OTTER CREEK ENGINEERING

WOODSTOCK AQUEDUCT COMPANY

WATER SYSTEM
90% PRELIMINARY ENGINEERING REPORT

WOODSTOCK, VERMONT

OCTOBER 2023

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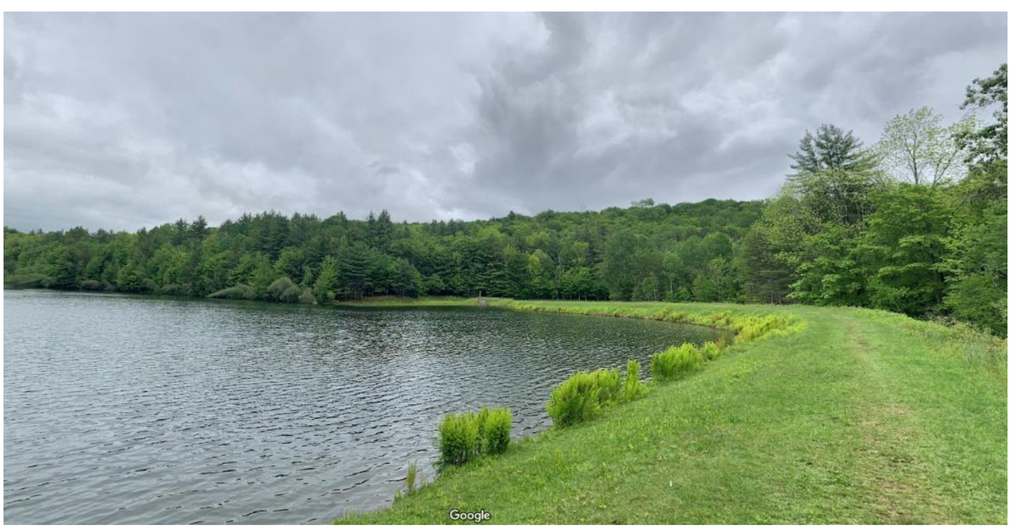
1.0 PROJECT PLANNING

a. **General** – The Town of Woodstock's water system, named the Woodstock Aqueduct Company (WAC), is regulated as a Public Water System by the State of Vermont Drinking Water and Groundwater Protection Division. The system, which is privately owned, provides potable water service to a mix of residential and commercial users. The system has just over 17 miles of water mains and 777 service connections serving an estimated year-round population of 2,473 people and 992 Equivalent Residential Units (ERUs). A current customer list is included in **Appendix A**. The system also provides fire protection.

b. **Location** – The water system is located entirely within the Town and Village of Woodstock, Vermont. The current service area is shown in **Figure 1** as an overview of the water system. The distribution system generally is located on Route 4, Route 12, Carlton Hill Road, College Hill Road, and River Street, with connections to other more minor roads.

c. **System History** – The WAC was first incorporated in 1880 for the purpose of constructing a water supply for the inhabitants of the Village of Woodstock. Construction of the original system was completed in 1887. The original water supplies for the system were the Cox earthen reservoir, which is located just north and uphill of the current water storage tank on Cox District Road, and the Carlton earthen reservoir which was on the southern side of the Ottauquechee on Carlton Hill Road. There were also some springs located on Mt. Peg which were connected to the system, but their yields were relatively low.



After some significant droughts in the 1950s, the Vondell earthen Reservoir was constructed in 1962 and had a storage capacity of 30 million gallons. The first wells on the system were constructed in the 1970s and would pump up into the reservoirs until the current water storage tank was constructed in 1988. Until that time, the system was completely fed by the reservoirs. At present, the Cox, Carlton, and Vondell Reservoirs are valved off and the supply is solely from the two wells located on VT Route 12.

d. **Need for Study** – This study was commissioned in order to address fire flow deficiencies which have been identified in the system. Some hydrants connected to the system cannot produce 500 gallons per minute (gpm) without dropping the pressure below 20 psi anywhere in the system. Which is the regulatory standard in the Vermont Water Supply Rule. This issue is exacerbated further when the wells are not running, and water is only entering the system from the water storage tank.

The hydraulic deficiency is due to small diameter mains within the Village and the friction loss related to the 8-inch water main which runs down from the water storage tank and into the distribution. Also, since this main was previously fed from surface water for almost 100 years, it is likely tuberculated and its inner diameter probably less than 8-inches.

The goal of the study is to identify potential improvements the WAC should consider to better the hydraulics of the water system during fire flow conditions.

e. **Project Area –** For this report, the WAC desires to review the water system in its entirety. The primary focus is addressing system hydraulics during fire flow condition. WAC would also like to identify other critical improvements throughout the system that should be considered and planned for over the next 20 years**.** The general water system area and components are depicted in **Figure 1**.

f. **Environmental Resources** - The existing service area for the water system was reviewed using the State of Vermont Agency of Natural Resources Online Interactive database and mapping. **Appendix B** includes ANR Resource Atlas Maps depicting known natural and environmental resources within the whole service area, and refined maps that are specific to the system's critical infrastructure. Environmental resources identified within the mapping limits include hazardous waste sites, hazardous waste generators, a brownfield, deer wintering areas, rare threatened or endangered species, prime agricultural soils, and Class II Wetlands.

- Rivers and Streams – The water system exists on both sides of the Ottauquechee River, and crosses it four times, both through connections to bridges and underground borings. The Ottauquechee River was identified on the State of Vermont's 2016 Stressed Waters List, with possible pollutants identified as: nutrients, enriched organics, temperature, sediment, E. Coli, runoff, and physical alternation (channelization from Tropical Storm Irene).

  Water system piping also crosses the Ottauquechee River, Kedron Brook and Barnard Brook in several locations.

- Wetlands –In addition to potential wetland impacts near the stream crossings, there are several mapped wetlands throughout the service area. Design documents should include wetland delineations and permitting, if necessary.

- Hazardous Waste Sites – There are 35 identified hazardous sites within WAC's service area. Of these, 27 have been closed and 31 are identified as being low or less priority. See **Table 1** for this breakdown, and **Appendix C** for a full summary table of all of these sites.

  Table 1 Hazardous Sites

Priority	CoC, NFAP, SMAC	Low	Medium	High
Number	26	5	3	1
% of All	74%	14%	9%	3%

  Note: CoC = Certificate of Completions, NFAP = No Further Action Planned, SMAC = Site Management Activities Complete

  Of all of these, only three are in areas where potential project alternatives are located, and contaminated soils are otherwise not anticipated to be encountered. In most cases, the Petroleum Cleanup Fund (PCF) will assist with the incremental costs of the water or sewer infrastructure which is directly impacted by contaminated soil or groundwater.

- Prime Agricultural Soils – Prime agricultural soil exists sporadically throughout the service area. However, most work for potential projects are expected to be pipe replacement/upgrades within the road corridor or in areas which have been previously developed and no longer can be agriculturally useful, so there will not be any impact on existing or future agricultural practices.

As is the case with all public community water system improvement projects receiving State or Federal funding, further review of existing environmental resources within the projects specific limits will be required, with appropriate investigations completed prior to final design approval and permitting of any improvements project.

g. **Present Population Trends** – Between 2000 and 2020, Vermont experienced a 5.6% population growth; however, Windsor County has experienced a lesser increase in population of 0.6%. The Town and Village of Woodstock have experienced a decline in population over this same time period as can be seen in the table below.

Table 2 Population Data

Year	Woodstock	Windsor County	Vermont
2000	3,232	57,418	608,827
2010	3,048	56,670	625,741
2020	3,005	57,753	643,077
% Change	-7.02	0.58	5.63

h. **Community Engagement** – Community involvement included a public outreach and informational meeting held by the WAC. A Project presentation and open forum meeting was held to review some of the findings of this report at this stage of its development. Specific capital projects developed from this report will need to go through additional public participation steps during the design phase of a given project.

2.0 EXISTING FACILITIES

a. **Overview -** A simple process flow diagram outlines the major components of the water system and is shown as **Figure 2.** The major components of the water system include the two supply wells, sodium hypochlorite disinfection, transmission mains, finished water storage tanks, and the distribution system.

b. **Water Sources**

i. **Well** – The water system has three wells, identified as Well #001, Well #004, and Well #005 on the water system's operating permit (**Appendix D**). Only two of these wells are currently active on the system (Well #001 and Well #005). Information on all wells is summarized below in **Table 3**.

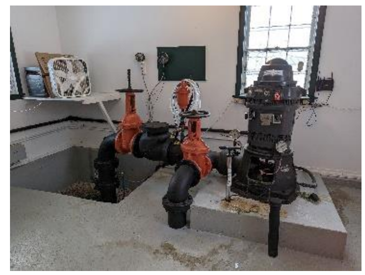


Table 3 Well Summaries

Source Identification	Year Installed	Authorized Rate (GPM)	Size	Depth	Length of Casing
Well #001	6/15/1971	350	24-inch	66'	46'
Well #004	1/6/1993	21 (inactive)	16-inch	63'	56'
Well #005	1/15/1993	103	16-inch	71'	60'
Total Permitted Source Capacity		**453**			

All the wells are on two properties (owned by the WAC) on VT Route 12 and Stimets Road to the north of the Village.

A well and pump inspection report done by Weston & Sampson in 2021 produced the following table on actual well performance and corresponding pumping rates. The report in its entirety can be found in **Appendix E**.

