Issue Analysis Form

Date: June 23, 2020
Item: Request to Start Design of Temple Avenue Tank &Booster Station, and Design of Waterline Extension to Route 10.

Lead Department: Engineering & Utilities

Contact Persons: Frank Haltom, Director

Description and Current Status

The Preliminary Engineering Report (PER) for the Temple Avenue tank and booster station was completed in April. The recommended project is a 1 million gallon water tank and 4 MGD water booster station to be located in the vicinity of the Temple Avenue and River Road intersection. This project will maximize the use of the ARWA transmission main to deliver 2 MGD to the Southpoint Business Park, a primary goal of the 2016 Master Plan. It will also decommission the existing booster station located near the Jefferson Avenue and Middle Road intersection. The total project is anticipated to cost $4,250,000.

The PER for the extension of the central water system to the Route 10 corridor was also completed in April. The recommended project is a 4.5 mile, 12" water line extension. It will begin at the current end of service on Sandy Ridge Road running east to Ruffin Road, then north to Route 10 and then connect to the existing water systems at Jordan on the James (JoJ) and Beechwood Manor (BM). This project will serve the existing customers of JoJ, BM and be available for future extension to Rivers Edge. This project will also be the backbone for future development along the Route 10 corridor. The well systems at JOJ and BM would be decommissioned after connecting to the central system, resulting in a future cost avoidance to replace these aged systems. The total project is anticipated to cost $3,280,000.

The Government Path

Does this require IDA action?	☐ Yes	☒ No
Does this require BZA action?	☐ Yes	☒ No
Does this require Planning Commission action?	☐ Yes	☒ No
Does this require Board of Supervisors action?	☒ Yes	☐ No

Board Action Requested:
Request permission to pursue the design of the water system expansion projects.

Fiscal Impact Statement

The appropriated budget within the Utility CIP fund will cover the design cost of these projects.

Prince George County Impact

None.

Notes

None.

WW Associates
Engineers
Surveyors
Planners

April 23, 2020

Mr. Frank Haltom, P.E.
Director of Engineering & Utilities
Prince George County
P.O. Box 68
Prince George, VA 23875

Re: Middle Road Pump Station Upgrade Evaluation

Dear Mr. Haltom:

This letter report will serve as a comprehensive evaluation of potential water system improvements in the Central Water System of Prince George County. Current conditions and forecasted increases in water demand indicate the need for upgrades to the Central Water System's infrastructure as the County prepares for future needs.

Background

System-wide hydraulic modeling in this report is based on recommendations discussed in several previous studies, which are summarized below:

- WW Associates, Inc. prepared a capital infrastructure needs assessment entitled *Capital Program Plan and Financial Analysis* for the Appomattox River Water Authority, dated December 2015. This study included a hydraulic analysis of the ARWA transmission main system and concluded that the Temple Avenue transmission main is properly sized to deliver the ARWA treatment plant allocations to both the City of Colonial Heights (at 4.13 MGD) and Prince George County (at 2.69 MGD). This analysis determined that ARWA can supply the allocation capacity, except during short summertime periods, and recommended a new booster pump station with additional storage along the Temple Avenue transmission main.

- A *Water and Wastewater Master Plan* for Prince George County dated January 2016 included an evaluation of water pressure in the Central Water System under a variety of conditions. This report identified a low-pressure zone along Temple

Avenue between the ARWA point of connection and the existing Middle Road Pump Station. The *Master Plan* explored short- and long-term water supply options, including strategies to maximize the ARWA connection with a new 3.0 MGD pump station along Temple Avenue.

- A Preliminary Engineering Report entitled "*Southpoint Business Park Utilities Evaluation*," dated July 2018, indicates that the County must prepare for water demands to increase along with development for industrial water consumers in the Southpoint Business Park. The PER states that the Business Park will require 2.0 MGD of maximum day water supply. This reports also states that average water use in the Central Water System in 2015 was 0.7 MGD, with a maximum day demand of approximately 1.0 MGD. Therefore, Prince George County must be prepared to meet a total demand of at least 3.0 MGD on peak flow days by fully utilizing its ARWA allocation and ensuring that all tanks are replenished during off-peak times.

  As a short-term measure, this PER recommended a new 3.0 MGD pump station, expandable to 9.0 MGD, with a 1.0 MG ground storage tank at the intersection of Temple Avenue and River Road. Upgrading a portion of the System's water lines from 12" to 16" diameter was advised in conjunction with the new pump station. The PER also addressed the need for long-term infrastructure improvements due to projected further growth in demand throughout the entire ARWA distribution network. It concluded that the most prudent long-term plan is for the County to provide its own water supply source by constructing a 4.0 MGD Water Treatment Plant and apply for a Virginia Water Protection Permit.

Purpose and Scope

The purpose of this report is to consider all previously-obtained water use and system flow data, along with new data derived from system-wide hydraulic modeling, to determine the infrastructure improvements that will be most beneficial to the County. Modeling will be conducted to identify the scenario with the best outcomes in terms of the following goals:

- To maximize the existing ARWA point of connection
- To bolster flows throughout the Central Water System
- To increase water pressure at locations vulnerable to low pressure

Analytical Methods

As previously noted, Prince George County's 2.69 MGD allocation from the Appomattox River Water Authority represents a treatment allocation, not a point-of-connection allocation. To predict flow conditions under each proposed improvement, the Central Water System's major infrastructure, including pumps, storage, water mains, and primary junctions, have been added as an extension to the hydraulic model of the Appomattox River Water Authority's transmission mains, created by WW Associates, Inc in Bentley WaterCAD format. This extended model was used to determine the suitability of proposed improvements and is displayed in Figure No. 1. The demands noted in Figure No. 1 represent peak day demands at locations throughout the System, each representing a cluster of residential, commercial, or industrial water users.

The primary goal of this analysis is to identify the best short-term strategy to maximize the use of the ARWA transmission main. Six different pumping and storage scenarios within the Central Water System were modeled. These scenarios are as follows:

Scenario 1: Existing infrastructure (to determine maximum flow available to the Southpoint area without upgrade)

Scenario 2: Upgraded pumps at the Middle Road Pump Station

Scenario 3: Upgraded pumps at the Middle Road Pump Station and a new ground storage tank located near the intersection of Temple Avenue and River Road

Scenario 4: A new pump station and ground storage tank located near the intersection of Temple Avenue and River Road

Scenario 5: A new pump station and tank as in Scenario 4, along with replacing a portion of the 12-inch diameter piping to the Southpoint area with new 16-inch piping

Scenario 6: A new 12-inch waterline linking the Central Water System to the Food Lion Water System, added to each of the above scenarios

Hydraulic system analysis has been conducted using both instantaneous-flow and 24-hour Extended Period Simulation water modeling. With this approach, the network can be analyzed with demands distributed throughout the System based on average and peak daily use.

Calculations within this model account for points of interconnection that establish beneficial loops in the System. This method can also provide insight into how pumping status at the ARWA Finished Water Pump Stations influences pressure in the distribution network in Prince George County. Assumptions made to construct this 24-hour model are as follows:

- Both pumping operations and system demands are assigned variable operating conditions under different circumstances. Up to five ARWA finished water pumps are operational at a given time, depending on demand and tank levels.
  - Up to three Finished Water Pump Station No. 1 pumps (16 MGD each)
    - One is programmed to turn on when system tanks begin to drain more than 3 feet below their overflow elevation.
    - Two follow a variable rate pumping schedule corresponding with average diurnal demands.
  - Up to two Finished Water Pump Station No. 2 pumps (23 MGD each)
    - Both are programmed to turn on when system tank levels drop as described.
  - Maximum instantaneous pumping rate = 94 MGD.

- Within Prince George County, the existing Middle Road Pump Station booster pumps and proposed River Road Pump Station booster pumps are also programmed into the model:
  - The existing Middle Road Pump station is programmed to pump up to 18 hours a day at a rate of 1.4 MGD, with active pumping during high-demand times and late at night to refill downstream tanks. Existing pumps are rated for 1.4 MGD at 135 ft TDH, and current conditions limit operation to one pump at a time.
  - The proposed River Road Pump Station in Scenarios 4 and 5 is programmed to pump at a rate of 4 MGD when the Southpoint Elevated Storage Tank drops below the determined threshold, with a pump curve selected for optimal performance at 220 ft TDH.

The three existing Central Water System elevated storage tanks have a nominal total volume of 0.5 MG each and an overflow elevation of approximately 285 ft. The proposed River Road ground storage tank referenced in Scenarios 3, 4, and 5 has a nominal total volume of 1.0 MG and an overflow elevation of 115 ft. The Food Lion ground storage

tank referenced in Scenario 6 has a nominal total volume of 1.0 MG and an overflow elevation of 203 ft.

All tanks are considered empty when they reach approximately half of their maximum volume; the model does not permit them to drain further.

Approximate future demands are distributed throughout the Central Water System as outlined in Table No.1. Diurnal demand follows a pattern based on typical early-morning and early-evening peaks. Commercial demand is characterized by a larger evening peak. Industrial demand models large spikes and decreases in demand throughout the day.

Table No. 1:

Location	**Type**	**Volume**	
Temple Ave	Commercial	0.3	MGD
Middle Rd	Diurnal	0.2	MGD
Courthouse area	Commercial	0.1	MGD
Courthouse area	Diurnal	0.1	MGD
Prince George High area	Diurnal	0.1	MGD
Southpoint Business Park	Industrial	2.0	MGD
460 Corridor	Diurnal	0.15	MGD
Baxter Road area	Diurnal	0.05	MGD
TOTAL		**3.0**	**MGD**

Results of Hydraulic Analyses

Scenario 1: Existing infrastructure with 1 MGD Demand in Southpoint Business Park

Instantaneous Hydraulic Analysis

As a result of the challenging hydraulic profile, the pressure required to fill the Southpoint Elevated Storage Tank with the current pump and piping configuration can be achieved only at flows significantly lower than the County's 2.69 MGD allocation.

This scenario models the results of gradually increasing demands in the Southpoint area to maximize the County's ARWA allocation using current infrastructure. This results in a maximum flow of 2.0 MGD into the County, with approximately 1.7 MGD pumped at the Middle Road Pump Station and 1.0 MGD reaching the Southpoint area at a hydraulic elevation of 282 ft. While these hydraulic conditions are suitable in the Southpoint area, the higher flow rate causes pressure to drop below 35 psi upstream of the pump station.

24-Hour Extended Period Simulation Water Modeling

Over the course of the 24-hour scenario, junctions along Temple Avenue experience low pressure events from 25-35 psi on a number of occasions.

Of the three elevated storage tanks with an approximately equal hydraulic grade line of 285 ft, two of them perform well in this scenario: the Middle Road tank drains to approximately 275 ft and the Courthouse tank to approximately 265 ft during peak demand, but both are completely refilled by the end of the simulation. However, the Southpoint tank drains to 260 ft and is only able to refill to 278 ft by the next day.

The highest instantaneous flow rates from the main ARWA connection point (exceeding 3.5 MGD) occur in the late-night and pre-dawn hours. While this accurately reflects the real-world practice of late-night tank filling, the tanks will not be able to completely refill unless the total flows into the County more consistently approach the 2.69 MGD allocation, allowing more stability in the system during peak hourly demands to prevent tanks from draining excessively.

Attempting to increase demands at Southpoint to 2.0 MGD (for a total demand of 3.0 MGD in the County) with the existing infrastructure generates multiple conflicts within the model, as the Middle Road Pumps cannot deliver the required flow on a number of occasions throughout the day.

Conclusion: 24-hour modeling indicates that flow rates cannot be substantially increased in the Southpoint Area without system upgrades.

Scenario 2: Upgrade the Middle Road Pump Station without a new tank

Instantaneous Hydraulic Analysis

This scenario assumes that new pumps are installed in the existing Middle Road Pump Station. Calculations are based on pumps rated for 2.7 MGD (1875 gpm) at 215 ft TDH (the head condition at that flow rate from Middle Road to the overflow elevation in the Southpoint Elevated Storage Tank). Flow rates begin at 3.0 MGD at the ARWA connection, decrease to 2.7 MGD at the Middle Road Pump Station, and ultimately deliver 2.0 MGD to the Southpoint Business Park.

At this higher initial flow rate, friction losses are even greater upstream of the Middle Road Pump Station than occur in Scenario 1, resulting in very low pressure on the suction end of those pumps. While the pumps are sized to account for this low hydraulic elevation and boost enough pressure to fill the Southpoint Tank, consumers upstream of the Middle Road Pump Station would have unacceptably low water pressure, well below 35 psi during times of peak demand. Thus, new pumps at the existing pump station only exacerbate the problem of low pressure along Temple Avenue.

