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# Urban Water System Permit Support Document

Rivanna Water and Sewer Authority
31430-005
May 14, 2021

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## List of Acronyms

| Abbreviation | Definition |
|---|---|
| ACOCD | Albemarle County Office of Community Development |
| ACSA | Albemarle County Service Authority |
| CWA | Clean Water Act |
| DCR | Virginia Department of Conservation and Recreation |
| DEQ | Virginia Department of Environmental Quality |
| DWR | Virginia Department of Wildlife Resources |
| DU | Dwelling Unit |
| EPA | U.S. Environmental Protection Agency |
| FW | Finished Water |
| JPA | Joint Permit Application |
| LRTP | Long Range Transportation Plan |
| MDD | Maximum Day Demand |
| MGD | Million Gallons per Day |
| MIF | Minimum Instream Flow |
| MF | Multifamily Residential |
| NF | Non-Residential |
| OWTP | Observatory Water Treatment Plant |
| RMDA | Ragged Mountain Dam Agreement |
| RMR | Ragged Mountain Reservoir |
| RWPS | Raw Water Pump Station |
| RWSA | Rivanna Water and Sewer Authority |
| SFR | Single Family Residential |
| SRR | South Rivanna Reservoir |
| SHR | Sugar Hollow Reservoir |

| Abbreviation | Definition |
|---|---|
| TNC | The Nature Conservancy |
| TJPDC | Thomas Jefferson Planning District Commission |
| TJSWCD | Thomas Jefferson Soil and Water Conservation District |
| T&E | Threatened and Endangered |
| USCOE | U.S. Army Corps of Engineers |
| UVA | University of Virginia |
| USGS | United States Geological Survey |
| VDH | Virginia Department of Health |
| VMRC | Virginia Marine Resources Commission |
| VaFWIS | Virginia Fish and Wildlife Information Service |
| VWP | Virginia Water Protection |
| WTP | Water Treatment Plant |

# 1. Introduction

Since 1973 the Rivanna Water and Sewer Authority (RWSA) has provided wholesale treated water to serve a current population of approximately 120,000 in Albemarle County, Virginia as well as the City of Charlottesville. The largest contiguous water system served by RWSA is known as the Urban System or Urban Service Area, as shown on Figure 1. RWSA operates three water treatment plants (WTP) with a current combined maximum production capacity of 21.7 MGD to supply its customers in its Urban System. The Urban System's water supply is derived from the North Fork Rivanna River, South Rivanna Reservoir (SRR), Ragged Mountain Reservoir (RMR), and Sugar Hollow Reservoir (SHR). Raw water derived from these sources is then treated at one of three treatment plants and distributed throughout the service area.

RWSA currently operates under a Virginia Water Protection (VWP) Individual Permit for its Urban System (Permit No. 06-1574). The VWP permit includes withdrawals from SRR with a tiered structure for minimum instream flow releases as well as minimum releases/and or withdrawals from SHR and RMR. Defined releases are a function of reservoir levels and useable storage available to the Urban System. In addition, RWSA has obtained a permit from the U. S. Army Corps of Engineers (USCOE), Norfolk District, pursuant to Section 404 of the Clean Water Act (CWA) for work associated with the Ragged Mountain Reservoir expansion (Permit No. 06-V1574). Both permits will expire in 2023.

In support of continued assessment of regional water supply needs and available resources, RWSA and their consultants went through a rigorous process in 2019 to evaluate system demands and required safe yield to provide sufficient water supply to meet the demands. Based on these evaluations, it was determined the water supply projects originally permitted in 2008 are still needed and are the least environmentally damaging, practicable options for the region's water resources needs. As described herein, this permit will serve as a continuation of RWSA's selected long-term water supply program for the Urban System.

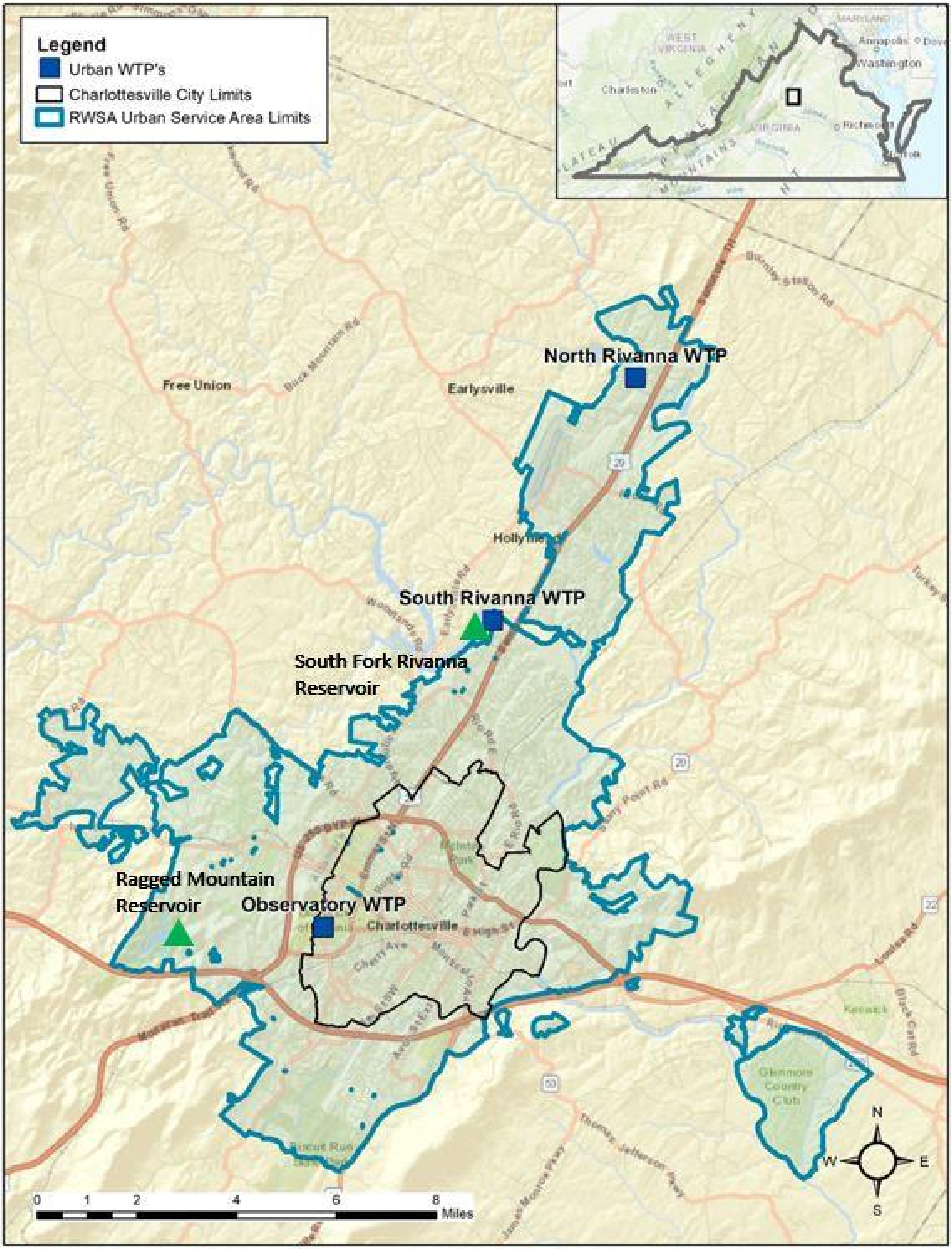


**Figure 1: RWSA Urban Service Area Boundaries and WTP Locations**

# 2. Statement of Purpose and Need (Project Summary) (JPA Section 3)

RWSA has a contractual obligation to the City of Charlottesville and the Albemarle County Service Authority as established in 1973 with the execution of the "Four Party Agreement[1]," to ensure and provide for the future drinking water needs of the broader community (as outlined in the RWSA 2021-2025 Capital Improvement Plan). Following a significant drought in 2002, RWSA began developing a long-term water supply plan to ensure sufficient regional water supply for the next 50 years. As part of this effort, RWSA engaged stakeholders through community meetings and met with local officials and state and federal agencies to inform the evaluation of dozens of water supply alternatives to serve the region over the coming decades. This effort culminated ultimately in the Community Water Supply Plan (Plan), whose central components include an expansion of the Ragged Mountain Reservoir and construction of a pipeline between South Rivanna Reservoir and Ragged Mountain Reservoir to allow RWSA to transfer water between the two, as needed. In addition, new pump stations at each facility will allow RWSA to convey flow in either direction. Federal and state permits for both projects were granted in 2008, were subsequently amended in 2011, and are set to expire in 2023.

RWSA has made substantial progress towards completion of the projects covered under the current permit. However, RWSA does not anticipate completing all permitted project elements prior to the 2023 expiration date. Therefore, RWSA is pursuing a permit renewal and extension to complete this work.

## 2.1 Project Description

The Community Water Supply Plan is comprised of several documents, agreements, and plans developed over several years. RWSA obtained a U.S. Army Corps of Engineers permit pursuant to Section 404 of the Clean Water Act (Permit No. 06-V1574) and Virginia Department of Environmental Quality (DEQ) permit pursuant to Section 401 of the Clean Water Act (VWP Permit No. 06-1574) in 2008 for the water supply infrastructure projects outlined in the Community Water Supply Plan. The Plan consists of several individual projects that collectively function to enable the long-term water supply and treatment needs of the Urban System to be met. As explained further in Section 3, these projects, which center around improvements to the Ragged Mountain Reservoir and South Rivanna Reservoir infrastructure, include the following:

- Replace the existing Ragged Mountain Reservoir dams with a new dam at a higher elevation (+12 feet) that would raise the reservoir's normal pool elevation;
- A nine-mile pipeline connecting Ragged Mountain Reservoir and South Rivanna Reservoir, and new pump stations at both reservoirs that can convey flow in either direction.
- A new pipeline from Ragged Mountain Reservoir to the Observatory WTP;

[1] The "Four Party Agreement" was executed on June 12, 1973 between the City of Charlottesville, the Albemarle County Service Authority, the Board of County Supervisors of Albemarle County, and RWSA. This agreement established the need for RWSA to acquire, finance, construct and maintain facilities for the supply of potable water to the City and County.

- A new raw water intake and low lift station at South Rivanna Reservoir;
- A pre-treatment facility at South Rivanna Reservoir;
- Expansion of the water treatment facilities at the Observatory and South Rivanna WTPs; and
- Release structures to meter flows and release water to the streams.

Of these projects, only the new Ragged Mountain Reservoir dam is complete. The other projects are at varying levels of planning and construction and are largely expected to be constructed within the timeline of the forthcoming USCOE Section 404 permit (2033) and DEQ VWP permit (2038). Over the course of the VWP permit term withdrawals from the water supply system needed to meet annual average day demands are expected to reach 11.43 MGD. Peak day demands over the new VWP permit term are expected to reach 18.5 MGD based on a peaking factor of 1.47 and a Virginia Department of Health Certification Factor of 1.1.[2] The implementation of the projects that comprise the Community Water Supply Plan will ensure adequate water supply and treatment capacity to meet forecasted demands through 2070 and significantly improve the overall reliability and resiliency of the water system.

The remainder of this section describes the existing Urban System as well as proposed changes to the system to address increased resiliency and meet the long-term water supply needs of the system. More detail on the Community Water Supply Plan and the proposed changes to the Urban System to address long-term supply and reliability needs is provided in Section 3.

### 2.1.1 Summary of Existing System

The source of supply for the Urban System is the Rivanna River Basin, which includes three water supply reservoirs, a low-head dam, and three water treatment plants (WTP) (Figure 2).[3] Of the three reservoirs, Sugar Hollow Reservoir is the furthest upstream, located approximately 15 miles northwest of the City, and is created by impounding the Moormans River with a low-head dam known as the Sugar Hollow Dam. Water from the Sugar Hollow Reservoir can be diverted to the Ragged Mountain Reservoir via the Upper Sugar Hollow Pipeline; spills and releases flow to the Moormans River and ultimately to the South Rivanna Reservoir, located approximately four miles northwest of the City and just west of US-29. The South Rivanna Reservoir was created by impounding the South Fork Rivanna River, and experiences greater turbidity, sedimentation and nutrient loading than the other reservoirs. Water withdrawn from the South Rivanna Reservoir is treated at the South Rivanna WTP. Spills and releases from the South Rivanna Reservoir flow to the South Fork Rivanna River.

The Ragged Mountain Reservoir, located approximately 4 miles west of the City, impounds streams in a small portion of the Rivanna River headwaters. Water diverted to Ragged Mountain Reservoir from Sugar Hollow Reservoir and collected from natural runoff is withdrawn and treated at the Observatory WTP. Releases and spills from Ragged Mountain Reservoir enter an unnamed tributary of Moores Creek, where it ultimately joins to the Rivanna River.

In addition to the reservoirs, RWSA has an intake upstream of a low head dam on the North Fork Rivanna River. Water withdrawn from the river at this location is treated at the North Rivanna WTP. Water

[2] Correspondence with B. McGurk, DEQ Office of Water Supply, January 2018.
[3] Chris Green Reservoir and Lake Albemarle are not operated for water supply and the Beaver Creek Reservoir is a part of the Crozet System.

flowing over the dam continues downstream along the North Fork Rivanna River until it meets the South Fork Rivanna River to form the Rivanna River.

