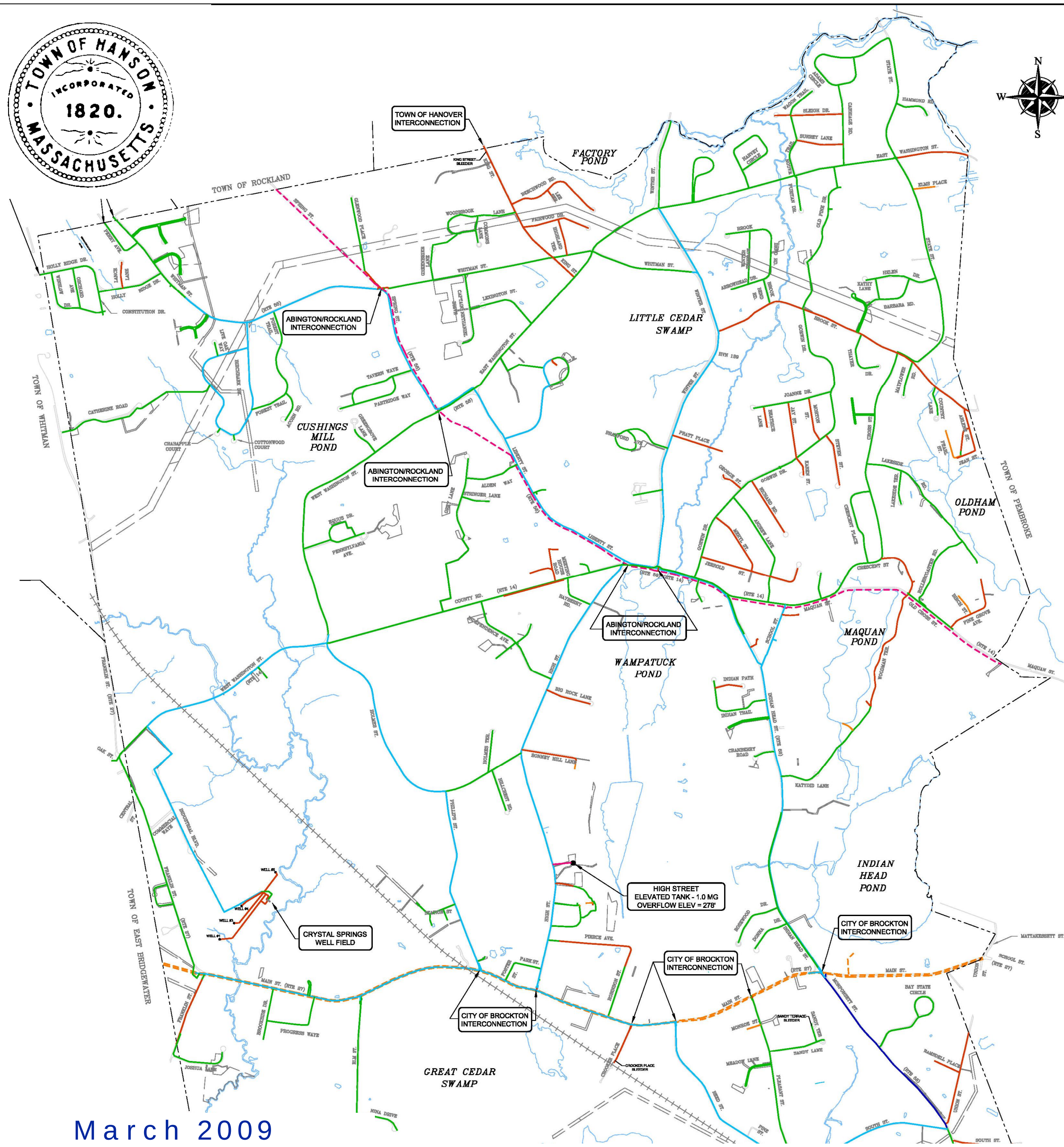
Final Report

Water System Master Plan

Town of Hanson, Massachusetts



March 2009

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FINAL REPORT

Water System Master Plan

Town of Hanson

Hanson, Massachusetts

March 26, 2009

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ACKNOWLEDGMENTS

Environmental Partners Group, Inc. would like to express our appreciation to the many Town Officials and Departments who assisted in the preparation of this report.

We wish to especially thank Mr. Neal Merritt, the Town of Hanson's Water Superintendent, and his staff for their cooperation and assistance throughout execution of this project and the preparation of this document.

EXECUTIVE SUMMARY

Environmental Partners Group was selected by the Town of Hanson Water Department to complete a *Water System Master Plan.* The assessment consisted of:

- An update of the 2001 Water System Atlas;
- The development of a hydraulic computer model of the water distribution system;
- An evaluation of the distribution system storage and piping;
- The preparation of a water system improvement plan and cost estimate.

A summary of the findings, conclusions, and recommendations of the Water System Master Plan are provided below:

Existing Water System

Hanson's water distribution system consists of approximately 71 miles of pipe, ranging in diameter from 1-inch through 16-inch. Water distribution storage is provided by one tank with a total capacity of 1.0 million gallons. Water is supplied by four groundwater wells at the Crystal Springs wellfield.

Water Demand

The existing average day demand for the Town is 0.65 MGD and the maximim day demand is 1.01 mgd.

Distribution System Assessment

Hanson's current useable water storage is 1.0 million gallons, which is not adequate to meet the existing water storage requirements with the fire flow requirement at the vacant Plymouth County Hospital. It is estimated that an additional 158,000 gallons of useable storage will be required to satisfy fire protection requirements. When and if the hospital complex is demolished or redeveloped the Town will no longer require the additional storage.

Several deficiencies were identified in Hanson's existing network of distribution piping. The deficiencies were identified utilizing pipe condition tests, hydrant flow tests, and a computerized hydraulic model.

Recommended Improvements

Improvements to the existing water distribution system were established to correct current deficiencies. The recommended improvements to the system include the construction of a 0.5 million gallon water storage tank (only if the existing Plymouth County Hospital complex remains) and the installation of approximately 10 miles of new 12-inch and 8-inch water main. The recommended storage tank is dependent on the fire flow requirement at the vacant Plymouth County Hospital complex and would not be required if that building is demolished or redeveloped.

In order to prioritize the improvements, it is recommended that the improvements be implemented in three phases. Phase I improvements address immediate water distribution system problems, such as deficiencies in water pressure or fire flow availability, and should be implemented as soon as possible. Phase II improvements are intended to prepare the water system for the near future, ensuring its ability to meet projected demands and future fire flow requirements. Phase III improvements, while not immediately critical, are intended to reinforce the water system and improve its overall performance and reliability. Additional improvements, which should be done whenever funding allows, include replacing vinyl-lined asbestos cement (VLAC) pipe and pipes 2-inches and smaller in diameter. The phased improvements are summarized in the following table:

TABLE E. 1
RECOMMENDED IMPROVEMENTS

	Recommended Improvement Description
Phase I Improvements	Install 0.5 MG water storage tank* Install 4,000' of 12" main Install 2,350' of 8" main
Phase II Improvements	Install 14,850' of 12" main Install 17,150' of 8" main
Phase III Improvements	Install 4,900' of 12" main Install 1,300 of 8" main
Additional Improvements	Replace 22,050' of pipes ≤2" Replace 72,605' of VLAC pipe

*Only if the existing Plymouth County Hospital complex remains

Estimated Cost of Recommended Improvements

Capital costs were established for each phase of the recommended improvements. The costs are summarized in the following table in terms of 2009 dollars.

TABLE E. 2
ESTIMATED CAPITAL COST SUMMARY

	CAPITAL COST
Phase I Improvements	$3,144,000*
Phase II Improvements	$2,396,500
Phase III Improvements	$2,964,500
Sub-Total Cost	**$8,505,000**
Additional Improvements	$10,723,860
Total Cost	**$19,228,860**

*Includes $750,000 for supplemental water storage tank

1. INTRODUCTION

1.1 PURPOSE

The purpose of this Water System Master Plan is to evaluate the Town of Hanson's water distribution system, and to recommend a long-range plan for water storage and distribution system improvements.

1.2 SCOPE OF WORK

The scope of work for this project is based on Environmental Partners' agreement with the Hanson Water Department dated July 14, 2008. A summary of the Project Scope of Work is outlined below:

Task 1: Update Existing Water System Distribution Map

Generate an electronic water distribution map showing the sizes of all water mains and the location of all gates, hydrants, wells, storage tank and other Hanson Water Department owned facilities.

Task 2: Prepare a Hydraulic Model of the Hanson Water System

Using the data collected in Task 1, construct the water distribution system model. Conduct C-factor and hydrant fire flow tests of the distribution system. In general these tests will be conducted at the same location as those conducted as part of the ISO rating tests, and reservoir storage elevations will also be recorded at the time of the tests. Water demand data will assigned to each node based on metered consumption by parcel ids. Pump station data (pumping rates, total dynamic head, flow) will be input utilizing pump curve data for each individual pump.

Task 3: Analyze Water System's Ability to Meet Existing Conditions

An assessment of the adequacy of available supplies, existing distribution storage, and existing pipe sizes to meet normal, seasonally high, and fire flow requirements of the distribution system will be conducted.

Task 4: Make Recommendations on Improvements to Water Supply, Storage, and Distribution Facilities

Recommendations of distribution system improvements will be identified and their related costs estimated. These results of this assessment will be reviewed with you and used to prepare a long-term Capital Improvement Plan. The improvements will be grouped in stages (i.e. those which need to be done immediately, those needed to be done in the next 3-5 years, 5-7 years, and 7-10 years).

Task 5: *Master Plan Report*

A report summarizing the findings from tasks 1-4. The report shall include an executive summary, detailed chapters on each of the tasks outlined above, tables of any data used to support the conclusions and recommendations made in the report, a printed map of the water distribution system, and a map of the distribution system showing the recommended improvements highlighted in color.

