Town of North Castle, NY

Water District No. 2 (Windmill Farm) Modeling Study

July 2012

WATER DISTRICT NO. 2 (WINDMILL FARM) MODELING STUDY

TOWN OF NORTH CASTLE, NY

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Executive Summary

Water District No. 2 (Windmill Farm) has adequate supply and storage. Water quality and pressure are adequate during normal conditions. However, model results indicate that adequate fire flow is not available for most of the system. Also, the distribution system has demonstrated reliability issues due to poor construction methods and materials.

Replacement of all of the pipe in the system is anticipated to cost $8-9 million and may be cost prohibitive based on the number of customers in the District, the current method of assessment, and the existing debt. This study identifies the minimum pipe replacements that improve fire flow based on a computer model of the system. This study also identifies and prioritizes pipes that should be replaced to improve system reliability. An opinion of construction cost is presented for the recommended pipe replacement projects.

1 Introduction

There are five water districts (Nos. 1, 2, 4, 5, and 7) within the Town of North Castle, NY. The Water District No. 2 (also known as Windmill Farm) distribution system is owned by the District and operated by the Town. It provides potable water and fire protection to 372 in-District residential customers and 2 out-of-District non-residential customers.

1.1 Purpose of Study

The purpose of this study is to provide a hydraulic analysis for the existing Water District No. 2 water distribution system utilizing a computer-based model. The existing water distribution network is about 60 years old and is constructed of asbestos cement, cast iron, ductile iron, and copper pipe; and has been subject to frequent failures that have incurred unanticipated repair expenses and unplanned service outages. Hydraulic modeling provides a cost-effective method of investigating the cause of failures and identifying concerns that may lead to a diminished level of service. This hydraulic analysis is intended to provide technical guidance for recommended pipe network improvements.

1.2 Scope of Services

GHD Consulting Engineers, LLC was retained to develop a computer-based hydraulic model of the Town of North Castle Water District No. 2 distribution system. The model was used to evaluate system hydraulic capacity, identify system adequacy, and develop prioritized recommendations for water system improvements. The scope of services for this study is as follows:

1. Data review of information provided by the Owner.
2. Development of a computer-based hydraulic model of the Water District No. 2 distribution system.
3. Calibration of the model based on Owner-provided data.
4. Evaluation of the adequacy of the existing system.
5. Identification and evaluation of distribution system deficiencies.
6. Recommendations for system improvements, priorities, and opinions of cost for construction.

2 Existing Conditions

2.1 Overview

The Water District No. 2 service area is located within Windmill Farm, Armonk, NY. The water system was predominantly constructed by residential developers in the 1940s and 1950s. It is not known if any formal review or approval of the system was completed by state or local authorities at the time of construction. In recent years, numerous pipe failures have initiated spot investigations and repair efforts. These incidents have revealed that the pipe network is constructed of disparate materials including cast iron, ductile iron, asbestos cement (Transite), and copper. About three quarters of the system is asbestos cement. Improper construction techniques were used, such as us of transite stubs to connect cast iron pipes and use of inferior bedding materials.

Water District No. 2 supplies potable water and fire protection to 372 residential service connections serving about 1,200 people. Two additional service connections (Coman Hill Elementary School and Brynwood Golf & Country Club) have been established along Route 22. These two service connections are out-of-District connections and are charged a higher water rate. At the present time, no expansion of residential development is anticipated within the District. Thus, no increase in water demand is anticipated in the foreseeable future. Irrigation is believed to be a major source of water demand by residential users in summer.

Potable water is sourced from the Mianus Aquifer and drawn from four system wells located at the intersection of Windmill and Long Pond Roads. The Mianus Aquifer is an unconfined aquifer, and disinfection is performed prior to pipe network distribution. In 2010, the system wells were upgraded with new pump controls, equipment, and emergency power.

After disinfection, water is conveyed from the system wells to a 10,000-gallon chlorine contact tank on Long Pond Road. Water from this tank is booster pumped to the distribution network to serve the District. The system is also served by a 600,000-gallon standpipe that provides storage for the system. The storage tank is located on Evergreen Row and was placed into service in 2006.

The location of the storage tanks, wells, and booster pump station is shown on Figure 1.

2.2 System Description

The system includes a 10,000-gallon contact tank at the location of the pump house east of Windmill Road and a 600,000-gallon post-tensioned, concrete storage tank at grade on Evergreen Row. Table 2-1 presents a summary of the details for the 600,000-gallon water storage tank.

Two booster pumps, one duty and one standby, supply water to the distribution system. The existing booster pumps are 30 HP, multi-stage vertical type. Pump details are provided in Table 2-2.

Table 2-1 Windmill Farm Water Storage Tank

Characteristic	Value
Total capacity	600,000 gallons
Tank height to overflow	63.5 feet
Inside diameter	40 feet
Overflow elevation	763 feet
Usable storage capacity at 20 psi service pressure	208,000 gallons
Type	AWWA D110 Type III
Isolation	12-inch gate valve
Inlet/outlet diameter	12 inches

Table 2-2 System Pump Data

Characteristic	Head (feet)	Discharge (gallons per minute [gpm])
Shutoff	454	0
Design	335	235
Maximum operating	235	319

The system consists of about 8 miles of water main constructed with four types of pipe: cast iron, ductile iron, asbestos cement (i.e., Transite), and copper. The majority of the existing pipe network is constructed of Transite, and the predominant diameter is 6 inches. Transite pipe, popular in the 1950s-1970s, is known to have a shorter service life than cast iron or ductile iron pipe. Table 2-3 gives the diameter and approximate total length of each type of pipe in the system.

Table 2-3 System Pipe Summary

Pipe Type	Diameter (inches)	Reported Length (feet)
Cast iron	4	1,005
	6	5,020
	8	5,005
Ductile iron	12	186
	8	522
Asbestos cement (Transite)	6	28,161
	8	1,700
Copper	1-1/4 to 2	1,280
Total		**42,879**

There are 77 fire hydrants and 55 isolation valves reported to exist within the Water District No. 2 distribution system.

3 Model Development

A water distribution system model is used to mathematically simulate hydraulic conditions in pipe networks. The hydraulic analysis was performed using WaterGEMS Version V8i, designed and distributed by Bentley Systems, Inc. Figure 2 provides a schematic of the existing water distribution system used by the model.

A steady-state simulation was performed for the existing network. This analysis is based on constant demand and boundary conditions with respect to time. To establish boundary conditions, the model includes distribution pipe information, customer demand data, pump performance curves, and storage tank level data. The model of the system is based on the following:

1. One pressure zone.
2. Distribution mains.
3. One storage tank.
4. One supply well.
5. One booster pump station with contact tank.
6. No projected demand increase.
7. USGS elevation data.

3.1 Model Inputs and Boundary Conditions

Once the model is constructed, data inputs must be determined. Water demand is an important model input and can be characterized as being customer demand, unaccounted-for demand, and fire flow demand. To evaluate the system, four demand conditions were modeled: average daily demand, maximum day demand, peak hour demand, and fire flow demand.

Elevation data is necessary for determining local system pressure. This data provides relative elevation differences between the system components for evaluating local pipe pressure variation across the system. Node and hydrant elevations were determined from surface elevations in USGS topographic quadrangle maps.

To construct the model, the length, diameter, and material of construction of the pipe segments were based on data provided by the Owner. Pipe material type was used in assigning an internal friction factor (Hazen-Williams C-value) to represent the roughness of the internal pipe surface. Pipe roughness influences the resistance to flow.

A factory performance curve for the existing booster pumps was provided by the Owner. The pumps will operate at a point on the curve that matches the pressure-flow characteristics of the distribution system. A range of data points from the pump performance curve was input to the system model to simulate the operation of the existing booster pumps.

Storage tank and contact tank type, elevations, and water level operating ranges were also provided by the Owner and input to the system model. These data provide the system boundary conditions.

3.2 Unaccounted-For Water

The modeled demand is based on pumping records, so it includes customer demand (metered sales) and unaccounted-for demand (losses). Customer meter records were only used in this model for the two large system users, Brynwood Golf & Country Club and Coman Hill Elementary School. Unaccounted-for water represents water that is not billed for and may be lost due to pipe leakage, water theft, fire flow, or inaccurate metering. The difference within any given year is the volume of unaccounted-for water. A figure comparing water sales to total water pumped is shown in Appendix A.

Typically, repair or improvement is indicated when unaccounted-for water is greater than 10 percent of total demand. In Water District No. 2, average unaccounted-for water is 16 percent of total based on 10 years of data from 2001 to 2011 (Table 3-1). However, there is some margin of error due to meter calibration discrepancies. Further, some of this unaccounted water may have been used for system maintenance or incidental use such as street sweeping.

