Village of Watkins Glen

303 North Franklin Street
Watkins Glen, NY 14891

PRELIMINARY ENGINEERING REPORT

for the

VILLAGE OF WATKINS GLEN
COMPREHENSIVE WATER SYSTEM STUDY

December 2019

MRB Group Project No. 2330.19001

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I. Executive Summary

In September 2018, representatives of the New York State Department of Health met with the Village of Watkins Glen to conduct a sanitary survey of the public water system. This survey was performed in response to previous surveys and events related to the boil water order issued in August 2018.

In response to the recommended improvements outlined by the DOH, the following engineering study provides a comprehensive analysis of the existing Village of Watkins Glen water system. These improvements include water supply, treatment, storage, and distribution system to address water age, infrastructure condition, and water quality. A hydraulic model was used to evaluate system performance and identify problem areas in the network.

After a full economic analysis considering the capital costs, the recommended improvements were separated into individual subprojects. The following table lists each subproject with an associated cost.

Project	Description	Est. Cost
A	Raw Water Intake & Pump Station	$4,555,000
B	Water Treatment Plant	$4,548,000
C	Steuben Street Tank	$277,000
D	Steuben Street Pump Station	$236,000
E	Distribution Network	$5,972,000
	Total	**$15,600,000**

The Village, and users from the Towns of Dix and Reading comprise about 1,782 EDUs. According to the 2017 ACS survey, the Village MHI is $45,938. Based on the outstanding DOH violations and existing state of equipment, storage, and distribution, it is likely the Village would qualify for 0% Hardship financing through grant opportunities with EFC. Based on discussions with the Village leaders and financial advisors, the subprojects will be prioritized and addressed based on community need and associated financing as to limit a drastic increase in user cost. It is evident that the Village significantly benefit from a low interest loan and/or some grant funds to help offset these costs.

It is recommended that this Preliminary Engineering Report be used to pursue funding assistance from multiple agencies, including the Environmental Facilities Corporation (EFC) through the Drinking Water State Revolving Fund (DWSRF) and Water Infrastructure Improvement Act (WIIA), USDA Rural Development (RD), and the New York State Office for Community Renewal Community Development Block Grant (CDBG) program.

II. Background

The Village of Watkins Glen ("Village") water district encompasses approximately 2.2 square miles and is situated in the central portion of Schuyler County at the south end of Seneca Lake. The Village is considering improvements to its water supply, treatment, and storage, and distribution system to address the age, condition, and water quality issues identified by the New York State Department of Health (DOH) public water system sanitary survey on November 30, 2018. The Preliminary Engineering Report (PER) includes documenting the existing Village water district system, identifying needed improvements, evaluating alternatives, preparing capital cost estimates, and presenting funding scenarios and estimated annual user costs. The PER planning effort will support future Village funding requests.

The Village will likely seek funding from multiple agencies, including the Environmental Facilities Corporation (EFC) through the Drinking Water State Revolving Fund (DWSRF) and Water Infrastructure Improvement Act (WIIA), USDA Rural Development (RD), and the New York State Office for Community Renewal Community Development Block Grant (CDBG) program. These programs require a PER prepared in accordance with program requirements, as part of the funding application process.

III. WATER SYSTEM

A Village water system analysis required assembly of data from the subsequent sections, as well as the preparation of an updated system map. The Village Water District map includes major system components, including pipelines, hydrants, pumps, and storage tanks, and serves as a foundation for system analyses and recommendations. A system network map and key components is included in Appendix A.

A. EXISTING SERVICE AREA

Seneca Lake serves as the source water supply for the Village of Watkins Glen Water District. The Village is responsible for the WTP and water infrastructure in the Village. The Village is also responsible to provide treated potable water to out-of-district users in the Towns of Reading and Dix. The out-of-district water infrastructure is owned by the respective towns, but the Village has separate water supply agreements with both Towns. The agreements require the Village to provide all user billing services and normal system operation and maintenance. The Village is reimbursed by both municipalities for incurred costs associated with all improvements and repairs to Town water infrastructure. This PER only focuses on capital improvements to the Village owned and maintained water system.

According to the Village 2018 Annual Drinking Water Quality Report, the water distribution system serves a Village district population of 2,149 through 942 metered service connections. The average daily use for the Village was 431,841 GPD and total annual consumption was 157,621,979 gallons. The Town of Reading district #1/#3 and #2 serves a total population of 86 through 38 metered connections. The average daily use was 4,230 GPD and total annual use was 1,544,100 gallons. The Town of Dix serves a population of 201 through 82 metered connections. The average daily use was 467,854 GPD and total annual use was 169,222,487 gallons. The water system is comprised of two major pressure zones, controlled by the Steuben Street and Padua storage tanks. A copy of the 2018 annual drinking water quality report is included in Appendix B.

B. SYSTEM COMPONENTS

The following sections outline the flow of water through the system, starting at the Seneca Lake intake, through treatment, into storage, and out to distribution.

1. Intake and Raw Water Pump Station

   Watkins Glen Public Water System is supplied by surface water from Seneca Lake. The water enters a pump well at an on shore pumping station. The intake is a 12 inch ductile iron main installed in the early 1900s. This intake line extends approximately 300 feet from shore at a lake depth of 35 feet. The water is seasonally treated with gaseous chlorine for zebra mussel control at the intake structure. From the pumping station, the water is pumped to the filtration plant by two vertical turbine low-lift pumps equipped with variable frequency drives. The pumps are set to alternate and pump approximately 840 gallons per minute, with a maximum discharge rate of 1,300 gallons per minute. The last significant pump station capital project was completed in 1993.

