Final Report

Town of

Hudson, NH

FINAL REPORT

Water Distribution System Study

January 2002

THE STATE OF NEW HAMPSHIRE
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Hudson, New Hampshire
WSE Job No. 200368

January 17, 2002

Mr. Paul Sharon
Town Administrator
Town of Hudson
12 School Street
Hudson, NH 03051

Re: Town of Hudson Water Distribution System Study

Dear Mr. Sharon:

We are pleased to submit to the Town of Hudson the attached Water Distribution System Study. This document presents the results of our comprehensive study of the Town's distribution system. A plan of improvements was prepared to ensure that the quality and quantity of water will meet future needs of the Town of Hudson.

We wish to acknowledge the assistance of Steve Malizia, Finance Director, Sean Sullivan, Director of Community Development, Mr. Michael Gospodarek, P.E., former Town Engineer, and the staff of Pennichuck Water Works who assisted the project team in gathering background information for the project. Their cooperation was essential to the completion of the report and is sincerely appreciated.

John J. Boisvert, P.E. was the project manager in charge of the project. Leah E. Hines, P.E. was the project engineer assisted by Jeffrey C. Provost.

Thank you for this opportunity to be of assistance.

Very truly yours,

WESTON & SAMPSON, ENGINEERS, INC.

Bruce W. Adams, P.E.
Vice President

cc: Bob Mann, NHDES

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LIST OF ABBREVIATIONS

AWWA	American Water Works Association
CI	Cast Iron
CICL	Cast Iron Cement-Lined
CMR	Code of Massachusetts Regulations
CL	Cement-lined with unknown pipe material
DEP	Department of Environmental Protection
DICL	Ductile Iron Cement-Lined
ENR	Engineering News Record
ft	Feet
GIS	Geographical Information System
gpd	Gallons per day
gpm	Gallons per minute
HGL	Hydraulic Grade Line
HP	Horsepower
I.D.	Identification
in.	Inches
ISO	Insurance Services Office
IWDS	Improvements to the Water Distribution System
MAPC	Metropolitan Area Planning Council
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MG	Million gallons
MGD	Million gallons per day
mgcd	Million gallons per capita per day
MGL	Massachusetts General Law
mg/l	Milligrams per liter
MWRA	Massachusetts Water Resources Authority
NBFU	National Board of Fire Underwriters
psi	Pounds per square inch

TDH	Total Dynamic Head
USGS	United States Geological Survey
WSE	Weston & Sampson Engineers, Inc.
WSS	Weston & Sampson Services, Inc.

CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations of this study are discussed in detail in this report and are summarized below as follows:

- In general, Hudson's water distribution system is able to supply average day and peak hour demands. However, the ISO identified 11 areas in 1992 that are unable to meet fire flow requirements. These are at the intersections of Wall Street and Central Street, Sagamore Park Road and Flagstone Drive, Webster Street and Garrison Farm Road, Library Street and School Street, Lowell Road and Riverside Avenue, Central Street and Memorial Drive, Melandy Road and Roosevelt Avenue, Pelham Road and Burns Hill Road, Lowell Road and Executive Drive, Lowell Road and Rena Street, and River Road and Pine Road. It is important for the fire safety and the insurance rating of Hudson that the fire flow capacities meet or exceed the recommended minimum as established by the ISO. The improvements recommended in this phased capital program alleviate the majority of these deficiencies.
- The distribution system is in good condition and relatively new. The majority of pipe is said to be cement lined. Original pipe in the downtown area installed before 1930 is suspected to be unlined cast iron and in need of replacement. Since the exact location of these older pipes is not known, we suggest that the Town instruct Pennichuck Water Works to document all internal pipe conditions in the downtown area during water main breaks or when new pipe or a hydrant or valve is installed over the next several years. This documentation will provide a clearer understanding of where unlined pipe exists and can be used to prioritize water main improvements in the future.
- The Town currently has adequate water supply, with the three Litchfield wells and the Taylor Falls Pump Station connection, to serve future (2020) maximum day demands. However, the Town does not have adequate capacity with the largest source out of service. Therefore we recommend that the Town continue to look for potential well sites in Hudson.

- The three municipal high service booster pump stations require many improvements. With the improvements to the Marsh Road pump station in 2001, the pumps are capable of meeting current maximum day demands. However, the pumps are not adequately sized for the future demands of the service areas. As the high service systems continue to grow and new users are added, the pump stations will become unable to meet demands and pressures will become unstable.
- The distribution system currently contains several transmission main deficiencies. We have recommended construction of larger diameter transmission mains in River Road, Lowell Road and Ferry Street. The water main installations in River Road and Lowell Road will alleviate flow and pressure deficiencies in the South Hudson area.
- A new water storage tank proposed to be located in South Hudson will improve fire flows and improve water supply redundancy to residents in case of a water main break in Lowell Road.
- A new 1.2 MG water storage tank proposed to be located on Barrett Hill in the newly combined Marsh Road and Windham Road High Service Area will serve to stabilize pressures in both high service areas. A new 12-inch water main proposed in Hazelwood Drive will connect the Marsh Road and Windham Road service systems. The proposed Windham Road pump station improvements will allow it to fill the new water storage tank.
- The Town currently contains significant areas of undeveloped land at high elevation that cannot be adequately served by the Main Service System. The Town has historically allowed developers to install booster pump stations for domestic water service and fire flows to serve these areas. Booster pump stations are not a desirable means of serving an area of high elevation. Generally we recommend installing water storage tanks in lieu of fire pumps in stations. With a water storage tank, fire flows are greater, pressures are more stable, and emergency supply is in place. In addition, the Town can save operation and maintenance costs with storage tanks versus pump stations. We recommend that the Town implement a protocol to include water storage for expansion of the water system for such customers/developments.

- WSE recommends a 20-year improvement program to provide the quantity and quality of water that will meet current and future demands. Implementing these improvements will require a phased construction program.
- The estimated cost of the recommended improvements is $6,785,155 over the 20-year phased capital improvement program.
- Phase A improvements specify improvements to be completed as early in the 20-year program as financially possible. These improvements are designed to eliminate or significantly reduce existing deficiencies including deficient fire flows, transmission main deficiencies, and high service system deficiencies.
- The Town of Hudson purchased the water distribution system from Consumers New Hampshire Water Company in 1997 for $27,000,000. WSE performed a study for the Town to identify the actual costs associated with providing new service to a customer within the existing water system. This was done to develop a one-time fee structure for new customers. The fee is $1,967.00 for a single family dwelling. We recommend that the Town work to generate the legal documentation needed to implement these fees. These fees are necessary to prevent existing customers from paying for additional capital water system expenses through increased rates that are required to serve future customers connecting to the water system. We recommend that the Town set up a separate account for these access fees that is to be used to fund capital improvement projects to the water system.

PURPOSE AND SCOPE OF THE REPORT

The Town of Hudson (Town) engaged Weston & Sampson Engineers, Inc. (Weston & Sampson) to develop a Water System Master Plan that uncovers distribution system weaknesses and recommends improvements to ensure that the Town can: 1) provide high quality water at adequate pressure to all homes and businesses without interruption and at a reasonable cost and; 2) provide sufficient fire flows to all areas within the distribution system.

In addition to conducting a comprehensive water distribution system analysis, Weston & Sampson developed a hydraulic model calibrated to actual field conditions to evaluate the existing distribution system weaknesses and develop improvement alternatives.

This water system master plan identifies the means of providing an adequate quantity and quality of water to meet the Town's present and future (2020) needs. The scope of work performed by Weston & Sampson includes:

1. Description of existing supplies and distribution facilities.
2. Estimate of water supply requirements through the year 2020.
3. Summary of regulatory requirements.
4. Analysis of the water storage requirements.
5. Description and results of fire flow and C-value field testing.
6. Hydraulic modeling of Hudson's water distribution system.
7. Evaluation of existing and future system deficiencies.
8. Recommendation of system improvements with cost estimates for the planning period.
9. Recommended 20 year phased improvement plan.
10. Develop a mission statement for the Hudson Water Utility.

1.0 EXISTING WATER SYSTEM

1.1 General

The Town of Hudson is a suburban community located in the southern New Hampshire's Nashua Region. The Town's Year 2000 population of 22,928 makes up approximately 11 percent of the Nashua Region population.

The existing water supply and distribution system was previously owned by Consumers New Hampshire Water Company (CNHWC). During the 1996 Annual Town Meeting, the Town of Hudson approved a measure to acquire the water system within its borders and operate that system as a municipal utility. In 1997, the Town of Hudson petitioned the New Hampshire Public Utilities Commission to order the sale of all physical assets of the CNHWC within the Town along with some additional distribution capabilities. The Town bonded the purchase of the water supply and distribution system in 1997 for $27,000,000 to be paid over 30 years.

While the Town of Hudson now owns three water supply wells located in the neighboring Town of Litchfield and the water distribution system within the town border of Hudson; operation and maintenance of the system is contracted to Pennichuck Water Works, Inc. (PWW) located in Nashua, New Hampshire. PWW is also responsible for maintaining the neighboring Towns of Litchfield, Nashua and Pelham water distribution systems.

Major components of Hudson's distribution system include; approximately 93 miles of cast iron and ductile iron pipe ranging from ¾-inch to 16-inches in diameter; three municipal high service booster pumping stations; two standpipe storage tanks that provide a total of 3.0 million gallons of storage; approximately 500 municipal hydrants; 180 fire services; and approximately 4,900 residential and commercial water services.

1.2 Water Supply Facilities

The Town of Hudson is supplied with water that is pumped to the distribution system from the Litchfield Wells. The three wells (Dame, Ducharme, and Weinstein) have a combined apparent safe yield between 2.0 and 2.2 million gallons per day (MGD) and serve water to the Towns of Hudson, Litchfield, and Pelham. Water enters the Hudson distribution system through an un-metered 16-inch water main off Adam Drive. Table 1-1 summarizes the water supply wells located in the Town of Litchfield owned by Hudson and operated by PWW.

TABLE 1-1

LITCHFIELD WELLFIELD WATER SUPPLIES

Source	Date Installed	Pumping Capacity (gpm)	Apparent Safe Yield* (MGD)
Dame Well	1985	750	1.2 to 1.3
Ducharme Well	1983	500	
Weinstein Well	N/A	750	0.85 to 0.93
TOTAL		2,000	2.05 to 2.23

*Safe Yield based on preliminary estimates from 2001 Safe Yield Study by WSE

Approximately 0.2 MGD of production from the wells is utilized by Town of Litchfield residents. Approximately 0.1 MGD is utilized by Town of Pelham residents through Hudson's distribution system and an un-metered 12-inch connection at Sullivan Road. PWW supplements the Town of Hudson's water supply with water from the Nashua River during periods of high demand through a metered 12-inch connection at the Taylor Falls Bridge Pump Station located at Ferry Street.

1.3 Booster Pumping Facilities

High pressure water is provided to three separate areas in the Town with high topographic land elevation through three municipal water booster pump stations. There are several privately owned and operated high service systems and booster pump stations that were not included in this evaluation. Table 1-2 summarizes the publicly owned high service booster pump stations in Town.

TABLE 1-2

HUDSON HIGH SERVICE BOOSTER PUMPING FACILITIES

Station	Year Constructed	Average HGL (ft)	Capacity* (gpm)
Marsh Road Booster Pump Station	1986	510	400
Windham Road Booster Pump Station		520	750
Compass Point Booster Pump Station	1996	440	375

*domestic flow capacity without fire pumps

1.3.1 Marsh Road Booster Pump Station

The Marsh Road Booster Pump Station is a pre-fabricated underground steel pump station manufactured by the Dakota Pump Company and constructed in 1986. The station draws water from, and is located immediately adjacent to the 2.0 MG Marsh Road water storage tank. The level of the Marsh Road Tank is maintained by the Main Service portion of the distribution system, which is fed from the water supply wells located in Litchfield. The Marsh Road Booster Pump Station increases the distribution system pressure to provide water service to the Rolling Green Condominiums, Old Derry Road, Greeley Street, and Springwood Circle which are included in the Marsh Road High Service System. Based on discussions with PWW personnel, the extent of the service area for the booster station has increased significantly from the initial design in 1986. It has also been noted that during the last several years the fire pump has been required on several occasions under peak hour demand conditions to maintain system pressure in the high service area. Before the improvements made to the pump station in 2001, the pump station contained a domestic pumping capacity of approximately 250 gallons per minute (gpm). The station was able to meet the maximum day domestic water demand of approximately 250 gpm, however, peak hourly flows out of the station were reported to have reached 350 gpm according to a May 19, 1999 memorandum from Mr. Don Ware, Chief Engineer of PWW. The peaks in domestic demand were triggering the operation of the fire pump to make up the difference between the peak system demand and the domestic pump capacity. The installation of a larger pump in the existing station in the summer of 2001 has greatly improved the pumping capacity to the Marsh Road High Service System and has alleviated any immediate flow deficiencies. The Marsh Road Booster Pump Station currently has the pumping capacity as described in Table 1-3.

TABLE 1-3

MARSH ROAD BOOSTER PUMP STATION PUMP DESCRIPTION

Pump #	Type	Speed (rpm)	Size (HP)	Year Installed	Design Flow (gpm)
1	Cornell	3500	30	2001	200
2	Berkeley	3450	30	1986	200
3	Peerless	1775	75	1986	1000

All of the pump motors are three phase 460-volt units. Pumps #1 and #2 operate to maintain system pressure and meet average and maximum system flows. Pump #3 operates to provide the system's fire flow. The station does not have emergency power, however, a mobile pump has been utilized to provide the pressure increase required to provide adequate system pressure during extended power or pump failure.

1.3.2 Windham Road Booster Pump Station

The Windham Road Booster Pump Station was constructed to replace the former Windham Road Pump Station. The station is an above grade pre-cast concrete type station with four pumps controlled by a pressure switch type control panel. The equipment is in good condition and is well maintained. There is a back-up gas fired engine used to power the fire pump on loss of commercial power. The station does not contain a surge relief valve on the discharge of the fire pump which can result in the creation of large pressure surges in the system when activated. These pressure surges can cause distribution system failures and the potential for a significant pipeline break. All electric motor driven pumps are three-phase 460-volt units. Table 1-4 summarizes the pumps in the station:

TABLE 1-4

WINDHAM ROAD BOOSTER PUMP STATION PUMP DESCRIPTION

Pump #	Speed (rpm)	Size (HP)	Year Installed	Design Flow (gpm)
1	VFD	25		250
2	Full Speed (FS) starter	25		250
3	FS starter	25		250
4	FS starter	100		1000

Pumps #1, #2, and #3 operate to maintain system pressure and serve domestic demands. Pump #4 operates to provide fire flows to the Windham Road High Service System.

1.3.3 Compass Point Booster Pump Station

The Compass Point Booster Pump Station is located in a pre-cast concrete above grade building constructed by a developer in 1996. The station has four pumps controlled by a Bristol Babcock PLC based SCADA panel. The building and equipment are in good condition and are well maintained. Table 1-5 summarizes the existing pumps in the station:

TABLE 1-5

COMPASS POINT BOOSTER PUMP STATION PUMP DESCRIPTION

Pump #	Type	Speed (rpm)	Size (HP)	Year Installed	Design Flow (gpm)
1	Berkeley	1600	7.5	1996	125
2	Berkeley	1600	7.5	19967	125
3	Berkeley	1600	7.5	1996	125
4	Berkeley			1996	750

Pumps #1, #2, and #3 are electric driven with single-phase 230-volt motors. Pump #4 is engine driven used to provide fire flows and designed for emergency applications only. In a June 23, 1999 memorandum to the Town, Mr. Ware indicated that peak domestic demands reached 350 gpm to 450 gpm. These peak demands have exceeded the station's domestic pump capacity provided by the three 7.5 hp pumps. The capacity shortfall causes the fire pump to be activated to meet domestic demands. This operational scenario is not an acceptable condition as the fire pump is not designed to meet average domestic demands and has resulted in the creation of large pressure surges in the system when activated. These pressure surges can cause distribution system failures and the potential for a significant pipeline break.

