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PROJECT ENGINEERING REPORT
SUPPLEMENT TO
COMPREHENSIVE PROJECT EVALUATION
NORTH ATTLEBOROUGH
WASTEWATER TREATMENT FACILITY

Town of North Attleborough, Massachusetts
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1. INTRODUCTION

1.1 INTRODUCTION

The Town of North Attleborough Wastewater Treatment Facility (WWTF) treats wastewater, septage, and infiltration/inflow from the sewer system serving the Town of North Attleborough, a portion of the Town of Plainville, and a portion of the City of Attleborough. The WWTF has unit operations for influent pumping, flow measurement, screening, grit removal, comminution, flash mixing, flocculation, primary sedimentation, pumping, two stage activated sludge with nitrification, filtration, chlorination, dechlorination, and sludge thickening. In general, the performance of the plant under the current discharge permit has been good with the biggest challenge being effective operation during sustained rainfall events, particularly when the ground water table is high and infiltration flows are up. The WWTF is facing additional challenges with more stringent nutrient removal requirements than the initial design provided for. More specifically, the Massachusetts Department of Environmental Protection (MADEP) has indicated that the effluent phosphorus limitation will be reduced to 0.2 milligrams per liter (mg/L) in the upcoming permit. In addition, a Total Maximum Daily Load (TMDL) analysis is now being completed for the Ten Mile River and may lead to even more stringent nutrient removal requirements. The current direction that MADEP is providing to the Town is for future permits to have effluent phosphorus concentrations less than 0.2 mg/L and effluent total nitrogen concentrations of 5.0 mg/l.

1.2 COMPREHENSIVE WWTF EVALUATION

The Town of North Attleborough retained Woodard & Curran to perform an independent, objective, comprehensive plant evaluation (CPE) to help them understand the capability and needs of the existing facility and to effectively plan for future expenditures to meet the present and future wastewater service needs of the community. The CPE provided a comprehensive assessment of the existing treatment system and equipment; reviewed and assessed plant process operations and performance; presented a predictive mass balance model of the facility; analyzed improvement opportunities; analyzed maintenance management systems and practices; evaluated opportunities for energy and chemical savings; evaluated staffing, organization, and financial status and opportunities; and presented optimization opportunities and potential cost savings.

MADEP has directed the Town of North Attleborough to submit a Project Engineering Report (PER) to support requested financial assistance under the CWSRF program for capital projects at the WWTF. The CPE was submitted to fulfill this requirement. MADEP reviewed the CPE report and in a letter dated May 30, 2003, provided comments on the CPE that must be addressed to satisfy the PER requirement.

1.3 SUPPLEMENTAL CPE/PER

To address the MADEP comments, MADEP requested the submission of a Supplement to the CPE. Upon acceptance of the supplemental material, the MADEP would issue an approval letter on the CPE and the supplement as an approved final PER. This would satisfy the requirements of the PER.

The purpose of this report is to address the comments of the MADEP as a supplemental CPE and final PER.

2. EXISTING CONDITIONS

2.1 INTRODUCTION

This chapter presents the current average and peak influent flow, biochemical oxygen demand (BOD) loading, total suspended solids (TSS) loading, phosphorous loading and nitrogen loading to the WWTF. These values are based upon analysis of WWTF operational data for the period from January 1998 through July 2003. Current flows and loads are summarized in Chapter 8 (Table 8.1).

2.2 INFLUENT FLOW

For the period analyzed the total average daily influent flow to the WWTF was approximately 3.34 million gallons per day (MGD). This value includes internal plant recycle flows of approximately 0.15 MGD. Influent flow to the WWTF can be separated into domestic flow, septage, industrial flow and inflow and infiltration (I/I). No data is available for institutional or commercial flow. Therefore institutional and commercial flows are assumed to be part of the domestic flow.

Data for the months of September 2001 and October 2001 were analyzed to estimate dry weather flow to the plant. Total rainfall during these months was 4.8 inches and the lowest groundwater levels are typically found during the months of September and October. Based on this information it can be assumed that I/I during these months was negligible and that the average flow during these months is includes only domestic flow, septage, industrial flow and plant recycle flow. The average daily influent flow to the WWTF for this time period was 1.48 MGD.

To determine average I/I the dry weather flow of 1.48 MGD was subtracted from the average daily influent flow of 3.34 MGD resulting in an average I/I flow of 1.86 MGD. The Town recently completed approximately $1,200,000 in I/I removal work. This work is expected to remove between 300,000 and 500,000 gallons per day (gpd) of I/I.

In a Local Limits Study performed by Camp, Dresser & McKee (CDM) in 1999 industrial flow to the WWTF was estimated to be approximately 340,000 gpd based on industrial discharge permits. Since that study was performed the largest permitted industrial user (150,000 gpd) has gone out of business. The value presented in the study also included the permitted flow for the Emerald Square Mall of 156,000 gpd. Actual water meter data for the Emerald Square Mall for the period from July 1, 2001 through June 30, 2002 indicate water consumption of 38,500 gpd. Assuming all water used at Emerald Square mall is discharged to the sewer the current industrial flow is estimated to be 72,500 gpd (340,000 gpd– (150,000 gpd + 150,000 gpd) + 38,500 gpd).

Current domestic flow to the WWTF was calculated to be 1.25 MGD. Domestic flow was determined by subtracting the average daily septage deliveries of 5,600 gpd, the industrial flow of 72,500 gpd, and the plant recycle flow of 150,000 gpd from the average dry weather flow of 1.48 MGD. Based on the reported sewered population of 23,000 people the per capita domestic wastewater discharge is 54.3 gallons per person per day. This value compares favorably with the average domestic water use of 60 gallons per person per day as reported in Metcalf & Eddy Wastewater Engineering Treatment, Disposal, and Reuse, 3rd Edition.

As indicated in the CPE, the actual peak instantaneous influent flow to the WWTF cannot be determined because peak flows exceed the upper limit of the influent flow measuring device of 10.4 MGD. It is estimated that the peak flow is approximately 10.9 MGD based on the maximum day flow recorded, however this value is above the limit of measurement of the influent flowmeter and therefore cannot be considered completely reliable. The CPE reported that for the period from January 1998 through December 2000 peak instantaneous flow to the plant exceeded the design peak flow of 9.4 MGD on 34 days. From January 2001 through December 2002 peak instantaneous flow to the plant exceeded design peak flow 13 times.

2.3 BIOCHEMICAL OXYGEN DEMAND AND TOTAL SUSPENDED SOLIDS LOADINGS

For the period analyzed the average raw influent BOD_5 concentration was approximately 122.4 mg/L. During the same time period the maximum raw influent BOD_5 concentration was approximately 270 mg/L. These values along with the average daily flow to the WWTF of 3.34 MGD were used to estimate the average day and maximum day BOD_5 loadings. The average daily BOD_5 loading to the WWTF is 3,410 lb/day. The maximum day (peak) BOD_5 loading to the WWTF is 7,521 lb/day. Since septage is added upstream of the sampling location these BOD_5 values incorporate septage loading to the plant and therefore septage loading has not been added in as a separate item.

Based on the average and maximum BOD_5 concentrations, the peaking factor for maximum day BOD_5 is 2.3. This value is slightly higher than 1.8 peaking factor listed in TR-16 Guides for the Design of Wastewater Treatment Works, but is reasonable based on the operational data from the plant.

The average day BOD_5 loading of 3,410 lb/day also appears reasonable when compared to an expected per capita BOD_5 loading that would typically be used for design. Based on a typical per capita loading factor of 0.17 lb BOD_5 and the sewered population of 23,000 people, the average day design loading to the plant is 3,910 lb/day.

For evaluation of the oxygen requirements and the biological nutrient removal capabilities of the secondary system, presented in Chapters 4 and 5 of this report, loadings based on the BOD_5 concentration of the primary clarifier effluent were used. These values are representative of what the actual oxygen demand on the aeration system will be. The average primary clarifier effluent BOD_5 for the period analyzed was 79.2 mg/L. The maximum primary clarifier effluent BOD_5 concentration for the same time period was 184.3 mg/L. Based on the average daily flow to the WWTF of 3.34 MGD, the average and maximum day BOD_5 loadings to the second stage aeration basins were 2,206 lb/day and 5,134 ld/day respectively.

For the period analyzed the average raw influent TSS concentration was 130 mg/L and the maximum raw influent TSS concentration was 306 mg/L. Based on these values and the average daily flow to the WWTF of 3.34 MGD, the average and maximum day raw influent TSS loadings are 3,621 lb/day and 8,524 lb/day respectively.

2.4 NITROGEN AND PHOSPHOROUS LOADINGS

For the period analyzed the average raw influent phosphorous and ammonia nitrogen concentrations where 3.5 mg/L and 11.9 mg/L respectively. Maximum raw influent phosphorous and ammonia nitrogen concentrations were 9.9 mg/L and 19.8 mg/L respectively. Based on the average daily flow of 3.34 MGD, the average raw influent phosphorous loading was 97 lb/day and the maximum day phosphorous loading was 331 lb/day. Similarly, the average daily ammonia nitrogen loading was 276 lb/day and the maximum day ammonia nitrogen loading was 552 lb/day.

