TOWN OF DOUGLAS, MASSACHUSETTS

WATER SYSTEM MASTER PLAN STUDY

APRIL 2009

FAY, SPOFFORD & THORNDIKE
BURLINGTON, MA

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1. INTRODUCTION

This report presents the results of our tests, investigations, calculations, and studies of the water supply and distribution facilities of the Town of Douglas, Massachusetts. The results obtained herein are the outcome of collecting and reviewing various data provided by the Town and other agencies such as population, land use and development, zoning, water production, and water use. This report was prepared in accordance with our May 2008 agreement with the Town of Douglas summarized as follows:

- Review previous studies and reports including the 1995 Master Plan, developed by Fay, Spofford & Thorndike, Inc. (FST).
- Review local zoning bylaws and other pertinent documents, and confer with Town planning officials to discuss existing and planned land usage.
- Update the existing water system map and hydraulic model to show improvements made to the water system since 1995.
- Determine the present Town population, service population, and current water requirements, and make projections through the year 2030.
- Conduct hydrant flow tests and make other system operation measurements as necessary to define system operations. Perform calculations to establish flow capacity at strategic locations in the pipe network and the carrying capacity of important existing mains.
- Investigate existing wellfields, including adequacy of current capacity, potential capacity increase of existing wells, and feasibility of rehabilitating or expanding existing wellfields.
- Determine adequacy of transmission and distribution mains, and storage facilities.
- Investigate potential growth in industrial areas of the Town. Evaluate improvement options needed to expand water service to these areas.
- Perform computer analyses of the distribution system to locate inadequacies and recommend improvements to establish system adequacy under domestic and fire flow conditions projected through the 20-year planning period.
- Develop a 20-year Capital Improvements Program, including project cost estimates, for each recommended improvement.

- Evaluate available funding sources for implementation of the recommended improvements.
- Show all recommended improvements on the Master Plan Map.
- Prepare a concise report outlining our findings and recommendations.
- Submit draft and five final copies of the Master Plan Study and Report.
- Confer with Town officials, as required, during the progress of the work.

2. WATER REQUIREMENTS

2.1 GENERAL

The factors that determine the requirements of a water supply system include the population served, type of water usage (domestic, commercial, municipal and industrial), unaccounted for water (leakage, breaks, main flushing, etc.), land use, and flows for fire protection service. The water requirements projected in this report are intended to be adequate through the year 2030, the 20-year planning period.

2.2 HISTORIC POPULATION

Evaluation of Douglas's water distribution system must take into account future as well as present populations. Any increase in population affects the water supply and distribution needs of the system.

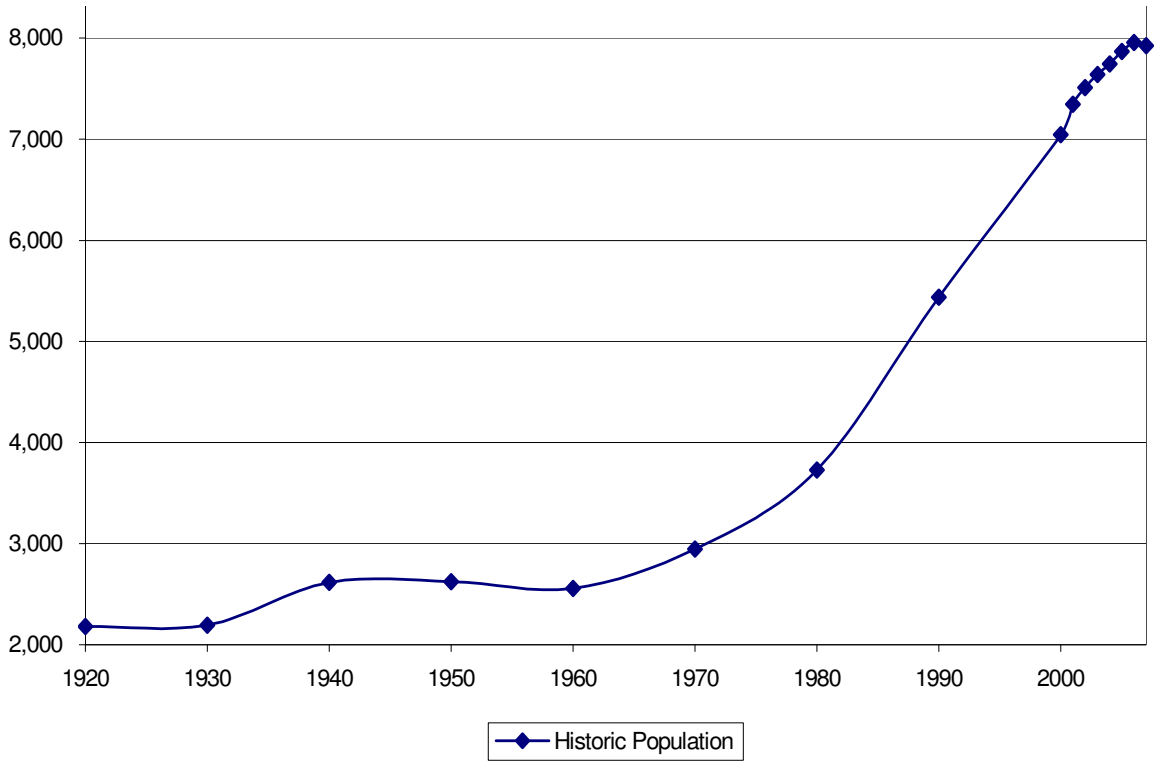
From 1920 to 2000, the Town of Douglas experienced a population increase of approximately 135%, reaching 7,045 in 2000. Since then, the population has been steadily increasing 1-2% per year, with a slight decline in 2007. In general, the population increase in Douglas is mostly due to the decentralization from urban life, or the tendency of people to move away from larger cities. With the expansion of highways, availability of transportation and telecommuting, people have begun to move away from the large cities into rural surroundings. The larger population increases in the Town of Douglas of the 1970's, 80's and 90's demonstrate this phenomenon.

Historic population data was provided by the Town of Douglas and the U. S. Census Bureau and is summarized in the following Table 2-1. Figure 2-1 shows this historic population information graphically.

Table 2-1: Historic Population – Town of Douglas

Year	US Census Population	% Change
1920	2,181	
1930	2,195	0.6%
1940	2,617	19%
1950	2,624	0.3%
1960	2,559	- 2.5%
1970	2,947	15%
1980	3,721	26%
1990	5,438	46%
2000	7,045	30%
2001	7,347	4.3%
2002	7,510	2.2%
2003	7,642	1.8%
2004	7,746	1.4%
2005	7,869	1.6%
2006	7,957	1.1%
2007	7,924	-0.4%

Figure 2-1: Historic Population – Town of Douglas



2.3 POPULATION PROJECTIONS

To get a better understanding of future population growth in the Town of Douglas, FST used an arithmetic method to make projections. This method is based on the rate of population change experienced in the past. The rate of change is divided by the time over which this rate of change occurred, to obtain a K value. A K value was obtained at ten-year increments from 1920 to 2000, and one-year increments for the years up to and including 2007 for the Town of Douglas. These values were then multiplied based on a factor that was directly related to the year when this change occurred. These weighted K values were then summed to ascertain a total K value for the successive annual increments from 1920 to 2007. This K value could then be multiplied by any time in the future and the product added to the present population to obtain a projection. Table 2-2 shows the results of the steps used to determine a K value for the Town.

Table 2-2: Determination of K Value

Year	Population	dP	dT	K=dP/dT	Weight	Weighted K
1920	2,181					
1930	2,195	14	10	1.4	1	0.014
1940	2,617	422	10	42.2	1	0.422
1950	2,624	7	10	0.7	1	0.007
1960	2,559	(65)	10	-6.5	1	-0.065
1970	2,947	388	10	38.8	5	1.94
1980	3,730	783	10	78.3	7	5.481
1990	5,438	1,708	10	170.8	7	11.956
2000	7,045	1,607	10	160.7	10	16.07
2001	7,347	302	1	302	10	30.2
2002	7,510	163	1	163	10	16.3
2003	7,642	132	1	132	10	13.2
2004	7,746	104	1	104	10	10.4
2005	7,869	123	1	123	10	12.3
2006	7,957	88	1	88	10	8.8
2007	7,924	(33)	1	-33	7	-2.31
						K Value =124.715

Using the K value determined above in the following equation, the various projections were obtained and are shown in Table 2-3 below.

Pt = Po + Kt: Where Pt is equal to the population at some time in the future, Po is the

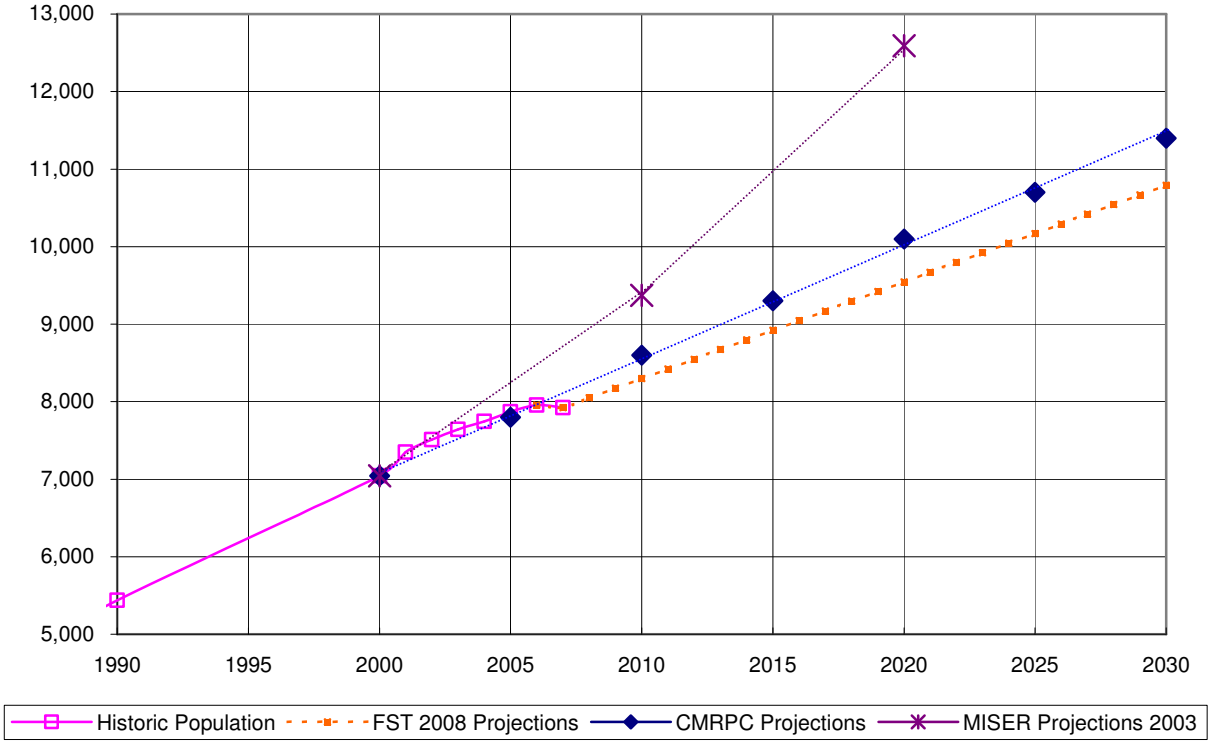
present population and t is the period of the projection.

The Massachusetts Institute of Social and Economic Research (MISER) and the Central Massachusetts Regional Planning Commission (CMRPC) also prepare population estimates for the Towns and Cities of Massachusetts to use for planning purposes. MISER's and CMRPC's most recent population projections are shown in Table 2-3, as are FST's projections using the above stated methodology. FST's projections will be used to project future water consumption in the Town of Douglas. This data is displayed with the recent historical Census data in Figure 2-2.

Table 2-3: Population Projections – Town of Douglas

Year	FST 2008 Projections	MISER 2003 Projections	CMRPC Projections
2010	8,298	9,370	8,600
2015	8,922		9,300
2020	9,545	12,591	10,100
2025	10,169		10,700
2030	10,792		11,400

Figure 2-2: Population Projections – Town of Douglas



2.4 SERVICE RATIO

To make projections on water consumption, we need to look at the percentage of the population that is served by the public water system. Since the Town doesn't provide public water to all its citizens, a service ratio must be determined. A service ratio can be calculated by dividing the Town Population by the population serviced by the Town's water system. To properly project the population served, an average of service ratios over the last ten years is calculated in Table 2-4 below.

Table 2-4: Estimation of Service Ratio – Town of Douglas

Year	Town Population	Service Population	Service Ratio
1991	5,296	2,383	0.45
1992	5,783	2,429	0.42
1993	6,032	2,473	0.41
1994	6,141	2,518	0.41
1995	6,291*	3,100	0.49
1996	6,441*	3,135	0.49
1997	6,591*	3,150	0.48
1998	6,741*	3,150	0.47
1999	6,891*	3,154*	0.46
2000	7,045	3,158*	0.45
2001	7,347	3,162*	0.43
2002	7,510	3,166*	0.42
2003	7,642	3,170	0.41
2004	7,746	3,170	0.41
2005	7,869	3,170	0.40
2006	7,957	3,170	0.40
2007	7,924	3,170	0.40

* Estimated with straight-line interpolation

While projecting a service population, the years from 2000 to 2007 are considerably more important than those preceeding, similar to developing the K value for the population projections. Taking an average of the results between 2000 and 2007 yields a service ratio for the Town of Douglas of 0.42. Table 2-4 also reveals that although the Town population has been steadily increasing, the percentage of population served with public water

has remained fairly stable. This may be a result of more development in areas of Town that are not served by the Town's water system. This historic data suggests that the service ratio method should closely project the future consumption of the water supplied by the Town.

2.5 LAND USE

The amount of land available for development has been determined based on current zoning. There are about 24,475 acres of land in the Town, divided into seven zoning districts. The seven zoning districts are defined below. Table 2-5 below shows a summary of the total useable acreage for each of these zoning districts based on current zoning. Useable acreage is that portion of a given zoning district that has no obvious restrictions that would prohibit development and includes land which is already developed. For the purposes of this report, we have assumed that areas of wetlands and/or 100-year floodplains are not useable. Also, taken into account when determining useable acreage is protected land which comprises about 19% of the Town of Douglas, or 4,650 acres. The acreage of the wetlands and floodplains (1,650 ac) and protected land (4,650 ac) result in a total of 6,300 acres of non-useable land in the Town. These areas were determined from the most recent FIRM Flood Insurance Rate Maps, USGS quadrangle sheets, and the Town's mapping website.

Table 2-5: Land Use (Acres)

Zone Code	District	% of Town	Total Acres	Useable Area *
C	Commercial	1.2	294	218
CB	Central Business	0.2	49	36
I	Industry	9.8	2,399	1,781
RC-1	Residential Commercial One	0.5	122	91
RC-2	Residential Commercial Two	2.8	685	509
VR	Village Residential	9.1	2,227	1,654
RA	Rural Agricultural	76.4	18,699	13,886
Total		100.0%	24,475	18,175

* Useable area includes both developed and undeveloped land.

As can be seen from Table 2-5, we estimate that approximately 18,175 acres of land in Town are available for development. Of this amount, just over 16,000 acres are available for residential development. Table 2-6 shows the potential for additional residential development, based on current minimum zoning requirements.

Table 2-6: Potential Residential Development

Zone Code	District	Minimum Lot Size	Useable Area Acreage (Square Feet)	Potential Dwelling Units
RC-1	Residential Commercial One	20,000 sf	91 ($3.9*10^6$)	198
RC-2	Residential Commercial Two	90,000 sf	509 ($22.2*10^6$)	246
VR	Village Residential	20,000 sf	1,654 ($72.0*10^6$)	3,602
RA	Rural Agricultural	90,000 sf	13,886 ($605*10^6$)	6,720
Total			16,140 ($703.1*10^6$)	10,766

This Table shows a total of 10,766 potential residential dwelling units available in the Town of Douglas. Applying the population density for the Town of Douglas obtained from the Central Massachusetts Regional Planning Commission (CMRPC) of 2.85 persons per dwelling to the total number of dwelling units available, we obtain an ultimate or saturation population of 30,683. This saturation population is approximately 3.8 times the current population. Maintaining the 42% water system service ratio, results in a service population of 12,887. These numbers reveal the tremendous potential for growth that the Town of Douglas possesses.

2.6 WATER CONSUMPTION PROJECTIONS

Projections of population served by the Town provide the basis for projecting water consumption and assessing system needs. Water consumption is typically comprised of residential,

commercial, municipal, and industrial demands as well as unaccounted for water. A breakdown of demand types and a brief description of each are shown below:

Domestic:	Water used in residences and apartments, for drinking, bathing, sanitation and lawn watering;
Commercial	Water used in restaurants, service stations and retail establishments;
Industrial:	Water used in manufacturing and warehousing facilities;
Municipal:	Water used by Town-owned facilities;
Unaccounted for:	Water that includes all unmetered uses, such as system leakage, hydrant flow for fire protection, flushing, and other uses (street cleaning, public landscaping, meter inaccuracy, etc).

When demand usage is estimated for a water system, multiple values are calculated including average day, maximum day and peak hour demands. The average daily rate of consumption, which represents the average amount of water delivered by the system over the course of a typical day, is used to determine adequacy of system supplies. The maximum daily rate of consumption, which represents the maximum amount of water delivered by the system in any given 24-hour period, is used to determine the adequacy of pumping facilities and system piping. Peak hour rate of consumption, which is the maximum water delivered by the system over an hour period and maximum daily demand plus fire flow requirements are used to determine the adequacy of storage facilities, transmission mains and distribution mains.

2.6.1 Domestic Water Consumption

Population, land use restrictions and water consumption habits collectively influence the pattern of domestic (residential) water use. Since it is primarily dependent on the population served, domestic water consumption is often expressed in terms of gallons per capita per day (gpcd). As stated in Section 2.4 previously, approximately 42% of the population of the Town of Douglas is served by the public water supply.

Projected future water use is essential in determining the future reliability of the system. The

following method was used for determining future residential demand:

1. Consumption records from 1991 to 2007 were supplied by the Town and are summarized in Table 2-7 below.
2. The historical residential demand (gpd) was divided by the service area population to determine the historical per capita residential demand (gpcd).
3. The average historical per capita residential demand was multiplied by the projected service population calculated for the future planning years.

Table 2-7: Historical Residential Per Capita Water Demand

Year	Population Served	Residential GPD	GPCD
1991	2,383	175,931	73.8
1992	2,429	183,421	75.5 (high)
1993	2,473	169,206	68.4
1994	2,518	172,131	68.4
1995	3,100	173,492	56.0
1996	3,135	199,309	53.6 (low)
1997	3,150	215,822	68.5
1999	3,154*	217,952	69.1
2000	3,158*	203,825	71.0
2001	3,162*	226,343	71.5
2002	3,166*	212,302	67.0
2003	3,170	223,004	70.3
2004	3,170	221,262	69.8
2005	3,170	220,965	71.0
2006	3,170	204,590	64.5
Average			**67.5**

* Estimated data; No data 1998, 2007

As shown in this Table, the per capita residential consumption rate has varied between a low of 53.6 and a high of 75.5 gpcd. The increase of programs designed to educate users of the benefits of reducing water use have possibly contributed to the relative downward trend in per capita consumption in the Town. In projecting the future domestic water consumption, it will be

assumed that the per capita consumption will be 68.0 gpcd. While this is a conservative estimate, FST encourages the Town to educate its residents in areas of water conservation to reduce this number further. Table 2-8 shows the estimated domestic consumption rates into 2030 using a per capita water demand of 68.0 gpcd.

Table 2-8: Residential Water Consumption Projections

Year	Estimated Town Population	Estimated Service Population	GPCD	Total Res. Usage (Gallons/Day)
2010	8,298	3,485	68.0	236,980
2015	8,922	3,747	68.0	254,796
2020	9,545	4,009	68.0	272,612
2025	10,169	4,270	68.0	290,360
2030	10,792	4,532	68.0	308,176

2.6.2 Commercial Water Consumption

Commercial water consumption is that which supplies water to restaurants, retail establishments, banks, and other similar facilities. The level of commercial development is difficult to project because of the many factors involved. Since commercial establishments often serve the general public, it is reasonable to deduce that an increase in population would correspond to an increase in commercial water usage. One approach for making commercial water consumption projections is to approximate commercial usage in terms of the relationship between commercial activity and the population which sustains it. Over the historic period, we have found that commercial consumption has been approximately 4% of the residential consumption (3% of the total water consumption). Since commercial establishments often serve the general public, it is reasonable to deduce that an increase in population would correspond to an increase in commercial water usage. We will assume that the commercial water demand will remain constant at approximately 4% of the residential water demand throughout the planning period. Table 2-9 shows the projected average daily commercial water consumption through the year 2030.