Table 3-1 Summary of Unaccounted-for Water

Year	Annual Water Pumped (gal/yr)	Annual Water Sales (gal/yr)	Annual Unaccounted-For Water (gal/yr)	Unaccounted-For Water (%)
2001	55,284,500	47,129,240	8,155,260	15
2002	53,103,000	46,090,620	7,012,380	13
2003	49,327,200	40,666,960	8,660,240	18
2004	53,020,600	41,183,890	11,836,710	22
2005	56,564,852	46,566,849	9,998,003	18
2006	49,413,760	42,853,930	6,559,830	13
2007	59,873,138	50,170,070	9,703,068	16
2008	58,229,898	47,209,124	11,020,774	19
2009	46,578,381	39,291,650	7,286,731	16
2010	57,344,324	47,014,050	10,330,274	18
2011	49,401,348	43,129,210	6,272,138	13
Average	**53,467,364**	**44,664,145**	**8,803,219**	**16**

3.3 Evaluation of Demand Data

The system was evaluated based on four demand conditions: average daily demand; maximum day demand; peak hour demand on the maximum day; and fire flow demand.

The Owner provided data reflecting the total volume of water pumped on a monthly basis over the period 1997 to 2011. The average daily demand for the system was determined by dividing the total volume of water pumped by the number of days in the period. A value of 0.15 million gallons per day (mgd) was assigned to the average daily demand.

Maximum day demand was determined from the 1997-2011 data set by identifying the maximum volume of water pumped in a single 24-hour period. The maximum day was identified as occurring on July 6, 2010; the water demand for that day was 0.37 mgd.

Peak hour demand was defined as the demand during the peak hour of the maximum day. Diurnal flow variations are typical for residential water systems, with the peak flow occurring during the early morning hours. Since actual system diurnal flow data is not available for Water District No. 2, a diurnal peaking factor was applied to the maximum day demand to estimate the peak hour demand. Per guidance in AWWA Manual M32, *Computer Modeling of Water Distribution Systems,* January 2005, a peaking factor of 2.5 is typically applied to average daily demand. However, based on the predominantly residential nature of Water District No. 2, a peaking factor of 3.0 was applied to the maximum day demand. This provided a value of 1.1 mgd for the peak hour demand of the maximum day.

Fire flow was evaluated at 500, 750, and 1,000 gpm, which are typical values for required residential fire flows. This report makes no recommendation as to what the minimum required fire flow should be. This should be based on the recommendations of the Insurance Services Office (ISO). Fire flow was modeled as occurring during peak hour demand. Once flow values were assigned to each demand scenario, the flows were allocated to nodes within the model. Nodal demand allocation is summarized in Table 3-2.

Table 3-2 Nodal Demand Allocation Summary

	Average Day	Maximum Day	Peak Hour(1)
In-District	96	240	720
Residential customer (gpm/customer)	0.26	0.65	2.0
Out-of-District			
Brynwood Golf & Country Club	5.3	13	40
Coman Hill Elementary School	1.2	3.0	9.0
TOTAL (gpm)	**100**	**260**	**770**
TOTAL (mgd)	**0.15**	**0.37**	**1.1**

(1) Peak hour is based on maximum day multiplied by a diurnal peaking factor 3.0.

4 Model Calibration

After the model was constructed and demand was allocated to all nodes for each condition, the model was calibrated based on data provided by the Owner. Hydrant flow data was obtained from Owner-provided ISO Commercial Risk Services, Inc. reporting performed on May 18, 2011 for hydrants listed in Table 4-1. This data was used to calibrate the model based on static and residual pressures (Appendix B). Calibration was performed by adjusting model parameters until model-predicted performance agreed with field-measured performance.

Table 4-1 Fire Flow Tests Performed May 18, 2011

Hydrant No.	Static Pressure (psi)	Residual Pressure (psi)	Pitot Pressure (psi)	Orifice	Flow (gpm)	Flow (gpm) at 20 psi
H-23	30	16			690	600
H-22			17	2.5	690	
H-44	82	42			960	1200
H-46			33	2.5	960	
H-11	44	10			560	450
H-10			11	2.5	560	

4.1 Calibration Methodology

The ISO test data provided a value for static pressure and residual pressure for each of three tested hydrants in the system. In ISO testing, a pressure gauge is installed on a hydrant and the static pressure is recorded. Subsequently, an adjacent hydrant is opened and a measurement of residual pressure is recorded. Flow rate from the open hydrant is measured with a pitot tube. This procedure was simulated by the computer-based model for hydrant locations that correspond to the locations of the ISO tested hydrants. Model parameters were adjusted to try to achieve simulated hydrant flow test results within 10 percent of field test data.

4.2 Pipe Age and Internal Roughness

An important parameter in calibrating the system model is the Hazen-Williams C-value. This factor represents the roughness of the pipe interior and the resistance to flow. A lower C-value represents more friction and greater resistance to flow. C-value tends to decrease over time due to corrosion and deposition inside the pipe. The C-value for new cement-lined ductile iron pipe is typically 120. As the pipe ages, this value normally decreases to 90 or lower. This creates greater resistance to flow and reduces system capacity.

Minor losses associated with open isolation valves in a given pipe segment are implicitly modeled and represented by an equivalent C-value.

4.3 Calibration Summary

The model was calibrated based on the average daily demand condition. The model was first calibrated using static pressure results from hydrant flow testing as summarized in Table 4-1. Node elevations were adjusted to simulate field static pressures. Tank level information at the time of field testing is not known, so the tank level was based on the pump-on setpoint of elevation 54 feet.

A second calibration effort involved use of residual pressure data from fire flow testing (Table 4-1). C-values were adjusted across the system to correlate model residual pressures with those reported in fire flow testing. Residual pressures were modeled using WaterGEMS Darwin Calibrator and manual calibration efforts. Table 4-2 shows the results from final model calibration and a comparison of model values with fire flow test results.

Table 4-2 Calibration Summary

	Field Data		Calibrated Results		
Hydrant No.	Static (psi)	Residual (psi)	Static (psi)	Residual (psi)	Flow (gpm)
H-11	44	10	44	11	
H-10		11		11	560
H-23	30	16	30	26	
H-22		17		26	690
H-44	82	42	83	41	
H-46		33		33	960

Two of the three hydrants correlated within 10 percent of the field test results. Simulation of Hydrant H-23 produced a residual pressure of 26 psi compared to the field test results of 16 psi. This was attributed to a closed or partially closed valve in the system. Thus, the model was considered to be calibrated and acceptable for use in evaluating the system.

Pipe C-values from model calibration were held the same for each simulation exercise. Lower C-values represent higher internal roughness or corrosion. No pipe was modeled with a C-value below 50. This would represent a severely corroded or obstructed pipe. A low C-value may indicate pipes in need of replacement.

5 Simulation of Existing Conditions

Hydraulic simulations were conducted using the calibrated model of the existing system to examine the system response to specific demand conditions. Hydraulic simulations were performed for average daily, maximum day, peak hour, and fire flow. Model outputs for static pressure, headloss, and velocity were evaluated for individual pipes in the system. Fire flow was simulated at each hydrant during peak hour demand to evaluate available flow and residual pressure in the system. Failure simulations were also performed to identify pipes that have the greatest consequence of failure. Local static pressure values were evaluated during average demand conditions to identify pipes that are under high stress.

5.1 Description of Simulations

This section describes the simulations that were conducted and the reasons for them. Results are discussed in Section 5.2.

5.1.1 Average Daily, Maximum Day, and Peak Hour Simulation

The operating characteristics of the system were simulated at the average daily, maximum day, and peak hour demand conditions described in Chapter 3. The model calculates and provides values for pressure that would be observed at each node and flow in each pipe during a given demand condition.

5.1.2 Fire Flow Simulation

This report does not identify or recommend what the minimum fire flow should be. Rather, the simulations were conducted over a range of fire flow values and the system response was documented. WaterGEMS Automated Fire Flow Analyst was utilized for the exercise.

1. Fire flow analysis tested hydrants at 500, 750 and 1,000 gpm.
2. Fire flows were added to peak hour of maximum day demands.
4. Modeled fire flows are based on *Recommended Standards for Water* Works (2007) and ISO recommendations for “Needed Fire Flow” for one- and two-family dwellings not exceeding two stories in height (ISO, 1980).

The model determines the available fire flow at each system hydrant. As a constraint, a minimum residual pressure of 20 psi everywhere in the system was specified. The model calculates the maximum flow that can be provided at each hydrant without system pressure dropping below 20 psi at any location in the system. Hydrants that cannot provide the lower flow limit (i.e., 500, 750, or 1,000 gpm) while sustaining residual pressure above 20.0 psi are designated as receiving insufficient fire flow.