1.4 Storage Facilities

The Town's water distribution system includes two storage tanks that provide approximately 3 MG of water storage capacity in the Main Service System. The Marsh Road Tank is located off Marsh Road in the northwest part of Town and the Gordon Street Standpipe is located off Gordon Street at the approximate geographic center of Town. Table 1-6 summarizes the water storage facilities in Town.

TABLE 1-6

WATER STORAGE FACILITIES

Storage Facility	Year Built	Diameter (ft)	Tank Height (ft)	Overflow Elevation (ft)	Capacity (MG)
Marsh Road Tank	1986	100	34	314	2.0
Gordon Road Standpipe	1967	54	56	314	0.95

1.4.1 Marsh Road Tank

The Marsh Road Tank was constructed in 1986 of pre-cast, pre-stressed concrete construction. The tank is approximately 34-feet tall, the elevation of the overflow is 314 feet mean sea level (MSL), and the capacity is approximately 2,000,000 gallons. The Marsh Road Tank was inspected by C/P Utility Services Company, Inc. in July 1994 and was found to have no immediate deficiencies.

1.4.2 Gordon Road Standpipe

The Gordon Road Standpipe was constructed in 1967 of welded steel type construction. The tank has a capacity of approximately 950,000 gallons. The tank is approximately 56-feet tall, the elevation of the overflow is 314 feet mean sea level (MSL). The Gordon Road Standpipe was inspected by Liquid Engineering Corporation in October 2000 and was found to be in satisfactory condition.

1.5 Distribution System

According to the 1996 Preliminary Major Capital Improvements Plan for the Proposed Town of Hudson water distribution system, "...the overall construction of the Hudson system is relatively new, of good quality, generally of cast iron or ductile iron pipe and in reasonably good condition at this time." However, given the age of the downtown area, we estimate that portions of the original water system are still in service and were constructed before 1930. Generally, we observe that most communities were using cast-iron cement lined pipe after 1930. This indicates that portions of Hudson's original water system may be unlined cast-iron pipe older than 70 years.

Water is currently transmitted through approximately 93 miles of water main ranging from ¾- inch to 16-inches in diameter. Pipe materials consist of cast iron, ductile iron, and copper. The distribution system contains approximately 1,600 gate valves, 500 fire hydrants, and 4,900 services. Water is supplied through two storage tanks, three groundwater wells, and three municipal booster pump stations. Table 1-7 shows the footage of each diameter of pipe in Town.

TABLE 1-7

WATER DISTRIBUTION SYSTEM PIPE SIZES

Water Main Size (inch)	Linear Footage of Pipe (ft)[1]	Percent of Distribution System (%)
≤ 2	24,455	5.0
4	8,936	1.8
6	86,698	17.6
8	213,578	43.5
10	1,358	0.3
12	128,566	26.2
16	27,373	5.6
TOTAL	**490,964 (93.0 miles)**	**100**

1. Footage of water main based on the Town's water system GIS as developed by WSE. In 2001

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2.0 WATER SUPPLY REQUIREMENTS

2.1 General

The purpose of this section is to estimate the amount of water that the Town of Hudson will need to meet present and future water system demands. To adequately prepare for future needs, water supply requirements are estimated through the year 2020. In order to reasonably project future water supply requirements, it is necessary to analyze historical water production and consumption records. Projections for future water demands are then calculated based upon the projected population to be served by the distribution system and projected per capita water usage.

2.2 Population

Population data for the Town of Hudson as reported by the U.S. Census Bureau and New Hampshire Office of State Planning (NHOSP) is shown in Table 2-1.

TABLE 2-1

U.S. CENSUS/NHOSP POPULATION DATA

Year	U.S. Census	NHOSP
1960	5,876	
1970	10,638	
1980	14,022	
1990	19,530	
1995		20,766
1996		21,072
1997		21,480
1998		21,723
1999		22,279
2000		22,928

Population projections for the Town have been prepared by the NHOSP; Weston & Sampson has also estimated the Town's future population, which are presented in Table 2-2. Figure 2-1 graphically presents historical population and the projected population.

Figure 2-1
Town of Hudson Population Projection

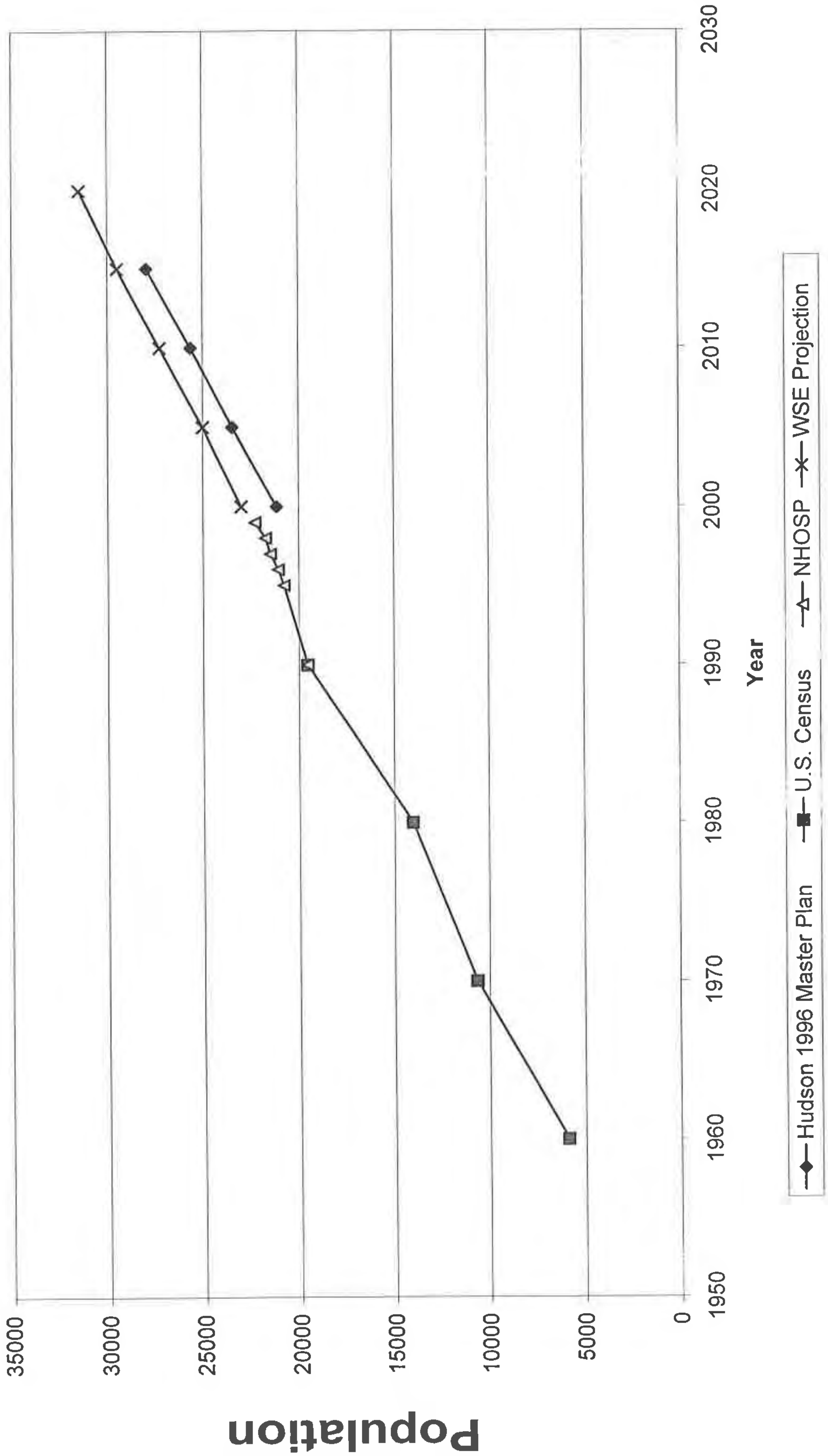

TABLE 2-2

POPULATION PROJECTIONS

Year	NHOSP Projection	WSE Projection
2005	23,465	25,500
2010	25,614	27,250
2015	27,939	29,500
2020	N/A	31,500

Based on a best-fit linear projection of population data dating from 1960 through 2000, Weston & Sampson estimates the population of Hudson will increase by approximately 40 percent over the next 20 years.

2.3 Estimated Population Served by the Town Water System

In Hudson, we estimate that approximately 15% of the residents utilize private well water for their sole source of water. Table 2-3 summarizes the estimated population served by the Town's water distribution system. The 1997 population was estimated using 4,400 residential water system accounts and multiplying the number of accounts by 4.2 persons/residence. All population increases from 1997 to 2000 were calculated utilizing the increase in population every year and the Town's average of 4.2 persons per residence.

TABLE 2-3

POPULATION SERVED BY TOWN'S WATER SYSTEM

Year	Estimated Population on Hudson Water System	Percentage of Town Population Served
1997	17,600	86%
1998	17,843	86%
1999	18,643	87%
2000	19,048	87%

2.4 System Demands

Water system demand data for the Town of Hudson water system between 1997 and 2000 is shown in Table 2-4. This data was analyzed to determine trends in the annual water production figures. The Town's water system average daily demand was determined by taking the amount of water pumped from the Litchfield Wells annually, less the water billed to residents of

Litchfield and Pelham annually, plus the amount of water purchased from PWW through the Taylor Falls Pump Station.

TABLE 2-4

AVERAGE DAILY WATER PRODUCTION & DEMAND

1997 to 2000

Year	Water pumped from Litchfield Wells (MGD)	Litchfield Average Day Demand (MGD)	Water purchased from PWW (MGD)	Pelham Average Day Demand (MGD)	Hudson Average day Demand (MGD)
1997	1.578	0.20	N/A	N/A	1.378
1998	1.677	0.251	N/A	0.10	1.326
1999	1.833	0.272	0.024	0.10	1.485
2000	1.757	0.265	0.157	0.08	1.569
Average	**1.711**	**0.247**		**0.09**	**1.440**

Un-accounted-for water is generally the difference between the amount of water that is billed and the amount of water supplied by the sources. The amount of un-accounted-for water is important because it represents "lost opportunity" in terms of revenue and also is an indication of leaks, inaccurate meters, and meters that are not installed or read. Un-accounted-for water includes water used to flush water mains; any billing discrepancies due to inaccurate meters; or any un-metered irrigation for municipal fields. Table 2-5 shows the billed water for 1999 and 2000.

TABLE 2-5

UN-ACCOUNTED-FOR WATER

Year	Hudson Average Day Demand (MGD)	Annual Water Billed to Hudson Residents (MGD)	Unaccounted for Water (MGD)	% Unaccounted-for
1999	1.485	1.255	0.230	18
2000	1.569	1.301	0.268	20

According to the Town's records and Table 2-5, the Town of Hudson water rate payers are paying to treat and pump approximately 250,000 gallons of water per day that is lost in either the Town's of Litchfield, Hudson or Pelham's water system. The percentage of unaccounted-for water is high in Hudson. We generally observe the percentage of unaccounted-for water to be between 10 and 15%.

Currently PWW pays for the water used in the Litchfield and Pelham water systems based on billed water consumption which does not include un-accounted-for water in those towns. Meter pits located at the Hudson/Litchfield and Hudson/Pelham lines will enable Hudson to bill the towns of Litchfield and Pelham for the actual water they use (including water lost through leaks and flushing). We suggest that Hudson prepare water bills to PWW based on the readings from these meters. This will prevent Town of Hudson rate payers from paying for the lost water in the towns of Litchfield and Pelham in the future.

The estimated maximum day pumping data for the Litchfield wells are shown in Table 2-6. Daily pumping records are not available for these wells. Therefore, the weekly data was used to determine the flows pumped during the highest water demand week. The weekly pump data from the Litchfield wells are only available for 1999 and 2000. The pumping data is based on demands and is dependent on the weather for that year and therefore highly variable. The summer of 2000 was much cooler and wetter than the summer of 1999, which explains the difference in the maximum day water demand data. The maximum weekly demand for each well pump station did not occur during the same week, therefore the estimated maximum daily demand in Table 2-6 may not reflect the actual maximum daily demand that was seen by the system in both 1999 and 2000.

TABLE 2-6

MAXIMUM DAY WATER PUMPING DATA

Year	Weinstein Well Maximum Day Water Demand (MGD)	Dates of Monitoring	Dame & Ducharme Maximum Day Water Demand (MGD)	Dates of Monitoring	Estimated Total Maximum Day Water Demand (MGD)
1999	0.976	August 4-13	1.581	June 16-24	2.548
2000	0.497	June 28-July 17	1.071	May 19-31	1.568
				Average	**2.06**

We observe the maximum day water demand for a town of similar size and make-up as Hudson to be typically 1.5 to 2.0 times the average day demand. It is not possible to determine the Town of Hudson's maximum day demands with the given discrepancies in the well pump data. In order to determine the maximum day demand in the Town of Hudson, daily pumping records would be required at the Litchfield wells, and at the Taylor Falls Pump Station as well as daily demands from the Towns of Litchfield and Pelham. Therefore to calculate the future maximum day demand a factor of 1.5 times the estimated future average day demand was used.

The peak hour demands are the highest hourly demands that occur during a 24-hour period and generally occur in conjunction with the maximum day demand. Because peak hour demands can typically vary from 1.0 to 3.0 times the maximum day demands, and are short-term demands, they can and should be met from distribution storage rather than from the well supply facilities. The peak hour water system demand is not known for the Town of Hudson. Towns in New England with development similar to Hudson typically experience a factor of 1.5 times maximum day demands. Therefore, we used the same factor to estimate peak hour demands for Hudson. This factor was used to determine projected (2020) peak hour demands in the hydraulic model. Table 2-7 shows the Year 2000 estimated maximum day and peak hour demands for the four service systems in Hudson.

TABLE 2-7

ESTIMATED YEAR 2000 MAXIMUM DAY AND PEAK HOUR DEMANDS BY SERVICE SYSTEM

Service System	Average Day Demand MGD (gpm)	Maximum Day Demand MGD (gpm)	Peak Hour Demand MGD (gpm)
Marsh Road	0.224 (155)	0.336 (235)	0.504 (350)
Windham Road	0.320 (220)	0.480 (335)	0.720 (500)
Compass Point	0.224 (155)	0.336 (235)	0.504 (350)
Main Service	0.801 (560)	1.202 (830)	1.803 (1,250)
Town of Hudson	1.569 (1,090)	2.354 (1,635)	3.531(2,450)

2.5 Future Demand Projections

Future average and maximum daily demands are projected based upon the expected population dynamics of the Town as well as expected trends or changes in the per-capita water use by economic or social status. Hudson is largely a residential community. Therefore, it is assumed that the industrial, commercial and municipal demands will increase in proportion to the population increase of the Town.

The average daily per capita demand value is calculated by dividing the total average demand by the number of residents served by the Town of Hudson water system. Table 2-8 shows the average daily per capita demand including unaccounted-for water, for the Town from 1997 to 2000. The 2000 average daily per capita demand value based upon the year 2000 total average daily flow (1.569 MGD) divided by the year 2000 population served by the Town's water distribution system (19,048) equates to 82.4 gallons per capita per day (gpcd). The average gpcd is estimated to have increased less than 5% from 1997 to 2000.

