Town of West Newbury, Massachusetts
Water Study Committee
February 2001

Water Master Plan

Executive Summary

Comprehensive Environmental Inc.

Executive Summary

Background & Purpose of Study

West Newbury's water system currently consists of one wellfield in the northeastern part of town, supplemented by water purchased from Newburyport. Twenty-seven miles of pipe distribute high quality water to primarily residential users. Two storage tanks linked by a booster pump station create the necessary water pressure and fire suppression capability. The system is quite small for a municipal system, with only 858 primarily residential customers (65% of residents are on town water).

Funding for a Water Master Plan was passed at the year 2000 Annual Town Meeting, to identify immediate and long-term capital needs, and review financial and management practices of the Water Department. A consultant, Comprehensive Environmental Inc. (CEI), was hired in October 2000 to prepare the plan. The Water Master Plan addresses the following questions:

- How much water will be needed through the Year 2020?
- What are the best and most cost-effective sources of additional water to meet this demand?
- What additional conservation measures could the Water Department take?
- What major system improvements are needed?
- Why are the water rates in West Newbury higher than in the surrounding towns?

The findings and recommendations of the Water Master Plan are summarized in this Executive Summary. Copies of the complete text are located at the West Newbury Town Hall and the G.A.R. Memorial Library.

Project Findings

How much water will be needed through the Year 2020?

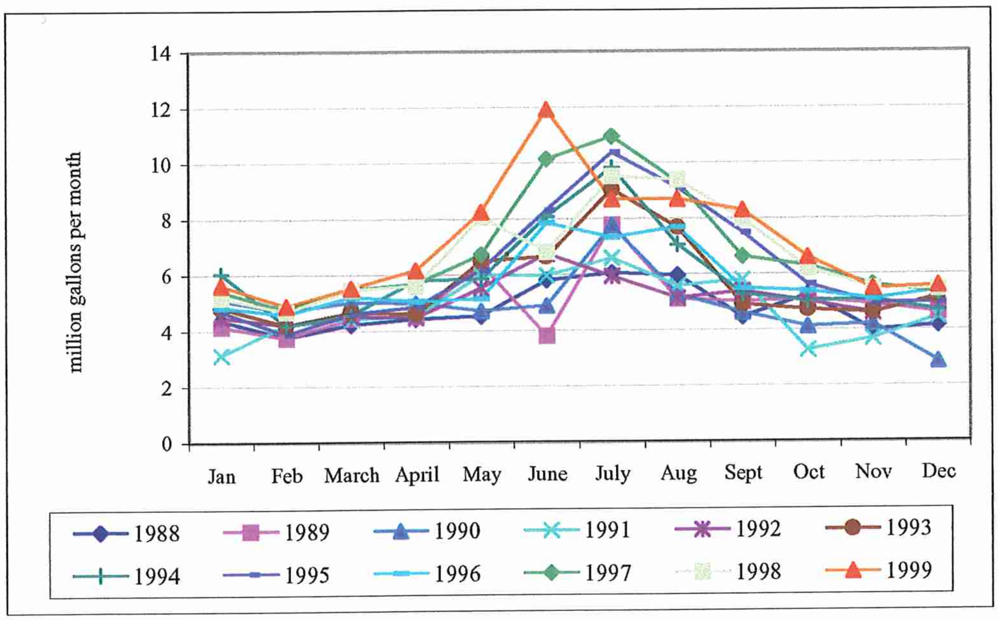
Future water demand was forecasted through the Year 2020 based on the town's growth projections and census data from state and federal agencies. By the Year 2020, the population of West Newbury is estimated to increase to 7800. The water service population was projected based on existing land use, zoning considerations, and estimates of the areas of West Newbury likely to be served by water supply in the future. This was assumed to be a population of about 5,300. The associated demand for water is expected to increase from about 75 million gallons per year (mgy) in 1999 to about 175 mgy in the Year 2020.

Currently, West Newbury meets any demand for water in excess of the wellfield's capacity by purchasing water from Newburyport. . New water sources are needed to meet current peak demands, as well as the projected water demand over the next 20 years. Because of the lack of control over the availability and cost of purchased water from Newburyport, this may not be a reliable long-term source for water. Furthermore, water purchased from Newburyport water is more expensive than the amortized cost of developing new wells in West Newbury.

In order to evaluate water demand, engineers calculate and compare two factors: **average day demand** and **maximum day demand**. The average day demand reflects daily consumption over the space of a year, while maximum day demand is actual peak consumption on a single day during the year. In New England, maximum demand typically occurs during summer days when water is being used for outside activities such as lawn irrigation and car washing. These numbers are important because water supply systems are designed to meet the maximum daily demand for water. If these high demands occur only during the summer, as in West Newbury, then it may be necessary for additional water sources to be brought on line just to supply non-essential uses during a short period of the year.

The ratio of the maximum day demand to the average day demand is often used to determine if an unreasonable seasonal demand exists for a community. Typically, a ratio greater than 1.5 is assumed to indicate excessive irrigation demand. West Newbury's ratio has been between 2.0 and 2.5 in recent years. Many communities are able to bring their ratios down to 1.5 through the use of water conservation measures. There are significant cost savings for the town if this can be achieved, as it may alleviate the need to develop an additional deep bedrock well.

These points are illustrated in the figure below, which shows that water demand is highly seasonal in nature. Overall consumption is trending upward (the lines move higher each year), but more alarmingly, the "peaks" in recent years (maximum day demand) is at a greater ratio to average day demand than in earlier years.



What are the best and most cost-effective sources of additional water to meet this demand?

Water supply options to meet the town's growth needs were evaluated by compiling and assessing existing information and studies on potential new sources, including: the Knowles wells, Andreas well, other potential bedrock wells, all potential surface water sources and purchase from other adjacent communities.

The only feasible additional sources of water found were bedrock wells and/or purchase from Groveland. Surface water sources such as the Merrimack River or new reservoirs would be far too costly to develop, based on existing and future treatment requirements imposed by the state Department of Environmental Protection (DEP) and the U.S. Environmental Protection Agency (EPA).

Projections of water demand show that the town will need more than one new source. A "present worth analysis" was completed for the potential water supply sources; this allows a comparison of total multi-year costs for alternate water sources. Based on this analysis, the most cost-effective sources of water for West Newbury are:

1. Developing the Knowles wells
2. Developing the Andreas well
3. If needed in the future, developing an additional bedrock well

Because it will take several years to develop these wells, purchase from Newburyport will need to continue for some time to meet peak demands. Because it is so much more expensive to purchase water than to produce it using town wellfields, it is recommended that these new wells be put on line as soon as feasible. A payback analysis completed for the new wells shows that within six years, the cost for construction of the new wells would be offset by the reduction of purchase costs from Newburyport. This is summarized in the following table.

Payback Analysis					
Option	**Description**	**Capital Costs**	**Potential Water Available**	**Cost Savings[1,2]**	**Payback Period**
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(1) Cost savings is the cost to purchase Option's available water minus the Option's total annual costs

(2) Purchase cost of water from Newburyport assumed at $3.25/1,000 gallons and assumes total water available with each option is available for purchase from Newburyport

(3) Payback period was calculated as capital costs divided by cost savings to determine number of years for payback.

What additional conservation measures could the Water Department take?

A water system built to accommodate the maximum demand shown on the figure above has far more capacity than is needed for the non-summer months. The cost of developing a third well to meet excessive demand would be a significant capital outlay. CEI recommends that maximum demand be reduced through a variety of measures. First, outside watering restrictions in the summer need not be used only to manage drought situations, but can be part of a strategy to limit system buildout costs. These restrictions, combined with block rates that penalize excessive lawn irrigation, will help West Newbury to meet future demands while utilizing the sources that are most cost-effective to develop. Demand can also be managed by modifying elements of Zoning and subdivision regulations, and by aggressively educating the public about the consequences to the town of excess water consumption during the summer.

What major system improvements are needed?

CEI performed a limited analysis of the existing storage and distribution system. The system's storage capacity is currently adequate due to the ability of the Pipestave Hill booster station to allow the town's two storage tanks to work together. In the event of a power outage, however, the booster station wouldn't function and the tanks could only operate individually. Inadequate water supply to some parts of the town could result.

As the town continues to grow, it is likely that additional water storage will be necessary. A detailed hydraulic analysis of the system is necessary to accurately forecast the need for and size of additional storage tanks.

The limited hydraulic analysis of the current system also indicated that some of the existing piping might need cleaning, relining or replacement because of age and deterioration. Because of a lack of information concerning the existing condition and age of each piping section, however, a complete evaluation of piping needs couldn't be made.

Why are the water rates in West Newbury higher than in the surrounding towns?

A rate comparison showed that West Newbury has high rates relative to other municipalities. This results from a relatively small user base having to pay for both the operation and maintenance of a wellfield and the purchase of water from Newburyport at the retail rate. Neighboring towns with less expensive water are independent groundwater-based communities, or are towns with surface water treatment facilities built in the 1980s when there was 90% federal matching money available. These communities will soon see higher rates, as they are required to upgrade these facilities to meet new, more stringent Safe Drinking Water Act requirements. Newburyport is an example of a town with lower rate because they have a much larger customer base to absorb system costs, but they will also see higher rates as surface water treatment costs increase. West Newbury's rates are likely to rise in the near term but then stabilize as reliance on Newburyport decreases, new sources come on-line, and more users are added as the town builds out.

Recommendations

The Water Master Plan recommendations were categorized into three groups. These are Capital Improvement, Management and Operations Recommendations. A description of these recommendations 2020 is provided below and followed by a proposed strategy for meeting the water demand for the Town of West Newbury through the Year 2020.

CAPITAL IMPROVEMENT RECOMMENDATIONS

Construct Knowles Wells

A detailed cost benefit analysis of options for new supplies clearly indicates the Knowles wells to be the most cost-effective sources to develop (there are two separate wells in close proximity on the same site). West Newbury is fortunate to have high yielding bedrock sources, which are somewhat unusual in New England, and should move forward immediately to develop this potential. The capital costs to develop the two Knowles wells are estimated at $687,400.

Construct Andreas Well

The Andreas well is the next recommended source of water to pursue. Its estimated capital cost is $737,100, higher than the Knowles wells because of longer piping requirements to connect to the existing distribution system. Bringing these sources online will substantially reduce the town's current reliance on Newburyport, resulting in much more cost-effective operations. This well should be added as soon as possible.

Pursue Testing And Additional Bedrock Well If Warranted

Based on the effectiveness of the Demand Management Program and the final production rates for the Knowles and Andreas wells, an additional bedrock source may be needed in the future. This will probably not be required for several years. It would be wise to identify potential locations for such a well as soon as possible, however, to reserve the land for future use. One possible site is under study by the United States Geologic Survey (USGS).

Install Emergency Backup Power

The Pipestave Hill booster station on Route 113 pumps water to the high-pressure zone of town. If it is disabled by a power outage, much of the town could lose water for residential consumption, and there could be a loss of adequate pressure for fire fighting. To reduce the likelihood of this occurring, an emergency backup power system should be added to this station. Its cost is estimated at $75,000.

MANAGEMENT RECOMMENDATIONS

Institute A Demand Management Program

It is crucial to limit maximum day demands on the water system by restricting excessive lawn irrigation and other luxury uses. To address this most cost-effectively, the institution of a Demand Management Program is recommended. The program will include elements of landscape design guidelines or standards, several regulatory modifications and the institution of a full-day, odd/even outside water ban. Also included are requirements for developers to retain topsoil onsite, and public education to explain to residents how to maintain an attractive landscape with less outside watering.

Negotiate Purchase Agreements

West Newbury will need to continue to purchase water until the new wells are online, possibly to a small degree afterwards, and in case of emergency. CEI recommends that the town negotiate a long-term purchase agreement with both Newburyport and with Groveland, though the latter would require costs for new infrastructure. Both sources have limited supplies that can be purchased by West Newbury, but the costs will undoubtedly increase rapidly if there is no agreement in place.

Hydraulic Analysis and Distribution System Model

Limited testing indicated that the 64-year old cast iron water main on Route 113 might have significant tuburculation (buildup of natural iron and manganese deposits). However, the most cost-effective method of rehabilitating the line, and an understanding of how much of it requires rehabilitation, is not known. A field testing program and the development of a computer model for the entire distribution system are recommended to establish the best plan for repairing/upgrading this important trunk line as well as other system piping. An added benefit of the study will be to minimize the cost of pipeline between the existing system and the new wells, by determining the best connection locations and type of pipe. The estimated cost to complete this study is $50,000. Completing this study now should reduce the cost for the engineering phase of wellfield construction.

Change to an Enterprise Fund Accounting System

To comply with the future accounting procedural requirements mandated by the new Government Accounting Standards Board Statement 34, it is recommended that the water department change to an Enterprise Fund method of accounting. This allows all of the costs of operating the department to be identified (direct costs, maintenance, administrative, debt service, etc.). Only after the true costs of running the Water Department have been identified, can the Water Commissioners set water rates and fees to meet the goal of making the department self-funding. Any need for supplemental funding from the town's General Fund will be clearly identified.

Modify the Rates and Rate Structure

The recommended capital improvements may be paid for in a number of ways. CEI has recommended that West Newbury adopt an increasing block rate. The basic rate covers the majority of the ratepayers and would be very similar to existing rates. A second, very high, rate is then used to discourage excessive water use, particularly by those residents who use large amounts of water in the summer for lawn watering.

In addition to the increasing rate blocks, CEI recommends that the town increase its service charges, or fixed fee revenues, instead of only increasing usage rates to pay for new projects. Usage-rate revenues may fluctuate significantly with rainfall and weather patterns, leaving the Water Department without adequate revenues to cover budgeted items during wet years. Increasing fixed fee service charge revenues is more fair and representative of true costs, such as personnel costs, debt service and so on.

The impacts of the rate and fee proposals outlined above must be quantified in order to determine which policies to carry out, and at what level, to achieve the necessary revenues. A rate study must also estimate the effect that changing over from costly purchase of Newburyport water to use of town produced water will have. The estimated cost for such a rate study is $20,000.

OPERATIONS RECOMMENDATIONS

Upgrade the Metering System

Customer meters should be replaced or rebuilt every 10-15 years because they tend to under-read more and more as they age. Water Department revenues may then decrease. As West Newbury's oldest water meters are replaced, CEI recommends installing outside meter sensors, which can be read from outside with a hand-held computerized device. This eliminates the labor expense and possible errors associated with Water Department personnel having to manually read and record the data from each meter.

These upgrades are estimated to cost about $40,000 for the entire system. As meter reading becomes even more time consuming with the increase in customers projected for the future and lost revenues from under-reading meters are minimized, some of the cost for upgrading to an automated system would be recovered.

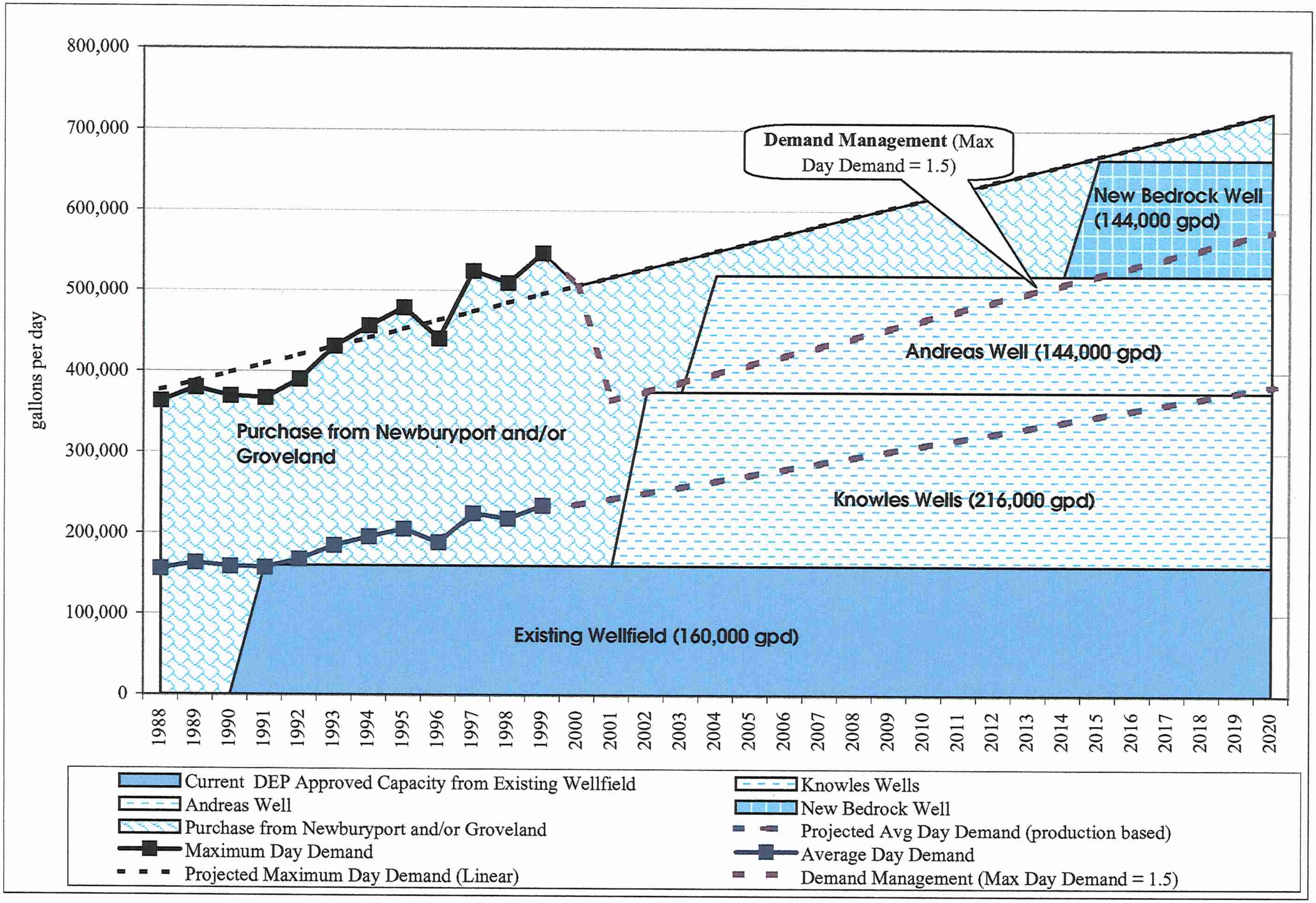
Add Additional Staffing

West Newbury's Water Department is currently understaffed in the summer. CEI recommends that a summer laborer be added to assist with construction projects and distribution system maintenance.

WATER SUPPLY STRATEGY

To continue to meet West Newbury's water supply requirements through the Year 2020, it will be necessary for the Water Department to develop new water sources, make capital investments in the existing water supply system and implement new management and operational practices. The next figure shows the proposed strategy that was developed to meet the increasing demand for water over the next 20 years.

Recommended Strategy



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INCORPORATED

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- Engineering
- Design

Providing community and corporate consulting for environmental issues and infrastructure

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- Wastewater
- Hazardous Waste
- Air Quality

February 13, 2001

Ms. Wendy Reed
Town of West Newbury
381 Main Street
West Newbury, MA 01985

RE: WATER MASTER PLAN

Dear Ms. Reed:

Comprehensive Environmental Inc. (CEI) is pleased to submit the complete Water Master Plan for the Town of West Newbury. Enclosed please find sixteen (16) copies of the plan. A separate set of originals and a CD containing the report in PDF format will be sent to your attention under separate cover.

If you have any questions, please do not hesitate to contact me at 1-800-725-2550 ext. 301. It was a pleasure working with you on this project.

Sincerely,

COMPREHENSIVE ENVIRONMENTAL INC.

Eileen Pannetier
President

450 Washington Street. Suite 100. Dedham. Massachusetts 02026 781-461-9944 Fax 781-461-9840
21 Depot Street. Merrimack. New Hampshire 03054 603-424-8444 Fax 603-424-8441
www.ceiengineers.com

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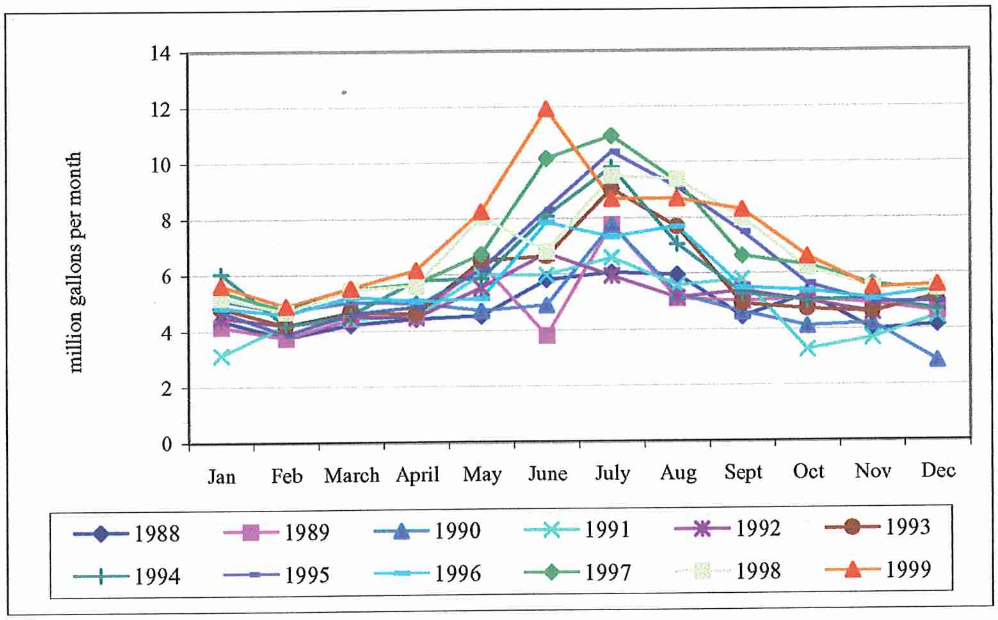

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WATER SUPPLY STRATEGY

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1.0 Introduction

1.1 Why A Master Plan?

There are thousands of small drinking water systems across the United States, many with problems and issues related to their size. Most of these issues center around the fact that small water production and delivery systems must deal with the same issues as larger systems, but without the economy of scale. What this means is that small systems tend to have high rates, but in spite of this can rarely afford adequate staffing and infrastructure investments.

Because drinking water production and distribution is so complex, most small systems would benefit from the development of a water supply master plan to help direct growth. Large systems almost always have these plans, but unfortunately they are usually created after growth has already had serious impacts on the system's infrastructure and ability to deliver water. Typically they call for millions in infrastructure costs, with much of the costs going to modifying, upgrading or redoing infrastructure that quickly became inadequate as the system grew. Worse, some larger systems must go back and replace or modify parts of their distribution system that were put in inadequately during the community's growth spurts.

By not waiting until it is too late, small systems that understand the critical importance of creating a water supply master plan can potentially save millions of dollars over the life of their system. West Newbury is one such community. Although the system has fewer than 1,000 connections, its size is expected to increase rapidly over the next one or two decades. Although many customers already believe the rates in West Newbury to be quite high, the Town nonetheless is committed to the development of a water supply master plan to help them deal with future needs of the system. This is a wise step in that ultimately substantial costs and problems may be avoided by West Newbury.

Water Supply Master Plans have the general goal of presenting a long-term program of infrastructure and other improvements. Some of these plans focus on a hydraulic distribution model that helps engineers identify weaknesses in the distribution system (pipes, tanks, services, meters). Others are more comprehensive and address sources of supply, supply needs, quality issues and managerial and financial issues.

1.2 West Newbury's Water Master Plan

The development of this plan lays the groundwork for West Newbury's future. Included in this plan is a brief review of the water system hydraulics with the intent that hydraulics modeling will be completed later. The plan consists of eight sections and appendices. Each section addresses a different component of the complex water supply plan, and generally contains 1) a description of the existing conditions as found during the project and from available records; 2) projections, where appropriate, as to the future of the system related to the aspect being considered; and 3) CEI's general and specific recommendations, if any, on the subject. A separate recommendations section pulls these items together at the end. Each section's general topic matter is described below.

Section 2.0 Water Demand Forecast

Section 2 details water demand forecasts for West Newbury. Describing existing water demand and forecasting future water demand are both critical to water supply master planning in that unexpectedly rapid growth has created dire situations in many small communities. Without planning for demand, small systems often run into situations where they must declare water emergencies on a regular basis due to the long-term nature of bringing on new supplies. In some communities, this means customers must go without adequate water pressure and deal with poor water quality on a regular basis. This section outlines West Newbury's projected demands and identifies some methods to reduce these projected demands.

Section 3.0 Water Supply Evaluation

Section 3 then follows with a description of potential sources of water, as West Newbury needs new sources both immediately and to meet the build out projected demand. This evaluation addresses all types of sources, ranging from additional groundwater sources, surface water sources and purchase from neighboring communities.

Section 4.0 Water Quality Issues and Analysis

Section 4 discusses water quality issues related to various supplies. Existing sources and proposed sources of water are evaluated in terms of their ability to meet State and Federal drinking water quality standards, as well as other aesthetics issues. Once the water is pumped into the system, however, many additional issues arise with distribution. These distribution influences are covered in Section 5.

Section 5.0 Hydraulic Analysis

Section 5 discusses distribution issues including hydraulics of the system, water storage and water metering. Potential future issues are also described. This section also contains a map of the existing system and a projected map showing where future distribution lines may be located based on growth projections from the town's Comprehensive Plan.

Section 6.0 Financial and Management Considerations

Section 6 describes both the budgetary and financial impacts of the previous sections' discussions and needs and also outlines methods to pay for it all. West Newbury's existing rate structure is compared to other surrounding towns, with additional information on why water seems expensive now, but will quickly be more in line with other communities as the Town grows.

Section 7.0 Cost Benefit Analysis

Section 7 addresses a cost benefit analysis of feasible water supply options, one of the biggest areas of water supply master planning.

The feasible options for additional water supply are compared and a recommended strategy for West Newbury is described. This portion of the plan ties in the water demand forecasts from Section 2.0, sources of supply from 3.0, quality from 4.0, and the distribution improvements needed from Section 5.0.

Section 8.0 Recommendations

The final section, Section 8, describes CEI's recommendations and a capital improvement program for the Town of West Newbury's Water Department. It outlines long-term needs presented in both the financial and managerial section (6.0) and the most cost-effective supplies from Section 7.0. Finally, the recommendations section outlines a proposed Capital Improvement Plan for West Newbury's Water Department.

2.0 Water Demand Forecast

Determining future water needs is crucial to a long-term water supply plan in that it may take years to develop new sources of drinking water. If population or other growth outstrips the water department's ability to provide water, serious consequences could result. For example, low reserves during summer droughts coupled with unexpected fires could result in life threatening situations. At the least, a lack of water could result in pressure and quality problems and potentially over pumping of limited resources with the resultant environmental impacts (such as loss of wetland resource areas, loss of aquatic vegetation and habitat, contamination of aquifer, etc.).

The purpose of forecasting water demands is to assure that water supplies are brought online before these situations occur, or to plan for how to otherwise address limited supplies. Since West Newbury is already water short and potentially faces rapid increased growth in the near future, it is particularly critical to plan now for buildout water supply needs. This section reports the water demand forecasting completed by CEI for the Water Master Plan. Section 3.0 then identifies where West Newbury can potentially obtain the needed water supplies.

Forecasting drinking water demand involves review of data from several state and federal agencies. From this information and from local population data, historical population estimates and local planning information are used to project future population. This is reported in Section 2.1. Concurrently, historical water demands are also plotted in relation to population, and this information is then used to develop a projected future water demand over a twenty-year period. Water demand projections for West Newbury are described in Section 2.2.

This projection is most accurate in the early projected years (years 1-5 in the future), potentially losing accuracy as time goes on. Because of this, the projection must be updated frequently (each 1-5 years depending on the rate of growth) to reflect changing conditions and development patterns. This continually updated look at the town's progress towards buildout thus provides a long-term planning tool for use in obtaining water supplies in a timely way and without imposing drastic emergency conditions.

Section 2.3 and 2.4 describe regulatory modifications that should be considered to further protect water supplies and a demand management and conservation strategy to reduce the need for additional water supplies. Sources of potential new water supply are then described in Section 3.0.

2.1 Existing and Projected Population

Historic population estimates were reviewed to develop a population projection for West Newbury. Population data was collected from the U.S. Census, Massachusetts Institute for Social and Economic Research (MISER), Merrimack Valley Planning Commission (MVPC), and the Town Clerk. Figure 2-1 shows the historical and projected population of West Newbury from each entity. Figures and tables are provided at the end of each section.

Population projections developed by CEI used the historic data available from the Town Clerk, which projected a constant rate of growth from years 2000 to 2020. The Comprehensive Plan also provided population projections through the year 2020. The Comprehensive Plan estimate was based on an increasing growth rate, as outlined in the Buildout section of the plan.

As can be seen from the figure, the town estimate is slightly higher than the federal, state, and regional estimates, which is not unusual. Many towns update estimates with birth and death data or even in-migration information, while the non-local agencies tend to look at the region as a whole. Thus, these agencies may not have the recent local data used by the Town.

The Metropolitan Area Planning Council (MAPC) also conducted population projections for the Town of West Newbury at the request of MVPC. These projections are included on the figure. MAPC values correspond to historic U.S. Census data. MISER historic estimates are somewhat lower than federal and town estimates, as is typical. These projections have many purposes and are used in several state and federal programs for decision-making. For the purposes of water supply projections, it is best to use the highest projections, since obtaining new water supplies takes many years and it is certainly better to overestimate growth than to underestimate and be unable to provide water.

Projected Population

Using town clerk estimates, a projection was made to 2020. This projection results in a slightly higher (about 200 people by 2020) projection. MAPC projections and US Census projections are identical, while the MISER projections are slightly lower, most likely due to the fact that MISER adjusts the U.S. Census data with birth and death rates and a factor for migration.

A review of the demography projections developed in May 2000 by the New England School Development Council shows that there are 1379 dwelling units in West Newbury. This corresponds to about 3.1 people per dwelling, slightly higher than the U.S. Census and MAPC person per dwelling estimate of 2.6.

Service Population

The West Newbury Water Department also keeps an estimate of the population served by water. Historically (1984-1992) the town has served between 69-71% of the population. More recently, the percentage of population served has fluctuated between 64-66%. Although this is not a significant decrease, it does explain why the projected population served by water is not parallel to the projected population of West Newbury. Under current requirements, developers are required to put in a connection to the town's water system if they are within 1,000 feet of the existing distribution system, so the percentage of homes served may increase over time in Residence Zones C (30,000 square feet) and B (40,000 square feet). Residence Zone C is already completely served with water, and Residence Zone B has service to roughly 1/3 of the zone. The most new customers are likely to come from Residence Zone B. Residence Zone A (80,000 square feet) may see the greatest growth overall, but most is likely to be too remote from the existing system to be connected. Further, this zone has the lowest density so cost per new customer would be high in most areas. Only a small portion of Zone A is currently served (parts of Crane Neck and Georgetown Roads, Hilltop Circle and part of Middle Street).

Land Use and Zoning Considerations

Land use and zoning considerations are also accounted for in population projections. As towns approach buildout, the rate of growth tends to slow. Current land use and zoning may also help give an overview of the area of town where development will occur, allowing for the Water Department to plan future infrastructure needs.

Town Owned Land

According to the *Comprehensive Plan* buildout estimate, one of the Town goals over the next 20 years is to purchase or otherwise control 200 acres of open space and reduce the use potential of 3,480 acres. This reduces the total projected buildout.

Zoning Bylaws

Zoning bylaws consist of three residential zones, Residential A (80,000 square feet minimum), Residential B (40,000 square foot minimum), and Residential C (20,000 square foot minimum). The buildout scenario in the *Comprehensive Plan* indicates that Residence A will see 600 new lots, Residence B will see 500 new lots, and Residence C will see 100 new lots developed in the next 20 years (based on GIS analysis, 1997).

Land Use

According to the *Comprehensive Plan*, land use is currently nearly 60% public land, open land, institutional, or farmland. The remaining 40% is primarily single family residential.

In addition, West Newbury has a large amount of land under Chapter 61 tax reduction programs. The *Comprehensive Plan* showed that 87 parcels (1,562 acres) as of 1998 are subject to growth if taken off Chapter 61. As many towns are finding out, when land values increase, the return from lot sales surpasses the advantages of Chapter 61 and these large lots are often sold to developers.

Build-Out

The *Comprehensive Plan* contained a buildout analysis using GIS that showed West Newbury's potential residential growth. Using GIS in the projection allowed for consideration of lot size, shape, and location and leads to a more accurate estimate than using the traditional buildout methodology of taking the total undeveloped land subtracting known undevelopable areas and dividing by minimum lot size. The plan also removed all wetland areas from the available developable land. The GIS buildout resulted in an estimated 1,200 new house lots available within the Town of West Newbury. These lots are dispersed throughout the Town, thus the impact of future development will be felt townwide. Further information on these lots is provided below:

The GIS projection indicated that there are 1,162 single-family home lots (1998) already developed. Of these lots, 196 of them are on lot sizes greater than the minimum required, indicating the possibility for expansion. Sixteen of the 196 lots are greater than 20 acres (suitable for significant subdivisions). This resulted in about 500 new units on land already developed within the town.

As discussed above, many agricultural lands are currently held under Chapter 61, however, should these owners decide to sell due to market conditions, an estimated 600 new lots could be developed in these locations.

Lastly, there are about 365 acres of open and developable, non-agricultural land that could produce up to another 100 house lots.

Growth Rate

According to the *Comprehensive Plan*, the residential growth rate could increase to 40-60 units per year over the next 20 years. This is higher than the existing growth rate of 25-40 new units per year. Taking this into consideration, the Town's projected buildout analysis indicates that by 2022, the Town may have reached a buildout condition where little more growth can occur. At 3.1 people per unit (1200 units spread throughout town) the projected population for 2020 is about 7,800, much higher than that projected by US Census, MISER, MAPC, or the Town. This estimate, however, assumes that buildout will occur by 2020, and the current growth rate does not reflect that. Nonetheless, this rapid increase has occurred elsewhere and it is preferable to overestimate growth rates in a Water Master Plan than to underestimate because of the critical nature of the need.

2.2 Water Demand Projections

A review of historic water data is also important in developing water demand projections for any town. Historic data from the West Newbury Water Department was reviewed to identify trends in water use over the past 10-15 years.

Total System Demand

The system demand has been rising steadily since the wellfield went online. Total system demand was determined by adding the amount West Newbury pumped from their existing wellfield to the amount of water purchased from Newburyport. Figure 2-3 shows the total historic system demand along with a projected demand for 2020 (as much as 175 million gallons per year (MGY) at buildout).

Figure 2-4 shows the trends in gallons per capita per day (gpcd) demand. This use, estimated as a per person usage, is a little more than national averages (roughly 75-80 gpcd) at about 85 gpcd. However, it has generally gone up in recent years.

Since the wellfield went online in 1991, West Newbury has pumped more water from the wellfield than purchased from Newburyport with the exceptions of 1994, 1995 and 1999. In general, pumpage from the wellfield has fluctuated between 40-50 MGY (averaging 110,000 gpd – 137,000 gpd).

Average and Maximum Day Demand

A review of the average day demand, maximum day demand and the ratio of the two can show an indication of the trends in water use, specifically whether the summer demand far outweighs winter demand. The average day demand is only important as a gauge of general systems demand, since fluctuations can strongly affect the system. Maximum day demand is more important because water source needs are typically sized to meet maximum day demand.

Maximum day demand is defined as the highest demand day in the year, and typically occurs in summer when heat and dry weather encourage people to water heavily outside. Although this peak demand day has been traditionally used to size systems, recent trends in New England have shown rapidly increasing maximum days in some communities, particularly wealthy ones, due to increasing outside water uses, including lawn watering and car washing.

This has caused some departments to bring on expensive new sources to serve this short period of summer, mostly for non-essential uses. Other water systems have limited the peak through outside water bans set to occur when the peak reaches a certain point, such as 1.5 times the current average day demand. Limiting the allowable peak is a much cheaper way to deal with maximum day demand.

Maximum day demand to average day demand ratios are often reviewed to determine if a majority of the summer demand is from irrigation. When wide fluctuations (ratios greater than 1.5) are seen, often it is the result of irrigation demand during the summer months. The ratio of historic maximum day demand to average day demand was reviewed for trending (Figure 2-5). This shows that over the past 10 years, the ratio of maximum day demand to average day demand has sometimes been well over two times the average day demand.

Although the revenues generated from this demand may be small because of its limited occurrence, it is very costly demand because purchase from Newburyport must now supply this demand. In the future, even with additional wells online, West Newbury may wish to curb this demand to avoid further expansions and purchase costs that far exceed the limited benefit. One method of limiting maximum day demand is to institute an all-day odd/even water restriction, which forces roughly half the customers to avoid watering outside on any given day. The total consumption may be similar in either case, but with the ban the peak is limited to what half the customers can use for irrigation.

Monthly Demand

Another way to show fluctuations throughout the year is to review the trending of monthly water demand. Figure 2-6 shows the historical monthly water demand, showing the months of June through August as the peak use. The peak monthly use generally occurs in July based on this data, however, in 1992 and 1999, more water was used during the month of June.

Note that the lowest trends on the curve represent data from 1988, 1989, and 1990, while the three highest trends on the curve represent 1999, 1997, and 1995. Again, the higher use in summer reflects irrigation uses such as lawn watering.

Demand by User Class

Total water demand in West Newbury is broken down into several user classes: residential, agricultural, commercial, municipal and unaccounted for water (Figure 2-7). By far, the user class with the greatest demand in West Newbury is residential at an average of 79% over the past 12 years. The second largest user is unaccounted for water. Agricultural, and commercial demand both account for less than 3% of the total demand. Municipal use fluctuates between 1 and 8 percent and averages 4%. The largest single users in the system are the schools (accounted for in the municipal use category). Demand from schools was about 3% of the total water demand in 1999.

Unaccounted for Water

Unaccounted for water is the amount of water produced by the system minus the amount of water sold to customers. The industry standard for unaccounted for water is less than 15%. For the past five years, the Water Department has reported less than 15% unaccounted for water.

Although unaccounted for water is the reporting figure for the Department of Environmental Protection (DEP), *unmetered* water may be a better internal gauge of the loss of water. This is because many systems find themselves vigorously "accounting" for the unaccounted for water (produced minus sold), which is not a problem but which may lead to a lack of understanding of how much leakage is really out there. For example, some water systems go so far as to "account" for pipe friction losses and evaporation, perhaps losing sight of the measurement's real usefulness as a comparison from year to year.

Although not a perfect measure, a simplified estimate for year to year comparison is *unmetered* water, the total produced minus the total metered, whether sold or not. This gives the department a useful gauge of what was potentially lost from leakage and unauthorized uses and is really a more accurate terminology. Measured or estimated flushing or fire flow water would be classified as metered.

West Newbury has used a similar approach, accounting for flushing and fire flow water plus all metered water. The following equation shows West Newbury's calculation for unaccounted for water for Calendar Year 1999:

Produced	85,721,700
Metered	76,388,000
Unmetered Total (11%)	9,333,700

Unmetered Breakdown	9,333,700
Flushing/street sweepers, etc.	54,100
Fire Flows/practice	20,000
Meter calibration	4,500
Leakage	9,255,100

CEI recommends continuation of this procedure, perhaps with the terminology change to "unmetered" as shown to reflect the difference between this reasonable measurement and the overly vigorous accounting done by some other systems. CEI recommends that leak detections be done every three years, or more often if unmetered water exceeds 15% of the total produced without a known explanation such as fire flows.

System Reliability & Inter-Connections

The West Newbury water supply system cannot presently supply its customers with water without supplementing the system with purchased water from Newburyport. The maximum output of the existing well is far short of meeting demands. This is not a good situation because it places reliance on another growing community for basic demands. During drought conditions, this water could become unavailable.

Currently, the inter-connection with Newburyport is the only interconnection West Newbury could reasonably use for emergency supply. In the past, water was received from Groveland, however, Groveland has indicated that to tie into their system again, improvements to the water main that connects the systems would be necessary. CEI recommends that the town pursue the Groveland connection to assist in potential emergencies and to potentially purchase water from an additional source. By having more than one potential purchase source, West Newbury will be in a better bargaining position and will not be as dependent on one entity as it is now. However, note that getting written agreements with either community will require one or two years and could potentially fail due to political issues.

2.3 Local Constraints Potentially Affecting Demand and Supply

Regulations and bylaws are developed by towns to protect residents from activities that might be detrimental or injurious to individuals, the community and its resources. As members of boards come and go, these controls become refined and may to some extent portray a town's character.

There are four particular areas of importance in local zoning and other controls related to water supply: 1) that local regulations provide for adequate wellhead protection; 2) that new and modified infrastructure for serving development is completed to the highest standards since the town will eventually be responsible for its repair and maintenance; 3) that the regulations and bylaws do not encourage more dense development than the town's infrastructure can handle; and 4) that the regulations discourage development that causes high peak summer demands. The first three of these needs are well met by West Newbury's rules and regulations, while the fourth is quite new in terms of conservation demand management and a few areas could be improved.

West Newbury has sought to encourage wellhead protection and open space/low density development through its bylaws and that is quite evident as one drives through town. This is an admirable course for the town to take and it is compatible with the type of water supply (groundwater) that the town has, and is currently pursuing. It is important to understand that the geology of the town may mean bedrock wells are the most likely remaining sources of groundwater to be used. Because any water source can be expensive to develop it is important to get the maximum use out of those that are online before searching for another. Conservation of existing municipal water is therefore even more critical in West Newbury than in other more water abundant communities.

Because water systems have to consistently supply water to meet the peak demands that might only occur during one summer week of the year they tend to be overcapitalized. That is, large sums of money can be spent to bring the next source online to be able to supply water at a high rate to meet a demand that is usually caused by many people watering their lawns at once. Instead, it makes sense for communities to find ways to limit this peak demand through conservation practices that reduce irrigation demand. A good place to look for water wastage is by reviewing town regulations that may have the unintended consequences of encouraging watering and driving up this peak demand.

CEI reviewed various Town regulations and bylaws and has suggested some changes that may help moderate increases in the Town's peak demand, while being sensitive to the Town's open space values. In addition, bylaws were reviewed for the purpose of system capability. For instance, parts of West Newbury have a hilly landscape that may affect system pressures.

Zoning Review

The West Newbury Zoning Bylaws were reviewed for water conservation and system capacity purposes. Below is a short description of which sections could be modified to allow for better conservation practices within the Town. In addition, suggestions are made to modify the existing bylaws to address possible pressure issues. Only those sections where modifications are suggested are included in this report.

Section 6.4.3.5.4.

Language should be added to stress the importance that a lot that is to be serviced with municipal water must also be able to provide a means for maintaining adequate water pressure for the purposes of fire protection.

Language should remind applicants that they must comply with all provisions of the Water Department Bylaws. This should include the furnishing and installation of all equipment necessary to adequately provide water at pressures equal to or above those needed for fire suppression.

7.1.11.1.

Wording should be added to refine the landscaping requirement to include "...suitably landscaped, *and to the extent possible, in a manner that minimizes watering needs*."

In addition, wording should reflect that clearing and topsoil removal or disturbance during construction should be minimized.

7.1.15.1.

Again, provide encouragement for alternative designs or flexibility for developers so that designs can be of value to them. This will reduce unnecessary water consumption, and not impact aesthetics of the Town.

Language could be as follows: "...plantings or grass, that use drought tolerant, low water demanding vegetation".

Subdivision Review

In addition to the Zoning Bylaws, subdivision regulations were also reviewed. Some suggestions for modifications include:

3.3.7.2

There is a need for the Water Department Superintendent to evaluate the effects a proposed subdivision (requiring municipal water) will have on system pressure. Currently this opportunity is not provided until just prior to definitive plan approval when the planning board *may* request written input on the proposed subdivision. Instead, a professional engineer should be required to review the plans specifically for water supply concerns early in the process.

Wording should explicitly require the solicitation of the Water Superintendent's written input when the proposed development is to use municipal water. Furthermore, discussions between the water and fire department and developer concerning any pressure problems and the need for the developer to furnish equipment to provide adequate pressure for fire suppression and domestic use should occur. Adequate pressures must be provided both within the new development and to mitigate any impacts caused by the new development on existing users. This early discussion affords all parties the flexibility to work out different approaches early on in the process

4.9.3.

Extension of utilities for property of the Applicant that is not being subdivided at the same time should include performance requirements beyond grade and size to include capacity and pressure. This should also be included in Section 5.3.1.3.

5.3.2.

New language should be added ensuring that developers install booster stations or other equipment necessary for adequate provision of water at pressures equal to or above those needed for fire suppression when water level in the municipal storage tanks is at the lowest of its normal operating range. A professional engineer registered in the Commonwealth of Massachusetts should make certification of compliance with this requirement.

Schedule D Part IV-Residential. G.

The Town of West Newbury's project information form serves to not only provide additional information for board decisions, but also has the indirect effect of making applicants aware of the cause and effect relationship that their development will have on natural and municipal resources. A planning board with a strong conviction to ensure that a developer minimizes these impacts, will send a message to developers that they can make a conscious decision to shorten or lengthen the approval process by either choosing to implement appropriate features or not.

One such feature that the Town could encourage is the use of landscaping that requires little, if any, watering, pesticide or fertilizer input. Another that should be discouraged are the in-ground sprinkler systems (commonly using up to 10 gallons per minute) programmed to operate whether the turf needs watering or not. Developers with even a little creativity can sell the attributes of a home with some of the newer commercially available grass types that require almost no mowing, and need little artificial watering, enabling homeowners to save substantial money on their water bills. Asking leading questions on the project information form should make the board's intent clear.

The same approach could be taken when the developer appears to be harvesting topsoil from the development site and then imports "topsoil" back to the site. Typically, good virgin organic topsoil is stripped off the surface and then either sold or blended (really diluted) with less desirable material that does not have good water retention characteristics. The result is soil that is droughty with a lawn that requires almost constant irrigation in the summer. This practice is becoming more common as good topsoil becomes more scarce and as advancements in seeding technology temporarily disguise underlying conditions.

Environmental Impact Statement 6. (c)(i)

Additional information that should be a part of the Water Supply and Distribution portion of the Public Utility Element include:

The developer should state the average and peak day demand for the proposed development as a percentage of total system average day demand and should be strongly encouraged to minimize both but particularly the peak demand.

Methods that the developer could use may include: 1) reserve 4-6" of topsoil for all lawn areas; 2) use drought-tolerant grass and landscape species; 3) minimize total cleared area of the development to allow wind reduction and shade; and 4) minimize total lawn areas and install drip irrigation systems instead of overhead irrigation.

A description of existing and anticipated water pressure issues and a discussion of how the developer intends on addressing the issue should also be required.

6. (f)(iii)

Native plantings or those that use less water should be encouraged in this sub element.