2. Water Treatment Plant

   The Watkins Glen water treatment plant (WTP) is a direct filtration plant with four filter beds built in 1993. The plant typically produces water for approximately 60 to 120 minutes at a time, 3 to 12 times a day. The typical daily production in 2018 ranged from about 300,000 to 800,000 gallons. The variation in volume of water produced is dependent on water usage at large events held at nearby Watkins Glen International (WGI) racetrack and other local industry seasonal demands. The plant can produce a maximum of approximately 1.87 MGD, however, the plant is rated for 1.3 MGD based on capacity with one filter out of service for backwashing. Alum is injected into the raw water pipeline prior to a static mixer. Next, water enters the flocculation chamber, then spills over a weird into one of four filters. The filter media consists of 18 inches of anthracite over a 12 inches of sand. Gaseous chlorine is added for disinfection and blended phosphate is added for corrosion control as treated water leaves the plant to the Steuben Street Tank for storage.

3. Distribution System

   The Village distribution system consists of two pressure zones. The lower zone serves most of the Village proper and is supplied from the Steuben Street Tank. The pressure in this zone ranges from 80 to 90 psi. The upper pressure zone is supplied from the pump station adjacent to the Steuben Street Tank. The pump station provides water to the Towns of Reading and Dix, and to Watkins Glen International (WGI) racetrack. The pressure in this zone ranges from 40 to 150 psi, but the majority of areas are below 100 psi.

4. Water Storage

   The Village owns and maintains two storage tanks: the Steuben Street Tank located at the

WTP site, which provides water to the low pressure zone, and the Padua site tank, which provides water to the high pressure zone and out of district customers.

a. Steuben Street Tank

The Steuben Street Tank is a 500,000 gallon welded steel tank constructed in 1989 with a separate inlet and outlet which provides contact time for the system. The water leaves the tank to feed two pressure zones. The tank provides storage and pressure to the lower zone, while the adjacent pump station pumps water from the Steuben Street Tank to the upper zone and Padua Tank for storage. The pump station contains two alternating pumps with a discharging capacity of approximately 150 gallons per minute.

b. Padua Tank

The original Padua Tank was a 250,000 gallon steel tank built in 1934. In 2019, a replacement 325,000 gallon tank with an aluminum domed top was constructed and the 1934 tank was demolished. The new tank location is about 600 feet north of the 1934 tank, adjacent to an existing Village right of way for ease of accessibility. The tank has a single inlet/outlet pipeline controlled by a pressure transducer manhole. The Padua Tank feeds the upper pressure zone, as well as the restroom and laboratory sink in the WTP.

IV. Assessment of Existing Conditions

The following sections outline violations issued by the New York State DOH, water quality deficiencies, as well as problem areas related to system hydraulics. These sections serve as focus areas for recommendations and subsequent modifications and improvements. A copy of the DOH inspection report in included in Appendix C.

A. Current Violations

In late September 2018, representatives of the New York State Department of Health met with the Village of Watkins Glen WTP chief operator and former public works director to perform a sanitary survey of the water distribution system.

The following violations were issued with regard to Title 10 of the New York State Code of Rules and Regulations:

1. Subpart 5-1, Public Drinking Water System Subpart 5-1.71 (b) for failure to exercise due care and diligence in the operation of a water treatment plant or distribution system.
2. Subpart 5-1.52 in that the location currently used to collect entry point samples does not meet the definition of entry point.
3. Subpart 5-1.72 (c) for failure to record and/or retain turbidity and chlorine readings during the time the plant is in operation.

B. Hydrant Test and Fire Storage Analysis

Hydrant testing is an important part of comprehensive water distribution network analysis. It provides data for system pressures and flow rates, can assess the condition and operability of the network, and can address water quality issues. According to the AWWA, it is recommended to perform a hydrant test every 10 years.

According to the 2012 Recommended Standards for Water Works (Ten States), the minimum storage capacity for systems not providing fire protection shall be equal to the average daily consumption. Based on the storage calculations, the available storage without fire flow is approximately 0.81 MG, which exceeds the average daily demand of 0.5 MG.

According to the American Water Works Association (AWWA), between 500 and 1,500 gpm of fire flow are required for one and two-family residential dwellings for 2 hours. For commercial and institutional buildings, the required fire flow is a minimum 3,500 gpm for 3 hours.

Hydrant flow tests were conducted at nine (9) locations in the Village on September 26, 2019. Based on the results of the test, the available fire flow at 20 psi for each location was calculated, to be used in subsequent hydraulic model calibration efforts.

Both the Steuben Street Tank and Padua Tank were evaluated to determine if the total available storage would meet average daily design demand of 1 MGD plus the maximum fire flow of 3,500 gpm for 3 hours. This equates to 0.63 MG required for fire storage, and a total required storage of 1.63 MG. Tank calculations were based on the following storage requirements: operating, equalizing, standby, fire suppression, and dead, where fire suppression storage is the summation of the equalizing storage and standby storage. Based on the analysis, the total available storage plus fire flow was 1.71 MG, which exceeds the required storage of 1.63 MG. Therefore, no additional storage is needed. A full analysis of storage tank and fire flow calculations, as well as a map of the hydrant test locations and results are included in Appendix D.

C. System Deficiencies

The following sections discuss the general existing conditions of the water system and the associated deficiencies outlined by the DOH. The intent of this report is to address each deficiency and provide an analysis of alternatives.

1. Zebra Mussels

Zebra mussels were first detected in Seneca Lake during the summer of 1992. Zebra mussel infestations have a significant effect on the environment and economy. Young zebra mussels are microscopic and easily pass through the intake screens. The mussels prefer slightly alkaline water with temperatures between 68 and 77 degrees Fahrenheit, but can survive more extreme ranges. Although zebra mussels reproduce throughout the year, the peak period occurs in the late spring and early summer. The largest populations occur in late summer and early fall when the water temperatures rise above 65 degrees Fahrenheit.

Unfortunately, zebra mussels attach to anything, including other mussels, producing thick mussel colonies. With an affinity for water currents, zebra mussels extensively colonize water pipelines and canals, such as those in drinking water treatment plants. Once inside an intake, the mussels are protected from predation and the weather, resulting in large densities. Mussel growth on this scale can severely reduce water flow, result in loss of intake head, obstruct valves, clog condensers and heat exchangers, result in noxious tastes and smells in treated water, produce nuisance methane gas, and increase electro-corrosion of steel and ductile iron pipelines. The Village is currently combating high zebra mussel colonies by dispersing chlorine into the Lake at the intake box. Unfortunately, annual inspections show that this solution is only somewhat effective, and the system experiences many of the negative impacts listed above.