2. WATER SYSTEM OVERVIEW

2.1 GENERAL

This chapter provides a brief description of the Town and an overview of the existing water system, including distribution system piping and storage facilities. A map of the Hanson water system is presented in Figure 2-1 – Existing Water System Map.

2.2 TOWN DESCRIPTION

The Town of Hanson, Massachusetts is situated in Plymouth County and is considered one of the inland towns of Massachusetts's South Shore, and is bordered by Rockland and Hanover to the north, Pembroke to the east, Halifax to the south, East Bridgewater to the west, and Whitman to the northwest. Hanson is located approximately nine miles east of Brockton and eighteen miles south-southeast of Boston. The Town of Hanson is predominantly a residential community with small commercial properties, light industry, and farming (including cranberry farming.)

Hanson has a total land area of approximately 16.1 square miles. As reported in the 2007 Annual Statistical Report, there were 8,860 people served with public water for consumption and fire protection from Hanson's water system.

2.3 WATER SUPPLY

The Hanson Water Department was created in 1916 by an act of the State Legislature. Prior to the development of its own source of water in the early 1980s the Hanson Water Department purchased all of its water from the City of Brockton and the Abington/Rockland Joint Waterworks. Currently Hanson operates four wells, known as the Crystal Spring Wellfield. The wellfield is located in the Poor Meadow Brook sub-basin of the Taunton River. It is in the western edge of the Town just east of Route 27 at the southern end of the Hanson Commerce Park. As reported in the 2007 ASR, the Town has a Water Management Act authorized withdrawal of 0.78 MGD. A listing of each groundwater source is presented in Table 2.1.

TABLE 2.1
GROUNDWATER SUPPLIES

Description	Type	Current Rated Capacity
Well #1	Gravel Packed	350 gpm
Well #3	Gravel Packed	200 gpm
Well #4	Gravel Packed	200 gpm
Well #5	Gravel Packed	200 gpm

It has been reported that due to hydraulic and chemical feed constraints Wells #3, #4, and #5 cannot run simultaneously. This limits the production at this site and causes the Town to use their interconnection with the City of Brockton at times of high demand. A summary of the Town's recent water demands is presented in Section 3.

2.4 WATER DISTRIBUTION STORAGE

Distribution system storage for the Hanson water system consists of a 1.0 million gallon elevated steel spheroid. The size, capacity, and overflow of Hanson's water storage tank are summarized in Table 2.2. An assessment of Hanson's water storage requirements is presented in Section 4.3 of this report.

TABLE 2.2
WATER STORAGE SUMMARY

Identification	Bowl Height (ft)	Bowl Diameter (ft)	Overflow Elevation (1) (ft)	Storage Volume (MG)
High Street Tank	40	30	278	1.0

Note: (1) Elevations are in USGS vertical datum 1929.

The High Street Tank was constructed in 1989. It is surrounded by a chain link fence that can be accessed through a secured gate located off of High Street.

2.5 WATER DISTRIBUTION PIPING

Hanson's water distribution piping consists of approximately 71 miles of pipe, ranging in diameter from 1-inch through 16-inch. A summary of the various pipe diameters and their quantities for the Hanson distribution system is presented in Table 2.3. Pipe lengths 6-inches and larger in diameter are representative of the distribution pipe network that was modeled as part of the distribution system evaluation.

TABLE 2.3
WATER DISTRIBUTION PIPING BY DIAMETER

Pipe Diameter	Quantity (ft)	Percent of Total
≤2-inch	5,593	1.5%
6-inch	58,261	15.6%
8-inch	216,738	58.2%
10-inch	4,036	1.1%
12-inch	87,480	23.5%
16-inch	381	0.1%
Total	**372,489**	**100%**

A review of the information provided in Table 2.3 indicates that the majority of the distribution piping (76.6%) is 8-inches and smaller in diameter, whereas, only 24.7% of the piping is 10-inches and larger. The majority of the Town's distribution system piping consists of asbestos cement pipe installed from the 1950's through the 1970's. An approximate breakdown of the distribution system piping materials of pipes 6-inches and larger is presented in Table 2.4.

TABLE 2.4
WATER DISTRIBUTION PIPING BY MATERIAL

Pipe Material	Quantity (ft)	Percent of Total
Cast Iron (Unlined)	17,767	4.8%
Polyvinyl Chloride (PVC)	25,369	6.9%
Cast Iron (Lined)	36,362	9.9%
Vinyl-Lined Asbestos Cement (V.L.A.C.)	80,029	21.8%
Cement Lined Ductile Iron (D.I.)	83,998	22.9%
Asbestos Cement (A.C.)	123,372	33.6%
Total		**100%**

2.6 WATER SYSTEM PRESSURES

Static water pressure refers to the pressure in a main when there is no water flowing. Recommended static water pressures for consumer use in public water supply systems range from a minimum of 35 pounds per square inch (psi) to a maximum of 100 psi (DEP Guidelines and Policies for Public Water Systems).

Normal working pressures are typically in the range of 60 psi. Pressures greater than 100 psi can result in increased leakage throughout the distribution system and rapid discharge of water from household plumbing fixtures.

Residual water pressure refers to the available water pressure when a pipe is flowing. Residual pressure is measured as the drop in static pressure when water is withdrawn from a main during a flow test. Required fire flows from hydrants are normally expressed at a residual pressure of 20 psi, which allows for friction losses in the hydrant branch, barrel, and suction hose to the fire engine pump.

Static pressures within Hanson's water distribution system were measured during the field-testing program conducted by Environmental Partners on August 12, 2008 and August 13, 2008. Flow testing data is provided in Appendix A, and the results of the "C"- Factor testing is provided in Appendix B. The pressure results measured during the field testing program are summarized in Table 2.5. A review of the information reported in Table 2.5 indicates that the static pressures throughout Town met DEP's guidelines. However, the residual pressure measured on Jean Street at Arlene Street was below DEP's guidelines.

TABLE 2.5
REPRESENTATIVE STATIC PRESSURES

Location	Static Pressure (psi)	Residual Pressure (psi)
Commercial Way @ Franklin Street	81	70
Carriage Road @ Sleigh Road	93	71
School Street @ Maquan School	69	60
Milford Street @ Ocean Avenue	95	35
Main Street @ Indian Head Street	75	64
Main Street @ Phillips Street	87	85
Holly Ridge @ Lance Lane	61	42
Jean Street @ Arlene Street	87	10
E. Washington Street @ Liberty Street	72	64
Arrowhead Drive @ Winter Terrace	94	56

3. WATER DEMAND REQUIREMENTS

This chapter of the report presents an assessment of the Town's ability to meet existing water supply needs. The adequacy of available supplies, existing distribution storage, and existing pipe sizes to meet normal, seasonally high, and fire flow requirements will be examined.

3.1.1 Average Day Demand

Water use data for the past three years (2005 through 2007) was provided to Environmental Partners by the Hanson Water Department, and is summarized in Table 3.1. Based on the information presented in Table 3.1, the Town's average water usage from 2005 to 2007 is approximately 238 million gallons (MG) per year or 0.65 million gallons per day (MGD).

TABLE 3.1
ANNUAL WATER CONSUMPTION (2005 TO 2007)

Year	Total Water Consumption (GAL)	Total Water Consumption (gpd)
2005	241,781,328	662,415
2006	235,580,000	645,425
2007	237,550,000	650,822
Avg.	**238,303,776**	**652,887**

The average day demand is defined as the average volume of water produced from all sources and pumped into the distribution system as well as any supply purchased from neighboring communities. Average day demand values provide the basis for determining the adequacy of water supply sources. Currently the Town's average day demand does not exceed its registered withdrawal volume.

3.1.2 Maximum Day Demand

The maximum day demand is defined as the largest 24-hour demand during the course of a calendar year. The maximum day demand is an essential component in the evaluation of water storage and pumping facilities. In addition, since maximum days often occur consecutively it is important to examine whether or not the source of water supply is also capable of delivering the maximum day demand. If the available yield from the water supply sources were less than the maximum day demand, the water level in the storage tanks would drop and jeopardize system pressures and emergency storage. Maximum day demand is typically expressed as a ratio of the average day demand (i.e. *Maximum Day Demand ÷ Average Day Demand*).

The magnitude of the maximum day to average day demand ratio depends upon the characteristics of the individual community water system. Typically, the maximum day demand ratio will be greater in residential communities, with low population densities and small amounts of industry. Conversely, highly industrialized, densely populated communities experience a smaller maximum day demand ratio, because large water consuming industries are generally not subject to seasonal fluctuations. A summary of average day, maximum day, and demand ratios between the years of 2005 to 2007 for the Town of Hanson is presented in Table 3.2. A review of the data shown in Table 3.2 indicates that the average maximum day to average day demand ratio is 1.53.

TABLE 3.2
MAXIMUM DAY DEMAND

Year	Average Day Demand (GPD)	Maximum Day Demand (GPD)	Demand Ratio
2005	662,415	1,082,884	1.63
2006	645,425	910,000	1.41
2007	650,822	1,010,000	1.55
Maximum Day Demand Ratio (Maximum Day ÷ Average Day)			**1.53**

3.1.3 Peak Hour Demand

The peak hour demand is defined as the maximum volume of water used within a 60-minute period. The peak hour demand typically occurs in conjunction with the maximum day demand. Because peak demands can be extremely variable, lasting only for a short duration, it is common water works engineering practice to satisfy these demands from distribution storage, rather than from supply sources. Consequently, peak hour demand will be considered when determining the adequacy of Hanson's water distribution storage facility.

4. DISTRIBUTION SYSTEM ASSESSMENT

This chapter of the report will review and discuss Environmental Partner's evaluation of the Hanson water distribution system. Two primary subjects are covered: a detailed discussion of the distribution system piping assessment using a computerized hydraulic model; and a detailed discussion of the water storage requirements and needs.