6. (g)

Consistency with the Water Master Plan should be described by the applicant under this sub-element.

Water Department Specifications

In addition to the Zoning Bylaws and Subdivision Regulations, West Newbury has Specifications specifically for the Water Department. These specifications reflect the materials and installation requirements regarding West Newbury's water system and its connections.

Section VI

The Water Department may want to have some language that opens the breadth of discussion between the developer, fire department and water department prior to submission of the Definitive plan, such as during the submittal of the Preliminary Plan. It is important for this discussion to include pressure issues early in the process before design details have been finalized.

The Department should require that the developer design, furnish, and install all equipment necessary to adequately provide water at pressures equal or above those needed for fire suppression when water level in the municipal storage tanks is at the lowest of its normal operating range. Once the required installations are complete, pressure tests should be done by the developer or their agent and certification that the above standards have been met should be given to the Water Department and noted on the as-built plans.

2.4 Demand Management and Conservation

As discussed previously, reducing the peak demand of a system will help reduce the magnitude of new sources that must be put online in the future and the purchase of outside water. Currently, maximum day demand is over two times the average day demand and has been as high as 2.6 times average. This clearly reflects irrigation in a residential community.

In towns like West Newbury, where the population is generally middle to upper class, landscaping around homes tends to be maintained better, which leads to higher irrigation use from the residential sector. Large lawns most often lend themselves to high-use sprinkler systems that use water when it is least available during periods of low rainfall.

Conservation Measures

In general, water conservation is realized through several different methods including:

- Public education

- Leak detection and repair
- 100% metering
- Adequate pricing
- Demand management

The Town currently has a number of these conservation measures in place. Recent public education, for example, has included leak detection kits in billings and articles in the local newspaper on conservation. Further, West Newbury has 100% metering of its system and its industrial, commercial, and institutional use make up only about 1% of the total demand combined.

The Town's water rates are moderate because of the low number of total customers to bear the water system costs. However, customers are currently billed using a flat rate structure, which does not discourage high consumption during peak demand. Under the flat rate structure, wealthy homeowners with large lawns are unlikely to be deterred since the average customer water bill is only $450 per year and even if the their water bill was $1,000 per year, some homeowners may still not consider conservation.

Finally, the Town now uses an odd/even outside watering restriction during drought conditions and requires rain sensors on new construction for demand management.

Based on the efforts already in place, additional conservation efforts should focus on 1) additional public education, 2) leak detection; 3) rates that hit high summer users with the greatest bills; and 4) additional demand management strategies. Based on the town's current and future ability to meet average day demand, all four efforts should focus on limiting peak day demand.

1. Additional Public Education

Public education efforts should focus on peak day demand and should include earlier adoption of irrigation (outside watering) restrictions to limit the peak demand to ½ of the customers at any given time. By using odd/even outside water bans (all day restriction), theoretically only half the people can water outside at any given time. Efforts to educate people should include additional bill stuffers on outside water use, newspaper articles and information on peak demand problems in the annual report.

2. Leak Detection

A partial leak detection survey was conducted in West Newbury in October 1999. No major leaks were detected during this survey, but the Water Department also has it's own leak detection equipment that it regularly uses to find leaks. This is a good process that should be continued along with full leak detection surveys every three years.

3. Rate Modifications

Rates should be modified to adopt an increasing block rate, discussed further in Section 6.0. This type of rate structure will not change the average customers' bill by much but will penalize high volume irrigation users, potentially reducing summer demand. If the high volume users are undaunted by the higher rate, at least they will then pay a greater and more fair share of the high costs of providing this water.

4. Demand Management

The town currently has several regulatory protections that help to keep the existing wellfield online and to protect general groundwater quality. These include:

- Groundwater Protection District – to protect Zones I and II of the town wellfield

- Public Water Supply Bylaw – to prohibit unauthorized connections
- Water Use Restriction Bylaw – for water conservation
- Rain Sensor Bylaw – to prevent excessive watering during rain

The water restriction bylaw should be used to issue a full-day ban based on groundwater levels or on reaching a maximum day demand of 1.5 times the average day demand. In addition, modifications to the Zoning bylaws and subdivision regulations as outlined in Section 2.3 can help achieve some water savings. West Newbury could also develop landscape management standards for new subdivisions and town owned lands that:

- Require the use of a certain percentage of native or drought-resistant grasses in new developments
- Encourage limits on clearing and removal of topsoil
- Recommend drip irrigation in place of in-ground sprinkler systems
- Encourage rain storage methods (to use during periods of drought)
- Encourage use of alternative road standards and other methods to decrease imperviousness (which will increase recharge)
- Encourage infiltration of stormwater instead of piping off-site.

Further information on landscape management is provided in Appendix D – Water Conservation Information. Conservation-friendly landscape design standards are not currently available for New England, but could incorporate these native plants and limits on clearing.

Figure 2-4. West Newbury gallons per capita per day (gpcd)

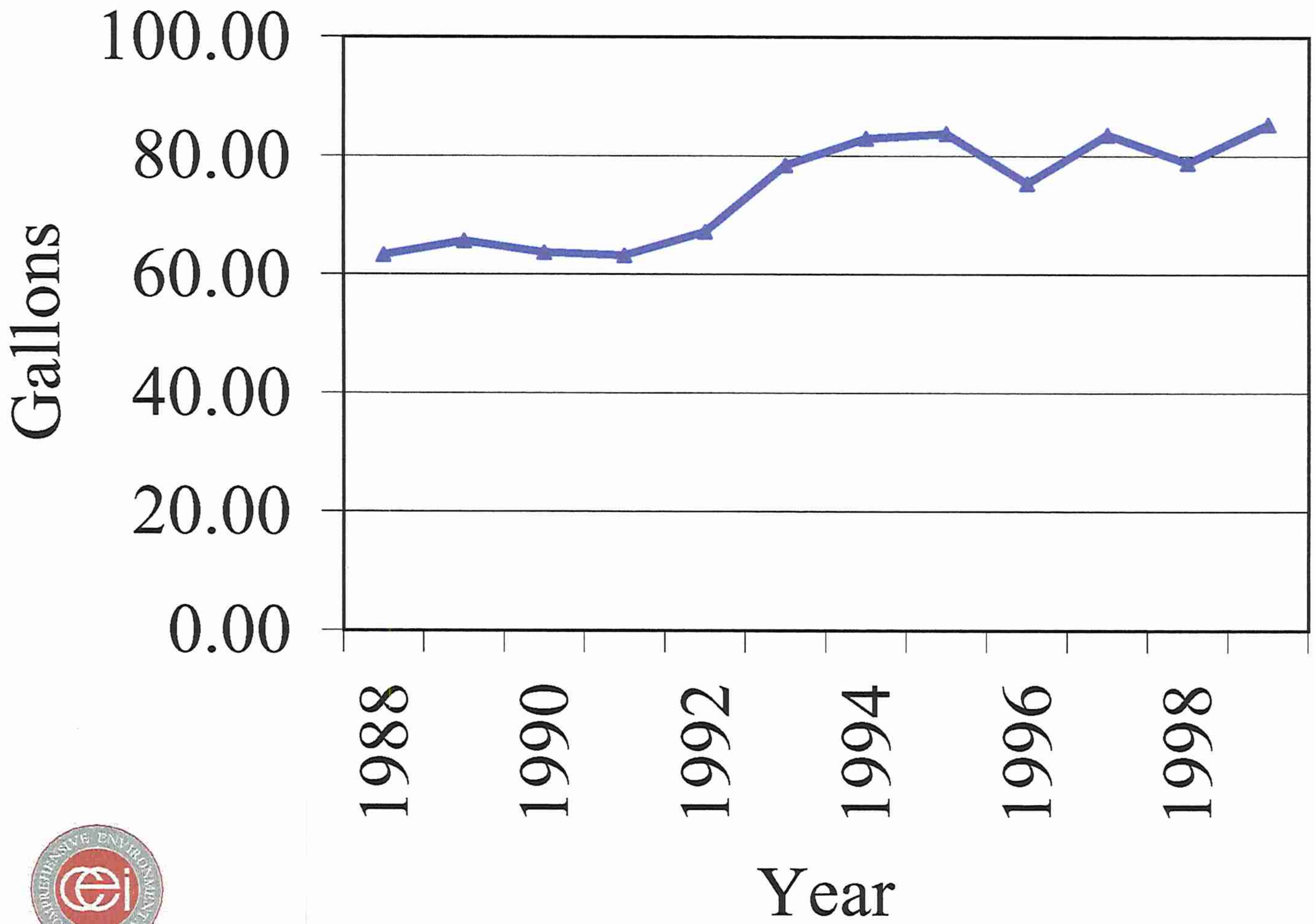
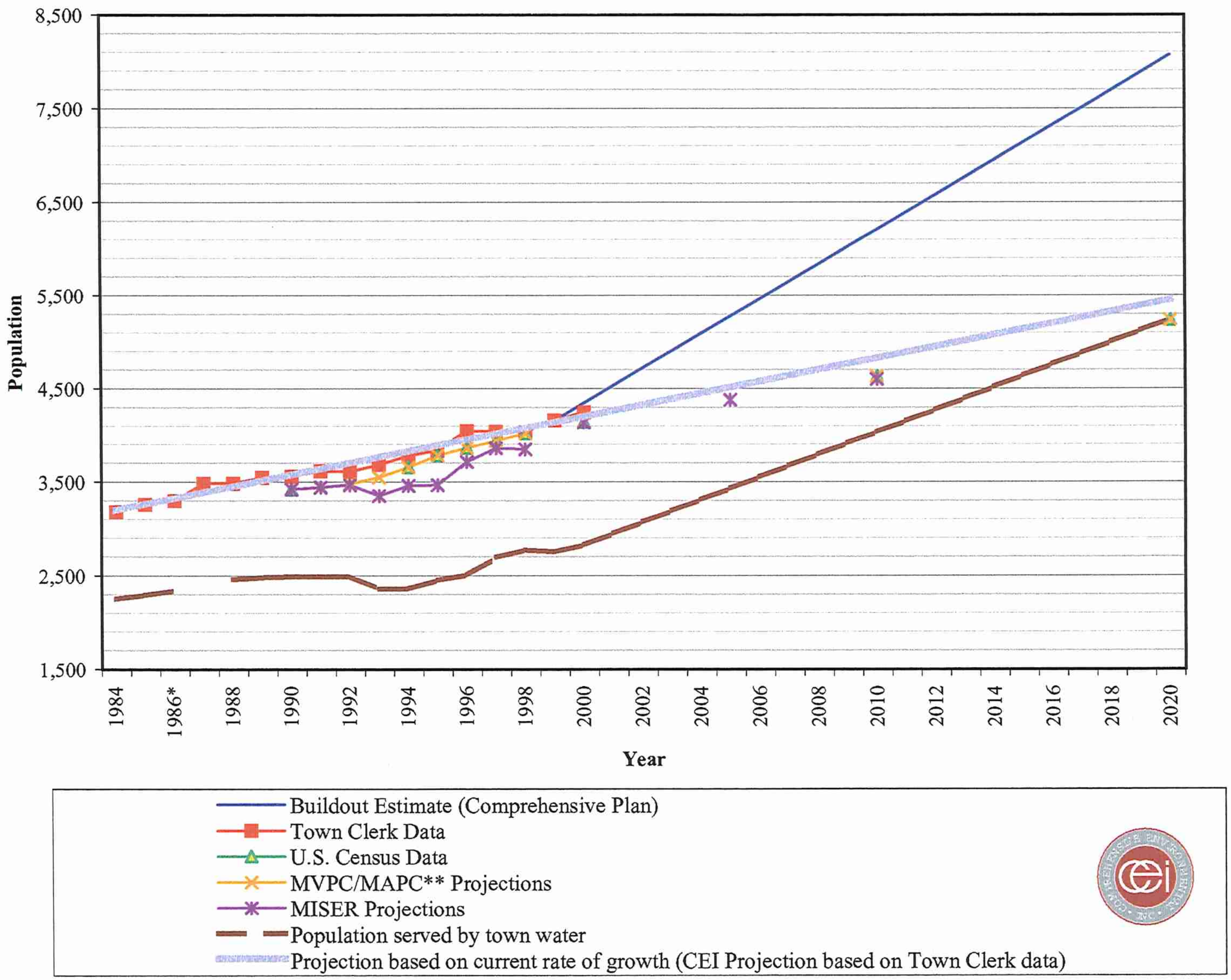


Figure 2-1. West Newbury Population Projections



* 1986 population was estimated at 3300, an actual count was not available

**MAPC conducted population estimates and projections for MVPC.

Note: Population served by town water was assumed to be 65% of the buildout population.

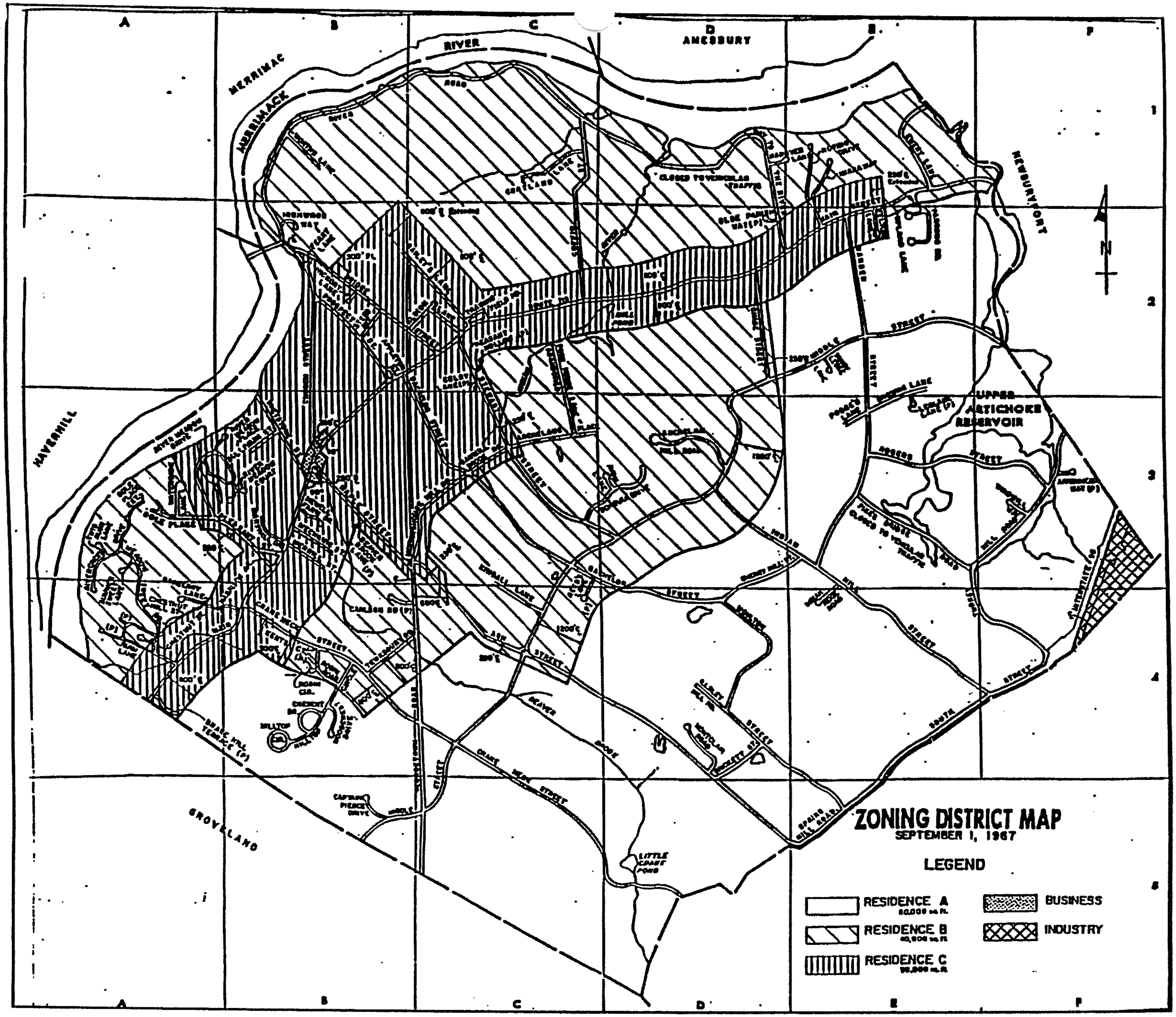
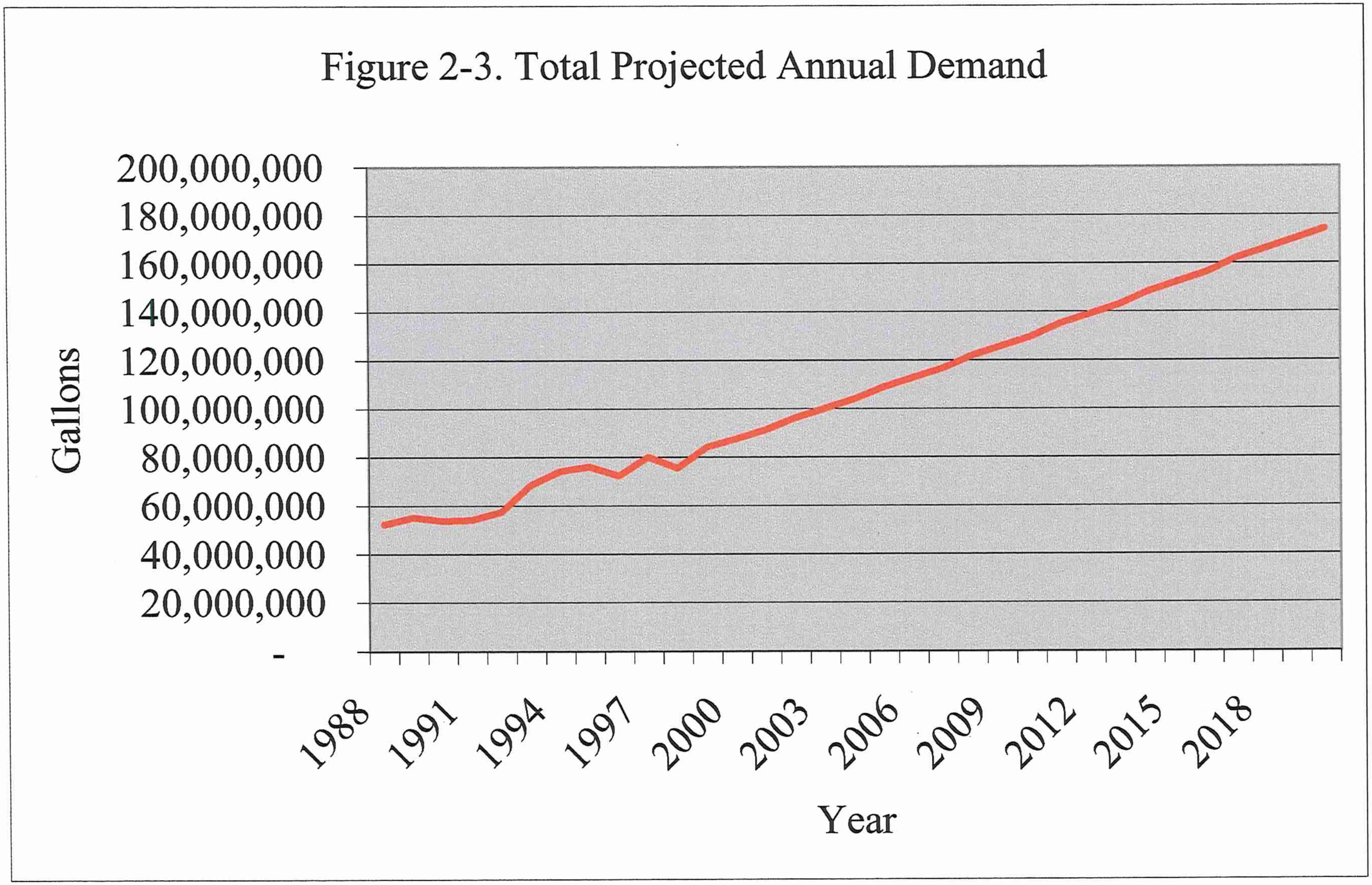


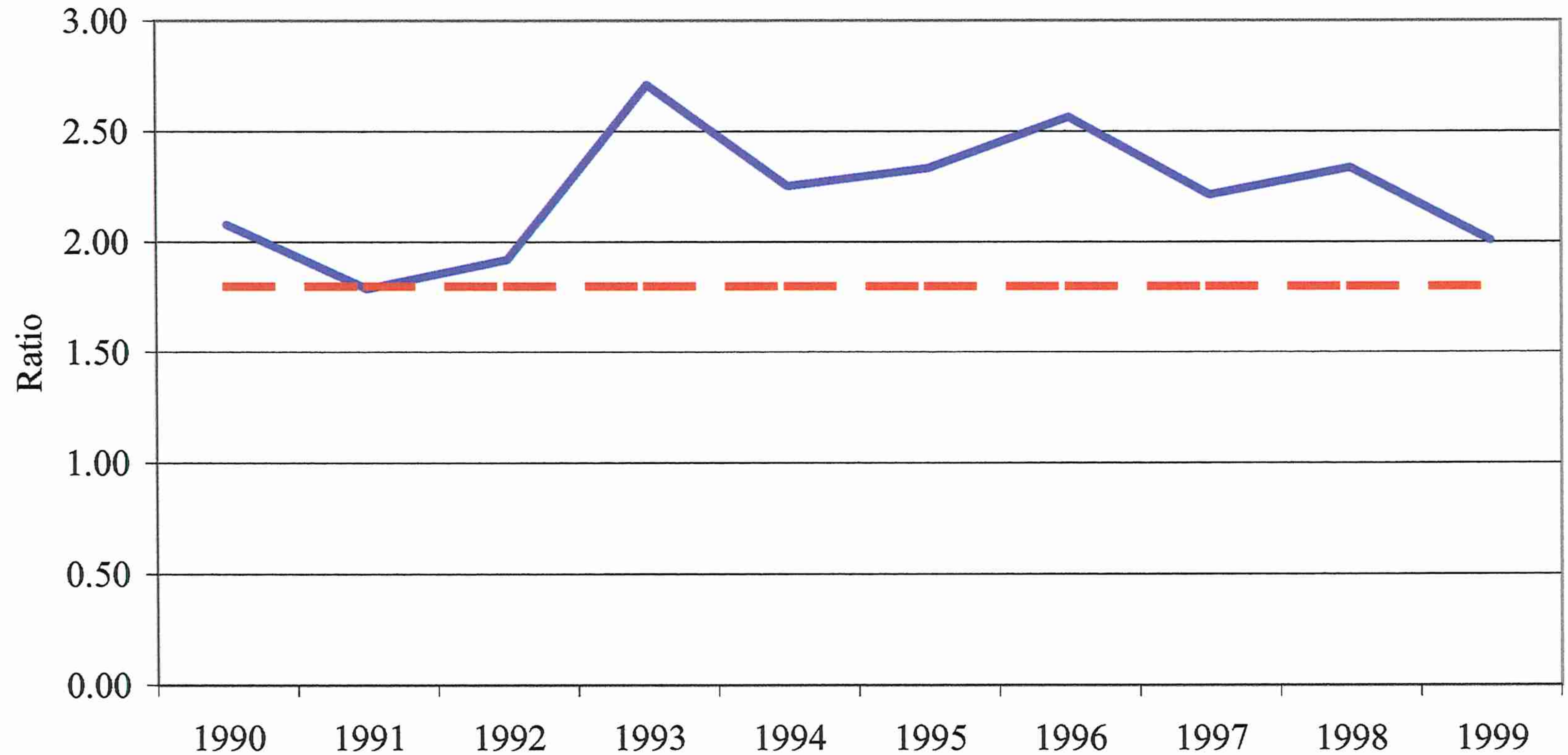
Figure 2-2
Town of West Newbury
Zoning Map

Source: John E. O'Donnell & Associates
Auburn, Maine
1968



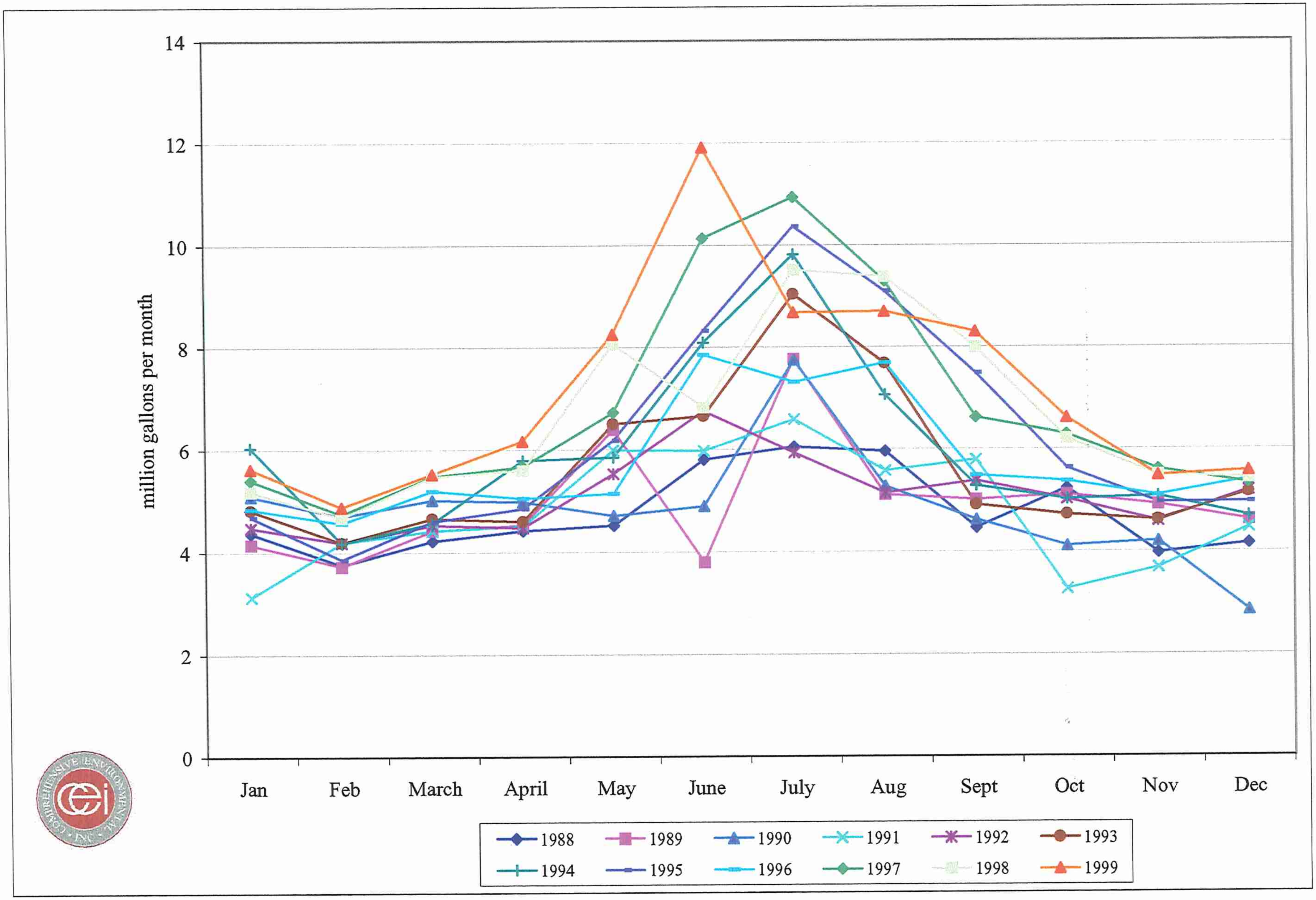
Note: This chart assumes that growth occurs as rapidly as projected in the Buildout of the Comprehensive Plan. Further assumptions: that the percentage served continues at 65% and per capita demand slowly rises to 90 gpcd.

Figure 2-5. Maximum Day Demand : Average Day Demand



Note: Typical ratios range from 1.5 to 1.8 (Lundberg, 2000)
Ratios greater than 1.5 generally reflect irrigation demand.
Some communities with aggressive water conservation programs and severe water shortages are able to achieve ratios of 1.1 or less.

Figure 2-6. Monthly Demand Over Time



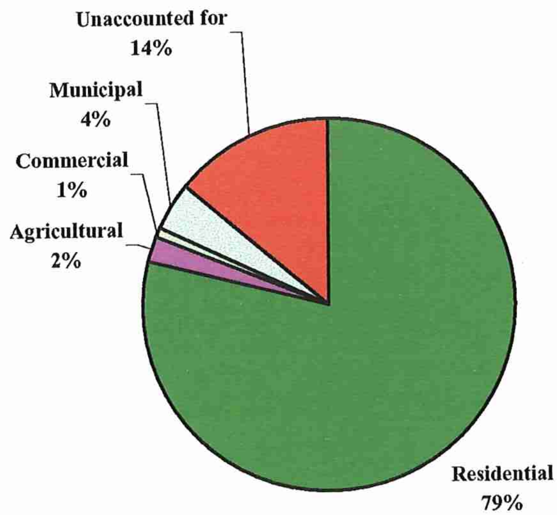
Source: Annual Statistical Reports, West Newbury Water Department.

Figure 2-7. Percent Water Demand by User

Percent

	Residential	Agricultural	Commercial	Municipal	Unaccounted for
1988	85	3	1	4	7
1989	78	3	1	3	15
1990	72	4	1	4	19
1991	86	3	1	4	6
1992*	64	3	1	4	28
1993	72	2	1	3	22
1994	73	4	1	4	18
1995	85	2	1	1	11
1996	89	1	1	4	5
1997	83	1	1	5	10
1998	77	1	1	7	14
1999	79	1	2	8	10
Average	79	2	1	4	14

* Reported numbers do not add up to 100% - added missing water to unaccounted for



Note: Chart reflects the average over 21 years.

3.0 Water Supply Evaluation

3.1 Summary of Existing Sources

Municipal water for residents and businesses in West Newbury is currently supplied by two sources; the town's wellfield and water purchased from Newburyport.

Existing Wellfield

The existing wellfield that provides municipal water for the town is known as Wellfield #1. It is located in the northeastern section of town near the eastern boundary with Newburyport and adjacent to the lower Artichoke reservoir. Based on evaluation, the wellfield is not under the direct influence of surface water[a] and therefore does not require filtration. The wellfield consists of seven 2½ inch diameter wells and one horizontal well[b]. Average daily withdrawal rates from the wellfield are about 110,000 GPD. Because of the shallow nature of the wellfield and limited (200 ft wide by approximately 1,000 ft long) areal extent of the water-bearing materials, sustained withdrawal at 140 gallons per minute for more than 14 hours is not possible during most months of the year.

The condition of the wells is considered to be good and maintenance in the form of surging and occasional treatment with muriatic acid is performed. Well yields started to decline despite these efforts and in 1994 the town installed a horizontal well (#8) to increase the yield from the wellfield.

Although capacity of the wellfield has not declined substantially since 1994, the wellfield yield is generally limited by the shallowest wells, #4 and #3.

Land located within the wellfield's zone of influence is under perpetual easement from the Society of Saint John the Evangelists. Previous studies have shown that there are no detectable drawdown effects on the Lower Artichoke Reservoir.[a]

Purchasing From Newburyport

Current Situation

West Newbury has purchased water from Newburyport since 1979. This water supplements the water provided to the system by the wellfield and allows the groundwater levels in the wellfield to recover. The annual volume purchased from Newburyport has varied over the past 22 years but in general has trended upward. An informal agreement between the two towns limiting the daily purchase to 125,000 gallons has never been enforced.

Newburyport gets its water from two wells and the Lower Artichoke Reservoir. The water is conveyed via a 10 inch main at 390 gallons per minute to the wellfield building in West Newbury. The two sources cannot be operated at the same time however. When water is being supplied from Newburyport, West Newbury's wellfield must be valved off due to the extreme differences in pressure of the two pumps.

While Newburyport has always been able to supply adequate quantities of water to West Newbury, there is a desire by Newburyport to extend service to Plum Island. This new service will be in addition to providing for normal townwide growth. Because of this and the need for Newburyport to effectively plan for its future obligations they have expressed that they would like to see West Newbury sign a 20 to 25 year contract if they intend to continue purchasing water on a regular basis. One term of the proposed contract is the adoption of a watershed overlay zoning district, which has caused concern among some West Newbury residents. This is discussed further below.

Newburyport would also like to limit the total amount purchased by West Newbury because of the town's potential for growth that could not be supplied by Newburyport.[c] Meanwhile, the West Newbury water department has tended to favor moving in the direction of water independence by developing new bedrock wells.

Watershed District

Newburyport has adopted a watershed overlay district in its own boundaries. In summary, it restricts certain land uses that are not friendly to water supply, including junk yards, horse paths and animal manure storage among others. Basic residential use is allowed but in certain zones large septic systems are not.

As a condition of a purchasing agreement, Newburyport would like West Newbury to adopt a similar zoning bylaw for areas within the reservoir watershed.

3.2 Future Potential Sources

Groundwater Sources

There are two typical types of groundwater sources: wells in the unconsolidated overburden and wells drilled into deep bedrock. Explorations for overburden wells in West Newbury have generally been unsuccessful. Therefore, recent efforts to identify a groundwater source for the town have focused on deep bedrock wells.

Shallow Overburden Sources

The surficial geology in the West Newbury area is generally not suitable for overburden wells. Bedrock is close to the surface and the overburden in most places consists of clays and tills with low transmissivity.[d]

The town has one overburden wellfield located adjacent to the Artichoke Reservoir ("Wellfield #1"). Starting in 1955, this area of West Newbury was identified as a potential groundwater source. Explorations, tests, and analyses leading to the development of this wellfield were conducted in 1967, 1974, 1975, 1980, and 1990. The wellfield is described further in Section 5.0. The quality of water from this wellfield meets all Federal and Massachusetts drinking water standards. Please see Section 4.0 for more information on the water quality in this wellfield.

In 1983, the town conducted one last survey for other overburden wells besides Wellfield #1. The D.L. Maher Company installed 18 test wells in areas of the town with the potential for overburden aquifers.[e] Only one of the eighteen test sites had a sufficient yield. A shallow well ("TW-82-12"), located on town property east of Bridge Street and south of River Road, was able to produce 100 gallons per minute. This test well could not meet the sanitary radius requirement, which requires that the water department own or control lands within 400 foot radius of well and prohibits land uses that may adversely impact water quality. However, the Water Department was encouraged by the yield results, so test wells were installed in a nearby cornfield that could meet the sanitary radius requirements. However, they found thick clay and no water in these wells.

Bedrock Sources

In 1983 and 1993, D.L. Maher Company completed fracture trace analyses[f] to identify potential locations for deep bedrock wells in West Newbury. The latter of these studies identified 12 locations that exhibited characteristics favorable for the occurrence of fractured bedrock and potential high yield wells. A number of these sites were investigated with two yielding desirable results: (1) the Andreas well site; and (2) the Knowles well site.

Considerations that affected the decision to investigate these locations first were: (1) proximity to existing water supply system; (2) ownership of the property; and (3) lack of development near the proposed well sites (sanitary radii). While these two sites met the priority criteria best, personnel present during the exploratory drillings have indicated that there were other promising sites nearby. It is possible that more exploratory work could find another site in this area, but this is an unknown.

The Andreas and Knowles wells have undergone 8-hour, 2-day, and 10-day pump tests. The final safe yield from each well has yet to be determined. However, it is estimated to be 100 gallons per minute at the Andreas site and 150 gallons per minute from the two wells (combined) at the Knowles site.[g] Effects on sensitive ecological receptors due to withdrawals from these wells are now being studied by the United States Geological Survey.[h]

The results of this study and relatively shallow locations of water bearing fractures could both lead to a reduction of the estimated safe yields when they go through the DEP approval process. For the purposes of this report the estimated safe yield has been reduced to 75% of that stated above. The USGS study is expected to be completed within the next two years. The water quality from these wells is discussed in Section 4.0.

The groundwater new source approval process consists of many steps, as further described in Appendix B. These steps are outlined below:

- Examination of potential sources of groundwater;
- Characterization of land within one-half mile of well;
- Complete well yield estimates and water quality analyses;
- Model aquifer;
- Complete Zone I and Zone II delineations;
- Conduct pumping test (completed in accordance with Pumping Test Proposal);
- Submit for approval a Source Final Report;
- Submit for approval the design plans for permanent works installation;
- Construct the permanent works;
- Demonstrate compliance with the Surface Water Treatment Rule (SWTR) through the Microscopic Particulate Analysis (MPA) test; and
- Comply with additional state and federal agency reviews (as necessary).

Surface Water Sources

New Impoundments

The creation of new surface waters by impounding water behind a dam creates an interesting situation in which the current water rights issue with Newburyport would likely provide the first hurdle to implementation. Assuming that West Newbury would own the water rights to a new reservoir (which is unlikely if the impoundment restricts a tributary to the Artichoke River) the next issue would be cost and impacts of developing such a source.

Two extensive reservoir-siting studies were conducted by United States Department of Agriculture in the early 1970's. One was completed for the Parker Basin and one for the Merrimack Basin. Two sites were evaluated within the Parker watershed and twelve sites within the Merrimack River watershed. The sites were primarily evaluated based on their ability to store sufficient water, however other features such as the loss of structures below the high water mark were also identified.

In both watersheds the loss of structures would be significant for seven of the potential sites. Not only does this have political implications, but also the cost to purchase the required land and relocate lost roadways would be extremely expensive. Five of the potential sites do not have enough catchment areas to provide sufficient water and depth for the reservoir to function efficiently as a means of storage.

The remaining two investigations were conducted to evaluate increased storage capacity at the two Artichoke reservoirs, which are owned by Newburyport. The site that appears to provide the best location for a new reservoir based on the 1971 information in the studies has already been developed by Newburyport and is known as the Moulton Reservoir.

Treatment requirements for surface water are very stringent and expensive, casting further doubt on surface water as a viable source for West Newbury due to the extreme capital expenditures that would have to be supported by a relatively small group of ratepayers.

Permitting is another major hurdle for new surface water supplies. Systems that have made the major investment required to obtain environmental approval for new reservoirs have sometimes then had their projects vetoed by the Environmental Protection Agency at the end, as the agency has opposed the creation of new reservoirs in the last 10-20 years due to wetland impacts.

Under the Surface Water Treatment Rule (SWTR), systems using surface water or groundwater under the direct influence of surface water are required to (1) disinfect their water; and (2) filter their water or provide the same level of treatment as filtration. The cost of complying with this rule would be prohibitive for a small system seeking to supplement existing supplies with surface water sources. Moreover, starting in 2002, treatment of surface water sources will also become more difficult when the Stage I Disinfection Byproduct Rule becomes effective.

Merrimack River

Using the Merrimack River as a source would require even more expensive permitting and treatment than that detailed above because of existing withdrawals, sewage treatment plant discharges and upstream combined sewer overflows.

Purchasing Sources

History

From 1936 to 1979 West Newbury purchased water from the neighboring town of Groveland. In 1979 contamination was found in one of Groveland's wells and West Newbury stopped purchasing water from them and started purchasing water from Newburyport. This continued to be the main source of water until West Newbury's wellfield was put on line in 1990. Since this time the wellfield has served as the principle source of water (1994 being the only exception) with purchases from Newburyport providing supplemental supply. However, there has been a general increase in the volume of this supplemental water purchased from Newburyport, especially to meet peak demand.

Newburyport

At the time of writing this report, both Newburyport and West Newbury were evaluating a 20-25 year contract for the purchase of water by West Newbury. Newburyport is requesting that West Newbury become independent from their system within the next five years, since they will need to supply water to Plum Island within five years. Maintaining the connection to Newburyport for the next five years allows West Newbury the time to investigate and develop new groundwater sources (in addition to the Knowles and Andreas sites). A discussion of these issues is presented in Section 7.0.

Groveland

Groveland currently has enough excess capacity in its system to supply West Newbury's current (35-50 MGY) purchasing needs. There may however be some purchasing restrictions that would limit the usefulness of this source in meeting West Newbury's peak demand. Groveland does not currently have a wholesale rate. A purchasing rate would be negotiated with their water commissioners. The town's current rates are as follows:

<17,950gal/ 6 months= $50.00
17,950 - 44,880 gal/6 months= $3.00/1000 gal
>44,880 gal/6 months= $6.68/1000 gal (residential)
$5.35/1000 gal (commercial).

Approximately 3,000 linear feet of new pipe might have to be installed to replace the abandoned interconnection that currently exists between the two towns[i]. Booster station pumps would likely need to be replaced for this connection. However the building that would house the equipment is currently there. One DEP Sanitary Survey report from 1999 states that:

> *The interconnection between Groveland and West Newbury is in very poor condition. There is a proposed development in this area of Groveland that has prompted discussion about upgrading the water main in this area if the development goes through. Upgrading the water main in this area would greatly increase the pressure and fire flow, eliminating a long-standing pressure problems for the upper Main Street area.*[j]

CEI recommends that the upgrades needed to reinstate this interconnection be explored further with Groveland, particularly in light of the potential for development that could pay for some portion of the upgrade needed.

Georgetown

The Water Superintendent for Georgetown stated that they do not have any excess capacity and currently have agreements with Groveland, Byfield and Rowley to supply water on an emergency basis only.[k]

Haverhill

The Water superintendent stated that the town does not have excess supplies and could only supply water on an emergency basis.[l]

Merrimac

Merrimac does not have any excess water and is currently searching for new sources.[m]

Amesbury

Amesbury currently has interconnections with other cities. At the present time these are used on an emergency basis only after vote at city council. Based on a conversation with Amesbury, the city is trying to manage their own water needs first.[n] There would likely be little support for providing water to West Newbury for anything other that on an emergency basis.

MWRA

The Massachusetts Water Resource Authority supplies water to a number of communities in Massachusetts. There are a number of criteria that an applicant to join their system must meet, some of which may be difficult for West Newbury to meet at this time. Even if in the near future West Newbury were to successfully meet the criteria, capital costs would be very high to connect to the system. The closest community (likely to be connected in the next two years pending approval of their application) is Peabody, Massachusetts.

MWRA requires communities to pay for all capital costs associated with connection. This would mean that West Newbury would have to pay for the design and installation of pipe booster stations and land to connect from Peabody through no less than four towns. Finally, once the infrastructure is in place the town could start purchasing water at per gallon rates that are higher than they currently pay to Newburyport. This option will be very expensive for the foreseeable future.

Regionalization

Regionalization as discussed in this section is the cooperation by adjacent communities in meeting the drinking water needs of those communities. This concept is commonly used to provide services that rely on specific valuable non-mobile resources, recognizing that some communities are blessed with geologic conditions that may benefit them in some respects and hurt them in others.

Regionalization projects have allowed communities to distribute resources equitably thereby allowing communities to continue to grow, where they would have otherwise been stifled by a lack of favorable resources within their boundaries. The distribution of water and treatment of sewage are two common examples.

A second reason for regionalization is the high capital costs often associated with the provision of certain services. In this case, the user base in the town may not be able to finance the upfront costs needed to provide the service. Public utilities, public transportation, and public education are three examples of services that are commonly addressed at a regional level due to the cost concerns.

The discussion above is relevant to West Newbury's situation with water; the town does not have abundant overburden areas suitable for even moderate groundwater withdrawals, its potential surface water supplies are owned by Newburyport, and its user base is small. In general, West Newbury could benefit from a regional water system. Unfortunately, there are some problems with water regionalization that may hinder its development.

First and foremost, most examples of regionalization have come from the top down. In many cases states have encouraged and provided seed money to get the process moving in inter-town efforts. At this point, no such pressure or incentive money has been allocated for a regionalized water system (with the exception of MWRA). MADEP recognizes the problems that West Newbury and other adjacent towns face with limited retrievable water and enormous growth, however current purchasing agreements such as the one that West Newbury has with Newburyport are viewed as default regionalized systems and therefore a more formal regional system may seem redundant. It is for these reasons that formal regionalization is not likely to occur in the region in the near future.

3.3 Summary of Screening

Table 3-1 at the end of this section presents a summary of the water supply options that were investigated and screened for feasibility. A brief description of feasibility is also included in the table.

3.4 Demand vs. Capacity

When determining whether there is sufficient source capacity to meet demand, maximum day demand trends are reviewed. Figure 3-1 shows the maximum day demand vs. supply of the system. Note that the maximum potential yields from the existing wellfields, Knowles and Andreas wells have been used in this figure. This is because wells may be pumped harder for short periods of time to meet maximum day demands, although it is undesirable to pump most wells potentially over capacity for long periods. In other areas of the report where annual estimates are needed, CEI has assumed lower production figures for all three wells to reflect a more conservative output that could continue indefinitely 24 hours per day.

For example, the safe yield and DEP approved capacity of the existing wellfield is 160,000 gpd. However, on average, the Water Department pumps about 110,000 gpd from their wellfield (based on data from 1995-1999). Often, the wellfield will yield up to 200,000 gpd, but there are many days within the year that the yield is much less, and this well may tend to be more sensitive to drought due to its shallow nature. For baseline conditions, a figure of 110,000 gpd will be used to reflect long-term wellfield production.

The DEP preliminary report regarding approval of the Andreas and Knowles wells indicate that there is a potential to pump 75 gpm from each of the Knowles wells (total 150 gpm) and 100 gpm from the Andreas well, however, actual pumpage may be less. To form a conservative estimate, 75% of the expected capacity was used except as noted above to meet maximum day demand. Assuming that both locations are pumped for 24 hours per day, the yield of these two wells could be about 270,000 gpd on a long-term basis, potentially higher for short periods.

Figure 3-1 also showed the added system capacity by putting these two well sites online. Note that this new capacity does not meet projected maximum day demand based on a linear trend. The linear trendline for max day (shown in red) shows a potential 2020 max day demand of over 700,000 gallons, roughly 200,000 gallons per day more than will be available with all wells online. Water will need to be purchased for these days or the maximum day will have to be limited by watering restrictions. If the peak is limited to 1.5 times the average day demand, then the 2020 maximum day might be around 570,000, much closer to what can be met by the existing well plus Knowles and Andreas wells.

As discussed further below, note that the system should be sized to meet maximum day demand with one well offline. If we assume that a limit of 1.5 times maximum day demand is allowed and that the average day demand in 2020 is roughly 380,000 gallons (buildout), roughly the same quantity (380,000 gallons/day) can be provided with one well offline. This is far short of meeting the potential maximum day demand of 570,000 even with demand management.

CEI recommends that the Water Department add the Knowles and Andreas wells as soon as possible and further explore bringing on one additional bedrock well site to meet demands. Most of the time, the Water Department will be able to rely on these wells for all the community's water needs. Purchased water can be used in the interim to supplement high demand periods, and may need to be continued during emergencies or when wells are offline.

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[a] Cammett Engineering, 1993. Exemption Application, Groundwater under the Influence of Surface Water for the West Newbury Water Commissioners. Amesbury, MA. October 18, 1993.