Table 4 2021 Weston & Sampson Well and Pump Inspection Report

Well/Pump Name	Flow Rate (gpm)	Specific Capacity (gpm/ft)	Pump TDF (ft)	MegOhm Reading @500V	Wire to Water Efficiency	Comments
Well 001	250	5.36	344.54	infinity	71%	Well performance is down 68% from original testing and down 28.7% from 2019 testing. Pump performance is 8% below design curve at 250 gpm. No unusual noises or vibrations noted during operation.
Well 005	38	0.88	468.76	115	28%	Well performance is down 26.67% from 2017 cleaning. Pump performance 8% below design curve when adjusted to full speed.

The important columns to note are the flow rate and wire to water efficiency. While these wells have an authorized rate of 453 gpm, in reality they are only producing at 288 gpm due to decreased yields. This is more prevalent in Well005, which has a wire to water efficiency of only 28%.

The WAC is currently in the process of developing and permitting a new water source to replace Well #005 with a new deep gravel packed well, with design dimensions of 24" x 18" x 65' deep. This well is being considered to be in the area of Well #001.

Well #005 is being replaced as its yield has been decreasing significantly in recent years. Though it is approved for 103 gpm it is currently only producing at 38 gpm. The replacement well is anticipated to utilize Well005's original authorized rate of 103 gpm.

The MDD is typically represented in gallons per minute, which is based on a 12-hour usage period. Based on the System's operating permit, the MDD for the water system is 453 gpm and translates to 326,160 gallons per day (gpd). Based on the well's actual current production, this MDD is actually 288 gpm and translates to 207,360 gpd which is less than the average daily use value from the past three years at 234,920 gpd.

ii. **Source Control** – The wells pump water which is injected with chlorine and achieves proper chlorine contact time through piping before entering the distribution system. The finished water storage tank is located on the west side of the system and floats on the water system. The level in the finished water tank is not maintained by floats, but rather by running the well pumps on timers to fit with daily usage. Based on current demands, this means that Well 1 runs from 4 am to 10 pm, and Well 5 typically runs from 5 pm to 11 am.

The WAC has determined that operating in this manner, based on current water demands, a typical water level between 29'-31' can be maintained in the tank. The system operates its well pumps approximately 18 hours a day, with both pumps running at times representing the peak usage hours in a given day. This is due to the wells not being able to produce at a rate high enough to meet daily usage within 12 hours. The operating hours are constantly changed to keep up with real-time water usage by the operator.

c. **Water Demand** - Water System Demand, as outlined in the Vermont Water Supply Rule (WSR), includes a water system's Average Day Demand (ADD) and Maximum Daily Demand (MDD).

The water system, through its telemetry and control systems, monitors and records the total water produced by metering the water that is produced by the wells. From 2020 to 2022, the calculated ADD based on metered records was 234,920 gpd. **Table 5** below shows the customer meter data for the 777 connections and a complete copy of the water records from 1998 to 2022 have been provided by the WAC and is included as **Appendix F**.

Table 5 Recent Produced Water Data

YEAR		Gallons Produced		
		2020	2021	2022
MONTH	January	7,447,100	8,036,900	7,050,981
	February	7,219,100	8,409,250	6,642,020
	March	6,560,200	8,871,220	5,959,930
	April	5,512,500	7,390,827	5,799,919
	May	6,215,700	8,036,505	6,815,023
	June	7,239,900	6,942,852	7,976,633
	July	8,288,000	7,252,075	7,976,633
	August	6,994,800	7,431,150	8,170,656
	September	6,625,500	7,099,881	8,095,313
	October	7,209,500	7,268,447	7,136,642
	November	6,857,500	6,567,261	7,135,830
	December	6,026,100	6,627,623	6,347,960
Total		82,195,900	89,933,991	85,107,540
Average Monthly Production		6,849,658	7,494,499	7,092,295
Average Daily		225,194	246,394	233,171
MDD (gpm)		313	342	324

The highlighted cells represent monthly peaks for the last three years, in which it can be seen that these mostly occur in the summer. The high flow numbers that occurred in early 2021 are believed to be from several bad leaks, as noted by the water system.

Table 6 below compares the amount of water produced vs the amount of water which was billed to the customer. Due to the system's billing regime, this represents a time frame of a year between mid-2021 and mid-2022, and thus the water produced is from that same time frame. The raw billed information can be found within the customer list in **Appendix A**.

Table 6 Master Meter Water Produced

2021-2022			
Gallons Produced	**Gallons Billed**	**Difference**	**% Not Billed**
84,547,056	58,191,189	26,355,867	31.17%

Approximately 31% of water that is produced is not charged to the customer, pointing to potentially significant water loss within the system. In general, water production and water use for the system is trending down and the system utilizes approximately 69% of its permitted MDD of 341,280 gpd. There are a few different reasons for this potential decline, one being the effects of the Covid-19 pandemic. Another could point to less production of water due to addressing mains that had significant leaks. Otherwise, declining population would certainly reduce water production as well.

The Vermont Water Supply Rule states that a source's ability to meet the average day demand is based on pumping 12 hours per day. The existing water sources have a combined permitted source capacity of 453 gpm, which when pumped for 12 hours equals 326,160 gallons. Accounting for declining yields, though, the source capacity should be considered to be 207,360 gpd. The current system demand (based on the master meter not actual billed usage) is 234,920 gpd which is approximately 28,000 gallons per day more than the equivalent MDD of the wells.

While this apparent inability to meet MDD within 12 hours is certainly of concern, the WAC is already working towards addressing it with the replacement of Well005 with a new well which will have its original full yield. This will bring the system's 12-hour pumping back to a value of 254,160 gallons which will cover its ADD.

d. **Water Quality** - The existing wells and points throughout the service area are tested, per the requirements of the system's State Operating Permit, for a variety of water quality parameters. The source water has consistently met the requirements of the WSR for quality.

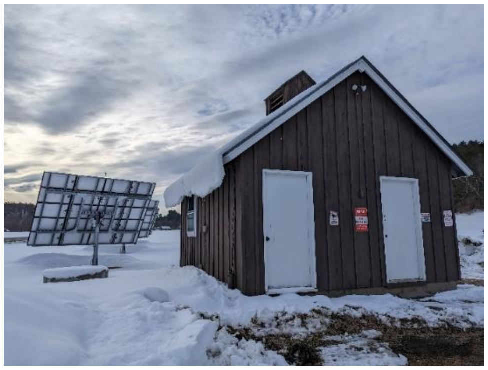
There have been sampled exceedances for lead at four addresses in the last three years within the water system. This could point to either the presence of lead or galvanized service lines, or older buildings which have fixtures that still contain lead.

Based on historical water quality sampling results and the recent PFAS samples collected, it appears the water system's sources raw water quality does not require additional treatment systems to meet current water quality standards. Although the addition of corrosion control to address lead exceedances, should continue to be monitored.

e. **Well 001 Well Pump Station –** The well pump building was constructed at the same time as the well itself in 1971 and is sited at 769 Barnard Road (VT Route 12). Refer to **Figure 1**. This land is owned by the WAC.

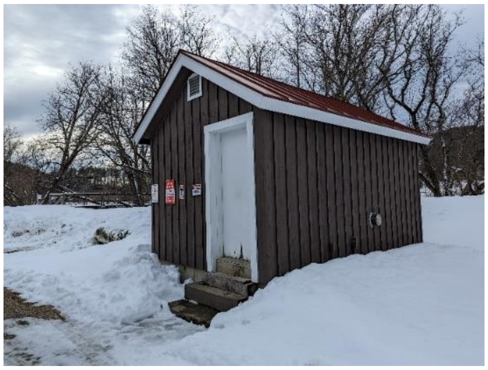
The building is constructed on concrete frost walls and a slab on grade finished floor. The exterior of the building is wood paneling. The Pump Station is in good condition overall.

Pump Model: Magnetek
Pumping Rate: GPD 506
Voltage: 460 V
Phase: 3 ph
Horsepower: 50 HP
Speed: 1780 rpm
Operating Point: 250 gpm at 344.54 feet TDH



f. **Well 005 Well Pump Station –** This well pump station was constructed around the same time as Wells 004 and 005 in 1993 and currently just serves Well 005. This building is located at 206 Stimets Rd. The land that this pump station is on is also owned by the WAC.

The building is constructed on concrete frost walls and a slab on grade finished floor. The exterior of the building is wood paneling. The Pump Station is in good condition overall.



Make: Yaskawa
Model: VFD
Voltage: 460 V
Phase: 3 ph

Horsepower: 15 HP
Speed: 3450 rpm
Operating Point: 38 gpm at 368.76 feet TDH

g. **Water Treatment** – The raw water quality meets all max contaminant levels (MCL) for regulated public water systems. The system provides continuous disinfection treatment by injecting sodium hypochlorite into the raw water at the wells before entering the distribution, which maintains a detectable residual throughout the distribution system. Treatment is provided at both well pump station locations, with TP001 treating water from Well 001, and TP002 treating Wells 004 (inactive) and 005. The water system is designed and permitted to apply a free chlorine concentration sufficient to provide 4.0 log inactivation. The peristaltic pump's rates are manually set to inject the needed chlorine into the system, and they are controlled by the well pumps. The chemical feed pump injects a 12.5% liquid sodium hypochlorite solution and chlorine contact time is achieved through piping post injection and before the first user to each well pump station.