3. FUTURE CONDITIONS

3.1 INTRODUCTION

This chapter presents the estimated flows and loadings to the WWTF for a 20 year planning period, i.e. flow projections will be the anticipated flow in the year 2023. Domestic flow to the WWTF is assumed to increase at the same rate as the Town's projected population increase. Similarly, BOD_5, TSS, phosphorous, and ammonia nitrogen loadings are assumed to increase with expected population increase. Future flows and loadings assume no major expansions to the sewer system will take place during the 20 year period. Current flows and loads are summarized in Chapter 8 (Table 8.1).

3.2 INFLUENT FLOWS

The Town has committed to spend approximately $400,000 per year in I/I removal work. It would be unrealistic to expect 100% removal of I/I flow over the 20 year planning period. However, it is reasonable to assume removal of 50% of the existing I/I given the Town's aggressive approach to I/I removal. It has also been assumed that permitted industrial discharges will increase to at least the previous total permitted value of 340,000 gpd. This should yield a conservative value for future industrial flows. Septage deliveries are not expected to increase significantly.

As presented in the CPE, based on data provided by the Southeastern Regional Planning and Economic Development District, population increase in the service area is anticipated to increase by approximately 0.06% per year. Domestic flow is expected to increase at the same rate as population increase, therefore domestic flow for the year 2023 is estimated to be 1.41 MGD.

Total influent flow for the year 2023 was calculated by adding the estimated reduced I/I flow, septage, and future anticipated industrial flow to the domestic flow. The estimated total influent flow is 2.69 MGD, excluding recycle flows. It is impossible to quantify exactly what the expected peak flow to the WWTF would be, it can be assumed that with a successful I/I removal program peak flows to the WWTF will be significantly reduced.

3.3 BIOCHEMICAL OXYGEN DEMAND AND TOTAL SUSPENDED SOLIDS LOADINGS

We have assumed future loadings will increase in proportion to the population increase in the sewered area. Based on the anticipated 0.06% per year population increase described above, the estimated average day raw influent BOD_5, primary clarifier effluent BOD_5, and raw influent TSS loadings are 3,843 lb/day, 2,486 lb/day, and 4,071 lb/day. Similarly, the estimated peak day raw influent BOD_5, primary clarifier effluent BOD_5, and raw influent TSS loadings are 8,477 lb/day, 5,786 lb/day, and 9,607 lb/day.

3.4 NITROGEN AND PHOSPHOROUS LOADINGS

Based on the anticipated 0.06% per year population increase, the estimated average day and maximum day influent phosphorous loading is estimated to be 109 lb/day and 373 lb/day respectively. Similarly, the average daily ammonia nitrogen loading is estimated to be 311 lb/day and the maximum day ammonia nitrogen loading is estimated to be 622 lb/day.

4. DEVELOPMENT AND EVALUATION OF WWTF ALTERNATIVES

4.1 INTRODUCTION

This chapter presents a discussion of the improvements originally recommended in the CPE, presents a cost effectiveness analysis where alternatives exist and makes updated recommendations. In general, most process equipment is over twenty years old and has reached the end of its useful life. Continued use of this equipment would likely result in frequent breakdowns that would significantly increase operation and maintenance costs and potentially cause permit violations. Since this is an existing facility there are limited feasible replacement options for most of the process equipment. Construction of additional structures to accommodate a different treatment technology is not cost effective in all cases. Most of the improvements recommended herein are "in kind" replacements, with newer, more efficient technology where available.

The work recommended in this chapter is intended to be performed in a phased approach. The work to be performed in each phase of construction will be defined in Chapter 8. Capital costs for each phase of work will also be presented in Chapter 8. Cost breakdowns for each phase will be presented as appropriate.

4.2 FALLS PUMP STATION

The Falls Pump Station pumps have reached the end of their useful life. To prevent breakdown of these pumps and the potential for overflows associated with the pumps failing we recommend that the three existing 1,100 gallons per minute (gpm) centrifugal pumps be rebuilt and that the existing pump motors be replaced with new premium efficiency motors. To save energy and to minimize surges in flow from the Falls Pump Station to the headworks of the WWTF we have also recommended that the existing "mag" drives be replaced with variable frequency drives.

We have recommended the replacement of the existing bubbler system with ultrasonic level elements to monitor wetwell level and control the pumps and the addition of a magnetic flowmeter to the pump discharge to allow flow measurement of the discharge from the station. A PLC based control panel shall also be installed at the Falls Pumps Station to allow for automatic control of the pumps, monitoring and recording of data such as wetwell level and station flow, and remote operation of the station when the Falls Pump Station control panel is connected to the future plant wide Supervisory Control and Data Acquisition (SCADA) system. The Falls Pump Station work was previously approved by MADEP and is included in Phase I of the WWTF upgrades, currently under construction.

4.3 HEADWORKS

New equipment recently installed in the headworks includes a reciprocating rake type mechanical bar screen installed in 1998, an in channel grinder (comminutor) installed in 1996, flocculating and flash mixers installed in 1999 and aerated grit chamber blowers and variable frequency drives installed in 1998. The CPE erroneously reported that the plunger type septage pumps were replaced in 1997. These pumps are original equipment installed at the WWTF.

As discussed in the CPE, the existing grit collection equipment has reached the end of its useful life. The existing equipment has historically done a good job at removing grit as the WWTF has experienced few grit problems downstream. Installation of a different grit removal technology is not cost effective due to the extensive structural modification that would need to be made to the headworks influent channels and has been screened from further evaluation. The only feasible option is to replace the existing equipment in kind or no action. To prevent breakdown of this equipment, and the increased maintenance costs associated with aged equipment, we recommend replacing the existing grit collection and washing equipment with equipment of similar design. Breakdown of this equipment could negatively impact the operation of the primary clarifiers and primary sludge pumps by allowing additional grit to enter the primary clarifiers. This could cause premature failure of the primary clarifier equipment.

As discussed in the CPE, the influent flowmeter is limited to a maximum flow rate of 10.4 MGD due to the placement of the ultrasonic level element. If the ultrasonic level element is raised such that it can measure the full range of the existing Parshall flume, influent flow measurement up to 13.7 MGD could be recorded. Since influent flowrate does occasionally exceed the capacity of the existing flow measuring device we recommend raising the ultrasonic level element and re-calibrating the unit to give a more accurate indication of peak influent flows. The cost of this work is estimated at $500.

The plunger type septage pumps are actually original equipment and have reached the end of their useful life. To prevent breakdown of the septage pumps we recommend replacing them. Historically the pumps have work well. To install a different type of septage pump would require extensive modification to the piping and mounting system and would likely not result in any better performance. We therefore recommend replacing the septage pumps with similar design plunger style pumps. We also recommend equipping the septage pumps with variable frequency drives and automatic control via the WWTF SCADA system to allow septage pumping rate to the headworks to be variable to prevent slug loadings and to allow septage pumping during low flow periods when loadings to the plant are low. Ultrasonic level elements should be added to the septage holding tanks to monitor level and ensure pumps are not allowed to run dry.

The alum storage and delivery system, located in the lower level of the headwork building, have reached the end of their useful life. Any phosphorous removal strategy at the WWTF will require the addition of alum. It is therefore critical that this equipment continue to function properly. Therefore we recommend the alum storage and delivery system be replaced in kind.

The existing odor control system at the headworks building has also reached the end of its useful life. To continue minimizing odors from the headworks building we recommend replacing the existing odor control system in kind.

4.4 PRIMARY CLARIFIERS

The primary clarifier mechanisms have reached the end of their useful life. The only feasible alternatives regarding the primary clarifiers are to replace the mechanisms or no action. We recommend that the clarifier mechanisms be replaced to prevent breakdown of this equipment and to avoid the increased maintenance costs associated with aged equipment. In addition to increased costs, if this equipment fails the capture efficiency of the clarifiers could be significantly reduced resulting in excess BOD and solids being carried to the secondary system. This would cause unnecessary energy consumption as excess BOD not removed in the primary clarifiers would have to be oxidized in the secondary system. Additionally, we recommend increasing the size of the influent well and addition of a peripheral baffle to increase capture efficiency of the clarifiers. Increased capture efficiency will result in lower BOD_5 and solids loadings to the secondary system. The clarifiers should also be re-painted/recoated to protect the existing concrete structure.

4.5 FIRST STAGE PUMP BUILDING

The four primary sludge/scum pumps in the First Stage Pump Building were replaced in 1998. The three centrifugal lift pumps were rebuilt and variable frequency drives and new level controls were installed in 1999. The only recommended upgrade to the First Stage Pump Building is the installation of radio communications for the existing control panel. Installation of the radio system will allow remote control and monitoring of the pump station via the WWTF SCADA system (described later in this chapter).

4.6 FIRST AND SECOND STAGE AERATION SYSTEMS

Currently, the First Stage Aeration System is not used to treat the WWTF flows. However, the existing mechanical surface aerators are original equipment and are approaching the end of their anticipated useful life. To ensure that this system is available for use in the future if needed or desired by the operations staff, we recommend that the existing equipment be evaluated by the manufacturer to determine if it can be rebuilt to like new condition or if new equipment will need to be installed. For planning purposes we will include the costs for replacing the existing equipment in kind in the recommended plan in Chapter 8. If it is determined that the existing equipment can be utilized any remaining funds can be put to use elsewhere at the WWTF.

