STUDY OF THE
TOWN OF HINGHAM'S
WATER SERVICE

HINGHAM, MASSACHUSETTS

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

J.N. 84-272

APRIL, 1985

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COMMONWEALTH OF MASSACHUSETTS
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W&H

April 30, 1985

Water Supply Committee
Town Hall
Hingham, MA 02043

Members of the Board:

In accordance with our agreement, we are pleased to submit twenty-five copies of the following final report of the revised preliminary report dated January, 1985 entitled, "Study of the Town of Hingham's Water Service", dated April, 1985.

This report includes the results of our analysis and evaluation of the present water supply, storage and distribution system in meeting projected future water demands through the year 2010.

We wish to express our appreication to your Committee, Mr. Robert Garvin; Deputy Fire Chief, Mr. Brien Sullivan; Highway Superintendent, Mr. Greg Russ; Landfill Manager, Mr. Arthur J. Vinal, Jr.; Planning Aide, and our special thanks to Mrs. Catherine Salisbury, Committee Chairperson, for their cooperation and assistance in relation to this study.

Very truly yours,

WHITMAN & HOWARD, INC.

Elias A. Cooney

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

EAC/lf
84-272

HINGHAM, MASSACHUSETTS

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INTRODUCTION

1.1. SCOPE OF STUDY

The Town of Hingham, Massachusetts is primarily a residential community with two areas of industrial development in its northwestern and southwestern corners. The Hingham Water Company is a private water utility that provides water to the Town of Hingham, Hull and a portion of Cohasset. The Town of Hull is a penisula of land that extends northwestward from Hingham and experiences a large influx of summer residents and visitors. The majority of water furnished will require treatment due to its natural quality and its surface water origin (Accord Pond). To adequately satisfy expected future demand and existing fire flow requirements the water system will have to be expanded and improved.

This portion of the study considers such factors as population and future water consumption, existing and future sources and treatment of water supply, transmission works and storage facilities.

The primary purpose of this portion of the report is to present the results of an engineering evaluation of the Hingham Water Company's water works system. Through this report, the Town of Hingham is considering the possible purchase of the Hingham Water Company. The Hingham Water Company felt that it should release a minimum of its information. The evaluation is based on the following procedures:

1. Review all Town records, planning studies, land use plans, zoning, etc., and all available regional studies, state studies, etc., in order to determine present and future population.
2. Review all available Hingham Water Company records and reports, meet with the Hingham Water Company, undertake flow testing in order to assess condition of present system. The majority of the information on the Hingham Water Company was obtained from the reports filed with the Massachusetts Department of Public Utilities.
3. Determine areas presently not served by data available from the Town or Water Company.
4. Determine improvement necessary to upgrade system to meet current standards of water supply quality and quantity (including fire protection).
5. Provide cost, priorities for these improvements including operation cost if Town ownes system.

2.1 POPULATION PROJECTIONS

The Town of Hingham was established in 1635 and ranks twelfth in the order of towns founded in Massachusetts. Its early growth was spurred by its industrial progress. In the 17th century corn, saw and grist mills were established. An iron works was established in 1703 with fulling mills woolen factory also begun in the early 18th century. From nails and guns to leather and shoes to homegrown silk, Hingham's various industries were widely known and used. In the 19th century the bay was a bustling area of activity. At one time over 75 sailing fishing vessels, many of which were built in local shipyards, were moored in its harbor. The harbor was an official part of entry to the United Sates and had a custom house for 45 years. Even today, the commuter boats to downtown Boston leave its shores.

During World War II the Naval shipyard, Beal Cove area and the ammunition dump which is now Wompatuck State Park became a major source of ammunitions and ships for the the war effort. It was reported that a destroyer escourt could be constructed in 100 days. Today the Quincy Shipyard is a major source of employment and support services for the entire area.

The Town experienced its largest population growth in the 1950's and 1960's. The population grew by 75 percent in the fifteen years between 1950 and 1965. With the construction of Route 3 and Route 128, migration to the area contributed greatly to the population. These expressways allowed people to commute longer distances to work and also increased the summer population especially to the recreational beach areas of Hull.

Recent population projections by the Massachusetts Department of Public Health (DPH), Metropolitan Area Planning Council (MAPC), the Metropolitan District Commission (MDC), and the Town of Hingham's Conservation and Recreation Commissions all show an increase in population at a decreasing percentage. We have estimated a population growth rate slightly higher than those of the DPH, MAPC and the MDC but significantly below that of the Town's commissions. We have based this estimate on the anticipated "baby boom" which appears to be starting, and the development of the Beal Cove area and former Maryknoll property. The actual population of Hingham from 1930 through 1980 and the estimated population growth can be seen in Table No. 1 and Plate No. 1.

The Town of Hull which is also served by the Hingham Water Company is expected to remain at a relatively stable year round population. However, this community experiences a drastic influx of summer residents and visitors that is estimated to be as high as three times the year round population. We have estimated that the year round population of Hull will grow slightly with the development of the Spinnaker Island Condominiums and the proposed development in the Nantasket Beach Amusement Park. The actual population of Hull from 1930 through 1980 and the estimated population

TABLE NO. 1

ACTUAL AND PROJECTED POPULATION

HINGHAM, MASSACHUSETTS

HULL, MASSACHUSETTS

Year	Hingham's Population	Hull's Population
1930	6657	2047
35	7330	2619
40	8003	2167
45	9676	3388
50	10665	3379
55	13418	5824
60	15378	7055
65	17576	8836
70	18845	9961
75	19544	10572
80	20339	9714
85	22200	10250
90	23750	11000
95	24950	11750
2000	25440	12100
2010	25950	12100

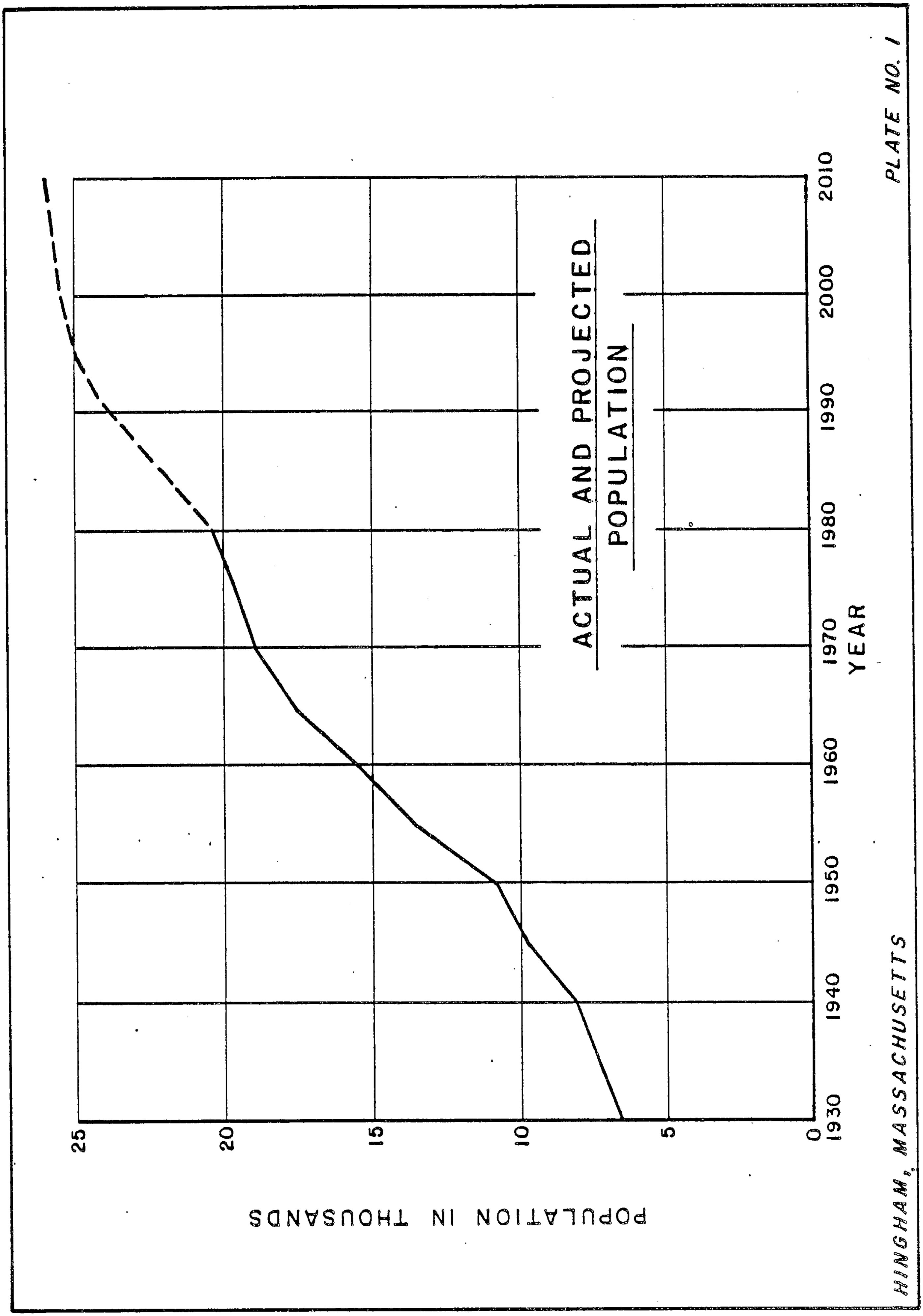


PLATE NO. I
ACTUAL AND PROJECTED
POPULATION
POPULATION IN THOUSANDS
YEAR
0
5
10
15
20
25
1930
1940
1950
1960
1970
1980
1990
2000
2010
HINGHAM, MASSACHUSETTS

growth can also be seen on Table No. 1. There is a difference in the census taking procedure between the State and Federal censuses. This could explain the increasing and decreasing population for Hull. The number of summer residents is almost impossible to predict. We have made the assumption that the present high summer influx of people will also remain relatively stable. The total year round population served by the Hingham Water Company will increase as shown on Table No. 1. However, due to the large influx of summer residents and visitors to Hull, the increase in year round residents will have a minimal impact on the maximum day demands of the system.

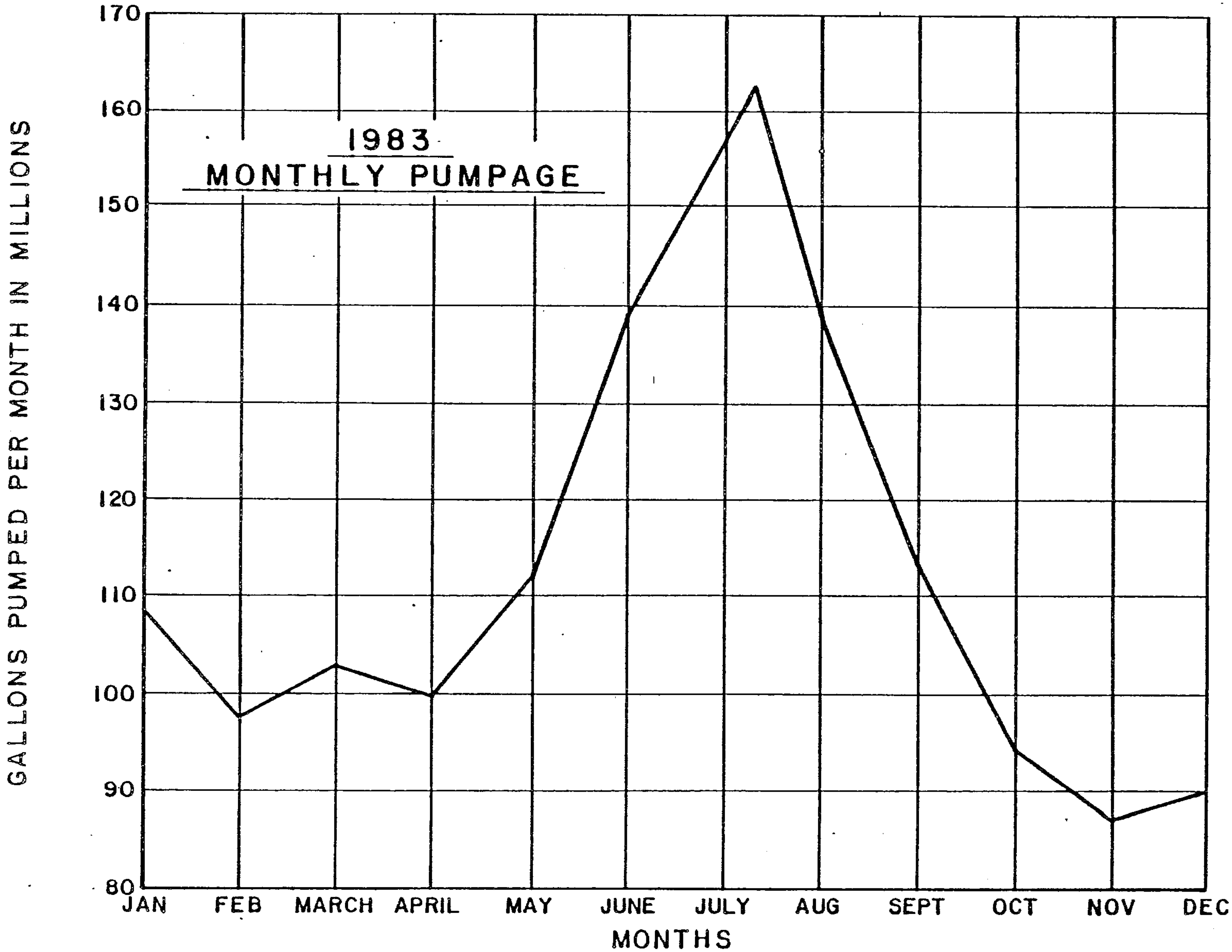
2.2 WATER CONSUMPTION

Investigations of past per capita consumption would show a general increase in per capita consumption due primarily to consumers acquisition of more water consuming devices such as garbage disposals, dish washers, washing machines, sprinkler systems, etc. In predicting future per capita consumption it was assumed that the increase in per capita consumption is tapering off and will level out as the majority of existing customers will have acquired these water consuming devices. Most future customers will have these products initially and an effort to promote water conservation programs will become a more important part of future water system development. Therefore, we have used a constant rate of consumption in our projections.

By using past population figures and corresponding consumption data, the per capita consumption can be calculated. The present average day per capita consumption for the Hingham Water Company is approximately 110 gallons per day. The water use trends, discussed above, are normally used to indicate the future per capita consumption expected. This along with future population projections are the critera generally used to predict future water consumption. The estimated future year round population of Hingham and Hull was discussed in the previous section. Due to the large influx of summer residents and visitors in Hull, and the unpredictability of the number of future summer residents and visitors, the use of year round population projections was not practical to use for the Town of Hull. Instead past consumption records, the total number of services in Hull, and the projected population in Hingham were used to obtain future consumption.

Water system facilities are generally designed using the following guidelines. Treatment plants and pumping stations are designed for maximum day flow so that storage facilities may be replenished during off-peak times in the night. Storage facilities are designed to help meet fire demands and some portion of the peak hourly demand so that the facility is nearly full of water at the time of a conflagration. Transmission lines must be designed to carry peak hourly demands and/or fire flow to any point in the system.

The Average Daily Consumption is defined as the total consumption for a year divided by the number of days in the year. The present average daily consumption for the Hingham Water Company is approximately 3.6 million gallons per day (MGD). The Maximum Day Consumption is the largest 24 hour demand for the year. This one day demand can be several times the average day demand. The impact of the large influx of summer residents and visitors to Hull on the system's demand can be seen on Plate No. 2. This graph represents total monthly pumpage and does not show the even more drastic impact of the maximum day demand. In recent years the maximum day demand has been approximately 7.0 MGD or about 1.87 times the average daily demand. As previously mentioned since sources of supply and treatment facilities are designed



HINGHAM, MASSACHUSETTS

PLATE NO. 2

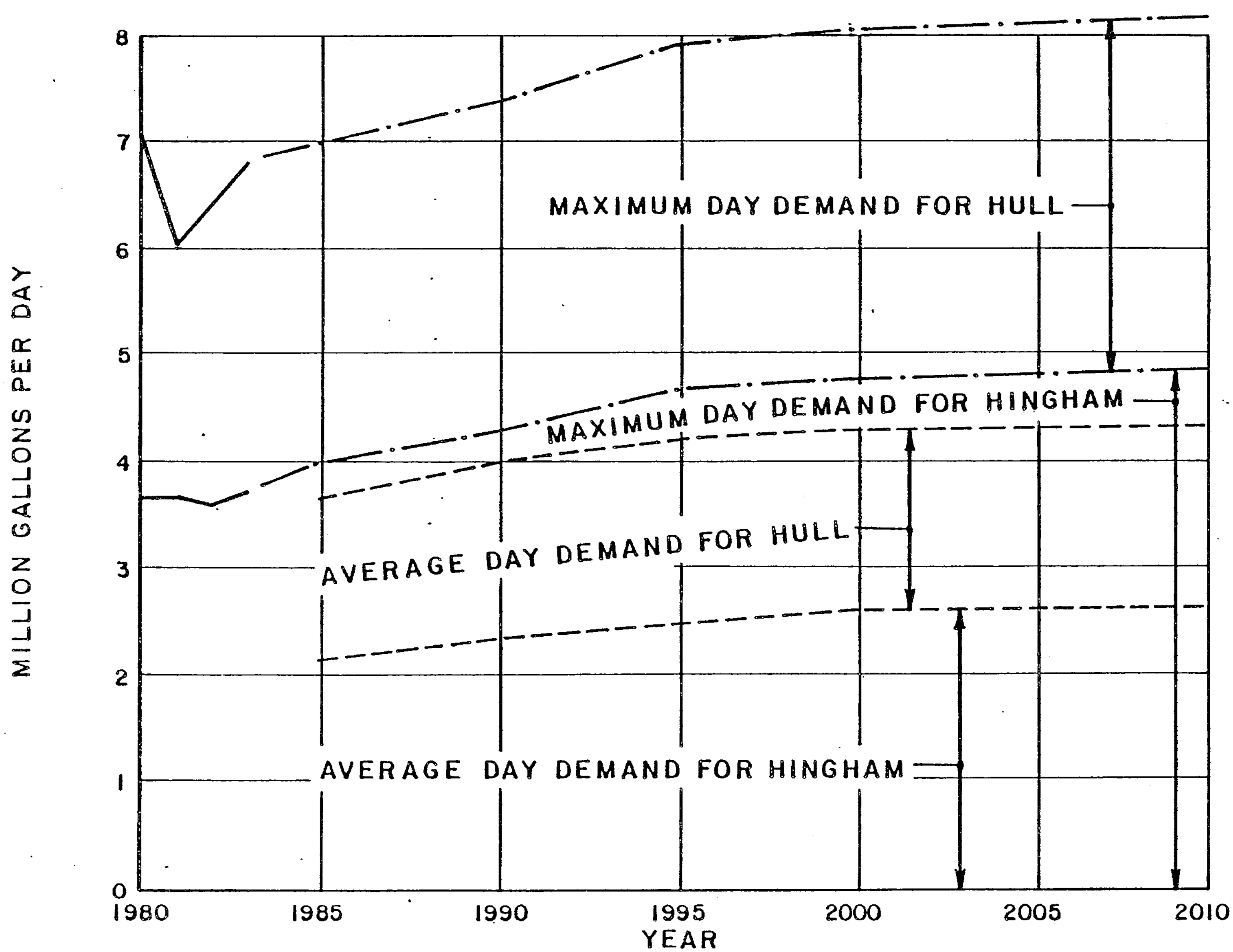
to supply this increased rate, we have projected the maximum day demand to be served by the existing system as shown on Table No. 2.