[b] Cammett Engineering, 1990. Add 7th Well Change No. 3. Plan view and cross-section drawings (see also Appendix A).

[c] Colby, Paul, Water Superintendent, Newburyport Water Department. December 8, 2000. Telephone Conversation with Eileen Pannetier of CEI.

[d] D.L. Maher Co., 1993. Fracture Trace Bedrock Groundwater Well Investigation, West Newbury, Massachusetts. North Reading, MA. January 13, 1993.

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[e] D.L. Maher Co., 1983. Letter from J. Theodore Morine to Board of Water Commissioners, West Newbury, Massachusetts. North Reading, MA. April 11, 1983.

[g] Massachusetts Department of Environmental Protection, April 7, 2000. Letter from Joe Cerutti to Michael Gootee, West Newbury Water Department re: Safe Yield, Knowles and Andreas Sites. Drinking Water Program, Boston, MA. April 7, 2000.

[h] U.S. Geological Survey, November 1, 1999. Letter from Bruce Hansen to Janet Tatarczuk. U.S. Department of the Interior, Geological Survey. November 1, 1999.

[i] G. Smith, Groveland Water Superintendent. October 2000. Tel conversation with Tyler Philips, CEI.

[j] Morris, Madeline. April 27, 1999. Sanitary Survey Compliance Plan. Letter to Glenn Smith, Groveland Water Department from Department of Environmental Protection.

[k] D. Peatfield, Water Superintendent of Georgetown. October 2000. Telephone conversation with Tyler Philips, CEI.

[l] W. Park, Water Superintendent of Haverhill. October 2000. Telephone conversation with Tyler Philips, CEI.

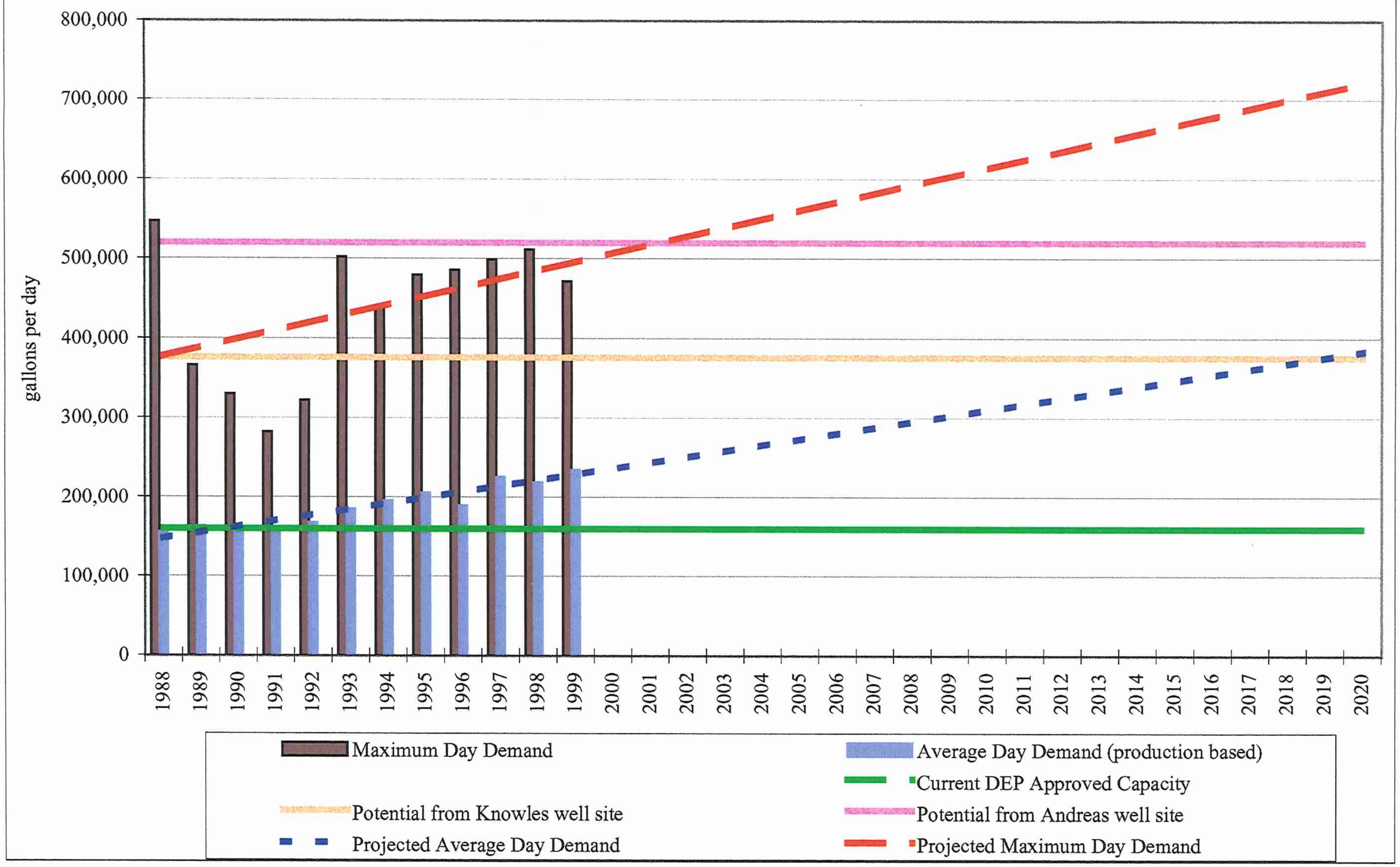
[m] L. Souci, October 2000. Telephone conversation with Tyler Philips, CEI.

[n] J. Bogel, October 2000. Telephone conversation with Tyler Philips, CEI.

Table 3-1.
Summary of Water Supply Option Feasibility

Option	Feasible	Description of Limitations
Groundwater Sources		
Overburden Sources	NO	Poor geology, inadequate sanitary radii.
TW-82-12	NO	High salt content, inadequate sanitary radii.
Improve Wellfield	NO	No significant yield increase.
Knowles Wells	YES	Approved yield may be less than anticipated.
Andreas Well	YES	Approved yield may be less than anticipated.
New Bedrock Wells	YES	Exact locations/yield unknown.
Surface Water Sources		
New Impoundments	NO	Lack water rights, expense of treatment and infrastructure relocation high.
Merrimack	NO	Treatment costs high, susceptible to upstream impacts, permitting issues major.
Purchasing		
Newburyport	YES	A supplemental source only. Contract negotiations are ongoing. Purchase rate is likely to increase due to Newburyport's expected future capital expenditures.
Groveland	YES	Rates unknown, purchasing restrictions may limit practicality
Georgetown	NO	No excess supply.
Haverhill	NO	Emergency only.
Merrimack	NO	No excess supply.
Amesbury	NO	Emergency only.
MWRA	NO	Infrastructure costs too high.

Figure 3-1. Maximum Day Trendlines Compared with Capacity



The DEP approved capacity of the existing wellfield is 160,000 gpd.
DEP preliminary review of Knowles and Andreas well sites estimated a yield of 217,000 gpd and 144,000 gpd respectively.

4.0 Water Quality Issues and Analysis

4.1 Regulatory Requirements

Drinking water sources in Massachusetts are regulated under the Federal Safe Drinking Water Act as well as the Massachusetts Drinking Water Standards and the Massachusetts Surface Water Standards. These are important in terms of existing wellfield quality and the projected quality of future wells. These issues are discussed further in Section 4.2 and 4.3. Sections 4.5 and 4.6 then describe existing treatment needed to address quality issues, and projected treatment needs for the new wells. A summary of the Federal Safe Drinking Water Act and the Massachusetts Drinking Water and Surface Water Standards are included in Appendix C.

4.2 Water Quality of Existing Sources

West Newbury Wellfield #1

In the past two years, no contaminants above drinking water standards have been detected in the water supplied by Wellfield #1. The levels of some common contaminants and additives in West Newbury water from Wellfield #1 are provided in Table 4-1 at the end of this section.

In 1998 and 1999, the only reported bacterial contamination in the West Newbury water supply was in August 1999 when total coliforms were detected at the Pentucket High School. The detection was attributed to bacterial growth in the water pipes due to low water use at the school while classes were out of session. Fecal coliforms or *E. coli* bacteria were not detected. The water department has adopted a schedule of line flushing during the summer months to prevent the recurrence of total coliform detections.

Wellfield #1 has been granted a source waiver by MDEP for inorganic compounds because of the good quality of the water. Therefore, no recent test results for arsenic have been reported. In 1980, the arsenic concentration in the wellfield aquifer was 0.0004 mg/L, which is below the proposed MCL of 0.005 mg/L. That same year, the water was tested for radionuclides (as gross alpha and beta activity), but none were detected.[a] The next scheduled test for radionuclides will be in the second quarter of 2001.

Newburyport Water Supply

West Newbury currently receives water from the Town of Newburyport. The quality of the treated water from both West Newbury and Newburyport supplies are summarized in Table 4-1.

The quality of the water received from Newburyport meets all Federal and Massachusetts drinking water standards. The primary difference between the two supplies is the concentration of disinfection byproducts. Most of the Newburyport supply is from surface water sources (i.e., the Artichoke Reservoir), which, when chlorinated, produce greater concentrations of disinfection byproducts than groundwater sources. As a result, concentrations of disinfection byproducts are approximately ten times greater in the Newburyport water than the groundwater from Wellfield #1. The levels of disinfection byproducts in Newburyport water meet the current MCLs, but are close to the proposed MCLs that will start to become effective in 2002. This may result in greater treatment costs.

4.3 Water Quality of Proposed Sources

Andreas Bedrock Well

The Andreas well was tested for water quality during the 10-day pump test in December 1999. At the conclusion of 10 days of pumping, the water was tested for metals, volatile organic compounds (VOCs), synthetic organic compounds (SOCs), and radionuclides. The water was also tested multiple times during the 10-day pump test for total coliform bacteria, secondary contaminants, and nitrate/nitrite. The compounds detected during these tests are summarized in Table 4-2. Results above existing or proposed standards are shaded in this table.

For the Andreas well water, four parameters did not meet existing or proposed MCLs: arsenic, manganese, radon, and turbidity (cloudiness of water). The measured arsenic concentration (0.02 mg/L) was less than the current MCL (0.05 mg/L), but greater than the proposed MCL (0.005 mg/L). Naturally occurring arsenic is common for bedrock wells in New England. USEPA reported typical arsenic concentrations for New England, North Central, and Midwest Central states in the range of 0.002 to 0.01 mg/L [65 FR 38887 (6/22/00)]. Similarly, the concentration of radon[b] (1,700 pCi/L) met the existing Massachusetts Guideline of 10,000 pCi/L, but was greater than the MCL proposed by USEPA (300-4,000 pCi/L). West Newbury is unlikely to be affected by these rules, even if finalized at these levels, for 10-15 years.

Manganese concentrations (0.07-0.08 mg/L) exceeded the non-enforceable secondary MCL (0.05 mg/L) which indicates potential aesthetics problems if this water is used without treatment. Cost assumptions have therefore included sequestering to reduce these levels.

Lastly, the water exceeded Federal and Massachusetts's requirements for turbidity during the pump test. Technically, these requirements only apply to surface water supplies and it is likely that the well will "settle down" as pumping begins full-time. However, elevated turbidity could impede treatment systems for other parameters. The turbidity results varied during the 10-day test, which is illustrated in Table 4-2. The turbidity test results show that the turbidity met the Federal and Massachusetts MCLs at the beginning and end of the 10-day pump test.

Knowles Bedrock Wells

As with the Andreas well, the Knowles wells were tested for water quality during the 10-day pump test in December 1999. At the conclusion of 10 days of pumping, the water was tested for metals, volatile organic compounds (VOCs), synthetic organic compounds (SOCs), and radionuclides. The water was also tested multiple times during the 10-day pump test for total coliform bacteria, secondary contaminants, and nitrate/nitrite. The compounds detected during these tests are summarized in Table 4-3.

Based on the test results, the water quality for the Knowles wells are similar to the Andreas well. The exception is that Knowles wells seem to have lower turbidity levels. Concentrations of arsenic, radon, and manganese are greater than proposed or existing MCLs. Given the similar water quality between the Knowles and the Andreas wells, other bedrock wells drilled in West Newbury may also have similar water quality.

The bedrock geology of the area also supports the assumption that water quality in the bedrock aquifer is relatively similar throughout the town. The bedrock beneath West Newbury is composed of two rock formations[c]. The Merrimack Group is a group of massive-splitting to very friable metamorphic rocks of Pre-Middle Ordovician age. This group comprises light-gray to dark gray phyllites, which range from those almost wholly composed of muscovite and quartz to those in which the dominant minerals other than quartz are biotite and/or carbonate. The other major formation is the Newburyport Quartz Diorite. This formation comprises igneous intrusions of Middle Ordovician age. According to the USGS, both of these rock types have been associated with radon production[c]. Therefore, it is unlikely that there are locations within West Newbury where a bedrock well that did not have elevated radon concentrations could be found.

Bedrock wells throughout New England have water quality results that are similar to those reported at the Knowles and Andreas sites. These results could best be described as typical for the region. There is currently a debate in the scientific community as to what level of arsenic is considered harmful as some studies have found it to be an essential nutrient. These two factors combined should allay any concern that the proposed wells have poor water quality.

4.4 Treatment of Existing Sources

West Newbury Wellfield #1

Groundwater from West Newbury Wellfield #1 currently receives the following treatment before entering the distribution system:

- Chlorination for disinfection;
- Addition of potassium hydroxide to raise the pH, and prevent lead leaching from homeowner's plumbing; and
- Addition of sodium fluoride to prevent tooth decay.

Newburyport Water Supply

Eighty percent of the Newburyport water supply is from surface water sources. This water undergoes rigorous treatment in order to comply with the Surface Water Treatment Rule and the Interim Enhanced Surface Water Treatment Rule.

- Chlorination for disinfection
- Coagulation, sedimentation, and filtration to remove suspended solids and pathogenic cysts;
- Addition of caustic soda to raise the pH of the water;
- Addition of phosphoric acid for corrosion control; and
- Addition of fluoride to prevent tooth decay.

Treatment Deficiencies of Existing Sources

The water quality of the existing wellfield is very good. Those parameters tested at the wellfield are below the current and proposed federal and state drinking water standards. Chlorine is being added for disinfection and potassium hydroxide is added to raise the pH of the water.

Water from Newburyport is extensively treated prior to distribution to West Newbury. There are no known deficiencies in this water. As with many surface water sources, disinfection by-products may exceed the proposed MCLs expected to become effective in 2002. Newburyport is currently preparing a Master Plan[d] to address this and other future needs.

4.5 Treatment of Proposed Sources

Andreas Bedrock Well

The Andreas well could require treatment at some future date to remove arsenic and radon if the standards levels for these contaminants are set as now proposed. However, systems in West Newbury's size category are likely to be last to be required to treat, so it may be many years away. Also, the currently proposed levels are unlikely to be finalized without change, as there is significant ongoing debate on the limited health benefits compared to the potential cost nationwide. In many cases where a similar debate occurred, the final regulation was somewhere in the middle ground.

Radon

EPA has proposed a radon MCL of 300 picoCuries per liter (pCi/l) or 4,000 pCi/l if the state develops a program for dealing with indoor air sources of radon, which are typically much larger than the amount from water (radon typically seeps in through the basement floor as a gas, while it comes in drinking water mostly through the shower). The best available technology (BAT) for radon removal from water is high-performance aeration.[c] The preferred aeration treatment technologies and their estimated percentage removals are listed in Table 4-4.

The Andreas well's radon level was 1,700 pCi/l during the pump test. If DEP does not develop a Multimedia radon program (which it likely will) then West Newbury may have to treat this well for radon. If required, radon treatment is likely to be minimal and may be accomplished by one of the simpler technologies such as low technology aeration through a Venturi or at most slat tray aeration. The cost to treat this well is unlikely to exceed $50,000 with $10,000 in annual costs. This is not likely to be needed for several years, however, since EPA has not finalized the rule. During this time, costs may be reduced as technologies improve. To address future treatment, the proposed pump house for the Andreas well has adequate space for adding radon treatment when and if needed.

Arsenic

For arsenic, that middle ground might be an MCL of 0.01 mg/l, which has now been proposed by the state of New Hampshire as an interim, instead of EPA's proposed 0.005 mg/l (the standard is now 0.05 mg/l). There are several BAT options for arsenic removal. These options and their estimated efficiencies are listed on Table 4-5.

The Andreas well test showed a level of 0.02 mg/l, just over the middle ground. However, there is typically some variability between what the pump test shows and what is actually produced, which may be less since portion of the arsenic tends to be associated with particles of sediment that may have been entrained during the pump test. Further, West Newbury is in the smallest system size category, and this category of systems typically does not have to comply with new regulations for several years after finalization (typically 5-10) or not at all.

Treatment for arsenic is quite expensive, and even for this small well could be about $250,000 with an annual cost of about $10,000 for the lowest technology treatment of filtration. However, by the time arsenic treatment is needed at this well, if at all, treatment technologies may improve. This may reduce costs for small systems like West Newbury, particularly where the concentrations of the contaminant are marginal.

Because of these unknowns, treatment for arsenic has not been included in the costs for wells at this time, pending the final rule's outcome. However, the proposed pump house for this well does include space for arsenic treatment should it be needed in the future.

Manganese

The Andreas well has moderate levels of manganese (0.07-0.08 mg/l) compared to the secondary standard of 0.05 mg/l. The secondary standard is a non-enforceable, aesthetic "recommended" level. In many cases, a simple treatment procedure called sequestering can be used to minimize the aesthetic impact of manganese on customers. Aesthetic effects typically include sporadic or regular problems with brown water, stained dishwashers and laundry. Many systems deal with these by over the counter products given to customers that have complaints combined with finding a good sequestering agent. If these methods do not address the problem adequately, then further treatment may be needed. Most well with levels similar to the Andreas have been able to deal with it through sequestering. Typically a drum is installed in the pump house to feed in the sequestering agent.

More extensive treatment involves using one of three primary options. These options are: Greensand, membrane filtration and conventional filtration. These are not typically needed unless the total iron and manganese at the well exceeds 1.0 mg/l combined. The highest tested level of iron at the Andreas well was 0.10 mg/l. Combined with the highest tested level for manganese of 0.08 mg/l, the total is 0.18 mg/l, so it is unlikely that treatment will be required beyond sequestering.

Although the Andreas well also had some turbidity during the pump test, this in not regulated in groundwater. It is also likely to settle down during the initial startup and once it is online. Other parameters were within all expected limits or were not detected at all.

Knowles Bedrock Wells

The Knowles wells would likely require the same treatment as the Andreas well. Levels of arsenic are slightly lower and may meet any final MCL, while radon levels are very similar. Manganese is also lower than the Andreas well, but in the same range (0.06 mg/l maximum during the testing). Iron was very low, a maximum of 0.15 mg/l. The well's combined iron and manganese is then 0.21 mg/l during the pump test, so treatment is unlikely to be needed. However, space for treatment for arsenic, radon and sequestering has been included in the proposed well construction costs.

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[a] Cammett Engineering. (1993) Exemption Application, Groundwater Under the Influence of Surface Water for the West Newbury Water Commissioners. Amesbury, MA. October 18, 1993.

[b] USGS. 1993. U.S. Geological Survey. (1993) The Geology of Radon. U.S. Department of the Interior, Geological Survey. U.S. Government Printing Office. ISBN 0-16-037974-1. 1993. U.S. Geological Survey, 1981. Hydrologic Data of the Lower Merrimack River Basin, Massachusetts, from Concord River, Lowell, to Plum Island, Newburyport. Massachusetts Hydrologic Data Report No. 24. U.S. Department of the Interior, Geological Survey. 1981.

[c] Federal Register, 64 FR 59246. November 2, 1999.

Table 4-1.
Water Quality of Existing Sources

Compound	Highest Level Detected 1998-1999	Federal MCL Existing	Federal MCL Proposed	Massachusetts MCL Existing	Massachusetts MCL Proposed
West Newbury Wellfield #1					
Fluoride	1.10 mg/L	4 mg/L		4 mg/L	
Nitrate	0.97 mg/L	10 mg/L		10 mg/L	
Sodium	12.5 mg/L	None		None	(1)
Total Trihalomethanes	7.9 ug/L	100 ug/L	80ug/L (2)	100 ug/L	80ug/L (2)
Newburyport Water Supply					
Fluoride	1.4 mg/L	4 mg/L		4 mg/L	
Nitrate	1.5 mg/L	10 mg/L		10 mg/L	
Sodium	36 mg/L	None		None (1)	
Total Trihalomethanes	66 ug/L	100 ug/L	80 ug/L (2)	100 ug/L	80 ug/L (2)
Haloacetic Acids	59 ug/L	None	60 ug/L (2)	None (2)	60 ug/L (2)
1,2-Dichloroethane	2 ug/L	5 ug/L		5 ug/L	
Turbidity	1.3 NTU	1 to 5 NTU (3)		1 to 5 NTU (3)	

(1) MDEP has established a non-enforceable drinking water guideline for sodium of 20 mg/L. All detections of sodium must be reported. See 310 CMR 22.06A for the specific requirements.

(2) The MCL for total trihalomethanes will decrease from 100 ug/L to 80 ug/L and the new MCL for haloacetic acids of 60 ug/L will become effective starting in January 2002.

(3) For surface water supplies, the Massachusetts MCL for turbidity is 1 nephelometric turbidity units (NTU) as determined by a monthly average (with certain exceptions), and 5 NTU as determined by the arithmetic mean of two consecutive daily samples (310 CMR 22.08). The Federal MCL is that turbidity cannot exceed 5 NTU at any time, and that at least 95% of the daily samples for any single month should not have turbidity higher than 1 NTU (0.5 NTU for conventional or direct filtration). The Newburyport water meets these standards.

Table 4-2.
Water Quality of Proposed Sources
Andreas Bedrock Well

Compound	Range of Concentrations (10-day Pump Test)	Federal MCL		Massachusetts MCL	
		Existing	Proposed	Existing	Proposed
Aluminum	<0.005-0.13 mg/L	0.05 to 0.2 mg/L*		0.05 to 0.2 mg/L*	
Arsenic	0.02 mg/L	0.05 mg/L	0.005 mg/l (1)	0.05 mg/L	0.005 mg/l (1)
Barium	0.01 mg/L	2 mg/L		2 mg/L	
Fluoride	0.2 mg/L	4 mg/L		4 mg/L	
Manganese	0.07-0.08 mg/L	0.05 mg/L*		0.05 mg/L*	
Sodium	44.6-53.6 mg/L	None		None	(2)
Sulfate	39.5 mg/L	250 mg/L*		250 mg/L*	
Radon	1,700 pCi/L	None	300-4,000 pCi/L (3)	10,000 pCi/L	300-4,000 pCi/L (3)
Gross Alpha Activity	1.6 pCi/L	15 pCi/L		15 pCi/L	
Beta Particle Activity	2.2 pCi/L	NA (4)		NA (4)	
Turbidity	0.33-17 NTU	1 to 5 NTU (5)		1 to 5 NTU (5)	
Di(2-ethylhexyl)phthalate	2.66 ug/L	6 ug/L		6 ug/L	
Dicamba	1 ug/L	None		None	
Turbidity Pump Test Dates					
12/09/1999	0.60 NTU	1 to 5 NTU		1 to 5 NTU	
12/12/1999	1.4 NTU	1 to 5 NTU		1 to 5 NTU	
12/14/1999	1.3 NTU	1 to 5 NTU		1 to 5 NTU	
12/16/1999	17 NTU	1 to 5 NTU		1 to 5 NTU	
12/18/1999	7.5 NTU	1 to 5 NTU		1 to 5 NTU	
12/21/1999	0.33 NTU	1 to 5 NTU		1 to 5 NTU	

* Non-enforceable secondary MCL pertaining to aesthetic qualities relating to public acceptance of drinking water.

Shaded cells indicate test results exceeded the existing or proposed standards.

(1) USEPA has proposed to lower the MCL for arsenic from 0.05 to 0.005 mg/L, however, this is unlikely to affect small communities like West Newbury for 10-15 years or more.

(2) MDEP has established a non-enforceable drinking water guideline for sodium of 20 mg/L. All detections of sodium must be reported. See 310 CMR 22.06A for the specific requirements.

(3) USEPA has proposed a MCL for radon of 300 pCi/L (or 4,000 pCi/L if States or individual water supplies develop programs to address the health risks from radon in indoor air).

(4) According to 310 CMR 22.09, if gross beta particle activity exceeds 50 pCi/L, an analysis of the sample shall be performed to identify the major radioactive constituents present and the appropriate organ and total body doses shall be calculated to determine compliance with 310 CMR 22.09(2)(a). The gross beta particle activity measured in this well was below 50 pCi/L so not further action is required.

(5) For surface water supplies, the Massachusetts MCL for turbidity is 1 nephelometric turbidity units (NTU) as determined by a monthly average (with certain exceptions), and 5 NTU as determined by the arithmetic mean of two consecutive daily samples (310 CMR 22.08). The Federal MCL is that turbidity cannot exceed 5 NTU at any time, and that at least 95% of the daily samples for any single month should not have turbidity higher than 1 NTU (0.5 NTU for conventional or direct filtration). The results of the 10-day test do not meet these standards, however, this is likely to settle down as the well is pumped.

Table 4-3.
Water Quality of Proposed Sources
Knowles Bedrock Wells

Compound	Range of Concentrations (10-day Pump Test)	Federal MCL		Massachusetts MCL	
		Existing	Proposed	Existing	Proposed
Aluminum	<0.005-0.05 mg/L	0.05 to 0.2 mg/L*		0.05 to 0.2 mg/L*	
Arsenic	0.01 mg/L	0.05 mg/L	0.005 mg/l (1)	0.05 mg/L	0.005 mg/l (1)
Barium	0.03 mg/L	2 mg/L		2 mg/L	
Manganese	0.04-0.06 mg/L	0.05 mg/L*		0.05 mg/L*	
Sodium	18.3-33.4 mg/L	None		None	(2)
Sulfate	23.5-30.6 mg/L	250 mg/L*		250 mg/L*	
Radon	1,700 -2,200 pCi/L	None	300-4,000 pCi/L (3)	10,000 pCi/L	300-4,000 pCi/L (3)
Gross Alpha Activity	2.2-3.9 pCi/L	15 pCi/L		15 pCi/L	
Beta Particle Activity	3.6-3.9 pCi/L	NA (4)		NA (4)	
Turbidity	<0.1-1.4 NTU	1 to 5 NTU (5)			
Toluene	<0.4-1 ug/L	1,000 ug/L		10,000 ug/L	
Xylenes	<0.4-1 ug/L	10,000 ug/L			

* Non-enforceable secondary MCL pertaining to aesthetic qualities relating to public acceptance of drinking water.
Shaded cells indicate test results exceeded the existing or proposed standards.

(1) USEPA has proposed to lower the MCL for arsenic from 0.05 to 0.005 mg/L.

(2) MDEP has established a non-enforceable drinking water guideline for sodium of 20 mg/L. All detections of sodium must be reported. See 310 CMR 22.06A for the specific requirements.

(3) USEPA has proposed a MCL for radon of 300 pCi/L (or 4,000 pCi/L if States or individual water supplies develop programs to address the health risks from radon in indoor air).

(4) According to 310 CMR 22.09, if gross beta particle activity exceeds 50 pCi/L, an analysis of the sample shall be performed to identify the major radioactive constituents present and the appropriate organ and total body doses shall be calculated to determine compliance with 310 CMR 22.09(2)(a). The gross beta particle activity measured in this well was below 50 pCi/L so not further action is required.

(5) For surface water supplies, the Massachusetts MCL for turbidity is 1 nephelometric turbidity units (NTU) as determined by a monthly average (with certain exceptions), and 5 NTU as determined by the arithmetic mean of two consecutive daily samples (310 CMR 22.08). The Federal MCL is that turbidity cannot exceed 5 NTU at any time, and that at least 95% of the daily samples for any single month should not have turbidity higher than 1 NTU (0.5 NTU for conventional or direct filtration).

Table 4-4. Best Available Technology for Radon Removal	
Treatment Technology	**Maximum Percent Removal (1)**
Packed Tower Aeration	99.9
Diffused Bubble Aeration	99.9
Spray Aeration	99
Slat Tray Aeration	94
Low Technology Aeration (Venturi, free-fall aeration, spray nozzles)	96
Granular Activated Carbon (GAC)	99

Table 4-5. Best Available Technology for Arsenic Removal	
Treatment Technology	**Maximum Percent Removal (1)**
Ion Exchange	95
Activated Alumina	90
Reverse Osmosis	>95
Modified Coagulation/Filtration	95
Modified Lime Softening	80
Electrodialysis Reversal	85

(1) The percent removal figures are for arsenic (V) removal.
Source: 65 FR 38887 (6/22/00)

5.0 Hydraulic Analysis

West Newbury's drinking water distribution system consists of the well pumps, piping, storage tanks, fire hydrants, customer services and meters and all the appurtenant facilities that function to distribute drinking water. The system's hydraulics refers to its capability to pass water through pipes and deliver it to the customers at the desired pressures and quantities. Poor hydraulics may result in low pressures or stagnant areas of the system or areas with inadequate fire flow capability. By nature, water distribution systems are built over long periods of time and are mostly underground, hence, maintenance is difficult and the results hard to gauge.

Because problems with distribution systems are common but hard to evaluate, engineers use tools like basic hydraulics analysis, pressure testing and hydraulics computer models to identify the causes and help determine the best remedies for problems such as low pressure and poor quality.

This section reports on a basic hydraulic analysis with limited pressure testing that was conducted to identify weak areas in the distribution system. The hydraulic analysis consists of a review of the current condition and general capabilities of the distribution and storage system. A hydraulics computer model was not run at the time of this project but will be a recommended step once sufficient data can be developed for reliable model inputs.

5.1 Overview of Existing System

West Newbury's sources of water currently include one wellfield on the northeastern part of town with supplemental water purchased from Newburyport. The wellfield has 8 driven wells, and this source and other potential sources were described in terms of quantity and quality in Section 3.0 and 4.0. To distribute the water, the town has 27 miles of underground piping consisting of mostly 8-10 inch water main with some as small as 2 inch. The distribution system also has two storage tanks that pressurize the system and contain stored water for emergency use and balancing, and one booster pump station (see Figure 5-1 at the end of this section). West Newbury has 181 fire hydrants of various types located along the distribution system and a total of 858 residential, commercial and agricultural customers.

The distribution system was established in 1936, but the wellfield did not come on line until 1991. Prior to 1991, all water was purchased from Groveland and Newburyport to supply customers.

5.2 Wellfield

Currently, water is supplied from one location, the pump house on Route 113 in the northeastern portion of town. The wellfield provides water to West Newbury customers with two 140-gpm pumps working interchangeably. Water is pumped to Pipestave Tank, about 1.5 miles to the west on Route 113. When the wellfield is offline and recharging, water purchased from Newburyport flows through the well house to Pipestave Tank via a 390-gpm pump.

There are 7 gravel packed wells and one horizontal well that make up the wellfield of the West Newbury system. A pump house for the wellfield contains two 140 gpm pumps plus a 390 gpm pump for the Newburyport transfer. It also contains a chemical feed station for chlorine, pH adjustment and fluoride. A new SCADA system will be installed in the pump house by mid-2001. There is also a generator at the pump house in case of power outage.

Currently, water cannot be pumped simultaneously from Newburyport and the wellfield, which means that the Newburyport feed must be either on or off, and cannot just supplement the system. In part, this is because the Newburyport pump overpowers the wellfield pump (it pumps at a much higher rate and volume), so the Wellfield #1 pump is not powerful enough to pump water into the system at the same time. In addition, there is also a limitation of the 10 inch cast iron main along Route 113 (see Section 5.5), which has reduced capacity as a result of corrosion buildup in the pipe that has probably occurred due to its advanced age and cast iron construction. These problems could be evaluated further for possible resolution by completing a thorough cleaning and lining of the pipe or replacement of the 10-inch main along Route 113.

In addition, when the Wellfield #1 pumps need refurbishing in the future, the use of variable frequency drives (VFDs) should be considered since these drives may improve the efficiency and operation of the system. Typically, VFDs have a considerably higher capital cost but may be more efficient in electricity use and may extend the life of the pump drives. However, none of these improvements will alleviate the wellfield's existing capacity limitations.

At present, it appears a better resolution is to put additional groundwater sources in other locations of the community on-line. The 10 inch main along Route 113 is considered the backbone of the distribution system and should be further evaluated to determine the most cost-effective rehabilitation so that fire flows are uninterrupted. This is discussed further in Section 5.5. The limitations of the existing wellfield are described below.

The capacity of the wellfield is not limited by the pump hydraulics, but rather the depth of the wellfield and the small size of the aquifer. Currently, the wells are shut off when the drawdown falls to 3 feet above the well screen at Well #4 (the shallowest of the vertical wells). The table below shows the wellfield depths. Appendix A contains plans that show the profile of the wellfield and the general layout. The static water elevation in the wellfield was about 3 feet below ground when the wellfield was installed.[a]

Wellfield Depth

Well	Elevation of Top of Screen
Well #8 (horizontal well)	-8 to -10
Well #4	-11.6
Well #3	-14.2
Well #1	-17.5
Well #5	-17.5
Well #6	-20.1
Well #2	-20.7
Well #7	-23.9

Elevations above Mean Sea Level

According to the *Report on the Development of Well Site No. 1*[b], the pumping rate was determined to be 18 gpm for each well and the transmissivity was 1980 gpd/ft. The safe yield was also determined to be 165 gpm. The aquifer is made of peat, clay, fine sand and gravel. In addition to the seven driven wells, a horizontal well was added to achieve better pumpage from the wellfield. The horizontal well was installed in 1994 as a pilot test with DEP.

In 1999, both pumps at the existing wellfield were inspected by Maher Drilling and Pump Services. Flow tests were conducted on both pumps. Results indicated that pump #1 should be removed from the pump house and inspected, but that pump #2 was still in good condition. Pump #1 was inspected and repaired in July 2000.[c]

CEI reviewed the possibility of redrilling Well #4 because of its limitation on the system since it has the highest elevation screen top. As shown on the above table, the next elevation screen is Well #3, only 2.6 feet below Well #4's screen. If these two were replaced with deeper wells, an additional 5.9 feet could potentially be tapped. However, conversations with the driller indicate that these wells tapped into the best material available when they were drilled.[d] Below these existing screens the sand and gravel material are likely to bear less water, so redrilling these particular wells is not recommended. Discussions with D.L. Maher[e] indicated that if the well were rehabilitated in the future then they may recommend using 8-10" boreholes with gravel packing for the wells instead of the drilled wells now used. This newer method has been more productive at some tubular well sites. Should the wellfield decline significantly in yield or otherwise need significant work in the future, CEI recommends that a feasibility study should be performed to determine the best method for rehabilitation considering the best technologies available at the time.

5.3 Booster Station

The booster station located across the street from Pipestave Tank and the Page School on Route 113 consists of a precast vault housing the pump itself under a precast pump house. The facility is in fair condition but lacks adequate storage area for chemical feeds. The chlorination should also be redesigned to put in a more reliable chlorinator feed with a calibrated drip injector or similar design. The booster station is also without emergency power, and would be unable to pump water to the Brake Hill tank during power outages. This could have potentially serious consequences in the event of fire in the high pressure zone.

CEI recommends that the booster station be rehabilitated to improve access, storage and treatment facilities and that an emergency generator be installed at the booster station.

5.4 Storage Analysis

It is important to note that the West Newbury system is a two-pressure zone system due to the hilly nature of the community. Each zone is served by one of the existing tanks. The low pressure system lies along the eastern edge of the community on Route 113 beginning at the well and ending east of Mill Pond. It is served by the Pipestave Hill Tank, a 500,000 gallon precast roughly 50-foot diameter concrete storage tank built in 1982. The high pressure system serves the bulk of the community from Brake Hill Tank, a 312,000 gallon, 30-foot diameter riveted steel standpipe style storage tank built in 1936 and deleaded and recoated in 1994. A booster station pumps water from the Pipestave Hill Tank to the Brake Hill Tank (as discussed below). The areal extent of each pressure zone is shown on Figure 5-2.

When the water level in Pipestave Tank falls below 35 feet, water is pumped from the well house to Pipestave Tank. The wellfield is shut off when the water level reaches 39 feet, indicating that the tank is full.

Pipestave Tank feeds both the northeastern section of town and Brake Hill Tank through the booster station located on Main Street (Route 113) near Pipestave Hill Tank. When the water level in Brake Hill tank falls below 54 feet, the booster station turns on and pumps water from Pipestave Hill to Brake Hill Tank. Once the water level reaches 59 feet, the booster station is turned off.

Distribution storage is provided to meet peak demand of short duration (hourly fluctuations), minimize pressure fluctuations during periods of demand changes, and to provide the required water for fires. Storage can also be used to provide emergency supply in case of a temporary breakdown of other system facilities.

The Pipestave Hill tank has a 46 foot inside diameter with an 8" inlet/ outlet pipe. In addition, there is an 8" overflow pipe. For every foot of water in the tank, there is 12,425 gallons of water. The floor elevation of the tank is 192 feet. The outlet pipe is six feet above the floor elevation of the tank at elevation 198 feet. The tank is 40 feet high (to dome) storing a maximum of 39 feet of water. Of this 39 feet, 33 feet is available as useable storage, or 410,025 gallons. The shutoff elevation of the tank is at 231 feet (one foot below overflow elevation). The tank was inspected in late 2000.

Brake Hill Tank is a 30-foot diameter, 60-foot high tank and was inspected in 1993. For every foot of water in the tank, there are 5,285 gallons of water. The base elevation of the tank is 241 feet. The total capacity is about 312,000 gallons. The shutoff of the tank is at height 59 feet, making the overflow elevation 300 feet. Brake Hill Tank was inspected and painted in 1998.

Although the Pipestave Hill Tank is larger, it serves a smaller portion of West Newbury than the smaller Brake Hill Tank. However, because of the booster pumps, the storage capacity of the Pipestave Hill Tank is essentially available to the larger high pressure zone.

The recommended storage required in a water system is equal to:

1. equalization volume (typically 20-25% of maximum day demand),
2. fire volume (dependent on land use), and
3. emergency storage (emergency storage is considered good practice but is not required by DEP – the connection with Newburyport can be used for emergencies if there is a lack of storage).

Equalization Volume

The equalization storage volume is the storage required to meet short-term fluctuations in demand. This volume is the amount above and beyond that required to meet fire flows and emergencies. Equalization storage volume is generally provided by the portion of the tank that is above the water level required for adequate system pressures. DEP guidelines indicate that 35 psi of pressure should be provided to customers under normal demand conditions. Under fire flow conditions, the minimum suggested pressure is reduced to 20 psi at all points in the distribution system.

There are two pressure zones in West Newbury. Pipestave Tank serves pressure zone 1, the main pressure zone. Under normal operating conditions the tank fluctuates between elevations 224 feet and 231 feet (Tank Charts, Thursday, August 17, 2000). When the water level is at 224 feet, this tank can theoretically provide adequate pressures to customers up to elevation 143 feet within that portion of town (224 feet-81 feet required to achieve 35 psi residual). The highest elevation served in that portion of town is at about elevation 140 feet. Therefore, all water above elevation 224 feet can be used for equalization (7 feet of water, or 87,000 gallons). Figure 5-3 shows that this is more than enough water to provide equalization to the main pressure zone of West Newbury.

Brake Hill tank serves the high pressure zone, pressure zone 2. Brake Hill tank can theoretically serve customers up to elevation 212 feet within pressure zone 2 with 35 psi of pressure. There are a few residences above elevation 212 feet in the system, primarily located along Crane Neck Hill. Brake Hill, Gunner's Hill and Archelaus Hill are three other areas in the high pressure zone with elevations greater than 212 feet. Residences in these locations may need additional pumping to obtain 35 psi of pressure.

Because there are residences above 212 feet in the high pressure zone, equalization storage is not available from Brake Hill Tank alone. Excess water in Pipestave Hill Tank could be used to provide additional useable storage if there was a generator in case of power outage at the booster station (which can pump all the water from the tank to Brake Hill). The storage analysis for Brake

Hill tank assumes that a generator will be provided at the booster station (refer to Figure 5-4) A storage analysis is also provided as Figure 5-5 for the Brake Hill Tank assuming no generator is provided at the booster station.

Fire Storage

For residential areas, the required fire storage is about 1500 gpm for 3 hours.[f] Since the town is mostly residential, the required fire flow was estimated to be 1500 gpm for 3 hours (270,000 gallons) in case of fire at all locations in town.

Water available for fire is equal to the useable storage in the tank minus that required for equalization. In Pipestave tank, this is equal to 397,025 gallons of water in 2020 (410,025 gallons of useable storage minus 13,000 gallons for equalization); adequate to provide fire flow to the main pressure zone.

In Brake Hill tank, this is equal to 371,000 gallons of water in 2020, adequate to provide fire flow in the high pressure zone if emergency power is provided at the booster station.

Emergency Storage

In addition to fire and equalization requirements, emergency storage is also sometimes included in storage. In West Newbury's case, it was assumed that emergencies would be provided for by using water from Newburyport and therefore was not considered in these calculations. Figure 5-3 reflects the above discussion.

Figure 5-3 shows that both Pipestave Hill Tank and Brake Hill Tank are expected to have enough storage to provide equalization plus fire requirements in West Newbury through 2020. If emergency power is not provided at the booster station, then storage shortfalls will occur in the high pressure zone of town.

5.5 Distribution System

Overview

The West Newbury distribution system consists of 27 miles of 2-inch to 10-inch diameter pipes. Most pipes are cast and ductile iron, however, there are some 6" asbestos cement pipes located in the older parts of town. A schematic of the distribution system is included as Figure 5-1.

Corrosion and tuberculation (buildup in pipes) can result in lowering the carrying capacity of pipes. Unlined cast iron pipes are particularly susceptible. Cleaning to remove tuburculation followed by cement lining of these pipes is recommended to help prevent corrosion and tuberculation.

Asbestos cement piping is somewhat better than unlined cast iron in that it tends to retain its carrying capacity and does not tend towards tuburculation. However, well water tends to have a low pH, which may slowly compromise asbestos-cement piping if the pH is not adjusted (as required with the Lead and Copper rules). AC pipe is no longer used due to asbestos concerns, mostly with storage and installation. CEI recommends periodic checks of the condition of AC pipe when breaks or other openings occur to evaluate its condition.

Cement lined ductile iron pipes are today considered the best pipe available in terms of longevity and resistance to traffic loadings, corrosion and resiliency to less than ideal installation methods. Lined ductile pipe usually maintains its high carrying capacity for many years, and is heavily used by water departments in Massachusetts for pipe sizes 8 inches and larger. Under 8 inches, plastic pipe is usually much more cost-effective, but smaller diameter pipe is not generally recommended. CEI recommends that West Newbury not install any new pipe that is less than 8 inches and continue to use cement lined ductile iron. Smaller pipes around the system should be replaced with 8 inch ductile when major roadwork is done and the streets are open for other reasons. All unlined cast iron pipes should be evaluated for integrity and tuburculation.

Field Testing

Limited field-testing was conducted to characterize the possible condition of different pipes in West Newbury's piping network. Field testing consisted of measuring the C-value of various sections of piping. The field testing results are provided in Appendix F. The C-value of a pipe is the roughness coefficient, which is measured by calculating the headloss in the pipe or energy lost due to friction. A greater C-value means a lower headloss in the pipe.

The locations for C-value testing were chosen based on pipe sizes and locations in the distribution system. The C-value testing occurred as follows:

- Hydrants were located in the field (3 hydrants in a row for each test);
- 100-psi pressure gages were placed on each hydrant;
- Keeping the valve closed so that no water flowed through the gage, each hydrant was opened;
- Once all hydrants were open to the gage but not flowing, readings were taken ("static" in the attached table);
- The "static" ("P") hydrant only was opened to a flowing condition and readings were taken at all three hydrants (column Residual 1).

Calculations were performed as shown on the tables in Appendix F. Results of the testing are summarized in the table below.

C-Value Testing				
Pipe Location	**Pipe Diameter**	**Type of Pipe**	**C-value (new pipe)[g]**	**C-value (test result)**
Parson's Road	8"	Ductile Iron	140	101
Route 113	10"	Cast Iron	80-150	74
Church Street	6"	Asbestos Cement	140-160	250
Crane Neck	8"	Asbestos Cement	140-160	141

The 8-inch mains on Parson's Road and Crane Neck Road appear to have a capacity slightly lower than expected, indicating minor corrosion or tuberculation. However, the 10-inch main on Route 113 appears to be flowing at under 1/3 the original capacity. This main is one of the oldest in the system and should be examined further to consider cleaning and lining or replacement. CEI recommends either more extensive C-value testing of this main or camera inspection of the line. The Church Street 6-inch main appears from the test to be in good condition, as might be expected in this high pressure area and with AC pipe. Note that AC pipe often tests very well, sometimes better than new values as happened here.

Operation and Maintenance

Each year, the distribution system is flushed for maintenance. One week during the fall and one week during the spring are spent flushing the system via the hydrants. The entire system is flushed each year with dead-end areas being addressed at both times. CEI recommends continuation of this highly valuable practice.
The Water Department currently records the locations of all water line breaks in order to identify potential problem areas. During water line breaks or other repairs, the approximate age and condition of each water main should also be recorded so that a good record of the ages of pipes can be developed. Currently, the lack of age information on the system's piping prevents extrapolation of the C-value testing to other areas of the system.

Hydrants

The major purpose of a hydrant in a water system is for fire protection. They provide an easy access to the water supply in emergency situations. Hydrants are typically located near street intersections and far enough away from buildings so a hose can be strung to fight a fire in several directions. They are generally placed a few feet from a roadway to avoid cars from striking them and plows from covering them with snow. A variety of hydrants are located throughout West Newbury, including:

- 59 American Darling
- 41 Corey
- 40 Kennedy

- 16 Rensselaer
- 21 Mueller
- 4 Metropolitan

The Water Department Standard Specifications for Water Service Installation specify American Darling or Kennedy type hydrants for new developments or replacement hydrants. Currently, the Water Department replaces about 5 hydrants per year. Hydrants are inspected and maintained during the flushing program each fall and spring.

Discussions with the West Newbury Water Department indicate that several locations within West Newbury have low pressure issues. The normal working pressures in a distribution system are between 35 and 60 psi. Fire fighting requires at least 20 psi at all points in the system during a fire. Keeping hydrants at no less than 35 psi allows for a factor of safety.

In the main pressure zone (see Figure 5-2), homes at elevations greater than 143 feet are likely to have problems with low pressure (less than 35 psi). Homes at elevations greater than 178 feet in the main pressure zone may not have sufficient fire flows (pressure less than 20 psi). In the high pressure zones, homes at elevations greater than 212 feet are likely to have problems with low pressures and homes at an elevation greater than 247 feet may not have sufficient pressure during a fire (20 psi). Currently, the highest elevation served is at elevation 246 feet.

