Executive Summary

Introduction

The Town of Lincoln, Massachusetts contracted with CDM to assess the current condition, existing and future usage and transfer of ownership of the Lincoln Woods Wastewater Treatment Plant (WWTP) to the town. The plant is privately owned by Lincoln Woods Cooperative and has been in operation since 1976. The WWTP, currently permitted to discharge 26,000gpd, provides service to the Lincoln Woods Condominiums and the Mall at Lincoln Center.

The goals and objectives of this study are to present an engineer's opinion of the present and future viability of the plant from a technical and economical standpoint. More specifically:

- To assess the condition of existing equipment at the WWTP and make recommendations for equipment repair or replacement, if necessary,
- To estimate current and future flows and loads to the WWTP in order to assess the plant's performance and make recommendations for treating future flows and loads,
- To provide financial estimates for annual operation and maintenance (O&M), and capital expenses at the WWTP,
- To define the obstacles in optimizing the remaining useful life of the WWTP and outline the risks in owning and operating such a facility, and
- To present a plan for future use of the plant and expansion of the collection system.

General Assessment of Existing Plant

The original WWTP was built in the mid 1970's with a contact stabilization type process. While some of the original equipment was replaced in recent years, much of the original equipment is still in operation. There have also been recent process additions that are reliable and are in good condition. The installations of these processes were necessary for the WWTP to comply with its existing discharge permit.

In general, the plant has been operating reliably and meets the current groundwater discharge permit. However, the process arrangement is not ideal and is complicated for a small WWTP. This is due mainly to the recent installation of process equipment, including a denitrification filter and a UV disinfection system.

Of greatest concern is the integrity of the existing steel biological treatment tank, which is original to the plant. The condition of the subsurface steel is unknown and the lack of redundancy increases the complications presented in the event of a tank failure. Based on the industry standard of process equipment having a life expectancy of approximately 20 years, the tank has exceeded its useful life. To assess the condition of the tank, it is recommended that the tank be dewatered and inspected to define the potential for future service.

The plant, originally designed to receive an average day flow of 30,000gpd, is permitted for 26,000gpd, and receives 12,900gpd. Therefore, the plant is operating at approximately 50 percent of its design and permitted capacity.

Feasibility for Expansion

The WWTP has the ability to receive additional flow without major capital investments, but would require collection system expansion to convey this flow. A sizable capacity increase to the WWTP would require the replacement of the existing biological (steel tanks) treatment system and installation of a modern system. The capacity increase would also require an expansion of the existing leaching beds. It is unlikely that both treatment system replacement and leaching bed expansion could occur within the current property limits. It is recommended that the property limits be expanded to accommodate the capacity expansion from 26,000gpd to the required 45,000gpd, which is the future build-out capacity within the South Lincoln Sewer District.

Recommended Plan, Capital and O&M Costs

CDM recommends three options for providing wastewater service to the South Lincoln Sewer District. The plans and capital cost for each are provided below.

Option I is a no action alternative that would result in the Town not purchasing the Lincoln Woods WWTP. There are no associated costs with this option and as a result, there will be limited ability to increase growth in the South Lincoln area. The existing influent flow would likely remain constant since no additional users are being considered.

Option II would increase influent flows with minor plant modifications, while maintaining permit compliance. The average day flow would increase from 12,900gpd to 17,300gpd and there would be minimal collection system additions. The anticipated capital cost for Option II is $2,032,000. This includes the estimated purchase fee for the treatment plant and land, a new pump station located on town property, a force main from the new pump station to the WWTP and installation of sewer pipe in Lincoln Road.

Option III is to perform a process upgrade to increase the average day flow from 17,300gpd to the permitted limit of 26,000gpd, while maintaining permit compliance. There would be more significant collection system improvements. The anticipated capital cost for Option III is $2,491,000.

Option IV is full replacement of the existing facility with a plant capacity to treat future build-out flow from the South Lincoln District, taking into account probable future discharge permit limits. The WWTP's average day flow capacity would increase from 26,000gpd to 45,000gpd. Collection system expansion would serve the entire South Lincoln Sewer District, including Lincoln School. The anticipated cost for Option IV is $5,799,000.

Operation and Maintenance

Annual O&M costs are anticipated to be $154,000 in the first year, which includes the initial fee to establish the DEP required reserve account. The second year O&M is estimated to be $118,000 and a planned increase of 6 percent for each year thereafter.

The above phasing and costs are preliminary and may be revised based on the Town's interests. For example, Phase I and Phase II may be combined into one phase. In addition, the recommendations are conservative and present the higher cost alternatives, which might not be desired by the Town.

Summary

CDM assessed the condition of the existing plant and explored the potential for expansion to serve portions of South Lincoln. As part of the assessment, CDM identified the risks and rewards that may occur should the Town of Lincoln take ownership of the existing plant.

Of most concern are the age, vulnerability, and lack of redundancy of the existing plant. A breach or failure of the steel aeration tank would render the plant inoperable and require that all influent wastewater be truck off site for disposal at another treatment facility. CDM has estimated that an alternative disposal would cost approximately $14,000 per week and may be required for several weeks before repairs are completed. If purchased, the Town would relieve Lincoln Woods Cooperative of a significant liability. However, there remain many advantages to the Town pursuing ownership of the plant

Section 1
Project Background

1.1 General

The Town of Lincoln, Massachusetts contracted with CDM to assess the existing condition, current and future use and ownership of the Lincoln Woods Wastewater Treatment Plant (WWTP). The plant is privately owned by Lincoln Woods Cooperative and has been in operation since 1976. The WWTP, permitted to discharge 26,000 gallons per day (gpd) provides service to the Lincoln Woods Condominiums and the Mall at Lincoln Center.