24-Hour Extended Period Simulation Water Modeling

During the 24-hour model, pressures upstream of the Middle Road Pump Station are sufficient as long as the ARWA finished water pumps are providing additional flow to the Colonial Heights/Prince George County area. However, during intervals when flows from ARWA are consumed by high demands elsewhere in the system, the Colonial Heights/Prince George branch can only derive pressure from the two Colonial Heights tanks (each with an overflow elevation of 209 ft). With the hydraulic grade line constrained in this way, pressure quickly drops to 25 psi in the Middle Road area. When flows from the Colonial Heights tanks are limited during peak demand, the three existing Prince George County tanks quickly drain, leading to low pressure throughout the system during these intervals. This indicates that even with more powerful pumps in the current location, the Central Water System will struggle to replenish tanks following periods of high demand.

Conclusion: Upgraded pumps at the existing Middle Road Pump Station allow for an increase in total flow from the ARWA connection compared to current conditions. Low pressure zones are still present, however, and Prince George County's three elevated storage tanks may not provide enough storage to cover peak demand periods for long enough to ensure adequate supply.

Scenario 3: Install upgraded pumps at the Middle Road Pump Station, and a new tank located near the intersection of River Road and Temple Avenue

In this scenario, a new ground storage tank with a volume of 1.0 MG and an overflow elevation of 115 ft is constructed near the intersection of River Road and Temple Avenue, and the Middle Road Pump Station is outfitted with upgraded pumps as described in Scenario 2.

Instantaneous Hydraulic Analysis

Since the instantaneous analysis assumes that no pressure boost is provided by flows from the main ARWA connection (as is the case when pumps are off or no flow is reaching the Temple Avenue area because of high demands elsewhere), the hydraulic grade line entering the county is again constrained by the overflow elevation of 209 ft in the Colonial Heights elevated storage tanks. The highest hydraulic elevation with 3.0 MGD flowing in and with pressure provided only by the Colonial Heights tanks is 165 ft. This would be sufficient to keep the new ground storage tank full so that stored water could be used as needed. However, the hydraulic grade line beyond this point would match the ground storage tank's overflow elevation of 115 ft, leading once again to unacceptably low pressure along Temple Avenue.

Thus, additional storage does not improve outcomes in terms of instantaneous analysis.

24-Hour Extended Period Simulation Water Modeling

The 24-hour model highlights some benefit to additional storage in the River Road area. Without improving the hydraulic grade line, tank levels in Prince George County remain higher than with upgraded pumps at Middle Road alone. By creating a new storage buffer closer to the Central Water System demands, flows are more consistent throughout the day, maximizing the benefit of loops in the system to limit head loss in the Southpoint area.

However, increased storage does not address the major pressure drops upstream of the Middle Road Pump Station. At several points during high-demand intervals, pressures ranging from 20 to 25 psi are reported along Temple Avenue during this simulation.

Conclusion: A new ground storage tank at River Road offers improvement in terms of consistent ability to deliver desired flows, but does not protect against pressure drops during periods of high demand.

Scenario 4: Replace Middle Road Pump Station with new higher-capacity River Road Pump Station and ground storage tank

In this scenario, development at the intersection of River Road and Temple Avenue includes not just the ground storage tank discussed in Scenario 3, but also a new pump station drawing from the new tank. The storage tank has a volume of 1.0 MG and an overflow elevation of 115 ft and is equipped with an altitude valve to prevent tank overflow as water enters the system from a higher hydraulic elevation. The pump station has a capacity of 4.0 MGD at 220 ft TDH. The existing Middle Road Pump Station is decommissioned in this scenario.

Instantaneous Hydraulic Analysis

By boosting the pressure immediately downstream of the new storage buffer, the low-pressure zone along Temple Avenue is eliminated. Demands are partially met by the three existing elevated storage tanks and partially met by the consistent supply from the River Road Pump Station, which can operate at its full capacity and boost the hydraulic grade line of the entire system even when no flow is provided from the ARWA connection for up to eight hours.

Hydraulic modeling results showing instantaneous flow rates at peak demand are displayed in Figure No. 2. The new River Road Pump Station is pumping approximately 4.0 MGD at 220 ft TDH. The Middle Road and Courthouse tanks are both momentarily filling while the Southpoint tank begins to drain to help meet high local demands of 2.0 MGD. Loops in the system allow flows to reach the Southpoint area from several directions simultaneously, so half the demand in that area is met by the system and half is met by the local tank.

In this scenario, maximum pressure immediately downstream of the River Road Pump Station is approximately 100 psi. These conditions may require pressure-reducing valves for water consumers along that section of Temple Avenue. At the Middle Road junction, pressure decreases to approximately 84 psi.

At average demand, all tanks are able to be refilled while local demands are simultaneously being met. Fill rate at the Southpoint Elevated Storage Tank is 0.432 MGD, even as the adjacent Southpoint Business Park is demanding 1.18 MGD.

Under both peak and average demands, pressure at the Southpoint Business Park never drops below 55 psi. The lowest reported system pressure at a major junction is 50.5 psi at the intersection of County Drive and Bull Hill Road.

24-Hour Extended Period Simulation Water Modeling

The extended simulation shows this system meeting all desired outcomes over 24 hours:

- All local demands are met.
- No low-pressure zones are reported.
- After eight hours of peak demand and no flow from ARWA, the River Road ground storage tank has provided enough flow to prevent the three elevated tanks from completely draining.
    - The Southpoint and Courthouse tanks drain to approximately 266 and 279 ft, respectively, at their lowest water levels.
    - The Middle Road tank, which is hydraulically somewhat isolated from the other two tanks and most of the demands, does not drain lower than 283 ft.
- After 24 hours of fluctuating demands representing an average day (including 8 hours with no flow from ARWA), all three tanks completely refill overnight.
- Total flow from the ARWA point of connection is 3.1 MG over 24 hours.

Conclusion: A new River Road Pump Station offers notable advantages in terms of ARWA allocation utilization, storage stability, and consistently adequate pressure levels at major connections. This scenario consistently provides for 2.0 MGD in the Southpoint Business Park and maximizes the use of the ARWA transmission main.

Scenario 5: Replace Middle Road Pump Station with higher-capacity River Road Pump Station and upgrade piping

This scenario involves constructing the new River Road Pump Station and tank and also upgrading the piping along Allin Road (between Jefferson Park Road and Sawmill Road) from 12" to 16". This 0.57-mile-long upgrade would extend the 16" piping to the junction that forms the beginning of a large interconnected loop, through which flows can eventually reach the Southpoint area from several directions.

Instantaneous Hydraulic Analysis

This upgrade would have the effect of increasing the share of the total pumped flow that travels south from the Middle Road junction, much of which eventually reaches the Southpoint area; this flow would increase from 1.898 MGD to 2.243 MGD. This has the effect of slightly decreasing the short-term reliance on the Southpoint Elevated Storage Tank to meet demands in the Southpoint area. Instantaneous flow rates out of the Southpoint tank are reduced from 1.024 MGD to 0.974 MGD, as more of the demand is met by water in the system from the River Road Pump Station.

24-Hour Extended Period Simulation Water Modeling

Over a 24-hour period, the advantage of upgrading this piping is minimal. Tank levels at the end of the 8-hour high demand period are only one to two feet higher than without upgrade, allowing them to refill slightly faster over the remaining 16-hour average demand period. However, tanks do refill within 24 hours with or without piping upgrade.

Conclusion: Upgrading this section to 16" diameter piping offers negligible benefit, and is therefore not needed for meeting the stated goal of maximizing use of the ARWA transmission main.

Scenario 6: Extend Central Water System to incorporate the Food Lion Water System Ground Storage Tank

The final analyzed scenario involves adding a proposed water line along Route 460 to link the Central Water System to the existing Food Lion Water System. This groundwater-supplied local system is equipped with a 1.0 MG ground storage tank and has an average day demand of approximately 38,000 GPD.

Linking the two systems would make public water service available to additional customers along the Route 460 corridor and eliminate the Food Lion system's reliance on well water. It would also increase total water storage in the Central Water System, where significant growth in demand is expected.

For this analysis, a new 12" water line approximately one mile long has been added to the hydraulic model, linking the Central Water System to the 1.0 MG Food Lion ground storage tank. The specific objective of this modification is to determine whether this additional stored water volume, in conjunction with each of the above scenarios, allows a higher flow rate to reach the Southpoint Business Park.

Instantaneous Hydraulic Analysis

The overflow elevation of the Food Lion Ground Storage Tank is approximately 203 ft, significantly lower than the three elevated storage tanks in the Central Water System (285 ft) and the hydraulic grade line established by the River Road Pump Station (320 ft). As a result, all system demands are met by those higher-elevation sources. In a steady-state analysis of each scenario, the Food Lion Ground Storage Tank does not drain, so it does not improve any outcomes.

24-Hour Extended Period Simulation Water Modeling

In each scenario, water from the Food Lion Ground Storage Tank only begins to flow towards connections in the Central Water System when all other system tanks have reached their effective minimum volume, at which point the model does not permit them to drain further. While some flow from the Food Lion tank is able to reach the Southpoint Area, pressures are significantly below the required 35 psi in all scenarios.

Extended period simulation modeling was also conducted to determine whether the current Central Water System infrastructure would have the capacity to meet peak demand and provide fire flow in the Food Lion Water System if the waterline is extended to those connections. For this scenario, all current Food Lion system peak demands were incorporated into the hydraulic model with the Route 460 extension in place, and a 1250 GPM two-hour fire flow was also added to a single junction in that area. Stored water in the three existing Central Water System elevated storage tanks successfully met all system demands and provided the fire flow for the duration of the two-hour simulation, with sufficient water pressure reported at all system junctions.

Conclusion: Linking the Central Water System to the Food Lion Ground Storage Tank does not improve flow or pressure in the Southpoint Business Park. Current pumping and storage infrastructure is sufficient to meet all current demands and also provide a two-hour fire flow in the Food Lion area if the two systems are linked.

Future Water Treatment Plant

The hydraulic analyses discussed above are conducted to inform short-term improvements to maximize the ARWA point of connection. The long-term strategy for Prince George County's water supply must consider these analyses along with a number of other factors.

As water demand throughout the entire ARWA service area is projected to increase over the coming decades, it is in the County's best interest to establish a water source that is within their own day-to-day control. This would allow the design of pumping and storage infrastructure to be based only on County needs and priorities, rather than having to consider the operational practices of a third-party entity such as ARWA or a private water company. Thus, a County-owned water supply and treatment facility offers logistical benefits and the potential for greater hydraulic efficiency.

Conclusions and Recommendations

Based on the results of the two-part hydraulic analysis of all six scenarios, we recommend Scenario 4, a new pump station and tank located near the intersection of Temple Avenue and River Road.

This proposal offers several advantages which are confirmed by water modeling results:

(1) It maximizes the use of the ARWA transmission main.
(2) It consistently delivers 2.0 MGD to the Southpoint Business Park, successfully meeting a primary goal of the Master Plan.
(3) The higher hydraulic grade line established by boosting pressure near the ARWA connection point to a hydraulic elevation of 320 ft eliminates the low-pressure zone along Temple Avenue and in the vicinity of the existing Middle Road Pump Station.
(4) This hydraulic elevation is sufficient to support adequate pressure throughout the Central Water System, including at the three existing tanks with overflow elevations of 285 ft.
(5) Adding a fourth storage tank with a nominal volume of 1.0 MG significantly expands total storage from 1.5 MG to 2.5 MG. This will smooth over spikes in demand and provide enough volume to cover peak demands for at least eight hours, allowing all demands to be met even when the Colonial Heights/Prince George County portion of the ARWA system is not receiving flows from the ARWA finished water pumps.
(6) Upgrading pipe diameters leading to the Courthouse and Southpoint area does not offer substantial advantages for any major criteria. Modeling indicates that all tanks can be refilled over a 24-hour period without piping upgrade, confirming the sufficiency of the existing piping network.
(7) Additional stored water in the Food Lion water system does not improve flow or pressure in the Southpoint area when this system is linked to the Central Water System.

