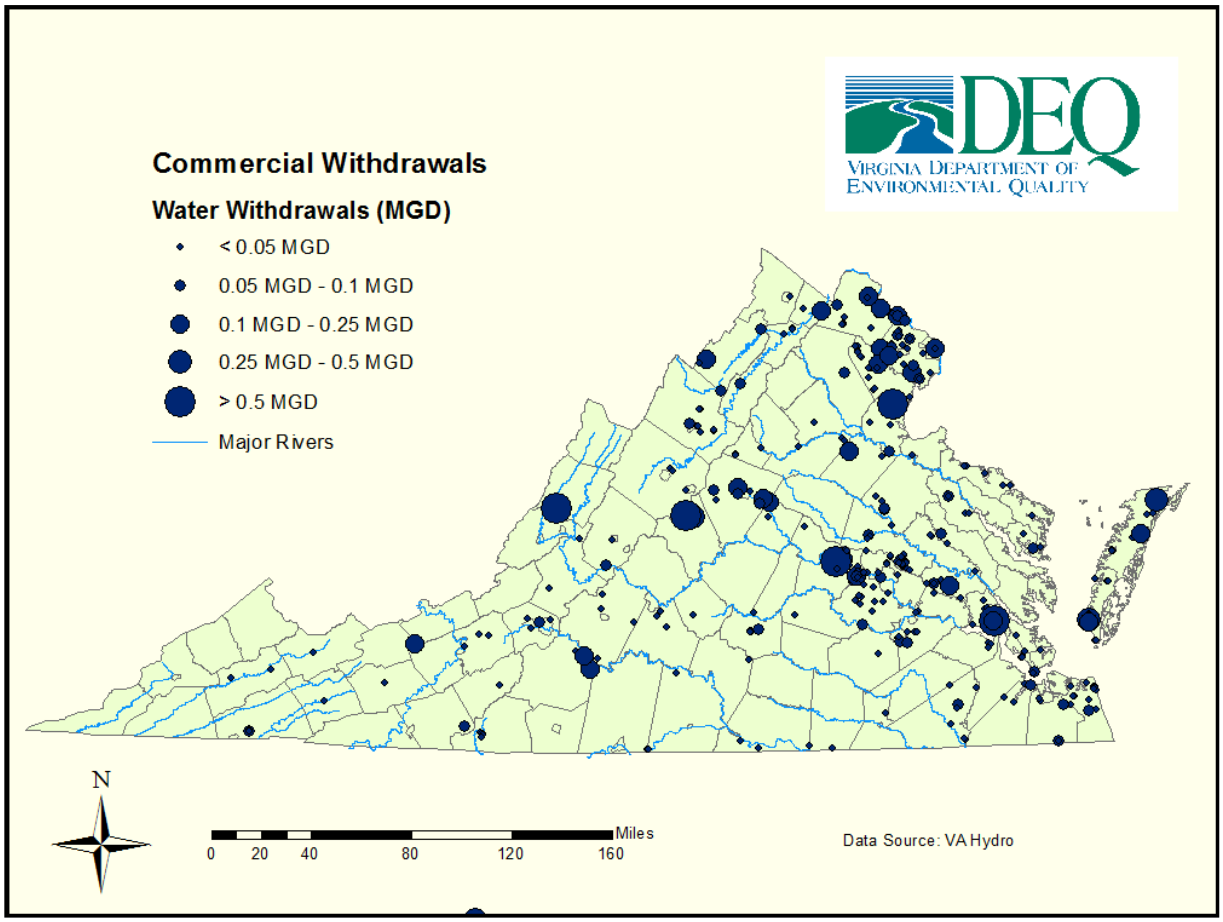


Figure 20: Commercial water withdrawals by withdrawal point location

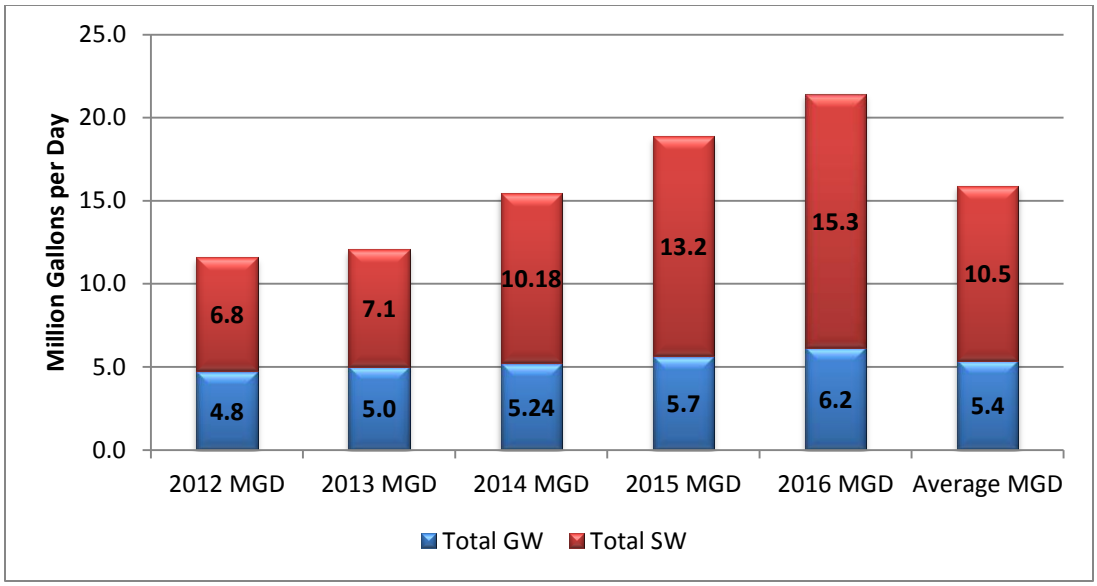


Figure 21: 2012-2016 Commercial water withdrawals by source type

Source Type	2012 MGD	2013 MGD	2014 MGD	2015 MGD	2016 MGD	Average MGD	Absolute Change (MGD)	% Change
Total GW	4.8	5.0	5.24	5.7	6.2	5.4	0.5	10
Total SW	6.8	7.1	10.18	13.2	15.3	10.5	2.0	19
Total GW + SW	11.6	12.1	15.4	18.9	21.4	15.9	2.6	16