On the other end of the spectrum, hydrant pressure greater than 110 psi is excessive at the street level. High-pressure systems may lead to greater leakage and could result in a rapid discharge of water at the tap, leading to increased water waste. Massachusetts plumbing codes (248 CMR 14.00) require pressure-reducing valves in all buildings with greater than 80 psi of pressure. The Water Department uses pressure control devices at homes with high pressures.

Meters

Water meters are used to measure the amount of water to a service connection. Their primary function is to help water utilities account for the water flowing out of their system. Meters are used to determine billing charges and to minimize leakage in the system. A majority of the customers in West Newbury have Badger meters, however there are some Neptune and Carleton meters scattered throughout town. According to Stiles Company, who has provided the Badger meters for the town for several years, about 518 meters have been sold to West Newbury since 1992.[h]

Meter reading can be done in three ways: direct reading, remote reading and automatic reading. West Newbury uses the direct reading method in which a Water Department employee goes from one meter to another and reads the registers. This has many problems associated with it including the increased possibility of misreading and time spent returning to a meter due to an inability to gain access the first time, although the Water Department has taken the wise step of locating most of the meters outside the homes and businesses.

The most cost-effective way of reading meters for a small system is to install outside meter sensors at the home or building that the meter reader holds a reading/recording device up to. The readings are then downloaded onto a computerized billing system from the hand-held devices (commonly called a Unigun). In this way, both meter misreads and access problems are minimized. There are also radio systems that can be used with either a call in option for the meter or a drive-by reading. These tend to be fairly costly for small systems with few customers, however, and may not be warranted at this time.

Based on Stiles data, if 518 of the 858 customer meters have been purchased since 1992, then as many as 340 meters are 8 years or older. Customer meters should be replaced with new or rebuilt meters every 10-15 years. If not, they will tend to underread more and more as they get older, and may not record all of the water used. Replacement can be done on a rotating schedule, replacing 1/2 of the system every five years. CEI recommends that the Town evaluate switching to a Unigun system. The systems software reports to the billing system software, although this must be evaluated for compatibility prior to budgeting. Cost for West Newbury for this portion of the reading system is probably around $10,000 and may free up an operator part of the time for other work.[i] The meter needed to match the Unigun costs $56 per meter or $75 to $80 for handheld reading units. If the oldest meters are replaced with the current meters, the cost would be around $40,000 including the software (see quote in Appendix E).

5.6 Other Water Department Facilities

The Water Department maintains a one bay garage adjacent to the Page School that is used for storage of some smaller equipment and materials. Other materials are stored at other various locations throughout town. The access to the garage is located within the school's playground area and presents a potential safety issue. The storage space does not allow for a workshop. CEI recommends that the Water Department add a storage shed on Town-owned property to house equipment and spare parts.

5.7 Projected Distribution System

As growth continues to occur, new connections to the existing water system will increase. Currently, if a development is within 1,000 feet of the existing water system, the developer is required to connect to the system. Anticipated development patterns and distribution system upgrades that will coincide are discussed below.

Anticipated development patterns

From the buildout completed as part of the *Comprehensive Plan* it appears that development will occur mostly in the area of town zoned Residence A. Therefore, since most Residence A parcels are outside the 1,000 foot zone from the existing system, (see Zoning District Map), it is unlikely that developments in this part of town will be required to connect to the system before developments in Residence B and C zones. These houses are also on larger lots and are more likely to have suitable private wells.

The existing water distribution system already serves much of the Residence C zone. It is anticipated that most of the development that occurs that will effect the water distribution system will occur within the Residence B zone.

There is another section of town that is not currently developed north of Route 113, between Coffin Street and Bailey's Lane. West Newbury already owns much of this land, however, there is a large parcel that is marked as Chapter 61 land that could be developed, and will affect the system.

Distribution System Upgrades

Adding the two new well sites to the distribution system will require some new piping to the existing system. Knowles wells can be connected to the system in two ways; by piping up to Main Street beyond Pipestave Tank, or by connecting Chase Street to Stewart via Middle. Andreas well can be connected to the system via Middle Street.

CEI's projected distribution map is shown on Figure 5-6. Lines to the new Knowles and Andreas wells are shown, and have been included in the costs in Section 7.0. The other primary new water main runs down Middle Street and connects in at Bachelor Street. These lines will connect the Residence B Section, the most probable area for housing in densities warranting water service. Water service is less likely to be cost-effective outside this zone, although if developers wish to pay the costs of providing service, some growth could also be seen in the Residence A zone.

Dead ends in a system often lead to pressure problems and strain on water mains and hydrants. It is good practice to loop dead ends where possible. New developments in already developed parts of town can be used to achieve this if they are required to loop water lines in order to tie in near a dead end. As a rough estimate, water lines cost approximately $100 per linear foot to install.

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[a] W.C. Cammett Engineering, Inc., "Add 7th Well Change No. 3" plan dated 7/23/90.

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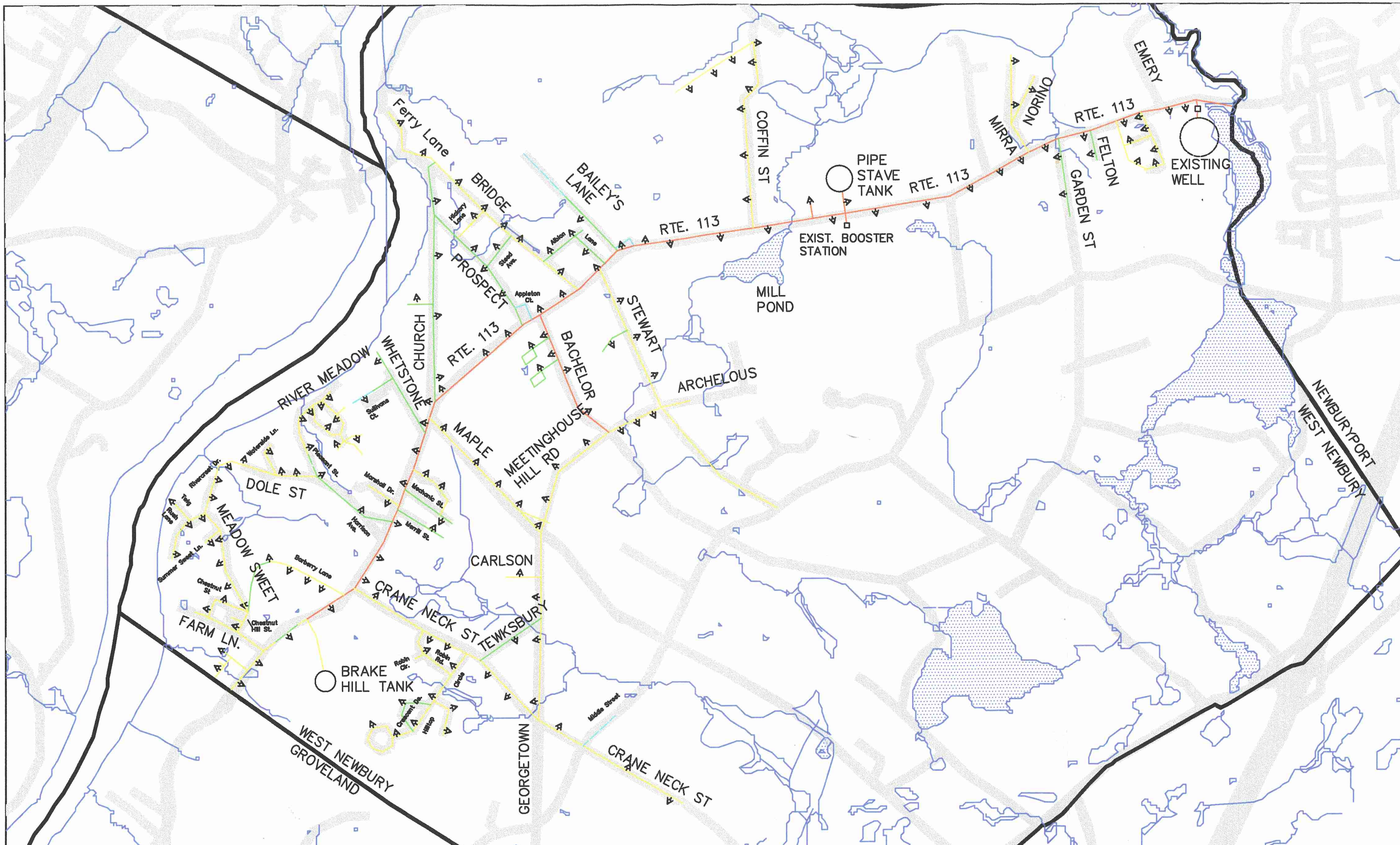
[b] W.C. Cammett Engineering, Inc., "Report on the Development of Well Site No. 1."
[c] D.L. Maher, 11/23/99. Pump Inspection Report in letter to Mike Gootee signed by Peter C. Maher.
[d] Bomengen, Reideir, D.L. Maher. 12/13/00. Telephone conversation with Eileen Pannetier, Comprehensive Environmental Inc.
[e] Bomengen, Reideir, D.L. Maher. 12/13/00. Telephone conversation with Eileen Pannetier, Comprehensive Environmental Inc.
[f] Lindeburg, 2000.
[g] Lindeburg, 2000
[h] Gillon, Joe, Stiles Co. Inc. 12/13/00. Telephone conversation with Eileen Pannetier, Comprehensive Environmental Inc.
[i] Stiles Co. Inc. Quote, 12/13/00. See Appendix _ for quote.



NO.	DATE	DESCRIPTION	BY

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

LEGEND

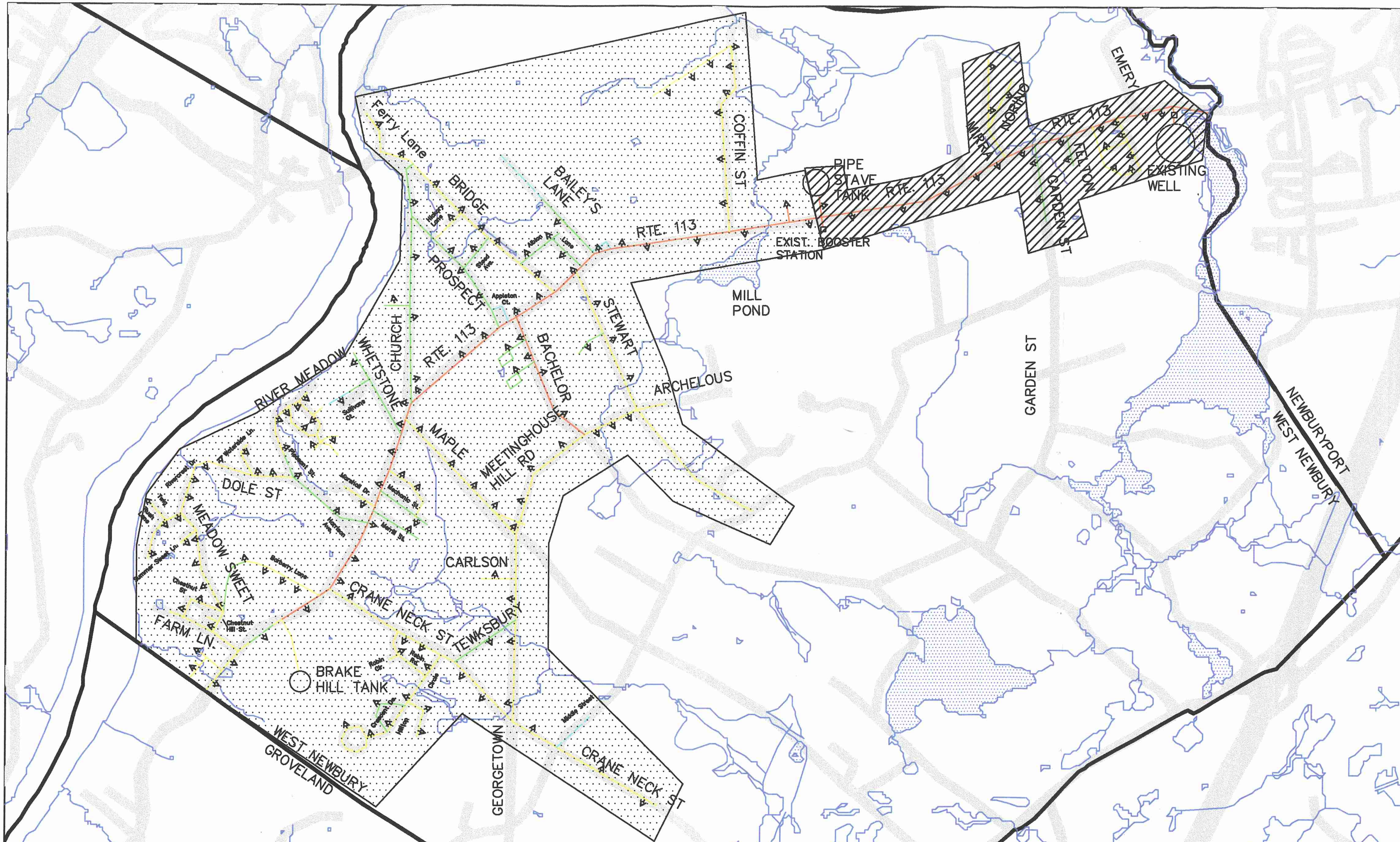
- 10" Water Main
- 8" Water Main
- 6" Water Main
- 2" Water Main
- Hydrography
- Town Line
- Roads

JOB NAME: WATER SUPPLY MASTER PLAN
LOCATION: WEST NEWBURY, MASSACHUSETTS

Figure 5-1

DESCRIPTION: EXISTING WATER DISTRIBUTION SYSTEM
SOURCE: WEST NEWBURY WATER DEPARTMENT

DRAWN BY: CR	CHECKED BY: ML
SCALE: 1" = 1800 FT	
DATE: DEC. 2000	
JOB NUMBER	SHEET



NO.	DATE	DESCRIPTION	BY

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

LEGEND
- 10" Water Main
- 8" Water Main
- 6" Water Main
- 2" Water Main
- Hydrography
- Town Line
- Roads
- High Pressure Zone
- Main Pressure Zone

JOB NAME: WATER SUPPLY MASTER PLAN
LOCATION: WEST NEWBURY, MASSACHUSETTS

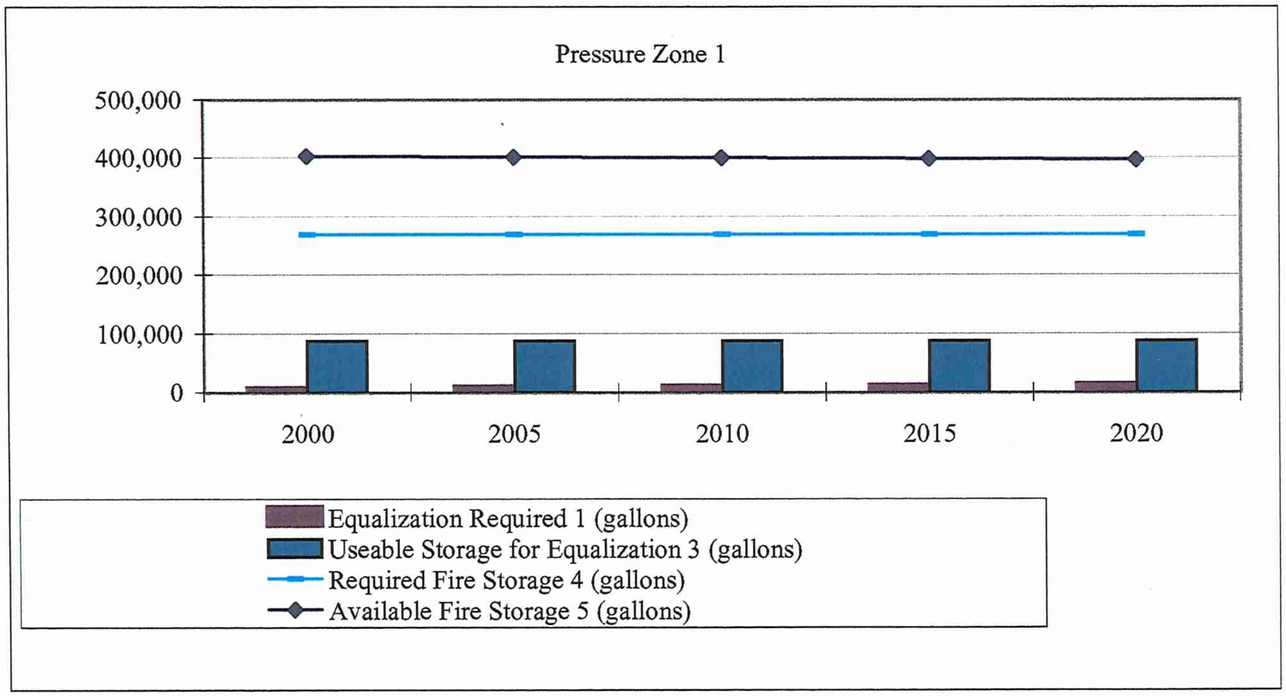
Figure 5–2

DESCRIPTION: EXISTING PRESSURE ZONES
SOURCE: WEST NEWBURY WATER DEPARTMENT

DRAWN BY: CR	CHECKED BY: ML
SCALE: 1" = 1800 FT	
DATE: DEC. 2000	
JOB NUMBER	SHEET

Figure 5-3. Storage Analysis
Pipestave Tank - Main Pressure Zone 1

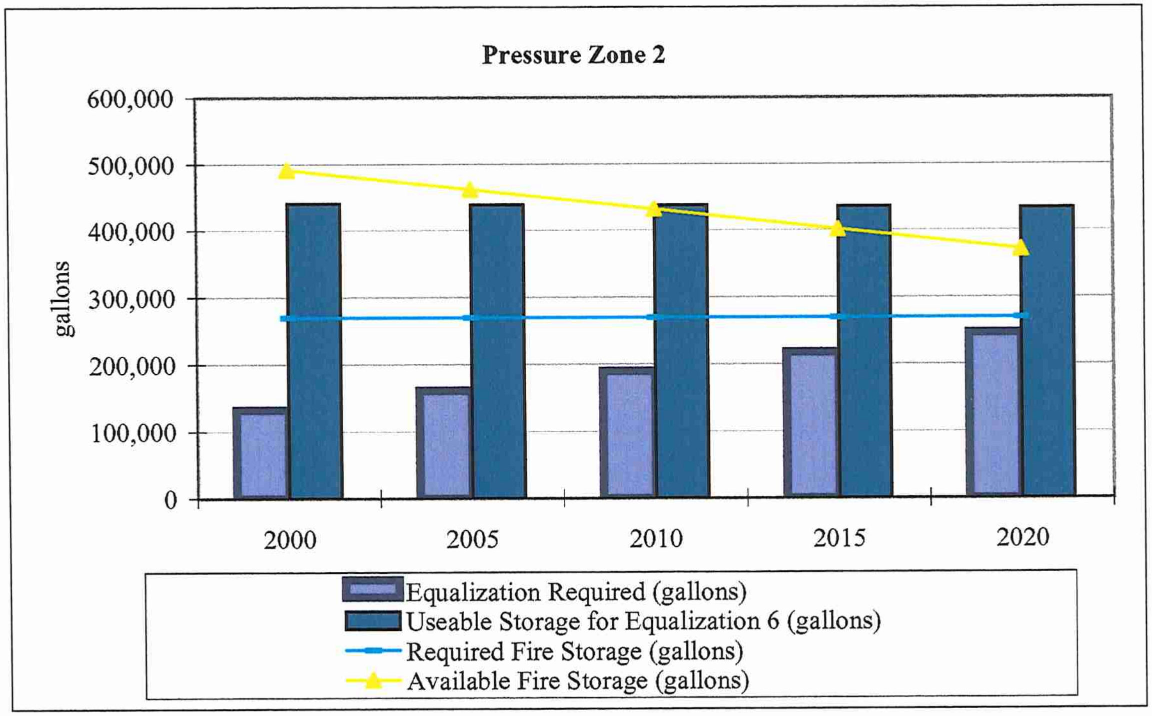
	Max Day	Equalization Required [1] (gallons)	Total Useable Storage [2] (gallons)	Useable Storage for Equalization [3] (gallons)	Adequate Equalization?	Required Fire Storage [4] (gallons)	Available Fire Storage [5] (gallons)	Adequate Fire?	Emergency	Deficit
2000	28,000	7,000	410,025	86,975	yes	270,000	403,025	yes	Newburyport	no
2005	34,000	8,500	410,025	86,975	yes	270,000	401,525	yes	Newburyport	no
2010	40,000	10,000	410,025	86,975	yes	270,000	400,025	yes	Newburyport	no
2015	46,000	11,500	410,025	86,975	yes	270,000	398,525	yes	Newburyport	no
2020	52,000	13,000	410,025	86,975	yes	270,000	397,025	yes	Newburyport	no



Notes:
1. Equalization = 25% of maximum day demand weigted for each pressure zone
2. Total useable storage = amount of water available in a full tank to keep system pressures above 20 psi
3. Useable storage for equalization = the amount of water available that keeps system pressures above 35 psi
   = 86,975 gallons from Pipestave Hill Tank (7 feet of water)
   = 36,995 gallons from Brake Hill Tank (7 feet of water)
4. Required Fire Storage = 1500 gpm for 3 hours
5. Available Fire Storage = Total useable storage volume minus volume used for equalization

Figure 5-4. Storage Analysis
Brake Hill Tank - High Pressure Zone 2

	Max Day	Equalization Required (gallons)	Total Useable Storage from Brake Hill Tank (gallons)	Useable Storage for Equalization [6] (gallons)	Adequate Equalization?	Required Fire Storage (gallons)	Available Fire Storage (gallons)	Adequate Fire?	Emergency	Deficit*
2000	532,000	133,000	184,975	440,020	yes	270,000	491,995	yes	Newburyport	no, with booster station
2005	646,000	161,500	184,975	438,520	yes	270,000	461,995	yes	Newburyport	no, with booster station
2010	760,000	190,000	184,975	437,020	yes	270,000	431,995	yes	Newburyport	no, with booster station
2015	874,000	218,500	184,975	435,520	yes	270,000	401,995	yes	Newburyport	no, with booster station
2020	988,000	247,000	184,975	434,020	yes	270,000	371,995	yes	Newburyport	no, with booster station



Notes:

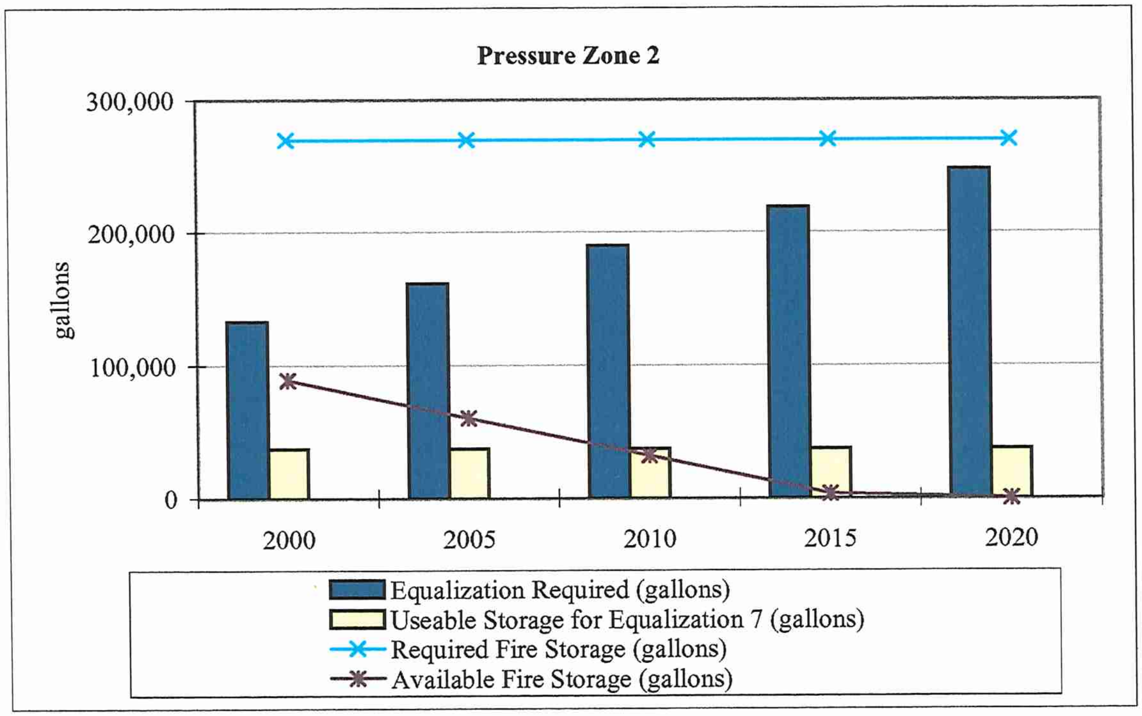
6. This analysis assumes that a generator is operational at the booster station and therefore excess water in Pipestave Tank can be used for equalization and fire at Brake Hill Tank. Therefore, total useable storage for equalization at Brake Hill Tank is 36,995 gallons + excess from Pipestave (water left over after taking into account equalization for main pressure zone

* Note that if the booster station has no emergency power, this tank cannot provide adequate storage for these needs in 2000 and beyond

Figure 5-5. Storage Analysis

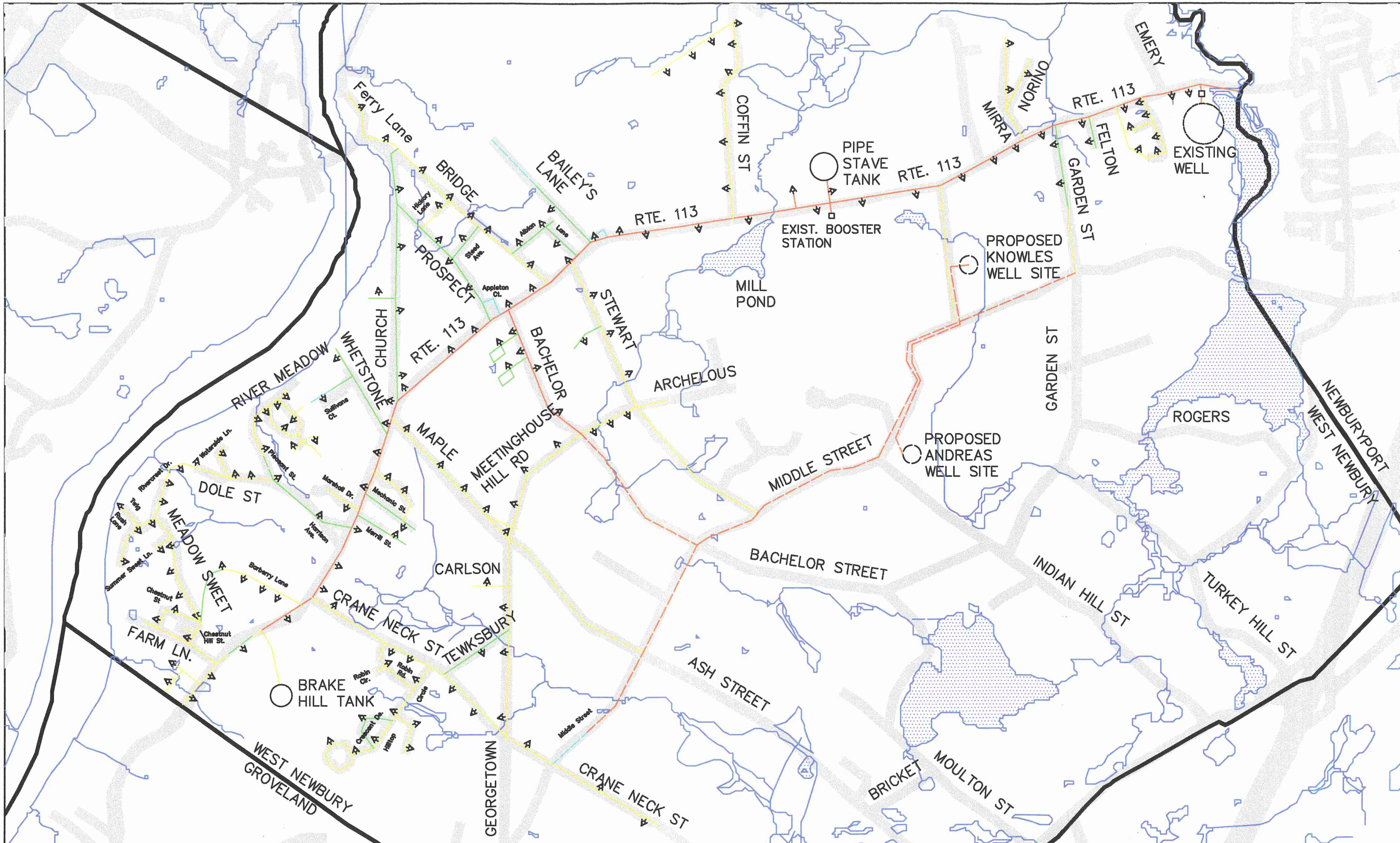
Brake Hill Tank - High Pressure Zone 2, No Generator

	Max Day	Equalization Required (gallons)	Total Useable Storage from Brake Hill Tank (gallons)	Useable Storage for Equalization [7] (gallons)	Adequate Equalization?	Required Fire Storage (gallons)	Available Fire Storage (gallons)	Adequate Fire?	Emergency	Deficit
2000	532,000	133,000	184,975	36,995	yes	270,000	88,970	yes	Newburyport	YES
2005	646,000	161,500	184,975	36,995	yes	270,000	60,470	yes	Newburyport	YES
2010	760,000	190,000	184,975	36,995	yes	270,000	31,970	yes	Newburyport	YES
2015	874,000	218,500	184,975	36,995	yes	270,000	3,470	yes	Newburyport	YES
2020	988,000	247,000	184,975	36,995	yes	270,000	0	yes	Newburyport	YES



Notes:

7. This analysis assumes that a generator is NOT available at the booster station and therefore excess water in Pipestave Tank CANNOT be used for equalization and fire at Brake Hill Tank. Therefore, total useable storage for equalization at Brake Hill Tank is



NO.	DATE	DESCRIPTION	BY

COMPREHENSIVE ENVIRONMENTAL INCORPORATED

LEGEND

- 10" Water Main
- 8" Water Main
- 6" Water Main
- 2" Water Main
- Hydrography
- Town Line
- Roads

JOB NAME: WATER SUPPLY MASTER PLAN
LOCATION: WEST NEWBURY, MASSACHUSETTS

Figure 5-6

SOURCE: WEST NEWBURY WATER DEPARTMENT
DESCRIPTION: POTENTIAL FUTURE WATER DISTRIBUTION SYSTEM

DRAWN BY: CR | CHECKED BY: ML
SCALE: 1" = 1800 FT
DATE: DEC. 2000
JOB NUMBER | SHEET

6.0 Financial and Management Considerations

6.1 Financial

Metering & Billing

The water department reads customer meters and bills every 6 months. There are 865 customer meters, mostly Badger meters, but also some Neptune and Carleton meters. Meter replacement was discussed in Section 5.5.

Each meter is read by the operator and recorded in the record book. Meter readings are taken in gallons. The current meter reading is subtracted from the previous meter reading to obtain the total gallons used since the last meter reading. This amount is then recorded into a computer program for billing. The computer program is a batch pilot program that the Water Department received from the state. The department reports that there have been no problems with this billing system in the past. If a meter reading appears to have decreased significantly from the previous billing, the operator is sent out to double-check the meter.

West Newbury Water Department offers a 2% discount on the customer bill if paid within 10 days. In addition, if the bill is late, a fee of $5 plus 14% interest is added to the bill. A demand of payment notice is sent to customers with past due accounts at 30 days. Final notices are sent out seven days after the demand of payment. If the final notice is not paid, then a "red card" is delivered. The customer then has seven days to pay the past due bill or the water service is shut off. As a result, there are no past due accounts. A water lien has only been needed once in the past 10 years. However, note that the late charges ($800) go directly to the general fund for the town and not the Water Department.

CEI recommends simplifying the late charge assessment to a flat fee of $25 as this may generate revenues from those who cost the most in collection efforts. These are used by many utilities in Massachusetts. The revenues generated from late fees should revert to the Water Department account.

Budgeting

Annual Budget

The Board of Water Commissioner, Water Superintendent, and Water Department Administrative Assistant prepare the budget each year for the Water Department.

The budget includes items for:

1. Total salaries and wages
2. Facilities expenses (heat, electricity, phone)
3. Office expenses (postage, bottled water, printing, advertising, office supplies, and office equipment maintenance)
4. Reserve fund repayment
5. Professional Association (dues, licenses, expenses, education, legal)
6. Outside Services/Training (consulting, state road opening permits, instrumentation control maintenance, water testing, and seminars)
7. Computer expenses (computer consultants, maintenance, supplies)
8. Vehicle/Equipment expenses (gas, maintenance, equipment rental, tool rental)
9. Materials/Supplies (water purchase from Newburyport, chemical, meter materials, brass goods, hydrant materials, road repair materials, outlays/tool purchase, equipment purchase, planned system maintenance)
10. Safe Drinking Water Assessment
11. Insurances
12. Debt Service

The budget is prepared in December of each year and a final budget is due to the Financial Director in January of the following year. West Newbury also has a Form B – Capital Project/Equipment Request form to fill out for new projects or necessary equipment.

Budgeting Capital Improvements

A list of projected capital improvements is submitted with the budget at the annual town meeting. Past capital improvement plans are kept at the Water Department at the Town Offices. The Finance Director keeps copies of the capital improvements for other departments.

Capital projects are typically submitted with a Form B (see Appendix G). Previously, capital improvements have been funded by anticipating Water Revenue and with the Water Unreserved Fund Balance Account (potential carryover amounts). The Finance Director keeps the capital improvement Form B's.

Accounting

The Water Department's accounting occurs on two levels. At the department, the administrative assistant keeps source records such as meter readings, budgets and expense tracking. Financial accounting is done at the town level, with the water department classified as a "special revenue" account. The town can choose to 1) continue using a Special Revenue Fund; 2) adopt Enterprise Accounting or 3) use a department budget account. The advantages of each are described below.

Special Revenue Fund

The Water Department provides public water under a 1936 special act of the legislature that designates an elected Board of Water Commissioners and allow them to set water rates. The Act also calls for operating the department using a Special Revenue Fund.[a] Special revenue funds are restricted funds. Their application is restricted to specific areas of expenditure as established by statutory requirements or policy. West Newbury's Special Revenue fund for water, according to the town's auditor, is not too different from an Enterprise Fund or Account. The purpose of the fund is to allow the department to carry over revenues from one year to another.[b]

Enterprise Account or Fund

The Enterprise Accounting method is highly recommended by both DEP and the Department of Revenue (DOR). It allows better carryover of monies, which may be important in future years. As with the Special Revenue Fund, revenues should be generated by ratepayers, but if a deficit occurs, money can be transferred into the Department from the Town's general fund. Money cannot be transferred out, however.

Although the use of the Special Revenue Fund has essentially the same effect over the last 10 years, the use of Enterprise Accounting would formalize the separation of the department in terms of costs. Amounts of money or services from other town departments are shown within the financial information similar to the accounting for transactions for outside entities.

The use of an Enterprise accounting method would not be a big change from the current use of a Special Revenue Fund, and is likely required under the new Government Accounting Standards Board (GASB) Statement 34.[c] Statement 34 requires that municipalities account for infrastructure in accordance with specific procedures, including expanded depreciation, and requires the use of Enterprise Funds for some rate-based utilities. West Newbury is in Phase III of Statement 34, meaning the accounting changes are scheduled for 2003.

Department Budget

Many water departments operate under the umbrella of the community either in a Department of Public Works budget or a separate Water line item. Most larger communities have, over time, incorporated the small water districts and commissions with separate boards under a Town Manager/Administrator. Usually this is related to local politics and occurs when the water board fails to adequately provide adequate or safe water and town officials believe they can do a better job under a public works umbrella. However, in well-run water boards/departments, the separation usually prevails and the water district or commission grows larger.

An advantage of this system is better coordination with other town departments. A major disadvantage is that the nature of water supply requires a complex operation and understanding for good decision-making. Water departments that operate with Boards of Selectmen acting as Water Commissioners are at a great disadvantage because the staff is afforded only a few minutes each week at the Selectmen's meeting, while separate water boards have their own dedicated water commissioners.

Another advantage of this system is that the water department can operate in deficit, essentially borrowing from the general fund when expenses exceed revenues and sometimes for all capital projects. However, this is a double edged sword in that excess revenues may also be taken out of the water budget.

CEI's experience has been that the latter occurs more often than the former, resulting in some of the most neglected systems in the state. This is largely because a water system's needs are not necessarily easily understood or seen. Major expenses for cleaning and lining of tuburculated pipes, for example, must now compete with the new fire truck, policeman or smaller classroom size – and the result is usually putting off pipe rehabilitation and other expenditures except for dire emergencies.

CEI recommends that the town obtain a written opinion from the Department of Revenue on whether the existing Special Revenue Fund will be adequate under Statement 34. If so, then this accounting could be maintained in place. CEI recommends Enterprise Accounting, but recognizes the difficulty of the change.

Converting to a department fund is possible but would probably end up in an Enterprise Account as a result of Statement 34. Also, CEI recommends that either 1) a separate board be maintained for the water department so that elected officials can devote the necessary time to the subject; or 2) if the water department is placed under a Department of Public Works at some point in the future, that the Public Works director have a strong water supply background. Methods other than tapping townwide tax revenues for capital projects are discussed below.

Cost Distribution

There are several ways that costs can be distributed to residents of West Newbury. Typical systems use either a department budget-based system where deficits and sometimes capital projects are funded out of the Town's general fund, while other systems pay for all budgeted and capital improvement items through rate-based user charges. All systems have potential benefits and drawbacks. Further, there are additional methods that can be adapted for use in West Newbury. Some of these are described below.

Subsidies to Water Department, Enterprise Fund Accounting

Subsidies through the Town general fund may be applied to the Water Department. The enterprise fund accounting indicates the amount of subsidy financed from taxes or otherwise, but does not prohibit the subsidy. For example, the town could implement a policy of allocating monies to cover some proportion of the water department budget or to cover capital items only from the general fund. A legal opinion would be needed to determine whether this is allowable under the Water Department's existing legislation.

General Obligation Bonds

Capital items could be paid for through the Town's general bonding capability. This could be done instead of bonding through the Water Department's Special Revenue Fund, although again, a legal opinion should be sought on whether this is allowable.

Revenue Bonding

Instead of general obligation bonding through the Town, the Water Department could directly bond for capital expenditures. Direct Water Department revenues will then be needed to pay the principal and interest.

Environmental Mini-Bonds

The Water Department and/or Town could issue mini-bonds. These are bonds that are issued in small denominations, such as $500, for purchase by the general public. The proceeds could be designated for specific capital projects. The Environmental Finance Center reports that the cost of issuing mini-bonds is $6-8 per thousand dollars of bond, so a mini-bond for a $600,000 capital project might cost as much as $10,000. The costs for administrative handling, the bond council, charges by rating agencies and printing and distribution of official statements should be investigated prior to further consideration.

Marginal Cost Pricing

This method is the way to recoup the costs of the existing water system assets through new users. It is typically done through a hookup charge that is in the thousands of dollars. This type of pricing is usually considered the most fair since new users pay for the full cost of the extension to connect them and existing users are unaffected.

As discussed in Section 2.1, the projected population provided in the Comprehensive Plan (assuming build-out in year 2020) is approximately 7,800. With 3.1 persons per household, a total of 2,517 households might be added. If roughly 65% of the Town's households obtain water service, it could mean as many as 1,500 new services. There are a great deal of unknowns, however, since not all of these new residences will be on town water, and the build-out may not occur as rapidly as projected. If the Department added another 1,500 customers, the current new service tie-in fee of $1,500 could generate as much as $2.2 million. Alternatively, the new service tie-in could be doubled to $3,000 and generate as much as $5 million through build-out.

Rate Changes

Rates could be modified to generate the additional revenue needed for capital and other improvements. While the Town currently has some of the higher rates in the area, (see Table 6-1) in reality most of these rates are probably on their way up. The towns with the lowest rates are much larger communities and have a much larger rate base. Additionally, these communities have new surface water rules related to disinfection byproducts to contend with. These may increase rates substantially for these systems. The next most cost-effective systems are small groundwater-based communities (Groveland and Georgetown). Neither of these communities purchase water outside and have stabilized rates because of their groundwater supplies. Since they have more than double the number of customers that West Newbury has, they are naturally more cost-effective. The next systems on the rate chart include Amesbury, Ipswich and Merrimac. Although their rates may currently be lower than West Newbury's, the treatment plants for both Amesbury and Ipswich were built more than 20 years ago during the construction grants days when the federal government paid 90% of capital costs for water treatment improvements. Once these plants upgrade, as will probably be needed in the next ten years, these costs may increase substantially.

It is also notable that despite the fact that West Newbury has rates that are higher on this table than most others in the area, they still only represent an annual charge of less than $500. Considering the importance of drinking water to life and for use in fire suppression, $500 is not excessive. Most residents of West Newbury probably pay that much during two months of another utility's bills.

The Town's current rate structure and proposed modifications are discussed further below.

Rate Structure

The Town currently supplies water to 858 users, approximately 65 percent of the Town's water users. The average customer uses 222 gallons per day during the fall, winter and spring months. During the summer months, the average usage increases to 466 gallons per day due to irrigation demands.

The existing rate structure (effective Fall 1998) consists of a flat usage rate of $5.25 per 1,000 gallons and customers are billed semi-annually. The table below provides a summary of the average user annual charges under the existing rate structure.

USAGE CHARGES: EXISTING RATE STRUCTURE		
AVERAGE USER	**USAGE CHARGES**	**AVG. USER BILL (Semi-Annual)**
222 gpd	*$5.25 per 1,000 gal*	$212
Total Revenue from Usage Charges (FY 1999) = **$387,230**		

In addition to the usage charges, users are also charged for several "miscellaneous fees" for water services, as shown in the next table.

MISCELLANEOUS FEES: **EXISTING RATE STRUCTURE**	
DESCRIPTION	**FEE**
Unscheduled Meter Reading	$30
Turn-On/Offs (@ Owner's Request)	$25
Meter Testing (@ Owner's Request)	$30
Push Fee	$500
Backflow Testing	$50
New Development Charges	
Mainline Tap Charge	$425
New Service Tie-In	$1,500
New Meter	$100

Penalty Fees	
Late Payment Fee	$5
Interest On Overdue Accounts	14%
Total Revenue from Misc. Fees (FY 1999) = **$21,700**	

The Water Department is not currently operating in a deficit. However, operation and maintenance costs increase annually and significant increases in expenses may be incurred if Newburyport increases their water rates and as capital improvement projects are implemented and another operator hired. It is likely that the Town will be facing all three of these increased expenses, especially with the high rate of development expected throughout the Town. To cover these additional expense there are several options:

- Increase the existing usage rates;
- Increase the miscellaneous fees currently charged and/or initiate new charges; or
- Modify the existing usage rate structure.

As stated in the Town of West Newbury Comprehensive Plan, the current usage rates of $5.25 per 1,000 gallons are somewhat high, although water is still one of the least expensive commodities available. Nonetheless, increasing the existing usage rates is not recommended as a way to cover additional expenses described above. Instead, the Town should evaluate the other sources of revenue, thus reducing the impact to the average user of the system and possibly forcing excessive water users to pay for any increases in system demand.

The American Water Works Association (AWWA) states that the water rate schedules should be established with equitable charges to all customers that are commensurate with the costs of providing the service. In addition, one must consider the objectives of the community, the utilities operations and economic environment, and the water customers. In accordance with the AWWA Manual of Water Supply Practices M34 Alternative Rates, rate structures must be evaluated for the following prior to adopting a new rate structure:

1. Financial Sufficiency;
2. Ease of Implementation;
3. Impact on Customers;
4. Equity to All Customers;
5. Water Conservation;
6. Simplicity and Understandability by Customers; and
7. Legality.

The MA DEP often requires Towns to adopt an increasing block rate structure in Administrative Consent Orders. It is also encouraged by DEP as part of Water Management Act Permit(s) for new source approval and other permits. The increasing block rate structure is also recommended by AWWA for those systems where water is in short supply and industrial customers are not a major factor in the local economy. This encourages water conservation while easing the financial impact on average users.

The increasing block rate structure for the Town of West Newbury could be established so that the usage less than the average (222 gpd) is charged at the same rate of $5.25 per 1,000 gallons while usage greater than the average is charged at a higher rate. This higher rate is generally set at a 50% increase or approximately $7.80 per 1,000 gallons. This rate structure minimizes the impact to the average user while forcing excessive users to pay for the increased demand on the system.

Service charges are another source of generating fixed revenue and are used by many Massachusetts water systems. The existing rate structure is based solely on revenue from usage. This means that during a year when usage is low, which can occur if there is a lot of rain during the summer months, then revenues will be low. Variable revenues are those revenues based on system production, however there are also fixed costs which do not vary depending on production (i.e., rent, debt payments, etc.). In order to "flatten" this uncertainty in revenue, a service charge can be instituted.

Generally service charges are a way to cover a portion of the fixed costs associated with the cost of providing service. With 858 users of the system a service charge of only $30 semi-annually would generate an additional $50,000 each year. It is also recommended that these service charges be higher for those with larger meters. Most communities charge at least $25 per quarter for a service charge and some use minimum charges that include some minimal usage amount. These charges should be adjusted to pay for capital improvements and additional staffing.

The miscellaneous fees charged by the Town may be a large source of income when new development begins. The current fees seem reasonable, however, it is important that strict development guidelines be instituted requiring separate metered accounts for each unit. This will help ensure that each user is charged equally for their usage. Another option for revenue under miscellaneous fees is a hydrant charge. Typically hydrant charges can range from $20 to $50 per year for customers within a 600-foot radius of a hydrant. This charge recognizes the added benefit of those users near a hydrant. The water department currently maintains 181 hydrants throughout the Town.

RECOMMENDED ADDITIONAL REVENUE SOURCES		
Increasing Block Rate Structure		**Potential Revenue**
Usage Charges	*$5.25 per 1,000 gal. for usage < 222 gpd* *$7.80 per 1,000 gal. for usage > 222 gpd*	unknown*
Service Charges		
Service Charges	$30 semi-annually	$50,000/year
Miscellaneous Fees		
Hydrant Charges	$50 annually for users within 600 feet of a hydrant	$40,000/year

*a detailed rate analysis is needed to evaluate revenue from this change.