5.1.3 Headloss and Velocity Simulations

The model can estimate the dynamic headloss (pressure drop) and the flow velocity for each pipe segment during the specified demand conditions. Pipe runs identified as exhibiting high headloss or high velocity may be undersized or excessively corroded.

5.1.4 Pipe Failure Simulations

The location of a pipe failure will affect the consequences of that failure. Pipe breaks were simulated at various locations to identify pipes associated with the greatest consequence of failure. For this study, consequence was based on the number of users that would not have at least 35 psi of available pressure should a given pipe fail.

5.2 Results of Simulations

This section presents the results of the simulation exercises described above.

5.2.1 Average Daily Demand and Maximum Day Demand Simulation

For average daily demand simulation, the total system demand was 0.15 mgd, and for maximum day demand simulation, the total system demand was 0.37 mgd. The following observations were made:

1. The system exhibits low static pressure (<30 psi) at nodes nearest the storage tank on Evergreen Row during average demand conditions. This is due to this location's relatively high elevation, including portions of Upland Lane, Hardscrabble Circle, North Ridge Road, and Spruce Hill Road.
2. The system has a high pressure gradient along Long Pond Road, which is the location of highest static pressure in the system (145 psi).
3. The system exhibits high static pressure at the end of Thornwood Road and at locations along Windmill Road.
4. Water flows into the storage tank during average daily demand and out during the maximum day demand. Flow direction is reversed along Evergreen Row during the maximum day simulation.

5.2.2 Peak Hour Simulation

For peak hour simulation, the total system demand was based on 1.1 mgd. The following observations were made:

1. Increased system demand results in a drop in static pressures (<35 psi) along Evergreen Row within proximity to the storage tank. This is most likely because the tank is drawn down during higher demands.
2. Static pressure below 35.0 psi was identified on Spruce Hill Road. Normal working pressure as guided by the *Recommended Standards for Water Works* (Great Lakes – Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers, 2007) is suggested as not less than 35 psi for distribution system piping.

5.2.3 Headloss and Velocity Simulations

High flow velocity and internal roughness in pipe increases dynamic headloss. The model calculates a headloss gradient for each pipe segment. A steep gradient may indicate pipes in need of replacement because they are undersized or excessively corroded. High flow velocity may indicate undersized lines. A high friction factor (C-value) may indicate corrosion. Pipes along Long Pond Road, Evergreen Row, and the intersection of North Lake Road with Windmill Road exhibited the greatest headloss and the highest flow velocities in the system.

5.2.4 Fire Flow Simulation

Most of the hydrants in the system could not provide fire flow at 500 gpm during peak hour demand while maintaining 20 psi or more throughout the system. No hydrants were able to provide a fire flow of

1,000 gpm during peak hour demand. With the pump off, fire flow as low as 250 gpm was observed during peak hour demand at some hydrants.

A list of hydrants that did not satisfy flows under the fire flow simulations for 500, 750 and 1,000 gpm is shown in Appendix C.

5.2.5 Pipe Failure Simulations

Pipe failure simulations indicated that the water main in Evergreen Row is critical to maintain system operation under peak hour demand simulation. A pipe failure in this pipe section was found to cause an inadequate level of service during peak hour demand. In the event of a failure of this section, system pressure losses increase to the point where pressures fall below acceptable service levels for about half of the customers in the system. This pipe is identified as having a high consequence of failure.

5.3 Summary of Simulation Results

1. The existing system was identified as having undersized mains, uneven pressure distribution, and low carrying capacity due to possible tuberculation or scaling of aged pipes.
2. The existing system can meet demand requirements for average daily, maximum day, and peak hour demand conditions.
3. The existing system cannot provide fire flow of 500 gpm to all hydrants while maintaining 20 psi during the peak hour demand simulation.
4. The pipe along Evergreen Row south of the storage tank connection has a high consequence of failure, in that about half of the system would lose adequate pressure during a line break event. However, this area does not have a history of failures.
5. High pressure, which causes high internal pipe stress, was identified in Long Pond Road (145 psi), Thornwood Road (137 psi), and Windmill Road (103 psi). These pipes are asbestos cement and are considered to have a higher likelihood of failure due to their material of construction and high pressure.
6. Distribution mains on Evergreen Row near the 0.6 million gallon storage tank have low static pressure. Pressure as low as 28 psi was identified during average daily demand conditions. This location is at a high elevation relative to most of the system.

6 Prioritization and Ranking of Pipe Replacements

To assist the District in developing a capital improvement plan to improve the distribution system, this study assigns a replacement priority to each pipe segment. In order to mitigate the budgetary impact of extensive system upgrades, improvements may be implemented over a period of time and through sequential capital projects. The cost benefit achieved by a capital improvement project can be maximized by limiting the scope of the near-term project to higher priority pipes. To provide a basis for this prioritization, three criteria were developed:

1. Provide fire flow of 500 gpm during peak hour demand for each hydrant in the system, while maintaining minimum residual pressure at all system nodes greater than or equal to 20.0 psi.
2. Based on information provided by the Owner, identify lines that are known to have reliability issues due to poor construction methods and materials.
3. Identify lines that have a high consequence of failure. This assessment is based on simulations of pipe breaks.
4. Identify lines with the apparent greatest likelihood of failure. This assessment is based on observed node pressures, pipe friction factors (C-values) as determined by the model, and pipe material.

Using these criteria, each pipe segment was assigned Priority 1, 2 or 3.

6.1 Modeling of System Modifications to Improve Fire Flow

To achieve the desired fire flow criteria with the minimum number of system modifications, the model was modified by strategically changing selected existing pipes. Fire flow simulations were repeated in an iterative procedure on the modified model until it was demonstrated that fire flow of 500 gpm during peak hour demand could be achieved at each hydrant in the system while maintaining at least 20 psi throughout the system. Through this process, a number of pipe replacements were identified, as listed in Table 6-1 and shown graphically in Figure 3. For the purposes of this report, these replacements are considered Priority 1.

Table 6-1 Pipe Replacements to Meet Fire Flow Criteria (Priority 1)

Location	Approximate Length (Feet)	Existing Pipe	New Pipe
Evergreen Row	1,000	6- and 8-inch cast iron	12-inch DIP
Evergreen Row	1,300	6-inch asbestos cement	8-inch DIP
Evergreen Row	200	2-inch copper	8-inch DIP
Evergreen Row(1)	500	None existing	8-inch DIP
North Lane	840	6-inch cast iron	8-inch DIP
North Lake	680	6-inch cast iron	8-inch DIP
Spruce Hill Road	1,700	6-inch asbestos cement	8-inch DIP
Long Pond Road	1,900	6-inch asbestos cement	8-inch DIP
Long Pond Road	570	6- and 8-inch cast iron	8-inch DIP
Total (rounded)	**8,700**		

(1) This is a new pipe that will close a loop and eliminate a dead end.

6.2 Evaluation of Failure and Repair History

Based on information provided by the system operator (Owner), pipes with a known history of issues were identified and assigned Priority 2. Priority 2 pipe segments are shown in Table 6-2 and Figure 3.

6.3 Evaluation of Model Parameters to Improve System Reliability

The model simulation data was evaluated to identify pipes with a high consequence of failure. Those pipe segments were identified by simulating line breaks and observing the number of customers affected by a reduced level of service. The pipe in Evergreen Row was identified as having a high consequence of failure. A portion of this pipe was previously categorized as a Priority 1 replacement based on satisfying the fire flow criteria. The remainder of this pipe was assigned Priority 2.

The remainder of the pipes in the system were assigned Priority 3. All Priority 3 pipe segments are listed in Table 6-3. The Priority 3 line segments were ranked by pipe material and static pressure. This approach was intended to identify pipes with a higher likelihood of failure. Pipes that experience high static pressure and are constructed of asbestos cement were considered to be the most prone to failure.