TABLE 2-8

AVERAGE PER CAPITA WATER DEMAND

Year	Average Day Demand (MGD)	Population Served	Average per Capita Demand (gpcd)
1997	1.378	17,600	78.3
1998	1.326	17,843	74.3
1999	1.485	18,643	79.7
2000	1.569	19,048	82.4

Figure 2-2 shows the average daily per capita water demand from 1997 to 2000 and projected per capita water demand from 2000 to 2020, for the Town of Hudson. Weston & Sampson has assumed that this trend of residents using more water will continue in the future. Therefore, for the purposes of estimating future water demands, we have assumed that the per capita water use will increase approximately 5% every five (5) years over the next 20 years. The drawback to projecting the future gpcd water use too high is that as the cost of water increases over the next 20 years, there could be a stabilization in per capita water use. The industry standard, average per capita demand is typically between 75 and 125 gpcd. Therefore, our projected per-capita demand in the year 2020 of 100 gpcd is within industry standards.

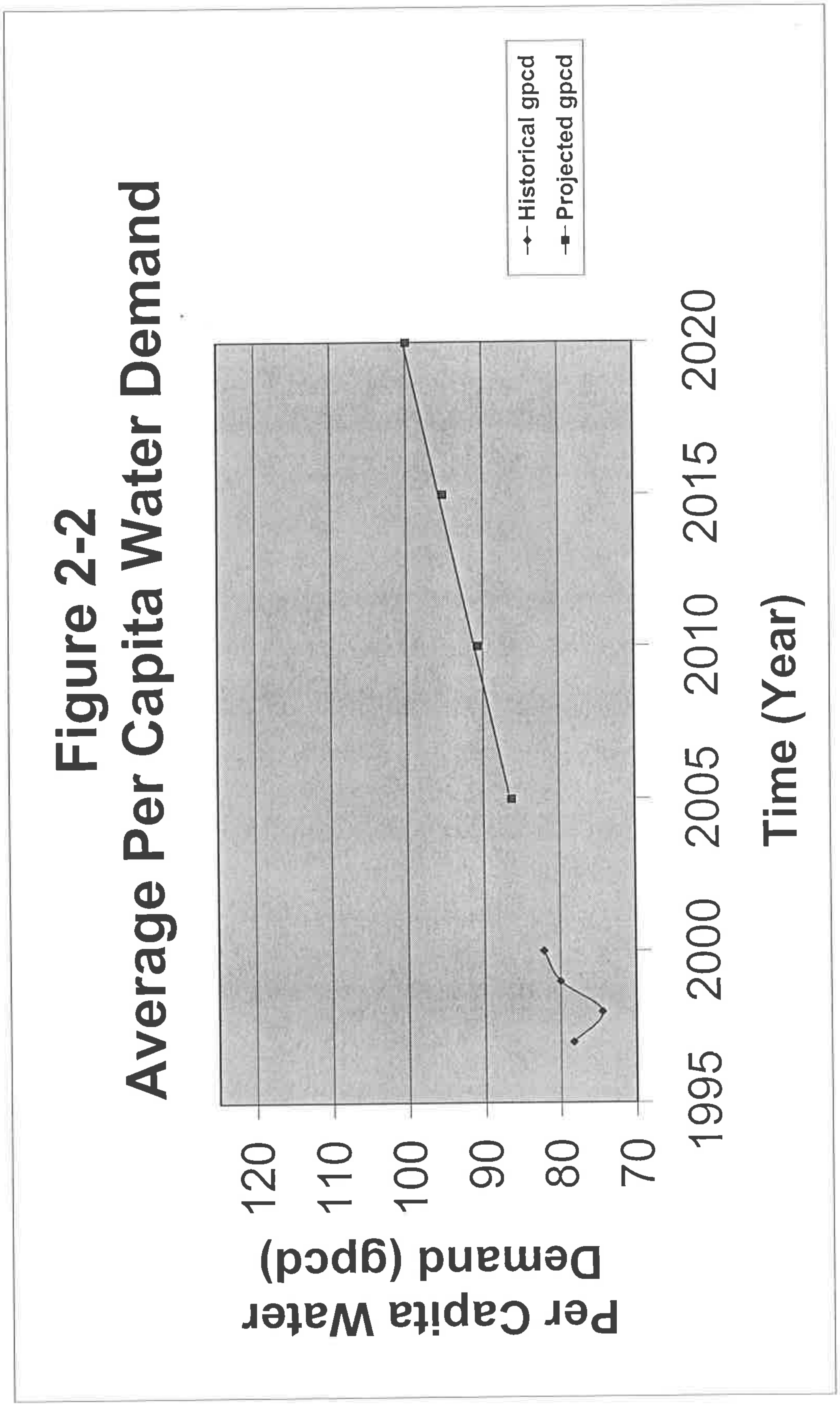
Figure 2-2
Average Per Capita Water Demand
Per Capita Water Demand (gpcd)
120
110
100
90
80
70
1995
2000
2005
2010
2015
2020
Time (Year)
Historical gpcd
Projected gpcd

Water demand projections through the year 2020 were determined utilizing the projected average per capita demands and the projected population to be served by the Town's water distribution system. The projected population to be served by the Town's water distribution system was determined assuming that 10% of the projected population (Year 2020) will receive water from private wells. Table 2-9 shows the projected future average day water demands, and the per capita water demand.

TABLE 2-9

PROJECTED AVERAGE DAY DEMAND

Year	Projected Average per Capita Demand (gpcd)	Projected Population served by the Town System	Projected Average Day Demand (MGD)
2005	86.3	22,950	1.98
2010	90.6	24,525	2.22
2015	95.2	26,550	2.53
2020	100.0	28,350	2.84

The estimated average daily demand for the year 2020 is 2.84 MGD. This assumes that the percentage of residents using well water will decrease from 15% to 10% by 2020. Table 2-10 shows the future maximum day and peak hour demand projections for the Town of Hudson through the year 2020.

TABLE 2-10

PROJECTED MAX DAY AND PEAK HOUR DEMANDS

Year	Maximum Day Demand (MGD)	Peak Hour Demand (MGD)
2005	2.97	4.46
2010	3.33	5.00
2015	3.80	5.69
2020	4.26	6.39

The maximum day demand for the Town of Hudson is projected by multiplying the projected average day demands by a ratio of 1.5. Utilizing the peaking factor of 1.5 times maximum day demand for peak hour demand, the peak hour water demand in the year 2020 is estimated to be approximately 6.4 MGD.

2.6 Water Supply Requirements

The Town of Hudson is supplied with water that is pumped to the distribution system from the Litchfield Wells. The three wells (Dame, Ducharme, and Weinstein) have a combined apparent safe yield between 2.0 and 2.2 MGD. The wells serve water to the Town of Hudson, Litchfield and Pelham. The maximum capacity of the Litchfield Wells is 2.8 MGD. In addition water is also purchased from PWW through the Taylor Falls Pump Station. The maximum pumping capacity of the Taylor Falls Pump Station is approximately 3.2 MGD. Table 2-11 shows the present and future maximum day demands for the communities served by the Hudson water supplies.

TABLE 2-11

MAXIMUM SYSTEM DEMANDS

	Hudson Maximum Day Demand (MGD)	Pelham Maximum Day Demand (MGD)	Litchfield Maximum Day Demand (MGD)	Total Maximum Demand (MGD)
Present	2.20	0.15	0.37	2.72
Future (2020)	4.26	0.29	0.72	5.27

The present maximum day demand was calculated by multiplying the average day demands presented in Table 2-4, by 1.5. To calculate the future maximum day demands for Pelham and Litchfield it was assumed that these areas will observe a similar demand increase as Hudson. The maximum day demand for Hudson has been projected to increase approximately 195% from 2000 to 2020. The Pelham and Litchfield present average day demands were increased by 195% and multiplied by the peaking factor of 1.5 to determine the projected 2020 maximum day demands. The revised safe yield of the water supply wells, with all three wells pumping constantly (2.2 MGD) along with the Taylor Falls Pump Station running constantly (3.2 MGD) is approximately 5.4 MGD (3,750 gpm). The projected future maximum day demand is 5.27 MGD (3,690 gpm). Based upon these calculations, the Town of Hudson will have adequate water supply with the Taylor Falls Pump Station to meet future (2020) maximum day demands provided all well supplies are in service. However, the Town will be dependent on PWW for the additional supply and will pay more for the water from the Taylor Falls Pump Station than from the Litchfield Wells. Even if the Town of Hudson had all the water supply from the Litchfield

Wells, they will still need to purchase water from PWW through the Taylor Falls Pump Station in the year 2020 to supplement their future demands according to our projections. We also recommend that the Town be capable of maintaining projected 2020 maximum day demands with the largest well source out of service. With the largest source out of service, the Town will have 4.5 MGD water supply. This is not adequate to meet the projected 2020 water system demands. The Town should consider all potential water supply alternatives.

2.7 Service System Demand Projections

In order to determine the projected demands in the high service systems, we computed the percentage of the total Town demand that each system comprises and projected the future demands using these ratios and the projected Town demand (2.84 MGD). Table 2-12 summarizes the future 2020 demand projections for the high service systems. The same peaking factors were used to determine the future maximum day and peak hour demands for the high service areas that were used to determine the present day high service system demands. These demand projections may be slightly lower than what will actually be observed, based on the amount of undeveloped land in the vicinity of the high service systems, however, it is very difficult to accurately determine these demand projections without annual average and hourly pumping records at the stations.

TABLE 2-12

2020 DEMAND PROJECTIONS FOR SERVICE SYSTEMS

Service System	% of current Town Demand	Average Day MGD (gpm)	Maximum Day MGD (gpm)	Peak Hour MGD (gpm)
Marsh Road	14%	0.396 (275)	0.598 (415)	0.893 (620)
Windham Road	20%	0.562 (390)	0.842 (585)	1.260 (875)
Compass Point	14%	0.396 (275)	0.598 (415)	0.893 (620)
Main Service	52%	1.486 (1,035)	2.222 (1,545)	3.344 (2,320)
Town of Hudson	100%	2.840 (1,975)	4.260 (2,960)	6.390 (4,435)

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3.0 DISTRIBUTION SYSTEM REGULATORY REQUIREMENTS

3.1 General

The purpose of this section of the report is to present information on pertinent regulations and standards as they relate to Hudson's water system. Information is presented on the Insurance Services Office (ISO) requirements as they relate to water systems, and the New Hampshire Department of Environmental Services (NHDES) Drinking Water Protection Rules.

3.2 ISO Recommendations

A water distribution system has two primary functions. The first is to supply water for domestic, commercial and industrial use, and the second is to provide adequate fire protection. The ISO has established certain standards by which the adequacy of a public water system to provide fire protection can be rated. When establishing fire flow recommendations for a community, the ISO commonly considers the different types of development within the community and establishes a recommended hydrant flow for each type. The recommended rate and duration of flow is based on building structural conditions, type of occupancy, and the congestion of buildings in the Town under consideration. The largest fire flow demands generally occur in the principal business and industrial districts of a community.

The degree of compliance with ISO recommended standards is used to set fire insurance rates within a community. In the design of waterworks, it is considered good practice to adhere to these standards, not only to minimize fire insurance rates within a community, but also to reduce the risk of human casualties and property damage resulting from fires.

3.2.1 Recommended Fire Flows

Recommended fire flows are defined as the recommended minimum fire flow rate from the distribution system. The ISO recommends that the Town maintain a minimum pressure of 20 pounds per square inch (psi) in the water mains at all times during a fire flow event. In 1992, the ISO evaluated the Town of Hudson. Twenty-two fire flow tests were performed. Twelve of the 22 sites tested had inadequate fire flows. The results of the Hudson ISO evaluations are shown in Appendix A.

3.2.2 Time Duration Requirements

In addition to setting recommended fire flow requirements, the ISO has established recommended time duration requirements during which the needed fire flow should be maintained. In general, fire flows up to 2,500 gpm should be available for two hours, while fire flows greater than 2,500 gpm should be maintained for three hours or more, depending on the flow. The ISO standards for time-duration for recommended flows are shown in Table 3-1.

TABLE 3-1

ISO FIRE FLOW DURATION RECOMMENDATIONS

Recommended Fire Flow (gpm.)	Recommended Duration (hours)
2,500 and less	2
3,000	3
3,500	3
4,000 and greater	4

3.3 NHDES Distribution System Requirements

The NHDES, Water Supply Engineering Bureau, promulgates New Hampshire state regulations regarding water distribution system and source requirements as specified in the Drinking Water Protection Program published rules in 13 sections of Env-Ws 300. The NHDES also specifies general water distribution and supply design criteria and considerations in the Standards of the Great Lakes Upper Mississippi River Board of State Public Health and Environmental Managers (Ten States' Standards).

3.3.1 Pressure Requirements

Ten States' Standards, Recommended Standards for Water Works states that "The system shall be designed to maintain a minimum pressure of 20 psi at ground level at all points in the distribution system". This pressure is equivalent to 46 feet in elevation and will permit water to overcome the frictional resistance of house plumbing and rise to a height equivalent of about a three-story building. Under all conditions of flow, the normal working pressure in the distribution system should be approximately 60 to 80 psi and not less than 35 psi.

Ten States' Standards allows a maximum system pressure of 100 psi. Any portion of the system where pressure is expected to exceed 100 psi shall have pressure-reducing valves installed on each individual water service line or on the main line, to maintain pressure at less than 100 psi. High pressures result in rapid discharge of water at fixtures, leading to wasted water, and also increased leakage throughout the system.

3.3.2 Design Requirements

Part 8 of Ten States' Standards addresses several requirements for distribution system design:

- The minimum size of water main for providing fire protection and serving fire hydrants shall be six-inch diameter. Larger size mains will be required if necessary to allow the withdrawal of the required fire flow while maintaining the minimum residual pressure.

- When fire protection is to be provided, system design should be such that fire flows and facilities are in accordance with the requirements of the state Insurance Service Office (ISO).

- Fire hydrants shall not be provided on water mains not designed to carry fire flows. Hydrants should be located at each street intersection and at intermediate points between intersections as recommended by the ISO. Generally, hydrant pacing may range from 350 to 600 feet depending on the area being served. The hydrants leads shall have a valve and be a minimum of 6 inches in diameter.

- Valves shall be located at not more than 500-foot intervals in commercial districts and at not more than one block or 800-foot intervals in other districts.

- If practical, dead-ends should be eliminated. Where dead-end mains occur, they shall be provided with a fire hydrant if flow and pressure are sufficient, or with an approved flushing hydrant or blow-off for flushing purposes.

3.3.3 Cross Connections

NHDES Water Division Env-WS 364 establishes regulatory requirements for cross-connection control. A cross connection is defined as an actual or potential connection between a potable and non-potable water supply. These connections constitute a serious public health hazard. Cross connections have been the cause of many well-documented public drinking water contamination events that resulted in the spread of diseases. The NHDES requires that all actual and potential cross connections be protected through the use of approved backflow prevention devices. The Town of Hudson has administered the protection of all high hazard cross connections.

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4.0 FIELD FLOW TESTING AND RESULTS

4.1 General

In order for a distribution system to provide adequate service, it must be able to meet demands during periods of peak consumption. The system must also be capable of delivering hydrant flows at adequate pressures for fire protection. Deterioration of the distribution system will affect the ability of the system to deliver these flows. Hydrant flow test results provide an indication of the distribution system's ability to meet these requirements.

