HEARINGS, MEETINGS, LICENSES
7-11-11

CDM

Memorandum

To: *Town of Middleborough, MA*

From: *William Dana Green, P.E.*

Date: *May 11, 2011*

Subject: *WPCF NPDES Permit Review and Roadmap*

Introduction

The Town of Middleborough owns and operates the Middleborough Water Pollution Control Facility (WPCF) located at 70 Access Road within the Town limits. The WPCF is designed to treat an average daily flow of 2.16 million gallons per day (mgd). It discharges treated effluent to the Nemasket River in the Taunton River watershed, which eventually flows into Narragansett Bay. The WPCF currently operates under a National Pollutant Discharge Elimination System (NPDES) permit issued by the US Environmental Protection Agency (EPA) on September 26, 2003. NPDES permits are typically reissued on a five-year basis. Thus, it is anticipated that Middleborough will receive a new NPDES permit in the not too distant future.

Water bodies around the Commonwealth are increasingly showing visible impacts caused by nutrient loadings. As a result, more recent NPDES permits are setting nutrient loading limits, namely for nitrogen and phosphorus. Nitrogen is found in all living organisms as well in many industrial compounds. It is a natural and essential part of both marine and terrestrial environments. However, when loads of nitrogen from fertilizers, septic tanks and wastewater treatment plants exceed the capacity of natural ecosystems, it may enter surface waters. An overabundance of nitrogen acts as a fertilizer to aquatic plants, causing algal growth, reducing oxygen content and ultimately destroying much aquatic life. The impacts are especially felt in coastal areas of Massachusetts and Rhode Island and are being addressed as part of the Massachusetts Estuaries Project and Narragansett Bay Estuary Program, respectively.

Phosphorus is another critical nutrient for all forms of life, but like nitrogen, excess phosphorus from treatment plants may enter lakes and streams via receiving waters. Because phosphorus is often the limiting nutrient in these bodies of water, an excess may contribute to unsightly algal blooms. In large quantities, algae decreases light transmission and oxygen levels needed by fish and other aquatic species. Depending on the conditions of receiving waters, some treatment plants are receiving both nitrogen and phosphorus limits, while others are only subject to one or the other. Either way, these nutrient limits are spurring major treatment plant upgrades.

Unfortunately, it is widely understood that much of the contributions of nutrients to water bodies and receiving waters is due to "non-point" sources, including agriculture, fertilizer, drainage runoff, and other sources that cannot be easily regulated. Despite this understanding, regulators have only the ability to regulate and enforce nutrient limits at "point" discharges such as treatment plants, CSOs, and drainage outfalls, and therefore have focused their efforts at tightening NPDES permit limits for nutrients.

In anticipation of nutrient limits in its next NPDES permit, and the need to replace aging equipment at the WPCF, Town officials have retained CDM to assist Middleborough as it proactively prepares for future nutrient limits. This memorandum presents a roadmap for the town to meet the requirements of its next NPDES permit cycle.

Current WPCF Characteristics

The original Middleborough WPCF was constructed in 1949 with a capacity of 0.75 mgd. In 1977, construction was completed on a new treatment facility that replaced the original plant at the same site with a capacity of 2.16 mgd. This was the last major upgrade to the current facility.

The WPCF and related collection system serve a residential population of approximately 7,200, approximately 35 percent of the Town's population. Additionally, the system serves commercial and industrial areas within the Town, as well as Ocean Spray headquarters in Lakeville, Massachusetts. The collection system consists of 29 miles of gravity sewer, five pump stations, and parallel siphons. The original portions of the system were constructed as a combined storm and sanitary sewer system over 100 years ago. Over time, the system was expanded and converted to a sanitary-only sewer system. The system includes approximately 1,780 service connections.

The Middleborough WPCF is an advanced treatment facility. The facility processes include primary clarification, activated sludge treatment, secondary clarification, sand filters, seasonal chlorination (using sodium hypochlorite) and dechlorination (using sodium bisulfite), and post aeration. The facility removes phosphorus seasonally through chemical precipitation using ferric chloride. Septage is received from the Towns of Middleborough and Lakeville. Sludge solids are dewatered with a belt filter press and disposed of at the Middleborough Town Landfill.

Permit Schedule

The Middleborough WPCF continues to operate under its NPDES permit issued on September 26, 2003, NPDES Permit No. MA0101591. NPDES permits are typically issued every five years; however, there are no regulatory timeframes for EPA to issue a NPDES permit. The timeframe is dependent on EPA's workload and priorities. Typically, the permitting process takes approximately one year once the EPA begins the renewal process. In 2008, Tighe & Bond completed the report *Pre-Planning for Wastewater System Improvements* in anticipation of expansion of the Middleborough WPCF to treat flows from the proposed Mashpee Wampanoag Tribe Resort Development. Ultimately, development of the resort did not move forward, but the report indicated that the Town of Middleborough requested modification of its existing NPDES permit to meet projected flows. As described in more detail below, since the development of the resort did not move forward, the current permitted capacity of the WPCF is adequate for future design year flows and a permit modification is no longer needed.

Current and Future Permit Limits

NPDES Permit No. MA0101591 is jointly regulated by the EPA and the Massachusetts Department of Environmental Protection (MassDEP). The permit identifies the various effluent characteristics and in many instances quantifies the discharge limitations on a monthly, weekly, or daily basis. Table 1 below identifies the current NPDES limits for the Middleborough WPCF.

In terms of nutrient limits for nitrogen and phosphorus, total nitrogen is a composite of total kjeldahl nitrogen, total nitrate, and total nitrite. Currently, Middleborough is only required to report nitrogen limits and does not have a discharge limit. In regards to phosphorus, the WPCF is required to limit total phosphorus to 0.2 mg/L from April 1 to October 31, but is only required to report total phosphorus during the winter months from November 1 to March 31. Middleborough's prior NPDES permit from September 2000 required a 1.0 mg/L phosphorus limit.

Table 1: Middleborough WPCF NPDES Permit Limits

Effluent Characteristic	Units	Discharge Limitations		
		Average Monthly	Average Weekly	Maximum Daily
Flow	Mgd	2.16		
CBOD	mg/L lbs/day	7.0 126	10 180	15 270
TSS	mg/L lbs/day	7.0 126	10 180	15 270
Fecal Coliform Bacteria (April 1 - October 31)	cfu/100 ml	200		400
Total Residual Chlorine (April 1 - October 31)	ug/L	21		36
Total Ammonia Nitrogen, as N (June 1 - October 31)	mg/L	1.0	1.0	2.0

Total Ammonia Nitrogen, as N (November 1 - May 31)	mg/L	Report		
Total Kjeldahl Nitrogen	mg/L	Report		
Total Nitrate	mg/L	Report		
Total Nitrite	mg/L	Report		
Total Copper	ug/L	6.3		8.6
Total Lead	ug/L	1.3		
Total Phosphorus (November 1 - March 31)	mg/L lbs/day	Report		Report
Total Phosphorus (April 1 - October 31)	mg/L lbs/day	0.2 3.64		1.0 18

Future Phosphorus Limits

CDM reviewed approximately 30 NPDES permits for communities in the eastern half of Massachusetts, especially focusing on those watersheds that discharge to the Taunton, Ten Mile and Blackstone Rivers and ultimately to Narragansett Bay. These treatment plants have total phosphorus limits ranging from 0.1 mg/L to no limit. North Attleborough and Attleborough, which are in the Ten Mile River sub-watershed of Narragansett Bay, received new NPDES permits in 2008 and have limits of 0.1 mg/L. Upstream in the Taunton River sub-watershed further away from Narragansett Bay, Mansfield and Brockton, like Middleborough, have phosphorus limits of 0.2 mg/L while Bridgewater has a limit of 1.0 mg/L. However, these facilities are all operating under NPDES permits issued in 2005 or earlier.