The second stage mechanical surface aerators have reached the end of their useful life. Properly functioning aerators are critical to achieving the BOD_5 reduction and nitrification required for the WWTF to meet its effluent permit limits. The options to replace the existing mechanical surface aerators are:

1. Replace the existing two speed mechanical aerators in kind
2. Replace the existing two speed mechanical aerators with mechanical aerators driven by variable frequency drives
3. Replace the existing two speed with a fine bubble diffused air system
4. No action

The fine bubble diffused air system would require installation of a matrix of fine bubble diffuser membranes, blowers, piping, and the construction of a building to house the blower equipment. Because of the high capital cost associated with the installation of a fine bubble diffused air system this option is not cost effective and is screened from further consideration. Leaving the existing aerators in place is also not a feasible option as continuous operation of the aerators must be ensured. The capital costs to replace the existing mechanical surface aerators with either similar two speed aerators or aerators controlled by variable frequency drives are essentially the same. The deciding factors as to which option should be chosen are energy requirements and process flexibility. The aerators equipped with variable speed drives is the recommended option because it will allow the operators to control the dissolved oxygen in the basins much more closely than with the two speed system, which would likely result in over aeration. Over aerating the basins serves no process purpose and wastes electricity.

To monitor dissolved oxygen in the basins and provide a means to control the aerators based on dissolved oxygen level, a dissolved oxygen monitoring system is being installed as part of the Phase I Upgrade currently under construction. This system would be required for either mechanical aerator option chosen and therefore the cost to install the dissolved oxygen monitoring system would apply equally to either option.

While work is being performed in the basins the existing weirs, baffles, drain valves, and sluice gates should be replaced. These items have all reached the end of their useful lives and replacing them while performing other work in the aeration basins will result in lower construction costs.

The proposed upgrades to the second stage aeration system are consistent with the nutrient removal system recommended in Chapter 5.

4.7 FIRST AND SECOND STAGE SECONDARY CLARIFIERS

Currently, the First Stage Secondary Clarifiers are not used to treat the WWTF flows. However, the existing clarifier equipment is original and is approaching the end of its anticipated useful life. To ensure that this system is available for use in the future if needed or desired by the operations staff, we recommend that the existing equipment be evaluated by the manufacturer to determine if it can be rebuilt to like new condition or if new equipment will need to be installed.

For planning purposes we will include the costs for replacing the existing equipment in kind in the recommended plan in Chapter 8. If it is determined that the existing equipment can be utilized any remaining funds can be put to use elsewhere at the WWTF.

The second stage secondary clarifier mechanisms have reached the end of their useful life. The only feasible alternatives regarding the second stage secondary clarifiers are to replace the mechanisms or do nothing. We have recommended that the clarifier mechanisms be replaced to prevent breakdown of this equipment and to avoid the increased maintenance costs associated with aged equipment. In addition to increased costs, if this equipment fails sludge blankets could rise and eventually cause a loss of solids over the effluent weirs.

In order to maximize capture efficiency of the clarifiers we have recommended the addition of fiberglass density current (Crosby) baffles and a Los Angeles type energy dissipating inlet. To meet the expected future effluent phosphorous limit of 0.2 milligrams per liter (mg/L), chemical addition will be required prior to the secondary clarifiers. Maximum clarifier efficiency will allow for effective capture of the fine particles of chemically precipitated phosphorous and thereby allow the WWTF to meet its expected effluent phosphorous limit of 0.2 mg/L. Any future lower limits will likely require additional equipment after the secondary clarifiers. The work being performed on the secondary clarifiers will not be affected by any future additional equipment added and will not prevent the addition of any future additional equipment that may need to be added downstream.

The second stage secondary clarifier work was previously approved by MADEP and is included in Phase I of the WWTF upgrades, currently under construction. The clarifiers should also be re-painted/recoated to protect the existing concrete structure. Recoating the clarifiers was not included as part of Phase I.

4.8 SAND FILTERS

The existing traveling bridge sand filters have reached the end of their useful life. The filter's capacity is much less than the design capacity as evidenced by the frequency of filter bypass. When flow exceeds the capacity of the filters a portion of the filter influent flow bypasses the filters by flowing over a broad crested weir directly into the filter effluent channel. The existing sand filters are 16 ft wide and 59.83 ft long (usable filtration area. Based on original design average and peak loading rates of 1.92 gpm/ft^2 and 3.93 gpm/ft^2, the two filters should accommodate an average daily flow of 5.32 MGD and a peak flow of 10.9 MGD.

Updated design data from the filter manufacturer indicate average and peak loading rates of 2.0 gpm/ft^2 and 5.0 gpm/ft^2, which would result in total filtration capacity of 5.54 MGD average daily flow and 13.85 MGD peak flow. The CPE indicated that filter bypasses occur at approximately 8 MGD. Since the time the CPE was written the condition of the filters has worsened significantly, with bypasses occurring at approximately 4 MGD. This reduced capacity is likely caused by fouled filter media and inefficient backwashing due to the condition of the equipment. It is critical for the filters to function properly to ensure that solids, particularly phosphorous containing solids that may not have been captured by the secondary clarifier due to process upsets, high flows, etc. are captured and not discharged in the final effluent.

Regardless of which phosphorous removal option (described in Chapter 5) is employed, it is doubtful that the WWTF will be able to meet the anticipated effluent phosphorus limit of 0.2 mg/L if the sand filters are not able to accept peak flows without bypassing. Typical phosphorous concentration of biological solids is approximately 3%. For an effluent TSS level of 7 mg/L this equates to 0.21 mg/L of phosphorous. So the WWTF could be meeting its average monthly summertime effluent TSS limit of 7 mg/L and not meet the 0.20 mg/L phosphorous limit. Therefore, it is critical that the filtration system is operating at maximum performance to meet the anticipated effluent phosphorous limit of 0.2 mg/L

When the filters are upgraded, flowmeters should be added to the backwash discharge to allow a calculation of the amount of flow recycled to the headworks. This value could be deducted from the influent flowmeter reading to give a more accurate value of actual flow to the WWTF from the collection system.

Due to structural constraints, as well as hydraulic constraints, alternative filtration technologies are likely to be cost prohibitive. It appears that the only feasible options regarding the sand filters are to replace them in kind or no action. Therefore, we recommend the existing sand filters be replaced with similar equipment.

4.9 SLUDGE HANDLING

The WWTF is equipped with four second stage return activated sludge pumps and five sludge wasting/dewatering feed pumps. All of these pumps are original equipment and are reaching the end of their useful lives. The return sludge pumps are typical centrifugal pumps used for this application and should be replaced in kind. The sludge wasting/dewatering feed pumps are standard progressive cavity pumps and should also be replaced in kind. Continuous operation of the return sludge pumps and the sludge wasting/dewatering feed pumps will be required to allow successful operation of the biological phosphorous removal system described in Chapter 5.

The polymer feed system is also original equipment and should be replaced with similar equipment to provide continued reliable service in the processing of waste sludge. The polymer feed system is critical to the sludge dewatering process and should be upgraded to ensure continued reliable service. If jar testing shows that polymer addition results in a more cost effective chemical-physical phosphorous removal system, the existing polymer feed system would need to be upgraded to allow addition to either the primary or secondary clarifier feeds.

The thickened sludge holding tank mixers have reached the end of their useful life and should be replaced. The only feasible options are to replace the existing mixers with similar equipment or no action. To ensure proper mixing of the thickened sludge and to prevent problems pumping the thickened sludge if not properly mixed we recommend replacing the existing mixers in kind.

A flowmeter should be added to the rotary drum thickener filtrate line. Addition of a flowmeter to this line would allow a calculation of the amount of flow recycled to the headworks. This value could be deducted from the influent flowmeter reading to give a more accurate value of actual flow to the WWTF from the collection system.

To perform sludge thickening the WWTF is equipped with a rotary drum thickener (RDT) that was installed in 1999 and a dissolved air flotation unit (DAF) that is original equipment. The existing DAF has reached the end of its useful life and is not effective for sludge thickening. This unit has not been used since the RDT was installed. The RDT has performed well. We recommend replacing the existing DAF with a similar RDT to provide a redundant back up to the existing RDT. While the WWTF has not experienced maintenance problems with the existing RDT it is reasonable to expect that this equipment will need to be offline at some point in the future. A second RDT unit would allow the WWTF to continue wasting and thickening sludge. Consistent sludge wasting will be beneficial to the biological phosphorous removal system described in Chapter 5.

Four sludge handling options were presented in the CPE. These options were:

1. No action
2. Provide in line blending of primary sludge and waste activated sludge (WAS)
3. Convert one thickened sludge holding tank to WAS storage
4. Convert first stage aeration basins to WAS storage

Options 3 and 4 are related to providing WAS storage to eliminate storing WAS in the primary clarifiers or secondary system. This would be essential to reduce the potential for re-release of phosphorous in a biological phosphorous removal system. The two options will be further discussed in Chapter 5.

Option 2 consists of adding variable frequency drives to the primary sludge pumps, adding flow meters to each of the sludge lines, installing a control panel at the RDT, and automating control of the primary sludge and the WAS to provide inline blending of these streams. Thickening the blended sludge to 6% solids would resulting an annual savings in trucking costs of approximately $8,000. Polymer use would increase by an estimated $1,000 per year. The capital costs to make the modification described above would be approximately $73,000 including design (15%), engineering construction services (10%) and a contingency (10%). A cost effectiveness analysis was performed on option 2 assuming a discount rate of 5.875% and a planning period of 20 years. The present worth of this option is approximately -$8,000, indicating that this option is marginally cost effective. We do not recommend implementing this option now. If sludge disposal cost increases significantly the cost effectiveness of this option should be re-evaluated.