4.1 BACKGROUND

A distribution system must have sufficient capacity to meet demands during periods of peak consumption while maintaining adequate service pressures. At the same time, the system must be capable of delivering the volume of water required for fire protection. The ability of the system to meet these conditions, both now and in the future, is determined by pipe condition tests, hydrant flow tests, an evaluation of water storage, and a comprehensive hydraulic analysis of the distribution system.

4.2 CONDITION OF DISTRIBUTION MAINS

The condition of a water main, as discussed in this section of the report, alludes to both its carrying capacity and its physical condition. A pipe has its greatest carrying capacity when it is newly installed. Over time the interior surface of a pipe can become rough due to corrosion which can cause tuberculation and in some cases the formation of organic growth. As a result, the pipe gradually loses carrying capacity through a combination of increased fluid friction and reduced inside diameter. Deterioration occurs most rapidly in unlined cast iron pipe. Cement lined pipe, asbestos cement pipe and polyvinyl chloride (PVC) pipe generally retain close to their original capacity for many years.

The Hazen-Williams formula is commonly used to express the condition of pipes in a water distribution network. The coefficient "C" represents pipe roughness. New pipe usually has a "C" value between 120 and 140. However, in older distribution systems, "C" values as low as 30 are sometimes encountered. The lower the "C" value, the rougher the pipe.

On August 12, 2008 and August 13, 2008, Environmental Partners performed "C" factor flow tests on representative mains within Hanson's distribution system, and subsequently used the data to calculate "C" values for the representative pipe. Performing a "C" factor test involves measuring both the flow and pressure drop along a given distance of water main. The "C" value calculation takes into account the flow within the water main, the diameter of the main, the distance between the pressure drop measurement points, and the relative elevation of the measurement points. "C" values were calculated for each field test completed by Environmental Partners. The results of the "C" value testing are presented in Table 4.1 and the data is provided in Appendix B.

TABLE 4.1
SUMMARY OF "C" VALUE TEST RESULTS

Test No.	Location	Pipe Type	Diameter (inch)	Date Installed	"C" Value
1	Milford Street	Cast Iron	6	1931	31
2	Jerrold Road	Asbestos Cement	6	1969	140
3	Gorwin Drive	Asbestos Cement	8	1977	138
4	Winter Terrace	PVC	8	1986	124
5	High Street	Asbestos Cement	12	1973	141

Based on the results presented in Table 4.1, appropriate "C" values were assigned to all pipes comprising Hanson's water distribution system. Generally, the "C" flow test results indicate that piping installed after the 1950's is in good condition and the cast iron piping installed in the 1930's is in poor condition.

4.3 WATER DISTRIBUTION STORAGE ASSESSMENT

4.3.1 Evaluation Criteria

The purpose of water distribution storage is:

- To meet peak demands of short duration, allowing for more uniform water pumping rates.
- Provide a reserve to meet fire flow demands.
- To serve as an emergency supply in the event of a water main break, the temporary loss of a water supply or a treatment facility.
- To help to equalize pressure throughout the distribution system.

These were the criteria that were used to evaluate the adequacy of the water storage capacity of Hanson's distribution system.

4.3.2 Peak Hourly Demand

The amount of distribution storage required to meet peak hourly demands is a function of both the maximum daily demand and the available pumping capacity. If pumping capacity is equal to or greater than the maximum day demand, the storage required to meet peak hourly demands is estimated to be 30 percent of the maximum day demand, as referenced in the American Water Works Association Manual of Water Supply Practices. For this report, we assume that the Town's pumping capacity and additional supply from the City of Brockton will meet current maximum day demands.

Assuming that the Town's pumping capacity, including supply from the City of Brockton, will remain equal to or greater than the maximum daily demand, the required storage to meet peak hourly demands is shown in Table 4.2. Based on the ground surface and tank elevations, we have considered the entire volume in the tank as useable storage. Useable storage is defined as the volume of storage in the tanks above the elevation required to provide a minimum of 35 psi static pressure throughout the distribution system.

TABLE 4.2
PEAK HOURLY DEMAND STORAGE REQUIREMENTS

Maximum Day Demand (MDD)	Required Peak Hourly Demand Storage (30% MDD)	Total Storage Available (GAL)	Storage Surplus or *(Deficit)* (GAL)
1,010,000	303,000	1,000,000	697,000

4.3.3 Fire Protection

The quantity of distribution storage necessary for fire protection is based in part on the fire flow requirements established by the Insurance Services Office (ISO). Criteria established by ISO are used by insurance companies to set fire insurance rates. Based on the ISO report dated May 10, 1995, the highest fire flow required in Hanson is 9,000 gpm at the intersection of Main Street and Phillips. Since this intersection is also served by the City of Brockton's fire hydrants we did not base the Town's storage sizing on this fire flow.

It is estimated that the volume of water required to meet fire flow protection in Hanson is 855,000 gallons. This requirement was developed in accordance with ISO criteria and based on a fire flow requirement of 4,750 gallons per minute (gpm) for three hours at the vacant Plymouth County Hospital.

We have considered the volume of storage available as the amount of water in the storage tank minus the storage required for peak hourly demand. The results of this calculation are presented in Table 4.3.

TABLE 4.3
FIRE PROTECTION STORAGE REQUIREMENTS

	Required Fire Protection Storage (GAL)	Total Storage Available (GAL)	Storage Surplus or (*Deficit*) (GAL)
With the Plymouth County Hospital	855,000	697,000	(*158,000*)
Without the Plymouth County Hospital	495,000	697,000	202,000

As indicated by reviewing the data presented in Table 4.3, the total available storage after peak hourly demand is 697,000 gallons. The required fire protection storage for Hanson is estimated to be 855,000 gallons (based on the need to meet the existing fire flow demands of the Plymouth County Hospital). Thus, it appears that Hanson's current water storage is not adequate to meet fire protection requirements, as long as the Plymouth County Hospital presents a fire protection need of 4,750 gpm for three hours. At the time the Plymouth County Hospital is demolished or redeveloped, the current maximum fire protection need will be reduced to 2,750 gpm at the location of Indian Street Road at Camp Kiwanis. This would require a total storage volume of 495,000 gallons which would indicate a storage surplus in the amount of 202,000 gallons.

4.4 HYDRAULIC ANALYSIS OF DISTRIBUTION SYSTEM

A hydraulic analysis was conducted for Hanson's water distribution system in order to evaluate the capability of the water system to provide adequate service. By performing a hydraulic analysis, system deficiencies resulting from present flows, including fire flows, can be determined. Additionally, proposed improvements can be simulated to measure their effect on the system.

4.4.1 Hydraulic Model

The hydraulic analysis was performed using "WaterCAD Version 8 XM" by Bentley Systems, Inc. This program solves for the distribution of flows and hydraulic grades using the Gradient Algorithm. This method is an iterative process and is based on two principles:

1. The total flow entering the junction, of two or more pipes, must equal the flow leaving the junction; and
2. The change in pressure between any two points in the system must be equal by any and all paths connecting the points.

The computer software applies these two principles by assuming an initial flow pattern through the distribution system. Based on the assumed flow pattern, the software calculates head losses between the supply sources and the points of distribution. These head losses are compared and recalculated iteratively until the above stated principles are satisfied.

The computer model is a skeletonized version of the actual water system network. The model consists of a series of lines representing pipes, nodes simulating pipe intersections, reservoirs and pumps simulating groundwater supply wells, and storage tank. The model contains all pipes of 6-inch or larger diameter.

4.4.2 Data Input

The distribution system piping network was entered into the model. Numbers were assigned to each pipe and demand node, along with the following: the pipe diameter, pipe length, estimated "C" value, node intersections, node elevations, pump conditions and tank elevations.

Pipe information was obtained from Town personnel and the information is presented in Figure 2-1 (Existing Water System Map). "C" values were based on field tests performed by Environmental Partners on August 12, 2008 and August 13, 2008. The “C” value test results are presented in Table 4.1 and Appendix B of this report.

The hydraulic model includes approximately 600 nodes through the distribution system. Nodal demands were based on Hanson’s 2007 annual average daily flow. The average daily flow was distributed among each node according to the metered consumption by parcel id. The ten largest consumers simulated in the model are reported in Table 4.4. All of these nodal demands can be varied to simulate maximum day flows.

TABLE 4.4
LARGE WATER CONSUMERS

Name	Average Day Demand (gpm)

Crooker Place Bleeder Valve	2.38
Ocean Ave Bleeder Valve	1.39
Shaw's Supermarket	1.24
Sandy Terrace Bleeder Valve	1.17
80 Meeting House Lane	1.11
School Street	1.10
Main Street	0.96
1280 Main Street	0.93
80 Meeting House Lane	0.93
519 County Road	0.75

4.4.3 Calibration

After entering all of the data, the computer model was calibrated. The first step in calibration was accomplished by entering actual system conditions, including tank elevations, number of pumps in operation, pumping rates, and the total system demand as existed during each night of the hydrant flow tests performed on August 12, 2008 and August 13, 2008.

The next step in the calibration procedure is to check the nodal static pressures throughout the distribution system. Static pressures are dependent upon elevation of each node in the system. Nodal elevations were determined from Hanson's contour data layer from their GIS database. Thirteen (13) nodes were used in this step and all of the pressures were within 5% of the field measured static pressures.

The next means of the calibration procedure is to check flowing or "dynamic" conditions. This is accomplished by inputting the hydrant flows measured in the field and comparing actual residual pressures with those calculated by the model. Again, the system conditions that existed during the field tests were entered into the model (i.e. tank elevations, number of pumps operating, pump rates, and total system demand). Thirteen (13) hydrant flows were used for this test. After identifying several closed valves in the system, reasonable convergence, between the actual and model residual pressures, was achieved for the majority of the hydrant flows. It must be noted that the computer model is based upon system equilibrium, a condition that is likely not achieved during a few minutes of hydrant flow testing at each location. Therefore, small differences between the actual and the modeled residual pressures are attributed to this condition. In general, the model calibrated satisfactorily with the actual field readings to within 15%. Refer to Appendix C – Hydraulic Model Calibration Table for the tabulated results of the calibration process.