Towards the northwest of Narragansett Bay lies the Blackstone River sub-watershed. The Upper Blackstone Water Pollution Abatement District in Millbury has a phosphorus limit of 0.1 mg/L. The much smaller surrounding treatment plants in Upton and Northbridge have limits of 0.2 mg/L. These facilities are operating under NPDES permits issued between 2006 and 2008. In contrast, the neighboring community of Douglas has a phosphorus limit of 1.0 mg/L and it received its NPDES permit in 2007. Phosphorus limits for various communities in the Narragansett Bay watershed and throughout eastern Massachusetts are summarized in Table 2 and shown visually in Figure 1, both attached at the end of this memorandum.

As far back as 1996, MassDEP published a report titled *Taunton Watershed 1996 Assessment, Taunton River Basin* confirming that eutrophication is a problem in the Nemasket River due to elevated nutrient levels. Data for the Nemasket River showed a significant increase in phosphorus concentrations downstream of the Middleborough WPCF as compared to upstream measurements. As a result, a phosphorus limit of 0.2 mg/L was included in the WPCF's 2003 NPDES permit. Fast forward to today where MassDEP is in the process of developing total maximum daily loads (TMDL) for various waterbodies around the commonwealth. A TMDL is the greatest amount of a pollutant that a waterbody can accept and still meet water quality standards for protecting public health and maintaining the designated beneficial uses of those waters for drinking, swimming, recreation, and fishing.

The TMDL provisions require states to identify and list waterbodies that are threatened or not meeting water quality standards despite controls on point source discharges. According to MassDEP's website, it must develop approximately 1,500 TMDLs by 2012. Phosphorus TMDLs developed to date are primarily for lakes and ponds rather than rivers. However, a TMDL has been developed for the Assabet River, triggering a phosphorus limit of 0.1 mg/L for treatment plants in Westborough, Marlborough, and Maynard that discharge to the Assabet River. It is unclear when and if a similar TMDL level will be developed for rivers discharging to Narragansett Bay.

Based on the NPDES permits issued in the past several years, and the permitting trends for the Naragansett Bay watershed, it is likely that the Town will be required to meet a total phosphorus limit of 0.1 mg/L in their next permit cycle, potentially lower in future cycles.

Future Nitrogen Limits

The states of Connecticut and Rhode Island have established nitrogen removal programs to improve water quality in Long Island Sound and Narragansett Bay, respectively. Historically, treatment plants in Massachusetts have not been subject to effluent nitrogen limits. However, in Massachusetts communities in close proximity to coastal waters, some treatment plants have received nitrogen limits. Wareham and Scituate, for example, are required to meet nitrogen limits of 4 mg/L by their NPDES permits. Scituate received its NPDES permit in 2004 while Wareham received its permit in 2008. And farther inland, within the Narragansett Bay watershed, Upper Blackstone, Attleboro and North Attleboro currently have nitrogen limits of 5 mg/L, 8 mg/L, and 8 mg/L, respectively. These facilities received new NPDES permits in 2008 - 2009. Available nitrogen limits for various communities in the Narragansett Bay watershed and throughout eastern Massachusetts are also shown in Table 2 and Figure 1.

As part of its current NPDES permit, Middleborough is required to sample nitrogen once per month. Although no nitrogen limit is currently required, the possibility of future discharge limits was discussed as far back as 2002 as part of the NPDES permit authorization process. At that time, MassDEP and EPA received public comments suggesting that the NPDES permit include at least conservative nitrogen limits, stating that EPA's national guidance for nutrients provides a "compelling, scientifically and ecologically valid rationale" for instituting nitrogen concentration and loading limits because of documented problems in the Taunton River and Narragansett Bay. However, EPA and MassDEP countered that a comprehensive study is important before establishing a nitrogen TMDL and subsequent NPDES nitrogen discharge limits. Nevertheless, in anticipation of future nitrogen limits, EPA and MassDEP suggested in the NPDES permit comments that future plant upgrades should consider options that can either achieve higher levels of nitrogen control than are currently required or that can be most cost effectively retrofitted to provide higher levels of control in the future. While nitrogen TMDLs developed by MassDEP to date are primarily focused on coastal bays in Cape Cod and Islands watersheds, the nitrogen data collected at the

Middleborough WPCF over the last six years will most likely be used to help inform future nitrogen discharge limits for the Taunton River and Narragansett Bay.

Based on trends for NPDES permits issues in the Narragansett Bay watershed, the Town will likely receive a stringent total nitrogen permit limit in their next permit cycle. Based on internal EPA guidance memoranda, and conversations with regulators, it is likely that the TN permit may be as low as 5.0 mg/L. A less stringent limit of 8.0 mg/L is also likely a possibility, but it is unlikely that the current "report" requirement will be maintained and one of these stringent limits issues. As noted below, the MassDEP is not always in support of the stringent TN limits imposed by the EPA and may support the Town in negotiating this limit and the compliance schedule to meet it.

Compliance Schedule

Although Middleborough's current NPDES permit was issued in September 2003, town officials were able to successfully negotiate an effective date of April 1, 2005, for phosphorus discharge limit implementation, allowing the WPCF one full season to develop a compliance strategy. Some treatment facilities like Marlborough Easterly were given up to 78 months to allow for study, design and construction of plant upgrades to achieve a 0.1 mg/L total phosphorus limit. The smaller Marlborough Westerly WPCF was given a 54-month timeline to meet the same phosphorus limit. However, Attleborough and North Attleborough's NPDES permits only indicate a lag time of one year between the date of permit issuance and phosphorus discharge limit compliance.

The compliance schedule for nitrogen seems contingent upon further refinement and development of nitrogen TMDLs. In the case of the Attleborough WPCF, the 8 mg/L limit is a requirement of the EPA NPDES permit, however MassDEP has not imposed the total nitrogen limit contained in the permit. Specifically, MassDEP stated in the permit that this is the first instance "where EPA has proposed stricter nitrogen limits upon a Massachusetts discharger than imposed by Massachusetts itself and that this raises legal and policy issues arising from the interstate nature of the analysis." In North Attleborough, the total nitrogen limit is based on Rhode Island's water quality standards. However, compliance schedules to meet water quality based effluent limits may be included in NPDES permits only when that particular state's water quality standards clearly authorize such schedules. Thus a compliance schedule to meet nitrogen discharge requirements is not specifically identified in the North Attleboro NPDES permit.

The range of nutrient limits and compliance schedules discussed above indicated that EPA and MassDEP are still trying to develop consistent strategies to address nitrogen and phosphorus loading from wastewater treatment facilities. Based on this variability, it appears that communities have an opportunity to negotiate compliance schedules to allow adequate time to fund the design and construction of necessary upgrades.

To aid in this, since the town is moving ahead with planning for the future permit in advance of receiving it, if a preliminary design report is completed, which identifies an adequate schedule for compliance, and submits this to the regulatory agencies, the permit writer may be apt to include that schedule as the compliance schedule.

WPCF Upgrades

The last major upgrade of the Middleborough WPCF occurred in 1977. Over time the general wear and tear of pumps, process piping, electrical and control systems, and other equipment necessitates upgrades and improvements to bring the aging facility up to current practices and standards. In addition to making the necessary upgrades to meet new phosphorus and nitrogen nutrient limits, a plant wide assessment is recommended to evaluate the condition of the WPCF and identify where there are deficiencies with respect to age, current codes, and industry practice. This assessment would be based on plans and operating records, pertinent information on existing processes and related equipment, discussion with operations staff and a site visit. Assessment criteria would include compliance with building code regulations, health and safety requirements, energy efficiency, and physical and operating conditions.

Phosphorus Removal Strategies

Two primary mechanisms for phosphorus removal are biological and chemical. Currently, the Middleborough WPCF uses ferric chloride to remove phosphorus through a chemical precipitation process. Costs and space considerations to meet more stringent phosphorus discharge limits may necessitate the addition of a biological system and/or a modification of the chemical system.

