East End Water Supply Evaluation

Henrico County, Virginia
Department of Public Utilities

Final Report

February 2025

Prepared for Henrico County by WRA

County of Henrico, Virginia
Department of Public Utilities

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Table of Abbreviations

ADD – Average Day Demand
ASR – Aquifer Storage Recovery
BPS – Booster Pump Station
City – City of Richmond
EST – Elevated Storage Tank
FCV – Flow Control Valve
Ft – Feet
Ft bgs – Feet Below Ground Surface
GAC – Granular Activated Carbon
GEU – Greater Eubank Pressure Zone
GHM – Greater Hermitage Pressure Zone
GPM – Gallons Per Minute
HCDPU – Henrico County Department of Public Utilities
HGL – Hydraulic Grade Line
HP – Horsepower
HWTF – Henrico Water Treatment Facility
LAPS – Len Ave Pump Station
LAZ – Laburnum Azalea Pressure Zone
LF – Linear Feet
MDD – Maximum Day Demand
MGD – Million Gallons per Day
MPN – Most Probable Number
PRS – Pressure Reducing Station
PRV – Pressure Reducing Valve
PWS – Public Water Supply
ROM – Rough Order of Magnitude
RRD – River Road Pressure Zone
RWPS – Raw Water Pump Station
SCADA – Supervisory Control and Data Acquisition
SOC – Synthetic Organic Compounds
TCC – Three Chopt Central Pressure Zone
TCH – Three Chopt High Pressure Zone
TCG – Three Chopt Gravity Pressure Zone
TDH – Total Dynamic Head
TM – Transmission Main
USGS – United States Geological Survey
VDEQ – Virginia Department of Environmental Quality
VDH – Virginia Department of Health
VFD – Variable Frequency Drive
VOC – Volatile Organic Compounds
WBD – West Broad Pressure Zone
WPS – Water Pump Station
WRA – Whitman, Requardt and Associates

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ES Executive Summary

Henrico County (County) currently owns and operates the Henrico Water Treatment Facility (HWTF) and a water transmission and distribution system to serve over 100,000 Henrico County customers within the existing service area. Henrico County currently has multiple connection points for additional water supply from the City's water system. While a majority of the western and northern side of the system is fed directly from the HWTF; there is a portion of the County's system on the east side of Richmond that is largely dependent on the City of Richmond (City) for water supply.

During the week of January 6, 2025, the City experienced significant equipment failures at its water treatment plant. These failures resulted in system wide water outages for several days within both the City's system and the County's eastern pressure zones Laburnum Azelea (LAZ) and Greater Eubank (GEU). The County owned water system is not currently designed to supply water to the east end within the County system from the HWTF, as there are existing City water supply agreements in place through 2040 to supply water to these areas, and it is more economical to provide water to the eastern part of the County from the City.

Upon a review of available system data, the existing system operated as anticipated during the recent Richmond water outage. During the water outage, system modifications were made in an attempt to minimize impacts on the existing system. However, periods of complete water loss were unavoidable given the extended duration of the City's supply outage.

During the water outage, the County considered using their existing well system, which contains an aggregate 4 MGD (million gallons per day) pumping capacity between four separate existing wells. However, the Virginia Department of Health (VDH) did not permit use of the wells due to differences in disinfection processes between the well system and the City/County supply. These existing wells are allowed as emergency use wells by the County's VDH waterworks operations permit. However, since the well system does not have a groundwater withdrawal permit from the Virginia Department of Environmental Quality (VDEQ), they are of limited use for the County even if disinfection modifications were to be made to make them compatible with the existing City/County supply system. Based on available information from VDEQ, obtaining a groundwater withdrawal permit for the existing wells may not be feasible.

In response to the water outage, the County requested the following three levels of service be reviewed for both the LAZ and GEU pressure zones:

- Short-Term: Service will be analyzed assuming existing Average Daily Demands (ADD) are required to be met. This service level is intended to reflect providing a minimum level of service to the east end during an emergency condition under normal (average) day demands
- Mid-Term: The target mid-term 21 MGD supply value was selected to represent replacing supply from the main City connection into the GEU pressure zone, which is known as the "Shurm connection"
- Long-Term: Service will be analyzed assuming future Maximum Day Demands (MDD) for long-term service to all pressure zones. These demands include an allowance for planned growth within the GEU

WRA utilized the County's hydraulic water model to identify potential options to meet short-term, mid-term and long-term demand to obtain variable degrees of additional supply independent of the City's system. The purpose of this report is to provide high-level options for potential future implementation by the County. The following **Table ES.1** summarizes options that were reviewed:

Table ES.1: Summary of Additional Supply Options Reviewed			
Option	Improvement Required	Planning Level Cost	Implementation Schedule
Short-term Option A	• 54,000 lf 30" Transmission Main (TM) • Upgrade of ex. Len Avenue Pump Station	$117 M	5-6 Years
Short-term Option B	• Well permitting, rehabilitation and treatment	$20 M	3-4 Years
Mid-term Option A	• 70,000 lf 48" TM	$328 M	5-7 Years
Long-term Option A	• 107,000 lf of 42-48" TM • 40 MGD pump station and ground storage	$583 M	6-8 Years
Long-term Option B	• New regional water treatment plant and TMs	$1.289 B	10+ Years

1 Background

1.1 Project Purpose

Henrico County (County) currently owns and operates the Henrico Water Treatment Facility (HWTF) and a water transmission and distribution system to serve over 100,000 Henrico County customers within the existing service area. An overall system map is provided in **Figure 1.1**. A schematic of the County pressure zones and major City of Richmond (City) pressure zones that are interconnected to provide service is provided in **Figure 1.2.**

Henrico County currently has multiple connection points for additional water supply from the City's water system. While a majority of the western and northern side of the system is fed directly from the HWTF; there is a portion of the County's system on the east side of Richmond that is largely dependent on the City for water supply. These water zones are referenced as pressure zones Laburnum Azelea (LAZ) and Greater Eubank (GEU). The existing County water system is not currently designed to supply water to these zones from the HWTF, as there are existing City of Richmond water supply agreements in place through the Year 2040 and it is more economical to provide water to the eastern part of the County from the City at an annual cost of cost of $10-$15 million.

The City experienced significant equipment failures at its water treatment plant the week of January 6, 2025. These failures resulted in system wide water outages for several days within both the City's system and the County's GEU pressure zone and to a lesser extent within the County's LAZ zone. The events that occurred during the week of January 6, 2025, are referred to in this report as the "water outage".

The Henrico County Department of Public Utilities (HCDPU) has requested Whitman, Requardt & Associates (WRA) to provide support services to perform a high-level overview of the existing system, and a review options for future potential water supply increases to the eastern LAZ and GEU zones, which are referred to as the "east end" in this report. Schnabel Engineering supported WRA's scope of services in this report as it pertains to water supply wells, groundwater issues, and groundwater withdrawal permitting.

1.2 Project Scope

The primary scope items identified for WRA to complete for this study are as follows:

A. Data Gathering/Data Review – Obtain and review background information, mapping, engineering studies, and as-built drawings related to the project.
B. Gather documents to review the water outage's impacts to the County's system.
C. Review available options to increase water supply to the east end for short-term, mid-term and long-term demand goals.
D. Develop planning level costs and timelines for implementation of options.
E. Report Development – Develop a report to document and summarize the above scope items.

1.3 Report Organization

The following is a general outline of the sections provided within this report:

- **Section 2**: Provides background information and an overview on the existing system.
- **Section 3**: Discusses how the County's system responded during the water outage.
- **Section 4**: Describes available options to increase water supply to the east end for short-term, mid-term and long-term demand goals, along with costs, timelines, and benefits.
- **Section 5**: Summarizes the results of the above information.

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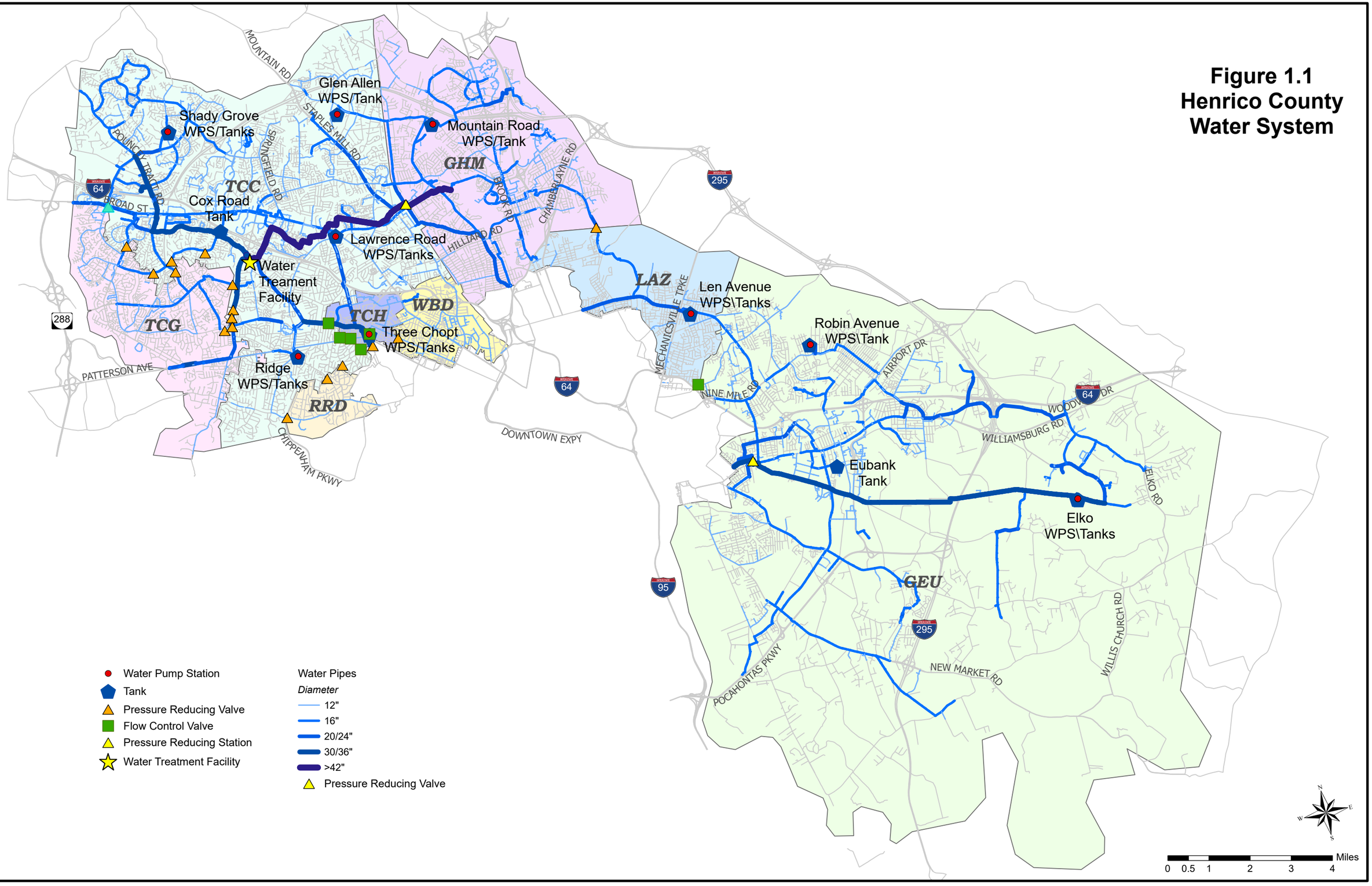
Figure 1.1
Henrico County
Water System