4.10 CHLORINATION SYSTEM

A detailed evaluation of the chlorination and dechlorination systems was presented in Chapter 7 of the CPE. The CPE recommended maintaining the existing chlorine gas system and adding automated control to the chlorine gas feed. The automated control of the chlorine gas feed will be accomplished by using a compound loop system based on effluent flow and chlorine residual. The recommendations presented in the CPE to upgrade the chlorination and dechlorination systems have been included as part of the Phase I upgrade currently under construction. The chlorine contact tanks should be repainted/recoated to protect the existing concrete structure.

4.11 POST AERATION

The existing post aerator was used continuously until 1993. As described in the CPE, contamination of the effluent from bird droppings in this basin was suspected and since that time the basin has been off line. The post aerator is original equipment and is approaching the end of its anticipated useful life. To ensure that this system is available for use in the future if needed or desired by the operations staff, we recommended that the existing equipment be evaluated by the manufacturer to determine whether or not it can be repaired to like new condition or new equipment will need to be installed. For planning purposes we will include the costs for replacing the existing equipment in kind in the recommended plan in Chapter 8. If it is determined that the existing equipment can be utilized any remaining funds can be put to use elsewhere at the WWTF.

4.12 REMOTE PUMP STATIONS

The Industrial Park Pump Station was installed in 1980 and the level control system, lift pumps, and odor control system have all reached the end of their useful life. These components of the pump station should be replaced with similar equipment to prevent breakdown of the equipment and the associated increase in maintenance costs, and to prevent overflows due to pump or level control system failure.

The Grimaldi Pump Station was installed in 1989 and the level control system, lift pumps, standby power system, heating system, and odor control system are all reaching the end of their useful lives. These components of the pump station should be replaced with similar equipment to prevent breakdown of the equipment and the associated increase in maintenance costs, and to prevent overflows due to pump or level control system failure.

4.13 SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEM

There is currently no SCADA at the wastewater treatment plant or at the remote facilities. The wastewater facilities technology dates back to the 1970's and the plant is run mostly in a manual mode. There are a number of problems, the solution to which supports migration to a new SCADA system and other modern technologies. These problems can be summarized as follows:

- Current operations are labor intensive. There are labor saving automation strategies that could relieve operators of time consuming manual control and monitoring functions.

- A fair amount of the current equipment is obsolete, and is at or part of the end of its useful life.

- Collecting and analyzing optimal data is slow, time consuming and not in real time.

The wastewater staff has a need for greater process automation and monitoring as well as more automatic data collection. The technology will be needed to improve operational efficiency.

The wastewater staff also requires a better means of controlling, monitoring, and maintaining remote pump stations. The current system is a mix of old lease line telemetry and local red flashing alarm lights at each station. The red light alarms at the stations alert neighbors to the alarm at the station and the homeowner calls authorities.

The WWTF SCADA system will incorporate programmable logic controller (PLC) based control panels in each building at the WWTF with radio communication between each building and the Control

Building. The pump station controls for six stations will be replaced with a PLC based control system and Teledesign radios. The remote site radio signals will be received by the existing master radio at the Whiting Street Water Filtration Plant. The data and alarms from the remote pump stations would then travel over the fiber optic link to the WWTF SCADA system. All pump station information would then be displayed at the WWTF. A portion of this work (installation of PLC based control panels at the Control Building, Falls Pump Station, Second Stage Pump Station and Rapid Sand Filter Building) has been incorporated in the Phase I upgrade currently under construction. Phase II work will incorporate the addition of a control panel at the Headworks Building and installation of a radio communications system at the First Stage Pump Building. The final SCADA system infrastructure would be installed during Phase III at the WWTF and the remote pump stations.

4.14 FIRE AND SECURITY ALARMS

Installation of new fire alarms, security cameras, and intrusion detectors at the WWTF and fire sensors and intrusion alarms at the remote pump stations are required to increase safety and reduce vulnerability of overall system operation. These upgrades will allow the Town to ensure that the WWTF and remote pump stations remain operational to the fullest extent possible.

4.15 STRUCTURAL CONCERNS

The CPE presented a structural evaluation of the WWTF in Section 6 – Structural Evaluation.

We recommend that the items listed as "High Level of Concern" be repaired to prevent further degradation. These items are also shown in Table 4.1 on the next page.

Table 4.1 – High Level of Concern Structural Repairs Required

Structure	Location	Observation	Recommendation
Control Building	SE corner at Chlorine Room	Diagonal cracking in masonry joint at top corner of opening. Crack is susceptible to moisture penetration. Does not appear to be a structural concern.	Masonry joint crack should be repointed at the present crack width to minimize moisture penetration.
Headworks	S. Wall exterior loading dock	Masonry façade has several broken bricks due to past impact damage and is susceptible to moisture penetration.	Remove all damaged masonry units and rebuild with new to match existing to minimize future moisture penetration.
First Stage Pump Building	SW corner exterior	Several masonry façade units are shifted, broken, loose, or out of position, leaving many gaps open to moisture penetration.	Remove all damaged masonry units and rebuild with new to match existing to minimize future moisture penetration.
First Stage Pump Building	SW corner exterior	Masonry façade on retaining wall has mortar joint deterioration, mold growth, and evidence of moisture penetration. Top of wall masonry with no cap flashing or coping.	See note below. Installation of aluminum coping along top of wall and repointing deteriorated masonry veneer joints would reduce future moisture problems.
Second Stage Pump Building	NW corner exterior	Masonry façade on retaining wall has mortar joint deterioration, mold growth, and evidence of moisture penetration. Top of wall masonry with no cap flashing or coping.	See note below. Installation of aluminum coping along top of wall and repointing deteriorated masonry veneer joints would reduce future moisture problems.
Second Stage Pump Building	W Wall exterior	Observed mold growth along face of masonry and in joints - appears to be the result of moisture penetration through roof parapet.	See note below. Installation of roof parapet coping and repointing deteriorated masonry veneer joints would reduce future moisture problems.
Second Stage Pump Building	N Entrance exterior	Diagonal cracking in masonry joints at top corner of opening. Gaps of 3/8" exist in masonry joints. Crack is susceptible to moisture penetration.	Masonry joint cracking should be repointed at the present crack width to prevent future moisture penetration.
Second Stage Aeration Tanks	S wall of tank	Handrail post embedded into top of tank wall has spalled concrete.	Repair spalled concrete with the appropriate repair mortar flush with wall surface.

Note – Both the 1st and 2nd Stage Pump Buildings have masonry roof parapets with no flashing cap, which are susceptible to moisture penetration. It appears that over the years moisture has penetrated into the parapets and migrated down the wall behind the masonry veneer. This has resulted in various moisture problems such as moisture staining on wall interiors, mold growth on mortar joints and on masonry veneer, deteriorated mortar joints, apparent trapped moisture inside the walls, efflorescence, horizontal cracks in wall behind brick shelves, etc. Aluminum cap flashing or coping should be installed on top of masonry parapets to minimize future moisture problems.

4.16 BACK-UP POWER

The existing standby generator is original equipment and is approaching the end of its useful life. Based on the fact that the actual operating time is significantly less than the useful life operating hours anticipated, we recommended that the existing generator be evaluated by the manufacturer to determine if the existing generator can be rebuilt to like new condition and/or if a new generator will be required. For planning purposes we will include the costs for replacing the existing generator in kind in the recommended plan in Chapter 8. If it is determined that the existing generator can be utilized any remaining funds can be put to use elsewhere at the WWTF.

5. DEVELOPMENT AND EVALUATION OF PHOSPHOROUS REMOVAL ALTERNATIVES

5.1 INTRODUCTION

This chapter re-introduces the nutrient removal alternatives evaluated in the CPE, presents the cost effectiveness analysis of each alternative, and makes updated recommendations. All recommendations are consistent with meeting the anticipated next effluent phosphorous limit of 0.2 mg/L and will be compatible with meeting possible lower future phosphorous limits and potential future nitrogen limits.

Capital costs presented in this chapter are based on values presented in the CPE and have been adjusted to an Engineering News Record (ENR) value of 6735. The costs shown also include design (15%), construction services engineering (10%), and a contingency (10%).

5.2 CURRENT TREATMENT STRATEGY

The current average monthly effluent permit limit for total phosphorous is 1.0 milligram per liter (mg/L) from May 1 through October 31. There is currently no total phosphorous limit from November 1 through April 30. The current average monthly permit limit for ammonia nitrogen is 1.0 mg/l from June 1 through October 31, 3.0 mg/L from May 1 through May 31, 7.0 mg/L from November 1 through November 30, and 10 mg/L from December 1 through April 30.

The WWTF is able to meet its current average monthly phosphorous limit using single point chemical addition. Alum is added just prior to influent flow entering rapid mix tank. From the rapid mix tank influent flows into flocculation tank and then on to the primary clarifiers where the phosphorous precipitate formed in the flocculation tanks settles and is removed with the primary sludge. A more detailed discussion of the existing flash mix tank and flocculation basin is presented in the CPE in Sections 8.4.1.5 and 8.4.1.6.