We propose constructing the 1.0 MG ground storage tank and adjacent 4.0 MGD pump station approximately 2000 feet from Temple Avenue on the northwest side of the Temple Avenue/River Road intersection. Should the County choose to construct a Water Treatment Plant off River Road in the future, this location would continue to be a suitable site for both water treatment and storage, as depicted in the draft site concept plan in Figure No. 3. Source water pumped from the Appomattox River could be treated at a new water treatment plant on this site and then flow by gravity to the new tank, where it would be stored until entering the distribution network via the new pump station. Thus,

the tank could be filled by the ARWA connection in the short term and the new Water Treatment Plant in the long term, offering maximum efficiency for the construction of new infrastructure.

One issue raised by results of all models with the expected increased demand is that the Middle Road Elevated Storage tank is rarely drained more than one to two feet, even during peak demand. This is due to high flows being forced to split at the Middle Road junction; rates exceeding 1.0 MGD flow down the Middle Road waterline even though demands are less than 0.5 MGD. This has the effect of keeping the Middle Road tank essentially full at all times, and it could lead to water age problems due to the lack of turnover in the tank.

This issue could be solved with a pressure-sustaining valve installed at the Middle Road junction, which would limit the share of total flow that splits off onto Middle Road, forcing a larger share to travel south where most of the Central Water System's demands are located. This would allow the Middle Road tank to more substantially drain and then refill on a diurnal basis, similar to the other two tanks. If further development extending down Middle Road and beyond increases demands off that branch of system, the valve could be deactivated.

A preliminary cost estimate for the short-term proposal, including a new 4.0 MGD pump station, 1.0 MG ground storage tank, all new associated piping and site work, is attached in Figure No. 4.

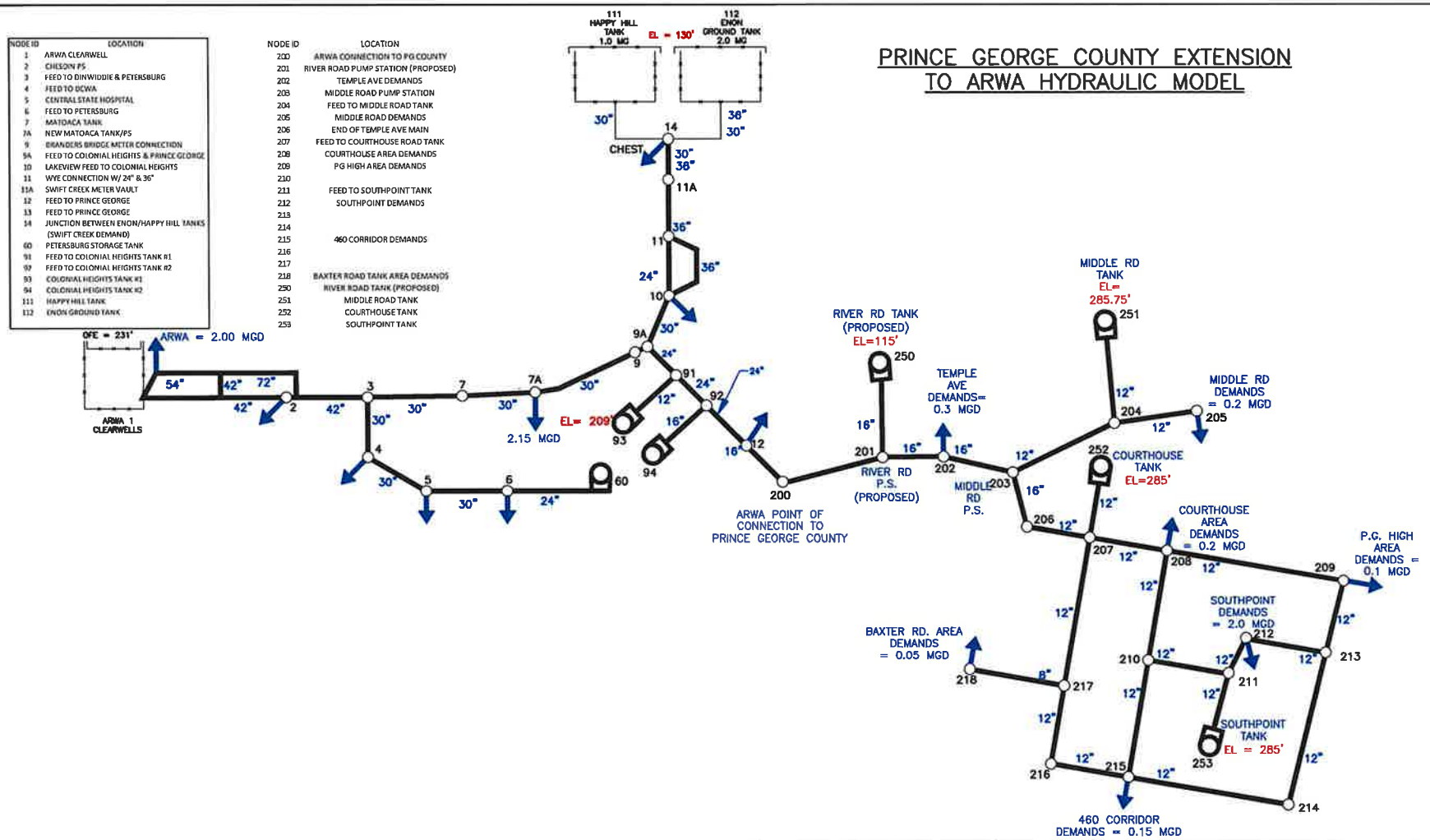
We are available to discuss this proposal with you at your convenience. Should you have any questions, please feel free to call.

Sincerely,

WW Associates, Inc.

Herbert F. White, III, P.E.
President

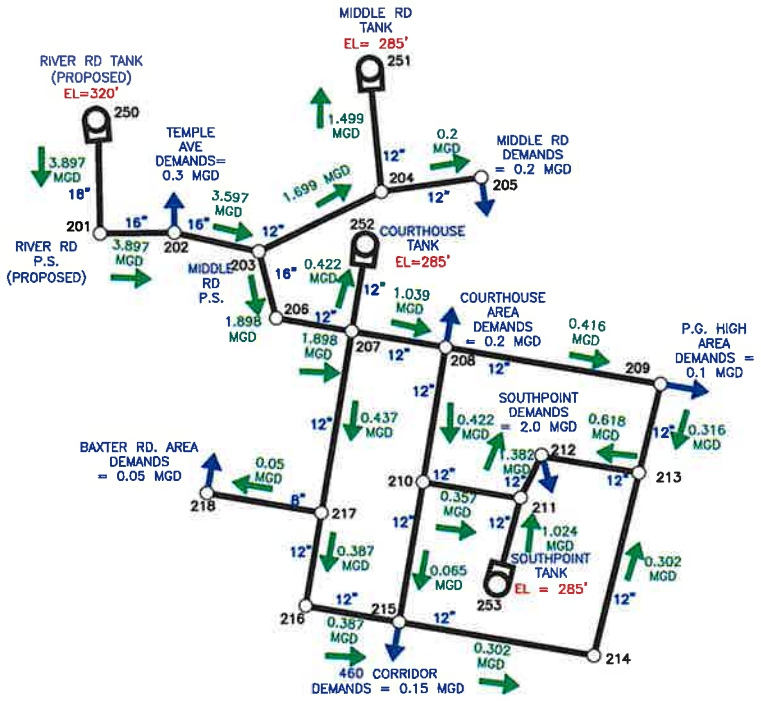
PRINCE GEORGE COUNTY EXTENSION TO ARWA HYDRAULIC MODEL



WW Associates — Engineers, Surveyors, Planners	SHEET: 1 OF 1	PROJECT: MIDDLE ROAD PUMP STATION WATER SYSTEM EVALUATION PRINCE GEORGE COUNTY, VIRGINIA	
	DRAWN BY: PCJ/JMA	FIGURE No. 1	
	REVIEWED BY: HFW		
	WWA NUMBER: 220002.00	FILE NAME: 000200L_PF-1.dwg	SCALE: N.T.S. / REVISION: – / DATE: 2-24-20

NODE ID	LOCATION
201	RIVER ROAD PUMP STATION (PROPOSED)
202	TEMPLE AVE DEMANDS
203	MIDDLE ROAD PUMP STATION
204	FEED TO MIDDLE ROAD TANK
205	MIDDLE ROAD DEMANDS
206	END OF TEMPLE AVE MAIN
207	FEED TO COURTHOUSE ROAD TANK
208	COURTHOUSE AREA DEMANDS
209	PG HIGH AREA DEMANDS
210	
211	FEED TO SOUTHPOINT TANK
212	SOUTHPOINT DEMANDS
213	
214	
215	460 CORRIDOR DEMANDS
216	
217	
218	BAXTER ROAD TANK AREA DEMANDS
250	RIVER ROAD TANK (PROPOSED)
251	MIDDLE ROAD TANK
252	COURTHOUSE TANK
253	SOUTHPOINT TANK

SCENARIO 4:
FLOW RATES AT PEAK DAY
DEMANDS IN PRINCE GEORGE COUNTY



WW ASSOCIATES
ENGINEERS SURVEYORS PLANNERS
PO Box 4119, Lynchburg, VA 24502, Phone: 434.316.6080
968 Olympia Drive Suite I, Charlottesville VA 22901, Phone: 434.964.2700
www.wwassoc.net

SHEET: 1 OF 1	PROJECT: MIDDLE ROAD PUMP STATION WATER SYSTEM EVALUATION PRINCE GEORGE COUNTY, VIRGINIA			
DRAWN BY: PCJ/JMA	FIGURE No. 2			
REVIEWED BY: HFW				
WWA NUMBER: 220002.00	FILE NAME: 000200L_PF-1.dwg	SCALE: N.T.S.	REVISION: -	DATE: 2-24-20

Figure 3: Site Concept Draft

Proposed site to develop for River Road Pump Station and eventual Water Treatment Plant

Figure No. 4

Project:	**Middle Road Pump Station Evaluation: Proposed River Road PS**
Location:	**Prince George County, VA**
WWA Project No:	**220002.00**
Date:	**April 22, 2020**
Estimate By:	**PCJ**
Checked By:	**HFW**
Status:	**Preliminary Engineering Cost Estimate**
Page:	**1**

ENGINEERS SURVEYORS PLANNERS
WW ASSOCIATES
P. O. Box 4119, Lynchburg, VA 24502, Phone: 434.316.6080
3040 Avemore Square Place, Charlottesville, VA 22911, Phone: 434.984.2700
www.wwassociates.net

Item	Units	Quantity	Unit Material Cost	Total Material Costs	Unit Labor Cost	Total Labor Costs	Total Unit Costs	Total Cost
Mobilization, Site Work, Misc.	LS	1			$25,000	$25,000	$25,000	$50,000
1 MG Ground Storage Tank	EA	1	$900,000	$900,000			$900,000	$900,000
4.0 MGD Pump Station								
CMU Pump Station Building	SF	1,200	$85	$102,000	$55	$66,000	$140	$168,000
2.0 MGD, 200-HP Pumps	EA	3	$30,000	$90,000	$7,500	$22,500	$37,500	$112,500
Variable Frequency Drive	EA	2	$15,000	$30,000	$7,500	$15,000	$22,500	$45,000
Instrumentation and Controls	LS	1	$50,000	$50,000			$50,000	$50,000
Electrical Power	LS	1	$500,000	$500,000			$500,000	$500,000
16" Ductile Iron Piping	LF	4,000	$220	$880,000			$220	$880,000
Subtotals				$2,552,000		$128,500		$2,705,500
5.3% Taxes (4.3% State, 1% local)								$135,256
Subtotal, Raw Cost								$2,840,756
Construction Markup @ 30 %								$852,227
Construction Cost								$3,692,983
Enginnering @ 10%								$369,298
Construction Contingency @ 5%								$184,649
TOTAL PROJECT COST								$4,246,930
Rounded								$4,250,000

WW Engineers Surveyors Planners Associates

April 16, 2020

Mr. Frank Haltom, P.E.
Director of Engineering & Utilities
Prince George County
P.O. Box 68
Prince George, VA 23875

Re: Evaluation of Central Water System Extension to Route 10

Dear Mr. Haltom:

This letter report will evaluate the feasibility of a potential extension to the Central Water System of Prince George County. This extension would allow the Central Water System to reach up to 530 additional existing service connections in the Jordan on the James, Beechwood Manor, and River's Edge subdivisions in the vicinity of Route 10.

Background

The three subdivisions in the area considered for the Central Water System extension currently derive their drinking water from a system of groundwater wells with a combined capacity of approximately 0.17 MGD. While this capacity is sufficient to meet average daily demands of approximately 0.156 MGD, peak demands are estimated to be 0.270 MGD.