It does not appear that the current sand filters and chemical system could consistently meet a 0.1 mg/L phosphorus limit, however, this is not a certainty. As a first step, the Town should attempt to meet a 0.1 limit, over a 30-day or similar reporting period (including some high flow events). This would require some process optimization, including consideration of multiple point chemical addition, careful control of sludge blankets in clarifiers, and other process modifications to operate the process most effectively. This "stress test," could identify that the town can successfully meet the 0.1 mg/L limit, with only modifications needed, not an entirely new system, or potentially by "simply" adding biological phosphorus removal in the secondary system.

In a biological phosphorus removal (BPR) system, anaerobic reactors are incorporated into secondary systems to provide a phosphorus release environment and thus promote the growth of phosphorus accumulating organisms (PAOs), otherwise known as bio-P bacteria. The phosphorus uptake by PAOs in the aerobic zone results in a net reduction of phosphorus when the phosphorus-rich sludge is wasted from the plant. Solids handling is critical to the success of BPR (to avoid re-release of phosphorus), and must be taken into consideration during a baseline improvements evaluation. The advantage of a BPR system is that it can achieve removal of phosphorus down to 0.75 to 1.0 mg/L through the suspended growth treatment system without having to add chemicals. Further study would be required to determine if this reduction in the secondary system, in conjunction with the chemical addition and existing sand filters would consistently meet the expected new permit. If not, to further reduce phosphorus levels to 0.1 mg/L, two different types of physical/chemical tertiary treatment technologies are used in conjunction with BPR: high rate clarifiers and continuous backwash sand filters.

High rate clarification, or ballasted flocculation, involves the rapid dispersion of coagulant/polymer/ballast mixture, followed by flocculation and settling. The superior particle removal achieved with ballasted flocculation makes the process ideal for tertiary phosphorus removal applications. There are three types of ballasted flocculation available on the market today: Kruger's ACTIFLO® system which utilizes fine sand as the ballast, Infilco Degremont Inc.'s (IDI) Densadeg® which utilizes treatment plant sludge as the ballast, and Cambridge Water Technology (CWT) CoMag™ process which uses magnetite as the ballast. The CWT CoMag™ process allows for much higher activated sludge concentrations and solids load rates on the clarifiers. Continuous backwash sand filters achieve continuous filtration when wastewater is distributed through a counter flow sand filtration material. The solids and impurities in the wastewater are trapped in this sand filter material. The effluent filtrate exits the sand bed via an effluent weir, while the sand particles are cleaned and recycled in the filter system. Three sand filter systems on the market are the Blue Water Technologies' Blue PRO® system, Parkson Corporation DynaSand® system and the Ashbrook Simon-Hartley Strata-Sand™ system. Any of these tertiary phosphorus removal systems would be an add-on process that would likely replace the existing sand filters, if they are determined to be necessary.

Lastly, as an alternative to BPR followed by tertiary treatment system, an integrated biological process utilizing a ballast added directly to the mixed liquor is an option. The BioMag™ process, also developed by CWT, employs magnetite as a ballast to create a high-density floc with good settling characteristics as part of the activated sludge process. The BioMag™ process, in theory, is based on enhancing the settling of both biological and chemical flocs through addition of metal salts and excess magnetite ballast prior to the setting tanks. The process is being full scale pilot tested in Sturbridge, Massachusetts with positive results. Further, it is being installed full scale at the Marlborough Easterly WWTF, currently under final design. For Middleborough, the process may have the potential to eliminate the need for a new secondary clarifier, intermediate pump station, and an enhanced phosphorus removal system. However, detailed study is necessary, including process modeling and pilot testing, to confirm details of any upgrades.

Nitrogen Removal Strategies

Removing nitrogen from wastewater is a multi-step process. An NPDES total nitrogen limit considers all forms of nitrogen in the effluent, not only ammonia and nitrate. Organic nitrogen in the influent is first oxidized to ammonia (ammonification), which, along with influent ammonia, is oxidized to nitrite and then nitrate (nitrification). Both processes are aerobic, meaning they require oxygen. However, the same mass of nitrogen still remains in the aqueous phase - only now, rather than organic nitrogen or ammonia, it exists as nitrate. When there is no oxygen present for oxidation of organic matter by serving as an electron acceptor, nitrate is used in its place. Nitrate is reduced to nitrogen gas as organic matter is oxidized (denitrification). (Loss of electrons = oxidation; gain of electrons = reduction). In this way nitrogen is removed from the aqueous phase. Since nitrogen in treatment plant influents is mostly (70 to 80 percent) ammonia, total nitrogen removal requires that nitrification occur first followed by denitrification. In the past, some wastewater treatment plants were required only to remove ammonia□nitrogen in wastewater to reduce toxicity to aquatic organisms with no limits on nitrate or total nitrogen. However, many treatment plants are now required to remove nitrogen because both ammonia□nitrogen and nitrate□nitrogen can stimulate algae and phytoplankton growth leading to eutrophication.

Biological nitrogen removal can be accomplished by a variety of treatment configurations using suspended growth, attached growth, or combined systems. Nitrification, denitrification and biochemical oxygen demand (BOD) removal can be accomplished in a single process with bioreactors followed by secondary clarifiers. Systems can also be designed as separate stage systems with nitrification and BOD removal occurring in the same bioreactor or in separate bioreactors, and denitrification occurring in a tertiary process. Membrane bioreactors can be used for solids separation instead of secondary clarifiers. Physical/chemical methods for nitrogen removal are not commonly used at municipal treatment plants. Sidestream treatment processes can be used to enhance nitrification. Supplemental carbon is often added for denitrification, and advanced solids separation such as membrane bioreactors (MBR) and effluent filtration can be used to achieve very low levels. Some common nitrogen removal technologies are shown in Table 3 below.

Depending on the TN limit received, the WPCF may not be able to meet a 5.0 mg/L with their existing tankage, however it may be possible to meet an 8.0 mg/L limit within existing tanks. In order to meet a potential 5.0 mg/L limit, either increased tankage would likely need to be built, or an integrated process such as BioMag (discussed above) or IFAS (Integrated Fixed Film Activated Sludge) would need to be constructed. Alternatively, an add-on process such as a denitrification filter could be added to meet a 5.0 mg/L limit. Depending on hydraulics, this may also require an intermediate pumping station. A detailed analysis and model must be conducted to evaluate the capacity of the existing plant for either an 8.0 or 5.0 mg/L TN limit. This analysis should be conducted during preliminary design.

Table 3: Matrix of Biological Nitrogen Removal Technologies

Configuration	Type	Technology
Single Process Unit for Nitrification and Denitrification	Suspended growth	- Modified Ludzack-Ettinger (MLE) - 4-Stage Bardenpho - MLE or 4-Stage Bardenpho with Membrane Bioreactor - Sequencing Batch Reactor - Oxidation Ditch with Anoxic Zone - Step Feed Biological Nitrogen Removal - Simultaneous Nitrification Denitrification
	Attached growth or Hybrid	- Integrated Fixed Film Activated Sludge - Moving Bed Biofilm Reactor
Separate Stage – Nitrification	Suspended growth	- Nitrification
	Attached growth or Hybrid	- Biological Aerated Filters
Separate Stage – Denitrification	Suspended growth	- Suspended Growth Reactors (not common)
	Attached growth	- Denitrification Filters - Downflow - Upflow Continuous Backwash

Design and Construction Schedule

The NPDES permit will typically include a design and construction compliance schedule the WPCF must follow to address new nutrient discharge limits. Typically, a preliminary design takes 6-9 months and includes final design criteria, concepts for each unit process and a flow diagram for major treatment systems. Preliminary design drawings typically include a site plan with major process units and yard piping as well as floor plans and/or cross sections of principal buildings or facilities showing major equipment, piping, elevations and the relations of floor level to finish grade. An estimate of probable construction costs is also typically included. It is recommended that this 6+ month preliminary design phase be implemented in advance of receipt of the NPDES permit so that appropriate planning can be done and in the hopes that a compliance schedule be established that can be referenced in the permit. Process optimization or stress testing of the sand filters and existing phosphorus system should be undertaken as part of this preliminary design phase, as well as modeling of the secondary system to determine ability to meet TN limits.