TABLE NO. 2
HINGHAM WATER COMPANY SERVICE AREA
MAXIMUM DAY DEMANDS

Year	Million Gallons Per Day		
	Hingham	Hull	Total
1985	4.0	3.0	7.0
1990	4.3	3.1	7.4
1995	4.7	3.2	7.9
2000	4.8	3.3	8.1
2010	4.9	3.3	8.2

The existing and projected average day demand and maximum day demands for Hingham and Hull can be found graphically on Plate No. 3. The maximum day consumption of the High Service System is approximately 15 percent of the total system. The actual consumption experienced in future years will of course, be dependent on the type and rate of development. These projections are based on the previous discussions and a moderate rate of industrial development. The industrially zoned area along Lincoln Street and in the south western part of Town could have a significant impact, if water intensive industries are developed.

AVERAGE DAY AND MAXIMUM DAY DEMANDS



HINGHAM, MASSACHUSETTS

PLATE NO. 3

3.1 SOURCE OF WATER SUPPLY

The Hingham Water Company presently recieves it's water supply from seven groundwater supplies and two surface water supplies. Ground water is obtained from six gravel packed wells and one large diameter well which is supplied from an infiltration gallery. The surface water supplies are Accord Pond and Accord Brook. One of the gravel packed wells previously used by the Hingham Water Company (Free Street No. 4) is presently not approved for use as a source of public water supply.

Gravel packed wells consist of a vertical solid casing with a vertical well screen located at the base of the solid casing. The well screen is located in natural sand and gravel formations that allow the movement of large quantities of water relatively easily. The natural extent of the saturated soil is called an aquifer. An aquifer is much like an underground lake with natural boundaries of impervious soils or ledge. In gravel packed wells the natural material surrounding the well screen is replaced with artificially graded coarser material. The new gravel pack acts like a natural screen to filter fine particles of sand and silt and allow for the transmission of larger volumes of water. As the well is pumped the water level in the area is drawn down causing a slope in the water table. This sloping water table naturally recharges the well. Gravel packed wells are located off of Downing Street, Free Street, Prospect Street and Scotland Street. The interior solid casings and screens vary between 18 and 24 inches in diameter with the gravel pack varying from 24 to 48 inches in diameter, respectively.

The induced infiltration gallery utilizes a different technique. Perforated pipes are installed within the saturated aquifer horizontally from a large diameter well. Ground water enters these pipes and is carried to the large diameter receiving well. The aquifer for these pipes can be artificially recharged by the addition of surface waters into recharge basins. The water then percolates into the ground and the water table. The Fulling Mill Well is recharged in this manner with waters from Accord Pond and Accord Brook.

Surface water can also be taken directly from Accord Brook, treated at the Fulling Mill Station and pumped into the distribution system.

3.2 SYSTEM SAFE YIELD

The safe yield of a source of supply is the quantity of water that can be removed continuously without imparing the quality or quantity of the source. On Table No. 3 we have listed the various sources of supply in both the High and Main Service Systems with the flow rates available from the existing pumping equipment. We have also listed the total quantity of water available per day with the stations pumping 16 hours per day and 24 hours per day. It is recommended that sources of groundwater supply be operated only 16 hours per day. This allows time for the aquifers serving the wells to recharge. It also allows for the equipment to rest and receive normal maintenance. Surface water supplies should be able to provide their safe yield continuously 24 hours per day.

The sources of supply should be able to meet the year's maximum day demands within 24 hours. The present maximum day demand is approximately 7.0 millions gallons per day. It can be seen from Table No. 3 that the present sources of supply cannot meet this demand in 16 hours of pumping and cannot quite meet the demand if allowed to pump 24 hours per day. If sources of supply are to always meet the maximum day demands under any condtions, they must be provided with auxiliary power or be able to provide the required water through gravity. No auxiliary power is presently provided to the Prospect Street, or Free Street No. 2 pumping stations.

TABLE NO. 3

HINGHAM WATER COMPANY

SYSTEM SAFE YIELD

	Gallons Per Minute (GPM)	Millions of Gallons 16 Hours Per Day	Millions of Gallons 24 Hours Per Day
High Service System			
Scotland Street	700	0.67	1.01
Prospect Street	300	0.29	0.43
Sub-Total	1,000	0.96	1.44
Main Service System			
Fulling Mill Station	1,760	1.69	2.53
Downing Street	400	0.38	0.58
Free Street No. 2	1,400	1.34	2.02
Free Street No. 3	250	0.24	0.36
Sub-Total	3,810	3.65	5.49
TOTAL OF ALL SOURCES	4,810	4.61	6.93

The Insurance Services Office (I.S.O.) recommends that the maximum day demand be met from the existing sources of supply with the largest source being considered out of service. This allows for a source to be out of operation due to mechanical failure or normal maintenance. Using this criteria neither the High nor Main Service Systems would be able to meet their present maximum day demands by a substantial margin.

We recommend that a test well program be initiated to locate an additional groundwater supply in the High Service System. This source should have a specific yield of atleast 550 gallons per minute. Auxiliary power should be provided for each source of supply. With the construction of a water treatment plant in the Free Street area, provisions should be made to allow the direct use of either the Accord Pond or Accord Brook water without infiltration into the Fulling Mill aquifer. Our calculations indicate that Accord Pond can be gravity fed to the Free Street area using the existing and propose raw water mains. Provisions should be made in the new water treatment plant for auxiliary power. We have assumed that with this auxiliary power, and the availability of Accord Pond water through gravity, that the Main Service System will be able to meet its maximum day demands within 24 hours.

In a letter to the Hingham Water Company dated March 13, 1985 the Massachusetts Department of Environmental

Quality Engineering (D.E.Q.E.) stated that the existing Free Street Pumping Station No. 4 is not an approved source. This is due to insufficient land ownership to protect the well, and the lack of submission and approval of construction plans for the pumping station. This source of supply was therefore not included in the safe yield analysis outlined on Table No. 3. The construction of a water treatment plant and the subsequent treatment of Free Street No. 4 would probably allow for its approval by the DEQE. If this source of supply was acceptable to the DEQE we would recommend the installation of auxiliary power. Free Street No. 4 has a capacity of 750 gallons per minute and would add 0.72 million gallons per day (mgd) if pumped for 16 hours and about 1.08 mgd if pumped 24 hours per day. Even with the addition of this well the sources of supply cannot meet the maximum day demand pumping 16 hours per day.

3.3 PUMPING FACILITIES

A brief physical and operational description of each of the facilities follows.

MAIN SERVICE SYSTEM

FULLING MILL POND PUMP STATION AND TREATMENT FACILITY

The Fulling Mill Well is the oldest well used by the water company. It was constructed in 1903 and is 40-feet in diameter and approximately 19-feet deep. The walls are built of dry laid stone to a height of 6-feet from the bottom of the well. From this level to the surface is approximately 1-foot thick cast in place concrete walls that form a stepped dome. At the top of the dome access is provided by a wooden bulkhead. At the time of our inspection the bulkhead was rotting and posed a possible hazard. Since the water level in the well is about 6-feet below the access at the top of the dome, if a person fell through this bulkhead into the well, they could not pull themselves out without assistance.

As previously outlined this well obtains its water from an infiltration gallery. Water can be obtained by gravity from Accord Pond through filter beds into the groundwater, or from Accord Brook into natural basins and into the groundwater, or from Accord Brook directly into the treatment facility. Water can be filtered through two diatomaceous earth filters. Diatomaceous earth is the skeltal remains of silica algae, and it is a common filtering agent used in swimming pools. Upon leaving the filters water can be treated with chlorine gas for disinfection, hydrated lime for corrosion control and sodium silicofluoride for the fluoridation of water to help prevent dental caries. The water is pumped into the distribution system by a 1961 Peerless Centrifugal Pump operated by either a 150 horsepower Fairbanks Morse electric motor or by a Waukesha gasoline V-8 engine. Also available for pumping is the original 1906 Platt Iron Works positive displacement, tri-plunger pump with a 75 horsepower Westinghouse electric motor. This pump is very well maintained and still operational. It should become a American Water Works Association historic site.

All of the automatic controls, monitoring charts and all the telemetry from the pumping stations centers here. This is considered the main pumping staion. All of the stations can be operated remotely from this station except Downing Street. The tank level charts are in this station. This building also houses the water company's laboratory. Here a chemist does all the major testing of the water's quality. The stations operators perform chlorine, fluoride and pH quality control tests hourly with color and turbidity done once for each shift. The company's garage with an inventory of spare parts and gate valves, hydrants, fittings, service materials, etc. is also on the property.

DOWNING STREET PUMPING STATION

This station serves a 24 x 48 inch gravel packed well that was installed in 1966. The well has a total depth of 66-feet with 10 feet of stainless steel screen installed in the bottom of the well. A U.S. Motors 40 horsepower electric motor drives the Byron Jackson deep well tubrine, 7-stage pump. Auxilliary drive is provided by a 6 cylinder Continental L.P. gas engine. Flow and pressure charts monitor the station. A separate chemical feed room provides sodium fluoride for fluoridation, and sodium hypochloride for disinfection.

FREE STREET PUMPING STATION No. 2

This station utlizies a 100 horsepower U.S. Motors electric motor to drive the Cook deep well turbine, 6-stage pump. Installed in 1951 the 73-foot deep well contains 20 feet of 24-inch stainless steel screen below a solid transite (asbestos cement) casing. Pressure and flow charts monitor the station but no auxiliary power is provided.

Water from this station enters the neighboring iron and manganese removal plant built in 1969. The Hungerford and Terry, Inc. Green sand filter system consists of 4 cylindrical pressure filters. These filters are periodically rejuvenated with potassium permangenate, an oxidizing agent. The iron and manganese in the water is oxidized by this chemical and is trapped by the filtering green sand. Upon leaving the filters the water is treated with Calgon (sodium hexa-meta phosphate) for corrosion control, chlorine gas for disinfection, and hydrofluorisilicic acid for fluoridation before being pumped into the distribution system by a 25 horsepower General Electric motor and centrifugal pump. The flow and pressure is also recorded at the treatment facility.

FREE STREET PUMPING STATION No. 3

This station was formerly Free Street No. 1, 1942, but it was rebuilt in 1968. The well is an 18 x 24 inch gravel packed well with 10 feet of stainless steel screen set at the bottom of the 88½ foot deep well. A 25 horsepower U.S. Motors electric motor drives the 7-stage, Worthington deep well turbine pump. An Allis Chalmers 6 Cylinder L.P. gas engine provides auxiliary drive. Pressure and flow charts monitor this station. Potassium hydroxide for corrosion control is stored outside the station in large steel tank. Also added to the water is hydrofluorisilicic acid for fluoridation and chlorine gas for disinfection. The electrical controls and chemical feed apparatus for Free Street No. 4 are housed in this station.

FREE STREET PUMPING STATION No. 4

This station is located over a 86 foot deep 24 x 48 inch gravel packed well. A 20-foot stainless steel screen was placed in the bottom of this well in 1982. The Peerless, 4-stage deep well turbine pump is driven by a 60 horsepower U.S. Motors electric motor. As previously stated the electrical and chemical apparatus for this station is housed in Free Street No. 3, because this station is only 5 feet square! The station is wooden 2 x 4's and plywood paneling with no insulation, set on the concrete well casing. No heat is provided and the discharge piping is exposed to the elements. This station, needless to say, has no auxiliary power. This source is presently not approved by the Massachusetts D.E.Q.E. due to insufficient land ownership.

EMERGENCY SUPPLY

At the intersection of Lazell Street and Free Street a small well (4-inch) with a 4-inch fire department steamer connection is available. This well can supply some quantity of ground water to the fire department's pumper trucks in an emergency.

HIGH SERVICE SYSTEM

SCOTLAND STREET PUMPING STATION

This station is the main supply for the high service zone. The 15-feet of stainless steel screen was installed at the base of the 45 foot, 24 x 48 inch gravel packed well in 1955. The 5-stage Byron Jackson pump is driven by a 60 horsepower Westinghouse motor. Auxiliary power is provided by a 6 cylinder Continental gasoline engine. The gasoline storage tank is next to the building. A large steel tank stores the potassium hydroxide outside of the station. A day tank inside the station allows for the addition of this chemical for corrosion control. Sodium fluoride is added for fluoridation and hypochloride is added for disinfection. Pressure and flow are recorded at the station.

PROSPECT STREET PUMPING STATION

This station was constructed in 1971. The 18 x 24 inch gravel packed well was installed to a total depth of 58 feet with a 10-foot stainless steel screen. The 20 horsepower U.S. Motors electric motor drives the 8-stage Byron Jackson deep well turbine pump. Charts record the station's flow and pressure, however, this station is not telemetered to the tank levels and must be run from the Fulling Mill Station manually. No auxiliary power is available, however, ample room does seem available for its installation. Calgon (sodium hexa-meta phosphate) is fed for corrosion control, hypochloride is fed for disinfection, and sodium fluoride is added for fluoridation. This station water level must be monitored if the Scotland Street Pumping Station is running.

3.4. STORAGE FACILITIES

The Hingham Water Company presently has three storage facilities. They consist of two elevated storage tanks and one standpipe, with a total capacity of 3,250,000 gallons.

HIGH SERVICE SYSTEM

The old standpipe at Accord Pond was dismantled in January of 1984 after 72 years of service. Its replacement is the existing elevated tank built in 1967.

The Accord Pond elevated storage tank has a total capacity of 750,000 gallons with an overflow elevation of 282-feet U.S.G.S. The ground elevation at the tank is approximately 170 feet U.S.G.S. The storage area of the tank is about 80 feet in diameter and approximately 20 feet in height. (262 to 282 feet U.S.G.S).

An altitude valve was recently installed at the inlet-outlet pipe to this tank. The altitude valve senses the level of the water in the tank through a pressure sensing device. When the water level in the tank reaches a preset level (usually just below the overflow elevation) the valve senses this and closes. This allow the pressure in the distribution system near the tank to exceed the pressure allowed by the overflow elevation, without the tank overflowing. As the pressure in the system decreases to below the overflow elevation, the altitude valve automatically opens allowing the tank to supply the system.

MAIN SERVICE SYSTEM

This system has two storage facilities, one on Strawberry Hill in Hull and one on Turkey Hill in Hingham.

The Turkey Hill standpipe was constructed in 1963. Its overflow elevation is about 240 U.S.G.S. with its base at 170 U.S.G.S. The tank is approximately 70 feet in diameter and contains water for its entire height. This tank also has an altitude valve.

The Strawberry Hill elevated storage tank was constructed in 1933, and has a capacity of 500,000 gallons. Its overflow elevation is about 186 feet U.S.G.S. The ground elevation at the tank is appròximatley 103 feet U.S.G.S. The storage area of the tank is about 50 feet in diameter and approximately 34 feet in height (152 to 186 feet U.S.G.S). This tank also has an altitude valve.

Since the overflow elevation of the Turkey Hill standpipe is 54 feet higher than the Strawberry Hill Tank's, the water in the Stawberry Hill tank sometimes becomes stagnant. In the winter, an air bubbler has been used to prevent the water from freezing solid. The water company is installing a 5 horsepower booster pump to pump water out of the tank. This should lessen the possibility of stagnation.

With the difference in elevations between the two tanks, the Turkey Hill standpipe would have to discharge approximatley 1,550,000 gallons before the Strawberry Hill tank's altitude valve would open. This is almost 78 percent of the Turkey Hill tank's total capacity and almost 50 percent of the entire storage capacity of both service zones!

With the installation of the booster pump at the Strawberry Hill tank, this storage facility becomes a pumped storage system. It relies on mechanical pumping to be an effective component of the system. Without this pumping, it is useless to the system except during extreme conditions. Since no provisions are provided for auxiliary power this cannot be considered a reliable component of the system.