State and Federal Funding Opportunities

West Newbury currently funds all projects through rates and service charges. Future projects may be fundable, to a limited extent, through other programs. Several programs are in existence, including:

Community Development Block Grant (CDBG) Program

A federal grant program administered in Massachusetts by the Massachusetts Department of Housing and Community Development. For non-entitlement communities (West Newbury is not an entitlement community and is therefore eligible for this program based on this requirement) populations must be under 50,000 and the projects must benefit low (<51% of area median income) and moderate (80% of area median income) income communities. Water lines and other infrastructure projects are eligible for funding. Unfortunately, West Newbury would have a tough time establishing the benefit to persons of low and moderate income due to its affluence.

United States Department of Agriculture Rural Utilities Service

Grants and loans available to communities with populations under 10,000 for the upgrade and repair of water systems. In addition, funds can generally be used for the purchase of land for siting these systems. Grants may be available to communities as needed when such infrastructure would significantly impact rates that are already high. Grant and low interest loan combinations are most common.

This program again has a low and moderate-income component, however there is some preference given to those communities with high water rates. This may provide an edge to West Newbury over the eligibility criteria used for the CDBG grants.

Funding allocations vary yearly, but average $7M-$10M for loans and grants combined. Applications are accepted year-round and materials to submit a preliminary eligibility application are available through the Wareham USDA office or by calling (508) 295-5151 and speaking with Mr. Tom McGarr.

State Revolving Fund -Drinking Water SRF

This fund is administered by the Massachusetts Department of Environmental Protection (MADEP) and provides low interest loans for projects that improve or protect drinking water supplies and distribution systems. MADEP adds preference to applicants that provide supporting documentation (such as this Water Master Plan), which has established need through accepted engineering and planning principles.

Applications are generally due in summer. This application requires a fair amount of detail from different sources, so it makes sense to begin the process early.

United States Department of Commerce Economic Development Administration

These grants can be used for a variety of projects and some of the assistance has been for water supply projects. The sums of money can be quite large, however the program is geared towards communities that are underdeveloped and have high unemployment.

Because West Newbury values its rural character and is not looking to develop a significant industrial sector to supply jobs to the unemployed, this program may not be suitable for the town. If at some point in the future the town is looking to provide an attractive environment for a large industry that is limited by West Newbury's infrastructure limitations, this program may be one to pursue.

Massachusetts Department of Environmental Protection Wellhead Protection Grants

These grants are available to public water suppliers for the protection of wellhead areas. Although the funds awarded may be less than many of the other grants described above they are well suited to small implementation projects. Wellhead Protection Grants may be used to:

- Install Fence Around Zone I
- Develop Wellhead Protection Plan & install controls
- Install Stormwater Best Management Practices
- Relocate Underground Storage Tanks (USTs) or septic systems within Zone I/II
- Lightning Protectors for wellhead
- Emergency response plans
- Drainage surveys near wellhead
- Conduct stormwater sampling
- Public information/announcements
- Post signs
- Install monitoring wells & sample
- Floor drain inspections & elimination
- Develop database of hazardous materials use/storage for local planning
- Develop or update local wellhead protection plans (best management practices, contingency plans, emergency response plans)
- Create or purchase GIS data layers and develop databases
- Storm water drainage improvements in recharge area of Public Water Supply (PWS)

Ineligible projects:

- Land or conservation restriction purchases
- Zone II delineations
- New wells or exploratory wells
- No corrosion control, security systems or back up power

Some of the features that a successful application should include are that it benefits the supply source, is a long-term solution, supports ongoing or planned efforts and that the project is implementable.

Most of the eligible projects shown above (except those related to businesses in the Zone II or III, which there are none) may be applicable to West Newbury and could be planned as part of a long-term wellhead protection program.

6.2 Management

Water Department Manpower Evaluation

Board of Water Commissioners

Currently the Board of Water Commissioners includes three people. Each person serves a three-year term with one person being replaced every year. The current Water Commissioners are:

David D. Jennell, term expires 2001
Raymond S. Dower III, term expires 2002
Richard Thurlow, term expires 2003

The Board of Water Commissioners meets every third Monday of the month at 7 pm. Typically, a meeting lasts between 2 and 4 hours. Notices of the meeting are posted on the Town Clerk's Bulletin Board 48 hours prior to the meeting time. Meetings are held generally to discuss any issues within the Water Department such as water quality, maintenance, repairs, billing, and Water Department correspondence. The Board of Water Commissioners also approves the budget every year for the Water Department.

Non-public sessions are held in the Town of West Newbury to discuss the competence, dismissal, discipline, or criminal misconduct of a town employee. Other reasons include strategy sessions, purchase of land, or initial screening of candidates for employment. These sessions must be convened in an open meeting. The chairperson announces the purpose of the Executive Session and a majority vote must be recorded.

The Board of Commissioners may wish to consider adopting an annual agenda in addition to discussing issues on an ad hoc basis. Some boards also establish formal commissioner assignments such as "personnel," "distribution," "rates" and "water quality/quantity." This can be helpful in establishing in-depth review procedures for the issues of the day. The board may also wish to consider making the minutes subject-specific, for example, the topic heading/the discussion/the vote or decision. This is helpful should legal actions ever require review of the minutes.

Water Department Personnel

The West Newbury Water Department is operated by three people. An Administrative Assistant, Water Superintendent, and Certified Licensed Operator. All are full-time positions and the operator certification is adequate. The Superintendent position is salaried, but the other two are hourly positions.

Every public water system must be operated by a certified Primary and/or Secondary Operator unless approved in writing by DEP (310 CMR 22.11B). DEP recommends that systems be operated by a certified operator for both treatment and distribution. The degree of certification is based on the treatment and distribution system classification rating.

Treatment system classifications are based on the treatment rating system as defined by the MA DEP Drinking Water Regulations. West Newbury treatment includes the addition of potassium hydroxide (KOH) for pH adjustment, fluoridation and chlorination. Based on the rating system, West Newbury is a Class II-T system. There are two operators in West Newbury. One has a Class II-D and Class III-T certification. The other is Class II-D and Class II-T certified. Distribution system classification is based on population served. Since West Newbury serves a population between 1,501 and 10,000, the distribution system rating is Class II-D.

MA DEP Drinking Water Regulations indicate that a public water system using treatment must be operated at least one day per week by a primary operator certified at least at the level of classification of the treatment system. A secondary operator shall also be available one day per week that has operator certification at no less than one class below that of the level of classification of the treatment system. Automated systems (such as SCADA) often result in less staff required by DEP during routine operation.

The Water Department follows the Personnel Bylaw and Policy of the Town of West Newbury. There is no employee manual specific to the Water Department.

Small systems often lack an economy of scale, so labor costs tend to be a larger proportion of the budget than they are in larger systems. While the current staff level in West Newbury is adequate for administrative purposes, additional staff are needed for responding to water main breaks and probably during construction season as development increases. However, hiring additional full time staff will strain budgeting. Borrowing of Public Works staff now occurs on an as-needed basis to supplement labor forces. This practice should be expanded and formalized to assure that the staff has adequate training and is budgeted. In addition, the department should hire a full-time summer laborer to assist with distribution system work during this busy season.

In addition to sharing of staff, West Newbury may wish to explore whether some of the free services available from the Northeast Rural Water Association (NERWA) and the Northeast Rural Community Assistance Program (RCAP) such as leak detection, training and other technical assistance could help reduce costs.

Water Department Operations

Emergency Response Plan/Safety Procedures/Cross Connection Control

The Water Department has an Emergency Response Plan that outlines the procedures that should occur in an emergency. A copy of the plan is located at the Water Department, Fire Department and Police Department and is also posted at the existing wellfield.

There are 18 backflow prevention devices within the Town of West Newbury. Each device is tested twice a year by the Water Department. Results are sent to DEP annually.

Specific spill response measures should be added to the emergency response plan by reviewing potential accident locations near the well and future well sites. Drainage should also be reviewed in these areas to see if improvements need to be considered that might someday prevent a spill from approaching the wellhead protection area through drainage. It is further recommended that chemicals that must be stored outside be stored in a specially-protected chemical storage tanks and a fence should be installed around the wellfield. The department is now represented on the Local Emergency Planning Committee (LEPC) as required under the Emergency Planning and Community Response Act (EPCRA) since the Water Commission Chair is also with the Fire Department. Typically the Fire Department takes the lead in LEPCs and the department should continue to coordinate either through commissioners or the superintendent.

Water Conservation – Drought Contingency Plan

Water conservation efforts in West Newbury include:

- Information to local newspapers on water conservation
- Leak detection kits included in water bills
- Water use restriction bylaw with fines for violations
    1. Odd/even day watering bans
    2. Outdoor watering ban
    3. Outdoor watering hours
    4. Prohibition on filling swimming pools
    5. Prohibition of automatic sprinkler use
- Rain sensor bylaw

The use bylaws should go well with developing serious water conservation efforts in West Newbury. As described previously, a policy or bylaw on topsoil removal and on drought tolerant vegetation could also be added. The department should also add a policy on full outside odd/even watering ban.

Unaccounted for Water and Leak Detection

Unaccounted for water is the amount of water lost in a system between the source and the customer meters. Unaccounted for water can be lost in a variety of ways:

- Inaccurate meters (usually under-read) due to normal wear and tear, damaged registers, broken seals, bypass lines, calibration
- Improperly sized meters
- Accounting and billing inaccuracies (estimating the amount of water used rather than using a meter)
- Unmetered uses (i.e., fire department, roads and drainage washing, construction, line flushing)
- Leaks

The Water Department currently keeps track of unmetered uses such as fire use and Water Department use. All accounts are metered, which eliminates inaccuracies due to estimation. Unmetered or unaccounted for water was discussed further in Section 2.2. Water conservation information may be found in Appendix D.

Bylaws & Policies

There are several bylaws in place in West Newbury to protect the town's water supply. These include:

- Groundwater Protection District – to protect Zones I and II of the town wellfield;
- Public Water Supply Bylaw – to prohibit unauthorized connections;
- Water Use Restriction Bylaw – for water conservation;
- Rain Sensor Bylaw – to prevent excessive watering during rain.

There are fines associated with violating the Water Department Specifications or Bylaws. These include:

- A fine of $300 per day is charged for unauthorized connections.
- A fine of $300 per day is charged for tampering with water system valves, hydrants, etc.
- A rain sensor bylaw was passed in 1999 requiring rain sensor shut offs on sprinkler systems. A $50 fine per day is imposed after the first warning is delivered.

These fines are enforceable by the Water Commissioners, agents, employees, and West Newbury Police Department.

Written policies in the West Newbury Water Department include the System Development Permit and Standard Specifications for Water Service Installation. These documents include provisions for:

- Application for a service connection;
- Water service, hydrant, and water main material specifications;
- Construction Details;
- Setting curb boxes;
- Location of service pipe;
- Meter pits;
- Electrical ground;
- Subdivision conditions of approval;

Other, unwritten policies include:

- Logging customer complaints and keeping the log in the file cabinet at the Water Department;
- Capital Improvements are funded by bond or budget depending on the balance in the Water Un-reserved fund;
- The procedure for hydraulic analysis of subdivisions is left to the Planning Board.

There are no policies for condominiums or multi-family residences since there are no such connections in West Newbury.

The following policies should be added to the town and/or the department policies, as appropriate:

1. Develop policies on condominiums and other multi-family units to require separate metering of each unit and to specify how they will be charged for connection fees.
2. Formalize all unwritten policies so that future legal problems can be avoided by all customers are treated equally and uniformly.
3. Assure that hydraulics are reviewed by the planning board's subdivision review engineer to avoid potential future pressure and dead end problems.
4. Develop a policy that includes limits on topsoil removal and encouragement of drought tolerant vegetation for new developments.

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[a] Town of West Newbury Comprehensive Plan, February 2, 2000.

[b] Hingston, Dick, West Newbury Financial Auditor, Giusti & Hingston. 12/13/00. Telephone Conversation with Eileen Pannetier, CEI.

[c] Griffith, Everett, Department of Revenue Municipal Division. 12/13/00. Telephone Conversation with Eileen Pannetier, CEI.

TABLE 6-1
Rate Survey of Surrounding Towns

Massachusetts Community		Customers (Approx. Number)	Sources (GW, SW, or Purch.)	Usage Rate ($/1,000 gallons)	Service/Min. Charges (Annual)	Typical User Charges (Annual)
1	Haverhill	15,860	SW	$1.97		$177.60
2	Newburyport	6,400	GW, SW	$2.00	$84.00	$234.00
3	Average					$235.00
4	Groveland	1,650	GW	$3.00	$100.00	$262.00
5	Georgetown	2,400	GW	$2.27	$80.00	$284.00
6	Amesbury	5,100	SW	$3.60		$324.00
7	Ipswich	4,451	GW, SW	$3.77		$339.60
8	Merrimac	1,580	GW	$4.00	$40.00	$400.00
9	**West Newbury**	**840**	**GW, Purch.**	**$5.25**		**$472.50**
10	Salisbury (American WW)	3,000	GW	$3.04	$200.88	$474.48

Typical User 90,000 gallons (annual)

NOTES:

1. All rates converted to $ per 1,000 gallons usage (annual).
2. Service charges or minimum charges totalled over one year.
3. Typical user profile from 1997 Water Rate Survey - MA Communities by Tighe & Bond.
4. Georgetown rates increase to $2.33 per 1,000 gallons for usage > 5,000 cu.ft./quarter.
5. Groveland has a $50 semi-annual charge that includes 18,000 gallons of usage; semi-annual usage > 18,000 gallons charged at $3.00 per 1,000 gallons (usage > 45,000 gallons charged at $6.67 per 1,000 gallons).
6. Newburyport has a $42 semi-annual charge that includes 7,500 gallons of usage.
7. Sources: GW-groundwater wells, SW-surface water (river, reservoir), Purch.-purchase water from other.

7.0 Cost Benefit Analysis

7.1 Feasible Options

As evidenced by the water demand forecasting provided in Section 2.2, additional water sources are necessary to meet the projected future demands. The feasible options to meet the forecasted water supply needs were identified in Section 3.0, which consisted of a screening process to review many types of possible sources. In Sections 4.2 and 4.3, each feasible source was evaluated for water quality issues. Based on these analyses, the feasible options for meeting a portion of the forecasted water supply needs are the following:

1. Continue Existing Operation
2. Develop Knowles Wells (2 wells)
3. Develop Andreas Well
4. Develop Other New Bedrock Well
5. Purchase From Newburyport
6. Purchase From Groveland
7. Demand Management

For each of these options the quantity of drinking water produced was compared to the demand (as shown in Figure 7-1 at the end of the section). As discussed in Section 2.2 and shown on Figure 2-3, the total projected annual demand ranges from 87 million gallons per year (mgy) or 238,000 mgd in the year 2000 to 174 mgy (477,000 mgd) in the year 2020. In this section, these seven options will also be compared based on the quantity of drinking water produced and comparative cost per million gallons (mg). A present worth analysis has been completed for each of the cost options as shown on Table 7-1, while Section 7.2 presents the recommended strategy for meeting demands. The present worth analysis is described first for background information.

Present Worth Calculations

A common method for comparing alternative engineering projects is the Present Worth Method. The calculated Present Worth is the sum which, if invested now at a given interest rate, would provide exactly the funds required to pay all present and future costs. The total project cost, used to compare alternatives, is the sum of the initial capital cost, plus the present worth of operation, maintenance, and repair (OM&R) costs, minus the present worth of the salvage value at the end of the 20-year planning period.

1. Continue Existing Operation

This option assumes continuation of the present situation with no new sources. Costs for purchase of Newburyport water are not included in the present worth table so the well operation itself can be compared to the other options. The existing wellfield has a DEP approved capacity of 160,000 gpd. The annual cost to treat the water and operate and maintain the existing system, including chemicals, power, etc., is about $20,000 (fiscal year 2001 budget). Current treatment at the wellfield includes disinfection, corrosion control and fluoridation.

2. Develop Knowles Wells

The Knowles well site (2 wells) has a combined estimated safe yield of 150 gpm or 216,000 gpd. The estimated cost to develop the Knowles well site is $687,400 as shown on Table 7-2. This cost estimate excludes any land acquisition costs. Much of the cost is in the water main connection, which is a very conservative estimate. Bidding may reduce this portion significantly. However, the higher cost estimate has been retained for a safety factor.

The annual operation and maintenance costs for the Knowles wells are roughly about $20,000. Although this is not a lot higher than the operations and maintenance costs for Wellfield #1, estimated at $15,000 currently, these wells will likely be somewhat less expensive to operate because there are fewer, newer and more efficient pumps but the wells will operate for more hours per day.

Treatment at the Knowles well site will be necessary for disinfection, corrosion control and fluoridation. Sequestering for manganese may also be needed. The cost to put in this treatment has been included in the cost estimate in Table 7-2. Further treatment may also be necessary in the next 10-15 years for arsenic and radon. Arsenic treatment costs could potentially be very high, however the levels of arsenic at the Knowles site are low so it is assumed that filtration treatment technology (or similar) can be used. Radon can be treated effectively with aeration processes with low annual costs. As a conservative approach, the annual treatment costs for arsenic, manganese, radon, and disinfection, corrosion control and fluoridation are estimated at $26,500 over the next 20 years. The cost estimate has used a large building to house the treatment equipment, sized for the potential that more treatment may be needed in 10-15 years.

3. Develop Andreas Well

The estimated safe yield from the Andreas well site is 100 gpm or 144,000 gpd (adapted from DEP, April 2000 letter). The cost to develop the Andreas well site is estimated at $737,100, as shown on Table 7-3. This cost estimate excludes any land acquisition costs. Again, about 5,000 feet of piping significantly increases this cost and actual costs may be less.

The annual operation and maintenance costs for the Andreas well are estimated at about $17,500. Treatment at the Andreas well site will be similar to the treatment discussed for the Knowles well site. Costs for a pre-engineered building have been included, however, treatment may be combined with the Knowles well also. This depends on the results of the preliminary engineering and hydraulics analysis of the best piping routes and entrance points to the distribution system. Treatment will be necessary for disinfection, corrosion control and fluoridation. Arsenic and radon will likely require treatment within the next 10-15 years. The annual treatment costs at this well site is estimated at $26,500, which is a conservative estimate considering treatment at this well for arsenic and radon may not be necessary for several years depending on future treatment rules.

4. Develop Other Bedrock Well Site

The fracture trace analyses completed by D.L Maher Company in 1983 and 1993 identified 12 potential locations for deep bedrock wells in West Newbury. Two of the sites have been investigated, and have been called the Andreas and Knowles well sites. For the purposes of this assessment, it is assumed that a new bedrock well will produce approximately 100 gpm or 144,000 gallons per day (gpd) based on the earlier investigation. Further investigations would have to be completed to confirm this assumption. The costs to develop a new bedrock well are estimated at $500,000 assuming there are similar issues as found with the Knowles and Andreas wells.

Treatment will likely be necessary at a new bedrock well, similar to the Knowles and Andreas well sites. Again, a placeholder of $26,500 has been used for annual treatment costs for future treatment of arsenic and radon and initial sequestering for manganese control, if needed. Disinfection, corrosion control and fluoridation costs are included. As with Knowles and Andreas, the costs for constructing arsenic and radon treatment facilities has not been included in the capital costs, except for the routine disinfection, fluoridation and sequestering.

5. Purchase from Newburyport

The maximum volume of water that could be transferred from Newburyport in the existing pipeline system (without modifications) is 117,000 gpd if West Newbury's wellfield is on because of a hydraulic restriction. For this analysis, it is assumed that West Newbury will purchase 20 mg annually, mostly during the summer months. This option provides supplemental water only and is not considered a stand-alone option. The cost to purchase this water is assumed to increase to $3.25 per 1,000 gallons over the 15-year period with no contract. The annual cost to purchase 20 mg at this rate is $65,000.

Annual operation and maintenance costs for the Newburyport water, which includes costs to pump the water, are estimated at $15,000 because of the larger size pump and the restrictions in the receiving water main that increase electricity costs. Costs for treatment are estimated at about $6,500 for disinfection, corrosion control and fluoridation.

6. Purchase Water from Groveland

The Town of Groveland recently put a new well on-line. As a result, Groveland has some extra capacity that could be used to service West Newbury. Based on conversations with the Town of Groveland, approximately 20 million gallons per year over the next 15 years may be available for West Newbury to purchase. This is the same volume assumed for purchase from Newburyport (Option 5). Capital costs for the infrastructure rehabilitation required prior to transferring water from the Groveland connection includes: replacing approximately 3,000 linear feet of pipe with new 8" pipe; and upgrading the existing booster station near the Groveland/West Newbury town line. The capital costs to complete this work are approximately $380,000, however, it is possible that a developer will do some of this work. The annual costs for operation and maintenance, including pumping costs, are estimated at $15,000. Treatment costs for this option are about $6,500, which covers the cost of chemicals (such as disinfection).

The cost to purchase water from Groveland would need to be negotiated with the Water Board, however the current rate structure for customers is $3.00 per 1,000 gallons for usage less than 89,760 gallons per year. Usage greater than this amount is charged at $6.68 per 1,000 gallons for residential customers and $5.35 per 1,000 gallons for commercial customers. For this option, the costs to purchase water from Groveland were assumed to increase to $3.50 per 1,000 gallons over the 15-year period. The annual purchase cost for 20 mg at this rate is $70,000.

7. Demand Management

Options 2 through 6 summarized above describe feasible water supply sources that can be implemented to help meet West Newbury's demand for water. No one option alone can provide enough water to meet demand.

As discussed in the water demand forecasting in Section 2, maximum day demand is the one-day per year when usage was highest. Often the cause of this peak demand is during the day when many people are watering their lawns, washing cars and filling pools. Unfortunately the town must pay for the year-round capacity to meet a demand that may only occur for a few days or weeks per year.

One way to meet this maximum demand is by developing enough sources to exceed any foreseeable peak day demand. However, peak day demands have been rising rapidly in New England over the last 10 years and in some communities have exceeded a factor of 10 times the average day demand. In other words, these demands have become excessive.

A preferable approach is to establish a "reasonable" maximum day demand to be supplied and then develop water supply capacity only to meet this demand. However, the demand must be reduced. West Newbury's current average peak demand is 2.3 times the average, which is quite high for a small residential community.

Some communities with aggressive programs that go beyond just odd-even outside watering restrictions have brought maximum day demand down to a factor of 1.1 times the average day demand (or a 10% increase over average day demand). Others have managed a maximum day demand of 1.2 times average day demand overnight by instituting the programs. A reasonable goal for West Newbury is 1.5 times average day demand.

One of the common reasons for the high maximum day demands is that many users will opt to use large volumes of water on the same day. Typically, this occurs during the summer with lawn irrigation during hot, dry periods. One way to dramatically lower this one-day usage without significant burden to users is to mandate odd-even outside water use, which essentially prohibits one-half of the users from watering each day.

The goal of this mandate is to spread the irrigation demands over two days. This also teaches people that lawns do not need to be watered daily. West Newbury has an odd-even watering restriction now, but it only limits the hours to off-peak times of the day. This should be modified to reduce the total peak that can occur on any give summer day. Further the odd-even restriction should be instituted in early May each year or applied year round to dampen excessive demand.

The cost for this option is virtually nothing and enforcement can be paid for by a fine system for those who do not comply. In most communities there is generally little need for personnel to patrol the streets due to the intense social pressure and citizen reporting of those who ignore the regulation.

The loss in revenues from this restriction is not expected to be large. To calculate the potential reduction in total water use, the projection of average day demand was multiplied out over the 20-year planning period. This average was then multiplied by 1.5 and compared with the projection of maximum day demand using a linear trend line of actual past increases in maximum day demand. The average loss or reduction in water use is only 2 million gallons per year, or about $10,000 in potentially lost annual revenue. Also, some towns have found that there was no loss in revenue, since their customers seemed to make a point of watering thoroughly on their designated days.[a]

7.2 Recommended Strategy

As shown on Figure 7-1, the recommended strategy includes developing the Knowles and Andreas wells as soon as possible, exploring and developing an additional bedrock well over a 5-10 year period, and the purchase of Newburyport and/or Groveland water to supplement for meeting maximum day demand. A payback analysis is included as Table 7-4. The payback analysis estimates the number of years before the capital costs are paid for with cost savings.

Additionally, the recommended strategy includes using demand management methods to reduce the maximum day demand to no greater than a factor of 1.5 over average day demand. Since this is often used as a national average (Lindenburg, Civil Engineering Reference Manual, Profession Publications, Inc., 1999, page 26-18), it is not an unreasonable maximum day demand. This strategy provides the least cost option for meeting a reasonable demand scenario.

To reduce demand, a combination of public education and odd-even watering restrictions should be used. Odd-even watering restrictions could be used on a year-round basis for simplicity, or could be instituted in May when demand begins to rise. There should also be additional modifications of the subdivision and site plan regulations to encourage drought resistant plantings and to discourage large lawn areas served by sprinkler systems. This was discussed further in Section 1 and 2. Additionally, an increasing block rate should be established as described in Section 6. This will further discourage residential irrigation use.

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[a] Wilson, Brian, Superintendent Merrimack Village District, Merrimack, NH. October 2000. Personal conversation with Eileen Pannetier, CEI.

Figure 7-1 : Recommended Strategy to Meet Demand

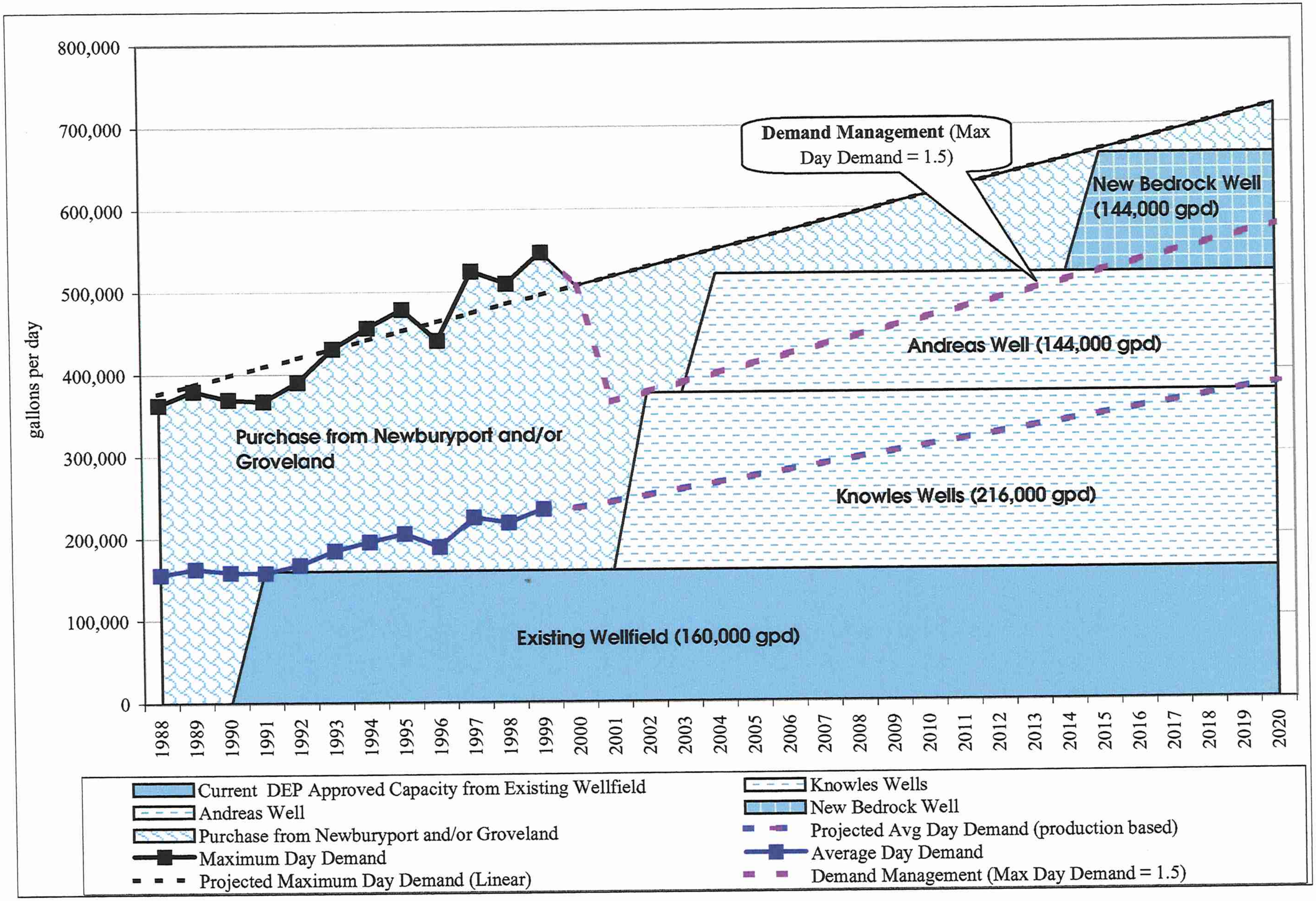


Table 7-1
Present Worth Analysis

Option	Description	Costs Capital	Annual O&M	Annual Treatment	Purchase	Total Annual Costs[1]	Present Worth[2]	Possible MG/Yr	Equalized Cost per MGD[5]
1	Continue Existing Operation	$0	$15,000	$5,000		$20,000	$229,398	58	$ 0.24
2	Develop Knowles wells	$687,400	$20,000	$26,500		$46,500	$1,220,750	79	$ 0.94
3	Develop Andreas well	$737,100	$17,500	$26,500		$44,000	$1,241,776	53	$ 1.44
4	Develop Other New Bedrock Well (s)	$500,000	$17,500	$26,500		$44,000	$1,004,676	47	$ 1.29
5	Purchase from Newburyport [3]								
	@ $3.25 per 1,000 15 years	$0	$15,000	$6,500	$65,000	$86,500	$992,146	20	$ 9.06
6	Purchase from Groveland[4]								
	@ $3.50 per 1,000 15 years	$380,000	$15,000	$6,500	$70,000	$91,500	$1,429,496	20	$ 13.05
7	Demand Management[6]	$0	$0	$0	$0	$0		2	$ -
							Total Possible	**279**	
							Total Conservative Projected Need 2020[7]	**163**	

Note: costs listed above have been equalized as much as possible but do not truly reflect real conditions. Purchase costs, in particular, are difficult to compare to new project costs because of the unknowns in negotiated costs. Purchase costs are worst-case and long-term contracts could reduce the price. Because the quantity potentially available over time for purchase is unknown, a figure of 20 million gallons per year was used for a placeholder.

[1]Annual Costs are the operation and maintenance costs including estimated costs for power, chemicals, etc.

[2]Present Worth is initial capital cost plus O&M cost times a factor of 11.4699 (assumes a 20 year 6% interest rate.)

[3]Purchase cost of water from Newburyport assumed to increase to 3.25 per 1,000 over a 15-year period, no contract.

[4]Purchase cost of water from Groveland is assumed to increase to $3.50 per 1,000 gallons (a slight increase over the current residential rate of $3.00 per 1,000 gallons), over a 15-year period.

[5] Equalized costs are arrived at by dividing the present worth total by the total life of the project (45 years for wells, 15 years for purchase) and dividing the result by the total MG/Yr.

[6] Demand management potential yield is based on reducing maximum day demand to 1.5 times average

[7] Total Conservative Projected Need in 2020 assumes buildout according to Comprehensive Plan. Note that using an annual total need masks the problem of Maximum Day Demand that goes over 1.5 times the average day demand.

Table 7-2. West Newbury Knowles Well Site

Item	Description	Quantity	Unit	Unit Price/	Subtotal
1	Site Preparation (Clear, Access Road, Bldg. Excavation)	1	ls	$15,000	$15,000
2	Piping (Chase St. To Rte 113 @ Booster Pump)	3,500	lf	$75	$262,500
3	Piping (Well to Chase St.)	1,000	lf	$75	$75,000
4	Electrical- Service/ Supply	1	ls	$20,000	$20,000
5	Pre- Engineered Building- Concrete Foundation & Slab	75	cy	$300	$22,500
6	Pre-Engineered Building- 30'X30'	900	sf	$30	$27,000
7	Pre-Engineered Building- Finish (Doors, Hardware, Etc)	1	ls	$5,000	$5,000
8	Pumps (Submersible, 30 HP)	2	ea	$10,000	$20,000
9	Mechanical Piping	1	ls	$10,000	$10,000
10	HVAC	1	ls	$2,000	$2,000
11	Chemical feed and day tanks	1	ls	$12,000	$12,000
12	Scada	1	ls	$20,000	$20,000
	Subtotal for All Items				**$491,000**
	Engineering/ Contingency Percentage (40%)				**$196,400**
	Grand Total				**$687,400**

Note:
1. This estimate is based on the assumption that water will be treated at this site.
2. The pre-engineered building proposed will house pump controls, instrumentation and minor treatment.
3. This estimate is based on information obtained from the Water Department.

Table 7-3 West Newbury Andreas Well Site

Item No.	Description	Quantity	Unit	Unit Price/ L.S. Price	Subtotal
1	Site Preparation (Clear, Access Road, Bldg. Excavation)	1	ls	$20,000	$20,000
2	Piping (Well to Middle St. To Chase St.)	5,000	lf	$75	$375,000
3	Electrical- Poles	4	ea	$750	$3,000
4	Electrical- Service/ Supply	1	ls	$20,000	$20,000
5	Pre- Engineered Building- Concrete Foundation & Slab	75	cy	$300	$22,500
6	Pre-Engineered Building- 30'X30'	900	sf	$30	$27,000
7	Pre-Engineered Building- Finish (Doors, Hardware, Etc)	1	ls	$5,000	$5,000
8	Mechanical Piping	1	ls	$10,000	$10,000
9	HVAC	1	ls	$2,000	$2,000
10	Pumps (Submersible, 30 HP)	1	ea	$10,000	$10,000
11	Chemical feed and day tanks	1	ls	$12,000	$12,000
12	Scada	1	ls	$20,000	$20,000
	Subtotal for All Items				**$526,500**
	Engineering/ Contingency Percentage (40%)				**$210,600**
	Grand Total				**$737,100**

Note:

1. This estimate is based on the assumption that water will be treated at this site.
2. The pre-engineered building proposed will house pump controls, instrumentation and minor treatment.
3. This estimate is based on information obtained from the Water Department.

Table 7-4
Payback Analysis

Option	Description	Costs Capital	Potential Water Available	Cost Savings[1,2]	Payback Period[3]
2	Develop Knowles Wells	$687,400	79 (MG/Yr)	$210,250	3.27 Years
3	Develop Andreas Well	$737,100	53 (MG/Yr)	$128,250	5.75 Years

Notes:

(1) Cost savings is the cost to purchase Option's available water minus the Option's total annual costs.

(2) Purchase cost of water from Newburyport assumed at $3.25/1,000 gallons and assumes total water available with each option is available for purchase from Newburyport.

(3) Payback period was calculated as capital costs divided by cost savings to determine number of years for payback.

8.0 Recommendations

CEI's recommended actions include the following 10 components.

1. Institute a Demand Management Program

Because of the rapidly increasing maximum day demands in West Newbury and throughout the region, CEI recommends that the Town institute a Demand Management Program. The details of this have been outlined in the report, but include the development of landscape design guidelines or standards, various regulatory modifications, the institution of a full-day, odd/even outside water restriction and encouragements to developers to retain topsoil onsite.

It also includes additional public education related to lawn watering and sprinkler systems. We recommend that the Water Department institute the ban when demand reaches 1.5 times the average day demand of the previous year. This may require odd/even watering restrictions all summer during some years. The West Newbury Water Commission is empowered to institute an Odd/Even Day Outdoor Watering Program pursuant to sections 4-6 in their Public Water Supply By-law. During seasons of high irrigation use the Commission can declare a State of Water Supply Conservation and an Odd/Even Day Outdoor Watering Program by simply notifying MADEP and citizens through normal public notice procedures.

This simple, yet effective measure has great potential to lower peak day demand while incurring very little burden to both the Commission and system users. While we recognize there may be some complaints related to this, the public education component of the program will help people to understand the reasoning for the watering restrictions.

2. Construct Knowles Wells

West Newbury's existing and projected demands for drinking water clearly show that new sources are needed. The most cost-effective of these sources, as demonstrated in Section 7.0, was the Knowles well site (2 wells). The cost estimate for construction, including extensive water main connections, is about $687,400. The site will potentially provide a total of nearly 80 million gallons per year at a very low cost. The cost estimate also includes the construction of an oversized pump station building to accommodate potential joint treatment for Knowles wells, Andreas well and potentially another bedrock well site in the vicinity. Minimal treatment as required now has been included in the construction cost, but the construction costs for future treatment (10-15 years) for arsenic is not included since the cost cannot be known at present.

3. Construct Andreas Well

The next well to bring online is the Andreas well. Although the present worth estimate shows this well as more expensive than another bedrock well ($737,100), this is due to piping costs to connect the well to the system. If the next bedrock well is in the vicinity, piping costs for the future well may be reduced since it can be connected to the new water mains put in place for the Andreas well. Also, the Andreas well is a tested site, while other bedrock wells have not yet been tested and may not materialize.

4. Pursue Testing and Additional Bedrock Well if Warranted

Based on the results of the USGS study which will be available in 2002, another bedrock well site may be feasible. The Town should identify this site as soon as possible, to be able to plan for installation of another bedrock well if a good site is located.

5. Negotiate Purchase Agreements

CEI recommends that West Newbury pursue purchasing agreements with both Newburyport and Groveland. While we recognize that this may take some time and could potentially fail due to political issues in any of the three communities, the Town must have emergency connections at the least and preferably options for purchase of water over the next 20 years. Even with all existing sites online (Knowles and Andreas wells) and an additional bedrock well, the Town may still need to purchase small amounts of water should build-out occur as rapidly as projected in the Comprehensive Plan.

To further negotiations with Newburyport, CEI suggests that the Town have an attorney review the watershed overlay zoning district ordinance in the proposed contract with Newburyport in light of the concerns regarding taking of property that have surfaced. West Newbury may be able to delete certain unacceptable portions of the ordinance rather than avoid it entirely. However, any modified ordinance would still require passage at Town meeting and may fail. Nonetheless, if a better rate can be negotiated for the purchases required over the next 10 years at least, the cost savings could be significant. Without a long-term contract, the costs for either Newburyport or Groveland water will probably increase more rapidly than West Newbury would like.

6. Emergency Backup Power

The booster station on Route 113 pumps water up to the high pressure zone. Without it, much of the town would not receive water at adequate pressures. CEI recommends that permanent emergency backup power be added to this site as the consequences of the booster station going down during a power outage could be life or death to West Newbury residents should a fire occur in the high pressure zone. Projections of the storage capabilities of the system with this booster station emergency backup power in place show no need for additional system storage. Without reliable backup power, a new tank would be required in the next few years. Rehabilitation of the pump station and the addition of emergency backup power is estimated at $75,000.

7. Distribution System Improvements

The 64-year old cast iron water main on Route 113 is troublesome in that this particular water main is the backbone of the current service area. Its apparent tuberculation in some locations could result in serious loss of fire suppression capabilities. This water main should be evaluated further to identify the best rehabilitation method. Either additional C-value testing or TV work is suggested. The estimated cost for additional C-value testing is $5,000-10,000.

Additionally, the remainder of the system needs to be evaluated in terms of hydraulics. This will require more information on the ages of existing piping, which is currently unavailable. CEI recommends that the Water Department have a more intensive field-testing program instituted. This would require C-value testing at many locations throughout the system. In the absence of good historic information on the distribution system, this testing will assist in identifying other potential areas where cleaning and lining of water mains is necessary. Once the field-testing program has been completed, then a simple network model can be developed to identify problem areas within the system and to model various options that might improve system hydraulics in low-pressure areas. Estimated costs to develop a network model are $40,000-$50,000 because of the extensive field work that will be needed to establish pipe ages. The field work alone may cost about $25,000. If the Water Department had GIS capabilities, then the much of the information obtained from the network mapping could be stored and analyzed by the department and cross-referenced to other local and regional data.

8. Upgrade Meters Over Time

Over the next few years, West Newbury should begin a conversion to a unigun system. This will involve the change-out of the oldest meters to meters that can be read with a unigun. The software to download the meter data into the Town's billing system will require evaluation before this step is taken to assure compatibility and effective implementation. The purchase of software and unigun equipment and replacement of the oldest meters may cost about $40,000.

9. Additional Staffing

The Water Department should add a summer laborer to assist with construction projects and distribution system maintenance. This will help to free up the Superintendent for reporting, planning and developing improvements to the system.

10. Modify Rates and Rate Structure

In order to cover the costs of the capital improvements and the additional staffing, CEI recommends that the Water Department institute a hydrant charge of $50 per year for all homes located within 600 feet of a hydrant. Further, CEI recommends that the Town institute a $30, bi-annual service charge. This will generate roughly $90,000 in the budget for use in paying for staff and other programs.

Any surplus monies from this rate charge can be set aside for capital improvements. In order to assure that the monies can be carried over, the Town's should investigate with its auditor and/or other financial accountants the best methodology for dealing with these issues. The Town should also be cognizant of the Statement 34 requirements recently issued by the Government Accounting Standards Board. These new requirements address how infrastructure and utilities are handled. West Newbury is subject to the new regulations beginning in 2003.

Additional monies may be generated for the capital improvements outlined above by increasing the new development charges (new service tie-in and the main line tap charges). In many communities, the service tie-in fee is several thousand dollars. If West Newbury does grow as expected in the Comprehensive Plan, then these charges will help to pay for improvements to the system. It is also a more fair way to deal with existing customers who have paid for the system as it exists today.

A Capital Improvement Plan schedule is shown on Table 8-1.

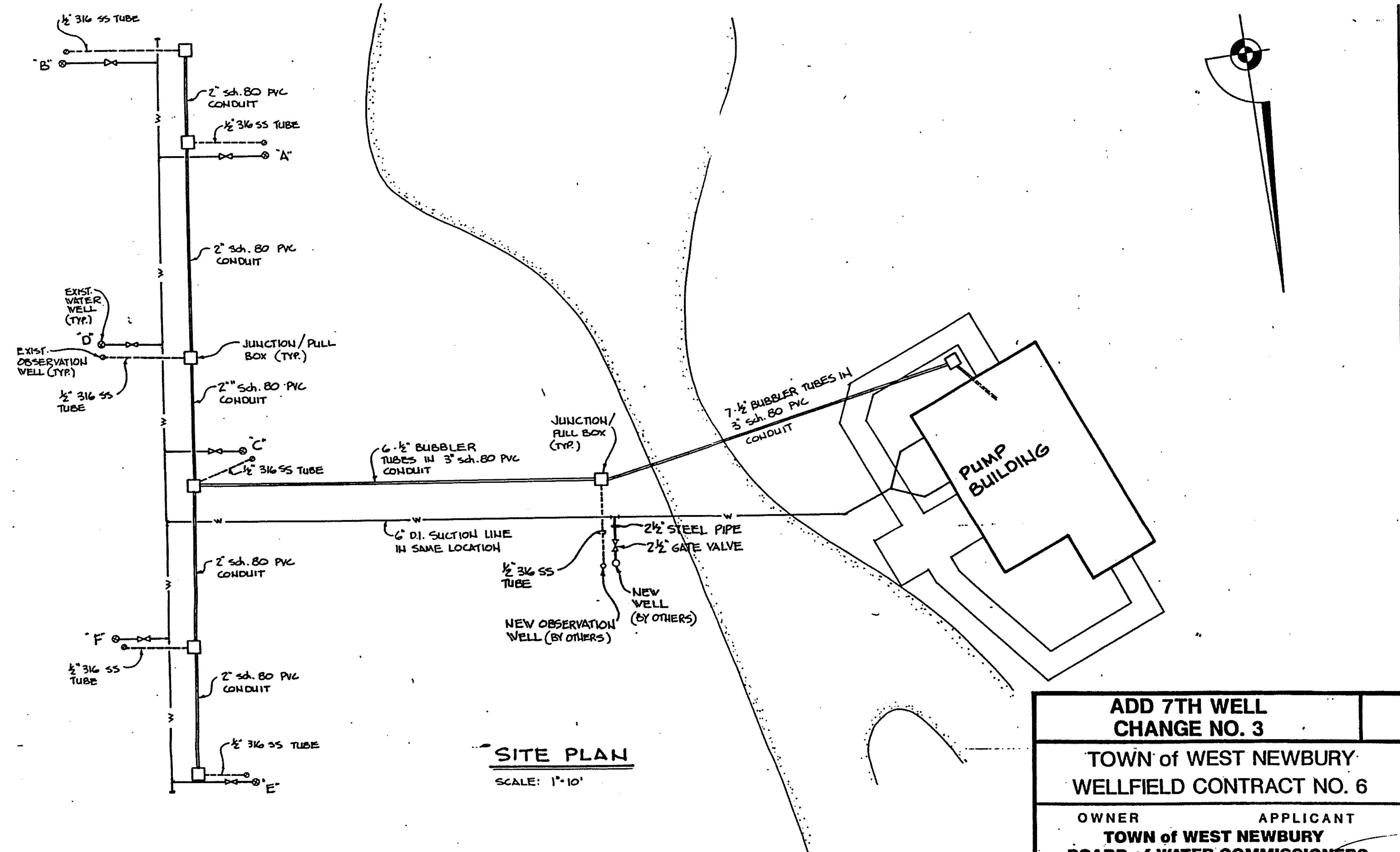
Table 8-1. Capital Improvement Plan FY2000-2020

ITEM	FY01	FY02	FY03	FY04	FY05-10	FY10-15	FY15-20
1. Construct Knowles Wells[1]		$687,400					
2. Construct Andreas Well[1]			$737,100				
3. Pursue Testing and Additional Bedrock Well[1]					$50,000	$450,000	
4. Emergency Backup Power & Booster Station Rehabilitation		$75,000					
5. Hydraulic Analysis and Distribution Testing	$50,000						
6. Upgrade Meters				$40,000		$40,000	
7. Rate Study	$20,000						
TOTALS	**$70,000**	**$762,400**	**$737,100**	**$40,000**	**$50,000**	**$490,000**	**$0**

[1] Costs to purchase land are not included in these capital improvement items.