Table 6-2 Priority 2 Pipe Replacement Schedule

Pipe Segment I.D.	Street Name	Existing Pipe						New Pipe		Replacement Priority
		Diameter (Inches)	Material	Modeled Length (Ft)	Roughness (C-Value)	Velocity (ft/s)	Static Pressure (psi)	Diameter (Inches)	Material	
P-42	Evergreen Row	8	Cast iron	50	76.5	0.31	54.3	8	Ductile iron pipe	3
P-56	Evergreen Row	6	Asbestos cement	112	95	2.12	27.6	8	Ductile iron pipe	3
P-57	Evergreen Row	6	Asbestos cement	462	95	2.12	35.5	8	Ductile iron pipe	3
P-58	Evergreen Row	6	Asbestos cement	312	95	2.12	58.8	8	Ductile iron pipe	3
P-59	Evergreen Row	6	Asbestos cement	262	95	1.93	55.6	8	Ductile iron pipe	3
P-60	Evergreen Row	6	Asbestos cement	412	95	1.93	51.9	8	Ductile iron pipe	3
P-61	Evergreen Row	6	Asbestos cement	262	95	1.93	65.2	8	Ductile iron pipe	3
P-62	Evergreen Row	2	Copper	203	130	0.40	73.2	8	Ductile iron pipe	3
P-115	Pond Lane	6	Asbestos cement	392	95	0.22	107.6	8	Ductile iron pipe	2
P-116	Pond Lane	6	Asbestos cement	412	95	0.22	101.1	8	Ductile iron pipe	2
P-114	Pond Lane	6	Asbestos cement	312	95	0.22	97.7	8	Ductile iron pipe	2
P-120	Pond Lane	6	Asbestos cement	162	95	0.04	94.0	8	Ductile iron pipe	2
P-119	Pond Lane	6	Asbestos cement	212	95	0.12	93.0	8	Ductile iron pipe	2
P-117	Pond Lane	6	Asbestos cement	62	95	0.22	91.2	8	Ductile iron pipe	2
P-118	Pond Lane	6	Asbestos cement	362	95	0.12	90.7	8	Ductile iron pipe	2
P-121	Pond Lane	6	Cast iron	150	75	0.04	97.5	8	Ductile iron pipe	2
P-130	Windmill Road	6	Asbestos cement	262	95	0.87	81.9	8	Ductile iron pipe	2
P-124	Windmill Road	6	Asbestos cement	112	95	0.06	77.1	8	Ductile iron pipe	2
P-131	Windmill Road	6	Asbestos cement	412	95	0.87	77.1	8	Ductile iron pipe	2
P-132	Windmill Road	6	Asbestos cement	562	95	0.87	72.4	8	Ductile iron pipe	2
P-123	Windmill Road	6	Asbestos cement	262	95	0.06	67.5	8	Ductile iron pipe	2
P-122	Windmill Road	6	Asbestos cement	1009	95	0.06	51.6	8	Ductile iron pipe	2
P-125	Windmill Road	6	Cast iron	150	75	0.23	81.4	8	Ductile iron pipe	2
P-11	Mill Lane	6	Asbestos cement	462	95	0.44	81.9	8	Ductile iron pipe	2
P-12	North Lake Road	6	Asbestos cement	562	95	0.12	77.9	8	Ductile iron pipe	2
P-126	North Lake Road	6	Asbestos cement	62	95	0.12	77.5	8	Ductile iron pipe	2
P-134	North Lake Road	6	Asbestos cement	62	95	0.49	68.9	8	Ductile iron pipe	2
P-133	North Lake Road	6	Cast iron	505	75	0.49	72.6	8	Ductile iron pipe	2
P-106	North Lake Road	6	Cast iron	305	75	0.49	68.1	8	Ductile iron pipe	2
P-103	North Lake Road	6	Cast iron	285	75	0.35	66.9	8	Ductile iron pipe	2
P-104	North Lake Road	4	Cast iron	93	66.5	0.79	64.3	8	Ductile iron pipe	2
P-96	North Lake Road	6	Cast iron	400	75	0.35	64.3	8	Ductile iron pipe	2
P-93	North Lake Road	6	Cast iron	255	75	0.35	64.3	8	Ductile iron pipe	2
P-94	North Lake Road	6	Cast iron	255	75	0.49	63.1	8	Ductile iron pipe	2
Total Length Modeled				**10,161**						

Table 6-3 Priority 3 Pipe Replacement Schedule

Pipe Segment I.D.	Street Name	Existing Pipe Diameter (Inches)	Existing Pipe Material	Modeled Length (Feet)	Roughness (C-Value)	Velocity (ft/s)	Static Pressure (psi)	New Pipe Diameter (Inches)	New Pipe Material	Replacement Priority
P-95	Banksville Road	6	Asbestos cement	112	95	0.09	110.8	8	Ductile iron pipe	3
P-105	Banksville Road	2	Copper	413	130	0.79	112.1	8	Ductile iron pipe	3
P-92	Windmill Place	6	Asbestos cement	62	95	0.07	102.9	8	Ductile iron pipe	3
P-85	Windmill Place	6	Asbestos cement	332	95	0.25	92.0	8	Ductile iron pipe	3
P-91	Windmill Place	6	Asbestos cement	432	95	0.07	90.7	8	Ductile iron pipe	3
P-143	Windmill Place	6	Asbestos cement	112	95	0.25	84.6	8	Ductile iron pipe	3
P-88	Windmill Place	6	Asbestos cement	262	95	0.25	84.3	8	Ductile iron pipe	3
P-86	Windmill Place	6	Asbestos cement	62	95	0.25	75.4	8	Ductile iron pipe	3
P-87	Windmill Place	6	Asbestos cement	412	95	0.25	73.2	8	Ductile iron pipe	3
P-144	Windmill Place	6	Cast iron	193	100	0.25	80.2	8	Ductile iron pipe	3
P-31	Windmill Road	6	Asbestos cement	271	95	0.40	51.6	8	Ductile iron pipe	3
P-142	Windmill Road	8	Cast iron	381	90	0.95	127.3	8	Ductile iron pipe	3
P-141	Windmill Road	8	Cast iron	450	90	0.95	115.4	8	Ductile iron pipe	3
P-138	Windmill Road	8	Cast iron	240	90	0.50	105.0	8	Ductile iron pipe	3
P-136	Windmill Road	8	Cast iron	200	90	0.54	104.6	8	Ductile iron pipe	3
P-137	Windmill Road	8	Cast iron	220	90	0.48	103.6	8	Ductile iron pipe	3
P-127	Windmill Road	8	Cast iron	340	90	0.54	102.5	8	Ductile iron pipe	3
P-140	Windmill Road	8	Cast iron	481	90	0.95	94.3	8	Ductile iron pipe	3
P-128	Windmill Road	8	Cast iron	440	90	0.54	92.2	8	Ductile iron pipe	3
P-139	Windmill Road	8	Cast iron	200	90	0.95	92.0	8	Ductile iron pipe	3
P-129	Windmill Road	8	Cast iron	240	90	0.54	89.8	8	Ductile iron pipe	3
P-135	Windmill Road	8	Cast iron	891	90	0.67	77.5	8	Ductile iron pipe	3
P-152	Windmill Road	2	Copper	313	130	0	105.0	8	Ductile iron pipe	3
P-153	Windmill Road	2	Copper	313	130	0	104.6	8	Ductile iron pipe	3
P-72	Dogwood Place	6	Asbestos cement	512	95	0.24	99.5	8	Ductile iron pipe	3
P-73	Dogwood Place	6	Asbestos cement	5	95	0	93.0	8	Ductile iron pipe	3
P-68	Elm Place	6	Asbestos cement	187	95	0.22	90.0	8	Ductile iron pipe	3
P-69	Elm Place	6	Asbestos cement	42	95	0.22	87.8	8	Ductile iron pipe	3
P-66	Elm Place	6	Asbestos cement	512	95	0.09	87.4	8	Ductile iron pipe	3
P-67	Elm Place	6	Asbestos cement	5	95	0	66.2	8	Ductile iron pipe	3
P-81	Fox Ridge Road	6	Asbestos cement	37	95	0.36	102.3	8	Ductile iron pipe	3
P-74	Fox Ridge Road	6	Asbestos cement	307	95	1.23	99.5	8	Ductile iron pipe	3
P-90	Fox Ridge Road	6	Asbestos cement	262	95	0.01	98.5	8	Ductile Iron Pipe	3

Table 6-3 (continued)