3.5. DISTRIBUTION SYSTEM

The distribution system in Hingham consists of water mains ranging in diameter from 1 inch to 20 inches. Presently, there are approximatley 140.6 miles of water mains 6 inches or larger, consisting of unlined cast iron, cement lined cast and ductile iron, asbestos cement, lock joints, wrought iron, steel and plastic. A breakdown of the length of the various sized mains as listed in the 1983 report to the Massachusetts Department of Public Utilities (DPU) can be found on Table No. 4.

TABLE NO. 4
MILES OF 6-INCH AND LARGER WATER MAINS FOR
HINGHAM, MASSACHUSETTS

Size of Water Main	Approximate Length In Miles
20-inch	7.8
16-inch	1.8
14-inch	0.8
12-inch	18.2
10-inch	2.7
8-inch	49.2
6-inch	55.2
Under 6-inch	52.4
SUPPLY WATER MAINS	
20-inch	0.6
14-inch	4.3
8-inch	-.1
Total	193.0

According to the DPU statistics, the water company has a total length of 193 miles of water mains. Therefore approximately 73 percent of all the water mains are 6-inches in diameter or larger.

3.6 OPERATION OF SYSTEM

The Hingham Water Company's Distribution system is presently divided into two pressure zones; the High Service System in the southern portion of Town and the Main Service System in the northern two thirds of Hingham, a portion of Cohasset and the entire Town of Hull. Each zone contains several sources of supply and one storage facility in the High Service System and two storage facilities in the Main Service System. Only one water main in Main Street connects the two systems and the separation is maintained through closed gate valves.

The High Service Service System is supplied by two pumping stations; Prospect Street and Scotland Street, and has one elevated storage tank at Accord Pond. The hydraulic gradient in this system is approximately 18 pounds per square inch (psi) higher than the Main Service System.

The Main Service system is supplied by four pumping stations; Free Street Pumping Stations No. 2 and 3, Downing Street, and Fulling Mill. The currently unapproved gravel packed well at Free Street Pumping Station No. 4 can also serve this system. The two storage facilities are the elevated storage tank in Hull on Strawberry Hill and the standpipe is Hingham on Turkey Hill. Due to the Elevation of the Turkey Hill Tank, the Strawbery Hill Tank will not naturally drain until most of the Turkey Hill Standpipe is empty. The Strawberry Hill Tank is equipped with a booster pump to pump water out of the tank to prevent stagnation.

Each pump station in the different systems, is controlled through telemetry from water level indicators located in the Accord Pond and Turkey Hill storage tanks. The Downing Street Pumping Station in the Main Service System and the Prospect Street Pumping Station in the High Service System are the only stations not controlled in this manner. These stations are only used during periods of high demand, and can, therefore, be operated manually.

The pumping stations in each zone are operated on a "lead-lag" basis. When the water level in a tank drops to a predetermined level, the telemetry system causes the "lead" pump to run. If the demand on the system is too great for the "lead" pumping station to supply a sufficient amount of water, then the water level in the tank will continue to drop. When a second, lower, predetermined level is reached the "lag" pumping station will operate to augment this supply. In the Main Service System with more than one "lag" pump station, as the water level in the tank continues to drop, other predetermined levels are reached and subsequent "lag" pumping stations will operate.

When the tank refills, separate predetermined water levels will be reached and the telemetry system causes the pumps to shut off. The shut off water levels for each pump station are set so several pumps are running to refill the tank, eliminating the need for the "lead" pump station to run continuously against system demand and filling the top portion of the tank. When the highest water level is reached and all the pump stations are shut off the system's demand is satisfied from water held in storage causing the tank water levels to drop until the predetermined level is reached where the telemetry system causes the pumps to operate through another cycle. In this manner of operation, the pump stations operate automatically, thus maintaining a continual balance between system supply and system storage, while satisfying system demand and maintaining adequate storage and pressure for fire protection. In the off-season, when the demand is low, the "lag" pumping stations may not be required to operate to meet the system's demands.

Located in the Fulling Mill Pumping Station are three seven-day chart recorders, representing the water level in each of the storage tanks. With each of these chart recorders are controls for the remote operation of the pumping stations. These controls enable the pumps to operate in the on, off, or automatic position. These controls can be overridden by similiar controls located in each pump station.

3.7 WATER QUALITY

The quality of the raw water presently being obtained by the Hingham Water Company has deteriorated over the years to the point that all of the sources of supply receive some form of treatment. The water company utilizes nine separate chemicals for oxidation, filtration, disinfection, corrosion control and fluoridation. Potassium permanganate is added for oxidation of iron and manganese at Free Street Pumping Station No. 2 green sand filtration plant. As a filtering aid, diatomaceous earth is continuously added to the raw water entering the diatomaceous earth filters at Fulling Mill. Disinfection is obtained by the addition of chlorine gas, or sodium hypochlorite; corrosion control is attempted with the addition of hydrated lime, or sodium hexametaphosphate, or potassium hydroxide; and fluoridation is achieved by the addition of sodium silicofluoride, or sodium fluoride, or hydro-fluorisilicic acid. The specific chemicals utilized at each of the sources of supply can be found in section 3.3.

The groundwater sources in the Main Service System experience quality problems associated with iron manganese and color. These three constituents are presently covered by the Massachusetts Department of Environmental Quality Engineering (D.E.Q.E.) and the United States Environmental Protectio Agency's (USEPA) Safe Drinking Water Act's, Secondary Standards. Iron, manganese and color are limited due to their aesthetic impact. Iron and manganese will stain fixtures and laundry and may impart an objectionable taste to beverages such as tea and coffee. The severity of the manganese problem was quite apparent after our flow testing. A more detailed description of the results of the Flow Tests can be found in Section 4.0. Although Free Street Pumping Station No. 2 is treated at the iron and manganese removal plant, the treated water quality still exceeds the recommended limit by three times while the treated Fulling Mill water exceeds the limit by five times! The Downing Street well experiences high levels of manganese that can exceed the recommended limit by 14 times and therefore is only used when absolutely necessary.

The Free Street area experiences very high groundwater. The standing surface water can be a direct source of contamination. The Hingham Water Company presently pumps the surface water into the Weir River to decrease the quality degradation. Free Street Pumping Station No. 4 is presently not approved as a source of supply by the D.E.Q.E. due to insufficient land ownership. The required land ownership is to provide some protection from contamination. Recent bacteriological samples have indicated some contamination is taking place. This source of supply probably will be approved for use if the recommended treatment is completed.

The Hingham Water Company presently adds some form of chlorine to all its sources of supply for disinfection purposes. Groundwater sources are not usually chlorinated. The natural filtration in the aquifer and natural bacterial decomposition are normally adequate. Chlorine will destroy the bacteria at the source and will also diminish the growth of bacteria in the distribution system caused by the buildup of iron and manganese. Once the chlorine has stabilized in the water, the remaining, or residual chlorine provides further antibacterial protection in the distribution system. To maintain a minimal chlorine concentration in the far reaches of the distribution system, the amount of chlorine in the water near the source of supply must be higher. This may result in some chlorine taste and odor complaints closer to the points of injection.

Although chlorine is used to protect us from bacteria, it can form with organics in the water to produce halogenated organics or carcinogens. The color experienced in the surface, as well as some groundwater sources, can be caused by colloidal (suspended in solution) organic particles. When chlorine is added to these waters the result can be halogenated organics. Chemical treatment of the water for clarification prior to filtration and organic removal can eliminate the organics that would naturally combine with the chlorine to form these potential carcinogens.

Recent water sampling by the D.E.Q.E. has indicated that these haloginated organics are being formed. The results of the analyses indicated a total trihalomethane concentration of 32 parts per million (ppm). The present maximum contaminant level is 100 ppm. Although the present limit is not being exceeded, it does provide a very good argument for conventional water treatment.

In October 1983, the American Water Works Service Company, Inc. completed a report entitled Investigation of Water Treatment Techniques for Hingham Water Company. As stated on page 1 of that report.

"Fulling Mill Station is supplied by Accord Brook indirectly through groundwater percolation, and Accord Pond. Although the high color of Accord Brook water is reduced during infiltration and blending with Accord Pond it still exceeds secondary standards most of the year. Additionally, the Accord Brook water picks up substantial manganese during infiltration. Accord Pond is replenished by a very limited watershed in a developed area. Since 1974 the Massachusetts Department of Environmental Quality Engineering (DEQE) has required that Accord Pond Water receive filtration and chlorination due to high bacterial levels."

The report outlined the necessary types of treatment as follows: "Accord Pond will always require filtration and may require color removal. Accord Brook will require color removal and filtration whenever it is used. Free St. well #2 will require manganese oxidation, coagulation and filtration whenever it is used, and Free St. wells #3 and #4 may or may not require manganese and/or color removal with subsequent filtration."

The treatment scheme recommended consists of conventional clarification/filtration with maximum flexibility for the introduction of each of the sources at various locations in the treatment process for optimum treatment efficiency.

Our review of the report produced the following comments. The results of the mixed media filtration tests differ little from the results of the dual media tests. The cost of mix media is almost four times the cost of dual media, therefore a dual media should be selected. The filter backwash procedure should include an air scour step with appropriate underdrains. This will reduce the required backwash water flow rate substantially as well as the size of any planned backwash water storage or waste holding tanks. There is also no need to settle the filter backwash waste suspended solids from the supernatant. It would simplify the equipment and operations and reduce the holding tank size.

The lime slurry feeding could be a continual problem at the plant, so consideration should be given to finding a substitute for this troublesome chemical.

The proposed plant should be sized to meet the future maximum day demand for the entire main service system including the Town's of Hull and a portion of Cohasset. The following is a breakdown of the estimated construction costs for a 7.0 million gallon per day conventional water treatment plant based on the U.S. Army Corps of Engineers curves.

Conventional Water Treatment Plant

(Includes site development, an administration chemical storage and control building, rapid mixing, flocculation, sedimentation and filtration)

	$ 6,675,000.
Oxidation	668,000.
Sludge Lagooning	267,000.
High Lift Pumping	700,000.
Subtotal Construction	$ 8,310,000.
10% Contingencies	830,000.
Design & Construction Engineering	$ 1,500,000.
Total Project Costs	$10,640,000.

4.0 FLOW TESTS

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

Corrosion and the deposition of sediment and precipitates on the interior of unlined iron mains is the cheif cause of reduced carrying capacity. Pipe corrosion, precipitation and sedimentation create deposits called tubercules, and often contribute to growths 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 are seriously diminished. Even without a significant "build-up" however, 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.

An empirical formula exists which allows the relative roughness (or carrying capacity) of pipes to be computed using certain measurable data. A term known as the Hazen-Williams 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 could have C-values of 40 or less.

The procedure for these 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, can be used to compute the C-Values.

Based on the results of these tests, 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 the skeletal computer model of the system.

The available fire flows at a give 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 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 required suction pressure for pumping equipment used by most fire departments. Fire flow tests were conducted by the Insurance Services Office (I.S.O.) in representative areas of the Town in November 1976. The results of this testing were reviewed prior to the selection of sites for our fire flow tests. The results of the I.S.O.'s tests can be found on Table No. 5. The deficient areas of concern were Sycamore Lane at Bayberry Lane, Central Street and Sanborn Road, South Junior High School, Plymouth River School, Industrial Park Road, and Beal Street at the shopping center.

Through conversations with Mr. Robert W. Garvin, Deputy Fire Chief, and Mrs. Catherine Salisbury, Chairperson of the Water Supply Committee, the following areas were also considered. Charles Street at Prospect, Charles Street at Mary Knolls, Charles Street at South Pleasant Street, Hobart Street at the landfill, Turkey Hill Lane at Leavitt Street, Fort Hill Street, Bradley Park Drive, Governor Long Road, and North Street.

On October 5, 1984 we met with the Hingham Water Company to disucss the flow tests and request various information. The Hingham Water Company stated that all requests must be made in writing and some restrictions would be required. Several sites were eliminated because of potential damage to private property. The Hingham Water Company wanted a written outline of the testing schedule, written approvals from the Town's Highway, Fire and School Departments as well

TABLE NO. 5
INSURANCE SERVICES OFFICE
FIRE FLOW TESTS
Town of Hingham, MA
November 9, 1976

			Hydrant Pressures		Discharge Gallons per Minute (see footnotes)		
District	No.	Location	1	2	3	4	5
Commercial	1	North St. and Main St.	91	83	1720	5600	4500
Commercial	2	Sycamore La. at Bayberry La.	88	54	820	1190	4500*
Commercial	3	Central St. at Sanborn Rd	78	66	1120	2620	3500*
Commercial	4	South Jr. High School	82	39	880	1070	3500*
Commercial	5	Stanford Dr. at Plymouth River School	72	22	470	480	3000*
Commercial	6	West St. at North St.	90	72	1420	2955	2500
Commercial	7	Hull St. and Rockland St.	93	80	1460	3710	2500
Commercial	8	Industrial Park near Commercial	58	32	1380	1700	2500*
Commercial	9	South St. at Thaxter St.	91	81	1380	3975	2000
Commercial	10	Beal St. at Shopping Plaza	88	50	710	970	2000*
Commercial	11	Main St. near Friend St.	80	75	1540	5890	2000
Commercial	12	Derby St. and Whiting St.	54	44	1280	2480	1500
Residential	13	Martins La. at Surry Rd.	80	66	650	1430	1000
Residential	14	Kimball Beach Rd. near Planters La.	84	48	670	910	750
Residential	15	Malcome St. near Marion St.	73	20	290	290	750*
Residential	16	Gov. Long and Gov. Andrew	64	45	720	1130	750
Residential	17	Leavitt St. and Popes La.	87	74	680	1650	750
Residential	18	Colonial near Hancock	113	74	620	990	750
Residential	19	Fort Hill St. near New Bridge St.	88	54	670	970	500
Residential	20	Cross St. at Hobart St.	78	66	950	2225	500

Note: Column 1. Static Pressure, hydrants closed.
Column 2. Residual pressure on main with hydrants flowing.
Column 3. Discharge obtained with residual pressure shown in Column 2.
Column 4. Discharge estimated for engine supply at residual pressure of 20 pounds.
Column 5. Required flow.

Note: The results of these tests indicated the rate at which water is available to certain locations in the distribution system and do not relate to any flow duration period.

* BELOW RECOMMENDED FIRE FLOW RATE

as any private organization involved, a signed agreement with a hold harmless clause and insurance certificates in amounts specified, advertisement in local papers, and payment for the services of water company personnel and water used. A frantic schedule of letters, phone calls, deliveries, consultation with insurance and legal representation followed. Finally on Friday November 16, 1984 flow tests were conducted from midnight to 3:30 AM.

The last test conducted on that night was at Main Street at South Pleasant Street. Water from the Fulling Mill facility usually flows northerly to the areas of high demand. It was requested by the Hingham Water Company that the flow test be conducted with the water flowing in the opposite direction or southerly. This would allow the test area to be fed by the Turkey Hill Tank and would eliminate the operation of any valves to isolate the flow test. The 20 or 14-inch valves are quite large and require alot of mechanical work to close them. Due to the lack of main line valves, several valves would have to be closed to get the proper isolation. At the end of the flow test the water discharging from the hydrants became black. The hydrant was allowed to flow at a lower rate and began to clear within thirty minutes. When people awoke on Friday they found there water black, opaque and oily. This was caused by the high concentration of manganese that is naturally occuring in the ground water. The 20-inch water main in

Main Street was designed for transmission of large volumes of water and fire flow conditions. Since the water main does not usually experience these large volumes of flow the manganese was allowed to settle out. Also the water main is old, unlined, cast iron which allows for the further corrosion and tuberculation as previously discussed.

Whitman & Howard, Inc. received over 100 calls and the Hingham Water Company reported over 300 calls on Friday. The people affected were curious, annoyed, inconvenienced and some very irrate. The Hingham Water Company flowed hydrants and bleeders to clear the mains and the writer returned over 80 phone calls to alleviate some of the concerns and answer questions. The severity of the probelm became apparent by the distribution of the complaints and longevity of the problem. Some areas were experiencing problems for up to one week. The effect on the system jeopardized the performance of any more flow tests.

Areas with chronic problems seemed to be North and South Streets and Hersey Street. It is our opinion that these areas continue to have problems due to the configuration of the distribution system. The 12-inch water mains leading to the center of Town from the large 20-inch water main can also experience the settling problems previously discussed. The water mains on the north and west side of Town do not allow for large volumes of water to be readily transmitted through the 12-inch water mains in Hersey, North and South Streets. The discolored water is allowed to build up sediments in these areas which are easily disturbed when the system is strained. To avoid problems of this magnitude several test sites were eliminated and after much discussion the second and last night of flow tests were conducted from midnight to 3:00 AM on November 27, 1984. Some dirty water was experienced during these tests but the inconvenience was minimal. The following Table No. 6 and Table No. 7 show the results of our fire flow and "C"-value tests.

TABLE NO. 6
WHITMAN & HOWARD, INC.
FIRE FLOW TESTS
Town of Hingham, MA
November 16 and 26, 1984

		Hydrant Pressures		Discharge Gallons per Minute (see footnotes)		
District	Location	1	2	3	4	5
Commercial	Industrial Park Road	54	21	1538	1563	2500
Commercial	S. Junior High School	84	50	677	953	3500
Residential	Saw Mill Pond Road	98	33	715	790	750*
Residential	Charles St. @ South Pleasant St.	65	20	1607	1607	750*
Residential	Fort Hill Street	80	22	702	715	750*
Commercial	Beal Street @ Shopping Plaza	80	61	610	1135	2000
Commercial	Hawthorne Rd. @ Sycamore Lane	89	73	538	1185	4500
Residential	Leavitt St. @ Turkey Hill Lane	67	52	760	1408	750
Residential	Hobart Street @ Landfill	81	10	221	204	750

Note: Column 1. Static Pressure, hydrants closed.
Column 2. Residual pressure on main with hydrants flowing.
Column 3. Discharge obtained with residual pressure shown in Column 2.
Column 4. Discharge estimated for engine supply at residual pressure of 20 pounds.
Column 5. Required flow.