Table 2-9: Projected Commercial Water Consumption

Year	Commercial Consumption (Gallons / Day)
2010	9,479
2015	10,192
2020	10,904
2025	11,614
2030	12,327

2.6.3 Municipal Water Consumption

Municipal water consumption includes the facilities and offices that use water and are owned by the Town. Municipal consumption generally accounts for only a small portion of the total demand. Using the same methodology as previously described, we have found that municipal consumption is approximately 6% of the residential consumption (4% of the total water consumption) over the historic period. For planning purposes, we have assumed that the municipal water usage will remain constant at 6% of the residential consumption through the planning period. Table 2-10 shows the projected average daily municipal water consumption through the year 2030.

Table 2-10: Projected Municipal Water Consumption

Year	Municipal Consumption (Gallons / Day)
2010	14,219
2015	15,288
2020	16,357
2025	17,422
2030	18,491

2.6.4 Industrial Water Consumption

Industrial consumption is less dependent upon population than domestic or commercial consumption and is influenced more by available water supply, access to transportation

corridors and the state of the economy. Industrial consumption in Douglas has decreased considerably, from 6.5% to 1.5% of the total water consumption from 1996 to 2007. This is due to the closing of the Guilford Industries Plant, the only large industrial user in Town. Currently the industrial consumption makes up only 1% (2,370 gpd) of the total consumption. FST is projecting that approximately 20% of the land that is available for industrial development (385 of 1,781 acres) will become developed and occupied by industrial users during the planning period (See Section 4.9), thereby significantly increasing the industrial water usage by 2030. We have assumed that the industrial water consumption will grow from 2,370 gpd in 2010 to 41,582 gpd in 2030. The following Table 2-11 shows our projected average daily industrial water consumption through the year 2030.

Table 2-11: Projected Industrial Water Consumption

Year	Industrial Consumption (Gallons / Day)
2010	2,370
2015	12,173
2020	21,976
2025	31,779
2030	41,852

2.6.5 Unaccounted For Water

Unaccounted for water is often difficult to quantify. It typically consists of water used for hydrant flushing and fire fighting as well as leaks and water main breaks. It is generally calculated as the difference between the volume of water supplied to the system and the volume of water passing through the customers' meters. Historically since 1995, the unaccounted for water in the Town of Douglas has ranged from 6% to 16% of the total water consumption. We will use an average of 11% of the total water consumption to project the unaccounted for into the 20-year planning period. following Table 2-12 shows our projected average daily unaccounted for water use through the year 2030.

Table 2-12: Projected Unaccounted Water Use

Year	Unaccounted for Water Use (Gallons / Day)
2010	28,935
2015	32,169
2020	35,406
2025	38,629
2030	41,863

2.7 TOTAL WATER REQUIREMENTS

One of the objectives of this report is to estimate future water demands and use these demands to determine if current water system supply and distribution facilities are adequate. If inadequacies are found, a plan for system improvements can be developed and implemented.

Estimated future demands include residential, commercial, industrial, municipal and unaccounted for water usage. Residential demand is dependent on changes in population and accounts for the majority of the water used in the Town of Douglas. Commercial and industrial demand depends on changes in economic development. As population and commercial and industrial activity increase, the amount of water needed increases. By estimating the future residential, commercial, municipal and industrial demands and knowing the percentage of total demand represented by the unaccounted for water, the future total demand was calculated.

2.7.1 Average Daily Demand

Estimates of average daily demand for the various usage categories, through the 2030 planning period, are presented in Table 2-13. Figures 2-3 and 2-4, below, show the historic and projected demands graphically.

Table 2-13: Projected Future Water Demand (GPD)

Year	Residential	Commercial	Municipal	Industrial	Unaccounted For	Total
2010	236,980	9,479	14,219	2,370	28,935	291,983
2015	254,796	10,192	15,288	12,173	32,169	324,618
2020	272,612	10,904	16,357	21,976	35,406	357,253
2025	290,360	11,614	17,422	31,779	38,629	389,804
2030	308,176	12,327	18,491	41,852	41,863	422,439

Figure 2-3: Historic Water Consumption

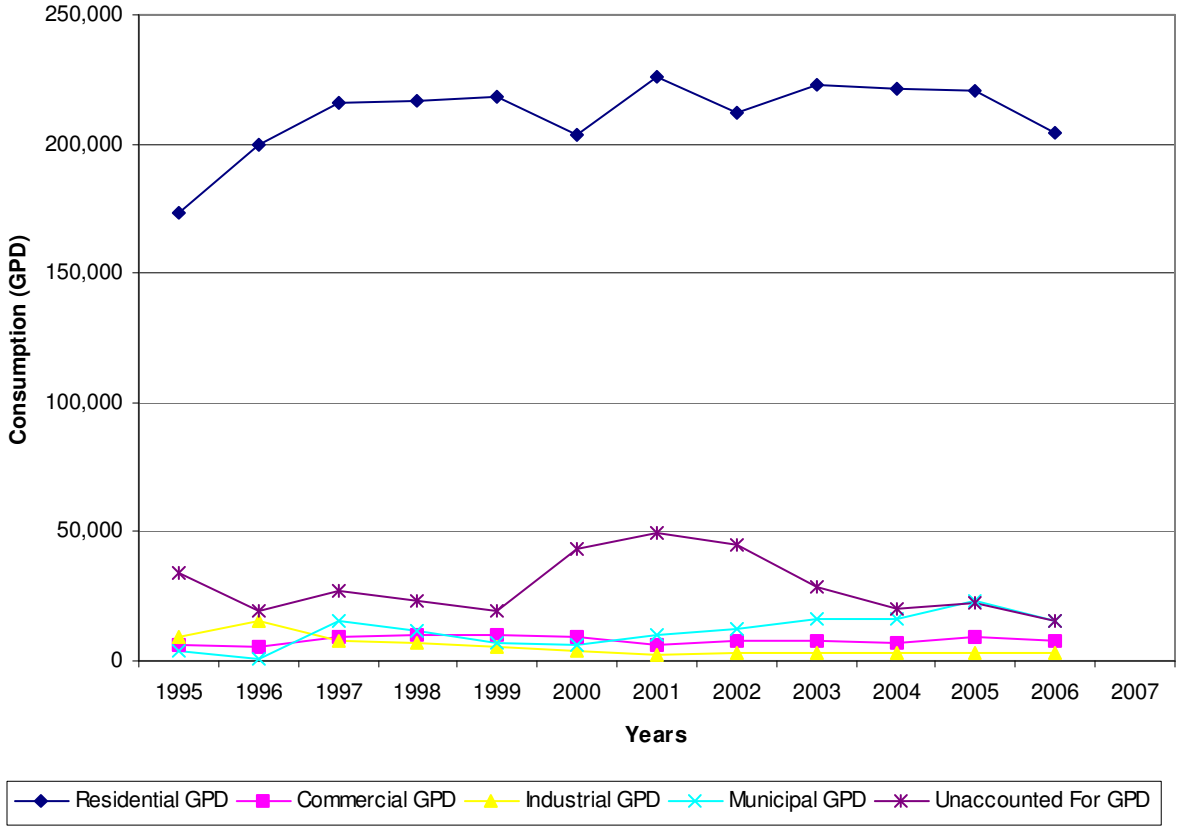
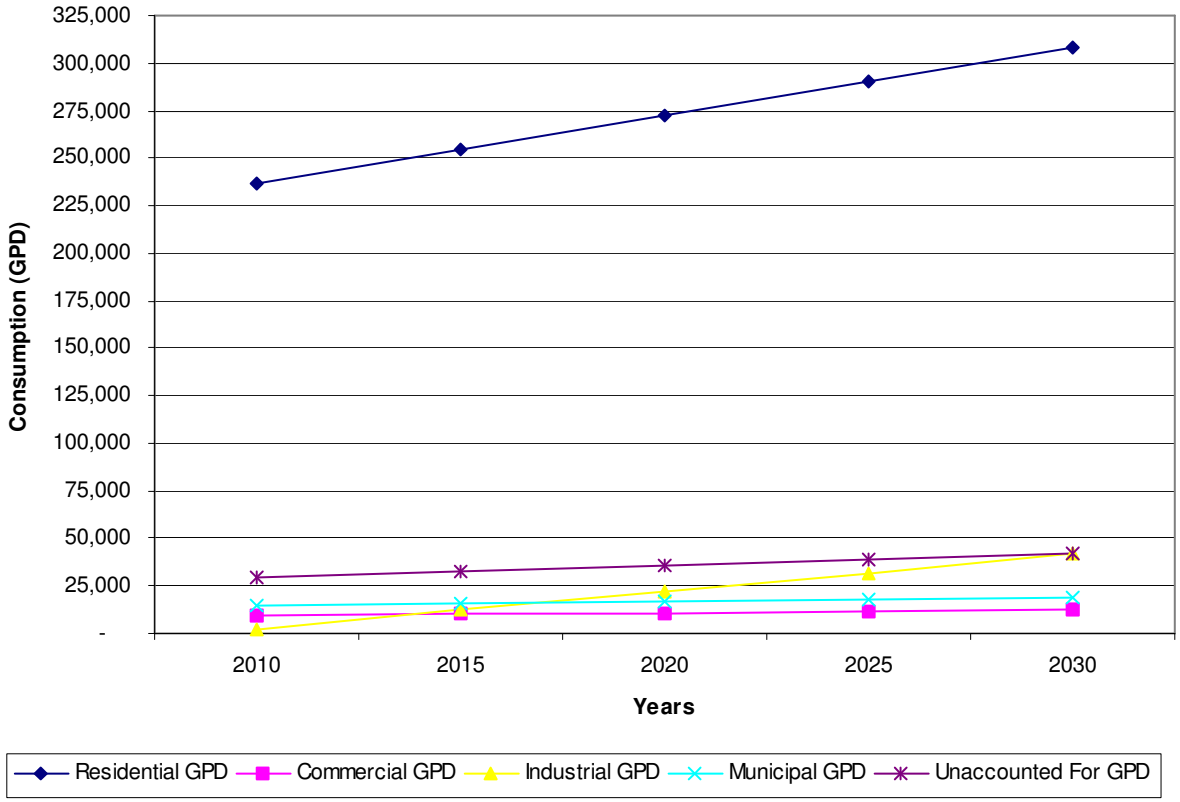


Figure 2-4: Projected Water Consumption



2.7.2 Maximum Daily Demand

Maximum daily rates of consumption are used to determine the adequacy of the supply sources and pumping facilities. Maximum daily demand is the largest volume of water used over a single 24-hour period during the year. It is determined from records and is expressed as a ratio of the average day, typically ranging from 1.4 to 2.5. In addition, this ratio is also a function of the relative importance of each component of the total demand: domestic, commercial, municipal and industrial. The ratio of maximum to average daily consumption is generally higher for residential use than it is for industrial and commercial use. Industry normally uses water at a relatively constant rate each day. Domestic consumers can easily double or triple their average daily consumption by such activities as lawn watering, car washing, and swimming pool filling. Water supply statistics on the maximum daily rate of demand are included in Table 2-14.

Table 2-14: Historic Maximum Day Demands

Year	Average Daily Demand (MGD)	Maximum Daily Demand (MGD)	Maximum Day Factor
1995	227,613	357,300	1.57
1996	240,711	394,600	1.64
1997	275,986	526,100	1.91
1998	282,931	495,700	1.75
1999	260,548	570,600	2.19
2000	265,117	447,400	1.69
2001	295,044	555,900	1.88
2002	279,757	497,700	1.78
2003	278,852	479,700	1.72
2004	267,995	452,800	1.69
2005	278,983	541,500	1.94
2006	254,065	546,500	2.15
Average			**1.83**

2.7.3 Maximum Hourly Demand

The maximum hourly or peak hour consumption is the maximum volume of water used over a single 60-minute period during any given day. It is typically used along with maximum daily rate of consumption plus fire flow to determine the adequacy of distribution storage facilities and transmission and distribution mains. Like maximum daily demand, peak hour consumption is typically projected by calculating the ratio of peak hour to average day demand and multiplying that value by the projected average day consumption.

Historically Douglas's maximum hourly consumption is 2.5 times the average rate of consumption for the day. To estimate future peak hour demands into the 20-year planning period, a peak hour to average day ratio of 2.50 will be used. Table 2-15 shows the current and projected water consumption rates we have adopted.

Table 2-15: Total Projected Water Requirements (MGD)

Demand Type	2006*	2010	2015	2020	2025	2030
Average Day	0.254	0.291	0.325	0.357	0.389	0.422
Maximum Day (1.83 x Average Day)	0.546	0.534	0.594	0.654	0.713	0.773
Peak Hour (2.5 x Average Day)	0.635	0.730	0.811	0.893	0.975	1.056

* Actual values

2.8 CONCLUSIONS

The projected water requirements have been estimated to continue to increase over the planning period. The Town of Douglas has experienced moderate growth over the past decade, but that appears to be slowing. Any new proposed developments should be carefully evaluated to determine the overall impacts on the water system. Total supply sources need to provide the Town with 0.422 MGD in the year 2030.

Maximum daily rates are used to determine the adequacy of the supply source(s) and pumping facilities. Typically, it is assumed that maximum daily rates will need to be met for three consecutive days. The total supply system and pumping facilities must be capable of supplying 0.773 MGD, for three consecutive days, in the year 2030.

Peak hour rates along with maximum daily demand and fire flow requirements are used to determine the adequacy of storage facilities, transmission mains, and distribution mains. The total supply, storage facilities, and distribution system need to support peak flows of 1.056 MGD in the year 2030.

3. WATER SUPPLY SYSTEM

3.1 GENERAL

The Town of Douglas provides drinking water to slightly less than half of the Town's population. The service population of the Town fluctuates slightly between approximately 3,100 and 3,170 depending on the season. The wells and corresponding pumping facilities provide the water source for the distribution system. The distribution system is divided into a high-pressure and a low-pressure zone. The low-pressure zone typically operates at a hydraulic gradeline of 602.0 feet and the high-pressure zone at 714.5 feet. Two (2) water storage facilities provide a total of 1.0 million gallons of storage for the system, one in each of the pressure zones. Overall, there are approximately 20 miles of water mains, ranging from 2-inch to 16-inch diameter.

3.2 WATER SUPPLY FACILITIES

The Town of Douglas has three gravel-packed wells and one tubular wellfield, with a total capacity of just over 1 MGD. These wells are in an aquifer that extends over much of East-Central Douglas. The main wellfield consists of eleven 2-1/2 inch wells and two 6-inch wells. The pump station uses a suction header attached to two centrifugal pumps to draw water out of these wells and pump it into the distribution system. The main wellfield produces approximately 240 gallons per minute (gpm). The second well is a 12-inch by 24-inch gravel packed well with a six stage vertical turbine pump. Historical data indicates that this gravel packed well produces approximately 200 gpm. The newest wells and pump station are located off of Glen Street. These wells went on-line in 1995. This pump station consists of a 24-inch x 48-inch diameter well and a 10-inch x 16-inch diameter well. The pump for Well #1 (24-inch well) consists of a deep well turbine pump that produces 135 gpm. The pump for Well #2 (10-inch well) is a submersible well pump that produces 160 gpm. This source supplies approximately 295 gpm into the system.

The locations of these water supply facilities are shown on the Master Plan located at the back of this report. Water supply sources are tabulated below:

Table 3-1: Sources of Supply

Description	Location	Operating Status	Type	Rated Pump Capacity
Main Wellfield	West Street	Active	Tubular	240 gpm (0.35 MGD)
Gravel-Packed Well	West Street	Active	Gravel-packed	200 gpm (0.29 MGD)
Glen Street Well #1	Glen Street	Active	Gravel-packed	135 gpm (0.19 MGD)
Glen Street Well #2	Glen Street	Active	Gravel-packed	160 gpm (0.23 MGD)
			Total	735 gpm (1.06 MGD)

Table 3-2 below shows the amount of water pumped from each source over the past several years.

Table 3-2: Historical Water Production (Gallons)

Year	West Street Main Wellfield	West Street Well	Glen Street Well #1	Glen Street Well #2	Total
1995	39,180,600	43,898,100	-	-	83,078,700
1996	25,988,500	25,001,700	17,239,200	19,630,200	87,859,600
1997	33,617,000	28,844,600	18,008,300	20,265,100	100,735,000
1998	21,092,700	29,296,500	25,046,700	27,833,800	103,269,700
1999	28,861,800	23,623,600	20,395,000	22,219,700	95,100,100
2000	31,474,600	21,020,900	20,727,000	23,545,200	96,767,700
2001	41,119,400	21,798,100	20,782,600	23,990,900	107,691,000
2002	30,821,300	35,077,900	16,837,900	19,374,100	102,111,200
2003	28,951,600	35,516,100	17,643,100	20,017,600	102,128,400
2004	28,928,800	34,022,300	15,543,000	18,137,200	96,631,300
2005	29,045,700	33,921,800	17,840,800	21,020,600	101,828,900
2006	26,528,400	31,920,100	15,612,900	18,672,500	92,733,900

According to the Department of Environmental Protection and in accordance with the Water Management Act, the Town of Douglas is registered to withdraw 0.20 MGD and permitted to

withdraw an additional 0.17 MGD, for a total of 0.37 MGD through February 2009. A new permit will be issued shortly with revised permitted withdrawal amounts. FST has projected the 2030 average day water demand to be 0.422 MGD, which is higher than the current permitted amount of 0.37 MGD.

3.2.1 Adequacy of Water Supply

The adequacy of a water supply source, pumping and transmission facilities is determined by their ability to supply the maximum daily flow while maintaining storage levels full. The ability of supply to deliver the required flows is dependent upon the size and condition of the transmission mains and hydraulic grade line elevation at the supply source. The water consumption trends and projections of the Town have been analyzed and documented in a previous section of this report. Based on these projections, it appears the Town can meet its increases in demands for this planning period with its current supply sources. The rated pumping capacity of the system is approximately 735 gpm (1.06 MGD). This is above the projected 2030 average day, maximum day and peak hour water demands.

3.2.2 Expansion of Existing Sources

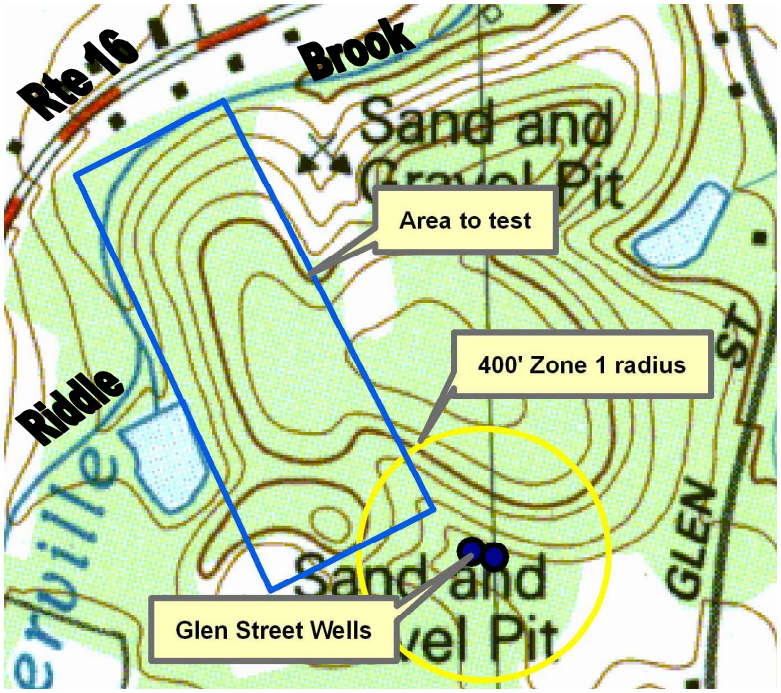
While the Town has sufficient water to meet its 2030 projected demands, it also has opportunities to develop additional sources of water. These opportunities lie near the existing sources and in areas identified by a previous hydrogeologic evaluation performed for the Town in 1986. Additionally, the Town has opportunities for additional water supply development at its existing well sites.

3.2.2.1 Glen Street Wells

The two Glen Street Wells supply approximately 295 gpm into the system. They are located along the southern edge of a large sand & gravel deposit that extends north toward Riddle Brook. The Town-owned parcel that the wells are located on extends to the brook west of the sand and gravel pit. Additional test wells are recommended for this area within the Town-owned parcel, particularly on the north end by the brook. A well in this area could take advantage of induced

recharge from the brook and cause less interference with the existing wells.

