WATER SYSTEM STUDY UPDATE

FOR

SOUTHBOROUGH, MASSACHUSETTS

1988

WHITMAN & HOWARD, INC.
45 William Street
Wellesley, Massachusetts 02181

ELIAS
A.
COOREY
NO. 21769

J.N. 86-327

AUGUST, 1988

Whitman & Howard
Environmental Engineers, Scientists, and Planners

August 24, 1988

Board of Water Commissioners
Water Department Office
Common Street
Southborough, MA 01772

Re: Water System Study

Gentlemen:

In accordance with our agreement dated January 14, 1987, we are submitting five (5) copies of our report entitled, "Water System Study, Southborough, Massachusetts", dated August, 1988.

This report includes the results of our analysis of the water supply, storage and distribution system of the Town of Southborough relative to existing and projected future water demands through the year 2006.

We would be pleased to meet with you to discuss the findings of our report.

Very truly yours,

WHITMAN & HOWARD, INC.

Ali M. Parand

Elias A. Cooney, P.E.
Senior Vice President

AMP/EAC/dfg
86-327

Established 1869

W&H

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I. EXECUTIVE SUMMARY

A. OBJECTIVE/SCOPE OF STUDY

This report presents the results of an engineering study designed to provide an updated long-range plan for the Southborough water system. Factors considered in this study included population projections, estimated growth in water consumption, present and future requirements for storage capacity, transmission and distribution system conditions.

Specifically, the workscope focused on the following tasks:

1. Determine overall population to be served for the next twenty years; based on a review of census records, applicable growth studies, available land, proposed industrial/commercial development, past and present engineering plans.
2. Perform hydrant flow tests at various locations to determine available fire flows.
3. Conduct pipeline friction coefficient tests in strategic transmission and distribution mains to aid in determining the conditions of existing water mains, to locate severe bottlenecks in the present system, and their effects on the distribution analysis.

4. Perform a comprehensive computer analysis of the total water supply, storage and distribution system. Use pumpage data, population trends, and other data to: (1) assess the ability of the system to meet current and future consumption and fire demands and (2) to identify and quantify needed improvements.

This study update provides a priority program for recommended improvements to ensure that present and future water demands can be met through the year 2006.

B. CONCLUSIONS AND RECOMMENDATIONS

The results of this study indicate that Southborough's water system is in need of upgrading in a number of areas:

- The distribution system will require a booster pumping station for full utilization of existing storage.
- An additional storage facility and reinforcement mains are required to increase fire flow.
- Some looping is required to eliminate dead-end sections of water mains.
- Larger size mains are needed in the vicinity of the Hosmer pumping station to better utilize this source of supply for the overall benefit of the water system.

Based on the detailed findings described in this report, Whitman & Howard, Inc. (W&H) recommends that the following improvements be made to the existing system by 2006:

1.	Construct a booster pumping station and install Pressure Reducing Valves:	$340,000
2.	Construct a two-million gallon storage facility off Deerfoot Road south of Route 9:	$679,000
3.	Install approximately 85,350 feet of new 12-inch water mains:	$9,031,000
4.	Install approximately 37,650 feet of new 8-inch water mains:	$3,508,000
	TOTAL:	$13,558,000

II. POPULATION AND WATER CONSUMPTION TRENDS

A. POPULATION

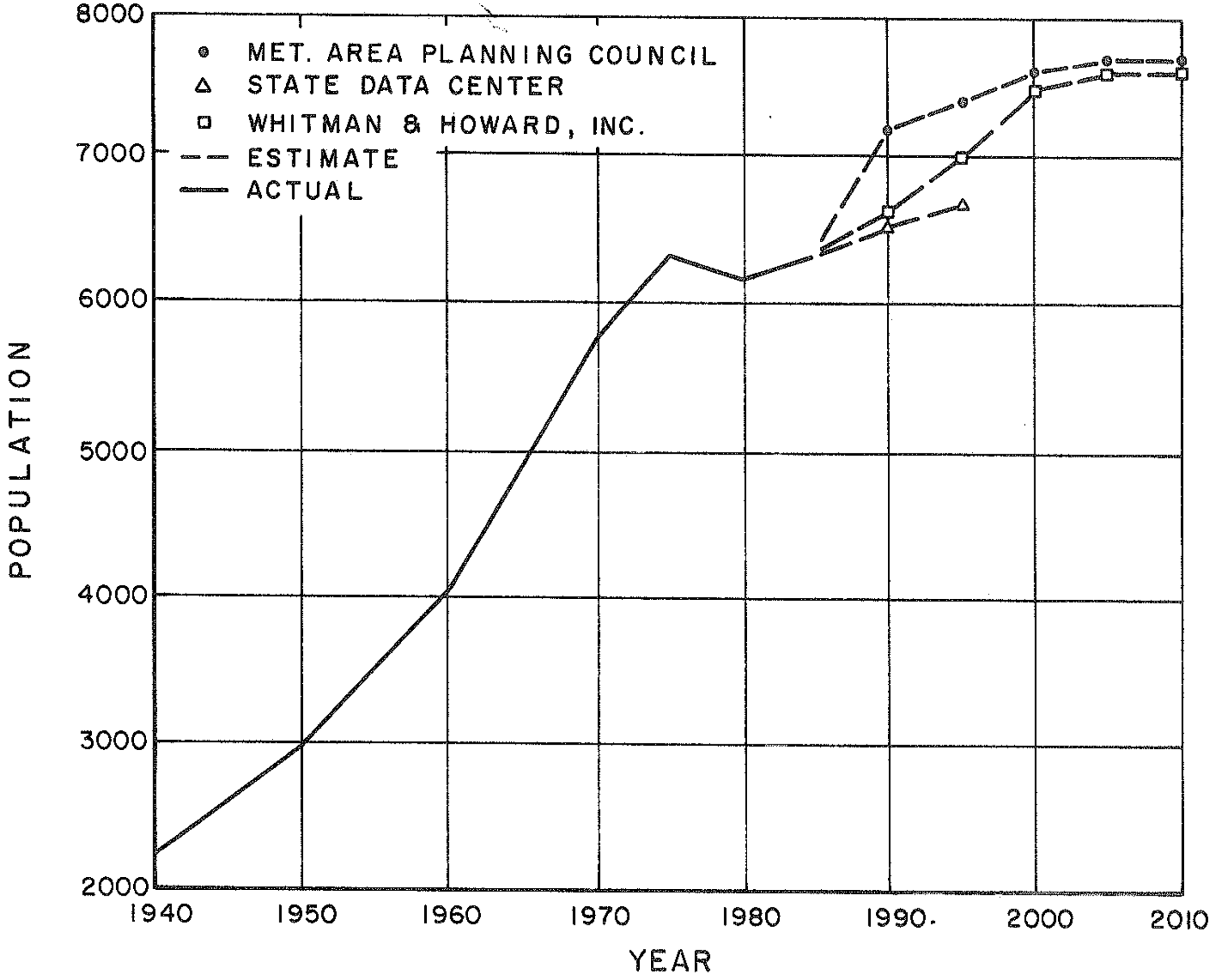
The 1985 census for the Commonwealth of Massachusetts shows Southborough's population as 6,334. (See Table 1 and Figure 1 for population growth trends and projections.)

Recent population projections by the Metropolitan Area Planning Council (MAPC) and the Massachusetts Institute for Social and Economic Research (MISER) at the University of Massachusetts were reviewed. The MISER data indicated that a 5.6 percent increase in population could be expected through 1995, with an estimate of 6,692 persons. MAPC also projected that population will increase at a higher rate through year 1990 and at a lower rate through the year 2010, with a population of 7,200 for year 1990, a population of 7,600 for year 2000, and a population of 7,700 for year 2010.

The estimated population growth used in this report was projected by Whitman & Howard, Inc. It is based on a review of population data from various agencies and from the projections of housing units and housing density contained in the update to the Master Plan for Southborough done in July 1986.

TABLE 1
PAST POPULATION AND PROJECTIONS
SOUTHBOROUGH, MASSACHUSETTS
1940 - 2010

Year	Population: Actual	Projected: W&H	Projected: MAPC	Projected: MISER
1940	2,250			
1945	2,600			
1950	3,000			
1955	3,550			
1960	4,200			
1965	4,900			
1970	5,798			
1975	6,326			
1980	6,193			
1985	6,334			
1990		6,570	7,200	6,549
1995		7,050		6,692
2000		7,530	7,600	
2005		7,600		
2006		7,600	7,700	



ACTUAL AND PROJECTED POPULATION
SOUTHBOROUGH, MASSACHUSETTS

FIGURE 1

B. WATER DEMANDS

In general, water system facilities are designed using the following guidelines:

1. Supply sources are designed for maximum day flow so that storage facilities may be replenished during off-peak times at night.
2. Storage facilities are designed to maintain system pressures, to help meet fire demands and some portion of the peak hourly demand so that adequate fire storage exists even during the periods of peak demand.
3. Transmission and distribution mains must be designed to carry peak hourly demands and/or fire flow to any point in the system.