4.2 Background

The capacity of the system to deliver flows depends on the carrying capacities of the individual pipeline segments. A distribution system is comprised of many segments of pipe. An individual pipe segment's ability to transfer water, or its carrying capacity, is a function of several factors including pipe diameter, length, material and inner surface condition. A significant number of pipelines with insufficient carrying capacity can seriously limit a distribution system's ability to deliver sufficient flows. The distribution system should be evaluated to determine if it has capacity to meet peak demands, as well as fire flow availability. Hydrant flow testing is useful in determining the flow characteristics of the distribution system.

Two approaches are used in order to determine a distribution system's ability to meet system demands. First, the system's demands are identified, then the distribution system is evaluated to determine if it has capacity to meet these demands, and to determine fire flow availability. Chapter 2 provides a summary of the system's water supply requirements under normal operating conditions. C-value tests and hydrant flow tests are used to determine system capacity with regard to individual pipe segment carrying capacity and fire flow availability.

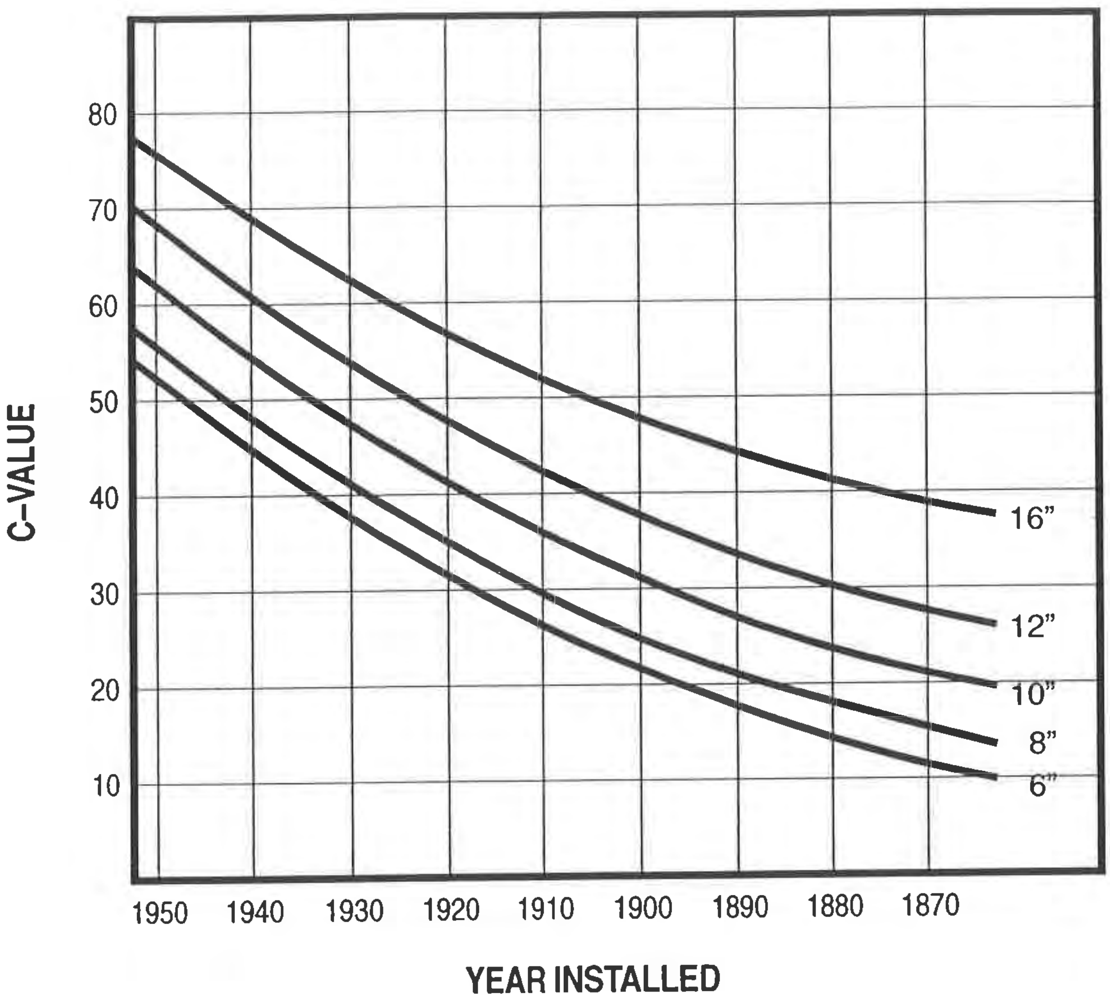


FIGURE 4-1

C–VALUES FOR UNLINED CAST IRON
AND PIT CAST IRON WATER MAINS

Figure 4-1 shows a series of curves prepared by WSE that are representative of the relationship between the C-value of an unlined cast iron pipe and its age for pipelines in typical New England communities. As an example, the C-value of a pipe that is 100-years old can range from 48 to 21. The corresponding carrying capacity of the pipe can range from 40 percent to 17 percent of the original carrying capacity. The cement lining found in ductile iron pipes and some cast-iron pipes is designed to prevent the corrosion of the internal surface of the pipe. It is generally accepted based on experimentation and actual experience that most cement-lined pipes will not experience noticeable deterioration of the internal surface until the pipes age reaches 70 to 100 years. The C-value will, therefore, remain at approximately 120 throughout most of its useful life. The cleaning and lining of unlined cast-iron water mains can also produce a C-value of approximately 110.

The curves presented in Figure 4-1 were used as a starting point for determining C-values in Hudson. The hydraulic model was used to further define the C-values to accurately reflect field conditions. It is generally accepted that when a pipeline's carrying capacity deteriorates to 50 percent of its original capacity, serious consideration should be given to replacement or rehabilitation of the pipeline to restore carrying capacities to near original levels. In addition to the seriously reduced carrying capacity, a pipeline at this stage has already built-up significant amounts of tuberculation on its inner surface. As the pipeline diameter decreases, the velocity of the water increases, which can result in the shearing/scouring of the tuberculation. This can yield significant water discoloration problems. As the pipeline ages the deterioration of the inner surface gets worse and the problems become more severe.

4.3 Hydrant Flow Tests

Hydrant flow testing by Weston & Sampson in May 2001 and data from ISO fire flow testing in 1992 were used to evaluate the Hudson distribution system's ability to supply recommended fire flows and meet recommended pressures.

4.3.1 ISO Fire Flow Testing

The ISO conducted 22 hydrant flow tests in Hudson in 1992. Available and recommended fire flows as determined by the ISO are discussed in Chapter 3 and are attached in Appendix A. It is apparent from the results of the ISO flow testing that 12 areas of the existing system did not meet

ISO fire flow recommendations at the time of testing. The ISO does not consider fire flow requirements greater than 3,500 gpm when determining the classification of the Town when using the fire suppression rating schedule. Therefore, we placed a lower priority on fire flow deficiencies over 3,500 gpm when identifying capital improvements. These locations are listed in Table 4-1 and shown on Figure 4-2.

TABLE 4-1

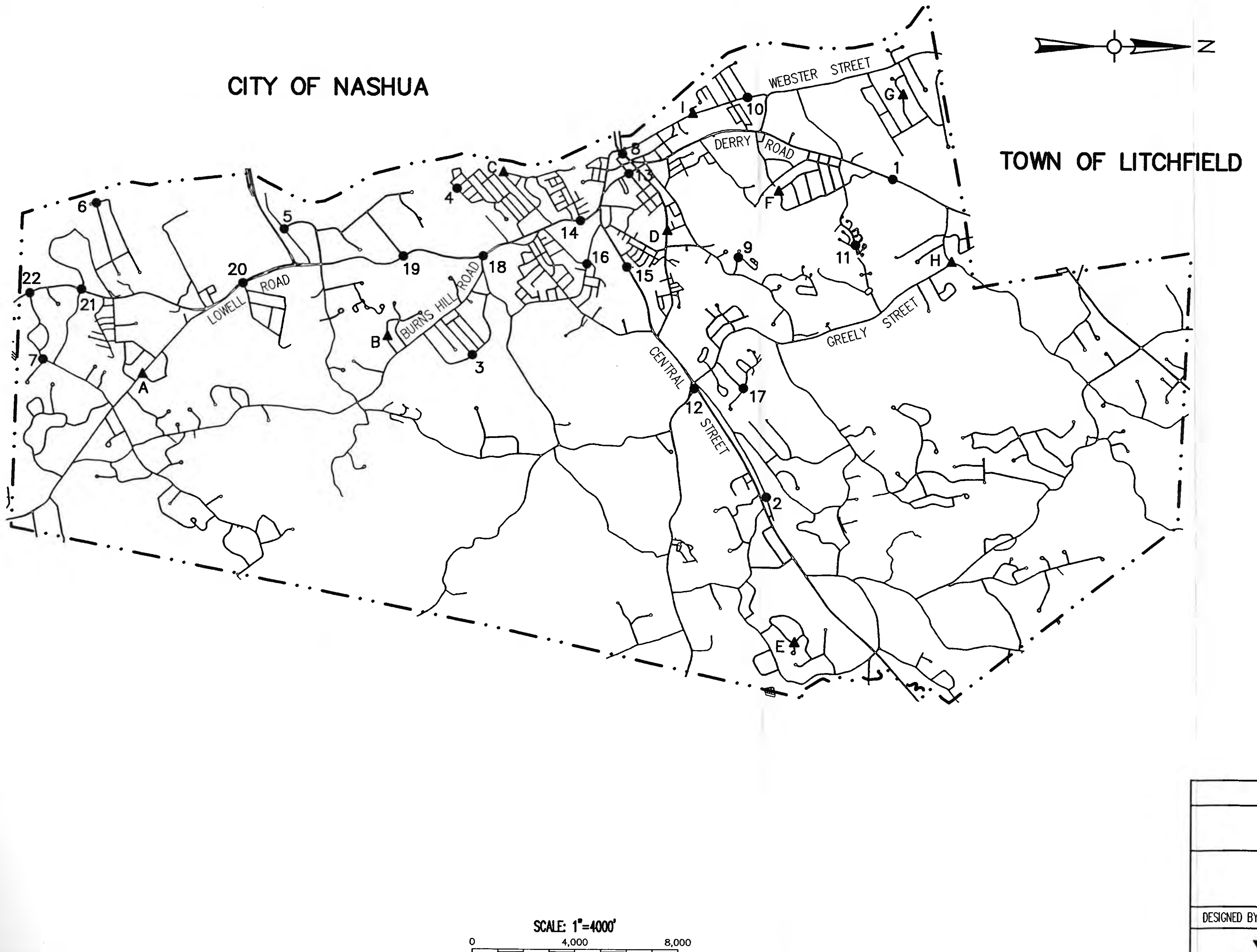
LOCATIONS OF INSUFFICIENT ISO FIRE FLOWS

Test No.	Test Designation and Location	Service System	ISO Recom. Flow (gpm)	Flow Available at 20 psi (gpm)	Percent of Recommended Flow Available
1	Derry St @ High School	Main	5,000[1]	3,500	100%
2	Wall St & Central St	Windham Road	5,500[1]	2,000	57%
5	Sagamore Park Rd & Flagstone Dr	Main	3,000	1,900	63%
10	Webster St & Garrison Farm Rd	Main	3,500	2,200	63%
13	Library St & School St	Main	3,000	1,700	57%
14	Lowell Rd & Riverside Ave	Main	3,000	1,600	53%
15	Central St & Memorial Dr	Main	4,000[1]	3,000	86%
16	Melandy Rd & Roosevelt Ave	Main	3,500	2,000	57%
18	Pelham Rd & Burns Hill Rd	Main	3,500	2,400	69%
19	Lowell Rd & Executive Dr.	Main	3,000	1,900	63%
20	Lowell Rd & Rena St	Main	3,500	2,200	63%
21	River Rd & Pine Rd	Main	3,500	1,500	43%

1. 3,500 gpm was assumed the highest fire flow the Town is responsible for

4.3.2 Weston & Sampson Flow Testing

Weston & Sampson conducted hydrant flow tests throughout the system on May 30, 2001. The results of these tests are shown in Table 4-2 and their locations are shown on Figure 4-2. These flow tests were conducted in order to calibrate the hydraulic model.



LEGEND:

1● ISO FIRE FLOW TEST

A▲ WSE FIRE FLOW TEST

FIGURE 4-2		
TOWN OF HUDSON, NEW HAMPSHIRE		
FLOW TEST LOCATIONS		
DESIGNED BY: JCP	CHECKED BY: -	DATE: JANUARY 2002
WESTON & SAMPSON ENGINEERS, INC.		

J\200368\FLOWTEST_FIG

TABLE 4-2

WESTON & SAMPSON HYDRANT FLOW TESTS

Test No.	Test Designation and Location of Hydrant	Service System	Pipe Diam. (inches)	Test Discharge (gpm)	Available Flow @ 20psi (gpm)
1	Dracut Rd. @ Sand Hill Rd	Main	12	890	1,430
2	St. Francis Place	Compass Point	8	600	580
3	Winnhaven Dr. @ Radcliffe Dr.	Main	8	1,025	2,570
4	Ferry St @ Gloria Ave	Main	6	680	2,940
6	Falcon Dr. @ Robin Dr	Main	8	975	3,340
7	Forest Rd. @ Forest Cir.	Main	6	975	2,160
8	Greeley St. @ Old Derry Rd.	Marsh Road	12	1,110	1,740
9	Daniel Webster @ Tolles St.	Main	8	1,095	7,120[1]

1. Flow test may be inaccurate due to the high flows and only one hydrant being flowed

4.4 C-Value Tests

Two C-value tests were performed in Hudson on pipe in the downtown area in order to determine if the pipe was cement-lined. According to DPW personnel, some of the water mains were installed in the early 1900's and are assumed to be unlined cast-iron pipe. We were using the C-value tests to try and verify the type of pipe installed. The C-value test requires a length of pipe with three hydrants and few connections with other pipes. The number of locations where a C-value test could be performed in the downtown area of Hudson was limited due to the dense grid of water mains and the high number of lateral connections. C-value tests were performed in the locations listed in Table 4-3 with the corresponding results.

TABLE 4-3
WESTON AND SAMPSON C-VALUE TESTS

Street Location	Water Main Size (inches)	C-Value
Lowell Road between Riverside Avenue and Winnhaven Drive	8”	75-105
Ferry Street between Second Street and Library Street	6”	105-125

The C-value test performed on the 8-inch water main in Lowell Road indicates that the pipe is cement lined and is in relatively good condition. The results of the C-value test for the 6” water main in Ferry Street may not be accurate due to the inability to locate and close the appropriate gate valves on the day of field testing. Water main and gate valve records were found to be inaccurate in the field for this test. Since the test is dependent on isolating the flow through the water main between the selected hydrants, a representative C-value could not be calculated with the data that was gathered. Weston & Sampson Engineers, Inc. recommends that the Town perform coupon testing on 6” and 8” water mains in the downtown area to inspect the interior condition of the water mains before making a final determination on rehabilitating/replacing any water mains. A coupon test is performed on a water main by removing a piece of the pipe to determine if the pipe is cement lined or not, and if the lining is in good condition. This can also provide an opportunity to install a new gate valve or hydrant and inspect the exterior condition of the pipe at the same time.

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5.0 HYDRAULIC ANALYSIS

5.1 General

The hydraulic model of Hudson's water distribution system was developed to investigate the ability of the system to meet water demands during periods of peak consumption and fire flow demands. A computer-aided hydraulic analysis was performed on the distribution system using the hydraulic model. All water distribution pipes included on the Town's existing water system mapping are included in the hydraulic model as well as recent improvements to the water distribution system.

5.2 Hydraulic Analysis by Computer Modeling

The distribution system analysis utilized the computerized hydraulic analysis program H2ONet®. H2ONet® version 3.1 is an AutoCAD add-in program developed by MW Soft, Inc.