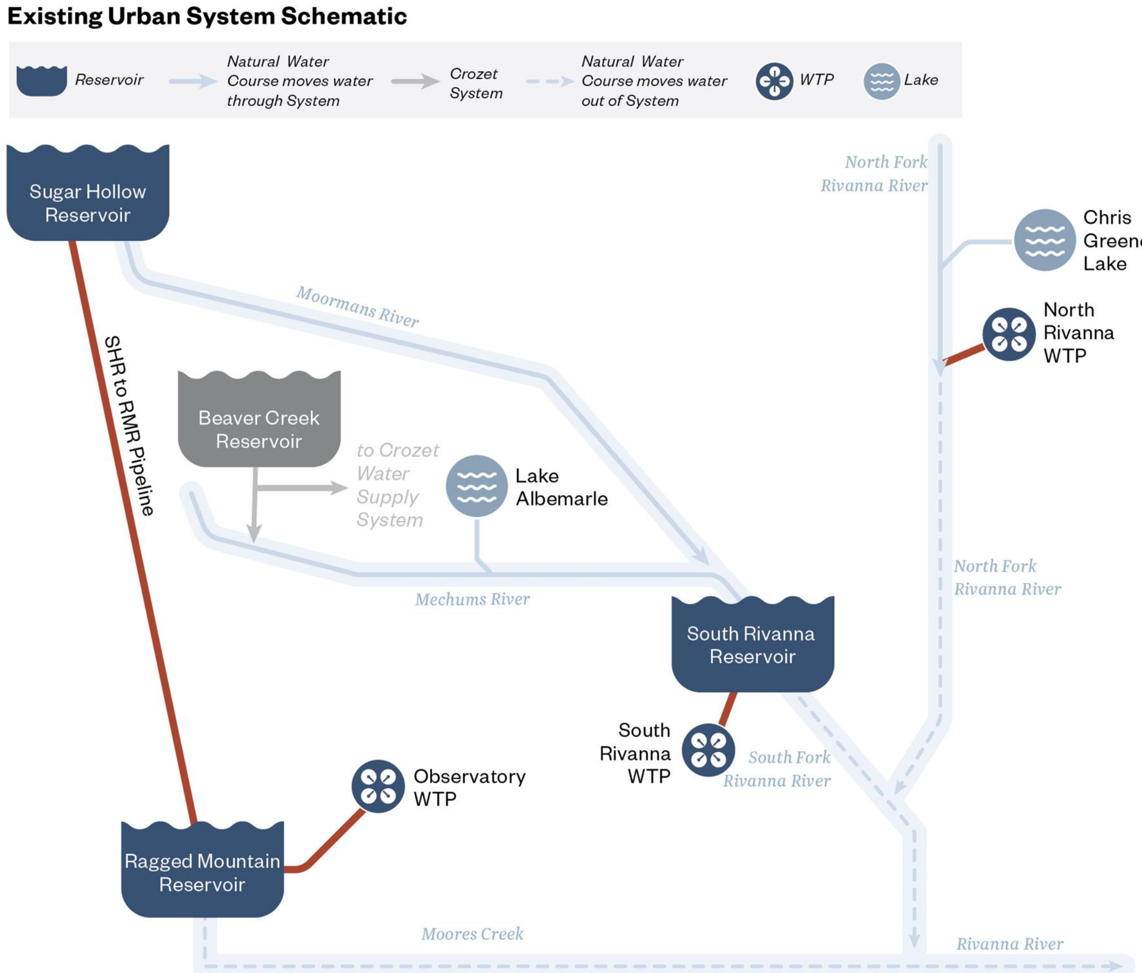


**Figure 2: Schematic of the Existing RWSA Urban Water Supply System**

### 2.1.2 Summary of Proposed System

RWSA is in the process of constructing a pipeline connecting the South Rivanna Reservoir with the Ragged Mountain Reservoir to allow RWSA to transfer water between the two, as needed, and will construct pump stations to facilitate flow in either direction (Figure 3). Flow transferred to the Ragged Mountain Reservoir will likely pass through a pre-treatment facility at the South Rivanna WTP to remove high levels of turbidity and nutrients. Once this new pipeline is operational, the existing Sugar Hollow Pipeline will be removed from service and abandoned in place, and the Ragged Mountain Reservoir normal pool elevation will be raised. To date, approximately one mile of pipeline across the University of Virginia Birdwood Golf Course has been constructed, with another 0.2 miles (1,100 linear feet) of pipeline planned to be completed between Fiscal Years 2022 to 2023.

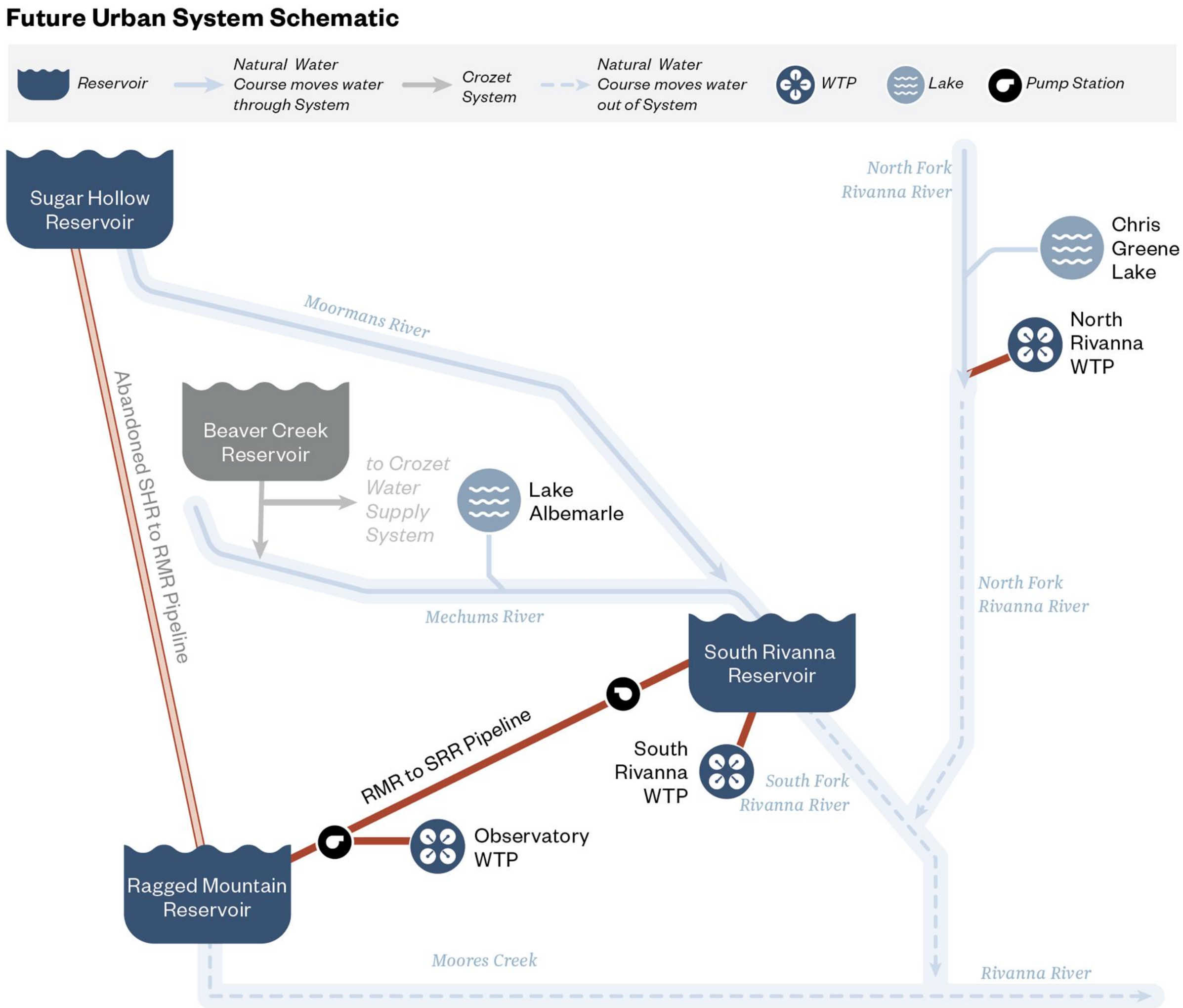


**Figure 3: Schematic of the Proposed RWSA Urban Water Supply System**

## 2.2 Potential Impacts from the Proposed Project

RWSA is committed to minimizing impacts from implementation of the proposed projects, including from the construction of the pipeline between South Rivanna and Ragged Mountain Reservoirs and associated pump stations. Despite these efforts, the potential for impacts remains for the construction of the proposed SRR intake. RWSA remains committed to identifying means to avoid adverse impacts to the extent possible and/or identifying measures to minimize and, where necessary, mitigate those potential impacts associated with the intake project.

RWSA has implemented the required release protocol to comply with F.4. of the current VWP permit, “Total downstream flow Provisions After an Expanded Ragged Mountain Reservoir is Operational, But Before the Pipeline from South Rivanna Reservoir to Ragged Mountain Reservoir is Operational” (RWSA, 2014). RWSA is committed to updating its operations manual to comply with the provisions of

F.5. “Total downstream flow provisions After Both an Expanded Ragged Mountain Reservoir and the Pipeline from South Rivanna Reservoir to Ragged Mountain Reservoir are Operational” as part of its renewed permit. RWSA does not anticipate any adverse impacts to natural resources from the operation of its reservoirs per this protocol.

RWSA is currently performing an evaluation of the North Rivanna WTP to determine whether to decommission the facility considering operating costs and capital costs to implement needed improvements for long-term operation of the plant. Currently, RWSA is evaluating other Urban System improvements that may eliminate or significantly minimize the need for the plant. If this facility were to be decommissioned, the currently permitted North Rivanna WTP withdrawal of 2 MGD would be eliminated, thereby increasing stream flow above currently permitted conditions in the North Fork Rivanna River and in the subsequent confluence with the mainstem of the Rivanna River. In that instance, RWSA would request modifications to the SRR minimum instream flow (MIF) protocol to account for the increased flow in the North Fork Rivanna River. This would equate to a commensurate reduction of required release from the South Fork River Reservoir, potentially up to 1.5 MGD.

Through the process of implementing the project elements originally permitted by DEQ and the USCOE, RWSA has worked to avoid and minimize potential impacts, mitigating for impacts only when unavoidable. RWSA plans to continue that approach through the construction and operation of project elements planned over the next permit term. Detailed discussion of potential impacts and proposed minimization and mitigation approaches is described later in this document.

# 3. RWSA Community Water Supply Plan

This section describes the Community Water Supply Plan including a summary of the alternative analyses from the plan development, the progress made to date under the current permit period and expected improvements over the next permit term.[4]

## 3.1 Community Water Supply Plan Development and Alternatives Analyses (JPA Section 25)

Beginning in the early 2000s, close to 40 alternatives were developed to satisfy the water supply needs of the growing population in the Charlottesville area (Gannett Fleming, 2004). Refer to Appendix A for a full list of alternatives evaluated previously. These alternatives underwent an extensive and iterative review process until RWSA adopted the elements that became part of the Community Water Supply Plan. Evaluation criteria focused on the alternatives that could adequately supply projected raw water needs, either partially or completely, over a 50-year planning horizon. Alternatives that did not completely provide the needed safe yield were considered in conjunction with other alternatives for comparison (Gannett Fleming and VHB, 2006). Other evaluation criteria included costs, impacts to natural resources (e.g., aquatic resources, streams, wetlands, endangered species) and historic or cultural resources, and project feasibility. The input of the community, provided as part of over a dozen public meetings, was carefully considered while determining the criteria and evaluating the alternatives.

The preferred alternative from this process includes an expansion of the Ragged Mountain Reservoir and construction of a pipeline between South Rivanna Reservoir and Ragged Mountain Reservoir to allow RWSA to transfer water between the two, as needed. This alternative achieved the supply objectives while also being the least environmentally damaging practicable alternative and received necessary permits from USCOE and DEQ pursuant to Sections 401 and 404 of the Clean Water Act in 2008.

Overall, the Community Water Supply Plan increases the safe yield of the water supply system by expanding the RMR from 0.5 to 1.4 BG in the near-term, and which will be increased to 2.1 BG when the water level is raised by 12 feet at the Ragged Mountain Dam. The SRR to RMR pipeline connecting Ragged Mountain and South River Reservoirs will increase the RMR fill rate from 3.2 to 25 MGD and will significantly improve the overall resiliency and redundancy of the water supply and treatment system by connecting RWSA's two largest water treatment plants creating significant water supply, treatment, and plant maintenance flexibility.

Initially described in supporting documents to the 2006 JPA submittal and subsequently revisited and slightly revised in the report titled *Review of Proposed Pipeline from South Fork Rivanna Reservoir to Ragged Mountain Reservoir* (Wiley Wilson, 2010), the primary elements remaining to be completed associated with the Community Water Supply Plan include the following:

[4] Additional information on the Community Water Supply Plan can be obtained from the RWSA Community Water Supply Plan website at https://www.rivanna.org/community-water-supply-plan/

- Installation of approximately 47,500 feet of 36-inch transmission line to complete the pipeline connecting South Rivanna and Ragged Mountain Reservoirs pipeline;
- Construction of the South Rivanna Reservoir intake facilities (41 MGD);
- Construction of the South Rivanna Reservoir pre-treatment facility (25 MGD), and three booster pump stations (41 MGD, 25 MGD, and 16 MGD conceptual capacity) to convey flow from Ragged Mountain Reservoir to the Observatory WTP and from the Ragged Mountain Reservoir to the South Rivanna WTP.

RWSA has performed studies in recent years in support of the Community Water Supply Plan, including the Urban Demand Forecast and Safe Yield Analysis, and is currently commissioning a study of the reservoir transfer pre-treatment facility needs and targets. These studies have refined the details associated with implementation of the Community Water Supply Plan elements that would occur during the forthcoming permit term.

## 3.2 Community Water Supply Plan Project Elements

This section describes the previously permitted project elements, current status and work planned under the forthcoming permit term. The major elements of the Community Water Supply Plan are depicted in Figure 4 along with current associated Capital Improvement Plan (CIP) costs.

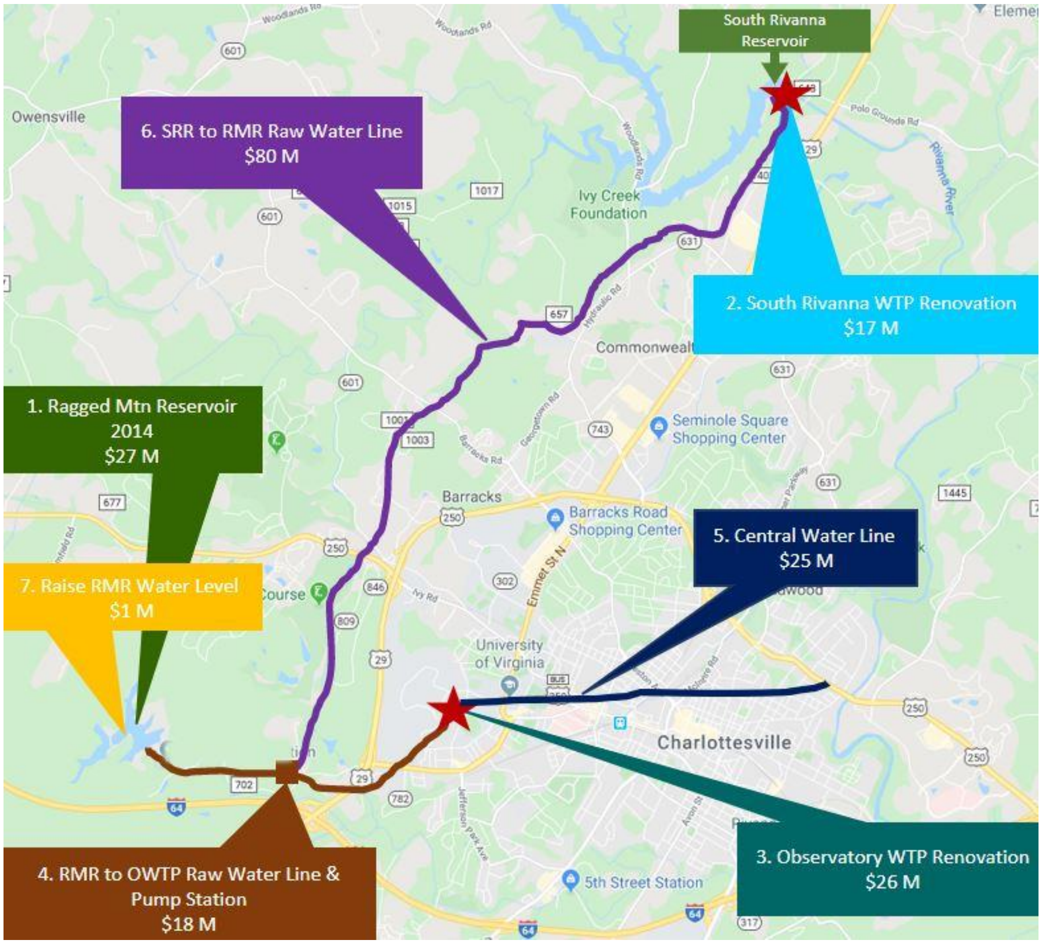


Figure 4: Map of Community Water Supply Plan Elements and Budget Estimates

### 3.2.1 Replace the Ragged Mountain Dam

The Community Water Supply Plan called for replacing the existing RMR dams with a new dam at a higher elevation. The new Ragged Mountain Dam was completed in 2014 and in February 2016 the reservoir reached full capacity at the current, interim normal pool elevation of 671 feet. This corresponds to a useable water storage capacity of approximately 1.44 billion gallons. All construction is complete on this project. During the forthcoming permit term, the reservoir level will be raised another 12 feet to its full design height, adding 728 MG of storage. Filling the reservoir to its higher elevation is planned when demands reach 85% of system safe yield, which is anticipated to occur by year 2045; however, discussions are also ongoing that may cause the normal pool to be raised concurrent with the SRR to RMR pipeline construction.