2. Chlorine Contact Time

The EPA reaffirms its commitment to the current Safe Water Drinking Act, which includes regulations related to disinfection and pathogenic organism control for drinking water supplies. The Surface Water Treatment Rule requires treatment for *Giardia lamblia* (*Giardia*) and viruses of all surface water and groundwater under the direct influence of surface water. Public water systems are required to comply with a new operating parameter referred to as a CT value, which is the concentration of free chlorine multiplied by the physical contact time in the storage tank. The CT value is used as an indicator of the effectiveness of the disinfection process. This parameter depends on pH and temperature to remove or inactivate *Giardia* and viruses that could pass through water treatment unit processes. According to Title 10 of New York Code of Rules and Regulations (10NYCRR), Subpart 5-1, Section 5-1.30 of the State Sanitary Code, total treatment of the system must achieve at least 99.9% (3-log) removal or inactivation of *Giardia* cysts and 99.99% (4-log) removal or inactivation of viruses. Direct filtration would account for a 2 credit log removal of *Giardia* and a 1 credit log removal of viruses. Therefore, 1-log removal of *Giardia* and 2-log removal of viruses are required through chlorine contact. The current treated water sampling point is directly downstream of the treatment plant, and therefore, only the volume of the Steuben Street tank is considered for chlorine contact time.

Based on the 2018 SCADA data for the filling and draining of the Steuben Street Tank, the maximum flow rate out of the tank was approximately 589 gpm. This flow rate was then compared to the design flow of 1.3 MGD and the peak design flow at 1.9 MGD. In order to determine the most conservative contact time for log inactivation, it was assumed that as the temperature decreases, the pH increases, and the chlorine residual is at a maximum value. The maximum pH was 8.5, the minimum temperature was 4 deg-C, and the maximum chlorine residual was 1.7 mg/L. Since no mixing or baffling exists in the Steuben

Street tank, an unbaffled value of 0.1 was used in calculations.

Based on the analysis, the Steuben Street tank far exceeds the 4-log inactivation requirement for viruses for all three flow rates, but only slightly exceeds the 3-log inactivation requirement for *Giardia* under existing flow conditions. The log inactivation for viruses with credit was approximately 71 at existing flow, 46.7 at design flow, and 32.2 at peak design flow. All three flow rates far surpass the 4-log required. The log inactivation for *Giardia* with credit was approximately 3.5 at existing flow, 3.0 at design flow, and 2.7 at peak design flow. Therefore, only existing flow rates meet the required 3-log inactivation and additional CT time is required.

In addition, the DOH requested monthly analysis *Giardia* to ensure 3-log inactivation is provided at all times during the year. Based on these results, only the months of August, September, and October fall below required limits without credit, but all months meet requirements with credit.

3. Water Quality

A drinking water system's water quality may be acceptable when the water leaves the WTP, but a variety of physical, chemical, and biological transformations can occur once the water enters and travels through the distribution system. The principal factors that affect water degradation during distribution are the system's structure, its operation, and a number of water quality factors like turbidity and age.

a. Turbidity

Turbidity is caused by particles suspended or dissolved in water that scatter light, making the water appear cloudy or murky. Particulate matter can include clay and silt sediment, fine organic and inorganic matter, soluble colored organic compounds, algae, and other microscopic organisms. Turbidity is tested in drinking water distribution systems to measure the filtration process effectiveness. Turbidity is measured in Nephelometric Turbidity Units (NTUs), where a greater scattering of light indicates low water clarity, and a lower scattering of light indicates high water clarity. The EPA maximum turbidity reading is 0.3 NTU, and New York State regulations require the turbidity always be below 1 NTU.

According to the Village 2018 Annual Drinking Water Quality Report, all three service areas (Village, Town of Dix and Town of Reading) were in violation for turbidity. The average level measured was 0.077 NTU, but the maximum recorded was 19.414 NTU. The regulatory level is considered Action Level (AL), where the concentration of containment, if exceeded, triggers treatment or other requirements which the water system must follow. The high levels of turbidity are a caused by soil runoff. According to the 2018 DOH inspection report, a review of the most recent water quality monitoring report results indicates there were two turbidity violations in August 2018, where more than 5% of the composite filter effluent turbidity readings were above the performance standard of 0.3 NTU in a single month. These violations were issued in a separate correspondence and public notification was completed on August 16, 2018 and November 2, 2018.

b. Water Age

Water age is a function primarily of water demand, system operation, and system design. As water demand increases, the amount of water that remains stagnant in the system decreases. The Water Industry Database indicated an average distribution system retention time of 1.3 days and a maximum retention time of 3.0 days based on a survey of over 800 utilities in the United States, but depending on the size of . There are a number of chemical, biological, and physical problems that can be caused or worsened by increased detention time in a distribution system. The following water quality problems have a direct potential public health impact:

- Disinfection By-Product (DBP) formation and biodegeneration
- Corrosion control effectiveness
- Nitrification
- Microbial regrowth, recovery, and shielding

The Village district and its purchased water systems in the Towns of Reading and Dix must work together to address disinfection by-products. The Environmental Protection Agency has set Maximum Containment Levels (MCLs) for total trihalomethanes (TTHMs) and haloacetic acids (HAAs) of 80 and 60 micrograms per liter, respectively, based on annual averages of quarterly sample results taken from the distribution system. Although the Village has not exceeded these standards, there are exceedances in both Towns that purchase water from the Village. It is recommended that the Village consider all options for the reduction of these contaminants within its system.

c. Pipe Size

The existing water distribution network contains pipes of 4, 6, 8, 10, 12 inch diameters. A significant portion of the system is comprised of unlined ductile iron, and small 4" diameter water mains. According the AWWA Manual M31, one of the most significant distribution system impacts from fire flow requirements includes providing adequate storage capacity and meeting requirements for minimum pipe sizes. Ten States specifies a minimum pipe diameter of 6" at all locations providing fire protection, but it is suggested to install a minimum of 8" diameter for the Village. For 4" pipes, the approximate delivery volume is 3,466 gallons per mile. For 8" pipes, the approximately delivery volume is 13,786 gallons per mile. Therefore, for every mile of 4" pipe that is replaced with 8" pipe, the effective volume of the distribution system increases by about 10,320 gallons.

d. Structural Factors

Cast or ductile iron pipes provide suitable environments for microorganism growth. Oxidant-resistant microorganisms settle on the pipe surfaces and become entrapped in the low flow areas, line obstructions, or dead-ends and produce biofilms. In addition, iron pipes are susceptible to corrosion.