The Town of Lincoln has a public water supply system but no wastewater disposal system. The majority of wastewater is disposed of by private septic systems. Not having a public wastewater disposal system restricts development and provides no relief to existing properties with failing on-site systems. The Lincoln Woods WWTP has potential for future expansion to meet the needs of some residents in Lincoln. The Town intends to assess the feasibility of owning and operating (or contract operations) the facility for the benefit of these residents.

1.2 Scope of Work

The Town of Lincoln contracted with CDM to perform this feasibility analysis. The specific scope of work includes the following task items.

Review Existing Documents

The Town is in possession of documents related to the Lincoln Woods Wastewater Treatment Plant, namely the discharge permit, non-compliance letters, upgrade documents, and an engineering assessment performed by another consultant. CDM reviewed these documents and identified areas of concern.

Facility Assessment

CDM conducted an independent assessment of the Lincoln Woods Wastewater Treatment Plant, including a site visit by a CDM process engineer and operations specialist. The visit focused on the condition of existing structures, utilities, and equipment.

Assessment of Capacity and Performance for Current and Future Conditions

CDM assessed the WWTP to estimate of the current and long-term reliability of the plant. The assessment of long-term reliability focused on the ongoing needs of the current users (i.e., Lincoln Woods and the Mall) and the potential demand associated with various South Lincoln growth scenarios. The planning scenarios were developed by the Town with technical guidance from the CDM.

CDM first assessed the capacity, or flow, that can be treated by the existing plant. The design flow and current flow were then compared to determine what capacity might be available without pursuing an upgrade. To allow for a capacity increase in the future, a summary of required upgrades needed to expand plant capacity were identified. A projected increase in flow was estimated based on the Town's plans for future developments such as those proposed in Southern Lincoln.

Performance data from the existing plant was reviewed and compared to the discharge requirements of the groundwater discharge permit. Regulatory compliance and future restrictions were researched and summarized.

Capital and Annual Improvements and Cost Summary

In this study, he Town is presented with planning level costs for the following:

- Capital cost required for modifications of the plant
- Capital cost required for the upgrade of the plant to increase capacity
- Annual operation and maintenance costs

CDM provides planning level estimates for any improvements required to modify and upgrade the plant. The short term capital plan focuses on improvements required to maintain reliable operation of the existing plant. The long term capital improvements plan includes the cost required to operate the WWTP throughout the typical planning period of 20 years, with consideration for a capacity upgrade as more homes and businesses in Lincoln connect to the sewer system.

Estimates for annual operation and maintenance costs are based on other facilities of similar size and treatment technology.

1.3 Goals and Objectives

The goals and objectives of this study are to present an engineer's opinion of the present and future viability of the plant from technical and economic standpoints. More specifically:

- To assess the condition of existing equipment at the WWTP and make recommendations for equipment repair or replacement, if necessary,
- To estimate current and future flows and loads to the WWTP in order to assess the plant's performance and make recommendations for treating future flows and loads,
- To provide financial estimates for annual operation and maintenance (O&M)and capital expenses at the WWTP,
- To define the obstacles in optimizing the remaining useful life of the WWTP and outline the risks in owning and operating such a facility, and
- To present a plan for future use of the plant and expansion of the collection system.

1.4 Review of Existing Documents

The Town was provided with many documents related to the existing Lincoln Woods Wastewater Treatment Plant. These contain information related to recent operation, maintenance, upgrade, compliance, and service by the existing plant. These documents were reviewed and the following presents a summary of relevant information from each.

The **Groundwater Discharge Permit** was provided for the current discharge of treated wastewater to the filtration beds. The permit was issued on August 14, 2008 and is effective through August 14, 2013. The discharge criteria are typical for a groundwater discharge and as defined in Massachusetts General Laws, 314 CMR 5.0 – Groundwater Discharge Permit Program. Past permits and renewal applications were also provided. Section 4 of this report provides an assessment of permit compliance.

An **Engineer's Assessment** of the existing facility was provided. The assessment was conducted by Martinage Engineering Associate, dated December 10, 2008 and completed for the Lincoln Woods Cooperative Housing Corporation. The report provides a 5 year capital improvements plan with specific work to be performed. The extended plan (5-20 years) suggests that the existing steel biological process tank be dewatered and inspected for corrosion, which allows for a better estimate for the remaining useful life. The alternative extended plan presented in the report is for the entire plant to be completely replaced for an approximate cost of $1,400,000.

Utility Invoices were provided to quantify the annual operation and maintenance costs. Recent invoices were for methanol and electrical use but excluded other costs, which were provided at a later date. A summary of anticipated annual O&M cost are presented in Section 6 of this report.

A Detailed Process Description was provided by Martinage Engineering Associate and contains many of the parameters needed to assess a facility capacity increase.

Discharge Monitoring Reports (DMRs) are forms required by the Massachusetts Department of Environmental Protection for reporting compliance with the discharge permit, for every month of operation. DMRs were provided for twelve months, September 2008 to September 2009. Two DMRs reported a minor permit violation of the discharge limitations. A summary of the data provided in these reports is included in Section 4.

Legal Documents were included for wastewater disposal services for Rural Land Foundation and the Mall at Lincoln Center. The documents define service limitations, fees, permitting, and easement documents. There was also a memorandum of understanding, which defines specific agreements between Rural Land Foundation and Lincoln Homes Corporation. These documents clearly explain and record the agreement between both parties.