Figure 3-1: Glen Street Wells

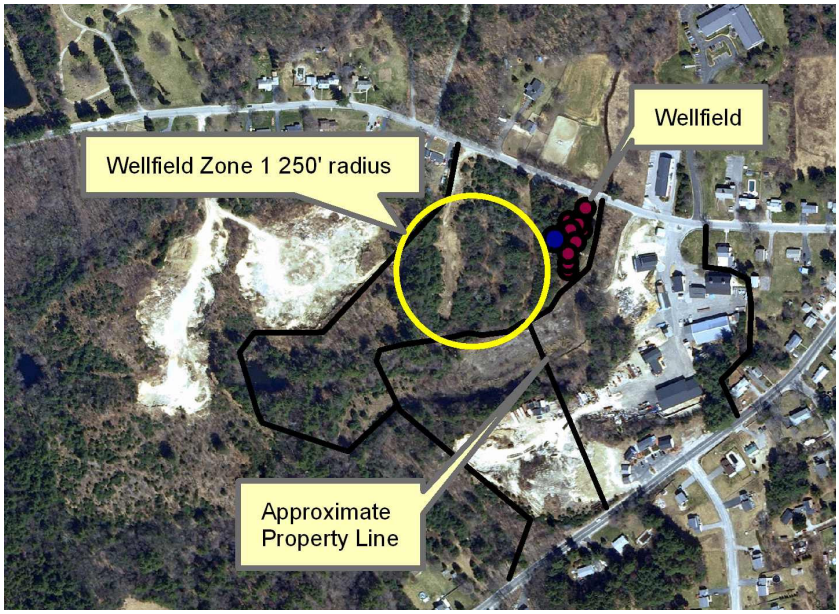


3.2.2.2 West Street Wellfield

The main wellfield on West Street consists of eleven 2-1/2 inch wells and two 6-inch wells connected by a suction header attached to two centrifugal pumps that draw water out of these wells and pump it into the distribution system. The main wellfield produces approximately 240 gallons per minute (gpm). The wells sit less than 250 feet from the road and an adjacent property. Further development of the existing wellfield appears limited by its proximity to the property line, as DEP has been reluctant to allow the Town to replace these wells. However, the remainder of the property may allow for additional wells. The property may have room west of the existing pump station to expand the wellfield. A 250-foot circle representing the required Zone 1 protective radius required by DEP just fits on the property west of the pump station. The entire property and the gravel pit west of the wellfield sit on the same glacial feature as the wellfield and represents an area recommended for testing. The Town would have to acquire additional land, to expand the wellfield onto that property. The installation of test wells on the

Town's property is recommended to evaluate the potential for expansion.

Figure 3-2: Main Wellfield on West Street

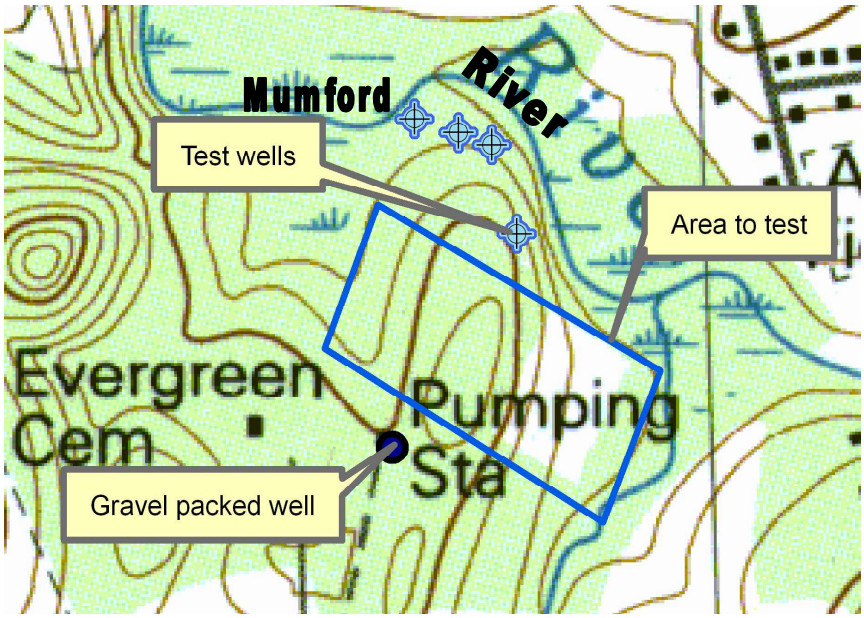


3.2.2.3 West Street Gravel Packed Well

The gravel packed well off of West Street also has potential for additional well sites. The existing well is a 12-inch by 24-inch gravel packed well and produces approximately 200 gpm. It is the Town's only source near the Mumford River. The well is in a north-south elongated glacial sand and gravel feature. The Town installed four 2 ½" test wells north of this well in 1986, with disappointing results. It is FST's opinion that these four wells were installed along the margin of this feature and missed the sand and gravel. These former test well sites are shown on Figure 3-3. Additional test wells are recommended north of the gravel packed well to define the extent of the sand and gravel and evaluate further the opportunities for added production from this area.

One test well reached a depth of approximately 90 feet, which is significantly deeper than the gravel packed well. This indicates the presence of a deep buried glacial channel along the river. This channel also represents a feature to consider for additional testing.

Figure 3-3: West Street Gravel Packed Well



3.2.2.4 Additional Sites

A previous hydrogeologic evaluation performed for the Town (Comprehensive Evaluation of Groundwater Resources, Douglas, Massachusetts, June 1986, GSC) identified eleven potential well sites to test. The Town tested two of these locations. Testing at the second one lead to the development of the two Glen Street wells. As these wells provided the desired yield, the Town did not test the other nine. All of them are located within delineated aquifer protection areas. It is recommended that the Town also consider further evaluation of these additional sites after conducting the recommended testing near its existing sources.

3.2.3 Conclusions

The Town of Douglas has adequate supply capacity to meet its 2030 projected demands. It is desirable for a water supply system to be able to provide its maximum day demand while pumping only 18 hours per day. This provides a margin of safety for the system and allows the sources to be put offline for regeneration or maintenance. For an 18-hour pumping period, the Town supplies are capable of pumping 793,800 gallons per day (0.793 MGD). With this supply capacity, the Town is still capable of meeting future maximum day demands (2030 max day =

0.773 MGD) while operating pumps for only 18-hour periods. Sources currently produce excellent quality water with little chemical treatment needed. These reasons lead us to believe that the Town supply is sufficient and no new provisions for water supply need to be considered at this time. However, it would be prudent for the Town to continue to search for new supply sources so these areas could be purchased and protected for future use.

3.3 WATER QUALITY AND TREATMENT

The Town's ground water sources produce excellent quality water, therefore very little treatment is needed. Potassium Hydroxide is added at the wells to provide for corrosion control and pH adjustment. While the Town's water is currently in compliance with all the regulations of the Safe Drinking Water Act (SDWA), it is important to consider potential upcoming drinking water treatment requirements.

The EPA promulgated the Final Groundwater Rule (GWR) in 2006 that applies to public water suppliers that produce and serve groundwater, and those that that mix surface water and groundwater. The purpose of the rule is "to reduce the risk of exposure to fecal contamination that may be present in public water systems that use ground water sources." The GWR establishes a "risk-targeted strategy to identify ground water systems that are at high risk for fecal contamination." The GWR also specifies when corrective action (which may include disinfection) is required to protect consumers who receive water from ground water systems from bacteria and viruses.

The four major components of the GWR include periodic sanitary surveys of the system; source water monitoring to test for *E. coli*, enterococci, and coliphage; corrective actions to be taken depending on deficiency or contamination (deficiency correction, elimination of contamination, alternative source water, treatment addition.); and monitoring to ensure treatment is achieving adequate contaminant removal.

The Town may consider evaluating the addition of disinfection facilities at each of the well locations to reduce the risk of exposure to fecal contamination of the system's drinking water.

3.4 AQUIFER PROTECTION

The Town of Douglas has developed an aquifer protection overlay district as part of its zoning by-laws. Its purpose is "To promote and protect the health, safety and general welfare of the Community by preserving and protecting surface and groundwater resources of the Town. It is necessary to prevent contamination of these water supplies from any use of land or building which may reduce the quality and/or quantity of the water resources." The by-law applies to the Water Resource District as delineated in 1986. The bylaw has permitted uses, prohibited uses and special permits. It generally follows an example by-law from DEP.

The bylaw defines the Water Resource District as "Regions that include primary recharge areas, and secondary recharge areas." The definitions of the recharge areas are:

> ***Primary Recharge Area:*** Those areas surrounding municipal wells including the stratified deposits in the area which are affected by a projected cone of influence that would develop by pumping the wells continuously (24 hours a day) for 180 days.
>
> ***Secondary Recharge Area:*** Those areas of stratified drift outside, but upgradient of the projected 180 day cone of influence. The water contained therein will eventually intersect and flow into the cone of influence thereby providing secondary recharge to the well.
>
> ***Tertiary Recharge Area:*** The areas of adjacent and upgradient glacial till which supply groundwater to the stratified drift deposits identified in the primary and secondary recharge areas.

Per the definitions in the by-law, the water resources district applies only to recharge areas contributory to municipal wells. The zoning map indicates areas that do not meet the definitions. An area between Whitin Reservoir and Laurel Lake is included in the Water Resources District but the Town has no municipal well there. The District also includes an area that extends east from the West Street Wells to Route 146 in the northeast corner of Town. The part of this area east of the Town's commercial center appears to be outside of the cone of influence of the

municipal wells. It is recommended that the Town consider evaluating the recharge areas, incorporating information developed since the 1986 report and revising the recharge area delineations to match the definitions in the by-laws.

4. WATER DISTRIBUTION SYSTEM

4.1 GENERAL

The water distribution system is made up of the pipe network, booster stations and storage facilities. The water distribution system should be capable of delivering the maximum rates of flow, including required fire flows, while maintaining suitable pressure within the system. The Department of Environmental Protection (DEP) Guidelines for Public Water Systems recommend the normal working pressures in the distribution system should not be less than 35 pounds per square inch (psi). In the case of fire flows, the Insurance Services Office (ISO), the agency responsible for grading a municipality's fire fighting capabilities, requires fire flows to be available at a residual pressure of 20 psi.

4.2 DISTRIBUTION PIPING

The distribution piping consists of approximately 23 miles of pipe of various diameters through 16-inch. About 26% of the piping is 6-inches or less in diameter. The system contains a majority of 8-inch pipe accounting for nearly 65% of the entire distribution system. The larger 10 and 12-inch mains form the remaining portion of the distribution system comprising about 9% of the system. One of the newest lengths is an 11,000 foot section of 12 and 16-inch ductile iron water mains installed in 2003 to upgrade the backbone of the distribution system along Main Street and to connect the new High School to the Town's water system. Piping in the system consists of mostly old cast iron pipe with some ductile iron and transite pipe scattered in various locations. New construction of mains and sound engineering has helped to loop some areas but in general many dead end mains exist. Much of the cast iron pipe was installed nearly 90 years ago and is unlined. Much of the unlined cast-iron pipe has diminished in carrying capacity over the years. There are approximately 229 hydrants and 1,109 services in the system.

4.3 DISTRIBUTION STORAGE

In the evaluation of a municipal water system, present as well as future storage requirements must be considered. Some of the major advantages of providing storage within a distribution system are:

1. Storage helps to dampen hourly demand fluctuations at pumping stations, thus reducing operational costs.

2. Storage helps to meet required fire flows, thus reducing pumping station capacity and cost.

3. Storage provides a volume of water for emergencies in case of a pipeline break, mechanical equipment malfunction or power failure.

4. Storage, if properly located, helps to equalize pressure throughout the system.

It is necessary to maintain storage levels as near to full as possible in order to maintain maximum available pressure in the distribution system and maximize availability. Currently, there are two water storage tanks in the Town's distribution system. The following Table 4-1 shows the pertinent hydraulic data for the two existing tanks.

Table 4-1: Water Storage Facility Data

Facility Name	Year Constructed	Construction Material	Overflow Elevation (USGS)	Diameter (ft)	Height (ft)	Capacity (gal)
Common Street Standpipe (high service system)	1950	Welded Steel	714.5	31.0	41.5	250,000
Franklin Street Tank (low service system)	1997	Pre-stressed Concrete	602.0	50.0	50.0	750,000
					Total	1,000,000

4.4 DISTRIBUTION PUMPING

The Common Street Tank (high service area) is supplied from a manually operated booster station located on Main Street near Glen Street. Records from this station indicate that it pumps approximately 37,000 gallons of water into the high service system per day. The interior of this pump station is in poor condition. The mechanical and electrical equipment in the station are outdated and unreliable. The station is also prone to flooding, which is dangerous to the equipment, the facility and the staff responsible for maintaining both.

The Franklin Street Tank is supplied from the existing pump stations on West Street and Glen Street. The West Street pump station is operated automatically based on the water level in the Franklin Street Tank. The Glen Street pump station is operated manually during the day and shut off at night. This allows the tank level to fluctuate over the course of the day during average demand conditions.

4.5 WATER SUPPLY & DISTRIBUTION SYSTEM ANALYSIS

4.5.1 Hydraulic Modeling

As part of this report, a previously developed hydraulic computer model prepared by FST, was updated, and used to analyze the water distribution system of the Town of Douglas under both existing and future conditions. Hydraulic computer models use the input information to perform calculations that approximate head loss in the model pipes and predict pressures at model nodes. Typically, models can be run in steady state mode, a snapshot of the system at any given time, or in extended period mode, a series of snapshots taken over a specified time. A properly calibrated hydraulic computer model has many benefits for the planning and operation of a water system. Some of these include:

- Simulate, analyze, and optimize improvements prior to constructing them.
- Simulate and refine system operational changes prior to implementing them.
- Determine system's adequacy in terms of fire fighting and storage.
- Emergency response planning.

4.5.2 Hydraulic Model Update

The Town's hydraulic model was created in 1995 by FST and has been updated in WaterCAD for the purposes of this report. WaterCAD is a hydraulic modeling software developed and distributed by Bentley Systems. Pipe data required by the model include diameter, length, material, and estimated Hazen-Williams "C" value (represents the condition of the interior surface of the pipe wall). Nodes, which are locations in the model where pipes intersect, end, or change characteristics, were also added into the model. Data for nodes include demands and elevations. Boundary nodes are locations in the model where the hydraulic gradeline is set. Boundary nodes typically include tanks, pumps and metered supply connections. To properly distribute demands in the model, large water users were first determined and their demands were allocated in the model at node locations near each user's address. The remainder of the Town's demand was evenly allocated throughout the model. Scenarios to simulate average day, maximum day and peak hour demand conditions were developed. Information to update the hydraulic computer model was gathered from the Town's records as well as FST's knowledge of the infrastructure improvements that have been made over the past several years. Water system infrastructure improvements since 1995 are presented in Table 4-2 below.

Table 4-2: Water System Improvements Since 1995

Year	Improvement
1995	Completion of Glen Street Well Pump Station
1995	Installation of 3,200 linear feet of 12-inch water main in Franklin Street
1997	Construction of the 750,000 gallon pre-stressed concrete water storage tank on Franklin Street. Demolition of the existing 250,000 gallon tank.
2001	Well cleaning and pump replacement on West Street
2002	Installation of 11,000 linear feet of 12-inch and 16-inch water main in Main Street and Davis Street.
2004	Installation of 1,500 linear feet of 12-inch water main in Lackey Dam Road.

4.6 ADEQUACY OF DISTRIBUTION SYSTEM PIPING

4.6.1 Pressure Requirements

The distribution system piping should be capable of delivering the maximum demand, including fire flows, while maintaining suitable pressures throughout the service area. Given the operating hydraulic gradeline of the water system, distribution piping can be considered adequate if fire flow requirements can be satisfied and a residual pressure of 20 psi can be maintained at all locations within the distribution system during a period of maximum daily consumption.

4.6.1.1 System Operating Pressures

Elevations in the distribution system vary from a high of 618 feet near the Common Street Tank to a low of 344 feet at the end of Gilboa Street at the Uxbridge Line. The higher elevations receive water from the Common Street Tank at a 714.5 foot overflow elevation. The lower elevations are served by the Franklin Street Tank with an overflow elevation of 602.0 feet. The maximum available operating pressures would be the difference in elevation between the overflow level of the corresponding storage tank and the elevation of the location in question, minus any minor system losses due to pipe friction. This results in an average pressure range of 42 psi near the Common Street Tank to a high of 109 psi at the end of Gilboa Street. Large pressure drops experienced in various locations during the hydrant flow tests indicate that the system piping is not functioning very efficiently. Dead end mains and decreasing pipe capacities are generally the most accountable factors for such high pressure drops. The fact that much of the piping in Douglas is very old and that many dead ends do exist, confirm our findings.

4.6.1.2 Operating Pressures of High and Low Service Areas

Pressure variations within each service area are due primarily to the elevation differences within the service area and in smaller measures due to the capacity of the distribution system.

<u>High Service Area</u>: Ground elevations in the high service area range from 470 feet on Grove Street to 618 feet near the Common Street Tank. With a water storage level of 714.5 feet in the Common Street Tank, a static pressure of 35 psi can be maintained to ground elevation 634 in the high service area. The actual elevation at which 35 psi could be maintained in the high service

area would be slightly below elevation 634 as a result of normal system friction losses and variations in the water level in the Common Street Tank.

Low Service Area. Ground elevations in the low service area range from 344.5 on Gilboa Street to 555.0 feet near the Franklin Street. With a water surface level of 602 in the Franklin Street Tank, a static pressure of 35 psi could be maintained to ground elevation 521. The actual elevation at which 35 psi could be maintained in the low service area would be slightly below elevation 521 as a result of normal system friction losses and variations in the Franklin Street Tank water levels.

Therefore, the Town should not consider any new developments located in areas above these elevations (634 in the high service area and 521 in the low service area) without provisions for booster pumping.

4.6.1.3 Inadequate System Pressures

Static pressures along North Street, and in the existing subdivisions off North Street, vary from 105 psi near Gilboa Street to 51 psi at the end of the system on North Street. This meets with the DEP guidelines of maintaining a static working pressure of 35 psi in a distribution system. However, when any large water demand occurs in this area, pressures drop to below acceptable levels. At the dead end on North Street and in the development on Towle Court, pressures of less than 15 psi have been recorded during fire flow testing. Additionally, the system is unable to meet the fire protection requirements north of the intersection of Towle Court, as shown in later sections of this report. With the exception of the areas surrounding the two tanks, the North Street area requires the most attention in terms of improving working pressures to within acceptable levels.

4.6.2 Fire Flow Requirements

The Insurance Services Office (ISO) grades the overall fire fighting capabilities of a community by evaluating a number of factors, including the fire flows available at a residual pressure of 20 psi. Several criteria go into determining the Needed Fire Flows, as defined by ISO. They include

building size, type of occupancy, materials of construction, proximity to other buildings, and the existence of sprinklers. Needed fire flows are site specific, however, according to Section 340 of the ISO Fire Suppression Rating Schedule, the Needed Fire Flow shall not exceed 12,000 gpm or be less than 500 gpm. The ISO has simplified the procedure for determining the Needed Fire Flows in areas of 1 and 2 family residential dwellings, not exceeding two stories in height. Table 4-3 presents these fire flow requirements.

Table 4-3: ISO Fire Flow Requirements

Distance between buildings	Required Fire Flow
Over 100 feet	500 gpm
31 - 100 feet	750 gpm
11 - 30 feet	1,000 gpm
10 feet or less	1,500 gpm

In addition, the ISO criteria for other habitational buildings is a maximum of 3,500 gpm. Where specific requirements based on ISO criteria have not been developed, FST has adopted an estimated fire flow based on the closest ISO location and corresponding requirement. Industrial and commercial areas generally have higher requirements than residential areas. Additionally, ISO has provided specific requirements at key locations within the Town such as near schools, warehouses, and heavily populated areas.

Needed fire flows at specific locations are used to determine the adequacy of the distribution piping. Individually, fire flows generally result in higher and more localized flow rates in the piping leading to the fire flow location. The higher flow rates result in greater headloss and decreases in system pressures. Deficient pipes are easily identified and localized improvements can then be proposed. The process of grading a municipality's fire fighting capabilities usually results in a number of site-specific flow tests of the system capacity and estimates of Needed Fire Flow at each test location.