The water treatment provided by the water system meets the Town's current needs and the requirements of the Water Supply Rule. There is currently no need for any associated improvements (beyond typical maintenance) or additional treatment systems. Although the addition of corrosion control to address lead exceedances, should continue to be monitored.

h. **Water Storage** - The water system is equipped with a single water storage tank. This tank is a 948,000 gallon 70-foot diameter fused glass to steel tank originally built in 1989. The tank was then rebuilt to be essentially new in 2002 after significant defects were found with the tanks paneling. The tank manufacturer replaced the tank at no cost to the water system. The tank overflow elevation is set at approximately 955.5 feet above medium sea level (m.s.l.) and the reported water depth in the tank is usually kept around 29-31 feet. Information about this tank is shown below in **Table 7**.

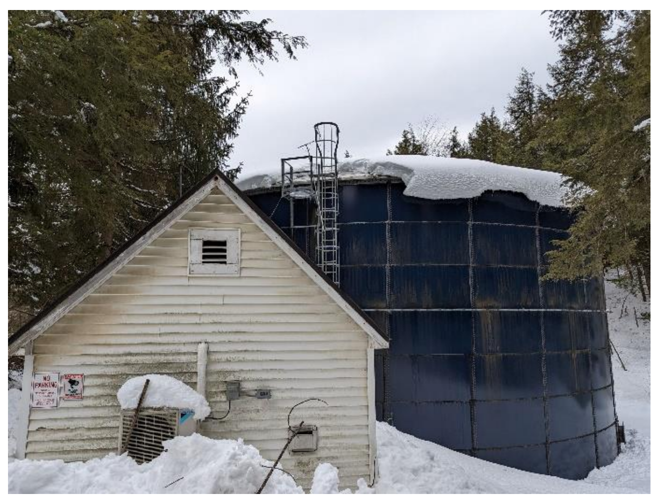


Table 7 Finished Water Tank Operational Volumes

Unit	Elevation (ft)	Height Above Finished Floor (ft)	Volume (gal)
Overflow	955.5	31.5	905,203
Outlet Pipe	924	N/A	0
Finished Floor	924	N/A	0
35 PSI at Highest Elev. in Distribution System	945.9	21.9	629,332
Min for ISO Fire Flow Capacity	955	30.7	881,280
Low Level	952	28	804,625

The minimum for ISO Fire Flow Capacity represents the storage required for a 3-hour 3,000 gpm firefighting event along with the ADD of the system.

Table 8 below also summarizes the Insurance Service Office's (ISO) recommended storage volumes for fire flow events of varying severity. These are generally based on building density and general construction makeup (i.e. wood framed, concrete, etc.). For example, the Woodstock downtown area would require a higher available fire flow value than some of the more rural connections on the outskirts of the service area.

Table 8 Fire Flow Volumes

Recommended Fire Flow (gpm)	3,000	2,000	1,000	500
Minimum Recommended Flow Duration (hours)	3	2	1	0.5
Required Fire Storage Volume (gallons)	540,000	240,000	60,000	15,000

WAC's water storage tank has the capacity to provide a fire flow of 3,000 gpm for 3 hours and still has enough capacity to satisfy the system's average daily demand, with a remaining 170,000 gallons of excess water stored. This is without factoring in the associated fill rate. This 3,000 gpm also corresponds to the system's basic fire flow as determined in its 2016 ISO report, included as **Appendix G**.

The tank is required to be inspected every 3-5 years and was last inspected in 2018. This report can be found in **Appendix H**. The inspection included the exterior and interior of the tank, to which it found that all outside elements were in good condition aside from a recommendation to clean off accumulated algae on the sidewalls. The interior was also found to be in good condition and the only recommendation in the tank inspection report was to install a new cathodic protection system. The tank will be inspected again in May 2023, according to the WAC owner.

i. **Water Distribution System** – According to conversations with the WAC, over 66% of the distribution system was constructed between 1890-1900 with the installation of the original water system, including the transmission mains that transmit water from the original earthen reservoir (now the location of the water storage tank). Refer to **Table 9** below for a general breakdown of pipe age range. It should be understood that the ages of the older pipes were ballpark estimates from the water system, and could be plus or minus 20 years, but would still put them at a minimum of 100 years old (which is the generally beyond expected useful life of ductile iron pipe).

Table 9 Distribution System Age

	0-100 Years Old	100+ Years Old
Length of Pipe (Miles)	5.88	11.55
% of System	33.74%	66.26%

Aside from minor water line improvements and additions, just 6% of the water mains were installed in the last 20 years. The major sizes and types of the mains are 4-inch and 8-inch, which comprise 77% of the system, and the pipe material varies from copper, ductile iron, galvanized, asbestos cement, pvc, and steel. A full breakdown of system pipe sizes and types is below in **Table 10**.

Table 10 Distribution Size and Type

Diameter (in)	Length (ft)	% of System	Material
1	372	0.40%	Copper
1.5	134	0.15%	Ductile Iron
	584	0.64%	Galvanized
2	2,270	2.47%	Ductile Iron
	1,553	1.69%	Galvanized
4	30,309	32.94%	Ductile Iron
6	414	0.45%	Asbestos Concrete
	6,688	7.27%	Ductile Iron
	2,412	2.62%	PVC
8	29,473	32.03%	Ductile Iron
	10,185	11.07%	PVC
	1,503	1.63%	Steel
12	6,115	6.65%	Ductile Iron

Over 48% of all the water mains are smaller than 8 inches. The Vermont Water Supply Rule Section 8.1.2. states that the minimum main diameter for systems with hydrants is 8-inch.

i. **Hydrants –** The water system currently has 96 hydrants connected to the system, and 53% of those hydrants are on undersized lines. A sanitary survey letter issued by the DWGPD dated July 24, 2013, and attached as **Appendix D**, identified that the system has insufficient fire flow in certain locations and that hydrants which could drop system pressures below 20 psi are not to be used. Since the issuance of the Sanitary Survey, WAC has developed an interim plan with the Fire Department and the DWGPD to allow continued use of all fire hydrants on the system. If any of the identified hydrants are used by the Fire Department, they will notify the WAC and the WAC will issue a voluntary Do Not Drink Notice and sample the water system, similar to a broken main. Once the WAC can demonstrate that there is no contamination issue through water quality testing (i.e. coliform and bacteria absent samples taken at least 24 hours apart) the Do not Drink Notice can be lifted.

To supplement this report, a Hydraulic Model was developed to further review current system hydraulics and the hydraulic impacts from proposed system improvements. Put simply, the hydraulic model was calibrated using hydrant flow tests and the current system demand. From the Hydraulic Model Report, **Tables 11 and 12** show the existing fire flows available throughout the system when the wells are on or off, and both conditions are important to note. Typically, the system is operated during the day with the wells on (during the time of the highest use), but a worst-case scenario of the system is when the wells are not running and the hydraulics of the system are based solely on the water storage tank. This existing model was calibrated using real field hydrant flow tests, the locations of which can be seen on **Figure 3**.

Table 11 Existing System Fire Flow Analysis Wells On

NFPA Color	Red	Orange	Green	Blue
GPM	(<500)	(500 - 1,000)	(1,000 - 1,500)	(1,500<)
Hydrants	23	72	1	0
% of Total	24.0%	75.0%	1.0%	0.0%

25% of the hydrants cannot provide over 500 gpm while keeping the rest of the system at 20 psi or above while the wells are pumping.

Table 12 Existing System Fire Flow Analysis Wells Off

NFPA Color	Red	Orange	Green	Blue
GPM	(<500)	(500 - 1,000)	(1,000 - 1,500)	(1,500<)
Hydrants	95	1	0	0
% of Total	99.0%	1.0%	0.0%	0.0%

When the wells are off, only 4 of the hydrants on the system can provide over 500 gpm fire flow while maintaining 20 psi throughout the system.

Obviously, this is a significant deficiency for a water system which provides fire protection. The WRS should be considered a minimum standard related fire protection and the issue is exacerbated further when consider the ISO standards described in previous sections.

j. **Financial / Water Billing** – The Town's financial/water billing information can be found below in **Tables 13, 14, and 15.** Note that the total yearly operating expense of the system as of 2021 was $514,716, which includes a current debt service of $88,956. The total-long term outstanding debt for the water system is $741,307, which is expected to be paid off over the next 15 years. A copy of the current operating budgets is within the system financial reports included in **Appendix I**.

Table 13 below shows the rates that the WAC charges its users. Considering that most residential units will be on 1" service lines (or less), this means that the system is charging $67.25 per quarter or $269.00 per year. The (DWSRF) recommends charging 1-2% of the median household income (MHI) per year for water. With Woodstock's MHI at $104,716, the WAC is only charging 0.3%, or only a tenth of the normally recommended value.

Table 13 Revenue Information

Charge	Rate
New Connection Charge	$500.00
Disconnection Charge	$100.00
Reconnection Charge	$100.00
Quarterly Rate per Unit	$60.00
Capacity Charges per Quarter:	
1" Service Pipe	$7.25
1.5" Service Pipe	$12.00
2" Service Pipe	$19.95
3" Service Pipe	$43.80
4" Service Pipe	$58.40
6" Service Pipe	$90.00

Note: Consumption in Excess of 300 Cubic Feet Per Quarter - $0.02961 per Cubic Foot ($29.61 per 1,000 Cubic Feet)

Table 14 summarizes the annual operating margin of the water system between 2016 and 2021. There is considerable fluctuation, which is driven by variable expenses (such as water main repairs), but on average the system has netted $10,000 per year.