As of November 2018, the Village was in the process of replacing approximately 1,900 linear feet of 8" diameter old pipe along NY State Route 14 between Bath and Division Street. The existing Village distribution currently includes approximately 17,000 LF of 4" diameter unlined ductile iron pipe. It is recommended the Village continues to implement a program to replace old and deteriorating ductile iron mains.

4. Water Loss

Old and poorly constructed pipelines, inadequate corrosion protection, poorly maintained valves, and mechanical damage are some of the factors contributing to leakage. One important effect of water leakage, besides the loss of water resources, is reduced pressure in the system. Raising pressures to make up for these losses increases energy consumption as well as making leaking worse. In general, a 10 to 20% allowance for unaccounted water is normal. A loss of more than 20% requires priority attention and corrective actions. There are different types of leaks, including service line leaks, valve leaks, and most commonly, main line leaks. The material, composition, age, and joining methods of the distribution system components can influence leak occurrence.

Unaccounted water is the difference between water produced at the treatment facility and metered use by customers. In 2018, the total annual use drawn from Seneca Lake and treated at the WTP was approximately 188.5 MG, whereas the total amount consumed was about 182.2. MG. The following equation was used to determine water loss in the distribution system.

$$Unaccounted\ water\ loss\ (\%) = \frac{Production - Consumption}{Production} \times 100\%$$

Therefore, the total unaccounted loss for the system is about 3.3%, which falls within the normal range. In order to prevent future leaks, it is recommended to initiate leak detection efforts in the near future that focus on distribution policies that encourage conservation, public education programs, pressure reduction, requests for voluntary cutbacks or bans on certain water uses, and water recycling. There are various methods for detecting water leaks, most of which involve using sonic leak-detection equipment. This equipment identifies the sound of water escaping a pipe, and the devices include pinpoint listening devices that make contact with valves and hydrants, and geophones to listen directly on the ground. In addition, correlator devices can listen at two point simultaneously to pinpoint the exact location of a leak.

V. HYDRAULIC MODEL

The updated system map was translated to a working hydraulic water distribution model to simulate existing conditions, identify problem areas in the network, and explore future improvements through "what if" scenarios. A visual screen capture of the model network is included in Appendix E. Please note the pipes are color-coordinated by diameter for easy reference with purple representing 4", blue representing 6", green representing 8", yellow representing 10", and red representing 12".

A. SOFTWARE

A hydraulic water distribution model was created in MIKE URBAN+, part of a software suite developed by DHI Water & Environment, Inc. The components are based on the worldwide standard EPANET engine, allowing for steady state, extended period, and water quality, and transient flow simulations. In addition, MIKE URBAN+ includes full GIS integration. Some of the most useful features include computing water demands for each node in the network, calculating water age in network, and determining available flow and residual pressure for a comprehensive fire flow analysis.

B. SYSTEM DEMANDS

Based on the 2018 water use data for the Village and Towns of Reading and Dix, the average demand was approximately 467,854 gpd, or approximately 325 gpm. The total annual usage was estimated at 170 million gallons. Residential use accounted for about 58%, commercial use accounted for 34%, institutional use accounted for 10%, and industrial use accounted for less than 1% of the total use. In order to simulate realistic demand conditions for the existing model, a demand curve was applied to all junction nodes in the network. However, it was important to assign higher demands to the top water users.

C. OPERATIONS & STORAGE

The hydraulic model includes six (6) storage tanks and four (4) pumps to represent actual system operations. The first tank, representing the intake from Seneca Lake, is modeled as a reservoir with a fixed hydraulic grade line of 443 feet. A lakeside pump station draws water from the lake and up to the WTP. The second tank, representing the WTP, is modeled as a variable tank with a maximum weir crest of 663 feet. The Steuben Street Tank has a storage capacity of 0.5 MG, and is modeled as a reservoir with a fixed hydraulic grade line of 653 feet. Although the water level in the tank fluctuates, for the simplicity of overall operations in the system, a reservoir was used instead.

There are two separate distribution mains from the existing Steuben Street Tank: the first provides low-pressure gravity flow to the majority of the Village system; and the second provides high-pressure pump flow to the northern part of the system and the Padua Tank. A pump station immediately downstream of the Steuben Street Tank services the high-pressure flow zone demands to the higher elevation areas and to fill the Padua tank.

The Padua Tank has a storage capacity of 0.325 MG, and is modeled as a variable tank with a base elevation of 800 feet and overflow elevation of 833 feet. In real-world operation there is one line in and out of the Padua tank, with a transducer manhole controlling the flow. Modeling flow from the Padua Tank to the distribution system was based on available demand data.

Flow from the distribution system supplies Watkins Glen State Park via a pump station. A variable storage tank inside to the park provides water to the adjacent gorge and the Six Nations Campground. Once flow distribution reaches the southern part of the system, the Franklin Street booster pump station sends flow to the Town of Dix via the South Tank at a higher elevation than the Village. The South Tank has a storage capacity of 0.18 MG, and is modeled as a variable tank with a base elevation of 972 feet and an overflow elevation of 992 feet.

D. SYSTEM PERFORMANCE

The following sections describe the results of a series of hydraulic model simulations based on tests performed and proposed system alternatives.