In addition, the Jordan on the James water system has reported elevated levels of both iron and manganese, which are both considered secondary drinking water contaminants at high concentrations. Secondary contaminants can have taste, odor, and aesthetic effects on water quality. While a greensand filtration system can remove iron and manganese, the level of contamination may increase over time with further development in the area, and additional groundwater wells drawing from the same aquifer will likely encounter the same problem.

The Prince George County *Water and Wastewater Master Plan* highlights the Route 10 area as a primary corridor for future residential and commercial development, and thus a priority for upgrade in order to meet growing system demands, improve system

reliability, and provide service to new subdivisions within the area. For these reasons, it is in the interest of Prince George County to evaluate whether extending the Central Water System could be an efficient solution to the potentially ongoing water quality and supply concerns in the Route 10 area. If hydraulic analysis indicates that this expansion can successfully meet current and future demands in the area, shifting from a localized groundwater system to the Central Water System would provide greater reliability for these connections.

The Central Water System constitutes the majority of public water customers in the County, and is supplied by a single connection to the Appomattox River Water Authority's (ARWA) Temple Avenue transmission main. Hydraulic modeling of the proposed extension is based on data analysis discussed in several previous studies, which are summarized below.

- WW Associates, Inc. prepared a capital infrastructure needs assessment entitled *Capital Program Plan and Financial Analysis* for ARWA, dated December 2015. This study included a hydraulic analysis of the ARWA transmission main system, and concluded that the Temple Avenue transmission main is properly sized to deliver the ARWA treatment plant allocations to both the City of Colonial Heights (at 4.13 MGD) and Prince George County (at 2.69 MGD). This analysis determined that ARWA can supply the allocation capacity, except during short summertime periods, and recommended a new booster pump station with additional storage along the Temple Avenue transmission main.

- The *Water and Wastewater Master Plan* for Prince George County dated January 2016 explored short- and long-term water supply options, including strategies to maximize the ARWA connection with a new 3.0 MGD pump station along Temple Avenue. It also projected substantial long-term growth in demand in the Route 10 area as described above, forecasting up to 0.57 MGD in daily demand by 2045. During high-demand intervals in a typical day, this could include peaks of up to 0.97 MGD.

- A Preliminary Engineering Report entitled "*Southpoint Business Park Utilities Evaluation*," dated July 2018, advises the County to prepare for water demands to increase in the Southpoint Business Park. The PER states that the Business Park will require 2 MGD of maximum day water supply, and reports a current maximum day demand of approximately 1.0 MGD in the rest of the Central Water System. To fully utilize the County's ARWA allocation, this PER recommended a new 3.0 MGD pump station, expandable to 9.0 MGD, with a 1.0 MG ground storage tank at the intersection of Temple Avenue and River Road. The PER also

addressed the need for long-term infrastructure improvements due to projected further growth in demand throughout the entire ARWA distribution network, including the Route 10 area. It concluded that the most prudent long-term plan is for the County to provide its own water supply source by constructing a 4.0 MGD Water Treatment Plant and applying for a Virginia Water Protection Permit.

- WW Associates, Inc., prepared a letter report titled "Middle Road Pump Station Upgrade Evaluation," dated March 2020. This letter report discussed the results of incorporating Prince George County's Central Water System infrastructure into the hydraulic model of the Appomattox River Water Authority's transmission mains, created by WW Associates, Inc. in Bentley WaterCAD format. This initial extension included the Middle Road Pump Station, Central Water System storage, water mains, and primary junctions, and enabled the simulation of the proposed improvements discussed in the above-mentioned studies. It recommended that a new 3.0 MGD pump station and 1.0 MG ground storage tank be constructed near the ARWA point of connection on River Road, to supply additional storage, boost pressure for the entire Central Water System, and allow for increased demands to be met in the Southpoint Business Park. It also concluded that the existing infrastructure could allow for up to 1.0 MGD of demand in the Southpoint area without improvement, and still meet the existing demand for the rest of the Central Water System.

Purpose and Scope

The purpose of this report is to use data derived from system-wide hydraulic modeling to evaluate the possibility of further extending the Central Water System to include connections in the Route 10 area. Modeling will determine whether this extension, under various short- and long-term demand scenarios, will result in acceptable hydraulic conditions for all users. Each scenario's suitability will be assessed in terms of the following goals:

- To meet all average and peak demands
- To sustain adequate pressure at all junctions throughout the system
- To allow all system tanks to completely refill at the end of 24 hours
- To meet two-hour fire flow demands in the Route 10 area

Analytical Methods

To predict flow conditions under several scenarios, the existing piping network in the Route 10 area has been added to the WaterCAD hydraulic model of the ARWA transmission main and Prince George County Central Water System, prepared by WW Associates, Inc. For these simulations, the Route 10 piping network is linked to the rest of the Central Water System by a 12" water line. This water line extends from the current Central Water System terminus near the intersection of Meadow View Boulevard and Sandy Ridge Road to Route 10 (Prince George Drive) via Ruffin Road. On Prince George Drive, it then extends to the three subdivisions via Jordan Point Road, Beaver Castle Road, and Tar Bay Road.

Potential future infrastructure modeled in some scenarios include the River Road Pump Station, a proposed 4.0-MGD pump station and 1.0 MG ground storage tank to be located near the intersection of River Road and Temple Avenue, and the Route 10 Area Elevated Storage tank, a 0.5-MG elevated storage tank with an overflow elevation of 285 ft.

This extended model was used to determine the feasibility of the proposed extension and is presented in Figure No. 1. The demands noted in Figure No. 1 represent current peak demands at locations throughout the System, each representing a cluster of residential, commercial, or industrial water users. Four different scenarios within the Central Water System were modeled. These scenarios are as follows:

Current System Demands

Scenario 1: Existing demands, pump station, and tanks.

Scenario 2: Existing pump station and tanks, maximum advisable demands at the Southpoint Business Park with no infrastructure changes.

Projected Future System Demands

Scenario 3: Projected 2.0 MGD peak demand in Southpoint Business Park, existing demand in Route 10 area. Existing storage infrastructure, plus proposed River Road Pump Station to replace Middle Road Pump Station.

Scenario 4: Projected 2.0 MGD peak demand in Southpoint Business Park, long-range future peak demand of 0.97 MGD in Route 10 area. Existing storage infrastructure, plus proposed River Road Pump Station to replace Middle Road Pump Station.

Scenario 5: Same demands as Scenario 4. Same infrastructure as Scenario 4 plus proposed Route 10 Area Elevated Storage Tank.

Hydraulic analysis has been conducted using both instantaneous and 24-hour Extended Period Simulation water modeling. Extended Period Simulation has also incorporated two-hour fire flows in the Route 10 area. With this approach, the network can be analyzed with demands distributed throughout the System based on peak and average daily use.

Calculations within this model account for points of interconnection that establish beneficial loops in the System. Assumptions made to construct this 24-hour model are as follows:

Both pumping operations and system demands are assigned variable operating conditions under different circumstances. Up to five ARWA finished water pumps are operational at a given time, depending on demand and tank levels:

- Up to three Finished Water Pump Station No. 1 pumps (16 MGD each)
  - One is programmed to turn on when system tanks begin to drain more than 3 feet below their overflow elevation.
  - Two pump according to a variable rate schedule corresponding with average diurnal demands.
- Up to two Finished Water Pump Station No. 2 pumps (23 MGD each)
  - Both are programmed to turn on when system tank levels drop as described.
- Maximum instantaneous pumping rate = 94 MGD

Within Prince George County, the existing Middle Road Pump Station booster pumps and proposed River Road Pump Station booster pumps are also programmed into the model:

- The existing Middle Road Pump station is programmed to pump up to 16 hours a day at a rate of 1.4 MGD during average demand periods to refill downstream tanks. Existing pumps are rated for 1.4 MGD at 135 ft TDH, and current conditions limit operation to one pump at a time.
- The proposed River Road Pump Station in Scenarios 3, 4, and 5 is programmed to pump at a rate of 4 MGD when the Southpoint Elevated Storage Tank drops below the determined threshold, with a pump curve selected for optimal performance at 220 ft TDH.

The three existing elevated storage tanks in Prince George County, as well as the proposed Route 10 Area tank referenced in Scenario 5, all have a nominal storage volume of 0.5 MG and an overflow elevation of approximately 285 ft. The proposed River Road ground storage tank referenced in Scenarios 3, 4, and 5 has a nominal total volume of 1.0 MG and an overflow elevation of 115 ft.

All tanks are considered "empty" when they reach approximately half of their maximum volume in order to maintain adequate fire flow storage; the model does not permit them to drain further under normal demand conditions.

Approximate current average and peak demands as modeled in Scenario 1 are distributed throughout the Central Water System as outlined in Table No. 1. Diurnal demand follows a pattern based on typical early-morning and early-evening peaks. Commercial demand is characterized by a larger evening peak. Industrial demand models large spikes and decreases in demand throughout the day.

Table No. 1:

Location	**Type**	**Current Average Demands (MGD)**	**Current Peak Demands (MGD)**
Temple Ave	Commercial	0.176	0.30
Middle Rd	Diurnal	0.118	0.20
Courthouse area	Commercial	0.058	0.10
Courthouse area	Diurnal	0.058	0.10
Prince George High area	Diurnal	0.058	0.10
Southpoint Business Park	Industrial	0.294	0.50
460 Corridor	Diurnal	0.088	0.15
Baxter Road area	Diurnal	0.029	0.05
Jordan on the James	Diurnal	0.035	0.06
Beechwood Manor	Diurnal	0.080	0.14
River's Edge	Diurnal	0.041	0.07
TOTAL		**1.04 MGD**	**1.77 MGD**

Demands for Scenario 2 are unchanged except for at the Southpoint Business Park; this scenario is designed to determine the maximum possible increase at that location assuming the Route 10 extension is completed. Demands for Scenario 3 are unchanged except for the Southpoint Business Park, which increases to a peak of 2.0 MGD. Scenarios 4 and 5 also increase total demand in the three Route 10 area subdivisions to a peak of 0.97 MGD.

Results of Hydraulic Analyses

Scenario 1: Current demands. Existing tanks and Middle Road Pump Station.

In this scenario, the three Route 10 area subdivisions of Jordan on the James, Beechwood Manor, and River's Edge are connected to the Central Water System by a proposed 12" water line, but no other changes are made to the existing infrastructure.

Instantaneous Hydraulic Analysis

Under current peak Central Water System demands totaling 1.77 MGD, including 0.5 MGD in the Southpoint Business Park and 0.27 MGD in the Route 10 area, all demands are successfully met. Demands along Temple Avenue totaling 0.3 MGD are met via the ARWA point of connection. The remainder of demands, including those in the Route 10 area, are met by stored water in the three existing elevated storage tanks throughout the Central Water System.

All three tanks are draining at a rate of approximately 0.49 MGD for this snapshot steady-state analysis, which depicts simulated conditions at 7:00 am. Pressure exceeds 35 psi at all junctions. Low elevation connections in the Jordan on the James subdivision experience pressures exceeding 100 psi, indicating the need for a pressure-reducing valve at the neighborhood's entrance.

Loops in the system allow high-demand junctions, such as the Southpoint Business Park, to receive flow from multiple directions, minimizing head loss. Instantaneous flow rates at peak demand are displayed in Figure No. 2.

24-Hour Extended Period Simulation Water Modeling

The extended period simulation begins with an 8-hour period of peak demand of 1.77 MGD as described above. During this phase, only stored water is available, as described in the instantaneous analysis, and the Middle Road Pump Station is turned off. By the end of the 8-hour peak demand phase, all three existing tanks have drained to an elevation of approximately 270 feet. Water pressure drops slightly below 35 psi for some connections along Temple Avenue for the final 30 minutes of this high-demand interval.

This is followed by a 16-hour period of average diurnal demand of 1.04 MGD. During this phase, water from ARWA's finished water pumps is flowing into Colonial Heights and subsequently into Prince George County. As soon as the supply from ARWA is restored, pressure along Temple Avenue is boosted and all demands are readily met. The Middle Road Pump Station is operational during this phase, pumping at an average rate of 1.4 MGD, meeting all local demands and simultaneously refilling depleted tanks.

Average flow rates recorded at 10:00 pm are presented in Figure No. 3. Between 12:00 am and 1:00 am, all tanks are fully replenished to their overflow elevations, well in advance of the next high-demand phase.