The distribution system was schematized into a system of pipe segments and pipe junctions (nodes) using Hudson's aerial digital base mapping. Each pipe segment and node was assigned a unique number. The hydraulic model developed for Hudson contains approximately 830 pipe segments and 730 nodes. Information on pipe diameters, internal pipe conditions (C-values), ground elevations, and water demands were collected and entered into the model database. The pipe lengths were scaled automatically by the hydraulic model.

The H2ONet® program output includes: a summary of input data (headloss, flow, and flow direction, velocity for each pipe segment) demand, pressure, and hydraulic gradient at each node. This output data was reviewed for hydraulic deficiencies based upon predetermined criteria. The output data may be shown graphically using functions in H2ONet® that will build pressure, hydraulic grade line, and elevation contours onto the H2ONet® hydraulic map.

5.3 Hydraulic Modeling Data

To initiate the analysis process, data pertaining to the system characteristics was collected and incorporated into an input data file. A recent water distribution map of Hudson's system was used to determine pipe diameter. Nodal elevations were obtained from the town of Hudson's GIS mapping. Information on the type of water main is generally not available for the Town of Hudson.

5.3.1 Average Day Water Demands

The average day demands were calculated using pumping data obtained from the Litchfield Wells and Taylor Falls Pump Station and billing records for the towns of Litchfield and Pelham. The demands were assigned to nodes according to building densities within the distribution system. A per household demand was determined and the aerial base mapping was used to assign an appropriate demand to each node.

Hudson has 17 single users that have a significant demand on the Town's distribution system. The 17 largest water users in the Town of Hudson accounted for 8% of the total water used in 2000. These users each used over 610,000 gallons per year and are described in Table 5-1. For each user, the appropriate demand was assigned to the nearest junction node in the hydraulic model.

TABLE 5-1

TOWN OF HUDSON'S 17 LARGEST WATER USERS

Company	Street Location	Flow Gal/Day
1. Southeastern	36 Executive Drive	24,034
2. Fairview Nursing	203 Lowell Road	17,482
3. UNAXIS USA Inc.	25 Sagamore Park	12,197
4. Performance Material	4 Park Avenue	10,915
5. Prolyn Corporation	18 Roosevelt Avenue	8,626
6. Hudson Color Concentrations	5 Executive Drive	7,445
7. Wal-Mart Stores	254 Lowell Road	6,955
8. T-Bones	77 Lowell Road	6,826
9. Superintendent	200 Derry Road	5,962
10. Century Park LLC	1 Wall Street	5,904
11. Greenmeadow Golf	59 Steele Road	5,674
12. APW Limited	20-24 Executive Drive	5,054
13. HWS Investments	3 Lions Avenue	4,363
14. Soap Opera Inc.	212 Lowell Road	4,262
15. Superintendent	10 Pelham Road	3,701
16. Dunkin Donuts	88 Derry Road	3,211
17. Soap Box Laundromat	76 Derry Road	1,670

5.3.2 C-Value Assignment

C-value tests are a method to measure an individual pipeline's carrying capacity. The C-value is a coefficient used in the Hazen-Williams equation for determining the pressure drop due to water flow through a segment of pipe. The C-value is a function of the roughness of the internal surface of the pipe and is directly proportional to the carrying capacity of the pipe segment. It is generally accepted that the C-value of a new cement-lined ductile iron pipe is approximately 120. Therefore, a pipe yielding a C-value of approximately 60 indicates that the carrying capacity of that pipe has been reduced by a factor of two.

The main cause of the reduction of the C-value of a pipeline is the corrosion and consequential deterioration of unprotected metal surfaces on the internal surface of the pipeline. The internal corrosion increases the roughness of the inner wall of the pipe and forms a buildup called tuberculation, which reduces the cross-sectional area of the pipe. These two results of corrosion reduce the C-value or carrying capacity of a pipe significantly. Generally, unlined cast-iron pipes manufactured during and before the 1920's do not have internal cement linings and are very susceptible to tuberculation.

The initial C-values assigned to the pipes in the hydraulic model are listed in Table 5-2. For the most part, all the pipe in the Town (except the downtown area) have C-values typical of cement lined pipe.

TABLE 5-2

INITIAL C-VALUES USED IN HYDRAULIC MODEL OF EXISTING SYSTEM

Description	C-value
2–inch ductile iron pipe	60
Unlined Cast Iron (All Sizes)	20-80
4-inch ductile iron pipe	80
6 –inch ductile iron pipe	100
8-, 10-, 12-, 16,–inch ductile iron pipes	120

5.3.3 Litchfield Water Supply Wells

The three Litchfield wells, Dame Ducharme and Weinstein, supply water for the Towns of Hudson, Litchfield and Pelham. The wells are modeled as a constant pumping rate demand at the hydraulic grade line of the water system. The Litchfield demand has been included in the hydraulic model at Adam Road. The Pelham demand is assigned to a node located on the Hudson/Pelham town line within the Windham Road High Service system at Sullivan Road. The remaining supply is fed into Hudson's distribution system and tanks.

5.3.4 Taylor Falls Pump Station

The Town of Hudson requires an additional water supply to supplement the Litchfield Wells during high demand periods. The Pennichuck Water Works located in Nashua, New Hampshire provides this additional water supply through a pump station located at the Merrimack River on Ferry Street. The Taylor Falls Pump Station is modeled as a constant speed pump with the pump curve inputed into the hydraulic model.

5.3.5 High Service Booster Pump Stations

Three areas within the Hudson water distribution system exist at an elevation higher than the main service can provide adequate service to. These areas are known as Marsh Road, Windham Road and Compass Point high service systems. Each system contains a booster pump station to provide the flow and pressure needed to allow the systems to operate at sufficient pressures. The pumps within each booster station are modeled as constant speed pumps with pump curves inputed into the hydraulic model. Each area is separated from the main service system by multiple closed gate valves. These systems were each evaluated to determine any deficiencies that may exist and what actions can be taken to alleviate any problems.

5.3.6 Water Storage Facilities

The Marsh Road Tank and the Gordon Street Standpipe were modeled as cylindrical tanks and were modeled using actual tank capacity, overflow elevations and base elevations with maximum drawdown levels equaling approximately 10 to 15 feet below overflow elevations. Initial tank levels in the model were similar to actual conditions observed in the field during hydrant flow testing.

5.4 Calibration of the Hydraulic Model

The first step of the hydraulic analysis was to calibrate the model. This was done by simulating the distribution system conditions using the hydrant flow testing performed by Weston & Sampson in May 2001. Pressure drops in the computer model should approximate the pressure drops in the distribution system measured during flow testing. If the pressure drops were not equal, adjustments were made to the computer model so that they were equal.

Results from the hydrant flow tests including static pressures, residual pressures, tank levels, and flows, were simulated in the computer model. Based on these results, adjustments were made to several water mains and pumps, and the model was found to be reasonably accurate.

5.5 Adequacy of Existing Distribution System

To determine the adequacy of the existing distribution system with current water demands, the system was analyzed under current maximum day with fire flow and peak hour demands. We have assumed that the Marsh Road Tank and Gordon Street Standpipe were 56% and 73% full, respectively, during peak hour and maximum day demands. The overall results of the analysis show that all areas of the system are adequate under peak hour demands (35-psi is maintained). However, the distribution system had weaknesses under the maximum day with fire flow demand condition which may be an indication that the transmission system is not adequate. There are several locations in Town that would benefit from transmission main distribution improvements. These are discussed in detail in Chapter 7.

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6.0 STORAGE AND PUMPING STATIONS IMPROVEMENTS

6.1 General

The purpose of this section is to assess the distribution system storage and pumping facilities with respect to the Town's present and future water system requirements and to identify any deficiencies that exist. Information on the existing system storage facilities, pump stations and hydraulic grade line (HGL) were presented in Chapter 1.

6.2 Highest Elevation Served

If Hudson's service areas are expanded in the future, buildings constructed at ground elevations above the maximum service elevation listed in Table 6-1 will have insufficient pressures. The minimum service elevation indicates buildings that will have too much pressure (greater than 100-psi). The map in Appendix B shows this data graphically and indicates which land in town, color coded by service area, is suitable for building without major changes in service area limits. It is important to note that this table and figure do not account for adequate water volumes to the service areas, only adequate pressure under static demands.

TABLE 6-1

EXISTING MAXIMUM SERVICE ELEVATIONS

Service System	Maximum Hydraulic Grade Line (feet)	Maximum Service Elevation (feet)	Minimum Service Elevation (feet)
Main Service	314	220	55
Marsh Road High Service	510	420	255
Windham Road High Service	520	430	265
Compass Point High Service	440	350	185

6.3 Water System Storage Requirements

Typically, average day and maximum day water demands are satisfied by the pumping capacity of the water supply facilities, and peak hour and fire flow requirements are satisfied by distribution system storage. Equalization, fire and emergency storage are typically allocated at specific levels within a storage facility to ensure the storage volume will be available at a hydraulic gradient adequate for the intended purpose. Equalization storage is provided within the top portion of the tank, with fire storage positioned immediately below. Emergency storage is located in the lowest portion of the tank.

The quantity of system storage has been calculated using the method outlined in the American Water Works Association (AWWA) M32 Manual for Water Supply Practices - Distribution Network Analysis for Water Utilities. Table 6-2 shows the results of the evaluation based on Town-wide water system demands and the Main Service System.

Calculation of the available storage was determined by the elevation of the highest house in the Main Service System (approximately 230-feet USGS) and the storage tanks' ability to provide minimum pressures as described below to that house. A water storage tank stores water to meet three distinct design criteria. These are as follows:

- Equalization Storage – to meet system demands in excess of water supply delivery capability. This volume is at the top of the tank within the operating range that the water level fluctuates over the course of the day. This water should be stored at an elevation such that, at its lowest level, it will still provide 35-psi pressure to all homes. The Town of Hudson has a significant amount of residential development which can create high peak hour demands due to lawn irrigation systems. Due to these high peaking factors, we used 25% of the maximum day demand to calculate equalization storage volume needed in the Town's tanks.

- Fire Storage – to meet fire flow requirements, typically those as required by the Insurance Services Office (ISO). This water should be stored at an elevation such that, at its lowest level, it will provide at least 20-psi pressure, in accordance with NHDES and Ten States' Standards.

- Emergency Storage – to meet emergency situations such as pipeline failures, mechanical equipment and pump failures, raw water contamination, power outages, and natural disasters.

TABLE 6-2

WATER SYSTEM DISTRIBUTION STORAGE REQUIREMENTS

	Current (2000) (MG)	Future (2020) (MG)
Equalization requirement (25 percent of Max. Day)	0.52	1.07
Fire Flow Requirement*	0.63	0.63
Emergency Storage (20 percent of fire flow and equalization)	0.23	0.34
Total Required Storage	1.38	2.04
Total Storage Available	2.65	2.65
Available Storage	1.27 surplus	0.61 surplus

*3,500 gpm fire flow for a three hour period

The highest house in the Town of Hudson's Main Service System is located at approximately 230-feet ground elevation (USGS) at the Lewis Street and County Road area. The entire volume of water in the 2.0-MG Marsh Road Tank is considered usable storage (greater than 20 psi) with approximately 0.20 MG available as equalization storage (greater than 35-psi), 1.80 MG available as fire storage (greater than 20-psi), and no emergency storage. The volume of usable storage in the Town's 0.95-MG Gordon Road standpipe (greater than 20 psi) is estimated to be approximately 0.65 MG with approximately 0.1 MG of equalization storage and 0.55 MG of fire storage. This makes the total volume of usable storage (greater than 20-psi) 2.65 MG. According to AWWA's criteria, this indicates that there is adequate water storage available in the Town of Hudson with the two existing storage tanks to satisfy AWWA criteria.

The water storage volume of the two tanks in Hudson is adequate for the Town's water system based on volume and system demands, however, the Town does not provide water storage at the appropriate height/pressure for the three high service systems. None of the three high service systems in Hudson have water storage available. These high service systems receive the required domestic and fire flows via booster and fire pumps that serve the three high service pump stations. Water storage tanks are desirable because they offer redundancy of water supply during power failures, minimize the size of peak hour domestic and fire pumps, and also reduce the operating costs of pump stations. They generally have a high capital cost but reduce the operation and maintenance costs of pump stations.

The Marsh Road Tank is in excellent condition and was reported to not require any improvements at the time of the inspection in 1994. We recommend that the Town perform these tank inspections every 5-years. Therefore we recommend that the Town schedule another inspection for the Marsh Road Tank. The cost of these inspections are generally between $3,000 and $5,000. According the inspection performed in 2000, the Gordon Street Standpipe needs the screen on the overflow pipe to be replaced. It was also recommended that the Town consider cleaning the sediment from the bottom of the tank and performing some touch-up painting in corroded locations to improve the coating life.

6.4 High Service System Water Storage

The Town of Hudson has adequate water storage in the Main Service System to supply current and future demands and meet AWWA requirements. The Marsh Road and Gordon Road standpipes are in good condition and do not require any work at this time. The Town has no water storage available in the high service systems. Therefore, the Town depends on pumps to deliver peak hour and fire flows to the high service systems. Given the problems discussed in this chapter and Chapter 1 with the high service systems and booster pump stations, we recommend that the Town construct a 1.2 MG tank on Barrett Hill and link the Marsh Road and Windham Road High Service Systems. The recommended volume of the proposed tank was sized based on future (2020) water demands and AWWA methodology (Table 6-3).

TABLE 6-3

COMBINED MARSH AND WINDHAM ROAD HIGH SERVICE SYSTEM DISTRIBUTION STORAGE REQUIREMENTS

	Current (2000) (MG)	Future (2020) (MG)
Equalization Storage (25% of max. day)	0.20	0.36
Fire Flow Requirement*	0.63	0.63
Emergency Storage (20% of fire flow and equalization)	0.17	0.20
Required Storage Volume	1.00	1.19

*3,500 gpm fire flow for a three hour period

If this storage tank is located on the top of Barrett Hill it would be 40 to 60-feet tall to maintain the existing hydraulic grade line of the Windham Road High Service System. The previous 1988 water storage tank design by CNHWC shows a proposed overflow elevation of 480-feet. This is 30 feet lower than the existing Marsh Road High Service System hydraulic grade line and 40-feet lower than the existing Windham Road High Service System. If the proposed location is the only site on Barrett Hill that the Town can utilize for a tank, we recommend that the Town construct a 70 to 80-foot tall tank on the site to achieve a finished overflow elevation of 510-feet for the combined high service system. We estimate a 1.2 MG, 80-foot high standpipe will cost approximately $1,500,000 (year 2001 cost). If the Town can locate a site for the proposed tank at a higher elevation on Barrett Hill, the tank can be much shorter and therefore less expensive to construct. We estimate the project cost to construct a new 1.2 MG water storage tank 40 feet tall to be approximately $1,200,000 (year 2001 cost). We recommend that the Town monitor the water system demands closely in the high service systems in the future to verify the estimated demands used to size the storage tank. We also recommend that the volume and height of the proposed tank be reevaluated before final design when more firm demand readings are available. A new 1.2 MG storage tank is adequately sized for the newly linked service area assuming that water demands per household will increase slightly. The tank has not been sized assuming that the rest of northeast Hudson will be developed and added to the newly combined high service system. If the Town anticipates significant growth with the new combined high service area or expansion of the system's current limits over what we have estimated, a 1.5 MG tank may be more appropriate.