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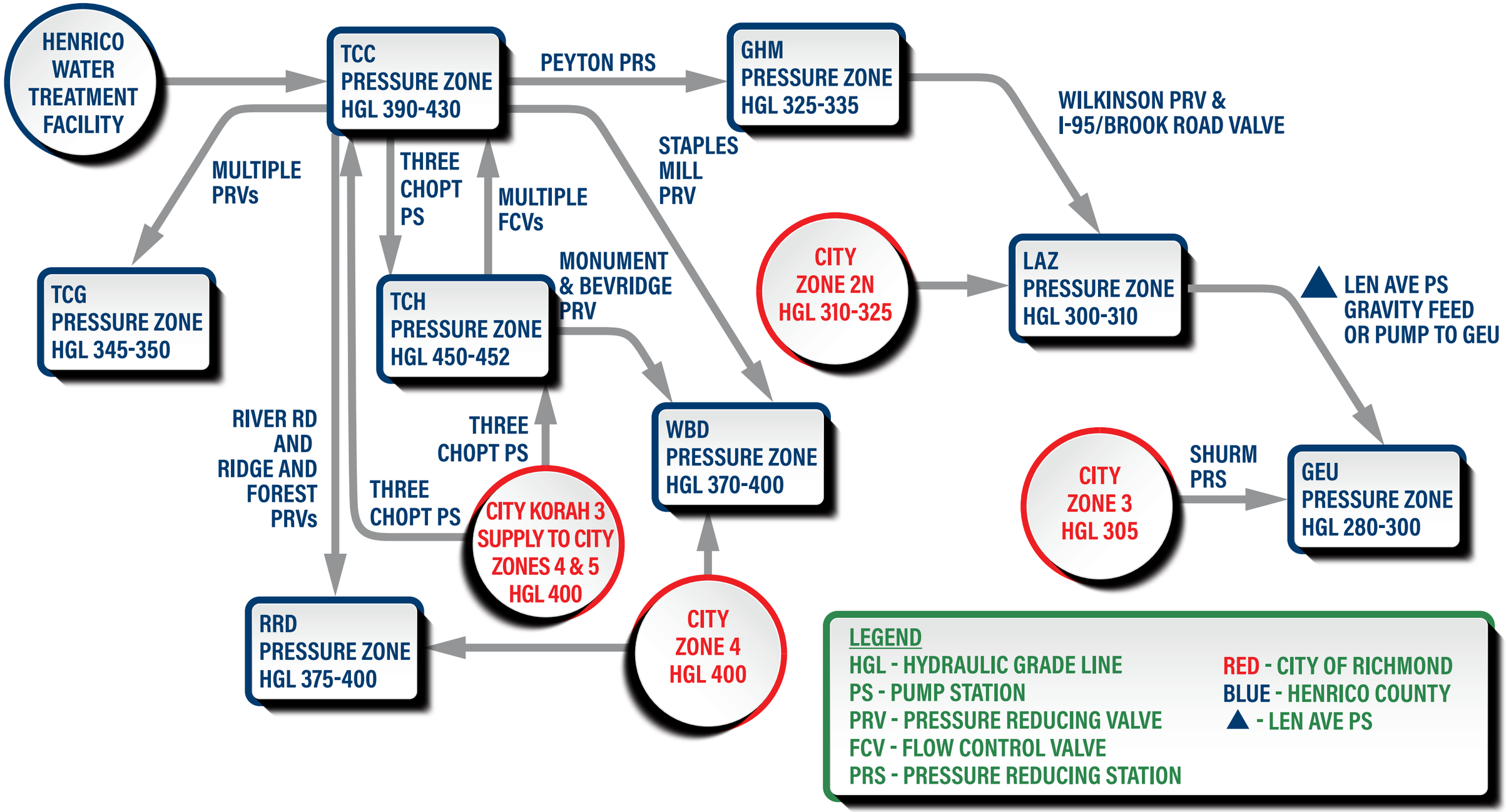
HENRICO WATER TREATMENT FACILITY
TCC PRESSURE ZONE HGL 390-430
PEYTON PRS
GHM PRESSURE ZONE HGL 325-335
WILKINSON PRV & I-95/BROOK ROAD VALVE
MULTIPLE PRVs
THREE CHOPT PS
MULTIPLE FCVs
STAPLES MILL PRV
TCG PRESSURE ZONE HGL 345-350
TCH PRESSURE ZONE HGL 450-452
MONUMENT & BEVRIDGE PRV
CITY ZONE 2N HGL 310-325
LAZ PRESSURE ZONE HGL 300-310
LEN AVE PS GRAVITY FEED OR PUMP TO GEU
RIVER RD AND RIDGE AND FOREST PRVs
THREE CHOPT PS
THREE CHOPT PS
CITY KORAH 3 SUPPLY TO CITY ZONES 4 & 5 HGL 400
WBD PRESSURE ZONE HGL 370-400
CITY ZONE 3 HGL 305
SHURM PRS
GEU PRESSURE ZONE HGL 280-300
RRD PRESSURE ZONE HGL 375-400
CITY ZONE 4 HGL 400
LEGEND
HGL - HYDRAULIC GRADE LINE
PS - PUMP STATION
PRV - PRESSURE REDUCING VALVE
FCV - FLOW CONTROL VALVE
PRS - PRESSURE REDUCING STATION
RED - CITY OF RICHMOND
BLUE - HENRICO COUNTY
▲ - LEN AVE PS

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2 Existing System Overview

The following section summarizes the available information obtained and collected for this project.

2.1 Existing Water Supply

The County supplies water to the public under a Virginia Department of Health (VDH) Waterworks Operation permit. According to VDH records, effective dates of permit coverage are July 1, 1979 (Permit No. 4087125), February 10, 2005 (Permit No. 4087125), April 15, 2009 (Permit No. 4087125-P), and October 15, 2010 (Permit No. 4087125) (amended).

Within the County's VDH permit, 80 million gallons per day (MGD) is permitted through a surface withdrawal from the James River which is treated and distributed from the HWTF. An additional 35 MGD water can be purchased from the City of Richmond's Water Treatment Plant through a contract expiring in 2040. Maximum and minimum flows of purchased water are reported within County records at 35 MGD and 18 MGD, respectively. Water is supplied from the City to the County through 39 metered connections.

The County owns four (4) Public Water Supply (PWS) wells as waterworks in the east end. The PWS wells include the Elko Road Well, Old Williamsburg Road Well, Sandston Woods Well (a.k.a. Memorial Drive Well), and White Oak Well. The wells are currently inactive and not used to supply water.

2.2 Overview of Existing Treatment and Conveyance System

The following sections provide an overview of the existing County system and discuss how water is supplied from the HWTF and City sources to the east end of the County. This overview is also given as background information in reference to both the resulting impacts of the water outage on the Henrico system and the County's response to water outage events. **Figure 2.1** provides a schematic of the primary components including regional transmission mains (TMs), Pressure Reducing Stations (PRSs), Pressure Reducing Valves (PRVs), Water Pump Stations (WPSs) and various City and County pressure zones that that are integral to and impact water supply to Henrico's east end. The following sections discuss these components.

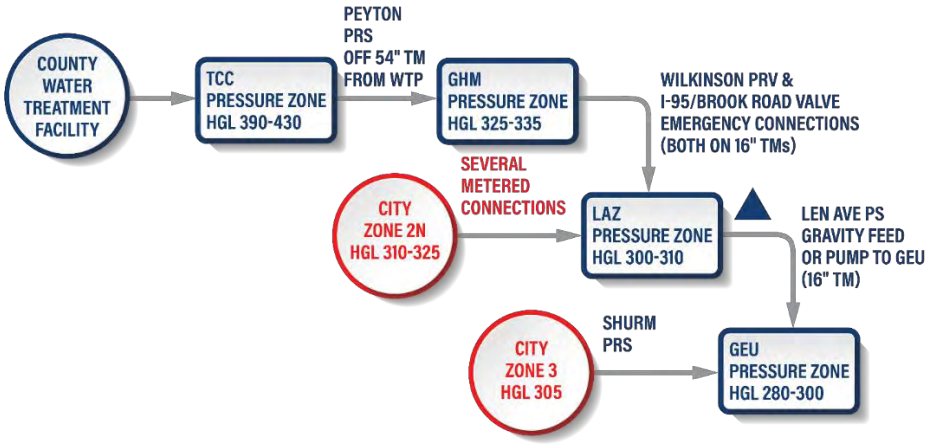

Figure 2.1: Existing Supply Routes to the East End

2.2.1 Existing City/County Interconnects

The County has many interconnections with the City throughout its system. The east end is primarily supplied by two existing interconnects with the City. These include an interconnection of the City's Zone 2N into LAZ and the City Zone 3 (The Shurm Connection) into GEU. In the west end, the River Road (RRD) and West Broad (WBD) Pressure Zones are primarily supplied by interconnects with the City's Zone 4 Pressure Zone. The County's Three Chopt WPS is partially supplied by the City's Korah 3 Supply to City Pressure Zones 4 and 5.

2.2.2 Henrico Water Treatment Facility

The HWTF is a conventional surface water treatment plant located off Three Chopt Road that was designed and commissioned between 1997 and 2004. The HWTF was originally constructed with a permitted capacity of 55 million gallons per day (MGD). Through a series of upgrades completed in 2012, the HWTF now is permitted to treat up to 80 MGD. The facility treats water from the James River, supplied to the HWTF from the County's Raw Water Pump Station (RWPS).

Once water reaches the treatment facility it undergoes coagulation, flocculation, and sedimentation, followed by ozonation and filtration. Treated water undergoes final disinfection and additional chemical treatment using chloramines within the HWTF's four (4) on-site clearwells, which provide an approximate 4.5-million-gallon combined capacity of finished water storage. Finished water is pumped from the clearwells by (4) vertical turbine pumps into the County's distribution system through one transmission main.