1. Working Pressure

According to Ten States Standards, the normal distribution system working pressure should be approximately 60 to 80 psi, but not less than 35 psi. Using this as a guideline, the model was calibrated based on the lowest operating level of the Steuben Street Tank which provides a minimum system pressure of 20 psi and a minimum system working pressure of 35 psi. On an average day, the peak demand occurs at 12 PM. At peak demand the point furthest from the tank has a pressure of approximately 59 psi. This pressure was used to determine ground elevations associated with the following recommended pressure zones:

- 20 psi: minimum system pressure during all flow events
- 35 psi: minimum system working pressure
- 40 psi: minimum pressure where a water service enters a house
- 65 psi: recommended normal working pressure
- 80 psi: recommended maximum working pressure
- 100 psi: maximum pressure allowed before individual PRVs are required

2. Fire Flow

Calibration of the hydraulic model based on the hydrant flow tests determined the majority of old ductile iron pipes in the Village perform as smaller diameter pipes. Although new ductile iron pipe has a Hazen-Williams C-factor of 140, each hydrant location was adjusted to determine the approximate roughness coefficient that corresponded to the calculated available flow. The following table shows the results.

Location	Diameter (in)	C-factor	Calc. FF (gpm)	Existing 4” Model FF (gpm)	Proposed 8” Model FF (gpm)
Howard St. & Bath St.	4	65	580	582	833
N. Madison St. & Partition St.	8	82	3,467	3,465	4,203
8th St. & Porter St.	8	88	3,975	3,982	4,883
10th St. & Magee St.	8	130	3,330	3,339	2,765
Wal-Mart (SW corner)	8	140	2,438	2,416	2,014
14th St. & S. Franklin St.	12	78	3,554	3,573	4,872
6th St. & N. Franklin St.	12	140	3,975	3,928	5,858

Therefore, an average roughness C-factor of 100 was assigned to the pipelines to represent age, tuberculation, excess sediment buildup, or one or more partially closed valves in the system.

Using the MU+ Fire Flow Analysis module, the maximum available flow rate was calculated for the selected hydrants given a minimum residual pressure of 20 psi. Using a C-factor of 100, the average fire flow available for the network was approximately 2,755 gpm, which falls between the upper residential range at 1,500 gpm and commercial range of 3,500 gpm. The hydrant locations represent a mix of residential and commercial properties. If the C-factor is increased to 140 across the system to represent brand new ductile iron pipe, the average fire flow available increased to 3,552 gpm. Therefore, it is evident the old pipeline has a significant impact on pipe flow.

In addition, the Fire Flow Analysis tool was used to evaluate the available fire flow for the entire distribution network. Using the existing network with 4" pipes, the average available fire flow was 3,109 gpm. However, when the 4" pipes were replaced with C-factor 140, new 8" pipes, the available fire flow increased to 3,726 gpm. A bar chart was created to compare the number of junctions within each flow range for both the 4" pipe and 8" pipe. Based on the results, there was an increase in the number of junction with more than 3,500 gpm of available fire flow, and fewer with less than 500 gpm available fire flow when the 4" pipes were replaced with 8" pipes. This bar chart is included in Appendix E. Therefore, increasing pipe diameter and replacing old pipe improves overall fire flow in the system.

3. Water Age

A point constituent tracer simulation was run for 7 days to simulate water age in the distribution system. To reflect existing operations, only the Padua Tank contains complete mixing operations; the Steuben Tank was simulated as first in, first out plug flow. The tracer represents DBPs formed in the Steuben Street Tank, and is set to the recommended concentration of 0.08 mg/L. Based on the results, the turnover in the Steuben Street Tank was approximately 64 hours, or 2.7 days. However, the average water age of the system was 97.7 hours, or 4.1 days. Improved mixing and flushing operations could improve turnover time and water age in the system.

In order to visually identify areas of the network with the highest water age, a color map was created with water age displayed in hours. As reflected by the results, the majority of the network has a water age around 4 days. However, the pipes with the highest water age reside at the edges of the system or dead-ends. Therefore, these are the areas that require the most attention for water quality issues, such as high levels of DBPs. The plot for water age is included in Appendix E.

VI. IMPROVEMENT ALTERNATIVES

Based on the analysis of existing conditions, the 2018 NYSDOH Sanitary Survey, and hydraulic model results, the following sections detail proposed system improvements, recommendations, and future capital projects.

A. DEPARTMENT OF HEALTH IMPROVEMENTS

In response to these violations, the DOH issued number recommendations and requirements. It is important to note that a number of the deficiencies outlined have already been addressed by the Village with the ongoing SCADA upgrade.

A chlorine gas leak alarm and a door alarm were installed at the raw intake pump station. The Village is in the process of developing Stand Operating Procedures (SOPs) for the WTP. In addition, at the treatment plant the Village identified an entry point sampling location, is currently taking plant operation and turbidity readings, installed chemical feed pump control valves, is in the process of installing door alarms connected to the SCADA system, and are taking pre-disinfection and raw water turbidity readings. At the Steuben Street Tank an entry point sampling location was identified. With regard to the distribution system, the Village acknowledges the requirement of annual cross-connection control testing and are actively addressing it. In addition, the Village periodically replaces system meters and will replace the backwash meter in the plant.

B. ZEBRA MUSSEL CONTROL

The DOH issued a requirement that the Village explore alternative forms of treatment at the raw water intake. The location of the chlorine gas adjacent to apartment buildings is a safety and health hazard. Using a different chemical for zebra mussel control may also improve disinfection by-product levels in the distribution system. Based on this issue, several alternatives were considered:

1. Intake Pipeline Depth

Based on a study conducted in 2007, the majority of zebra mussels residing in Seneca Lake were between 10 to 100 feet of the water surface. However, there were also large populations at depths between 150 to 250 feet. Very few mussels were seen below a depth of 300 feet. Currently, the normal surface level elevation of Seneca Lake is approximately 444 feet, with fluctuations between 442 feet and 449 feet depending on the year and season.

The intake box is located 60 feet below the water surface, at an elevation of 384 feet. Unfortunately, this depth falls precisely in the densest zebra mussel colony location.