Pipe Segment I.D.	Street Name	Existing Pipe						New Pipe		Replacement Priority
		Diameter (Inches)	Material	Modeled Length (Feet)	Roughness (C-Value)	Velocity (ft/s)	Static Pressure (psi)	Diameter (Inches)	Material	
P-78	Fox Ridge Road	6	Asbestos cement	412	95	0.36	97.1	8	Ductile iron pipe	3
P-79	Fox Ridge Road	6	Asbestos cement	20	95	0.36	96.1	8	Ductile iron pipe	3
P-76	Fox Ridge Road	6	Asbestos cement	312	95	1.23	94.1	8	Ductile iron pipe	3
P-71	Fox Ridge Road	6	Asbestos cement	112	95	1.47	93.8	8	Ductile iron pipe	3
P-75	Fox Ridge Road	6	Asbestos cement	562	95	1.23	93.0	8	Ductile iron pipe	3
P-89	Fox Ridge Road	6	Asbestos cement	192	95	0.01	90.7	8	Ductile iron pipe	3
P-70	Fox Ridge Road	6	Asbestos cement	462	95	1.47	90.0	8	Ductile iron pipe	3
P-64	Fox Ridge Road	6	Asbestos cement	212	95	1.82	82.9	8	Ductile iron pipe	3
P-63	Fox Ridge Road	6	Asbestos cement	212	95	1.82	73.2	8	Ductile iron pipe	3
P-151	Hardscrabble Circle	6	Asbestos cement	143	95	0	55.3	8	Ductile iron pipe	3
P-111	Hardscrabble Circle	6	Asbestos cement	212	95	0	48.8	8	Ductile iron pipe	3
P-150	Hardscrabble Circle	6	Cast iron	162	66.5	0	57.0	8	Ductile iron pipe	3
P-149	Hardscrabble Circle	6	Cast iron	143	66.5	0	53.1	8	Ductile iron pipe	3
P-16	Long Pond Road	6	Asbestos cement	362	95	0.66	98.9	8	Ductile iron pipe	3
P-17	Long Pond Road	6	Asbestos cement	192	95	0.66	98.1	8	Ductile iron pipe	3
P-18	Long Pond Road	6	Asbestos cement	232	95	0.48	91.1	8	Ductile iron pipe	3
P-19	Long Pond Road	6	Asbestos cement	312	95	0.48	85.5	8	Ductile iron pipe	3
P-20	Long Pond Road	6	Asbestos cement	482	95	0.26	81.6	8	Ductile iron pipe	3
P-21	Long Pond Road	6	Asbestos cement	182	95	0.26	73.0	8	Ductile iron pipe	3
P-22	Long Pond Road	6	Asbestos cement	102	95	0.09	72.1	8	Ductile iron pipe	3
P-23	Long Pond Road	6	Asbestos cement	237	95	0.09	72.1	8	Ductile iron pipe	3
P-24	Long Pond Road	2	Copper	38	130	0	70.4	8	Ductile iron pipe	3
P-33	Maple Way	6	Asbestos cement	132	95	0.20	65.9	8	Ductile iron pipe	3
P-32	Maple Way	6	Asbestos cement	232	95	0.20	60.7	8	Ductile iron pipe	3
P-34	Maple Way	8	Asbestos cement	448	95	0.34	60.7	8	Ductile iron pipe	3
P-35	Maple Way	8	Asbestos cement	298	95	0.38	59.3	8	Ductile iron pipe	3
P-36	Maple Way	8	Asbestos cement	328	95	0.38	59.3	8	Ductile iron pipe	3
P-37	Maple Way	8	Asbestos cement	278	95	0.41	58.4	8	Ductile iron pipe	3
P-38	Maple Way	8	Asbestos cement	348	95	0.41	52.8	8	Ductile iron pipe	3
P-40	Maple Way	6	Asbestos cement	42	95	0.82	51.8	8	Ductile iron pipe	3
P-39	Maple Way	6	Asbestos cement	362	95	0.82	48.9	8	Ductile iron pipe	3
P-102	North Lake Road	6	Cast iron	225	75	0.49	66.5	8	Ductile iron pipe	3
P-50	North Lane	6	Cast iron	85	75	0	40.9	8	Ductile iron pipe	3

Table 6-3 (continued)

Pipe Segment I.D.	Street Name	Existing Pipe: Diameter (Inches)	Existing Pipe: Material	Existing Pipe: Modeled Length (Feet)	Existing Pipe: Roughness (C-Value)	Existing Pipe: Velocity (ft/s)	Existing Pipe: Static Pressure (psi)	New Pipe: Diameter (Inches)	New Pipe: Material	Replacement Priority
P-148	North Ridge	4	Cast iron	393	66.5	0	48.9	8	Ductile iron pipe	3
P-30	Spruce Hill Road	6	Asbestos cement	1	95	0	51.6	8	Ductile iron pipe	3
P-147	Thornwood Road	6	Asbestos cement	337	95	0	127.4	8	Ductile iron pipe	3
P-80	Thornwood Road	6	Asbestos cement	292	95	0	111.8	8	Ductile iron pipe	3
P-84	Thornwood Road	6	Asbestos cement	82	95	0.52	101.5	8	Ductile iron pipe	3
P-77	Thornwood Road	6	Asbestos cement	582	95	0	97.6	8	Ductile iron pipe	3
P-82	Thornwood Road	6	Asbestos cement	502	95	0.52	97.4	8	Ductile iron pipe	3
P-83	Thornwood Road	6	Asbestos cement	662	95	0.52	88.8	8	Ductile iron pipe	3
P-170	To Brynwood Golf & CC	8	Asbestos cement	473	95	0.25	51.7	8	Ductile iron pipe	3
P-169	To Brynwood Golf & CC	8	Asbestos cement	158	95	0.25	49.1	8	Ductile iron pipe	3
P-172	To Coman Hill School	6	Asbestos cement	100	95	0.10	52.1	8	Ductile iron pipe	3
P-171	To Coman Hill School	6	Asbestos cement	300	95	0.10	49.1	8	Ductile iron pipe	3
P-43	To Out-of-District Users	6	Asbestos cement	412	95	0.55	53.8	8	Ductile iron pipe	3
P-107	Upland Lane	6	Asbestos cement	886	95	0.45	68.9	8	Ductile iron pipe	3
P-109	Upland Lane	6	Asbestos cement	212	95	0.26	51.8	8	Ductile iron pipe	3
P-110	Upland Lane	6	Asbestos cement	262	95	0.26	49.6	8	Ductile iron pipe	3
P-112	Upland Lane	6	Asbestos cement	686	95	0.45	48.0	8	Ductile iron pipe	3
P-108	Upland Lane	6	Asbestos cement	162	95	0.06	46.2	8	Ductile iron pipe	3
P-41	Upland Lane	6	Cast iron	145	75	0.76	49.6	8	Ductile iron pipe	3
P-10	Valley Lane	6	Asbestos cement	662	95	0.15	136.8	8	Ductile iron pipe	3
P-9	Valley Lane	6	Asbestos cement	412	95	0.15	129.0	8	Ductile iron pipe	3
Total Length Modeled				**25,057**						

7 Opinion of Project Costs

Table 7-1 represents an opinion of project cost to implement Priority 1 replacements.

Table 7-1 Priority 1 Improvements, Opinion of Probable Costs

Item	Opinion of Cost
New installed 8-inch Class 52 DIP (push-on joint, cement lined, Class 52) (includes trenching, excavation, bedding, backfill, pavement repair, and fittings), ±8,000 LF	$950,000
New installed 12-inch DIP (push-on joint, cement lined, Class 52) (includes trenching, excavation, bedding, backfill, pavement repairs, and fittings), ±1,000 LF	$140,000
New installed fire hydrants (includes removal of existing fire hydrant when necessary)	$110,000
New installed isolation valves	$40,000
New service lateral connections	$130,000
Rock removal	$50,000
Project Contingency	$280,000
Construction Subtotal Fiscal, Legal, Administrative, Engineering	**$1,700,000** $300,000
PROJECT COST	**$2,000,000**

Notes:

1) New fire hydrant installation and removal of old fire hydrant every 500 LF.
2) New service lateral connection every 100 LF.
3) New isolation valve installed every 1000 LF and at every major intersection.
4) All pipe installation is in asphalt roadway.
5) New pipe installed adjacent to existing pipe with abandonment of existing pipe (does not include cost of removing existing piping).
6) Figures are rounded.

Table 7-2 presents an opinion of cost for the replacement of Priority 2 pipelines.

Table 7-2 Priority 2 Improvements, Opinion of Probable Costs

Item	Opinion of Cost
New installed 8-inch Class 52 DIP (push-on joint, cement lined, Class 52) (includes trenching, excavation, bedding, backfill, pavement repair, and fittings), ±10,200 LF	$1,200,000
New installed fire hydrants (includes removal of existing fire hydrant when necessary)	$120,000
New installed isolation valves	$40,000
New service lateral connections	$130,000
Rock removal	$60,000
Project Contingency	$350,000
Construction Subtotal	**$1,900,000**
Fiscal, Legal, Administrative, Engineering	$340,000
PROJECT COST	**$2,240,000**

Notes:
1) New fire hydrant installation and removal of old fire hydrant every 500 LF.
2) New service lateral connection every 100 LF.
3) New isolation valve installed every 1000 LF and at every major intersection.
4) All pipe installation is in asphalt roadway.
5) New pipe installed adjacent to existing pipe with abandonment of existing pipe (does not include cost of removing existing piping).
6) Figures are rounded.

Table 7-3 presents an opinion of cost for the replacement of Priority 3 pipelines.