2.2.3 Existing Transmission and Distribution System

Henrico County owns and maintains almost 1,800 miles of existing water mains consisting of 3-inch to 54-inch transmission and distribution mains. The primary regional 48-inch/54-inch transmission main was constructed in phased construction in the early 2000's and conveys flows from the HWTF to Lydell Drive in the Greater Hermitage (GHM) pressure zone, between Parham Road and Woodman Road.

2.2.4 Pressure Reducing Valves

As indicated in the previous **Figure 2.1**, the Peyton Pressure Reducing Station (PRS) and the Wilkinson PRV both regulate supply to the east end. Under normal operating conditions, PRVs regulate water flow between pressure zones by reducing the hydraulic grade line (HGL) as required to manage elevation differences between zones, maintaining acceptable pressures downstream of the PRV.

2.2.5 Existing Pumping Stations

The primary existing County pump station that impacts flows within the LAZ and GEU pressure zones is the Len Avenue Pump Station (LAPS). The LAPS was constructed in 2004 along with two adjacent 1.25 million gallon ground storage tanks. The LAPS currently has three 125 horsepower (HP) pumps, each with a rated capacity of 2.8 MGD at 128-feet of total dynamic head (TDH) per pump. This results in a total station capacity (with two pumps operating and one pump on standby) of approximately 5.6 MGD. The LAPS serves three functions in the water system: to serve as an in-zone booster pump station to LAZ, as a pumping station to supply water to GEU or as a gravity feed to supply water to GEU via a PRV.

2.2.6 Existing Tank Storage

Under existing conditions, LAZ can be supplied from LAPS's 2.5 million gallons of ground storage tank capacity. If the ground storage tank capacity is full, LAZ can be supplied for 1.1 days under ADD conditions. To supply LAZ from these ground tanks, the connections between the City and LAZ must be closed to prevent backfeeding into the City if there is no pressure or low pressure on the City side.

Under existing conditions, GEU can be supplied from the following storage tanks for a cumulative storage capacity of 12.5 million gallons:

- LAPS (storage tank type: ground) – 2.5 million gallon storage capacity
- Robin Ave WPS (storage tank type: ground) – 3 million gallon storage capacity
- Elko WPS (storage tank type: ground) – 6 million gallon storage capacity
- Eubank Tank (storage tank type: elevated) – 1 million gallon storage capacity

If all tank storage is full and allocated to GEU, GEU can be supplied for 1.8 days under ADD conditions. Likewise, connections between the City and GEU must be closed to prevent backfeeding into the City if there is no pressure or low pressure on the City side.

2.3 Overview of Former Well System

The County formerly operated a well system in the east end. In 2005, these wells were designated for emergency use only and the Virginia Department of Environmental Quality (VDEQ) appropriations permit was terminated. Installation and aquifer testing dates of the wells are between 1988 and 1989, except for the Sandston Woods (Memorial Drive) Well which has an older installation and aquifer testing date of 1967. The locations of the former County water supply wells are shown in **Figure 2.2.**

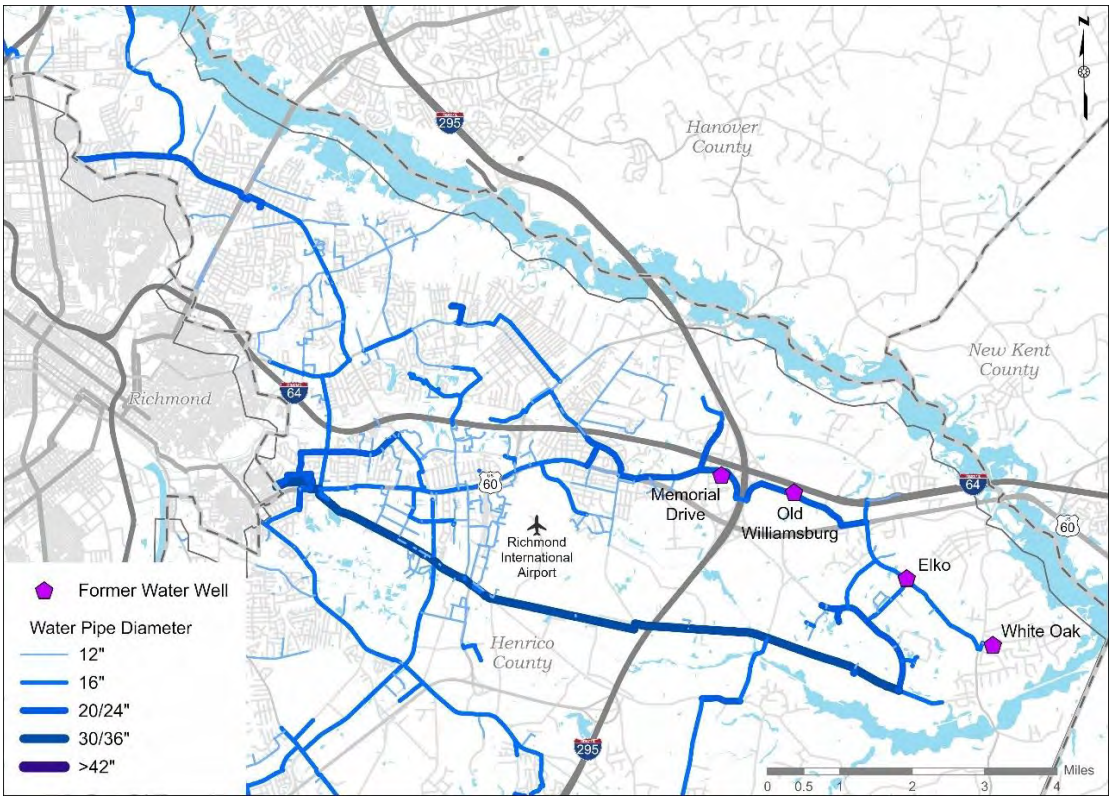

Figure 2.2: Locations of Former County Wells

The last use of these four wells was in July 1997. These wells are reported by Henrico County Operations as being physically able to operate. The exception to this is the Sandston Woods (Memorial Drive) well, which County operations reports needs pump repairs.

During the water outage, the County did successfully complete limited water quality testing for bacteria and discussed potential emergency use with VDH. However, VDH indicated that the former wells could not be used for water supply in the County's distribution system due to potential issues of mixing the chlorinated well water with the City/County supply, which both rely on Chloramines for final disinfection. Due to these limitations, the former wells are currently unusable by the County, even for emergency use such as was explored during the recent water outage. The following sections provide additional background on the well system, and a discussion concerning potential future use.

2.3.1 Hydrogeologic Setting of Former Wells

The County's PWS wells are situated within the western margin of Coastal Plain of Virginia. The Coastal Plain is a stratified sequence of sand and clay marine formations deposited during repeated transgressions and regressions of sea level. Coastal Plain sediments constitute a package of non-lithified seaward thickening formations that overlie crystalline bedrock. Three semi-confined Coastal Plain aquifers exist within the east end of the County where the County PWS wells are located. The deepest and thickest of those aquifers is the Potomac aquifer which is by far the most heavily used and regulated aquifer within Virginia because of its ability to store and transmit larger volumes of water than other Virginia Coastal Plain aquifers. For that reason, it is often targeted as a groundwater resource when large volumes of water are required for municipal and industrial purposes. The Aquia aquifer is positioned above the Potomac aquifer and is better suited for moderate withdrawals associated with light municipal and industrial uses, and residential uses. The Piney Point aquifer is the shallowest of the semi-confined aquifers mapped to be within the eastern-most reach of the County but has limited thickness and capacity, existing only as a feather-edged wedge in its rather limited occurrence within the County. For that reason, it is not considered a suitable groundwater resource for the needs of the County. Similarly, the unconfined water table aquifer (or Columbia aquifer) is not considered suitable for the County's municipal water supply needs due to its limited capacity, and susceptibility to both contamination and drought.

2.3.2 Existing Water Supply Well Withdrawal Capacities

Schnabel Engineering reviewed VDH permit information received from VDH and geologic information within USGS Professional Paper No.1404C (Hydrogeologic Framework of the Virginia Coastal Plain). From this information, the following **Table 2.1** was compiled indicating water supply well and aquifer information.

Table 2.1: Summary of Existing Well Water Supply Details

Well Name & Address	Date	Total Depth (ft)	Well Yield (gpm)	Screen Type	Total Screen Zones	Pump Type	Total Screen (LF)	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Aquifer
White Oak Hills #2 4932 White Oak Pl	1988	680	703	12-inch SS	7	100-HP Subm.	126	492	662	Potomac
Old Williamsburg Road 3200 Old Williamsburg, Rd	1989	535	851	12-inch SS	4	150-HP Subm.	152	324	525	Potomac
Elko Road 6029 Elko Rd	1989	578	850	12-inch SS	5	150-HP Subm.	86	372	568	Potomac
Sandston Woods / Old Memorial Dr 2001 Old Williamsburg, Rd	1973	600	1,150	8-inch SS	7	125-HP V.T.	96	362	590	Potomac

bgs = Below Ground Surface; SS = Stainless Steel; V.T. = Vertical Turbine; Subm. = Submersible
Note: Each Well Likely Drilled to Refusal on Bedrock.

VDH records present design pump flow capacities of 1.0 MGD for each well.

2.3.3 VDEQ Groundwater Characterization and Water Withdrawal Permitting Programs

The portion of the Henrico County situated east of Interstate I-95 is located within the Eastern Groundwater Management Area of Virginia which regulates well yields of 300,000 gallon per month or greater through the VDEQ Water division (9VAC25-610-50). VDEQ maintains a well network system collaboratively with USGS that provides VDEQ groundwater level information within the Coastal Plain. The well network data is used for modeling associated with assessing groundwater withdrawal permit applications and aquifer water levels within groundwater management areas. The model contains critical cells where groundwater levels have been determined to be at risk of declining to unacceptable levels within each aquifer. Schnabel Engineering assessed VDEQ information for the modeled critical cells within the Potomac and Aquia aquifers within the vicinity of the existing County water supply wells. Information for the Piney Point aquifer is not supplied for reasons discussed in the previous Section 2.3.1. The shaded areas within **Figures 2.3 and 2.4** are the identified critical cells in the vicinity of the east end for the Potomac and Aquia aquifers, respectively.

