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Effectiveness of Virginia's Water Resource Planning and Management

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JLARC
JOINT LEGISLATIVE AUDIT AND REVIEW COMMISSION

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JLARC Report 486

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COMMONWEALTH of VIRGINIA

Joint Legislative Audit and Review Commission
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February 8, 2017

The Honorable Robert D. Orrock Sr., Chair
Joint Legislative Audit and Review Commission
General Assembly Building
Richmond, Virginia 23219

Dear Delegate Orrock:

In 2015, the General Assembly directed the Joint Legislative Audit and Review Commission (JLARC) to study water resource planning and management in Virginia (HJR 623 and SJR 272). As part of this study, the report, *Effectiveness of Virginia's Water Resource Planning and Management*, was briefed to the Commission and authorized for printing on October 11, 2016.

On behalf of Commission staff, I would like to express appreciation for the cooperation and assistance of the staff of the Virginia Department of Environmental Quality and the Virginia Water Resource Research Center at Virginia Tech.

Sincerely,

Hal E. Greer
Director

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Summary

Effectiveness of Virginia's Water Resource Planning and Management

WHAT WE FOUND

Eastern Virginia has insufficient groundwater to meet demand

Recent efforts by the Department of Environmental Quality, if successful, will bring current use of groundwater in eastern Virginia to sustainable levels. This sustainability, though, is tenuous because of the strong likelihood of growth in permitted and unpermitted use. Sustainability concerns have already negatively affected municipal water supplies.

This tenuous sustainability means that there is currently insufficient groundwater in eastern Virginia to accommodate any major, new permit requests. According to analysis conducted for this study, new permit requests (for example, requests by industries seeking to locate in the region) for even a moderate amount of groundwater cannot be accommodated.

WHY WE DID THIS STUDY
In 2015, the General Assembly directed the Joint Legislative Audit and Review Commission (JLARC) to review Virginia's water resource management and planning. Interest in this topic was prompted by concerns about the sustainability of water supply and demand, especially in eastern Virginia.

ABOUT WATER RESOURCE PLANNING AND MANAGEMENT
Water resource planning and management seeks to ensure that water supplies will be available to meet human and environmental needs. This planning and management is accomplished through state and local plans, state permitting, and locally developed water supply projects.

Planning is too vague to be useful and not sufficiently regional

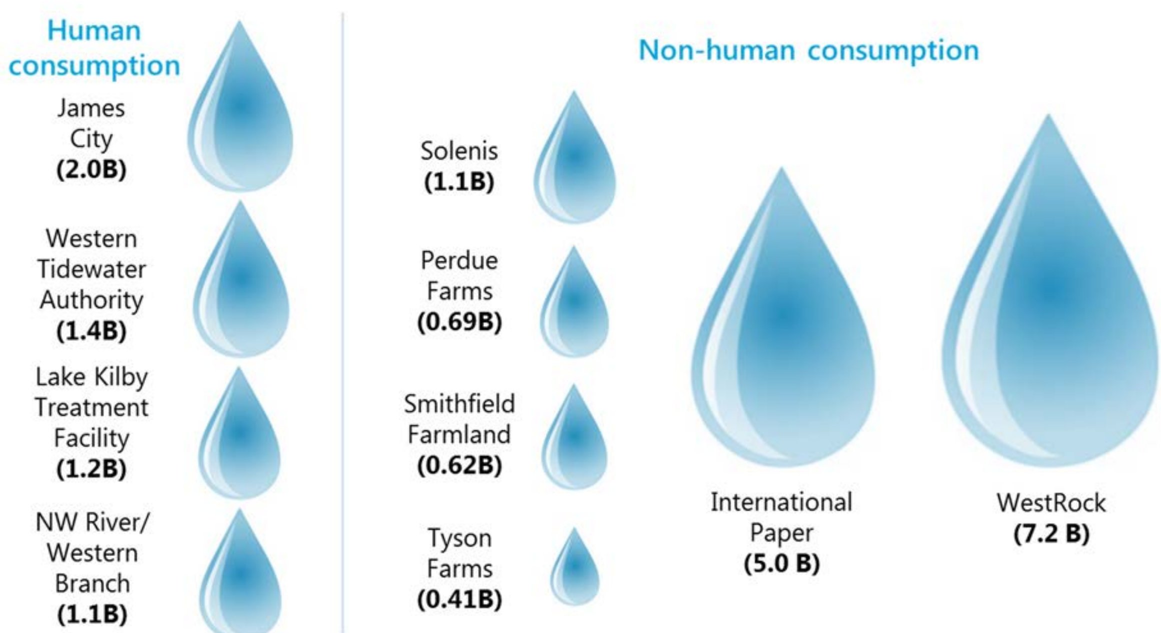
Virginia's state and local water plans are not sufficiently specific or aligned with water location and use. As a result, the state lacks a clear plan for addressing its most pressing sustainability challenges. The first ever state water plan was a major undertaking that has improved the state's understanding of how water is currently used throughout the state. However, the plan does not adequately define the state's water challenges and lacks detailed and actionable strategies to address those challenges.

Many of the local water plans have been useful to local stakeholders, but localities did not sufficiently collaborate to develop regional plans. For example, Richmond, Henrico, and Chesterfield did not fully coordinate their water resource plans, even though they all use the James River as an important source of water. Without regional planning, localities may miss opportunities to collaborate on high-cost water supply projects, and some localities may have greater access to water than others.

Eastern Virginia groundwater permitting does not prioritize human consumption

Despite statutory language underscoring that human consumption is the priority, more than 60 percent of all current permitted groundwater use in eastern Virginia is for industrial purposes. The Code of Virginia and the Virginia Administrative Code clearly establish that water withdrawals for human consumption should receive the highest priority when withdrawal permits are granted. Substantial industrial use of low cost, high quality water has the effect of "crowding out" higher priority use for human consumption. This crowding out is contributing to one municipal water authority embarking on a $128 million water supply project to develop alternatives to groundwater. The cost will be passed along to residents and businesses that are connected to this municipal water supply. Without substantial changes to the state's groundwater permitting process, this crowding out and higher costs to residential customers and businesses will continue.

Non-human consumption, industrial users are the largest withdrawers of eastern Virginia groundwater



SOURCE: Virginia Department of Environmental Quality, 2014.
NOTE: Use is shown to scale, in gallons per year.

Sustainability problems can be addressed through conservation and additional water supply projects, but state needs to take a more active role in planning

A combination of conservation and additional water supply projects can help address the state's sustainability problems. Relatively simple conservation measures, and more complex projects such as fixing leaking water infrastructure, may be the simplest and least expensive ways to ensure that supplies can meet demand. Municipal water authorities lose between 4 percent and 50 percent of their water through leaks, and repairing infrastructure can result in a considerable net increase in available water supply. In addition, a proposed aquifer injection project in eastern Virginia has the potential to substantially increase the coastal aquifer water supply, but its full implementation may take decades. The primary benefit of the injection project is that it would have sufficient scale to substantially increase groundwater levels.

A more active state role in project planning can help ensure that conservation measures and fixing leaky water infrastructure are sufficiently considered before embarking on costlier, higher-risk projects. If the state continues to take a minimal role in the planning of water supply projects, projects may be developed that are unnecessarily costly or high-risk. The state role in the financing and construction of water supply projects is also minimal, but Virginia's sustainability challenges are not significant enough to justify materially changing this role.

WHAT WE RECOMMEND

Legislative action

- Require that regional water supply plans be developed that are aligned with water location and common water use
- Prescribe that the state plan should define how the state will (i) facilitate regional planning and (ii) provide differentiated planning, policy, and technical assistance to each region
- Require that groundwater withdrawal permits in eastern Virginia primarily for human consumption be reviewed and approved prior to reviewing requests for all other types of use
- Require that no single permitted groundwater user in eastern Virginia be able to withdraw more than a specified percentage of total permitted withdrawal amounts
- Require an assessment of state resources needed to facilitate regional water planning, and a proposal for the state to take a more active role in water supply project planning

Executive action

- Develop a plan to reduce the amount of groundwater withdrawal capacity awarded to permit applicants to more closely reflect the amount used
- Identify the surface water segments in Virginia at the greatest risk of shortfalls

The complete list of recommendations is available on page v.

Recommendations

Effectiveness of Virginia's Water Resource Planning and Management

RECOMMENDATION 1

The General Assembly may wish to consider including language in the Appropriation Act directing the Virginia Department of Environmental Quality to identify high priority locations for additional sites for monitoring land subsidence, salt concentration, and groundwater level. Priority should be assigned based on (i) high potential to improve the accuracy of the state's modeling predictions for land subsidence, salt concentrations, and groundwater levels, and (ii) cost-effectiveness. (Chapter 2)

RECOMMENDATION 2

The Virginia Department of Environmental Quality should improve the accuracy of and confidence in its surface water demand and supply estimates through steps such as (i) reviewing research literature and consulting water resource researchers and planners to refine assumptions, and (ii) using a range of possible supply and demand assumptions to conduct multiple modeling scenarios. (Chapter 3)

RECOMMENDATION 3

The Virginia Department of Environmental Quality should model scenarios of surface water sustainability using a range of (i) measures for a shortfall and (ii) intervals between 10 and 30 years. (Chapter 3)

RECOMMENDATION 4

The Virginia Department of Environmental Quality should identify the river and stream segments in Virginia at the greatest risk for a water shortfall and establish a methodology to determine the reasons for the predicted shortfalls. (Chapter 3)

RECOMMENDATION 5

The General Assembly may wish to consider amending § 62.1-44.38 of the Code of Virginia to (i) clarify that reporting water withdrawal information would not alter the status of existing exemptions from permitting under the Virginia Water Protection program and (ii) authorize the State Water Control Board to impose a civil penalty for failure to report water withdrawal information (as required under § 62.1-44.38) on users of water from the river and stream segments at greatest risk of shortfall. (Chapter 3)

RECOMMENDATION 6

The General Assembly may wish to consider amending § 62.1-44.38:1 of the Code of Virginia to require the State Water Control Board to designate regional water planning areas based on (i) primary source of water, (ii) local jurisdictional boundaries, (iii) geographic proximity, (iv) existing regional groups that have already developed water resource plans, (v) existing regional entities, and (vi) other appropriate factors. (Chapter 4)

RECOMMENDATION 7

The State Water Control Board should amend the water supply planning regulations (9VAC25-780-40) to define the membership requirements of regional planning groups such that they incorporate representatives of a variety of local stakeholder groups. As applicable, local stakeholder groups should include representatives of local governments, industrial and agricultural water users, public water suppliers, developers and economic development organizations, and conservation and environmental organizations. (Chapter 4)

RECOMMENDATION 8

The General Assembly may wish to consider amending § 62.1-44.38:1 of the Code of Virginia to direct the State Water Control Board to require regional water planning groups to (i) evaluate potential projects using standardized criteria developed by the Board; (ii) identify a workable and cost-effective water supply strategy; and (iii) decide on a course of action to address the region's water supply needs. (Chapter 4)

RECOMMENDATION 9

The General Assembly may wish to consider amending § 62.1-44.38:1 of the Code of Virginia to require that, when regional water plans are completed, the Virginia Department of Environmental Quality report to the State Water Commission on the extent to which each regional plan (i) identifies a workable and cost-effective water supply strategy and (ii) reflects adequate regional cooperation. (Chapter 4)

RECOMMENDATION 10

The General Assembly may wish to consider amending § 62.1-44.38:1 of the Code of Virginia to require the Virginia Department of Environmental Quality to use the state water plan to clearly articulate how the state will (i) facilitate regional planning and (ii) provide planning, policy, and technical assistance to each region, differentiated according to each region's sustainability problems, existing resources, and other factors. (Chapter 4)

RECOMMENDATION 11

The General Assembly may wish to include language in the Appropriation Act directing the Virginia Department of Environmental Quality to assess and report on additional resources needed to facilitate regional planning and provide differentiated regional assistance. The report should be submitted to the State Water Commission, House Appropriations, and Senate Finance Committees no later than July 1, 2017. (Chapter 4)

RECOMMENDATION 12
The General Assembly may wish to consider amending the Groundwater Management Act (§§ 62.1-254 through 62.1-270 of the Code of Virginia) to require that the State Water Control Board issue permits for groundwater withdrawals for non-human consumptive uses only after meeting permit requests for human consumptive needs. (Chapter 5)

RECOMMENDATION 13
The General Assembly may wish to consider amending the Groundwater Management Act (§§ 62.1-254 through 62.1-270 of the Code of Virginia) to require that the State Water Control Board reduce permitted withdrawal amounts for non-human consumptive use as necessary to provide permit capacity to meet human consumptive needs. (Chapter 5)

RECOMMENDATION 14
The General Assembly may wish to consider amending the Groundwater Management Act (§§ 62.1-254 through 62.1-270 of the Code of Virginia) to establish a limit on the proportion of overall permitted withdrawal capacity to be granted to an individual permit holder in the coastal aquifer. (Chapter 5)

RECOMMENDATION 15
The Virginia Department of Environmental Quality should develop a plan to reduce the amount of withdrawal capacity granted by each groundwater permit issued, to more closely reflect the actual amount needed. The plan should be presented to the State Water Control Board and State Water Commission by December 1, 2017. (Chapter 5)

RECOMMENDATION 16
The Virginia Department of Environmental Quality should develop and publish a groundwater permitting process transition plan. The plan should specify how the groundwater permitting requirements and process will change, when the changes will be implemented, how the department will engage permit holders, and how the department will inform permit holders as new permit requirements and processes are implemented. (Chapter 5)

RECOMMENDATION 17
The State Water Control Board should amend the regulations for the Virginia Water Protection permit program (9VAC25-210) to specify the metrics that will be used to assess the likely impact of proposed surface water withdrawals from river segments at greater risk for water shortfalls. The Board should update the regulations no less than every five years to incorporate scientific and technological development in surface water metrics. (Chapter 5)

RECOMMENDATION 18
The Virginia Department of Environmental Quality should collaborate with the Virginia Department of Health and other relevant entities to identify all grandfathered surface water withdrawers in Virginia. (Chapter 5)

RECOMMENDATION 19
The General Assembly may wish to consider including language in the Appropriation Act directing the State Water Control Board to create an advisory panel to recommend amendments to § 62.1-44.15:20 of the Code of Virginia that would clarify (i) the conditions under which grandfathered users of surface water would be required to obtain a Virginia Water Protection permit and (ii) the criteria to be used to determine the amount of surface water to be permitted to grandfathered users. (Chapter 5)

RECOMMENDATION 20
The General Assembly may wish to consider including language in the Appropriation Act directing the State Water Control Board to create an advisory panel to clarify whether and how the definition of safe yield should be changed in the Virginia Administrative Code. (Chapter 5)

RECOMMENDATION 21
The General Assembly may wish to consider including language in the Appropriation Act directing the Virginia Department of Environmental Quality to develop a proposal for providing additional water planning assistance, to include (i) planning and policy guidance for projects with cross-jurisdictional impact and (ii) technical assistance for localities that lack technical resources and expertise in project identification, planning, and construction. The proposal, which should include an assessment of the feasibility of and resources needed to perform this new function, should be submitted to the State Water Commission and House Appropriations and Senate Finance Committees no later than July 1, 2017. (Chapter 6)

RECOMMENDATION 22
The General Assembly may wish to consider including language in the Appropriation Act directing the State Water Commission to evaluate the establishment of a fund to provide (i) incentives for regional collaboration in water planning and (ii) financing for regional water projects. (Chapter 6)

OPTION 1
The General Assembly could amend the Code of Virginia to establish statutory authority for a user fee for water withdrawn from the coastal aquifer. (Chapter 5)

OPTION 2
The General Assembly could amend the Code of Virginia to establish statutory authority for a priority system to award groundwater withdrawal permits to industrial users likely to have the greatest economic benefit. (Chapter 5)

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1 Water Resource Planning and Management in Virginia

SUMMARY Water is a critical natural resource that is needed for a wide range of human and environmental purposes. Most water used in Virginia is withdrawn and used for power generation, drinking water, and manufacturing. Water is withdrawn from surface water, such as rivers, and groundwater. The vast majority of withdrawals statewide are from surface water sources. Water resource management is intended to ensure that water supplies are adequate to meet the full range of human and environmental requirements now and in the future. A lack of adequate water supplies can increase the cost of obtaining water, hinder economic development, and harm the environment. The state and localities attempt to ensure water supplies are adequate by managing water withdrawals through permitting, developing additional water supply projects, and reducing water demand through conservation practices.

In 2015, the General Assembly directed JLARC to study Virginia's water resource management and planning. The mandate specifically required JLARC staff to assess sustainability of groundwater and surface water, the effectiveness of water resource planning, the effectiveness of state permitting, and the need for strategies and projects to improve sustainability. In 2016, the General Assembly further directed JLARC to study the likely impact of proposed changes to the state's water permitting regulations. (See Appendix A: Study mandates.)

Water is critical for humans and the environment

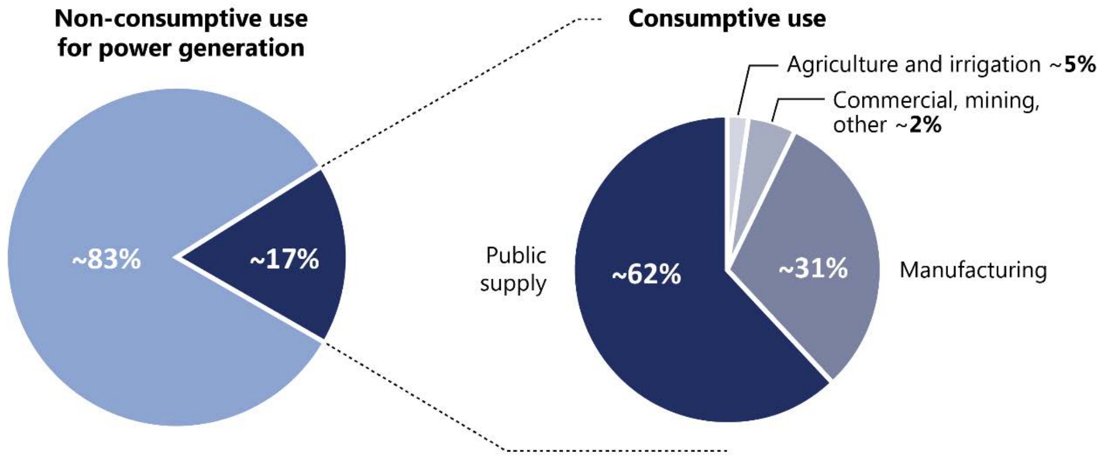
Water is essential for humans and the environment. Humans require water to survive, and humans also use water for agriculture and irrigation. Many industrial companies, such as paper mills and food processors, rely heavily on water to manufacture their products. Electric utilities use water to generate electricity directly or cool reactors in nuclear power plants. Rivers, streams, and lakes are home to a wide range of fish and other aquatic life, and at least a certain amount of water is needed to support these species. Rivers, streams, and lakes are also critical to assimilating waste materials from natural runoff and discharges by wastewater treatment or manufacturing facilities, as well as recreation and navigation.

Most water withdrawals in Virginia are for power generation and public water supply to meet drinking water needs of residents (Figure 1-1). More than 80 percent of the seven billion gallons withdrawn per day in 2014 was used by nuclear and fossil-fuel power plants. This water is primarily non-consumptive because the vast majority of it is returned directly to its source after use (sidebar). As a result, it has only minimal impact on the total supply of water and is largely outside the scope of this report.

Consumptive water use refers to water that is used and not returned to its source.

Non-consumptive water use refers to water that is used and then returned in its entirety to its source.

FIGURE 1-1
Most water withdrawals in Virginia are for power generation and public water supply (2014)



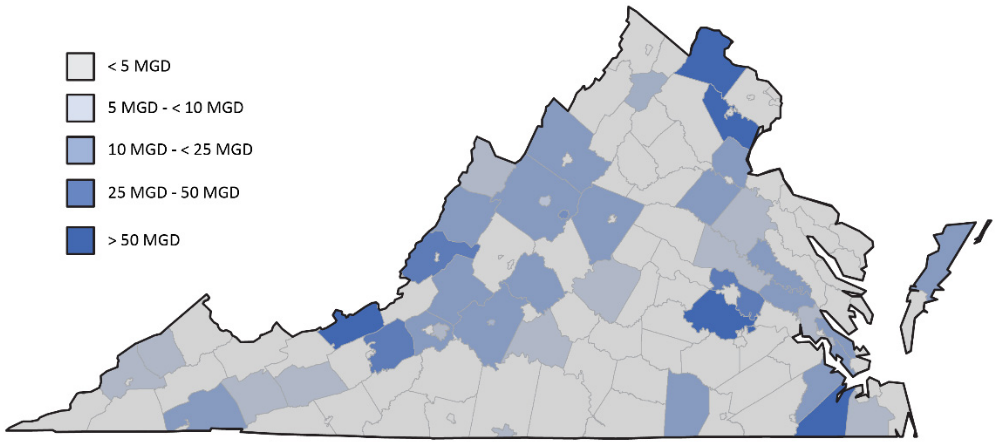
SOURCE: JLARC staff analysis of DEQ data.

The remaining 17 percent of withdrawals was consumptive use for purposes other than power generation. About 62 percent of these consumptive water withdrawals were estimated to be human consumption, primarily by municipal or regional water authorities that provide treated, clean water to businesses or residents in their homes. Industrial usage for manufacturing accounted for about 31 percent of consumptive withdrawals, with the largest withdrawals made by paper and chemical manufacturers. The remainder of withdrawals were for agriculture, irrigation, commercial, and mining activities.

The amount of water that is withdrawn varies substantially across Virginia. This is generally driven by the location of large industrial withdrawers and the state's population centers that require public water supplies. The heaviest withdrawals are generally concentrated in the most populated localities in the northern, central, and southeastern parts of the state (Figure 1-2). The exceptions are large industrial withdrawals in the southwestern part of the state.

Harnessing water for use often requires extensive and costly infrastructure to withdraw the water from its source, store it for later use, treat it to remove impurities, then distribute it to various users. This infrastructure can consist of various types of man-made reservoirs, wells, treatment plants, and distribution pipes. The cost of obtaining water can vary widely and depends heavily on the infrastructure needed to withdraw, treat, and distribute it. Water that requires extensive treatment, or that must be piped long distances for storage or use, is generally costlier.

FIGURE 1-2
Total water withdrawals vary substantially across Virginia



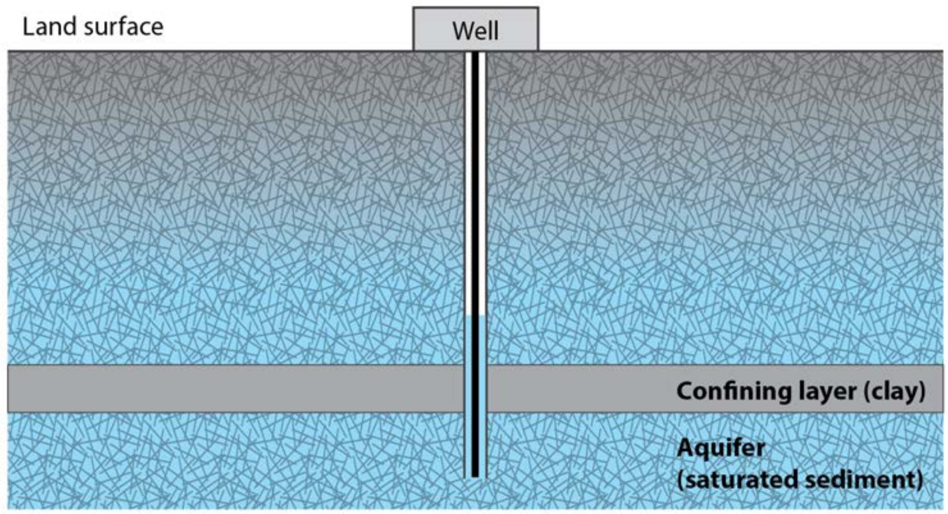
SOURCE: JLARC staff analysis of DEQ data.
NOTE: MGD = millions of gallons per day.

Water is withdrawn from surface and groundwater sources

Virginia has two sources of water: surface water in rivers, streams and other surface water bodies; and groundwater located in underground spaces known as "aquifers." The vast majority of water used in Virginia is withdrawn from surface water sources. Surface water is used for nearly 90 percent of all consumptive withdrawals, primarily from the state's network of rivers, streams, and man-made reservoirs. Virginia receives an average of 45 inches of precipitation each year, well above the national average of 31 inches. This precipitation directly recharges the amount of water available in surface water bodies.

Groundwater is the source of only 10 percent of consumptive withdrawals in Virginia and exists below ground in a complex network of aquifers. An aquifer is an underground layer of porous sediment that contains water (Figure 1-3), and recharges relatively slowly as precipitation trickles down through the soil over time. Most groundwater is withdrawn using wells that extend from the land surface, often down hundreds of feet, through a confining layer of clay, into the aquifer where the water is located. A majority of groundwater withdrawals in 2014 were in eastern Virginia and from the coastal aquifer, part of a vast aquifer along the east coast stretching from Alabama to Long Island, New York. Other groundwater withdrawals were concentrated in the Shenandoah Valley and other parts of western Virginia.

FIGURE 1-3
Aquifers are underground layers of sediment that contain water



SOURCE: Virginia Department of Environmental Quality and US Geological Survey.
NOTE: Figure is simplified for illustration purposes.

Water resource management attempts to ensure adequate water supplies to meet demands

Water resource management activities are intended to ensure that water supplies are available to meet the full range of human and environmental purposes. A central challenge in water resource management is ensuring that water withdrawals are sustainable. Water withdrawals are considered sustainable when they can be maintained indefinitely to meet the full range of human and environmental water purposes without causing unacceptable adverse effects on other users or the environment. Water withdrawals are unsustainable when they exceed—or are predicted to exceed—the available supply of water in surface water bodies and aquifers.

If water withdrawals continue at unsustainable rates, they can cause water shortfalls in which the supply of water is not adequate to meet the full range of human and environment purposes. Water shortfalls can have significant negative impacts on residential users and public water suppliers, manufacturers and other businesses, farmers, and other users. These impacts frequently include higher costs of obtaining water, which can increase water utility rates for customers of public water suppliers. Higher costs of obtaining water can also hinder state and local economic development by limiting the ability of water-intensive manufacturers to maintain or expand operations.

Water shortfalls can have significant negative impacts on the environment. Withdrawals that leave insufficient water in rivers and streams can harm fish and other aquatic species, and hinder the assimilation of waste materials, diminishing the quality of water. In the case of groundwater, withdrawals that cause underground water levels to drop too low can cause soil compaction, which can permanently reduce an aquifer's capacity to store water. Declining water levels in aquifers near the coast can result in the saltwater contamination of drinking water wells as underground saltwater flows into emptied aquifers.

Water sustainability can be influenced over time in two important ways. First, the amount of water available for human use can be increased through new water supply projects. These projects can include building new reservoirs to store water for later use and transferring water from areas with greater supplies. Various techniques are increasingly available to reclaim or reuse water by treating wastewater or desalinating seawater or brackish surface and groundwater in coastal areas. Some projects apply only to groundwater, such as artificially replenishing depleted aquifers through water injections.

Second, demand for water can be reduced or maintained through conservation, permitting, and technological advancements. Common practices include promoting voluntary conservation, especially during droughts, and repairing or replacing leaky infrastructure to reduce water loss. Permitting programs can be used to manage the amounts and locations of larger water withdrawals by public water suppliers, industrial users, and others to minimize the impacts of their withdrawals on other water users and the environment. Demand for water can also be reduced through technological improvements to processes and machinery—household, agricultural, commercial, and industrial—that require water.

The ability to influence sustainability, especially in the near term, depends on the type of water and specific characteristics of a geographic area. Surface water is usually replenished seasonally or annually, depending on precipitation. Ensuring the sustainability of surface water involves maintaining a minimum volume of water in a river or stream by limiting withdrawals or having reservoirs release water during dry or drought periods. Larger withdrawals are likely more feasible when precipitation is greater. Groundwater, in contrast, may be essentially a finite resource, depending on the rate at which it is replenished by precipitation and surface water. Groundwater far below the earth's surface and under dense layers of soil and rock, like the coastal aquifer in eastern Virginia, requires thousands of years to recharge naturally. These aquifers may require permitting or other limits on withdrawals to ensure they remain available over the long term. Groundwater much closer to the surface, like in the aquifers of western Virginia, recharges more quickly, often over months or years, and can be managed similarly to surface water.

Virginia manages water resources primarily by conducting long-range planning and issuing permits

Historically, state and local governments have played a limited role in determining who uses water. Water use in Virginia has been governed by the common law doctrine of riparian rights, which has been in place for the majority of the Commonwealth's existence and generally gives landowners the right to use water that is on, adjacent to, or below their land. Under the doctrine, conflicts among water users are resolved by the court system using case law. As the state's population has increased and the demand for water has grown, this doctrine has been supplemented by state and local efforts to manage water resources. Water resource management efforts aimed at protecting the full range of human and environmental water uses have been implemented through the state statutory framework as well as state and local regulations.