Extended period simulation modeling was also used to test the system's fire flow capacity. In this simulation, a two-hour 500 gpm fire flow demand was added at the junction located at the entrance to the Jordan on the James subdivision while peak demands are also present across the rest of the system. The simulation found that this fire flow could be sustained; pressure at the location of the fire flow demand was reported as greater than 55 psi for the duration of the simulated fire.

Conclusion: Demands in the Route 10 area can successfully be added as an extension to the Central Water System using current infrastructure, assuming current demands throughout the rest of the System. All tanks are easily refilled within 24 hours, and all demands are met at adequate pressure. Fire flow demands of 500 gpm for at least a two-hour period are also successfully met with adequate water pressure at peak demand.

Scenario 2: Maximum advisable increase in demand using existing tanks and Middle Road Pump Station.

In this scenario, the demands at the Southpoint Business Park were progressively increased to the maximum average and peak demands that could be sustained while allowing all system tanks to be refilled by the end of the 24-hour simulation. The highest possible peak flow rate to the Southpoint Business Park area was determined to be 0.8 MGD. Thus, total peak flow rate for Scenario 2 is 2.17 MGD, including 0.8 MGD at the Southpoint Business Park and 0.27 MGD in the Route 10 area.

Instantaneous Hydraulic Analysis

During the peak flow phase of the simulation, the three existing elevated storage tanks drain in order to meet all demands while the Middle Road Pump Station is turned off and water supply is limited to the stored water only. Instantaneous flow rates at 7:00 am are approximately 0.59 MGD out of all three elevated tanks; this represents a substantial increase in the rate of tank drainage as compared to Scenario 1.

All demands are met and all pressures at junctions within the Central Water System exceed 35 psi. Pressures again exceed 100 psi at some connections in the Jordan on the James subdivision. Pressure at the Southpoint Business Park is reported at 62 psi. Peak flow rates for this scenario are presented in Figure No. 4.

24-Hour Extended Period Simulation Water Modeling

Because of the higher demands in the Southpoint area, all tanks drain faster and to a lower minimum water level than in Scenario 1. By the end of the 8-hour peak demand phase of the simulation, the three elevated storage tanks have all drained to elevations between 267 and 268 feet. Slightly low pressure around 33 psi at the suction end of the Middle Road Pump Station is reported for a short duration toward the end of the peak demand period. The remaining 16 hour average demand period still allows all three tanks to be fully replenished in time for the following morning's peak demand period. Reported flow rates at 10:00 pm for this scenario are presented in Figure No. 5.

A two-hour fire flow of 500 gpm can be sustained during peak demand in the Route 10 area under this simulation as well. Pressure exceeds 55 psi during the fire simulation.

Conclusion: A peak flow rate of 0.8 MGD can be supported at the Southpoint Business Park and still meet the additional demands introduced by the proposed Route 10 area extension, based on utilizing existing infrastructure. This includes sufficient water supply and pressure for a two-hour fire flow.

Scenario 3: Projected future industrial demands. Existing tanks plus proposed River Road Pump Station and tank.

Should future demand at the Southpoint Business Park expand to the 2.0 MGD projected in the *Southpoint Business Park Utilities Evaluation*, the Central Water System's infrastructure must be updated to include additional storage and pressure boosting capabilities. For example, the new 4.0 MGD pump station and 1.0 MG ground storage proposed in the Middle Road Pump Station Evaluation letter report, authored by WW Associates, would allow the County to meet this increased demand. Scenario 3 was conducted with this proposed pump station and tank incorporated into the model, and the Middle Road Pump Station decommissioned, in order to assess the performance of this infrastructure assuming that the Route 10 area is also connected to the existing network.

Instantaneous Hydraulic Analysis

Total peak demands of 3.27 MGD, including 2.0 MGD at the Southpoint Business Park and 0.27 MGD in the Route 10 area, are successfully met with the upgraded River Road infrastructure. Initially, pumping at the River Road Pump Station allows all instantaneous demands to be met with only the Southpoint Tank draining during this steady-state snapshot; the other two tanks briefly start to fill. No low pressure zones or junctions are reported in the Central Water System. Some excessive pressure junctions are reported in the Jordan on the James area. Peak flow rates for this scenario are displayed in Figure No. 6.

24-Hour Extended Period Simulation Water Modeling

During the eight-hour peak demand interval, the Middle Road and Courthouse elevated storage tanks drain only to an elevation of approximately 281 feet (3 feet below overflow), while the Southpoint elevated storage tank drains to an elevation of approximately 276 feet (9 feet below overflow). Meanwhile, the proposed River Road ground storage tank drains nearly to its effective minimum volume, at an elevation of 100.1 feet. As peak demands shift to average diurnal demands, pumping at River Road continues at a rate ranging from 3.0 to 3.8 MGD over the next 16 hours. All tanks are easily refilled during this time. Average flow rates for this scenario are presented in Figure No. 7.

During a fire flow simulation, 500 gpm can be sustained in the Route 10 area, at pressure exceeding 55 psi, while peak demands are also met.

Conclusion: Expansion to current connections in the Route 10 area, along with projected increased demands in the Southpoint Business Park, can both be supported by the proposed River Road Pump Station and ground storage tank with no additional improvements. Fire flow for residences in the Route 10 area can also be supported by this infrastructure under current Route 10 area demand.

Scenario 4: Projected future industrial and residential demands. Existing tanks plus proposed River Road Pump Station and tank.

This scenario models the same conditions as Scenario 3, plus additional long-range future demands in the Route 10 area. These demands are based on the County's *Water and Wastewater Master Plan*, which projected growth in that area through 2045.

Instantaneous Hydraulic Analysis

The total peak demand of 3.97 MGD in this scenario includes peak demands of 2.0 MGD in the Southpoint Business Park and 0.97 MGD in the Route 10 area. Other system tanks' status depends on their proximity to localized demands: at 7:00 am, the Southpoint Tank is draining at approximately 0.35 MGD, while the Courthouse tank is draining at just 0.05 MGD and the Middle Road tank is not draining. Flow originating at the River Road Pump Station is sufficient to meet all Route 10 demands without relying on the Middle Road tank at all during this snapshot analysis.

24-Hour Extended Period Simulation Water Modeling

Towards the end of the 8-hour high-demand interval, the River Road tank approaches becoming functionally empty, and the other three tanks drain more significantly as a

result. Drainage rates of approximately 1.0 MGD are reported for all three elevated storage tanks during this phase. The Middle Road, Courthouse, and Southpoint tanks drain to elevations of 279 feet, 276 feet, and 268 feet, respectively, after 8 hours of peak demand.

Once the high-demand period ends, all three elevated tanks begin to refill, along with the River Road ground storage tank, while average diurnal demands are simultaneously met. The Middle Road tank is able to completely refill by the end of 24 hours. The Courthouse, Southpoint, and River Road tanks all come within one foot of their overflow elevation during this simulated 24-hour period. Thus, 100% tank refilling on high-demand days may be challenging.

A two-hour fire flow simulation demonstrates that 500 gpm can be sustained in the Route 10 area under average demand, with pressures of approximately 48 psi for the duration of the simulation. Under peak demand, pressure is reduced to 32 psi, which would be insufficient for fire protection.

Conclusion: With the proposed River Road Pump Station and Tank replacing the Middle Road Pump Station, storage is sufficient to meet projected long-term increases in industrial demands in the Southpoint area as well as residential and commercial demands in the Route 10 area. However, providing sufficient storage and pressure for fire flows may require the construction of an additional elevated storage tank closer to the projected development in the Route 10 area.

Scenario 5: Projected future industrial and residential demands. Existing tanks plus proposed River Road Pump Station and tank as well as new Elevated Storage Tank in Route 10 area.

To improve pressure during a fire simulation, Scenario 4 was re-run with a new 0.5 MG elevated storage tank located along the waterline extension to Route 10. The purpose of this tank is to provide for projected residential and commercial development in the Route 10 area. This tank would have an overflow elevation of 285 ft to match the hydraulic grade present at the other three elevated tanks in the Central Water System.

The proposed new tank is located near Node 302 for modeling purposes. Projected additional Route 10 area peak demand of 0.70 MGD and fire flow demand of 0.72 MGD are both located at a single node at the intersection of Route 10 and Jordan Point Road for modeling purposes.

Results show that an elevated tank in that area would successfully provide the additional pressure required to sustain domestic two-hour fire flows of 500 gpm under peak future demand conditions. Pressure throughout the duration of the fire exceeds 70 psi at this

node with the new elevated storage tank built into the model. In addition, two-hour fire flows up to 2000 gpm during periods of average demand can be met, sustaining pressures above 50 psi for the duration of the fire.

Because the tank raises the hydraulic grade in the area, pressures exceeding 100 psi during average and peak demand conditions are widespread in the entire Route 10 area.

Conclusion: An elevated storage tank in the Route 10 area would provide the storage and pressure required for fire protection under long-term forecasted increases in residential demand. This additional storage would also serve as a buffer during high demand periods when Central Water System tanks may be somewhat slower to refill during off-peak hours, thus providing additional water system security for consumers. A pressure-reducing valve will be required to prevent excessive pressure for connections in this area.

Conclusions and Recommendations

Based on the results of the three-part hydraulic analysis of all five scenarios, we recommend extending the Central Water System's piping network with a new 12" water line. This water line would begin at the current end of service on Sandy Ridge Road (approximately 130 feet southeast of Meadow View Boulevard), run east along Sandy Ridge Road, then north on Ruffin Road until crossing Route 10 and linking up with the existing piping networks in the Jordan on the James and Beechwood Manor subdivisions. This first phase would entail a total of approximately 4.5 miles of 12" water line. A pressure-reducing valve located at the entrance to the subdivisions would prevent the excessively high pressure that is otherwise likely to be present at the lowest-elevation connections in these neighborhoods.

This proposal offers several advantages which are confirmed by water modeling results:

(1) The existing Central Water System can incorporate all current Route 10 area demands without upgrading its pumping or storage infrastructure, as discussed in Scenario 1.

(2) Industrial water demand up to a peak of 0.8 MGD in the Southpoint Business Park can also be met by current infrastructure, while simultaneously meeting current Route 10 area demand, as discussed in Scenario 2.

(3) Should industrial growth in the Southpoint Business Park further expand to a projected 2.0 MGD, construction of the proposed River Road Pump Station and Ground Storage Tank would also be able to incorporate an extension of the Central Water System to Route 10, as discussed in Scenario 3.

(4) Longer-range demand projection, including up to 0.97 MGD peak demand in the Route 10 area along with 2.0 MGD in the Southpoint Business Park, suggests fire protection may require additional storage and pressure boosting in the Route 10 area, as discussed in Scenarios 4 and 5. Construction of the new waterline would allow this proposed future elevated storage tank to be added whenever demand increases to the extent that the storage buffer becomes necessary.

A preliminary cost estimate for the first phase of this proposal is attached in Figure No. 8. This estimate includes extending the 12" waterline to the intersection of Jordan Point Road and Eagle Place, where it will connect to existing infrastructure and serve 383 connections in the Jordan on the James and Beechwood Manor subdivisions via the current piping network in that area. A second phase could extend the 12" waterline another 1.65 miles to the River's Edge Subdivision in order to serve an additional 144 connections. Modeling was conducted using demand at all three subdivisions; therefore, the second phase has already been incorporated into this analysis should you elect to pursue the entire expansion at once.

We are available to discuss this proposal with you at your convenience. Should you have any questions, please feel free to call.