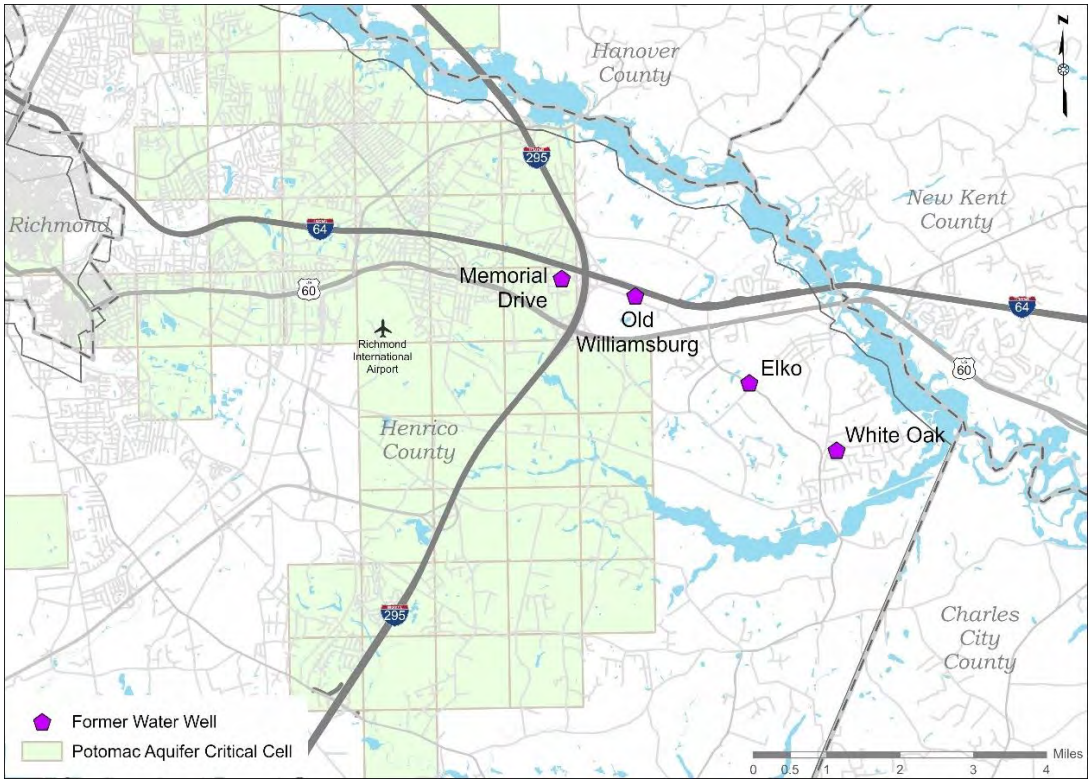

Figure 2.3: Potomac Aquifer Critical Cells

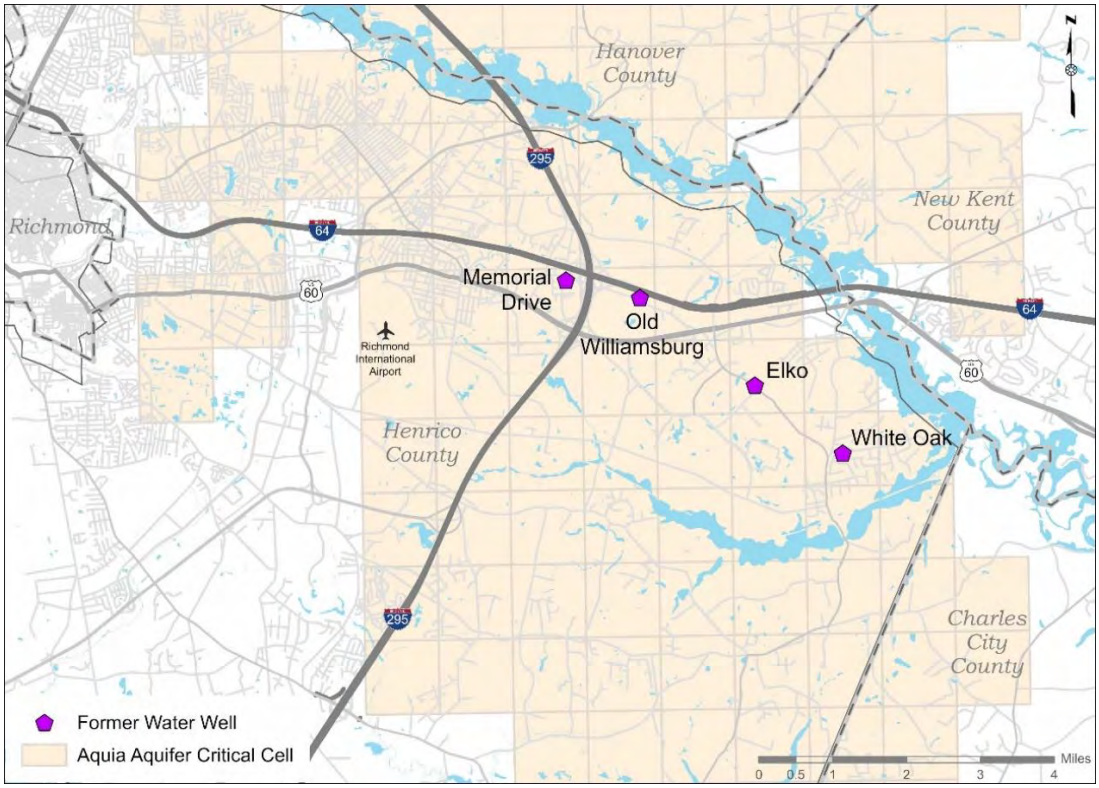

Figure 2.4: Aquia Aquifer Critical Cells

VDEQ critical cells exist for each of two semi-confined aquifers in the vicinity of the existing water supply wells. The VDEQ Water Withdrawal Program indicates VDEQ groundwater withdrawal permits have not been issued for the four remaining County PWS wells. Given the heavy occurrence of aquifer critical cells in the vicinity of the existing wells and within the eastern part of the County, it will be very challenging to obtain a VDEQ Water Withdrawal Permit for the volumes of groundwater that the County's existing wells are currently capable of pumping.

Regarding emergency use of the current wells, since there is no existing VDEQ groundwater withdrawal permits, each well is limited to a withdrawal of 300,000 gallons/month (9VAC25-610-50) or 1,200,000 gallons/month (0.04 MGD) for all four wells. Under current permit conditions, the existing wells appear to have an insignificant long-term use for the County without extensive permit modifications.

2.3.4 VDEQ Groundwater Withdrawal Permitting Modifications

If the County decides to further explore permitting its existing wells for actual beneficial use closer to their current withdrawal capacity, a preapplication meeting should be held with the VDEQ Office of Water Permitting incorporating VDH Richmond District Field Office or VDH Central Office to discuss proposed County plans, review of existing permits, projected groundwater supply needs and additional permitting requirements. If following the VDEQ meeting the County intends to continue well-use evaluation, a groundwater well location and permitting feasibility study would likely be required. The study will incorporate groundwater modeling using simulated pumping rates to identify projected impacts of new and existing wells on existing critical cells. The study will provide evaluation of existing well construction details related to current VDH and VDEQ permitting requirements and include water quality sampling of existing wells. The feasibility study would also identify those specific areas within the eastern section of the County which may be favorable for new groundwater supply development and establish what quantities are feasible for permitting from targeted well sites.

2.3.5 Well System Water Quality

In addition to required permitting for groundwater withdrawals with VDEQ, all water quality regulations would need to be addressed with VDH for the wells to be used as a drinking water source WRA verified with VDH that all wells would need to be completely retested for water quality before bringing each on-line and that disinfection modifications would be required to change the disinfection process at each well from the existing chorine disinfection to the use of chloramines to match the City/County supply disinfection method.

While the County has recently performed bacteria testing and had acceptable results, recent complete water quality data is not available for the County's existing wells. If the use of well water is to be further explored, initial steps in potentially bringing these wells on-line should include the following water quality sampling to assess feasibility and treatment requirements:

1. Bacteriological Sampling - Samples should be analyzed by a Most Probable Number (MPN) method for total coliform bacteria and E. coli.
2. Chemical, Physical and Radiological Sampling
   - Samples should be collected and tested for inorganic chemicals, organic chemicals (including VOC and SOC), physical, and radiological contaminants listed in Tables 340.1 through 340.4 of 12VAC5-590-340.
3. PFAS Sampling
   - All sample collection and testing should be in accordance with EPA Method 533: *Determination of Per- and Polyfluoroalkyl Substances in Drinking Water by Isotope Dilution Anion Exchange Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry*, latest revision.
   - PFAS samples should also be analyzed using EPA Method 537.1 to include all PFAS compounds included in the UCMR 5 list.
4. A sample should be tested for Total Organic Carbon

3 Water Outage

3.1 Systems Operation during the Water Outage

The HCDPU provided data from their Supervisory Control and Data Acquisition (SCADA) system from just prior to the water outage (January 5) through January 12. **Figures 3.1, 3.2, and 3.3** illustrate pump station flow and water tank elevations for key infrastructure impacting the study area from pressure zones GHM, LAZ and GEU, respectively. From these figures, the following observations can be made:

3.1.1 West End Pressure Zones

This report focuses on the loss of water in the east end of the County that affected both LAZ and GEU pressure zones. It should be noted that during the water outage, the County was able to make changes to pressure zones in the west end, which are primarily supplied by the City to prevent loss of water in these zones. The County opened boundary valves to feed RRD and WBD from the adjacent County pressure zones and closed their City connections. Three Chopt WPS operation was modified to supply Three Chopt High (TCH) pressure zone from TCC. These modifications were made and resulted in minimal interruption of service to the west end. These modifications were effective largely due to the vicinity of the west end to the County's WTF.

3.1.2 GHM Pressure Zone

The primary components graphed on **Figure 3.1** include GHM Flow (blue), which is the total combined flow from Peyton PRV and Mountain Road WPS, and the system pressure on the discharge side of the Peyton PRV (red).

The Peyton PRV is the main feed for GHM, coming from the adjoining Three Chopt Central (TCC) pressure zone. The Mountain Road WPS is a booster pump station in GHM.

As indicated on **Figure 3.1**, Peyton PRV provided consistent system pressure to GHM during the water outage. GHM resumed normal operation during the water outage with the exception of increased flow to supply LAZ as mentioned in Section 3.1.3.