Table 14 Water System Financials

Year	Revenue	Expenses
2016	$460,456	$424,082
2017	$467,504	$470,085
2018	$480,482	$445,216
2019	$483,920	$509,473
2020	$447,782	$440,100
2021	$514,716	$505,902
Total	$2,854,860	$2,794,858
Average Expenses		$465,810
Average Revenue		$475,810
Available for Debt		**$10,000**

Table 15 below shows the water system's current debts owed and when they are to be paid off.

Table 15 Total Water System Debts

Source	Payoff Date	Monthly Payment	Total Owed
Mascoma Savings Bank	2030	$2,227	$199,608
Kubota Credit Corp	2025	$1,481	$71,066
Mascoma Savings Bank	2027	$1,263	$77,699
Vermont Economic Development Activity	2038	$2,442	$392,934
Total		**$7,413**	**$741,307**

k. **Water/Energy/Waste Audits** – Water production is recorded through master meters at the wells. Usually, high daily flows to the distribution system are monitored by the Water System Operator. Consistent, above-average flows are indicative of water system leaks, which are subsequently located and repaired on an as-needed basis.

3.0 NEED FOR PROJECT

The Town needs to address the hydraulic deficiencies in their distribution system while also planning for future capital improvements to ensure that the water system remains cost efficient and affordable to all users. Utilizing the hydraulic model developed as part of this report, the following sections will identify and prioritize a list of water system improvements (capital improvement plan) for the system to consider. Projects will be prioritized based on addressing the current hydraulic deficiencies in the system and effects on future improvements to the water system.

Alternatives to consider include:

1A. Upgrade 8-inch transmission main on Cox District Road from the water storage tank

1B. Upgrade transmission line and Route 4 water main into Village center

2. Add an additional water storage tank on eastern end of distribution system closer to the water sources

Considerations to be included:

a. **Health, Sanitation, and Security** – As mentioned previously, the WAC's current sanitary survey letter identifies that the system has hydrants which could not provide at least 500 gpm without dropping pressures at any part of the system below 20 psi. This standard is in place to prevent contamination of distribution network during fire flow events.

   Exacerbating this risk is the fact that the majority of the WAC's service area overlaps with the Town of Woodstock's sewer service area. While highly unlikely, a leak of both in the same area could produce a pathway for waste to enter the drinking water network.

   All the alternatives considered are intended to increase the system's fire flow capacity and negate any potential health effects due to potential contamination.

b. **Aging Infrastructure** – Almost two-thirds of WAC's distribution system is over 100 years old, which generally exceeds the service life of ductile iron pipe. Not only is this pipe beyond its useful life, but since the system ran off the surface water reservoirs up until 1971, the piping would likely be significantly tuberculated. The table below shows the water main repairs that the system has had to do over the last 3 years, and their associated cost. The system has not yet had any repairs this year. As the system piping continues to age, breaks will become more frequent and severe.

Table 16 WAC System Repairs

Date	Main Size		Location	Cost
2019				
1/9/2019	12"		Rte. 12 Leak by BF&M	$ 11,134.56
2020				
5/27/2020	6"		Fix Leak by The Green	$ 2,740.10
11/16/2020	2"		Border Lane 2" Main Fix	$ 545.00
11/30/2020	4"		College Hill 4"Main Fix and Gravel 11/30/2020	$ 924.24
2021				
2/4/2021	8"		Elm St 8" Main Repair 2/4/21	$ 7,275.00
2/12/2021	4"		Elm St. Leak 2/12	$ 2,955.21
2/13/2021			Central St Leak 2/13	
3/23/2021	4"		3/23/21 River St. Leak	$ 270.50
3/29/2021	8"		3/29/21 Woodstock Rd Leak	$ 704.44
4/16/2021	4"		4" Main Fix Rte 4 in front of Cumberland Farms	$ 4,510.00
6/2/2021	4"		Water Leak By 45 Elm St	$ 3,310.40
8/12/2021	8"		Invoice 24999 Elm St. 8" Main	$ 3,507.60
8/16/2021	2"		Atwood Ave. Leak	$ 515.72
11/9/2021	4"		Invoice 25145 Golf Ave Valve	$ 3,207.44
	Total Breaks	14	Total Cost	$ 41,600.21

Figure 4 shows where these repairs occurred, or where they generally occurred as full addresses were not given for the repair locations. The majority of the repairs have been in the Downtown Woodstock area.

While none of the alternatives propose major pipe replacement in the immediate downtown, replacing some of the transmission piping leading to the downtown or adding an additional tank improves available water flow capacity and thusly allows the system to continue to function without pauses to service.

Due to the hydraulic issues and the current conditions of other water system components, improvements to the water sources and current water storage tank were not discussed further in this report.

c. **Reasonable Growth** – Over the last 20+ years, Woodstock has experienced a declining population mixed with addressing of water main breaks which has led to a decrease of needed water production of 100,000 gallons per day. If the WAC is successful in replacing Well005 with a new source which can utilize its full authorized rate of 103 gpm, the system should be able to produce 254,160 gallons a day with only 12 hours of pumping. This would leave a reserve capacity of approximately 19,000 gpd.

At the current average usage, the full water storage tank could provide a little over 28 hours of storage without bringing pressures anywhere the distribution system below 35 psi.

These alternatives mainly focus on addressing hydraulic related issues and increasing available fire flows, which could potentially incentivize growth as it may have an effect of decreasing building insurance rates for the service area. While assuredly not a primary deciding factor, lower rates and a higher sense of safety could certainly be positives for growth.

4.0 ALTERNATIVES CONSIDERED

Alternative No. 1A – Water Storage Tank Transmission Main Upgrade

a. **Description** – Since the main issue of the water system is a lack of available fire flow, this alternative looks at reducing friction loss in the transmission main by increasing the diameter. The current transmission main an 8-inch main which is over 100 years old. Even assuming this pipe has its original internal diameter (i.e., no tuberculation has occurred), a new 12-inch pipe would have almost 3 times the carrying capacity.

b. **Design Criteria** – The transmission main alignment would be the design item to be addressed. The current main goes cross country down to Route 4. An alternative route would be for the main to follow Cox District Road. Following Cox District Road, the piping would traverse approximately the same distance as the current main route, so the amount of piping necessary would be the same.

Following the route down Cox District Road would provide for easier continuation of service, as the existing line could be left undisturbed throughout construction. The cross-country route also would require clearing of trees, access road work, and field locating of the main, as precise mapping of the older main is nonexistent. Maintenance of the new transmission main would be easier than replacing the existing main in its current location. For these reasons this alternative will only consider the transmission main upgrades to be done along Cox District Road.

c. **Map** – Refer to **Figure 5**

d. **Environmental Impacts** – In the area of this upgrade, there are very few environmental aspects to consider. Mainly, Cox District Road follows a small stream which is fed by both the Vondell and Cox Reservoirs. While the road is near its river corridor, it is not considered a flood risk.

There is also the presence of a rare, threatened, and endangered plant species, but impacts from this are anticipated to be minimal as this species does not have any State or Federal protections. See **Appendix J** for this alternative's ANR Maps.

e. **Land Requirements** – Replacing the transmission main along Cox District Road would require an easement along the road from the town. Otherwise, no additional land would need to be procured for the construction of this alternative.

f. **Potential Construction Problems** – Although ANR mapping does not show any significant presence of bedrock in the area, bedrock could still pose a significant obstacle for this alternative. Therefore, ledge probes and soil borings will need to be included in the final design scope of services.

By proposing a new alignment, this alternative addresses the need to keep the water storage tank online throughout construction.

g. **Sustainability Considerations** – In addition to improving system pressure and fire flow conditions, replacing the main will reduce leakage, replace a high value system asset, and extend the overall useful life. Relocating the main along Cox District Road would improve access and corresponding maintenance cost. The WAC has a high amount of lost water within the distribution system, and reducing lost water will also reduce the cost associated with pumping and treatment.

This alternative also allows for the existing main to be utilized as a backup transmission main under emergency conditions.

h. **Hydraulic Benefit of Alternative** – In conjunction with this PER a hydraulic model report has been developed which allows reviews of the hydraulic benefits for each alternative considered. The model was calibrated using pipe age information from the water system, field calculated fire flow values, and current system usage demand under both operational scenarios (wells on and wells off).

For the alternatives, the system was modeled with demands which would represent their full MDD, being 453 gpm when all sources are operated.

The fire flow (with well pumps not running) output for this alternative is shown below in **Table 17**.

Table 17 Fire Flow Output

		Note
Max gpm	2,907	
Max gpm Hydrant	H-57	Route 4 Below Upgraded Main
Min gpm	162	
Min gpm Hydrant	H-32	South Street at Dead End
Average Fireflow (gpm)	822	
Fireflow Increase from Existing (gpm)	145%	

This alternative more than doubled the average available fire flow from the current system. **Table 18** below, shows that the alternative reduces non-compliant hydrants from 95 to 17.