The average daily demand is defined as the total pumpage for a given year, divided by the number of days in the year. According to 1986 data, the average daily demand for Southborough is approximately 0.62 million gallons per day (mgd). The maximum day demand is the greatest 24-hour demand for the year and can often be several times that of the average day demand. Over the past six years, the maximum day demand has averaged 1.13 mgd or about 2.05 times the average daily demand. However, this ratio has been as high as 2.25. Averaging these peak ratios results in a factor of 2.15. To better ensure that the maximum day demands will be met in the future, the ratio of 2.15 between average day and maximum day demands has been used in planning recommended system improvements.

The <u>average</u> day peak week demand is defined as the maximum weekly pumpage for a given year, divided by seven days.

The total annual demands (the average day, the average day of the peak week, and the maximum day demand) for the last 16 years are shown in Table 2. The historical average day and maximum day demands are also shown graphically in Figure 2. It can be seen that the average day demand has remained relatively stable for the past 16 years with the exception of 1977, 1980 and 1986, which the town experienced extensive construction. Conversely, the maximum day demand has fluctuated significantly over the same period of time.

C. <u>UNACCOUNTED-FOR WATER</u>

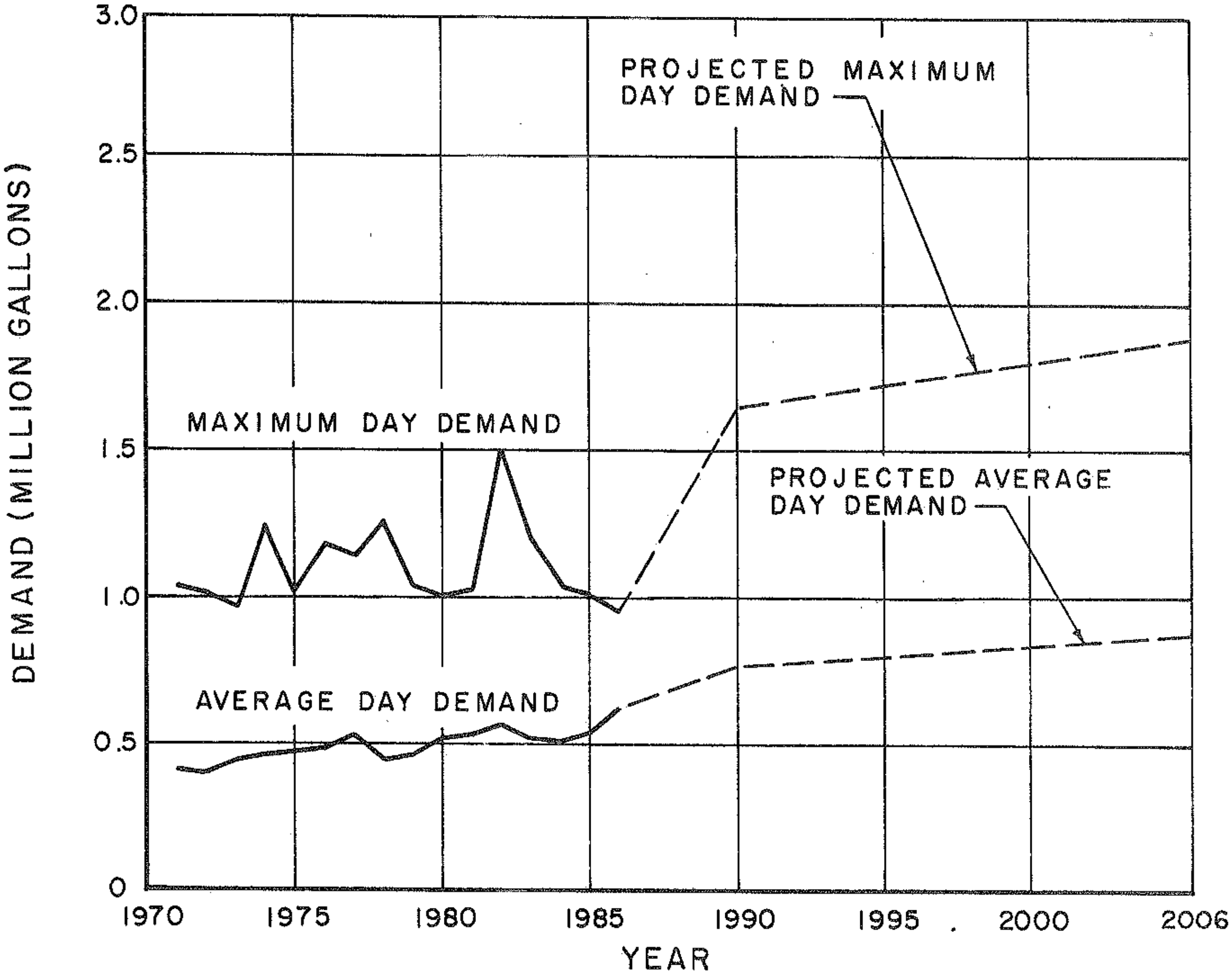
The actual amount of water consumed by customers can vary greatly from the actual amount of water pumped or delivered to the distribution system. The difference between water delivered to the system and that which is actually consumed by the customer is known as "unaccounted-for water." Included in this category is water lost through leakage, water used for flushing or cleaning water mains, or water used in fire fighting. Unaccounted-for water may also be due to under-registration of meters or unmetered uses.

The Town's leak detection program has reduced this "unaccounted-for water" to approximately seven percent by means of locating and repairing leaks throughout the water system (according to pumpage and consumption records). The seven percent figure is well below the industry average; thus,

TABLE 2
HISTORICAL WATER DEMAND DATA
1971 - 1986
SOUTHBOROUGH, MASSACHUSETTS

Year	Total (mg)*	Average Day (mgd)**	Average Day Peak Week (mgd)	Maximum Day (mgd)
1971	149.5	0.410	0.679	1.04
1972	146.9	0.403	0.688	1.02
1973	161.9	0.444	0.825	0.97
1974	169.3	0.464	0.960	1.25
1975	171.6	0.470	1.161	1.02
1976	174.5	0.478	0.871	1.18
1977	193.4	0.530	0.802	1.15
1978	164.5	0.451	0.830	1.27
1979	171.5	0.470	0.722	1.04
1980	190.4	0.522	0.772	1.01
1981	191.4	0.524	0.773	1.03
1982	204.9	0.561	1.077	1.51
1983	191.0	0.523	0.695	1.20
1984	190.7	0.522	0.779	1.04
1985	197.7	0.542	0.634	1.02
1986	225.5	0.618	0.710	0.95

* mg = million gallons
** mgd = million gallons per day



ACTUAL AND PROJECTED WATER DEMANDS
SOUTHBOROUGH, MASSACHUSETTS

FIGURE 2

it is indicative of a well-maintained, tight water system.

Since the water system must be able to supply not only the water consumed, but also the water that is "unaccounted-for", the projections in this report are for pumpage requirements. Refer to Appendix A for the report on "Water Leakage Survey" dated August 1987.

D. PER CAPITA WATER DEMAND

By using past population figures and corresponding pumpage data, the per capita pumpage can be calculated. The present average day per capita pumpage for Southborough is approximately 96 gallons per day. Water-use trends are normally used to indicate the future per capita pumpage expected. Future per capita pumpage data, together with population projections, are the criteria generally used to predict future water pumpage.

Investigations of past per capita consumption showed a general increase in per capita consumption due primarily to customers' acquisition of more water-consuming devices such as garbage disposals, dishwashers, washing machines, sprinkler systems, etc. In this study, it was assumed that increases in future per capita consumption will taper off because the majority of existing customers will have acquired these water-consuming devices. Most future customers will have these products initially. Additionally, efforts to promote water conservation will become a more important part of future water system development.

E. PER SERVICE WATER DEMAND

Relating the demand figures to the number of customers served results in a unit demand per water service. Table 3 lists the number of services, the average day, the average day of the peak week, and the maximum day demand per service connection.

F. FUTURE WATER DEMAND

In order to estimate future water consumption trends, we have based our projections on total number of services. This includes domestic-type demands (residential), nondomestic-type demands (commercial, municipal, industrial, office, retail uses), and unaccounted-for uses.

The average day demand per service has remained relatively stable for the last fifteen years at approximately 270 gallons per service per day. This has been adjusted to an anticipated maximum day demand per service of 627 gallons over the same period.

Southborough has approximately 2343 acres of residentially zoned "vacant" land. This is an additional 1,370 dwelling units at present zoning density.

According to the November 1984 MetroWest Growth Impact Study, only 20 percent of the 7.18 million square feet allowable under existing zoning bylaws has been developed.