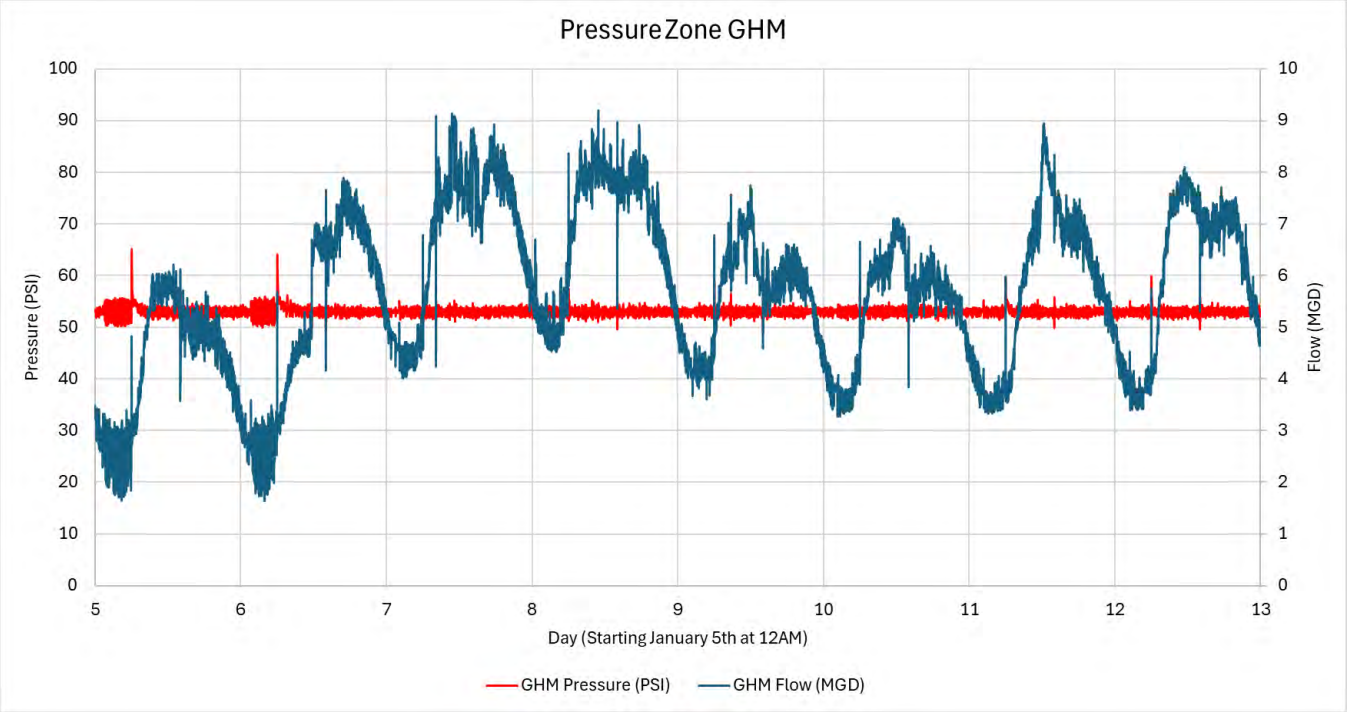

Figure 3.1: Pressure Zone GHM response during water outage

3.1.3 LAZ Pressure Zone

The LAPS is a major pump station within the LAZ pressure zone that impacts flows to the LAZ and the downstream GEU pressure zone. As noted previously, the LAPS serves three functions in the water system: to serve as an in-zone booster pump station to LAZ; as a pumping station to supply water to GEU; and as a gravity feed to supply water to GEU via a PRV.

The primary components graphed on **Figure 3.2** include the pressure on the suction side of the LAZ (red), the pumped flow coming from the LAPS (purple), the LAPS tank levels (green), and the gravity flow to GEU (blue). The disruption of water service is shown in **Figure 3.2,** as evidenced by a significant pressure drop in LAZ at the LAPS on January 6. Beginning on January 6, the County worked to increase flow to LAZ from GHM to supply LAZ through the Wilkinson PRV and by opening a zone boundary valve at Brook Road and I-95. LAZ system pressures did not return as expected. The County then took pressure readings around the LAZ. These results indicated that flow was back feeding from the County's system into the City's system. The County continued to work to isolate LAZ from the City and was successful on January 8 to restore partial pressure to LAZ. After the City service was reestablished on January 10, and water service was restored to both the LAZ and GHM pressure zones, the LAPS ground tanks were refilled.

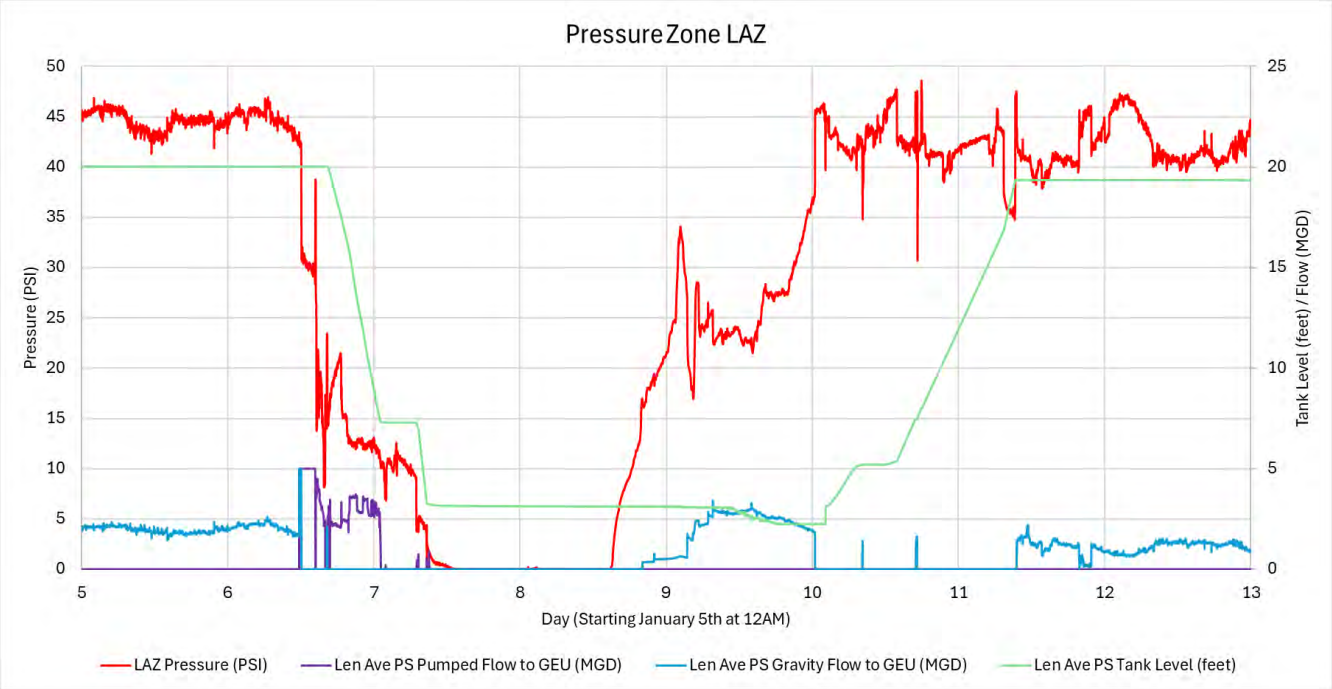

Figure 3.2: Pressure Zone LAZ response during water outage

3.1.4 GEU Pressure Zone

The primary components graphed on **Figure 3.3** include the following:

- The supply rate from the main City feed into GEU (orange) at the Shurm pressure reducing station.
- The GEU pressure (red) from the discharge side of the Shurm pressure reducing station.
- Tank elevations at the elevated Eubank storage tank (dark blue), which is the primary tank in the GEU zone.
- Tank elevations for the ground level storage tanks at the Robin (light blue) and Elko (green) booster pump stations.

On **Figure 3.3**, the extended disruption of water service from January 6 – January 8 is shown by the disappearance of flow and pressure from the Shurm pressure reducing station. With no flow from the City, the only supply was from the tanks in the system. After the water outage from Shurm ended on the evening of January 9 and the City was able to provide flow through the Shurm PRV, all water storage tanks refilled, and water service stabilized for the entire GEU zone.

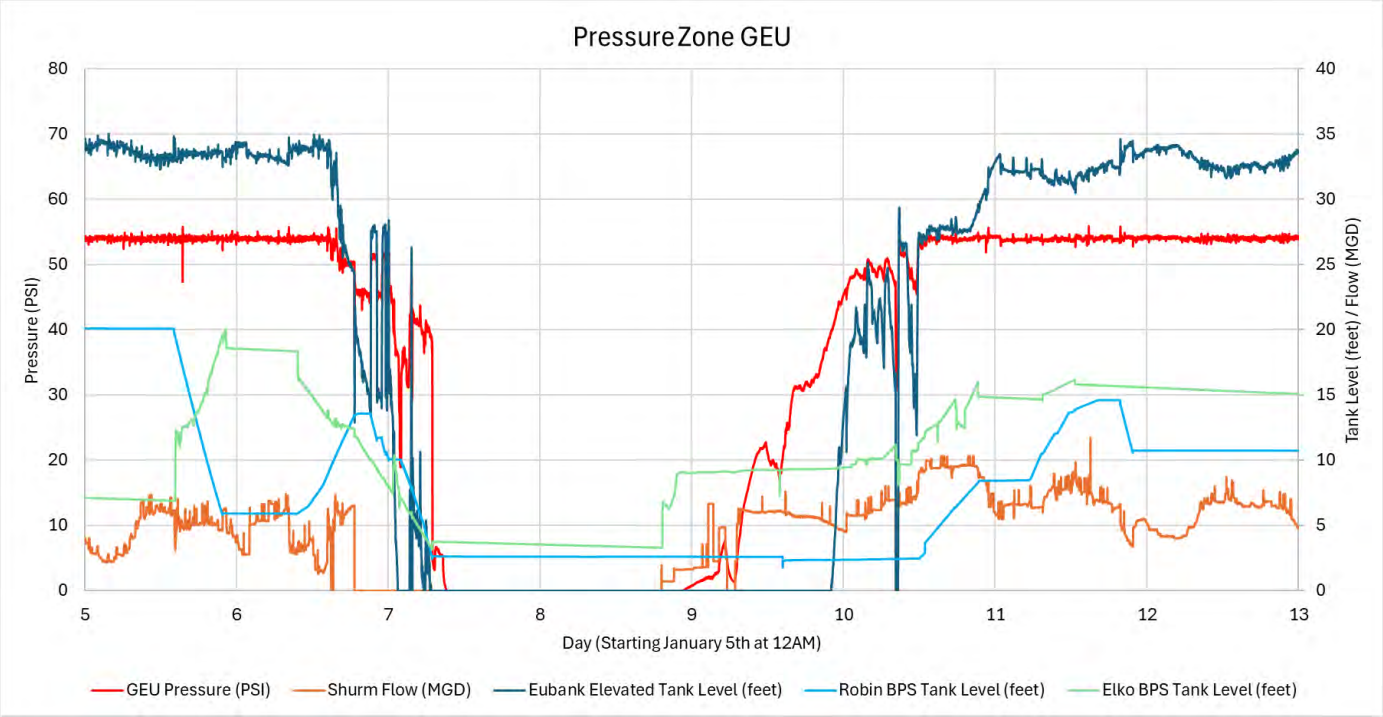

Figure 3.3: Pressure Zone GEU response during water outage

3.1.5 Valving Operations

During the water outage, WRA performed hydraulic modeling to assist the County in determining operational changes that could be made by opening/closing valves to increase water supplies to LAZ and GEU. Under normal system operations, the Wilkinson PRV's smaller PRV routinely opens to maintain water quality and the larger PRV is closed until pressures in LAZ drop below the set point. The I-95 at Brook Road Valve is normally closed. Using the hydraulic model, it was determined that if City supplies are shut off, the Wilkinson PRVs and open I-95 @ Brook Road Valve connection can supply the existing average day demand to LAZ. However, due to pressure losses in the system, there is no available excess flow to send to the GEU zone. This is consistent with the observations made by the County during the water outage. Subsequent to the water outage, WRA completed additional modeling in an attempt to further optimize the existing system under water outage conditions. There were no other valving operations identified that could have aided in increasing flow to the east end.