4.6.3 Hydrant Flow Tests

Hydrant flow tests and observations of system pressures were made on July 22, 2008 by Town

and FST personnel. These test locations are also shown on the distribution map located in the Appendix. The purpose of these tests was to observe normal system operation as well as system operation under stress; that is, under various fire flow conditions. The results of these tests were also used to assist in the calibration of the computer model of the distribution system. Flow tests were conducted by measuring the rate of discharge from selected hydrants while observing the resulting drops in system pressure. Continuous pressure recorders were set up throughout the distribution system and the supply facilities were monitored during the tests to help us understand the system's strengths and weaknesses. Hydrant elevations were obtained and used to determine the hydraulic gradeline (HGL). The gradeline elevations were compared to the HGL elevations at the tanks and were also compared to each other. The difference in HGL elevation between locations provides the driving force for moving water through the distribution system.

Table 4-4 identifies the flow test locations, observed pressures, and flows recorded during the flow tests as well as the Needed Fire Flow and Fire Flow Available at a residual of 20 psi. The shaded areas of Table 4-4 indicate locations where the fire flow available at 20 psi was less than the Needed Fire Flow (ISO). Of the fifteen flow tests performed, eight (8) were deficient. The pressure drop during the tests ranged from 3 to 101 psi, with the largest drop occurring at the end of Gilboa Street near Lackey Dam Road. Large pressure drops can generally be the result of a dead end main, closed valves, tuberculated pipe with decreased carrying capacity, and/or inadequately sized pipe.

Table 4-4: Fire Flow Tests

July 22, 2008

Test	Location	Static Pressure (psi)	Residual Pressure (psi)	Calculated Discharge (gpm)	2008 Calculated Discharge at 20 psi (gpm)	1995 Calculated Discharge at 20 psi (gpm)	Fire Flow Requirement (gpm)
	High Service Area Tests						
1	Southwest Main St.	38	28	503	691	729	500
2	Southeast Main St. @ Yew St.	67	58	1,186	2,897	2,474	750
3	Riedell St.	102	52	1,087	1,420	891	750
4	Main St.	69	58	1,222	2,737	2,040	2,000
	Low Service Area Tests						
5	Main St. @ West St.	78	75	1,332	6,593	1,558	2,500
6	Depot St. @ Martin St.	66	50	856	1,513	950	2,500
6A	Martin Rd. near Maple	48	30	605	768	-	750
7	Gilboa St. @ Caswell	85	28	475	509	588	2,250
8	North St. @ Prentiss Ct.	91	50	769	1,034	864	1,000
9	North St. @ Hayward Landing	102	88	1,300	3,376	1,027	3,500
10	NE Main St. @ Monroe St.	84	23	712	731	694	750
10A	Davis St. @ High School	59	50	1,048	2,313	-	2,000
11	Towle Ct.	61	9	650	572	337	750
11A	North St. end	52	12	503	446	-	750
12	Gilboa St. @ Old Lackey Dam Rd.	109	8	531	496	-	500

The quantity of water available at a flow test location may be shown graphically by a hydrant discharge curve. This curve shows the relationship between hydraulic gradeline elevation, or pressure, plotted on the vertical axis, and flow available, plotted on the horizontal axis. Hydrant discharge curves are generated by extrapolating the observed data of a single flow test using the formula:

$$\left(\frac{\Delta H_1}{\Delta H_2}\right)^{0.54} = \frac{Q_1}{Q_2}$$

Where Q_1 is the measured flow and ΔH_1 is the observed difference between the static HGL and the residual HGL. Q_2 is the flow computed for any difference in HGL, $\Delta H2$. Hydrant discharge curves have been prepared for the flow tests performed. The curves are used to illustrate the capacity of the existing system and also the anticipated effects of improvements on

the system capacity. Hydrant discharge curves can be found in the Appendix.

Using the hydraulic model, the locations of the deficient flow tests were evaluated for possible improvement scenarios. The analysis of the recommended improvements follow in Table 4-5.

Table 4-5: Fire Flow Improvements

Test	Location	Required Fire Flow (gpm)	Available Fireflow at 20 psi		Recommended Improvement
			Current	With Improvements	
6	Depot St. @ Martin Rd.	2,500	1,513	3,500	Install 1,500 lf of 12" in Depot Street from Main Street to Martin Street.
7	Gilboa St. @ Caswell	2,250	509	2,900	Install 2,120 lf of 8" in Gilboa Street and 1,730 lf of 8" in Mechanic Street.
9	North St. @ Hayward Landing	3,500	3,376	5,000	Install 1,650 lf of 12" in North Street from Main Street to Gilboa Street
11	Towle Ct.	750	572	1,150	Install 6,000 lf of 12" in North Street from Main Street to dead end
11A	North St. end	750	446	1,900	Install 6,000 lf of 12" in North Street from Main Street to dead end
12	Gilboa St. at Old Lackey Dam Rd.	500	496	1,125	Install 1,650 lf of 12" in North Street from Main Street to Gilboa Street; 3,000 lf of 12" in Gilboa to Lackey Dam Rd.

*All available fire flows were calculated using the calibrated computer model

As is evidenced in the above Table and the hydrant curves that follow, installation of 6,000 feet of new 12-inch water main on North Street is projected to increase the available water for fire protection to a point where it meets the ISO requirements at four of the currently inadequate test locations. This proposed improvement is also the first step in providing adequate fireflows to the industrial area in North Douglas. While a 12-inch main is adequate to meet fire protection requirements, the Town may consider installation of a 16-inch main to further increase the capacity in that area of Town, a pre-cursor to the installation of a new tank in this area. The improvements proposed on Maple Street, Depot Street, and Gilboa Street address the remainder of the inadequate flow test locations and improve the strength of the system both near the downtown area and near the Franklin Street Tank. The following hydrant curves show the increase in available fire protection that result from the improvements on Depot Street (Test 6) and on North Street (Test 11A).

Figure 4-1: Hydrant Discharge Curve Test 6 with Improvements

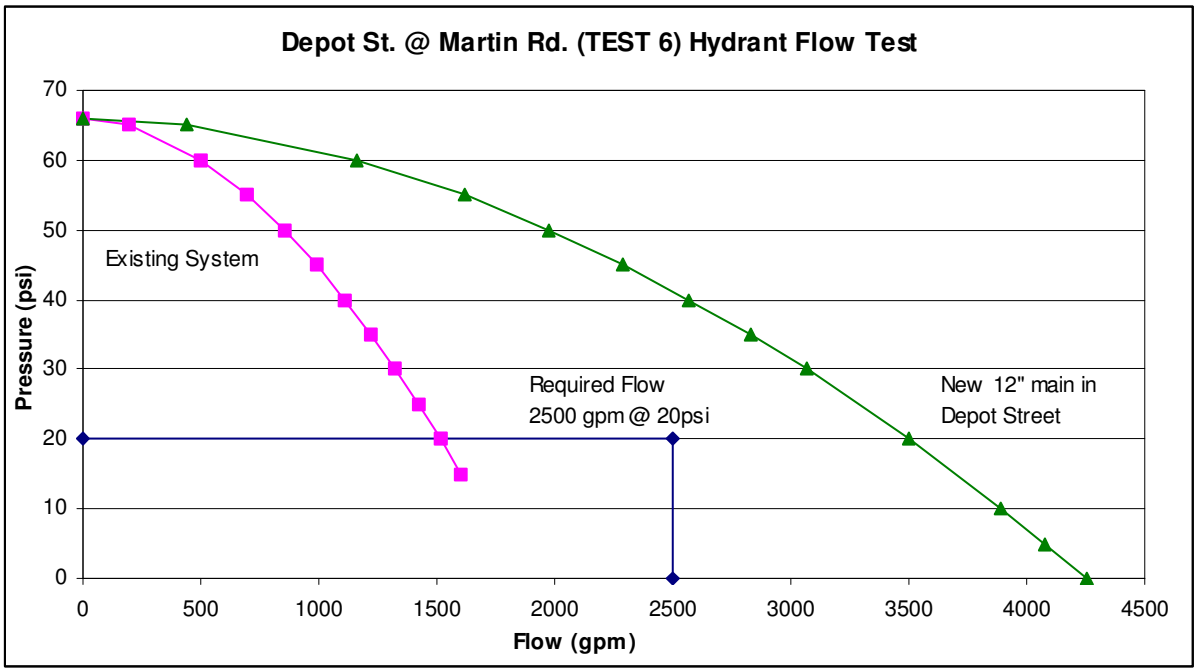
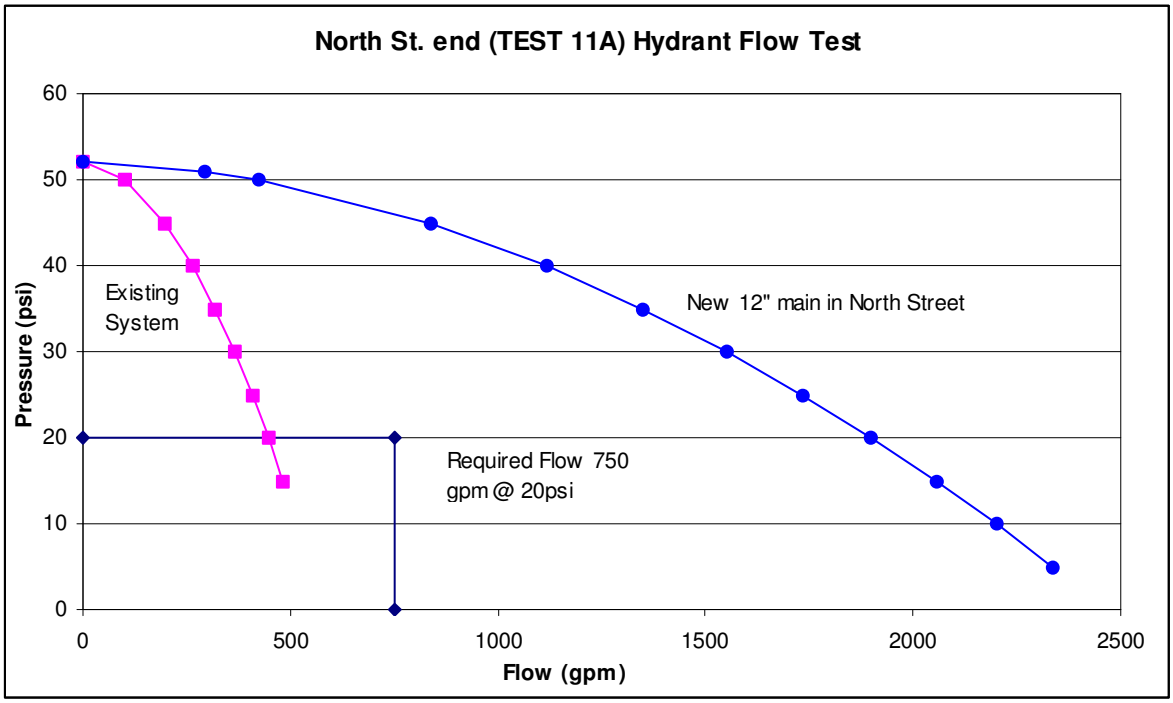


Figure 4-2: Hydrant Discharge Curve Test 11A with Improvements



4.7 ADEQUACY OF DISTRIBUTION STORAGE

The volume of water required for storage is dependent upon the equalizing storage requirement and storage needed for fire protection. As shown in Table 4-1, the total capacity of the storage facilities in Town amount to 1,000,000 gallons. Control valves have been installed in Main Street and West Street, which will open at predetermined pressure settings and allow water to flow from the high service area to the low service area during fire flow and high demand conditions.

4.7.1 Equalizing Storage

The volume of water required for storage is dependent upon the equalizing storage requirement and storage needed for fire protection. Our experience indicates that equalizing storage, which is the volume of water necessary to satisfy hourly fluctuations in water consumption, generally amounts to about 20 percent of the total water consumption of any given day. For this report, we will assume that this value will remain constant through the planning period. The current equalizing storage required is 109,200 gallons or 20 percent of the maximum day consumption. In the year 2030, the equalizing storage requirement is projected to be 20 percent of 773,000 (2030 max day) or approximately 154,600 gallons.

The Main Street Booster Station is the only source of supply to the Common Street Tank. Records from this station indicate that it pumps approximately 37,000 gallons of water into the high service system per day. This amounts to approximately 15% of the total water consumed in the Town of Douglas on an average day. To properly evaluate the equalizing storage requirement for the high and low service tanks, this value will be used. Multiplying current and future equalizing storage volumes by 15% amounts to 15,900 and 22,500 gallons needed for equalizing storage for the Common Street Tank. Subtracting these values from the total equalizing storage requirement gives us the needed equalizing storage volume for the Franklin Street Tank. The current and projected year 2030 values for equalizing storage for the low service Franklin Street Tank amount to 93,400 and 132,100 gallons respectively.

4.7.2 Fire Flow Storage

The Insurance Services Office (ISO) grades the overall fire fighting capabilities of a community by evaluating a number of factors, including how well the fire department receives fire alarms and dispatches its fire-fighting resources, the number of engine companies and the amount of water a community needs to fight a fire, and whether the community has sufficient water supply for fire suppression beyond daily maximum consumption. Differences in fire flow requirements for the two service zones are due to the fact that different building types exist in each service area. The high service zone consists mostly of residential housing units. We have adopted a fire flow storage requirement of 90,000 gallons for the high service area. This was developed using a 750 gpm fire flow for a two hour duration. The low service area serves the center of Town and all the schools. For the low service area, we have adopted a fire flow storage requirement of 630,000 gallons, based on a 3,500 gpm fire flow for a three-hour duration. For the purposes of this report, we have assumed that the year 2030 fire flow requirements will remain the same.

4.7.3 Current Total Storage Requirements

The total water storage requirement for the Town of Douglas is the sum of the equalizing storage and the required fire flow storage. The values are shown in Table 4-6.

Table 4-6: Total Water Storage Requirements (Gallons)

Year	Equalizing Storage	Fire flow Storage	Total Storage Required	Total Storage Available
2008	Low-93,400 High-15,900	Low-630,000 High-90,000	Low-723,400 High-105,900 Total - 829,300	Low-750,000 High-250,000
2030	Low-132,100 High-22,500	Low-630,000 High-90,000	Low-762,100 High-112,500 Total - 874,600	Low-750,000 High-250,000

4.7.4 Useable Storage

Total useable storage is based upon several factors. First, the minimum allowable water level in

each storage facility is that level at which a minimum pressure of 20 psi (approximately 46 feet) is present at all locations in the distribution system. The maximum level is the maximum height that the storage facility can achieve.

The highest elevation in the low service area is at elevation 521 feet around the Franklin Street Tank. To supply this area with water at a minimum pressure of 20 psi, the usable storage for the low service system is all water stored in the Franklin Street Tank above elevation 567 (521 ft elevation + 46 ft pressure). The tank's overflow elevation is 602.0 feet. This yields 35 feet of useable storage and a useable volume of 525,000 gallons for the Franklin Street Tank and the low service system.

The highest service elevation in the high service area is at elevation 618 feet on Church Street. To supply this location with water at a minimum pressure of 20 psi, the usable storage for the high service area is all water stored in the tanks above elevation 664 (618 ft elevation + 46 ft pressure), which is the entire volume of the Common Street Tank.

4.7.5 Future Total Storage Requirements

Assuming that the fire protection requirements remain the same throughout the planning period, and the equalizing storage requirement projections are accurate, Table 4-7 presents the total storage required compared to the total useable storage available.

Table 4-7: Total Useable Storage Available (Gallons)

Year	Equalizing Storage	Fire flow Storage	Total Storage Required	Total Storage Available	Total Useable Storage Available
2008	Low-93,400 High-15,900	Low-630,000 High-90,000	Low-723,400 High-105,900 Total - 829,300	Low-750,000 High-250,000	Low-525,000 High-250,000 Total - 775,000
2030	Low-132,100 High-22,500	Low-630,000 High-90,000	Low-762,100 High-112,500 Total - 874,600	Low-750,000 High-250,000	Low-525,000 High-250,000 Total - 775,000

As Table 4-7 indicates, the useable storage volume of 525,000 gallons is less than the total

storage required for the low service area. The total storage requirement in 2030 is estimated at 874,600 gallons, however the useable storage available is 775,000 gallons. Therefore, there is a short-fall of useable storage for the 20-year planning period. However, it is hydraulically possible for some of the water in the Common Street Tank (high service area) to be used to fight a fire in the low service area.

It is recommended that the Town consider constructing additional storage in the northern part of Town. There is a significant amount of undeveloped land along North Street, with varying acreage in areas zoned for industrial, commercial and residential use. Various hydraulic studies have found that additional water storage is required in this area of Town to provide fire protection for any future development. Ground elevations vary, but the highest locations are at 490-495 feet. A storage tank with an overflow of 602 feet to match the Franklin Street tank should be sited in this area. This facility would provide additional useable storage for fire protection and future development.

4.8 ADEQUACY OF DISTRIBUTION SYSTEM PUMPING

Maximum daily consumption rates are used to determine the adequacy of the supply source(s) and pumping facilities. Typically, it is assumed that maximum daily rates will need to be met for no more than three consecutive days. The total supply system and pumping facilities must be capable of supplying 0.679 MGD, for three consecutive days, in the year 2030.

The pumping facilities of the Town of Douglas are capable of supplying 0.793 MGD with the facilities pumping only 18 hours per day. These reasons lead us to state that the Town's pumping facilities are sufficient through the planning period.

However, potential residential, industrial, or commercial developments in the northern part of Town may require booster pumping to supply water to this area with adequate pressure. Further investigations will be required depending on the type of development, and the projected water demand for domestic use and fire protection.

4.9 DOUGLAS INDUSTRIAL AREAS

As noted in Section 2.5, there are approximately 1,781 acres of industrial zoned land in the Town of Douglas. The Town of Douglas Economic Development Commission features four development opportunities on their website, which are summarized below.

Table 4-8: Douglas Industrial Development Opportunities

Development Opportunity: 1	**General Area:** Western Douglas, Rt. 16 Webster Street
Detailed Description: Located south of Rt. 16, and 2.6 miles from Interstate 395, almost 2 million square feet of developable building area is available in eight potential lots. The Town of Webster has expressed its willingness to supply sewer and water access to the site. Areas mapped and protected by the Natural Heritage & Endangered Species Program make up a small portion of this land.	
Development Opportunity: 2	**General Area:** Eastern Douglas, Rt. 16 North to Uxbridge border
Detailed Description: North of Rt. 16, bordered by the Town of Uxbridge to the north and east, and Monroe St. to the west, this site has 385 acres available for development. It has the largest potential for feasible, profitable commercial/industrial development between the eastern industrial-zoned sites in Douglas. The site is within a mile from Route 146, and would not have significant traffic impacts to the downtown/historical district. Additionally, there are 130 acres of industrial land available directly south of Rt. 16 on the Uxbridge town line.	
Development Opportunity: 3	**General Area:** Northwest Douglas, Douglas Business Park
Detailed Description: Abutting both the Webster and Oxford lines, one owner has control over potentially eleven lots totaling 28.5 industrially zoned acres. Potential uses for these multi-acre lots include trade and building construction uses, small manufacturing, and warehousing. Current land occupants include a pipe valve and fitting distributor, a warehouse facility and a new, one-story building available for lease. Cliff Street provides access to the Douglas Business Park.	
Development Opportunity: 4	**General Area:** Eastern Douglas, Rt. 146/North & Gilboa Streets
Detailed Description: Approximately 550,000 sq. ft. of developable building area is available off Rt 146, near the Uxbridge and Sutton borders. Seventeen potential commercial and industrial lots have available water and sewer service in close proximity. These sites are noted for the ease of land ownership issues, proximity to Rt. 146, , and the Town's master plans to develop these sites to their full capacity.	