Table 18 Fire Flow Hydrant Summary

NFPA Color	**Red**	**Orange**	**Green**	**Blue**
GPM	**(<500)**	**(500 - 1,000)**	**(1,000 - 1,500)**	**(1,500<)**
Hydrants	17	58	14	7
Difference from Existing	-78	+57	+14	+7
% of Total	17.7%	60.4%	14.6%	7.3%

As expected, the hydraulic benefit is greater with the wells on. See **Tables 19 and 20** below for those results.

Table 19 Fire Flow Output with Wells On

		Note
Max gpm	3,325	
Max gpm Hydrant	H-89	Route 4 Below Upgraded Main
Min gpm	191	
Min gpm Hydrant	H-32	South Street at Dead End
Average Fireflow (gpm)	912	
Fireflow Increase from Existing (gpm)	172%	

Table 20 Fire Flow Hydrant Summary with Wells On

NFPA Color	Red	Orange	Green	Blue
GPM	(<500)	(500 - 1,000)	(1,000 - 1,500)	(1,500<)
Hydrants	13	62	10	11
Difference from Existing	-82	+61	+10	+11
% of Total	13.5%	64.6%	10.4%	11.5%

i. **Cost Estimate** – **Table 21** outlines estimated construction costs for this proposed alternative.

Table 21 – Construction Cost

Table 21 Construction Cost Estimate Water System Improvements				
Item	**Unit Quantity**		**Unit Cost**	**Total Cost**
12-inch C900 PVC Transmission Water Main and Appurtenances	3,810	L.F.	$ 210.00	$ 800,100.00
Interconnection	2	L.S.	$ 10,000.00	$ 20,000.00
General Conditions / Misc. Work	1	L.S.	$ 103,000.00	$ 103,000.00
			TOTAL OPINION OF PROBABLE COST =	**$ 923,000.00**

Alternative No. 1B – Transmission Main and Route 4 Upgrade

a. **Hydraulic Benefit of Alternative** – Produced in conjunction with this PER was a hydraulic model report, which took an existing water system model and updated it through hydrant flow testing in the summer of 2022. The model was calibrated using pipe age information from the water system and from the field calculated fire flow values, under both operational scenarios (wells on and wells off).

b. **Description** – This alternative, like Alternative 1A involves upgrading the transmission main coming down from the water storage tank but will then also include upgrading the 8-inch water main along Route 4 to the bridge over the Ottauquechee River.

c. **Design Criteria** – On top of the transmission main replacement (3,700 feet), this alternative includes approximately 6,900 feet of replacement down Route 4.

   There are currently 7 fire hydrants along this stretch of Route 4 whose condition should be considered whether they need replacement.

d. **Map** – Refer to **Figure 6**

e. **Environmental Impacts** – Aside from the environmental resources present in Alternative 1A, this alternative includes several more which are expanded upon below.

   - Rivers – In following Route 4, the pipe replacement would also be following the Ottauquechee River. Along this stretch, the Ottauquechee is identified as a stressed water due to sediment, physical alteration, and temperature. So as not to add on to the sediment problem, an erosion prevention and sediment control plan will have to be developed and strictly followed.

   - Wetlands – There are minimal wetlands and wetland advisory layers along this stretch of Route 4.

   - Hazardous Waste Sites – Three hazardous waste sites exist in the area of this alternative, and they are described below.

     - Former Cabot Building (Site Number 931364): During an underground heating oil tank closure at this site on January 26, 1993, contamination was discovered in the tank cavity within the soil. The pit showed very high levels of petroleum hydrocarbon contamination. A site investigation determined that removal of affected soils and installation of groundwater monitoring wells was the best course of action. Following this, the site was closed on September 1, 1993.

- Woodstocker Inn (Site Number 20063548): Similar to the Former Cabot Building, contamination was discovered at this site during an underground heating oil tank closure, which took place on July 5, 2006. Additional investigation in August 2006 included the installation of 3 monitoring wells, though none of them encountered water. Soils samples were taken during the boring of these wells and found lingering contamination, but at low enough levels which did not require further action. The site was closed on December 11, 2006.

- Woodstock Recreation Center (Site Number 20073627): On January 6, 2007, at the site of a former garage/auto sales operation, heating oil contamination was discovered during the removal of a 1,000-gallon underground storage tank, noted to be in poor condition, in which an estimated 900 gallons had been released into the soil. Following the initial cleanup, several groundwater monitoring wells were installed to determine the extent and severity of contamination.

  An additional tank was discovered and removed after Tropical Storm Irene, followed for removal of 7.13 tons of visibly stained soil in May 2012. Site monitoring continues to this day and the site carries a priority designation of Medium, meaning nearby sensitive receptors are potentially threatened with contamination.

• Prime Agricultural Soils – Along Route 4 in this area there are a couple swaths of land that’s identified has having prime agricultural soil. However, most of the work for pipe replacement will take place within the road corridor or in areas which have been previously developed and no longer can be agriculturally useful, so there will not be any impact on existing or future agricultural practices.

f. **Land Requirements** – It’s assumed that no additional easement would be needed for replacement along Route 4.

g. **Potential Construction Problems** – Aside from hitting layers of bedrock which appear to be present in a couple areas, other potential construction problems would stem from working within the Route 4 corridor in general. Traffic control alone will be an issue. From 2019-2021 there was an Annual Average Daily Traffic

(AADT) of 5,750 cars per day. Traffic control measures during construction will be a necessity and a substantial cost associated with this alternative.

This section of main also has several other utilities to consider and design around. This includes the existing water mains, overhead power lines, sewer lines, and stormwater infrastructure (see **Appendix J** for the sewer and stormwater infrastructure present). These factors will increase the costs associated with providing temporary water which will be necessary for this alternative.

h. **Sustainability Considerations** – Replacing the mains will reduce leakage, improve water availability, and relocating the main along would improve access and corresponding maintenance cost. The WAC already has a high amount of lost water within the distribution system, and reducing lost water will also reduce the cost associated with pumping and treatment.

i. **Hydraulic Benefit of Alternative** – Like Alternative 1A, this alternative was also analyzed through hydraulic modeling. The fire flow output is shown below in **Table 22**.

Table 22 Fire Flow Output

		Note
Max gpm	3,441	
Max gpm Hydrant	H-44	Route 4 East of Prosper Road
Min gpm	168	
Min gpm Hydrant	H-32	South Street at Dead End
Average Fireflow (gpm)	1,216	
Fireflow Increase from Existing (gpm)	263%	

This alternative more than tripled the average available fire flow from the existing system, and in **Table 23** below, took 80 hydrants out of the non-compliant <500 gpm category. This upgrade also increased the fire flow of half of the hydrants to over 1,000 gpm.

Table 23 Fire Flow Hydrant Summary

NFPA Color	Red	Orange	Green	Blue
GPM	(<500)	(500 - 1,000)	(1,000 - 1,500)	(1,500<)
Hydrants	12	35	27	22
Difference from Existing	-83	+34	+27	+22
% of Total	12.5%	36.5%	28.1%	22.9%

With the wells on, the hydraulic benefit of this alternative was even greater. See **Tables 24 and 25** for this analysis.

Table 24 Fire Flow Output

		Note
Max gpm	3,490	
Max gpm Hydrant	H-90	Route 4 East of Prosper Road
Min gpm	194	
Min gpm Hydrant	H-32	South Street at Dead End
Average Fireflow (gpm)	1,300	
Fireflow Increase from Existing (gpm)	287%	

Table 25 Fire Flow Hydrant Summary

NFPA Color	Red	Orange	Green	Blue
GPM	(<500)	(500 - 1,000)	(1,000 - 1,500)	(1,500<)
Hydrants	13	26	35	22
Difference from Existing	-82	+25	+35	+22
% of Total	13.5%	27.1%	36.5%	22.9%

j. **Cost Estimate** – **Table 26** outlines anticipated construction costs for this proposed alternative.

Table 26 – Construction Cost

Table 26				
Construction Cost Estimate				
Water System Improvements				
Item	**Unit Quantity**		**Unit Cost**	**Total Cost**
12-inch C900 PVC Transmission Water Main and Appurtenances	3,810	L.F.	$ 210.00	$ 800,100.00
12-inch C900 PVC Water Main and Appurtenances	7,890	L.F.	$ 200.00	$ 1,578,000.00
Fire Hydrants and Appurtenances	16	EA.	$ 5,000.00	$ 80,000.00
Water Service Pipe	1000	L.F.	$ 80.00	$ 80,000.00
Water Service Corporation Stop	50	EA.	$ 800.00	$ 40,000.00
Water Service Curb Stop	50	EA.	$ 900.00	$ 45,000.00
Traffic Control	1	L.S.	$ 55,000.00	$ 55,000.00
General Conditions / Misc. Work	12.5	%	$ 335,000.00	$335,000.00
			TOTAL OPINION OF PROBABLE COST =	**$3,013,000.00**

Alternative No. 2 – Additional Water Storage Tank

a. **Description** – This alternative reviews advantages of adding an additional storage tank to balance the system hydraulics, increase fire flow and a long-term replacement of the current water storage tank. The current tank's outlet is at approximately 924-feet above median sea level (msl), so a balancing tank should be at that same elevation. Review of areas with that elevation that are near the Village, show that there are several potential tank locations.