Among MetroWest communities, Southborough has the highest total acreage of parcels fronting on Route 9. Most of this area is assessed as commercial or industrial land and is just

TABLE 3
WATER DEMAND BY SERVICE CONNECTION
1971 - 1986
SOUTHBOROUGH, MASSACHUSETTS

Year	Number of Services	Average Day* (Gallons)	Average Day Peak Week* (Gallons)	Maximum Day* (Gallons)
1971	1,558	263	436	669
1972	1,608	250	428	633
1973	1,641	270	503	592
1974	1,657	280	579	754
1975	1,672	281	694	612
1976	1,701	281	512	692
1977	1,732	306	463	665
1978	1,760	256	472	723
1979	1,789	263	404	579
1980	1,802	289	428	561
1981	1,828	287	423	561
1982	1,848	304	583	815
1983	1,877	279	370	642
1984	1,915	273	407	541
1985	1,949	278	326	526
1986	1,988	311	357	477

* Per Service Connection

beginning to be developed, primarily for office and commercial uses.

To project water demands, we have assumed that an average of 200 gallons per day per 1000 square feet will be consumed. Presently, the Town anticipates approved developments to occur in the near future. Data related to these developments has been compiled from records of the Water Department (Table 4).

If all the approved developments take place and all become municipal water users, an additional average day demand of approximately 0.23 mgd could result. This figure is equivalent to 860 additional services by year 1990. Since this growth rate is not likely to continue, the future projections (beyond 1990) regarding the number of services was calculated based on the actual data for the last 16 years by using a method of linear regression or least square.

Table 5 lists the anticipated total services, average day demand and maximum day demand by year 2006. The total (domestic and nondomestic) projected demands are shown graphically in Figure 2.

The actual demand experienced in future years will, of course, be dependent on the type and rate of developments, water and sewer rates, climatological conditions, conservation practices and other factors.

TABLE 4
APPROVED PROPOSED DEVELOPMENTS
SOUTHBOROUGH, MASSACHUSETTS

Development Type	Location	Description
Retail	21-27 Turnpike Rd.	18,925 sq. ft.
Office Building	274 Turnpike Rd.	15,360 sq. ft.
Office Building	1 Firman Ave.	40,000 sq. ft.
Mall	112 Southville Rd.	10,000 sq. ft.
Medical Building	24-28 Newton St.	70,000 sq. ft.
General Office	24-28 Newton St.	30,000 sq. ft.
Post Office	24-28 Newton St.	10,000 sq. ft.
Office Park	Turnpike Rd.	130,000 sq. ft.
Residential	Sears Rd.	65/79 units
Residential	Southville Rd.	103 units
Residential	Sears Rd.	27 units
Residential	Woodbury Rd.	72 units
Residential	Flagg Rd.	37 units
Residential	Sears Rd.	45 units
Residential	Parkerville Rd.	170 units
Residential		42* units

* Total of smaller residential developments that are approved for construction throughout the Town.

TABLE 5
PROJECTED NUMBER OF SERVICES
AVERAGE DAY AND MAXIMUM DAY DEMAND
SOUTHBOROUGH, MASSACHUSETTS

Year	Number of Services	Average Day Demand (mgd)*	Maximum Day Demand (mgd)
1990	2,848	0.77	1.66
1995	2,980	0.81	1.74
2000	3,113	0.84	1.81
2005	3,246	0.88	1.89
2010	3,380	0.91	1.96

NOTE: These projections are based on the assumption that all future developments will be connected to the Town's water system.

* mgd = million gallons per day

III. DESCRIPTION OF PRESENT WATER SYSTEM

A. SOURCE OF WATER SUPPLY

The Town of Southborough presently obtains its water supply from the Hultman Pressure Aqueduct under contract with the Massachusetts Water Resources Authority (MWRA). According to the present contract, MWRA has allocated the withdrawal of two million gallons per day (mgd) for the Town of Southborough through January 1, 1997.

B. PUMPING FACILITIES

The Town of Southborough is presently served by two pumping stations. A brief physical and operational description of each station follows.

1. Boland Pumping Station

This station is located in the northwesterly section of the Town and draws water from the gradeline pressure aqueduct off Ward Road. It utilizes two 50-horsepower Fairbank Morse pumps with capacities of 450 and 550 gallons per minute (gpm) respectively.

2. Arthur L. Hosmer Pumping Station

This station was constructed in 1977 in the eastern section of the Town. It also draws water from MWRA's Hultman Pressure Aqueduct.

At this station, there are two 60-horsepower Marthon Electric pumps rated at 600 and 400 gallons per minute (gpm) respectively. Both of these pumps are equipped with Parco surge control valves.

Both pumps at Hosmer pumping station cannot run simultaneously because piping from the station is too small, and surge pressure turns the second pump off. On a high-demand summer day, the first pump runs 15 to 17 hours, while the second pump runs approximately one hour.

C. TREATMENT FACILITIES

The water received from MWRA requires minimal treatment. In Southborough, the water supply is disinfected using chlorine gas at both pumping stations.

There are two chlorinators (V-notch, Pennwalt, Wallace & Tiernan type) and a two-cylinder scale, all located in a separate enclosure at both pumping stations.

The present difficulty of using both pumps simultaneously at the Hosmer pumping station has caused one of the chlorinators to stall. Some maintenance will be required to make this chlorinator operational.

D. WATER QUALITY

Periodic complaints about rusty water have been received from a section of the Town (Cherry, Winter, and Pleasant Streets, in particular). On December 12, 1987, samples were collected from six locations. Hosmer pumping station (for our baseline sample) and five complaint sites were tested in the field for pH, alkalinity, dissolved oxygen and carbon dioxide. Additional samples were brought back to our laboratory and evaluated to determine chemical characteristics (Refer to Appendix B for the laboratory results.)

Many MWRA-member communities have experienced similar problems during the past few years. This condition prompted MWRA to conduct extensive studies to determine the cause of this periodic rusty color problem. MWRA will notify its members of the findings. Problems of this nature could be due to one of or a combination of the following reasons:

1. Aggressive nature of the water supply
2. Old, unlined cast iron mains
3. Circulation/flow patterns

E. STORAGE FACILITIES

Water storage for the Town of Southborough is provided by two standpipes, one reservoir, and one elevated tank. A brief description of each facility follows.

1. Oak Hill Standpipe

The standpipe located on Oak Hill has a capacity of 275,000 gallons and a 10-inch feed to Oak Hill Drive. The standpipe has an overflow elevation of 492.73 feet (USGS) mean sea level.

There are some minor breakdown of the interior sidewall in the high water area and also some on exterior sidewall. A complete coating of this facility is not recommended at this time, however it should be inspected periodically.

2. Clear Hill Standpipe

The standpipe located on Clear Hill has a capacity of 460,000 gallons and an overflow elevation of 493.32.

This standpipe was painted in 1985 and does not require futher maintenance at this time.

3. <u>Tara Road Reservoir</u>

The Tara Road reservoir has a capacity of 1,300,000 gallons and an overflow elevation of 515.00 feet USGS mean sea level. The Tara Road Reservoir was built with a higher overflow elevation than the other tanks so that the higher ground around Tara Road could be adequately served as that area developed. Water would be boosted into the reservoir, thus forming a high service area.

Presently this reservoir is utilized only up to elevation of approximately 490 feet USGS mean sea level.

This reservoir was painted in 1983.

4. <u>Atwood Elevated Tank</u>

The elevated tank is located on Atwood Street. It has a capacity of 150,000 gallons and an overflow elevation of 493.04 feet USGS mean sea level.

There is evidence of complete breakdown of interior coating, spider rods and all exterior parts of the roof. We recommend a complete painting of exterior and interior of this tank.

The total capacity of storage facilities is 2,185,000 gallons, but only 56 percent of this storage (1,229,000 gallons) is available.

F. <u>DISTRIBUTION SYSTEM</u>

The distribution system in Southborough consists of water mains ranging from 6 to 12 inches in diameter. Presently, there are approximately 61 miles of water mains (6 inches or larger) which consist of unlined cast iron, cement-lined cast iron, ductile iron, and polyvinyl chloride (PVC). Also, there are approximately 508 hydrants in the distribution system.

Water for Southborough's water distribution system is supplied from two pumping stations, Hosmer and Boland.

Storage facilities with the exception of Tara Road Standpipes are considered full at 72 feet deep. When the water level drops to 69 feet, pump #1 (at Boland) comes on-line. At 68.5 feet deep, pump #2 (at Hosmer) comes on-line, and when water level reaches 66 feet, pump #3 (the second pump at Boland Station) comes on.