Table 7-3 Priority 3 Improvements, Opinion of Probable Costs

Item	Opinion of Cost
New installed 8-inch Class 52 DIP (push-on joint, cement lined, Class 52) (includes trenching, excavation, bedding, backfill, pavement repair, and fittings), +25,000 LF	$3,000,000
New installed fire hydrants (includes removal of existing fire hydrant when necessary)	$280,000
New installed isolation valves	$75,000
New service lateral connections	$340,000
Rock removal	$150,000
Project Contingency	$750,000
Construction Subtotal	**$4,600,000**
Fiscal, Legal, Administrative, Engineering	$800,000
PROJECT COST	**$5,400,000**

Notes:

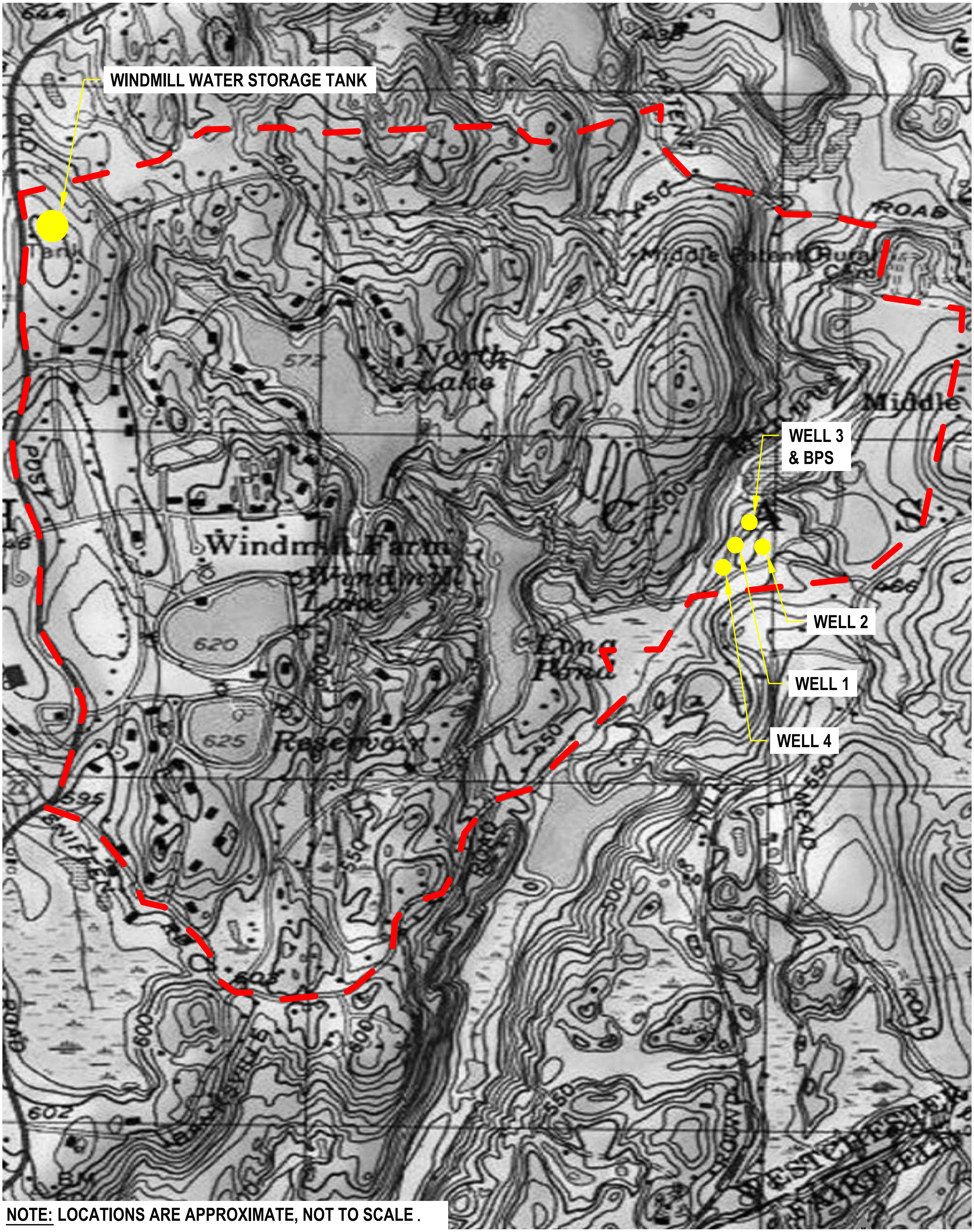
1) New fire hydrant installation and removal of old fire hydrant every 500 LF.
2) New service lateral connection every 100 LF.
3) New isolation valve installed every 1000 LF and at every major intersection.
4) All pipe installation is in asphalt roadway.
5) New pipe installed adjacent to existing pipe with abandonment of existing pipe (does not include cost of removing existing piping).
6) Figures are rounded.

8 Recommendations

The District should plan to design and construct the Priority 1 and Priority 2 replacements in the near term. The Priority 1 upgrades are anticipated to improve available fire flow. Implementation of Priority 2 replacements is anticipated to improve system reliability and reduce the incidence of line breaks and unplanned outages.

Based on the known history of the design, construction, and condition of the existing pipe network, the District should develop a long-term plan to replace the Priority 3 pipes in the system. A preventive approach may avoid the inconvenience of unplanned water outages and reduce operation and maintenance costs.

FIGURES



NOTE: LOCATIONS ARE APPROXIMATE, NOT TO SCALE .

LEGEND:

WATER DISTRICT NO. 2

N

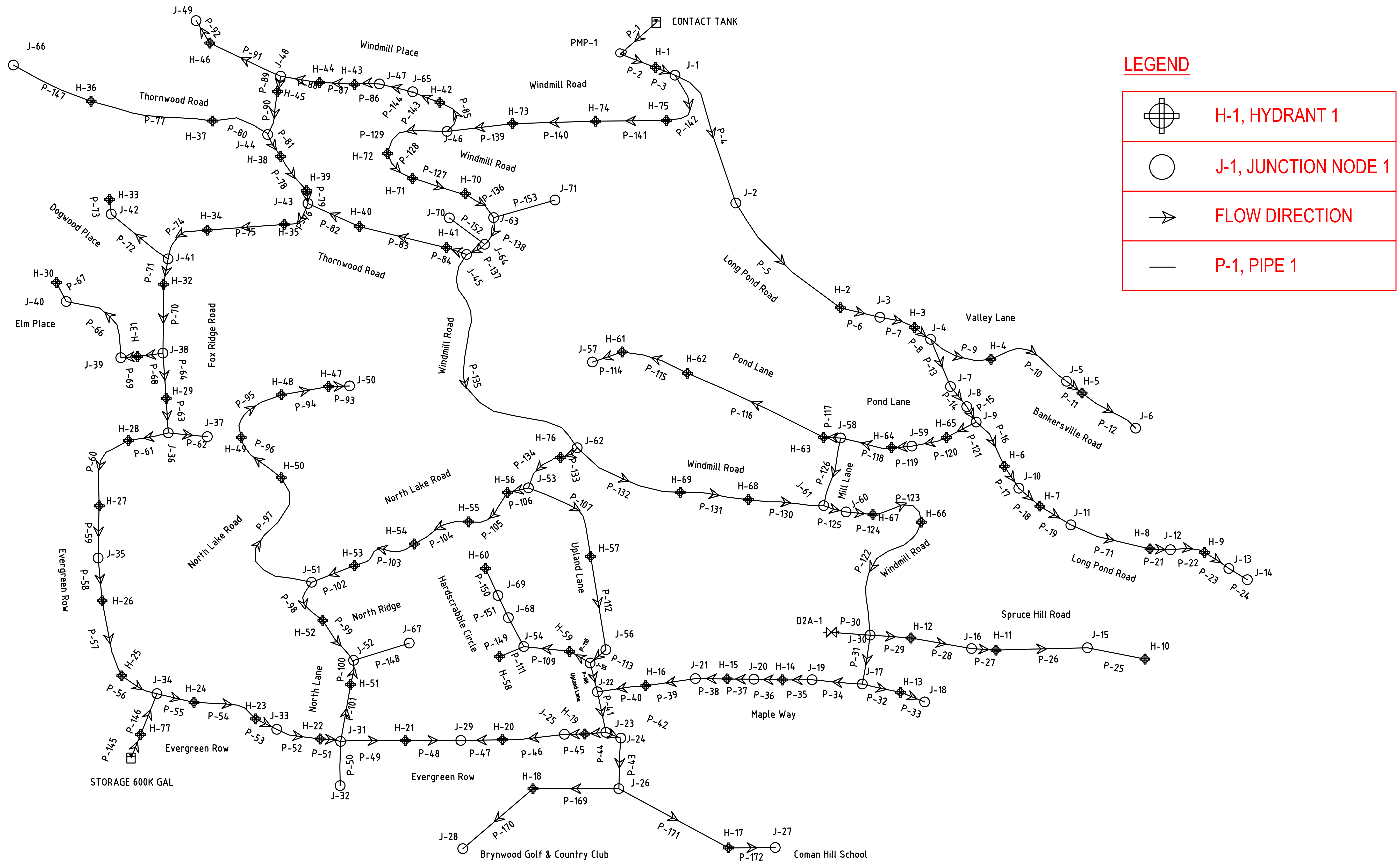
Town of North Castle
Water District No. 2
Hydraulic Modeling
USGS Location Map