Note: The results of these tests indicated the rate at which water is available to certain locations in the distribution system and do not relate to any flow duration period.

* Estimated based on similar I.S.O. Test locations.

TABLE NO. 7
WHITMAN & HOWARD, INC.
"C" FLOW TESTS
Town of Hingham, Massachusetts
November 16 and 26, 1984

Location	Size of Pipe (Inches)	Material	Calculated "C" Valve	Percent Carrying Capacity*
Beal St. east of Fottler St.	6	Cast Iron	49	38
Fort Hill Street south of New Bridge St.	8	Cast Iron	49	45
Main Street north of South Pleasant	20	Cast Iron	59	67
Longmeadow Road	8	Cast Iron Cement Lined	143	100+

* Based on a "C" Value of 130 for a new water main.

5.0 DISTRIBUTION SYSTEM ANALYSIS

The evaluation of the existing water supply system and proposed improvements in Hingham, Massachusetts was accomplished by using a high speed digital computer. The computer program utilized the Hardy Cross Method of distribution analysis and the Newton Raphson iteration technique in the computer process. In order to simulate a skeleton of the water system on the computer, the distribution system had to be schematically outlined in the form of a node map. This map includes all significant distribution and transmission mains in the water system, along with pump stations and storage tanks. Nodes are located at a point within the system which has significant water consumption, where pipes intersect or where pipes change in diameter. Some of the nodes represent hydrants that were utlized by Whitman & Howard, when we conducted our field tests. These particular areas were used to help simulate the existing system on the computer model. Consumption demands are set at each node based on population density in the vicinity of each node or set at the specific rate that may be known on the basis of consumption or actual flow tests. As requested by the Water Supply Committee we have included a copy of our working node map for their reference at the end of the report.

To evaluate the present and proposed water distribution system, it was necessary to simulate the present system by means of a mathematical model. The proper boundary conditions such as the system demands, the sources of supply, the pipe characteristics (length, size and "C" value), the levels of water in the storge tanks and the pumping rates from each well were entered into the computer. A comparison was then made of the computer output to the actual results obtained in the field from flow tests, pressure readings, etc. The boundary conditions in the model were then adjusted until the computer output accurately reproduced the actual data collected in the field.

Once the water system was simulated, the computer model could be used to determine the effectiveness of proposed improvements on alleviating present deficiencies in the water system. Although it was a skeletal model it significantly represented the distribtion system. As requested by the Water Supply Committee we have provided the committee with all of the computer printouts used in the calibration and analysis of the system.

A more detailed computer program would be a permanent record which could provide future analysis of the distribution system or detailed analysis of individual sections within the distribution system at any time the town may require it.

6.0 FUTURE WATER SUPPLY

For the purpose of design, present and project levels of maximum day water consumption of the Hingham Water Company will be met from existing and future sources of water supply. Water retained in storage shall be utilized for fire reserve and/or equalizing, or operating storage as required. On the basis of the foregoing, additional sources of water supply should be available at a rate necessary to satisfy requirements of projected maximum day water consumption. It is recomended that the available safe yield of developed sources of water supply be sufficient to meet maximum day consumption with the best producing signal source of supply removed from service. This allows for some reserve capacity in the event that an existing well and/or pumping equipment has to be removed from service for purposes of maintenance, repairs of for other reasons. In our opinion the foregoing criteria represents a sound principle for the analyses, evaluation and design of a system's water supply.

Presently the largest producing well in the High Service System is the Scotland Street Pumping Station with a capacity of 700 gallons per minute. Utilizing the above criteria, a new pumping station of equal capacity should be developed to meet the projected Maximum Day Demands in the High Service System.

The importance of acquiring future possible well sites cannot be overemphasized. Future test well programs should be used to located new sources of supply and quanitfy the expected yield from sites previously located. All possible sites should be located, inventoried and protected to ensure the availability of these sites as they are required. The costs associated with obtaining land necessary for a suitable water supply can only be expected to continually increase in the future.

The Main Service System cannot meet its maximum day demand with all sources operating 24 hours per day. This presents a very serious situation especially if a source of supply is removed from service due to mechanical problems, a power failure, or necessary maintenance. The maximum day demand will only be met if a water treatment plant is constructed. This treatment will allow the use of the Free Street No. 4 well and any additional surface water from Accord Pond or Brook.

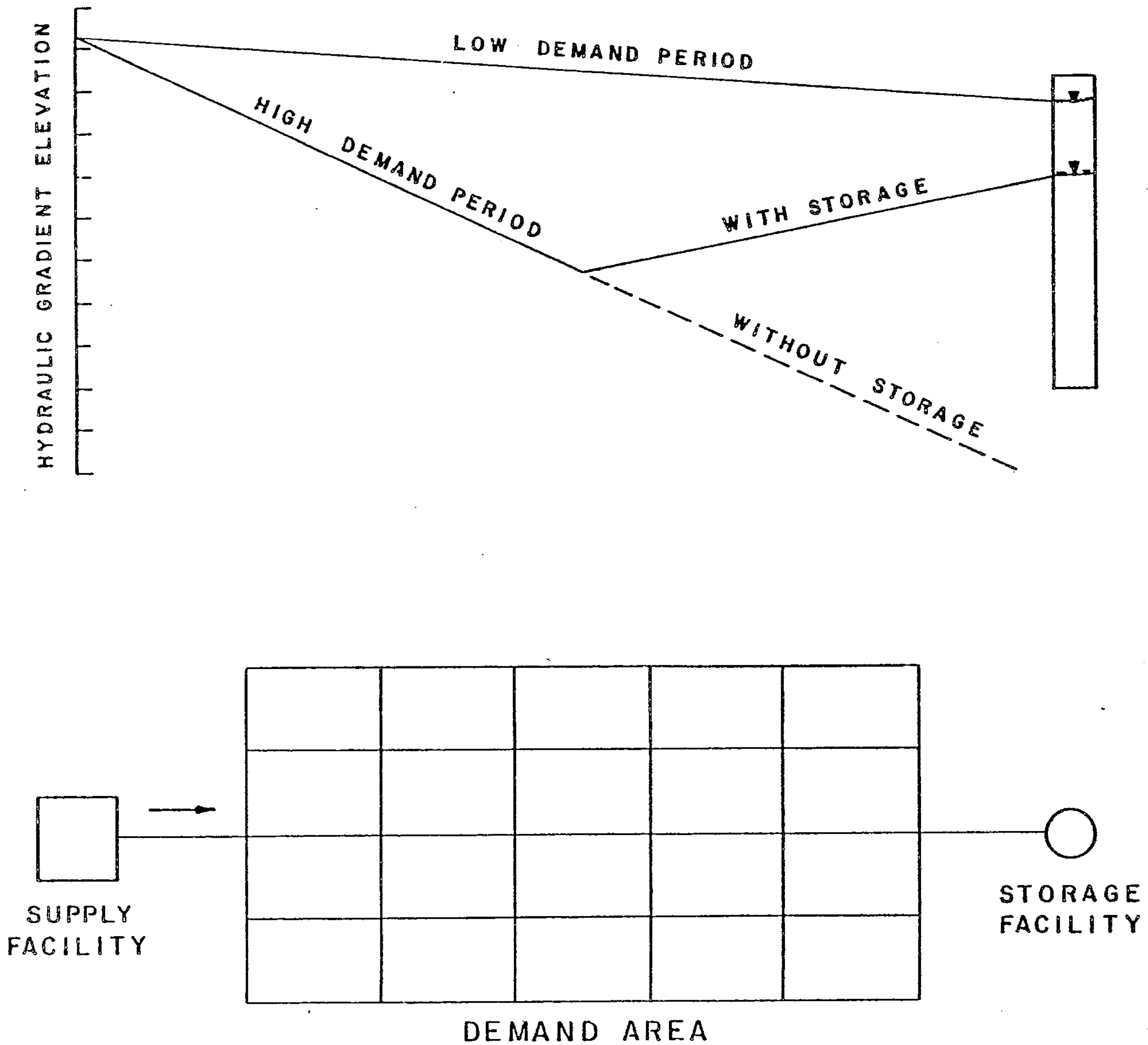
7.0 FUTURE STORAGE

The storage of portable 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 in providng the following:

1. Meeting water demands required for fighting fires.
2. Meeting maximum day peak hourly demands which usually occur during summer months.
3. Providing more uniform pressures within the system 24 hours a day.
4. Providing water to meet system demands if the existing groundwater supply capacity is temporarily lowered due to mechanical failure or periodic maintenance of pumping facilities.
5. Provide a safety outlet in the system to reduce the affects of water hammer.

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

As shown on Plate No. 4, storage provides an additional origin for the hydraulic gradient, thereby improving pressures in the distribution system. In addition, if a



EFFECT OF STORAGE ON HYDRAULIC GRADIENT

HINGHAM, MASSACHUSETTS

PLATE NO. 4

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 storage, three factors are considered.

The first is equalization storage, which is that portion of the storage required to meet the peak hourly fluctuation during the maximum daily demand period. This is usually represented as a percentage of the maximum daily demand. For the purpose of evaluating the Hingham Water Company's existing storage, we are using 30-35 percent of our estimate of the present maximum daily demand. We have estimated the present equalization storage required to be approximately 320,000 gallons for the high service area and approximately 2,475,000 gallons for the main service area.

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 (I.S.O.) guidelines.

The I.S.O. have, 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. The total usuable system storage required from the old standards, as compared to the new standards, has remained relatively the same, but the distribution system carrying capacity must be increased to provide for the greater 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 I.S.O. criteria determines specific fire flow requirements for individual buildings, or groups of buildings, they also establish a Basic Fire Flow requirements 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. Whitman & Howard, Inc. has determined the Basic Fire Flow for the high service area to be 2,500 gpm for three hours, and for the main service area to be 3500 gpm for three hours. We have estimated the present required fire flow storage to be 450,000 gallons and 630,000 gallons respectively.

The third factor is emergency storage, which is that portion of the available storage remaining after considering equalization and fire storage. Emergency storage is provided to sustain a community's needs during periods when there is a pump failure or a supply line is out of service for maintenance or repair.

The existing Accord Pond elevated storage tank has sufficient storage at the proper elevation to adequately provide the quantities of water calculated.

The existing storage facility that controls the gradient in the Main Service Area is the Turkey Hill Standpipe with an overflow elevation of 240.0 feet U.S.G.S. Using the overflow elevation of the storage tank and the approximate highest service elevation in the town, 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) in their Guidelines for Public Water Systems recommends a minimum service pressure of 35 pounds per square inch (psi). This is approximately equivalent to a column of water 80 feet high. The present maximum elevation served by the water system is approximately 120 feet U.S.G.S. Therefore, the lowest elevation for usable storage is 200 feet U.S.G.S. As previously discussed in Section 3.4. Storage Facilities, the Strawberry Hill Tank in Hull does not reach this elevation (overflow 186 feet U.S.G.S.) and therefore cannot be considered as having any usable storage. The Turkey Hill Standpipe's usable storage is the top 40 feet or 1,150,000 gallons.

As previously stated the amount of equalization storage required is 2,475,000 gallons, plus the fire flow storage of 630,000 gallons totalling 3,105,000 gallons. Subtracting the existing usable storage of 1,150,000 gallons, a deficiency of 1,955,000 gallons is calculated. As previously discussed and illustrated in Plate No. 4, elevated storage provides an additional origin for the hydraulic gradient, thereby improving pressures in the distribution system. With the major source of supplies located in the central portion of the town, and the existing standpipe on Turkey Hill on its eastern border, we recommend placing an additional storage facility in the western portion of town. The available land on Baker Hill is an excellent location for this facility. The existing ground elevation is fairly high at 150 feet U.S.G.S., and this land is presently undeveloped minimizing its aesthetic impact. This site is also adjacent to the Beal Street-Lincoln Street area that is expected to see significant development in the immediate future.

To provide the additional amount of usage storage (approximately 2 million gallons) above the base elevation of 200 feet U.S.G.S. would require the construction of an elevated storage tank. This tank would have an overflow elevation of 240 feet U.S.G.S. and must be 92 feet in diameter to have the necessary storage within the 40 foot range between the 200 and 240 feet U.S.G.S. elevations. An elevated tank is quite costly to construct since it must rest on "legs" or a pedistal to obtain the necessary elevations. An alternative to this design would be a standpipe similar to the existing Turkey Hill Standpipe. This standpipe can be designed to contain the required storage above the necessary base elevation of 200 feet U.S.G.S. by constructing a tank 90 feet high with a diameter of 92 feet and a capacity of 4.5 million gallons. This tank could be 40% less expensive than the elevated tank and have approximately 2.5 million gallons of additional emergency storage below the 200 foot U.S.G.S. base elevation. A third alternative would be the construction of a 2.0 million gallon standpipe 90 feet high with a 62 foot diameter. This tank would supply approximately 1.0 million gallons at the necessary elevation, with 1.0 million gallons of emergency storage below the 200 foot U.S.G.S. base elevation. This standpipe could be constructed at an even more significant cost savings. The final choice of size and type should be made following a more detailed storage analysis near the time of construction.

The future development of the industrial zoned area in the southwestern portion of Town may require additional storage. This storage could be placed at the proper elevation in the Pine Hill area. The capacity of this facility should be sized to meet the ultimate demand in the area.

8.0 FUTURE DISTRIBUTION SYSTEM IMPROVEMENTS

8.1. GENERAL

When improving or expanding a distribution system, the proper selection and location of water mains and the manner of their incorporation into the system are important factors in providing adequate flows and pressures. Any water main which extends 600 feet or more in length without a cross connection should have a minimum diameter of 8-inches. For lengths 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 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 large mains.

Another factor which should be considered in improving or expanding a system is that of fire protection. The construction of large residential complexes (apartment buildings, condominiums, etc.) results in higher fire flow demands being placed upon the system. Such a deficiency may result in a reduction in the overall rating of the system, thereby causing increased insurance premiums for the whole community. For this reason, such construction should not be approved until a determination is made of the fire flow requirements and its overall effect upon the rating of the system. Similarly, plans of proposed subdivisions should be examined to assure that the water mains involved may be satisfactorily incorporated into the system.

The Town of Hingham's Planning Board should review each proposed development with the benefit to the entire community in mind. The elimination of a potential dead end will help the system in the general area and may eliminate an existing dead end situation. The Planning Board can request that a proposed development obtain right-of-way easements, if necessary, in order to connect to several locations of the existing water mains. The resulting looping of water mains can improve water quality, system reliability, and increase available fire flows to an area.

The ideal water system should provide the water required by all customers at any time of the day or night every day of the year. The water should be from reliable sources and be of the highest quality. Sufficient storage should be available to provide the necessary large fire flow rates even during the day of maximum demand. The transmission system should be sized to carry these large flows and as the distribution system it should be properly gated, inter-connected and looped to provide maximum reliability. Every component of the system should be continuously checked and maintained to ensure that these high standards are achieved. Water is basic to life. People can not survive without water and a community can not grow and prosper without a well maintained water system.

Considering all the aspects of a water system we have only been able to complete a general review of the Hingham Water Company. The personnel we have come in contact with were professional and dedicated to their responsibilities. The mechanical equipment maintained by the company appeared to be in very good condition. An example is the 79 year old positive displacement pump in the Fulling Mill Pumping Station; not only is it an impressive piece of equipment, but it is also a utilized and dependable auxiliary component of the system. The following recommendations are intended to help achieve the ideal conditions the industry strives to meet.

Sources of supply should be protected from any form of contamination. We strongly recommend the gasoline auxiliary engines at the Scotland Street Pumping Station and the Fulling Mill facility be immediately converted to L.P. (liquid propane) gas carberation. If a leak occurs L.P. gas quickly vaporizes eliminating the possible contamination of a well. The existing gasoline storage facilities should be drained and removed. To provide water during a power shortage an auxiliary power supply of some kind should be provided at each source of supply. During our site visits, sufficient room appeared available at the Prospect Street Pumping Station for the installation of an L.P. gas auxiliary engine. Consideration should also be given to providing some type of auxiliary power to Free Street Pumping Stations No. 2 and No. 4.

Underground gasoline storage tanks can be a hazard to sources of water supply. These tanks may have small leaks that go undetected. Once the gasoline is in the groundwater and out of site, it is expensive and difficult to locate. The removal of gasoline from the aquifer can also very expensive. The recent leakage of a gasoline tank in the Queen Ann's Corner is presently being monitored by the Massachusetts D.E.Q.E. This area is not only adjacent to Accord Pond, but is also in the recharge area of Accord Brook and the aquifer serving the Hingham Water Company's High Service System. We recommend that all private and public gasoline or fuel oil tanks in Town be located, drained and removed. Tanks that remain in the ground should be tested and monitored frequently.

The Free Street Pumping Station No. 4 has not been approved by the D.E.Q.E. as a source of water supply, due to insufficient land ownership. This ownership is required to provide protection to the well's quality. Single bacteriological samples from this source did exceed the D.E.Q.E. standards in November and January. The amount of bacteria was very small and due to the averaging of the monthly samples, they do not exceed the maximum contaminent level allowed by the D.E.Q.E. It is an indication, however, that some form of contamination is present. The Free Street area experiences very high groundwater. The standing surface water is a direct access for contamination. The Hingham Water Company presently pumps the surface water into the

Weir River to decrease the quality degradation. With the introduction of treatment for this source of supply, the land ownership requirement will probably not be required. We do recommend that following D.E.Q.E. approval, a building with heating, lighting and auxiliary power be constructed at this well.