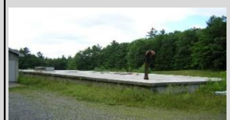
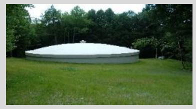
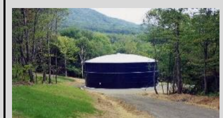
This alternative will only consider four of these locations, as they are reasonably close to the Village and at locations on the eastern side of the system (whereas the current tank is on the very western side). The four locations identified are shown in **Figure 7**.

- Tank Option 1 [Intentionally removed 10/13/2023 for privacy]
- Tank Option 2 [Intentionally removed 10/12/2023 for privacy]
- Tank Option 3 [Intentionally removed 10/13/2023 for privacy]
- Tank Option 4 [Intentionally removed 10/13/2023 for privacy]

b. **Design Criteria** – Finding the proper location for the tank is imperative. Other than the elevation requirement, it is most ideal to find a spot which is relatively flat and easily accessible. An additional consideration with the location is how noticeable the tank is. Considering Woodstock's historic setting and zoning overlay districts, it may be highly undesirable for the tank to be located in a spot where it could be easily seen from the downtown.

Besides location, tank type is also important to analyze. Shown in **Table 27** below are varying tank types, with their descriptions, applications, and pros and cons.

Table 27 Water Storage Tank Types

Summary of Alternative Water Storage Tank Types				
	Poured-in-Place Concrete 	**Pre-Cast, Pre-Stressed Concrete** 	**Painted, Welded Steel** 	**Glass-Fused-To-Steel** 
Maintenance	Minimal	Minimal	Requires interior and exterior repainting every 20 years	Minimal
Constructability	Quality is subject to bidding contractor and subcontractors; usually requires more extensive design and construction review	Requires large level landing and staging area for casting pre-cast panels on-site; Two cranes are usually used to erect structure	Minimal clearing is required for construction; Many different suppliers, of varying quality; usually requires specialty consultants for quality control review of tank construction and painting	Only requires 10 feet of clearance around tank for construction; Roof is constructed on ground level and panels are erected by jacking the structure; largest equipment is a skid-steer
Expandability	Another chamber could be added on in future, if provisions are made in initial design.	None	None	Additional panels can be added to raise height (volume) of tank.
# of Chambers	Unlimited, normally two	One	One	One
Vandalism Potential	Negligible	Negligible	Can be shot through with rifle.	Can be shot through with rifle. Rock throwing can damage glass coating and aluminum roof.
Freezing	Can be partially or completely buried to minimize freeze potential.	Can be partially or completely buried minimizing freeze potential.	Relies on minimum 1/3 total volume turnover to keep water temperature above freezing. Surface ice will form. Cannot be buried.	Relies on minimum 1/3 total volume turnover to keep water temperature above freezing. Surface ice will form. Cannot be buried over 6' above floor.

The existing tank is glass-fused to steel, and to simplify the operation and maintenance of the system, a similar type of tank should be chosen for the new tank.

c. **Map** – **Figure 7** shows four potential tank locations on the eastern side of the water system.

d. **Environmental Impacts** – Based on a desktop review, none of the potential tank sites are anticipated to have impacts to wetlands, as none are mapped on the ANR Atlas. While the mapping is not exhaustive, it generally provides a good idea of the presence of wetlands. Site visits to these sites will need to be conducted to confirm this.

The only site that may be affected by the location of a hazardous waste site is the Woodstock Resort property, which would possibly connect to Route 4 in an area which has several hazardous waste sites north of the Pleasant Street intersection. The actual connection point to the system could be moved to avoid these, based on the sites hazard priority designation.

Locating the tank up a mountainside all but eliminates it from having potential effects to prime agricultural soils, as farming (and suitable agricultural soil) are typically found lower in the valleys. This is the case for these tank sites as none of them pose any impact on prime agricultural soils as they are not present.

Potentially complicating this alternative are protected lands around Woodstock that these sites are located in or nearby. These include Marsh-Billings-Rockefeller National Historic Park and Mt Peg park. It is unknown at this time if being near or within these lands precludes a tank construction project.

Only the Mt. Peg tank site location has the presence of significant wildlife. This includes significant natural community of Dry Red Oak-White Pine Forest, with a state rank of S3. This isn't the rarest of communities but could be an obstacle to construction.

Mt. Peg also covers a large deer wintering area, and both a plant and animal species which are rare, threatened, and endangered, and have state (but not federal) protections.

e. **Land Requirements** – Additional land and/or easements will be required to accommodate any of the potential tank sites and associated piping, as all locations are not owned or controlled by the WAC. Securing land is a critical path component to this alternative. Additionally, easements may be needed for the transmission mains from the tank down to the rest of the distribution network.

f. **Potential Construction Problems** – Since the tank will be located up a mountain/hillside, the slope of these locations could pose some construction issues, though the tank will be sited in a flatter area if possible. The issue of access will also need to be navigated, as construction materials and machinery will be necessary for tank construction (magnitude of these also determined by tank type).

As shown in **Appendix J**, shallow depth to bedrock may be an issue for some of these tank locations. This would affect not only the construction of the tank, but the transmission mains which would connect them to the rest of the system. Further exploration will be necessary during design.

g. **Sustainability Considerations** – A balancing tank in a different location would help improve water age characteristics, provide redundancy for direct conveyance of treated water to the system and offers a solution to replace the existing water storage tank once it gets beyond its useful life. A tank in another location would also allow the existing tank to be taken offline for maintenance.

h. **Tank Locations Analysis** – When considering which of these locations would best suit the water system, the main point of emphasis was put on which would be most hydraulically beneficial. This falls in line with the goals of the study which included improving fire flows and eliminating hydraulically deficient hydrants. Each tank location is summarized in the next subsections and their benefit to the system as produced in the model are shown.

   i. **Intentionally deleted specific location information of tank options.**

i. **Selected Tank Location** – Since this report is aiming to propose projects which would be the most hydraulically beneficial to the system, and eliminate fire flow deficiencies which currently exist, the selected tank location is that of Tank Option 1 [--------]. While Tank Option 4 does show a slightly higher hydraulic benefit, it'll be shown below that it's more costly than option 1, with a rather minimal additional benefit.

j. **Cost Estimate** – **Table 36** outlines estimated construction costs for these proposed tank options. Note that these costs only include pure construction costs.

Table 36 – Construction Cost

Table 36 Construction Cost Estimate Water System Improvements				
Item	**Unit Quantity**		**Unit Cost**	**Total Cost**
Tank Option 1				
950,000 gallon Glass Fused to Steel Tank	1	L.S.	$ 1,250,000.00	$ 1,250,000.00
Safety/Access Appurtenances	1	L.S.	$ 94,000.00	$ 94,000.00
Site Work	1	L.S.	$ 781,000.00	$ 781,000.00
12-inch C900 PVC Transmission Water Main and Appurtenances to Tank	3,180	L.F.	$ 150.00	$ 477,000.00
Access Road Improvements to Tank	1	L.S.	$ 50,000.00	$ 50,000.00
Allowance for Ledge Removal	1	L.S.	$ 100,000.00	$ 100,000.00
General Conditions / Misc. Work	1	L.S.	$ 413,000.00	$ 413,000.00
			TOTAL OPINION OF PROBABLE COST =	$ 3,165,000.00
Tank Option 2				
950,000 gallon Glass Fused to Steel Tank	1	L.S.	$ 1,250,000.00	$ 1,250,000.00
Safety/Access Appurtenances	1	L.S.	$ 94,000.00	$ 94,000.00
Site Work	1	L.S.	$ 781,000.00	$ 781,000.00
12-inch C900 PVC Transmission Water Main and Appurtenances to Tank	1,660	L.F.	$ 150.00	$ 249,000.00
Access Road Improvements to Tank	1	L.S.	$ 66,400.00	$ 66,400.00
Allowance for Ledge Removal	1	L.S.	$ 100,000.00	$ 100,000.00
General Conditions / Misc. Work	1	L.S.	$ 381,000.00	$ 381,000.00
			TOTAL OPINION OF PROBABLE COST =	$ 2,921,000.00
Tank Option 3				
950,000 gallon Glass Fused to Steel Tank	1	L.S.	$ 1,250,000.00	$ 1,250,000.00
Safety/Access Appurtenances	1	L.S.	$ 94,000.00	$ 94,000.00
Site Work	1	L.S.	$ 781,000.00	$ 781,000.00
12-inch C900 PVC Transmission Water Main and Appurtenances to Tank	1,020	L.F.	$ 150.00	$ 153,000.00
8-inch C900 PVC Transmission Water Main and Appurtenances	200	L.F.	$ 130.00	$ 26,000.00
Access Road Improvements to Tank	1	L.S.	$ 48,800.00	$ 48,800.00
Allowance for Ledge Removal	1	L.S.	$ 100,000.00	$ 100,000.00
General Conditions / Misc. Work	1	L.S.	$ 368,000.00	$ 368,000.00
			TOTAL OPINION OF PROBABLE COST =	$ 2,821,000.00
Tank Option 4				
950,000 gallon Glass Fused to Steel Tank	1	L.S.	$ 1,250,000.00	$ 1,250,000.00
Safety/Access Appurtenances	1	L.S.	$ 94,000.00	$ 94,000.00
Site Work	1	L.S.	$ 781,000.00	$ 781,000.00
12-inch C900 PVC Transmission Water Main and Appurtenances to Tank	1,900	L.F.	$ 150.00	$ 285,000.00
River Crossing	1	L.S.	$ 150,000.00	$ 150,000.00
Access Road Improvements to Tank	1	L.S.	$ 127,200.00	$ 127,200.00
Allowance for Ledge Removal	1	L.S.	$ 100,000.00	$ 100,000.00
General Conditions / Misc. Work	1	L.S.	$ 395,000.00	$ 395,000.00
			TOTAL OPINION OF PROBABLE COST =	$ 3,182,000.00

Additional Considerations - Review and Assess Opportunities to Expand the Service Area to Increase User Base and Overall Affordability.

a. **Description** – The theoretical service area (TSA) for the system, without booster pumping, would be any location in which the elevation is at or below 873'. This elevation represents the level below the typical water level in the storage tank in which a minimum of 35 psi could be achieved. There are some opportunities for expansion into areas not currently on the system which would not require boosting. Refer to **Figure 9** for the theoretical service area delineation.