The 1988 storage tank design was for a 1.5 MG tank 40 feet high. We modeled this tank in the system under maximum day and peak hour conditions for the year 2020 and found the fire flow requirements of 1,250 gpm at 20 psi were met in the Marsh Road High Service System. This fire flow is typical for the area and is acceptable as long as Marsh Road does not receive any additional industrial and/or commercial development. The residential fire flow demand in the Windham Road High Service System of 750 gpm was satisfied, however, the commercial fire flow of 5,500 gpm at 20 psi was not. The tank was capable of delivering a fire flow of 3,500 gpm at 20 psi to this location.

The peak hour demands were checked to ensure at least 35 psi pressures were maintained with the shorter tank design. At the highest point in the combined systems, 35 psi was maintained. At the lowest point in the two systems, a water pressure of 120 psi was produced. The grade line of this tank, however, is at 480-feet. The Marsh Road and Windham Road pump stations currently maintain a grade line of 510- to 520-feet, respectively. Using a tank with an overflow elevation of 480 feet would decrease the existing pressure by 15 psi. This could lead to a series of resident's complaints about low water pressures. However, less pressure fluctuations will be observed with a storage tank versus the booster pump station.

Using the higher tank design with an overflow elevation of 520 feet would produce greater fire flows in the combined system. Approximately 150-250 gpm of additional fire flow is available with the higher tank. Although this additional volume is not required based on present day predictions of growth in that area, the added storage will be available should a larger water user demand it.

In order for a new tank to support a new combined Marsh Road and Windham Road High Service System, a new water main will need to be constructed to connect the two service systems. The hydraulic model indicates that a 12-inch transmission main is adequate. The estimated project cost to construct 5,200 linear feet of 12-inch ductile iron pipe in Hazelwood Drive from Rangers Drive to Greeley Street is approximately $700,000 (year 2001 cost).

6.5 South Hudson Water Storage

The southern portion of Hudson is serviced by one 12-inch transmission main in Lowell Road, which is not capable of providing the necessary fire flows to the south Hudson area. The hydraulic model indicates that a 16-inch or 20-inch transmission main improvement would be required to strengthen the water system enough to improve fire flows in the south Hudson area. This water main would be more costly and less reliable than constructing a new water storage tank in the South Hudson area. The tank would be sized for 0.35 MG of equalization storage (25% of the maximum day demands) and 0.45 MG of fire storage (2,500 gpm for three hours). This volume of 0.80 MG must be located at a useable HGL (greater than 20 psi) which will dictate the base elevation that the tank can be constructed. There is a small hill near the Groves Farm Road area that has an elevation of 250 feet that would be a good location for the tank. At this location, a 65-foot high standpipe with a 314-foot overflow elevation could be constructed costing approximately $1.0 million dollars (year 2001 cost).

6.6 Litchfield Well Sources

The Town of Hudson owns the Dame, Ducharme and Weinstein Wells located in the Town of Litchfield. These wells pump water through Litchfield and into Hudson. The water quality in these wells is very good. We recommend that the Town continue to perform maintenance on these well pump stations. Improvements should be made to the pump stations such that daily pumping can be monitored and recorded from each well. This information should be at a minimum, recorded at the pump station but if possible telemetered to the PWW treatment facility in Nashua, for recording in the Town's computer SCADA system. New flow meters or other telemetry improvements may be required at the well pump stations to do this. We anticipate that these wells will require redevelopment within the next 2 to 5 years and then every 5-years after that. We estimate the cost for re-development and cleaning wells is between $10,000 to $15,000 per well (year 2001 cost). The cost to perform upgrades to the flow meters at the well pump stations is estimated to be $20,000 for three new flow meters, transmitters and telemetry equipment. Utilizing the existing flow meters if possible can reduce this cost.

6.7 High Service Booster Pumping Station

The Town of Hudson is currently experiencing problems in their high service systems and with the high service booster pump stations. The Town receives numerous low water pressure complaints from residents in the high service areas during high summer demands. The pump stations, for the most part, were not adequately sized for the growth and increased demands that have occurred in these service systems. Several of the pump stations have trouble maintaining system pressure during summer demands due to inadequate domestic pumping capacity. The fire pumps in these stations have been turning on to increase pressure, which creates pressure surges and puts additional wear on the fire pumps that were not designed to operate in this manner.

6.7.1 Marsh Road Pump Station

The Marsh Road High Service System has developed significantly since it was built in 1986. As the service area has developed, the pump station has become insufficient to deliver adequate pressure and flows. The pump installed in the summer of 2001 will deliver an additional 200

- Remove the existing pump control panel and replace with a new programmable panel based on system pressure. The station operation will then be PLC based.
- Install a pressure transmitter on pump discharge water main. The transmitter should have 4-20 milliamp output for direct hard wire connection to the pump control panel.
- Install stand-by emergency power to operate the station in the event that commercial power is lost.

The estimated cost to maintain the Marsh Road Pump Station as a booster station for the Marsh Road High Service System and bring the station up to NHDES standards as listed above is $325,000 (year 2001 costs). If the Town utilizes this station as the back-up for the new combined Marsh Road and Windham Road High Service System with a tank, no additional costs will be required except maintenance costs.

6.7.2 Windham Road Pump Station

The Windham Road Pump Station is capable of meeting current peak hour demands with it's 750 gpm domestic pumping capacity. However, the Town has experienced problems with the stations telemetry and controls, which have caused low pressure problems and complaints on several occasions. The Town has requested that PWW correct this problem. Based on our projections of future growth and increased water demands in this service area, the existing pumping capacity will not be capable of meeting future (2020) peak hour demands. We have projected the future (2020) peak hour water demand in the Windham Road High Service System to be approximately 875 gpm.

The Windham Road High Service System has approximately the same hydraulic grade line as the Marsh Road High Service System. According to the Map in Appendix B and the maximum service elevations in Table 6-2, the majority of land in northeast Hudson would need to be located on either the Marsh Road or Windham Road high service systems. This area is quite extensive and contains land that is not yet developed and land that already has houses constructed but no municipal water service. Based on the potential size and grade lines of the systems and the problems that the Town has experienced with the booster pump stations, we recommend that the Town combine the Marsh Road High Service and the Windham Road High Service systems into one larger high service system and construct a new water storage tank to serve both systems on Barrett Hill. Based on the fact that the Windham Road Pump Station is an above ground building with more pumping capacity than the Marsh Road Pump Station, we recommend that the Town utilize the Windham Road Pump Station as the primary station to fill the new tank.

As the pump station is currently configured, it does not have enough domestic pumping capacity to supply water to a new water storage tank in the combined high service system. We recommend that the town utilize the existing fire pump with a new soft starter to fill the tank. The total pumping capacity would be 1,750 gpm with all four pumps pumping. However, we recommend that the Town utilize the 1,000 gpm fire pump for normal operation. Based on our projections, this would be adequate to deliver the future (2020) maximum day demands of the combined high service system. Control changes will be required at the Windham Road Pump Station to telemeter alarms and control the station remotely at the PWW treatment plant and reconfigure how the pump station operates. Stand-by power and VFD's on the existing pumps will not be required as the tank will deliver water during a power failure and VFD's are not necessary to fill a storage tank.

The pump station evaluation report conducted by WSE in February 2001 identified the following improvements that are necessary at the Windham Road Pump Station to bring it up to NHDES standards and provide adequate capacity for future growth utilizing it as a primary booster pump station for the Windham Road High Service system.

- Install VFD units to operate Pump #2 and Pump #3.
- Replace the existing 100 hp fire pump motor starter with a new 100 hp solid state reduced voltage motor starter to help minimize pressure surges during start up.
- Pressure and flow data needs to be gathered and assessed in order to evaluate the adequacy of the existing pumping equipment.
- By-pass piping should be installed around the existing Pressure Reducing Valve (PRV) to allow for servicing the valve and to maintain station operation during servicing.
- Remove the existing back-up engine and install standby generator to operate the entire station upon loss of commercial power.

The estimated cost to maintain the Windham Road Pump Station as a booster station for the Windham Road High Service System and bring it up to NHDES standards as listed above, is $260,000. If the Town utilizes this station to fill the new tank in the combined Marsh Road and Windham Road High Service System, the cost to perform the upgrades is expected to be $200,000 (year 2001 costs).

6.7.3 Compass Point Pump Station

The Compass Point High Service System has three (3) domestic pumps capable of pumping 125 gpm each. Based on discussions with PWW, the high service system already experiences domestic demands greater than the pumps are capable of delivering. This causes low pressure problems and the fire pump to cycle on and off to maintain pressure in the high service area. Cycling of the fire pump causes pressure surges and additional wear on the fire pump.

The pump station evaluation report performed by WSE in February 2001 identified the following improvements that are necessary at the Compass Point Pump Station to bring it up to NHDES standards and provide adequate capacity for future growth:

- Upgrade the power feed from the electric distribution grid to 480-volt three phase. The existing power is 240-volt single phase. The maximum hp motor that can be generated using a 230-volt single-phase power source is 7.5 hp. The existing demands cannot be met by the three existing 7.5 hp single-phase domestic booster pumps.
- Replace all of the pumps with a minimum of three 300 gpm, three phase 460-volt units.
- Install VFD units to operate the 300 gpm domestic
- Remove the existing engine driven fire pump and replace it with a new electric motor driven unit connected to a solid-state reduced voltage motor starter.
- Add a surge control valve on the discharge side of the fire pump to minimize pressure surges upon fire pump start up.
- Upgrade the existing pump control panel to accommodate the new pump configurations and VFD units.

- Install a standby generator to operate the entire station during loss of commercial power.

Based on the demand projections for the Compass Point High Service System we estimate that the future (2020) peak hour water demand in the high service system will be approximately 620 gpm. Based on the available pumping capacity of 375 gpm this is not adequate to serve current or future demands. Based on the size of the service area, we do not recommend that the Town construct a water storage tank. There is undeveloped land between the Compass Point and Windham Road high service systems that could be serviced by the Compass Point High Service System. However, given the limitations of the existing Compass Point Pump Station, we recommend that the Town not expand this service system significantly more than it already is unless a new larger pump station is constructed. Even if the service system is not expanded in the future, the pump station capacity will need to be increased to serve future demands. We recommend that the existing pumps in the Compass Point Pump Station be removed and replaced with new larger pumps of approximately 250 gpm each with VFD's. Two pumps could be installed to deliver current peak hour demands and the third installed in the future as the demands increase.

The Town will also need to perform the improvements outlined in the WSE pump station evaluation in order to bring it up to NHDES standards. We estimate the total cost to make improvements to the Compass Point Pump Station as outlined above and in the pump station evaluation memo to be approximately $700,000 (year 2001 costs). If a developer wants to build on land near the Compass Point High Service System, we recommend that the Town consider requiring them to construct a water storage tank. This would enable them to develop the High Service area beyond the existing pumping capacity and utilize the existing pump station to fill it.

6.8 Summary of Recommended Improvements

Based on the discussions above, we recommend the improvements in Table 6-4.

TABLE 6-4

PUMP STATION AND STORAGE RECOMMENDED IMPROVEMENTS

Project Description	2001 Estimated Cost
Install flow meters on water supply wells with telemetry to PWW	$20,000
Perform Marsh Road Tank inspection	$5,000
Clean sediment from Gordon Road Standpipe and perform miscellaneous improvements to tank coating system	$20,000
Construct 1.2 MG storage tank on Barrett Hill	$1,500,000
Construct 12-inch Transmission Main in Hazelwood Drive	$700,000
Improvements to Windham Road Pump Station to reconfigure it for a combined high service system	$200,000
Improvements to Compass Point Pump Station	$700,000
Construct 0.8 MG storage tank in South Hudson	$1,000,000
Clean and redevelop Litchfield water supply wells (3 wells)	$45,000

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7.0 DISTRIBUTION SYSTEM IMPROVEMENTS

7.1 General

In Chapter 6, existing and proposed water storage facilities and pumping station improvements to the high service areas were discussed. This chapter will outline distribution improvements with the focus directed towards transmission main deficiencies in the main service and high service systems. Recommendations are presented in this chapter to alleviate water system hydraulic deficiencies. The improvements are recommended to be constructed over the next 20 years in a phased Capital Improvements Program (CIP).

7.2 Water Distribution System Recommended Improvements

The hydraulic model was used to determine if the proposed improvements to the distribution system were adequate to alleviate deficiencies. The computer model of the distribution system with recommended improvements was run under peak-hour water demand conditions for the year 2020 to determine if the system is adequate to meet the future water demands. The model was also run under maximum-day water demand conditions for the year 2020 with fire-flows in the areas that the ISO tested in 1992. The ISO tests are representative of typical commercial/industrial and residential development and required fire flows in Hudson. The results of this analysis showed that the upgraded water system is capable of meeting future average day, maximum day, and peak hour demands.

7.3 Transmission Main Deficiencies

The transmission system is the foundation for the entire distribution system and is composed of the network of large diameter (10-inches and greater) water mains. It provides water to the small-diameter neighborhood pipes throughout the distribution system. Any deficiencies in the system can affect the overall carrying capacity of the network. The reduction in carrying capacity can be the direct result of the build-up of tuberculation on the interior surface of unlined pipes. This is a problem in older communities that have unlined pipes in their transmission system because it can also lead to plugged water services, poor water quality (rust and color), and bacteria growth. However, based on discussions with Town and PWW personnel, most of the water mains in Hudson were installed after 1930 and should be cement lined. They have indicated that there may be unlined pipe in the downtown area, but most of these potentially unlined water mains are small diameter mains, not transmission mains.

The Town of Hudson's transmission system includes a 16-inch water main in the main service system originating from the Litchfield wells, passing through the Town center and ending at the Gordon Street Standpipe. A 12-inch transmission main proceeds from the Gordon Street Standpipe down Lowell Road to the end of the distribution system in South Hudson. South Hudson has only the one 12-inch water main in Lowell Road to deliver water to this portion of the distribution system. If this water main breaks, South Hudson is without water. In addition to the lack of redundancy, the single transmission main is not large enough to provide adequate fire flows to the area. The hydraulic model has indicated that constructing a new tank would be most effective for providing the necessary fire flows to the area. The tank would have an overflow elevation of 314-feet to match the overflow elevation of the other two tanks in the Main Service System. The tank does not, however, solve the problems associated with redundancy of the transmission main in case of a water main break in Lowell Road.

Table 7-1 includes a list of recommended 16-inch and 12-inch transmission mains. The exact location and route of the proposed transmission mains can be adjusted depending on the Town's plans for street paving, or other infrastructure improvement programs.

TABLE 7-1

PROPOSED NEW TRANSMISSION MAINS

Street	From	To	Proposed Size (inches)	Length (Feet)	YR 2001 Estimated Cost
River Road	Lowell Road	End of Pipe in River Road	12-inch	2,900	$400,000
Lowell Road	Central Street	Birch Street	16-inch	3,250	$455,000
Ferry Street	Webster Street	Library Street	16-inch	800	$115,000
Lowell Road	Watson Road	River Road	12-inch	5,000	$675,000
Patricia Drive	Laurent Drive	Alvirne Drive	16-inch	1,630	$227,500
Alvirne Drive	Patricia Drive	End of Alvirne Drive	16-inch	770	$110,800
Cross-country	End of Alvine Drive	End of 16-inch pipe in Derry Road	16-inch	1,170	$165,800
Sagamore Park Road	End of pipe in Sagamore Park Road	Lowell Road	12-inch	1,100	$150,000
Pelham Road	Lowell Road	Burns Hill Road	12-inch	550	$75,000

The new transmission main in River Road will provide looping for the South Hudson area and increase the carrying capacity to the lower portion of South Hudson. The proposed 16-inch transmission main in Lowell Road between Central Street and Birch Street will increase the water capacity for South Hudson. The 12-inch transmission main in Lowell Road between Watson Road and River Road will provide redundancy and greater capacity to South Hudson. The 12-inch water main in Sagamore Park Road will loop this area of Town and improve fire flows. Replacing the 8-inch water main in Pelham Road with a 12-inch water main will improve the fire flow to the area but is considered lower priority to the CIP.