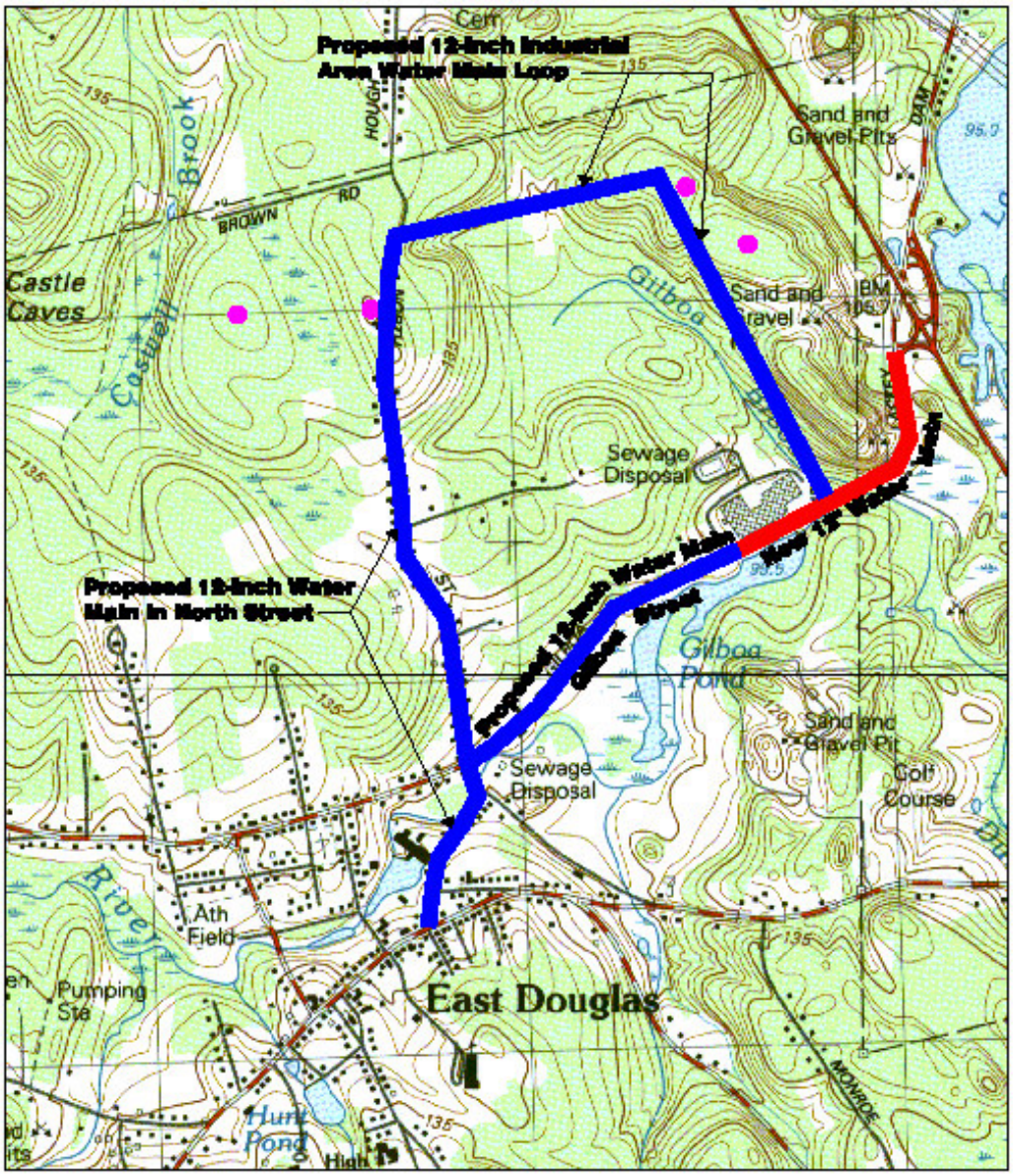
Source: www.douglasland.org

Areas 2 and 4 are of particular interest in terms of the water supply system of the Town of Douglas. These sites require upgrades and/or extensions to the existing Douglas water system to provide adequate water for daily use as well as fire protection. FST has previously evaluated the expansion of the water system into North Douglas (Location #4), and determined the infrastructure improvements necessary to provide this area with water. Figure 4-3 presents the

improvements proposed at that time. Since the report was completed a new 12-inch water main was installed on Gilboa Street towards Lackey Dam Road. And while the proposed North Street water main installation is needed for expanding the system for future industrial development, it is also necessary to meet the fire flow requirements of the existing system in that area.

Developers who pursue building in these areas must have their plans and proposed developments reviewed and approved by the Town. Sharing of the costs of water infrastructure improvements may be an efficient way to improve the system and help grow the Town's industrial base.

Figure 4-3: Proposed Industrial Improvements



POTENTIAL TANK LOCATIONS

PROPOSED IMPROVEMENTS

12" WATER MAIN INSTALLED IN 2005

4.10 DISTRIBUTION SYSTEM OPERATION

In order for the system to properly function, pumps must be capable of supplying the maximum day rate, storage tanks must have sufficient capacity to balance supply rates with consumption demands while maintaining a storage reserve for emergencies. The distribution pipe network must have sufficient capacity to distribute water during periods of maximum consumption while maintaining suitable pressures.

The current high service area is supplied from the Main Street booster station that is manually operated for about 8 hours per day. This is generally an adequate amount of time to keep the high service tank near its overflow. The Common Street Tank and the Franklin Street Tank have enough capacity to provide water on days of maximum and peak hour demand while still maintaining adequate water levels in the tanks. A problem does occur, however, if a large fire demand is required in the high or low service area after the booster station has been shut down for the night. If this flow requirement drains the high service tank, then water will only be available in the high service area if someone from the Town goes out after the fire and turns on the booster station. We recommend that the booster station be automated to turn on and off manually based on some preset tank level. This would allow the assurance that the tank level is monitored automatically on a 24 hr basis.

The Franklin Street Tank is supplied from the existing pump stations on West Street and Glen Street. The West Street pump station is operated automatically based on the water level in the Franklin Street Tank. The Glen Street pump station is operated manually during the day and shut off at night. This allows the tank level to fluctuate over the course of the day during average demand conditions. Some fluctuation in tank levels should be experienced to keep water from becoming stagnant within the tank. This will assure that the water quality does not degrade from sitting in the tank for long periods of time.

4.10.1 Pipe Maintenance

The Town of Douglas conducts distribution system flushing every year. The Town also operates valves during the flushing to increase the velocity in the pipes and properly flush specific areas.

Leak Detection and Leak Repair Program

A leak detection survey helps to locate leaks in the system and determine to what extent water is being lost through each leak. It also reduces the potential for contamination to enter the water system. Leak detection surveys are performed every three years in Douglas, the most recent one being completed in 2007.

The Town's should continue with its regularly planned leak detection practices. The information obtained through a leak detection study is invaluable when trying to reduce the unaccounted-for water usage of a system. The Town's unaccounted-for water usage has dropped from 20% of the Town's demand in 1995 to 11% in 2007. Typical unaccounted-for rates should not exceed 10%.

Flushing and Valve and Hydrant Maintenance Program

It is imperative to the satisfactory operation of a water distribution system that all valves and hydrants are accessible and operable. Occasionally, valves are discovered to be half-closed, fully closed, or inaccessible due to their valve boxes being full of dirt. Additionally, hydrants are sometimes found to be inoperable, primarily due to age and lack of use, or inoperable branch valves.

The Town does not currently have a valve and hydrant maintenance program, however the Water Department does have an annual hydrant flushing program. The Town's flushing program should be continued and expanded to help mitigate potential colored water and bacteria problems. Valves should be operated in parallel with the hydrant flushing program. Hydrant and valve condition, direction and number of turns to open, and other pertinent statistics should be recorded during the program.

4.10.2 Tank Maintenance

The Common Street Tank was inspected in 1993, and was found to be in need of coating and structural repairs. The tank was cleaned and painted in 1994. Structural repairs at that time included a new roof manhole, a new shell manhole, a finial vent, an access ladder with safety cage, and some anchor bolt replacement. It is recommended that the Common Street Tank be inspected every 5 years for coating and structural integrity. Depending on the results of the annual inspections it should be cleaned and painted every 15-20 years.

The Franklin Street Tank was last inspected in October 2008, and found to be in good condition. It is recommended to perform inspection at the Franklin Street Tank every 5 years. If these inspections report serious deterioration issues then further repairs may be necessary.

4.10.3 Water Main Replacement

The highest priority for water main replacement is the 8-inch main in North Street. Increasing this to a 12-inch main would provide adequate fire protection to more than half of the inadequate fire flow test locations. Additionally,it would open up an area of Town to future development that has been previously unavailable due to inadequate water supply and fire protection. Table 4-8 below shows the other recommended pipeline improvements.

Table 4-9: Water Main Improvement Recommendations

Streets	Size	Total Length
North Street from Main Street to Gilboa Street	12”	1,650
North Street from Gilboa Street to the current terminus near the Sutton Town Line	12”	4,350
Gilboa Street from North Street (west) to Mechanic Street	8”	2,120
Gilboa Street from North Street (east) to new 12-inch main (2004)	12”	3,000
Depot Street from Railroad Avenue to Maple Street	8”	800
Depot Street from Main Street to Cottage Street	12”	500

Depot Street from Cottage Street to Martin Street.	12”	1,000
Davis Street from high school, southeasterly	12”	4,000
Towle Court and Colonial Estate, closing loop	8”	200

4.11 AVAILABLE FUNDING SOURCES

Funding sources from the DEP, USDA, and CDBG/USHUD were investigated for this report. The following table presents a summary of the funding sources, description of the intent of the programs, application deadlines, and the likelihood this funding could be obtained for the project.

Table 4-10: Available Funding Sources

1. Drinking Water State Revolving Fund from the Department of Environmental Protection	
Description of Funding	This funding is available for projects whose purpose it is to mitigate existing water supply problems and their impacts to public health or the environment, as opposed to providing extra capacity that will encourage sprawl. (source: www.mass.gov/dep)
Deadline to apply	Annual program. A Project Evaluation Form submitted in August 2009 and approved by DEP January 2010 would yield a construction start in Spring 2011.
Type of Assistance	Reimbursement Program via a low interest loan
Likelihood	Depending on the project and other system considerations, the Town could receive funding.
2. Water and Waste Water Loans and Grants from the USDA Rural Utility Services	
Description of Funding	This funding is available for projects whose purpose it is to reduce water and waste disposal costs to a reasonable level for rural users. Grants may be made for up to 75% of eligible project costs in some cases. The same types of applicants are eligible for grants as are for loans. (source: www.usda.gov/rus/water)
Deadline to apply	No specific deadlines. Funds are made available on a quarterly basis, but there are several documents to fill out and approval processes to go through.
Type of Assistance	Up to 75% Federal Grant, 25% Non-Federal Funds; Low interest Loan
Likelihood	Most projects should be eligible according to RUS Instruction 1780. USDA should be contacted prior to commencing an application to determine the Town’s financial eligibility. Town has secured this type of funding in the past.

3. Community Development Block Grant (CDBG) from U.S. Housing & Urban Development (HUD)	
Description of Funding	HUD awards grants to entitlement communities to carry out a wide range of community development activities directed toward revitalizing neighborhoods, economic development, and providing improved community facilities and services – such as construction of public facilities and improvements, such as water and sewer facilities, streets, neighborhood centers, and the conversion of school buildings for eligible purposes. (source: www.hud.gov and www.grants.gov)
Deadline to apply	Available CDBG grants are always being updated. Further investigation would be needed to determine what grants may be available for the recommended projects.
Type of Assistance	HUD determines the amount of each entitlement grant by a statutory dual formula using several objective measures of community needs, such as population, and economic status. A minimum of 65% of CDBG funds are granted to agencies providing bricks and mortar projects; a maximum of 15% of funds are granted for public service projects; and a maximum of 20% of the funds are set aside for program administration.
Likelihood	Further investigation would be needed to determine what projects may be eligible for grants that are open.
4. Water Supply Protection Grants (DEP)	
Description of Funding	This program provides grants to municipalities and public water systems to purchase land or conservation restrictions for the purpose of protecting existing public drinking water supplies. (www.mass.gov/dep/water/dwgrant.htm)
Deadline to apply	Annual Program. FY 09 funding closed in September 2008. Investigate for future years.
Type of Assistance	Reimbursement of up to 50% of project cost, up to $500,000
Likelihood	Further investigation would be needed to determine what projects may be eligible for grants that are open

5. FINDINGS AND RECOMMENDATIONS

1. From 1920 to 2000, the Town of Douglas experienced a population increase of approximately 135%, reaching 7,045 in 2000. Since then, the population has been steadily increasing 1-2% per year, with a slight decline in 2007.
2. Under current zoning regulations, the Town's saturation population would be approximately 30,683. This indicates that there is tremendous growth potential for the Town of Douglas.
3. The Town of Douglas currently provides drinking water to slightly less than half of the Town's population. The current service ratio for the water supply system is 42%.
4. The water supply available to the Town is adequate for current and projected average day, maximum day and peak hour requirements. The addition of the Glen Street well and pump station in 1995 has allowed the Town to meet these supply requirements now and into the 20-year planning period. However, it is prudent for the Town to continue to look for new supply sources so that land can be purchased and protected.
5. The projected 2030 average day water demand of 0.422 MGD exceeds the withdrawal amount that the Town is currently registered and permitted for through the Water Management Act. An increase in the permitted withdrawal amount should be requested.
6. The Town of Douglas should consider re-evaluating and revising the aquifer and watershed recharge areas to coincide with the Town's bylaws.
7. Much of the distribution piping is old and consists of unlined cast iron main. The reduced carrying capacity of these mains and the fact that many areas are not adequately looped, causes poor fire flow capabilities in many areas of the system. These dead end mains could also be the source of poor water quality issues. A looped system provides reliability and is preferred over a dead ended system, since looped pipe can supply water for consumption and fire protection from more than one direction and also prevents water from stagnating as may occur in a dead ended pipe, where circulation is limited.
8. The Common Street and Franklin Street storage tanks currently provide distribution storage to the Town of Douglas water system. The storage volume of the Common Street Tank is more

than adequate to meet the requirements of the high service area. The Franklin Street Tank provides the needed capacity for equalizing and fire flow requirements currently, but in order to meet storage requirements into the planning period, additional storage will be required in the low service area.

9. The Main Street booster pumping station is in need of replacement. The electrical and mechanical equipment are outdated and inoperable at times. Additionally, the station is prone to flooding which can be detrimental to the equipment and the Town personnel charged with maintaining it. It should also be automated to run off of water levels in the Common Street Tank.

10. Results of hydrant flow tests conducted by FST in July of 2008 indicate that many fire flow deficiencies exist throughout the system, particularly in the low service area.

11. Reinforcement and replacement of distribution piping is needed in key areas to eliminate fire flow deficiencies and help maintain pressures and provide reliable service.

12. The Town cannot adequately serve development above elevation 634 in the high service area and elevation 521 in the low service area without booster pumping facilities.

13. There are several industrial-zoned areas that the Town is promoting for development. Two of these areas would need water supply from the Douglas system to provide average day usage as well as fire protection. Infrastructure improvements will be required within the existing water system before these new developments can be approved.

14. A program for annual valve and hydrant replacement should be budgeted for and implemented.

15. All supply sources should be metered and supply meters should be calibrated on an annual basis.

16. Unaccounted for consumption is approximately 11% of the total volume supplied. A leakage study and water audit should be conducted to determine what steps are needed to reduce this percentage.

17. There are several funding sources available through Federal and State Agencies that should be investigated when the Town decides to move forward with system improvements.

18. The Master Plan should be reviewed and updated by the Town every fifteen years.

6. RECOMMENDED IMPROVEMENT PROGRAM

The following program of improvements, when completed, will provide adequate distribution, storage and supply facilities though the year 2030. Our sequence for construction and estimated 2009 construction costs are shown on the following pages. Engineer's estimates of probable costs include allowances for pavement replacement, rock excavation, police detail, and other items usually involved in water system infrastructure improvements. The estimates include a 15 percent allowance for engineering and contingencies assuming the work will be performed under competitive bid construction contracts. The estimates do not include legal fees, land and easement costs or Town administrative costs.

Phase I improvements include the replacement of the Main Street Booster Pump Station, the replacement of the water mains on North Street and Gilboa Streets to increase the system's reliability and available fire protection to this area of the town, and investigation of new water supply sources. Phase II improvements include a siting study for a new tank in North Douglas, as well as the replacement of the water mains in Gilboa and Mechanic Streets to increase the system's capacity in the northern part of Town. Phase III improvements include the inspection and maintenance of the tanks, and the replacement of the water main in Depot Street to maintain the storage facilities and upgrade undersized mains. Phase IV improvements include the construction of a new tank in North Douglas and a water main extension on Davis Street and a loop closure on Towle Court.

6.1 PHASE I RECOMMENDATIONS

Phase I improvements include the replacement of the Main Street Booster Pump Station, and the replacement of the water main on North Street and Gilboa Streets to increase the system's reliability and available fire protection to this area of the Town. This phase also includes a recommendation that the Town continue to investigate for a new source of water supply.

Table 6-1: Phase I Improvement Recommendations

Item No.	Improvement Recommendation	Estimated Cost	Recommended Funding to Pursue
1A	Install 1,650 feet of 16-inch water main in North Street from Main Street to Gilboa Street	$280,000	1,2,3
1B	Install 3,000 feet of 12-inch water main in Gilboa Street from North Street (east) to existing 12-inch main	$470,000	1,2,3
1C	Install 4,350 feet of 12-inch water main in North Street from Gilboa Street to the terminus near the Sutton Town Line	$675,000	1,2,3
1D	Replace Main Street pump station	$500,000	1,2,3
1E	Investigate new sources of water supply	$25,000 / yr	Town
1F	Perform a Water Rate Study	$25,000	Town

6.2 PHASE II RECOMMENDATIONS

Phase II improvements include a siting study for a new tank in North Douglas, as well as the replacement of water mains in Gilboa and Mechanic Streets to increase the system's capacity in the northern part of Town. Our findings determined that there is inadequate useable storage in the low service area to meet the planning period requirements. A tank siting and sizing study should be performed to evaluate possible locations for a new water storage tank, and determine the capacity required to meet potential future demands for maximum daily use and fire protection.

Table 6-2: Phase II Improvement Recommendations

Item No.	Improvement Recommendation	Estimated Cost	Recommended Funding to Pursue
2A	Perform tank siting and sizing study	$10,000	Town
2B	Install 2,120 feet of 8-inch water main in Gilboa Street from North Street to Mechanic Street	$300,000	1,2,3
2C	Install 1,730 feet of 8-inch water main in Mechanic Street from Gilboa Street to Main Street	$250,000	1,2,3

6.3 PHASE III RECOMMENDATIONS

Phase III improvements include the inspection and maintenance of the tanks, and the installation of new water main in Depot Street to maintain the storage facilities and upgrade undersized mains. As previously stated, the Common Street Tank was last cleaned and painted in 1994. It is recommended that the Common Street Tank be inspected every 5 years and cleaned and painted every 15-20 years. The Franklin Street Tank should also be inspected every 5 years. If these inspections report serious deterioration issues then further repairs may be necessary.

Table 6-3: Phase III Improvement Recommendations

Item No.	Improvement Recommendation	Estimated Cost	Recommended Funding to Pursue
3A	Inspect Common Street Tank every 5 years	$5,000	Town
3B	Clean, Paint and Repair Common Street Tank every 20 years	$350,000	1,2,3
3C	Inspect Franklin Street Tank every 5 years	$5,000	Town
3D	Clean interior of Franklin Street Tank every 5 years	$2,000	Town
3E	Install 1,500 feet of 12-inch water main in Depot Street from Main Street to Martin Street	$220,000	1,2,3

6.4 PHASE IV RECOMMENDATIONS

Phase IV improvements include the construction of a new tank in North Douglas, the extension of the water main on Davis Street and the closure of the dead end on Towle Court.

Table 6-4: Phase IV Improvement Recommendations

Item No.	Improvement Recommendation	Estimated Cost	Recommended Funding to Pursue
4A	Construct new water storage tank in northern part of Town	$1,500,000	1,2,3
4B	Install 4,000 feet of 12-inch water main in Davis Street from the vicinity of the high school southeasterly to extend the water system to the industrial area in the southern part of Town	$625,000	1,2,3
4C	Install 200 feet of 8-inch water main in Towle Court and Colonial Estates, looping together two dead ends.	$30,000	1,2,3
4D	Install disinfection facilities at all well locations	$105,500	1,2,3

6.5 ADDITIONAL IMPROVEMENT RECOMMENDATIONS

Water system operation and maintenance improvement recommendations are listed below.

Table 6-5: Operation and Maintenance Recommendations

Item No.	Improvement Recommendation	Estimated Cost	Recommended Funding to Pursue
5A	Perform a Leak Detection Study every 3 years	$15,000	Town
5B	Allowance for repair of leaks encountered during Leak Detection Study	$5,000	Town
5C	Comprehensive Hydrant Flushing and Maintenance and Valve Exercising Program, annually	$10,000	Town
5D	Allowance for repairs to valves and hydrant encountered during the Hydrant Flushing & Valve Exercising Program	$5,000	Town

7. ACKNOWLEDGEMENTS

FAY, SPOFFORD & THORNDIKE, LLC is pleased to record our appreciation for the cooperation and valued assistance received from the members of the Town of Douglas Water-Sewer Department.