The wooden bulkhead over the large well at the Fulling Mill should be replaced. The new bulkhead should be able to withstand vandalism and prevent an accident.

8.2. PHASE I IMPROVEMENTS - PRESENT-1990

In order to achieve the ideal water system we have proposed the following improvements. Our recommendations utilize the existing water system and try to obtain the greatest benefit from the most cost effective alternatives. As requested by the Water Supply Committee, we have included a working plan of the water system that indicates each of the improvements of the four phases at the end of the report.

The Hingham Water Company plans to install approximately 1,800 linear feet of 8-inch water mian in Hobart Street from the ends of the existing 8-inch water main at the landfill and Blue Sky Drive this year. Since this project is definitely planned and budgeted by the Hingham Water Company we have not included it in the following recommendations. We have included it in our computer analysis and agree with its construction. We have also not included the costs for the previous outlined improvements (removal of gasoline storage, bulkhead replacement, etc.) since these items could be incorporated into normal system maintenance.

As previously discussed in the Water Quality Section of this report, we recommend the construction of a conventional water treatment plant. This plant will have the capability to treat both the surface and groundwater sources of the Main Service System. The surface water form Accord Pond requires treatment by order of the D.E.Q.E. The Accord Brook water gains manganese when infiltrated into the groundwater at Fulling Mill and still exceeds the recommended concentration following its treatment at the Fulling Mill Plant.

Groundwater sources at the Free Street facilities can receive contamination from the high groundwater in the immediate area. This is evident from the bacteriological samples obtained from Free Street Pumping Station No. 4. The use of this station is presently not approved by the D.E.Q.E. due to insufficient land ownership. The station design has also not been approved and use of this station could be indefinitely prohibited without treatment.

The treated water leaving the iron and manganese removal plant serving Free Street Pumping Station No. 2 still exceeds the recommended limit for manganese. The removal of iron and manganese will improve the aesthetic quality of the water and eliminate the build up of sediments in the distribution system.

Recent water analyses by the D.E.Q.E. have indicated that trihalomethanes are being formed. Although they have not exceeded the recommended level they are cause for concern. With the removal of color from the water, the possible production of carcinogens with the addition of chlorine will be eliminated. Without a water treatment facility, and therefore the loss of Free Street Pumping Station No. 4, the Hingham Water Company cannot meet its maximum day demands. For these reasons, we have recommended construction of a conventional water treatment plant.

The water treatment plant will include oxidation, coagulation, flocculation, sedimentation, filtration, sludge lagooning and high lift pumping. If the plant is constructed at the proposed Free Street site, several distribution system changes will be required for the delivery of raw and finished water. About 4,400 feet of 8-inch raw water ductile iron discharge piping will be required to the new water treatment plant from the Downing Street Pumping Station.

Due to its age and deteriorated condition we recommend utilizing the existing 14-inch water main in South Pleasant Street and the 20-inch water main in Main Street for the raw water feed line from the Fulling Mill Facility. An additional 1750 feet of 12-inch ductile iron water main is required in Free Street from Main Street to the new water treatment plant to complete this raw water line from the Fulling Mill site.

About 7,100 feet of 12-inch ductile iron water main in Main Street and South Pleasant Street will be required to replace the existing water main used for the raw water feed line from the Fulling Mill site.

As a finished water main about 1,750 feet of 16-inch ductile iron water main in Free Street from the new water treatment plant to Main Street will be needed. This completes the necessary system improvements associated wth the construction of the water treatment plant.

The quality of the water furnished to the customers will be a major improvement. A semi-annual flushing program should be initiated to clean the system. Sufficient flows should be achieved to actually scour the water mains. As previously discussed in the Flow Tests Section, the Hingham Water Company's previous scouring program did not reach the necessary flow rates. In fact some flows were still below the rate required to prevent deposition of sediment. We recommend flow rates sufficient to generate 6 to 7 feet per second velocities. Once the water mains have been scoured and the treatment plant has been in operation, the areas affected by quality problems should be limited to a few dead end conditions

The next step in the proposed improvements is to increase fire flows to areas that were deficient. The next three recommendations will improve fire flows in the Beal Street - Shipyard area, the Plymouth River School area, and to the South Junior High School.

The Massachusetts Department of Public Works (M.D.P.W.) is planning to reconstruct a section of Lincoln Street (Route 3A) from the River to the Fottler Road area. Included in this work will be the removal of the railroad bridge at the former U.S. General Services Administration property. It is the policy of the M.D.P.W. to declare a moratorium of 5 years on any road opening permits following the reconstruction of a roadway. Therefore, we recommend the immediate design and construction of about 11,200 feet of 12-inch ductile iron water main in Lincoln Street from North Street to Beal Street. If this can not be scheduled this rapidly then some provisions (easements, work out of the roadway, casings, etc.) should be investiagted.

To improve fire flows to the Plymouth River School area the existing 6-inch water main should be replaced with about 2,500 feet of 12-inch ductile iron water main in High Street from Main Street to Friend Street and from Tower Road to White Horse Road.

The existing 6-inch water main in the access roadway to the South Junior High School is limiting the fire flow available to the school. We recommend the installation of about 800 feet of 8-inch ductile iron water main in the private drive to the South Junior High School from Main Street.

The looping of the distribution system increases reliability and available fire flow. To eliminate the dead end about 1,450 feet of 8-inch ductile iron water main should be constructed in Grenadier Street from the end of the existing 8-inch water main to Main Street.

The final recommendation for Phase I is the purchase of land for a future storage facility on Baker Hill. This site is outlined in the Future Storage section of the report. Baker Hill is a very desirable location with a view of Boston. Although some opposition may be experienced it will be much easier and cheaper to acquire this land before any development takes place.

8.3 Phase II 1990 to 1995

To complete the looping of the Beal Street, Lincoln Street area and increase fire flows we recommend the construction of about 7850 feet of 12-inch ductile iron water main in Beal Street from South Street to Lincoln Street.

In order to improve the reliability of the fire flows to the industrial zoned area in the southwestern section of Town we recommend the installation of about 5,100 feet of 12-inch ductile iron water main in Derby Street to the Industrial Park Road. This will require approvals from the M.D.P.W. and possibly the Federal Government for crossing the interstate highway.

The quality of water reaching the customers has improved dramatically. To increase the capacity of the existing unlined water main in Main Street the Town should clean and line about 8,300 feet of the existing 20-inch cast iron water main in Main Street from Free Street to Leavitt Street. Additional valves should also be installed at this time to ensure convenient operation of the system.

To provide a major transmission water main from the sources of supply in the High Service System to the tank at Accord Pond we recommend the construction of about 6,150 feet of 12-inch ductile iron water main in Main Street from Longmeadow Road to Whiting Street.

To eliminate the existing dead ends in French Street construct about 1,200 feet of 12-inch ductile iron water main in French Street from Fort Hill Street to Hobart Street, and an additional 600 feet from Woodlock Road to High Street.

For an additional transmission water main to the Beal-Lincoln Street area and for the future connection to the Baker Hill Tank, construct about 3,500 feet of 12-inch ductile iron water main in Thaxter Street from North Street to Lincoln Street.

To eliminate some dead ends in the High Service System and promote looping, construct about 700 feet of 8-inch ductile iron water main in Prospect Street from Amber Road to Longmeadow Road and approximately 1,250 feet of 8-inch ductile iron water main in Burditt Avenue from Lincoln Street to Otis Street.

To allow the High Service System sources of supply to be able to meet their maximum day demands with the largest existing source out of service we recommend the construction of an additional groundwater supply with a capacity of at least 550 gallons per minute.

As a major transmission water main from the Turkey Hill Tank area to the downtown area of Hingham construct about 4,300 feet of 16-inch ductile iron water main in Chief Justice Cushing Highway from Summer Street to Kilby Street.

In order to eliminate two more dead end conditions in the High Service area, construct about 150 feet of 8-inch ductile iron water main in Palmer Street from Scotland Street to Polk Street and approximately 1,000 feet of 8-inch ductile iron water main in Recreation Park Drive from the end of the existing 8-inch water main to Derby Street.

8.4 Phase III 1995 to 2000

The construction of the Baker Hill tank will be the major project of this phase. As explained in Section 7 Future Storage, the tank can either be an elevated storage tank or a standpipe. Along with the site work and tank construction the discharge water main will require the construction of about 3,700 feet of 16-inch ductile iron water main in Bradley Park Drive from Thaxter Street to the tank site at Baker Hill.

To improve the looping and capacities of the water mains in the northern portion of Hingham we suggest the construction of about 1,650 feet of 8-inch ductile iron water main in Fearing Road from Burditt Avenue to Cottage Street, about 1,000 feet of 8-inch ductile iron water main in Downer Avenue from Lincoln Steet to Crow Point Lane, about 2,750 feet of 8-inch ductile iron water main in Summer Street from Chief Justice Cushing Highway to Rockland Street, and about 1,200 feet of 8-inch ductile iron water main in Nokomis Road from the end of the existing 6-inch water main to Downer Avenue.

8.5 Phase IV 2000 to 2010

To complete looping in the Beal-Lincoln Street area and provide additional drainage from the Baker Hill Tank, we suggest the construction of about 2,400 feet of 12-inch ductile iron water main in Fottler Street from Beal Street to Lincoln Street, and approximately 2,400 feet of 16-inch ductile iron water main in Brookside Drive from the Baker Hill Tank's discharge water main to Fottler Street.

Continuing the 12-inch water main in the High Service System about 3,200 feet of 12-inch ductile iron water main in Main Street from Longmeadow Road to Liberty Pole Road should be installed.

In order to complete the major 12-inch loop from Main Street to Beal Street we recommend the construction of about 5,000 feet of 12-inch ductile iron water main in High Street to complete the 12-inch loop and approximately 5,200 feet of 12-inch ductile iron water main in Fort Hill Street from French Street to West Street. To allow further flexibility of the Baker Hill Tank we suggest the construction of approximately 2,500 feet of 12-inch ductile iron water main from the Baker Hill Tank to North Street.

To support the development of Gardner Street and New Bridge Street we would suggest the construction of about 4,900 feet of 8-inch ductile iron water main in Gardner Street from Whiting Street to the end of existing 12-inch water main, and approximately 3,800 feet of 8-inch ductile iron water main in New Bridge Street from Gulf View Drive to Fort Hill Street. The aging 6 and 4-inch water mains in Hobart Street should be replace with about 2,600 of 8-inch ductile iron water main in Hobart Street from Main Street to New Bridge Street.

In order to improve the looping of several areas of town we suggest constructing about 2,800 feet of 8-inch ductile iron water main in Water Street from Main Street to Summer Street, about 2,400 feet of 8-inch ductile iron water main in Elm Street from Hersey Street to Main Street, and approximately 350 feet of 8-inch ductile iron water main in Brewster Drive from Brewster Road to Winthrop Road.

To eliminate two more dead ends we recommend the installation of about 300 feet of 6-inch ductile iron water main Polk Road from the end of the existing 6-inch water main to Main Street and approximately 950 feet of 8-inch ductile iron water main in Union Street from Triphammer Road to the existing 20-inch water main.

The estimated construction costs for these recommendations can be found in the following section. These recommendations are also highlighted for each phase on the enclosed Town of Hingham Highway map.

The major looping of the system increases the available flow rates as well as improve the reliability and integrity of the system. We suggest the construction of about 4,000 feet of 12-inch ductile iron water main in Cushing street from Old County Road to Pioneer Road to connect the existing dead ends. The ultimate development of the system would have 12-inch loops in Main Street, Cushing Street and also Lazell Street. The development of these areas will regulate when these water mains are installed. The future development of the industrial zoned area in the southwestern portion of Town may require additional storage. This storage could be placed at the proper elevation in the Pine Hill area.

As previously mentioned, as requested by the Water Supply Committee, we have included a working plan of the water system that indicates each of the improvements of the four phases at the end of the report.

9.0 ESTIMATED CONSTRUCTION COSTS

The following estimates are based on January 1985 construction costs. Allowance for construction, engineering and contingencies are included in these estimates. These estimates do not include the costs of the land acquisition, rights of way surveys, appraisals and related legal services.

9.1 Phase I Present to 1990

The Hingham Water Company plans to install approximately 1800 linear feet of 8-inch water main in Hobart Street from the ends of the existing 8-inch water main at the landfill and Blue Sky Drive this year. We have not included this in our proposed recommendations although we agree with this project.

1-A) Design and Construct a conventional water treatment plant including sludge lagooning and high lift pumping.	$10,600,000.
About 4400 feet of 8-inch ductile iron discharge piping to the new water treatment plant from the Downing Street pumping station	$ 210,000.

Utilizing the existing 14-inch water main in South Pleasant Street and the 20-inch water main in Main Street for a raw water feed line, an additional 1750 feet of 12-inch ductile iron water main is required in Free Street from Main Street to the new water treatment plant.	$ 100,000.
About 7100 feet of 12-inch ductile iron water main in Main Street and South Pleasant Street to replace the existing water main used for raw water feed line.	$ 425,000.
About 1750 feet of 16-inch ductile iron water main in Free Street from the new water treatment plant to Main Street.	$ 125,000.
Sub Total	$11,460,000.
1-B) About 11,200 feet of 12-inch ductile iron water main in Lincoln Street from North Street to Beal Street.	$ 700,000.

About 2500 feet of 12-inch ductile iron water main in High Street from Main Street to Friend Street and from Tower Road to White Horse Road.	$ 150,000.
About 800 feet of 8-inch ductile iron water main in the private drive to South Junior High from Main Street.	$ 35,000.
About 1450 feet of 8-inch ductile iron water main in Grenadier Street from the end of the existing 8-inch water main to Main Street.	$ 65,000.
Sub Total	$ 950,000.
Purchase land for proposed Baker Hill tank site and access roadway.	
TOTAL COST OF PHASE I IMPROVEMENTS*	$12,410,000.

*Cost does not include surveys and land acquisition for the Baker Hill Tank Site.

9.2 Phase II 1990 to 1995

2-A) About 7850 feet of 12-inch ductile iron water main in Beal Street from South Street to Lincoln Street.	$	470,000
About 5,100 feet of 12-inch ductile iron water main in Derby Street to the Industrial Park Road.	$	375,000
Sub Total	$	845,000
2-B) Clean and line about 8,300 feet of the existing 20-inch cast iron water main in Main Street from Free Street to Leavitt Street.	$	450,000
About 6,150 feet of 12-inch ductile iron water main in Main Street from Longmeadow Road to Whiting Street.	$	370,000
Sub Total	$	820,000
2-C) About 1,200 feet of 12-inch ductile iron water main in French Street from Fort Hill Street to Hobart Street, and an additional 600 feet from Woodlock Road to High Street.	$	110,000

About 3,500 feet of 12-inch ductile iron water main in Thaxter Street from North Street to Lincoln Street.	$	210,000
About 700 feet of 8-inch ductile iron water main in Prospect Street from Amber Road to Longmeadow Road.	$	13,000
About 1,250 feet of 8-inch ductile iron water main in Burditt Avenue from Lincoln Street to Otis Street.	$	60,000
Construct an additional source of ground water supply in the High Service System of approximately 550 gallons per minute capacity	$	500,000
Sub Total	$	893,000
2-D) About 4,300 feet of 16-inch ductile iron water main in Chief Justic Cushing Highway from Summer Street to Kilby Street.	$	310,000
About 150' of 8-inch ductile iron water main in Palmer Street from Scotland Street to Polk Street.	$	8,000

About 1,000 feet of 8-inch ductile iron water main in Recreation Park Drive from the end of the existing 8-inch water main to Derby Street.	$	50,000
Sub Total	$	368,000
TOTAL COST OF PHASE II IMPROVEMENTS	$	2,926,000

9.3 <u>Phase III 1995 to 2000</u>

3-A) About 3,700 feet of 16-inch ductile iron water main in Bradley Park Drive from Thaxter Street to the tank site at Baker Hill. $ 270,000

Baker Hill tank, 2 million gallon elevated storage tank. $ 1,700,000

Sub Total $ 1,970,000

3-B) About 1,650 feet of 8-inch ductile iron water main in Fearing Road from Burditt Avenue to Cottage Street. $ 80,000

About 1,000 feet of 8-inch ductile iron water main in Downer Avenue from Lincoln Street to Crow Point Lane. $ 50,000

About 2,750 feet of 8-inch ductile iron water main in Summer Street from Chief Justice Cushing Highway to Rockland Street. $ 135,000