The WWTF is also able to meet its current ammonia nitrogen limits. Nitrification is the process of microorganisms converting ammonia nitrogen, or more specifically ammonium ions, to nitrites then to nitrates. In the aeration basins, after most of the soluble BOD has been oxidized microorganisms use dissolved oxygen to perform nitrification by oxidizing ammonium ion to nitrate. The oxidation of ammonia to nitrate requires approximately 4.6 pounds of dissolved oxygen per pound of ammonia nitrogen converted to nitrate nitrogen. Based on the levels of ammonia nitrogen in the WWTF effluent it can be assumed that the plant is achieving full nitrification with the five basins that are typically on line. This indicates that the existing surface aerators that are typically on line are supplying sufficient dissolved oxygen for BOD_5 removal and nitrification.

5.3 MEETING FUTURE PHOSPHOROUS LIMITS

As presented in the CPE, there are two feasible options for phosphorous removal that could be utilized at the WWTF to meet an effluent phosphorous limit of 0.2 mg/L; two stage chemical-physical phosphorous removal with sand filtration and biological phosphorous removal followed by chemical-physical phosphorous removal and sand filtration. Each alternative is evaluated in the following sections.

5.3.1 Two Stage Chemical-Physical Phosphorous Removal Followed by Sand Filtration

As discussed previously, the WWTF currently performs phosphorous removal by adding alum upstream of a flash mix tank and flocculation basin and settles the phosphorous precipitate with the primary sludge in the primary clarifiers. The WWTF should be able to meet an effluent limit of 0.2 mg/L by adding additional chemical after the second stage aeration system, settling the phosphorous precipitate in the secondary clarifiers, and utilizing upgraded sand filters.

The chemical delivery system currently in place at the WWTF allows for two stage chemical addition as described. The chemical injection point near the secondary clarifier splitter box should be modified to ensure even distribution of the chemical across the effluent channel. Also, a mechanical mixer (1 HP) should be added to the secondary clarifier splitter box as discussed in the CPE. Since all phosphorous removal strategies presented here include chemical physical phosphorous removal in the secondary system these recommendations apply to the removal strategies discussed later in this chapter.

In addition, as discussed in the CPE, to optimize the two stage chemical-physical phosphorous removal process upgrades will be required for the flash mixers, flocculators, primary clarifiers, and secondary clarifiers. The mixers in both the flash mix tanks and the flocculation tanks impart excessive energy to the basins, which can cause floc shear and adversely affect the first stage phosphorous removal. When these units need to be replaced due to age they should be replaced with units that minimize floc shearing.

The existing primary clarifier center wells are undersized based on current design practices. As indicated in Chapter 4, the primary clarifier mechanisms have reached the end of their useful life and should be replaced. Increasing the size of the center well when the clarifiers are upgraded should increase capture efficiency of BOD_5, TSS and chemically precipitated phosphorous. Also, the addition of peripheral baffles should also increase capture efficiency of the primary clarifiers and should be included as part of the upgrade.

Similarly, the second stage secondary clarifier mechanisms have reached the end of their useful life and are scheduled to be replaced starting in December 2003. Upgrades to the secondary clarifiers include replacement of existing mechanisms, installation of LA type energy dissipating inlets, and installation of density current (Crosby) baffles. These upgrades should result in increased capture efficiency of the secondary clarifiers which will benefit any chemical removal of phosphorous in the secondary system.

It is critical that the sand filtration system be able to accept peak flows without bypassing in order to meet the anticipated effluent phosphorous limit of 0.2 mg/L. The existing sand filters must be upgraded to ensure that they can accept peak flows without bypassing.

These upgrades are beneficial to this phosphorous removal strategy as well as the strategies presented later in this chapter because all strategies utilize chemical-physical phosphorous removal in the secondary clarifier and sand filtration to achieve the anticipated 0.2 mg/L effluent phosphorous limit.

The estimated cost for adding a mixer to the secondary clarifier splitter box and modifying the chemical injection point is approximately $5,700. Increased alum costs and chemical sludge disposal costs have been estimated at $3,000 per year and $4,000 per year respectively. Electrical costs as a result of continuously running the 1 HP mixer will increase by an estimated $500 per year. Primary and secondary clarifier upgrade costs and sand filter upgrade costs will not be included in the cost effectiveness evaluation of the phosphorous removal alternatives because these upgrades are required no matter which phosphorous removal option is selected.

5.3.2 Biological Phosphorous Removal Followed by Chemical-Physical Phosphorous Removal and Sand Filtration

This system would consist of biological phosphorous removal in the second stage aeration tanks followed by chemical physical phosphorous removal in the secondary clarifiers and sand filtration. The same modifications required for chemical physical phosphorous removal in the secondary clarifiers as described in the previous section (modification to injection point, splitter box mixer, secondary clarifier upgrades) would also be required for this option. Similarly, the upgrades to the sand filters described above would also be needed for this option. If this option is utilized, chemical physical removal of phosphorous in the primary clarifiers would be discontinued. The chemical feed equipment, rapid mixers, and flocculators associated with phosphorous removal in the primary clarifiers would remain in place to serve as a back up in case of failure of the biological system.

Biological phosphorous removal is accomplished by bacteria that are able to perform "luxury uptake" of phosphorous. Luxury uptake of phosphorous is the term used to define the uptake of phosphorous by bacterial cells in excess of cellular requirements. Anaerobic conditions exist when little or no dissolved oxygen or nitrates are present in the basin. Under anaerobic conditions volatile fatty acids are produced through fermentation. The phosphorous removing bacteria release their stored phosphorous in the anaerobic zone and rapidly absorb and store the volatile fatty acids. The phosphorous removing bacteria are therefore preferentially selected over other bacteria in the anaerobic zone due to their ability to out compete the other bacteria for the available food source under these conditions. Then under aerobic conditions the bacteria use the free molecular oxygen available to degrade the stored fatty acids. While the bacteria degrade their stored fatty acids they also simultaneously absorb phosphorous, not only the phosphorous that was released in the anaerobic zone but also phosphorous that was present in the primary clarifier effluent. When sludge is wasted this excess phosphorous contained within the bacteria is removed from this system.

Typical activated sludge phosphorous content is approximately 1% to 3%. When biological phosphorous removal methods are used the phosphorous content of the activated sludge is approximately 4% to 7%. It is very important in these types of systems to prevent re-release of phosphorous from the wasted sludge during sludge processing. This can be accomplished by keeping the wasted sludge under aerobic conditions.

The CPE recommended converting Aeration Basin No. 1 in the second stage aeration system into an "anaerobic cell" by removing the mechanical aerator and installing a mixer. To allow operators maximum flexibility in the treatment system we are revising this recommendation. Aeration Basin No. 1 should be equipped with submersible mixers and the existing surface aerator should remain in place and available for the operators use. We also recommend making the same modifications to Aeration Basin No. 2. This approach will allow either Aeration Basin No. 1 or Aeration Basin No. 2 to be the "anaerobic cell". It is assumed that the practice of storing return activated sludge (RAS) in an aeration basin will be discontinued as part of the implementation of a biological phosphorous removal system.

The conditions required to create an "anaerobic cell" for a biological phosphorous removal system are essentially no dissolved oxygen and little to no nitrates. A challenge to creating anaerobic conditions in the "anaerobic basin" is nitrates entering the basin in the RAS. As described previously, nitrification is required for the WWTF to meet its effluent ammonia nitrogen limit. As a result of this process nitrates are present in the RAS. The model used in the CPE indicated that nitrates should not be a factor; however review of available literature suggests that the presence of nitrates in the "anaerobic cell" may decrease the efficiency of the biological phosphorous removal system due to the nitrate reduction taking place.

Nitrate reduction in the anaerobic zone utilizes substrate that would have been converted to volatile fatty acids required by the phosphorous storing organisms to perform luxury uptake of phosphorous.

A review of available literature also indicates that another factor that may reduce the effectiveness of the biological phosphorous removal system is the level to which volatile fatty acids (VFAs) are produced in the anaerobic zone. Unfortunately, there is not a method of accurately predicting how much of the soluble BOD_5 will be converted to VFAs in the anaerobic zone. If insufficient VFAs are formed the ability of the phosphorous removing bacteria to perform luxury uptake of phosphorous could be limited. Having a limited supply of VFAs available, the bacteria will not have stored as much as they could under non-limiting conditions and therefore will not be able to uptake as much phosphorous in the aerobic zone. Optimization of the biological phosphorous removal system will provide an indication whether or not sufficient VFAs are being produced.

If insufficient VFAs are created in the anaerobic zone supplemental VFAs acids can be added if available. Other sources of VFAs would be gravity thickeners or anaerobic digesters. In the case of the North Attleborough WWTF there are currently no other processes available to produce supplemental VFAs. While not likely, if supplemental VFAs are required some kind of off line fermentation process would likely need to be considered.