3.1.6 Summary of Existing System Operations and Restrictions

Based on existing agreements for water supply from the City, under normal operating conditions, the County-owned water infrastructure is not designed to supply water to pressure zones LAZ and GEU directly from the HWTF. During the water outage, the County attempted to operate the system to minimize supply issues to these pressure zones. However, the current transmission mains within the system are not adequately sized to convey the required supply rates without excessive energy loss occurring in the system. These increased energy losses decreased the system pressure and prevented the adequate transmission of water from the west side of the County's system to the east end. See **Figure 3.4** for the final restrictions identified during the water outage.

In summary, there are capacity restrictions between GHM and LAZ pressure zones and LAZ and GEU pressure zones. These connections limit flows into LAZ to 3.1 MGD. The LAPS is the primary restriction from LAZ to GEU on a normal operating basis. However, during the water outage, the suction side piping restrictions were ultimately the limiting factor for conveying water from the west to the east.

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Figure 3.4
Final Modeled Restrictions from Pressure Zone GHM to LAZ to GEU

Mountain Road WPS

Mountain Road Tank

GHM

Peyton PRS

Wilkinson PRV (Open)
Avg. Flow: 1.4 MGD
2.0 MGD Restriction

TCC

Brook Road at I-95 Valve (Open)
Avg. Flow: 0.8 MGD
1.1 MGD Restriction

LAZ

WBD

Len Avenue WPS (5 MGD Restriction)

Len Avenue Tank #1

Len Avenue Tank #2

GEU

Monument &
Bevridge PRV

Robin Avenue WPS

Robin Avenue Tank

Shurm
PRS

Eubank Tank EST

N
W
E
S

Legend

- Tanks
- Water Pumping Stations
- Pressure Reducing Stations
- Pressure Reducing Valves
- Closed Valves

Water Pipes
Diameter
- 0 - 8
- 8 - 12
- 12- 16
- 16 - 20
- 20 - 24
- 24- 30
- 30 - 54
- Pressure Zone Boundary

WRA

0 2,000 4,000 8,000 Feet

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4 East End Water Supply Review

4.1 Demand Projections

In performing the east end water supply review, the first step is to develop the anticipated demand projections for the east end. The following documents were reviewed in establishing the demand projections to be used for this analysis:

- 2007 Facilities Plan
- 2016 East End Supply Study
- 2023 Portugee Pump Station Evaluation
- Current Facilities Plan (in progress)

From reviewing the above documents, the following **Table 4.1** provides a summary of the demand projections used in this study:

Table 4.1: Summary of Demand Projections

Service Level	Demand Condition	Pressure Zone LAZ	Pressure Zone GEU
Short-term	Existing ADD	2.2 MGD	6.8 MGD
Mid-term	Replacement of existing City Shurm connection	5 MGD	21 MGD
Long-term	Future MDD	10 MGD	40 MGD

The rationale for the various levels of service for both the LAZ and GEU pressure zones are discussed below:

- Short-Term: Service will be analyzed assuming existing Average Daily Demands (ADD) are required to be met. This service level is intended to reflect providing a minimum level of service to the east end during an emergency condition under normal (average) day demands
- Mid-Term: The target mid-term 21 MGD supply value was selected to represent replacing supply from the main City connection into the GEU pressure zone, which is known as the “Shurm connection”
- Long-Term: Service will be analyzed assuming future Maximum Day Demands (MDD) for long-term service to all pressure zones. These demands include an allowance for planned growth within the GEU

4.2 Hydraulic Modeling

The County’s existing hydraulic model is in InfoWater Pro. The model is from the current Facilities Plan and was recently calibrated in 2024 and verified with County SCADA data. The model was used for all hydraulic analysis performed in reviewing improvement options for this project. All options reviewed are to increase County water supply to the LAZ and GEU, primarily served by the City, without impacting supply or pressures in other parts of the County system. Identification of additional smaller distribution or storage projects needed to distribute water from the proposed transmission mains to the surrounding water system was not performed. In all model runs, the City’s water supply was offline to GHM, LAZ and GEU. All short-term, mid-term and long-term options require the valving operations discussed in section 3.2.4, where the valves from the City are closed. When the valves between GHM and LAZ are opened, the LAZ and GHM pressure zones become combined at the hydraulic grade line of GHM.

4.3 Supply Options

The following sections provide a discussion of short-term, mid-term and long-term options that have been identified for potentially increasing the supply to the east end of the County's system. These options largely center on modifications to the County's existing transmission system, well system, or a combination of the two.

4.3.1 Cost Estimates

Cost estimates performed for all options are rough order of magnitude (ROM) costs, based on the best available information and engineering judgement for the anticipated scope of the project. All costs are intended to include total project costs (typical engineering, County administration, construction administration/inspection, easements, etc.), with a 30% contingency added to the total project cost due to project unknowns. All pipeline costs were developed based on planning level numbers scaled by pipe diameter as developed by WRA for previous capital improvement projects in the region, with a review of recent bids for comparative data and incorporation of current budget pricing from pipe manufacturers. Cost estimates for all options do not include costs for localized distribution piping, system storage improvements or capacity upgrades at the HWTF that may be required in conjunction with future growth in the system.

4.3.2 Project Timelines

Planning level project timelines are also provided. Timelines for pump station and well improvements are typically more definable as compared to water transmission main improvements. For all transmission main projects, a formal alignment study will be required to identify the most optimum alignment based on installation conditions, costs, and easements and permitting requirements. Given the installation length and required transmission main sizes, phased construction will likely be necessary along with significant easement acquisition, both of which will impact the overall project timeline.

4.4 Short-Term Options

The following are modifications that can be made to the existing system to increase supply to the east end to meet short-term demand, which has been defined as the existing ADD for the east end.

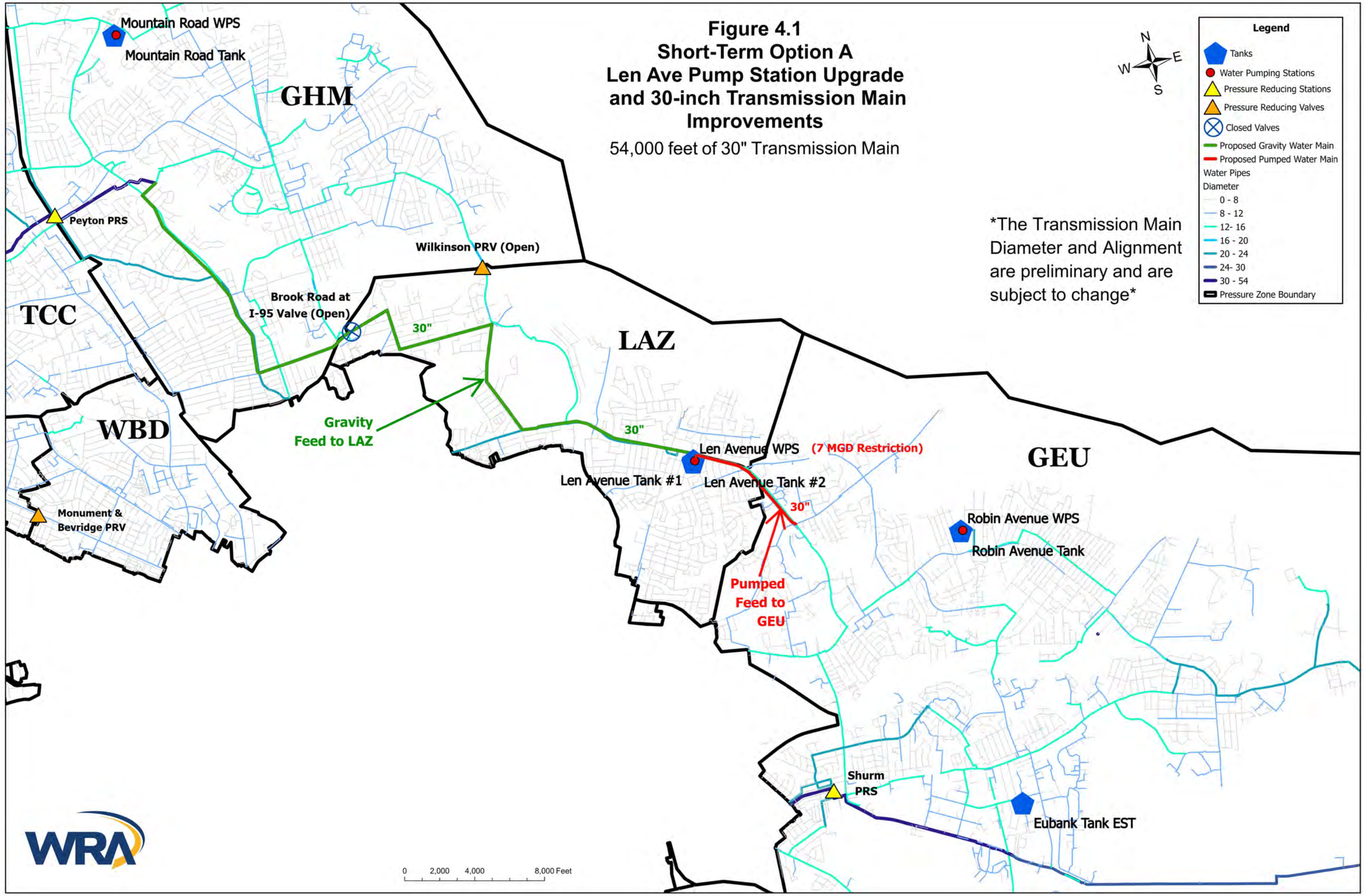
4.4.1 Short-Term Option A: Pump Station and Pipeline Improvements

Short-term Option A includes upgrades to the LAPS and transmission main improvements. The existing pump curves for the LAPS were reviewed and a site visit was completed. From the pump curve information, the LAPS can be upgraded from its current 2.8 MGD capacity/pump to approximately 3.5 MGD capacity per pump by replacing the existing pump impellers with the largest impellers available for the current pumps. While installing completely new pumps will not be required, the larger impellers will increase the electrical load to the pumps and require electrical upgrades including new variable frequency drives (VFDs) and a new generator. These upgrades would increase the LAPS capacity to approximately 7 MGD (with two pumps operating), which would meet the average day demand requirements of GEU.