The Constitution of Virginia sets forth water as a general policy priority, and the Code of Virginia gives the State Water Control Board (SWCB) broad authority over water quality and quantity. The SWCB is one three primary state entities responsible for managing water resources in Virginia (Figure 1-4). The SWCB is responsible for administering the State Water Control Law (§§ 62.1-44.2 to 62.1-44.34:28), and in the context of water quantity, is directed to formulate a coordinated state policy for the use of state water resources (§ 62.1-44.36). In formulating this policy, the SWCB is directed to consider several principles, including:

- protecting and preserving existing water rights subject to the principle that all waters in Virginia belong to the public;
- giving preference to water for human consumption over all other uses when proposed uses are in conflict or water supplies are insufficient;
- maintaining sufficient stream flows to support aquatic life and minimize water pollution; and
- integrating and coordinating water uses and augmenting water supplies to support economic development.

The Virginia Department of Environmental Quality (DEQ) executes much of the state's role on behalf of the SWCB. The State Water Commission, which comprises legislative and non-legislative citizen members, is responsible for coordinating legislative recommendations regarding water supply and allocation issues in Virginia.

The federal government has very limited involvement in managing the supply of, and demand for, water. Its primary role is to ensure that water is of acceptable quality for its various human and environmental purposes. This federal role, and the topic of water quality, generally, are outside the scope of this report.

FIGURE 1-4
Three state entities have primary responsibility for managing water resources in Virginia

Legislative

State Water Commission
- Coordinate legislative activity regarding water supply and allocation
- Study water supply and allocation problems

Regulatory

State Water Control Board
- Develop regulations for surface and groundwater withdrawal permitting
- Designate surface and groundwater management areas
- Develop state policy for conserving and developing water resources

Implementation

DEQ Office of Water Supply
- Administer surface and groundwater withdrawal permitting programs
- Conduct state water resource planning
- Assess sustainability of surface and groundwater

SOURCE: Code of Virginia.

DEQ collects and analyzes water supply and demand data, which indicate sustainability challenges

DEQ collects data from various parts of the state to monitor both surface and groundwater usage. It collects data about the quantity of surface water to help decide how much water can be used and determine the severity of floods or droughts. This data collection is through a variety of methods, including measurement of the volume of water moving through various streams. DEQ also collects data about the quantity of groundwater to understand the impact of permitted withdrawals. The agency spends about $1.7 million annually for its data collection and analysis efforts, which encompass water supply and demand.

According to DEQ, recent predictions using these data inputs and its modeling capabilities suggest water may not be sustainable to meet future demand, especially in certain parts of eastern Virginia. DEQ has indicated that current withdrawals from the coastal aquifer in the region are not sustainable and are contributing to land subsidence and saltwater contamination of drinking water wells. To protect the long-term viability of the aquifer, the department is currently negotiating permit reductions with the 14 largest groundwater permit holders in the region, including paper mills in Franklin City and the town of West Point, as well as the water authority serving James City County. In addition, the 2015 General Assembly created the Eastern Virginia Groundwater Management Advisory Committee to assist the State Water Commission and DEQ in developing a management strategy for the coastal aquifer (sidebar).

Eastern Virginia Groundwater Management Advisory Committee and its workgroups have been meeting regularly since summer 2015 and by August 1, 2017 must develop statutory, budgetary, and regulatory recommendations to improve the long-term sustainability of the aquifer.

DEQ has also asserted that long-term surface water use may not be sustainable in several parts of Virginia. Based on estimates provided by localities, the department predicts a 32 percent increase in water demand statewide through 2040, with the largest increases concentrated in central, eastern, and northern Virginia.

Statewide water resources plan was developed using local plans

The state, through DEQ and the SWCB, oversees a planning process to develop and maintain local, regional, and state water supply plans. Under Code, the SWCB is tasked with establishing a comprehensive water supply planning process (§ 62.1-44.38:1). Virginia's first statewide water resources plan was completed in 2015 and attempts to assess the sustainability of surface and groundwater resources over 30 years (through 2040). DEQ indicates the plan is intended to help state and local policy-makers develop more informed water management policies and water supply projects. The plan was developed by DEQ staff with information from local and regional water supply plans, and uses complex computer simulation modeling to assess sustainability. The state plan examines water quantity statewide, identifies areas of the state where future demand is likely to strain water supplies, and makes recommendations to ensure sustainability. DEQ is required to update the analysis and findings of the state plan every five years.

Localities are responsible for developing plans to ensure a sufficient supply of water to meet residential, industrial, commercial, and agricultural purposes, but not environmental purposes, as directed in the state plan. There are a total of 48 local plans that DEQ reviewed and used to help develop the statewide plan (there are fewer local plans than total localities because some localities participated in regional planning efforts rather than producing their own plans).

State issues permits for water use, but most water withdrawals do not require permits

The minimal role that government has historically played in water use means that the majority of water withdrawn in Virginia is not subject to permitting requirements. DEQ administers two permitting programs for water supply and demand, but many water withdrawals are exempt from permitting. DEQ administers the Virginia Water Protection Permit program, which requires permits for any withdrawal of 300,000 gallons or more per month from surface water sources. However, any user of surface water that was making withdrawals prior to 1989 is not required to obtain a permit unless the amount withdrawn is increased. These and other surface water withdrawals exempt from permitting represent an estimated 80 percent of surface water used in Virginia.

DEQ also issues groundwater withdrawal permits in parts of the state designated by the SWCB as groundwater management areas. Only users within the eastern Virginia or Eastern Shore management areas and withdrawing 300,000 gallons or more per month must obtain a groundwater withdrawal permit. Users in these regions withdrawing less than this threshold, and all users in the rest of the state, do not need permits. Statewide, slightly less than half of all groundwater withdrawals are subject to permitting requirements. DEQ spends about $1.1 million annually for its surface and groundwater withdrawal permitting efforts. Nearly half of these funds are raised through a fee charged to obtain a permit.

2 Sustainability of Groundwater in Eastern Virginia

SUMMARY Ongoing efforts to reduce allowable withdrawal amounts will—if successfully completed—improve the sustainability of groundwater in eastern Virginia. Groundwater use will likely be sustainable over the next few years, but in the longer term growth in unpermitted and permitted withdrawals can still easily lead to unsustainable use. There will likely not be enough groundwater to accommodate future growth in the region without additional permit reductions or increasing supply through large-scale, long-term water projects. In fact, a public water supplier in the region has already begun to pursue more costly alternatives to groundwater. The extent and timing of additional sustainability difficulties will depend on the rates of growth in permitted and unpermitted use. In the future, though, it will most likely be difficult for large new industrial water users to open and operate in eastern Virginia.

The purpose of predicting the sustainability of groundwater is to gain insight into when, if ever, there will be insufficient water. This is especially important in eastern Virginia because groundwater contained in aquifers has been a source of low-cost, high-quality water for human consumption, industrial, and other use for more than a century and fresh surface water options are often limited in the region. The coastal plain aquifer system, which stretches from the I-95 corridor to the shore of the Chesapeake Bay, is made up of multiple distinct confined aquifers stacked atop one another and separated by layers of clay and rock (Figure 2-1). The aquifer system supplies industrial, public water supply, agricultural, and domestic residential users who rely on private wells. The Potomac aquifer is the largest, deepest, and generally most productive aquifer layer. More than 90 percent of reported use of the aquifer system in 2015 was from the Potomac aquifer, according to DEQ.

Groundwater in eastern Virginia is both inexpensive to access and very high quality.

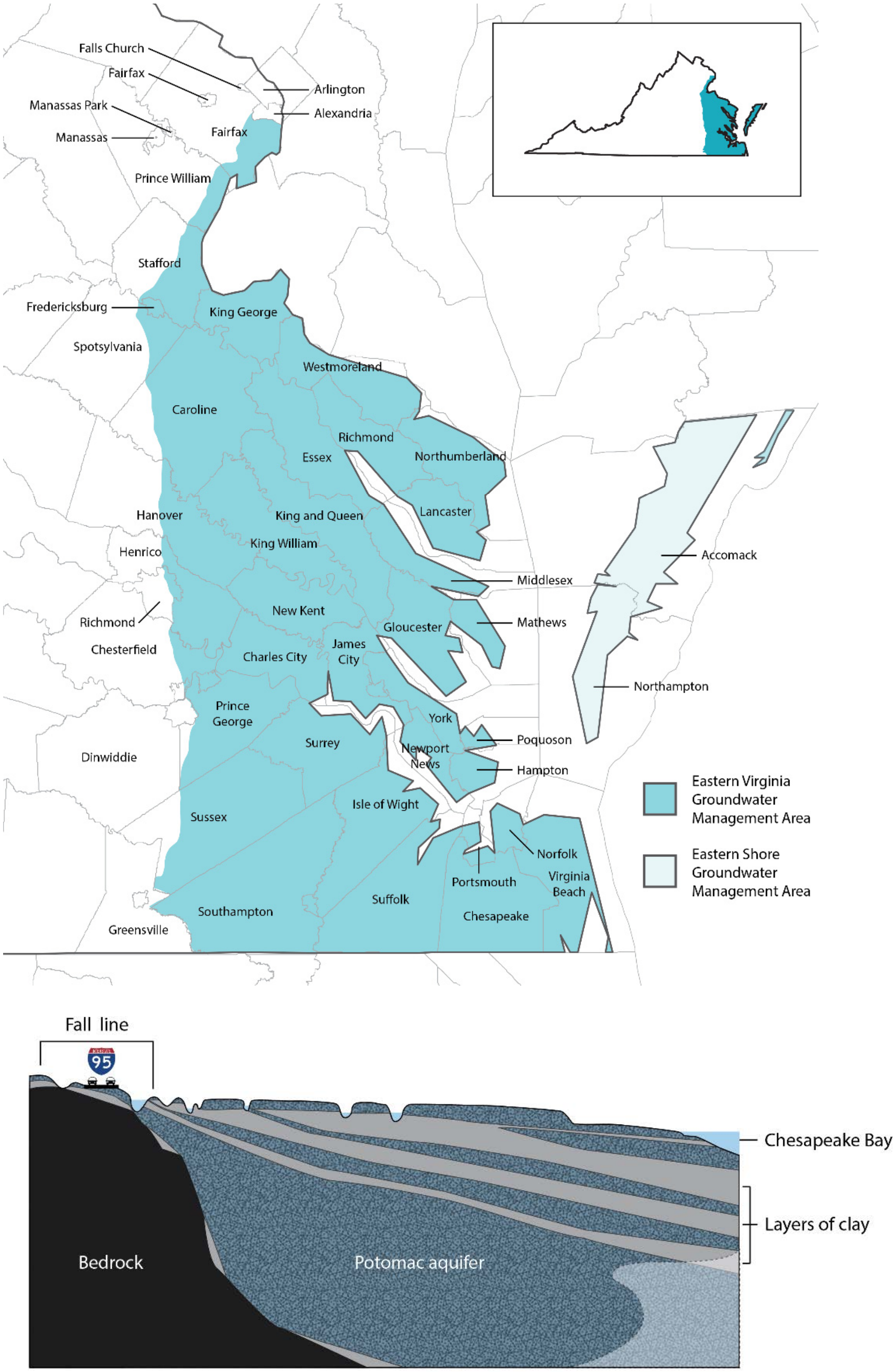
The cost to access groundwater is low because the natural pressure of the aquifer reduces the need for pumping. Water can be accessed with wells at almost any location, which minimizes the need for piping infrastructure.

The quality of the water is high because it has been naturally filtered over a long period of time along its route from surface to aquifer.

The state currently uses a computer simulation model to make long-range predictions about groundwater sustainability in Virginia's coastal aquifer system. The groundwater model is used to predict changes in water levels in the aquifer system and to evaluate whether withdrawals being proposed in groundwater permit applications meet state regulatory criteria.

JLARC worked with the Virginia Water Resources Research Center (VWRRC) at Virginia Tech to evaluate the modeling, assumptions, and sustainability conclusions being presented by DEQ. JLARC staff also interviewed numerous experts in the area of groundwater modeling and sustainability to learn more about modeling and the impacts of groundwater shortfalls.

FIGURE 2-1
Virginia's coastal plain aquifer system stretches from I-95 to the Chesapeake Bay



SOURCE: USGS data and DEQ.
NOTE: Generalized display of the Virginia coastal plain aquifer system. Not to scale.

Even with recent reductions, maintaining groundwater sustainability will be difficult

Even with the recent reductions to permitted use, the state will face continued difficulty ensuring the sustainability of withdrawals from the coastal plain aquifer system because of potential increases in withdrawals by permitted and unpermitted users. In the very near term, groundwater withdrawals are likely to be sustainable. Assuming DEQ achieves the proposed permit reductions it is currently negotiating and current reported withdrawals continue unchanged over the next few years, water levels are predicted to show only small declines and fall below regulatory minimum levels in only a few parts of the aquifer over 50 years. This means that, at least during the next few years, supply and demand will be approximately the same.

Beyond the next few years, though, sustainability is tenuous and can easily be tipped out of balance. Potential growth in both unpermitted and permitted withdrawals can easily push demand in excess of supply, leading again to unsustainable use. Predictions of when withdrawal rates would become unsustainable depend on two main variables: the geographic location of the growth and the rate of increase in withdrawals. DEQ can address the latter through the permit cycle, but only for permitted uses.

Unpermitted withdrawals, currently estimated at 40 million gallons per day (MGD), are predicted to increase by one MGD annually over the next decade. DEQ does not have the authority to regulate the growth of the smaller, unpermitted withdrawals—less than 300,000 gallons per month—that are used for residential, agricultural, commercial, or industrial purposes. Consequently, in order to accommodate growth in unpermitted withdrawals, future withdrawal reductions would have to come from permitted users.

Permitted withdrawers will likely be withdrawing between 43 and 58 MGD in the near term if the reductions DEQ is negotiating with the 14 largest permit holders are finalized. (See Chapter 5 for information on current efforts by DEQ to reduce permitting.) These permitted users, though, have substantial additional permitted capacity that they can use if they wish. Even relatively small increases in withdrawals by permitted users, in combination with the projected growth in unpermitted use, will lead to demand being greater than supply, leading again to unsustainable use. The amount of groundwater allowed to be consumed by permitted and unpermitted users leaves very little available withdrawal capacity to issue new permits.

These negotiated reductions have in part been necessary because DEQ concluded that permitted groundwater withdrawals were over-allocated, primarily due to weaknesses in the old model it used to predict sustainability (sidebar). Unless changes are made, withdrawals at maximum permitted and current reported rates would cause continued declines in water levels. As a result, areas of the aquifer system would

DEQ's prior groundwater model was based on an outdated geological and hydrogeological understanding of the coastal plain aquifer system. The model and data collected were insufficient to predict the impact of withdrawals over time. DEQ stopped using this model in 2012.

Over-allocation of permits occurred because the groundwater model was inadequate. The current model, adopted in 2012, revealed the over-allocation due to the prior model.

likely fall below regulatory minimum levels within the next 50 years. Analysis conducted on behalf of JLARC by VWRRC at Virginia Tech validated this conclusion. A total of 130 square miles of the Potomac aquifer would fall below regulatory minimum levels under the current reported withdrawal simulation, with a majority of those areas being near the fall line just east of Richmond, in Henrico and Chesterfield Counties. The area of the aquifer that would fall below regulatory minimum levels under the maximum permitted scenario would be far more extensive.

Public suppliers have been negatively impacted and economic development may also be hindered

Public water suppliers have already been negatively impacted by the unsustainable use of groundwater in eastern Virginia. For example, in response to DEQ's initiative to reduce its groundwater permit, the James City Service Authority (JCSA), which provides water and wastewater service for James City County, has recently embarked on a long-term, $128 million water surface water supply project that will reduce its reliance on groundwater. This project will raise the cost of water for residential users that rely on this public water supplier. At least five other public water suppliers in the region could face a similar dilemma in the future because their maximum permitted withdrawals are being reduced, which will limit their ability to accommodate growth through increased groundwater withdrawals. (See Chapter 5 on the impact of unsustainability on public water suppliers and how the permit process can be used to address it.)

In the future, this unsustainable use will also potentially hinder economic development. It is highly unlikely that the state can grant any new, large withdrawals by industrial or other potential users. Analysis conducted on behalf of JLARC by VWRRC at Virginia Tech concluded that proposed withdrawals of moderate to large amounts are likely to cause water levels to fall below minimum thresholds and therefore be denied by DEQ. (See Appendix C for information on why future withdrawals would likely be denied.) Because of the aquifer's characteristics and location of current users, the extent of additional permits that could be issued depends in part on the location of the withdrawal.

JLARC surveyed local economic development staff across Virginia to better understand how the availability of water affects economic development efforts.

Difficulty in acquiring new permits will make it challenging for businesses that use substantial amounts of water to locate in eastern Virginia. About 85 percent of local economic developers responding to a JLARC survey reported that availability and affordability of water were important factors for at least one new project during the past three years. The survey respondents reported three separate instances when potential projects did not materialize because developers believed that obtaining a permit for groundwater would be difficult. In addition, at any given time DEQ can have several businesses that have submitted a new permit application and are waiting for approval to withdraw more groundwater. Some water-intensive businesses, such as advanced manufacturing firms that make microchips or those that process food and beverages, may have difficulty identifying a location in the aquifer where they can obtain a permit from DEQ for the water they need. Some large users may be forced to find alternative water sources, many of which are lower quality and higher cost than groundwater.

State makes reliable predictions about groundwater sustainability

The state's approach to predicting groundwater sustainability in eastern Virginia is now rigorous and reliable enough to be used for decision-making as part of the state's water planning and permitting process. DEQ has chosen an appropriate model, VAHydro-GW, originally developed by staff of the U.S. Geological Survey (USGS), to predict the sustainability of groundwater in eastern Virginia. DEQ began using this model in 2012, when it replaced the prior model that had a number of weaknesses. According to VWRRC, "the VAHydro-GW model is a sophisticated quantitative tool and is the best available option for this work."

VAHydro-GW model is a computer simulation of groundwater conditions in the coastal plain aquifer system that DEQ uses to predict future groundwater levels resulting from groundwater withdrawals. DEQ also uses VAHydro-GW to perform the technical evaluation component for groundwater permit applications in the Eastern Virginia Groundwater Management Area.

The model has a number of strengths that yield reliable predictions (Table 2-1). For example, the model incorporates the most comprehensive and recent understanding of the geology and hydrology in the coastal plain aquifer system and includes a rigorous calibration to verify model results compared to actual observed water levels. Prior reviews of the model by independent consultants and researchers with the USGS have reached similar conclusions. (See Appendix C for more information about the VAHydro-GW model.)

TABLE 2-1
Primary strengths of the groundwater model

Strength	Description
Up-to-date understanding of aquifer	• Model includes most up-to-date understanding of the aquifer's physical structure and how water moves in it • Model incorporates meteor impact crater and location of saltwater transition boundary
Comprehensive network of monitoring wells	• Model includes data from a network of over 400 monitoring wells throughout the region • Monitoring network is particularly strong in areas with high population and where many withdrawals are located
Rigorous / calibration	• Model predicts water levels in aquifer with an average error rate of 3.6 feet • Model's calibration period spans from 1890 to 2012, making it suitable for predicting water levels 50 years into the future
Scale of model	• Model encompasses nearly the entire Eastern Virginia Groundwater Management Area to provide a view of the aquifer system in its totality • Model is precise enough to measure the impact of withdrawals on each layer of the aquifer at a scale of one square mile

SOURCE: USGS, Virginia DEQ, and research by VWRRC at Virginia Tech.

Many of the model's thresholds, which are stipulated in state regulations, seem reasonable given the goal of ensuring sustainable withdrawals. Chief among these is the threshold for no more than 80 percent of the water levels in the aquifer to be drawn down through permitted use (9VAC25-610-110.D). According to national experts and subject matter experts at Virginia Tech, even if groundwater levels decline as much as 80 percent, the remaining 20 percent provides a reasonable "buffer" to prevent water levels from falling below the top of the aquifer. (See Appendix C for information about regulatory criteria.)

Predictions can be improved by addressing land subsidence, saltwater intrusion, and smaller aquifers

More information can be developed to further improve the usefulness of the VAHydro-GW model's predictions. These improvements will be essential to better understand and respond as needed to the effects of the declining groundwater in the eastern Virginia aquifer. These improvements include better monitoring and modeling of

Land subsidence occurs when saturated soil in an aquifer settles as water is withdrawn. Any amount of groundwater withdrawal can lead to land subsidence. The amount of land subsidence generally increases with greater quantities of withdrawals. Land subsidence contributes to relative sea level rise and increases the risk of flooding in coastal and low lying areas.

- Land subsidence – There are only two land subsidence monitoring sites currently in operation, one in Franklin City and one in Suffolk County. DEQ has recently added the capability to predict land subsidence but needs more and better quality data to improve the accuracy of predictions.
- Saltwater intrusion – There are very few saltwater intrusion monitoring sites. DEQ is modifying the model to predict the changes in salt concentrations that may occur as a result of withdrawals, but accurate predictions will require more and better quality data.
- Water levels in less commonly used parts of the aquifer system – There are only a few water level monitoring sites in the smaller Piney Point and Aquia aquifers and in the northern and southwestern regions of the Potomac aquifer. Although the model can predict changes in water levels in these areas, DEQ needs more and better quality data to calibrate predictions with actual water levels.

Saltwater intrusion, the contamination of groundwater with chloride, occurs when groundwater withdrawals allow saltwater to enter freshwater aquifers. Saltwater intrusion changes the concentration of salt in groundwater, so that water may require additional treatment.

Having so few monitoring sites limits DEQ's ability to precisely understand and predict the consequences of withdrawals from all portions of the coastal aquifer. Land subsidence and saltwater intrusion pose threats to coastal Virginia by contributing to relative sea level rise and the contamination of groundwater wells, respectively. Improving the accuracy of model predictions through additional monitoring is critical for the state to effectively manage the impact of groundwater withdrawals on water levels, land subsidence, and saltwater intrusion.

DEQ should identify the highest priority locations for additional monitoring sites. Monitoring sites for land subsidence and saltwater intrusion could be developed first in areas at greatest risk for declining land levels or changes in salt concentrations. These sites and the reasons why they are the highest priority should be identified and updated as needed. Monitoring sites for less commonly used parts of the aquifer system could be developed first in areas where population growth is occurring or new withdrawals are being proposed. Placing these monitoring sites in the most needed locations is critical because an individual site can cost between $500,000 and $1 million. Based on the sites identified by DEQ as the highest priorities, the General Assembly could then consider providing funding for the construction of additional sites.

RECOMMENDATION 1

The General Assembly may wish to consider including language in the Appropriation Act directing the Virginia Department of Environmental Quality to identify high priority locations for additional sites for monitoring land subsidence, salt concentration, and groundwater level. Priority should be assigned based on (i) high potential to improve the accuracy of the state's modeling predictions for land subsidence, salt concentrations, and groundwater levels, and (ii) cost-effectiveness.

3 Sustainability of Surface Water

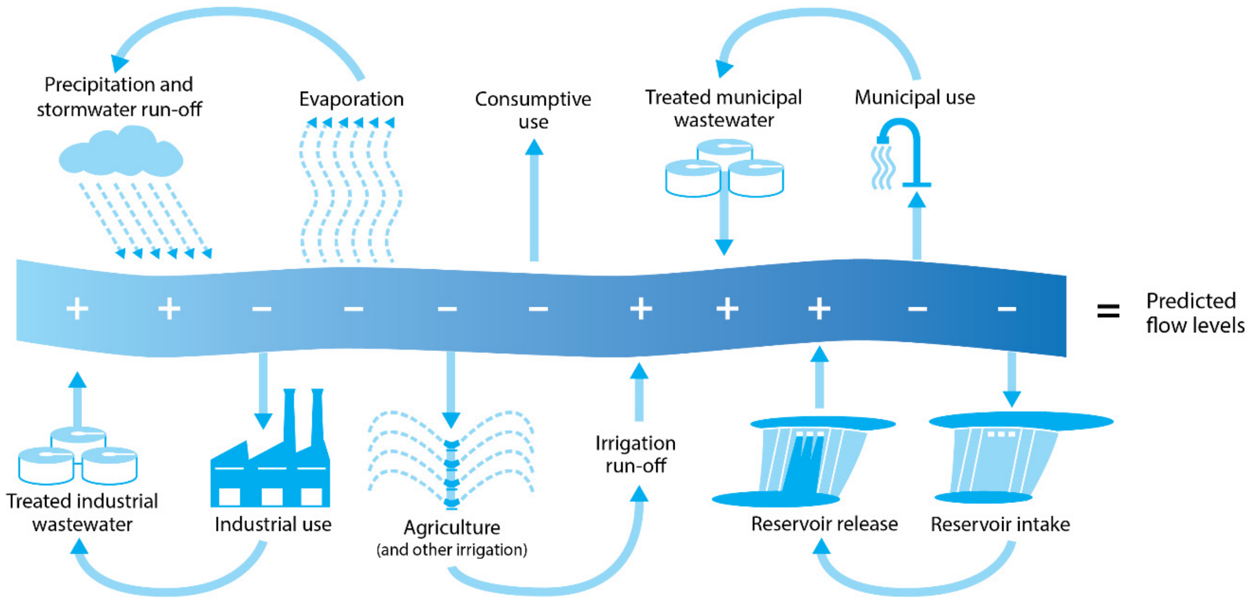
SUMMARY Even though certain parts of the state came close to experiencing serious surface water shortfalls in 2002, the state still lacks the ability to make accurate predictions of the location, timing, and magnitude of future potential surface water shortfalls. The uncertainty exists because of the inherent complexity in predicting future surface water supply and demand, but also because current state predictions are not reliable enough to use for decision-making. The lack of reliability stems from a variety of limitations, including major gaps in data about current surface water usage and unrealistic or imprecise assumptions about future demand and supply. The Virginia Department of Environmental Quality could improve the reliability of its surface water sustainability predictions by using more realistic assumptions and running multiple modeling scenarios using a range of likely assumptions. Once these limitations are addressed, the improved sustainability predictions can be used to identify the surface water segments at greatest risk for water shortfalls, which can then be subject to additional data collection and more detailed analysis.

The purpose of predicting the sustainability of surface water is to gain insight into when, if ever, rivers, streams, and other bodies of surface water may not contain enough water to fulfill both human and environmental purposes. This is critically important because rivers and streams are the primary or only source of water for the majority of Virginians and serve a number of other purposes such as providing habitat for aquatic species. Concern about the sustainability of surface water in Virginia is warranted. In 2002, during the most extreme drought ever recorded in many parts of the state, certain moderate to large public water suppliers were within 60 days of running out of water. Other water suppliers were forced to move intake valves to alternative locations in a river, or to a different river altogether, in order to withdraw enough water to meet demand.

The state currently uses a computer simulation model to predict how surface water supply and demand may interact over time and how that interaction is likely to affect the sustainability of surface water. These predictions are used to complement the surface water permitting process and to identify parts of the state that may experience future shortfalls.

Making reliable, usable simulations, though, is challenging because of the complexity of surface water systems and general difficulty associated with predicting future human and climate behavior. There are many variables that affect surface water sustainability (Figure 3-1). The amount and frequency of future precipitation is one of the most challenging aspects of surface water to predict.

Figure 3-1
Many variables influence surface water sustainability



JLARC staff worked with the Virginia Water Resources Research Center (VWRRC) at Virginia Tech to evaluate the modeling, assumptions, and sustainability conclusions being presented by DEQ. JLARC staff also interviewed numerous surface water modeling and sustainability experts.

Demand for water is difficult to predict, and planning entities in Virginia and around the nation have faced similar challenges. The Interstate Commission on the Potomac River Basin, which conducts water resource planning for the Potomac River Basin, had predicted that water demand would increase by approximately 32 percent in the region from 2000 to 2015. In reality, water demand decreased by approximately 10 percent over that time period.

Data, estimates, and state's approach limit the reliability of surface water sustainability predictions

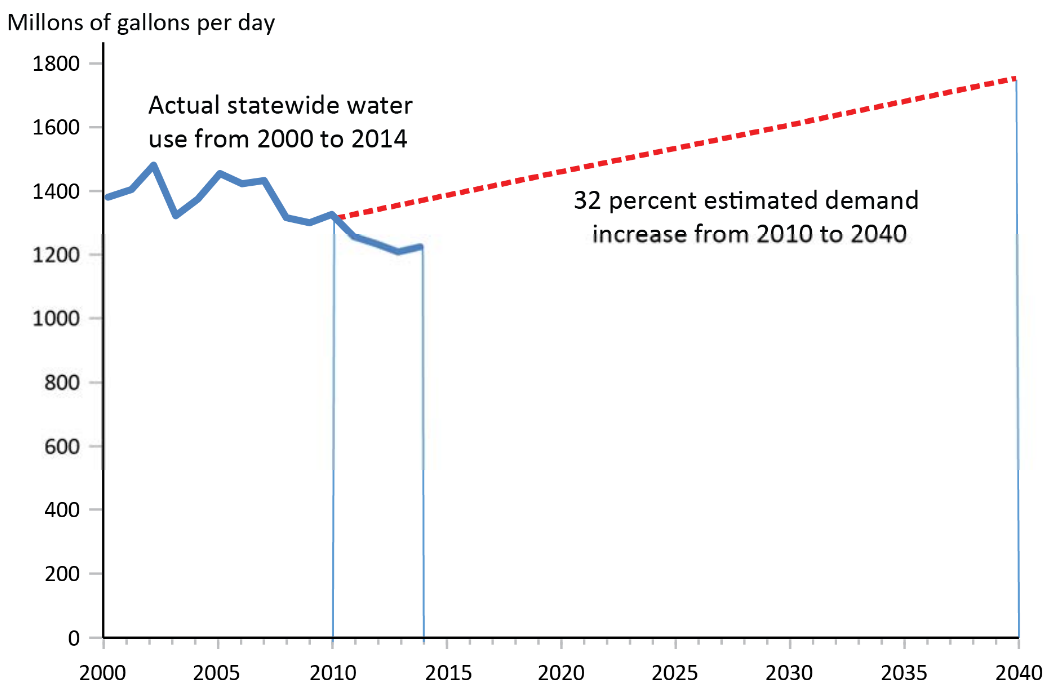
The state's surface water sustainability modeling is currently not reliable enough to inform planning decisions. This is due to five fundamental limitations, which are related to the difficulties inherent in predicting future population and water consumption behavior; uneven data collection; and subjective or faulty assumptions.