   Mainly, areas which could be served are along the Route 4 and 12 corridors through the town. The majority of these areas, though, are low density and extending a main to serve these relatively small populations would be cost prohibitive. The area with the most potential would be the hamlet of Taftsville on the eastern side of the town. To serve this population approximately 2.25 miles of water main would need to be installed. Along with serving Taftsville, multiple residences could be served down the stretch, including the Blake Hill Townhouses development.

b. **Design Criteria** – The theoretical service area was developed based on meeting minimum pressure requirements outlined in the Water Supply Rule and assuming no additional booster pumps or new water storage tanks. The TSA is intended to demonstrate where service could be extended based on the current hydraulic constraints of the water system. The TSA shown only includes areas within the Town of Woodstock and does not extend beyond Woodstock's town boundary in to neighboring towns.

c. **Environmental Impacts** – Refer to **Appendix K** for the ANR maps which depict the environmental resources of the selected expansion location. Of most note is being within the river corridor and floodplain, which is not expected to have any hindering effects to a potential expansion.

   The other element needing attention is avoiding any impacts to sewer collection systems in the area of Route 4 and in Taftsville.

d. **Land Requirements** – There should be no need for additional land for this alternative as it is proposed to occur entirely within the Town and State ROWs.

e. **Potential Construction Problems** – Not all utilities of the areas are known and there could be complications that arise from the areas which are connected to sewer collection systems. The extent of bedrock is also unknown for the expansion route.

f. **Analysis of Theoretical Service Area (TSA)** – The TSA of the water system extends well beyond the current system's service limits. Extension of the water system is possible and should be considered on a case-by-case basis. New connections to the water system should be identified by the TSA to ensure adequate service can be provided before new water allocations are issued. The extents of the TSA can be seen in **Figure 9**.

Estimate of Total Project Cost– Beyond the actual construction costs, project expenses also include:

Technical Services – Over the years, the Agency of Natural Resources and United States Department of Agriculture (Rural Development) have developed a technical services fee "curve" for water supply projects which is used as a general guideline during the planning and preliminary engineering phases of a project for assessing the engineering level of effort. The "fee curve" is based directly on the estimate of construction cost for each alternative and is a good starting point for engineering fees at this phase of project development.

Land Acquisition – None of the alternatives being considered, outside of source development, would require any additional land. Land acquisition would only be required if the Town proceeded with the development of a second groundwater source.

Legal/Fiscal/Administrative Expenses – In addition to the technical fees, projects of this nature will incur costs for legal and accounting services. In some instances, additional fiscal expenses for short-term (interim) financing will be required in order to bridge the gap between expenditures and the release of project funds.

Contingency – Given the early stage of this project, it is prudent to include a contingency in the overall budget to account for variability of construction, material, and equipment costs, as well as unanticipated design considerations. An overall project contingency of 25% has been included and is consistent with industry standards for cost estimating.

Table 37 provides a summary of Total Project Cost by alternative.

Table 37						
Total Project Cost Summary by Alternative						
	Alternative 1A	Alternative 1B	Tank Option 1	Tank Option 2	Tank Option 3	Tank Option 4
Construction Cost	$ 923,000	$ 3,013,000	$ 3,165,000	$ 2,921,000	$ 2,821,000	$ 3,182,000
Technical Services (25%)	$ 230,750	$ 753,250	$ 791,250	$ 730,250	$ 705,250	$ 795,500
Land Acquisition (5%)	$ -	$ -	$ 158,250	$ 146,050	$ 141,050	$ 159,100
Legal Administration (1%)	$ 9,230	$ 30,130	$ 31,650	$ 29,210	$ 28,210	$ 31,820
Contingency (20%)	$ 184,600	$ 602,600	$ 633,000	$ 584,200	$ 564,200	$ 636,400
Total Project Cost	**$ 1,347,580**	**$ 4,398,980**	**$ 4,779,150**	**$ 4,410,710**	**$ 4,259,710**	**$ 4,804,820**

5.0 SELECTION OF AN ALTERNATIVE

In selecting a recommended alternative, considerations of both monetary and non-monetary factors should be made. Factors considered when evaluating the alternatives included:

a. **Affordability (Capital Cost)** –For comparison, all of the project alternatives were reviewed with the following funding:

Funding Source: DWSRF
Loan Term: 40 Years
Loan Subsidy: 0

Since WAC is a private company, they are not eligible for any loan subsidy.

Table 38			
Effect on Annual User Rates - All Project Alternatives			
	Funding / Financing Scenarios		
	Alternative 1A	**Alternative 1B**	**Alternative 2 Tank Option 1**
Project Cost[1]	$ 1,347,580	$ 4,398,980	$ 4,779,150
Total Financing Required	$ 1,347,580	$ 4,398,980	$ 4,779,150
% Grant	0%	0%	0%
Grant	$ -	$ -	$ -
Loan	$ 1,347,580	$ 4,398,980	$ 4,779,150
Amount Borrowed	$ 1,347,580	$ 4,398,980	$ 4,779,150
Interest Rate	2%	2%	2%
Loan Term	40	40	40
Annual Debt Service Payment	**$ 49,262**	**$ 160,808**	**$ 174,705**
Number of Users	**2,473**	**2,473**	**2,473**
Annual Cost Per User	**$ 19.92**	**$ 65.03**	**$ 70.65**
Monthly Increase	**$ 1.66**	**$ 5.42**	**$ 5.89**
Notes:			
1. Project Cost is as outlined on the Project Cost Summary, and includes construction cost, technical			
General Notes:			
A determination of funding eligibility is required from both Rural Development (RD) and DWSRF approval.			

Under this funding scenario, annual increases for the alternatives range from just $1.66 to $5.89 per ERU. The table also demonstrates that Alternative 2 will have the highest impact to user rates. The recommendation of this report is to pursue Alternatives 1B and 2 in a phased approach, as this will have the greatest impact to the system hydraulically. While this would increase the user rates by $11.31 per month (an equivalent increase of 34% per month), this would still only put WAC's charged rates at .4% of Woodstock's MHI.

b. **Design Life** – The design life of the replacement project should exceed the terms of the loan. For this project, the design of all alternatives should exceed 40-years. With an expected life expectancy of 60 to 80 years.

Summary

Although the options are laid out as Alternatives, OCE is recommending pursuing both Alternatives in phases. Paramount to the system is Alternative 1A, which has a large impact for the relatively low cost and complexity of project. Since Alternative 1B includes the improvements of 1A, this is recommended as the first phase. OCE is recommending Tank Option 1. Although the tank's proposed location is on Federal Government land and may add complexity to potential construction and associated timelines, the location of the tank and where it would connect to the rest of the system is the most beneficial, in terms of hydraulics and cost, of all the tank locations.

6.0 PROPOSED PROJECT

1. **Preliminary Project Design –** It is recommended that the WAC proceed with constructing, in phases, Alternative 1B and Alternative 2**.**

   a. **Preliminary Design Consideration** – Alternative 1B will replace the distribution main from the water storage tank down to the Cox District Road Route 4 intersection. The replacement would continue along Route 4 to bridge. Depending on landowner negotiations, design of Alternative 2 could be done simultaneously with Alternative 1B or consecutively.

      This prioritization of improvements is based on OCE's opinion of the following criteria:

      i. Effect on the safety, health, and welfare of the public.
      ii. Regulatory compliance.
      iii. Engineer's Opinion of Risk, Cost and Benefits.

   b. **Permit Requirements** – The proposed project will require a number of State permits prior to the start of construction. Based on our understanding of the project at this time, we anticipate needing to obtain the following permits:

      i. State of Vermont DWGPD General Permit
      ii. State of Vermont ANR – Stream Alteration Permit
      iii. US Army Corps of Engineers – General Permit
      iv. State of Vermont ANR – Construction General Permit
      v. State of Vermont Agency of Transportation, Section 1111 Work-in-Right-of-Way Permit
      vi. Local permit for construction within the Flood Hazard area.

   c. **Project Schedule** – The schedule below is based on Alternative 1B only since that alternative does not require third party participation. For the purpose of this preliminary engineering study, we have included an approximate design, shown below on **Table 39**.

   d. **Construction Cost Estimates** – Based on the previously described recommended improvements, preliminary opinions of construction cost have been prepared. These estimates are based on experience with similar construction projects, recent construction bid tabulations, and our current understanding of the site conditions and project scope.