A **Draft Administrative Consent Order** was issued by the Commonwealth of Massachusetts in 1997 but there's no indication that the Order was filed. It states that "Based on its interpretation of applicable regulations, and its review of monitoring data, the Department has determined the wastewater treatment facility at Lincoln Woods, 50 Wells Road, Lincoln does not treat the discharges from the facility to comply with the maximum effluent limitation of 10 mg/l for both nitrate-nitrogen as N, and total nitrogen as N." The Town should confirm if this Order was executed and if full compliance has been met. The treatment plant has since been upgraded to improve the removal of nitrogen and recent performance indicates full compliance with the nitrogen discharge limit.

A **Notice of Noncompliance** was issued by the Commonwealth of Massachusetts on May 14, 2009 for failing to meet permit requirements. Before August 1, 2009, Lincoln Home Corporation was required to submit an Engineering Report, detailing future compliance requirements and a capital plan for future operations. The report was submitted but the Town should confirm that the requirements of the Notice have been fully met.

Recent **Capital Improvement** documentation is provided, which details upgrades performed in 2008 and 2009. The scope of work and fee for the work was provided.

Section 2
Wastewater Flows and Organic Loadings

2.1 Existing Flow and Loads

Based on the original construction drawings, dated March 1976, the Lincoln WWTP was designed to treat 30,000 gallons per day (gpd) of residential wastewater. To evaluate current flows and loadings to the WWTP, information from the discharge monitoring reports (DMRs) from September 2008 to September 2009 was reviewed and summarized. See Appendix B for a summary of DMR data. To estimate historical influent and effluent flows and loads, “outliers” were removed from the data set. It is CDM’s design practice to remove data points from the data set that are above the 95th percentile and below the 5th percentile.

Table 2.1 summarizes the historical influent loads but not influent flow because it’s not recorded at the WWTP. It is assumed that influent flows are equal to effluent flow measurements, excluding any recycle. Table 2.2 summarizes the historical effluent flows and loads from the WWTF. The acronyms within these tables are as follows: biochemical oxygen demand (BOD), total suspended solids (TSS), total solids (TS), ammonia-nitrogen (NH_3 as N), total nitrogen (TN) and nitrate (NO_3-N).

Table 2.1, Historic Influent Loads Summary

	BOD mg/l (lbs/day)	TSS mg/l (lbs/day)	TS mg/l (lbs/day)	NH_3 as N mg/l (lbs/day)
Average	189 (20)	229 (25)	504 (55)	30 (3)
Maximum Day	320 (45)	480 (68)	724 (102)	39 (5)
Peak Factor by Loading	2.3	2.7	1.9	1.7

Table 2.2, Historic Effluent Discharge Flow and Loads Summary

	Flow gpd	BOD mg/l (lbs/day)	TSS mg/l (lbs/day)	TN mg/l (lbs/day)	NO_3-N mg/l (lbs/day)
Average	12,900	9 (0.97)	3 (0.32)	6 (0.64)	5 (0.53)
Maximum Day	19,600	19 (3.1)	7 (1.14)	13 (2.1)	12 (2.0)

Based on data from the DMRs, the WWTP received 50 percent (12,900gpd/26,000gpd) of the permitted flow rate of 26,000gpd on average while maximum day flows reached 75 percent (19,600gpd/26,000gpd) of the permitted flow rate. From this data, a historical maximum day to average peaking factor of 1.5 is calculated (19,600gpd/12,900gpd).

2.2 Influent Flow and Loads at Permit Limits

The existing NPDES groundwater discharge permit has an effluent limit of 26,000gpd for average annual flow, even though the original design capacity of the facility is 30,000gpd. Based on the existing NPDES permit limit and recent average daily flow, the WWTP could accept an additional 13,100gpd (26,000gpd - 12,900gpd) of flow but must also provide the treatment to meet the discharge limitations. To evaluate the plant's performance at this upper limit of 26,000gpd (average daily flow), the influent has been characterized.

Table 2.3 presents the flow and load estimates at the NPDES average flow limit of 26,000gpd. From the DMRs, the peaking factor for the historical average to maximum day flow is 1.5. Design guidelines recommended a more conservative peaking factor of 2 be used to estimate maximum day flow. Maximum day loading estimates are based on peaking factors calculated from historical influent characteristics, as given in Table 2.1

Table 2.3, Influent Flows and Loads at Permit Limits

Flow Component	Flow gpd	BOD mg/l (lbs/day)	TSS mg/l (lbs/day)	NH3 as N mg/l (lbs/day)
Average	26,000	189 (41)	229 (50)	30 (6.5)
Peak Factor by Loading	2	2.3	2.7	1.7
Maximum Day	52,000	(94)	(135)	(11)

2.3 Expanded Service Area (Future) Flow and Loads

The expanded service area has been defined as the South Lincoln Sewer District and the limit of this area shown on Figure 2.1. This area straddles a set of tracks owned by Massachusetts Bay Transit Authority and adjacent to the intersection Lincoln Road. There is mixed property use including residential, commercial, municipal and institutional.

The existing WWTP receives flow from the Lincoln Woods Condominiums and the Mall at Lincoln Center. The service area will be expanded to include a build-out of area shown on Figure 2.1. This build-out analysis was performed to predict the maximum wastewater flow that could be generated from within this area. In summary, the build-out of the future service was estimate to contain:

- Twenty, 1 to 3 family homes,
- Four hundred and sixty-five, apartment and condominium units,
- One church,
- One mall, and
- One school.