Final design and anticipated permitting will take approximately 12 months with bidding of plans and specifications and contract award taking an additional 4 months.

Construction of facility upgrades and acceptance testing to bring new and upgrading systems on-line typically takes approximately three years, though the preliminary design should determine this schedule more accurately. Construction schedule will be effected by project scope and project size, but more importantly, construction sequencing has a great effect on schedule. Construction must take place while the town continues to operate the WPCF and meet current NPDES permit requirements. Generally this means that half of a given system must be replaced or upgraded while the second half remains operational, then the second half is upgraded while the new, first half, is operational. The more instances where this is required, the longer the project schedule.

Financing

In 2008, CDM and Stearns & Wheler, LLC completed a study for MassDEP titled *Engineering Feasibility & Cost Analyses of Nitrogen Reduction from selected POTWS in Massachusetts*. The study identified "order of magnitude" costs to various treatment plants to meet nitrogen reductions of 5 mg/L and 8 mg/L. For large facilities like Upper Blackstone, cost estimates ranged from $90 to $180 million to add aeration tanks, new clarifiers, a denitrifcation filter and an intermediate pump station. For smaller treatment plants like Upton, Northbridge, and North Attleboro, cost estimates ranged from $5 to $25 million depending on such factors as the existing treatment process and space need for reconfiguration. The usefulness of this study lies not in the individual facility evaluations, but more in the estimated total dollars established for upgrades in the individual watersheds for the entire project. It will also assist MassDEP in effectively assessing the financial impacts of future total nitrogen limits within each watershed required to meet the water quality goals of Narragansett Bay and Long Island Sound.

In terms of upgrade costs to meet phosphorus limits, the City of Marlborough began the process of updating their two wastewater treatment facilities to meet phosphorus limits of 0.1 mg/L. Marlborough Westerly WWTF is estimated to cost $33 million for engineering and construction costs. Marlborough Easterly WWTF is estimated at $59 million for engineering and construction costs and includes baseline improvements. The upgrade of the North Attleboro treatment plant, to meet both a phosphorus limit of 0.1 mg/L and nitrogen limit of 8.0 mg/L, is schedule for 2011 to 2013 with an estimated construction cost of $30 million. Available construction costs are shown in Table 2. Given these similar facilities, the likely total program cost for the Middleborough upgrade would be in the $25 million to $40 million range. For the purposes of the financial analysis presented below, we have assumed $30 million for engineering and construction costs.

Approach

To assist the Town in developing of its anticipated wastewater capital improvement plans, CDM has developed a set of preliminary rate and household bill impacts, for the purpose of providing the Town with a sense of the magnitude of the program's impact, along with the effects of various financing alternatives. Undertaking large capital projects can often create rate shock, so as the Town prepares its anticipated capital improvement plan (CIP) it will be useful to review financing alternatives in parallel. To the extent the Town can appropriately time and budget its expenses, it will help minimize the impact to ratepayers.

At a minimum, providing ratepayers with accurate information on expected rate impacts will allow for appropriate planning and budgeting. Additional considerations for the Town, if it wishes to further reduce the impact to rate payers, include obtaining SRF funding and building up a capital reserve fund for the purpose of cash funding capital expenditures.

Methodology

This analysis has been conducted by compiling data from the Town and pairing that data with an anticipated CIP to develop a simple model that replicates the Town's cash-flows. A set of financial assumptions has been applied to this data to project revenue requirements in future years. Lastly, projected increases in the revenue requirement have been applied to household bills to provide the Town with a more measurable indicator of the impact of the anticipated CIP.

Data

The following data was used in undertaking this analysis:

- Fiscal year (FY) 2012 wastewater budget
- FY 2005 through 2011 wastewater revenues
- Sewer rates effective April 1, 2010
- Anticipated CIP (provided by CDM)

Assumptions

The following assumptions were made in developing this analysis:

- Consumable costs are inflated at 5.0 percent annually

- All other non-consumable O&M costs grow at 3.0 percent annually
- Capital costs are inflated at 4.5 percent annually
- Debt Service Expense, Capital Outlay and Non Rate Revenues remain constant throughout the course of projections
- The anticipated capital program is $30 million, which has been estimated solely on the basis of similar programs at similar facilities and is not based on estimate or detailed project scope.
- The anticipated capital program has been spread evenly over five years from FY 2012 through FY 2016. While is it recognized that actual expenditures will likely not follow with pattern, this assumption has been made to simplify the analysis.
- For the purpose of comparing various financing alternatives, CDM has projected revenue requirements using two separate interest rates on debt service of 2 and 6 percent, and two separate bond terms of either 20 or 30 years.
- The interest rate on short term anticipation notes issued by the Town is 3 percent.
- The typical household bill is estimated using rates implemented on April 1, 2010 and is based on quarterly bill with consumption of 100 hundred cubic feet (HCF) annually

Revenue Requirement

The revenue requirement is total expenses, less non rate revenues, which is equal to the amount of revenue that must be recovered through rates to fully fund the utility. The revenue requirement was determined by projecting expenses and non rate revenue, and pairing that with projected debt service payments based on the anticipated CIP. In order to capture the full impact from the proposed capital improvement program, we have projected rates from FY 2012 through FY 2017, which is the final year in which debt service will incrementally increase from the anticipated CIP.

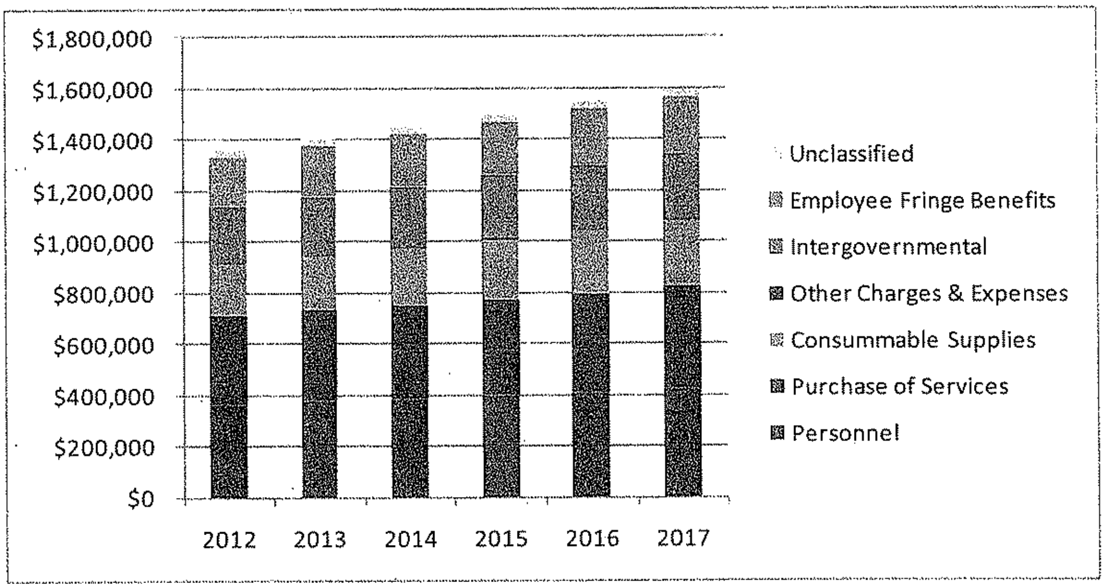
Operations & Maintenance

Expenses have been determined using the Town's FY 2012 anticipated budget. Initially in FY 2012 total O&M is $1.358 million. Based on assumed inflation, this figure grows to $1.598 million in FY 2017. This represents average annual growth of 3.3 percent. These expenses are shown in **Table 1** and represented graphically in **Figure 1**.