### 3.2.2 Proposed SRR to RMR Pipeline

The purpose of the pipeline is to convey pretreated South Rivanna Reservoir water to the RMR, which supplies water to the Observatory WTP. Additionally, the pipeline enables the transfer of raw water from the RMR to South Rivanna WTP to add flexibility and redundancy to the system. The pipeline requires pump stations to transfer water between the reservoirs, described below.

An approximately one-mile section of 36-inch raw water pipeline has been completed of the total nine miles needed. The remainder of the alignment is at the 30% design level, and RWSA is in the process of obtaining easements from property owners along the alignment. Currently, RWSA has obtained 17 of the 30 easements necessary for pipeline construction and is negotiating with property owners to obtain the remaining easements.

The remaining eight miles of 36-inch raw water pipeline is planned to be completed during the permit term (by approximately the year 2035). This includes finalizing easement acquisition and potential alignment revisions, completing detailed design and construction.

### 3.2.3 Proposed SRR Intake Facilities

The proposed intake at the SRR is planned to have a capacity of up to 41 MGD, which will provide for up to 16 MGD of raw water supply from SRR to the expanded South Rivanna WTP, up to 10 MGD to the Observatory WTP, and up to 15 MGD to the RMR. The existing intake will remain in service during construction of the new facilities, after which it will likely be abandoned; however, the final decision on whether or not to retain the existing intake will be made during preliminary design of the facilities. This project continues to be conceptually planned along with other improvement projects to ensure that space is allocated for this project at the South Rivanna WTP. The intake, and associated pump station, are planned to be completed during the permit term by fiscal year 2035 along with the pre-treatment facility and the RMR to SRR pipeline.

### 3.2.4 Observatory Pipeline

This project consists of a raw water pipeline to connect the Observatory WTP to the RMR to SRR pipeline. This project is at the 30% design phase. The full 14,000 linear feet of 36-inch raw water pipeline is planned to be completed during the permit term by fiscal year 2033 and includes the same remaining project activities as the SRR to RMR pipeline.

### 3.2.5 RMR to South Rivanna WTP Pump Station

A 16 MGD pump station is required to enable transfer of water from the RMR to the South Rivanna WTP during drought conditions or during disruptions at the SRR. The 16 MGD pump station replaces the existing RMR pump stations that move water from RMR to the Observatory WTP. Therefore, the station will also be capable of conveying a maximum of 10 MGD from the RMR to the Observatory WTP. The RWSA Capital Improvement Plan (CIP) for Fiscal Years 2021 – 2025 (adopted June 2020) includes an initial approximately $2.5 million for the start of this project. The pump station is planned to be completed during the permit term by fiscal year 2035.

### 3.2.6 SRR to RMR Raw Water Pump Station

A 25 MGD pump station is planned to deliver up to 10 MGD to the Observatory WTP and 15 MGD to the RMR from the SRR through the planned 9-mile pipeline that will connect the SRR to the RMR. The conceptual maximum capacity of the station was determined based on detailed water budget modeling that reflects the anticipated minimal recovery rates in post-drought conditions at RMR.

### 3.2.7 Proposed SRR Pretreatment Facilities

The purpose of the pretreatment facility is to partially remove suspended solids and nutrients from SRR water, so the quality of the water being conveyed from SRR to RMR is better than what is normally observed in SRR. A preliminary screening of potential process alternatives was performed to identify potential treatment approaches and to assess overall concept feasibility (Black & Veatch, 2018). While this evaluation suggested a potential use of ballasted flocculation coupled with a reactive sand filter system to treat the SRR water, this analysis was highly preliminary in nature and performed in a relatively short time period. While there was uncertainty surrounding the specific treatment processes to employ, the study did suggest that the overall concept (design, construction and operation) was feasible and could be effectively implemented.

RWSA is currently initiating a new detailed pretreatment study to review the prior concept design in the context of operational and physical needs to achieve the required sediment and nutrient removal from SRR water as well as to consider operational modifications to avoid the need for the pretreatment facility (i.e., selective withdrawal). The current study is a more robust evaluation, covering a planned timeframe of 18 months and including assessment of specific treatment targets and overall pretreatment goals, an updated process evaluation, pilot testing and ultimate process selection. The results of this new study will be incorporated into the overall CWSP as well as the planning for other improvements at the South Rivanna WTP (such as the SRR intake and low-lift pump station) to ensure that sufficient space is allocated for this project. The pre-treatment facility is planned to be completed by fiscal year 2035.

### 3.2.8 South Rivanna Water Treatment Plant Site Plan Update

Facility expansions and additions at the South Rivanna WTP site are proposed to accommodate much of the planned infrastructure needs for the Community Water Supply Plan. The RWSA has plans to raise the hydraulic (and permitted) capacities at the WTP to 16 MGD. RWSA commissioned an evaluation to determine the space requirements and resulting footprints involved with expanding the WTP to 16 MGD, constructing a 41 MGD raw water pump station (RWPS), a 25 MGD pretreatment facility and pump station and expanding the solids handling capacity at the site to accommodate the subsequent increase in residual flows from the South Rivanna WTP and Pretreatment/RWPS facilities (SEH, 2020). A schematic from the evaluation is included in Figure 5. Near term improvements, indicated in red, are planned to be completed by 2023, improvements shown in blue indicate updates related to the SRR to RMR raw water project, and improvements highlighted in green identify projects that must be completed before or at the 16 MGD upgrade.

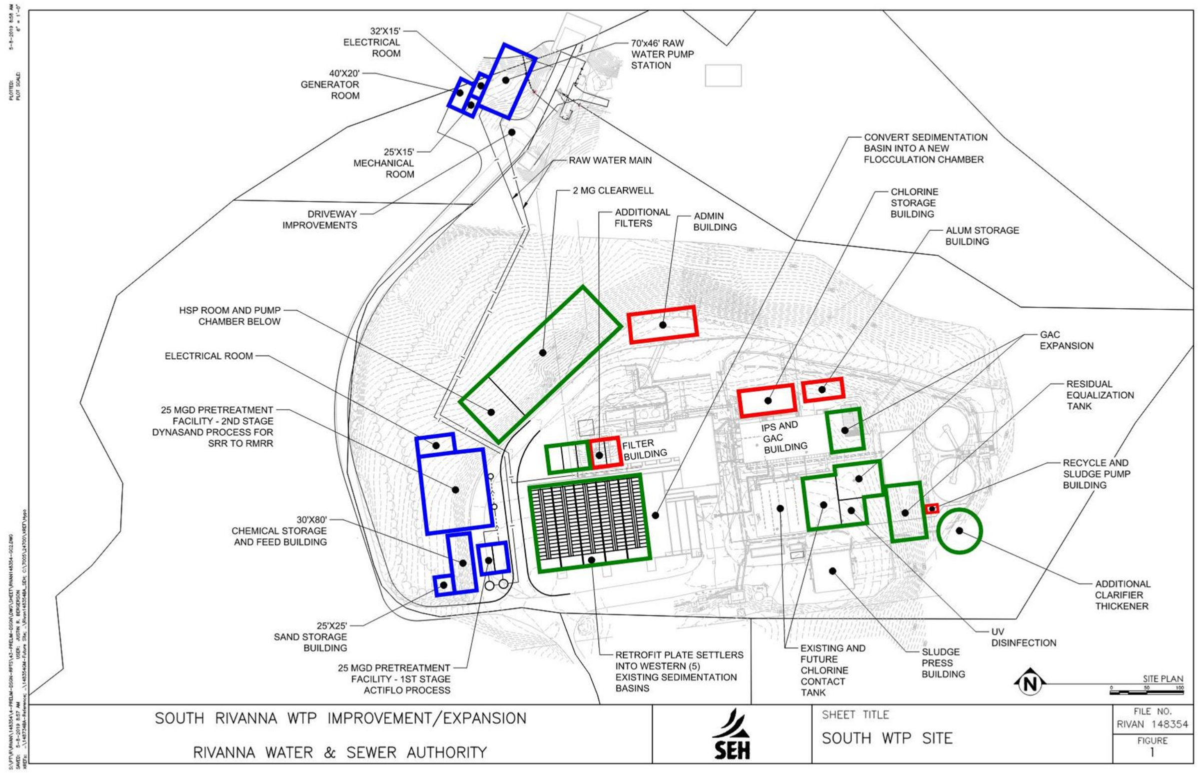


**Figure 5: South Rivanna WTP Upgrades**

### 3.2.9 Observatory WTP Improvements and Expansion of Capacity to 10 MGD

The Observatory WTP (OWTP) facility improvements and expansion are underway to accommodate the planned infrastructure needs for the Community Water Supply Plan (Figure 6). A complete upgrade has not taken place since the 1950s, so the OWTP upgrade includes improvements to the flocculators, sedimentation basins, filters, and chemical feed facilities. The upgrades will increase the plant capacity from 7.7 MGD to 10 MGD (RWSA, 2020). In August 2020, RWSA renewed their lease of Observatory WTP for a minimum of 49 years with the University of Virginia. The water treatment plant improvements are planned to be completed by 2023.

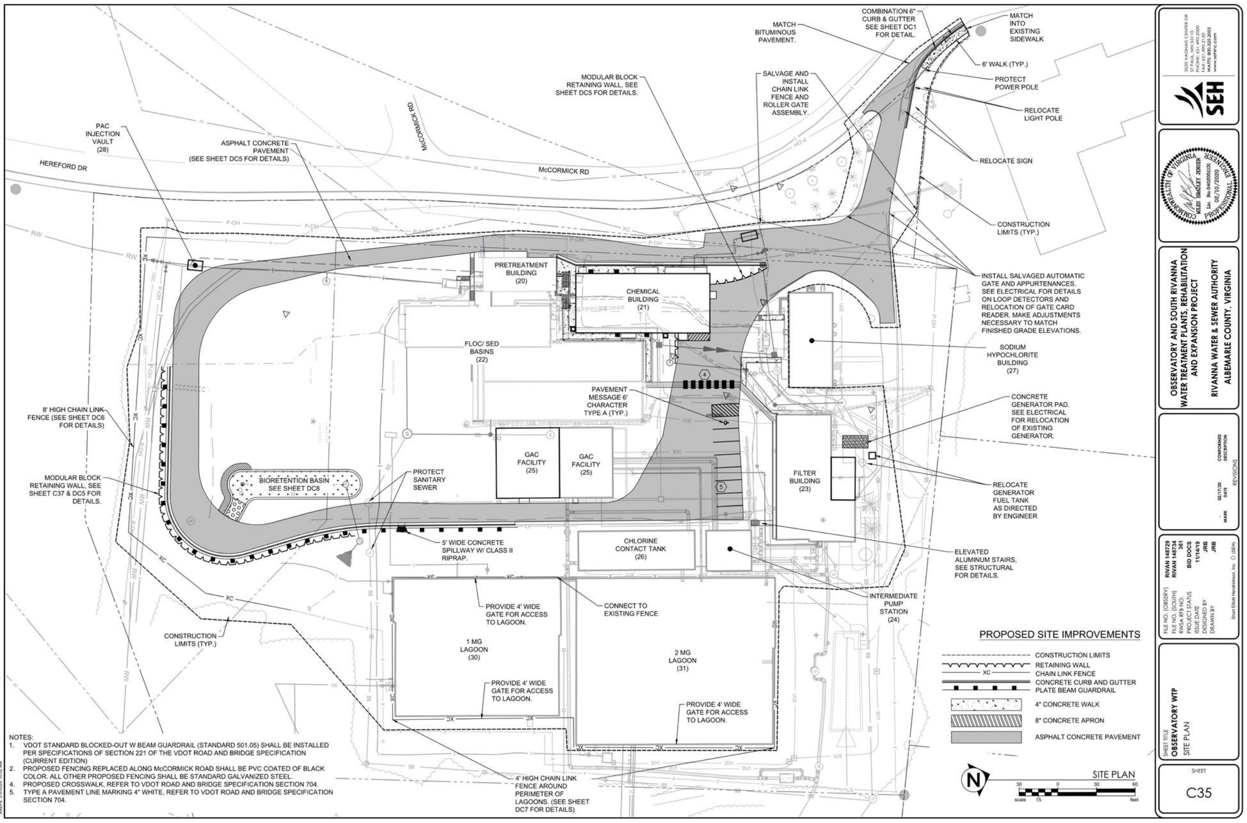


**Figure 6: Observatory WTP Upgrades**

### 3.2.10 South Rivanna Dam Gate Repairs

The CIP included $900,000 to repair or replace the gates and components as needed to restore full functionality of the gate structures, which will improve release capability and control to meet minimum instream flows when the dam is not spilling. These improvements have been constructed and are in operation.

# 4. Water Demand Projections (JPA Section 25)

This section summarizes the results of the 2020 Urban System Water Demand Forecast Study prepared for RWSA (Hazen, 2020). The study defines expected water demand through 2070 which in turn will guide the path for implementation of water supply, treatment, and distribution improvements necessary to meet the RWSA's needs over the next 50 years. Since 2008, the Urban Service Area has experienced a steady annual average finished water demand around 9.5 MGD despite a population growth rate averaging 2.2% per year (for a total increase of about 25% since 2008). Reductions in aggregate per capita usage have offset population growth over the same period leading to near zero growth in demand. Flat or even declining demand trends have taken many water utilities across the country by surprise over the past 10-15 years, and a key question facing the RWSA and utilities in similar situations is to determine whether demand growth will resume, when, and at what rate. Looking to the future, the Urban Service Area does have space to accommodate significant population growth, especially within the areas of the County served by the ACSA, and the City and UVA are currently undergoing in-fill development and densification.

The foundation of the forecast is a series of finished water demand projections that are developed based on contemporary planning documents, current zoning regulations, finished water production records, account-level billing data, and assumptions about how the service area will continue using water into the future. These projections identify the amount of raw and finished drinking water needed in the Urban Service Area through the year 2070, broken down into five-year increments, which will aid in activities planning needed to maintain a high service quality and meet anticipated changes in demand over the planning horizon.

## 4.1 Demand Forecast Modeling Approach

The demand forecast was developed through the application of a land use model and water use intensity model of the service area. A simplified schematic, presented in Figure 7, describes the major classes of information and the process flow used to produce the RWSA water demand forecast. The land use model (orange fields) utilized population and employment projections from independent agencies to pace the development rate within the service area. The land use model was used to spatially disaggregate the demands across the Urban System. The spatially linked information it produces can be used to sum up the number of residential and non-residential spaces across a spatial boundary like a pressure zone. The water intensity model (blue fields) relies on weather data, water meter location, and billing data to determine how much water residential and non-residential spaces are likely to use.

