MEMORANDUM

To:	Public Works and Environmental Concerns Committee
From:	Brian Jack, Utilities Superintendent
Through:	Carl Goldsmith, Director of Public Works
Date:	October 8, 2024
Subject:	**Water System Network Analysis – 2023/2024 Executive Summary**

Background

The Village of Lombard Board of Trustees awarded a contract in May of 2023 to Baxter & Woodman Consulting Engineers for a Water System Network Analysis. This project was a ten-year update from the previous network analysis completed in 2013 by Alfred Benesch & Company.

The objective for the Water System Network Analysis was to complete a thorough review of the Village's water distribution system, facilities, and operations to provide recommendations for capital improvement projects regarding water operations, facilities, and the distribution system with a comprehensive computer model. The model also provides insights to future data collection regarding water main break analysis and predictability, and water quality considerations regarding future unregulated contaminant regulations.

The report provides a systematic approach to decision making for planning both capital improvement projects and operational efficiencies/improvements.

Executive Summary

The Water System Network Analysis utilized an OpenFlow WaterGEMS® hydraulic model of the Village's water distribution system to verify system pressures, fire flow capabilities, and the development of water main improvements with alternative operational schemes and procedures.

The Water System Network Analysis includes the following components:

1. Review of past water use.
2. Review of distribution system data and development of the model based on the Village's Geographic Information System (GIS) database.
3. Analysis of pressure characteristics, fire flows, and existing critical facilities.
4. Use of the new water model and the Village's historical water main break data to analyze and recommend priority ranking for water main replacement.

5. Extended period simulation analysis to evaluate the Village's distribution system for a 96-hour period to identify problem areas int existing system during a variety of flow conditions, hourly demands, and control settings.
6. Review of the total volume of water storage available in the distribution system and comparison to existing and maximum day peak and hourly water demands.
7. Evaluation of emergency supplies including wells and interconnects and the impact on the system under emergency conditions.
8. Prioritized recommendations for infrastructure needs based on results of water system modeling, including estimated project costs.

Along with the above general components of the network analysis, there were three priority areas of focus:

1. Flow capacity in Lombard Fire District 501.
2. Emergency backup wells needs assessment
3. Water main rehabilitation

Flow Capacity in Lombard Fire District 501

Lombard Fire District 501 bordering Parkside Ave. to the north, Madison St. to the south, Main St. to the west, and Grace St. to the east is subject to low fire flow capabilities due to the age and size of the water mains in that area. This neighborhood is served by four-inch mains that have been in service since the 1940's. Today's standard size of water main in a typical residential neighborhood is eight inches. The network analysis evaluated the current flow capacities under normal and emergency maximum flow conditions and verified the assumptions and field data from Village Staff. The model confirmed that the water mains in this neighborhood are undersized and do not provide sufficient fire flow capabilities.

A three to five year phased approach to replacing and upsizing the water mains is the recommendation from the network analysis. An added benefit to this project would be the replacement of over 400 (or approximately one third) of the lead water service lines in our system to comply with the Lead Service Line Replacement and Notification Act (LSLRNA Public Act 102-0613).

The project would replace the existing four-inch water mains with eight-inch mains, install strategic larger "feeder" mains to add redundancy and increase water quality, replace fire hydrants that have been in service up to 70 years, and replace lead service lines.

Emergency Backup Wells Needs Assessment

Lombard currently has three emergency backup wells that are in place in the event we cannot receive water from the DuPage Water Commission. These wells have been maintained since the Village transitioned to Lake Michigan water in 1992. We have not pumped water from the wells into the distribution system since the change to Lake Michigan water, however, they are exercised and run monthly to test and take water samples.

The well equipment of pumps, electrical panels, contactors, and controls are well beyond their useful life and require great care while operating. As they are for emergency use only, the equipment has only been maintained and not upgraded over the past 30 years. In the past two years, two of the wells have gone out of service due to equipment and well pipe wall failures. Costs estimates for repairs were received and were well out of range to include in existing budgets. The network analysis evaluated scenarios to include rehabilitation, replacement, increase of pumping capacity, and abandonment.

Results of the model demonstrate that in an emergency the three wells would be able to provide sufficient flow capacity under normal conditions. However, if one of the wells would fail or need to go out of service for repair, water restrictions would be necessary. More detailed information regarding these scenarios is on page 34 of the full report.

Although significant work would be needed to bring the well equipment up to today's standards, the cost estimates are considerably less than originally anticipated and would be well worth the investment.

Water Main Rehabilitation

Overall, the network analysis has shown that the water distribution system is in relatively good condition. As a general rule, water main useful life ranges between 50 and 100 years. The average useful weighted life of Lombard's water distribution system is approximately 93 years. Following the American Water Works Association's recommendation of a 1% replacement per year, Lombard would need to replace or rehabilitate approximately 2.1 miles of water main each year. That would equate to $4.4 - $6.7 million dollars per year.

The network analysis has identified areas within the system that are in need of improvement. These locations were based upon water main break history and criticalities, fire flows, and water age/connectivity that could effect water quality. The current Capital Improvement Plan does identify funding for continued water main replacement and/or rehabilitation through lining. It is imperative these programs continue to be funded or increased as the system ages.

Representatives from Baxter & Woodman Consulting Engineers have been invited to present the Water Network Analysis and review the findings, project impacts, and recommendations for future improvements.

Staff recommends and requests the Committee accept the report and further recommend to the Village Board of Trustees for their consideration and acceptance as a guiding document for project planning.

Water System Network Analysis

Village of Lombard, IL

August 2024

BAXTER & WOODMAN
Consulting Engineers

Village of Lombard, Illinois
Water System Network Analysis
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EXECUTIVE SUMMARY

The Village of Lombard's potable water supply system consists of one elevated storage tank, two ground level reservoirs, one standpipe, two pumping stations, four DuPage Water Commission (DWC) Pressure Adjusting Stations, and approximately 193 miles of water main. The water system currently provides 3.6 MGD of water on an average at pressures ranging from 35-95 psi. During the summer months, water demand can increase to over 6.2 MGD. This demand is supplemented by 5.6 MG in storage. A map of the water system including major facilities is included as Exhibit A.

The Village's objective for the Water System Network Analysis is to complete a thorough review of the water system facilities and operations to achieve a comprehensive water system planning document for water operations, facilities, and the distribution system. This report provides a systematic approach for making both capital and operational improvements to help the Village build a roadmap for future improvements.

The Water System Network Analysis includes the following components:

1. Review of past water use.
2. Review of distribution system data and development of an OpenFlows WaterGEMS hydraulic distribution model developed from the Village's Geographic Information System (GIS) database.
3. Analysis of pressure characteristics, fire flows, and existing critical facilities within the water model.
4. Use of the new water model and the Village's historical main break data to prepare a water main break analysis and recommend a priority ranking for water main replacement.
5. Extended period simulation analysis to evaluate the Village's distribution system for a 96-hour period to identify problem areas in the existing system during a variety of flow conditions, hourly demands, and control settings.
6. Review of the total volume of water storage available in the distribution system and comparison to existing and maximum day and peak hourly water demands.
7. Evaluation of emergency supplies including wells and interconnects and the impact on the system under emergency conditions.
8. Prioritized recommendations for infrastructure needs based on results of water system modeling, including estimated project costs.

An OpenFlows WaterGEMS® hydraulic model of the Village's water distribution system was developed and used to assist with verification of system pressures, fire flow capabilities, and development of water main improvements along with review of alternative operational schemes.

Data from the model can be linked directly to GIS so that pressures and fire flows are readily available to Village staff.

The water system is capable of meeting required system pressures set forth by the Illinois Environmental Protection Agency (IEPA) which range from a minimum of 35 psi to a maximum of 100 psi. Much of the water system has adequate fire suppression, however, fire flows in some portions of the system are below the recommended Insurance Service Office (ISO) values. Inadequate flows are found in areas with older, undersized mains or dead ends.

Recommended distribution system improvements were developed and simulated with the model to address system deficiencies. Recommendations were included to provide insight during the project planning process and allow for flexibility in future improvement programs.

Select major distribution improvements are noted in Table 1 along with budgeted costs to cover expected cost of construction, bidding, and engineering in 2024 dollars. All estimates should be evaluated during the design stage of a project when more information is available. Actual construction costs may differ due to presently unknown project requirements such as soil condition, land acquisition, and conflicting utilities.

TABLE 1

Recommended Improvements

Improvement Description	Proposed Diameter (in)	Length (ft)	Estimated Project Cost
FD450	8	23,000	$ 15,000,000
N Charlotte, Prairie, and View St	8	3,100	$ 2,000,000
Central Hammerschmidt, and Norbury Ave	8	3,500	$ 2,200,000
St Charles and Westmore-Meyers Rd	8	2,700	$ 1,700,000
DuPage Ave	12	2,200	$ 1,700,000
Meadow Ave	8	2,200	$ 1,400,000
Lombard Circle and School St	6/8	3,400	$ 2,100,000
Cherry, Apple, and Fairview	6/8	3,800	$ 2,300,000

Improvement Description	Proposed Diameter (in)	Length (ft)	Estimated Project Cost
West Central Lombard Utility Improvements	6/10	7,000	$ 4,300,000
Manor Hill Subdivision	6/8	6,200	$ 3,800,000
Eisenhower Ln S	12	2,100	$ 1,600,000
		Subtotal:	**$ 38,100,000**

1. INTRODUCTION

1.1 Background

The Village of Lombard is committed to continuing the high quality of life enjoyed by the citizens and businesses on their water system. Completing the Water System Network Analysis is a step towards fulfilling that mission by ensuring that the water system customers will have an ample supply of high-quality water at a reasonable cost. A detailed water system plan is needed to support fiscally sound and responsive decisions while focusing on capital and operational efficiencies.

The Village owns and operates a well-maintained water distribution, pumping, and storage system. The Village's objective is for the Water System Network Analysis project to be a thorough study, review, and analysis of the entire water system to achieve an efficient, economical water system plan for operations, facilities, and the distribution system.

1.2 Study, Purpose and Goals

The purpose of the Village's Water System Network Analysis Report is to develop a systematic approach for making capital improvements and operational modifications intended to meet their system's water supply needs and optimize operations. The Village's primary concerns include meeting or exceeding water quality standards; ensuring reliable supply and service to its residents, businesses, and potential customers; maintaining adequate pressures and fire flows; evaluating system operational changes; and improving the system efficiency and cost effectiveness.

The Water System Network Analysis Report will be a valuable tool for making near-term and long-term capital and operational improvements. The Water System Network Analysis Report includes the following:

1. Estimates of existing residential population and water demands.
2. An OpenFlows WaterGEMS® hydraulic water model based on the Village's GIS and field fire hydrant flow testing.
3. Use of the new hydraulic water model to identify areas of improvement and proposed solutions within the distribution system under a variety of demand conditions. Analysis of pressure characteristics, areas with inadequate fire flows, and existing critical facilities within the water model.
4. Water main break analysis using the water model and the Village's historical main break data to develop projects for water main replacement.

5. Extended period simulation analysis to evaluate the Village's distribution system in a real time mode for a 96-hour period to identify problem areas in the existing system during a variety of flow conditions, hourly demands, and control settings.

6. Review of the total volume of water storage available in the distribution system and compare to recommended storage quantities.

7. Evaluation of emergency interconnects and the impact on the system under emergency conditions.

8. Recommendations for projects based on results of water system modeling. Estimates of capital costs of the distribution system improvements are included.

2. EXISTING WATER SUPPLY SYSTEM

2.1 General Description

The Village's Water System consists of four primary connections with the DuPage Water Commission (DWC), two ground storage reservoirs with an attached booster station, a standpipe, an elevated tank, two interzone booster stations each consisting of pumps and pressure reducing valves, and 193 miles of water main within two pressure zones. The system also has five emergency interconnections with Glen Ellyn, Villa Park, Oak Brook, Oak Brook Terrace, and DuPage County as well as three emergency backup wells. A map of the water system and major facilities is displayed in Exhibit A. The water system is illustrated as a schematic shown in Appendix A.

This section of the report summarizes general information on the water system including supply, emergency supply, distribution system piping, pumping capacity, valves, and operations. Sections 5, 6, and 8 provide detailed evaluations and recommendations.

2.2 Water Supply

2.2.1 Primary Supply

The Village receives treated Lake Michigan water from the DWC through four delivery structures. These delivery structures are described in Table 2.

TABLE 2

Primary Water Supply Facilities

Description	Location	Zone	Design Capacity (gpm)
Highland DWC PAS 14-A	2020 S. Highland Ave	High Zone	3576
North Avenue DWC PAS 14-B	920 N. West Road	Low Zone	2382
Central PAS DWC PAS 14-C	E St. Charles St Between N. Main and N. Charlotte St.	Low Zone	1500
Civic DWC PAS 14-D	1030 S. Stewart Ave.	Low Zone	5514

2.2.2 Emergency/Backup Supply

The Village of Lombard has five emergency water supply connections and three emergency wells, which are outlined in Table 3 and Table 4 respectively.

TABLE 3

Secondary Water Supply Facilities - Interconnects

Description	Location	Zone	Size (in)	Supplied by
Glen Ellyn Interconnect	1175 S Finley Rd.	Low Zone	8"	DWC
Villa Park Interconnect	300 W. Roosevelt Rd.	Low Zone	8"	DWC
Oak Brook Interconnect	720 E Butterfield Rd.	High Zone	10"	DWC
Oak Brook Terrace Interconnect	2020 S. Westmore/Meyers Rd.	High Zone	8"	DWC
DuPage County Interconnect	1519 S. Fairfield Ave.	High Zone	8"	DWC

TABLE 4

Secondary Water Supply Facilities - Wells

Description	Location	Zone	Well Type	Available Flow (gpm)	Size (in)
Well 7	1000 Main St.	Low Zone	Deep	1,200	20" casing
Well 8	22nd and Highland St.	High Zone	Deep	1,200	22" casing
Well 10	1030 S. Stewart Ave.	Low Zone	Shallow	687	12" casing

2.3 Distribution System Piping

The Village's distribution system contains approximately 193 miles of water main with diameters ranging between four and twenty inches. A breakdown of pipe lengths by diameter is included in Table 5.

TABLE 5

Distribution System Piping Size

Diameter (in)	Length (miles)	Percent of Water Main
4	4.5	2%
6	57.3	30%
8	70.7	36%
10	22.3	12%
12	31.0	16%

Diameter (in)	Length (miles)	Percent of Water Main
14	0.1	0%
16	5.0	3%
20	2.0	1%
Total	**192.9**	**100%**

The Village's distribution system ranges in age with mains which were constructed as part of the original water system in the 1920s, to new water mains installed in conjunction with ongoing public works projects. Approximately half of the Village's water main has been installed since the 1980s, indicating that the Village has grown and replaced main since this time. A summary of pipe age is shown in Table 6. The darker line separating the 1950s and the 1960s separates pipes that are beyond their useful life and pipes that have remaining useful life.

TABLE 6

Distribution System Piping Age

Decade of Installation	Length (miles)	Percent of Water Main	Predominant Pipe Type
1920s	2.2	1%	Cast Iron
1930s	10.2	5%	Cast Iron
1940s	1.0	1%	Cast Iron
1950s	37.2	19%	Cast Iron
1960s	17.1	9%	Cast Iron
1970s	25.6	13%	Ductile Iron
1980s	27.5	14%	Ductile Iron
1990s	31.5	16%	Ductile Iron
2000s	25.7	13%	Ductile Iron
2010s	12.0	6%	Ductile Iron
2020s	2.2	1%	Cast Iron
Total	**192.9**	**100%**	

The distribution system is comprised of cast iron and ductile iron pipe. A summary of pipe material is outlined in Table 7.

TABLE 7

Distribution System Piping Material

Pipe Material	Length (miles)	Percent of Water Main
Cast Iron	68.9	36%
Ductile Iron	124.0	64%
Total	**192.9**	**100%**

The life spans of ductile iron and cast iron pipes can vary depending on water chemistry, soil properties, installation practices, pressure fluctuations, and other factors. The primary drivers for replacement of such pipes are the need for additional capacity to meet hydraulic fire flow requirements, to transfer water to outlying areas, and high frequencies of water main breaks. The Village should continue to monitor the break frequency and identify areas for replacement based on need. A design life of 75 years is recommended for cast iron and ductile iron pipes built in the 1950s and 1960s based on experience with similar water systems throughout the area. A design life of 100 years is used for ductile iron installed after 1970.