Based on the demand projections and the revised safe yield of the Litchfield wells, the Taylor Falls Pump Station will run more frequently in the future to supply water to Hudson residents. The existing 8-inch water main that delivers water into the Hudson distribution system will not be adequate for future demands. We recommend constructing a 16-inch water main in Ferry Street from the existing 12-inch water main to the 16-inch water main in Library Street.

7.4 Small Diameter Unlined Water Mains

Unlined 6- and 8-inch diameter water mains are a problem because they can reduce the fire flow capacity to a neighborhood and cause water quality problems. NHDES Guidelines and industry standards state that the smallest new pipe that should be installed in a distribution system that is providing fire flows is 8-inch. Since it is not economical to clean and line 6- and 8-inch diameter pipe, it is more cost effective to replace them with 8-inch water mains. It is therefore recommended that all unlined 6- and 8-inch diameter water mains eventually be replaced with 8-inch ductile iron water mains. It should be noted, however, that cleaning and lining is a possible option with regard to improving existing small diameter water mains where construction of a new main is physically impossible, too costly, or too disruptive to traffic. Although most of Hudson contains cement-lined pipes, there are pipes, particularly in downtown Hudson, that are anticipated to be unlined pipe. Since the exact location of these pipes is not known, we suggest the Town instruct PWW to document all internal pipe conditions in the downtown area during water main breaks or when new pipe or a hydrant or valve is installed over the next several years. This documentation can then be used to gain a clearer understanding of where unlined pipe exists and used to prioritize water main improvements. These smaller diameter water main replacements should be performed at a lower priority later in the Capital Improvement Program (CIP).

7.5 Parallel Mains to be Abandoned

There are several small diameter water mains in streets that parallel large diameter water mains. These smaller, sometimes unlined mains can be a detriment to the system for several reasons. They can collect debris and sediment because the larger parallel water mains carry the majority of the water flow. Due to numerous cross connections to the parallel mains, the older mains can also be difficult to properly flush. These older mains often tend to experience more leaks and breaks. Another problem with unlined parallel mains is that the hydrants are often connected to the larger diameter main instead of the small diameter main. This can result in an inability to properly flush the main and avoid microbial growth and outbreaks. For these reasons, we recommend that any older, unlined mains be abandoned and all services and hydrants be transferred to the newer, larger water main in the street. Abandonment should include removing the tee at the connection with the newer main. The removal of the tee will eliminate water quality problems that may arise from stagnant water in a capped tee. A capped tee is also very susceptible to breaks during excavation at some future date. The overall effect of the abandonment procedure will be an improvement in water quality and simpler system operation and maintenance. Table 7-2 shows many of the smaller diameter parallel water mains in Hudson. The Town should monitor the internal condition and consider these mains for abandonment if unlined. These abandonments should be performed at a lower priority later in the CIP.

TABLE 7-2

PARALLEL MAIN ABANDONMENT

Street	From	To	Size (inches)	Length (Feet)	YR 2001 Estimated Cost
Elm Ave	Webster St	End of 16-inch pipe in Elm Ave	6-inch	1,000	$25,000
Central St	Near Memorial Dr	Approximately 700 feet from Memorial Dr	8-inch	700	$20,000
Lowell Rd	Flagstone Dr	100 feet beyond Sagamore Park Rd	8-inch	500	$15,000
Lowell Rd	300-feet south of Sagamore Park Rd	Walmart Boulevard	6-inch	800	$20,000

7.6 Deficient Fire Flows

Insufficient fire flows in the system are caused by pipes with inadequate carrying capacity (small-diameter or low C-values) that result in high pressure losses through the pipelines at high flows. Replacing unlined cast iron mains, increasing the size of major transmission mains and/or looping existing water mains into nearby water mains can increase these fire flows. Looping of existing water mains during the replacement program will increase the flow to an area by providing better circulation and multiple supplies to the particular segment of pipe.

The 1992 ISO results provide an indication of fire flow deficiencies in the system. The current hydraulic model indicates that the 16-inch transmission main that runs through the center of town provides adequate fire flow, but areas beyond this water main experience deficiencies. The following test sites were found to be deficient during the ISO testing: Derry Street at High School; Wall Street at Central Street; Sagamore Park Road at Flagstone Drive; Webster Street at Garrison Farm Road; Library Street at School Street; Lowell Road at Riverside Avenue; Central Street at Memorial Drive; Melandy Road at Roosevelt Avenue; Pelham Road at Burns Hill Road; Lowell Road at Executive Drive; Lowell Road at Rena Street; and River Road at Pine Road.

It is important for fire safety and the insurance rating of Hudson that fire flow capacities meet or exceed the recommended minimum as established by the ISO. These improvements, therefore, become a high priority in scheduling system repairs.

- Derry Street at High School.

  The ISO test #1, performed in 1992 at Derry Street, yielded 70 percent of the recommended 5,000 gpm fire flow at 20 psi for the High School. However, according to the ISO, the Town is only responsible for maintaining 3,500 gpm at 20 psi and anything above that is the responsibility of the building owner and not calculated into the Town's insurance rating. If the Town uses the required flow of 3,500 gpm there is no flow deficiency at this location. The fire flow can improved by looping a 16-inch water main through Patricia Drive and cross-country to Derry Road at the high school. A 16-inch water main will improve the transmission system to the Marsh Road tank as well as fire flows at the school. A 16-inch water main will provide up to 4,400 gpm at 20 psi. A 12-inch diameter water main will provide up to 4,000 gpm of fire flow at 20 psi. We consider these fire flows to be excellent and recommend that the Town construct the 16-inch water main as a lower priority in the CIP. Installation of a sprinkler system in the school building will reduce the ISO required fire flows to less than 4,000 gpm at 20 psi.

- Wall Street at Central Street.

  The ISO test #2, performed in 1992 at Wall Street, yielded 36 percent of the recommended fire flow of 5,500 gpm at 20 psi for the commercial area. However, according to the ISO, the Town is only responsible for maintaining 3,500 gpm at 20 psi and anything above that is the responsibility of the building owner and not calculated into the Town's insurance rating. If the Town uses the required flow of 3,500 gpm the flow deficiency is reduced, indicating that the Town can get approximately 57% of the required flow. The hydraulic model indicates that a new tank in the Windham Road High Service area will provide the necessary fire flows required under maximum day conditions for the year 2000 and 2020.

- Sagamore Park Road at Flagstone Drive.

  The ISO test #5, performed in 1992 at Sagamore Park Road, yielded 63 percent of the recommended fire flow of 3,000 gpm at 20 psi for the commercial area. The recommended construction of a 16-inch transmission main in Lowell Road from Central Street to Birch Street and the addition of the South Hudson tank will provide the necessary fire flows to this area. Looping the 12-inch transmission main in Sagamore Park Road to the 12-inch transmission main in Lowell Road will further strengthen the fire flow to the area.

- Webster Street at Garrison Farm Road.

  The ISO test #10, performed in 1992 at Webster Street, yielded 63 percent of the recommended fire flow of 3,500 gpm at 20 psi for the commercial area. The model indicates there is adequate fire flow in the 16-inch transmission main on Elm Avenue and that the 8-inch main in Webster Street may be unlined. We recommend that the Town perform a coupon on this water main to determine the condition and replace it if in poor condition.

- Library Street at School Street.

  The ISO test #13, performed in 1992 at Library Street, yielded 57 percent of the recommended fire flow of 3,000 gpm at 20 psi for the commercial area. The hydrant was modeled on the 2-inch water main in School Street. The model indicates that replacing the 2-inch pipe in School Street with 8-inch water main will provide the necessary fire flow for this area. While the Town is replacing the 2-inch pipe in School Street from Library Street to 3rd Street, we recommend that the Town also replace the 2-inch pipe in 3rd Street.

- Lowell Road at Riverside Avenue.

  The ISO test #14, performed in 1992 at Lowell Road, yielded 53 percent of the recommended fire flow of 3,000 gpm at 20 psi for the area. A new transmission main is recommended in Lowell Road between Central Street and Birch Street to replace the 8-inch water main that currently exists. The model indicates that this new 16-inch main will provide 3,000 gpm at 20 psi to the area.

- Central Street at Memorial Drive.

  The ISO test #15, performed in 1992 at Central Street, yielded 75 percent of the recommended fire flow of 4,000 gpm at 20 psi for the commercial area. However, according to the ISO, the Town is only responsible for maintaining 3,500 gpm at 20 psi and anything above that is the responsibility of the building owner and not calculated into the Town's insurance rating. If the Town uses the required flow of 3,500 gpm the flow deficiency is reduced, indicating that the Town can get approximately 86% of the required flow. The hydrant was modeled on the 8-inch parallel main in Central Street. Abandoning this main and connecting all hydrants to the 16-inch transmission main will eliminate this flow deficiency.

- Melandy Road at Roosevelt Avenue.

  The ISO test #16, performed in 1992 at Melandy Road, yielded 57 percent of the recommended fire flow of 3,500 gpm at 20 psi for the commercial area. The model indicates that there are unlined water mains in this area. The Town should perform a coupon test on several water mains in this area to identify which water mains are unlined and should be replaced.

- <u>Pelham Road at Burns Hill Road.</u>

  The ISO test #18, performed in 1992 at Pelham Road, yielded 69% of the recommended fire flow of 3,500 gpm at 20 psi for the commercial area. The construction of a 16-inch transmission main in Lowell Road will provide adequate flow to the area. At present, an 8-inch water main in Pelham Road prevents the area from receiving a 3,500 gpm at 20 psi fire flow. Constructing a 12-inch water main in Pelham Road between Lowell Road and Burns Hill Road will alleviate this problem but should be considered a lower priority in the CIP.

- <u>Lowell Road at Executive Drive.</u>

  The ISO test #19, performed in 1992 at Lowell Road, yielded 63% of the recommended fire flow of 3,000 gpm at 20 psi for the commercial area. The recommended construction of a 16-inch transmission main in Lowell Road from Central Street to Birch Street and the addition of the South Hudson tank will allow this area to meet and exceed the 3,000 gpm at 20 psi fire flow as required by the ISO.

- <u>Lowell Road at Rena Street.</u>

  The ISO test #20, performed in 1992 at Lowell Road, yielded 63% of the recommended fire flow of 3,500 gpm at 20 psi for the commercial area. The recommended construction of a 16-inch transmission main in Lowell Road from Central Street to Birch Street and the addition of the South Hudson tank will allow this area to meet and exceed the 3,500 gpm at 20 psi fire flow as required by the ISO.

- <u>River Road at Pine Road.</u>

  The ISO test #21 performed in 1992 at River Road, yielded 43% of the recommended fire flow of 3,500 gpm at 20 psi for the commercial area. The recommended construction of a 16-inch transmission main in Lowell Road from Central Street to Birch Street, the addition of the South Hudson tank and the addition of a transmission main in River Road will allow this area to meet the 3,500 gpm at 20 psi fire flow as required by the ISO.

7.7 Dead-End Water Mains

Water main dead-ends are found in Hudson at the dead-end roads and in areas where looping has not been completed. Water can stagnate in these mains because the demands are usually small and there is little or no circulation through the mains. This will often result in poor water quality. It is recommended that, where possible, these mains be looped into a nearby main to promote circulation. It is also recommended that all developments be looped when possible.

We recommend that the Town have PWW compile a list of water quality complaints over the next 5 years. Based on this information, a priority list can be created and a looping program implemented. The looping of the dead-end mains is a lower priority than other recommendations in this chapter and can be incorporated into the CIP at a later date.

7.8 Distribution System Improvements

We recommend that the Town continue to work to install the meter pits at the connections between the Towns of Hudson, Litchfield and Pelham. The water use through these meters will enable water use to be allocated between the Towns of Hudson, Litchfield and Pelham. This will allow the Town of Hudson to bill the Towns of Litchfield and Pelham for all of the water that is used or unaccounted for in their water systems. We estimate the project cost to install these meter pits to be between $50,000 and $75,000.

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8.0 MISCELLANEOUS MAINTENANCE

8.1 General

In addition to the water main replacement program recommended in Chapter 7, we recommend that certain maintenance efforts be continued on a yearly basis. This includes adopting a set of minimum standards for piping materials, appurtenances and construction methods, systematic flushing of the distribution system, inspecting hydrants and gate valves, testing and replacing of water meters, and record keeping practices. PWW is currently doing an acceptable job of maintaining the water system and is performing many of these tasks. It is important to adopt these maintenance and record keeping practices as standard operating procedures.

8.2 System Flushing

Systematic flushing of the water distribution system; should be scheduled a minimum of once per year to help prevent rust and sediment accumulation in the distribution system. Piping frequently builds up deposits that must be removed to maintain carrying capacity of the mains and to prevent water quality problems. We recommend that the Town consider uni-directional flushing program. This is a useful tool to exercise gate valves and search for closed valves while flushing the water system. Uni-directional flushing creates higher than normal velocities and scours the walls of the pipe, thus removing scale and debris. It also creates less disturbance to the water system because the dirty water is isolated and removed from the system. Unidirectional flushing should be performed in a manner that produces flow directions opposite of normal directions. Flushing is especially important in older and dead-end mains. The volume of water used for flushing should be measured and recorded. This will enable the Town to identify how much of the water being lost in the system is unaccounted for.

8.3 Valve Inspection

All hydrants and gate valves should be inspected periodically. Both should be opened and closed to establish their condition. By checking and operating each valve it can be determined whether a valve was left in the correct position, and the condition of the valves, stems, and operators can be established. It is recommended that the Town adopt a valve-exercising program during which each hydrant and gate valve should be inspected at least once every two years, preferably in the spring or fall. It is advisable to check all hydrants after any usage. The system flushing and valve and hydrant inspection can be performed consecutively to maximize efficiency.

8.4 Water Meters

The water meter replacement program already in place in the Town should be continued. This is recommended to ensure that the cost of water service is equitably distributed among all customers, and to reduce loss of revenue to the Town that may occur if the meters are not maintained at a reasonable level of efficiency.

It is advisable to provide for more frequent tests of large meters, based on AWWA C700 recommendations, on the logical premise that an error in its registration affects revenue to a much greater extent. Older meters and those carrying the heaviest volume should be given priority in a testing program. In addition, displacement meters, which are the type most commonly used, may seriously under-register for long periods without complete stoppage. Turbine meters are poor for applications where low or variable flow rates will be experienced.

It is necessary to test meters periodically to minimize loss of revenue. The accuracy of meters in service are subject to change and may either under- or over-register. The period of time for which water meters retain overall accuracy is variable and depends mainly on the characteristics and quality of the water being measured. The rates charged for water service also have a distinct bearing on how frequently meters should be tested. Meter testing should be in accordance with AWWA standards. While it is difficult to determine the economic balance between the cost of more frequent testing and potential loss in revenue caused by meter under-registration, meter testing is necessary.

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9.0 PHASED IMPROVEMENT PROGRAM

9.1 General

In the preceding chapters, we described the various recommended improvements for the water distribution system to eliminate current system deficiencies and maintain the system in good working order. The Phase A and B recommendations in the previous chapters, totaling an estimated cost of $6,785,155 were prioritized with the most important improvements to be constructed first.

9.2 Estimated Project Costs

The estimated costs for each phase of improvements in this chapter include construction costs, engineering costs, and contingencies. The estimated costs were developed in part by using recent construction costs for towns with similar development and geographic location to Hudson. These costs were updated to an Engineering News Record (ENR) Boston index of 7133. Other sources include the 2000 Means "Building Construction Cost Data" and manufacturers' quotations. For comparison purposes, it should be noted that the estimated costs listed in this report reflect year 2001 construction cost only and no steps were taken to reflect future construction costs.