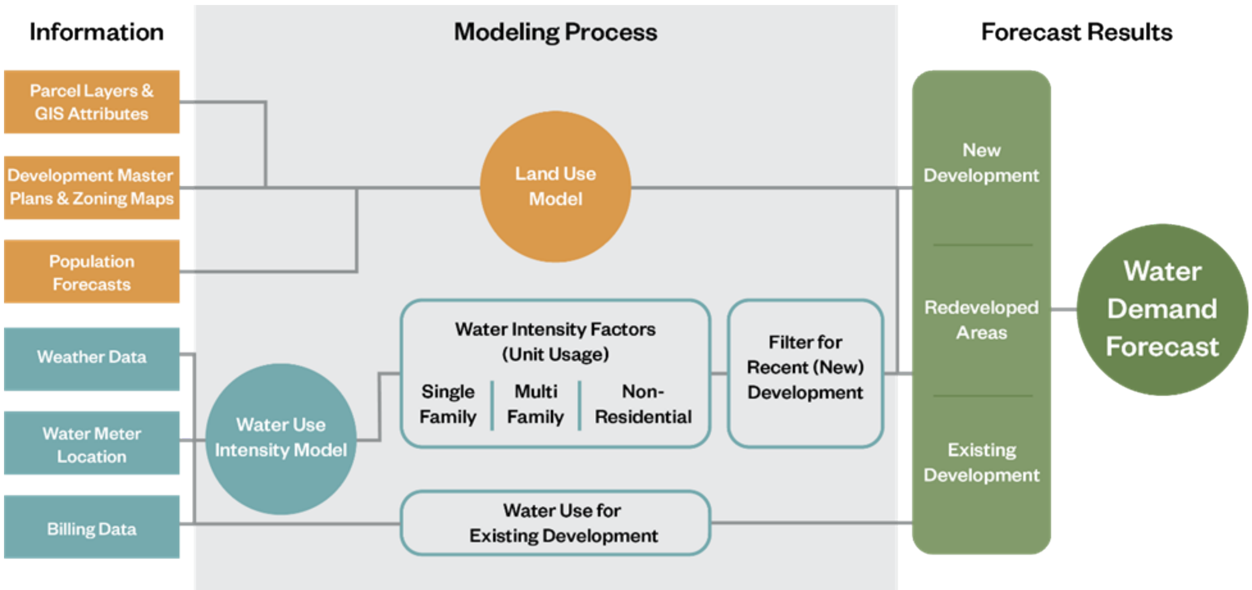


**Figure 7: Overview of Demand Forecast Modeling Process**

### 4.1.1 Land Use Model Development

The methodology underpinning the land use model involved assigning each parcel to a *partition* according to its pressure zone, zoning or master plan specification, and current development status (built upon or vacant/undeveloped). Together, these characteristics were used to define assumptions about how land will develop in the service area, the assumed rate of development, and the pressure zone to which its water use would be assigned. Partitioning involved grouping parcels into nonoverlapping areas wherein current and future demands were estimated using a consistent set of assumptions within each partition. Thus, each partition in the model represents a group of parcels (an area) within the Urban Service Area in which the same set of assumptions are applied with respect to the type of development (e.g., residential, non-residential, or mix thereof), timing of development, and density of development expected over the forecast horizon.

Development within the land use model was bounded on the upper end by the maximum densities allowed by current zoning regulations. The model generally assumed no adjustments to the existing zoning and masterplan regulations within Albemarle County. Undeveloped parcels were assumed to develop in accordance with their associated zone or masterplanned densities. Parcels with existing development and water meters were assumed to remain as-is throughout the forecast horizon unless they fell within one of the areas where redevelopment was expected. For example, parcels in proximity to specific high-growth areas, such as the UVA Medical Center, were assumed to redevelop to mixed use at higher densities than their zones may currently allow. This assumption is based on the precedence for zoning variances issued in those areas of the City in the recent past.

The degree of development at target forecast dates was set within the model such that a sufficient number of new housing units and non-residential space would be added to accommodate the anticipated employment growth within the City or ACSA service areas. Population growth guidance through 2045 is available from both the UVA Weldon Cooper Center and the Thomas Jefferson Planning District

Commission's (TJPDC) 2045 Long Range Transportation Plan (LRTP). The projections for both Charlottesville and the ACSA are shown in Table 1 and Table 2, respectively. The population target for 2070 was based on a rough estimate from the City of Charlottesville Neighborhood Development Services of the maximum population capacity of Charlottesville without any changes to the zoning ordinance but allowing for redevelopment of currently developed areas. The 2070 population target for the ACSA is based on the High Development Area Population at buildout from the Albemarle County Office of Community Development (ACOCD). Figure 8 shows these projected populations for the City, ACSA, and total service area.

**Table 1: Charlottesville Population Projections**

| Source | 2015 | 2045 | 2070 |
|---|---|---|---|
| Weldon-Cooper | 48,210 | 55,969 | - |
| TJPDC LRTP | 48,326 | 56,770 (+17%) | - |
| Adopted for this study | 48,326 | 56,770 | 65,000 |

**Table 2: ACSA Population Served Projections**

| Source | 2015 | 2045 | 2070 |
|---|---|---|---|
| ACSA | 61,113 | - | - |
| TJPDC LRTP | 61,629 | 95,829 | - |
| Adopted for this study | 61,113 | 95,300 (+56%) | 106,650 |

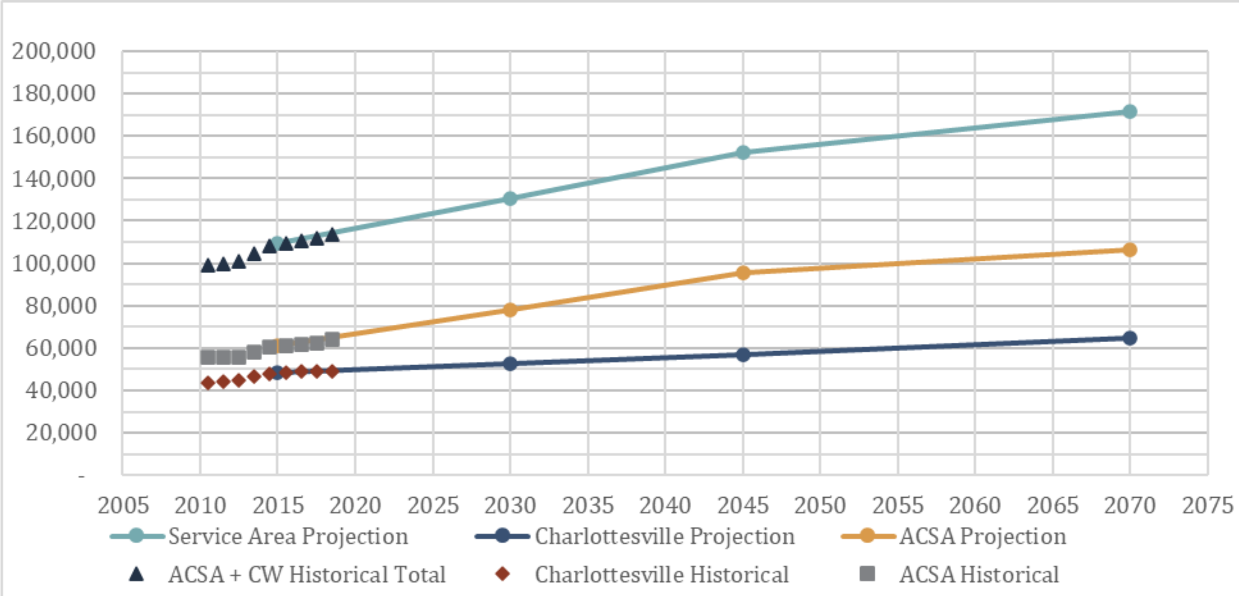


**Figure 8: Population Projections for Charlottesville and the ACSA**

Employment estimates were used as guidance for the addition of new non-residential (NR) space to the service area. At present there is around 500 square feet of NR space in the service area per employee. The amount of new NR space per additional employee through 2045 is closer to 750 square feet, but this figure itself does not account for the replacement or demolition of existing NR space which will often be required to accommodate the new NR structures. There are no employment projections for 2070 available so the ratio of new residential to new NR space was kept fixed after 2045.

### 4.1.2 Demand Intensity Model Development

Unit demand, also referred to as demand intensity, represents the amount of water used per person, employee, dwelling unit, or per unit area. The Urban System Water Demand Forecast Study disaggregated the per capita unit demands among several class types (or use sectors): single family residential (SF), multifamily residential (MF) and non-residential (NR). The unit demands for the three sectors were specified as: SF demand per dwelling unit (DU), MF demand per DU, and NR demand per thousand square feet (ksf) of building space. The demand intensities in the water use sectors were estimated using FY 2017 meter data. The results are shown in Table 3.

**Table 3: Estimated FY 2017 Demand Intensity by Sector**

| Sector | Estimated Intensity |
|---|---|
| Single-family | 120 gal/DU/day |
| Multifamily | 75 gal/DU/day |
| Nonresidential | 85 gal/ksf/day |

Given the improved water efficiency of modern construction and building code requirements, it was important to identify the demand intensity of new construction for growth projections. The ACOCD was able to provide parcel-level unit information for housing stock constructed since 2010. These were matched with meter records such that demand intensities for this subset of SF and MF dwellings could be calculated as shown in Table 4. These unit demands were assumed reasonable and applied to all future development. Future NR unit demand was estimated at 75 gpd/ksf based on data for University buildings and the expectation of some improvement in efficiency over the present aggregate NR stock (85 gpd/ksf).

**Table 4: Estimated FY 2017 Demand Intensities for post-2010 Development by Sector**

| Sector | Estimated Intensity |
|---|---|
| Single-family | 109.4 gal/DU/day |
| Multifamily | 79.5 gal/DU/day |
| Nonresidential | 75.0 gal/ksf/day |

The University of Virginia (UVA) is located on the west side of Charlottesville and has a large influence on water usage in the RWSA service area and is the single largest consumer. A separate forecast method was developed for the University of Virginia (UVA) because the University does not have a comprehensive parcel-based long-range plan beyond 10 years and is not subject to zoning requirements that could guide a model beyond the next 10 years in the future. Further, the University has its own conservation strategies and has made steady progress toward its stated goal of reducing total water use through the year 2035.

#### 4.1.3 Non-Revenue Water

It was assumed that non-revenue water will continue to average 12-13% of the retail volume. Non-revenue water refers to water use that does not generate revenue, including that used for line flushing, fire flows, loss to leakage, unauthorized connections, unbilled accounts, or otherwise used at points that are unbilled. While each of these possibilities represent specific ways water can end up in the non-revenue category, not all utilities exhibit each type of non-revenue water and a non-revenue analysis was not conducted for the RWSA as part of the Urban Water Demand Forecast Study.

### 4.2 Raw and Finished Water Forecasts

Combining the forecast methods used for the ACSA, City, and UVA as described previously produces an overall retail water demand forecast by pressure zone. Demand growth is not anticipated to be uniform on a percentage basis across pressure zones. Seven of the outlying pressure zones are anticipated to grow faster in their water consumption on a percentage basis than the Urban Zone while four are expected to exhibit little growth. Nevertheless, the Urban Ring Pressure Zone demand growth will continue and is expected to account for 60-65% of retail water sales throughout the forecast period.

Given the potential uncertainty in demand forecast components, sensitivity analyses were conducted to aid in RWSA's decision making process when facing choices that require anticipating long-range water demands. The primary forecast developed for this report was developed with the principal goal of ensuring that RWSA plans for an adequate supply to meet future needs and is therefore the recommended forecast for infrastructure planning. The primary forecast also assumes that future development will continue to be as efficient as the development over the past 9 years which has led RWSA to be among the most water efficient utilities in the nation. Furthermore, the RWSA should provision for sufficient finished water (FW) to satisfy the increased annual average demand under sustained hot dry conditions that exceed the primary forecast (which assumes near average historical weather conditions) as shown in Figure 9. This additional demand may be met by either assuring sufficient additional supply during hot/dry years or imposing mandatory conservation such that demand can be curtailed to a level no greater than the reliable supply, or a combination of the two. To estimate raw water (RW) demand, which is needed to identify future supply requirements, FW values were increased to account for water lost through the treatment process (e.g., in-plant water use, residuals).

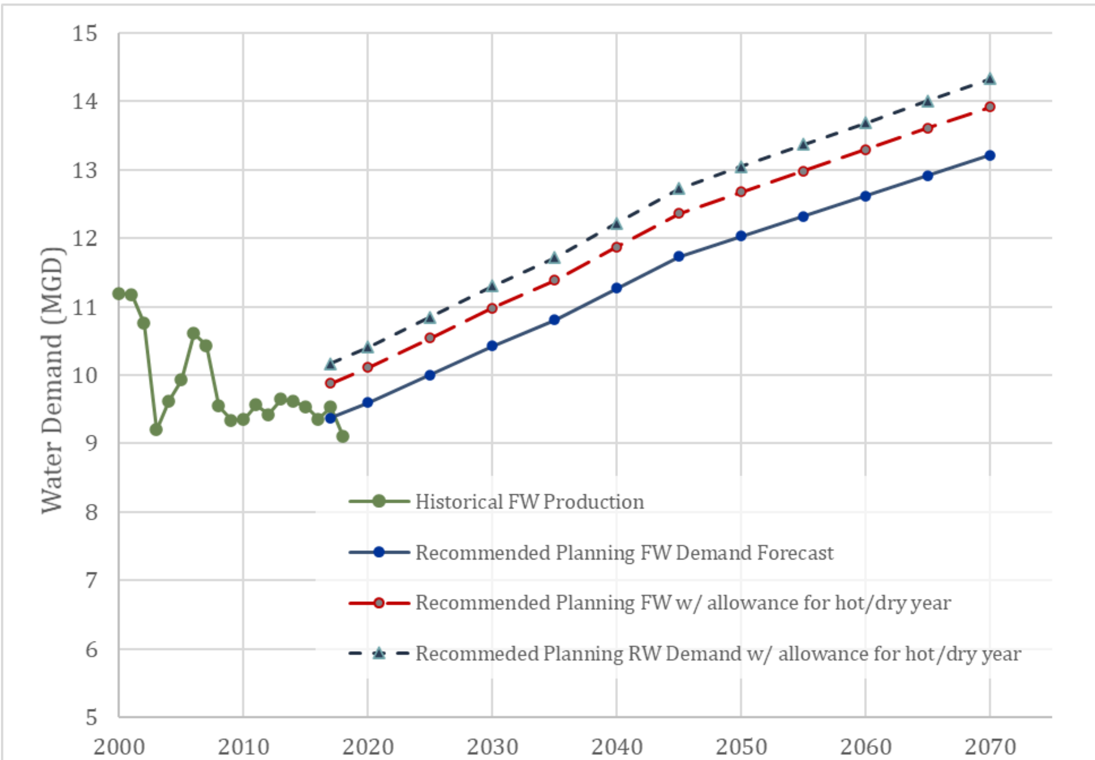


**Figure 9: RWSA Raw and Finished Water Demand Forecasts**

### 4.2.1 Peak Day Factor Analysis and Maximum Day Demand Forecast

Peak day demand, also referred to as maximum day demand (MDD) is the highest daily demand that occurs in a given year. Water treatment plants, as well as raw and finished water pump stations, are typically sized with peak day criteria in mind. A peaking factor for planning purposes was estimated using RWSA's historical daily finished water pumping data for North Rivanna WTP, South Rivanna WTP, and Observatory WTP (including non-revenue water) for 2010 to 2018. The annual peak day ratio (highest daily demand divided by annual average daily demand) had an average value of 1.37 over the 9-year period. The maximum and minimum peaking factors were 1.50 in 2017 and 1.22 in 2014. The 95$^{th}$ percentile peaking factor was estimated to be 1.47 based on these 9 years of data and will be used for planning facilities that need to be sized for maximum day demands.