Appendix A

Wellfield #1 Plans



SITE PLAN

SCALE: 1"=10'

ADD 7TH WELL
CHANGE NO. 3

TOWN of WEST NEWBURY
WELLFIELD CONTRACT NO. 6

OWNER APPLICANT

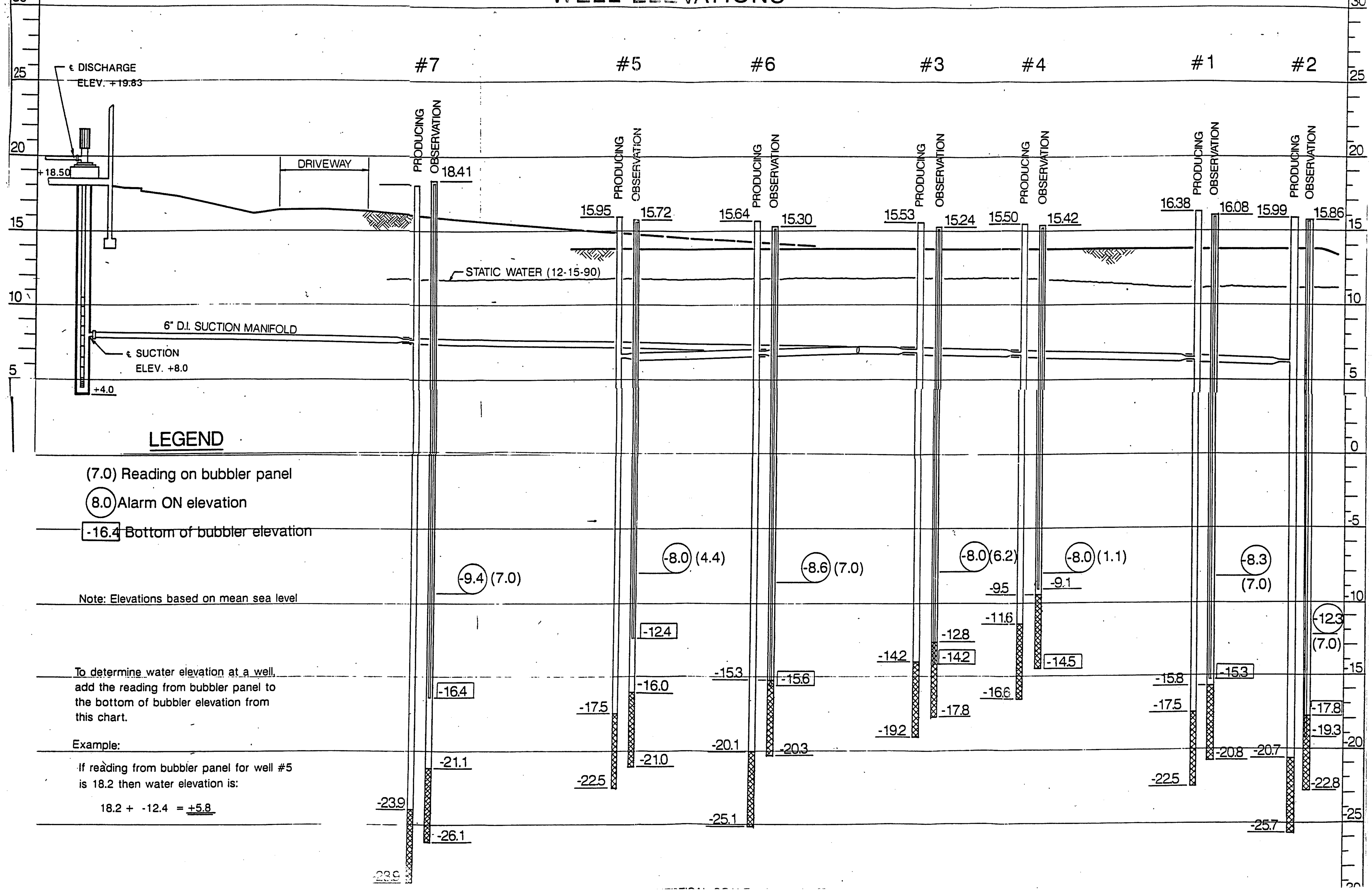
TOWN of WEST NEWBURY
BOARD of WATER COMMISSIONERS

ENGINEERS :
W.C.CAMMETT ENGINEERING , INC.
297 ELM STREET - AMESBURY , MA.

DES.BY: D.M.H.
DR.BY : D.M.H.
CK.BY : W.C.C.
DATE : 7-23-90

WEST NEWBURY WELLFIELD NO. 1

WELL ELEVATIONS



To determine water elevation at a well, add the reading from bubbler panel to the bottom of bubbler elevation from this chart.

Example:

If reading from bubbler panel for well #5 is 18.2 then water elevation is:

18.2 + -12.4 = +5.8

Appendix B

Groundwater Source Approval Information

Appendix B

Groundwater Source Approval Process

The following outlines the major components of the source approval process for all public supply wells.

Groundwater Exploration

The exploratory phase of the Source Approval process includes the examination of potential sources of groundwater. If contaminants listed in the Massachusetts drinking water standards are discovered in the test well, the sequence of the Source Approval process will be altered. Pumping and redevelopment of the test well, followed by resampling using sanitary sampling protocols, will be required. If contaminants are still present, alternative sources should be considered or a request for an evaluation of the health effects of the detected chemicals should commence to determine the necessary treatment and subsequent source approval steps.

Request for Site Exam

The Request for Site Exam must contain a characterization of land use within a one-half mile radius around the well to include:

- Current land use map with approved water withdrawals, zoning, and existing and potential sources of contamination, and
- Discussion/evaluation of potential impacts of existing and potential sources of contamination to the new water supply.

Water quality analysis results, well yield estimates, and well log and as-built construction design are required for test wells installed at potential production well sites.

Site exam requests for wells with planned yields 100,000 gpd and greater must also include:

- Preliminary conceptual model of the aquifer,
- Surveyed site plan to include the Zone I and all well locations and elevation,
- Preliminary conceptual Zone II delineations,
- Preliminary water quality results (to be submitted before the prolonged pumping test), and
- Strategy for meeting wellhead protection requirements.

DEP Site Exam

The site exam is conducted by DEP's regional source approval staff, the water supplier, and the consultant. It includes a land use/sanitary survey of the preliminary Zone II and a review of proposed observation well locations for the pumping test. Special conditions for pumping test design and performance are also discussed along with the status of Zone I ownership or control.

Assess Viability (for small systems only)

New small community and specified nontransient noncommunity systems serving less than 1,000 people must undergo a viability assessment. DEP uses this procedure to determine whether an applicant has adequately identified the resources necessary to ensure compliance with the State Drinking Water Act. This procedure also describes how DEP will assist the applicant to adequately determine its resource needs.

Conceptual Zone II Delineation

Wells with planned yields equal to or greater than 100,000 gpd require the preliminary Conceptual Zone II be submitted with a Request for Site Exam. The Conceptual Zone II delineation must be included as part of the Source Final Report.

Submittal of Pumping Test Proposal

The primary objective of the pumping test is to resolve questions concerning safe yield and existing/potential water quality. The proposal must include:

- Planned pumping rate
- Planned duration of test
- Location of discharge point
- Plan with location of observation wells (if applicable)
- Frequency of reading of observation wells (if applicable)
- Types of samples to be collected along with the name of the certified laboratory to complete the analysis
- Water quality sampling frequency and locations
- Required permits, registrations, or notices

Wells with planned yields of 100,000 gpd and greater must also include:

- Discussion of monitoring well locations
- Methods for delineating Zone II or Zone III
- Discussion of zoning/non-zoning controls

The Pump Test Proposal must address:

- Duration/stabilization
- Observation/monitoring wells
- Discharge lines
- Drawdown readings
- Recovery readings
- Water quality analysis

Pumping Test Proposal Review and Approval

The DEP Regional Office shall review the pumping test proposal and discuss pump test start-up dates and a pumping test site visit will be scheduled.

Conduct Pumping Test

The pump test is conducted according to the approved pumping test proposal.

Shut Down Pumping Test

Recovery readings are taken in accordance with the approved pumping test proposal. The pumping test may be shut down only after consultation with the DEP Regional Office, to assure that DEP agrees that stabilization has been achieved.

Submit Source Final Report to DEP Regional Office

The Source Final Report must be submitted to the DEP Regional Office. Major components of the Source Final Report include:

- All data from and analysis of the prolonged pumping test
- Delineated Zone II, if applicable, and Zone III
- Groundwater monitoring well program
- Final draft or adopted wellhead protection zoning and non-zoning controls and proposed or adopted map indicating aquifer protection district where controls apply. Evidence of "best effort" to achieve protection of Zone II areas outside of the control of the water supplier must also be submitted at this time.

Source Final Report Approved

DEP approves the source final report.

Submit Design Plan for Permanent Works to the DEP Regional Office

The design plans for permanent works installation is submitted. The water supplier must have demonstrated ownership or control of the Zone I at this point.

Permanent Works Installation Approved

DEP approves the permanent works installation design plan.

Notify DEP Regional Office When System is Complete

The design plan must identify the owner and party responsible for the public water system with any change in designee reported to the DEP Regional Office. Additionally, any modification in design must be noted.

Site Inspection of Permanent Works

DEP will inspect the site and collect a sample for water quality analysis after pumping to waste for one hour. Certain hydrogeological, geological, or logistical situations may exist that cause the Department to require activities during the source approval process that may exceed the minimum requirements.

Meet Requirements of the Surface Water Treatment Rule

The Surface Water Treatment Rule (SWTR), an amendment to the federal Safe Drinking Water Act, requires DEP to notify the U.S. EPA of groundwater sources determined to be under the direct influence of surface water and at risk for carrying waterborne diseases. Water suppliers developing groundwater sources must demonstrate compliance with the SWTR by either receipt of a DEP SWTR exemption, institution of appropriate wellhead/watershed protection, or installation of adequate filtration. Exemptions are granted based upon well siting, well construction, or the results of microscopic particulate analysis.

Additional State and Federal Agency Review

Groundwater source development frequently involves state and federal agencies other than DEP when sites are located on state-owned parkland or when the development processes impact wetlands from activities such as construction of temporary and permanent access roads, construction of permanent pumping and/or treatment facilities, and long-term drawdown of groundwater levels. DEP requires identification and assessment of wetlands impacts during the Source Approval process to ensure that the Army Corps of Engineers, DEP Wetlands and Waterways Program, and DEP Watershed Management Program receive the information necessary for prompt evaluation of permit applications.

Appendix C

State and Federal Drinking Water Regulations

Appendix C
Summary of Existing and Proposed Federal and State Regulations

Federal Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) was first passed by Congress in 1974 and has been amended twice, in 1986 and 1996. The primary objective of the law is to protect the public health by regulating the nation's public drinking water systems. Under the act, the United States Environmental Protection Agency (USEPA) is authorized to establish enforceable maximum contaminant levels (MCL) for particular contaminants in drinking water or required treatment techniques to remove contaminants. Private drinking water wells that serve fewer than 25 people are not regulated under the SDWA.

Since 1974, USEPA has established a number of regulations under the SDWA which are codified in 40 CFR 141.00 - 144.00. The final and proposed rules relevant to water quality are summarized below.

Total Coliform Rule (Final Rule, 1989. 54 FR 27544)

The Total Coliform Rule (TCR) establishes standards and testing procedures for bacteria in public drinking water supplies. It became effective on December 31, 1990.

Surface Water Treatment Rule (Final Rule, 1989. 54 FR 27486)

The Surface Water Treatment Rule (SWTR) requires systems using surface water or groundwater under the direct influence of surface water to (1) disinfect their water; and (2) filter their water or provide the same level of treatment as those who filter. Treatment must reduce the levels of *Giardia lamblia* by 99.9% and viruses by 99.99%. The rule also establishes limits on the turbidity (cloudiness of water).

Lead and Copper Rule (Final Rule, 1991. 56 FR 26460 and 65 FR 1949)

The Lead and Copper Rule (LCR) established action levels for lead (0.015 mg/L) and copper (1.3 mg/L) in public drinking water supplies. In order to meet these action levels, public water systems must conduct periodic monitoring and optimize corrosion control. In addition, these systems must:

- Perform public education when the level of lead at the tap exceeds the lead action level;
- Treat source water if it is found to contribute significantly to high levels of lead or copper at the tap; and

- Replace lead service lines in the distribution system if the level of lead at the tap continues to exceed the lead action level after optimal corrosion control has been installed.

The rule underwent minor revisions in 1999 to streamline its implementation, but the action levels and basic requirements did not change.

Information Collection Rule (Final Rule, 1996. 61 FR 24354)

The Information Collection Rule (ICR) established monitoring and data reporting requirements for large public water systems. This rule was intended to provide EPA with information on the occurrence in drinking water of: (1) chemical byproducts that form when disinfectants used for microbial control react with chemicals already present in source water (disinfection byproducts) and (2) disease-causing microorganisms (pathogens), including *Cryptosporidium*. Only surface water systems serving at least 100,000 people and ground water systems serving at least 50,000 must monitor. The rule became effective June 18, 1996 and will remain effective until December 31, 2000.

Consumer Confidence Report Rule (Final Rule, 1998. 63 FR 44511)

The Consumer Confidence Report Rule (CCR Rule) required community water systems to prepare and provide to their customers annual consumer confidence reports on the quality of the water delivered by the systems.

This final rule became effective on September 18, 1998. Minor modifications were made to the CCR Rule when the Public Notification Rule was promulgated on May 4, 2000.

Interim Enhanced Surface Water Treatment Rule (Final Rule, 1998. 63 FR 69477)

The Interim Enhanced Surface Water Treatment Rule (IESWTR) builds upon the treatment technique requirements of the 1989 Surface Water Treatment Rule. Key provisions established in the IESWTR include:

- A Maximum Contaminant Level Goal (MCLG) of zero for *Cryptosporidium*;
- 2-log *Cryptosporidium* removal requirements for systems that filter;
- Strengthened combined filter effluent turbidity performance standards and individual filter turbidity provisions;

- Disinfection benchmark provisions to assure continued levels of microbial protection while facilities take the necessary steps to comply with new disinfection byproduct standards;
- Inclusion of *Cryptosporidium* in the definition of ground water under the direct influence of surface water and in the watershed control requirements for unfiltered public water systems;
- Requirements for covers on new finished water reservoirs; and
- Sanitary surveys for all surface water systems regardless of size.

This regulation became effective on February 16, 1999.

Stage I Disinfection Byproducts Rule (Final Rule, 1998. 63 FR 69389)

The Stage I Disinfection Byproducts Rule (Stage I DBPR) established or lowered acceptable levels of disinfection byproducts in drinking water supplies that treat their water with a chemical disinfectant for either primary or residual treatment. In particular, the rule finalized:

- Maximum residual disinfectant level goals for chlorine, chloramines, and chlorine dioxide;
- Maximum contaminant level goals for four trihalomethanes (chloroform, bromodichloromethane, dibromochloromethane, and bromoform), two haloacetic acids (dichloroacetic acid and trichloroacetic acid), bromate, and chlorite; and
- National Primary Drinking Water Regulations for three disinfectants (chlorine, chloramines, and chlorine dioxide), two groups of organic disinfection byproducts (total trihalomethanes--a sum of the four listed above, and haloacetic acids--a sum of the two listed above plus monochloroacetic acid and mono- and dibromoacetic acids), and two inorganic disinfection byproducts (chlorite and bromate). The regulations consist of maximum residual disinfectant levels or maximum contaminant levels or treatment techniques for these disinfectants and their byproducts. The regulations also include monitoring, reporting, and public notification requirements for these compounds.This regulation became effective on February 16, 1999.

Radon in Drinking Water Rule (Proposed Rule, 1999. 64 FR 59246)

EPA proposed new regulations to reduce the public health risks from radon on November 2, 1999. The proposal provides states flexibility in how to limit exposure to radon by allowing them to focus their efforts on the greatest radon risks - those in indoor air - while also reducing the risks from radon in drinking water. Two options were proposed:

- First Option: States can choose to develop enhanced state programs to address the health risks from radon in indoor air -- known as Multimedia Mitigation (MMM) programs -- while individual water systems reduce radon levels in drinking water to 4,000 pCi/L or lower.
- Second Option: If a state chooses not to develop an MMM program, individual water systems in that state would be required to either reduce radon in their system's drinking water to 300 pCi/L or develop individual local MMM programs and reduce levels in drinking water to 4,000 pCi/L. Water systems already at or below 300 pCi/L standard would not be required to treat their water for radon.

The proposed rule was open for public comment between November 2, 1999 and February 4, 2000. The final rule was scheduled to be promulgated in August 2000.

Public Notification Rule (Final Rule, 2000. 65 FR 25981)

The Public Notification Rule (PNR) set the requirements that public water systems must follow regarding the form, manner, frequency, and content of a public notice. Owners and operators of public water systems are required to notify persons served when they fail to comply with the requirements of the National Primary Drinking Water Regulations; have a variance or exemption from the drinking water regulations; or are facing other situations posing a risk to public health. This rule became effective on June 5, 2000.

Groundwater Rule (Proposed Rule, 2000. 65 FR 30193)

Through the Groundwater Rule, USEPA is proposing to require a targeted risk-based regulatory strategy for all groundwater systems. The proposed strategy addresses risks through a multiple-barrier approach that relies on five major components:

- Periodic sanitary surveys of ground water systems requiring the evaluation of eight elements and the identification of significant deficiencies;
- Hydrogeologic assessments to identify wells sensitive to fecal contamination;
- Source water monitoring for systems drawing from sensitive wells without treatment or with other indications of risk;
- A requirement for correction of significant deficiencies and fecal contamination (by eliminating the source of contamination, correcting the significant deficiency, providing an alternative source water, or providing a treatment which achieves at least 99.99 percent (4-log) inactivation or removal of viruses), and

- Compliance monitoring to insure disinfection treatment is reliably operated where it is used.

The Groundwater Rule was proposed on May 10, 2000. Public comments on the rule were accepted through August 9, 2000. The final rule is scheduled to be promulgated during the winter of 2000.

Revision to Arsenic Drinking Water Standard (Proposed Rule, 2000. 65 FR 38887)

In June 2000, USEPA proposed to change the MCL for arsenic from 0.05 mg/L to 0.005 mg/L to more adequately protect public health. The proposed rule was open for public comment between June 22, 2000 and September 20, 2000. The final rule is scheduled to be promulgated in January 2001.

Massachusetts Drinking Water Standards

Under the SDWA, a State may be granted primacy for implementing the provisions of the SDWA if they can show that they will adopt standards at least as stringent as USEPA's and make sure water systems meet these standards. Massachusetts Department of Environmental Protection (MDEP) has primacy for implementation of the SDWA in Massachusetts.

The Massachusetts MCLs listed in 310 CMR 22.00 of the drinking water regulations, as well as the promulgated MCLs set by the EPA which have become effective, constitute the Massachusetts Drinking Water Standards, which are listed as MMCLs on the Drinking Water List. The MDEP Office of Research and Standards issues guidance for chemicals other than those with Massachusetts MCLs in drinking water. Standards promulgated by the EPA but not yet effective may be included on the Guidelines list.

Massachusetts Surface Water Quality Standards

MDEP establishes and enforces the Massachusetts Surface Water Quality Standards under 310 CMR 4.00. This regulation:

- Designates the most sensitive uses for which the various waters of the Commonwealth shall be enhanced, maintained, and protected;
- Prescribes the minimum water quality criteria required to sustain the designated uses; and

Contains regulations necessary to achieve the designated uses and maintain existing water quality including, where appropriate, the prohibition of discharges.

Appendix D

Water Conservation Information

Garden and Landscaping Water Conservation Tips

Summer is an especially important time to save water. Outdoor water use increases residential consumption from 10% to 50% in June, July, August and September. These tips will show you ways to use water more efficiently outdoors, save money -- and help lower garden maintenance, too!

WATER YOUR LAWN ONLY AS NEEDED

Frequent light watering can actually weaken your lawn by encouraging shallow roots that are less tolerant of dry periods and more susceptible to insect damage. Wet grass can also burn in the hot sun and is vulnerable to disease from mildew and fungus.

Test your soil for dryness by digging your finger below the surface of the soil. Water only when the soil is dry to a depth of 1 1/2 inches. When watering, check to see that water soaks down 3-4 inches. This encourages deep root growth.

Timing is critical! The best time to water is very early morning or early evening.

Watering mid-day will result in a high rate of evaporation and sunburned grass.

Roots can maintain plenty of moisture even after several days without rain. Before watering, look for signs that it's needed: patchy areas, a general change in color or footprints that remain in the grass long after being made.

Give it a rest.

If your lawn "fades" in the summer, don't panic. Grass becomes naturally dormant during hot, dry periods. It will revive quickly after a good rainfall or when the weather turns cooler.

THE INCH RULE: DON'T OVER-WATER !

Established lawns and shrubs and most vegetables and flowers need just one inch of water a week. If there has been an inch of rainfall during the week, you don't need to water at all.

How can you tell if your yard has received an inch of water? Collect rainfall or sprinkler water in a container such as a coffee can, then measure with a ruler. Inexpensive gauges are available at most garden centers.

GET A PRINTER-FRIENDLY VERSION OF
Gardening & Landscaping Fact Sheet
Free readers for PDF files and more information about PDF are available from Adobe Systems

- One inch of water a week (rain plus supplemental watering) should be plenty.
  After heavy rains, you may not need to water for 10-14 days. Water very early in the morning.
- Never water when it's windy, rainy or very hot.
- Raise the blade level of your mower to 2 -3 inches or more. Longer grass retains more moisture because it shades the roots. It encourages deeper rooting, requires less fertilizer and competes better against weeds.

- Never water faster than the soil can absorb it. Avoid puddling and run-off.
- Be sure your hose has a shut-off nozzle. Hoses without a nozzle can sprout 10 gallons or more per minute.
- If you have an automatic sprinkler system, make sure the timer or "controller" is set to water each landscape zone efficiently. Program the controller to operate according to the watering needs of your lawn or garden. Better still, install a rain sensor or soil moisture sensor that turns the system off if it's raining or if moisture is present in the soil.
- Do not apply fertilizer in the summer - new growth requires more water. Apply in early spring and or fall.
- Aerate your soil in April, September or October to aid water absorption and retention.

Choose the right automatic sprinklers.

Determine the best sprinkler system to fit your lawn size and configuration. Follow this link for some design ideas and tips www.toro.com/home/sprinkler.

Install good quality sprinkler heads that provide a low precipitation rate and keep them in good repair. Check the sprinkler heads frequently for proper direction and even spray pattern. Studies have shown that automatic sprinkler systems often use 20% - 30% more water than hand-held hose watering. Applying the right amount of water is possible with a well-designed in-ground sprinkler system but it requires careful management. Use the "controller" to manage efficient operation of the system. Here are a few important features to look for:

1. At least three independent programs to allow watering different parts of the yard on different days.
2. Station run times from one to 200 minutes
3. Three start times per program
4. Odd, even, weekly and interval program capability up to 30 days
5. Rain shut-off device capability

Effective watering will result in a healthy lawn that looks great and can withstand disease as well as seasonal and environmental stress. For more information, check out the following web sites:

www.irrigation.org
www.waterwiser.org
www.umass.edu/umext/programs/agro/turf_grass/home.html

Prepare new lawns properly.

Many new lawns require more water than they should because they are seeded on improperly prepared soil beds. Grass needs at least 3-6 inches of very good topsoil. Rich loam mixed with plenty of peat moss or composted leaves will hold moisture and allow for good, deep root development. The kind of grass you grow is a factor to consider. Lawns planted with fescue grasses do better than bluegrasses during periods of low rainfall and are slower to go dormant.

LANDSCAPE, GARDEN AND FLOWER CARE

The amount of water you use outdoors (and can save) depends on your watering technique as well as the size, type and location of your lawn, shrubs and gardens.

Xeriscape
\'zir-i-skap\ n.
[Greek, *xeros, dry*]
Xeriscape, a concept that originated in the arid Southwest, is water conservation through creative landscaping. Xeriscape principles, similar to those described here, emphasize proper siting, planning and design, soil improvements, mulching, plant selection, and maintenance for efficient water use.

Plan & design your garden for efficient outdoor watering.

Be aware of the various zones in your yard (hot/sunny, cool/shady, moist, dry, etc.) and plan your gardens and plantings accordingly. For example, if your have a hot, dry zone, carefully select plants that can endure hot, dry conditions.

Cluster plants that require extra care.

If you choose shrubs, flowers or vegetables that need lots of sun *and* moisture, place them near each other. You'll save time and water by watering just one area of your yard.

Use Low-Water Plants.

There are many varieties of low water use plants that can withstand dry summers, and that actually thrive in drier soil. Here are a few of them: **32 Low-Water Plants**

Remember: All newly planted trees, shrubs and flowers intially need water to get established. But once established, drought tolerant plantings can survive without supplemental watering. One excellent resource for gardeners is the Massachusetts Horticultural Society www.masshort.org

Mulch to keep roots cool & moist.

Mulch can serve as a ground cover that reduces water evaporation from the soil and reduces the number of weeds that would otherwise compete with the plant for available soil moisture.

Mulch flowers, shrub beds and trees with pine bark mulch. In your vegetable beds, use salt marsh hay, newspaper (no color pages), black plastic, or better yet, landscape fabric - that allows water to penetrate the fabric but keeps down weed growth. On a sweltering 100° day, a 3-inch mulch can keep the soil underneath up to 25° cooler! Avoid white marble chips that can damage acid-loving plants like rhododendrons. Stones or pebbles are good on shady areas. They shouldn't be used near the house because they give off too much heat. Ground covers, such as ivy or pachysandra, also prevent evaporation around established shrubs and ornamental trees.

Organic matter will help your soil retain more moisture.

Peat moss, composted leaves (leaf mold), composted manure, composted kitchen vegetable scraps and grass clippings will all improve soil structure and enhance moisture-retaining capabilities.

Incorporate organic matter into your flower and vegetable beds, preferably 12"-18" deep.

Drip irrigation & soaker hoses - the best ways to water your garden

Unfortunately, much of the water dispersed through sprinklers and hoses by enthusiastic gardeners evaporates before it ever reaches its intended source - thirsty roots.

Use a drip irrigation system or soaker hose in gardens that need the most water ("moisture-zoned" gardens) - vegetables, fruits, newly planted trees and shrubs, and some flower gardens.

Once a secret of professional gardeners, drip irrigation is excellent for home use. This highly efficient watering method consists of a system of nozzles that deliver small quantities of water at low pressure directly to where it does the most good - the root zones of plants.

Drip (or trickle) irrigation can save 30%-70% of the water used by overhead sprinkler systems.

A soaker hose is a canvas or rubber hose with perforations. It is most effective when it lies on top or slightly below soil level and mulch is placed over the soil and hose. You can install the hose in the spring and leave it in place all season.

In general, use the drip (or trickle) irrigation or soaker hose methods until the soil is moist 3-4 inches below the surface.

If your garden is small, use a hose to apply water very slowly at the base of each plant - not on leaves and foliage.

Saucer-like basins around each plant help to concentrate water where it is most needed - at the plant's roots. Watering by hand is easy when there are saucers to fill up.

Rain barrels.

Place barrels or other large containers under downspouts to collect rain water to use for watering your garden. Use a lid, mesh fabric or several drops of baby oil on the surface of the water to prevent mosquitoes from breeding.

Rain barrels are particularly useful if your can locate plants or beds that require moist soil nearby.

For more information contact:

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Low Water Use Plants

There are many varieties of low water use plants that can withstand dry summers, and that actually thrive in drier soil. Here are a few of them.

Because some plants have several common names, we have also listed their botanical names in Latin, the universal language of horticulture and botany.

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	Common name	Botanical Name	Height
TREES	Amur Maple	*Acer ginnala*	20'-25'
	Austrian Pine	*Pinus nigra*	50'
	Japanese Black Pine	*Pinus thunbergii*	6-10'
	Cornelian Cherry	*Cornus Mas*	20-25'
	London Plane	*Platanus x acerifolia*	50'
	White Oak	*Quercus alba*	50'
SHRUBS	Broom	*Cytisus scoparius*	5-6'
	Flowering Quince	*Chaenomeles specoisa*	6'-10'
	Junipers	*Juniperus sp.*	2'-9'
	Cinquefoil	*Potentilla*	3'-4'
	Butterfly Bush	*Buddleia davidii*	6-10'
	Rose-of-Sharon	*Hibiscus syriacus Diana*	6-8'

	Winterberry	*Ilex verticillata*	8-10'
	Mugo Pine(dwarf)	*Pinus mugo*	3-4'
GROUND COVERS	Bearberry	*Arctostaphylos uva-ursi*	6-8"
	Creeping Lilly-turf	*Liriope spicata*	6-8"
	Violets	*Viola sp..*	6-8"
	Snow-in-Summer	*Cerastium tomentosum*	6-8"
PERENNIALS	New England Aster	*Aster Novae-angliae*	15-30"
	Common Blanketflower	*Gaillardia aristata*	24-36"
	Moonbeam	*Coreopsis verticillata*	24-36"
	Purple Coneflower	*Echinacea purpurea*	24-36"
	Lavender	*Lavendula 'Hidcote Blue*	12-36"
	Sedum (Acre, Red Carpet, Ruby Glow, Stoliniferum, Spectabile)	*Sedum sp.*	18-24"
	Daylily	*Hemerocallis*	18-48"
	Yarrow, The Pearl, Summer Pastels	*Achillea sp.*	18-36

ANNUALS/ BIENNIALS	Cosmos	*Cosmos sp.*	3'
	Gazania	*Gazania*	6-18"
	Marigold	*Dimorpotheca sp.*	4-6"
	Portulaca	*Portulaca gradiflora*	8"
	Strawflower	*Heliochrysum bracteatum*	3'
	Sweet William	*Dianthus Barbatus*	2'<

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Xeriscaping means a beautiful yard during drought

By Kathleen Driscoll
CNC CORRESPONDENT

Hydrangeas are bad. Rhododendrons are good.

Kentucky bluegrass is bad. Tall fescue is good.

So goes the law of xeriscaping, the art of lush gardening using little or no water.

Xeriscaping, a relatively new gardening concept, was developed in the arid Southwest little more than a decade ago.

While drought conditions are a way of life in San Diego, where the annual rainfall is only 13 inches, in Massachusetts we can expect 45 inches of rain each year. Maybe. Drought is a frequent summer visitor here and with it comes summer water bans in many communities.

"Xeriscaping has worked wonders in San Diego," says Wayne Southworth, Easton's water superintendent, "so there is no reason it couldn't work here, as well" as an alternative to living with burnt-brown lawns all summer.

Southworth practices what he preaches. Outside his office win- a prototype xeriscape garden with perennials that require little or no watering. In good weather, he eats lunch in the garden. And at home Southworth has designed a vegetable and flower landscape that uses little or no irrigation now that the roots of his shrubs and plants have been "trained" to reach far into the earth for moisture.

Water Dept. Supt. Wayne Southworth, right, and Systems Technician Richard Mueda inspect the xeriscaping demonstration garden at Easton's Water Department. The garden features plants that are drought-resistant.

Water bans

Xeriscaping is not an expensive undertaking, nor does it require planting cacti in New England, according to Southworth. It's simply a different way of thinking, a different way of planning that allows nature to do the watering after the homeowner does the nurturing. "It's a matter of choices, not a matter of unusual expense.

"With the price of water going up and water bans going into effect when drought conditions prevail, it's worth the time and effort to create landscaping that doesn't rely on irrigation," he says.

Water usage spikes during the summer months, especially with so many more homeowners installing lawn irrigation systems, according to Raymond J. Raposa, director of New England Water Works, a consortium of water department and other water experts now based in Holliston.

"Especially when the economy is strong, people have the money to spend on irrigation systems. They want their homes to be surrounded by green lawns and colorful landscaping."

And, according to Southworth, sometimes that means that people happily pay the fines levied for water ban violations. "In this good economy, it's not unusual for people to purposely violate the ban and just pass over a big check to the town to pay the fine."

But Southworth and Raposa warn that violating water bans isn't a good solution — for anybody. In fact, it can be downright dangerous.

Water bans are instituted to conserve water for vital needs. Violating a water ban by watering your yard depletes potable water — drinking water. And violations also can contribute to dangerous drops in water pressure during drought season. Good water pressure is necessary for fighting fires, notes Raposa.

However, "it's easy to see why people want their landscapes to look healthy," adds Raposa. "A visit to any Home Depot is a lesson in what lengths people will go to in order to have greenery around their homes. You can see at a glance how much money is being spent on landscaping issues. No wonder they want to protect their investment by keeping the lawn and plants alive," he says.

"But there is another answer and that is xeriscaping. Their lawns can be green and the gardens can be colorful without using exorbitant amounts of water. Trained roots can do all the work for them. And, once established, the garden waters itself for free," Raposa said.

Plants with long roots

"The key to effective xeriscaping is long roots," agrees Southworth. "If you train grass and shrubs to reach deep into the soil, you should be able to maintain a green lawn and colorful garden using nothing but rainfall. That is the goal. That is the ideal.

"Irrigating properly is paramount in promoting long root systems. Homeowners should water only once every 10 days, let the ground get soaked and then leave it for another 10 days," Southworth says. "That way, the roots learn to reach for water and a sturdy, long-reaching root system is established."

And for those homeowners who think grass equals landscape, Southworth says a little education goes a long way.

"Some lawn is good, but it should be broken up by shrubs and trees and perennials."

Trees that fare well without irrigation include maples, oaks, hickories, sweet-gum, plane-tree, birches, lindens, Zelkova, all the native conifers, hawthorns, crabapples, Japanese tree-lilacs, golden-rain-tree, fringe trees, Bradford pears, Russian olives, and redbud. After one season of keeping the soil balls of these trees watered, the homeowner can just sit back and relax and let nature do its job, the water conservation experts say.

Conservation-friendly shrubs and ground covers keep their color without racking up huge water bills and guzzling valuable water.

Good shrubs for the xeriscape garden are: mock-orange, beauty-bush, the viburnums, Cornelian-Cherry, highbush and lowbush blueberry, Buddleia alternifolia, cotoneaster, Scotch broom, flowering quince, Rose of Sharon, purple leaf sand cherry, Carolina and Rosebay rhododendrons, mountain laurel, mountain andromeda, inkberry and Japanese ilex, as well

XERISCAPING, Page 11

75 EASY-to-Grow Native Plants

General Growing Information

All of the native plants on this list make excellent garden plants. To assure your success with these wildflowers, select plants that best match the conditions of your site. Don't try to grow sun-loving plants in the shade and vice versa. In addition, amend you soils to suit the plant's cultivation requirements.

Moist-growing plants need soils that are moist, but well-drained (no standing water), with plenty of organic matter. If the soil is low in organic matter, several inches of compost, leaf mold, or well-aged cow manure should be dug into the soil to a depth of 8 inches or more before planting. An organic mulch should be applied every year to maintain soil fertility, conserve moisture and suppress weeds. These plants should be well-watered until established.

We soils have standing water for a brief time in the spring, and constant soil moisture for the rest of the year. Boggy soils are wet for most of the year. Plants that grow in boggy soils are appropriate for the edge of a pond or stream, or in a low spot in a landscape that fills with water after rain.

Dry soil conditions occur when soils are sandy and/or low in organic matter. These conditions are common in coastal areas and around houses where topsoil was removed or compacted during construction. One to two inches of compost should be worked into the soil before planting. Plants (even drought-tolerant species) should be watered until established. Dry shade conditions also occur under the canopy of certain trees, such as maples, that are shallow-rooted and absorb moisture and nutrients from the upper layers of soil. A small amount of compost should be worked into the pockets of soil between the larger roots before planting in these conditions. In both situations, plants should be mulched and watered well until established.

Most of the species listed on these pages are growing at Garden in the Woods, the botanical garden of the New England Wild Flower Society, 180 Hemenway Road, Framingham, MA 01701; office (508)877-7630, fax (508)877-3658; e-mail newfs@newfs.org; website www.newfs.org. Al of them are nursery propagated and are available for sale when the Garden is open – every day from April 15 to June 15, and Tuesday – Sunday from June 16 to October 31. Hours are 9 a.m.-5 p.m., with extended May hours to 7 p.m. For additional sources of propagated native plants, consult our publication, *Sources of Propagated Native Plants and Wildflowers.*

The bloom time, flower color, height, and other comments follow the name of each plant. The key to the cultivation requirements and to other plant characteristics is at the bottom of page 4.

Easy Native Plants For Shady Conditions

The following plants grow in full- to part-shade. Full-shade sites, such as the north side of a building or under the canopy of trees, receive no direct sunlight for most of the growing season. Part-shade sites may get several hours of direct sunlight, but full-shade the rest of the day. These conditions typically occur on the east or west side of a building, woodland edge, or woodland opening.

Herbaceous Plants

Allium cernuum (Nodding Onion) July; Pink; 1-2 ft.; Part-shade to full sun. (shd)
Aquilegia canadensis (Wild Columbine) May; Red with yellow; 1 ft.; Part-shade. (shm, w)
Arisaema triphyllum (Jack-in-the-pulpit) May; Green with purple stripes; 2 ft.; Red berries in some years. (shm, n) **
Asarum canadense (Wild Ginger) Late April-May; Maroon (inconspicuous); 8 in.; Deciduous species with bold leaves, great with fine textured plants like Maidenhair Fern. (shm, g, n)

Aster acuminatus (Whorled Aster) July-Sept.; White; 18 in. (shm, w, n)
Aster cordifolius (Blue Wood Aster) Sept.; Pale blue; 2 ft. (shd, w, n)
Aster divaricatus (White Wood Aster) July – Oct.; White; 1-3 ft. (shd, w, n)
Dennstaedtia punctilobula (Hay-scented Fern) Leaves grow singly, but spread rapidly from under ground rootstocks; Lacy, yellow-green leaves are fragrant when crushed. (shd, g, n) **
Athyrium filix-femina (Lady Fern) 2.5 ft.; Lacy; delicate leaves. (shm, n) **
Chelone lyonii (Pink Turtlehead) Aug.-Sept.; Pink; 2-3 ft.; Part-shade to full sun. (shm)
Chrysogonum virginianum (Green-and-gold) May-Sept.; Yellow; 8 in.; Part-shade to full sun. (shm, g)
Cimicifuga racemosa (Black Cohosh) July; White; 5-8 ft.; Tall spires of frilly white flowers add life to midsummer shade gardens. (shm, n)
Dicentra eximia (Wild Bleeding Heart) May-Sept.; Pink; 1 ft.; One of the longest blooming natives; Finely cut foliage; Good moisture and deadheading insures longest bloom. (shm)
Geranium maculatum (Wild Geranium) May-June; Rose-purple; 1 ft.; Part-shade to full sun. (shm)
Gillenia trifoliate (Bowman's Root) June; White; 3 ft.; Delicate star-like flowers; Red fall foliage; Part-shade to sun. (shed, n)
Heuchera americana (Alumroot) May; Greenish; 2 ft. (shm, g)
Lobelia siphilitica (Great Lobelia) Aug.-Sept.; Blue; 2-3 ft. (shm, n)
Penstemon smallii (Small's Beard-tongue) June-July; Pink-purple; 2 ft. (shd)
Phlox stolonifera (Creeping Phlox) May; Pink-violet; 6 in. (shm, g)
Polystichum acrostichoides (Christmas Fern) 2 ft.; Shiny, evergreen leathery leaves. (shm, n) **
Sanguinaria canadensis (Bloodroot) April; White; 8 in. (shm, n) **
Sedum ternatum (Wild Stonecrop) May-June; White; 4 in. (shd, n)
Solidago caesia (Wreath Goldenrod) Aug.-Oct., Yellow; 1-3 ft. (shm, shd, w, n)
Stylophorum diphyllum (Celandine Poppy) May; Yellow; 1 ft.; Part-shade only. (shm)
Tiarella cordifolia (Foamflower) May; White; 10 in.; Evergreen. (shm, shd, g)
Viola labradorica (Labrador Violet) May; Purple; 8 in.; Purple cast to leaves. (shm, g)

Shrubs

Hydrangea quercifolia (Oak-leaved Hydrangea) June; White turning rose; 6 ft.; Red fall foliage. (shm, shd)
Kalmia latifolia (Mountain Laurel) June; Pink/white; 3-8 ft.; Evergreen. (shm, shd, w, n) **
Leucothoe fontanesiana (Dog Hobble) May; White; to 6 ft.; Evergreen. (shm)
Lindera benzoin (Spicebush) Late April-May; Blooms before leaves come out; Yellow flowers, red fruit; to 12 ft. (shm, w, n)
Rhododendron arborescens (Sweet Azalea) July; White to light pink; to 9 ft.; Fragrant; Dark green leaves turn red in fall. (shm, n)
Rhododendron calendulaceum (Flame Azalea) June; Yellow, orange, or red; 2-15 ft.; Colors very variable; Slightly fragrant. (shm)
Rhododendron carolinianum (Carolina Rhododendron) Late May-June); Pale to deep pink; 6 ft.; Small, evergreen leaves. (shm)
Rhododendron catawbiense (Catawba Rhododendron) June; Magenta; 6 ft.; Evergreen. (shm)
Rhododendron maximum (Rosebay Rhododendron) July; Pink or white; 12-15 ft.; Large, evergreen leaves. (shm, n) **
Rubus odoratus (Pink-flowering Raspberry) June; Rose; 5 ft.; Thornless; May spread aggressively. (shm, w, n)
Vaccinium augustifolium (Lowbush Blueberry) May; White, sometimes tinged with pink; to 2 ft.; Sweet berries in summer; Red autumn foliage. (shd, w, n) **
Vaccinium corymbosum (Highbush Blueberry) May; White; Blue berries in summer; 6-8 ft. (shm, w, n)
Viburnum dentatum (Arrowwood Viburnum) May-June; White to cream; 6-8 ft.; Blue to blue-black berries; Part-shade only. (shd, w, n)

Viburnum trilobum (Highbush Cranberry) May; White; 6-10 ft.; Bright red berries held into winter; Part-shade only. (shm, w, n)

Easy Native Plants for Sunny Conditions

The following plants tolerate full sun. Full sun means at least six hours of direct sunlight a day, such as an open meadow or the south side of a building.

Herbaceous Plants

Allium cernuum (Nodding Onion) July; Pink; 1-2 ft.; Part-shade to full sun. (sd)

Amsonia spp. (Blue Star) Late May-June; Blue; 2-3 ft. (sm)

Asclepias incarnata (Swamp Milkweed) July-Aug.; Rose; 3 ft.; Attracts butterflies. (sm, sw, w)

Asclepias tuberosa (Butterfly Weed) July; Orange; 2 ft. (sd, w, n)

Aster laevis (Smooth Aster) Sept.; Light blue; 2 ft. (sm, sd, w, n)

Aster novae-angliae (New England Aster) Sept.; Deep violet; 3-6 ft.; Pink forms also available. (sm, w, n)

Baptisia australis (False Indigo) Late May-June; Blue; 4 ft. (sd)

Boltonia asteroids (Snowbank or Boltonia Aster) Sept.-Oct., White; 4-5 ft.; Compact form of our native. (sd, sm, w, n)

Chelone lyonii (Pink Turtlehead) Aug.-Sept.; Pink; 2-3 ft.; Part-shade to full sun. (sw)

Chrysogonum virginianum (Green-and-gold) May-Sept.; Yellow; 8 in.; Part-shade to full sun. (sm, g)

Echinacea purpurea (Purple Coneflower) July; Pink-purple; 2-3 ft.; Infallible and dramatic, an all-time favorite native wildflower for sun. (sd, sm, w)

Eupatorium spp. Aug.; Purple or white; 5-8 ft.; Tall, dramatic species with massive heads of flowers on strong stems. (sm, sw, w, n)

Euphorbia corollata (Flowering Spurge) Aug.; White; 1-3 ft.; Clouds of small flowers resemble Baby's Breath; Brilliant orange fall color. (sd)

Gentiana clausa (Bottle Gentian) Sept.-Oct.; Blue; 18 in.; Frilly petal tips. (sm, n)**

Geranium maculatum (Wild Geranium) May-June; Rose-purple; 1 ft.; Part-shade to full sun. (sm, n)

Gillenia trifoliate (Bowman's Root) June; White; 3 ft.; Delicate star-like flowers; Red fall foliage; Part-shade to sun. (sm, n)

Hibiscus moscheutos (Common Rose Mallow) Aug.; Pink; 4 ft.; Other *Hibiscus* spp. also easy to grow.

Liatris spp. (Blazing Star) All bloom in July-Aug.; Shades of purple; Species vary from 2-6 ft. (sd, sm, w)

Lobelia cardinalis (Cardinal Flower) Aug.-Sept.; Red; 2-3 ft.; Stunning crimson flowers on tall spikes; Self-sows. (sm, sw, w, n)

Lobelia siphilitica (Great Lobelia) Aug.-Sept.; Blue; 2-3 ft.; Blue spires spring from over-wintering rosettes; Dramatic plant rare in New England. (sm, sw, n)

Matteuccia pensylvanica (Ostrich Fern) 5 ft.; Dark green leaves resemble ostrich plume; Feathery fertile fronds are 2 ft, green then turning brown. (sw) **

Monarda didyma (Bee Balm) July; Red; 3 ft. (sm, w)

Monarda punctata (Horsemint) Aug.-Sept.; Pink-to-cream; 2 ft.; Showy, tiered bracts; Self-sows. (sd, w, n)

Osmunda cinnamomea (Cinnamon Fern) 3 ft.; Robust leaves; Fertile fronds separate and narrow, turning cinnamon-brown when ripe; Fiddleheads also cinnamon-colored as the leaf uncurls. (sw, n) **

Osmunda regalis (Royal Fern) 5 ft.; Large coarse leaves; Fertile leaflets at tips of leaves; Fiddleheads smooth and wine-colored. (sw, n) **

Penstemon digitalis (Beard-tongue) June; White; 3 ft.; Robust eastern species with glossy foliage often tinged with red. (sd, n)

Physostegia virginiana (False Dragonhead) July-Aug.; Pink; 3 ft.; White form also available. (sm, g, n)

Rudbeckia fulgida var. *sullivantii* (Black-eyed Susan) July-Aug.; Orange-yellow; 2 ft.; Perennial form of familiar New England native: *Rudbeckia hirta* (n) (biennial) also easy. (sd, sm, w)
Silene caroliniana spp. *pensylvanica* (Carolina Pink) May; Pink; 8-12 in.; Good rock garden plant; Self-sows. (sd, n)
Siiphium spp. (Rosinweed) July-Aug.; Yellow; 3-8 ft.; Drought-tolerant plants. (sm)
Sisyrinchium mucronatum (Blue-eyed Grass) June; Blue; 8 in.; Not grass, but Iris relative; Starry flowers open during the day, close at night. (sm, n)
Stokesia laevis (Stokes Aster) June; Lavender-blue; 1 ft. (sm, w)
Trollius laxus spp. *laxus* (Spreading Globeflower) April-May; Pale yellow; 1 ft.; Rare plant in New England, but easy to please if given adequate moisture. (sw, n)
Zizia aptera (Heart-leaved Alexanders) May-June; Yellow; 1 ft.; Evergreen leaves, flowers like Queen Anne's Lace, self sows. (sm, n)

Shrubs and Trees

Arctostaphylos uva-ursi (Bearberry) May; White; 5 in.; Evergreen; Red berries in fall. (sd, g, w)
Clethra alnifolia (Sweet Pepperbush) July-Aug.; White, fragrant spikes of flowers; 3-10 ft. (sm, sw, w, n)
Fothergilla gardenii (Dwarf Fothergilla) May; White, 3 ft.; Fragrant bottle-brush flower clusters; Yellow/orange/scarlet fall foliage. *Fothergilla major* similar but 5-7 ft. (sm, sw)
Ilex glabra (Inkberry) June; White (inconspicuous); 2-6 ft.; Single black berries on female shrubs; Evergreen holly. (sm, sw)
Ilex verticillata (Winterberry) June; White (inconspicuous) 6-10 ft.; Brilliant red berries on female shrubs in fall and winter. (sw, w)
Magnolia virginiana (Sweetbay Magnolia) May; White; 15 ft.; Fragrant; Not evergreen in New England. (sm, sw, w, n)
Myrica pensylvanica (Bayberry) April; Brown catkins not showy; 6 ft.; Aromatic foliage; Gray, waxy berries persist in winter. (sd, w, n)
Rubus odoratus (Pink-flowering Raspberry) June; Rose; 5 ft.; Thornless; May spread aggressively. (sm, w, n)
Sambucus canadensis (American Elderberry) June-July; White (black berries in late summer); 5-10 ft. (sm, n)
Viburnum dentatum (Arrowwood) June; White; 6 ft. Grows in part-shade also. (sd, w, n)
Viburnum trilobum (American Cranberrybush) May; White; 8-10 ft., Red berries into winter. (sm, w, n)
Vaccinium corymbosum (Highbush Blueberry) May; White to pink; 6-8 ft. Delicious blue berries in summer. (sm, sw, w, n) **
Vaccinium macrocarpon (American Cranberry) June; White to pink; 6 in.; Evergreen. (sw, w, n)

Key To Symbols

shd = shady, dry conditions
shm = shady, moist conditions
sd = sunny, dry conditions
sm = sunny, moist conditions
sw = sunny, wet conditions
g = good ground cover
n = New England native
w = attractive to wildlife
** These species are sometimes wild-collected so please ask your supplier whether or not they have been nursery-propagated. Please buy only nursery-propagated plants.