Job Number	86-14901
Revision	A
Date	4/2012

Figure 01

One Remington Park Drive, Cazenovia NY 13035 USA **T** 1 315 679 5800 **F** 1 315 679 5853 **E** cazmail@ghd.com **W** www.ghd.com

Plot Date: 16 April 2012 - 10:23 AM Cad File No: G:\86\14901\CADD\Drawings\86-14901-F01.dwg



NOTES:

1. ALL LOCATIONS ARE APPROXIMATE.
2. DRAWING NOT TO SCALE, MODEL SCALED FROM OWNER DATA.
3. FLOW DIRECTION BASED ON PEAK-HOUR DEMAND SIMULATION

GHD

CLIENTS | PEOPLE | PERFORMANCE

Town of North Castle
Water District No. 2
Hydraulic Modeling
Model Schematic

Job Number	86-14901
Revision	A
Date	4/2012

Figure 02

One Remington Park Drive, Cazenovia NY 13035 USA T 1 315 679 5800 F 1 315 679 5853 E cazmail@ghd.com W www.ghd.com

Plot Date: 16 April 2012 - 12:01 PM Cad File No: G:\86\14901\CADD\Drawings\86-14901-F02.dwg

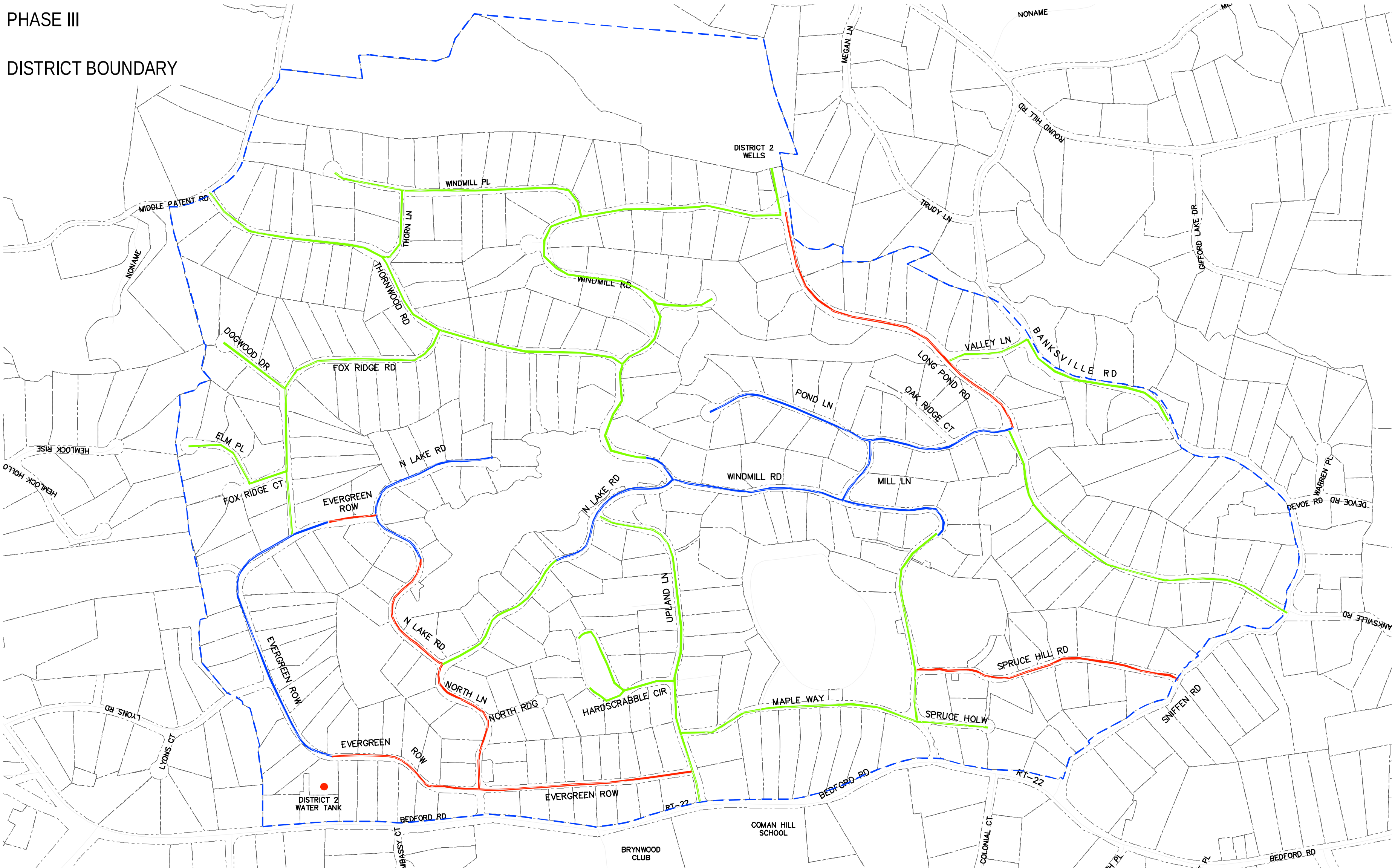
LEGEND:

PRIORITY I

PRIORITY II

PHASE III

DISTRICT BOUNDARY



TOWN OF NORTH CASTLE, NY
WATER DISTRICT NO. 2 (WINDMILL FARM)
MODELING STUDY

PRIORITIZED PIPELINE REPLACEMENTS

Job Number	8614901
Revision	A
Date	07/2012

Figure 03

One Remington Park Drive, Cazenovia NY 13035 USA T 1 315 679 5800 F 1 315 679 5853 E cazmail@ghd.com W www.ghd.com

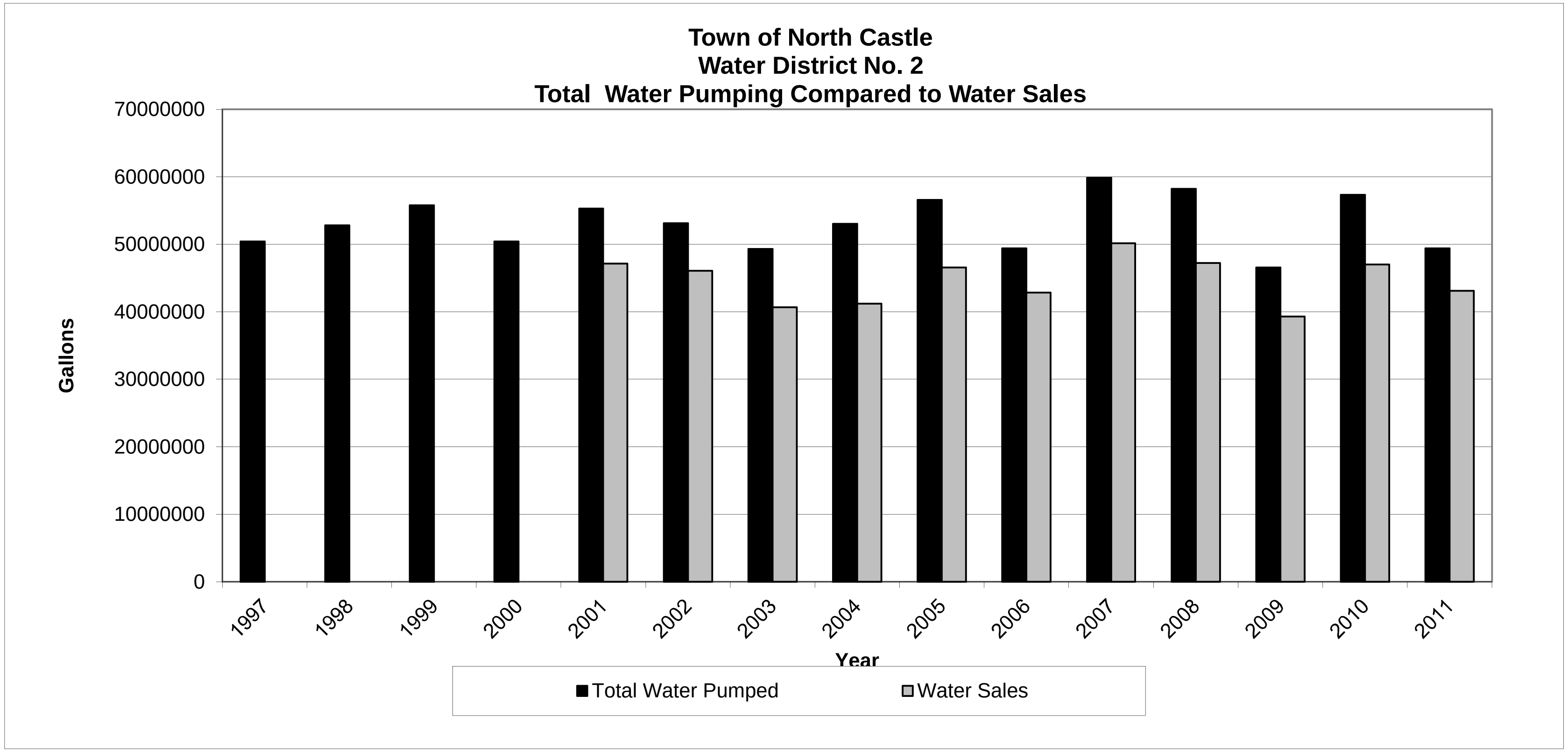
Plot Date: 19 July 2012 - 10:21 AM Cad File No: G:\86\14901\CADD\figures\STUDY FIGURE 3.dwg