Sincerely,

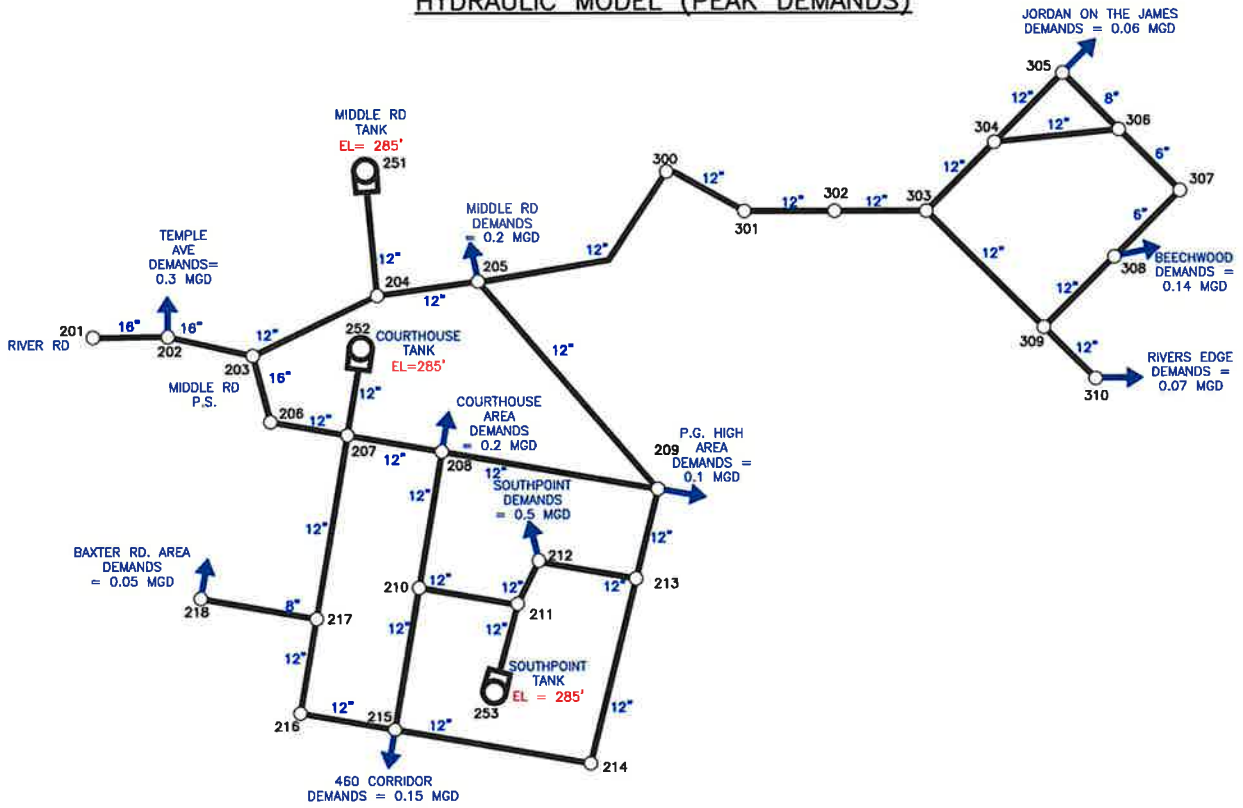
WW Associates, Inc.

Herbert F. White, III, P.E.
President

NODE ID	LOCATION
201	RIVER ROAD PUMP STATION (PROPOSED)
202	TEMPLE AVE DEMANDS
203	MIDDLE ROAD PUMP STATION
204	FEED TO MIDDLE ROAD TANK
205	MIDDLE ROAD DEMANDS
206	END OF TEMPLE AVE MAIN
207	FEED TO COURTHOUSE ROAD TANK
208	COURTHOUSE AREA DEMANDS
209	PG HIGH AREA DEMANDS
210	
211	FEED TO SOUTHPOINT TANK
212	SOUTHPOINT DEMANDS
213	
214	
215	460 CORRIDOR DEMANDS
216	
217	
218	BAXTER ROAD TANK AREA DEMANDS
251	MIDDLE ROAD TANK
252	COURTHOUSE TANK
253	SOUTHPOINT TANK

NOD ID	LOCATION
300	PRINCE GEORGE RD/SANDY RIDGE DR
301	END OF EXISTING 12" LINE
302	RUFFIN RD/SANDY RIDGE RD
303	JORDAN POINT RD/ROUTE 10
305	JORDAN ON THE JAMES DEMANDS
308	BEECHWOOD DEMANDS
310	RIVERS EDGE DEMANDS

ROUTE 10 AREA EXTENSION TO PRINCE GEORGE COUNTY HYDRAULIC MODEL (PEAK DEMANDS)



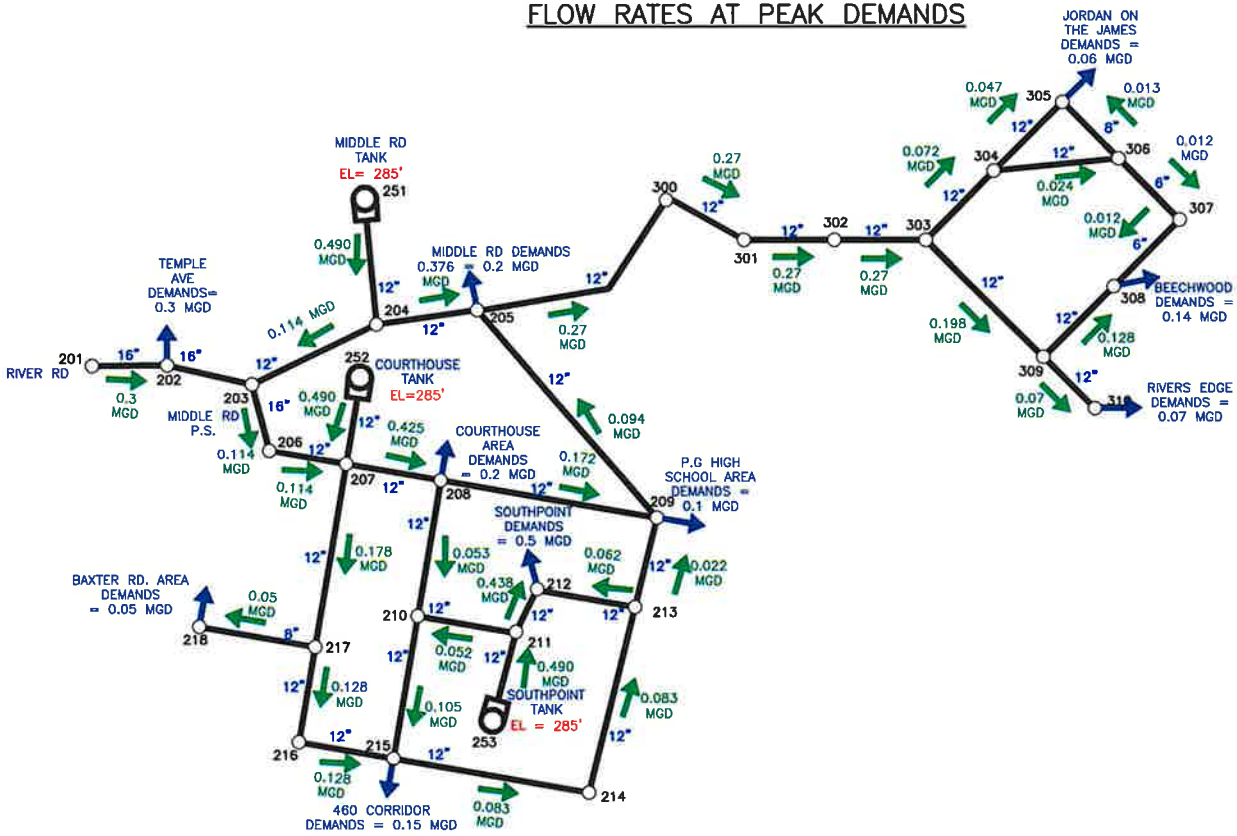
ENGINEERS SURVEYORS PLANNERS
WW ASSOCIATES
PO Box 4119, Lynchburg, VA 24502, Phone 434 316 6680
968 Olympia Drive Suite I, Charlottesville, VA 22901, Phone 434 964 2700
www.wwassoc.net

SHEET: 1 OF 1	PROJECT: MIDDLE ROAD PUMP STATION WATER SYSTEM EVALUATION PRINCE GEORGE COUNTY, VIRGINIA			
DRAWN BY: PCJ/JMA	FIGURE No. 1			
REVIEWED BY: HFW				
WWA NUMBER: 220002.00	FILE NAME: 000200L_PF-1.dwg	SCALE: N.T.S.	REVISION: –	DATE: 2-24-20

NODE ID	LOCATION
201	RIVER ROAD PUMP STATION (PROPOSED)
202	TEMPLE AVE DEMANDS
203	MIDDLE ROAD PUMP STATION
204	FEED TO MIDDLE ROAD TANK
205	MIDDLE ROAD DEMANDS
206	END OF TEMPLE AVE MAIN
207	FEED TO COURTHOUSE ROAD TANK
208	COURTHOUSE AREA DEMANDS
209	PG HIGH AREA DEMANDS
210	
211	FEED TO SOUTHPOINT TANK
212	SOUTHPOINT DEMANDS
213	
214	
215	460 CORRIDOR DEMANDS
216	
217	
218	BAXTER ROAD TANK AREA DEMANDS
251	MIDDLE ROAD TANK
252	COURTHOUSE TANK
253	SOUTHPOINT TANK

NOD ID	LOCATION
300	PRINCE GEORGE RD/SANDY RIDGE DR
301	END OF EXISTING 12" LINE
302	RUFFIN RD/SANDY RIDGE RD
303	JORDAN POINT RD/ROUTE 10
305	JORDAN ON THE JAMES DEMANDS
308	BEECHWOOD DEMANDS
310	RIVERS EDGE DEMANDS

SCENARIO 1:
FLOW RATES AT PEAK DEMANDS



ENGINEERS SURVEYORS PLANNERS
ASSOCIATES

SHEET: 1 OF 1	PROJECT: MIDDLE ROAD PUMP STATION WATER SYSTEM EVALUATION PRINCE GEORGE COUNTY, VIRGINIA			
DRAWN BY: PCJ/JMA				
REVIEWED BY: HFW	FIGURE No. 2			
WWA NUMBER: 220002.00	FILE NAME: 000200L_PF-1.dwg	SCALE: N.T.S.	REVISION: -	DATE: 2-24-20

NODE ID	LOCATION
201	RIVER ROAD PUMP STATION (PROPOSED)
202	TEMPLE AVE DEMANDS
203	MIDDLE ROAD PUMP STATION
204	FEED TO MIDDLE ROAD TANK
205	MIDDLE ROAD DEMANDS
206	END OF TEMPLE AVE MAIN
207	FEED TO COURTHOUSE ROAD TANK
208	COURTHOUSE AREA DEMANDS
209	PG HIGH AREA DEMANDS
210	
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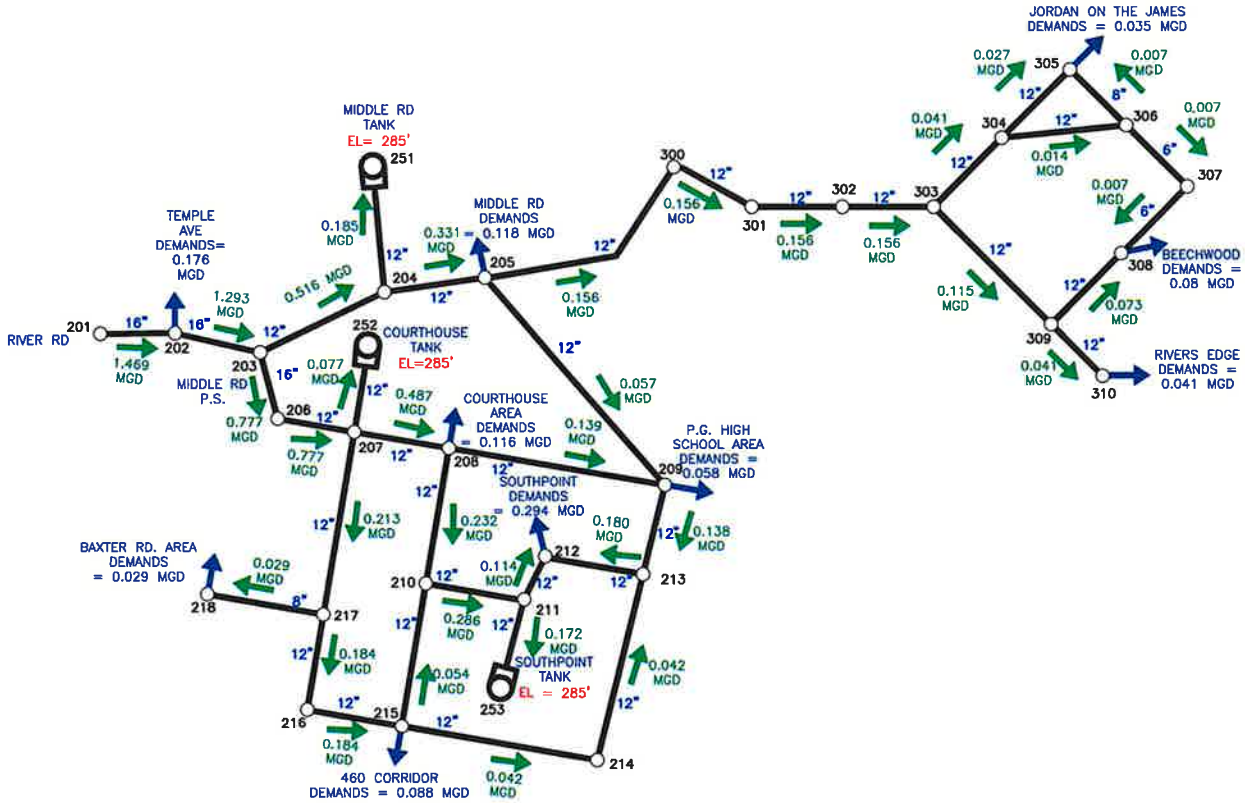
253	SOUTHPOINT TANK