The USGS climate data for Seneca Lake during September 2018 showed a temperature range between 60 and 68 degrees Fahrenheit at a depth of 48 feet, and a range between 45 and 65 degrees Fahrenheit at a depth of 97 feet. Therefore, the intake box at 60 feet falls within the highest growth temperature range.

As a first alternative, it was investigated whether extending the raw intake pipeline to a deeper and colder location would minimize zebra mussel intake through altering the preferred ecosystem. After reviewing the bathymetry of Seneca Lake, the maximum depth occurs at 620 feet below the surface elevation near the northern boundary of Schuyler County. At the southern end near the Village of Watkins Glen, the maximum depth occurs at 230 feet below the surface elevation, at about 3,000 feet from shore. The existing intake pipeline runs approximately 300 feet from shore. Therefore, it is infeasible to run a pipeline an additional 2,700 feet. A detailed map displaying Seneca Lake depth is included in Appendix F.

2. Intake Screen

The Village employs pre-chlorination to combat the high zebra mussel population in Seneca Lake. However, a problem with pre-chlorination is that chlorine is applied to water where it contain the highest concentration of natural organic matter, which reacts with chlorine to form harmful disinfection by-products. Ideally, chlorination should be delayed until as much natural organic material is removed from the water as possible through the processes at the WTP. Although eliminating pre-chlorination completely at the raw intake is not plausible, it is recommended to conduct a pilot study to ensure the chlorine used at this point is properly dosed. Installation of a copper-based intake screen in conjunction with a lower chlorine dose could significantly reduce DBPs.

Under current operations, the raw water intake pipeline has a capped end through which chlorine is dispersed into the lake to inhibit zebra mussel attachment and growth. An alternative is the Passive Intake Screen Z-Alloy developed by Johnson Screens®, part of the Aqseptence Group. The high capacity passive intake screens provide uninterrupted water withdrawal from lakes and are custom designed to provide maximum efficiency, while minimizing installation, operation, and maintenance costs. The product is environmentally friendly, with an intake approach that meets the EPA's 316b regulations for fish protection. There is no waste stream, easy cleaning, and no moving parts. The 304 stainless steel option is applicable for fresh water and the Z-Alloy has shown to specifically repel zebra mussels. The dual-flow modifier creates a nearly uniform low flow velocity through the entire screen surface. This significantly reduces impingement and entrainment of debris, while protecting aquatic organisms. A pilot study would determine the need for the use of chlorine or similar chemicals in conjunction with the proposed intake screen. Product information, design specs, and an associated quotes for Johnson Screens® is included in Appendix G.

There is current concern of cavitation occurring at the raw water intake pump station with only one intake line. Approach velocity and flow patterns are two of the most important characteristics required for efficient sump pumps. An approach velocity between 0.5 fps and 1.5 fps, evenly distributed flows to the pump suction, and no turbulence is required. The effect of vortex formation on pump operations is associated with free surface vortices causing aerated flow, air ingestion, rumbling noises, and submerged or free surface vortices imposing load fluctuations on impeller blades. As a result, the pump experiences vibrations, rough running, cavitation, and damage and erosion to the impeller. Headloss calculations were performed at the intake crib, as well at the pump station to ensure the existing pumps supply sufficient suction.

Based on the calculations, there is adequate submergence for the two (2) pumps, and the approach velocity is about 1.28 fps at average operation at 1.3 MGD. However, if both pumps operate at their maximum output and the WTP produces a maximum of about 1.9 MGD, the approach velocity is 1.87 fps, which exceeds the maximum recommended value. The plant can only safely produce a maximum about 1.5 MGD to maintain evenly distributed flow. The proposed Johnson Screen has a dual-flow modifier with a maximum flow of 1,300 gpm, which equates to about 1.9 MGD. The average slot velocity is about 0.4 fps, and the maximum slot velocity is about 0.47 fps. Therefore, even flow is maintained even at maximum WTP capacity. Headloss and submergence calculations for the intake and raw water pump station are included in Appendix H.

3. Chemical Treatment Alternatives

Alternatives to chlorine were investigated to control zebra mussel growth and limit potential risks to the water distribution system. Although there are numerous chemical and physical solutions available, the following paragraphs discuss two of the best alternatives based on previous applications and successful case studies in the Great Lakes and Finger Lake Regions.

Although there are chemical alternatives to chlorine such are bromine and copper, the best alternative, although costly, is the biological pesticide Zequanox®. This molluscicide controls the invasive species during all life stages, from larva to adult. Once ingested, it deteriorates the digestive lining of the mussels, resulting in mortalities over a period of several days to weeks. The advantage is this product delivers efficacy comparable to chemical solutions, but does not endanger employees, damage equipment, or result in harmful impacts to the environment or other aquatic organisms when used properly. It is ideal for open water systems because it is highly selective with no significant effect on water quality of non-target organisms. In addition, Zequanox® can be applied using standard mixing and injection equipment. Unlike mechanical solutions, there is no need for costly capital investments or complicated installation and maintenance. The treatments are non-corrosive, non-volatile, and do not require detoxification or deactivation before water discharge. Each treatment is customizable, designed to fit the needs for an individual water system based on the degree of infestation and desired level of control. The treatments can be completed between 2 and 8 hours. Finally, the EPA approves Zequanox® and classifies it as a reduced-risk aquatic pesticide and there are minimal regulatory restrictions in comparison to chemical alternatives. A product brochure for Zequanox® is included in Appendix I.

C. Pump Station Upgrades

The equipment and layout of both the raw water intake pump station and the Steuben Street pump station are dated and nearing the end of their useful lives. In addition, the Village discussed a concern that the pumps at the raw intake station are improperly sized, and consequently inefficient. In 2011, there was a proposed 2-phase raw water station improvement project, but the plans were never implemented. It is recommended to revisit these proposed plans and make upgrades or adjustments as needed. Both pump stations upgrades are included in the cost estimate.