IV. DISTRIBUTION SYSTEM ANALYSIS

A. FLOW TESTS

1. Purpose of Tests

As part of this study, it was necessary to conduct condition tests on various pipes which comprise the existing distribution system. The purpose of these tests was to determine the hydraulic carrying capacity of the pipes within the system. The roughness of the inside wall of a pipe has considerable bearing on the ease with which water will flow through it. In general, new cement-lined cast iron, ductile iron, asbestos-cement, and PVC pipes perform quite satisfactorily, while older unlined cast iron mains transmit water very inefficiently.

Corrosion and the deposition of sediment and precipitates on the interior of unlined, cast iron mains is the primary cause of reduced carrying capacity. Pipe corrosion, precipitation, and sedimentation create deposits called tuberculous, which often contribute to the growth of filamentous bacteria. As a result, pipe flow is influenced in two basic ways. Under certain conditions, tuberculation can build up in thickness to a point where the cross-sectional area and carrying capacity of a pipe is seriously diminished. However, even without a significant "build-up," corrosion and tuberculation greatly increase the roughness of the pipe's interior wall; the result is increased friction or resistance to flow. In either case, the available flow and/or pressure is significantly reduced.

2. C Flow Tests

An empirical formula exists which allows the relative roughness (or carrying capacity) of pipes to be computed. A term known as the Hazen-Williams Flow coefficient, or C value, is used to define that relative capacity. In general, new cement-lined iron pipes have C values between 120 and 140. In comparison, older unlined cast iron pipes have C values of 40 or less.

The procedure for conducting C flow tests requires isolating a section of main, flowing a hydrant at one end of the test main, and measuring the flow as well as the pressure drop (head loss) between selected points on the test main. This data, along with measured distances between the selected points and known diameter of the pipe are used to compute the C value.

Based on the results of these tests made on the system , C values were calculated. Using these C values as a basis for comparison, the remaining water mains were assigned C values according to their diameter, age, and location within the system. This information was used in the development of a computer model of the system.

3. Fire Flow Tests

The available fire flows at a given location are dependent upon both the condition of the water mains and the available system pressure at the location of the test. Fire flow tests are conducted by flowing a hydrant and determining what pressure drop occurs at an observation hydrant at that flow rate. This data is then used to determine what flow would be available at a given residual pressure. A residual pressure of 20 psi is usually used since this is the minimum required suction pressure for pumping equipment used by most fire departments.

Fire flow tests were conducted by the Insurance Services Office (ISO) in representative areas of the Town on April 23, 1974. The results of those tests were reviewed prior to the selection of sites for our fire flow tests. (Results of the ISO's tests can be found in Table 6. Deficient areas and the recommended fire flows are highlighted for reference.)

On the nights of Monday, May 4, and Thursday, November 5, 1987, personnel from Southborough's Water Department and representatives from Whitman & Howard conducted fire and C value tests throughout the distribution system. The results are described below.

4. Test Results

The results of the fire flow tests are shown in Table 7. The deficient areas are addressed in our discussion on distribution system improvements, presented further on in this report.

TABLE 6
FIRE FLOW TESTS*
BY INSURANCE SERVICES OFFICE
APRIL 23, 1974
SOUTHBOROUGH, MASSACHUSETTS

District	No.	Location	Hydrant Pressure (psi) 1	2	Discharge (gpm) (See Notes.) 3	4	5
Commercial	1	Main St. & Cordaville Rd.	76	57	1920	3440	5500**
Commercial	2	Route 9 & Central St.	75	43	1500	2000	3500**
Commercial	3	Cordaville & Mt. Vickery Rds.	84	21	1290	1300	3000**
Commercial	4	Coslin Dr. near Route 9	69	59	1900	4480	3000
Commercial	5	Cordaville & Southville Rds.	100	76	1625	3120	2500
Commercial	6	Route 9 & Parkerville Rd.	70	15	1370	1300	2500**
Commercial	7	Southville & Parkerville Rds.	95	75	1440	2950	2000
Residential	8	Richards & Moulton Rds.	87	78	1220	3600	750
Residential	9	Hickory Rd. at dead end	67	47	1020	1620	750
Residential	10	Boston & Dam Rds.	119	35	865	950	750
Residential	11	Foley Dr. & Peggy La.	90	50	990	1340	750
Residential	12	Pinecone Dr.	95	29	1230	1320	750
Residential	13	East Main St. & Overlook Rd.	71	43	1580	2180	750

NOTES

Column

1 Static pressure, psi, hydrants closed
2 Residual pressure, psi, on main with hydrants flowing
3 Discharge, gpm, obtained with residual pressure shown in column 2
4 Discharge, gpm, estimated for engine supply at residual pressure of 20 psi
5 Required flow, gpm

* The results of these tests indicate the rate at which water is available to certain locations in the distribution system; they do not relate to any flow duration period.

** Below the recommended fire flow rate.

TABLE 7
FIRE FLOW TESTS*
BY WHITMAN & HOWARD, INC.
MAY 5, 1987
SOUTHBOROUGH, MASSACHUSETTS

District	No.	Location	Hydrant Pressure (psi) 1	2	Discharge (gpm) (See Notes.) 3	4
Residential	1	Framingham Rd. near E. Main St.	95	86	750	2,357
Residential	2	Oak Hill Rd. at Maple St	38	26	919	1,144
Residential	3	Oregon Rd. at Edgewood	78	67	671	1,647
Residential	4	Flagg Road at Love Lane	65	62	978	4,221
Residential	5	Ward Rd. at Bigelow Rd.	80	74	1,453	5,038
Residential	6	Parkerville Rd. near Knox St.	88	77	628	1,679
Residential	7	Bagley Rd. at Partridge Hill	100	90	949	2,917
Residential	8	Sears Rd. at Mouetts Subdiv.	43	34	712	1,182
Residential	9	Main St. at Sears Rd.	89	82	1,034	3,557
Industrial	10	Route 9 between Flagg Rd. & Deerfoot Rd.	68	64	888	3,398

NOTES

Column

1 Static pressure, psi, hydrants closed
2 Residual pressure, psi, on main with hydrants flowing
3 Discharge, gpm, obtained with residual pressure shown in column 2
4 Discharge, gpm, estimated for engine supply at residual pressure of

* The results of these tests indicate the rate at which water is available to certain locations in the distribution system; they do not relate to any flow duration period.

The results of the C value tests indicate that some of the older cast iron water mains have decreased carrying capacities. The results of these flow tests and the estimated percent of original carrying capacity of the water mains tested can be found in Table 8.

The farther away from the sources of supply or storage that water travels in the distribution system, the more it is affected by these lower-capacity water mains. As the flow rate through the water mains increases during a fire flow situation, the pressure and the amount of water available elsewhere decrease exponentially.

Tests conducted in 1972 and on May 1987 showed a C value of 52 and 45 respectively for the 10-inch main on Oak Hill Road between the Oak Hill Standpipe and Route 9.

On November 5, 1987, C value tests were also conducted at two locations along Oak Hill Road (Table 8, Test Nos. 1 & 2). The results of the tests confirmed (C equal to 55 and 27) that a problem exists between Maple Street and Route 9.

A low C value is an indication of large head loss in the pipe for a given flow. This problem could be due to a number of reasons; for example, tuberculation, a partially closed gate valve or other obstruction. It is our recommendation that Southborough Water Department investigate this problem further to determine the cause of the recorded low C values for Oak Street main.

TABLE 8
C VALUE FLOW TESTS
BY WHITMAN & HOWARD, INC.
NOVEMBER 5, 1987
SOUTHBOROUGH, MASSACHUSETTS

Test No.	Location	Size of Pipe (inches)	Material	Calculated C Value	Percent Carrying Capacity*
1	Oak Hill Rd. between standpipe and Maple St.	10	Cast Iron (Cement-Lined)	84	55
2	Oak Hill Rd. between Maple St. and Route 9	10	Cast Iron (Cement-Lined)	35	27
3	Cordaville Rd. @ Rock Point Rd.	8	Cast Iron (Cement-Lined)	84	55
4	Woodbury Rd. @ Woodland Rd.	8	Asbestos Cement	97	66
5	Lynbrook Rd. near Love Lane	12	Asbestos Cement	55	42

* Based on a C value of 130 for a new water main

B. COMPUTER MODEL SIMULATION

In Phase I of this project, the 1972 computer simulation model was updated to include the addition of the Boland pumping station, new water mains, and major loop closures.

To evaluate the present and proposed water distribution system, it was necessary to simulate a variety of flow conditions with the computer model. The following data was entered into the computer: proper boundary conditions such as system demands, pipe characteristics (length, size, and C Value), water levels in the storage reservoirs, and pumping rates from each source of supply. A comparison was then made between the computer output and the actual results obtained in the field from flow tests, from pressure readings, etc. The boundary conditions in the model were then adjusted until the computer model output closely reproduced the actual data collected in the field. A comparison of the field results with the computer-simulated results can be found in Table 9.

Once the water system was simulated, the computer model was used to determine the following characteristics:

1. Deficiencies of the System.

   Deficiencies were determined by computing fire flow values at different locations and then comparing those values with fire flow requirements. (See requirements in Table 6.)