## 4.3 Summary of Estimated Withdrawals during the Future Permit Term

The current VWP permit expires in 2023, and the new DEQ VWP permit term will be for 15 years, expiring in 2038 (the USCOE Section 404 permit will expire in 2033). Over the course of the VWP permit term withdrawals from the water supply system needed to meet annual average day demands are expected to reach 11.43 MGD. Peak day demands over the new VWP permit term are expected to reach 18.5 MGD based on a peaking factor of 1.47 and a Virginia Department of Health Certification Factor of 1.1.[5] A peak month factor was not calculated in the *2020 Urban System Water Demand Forecast Study*, therefore the standard factor used by DEQ of 1.25 was used to calculate the max monthly volume of 487.1 MG.[6]

[5] Correspondence with B. McGurk, DEQ Office of Water Supply, January 2018.
[6] Max Monthly Vol = Avg Annual Withdrawal * 1.25 * 1.1 * 31 days/month

# 5. Hydrologic Analysis (JPA Section 24)

RWSA uses a water resources systems model for analysis of the water supply system, including safe yield and drought trigger development. The model, developed in OASIS, simulates the operation of the system using physical characteristics of reservoirs, pipelines, pump stations and treatments plants; operating rules and regulatory constraints; and natural hydrology. Accurate representation of the system components is necessary for reliable modeling to support decision-making. A detailed description of the model and its inputs and outputs is available in 2018 reports (HydroLogics, 2018) that are provided in Appendix G.

## 5.1 RWSA OASIS Model Overview

OASIS is used to model the raw water supply operations of RWSA; a schematic depicting the model components is provided in Figure 10. The model includes nodes for reservoirs, raw water withdrawals (water treatment facilities), finished water demands, and pumping stations; arcs are used to represent conveyance of water between nodes. The schematic and associated physical data (reservoir bathymetry, infrastructure capacities, etc.) were developed with input from RWSA staff. The Crozet system includes Beaver Creek Reservoir and its demand node; this system is not used to support Urban System operations. Also, Chris Greene Lake and Lake Albemarle are not used to support Urban System operations.

Water treatment plant and transmission constraints are defined by maximum capacities on arcs. Targets for the desired conveyance of water between points in the water supply system are defined in the model code. Nodes associated with treatment plant production and finished water demands use an annual average demand subject to a monthly pattern. Inflows in the model represent incremental unregulated runoff to the point specified.

The model uses an inflow data set that extends from October 1, 1925, through present. This data set was developed using an approach that relies on USGS gages within the Rivanna River Basin and gages from nearby basins.

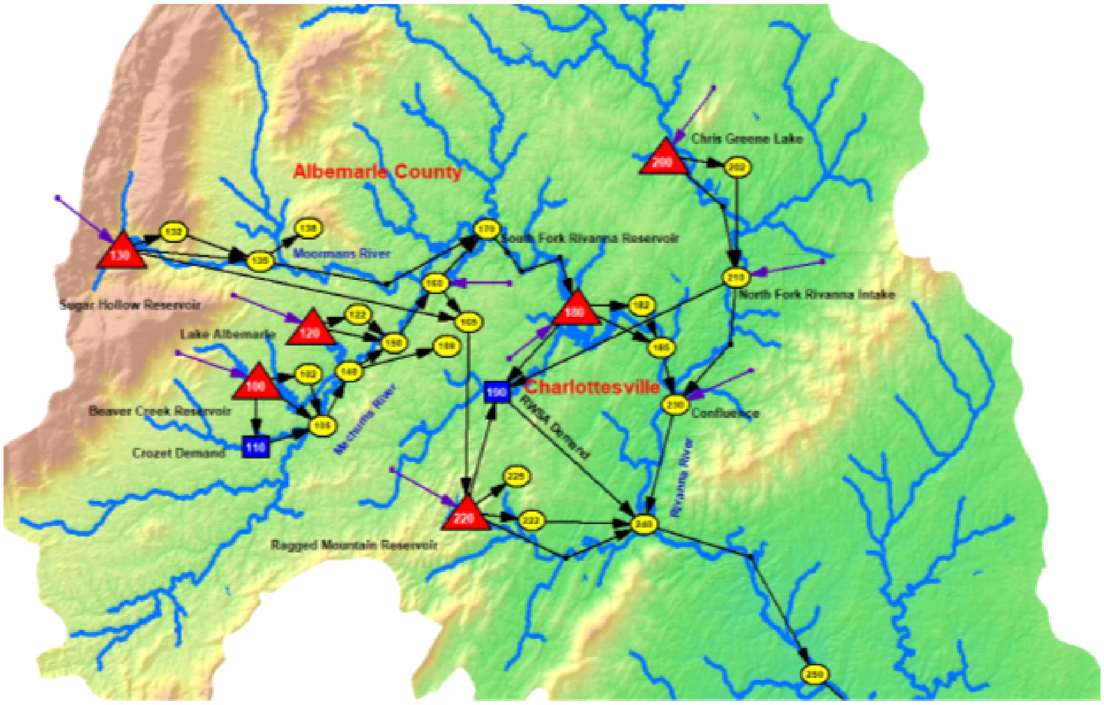


**Figure 10: Schematic of the RWSA Urban Water Supply System**

The water allocation priorities are set by the user in the model code by applying weights to nodes and arcs, and by specifying operations in the model. The most common operating rules are for storing water in reservoirs versus releasing the water to meet local water supply demands or minimum releases, and these are reflected by the weighting scheme. Simply stated, if a minimum flow in a river is more important than meeting the demand, a higher weight on the minimum flow means water supply deliveries will be scaled back as needed during drought to meet the minimum flow. The minimum flows simulated in the model reflect the protocols in RWSA's VWP permit from DEQ (Table 5). Operating rules also include probability-based drought triggers that result in demand reductions to conserve water supply. As with the inflows, the operating rules were verified based on the comparison of model output and historic data to ensure accurate representation of the water supply system.

**Table 5: Current RWSA Reservoir System Minimum Release Rules**

| Reservoir | Minimum Release Rules |
|---|---|
| Sugar Hollow Reservoir (SH) | < 1080 MG useable Ragged Mountain (RM) storage, release 100% of the natural inflow (3-day avg.) or 2 MGD, whichever is less.<br>Otherwise, release 100% of the natural inflow or 10 MGD, whichever is less. |
| South Fork Reservoir (SF) | < 750 MG useable (SH + SF + RM), release 30% of natural inflow (3-day avg.)<br>< 1600 MG useable (SH + SF + RM), release 50% of natural inflow<br>Otherwise, release 70% of the inflow or 1.3 MGD, whichever is more.<br>At a minimum, always release 1.3 MGD (unless SF is empty); at a maximum, release 20 MGD (unless spilling). |
| Ragged Mountain Reservoir (RM) | 0.03 MGD |

## 5.2 Reservoir Inflows

The inflow to the reservoirs is perhaps the most important parameter because it establishes the available supply for drinking water withdrawals, instream flow needs, and other beneficial uses. RWSA's Urban System VWP Section F.1. specifies methods for calculating natural inflows to Sugar Hollow and South Rivanna Reservoirs based on scaling the USGS Mechums River stream gage by their drainage areas. While the method may be appropriate for gages in similar watersheds, it became evident to RWSA staff that the permit method for estimating inflows to Sugar Hollow Reservoir was problematic because the reservoir was regularly getting drawn down lower than it should have based on mass balance checks (Figure 11). This behavior for the reservoir is indicative of over-estimation of inflows, which led to RWSA initiating a full-scale re-analysis of the inflows for all of its reservoirs in 2018.

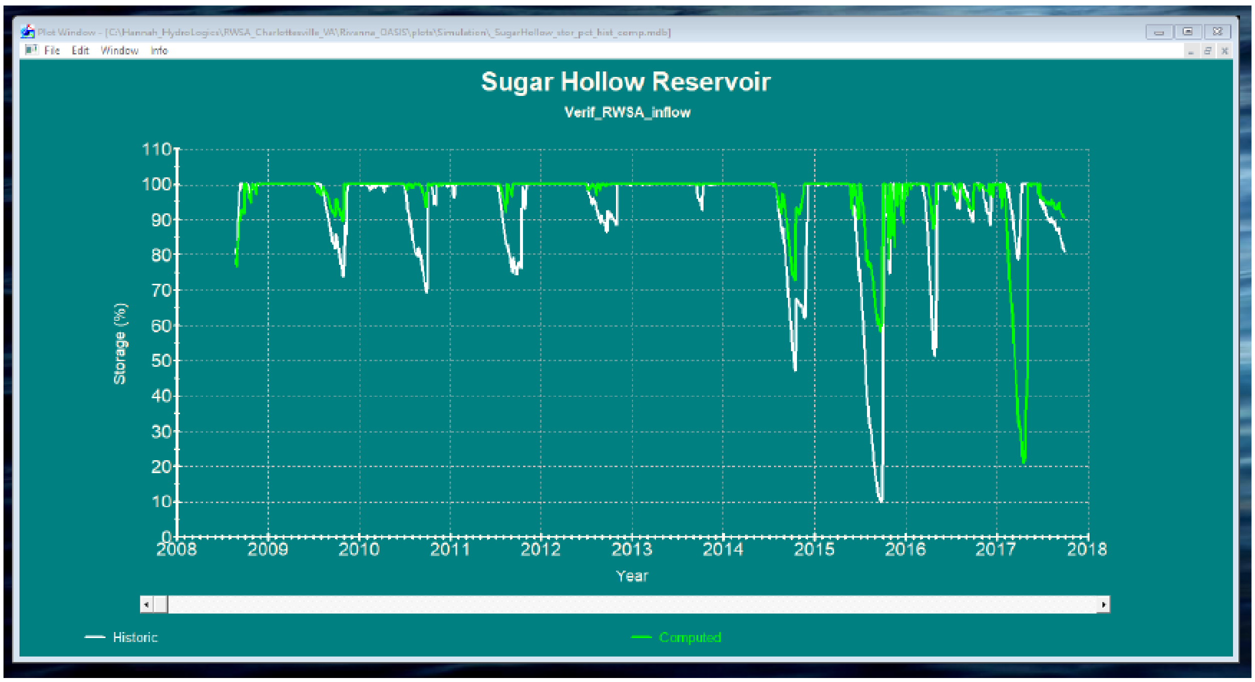


**Figure 11: Historic vs. Computed Reservoir Storage for Sugar Hollow Reservoir**

Since the Mechums gage was not representative of the Moormans watershed, RWSA proposed a modification to the permit to base inflows to Sugar Hollow on the downstream Free Union at Moormans River gage. Further discussion with DEQ resulted in a proposed method by DEQ which would also take into account measured releases from the dam itself. That methodology has been accepted by RWSA was formally incorporated into Minor Modification No. 2 to VWP Permit No. 06-1574 on December 21, 2020. Under the approved inflow calculation modification, the incremental runoff between the dam and the Moormans gage is estimated and converted to unit runoff in terms of flow per square mile, then multiplied by the drainage area of Sugar Hollow to compute the inflow to the reservoir.

The use of the Mechums gage for estimating inflow to the other reservoir for which minimum flows are required (South Rivanna Reservoir) is more representative since the majority of the watershed is in the Mechums. However, with the recent installation of a USGS gage downstream of the dam – put in place to better estimate discharges—RWSA has proposed updating inflow calculations using this gage. In this case, it would represent "back-calculation" of the release, in which using mass balance, the unregulated inflow (or the natural inflow with impacts of historic regulation removed) is equal to:

*Unregulated South Rivanna Reservoir inflow = downstream gage flow + change in reservoir storage + reservoir net evaporation + reservoir water supply withdrawal*

## 5.3 System Yield

As part of keeping RWSA's comprehensive water supply and infrastructure planning up-to-date, and in accordance with the Ragged Mountain Dam Agreement (RMDA) dated January 1, 2012, RWSA recently conducted a safe yield analysis for the Urban System. The RMDA states that at least once every ten years after the date of the Agreement, and not later than the year 2020, RWSA shall "update the analysis of safe yield of the Urban System following each new bathymetric survey of the South Rivanna Reservoir…using the latest available data on useable storage in the South Rivanna Reservoir, the Ragged Mountain Reservoir, and the Sugar Hollow Reservoir." The method for determining safe yield "shall be as set forth in the regulations of the Virginia Department of Health [VDH]". The following text is a summary of the analysis described in the July 2020 RWSA Safe Yield and Reliability Analysis Update Report by Hazen and Sawyer as provided in Appendix C.

### 5.3.1 Safe Yield Definition

Per 12VAC5-590-830 of VDH regulations for surface water sources, the safe yield for a "complex intake", which is applicable to RWSA, is defined as "the minimum withdrawal rate available to withstand the worst drought on record in Virginia since 1930."

### 5.3.2 Safe Yield Analysis Approach

The analysis consisted of a collaboration between consultant and RWSA staff to develop a comprehensive matrix of yield model runs for a wide variety of structural and non-structural scenarios over a 50-year planning horizon. These in turn were distilled into timelines to inform the sequencing of capital investments relative to the projected demands.[7]

Key structural improvements considered in the safe yield analysis included:

1. Upgrades to the Observatory WTP in 2023, which raises the capacity from 7.7 to 10 MGD and no longer requires a minimum production level
2. Construction of the South Fork to Ragged Mountain Pipeline accelerating refill of Ragged Mountain, allowing water to be pumped in both directions, and increasing flow in the Moormans River by abandoning the Sugar Hollow to Ragged Mountain Pipeline. In connection with the pipeline, Ragged Mountain Reservoir would be raised 12 feet to a normal full pool elevation of 683 feet to increase storage capacity and yield (unless the decision is made to defer raising the

[7] RWSA Urban System Water Demand Forecast Report, Hazen and Sawyer, July 14, 2020. Hazen and Sawyer Project No. 31430-000.

pool until demands reach 85% of system safe yield). These improvements are expected to be implemented by 2033.

As detailed in the *RWSA Safe Yield and Reliability Analysis Update* (Hazen, 2020), yields were computed in OASIS using a set of facilities (infrastructure), demands, and operating rules. These were simulated for the nearly 100-year inflow record as if they were in place for the 100 years. Annual average demand was increased for each simulation until the system storage (useable storage in Sugar Hollow, South Rivanna, and Ragged Mountain) reached a pre-determined minimum. Three yield definitions were considered: “theoretical”, “operational”, and “protective”.

The calculation of safe yield historically considered only the limitations of the supply sources and not operational constraints or a minimum reserve. Safe yield in prior water supply planning was reported to be 18.7 MGD in the year 2070 based on full buildout of the system, which would include Ragged Mountain Reservoir at its full pool level (683 feet) and declining loss of useable storage in South Rivanna Reservoir due to sedimentation. This represents the maximum sustained withdrawal from the supply sources in the worst drought and is considered the “theoretical” safe yield.