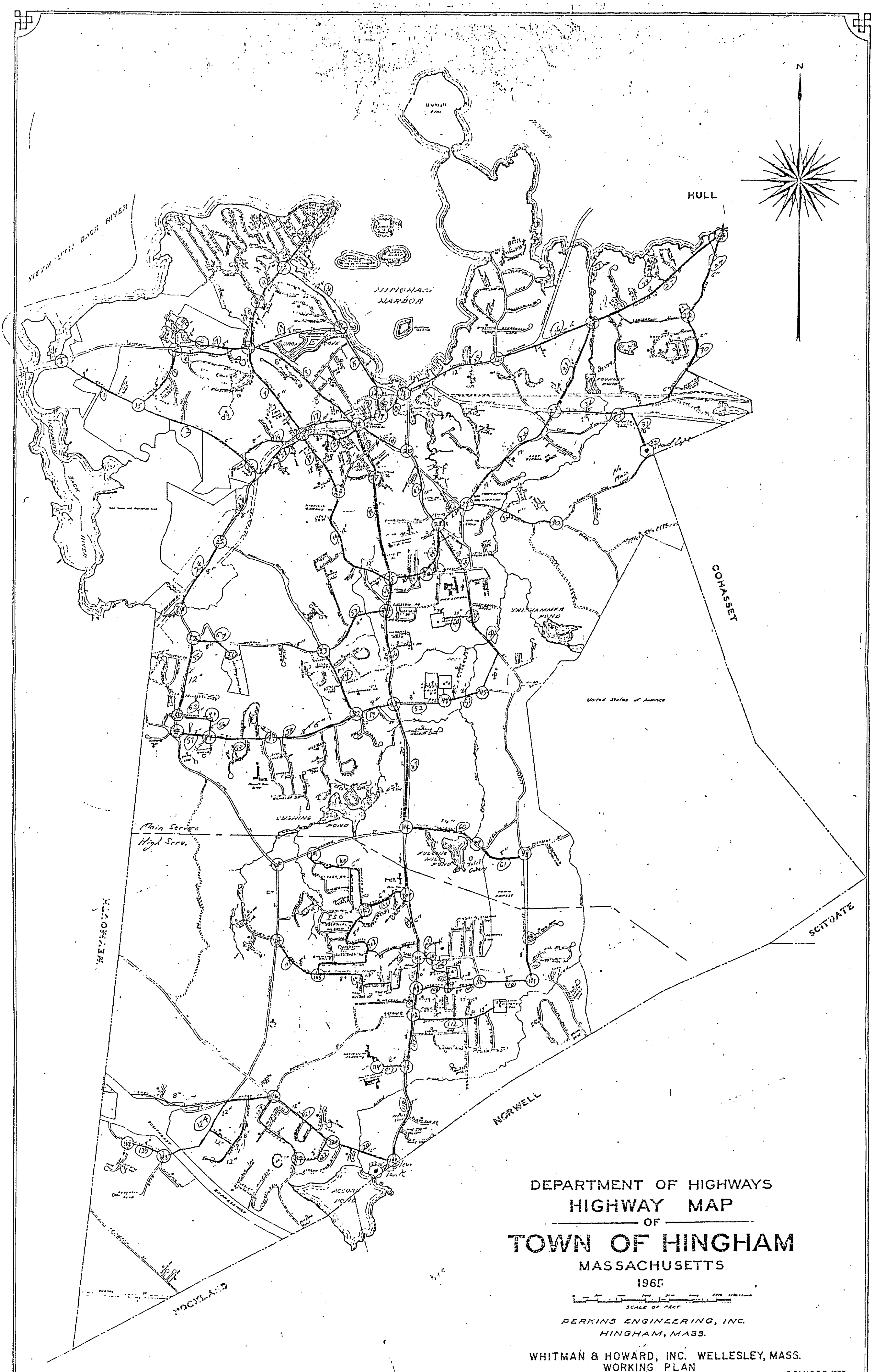
About 1,200 feet of 8-inch ductile iron water main in Nokomis Road from the end of the existing 6-inch water main to Downer Avenue.	$	60,000
Sub Total	$	325,000
TOTAL COST OF PHASE III IMPROVEMENTS	$	2,295,000

9.4 Phase IV 2000 - 2010

4-A) About 2,400 feet of 12-inch ductile iron water main in Fottler Street from Beal Street to Lincoln Street.	$	145,000
About 2,400 feet of 16-inch ductile iron water main in Brookside Drive from the Baker Hill Tank's discharge water main to Fottler Street.	$	175,000
About 3,200 feet of 12-inch ductile iron water main in Main Street from Longmeadow Road to Liberty Pole Road.	$	175,000
Sub Total	$	495,000
4-B) About 5,000 feet of 12-inch ductile iron water main in High Street to complete the 12-inch loop.	$	300,000
About 5,200 feet of 12-inch ductile iron water main in Fort Hill Street from French Street to West Street.	$	300,000
About 2,500 feet of 12-inch ductile iron water main from the Baker Hill Tank to North Street.	$	150,000

Sub Total	$	750,000
4-C) About 4,900 feet of 8-inch ductile iron water main in Gardner Street from Whiting Street to the end of existing 12-inch water main.	$	245,000
About 3,800 feet of 8-inch ductile iron water main in New Bridge Street from Gulf View Drive to Fort Hill Street.	$	190,000
About 2,600 of 8-inch ductile iron water main in Hobart Street from Main Street to New Bridge Street.	$	130,000
Sub Total	$	565,000
4-D) About 2,800 feet of 8-inch ductile iron water main in Water Street from Main Street to Summer Street.	$	140,000
About 2,400 feet of 8-inch ductile iron water main in Elm Street from Hersey Street to Main Street.	$	120,000
About 350 feet of 8-inch ductile iron water main in Brewster Drive from Brewster Road to Winthrop Road.	$	15,000

About 4,000 feet of 12-inch ductile iron water main in Cushing Street from Old County Road to Pioneer Road.	$	240,000
About 300 feet of 6-inch ductile iron water main in Polk Road from the end of the existing 6-inch water main to Main Street.	$	10,000
About 950 feet of 8-inch ductile iron water main in Union Street from Trip-hammer Road to the existing 20-inch water main.	$	45,000
Sub Total	$	570,000
TOTAL COSTS OF PHASE IV IMPROVEMENTS	$	2,380,000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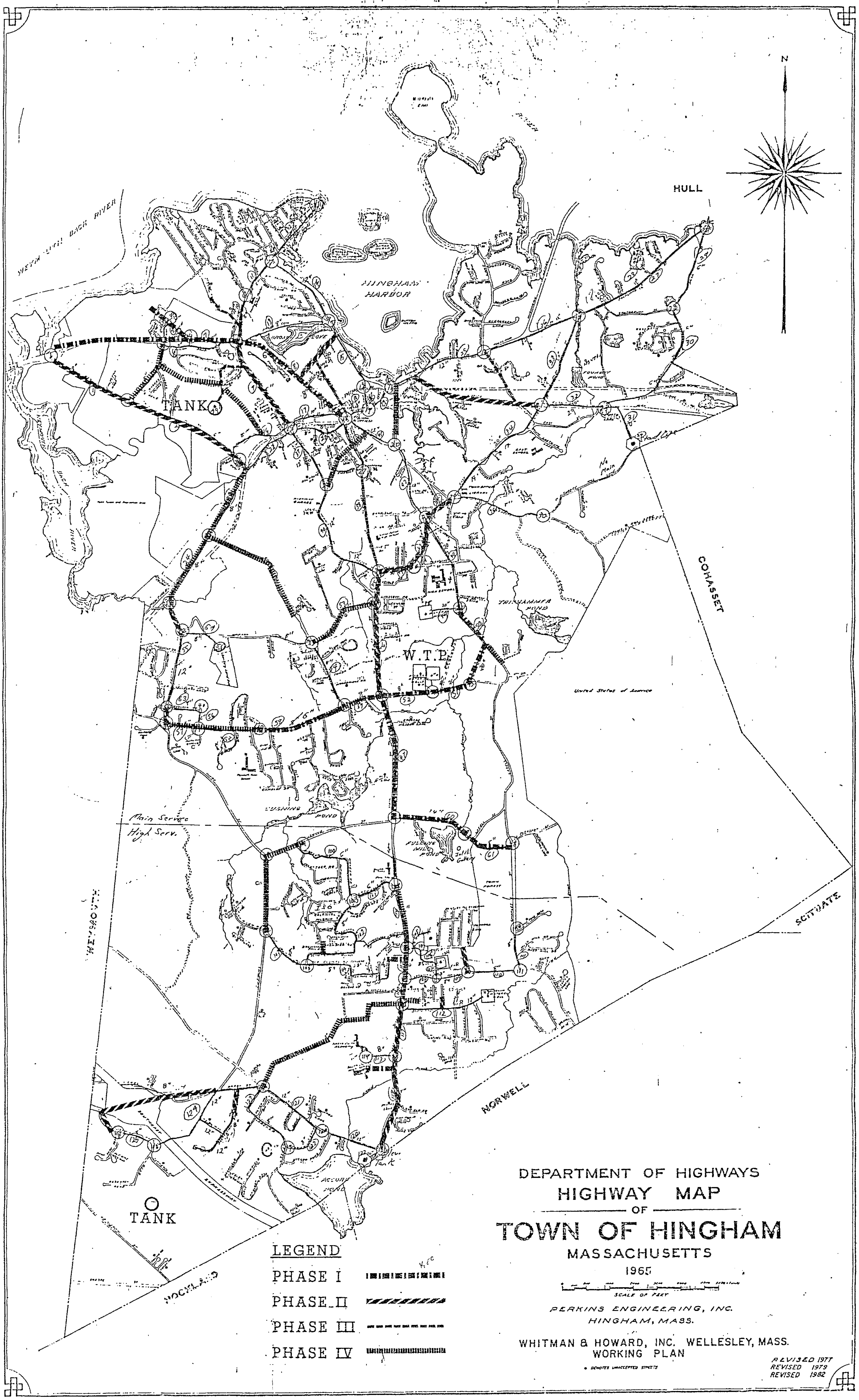
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CONSULTANTS TO MANAGEMENT, INC.
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PROVIDENCE R.I. 02903
(401) 273-2220

April 1985

Water Supply Committee
Town of Hingham
7 East Street
Hingham, Massachusetts 02043

To the Members of the Committee:

In accordance with our agreement we are pleased to submit our report on the financial aspects of the "Study of the Town of Hingham's Water Service".

This report includes the results of our analysis and evaluation of the objectives established in our proposal.

We have prepared an appendix under separate cover which contains the computer data compiled during our review for three types of ownerships; i.e. Privately Owned, Municipally Owned and District Owned for the period January 1, 1985 through December 31, 1989. Each set of schedules is preceeded by a narrative description of the exhibit.

We wish to thank the many people that assisted us during the study.

Very truly yours,

CONSULTANTS TO MANAGEMENT, INC.

Wesley T. Gardner

Wesley T. Gardner, Jr., CPA
President

April 1985

Water Supply Committee
Town of Hingham
7 East Street
Hingham, Massachusetts 02043

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HINGHAM, MASSACHUSETTS

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II SUMMARY

The results of our review are detailed in the report, however, eight major conclusions have been developed because of our efforts.

1. The purchase price for the water company should range from a low of $3,917,000 based on depreciated rate base to a high of $6,140,000 based on Chapter 139 Act of 1879 if the town votes to purchase the stock. Individual assets cannot be purchased according to recent Massachusetts court decisions.

2. The purchase will require the issuance of uninsured 15 year general obligation bonds.

3. The construction of a treatment plant under any ownership will increase minimum water rates an average of 1 1/2 times during the next five years. Without a treatment plant minimum water rates will increase an average of 3/4 during the next five years.

4. Hydrant charges will remain constant with a treatment plant but will increase up to 25 percent without a treatment plant.

5. Two step water rates are recommended over the present six steps. Under the present system the residential customer is supporting large water use customers.

6. Future costs under any ownership i.e. private, municipal or district will be approximately the same until the debt service that was used to purchase the company is retired.

7. The loss of property tax revenue to the town of Hingham will be approximately $.30/$1000 valuation on the tax rate if the town purchases the HWC. Conversely, if the company remains privately owned the construction of a treatment plant will decrease the tax rate by approximately $.50/$1000 valuation.

8. The ability of the town to obtain a state grant to build the water treatment plant, whether or not the town purchases the HWC, will reduce the overall cost to the water customer.

I. Introduction

A. OBJECTIVES

The objectives of our part of the study were to:

1. Determine a fair purchase price to be made as an offer to the Hingham Water Company (HWC) if it was deemed appropriate to make an offer. This analysis considered whether to offer to purchase the company in total or offer to purchase the fixed assets of the Company.

2. Determine the alternatives to fund and finance the potential purchase of the HWC and recommend a method consistent with the overall objectives of the Town of Hingham. We considered the financial impact on the residents and rate payers.

3. Determine the costs to operate the HWC assuming first that they will continue to operate as a separate company; second, if the Town purchases the Company; and third, if a multi-town water district is formed.

We completed each of the objectives and the results of our review and analysis are outlined in the following sections of the report.

B. APPROACH

Our approach to the financial portion of the study was to complete the following steps.

1. <u>Met with water supply committee</u>

We met with Mrs. Salisbury and Whitman $ Howard, Inc. to determine the direction we would follow, potential problems we would encounter and to review our detailed work plan.

2. <u>Met with Hingham Water Company</u>

We met with officials of the Hingham Water Company, Mrs. Salisbury and Whitman $ Howard, Inc. We provided three data requests to the HWC during the study. We were unable to obtain all of the information we requested, however, we were able to obtain answers to our questions through other means.

3. <u>Received general laws and other pertinent data</u>

We reviewed considerable data pertaining to laws, court cases and rate case information.

a. <u>Laws</u> - The laws we reviewed included the chapter(s) that established the Hingham Water Co. and subsequent laws to expand the system, Chapter 44 Municipal Finance - annotated Laws of Massachusetts, and Chapter 165 water and aqueduct companies.

b. <u>Court Cases</u> - We reviewed the following Massachusetts court cases that apply to this study.

- Town of Oxford vs Oxford Water Company
- Town of Southbridge vs Southbridge Water Supply Company
- Dedham Water Company vs Town of Dedham

c. Rate Cases and Studies - We reviewed the following rate cases in conjunction with the study.

- Hingham Water Company - Docket #1590
- Hingham Water Company - Docket #1590A
- Coffin $ Richardson, Inc. - Study to determine cost to provide water service to the Hull Division compared to the Hingham Division.
- Data request information provided by the HWC in Docket #1590.

d. Data Gathering - We completed the data gathering for our financial projections through a number of sources.

i. Interviews - We conducted numerous personal and telephone interviews to obtain the data we needed to complete the study. When information was to volumous or unavailable over the telephone, we usually received the information in the mail.

ii. Company Records - We had in our possession numerous reports, records, etc. obtained from our review of the HWC as intervener in Docket #1590. We utilized the HWC 1983 annual report, special studies and from our workpapers prepared during the review of Docket #1590. The information we had on hand made it possible to complete financial projections that otherwise would have been unsupportable estimates.

iii. Publications - We obtained a number of publications from organizations that made it possible to analyse the alternative situations. Some of the publications include:

- AMBAC Municipal Bond Insurance
- Pitfalls in Issuing Municipal Securities

- Annual Report - Dennis Water District
- HWC Annual Reports 1939 to 1983

4. Calculated the Financial Feasibility of Three Alternatives

We calculated the revenue requirements and rate per class of customer for each of the three alternative forms of ownership. The calculations were completed assuming a new treatment plant and without a new treatment plant for the period January 1, 1985 through December 31, 1989.

The calculations for revenue requirements were completed yearly, with the rate structure being calculated based on a five year average of the costs. The exhibits and the explanation of each exhibit was prepared as an appendix under separate cover. The appendix is quite technical and too large to include in the body of the report.

The calculations were completed with the aid of a computer system designed by our firm to calculate the rates by class of customer.

5. Meetings/Progress Reports - We provided monthly progress reports on our status of the study and attended three meetings with the committee. We presented our report to the Committee for review and attended public meeting(s).

III Purchase Price

The recommendation of a purchase price to offer the Hingham Water Company is dependent on a number of factors. Following the summary we have detailed our review of the laws affecting a purchase and the purchasing alternatives.

A. SUMMARY

The recommended purchase price the Town of Hingham should offer the Hingham Water Company for its stock, if a decision is made to purchase the company, is a low of $3,917,000 based on depreciated rate base to a high of $6,140,000 based on the actual cost definition of Chapter 139 Act of 1879 and the court's decision of the Town of Oxford vs the Oxford Water Company. Any asset additions by the company will result in an adjustment to the purchase price up to the time the Town votes to acquire the company. The Town cannot purchase selected assets but are required to buy the entire operation. The Town must first make a decision whether they want to purchase the water company. There are two questions which the town must have answered before they make the decision.

1. Are the future water rates going to be significantly lower using a municipal or district operation or as a private company operation?

2. Since the HWC has made a commitment to build a water treatment plant in Hingham, what are the financial impacts on the water rates if the town is involved in the financing?

B. ALTERNATIVES

The interest by the Town of Hingham in evaluating the purchase of the Hingham Water Company results in a question of what is a fair and reasonable price. The evaluation of the purchase price alternatives required us to review the various charters that affect the Hingham Water Company, recent Massachusetts court cases that address the question of cost or price, and industry accepted purchase price alternatives.

The balance of this section outlines the areas of our review, alternatives selected and the calculation of the recommended purchase price if the Town's decision is to proceed.

1. Review of Laws and Court Cases

a. Act to incorporate the Hingham Water Co.

The Hingham Water Company was established by Chapter 139 Act of 1879 to incorporate the company. A synopsis of the Chapter states:

"The town of Hingham has the right at any time to purchase the water company at the actual cost with interest not to exceed 10 percent per annum plus all actual loss or damage paid by the company for injury to persons or property and deducting all dividends paid or at any price mutually agreed upon by the company and the town of Hingham."

"The sale is conditional on the approval of two-thirds of the voters present and voting at any annual meeting or a legal meeting called for the said purpose of voting on such a purchase."

"The Town Treasurer is authorized to issue notes, bonds or other legal indebtedness not to exceed the purchase price to purchase the water company up to 6 percent per annum with a maximum maturity of 30 years. A maximum of $5,000 per year is allowed to retire the principal."

The chapter specifically provides a formula to establish a purchase price, however, the formula does raise a number of questions which we address in this section of the report.

a. What is meant by actual cost?

b. The interest rate cannot exceed 10 percent, however, how low a rate is reasonable?

c. The indebtedness to the Town of a maximum 6 percent per annum and $5,000 in principal payment is unrealistic today, therefore, what are more reasonable amounts?

d. What legal steps must be taken to change the chapter provisions if a sale is to result from negotiations? The chapter states the per annum rate cannot exceed 10 percent. We can safely assume that the percent cannot be zero (0) but must be a percentage within this range.