2.4 Water Storage Facilities

Water storage in the system is currently provided as both elevated and ground level storage. A summary of the available storage is noted in Table 8.

TABLE 8

Available Storage Volume and Locations

Storage Type	Name/Location	Volume (MG)
Elevated Tanks	Highland Elevated Tank	1.0
	Subtotal	**1.0**
Standpipe	North Standpipe	1.6
	Subtotal	**1.6**
Ground Level	Civic Center North	1.5
	Civic Center South	1.5
	Subtotal	**3.0**
TOTAL		**5.6**

Elevated storage tanks can instantly respond to changes in demand, without the use of booster pumps, controls, or electrical power. Water from ground level reservoirs must rely on pumps and controls to promptly deliver water into the distributions system. Standby power is required to allow for storage in the ground level reservoirs to be pumped into the system during power failures.

2.5 High Service Pumping Capabilities

High service booster pumping stations (HSP) are located at the Civic Reservoirs and the Highland Pressure Adjusting Station. In addition, there is a pump located at the North Standpipe, however this is not included in the high service pumping capacity analysis as it is primarily used to drain the standpipe for maintenance. A breakdown of the system's high service booster pumping capabilities is noted in Table 9 for the two pumping stations. The "Firm" pumping capacity is calculated when the largest pump is assumed to be out of service. The Illinois EPA requires that a system be evaluated assuming the largest pump is out of service at each pumping station. The system's total firm pumping capacity is 7,600 gpm (10.9 MGD). This is 5,072 gpm above the average day demand of 2,528 gpm (3.6 MGD) and 3,311 gpm above the maximum day demand of 4,289 gpm (6.2 MGD).

TABLE 9

Pump Capacity by Location

Location	Booster Capacities (gpm)	Firm Capacities (gpm)
Civic Center	6 pumps @ 1,040 gpm	5 pumps @ 1,040 gpm
Subtotal	6,240	5,200
Highland	3 pumps @ 1,200	2 pumps @ 1,200
Subtotal	3,600	2,400
TOTAL	**9,840**	**7,600**

The Civic Center Reservoir Pumps have significant storage and ample high service pump capacities which can deliver large volumes of water into the distribution system at any time to meet peak hourly (1.5 times the maximum daily rate of use over a 12 hour period) and fire suppression (3,500 gpm for a three hour duration to accommodate industrial, institutional, and commercial buildings) demands.

2.6 Water System Operations

The Village utilizes its SCADA system to control, manage, and monitor pumping operations within the water system. The SCADA system provides the water system resilience to varying conditions and operational flexibility. In general, the system operates to call for set flow rates at the pressure adjusting stations based on tank levels and local system pressures.

3. WATER USE

This section describes past water use. Historical water demand information is based on water pumpage data provided by the Village. The Village's population data (as estimated from U.S. Census data) is used to estimate average per capita demands..

3.1 Historical Water Use

3.1.1 Water Pumpage Data

Table 10 shows the Village's average and maximum day (the highest total pumpage over a 24-hour period) demands for the last six years, along with a calculated ratio of the maximum to average day (MDD:ADD).

TABLE 10

Historical Water Pumpage Data

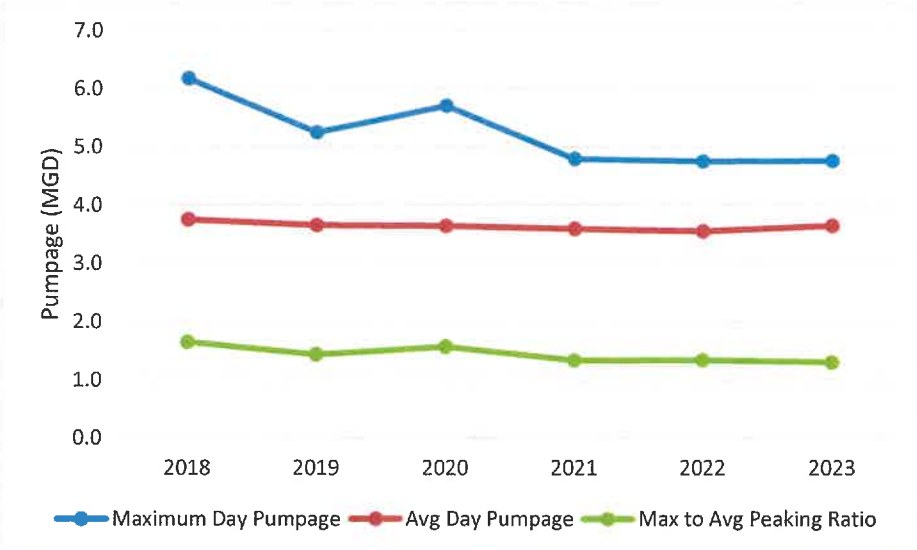
Year	Average Day Demand (MGD)	Maximum Day Demand (MGD)	MDD:ADD Ratio
2018	3.8	6.2	1.65
2019	3.7	5.3	1.44
2020	3.6	5.7	1.57
2021	3.6	4.8	1.33
2022	3.6	4.8	1.34
2023	3.6	4.8	1.31
	Average: 3.6	**Max: 6.2**	**1.72**

The system's average day water pumpage has remained constant over the last six years. The maximum day demand has been decreasing since 2018. This study used an average day demand of 3.6 MGD and a maximum day demand of 6.2 MGD.

Figure 1 plots the average day demand, maximum day demand, and MDD:ADD ratio. The MDD:ADD ratio ranged from a low of 1.31 to a high of 1.65 and is similar to other nearby communities. This study uses a conservative value of 1.72 for the MDD:ADD ratio which is the max from the last six years dived by average of the last six years.

FIGURE 1

Historical Water Pumpage



3.1.2 Water Consumption Data

The water system's average day demands are calculated by dividing the total yearly water pumpage divided by the number of days in the year. Average per capita water pumpage data is calculated by dividing the average day pumpage by the estimated population for the year.

Table 11 shows past average day pumpage and population to calculate average per capita demand. The population is the assumed population of the entire system. A plot of average per capita pumpage is also shown in Figure 2. For the purposes of this report, we will assume per capita pumpage at 82.5 gallons per day, which is based on average use over the last five years.

TABLE 11

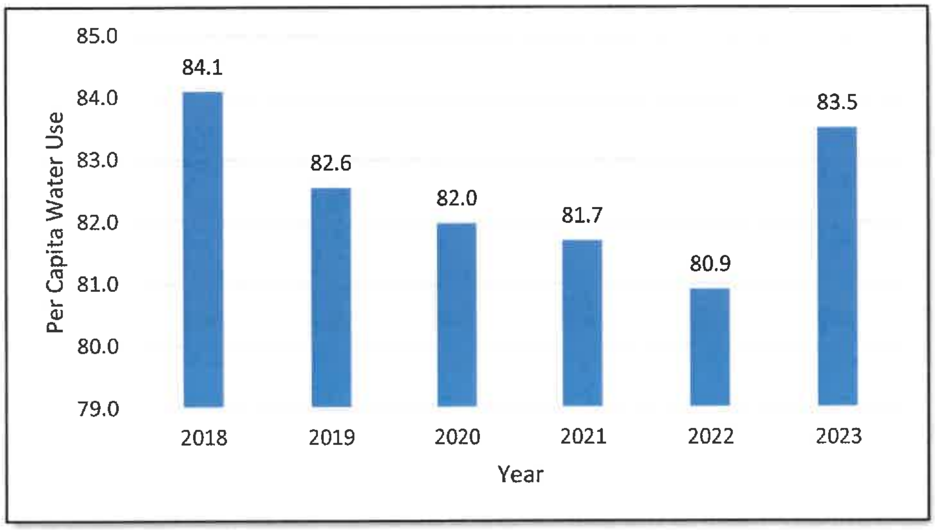
Population, Per Capita, Average, and Maximum Day Pumpage Data

Year	Population	Average Day Pumpage (MGD)	Average Per Capita Pumpage (gcd)
2018	44,600	3.8	84.1
2019	44,300	3.7	82.6
2020	44,400	3.6	82.0
2021	44,000	3.6	81.7
2022	43,900	3.6	80.9
2023	43,700	3.6	83.5
Average	-	**3.6**	**82.5**

Figure 2 shows the average consumption per capita from 2018 through 2023. According to this analysis, the average consumption peaked in 2018 with a value of 84.1 gcd and was at a low of 80.9 gcd in 2022. While the per capita usage had been trending downward since 2018, it increased slightly in 2023. This was likely due to a slight decrease in population while average day pumpage remained the same.

FIGURE 2

Average Day Per Capita Water Pumpage



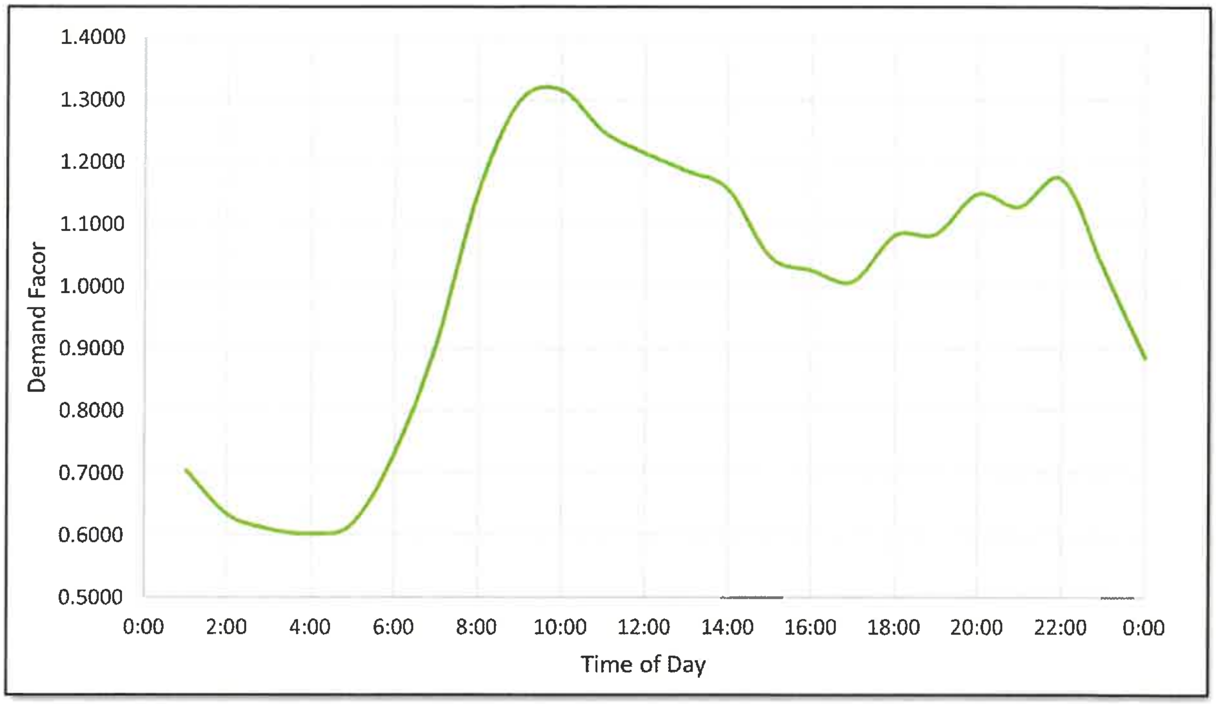
There is no standard from the American Water Works Association (AWWA) for average water consumption as water use varies from community to community. However, average residential consumption has decreased in the Chicagoland region over the past 20 years from approximately 100 gallons per day to 80 gallons per day. This reduction in water demand can be attributed to factors such as increased education on water conservation and low flow appliances.

3.1.3 Diurnal Analysis

Water use is not consistent throughout the day. In general, water use peaks early in the morning and again in the evening before dropping overnight. Figure 3 below shows graph of water use throughout the day, which was developed using SCADA data of daily flows and tank levels provided by the Village. In this analysis, system inflows as well as changes in tank levels are used to determine how much water is flowing into the system at any given time. The water flowing into the system for each hour is then divided by the total amount of water used in the whole day to give a factor for each hour. This normalized factor can then be used in any given demand scenario to give the changing demands throughout the day.

FIGURE 3

Diurnal Curve



4. WATER MODEL DEVELOPMENT

4.1 General Description

The Village of Lombard's water system was modeled using a software called OpenFlows WaterGEMS®. The hydraulic model is representative of the entire water system including water sources, storage facilities, pumping facilities, and all the public water mains within the distribution system. Two analyses were performed in the model. The steady state analysis looks at the system at a moment in time. The extended period simulation, looks at how the system changes over a period of time. The distribution model provides several advantages to the system and was used for the following evaluations:

1. Identify inadequately sized water mains and evaluate proposed improvements to correct inadequacies.
2. Simulate a variety of existing or proposed facility operating scenarios and/or demand conditions.
3. Estimate the delivery capability at any point in the system without conducting hydrant tests in the field.
4. Simulate water operations and analyze estimated water age throughout the system.

Model Description - The OpenFlows WaterGEMS® water distribution analysis and design software was used to build the water system model for this project. The model includes pipes, pipe intersections (junctions), fire hydrants, control valves, storage facilities, and pumps corresponding to the actual physical elements of the distribution system. The data required to run the software includes various pipe characteristics (diameter, material, age, and Hazen-Williams coefficient), ground elevations throughout the service area, geographically-based water demands, storage facility characteristics (volume, geometry, and elevations), and pump characteristics (pump curves and operational controls).

4.2 Hydraulic Model Development

The creation of the new water model began by obtaining the most up-to-date distribution and facility system data from the Village's GIS. The model was built by importing data such as elevations, water main attributes, and storage tank locations from the GIS and assigning the data to the applicable model features. Additional information was added where needed to ascertain the size, length, material, location, and approximate age of every water main in the system. Village staff helped review the distribution system data and provided information on any missing or incorrect pipe age, material, and diameter.

The Village provided billing data for each water billing account, including annual consumption records and physical meter addresses. The billing information was geocoded in GIS to spatially allocate the demands in the model. This method of spatial demand assignment accurately reflects how water demands vary throughout the system.

Ground surface elevations were assigned to each pipe junction and fire hydrant location using elevation contours obtained from DuPage County. This provides a highly accurate indication of how pressures vary throughout the system based on ground surface elevations.

4.2.1 Demand Scenarios

The model represents the different demands experienced in a water system using different demand scenarios. Normal conditions are modeled using the average day demand (ADD) scenario with a demand of 3.6 MGD. High demand days are modeled in the maximum day demand (MDD scenario) with a demand of 6.2 MGD. In each of these scenarios, the ADD and MDD respectively were applied to the system and the corresponding results for fire flow, pressure, and water age were calculated.

4.3 Field Testing and Model Calibration

Fire hydrant flow tests were performed to stress the system by creating large local pressure drops caused by the high hydraulic pipe friction losses associated with increased water main velocities. Field testing was conducted in September 2023 and included fire hydrant flow tests and pressure monitoring. Exhibit B shows the locations of the 14 flow tests completed.

Hydrant flow and local pressure data was recorded at each flow test location. Pressures, flow rates, elevated tank water levels, and pumping rates were recorded during the field testing and used to calibrate the model.

Calibration was performed by adjusting Hazen-Williams C-factors within the model so that simulated model results match field data obtained as closely as possible. C-factors indicate the degree of roughness within a pipe; pipes with high C-factors have less frictional head loss than pipes with low C-factors. Pipes with low C-factors tend to be older and can indicate tuberculation or other hydraulic or water quality issues.