The first limitation is that the state lacks data about much of the surface water usage in the state, primarily because many users do not report the quantity, timing, and location of their water usage. The Code of Virginia requires water users to report withdrawals for crop irrigation that exceed one million gallons in any single month, and withdrawals for all other purposes that average more than 10,000 gallons per day in a single month, but many users fail to report their withdrawals as required (§ 62.1-44.38). DEQ has water usage data for permit holders, but the agency does not have this data for unpermitted users that do not report their withdrawals. The computer simulation model is calibrated to correct for unknown usage to the greatest extent possible, but the lack of data still substantially limits the reliability of the model.

The second limitation with predictions of sustainability is with the estimate of future water demand in the state water resources plan, which appears to overstate the likely growth of demand. It assumes that demand and population each will increase approximately 32 percent statewide by 2040 (Figure 3-2). In effect, the current estimate assumes that per capita water consumption will not change and that increases in future water use will correspond to future population growth. However, statewide water use has actually declined in recent years, despite population growth, primarily because of the adoption of more water-efficient technologies. Total statewide water use has declined by 10.1 percent since 2000, even as population has grown by 17.2 percent during that time period. It is likely that declines in per capita water use will slow as fewer inefficient technologies are left to replace, but it is unclear to what extent, making it difficult to predict how future water usage will change with population growth.

To more accurately predict future water demand, DEQ should examine the potential for further declines in per capita consumption by reviewing the research literature and consulting with water resource planners around the state. During the next planning cycle, the department should also develop and use a range of future demand estimates based on differing, but still likely, assumptions for per capita water consumption.

FIGURE 3-2
Given prior growth in demand for water, future estimates seem unrealistic



SOURCE: DEQ Status of Virginia's Water Resources Report and DEQ State Water Resources Plan.
NOTE: Data exclude non-consumptive withdrawals for power generation.

The third limitation is that future supply estimates in the state water resources plan do not fully account for the return of water to the water supply or for the effect of rising temperatures and changes in precipitation patterns. Supply predictions for new future withdrawals do not incorporate any estimate of water returned to the system because the ratio and location of return are difficult to predict. In reality, supply is often replenished to some degree; public water suppliers and most large industrial users treat and return some used water to rivers and streams. The current surface water model also assumes that temperature and precipitation patterns will remain relatively constant, but there is widespread agreement that temperatures and precipitation patterns are changing in ways that are likely to affect water supply: more surface water may be lost through evaporation due to higher temperatures and precipitation may occur with greater volume but with longer periods between rainfall events, causing greater fluctuation in water supply. Although future water supply is difficult to predict, DEQ should attempt to develop reasonable assumptions for the return of used water and temperature and precipitation patterns in the future. To do so, the department may need to review research literature and consult with water resource researchers and planners. During the next planning cycle, DEQ should also run multiple modeling scenarios to examine how differing assumptions for future water supply change its sustainability predictions.

RECOMMENDATION 2

The Virginia Department of Environmental Quality should improve the accuracy of and confidence in its surface water demand and supply estimates through steps such as (i) reviewing research literature and consulting water resource researchers and planners to refine assumptions, and (ii) using a range of possible supply and demand assumptions to conduct multiple modeling scenarios.

Surface water shortfalls are identified for river or stream segments where water levels are predicted to fall more than a certain percentage (threshold percentage) below one or more of four low-flow metrics.

Low flow metrics represent a range of dry or drought conditions at which it may become difficult for water supplies to meet all human and environmental needs.

(Definitions are from DEQ. See Appendix D.)

The fourth limitation is that the state uses subjective percentages as the thresholds to predict surface water shortfalls. Even small changes in the percentage used can cause sizeable variation in the number of river and stream segments predicted to experience shortfall, according to analysis by VWRRC at Virginia Tech. There is no way to fully remove the subjectivity associated with setting the percentages, but DEQ should develop a more robust approach that relies on multiple methods to improve the quality of shortfall predictions in given geographic areas. Such an improved approach might include a scientific peer review of the percentages used as the thresholds for a shortfall, or the use of a variety of shortfall thresholds, such as the magnitude of a predicted decline and the number of thresholds exceeded.

The fifth limitation of the state's surface water predictions is that it is used to make only one prediction for a point in time 30 years in the future. The complexity of surface water sustainability necessitates running numerous scenarios with varying assumptions to produce a range of predictions for the near term and the longer term.

Such an approach would produce a better understanding of how supply and demand could interact over time to affect sustainability. Numerous scenarios could include different, but still likely, demand and supply estimates, and examine interim time periods of less than 30 years.

RECOMMENDATION 3

The Virginia Department of Environmental Quality should model scenarios of surface water sustainability using a range of (i) measures for a shortfall and (ii) intervals between 10 and 30 years.

Overcoming these limitations of the state's surface water sustainability predictions may require additional DEQ resources. Chapter 4 provides more information about the potential need for more DEQ resources for planning purposes.

Computer model state uses to make surface water predictions is appropriate

Although there are limitations to the data, estimates, and approach, the computer model used by DEQ is appropriate and well suited to the task. VAHydro, the model used to simulate and predict surface water sustainability, was adapted for use in Virginia from a widely-recognized modeling platform. VAHydro's characteristics also make it appropriate for modeling the behavior of various types of surface water. According to VWRRC,

> The obvious strength of the modeling is the effort and care taken by DEQ to build upon an accepted robust modeling tool developed by the Chesapeake Bay Program.… The strength of this model is that it incorporates a comprehensive, though empirical, representation of watershed and stream processes. It is a continuous (rather than event-based) model so it is particularly well-suited to modeling flows in streams over the long time periods that can occur between rainfall events, especially during low flow or drought conditions.

The VAHydro model is comprehensive and uses actual data about surface water flow. For example, the model accounts for a wide range of inputs that are known to impact flow levels, such as land use, known withdrawals and point source discharges, and reservoir operating patterns. The model is informed by comprehensive data on flow levels from an extensive network of stream monitors and gauges. Flow estimates are modeled using data from past measured flow levels over a 21-year period, which is considered adequate to represent the range of meteorological conditions common to Virginia. (See Appendix D for more information about the VAHydro model.)

Improved predictions can be used to target segments for additional reporting and analysis

Segments of rivers and streams, delineated by watershed, are used by DEQ for predicting surface water sustainability with VAHydro.

The 277 river and stream segments used in the model do not include those near the Atlantic Ocean and Chesapeake Bay, where water levels are affected by the tides.

(See Appendix D.)

Despite the complexity and challenges of predicting the sustainability of surface water resources, improving the predictions to inform decision-making is important because (1) the consequences of not having a sufficient supply of surface water may be severe; (2) the terms of water usage permits are long, once granted; and (3) the development of alternative water sources requires a long lead time. Additionally, effective state water planning efforts rely heavily on future predictions of water levels. Initial DEQ efforts to predict surface water sustainability, limitations notwithstanding, have been a valuable first step towards producing this important information.

After the reliability of the state's predictions has been improved as recommended above, the predictions made using the surface water model should be detailed enough to identify surface water segments at the greatest risk of experiencing future shortfalls. Identifying these segments will help crystalize where additional data reporting and analysis may be necessary to better understand the dynamics leading to the predicted shortfall. Identifying the segments will also reduce or eliminate sustainability concerns in parts of the state that have a very low risk of experiencing shortfalls in the future.

Once the surface water segments that have the greatest risk of experiencing shortfalls are identified, a methodology should be developed to build a more detailed understanding of the dynamics leading to the predicted shortfall. This is important because there may be data gaps or imprecise assumptions that, when corrected, reveal that there is actually less risk of shortfall occurring in some segments than initially predicted. Alternatively, this more detailed understanding may confirm a high risk of future shortfalls, at which point localities and others in the region can begin using the planning process to decide how best to address the potential shortfall. At a minimum, the methodology should consist of

- better understanding the usage and operating rules of unpermitted users and reservoirs;
- clarifying the exact location of withdrawals and point source discharges;
- reviewing and improving the methodology behind local demand estimates; and
- conducting additional streamflow monitoring.

RECOMMENDATION 4

The Virginia Department of Environmental Quality should identify the river and stream segments in Virginia at the greatest risk for a water shortfall and establish a methodology to determine the reasons for the predicted shortfalls.

As noted earlier in this chapter, some water users exempt from permit requirements under grandfather or other provisions do not report withdrawal data as required by statute. According to DEQ staff, the state lacks data for approximately half of surface water users that are exempt from permitting under grandfather and other exemptions. These exempt surface water users collectively accounted for an estimated 82 percent of the total surface water withdrawn statewide in 2013. Incomplete surface water withdrawal data creates a significant ongoing hindrance to DEQ's ability to accurately predict surface water sustainability. Data regarding the quantity, timing, and location of water withdrawals provides planning and modeling staff with a more accurate understanding of water use throughout the state, how that use impacts surface water levels, and what this means for future water sustainability. Water is a public resource and a finite commodity that faces increasing future demand. It is in the interest of all stakeholders that DEQ has access to the data it needs to accurately predict, and then prevent, future shortfalls.

DEQ does not have statutory authority to compel compliance with reporting requirements. Under current statute, there is no consequence or penalty for a water user that does not report their withdrawal as required. At least some of these users do not report because of concerns that reporting their withdrawals may make the state more likely to require permits or place other restrictions on their use in the future.

The 2011 General Assembly passed legislation (HB 1738) authorizing the State Water Control Board to impose a civil penalty of up to $1,000 on users that fail to register and report water withdrawal information required under statute. The legislation was vetoed by the governor, who cited a reluctance to place financial penalties on commercial and agricultural water users and the need to promote voluntary reporting.

The General Assembly may wish to consider similar legislation that would amend the Code of Virginia and allow the State Water Control Board to impose a civil penalty, but only for those users who (1) do not report their water usage in compliance with statutory requirements and (2) withdraw surface water from segments found by DEQ to be at the greatest risk of experiencing future shortfalls. The General Assembly could allay the concerns of some users by also amending the Code to state that reporting withdrawal data would not, absent other factors, alter the status of any existing exemptions to the surface water permitting requirements. DEQ could also continue to encourage grandfathered users and localities to report usage, including the operational rules by which reservoirs withdraw and release water, through the planning process.

RECOMMENDATION 5

The General Assembly may wish to consider amending § 62.1-44.38 of the Code of Virginia to (i) clarify that reporting water withdrawal information would not alter the status of existing exemptions from permitting under the Virginia Water Protection program and (ii) authorize the State Water Control Board to impose a civil penalty for failure to report water withdrawal information (as required under § 62.1-44.38) on users of water from the river and stream segments at greatest risk of shortfall.

For the surface water segments that are confirmed to be at high risk of future shortfalls, more precise steps can be taken to ensure a sufficient supply of surface water remains available to meet both human and environmental purposes. Water supply planning can then identify actionable strategies to prevent the shortfall from occurring, either through more stringent permitting, additional water supply projects, water conservation measures, or all three.

4 Water Planning

SUMMARY Virginia's state and local plans are not sufficient to fully inform stakeholders about the state's most pressing sustainability problems and how they will be addressed. The first state plan was a significant undertaking and has improved the state's understanding of water use. However, many stakeholders are minimally aware the plan exists or do not find it useful, while others do not believe their input was sufficiently considered when the plan was being developed. Many of the local water plans have been useful to local stakeholders, but localities did not sufficiently collaborate to develop regional plans. In the next planning cycle, plans need to be regional instead of local and aligned with common water use and needs. The state planning role needs to be focused on facilitating this regional collaboration and helping facilitate policies, expertise, and resources for each region as needed.

The purpose of water planning is to clearly define sustainability problems and articulate which entities will do what, by when, to address them. To achieve this, the State Water Control Board is required to "establish a comprehensive water supply planning process for the development of local, regional, and state water supply plans" (§ 62.1-44.38:1). Statute requires the plans to address groundwater and surface water sustainability, a requirement generally fulfilled by the plans, and to identify water management problems and ways to solve those problems.

State plan improved understanding of water use but is too vague to inform decision-making

Few states are currently predicting future water availability on a statewide scale. Most states make an effort to assess their water supply and calculate water use, but there is wide variation in the methods states employ to plan for their water supply. Especially in states with significant statewide variation in water supply and demand, compiling a single plan that is useful can be difficult.

Virginia's first statewide water plan, released in October 2015, contains a tremendous amount of information, including sections on current water use, sustainability, and water supply challenges and recommendations. The plan has several appendixes, including discussions by river basin of water use and sustainability. However, the state plan has thus far been used only minimally by stakeholders. The planning process did not sufficiently incorporate stakeholder input, and the plan itself is too vague to be used to make decisions.

A **river basin** is an area of land that drains into a particular river.

State plan improved understanding of water use and sustainability

The development of state and local water supply plans has enabled the state to obtain more comprehensive information on water use in Virginia. Analysis conducted on behalf of JLARC by the Virginia Water Resources Research Center at Virginia Tech concluded that a detailed, robust database of current and future water use calculations throughout the state is critical for effective water resource modeling, and the database constructed by DEQ for the development of the state plan made significant progress in achieving this. The plan incorporates DEQ's most comprehensive accounting of statewide water use to date. Localities and regions are required to include estimates of current and future water use as part of their local plans, and through this process DEQ obtained 300,000 additional pieces of data from users than previously recorded. DEQ historically has had difficulty ensuring compliance with statutory requirements for water withdrawal reporting. During the planning process, the department was able to target and gather additional information from certain types of users known to be underreporting, such as golf courses and agricultural users. In the future, DEQ may be able to accept information on water use via an online system, which could further increase the number of users DEQ is able to reach (sidebar).

DEQ is developing an **electronic data reporting system** by which localities will have the ability to submit their data directly online. This information will be available to DEQ for predicting the sustainability of surface water resources.

Localities and other water users will also be able to review data on current and predicted water use around the state in order to inform their own plans.

State plan is of limited use to stakeholders, whose input was not sufficiently incorporated

The vast majority of potential users of the state water plan have either not heard of the state plan, or are aware of it but have not yet looked at it. A plan only has value to the extent that it is used to make decisions, and by this measure the state plan currently has minimal value for stakeholders. A state plan could potentially be useful to local administrators and planners, municipal water suppliers, industrial or other large water users, and even economic development staff. The state plan was only released in 2015, so it is possible that some of these potential users simply have not yet had a reason to use the plan to inform their decision-making.

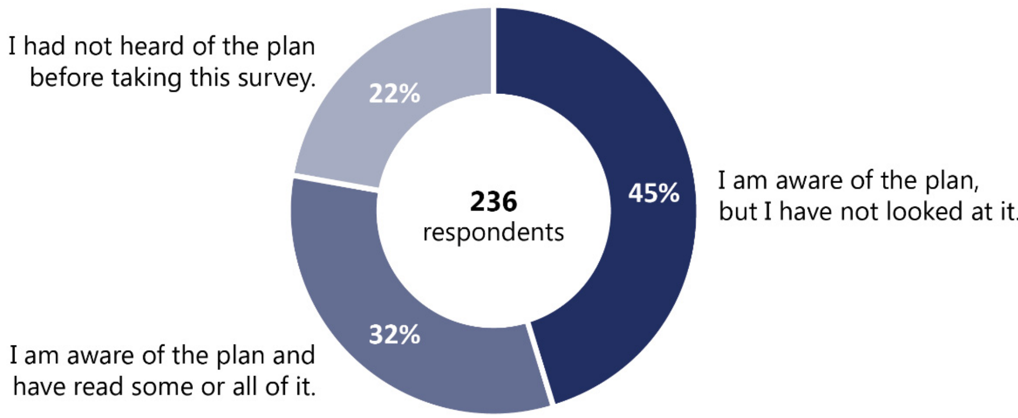
JLARC's survey of local water stakeholders included city and county administrators, public water suppliers, private industrial water users, and local economic developers.

Survey participants were asked for their opinions on state and local water plans, how water availability has affected economic development, and state water withdrawal permitting programs.

More than two-thirds of respondents to JLARC's survey of stakeholders reported that they had either not heard of the state plan or had heard of it but had not looked at it (Figure 4-1). Almost half of respondents indicated the latter, suggesting that even though DEQ notified the majority of local stakeholders of the plan's existence, many did not feel the need to read it.

The localities, public water suppliers, and businesses who indicated that they had used the plan most commonly reported that they used it to help anticipate changes to state legislation or regulations that may affect them (38 percent), and to verify or learn information on predicted water availability (35 percent) and current water use (31 percent). Fewer used it for purposes that more directly influenced their own planning efforts, including to consider: capital investments (22 percent), strategies to reduce water use (22 percent), and alternative sources of water (4 percent). (Note: Survey respondents could select more than one response.)

FIGURE 4-1
Two-thirds of local stakeholders have not reviewed the state plan



SOURCE: JLARC survey of local water stakeholders, 2016.

Several water users explained that they had not found a need to use the state plan because it does not contain actionable solutions for meeting their water supply needs. One public water supplier noted that while the plan identified challenges and issues, it fell short on offering strategies or solutions. Similarly, a large industrial user characterized the current plan as a list of problems. An economic developer suggested that the plan could be improved by giving it "more teeth" to enact solutions, describing the current plan as a "document that just sits on a shelf."

DEQ did not provide enough opportunities for stakeholder feedback in the planning process. During the development of the first plan, DEQ's efforts to involve stakeholders primarily included participation in the State Water Supply Plan Advisory Committee and a public comment period. The Advisory Committee gave a small number of stakeholders an opportunity to provide in-depth input in the planning process, but most stakeholders did not have this opportunity. DEQ received numerous public comments on the plan, but the agency did not act on them beyond acknowledging them in an appendix.

State Water Supply Plan Advisory Committee was established by the 2010 General Assembly to assist DEQ in "developing, revising, and implementing the state water resource plan." The committee met and discussed a variety of topics related to the plan and issued a final report in December 2012.

Many local stakeholders would be interested in contributing to the water resource planning effort in some capacity, according to the JLARC survey of stakeholders. Survey respondents most commonly indicated that they would like to participate by giving feedback on drafts of the plan, identifying water supply concerns to be included in the plan, and identifying strategies to address water supply concerns.

State plan does not set clear priorities or include actionable strategies

The state plan does not articulate specific priorities or sufficiently detail what the state will do to address those priorities, even though statute directs the State Water Control Board to "identify water management problems and alternative water management plans to address such problems" (§ 62.1-44.38). There are substantial water management problems that need to be addressed. Among these challenges are sustainability issues with eastern Virginia groundwater, the need to more reliably identify parts of the state at the greatest risk for surface water shortfalls, and important decisions that need to be made with the state's permitting and supply project development.

The state plan identifies 12 challenges, three of which pertain to water supply, but these three challenges do not encompass the scope of the state's water supply issues. For example, the plan does not address the important issue of water supply and demand in eastern Virginia. The plan offers recommendations to address each of its three water supply challenges, but the recommendations are not nearly specific enough to be acted upon (Table 4-1).

Of the three water supply challenges identified in the state plan, reservoir site development is likely the area where DEQ has the most control and potential to play a role. However, DEQ does not detail how and under what circumstances the agency would assist localities in developing reservoirs. Localities have reported difficulty with initiating these projects in the past. Some localities may have difficulty finding sites that comply with state and federal regulations; others may have difficulty finding sufficient space for a reservoir.

One locality described a need for help from the state with planning and advocating for large projects, such as reservoirs, that would support multiple localities. Another locality indicated a need for help from DEQ with obtaining permits from the US Army Corps of Engineers and the US Environmental Protection Agency. DEQ does not currently take on this role, and the plan does not explain how DEQ would support reservoir development.

TABLE 4-1
Water supply challenges and recommendations included in the state plan

Challenge	DEQ's recommendation
Reservoir site development is a difficult, resource-intensive process; in the future many localities will need to build reservoirs to meet their water needs.	DEQ will assist, as appropriate, in any efforts to optimize the use of reservoirs.
Water infrastructure is aging and probably leaking in many parts of the state, likely resulting in water loss.	DEQ will provide the Virginia Department of Health (VDH) with a list of localities whose water supply plans indicated that they have high water loss so VDH can consider them for funding to improve their infrastructure.
There is potential for water conflicts between localities.	DEQ will continue to work within the current regulatory framework to resolve conflicts identified in local and regional plans.

SOURCE: DEQ State Water Resource Plan, 2015.

The state water plan also includes challenges related to DEQ's data quality and management, water quality, and efforts to reduce water demand through conservation and raising public awareness of water supply issues. (See Appendix E.) Although addressing any of these topics could be beneficial to Virginia, they are not of equal importance to ensuring that the state is equipped to meet all future water needs.

Water planning should be more regional, with a targeted state role

Water plans need to be sufficiently detailed to inform decision-making. A major way to achieve this level of detail is to focus on specific geographic areas. During the state planning process, localities developed 48 local plans. These plans have improved the state's understanding of local water supply and demand, but they often do not include sufficient information to facilitate project development. Planning group boundaries do not adequately correspond to regional sharing of water use in river basins and subbasins.

In order to effectively manage Virginia's water, localities must work together to determine how to best meet their water needs. Regional planning allows localities to be more efficient with their time and resources. The nature and magnitude of sustainability problems—and the ways in which supply and demand need to be managed to address them—vary considerably by region of the state and water source. Plans must be carefully tailored to each region; otherwise they will be too vague to be useful to decision-makers.

The state's less-than-effective planning approach has not resulted in major problems thus far, mostly because Virginia is generally a water-rich state. Other states, especially Florida, Texas, and Georgia, take a more regional approach to water planning than Virginia. (See Appendix E for information on how other states conduct regional water planning.)

Local plans lack clarity on how localities will address water supply problems

Local water plans generally do not include enough information to identify the most feasible and effective water supply strategies for the region. Localities are required by DEQ to consider possibilities for increasing their water supply and decreasing their water demand, but there is no standard process for evaluating the options, nor are they required to decide on a strategy or develop a plan of action.

Localities evaluate their ability to meet current and future needs and identify alternatives for increasing water supply by including the following information in their local plans:

- Potential water savings by implementing each strategy;
- Potential water sources for new supplies, including an estimated volume available from each source; and

- Resource issues or impacts known for each potential new water source.

These components are important for analysis of water supply alternatives, but they do not represent all the information needed for the development and implementation of necessary water supply projects. In interviews, planning staff at DEQ explained that when localities developed local plans, they were not directed to pick a strategy to address local water supply issues in order to ensure that all potential strategies remain under consideration. However, localities would be in a better position to implement necessary strategies if the planning process required them to evaluate potential projects using standardized criteria, choose an appropriate strategy, and decide on a course of action. Options that are not chosen but become appropriate and workable over time would still be included in the plan and could be implemented later.

The American Water Works Association's manual on water resources planning recommends that when plans outline resource options, they evaluate them according to set objectives and criteria.

The development of local water supply plans has improved the ability of localities to understand whether adequate water supplies are available for their residents and the businesses located within their jurisdictions. Of survey respondents who were familiar with their local water supply plan, 76 percent reported at least one benefit the local planning process had on their locality. Benefits to stakeholders included a better understanding of current local water needs, future water needs, and future water availability.

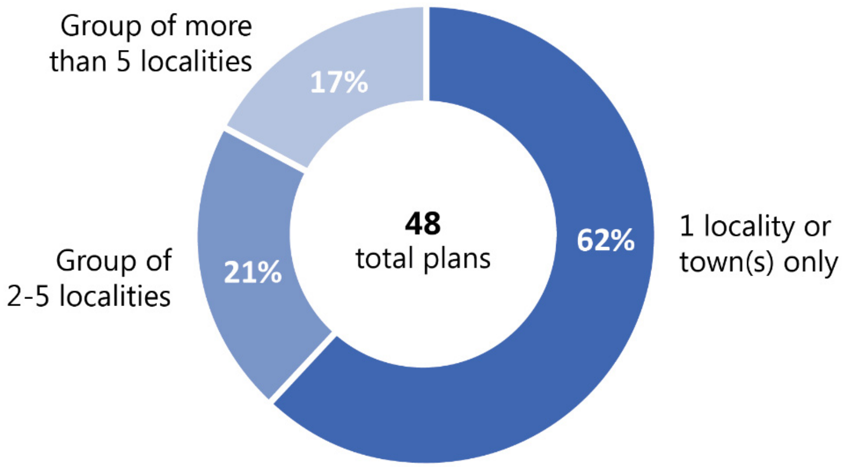
Local plans not sufficiently reflective of regional, common water use and issues

The current water supply planning process has not produced plans that are sufficiently aligned with where water is located and how it is used, especially within river basins and sub-basins. The Code of Virginia requires the State Water Control Board to "prepare plans and programs for the management of the water resources of this Commonwealth… for each major river basin of the Commonwealth, and appropriate sub-basins therein" (§ 62.1-44.38). This is critical for effective planning because surface water and groundwater resources cross jurisdictional boundaries, such that a single source often provides water for several localities and private water users. Planning should be coordinated so that localities and major water users can identify opportunities for joint water supply projects. Coordinated planning would also help ensure that local projects do not deplete the water supply of adjacent localities or harm the aquatic ecosystem.

The majority of water supply plans developed by localities do not correspond to river basins or sub-basins. Of the 48 plans submitted to DEQ during the first planning cycle, 30 plans—62 percent—represented only one city or county (Figure 4-2).

Twenty-five of these plans were submitted by a single city or county (though most included unincorporated towns within their jurisdictions), and five plans were completed by a single town or group of towns. Notably, there were several regions that incorporated large groups of localities. The Hampton Roads Planning District Commission

FIGURE 4-2
Majority of local plans were only for a single locality



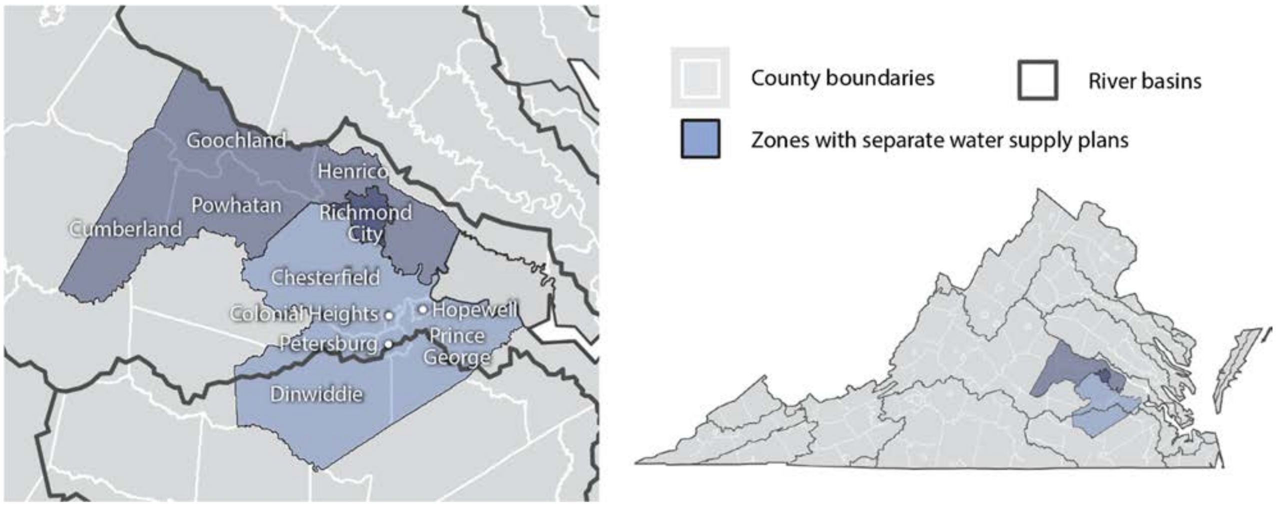
SOURCE: JLARC staff analysis of DEQ local water plans.
NOTE: Most towns chose to join with a nearby city or county to complete their water supply plan, but four towns completed individual plans and two towns joined with each other to complete a plan.

developed a plan that represented 16 cities and counties; southwest Virginia's plan represented 16; and the Northern Virginia Regional Commission's plan represented nine. (Most towns chose to join with a nearby city or county).

In many cases, localities did not collaborate to develop regional water supply plans despite relying on the same water sources or being located in close proximity to one another. For example, in the James River basin, Richmond City and Henrico and Chesterfield Counties did not collaborate on a plan, even though they all use the James River as an important source of water, and both Henrico and Chesterfield purchase a portion of their water from Richmond (Figure 4-3). Richmond completed a plan individually, while Henrico and Chesterfield completed plans with other localities, but not each other. Similarly, Caroline and Hanover counties developed separate plans. Caroline County has a standing agreement to purchase water from Hanover County through 2038. The agreement provides 500,000 gallons of water per day and must be limited to service in Caroline's Meadow Event Park. Although Caroline does not currently rely on Hanover to obtain a large portion of its water supply, planning together could have benefitted both counties by making each other aware of future water needs earlier and allowing them to plan accordingly.