RWSA also evaluated “operational” safe yield, which incorporates operating constraints like limits to water treatment plant capacity and factors in the use of demand restrictions during a severe drought. Operational safe yield depends on the operational constraints in place, so RWSA computed the yield under a range of capacity upgrades. For today’s system, the operational yield is only 12.8 MGD, limited mostly by what can be produced at the Observatory WTP. With full construction of the Community Water Supply Plan upgrades largely being completed within the 15-year term of the DEQ VWP permit, including building the SRR to RMR pipeline and assuming the pool raise is performed at RMR, the operational yield would increase to 21.4 MGD, then decline to about 20 MGD in year 2070 due to sedimentation in SRR. This is higher than the theoretical yield because demand restrictions included in the operational yield scenario extend the available supply in a severe drought.

RWSA also evaluated DEQ’s recent preference for modifying the “operational” yield calculation to include a 60-day storage reserve in the worst drought, which significantly reduces safe yield.[8] The resulting yield, termed “protective” yield to differentiate it from operational or theoretical yield, is only 12.0 MGD for today’s system. Protective yield remains relatively low for future capacity upgrade scenarios due to the large volume of storage (60 days of supply) withheld from use in a severe drought. Given the realities of system operations, and the lack of formal regulation with respect to “protective” yield, RWSA focused on “operational” yield to identify the timing of planned system improvements.

All safe yield runs included the assumed 15 MG per year loss of useable storage in South Rivanna Reservoir storage due to sedimentation, as well as the minimum release policies in the permit that change with the status of the project completion.

[8] Per 12VAC5-590-830 of VDH regulations for surface water sources, the safe yield for a “complex intake”, which is applicable to RWSA, is defined as “the minimum withdrawal rate available to withstand the worst drought on record in Virginia since 1930.”

### 5.3.3 Safe Yield Results

As shown graphically in the Safe Yield Report, Current “operational” safe yield is calculated at 12.8 MGD, which is sufficient to meet current demands. Over the upcoming permit term (2023 to 2038), safe yield will initially rise with the completion of the Observatory WTP upgrades in 2023 but will decrease over time due to storage loss from sedimentation of the South Rivanna Reservoir. With full buildout anticipated in the permit term, in which the SRR-RMR pipeline is operational and the RMR pool is raised to its full level of 683 feet, operational yield will increase to 21.5 MGD, dropping due to sedimentation to 20 MGD by the end of the planning horizon in 2070. This yield will be enough to meet projected system demand through the year 2120.

## 5.4 MIF Modifications and Safe Yield Implications

The minimum instream flows (MIFs) are based on a percentage of the reservoir inflow, with reductions typically occurring as drought conditions develop and reservoir storage declines. The calculation of the inflow to the reservoirs will change as described previously.

RWSA also evaluated additional changes to the MIF permit requirements to provide for more flexibility and reliability, particularly before the planned improvements to the system are made (including the SRR to RMR pipeline). The changes included:

- Adjusting the caps that place an upper bound on releases when reservoirs are below full
- Adjusting the percentage of inflow that is released when reservoirs are below full
- Reducing SRR reservoir minimum release by 1.5 MGD, equivalent to the amount no longer being withdrawn from the North Fork Rivanna should the water treatment plant be abandoned.

Results were shown in the pre-application permit meeting in October 2020. From the analysis, RWSA determined that the most beneficial changes would be reducing the percentage of inflow from Sugar Hollow and the SRR MIF release credit for North Rivanna WTP decommissioning.

For Sugar Hollow, the current release is 100% of the inflow when below full. Since that increases drawdown and slows refill, the proposed change to 90% would increase reliability of Sugar Hollow supply. Minimal impact on downstream flows was observed in modeling runs. Note that when the pipeline is operational, the percentage will drop to 90% regardless as stipulated in the permit. This change from 100% to 90% is for the interim period.

Similarly, a slight reduction in the MIF for SRR would increase reliability of that reservoir.

## 5.5 Consumptive Use and Return Flows

Consumptive use is the withdrawal of surface waters without returning waters to their original source. Some examples of consumptive water use include cooling towers, irrigation, outdoor water use, and residents served by septic systems. Data on drinking water production and wastewater treatment volumes were compared for the last five years to estimate consumptive use for the Urban System. Consumptive use was calculated using the equation below:

$$\frac{(Total\ Urban\ Water\ Production - (Total\ Wastewater\ Flows -\ Wastewater\ Infiltration))}{Total\ Water\ Production}$$

Urban system wastewater is treated at three plants (Figure 12).

- Moores Creek Advanced Water Resource Recovery Facility: 695 Moores Creek Lane, Charlottesville, VA 22902
- Glenmore Water Resource Recovery Facility: 3395 Carroll Creek Road, Keswick, VA 22947
- Stone Robinson Water Resource Recovery Facility 958 Milton Rd; Keswick VA 22911

In addition, water supply produced by the Crozet System is treated at the Moores Creek Advanced Water Resource Recovery Facility. Therefore, wastewater flows for the urban system are calculated by summing the metered wastewater flows to the Moores Creek, Glenmore, and Stone Robinson Water Resource Recovery Facilities and subtracting the wastewater flows from the Crozet System. Estimated infiltration to the wastewater system was subtracted from the total wastewater flows to get direct flows from the sewer system. Total Urban Water Production was calculated from the metered production data from the water treatment plants.[9]

Data indicate consumptive use of approximately 24%, which equates to approximately 66 million gallons per month on average. All of the return flows from these facilities are discharged back into the Rivanna River Basin.

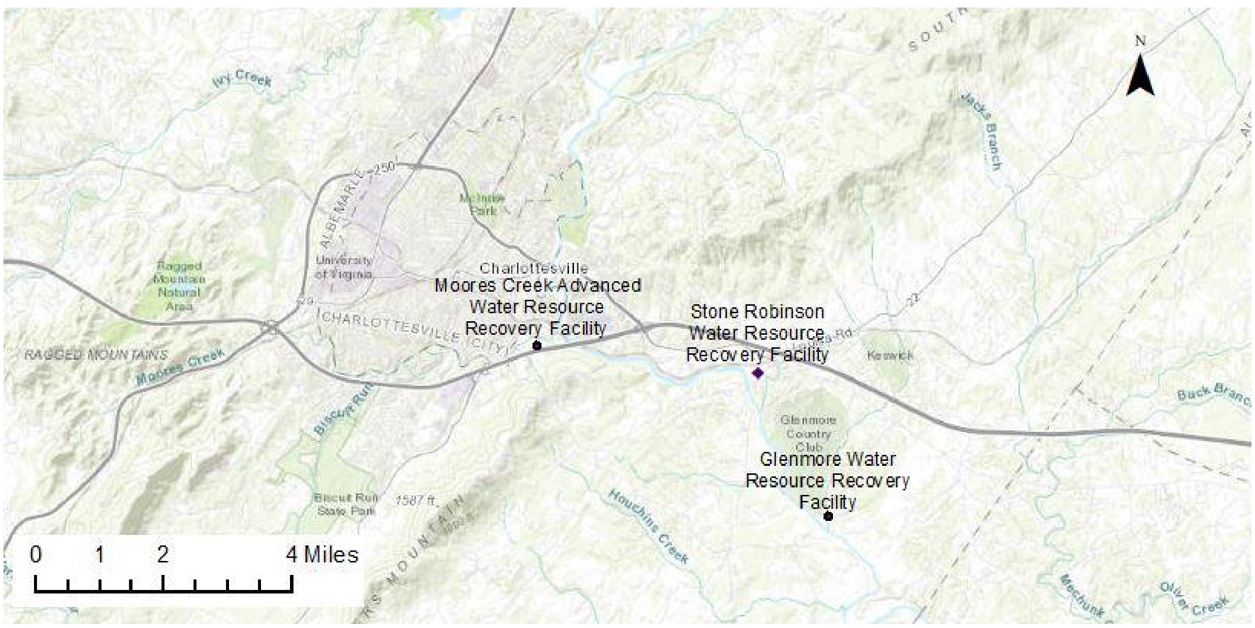


**Figure 12: Urban System Wastewater Treatment Plants**

[9] Process water used at South Rivanna WTP and North Rivanna WTP are discharged back to the source rivers. Process water at Observatory WTP is discharged to the sewer system.

# 6. Resource Assessments

This section consists of the results of the desktop analyses conducted to evaluate potential impacts to resources that may require avoidance or mitigation. This section also includes an overview of the resource assessments anticipated for the implementation of the project elements under the forthcoming permit term, in particular the completion of the SRR to RMR pipeline, SRR intake, and associated pump stations.

## 6.1 Beneficial Use and Aquatic Life (JPA Section 25)

The water resources utilized for the Urban System provide public water supply, irrigation water supply, recreation and supports aquatic habitat. Installation and operation of the proposed pipeline is not anticipated to result in significant adverse impacts to the existing or post-construction flow-dependent instream or off-stream beneficial uses within the region. Further, the current VWP permit has minimum instream flow and release requirements for the reservoirs that are designed to prevent adverse impacts to downstream beneficial uses and aquatic habitat. The following sections provide an overview of recreational resources and a review of the available data on fisheries resources in the vicinity of the Urban System.

### 6.1.1 Recreation

While water supply is the primary purpose of the reservoirs, they also provide a variety of recreational opportunities for the region.[10] Fishing is allowed at all of the water supply reservoirs. Some of the reservoirs are stocked with various fish by the Department of Wildlife Resources. Bird watching is allowed on and around all the water supply reservoirs. Kayaking and canoeing are allowed at SRR and RMR without a special permit as well as UVA Rowing Club's use of SRR, and these activities are not expected to be negatively impacted by the CWSP projects. Boating of any kind is not allowed at SHR. Gas-powered boats are not allowed at any of the reservoirs, and swimming is not allowed in any of the reservoirs. Water supply project construction and operations over the next permit term are not expected to result in significant adverse impacts to recreational opportunities at these reservoirs; however, there may be temporary impacts at SRR during construction of the proposed intake. Additional details related to the proposed SRR intake will be developed during the permit term as the concept is further developed.

### 6.1.2 Anadromous Fisheries

The historical range for a number of anadromous fish species may have extended into the RWSA watershed areas for the sources of supply (USGS, 2013; NOAA NMFS, 2009). However, the presence of numerous dams in the river basin, many of which were constructed over fifty years ago, have limited the available spawning habitat for these species.

[10] The City of Charlottesville owns RMR, SHR, and SRR and makes recreational land use decisions regarding these water bodies; the reservoirs are also regulated by Albemarle County ordinance.

To confirm the current status of anadromous fisheries in the vicinity of RWSA dams and reservoirs, determinations from Virginia Department of Wildlife Resources (DWR) and The Nature Conservancy (TNC) were reviewed both upstream and downstream of each dam. The DWR *Anadromous Fish Use Areas* GIS layer (Virginia DWR, 2020) includes mapping for "confirmed" and "potential" use areas. The Nature Conservancy Chesapeake Fish Passage Prioritization Tool (Martin, 2019) categorized stream segments into four categories for each species in the study.[11]

1. Current – there is documentation (observance record or other direct knowledge) of a given species using a given reach. "Using" in this context refers to spawning or other critical life stages and the reaches that would need to be traversed to access that reach from the Bay.
2. Potential Current – there is not documented evidence of a given species using a given reach, but based on similar streams/rivers, there is an expectation that they might be or could be using that reach.
3. Historical – a given species does not currently use a given reach, but historically (prior to the erection of anthropogenic barriers), they would be expected to.
4. None Documented – no use or expected historical use of a given reach by a given species

The data for the watershed upstream of the Rivanna Dams, including the Sugar Hollow Dam watershed, indicated there was no confirmed or potential usage (DWR), but that there was historical habitat (TNC) for anadromous fish species.[12] The South Fork Rivanna River downstream of the dam was noted to include potential usage (DWR) as well as current presence of American shad and potential presence of alewife and blueback herring (TNC).

The data for the watershed upstream of the Ragged Mountain Dam indicated there was no confirmed or potential usage (DWR), but that there was historical habitat (TNC) for anadromous fish species. The Moores Creek watershed downstream of the dam had no confirmed or potential usage (DWR) but was noted to include potential current presence of anadromous fish species (TNC).

Data for the watershed upstream of the low head dam on the North Fork Rivanna River indicated there was potential usage (DWR), as well as current presence of American shad and potential presence of alewife and blueback herring (TNC). However, this was limited to the stream segments upstream to the Advance Mill and Chris Greene dams, where there was only historical presence (TNC) upstream of those dams. The North Fork Rivanna River downstream of the dam was noted to include potential usage (DWR) as well as current presence of American shad and potential presence of alewife and blueback herring (TNC).

In summary, there was no current potential habitat upstream of RWSA's dams for anadromous fish except the North Fork Rivanna low head dam. The nearest confirmed presence of alewife and blueback herring downstream of the RWSA reservoirs is over 60 miles downstream in the James River near Goochland,

[11] Species include American shad, hickory shad, blueback herring, alewife, striped bass, Atlantic sturgeon, shortnose sturgeon, and American eel.
[12] The Chesapeake Fish Passage Prioritization Tool indicated over 40 barriers to fish passage upstream of the RWSA South Fork Rivanna River Dam.

VA. The continued presence and operation of RWSA's facilities, which have been in operation from 54 years (South Rivanna Reservoir) to over 100 years (Ragged Mountain Reservoir), does not result in a change to the available habitat for anadromous fish species. Further the addition of the South Fork to Ragged Mountain Pipeline would not be expected to result in entrainment of anadromous fish eggs or larvae because the dams are significant barriers that prevent access to the upstream watershed for spawning.

### 6.1.3 Non-Migratory Fisheries Resources

Available data, maps and reports on the non-migratory fish resources in the SRR, SHR, and RMR, as well as the Rivanna River were reviewed to determine the condition of the fisheries affected by the operations of the Urban System. There is some trout habitat in the tributaries to the RWSA reservoirs, which is limited to tributaries of the SHR and northwestern tributaries of the North Fork Rivanna River.[13] The Virginia DWR stocks trout in SHR and the south fork of the Moormans River.[14] Limited data was available for SHR and RMR. The Virginia DWR lists largemouth bass and bluegill as typical fish species in RMR.[15,16] More extensive biologist reports were available for SRR and the mainstem of the Rivanna River. Both resources were described as having healthy fisheries resources with substantial diversity of species. The SRR has been sampled for fish species since approximately the year 2000 and has been described as a high-quality fishing lake since it's impoundment in 1962. The most recent biologist report for the SRR from 2017 indicated a total of 11 fish species collected from sampling conducted in 2016.[17] The biologist report for the Rivanna River from 2010 indicated exceptional diversity with 46 fish species present in the river.[18] Given that the years of prior operation of the intakes at the RWSA reservoirs have had no observed adverse effect on the local fisheries resources, it is not anticipated that changes to the intakes and operations related to the abandonment of the SHR to RMR pipeline and the operation of the completed RMR to SRR pipeline would negatively impact local fisheries resources.

## 6.2 Threatened and Endangered Species (JPA Section 6)

The Virginia Fish and Wildlife Information Service (VaFWIS) and the US Fish and Wildlife Service IPaC database were reviewed for the presence of threatened and endangered (T&E) species in the vicinity of RWSA's reservoirs and infrastructure. Appendix H provides a list of all species found in the database search.