[1] Absolute Change = difference between 2016 water withdrawals and average 2012-2016 water withdrawals
[2]% Change = percent difference in 2016 water withdrawals from average 2012-2016 water withdrawals

Table 9: 2012-2016 Commercial Water Withdrawals by Source Type

Facility	Locality	Type	Major Source	Average MGD	2016 MGD
Wintergreen Partners, Inc: Lake Monocan	Nelson	SW	Lake Monocan	0.934	1.11
Colonial Williamsburg Hotel	Williamsburg	GW	3 Wells	1.126	0.99
US Government: Post Camp Water Treatment Plant	Prince William	SW	Breckenridge Reservoir	1.048	0.96
Homestead Water Co: Virginia Hot Springs	Bath	SW	3 Springs	0.586	0.77
Bay Creek Resort & Club: Bay Creek Resort & Club	Northampton	SW	Two Lakes	0.464	0.6

[1]Average = Average water withdrawals from 2012-2016

Table 10: Top water withdrawals by commercial facilities

MINING WATER WITHDRAWALS

Mining includes operations such as sand, rock, and coal mining. Figure 22 illustrates the distribution of reported 2016 groundwater and surface water withdrawals for mining purposes statewide. The majority of stone and sand mining facilities are located along the I-95 corridor. Coal mining withdrawals are located in the Appalachian Basin in southwestern Virginia. Water used for mining purposes comes from predominantly surface water sources, though groundwater makes up over 30% in 2016 (Figure 23). This is mainly due to Kimballton Plant 2 withdrawing over 4 MGD more than their five-year average (Table 12). Total water withdrawals in 2016 for mining purposes were greater than those reported over the last three years and 4.7 MGD higher than the 2012-2016 average (Table 11). While surface water remained the major water source type for mining purposes with 13 MGD of a total 21.4 MGD, reported surface and groundwater withdrawals both increased from 2015 totals. Because there are no major transfers of water for mining purposes, the water withdrawals also represent water use. The five facilities reporting the largest 2016 mining withdrawals are listed in Table 12. Water withdrawals from mining make up about 1% of all non-power generation withdrawals in Virginia.