There were also several cases where localities that did not plan together may have a greater need for collaboration in the future and could benefit from coordinating their plans. In the York and Rappahannock River basins, most localities completed their plans without partnering with another city or county, and many currently rely primarily on groundwater to meet their water supply needs. These localities may encounter a growing need to pursue alternative water sources in the future, including surface water,

FIGURE 4-3
Several localities in central Virginia did not use a sufficiently regional approach when developing water supply plans



SOURCE: JLARC staff analysis of DEQ planning documents.

which would make planning together beneficial. Stafford County recently completed the Rocky Pen Run Reservoir, which draws from the Rappahannock River. Stafford is located directly upstream from King George County, which also draws from the Rappahannock to support some of its water needs. It may be beneficial for these two localities to conduct their planning together in order to ensure that their water withdrawals do not impact one another.

The lack of alignment between planning groups and water location and use hinders Virginia's ability to manage its water resources in two ways. First, it limits the state's ability to ensure that the most cost-effective water supply solutions are identified. Within their current planning groups, localities have limited opportunity to identify and resolve water conflicts or identify opportunities to develop regional water supply projects. Planners are not expected to consult with adjacent localities when evaluating water supply projects, even though adjacent localities may impact each other's water availability when they draw on the same water source. For example, a project involving a large water withdrawal upstream could limit the amount of water available to downstream withdrawers, potentially leading to opposition from affected withdrawers, legal challenges, and delays in the project. Consulting with other localities and major water users when evaluating water supply projects may increase opportunities for the development of regional projects, which are often more cost-effective than those done individually.

Second, the lack of coordinated water supply planning poses unique challenges for smaller localities with fewer planning resources. When compared to the regional groups planning for multiple localities, such as the Hampton Roads Planning District

Commission and the Northern Virginia Regional Commission, individual localities are at a severe disadvantage. Regional planning groups have many more resources at their disposal, including dedicated planning staff and access to more established, comprehensive water resource datasets and tools. Without such resources, smaller localities planning on their own must hire contractors to complete their water resource management plans. Across the state, localities vary greatly in funding, expertise, and staff available for water planning. Regional planning compensates for some of this variation, as localities are able to combine resources and develop a single plan.

State should require a more regional approach to water plans

Moving forward, the best way for the state to effectively conduct water planning is to take a more regional approach. Regional planning groups should comprise localities and water users that rely on the same water sources and could benefit from coordinating their planning and project development. Planning groups in each region would be made up of local stakeholders that represent a variety of sectors as appropriate for the region. This approach is more consistent with current statutory direction to develop plans by river basin or sub-basin.

A regional approach would have a variety of benefits, including earlier identification of cross-locality conflicts, multi-locality supply project opportunities, and more efficient use of scarce planning resources. For example, because localities would be working together from the beginning of the planning process, they would be aware of each other's water resource needs and plans for meeting them before they begin project development. Water supply projects are generally costly and time-intensive to the developers and are often best done in conjunction with other localities.

Planning in regional groups would facilitate the development of regional water supply projects by involving local stakeholders throughout the planning process. This would be particularly useful in evaluating the most feasible water supply strategies. In Texas, where statewide water planning takes a bottom-up approach beginning with 16 regional planning groups, state water planning staff report an important benefit of their planning structure: greater awareness of water supply issues among local stakeholders and users. The process in Texas has evolved to allow for stakeholder feedback on findings and revisions to the plans as needed.

Regional planning would likely be more cost-efficient—for both the state and localities—than the current local planning process. The plans would represent larger geographic areas than most current local plans, such that DEQ would have fewer plans to review and approve. DEQ reported that a substantial amount of staff time was devoted to consulting with localities on their plans, reviewing the content of plans for compliance with state regulations and communicating with localities on the status of their plans. A regional planning process would also be less costly to localities, because they would share resources to develop a single plan.

It may be necessary to require localities to work in regional groups when they develop water supply plans; otherwise, localities may opt to still develop their own projects and maintain independent control over their water resources. As one county administrator explained, "The responsibility for managing water resources is a responsibility of many local elected officials . . . and there is a lack of incentive and authority to address this issue on a regional or watershed basis."

In order to maximize the benefits of regional cooperation, the State Water Control Board should establish planning groups made up of localities in the same river basin or sub-basin, or localities that use the same sources of water, while ensuring that—where appropriate—existing planning groups are maintained. The State Water Control Board should also specify which types of local stakeholder groups should be included in the development of the regional plans. Representatives from a variety of industries and types of water users would be responsible for participating in the development of plans that address local and regional water supply issues.

RECOMMENDATION 6

The General Assembly may wish to consider amending § 62.1-44.38:1 of the Code of Virginia to require the State Water Control Board to designate regional water planning areas based on (i) primary source of water, (ii) local jurisdictional boundaries, (iii) geographic proximity, (iv) existing regional groups that have already developed water resource plans, (v) existing regional entities, and (vi) other appropriate factors.

RECOMMENDATION 7

The State Water Control Board should amend the water supply planning regulations (9VAC25-780-40) to define the membership requirements of regional planning groups such that they incorporate representatives of a variety of local stakeholder groups. As applicable, local stakeholder groups should include representatives of local governments, industrial and agricultural water users, public water suppliers, developers and economic development organizations, and conservation and environmental organizations.

The State Water Control Board should require that regional plans include a course of action to address any unmet current or future water supply needs in the region. In order for plans to result in actionable strategies, they must include an analysis of the potential solutions and rationale for moving forward with one or more of them. The State Water Control Board should develop standardized criteria by which localities would evaluate water supply projects. Upon thorough analysis, regions could select the most cost-effective and feasible strategy and document their intended course of action. (See Appendix E for an example of how another state's regions evaluate alternatives.)

To ensure that the state makes progress toward more regional water supply planning, the Code of Virginia could be amended to require that DEQ report to the State Water Commission on the status of local collaboration and the content of the regional water plans at the end of each planning cycle. Given the historical resistance to regional collaboration, it is likely that the regional planning process will need to be monitored and refined over time. This periodic reporting would ensure accountability for local participation in regional planning. It would also allow the state to refine planning groups to better align them with local water use and needs, and to ensure that regional plans are developed as effectively as possible.

RECOMMENDATION 8
The General Assembly may wish to consider amending § 62.1-44.38:1 of the Code of Virginia to direct the State Water Control Board to require regional water planning groups to (i) evaluate potential projects using standardized criteria developed by the Board; (ii) identify a workable and cost-effective water supply strategy; and (iii) decide on a course of action to address the region's water supply needs.

RECOMMENDATION 9
The General Assembly may wish to consider amending § 62.1-44.38:1 of the Code of Virginia to require that, when regional water plans are completed, the Virginia Department of Environmental Quality report to the State Water Commission on the extent to which each regional plan (i) identifies a workable and cost-effective water supply strategy and (ii) reflects adequate regional cooperation.

State can better fulfill planning role through more targeted state plan

If a more rigorous approach to regional planning is implemented, a comprehensive state plan will be less necessary. Some of the deficiencies in the current state plan, which stem from the difficulty of being specific in a statewide plan document, would be resolved with the introduction of the regional planning structure. Statute directs a state planning process and state plan but does not prescribe the plan's contents. Guidance provided by the State Water Supply Plan Advisory Committee was used by DEQ to produce the current plan, and the result was a document that is too vague to inform decision-making.

The state's more important role moving forward is to facilitate the regional plans recommended above and to use its modeling results as the basis to help set policy priorities and allocate resources among the regions. Each region has unique geographic and hydrogeological characteristics, varying degrees of water sustainability problems—including many localities with no sustainability problems at all—and widely varying planning expertise and resources. The state can be more effective at facilitating water planning by devoting resources to understanding each region's unique circumstances and then adapting plans and policies for each region as follows:

- Planning requirements and expectations – Regions with major sustainability problems need to conduct comprehensive, detailed planning. Other regions may need minimal planning.

- Policy development and technical assistance – Regions with major sustainability problems may need the state to play a consultative or leadership role in matters related to permitting and water supply projects. Other regions may need minimal state support.

The result of this effort would not necessarily be a comprehensive state plan but a targeted approach to state planning that can be detailed in a fairly concise document. (See Appendix E for an example of another state's statewide report on regional water supply planning.)

The General Assembly may wish to clarify the state's role in water supply planning, and DEQ should assess the number and types of resources it will need to effectively execute this role. In order to facilitate the regional planning process, DEQ may need to assign water supply planning staff to communicate with and provide technical support to each region. DEQ also may need to rely on private sector or academic resources to help with certain aspects of its policy development or technical assistance role, which would require contract funding in addition to DEQ staffing resources.

RECOMMENDATION 10

The General Assembly may wish to consider amending § 62.1-44.38:1 of the Code of Virginia to require the Virginia Department of Environmental Quality to use the state water plan to clearly articulate how the state will (i) facilitate regional planning and (ii) provide planning, policy, and technical assistance to each region, differentiated according to each region's sustainability problems, existing resources, and other factors.

RECOMMENDATION 11

The General Assembly may wish to include language in the Appropriation Act directing the Virginia Department of Environmental Quality to assess and report on additional resources needed to facilitate regional planning and provide differentiated regional assistance. The report should be submitted to the State Water Commission, House Appropriations, and Senate Finance Committees no later than July 1, 2017.

5 Water Withdrawal Permitting

SUMMARY Industrial users are the largest withdrawers of increasingly scarce groundwater in eastern Virginia. This is crowding out water needs for human consumption, which will ultimately impose considerable costs on residential rate payers. To ensure the groundwater remains sustainable, several changes are needed in how the state allocates groundwater permits. The state should take steps to (1) ensure that water for human consumption is prioritized as mandated by statute through the permitting process, (2) limit the size of groundwater withdrawal by any single user, and (3) reduce the amount of permitted, but unused, water. The state could also consider assessing groundwater user fees and allocating permits to non-human consumptive to users that provide the most economic benefits to Virginia. With regard to surface water sustainability, Virginia does not face immediate challenges; still, several aspects of surface water permitting should be clarified before challenges arise. The permitting process needs clarification on who is required to obtain a permit and how the state will decide whether to approve permit applications.

Permitting water withdrawals is DEQ's primary tool for managing and regulating the demand for the state's groundwater and surface water resources. An effective permitting program helps ensure that water is available for all who need it, especially the highest priority uses. In the absence of an effective permitting program, too much water may be used for lower priority purposes and water shortages may result.

Fundamental changes required in how state allocates groundwater permits

Groundwater in eastern Virginia is a finite resource that is being depleted faster than it is being replenished. (See Chapter 2 on groundwater sustainability.) Given existing groundwater withdrawals, currently there is not the capacity to accommodate (1) much growth in small unpermitted use, such as residential land owners, (2) any appreciable growth in public water suppliers or industrial withdrawers that currently have permits, or (3) new permitted withdrawals of even moderate size, such as new businesses that wish to locate in the region.

This unsustainable rate of withdrawal creates a substantial constraint on access to and use of water from the aquifer not previously faced by the state. For decades, industries, public water suppliers, and others were able to take virtually as much low cost, high quality groundwater as they needed. The unsustainable path now means that this scarce public resource needs to be more actively managed to ensure that it is protected and preserved and remains sustainable as a water resource.

The state's current groundwater permitting program has several positive aspects. For example, DEQ's groundwater permitting process is clear and transparent. The statute and regulations clearly lay out when a withdrawal permit is required and when it is not, and the regulations clearly identify the criteria used to evaluate applications. In addition, the 10-year length of groundwater permits seems to be a reasonable balance between long-term stability for permit holders and flexibility for DEQ to make adjustments as sustainability changes over time. (See Appendix F for information on permit lengths in other states.)

Given, though, that there is now insufficient groundwater to meet even current demand, the state needs to take further steps to manage this valuable, finite public resource so that it will remain sustainable. This includes the development of a modified permitting approach that prioritizes human consumption and ensures the efficient allocation of the resource.

There is currently a project under development that may substantially increase the water supply in the aquifer and reduce the current pressure on demand. (See Chapter 6 for discussion of aquifer injection project.) However, that project has not yet received federal regulatory approval, and full implementation will take decades. Therefore, the state needs to develop a permit program for the near term, to prioritize withdrawal applications, and potentially for the longer term, if the injection project is not developed or if the demand for groundwater continues to grow in eastern Virginia.

Contrary to statute, permit program does not prioritize human consumption; as a result, ratepayers will likely pay more

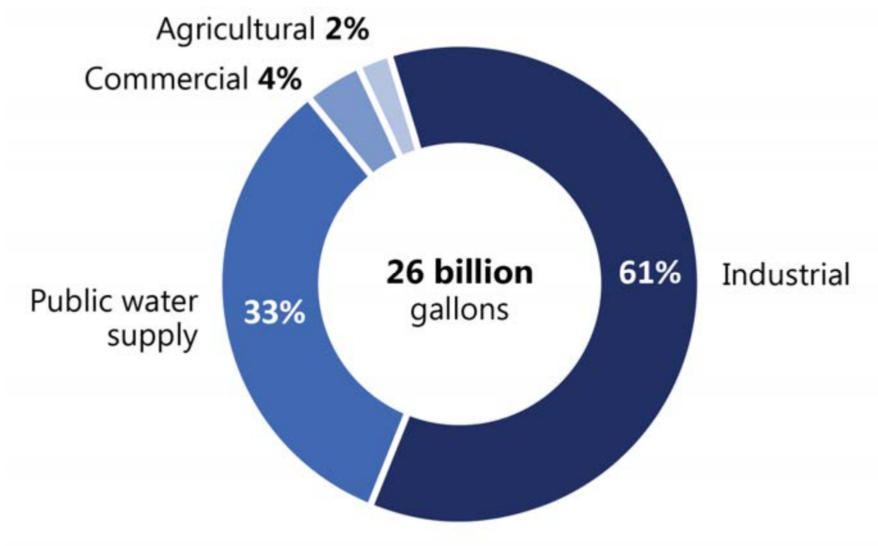
Human consumption, as defined in DEQ groundwater regulations, is use of water "to support human survival and health, including drinking, bathing, showering, cooking, dishwashing, and maintaining hygiene" (9VAC25-610-10).

Despite statutory language that prioritizes human consumption, some public water suppliers in eastern Virginia that primarily provide water for human consumption are having their permitted amounts reduced. These reductions have occurred even as more than 60 percent of current groundwater use is for industrial purposes (Figure 5-1). Through the Code of Virginia, the General Assembly clearly established that water withdrawals for human consumption should be given highest priority when withdrawal permits are granted. This priority appears repeatedly in statute, in regulations, and in broad policy statements regarding the state's water resources and provisions specific to the groundwater permitting program.

In the State Policy as to Waters, Code states that "Public water supply uses for human consumption shall be considered the highest priority" (§ 62.1-10). This priority is also expressed in the statute that governs groundwater permitting:

> "When proposed uses of groundwater are in conflict or when available supplies of groundwater are insufficient for all who desire to use them, preference shall be given to uses for human consumption, over all others." (§ 62.1-263)

FIGURE 5-1
Industrial usage accounts for 61 percent of total permitted withdrawals (2014)



SOURCE: VWUDS database, Virginia DEQ, 2014.

Likewise, human consumption is given priority in state regulation: "(1) Applications for human consumption shall be given the highest priority; (2) Should there be conflicts between applications for human consumption, applications will be evaluated in order based on the date that said applications were considered complete" (9VAC25-610-110.E).

Statutory and regulatory language clearly prioritizes human consumption, but the current groundwater permitting process does not. DEQ has historically evaluated proposed groundwater withdrawals in the order that applications are received, and new withdrawals are unlikely to be permitted if available groundwater has already been allocated to existing permit holders. There is no minimum amount of groundwater set aside for public water suppliers. In some cases, industrial users make large withdrawals that affect the surrounding aquifer and other users. (See Appendix C for information on the effect of withdrawals on aquifer levels.) This approach has the effect of giving priority to existing permit holders—the largest of whom are industrial users—at the expense of public water suppliers.

Withdrawals for human consumption have not been prioritized during recent efforts by DEQ to reduce total permitted withdrawals from the coastal aquifer. This lack of prioritization of public water suppliers is having the effect of "crowding out" public water supply needs. DEQ is seeking roughly equal percentage permit reductions from each of the 14 largest permit holders—including both industrial users and public water suppliers—although the reductions will have different impacts on the permit holders depending on their water usage and individual circumstances. As a result, groundwater withdrawal permits are likely to be reduced for several public water suppliers in eastern

Virginia, including the James City Service Authority (JCSA), Western Tidewater Water Authority, Portsmouth City, Newport News City, and Franklin City. The permit reductions proposed by DEQ for most of these public suppliers would limit their ability to increase withdrawals in the future but not reduce withdrawals below current levels.

In the case of JCSA, though, the permit reduction proposed by DEQ would require this public water supplier to reduce its groundwater use below its current withdrawal level. JCSA provides municipal water and wastewater service to the residents of James City County and parts of other surrounding localities. JCSA will likely have to reduce its actual groundwater withdrawals by 30 percent (or 1.5 MGD).

As a result of the permit reductions, JCSA is planning to initiate a $128 million surface water supply project. JCSA may also have to pay Newport News Waterworks up to $34 million in 2019 for the right to purchase additional water after that, and invest $15 to $17 million in infrastructure improvements to accept the water from Newport News. It is likely that JCSA will pass some or all of these costs onto its users, and JCSA staff indicated that the impact on ratepayers could be significant. Based on JLARC staff estimates, to pay for the surface water supply project, the right to purchase water from Newport News, and the infrastructure improvements, JCSA would need to recover, on average, approximately $23 to $33 per month per ratepayer, depending on various factors such as the period of time over which the debt would be paid off.

DEQ reports need for more statutory direction and authority to implement legislative intent to prioritize human consumption

DEQ staff are aware of the statutory mandate to prioritize human consumption, and they have expressed a need for more explicit legislative guidance about how to set priorities. Their concern is that some users might take legal action if their permits are denied or withdrawals reduced. Because of this legal risk, DEQ is reluctant to proceed with the permitting changes that would be necessary to prioritize human consumption.

If DEQ does not receive additional statutory authority and direction to prioritize human consumption, the current approach to granting permits will likely continue. Industrial users will continue to benefit, but public water suppliers—and consequently their ratepayers—will face increasing costs for water as they are required to meet the growth in demand. Without increased access to the aquifer, public water suppliers will be required to develop alternative, but more expensive, water supplies.

Two potential statutory changes could be enacted to ensure that DEQ has sufficient authority to prioritize human consumption. The first change would be to reaffirm the legislature's historical intent to prioritize human consumption by amending the Code of Virginia to require the State Water Control Board to review and issue permits that are primarily for human consumption before reviewing permits for other non-human consumptive uses, including industrial use. The second change would be to grant express authority to reduce non-human consumptive withdrawals during the permit review process.

RECOMMENDATION 12
The General Assembly may wish to consider amending the Groundwater Management Act (§§ 62.1-254 through 62.1-270 of the Code of Virginia) to require that the State Water Control Board issue permits for groundwater withdrawals for non-human consumptive uses only after meeting permit requests for human consumptive needs.

RECOMMENDATION 13
The General Assembly may wish to consider amending the Groundwater Management Act (§§ 62.1-254 through 62.1-270 of the Code of Virginia) to require that the State Water Control Board reduce permitted withdrawal amounts for non-human consumptive use as necessary to provide permit capacity to meet human consumptive needs.

Prioritizing human consumption in this manner will undoubtedly impose costs on industrial users who will have their permitted withdrawal amounts reduced. However, this approach will benefit public water suppliers who will need to provide increasing amounts of water for human consumption to accommodate future population and economic growth.

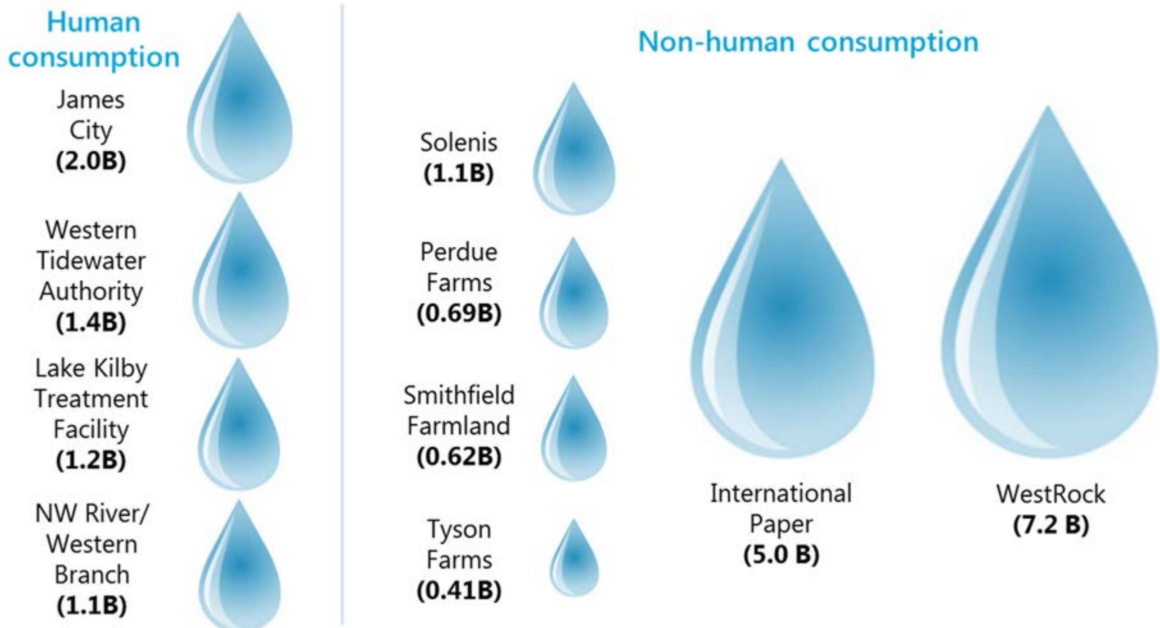
Along with giving preference to public water suppliers, the state may want to impose obligations on them to maximize the efficient use of the water from the aquifer. This could include requiring public water suppliers to minimize infrastructure leaks to reduce water loss. It could also include requiring public suppliers to minimize the amount of water used for non-human consumptive use, such as watering lawns.

The state could also take steps to minimize the impact of permit reductions on industrial users by phasing in the reductions over time. This would help ensure that industrial users have sufficient time to develop alternative water supplies without significantly disrupting their operations.

State may wish to consider establishing limits on groundwater consumption by a single entity

A substantial amount of all permitted use is concentrated among several very large industrial permittees (Figure 5-2). Two paper mills used seven billion and five billion gallons of groundwater, each, in 2014. These two mills—WestRock in West Point and International Paper in Franklin—together used nearly half of all permitted groundwater. The WestRock mill withdraws 28 percent of all actual withdrawals subject to permits. The International Paper mill withdraws almost 20 percent of all withdrawals subject to permits. The remaining large users were a combination of public water suppliers and other industrial users. The next largest permit holder, the JCSA, used two billion gallons, or about eight percent of all permitted withdrawals.

FIGURE 5-2
Two paper mills use far more water than any other permitted user (2014)



SOURCE: VWUDS database, Virginia DEQ, 2014.
NOTE: Use is shown to scale, in gallons per year.

The magnitude of these two industrial withdrawals relative to other withdrawals presents two major impediments to the state's ability to manage the sustainability of groundwater in eastern Virginia. First, having such a large portion of a scarce, *public* resource being consumed by two *private* entities seems inconsistent with the statutory language that "all waters in Virginia belong to the public" (§ 62.1-44.36). Second, having so much of the region's scarce, low cost, and high quality groundwater being consumed by only two withdrawers severely constrains the state's ability to re-allocate permits as necessary over time to accommodate growth among existing users, or new users. The two paper mills' combined usage could be re-allocated over time to, for example, easily accommodate a doubling or tripling of use by the region's large public water suppliers. Their combined usage could also be re-allocated among hundreds of small or medium sized withdrawers such as public water suppliers as well as industrial, agricultural, and other users.

To provide increased withdrawal capacity for public water suppliers and new users, the General Assembly may wish to set a limit on the proportion of the overall permit capacity that a single permit holder may be awarded. It might be appropriate to limit individual industrial users to five percent of the overall permitted capacity—almost all industrial users other than paper mills have permitted capacity below five percent. For public water suppliers, it may be reasonable to set a higher limit such as 10 percent. Five public water suppliers have permitted capacity between five and 10 percent of total permitted capacity. The General Assembly may also wish to give consideration to providing higher limits for current permit holders but, in the case of the paper mills, not to the level of their current withdrawals; together they use 48 percent of total permitted withdrawals. The General Assembly could establish an advisory group of experts to make recommendations on the appropriate limits.

RECOMMENDATION 14

The General Assembly may wish to consider amending the Groundwater Management Act (§§ 62.1-254 through 62.1-270 of the Code of Virginia) to establish a limit on the proportion of overall permitted withdrawal capacity to be granted to an individual permit holder in the coastal aquifer.

DEQ should reduce inefficiency associated with groundwater withdrawals that are permitted but not used

With demand for groundwater now greater than supply in eastern Virginia, it is more important to ensure that applications for permitted use are based on a realistic and accurate estimate of current and future water needs. Otherwise, permit holders essentially hoard capacity that could be used for other purposes. DEQ reviews each permit application to ensure there is a justified need for the requested withdrawal amount. As demand has begun to exceed supply, DEQ has more closely scrutinized the rationale for each requested amount. DEQ's recent efforts to improve groundwater sustainability have focused primarily on reducing total maximum permitted amounts.

Between 2010 and 2015, DEQ permitted the use of about 170 MGD of groundwater in eastern Virginia each year. For most of this time, only 30 to 40 percent of this total permitted amount was actually used. After DEQ's efforts to reduce maximum permitted amounts are completed, there could be about 112 MGD of total permitted use, of which about 40 percent will be initially withdrawn. (As of October 2016, DEQ is still in the process of completing permit reductions for the 14 largest permit holders.) Some of the unused 68 MGD likely will be needed by permit holders, but some may not be and could be reallocated to new groundwater users or existing permit holders wishing to increase their permitted withdrawals.

Permit applicants attempt to maximize their permit capacity because

- they bear no cost for requesting permit capacity that they do not use; and
- they build in a substantial margin of safety in case their water needs grow in the future.

This hoarding of capacity is not efficient and unnecessarily reduces the amount of water available for withdrawal. Water that is permitted—whether or not it is used—cannot be withdrawn by other users. This approach to permitting impedes the fair and efficient allocation of water; further, it may impede economic growth, and it does not prioritize human consumption.

Determining how permitted withdrawal capacity should be reduced to better reflect actual water needs will require more detailed review. DEQ could make greater use of existing authority. The department has the discretion to reduce permit amounts during the permit term if the amount withdrawn averages less than 60 percent of the maximum permitted amount over a five-year period. DEQ has never used this authority to reduce the maximum withdrawal in a permit. However, doing so could have the unintended consequence of giving withdrawers incentive to be less efficient with their groundwater to justify larger permitted withdrawals. DEQ should examine the feasibility of these and other measures to reduce the permitted withdrawal capacity to better reflect actual water needs, and develop a plan that documents the steps it will take to do so.

RECOMMENDATION 15

The Virginia Department of Environmental Quality should develop a plan to reduce the amount of withdrawal capacity granted by each groundwater permit issued, to more closely reflect the actual amount needed. The plan should be presented to the State Water Control Board and State Water Commission by December 1, 2017.

If the recommendations in this chapter are adopted, it will be important for the state to clearly convey to current and prospective permit holders how the permitting process will change over time. This will be important to continue the currently transparent approach to the permitting process, but also to allow permit holders that may experience reductions or changes in their permit the next time they apply to appropriately plan for how these changes may impact them. Many of these changes can be phased in over the long term—consistent with 10-year permit cycles—to provide current permit holders enough lead time to plan for whether and how they will secure additional, non-groundwater supplies.

RECOMMENDATION 16

The Virginia Department of Environmental Quality should develop and publish a groundwater permitting process transition plan. The plan should specify how the groundwater permitting requirements and process will change, when the changes will be implemented, how the department will engage permit holders, and how the department will inform permit holders as new permit requirements and processes are implemented.

State could charge users for groundwater

An alternative option that the General Assembly could consider to address the sustainability challenge would be to charge users for water from the coastal aquifer. This would have the benefit of reducing demand for and use of water and generate revenue that could be used to fund efforts to increase the water supply for the region. User fees have a number of advantages that can make them effective ways to achieve specific policy goals. Fees often allow markets to operate more efficiently, for example by applying a fee to a resource that has been overused because it was free. The fee monetizes the "cost" of the resource that has historically been shifted to others or not borne at all. Another benefit of such a system is that it is likely to help reduce requests by permit applicants for withdrawal capacity beyond what they would actually use. If the fee charged is based on permitted authority, permittees are not likely to request excess capacity.

While charging user fees would be a major change in Virginia, is it not uncommon for states to charge for groundwater usage. At least 12 other states charge some form of user fee based on the volume of groundwater used. This is separate from a permit fee, which Virginia currently charges (which can range from $600 to $6,000). The user fees in other states vary widely, from $8.50 per million gallons withdrawn in Massachusetts to $5,500 per million gallons in Arizona. (See Appendix G for more information.) A typical fee is about $30 per million gallons. If this rate was applied in Virginia, the cost to withdraw one MGD would be $10,950 per year. The cost to withdraw five MGD would be $54,750 per year, and the cost to withdraw 20 MGD would be $219,000 per year.