Based on the predicted property use, an estimate was made for the maximum number of people within the service area, which was multiplied by an average wastewater generation rate of 40 or 55 gallons per day per person (Metcalf &Eddy, page 1019), depending on the property use. Wastewater estimates for future commercial buildings were based on Massachusetts Department of Environmental Protection Guideline (Title 5). The sum of the estimated average flows was multiplied by a factor of 2 to estimate the maximum daily flow rate, which serves as the basis of design for any capacity increase.

The historical average to maximum day peaking factor for flow is 1.5. Based on design guidelines, (Metcalf & Eddy, page 1020) a more conservative peaking factor of 2 was used to predict maximum daily flows in the South Lincoln Sewer District. Future loads were based on the estimated future flow, historical pollutant peaking factors and current concentrations.

Table 2.4 presents the future flow and load estimates predicted for the South Lincoln Sewer District. Maximum day load estimates are all based on peaking factors calculated from historical influent characteristics, as given in Table 2.1. The information contain in this table will be used size and select the appropriate treatment system to replace the existing.

Table 2.4, Estimated Future Influent Flows and Loads

Flow Component	Flow gpd	BOD mg/l (lbs/day)	TSS mg/l (lbs/day)	NH3 as N mg/l (lbs/day)
Average	45,000	189 (71)	229 (86)	30 (11)
Peak Factor by Loading	2	2.3	2.7	1.7
Maximum Day	90,000	(163)	(232)	(19)

Section 3
Description of Existing Wastewater Collection and Treatment Facilities

3.1 Background

The Wastewater Treatment Plant (WWTP), owned by the Lincoln Woods Cooperative was designed in the mid-1970s to treat an average of 30,000 gallons per day (gpd). The WWTP was originally built to serve homes in the Lincoln Woods housing complex. In the 1990s, the Mall at Lincoln Center, adjacent to the housing complex, was tied into the WWTP.

The WWTP is an activated sludge facility, operating in extended aeration mode. The existing facility was originally designed to remove primarily BOD and suspended solids in the wastewater. In 2003-2004, significant modifications and upgrades were made to the WWTP in order to meet groundwater discharge quality standards and a UV unit was installed in 2009 to replace the chlorine disinfection system.

The original treatment system included the following components:

- Main pump station at housing complex (duplex ejector pumps)
- Comminuter and bypass rack
- Aeration Tank,
- Clarifier
- Aerobic sludge digester
- Chlorine contact chamber
- Polishing filters
- Dosing siphon
- Final sand filters (leaching beds)
- Effluent storage tank for overflow

In 2001, the Massachusetts Department of Environmental Protection required Lincoln Woods to upgrade their facility to meet current environmental regulatory standards. With the upgrades completed, the existing WWTF includes the following major components:

- Main pump station at housing complex (original duplex ejector pumps replaced with pneumatic pumps)
- Flow equalization tank (recent)
- Flow control box with bar rack (recent)
- Comminuter (original replaced)
- Aeration tank (original)
- Clarifier (original)
- Aerobic sludge digester (original)
- Denitrification filters with methanol and alkalinity chemical systems (recent)
- Clear well and dosing pumps (recent)

- UV system (recent)
- Leaching beds (original)

3.2 Collection System

Wastewater from the Lincoln Woods Condominiums and the adjacent Mall at Lincoln Center, flows by gravity to the main pumping station and is pumped to the flow equalization chamber at the WWTP. The pumping station contains two pneumatic ejector pumps, each with a rated capacity of 75 gallons per minute (gpm). In 2001, an alarm system was installed to alert Lincoln Woods maintenance staff of any problems at the station.

3.3 Wastewater Treatment Major Unit Processes

The major process units at the WWTP consists of a flow equalization chamber, an aeration tank, a clarifier, denitrification filters, UV system for disinfection and leaching beds.

Flow Equalization Tank

The aerated flow equalization tank (FET) is designed to equalize the incoming wastewater flow to provide a constant flow through the remainder of the treatment system. The FET has a working volume of approximately 10,000gpd and a maximum volume of approximately 16,400gpd. A blower is located nearby for continuous aeration of the FET. Flow from the FET is lifted to the treatment system by dual alternating grinder submersible pumps. The comminuter was recently taken out of service and replaced.

Flow Control Box and Bar Rack

A flow control box with bar rack was installed to distribute the flow to the remainder of the treatment system over 24 hours. Flow equalization to accommodate peak flows is accomplished by the weir setting on the flow control box at the head of the aeration tank. The flow control box has a return line to the FET so the flow entering the aeration tank is stabilized.

Aeration Tank

The aeration basin provides biological treatment to break down the organics in the wastewater and convert ammonia and organic forms of nitrogen into nitrite and nitrate (nitrification). The aeration basis has an approximate volume of 7,174 cubic feet (ft^3), with a diameter of 37 feet. In 2009, the existing blowers were replaced with two, higher efficiency blowers.

Clarifier

The existing clarifier, located in the center of the aeration tank, is 15 feet in diameter. In the clarifier, sludge settles to the bottom and is pumped back to the aeration basin. Periodically excess sludge is pumped to the aerobic digester/sludge holding tank and is removed by a septage hauler. Supernatant from the clarifier passes over a weir and flows by gravity to the deep bed denitrification filters. Scum floating on the top of the clarifier is removed from the surface and returned to the aeration tank to be broken down.