As discussed in Chapter 4, the mechanical surface aerators have reached the end of their useful life and should be replaced. Based on the WWTF's ability to meet current maximum day BOD_5 and nitrogen loadings with six aeration basins on line, the calculated oxygen transfer of the existing aerators is approximately 2.2 pounds of oxygen per horsepower per hour. Newer mechanical surface aerator technology should result in at least 15% higher oxygen transfer efficiency than the current aerators, therefore the new aerators should provide approximately 2.6 pounds of oxygen per horsepower per hour. Assuming a 10% BOD_5 reduction in the anaerobic zone the total oxygen demand for the projected future maximum day BOD_5 and ammonia nitrogen loading is approximately 8,900 pounds of oxygen per day (assumes 1.1 pounds of oxygen is required per pound of BOD_5 oxidized and 4.6 pounds of oxygen is required per pound of ammonia nitrogen converted to nitrate nitrogen). If this option is employed, the six new mechanical surface aerators should be able to provide approximately 9,200 pounds of oxygen per day; therefore the proposed system should be able to meet the projected oxygen demands for the 20 year planning period. This does not include the 1,320 pounds of oxygen per day available from the existing aerator that remains in the redundant back up "anaerobic cell". If needed in the future this cell could be utilized as an aerobic basin.

Under normal weekday operations waste activated sludge is sent directly to the sludge thickening process. On weekend sludge is either wasted back to the headworks of the plant and then co-settles in the primary clarifiers with the primary sludge or not wasted at all. If this option is employed, to prevent rerelease of phosphorous the practice of co-settling waste activated sludge with primary sludge should be avoided, as well as allowing sludge to collect in the secondary clarifiers over a weekend. To accommodate the waste sludge the CPE recommended that one of the thickened sludge holding tanks be converted to a waste sludge holding tank. Very minor piping modifications would need to be made to accomplish this. However, if waste sludge is stored in a holding tank the tank would need to be aerated to prevent anaerobic conditions and the release of phosphorous in the sludge thickener filtrate.. This can be accomplished by adding a coarse bubble diffuser to the waste sludge storage tank and providing a positive displacement blower (and a redundant back up) and associated piping.

Another option for waste sludge storage is to convert the First Stage Aeration Basins to an aerated sludge storage system. This option would require replacing the existing surface aerators with diffused aeration, piping (both yard piping and piping in the Control Building) and pump modifications to pump waste sludge to and from the proposed basins. The capital costs for this option approximately five times greater than the capital costs for the proposed modification to the thickened sludge holding tank to allow waste sludge storage. Electrical costs for the two options are approximately equal. Therefore modifying the thickened sludge holding tank to store waste sludge is the more cost effective of the two waste sludge storage options and this option will be used in the cost effectiveness of the whole biological phosphorous removal system.

As discussed in the CPE, for this system there is an expected net savings associated with less alum use and less chemical sludge disposal of approximately $24,000 per year. Electrical savings have been estimated to be approximately $10,500 per year assuming the flocculators and rapid mixers are turned off, the splitter box mixer is run 24 hours per day, two submersible mixers in the active anaerobic zone are run 24 hours per day, the RAS storage mechanical aerator operation is eliminated, BOD_5 is reduced by 10% in the anaerobic zone (results in less oxygen required in the aerobic zone and therefore less energy used) and an electrical cost of $0.08 per kw-hr. These savings have been calculated based on the assumption that the biological phosphorous removal system will achieve the levels of phosphorous removal predicted by the model. If the presence of nitrates or insufficient VFA production does not allow maximum biological phosphorous removal the savings would not be as high as indicated here. However, even a partially effective biological phosphorous removal system should result in significant savings in alum use, sludge disposal, and electricity.

Capital costs for installation of mixers in the first two basins, converting a thickened sludge holding tank to a waste sludge storage tank, adding a mixer to the secondary clarifier splitter box, and modifying the chemical injection point would be approximately $291,400.

5.4 MEETING FUTURE TOTAL NITROGEN REQUIREMENTS

The biological phosphorous removal system described above can easily be converted to a biological nutrient removal system to include the biological removal of nitrogen. In a biological nutrient removal system the first basin in line is an anaerobic basin and the second basin in line is an anoxic basin. The anaerobic basin would function exactly as described for the biological phosphorous removal system. The anoxic basin, a basin with very little dissolved oxygen and a high concentration of nitrates, is where denitrification takes place. In the presence of a carbon source (BOD_5) and very low dissolved oxygen there are many microorganisms typically found in municipal wastewater that are capable of converting nitrate to nitrogen gas (denitrification).

To create the anoxic environment required in the second basin (Aeration Basin No. 2) the previously installed mixers would be utilized and a recycle pump would need to be installed. The recycle pump would be placed in the last cell of the treatment train to return the nitrate rich mixed liquor to the second basin, where it would then be denitrified. This system would eliminate the concern over nitrate in the RAS effecting the performance of the biological phosphorous removal, as the RAs would no longer contain significant levels of nitrates.

In addition to the capital costs listed for the biological phosphorous removal system above, conversion to a biological nutrient removal system would require approximately $264,300 for the installation of a 40 HP recycle pump and associated electrical and piping work. The system would save approximately $1,000 per year due to reduced caustic addition. Additional electrical costs of approximately $5,500 per year would result from running the 40 HP recycle pump 24 hours per day (recovered oxygen as a result of denitrification was incorporated into this calculation). The same savings in alum and sludge disposal costs can be expected with this system as with the biological phosphorous removal system.

Nitrogen removal can also be implemented with the two stage chemical-physical phosphorous removal system; however mixers would need to be installed as well as the RAS recycle pump since they would not be installed as part of the two stage chemical-physical phosphorous removal option. The proposed systems are therefore consistent with potential future total nitrogen limitations. It should be noted that the ammonia nitrogen content of the influent wastewater is relatively low, approximately 12 mg/L on average.

5.5 COST EFFECTIVENESS

The present worth of each option, shown in Table 5.1 and 5.2 below, was calculated assuming a 20 year planning period and a discount rate of 5.875%. For each alternative, maintenance costs are considered negligible when compared to operational costs and therefore are not included in the present worth calculation. It has also been assumed that none of the capital improvements will have any salvage value at the end of the 20 year planning period. Operation and maintenance values shown are relative to existing to existing costs with negative values indicating a cost savings. The present worth is the sum that would need to be deposited, collecting the given interest (discount) rate, to exactly pay for all expenditures through the life of the proposed system.

Table 5.1 - Two Stage Chemical Physical Phosphorous Removal

Capital Costs	
Add mixer to secondary clarifier splitter box and modify existing chemical injection point.	$5,700
Operation and Maintenance Costs	
Chemical addition	$3,000/year
Sludge disposal	$4,000/ year
Electrical	$500/year
Present Worth	$92,700

Table 5.2 – Biological Phosphorous Removal followed by Chemical Physical Phosphorous Removal

Capital Costs	
Add mixer to secondary clarifier splitter box, modify existing chemical injection point, install submersible mixers, and modify sludge holding tank.	$291,400
Operation and Maintenance Savings	
Chemical addition and sludge disposal	($24,000/year)
Electrical	($10,500/year)
Present Worth	($108,700)

5.6 RECOMMENDATIONS

Based on the present worth of the two options, biological phosphorous removal followed by chemical physical phosphorous removal and sand filtration is the preferred option. The present worth value shown for the biological phosphorous removal system assumes the system will achieve phosphorous removal levels shown in the CPE model. Even if the biological phosphorous removal system achieves only half of the phosphorous removal predicted by the model it is still the more cost effective option.

To ensure this system works efficiently it is important that the upgrades to the secondary clarifiers and sand filters described in Chapter 4 be performed as soon as feasible. Upgrades to the alum storage and feed systems should be made to ensure continued reliable service.

All modifications required for two stage chemical-physical phosphorous removal are also required for the recommended plan. Therefore the ability to operate as a two stage chemical-physical phosphorous removal system will be available as a redundant back-up to the biological system without expending addition capital costs.

The recommended modifications should allow the WWTF to meet the anticipated phosphorous limit of 0.2 mg/L. Future lower phosphorous limits likely will not be able to be met by any of the currently available options. However, the recommended phosphorous removal system would not have a negative effect on future treatment technology that may need to be added downstream to achieve lower effluent phosphorous limits. Similarly, the recommended plan will easily allow for the future addition of nitrogen removal with the addition of a recycle pump and a simple change in the flow pattern through the secondary aeration system.

6. INSTITUTIONAL, FINANCIAL, LEGAL AND MANAGEMENT ARRANGEMENTS

6.1 INTRODUCTION

The following sections present the institutional, financial, legal and management arrangements, if any, that are necessary to implement the recommended plan presented in Chapter 8.

6.2 INSTITUTIONAL

The recommended plan does not require any new institutional arrangements, such as intermunicipal agreements, establishment of sewer districts or septage management districts, etc., or any special state or local legislative or regulatory action for implementation of the plan. Funding of the future phases (Phases III through VI) of the recommended plan, will require approval by the Board of Public Works (BPW), Selectmen and Town Meeting.

6.3 FINANCIAL

To implement the recommended plan the Town, through its BPW will phase the plan over a six year period, in financial increments of approximately $1,500,000 per year. Funding will be provided through increases in the sewer rates established by the BPW. Depending upon the favorability of the CWSRF loan rates, the BPW may elect to apply for CWSRF loans for the individual phases of the plan.

Phase I (currently under construction) and Phase II (currently under design) of the recommended plan have been funded through increases in the sewer rates in FY 2003 and FY 2004 of 10 percent and 18 percent, respectively. Phase I has been financed under the CWSRF program and an application for CWSRF funding for Phase II will be submitted on October 15, 2003.

6.4 LEGAL

The recommended plan does not require any new legal arrangements for implementation of the recommended plan.