The appropriate amount to charge would ultimately depend on the urgency to reduce demand, the elasticity of demand, and the need for a funding source to pay for alternative water supply projects in the region. Setting the fee too high could have the unintended consequence of hindering economic development in eastern Virginia by imposing substantial new costs on companies without an affordable alternative to groundwater. Setting the fee too low would limit the impact or benefit. If human consumption remains the priority, then the user fee charged to public water suppliers should be less than that applied to industrial or other users.

OPTION 1
The General Assembly could amend the Code of Virginia to establish statutory authority for a user fee for water withdrawn from the coastal aquifer.

State could award groundwater permits to industrial users based on economic benefit

The General Assembly could consider taking an economic development approach in awarding permit capacity to industrial users that seek permits to withdraw water from the coastal aquifer. After human consumption needs are met, if there is more demand for the remaining water by industrial users than there is supply, industrial users seeking groundwater withdrawal permits could be prioritized based on their economic value much like the Virginia Economic Development Partnership prioritizes the award of some economic development grants. Factors such as the number of jobs created, wages paid, and taxable revenue could be criteria used in determining how to prioritize the award of permitted withdrawal capacity.

OPTION 2

The General Assembly could amend the Code of Virginia to establish statutory authority for a priority system to award groundwater withdrawal permits to industrial users likely to have the greatest economic benefit.

Surface water permitting process needs further clarity before sustainability challenges arise

The state's surface water permitting program, the Virginia Water Protection (VWP) permit, has several positive aspects. For example, DEQ and many of the southeastern states reviewed by JLARC staff consider the type of use, the applicant's justification of the requested withdrawal amount, the need for the withdrawal, and the impact of the withdrawal on fish and wildlife habitat, waste assimilation, recreation, and navigation. DEQ also requires applicants to analyze alternatives to surface water to prove that alternative sources are not feasible. Survey respondents and DEQ staff both indicated that the length of surface water permits (15 years) is reasonable. (See Appendix F for more information.)

Despite these strengths, certain aspects of the surface water permitting program are not sufficiently clear. This lack of clarity has created confusion about who should apply for a permit and which applicants are likely to receive a permit. Given the tradeoffs that may be inherent in clarifying some of these aspects of surface water permits, it would be prudent to make these decisions before major sustainability challenges occur.

DEQ's criteria to evaluate impact of proposed surface water withdrawals are not well documented

DEQ does not have uniform, well documented criteria to assess whether a proposed withdrawal would lower surface water levels too far. Statute, regulations, and DEQ guidance documents do not specify metrics and thresholds for measuring flow levels in rivers and streams and determining how low levels can be without adversely impacting fish and wildlife habitat, waste assimilation, recreation, and navigation. DEQ currently uses a range of criteria depending on the ecosystem of the river where the withdrawal is proposed, but these criteria are not documented in the Code of Virginia or DEQ's regulations, though they are listed in the State Water Resource Plan. The lack of standard criteria documented in state regulations for evaluating the impact of proposed surface water withdrawals could hinder the effectiveness of the permitting process in the future. Without standard well documented criteria, the permitting process lacks long-term regulatory clarity for applicants and users.

Florida's surface water permitting criteria allow for specific percentage reductions in flow levels resulting from water withdrawals. The criteria are intended to prevent significant harm to the water resources or ecology of a river. Each of the state's five water management districts has developed numeric criteria for their priority rivers.

The use of standard criteria in permitting regulations would have a number of benefits for applicants; in particular, it would create greater regulatory certainty. For example, applicants would better understand the likelihood of approval when they propose a withdrawal. The use of standard, well documented criteria would increase transparency, so that applicants could readily determine whether DEQ's permit review and decisions were fair and reasonable. The added transparency might also reduce the potential for legal challenges to DEQ's permitting decisions.

DEQ staff are currently working with the United States Geological Survey and Virginia Tech to evaluate surface water flow metrics that strongly correlate with the health of aquatic species. Given the time and resources needed to research surface water metrics, DEQ should focus this effort on identifying appropriate metrics for the highest priority rivers—or those rivers at greatest risk for water shortfalls. DEQ estimates that nearly all future surface water withdrawals will come from just one-fourth of all river and stream segments in the state, so it will be important to use criteria that ensure the protection of these stream segments. Once the metrics are identified, the State Water Control Board should amend the regulations for the VWP program to specify the metrics that could be used for the rivers in the state at greatest risk. This will allow DEQ to maintain flexibility in using the best metric for each surface water body. At least one state has developed specific, documented metrics for each of its major rivers.

RECOMMENDATION 17

The State Water Control Board should amend the regulations for the Virginia Water Protection permit program (9VAC25-210) to specify the metrics that will be used to assess the likely impact of proposed surface water withdrawals from river segments at greater risk for water shortfalls. The Board should update the regulations no less than every five years to incorporate scientific and technological development in surface water metrics.

Permit requirements for grandfathered withdrawers are vague and will likely cause water conflicts in the future

It is critical that the state clearly define when withdrawers are required to obtain permits and how much water they can legally withdraw under a permit. Without greater clarity, public water suppliers and industrial withdrawers may make investment decisions based on false expectations of future water supplies. A lack of clarity could also result in conflicts—including potential legal challenges—between withdrawers using the same surface water source, and between withdrawers and DEQ over their interpretations of the VWP permit statute.

Historically, the state has had a limited role in managing surface water because withdrawals have traditionally been governed by the common law doctrine of riparian rights. In creating the VWP permitting program in 1989, the state overlaid the traditional system of riparian rights with a regulatory system of permitting. The VWP statute provides several grounds for exempting surface water withdrawers from withdrawal permitting, including an exemption for existing—or *grandfathered*—withdrawers (sidebar). Under these exemptions, more than 90 percent of surface water withdrawers statewide are not required to obtain permits.

Grandfathered surface water withdrawers include those that:

- had an existing surface water withdrawal before July 1, 1989;
- had an existing withdrawal between July 1, 1989 and July 25, 2007 and have complied with DEQ's water withdrawal reporting regulations;
- received a §401 certification before July 1, 1989 but had not started to make withdrawals as of that date.

§401 certifications are required by the federal Clean Water Act for surface water withdrawals that have the potential to change the physical, chemical, or biological properties of a river or stream. DEQ grants §401 certifications on behalf of the federal government through the Virginia Water Protection permit program.

The state has not determined the precise circumstances under which a grandfathered surface water withdrawer would need to obtain a VWP permit. According to statute, withdrawers need to obtain a surface water permit "if a new §401 certification is required to increase a withdrawal" (§ 62.1-44.15:22B); but beyond this language, there is little guidance in statute or regulations. As a result, there are significant disagreements between DEQ and grandfathered withdrawers on this issue, including whether withdrawers must obtain a permit if they

- increase the capacity of their intake structure to withdraw water;
- increase their withdrawal rate beyond their historical maximum; or
- conduct maintenance work on their intake structure, such as upgrading or replacing equipment.

For example, some grandfathered withdrawers have argued that they would not be required to obtain a permit if they increased their withdrawal amount but did not expand the capacity of their intake structure. DEQ staff believe a permit would be required in this case, but DEQ may not be able to require a permit. It is not clear how much grandfathered users are entitled to withdraw and how much they can withdraw before triggering the permit requirement. Some grandfathered withdrawers have argued that they are not required to obtain permits because their riparian rights to water supersede the state's VWP permit requirements. DEQ staff and grandfathered users acknowledge these disagreements and point to a lack of legislative direction on when permits are required.

The amount of water that a grandfathered user would be entitled to withdraw once they were required to obtain a surface water withdrawal permit is also unclear. For withdrawers who were grandfathered because their withdrawals existed prior to July 1, 1989, there is nothing in the Code or DEQ's regulations regarding the amounts they are entitled to withdraw. (For users who were grandfathered between July 1, 1989 and July 25, 2007, the regulations do provide some guidance.) According to DEQ staff, having grandfathered status does not entitle a user to a specific amount of water; it simply means that a user is not required to have a surface water permit. Many grandfathered users reportedly believe that they are allowed to withdraw as much as their intake structure allows, or as much as their treatment plant can safely treat.

The amounts that grandfathered users believe they would be entitled to under a permit may be substantially larger than their current withdrawal rates and the amount that DEQ believes they are entitled to withdraw. For example, the difference between what one large public water supplier believes it is entitled to withdraw and what DEQ believes it can withdraw is 329 MGD. If grandfathered users, operating under the belief that they are entitled to more water, were to substantially increase their withdrawals, they could deplete the water supply, potentially to the detriment of other users and aquatic life.

To avoid potential surface water conflicts in the future (between DEQ and grandfathered withdrawers, and between individual grandfathered withdrawers), the state should take two steps to clarify the surface water grandfathering provisions. First, DEQ should identify all grandfathered users and the amounts that they are withdrawing. Doing so would allow DEQ to identify the surface water withdrawers that could be impacted if changes are ever necessary to the grandfathering statute. DEQ should collaborate with the Department of Health (VDH) and other entities to obtain withdrawal amounts and other information as needed, potentially through a survey.

RECOMMENDATION 18
The Virginia Department of Environmental Quality should collaborate with the Virginia Department of Health and other relevant entities to identify all grandfathered surface water withdrawers in Virginia.

Second, the State Water Control Board should convene an advisory panel to decide how to more clearly define the specific conditions that would require grandfathered surface water withdrawers to obtain a permit. The panel should address how DEQ should consider historical withdrawal rates and past investments in water supply infrastructure when determining the amount of water grandfathered users would be approved to withdraw under a VWP permit. The panel should recommend changes to the grandfather provisions of the VWP statute that address these issues. Similar to the Eastern Virginia Groundwater Management Advisory Committee, the advisory panel should include representatives from public and private stakeholders, including public water suppliers, industrial entities, and other types of withdrawers currently exempt under the VWP grandfather statute.

RECOMMENDATION 19
The General Assembly may wish to consider including language in the Appropriation Act directing the State Water Control Board to create an advisory panel to recommend amendments to § 62.1-44.15:20 of the Code of Virginia that would clarify (i) the conditions under which grandfathered users of surface water would be required to obtain a Virginia Water Protection permit and (ii) the criteria to be used to determine the amount of surface water to be permitted to grandfathered users.

Standard used to verify processing capacity of water facilities is not clearly defined or commonly understood by stakeholders

Concern about a recently proposed, but then removed, regulatory change underscored the lack of clarity about the term "safe yield." Different understandings of the term and its implications have caused conflict between DEQ and public water suppliers. Public water suppliers in Virginia must undergo an assessment by DEQ and VDH of their facility's safe yield to receive a waterworks permit from VDH (sidebar). The purpose of determining the safe yield is to verify that the proposed facility has a sufficient amount of source water to meet the drinking water needs of its customers. The safe

Safe yield is defined under current regulations as the minimum withdrawal rate available during a day and recurring every 30 years, or the minimum withdrawal rate available to withstand the worst drought of record in Virginia since 1930.

yield calculation does not address the impact of the withdrawal on the water source, which is addressed through DEQ's water withdrawal permitting process.

In early 2015, DEQ proposed changes to the VWP regulations, including modifications to the definition of safe yield. DEQ's primary reason for the proposed revision to the definition of safe yield was that some withdrawers believed their safe yield is the amount they are entitled to withdraw, which DEQ indicates is not the case. According to DEQ staff, for many public water suppliers around the state, withdrawing sufficient surface water to meet the maximum capacity of their water treatment could deplete the water supply, potentially to the detriment of other users, fish and wildlife habitat, waste assimilation, recreation, and navigation.

Representatives of grandfathered public water suppliers expressed significant concerns with the proposed changes to safe yield, describing them as a "sweeping shift in regulatory practice" and a major change in public policy. According to one assessment, the new definition would have had the practical effect of eliminating the grandfather exemption for surface water withdrawers by allowing DEQ to evaluate the potential impact of a public water supplier's withdrawal on other water users and aquatic life during the VDH waterworks permitting process. Some grandfathered users were also concerned that the new definition could reduce the amount of water they are authorized to withdraw under their waterworks permit—in effect, requiring their compliance with the VWP statute even though they are legally exempt from it. A reduction in the amount withdrawn could result in substantial costs to a water system.

In response to these concerns, DEQ restored the original definition of safe yield to the regulations in early 2016. The impact of the modified definition on public water suppliers ultimately would have depended on how DEQ would have changed—if at all—its process for determining a treatment facility's safe yield.

The fact that there was considerable misunderstanding between DEQ staff and grandfathered withdrawers about the meaning of safe yield indicates that the term needs to be clarified. To accomplish this, the State Water Control Board should create an advisory panel of stakeholders (including grandfathered public water suppliers and staff from DEQ and VDH) to review and clarify the definition of safe yield, considering whether and how it should be changed, and what the implications would be on grandfathered withdrawers and DEQ's permitting process. The working group should also study the benefits and implications of moving the definition from VDH regulations to DEQ regulations.

RECOMMENDATION 20

The General Assembly may wish to consider including language in the Appropriation Act directing the State Water Control Board to create an advisory panel to clarify whether and how the definition of safe yield should be changed in the Virginia Administrative Code.

6 Conserving, Increasing, and Trading Water

SUMMARY The state can facilitate a variety of approaches to improving the supply of water that include conservation, fixing leaking infrastructure, new multi-jurisdictional water supply projects, and even trading of water among permitted users. To sufficiently address Virginia's water sustainability challenges, the state needs to take a more active role working with localities to plan water supply projects. This more active state role in water project planning is consistent with a more regional, state-assisted approach to water resource planning. This more active role can also help ensure that relatively simple conservation measures, and more complex but still viable projects such as fixing leaking water infrastructure, are sufficiently considered before embarking on more costly, higher-risk projects. A more active state role would seem essential for the eastern Virginia aquifer injection project. This project has the potential to substantially address the region's sustainability challenges over the long term. The project is complex, though, and its full implementation may take decades.

The purpose of water conservation and water supply projects is to sustain and expand access to water for human uses and to more efficiently utilize existing water supplies. Large water supply projects are extremely complex, costly, and long-term endeavors that require years of planning. Water supply project planning involves navigating the specific circumstances of each project and selecting the approach best suited to each circumstance. Given the complexity, cost, and risk involved in developing water supply projects, and the potential benefits of regional projects, there is a need to coordinate local water supply projects.

Several types of water supply projects and practices have potential benefits for Virginia

JLARC staff identified four types of water supply projects and practices with the greatest potential for success in Virginia:

- Repair or replacement of leaking infrastructure;
- Conservation;
- Reservoirs; and
- Aquifer injection.

These four strategies were identified after analysis of 15 different water supply strategies; interviews with public water suppliers; and a review of the research literature.

The potential for benefit depends on a number of factors, including

- the volume and quality of the water needed, and how soon additional supplies must be developed;
- the source and quantity of water available, and whether there are competing claims for the water;
- the cost of a project, capital and financing options, and impact on customer water rates; and
- the likelihood of obtaining necessary state and federal permits.

(See Appendix H for other water supply projects and practices that may be cost-effective in a few specific circumstances.)

JLARC staff surveyed public water suppliers as part of a water resources survey that included staff of various public and private water stakeholders in Virginia.

Other survey participants included staff of industrial, commercial, and agricultural users of water; staff of economic development offices; and city and county administrators.

(See Appendix B for information about the JLARC water resources survey.)

Leaking water infrastructure can be repaired or replaced

Repairing or replacing aging or damaged infrastructure can be an extremely effective way to increase water supply. Repair and replacement of infrastructure was most commonly cited by public water suppliers as among the three most cost-effective ways to increase water supply (selected by 41 survey respondents, or 48 percent). Some of Virginia's oldest water supply infrastructure has been in place for over a century, and many systems have not been adequately maintained because planning and funding have been insufficient. There is no industry standard for an acceptable percentage of water loss due to leakage, but the local water supply plans submitted to DEQ reported system losses ranging from 4 to 50 percent, depending primarily on the age of the infrastructure. For example, two major public water suppliers in eastern Virginia, a region that is already facing water supply challenges, reported that 15 and 17 percent of their water supply was lost to leaks in 2011. State funding for repairing or replacing water infrastructure is available from the Virginia Department of Health (sidebar).

The **Drinking Water State Revolving Fund** is administered by the Virginia Department of Health and provides local public water suppliers with low interest loans and grants for a variety of purposes intended to enhance the public water supply, including projects to repair or replace water infrastructure.

Since 1998, approximately $150 million has been provided for water projects through the program.

Conservation is effective and relatively inexpensive

Water conservation is another effective strategy for addressing sustainability challenges, especially for short periods of time during droughts. Water conservation has the added benefit of avoiding, postponing, or reducing capital costs associated with new facilities because it can diminish the need for additional water supplies through more efficient use of existing supply. Conservation strategies were the second most frequent option chosen by public water suppliers (selected by 33 survey respondents, or 38 percent) as one of the three most cost-effective ways to increase or preserve water supplies. Conservation efforts can improve sustainability by between 10 and 20 percent, according to the American Water Works Association.

A wide variety of conservation practices have the potential to reduce water consumption, including

- public education and awareness campaigns that promote conservation;
- incentives that promote water-efficient appliances or fixtures;

- incentives that promote water-efficient landscaping;
- limits on water use for landscape irrigation;
- rain harvesting for irrigation or other outdoor use; and
- tiered pricing structures that charge users more for monthly water usage over a certain quantity.

Reservoirs may be a good option in some parts of the state

Reservoirs, one of the most effective ways to increase water supply, have the benefit of making much more efficient use of the water available in rivers by withdrawing and storing water during times of high flow, then releasing water during times of low flow (Table 6-1). This may become increasingly important if precipitation events become less frequent but more severe, as is predicted by many experts in the field of climate research. Additional storage through reservoirs was the third most common type of project cited by public water suppliers (selected by 25 survey respondents) as among the three most cost-effective options for meeting future demand.

TABLE 6-1
Reservoirs can be effective if siting problems can be addressed

Benefits	• Water can be stored during periods of excess, then used to supply users or augment river flow during periods of scarcity • Provides a reliable and consistent source of water • Can be built in a variety of sizes and methods to best fit needs of specific project
Costs / risks	• Infrastructure for impoundment, pumping, and piping can be costly • Siting can be difficult due to presence of wetlands, utility lines, historically significant sites, or development • Planning, approval, financing, and construction can require years or decades

SOURCE: Eastern Virginia Groundwater Management Advisory Committee materials and Virginia Department of Environmental Quality.

In some parts of the state, especially the Shenandoah Valley and central Virginia, reservoirs can be among the best ways to address sustainability challenges if the logistical problems can be addressed. In many cases, the greatest impediment to building a reservoir is the inability to find an appropriate site.

Unfortunately, reservoirs have recently proven extremely difficult to site and develop in eastern Virginia, where sustainability is of greatest concern. The landscape of eastern Virginia creates many complications for building reservoirs; in many areas it is not possible to find a viable location and obtain the necessary approval and permits. Because the terrain is flat, a large physical area would be needed to contain enough water.

Vast areas of eastern Virginia are wetlands, particularly near surface waterways, and changes to wetlands must be offset through mitigation, which is expensive.

Using treated wastewater to augment water storage in reservoirs, referred to as indirect potable reuse, is another water supply strategy that has had success in Virginia. Since 1978, the strategy has been used in the Occoquan Reservoir by the Upper Occoquan Sewage Authority, which discharges wastewater treated to drinking water standards to supplement existing reservoir supply with a substantial amount of additional water. This strategy has the benefit of reusing water rather than discharging it to rivers, where much of it is lost to the Chesapeake Bay. It uses existing drinking water treatment and piping infrastructure and precludes the additional cost that would otherwise be imposed by piping treated wastewater directly to an end user.

The **Hampton Roads Sanitation District** (HRSD), a political subdivision of the state, operates 13 wastewater treatment plants and provides service to 17 localities. HRSD is supported largely by user fees from its 1.7 million customers.

HRSD aquifer injection has potential to substantially increase aquifer water supply, but full implementation may take decades

Ensuring that Virginia's coastal aquifer is a sustainable source of high-quality low-cost water will be an ongoing challenge for decades to come. (See Chapter 2 on groundwater sustainability.) The Hampton Roads Sanitation District (HRSD) is in the preliminary stages of planning an aquifer injection project that has significant potential to improve the sustainability of the coastal aquifer.

The primary benefit of HRSD's aquifer injection project is that it would have sufficient scale to increase water levels in the coastal aquifer (Table 6-2). Water injections would total about 120 million gallons per day (MGD) once the project was fully implemented. (Estimated current withdrawals from the entire aquifer system are approximately 100 MGD.) Over time this could allow substantially more groundwater to be withdrawn from the aquifer, helping preserve the aquifer as a long-term source of water for residential, industrial, agricultural, and other groundwater users in eastern Virginia.

Aquifer injection is the process of pumping water into an aquifer through injection wells in order to augment naturally occurring water levels.

The project would raise water levels by injecting treated wastewater into the aquifer. HRSD plans to locate injection sites at seven wastewater treatment plants, which will be equipped to treat wastewater to drinking water quality prior to injection. The aquifer would essentially store the treated wastewater, meaning the wastewater would not be directly cycled back into the drinking water supply. As a result, HRSD does not believe the project is classified as direct potable reuse (sidebar). The direct reuse of treated wastewater for human consumption is not allowed under current state regulations. Predictions for increased groundwater levels from the aquifer injection project are made with the VAHydro-GW model and are preliminary. HRSD plans to use data collected at its pilot injection site in 2018 to improve the model's ability to predict increased water levels resulting from injection.

Direct potable reuse is defined in state regulations as the discharge of reclaimed water directly into a drinking water treatment facility or distribution system (9VAC25-740-10).

TABLE 6-2
Aquifer injection to replenish groundwater has major benefits, costs, and challenges

Benefits	• Preliminary analysis predicts substantial increase in aquifer water levels • Increases in groundwater levels can help mitigate water level decline, saltwater intrusion, and land subsidence • Reduced discharges to the Chesapeake Bay • Reused water that is injected into the aquifer moves throughout the system and would be available to all users in eastern Virginia, rather than just those in close proximity to treatment plants
Costs / challenges	• $1.2 billion in upfront costs to establish water treatment and injection infrastructure • Injections can pose localized water quality hazards if water composition is not compatible • Negative public perception of drinking treated wastewater

SOURCE: Hampton Roads Sanitation District.

The aquifer injection project would also help reduce the amount of nutrients being released into the Chesapeake Bay and has the potential to reverse the land subsidence and saltwater intrusion observed in the region. There is a need, though, for additional land subsidence monitoring sites to better determine whether aquifer injection could prevent or reverse land subsidence in the region. (See Chapter 2.)

Total capital costs for the project are estimated at $1.2 billion. Capital funding would be needed for upgrading water treatment facilities to drinking water quality standards and for building injection facilities. Annual operating costs are estimated to be between $21 million and $43 million. HRSD plans to cover capital costs with bonds secured by future fees paid by its customers; in addition, HRSD plans to use fees paid by customers to pay for operating costs. According to HRSD staff, it plans to look for alternative revenue sources to pay for operating costs, including fees assessed on groundwater users in eastern Virginia that directly benefit from the injection project. Presently, HRSD has not requested state funds to support the project.

The injection project has not yet received federal regulatory approval, and the aquifer cannot be replenished through injection without this approval. The project requires a federal permit from the Environmental Protection Agency's Underground Injection Control Program. Similar injection projects have been permitted in other states, but there will remain some uncertainty about the project until approval has been granted.

Three factors may lengthen time required to implement project

The aquifer injection project could begin to increase water levels in the aquifer within the next 10 years, but the full benefits of increased water levels likely will not be realized for more than two decades under the best-case scenario. Relatively localized increases to groundwater levels from the project may occur as early as 2022 to 2024 if the first treatment sites are completed and injections begin as currently planned. However, with project planning, injection piloting, and the construction of treatment plants, the project will not be fully operational until 2030 even if there are no unforeseen delays. Within a few years, water levels would rise near new injection sites. In areas farther from injection sites, levels would not fully rise for another 10 to 20 years.

Three factors could delay completion of the aquifer injection project and increases in groundwater levels. First, there could be delays in obtaining federal regulatory approval for the project. The length of the federal environmental permitting process can be difficult to predict and will be largely outside the control of HRSD and the state. HRSD plans on applying for the federal permit after completion of its pilot injection in 2018 and hopes that the permit process will be completed by the end of 2019.

Similar aquifer injection projects include a smaller scale project in the City of Chesapeake, Virginia, as well as larger scale projects in Orange County, El Segundo, and Long Beach, California; Scottsdale, Arizona; and El Paso, Texas.

Second, the large scale of the injection project could delay its completion beyond 2030. Each of the seven injection sites is its own substantial capital project requiring construction of a facility that can treat wastewater to drinking water quality standards and then inject that water into the aquifer.

Third, the aquifer injection project must ensure aquifer compatibility, which is technically complex. The injected water must be compatible with the natural groundwater, sediments, and minerals contained in the aquifer. Similar projects have generally been successful but have experienced incompatibility issues associated with injection. Incompatible water has the potential to dissolve and mobilize minerals dangerous to human health, such as manganese and arsenic, that are normally trapped in sediment, and release them into parts of the aquifer—though the impacts of any contaminated groundwater would likely be localized to the injection site. If the injected water is not compatible, the project may be delayed or the amount of water being injected could be smaller than expected, at least for a period of time. The compatibility challenge is compounded by the fact that each injection site is unique, with different soil and water composition. Therefore, ensuring compatibility will be a separate and distinct process at each of the seven injection sites.

HRSD staff acknowledge this compatibility challenge and plan to address it by using existing technology that is already in use by other injection projects. HRSD is working with the City of Chesapeake to learn from the aquifer storage and recovery system it has operated in the Potomac aquifer for nearly 20 years. HRSD also plans to develop a pilot injection site first, and test water and soil samples at each of the seven injection sites to ensure compatibility between injected water and the aquifer.

Funding for the ongoing costs of the project has not been determined

A funding source to cover the operating costs of the aquifer injection project (estimated to be $21 to $43 million annually) has yet to be fully determined. HRSD staff have indicated that fees from existing customers can be used to support operating costs, but they are also continuing to consider additional revenue sources. HRSD has also suggested a user fee could be charged to groundwater users to cover operating costs.

Funding the operating costs of aquifer injection through a user fee may be difficult because it would likely require establishing ownership of the water that is withdrawn. Injected water will increase water levels in the coastal aquifer well beyond the jurisdiction of HRSD, and any user in the region will have access to the water. It is unclear whether users outside HRSD's jurisdiction could be compelled to pay a user fee for their withdrawals, as well as which groundwater users would be required to pay, and the amount of the fee that would be levied. If groundwater users are clearly withdrawing water owned and injected by HRSD, there may be more of a basis for assessing a withdrawal fee. If water is withdrawn far from injection sites, users are less likely to be withdrawing water actually injected by HRSD and may instead be withdrawing public water already in the aquifer. In this case, there may be less of a basis for assessing a withdrawal fee.

Ensuring a consistent supply of injected water

Ensuring a continued and consistent supply of injected water is important from a permitting and planning perspective. Future permit evaluation decisions would likely be made assuming the aquifer injection and the subsequent increase in water levels. Any interruption or reduction, though, to injection operations would reduce groundwater availability and could result in groundwater being over-permitted relative to supply. Similarly, planning efforts in the region would assume certain quantities of groundwater will be available from aquifer injections.

Groundwater trading could be effective, but has significant implementation and policy challenges

Systems for trading groundwater withdrawal rights are used in other states to ensure groundwater withdrawals are sustainable, and such an approach could be an effective way to manage Virginia's coastal aquifer. However, implementing a trading system could be complex and would require making numerous policy decisions. A groundwater trading system is a market-based approach in which users can buy and sell groundwater rights to increase or decrease their withdrawal amounts. Trading systems can promote more efficient and effective use of a scarce resource by assigning a monetary value to it. For example, a trading system could allow water users to withdraw more by buying unused allocations from others using less. A trading system could also accommodate economic growth by allowing new groundwater users to buy unused allocations. North Carolina has used a trading system to reduce overall withdrawals in parts of its coastal aquifer, and trading systems are also used in some western states.

Using a groundwater trading system in Virginia's coastal aquifer would require addressing at least three important policy considerations. First, implementing trading would require a policy determination about whether it is appropriate to allow water users to benefit financially from the sale of a scarce public resource. The Code of Virginia states that "all waters in Virginia belong to the public" (§ 62.1-44.36). A trading system would enable some water users to sell their allocations for monetary or other gains and essentially profit from a public good. Some water users currently sell excess surface water supply for revenue, but groundwater in eastern Virginia is a low-cost, high-quality water resource that is increasingly scarce.

Second, prior to beginning, the state would need to determine how water allocations would initially be made to users. The initial allocation would have important implications for which users would need to buy additional withdrawal rights and which users could sell unused rights. If the state used the current allocation of groundwater permit amounts, public water suppliers may face significant costs to buy needed capacity.

Third, implementing a trading system would likely require the state to divide the coastal aquifer into administrative zones. Because the depth and structure of the aquifer system varies considerably, a withdrawal in one location may have different impacts on water levels than the same volume withdrawal in another location. Trades involving withdrawals in close proximity to each other are unlikely to have a significantly different impact on the aquifer, and the state would likely need to designate geographic zones within which trades would require little or no modeling to predict their impact on the aquifer. In contrast, trades involving withdrawals farther apart—such as in different zones—could have differing impacts on the aquifer, and would require more extensive modeling to ensure that water levels do not fall below regulatory minimum levels.