Table 1
O&M Expenses

	2012	2013	2014	2015	2016	2017
Personnel	$364,582	$375,519	$386,785	$398,389	$410,340	$422,650
Purchase of Services	$343,732	$354,044	$364,665	$375,605	$386,873	$398,480
Consumable Supplies	$202,650	$212,783	$223,422	$234,593	$246,322	$258,638
Other Charges & Expenses	$920	$948	$976	$1,005	$1,035	$1,067
Intergovernmental	$231,695	$238,646	$245,805	$253,179	$260,775	$268,598
Employee Fringe Benefits	$188,860	$194,526	$200,362	$206,372	$212,564	$218,941
Unclassified	$26,920	$27,728	$28,559	$29,416	$30,299	$31,208
Total O&M	**$1,358,080**	**$1,402,875**	**$1,449,217**	**$1,497,162**	**$1,546,769**	**$1,598,099**

Figure 1
O&M Comparison



Capital Spending

Capital Outlay and Existing Debt Service Schedule

Capital spending contains three categories: Capital Outlay, Existing Debt Service and Anticipated Debt Service. The Capital Outlay is from the Town's FY 2012 budget and has been assumed to remain constant throughout projections. Existing debt service through the course of projections has been provided by the Town. The Town's anticipated capital outlay and existing debt service schedule are shown in **Table 2**.

Table 2
20 Years- Alternative One: 0 Percent SRF Debt Service

	2012	2013	2014	2015	2016	2017
Capital Outlay	$40,000	$40,000	$40,000	$40,000	$40,000	$40,000
Existing Debt Service	$311,035	$298,886	$294,134	$283,588	$274,908	$274,433

Anticipated Debt Service

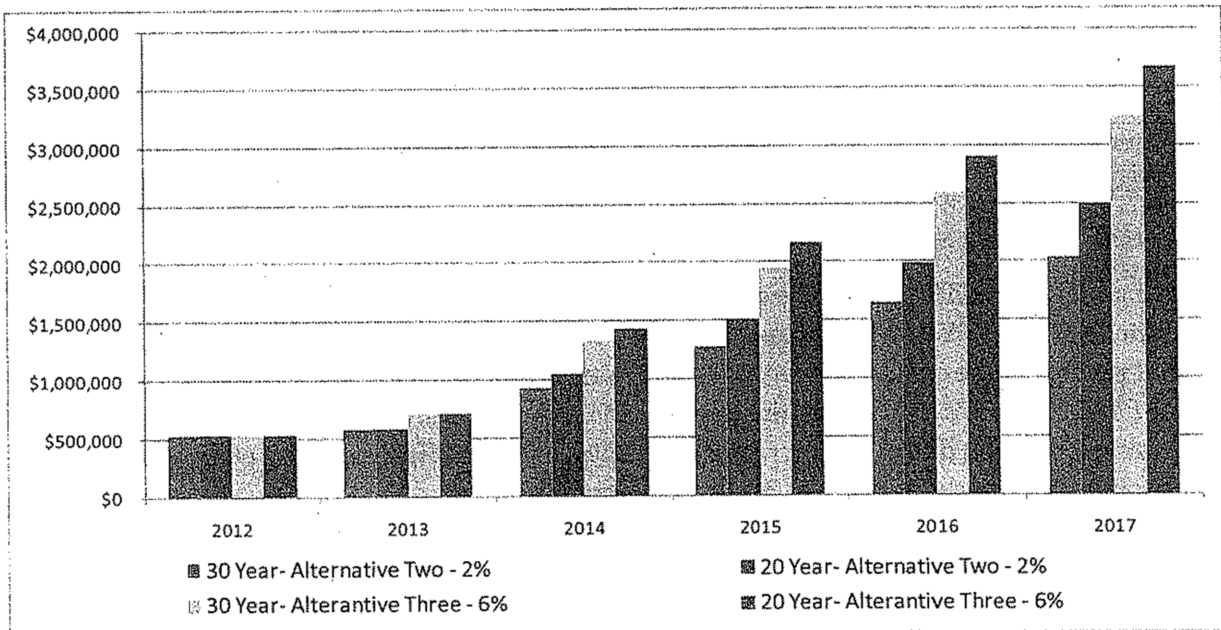
The anticipated CIP used in these projections is $30.0 million spread evenly over five years from FY 2012 to FY 2017. This equates to $6.0 million in capital expenditures annually during that period. These costs have been inflated at an annual rate of 4.5 percent, with a base year for FY 2011. In order to reflect the Town's actual cash flows, we have assumed that prior to issuing long term debt, the Town will issue short term anticipation notes equal to annual capital expenditures at a rate of 3.0 percent annually.

For the purpose of comparing various financing alternatives, CDM has projected revenue requirements using two separate interest rates on debt service of 2 and 6 percent, and two separate bond terms of either 20 or 30 years (**Tables 3**). These tables are represented graphically in **Figures 2**.

Table 3
Debt Service Comparison

	2012	2013	2014	2015	2016	2017
30 Year- Alternative Two - 2%	$531,035	$584,407	$930,960	$1,283,159	$1,649,180	$2,035,899
20 Year- Alternative Two - 2%	$531,035	$584,407	$1,039,617	$1,503,178	$1,983,387	$2,487,250
30 Year- Alternative Three - 6%	$531,035	$715,450	$1,327,802	$1,949,025	$2,587,439	$3,250,073
20 Year- Alternative Three - 6%	$531,035	$715,450	$1,435,366	$2,162,442	$2,904,920	$3,669,748

Figure 2
Debt Service Comparison



Non-Rate Revenue

Non rate revenues used in this financial analysis are as presented in **Table 4**. These figures have been provided by the Town for FY 2012 and remain constant over the course of projections. Non-rate revenue of $649,114 is assumed to be the same across all alternatives.

Table 4
Non-Rate Revenue

	2012	2013	2014	2015	2016	2017
Septage	$170,000	$170,000	$170,000	$170,000	$170,000	$170,000
Liens	$77,000	$77,000	$77,000	$77,000	$77,000	$77,000
Interest Charges	$127	$127	$127	$127	$127	$127
Earnings on Investments	$14,275	$14,275	$14,275	$14,275	$14,275	$14,275
Betterments	$7,100	$7,100	$7,100	$7,100	$7,100	$7,100
Other Charges	$280	$280	$280	$280	$280	$280
Permits	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000
Leachate	$375,332	$375,332	$375,332	$375,332	$375,332	$375,332
Total	**$649,114**	**$649,114**	**$649,114**	**$649,114**	**$649,114**	**$649,114**