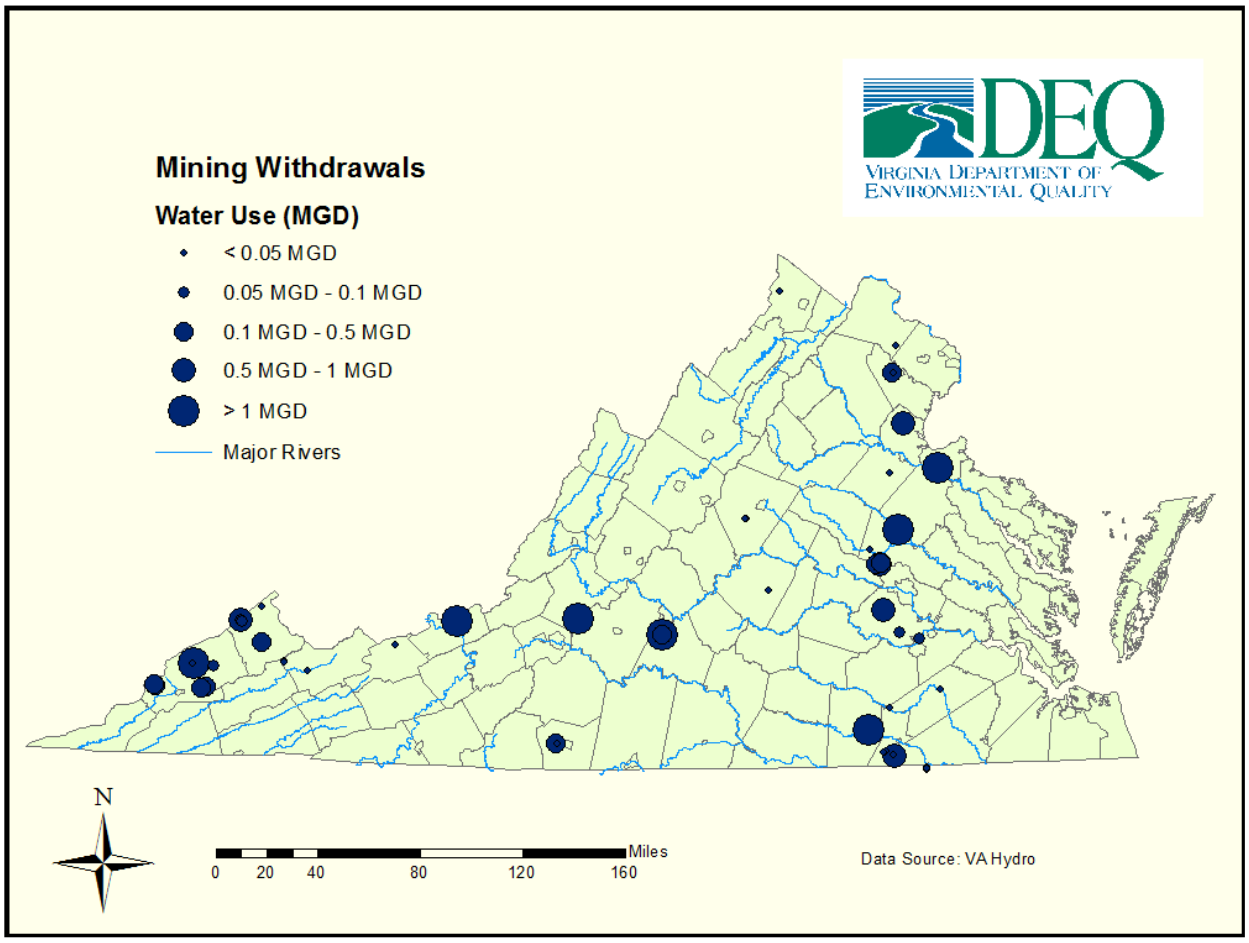


Figure 22: Mining water withdrawals by withdrawal point location

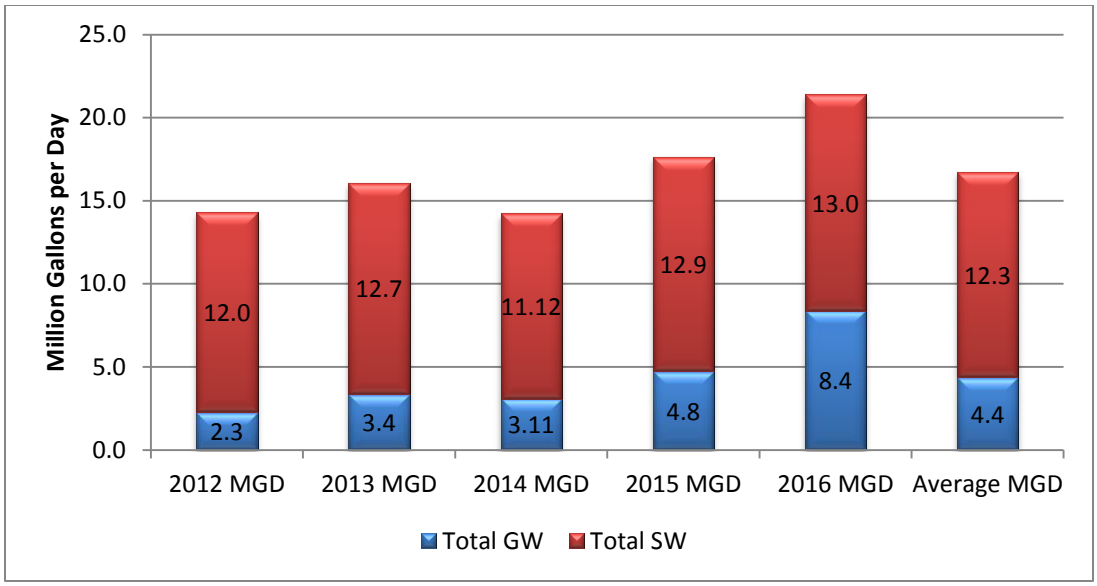


Figure 23: 2012-2016 Mining water withdrawals by source type

Source Type	2012 MGD	2013 MGD	2014 MGD	2015 MGD	2016 MGD	Average MGD	Absolute Change (MGD)	% Change
Total GW	2.3	3.4	3.11	4.8	8.4	4.4	3.6	83
Total SW	12.0	12.7	11.12	12.9	13.0	12.3	0.1	1
Total GW + SW	14.3	16.1	14.2	17.6	21.4	16.7	3.8	22

[1] Absolute Change = difference between 2016 water withdrawals and average 2012-2016 water withdrawals
[2]% Change = percent difference in 2016 water withdrawals from average 2012-2016water withdrawals

Table 11: 2012-2016 Mining water withdrawals by source type

Facility	Locality	Type	Major Source	Average MGD	2016 MGD
Lhoist North America of Virginia, Inc: Kimballton Plant 2	Giles	SW/GW	Stony Creek and Quarry Well	1.89	6.19
Boxley Materials Company: Blue Ridge Plant	Bedford	SW	Quarry	1.46	1.99
Martin Marietta Aggregates: Doswell Quarry	Hanover	SW	Quarry	0.93	1.35
Mid-Atlantic Materials: Rappahannock Farms Sand & Gravel	King George	SW	Rappahannock River	0.82	1.26
Dickenson-Russell Contura, LLC: McClure Mine & Prep Plant	Dickenson	SW	Caney Creek	1.12	1.25

[1]Average = Average water withdrawals from 2010-2015

Table 12: Top water withdrawals by mining operations

MANUFACTURING WATER WITHDRAWALS

Manufacturing includes operations such as chemical and plastics manufacturing, paper mills, food processors, drug companies, furniture, and concrete companies. Water withdrawals reported in 2016 for manufacturing purposes are spread throughout much of Virginia (Figure 24). Clusters of large-scale withdrawals occur in the Tidewater, Richmond, and Shenandoah Valley regions, as well as the New River and the Jackson/Upper James River basins. All of the manufacturing locations with large withdrawals are situated on or near major rivers to facilitate water supply.

Figure 25 illustrates the distribution and annual changes in statewide totals of groundwater and surface water withdrawals for manufacturing from 2012-2016, respectively. Reported manufacturing withdrawals during 2016 decreased slightly relative to the previous year and are about 4.5 MGD less than the five-year average (Table 13). Surface water is the predominant water source type for manufacturing, accounting for about 83% of the total withdrawals in 2016. There are no major transfers of water reported for manufacturing purposes, so the water withdrawals generally represent water use. Table 14 lists the five largest facilities in terms of manufacturing water withdrawals in 2016, all of which happen to be surface water withdrawals. Table 15 lists the top 5 manufacturing facilities in terms of groundwater withdrawals. Water withdrawals from manufacturing make up about 30% of all non-power generation withdrawals in Virginia.