NOD ID	LOCATION
300	PRINCE GEORGE RD/SANDY RIDGE DR
301	END OF EXISTING 12" LINE
302	RUFFIN RD/SANDY RIDGE RD
303	JORDAN POINT RD/ROUTE 10
305	JORDAN ON THE JAMES DEMANDS
308	BEECHWOOD DEMANDS
310	RIVERS EDGE DEMANDS

SCENARIO 1:
FLOW RATES AT AVERAGE DEMANDS

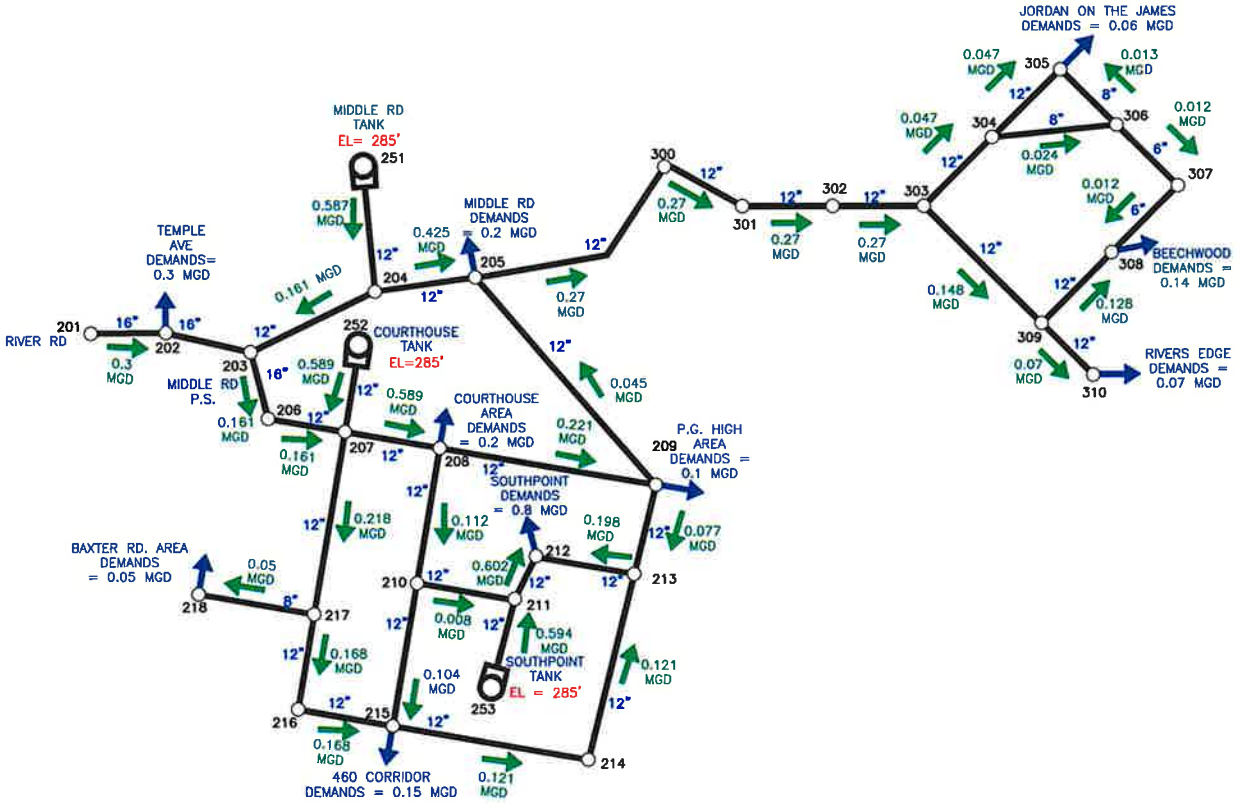


WWA Engineers Surveyors Planners Associates	SHEET: 1 OF 1	PROJECT: MIDDLE ROAD PUMP STATION WATER SYSTEM EVALUATION PRINCE GEORGE COUNTY, VIRGINIA FIGURE No. 3		
	DRAWN BY: PCJ/JMA			
	REVIEWED BY: HFW			
WWA NUMBER: 220002.00	FILE NAME: 000200L_PF-1.dwg	SCALE: N.T.S.	REVISION: –	DATE: 2-24-20

NODE ID	LOCATION
201	RIVER ROAD
202	TEMPLE AVE DEMANDS
203	MIDDLE ROAD PUMP STATION
204	FEED TO MIDDLE ROAD TANK
205	MIDDLE ROAD DEMANDS
206	END OF TEMPLE AVE MAIN
207	FEED TO COURTHOUSE ROAD TANK
208	COURTHOUSE AREA DEMANDS
209	PG HIGH AREA DEMANDS
210	
211	FEED TO SOUTHPOINT TANK
212	SOUTHPOINT DEMANDS
213	
214	
215	460 CORRIDOR DEMANDS
216	
217	
218	BAXTER ROAD TANK AREA DEMANDS
251	MIDDLE ROAD TANK
252	COURTHOUSE TANK
253	SOUTHPOINT TANK

NOD ID	LOCATION
300	PRINCE GEORGE RD/SANDY RIDGE DR
301	END OF EXISTING 12" LINE
302	RUFFIN RD/SANDY RIDGE RD
303	JORDAN POINT RD/ROUTE 10
305	JORDAN ON THE JAMES DEMANDS
308	BEECHWOOD DEMANDS
310	RIVERS EDGE DEMANDS

SCENARIO 2:
FLOW RATES AT PEAK DEMANDS



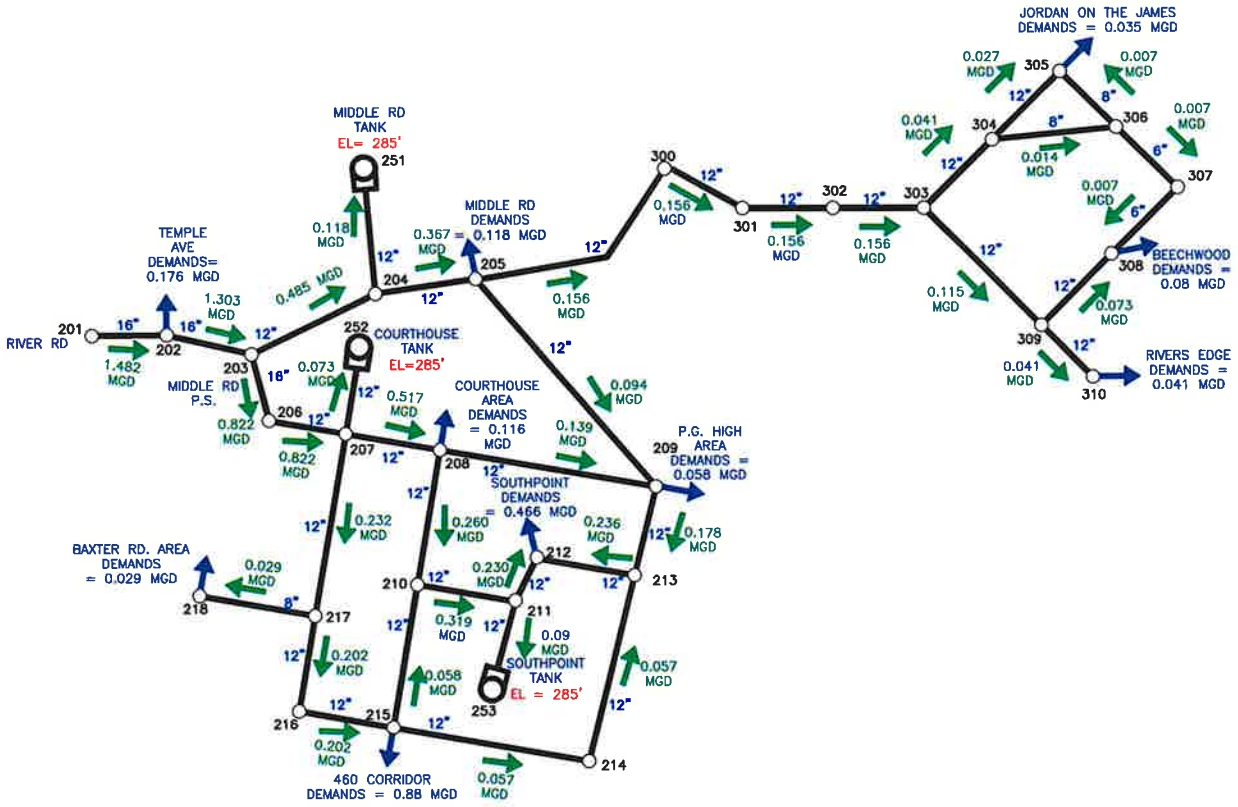
ENGINEERS SURVEYORS PLANNERS
WW ASSOCIATES

SHEET: 1 OF 1	PROJECT: MIDDLE ROAD PUMP STATION WATER SYSTEM EVALUATION PRINCE GEORGE COUNTY, VIRGINIA			
DRAWN BY: PCJ/JMA				
REVIEWED BY: HFW	FIGURE No. 4			
WWA NUMBER: 220002.00	FILE NAME: 000200L_PF-1.dwg	SCALE: N.T.S.	REVISION: -	DATE: 2-24-20

NODE ID	LOCATION
201	RIVER ROAD
202	TEMPLE AVE DEMANDS
203	MIDDLE ROAD PUMP STATION
204	FEED TO MIDDLE ROAD TANK
205	MIDDLE ROAD DEMANDS
206	END OF TEMPLE AVE MAIN
207	FEED TO COURTHOUSE ROAD TANK
208	COURTHOUSE AREA DEMANDS
209	PG HIGH AREA DEMANDS
210	
211	FEED TO SOUTHPOINT TANK
212	SOUTHPOINT DEMANDS
213	
214	
215	460 CORRIDOR DEMANDS
216	
217	
218	BAXTER ROAD TANK AREA DEMANDS
251	MIDDLE ROAD TANK
252	COURTHOUSE TANK
253	SOUTHPOINT TANK

NOD ID	LOCATION
300	PRINCE GEORGE RD/SANDY RIDGE DR
301	END OF EXISTING 12" LINE
302	RUFFIN RD/SANDY RIDGE RD
303	JORDAN POINT RD/ROUTE 10
305	JORDAN ON THE JAMES DEMANDS
308	BEECHWOOD DEMANDS
310	RIVERS EDGE DEMANDS