Complexity of water supply likely requires more active state role in water supply project planning

The potential benefits, costs, and risks of the more complex water supply projects—especially reservoirs and aquifer injection—underscore the importance of a regional, state-assisted planning approach. (See recommendations in Chapter 4.) In interviews, water users and experts indicated that in the future Virginia is likely to experience water supply challenges in particular locations rather than statewide. Currently the state has no role in developing water supply projects and there is no compelling reason for the state to have a new, major role in the construction of water supply projects. However, the state will likely need to be more involved in planning large-scale projects that affect the water supply of more than one locality. Other states, especially Texas, are more involved than Virginia in the process of planning water supply projects. (See Appendix E.)

State could ensure critical project planning and policy considerations are addressed for water projects with cross-jurisdictional impact

Large water supply projects should not be undertaken without fully considering whether they are truly the most cost-effective long-term option. For example, much more cost-effective options may include replacing leaking water infrastructure and simpler conservation measures. The risk and cost associated with large water supply projects necessitate ensuring that all other available water supply options have been sufficiently examined before proceeding.

Despite the potential of regional water projects, localities often undertake water supply projects—which often have cross-jurisdictional impact—on their own. Historically, localities have often competed over water resources and developed water supply projects independently. The result can be stark differences between localities in their available supply of water. For example, several localities in Hampton Roads have water supplies well above current demand and sell excess supply to other localities, often at a premium. Some contractual arrangements include one-time capital payments for the right to purchase water at a later date. One public water supplier stated that in many cases "larger localities have locked up the easiest attainable water supplies, requiring smaller localities with limited resources to fend for themselves" (survey response).

A more active state role can help ensure that the key project planning questions are fully addressed:

- Have lower-cost options (e.g., fixing leaking infrastructure) or lower-risk options (e.g., conservation) for water supply been sufficiently explored?
- Have all affected localities been given the opportunity to (1) understand how the project may affect their water supply, (2) participate in the development of the project, and (3) benefit from the additional water supply?
- Have policy decisions been made about (1) how confident localities in the region can be that the project poses sufficiently low technical and environmental risks, (2) who will own the water, and (3) who will pay for the water?

For example, the state could take steps to ensure that appropriate project planning and policy considerations are fully addressed before the aquifer injection project by HRSD is fully operational. Given the costs, challenges, complexity, and multi-jurisdictional nature of the project, an expanded state role may be critical to ensuring its success.

DEQ could provide targeted technical assistance or financial incentives

Large regional public water suppliers have a number of staff with the environmental, technical, and regulatory expertise to plan and build complex water supply projects. Others, though, may lack this full range of expertise. DEQ could offer technical assistance to localities and public water suppliers in identifying potential projects, during planning stages, and during project construction. For example, DEQ could educate localities about the types of projects that may best fulfill their water supply needs with available resources and identify examples of these projects in Virginia and nationwide.

The **Texas Water Development Board provides technical assistance** through project development teams composed of financial analysts, engineers, and environmental reviewers that assist entities in financing, planning, acquisition, design, and construction of projects.

The **Texas State Water Plan includes reservoir site recommendations** for the legislature. The legislature may then designate a recommended site as suitable for construction of a reservoir. Once a site is designated as such, a state agency or political subdivision may not develop on the site to the extent that future reservoir construction would be prevented.

DEQ staff could also help prepare local staff to navigate the complex regulatory and permitting processes involved in completing a project.

In addition, DEQ could assist localities with the technical task of identifying suitable locations for water supply projects, particularly reservoirs. In interviews, public water suppliers and local staff described a number of obstacles to identifying a site for a reservoir, acquiring that site, and gaining required approvals. Working with the federal government on permits, especially for reservoirs, could be a concerted effort by state and local staff.

Cooperation among localities is an emphasis of GO Virginia (Virginia Initiative for Growth and Opportunity in Each Region), which was established in 2016 through legislation by the General Assembly.

A 2012 JLARC study, *Encouraging Local Collaboration Through State Incentives*, also underscored the benefits of incentivizing cooperation among localities.

The state could also provide incentives for regional cooperation on water supply projects, through grants to assist with regional planning or assistance with financing of regional projects. In interviews, staff of public water suppliers explained that the availability of funding is often the greatest hurdle for supply projects and often prevents localities from pursuing their ideal option.

Fulfilling this more active state role in water supply project planning would represent an incremental but significant change in the relationship between DEQ and localities regarding water supply. The feasibility of this new state role should be more fully explored by DEQ, localities, and other key stakeholders. Part of exploring the feasibility of this more active state role is determining whether DEQ would simply report periodically to the State Water Commission about regional planning (as recommended in Chapter 4), or whether DEQ would have some additional oversight or authoritative role in approving projects. Assuming this more active role is feasible in some form, DEQ would need additional staff resources with varying skills and expertise. DEQ should develop a proposal for providing planning and policy guidance through a greater state role in water supply project planning, and assess the feasibility of and resources needed for performing these functions.

RECOMMENDATION 21

The General Assembly may wish to consider including language in the Appropriation Act directing the Virginia Department of Environmental Quality to develop a proposal for providing additional water planning assistance, to include (i) planning and policy guidance for projects with cross-jurisdictional impact and (ii) technical assistance for localities that lack technical resources and expertise in project identification, planning, and construction. The proposal, which should include an assessment of the feasibility of and resources needed to perform this new function, should be submitted to the State Water Commission and House Appropriations and Senate Finance Committees no later than July 1, 2017.

RECOMMENDATION 22

The General Assembly may wish to consider including language in the Appropriation Act directing the State Water Commission to evaluate the establishment of a fund to provide (i) incentives for regional collaboration in water planning and (ii) financing for regional water projects.

Appendix A: Study mandates

2015 Session

HOUSE JOINT RESOLUTION NO. 623
Agreed to by the House of Delegates, February 9, 2015
Agreed to by the Senate, February 24, 2015

SENATE JOINT RESOLUTION NO. 272
Agreed to by the Senate, February 26, 2015
Agreed to by the House of Delegates, February 26, 2015

Directing the Joint Legislative Audit and Review Commission to study Virginia's water resource planning and management.

WHEREAS, Article XI, Section 1 of the Constitution of Virginia states that it shall be the policy of the Commonwealth to conserve, develop, and utilize its natural resources and protect its waters for the benefit, enjoyment, and general welfare of the people of the Commonwealth; and

WHEREAS, § 62.1-11 of the Code of Virginia stipulates that the right to the use of water or to the flow of water from any natural stream, lake, or other watercourse is limited to what may be reasonably required for the beneficial use of the public and that the intent of the Commonwealth is to maintain flow conditions to protect instream beneficial uses and public water supplies for human consumption; and

WHEREAS, Virginia has a complex water system that includes many aquifers, nine major watersheds, and 52,232 miles of rivers and freshwater streams with a total combined flow of 22.5 billion gallons per day; and

WHEREAS, there is no statewide, comprehensive assessment of state and local water resource plans and their role in the water withdrawal permit process, and the Department of Environmental Quality is currently developing a State Water Plan to build upon and guide local and regional water supply plans; and

WHEREAS, the Department of Environmental Quality issues water protection permits for surface water and groundwater withdrawals, and it has reported potential risk to the water supply, including groundwater, given changes in population and demand for water for industrial, recreational, and residential use; and

WHEREAS, recent withdrawals of groundwater in eastern Virginia may have contributed to topographical and hydrological changes, including lower water tables, land subsidence, and higher risk of saltwater contamination of groundwater; and

WHEREAS, the Department of Environmental Quality has appropriated approximately $40 million annually for water protection functions, including planning, permitting, and compliance; now, therefore, be it

RESOLVED by the House of Delegates, the Senate concurring, That the Joint Legislative Audit and Review Commission be directed to study Virginia's water resource planning and management.

In conducting its study, the Joint Legislative Audit and Review Commission shall (i) assess the extent to which groundwater and surface water consumption is unsustainable, the potential effects of any unsustainable consumption, and the risk of overconsumption in the future; (ii) assess the effectiveness of the state's permitting process for groundwater and surface water withdrawals; (iii) assess the effectiveness of state and local water resource planning, particularly with regard to groundwater, including the role state and local plans play in water withdrawal permitting; (iv) examine the adequacy of current funding and staff levels for managing Virginia's water resources; (v) consider the need for strategies and practices to preserve or increase the amount of groundwater and surface water available for future consumption; and (vi) review any other issues and make recommendations as appropriate.

Technical assistance shall be provided to the Joint Legislative Audit and Review Commission by the Department of Environmental Quality, the State Water Control Board, and the Virginia Department of Health. All agencies of the Commonwealth, local governments, and water resource authorities shall provide assistance to the Joint Legislative Audit and Review Commission for this study, upon request.

The Joint Legislative Audit and Review Commission shall complete its meetings for the first year by November 30, 2015, and for the second year by November 30, 2016, and the chairman shall submit to the Division of Legislative Automated Systems an executive summary of its findings and recommendations no later than the first day of the next Regular Session of the General Assembly for each year. Each executive summary shall state whether the Joint Legislative Audit and Review Commission intends to submit to the General Assembly and the Governor a report of its findings and recommendations for publication as a House or Senate document. The executive summaries and reports shall be submitted as provided in the procedures of the Division of Legislative Automated Systems for the processing of legislative documents and reports and shall be posted on the General Assembly's website.

2016 Session

Budget Bill – HB30 (Chapter 780)

Joint Legislative Audit and Review Commission

Item 33

Authority: Title 30, Chapters 7 and 8, Code of Virginia.

G. As a component of its review of water resource planning and management pursuant to House Joint Resolution 623 from the 2015 Session of the General Assembly, the Joint Legislative Audit and Review Commission shall also (i) identify and report a list of the water systems and other water dependent facilities that could be affected by changes, including those that may relate to current "grandfathering" provisions, to the state's water protection permit regulations pursuant to 9 VAC 25-210; and (ii) describe the nature and magnitude of the impact on affected water systems and other water dependent facilities.

Appendix B: Research activities and methods

JLARC staff conducted the following primary research activities:

- structured interviews with state agency staff, public and private water users, and water supply planning and modeling experts;
- collaboration with the Virginia Water Resource Research Center at Virginia Tech;
- a survey of localities, public water suppliers, industrial and other private users, and economic developers;
- reviews of other states;
- attendance at meetings of Eastern Virginia Groundwater Management Advisory Committee;
- reviews of research literature and documents; and
- quantitative analysis of water withdrawal data.

Structured interviews

Structured interviews were a critical part of the research conducted by JLARC staff in reviewing the effectiveness of water resource planning and management. JLARC staff conducted over 50 structured interviews throughout its review and interviewed a wide variety of individuals with various roles and interests in the state's management of its ground and surface water resources, including state agency staff, public and private water users, and modeling and planning experts.

Structured interviews of state agency staff

JLARC staff conducted a total of 15 structured interviews with staff in DEQ's Office of Water Supply. The purpose of these interviews was to (1) better understand DEQ's planning and permitting processes, and the strengths and limitations of these processes; (2) better understand DEQ's ground and surface water modeling, and the strengths and limitations of the models; and (3) obtain DEQ staff's perspectives on how, if at all, the state's management of ground and surface water resources could be improved.

JLARC also interviewed staff in the Virginia Department of Health (Office of Drinking Water) and the Virginia Economic Development Partnership (VEDP). The main goals of the VDH interview were to learn about VDH's waterworks permit process, understand VDH's and DEQ's roles in the calculation of safe yield for waterworks permits, and discuss DEQ's proposed regulatory changes to the definition of safe yield. The purpose of the VEDP interview was to better understand the role of water availability in VEDP's efforts to attract new businesses to Virginia, obtain information on projects that did not materialize due to lack of sufficient water, and learn how predicted water supply will impact future economic development projects.

Structured interviews of public and private water users

JLARC staff conducted interviews with five public water suppliers:

- Henrico County Public Utilities,
- Fairfax Water Authority,
- James City Service Authority,
- Newport News Waterworks, and
- Chesapeake City Public Utilities Department.

The purpose of these interviews was to gain an understanding of the local water planning process and each utility's role in the state water supply planning process, if any; determine their level of satisfaction with DEQ's water permitting processes; learn about any water supply projects or conservation efforts they had undertaken or were planning to undertake in the future; and identify ways the state could assist them in managing their water supply, if at all. In order to understand the cost and complexity of water supply infrastructure, JLARC staff also toured a water treatment plant operated by the Fairfax Water Authority.

JLARC staff conducted interviews with three large industrial users—International Paper, WestRock, and Dominion Resources—to discuss the role of water in their industrial processes, their assessment of Virginia's water supply planning process and the State Water Resource Plan, their opinions of DEQ's permitting processes, and the potential effects of permit reductions on their business operations (if applicable). JLARC staff toured the paper mills operated by International Paper in Franklin City and by WestRock in the town of West Point to better understand how water is used in their manufacturing processes, including how the companies have developed more water-efficient manufacturing processes.

JLARC staff interviewed several stakeholder organizations representing various water-related perspectives. The purpose of these interviews was to obtain their perspectives on the JLARC study and on DEQ's planning and permitting processes, and to learn about their members' concerns with future access to water and the impact of potential water shortfalls. The following organizations were interviewed:

- Virginia Farm Bureau,
- Virginia Agribusiness Council,
- Virginia Homebuilders Association,
- The Nature Conservancy, and
- Mission H2O.

JLARC staff interviewed staff at the Hampton Roads Sanitation District (HRSD) regarding their project to inject treated wastewater into Virginia's coastal aquifer. JLARC staff also reviewed presentation materials from HRSD staff describing the project. The purpose of these activities was to obtain an update on the status of the project, and understand the potential benefits and technical, regulatory, and funding challenges associated with the project.

Structured interviews of modeling and planning experts

JLARC staff conducted interviews with several modeling and planning experts, including staff from the United States Geological Survey (USGS), Interstate Commission on the Potomac River Basin, Hampton Roads Planning District Commission, and the Chesapeake Bay Program, as well as private consultants in the field of groundwater modeling.

Topics addressed during these interviews included:

- the strengths and limitations of DEQ's ground and surface water models;
- their assessments of the sustainability of Virginia's ground and surface water;
- the strengths and limitations of the Virginia State Water Resources Plan, including its conclusions regarding ground and surface water sustainability; and
- issues specific to groundwater in eastern Virginia, including the adequacy of DEQ's regulatory framework for issuing groundwater permits, efforts in other states to manage groundwater, and the effectiveness of Virginia's approach to managing groundwater.

Collaboration with Virginia Water Resource Research Center and other experts

DEQ relies heavily on computer simulations to predict future water supply and demand and assess the sustainability of Virginia's surface and groundwater resources. Because this modeling is highly complex, JLARC staff collaborated with the Virginia Water Resource Research Center (VWRRC) at Virginia Tech to determine the future sustainability of the state's water resources.

VWRRC assembled an advisory panel to help identify qualified subject matter experts and to review research findings. The panel comprised faculty and research staff from Virginia Tech, College of William & Mary, and University of Maryland, as well as DEQ staff. Collectively, panel members had expertise in surface and groundwater modeling, water supply planning, water economics, and water quality.

The subject matter experts chosen by VWRRC and the advisory panel both have extensive experience in water resource modeling. They conducted sensitivity analyses of DEQ modeling and evaluated the surface and groundwater models used by DEQ.

Subject matter expert – Groundwater

Mark A. Widdowson, PhD
Professor of Environmental and Water Resources Engineering
Department of Civil & Environmental Engineering
Virginia Tech

Widdowson examined how the total amount of water that can be withdrawn from the aquifer depends on (i) the rates and locations of individual withdrawals and (ii) the regulatory standards used by the State Water Control Board to review proposed withdrawals. He also assessed the strengths and limitations of the VaHydro-GW model.

Subject matter expert – Surface water

Glen Moglen, PhD
Professor of Environmental and Water Resources Engineering
Department of Civil & Environmental Engineering
Virginia Tech
Director, Occoquan Watershed Monitoring Laboratory (Manassas)

Moglen examined how DEQ's conclusions about future surface water shortfalls depend on the metrics and threshold percentages used to define a "shortfall." He also assessed the strengths and limitations of the VaHydro surface water model.

Survey of localities, public water suppliers, industrial users, and economic developers

JLARC staff administered an electronic survey to obtain the perspectives of water users and key stakeholders, including localities, public water suppliers, industrial and business users, and local economic developers. The purpose of the survey was to gather feedback on a range of study topics, including state and local water planning, the impact of water availability on local economic development efforts, and DEQ's permitting processes for ground and surface water.

The planning section of the survey asked respondents about the usefulness of the state and local water resource plans, their level of participation in the state water resource planning process, their perspectives on the accuracy of the plan in identifying local and regional challenges and strategies, and suggestions for improving state and local plans. The economic development section asked respondents about the importance of water supply for local economic development projects, information on projects that did not materialize or were reduced in scope due to lack of sufficient or affordable water, and their perspectives on how predicted water supply will impact future economic development projects. The permitting section asked survey respondents about the clarity and transparency of DEQ's ground and surface water permitting processes, the reasonableness of the length of time to obtain a permit, and their satisfaction with the permit itself, including the permit amount, permit length, and permit conditions.

A total of 236 respondents completed the survey for an overall response rate of 31 percent (Table B-1). Response rates for individual user types ranged from 19 to 46 percent.

TABLE B-1
Response rates for JLARC survey on water resources

Type of user	# of surveys sent	% of individuals responding
Localities	132	25%
Public water suppliers	187	46
Industrial and business users	333	29
Local economic developers	104	19
All respondents	**756**	**31%**

Reviews of other states

JLARC staff reviewed several other states' water resource planning and permitting processes to better understand how other states manage their water resources. The reviews included Internet reviews and document reviews of other states' programs, and included most southeastern and mid-Atlantic states. For the planning issue, staff reviewed state—and in some cases regional—planning documents to understand the process for developing the plans, determine the type of information included in the plans, and identify any aspects of the plans that could be applicable to Virginia. For the permitting issue, the team reviewed and collected information on various aspects of the permitting processes used in other states, including the circumstances under which water withdrawal permits are required, the lengths of permit terms, the factors used to evaluate proposed permits, and the approaches used to ensure the sustainability of ground or surface water resources.

To supplement these reviews, JLARC staff conducted structured phone interviews with five states to examine their planning and permitting programs in more detail. These states were selected based on factors such as their geographic proximity to Virginia and the comprehensiveness of their state and local plans. The five states interviewed were Florida, Georgia, Maryland, North Carolina, and Texas.

Attendance at meetings of the Eastern Virginia Groundwater Management Advisory Committee

JLARC staff closely followed the proceedings of the Eastern Virginia Groundwater Management Advisory Committee as it works to develop a strategy for managing groundwater in eastern Virginia. Staff attended numerous meetings of the full committee as well as its work groups on

- alternative water sources;
- alternative management structures, including water permit trading systems;
- alternative permitting criteria; and
- water supply funding.

JLARC staff also reviewed presentation materials and meeting minutes for each of the committee and work group meetings held during the review.

Review of research literature and documents

Numerous documents and literature pertaining to water resources management were reviewed by JLARC staff during the course of the study, including:

- prior state studies and reports on Virginia's water resources, including annual reports of the State Water Commission and DEQ's annual reports, "Status of Virginia's Water Resources;"
- various USGS reports, circulars, and professional papers, including The Sustainability of Ground-Water Resources (USGS Circular 1186), The Virginia Coastal Plain Hydrogeologic Framework (Professional Paper 1731), and Simulation of Groundwater Flow in the Coastal Plain Aquifer System of Virginia (Scientific Investigations Report 200905039);
- various planning documents, including the Commonwealth of Virginia State Water Resources Plan and numerous water supply plans developed by localities;

- DEQ permitting documents, including A Public Guide to the Wetland Permitting Process in Virginia, "Virginia Water Protection Permit Program Overview", and sample groundwater and surface water permits and permit applications provided by DEQ;
- Water Resources Planning Manual of Water Supply Practices, Second Edition, American Water Works Association;
- An Investigation of the Economic Impacts of Coastal Plain Aquifer Depletion and Actions That May Be Needed to Maintain Long-Term Availability and Productivity, by Kurt Stephensen and Abt Associates, Inc.

Quantitative analysis

JLARC staff analyzed data from DEQ's Virginia Water Use Database, which contains basic data for most surface and groundwater permits, and water use data from water withdrawers (permitted and non-permitted) who report their withdrawals to DEQ. JLARC staff used this data to calculate statistics for the report, including annual water use by type of user, and the differences between groundwater permit amounts and actual use.

Appendix C: Groundwater withdrawals in eastern Virginia

This appendix describes several topics pertaining to groundwater in eastern Virginia. These include:

- descriptions of how substantial groundwater withdrawals cause declining water levels and can permanently damage the coastal aquifer,
- historical and predicted declines in water levels in the coastal aquifer,
- modeling predicted changes to water levels, and
- Virginia's groundwater permitting regulatory criteria and groundwater withdrawal permit application evaluation process.

Much of the information in this appendix is drawn from research conducted on behalf of JLARC staff by Mark Widdowson.

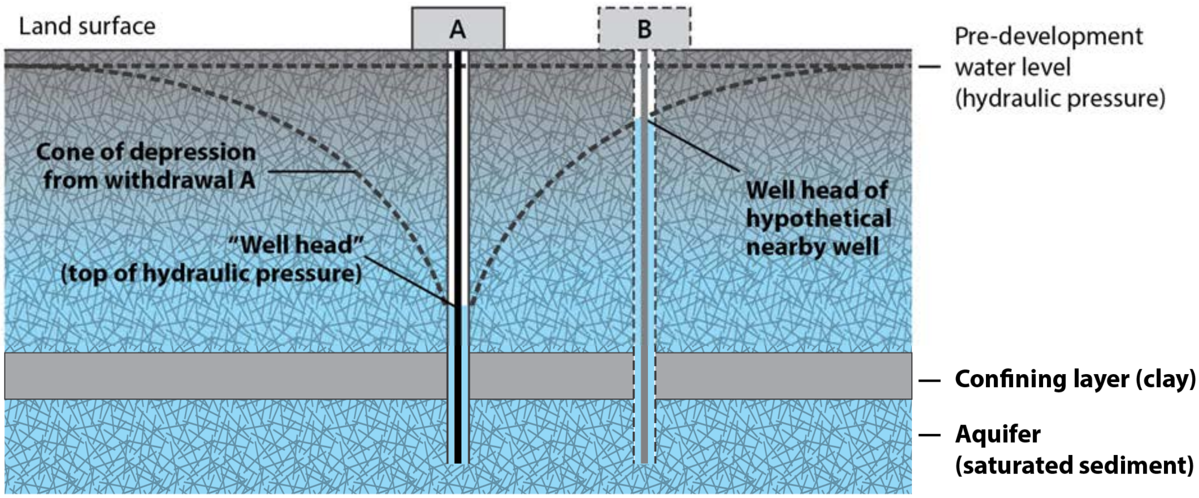
Substantial groundwater withdrawals decrease water levels and can permanently damage the coastal aquifer

The confined aquifer system in Virginia's coastal plain is a depletable resource due to the extremely slow rate of natural recharge. Confined aquifers replenish slowly because they tend to be deeper beneath the earth's surface and below multiple layers of impermeable clay and rock that prevent surface water from seeping into the aquifer from above. Instead, water seeps into confined aquifers from lateral areas where the impermeable layer is less dense or does not exist, such as near the fall line in central Virginia. Thus, recharge can occur miles away from portions of the aquifer and the water replenishing the system must move horizontally, which adds to the time it takes for surface water to reach all parts of the aquifer.

Groundwater withdrawals cause water levels in a confined aquifer to decline because they decrease the pressure in the aquifer. Confined aquifers consist of saturated porous sediment compressed between thick impermeable layers of clay or rock, which results in water in the aquifer being under pressure. Before a well begins to pump, the natural pressure in a confined aquifer pushes water up the well to a level known as the *well head* (Figure C-1). This natural pressure is one of the main benefits of a confined aquifer because it reduces the need for pumping and increases the amount of water that a well produces, reducing the overall cost of withdrawing water. Every withdrawal from a confined aquifer causes a decrease in pressure around the withdrawal. The magnitude of the pressure decrease corresponds with the amount of water being withdrawn at that location. This loss of pressure is greatest at the immediate point of withdrawal and exponentially decreases as it moves laterally away from the well. The resulting area of reduced pressure forms a *cone of depression* around the withdrawal (Figure C-1).

The reduction of pressure in a confined aquifer is a concern because it can increase the cost of withdrawing groundwater. Large withdrawals can substantially reduce pressure and increase withdrawal costs over large portions of an aquifer. As the natural pressure from the aquifer decreases, there is a need for deeper wells, stronger pumps, or additional wells to withdraw the same amount of water. As illustrated in Figure C-1, a large user (A) can create a large cone of depression that reduces pressure—and increases withdrawal costs—for a nearby well (B). Nearby well owners closest to the large users experience the greatest reduction in pressure and increase in costs.

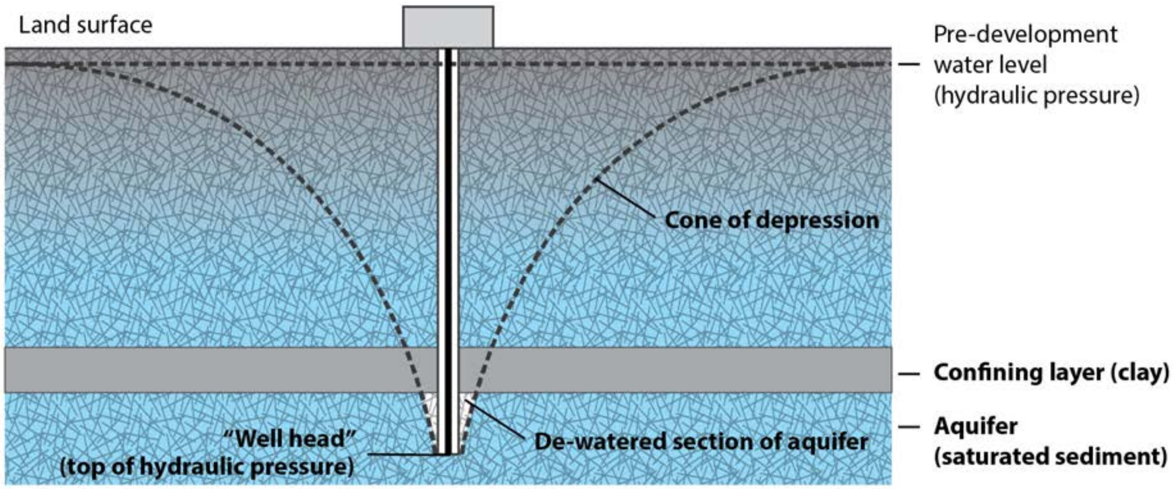
FIGURE C-1
Large withdrawals can decrease water levels for nearby wells



SOURCE: Virginia Department of Environmental Quality and United States Geological Survey.
NOTE: Pre-development water level is included in figure to show water level declines resulting from illustrated withdrawal. DEQ regulatory criteria measure drawdown from land surface.

Withdrawals of a large enough scale and over a long enough period can cause water levels to fall below the top of a confined aquifer, which results in permanent damage to the aquifer. Once water levels fall below the top of the aquifer, any additional withdrawals in that location will dry—or *de-water*—the sediment in the aquifer (Figure C-2). De-watered sediment compacts, and that compaction often means the sediment cannot recover the same amount of saturation it had before de-watering occurred. This results in the permanent loss of water that can be stored in the aquifer. If withdrawals to the area are stopped or sufficiently reduced to allow for recovery, the de-watered parts of the aquifer will only produce 60–70 percent of water originally available. Recovery rates for de-watered parts of an aquifer vary depending on the type of soil and the pressure and stress conditions that exist in that location.

FIGURE C-2
Aquifers can permanently lose storage capacity when water levels fall below top of aquifer

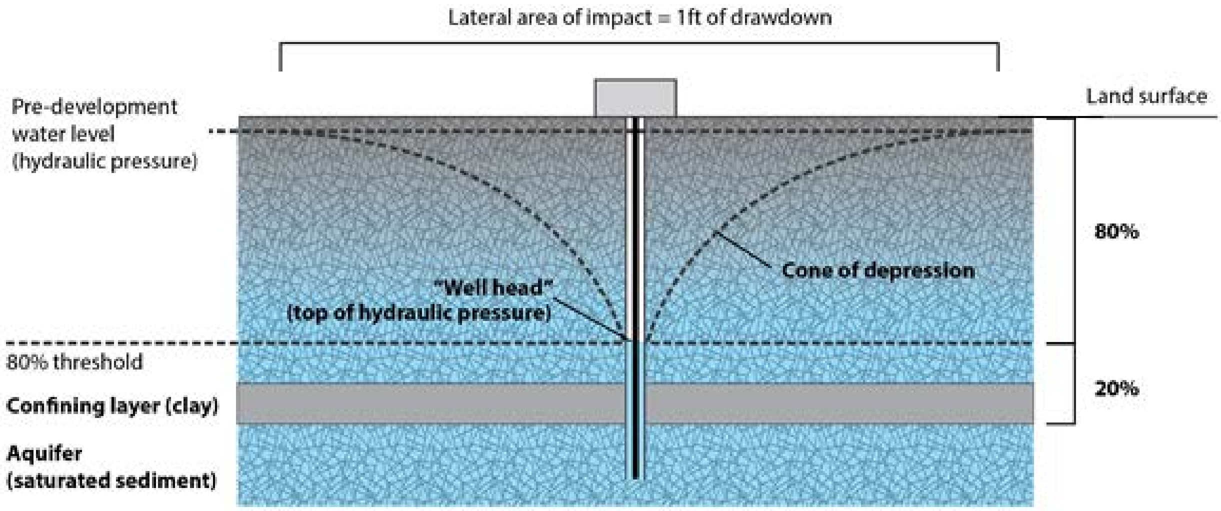


SOURCE: Virginia Department of Environmental Quality and United States Geological Survey.
NOTE: Pre-development water level is included in figure to show water level declines resulting from illustrated withdrawal. DEQ regulatory criteria measure drawdown from land surface.