Revenue Requirement

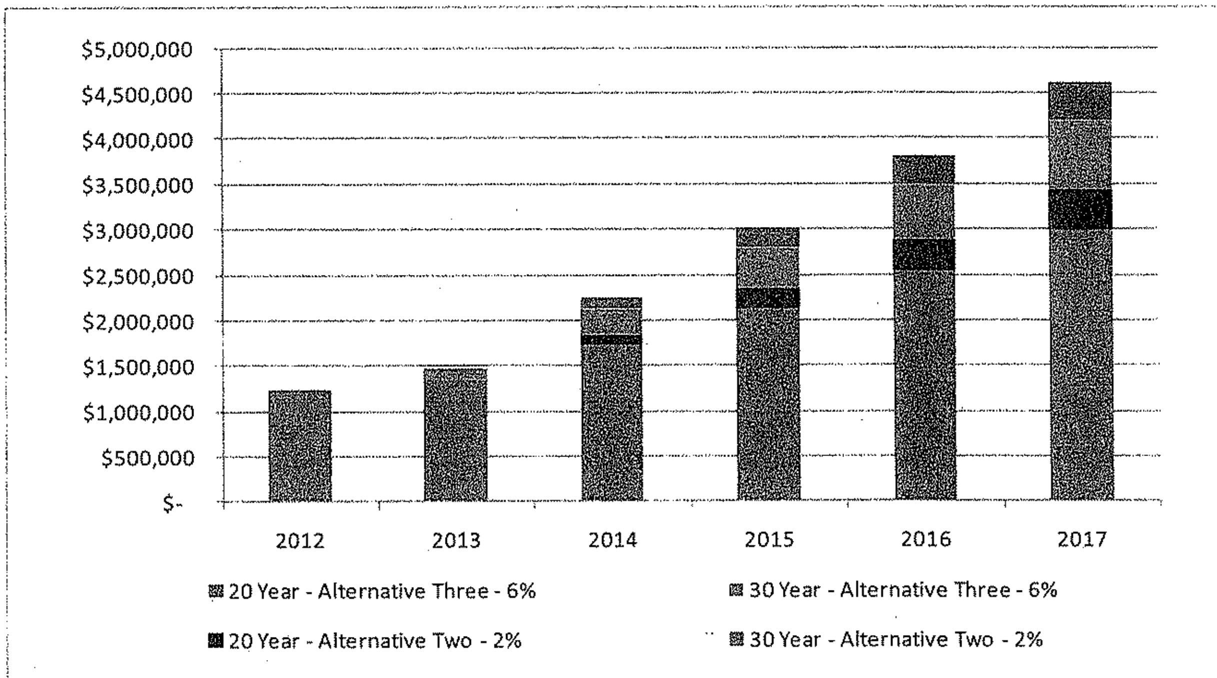
As noted previously, the revenue requirement is calculated as total expenses, less non rate revenue. Total expenses are the sum of O&M expenses and capital expenses. Both of which are detailed in the preceding sections. Given the detail of the previous sections and to avoid redundancy, we have presented revenue requirements for the four alternatives in **Table 5** and **Figure 3**.

The annual increase in revenue requirement for each alternative is also included. For the purpose of this analysis, we have assumed that rates will increase at same rate as the Town's revenue requirement. The average annual increase for each of the 20 year alternatives is 22.6 and 30.1 percent, respectively. For the 30 year alternatives rates increase at an average annual rate of 19.2 and 27.6 percent, respectively.

Table 5
Revenue Requirement Comparison

	2012	2013	2014	2015	2016	2017
30 Year - Alternative Two - 2%	$1,240,001	$1,338,169	$1,731,063	$2,131,207	$2,546,835	$2,984,883
Annual Increase Percentage	0%	8%	29%	23%	20%	17%
20 Year - Alternative Two - 2%	$1,240,001	$1,338,169	$1,839,720	$2,351,226	$2,881,042	$3,436,235
Annual Increase Percentage	0%	8%	37%	28%	23%	19%
30 Year - Alternative Three - 6%	$1,240,001	$1,469,212	$2,127,905	$2,797,073	$3,485,094	$4,199,057
Annual Increase Percentage	0%	18%	45%	31%	25%	20%
20 Year - Alternative Three - 6%	$1,240,001	$1,469,212	$2,235,470	$3,010,490	$3,802,575	$4,618,733
Annual Increase Percentage	0%	18%	52%	35%	26%	21%

Figure 3
Revenue Requirement Comparison

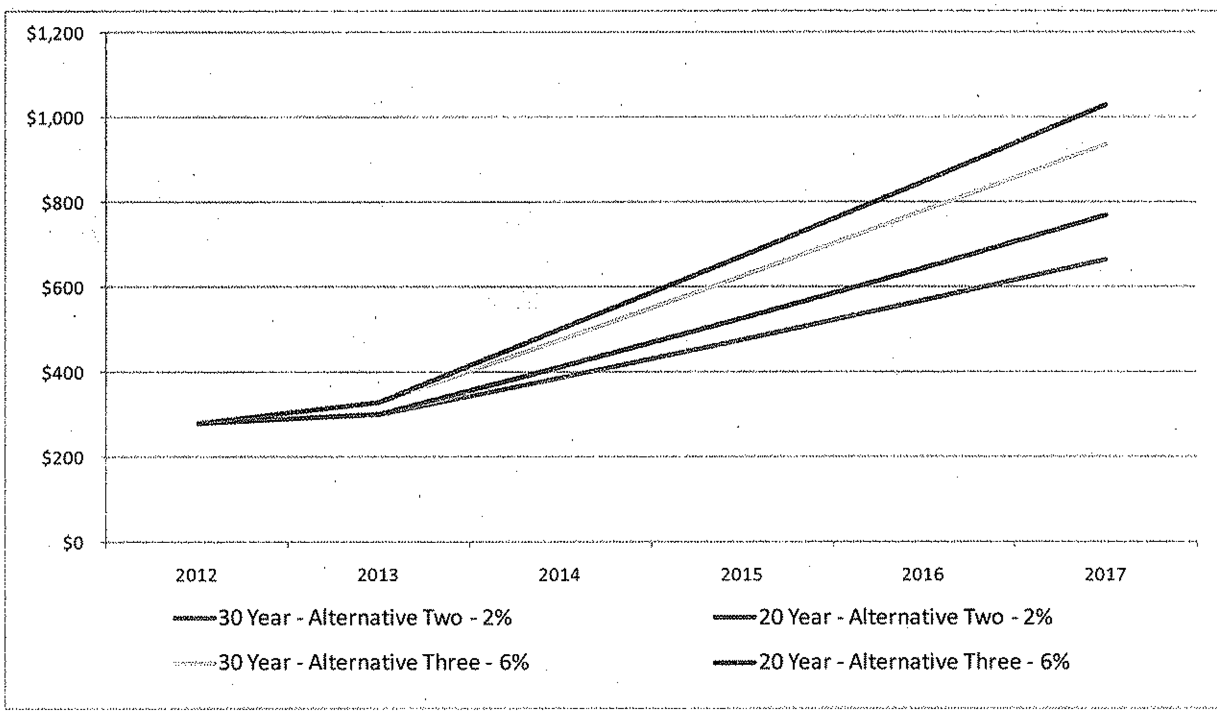


Household Bill Impacts

In order to put this analysis in more measurable terms, we have developed a set of projected annual household bills. This portion of the analysis makes two key assumptions. The first is that the Town's current budget is sufficient to meet its revenue requirement. In addition to this, CDM has assumed that growth in the revenue requirement translates directly through to rates and, in turn, household bills. This simplifying assumption will allow for a reasonable estimation of the impact on the Town's rates. However, CDM recommends the Town conduct a more detailed analysis before determining future rates.

The impact for three alternatives using both the 20 and 30 year debt terms is shown in **Figure 4.** Initially, the annual household bill in the Town is estimated $276, based on consumption of 100 HCF. Comparatively, with a 20 year debt service term the typical household bill will grow to $766 and $1,030 for the respective interest rates of 2 and 6 percent. With a 30 year debt service term, the typical household bill will grow to $666 and $930, for the respective interest rates of 2 and 6 percent.