Field-recorded flow rates and residual pressures were compared with the flows and residual pressures simulated in the hydraulic model. In cases where the actual and simulated values for flow and pressure were different, the C-factors within the model were adjusted to recreate the field results as closely as possible. Of the 14 tests completed, 11 fell within the targeted accuracy range of plus or minus 5 psi for flow conditions. It is not uncommon to have some test locations that do not meet the targeted calibration accuracy due to possible errors in GIS data, including incorrect pipe attributes, incorrect connections, undocumented field changes, and the potential for closed distribution valves.

The model should be periodically recalibrated to incorporate major distribution revisions as they are constructed, correct mapping anomalies, or update closed valves identified since the prior calibration.

4.4 Static Model Simulation

Static simulations of maximum day and average day demand conditions were conducted to determine expected operating conditions under varying degrees of demand. Exhibit C shows pressures under current maximum day demands with elevated tank levels set at typical operating levels.

Pressures were primarily within Ten State Standards recommended range of 35 psi minimum working pressure and 50-80 psi average working pressure. The water model demonstrates the expected maximum day pressures throughout the system range from about 35 to 97 psi.

The available fire flow within the system varies significantly by location and water main size with recommended levels of fire flow provided in most areas. The results of these and related analyses are discussed in greater detail within Section 5.

4.5 Extended Period Simulation

An extended period simulation (EPS) was developed to simulate operational performance over a period of 96 hours. The EPS contains the same pipe and tank information as the steady state model but integrates water delivery flow rates from DWC transmission mains along with booster pump, reservoir, and elevated tank operations to simulate tank filling and withdrawal controls. The EPS simulates tower and reservoir cycling in response to varying demand conditions established by the system's diurnal pattern.

Extended period simulations are useful for identifying potential water quality concerns. Water age is evaluated throughout the system under varying demand levels, control set points, and scenarios for a period of seven days. Estimated water age is used to evaluate tank turnover and to predict areas in the distribution system which may experience lower water quality. The results of these analyses are discussed in greater detail in Section 5.

5. WATER SYSTEM HYDRAULIC EVALUATION

5.1 Pressure

Water pressures in water distribution systems are determined primarily by hydraulic grade line (HGL) as it relates to ground surface elevation (GSL) in a particular area. The system relies on delivery pressure from DWC to maintain the HGL in the system. Currently the system's pressures range from 35-97 psi. Under normal operations, one hydrant experiences a pressure of 35 psi under average day conditions near E Wilson Ave and S Norbury Ave. This area is the highest elevation in the low pressure zone, leading to lower pressures. This area could be susceptible to losing acceptable pressures during emergencies and should be monitored during these times.

5.2 Fire Flows

Table 12 shows recommended minimum levels for fire protection based on land use. These recommended fire flows for residential land uses are based upon Insurance Service Office (ISO) standards for single family homes and the value corresponding to maximum credit for community water systems under the scoring for ISO's community protection ratings. The recommended fire flows shown for General Commercial, Office/Research, and Multi-family residential are interpolated based on the target for single family homes and the 3,500 gpm value corresponding to the maximum system credit. Together, the table provides a rule of thumb for desired fire protection and prioritization of distribution improvements.

The actual required fire flow for all building classifications except single family homes is a function of several attributes including building size, materials of construction, and on-site fire protection measures such as individual building sprinklers. In many cases, the calculated needed fire flow of an individual building will exceed the 3,500 gpm design fire flow for community water systems. In these cases, onsite measures should be pursued to limit the required fire flow to the distribution system capabilities. In areas of new development, it is recommended that the minimum recommended fire flow rates in Table 12 be used to establish minimum standards for distribution system sizing.

TABLE 12

Minimum Recommended Fire Flow Rates

Land Use	Minimum Fire Flow (gpm)
Single-Family Residential	1,000
Multi-Family Residential	2,500
Commercial – General	2,500
Office/Research	2,500
Commercial – Downtown	3,500
Institutional	3,500
General Manufacturing	3,500

The hydraulic model was used to evaluate fire flow throughout the system. The model simulated available flows under maximum day demand conditions. The available fire flow represents the flow that can be obtained from a given junction or hydrant while maintaining a system residual pressure of 20 psi. The model applied an upper limit of 5,000 gpm, so that no hydrant was able to flow more than 5,000 gpm. This is well above the highest minimum recommended fire flow 3,500 gpm.

Some portions of the system were found to have unsatisfactory fire flow. In general, most of the areas with low fire flow are within the oldest parts of the system with smaller diameter mains or dead ends. There are also some areas with large industrial users that require higher fire flows. This is typical of communities that developed at the same time as the Village. Smaller diameter mains were not originally designed to deliver the modern day required fire flow. The maximum day fire flows are illustrated in Exhibit D. Exhibit E highlights the areas where the available fire flows are less than the flow recommended for that land use classification.

Improvements to fire flows can be made with a combination of upsizing pipes, improving connectivity, and making operational changes. These improvements are discussed in more detail in Section 8, after a review of other water main and distribution subjects.

5.3 Water Storage Evaluation

Water storage facilities provide water to meet the peak hourly demands, water for fire protection, and a reserve capacity for emergencies such as periods when the supply system is inoperable. The Lombard System currently has two ground storage facilities, one elevated tank, and one standpipe with a total capacity of 5.6 MG, as outlined in Table 8.

Several design methods were used to evaluate the system's overall system storage:

1. One Average Day Storage Volume Plus Fire Suppression Needs
2. Peak Hour, Fire Suppression, and Emergency Reserve
3. DWC Recommended Storage Volume

5.3.1 Average Day Storage Volume and Fire Suppression Recommendation

For the one average day storage volume calculation, the average day demand and fire suppression is added to equal a recommended storage volume, as shown in the equation below.

$$Average\ Day\ Demand + Fire\ Supression = Storage\ Recommendation$$

Average Day Demand – The IEPA commonly refers to a Ten States Standards guideline which advocates that water systems have a minimum storage volume equal to the amount of water that the system would normally deliver during one average day demand period plus fire suppression needs. For the Village of Lombard System, one average day is equivalent to 3.6 MG of total system storage.

Fire Suppression – The storage volume required for fire protection is dependent on the fire flow rate and duration. The maximum fire flow rate is recommended to be 3,500 gpm for a three-hour duration to accommodate industrial, institutional, and commercial buildings. This is equivalent to a total of 630,000 gallons. This fire flow volume is to be added to the average day demand volumes requirement calculated above.

The recommended combined Average Day Demand and Fire Suppression equates to 4.27 MG, as shown in Table 13. With 5.6 MG of existing storage, the system has more than adequate storage to meet the one average day criterion with an allowance for additional fire protection.

TABLE 13

Average Day Storage Volume Recommendation

Storage Requirements	Volume (MG)
Average Day Demand	3.64
Fire Suppression	0.63
Total Required	**4.27**
Existing Storage Volume	5.60
Excess Storage	**1.33**

5.3.2 Peak Hourly, Fire Flow, and Emergency Reserve Analysis

For the peak hour, fire suppression, and emergency reserve storage calculation, the peak hour demand, fire suppression, and emergency reserve volume are added to equal a recommended storage volume, as shown in the equation below.

$$Peak\ Hour\ Demand + Fire\ Suppression + Emergency\ Supply = Storage\ Recommendation$$

Peak Hour - Higher than average demands normally occur between the hours of 7:00 AM and 7:00 PM on any given day. A conservative method to determine the amount of storage necessary to meet this peak domestic water use is the difference between the peak hourly rate (1.5 times the maximum rate of use) and the average delivery rate for a 12-hour period. This approach estimates the amount of storage needed to provide water more than the average hour demands during a maximum day. For the Lombard System, this equates to a recommendation for peak hour, fire suppression, and emergency supply storage requirements during design maximum day at 6.58 MG.

Fire Suppression - The storage volume required for fire protection is dependent on the fire flow rate and duration. The maximum fire flow rate is recommended to be 3,500 gpm for a three-hour duration to accommodate industrial, institutional, and commercial buildings. This is equivalent to a total of 630,000 gallons. This fire flow volume is to be added to the peak hourly demand volumes requirement calculated above.

Emergency Supply - An additional amount of storage is also recommended to provide a reserve supply of water to meet system demands during emergencies and provide additional backup storage in the event of a major fire occurring when system storage is partially depleted. This reserve amount is typically set at 25% of total storage provided. For this calculation, the amount of combined storage estimated above (peak hour plus fire flow) and was multiplied by 0.25 to obtain a reserve amount equal to 25% of the total. For the Village, the emergency reserve storage volume is 1.32 MG.

The recommended combined peak hourly, fire suppression, and emergency reserve storage volume for the system is shown in Table 14. The system does not currently have the recommended peak hourly storage. However, the Village is in the process of constructing a new 1.5 MG elevated tank planned to be completed in 2025 which will increase the storage volume above the recommended peak hourly storage volume.

TABLE 14

Peak Hourly, Fire Flow, and Emergency Reserve Storage Volume

Storage Requirements	Volume (MG)
Peak Hourly Demand	4.63
Fire Suppression	0.63
Emergency Supply	1.32
Total Required	**6.58**
Existing Storage Volume	5.60
Storage Deficit	**0.98**

5.3.3 DWC Required Storage Recommendation

The Village's water supplier, DWC, recommends their communities keep additional storage in the case of a supplier outage. DWC recommends each of their communities have two times their average day demand in total storage. Table 15 details the required storage under this scenario.

TABLE 15

DWC Recommended Storage Volume

Storage Requirements	Volume (MG)
Average Day Demand	3.64
Total Required	**7.28**
Existing Storage Volume	5.60
Storage Deficit	**1.68**

5.4 High Service Booster Pump Evaluation

High service booster pumps are necessary to deliver water out of the ground level reservoirs. Booster pumps are sized to meet high demand conditions during maximum day demand periods as well as during emergencies for fighting fires or water main breaks.

As noted in Section 2.5, the system has 14.1 MGD (9,840 gpm) of total pumping capacity and 10.9 MGD (7,600 gpm) of firm pumping capacity. Using a peak hour demand during the day at 1.5 times the maximum day for 12 hours, the recommended design peak hourly high service pump capacity need within the Village's system (ignoring any contribution from elevated storage) is 8.1 MGD (11,952 gpm).

TABLE 16

Excess Pump Capacity

Storage Requirements	Volume (MG)
Firm Pump Capacity	10.9
Recommended Peak Hourly Pump Capacity	4.6
Excess Pump Capacity	**6.3**

5.5 Water Age

It is important for a distribution system to circulate its water to reduce the amount of stagnant water and maintain adequate chlorine residual. Inadequate chlorine residual levels tend to occur when water age is greater than five days. Average water age can be lowered throughout a system by providing adequate mixing and turnover in storage facilities.

Extended period simulations evaluated existing demand and operating conditions. Estimated water age after 96 hours of simulation during average day conditions is shown in Exhibit F. Results of the extended period simulation modeling show that, as expected, the extreme edges of the system show the highest expected water age due to the distance from the delivery structures.

In addition to the average day scenario, the proposed water tower was evaluated using the extended period simulation. In this scenario, an additional 1.5 MG water tower was added at the south end of the system on Butterfield Road. The maximum water age in this scenario is shown in Exhibit G. This shows that increasing the storage in the system does increase water age in the high zone slightly. However, this increase in water age is minimal compared to the benefits of having adequate water storage in the case of an emergency. Including a mixer or a separate inlet and outlet can negate the increased water age.

There is also a slight decrease in water age in the low zone. The new tower helps maintain pressures across the system and slightly reduces the flow called for from the DWC Pressure Adjusting Stations. This leads to water being turned over slightly more quickly in the low zone.

5.6 Water System Operations

In general, the Village is seeing good turnover in their tanks and experiences few operational challenges. Recent changes to the North DWC Pressure Adjusting Station and North Standpipe have caused some uncertainties regarding the setpoints at this location. The Village may adjust their setpoints at this tower to increase turnover and reduce water age in this area.

The Village also has three pressure reducing valves between the two zones. The valve at Roosevelt and Finley Road does not have the capability to monitor flow whereas the PRVs at the Main and South Booster Stations are monitored. Adding a flow monitor at the Roosevelt and Finley Road location would help staff better understand how water is moving between the two zones at this location.

6. WATER DISTRIBUTION SYSTEM EVALUATION

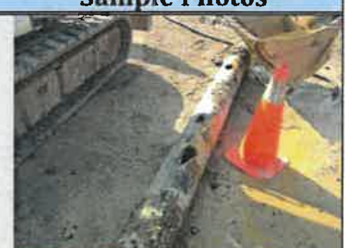
6.1 Water Main Breaks

Exhibit H shows the location of main breaks in terms of the number of breaks per pipe segment for the Village of Lombard. The AWWA literature estimates the average rate of water main breaks experienced annually is approximately 25 breaks per 100 miles of water main. With 193 miles of water main, this benchmark equates to an estimated 48 annual water main breaks for the Village. The Village's FY2021-2024 Strategic Plan has goal to reduce water main break rate to 20 breaks per 100 miles, which equates to 39 breaks per year. Continued investment in the distribution system and replacement of aging mains is needed to achieve the Village's goal.

Main breaks cause temporary water quality deterioration, service disruptions for customers, pose a risk to the field crews entering excavations to repair breaks, cost money to repair in terms of labor and materials, and force the Village to spend additional money as the lost water must be purchased and repumped. Water main breaks typically fall into one of the three categories outlined in Table 17.

TABLE 17

Main Break Types

Type	Failure Description	Typical Causes of Failure	Sample Photos
Blow Out	Hole in pipe with defined shape and area	Isolated point of pressure or corrosion	
Stress/Shear	Circular break around perimeter of the water main	Poor installation, frost heave, inadequate pipe support, water hammer	
Lateral	Elongated main break	Stress caused by inadequate pipe bedding	

Other miscellaneous main break types include "pinhole" leaks caused by point corrosion and pipe joint failures generally caused by improper installation.

There are multiple factors that contribute to water main breaks which include the following:

Pipe Age: While age is not a direct cause of water main breaks, it can contribute significantly when considered with other factors such as local corrosion rates and pipe material. It has been our experience that ductile iron and spun cast iron pipes manufactured and installed in the 1950s and 1960s tend to corrode and fail prematurely. Thirty-five percent of the Village's system was installed before 1960. Table 18 shows that the water mains from the 1960s experience the highest frequency of breaks, at 49.6 breaks per mile of main installed. Break frequency was calculated by dividing the total number of breaks occurring on water main installed in a particular decade by the total length of main installed in that decade.

TABLE 18

Number of Breaks per Decade of Installation

Decade of Installation	Number of Breaks	Break Frequency (Breaks per Mile)	Percentage of Total Breaks
1920	44	19.7	1%
1930	166	16.3	5%
1940	21	21.0	1%
1950	1,101	29.6	33%
1960	850	49.6	25%
1970	433	16.9	13%
1980	235	8.5	7%
1990	287	9.1	8%
2000	164	6.4	5%
2010	6	0.5	0%
2020	68	31.6	2%
Total	**3,375**	**209.3**	**100.0%**

Pipe Size: Smaller mains generally experience higher failure rates than larger diameter mains because they have a smaller cross-sectional area and have thinner wall thicknesses than larger diameter pipes. These characteristics make smaller pipes more vulnerable to beam failure and corrosion. For the Village, 6-inch diameter mains exhibit the highest frequency and number of breaks, as shown in Table 19.

TABLE 19

Number of Breaks per Pipe Diameter

Diameter (in)	Number of Breaks	Breaks per Mile	Percentage of Total Breaks
4	105	23.4	3%
6	1,953	34.1	58%
8	761	10.8	23%
10	272	12.2	8%
12	279	9.0	8%
14	0	0	0%
16	5	0.99	0%
20	0	0	0%
Total	**106**	**90.5**	**100.0%**

Pipe Material: Common water main piping materials include cast iron, ductile iron, asbestos cement (also called transite), PVC, HDPE, and prestressed concrete cylinder pipe. Varying material characteristics such as wall thickness, corrosion resistance, and flexibility all factor into water main breaks. The Lombard system is 100% comprised of Cast Iron and Ductile Iron pipe material. As described above, ductile iron and spun cast iron pipes manufactured and installed in the 1950s and 1960s tend to corrode and fail prematurely in the Chicagoland area.