State regulations require DEQ to maintain minimum groundwater levels in the coastal aquifer

The state's groundwater withdrawal regulations require DEQ to ensure that groundwater levels in the coastal aquifer do not fall below regulatory minimum levels. The agency uses two criteria to determine the regulatory minimum water level at any place in the aquifer. First, DEQ defines the area of impact (AOI) laterally around a proposed withdrawal. Under state regulations, the AOI is defined as the area over which water levels in the aquifer decline one foot or more in the vicinity of a proposed withdrawal. Second, DEQ applies the "80 percent" criterion to determine whether groundwater withdrawals will cause water levels to decline too much. State regulations define the 80 percent criterion as the maximum acceptable water level decline in an aquifer due to pumping. The 80 percent criterion is determined by calculating 80 percent of the difference between the land surface and the top of the aquifer and subtracting this amount from the land surface (Figure C-3).

FIGURE C-3
Regulatory minimum water level defined by "80 percent" criterion



SOURCE: Virginia Department of Environmental Quality and United States Geological Survey.
NOTE: Pre-development water level is included in figure to show water level declines resulting from illustrated withdrawal. DEQ regulatory criteria measure drawdown from land surface.

Mark A. Widdowson at the Virginia Water Resource Research Center at Virginia Tech examined two scenarios for changing the current regulatory minimum water level using less stringent definitions to determine the extent to which additional water could be withdrawn from the aquifer under such alternatives. The two less stringent alternative regulatory minimum water levels examined were (1) a 90 percent drawdown criterion that would allow water level drawdown of 90 percent of the distance between the land surface and the top of the aquifer, and (2) regulatory criteria that used the top of the aquifer as the benchmark and requires water levels to remain at least 10 feet above the top of the aquifer where groundwater is withdrawn. The hypothetical 90 percent drawdown criterion is analogous to current regulatory standards but with an additional 10 percent of permissible water withdrawal. The 10-foot criterion would be an even less stringent definition that would essentially minimize the extent to which water levels are required to remain above the top of the aquifer.

Using less stringent regulatory minimum water levels results in a substantial reduction in the area of the Potomac aquifer that is projected to fall below regulatory minimum water levels when assuming 2015 total permitted use over a 50-year period. The area of the Potomac aquifer that is projected to fall below regulatory minimum levels decreases from 1,666 square miles under current regulatory criteria to 1,019 square miles (39 percent reduction in area) and 916 square miles (45 percent reduction in area) under the 90 percent criterion and 10-foot regulatory criterion, respectively, when assuming total permitted withdrawal rates. Similar results were found for other layers of the aquifer system.

Combining less stringent regulatory criteria for minimum water levels with a less stringent definition of the area of impact (changing from one foot of drawdown to two feet and five feet respectively) would likely allow additional withdrawals to be permitted that would not currently meet regulatory criteria. New withdrawals of small to moderate amounts would be more likely to be approved, but withdrawals of large scale (>1 MGD) would still likely exceed regulatory standards because areas near the fall line would still be below regulatory minimum levels.

Use of less stringent regulatory criteria would cause an increase in negative impacts that are associated with additional water withdrawals. Water levels in the Potomac aquifer would fall to a greater extent under alternative criteria, which would further negate the benefits of maintaining water levels as discussed in Chapter 2. Additional permitted withdrawals would also likely increase the extent to which land subsidence and salt water intrusion may occur.

Groundwater model has several strengths that make it well-suited to managing the coastal aquifer

The "VAHydro-GW" model used by DEQ to estimate future groundwater levels in the coastal aquifer has two key strengths that make it ideal for managing the aquifer. First, the model is a significant improvement over past models because it represents the most up-to-date understanding of the hydrogeological framework of Virginia's coastal aquifer. The foundation of the model is a groundwater flow model known as the Virginia Coastal Plain Model (VCPM), which was created by the US Geological Survey to incorporate well-established principles of groundwater flow and storage. A key improvement of the VCPM model was its inclusion of the Chesapeake Bay impact crater, which was created about 35 million years ago when a comet or asteroid hit the earth in present-day Northampton County on Virginia's Eastern Shore. The discovery of the impact crater drastically changed the understanding of how groundwater flows in the aquifer and how salty groundwater near the coast is distributed.

Second, the VAHydro-GW model is broad enough to make predictions for much of the coastal aquifer in Virginia, but at a sufficiently detailed level to accurately predict the impact of proposed groundwater withdrawals. The model represents much of the Atlantic Coastal Plain aquifer within Virginia, including groundwater beneath the Chesapeake Bay, the Eastern Shore of Virginia, parts of southern Maryland north of the Potomac River and on the Delmarva Peninsula, and parts of North Carolina adjacent to the Tidewater region. At the same time, the computational grid of the model has 437,376 cells, each of which is simulated independently by the model.

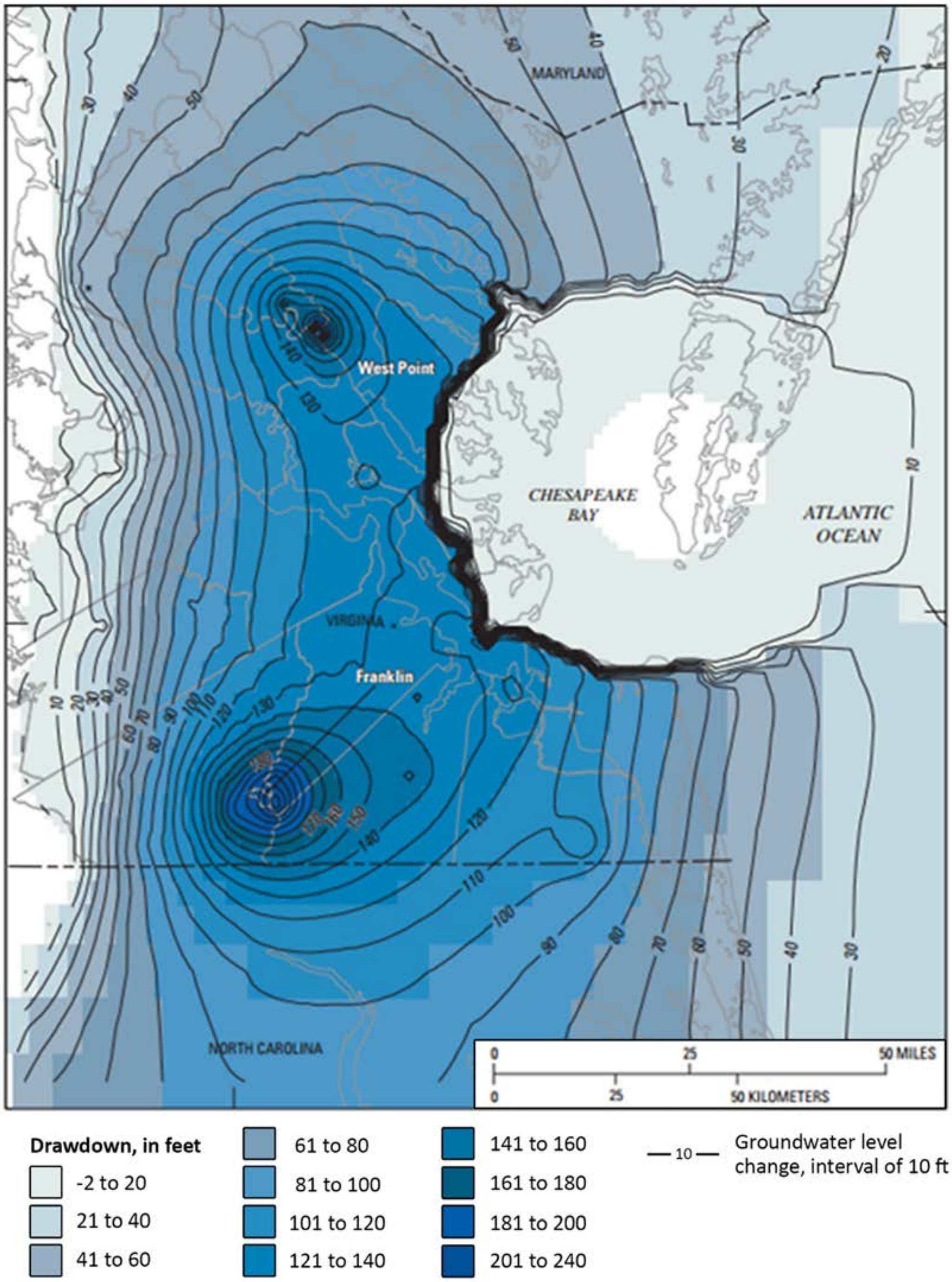
Previous withdrawals have caused declining water levels, and future withdrawals would cause water levels to decline below regulatory minimum levels

Water levels in much of the coastal aquifer have steadily declined over time, with the largest declines centered around the town of West Point and Franklin City, where paper mills have withdrawn substantial amounts of water for several decades (Figure C-4). Groundwater withdrawals from the Potomac aquifer increased substantially in the mid twentieth century, causing declines in water levels of 150-200 feet or more in many parts of the aquifer). Those declines have meant a substantial loss in the natural pressure of the coastal aquifer. In 1941, pressure from the Potomac aquifer pushed water about 7 feet *above* the land surface in a well near the City of Franklin. Today, measurements at wells near the same location indicate water levels more than 200 feet *below* the land surface.

Continued withdrawals from the Potomac aquifer at the maximum permitted or current reported withdrawal rates would cause large areas of the aquifer to fall below regulatory minimum water levels.

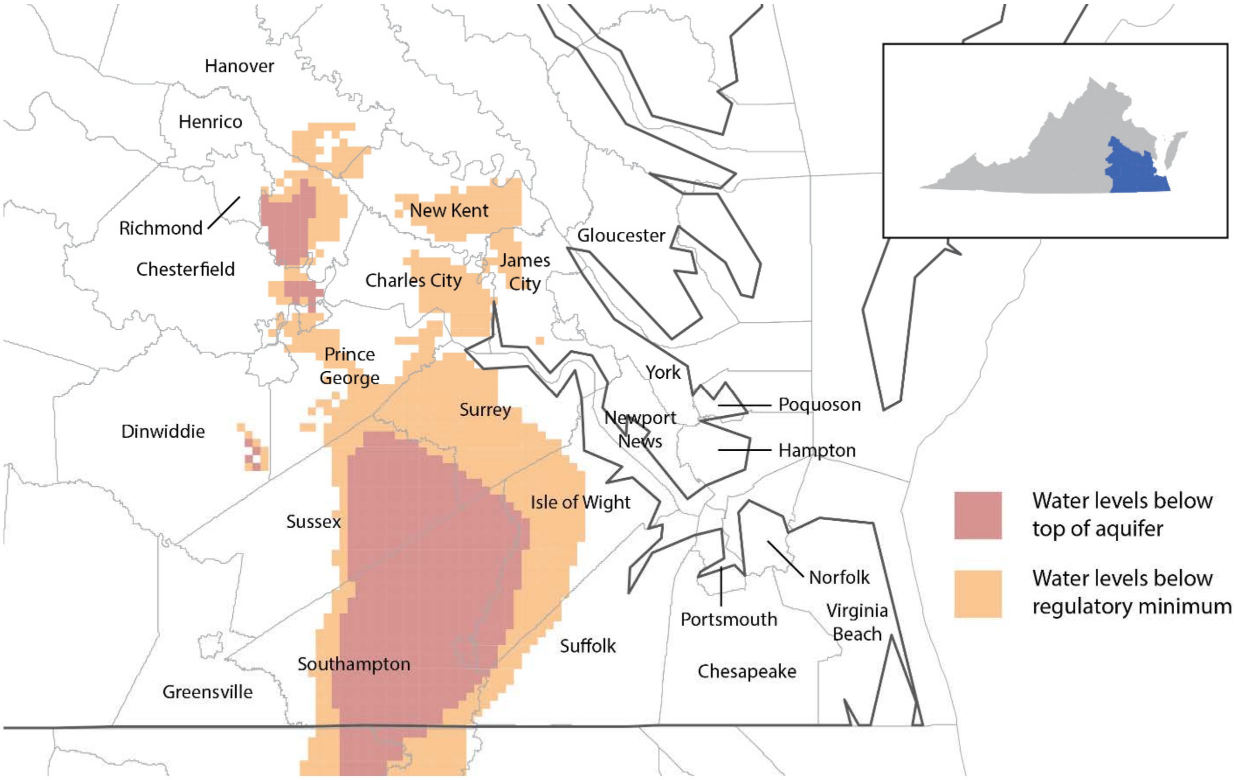
Under maximum permitted withdrawal rates, more than 1,600 square miles—or about 14 percent of the aquifer—would fall below regulatory minimum levels over the next 50 years (Figure C-5). In much of that area, particularly Southampton and Surry counties and along the fall line, water levels would fall below the top of the aquifer and permanently damage the resource. Under current withdrawal rates, water levels would fall below the regulatory minimum in a smaller portion of the aquifer, primarily in the eastern parts of Henrico, and Chesterfield counties (Figure C-6). Other aquifer layers such as the Piney Point and Aquia would experience water levels falling below regulatory minimum water levels, primarily near the fall line, under maximum permitted or current reported withdrawal rates.

FIGURE C-4
Largest declines in water levels have occurred in West Point and Franklin City (2003)



SOURCE: Simulation of Groundwater Flow in the Coastal Plain Aquifer System of Virginia. USGS Scientific Investigations Report 2009–5039.
NOTE: Simulated drawdown from predevelopment to 2003 in the Potomac aquifer of the Virginia Coastal Plain.

FIGURE C-5
Areas of the Potomac aquifer predicted to fall below regulatory minimum levels under maximum permitted withdrawals



SOURCE: Prepared by Aquaveo LLC. For the Virginia Department of Environmental Quality.
NOTES: Simulation conducted in 2016. 50-year prediction period. Northern portion of the coastal aquifer is not pictured.

Groundwater users will face difficulty getting approval for new or increased permits

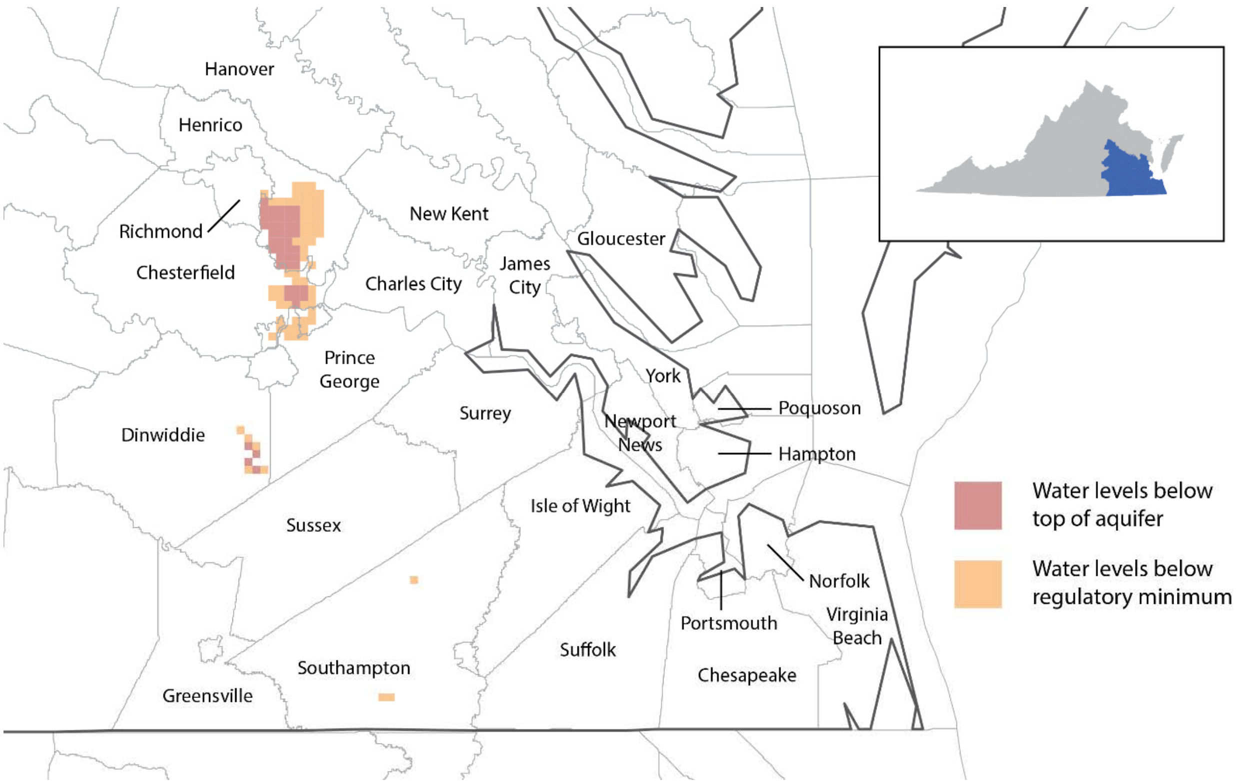
Consistent with the state's groundwater withdrawal regulations, proposed groundwater withdrawals in the eastern Virginia aquifer must meet two requirements to be approved. First, the AOI of a proposed withdrawal cannot cross into an area of the aquifer system that is already below or will fall below regulatory minimum water levels. Second, a proposed withdrawal cannot cause water levels to fall below regulatory minimum levels in any new areas of the aquifer.

Based on these regulatory standards, and given that current withdrawals are near maximum sustainable rates, both new users and current permit holders that need moderate to large amounts of additional groundwater are unlikely to be approved for permits. Analysis by Mark A. Widdowson and the VWRRC at Virginia Tech indicates that future withdrawals of moderate to large amounts are likely to cause water levels to fall below minimum levels and therefore be denied (Figure C-7). The AOI resulting from a hypothetical withdrawal of two MGD in eastern New Kent County would intersect areas that have already fallen below regulatory minimum water levels. According to Widdowson, withdrawals of a similar or larger amount in most parts of the aquifer would be denied. A two MGD withdrawal is similar in scale to a water intensive manufacturing process such as chemical production or a small scale public water provider.

Small to moderately sized withdrawals would have greater potential to be approved, but would often still fail, confirming the difficulty obtaining a new permit in eastern Virginia. For example, analysis by an independent hydrologist shows that smaller hypothetical withdrawals of 0.4 or 0.5 MGD near the center of Surry County would not be approved because water levels would fall below regulatory minimum levels. However, these hypothetical drawdowns do have less substantial areas of impact, so they may meet regulatory criteria depending on their exact location in the aquifer.

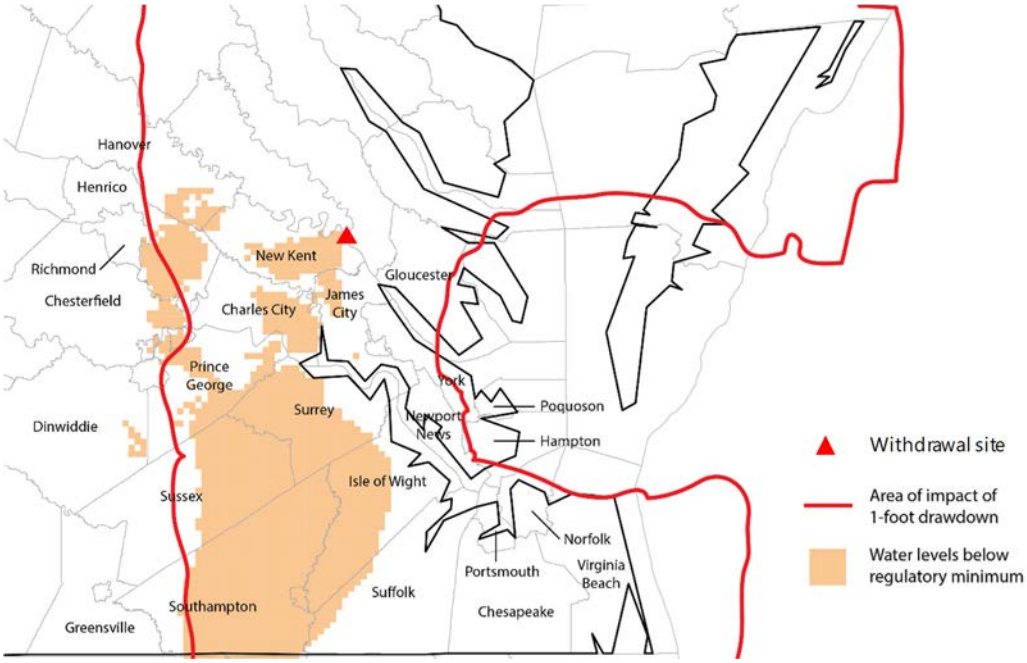
FIGURE C-6

Areas of the Potomac aquifer predicted to fall below regulatory minimum levels under current reported withdrawals



SOURCE: Prepared by Aquaveo LLC. For the Virginia Department of Environmental Quality.
NOTES: Simulation conducted in 2016. 50-year prediction period. Northern portion of the coastal aquifer is not pictured.

FIGURE C-7
Hypothetical 2 MGD withdrawal from the Potomac Aquifer would be denied



SOURCE: Mark A. Widdowson, Virginia Tech. 2016 simulation.
NOTE: Based on maximum permitted withdrawals. Northern portion of the coastal aquifer is not pictured.

Appendix D: Surface water modeling

This appendix provides additional information about four aspects of managing surface water in Virginia, including:

- the primary factors impacting surface water flow levels,
- the VAHydro model for assessing surface water sustainability,
- the low flow metrics and screening thresholds used by DEQ to define a surface water shortfall, and
- the river and stream segments for assessing surface water sustainability.

Much of the information in this appendix is drawn from research conducted on behalf of JLARC staff by Glenn Moglen.

Surface water flows are influenced by natural factors and human activity

Flow levels in rivers and streams fluctuate throughout the year in response to natural factors and human activities. For example, seasonal changes in precipitation and weather greatly influence surface water levels. The highest flow levels generally occur in the spring due to greater rainfall amounts and run-off from snow melt. Flow levels are typically lowest in the summer and early fall when higher temperatures result in more evaporation and there is less rainfall.

A range of human activities also impact flow levels in rivers and streams. These are most commonly water withdrawals and wastewater discharges by public water suppliers and industrial, agricultural, and other users. Other activities such as changes to stream channels, reservoir intakes and releases, evaporation from reservoir surfaces, and changes to land use (which impacts rainfall run-off patterns) can also vary flow levels in rivers and streams. Depletion of groundwater due to groundwater withdrawals may reduce river and stream flows, especially in central and western Virginia where groundwater can be relatively close to the surface and is often one of the primary sources of the water in a river or stream.

Surface water model has capacity to make highly precise predictions of flow levels

The VAHydro model used by the Virginia Department of Environmental Quality (DEQ) has three key strengths that make it well-suited for assessing surface water sustainability. First, the model was developed from the highly regarded Chesapeake Bay Program Phase 5.3 Chesapeake Bay Watershed Model, which is used to simulate nutrient flows into the Chesapeake Bay. The Watershed Model uses a well-known computer program for simulating hydrologic conditions (known as Hydrological Simulation Program-FORTRAN). In developing the VAHydro model, DEQ staff expanded the Watershed Model beyond the Chesapeake Bay watershed to include the entire state of Virginia.

Second, the VAHydro model acts as a "metamodel" that relies on a number of other models and data sources to represent the natural factors and human activities that influence flow levels in rivers and streams. For example, the VAHydro model uses a sophisticated methodology to simulate the often complex operational rules by which reservoirs withdraw and release water throughout the year.

Third, VAHydro can provide a detailed simulation of river and stream flow levels in specific areas at specific times. With adequate data, the model could produce highly precise predictions of surface water shortfalls. VAHydro has the capacity to predict flow levels down to the hour, or in 15-minute increments in some areas, which DEQ aggregates at the daily, monthly, and annual averages to reduce volatility of their estimates. The model is informed by a comprehensive, statewide network of gages that measure river and stream flows throughout the state, allowing it to predict flow levels for specific river and stream segments. (See below.)

DEQ uses four low-flow metrics and thresholds to assess surface water sustainability

As part of its assessment of surface water sustainability, DEQ defines a surface water shortfall using four low-flow conditions that represent periods of low flow or drought and a corresponding screening threshold for each metric (Table D-1). The most common threat to surface water sustainability in Virginia is dry or drought periods, which could result in flow levels that are not sufficient to meet all human and environmental needs. The four metrics used by DEQ were selected to capture a range of dry or drought conditions that could occur. They also represent relevant flow conditions that are commonly considered by the state and other experts when conducting water sustainability research, planning, and permitting efforts. River or stream segments predicted to fall below one or more of the screening thresholds are considered by DEQ to be at a higher risk of shortfall and warrant greater scrutiny or planning.

TABLE D-1
Low flow metrics used by DEQ

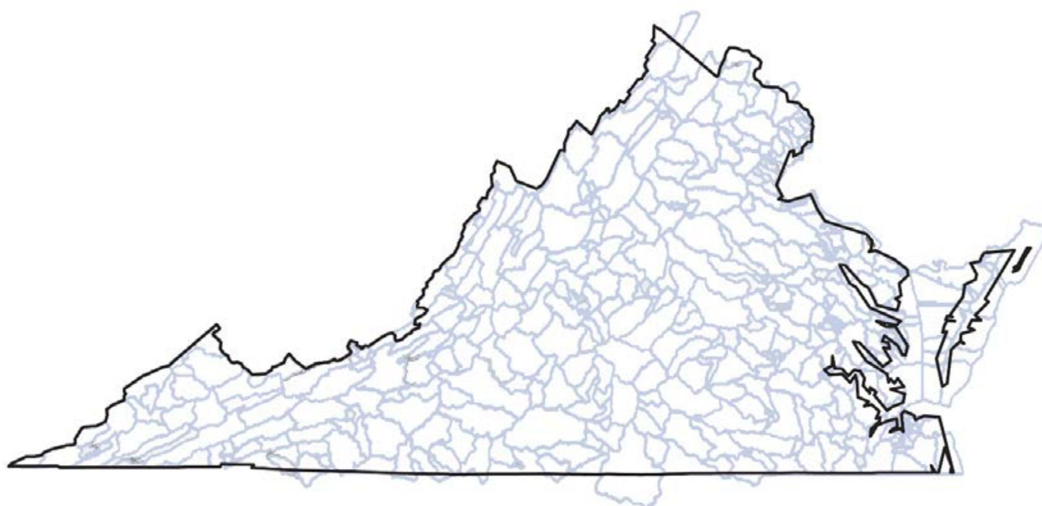
Metric	Description	Screening threshold
Changes in August Low Flow (ALF)	ALF describes a moderately dry condition that falls outside drought ranges. Watersheds experiencing substantial decreases in ALF face increased risk of negative impacts to aquatic life. ALF is one of several factors considered in the surface water permitting program, so negative impacts to ALF will present a challenge for the issuance of new or expanded withdrawal permits.	Decrease in ALF flow of ≥10%
Withdrawals as percentage of September Drought Warning Flows (W9W)	September drought warning flows describe a condition of moderate drought, with flow levels between the ALF and 7Q10 levels. Rivers with withdrawals as a high percent of W9W flows face increased risk of algal blooms and water shortfalls.	Withdrawals ≥25% of the W9W
Changes in 7Q10	The 7Q10 flow represents the lowest mean 7-day flow that statistically occurs once every 10 years. Areas that suffer decreases in 7Q10 flows will have decreased flows for off-stream uses such as human consumption and industrial use and experience a loss of capacity to sufficiently assimilate waste into waterways, resulting in lower water quality.	Decrease in 7Q10 flow ≥5%
Changes to Drought of Record flows (DoR)	The lowest mean daily flow levels measured during the drought of 2002 is used to represent the DoR (The 2002 drought was the drought of record for a majority of Virginia, and mean flow levels were lowest during September). Due to the extreme low flow at this level, even small changes to the DoR flow present substantial risk of a water shortfall.	Decrease in DoR Flow >5%

SOURCE: DEQ State Water Resource Plan, 2015.

Surface water model attempts to predict flow levels for river and stream segments

DEQ's surface water modeling simulates and predicts flow levels for 277 separate river and stream segments throughout Virginia (Figure D-1). Segments are geographical components of river basins, and represent the area over which water drains to a specific portion of a river or stream. The state water resource plan presents results from DEQ's assessment of surface water sustainability for the 277 segments that are not influenced by coastal tides and that lie primarily within state boundaries. River and stream segments that are excluded due to tidal influences represent a significant portion of eastern Virginia, but these areas are less susceptible to flow variation due to consistent tidal supply. The model predicts flow rates for each segment and these rates can be predicted to improve (increase), remain the same, or degrade (decrease).