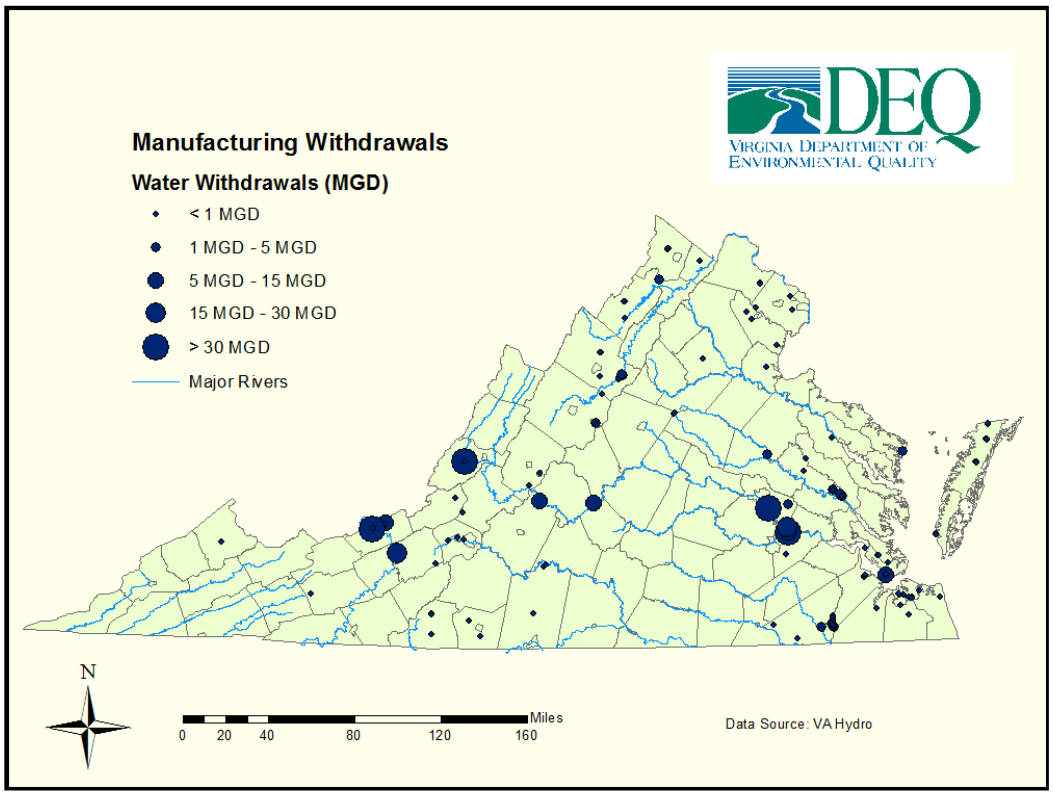


Figure 24: Manufacturing water withdrawals by withdrawal point location

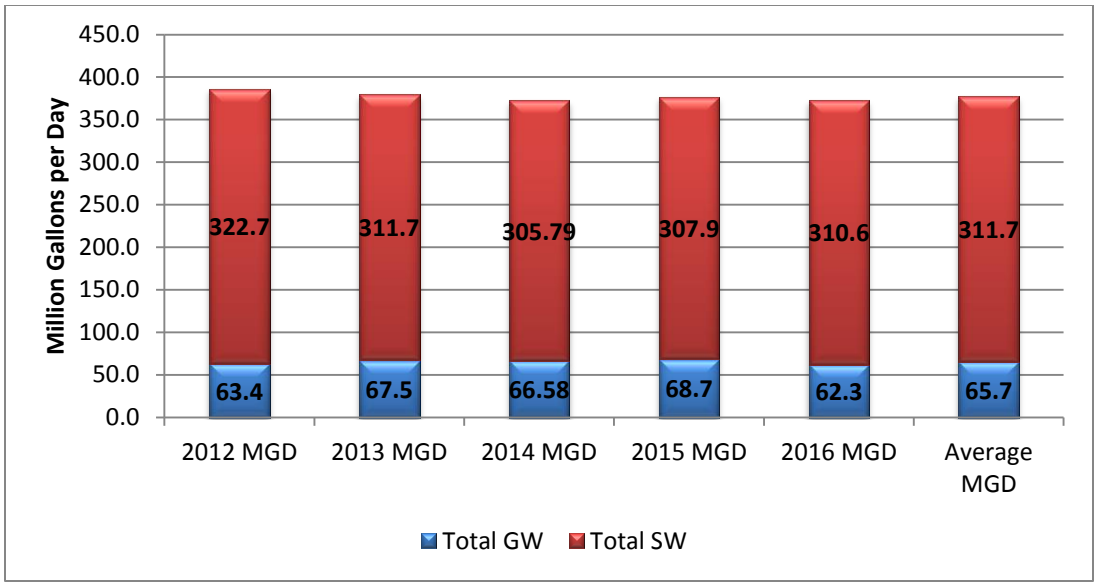


Figure 25: 2012-2016 Manufacturing water withdrawals by source type

Source Type	2012 MGD	2013 MGD	2014 MGD	2015 MGD	2016 MGD	Average MGD	Absolute Change (MGD)	% Change
Total GW	63.4	67.5	66.58	68.7	62.3	65.7	6.4	10
Total SW	322.7	311.7	305.79	307.9	310.6	311.7	2.7	1
Total GW + SW	386.1	379.2	372.4	376.6	372.9	377.4	3.7	1

[1] Absolute Change = difference between 2016 water withdrawals and average 2012-2016 water withdrawals
[2]% Change = percent difference in 2016 water withdrawals from average 2012-2016 water withdrawals

Table 13: 2012-2016 Manufacturing water withdrawals by source type

Facility	Locality	Type	Major Source	Average MGD	2016 MGD
Honeywell International: Hopewell Plant	Hopewell	SW	James River	105.78	96.21
Celanese Acetate LLC: Celco Plant	Giles	SW	New River	52.77	56.51
WestRock Virginia: Covington Plant	Alleghany	SW	Jackson River	38.64	38.44
DuPont E I De Nemours: Spruance Plant	Chesterfield	SW	James River	29.63	34.63
Honeywell Resins & Chemicals: Chesterfield Plant	Chesterfield	SW	James River	13.5	19.28

[1]Average = Average water withdrawals from 2012-2016

Table 14: Top surface water withdrawals by manufacturing facilities

Facility	Locality	Type	Major Source	Average MGD	2016 MGD
WestRock CP, LLC: West Point Mill Water System	King William	GW	14 Wells	18.13	16.13
International Paper: Franklin Plant	Isle of Wight	GW	10 Wells	10.01	9.21
Lhoist North America of VA, Inc: Kimballton Plant 1	Giles	GW	Quarry Well Dewatering	8.334	8.99
Merck & Co: Elkton Plant	Rockingham	GW	11 Wells	7.268	5.62
Solenis LLC: Solenis	Southampton	GW	4 Wells	2.71	3.04

[1]Average = Average water withdrawals from 2012-2016

Table 15: Top groundwater withdrawals by manufacturing facilities

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 systems are small systems that use groundwater (nearly 86%), 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 DC, 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 26).

Total water withdrawals for public water supply during 2016 were about 12.3 MGD greater than the average for the 2012-2016 period (Figure 27). 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 about 93% of the total 2016 public water supply withdrawals in Virginia (Table 16). Table 17 lists the ten facilities that withdrew water for public water supply at the greatest rates during 2016.