Soil Type: Some soils create a corrosive environment for cast iron, ductile iron, and steel water main pipe. For example, silty clay loam is generally poorly to moderately drained and generally classified as corrosive to metallic pipes.

Temperature: Main break occurrences can be related to temperature. Freezing temperatures penetrate soil and pavement above water mains and create soil and pipe stresses due to expansion and contraction of the soil and pipe. Drought conditions also lead to main breaks by causing the ground to pull away from the main, leaving it more susceptible to movement and resulting in increased stress on the water main.

Pressure Differentials: If the water pressure in a system frequently fluctuates over a substantial range of pressures, it will have a fatiguing effect on the pipe as it expands and contracts in response.

Installation and Location: Water mains installed in heavily traveled areas are sometimes more susceptible to breaks due to increased vibrations and loadings. Water mains located in proximity to construction activities can also be vulnerable due to subsurface disturbances and increased loadings from construction equipment. Installation methods can also contribute to water main breaks. It is theorized that a combination of early application ductile iron pipe produced in the 1950s-1960s, in combination with a lack of pipe bedding during the same period, has contributed to premature failure of these pipes.

6.2 Water Main Break Ranking

To assist with the prioritization of water main replacements, the mains with a history of main breaks were ranked using measurable parameters. This task was accomplished using the Village's GIS system in conjunction with the water model and a water main break ranking equation.

The water main break ranking equation is based on selection of factors that best predict if a particular water main segment will develop a leak and the potential impact of that leak on the distribution system and its customers. The equation considers the historical frequency of main breaks per segment, the length each segment, the estimated remaining useful life of the pipe, the water flow volume, and head loss. Mains with breaks that have been replaced in the past seven years have been removed from the ranking process.

Four key factors have been calculated for every pipe segment in the water system that has experienced a main break and the resulting values inserted into the following basic ranking equation:

*TOTAL RANK = (0.4 * Water Main Break Frequency Rank) + (0.15 * Flow Volume Rank)*
*+ (0.15 * Head Loss Rank) + (0.3 * Remaining Useful Life Rank)*

The weight used for the four key factors is represented as 40% for Water Main Break Frequency, 15% for Flow Volume Rank, 15% for Head Loss Rank, and 30% for the Remaining Useful Life Rank. The criticality factors are based on discussions with Village staff and best practices in the water system industry. Percentiles were used to calculate each rank. Using this approach for each factor, the calculations resulted with a score of ten for the highest 5% of segments, a score of zero for the lowest 5%, and the remaining pipe segments evenly assigned rankings between one and nine, inclusive.

The "Water Main Break Frequency Rank" is based on the number of main breaks per 1,000 lineal feet since 2015. Pipe segments are first sorted from highest to lowest based on the number of breaks per 1,000 feet and the percentile ranking of that segment relative to the other mains (top ten percent). The percentile value is then multiplied by 10 and rounded to the nearest whole number.

The "Flow Volume Rank" indicates which pipe segments have the most hydraulic importance to the system. A main break on a large water main conveying a large volume of water will impact a greater portion of the system than will smaller, low flow segments. The Flow Volume Rank is based on each segment's flow relative to the maximum observed pipe flow. Pipe segments are first sorted from highest to lowest based on their flow and the percentile ranking of that segment relative to the other mains. The percentile value is then multiplied by 10 and rounded to the nearest whole number.

The "Head Loss Rank" is based on friction head loss (in feet) per 1,000 lineal feet of pipe. This variable indicates whether a pipe has adequate cross-sectional area to meet flow requirements. Increased head loss occurs due to build-up of deposits in the pipe, inadequate pipe size, or obstructions present in the pipe. The model uses the same maximum day demand simulation as for the Flow Volume Rank to calculate a friction head loss value for each pipe segment. Pipe segments are first sorted from highest to lowest based on their head loss and the percentile ranking of that segment relative to the other mains. The percentile value is then multiplied by 10 and rounded to the nearest whole number.

The "Remaining Life Rank" is based on the expected remaining useful life of the pipe segment. We estimated remaining life based on the criteria in Table 20.

TABLE 20

Estimated Useful Life by Pipe Material

Pipe Material	Estimated Life (years)
PVC	100
Ductile Iron (post-1970)	100
Cast Iron	75
Asbestos Cement	70
Ductile Iron (pre-1970)	50

Remaining life was calculated for each pipe segment in the system based on the pipe material and install date. The percentile value is then multiplied by 10 and rounded to the nearest whole number.

The four ranking factors are then multiplied by their assigned factors as shown in the formula and summed to provide the total rank for each water main segment. The maximum possible segment rank is a value of 10 with the adjustment factors shown above.

All segment numbers and their corresponding ranking ranges are then displayed within the GIS system as shown in Exhibit I. This ranking should then be considered in conjunction with fire flow findings and other capital projects as a means of setting the final pipe replacement prioritizations.

6.3 Water Main Repair and Rehabilitation Considerations

Methodologies considered include open-cut replacement, horizontal directional drilling, and cured-in-place liners. It is important to keep in mind that every water main replacement or rehabilitation is site specific, and the cost should be calculated on the known conditions. Prices used to develop the cost estimates include water service replacement, new valves, new hydrants, trench backfill, and trench patching or lawn restoration.

In most locations, open-cut replacement will be the most cost-effective means to improve fire flow and reduce water main break frequency. There may be some instances that pipe rehabilitation will be more cost effective or practical than traditional open-cut construction. We recommend the Village consider these methodologies on a case-by-case basis for each project.

6.4 Emergency Backup Supply Analysis

The Village also maintains three backup wells and five interconnects to provide water in the case of an emergency. However, the interconnects are also supplied by DWC. In the case of a supplier outage, the Village would be required to rely on their three backup wells. The three backup wells are described in Table 4. Baxter & Woodman previously provided a technical memo regarding the wells and emergency operations. The results of this memo are summarized below.

In an emergency scenario, the Village would turn on their emergency wells to provide enough water to meet the required demands. Table 21 describes various scenarios of turning on wells under average and max day demand conditions. The times presented in these tables represent the amount of time it would take from the storage being completely full to the storage being empty. This analysis assumes the wells would be able to run for 24 hours a day.

TABLE 21

Emergency Backup Supply Times – 24 Hour Runtime

Demand		Storage Only		1 Deep Well		1 Shallow Well		1 Deep, 1 Shallow		Both Deep		All Wells	
	MGD	Hours	Days	Hours	Days	Hours	Days	Hours	Days	Hours	Days	Hours	Days
Average	3.6	36.9	1.5	70.3	2.9	40.4	1.7	84.2	3.5	729.2	30.4	∞	∞
Max	6.2	21.8	0.9	30.2	1.3	22.9	0.9	32.5	1.4	49.4	2.1	55.9	2.3

While the wells may be able to run 24/7 for a short period of time, if an outage extends beyond a couple days, the Village may need to take down a well for maintenance or other reasons. Therefore, it is safer to assume that during an extended outage the wells would run for 18 hours each day. Table 22 performs the same analysis as Table 21, however this analysis assumes an 18-hour runtime for the wells.

TABLE 22

Emergency Backup Supply Times – 18 Hour Runtime

	Demand	1 Deep Well		1 Shallow Well		1 Deep, 1 Shallow		Both Deep		All Wells	
	MGD	Hours	Days	Hours	Days	Hours	Days	Hours	Days	Hours	Days
Avg	3.6	57.3	2.4	39.5	1.7	63.8	2.7	128.2	5.3	165.6	6.9
Max	6.2	27.5	1.2	22.6	0.9	28.9	1.2	37.5	1.6	40.2	1.7

An emergency operations scenario was also run in the model as an extended period simulation where the DWC feeds were shut off and the emergency backup wells were turned on. The water age results are improved in this scenario because less water is being supplied. However, the pressures decrease, and tower levels slowly drain. The pressures in this scenario are shown in Exhibit J. The lowest pressures are as low as 28 psi, which is less than the IEPA recommendation for pressure, but would not warrant a boil order. These low pressure areas are located near E Wilson Ave and S

Norbury Ave. In the case that the Village does need to operate without their normal supply, they will need to do what they can to provide water but should closely monitor the system in this area for low pressures. The Village may want to consider adding an interconnect or an additional well to increase their emergency preparedness.

7. EXISTING AND IMPENDING REGULATIONS

7.1 Existing Regulations

USEPA and IEPA regulations mostly govern water system planning and design, and they set numerical water quality limits that drinking water must meet. AWWA provides a wide range of industry standards and best practices to maintain the reliability and redundancy of water systems to prolong their useful life and maximize reliability in the most cost-effective manner.

7.2 Lead Service Line Replacement Programs

Under the recent Lead and Copper Rule additions, the IEPA requires the full replacement of lead services, partial lead service replacement has been shown to elevate lead levels. In addition, the Illinois Department of Public Health (IDPH) is no longer approving partial lead service replacements under the Illinois Plumbing License Law.

Communities are required to start and submit a lead service line inventory by April 15, 2023. This inventory will require an itemized list of all service lines including the material of both the private and public materials. Unknown service lines will be assumed lead. Depending on the amount of lead service lines in a system, the IEPA will assign a rate of lead service line replacement.

8. WATER SYSTEM IMPROVEMENT; RECOMMENDATIONS AND COSTS

This section provides overall recommendations and costs for proposed distribution improvements.

The Village currently has a number of facility and water main improvements projects budgeted and in progress. This report and associated priority project list contain a list of proposed projects. These future projects are not planned out yearly, but rather they are given a priority ranking to give the Village flexibility in determining yearly improvement projects based on available funding, other capital improvement projects, and other roadway and utility capital improvement projects. This report does not, however, specifically identify all replacements for the facilities or distribution system including undersized mains, older water mains, or mains with high break history.

Costs presented in this report are based on current year (2024) construction based on past projects. All estimates should be verified during the preliminary design stage of a project in advance of bidding, after consideration of more detailed pilot study results, field survey reconnaissance, and other more detailed information. A summary of proposed improvement projects and the estimated costs are shown in Appendix B.

8.1 Recommendations

8.1.1 Water Distribution System

This report identifies a priority project list for water main improvement projects. These are shown in Exhibit K. Improvements were identified to address main breaks, improve service to critical users, increase fire flows, and to complete desired large water main connectivity and improve capacity. The improvements are noted in Table 23.

TABLE 23

Distribution Improvements

Proposed Improvements	Main Breaks	Fire Flow	Water Age /Connectivity
FD450	X	X	X
N Charlotte, Prairie, and View St	X	X	
Central Hammerschmidt, and Norbury Ave	X		
St Charles and Westmore-Meyers Rd	X	X	
DuPage Ave	X		
Meadow Ave	X	X	
Lombard Circle and School St	X		
Cherry, Apple, and Fairview	X		
West Central Lombard Utility Improvements	X		
Manor Hill Subdivision	X		
Eisenhower Ln S	X		

As a general rule, with a water main design life ranging between 50 years and 100 years for different pipe materials, and with the assumed useful life of the 192.9 miles of public water main and the projected life spans, a replacement recommendation was determined by assigning a useful life to each type of pipe in the system. A weighted average lifespan of the pipes is then calculated based on the mileage of each type of pipe. The average useful life of the system is approximately 93 years. To replace all the pipes in a 93 year timeframe, the Village would need to replace 1.1% of their system per year, or 2.1 miles of water mains annually. With average installation costs ranging from $400 - $600 per foot (not including design and construction engineering), 2.1 miles of main replacement would equate to approximately $4,400,000 to $6,700,000 per year.

8.1.2 Water System Storage

Currently, the system has four storage facilities including one elevated tank, two reservoirs, and a standpipe with a total capacity of 5.6 MG, as previously outlined in Table 8. Several design criteria can be considered when developing overall system storage recommendations, as described in Section 5.3. The recommended combined peak hourly, fire flow, and emergency reserve storage volume for the Village is 6.58 MG. Additionally, the supplier's storage requirements of two times the average day demand equate to 7.28 MG. The system will need an additional 0.98 – 1.68 MG to meet this requirement, but the Village is currently constructing the 1.5 MG water tower that will meet this recommendation. For this reason, no additional storage improvements are recommended for the system.

8.1.3 Water System Pumping Capacity

As noted in Section 2.5, the system currently has 10.9 MGD (7,600 gpm) of firm pumping capacity. The peak hour demand over 24 hours is 9.2 MGD. The total available "firm" high service booster pumping capacity of 10.9 MGD greatly exceeds the peak hourly demands; therefore, no booster capacity improvements are recommended.

8.1.4 Future Considerations

When considering future improvements, the Village should consider water main break history, upcoming roadway improvements, and upcoming sewer improvement projects. The Village should consider working and coordinating with residents to perform full lead service replacements when doing any projects involving lead services.

8.2 Costs

Budget-level costs presented in this report are in 2024 dollars. All estimates should be evaluated during the design stage of a project when more information is available. A summary of proposed improvement projects and the estimated costs are shown in Appendix B.

8.2.1 Water Distribution System

Eleven distribution system improvements were developed and simulated with the model to address system deficiencies. Table 24 details the improvements, including proposed diameter and length and estimated project costs.

Exhibit K shows the project locations listed in Table 24. The available fire flows after the projects are completed are shown in Exhibit L. The resulting fire flow needed after all projects are completed based on land use is shown in Exhibit M.

TABLE 24

Distribution Improvement Costs

Improvement	Proposed Diameter (in)	Length (ft)	Estimated Project Cost
FD450[1]	8	23,000	$ 15,000,000
N Charlotte, Prairie, and View St	8	3,050	$ 2,000,000
Central Hammerschmidt, and Norbury Ave	8	3,500	$ 2,200,000
St Charles and Westmore-Meyers Rd	8	2,700	$ 1,700,000
DuPage Ave	12	2,200	$ 1,700,000
Meadow Ave	8	2,200	$ 1,400,000
Lombard Circle and School St	6/8	3,300	$ 2,000,000
Cherry, Apple, and Fairview	6/8	3,850	$ 2,300,000

Improvement	Proposed Diameter (in)	Length (ft)	Estimated Project Cost
West Central Lombard Utility Improvements	6/10	7,000	$ 4,300,000
Manor Hill Subdivision	6/8	6,150	$ 3,800,000
Eisenhower Ln S	12	2,100	$ 1,600,000
		Subtotal:	**$ 38,000,000**

[1]FD450 can be split into multiple phases. Several phasing options are provided in Appendix C.

8.2.2 Water System Storage

As described in Section 8.1.2, the system will need an additional 0.98 MG -1.6 MG to meet a peak hourly storage recommendation or the DWC storage recommendation. Since the Village is currently constructing the 1.5 MG water tower that will meet this recommendation, no additional storage improvements are recommended for the system at this time.

8.2.3 Water System Pumping Capacity

As noted in Section 2.5, the system currently meets booster pumping capacity recommendations. Therefore, no booster capacity improvements are recommended.