D. Water Treatment Plant Upgrades

Although the WTP operates well, there were a few recommendations outlined by the DOH inspection, many of which are already being addressed by the Village. The following sections describe outlying required upgrades to the chlorine room, current filter and processes, and recommendations for combating and monitoring high turbidity levels reported in treatment plant effluent. An existing and updated hydraulic profile are included in Appendix J.

1. Chlorine Room Ventilation

As addressed during the DOH inspection, there is improper ventilation for the chlorine room. In the event of a gas leak, the fan discharges adjacent to the access door to the treatment plant, which poses a serious health and safety concern for plant operators. According to Ten States, the ventilating fan requires a capacity to complete one air change per minute when the room is occupied. The fan should take suction near the floor and be installed at as great a distance as is practical from the door and air inlet, with the point of discharge located so as not to contaminate air inlets to any rooms or structures. It is also recommended the new vents discharge to the outside atmosphere above grade and remote from air intakes.

2. Turbidity Reduction

The relationship between turbidity breakthrough and limiting headloss is also strongly affected by the efficiency of chemical pre-treatment. Currently, alum is added as a coagulant as the raw water influent enters the flocculation chamber. The operators at the plant noted that when large meteorological events occur, the sediment in Seneca Lake churns up, and the turbidity of the influent water significantly increases. It is possible to add more during these events, but this is not a practical long term solution. Additional coagulant and polymer use could be considered in addition to another form of pre-treatment.

Currently the WTP does not include any clarifiers. Although the clarification process is commonly used for treating raw surface water, it is not considered an economical alternative due to capital and operation costs, as well as the time required to bring the process online. In addition, clarifiers need to be on line for several days before providing effective pre-treatment, and since the high turbidity is tied to irregular meteorological events, this is not a reliable alternative. Finally, multiple clarifiers would be required to treat the 2.5 MGD peak design flow. The size of the units, the required land area for construction, and the cost of materials and construction is prohibitive for a process that is needed only after significant meteorological events.

Adding pre-filtration in the form of pressure filters or bag filters was considered the most effective alternative. Pressure roughing filters can be brought on line quickly as raw water turbidity increases, and allows for the use of coagulants to further reduce turbidity levels if necessary. It is recommended to install a pressure filter system which included three trains, with each train consisting of a contact clarifier followed by an anthracite filter to capture some of the larger solids before flow reaches the finishing filters. Therefore, adding vertical pressure roughing filters to the raw water influent end of the WTP would maintain low turbidity effluent regardless of meteorological events, and subsequently decrease the solids load on the finishing filters downstream. Filter details and updated WTP site plans are included in Appendix K.

According to Ten States, for systems with three or more filters, online turbidimeters should be installed on the effluent line from each filter. Turbidimeters on individual filters should have an alarm that sounds when the effluent levels exceeds 0.3 NTU. Therefore, monitoring these events using a SCADA system at both the intake and entrance to the treatment plant would assist in managing pre-treatment doses prior to filtration.

3. Filtration Processes

The WTP houses four (4) 10 feet x 10 feet filtration cells, with three (3) active and one (1) for backwash in typical operations. The filter media is 30 inches thick, with the top layer comprised of 18 inches of 1.0 – 1.2 mm anthracite, and the remaining 12 inches comprised of 0.45 – 0.55 mm sand. The larger grain size of the anthracite layer permits greater depth penetration of solids and larger solids storage volume in the filter. The sand layer is used as a protective barrier against breakthrough. Although a dual-media filter is preferred over mono-sand filters, the WTP effluent still contains high turbidity and disinfection byproducts.

Two factors are important for media selection: the time required for turbidity to break through the filter bed and the time required for the filter to reach limiting headloss. With properly selected media, these times should be about the same. Based on an average flow rate of 1.3 MGD produced by the plant with (3) filters in use and (1) reserved for backwash, the approximate filtration rate per filter is about 3.62 gpm/ft2.

Granulated Activated Carbon (GAC) is effective in reducing taste and odor control (TOC), as well as adsorbing natural organic compounds and synthetic organic chemicals. GAC is made from organic materials with high carbon contents such as wood, lignite, and coal. It typically has a diameter ranging between 1.2 – 1.6 mm. GAC has a high uniformity constant to promote stratification after backwashing, and minimize desorption and premature breakthrough. Existing rapid sand filters can easily be retrofitted to replace anthracite with GAC, and pilot studies have shown GAC filters outperforms anthracite filters with superior reduction of organics, lower chlorine demand, and lower TTHM formation, while maintaining similar run times and filtered water turbidities. By retrofitting the existing underdrains to include air scouring, the media bed can be expanded by 30%. This will accommodate 12 inches or sand and 32 inches of GAC. At design flow of 1.3 MGD, this provides approximately 7.5 minutes of Empty Bed Contact Time (EBCT). At peak design flow of 1.9 MGD, this provides approximately 6.1 minutes of EBCT. If at a future date, the plant requires additional TOC, free standing GAC vessels can be added to the filtration process. However, at this point, retrofitting the existing filters is the most cost-effective solution. The product information and drawings for the proposed GAC retrofitted filters are included in Appendix L.

E. Steuben Street Tank

The Steuben Street Tank is a critical part of the water distribution system. It houses treated water directly from the clear well and stores it for the entire lower pressure zone of the network.

1. Chlorine Contact CT

According to the DOH report, after evaluating monthly operation reports, it is not clear that adequate concentration time to meet the 3-log removal and/or inactivation requirement for *Giardia* cysts is provided at all times during the year at the Steuben Street tank and pump stations. Based on the previous analysis, the months of July, August, and September were in violation. However, when the 2-log credit for direct filtration is applied, all 12 months exceed the 3-log inactivation requirement. Since the contact time is very close to the limit, it is recommended to improve baffling factor of the Steuben Street Tank by adding inlet and outlet baffles.

In addition, as the existing tank does not provide sufficient contact time to meet the 3-log inactivation of *Giardia*, an additional 0.5 MG tank is recommended. This will also create redundancy for the existing 0.5 MG tank, and prevent disruption in operations when one tank needs maintenance or repair. With an additional 0.5 MG of storage, the log inactivation time is approximately 63.5 for viruses and 3.3 for *Giardia*. A summary of all CT calculations is included in Appendix M.