2. Effectiveness of Proposed Improvements

   To alleviate present deficiencies in the water system, some improvements were incorporated into the model. Fire flow values were then determined at the same locations noted above in Item 1. Recommended improvements were based on a comparison of these values with existing flows.

This computer model can provide future analysis of individual sections within the distribution system, at any time the Town may require it.

TABLE 9
RESULTS OF MODEL SIMULATION OF HYDRANT FLOW TESTS
BY WHITMAN & HOWARD, INC.
SOUTHBOROUGH, MASSACHUSETTS

Test No.	Flow (gpm)*	Model Node Number	Field Static (psi)**	Field Residual (psi)	Simulated Static (psi)	Simulated Residual (psi)
1	750	86	95	86	95	88
2	919	110	38	26	38	28
3	671	64	78	67	77	69
4	878	35	65	62	66	58
5	1,453	232	80	74	81	73
6	628	7	88	77	88	76
7	949	65	100	90	99	90
8	712	104	43	34	43	35
9	1,034	29	89	82	90	85
10	888	36	68	64	68	65

* gpm = gallons per minute
** psi = pounds-force per square inch

V. SYSTEM DEVELOPMENT PLAN

A. SOURCE OF SUPPLY

The present contract between Southborough and the MWRA expires on January 1, 1997. Presently, the permit required for source of supply beyond this date is in draft form. This form ("Policy and Procedure for Approval of Water Supply Permit") must be completed by the Town's Water Department when the MWRA submits its new guidelines. It is strongly recommended that Southborough officials review and respond promptly to these guidelines.

According to our projected average day demand for Southborough, the two million gallons per day allotted by the MWRA is sufficient through the year 2006. However, our projected maximum day demand seems to be approaching above limit, and at some point before 2006 the Town might require more than two million gallons per day to meet its maximum day demand. This emphasizes the importance of greater storage capacity to meet the projected maximum day demand. We recommend that the Town negotiate possibility of additional supply with MWRA at the time of contract renewal.

B. TREATMENT FACILITIES

As discussed earlier, the present difficulty of using both pumps simultaneously at the Hosmer pumping station has caused one of the chlorinator to stall. We recommend that the Town perform required maintenance on this chlorinator after this restriction has been resolved. It is also recommended that the chlorine injection locations be moved to the discharge side of each pump. This will prevent further periodic damage to the pumps.

C. STORAGE FACILITIES

The storage of potable water within a water system is one of the most essential elements of a domestic water supply and distribution system. The purpose of water storage in a distribution system is to increase the capacity and proficiency of the water system to:

- Meet water demands for fighting fires
- Meet maximum day and peak hourly demands which usually occur during the summer months
- Provide more uniform pressures within the system 24 hours a day
- Provide water to meet system demands if the existing supply capacity is temporarily lowered due to mechanical failure or due to periodic maintenance of pumping facilities
- Provide a safety outlet in the system to reduce the effects of pressure surges known as water hammer

The primary purpose of storage is to provide a source of pressure and standby supply that will result in a more balanced system pressure and in an equalization of system supply and demand. Storage "rides" on the hydraulic gradient of the distribution system so power outages don't affect the immediate ability of the storage facilities to supply the water system.

In addition, if a system had no storage, the water supply pumping facilities would have to be capable of supplying the maximum, instantaneous rate of consumption, regardless of how infrequently this rate might occur.

In order to evaluate the adequacy of the water system's storage, three factors are considered: equalization, fire flow and usable storage, described below.

1. Equalization Storage

   Equalization storage is that portion of storage required to meet the peak hourly fluctuation during the maximum day demand period. This storage volume is generally assumed to be approximately 30 percent of the maximum day demand. The projected maximum day demand for the year 2010 is 1.96 mgd. Therefore, the equalization storage calculated for the year 2010 would be 0.6 million gallons (0.30 x 1.96 = 0.60).

2. Fire Flow Storage

   The second factor to be considered is fire flow requirements. This calculation is based on the Basic Fire Flow required for the individual community as determined by the Insurance Services Office (ISO) guidelines.

   The ISO has, within the last ten years, adopted a new set of standards for determining fire flow rates and durations. The new standards call for increased available flow rates for shorter durations as compared to the previous standards. In result, the total usable system storage requirement for Southborough has decreased substantially but the distribution piping carrying capacity must be increased to provide for the greater fire flow rate.

The determination of "required fire flow" for a given building or group of buildings, involves an evaluation of a number of factors such as: area and height of building(s), materials of construction, occupancy and contents of building(s), proximity and exposure to adjacent building(s), and availability of sprinkler systems.

While ISO criteria determine specific fire flow requirements for individual buildings, or groups of buildings, they also establish a Basic Fire Flow requirement for the community as a whole. This Basic Fire Flow is defined as "...a fire flow indicative of the quantities needed for handling fires in important districts", and usually serves to mitigate some of the higher specific fire flows. Using the ISO's Fire Suppression Rating Schedule dated 1980, Whitman & Howard, Inc. has determined the Basic Fire Flow to be 5,500 gpm for four hours. Based on this, the estimated present required fire flow storage is 1.32 million gallons.

Add the fire flow storage requirement of 1.32 million gallons and equalization storage of 0.60 million gallons, and the system storage requirement becomes 1.92 million gallons.

Presently the total storage capacity is 2.185 million gallons but only 1.23 million gallons is being utilized. This is approximately 700,000 gallons less than 1.92 million gallons of usable storage required for equalization and fire. This emphasizes the need for additional storage in Southborough.

The following recommendations are made to increase the storage capacity within the existing system:

a. Create a high pressure zone by boostering the water into Tara Hill Reservoir up to elevation 514± feet USGS. This will provide an additional storage of 700,000 gallons.

b. Investigate the possibility of modifying the telemetering system to raise the working elevations of the other three facilities from 488 to 492± USGS. This is a potential for 80,000 gallons of additional storage.

Boostering the water in Tara Hill reservoir up to elevation 514± feet USGS will create a higher pressure zone which requires pressure reducing valves to be installed at locations where the high-low pressure area of the system are tied together.

The above improvements will increase the system storage capacity to 2.0 million gallons which in result will narrowly satisfy the equalization and fire storage requirements.

3. Usable Storage

The existing storage facilities control the gradient in the water distribution system. The overflow elevations of the storage facilities, except for the Tara Road reservoir, are about 493 feet USGS. The Tara Road reservoir overflow is at elevation of 515.00 feet USGS. Using the overflow elevations of the storage facilities and the approximate highest service elevation in the system, the usable storage can be determined.

Usable storage is that portion of the total storage which provides the higher elevations of the system with a certain minimum static pressure. The Massachusetts Department of Environmental Quality Engineering (DEQE) Guidelines for Public Water Systems recommends a minimum service pressure of 35 pounds per square inch (psi). The elevation of the high ground in Southborough is approximately 460 feet USGS. Therefore, the lowest elevation for usable storage is 540 USGS (460 + 80 = 540). Since the overflow elevation of all four storage facilities are below 540 feet USGS the system does not have any usable storage.

According to our calculations elevation 415 feet USGS is the highest ground that the system will be capable of maintaining a minimum static pressure of 35 psi on a maximum day demand, and a minimum static pressure of 20 psi during a fire on a maximum day demand.

However, based on USGS Topo maps, area of the Town higher than 415 feet elevation represent approximately eight percent of the total land, with mostly located on Tara Hill, Fairview Hill and Pine Hill areas. Full utilization of Tara Hill Reservoir up to elevation 515 feet USGS will minimize the pressure problem in this area. Fairview Hill contains majority of high grounds and requires much attention. The improvement on Tara Hill reservoir will also improve pressure on Fairview Hill but is less significant due to headloss between the two areas.

To minimize pressure problems in this area, we recommend construction of a 2.0 million gallon storage facility on Fairview Hill. This facility should have an overflow elevation of 515 feet USGS.

This additional 2.0 million gallons of storage will be a safety factor in case of:

- o Any of the two pumping station are out of service for a long period of time.
- o The water demand exceeds beyond our projection.
- o Any of the existing tanks is abandoned.
- o Any of the existing facilities is taken off line for periodic maintenance or for any other reason such as painting.

Presently, the Pine Hill area is not being served by Southborough's water system and only a small section have elevation higher than 415 feet USGS. Therefore it is not economically feasible to construct an additional storage facility for this area; however, we recommand that the system storage capacity be evaluated after implementation of previously mentioned improvements.

Improvements recommanded in this section will minimize the pressure problems of high grounds but it does not eliminate them completely. Therefore several solutions are presented here to further minimize the pressure problems at high grounds:

- o Prohibit all developments above elevation 415 feet USGS.
- o Require developers to construct necessary water tanks and booster systems to provide required pressure in high elevation area.