4.4.4 Results of Hydraulic Analysis

The distribution system model was operated using both current average day demands and maximum day demands. In addition, the model was used to determine the availability of fire flows. Deficiencies in the system were noted when pressures dropped below 20 psi during fire flows and below 35 psi for average day and maximum day.

It should be noted that the computer analysis cannot be considered more accurate than the data that was applied. The base map of the existing system (used to create the model) was verified as much as possible, with the aid of Water Department Staff, and assumed to be accurate. Unknown complications in the system, such as partially or fully closed valves, or blockages in the pipes, can affect the results.

4.4.4.1 Service Pressures

The results of the hydraulic analysis indicated that the existing water distribution system is capable of providing service pressure (above 35 psi) under normal operating conditions (i.e. average day and maximum day demands) to all customers.

Based on the hydraulic analysis, the lowest system pressures were observed in North Hanson on Whitman Street near the Whitman town line. These were still above a pressure of 50 psi. It should be noted that these lower pressures are not the cause of inadequate distribution piping but the result of higher water service elevations

4.4.4.2 Fire Flow Availability

The computer model was also utilized to evaluate the availability of fire flows, with projected maximum day demands, at all nodes throughout the distribution system. Specifically, areas served by 6-inch diameter pipes were evaluated because of concern for the condition and carrying capacity of these mains. Areas of the distribution system in the proximity of heavily developed business, industry, and schools, where fire protection is essential were also evaluated.

The evaluation, with respect to available fire flow protection, was based on requirements set forth by the Insurance Services Office (ISO). ISO needed fire flows, for one and two family dwellings, are summarized in Table 4.5.

TABLE 4.5
ISO NEEDED FIRE FLOWS (ONE AND TWO FAMILY DWELLINGS)

Distance between Dwellings (feet)	Needed Fire Flow (gpm)
Greater than 100	500
31 – 100	750
11 – 30	1000
Less than 10	1500

ISO needed fire flows for commercial and industrial buildings are determined on an individual basis and are typically much greater than those listed Table 4.5. In the hydraulic analysis, it was assumed an average needed fire flow of 2,500 gpm for commercial and industrial developments.

In all, over 600 locations were evaluated for fire flow availability. The hydraulic analysis indicated adequate fire flow to many of these locations. The results of the analysis also helped to evaluate the adequacy of the 6 and 8-inch diameter mains, which comprise a large portion of the distribution system. In cases where these mains are well networked, the effect of their limited carrying capacity is minimized. However, the hydraulic analysis did identify deficient areas with respect to available fire flow under modeled conditions. Table 4.6 and Figure 4-1, summarize the results of the hydraulic analysis at locations where fire flow deficiencies were determined.

TABLE 4.6
AREAS WITH DEFICIENT FIRE FLOW AVAILABILITY

	Area	Type of Development	Available Fire Flow (with 20 psi residual pressure), gpm	Assumed Minimum Required Fire Flows (ISO), gpm
1	Monponsett Area	Residential	250	1,000
2	Oldham Pond Area (North)	Residential	420	1,000
3	Oldham Pond Area (South)	Residential	715	1,000
4	East Washington Street (Pembroke town line)	Residential	535	750

It was also identified that there are a number of mains less than 2-inches that are used to provide water to Hanson's customers. Locations with mains less than 6-inches have no hydrants for fire protection, therefore these areas were also determined to be deficient.

4.4.4.3 Pipe Discontinuity

In addition to identifying areas of deficient fire flow, the effectiveness of the large transmission mains, or trunk lines, in Hanson's water distribution system were analyzed. Furthermore, all sources of supply and storage should be linked together by these large transmission mains, providing an efficient means for source water to enter the distribution system. Without adequate transmission main looping, fluctuations in system pressure and storage tank levels will occur during periods of high demands.

In performing this analysis, the model was utilized to identify all of Hanson's transmission mains that are 10-inches in diameter or greater. Upon establishing the location of these large mains, gaps, or areas of discontinuity between them were identified. The analysis revealed several areas of discontinuity between these large mains. Presented in Table 4.7 is a summary of our water main discontinuity findings.

TABLE 4.7
AREAS OF TRANSMISSION MAIN DISCONTINUITY

Area	Description
Main Street (Route 27)	There is no Hanson water main on Main Street from Reed Street to Indian Head Street (Route 58).
West Washington Street	Approximately 6,300 ft of 8-inch lined cast iron main connects a 12-inch main on West Washington at Holmes Street and at Spring Street.
East Washington Street	Approximately 5,400 ft of 8-inch lined cast iron main connects a 12-inch main at Liberty Street and Winter Street.

The results of this hydraulic analysis, in addition to the water storage evaluation, form the basis of the recommendations presented in Section 5 - Recommended Water System Improvements.

5. RECOMMENDED WATER SYSTEM IMPROVEMENTS

5.1 Overview

Our assessment of Hanson's existing water system provided in the previous sections has identified various deficiencies and performance limiting factors. Furthermore, as future water demands increase, these deficiencies have the potential to become greater. Numerous water system improvements are being recommended to address these deficiencies and are summarized in this Section.

In order to give some priority to the recommended water system improvements and to aid the Town in financing the proposed program, it is recommended that the improvements be implemented in three phases, each consisting of five years. However, it is not necessary that the order listed within this chapter be followed exactly. More importantly, the Town should address those issues which can be reasonably financed and which respond to local concerns.

5.2 Recommended Improvements

Phase I Improvements address immediate water distribution system problems, such as deficiencies in water pressure or fire flow availability, and should be implemented as soon as possible. Phase II Improvements are intended to prepare the water system for the near future, ensuring its ability to meet projected demands and fire flow requirements. Phase III Improvements, while not immediately critical, are intended to reinforce the water system and improve its overall performance and reliability. Additional Improvements are described after the Phase III Improvements. Additional Improvements include the replacement of vinyl-lined asbestos cement water main and water mains 2-inch and smaller.

The improvements for each phase are described in detail in the following tables and are also shown schematically on Figure 5-1.

5.2.1 Phase I Improvements

TABLE 5.1
PHASE I IMPROVEMENTS

DESCRIPTION	
Storage	
1	Install a 0.5 million gallon elevated water storage tank. The tank would have a minimum useable volume of 0.5 million gallons, capable of providing peak hourly demand storage and fire protection storage to the Town. This is only required as long as the fire flow demand at the vacant Plymouth County Hospital is a need. If this building is either demolished or redeveloped, this fire flow requirement would not be necessary and the Town would have sufficient storage.
Distribution	
1	Install a 12-inch main on Monponsett Street from South Street to Woodbine Avenue. This will replace an 8-inch unlined cast iron main and improve fire flow availability in this area. (4,000')
2	Install an 8-inch main on Monponsett Street from Woodbine Avenue to Short Street. This will replace an 8-inch unlined cast iron main and improve fire flow availability in this area. (2,350')
3	Install an 8-inch main on Short Street from Monponsett Street to Upton Street. This will replace a 6-inch unlined cast iron main and improve fire flow availability in this area. (400')
4	Install an 8-inch main on Upton Street from Short Street to Halifax town line. This will replace a 6-inch unlined cast iron main and improve fire flow availability in this area. (500')
5	Install an 8-inch main on Hancock Street from Monponsett Street to White Street. This will replace a 6-inch unlined cast iron main and improve fire flow availability in this area. (925')
6	Install an 8-inch main on Milford Street from Hancock Street to Ocean Avenue. This will replace a 6-inch unlined cast iron main and improve fire flow availability in this area. This will also allow the elimination of a bleeder valve which would result in the conservation of water. (1,800')
7	Install an 8-inch main on Waltham Street from Hancock Street to Halifax town line. This will replace a 6-inch unlined cast iron main and improve fire flow availability in this area. (1,450')
8	Install an 8-inch main on Brook Street from State Street to Pembroke town line. This will replace a 6-inch asbestos cement main and improve fire flow availability in this area. (1,450')
9	Install an 8-inch main on Arlene Street, Jean Street, and Beckett Street. This will replace a 6-inch asbestos cement main and improve fire flow availability in this area. (2,150')

DESCRIPTION	
10	Install an 8-inch main on Pine Grove Avenue. This will replace a 6-inch asbestos cement and unlined cast iron main and improve fire flow availability and water quality in this area. (1,375')
11	Install an 8-inch main on East Washington Street from State Street to Pembroke town line. This will replace a 6-inch unlined cast iron main and improve fire flow availability and water quality in this area. (1,400')

5.2.2 Phase II Improvements

TABLE 5.2
PHASE II IMPROVEMENTS

DESCRIPTION	
Distribution	
1	Install a 12-inch main on Main Street from Reed Street to Indian Head Street. This main will create a loop, eliminate the dead ended main on Pleasant Street, and improve fire flow availability in this area. (3,150')
2	Install a 12-inch main on West Washington Street from County Road (Route 14) to Spring Street. This will replace an 8-inch lined cast iron pipe and improve the transmission system continuity and water quality issues. (6,300')
3	Install a 12-inch main on East Washington Street from Liberty Street (Route 58) to Winter Street. This will replace an 8-inch lined cast iron pipe and improve the transmission system continuity and water quality issues. (5,400')
4	Install an 8-inch main on Squantum Avenue and Union Park Street. This will replace a 6-inch unlined cast iron pipe and improve water quality issues and fire flow availability in this area. (1,300')

5.2.3 Phase III Improvements

TABLE 5.3
PHASE III IMPROVEMENTS

DESCRIPTION	
Distribution	
1	Install 8-inch main on Brook Street from Winter Street to State Street. This main will replace a 6-inch unlined cast iron and improve fire flow availability in this area. (4,500')
2	Install 8-inch main on Lapham Street and a partial portion of Baker Street. This main will replace a 6-inch unlined cast iron main and improve water quality and fire flow availability in this area. (1,100’)