2. Tank Rehabilitation

In 2019, the Steuben Street Tank was inspected in response to a violation to AWWA Standard G-200 that internal inspections on storage tanks be conducted every 5 years. Based on the structural conditions from the inspection, the seal between the base and tank bottom needs attention and the exterior sidewall welds, plate surfaces and roof exterior plates are corroded. There was less than 1 inch of sediment in the tank. The general recommendations include reinspecting the tank in 5 years, recoating the tank exterior, and resealing the junction of the exterior tank bottom and concrete base. In addition, it is recommended that lead paint tests be conducted. A copy of the inspection report is included in Appendix N.

F. Water Quality

According to the 2018 Annual Drinking Water Quality Report issued by the Village, the total trihalomethanes (TTHMs) were in violation in the Town of Reading. From the four samples taken over the course of the year, the average level detected was 72.6 µg/L with a range of 45 to 100 µg/L. In the Town of Dix, four samples were taken as well. The average level detected was 98.8µg/L with a range of 80.2 to 110µg/L. The Maximum Containment Level (MCL) issued by the EPA is 80µg/L. An MCL is the highest level of containment that is allowed in drinking water. It is likely the high levels of TTHMs are a by-product of drinking water chlorination. Consuming drinking water with high levels of TTHMs over many years may experience liver physiological problems related to the liver, kidneys, or central nervous system, in addition to an increased risk of cancer.

Although the majority of water quality issues were reported in the Town of Dix and Town of Reading, it is important to consider alternatives to prevent formation of disinfection by-products (DBPs). There are many alternative strategies to minimize DBPs, such as eliminating pre-chlorination, moving the chlorination point, practicing enhanced coagulation, optimizing chlorine dosing through disinfection benchmarking, and switching to chloramines for secondary disinfection.

The newly constructed Padua Tank includes a mixing system, but not a THM removal system with aeration. As this point the Village is not in violation of high THMs, so the mixing is sufficient. If the levels increase in the future, it is suggested to add THM removal systems to both the Padua Tank and the South Tank.

G. DISTRIBUTION SYSTEM UPGRADES

Much of the water distribution network was installed in the early 1900s and consists of old ductile iron or ductile iron piping. Based on the model results, DOH inspection, and direct correspondence with the Village, the following sections discuss recommended improvements to address the boil water notice and improve overall system efficiency.

1. Water Age

From an operational perspective, tanks, valves, pipe diameter, and pumping rates have a direct impact on water age and quality. Finished water storage facilities may exhibit poor mixing conditions because tank turnover is limited by minimum available fire flow requirements. Tank mixing can also be optimized by cycling the tanks periodically or installing mechanical devices, such as diffusers and nozzles to achieve higher velocities. Valve settings and pumping rates determine water velocities and flow direction. Velocity, in turn, impacts hydraulic pathway and retention time. Therefore, it is recommended to assess system pressures and valve position on a regular basis, such that the operators can adjust as needed to induce flow in the system in a direction that can minimize water age. In addition, the Village should work with the Towns of Reading and Dix to develop and implement a robust flushing program.

2. Pipe Size and Dead-Ends

Based on the results of the hydrant flow test and hydraulic model calibration efforts, it is evident the existing pipeline it causing excess resistance to flow. Much of the system is operating as a smaller diameter pipeline due to age and tuberculation. In addition, Ten States specifies a minimum pipe diameter of 6 inches for all locations providing fire protection. Therefore, it is recommended to replace the 4-inch pipes with larger diameter 8-inch pipes to increase flow and volume in the system.

There are several locations in the network with dead-ends lines. In conjunction with replacing old 4-inch diameter pipes, it is recommended to connect any associated dead-end lines into the rest of network, in order to provide increased reliability of service and reduce head loss. Any remaining dead-end mains should be equipped with a means to provide adequate flushing.

3. Valve Exercising Program

Valves are an essential part of a water distribution system that regulate, stop, and start the flow of water. Some of the benefits of fully operational valves include being able to isolate a water main break, which in turns reduces water loss, makes repairs easier, and reduces property damage. If valves aren't used over an extended period of time, they can seize up from corrosion and become inoperable. Currently, the Village has no master record of existing valve and hydrant locations, but they are aware of numerous non-operational valves that need testing and replacement. Therefore, it is recommended to create a valve exercising and maintenance program to prolong the useful life and operation of the water system. The location of the valves and hydrants can be recorded using GPS-based equipment and software for record keeping and future use. This database should also include documentation of maintenance records and digital photos.

H. Additional System Improvements

The Village is currently undergoing SCADA upgrades throughout the distribution system. These upgrades are scheduled for completion by December 31, 2019.

VII. COST ESTIMATE

The following economic analysis includes review of water use and associated costs per dwelling and type of user, a cost estimate of overall system improvements, and a Village prioritized list of improvements.

A. EDU ANALYSIS

An Equivalent Dwelling Unit (EDU) is defined as a one single-family residential household. It is the unit of measure by which the user is charged for water services provided by the municipal water district. It is calculated and imposed upon each improved property served as determined in accordance with district approved ordinances. Non-residential facilities EDU's are calculated based on their demand.

The Village serves a population of 2,149 through 943 metered connections. In addition, the Town of Reading serves a population of 86 through 38 metered connections and the Town of Dix serves a population of 201 through 82 metered connections. The total annual use for the three service areas is approximately 170,766,487 gallons, with an average daily use of 467,854 gpd. Based on the calculations for water use in the community, the average residential consumption rate was 262 gpd, with a total of 1,782 EDUs. Using the average residential value, the breakdown of EDUs for all residential, commercial, institutional, and industrial users are as follows.

Property Use	No. of EDUs
Residential	989
Commercial	603
Institutional	183
Industrial	8
Total	**1,782**

A copy of the 2019 water budget and full analysis of EDU calculations for the Village and Towns is included in Appendix O.