[13] VA DWR Cold Water Streams Survey GIS
[14] VA DWR 2021 Catchable Trout Stocking Plan
[15] https://dwr.virginia.gov/waterbody/sugar-hollow/
[16] https://dwr.virginia.gov/waterbody/ragged-mountain-reservoir/
[17] https://dwr.virginia.gov/waterbody/rivanna-reservoir/
[18] https://dwr.virginia.gov/waterbody/rivanna-river/

**Table 6: Federally Listed Threatened and Endangered Species in the Vicinity of the RWSA Urban System**

| Common Name | Scientific Name | Federal Listing Status |
|---|---|---|
| James spinymussel | *Parvaspina collina* | Endangered |
| Virginia big-eared bat | *Corynorhinus townsendii virginianus* | Endangered |
| Indiana bat | *Myotis sodalis* | Endangered |
| Northern long-eared bat | *Myotis septentrionalis* | Threatened |
| Yellow lance | *Elliptio lanceolata* | Threatened |

Under the prior permit with the U.S. Army Corps of Engineers (permit number 06-V1574), The James spinymussel (*Parvaspina collina*) and the Indiana bat (*Myotis sodalis*) were the only endangered species noted. The current review identified those and other species to be avoided during construction of the RMR to SRR pipeline (Table 6). No critical habitat was noted in the vicinity of the project for any of the threatened or endangered species. The measures employed under the prior permit (e.g., time of year restrictions on tree clearing and mussel surveys for open trench stream crossings) are anticipated to be protective of the additional species potentially present in the project area. Continued operation of the water supply system is not anticipated to result in impacts to T&E species in the region.

## 6.3 Historic Resources (JPA Section 7)

The current permit for the construction of the new Ragged Mountain Dam, RMR to SRR pipeline and associated facilities includes a programmatic agreement on addressing historic resources. The document, “Programmatic Agreement Between the Rivanna Water and Sewer Authority, the Virginia Department of Historic Resources and The Norfolk District, Corps of Engineers Concerning the Expansion of Ragged Mountain Reservoir in Albemarle County, Virginia” (2009) stipulated that because the alignment for the pipeline had not been finalized, the project could be permitted and RWSA would evaluate historic resources impacts after the pipeline alignment was finalized. RWSA proposes to continue with the provisions of this programmatic agreement for the renewal of its permit.

At this stage, the alignment is not finalized. However, based on the 30% design level documents, substantial portions of the RMR to SRR pipeline (40%) and the portion from RMR to the Observatory WTP (60%) are within existing road right-of-way. These sections of the alignment would not be expected to result in the potential presence of historic resources because they have been previously disturbed from road construction. Similarly, the proposed improvements near the RMR dam (for the new pump station) and on the site of the South Rivanna WTP (for the proposed intake, pretreatment and pumping facilities) are not anticipated to have historic resources on site. RWSA would conduct Phase I surveys necessary to identify archaeological and historic resources within the alignment of the pipeline and other program elements as described in the programmatic agreement.

## 6.4 Wetlands and Waters of the United States (JPA Section 8)

The SRR to RMR and the RMR to Observatory WTP pipeline alignments were compared to the National Wetlands Inventory, which identified ten stream crossings (Figure 13). RWSA is evaluating pipeline cros sing options, which include potential installation of the pipeline via directional drilling at these locations; however, temporary impacts to streams and wetlands may occur. In order to determine the need for additional permitting through the Virginia Marine Resources Commission (VMRC), the drainage area for each crossing was checked using the USGS StreamStats tool. The drainage area at each crossing was less than the five square mile threshold per VMRC (Table 7). In addition to pipeline crossing, the SRR intake construction may result in temporary impacts during the construction of the cofferdam, which will enable construction in dry conditions. Any in-water construction will conform to time of year restrictions to limit impacts to sensitive species. As the concept design for the intake is developed, additional details will become available for the construction methods.

**Table 7: Pipeline Stream Crossings**

| Stream Crossing | Drainage Area (sq mi) |
|---|---|
| 1 | 0.15 |
| 2 | 0.06 |
| 3 | 0.13 |
| 4 | 0.82 |
| 5 | 0.92 |
| 6 | 0.46 |
| 7 | 0.16 |
| 8 | 1.30 |
| 9 | 0.15 |
| 10 | 2.97 |

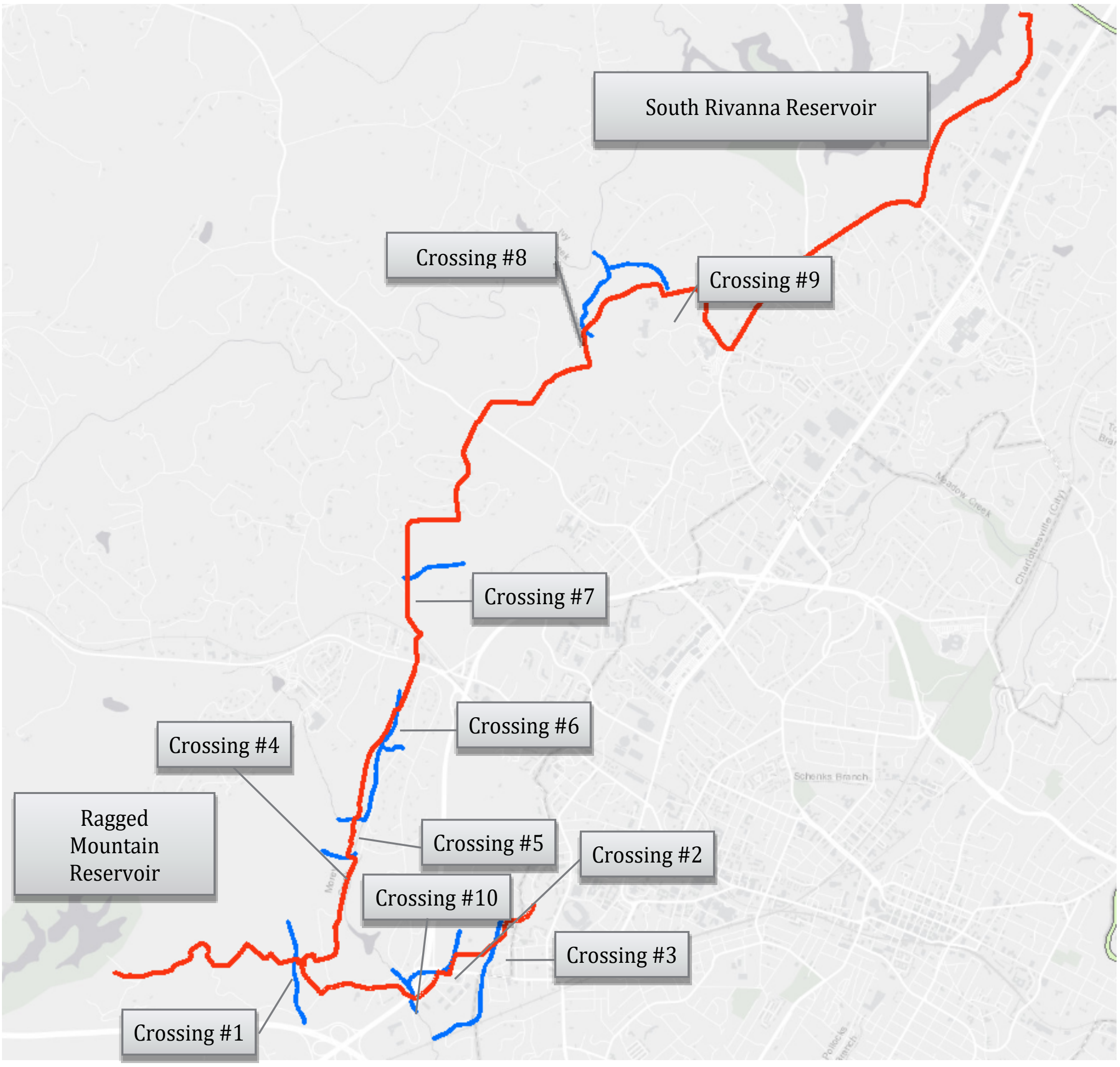


**Figure 13: RMR to SRR Pipeline Wetland Stream Crossing Locations**

# 7. Avoidance, Minimization and Mitigation of Impacts

Through the process of implementing the project elements originally permitted by DEQ and the USCOE, RWSA has worked to avoid and minimize potential impacts, mitigating for impacts only when unavoidable. RWSA plans to continue that approach through the construction and operation of project elements planned over the next permit term.

## 7.1 Completed Mitigation

Under the original permit, RWSA utilized avoidance measures, such as directional drilling under streams for pipeline crossings and time of year restrictions on construction, to limit the need for mitigation. However, there were unavoidable impacts to streams and wetlands from the construction of the Ragged Mountain Dam, which impacted 2.61 acres of nontidal wetlands and 13,163 linear feet of stream along unnamed tributaries to Moores Creek in the Rivanna River watershed. RWSA developed a compensatory mitigation plan for these project impacts at two sites: the Buck Mountain Creek site and the Moores Creek site. The loss of stream function at RMR was mitigated at the Buck Mountain Creek site using stream channel enhancement, riparian buffer enhancement, and riparian buffer preservation within a 1,315-acre portion of the watershed. The loss of wetland function at RMR was mitigated at the Moores Creek site through wetland creation and enhancement within a 13.56-acre floodplain landscape (VHB, 2006).

Important goals of the Buck Mountain Creek site were to promote, preserve, and enhance water quality in critical areas. The Buck Mountain Creek site is located within the watershed of the SRR, and improvements to water quality as a result of mitigation there would benefit the water quality of SRR. To achieve this, several types of stream mitigation were performed at several different locations within the Buck Mountain Creek watershed. Mitigation types included stream channel enhancement, upland buffer enhancement, and preservation of all enhancement areas. Figure 14 depicts the overall mitigation activities for the Buck Mountain Site while Figure 15 provides an enlarged view of one of the mitigation areas.

Stream channel enhancement included improvements to approximately 570 linear feet of unstable stream bank along Buck Mountain Creek just south of Route 665. Stream enhancement features were designed to reduce excessive sediment inputs and promote improvements to aquatic habitat quality, particularly for the endangered James spinymussel (*Pleurobema collina*). The design plan was structured to ensure that the stream bank stabilizing measures remained self-sustaining, and a methodology to assess the postconstruction efforts was initiated based on detailed field observations and reporting, which will occur over a 10-year period.

Stream buffer enhancement and/or preservation of riparian habitat occurred along more than 80,000 linear feet of perennial stream spread across over 1,300 acres of agricultural and forested land currently owned by RWSA. This included approximately 93 acres of forested riparian buffers established at various locations along Buck Mountain Creek, Piney Creek, and Burruss Branch, including several first and second order tributaries. Work to enhance the buffers included the planting of hardwood species in areas generally void of woody species within the specified conservation easement width, where agriculture and livestock grazing had previously been the primary land uses.