Figure D-1
Virginia's river and stream segments



SOURCE: DEQ State Water Resource Plan, 2015.
NOTE: Map shows all 439 river and stream segments. DEQ assesses the 277 segments that are not tidally influenced and lie primarily within Virginia.

Climate change scenarios affecting modeling results

Climate change will influence surface water sustainability and should be considered when performing sustainability modeling exercises. The VAHydro model presently does not have the capability to incorporate climate change scenarios into predictions, but could be modified to do so at a later date. According to Glenn Moglen at the Virginia Water Resources Research Center at Virginia Tech, doing so is critical:

> Climate change will undoubtedly influence water resources in Virginia. Individual climate models differ on the degree and nature of climate change, though there is widespread agreement of increases in temperature and greater variability in rainfall intensities and volume. Based on such forecasts, streams are likely to become more variable in flows over time and reservoirs will likely mirror this variability in storage. Simply put, future water supply will become both more variable and uncertain under climate change.

A common refrain of those who challenge the need to consider climate change in contexts such as these is that climate change is simply a source of variability and uncertainty. These sources are already noted above. However, climate change is more than this. There is a directionality to climate change and this directionality points to greater concerns for water supply.

Appendix E: Water planning in Virginia and other states

This appendix provides additional information about water supply planning, including:

- the challenges that DEQ outlined in Chapter 6 of the state plan that were not discussed earlier in this report,
- how other states conduct a regional water supply planning process, and
- examples from plans in other states that have a more regional approach.

Virginia's water supply challenges

In addition to the three water supply challenges discussed in Chapter 4 of this report, DEQ included nine other challenges and recommendations in its State Water Resource Plan (Table E-1). Two reported on the possibility of issues with water quality, and another two describe efforts that the state

TABLE E-1
Challenges and recommendations described in the State Water Resource Plan

Challenge	DEQ's recommendation
The vast majority (82%) of total surface water withdrawn is unpermitted	Investigate whether operational rules can be developed for those surface water withdrawals and impoundment releases currently excluded from VWP permitting
There are gaps in data on ground and surface water use among certain industries	Initiate a more systematic approach to registering facilities that includes training localities and other water purveyors to directly input data into the content management system
There is uncertainty regarding groundwater availability outside of the groundwater management area (GWMA)	Consider installing monitoring wells in localities outside the GWMA with expected significant increases in 2040 demands from groundwater
Localities identified threats to water quality	Evaluate ALF and 7Q10, incorporating additional conditions to be considered as resources allow
The magnitude of impact of consumptive use on water supply is poorly understood	Request approval to revise water withdrawal reporting regulation to include consumptive use
Greater adoption of water conservation practices across localities could reduce demand for water	Encourage localities and regions to place more emphasis on conservation efforts
Environmental issues may impact water supply	Conduct cumulative impact analysis annually with best available climate change model scenarios and develop a subsidence monitoring plan
Many localities were identified by VDH to have water sources with high susceptibility	Encourage localities to develop and implement Source Water Protection Plans
A comprehensive, statewide public education and outreach program could have a positive impact on Virginia's water resources	Inform localities of State Water Resources Plan findings and assist with plan compliance, improve water demand data, and emphasize importance of water supply planning and conservation during drought to public

SOURCE: JLARC staff analysis of DEQ State Water Resource Plan, 2015.

could undertake to encourage water conservation and water supply awareness programs among localities and regions. Though the plan suggests that conservation practices will become increasingly important over time, the descriptions of these "challenges" do not detail specific problems that must be addressed. They provide general commentary on the theoretical benefits of implementing these educational programs. The remaining five out of the state plan's 12 challenges described issues with DEQ's data collection and management, which are intended to be addressed by DEQ and improved upon in revisions to the state plan.

Regional water planning in other states

Nationwide, there is wide variation in terms of how states plan for their water supplies. Some states focus their planning efforts almost exclusively at the local level, while others have a much larger state role. There are several states that currently conduct water supply planning regionally, including Florida, Georgia, and Texas. Florida's planning is primarily done by staff in water management district offices in conjunction with local stakeholders, including local governments, regional water supply authorities, water utilities, and other interested parties. Georgia and Texas both established regional planning groups that are made up of a variety of local water stakeholders and are responsible for developing water supply plans for their regions. All three of these states rely on their regional plans to identify the most feasible and effective solutions to any water supply needs.

Florida

Planning process: Florida is divided into five water management districts that are each responsible for coordinating the development of water supply plans by the regions within their districts. Every five years, districts conduct a water supply assessment to identify regions where current water supply does not meet expected water demand over the following 20 years. Regional water supply plans detail how anticipated water needs will be met, including planned and in-progress water supply development projects. Because Florida relies on its water management districts to manage the completion of regional water supply plans, the state does not prepare a comprehensive water resource or supply plan. Rather, it completes an annual report that summarizes the regional plans and provides updates on any relevant issues or projects. (See Figure E-1 for an excerpt from Florida's annual report. The full report is available at http://www.dep.state.fl.us/water/waterpolicy/docs/2015_Annual_Reg_Water_Supply.pdf) When needed, the state facilitates planning between districts through specific efforts, such as the Central Florida Water Initiative (CFWI) and the North Florida Regional Water Supply Partnership. The CFWI was established to address concerns over groundwater withdrawals from the Floridan aquifer, which has historically provided most of the region's water. It includes the three affected districts and a steering committee made up of state and water management district staff and other stakeholders to oversee it. The group is charged with identifying alternative sources of water to meet predicted demands that are currently unsustainable.

State role in planning: In addition to developing the state's Annual Report on Regional Water Supply Planning, the Florida Department of Environmental Protection's Office of Water Policy oversees the five district offices. There are six staff serving in this office. State staff report that district offices are generally self-sufficient and staffed with the expertise necessary to complete the regional plans, but the state does have staff members responsible for communicating with each district and developing statewide policy to guide the water management districts in developing regional water supply plans, among other responsibilities.

Georgia

Planning process: There are 11 water planning regions in Georgia, which were defined based on both jurisdictional boundaries and sources of water used. Upon the initial creation of the planning regions, counties at the borders of regions had the opportunity to petition for reassignment to a contiguous planning region. Each region has a water planning council responsible for preparing water development and conservation plans (WDCPs) every five years. WDCPs contain forecasts of future water supply and capacity needs and identify the optimal water management practices for the region. Each council is made up of 28 members representing an array of local water stakeholders, including those from agriculture, industry, local government, water utilities, tourism and regional development centers. Members are appointed by the Governor, Lieutenant Governor, and the Speaker of the Georgia House of Representatives, and councils elect a chair and a vice-chair for each planning cycle. State staff report that councils have taken on the majority of the responsibilities associated with regional planning, but they also work with contractors to help manage the group's operations.

State role in planning: The State of Georgia, with agency support from the Georgia Environmental Protection Division (EPD), completed its first and only state water management plan in 2008. (The state is directed to consider whether a revised state plan is needed every three years, and it has not yet been deemed necessary.) According to department staff, this process started a statewide conversation about water resources and facilitated communication among the state's various water sectors. Importantly, the plan established the process by which regions would begin planning for their water supply needs. This process includes the provision of two sets of technical products to councils by EPD: forecasts of water demand and assessments of resource capacity to meet demand. Councils use the technical products provided by EPD as the building blocks for regional plans that specify management practices appropriate to the water resources and water users in each region.

Texas

Planning process: Texas is divided into 16 planning regions based on jurisdictional lines. Planning groups consist of 23 members on average and represent at least 12 statutorily required interests, including the public, local government, water management districts and authorities, various industries, agriculture, the environment, and small business. Regional plans are completed every five years and help inform the state's water plan. In regions where the current supply is not predicted to meet future water demand, plans must include recommended water management strategies. All potential strategies must be compared according to the quantity of water they could produce, reliability, cost, environmental factors, and impacts on agricultural resources, among other considerations (Figure E-2). Planning groups submit recommended strategies to the Texas Water Development Board (TWDB) as part of their regional water plan, where they must be approved.

Although planning groups are not regulatory entities and have no authority to direct the implementation of water management strategies, planning group members often represent the large local water providers and industries that will become project sponsors. Since these entities are involved in the process of identifying the most feasible and effective water supply projects, they may be more likely to take them on. The TWDB conducts an implementation survey to track whether recommended projects are being developed.

State role in planning: The TWDB has more than 50 staff responsible for assisting entities with the regional water supply planning process and subsequent project implementation. In addition to regional and state planning staff who work directly with planning groups, there are six project development teams that assist regions with securing financial assistance for projects as well as project planning, such as preliminary engineering, land acquisition, project design, and project construction. Planning staff are responsible for managing water planning data and developing population and water demand projections for use within the regions. The Texas Commission on Environmental Quality conducts statewide surface water availability modeling, the results of which are made available to each regional planning group before it begins developing a plan.

FIGURE E-1
Excerpt from Florida state water report

Table 1 summarizes the status of RWSPs in the districts. Between 2015 and 2035, statewide demand for fresh water is estimated to increase by at least 1.1 bgd. Of that, only 320.5 mgd is not met by existing allocation, capacity, or source. To date, the RWSPs have identified potential water conservation savings at 326.7 mgd and alternative water supply projects that could, if constructed, produce approximately 1.1 bgd of water by 2030-2035. This quantity, combined with the projects yet to be identified in the North Florida Regional Water Supply Partnership (NFRWSP) and the St. Johns River Water Management District's (SJRWMD) Central Springs and East Coast RWSP, will be more than adequate to meet projected 2030-2035 needs.

Table 1. Status of Regional Water Supply Plans

WMD/Planning Region	Net Demand Change (mgd)	Future Demand Not Met with Existing Allocation, Capacity, or Source (mgd)	Potential Conservation Savings Identified in RWSP (mgd)	Future Demand Not Met After All Conservation Implemented (mgd)	Potential Water from Alternative Water Supply Projects Identified in RWSP (mgd)
Northwest Florida WMD	**2015-2035**[4]				
Region II	19	1.8	6.5	0	59
Region III	9	0	9.5	0	35[5]
Regions I, IV, V, VI, & VII	10	n/a[6]	3.6[4]	n/a	n/a
Districtwide	**38**	**1.8**	**19.6**	**0**	**94**
St. Johns River WMD	**2015-2035**[7]				
North Florida (Region 1)	Included in NFRWSP	Included in NFRWSP	Included in NFRWSP	Included in NFRWSP	Included in NFRWSP
Central Springs East Coast (Regions 2, 4, and 5)	78.75	Under Development	47	Under Development	Under Development
Central Florida (Region 3)	Included in CFWI	Included in CFWI	Included in CFWI	Included in CFWI	Included in CFWI
CSEC Portion of SJRWMD	**57**		**47**		
South Florida WMD	**2015-2030**[8]				
Lower Kissimmee Basin	15	0	0	0	0
Upper Kissimmee Basin	Included in CFWI	Included in CFWI	Included in CFWI	Included in CFWI	Included in CFWI
Upper East Coast	23	3	14	0	70
Lower East Coast	189	10	52	0	76
Lower West Coast	257	10	41	0	66
Districtwide	**484**	**23**	**107**	**0**	**212**
Southwest Florida WMD	**2015-2035**				
Northern (excluding CFWI)	50.7	26.7	18.8	7.9	90.9
Tampa Bay	74.3	5.4	41.6	0	103
Heartland (excluding CFWI)	8.3	0.9	3.5	0	4.7
Southern	55.2	12.7	15	0	185.4
Districtwide	**188.5**	**45.7**	**78.9**	**7.9**	**384**
Central Florida Water Initiative (CFWI)	**2015-2035**				
Portions of SJR, SWF & SF	**234**	**250**	**42**	**208**	**455**
Suwannee River WMD	**2015-2035**				
Alapaha River Basin	North Florida Regional Water Supply Plan Under Development				
Lower Santa Fe River Basin					
Upper Santa Fe River Basin					
Upper Suwannee River					
Rest of SRWMD	**22**	**n/a**	**n/a**	**n/a**	**n/a**
North Florida RWSP	**2015-2035**				
Portions of SJR & SR	**125.3**	Under development	**32.2**	Under development	Under development
Statewide Total	**1,148.8**	**320.5**	**326.7**	**224**	**1145**

[4]Net demand change and potential conservation savings from NWFWMD 2013 Water Supply Assessment.
[5]Represents capacity of new upstream surface water intake (30 mgd) plus anticipated additional reclaimed water available (5 mgd).
[6] n/a indicates that a RWSP has not and does not need to be developed for that region.
[7] Source is Draft Joint NFRWSP Projections, 2016.
[8]SFWMD is transitioning from their 2010-2030 RWSPs to their 2015-2035 RWSPs, so numbers reported are for 2010-2030.

SOURCE: Florida Department of Environmental Protection's 2015 Annual Report on Regional Water Supply Planning

FIGURE E-2
Example of strategy evaluation matrix from a regional water supply plan

Entity	County Used	Basin Used	Strategy	Quantity (Ac-Ft/Yr)	Maximum Need	Percentage of Max Need Met	Quantity Score	Reliability	Anunal Cost ($/Ac-Ft)	Cost Score	Impacts of Strategy on: Environmental Factors	Impacts of Strategy on: Agricultural Resources/ Rural Areas	Impacts of Strategy on: Other Natural Resources	Impacts of Strategy on: Key Water Quality Parameters	Overall Score (5-40)
Claude	Armstrong	Red	Conservation	29	110	26%	2	3	$714	4	5	5	5	5	29
			New Groundwater (Ogallala)	400	110	363%	5	3	$790	4	4	4	4	4	28
Panhandle	Carson	Red	Conservation	48	582	8%	1	3	$795	4	5	5	5	5	28
			New Groundwater (Ogallala)	600	582	103%	5	5	$621	4	4	4	4	4	30
Wellington	Collingsworth	Red	Conservation	50	595	8%	1	3	$806	4	5	5	5	5	28
			New Groundwater (Seymour)	180	595	30%	2	2	$1,485	3	4	4	3	4	22
			Nitrate Removal (RO Treatment)	500	595	84%	4	2	$1,029	3	4	4	3	3	23
Dalhart	Dallam	Canadian	Conservation	113	2,807	4%	1	3	$364	5	5	5	5	5	29
			New Groundwater (Ogallala)	2,700	2,807	96%	4	3	$213	5	4	4	4	4	28
Texline	Dallam	Canadian	Conservation	28	161	17%	1	3	$656	4	5	5	5	5	28
			New Groundwater (Ogallala)	150	161	93%	4	5	$778	4	4	4	4	4	29
Irrigation	Dallam	Canadian	Conservation	140,612	94,226	149%	5	3	$17	5	5	5	5	5	33
McLean	Gray	Red	Conservation	27	182	15%	1	3	$897	4	5	5	5	5	28
			New Groundwater (Ogallala)	200	182	110%	5	5	$446	5	4	4	4	4	31
Pampa	Gray	Canadian	Conservation	240	3,806	6%	1	3	$619	4	5	5	5	5	28
			New Groundwater (Ogallala)	2,000	3,806	53%	3	5	$490	5	4	4	4	4	29
Memphis	Hall	Red	Conservation	34	133	25%	2	3	$964	4	5	5	5	5	29
			New Groundwater (Ogallala)	150	133	113%	5	3	$848	4	4	4	4	4	28
County-Other	Hall	Red	Conservation	26	50	52%	3	3	$744	4	5	5	5	5	30
			New Groundwater - Turkey (Ogallala)	100	50	200%	5	3	$1,380	3	4	4	5	5	29
			New Groundwater- Brice-Lesley (Ogallala)	50	50	100%	4	3	$688	4	4	4	3	4	26
			New Groundwater-Estelline (Seymour)	50	50	100%	4	3	$360	5	4	4	3	4	27
			Nitrate Removal (Lakeview)	75	50	150%	5	3	$3,345	1	4	4	3	3	23
Gruver	Hansford	Canadian	Conservation	31	344	9%	1	3	$943	4	5	5	5	5	28
			New Groundwater (Ogallala)	350	344	102%	5	3	$450	5	4	4	4	4	29
			Develop PDRA Transmission System	271	344	79%	4	1	$4,866	1	4	4	3	3	20
Spearman	Hansford	Canadian	Conservation	27	634	4%	1	3	$615	4	5	5	5	5	28
			New Groundwater (Ogallala)	650	634	103%	5	3	$636	4	4	4	4	4	28
			Develop PDRA Transmission System	116	634	18%	1	1	$1,708	3	4	4	3	3	19
Irrigation	Hansford	Canadian	Conservation	37,260	0	N/A	5	3	$17	5	5	5	5	5	33
Irrigation	Hartley	Canadian	Conservation	120,509	98,650	122%	5	3	$17	5	5	5	5	5	33
Canadian	Hemphill	Canadian	Conservation	93	0	N/A	5	3	$681	4	5	5	5	5	32
Stinnett	Hutchinson	Canadian	Conservation	37	216	17%	1	3	$827	4	5	5	5	5	28
			New Groundwater (Ogallala)	225	216	104%	5	3	$477	5	4	4	4	4	29
			Develop PDRA Transmission System	116	216	54%	3	1	$6,407	1	3	4	3	3	18
TCW	Hutchinson	Canadian	Conservation	59	569	10%	1	3	$570	4	5	5	5	5	28
			New Groundwater (Ogallala)	575	569	101%	5	3	$736	4	4	4	4	4	28
Irrigation	Hutchinson	Canadian	Conservation	10,281	0	N/A	5	3	$17	5	5	5	5	5	33
Booker	Lipscomb	Canadian	Conservation	21	575	4%	1	3	$597	4	5	5	5	5	28
			New Groundwater (Ogallala)	700	575	122%	5	5	$270	5	4	4	4	4	31
Dumas	Moore	Canadian	Conservation	231	4,437	5%	1	3	$629	4	5	5	5	5	28
			New Groundwater (Ogallala)	4,500	4,437	101%	5	2	$332	5	4	4	4	4	28
			Develop PDRA Transmission System	1,356	4,437	31%	2	1	$3,620	1	3	4	3	3	17

SOURCE: Texas Region A’s Panhandle Water Plan, 2016.

Appendix F: Water withdrawal permit lengths in other states

The lengths of water withdrawal permits in Virginia are similar to or shorter than permit lengths in many other mid-Atlantic and southeastern states (Table F-1). Groundwater permits in Virginia are valid for 10 years and surface water permits are valid for 15 years. Permit lengths range from five to 50 years in selected mid-Atlantic and southeastern states that require permits. These states grant permits for differing lengths depending on a range of factors. For example, in Georgia, the permit lengths can be based on factors such as the source of supply and the type of use.

TABLE F-1
Groundwater and surface water permit lengths for selected other states

	Groundwater permit length (years)	Surface water permit length (years)
Virginia	10	15
Delaware	30 [1]	30 [1]
Florida	20 [2]	20 [2]
Georgia	10–50 [3]	10–50 [3]
Maryland	12	12
North Carolina	10 [4]	NA
South Carolina	5 [5]	20–50

SOURCE: JLARC staff review of state web sites and other documents.
[1] Permits are 30 years, but can be shorter in cases of hydrologic complexity or uncertainty, or if there are water quality or quantity concerns.
[2] Permits can be up to 20 years. Longer terms, such as 30 years, have been granted to incentivize developing alternative water supply projects.
[3] The duration of the permits can be based on various factors, including the source of supply and type of use.
[4] Permit length is 10 years, or the amount of time necessary for reasonable amortization of the applicant's water withdrawal and water use facilities.
[5] Permit length is 5 years, or the length of time the permit agency believes is necessary to conserve and protect the resource, prevent waste, and provide and maintain conditions that are conducive to the development and use of water resources.

States that have longer permit terms often require permits to undergo mid-term reviews. Three states reviewed by JLARC staff have these requirements. In Delaware, permits are valid for 30 years but are subject to review every five years. These reviews are coordinated with periodic analysis of water withdrawal and hydrologic conditions on an aquifer or drainage-wide basis where possible. In Maryland, permits are reviewed at least once every three years, or more frequently at the discretion of the state. During these reviews, the state may adjust the amount of the permit or add a condition to the permit for resource management purposes, such as avoiding or mitigating unreasonable adverse impacts on public health or the environment. In Georgia, statute requires the "review of permits periodically or upon a substantial reduction in average annual volume of the water resource which adversely affects water supplies." The reviews are intended to verify that the permit holder remains in compliance with the conditions of the permit.

States with longer permit lengths can have other requirements in addition to mid-term reviews. For example, for permits valid for 25 years or more in Georgia, the permitting agency must ensure the water supply is adequate to meet the needs of the citizens for the term of the permit. The permit must also be based on a regional water development and conservation plan that promotes the conservation and reuse of water, guards against water shortages, promotes the efficient use of the water resource, and is consistent with the public welfare of the state.

Appendix G: Charging fees for water in other states

Several states charge a fee for groundwater withdrawals. At least 12 states currently charge a fee based on the amount of water withdrawn (Table G-1), and the state of Pennsylvania is considering a fee for certain surface water withdrawals. Another 14 states, including Virginia, charge a fee for water that is unrelated to the amount withdrawn, such as a permit application fee or well construction fee. At least five states do not charge any fees for groundwater withdrawals.

As discussed in Chapter 5, rates charged vary substantially from state to state (Table G-1). The fee structure also varies among the states, with many states charging more for larger withdrawals. Alaska and Connecticut, for example, charge a flat fee based on the amount withdrawn, with larger withdrawals having higher fees. Several states—including Arizona, Maine, Massachusetts, Rhode Island, and Vermont—charge a per gallon fee, so larger withdrawers pay more. Some states have fees that only apply to public water suppliers, including Arizona, Kansas, Vermont, and Rhode Island. Pennsylvania, on the other hand, would exempt public water suppliers from its proposed fees. Other states have different fees based on type of use: Texas, for example, charges less for agricultural uses than for non-agricultural uses.

The purpose of the fees varies from state to state. Some states appear to charge fees to limit the amount of groundwater withdrawn. In Arizona, for example, the active management area fee is only charged in areas where groundwater has been heavily withdrawn, so the fees may serve as a disincentive to withdraw large amounts in these areas. In Pennsylvania, the impetus for considering fees appears to be the need to raise revenue for state environmental agencies and for Chesapeake Bay cleanup.

FIGURE G-1
States with volume-related groundwater fees

	Description	Amount
Alaska	General withdrawal fee	$200 for amounts less than or equal to 5,000 gallons per day, up to $900 for amounts greater than 100,000 gallons per day
Arizona	Active management area fee and municipal water supply permit fee	$1 to $3 per acre foot (active management area fee) $0.0055 per gallon (municipal water supply permit fee)
California	Flat fee and volumetric fee	$100 (flat fee) $0.030 per acre foot (>10 acre feet)
Connecticut	Large water withdrawal fee	$2,050 if greater than 50,000 gpd $4,000 if greater than 500,000 gpd $6,250 if greater than 2 MGD
Kansas	Water Appropriation Act permit (non-domestic uses), public water supply fee, clean water protection fee	Non-domestic uses: $200 for amounts ≤ 100 acre feet; $300 for amounts above 100 acre feet; if above 320 acre feet, $20 for each additional 100 acre feet above 320 Public water suppliers: $.03 per 1,000 gallons (public water supply fee) + $.03 per 1,000 gallons (clean water protection fee)
Maine	Base withdrawal fee	$250 base fee + $50 per million gallons
Massachusetts	Safe Drinking Water Act Assessment Charge	$8.50 per million gallons
Missouri	Public Water System Fee[1]	$1.08–$3.24 per year (domestic customers) $7.44–$82.44 per meter per year, max. $500 per year (commercial customers)
Texas	Groundwater withdrawal fee	$1.00 per acre foot (agricultural uses) $10.00 per acre foot (non-agricultural)
Rhode Island	Water supplier surcharge	$.0292 per 100 gallons
Vermont	Public Community Drinking Water Supply Fee	$.0439 per 1,000 gallons
Washington	Application fee and appropriation fee	$450 (application fee) $1 per hundredth cubic foot per second

SOURCE: JLARC staff analysis of *Taxing Vermont's Groundwater*, Vermont Natural Resources Council, November 6, 2013.
NOTE: An acre foot is equivalent to 325,851 gallons of water.
[1]This fee is considered a user fee. It is not paid by the public drinking water system, but is instead paid by household customers and businesses who receive drinking water from Missouri's public water systems.

Appendix H: Additional water supply projects

A wide range of water supply projects can be considered for increasing or conserving the supply of water available for human use. Several types of projects have more limited potential statewide, but may still be feasible and cost-effective under certain circumstances (Table H-1). Many types of projects have more limited potential because they would require extensive infrastructure or water treatment, substantially increasing the cost of a project. For example, reusing wastewater for non-drinking water purposes, such as manufacturing, would require separate piping infrastructure that parallels existing public water supply infrastructure. Other types of projects have unique challenges that further limit their potential. Desalination of seawater would draw on an abundant supply of water in coastal areas, but the cost of removing salt and other minerals is substantial and there are limited options for disposing of the resulting salt concentrate. Reusing wastewater for drinking water purposes could reduce flow levels in rivers and streams that rely on the discharge of treated wastewater. The reuse of wastewater also generates significant concern about water quality and potential contaminants in the drinking water supply.

TABLE H-1
Advantages and disadvantages of certain water supply projects

Type of project	Advantage	Disadvantage
Transferring or purchasing water supplies	• Uses existing excess water capacity • Best suited for localities with public water systems in close proximity	• Can require additional piping to connect neighboring systems • Water is often purchased above cost, with right-to-buy capital payments
Aquifer storage and recovery (ASR)	• Uses excess capacity by allowing surplus drinking water to be injected into aquifer, and withdrawn when and where needed • Injected water is withdrawn through wells, eliminating the need for piping infrastructure to reach end users	• Many water providers have little incentive to pursue ASR projects because the injection process requires additional operating costs • Potential to contaminate or damage the aquifer system if injected water does not match the composition of naturally occurring groundwater
Retaining stormwater	• Low cost: generally requires little infrastructure • Little to no large-scale planning needed; projects are site-specific and localized • Useful for supplying agricultural, residential, or commercial irrigation	• Results in untreated water so uses are limited • Use can be limited to immediate proximity of impoundment; additional piping needed if used farther away • Could reduce flow levels and impact downstream users by diverting water otherwise discharged into rivers • Rainfall is inconsistent and hard to predict
Directly reusing wastewater for drinking water purposes	• Utilizes treated wastewater otherwise discharged into rivers and streams • Little or no additional infrastructure needed because treated wastewater directly enters drinking water system • Abundant and consistent supply of water	• Negative public perception associated with using wastewater for human consumption • Could reduce flow levels and impact downstream users by diverting water otherwise discharged into rivers • Currently prohibited by state regulations
Reusing wastewater for non-drinking water purposes	• Utilizes treated wastewater effluent, potentially limiting level of treatment needed • Abundant and consistent supply of water	• Need for piping infrastructure that parallels piping for freshwater • Could reduce flow levels and impact downstream users by diverting water otherwise discharged into rivers • Generally requires a specific end user that will guarantee use in order to justify project costs • Limited number of uses for graywater
Desalination of seawater	• Abundant and consistent supply of water	• Feasible only in coastal areas • High treatment costs due to the need for intensive filtering • Difficulty disposing of salt concentrate removed from water during treatment
Desalination of brackish water	• Abundant and consistent supply of water • Lower treatment costs compared to seawater desalination (fewer dissolved minerals)	• Feasible only in coastal areas • Higher treatment costs compared to fresh water • Difficulty disposing of salt concentrate removed from water during treatment

SOURCE: JLARC staff analysis.

Appendix I: Agency response

As part of an extensive validation process, state agencies and other entities involved in a JLARC assessment are given the opportunity to comment on an exposure draft of the report. JLARC staff provided an exposure draft of this report to

- Virginia's Secretary of Natural Resources;
- Virginia Department of Environmental Quality;
- Subject matter experts with the Virginia Water Resources Research Center at Virginia Tech;
- Hampton Roads Sanitation District;
- James City Service Authority; and
- Water resources management staff in other states that were referenced in the report.

Appropriate corrections resulting from technical and substantive comments have been made in this version of the report. This appendix includes a response letter from the Virginia Department of Environmental Quality.

COMMONWEALTH of VIRGINIA

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September 30, 2016

Mr. Hal E. Greer, Director
Joint Legislative Audit and Review Commission
General Assembly Building, Suite 1100
201 North 9th Street
Richmond, VA 23219

Dear Mr. Greer:

The Department of Environmental Quality (DEQ) would like to thank the staff of the Joint Legislative Audit and Review Commission (JLARC) for their professional and diligent efforts they undertook in the preparation of this report to understand and communicate many of the complex aspects of Virginia's water resource planning and management programs. We appreciate the opportunities JLARC staff provided to meet, discuss, and clarify issues throughout the development of this report.

DEQ received and has reviewed the exposure draft of this report. A number of the recommendations identify issues that have been raised by DEQ and others and have the potential to improve water resource planning and management activities. As pointed out in the report, DEQ is moving forward on several of them as authority and resources allow. These programs have historically been resource limited. DEQ appreciates the recommendation that will allow agency identification of these needs and the opportunity for consideration.

In closing, we wish to acknowledge that despite the management challenges identified in the report, Virginia has made significant progress in taking steps to install a comprehensive foundation for water resources planning and management. This report is timely as the sustainability issues Virginia is facing are relatively new, and the dialogue among effected parties to develop steps to address them are evolving.

Sincerely,

David K. Paylor

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