DESCRIPTION	
3	Install 8-inch main on King Street from East Washington Street to Hanover town line. This main will replace a 6-inch unlined cast iron main and improve water quality and fire flow availability in this area. This will also allow the elimination of a bleeder valve which would result in the conservation of water. (3,250’)
4	Install 8-inch main on Pierce Avenue. This main will replace a 6-inch unlined cast iron main and improve water quality and fire flow availability in this area. (2,000’)
5	Install an 8-inch main on Pleasant Street from Main Street (Route 27) to approximately house #621. This main will replace an 8-inch lined cast iron main and improve water quality and fire flow availability in this area. (6,300’)
6	Install a 12-inch main on East Washington Street from Winter Street to State Street. This will replace an 8-inch cast iron pipe and improve the transmission system continuity and water quality issues. (4,900')

5.2.4 Additional Improvements

The following recommendations are not based on hydraulics but water quality and water conservation. The following streets in Town are assumed to have vinyl-lined asbestos cement (VLAC) piping. Recently is has been discovered that drinking water transported in VLAC pipe may contain elevated levels of tetrachloroethylene (PCE). Based on water quality testing, the Town has installed multiple bleeder taps to continuously flush impacted areas. It is recommended that the pipes listed in the following be replaced with cement lined ductile iron to reduce any possible health impacts. The bleeder valves located at Cooker Place and Sandy Terrace result in an average yearly water loss of approximately 1.87 million gallons so it would be recommended that these be replaced first.

TABLE 5.4
VINYL-LINED ASBESTOS CEMENT PIPE

Street	Length, ft	Diameter, in
Barbara Road	885	8
Bay State Circle	2,366	8
Bayberry Road	824	8
Beatrice Lane	430	6
Constitution Drive	412	8
Crooker Place*	794	6
Elm Street	5,964	8
Forest Trail	1,789	8

Street	Length, ft	Diameter, in
Glenwood Place	1,514	8
George Street	503	6
Greenbrier Lane	642	8
Hawks Avenue	1,380	12
Helen Drive	1,274	8
High Street	9,495	12
Holly Ridge Drive	2,959	8
Holmes Terrace	874	8
Indian Path	571	6
Jerrold Street	1,173	6
Joanne Drive	213	8
Karen Street	394	6
Kathy Lane	437	8
Katydid Lane	824	8
Lance Lane	541	6
Liberty Street	1,173	12
Mayflower Road	757	8
Meetinghouse Lane	1,346	6
Orchard Avenue	847	8
Plymouth County Hospital	1,957	8
Ramsdell Place	572	6
Reed Street	3,870	12
Richard Road	1,253	6
Rollercoaster Road	1,538	8
Sandy Lane	1,163	8
Sandy Terrace*	348	8
Spring Street	2,989	12
Station Street	910	8
Whitman Street	6,264	12
Winslow Drive	1,605	8
Winter Street	9,755	12

*Street which contains a bleeder valve

In addition to the removal and replacement of the water mains indicated above, The Town should also plan to replace the 4,500 feet of mains 2-inches in diameter and less listed in Table 5.4 with new 8-inch main. This will improve fire flow availability and water quality concerns in Town.

TABLE 5.5
MAINS 2-INCHES IN DIAMETER AND LESS

Street Name	Length (ft)
Birch Street	360
Elm Place	540
Ferris Street	360
Hanson Court	300
Ocean Avenue	565
Pearl Street	780
Robinson Street	588
School Street	360
Wilbur Avenue	180
Cranberry Cove	660
Arthur Street	300
Village Road	600
Cranberry Cove	660

6. ESTIMATED COST OF RECOMMENDED IMPROVEMENTS

6.1 GENERAL

In this chapter, cost estimates are established for all of the previously recommended water system improvements.

6.2 ESTIMATED CAPITAL COSTS

The estimated capital costs presented in this section represent all the costs for the study, design, and construction, including contingencies and engineering assistance for bidding, construction administration, and resident engineering services for construction projects. All of these costs are current as of March 2009, using an ENR Construction Cost Index of 8534.05. The future use of this cost data must be adjusted accordingly. The unit cost estimate, utilized in this report for new water main construction, includes the material costs for piping and appurtenances (valves, hydrants, etc.), design and engineering, installation, paving and appurtenant items required for a complete project. Unit costs for construction items are based on recent bid tabulations for similar work are presented in Table 6.1.

TABLE 6.1
UNITS COSTS FOR CONSTRUCTION

Item	Units	$/Unit	Engineering, Design and Resident Observation	Contingency	Total ($/unit)
8” Pipe	L.F.	$95	**25%**	**10%**	$130
12” Pipe	L.F.	$110	**25%**	**10%**	$150

The estimated costs for completing the recommended improvements are presented in Tables 6.2 through 6.4.

6.2.1 Cost of Phase I Improvements

TABLE 6.2
COST OF PHASE I IMPROVEMENTS

DESCRIPTION		ESTIMATED COST
Storage		
1	Install a 0.5 million gallon elevated water storage tank. The tank would have a minimum useable volume of 0.5 million gallons, capable of providing peak hourly demand storage and fire protection storage to the Town. This would no longer be required if the vacant Plymouth County Hospital is either demolished or redeveloped.	$750,000
Distribution		
1	Install a 12-inch main on Monponsett Street from South Street to Woodbine Avenue.	$600,000
2	Install an 8-inch main on Monponsett Street from Woodbine Avenue to Short Street.	$305,500
3	Install an 8-inch main on Short Street from Monponsett Street to Upton Street.	$52,000
4	Install an 8-inch main on Upton Street from Short Street to Halifax town line.	$65,000
5	Install an 8-inch main on Hancock Street from Monponsett Street to White Street.	$120,250
6	Install an 8-inch main on Milford Street from Hancock Street to Ocean Avenue.	$234,000
7	Install an 8-inch main on Waltham Street from Hancock Street to Halifax town line.	$188,500
8	Install an 8-inch main on Brook Street from State Street to Pembroke town line.	$188,500
9	Install an 8-inch main on Arlene Street, Jean Street, and Beckett Street.	$279,500
10	Install an 8-inch main on Pine Grove Avenue.	$178,750
11	Install an 8-inch main on East Washington Street from State Street to Pembroke town line.	$182,000

6.2.2 *Cost of Phase II Improvements*

TABLE 6.3
COST OF PHASE II IMPROVEMENTS

DESCRIPTION		ESTIMATED COST
Distribution		
1	Install a 12-inch main on Main Street from Reed Street to Indian Head Street.	$472,500
2	Install a 12-inch main on West Washington Street from County Road (Route 14) to Spring Street.	$945,000
3	Install a 12-inch main on East Washington Street from Liberty Street (Route 58) to Winter Street.	$810,000
4	Install an 8-inch main on Squantum Avenue and Union Park Street.	$169,000

6.2.3 *Cost of Phase II Improvements*

TABLE 6.4
COST OF PHASE III IMPROVEMENTS

DESCRIPTION		ESTIMATED COST
Distribution		
1	Install 8-inch main on Brook Street from Winter Street to State Street.	$585,000
2	Install 8-inch main on Lapham Street and a partial portion of Baker Street.	$143,000
3	Install 8-inch main on King Street from East Washington Street to Hanover town line.	$422,500
4	Install 8-inch main on Pierce Avenue.	$260,000
5	Install an 8-inch main on Pleasant Street from Main Street (Route 27) to approximately house #621.	$819,000
6	Install a 12-inch main on East Washington Street from Winter Street to State Street.	$735,000

6.2.4 Additional Improvements

Depending on available funds that the Town obtains for water distribution system improvements in a given year, the following improvements should be accomplished during the next fifteen years.

6.2.4.1 Vinyl-lined Asbestos Cement Pipe

TABLE 6.5
VINYL-LINED ASBESTOS CEMENT PIPE

Street	Length, ft	Estimated Cost
Barbara Road	885	$115,050
Bay State Circle	2,366	$307,580
Bayberry Road	824	$107,120
Beatrice Lane	430	$55,900
Constitution Drive	412	$53,560
Crooker Place*	794	$103,220
Elm Street	5,964	$775,320
Forest Trail	1,789	$232,570
George Street	503	$65,390
Glenwood Place	1,514	$196,820
Greenbrier Lane	642	$83,460
Hawks Avenue	1,380	$207,000
Helen Drive	1,274	$165,620
High Street	9,495	$1,424,250
Holly Ridge Drive	2,959	$384,670
Holmes Terrace	874	$113,620
Indian Path	571	$74,230
Jerrold Street	1,173	$152,490
Joanne Drive	213	$27,690
Karen Street	394	$51,220
Kathy Lane	437	$56,810
Katydid Lane	824	$107,120
Lance Lane	541	$70,330
Liberty Street	1,173	$175,950

Street	Length, ft	Estimated Cost
Mayflower Road	757	$98,410
Meetinghouse Lane	1,346	$174,980
Orchard Avenue	847	$110,110
Plymouth County Hospital	1,957	$254,410
Ramsdell Place	572	$74,360
Reed Street	3,870	$580,500
Richard Road	1,253	$162,890
Rollercoaster Road	1,538	$199,940
Sandy Lane	1,163	$151,190
Sandy Terrace*	348	$45,240
Spring Street	2,989	$448,350
Station Street	910	$118,300
Whitman Street	6,264	$939,600
Winslow Drive	1,605	$208,650
Winter Street	9,755	$1,463,250