New England Wild Flower Society
Garden in the Woods, 180 Hemenway Road, Framingham, MA 01701
Phone: (508)877-7630; Fax (508)877-3658; E-mail newfs@newfs.org; Website: www. newfs.org

Additional Resources

The following agencies and organizations can provide information on a variety of topics related to effective and environmentally responsible lawn and landscape care:

Massachusetts Department of Environmental Protection,
Division of Watershed Management
One Winter Street
Boston, MA 02108
Contact Person: Laura Kursman
www.state.ma.us/dep

Massachusetts Department of Food and Agriculture
Pesticide Bureau
100 Cambridge Street
Boston, MA 02202
617-727-3020
www.massgrown.org/index.html

Soil Testing Laboratory
West Experiment Station
University of Massachusetts
Amherst, MA 01003-2082
413-545-2311
www.umass.edu/umext/programs/agro

National Pesticide Telecommunications Network
800-858-7373
EPA-sponsored hotline
www.epa.gov

Massachusetts Audubon Society
Natural History Helpline
781-259-9506 ext. 7416
www.massaudubon.org

Massachusetts Horticultural Society
Garden Line: 781-235-2116
Monday, Wednesday, Friday
10 a.m. - 2 p.m.
www.masshort.org

Master Gardener Association of Western Massachusetts
Berkshire Botanic Garden, Lenox
413-298-5355
Tuesday only: 9 am – 1 pm,
May 1 – October 1
Smith Greenhouse, Amherst
413-585-2748
Saturday only: 9 am – 1 pm,
May 1 – October 1

New England Wild Flower Society
180 Hemenway Road
Framingham, MA 01701-2699
508-877-7630
www.newfs.org

Tower Hill Botanic Garden
Worcester County Horticultural Society
11 French Drive, POB 598
Boylston, MA 01505-0598
508-869-6111 ext. 10
Wednesday only: 2-4 pm
www.towerhillbg.org

Massachusetts Watershed Coalition
POB 577
Leominster, MA 01453
508-534-3379

Congress of Lakes and Ponds
135 Washington Street
Holliston, MA 01746
508-429-5085

Committee for Alternatives to Pesticides GreenCAP
Green Decade Coalition/Newton
474 Centre Street
Newton, Massachusetts 02158
617-965-1995
(a community organization)

Recommended Publications

The following documents contain additional information about lawn and landscape care in your watershed:

- "Fact Sheet #8: Functions of Riparian Areas for Pollution Prevention," MA Dept. of Fisheries, Wildlife, and Environmental Law Enforcement, Riverways Program, 1992. To obtain call 617-727-9800.
- "Don't Trash Grass," MA Dept. of Environmental Protection, Division of Solid Waste Management, 1993. Available on the DEP web site: www.state.ma.us/dep.
- "A Homeowner's Guide to Environmentally Sound Lawn Care: Maintaining a Healthy Lawn the IPM Way," MA Dept. of Food and Agriculture, Pesticide Bureau, 1997. To obtain call 617-727-3020.

Appendix E

Water Meter Quote

STILES CO Inc
WATER WORKS PRODUCTS

922 Pleasant Street
Norwood, MA 02062

TEL 781-769-2400
1-800-426-6246
FAX 781-769-8222

QUOTATION

12/13/2000

102217

Page 1

To: Cust# 234
CASH ACCOUNT Massachusetts

, MA

Terms:

Quantity	Part #	Description	Unit	Unit Price	Extention
1	COMPREHENSIVE	envirmental		0.00	0.00
0	603-424-8441	eileen Pannetier		0.00	0.00
0	MERRIMAMC			0.00	0.00
1	PI	portable interragator		9800.00	9800.00
1	CONNECT	software		0.00	0.00
1	TRAINNING			0.00	0.00
0	BR2-12	3/4X7-1/2 ROM 25B GL METR	ea	56.00	0.00

Sandra R. Stiles

SEE SPECIAL OFFER

Total 9800.00

FORD Badger UNI-FLANGE REED

Appendix F

C Value Testing Results

Church Street
October 20, 2000

	Static (psi)	Residual 1 (psi)	h_f (psi)	h_f (ft)
P	104	52	52	119.6
H-1	112	107	5	11.5
H-2	115	115	0	0

Static conditions: no hydrants flowing
Residual 1: P hydrant flowing
Residual 2: P hydrant + H-1 flowing
Residual 3: all hydrants flowing

L	1333 feet	c	0.9
Q	604.99 gpm	d	2.5 in
h_f	11.5 feet	P	52 psi
D	6 inches		

Full flow in 6" CI pipe:

Q= $29.83 * c * d^2 * P^{1/2}$ 1209.98 1/2 flow between H-1 and H-2, 1/2 down Old Wharf Rd.

$$C^{1.85} = \frac{10.44LQ^{1.85}}{h_f D^{4.8655}}$$ (Hazen-Williams equation)

C = 250.73

Route 113
October 20, 2000

	Static (psi)	Residual 1 (psi)	h_f (psi)	h_f (ft)
P	33	17	16	36.8
H-1	48	45	3	6.9
H-2	55	55	0	0

Static conditions: no hydrants flowing
Residual 1: P hydrant flowing

L	778 feet	c	0.9
Q	691.83 gpm	d	2.5 in
h_f	6.9 feet	P	17 psi
D	10 inches		

Q= $=29.83*c*d^2*P^{1/2}$ 691.83

$$C^{1.85} = \frac{10.44LQ^{1.85}}{h_f D^{4.8655}}$$ (Hazen-Williams equation)

C = 73.80

Parsons
October 20, 2000

	Static (psi)	Residual 1 (psi)	h_f (psi)	h_f (ft)
P	64	28	36	82.8
H-1	67	65	2	4.6
H-2	65	64	1	2.3

Static conditions: no hydrants flowing
Residual 1: P hydrant flowing

L	199 feet		c	0.9
Q	887.88 gpm		d	2.5 in
h_f	4.6 feet		P	28 psi
D	8 inches			

Q= $29.83 * c * d^2 * P^{1/2}$ 887.88

$$C^{1.85} = \frac{10.44LQ^{1.85}}{h_f D^{4.8655}}$$ (Hazen-Williams equation)

C = 101.45

Crane Neck
October 20, 2000

	Static (psi)	Residual 1 (psi)	h_f (psi)	h_f (ft)
P	87	48	39	89.7
H-1	86	84	2	4.6
H-2	81	80	1	2.3

Static conditions: no hydrants flowing
Residual 1: P hydrant flowing

L	801 feet	c	0.9
Q	581.25 gpm	d	2.5 in
h_f (ft)	4.6 feet	P	48 psi
D	8 inches		
S	0.01 ft/ft		

where $Q = 29.83*c*d^2*P^{1/2} =$ 1162.51 1/2 the flow past H-1 and H-2, 1/2 down Robin Rd
h_f (ft) =("static" - "residual 3") h_f from table above

$$C^{1.85} = \frac{10.44LQ^{1.85}}{h_f D^{4.8655}}$$ (Hazen-Williams equation)

C = 140.94

8" AC pipe

Appendix G

Form B

FORM B

Department: ______________________
(see instructions on reverse side)

Date Prepared______________
Contact Person ______________
Telephone______________

West Newbury
CAPITAL PROJECT\EQUIPMENT REQUEST

1. Project Title: ______________________ . Status: (New _____Modify_____Cancel_____)
(check one at the above)

3. Priority: ______________________(within budget year)

4. For non-equipment:
Location:______________________
For equipment
\# of units:______________________

5. Description: (check if additional material attached____)

____

____

____

____

6. Need: (check if additional material attached____)

____

____

____

____

7. Cost in fiscal

Suggested sources of financing:
(include. state aid, grants, sale, trace in etc.)

Yr.	budget year ending	
0	June 30, _____	$______________
1	_____	$______________
2	_____	$______________
3	_____	$______________
4	_____	$______________
5	_____	$______________

6-year Total $______________ (do not include interest charges in cost)

8. Replaced equipment items______________________________________

____

9. Submitting authority: ______________ (department) ______________ (signature) ______________ (position)

10. Reserved for CIP Committee comments:

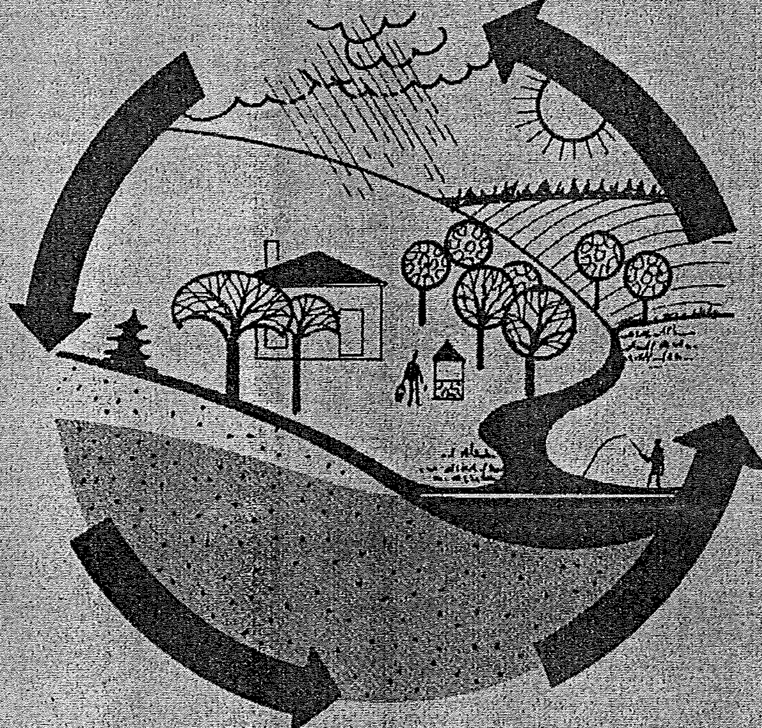
Appendix H

Accounting Information

WATER RATES AND IMPROVED WATER UTILITY MANAGEMENT

A Guide for Local Officials

James Goldstein



Massachusetts Audubon Society
March, 1984

Contents

Introduction

The citizens of Massachusetts have historically viewed potable water as an inexpensive, virtually limitless resource. Blessed with abundant annual rainfall averaging 44 inches per year, Massachusetts has long been considered a water-rich state. Recent events, however, have led local and state leaders to question the adequacy of the state's water resources, both in terms of quantity and quality. A below normal rainfall in 1980 and 1981 served as a powerful reminder that our water resources are, in fact, not limitless, and must be protected and managed wisely. According to the *Massachusetts Water Supply Policy Statement* (1978) of the Executive Office of Environmental Affairs:

"Water of unlimited quantity and high quality can no longer be taken for granted. If the Commonwealth wishes to assure long range availability of the resource, its judicious control, management and allocation is essential."[1]

It is within this context that the Massachusetts Audubon Society has identified the protection and management of water resources as a key environmental priority for the 1980s. In its 1982 annual report the Society states: "The water resource issue is pervasive, touching the political, social, and economic life of the Commonwealth. The development of a sound water policy may be the most critical issue facing Massachusetts in the years ahead.

"Greater public awareness and education about water resources and increasing sophistication on the part of citizen advocates and officials will help in the development of plans to manage water wisely."[2]

Good water-resource management requires water utilities to practice sound financial management to ensure adequate funds for operating, maintaining, and improving supply systems. One vital component of sound financial management policy is appropriate water pricing — charging rates which reflect the full cost of providing water. With municipalities throughout Massachusetts suffering from budgetary limitations imposed by Proposition 2½, adequate pricing and sound financial management have become even more important.

The purpose of this publication is to demonstrate to local officials and concerned citizens the need for full-cost pricing and improved financial management of municipal water utilities, and to provide practical recommendations on how to implement these practices. Our goal is to encourage municipalities to make their water utilities self-supporting, thereby improving the management of this vital resource. The guide may be most useful to municipal officials in communities which face large capital outlays (for new wells, treatment facilities, or system rehabilitation) or projected water deficits. Though the scope of this publication is limited to municipal water utilities, many of the issues discussed and recommendations offered are also relevant to municipal sewer systems.

This guide is divided into six parts plus an appendix. Following the introduction, there is a summary of recommendations. Section I reviews the historical pricing and financial management practices of water utilities and describes the present water supply system throughout the state. The second section outlines the criteria for evaluating water rates and discusses the various options for structuring rates.

Section III suggests the need for and advantages of full-cost pricing as a means of achieving self-supporting water utilities with sound financial management practices. The obstacles to the implementation of full-cost pricing are identified in the fourth section, with particular attention given to the rate-making process itself, accounting practices, and the institutional structure of municipal water utilities.

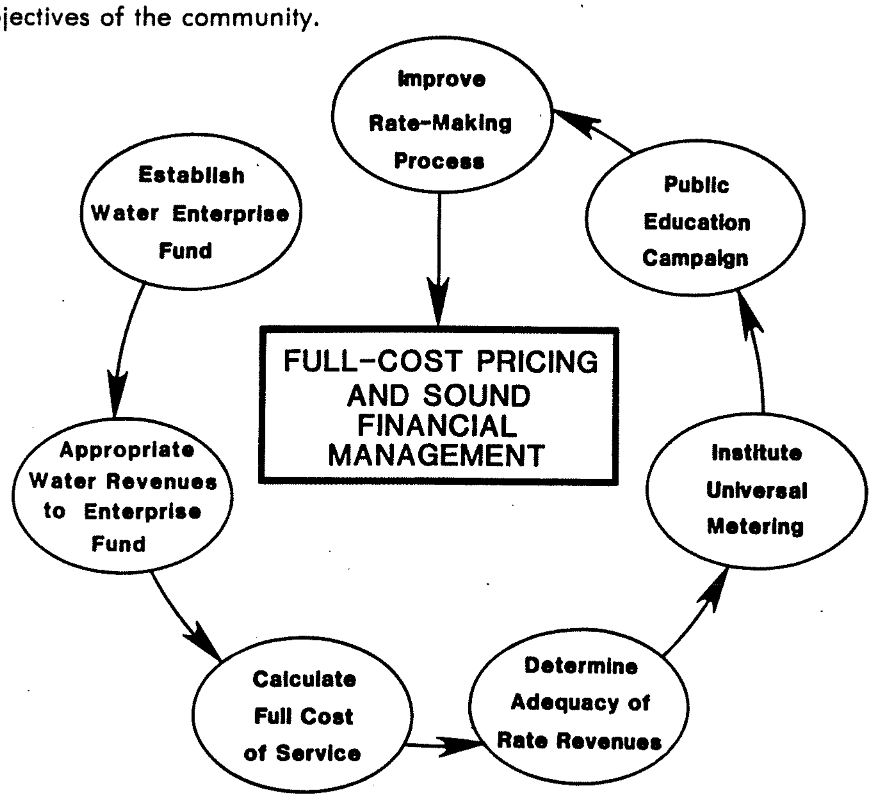
The fifth section of the guide gives recommendations for overcoming these obstacles and suggests ways in which water utilities can improve their pricing and financial management practices. Section VI presents case studies of municipalities that have successfully implemented full-cost pricing and become self-sustaining. Finally, an appendix is included to provide a sample listing of water rates in Massachusetts.

This publication is part of an ongoing effort by the Massachusetts Audubon Society to encourage sound water-management policies throughout the Commonwealth and to increase public awareness of important water resource issues.

Summary of Recommendations

The people and businesses of the Commonwealth can be served best by water utilities which are well-managed, self-sustaining enterprises. Recognizing the goal of improved water utility management is only the first step. To ensure adequate funding to meet this goal, a municipal water utility must take concrete actions. By setting water rates based on the full cost of service and devoting water revenue to water utility expenses only, municipal water utilities can ensure adequate financing, encourage conservation, and increase public awareness concerning the true value of our water resources. Recommendations for achieving self-sustaining utilities are discussed in detail in Section V and are summarized below.

1. Separate the expenditures and revenues of the water utility from the municipality's general fund by establishing a water enterprise fund.
2. Seek to have the local government adopt a policy to annually appropriate all water revenues to the water enterprise fund for use on water utility expenses only.
3. Calculate the full cost of providing water, including such expenses as depreciation of fixed assets, debt service, capital improvements, employee benefits and indirect expenses. This calculation identifies the revenue needs of the water utility.
4. Determine the extent to which revenues generated from water rates cover the full cost of service.
5. Institute universal (100%) metering of all water consumers, including municipal users.
6. Inform the public and local officials, through an educational campaign, about the full cost of providing water and the inadequacies of current pricing and financial management practices for meeting this cost.
7. Improve the rate-making process by minimizing political considerations and focusing on the operational, maintenance, and capital improvement needs of the system. This may require appointing a special board or committee or hiring a consulting firm to examine these needs and recommend appropriate water rates and related policies.
8. Establish a water rate structure and level which equitably recovers the full cost of service and is consistent with other policy objectives of the community.



ELEMENTS OF IMPROVED PRICING AND FINANCIAL MANAGEMENT OF MUNICIPAL WATER UTILITIES

I. Water Pricing and Improved Water System Management

Most electric and gas utilities charge rates to their consumers based on the cost of providing service. Payments generated from rates determine the amount of revenue available to operate and maintain the utility and to retire debt. With rates based on costs, a utility can be self-supporting and not need subsidies from general revenues. Thus, it has a relatively stable and reliable source of revenue — a necessity for efficient management and planning.

Water utilities, most of which are municipal departments or other public agencies, often have not operated in this way. Frequently water rates have not been based on the full cost of providing the water or the revenue needed to run the supply system. Instead, rates are set by an elected body of local officials, water revenues are placed in the general fund, and the water utility's funding is based on municipal budget appropriations which often have no relation to total customer payments for water. In some instances, communities use water revenue to subsidize the cost of providing other municipal services. More often, a utility contributes less to the general fund than it receives from the budget appropriation process and requires subsidy from tax revenue.

Most Massachusetts Water Utilities Not Self-Supporting

In a recent survey conducted by the Massachusetts Department of Environmental Management, Division of Water Resources, less than 45% of municipal water utilities claimed to cover all of their costs from water revenues.[3] And since water utilities often do not include all of the indirect costs in their calculations, those that are truely self-sustaining are even less common. In fact, in the survey only 14 municipal water utilities (less than 7%) explicitly stated that they were self-supporting.

Water utilities dependent on appropriations from the municipality's general budget must compete for funds with other municipal services such as the police and school departments. Water utilities generally do not compete well in this process since they are capital intensive and lack a large interest group for lobbying, and because a water system's maintenance and other needs are often not recognized by the public.

This situation has produced several dysfunctional results including rate levels that are below the full cost of supplying water, inadequate revenues for proper system maintenance and capital renewals, inequitable rate structures, and a lack of incentives for conservation. Though short-term costs may be reduced by not investing in the supply system on an ongoing basis, long-term costs are increased due to postponement of system improvements, accelerated deterioration of fixed assets, and a lack of overall planning. By pricing water at its full costs and devoting water revenues to water system expenses only, a municipal water utility can eliminate these problems and assure that adequate funds exist to properly operate and maintain the water supply system. In addition, annually appropriating all water revenues to a water enterprise fund allows the accrual of funds to be used for capital improvements to the system.

A Brief History of Water Pricing in Massachusetts

Most public water supply systems in Massachusetts were developed in the middle and late 1800s. Two major reasons prompted municipalities to establish public water supplies during this period: to improve public health and to fight fires.

Anticipating population and industrial growth and taking advantage of economies of scale and the availability of additional cheap water supplies, planners and engineers constructed water systems with substantial excess capacity. The early charges for water were deliberately set below the actual cost of supply in order to encourage water use. This was done for economic reasons as well as for the health and safety concerns mentioned above. Not only did municipalities want to attract industry, but by expanding the use of the water supply system the average cost per unit of supply to all customers was lowered. From this early period to the present, many municipalities have subsidized the cost of supplying water by drawing on general tax revenues. Despite such subsidies, water system budgets have often been insufficient to cover the costs of necessary maintenance and capital improvement programs, resulting in substantial deterioration in water supply systems throughout the state. Unlike other municipal services, a poorly maintained water supply or sewer system can go unnoticed by the public literally for decades.

During the 1970s, the cost of supplying water rose dramatically due to higher energy costs for pumping, increased need for and price of chemicals for treatment, high inflation, and increased maintenance costs for aging infrastructure. The pressure on what had already become a strained water supply system was intensified by population growth and industrial development, particularly in eastern Massachusetts, as well as the loss of supplies due to contamination from hazardous wastes and other sources. The increased cost of providing water was only partly met by water rate increases; the remainder was met from larger subsidies from general revenues or was not met, which resulted in more deferred maintenance and capital improvements.

The passage of Proposition 2½ in 1980 placed strict limitations on property taxes, traditionally the major source of revenue for municipalities in Massachusetts. Federal cutbacks by the Reagan Administration have further reduced the funds available to cities and towns. Unable to maintain past levels of subsidy, municipalities across the state are re-examining the level and structure of their user rates for water and other services. It is in this context that many municipalities are looking at increased water rates as a means to: (1) make their water systems more self-supporting and alleviate pressure on limited general revenues; (2) provide revenues for long-needed maintenance and capital improvements; and (3) improve overall water management and water system efficiency.

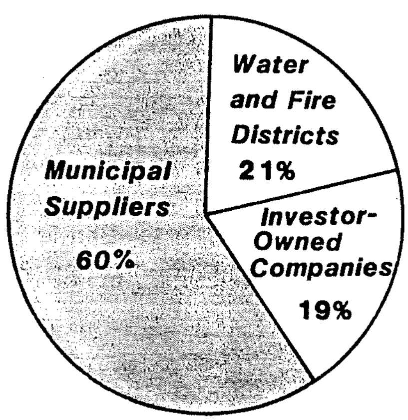
Water Supply Systems in Massachusetts Today

Massachusetts presents a complex water supply picture. Central water supply systems serve 5.3 million people or about 93% of the state's population, with the remaining population served by private on-site wells. There are 363 central water supply systems in 293 cities and towns throughout the state: 60% are municipal suppliers, 21% are fire and/or water districts, and 19% are private, investor-owned water companies. Some communities have more than one supply system, and it is fairly common for towns with central systems to also have some users on private wells. In terms of population served, approximately 87% or 4.61 million of those on central systems are supplied by municipal water purveyors, 8% by fire and water districts, and about 5% by investor-owned water companies.[4]

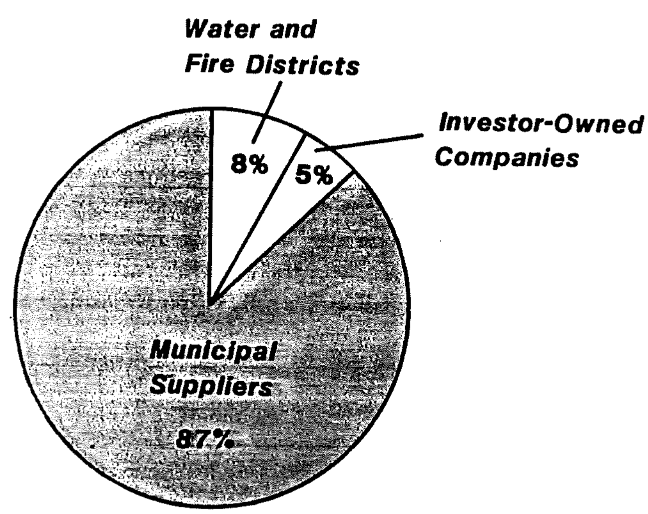
A very important factor in the state's water supply is the Metropolitan District Commission (MDC). The MDC is by far the largest water wholesaler in Massachusetts. It supplies water to about 2.5 million people in 45 communities, 35 of which are in the Boston metropolitan area.

The MDC Water District is required by law to be self-supporting. It has the authority to set water rates, but can not make a profit. In the early 1970s, however, the MDC was not covering the cost of water service from rate revenues. In 1975 the MDC raised its water charges to member communities from $200 to $240 per million gallons. Since this rate increase went into effect, the Commission has covered the full cost of service from water revenue.

Municipally-owned water suppliers serve urban and suburban areas, where the vast majority of those on a central supply live. In a typical city water department, the mayor, city council, or the director of public works appoints



TYPE OF WATER UTILITY IN MASSACHUSETTS



% POPULATION SERVED

a water superintendent to operate the system. The city council, acting as the board of water commissioners, sets water policy and water rates. In a town, water supply is usually managed through a water department or a department of public works. Typically, an elected board of selectmen appoints a board of public works who in turn appoints a water superintendent to operate the system. The board of public works sets water policy, but rates are approved by the board of selectmen. (These institutional structures are merely examples; there are many variations.) Due to age and inadequate revenues to cover costs, many municipal water utilities have deferred necessary maintenance programs and, as a consequence, their fixed assets, especially water mains, have suffered considerable deterioration.

Water and sewer commissions have been established in a few communities, mainly in response to financial pressures; the municipal system could not cover the full cost of supply from existing revenue sources. Water and sewer commissions are autonomous agencies established through special legislative acts and take over responsibility for water supply from the municipality. Once a water and sewer commission is established, it is required by law to be self-supporting and set rates which cover the full cost of service. The Boston Water and Sewer Commission is an excellent example of this arrangement.

Water and fire districts are usually found in suburban or rural areas and it is not uncommon for a community to be divided into more than one district. Water and fire districts are established through an act of the legislature and by definition are self-supporting. As autonomous bodies, they set rates based on the full cost of supplying water and retain all revenues collected. As a result of their institutional structure, and because most are less than 50 years old, water districts generally have less deferred maintenance than municipal systems.

Private investor-owned water companies also serve suburban or rural communities. They operate as other private companies do: in order to remain in business they must cover all costs (plus a profit margin) through water rates. Unlike other water suppliers, private companies are regulated by the state's Department of Public Utilities. Almost 70 private water companies are scattered throughout all parts of the Commonwealth. Though a few private companies serve populations over 10,000, most are very small and serve a few hundred customers or less.

It is evident, therefore, that the institutional structure and the funding base of a water utility are important determinants of how well it operates, as well as the level of maintenance and capital improvements.

Most municipalities in Massachusetts received the authority to establish a water utility and provide water service either by a special enabling act of the legislature, or by accepting Chapter 40, Sections 39 through 42 of the Massachusetts General Laws. Chapter 40 delineates the powers of a municipality with regard to water supply, while another law, Chapter 41, Section 69B outlines the duties of municipal officials. The latter states that an elected board of water commissioners, or the board of selectmen who serve as commissioners, has control over the water utility and is empowered to "fix just and equitable rates for the use of water...The income of the water works shall be appropriated to defray all operating expenses, interest charges and payments on the principal..."

For the most part, enabling acts mirror the provisions of Chapter 40, Sections 39 through 42. One notable exception is that enabling acts contain the term "shall," meaning the provisions are mandatory while Chapter 40 uses the term "may," indicating that its provisions are optional.

Most water utilities which were formed through enabling acts, therefore, are legally mandated to cover all costs from revenue derived from rates and to be self-supporting. This is not generally the case, however, as the provision has not been enforced.

Chapter 41 Section 69B states that water revenues cannot be used for purposes other than the provision of water. Unfortunately, this provision has not been enforced either and in some localities water revenues continue to be diverted to defray the cost of other municipal services.

II. Water Rates: Price Structure

It is necessary to distinguish two components of water rates: the price *structure* and the price *level*. The price structure refers to a method of charging for water based on the quantity used or the time of use. The price level refers to the actual price charged for a given volume of water. While price structure and price level are in theory independent of each other, often they are considered together in the rate-setting process. Any water rate can recover the total cost of service as long as the price level is high enough. Through the combination of an appropriate price structure and level, a water utility can produce adequate revenues to cover all its costs and, at the same time, help a community meet other policy goals.

Water utilities often include a minimum charge in their water rates, regardless of the price structure employed. The minimum charge entitles the consumer to use up to a specified volume of water. Water use above this volume is charged according to the price structure in effect. A minimum charge is useful to a water supplier because it ensures a certain level of income from water rates. It is considered inequitable, however, since consumers who use less than the volume allotted still must pay the minimum charge. Increasingly, minimum charges are being replaced by service charges. Service charges cover all the administrative costs of maintaining water service, but unlike minimum charges, they do not penalize low-volume consumers by charging for water which is not used.

In evaluating the appropriateness of a water rate, the following questions must be addressed:

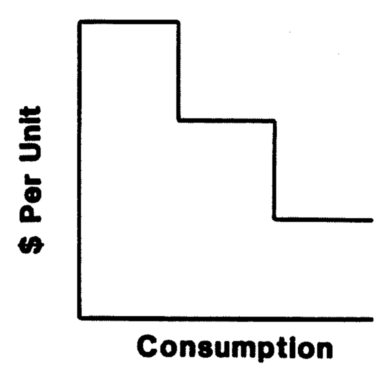
1. Does the rate provide *adequate revenues* to cover all costs of service?
2. Are costs fairly apportioned to each class of consumer, i.e., is the rate *equitable* to residential, commercial, and industrial users?
3. Are the rates *acceptable* to the public and local officials responsible for administering them?
4. Does the rate encourage or discourage *water conservation*?

No single price structure is best for all communities. The price structure which is most appropriate depends on local conditions and policy objectives, i.e., on what a municipality wants its water rates to accomplish. For example, rates can be structured to encourage water conservation, reduce peak demand, attract industry, or to help meet other goals. The following sections discuss the principal types of price structures.

Declining Block Rate

Until recently, the most typical rate structure for water service in Massachusetts was the declining block rate. Under this structure, customers usually pay a minimum charge and are entitled to use a specified amount of water at no additional cost. Water use above this specified amount is divided into blocks. Each consecutive block of water used is priced at a lower rate per unit. This form of pricing dates back to the period when most water systems were constructed and had substantial excess capacity. Through the declining block rate structure, maximum use of water was encouraged in order to lower the average cost per unit to all customers.

As new water supplies have become scarce, and as many supply systems in the state are now operating at or close to full capacity, declining block rate structures no longer meet the policy objectives of most municipal suppliers and are slowly being replaced. Recently, attention has focused on conservation, equity, and economic efficiency. As a result, other pricing policies are receiving more consideration and are being implemented in greater numbers across the state.



DECLINING BLOCK RATE

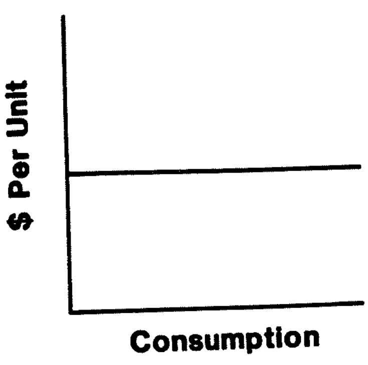
Flat or Uniform Rate

A flat or uniform rate is simply a constant price per unit of volume for all water use by all customers. This structure can encourage conservation since it eliminates the quantity discounts provided under a decreasing block rate which may encourage wasteful or non-essential water use. The flat rate has the advantage of being simple to design and administer, and is considered by many to be equitable because all customers are charged the same rate per unit. However large users, and in particular industrial users, argue that the flat rate is inequitable. Industrial users tend to equalize their water use over the course of the day or year, resulting in relatively less usage during peak demand times. Since the investment in additional supplies and storage capacity needed to meet peak demand adds substantially to the cost of service, large users argue that they are less responsible for these costs and should not be required to pay them.

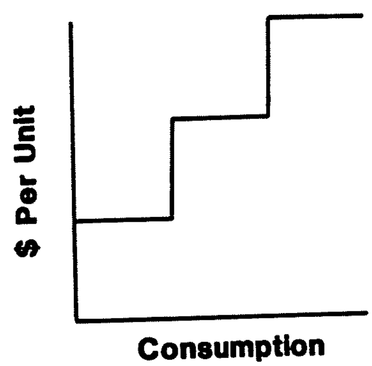
Increasing Block Rate

In the increasing block rate structure, each succeeding block of water used is priced at a higher rate per unit than the previous block. As with other rate structures, there is often a minimum charge that entitles the user to a specified volume of water (the first block). This rate is often implemented in cases where there is a supply shortage or where water conservation is a critical concern. The increasing block rate structure can be designed to allow for essential domestic use at lower rates (similar to lifeline rates for electricity), with higher rates for large volume consumers. The town of Hanover is just one example of the effective use of the increasing block rate structure.

A problem with increasing block rates is that they can have a severe impact on large users. As with the flat rate, large industrial users argue that the increasing block rate structure is inequitable. Thus, this rate structure may be best suited for areas with primarily residential customers or those communities trying to discourage industrial development. In addition, increasing block rates may be an unstable source of revenue since reductions in water use occur at the highest rate block.



FLAT OR UNIFORM RATE



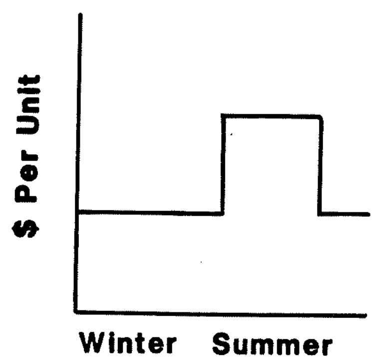
INCREASING BLOCK RATE

Seasonal or Peak Rate

Seasonal or peak rates provide for higher charges for water during periods of peak demand. The rates reflect the situation described earlier, where peak demand, especially during summer months, requires large investments in storage and other facilities. In fact, the key determinant in sizing a water supply system's capacity is the need to meet peak demand.

The seasonal or peak rate may be used in conjunction with any price structure but is most commonly used with the flat rate. The seasonal or peak rate can be applied to all water use during the peak period, or only to water use above a predetermined amount, such as average (off-peak) use. The latter method is considered more equitable because customers can meet their basic water needs without paying a penalty. Administering peak rates may require additional meter reading. The town of Wellesley is one of the few in Massachusetts which has implemented a peak rate (see Wellesley case study, p. 20).

There are a number of potential advantages to peak rate pricing. Higher revenues are received from peak rates in the summer, just when more funds are needed to pay for the capital maintenance and improvement work which usually occurs during this season. Peak rate pricing allows a utility to keep non-peak rates lower than they would otherwise be. In addition, peak rates can be used to encourage conservation.

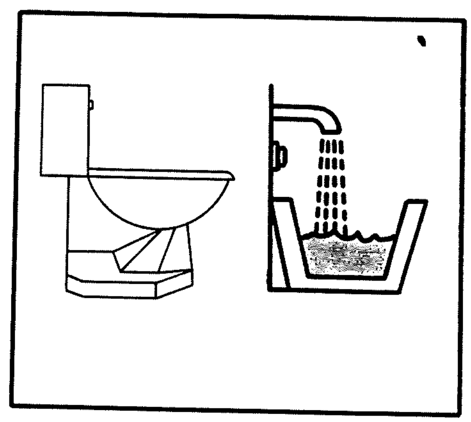


SEASONAL/PEAK RATE

Rates for Unmetered Service

The majority of communities in Massachusetts with municipally supplied water are metered to record water use. However, there are still some communities, usually small towns, which are not metered. For unmetered water service, there is no relationship between consumption and the charge for water. As a result, these communities cannot use pricing to encourage conservation or achieve some of the other policy goals that they might have.

The most common methods of charging for water service in municipalities with little or no metering is simply a uniform charge for each service, or a fixture rate whereby charges are based on the number of water fixtures in the household. This method of pricing can be inequitable since charges are not based on usage. Also, it provides no incentive to conserve water.



Fixture Rate

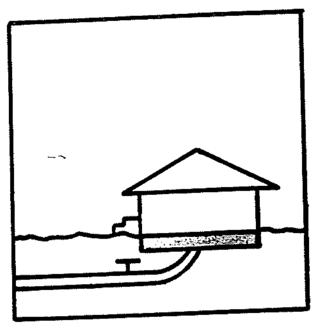
FEE PER WATER FIXTURE

Rates for New Users

Extending a water supply system to provide service to new users is usually very expensive. These extensions may be paid for in a variety of ways, depending on the policy objectives of the municipality. For example, a community wanting to encourage new residential or industrial development by extending the water system may sell bonds to pay for the project and recoup the cost from all system users. This is done by adjusting the rates to include the principal and interest charges in the cost-of-service calculation.

Alternatively, a community that wants to discourage new development may choose to charge the developer or builder for the total cost of extending the system. A requirement to pay all or part of this cost up front, before building begins, is often enough to dissuade potential developers. Sometimes, however, the developer simply passes on this cost to the future property buyers.

A community that is not opposed to the development but does not want to charge present users for the cost of extending the system may recoup these costs from the new users directly. Usually this occurs via a hookup charge, which may run as high as thousands of dollars per new user! Many argue that this method of charging for system extension (marginal cost pricing) is the most equitable since new users pay for the full cost of system extension and the rates to existing users are not affected.



Hook-up Fee Per Service

RATES FOR NEW USERS

III. Water Rates: Price Level

What is Full-Cost Pricing?

Full-cost pricing exists when a water utility sets price levels that recover all the direct and indirect costs associated with providing water. To become self-sustaining, a water utility must employ full-cost pricing. Rates based on full-cost pricing may be higher than those based on other pricing practices as they include such costs as capital expenditures, debt service, depreciation, employee benefits, billing and administration, and services provided by other municipal departments. (See Recommendations, Calculation of the Full Cost of Service, p. 16). It is important, however, to remember that these costs are not new; they have simply been subsidized from tax revenues in the past.

The cost of providing water varies widely among municipal water utilities, even those with the same source of supply such as members of the Metropolitan District Commission. Besides the source of supply, factors that affect this cost include: age of the system, need for and type of treatment, need for pumping, size of service area, total average and peak demand, and other considerations. (See Appendix for a sample listing of water rates in Massachusetts.)

Benefits of Full-Cost Pricing

Whatever the particular policy goals of a water utility and whatever its rate structure, there are many reasons for establishing price levels which produce adequate revenue to cover the full cost of providing water and for appropriating all such revenue to the water enterprise fund. Full-cost pricing contributes to good water resources management in the following ways:

1. Overall long-term costs of supplying water are reduced as adequate funds become available for regular maintenance. This reduces water loss and prolongs the expected life of the system's fixed assets.
2. The cost of water is no longer subsidized, so wasteful use is discouraged and conservation is encouraged. This may postpone, reduce, or eliminate the need for investment in a new supply source or waste water treatment facility.
3. All users are charged based on actual quantities used, thus making the pricing system more equitable.
4. Environmental costs of controlling or acquiring land necessary for water supply are reflected in water rates, thereby providing sufficient funds to protect water sources and recharge areas.
5. Incentives for sound financial management practices are introduced, since the budgets of self-sustaining water utilities are related to the level of efficiency with which the utility manages its resources.
6. Sufficient revenues are provided on an ongoing basis to plan for future demand, thus ensuring a reliable, high-quality water supply — increasingly an important concern to industry.
7. Public awareness of the true value of water supply is increased, since a change to full-cost pricing usually requires a public education campaign.

In addition, state grant programs for municipal water utilities, such as those for leak detection and repair (Chapter 805 of the Acts of 1979) and system rehabilitation (Chapter 286 of the Acts of 1982), give priority to utilities with full-cost pricing.

Water Pricing and Conservation

As with other commodities, the price of water has an impact on its usage and can be utilized as a component of a water conservation program. Though the degree of this impact (elasticity) varies considerably from case to case, in Massachusetts, pricing must generally be used in combination with other conservation efforts in order to be effective. Pricing has been shown to be most effective in encouraging reduction of residential peak use and of commercial and industrial average use.

Many Massachusetts communities have experienced a decline in water use immediately following a price increase, only to have the consumers get used to paying the higher price and revert to past consumption levels. As water price levels increase, the response to rate hikes by consumers is likely to be more lasting. Where water charges are combined with sewer fees, the raised price level may be particularly effective at reducing consumption.

An important consideration in increasing water rates is the impact on total utility costs and revenues. Water utilities generally have high fixed costs (debt service, administration, and overhead) and relatively low variable costs (energy and chemicals). As a result, when increased water rates cause conservation, the total cost to the utility providing service declines, but the average cost per unit of water provided increases.

Depending on the extent of conservation resulting from a rate increase (i.e., elasticity of demand), total water utility revenues may increase or decrease. That is, if little conservation occurs because of a rate increase, total revenues should increase, while if a high level of conservation occurs, total water utility revenues may decline. Given the historical underpricing of water by most utilities in Massachusetts and the relatively low elasticity of demand for residential use, price increases will generally increase total water utility revenues. In addition, for conservation programs not relying on pricing as a strategy, pricing can be utilized to restore lost income to the utilty. It is important that a water utility considering an increase in its water rates has a good estimate of the impact on water use, and that this information is considered in the rate-setting process.

The major advantage of using pricing to encourage conservation is that it allows the consumers to decide which uses should be curtailed rather than imposing restrictive use policies. The major disadvantage is the uncertainty of the impacts of a particular price change on water use and the utility's revenues.

IV. Difficulties with the Implementation of Full-Cost Pricing and Improved Financial Management Practices

Though there are many good reasons to implement full-cost pricing, it is often difficult for the public and for municipal officials responsible for water supply to recognize these reasons and to adopt full-cost pricing and improved management practices. This difficulty stems from historical underpicing, limitations of conventional accounting systems, political concerns, and institutional constraints. These difficulties should not be underestimated as they have been formidable obstacles for many utilities.

Since the passage of Proposition 2½, municipal officials and interested citizens have become more concerned about the financing of municipal services, such as water. In broad terms, there is a shift in municipal philosophy underway. Municipal water suppliers are increasingly being viewed as utilities, and water, as the commercial product of a public enterprise (similar to gas or electricity), is being priced accordingly.

Lack of Metering

Some 35 water utilities throughout Massachusetts still do not meter their customers. A much larger number meter most but not all users, with municipal departments frequently remaining unmetered. Since municipal users often consume large amounts of water, this can result in higher charges to other consumers or increased subsidies from general revenues.

Without metering, a utility cannot charge its customers in an equitable manner based on consumption, nor can it use pricing as a management tool for accomplishing conservation or other goals. In addition, lack of metering makes it difficult for a utility to detect leaks or trace unaccounted-for water.

Historical Underpricing

Historically, water prices to the consumer have been below the cost of service. Consumers have been encouraged to view water supply as a public service similar to fire and police protection. Indeed, water works managers, themselves, have considered an adequate supply of clean water a form of public health protection. Few consumers or public officials, therefore, are aware of the full cost a municipality must bear to supply its users with water. As the cost of providing water has risen in recent years, it has not always been matched by comparable rate increases. This has resulted in the need for increased subsidies from tax revenues. In some cases water service may have become so underpriced that implementation of full-cost pricing will require relatively steep price increase (usually very unpopular with consumers).

Accounting Systems

Traditional municipal accounting practices often do not provide the necessary data on costs and revenues for water utilities to become self-supporting. Most often water department income and expenditures are lumped together with those of other municipal services in the general fund or public works account, rather than in a separate water enterprise fund. For example, water department capital expenditures are commonly part of general revenue bond issues included in the debt service account and not attributed to water department costs. As a result, many municipalities have not known the true costs associated with the provision of water. It is difficult to calculate the cost of service and the degree to which revenues cover costs without separately accounting for the financial transactions of the water department. In addition, the water utility's budgeting and financial planning is hindered by this lack of data. With the accounting function often performed by an outside accountant, water managers must play an active role in supplying necessary figures to assure accounting accuracy. Unless waterworks professionals are convinced of the advantages to the water utility of altering the accounting practices, they may not actively support such changes.

Nature of the Rate-Setting Process

In most cases those responsible for setting water rates are elected officials such as city councilors, town selectmen, or boards of public works. As such, the rate-setting process is subject to the full range of political concerns. Since price increases are usually unpopular among residents and industries, elected officials responsible for rate-making may be reluctant to support higher rates, regardless of the need.

The most obvious source of political pressure is from public opposition — water consumers often resist increased rates. With water costs still widely subsidized from tax revenue, many citizens view water payments as a tax rather than as a payment for a utility or service. If no observable problem exists with the water supply system, citizens may consider rate increases unnecessary and subversive to the intentions of Proposition 2½. In fact, some experts believe that only a crisis situation such as a drought, a water ban, or a noticeable deterioration in water quality will gain public acceptance of increased water rates.

Citizens often mistrust the figures presented by local officials, yet the public generally lacks the data to question them effectively or to satisfy themselves that the numbes are accurate.

In addition, the pressure from industry not to increase rates, in order to stabilize the cost of doing business and encourage industrial development, may be substantial. In communities with numerous water-dependent companies (such as textiles or paper mills) this is especially true, since these industries have claimed that increased water rates would force a reduction in employment or even plant closures, neither of which is politically acceptable to municipal officials.