6.5 MANAGEMENT

The recommended plan does not require any new management arrangements for implementation of the recommended plan. Implementation of the recommended plan will be managed by the existing Town of North Attleborough Department of Public Works under the direction of the BPW.

7. PUBLIC PARTICIPATION

7.1 INTRODUCTION

The following sections of this chapter present the public participation program.

7.2 PUBLIC MEETINGS

Two public meetings were held in reference to the original CPE. The first public meeting was held on January 18, 2000 at a BPW meeting to discuss the scope of services for the CPE. The second public meeting was held on June 26, 2001, also at a BPW meeting, to discuss the results of the CPE, including recommendations and costs.

7.3 PUBLIC HEARING

A public hearing to discuss the CPE recommendations and costs was held on March 12, 2003 at the Board of Selectmen's Meeting and at the 2003 annual Town Meeting.

8. RECOMMENDED PLAN

8.1 INTRODUCTION

The recommendations presented in the chapter should allow the WWTF to meet their current and projected future permit limits for BOD, TSS, and ammonia nitrogen. The recommendations for phosphorous removal should allow the WWTF to meet its next anticipated phosphorous limit of 0.2 mg/L. Future lower phosphorous limits will likely require addition of more advanced treatment technology. Also, the recommendations presented here will allow for simple modifications to the second stage aeration system to meet future total nitrogen limits if they are imposed.

8.2 FLOWS AND LOADS

The existing and estimated future flows and loads to the WWTF are presented below in Table 8.1. A full discussion of how flows and loads were developed in presented in Chapters 2 and 3.

Table 8.1 – Flow and Load Projections[1]

	Year 2003	Design Year 2023
Total Population	27,600	31,100
Sewered Population[2]	23,000	25,900
Domestic Flow	1.25 MGD	1.41 MGD
Industrial/Commercial/Institutional[3]	72,500 gpd	340,000 gpd
I/I[4]	1.86 MGD	0.93 MGD
Septage	5,600 gpd	5,600 gpd
Total Average Daily Flow[5]	3.19 MGD	2.69 MGD
Peak Flow[6]	10.9 MGD	< 10.9 MGD
BOD_5 Loading	2,200 lb/day (average) 5,100 lb/day (peak)	3,800 lb/day (average) 8,500 lb/day (peak)
TSS Loading	3,600 lb/day (average) 8,500 lb/day (peak)	4,000 lb/day (average) 9,600 lb/day (peak)
Total Phosphorous Loading	97 lb/day (average) 331 lb/day (peak)	109 lb/day (average) 337 lb/day (peak)
Ammonia Nitrogen Loading	276 lb/day (average) 552 lb/day (peak)	311 lb/day (average) 622 lb/day (peak)

1 = domestic flows and BOD_5, TSS, phosphorus, and ammonia nitrogen loadings have all been assumed to increase proportionally with expected increase in sewered population

2 = design year sewered population based on increase of 0.6%/year to match expected increase in total population, does not include major expansions to the collection system

3 = assumes industrial flows will reach previous high value for permitted flows

4 = assumes I/I will be reduced by 50% over the planning period due to the town's aggressive I/I removal program. The Town is committed to spend approximately $400,000 per year in I/I removal work.

5 = excludes recycle flows

6 = actual future peak flow cannot be accurately quantified, but with a successful I/I removal program future peak flows are expected to be significantly reduced

8.3 RECOMMENDED IMPROVEMENTS

Each recommendation is based on the evaluation of improvements and evaluation of nutrient removal options presented in Chapters 4 and 5, respectively. Refer to these sections of the report for a full description of the basis for each recommendation

8.3.1 Falls Pump Station

- Rebuild the three existing 1,100 gpm centrifugal pumps and install new premium efficiency motors
- Add variable frequency drives to each pump.
- Replace the existing bubbler system with ultrasonic level elements
- Add a magnetic flowmeter
- Install a PLC based control panel

8.3.2 Headworks

- Replace the existing grit collection and washing equipment with equipment of similar design
- Replace the septage pumps with similar design plunger style pumps.
- Equip the septage pumps with variable frequency drives
- Install a PLC based control panel
- Re-locate and re-calibrate influent flow metering ultrasonic level element
- Provide ultrasonic level elements to monitor septage holding tank level
- Replace the existing alum storage and delivery system
- Replace the existing odor control system

8.3.3 Primary Clarifiers

- Replace the existing primary clarifier mechanisms
- Increase the size of the influent well
- Addition a peripheral baffle

8.3.4 First Stage Pump Building

- Install radio communications for the existing PLC based control panel
- Replace the existing trolley crane

8.3.5 Second Stage Aeration System

- Replace six of the existing eight two speed mechanical surface aerators with mechanical surface aerators equipped with variable frequency drives and newer rotors that provide more efficient oxygen transfer
- Install two submersible mixers in Aeration Basin No. 1 to allow for allow implementation of a biological phosphorous removal system. The existing mechanical surface aerator will remain in place and operational.
- Install two submersible mixers in the Aeration Basin no. 2 to provide for operational flexibility. The existing mechanical surface aerator will remain in place and operational.
- Install a dissolved oxygen monitoring system
- Replace the existing weirs, baffles, drain valves, and sluice gates

8.3.6 Second Stage Secondary Clarifiers

- Replace the existing second stage secondary clarifier mechanisms
- Install a fiberglass density current (Crosby) baffle in each second stage secondary clarifier
- Replace the existing inlets with "Los Angeles type" energy dissipating inlets

8.3.7 Sand Filters

- Replace the existing sand filter and traveling bridges
- Install magnetic flowmeters on the backwash discharge line of each filter

8.3.8 Sludge Handling

- Replace the existing return sludge pumps
- Replace the existing sludge wasting/dewatering feed pumps
- Install a flowmeter in the rotary drum thickener filtrate discharge line
- Replace the existing sludge holding tank mixers
- Replace the existing polymer feed system
- Install a coarse bubble diffused air system and blowers with variable frequency drives to allow aerobic storage of waste activated sludge

8.3.9 Chlorination System

- Add automated control to the chlorine gas feed.
- Provide a compound loop control system based on effluent flow and chlorine residual.

8.3.10 Remote Pump Stations

- At the Industrial Park Pump Station replace the existing the level control system, lift pumps, and odor control system
- At the Grimaldi Pump Station replace the existing level control system, lift pumps, standby power system, heating system, and odor control system

8.3.11 SCADA

- Incorporate PLC based control panels in each building at the WWTF with radio communication between each building and the Control Building.
- Replace the existing pump station controls for six remote pump stations with a PLC based control system and Teledesign radios.

8.3.12 Fire and Security Alarms

- Install new fire alarms, security cameras, and intrusion detectors at the WWTF and fire sensors and intrusion alarms at the remote pump stations.

8.4 IMPLEMENTATION

The recommended improvements will be performed in 6 phases over a 6 year period (2002 through 2008). Upon completion of Phase III, the WWTF should be able to meet an effluent phosphorous limit of 0.2 mg/L utilizing biological phosphorous removal followed by chemical-physical phosphorous removal and sand filtration. To meet an effluent phosphorous limit lower than 0.2 mg/L additional treatment technology such as membrane technology or the patented

CoMag process would be required. The recommended phosphorous removal system can easily be converted to a biological nutrient removal system capable of meeting typical total effluent nitrogen limits that may be imposed in the future.

8.4.1 Phase I

The work of Phase I include the following as approved for CWSRF funding by MADEP:

- Upgrades to the Second Stage Secondary Clarifiers, including replacement of all clarifier equipment, the addition of density current (Crosby) baffles, and the addition of the newest available energy dissipating inlet technology.
- Upgrades to the Falls Pump Station, including rehabilitation of the existing pumps, the addition of variable frequency drives and a local PLC based control panel, replacement of wetwell level monitoring equipment, and the addition of a magnetic flowmeter to monitor and record flow from the station.
- Upgrades to the chlorination and dechlorination system, including replacement of the existing chlorinators, installation of new chlorine residual analyzers, replacement of the existing sodium bisulfite feed pumps, and automation of the chlorine and sodium bisulfite feed systems.
- Installation of a dissolved oxygen monitoring system in the Second Stage Aeration basins.

8.4.2 Phase II

The work of Phase II as included in the FY 2003 Project Evaluation Form (PEF) will include the following:

- Upgrades to the Second Stage Aeration System, including replacement of existing surface mounted aerators in basins 3 thru 8, addition of two submersible mixers in basin 1 and basin 2, replacement of the weirs and scum baffles, replacement of sluice gates and installation of a flash mixer at the aeration splitter box. These upgrades will allow WWTF operators to configure the treatment scheme to allow for biological phosphorous removal. An optimization study of the biological system will be required to ensure that biological phosphorous removal is maximized.
- Upgrades to the Headworks Building including replacement of the grit collection screws bucket conveyor systems, grit washer and aeration headers, replacement of the existing plunger type septage pumps and the addition of variable frequency drives to the septage pumps, and the addition of a screenings dewatering system.
- Conversion of one of the Thickened Sludge Holding Tanks to a Waste Activated Sludge Storage Tanks by adding a coarse bubble aeration header and blower and modifying existing piping.

8.4.3 Phase III

The work of Phase III as included in the FY 2004 PEF will include the following:

- Upgrades to Primary Clarifiers, including replacement of the clarifier drives and center well and the installation of a peripheral baffle system.
- Upgrades to the Sand Filters including replacement of the traveling bridges, replacement of the filter media and filter media support system, and installation of flow meters on the backwash waste lines of each traveling bridge.