Nitrification Filters

A denitrification filter was installed below grade and includes a media bed, media support gravel, backwash pumps, an under drain and a control system. Clarifier effluent is conveyed by closed pipe from the clarifier to the deep bed filter. To convert nitrate to nitrogen gas

(denitrification), anaerobic digestion occurs within the deep filter bed. Methanol is used as a carbon source for this process. Additionally, the filter media is used to remove suspended solids from the clarifier effluent.
The operations of the filter and backwash cycles are automatic. Trapped solids removed from the filter media are discharged back to the FET during the backwash process.

Clear Well and Dosing Tank
A combined clear well and final dosing tank system is designed to store backwash water for the denitrification filter. The tank is designed to store two backwash cycle volumes or approximately 3,400 gallons. The dosing volume is approximately another 3,400 gallons.

UV System
The UV system, installed in 2009 to replace the chlorine disinfection system, is located in the Control Building and is designed to disinfect approximately 40,000gpd.

Leaching Beds
The existing leaching system consists of four beds, each approximately 52.5 feet by 50 feet, for a total surface area of 10,500 square feet.

3.4 Groundwater Discharge Permit

The WWTP currently has a groundwater discharge permit (Number W159768/3-3), issued by the Massachusetts Department of Environmental protection in August 2008. The permit expires in August 2013 and its requires that monthly influent sampling and reporting for Biological Oxygen Demand (BOD), Total Suspended Solids, Total Solids (TS) and Ammonia Nitrogen (NH_3) be reported. It should be noted that, based on the original construction drawings, the WWTP was designed to treat 30,000 gallons per day (gpd) of residential wastewater. However, the existing permit has a discharge limit of 26,000gpd (annual average).

The effluent parameters required to be reported, the discharge limits, and the minimum frequency of analysis are summarized in Table 3.1. The permit requires that flow, BOD, TSS, TS, Nitrate Nitrogen (NO_3-N), Total Nitrogen (TN), oil and grease, surfactants, fecal coliform, total phosphorus (TP), orthophosphate and volatile organic compounds (VOCs) be reported.

Each month, the influent and effluent sampling results are summarized and submitted to the Massachusetts Department of Environmental Protection in discharge monitoring reports (DMRs).

Table 3.1, Discharge Permit, WWTF Effluent Characteristics Summary

Parameter	Discharge Limits	Minimum Frequency of Analysis
Flow	26,000	Daily
BOD	30 mg/l	Monthly

TSS	30 mg/l	Monthly
TS	Report	Monthly
Nitrate Nitrogen	10 mg/l	Monthly
Total Nitrogen	10 mg/l	Monthly
Oil and Grease	15 mg/l	Monthly
Surfactants	1.0 mg/l	Monthly
Fecal Coliform	200/100 ml	Monthly
Total Phosphorus	Report	Quarterly
Orthophosphate	Report	Quarterly
Volatile Organic Compounds	Report	Annually

Section 4
Assessment of Existing Wastewater Treatment Plant

4.1 General

A site visit was made on November 16, 2009 to assess the condition of the existing WWTP. The focus was to gather information on existing equipment and non process features, and to make observations of the condition. The following assessment is based on findings of this site visit and includes a paper interpretation of performance.

4.2 Assessment of Existing Treatment Processes

The main components of the WWTP include influent pumps, flow equalization, an aeration basin with coarse bubble diffusers, a secondary clarifier, a denitrification filter, a UV system for disinfection and leaching beds. To assess the existing treatment plant, each component was evaluated based on capacity, condition and redundancy.

Influent Pump Station

Wastewater from the Lincoln Woods Condominiums and the adjacent Mall at Lincoln Center flows by gravity to the main pumping station and is pumped to the flow equalization chamber at the WWTP. The existing pumping station contains two pneumatic ejector pumps (one operational, one standby for redundancy), each with a rated capacity of 75gpm. This station was recently upgraded per recommendations of the Engineers Assessment, Existing Wastewater Treatment Plant, Martinage Engineering Associates, December 2008.

Flow Equalization Tank

The FET has a working volume of approximately 10,000gpd and a maximum volume of approximately 16,400gpd. A blower is located nearby for continuous aeration of the FET. Flow from the FET is lifted to the treatment system by dual alternating grinder submersible pumps (installed in 2003) with controls rated at 75gpm. The comminuter was recently taken out of service and replaced.

Aeration Basin

The existing aeration tank at the Lincoln Woods WWTP has approximately 7,174 cubic feet of volume (53,700 gallons). From the Mass DEP's Guideline for the Design, Construction, Operation and Maintenance of Small Wastewater Treatment Facilities with Land Disposal, for extended aeration systems, the average organic loading to the aeration tank is 12.5 to 17 pounds of BOD5/1,000 cubic feet/day. Thus, the allowable organic loading to the existing aeration system is approximately 122 pounds of BOD/day. From the DMRs summarized in Section 2, the average BOD loading to the aeration tank is 20 pounds/day and the maximum BOD loading is 45 lbs/day.

In terms of hydraulic capacity, most extended air systems are designed to have a detention time of 24 hours. With the aeration basin having a volume of 53,700 gallons, the tank has the hydraulic capacity for existing maximum day historical flow (19,600 gpd) and maximum day flow at permit limits (52,000 gpd).

The steel aeration/clarifier tank appeared to be in good condition. However, there is a concern that subsurface corrosion of the outer wall could exist and unexpectedly result in a tank failure. If sacrificial anodes were maintained, then the condition of the wall is anticipated to be acceptable. The only method for assessing the steel integrity of the tank, however, is either to dewater the tank or excavate test pits along the outer wall. Because there is only one aeration/clarifier tank, if the tank must be taken out of service for repair or replacement, no redundancy exists.