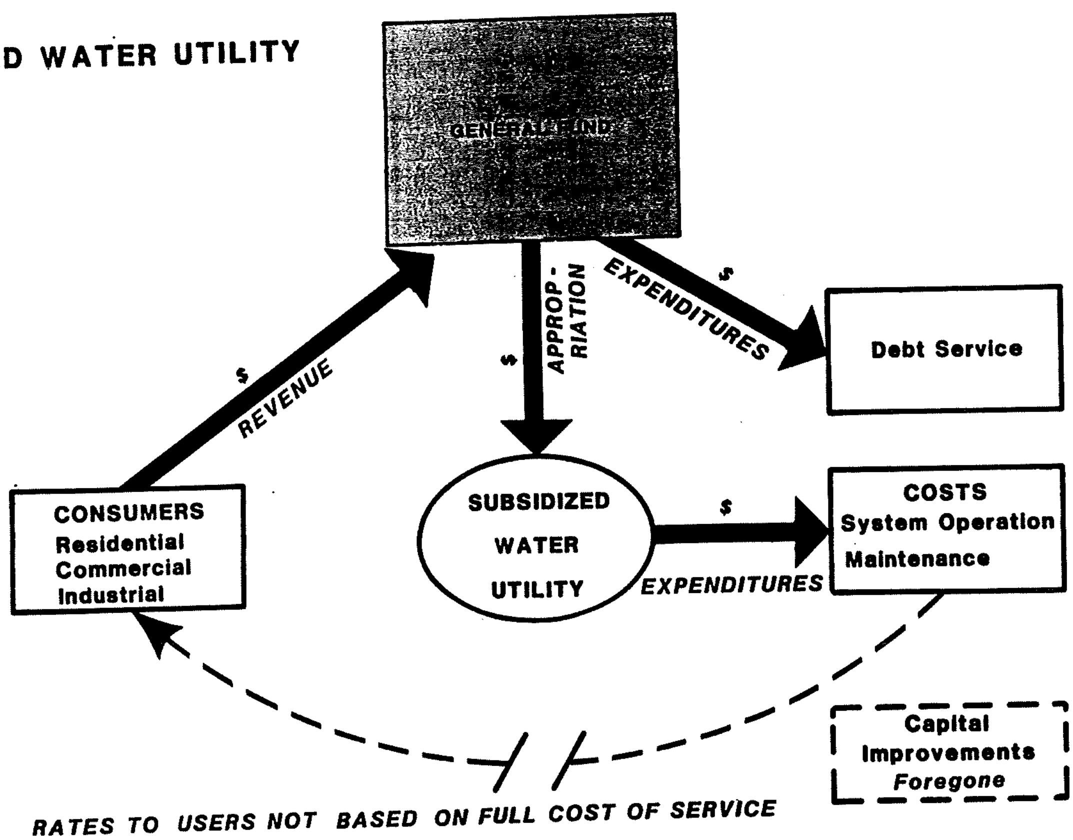
Institutional Structures

As with any government activity, the institutions responsible for administering water departments have developed certain patterns of conducting their activities. Where these patterns are perceived as having met past needs adequately, they often have become institutionalized and difficult to change.

Since many municipalities already lack adequate funds to operate and maintain their supply systems properly, local waterworks managers are understandably reluctant to spend limited funds on administrative changes. Waterworks professionals may also fear that implementation of full-cost pricing will result in a reduction in total revenues due to conservation on the part of consumers.

Implementation of a new accounting and pricing system may be seen as too much of a financial strain or as a misallocation of resources. Local finance offices are often understaffed so any additional work or change in present practices may be a burden. Unless water works professionals and municipal finance officials are convinced that changing the accounting and pricing systems will benefit the water utility over the long term, they may be reluctant to support such changes. Because these groups provide much of the information and labor needed to establish and administer new water rates, gaining their support is critical for implementing full-cost pricing and improved financial management practices.

SUBSIDIZED WATER UTILITY



V. Recommendations

The following recommendations are geared to municipal officials, water works professionals, and citizens concerned with the management of local water utilities and the setting of appropriate water rates. The general objective is to improve water resource management policies in Massachusetts. The specific policy goal is to encourage communities to make their water utilities self-supporting by pricing water at its full cost and appropriating all water revenue to water enterprise funds. A closely related goal is to increase public awareness regarding the full cost of water and to promote the wise use of this vital resource.

Since 1965, the American Water Works Association has endorsed the establishment of self-sustaining water utilities, adequately financed by revenues derived from user charges. For a water utility to become self-sustaining and institute sound financial management policies, it should price water at its full cost, be assured that its yearly revenue is appropriated to the water enterprise fund, and be allowed to manage its own funds. In this way, the water utility can meet current operating needs and accrue funds for future capital projects. Improving traditional municipal accounting practices is the first step towards achieving these goals and serves as the basis for most other recommendations.

Improved Accounting Practices: Establishment of Enterprise Fund Accounting

Most municipal water utilities need to improve their accounting practices in order to determine their full cost of providing service. Only in this way can they begin to charge adequate water rates and become self-sustaining. This determination requires an accounting of water utility costs and revenues separate from the general fund. This separation has not been widely practiced in the past, since municipal water suppliers generally have not been considered self-sustaining utilities. Water utility costs and revenues have been lumped together with general municipal expenditures and receipts, so accounting records do not indicate where water revenues have been diverted to pay for other municipal services or where they have been inadequate to cover all water utility costs.

The separate accounting of a municipal utility's costs and revenues from the general fund is referred to as *enterprise fund accounting*. According to the National Council on Governmental Accounting, enterprise funds are used:

"to account for operations (a) that are financed and operated in a manner similar to private business enterprises -- where the intent of the governing body is that the costs (expenses, including depreciation) of providing goods or services to the general public on a continuing basis, be financed or recovered primarily through user charges..."[5]

> Enterprise fund accounting for water utilities has been recommended by the professional organizations of the accounting profession (National Council on Governmental Accounting, Municipal Finance Officers Association, American Institute of Certified Public Accountants), as well as the professional organizations of water utility managers (American Water Works Association, New England Water Works Association).

By identifying the total cost of providing water, an enterprise fund system identifies the revenue needs of a municipal water supplier. Though enterprise fund accounting is commonly adopted by municipalities which are making their water utilities self-sustaining, the establishment of an enterprise fund system does not mandate that the utility be self-sustaining, or that it finance a certain percentage of the costs of providing water through user charges. This is a decision which ultimately must be decided by the local government. Enterprise fund accounting merely provides the necessary financial information to determine the full cost of service and the extent to which revenues generated from rates cover this cost. If water rates do not produce adequate revenue to cover the full cost, enterprise fund accounting indicates the amount of subsidy that must be financed from taxes or other sources.

Enterprise fund accounting places the water utility on a more appropriate accounting and financial reporting basis. By distinctly accounting for each cost component of providing water service, the enterprise fund system provides the utility manager with the detailed data necessary fc close financial oversight and accounting control. In addition, the information is useful for budgeting and planning.

Communities should adopt the policy of annually appropriating all water revenues to the water enterprise fund. If this policy is adopted in conjunction with full-cost pricing, a community makes its water utility self-supporting and provides it with a consistent and reliable level of funding, based on user fees rather than subsidies from tax receipts. In addition, the water utility manager has more control over how revenues are spent and more flexibility to operate, maintain, and improve the system.

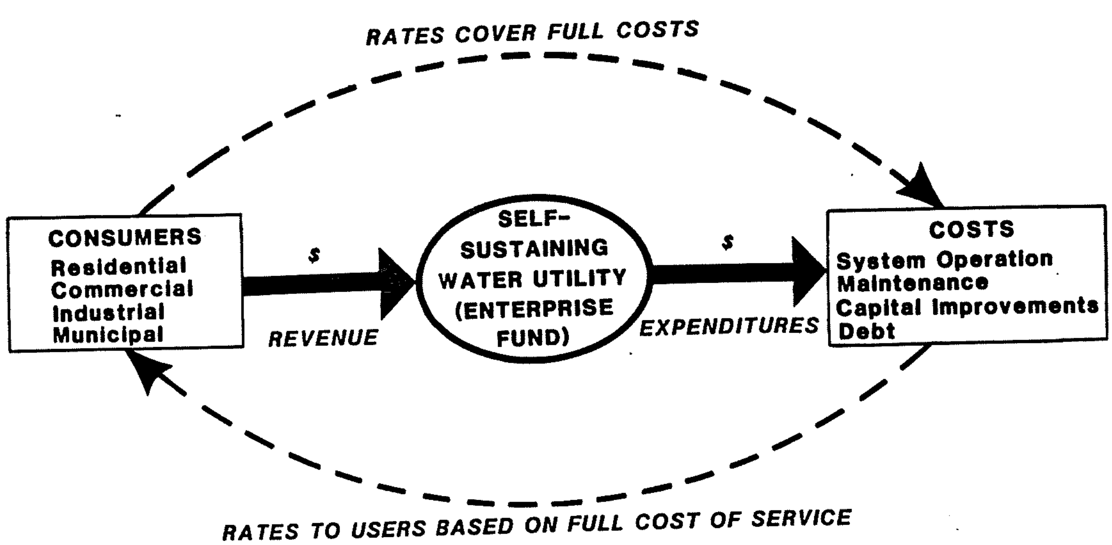
The annual appropriation of all water revenues to the water enterprise fund permits the utility to accrue funds for capital projects planned for the future. This creates an incentive to operate as efficiently as possible since any savings are appropriated to the water enterprise fund.

Traditional municipal accounting has generally been on a cash basis, meaning revenues and costs are accounted for at the time funds are actually received or expended. Enterprise fund accounting requires use of the accrual system whereby revenues are recorded when earned (i.e., when water is provided), and expenses are accounted for when incurred. This conforms to generally accepted accounting principles (GAAP) as well as *Governmental Accounting, Auditing and Financial Recording* (GAAFR) practices. Under the accrual accounting method the water utility matches costs against the revenues generated by these costs, thereby providing the data necessary to more accurately determine the financial position and operating results of the enterprise.

To help ensure the accuracy of financial statements, enterprise fund accounting requires that goods and services provided by other governmental departments to the water enterprise be accounted for in the same manner as transactions with outside parties.

The Massachusetts Bureau of Accounts, which oversees the accounting practices of local and state governmental bodies, has recently recommended adoption of enterprise fund accounting for comprehensive financial reporting purposes throughout the Commonwealth. The recommended approach is contained in the Bureau's 1980 publication entitled the *Uniform Municipal Accounting System* (U.M.A.S.).

Presuming the enterprise fund accounting system is implemented as a tool for making a water utilty self-supporting, it has significant benefits to the general fund. Most important, by eliminating the need for subsidies, it reduces the demand on the resources of the general fund. As a result, the limited tax revenue available to communities under Proposition 2½ can be used to pay for those municipal services that cannot be financed through user charges or other revenue sources. In addition, the enterprise system will usually result in some payment by the water utility to the general fund to cover the cost of services provided by other municipal departments. Also, annually appropriating all water revenues to a self-supporting water enterprise fund eliminates the practice of using water revenues to pay for other municipal services.



SELF-SUSTAINING WATER UTILITY
(Based on Full-Cost Pricing and Appropriation of all Water Revenue to Water Enterprise Fund)

Calculation of the Full Cost of Service

In order to anticipate future costs, determine future revenue requirements, and set appropriate rates, a water supplier must have accurate and complete information on the full cost of service. Municipal water utilities have traditionally not accounted for the cost of depreciation and certain labor and administrative costs, as these services were provided by other municipal departments and paid for by the general fund. For example, managerial personnel (such as the town manager or the director of public works) spend a certain percentage of their time on water utility work. The cost of that portion of their salary should be accounted for as a cost to the water utility. Likewise, labor or equipment provided by other municipal departments, such as billing and administrative services, should be charged to the water enterprise and included when calculating the cost of providing water service.

Capital costs, such as those associated with the construction of new supply facilities or a treatment plant, commonly have not been included in cost-of-service calculations. These costs have traditionally been paid for through state grants or by issuing bonds, with the principal and interest paid out of general revenues. Such capital costs should be reflected in the full cost of service by including the principal and interest charges as costs to the water enterprise.

The costs to be included in the cost of service are not legislated by statute. Therefore, a utility may include any costs which are reasonably related to providing water service, as long as supporting documentation exists. The following is a general list of possible costs to a municipal water utility. (Note that each system is different and not all costs listed apply to all systems.)

1. land acquisition, management, and protection
2. fixed assets including reservoirs, wells, pumping stations, water mains, treatment plants, storage tanks, etc.
3. water itself if purchased from a wholesaler or another supplier
4. maintenance of fixed assets, including equipment and materials
5. pumping costs (energy)
6. labor including fringe benefits, overtime, emergency and part-time personnel
7. treatment costs (chemicals)
8. planning and supply augmentation, including cost of contracts for emergency supply, hiring of consultants, etc.
9. office overhead, including electricity, heating, equipment and supplies
10. insurance for fixed assets, vehicles and equipment
11. billing and administration, including computer services, meter reading, and services provided by other municipal departments
12. fire protection services
13. principal and interest on outstanding debt

For a more detailed list of these costs refer to *Water Utility Accounting* (1980), published by the American Water Works Association. Also, review *Governmental Accounting, Auditing, and Financial Reporting* (GAAFR), published by the National Council on Governmental Accounting (1968) and be sure to discuss this matter with your outside auditor.

Valuation of Fixed Assets and Determination of Depreciation Costs

Until recently, the Massachusetts Bureau of Accounts did not actively encourage municipalities to establish enterprise funds. With water utility financial information traditionally included in the general fund, local accounting departments and auditors have not been required to record fixed assets (water mains, treatment plants, pumping facilities, etc.) and their depreciation as a cost of providing water. As a result, many municipal water utilities have inadequate information concerning the age, size, and condition of fixed assets. This lack of information inhibits good water management and makes it difficult to set rates adequate to cover the full cost of service.

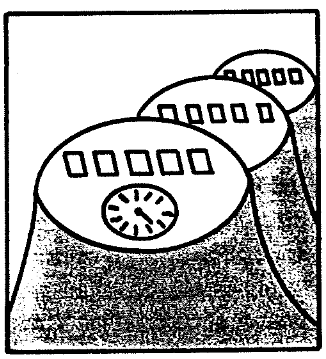
Under enterprise fund accounting, however, depreciation of fixed assets must be included as a cost of providing the service. Ideally, an exact valuation of assets should be undertaken as the basis for calculating depreciation costs. Usually such a valuation cannot be handled by water utility personnel and must be contracted out to a consulting (engineering or accounting) firm. As a result, an exact valuation has been beyond the means of many municipal water utilities.

There is a low-cost alternative method for valuation of fixed assets which relies on already existing resources. In many cases, a long-time employee of the water utility may be able to provide some of the needed information concerning existing assets. This information should be supplemented with data obtained from the following sources, if available: construction records, repair records, past consulting reports, and past billing records. By piecing together the data from as many of these sources as possible, water utility personnel should be able to arrive at an approximate valuation of fixed assets. While not as precise as a formal valuation of assets study, this approximation is usually adequate for calculating reasonable annual depreciation costs. Since depreciation in public enterprises is a complex issue, the valuation of assets and depreciation calculations should be reviewed by the municipality's accountant or outside auditor before being put into use.

The valuation of assets is not only essential for the calculation of depreciation costs, it provides valuable information on the present condition and future needs of the water supply system.

Increased Use of Meters

If resource management is to be improved and sound financial management practices established through full-cost pricing, water utilities must institute universal (100%) metering. A municipal water supplier can charge equitable rates based on water usage only if all its customers are metered. In addition, 100% metering is necessary for tracing unaccounted-for water and for leak detection, thereby contributing to water conservation. The *Massachusetts Water Supply Policy Statement* endorses "complete and accurate metering" as a necessary component of sound water management policy.[6]



METERING

A water utility just starting to meter or one that has been metering for some time should establish a meter maintenance and replacement program, whereby meters are checked regularly and replaced when necessary. Some water utilities have programs to replace all meters which have been in service a specified period of time, usually 10 or 15 years. Since older meters tend to under-register the volume of water being used, thereby reducing revenues to the utility, maintenance and replacement of meters should pay for itself in a short period of time. In these programs it is advisable to repair and/or replace the meters of the largest users first, as under-registering of these meters results in the largest loss of revenue.

The reading of meters, as well as the meter maintenance and replacement program, requires considerable labor time. These personnel costs should be reflected in the cost of service and the rate charges. The costs of the actual meters can be charged to the user's account as a service or hookup charge either in one lump sum or spread over several billing periods, or it can be included in the rates.

The frequency of meter reading and billing depends on each community's needs and capabilities. Most suppliers in Massachusetts read meters and bill their customers semi-annually or quarterly. To improve cash flow some utilities increase the billing frequency, or bill very large customers on a monthly or bi-monthly schedule. In cases where seasonal peak pricing is in effect (Wellesley, for example), meter-reading practices may need to be altered so that meters are read immediately before and after the peak price period.

Public Education

With the historical underpricing of water, it is not surprising that the public is generally unaware of the full cost of providing water and the degree to which rate revenues cover costs. Enterprise fund accounting will facilitate the gathering of information concerning the full cost and will clearly identify the current amount of subsidy from taxes.

For municipal water suppliers to become self-supporting and implement sound resource and financial management policies, public education and support is vital. The key to gaining public support is the raising of public awareness concerning the full cost of water service and the reasons why the present pricing system is inadequate to meet this cost. Informing local officials and gaining their backing is often a very important step in achieving public approval. To be effective, the public education effort should not be a general campaign on the virtues of full-cost pricing; rather, it must identify precise costs and system needs and be linked to specific policy proposals.

If a price increase is being proposed, information on the increased cost of providing water since the last rate increase should be made available, highlighting such items as labor, energy, and inflation. At the same time, the inadequacies of past revenue levels and the deferral of maintenance and capital improvements that resulted should be demonstrated where appropriate. This can be shown most dramatically by displaying a badly deteriorated section of water pipe which did not receive needed maintenance and had to be replaced. Testimony from the residents affected is also very convincing. Employees of the local fire department can be the most persuasive in presenting public-safety justifications for full-cost pricing, particularly for the need to maintain adequate water pressure.

The public should also be informed of the potential benefits of full-cost pricing and self-sustaining water utilities. As discussed earlier the benefits include: improved water resource management as adequate funds are made available for maintenance; reduced demands on general revenues, thereby freeing up funds for other municipal services; and more equitable pricing since the cost of service is being paid for by all users and is no longer underwritten by property taxes. The general public may not readily understand complex financial figures, so numbers must be carefully prepared and clearly presented if the benefits of full-cost pricing are to be "sold" effectively.

Organizing a citizens advisory committee is often an effective way to involve the public and focus the community's attention on water pricing and water utility management issues. The following section on improving the rate-making process deals with the role of the citizens advisory committee in more detail. In addition, existing local interest groups such as conservation organizations or the League of Women Voters may be willing to sponsor educational programs on water pricing and management.

Along with the educational campaign on increased rates, the water utility should provide information on conservation techniques to save water and keep bills low. This is often viewed by consumers as an indication of sensitivity to their needs on the part of the utility and may foster public support for the new rates.

The process by which the utility or local government involves citizens in the rate-making procedures is important. Informing the public after the fact — after a new rate has been established and approved — is bound to foster public resentment or opposition. Rather, when the new rates are first proposed it is advisable to initiate a public education campaign, inform the public of the proposal, and solicit citizen response.

There are numerous ways to accomplish these tasks, many of which are listed below:

- public hearings
- speeches at meetings of local organizations
- bill inserts
- letters to the editor
- local radio shows or announcements
- school programs
- flyers
- handouts
- advertisements in local newspapers
- posters
- cable television shows

While there is a cost to some of these public education tools, many are free or very inexpensive. (See Wellesley case study, p. 20). In all of these, organization and clear presentation are very important.

Often an important long-term beneficial result of public education is a group of informed and concerned citizens who take an active role in promoting full-cost pricing and improved management practices in the face of changing political situations. In fact, citizens can play a leading role by advocating actions that public officials may not otherwise consider because they are not a priority or are politically unpopular.

The success of a public education campaign can be judged by the degree of public support generated for the proposed rates. A utility with a past record of good service to a community will receive far greater public support than a utility with a history of poor water quality and service. Even with a sound and equitable rate proposal and an effective public education effort, some public oppositio usually remains. Clearly, not everyone's needs or interes. can be met.

Improved Rate-Making Process

In most communities water rates are set by an elected body such as town selectmen, city councilors, or local boards of water commissioners, or by vote at a town meeting. This brings the rate-making process itself into the political arena and may at times make full-cost pricing and effective rate-setting impossible. In cases where local political considerations prevent effective rate-making, a less political and more professional rate-setting procedure can be achieved by establishing an autonomous body (such as the Boston Water and Sewer Commission) to manage the water utility and set appropriate rates. Understandably, many local governments are reluctant to delegate this responsibility to an independent body, over which they exert little or no control.

An alternative is to appoint an independent board of water commissioners or an advisory committee or to hire a consultant to study the situation and recommend appropriate rate changes. While the ultimate authority for rate-making may still lie with elected officials who accept or reject the recommendations of the appointed board, committee, or consultant, direct political considerations are diminished. The best means for reducing undue political influence in a particular community's rate-setting process will depend on the specific political situation.

One proven method of improving the rate-setting process is by appointing a citizens advisory committee on water. The citizens committee should be a representative group including members from each consumer class: residential, commercial, and industrial. It is essential that the citizens committee work very closely with local waterworks professionals. The task of the citizens committee is to become well informed on the water system's needs and financing so that it is able to make useful recommendations to local officials responsible for setting water rates and deciding other related policies. They can also make suggestions on how the utility can best utilize the public education campaign to gain the support of local officials and the public. Due to the committee's broad composition, its recommendations should be widely accepted within the community and improve the credibility and effectiveness of the rate-making process.

The implementation of enterprise fund accounting also helps to improve the rate-making process. The enterprise fund provides detailed cost-of-service information to the public, municipal officials, or an outside auditor. For communities which appropriate all revenues collected from user charges to a self-sustaining water enterprise fund a clear and direct relationship exists between rate revenues and the funds available to provide water service. This type of water utility is therefore less subject to the political considerations of the local budget appropriations process.

Achieving Full-Cost Pricing

In most cases, before full-cost pricing can be achieved a municipal water utility should implement improved management practices as described above. The foundation for full-cost pricing is the enterprise fund accounting system; this can be established most effectively through local implementation of the Massachusetts Bureau of Accounts' *Uniform Municipal Accounting System*.

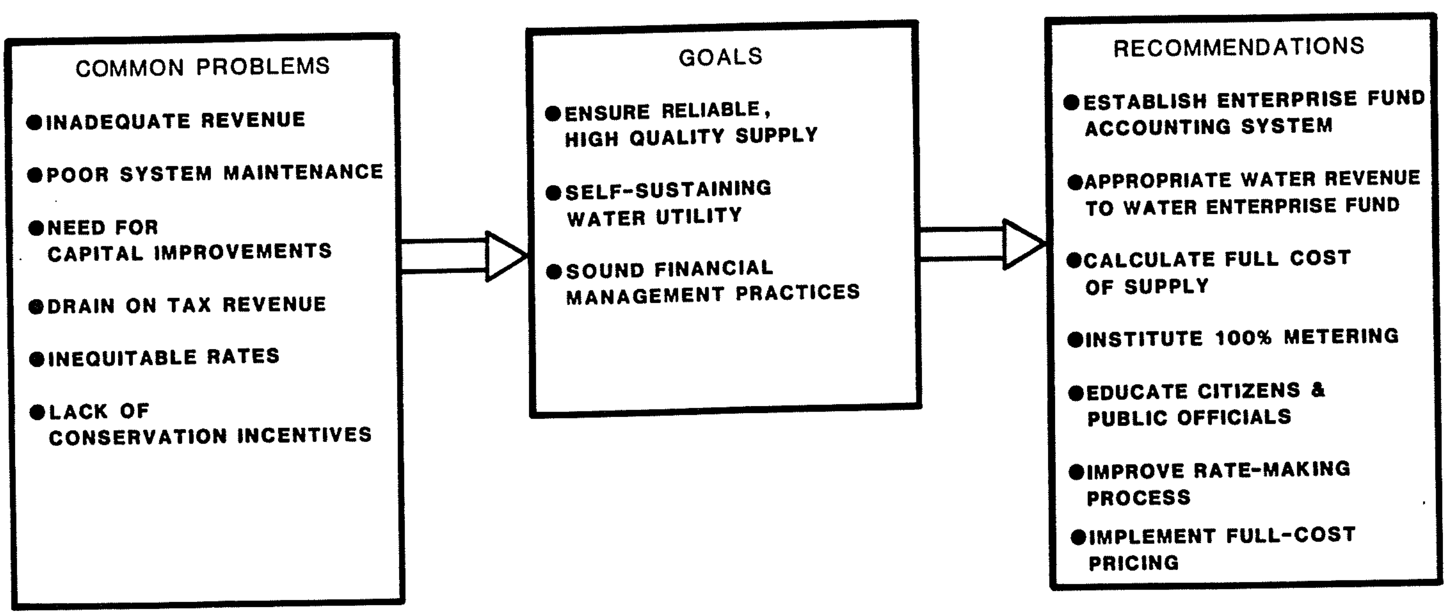
Since any significant price increase usually results in some conservation by consumers, an estimate of the reduction in consumption must be included in the cost-of-service calculations and revenue projections used to set an appropriate rate.

A water utility that wants to implement full-cost pricing may do so through one large price increase or by several incremental increases. Most water utilities plan their rates to cover a two to four-year time span, while some adjust rates annually. Public opposition and a loss in consumers' confidence in the utility may result from frequent price hikes. In some cases it is preferable for the utility to raise prices only once within a two to four-year period.

On the other hand, due to the historical underpricing of water in Massachusetts, achieving full-cost pricing with one large price increase may be unacceptable to local officials and/or consumers. In such cases, incremental price increases can be implemented, making it clear at the outset that the goal is to recover the full cost of service from rates by a specific date and that a series of increases is planned.

To set appropriate rates requires cooperation between engineers, accountants (either in-house or consultants), and water works managers. Based on the full cost of service calculation, as well as revenue requirements information, rate makers should adopt an appropriate rate structure and level to fully cover costs, meet future revenue needs, and help meet local policy goals.

There is no best rate structure which can be generalized to all municipal suppliers. It is clear, however, that rate levels must be revised — in most cases increased — to fully cover the costs of supply, eliminate subsidies from tax revenue, and place the water utility on sound financial ground.



ACHIEVING SELF-SUFFICIENCY AND IMPROVED MANAGEMENT OF WATER UTILITIES

VI. Case Studies

The conditions and management practices of water utilities vary greatly among communities. What works in one community may not necessarily be effective in another. Available financial and personnel resources differ from town to town as do local policies and political environments. Despite such differences, the experience gained in one community may provide others with valuable information in considering policy options for water pricing and water utility management.

Wellesley[7]

The Town of Wellesley provides an excellent example of a community that has established a self-sustaining water utility through full-cost pricing. In addition, Wellesley has met its major policy goal of reducing peak demand by instituting a peak demand pricing structure and an effective conservation program that complements its overall policy objectives.

Wellesley is a residential community about ten miles west of Boston with a population of approximately 27,000. In addition to 8,000 homes, there are several colleges and retail shopping areas, as well as a number of office parks. The town has no industrial base.

Wellesley is served by the Water/Sewer Division of the Department of Public Works. All of the town's water is supplied by its own municipal wells and the system is fully metered. Total water consumption has increased with Wellesley's population and business growth. In 1981, average daily consumption was about 3 million gallons per day, with peak demand at about 5.8 million gallons a day. The safe yield of the town's water supply is 5.2 million gallons a day. Residential users account for 75% of the water consumption, with the remaining 25% consumed by commercial or municipal users.

In 1973, Wellesley was one of the first communities in Massachusetts to adopt an increasing block rate structure to provide adequate revenues for its water program and to encourage water conservation by its residential customers. The 1973 rates were as follows: a minimum charge of $5.00 per two-month period for 500 cubic feet, $0.60 per 100 cubic feet in excess of 500 cubic feet, and $0.70 per 100 cubic feet in excess of 3,000 cubic feet (for residential customers only).

Like most communities, Wellesley has adequate water supplies to meet current and even projected *average-day* demand. The difficulty, however, is meeting present and future *peak-day* demand. From 1970 to 1981, daily demand exceeded safe yield an average of ten days each summer. This has necessitated emergency measures including restrictions on outdoor water use.

Rates remained the same from 1973 until fiscal year (FY) 1981, when it became clear that additional measures were needed to reduce seasonal peak demand. In addition, net income for the water program in FY 1981 was negative as revenues did not fully cover costs. With the water enterprise fund low on cash, a rate increase was necessary.

The Wellesley Department of Public Works identified three major objectives of new water rates:

1. to ensure adequate revenue to provide continuing water quality and quantity to meet demand;
2. to encourage water conservation, especially during peak demand periods; and
3. to ensure a fair and equitable rate schedule.

In addition, the Wellesley DPW wanted to "keep it simple," so that rates were easily administered by the department and easily understood by the public.

WELLESLEY'S PEAK RATE

To meet these objectives, Wellesley implemented a seasonal peak demand rate in June 1981. The new rate structure applies to all customer classes. It is in effect from mid-April through mid-October. The seasonal peak rate is phased in each summer and phased out each fall. Due to a staggered billing schedule, half the customers are charged peak rates from mid-April through mid-August, while the other half are charged peak rates from mid-June to mid-October. All customers are under the peak period between June 15 and August 15 when demand is highest.

The new rates are flat except during the two summer billing periods. The flat rate is $1.10 per 100 cubic feet. During the two summer billing periods, for customer consumption exceeding 2,500 cubic feet bimonthly, the rate is $1.60 per 100 cubic feet. The peak rate is more than 45% higher than the regular rate. Since studies have shown that water demand is relatively inelastic — that consumption is not greatly affected by price — Wellesley officials thought this large differential was needed to serve as an effective deterrent to high consumption.

Approximately one third of the residential customers and one half of commercial customers paid the peak rate in 1981. Water bills of these large customers increased dramatically during summer months. Rather than gradually getting used to higher rates over time, the cost increases significantly each summer period (and declines each fall), reminding large users that they are paying a premium price for extra summer consumption.

The sewer charge was also changed. Prior to June 1981, sewer charges had been part of the property tax bill and did not completely cover the cost of sewer service. With the strong backing of the DPW, Wellesley's sewer system was put on an enterprise fund account in FY 1982 with sewer rates covering the full cost of sewer service. This change required a substantial rate increase. The new sewer charges were placed on the water bill ensuring that tax-exempt users will pay their fair share of costs, while non-users will not have to pay for a service they do not receive.

In addition to peak pricing to reduce peak demand, Wellesley initiated a public education campaign and a voluntary conservation program. The conservation program centers around outdoor water management during summer months and a water education teaching (WET) program in the elementary schools. Specifically, customers are requested to use water outdoors on even-numbered days only or on odd-numbered days only (depending on whether their street address is even or odd). The use of water-saving devices is also actively promoted through bill inserts and other efforts.

The extra revenues generated by the seasonal peak demand rate allowed Wellesley to set a lower water rate for off-peak months than would have been possible under a flat year-round pricing system. This lower off-peak rate helped to reduce public opposition to the peak rates. In fact, the new pricing structure and the conservation program associated with it generated considerable public support. The rates were viewed as equitable because all customers were affected, not just residents, so each class of user pays its fair share, and because smaller users received smaller percentage increases in their water bills. As Wellesley's Director of Public Works stated:

> "No one likes rate increases, but in this case, the seasonal peak demand structure was accepted by the public, and for some, it was a very positive approach to tempering water consumption..."[8]

The seasonal peak demand structure in conjunction with a community education program and the odd/even watering program has been very effective in Wellesley. Most important, it has provided needed revenues. Secondly, it has reduced peak demand and the ratio between peak-day demand and average-day demand.

Since the peak pricing and conservation programs went into effect in June 1981, Wellesley's demand for water has not once exceeded its safe yield. This has been accomplished not by imposing water bans, as had been done in past years, but through voluntary cooperation. A survey of Wellesley households conducted in August 1981 indicated that 21% of those (who said they were) using less water outdoors were doing so primarily because of the increased price.

Another benefit of the seasonal peak rate is improved cash flow for the water program. More revenues are generated early in the fiscal year, resulting in additional interest income, and revenues are greatest during the summer months when they are most needed due to higher expenditures for construction and maintenance work.

As a result of these initiatives, Wellesley's DPW and its customers have changed from a crisis management approach to one of crisis prevention. Not only is the department viewed as better managed than before, the inconveniences of water bans have been significantly reduced.

In its efforts to increase public awareness and gain support for its programs, Wellesley utilized most of the techniques listed above in the section on public education campaigns. The director of the DPW identified the following key actors in Wellesley's conservation effort: The Board of Public Works, the local newspaper which supported the program, a college student intern, meter readers who distributed handouts and posters, other town boards that supported the program and, most importantly, conservation-minded citizens. In a DPW survey of Wellesley households, 95% were aware of the program, 75% supported the program, and over 50% actively participated in outdoor water conservation efforts.

The total cost of Wellesley's public education campaign was $2,400 during its first year. Most of these funds were for hiring the college intern to manage the program and for posters, bill inserts, and newspaper advertisements. With the program in place, DPW personnel indicated that these costs should be reduced in future years.

The results and long-term implications of Wellesley's peak pricing and conservation programs are significant. By combining the peak pricing strategy with conservation and a public education campaign, peak pricing was widely accepted. Water revenues have increased and fully cover the costs of providing water service. Peak demand has not exceeded safe yield, even for one day. The broad support and citizen awareness generated by these programs should make it easier to gain public approval in the future for other water projects such as capital improvements.

In short, Wellesley has placed its water utility on a sound financial basis so that it may remain self-supporting, and overall water management has been improved.

Boston[9]

The case of the Boston Water and Sewer Commission (BWSC) provides an excellent example of how a municipality can greatly improve the financial and operational management of its water (and sewer) system by establishing an autonomous, self-sustaining water utility. Since the Commission was created in 1977, it has been able not only to transform a heavily subsidized utility into one which is self-supporting with a sound financial base, but also to implement long-needed maintenance and capital improvement programs.

Until 1978, the City of Boston's Public Works Department (DPW) was responsible for providing water and sewer service to about 87,000 accounts. Historically, the Public Works Department did not charge its users the full cost of supplying these services. Instead, the city subsidized these costs from general tax revenues. Competing for what were often scarce resources, the DPW often did not receive adequate funds to properly operate, maintain, and improve the water and sewer systems. Most of Boston's water distribution system is very old; about 20% of it is more than 80 years of age. Due to lack of proper maintenance, the infrastructure has deteriorated substantially. Faced wth the prospects of either continually increasing the subsidy for the cost of water and sewer service, or increasing the rates to cover these costs (which was very unpopular politically), it was proposed that Boston's water and sewer service be provided by an autonomous agency with the authority to set rates at the full cost of service.

In response to this proposal, in August 1977 the Massachusetts legislature passed a special enabling act establishing the Boston Water and Sewer Commission (BWSC).[10] The Commission is a subdivision of the Commonwealth, and from January 1978 has assumed responsibility for Boston's water and sewer service. The Commission is comprised of a three-member board appointed by the Mayor of Boston with City Council approval. BWSC purchases all its water from the Metropolitan District Commission (MDC), as did its predecessor, and has the authority to set water and sewer rates, subject to the approval of the Board of Water and Sewer Commissioners.

The legislation that established BWSC requires the Commission to be self-sustaining and to cover all current expenses and debt service costs from water and sewer rates. The purpose of forming BWSC, therefore, was to remove the political constraints on pricing water and sewer service at their true cost, thereby providing sufficient revenue to improve the management of these services. By requiring the Commission to be self-supporting, the legislation assured that adequate funds would be raised to properly operate, maintain, and improve the water and sewer systems. Any surplus revenues must be returned to the City of Boston or be reflected in the following year's rates. Like other municipal water and sewer utilities, the Commission receives some state and federal funds for very large capital projects.

The Commission's policy is to pay for all regular maintenance and replacement of existing infrastructure out of the operating budget, but to implement its authority to sell bonds in order to pay for new capital projects. For example, BWSC sold bonds to finance the $13 million capital improvements program which is now underway. The annual principal and interest charges are reflected in the water and sewer rates. By spreading debt service costs over 20 to 25 years, the Commission is able to maintain more stable rates, and the costs of new capital projects are born by future water system users as well as present ones.

BWSC Water Rates

The legislation that established BWSC requires that water and sewer charges be equitable, and that all users pay their fair share based on water use. (A provision was included, however, for a 15% discount for the elderly and disabled.) A flat rate structure was also mandated. By establishing rates based on water use, the Commission did away with subsidies from tax revenue, thereby eliminating the non-use related burden on property taxpayers. Given the large number of educational, cultural, and other tax-exempt institutions in Boston, this subsidy had been substantial.

Prior to the formation of BWSC, the city's rate system did not always produce sufficient revenues to cover all costs of water and sewer service. In addition, until 1978 high-volume users received a discount as charges declined at very high levels of use. While Boston water rates increased an average of 4.5% per year between 1961 and 1982, the cost of its water from MDC increased an average of 6% per year during this period. In 1977 before BWSC took over, Boston's water rate was $7.65 per 1,000 cubic feet. In 1978, its first year, the Commission increased this charge to $8.40. However, in 1979 the Commission reduced the water rate to $7.55 per 1,000 cubic feet. This price remained until 1983 when the charge was lowered further to $7.48.

The reduction was due largely to BWSC's successful leak detection program and other conservation measures which in recent years have reduced the volume of water purchased from MDC. For example, in 1979 112 leaks were found and repaired which reduced water loss by about 2.9 million gallons per day. This has resulted in lower water payments to MDC, and allowed the BWSC to absorb inflation of other costs without increasing the water rate. At the same time, water revenues no longer subsidize the cost of sewer service and are now used only for water system expenses.

BWSC Sewer Rates

While BWSC has allowed the charge for water to remain essentially unchanged since its establishment in 1978, the Commission has increased sewer charges substantially. The increases were due largely to the historic undercharging for sewer service; Boston's sewer rates had remained unchanged from their adoption in 1961 until BWSC took over in 1978! Following is a summary of the changes in Boston's water and sewer rates since 1961.

Note that sewer rates almost tripled in BWSC's first year. This was necessary to bring such charges in line with growing costs of the long-neglected metropolitan sewer system. Also, sewer rates under BWSC were no longer subsidized by the City of Boston. As is the case with water charges, the legislation which created the Commission mandates that sewer rates be flat charges based on volume of use.

Though BWSC sewer rate increases have been large, the average annual increase from 1961 to 1982 was about 8.4%. During the same period, the MDC sewer charges to Boston have increased on the average 10% per year. In the supporting documentation for its proposed 1983 rate schedule, BWSC stated that charging higher sewer rates has allowed it to increase sewer maintenance and construction funding to "realistic levels" to comply with federal, state, and local clean water requirements. Complying with federal EPA standards is an eligibility requirement for receiving federal and state grant funding — monies which are crucial if the sewer system is to be significantly improved.

Rate History*

(per 1,000 cubic feet)

Year	Water Rate	% Change From Prior Year	Sewer Rate	% Change From Prior Year	Combined Rate	% Change From Prior Year
1961	$3.00	—	$1.00	—	$ 4.00	—
1973	5.00	67%	1.00	—	6.00	50%
1976	7.65	53%	1.00	—	8.65	44%
1977	7.65	—	1.00	—	8.65	—
1978	8.90	16%	3.96	296%	12.86	49%
1979	7.55	−15%	3.59	−9%	11.14	−13%
1980	7.55	—	4.04	13%	11.59	4%
1981	7.55	—	4.04	—	11.59	—
1982	7.55	—	4.94	22%	12.49	7.7%
1983	7.48	−1%	5.46	11%	12.94	3.6%

Source: Boston Water and Sewer Commission

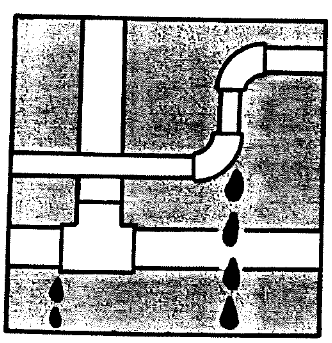
*The City of Boston established water and sewer rates through 1977. The Boston Water and Sewer Commission assumed responsibility for setting rates in 1978.

Improved Water System and Resource Management Under the Boston Water and Sewer Commission

Since the establishment of BWSC and adoption of rates which reflect the full cost of service, management of the city's water and sewer system has improved in many noticeable ways. In its efforts to ensure adequate supplies and improve system operations, BWSC has instituted three major programs: metering, leak detection, and replacement or relining of mains.

When BWSC took over in 1978, almost 50% of the water purchased from the MDC was not billed to its customers and was considered "unaccounted for." Unaccounted-for water included not only water lost due to system leakage, but also water used by unmetered users such as the City of Boston, under-registering of water use due to meter slippage, and water used within the system for fire fighting and other purposes. Prior to the creation of the Commission, the City of Boston was not charged for water. As required by legislation, BWSC has been charging the City of Boston for its water and sewer use. Because many facilities contained old or faulty meters, or were unmetered, from 1978 to 1980 the Commission based its billing to the City on estimates of water usage. Since 1981 metering has been completed in nine city departments including police, fire, libraries, and schools, and billings to these departments have been based on actual metered use. Until the remaining city departments are metered, their billings will continue to be based on estimated use.

The program also includes a meter testing and replacement effort which involves replacement of under-registering meters, and annual meter testing for the system's 250 largest users. These users are responsible for 40% of the Commission's total revenues.



LEAK DETECTION AND REPAIR

The leak detection and repair program has also been a success. Hundreds of leaks, responsible for the loss of millions of gallons of water per day, have been repairec The BWSC has initiated a program to reline or replace all water mains 100 years or older by the year 2000. Though this appears to be a reasonably ambitious program involving about 11 miles of pipe per year, the very goal of the program — to have the infrastructure no more than 100 years old — is a good indication of the age of the system and the seriousness of its deterioration problems.

The metering, leak detection, and pipe relining and replacement programs have decreased unaccounted-for water by 21%, so that by 1982 BWSC charged its customers for about 63% of the water it purchased from MDC. The Commission has also dramatically improved the collection of water bills. When BWSC took over in 1978, only about 70% of water and sewer bills were paid within 18 months. By 1982, approximately 95% of bills were payed within 12 months.

The Boston Water and Sewer Commission's success with the various programs described above was dependent upon adequate funding. It is likely that without the legislation which created BWSC, the City of Boston would have to increasingly subsidize the cost of water and sewer service, funding would not have been available to initiate the system-improvement programs, and the provision of water and sewer service would be less efficient and more expensive.

Appendix

Selected Water Rates in Massachusetts (Population Over 30,000)

Municipality	Rate Per 100 ft³ at 5,000 ft³	Bill Per 5,000 ft³*	Rate Per 100 ft³ at 10,000 ft³	Bill Per 10,000 ft³	Rate Per 100 ft³ at 50,000 ft³	Bill Per 50,000 ft³
Boston	$ .755	$37.75	$ .755	$ 75.50	$ .755	$377.50
Brockton	1.00	50.00	1.00	100.00	1.00	500.00
Dedham	1.53	68.85	.70	103.85	.40	327.35
Fitchburg	.32	16.00	.22	27.00	.17	95.00
Haverhill	1.39	69.50	.85	112.00	.48	348.40
Holyoke	.60	30.00	.52	57.36	.41	225.10
Lowell	.405	20.25	.405	40.50	.405	202.50
Melrose	.65	32.50	.75	70.00	.90	427.50
Northampton	.49	24.50	.49	49.00	.49	245.00
Quincy	.90	45.00	.90	90.00	.90	450.00
Taunton	1.15	57.50	1.15	115.00	1.15	575.00

Source: Survey by Worcester Department of Public Works, 1982.

*Bills at 5,000, 10,000 and 50,000 cubic feet per six-month period correspond to consumption by an average single family home, two family or three family house, and a commercial establishment or light industry.

Selected Water Rates in Massachusetts (Population Less Than 30,000)

Municipality	Rate Per 100 ft³ at 5,000 ft³	Bill Per 5,000 ft³*	Rate Per 100 ft³ at 10,000 ft³	Bill Per 10,000 ft³	Rate Per 100 ft³ at 50,000 ft³	Bill Per 50,000 ft³
Agawam	$1.05	$52.50	$1.05	$105.00	$ .90	$465.00
Ayer	.50	25.00	.50	50.00	.50	250.00
Chatham	1.397	69.85	1.397	139.70	1.047	602.93
Cohasset	1.80	90.00	1.80	180.00	1.80	900.00
Easthampton	.25	16.00	.25	28.50	.12	106.80
Essex	1.35	67.50	1.35	135.00	1.35	675.00
Gardner	.77	39.55	.63	74.55	.63	326.55
Pepperell	.80	40.00	.80	80.00	.80	400.00
Shrewsbury	.56	34.25	.94	74.79	.94	450.79
South Hadley	.36	19.00	.28	35.60	.19	116.10
Webster	.50	25.00	.50	50.00	.50	250.00
Yarmouth	.66	33.00	1.00	76.31	1.23	560.72

Source: Survey by Worcester Department of Public Works, 1982.

Notes

1) Massachusetts Executive Office of Environmental Affairs, (1978) *Massachusetts Water Supply Policy Statement*, p. 7.

2) Massachusetts Audubon Society, (1982) *Massachusetts Audubon Society 1982: A Year of Progress*.

3) Based on data from "Municipal Water Resources Management Plan — Phase II Questionnaire," (1982) Massachusetts Department of Environmental Management, Division of Water Resources.

4) Ibid.

5) National Council of Governmental Accounting, *Governmental Accounting and Financial Reporting Principles, Statement 1*. (1978), p. 1.

6) Massachusetts Executive Office of Environmental Affairs, (1978) *Massachusetts Water Supply Policy Statement*, p. 54.

7) Information for the Wellesley case study was obtained from unpublished documents at the Wellesley Department of Public Works and from personal interviews with Mr. William Edgerton, Programs Manager of the DPW.

8) Unpublished speech given by Mr. Maurice Berdan, Director of Wellesley's Department of Public Works, (1981).

9) Information for the Boston case study was obtained from the Boston Water and Sewer Commission's *Supporting Documentation for the Proposed 1983 Rate Schedule*, (1982).

10) Chapter 436 of the Acts of 1977.

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New England Water Works Association. *Recommended Manual of Practice for Rates and Revenues for Nonregulated Water Utilities,* 1978.

For Further Information

The following organizations can provide expertise on *enterprise fund accounting*:

Massachusetts Bureau of Accounts
100 Cambridge Street
Boston, MA 02202
(617) 727-4212

Massachusetts Municipal Association
131 Tremont Street
Boston, MA 02111
(617) 426-7272

For information about the experience of communities with *full-cost pricing and self-sustaining water utilities*:

William Edgerton
Programs Manager
Wellesley Dept. of Public Works
455 Worcester Street
Wellesley Hills, MA 02181
(617) 235-7600

Philip Beal
Deputy Superintendent
Hanover Dept. of Public Works
40 Pond Street
Hanover, MA 02339
(617) 826-3189

For more information about *establishing an autonomous agency to provide water*:

Boston Water and Sewer Commission
Ten Post Office Square
Boston, MA 02109
(617) 426-6046

Special Legislative Commission on Water Supply
State House, Room 312A
Boston, MA 02133
(617) 722-1233