D. <u>PUMPING FACILITIES</u>

The two available pumping stations have a total of four pumps with combined capacity of 2,000 gpm. Hosmer pumping station has not been fully utilized because the water mains surrounding the station are too small and are not able to withstand the pressure and flow from both pumps running simultaneously. Thus, the Town will be limited to one pump if Boland pumping station is removed from service for maintenance, for repairs, or for other reasons.

In order to use the Hosmer pumping station at its full capacity, it is recommended that items 1a through 1c of proposed Phase I improvements be implemented soon (as discussed in Section VI).

E. <u>UNACCOUNTED-FOR WATER</u>

The Town's leak detection program has reduced the unaccounted-for water to approximately seven percent. The following recommendations are made to further reduce the unaccounted-for water:

1. Calibrate flow meters and recorders at each station on a regular basis.
2. Maintain organized records of pumpage, domestic and nondomestic (commercial, industrial and municipal) water use.
3. Continue an ongoing water leakage program on a timely basis (at least once every five years).
4. Maintain that all fire hydrants are properly closed.

It is also recommended that the Town allocate annual budget for conducting above program.

F. WATER QUALITY

The quality of water from the Quabbin and Wachusett Reservoirs meets or exceeds present EPA and DEQE drinking water standards except for bacteria and corrosivity. The low pH, alkalinity, and hardness point to the problem of corrosivity.

Because raw water quality meets most DEQE and EPA drinking water standards, it is not surprising that past treatment was limited to disinfection in Southborough. Aggressive water corrodes distribution system piping and plumbing and leaches these materials into the water supply. This results in increasing the concentrations of these metals above drinking water standards. It is recommended that Southborough incorporate sufficient funds in water department budget to further investigate the corrosion problem.

VI. PROPOSED DISTRIBUTION SYSTEM IMPROVEMENTS

A. BASIC CONSIDERATIONS

Several important factors must be considered in planning improvements or expansion of a distribution system. These include the proper size selection and location of water mains and the manner of their incorporation into the system to ensure adequate flows and pressures. For example, any pipe which extends 600 feet or more without a cross-connection should have a minimum diameter of 8 inches. For pipes extending less than 600 feet, the minimum pipe diameter can be reduced to 6 inches only if the water main is used to complete a water main loop. Wherever possible, dead-ends should be eliminated by looping or by interconnection, and all water mains should be cross-connected at reasonable intervals. In addition, the system should not contain any bottlenecks in which a smaller water main is the sole means of transporting water between larger mains.

Another major factor which should be considered in improving or expanding a system is that of fire protection. The construction of large developments (apartment buildings, condominiums, industrial, offices, etc.) results in high fire flow demands being placed on the system. If the water distribution system cannot meet such demands, a reduction in overall rating of the system may result, causing increased insurance premiums for the whole community.

For this reason, construction of large residential/ industrial complexes should not be approved until a determination is made of the fire flow requirements and the overall effect on the system. Similarly, plans of proposed subdivisions should be examined to ensure that the proposed water mains can be satisfactorily incorporated into the system.

The following recommended improvements have examined these basic considerations through four phases of development:

Phase I - Present to 1990

Phase II - 1990 to 1995

Phase III - 1995 to 2000

Phase IV - 2000 to 2006

These improvements in Southborough's water system are shown on a water distribution map (shown in Plan II in pocket).

B. PHASE I: Present-1990

Our phase I recommendations for improving the system include efficient utilization of the existing system.

Overall improvements include:

1. Full utilization of the Hosmer pumping station with the following improvements:
    a. Install 1,800 feet of 12-inch main in Boston Road from Central Street to Framingham Road.
    b. Install 1,070 feet of 12-inch main in Framingham Road, extending the main (item a) northerly to East Main Street.

c. Install 830 feet of 12-inch main in East Main Street, extending the main (item b) westerly to Overlook Drive.

This will increase the carrying capacity of the pipes and will result in eliminating surge created by both pumps running simultaneously at Hosmer pumping station.

2. To improve storage capacity within the system for fire flow and for maximum day demand we recommend the following:

   a. Create two separate pressure zones by installing pressure reducing valves at locations where the high pressure zones are connected to low pressure zone. We aniticipate a minimum of four PRV's required. However, additional PRV's should be installed on any new mains that will connect the two zones.

   b. Construct a booster pumping station to raise the water level to elevation 514± feet USGS in Tara Hill reservoir.

      The possibility of revising the Boland pumping station to include the booster pump should be investigated as a first option.

   c. Install 1,550 feet of 12-inch pipe on Route 9 from Crystal Pond Road to existing 12-inch pipe west of Deerfoot Road.

   d. Install 2,200 feet of 12-inch water main from existing 12-inch main on Deerfoot Road to 10-inch main on High Ridge Road.

e. Construct a 2,000,000 gallon storage facility to be located within the high pressure zone on Fairview Hill Road which is south of Route 9 and west of Parkerville Road.

These improvements will increase the pressure for future development such as the proposed 174 units of affordable housing planned in the Southville area of Town.

3. To alleviate the water quality problem created by old unlined cast iron water mains, the following recommendations are proposed:

   a. Install 1,100 feet of 8-inch main to replace existing 6-inch main in Pleasant and Cherry Streets.

   b. Install 1,100 feet of 8-inch main to replace existing 6-inch main in Summer and Winter Streets.

C. <u>PHASE II: 1990-1995</u>

The following three major recommendations are made for Phase II:

1. To facilitate flow in and out of the proposed 2,000,000 gallons storage tank on Fairview Hill and to provide water to the Middle Road area the following improvements are needed:

   a. Install 1,300 feet of 12-inch main in Route 9 from Parkerville Road easterly to Middle Road.

   b. Install 2,400 feet of 8-inch main in the Middle Road area from Route 9 southerly to existing 8-inch main near Mt. Vickery Road.

c. Install 2,500 feet of 8-inch main along Deerfoot Road from Clifford Road southerly to pass through existing sleeve under Route 9 and connect to the existing 12-inch main.

d. Install 800 feet of 12-inch main in Route 9; connect to above main (item c) on Deerfoot Road and continue westerly to existing 12-inch main.

2. To increase fire flow demand, we recommend the following:

   a. Install approximately 1,150 feet of 12-inch pipe in Willow Street from existing 8-inch main to Route 9.

   b. Install 1,850 feet of 12-inch pipe in Route 9 from above main (item 2a) in Willow Street, westerly to the 8-inch main on Central Street.

   c. Install 5,850 feet of 12-inch pipe on Parkerville Road from Fairview Drive to Highland Street. Install a PRV on this main.

3. The following recommendations are made to improve the capacity of the existing system and to be able to supply water to developing areas of the Town:

   a. Install 6,700 feet of 12-inch main along Walnut Drive and Oregon Road from Oak Hill Drive, continuing through existing sleeve under Route 9, then on Oregon Road westerly to connect to existing 8-inch main on Woodland Road.

   b. Install 3,200 feet of 12-inch main on Edgewood Road from the 12-inch main (item 3a) on Oregon Road to near the Ashland town line, then connect to Liberty Estate Development area.

c. Install 3,400 feet of 12-inch main on Sears Road from 10-inch pipe on Main Street northerly to existing 12-inch main near Sadie Hutt Lane.

d. Install 2,200 feet of 8-inch main on Breakneck Road from existing 8-inch main to the 8-inch on Mt. Vickery Road.

e. Install 700 Feet of 12-inch pipe from existing 12-inch main in Northboro Road, crossing the railroad Bridge to Fisher Road.

f. Install 5,100 feet of 8-inch main on Fisher Road, connecting to above main (item 3e) from one side and to existing 12-inch main through Presidential Drive from the other side.

g. Install 3,120 feet of 8-inch pipe on Northboro Road from Main Street northerly to existing 10-inch main.

h. Install 3,200 feet of 8-inch pipe on Parkerville Road from Main Street southerly to existing 8-inch main.

i. Install 4,500 feet of 12-inch main on Chestnut Hill Drive from Main Street to Northboro Road.

D. PHASE III: 1995-2000

At the present time, approximately 20 homes at the end of Pine Hill Road obtain their water from the Town of Framingham. Also, current information on housing projects indicate that approximately 300 additional homes may be constructed in this area. The following major improvements are being recommended to supply water to this section of the Town:

1. To meet the increased water demand:

   a. Install 9,000 feet of 12-inch main in Boston Road from Central Street to Clemmons Street on Pine Hill area.

   b. Install 16,000 feet of 12-inch main on Pine Hill Road and vicinity. (Refer to Plan II located in rear pocket.)

   c. Install 6,600 feet of 8-inch main on Pine Hill Road area. (Refer to Plan II located in rear pocket.)