*Street which contains a bleeder valve

6.2.4.2 Mains (≤2-inches) Replacement

TABLE 6.6
MAINS (≤2-INCHES) REPLACEMENT

Street	Length, ft	Estimated Cost
Birch Street	360	$46,800
Elm Place	540	$70,200
Ferris Street	360	$46,800
Hanson Court	300	$39,000
Ocean Avenue	565	$73,450
Pearl Street	780	$101,400
Robinson Street	588	$76,440
School Street	360	$46,800
Cranberry Cove	660	$85,800

6.3 TOTAL CAPITAL COST SUMMARY

In summary, the costs associated with each phase of the recommended improvements are as follows:

TABLE 6.7
ESTIMATED CAPITAL COST SUMMARY

	CAPITAL COST
Phase I Improvements	$3,144,000*
Phase II Improvements	$2,396,500
Phase III Improvements	$2,964,500
Sub-Total Cost	**$8,505,000**
Additional Improvements	$10,723,860
Total Cost	**$19,228,860**

*Includes $750,000 for supplemental water storage tank

FIGURES

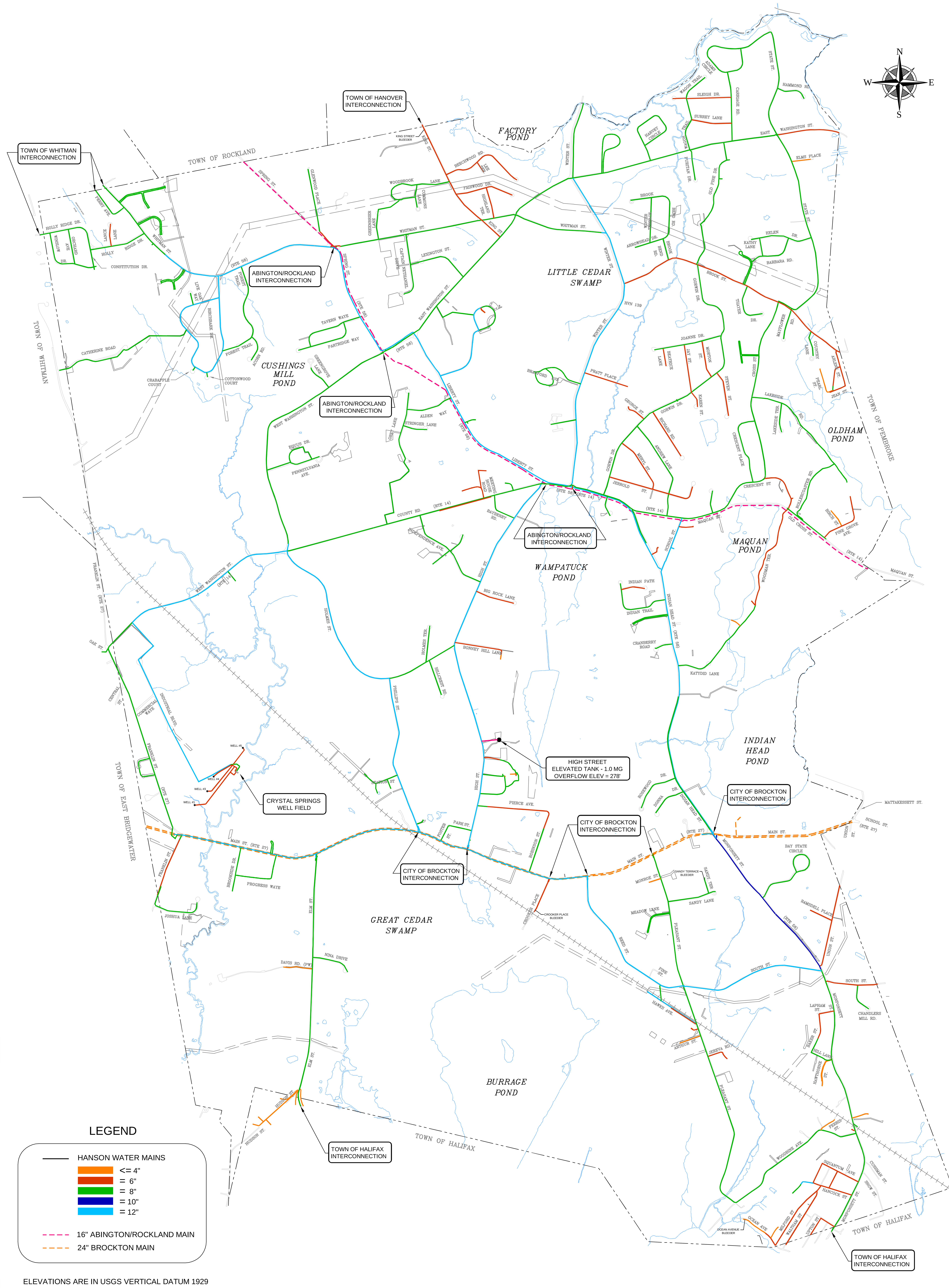

FIGURE 2-1
EXISTING WATER SYSTEM MAP

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WATER SYSTEM MASTER PLAN
HANSON, MASSACHUSETTS
MARCH 2009

TOWN OF HANSON INCORPORATED 1820. MASSACHUSETTS

I:\Hanson.160\Water System\160-0802 Water System Master Plan\Task 05 - Master Plan Report\Figures-Final\MP FIGURE 2-1.dwg

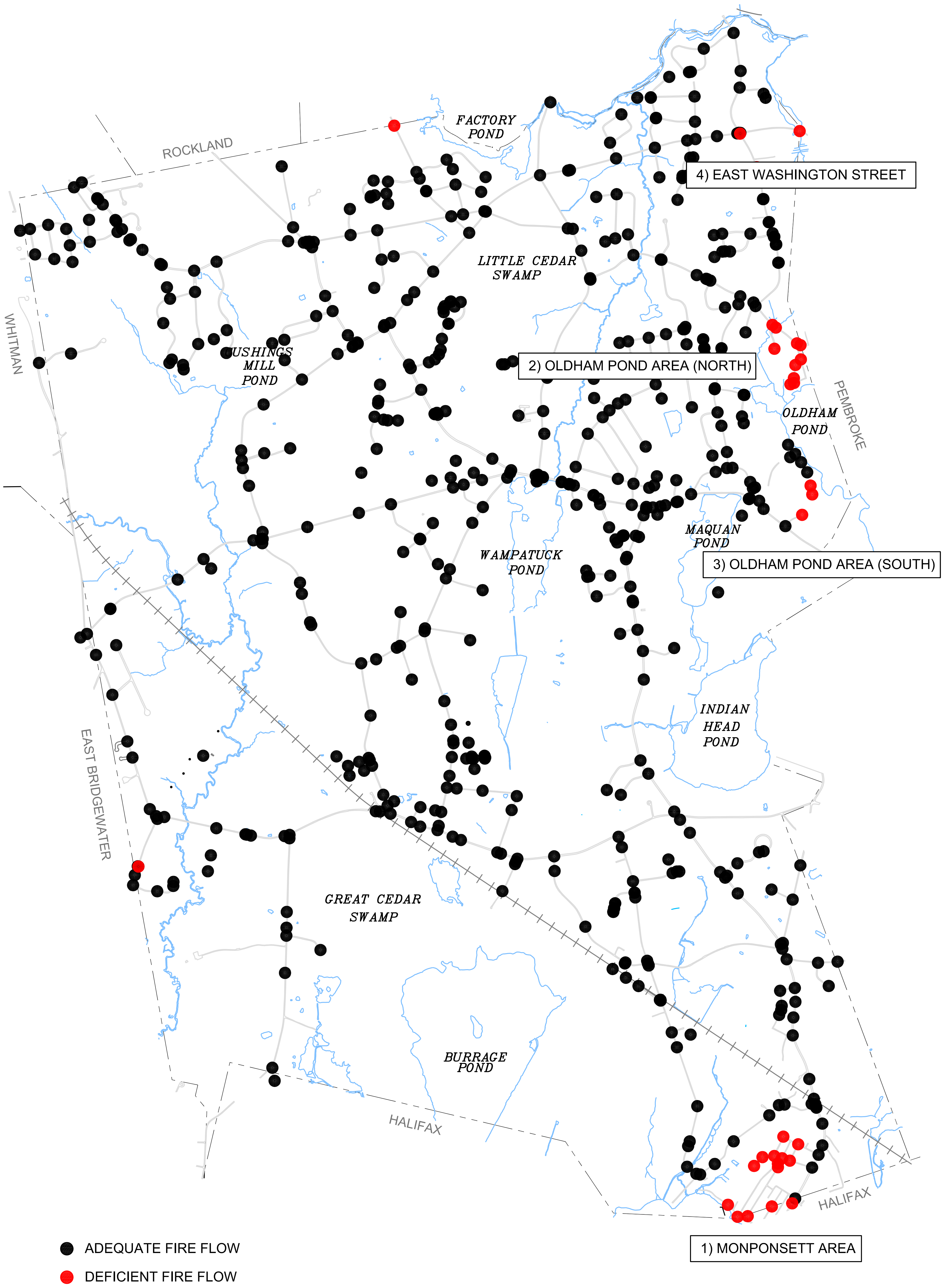

Figure 4-1	Scale	NTS
	Date	March 2009
Water System Fire Flow Deficiencies	Job No.	160-0801
	Drawn by	LMG