The indebtedness could possibly be 6 percent, depending on the bond market conditions at the time of sale. Presently, the bond market is in a position of lower rates, however, this situation could change and the effect of the law could create an indebtedness problem at the time of sale.

The Town's attorney must determine the legal steps that must occur if the town votes to purchase the water company to revise the chapter to increase the percent of interest and annual principal payments allowed.

Actual Cost

The question of actual cost has been presented before the Commonwealth of Massachusetts in the "Town of Oxford vs Oxford Water Company. This case addresses the definition of actual cost for the purpose of the town determining a purchase price to pay the private owners for the water company.

The court did define actual cost and the case will have far reaching consequences because it has set a precident for similar cases that will arise in Massachusetts.

The court held that "The actual cost shall be determined on the basis of original cost. It shall not be reduced by a deduction for accrued depreciation nor shall it include the cost of that property contributed or advanced to the company. Any sum added to ensure a 5% per annum return to the stockholders shall be based on the stock only."

The court went on to state that: "It seems quite clear on the record before us that in 1904 the legislature intended actual cost to mean original cost, the amount of money originally paid, as distinguished from any estimated cost, such as fair market value, or depreciated value."

"The 1904 legislature defined actual cost to provide that the price to be paid by the town should not depend upon opinions as to the market value of the property when taken, but should be restricted to what it had cost the company. The intent of the legislature, then, was to reimburse the company for its investment and to guarantee to the corporation the return of all the money invested in the enterprise."

A previous Commonwealth of Massachusetts court case - Southbridge vs Southbridge Water Supply Company - resulted in the court establishing a different definition of actual cost, however, the court in the Oxford case did not feel bound to accept the prior

Southbridge case's definition of the term actual cost.

b. Other Laws - Hingham Water Company

Additional chapters were included in the laws of the Commonwealth regarding the Hingham Water Company. These include:

Chapter #59 Act 1881 - Act in addition to incorporate

Chapter #88 Act 1886 - Act to increase water supply

Chapter #54 Act 1910 - Act to increase capital stock

Chapter #482 Act 1914 - Act to increase stock/extend to Norwell

Chapter #168 Act 1924 - Act to extend service to Norwell

Each of the chapters provide additional stock or expansion of the water system, none of the provisions directly affect the setting of the purchase price.

c. Other Court Cases

A number of court decisions throughout the United States have addressed the question of just compensation for the purchase of privately owned utility property. Some of the methods of determining just compensation include:

- Reproduction cost new less accrued depreciation
- Original cost of rate base components less depreciation
- Comparable sales

- Capitalized earnings
- Present day costs

Our review of various cases indicated that each court decision was based on a number of factors, but there are three points on which they agreed. The points are:

i. The criteria of "Fair Market Price" has been questioned when applied to the taking of utility property because there is only a limited market for such property and the utility is not subject to the economics of the market place.

ii. Where the utility stock is publically traded an investor may be willing to pay more than book value; however, where the stock is closely held, such market forces do not exist and the price is usually closer to rate base.

iii. Almost any property is available on a voluntary basis at any price. The essence of eminent domain is that the public may not be held up for an extra price.

d. <u>Conclusions</u>

The conclusions that we can determine from an analysis of the above matter are as follows:

1. That the courts can and do change the definition of terms in an individual case if they have sufficient facts to support a change.

2. That reproduction cost less depreciation is not the normal way of setting a selling price. It seems quite clear that each case is reviewed on the statutes and acts that have created a water company and the decisions are based on those relevant facts.

3. The act that created the water company in Hingham quite specifically outlines the way to develop a purchase price if the parties cannot agree to any other reasonable method.

2. Purchase Price Alternatives

Our review and calculation of the alternative purchase prices resulted in two alternative calculations.

1. Actual cost based on Chapter 139 Act of 1879
2. Original cost rate base

We did not complete calculations of the Reproduction Cost New Less Accrued Depreciation because this method is difficult and time consuming to calculate, has not received acceptance recently, and the concept of replacement cost less depreciation is not in keeping with recent Massachusetts court decisions.

a. Actual Cost Based on Chapter 139 Act of 1879

The calculation resulted in a purchase price of $6,140,000. Refer to exhibit I. The calculation was based on the 1983 annual report actual cost of $7,221,907 less contributed property of $1,085,364 for a gross actual cost of $6,136,543.

We completed a detailed analysis of the annual damages and injuries and dividends paid by the Hingham Water Company from 1939 through 1983 from the annual report. The year 1939 was selected as the base year because it is our understanding that it was the year that the company came under the control of the American Water Works Service Company ownership. The annual report does not state the purchase date and we were unable to verify the date either through the Department of Public Utilities or the company. The 44 years of damages and injuries were $3,583 and the dividends paid were $2,424,268. The final amount calculated was the per annum interest to be added to the gross actual cost. We determined the most appropriate amount was approximate 1 1/2 percent per annum on annual assets. This was based on the fact that a return has been paid to the stockholders over the past 44 years based on the Department of Public Utilities orders. The rate of return allowed is not guaranteed, therefore, We believe the per annum interest should equal the dividends paid during the same period to offset the percentage allowed in the Charter.

b. <u>Original Cost Rate Base</u>

The calculation results in a purchase price of $3,917,004. The original cost rate base method is one of the standard methods of calculation. This method provides for a reduction in the utility plant assets by the amount of accumulated depreciation. The method also provides for the reduction in the net utility plant for unrefunded advances for construction and the unamortized contribution in aid of construction. These amounts are not contributed by the company and must be deducted to arrive at the depreciated rate base.

HINGHAM, MASS.

Purchase Price Alternatives

Chapter 139 Act of 1879

12/31/83 fixed asset cost	7,221,907
Less: Contributed property	1,085,364
Gross actual Cost	6,136,543
Per annum interest	2,424,268
Damages and injury	3,583
Sub-total	8,564,394
Less: Dividends	2,424,268
Total	6,140,126

Original Cost Rate Base

Depreciated utility plant	6,914,418
Capitalized items previously expensed	14,587
Sub-total	6,929,005
Reserve for depreciation	1,926,637
Net Utility Plant	5,002,368
Unrefunded advances for construction	(102,898)
Unamortized contribution in aid of construction	(982,466)
Depreciated Rate Base	3,917,004

IV FINANCING ALTERNATIVES

The financing alternatives that are available to the town of Hingham to purchase the water company are limited for a number of reasons, although, there are various options within the alternatives. Following the summary is a detailed explanation of the funding sources, factors affecting bond ratings, bond ratings, investor requirements and municipal bond insurance. The detailed information is background material which supports our recommendation.

A. SUMMARY

The recommended method of funding, if the town votes to purchase the water company, is to use uninsured, 15 year, general obligation bonds. The recommendation for the purchase as a water district would be insured, 15 year, special revenue bonds. The bonds would be issued approximately one year after the purchase of the company whether a municipal or district operation.

1. Bond Anticipation Notes

The purchase price for the company would be negotiated using bond anticipation notes for one year at a currently projected interest rate of 6 percent for a municipal operation and 9 percent for a district operation. During the first year steps would be taken to prepare a prospectus to sell the bond issue. The bond issue should be $4,000,000 to $6,200,000. which would provide funds for the underwriters and other related costs depending on the final purchase price.

2. Length of Maturity

Our analysis shows that the 15 year period is the most cost effective period of time in which to fund a purchase. Using 20, 25 or 30 years only increases the total interest payments to be paid, thereby creating longer debt payments to be met through the sale of water. In addition, the interest rate itself would be higher the longer the length of maturity.

3. Type of Bond

a. Municipal

The general obligation bond is the most attractive method of financing for the town of Hingham. The determination of an interest rate is dependent on many factors, the most important being past experience, present bond rating and authority to raise the funds to pay the debt.

The town of Hingham does not have past experience operating a water department, however, the town's ability to raise taxes does provide the security for an interest rate that would be in the A rating range. The town's long term debt is low and the ability to borrow with general obligation bonds is positive. The town's excellent rating precludes borrowing through the Farmers Home Administration because the rate would be higher than on the open market.

It is also possible to purchase insurance to protect the investor, however the town's rating is high enough so that the cost of the insurance would not be justified.

Revenue bonds are not recommended because of the lack of past experience operating a water department and the limited taxing or revenue producing power compared to general fund obligations. It is questionable how a revenue bond would be received by bond underwriters and investors. One fact is certain; the interest rate would be unattractive to the town compared to the general obligation bond.

b. District

The revenue bond is the main option open to a water district. However, this option also creates funding problems for the same reasons as the municipal operation. The district has not operated a water department, may not have unlimited taxing authority, and does not have any financial experience or background. The creation of a water district would require the use of BAN's to fund the purchase for one to three years. This is required in order to establish operating experience and to give the bond underwriters and investors an opportunity to evaluate the district. The use of bonds issued through the Farmers Home Administration might be possible, however, it is difficult to estimate if such financing will be available in two or three years. We believe that the water district option is the least desirable of the three types of ownership we studied.

B. ALTERNATIVES

Our analysis resulted in determining a number of factors that affect the financing of a water company. This section of the report reviews the following five areas.

1. Funding Sources

There are a number of factors that affect the method and timing of the financing. The following sections will describe the types of funding, advantages and disadvantages of each and how two or more methods of funding might interact.

a. General Obligation Bonds

General obligation bonds are backed by a government with power to levy taxes and promise unconditionally to pay the interest and principal. The full faith and credit of the issuing community is pledged through the taxing levy. General Obligation Bonds have had great appeal to investors because of the broad tax base. This method of financing has generally remained the least

The federal government has provided funds for water related investment, and although funds are presently scarce, this method of financing cannot be overlooked. There are a number of methods and sources of funds. These include:

State Funds

Commonwealth of Massachusetts Funding - DEQE

The Commonwealth of Massachusetts D.E.Q.E. has a number of funding sources for water utilities.

Chapter 406 Act 1978 Water Filtration Plants

The water filtration funding through Chapter 46 of the Act of 1979 provides for a 50/50 funding. However, to be eligible for the grant, the community must own and operate the facility. Therefore, in order for Hingham to take advantage of the grant, the Town must purchase the water company or a water district must be formed.

Chapter 805/1979 amended by Chap 286/1982 Act for Identifying Sources of Loss of Potable Water and Rehabilitate Water Supply Distribution Systems

The system rehabilitation funding through Chapter 805 provides for a 50/50 funding for relining pipes, looping dead ends and replacing old pipe. Again, the Town must own and operate the system or form a water district to be eligible.

Leak Detection Program

The leak detection program funding provides for a 50/50 funding for leak detection services. Again, the Town must own and operate the system or form a water district to be eligible.

Chapter 286/1982 Acquifer Land Acquisition

The acquifer land acquisition funding provides for 100% financing for the purchase of watershed land.

Chapter 286/1982 Water Supply Correction Program

This program provides funds for the clean up of well field problems. At the present time we are unaware of any such problems.

d. Other Methods of Financing

Other methods of financing are available to a community that is planning to make a major investment in plant and improvements. The opportunity to immediately borrow funds through the sale of bonds is not that simple. The bond rating agency established a rating based on past history and future revenue collections. If a water department cannot provide a proven track record, the rating will be lower resulting in higher interest payments. This, therefore, requires the to establish a track record in the ensuing years. What does the department do for financing in the meantime. There are other potential financing opportunities.

Bond Anticipation Notes

The sale of Bond Anticipation Notes (BAN's), backed by the taxing power of the community, is a method of short-term financing prior to selling general obligation or revenue bonds. The BAN's provide the means of getting started while the bond issue is being prepared and a track record of operations is being established.

Generally, the BAN rate is tied to the community's present rating and the condition of the money market. However, the interest rate can generally be fairly accurately estimated when estimating interest costs for the period the BAN's will be in effect.

2. Factors Affecting Bond Rating

There are many factors which affect the bond rating. Described below are a number of the factors and their effect on the rating which translates to the amount of interest to be paid.

- Can the bonds be issued for the amount required. Are the bond's principal within the debt limits of the community.
- The central consideration is the source from which the debtor will pay the obligation.
- What affect will the bond amounts have on long-term capital improvement programs.
- The cost for bond issue (interest) depends upon the evaluation that is completed by the bond rating agency. This is based on the bid specification presented, the type of issue and

the supply of similar securities in the marketplace.

- Refunding of bond issues must be considered as possible in the future when bonds are sold during high interest rate periods.

- Ratings affect the eligibility of bonds for purchase by institutional investors and can influence the interest rate a community must pay on the bonds.
- The agency determines future performance in terms of debt service requirements. A ratio of debt to wealth is calculated by comparing the debt commitment to the pledged resources. The ability to convert pledged wealth into sustainable accrued future income is also appraised.

a. <u>General Obligation Bond Analysis</u>

There are four areas for evaluation of general obligation bonds.

<u>Debt</u>

Relates to the impact of all debt obligations and the ability of taxpayers to meet the debt burden. This includes local debt and the proportionate share of the debt obligation of overlapping governmental units on the taxpayers of that unit.

The gross bonded debt is adjusted to net by subtracting sinking fund or self supporting utility operations. To the net amount we add a proportionate share of any county, school and other net debt payable from the same tax base. This results in the overall net debt which confronts the taxpayer. The overall net debt is related to the assessed valuation of all taxable property adjusted to reflect market value. This is the equalization ratio. Empirical evidence indicates there is good reason to expect difficulty in meeting debt obligations when the debt burden exceeds 12%. A reasonable measure of payment is half the debt of a community over ten years.

Financial

An examamination of the most recent financial obligation reveals the communities performance under existing conditions.

The revenue system reveals the reliance of the unit on property taxes, trend of assessed valuation and tax delinquencies and the diversification of the revenue structure.

A prime concern is that the current account be soundly maintained. This requires a review of the year-end relationship of current liabilities to available cash and the promptness in paying casual deficits and methods to prevent deficits from accumulating.

Government

A determination is made of the staffing and administration policies and how well they performed the functions. A major aspect is the availability of adequate financial documents, annual reports and a meaningful capital improvement plan.

Economic

A determination of the wealth of a community and measuring its ability to service debt is extremely important. The future is more important than the past. The location, geography and land use are important measures to the communities future development. Other data is important to analyze such as population, income levels, age of housing, new construction, etc. The economic structure of a community is one of the most important factors to be examined.

b. Revenue Bond Analysis

Revenue bond analysis is less elusive than general obligation bond analysis. There are a finite number of variables which are quantifiable. Revenue debt is directly related to the earnings of an enterprise. The credit analysis is similar, however, the emphasis is on the user enterprise receiving benefit, not the taxing power.

System capability through physical plant evaluation and the ability to produce a service that can be sold at prices consumers are willing to pay is critical. This results in determining the ability of management to operate with financial success.

It is important to determine the covenants in the trust indenture or bond resolution. The flow of funds is important along with additional bond clauses and the rate covenant. The rate covenant establishes a base by which to measure management and its performance.

3. Bond Ratings

There are three major rating agencies in the United States. Moody's is the major agency whom we have discussed our review of potential bonds for the purchase of the water company.

The rating results in a fee to the community requiring a bond rating. The rating is dependent on the quality of the bond issue, the rating does not bestow quality on the issue.

The rating should not be used along as a basis for investment decisions. Market prices in bonds are influenced by the quality, changes in money rates, general economic trends and the length of maturity.

The ratings involve judgement on the future and determining the worst potential problems. They are appraisals of long-term risks. The rating of the factors of debt, finance, government and economics are weighted and are based on their interrelationships. There is no one formula. The ability and willingness to pay are the most important factors. Each time an issue comes to the market, a rating is assigned and outstanding ratings can change either up or down depending on current factors.

There are certain basic information requirements that are reviewed by the rating agency. These include:

a. Long-term Debt

All long-term funded debt must be reported. This includes bonds and debt instruments whether legally titled term warrants, certificates, and regardless of type of security or source of funds for payment. A comparison is made of current outstanding indebtedness to one, five and ten years ago.

b. Overlapping Debt

The layers of debt from the tiered structures of government must be determined for the overlapping units. It is important that the statement of debt is complete, deductions are adequately explained and the basis of allocation is clear.

c. Provisions of Debt Retirement

The prime concern is the rate at which bond principal will be paid and the amount of principal and interest which will be due annually. The annual financial statement should show the purpose, composition and structure of all indebtedness. A separate debt service schedule is required for special or enterprise fund debt. Declining annual debt service is preferred to level or slowly rising requirements.

d. Capital Improvement Program

The capital improvement program (CIP) should be provided showing the amount to be spent and the source of funds; i.e.

current operating revenues, state funds, federal funds, surplus, bonds, BAN's, etc.

e. Assessed Valuations and Tax Rates

The review requires a community's assessed valuation for the current and preceding nine years. Separate amounts for land, improvements and personal property should be provided. The tax rates should include the governmental unit and the total rate for all overlapping local governments combined. Tax rate data should cover the same ten year period on the assessed valuation data.

f. Tax Collections

Tax collections relate directly to financial condition. A schedule of the tax levy collectible and amount uncollected for five years is required. Failure to hold tax sales regularly also discourages prompt tax payment.

g. Financial Operations

Most debt difficulties are caused by incurring excessive debt and spending more money than is received as revenue. Two sets of documents, the annual financial report and the annual budget supply answers to various financial questions. Three prior years documents are required for review. The reports and budgets provide evidence of the fiscal policies and procedures followed by the local government.