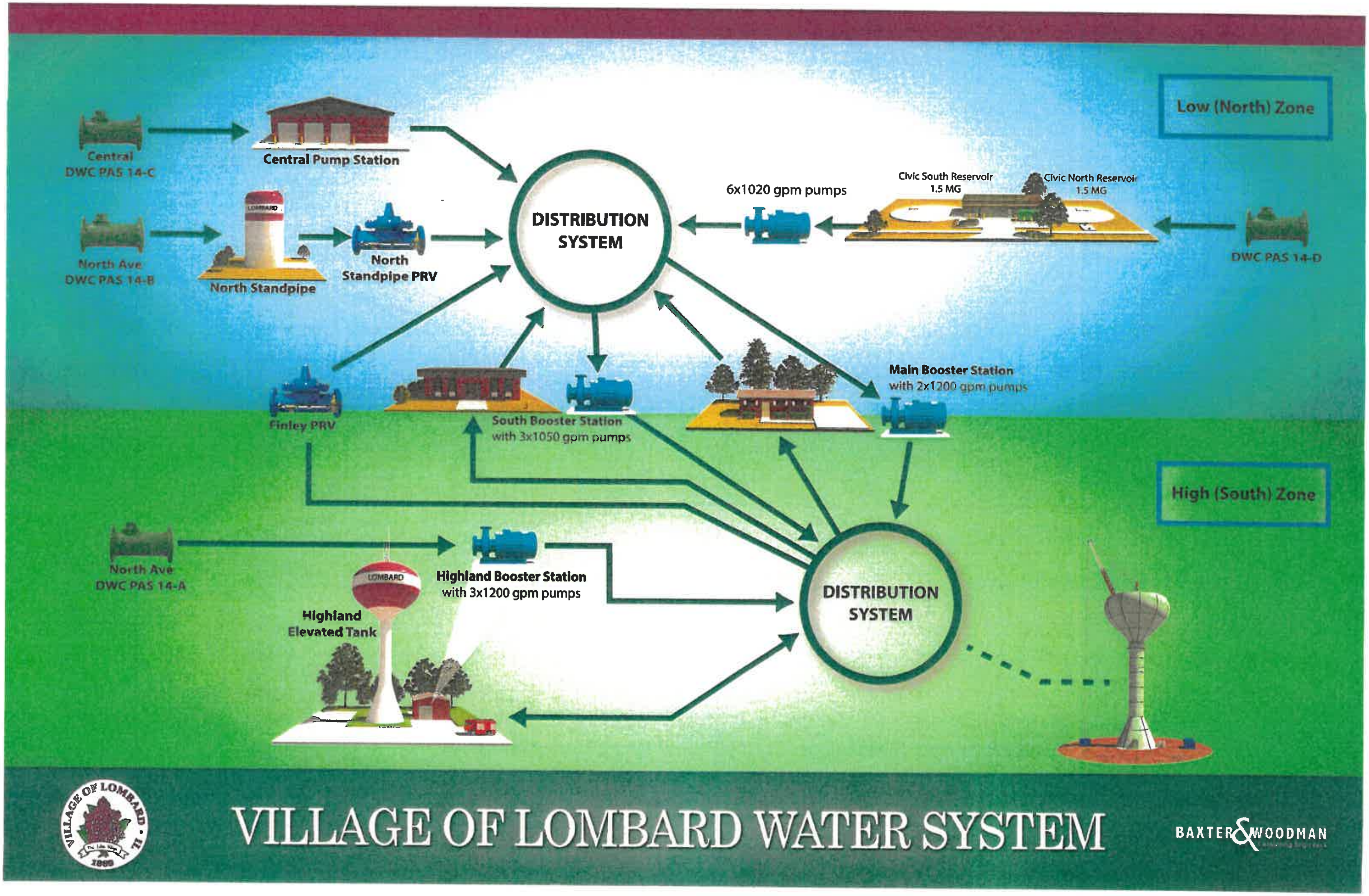
As pumps age and the Village considers replacement, we recommend that the Village conduct a pump capacity study. Large, rarely used pumps that are sized for fire flow demand could be replaced with smaller capacity pumps or even removed entirely. The study should include an evaluation of VFDs for operational flexibility.

8.3 Funding Opportunities

The IEPA revolving loan program is a potential funding source for many communities. While no grant contributions are anticipated soon, the IEPA interest loan rate is projected to remain near 2%.

APPENDICES

BAXTER & WOODMAN
Consulting Engineers



Low (North) Zone
Central
DWC PAS 14-C
Central Pump Station
North Ave
DWC PAS 14-B
North Standpipe
North
Standpipe PRV
DISTRIBUTION
SYSTEM
6x1020 gpm pumps
Civic South Reservoir
1.5 MG
Civic North Reservoir
1.5 MG
DWC PAS 14-D
Finley PRV
South Booster Station
with 3x1050 gpm pumps
Main Booster Station
with 2x1200 gpm pumps
High (South) Zone
North Ave
DWC PAS 14-A
Highland Booster Station
with 3x1200 gpm pumps
Highland
Elevated Tank
DISTRIBUTION
SYSTEM
VILLAGE OF LOMBARD WATER SYSTEM
BAXTER & WOODMAN

Village of Lombard

BAXTER & WOODMAN

Recommended Water Distribution System Improvements

Project	Description	Main Breaks	Low Fire Flow	Connectivity /Looping	Under Sized Mains	Pipe ID Number	Installation Decade	Existing Pipe Material	Existing Diameter (in)	Proposed Diameter (in)	No. of Public LSLs	No. of Private LSLs	LSL Cost	Length	Unit Price	Estimated Cost (Construction)	Contingency (15%)	Design and Construction Engineering (20%)	Total Estimated Project Cost
FD450 - Replace 4" with 8"	Replace 4" main on Charlotte St (Parkside - Maple), Martha St (Parkside - Maple), Craig Pl (Parkside - Madison), Stewart (Parkside - Maple), Lombard Av (Parkside - Morningside), Parkside (Grace-Lombard), and add new main on Maple (Martha - Grace)	X	X	X	X	P767	1930	Cast Iron	4	8	179	146	$ 730,000	23,000	$450	$ 11,080,000	$ 1,670,000	$ 2,216,000	$ 15,000,000
N Charlotte, Prairie, and View St	Replace 4" on N Charlotte (Great Western trail - Pleasant Ln), Prairie (Main - N Charlotte), and View St (Main St - N Charlotte) with new 8" pipe	X	X		X	P4654	1930	Cast Iron	4	8	13	16	$ 80,000	3,050	$450	$ 1,460,000	$ 220,000	$ 292,000	$ 2,000,000
Central, Hammerschmidt, and Norbury Ave	Replace 6" pipe with new 8" pipe on Central Av (Charlotte - Hammerscmidt), Hammerscmidt (Central - Wilson), and Norbury (Central-Wilson)	X			X	P2358	1950/1960	Cast Iron	6	8	0	0	$ -	3,500	$450	$ 1,580,000	$ 240,000	$ 316,000	$ 2,200,000
St Charles and Westmore-Meyers Rd	Replace 6" pipe with new 8" pipe on Westmore-Meyers Rd (RR - St Charles Rd), and St Charles (Westmore-Meyers Rd - System End)	X	X		X	P9189	1930/1950/1960	Cast Iron	6	8	15	3	$ 15,000	2,700	$450	$ 1,235,000	$ 190,000	$ 247,000	$ 1,700,000
DuPage Ave	Replace 10" pipe with new 12" pipe on Dupage Av (North Av - Main St)	X				P3154	1970	Ductile Iron	10	12	0	0	$ -	2,200	$550	$ 1,210,000	$ 190,000	$ 242,000	$ 1,700,000
Meadow Ave	Replace 6" pipe with new 8" pipe on Meadow Road from Columbine Road to West Road, and from Broadview Av from Meadow Av to Greenfield Av	X	X		X	P7511	1930-1980	Cast/Ductile	6	8	0	0	$ -	2,200	$450	$ 990,000	$ 150,000	$ 198,000	$ 1,400,000
Lombard Circle and School St	Replace 8" pipe on Lombard Circle with new 8" pipe and replace 6" pipe on School St and School Ct with new 6" pipe	X				P8316	1960	Cast Iron	6/8	6/8	0	0	$ -	3,300	$440	$ 1,460,000	$ 220,000	$ 292,000	$ 2,000,000
Cherry, Apple, and Fairview	Replace pipe on Cherry (Fairview - Wilson) Apple (Fairview - Wilson), and Fairview (Norton - Wilson) with new same-size pipe	X				P9031	1960	Cast Iron	6/8	6/8	0	0	$ -	3,850	$440	$ 1,700,000	$ 260,000	$ 340,000	$ 2,300,000
West Central Lombard Utility Improvements	Replace Water Main on W Central Ave (Main St to Edison Ave), Edison Ave (Elizabeth St to Wilson Av), and Finley St (Edward St to W Wilson Ave)	X				P6642	1960	Cast Iron	6/10	6/10	0	0	$ -	7,000	$450	$ 3,150,000	$ 480,000	$ 630,000	$ 4,300,000
Manor Hill Subdivision	Line Water main on S Elizabeth St (Colleen to Bike path) Colleen Dr (16th St to Elizabeth), Manor Hill (Finley to Colleen), Manor Hill Ct, Colony Ct, Hillcrest Ln, and Hillcrest Ct	X				P4666	1960	Cast	6/8	8-Jun	0	0	$ -	6,150	$450	$ 2,770,000	$ 420,000	$ 554,000	$ 3,800,000
Eisenhower Ln S	Replace the bottom half of the loop on Eisenhower Ln	X					1970	Ductile Iron	10	12	0	0	$ -	2,100	$550	$ 1,160,000	$ 180,000	$ 232,000	$ 1,600,000

1. Prices include new valves, new hydrants, trench backfill, pavement or lawn restoration, traffic control, erosion control, construction layout, and mobilization. Water main replacement costs also assumes street reconstruction is being completed.
2. Prices do not include right-of-way acquisition, temporary or permanent easements, or relocating other utilities.
3. Unit prices are based on Village projects and feedback and are current for 2024.

Appendix C

Village of Lombard
Fire District 450 Phasing

BAXTER & WOODMAN

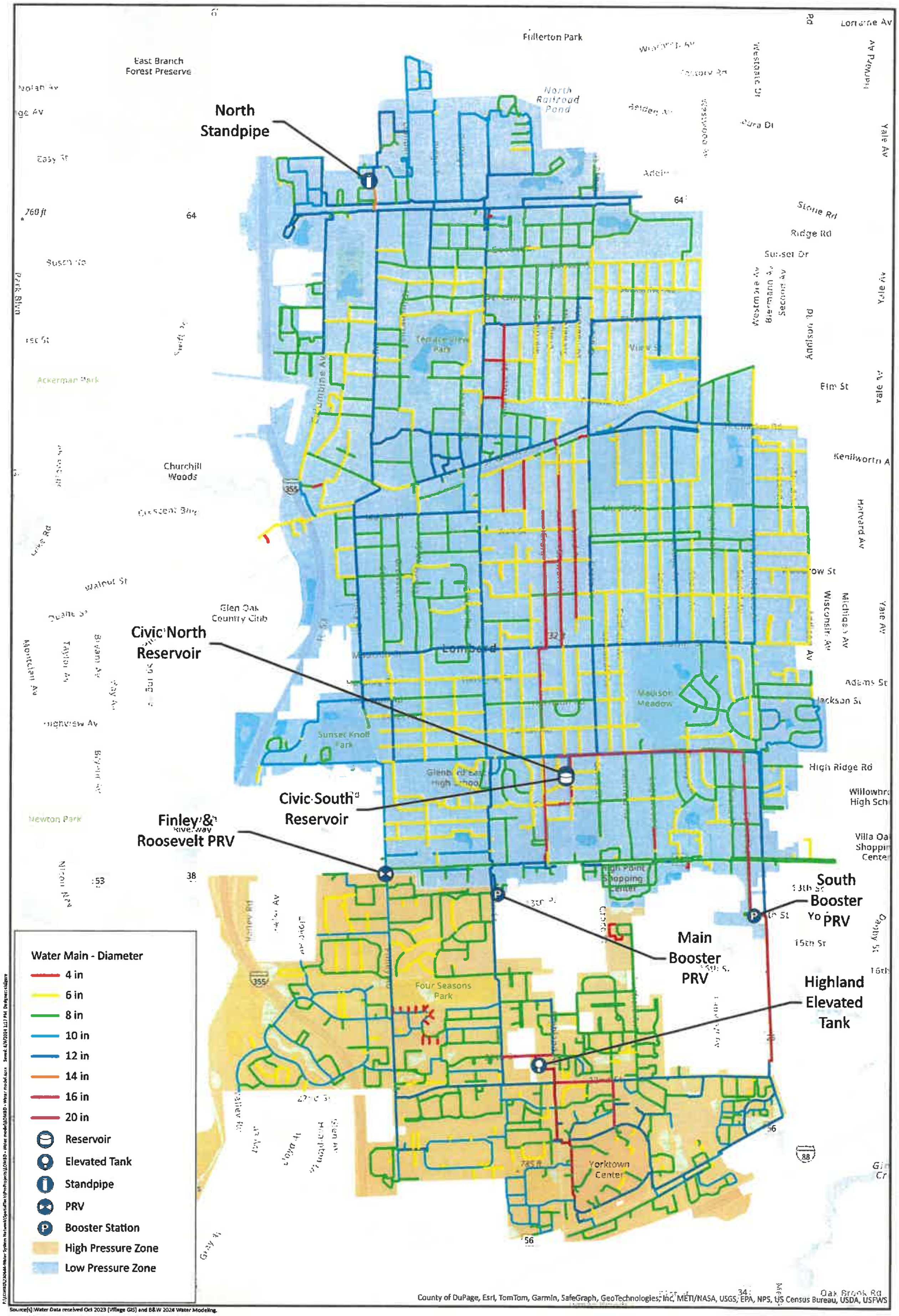
Year	Project	Description	No. of Private LSLs	No. of Public LSLs	LSL Cost	Length	Unit Price	Estimated Cost (Construction)	Contingency (15%)	Design and Construction Engineering (20%)	Total Estimated Project Cost
Option I - shorter sections on several streets	Phase I - North of Maple	Charlotte (Mapte - Parkside), Martha (Maple - Parkside), Craig (Maple - Parkside), Stewart (Maple - Parkside), Lombard (Maple - Parkside), Parkside (Grace - Lombard and Charlotte to Craig), Elm (Craig to Grace)	74	91	$ 370,000	8,300	$ 450	$ 4,110,000	$ 620,000	$ 822,000	$ 5,552,000
	Phase II - Maple to Hickory	Craig (Maple to Hickory), Stewart (Maple to Hickory), Lombard (Maple to Hickory) Maple (Main to Grace), Ash (Main to Grace)	45	62	$ 225,000	8,800	$ 450	$ 4,185,000	$ 630,000	$ 837,000	$ 5,652,000
	Phase III - Hickory to Madison	Craig (Hickory to Madison), Stewart (Hickory to Madison), Lombard (Hickory to Morningside)	27	26	$ 135,000	5,900	$ 450	$ 2,795,000	$ 420,000	$ 559,000	$ 3,774,000
Option II - full streets	Phase I	Charlotte St (Maple - Parkside), Martha St (Maple to Parkside), Maple St (Main to Grace), Parkside (Charlotte to Craig)	19	33	$ 95,000	5,400	$ 450	$ 2,525,000	$ 380,000	$ 505,000	$ 3,410,000
	Phase II	Craig Pl (Parkside to Madison), Ash (Main - Craig), Elm (Craig-Stewart)	46	66	$ 230,000	6,800	$ 450	$ 3,290,000	$ 500,000	$ 658,000	$ 4,448,000
	Phase III	Stewart Av (Parkside to Madison), Ash (Craig to Grace), Elm (Stewart - Lombard)	42	39	$ 210,000	5,800	$ 450	$ 2,820,000	$ 430,000	$ 564,000	$ 3,814,000
	Phase IV	Lombard (Parkside to Morningside), Ash (Craig to Grace), Parkside (Lombard - Grace), Elm (Lombard - Grace)	40	50	$ 200,000	5,500	$ 450	$ 2,680,000	$ 410,000	$ 536,000	$ 3,626,000
Option III - shorter sections, 4 phases	Phase I	Charlotte St (Maple to Parkside), Martha St (Maple to Parkside), Craig Pl (Maple to Parkside), Maple St (Main to Craig), Parkside (Charlotte to Craig)	33	47	$ 165,000	6,100	$ 450	$ 2,915,000	$ 440,000	$ 583,000	$ 3,938,000
	Phase II	Stewart Av (Parkside to Ash), Lombard Av (Parkside to Ash), Craig (Ash to Maple), Elm (Craig to Grace), Maple (Craig to Grace)	56	66	$ 280,000	7,200	$ 450	$ 3,520,000	$ 530,000	$ 704,000	$ 4,754,000
	Phase III	Craig (Ash to Washington), Stewart (Ash to Washington), and Lombard Av (Ash to Washington), Ash (Main to Grace)	53	63	$ 265,000	7,600	$ 450	$ 3,685,000	$ 560,000	$ 737,000	$ 4,982,000
	Phase IV	Craig (Washington to Madison), Stewart (Washington to Madison), and Lombard Av (Washington to Morningside)	1	2	$ 5,000	3,200	$ 450	$ 1,445,000	$ 220,000	$ 289,000	$ 1,954,000