9.3 Financial Assistance

The Town can apply for federal funding to seek financial assistance for these projects. The pre-application is due in January 2002 for 2002 awards. The rankings for federally funded projects are determined in late spring/early summer with funding made available in late summer/early fall. We have spoken to state officials that have informed us this project is eligible for State Revolving Funding (SRF). Funding depends on the ranking assigned during the ranking process. There is no additional funding available at this time.

9.4 Phased Improvements Program

As described in this report, the metering of water usage, the improved functioning of the high service areas and the addition of redundancy and fire flow storage for South Hudson are the most critical improvements to eliminate existing deficiencies in the distribution system. As the system ages the magnitude and frequency of these deficiencies will increase. We have grouped the high priority improvements into Phase A as listed in Table 9-1 by the area and type of improvement. Table 9-2 summarizes the lower priority improvements (Phase B) discussed in this report. We have not attempted to schedule the Phase B improvements at this time. We have attempted to scheduled improvements to be coordinated with other Town improvement projects. The total year 2001 estimated cost for each type of improvement is included in Table 9-1.

TABLE 9-1

PHASE A IMPROVEMENTS

Schedule	Description	YR 2001 Estimated Cost
2002	Install flow meters on water supply wells with telemetry to PWW	$20,000
2002	Install flow meters at the connection to the Town of Litchfield and the Town of Pelham	$50,000
2002	Clean and redevelop Litchfield water supply wells (3 wells)	$45,000
2002	Perform Marsh Road Tank inspection	$5,000
2002	Clean sediment from Gordon Road Standpipe and perform miscellaneous improvements	$20,000
2003	Construct a 1.2 MG storage tank on Barrett Hill in the Windham Road High Service Area	$1,500,000
2003	Construct a 12-inch transmission main in Hazelwood Drive to link the Windham Road and Marsh Road High Service Areas	$700,000
2004	Improvements to Windham Road Pump Station to reconfigure it for a combined high service system	$200,000
2006	Improvements to the Compass Point Pump Station	$700,000
2008	Construct a 12-inch transmission main in River Road between Lowell Road and the end of 12-inch pipe in River Road	$400,000
2010	Construct a 0.80 MG storage tank in South Hudson	$1,000,000
2012	Construct a 16-inch transmission main in Lowell Road between Central Street and Birch Street	$455,000
2014	Construct a 16-inch transmission main in Ferry Street between Webster Street and Library Street	$115,000
2014	Construct a parallel 12-inch transmission main in Lowell Road between Watson Road and River Road	$675,000
2016	Construct a 16-inch transmission main in Patricia Drive between Laurent Drive and ending at Alvirne High School	$500,000
2018	Construct a 12-inch transmission main in Sagamore Park Road between end of pipe in Sagamore Park to Lowell Road	$150,000
TOTAL		$6,535,000

TABLE 9-2
PHASE B IMPROVEMENTS

Description	YR 2001 Estimated Cost
Construct 12-inch transmission main in Pelham Rd from Lowell Rd to Burns Hill Rd	$75,000
Abandon 6-inch water main in Elm Ave	$25,000
Abandon 8-inch water main in Central St	$20,000
Abandon 8-inch water main in Lowell Rd near Flagstone Dr	$15,000
Abandon 6-inch water main in Lowell Rd near Sagamore Park Rd	$20,000
Replace 2,400 l.f. of 2-inch water main in the School St area with new 8-inch pipe	$250,000
TOTAL	$250,155

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10.0 NEW WATER CUSTOMER ACCESS FEES

10.1 General

WSE performed an evaluation for the Town of Hudson under a separate contract to assess a fair water system access fee for new customers that connect to the Town's water system. The report as submitted in August is outlined in this Chapter.

The system access fees are a one-time fee to be paid at the time a new domestic water service connection is made to the Town's system. These fees are necessary to prevent existing customers from paying for additional capital water system expenses through increased rates that are required to serve future customers connecting to the water system. We recommend that the Town set up a separate account for these access fees that is to be used to fund capital improvement projects to the water system.

The Town of Hudson has a geographically large and complex water distribution system. The three high service areas with booster pumps and storage tanks make for an expensive water system to build and maintain. In addition to the large and complex water distribution system, the lot sizes in Hudson are large and there is a greater spacing between houses. Therefore, the housing densities are not high. Lower density development creates higher capital costs per house or service than a more densely populated town or city. Based on the purchase and value of the Town's water system of $27,000,000, and the current number of services (4,900), Hudson rate payers will pay approximately $5,500 in principal payments over the 30 year bond period for the water system, plus interest, operation costs and capital improvement expenses. We assumed that all capital improvement expenses in the future will be bonded and be paid through rates.

10.2 Water Supply Access Fee

We have assumed that the existing water supply wells are adequate to serve existing customers only, and that all new development in Town will need to pay the cost to develop a new additional water supply(s) based on the anticipated water demands of the given unit. Typical single dwelling unit costs for developing a water supply were calculated using the estimated average per dwelling unit water demand. The base fee for developing a water supply for a single-family dwelling unit is calculated at $1,500. This cost includes exploration, safe-yield analysis, land acquisition, engineering, and construction of a well or supply pump station and treatment facilities. We have assumed this is the base access fee that all new customers connecting to the Town's water system should pay.

10.3 Water Distribution System Access Fee

The water storage, pump station and distribution portions of the system are grouped together into a separate access fee category. The estimated current value of these existing facilities without the value of the water supplies is approximately $25,000,000 based on the recent purchase price from Consumers. Based on the 3-year standing in the bond, we estimate that the Town currently contains approximately $2,850,000 in equity in the water system. The new customers portion of the distribution access fee for $2,850,000 in 2001 is $413.00 per dwelling. We have assumed that the new residents and the existing residents will pay the cost to purchase the water company and perform capital improvements over the next 27 years through water rates. As time passes, residents of the Town will continue to pay down the debt from the purchase of the water system and pay for system improvements continuing to build equity in the water system. New residents of Hudson should pay existing residents based on the amount of equity the Town holds in the water system or the amount of debt that has been paid down. We have provided a chart for the Town to follow that will calculate the new residents connection fee for a single-family dwelling unit based on this equity (Table 10-1).

10.4 Combined Total Water System Access Fee

The total access fee that a new customer will pay will be their percentage of the cost to provide new water supply plus the cost to utilize the Town's water distribution system (pump stations, water mains, and storage tanks). The total fee to be paid by each new customer will be lower now because the existing residents do not have a significant amount of equity in the system. New customers that connect early in the 30-year bond program will help pay this debt down either faster or will create additional funds through their rates that enable the Town to fund capital programs. New customers will pay a larger fee later in the 30-year program to compensate existing customers to pay their fair share of the water system. We have assumed the rate of inflation over the next 30 years will equal the rate of depreciation of the water system. Therefore none of these costs were included in the cost analyses model.

These access fees are adequate for undeveloped land where the developer pays the cost to extend the water mains to the new developments. They are also adequate for land that is developed that already contains a water main adequately sized for the required domestic and fire flows that the developer can connect to. If the water main is not adequately sized for domestic and fire flows, the developer may need to pay the cost to upgrade the water main in addition to the proposed access fees. This access fee does not include the cost if the Town constructs a new water main for an existing house or development. The additional cost for the Town to do this should be assessed through a betterment fee.

The access fees for large commercial / industrial accounts should be assessed on a per account basis. The projected average day demand (gallons per day) should be determined for each commercial/industrial connection. This demand should be divided by the average single dwelling unit demand (300 gallons per day). This ratio then should be multiplied by the value located in Table 1 for the year the connection is being made. This is the proposed access fee for the commercial / industrial building.

TABLE 10-1

NEW CUSTOMER WATER SYSTEM ACCESS FEE

Year Connection is Made to Water System	Water Supply Development fee	Water Distribution Development Fee	Total Combined Connection Fee per Dwelling Unit
2001	$1,500	$467	$1,967
2002	$1,500	$659	$2,159
2003	$1,500	$851	$2,351
2004	$1,500	$1,043	$2,543
2005	$1,500	$1,236	$2,736
2006	$1,500	$1,428	$2,928
2007	$1,500	$1,620	$3,120
2008	$1,500	$1,812	$3,312
2009	$1,500	$2,004	$3,504
2010	$1,500	$2,196	$3,696
2011	$1,500	$2,388	$3,888
2012	$1,500	$2,580	$4,080
2013	$1,500	$2,772	$4,272
2014	$1,500	$2,964	$4,464
2015	$1,500	$3,156	$4,656
2016	$1,500	$3,348	$4,848
2017	$1,500	$3,540	$5,040
2018	$1,500	$3,732	$5,232
2019	$1,500	$3,924	$5,424
2020	$1,500	$4,116	$5,616
2021	$1,500	$4,308	$5,808
2022	$1,500	$4,500	$6,000
2023	$1,500	$4,692	$6,192
2024	$1,500	$4,884	$6,384
2025	$1,500	$5,076	$6,576
2026	$1,500	$5,130	$6,630
2027	$1,500	$5,185	$6,685
2028	$1,500	$5,239	$6,739

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APPENDIX A
ISO FLOW TEST RESULTS

INSURANCE SERVICES OFFICE, INC.

HYDRANT FLOW DATA SUMMARY

CITY: HUDSON STATE: NH ZIP CODE: 03051 WITNESSED BY: INSURANCE SERVICES OFFICE DATE: OCTOBER 6, 1992
COUNTY: HILLSBOROUGH

				FLOW - GPM				PRESSURE PSI		FLOW AT 20 PSI		
TEST NO.	TYPE DIST. *	TEST LOCATION	SERVICE	INDIVIDUAL HYDRANTS			TOTAL	STATIC	RESID.	NEEDED **	AVAIL.	REMARKS
1	Comm Res	Derry St. @ H. S.	MS	1440			1440	51	45	5000 750	3500	
2	Comm	Wall & Central	OWBPS	1350			1350	90	56	5500 5000 1500	2000	
3	Res	Darkhust & Glenn	PBPS	815			815	74	31	500	900	
4	Res	Butternut & Cottonwood	MS	980			980	67	53	750	1900	
5	Comm	Sagamore Park & Flagstone	MS	1430			1430	70	40	3000	1900	
6	Res	Fairway & Par Dr's.	MS	890			890	75	22	500	850	
7	Res	Winslow Farm & Pine Rds.	MS	880			880	56	17	500	850	
8	Comm	Central St. @ Bridge	MS	1225			1225	77	68	2000	3300	A
9	Res	Bonnie LA. @ Bonnie Hts.	MS	730			730	35	19	750	750	A
10	Comm	Webster & Garrison	MS	1300			1300	86	60	3500	2200	A
11	Res	Marsh & Riviera	MBPS	1165			1165	107	49	1250	1400	A
12	Comm	Central & Windham	MS	950			950	50	32	1000	1300	A

THE ABOVE LISTED NEEDED FIRE FLOWS ARE FOR PROPERTY INSURANCE PREMIUM CALCULATIONS ONLY AND ARE NOT INTENDED TO PREDICT THE MAXIMUM AMOUNT OF WATER REQUIRED FOR A LARGE SCALE FIRE CONDITION. THE AVAILABLE FLOWS ONLY INDICATE THE CONDITIONS THAT EXISTED AT THE TIME AND AT THE LOCATION WHERE TESTS WERE WITNESSED.

* Comm = Commercial; Res = Residential
** Needed is the rate of flow for a specific duration for a full credit condition. Needed Fire Flows greater than 3,500 gpm are not considered in determining the classification of the city when using the Fire Suppression Rating Schedule.

INSURANCE SERVICES OFFICE, INC.

HYDRANT FLOW DATA SUMMARY

CITY: HUDSON STATE: NH ZIP: 03051 WITNESSED BY: INSURANCE SERVICES OFFICE DATE: OCTOBER 6, 1992
COUNTY: HILLSBOROUGH

				FLOW - GPM				PRESSURE PSI		FLOW AT 20 PSI		
TEST NO.	TYPE DIST. *	TEST LOCATION	SERVICE	INDIVIDUAL HYDRANTS			TOTAL	STATIC	RESID.	NEEDED **	AVAIL.	REMARKS
13	Comm	Library & School	MS	1100			1100	60	43	3000	1700	A
14	Comm	Lowell & Riverside	MS	1135			1135	72	46	3000	1600	A
15	Comm	Central & Memorial	MS	1250			1250	65	56	4000 1500	3000	A
16	Comm	Melandy & Roosevelt Rd.	MS	1145			1145	62	47	3500	2000	A
17	Res	Fox Run & Webster	OWBPS	1060			1060	97	40	750	1200	A
18	Comm	Pelham & Burns Hill	MS	1030			1030	58	50	3500	2400	A
19	Comm	Lowell & Executive Dr.	MS	1090			1090	58	44	3000	1900	A
20	Comm	Lowell & Rena	MS	1100			1100	64	52	3500	2200	A
21	Comm	River & Pine	MS	1090			1090	80	47	3500	1500	A
22	Res	River & Winslow Farm Rd.	MS	1090			1090	80	50	500	1600	A
		A=Denote tests connected by So. N. H. Water Company & Hudson Fire Department.										
		MS=Denotes Main Service										

THE ABOVE LISTED NEEDED FIRE FLOWS ARE FOR PROPERTY INSURANCE PREMIUM CALCULATIONS ONLY AND ARE NOT INTENDED TO PREDICT THE MAXIMUM AMOUNT OF WATER REQUIRED FOR A LARGE SCALE FIRE CONDITION. THE AVAILABLE FLOWS ONLY INDICATE THE CONDITIONS THAT EXISTED AT THE TIME AND AT THE LOCATION WHERE TESTS WERE WITNESSED.

* Comm = Commercial; Res = Residential
** Needed is the rate of flow for a specific duration for a full credit condition. Needed Fire Flows greater than 3,500 gpm are not considered in determining the classification of the city when using the Fire Suppression Rating Schedule.

INSURANCE SERVICES OFFICE, INC.

HYDRANT FLOW DATA SUMMARY

CITY: HUDSON STATE: NH ZIP: 03051 WITNESSED BY: INSURANCE SERVICES OFFICE DATE: OCTOBER 6, 1992
COUNTY: HILLSBOROUGH

				FLOW - GPM			PRESSURE PSI		FLOW AT 20 PSI		
TEST NO.	TYPE DIST. *	TEST LOCATION	SERVICE	INDIVIDUAL HYDRANTS		TOTAL	STATIC	RESID.	NEEDED **	AVAIL.	REMARKS
		OWBPS=Denotes Old Windham Rd. Booster Pump Service.									
		PBPS=Denotes Prince Dr. Booster Pump Service.									
		MBPS=Denotes Marsh Rd. Booster Pump Service.									

THE ABOVE LISTED NEEDED FIRE FLOWS ARE FOR PROPERTY INSURANCE PREMIUM CALCULATIONS ONLY AND ARE NOT INTENDED TO PREDICT THE MAXIMUM AMOUNT OF WATER REQUIRED FOR A LARGE SCALE FIRE CONDITION. THE AVAILABLE FLOWS ONLY INDICATE THE CONDITIONS THAT EXISTED AT THE TIME AND AT THE LOCATION WHERE TESTS WERE WITNESSED.

* Comm = Commercial; Res = Residential
** Needed is the rate of flow for a specific duration for a full credit condition. Needed Fire Flows greater than 3,500 gpm are not considered in determining the classification of the city when using the Fire Suppression Rating Schedule.

APPENDIX B
EXISTING WATER DISTRIBUTION MAP