Blowers
In 2009, the blowers were replaced with new, higher efficiency rotary lobe blowers. One blower is duty, the other standby, providing redundancy. The blowers, Kaesar model BB68C, are each 10 hP, 204 SCFM and 6 psig. From the Mass DEP guidelines, 20-30 standard cubic feet per minute (SCFM) of air is required per 1,000 cubic feet of volume for mixing the aeration tank. The oxygen supply required is 0.85 to 1.2 pounds of oxygen per pound of BOD removed and 4.2 pounds of oxygen per pound of ammonia nitrogen oxidized.

Based on preliminary calculations, using an intermediate design value of 25 SCFM of air for mixing, approximately 180 SCFM is required for mixing and approximately 40 SCFM is required for BOD removal and ammonia oxidation at average day flows and loadings. At peak conditions, approximately 70 SCFM is required for BOD removal and ammonia oxidation. In this case, the air required for mixing governs and it is estimated that 180 SCFM of air is required for the aeration system.

Diffusers
The aeration tank is equipped with coarse bubble diffusers to deliver air from the blowers to the aeration basin. The diffusers are located approximately 8 inches off the bottom of the aeration basin. Per Mass DEP guidelines, the aeration equipment should maintain a minimum dissolved oxygen level of 2 mg/l in the aeration tank. From the DMRs, DO levels of the mixed liquor in the aeration tank have ranged from 1.3 mg/l to 3.25 mg/l. The low levels of D.O. in the aeration tank may be due to broken or missing diffusers, or just the low efficiency of coarse bubble diffusion as compared to more modern, fine bubble diffuser systems.

Secondary Clarifier
The existing clarifier is 15 feet in diameter with an adjustable v-notch weir. The surface area of the clarifier is 147 feet and a side water depth of 7 feet. From the Mass DEP guidelines, the permissible surface overflow rate (SOR) for extended air systems is 300 gallons/day/square foot at average design flow (<700 gallons/day/square foot at peak conditions). These values from Mass DEP guidelines are based on a side water depth of at least 10 feet. As the side water depth of the existing clarifier is only 7 feet, it is likely that the permissible SOR is much less than the design values stated in the DEP guidelines.

Based on existing average and peak flows, the SORs are approximately 85 and 135 gallons/day/square foot, respectively. The calculated SORs for the clarifier are much less than the design values given in the guidelines. However, because the design guidelines are for clarifiers with a side water depth of at least 10 feet, it is difficult to estimate the remaining hydraulic capacity of the clarifier.

The permissible range for solids loading rate (SLR) is 0.2 to 1.0 pounds/hour/square foot at average day flow (<1.4 pounds/hour/square foot at peak conditions). The historical SLRs are approximately 0.10 and 0.20 pounds/hour/square foot, respectively. Because return activated sludge (RAS) rates and MLSS data is not available, it is assumed that the RAS flow is approximately 50% of incoming flow and the MLSS is 2,500 mg/l.

Denitrification Filters

In 2003, a denitrification filter with a hydraulic capacity (average and maximum) of 26,000gpd was installed to remove excess nitrogen from the wastewater treated in the biological treatment system. The denitrification filter, manufactured by Severn Trent Tetra, was installed below grade and includes a media bed, media support gravel, backwash pumps, and under drain and an alkalinity control system. A methanol storage cabinet, located near the Equipment Building, is sized to store three, 55 gallon drums.

UV System

In 2009, a UV system was installed to replace chlorine as a disinfectant. The UV system, manufactured by Siemens, includes a 4" diameter, 2 lamp unit, with a hydraulic capacity of approximately 40,000gpd.

Leaching Beds

The existing leaching system consists of four beds, each approximately 52.5 feet by 50 feet, for a total surface area of 10,500 square feet. At the current design flow rate of 26,000gpd, based on the WWTP's existing NPDES permit, this results in a loading rate of 2.5gpd per square foot. From the Mass DEP guidelines, a design loading rate of 2gpd per square foot recommended for open sand leaching beds. The current leaching system exceeds DEP guidelines the design flow rates. An increase in plant capacity will require an expansion of the existing leaching beds.

See Table 4.1 for an assessment summary of the existing facility.

Table 4.1, Summary of Existing WWTP Unit Processes

Unit Process	Number of Operating Units	Number of Redundant Units	Rated Capacity	Existing Maximum Flow or Loading Condition	Percent Capacity	Condition/Notes
Influent Pumps	1	1	75 gpm each (108,000 gpd each)	19,600 gpd	18%	Original pumps replaced in 2009
Flow Equalization Tank	1	0	10,000 gpd working volume; 16,400 gpd maximum volume			Installed 2003
Aeration Tank	1	0				Original to WWTF
Organic Capacity			122 lbs BOD/day	45 lbs BOD/day	37%	
Hydraulic Capacity			53,700 gpd	19,600 gpd	36%	
Aeration Tank Blowers	1	1				Installed in 2009
For BOD removal and nitrification			204 SCFM	70 SCFM	34%	
For aeration tank mixing			204 SCFM	180 SCFM	88%	Using design value of 25 SCFM per 1,000 ft3 of aeration volume
Secondary Clarifier	1	0				Original to WWTF
Surface Overflow Rate			700 gpd/ft2 at peak conditions	135 gpd/ft2	20%	Rated capacity of clarifier may be less than design guidelines, side wall depth is 7-ft (10-ft min. is standard)
Solids Loading Rate			<1.40 lbs/hour/ft2 at peak conditions	0.20 lbs/hour/ft2	14%	
Denitrification Filters	1	0	26,000 gpd	19,600 gpd	75%	Installed 2003
UV Unit	1	0	40,000 gpd	19,600 gpd	50%	Installed in 2009
Leaching Beds	4 Beds		21,000 gpd	19,600 gpd	93%	Using DEP design guide loading rate of 2 gpd/ft2

4.3 Assessment of Site Facilities

Site facilities include all non-process equipment and features required for the facility to operate in compliance with the discharge permit and current codes. The following comments are based on observations made during the site visit and a review of existing documentation.