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 2016 Public Drinking Water Annual Compliance Report. The report lists the number of public water supply waterworks by type and the total population served by all of these systems (population served by type of waterworks was not available).

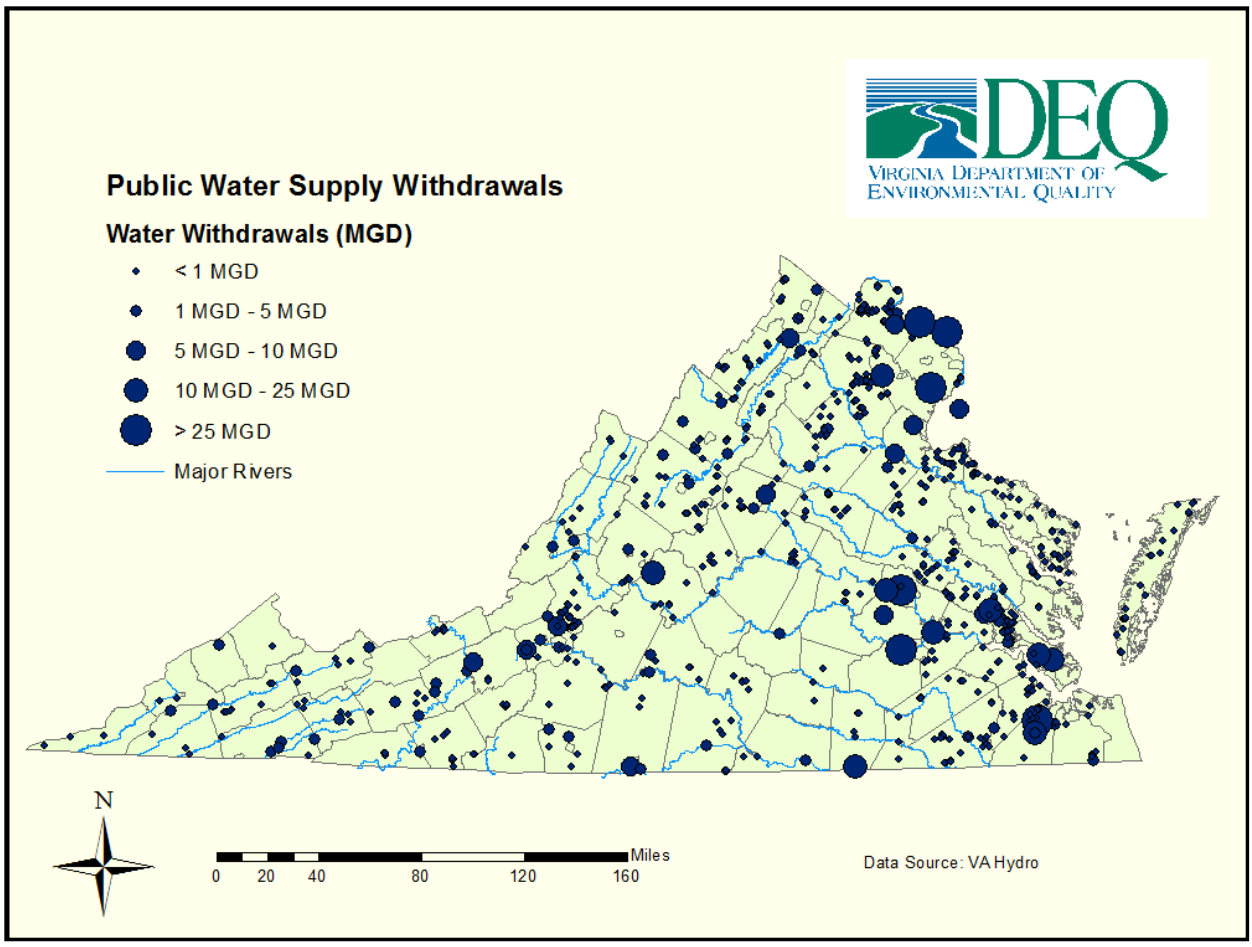


Figure 26: Public water supply withdrawals by withdrawal point location

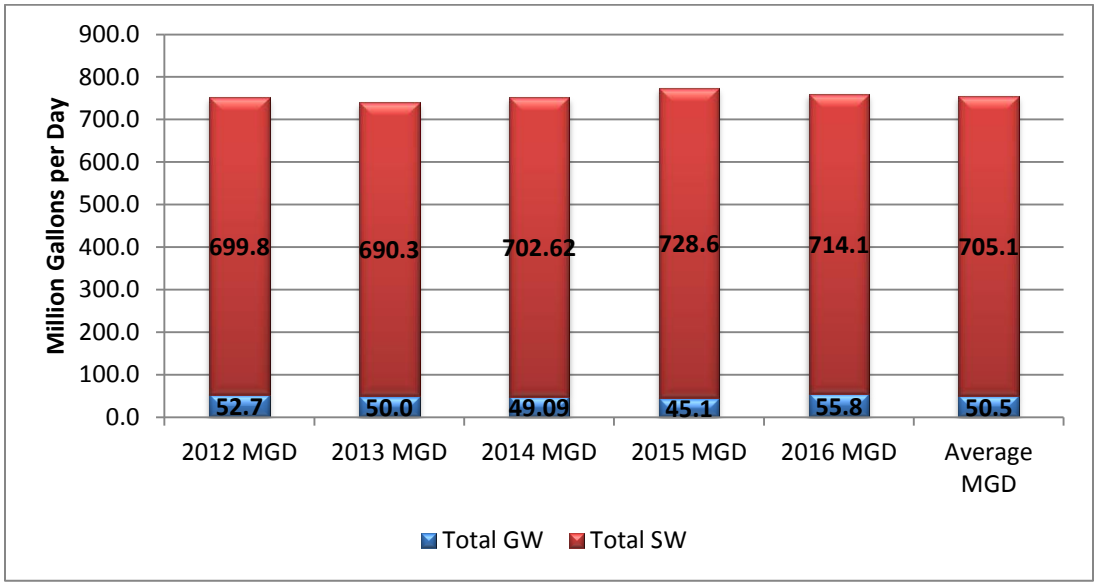


Figure 27: 2012-2016 Public water supply water withdrawals by source type

Source Type	2012 MGD	2013 MGD	2014 MGD	2015 MGD	2016 MGD	Average MGD	Absolute Change (MGD)	% Change
Total GW	52.7	50.0	49.09	45.1	55.8	50.5	10.7	21
Total SW	699.8	690.3	702.62	728.6	714.1	707.1	14.5	5
Total GW + SW	752.4	740.3	751.7	773.7	769.9	757.6	3.8	2