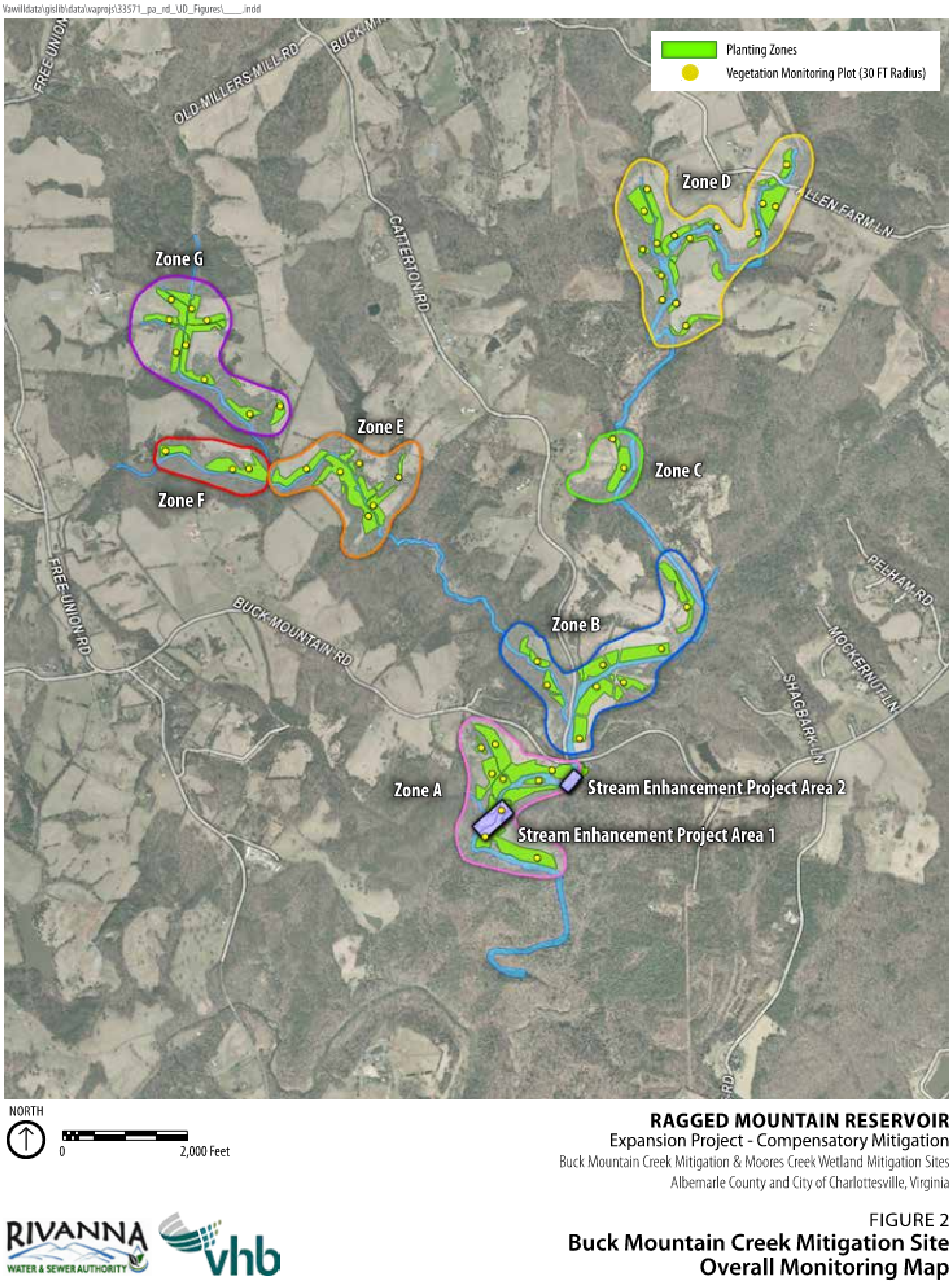


**Figure 14: Buck Mountain Creek Mitigation Site Overall Monitoring Map**

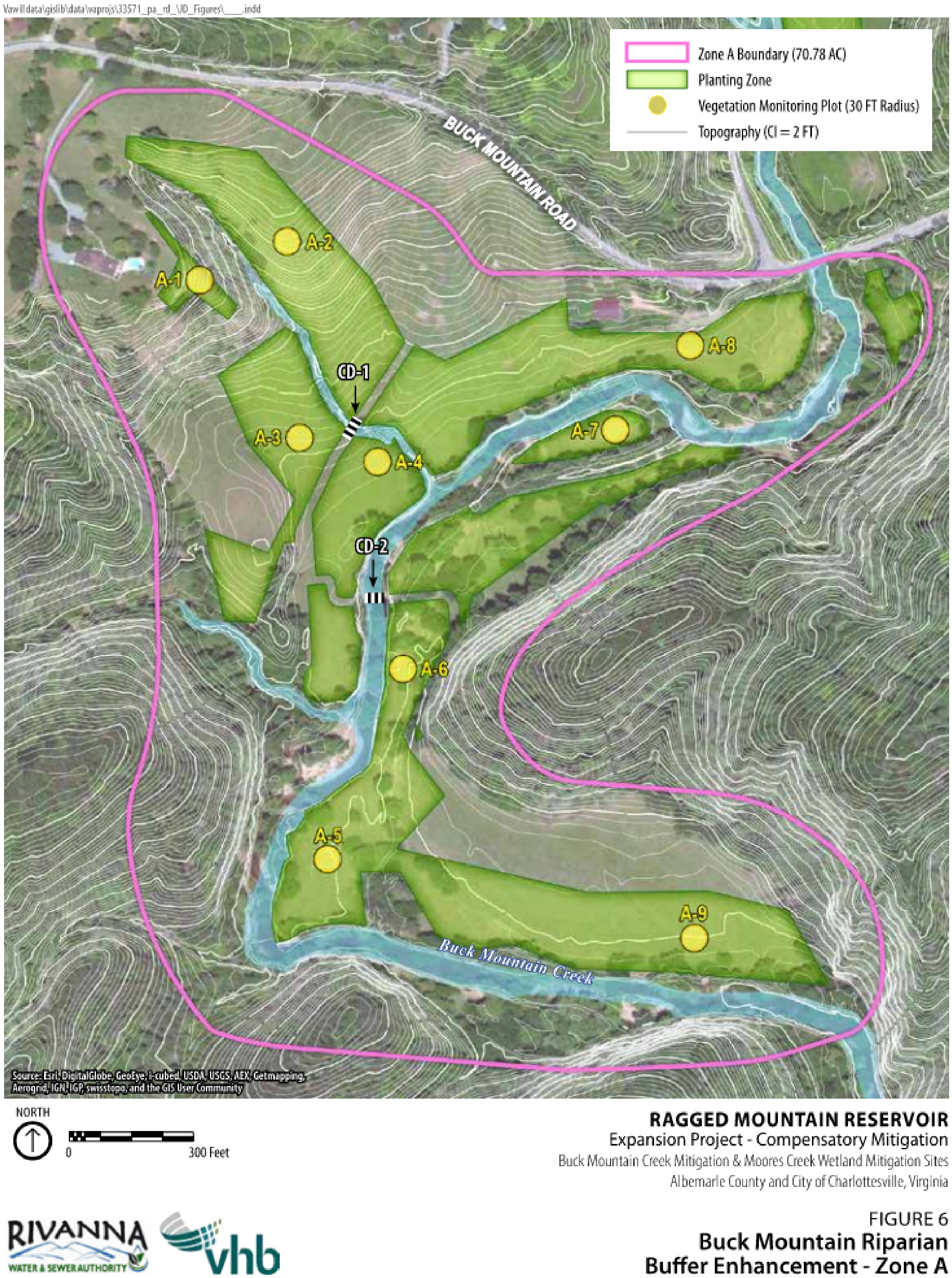


**Figure 15: Example of Riparian Buffer Enhancements – Buck Mountain Site**

Preservation of these enhancement areas was achieved throughout the course of the permit approval process, with the land eventually placed in deed restrictions tied to each RWSA deed and protected in perpetuity (VHB, 2014). Ongoing monitoring of the Buck Mountain Mitigation Sites has indicated some geomorphic change, but that the sites are remaining generally stable with healthy vegetation coverage (Figure 16) (ECS, 2020).

An important goal of the Moores Creek site was to focus on mitigating wetland functions through conversion of a small pasture area with very limited functional capacity, to a fully functioning forested wetland floodplain ecosystem. Target functions included flood flow attenuation, sediment/toxicant removal, water quality filtration to downstream systems, groundwater discharge, and wildlife habitat. To achieve this, a variety of mitigation techniques were used at the Moores Creek site including wetland creation, wetland enhancement, and upland riparian buffer enhancement. Specifically, wetlands were created within approximately 4.55 acres of low-lying uplands within the floodplain of Moores Creek, and approximately 2.45 acres of existing wetlands were planted with additional trees to enhance the forested ecosystem. Upland riparian buffers were also enhanced with additional trees planted within the 6.5 acres of non-wetland area that surround the wetland creation and enhancement areas. The buffer improvements supplemented the existing scattered clumps of trees and improved upland habitat quality and streamside riparian buffer functions.

**Figure 16: Buck Mountain Mitigation Project Area 2, Cross Section 1, Looking Upstream from October 2014 (left) and September 2020 (right) (VHB, 204; ECS, 2020)**

The chief hydrologic alteration at the Moores Creek site was the addition of supplementary surface flow via stormwater drainage that had been redirected to the site. This outlet was designed to direct site runoff into a network of shallow, sinuous channels to promote the hydrology necessary to establish palustrine forested wetlands. Once wetland hydrology was confirmed by regulators, native wetland tree species and wetland emergent ground cover were installed. Further, since the site had been previously used as a livestock holding facility, the mitigation area required a new fence to keep livestock on the adjacent parcel out of the creation and enhancement areas. Preservation of the Moores Creek mitigation area was achieved throughout the course of the permit approval process, with the land eventually placed in deed restriction and protected in perpetuity (VHB, 2014).

Years 1 through 3 (2014-2016) of the mitigation monitoring period showed continued progress towards the established mitigation goals. In year 3, the Buck Mountain Creek site channel enhancement and riparian buffer enhancement components and Moores Creek wetland enhancement areas continued to stay on target to reach the mitigation goals set by the regulatory agencies despite increases in invasive species in the mitigation areas (VHB, 2016). Year 5 (2018) continued to show an increase in invasive species at both locations, but overall, the sites are meeting the mitigation goals.

**Figure 17: Moores Creek Mitigation Site Woody Vegetation Monitoring for Plots MW-5 (left) and MW-7 (right), September 2020 (ECS, 2020)**

Recommendations from the year 5 report include continued monitoring of the woody stem success and the channel stability of the Buck Mountain Creek site in addition to mitigation monitoring at both sites (ECS, 2019). Drainage improvements to Moores Creek occurred in summer 2019 to improve water levels for the forested wetland system to be established in the area (ECS, 2019). Per the year 7 (2020) mitigation report, a steady increase was observed for woody stem counts and herbaceous cover from the 2018 monitoring period at the Moores Creek site (Figure 17). Invasive species eradication treatments were completed at both the Buck Mountain Creek and Moores Creek sites in the summer of 2020. Supplemental tree planting was completed in the summer of 2020 and is planned for spring 2021 (ECS, 2020). Recommendations from the year 7 report include continued monitoring of invasive species at both sites, monitoring of woody stem success at the Buck Mountain Creek site, and some corrective actions to ensure better stream channel stability at Buck Mountain Creek (ECS, 2020).

## 7.2 Future Construction

For the completion of the remaining CWSP project elements under the forthcoming permit term, RWSA is committed to minimizing construction-related impacts. RWSA will employ similar methods for avoiding and minimizing impacts as were employed previously to construct project elements to date. These methods include:

- Avoidance of wetlands
- Time of year restrictions on construction activities, as necessary
- Targeted endangered species surveys and relocation (e.g., James spinymussel), as necessary

- Phase I surveys for historic resources for undisturbed sites
- Revegetation of disturbed areas

Therefore, RWSA does not anticipate significant adverse impacts from the continued implementation of the pipeline, intake or pump stations during the next permit term that would require mitigation. Temporary construction impacts are expected from the construction of the pipeline, SRR intake and associated project elements, but the above measures are expected to limit the magnitude of these potential impacts.

## 7.3 Future Operations

RWSA has implemented the required release protocol to comply with F.4. of the current VWP permit, "Total Downstream Flow Provisions After an Expanded Ragged Mountain Reservoir is Operational, But Before the Pipeline from South Fork Rivanna Reservoir to Ragged Mountain Reservoir is Operational" (RWSA, 2014). RWSA is committed to updating its operations manual to comply with the provisions of F.5. "Total Downstream Flow Provisions After Both an Expanded Ragged Mountain Reservoir and the Pipeline from South Fork Rivanna Reservoir to Ragged Mountain Reservoir are Operational" as part of its renewed permit. RWSA does not anticipate significant adverse impacts to natural resources from the operation of its reservoirs per this protocol that would require mitigation.

In the interim time period between permit renewal and the construction and commissioning of the RMR to SRR pipeline and the associated RMR pool raise, RWSA is proposing a potential MIF protocol modification under the new permit. As discussed in Section 5.4, RWSA is proposing to reduce the MIF associated with SHR operations such that reservoir releases are reduced from 100% to 90% of the inflow when SHR is below full. Modeling of this proposed operational change suggests minimal impacts to downstream flows while providing an increased refill rate and overall reliability improvements to the SHR supply. Figure 18 shows the minimal difference in downstream flows under the current 100% and proposed 90% release protocol.

As noted in Section 2 of this document, RWSA is also performing an evaluation of the North Rivanna WTP to determine whether or not to decommission the facility. If this facility were to be decommissioned, the currently permitted North Rivanna WTP withdrawal of 2 MGD would be eliminated, thereby providing increased natural stream flow in the North Fork Rivanna River and in the subsequent confluence with the remainder of the Rivanna River. RWSA would request modifications to the MIF protocol associated with the SRR that would account for the increased flow in the North Fork Rivanna River and a commensurate reduction of required release from the SRR (potentially up to 1.5 MGD).

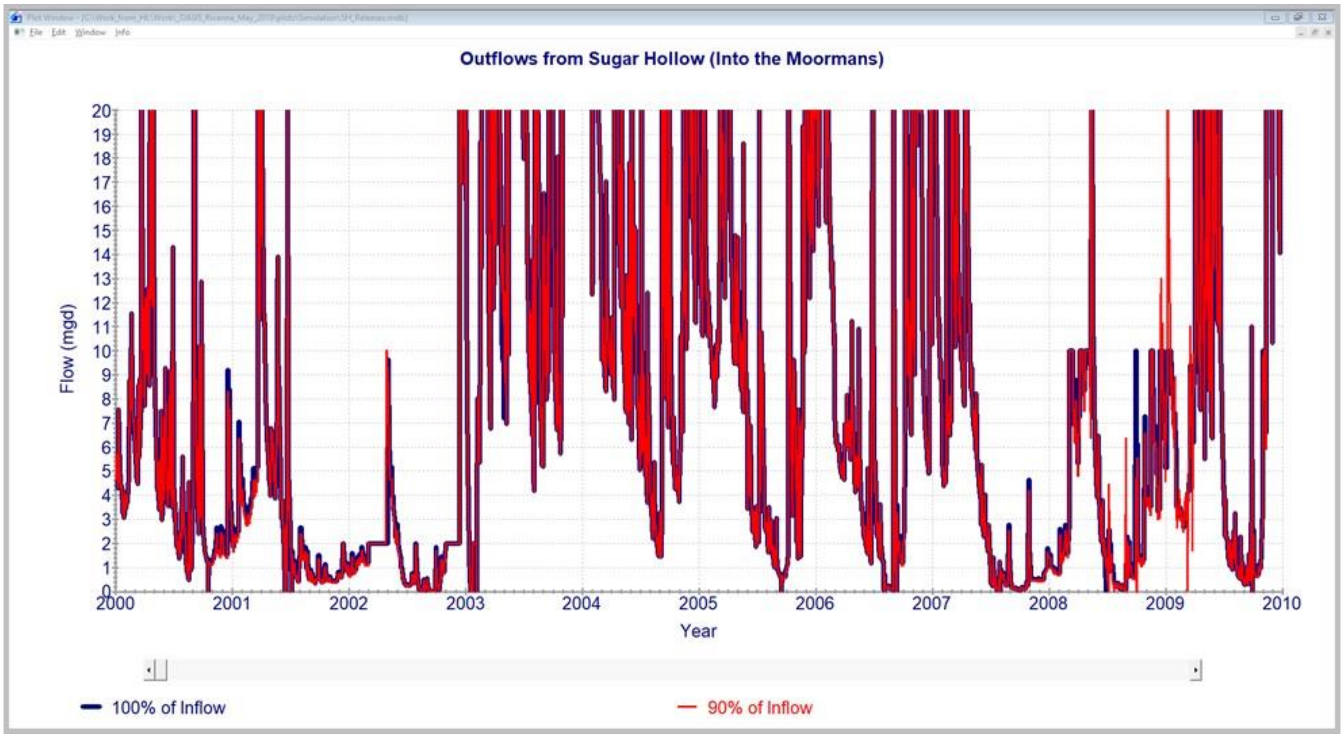


**Figure 18: Comparison of SHR Outflows Under 100% of Inflow and 90% of Inflow Operating Regimes**

# 8. Agency Coordination and Public Outreach (JPA Section 5 and Section 26)

## 8.1 Agency Coordination

On October 2, 2020, RWSA and Hazen and Sawyer met with the Albemarle County Service Authority (ACSA), the Virginia Department of Environmental Quality (DEQ), the Virginia Department of Wildlife Resources (DWR), the U. S. Environmental Protection Agency (EPA), the Virginia Marine Resources Commission (MRC), the Virginia Department of Conservation and Recreation (DCR), the Virginia Department of Health (VDH), and the Thomas Jefferson Soil and Water Conservation District (TJSWCD) in a pre-application meeting. The purpose of the meeting was to familiarize the agencies with the Urban System and the proposed Community Water Supply Plan elements and to review the key supporting information associated with the upcoming permit renewal and submittal.

Hazen and RWSA described the on-going projects that are a part of the previous VWP and the status of elements outlined in the Community Water Supply Plan including the upgrades at the Observatory WTP, the South Rivanna WTP, and the RMR to Observatory WTP and the RMR to SRR pipelines. These upgrades are a reflection of the projected increase in demand for the Urban System and recognize the significant benefits of the proposed projects to overall water system reliability and resiliency. The implementation of the RMR to SRR pipeline and raising the RMR pool elevation to 683 feet will greatly increase the resiliency and reliability of the system by providing the ability to convey flow between the sources and treatment facilities, which eliminates the potential for one source or facility to become “stranded” if an operational issue were to occur. The operational yield of the water supply system with these changes in place will increase to 21.4 MGD.

RWSA proposed adjustments to the inflow calculation methodology to more accurately reflect the inflow to the reservoirs preventing excess releases that can lead to overdrafting of the reservoirs and delayed refill. The proposed method uses gages that are more reflective of the watersheds the reservoirs are in. Potential adjustments to the Minimum In-stream Flow (MIF) are being considered as RWSA decides how to proceed with the North Fork WTP.

RWSA plans to continue to comply with the resource assessments and mitigation requirements established under the existing permit for the remaining infrastructure to be constructed.

## 8.2 Public Outreach

As the permitting process moves forward, RWSA is committed to proactive communication and public outreach about the Community Water Supply Plan and associated project elements. Potential activities that will be performed as the program continues include the following:

- Board meeting
- Public meeting
- Other public notification (e.g., newspaper announcement)
- www.rivanna.org

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# Appendices