SCENARIO 2:
FLOW RATES AT AVERAGE DEMANDS

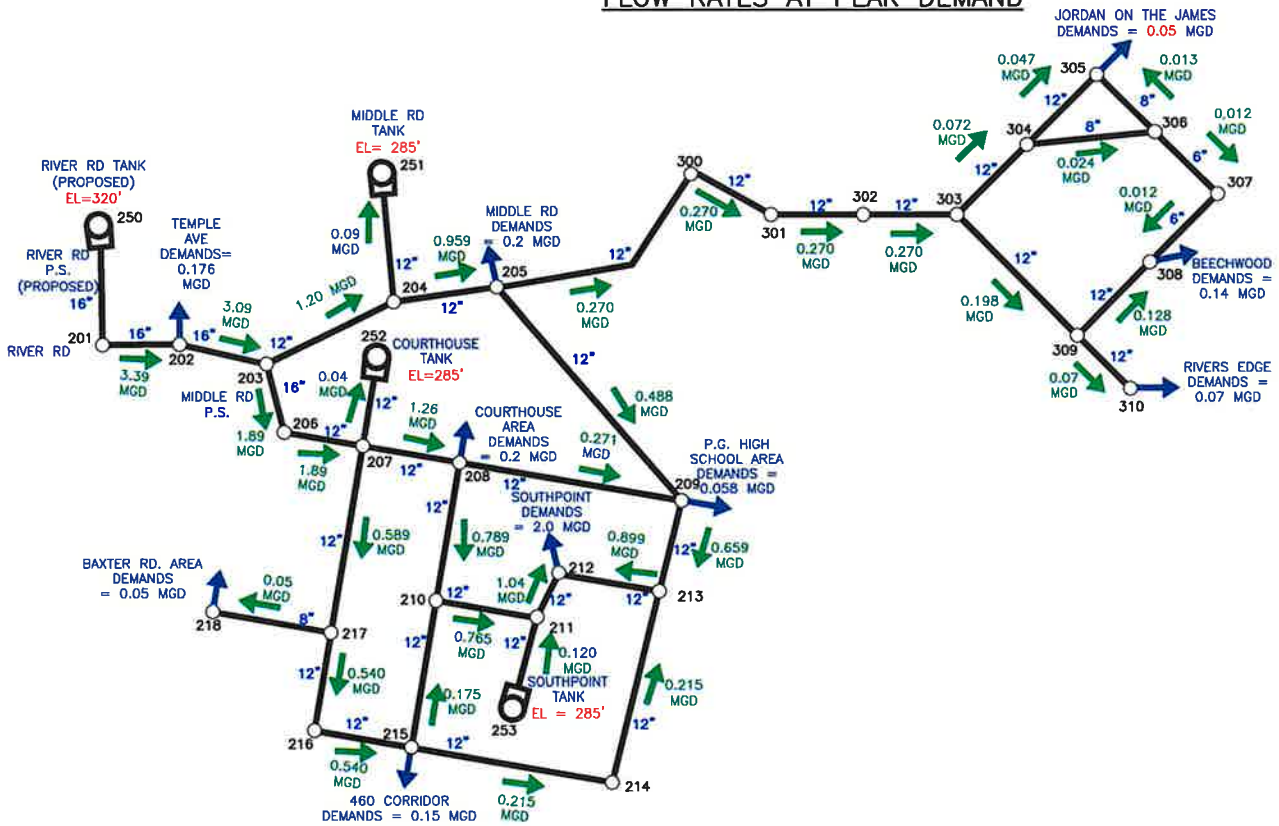


WW Associates — Engineers, Surveyors, Planners	SHEET: 1 OF 1	PROJECT: MIDDLE ROAD PUMP STATION WATER SYSTEM EVALUATION PRINCE GEORGE COUNTY, VIRGINIA		
	DRAWN BY: PCJ/JMA	FIGURE No. 5		
	REVIEWED BY: HFW			
	WWA NUMBER: 220002.00	FILE NAME: 000200L_PF-1.dwg	SCALE: N.T.S.	REVISION: -	DATE: 2-24-20

NODE ID	LOCATION
201	RIVER ROAD
202	TEMPLE AVE DEMANDS
203	MIDDLE ROAD PUMP STATION
204	FEED TO MIDDLE ROAD TANK
205	MIDDLE ROAD DEMANDS
206	END OF TEMPLE AVE MAIN
207	FEED TO COURTHOUSE ROAD TANK
208	COURTHOUSE AREA DEMANDS
209	PG HIGH AREA DEMANDS
210	
211	FEED TO SOUTHPOINT TANK
212	SOUTHPOINT DEMANDS
213	
214	
215	460 CORRIDOR DEMANDS
216	
217	
218	BAXTER ROAD TANK AREA DEMANDS
250	RIVER ROAD PUMP STATION (PROPOSED)
251	MIDDLE ROAD TANK
252	COURTHOUSE TANK
253	SOUTHPOINT TANK

NOD ID	LOCATION
300	PRINCE GEORGE RD/SANDY RIDGE DR
301	END OF EXISTING 12" LINE
302	RUFFIN RD/SANDY RIDGE RD
303	JORDAN POINT RD/ROUTE 10
305	JORDAN ON THE JAMES DEMANDS
308	BEECHWOOD DEMANDS
310	RIVERS EDGE DEMANDS

SCENARIO 3:
FLOW RATES AT PEAK DEMAND

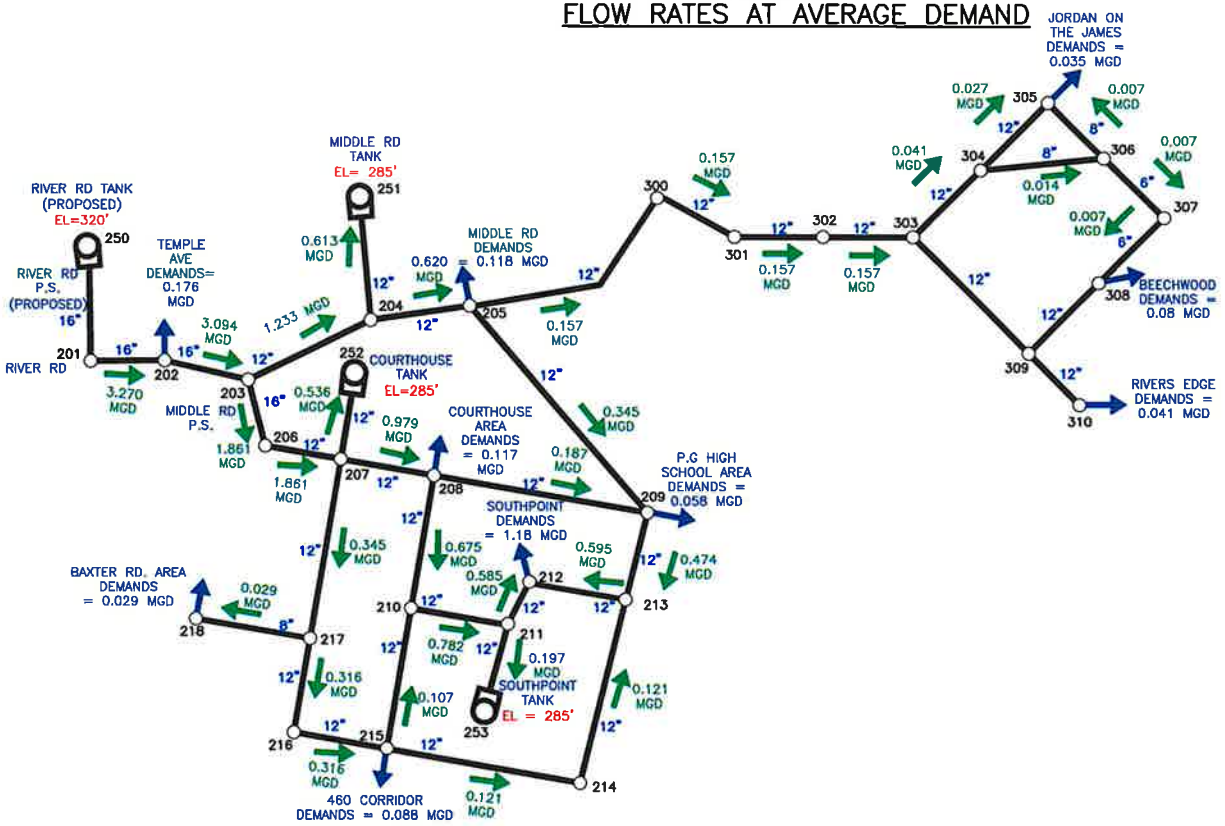


WWA Engineers Surveyors Planners Associates	SHEET: 1 OF 1	PROJECT: MIDDLE ROAD PUMP STATION WATER SYSTEM EVALUATION PRINCE GEORGE COUNTY, VIRGINIA FIGURE No. 6		
	DRAWN BY: PCJ/JMA			
	REVIEWED BY: HFW			
	WWA NUMBER: 220002.00	FILE NAME: 000200L_PF-1.dwg	SCALE: N.T.S.	REVISION: -	DATE: 2-24-20

SCENARIO 3:
FLOW RATES AT AVERAGE DEMAND

NODE ID	LOCATION
201	RIVER ROAD
202	TEMPLE AVE DEMANDS
203	MIDDLE ROAD PUMP STATION
204	FEED TO MIDDLE ROAD TANK
205	MIDDLE ROAD DEMANDS
206	END OF TEMPLE AVE MAIN
207	FEED TO COURTHOUSE ROAD TANK
208	COURTHOUSE AREA DEMANDS
209	PG HIGH AREA DEMANDS
210	
211	FEED TO SOUTHPOINT TANK
212	SOUTHPOINT DEMANDS
213	
214	
215	460 CORRIDOR DEMANDS
216	
217	
218	BAXTER ROAD TANK AREA DEMANDS
250	RIVER ROAD PUMP STATION (PROPOSED)
251	MIDDLE ROAD TANK
252	COURTHOUSE TANK
253	SOUTHPOINT TANK

NOD ID	LOCATION
300	PRINCE GEORGE RD/SANDY RIDGE DR
301	END OF EXISTING 12" LINE
302	RUFFIN RD/SANDY RIDGE RD
303	JORDAN POINT RD/ROUTE 10
305	JORDAN ON THE JAMES DEMANDS
308	BEECHWOOD DEMANDS
310	RIVERS EDGE DEMANDS



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SHEET: 1 OF 1	PROJECT: MIDDLE ROAD PUMP STATION WATER SYSTEM EVALUATION PRINCE GEORGE COUNTY, VIRGINIA			
DRAWN BY: PCJ/JMA	FIGURE No. 7			
REVIEWED BY: HFW				
WWA NUMBER: 220002.00	FILE NAME: 000200L_PF-1.dwg	SCALE: N.T.S.	REVISION: –	DATE: 2-24-20

Figure No. 8

Project:	**Waterline Extension to Route 10**
Location:	**Prince George County, VA**
WWA Project No:	**220004.00**
Date:	**14-Apr-20**
Estimate By:	**PCJ**
Checked By:	**HFW**
Status:	**Preliminary**
Page:	**1 of 1**

ENGINEERS SURVEYORS PLANNERS
ASSOCIATES
P. O. Box 4119, Lynchburg, VA 24502, Phone: 434.316.6080
3040 Avemore Square Place, Charlottesville, VA 22911, Phone: 434.984.2700
www.wwassociates.net

Item	Units	Quantity	Unit Material Cost	Total Material Costs	Unit Labor Cost	Total Labor Costs	Total Unit Costs	Total Cost
Mobilization	LS	1	$10,000.00	$10,000	$5,000.00	$5,000	$15,000	$ 15,000
Asphalt Pavement Repair/Replacement	SY	300	$30.00	$9,000	$15.00	$4,500	$45	$ 13,500
Erosion and Sediment Control	LS	1	$2,000.00	$2,000	$7,500.00	$7,500	$9,500	$ 9,500
Connect new Waterline to existing water main	EA	1	$1,000.00	$1,000	$1,000.00	$1,000	$2,000	$ 2,000
12" C900 Pipe	LF	24,000	$40.00	$960,000	$10.00	$240,000	$50	$ 1,200,000
Trench (4' wide, 5' deep)	LF	24,000	$10.00	$240,000	$15.00	$360,000	$25	$ 600,000
Crushed stone (4" deep)	CY	1,000	$25.00	$25,000	$10.00	$10,000	$35	$ 35,000
Air Release Valve Assembly	EA	8	$7,500.00	$60,000	$1,500.00	$12,000	$9,000	$ 72,000
Hydrant Assembly	EA	35	$2,500.00	$87,500	$1,000.00	$35,000	$3,500	$ 122,500
Blowoff Valve Assembly	EA	6	$7,500.00	$45,000	$1,500.00	$9,000	$9,000	$ 54,000
Miscellaneous 12" Fittings	EA	15	$200.00	$3,000	$50.00	$750	$250	$ 3,750
Pressure Reducing Valve	EA	1	$12,000.00	$12,000	$3,000.00	$3,000	$15,000	$ 15,000
Jack and Bore (including carrier pipe)	LF	275	$200.00	$55,000	$220.00	$60,500	$420	$ 115,500
Jack and Bore Pits	LS	1	$0.00	$0	$5,000.00	$5,000	$5,000	$ 5,000
Subtotals:				$1,509,500		$753,250		$ 2,262,750
5.3% Sales Tax on Materials								$ 80,004
							SUBTOTAL	$ 2,342,754
							CONSTRUCTION MARKUP @ 35%	$ 819,964
							CONTINGENCY 5%	$ 113,138
							EASEMENT ACQUISITION	$ 50,000
							TOTAL AFTER CONSTRUCTION MARKUP	$ 3,275,855
							ROUNDED ESTIMATE	**$ 3,280,000**