Figure 4
Projected Annual Household Bill Comparison

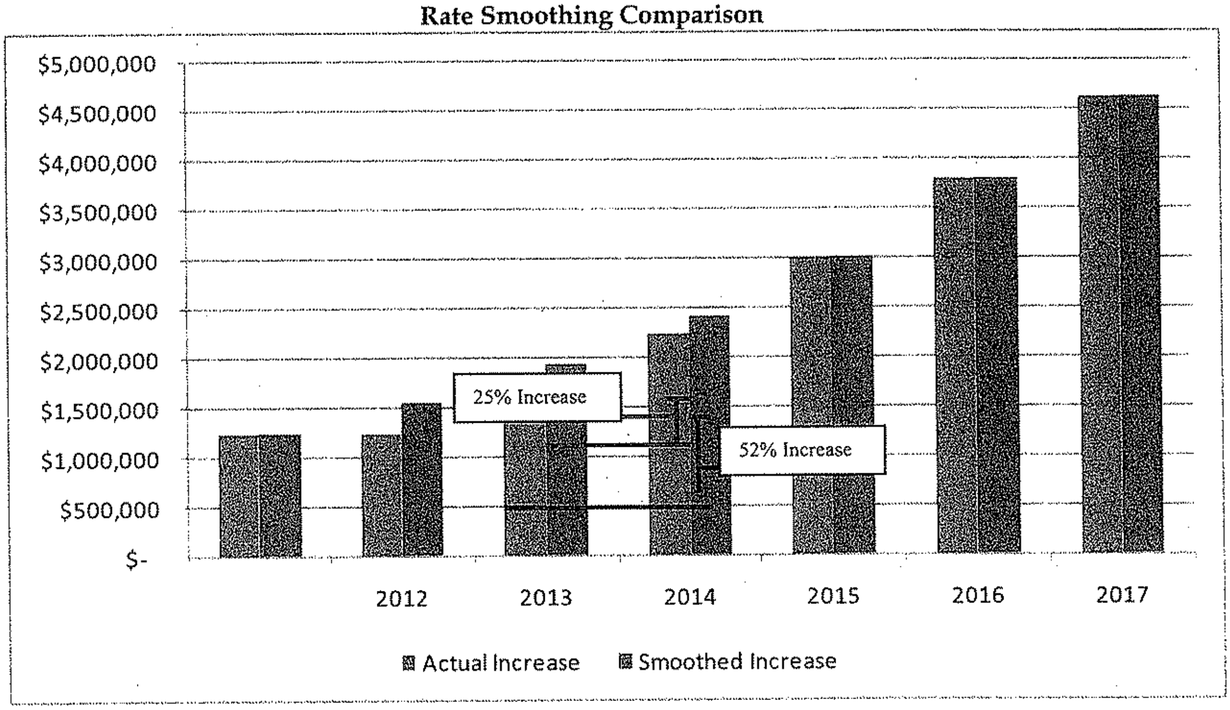


Rate Smoothing

Given the projected impact of the anticipated CIP, CDM believes it may be beneficial for the Town to evaluate smoothing its rate increase schedule. This would entail increasing rates earlier, but in smaller increments. In order to set adequate rate levels in FY 2014 it will require rate increases of 29and 45 percent for the 30 year bond term or 37 and 52 percent for the 20 year bond term. However, the Town could begin increasing rates in FY 2012 in anticipation projected revenue requirement increases in out years.

To illustrate this point, in **Figure 5** we show in blue the increase in revenue requirements for the 20 year, 6 percent alternative. In red we have shown an alternative rate increase schedule, that smoothes the rate increase pattern. Rather than increases of 19, 52 and 35 percent in FYs 2013, 2014 and 2015, respectively, we have increased rates constantly, at 25 percent, starting FY 2012, through FY 2015.

Figure 5
Rate Smoothing Comparison



Similarly, if the Town wished to pursue a rate smoothing option for the other alternatives, it could put in place average annual increases shown in **Table 6.**

Table 6
Revenue Requirement Comparison

	2012	2013	2014	2015	2016	2017
30 Year - Alternative Two - 2%	$1,419,786	$1,625,638	$1,861,336	$2,131,207	$2,546,835	$2,984,883
Annual Increase Percentage	14%	14%	14%	14%	20%	17%
20 Year - Alternative Two - 2%	$1,455,091	$1,707,490	$2,003,670	$2,351,226	$2,881,042	$3,436,235
Annual Increase Percentage	17%	17%	17%	17%	23%	19%
30 Year - Alternative Three - 6%	$1,519,646	$1,862,357	$2,282,356	$2,797,073	$3,485,094	$4,199,057
Annual Increase Percentage	23%	23%	23%	23%	25%	20%
20 Year - Alternative Three - 6%	$1,547,839	$1,932,100	$2,411,756	$3,010,490	$3,802,575	$4,618,733
Annual Increase Percentage	25%	25%	25%	25%	26%	21%

An important caveat to using this approach is that it will generate excess revenues in the initial years, when rates are set above projected revenue requirements. However, given the magnitude of the Town's CIP, this excess cash could be used to cash fund future capital improvements and save rate payers interest expense on anticipated debt service in future years. The anticipated cumulative excess revenue that is projected to be generated in each of the scenarios by FY 2015 is shown in **Table 7**. It is critical to not that the impact of this free cash being used to decrease the Town's capital expense is not shown in this analysis.

Table 7
Projected Cumulative Excess Revenue

	Cumulative Excess Revenue
30 Year - Alternative Two - 2%	$597,526
20 Year - Alternative Two - 2%	$748,362
30 Year - Alternative Three - 6%	$827,241
20 Year - Alternative Three - 6%	$947,013

Conclusion

The projected impact of the anticipated CIP is likely to at a minimum to double household bills over the course of projections, from their current level of $276. Given the magnitude of this impact, appropriately planning for its cost and effectively communicating its impacts will be useful to helping mitigate the impact to rate payers. Additionally, given the level of cost savings associated with doing so, we strongly recommend the Town seek SRF funding for its project, as it has significant benefits and minimal drawbacks.

A second method for reducing the impact of this program in the longer term is to build up a capital reserves. Doing so will create a significant up-front burden to rate payers, but will reduce the Town's interest expense in the future. However, despite this benefit, and in addition to the initial up-front rate impact, cash funding capital projects through a capital reserve requires significant planning, transparency and long-term commitment. Given the far-sightedness of this approach, a lack of political continuity in the Town could create difficulty in implementing and maintaining this policy.

"Roadmap" (Summary)

The Town of Middleborough WPCF NPDES permit is likely to be issued in the next months or year.

Based on comparisons of similar NPDES permits, at similarly sized facilities in the area, it is likely that the Town of Middleborough NPDES permit, when issued, will include a TP limit of 0.1 mg/L and a TN limit of either 8.0 mg/L or potentially as low as 5.0 mg/L.

Both of these limits will require substantial upgrades to existing facilities, and potentially require new add-on systems.