[1] Absolute Change = difference between 2016 water withdrawals and average 2012-2016 water withdrawals
[2] % Change = percent difference in 2016 water withdrawals from average 2012-2016 water withdrawals

Table 16: 2012-2016 Public water supply water withdrawals by source type

Facility	Locality	Type	Major Source	Average MGD	2016 MGD
Fairfax Water Authority: Potomac River WTP	Fairfax	SW	Potomac River	90.68	94.56
Norfolk: Western Branch Reservoir	Suffolk	SW	Western Branch Reservoir	60.558	68.39
Fairfax Water Authority: Occoquan Reservoir	Prince William	SW	Occoquan Reservoir	63.476	68.14
City of Richmond: Richmond WTP	Richmond, City	SW	James River	62.904	66.28
Portsmouth: Lake Kilby WTP	Suffolk	SW/GW	Lake Kilby, Meade & 6 wells	24.708	33.5
Appomattox River Water Authority: Chesdin Reservoir WTP	Chesterfield	SW	Chesdin Reservoir	31.54	31.26
Henrico County: Henrico County WTP	Henrico	SW	James River	25.382	23.99
Newport News: Lee Hall WTP & ROF	Newport News	SW	Lee Hall Reservoir	23.656	22.68
Virginia American Water: Hopewell District	Hopewell	SW	Appomattox River	20.618	20.37
Virginia Beach: Virginia Beach Service Area	Virginia Beach	SW	Lake Gaston	24.086	19.47

[1]Average = Average water withdrawals from 2012-2016

Table 17: Top water withdrawals by public water supply facilities

	Community Waterworks	Nontransient Noncommunity Waterworks	Transient Noncommunity Waterworks	Total
Number of Systems	1,131	530	1,140	2,801
Population Served	--	--	--	7,443,576

Source: VDH 2016 Pubic Drinking Water Annual Compliance Report (accessed 8/18/2017)

Table 18: Number of public water systems and total population served, 2016

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 III for a description of non-consumptive water use). Withdrawals during 2016 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. Virginia has two nuclear-powered generating plants, located in Louisa and Surry counties (Figure 28).Groundwater withdrawals by power generators in 2016 were insignificant compared to surface water withdrawals, which is true historically as well (Figure 29). Total power generation withdrawals increased 42 MGD from 2015 totals, though that only represents a 1% increase (Table 19). Surface water and groundwater withdrawals reached 5,370 MGD in 2016. While total power withdrawals remained relatively consistent, fossil power withdrawals decreased by 227 MGD whereas nuclear power withdrawals increased by 269 MGD. The five power generation facilities with the greatest 2016 withdrawals are listed in Table 20.