EXHIBITS

BAXTER & WOODMAN
Consulting Engineers

WATER SYSTEM MAP

Water System Network Analysis
VILLAGE OF LOMBARD, ILLINOIS



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Not to Scale

Exhibit A

BAXTER & WOODMAN Consulting Engineers

FLOW TEST LOCATIONS

Water System Network Analysis
VILLAGE OF LOMBARD, ILLINOIS

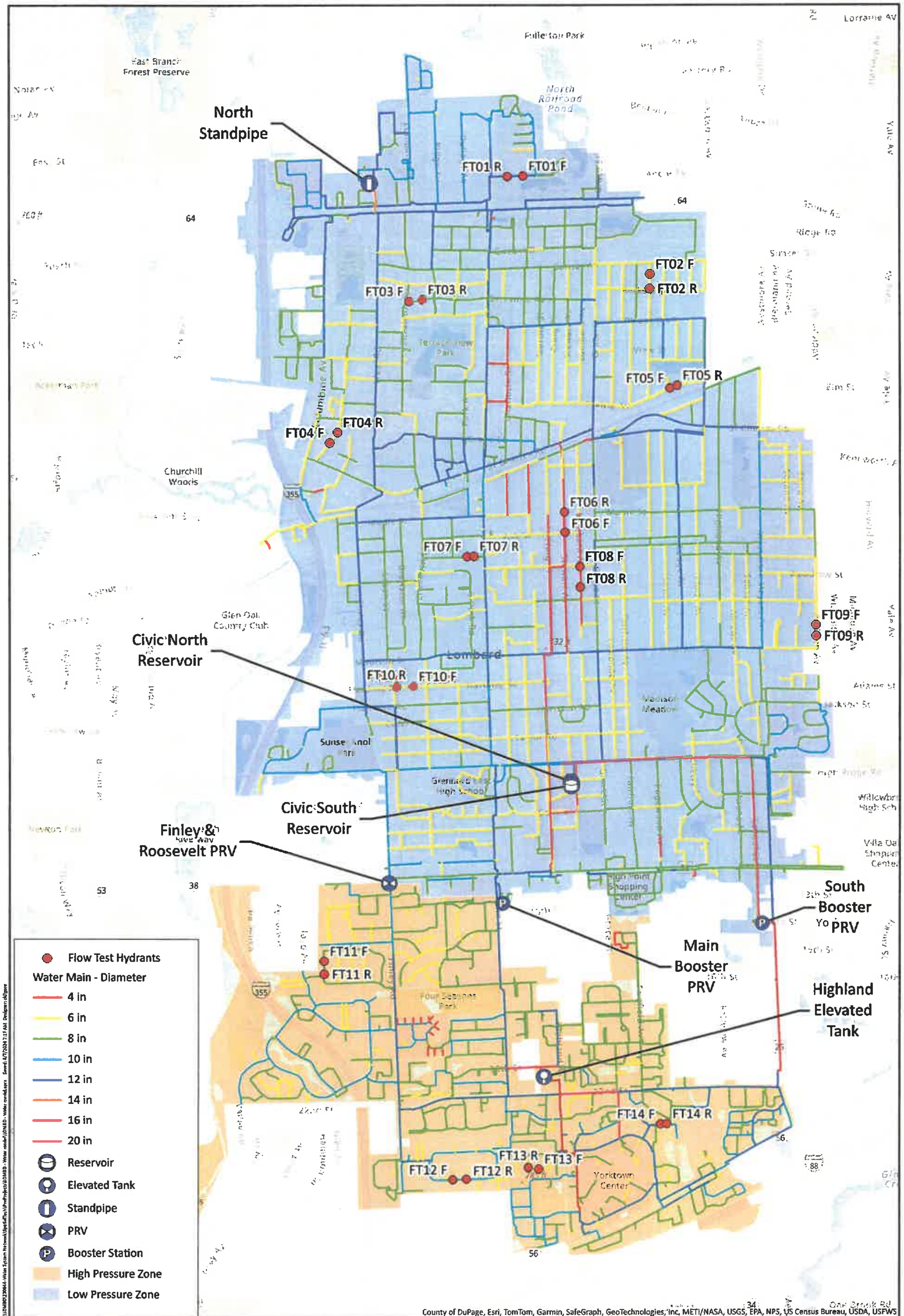

Exhibit B

BAXTER & WOODMAN Consulting Engineers

PRESSURE

Average Day Demand

Water System Network Analysis

VILLAGE OF LOMBARD, ILLINOIS

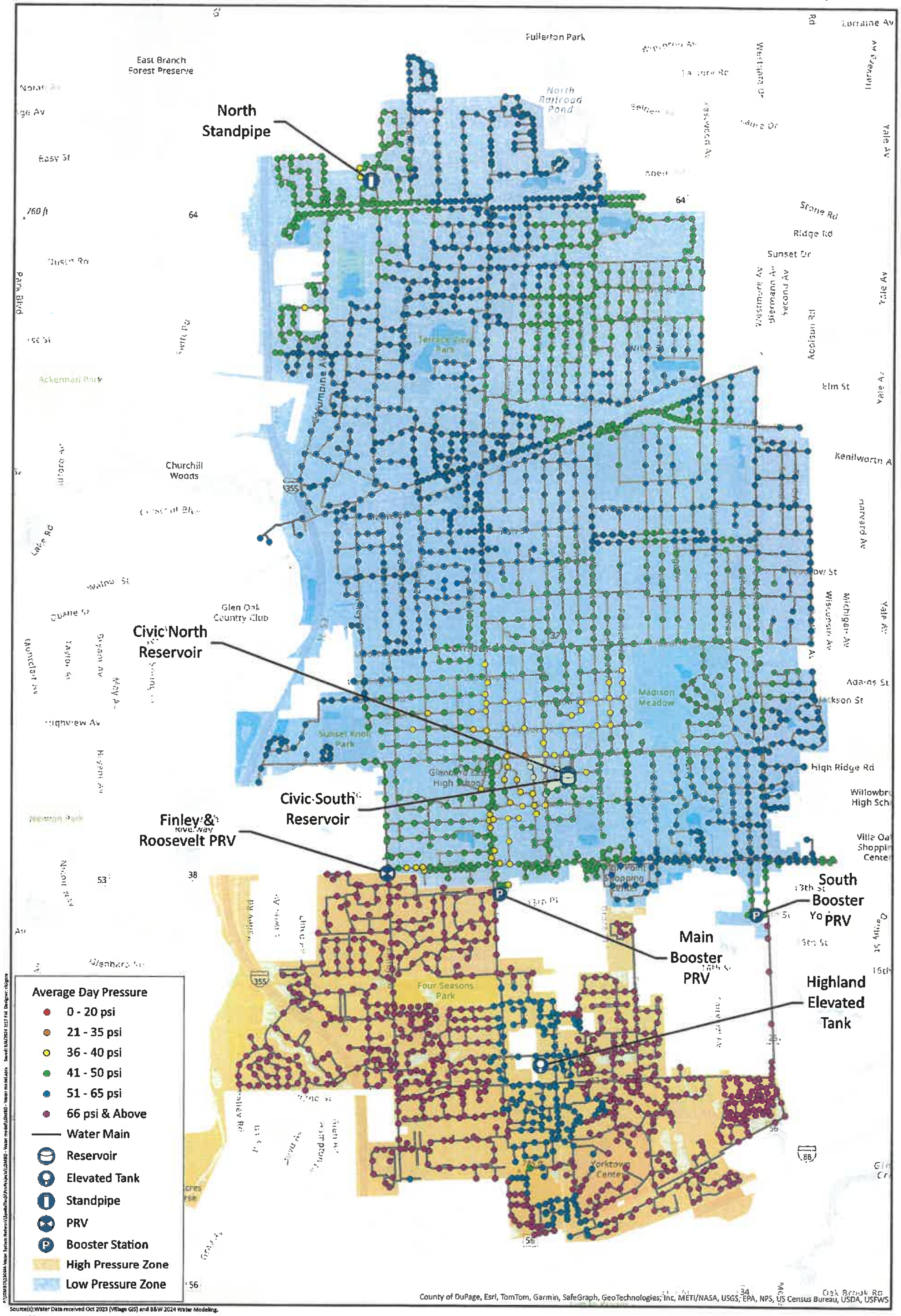

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Exhibit C

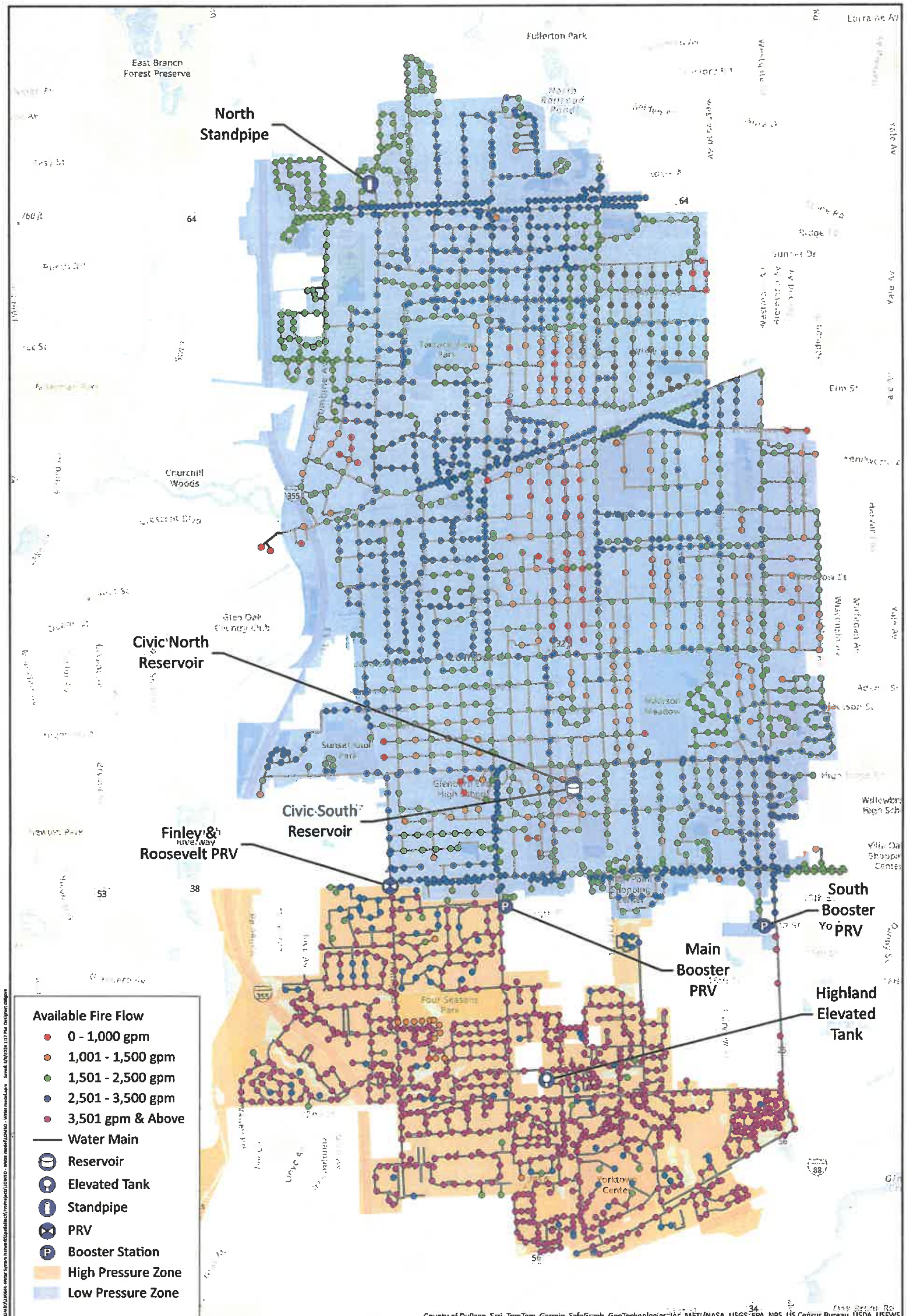
BAXTER & WOODMAN Consulting Engineers

AVAILABLE FIRE FLOW

Maximum Day Demand

Water System Network Analysis

VILLAGE OF LOMBARD, ILLINOIS



Source(s): Water Data received Oct 2023 (Village GIS) and B&W 2024 Water Modeling.

N

Not to Scale

Exhibit D

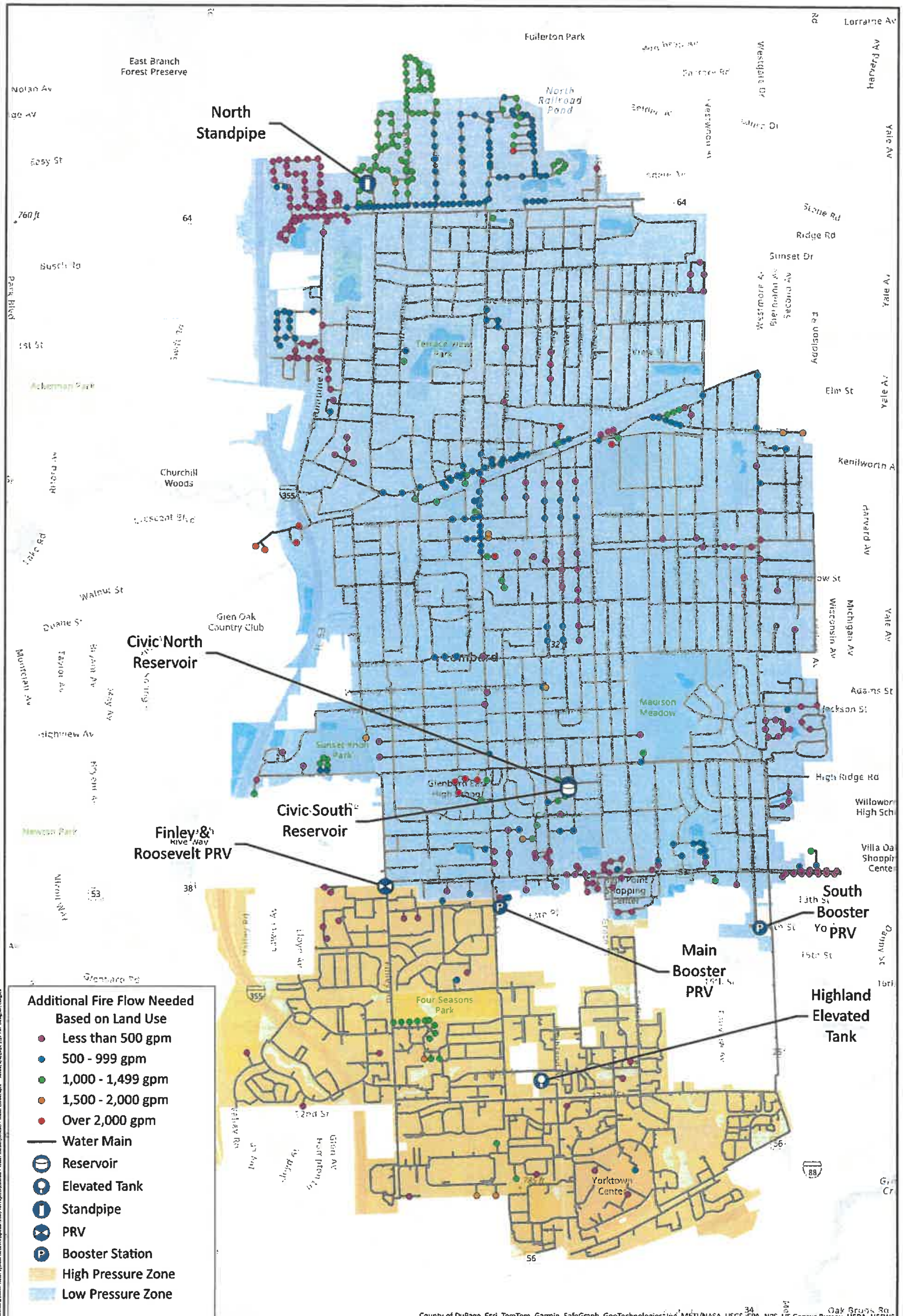
BAXTER & WOODMAN Consulting Engineers

FIRE FLOW NEEDED

Maximum Day Demand

Water System Network Analysis

VILLAGE OF LOMBARD, ILLINOIS



Source(s): Water Data received Oct 2023 (Village GIS) and B&W 2024 Water Modeling.