In addition to pump station upgrades, piping improvements are required on both the suction and discharge sides of the LAPS to reduce friction losses in the system to allow the LAPS to operate at 7 MGD. As shown on **Figure 4.1**, transmission line upgrades are required from both the end of the 48-inch transmission main in GHM to LAPS and from the LAPS to the intersection of Creighton Road/North Laburnum Ave. These sections will require a combined total of approximately 54,000 linear feet (lf) of 30-inch Transmission Main.

Figure 4.1
Short-Term Option A
Len Ave Pump Station Upgrade and 30-inch Transmission Main Improvements

54,000 feet of 30" Transmission Main



The Transmission Main Diameter and Alignment are preliminary and are subject to change

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4.4.1.1 Short-Term Option A Costs and Implementation Timeline

Option A could be implemented in 5-6 years at an estimated cost of $117 million based on the following **Table 4.2**.

Table 4.2: Summary of Short-term Option A Costs

Item	Unit	Total Units	Unit Cost	Total Cost
30-inch Transmission Main	LF	54,000	$1,600	$86,400,000
Len Ave WPS Upgrade	LS	1	$3,000,000	$3,000,000
			Sub-total	$89,400,000
			30% Contingency	$26,820,000
			Total (Rounded)	**$117,000,000**

The LAPS improvements are inclusive of impeller, variable frequency drive (VFD) and Generator upgrades. The critical path for Short-term Option A would be the planning, design, and construction of the transmission main. **Figure 4.1** indicates conceptual level transmission main alignments.

4.4.1.2 Short-Term Option A Benefits and Challenges

One benefit of this option is the County would have a backup source for the City's water supply to meet the average day demands of LAZ and GEU. Another benefit is that this option allows the County to eliminate the use of many City connection points to LAZ thus reducing exposure to events such as this water outage. In addition, this transmission main would establish a third connection between GHM and LAZ, enhancing system redundancy and service reliability. A disadvantage of this option is the County would still be unable to supply current GEU maximum day demands in the high demand summer months without the existing City connections. Also, two LAPS duty pumps would have to run nonstop to supply the average day demand, so fully supplying GEU would be for emergency situations only. Under normal operation, short-term Option A would supply LAZ and GEU with partial of the LAPS upgrade capacity to turn over water in the transmission main and prevent water quality issues.

4.4.2 Short-term Option B: Well Rehab and Treatment Upgrades

As noted previously, the County currently owns four (4) well systems in the east end, with a combined estimated pumping capacity of 2,800 gpm (4 MGD) per VDH records. If the existing wells were rehabbed and brought back on-line, the targeted short-term supply of 7 MGD could not be obtained. However, the 4 MGD capacity would be a significant benefit to providing limited water supply, which would likely require water restrictions if implemented in an emergency case.

In addition to existing County well supplies, the County requested that other water purveyors in the area be contacted regarding potential water sources for the County. Specifically, WRA contacted Diamond Springs Inc., which is a bulk water supplier in the region. Based on discussions with Diamond Springs, all water is sourced and treated from a spring. The potential volumes that could be supplied from Diamond Springs are not significant in comparison to the required volumes being reviewed for this report.

4.4.2.1 Short-Term Option B Costs and Implementation Timeline

Short-term Option B could be implemented in approximately 3-4 years at a cost of $20 million for Well Rehabilitation, Filtration and Heavy Treatment under the following assumptions:

- Treatment upgrades will be required at individual wells
- Reactivate existing treatment: chlorination, phosphate (corrosion inhibitor) and fluoride
- Additional treatment to include new well pumps, GAC contactors, chloramination

- Additional upgrades are required including well pumps, well rehabilitation, Granular Activated Carbon Filtration (GAC), Chemical System Upgrades, and electrical and instrumentation
- Groundwater appropriations permit is granted

4.4.2.2 Short-Term Option B Benefits and Drawbacks

Short-term Option B is the most cost effective and shortest timeframe to implement. The existing wells are in the location of the future Technology Pressure Zone that has an existing average day demand of 2.4 MGD and a maximum day demand of 3.7 MGD as stated in the Portugee Road Water Booster Pump Station Study. Even if not used for a long-term solution for the entire GEU pressure zone, the wells could be isolated from the GEU pressure zone to supply an area such as the Technology Pressure Zone that is within their capacity. The largest drawback is the uncertainty as to if a groundwater appropriations permit could be obtained from DEQ. All potential water quality issues with VDH would also need to be reviewed and addressed.

4.5 Mid-Term Options

The stated goal of all mid-term options is to provide 5 MGD supply to LAZ and 21 MGD supply as required to replace the main City Shurm connection into the GEU pressure zone.

4.5.1 Mid-Term Option A: 48-inch Transmission Main

Mid-term Option A consists of the construction of approximately 70,000 lf of 48-inch water transmission main. This main will extend from the end of the 48-inch transmission main in GHM to the existing 36-inch transmission main near Eubank elevated tank as indicated on **Figure 4.2.** This extension will benefit both the GHM and LAZ pressure zones, increasing the supply to LAZ to 5 MGD and 21 MGD to GEU by gravity. This project is in the County's current facilities plan.

4.5.1.1 Mid-Term Option A Costs and Implementation Timeline

It is estimated that Mid-term Option A could be implemented in 5-7 years at a cost of $328 million as outlined in the following **Table 4.3**. The previous **Figure 4.2** indicates conceptual transmission main alignments.

Table 4.3: Summary of Mid-term Option A Costs

Item	Unit	Total Units	Unit Cost	Total Cost
48-inch Transmission Main	LF	70,000	$3,600	$252,000,000
			Sub Total	$252,000,000
			30% Contingency	$75,600,000
			Total (Rounded)	**$328,000,000**

4.5.1.2 Mid-Term Option A Benefits and Drawbacks

One benefit of this option is a fully redundant source to the Shurm PRV is provided. Likewise, this option, when combined with the capacity of Shurm PRV, meets GEU's long-term demand of 40 MGD. Also, LAZ and GEU are supplied by gravity which reduces the complexity of the operation by not having a pump station to maintain and operate. Another benefit is that this option allows the County to eliminate the use of many if not all of the City connection points to LAZ, thus reducing exposure to events such as this water outage. One potential negative is regarding potential water quality issues. The lengthy 48-inch transmission main conveyance holds a large volume of water. Under low flow conditions, there may be issues with turning over the water in the pipe, creating water quality issues within the system.

Figure 4.2
Mid-Term Option A
48-inch Transmission Main Improvements

70,000 feet of 48" Transmission Main

This alternative is in lieu of Short Term Capacity Upgrade of 30" Transmission Main and Len Ave. Pump Station Upgrade

The Transmission Main Diameter and Alignment are preliminary and are subject to change

Legend
- Tanks
- Water Pumping Stations
- Pressure Reducing Stations
- Pressure Reducing Valves
- Closed Valves
- Proposed Gravity Water Main

Water Pipes
Diameter
- 0 - 8
- 8 - 12
- 12- 16
- 16 - 20
- 20 - 24
- 24- 30
- 30 - 54
- Pressure Zone Boundary

N E S W

Mountain Road WPS
Mountain Road Tank
GHM
Peyton PRS
48"
Brook Road at I-95 Valve (Open)
Wilkinson PRV (Open)
TCC
LAZ
Gravity Feed to LAZ and GEU
48"
WBD
Len Avenue WPS
Len Avenue Tank #1
Len Avenue Tank #2
GEU
Robin Avenue WPS
Robin Avenue Tank
Monument & Bevridge PRV
48"
Shurm PRS
Eubank Tank EST

0 2,000 4,000 8,000 Feet

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4.5.2 Mid-Term Option B: Additional Wells with Treatment

Mid-term Option B would consist of the following three components:

- Complete well-rehab and treatment modifications as required by Short-term Alternative B.
- Permit and construct additional groundwater wells for an additional 5 MGD of groundwater supply.
- Construct a 42-inch transmission main similar to Mid-Term Option B.

These combined improvements would result in a 21 MGD supply to GEU. However, given the uncertainty of obtaining a groundwater appropriations permit for the County's existing wells, the likelihood of obtaining even higher withdrawal rates from existing wells or establishing new wells of significant capacity does not appear feasible. Therefore, this alternative was removed from additional discussion.

4.6 Long-Term Options

The stated goal of all long-term options is to provide 10 MGD supply to LAZ and 40 MGD supply as required to the GEU pressure zone.

4.6.1 Long-Term Option A: Transmission Main and Pump Station

Long-term Option A consists of the construction of approximately 70,000 lf of 48-inch and 37,000 lf of 42-inch water transmission mains. The 48-inch main will be extended from the end of the 48-inch transmission main in GHM to the existing 36-inch transmission main in Charles City Road near Eubank elevated tank and will be accompanied with a new 40 MGD pump station and ground storage tank to allow the full capacity of the 48-inch main to be utilized. The 42-inch main will extend from the end of the 48-inch transmission main in GHM to the 24-inch transmission main in LAZ to feed LAZ by gravity. The transmission mains are depicted on **Figure 4.3.**

These transmission mains will benefit both the GHM and LAZ pressure zones, increasing the supply to LAZ to 10 MGD and 40 MGD to GEU.

4.6.1.1 Long-Term Option A Costs and Implementation Timeline

It is estimated that Long-term Option A could be implemented in 6-8 years at a cost of $583 million as outlined in the following **Table 4.4**.

Table 4.4: Summary of Long-term Option A Costs

Item	Unit	Total Units	Unit Cost	Total Cost
48-inch Transmission Main	LF	70,000	$3,600	$252,000,000
40 MGD Pump Station and Ground Tank	LS	1	$100,000,000	$100,000,000
42-inch Transmission Main	LF	37,000	$2,600	$96,200,000
			Sub Total	$448,200,000
			30% Contingency	$134,460,000
			Total (Rounded)	**$583,000,000**

This timeline covers the planning, design, and construction of the transmission mains and new pump station. **Figure 4-3** indicates conceptual level transmission main alignments.