1. The existing access road is in poor condition and should be regarded and resurfaced with a layer of crushed stone. Asphalt paving is not necessary.

2. The site is not located within the 100 year flood plain and is outside of water supply protection areas. It is not within a Zone II drinking water protection zone.

3. The building structure contains the laboratory, toilet, dry chemical storage, blowers, disinfection equipment, and miscellaneous items. The panel structure is built on a slab foundation with concrete retaining walls. There were no observed defects or issues (water leaks) with the existing structure. However, it is not constructed of materials typical for industrial purposes. This will limit the useful life and requires greater annual maintenance.

4. A circuit breaker type electrical panel exists in the blower room and appears to be in fair condition. An overall load analysis should be performed to determine if the existing service and generator are sufficient for the power demand. This analysis is outside the scope of service for the analysis.

5. There is a limited heating, ventilation and air conditioning system. There's no air conditioning system and a wall mounted heating unit which cannot service the entire building.

6. There is a bottle type eye wash station which should be replaced with a hard pipe eye wash connected to a tepid water source.

7. There was no evidence of spare parts or lubricants which should be readily available to service process equipment.

8. There doesn't appear to be an official operation and maintenance manual. This would be necessary to confirm annual maintenance requirements and to retrieve equipment data.

9. The Martinage construction drawings for the denitrification filter upgrade show the addition of the outdoor methanol storage cabinet. There are three-55 gallon drums stored in this cabinet, which only provides 100 gallons of spill containment. For hazardous chemicals, DEP regulations require containment of 125% of the stored fluid. To comply with the DEP regulations, 206 gallons of containment should be provided, or the volume of methanol stored onsite reduced.

In addition to the above observations, an existing engineering report (Engineers' Assessment, Existing Wastewater Treatment Plant, Martinage Engineering Associates, December 2008) summarizes required improvements which have not been implemented. These include

1. Inspection and repair of the steel aeration tank,
2. Repair clarifier drives, and
3. Miscellaneous electrical repair.

4.4 Plant Performance, Reliability and Redundancy

From the information provided to CDM for the purpose of this evaluation, the WWTP is operating at approximately 50% of its designed capacity of 30,000gpd. From the Mass DEP guidelines, multiple treatment units should be provided when the average daily flow exceeds 40,000gpd, including the biological processes and clarifiers. The existing facility has no redundancy and cannot by bypassed or shut down in case of a catastrophic failure or for maintenance. If the Town were to install a new plant, it would be highly beneficial to provided full plant redundancy.

The Mass DEP guidelines state that the wastewater infiltration beds are preferred to have a reserved area for 100 percent. For the existing plant, these guidelines suggest that 10,500 square feet of open area be set aside for a backup groundwater disposal.

4.5 Regulatory Compliance

Table 4.2 summarizes the WWTFs history of compliance and makes note of any violations to the facility's existing groundwater discharge permit, based on the facility's DMRs.

Table 4.2, History of Compliance, September 2008 to September 2009

DMR Date	Compliance Status
Sep-08	All permit parameters met
Oct-08	All permit parameters met
Nov-08	All permit parameters met
Dec-08	Nitrate and total nitrogen permit limits exceeded
Jan-09	All permit parameters met
Feb-09	All permit parameters met
Mar-09	Effluent fecal coliform exceeded permit limit
Apr-09	All permit parameters met
May-09	All permit parameters met
Jun-09	All permit parameters met
Jul-09	All permit parameters met
Aug-09	All permit parameters met
Sep-09	All permit parameters met

Section 5
Recommendations for Collection System and Treatment Plant Modifications

5.1 Modifications to Existing Plant

5.1.1 Capital Improvements for Existing Plant

Based on CDM's assessment of the WWTP, several improvements are recommended to gain reliable operation into the near future, improve the plant's performance and ensure regulatory compliance, including:

- Repair/replace broken or missing diffusers in aeration tank
- Install cathodic protection on existing aeration tank to prevent corrosion
- Increase volume of methanol containment

To repair or replace the broken diffusers in the aeration tank, the tank has to be taken offline and drained. Because there is no redundant aeration tank, the incoming wastewater may be stored in the flow equalization tank and be trucked offsite by a septage hauler while the diffusers are being repaired.

While the tank is dewatered, it can be inspected for corrosion of the metallic surfaces. In addition, all sacrificial anodes should be replaced.

Any modifications to the existing biological system will be difficult since a shut down cannot be provided for periods sufficient to complete certain improvements. Typically, a facility will have the necessary redundancy and bypass system that can accommodate this work. If a catastrophic failure were to occur with the biological treatment tank, then the facility would have to be shut down and wastewater flow truck to another treatment facility.