N

Not to Scale

Exhibit E

BAXTER & WOODMAN Consulting Engineers

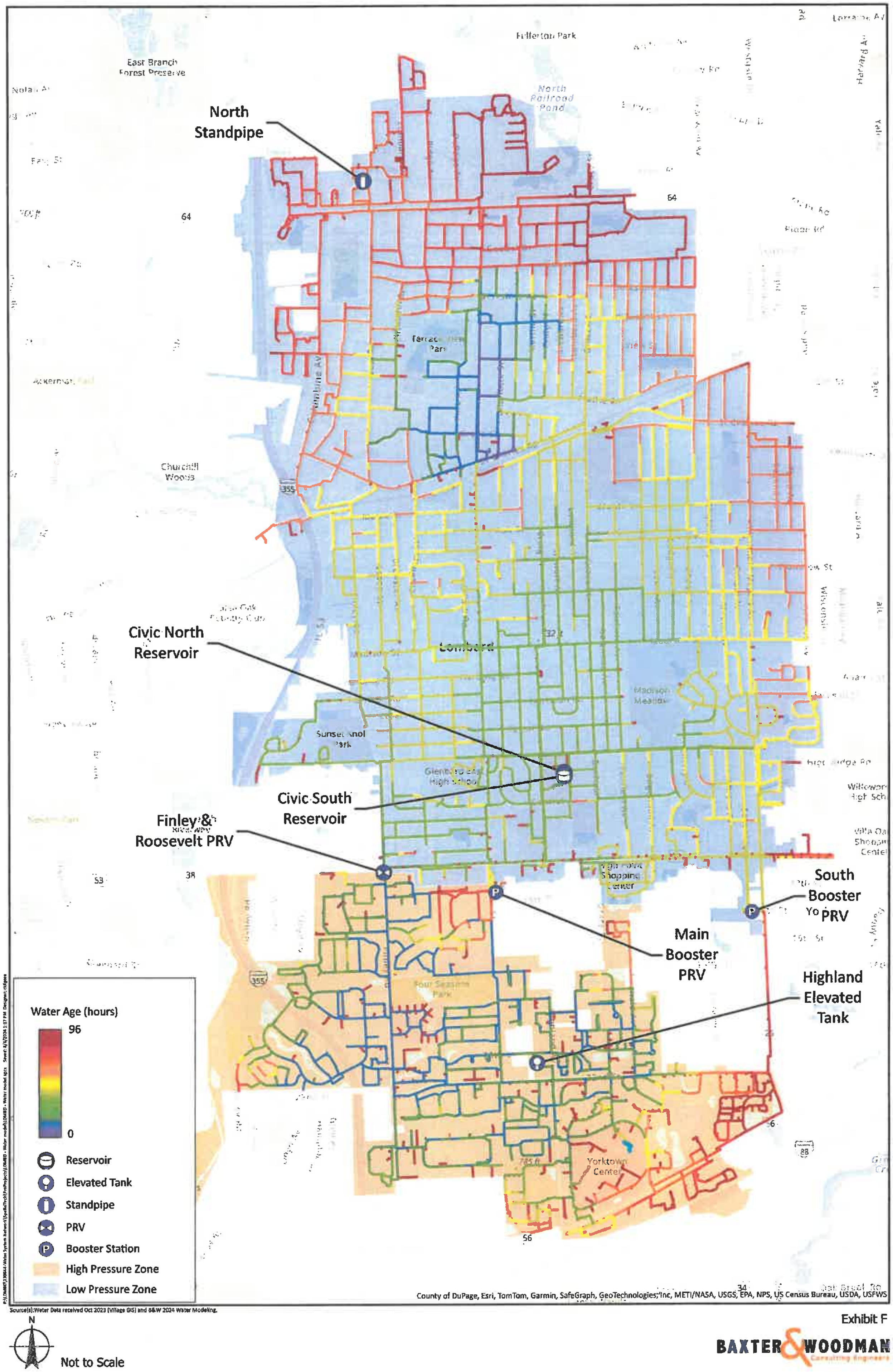


Exhibit F

BAXTER & WOODMAN Consulting Engineers

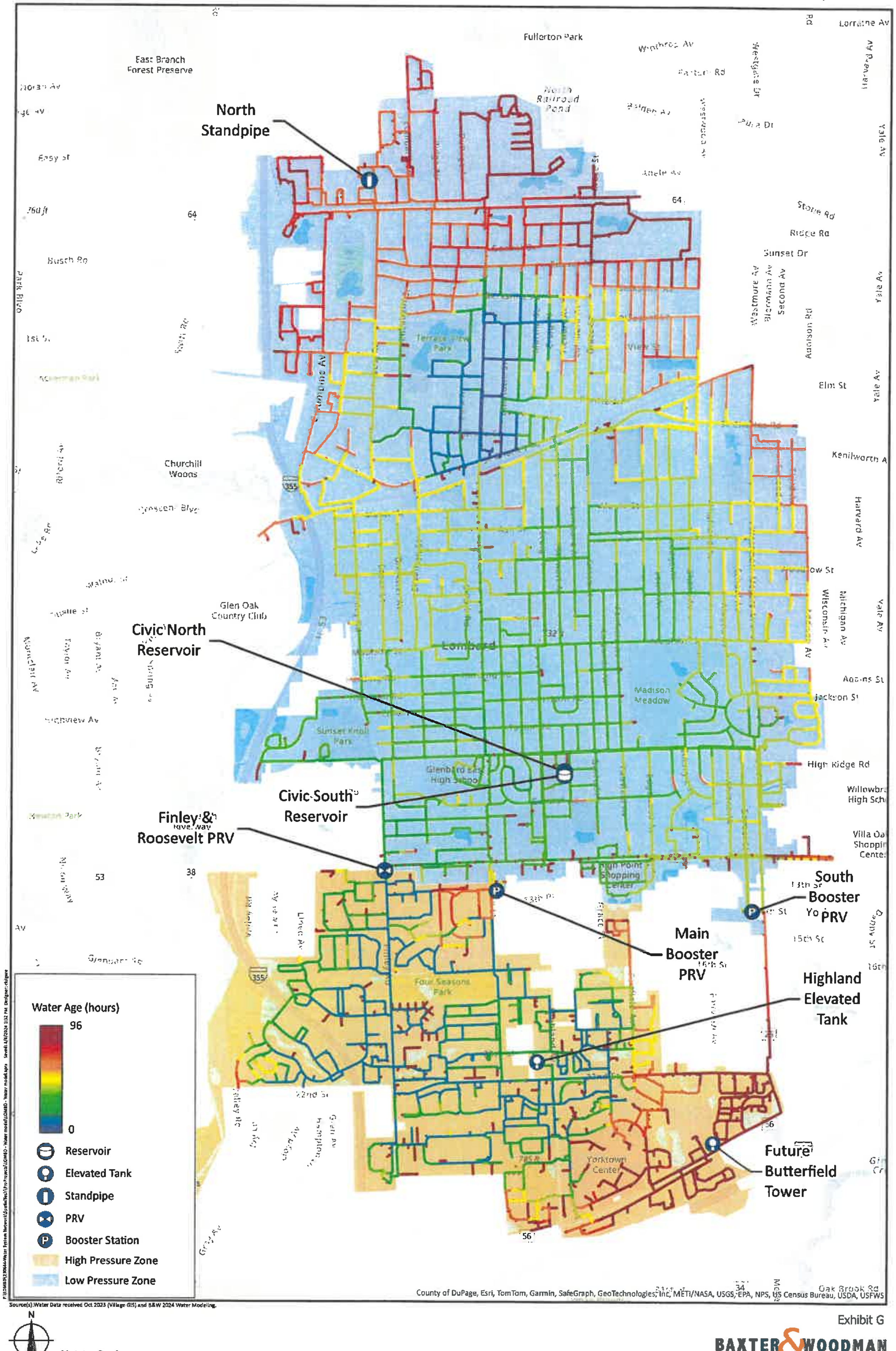


Exhibit G

BAXTER & WOODMAN Consulting Engineers

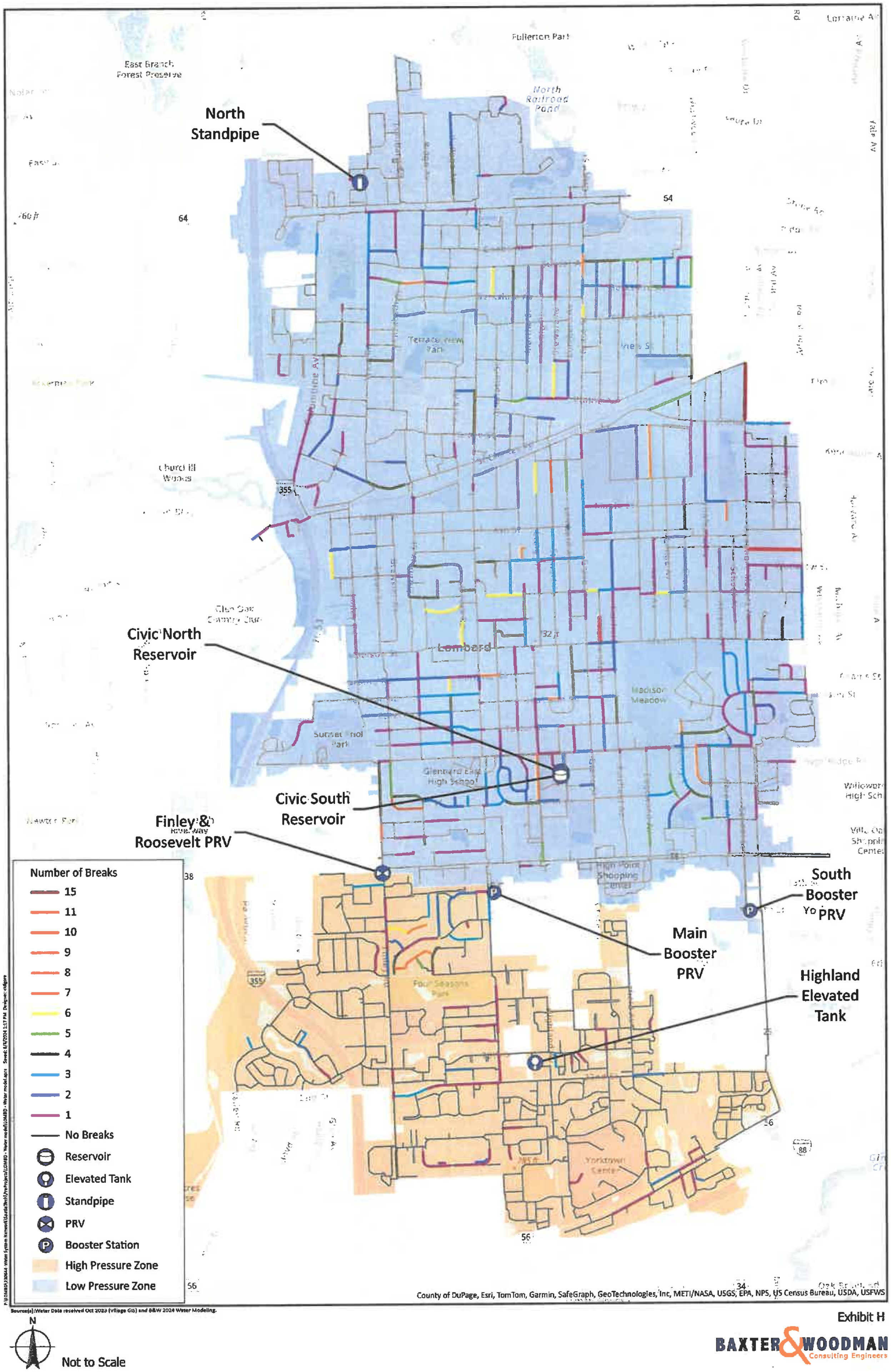
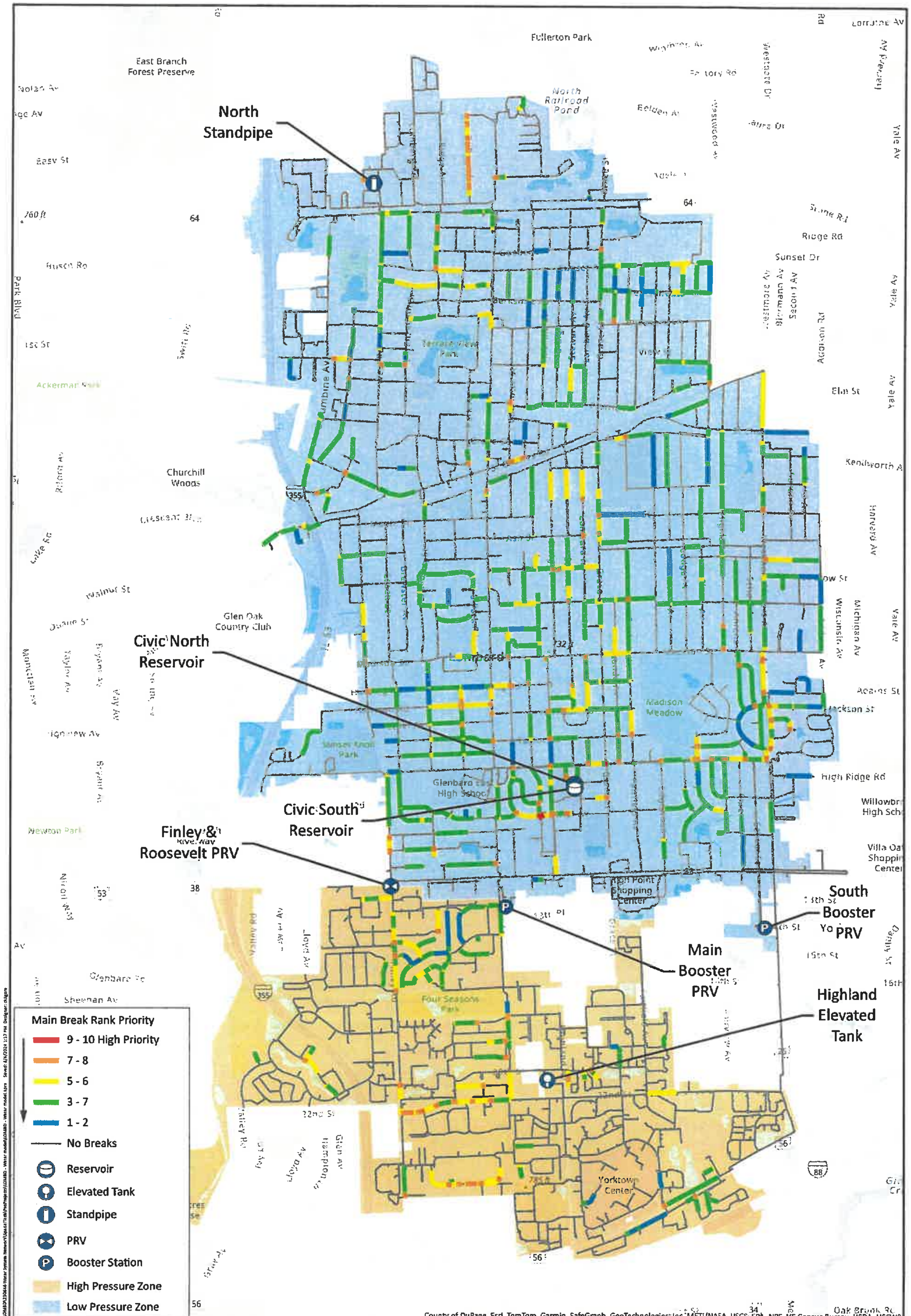