4.6.1.2 Long-Term Option A Benefits and Drawbacks

One benefit of this option is a source of water is provided to GEU when Shurm PRV's capacity is exceeded. This Option is comprised of the 48-inch transmission main in Mid-Term Option A and if the transmission main in Short-

Term Option A is upsized to a 42-inch main, a large portion of the 42-inch transmission main can supply LAZ's long-term demand from GHM by gravity. A 42-inch gravity transmission main from GHM to LAZ provides more flexibility for where the future pump station can be located and limits the pumped transmission main to 48-inches. Another benefit is that this option allows the County to eliminate the use of many if not all of the City connection points to LAZ thus reducing exposure to events such as this water outage. A drawback of this option is under low flow conditions, there may be issues with turning over the water in the large pipes, creating water quality issues. The combined long-term demand of 50 MGD to LAZ and GEU will require the HWTF to upgrade its capacity. Any HWTF costs are not included in the cost estimate listed above.

4.6.2 Long-Term Option B: New Regional Water Treatment Facility and Transmission Main

Long-term Option B would involve constructing a completely new water treatment facility independent of the County's existing WTF, which would provide dedicated service to the GEU. One significant issue for the new WTF on the eastern end of the County is the absence of an obvious water intake to a readily available water supply. Both the City and County have wastewater reclamation facilities with discharge pipes into the James River located approximately 1 mile apart along the James River in the vicinity of GEU. As such, there does not appear to be a location along the James River where a water intake could be sited due to geographical limitations associated with the water reclamation plant discharge locations.

Other options could be explored such as constructing a WTF with an intake into an alternate water source such as the Pamunkey River. Due to its location and likely cost, it would appear reasonable that the WTF would provide supply for regional partners outside of the County. There are however limitations to an intake such as potential volume limitations or salinity impacts that would require significant reviews to determine project feasibility.

4.6.2.1 Long-Term Option B Costs and Implementation Timeline

The development of a source water as well as the construction of a new WTF would be an extended process, with implementation periods exceeding 10 years. The costs of the required facilities would also be significant and have been estimated for discussion purposes at $1.29 billion as outlined in the following **Table 4.5,** under the assumption that 10 miles of major transmission main would be required.

Table 4.5: Summary of Long-term Option B Costs

Item	Unit	Total Units	Unit Cost	Total Cost
Henrico County to be supplied 40 MGD from Regional WTP	LS	1	$800,000,000	$800,000,000
48-inch Transmission Main*	LF	53,000	$3,600	$190,800,000
42-inch Transmission Main**	LF	37,000	$2,600	$77,394,240
			Sub Total	$990,800,000
			30% Contingency	$297,240,000
			Total (Rounded)	**$1,289,000,000**

*Feed to GEU from new water treatment facility
**Feed to LAZ from GHM

Figure 4.3
Long-Term Option A
New 40 MGD Pump Station and 42-inch and 48-inch Transmission Main Improvements

Gravity Feed to LAZ
37,000 feet of 42" Transmission Main

Pumped Feed to GEU
70,000 of 48" Transmission Main and
New 40 MGD Pump Station

The Transmission Main Diameter and Alignment are preliminary and are subject to change

Legend
- Tanks
- Water Pumping Stations
- Pressure Reducing Stations
- Pressure Reducing Valves
- Closed Valves
- Proposed Gravity Water Main
- Proposed Pumped Water Main

Water Pipes
Diameter
- 0 - 8
- 8 - 12
- 12- 16
- 16 - 20
- 20 - 24
- 24- 30
- 30 - 54
- Pressure Zone Boundary

N E S W

Mountain Road WPS
Mountain Road Tank
GHM
Pumped Feed to GEU
48"
Peyton PRS
42"
Brook Road at I-95 Valve (Open)
Wilkinson PRV (Open)
TCC
LAZ
WBD
Gravity Feed to LAZ
42"
Len Avenue WPS
Len Avenue Tank #1
Len Avenue Tank #2
GEU
Monument & Bevridge PRV
Robin Avenue WPS
Robin Avenue Tank
48"
Shurm PRS
Eubank Tank EST

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4.6.2.2 Long-Term Option B Benefits and Drawbacks

The primary benefit of Long-Term Option B is the County would presumably have access to a different water supply than the James River. However, the required costs and uncertainty as to if the supply for the project can be permitted are significant drawbacks to this option.

4.6.3 Summary of Options

The following **Table 4.6** provides a summary of the short-term, mid-term, and long-term supply options reviewed for this study. In addition to these options, as part of a long-term phased approach, additional analysis could be performed to meet long range planning objectives of the County that evaluate other sources of water supply. Other sources may include but are not limited to quarry conversions, pumped storage reservoirs, surface water withdrawal, deep wells into bedrock, and Aquifer Storage Recovery (ASR – aka aquifer injection). The purpose of this study was not to come to a final recommendation as to how to proceed. Rather the goal of this project was to review the impacts of the water outage on Henrico's existing system and outline potential options for future additional review.

Table 4.6: Summary of East End Supply Options			
Option	Total Cost	Benefits	Challenges
Short Term Option A 54,000 LF 30-inch Transmission Main Len Ave WPS Upgrade Result: 7 MGD to GEU (ADD) Timeline: 5-6 years	**$117 M**	*Provides redundant supply for GEU existing ADD *Existing LAPS can be modified for the increased flow which is significantly cheaper than a new WPS *Reliability and system redundancy improved to LAZ with third connection to GHM *No supply/treatment permit modifications are required * Allows the County to eliminate the use of many of the City connection points to LAZ thus reducing exposure to events such as this water outage.	*Option requires City supply to meet maximum day demand in summer months *To meet the upgraded demand of 7 MGD, LAPS pumps are required to run continuously which is not recommended for a long duration
Short Term Option B Well Rehab and Heavy Treatment Result: 4 MGD to GEU Timeline: 3-4 years	**$20 M**	*Most cost effective option *Potentially shortest time to implement *Potential long-term service dedicated to a portion of GEU	*New groundwater appropriations permit required, with feasibility currently unknown *Does not meet short-term supply goal
Mid Term Option A 70, 000 LF 48-inch Transmission Main Result: 21 MGD to GEU (Replace City Shurm Conn.) Timeline: 5-7 years	**$328 M**	*Provides full redundancy to existing City Shurm connection supply *Reliability and system redundancy improved to LAZ with third connection to GHM *Long-term service dedicated to LAZ and GEU *Combined with the capacity of Shurm connection, this option meets GEU's long term demand of 40 MGD (Shurm connection capacity is exceeded) *No supply/treatment permit modifications are required * Allows the County to eliminate the use of many if not all of the City connection points to LAZ thus reducing exposure to events such as this water outage.	* Potential water quality issues for new transmission main

Table 4.6: Summary of East End Supply Options (Continued)			
Option	Total Cost	Benefits	Challenges
Long Term Option A 70,000 LF 48-inch Transmission Main 40 MGD Pump Station and Ground Tank 37,000 LF 42-inch Transmission Main Result: 40 MGD to GEU Timeline: 6-8 years	**$583 M**	*Provides full supply of Long-term Demand, with no City flow *Long-term service dedicated to LAZ and GEU *Flexibility is provided in where to site new WPS and ground storage tanks with gravity feed to LAZ *Reliability and system redundancy improved to LAZ with third connection to GHM *Can be phased with Mid-Term Option A and Short-Term Option A (if upsized) *No supply/treatment permit modifications are required. * Allows the County to eliminate the use of many if not all of the City connection points to LAZ thus reducing exposure to events such as this water outage.	* Potential water quality issues for new transmission main
Long Term Option B GEU to be supplied 40 MGD from Regional WTP 53,000 LF 48-inch Transmission Main 37,000 LF 42-inch Transmission Main Result: 40 MGD to GEU Timeline: 10+ years	**$1.289 B**	*Provides full supply of Long-term Demand, with no City flow * Alternate supply source to the James River provided * Allows the County to eliminate the use of many if not all of the City connection points to LAZ thus reducing exposure to events such as this water outage.	*New withdrawal permit from alternate water source required with current source unknown *Longest timeline *Highest cost option *Requires regional buy-in

5 Supply Review Study Summary

The primary scope items identified for WRA to complete for this study were as follows:

1. Data Gathering/Data Review – Obtain and review background information, mapping, engineering studies, and as-built drawings related to the project.
2. Gather documents to review the water outage's impacts to the County's system.
3. Review available options to address short-term, mid-term and long-term demand goals to increase water supply to east end.
4. Develop planning level costs and timelines for implementation of options.
5. Report Development – Develop a report to document and summarize the above scope items.

The County owned water system is not currently designed to supply water to the east end within the County system from the HWTF, as there are existing City water supply agreements in place through 2040 to supply water to these areas, and it is more economical to provide water to the eastern part of the County from the City.

Upon a review of available SCADA data, the existing system operated as anticipated during the recent Richmond water outage. During the water outage, system modifications were made in an attempt to minimize impacts on the existing system. However, periods of complete water loss were unavoidable given the extended duration of the City's supply outage.

During the water outage, the County considered using their existing well system, which contains an aggregate 4 MGD pumping capacity between four separate existing wells. However, VDH did not permit use of the wells due to differences in disinfection processes between the well system and the City/County supply. These existing wells are allowed as emergency use wells by the County's VDH waterworks operations permit. However, since the well system does not have a groundwater withdrawal permit from VDEQ, they are of limited use for the County even if disinfection modifications were to be made to make them compatible with the existing City/County supply system. Based on available information from VDEQ, obtaining a groundwater withdrawal permit for the existing wells may not be feasible.

WRA utilized the County's hydraulic water model to identify potential options to meet short-term, mid-term and long-term demand to obtain variable degrees of additional supply independent of the City's system. The purpose of this report was to provide high-level options for potential future implementation by the County. The following **Table 5.1** summarizes options that were reviewed:

Table 5.1: Summary of Additional Supply Options Reviewed

Option	Improvement Required	Planning Level Cost	Implementation Schedule
Short-term Option A	• 54,000 lf 30" TM • Upgrade of ex. LAPS	$117 M	5-6 Years
Short-term Option B	• Well permitting, rehabilitation and treatment	$20 M	3-4 Years
Mid-term Option A	• 70,000 lf 48" TM	$328 M	5-7 Years
Long-term Option A	• 107,000 lf of 42-48" TM • 40 MGD PS and ground storage	$583 M	6-8 Years
Long-term Option B	• New regional WTP and TMs	$1.289 B	10+ Years

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