2. To meet future demands for greater water supply, for fire flows, and for reliability of the system:

   a. Install 5,200 feet of 12-inch main on Southville Road from Parkerville Road to Woodbury Road.

   b. Install 2,150 feet of 12-inch main in Jericho Hill Road from Fisher Road to Marlborough town line.

   c. Install 4,100 feet of 12-inch main in Northboro Road near railroad track to Marlborough town line.

   d. Install 3,500 feet of 8-inch main in Marlboro Road from Acre Bridge Road northerly to Sears Road. Install a PRV on this main (including a railroad crossing).

E. <u>PHASE IV: 2000-2006</u>

The following improvements are being recommended to increase fire flow and to eliminate bottlenecks in the system:

1. Install 480 feet of 8-inch main in Cross Street between Marlboro Road and Newton Street.

2. Install 1,100 feet of 8-inch main in Flagg Road from Route 9 to existing 8-inch main.

3. Install 2,850 feet of 12-inch main on Old Mill Road from Route 9 to Oak Hill tank.
4. Install 1,900 feet of 8-inch main on Fisher Road from Presidential Drive to the Southborough-Marlborough line.
5. Install 1,550 feet of 12-inch main from Cross Street southerly to School Street (including railroad bridge crossing).
6. Install 1,800 feet of 8-inch main on School Street from Marlboro Road southerly to existing 8-inch main.
7. Install 3,900 feet of 8-inch pipe on Middle Road between Route 9 and Main Street.
8. Install 2,750 feet of 8-inch main on Clifford Street from Deerfoot Road to Parkerville Road.
9. Install 2,500 feet of 12-inch main from Middle Road to Cordaville Road (to replace existing 6-inch main).

VII. ESTIMATED COSTS FOR IMPROVEMENTS

A. OVERVIEW

The following estimates (by phase) are based on May, 1988 construction costs at an Engineering News Record cost index of 4493. Allowance for construction, engineering, and contingencies are included in these estimates. These estimates are based on work of a similar nature and do not include the costs of land acquisition, rights-of-way surveys, easements, appraisals, and related legal services. Field investigations of the proposed work sites should be conducted in order to more closely approximate expected costs for a paraticular projects listed. (In the future, estimates should be updated for the actual year construction is to take place.)

The total costs per phase (listed below) are detailed in the following paragraphs:

Phase		Total Costs
I	(Present-1990)	$2,019,000
II	(1990-1995)	$4,957,000
III	(1995-2000)	$4,696,000
IV	(2000-2006)	$1,886,000

B. PHASE I: PRESENT-1990

	Construction Work	Estimated Costs
1.	Boston Road 1,800 feet of 12-inch main from Central Street to Framingham Road	DONE $204,000

2. Framingham Road
   1,070 feet of 12-inch main from (YES)
   Boston Road to East Main Street — $110,000

3. East Main Street
   830 feet of 12-inch main from (8")
   Framingham Road to Overlook Road — $85,000

4. Install four pressure reducing vavles (YES)
   to isolate the higher pressure zone — $60,000

5. A booster pumping station to raise (NO)
   the water elevation in Tara Hill
   reservoir up to elevation 514± feet — $280,000

6. Route 9
   1,550 feet of 12-inch main from (YES)
   Crystal Pond Road to Deerfoot Road — $ 176,000

7. Deerfoot Road (PARTIAL)
   2,200 feet of 12-inch main from
   Route 9 southerly to High Ridge Road — $227,000

8. A water storage facility with a
   capacity of 2,000,000 gallons to be (NOT)
   located within the high pressure zone
   off Deerfoot Road, south of Route 9
   and west of Parkerville Road — $679,000

9. Winter and Summer Streets 1,100 feet (WINTER YES)
   of 8-inch main to replace existing (NO SUMMER)
   6-inch main — $99,000

10. Pleasant and Cherry Streets YES
1,100 feet of 8-inch main to replace existing 6-inch main $99,000

TOTAL COST - PHASE I IMPROVEMENTS: $2,019,000

C. PHASE II: 1990-1995

Construction Work		Estimated Costs
1. Route 9 1,300 feet of 12-inch main from Parkerville Road easterly to Middle Road	NO	$147,000
2. Middle Road 2,400 feet of 8-inch from Route 9 southerly to Mt. Vickery Road	NO	$216,000
3. Deerfoot Road 2,500 feet of 8-inch main from Clifford Road southerly to pass through existing sleeve under Route 9 and connect to exising 12-inch main	PARTIAL	$283,000
4. Route 9 800 feet of 12-inch main from Deerfoot Road westerly to existing 12-inch main	YES	$90,000
5. Willow Street 1,150 feet of 12-inch main from Boston Road to Route 9	YES	$118,000

6. Route 9
   1,850 feet of 12-inch main from NO
   Willow Street to Oak Hill Drive $210,000

7. Parkerville Road
   5,850 feet of 12-inch main from NO
   Fairview Drive to Highland Street
   (included installation of a PRV) $617,000

8. Walnut Drive and Oregon Road YES
   6,700 feet of 12-inch main from Oak
   Hill Drive to Woodland Road $690,000

9. Edgewood Road
   3,200 feet of 12-inch main from YES
   Oregon Road to Ashland Town Line
   (to connect to the existing main at
   Liberty Estate) $330,000

10. Sears Road YES
    3,400 feet of 12-inch main from Main
    Street to Sadie Hutt Lane $350,000

11. Breakneck Road
    2,200 feet of 8-inch main from Mt. PARTIAL
    Vickery to existing 8-inch main $198,000

12. Northboro Road
    700 feet of 12-inch main from YES
    Northboro Road to Fisher Road
    (included railroad bridge crossing) $150,000

13. Fisher Road

5,100 feet of 12-inch main from (PARTIAL)
Jericho Hill Road to existing 12-inch
through Presidential Drive — $525,000

14. Northboro Road

3,120 feet of 8-inch main from Main (NO)
Street northerly to existing 12-inch
main — $281,000

15. Parkerville Road

3,200 feet of 8-inch pipe from Main (NO)
Street southerly to existing 8-inch
main — $288,000

16. Chestnut Hill Drive (NO)

Install 4,500 feet of 12-inch main on
Chestnut Hill Drive from Main Street
to Northboro Road — $464,000

TOTAL COST - PHASE II IMPROVEMENTS: $4,957,000

D. PHASE III: 1995-2000

Construction Work	Estimated Costs
1. Boston Road (NO) 9,000 feet of 12-inch main from Central Street to Clemmons Street On Pine Hill area	$927,000

2.	Pine Hill Area 16,000 feet of 12-inch main on Pine Hill Road and vicinity (Refer to plan II bound in pocket.)	$1,620,000
3.	Pine Hill Area 6,600 feet of 8-inch main on Pine Hill area (Refer to Plan II bound in pocket.)	$594,000
4.	Southville Road 5,200 feet of 12-inch main from Parkerville Road to Woodbury Road	$536,000
5.	Jericho Hill Road 2,150 feet of 12-inch main from Fisher Road to Marlborough Town Line	$221,000
6.	Northboro Road 4,100 Feet of 12-inch main north of railroad track to Marlborough Town Line	$422,000
7.	Marlboro Road 3,500 feet of 8-inch main from Acre Bridge Road northerly to Sears Road (Including a railroad crossing and installation of a PRV)	$376,000
	TOTAL - PHASE III IMPROVEMENTS:	$4,696,000

E. PHASE IV: 2000-2006

	Construction Work		Estimated Costs
1.	Cross Street 480 feet of 8-inch main between Marlboro Road and Newton Street	NO	$43,000
2.	Flagg Road 1,100 feet of 8-inch main from Route 9 to existing 8-inch main	NO	$99,000
3.	Old Mill Road 2,850 feet of 12-inch main from Route 9 to Oak Hill Tank		$294,000
4.	Fisher Road 1,900 feet of 8-inch main from Presidential Drive to the Southborough-Marlborough Line		$171,000
5.	Marlboro Road 1,550 feet of 12-inch main from Cross Street southerly to School Street (Including railroad bridge crossing)		$260,000
6.	School Street 1,800 feet of 8-inch main from Marlboro Road southerly to existing 8-inch main		$162,000
7.	Middle Road 3,900 feet of 8-inch pipe between Route 9 and Main Street		$351,000

8.	Clifford Street 2,750 feet of 8-inch pipe from Deerfoot Road to Parkerville Road	$248,000
9.	Mt. Vickery 2,500 feet of 12-inch main from Middle Road to Cordaville Road	$258,000
	TOTAL COST - PHASE IV IMPROVEMENTS:	$1,886,000

APPENDIX A

WATER LEAKAGE SURVEY

TOWN OF SOUTHBORO

Conducted by

WATER & WASTE PIPE TESTING INC.

August 30, 1987

Water & Waste Pipe Testing Inc.