Exhibit H

BAXTER & WOODMAN Consulting Engineers

MAIN BREAK RANK

Water System Network Analysis
VILLAGE OF LOMBARD, ILLINOIS



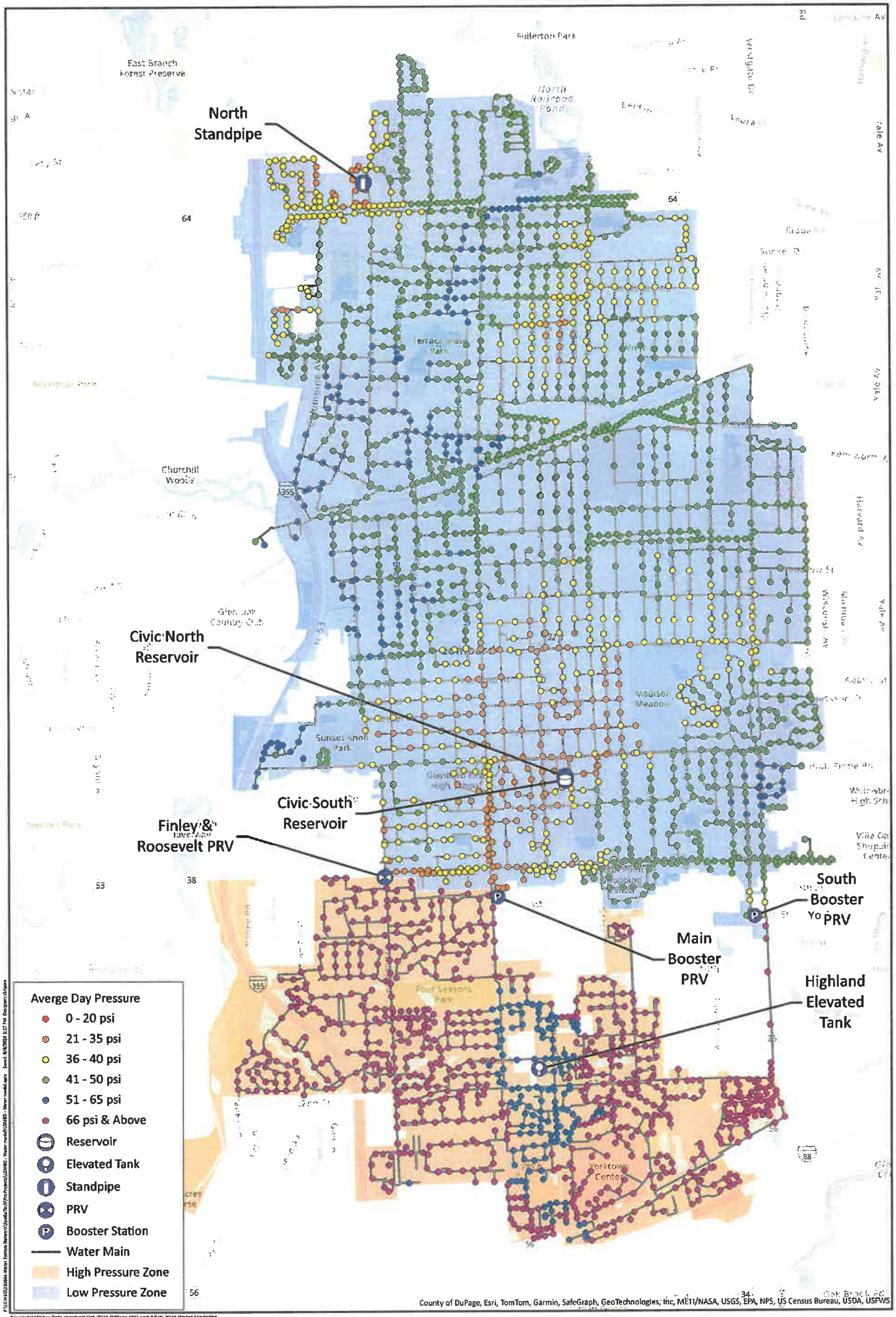
Source(s): Water Data received Oct 2023 (Village GIS) and B&W 2024 Water Modeling.

Exhibit I

Not to Scale

BAXTER & WOODMAN Consulting Engineers

EMERGENCY OPERATIONS PRESSURES



Sources: Water Data received Oct 2023 (Village GIS) and B&W 2024 Water Modeling.

N

Not to Scale

Exhibit J

BAXTER & WOODMAN Consulting Engineers

PROJECT LOCATIONS

Water System Network Analysis
VILLAGE OF LOMBARD, ILLINOIS

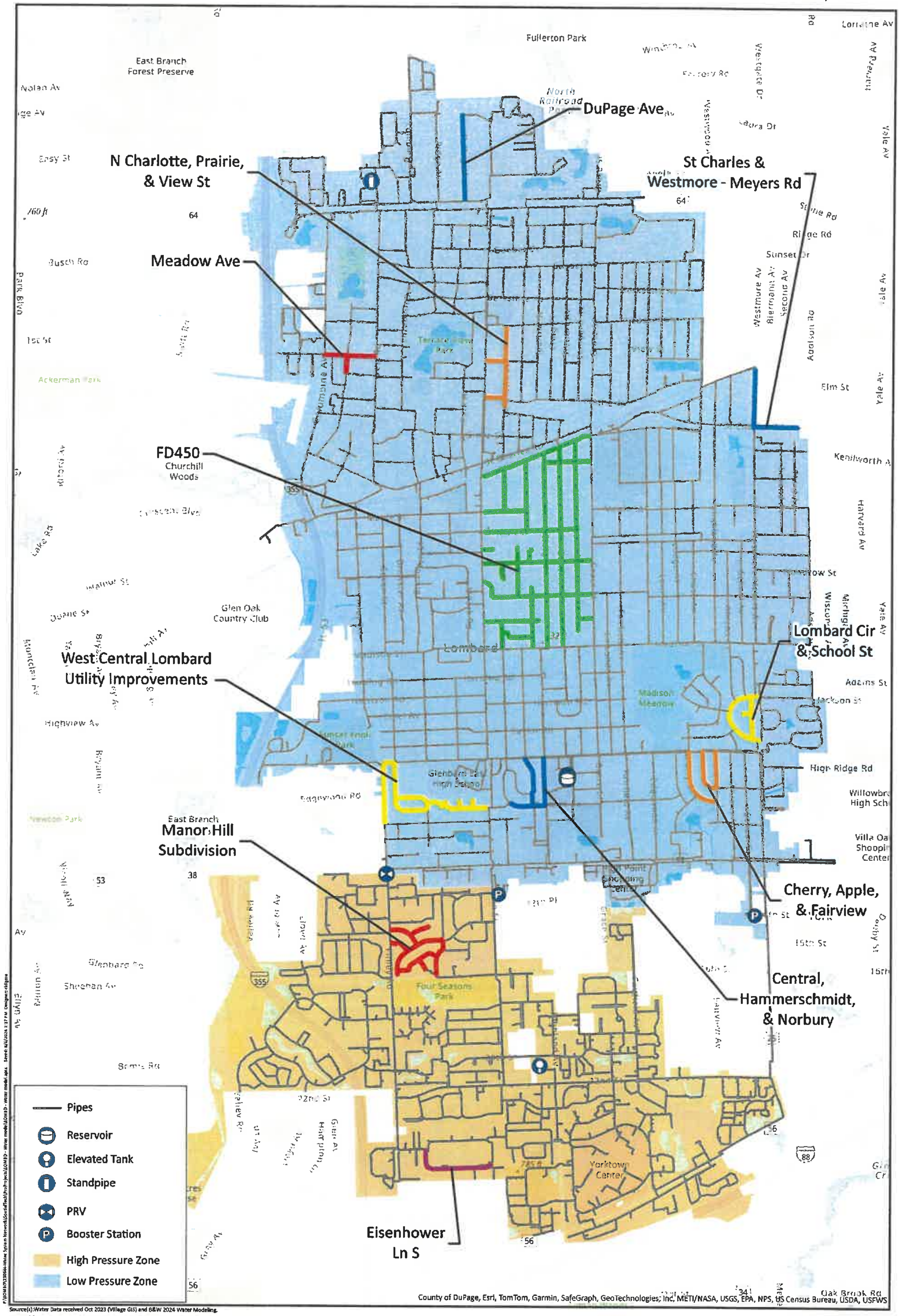


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Exhibit K

BAXTER & WOODMAN
Consulting Engineers

FIRE FLOWS AFTER IMPROVEMENTS

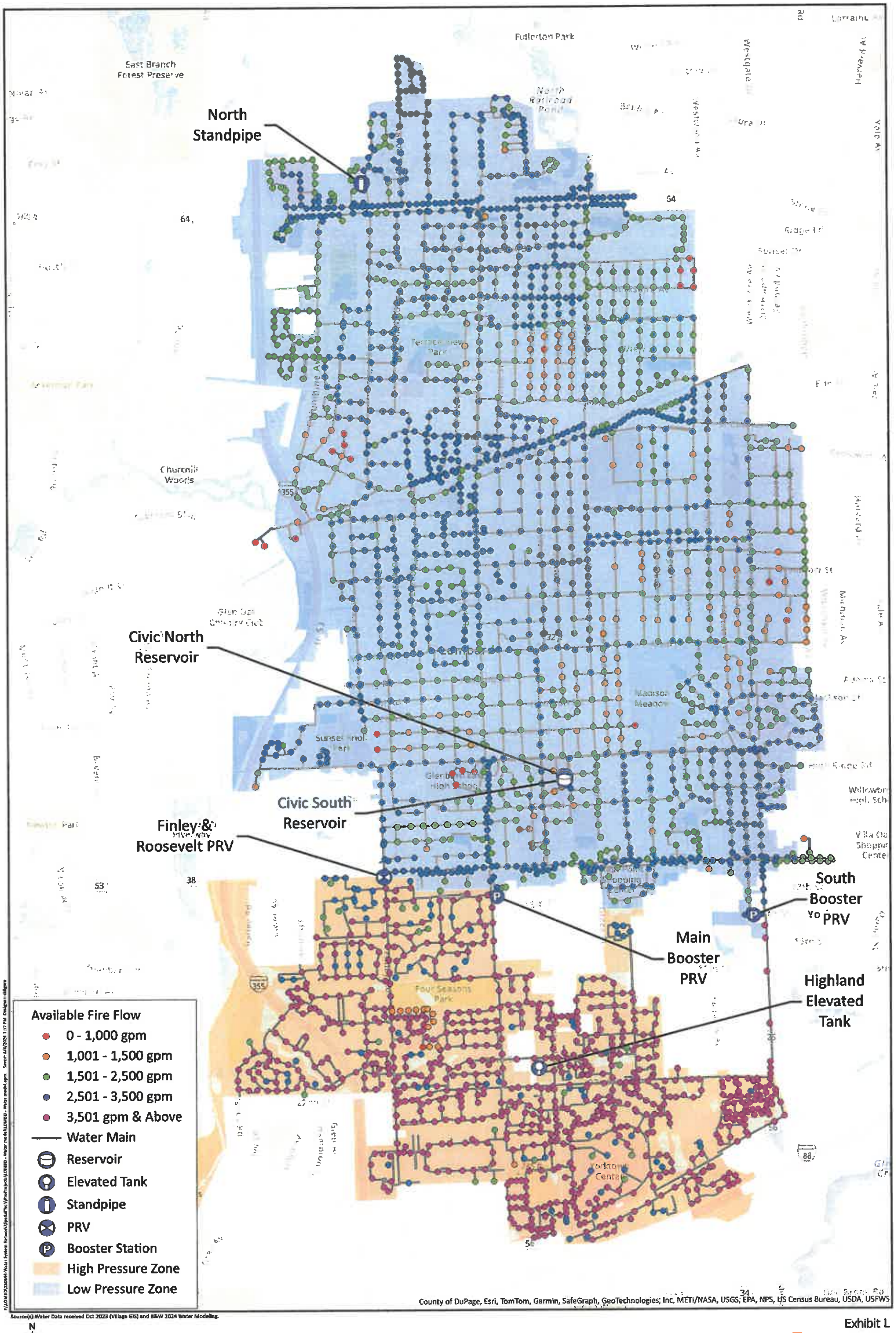

Exhibit L

BAXTER & WOODMAN Consulting Engineers

FIRE FLOW NEEDED AFTER IMPROVEMENTS

Water System Network Analysis

VILLAGE OF LOMBARD, ILLINOIS

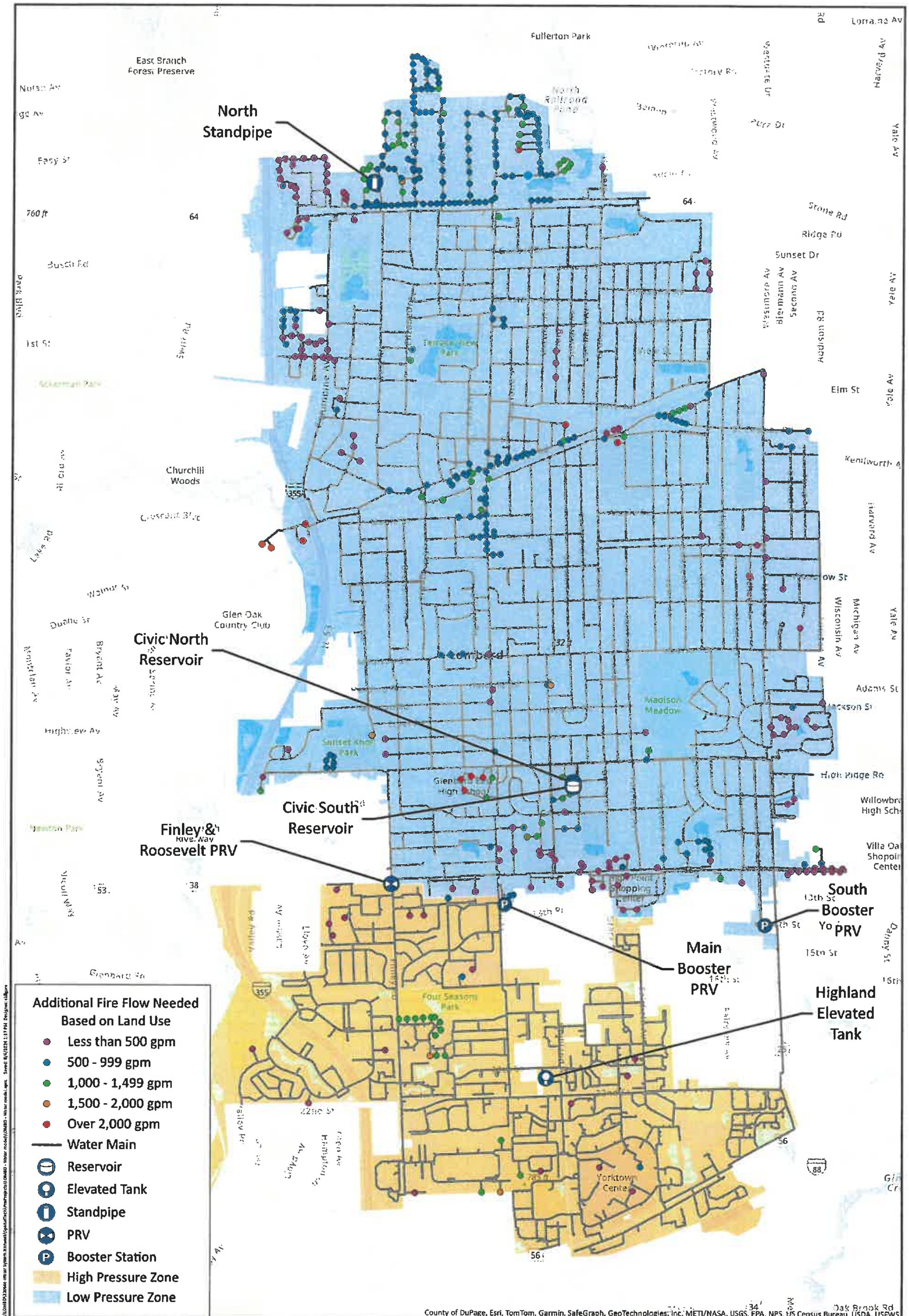

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Exhibit M

BAXTER & WOODMAN Consulting Engineers