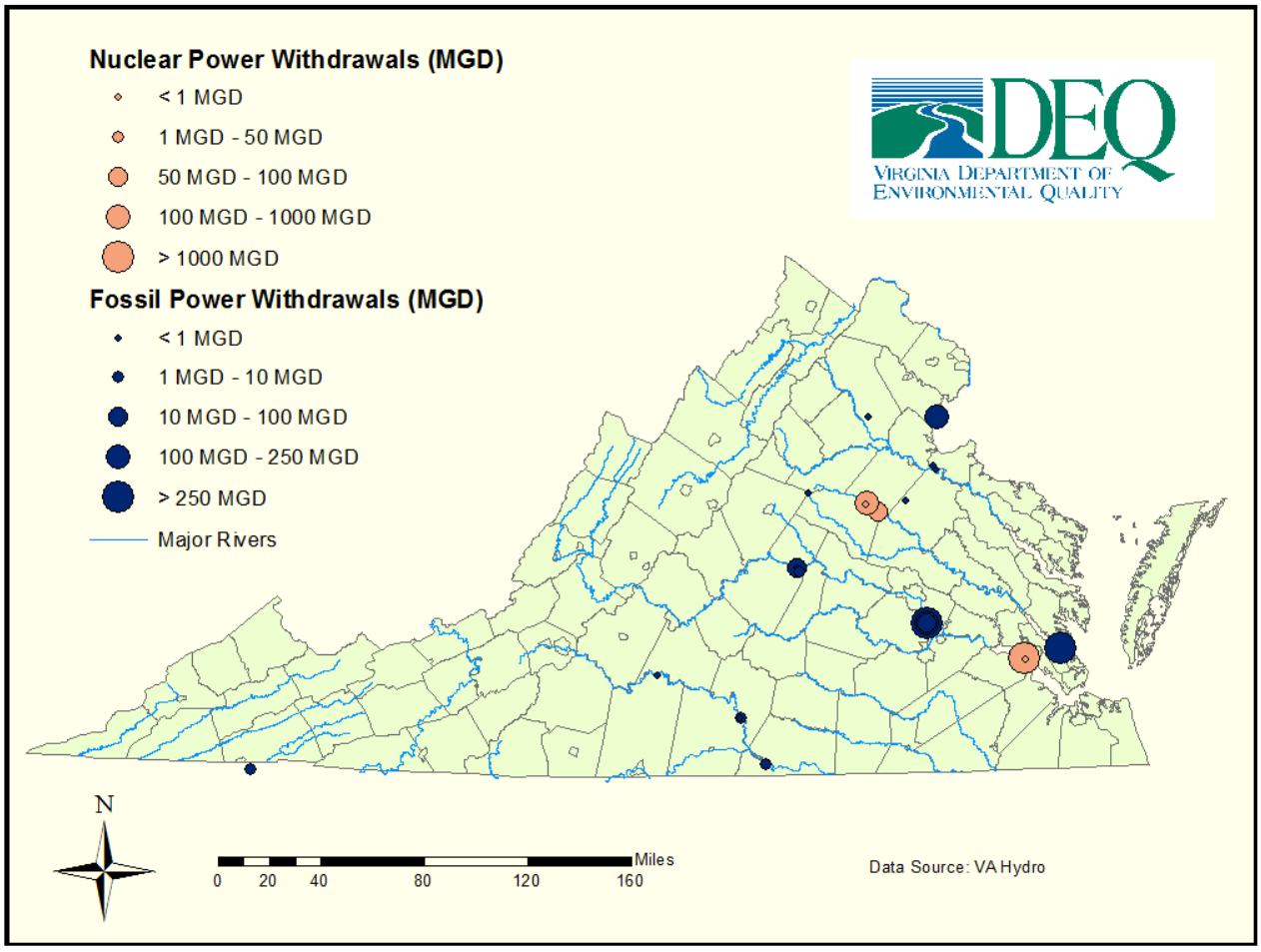


Figure 28: Power generation withdrawals by withdrawal point location

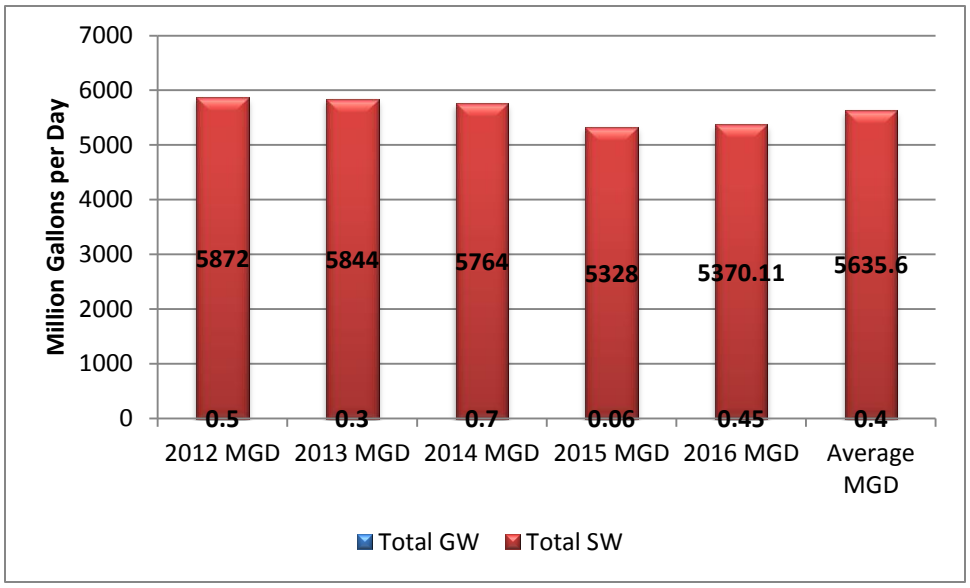


Figure 29: 2012-2016 Power generation withdrawals by source type

Source Type	2012 MGD	2013 MGD	2014 MGD	2015 MGD	2016 MGD	Average MGD	Absolute Change (MGD)	% Change
Total GW:	0.5	0.3	0.7	0.06	0.45	0.4	0.4	97
Fossil - GW	0.2	0.02	0.5	0.05	0.08	0.2	0.0	18
Nuclear - GW	0.3	0.3	0.2	0.01	0.37	0.2	0.4	153
Total SW:	5872	5844	5764	5328.28	5370.11	5635.7	41.8	1
Fossil - SW	2025	2185	2069	1576.28	1348.67	1840.8	227.6	12
Nuclear - SW	3847	3659	3695	3752	4021.44	3794.9	269.4	7
Total GW + SW	5873	5844	5765	5328.34	5370.56	5636.2	42.2	1

[1] Absolute Change = difference between 2016 water withdrawals and average 2012-2016 water withdrawals
[2]% Change = percent difference in 2016 water withdrawals from average 2012-2016 water withdrawals

Table 19: Power generation withdrawals by Source Type for 2012-2016 (excluding hydropower)

Facility	Locality	Type	Major Source	Average MGD	2016 MGD
Dominion Generation: Surry Nuclear Power Plant	Surry	N	James River	2000.408	2233.36
Dominion Generation: North Anna Nuclear Power Plant	Louisa	N	Lake Anna	1780.93	1788.45
Dominion Generation: Chesterfield Power Station	Chesterfield	F	James River	818.938	809.89
Dominion Generation: Yorktown Fossil Power Plant	York	F	York River	533.108	298.38
Possum Point	Prince William	F	Potomac River	154.81	150.21

[1]N = Nuclear; F = Fossil
[2]Average = Average water withdrawals from 2012-2016

Table 20: Top water withdrawals by power generation facilities

APPENDIX 5: WATER WITHDRAWALS BY LOCALITY IN 2016 (excluding power generation and Dalecarlia Water Treatment Plant)

Locality	GW Withdrawal MGD	SW Withdrawal MGD	GW+SW Withdrawal MGD	% of Total Withdrawal
Accomack	7.9	1.8	9.7	0.8%
Albemarle	0.4	11.4	11.8	1.0%
Alexandria	0.02	0.01	0.03	0.0%
Alleghany	0.3	39.2	39.5	3.2%
Amelia	0.1	0.03	0.1	0.0%
Amherst	0.0	17.6	17.6	1.4%
Appomattox	0.0	0.02	0.02	0.0%
Arlington	0.03	0.1	0.1	0.0%
Augusta	3.3	9.5	12.8	1.0%
Bath	0.2	13.0	13.2	1.1%
Bedford	2.0	15.8	17.8	1.4%
Bland	0.04	0.1	0.1	0.0%
Botetourt	0.5	2.3	2.8	0.2%
Bristol	0.0	0.0	0.0	0.0%
Brunswick	0.03	2.2	2.2	0.2%
Buchanan	0.3	1.2	1.5	0.1%
Buckingham	0.0	0.0	0.0	0.0%
Buena Vista	0.0	0.02	0.02	0.0%
Campbell	0.1	6.5	6.6	0.5%
Caroline	1.1	5.3	6.4	0.5%
Carroll	0.2	0.3	0.5	0.0%
Charles City	0.1	1.1	1.2	0.1%
Charlotte	0.1	0.02	0.1	0.0%
Charlottesville	0.0	0.0	0.0	0.0%
Chesapeake	3.2	2.2	5.4	0.4%
Chesterfield	0.5	98.9	99.4	8.1%
Clarke	0.1	0.6	0.7	0.1%
Covington	0.0	2.2	2.2	0.2%
Craig	0.0	3.5	3.5	0.3%
Culpeper	0.01	2.1	2.1	0.2%
Cumberland	0.0	0.03	0.03	0.0%
Danville	0.0	5.2	5.2	0.4%
Dickenson	0.1	6.1	6.2	0.5%
Dinwiddie	0.02	0.2	0.2	0.0%
Emporia	0.0	0.8	0.8	0.1%
Essex	0.04	0.1	0.1	0.0%