Pressure Testing, Air Testing, Disinfection and Leak Detection

P. O. Box 174
Lynnfield, Massachusetts 01940
(617) 245-6705

Sept. 10, 1987

Town of Southboro
Water Department
Main St.
Southboro, MA 01772

ATTN: Donald Buzzell,
Water Superintendent

Dear Mr. Buzzell,

Water & Waste Pipe Testing, Inc., of Lynnfield, MA, conducted and completed a water leakage survey on the entire water distribution system for the Town of Southboro, MA, on August 30, 1987. The following report will summarize the water leakage survey results by indicating exactly the number of leaks detected during this survey, the description of each leak and the date the leak was repaired, and to offer some recommendations to the Southboro Water Department.

We would like to mention our appreciation to Mr. Buzzell and to his personnel for their full cooperation in assisting our crew during this survey. We look forward to working with the Department when our services are needed in the future and to continue our work in successfully detecting water leakage occuring within the system.

Sincerely,

Carl M. Sopper, President

SUMMARY OF

WATER LEAKAGE SURVEY RESULTS

During the course of the survey 11 leaks were pinpointed and reported to the Southboro Water Department. After repairs were made by the Water Department, the area of the leak was resurveyed to determine if any additional leakage existed. The water leaks detected during the survey can be defined as the difference between the amount of water produced and the amount of water sold which is registered on the customers' meters. Water used for firefighting, street washing and metering errors is not included in the unaccounted water loss in the system. The majority of leaks detected were hydrant leaks. Although only one main leak was detected throughout the system, this main leak accounted for the most water leakage within the system. Hydrant leaks may seem to be of less importance but we must mention the fact that some hydrants can be leaking as much as 3 GPM. The most important fact that we must stress is that the leaks detected make up the unaccounted for water loss within the system. If not detected each year these leaks can get larger and create problems for the Water Department. Otherwise, the leaks located in the system do not indicate any particular fault with the system but rather show that most of the underground leaks in the Town of Southboro are the commonly encountered type of leaks found in similar transmission and distribution systems.

The water leaks found in the system are divided into four general categories:

1) Leaks on mains

2) Leaks on service pipes

3) Leaks at hydrants (improperly closed valves)

4) Miscellaneous leaks

MAIN LEAK

One main leak was detected on 10" cast iron pipe from the storage tank in the wooded area off Oak Hill Drive. When excavated and exposed a 5" radial crack was discovered. Approximately 5 to 6 gallons per minute was the estimated loss of water due to this leak. This leak was first detected on the hydrants on Oak Hill Drive. Both hydrants on Oak Hill Drive had very strong leak readings. Further investigation led us to the controlling 10" valves located off Oak Hill Drive leading towards the tank area. These valves also had strong readings. Approximately 50 yards in off Oak Hill Drive in the wooded area we found considerable water dampness and soft ground, indicating the area of the leak. After repairs were conducted the area was relistened to for determining if any additional leakage existed.

SERVICE LEAKS

Two service leaks were detected during the course of the survey. At Lot #5 on Gilmore Rd. a curb stop was found to be partially on resulting in water loss through the bleeder hole at the curb stop. This leak was quickly eliminated by turning the valve to the "off" position, thus stopping the water loss at this valve.

At Hillside Ave. a leak was pinpointed on the 1" service that feeds two homes on this street. This was the second largest leak found within the system. When excavated and exposed a fairly large hole was discovered in the 1" copper pipe. It was estimated to be a loss of approximately 8 GPM of water. After this leak was repaired, 3 smaller pinholes in the pipe were discovered 10 feet upward from the original leak. These leaks were repaired and no further leakage was found to exist after repairs. During our investigation of this leak we also found a small body of surface water directly across from the leak in a wooded area. We believe that this surface water is associated with the leaks found on Hillside Ave. It also indicates the possibility that the leaks detected had been leaking for quite some time.

HYDRANT LEAKS

Six hydrant leaks were detected during the survey. Hydrant leaks occur when the hydrant is improperly closed, or when a foreign object such as a stone or a piece of wood gets caught in the seat of the hydrant. Water passes by the improperly closed valve seat and escapes out the drain holes. In some instances the drain holes can be partially blocked or clogged resulting in the hydrant barrel filling with water to the hydrant caps. This could prove to be a very dangerous situation in the winter season when the hydrant will freeze solid with ice making this hydrant useless for the Fire Department during an emergency situation. All the hydrants found to be leaking were reported immediately and quickly repaired by the Water Department.

At #14 Prentiss St. a leak at the bottom of the hydrant barrel was discovered when excavated and exposed. Apparently the lead joint had blown out under pressure at this hydrant. It was quickly repaired and relistened to, and no other leakage was discovered after repairs.

MISCELLANEOUS LEAKS

In the area of Lot #5 on Gilmore Rd., where a service leak was located, another leak was detected at the hydrant gate packing gland. This leak was simply resolved by exercising the valve up and down and eliminating the leakage at the valve packing gland.

Another leak was detected at the intersection of Parkerville

Rd. and Clifford Rd. This leak has not been exactly pinpointed. A location has been determined for conducting an exploratory excavation to either possibly find the leak at that location or to give some clue as to where the leak might be. This excavation will be conducted by Don Buzzell and our company at a time and date to be set at the Southboro Water Department's convenience.

LIST OF LEAKS DETECTED

THROUGHOUT THE

WATER DISTRIBUTION SYSTEM

LEAK #	DATE LOCATED	LOCATION OF LEAK	DESCRIPTION OF LEAK	DATE REPAIRED & GPM
1	7/9/87	Cor. of Mt. Vickory & Middle Rd.	Hydrant leak	7/9/87 - 1 GPM
2	7/10/87	Gilmore Rd., House Lot #5	Curb stop leak	7/10/87 - 4 GPM
3	7/10/87	#14 Prentiss	Hydrant joint blown out	7/29/87 - 4 GPM
4	7/10/87	#28 Highland St.	Hydrant leak	7/14/87 - 1 GPM
5	7/10/87	Last hydrant on Gilmore Rd.	Hydrant gate Packing leak	8/20/87 - 1 GPM
6	8/5/87	Hillside Rd.	1" service leak hole in pipe	9/4/87 - 8 GPM
7	7/14/87	On Central St. at Reservoir Rd.	Hydrant leak	7/29/87 - 1 GPM
8	7/21/87	Oak Hill Standpipe 10" line	5" radial crack in main	7/30/87 - 5 GPM
9	8/4/87	Main St. at Post Office	Hydrant leak	8/21/87 - 2 GPM
10	8/8/87	Intersection of Clifford & Parkerville	Possible leak	Not repaired
11	8/21/87	End of Southville Rd.	Hydrant leak	8/21/87 - 1 GPM

CONCLUSIONS AND RECOMMENDATIONS

RESULTING FROM

WATER LEAKAGE SURVEY

Based on the results of this leak detection survey the unaccounted water leakage found can be attributed to the detectable and repairable water leaks in the system. It does not include water used for fire fighting, flushing programs, etc. The Southboro leakage survey appears to be a worthwhile investment. The survey costs are paid back by at least 10 times in one year.

Some additional benefits of having a water leakage survey conducted are:

-Less wear and tear on pumps

-Reduced electricity costs

-Reduced property damage

-Reduced risk of contamination

-Cheaper water rates for consumers since it is they who indirectly pay for the leakage

May we suggest that the following recommendations be taken into consideration:

1) Continue an ongoing water leakage survey annually.
2) Repair the leaks that have not been repaired on the list included in this report as soon as possible.
3) Maintain that all fire hydrants be properly closed

during any operation of the hydrants within the system.

We strongly believe that a continuous water leakage survey conducted annually would continue in the present reduction of water loss, thus increasing revenue in the Water Department's budget.

APPENDIX B

Whitman & Howard, Inc.
Engineers and Architects

LABORATORY REPORT

December 28, 1987
W&H #2566

CLIENT: Southborough, MA

SAMPLE: Southborough -

#2 Winter St. #3 Shaft
#12 Cherry St. #16 Winter St.
#64 Central St. New England Center

SAMPLE COLLECTED DATE: 12/21/87

Results of Analysis

		#2	#3	#12	#16	#64	NEC
Color Units		2	3	5	3	7	5
pH		6.5	6.6	6.7	6.7	6.8	6.8
Turbidity	NTU	0.38	0.42	0.56	0.54	0.62	0.46
Ammonia-N	mg/l	0.13	0.13	0.16	0.19	0.17	0.13
Nitrate-N	mg/l	0.09	0.09	0.12	0.10	0.12	0.10
Nitrite-N	mg/l	0.007	0.007	0.009	0.007	0.013	0.007
Iron	mg/l	0.05	0.05	0.40	0.13	0.56	0.16
Calcium	mg/l	4.2	4.0	4.2	4.2	4.2	4.2
Total Dissolved Solids	mg/l	34	31	34	32	35	34
Total Coliform	#/100ml	0	0	0	0	0	0
Standard Plate Count	#/ml	0	0	0	0	0	0

Analyzed by [signature]
Chih-Chung Liu

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