- Upgrades to the Sludge Storage Tank mechanical mixers and installation of flow measurement on the Rotary Drum Thickener filtrate line.
- Improvements to the Fire Alarm System and the Security Systems at the WWTF and remote pump stations.
- Upgrades to the Industrial Park Pump Station including replacement of the level control system, replacement of lift pumps, and replacement of the make-up air/exhaust/odor control system.
- Install final SCADA system infrastructure at WWTF and remote pump stations and implement SCADA system.
- Perform structural repairs indicated as "high level of concern" (this item was not part of the PEF, however this work should be completed as soon as possible to prevent conditions from worsening and becoming more costly).

8.4.4 Phase IV

The work of Phase IV will include the following:

- Replacement of the return sludge pumps
- Replacement of the sludge wasting/dewatering feed pumps
- Upgrades to polymer mixing and feed system
- Upgrades to alum storage and feed system
- Upgrades to Headworks Building odor control system
- Recoat primary and second stage secondary clarifiers

8.4.5 Phase V

The work of Phase V is assumed to include will include the following:

- Replacement of the stand-by generator
- Recoat chlorine contact tanks
- Replace first stage aerators
- Replace post aerator
- Upgrade Grimaldi Pump Station

8.4.6 Phase VI

The work of Phase VI is assumed to include will include the following:

- Replace DAF with RDT
- Upgrade first stage secondary clarifiers

8.5 SCHEDULE

Phase I construction activities have begun and are expected to be complete by June 2004. Bidding of the Phase II work is expected to take place in January 2004, then contract award would be expected by April 2004 and construction activities would be expected to be complete by April 2005.

Phase III design is anticipated to be completed in the Fall of 2004. Bidding for Phase III work is expected to take place in January 2005. Contract award would then be expected by April 2005 and construction activities would be expected to be complete by April 2006.

Phase IV design is anticipated to be completed in the fall of 2005. Bidding for Phase IV work is expected to take place in January 2006. Contract award would then be expected by April 2006 and construction activities would be expected to be complete by April 2007.

Phase V design is anticipated to be completed in the fall of 2006. Bidding for Phase IV work is expected to take place in January 2007. Contract award would then be expected by April 2007 and construction activities would be expected to be complete by April 2008.

Phase VI design is anticipated to be completed in the fall of 2006. Bidding for Phase IV work is expected to take place in January 2007. Contract award would then be expected by April 2007 and construction activities would be expected to be complete by April 2008.

8.6 CAPITAL AND OPERATION & MAINTENANCE COSTS

The capital costs for each phase of work are shown in the tables below. The Phase I work is currently under construction and therefore the costs shown are based on the actual bid price. Phase II is currently under design and the costs shown are based on the engineer's opinion of probable construction costs prepared for the 80% design. All other costs are planning level costs based on values presented in the CPE and adjusted to an ENR value of 6735.

Maintenance costs over the life of the new equipment are expected to be similar to that of the existing equipment. Operational costs for the new second stage aerators are expected to decrease due to installation of variable frequency drives with dissolved oxygen level based control and more efficient oxygen transfer. With implementation of biological phosphorous removal there should be cost savings due to less alum usage and less sludge disposal of approximately $24,000 per year and costs savings due to reduced electrical usage of approximately $10,500 per year.

Table 8.2 - Phase I Upgrade Capital Costs

Bid price	$1,094,000
Post bid contingency – 5%	$54,700
Engineering services during construction	$141,000
Total	**$1,289,700**

Table 8.3 – Phase II Upgrade Capital Costs

Design	$104,500
Grit equipment	$246,000
Septage pumps	$54,000
Modifications to sludge holding tanks	$70,000
Aeration upgrade/biological phosphorous removal	$847,600*
Electrical	$121,000
Mobilization/Bonds/Insurance	$53,000
Contingency – 10%	$139,100
Engineering services during construction	$185,800
Other - planning	$57,000
Total	**$1,878,000**

* includes $160,000 for replacement of ten sluice gates to be bid as alternate 1

Table 8.4 – Phase III Upgrade Capital Costs

Design	$164,200
Sludge holding tank mixers	$168,100
Sand filter upgrades	$428,000
Primary clarifier upgrades	$465,300
SCADA system infrastructure	$93,000
Fire alarm and security system	$47,000
Industrial Park Pump Station upgrades	$22,800
Structural repairs	$35,000
Contingency – 10%	$122,400
Engineering services during construction including SCADA implementation	$305,400
Total	**$1,851,200**

Table 8.5 – Phase IV Upgrade Capital Costs

Design	$146,700
Return sludge pumps	$235,300
Sludge wasting/dewatering feed pumps	$253,200
Polymer feed upgrade	$253,200
Alum system upgrade	$64,600
Headworks odor control	$64,600
Recoat clarifiers	$107,000
Contingency – Planning Level 25%	$244,500
Engineering services during construction	$97,800
Total	**$1,467,000**

Table 8.6 – Phase V Upgrade Capital Costs

Design	$191,600
Stand by generator	$386,200
Recoat chlorine contact tanks	$38,600
First stage aerators	$207,600
Post aerator	$51,900
Grimaldi Pump Station	$593,200
Contingency – Planning Level 25%	$319,400
Engineering services during construction	$127,700
Total	**$1,916,000**

Table 8.7 – Phase VI Upgrade Capital Costs

Design	$198,500
Replace DAF with RDT	$556,500
First stage clarifiers	$766,900
Contingency – Planning Level 25%	$330,800
Engineering services during construction	$132,300
Total	**$1,985,000**

8.7 COST IMPACTS

The Town has carefully planned for the needed improvements at the WWTF. Rather than performing all of the recommended work in one large upgrade project the Town has elected to perform the work in a phased approach. The phased approach is preferable to the Town because it will allow them to perform the work without imposing a large rate increase on their users. Instead Town will increase sewer rates as needed to generate the revenue needed to repay the loans required to perform approximately $1,500,000 of capital improvements, including engineering fees, each year at the WWTF. Projects with be financed either by bonds or by CWSRF funding where available.

Phase I (currently under construction) and Phase II (currently under design) of the recommended plan have been funded through increases in the sewer rates in FY 2003 and FY 2004 of 10 percent and 18 percent, respectively. Phase I has been financed under the CWSRF program and an application for CWSRF funding for Phase II will be submitted.

8.8 BASIC DESIGN DATA

Listed below is a summary of the basic design data for the original WWTF design and the planned upgrades. A site plan of the WWTF is contained in Appendix A.

Headworks

- Grit collection equipment - grit screws, bucket conveyors, grit dewatering screw sized to match existing equipment
- Septage pumps – 3HP, 50 gpm plunger pumps

Primary Clarifiers

- Replacement equipment for two existing 80 ft diameter, 12 foot deep primary clarifiers
- Original design average surface overflow rate = 525 gallons per day per square foot
- Peripheral baffles and 12 ft diameter, 4 to 5 ft deep inlet well

First Stage Aerators

- Four 20 HP constant speed mechanical surface aerators
- Oxygen transfer of new aerators – approximately 2.6 pound of oxygen per HP per hour

First Stage Secondary Clarifiers

- Replacement equipment for existing two 80 ft diameter, 12 foot deep secondary clarifiers.
- Original design average surface overflow rate = 525 gallons per day per square foot
- Density current baffles and "Los Angeles type" energy dissipating inlets

Second Stage Aerators

- Six 25 HP VFD equipped mechanical surface aerators
- Oxygen transfer of new aerators – approximately 2.6 pound of oxygen per HP per hour
- Two existing 2-speed (18.75/25 HP) mechanical surface aerators to remain
- Four 2.5 HP submersible mixers
- Flash mixer (1.5 HP) at secondary clarifier splitter box

Second Stage Secondary Clarifiers

- Replacement equipment for three existing 80 ft diameter, 12 foot deep secondary clarifiers
- Original design average surface overflow rate = 350 gallons per day per square foot
- Density current baffles and "Los Angeles type" energy dissipating inlets

Second Stage Return Sludge Pumps

- Four 20 HP, 1200 gpm centrifugal pumps

Rapid Sand Filters

- Usable filter area 16 ft x 59.83 ft, two filters
- Average loading rate 2.0 gallons per minute per square foot
- Peak loading rate 5.0 gallons per minute per square foot

APPENDIX A: EXISTING SITE PLAN

APPENDIX B: LIST OF ACRONYMS

BOD	biochemical oxygen demand
BPW	Board of Public Works
CDM	Camp Dresser & McKee
CPE	Comprehensive Project Evaluation
CWSRF	Clean Water State Revolving Fund
DAF	dissolved air flotation unit
ENR	Engineering News Record
gpd	gallons per day
gpm	gallons per minute
I/I	Inflow Infiltration
MADEP	Massachusetts Department of Environmental Protection
MGD	million gallons per day
mg/L	milligrams per liter
PEF	Project Evaluation Form
PER	Project Engineering Report
PLC	programmable logic controller
RAS	return activated sludge
RDT	rotary drum thickener
SCADA	Supervisory Control and Data Acquisition
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
VFA	volatile fatty acids
WAS	waste activated sludge
WWTF	Waste Water Treatment Facility