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A partnership for engineering solutions.
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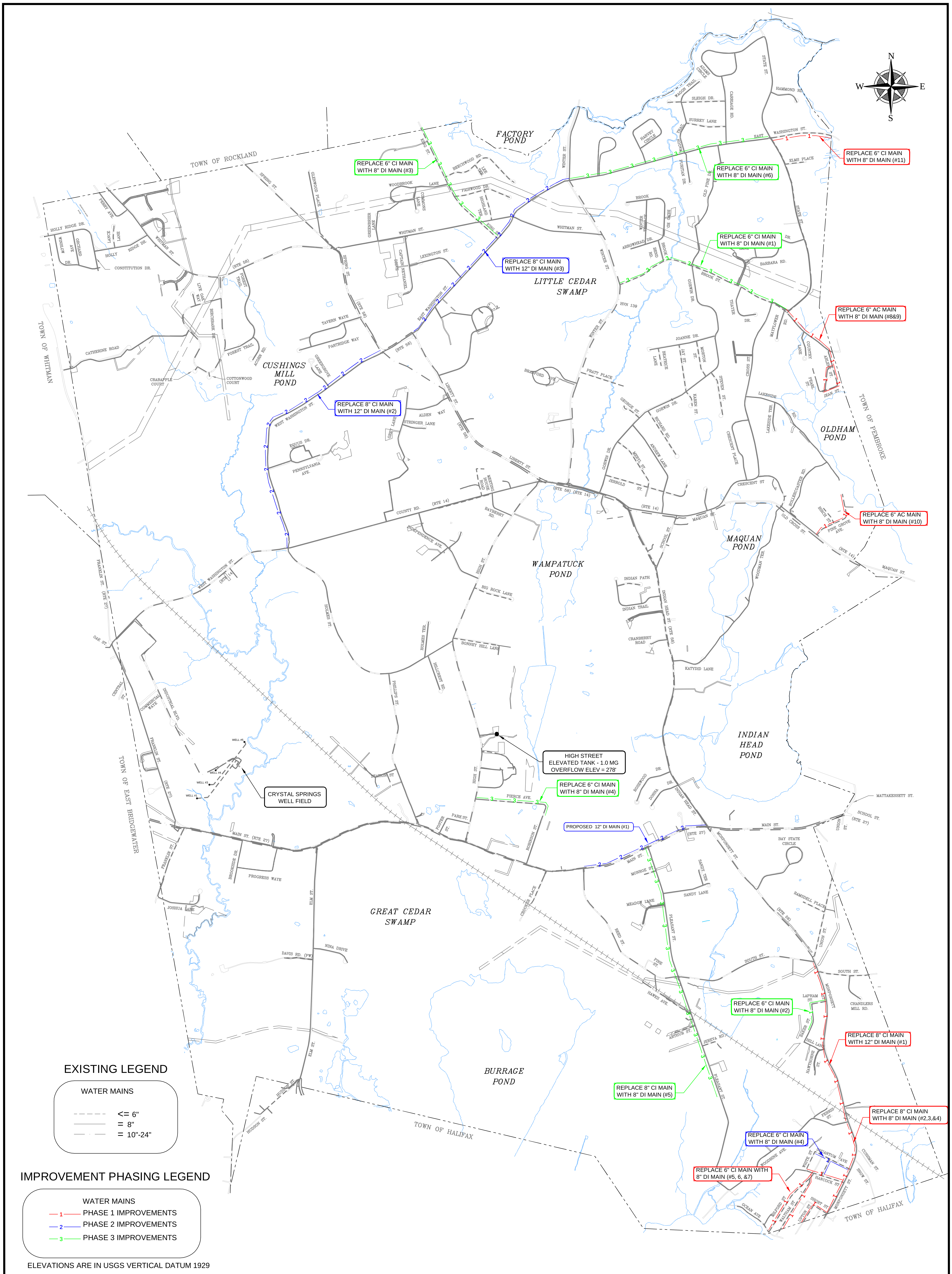

FIGURE 5-1

RECOMMENDED SYSTEM IMPROVEMENTS

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WATER SYSTEM MASTER PLAN
HANSON, MASSACHUSETTS
MARCH 2009

TOWN OF HANSON INCORPORATED 1820. MASSACHUSETTS

I:\Hanson.160\Water System\160-0802 Water System Master Plan\Task 05 - Master Plan Report\Figures-Final\MP FIGURE 5-1.dwg

APPENDIX A - FIRE FLOW TEST DATA

FIRE FLOW TEST

JOB NAME: WATER MODEL
LOCATION: Hanson, MA
JOB NO: 160-0801

EPG PERSONNEL: LMG, Claire

OWNER: Neal, Steve, Jerry

DATE	TIME	TEST HYDRANT		FLOWING HYDRANT 2				TOTAL FLOW	
		U (psi)	RESIDUAL (psi)	PITOT (psi)	DIAMETER (in)	THEOR FLOW (gpm)	HYD COEF	ACTUAL FLOW (gpm)	AT 20 psi (gpm)
12-Aug-08	9:48 PM	80	70	50	2.5	1,318	0.9	1,186	3,122

Franklin Street and Commercial Way

SKETCH OF FLOW TEST LOCATION:

FIRE FLOW TEST

JOB NAME: WATER MODEL
LOCATION: Hanson, MA
JOB NO: 160-0801

EPG PERSONNEL: LMG, Claire

OWNER: Neal, Steve, Jerry

		TEST HYDRANT		FLOWING HYDRANT 2				TOTAL FLOW	
DATE	TIME	U (psi)	RESIDUAL (psi)	PITOT (psi)	DIAMETER (in)	THEOR FLOW (gpm)	HYD COEF	ACTUAL FLOW (gpm)	AT 20 psi (gpm)
13-Aug-08	9:45 PM	93	71	52	2.5	1,344	0.9	1,210	2,312

Carriage Rd @ Sleigh Rd

SKETCH OF FLOW TEST LOCATION:

FIRE FLOW TEST

JOB NAME: WATER MODEL
LOCATION: Hanson, MA
JOB NO: 160-0801

EPG PERSONNEL: LMG, Claire

OWNER: Neal, Steve, Jerry

		TEST HYDRANT		FLOWING HYDRANT 2				TOTAL FLOW	
DATE	TIME	U (psi)	RESIDUAL (psi)	PITOT (psi)	DIAMETER (in)	THEOR FLOW (gpm)	HYD COEF	ACTUAL FLOW (gpm)	AT 20 psi (gpm)
12-Aug-08	11:25 PM	65	61	30	2.5	1,021	0.9	919	3,396

School Street @ Maguan School

SKETCH OF FLOW TEST LOCATION:

FIRE FLOW TEST

JOB NAME: WATER MODEL
LOCATION: Hanson, MA
JOB NO: 160-0801

EPG PERSONNEL: LMG
Claire

OWNER: Neal
Steve
Jerry

DATE	TIME	TEST HYDRANT		FLOWING HYDRANT 2				TOTAL FLOW	
		U (psi)	RESIDUAL (psi)	PITOT (psi)	DIAMETER (in)	THEOR FLOW (gpm)	HYD COEF	ACTUAL FLOW (gpm)	AT 20 psi (gpm)
12-Aug-08	11:15 PM	95	22	3	2.5	323	0.9	291	295

Milford Street @ Ocean Avenue

SKETCH OF FLOW TEST LOCATION:

FIRE FLOW TEST

JOB NAME:	WATER MODEL	EPG PERSONNEL:	LMG	OWNER:	Neal
LOCATION:	Hanson, MA		Claire		Steve
JOB NO:	160-0801				Jerry

		TEST HYDRANT		FLOWING HYDRANT 2				TOTAL FLOW	
DATE	TIME	U (psi)	RESIDUAL (psi)	PITOT (psi)	DIAMETER (in)	THEOR FLOW (gpm)	HYD COEF	ACTUAL FLOW (gpm)	AT 20 psi (gpm)
12-Aug-08	10:35 PM	76	62	44	2.5	1,237	0.9	1,113	2,353

Main Street @ Indian Head Street

SKETCH OF FLOW TEST LOCATION:

FIRE FLOW TEST

JOB NAME: WATER MODEL
LOCATION: Hanson, MA
JOB NO: 160-0801

EPG PERSONNEL: LMG, Claire

OWNER: Neal, Steve, Jerry

		TEST HYDRANT		FLOWING HYDRANT 2				TOTAL FLOW	
DATE	TIME	U (psi)	RESIDUAL (psi)	PITOT (psi)	DIAMETER (in)	THEOR FLOW (gpm)	HYD COEF	ACTUAL FLOW (gpm)	AT 20 psi (gpm)
12-Aug-08	10:20 PM	89	86	60	2.5	1,444	0.9	1,300	7,066

Main Street @ Phillips Road

SKETCH OF FLOW TEST LOCATION:

FIRE FLOW TEST

JOB NAME: WATER MODEL

LOCATION: Hanson, MA

JOB NO: 160-0801

EPG PERSONNEL: LMG, Claire

OWNER: Neal, Steve, Jerry

DATE	TIME	TEST HYDRANT		FLOWING HYDRANT 2				TOTAL FLOW	
		U (psi)	RESIDUAL (psi)	PITOT (psi)	DIAMETER (in)	THEOR FLOW (gpm)	HYD COEF	ACTUAL FLOW (gpm)	AT 20 psi (gpm)
13-Aug-08	9:20 PM	64	42	28	2.5	987	0.9	888	1,291

Holly Ridge @ Lance Lane

SKETCH OF FLOW TEST LOCATION:

FIRE FLOW TEST

JOB NAME: WATER MODEL
LOCATION: Hanson, MA
JOB NO: 160-0801

EPG PERSONNEL: LMG, Claire

OWNER: Neal, Steve, Jerry

		TEST HYDRANT		FLOWING HYDRANT 2				TOTAL FLOW	
DATE	TIME	U (psi)	RESIDUAL (psi)	PITOT (psi)	DIAMETER (in)	THEOR FLOW (gpm)	HYD COEF	ACTUAL FLOW (gpm)	AT 20 psi (gpm)
13-Aug-08	10:25 PM	87	10	7	2.5	493	0.9	444	412

Jean St @ Arlene St

SKETCH OF FLOW TEST LOCATION:

FIRE FLOW TEST

JOB NAME: WATER MODEL | EPG PERSONNEL: LMG | OWNER: Neal
LOCATION: Hanson, MA | Claire | Steve
JOB NO: 160-0801 | | Jerry