4. Investor Requirements

The bond investor looks for certain factors that make one issue more attractive than another issue. These include:

a. Maturity Schedule

The maturity schedule must comply with the maximum and minimum requirements of state law. Shortening the life of the loan reduces the interest payment periods and could help to reduce the interest rate. The schedule also depends on whether the issuer chooses to use the straight serial (equal amounts per year) or the serial annuity (principal repayments increase yearly so principal and interest remain constant). The straight serial type is more conservative and results in a shorter average life and they produce lower interest costs.

b. Amount of Each Maturity

Investors prefer lot sizes from $5,000 to $25,000 and institutions prefer denominations of $25,000 to $100,000.

c. Call Privilege

The call privilege permits the issuer to take advantage of a downswing in interest rates. When exercised, the outstanding bonds are called and replaced with bonds earning lower interest rates. The windfall of additional cash can also make the call attraction useful to the issuer of bonds. The effective yield on a callable issue should be greater than the effective yield if held to maturity. Generally a premium is paid if the call privilege is exercised.

d. Interest payments

Most investors prefer semi-annual interest payments to annual payments. This feature can assist the attractiveness of the issue.

e. Timing of a Bond Issue

The timing of an issue is important. It is sometimes prudent to use temporary financing such as BANs. The use of short-term funds can allow time to issue bonds at more favorable interest rates. Temporary borrowing can be an integral part of a capital improvement program.

5. Municipal Bond Insurance

Municipal bond insurance is a recent method to assure the bond issuer and the investor that the principal and interest of the bond issue will be paid on time in the event that the municipality is unable to meet its debt obligations on time. Obtaining municipal bond insurance, however, is not automatic. The bond issue must go through a stringent review before it is approved by the bond insurance company.

Two companies provide municipal bond insurance. They are American Municipal Bond Assurance Corporation (AMBAC) and Municipal Bond Insurance Association (MBIA) both located[in New York City. The main advantage to purchasing municipa[bond insurance is to reduce interest costs. However, the insurance cost must be less than interest saved.

a. Benefits

The use of bond insurance is beneficial in a number of ways.

- If a small government not known in the financial market
- Infrequent local government borrowers
- Issued for an unusual purpose
- If issue is not qualified for the general market
- If thin credit sensitive market
- Upgrades ratings, reduces interest costs and broaden the market
- If marketability prejudiced by adverse conditions

b. Coverage

Such insurance policies are noncancelable and contracts to pay all or any part of scheduled principal and interest as it becomes due and payable if it is not provided by the issuer. The policy is effective for the life of the issue.

c. Eligibility

Most general obligation and revenue bond issues are eligible for the bond insurance as well as special and excise taxes. The bond issue must be at least $1 million par value.

d. Cost

The insurance premiums can range from 1/2% to 2 1/2% of the principal and interest payments and is based on the insurance risk involved. The insurance premium is payable in full when the bonds are issued. There are no additional premiums.

e. Obtaining Coverage

There are two methods to obtain coverage.

i. Direct Purchase - The issuer will decide in advance that the insurance will be purchased if eligible.

ii. Elective Bidding - The issuer or bidding underwriter can elect to purchase the insurance on a new issue being offered via a competitive bid.

f. <u>Advantages to Using Insured Bonds</u>

There are a number of advantages to insuring municipal bonds.

i. The policy cannot be cancelled

ii. Generally the highest yielding bonds available

iii. Bonds meet investment grade standards

iiii. Provides marketability in case of default

iiiii. Provides security to local issues for access to national markets, increases liquidity and narrows the bid-ask spread

The use of bond insurance can provide a number of benefits to the issuer and the investor. However, each issue must be reviewed on its own merits and the cost of the insurance premium should be analyzed in relationship to the savings in interest costs over the life of the issue and the potential increased marketability.

V. WATER RATE STRUCTURE

The development of the water rate structure for the five year average for the period 1985 through 1989 required us to calculate the operating and maintenance expenses, rate of return, debt service and the allocation of costs between classes of customers. The capital improvement costs were developed by Whitman $ Howard, Inc. as part of their engineering study and were included in our calculations.

Our review and analysis of the financial data is summarized as follows:

A. Rate Structure

The rate structure that we developed for the five year period is summarized in exhibit I to exhibit IV. The results of the analysis are described below.

1. Comparative Rates Summary

a. Metered Rates

A comparative rates summary, exhibit I, presents the minimum quarterly charge for each meter size, the quantity of water allowed for such minimum charge without further cost and the rates which would be charged per 100 cubic feet for all water used in excess of the quantities allowed for the minimum charge.

i. Current company rates

The current rates charged by the company include a minimum charge with a minimum allowance of water in cubic feet for each meter size plus a six step rate for water used in excess of the minimum. This rate structure results in the average residential customer using the minimum water allowed through a 5/8" meter paying the following charge.

Hingham	$16.59
Hull	20.43

The 3/4" meter through the 8" meter, public fire hydrants and private fire protection rates are shown as calculated.

ii. Projected rates by ownership

The projected five year average rates which would be charged with a minimum allowance of water of 7 (100) cubic feet for the average residential customer using the minimum water allowed for a 5/8" meter through an 8" meter, annual public hydrant charge and the private fire connection charge by size is shown to the right of the current company charge by each alternative method of ownership and the status of a water treatment plant (Exhibit Ia and Ib).

Each of the alternatives represents the following set of facts.

Company - No treatment Plant - The HWC maintains ownership, no treatment plant but $2 million in improvements are completed.

Municipal - No treatment plant - A $6.2 million purchase price paid by the town, no treatment plant but $2 million in improvements are completed.

District - No treatment plant - A $6.2 million purchase price paid by a newly formed water district, no treatment plant but $2 million in improvements are completed.

Municipal - No treatment plant - A $4 million purchase price paid by the town, no treatment plant but $2 million in improvements are completed.

Company - Treatment plant - The HWC maintains ownership, a $10.5 million treatment plant is built and $2 million in improvements are completed.

Municipal - Treatment plant - A 6.2 million purchase price is paid by the town, a $10.5 million treatment plant is built and $2 million in improvements are completed with general obligation bonds funding the entire expenditure.

District - Treatment plant - A $6.2 million purchase price is paid by the newly formed district, a $10.5 million treatment plant is built and $2 million in improvements are completed with revenue bonds funding the entire expenditure.

Municipal - $6.2 million purchase and a $6 million grant - A town purchase of the water company, a $10.5 million treatment plant funded with a $6 million grant and $2 million in improvements are completed with general obligation bonds.

Municipal - $4 million purchase, no grant but a plant - A town purchase of the water company, a $10.5 million traetment plant and $2 million in improvements are completed funded by general obligation bonds.

Municipal - $4 million purchase, $6 million grant - A town purchase of the water company, a $10.5 million treatment plant with a $6 million state grant and $2 million in improvements are completed funded by general obligation bonds.

Private - Leased treatment plant - The HWC maintains ownership, the town builds the treatment plant and leases the plant to the HWC. The HWC completes $2 million in improvements.

A comparison of the 5/8" meter shows that the most advantageous alternative, cost wise, is for the town to purchase the water company for $4 million without building a treatment plant and the worst alternative is company ownership and building a treatment plant. All of the remaining nine alternatives range within the low of $25.91 to a high of $44.85 for a quarterly minimum charge for the 5/8" meter.

The charge per quarter at 2500 cubic feet would be a low of $41.72 with a town owned system at $4 million and no treatment plant to a high of $78.39 for a company owned system with a treatment plant.

It is important to note that the projected rates are averages. You can expect the rates on January 1, 1990 to be approximately 9% higher without a treatment plant and 24% higher with a treatment plant.

b. Hydrant Charges

The public hydrant charges will not rise significantly during the five year period. For example, the present HWC hydrant charge is $363.68 per hydrant, annually. The Hingham hydrant charges for the three ownerships will range from $413.00 to $452.00 without a treatment plant and $385.00 to $395.00 with a treatment plant. The same relationship would result for Hull public hydrant charges. As you might have noted the public hydrant charges with a treatment plant are less than hydrant charges without a treatment plant. This results because the purpose of a treatment plant is to increase the purity of the water for human consumption. The treatment plant is not necessary for fire protection purposes. The allocation of the treatment plant costs are allocated to the metered rates that the residential, commercial and industrial customers use. Therefore the hydrant rates does not change significantly. The same situation results for private fire connections; i.e. the treatment plant fire protection costs are less than if there is no treatment plant.

2. Comparative Metered Sales Step Rates

A comparative metered sales step rate per 100 cubic feet, exhibit II, presents the 2 step rates calculated as a result of the allocation of costs to class of customer. The present HWC rates are allocated to six declining steps, however, we are unable to justify a six step rate for our analysis. The trend has been to reduce the number of steps and we believe a two step rate is more reasonable for our analysis.

a. First step rate

The first step is the rate used to calculate the minimum 7 (100) cubic feet and the next 3 (100) cubic feet. Any usage, for any meter size in excess of 10 (100) cubic feet per quarter is billed at the second step. The HWC also allows a proportionately high cubic feet in the minimum as the meter size increase, however, the AWWA accepted practice is the same cubic feet for any meter size because usage is not dependent on meter size. The two steps were calculated based on the base-extra capacity method. The base costs relate to average day demand. We determined the average day demand and related the amount to the equivalent meters. The first step rate is a result of dividing the cost allocated to base cost by the base consumption. The results of the analysis show that the first step rate for Hingham and Hull are less than the current rate without a treatment plant and slightly higher than the current HWC first step rate with a treatment plant. The reason that the first step amounts for the HWC and the projected rates are similar is that using two steps rates instead of the present six step rates flattens out the spread between steps. The present HWC step rates must make up in the first few steps what is lost in the last few steps. Using a six step rate impacts the residential user with higher bills.

b. Second step

The second step rate is a result of dividing the cost allocated to extra capacity, which is the difference between average day and maximum day usage, by the extra capacity consumption. Any customer usage in excess of 10 (100) cubic feet each quarter will be charged at the second step rate.

3. Impact Analysis of Rates

An impact analysis of rates, exhibit III, presents the effect of current and projected rates for each of the ownerships for a number of meter sizes. The meter sizes compared are 5/8", 1", 1 1/2" and 2" for 2500 cubic feet of water per quarter. The results of the analysis indicate that the most common user of water, i.e. the Hingham residential customer with a 5/8" meter, would have their cost stay approximately the same as they are in 1984 without a treatment plant under any of the three ownerships. The treatment plant will result in an increase of approximately 60%. Hull would result in a potential decrease for 2500 cubic feet usage per quarter without a treatment plant and an approximate 35% increase with a treatment plant.

Any meter size above 5/8" will result in somewhat higher projected bills because presently the HWC gives a proportionate increase in minimum water usage related to the size of the meter. This penalizes the residential 5/8" meter user.

B. OPERATING AND MAINTENANCE EXPENSES

The preparation of the operating and maintenance expenses was based on historical data of the Hingham Water Company and known and measurable charges and inflation estimates for the period January 1, 1985 through December 31, 1989.

1. Revenue Requirements

The 5 year average revenue requirements, exhibit IV, summarizes and compares the 5 year average revenue requirements to the total 1989 revenue requirements for a treatment plant. The percentage increases reflect the difference between the 5 year average and the fiscal 1989 revenue requirements. The five year average revenue requirement with or without a treatment plant shows that the least costly alternative is a municipal department operation. The district operation is the more costly alternative. The private water company falls in between the other two alternatives. The question that can be raised at this point is why is a private company not more costly because of the rate of return, tax liabilities, and other overhead not associated with a non-profit operation. The answer to this question can be found by analyzing the financial data in the appendix. The municipal and district operation must amortize the debt service cost to purchase the company over 15 years. During the 15 year period the additional costs result in revenue requirements similar to the private water company. The financial advantages of public ownership will not appear until the purchase price debt has been retired. If the debt service is amortized over 20, 25 or 30 years, the financial advantage will not appear until the debt is retired.

2. Detailed Expenses

The preparation of the financial projections were completed for the three forms of ownership considering a treatment plant and without a treatment plant. The six sets of worksheets are located in the appendix with an explanation for each exhibit. The preparation of the expenses was based on adjusting the actual 1983 operations of the HWC for known and measurable charges and inflation allowances. The 1983 annual report of the HWC was used to obtain actual operating and maintenance expenses. The rate filing Docket #1590 contained worksheets that provided percentage relationships that allowed us to determine the percentage of adjusted and unadjusted expenses. We used the percent relationship each year to develop an adjusted base to which we added known and measurable changes and inflation allowances where other data was not available. The known and measurable changes were based on discussions with vendors, suppliers and we adjusted each of the ownerships appropriately. There were expenses that affected the ownership jointly and separately based on the need for employees, benefits, etc. The debt service costs represent the largest expense affecting the municipal and district operation that does not affect the private ownership. Other similar type expenses are billing expenses, outside professional services, and central services provided by the town employees.

The private ownership main difference with the other ownerships is the rate of return, depreciation, service company charges and leased vehicles.

The inflation allowance we used was 5 percent per year for all three ownerships. The only difference was a 6 percent increase in salary and wages for the private company. The union contrast has recently been settled at approximately 6 percent.

3. Capital Improvement Costs

The capital improvement costs were obtained from the Whitman $ Howard, Inc. report. We used the projected costs for the period "Phase I Present to 1990". The report showed the treatment plant costs of $11,460,000 and other construction costs of $950,000 for a total of $12,410,000.

We rounded the amounts in an analysis to $12,500,000 with the treatment plant and assumed $2,000,000 capital costs for transmission and distribution if a treatment plant is not built. The capital improvements costs for the municipal and district operation are shown on the operating expense worksheet as debt service calculated using the level payment method.

The financing incurred by the private company would be considered 65 percent long term debt and 35 percent additional capital stock according to representatives of the HWC. The amounts are included in the capitalization schedules and revise the calculation of the rate of return. The interest expense and return on equity is included in the operating expense worksheet on the rate of return line.

C. RATE OF RETURN

The rate of return calculated for the projected privately owned water company averaged 12.27 percent for the five years.

We assumed the commission approved return on equity for Docket #1590 of 14.50 percent would continue for the five year period.

The return on rate base was calculated by multiplying the rate base times the rate of return for each year.

The rate base increases from $3,944,344 in 1985 to $5,484,003 in 1989 without a treatment plant, and to $15,175,385 in 1989 with a treatment plant.

METER SIZE	›n $4 Million 'Purchase 'No Grant But Plant MUNICIPAL	$4 Million 'Purchase $6 Million Grant MUNICIPAL	Leased Plant PRIVATE
5/8"/3/	$37.51	$32.47	$38.34
3/4"	$47.59	$41.20	$46.51
1"	$67.76	$58.66	$62.84
1 1/2"	$118.17	$102.30	$103.68
2"	$178.66	$154.67	$152.69
3"	$339.98	$294.33	$283.38
4"	$521.46	$451.44	$430.40
6"	$1,025.98	$887.87	$838.80
8"	$2,336.29	$2,022.58	$1,900.63

Public Hydrant	$350.00	$314.00	$435.00

Private f			
4" conn.	$175.00	$157.00	$217.00
6" conn.	$350.00	$314.00	$435.00
8" conn.	$805.00	$721.00	$1,000.00
10" conn	$1,329.00	$1,192.00	$1,652.00

	Leased Plant PRIVATE
5/8" -	$44.15
3/4" me	$53.47
1" mete	$72.11
1 1/2"	$118.71
2" mete	$174.62
3" mete	$323.74
4" mete	$491.49
6" mete	$957.46
8" mete	$2,168.99
	Average
Seasonal	$244.52
Public hy	$435.00
Private f	
4" conne	$217.00
6" conne	$435.00
8" conne	$1,000.00
10" conn	$1,652.00

HINGHAM, MASSACHUSETTS EXHIBIT II
COMPARATIVE METERED SALES STEP RATES
PER 100 CUBIC FEET
5 YEAR AVERAGE 1985 - 1989

	HINGHAM Step 1	HINGHAM Step 2	HULL Step 1	HULL Step 2
Company Current	$1.8980	$1.7100	$2.1400	$1.9140
NO TREATMENT PLANT				
Municipal ($6.2 million pur price)	$1.7080	$0.8172	$1.2852	$0.0000
Private	$1.7720	$0.8459	$1.7575	$0.8448
District	$2.1131	$1.0094	$1.8774	$0.9078
Municipal ($4 million pur price)	$1.5532	$0.7431	$1.0697	$0.0000
TREATMENT PLANT				
Municipal	$2.6613	$1.2696	$2.0608	$0.0000
Private	$3.3053	$1.5747	$3.2890	$1.5736
District	$3.4845	$1.6607	$2.9779	$1.4345
$6 Million Grant Municipal	$2.3286	$1.1190	$1.6700	$0.0000
Leased Plant Private	$3.1435	$1.4836	$3.6447	$1.7223
$6 Million Grant/$4 Million Purchase Price Municipal	$2.1451	$1.0234	$1.4544	$0.0000
No Grant/$4Million Purchase Price Municipal	$2.4778	$1.1821	$1.8452	$0.0000

	on $4 Million Purchase No Grant But Plant 'MUNICIPAL	$4 Million Purchase $6 Million Grant MUNICIPAL	Leased Plant PRIVATE
5/8" me	$62.67	$54.26	$70.02
% to cur	30.9%	13.4%	46.3%
1" meter	$92.92	$80.45	$94.52
% to cur	134.5%	103.0%	138.5%
1 1/2" m	$143.33	$124.09	$135.36
% to cur	93.5%	67.5%	82.7%
2" meter	$203.82	$176.46	$184.37
% to cur	79.5%	55.4%	62.3%
5/8" met			$80.92
% to curr			45.2%
1" meter			$108.88
% to curr			133.7%
1 1/2" m			$155.48
% to curr			78.5%
2" meter			$211.39
% to curr			54.5%

APPENDIX

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