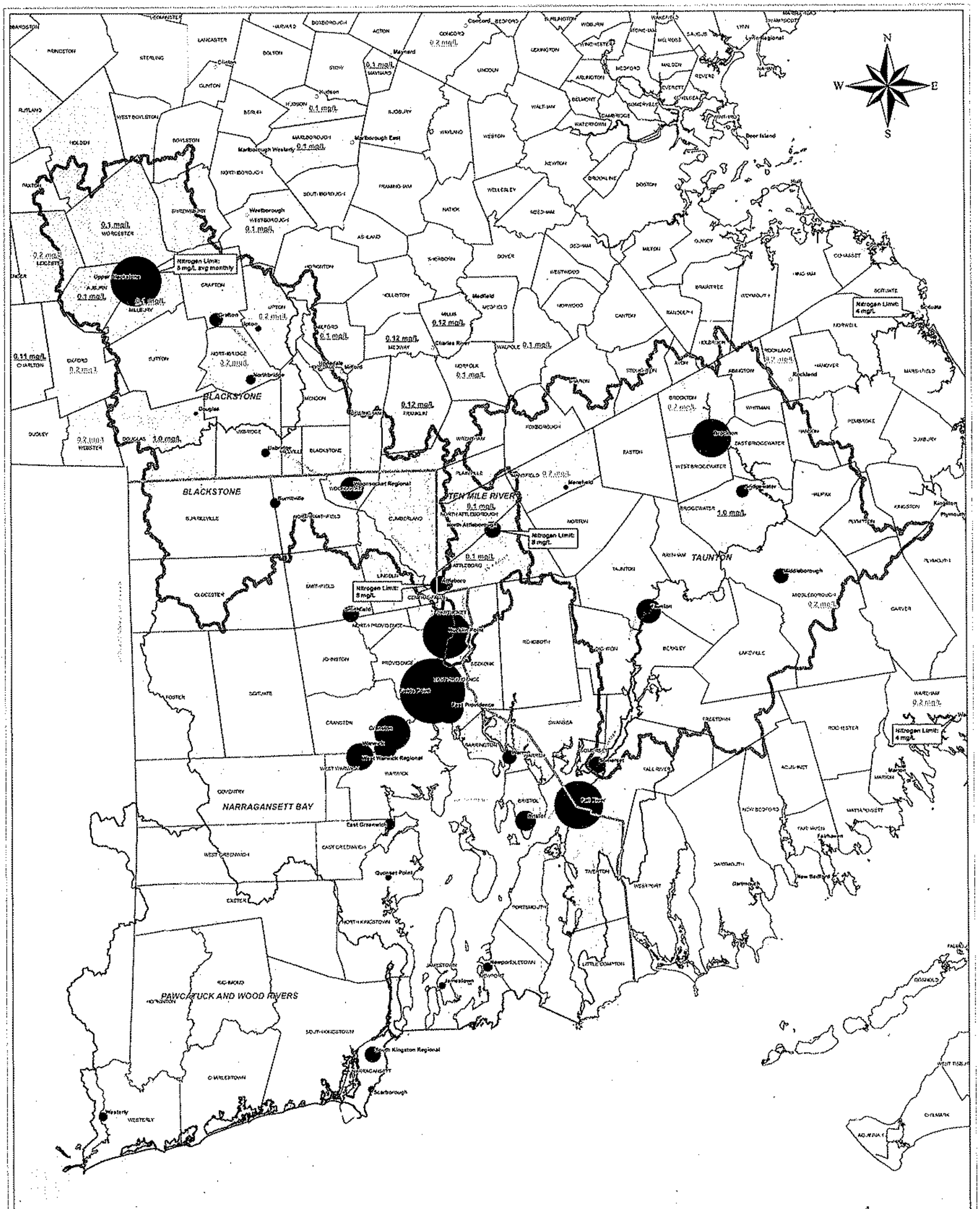
Further, the plant facilities and equipment have not received significant upgrade for decades, and systems not directly related to new NPDES limits will also require repair or replacement.

In order to stay ahead of the process and work proactively, CDM recommends advancing the preliminary design in 2011, likely prior to receipt of the new NPDES permit. Significant elements would include a model and analysis to determine the capacity of existing tankage to meet more stringent TN limits, an optimization study of the existing phosphorus removal systems, and an evaluation of "baseline" improvements to bring existing equipment and facilities up to current codes and standards of practice. Additionally, with these elements completed, and the project scope identified, the preliminary design would include a detailed cost estimate and schedule. Preliminary design is expected to take about 6-9 months.

Preliminary design report should then be submitted to the MassDEP and EPA in order to identify a favorable compliance schedule established.

Final design would then begin, but only after receipt of the NPDES permit, and confirmation of the permit limits. Final design is likely to take about 12 months. Bidding, award, and construction will likely take up to 42 months.

It is also recommended that the town consider rate increase in advance of the full implementation of this program. This will mitigate "sticker shock" and allow a more gradual rate increase to fund the upcoming expenditures. Further, building up of capital reserves will reduce interest payment, and the overall cost to the town.



Legend

Average Monthly Annual Total Nitrogen Discharges
April 2003 - April 2006

- 10 lbs/day
- 100 lbs/day
- 500 lbs/day
- 1,000 lbs/day

WWTP
Watershed Boundary
Rhode Island - Massachusetts State Boundary
MA Communities with Stringent Phosporus Limit

0.0 mg/L — Phosphorus Limit for WWTP
Nitrogen Limit: 0 mg/L — Nitrogen Limit for WWTP

Figure 1

Phosphorus & Nitrogen Limits At Wastewater Treatment Plants in Eastern Massachusetts

CDM

Table 2: Comparison of Nitrogen and Phosphorus Limits at Various Massachusetts Water Pollution Control Facilities

Project Name and Location	Year Completed	Design Flow (mgd)	Cost	Upgrade Driver	Total Phosphorus Limit (mg/L)	Total Nitrogen Limit (mg/L)	Watershed	Permit Issue Date
Attleboro WPCF	-	8.6			0.1	8.0	Narragansett Bay	Sep-08
Bridgewater WWTF	-	-			1.0	-	Narragansett Bay	Dec-03
Brockton WRF	2009	20.5	$80M construction	Upgrade partly due to total P limit of 0.2 mg/L	0.2	No nitrogen limit in permit; design targets 5.5 mg/L year round	Narragansett Bay	May-05
Charlton		0.5			0.11		[illegible]	Jan-11
Concord	2007	1.2			0.2	-	Merrimack River	Jan-06
Douglas	-	0.6			1.0	-	Narragansett Bay	Mar-07
Fall River	-	30.9			-	-	Narragansett Bay	Dec-00
Fitchburg	-	12.4			1.0	-	Merrimack River	Sep-02
Kingston	2001	0.4			-	10.0		
Hudson	-	3.0			0.1	-	Merrimack River	May-05
Leicester		0.4			0.2		[illegible]	Sep-10
Leominster	2011	6.9			0.2	-	Merrimack River	Sep-06
Mansfield	-	3.1			0.2	-	Narragansett Bay	Apr-04
Marion	2005	0.6	$10M construction	Upgrade was due to ammonia-N limit	No P limit in permit; plant has been asked to assess feasibility of achieving 0.2 mg/L	No nitrogen limit in permit; "target" of 7-10 mg/L year round	Buzzards Bay	May-07
Marlborough Westerly Marlborough	2010	4.2	$26M bid cost ($33M including engineering, OPM, contingency, change orders)	New NPDES permit with phosphorus limits	0.1	-	Merrimack River	May-05
Marlborough Easterly Marlborough	to be completed 2012	5.5	$48M bid estimate ($59M including engineering, includes "baseline" improvements	New NPDES permit with phosphorus limits	0.1	-	Merrimack River	Oct-06
Maynard	-	1.5			0.1	-	Merrimack River	May-05
Medway Charles River PCD	1998	5.4			0.12	-	Mass Bay/Cape Code Bay	2008 draft
Middleborough WPCF	-	2.2			0.2	-	Narragansett Bay	Sep-03

Project Name and Location	Year Completed	Design Flow (mgd)	Cost	Upgrade Driver	Total Phosphorus Limit (mg/L)	Total Nitrogen Limit (mg/L)	Watershed	Permit Issue Date
Milford		4.3			0.1		Mass Bay/Cape Code Bay	2010 draft
Millbury Upper Blackstone Water Pollution Abatement District	2009	45.0			0.1	5.0	Narragansett Bay	Apr-09
MCI Norfolk - Walpole	-	0.5			0.1		Mass Bay/Cape Code Bay	Sep-08
North Attleboro	2011 -2013 (currently out to bid)	4.6	$30M (engineer estimate)	New NPDES permit with nitrogen and phosphorus limits	0.1	8.0	Narragansett Bay	Feb-08
Northbridge WWTP Upgrade	-	2.0			0.2	-	Narragansett Bay	Mar-08
Otis	2003	0.0			-	10.0		
Oxford-Rochdale		0.5			0.2		Long Island Sound	Jul-10
Rockland	-	2.5			0.2	-	Mass Bay/Cape Code Bay	Jan-06
Scituate	2000	1.6			-	4.0	Mass Bay/Cape Code Bay	Nov-04
Somerset WPCF	-	4.2			-	-	Narragansett Bay	May-04
Taunton WWTP	-	8.4			-	-	Narragansett Bay	Sep-01
Upton	-	0.4			0.2	-	Narragansett Bay	Mar-06
Wareham	2005	1.6			0.2	4.0	Buzzards Bay	Apr-08
Webster	2010	6.0	$8M construction ($9M including engineering, OPM, change orders)	New NPDES permit with phosphorus limits	0.2	-	Long Island Sound	Mar-06
Westborough	-	7.7			0.1	-	Merrimack River	May-05