DATE	TIME	TEST HYDRANT		FLOWING HYDRANT 2				TOTAL FLOW	
		U (psi)	RESIDUAL (psi)	PITOT (psi)	DIAMETER (in)	THEOR FLOW (gpm)	HYD COEF	ACTUAL FLOW (gpm)	AT 20 psi (gpm)
13-Aug-08	9:35 PM	71	64	38	2.5	1,149	0.9	1,034	3,023

East Washington Street @ Liberty Street

SKETCH OF FLOW TEST LOCATION:

FIRE FLOW TEST

JOB NAME: WATER MODEL
LOCATION: Hanson, MA
JOB NO: 160-0801

EPG PERSONNEL: LMG, Claire

OWNER: Neal, Steve, Jerry

DATE	TIME	TEST HYDRANT U (psi)	TEST HYDRANT RESIDUAL (psi)	FLOWING HYDRANT 2 PITOT (psi)	FLOWING HYDRANT 2 DIAMETER (in)	FLOWING HYDRANT 2 THEOR FLOW (gpm)	FLOWING HYDRANT 2 HYD COEF	TOTAL FLOW ACTUAL FLOW (gpm)	TOTAL FLOW AT 20 psi (gpm)
13-Aug-08	10:00 PM	94	56	42.5	2.5	1,215	0.9	1,094	1,568

Arrowhead Dr. @ Winter Terrace

SKETCH OF FLOW TEST LOCATION:

FIRE FLOW TEST

JOB NAME: WATER MODEL
LOCATION: Hanson, MA
JOB NO: 160-0801

EPG PERSONNEL: LMG
Claire

OWNER: Neal
Steve
Jerry

		TEST HYDRANT		FLOWING HYDRANT 2				TOTAL FLOW	
DATE	TIME	U (psi)	RESIDUAL (psi)	PITOT (psi)	DIAMETER (in)	THEOR FLOW (gpm)	HYD COEF	ACTUAL FLOW (gpm)	AT 20 psi (gpm)
13-Aug-08	10:40 PM	77	31	56	2.5	1,395	0.9	1,256	1,410

County Road @ Independence Avenue

SKETCH OF FLOW TEST LOCATION:

FIRE FLOW TEST

JOB NAME: WATER MODEL
LOCATION: Hanson, MA
JOB NO: 160-0801

EPG PERSONNEL: LMG
Claire

OWNER: Neal
Steve
Jerry

DATE	TIME	TEST HYDRANT U (psi)	TEST HYDRANT RESIDUAL (psi)	FLOWING HYDRANT 2 PITOT (psi)	FLOWING HYDRANT 2 DIAMETER (in)	FLOWING HYDRANT 2 THEOR FLOW (gpm)	FLOWING HYDRANT 2 HYD COEF	TOTAL FLOW ACTUAL FLOW (gpm)	TOTAL FLOW AT 20 psi (gpm)
12-Aug-08	10:49 PM	78	50	37.5	2.5	1,142	0.9	1,028	1,523

Monponsett Street @ South Street

SKETCH OF FLOW TEST LOCATION:

FIRE FLOW TEST

JOB NAME: WATER MODEL — EPG PERSONNEL: LMG — OWNER: Neal
LOCATION: Hanson, MA — Claire — Steve
JOB NO: 160-0801 — Jerry

		TEST HYDRANT		FLOWING HYDRANT 2				TOTAL FLOW	
DATE	TIME	U (psi)	RESIDUAL (psi)	PITOT (psi)	DIAMETER (in)	THEOR FLOW (gpm)	HYD COEF	ACTUAL FLOW (gpm)	AT 20 psi (gpm)
12-Aug-08	10:06 PM	80	59	40	2.5	1,179	0.9	1,061	1,871

Elm Street @ Davis Road

SKETCH OF FLOW TEST LOCATION:

APPENDIX B – “C” VALUE TEST DATA

C-FLOW TEST

JOB NAME: Water Model
LOCATION: Hanson, MA
JOB NO: 160-0801

EPG PERSONNEL: LMG
Claire

OWNER: Neal
Steve
Jerry

DATE	TIME	WATER MAIN		OBSERVATION HYDRANT #1		OBSERVATION HYDRANT #2		FLOW HYDRANT				WATER MAIN	
		DIA. (in)	LENGTH (ft)	STATIC (psi)	RESIDUAL (psi)	STATIC (psi)	RESIDUAL (psi)	DIA. (in)	PITOT (psi)	HYD COEF	FLOW (gpm)	HEADLOSS (ft)	C-FACTOR
12-Aug-08	11:15 PM	6	465	86	35	95	22	2.5	3	0.9	291	50.82	30.58

6" CI Milford Road 1931

SKETCH OF FLOW TEST LOCATION:

C-FLOW TEST

JOB NAME: Water Model
LOCATION: Hanson, MA
JOB NO: 160-0801

EPG PERSONNEL: LMG
Claire

OWNER: Neal
Steve
Jerry

		WATER MAIN		OBSERVATION HYDRANT #1		OBSERVATION HYDRANT #2		FLOW HYDRANT				WATER MAIN	
DATE	TIME	DIA. (in)	LENGTH (ft)	STATIC (psi)	RESIDUAL (psi)	STATIC (psi)	RESIDUAL (psi)	DIA. (in)	PITOT (psi)	HYD COEF	FLOW (gpm)	HEADLOSS (ft)	C-FACTOR
12-Aug-08	11:52 PM	6	1,139	75	55	80	38	2.5	24	0.9	822	50.82	140.21

6" AC Jerrold Road 1969

SKETCH OF FLOW TEST LOCATION:

C-FLOW TEST

JOB NAME: Water Model
LOCATION: Hanson, MA
JOB NO: 160-0801

EPG PERSONNEL: LMG
Claire

OWNER: Neal
Steve
Jerry

		WATER MAIN		OBSERVATION HYDRANT #1		OBSERVATION HYDRANT #2		FLOW HYDRANT				WATER MAIN	
DATE	TIME	DIA. (in)	LENGTH (ft)	STATIC (psi)	RESIDUAL (psi)	STATIC (psi)	RESIDUAL (psi)	DIA. (in)	PITOT (psi)	HYD COEF	FLOW (gpm)	HEADLOSS (ft)	C-FACTOR
13-Aug-08	12:15 AM	8	941	73	44	79	44	2.5	32	0.9	949	13.86	138.29

8" AC Gorwin Drive 1973

SKETCH OF FLOW TEST LOCATION:

C-FLOW TEST

JOB NAME: Water Model
LOCATION: Hanson, MA
JOB NO: 160-0801

EPG PERSONNEL: LMG
Claire

OWNER: Neal
Steve
Jerry

		WATER MAIN		OBSERVATION HYDRANT #1		OBSERVATION HYDRANT #2		FLOW HYDRANT				WATER MAIN	
DATE	TIME	DIA. (in)	LENGTH (ft)	STATIC (psi)	RESIDUAL (psi)	STATIC (psi)	RESIDUAL (psi)	DIA. (in)	PITOT (psi)	HYD COEF	FLOW (gpm)	HEADLOSS (ft)	C-FACTOR
13-Aug-08	10:10 PM	8	468	96	53	94	47	2.5	35	0.9	993	9.24	123.51

8" PVC Winter Terrace 1986

SKETCH OF FLOW TEST LOCATION:

C-FLOW TEST

JOB NAME: Water Model
LOCATION: Hanson, MA
JOB NO: 160-0801

EPG PERSONNEL: LMG
Claire

OWNER: Neal
Steve
Jerry

		WATER MAIN		OBSERVATION HYDRANT #1		OBSERVATION HYDRANT #2		FLOW HYDRANT				WATER MAIN	
DATE	TIME	DIA. (in)	LENGTH (ft)	STATIC (psi)	RESIDUAL (psi)	STATIC (psi)	RESIDUAL (psi)	DIA. (in)	PITOT (psi)	HYD COEF	FLOW (gpm)	HEADLOSS (ft)	C-FACTOR
13-Aug-08	10:52 AM	12	935	51	50	52	50	2.5	41	0.9	1074	2.31	141.49

12" AC High Street 1973

SKETCH OF FLOW TEST LOCATION:

APPENDIX C – HYDRAULIC MODEL CALIBRATION TABLE

HYDRAULIC MODEL CALIBRATION TABLE

	Flow (gpm)			Pressure (psi)			
	Actual	Model		Actual	Model		Location
FF 1	3,122	3,122	0%	80	79	1%	Commercial Waye @ Franklin St
FF 2	2,312	2,241	3%	93	92	1%	Carriage Rd @ Sleigh Rd
FF 3	3,396	3,714	-9%	65	65	0%	School Street @ Maquan School
FF 4	295	280	5%	95	94	1%	Milford St @Ocean Ave
FF 5	2,353	2,063	12%	76	79	-4%	Main Street @ Indian Head St
FF 8	7,066	7,475	-6%	89	89	0%	Main St @ Phillips
FF 9	1,291	1,364	-6%	64	67	-5%	Holly Ridge @ Lance Lane
FF 10	412	440	-7%	87	90	-3%	Jean St @ Arlene St
FF 11	3,023	3,262	-8%	71	72	-1%	East Washington Street @ Liberty Street
FF 12	1,568	1,607	-3%	94	93	1%	Arrowhead Dr. @ Winter Terrace
FF 13	1,410	2,238	-59%	77	76	1%	County Road @ Independence
FF 14	1,523	1,340	12%	78	80	-3%	Montponsett St @ South Street
FF 15	1,871	1,600	14%	80	81	-1%	Elm Street @ Davis Road

J-1645	
J-158	
J1323	
J-73	
J-606	1 valve closed @ Reed/Main
J-1379	
J-31	
J-525	
J-430	
J-596	
J-756	1 valves closed @ Independence Ave
J-191	1 valve closed @ Reed/Main
J-710	

APPENDIX D – DIGITAL HYDRAULIC MODEL AND FILES

TOWN OF HANSON
INCORPORATED
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