APPENDICES

Appendix A

Comparison of Water Sales to Total Water Pumped

APPENDIX A
COMPARISON OF WATER SALES TO TOTAL WATER PUMPED



Appendix B

ISO Report: Hydrant Flow Data for Model Calibration

APPENDIX B
ISO REPORT: HYDRANT FLOW DATA FOR MODEL CALIBRATION

City North Castle TS WD#4 and #7 and WD #2 - May 18, 2011 **2011**
County Westchester **State** NY

613 & 614 HYDRANT FLOW DATA (MC(1) & HD(1))

Test No.	Location	Needed Fire Flow	Service Level	Pressure (PSI) Static	Residual	Pitot	Orifice	Flow GPM	Flow GPM@ 20 psi	Hydrant Condition
1	MacDondald Ave hyd in circle (hyd #5)		WD 7	94	76			1390	3000	OK
	Wampus Ave 1st hyd north of circle (hyd #6)					69	2.5	1390		OK
2	Bedford Rd hyd at Maple Ave (hyd #18)		WD 4	96	88			1480	5000	OK
	Bedford Rd 1st hyd east of Maple Ave (hyd #22)					78	2.5	1480		OK
3	Business Park Dr 5th hyd south of Rt 22 (hyd #71)		WD4	97	85			1520	4100	OK
	Business Park Dr 6h hyd south of Rt 22 (hyd #72)					82	2.5	1520		OK
4	Main St hyd at Maple (hyd #21)		WD4	90	84			1500	5700	OK
	Maple Ave hyd opp pond (hyd #18)					80	2.5	1500		OK
5	Old Rte 22 hyd at Kaysal Rd (hyd #40)		WD4	92	70			1300	2500	OK
	Old Rte 22 1st hyd south of Kaysal Rd (hyd#41)					60	2.5	1300		OK
6	Evergreen Row 1st hyd north of North Ln (hyd #23)		WD2	30	16			690	600	OK
	Evergreen Row hyd at North Ln (hyd #22)					17	2.5	690		OK
7	Windmill Pl 1st hyd south of Thorne Ln (hyd #44)		WD2	82	42			960	1200	OK
	Windmill Pl 1st hyd north of Thorne Ln (hyd #46)					33	2.5	960		OK
8	Spruce Hill Rd 2nd hyd north of Sniffin Rd (hyd #11)		WD2	44	10			560	450	OK
	Spruce Hill Rd 1st hyd north of Sniffin Rd (hyd #10)					11	2.5	560		OK

Appendix C

Peak Hour Fire Flow Analysis

APPENDIX C
PEAK HOUR FIRE FLOW ANALYSIS

Description:
Result data is from peak hour demand simulation with minimum system residual pressure set at 20.0 psi.
Maximum fire flow is calculated iteralively at every system hydrant while maintaining the assigned minimum system residual pressure.
Residual pressures provided in the table are calculated from the fire flow available at the specific hydrant.

Key:
Failed Hydrant Flow

	500 GPM FIRE FLOW REQUIREMENT		750 GPM FIRE FLOW REQUIREMENT		1000 GPM FIRE FLOW REQUIREMENT	
Hydrant ID	**Fire Flow Available (gpm)**	**Residual Pressure (psi)**	**Fire Flow Available (gpm)**	**Residual Pressure (psi)**	**Fire Flow Available (gpm)**	**Residual Pressure (psi)**
H-1	338	115.6	338	115.6	338	115.6
H-2	317	93.8	317	93.8	317	93.8
H-3	313	96.4	313	96.4	313	96.4
H-4	312	102.5	312	102.5	312	102.5
H-5	311	72.3	311	72.3	311	72.3
H-6	308	63.7	308	63.7	308	63.7
H-7	308	47.5	308	47.5	308	47.5
H-8	307	28.8	307	28.8	307	28.8
H-9	308	25.9	308	25.9	308	25.9
H-10	215	36.3	215	36.3	215	36.3
H-11	216	20.6	216	20.6	216	20.6
H-12	245	26.6	245	26.6	245	26.6
H-13	268	39.8	268	39.8	268	39.8
H-14	274	34.6	274	34.6	274	34.6
H-15	279	28.1	279	28.1	279	28.1
H-16	302	27.3	302	27.3	302	27.3
H-17	312	21.7	312	21.7	312	21.7
H-18	312	23.1	312	23.1	312	23.1
H-19	312	29.3	312	29.3	312	29.3
H-20	330	32.5	330	32.5	330	32.5
H-21	318	31.0	318	31.0	318	31.0
H-22	340	20.8	340	20.8	340	20.8
H-23	483	20.1	483	20.1	483	20.1
H-24	711	20.0	711	20.0	711	20.0
H-25	1,441	20.0	1441	20.0	1441	20.0
H-26	860	33.8	860	33.8	860	33.8
H-27	610	26.4	610	26.4	610	26.4
H-28	527	39.4	527	39.4	527	39.4
H-29	464	56.8	464	56.8	464	56.8
H-30	444	30.0	444	30.0	444	30.0
H-31	444	59.0	444	59.0	444	59.0
H-32	410	67.5	410	67.5	410	67.5
H-33	403	60.6	403	60.6	403	60.6
H-34	388	67.9	388	67.9	388	67.9
H-35	363	71.4	363	71.4	363	71.4
H-36	347	92.5	347	92.5	347	92.5
H-37	347	81.7	347	81.7	347	81.7
H-38	347	69.4	347	69.4	347	69.4
H-39	352	69.9	352	69.9	352	69.9
H-40	344	62.3	344	62.3	344	62.3
H-41	337	75.8	337	75.8	337	75.8
H-42	342	57.2	342	57.2	342	57.2
H-43	345	45.1	345	45.1	345	45.1
H-44	345	55.9	345	55.9	345	55.9
H-45	346	70.3	346	70.3	346	70.3
H-46	345	70.9	345	70.9	345	70.9
H-47	315	26.4	277	26.4	277	26.4
H-48	331	20.0	277	20.0	277	20.0
H-49	331	33.0	299	33.0	299	33.0
H-50	331	35.3	328	35.3	328	35.3
H-51	318	27.5	318	27.5	318	27.5
H-52	326	38.1	326	38.1	326	38.1
H-53	335	47.1	334	47.1	334	47.1
H-54	343	41.7	343	41.7	343	41.7
H-55	344	36.9	344	36.9	344	36.9
H-56	337	43.5	337	43.5	337	43.5
H-57	325	21.6	325	21.6	325	21.6
H-58	294	20.0	295	20.0	295	20.0
H-59	307	22.7	307	22.7	307	22.7
H-60	308	23.8	308	23.8	308	23.8
H-61	300	73.1	300	73.1	300	73.1
H-62	300	69.3	300	69.3	300	69.3
H-63	300	62.2	300	62.2	300	62.2
H-64	303	63.4	303	63.4	303	63.4
H-65	306	66.9	306	66.9	306	66.9
H-66	281	41.5	281	41.5	281	41.5
H-67	286	50.9	286	50.9	286	50.9
H-68	299	50.8	299	50.8	299	50.8
H-69	307	46.3	307	46.3	307	46.3
H-70	337	76.7	337	76.7	337	76.7
H-71	338	66.2	338	66.2	338	66.2
H-72	339	63.6	339	63.6	339	63.6
H-73	339	68.0	339	68.0	339	68.0
H-74	339	88.7	339	88.7	339	88.7
H-75	339	100.4	339	100.4	339	100.4
H-76	330	52.7	330	52.7	330	52.7
H-77	1,500	26.4	1500	26.4	1500	26.4