Respectfully Submitted

FAY, SPOFFORD & THORNDIKE, LLC
By

_____

Dennis P. Boucher, P.E.
Vice President

Appendix

CAPITAL IMPROVEMENT PLAN

TOWN OF DOUGLAS, MASSACHUSETTS
20-YEAR CAPITAL IMPROVEMENT PLAN

	PROJECT TASKS	COST	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	TOTAL 20-YEAR COST
	DISTRIBUTION SYSTEM IMPROVEMENTS																								
	Pipeline Improvements to Meet Fire Flow Requirements																								
1A	Install 1,650 feet of 16-inch water main in North Street from Main Street to Gilboa Street.	$280,000		$280,000																					**$280,000**
1B	Install 3,000 feet of 12-inch water main in Gilboa Street from North Street (east) to existing 12-inch main	$470,000				$470,000																			**$470,000**
1C	Install 4,350 feet of 12-inch water main in North Street from Gilboa Street to dead end.	$675,000				$675,000																			**$675,000**
2B	Install 2,120 feet of 8-inch water main in Gilboa Street from North Street to Mechanic Street	$300,000								$300,000															**$300,000**
2C	Install 1,730 feet of 8-inch water main in Mechanic Street from Gilboa Street to Main Street	$250,000								$250,000															**$250,000**
3E	Install 1,500 feet of 12-inch water main in Depot Street from Main Street to Martin Street	$220,000												$220,000											**$220,000**
4B	Install 4,000 feet of 12-inch water main in Davis Street southeasterly.	$625,000																			$625,000				**$625,000**
4C	Install 200 feet of 8-inch water main in Towle Court and Colonial Estate to close loop	$30,000																			$30,000				**$30,000**
	Distribution System Operation Improvements																								
1D	Replace Main Street Booster Pump Station	$500,000		$500,000																					**$500,000**
1F	Perform a Water Rate Study	$25,000	$25,000																						**$25,000**
5A	Perform Leak Detection Survey of 23 miles of water main (every 3 years)	$15,000 /3yrs	$15,000			$15,000			$15,000			$15,000			$15,000			$15,000			$15,000			$15,000	**$120,000**
5B	Annual Allowance for leak repairs	$5,000 /yr	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	**$110,000**
5C	Comprehensive Hydrant Flushing & Valve Exercising Program	$10,000 /yr	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	**$220,000**
5D	Valve and Hydrant Repair and Replacement Allowance	$5,000 /yr	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	**$110,000**
	SUB-TOTAL DISTRIBUTION SYSTEM IMPROVEMENTS		***$60,000***	***$800,000***	***$20,000***	***$1,180,000***	***$20,000***	***$20,000***	***$35,000***	***$570,000***	***$20,000***	***$35,000***	***$20,000***	***$240,000***	***$35,000***	***$20,000***	***$20,000***	***$35,000***	***$20,000***	***$20,000***	***$690,000***	***$20,000***	***$20,000***	***$35,000***	***$3,935,000***
	WATER STORAGE FACILITY IMPROVEMENTS																								
	General Storage Facility Improvements																								
2A	Perform Tank Siting and Sizing Study	$10,000	$10,000																						**$10,000**
4A	Construct New Water Storage Tank in North Douglas	$1,500,000									$1,500,000														**$1,500,000**
	Common Street Water Storage Tank																								
3A	Inspect and Evaluate Common Street Storage Tank (every 5 years)	$5,000 /5yrs					$5,000					$5,000					$5,000					$5,000			**$20,000**
3B	Cleaning and Painting Common Street Tank (every 20 years)	$350,000 /20yrs						$350,000																	**$350,000**
	Franklin Street Water Storage Tank																								
3C	Inspect and Evaluate Franklin Street Storage Tank (every 5 years)	$5,000 /5yrs					$5,000					$5,000					$5,000					$5,000			**$20,000**
3D	Cleaning Franklin Street Tank (every 5 years)	$2,000 /5yrs					$2,000					$2,000					$2,000					$2,000			**$8,000**
	SUB-TOTAL WATER STORAGE FACILITY IMPROVEMENTS		***$10,000***	***$0***	***$0***	***$0***	***$12,000***	***$350,000***	***$0***	***$0***	***$1,500,000***	***$12,000***	***$0***	***$0***	***$0***	***$0***	***$12,000***	***$0***	***$0***	***$0***	***$0***	***$12,000***	***$0***	***$0***	***$1,908,000***
	WATER SUPPLY IMPROVEMENTS																								
1E	Investigate new sources of water suuply	$25,000 /yr	$25,000	$25,000	$25,000	$25,000	$25,000																		**$125,000**
4D	Install disinfection facilities at all well locations	$105,500													$105,500										**$105,500**
	SUB-TOTAL WATER SUPPLY IMPROVEMENTS		***$25,000***	***$25,000***	***$25,000***	***$25,000***	***$25,000***	***$0***	***$0***	***$0***	***$0***	***$0***	***$0***	***$0***	***$105,500***	***$0***	***$0***	***$0***	***$0***	***$0***	***$0***	***$0***	***$0***	***$0***	***$230,500***
	CAPITAL COST PER YEAR		**$0**	**$780,000**	**$0**	**$1,145,000**	**$0**	**$350,000**	**$0**	**$550,000**	**$1,500,000**	**$0**	**$0**	**$220,000**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$655,000**	**$0**	**$0**	**$0**	**$5,200,000**
	BUDGET COST PER YEAR		**$70,000**	**$45,000**	**$45,000**	**$60,000**	**$57,000**	**$20,000**	**$35,000**	**$20,000**	**$20,000**	**$47,000**	**$20,000**	**$20,000**	**$140,500**	**$20,000**	**$32,000**	**$35,000**	**$20,000**	**$20,000**	**$35,000**	**$32,000**	**$20,000**	**$35,000**	**$848,500**
	TOTAL COST PER YEAR		**$70,000**	**$825,000**	**$45,000**	**$1,205,000**	**$57,000**	**$370,000**	**$35,000**	**$570,000**	**$1,520,000**	**$47,000**	**$20,000**	**$240,000**	**$140,500**	**$20,000**	**$32,000**	**$35,000**	**$20,000**	**$20,000**	**$690,000**	**$32,000**	**$20,000**	**$35,000**	**$6,048,500**

DISTRIBUTION MAP AND MASTER PLAN MAP

SUTTON

UXBRIDGE

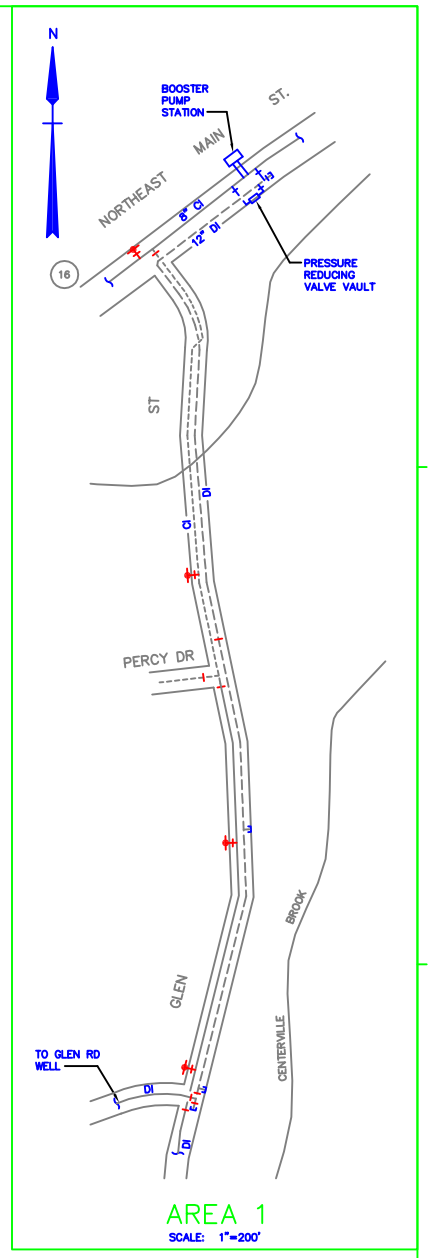
DOUGLAS

STEVENS POND
MANCHAUG POND
WHITIN RESERVOIR
LACKEY POND
BADLUCK POND
MORSE POND
DUDLEY POND
COLONIAL ESTATES
HUNT POND
MEEKS POND
ELEM SCHOOL
ELEMENTARY SCHOOL
HIGH SCHOOL
REDDINGS LANDING
LAND FILL

VAULT FOR FUTURE MASTER METER
PRESSURE REDUCING VALVE VAULT
GRAVEL PACKED WELL
TUBULAR WELLFIELD
LIMITS OF HIGH SERVICE AREA
BOOSTER PUMP STATION
PRESSURE REDUCING VALVE VAULT
AREA 1
COMMON STREET 250,000 GALLON STEEL TANK 31' DIA, 41.5' HT
FRANKLIN STREET 750,000 GALLON CONCRETE TANK 50' DIA, 50' HT
GLEN ROAD WELL & PUMPING STATION
EXISTING RAILROAD R.O.W.

PLAN
SCALE: 1"=800'

1"=800' 1000' 0' 1000' 2000' 3000'
1"=200' 200' 0' 200' 400' 600' 800'



AREA 1
SCALE: 1"=200'

LEGEND

6" WATER MAIN, SMALLER	
8" WATER MAIN	
10" WATER MAIN	
12" WATER MAIN	
16" WATER MAIN	
HYDRANT	
GATE VALVE	
BLOWOFF	
CAST IRON	CI
DUCTILE IRON	DI
ASBESTOS CEMENT	AC
LIMITS OF HIGH SERVICE AREA	
FST FLOW TEST LOCATION JULY 22, 2008	10

TOWN OF DOUGLAS, MASSACHUSETTS
WATER AND SEWER DEPARTMENT

WATER DISTRIBUTION SYSTEM PLAN

SCALE: AS NOTED
JANUARY 2009
FAY, SPOFFORD & THORNDIKE, INC., ENGINEERS, BURLINGTON, MA

WD-090

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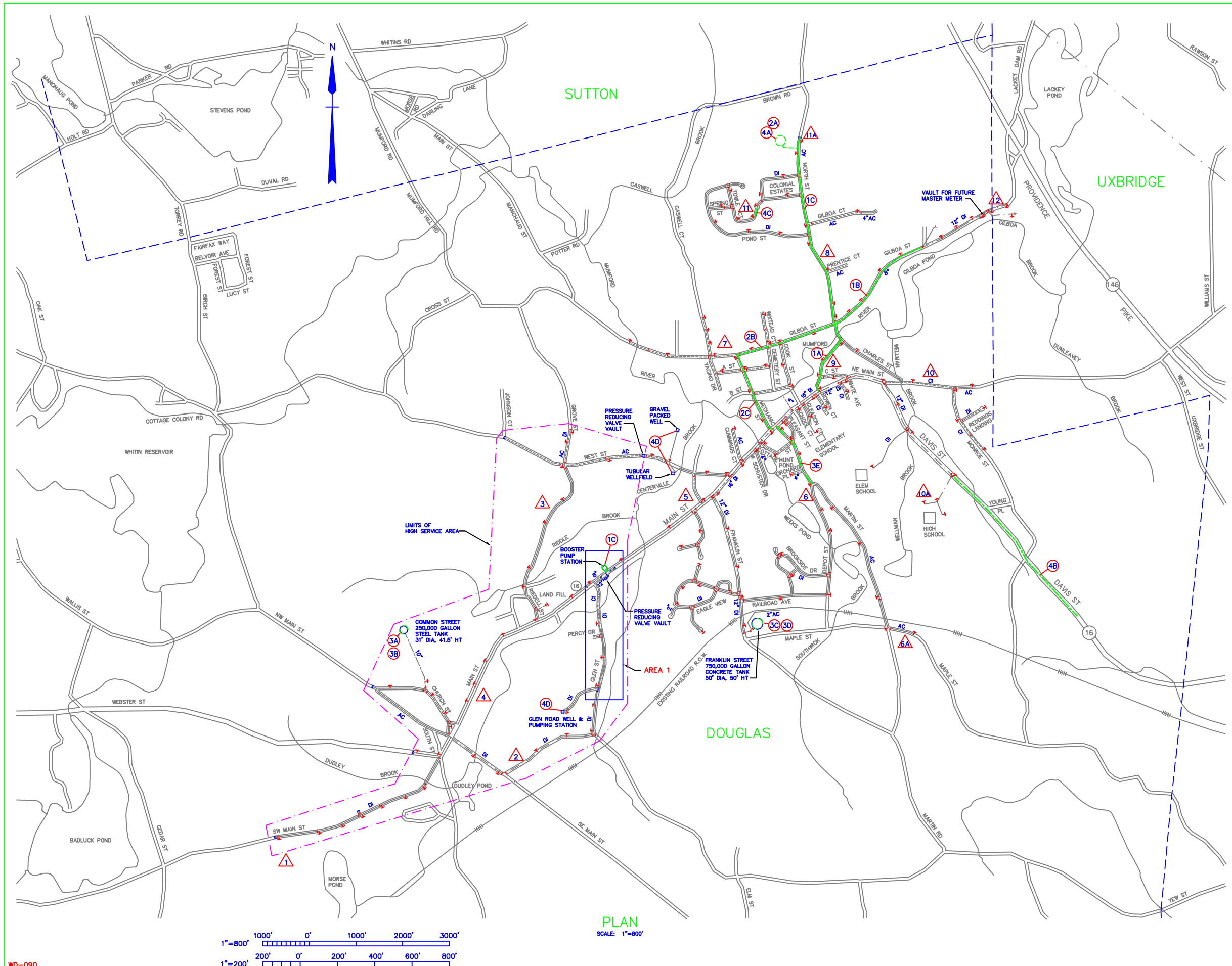
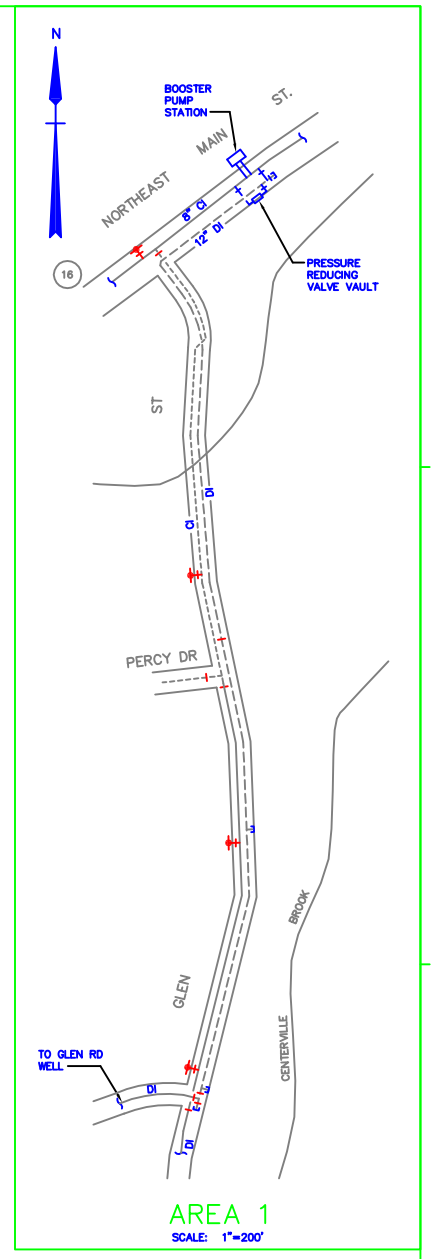


PLAN
SCALE: 1"=800'

1"=800' 1000' 0' 1000' 2000' 3000'
1"=200' 200' 0' 200' 400' 600' 800'



AREA 1
SCALE: 1"=200'

LEGEND

6" WATER MAIN, SMALLER	
8" WATER MAIN	
10" WATER MAIN	
12" WATER MAIN	
16" WATER MAIN	
HYDRANT	
GATE VALVE	
BLOWOFF	
CAST IRON	CI
DUCTILE IRON	DI
ASBESTOS CEMENT	AC
LIMITS OF HIGH SERVICE AREA	
PHASE I IMPROVEMENTS	1A
PHASE II IMPROVEMENTS	2B
PHASE III IMPROVEMENTS	3C
PHASE IV IMPROVEMENTS	4A
FST FLOW TEST LOCATION JULY 22, 2008	10

TOWN OF DOUGLAS, MASSACHUSETTS
WATER AND SEWER DEPARTMENT

WATER DISTRIBUTION SYSTEM WITH RECOMMENDED IMPROVEMENTS

SCALE: AS NOTED
JANUARY 2009
FAY, SPOFFORD & THORNDIKE, INC., ENGINEERS, BURLINGTON, MA

WD-090

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HYDRANT DISCHARGE CURVES

Douglas
Hydrant Flow Tests

Location: Southwest Main Street - (TEST1) Date: 7/22/2008 Time: 8:00AM

Flow Hydrant: F-1

Gauge Hydrant: G-1

Requirement **500 gpm**
20 psi

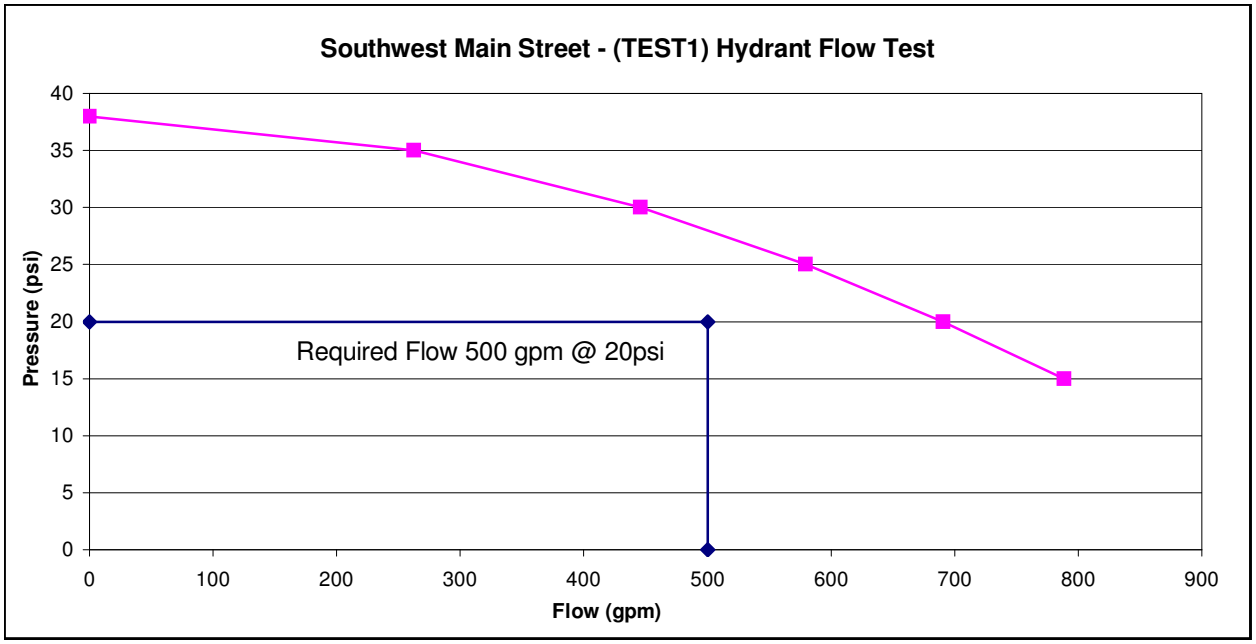
Nozzle Dia: 2.5 inches

	Static Pressure (psi)	Residual Pressure (psi)
Gauge Hydrant	38	28

Pitot Reading: 9 psi

Pitot Reading: 503 gpm

Flow at 20 psi: 691 gpm



Note:

Fay, Spofford & Thorndike
Burlington, MA

Douglas
Hydrant Flow Tests

Location: SE Main St. @ Yew St. (TEST 2) Date: 7/22/2008 Time: 8:24AM

Flow Hydrant: F-2

Gauge Hydrant: G-2

Nozzle Dia: 2.5 inches

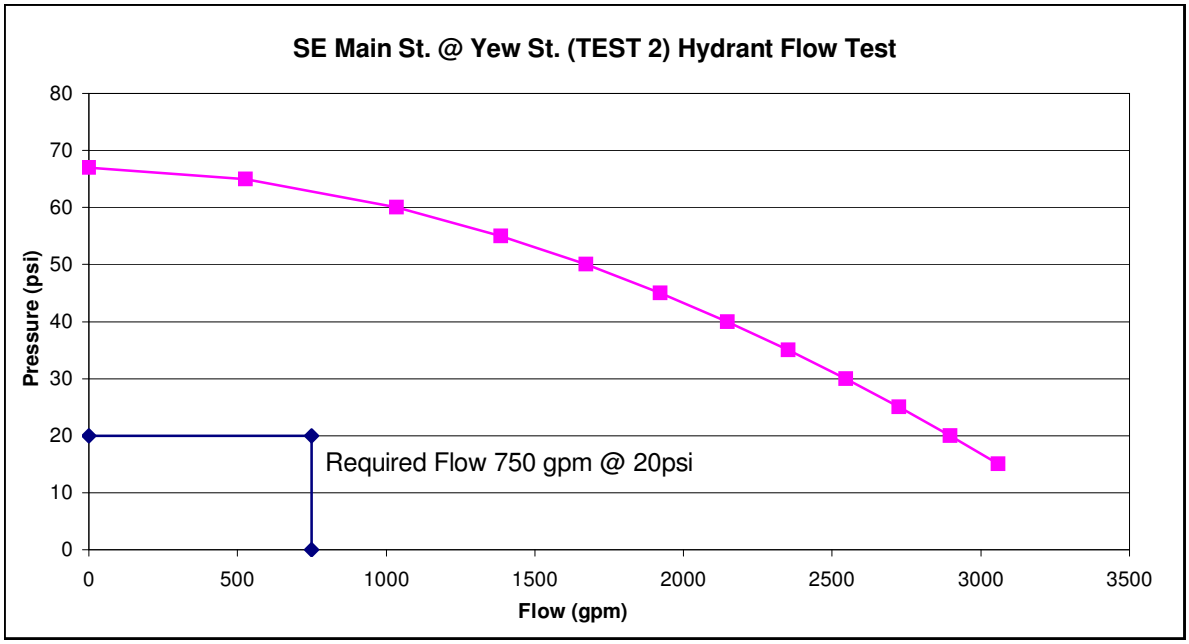
Requirement **750** gpm
20 psi

	Static Pressure (psi)	Residual Pressure (psi)
Gauge Hydrant	67	58

Pitot Reading: 50 psi

Pitot Reading: 1186 gpm

Flow at 20 psi: 2897 gpm



Note:

Fay, Spofford & Thorndike
Burlington, MA

Douglas
Hydrant Flow Tests

Location: Riedell St. - HS (TEST 3) Date: 7/22/2008 Time: 8:55AM

Flow Hydrant: F-3

Gauge Hydrant: G-3

Nozzle Dia: 2.5 inches

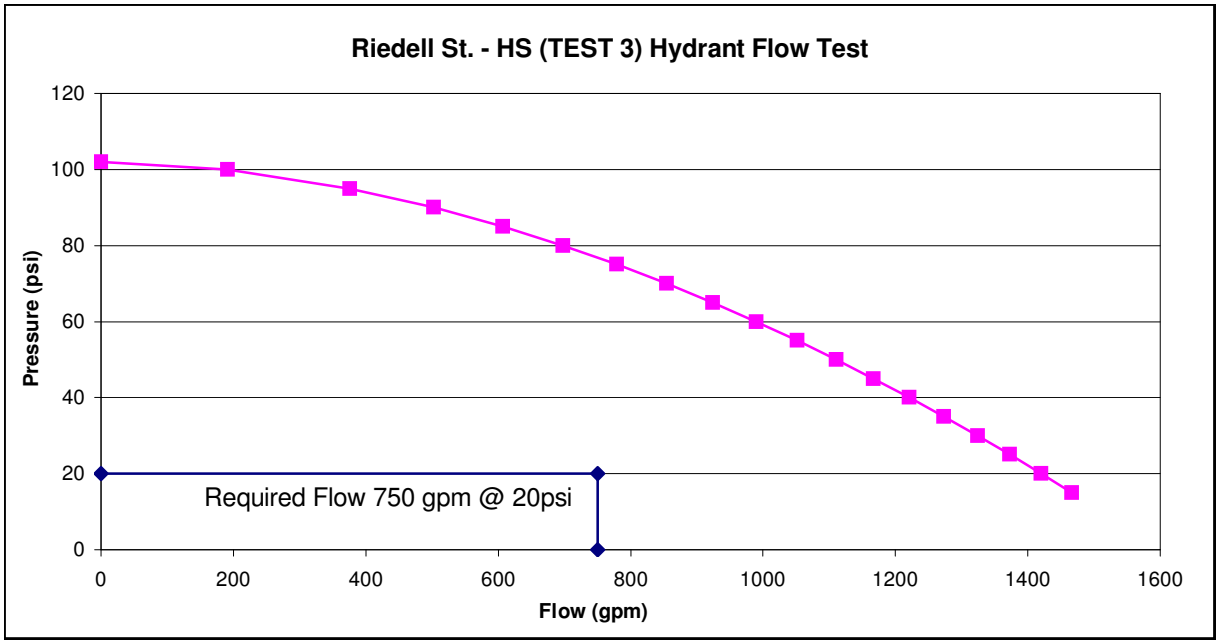
Requirement **750** gpm
20 psi

	Static Pressure (psi)	Residual Pressure (psi)
Gauge Hydrant	102	52

Pitot Reading: 42 psi

Pitot Reading: 1087 gpm

Flow at 20 psi: 1420 gpm



Note:

Fay, Spofford & Thorndike
Burlington, MA

Douglas
Hydrant Flow Tests

Location: Main St. - HS (TEST 4) Date: 7/22/2008 Time: 8:38AM

Flow Hydrant: F-4

Gauge Hydrant: G-4

Nozzle Dia: 2.5 inches

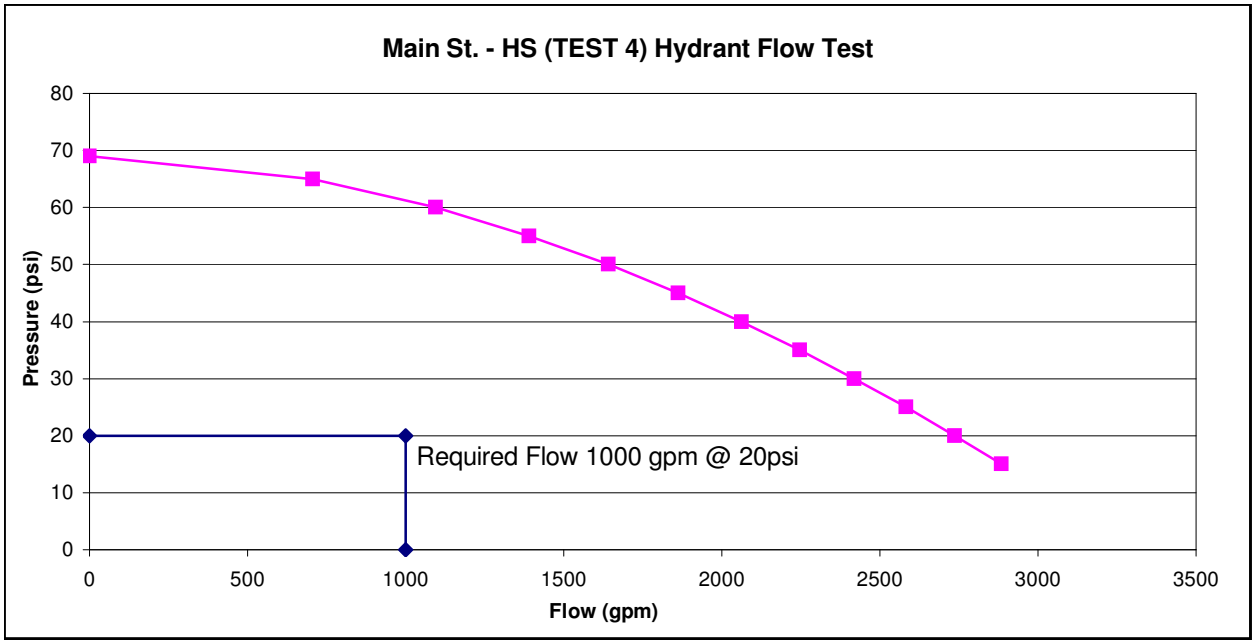
Requirement **1000** gpm
20 psi

	Static Pressure (psi)	Residual Pressure (psi)
Gauge Hydrant	69	58

Pitot Reading: 53 psi

Pitot Reading: 1222 gpm

Flow at 20 psi: 2737 gpm



Note:

Fay, Spofford & Thorndike
Burlington, MA

Douglas
Hydrant Flow Tests

Location: Main St. @ West St. (TEST 5) Date: 7/22/2008 Time: 9:12AM

Flow Hydrant: F-5

Gauge Hydrant: G-5

Nozzle Dia: 2.5 inches

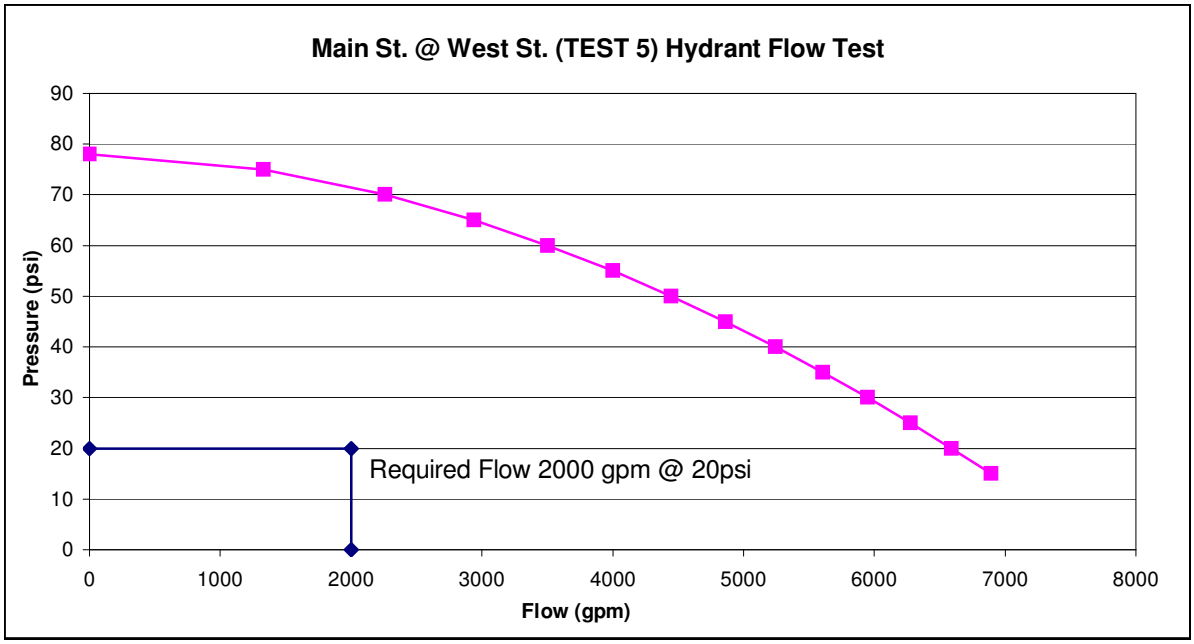
Requirement **2000** gpm
20 psi

	Static Pressure (psi)	Residual Pressure (psi)
Gauge Hydrant	78	75

Pitot Reading: 63 psi

Pitot Reading: 1332 gpm

Flow at 20 psi: 6593 gpm



Note:

Fay, Spofford & Thorndike
Burlington, MA

Douglas
Hydrant Flow Tests

Hydrant Flo
Depot St. @

Location: Depot St. @ Martin Rd. (TEST 6) Date: 7/22/2008 Time: 9:30AM

Flow Hydrant: F-6

Gauge Hydrant: G-6

Nozzle Dia: 2.5 inches

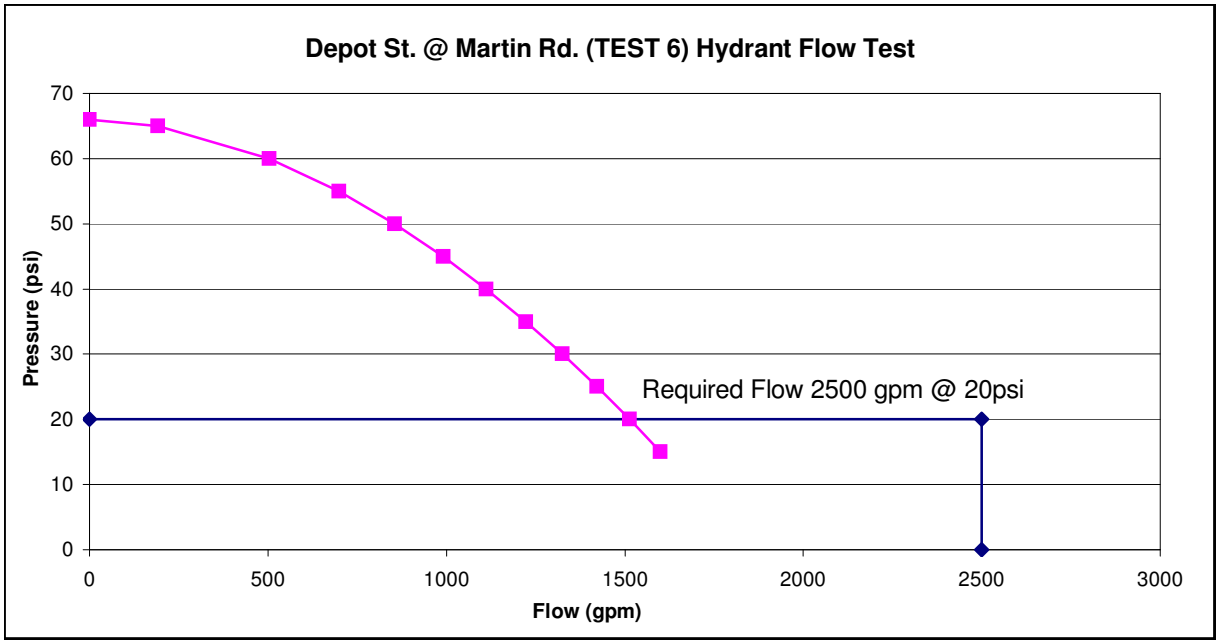
Requirement **2500** gpm
20 psi

	Static Pressure (psi)	Residual Pressure (psi)
Gauge Hydrant	66	50

Pitot Reading: 26 psi

Pitot Reading: 856 gpm

Flow at 20 psi: 1513 gpm



Note:

Fay, Spofford & Thorndike
Burlington, MA

Douglas
Hydrant Flow Tests

Location: Martin Rd. near Maple (TEST 6A) Date: 7/22/2008 Time: 9:48AM

Flow Hydrant: F-6A

Gauge Hydrant: G-6A

Nozzle Dia: 2.5 inches

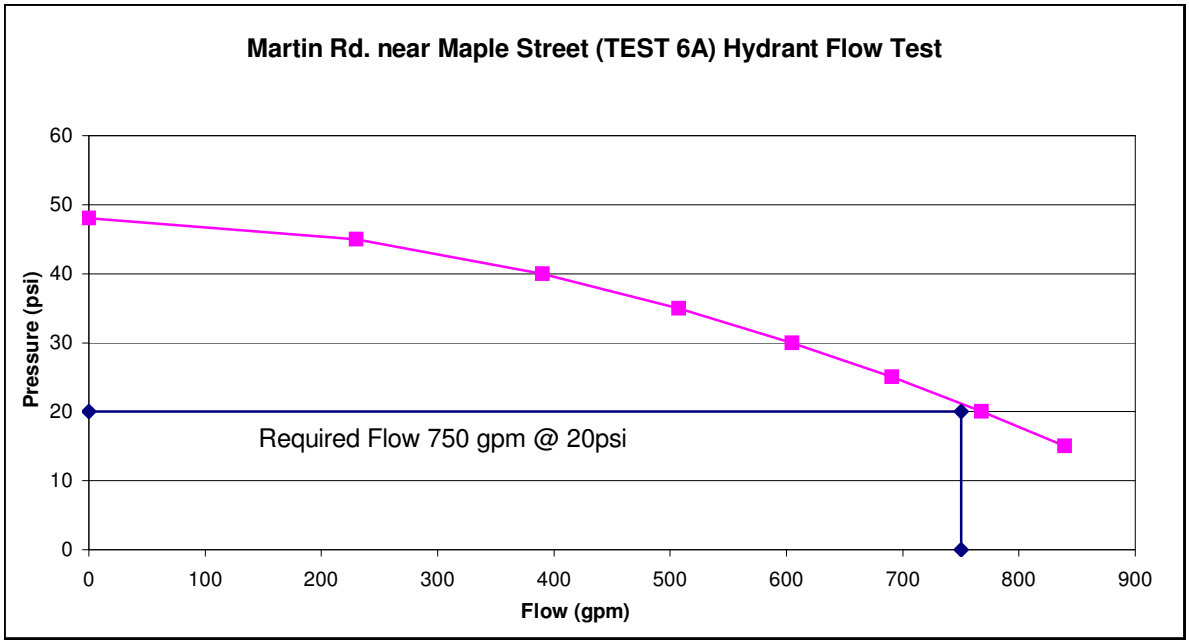
Requirement **750** gpm
20 psi

	Static Pressure (psi)	Residual Pressure (psi)
Gauge Hydrant	48	30

Pitot Reading: 13 psi

Pitot Reading: 605 gpm

Flow at 20 psi: 768 gpm



Note:

Fay, Spofford & Thorndike
Burlington, MA

Douglas
Hydrant Flow Tests

Location: Gilboa St. @ Caswell (TEST 7) Date: 7/22/2008 Time: 10:08AM

Flow Hydrant: F-7

Gauge Hydrant: G-7

Nozzle Dia: 2.5 inches

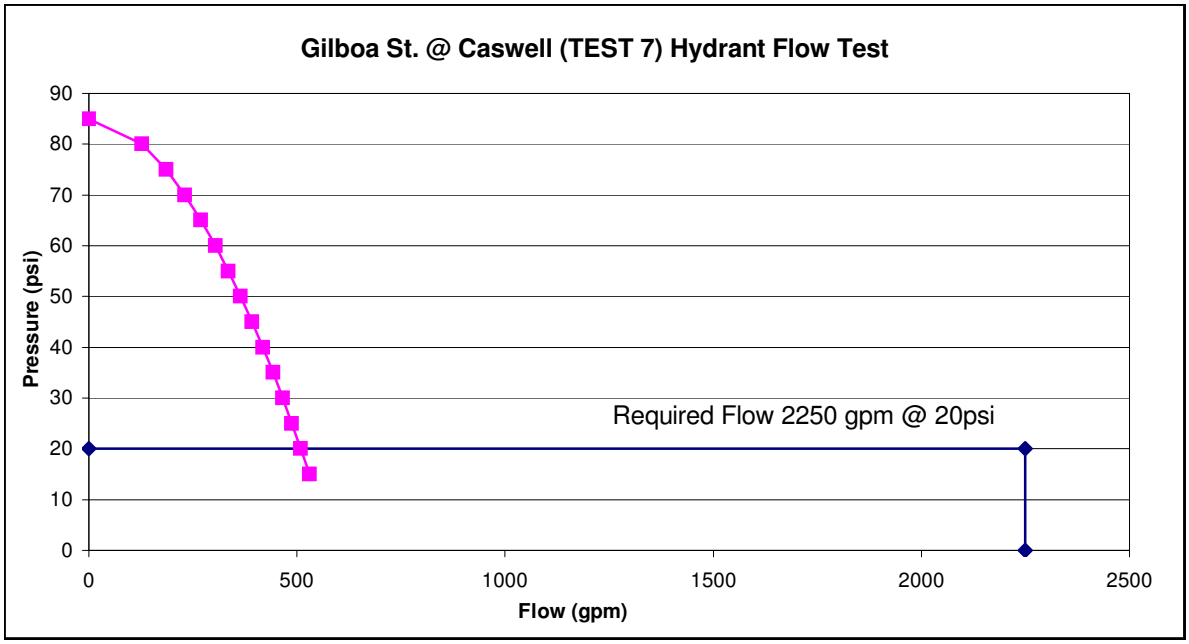
Requirement **2250** gpm
20 psi

	Static Pressure (psi)	Residual Pressure (psi)
Gauge Hydrant	85	28

Pitot Reading: 8 psi

Pitot Reading: 475 gpm

Flow at 20 psi: 509 gpm



Note:

Fay, Spofford & Thorndike
Burlington, MA

Douglas
Hydrant Flow Tests

Location: North St. @ Prentiss Ct. (TEST 8) Date: 7/22/2008 Time: 11:25AM

Flow Hydrant: F-8

Gauge Hydrant: G-8

Nozzle Dia: 2.5 inches

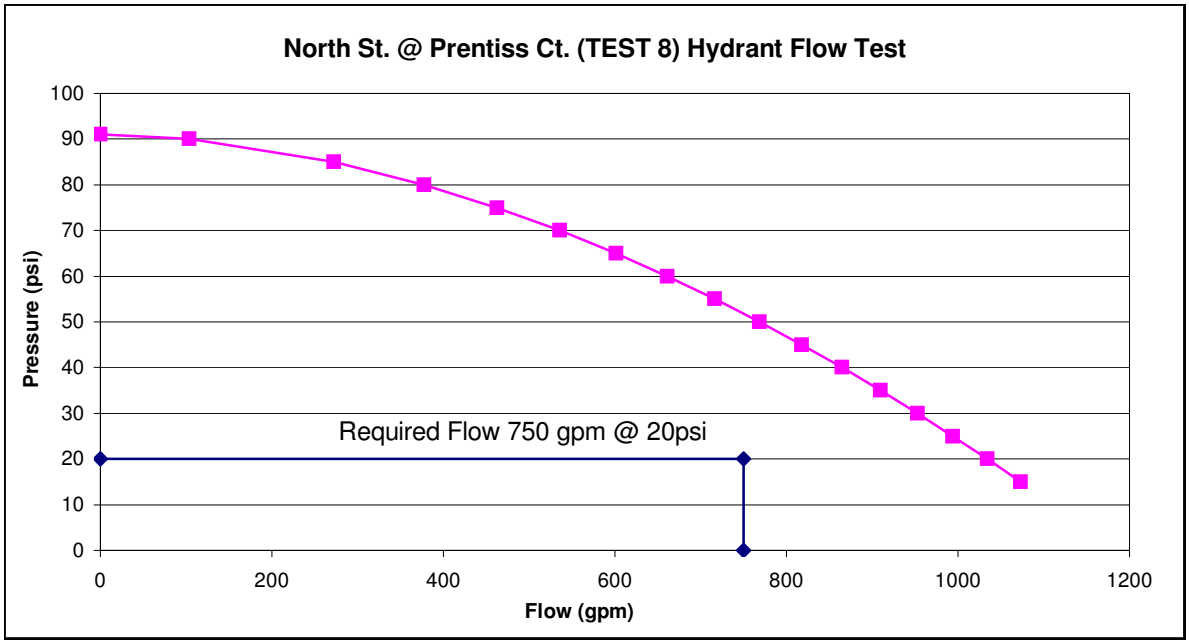
Requirement **750** gpm
20 psi

	Static Pressure (psi)	Residual Pressure (psi)
Gauge Hydrant	91	50

Pitot Reading: 21 psi

Pitot Reading: 769 gpm

Flow at 20 psi: 1034 gpm



Note:

Fay, Spofford & Thorndike
Burlington, MA

Douglas
Hydrant Flow Tests

Location: North St. @ hayward Landing (TEST 9) Date: 7/22/2008 Time: 10:28AM

Flow Hydrant: F-9

Gauge Hydrant: G-9

Nozzle Dia: 2.5 inches

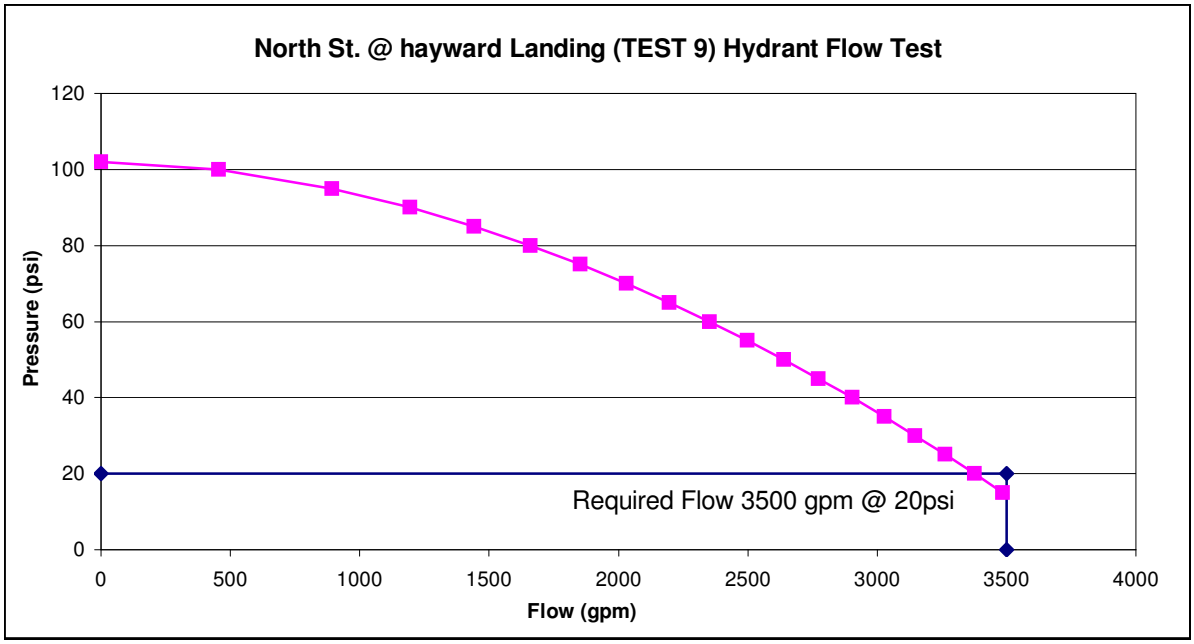
Requirement **3500** gpm
20 psi

	Static Pressure (psi)	Residual Pressure (psi)
Gauge Hydrant	102	88

Pitot Reading: 60 psi

Pitot Reading: 1300 gpm

Flow at 20 psi: 3376 gpm



Note:

Fay, Spofford & Thorndike
Burlington, MA

Douglas
Hydrant Flow Tests

Location: NE Main St. @ Monroe St. (TEST 10) Date: 7/22/2008 Time: 12:02PM

Flow Hydrant: F-10

Gauge Hydrant: G-10

Nozzle Dia: 2.5 inches

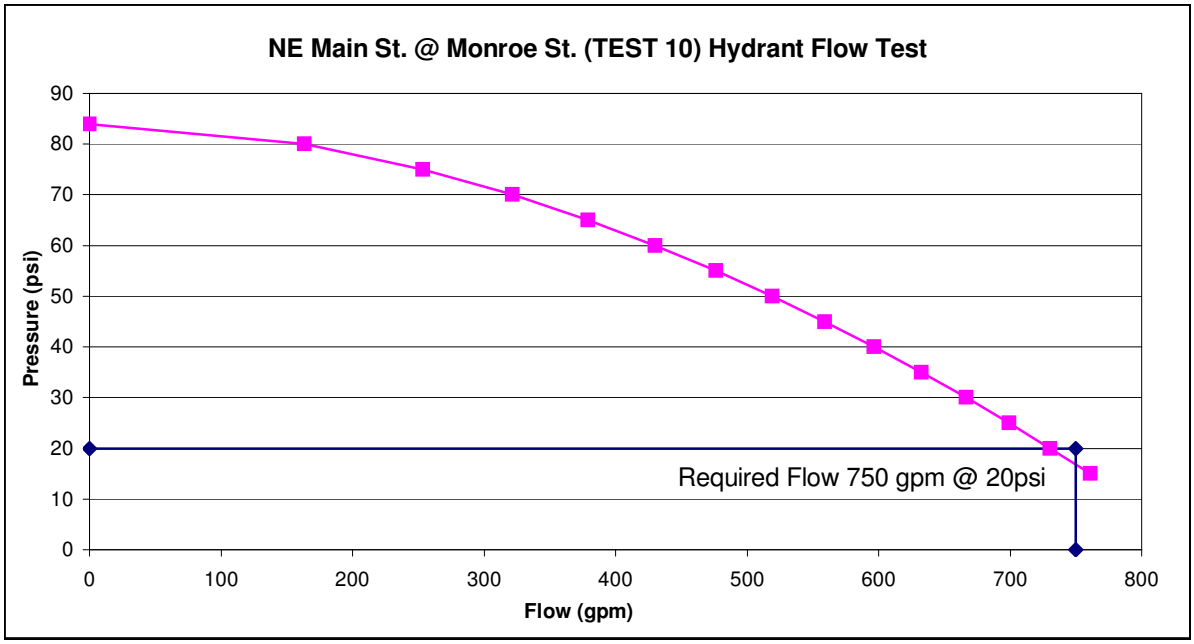
Requirement **750** gpm
20 psi

	Static Pressure (psi)	Residual Pressure (psi)
Gauge Hydrant	84	23

Pitot Reading: 18 psi

Pitot Reading: 712 gpm

Flow at 20 psi: 731 gpm



Note:

Fay, Spofford & Thorndike
Burlington, MA

Douglas
Hydrant Flow Tests

Location: Davis St. @ High School (TEST 10A) Date: 7/22/2008 Time: 12:20PM

Flow Hydrant: F-10A

Gauge Hydrant: G-10A

Nozzle Dia: 2.5 inches

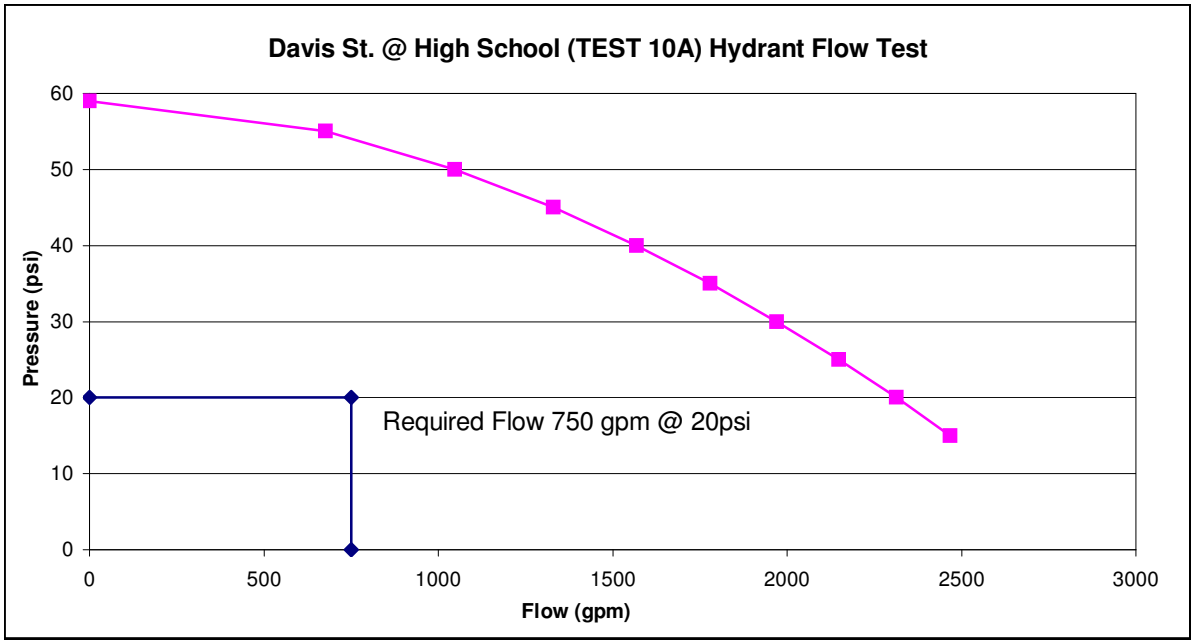
Requirement **750** gpm
20 psi

	Static Pressure (psi)	Residual Pressure (psi)
Gauge Hydrant	59	50

Pitot Reading: 39 psi

Pitot Reading: 1048 gpm

Flow at 20 psi: 2313 gpm



Note:

Fay, Spofford & Thorndike
Burlington, MA

Douglas
Hydrant Flow Tests

Location: Towle Ct. (TEST 11) Date: 7/22/2008 Time: 10:53AM

Flow Hydrant: F-11

Gauge Hydrant: G-11

Nozzle Dia: 2.5 inches

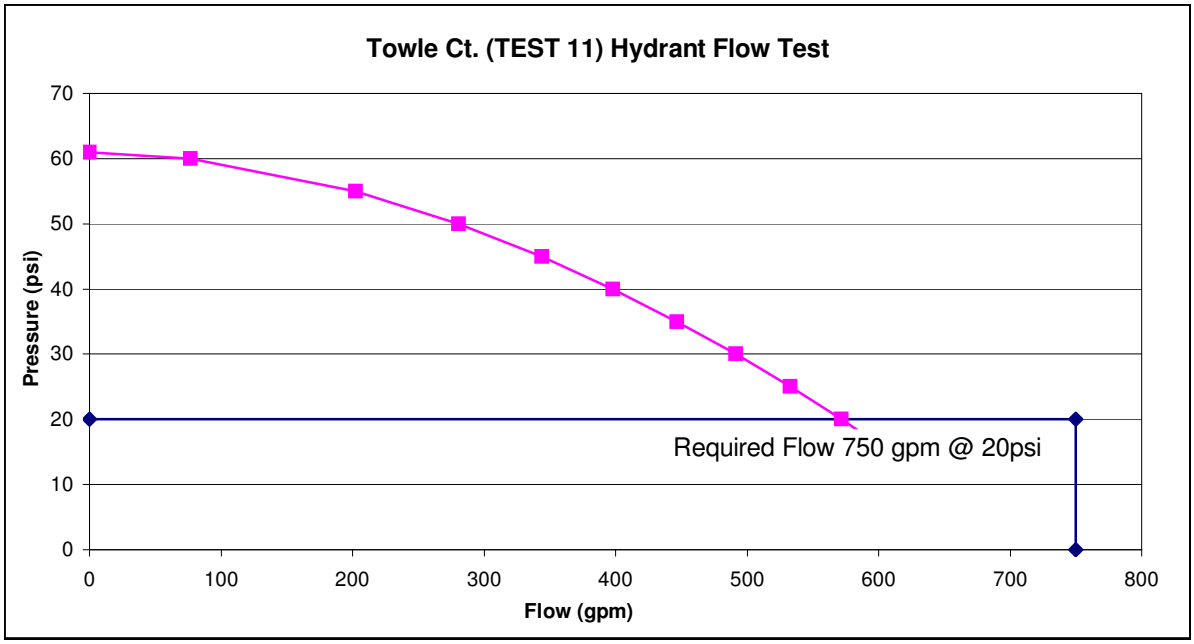
Requirement **750** gpm
20 psi

	Static Pressure (psi)	Residual Pressure (psi)
Gauge Hydrant	61	9

Pitot Reading: 15 psi

Pitot Reading: 650 gpm

Flow at 20 psi: 572 gpm



Note:

Fay, Spofford & Thorndike
Burlington, MA

Douglas
Hydrant Flow Tests

Location: North St. end (TEST 11A) Date: 7/22/2008 Time: 11:10AM

Flow Hydrant: F-11A

Gauge Hydrant: G-11A

Nozzle Dia: 2.5 inches

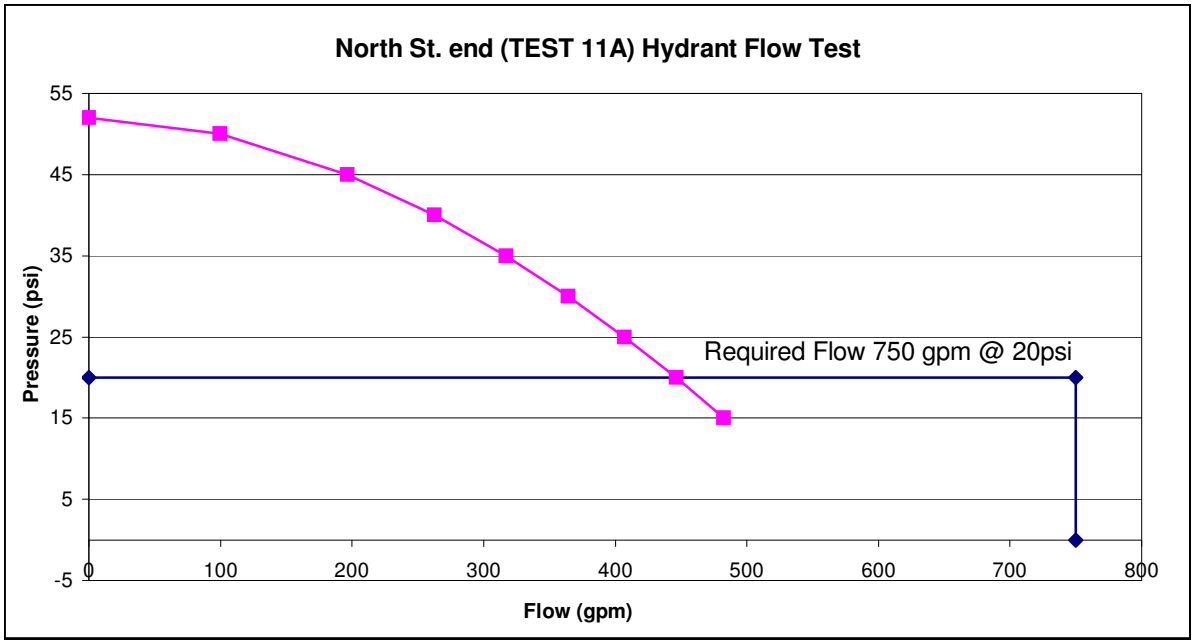
Requirement **750** gpm
20 psi

	Static Pressure (psi)	Residual Pressure (psi)
Gauge Hydrant	52	12

Pitot Reading: 9 psi

Pitot Reading: 503 gpm

Flow at 20 psi: 446 gpm



Note:

Fay, Spofford & Thorndike
Burlington, MA

Douglas
Hydrant Flow Tests

Location: Gilboa St. @ Old Lackey Dam Rd. (TEST 12) Date: 7/22/2008 Time: 11:45AM

Flow Hydrant: F-12

Gauge Hydrant: G-12

Nozzle Dia: 2.5 inches

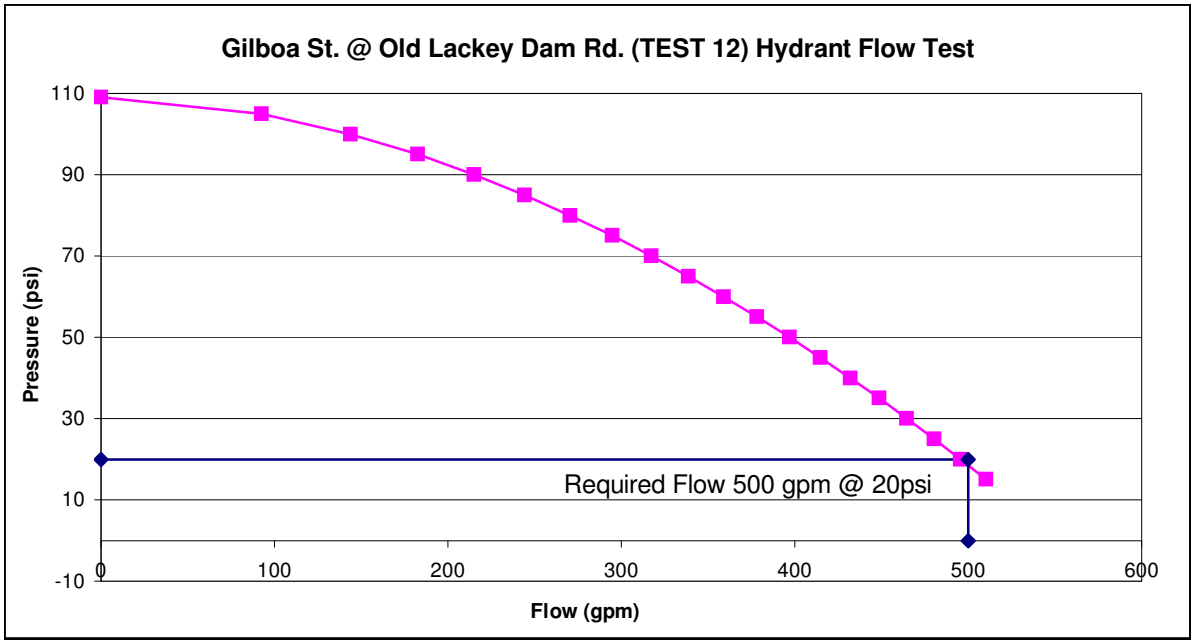
Requirement **500** gpm
20 psi

	Static Pressure (psi)	Residual Pressure (psi)
Gauge Hydrant	109	8

Pitot Reading: 10 psi

Pitot Reading: 531 gpm

Flow at 20 psi: 496 gpm



Note:

Fay, Spofford & Thorndike
Burlington, MA