Fairfax County	0.3	95.9	96.2	7.8%
Fairfax City	0.02	0.04	0.06	0.0%
Fauquier	1.8	1.3	3.1	0.3%
Floyd	0.1	0.1	0.2	0.0%
Fluvanna	0.2	0.8	1.0	0.1%
Franklin	1.0	1.1	2.1	0.2%
Frederick	1.2	3.8	5.0	0.4%
Fredericksburg	0.0	0.02	0.02	0.0%
Galax	0.0	1.8	1.8	0.1%
Giles	19.5	53.2	72.7	5.9%
Gloucester	0.4	1.0	1.4	0.0%
Goochland	0.1	2.2	2.3	0.2%
Grayson	0.1	0.0	0.1	0.0%
Greene	0.0	0.7	0.7	0.1%
Greensville	0.04	1.1	1.1	0.1%
Halifax	0.1	1.9	2.0	0.2%
Hampton	0.03	0.01	0.0	0.0%
Hanover	0.7	6.4	7.1	0.6%
Harrisonburg	0.0	0.1	0.1	0.0%
Henrico	0.03	24.4	24.4	2.0%
Henry	0.02	3.2	3.2	0.3%
Highland	0.1	7.4	7.5	0.6%
Hopewell	0.0	128.9	128.9	10.5%
Isle of Wight	10.8	4.3	15.0	1.2%
James City	5.5	3.8	9.3	0.8%
King and Queen	0.03	0.8	0.8	0.1%
King George	1.1	1.7	2.8	0.2%
King William	18.7	0.6	19.3	1.6%
Lancaster	0.3	0.1	0.3	0.0%
Lee	0.0	0.8	0.8	0.1%
Loudoun	1.7	11.5	13.1	1.1%
Louisa	0.4	0.4	0.7	0.1%
Lunenburg	0.0	0.5	0.5	0.0%
Lynchburg	0.0	0.1	0.1	0.0%
Madison	0.1	0.04	0.1	0.0%
Manassas	0.3	13.4	13.7	1.1%
Manassas Park	0.0	0.02	0.0	0.0%
Martinsville	0.0	2.0	2.0	0.2%
Mathews	0.02	0.0	0.0	0.0%
Mecklenburg	0.1	1.8	1.9	0.2%
Middlesex	0.1	0.1	0.2	0.0%

Montgomery	0.1	24.4	24.5	2.0%
Nelson	0.1	2.7	2.9	0.2%
New Kent	0.8	17.7	18.5	1.5%
Newport News	1.6	31.0	32.6	2.6%
Norfolk	0.05	0.6	0.6	0.1%
Northampton	1.0	1.4	2.3	0.2%
Northumberland	0.4	1.6	1.9	0.2%
Norton	0.0	0.7	0.7	0.1%
Nottoway	0.0	1.1	1.1	0.1%
Orange	0.02	2.0	2.1	0.2%
Page	1.1	0.8	1.9	0.2%
Patrick	0.2	0.9	1.0	0.1%
Petersburg	0.04	0.03	0.1	0.0%
Pittsylvania	0.01	2.0	2.0	0.2%
Portsmouth	0.2	0.0	0.2	0.0%
Powhatan	0.1	0.2	0.2	0.0%
Prince Edward	0.1	1.1	1.3	0.1%
Prince George	0.3	0.1	0.5	0.0%
Prince William	0.5	70.0	70.5	5.7%
Pulaski	0.0	4.3	4.3	0.3%
Radford	0.0	2.4	2.4	0.2%
Rappahannock	0.04	0.0	0.0	0.0%
Richmond County	0.3	0.0	0.3	0.0%
Richmond City	0.04	66.5	66.6	5.4%
Roanoke County	0.03	11.0	11.0	0.9%
Roanoke City	0.9	14.0	15.0	1.2%
Rockbridge	0.6	1.5	2.0	0.2%
Rockingham	14.6	9.7	24.3	2.0%
Russell	0.4	0.9	1.3	0.1%
Salem	0.9	3.3	4.2	0.3%
Scott	0.1	0.8	0.9	0.1%
Shenandoah	3.5	3.9	7.4	0.6%
Smyth	0.9	5.5	6.4	0.5%
Southampton	3.8	2.5	6.2	0.5%
Spotsylvania	0.3	11.3	11.6	0.9%
Stafford	0.0	10.6	10.6	0.1%
Suffolk	2.6	101.6	104.2	8.5%
Surry	0.2	0.1	0.3	0.0%
Sussex	1.0	0.7	1.7	0.1%
Tazewell	0.02	4.1	4.1	0.3%
Virginia Beach	0.1	19.7	19.8	1.6%

Warren	0.1	10.2	10.4	0.8%
Washington	0.1	11.0	11.1	0.9%
Waynesboro	3.8	0.9	4.7	0.4%
Westmoreland	1.0	0.6	1.6	0.1%
Williamsburg	1.0	0.0	1.0	0.1%
Wise	0.3	4.5	4.8	0.4%
Wythe	0.2	7.5	7.7	0.6%
York	0.4	17.9	18.3	1.5%
Totals	129.2*	1111.9*	1241.1*	100%

Table 21: Water Withdrawals by Locality, 2016