At this phase in project estimating, some assumptions have been made on the following, among others:

i. General soil conditions / depth to groundwater..
ii. Depth to ledge / volume of ledge to be removed.
iii. Bituminous concrete pavement disturbance and replacement (not included with WAC's project), and
iv. Regulatory and funding requirements

Table 40 and 41 show the effects on users rates under two specific scenarios. Table 40 shows the effect on users rates assuming the project is eligible for Drinking Water State Revolve Fund at 2% interest and no subsidy. This table assumes the Town takes ownership of the water system and using its bonding capacity to support the project.

Table 40 Effect on Annual User Rates	
	Alternatives 1B and 2
Project Cost[1]	$9,178,130
Total Financing Required	$9,178,130
% Grant/Subsidy	0%
Grant	$0
Loan	$9,178,130
Amount Borrowed	$9,178,130
Interest Rate	2%
Loan Term	40
Annual Debt Service Payment	**$335,513**
Number of Users	**2,473**
Annual Cost Per User	**$135.67**
Monthly Cost Per User	**$11.31**
Notes:	
1. Project Cost is as outlined on the Project Cost Summary, and includes construction cost, technical services and contingency.	
General Notes:	
A determination of funding eligibility is required from DWSRF	
Loan terms and conditions shown as estimates. Actual funding determination made with application approval.	

Table 41 shows the effect on users rates assuming current market interest rates assuming the WAC can collateralize the loan or receives similar terms from a private equity. This table does not account for cost associated in applying for a rate increase with the Public Service Board.

Table 41 Effect on Annual User Rates	
	Alternatives 1B and 2
Project Cost[1]	$9,178,130
Total Financing Required	$9,178,130
% Grant/Subsidy	0%
Grant	$0
Loan	$9,178,130
Amount Borrowed	$9,178,130
Interest Rate	7%
Loan Term	40
Annual Debt Service Payment	**$688,444**
Number of Users	**2,473**
Annual Cost Per User	**$278.38**
Monthly Cost Per User	**$23.20**
Notes:	
1. Project Cost is as outlined on the Project Cost Summary, and includes construction cost, technical services and contingency.	
General Notes:	
Intrest rate shown based on current market rates	
Loan terms and conditions shown as estimates.	

7.0 FUNDING OPTIONS

If the water system becomes municipally controlled, funding for publicly-owned community water projects in Vermont is available from a variety of programs such as:

- USDA Rural Development (RD): grants and loans (typically 1-4%).
- Vermont Bond Bank: loans.

Otherwise, the funding is limited to:

- The Vermont Agency of Natural Resources Water Investment Division: low interest (0% to 3%) loans
- Securing private funding through outside sources

A goal of any water system improvement project is to make the necessary improvements at the lowest resultant cost to the user without compromising quality and longevity. By optimizing grant funding and minimizing the local share of the project, less debt retirement will be passed on to the individual system users. The water system is only eligible for funding from the programs listed if it ceases to be privately owned. These funding sources are described in detail below.

a. **Rural Development** - Funding for municipally owned water projects is available through Rural Development (formerly known as the Farmer's Home Administration). To be eligible for funding, an applicant must be:

- A public entity (such as a Town, Village, or Fire Town).
- Non Profit.
- Located in a community of less than 10,000 people.
- Unable to afford commercial credit.

There are also several requirements for a project to be eligible for Rural Development funding, specifically:

- The project must be financially feasible.
- It must be modest in size, cost, and design.
- The completed system must primarily serve residential users.
- The project should contain reasonable growth capacity.

Funding through Rural Development can take the form of either loans, grants or both. Loan rates are based upon financial need as determined by the municipalities (or systems) median household income (MHI) and currently range from the Poverty Rate (1.75%) to the Intermediate Rate (2.375%), to the Market Rate (3.00%), all subject to market fluctuation until fixed by a bond vote. Interest rates are fixed for the life of the loan, typically 40 years for water projects.

Grant funding is based upon economic need. To be eligible for RD grants, the project must:

- Service a community whose median family income is less than the State's 2015 non-metropolitan median household income ($55,176) and,
- Result in "reasonable user fees" upon completion of the project.

Reasonable user fees are defined as:

- The debt service portion of the annual user fee does not exceed 1% of the median household income (MHI).
- Total annual water cost is approximately 1.00 to 1.25% of MHI.
- Total user cost (debt service plus operation and maintenance) does not exceed the current average water cost in the State. Currently the average cost of water, per single family unit, is approximately $500± in Vermont (2017 Statistic).

As indicated above, both loan and grant eligibility is based upon determination of the median household income for the Town or service area, whichever is most advantageous to the applicant.

If the community's Fiscal Year 2015 MHI is below $44,141 the community is considered eligible for poverty rate funding. This category has a current loan interest rate of 1.750% and grant funding up to 75% of the project cost. However, to receive a grant over 45% of the project cost, the applicant must demonstrate a health related need for the project. These criteria should be discussed with USDA-RD immediately, before deciding on the overall project scope. Rural Development funding requires that the applicant first "spend" the loan portion of the funding package, before grants will be administered. If the MHI is between $44,141 and $55,176, the community is eligible for intermediate rate loans (currently at 3.75%) and grants up to 45% of the project cost. Woodstock's MHI far exceeds the MHI's mentioned above and thusly it does not qualify for favorable grant funding.

Additionally, USDA offers loan only programs for qualifying communities and projects which meet all of the criteria outlined above, with the exception of the income requirements above.

b. **Vermont Bond Bank** - Financing for municipal infrastructure projects is available from the Vermont Bond Bank. The term for water projects is 30 years and the interest rate is fixed at the time of the bond sale. Current municipal rates are between 4% and 5%, with no subsidy. OCE does not recommend the pursuit of funding directly through the Bond Bank for communities such as the Town.

The system as a privately owned company has the following funding options available to them:

c. **Drinking Water State Revolving Fund for Water Supply Project (DWSRF) -** The State of Vermont Drinking Water and Groundwater Protection Division (DWGPD) administers a combined Federal (EPA) and State Revolving Loan Program for community water system improvements. Various aspects of these programs are described as follows:

i. **Funding Priority List** - For a project to be eligible for DWSRF funding, it must be placed upon the Water Supply Project Priority List. Projects are ranked to ensure that the most critical needs receive first consideration in awarding available dollars. Projects are funded based on their priority and ability to proceed. If a project is not ready to proceed, it must reapply for the next year's funding. In general, DWSRF funding is limited to improvements to existing water systems and cannot be used to create new water systems.

ii. **Planning Assistance** - Planning for most water improvement projects requires investments in engineering and hydrogeological services before actual construction of any improvements can occur. To help offset the "front end" burden on the water system, the State can provide a DWSRF planning loan. DWSRF planning loans are not grants; they are 0% interest loans that must be paid back within 5 years or when the project goes to construction, whichever comes first. Planning advances are typically available for preliminary studies, hydrogeological services, final design, surveys, and the development of plans, specifications and bid documents. Such funding has been utilized for this preliminary study and may be used for final design, if the project proceeds. Once a project goes to construction, the previously issued planning loans are then rolled into a DWSRF construction loan, as discussed in further detail below.

iii. **DWSRF Construction Loans** - DWSRF is available for construction of water system improvements for both public and private community water systems. This fund provides low interest loans for all project costs associated with a water system improvement project. Interest rates vary between 0 and 3% for a 20 year loan term.

d. **Financing and Estimated Water Rates** - It is the opinion of OCE that the most advantageous funding for the project is to utilize the Drinking Water State Revolving fund. **Table 40** summarizes the anticipated project cost and impact on user rates. The user rates would increase approximately $135.72 per year as a result of the debt service from all phases.

8.0 CONCLUSIONS AND RECOMMENDATIONS

The primary goal of this evaluation is to identify necessary improvements to ensure that system users continue to receive safe, reliable, and affordable drinking water. Through the course of evaluating the existing facilities of the water system, Otter Creek Engineering was able to draw the following conclusions:

- The WAC is managed and maintained in a responsible manner by a Vermont Licensed Water System Operator.

- The system's sources have adequate water quantity and quality to meet the needs of the users.

- The existing water storage tank is adequate to meet existing and projected average daily demands of the water system.

- The water system has 23 of 96 hydrants which do not meet the water supply rule of providing 500 gpm while maintaining a minimum of 20 psi throughout the system when the well pumps are in operation. This number increases to 95 when the well pumps are off. Thusly, the fire suppression system does not meet recommendations outlined in the systems ISO report.

- The water system should consider adding in the proper telemetry for maintaining the level in its current water storage tank to supplement the manual way in which it is maintained currently.

- A large portion of the water distribution system is original and approaching the end of its useful life. The pipe sizes range between 1½-inch and 16-inch in diameter and consist of pvc, galvanized iron, ductile iron, steel, and copper piping. The distribution system material, age, pipe orientation and diameter have presented operational challenges for the WAC, and a long-range capital investment plan should be developed.

- Regardless of the immediate decision by the WAC, OCE recommends that they adopt a practice of slight increases to user rates annually. Although this will result in additional operating margin in the short-term, it will more importantly allow for increasing capital debt in the future, without significant increases in user fees. OCE would suggest increasing rates approximately $100 per year.

- The WAC should continue discussions with the municipality about taking ownership of the water system to allow for more funding options to be available to pay for system improvements.

- WAC should begin initial conversations with landowners for the 4 tank sites to determine interest and overall viability of each potential site.