5.1.2 Capacity Modifications to Existing Plant

To accommodate a partial expansion of the collection system to an average flow of 26,000gpd and a maximum day flow of 52,000gpd, several improvements are necessary, including:

- Installation of a second denitrification filter. The existing denitrification filter has a hydraulic capacity of 26,000gpd. To accommodate a maximum day flow of 52,000gpd, a second denitrification filter should be installed.
- The existing UV unit has a hydraulic capacity of 40,000gpd. A second UV unit should be installed to disinfect a maximum day flow of 52,000gpd.

5.2 Modifications to Replace the Existing Plant

Modifications to the existing treatment facility will focus replacement of the biological process with one having capacity of 45,000gpd (average daily flow). Many of the other treatment processes and facilities would remain and operate with the new biological system. The existing biological system is defined as Contact Stabilization and is the open steel tank located on site.

This section offers a replacement of similar technology or with other technologies. An alternatives analysis of the different technologies is outside the scope of this study. The following is intended to list potential options and to make a conceptual selection for the most feasible technology.

5.2.1 Technologies

A **Membrane Bioreactor** (MBR) consists of a suspended-growth biological reactor integrated with membranes. An MBR system designed to achieve total nitrogen removal would consist of anoxic zones, aerobic zones, and membrane tanks. Influent to an MBR system would flow into the anoxic zone of the bioreactor. Denitrification, or the conversion of nitrate to nitrogen gas, occurs in the anoxic zone and would require supplemental carbon addition to guarantee achieving 5 mg/L TN. The anoxic zone is followed by an aerobic zone for nitrification, or the conversion of ammonia to nitrate. Because nitrification consumes alkalinity, an alkalinity adjustment would need to be made with sodium hydroxide or another suitable chemical. Mixed liquor/suspended growth from the aerobic zone then flows into the membrane tanks where solids are separated from the treated wastewater. The ultrafiltration membranes, employing a reinforced structure to handle a high solids environment, are immersed directly into the mixed liquor, thereby precluding the need for a secondary clarifier. Coarse bubble aeration is used to scour the external surface of the hollow fiber membranes to keep them clean and also provides process aeration. Supplemental oxygen for biological treatment is provided by a separate diffused aeration system.

The ZeeWeed® MBR process, a product of Zenon Environmental Incorporated would be considered for this process replacement. There are hundreds of ZeeWeed® MBR installations in the US. A 300,000gpd ZeeWeed® has been in operation in Cohasset, Massachusetts since 2000. Other vendors of MBR processes include Enviroquip, Ionics, and US Filter.

A **Rotating Biological Contactor** (RBC) consists of a series of closely-spaced plastic disks attached to a horizontal shaft. Mechanical drives are used to slowly rotate (at 1.0 to 1.5 revolutions per minute) the units. As wastewater flows down through the disks, biological growth and treatment occurs on the surface of the disks. Excess growth is continuously shed from the surface of the disks. To achieve carbon oxidation and nitrification, the disks are partially (usually 40 to 45 percent) submerged in wastewater. The aeration required for biological treatment occurs via contact with the air, although supplemental diffused air can also be provided. Because nitrification consumes alkalinity, an alkalinity adjustment would need to be made with sodium hydroxide or another suitable chemical. To achieve denitrification, the disks are fully submerged in the wastewater and supplemental carbon is added. RBC systems require pretreatment with primary clarification or fine screens, as well as secondary clarifiers.

The Envirex® RBC would be considered for this process replacement. There are over 125 Envirex® RBC installations in the US, including approximately 40 in Massachusetts. Other vendors of RBC systems include RBC Services and Walker Process Equipment.

In a **Sequencing Batch Reactor** (SBR), a series of wastewater treatment steps are carried out in the same reactor. Therefore, aeration and clarification are done in a single tank operating on time-controlled cycles. Return activated sludge for mixed liquor control and internal recycle for nitrogen removal are not required because solids never leave the tank. Generally, at least two reactors – each operating in a predetermined operation sequence – are used to attain optimum treatment results.

The steps utilized in an SBR are: (1) fill, (2) react, (3) settle, (4) decant, and (5) idle. The fill step can be mixed or mixed and aerated, or a combination of both, depending on whether nitrogen or phosphorus removal is required. The react phase is typically mixed and aerated, although intermittent anoxic periods can be used if needed. Sludge wasting occurs during the idle phase.

The Aqua-Aerobic Systems, Inc. AquaSBR® process was considered for the purposes of preliminary sizing and cost estimates. Other SBR vendors include ABJ/Sanitaire, Fluidyne, and JetTech.

Contact Stabilization is the primary treatment process which currently exists at the Lincoln Woods plant. These are typically steel or concrete circular tanks and provide the biological treatment. The outer ring wall provides biological treatment and the inner tank is a settling zone for solids removal. Sludge treatment (digestion) and disinfection (chlorine contact) zones are commonly provided but can be replaced by other treatment methods. In some instances, advance treatment can be achieved by adding zones and sludge recycling. This process, Modified Ludzack-Ettinger (MLE) can provide greater nitrogen removal. With chemical addition, this process can achieve less than 3mg/l of effluent total nitrogen.

The Davco process, a product of Siemens Water Technologies would be considered for this process replacement. There are many older installations of this process throughout the country.

5.2.2 Recommended Process

For the biological treatment replacement at Lincoln Woods WWTP, CDM makes the preliminary recommendation that the existing technology be replaced by a Sequencing Batch Reactor (SBR). This technology has a lower capital cost than MBRs and RBCs, and has greater treatment capability than a new Contact Stabilization tank. The new SBR would only replace the existing Contact Stabilization tanks, which are original and have exceeded their useful life. Many of the other treatment process (and facilities) can remain and would operate in series with the new SBR. These include the equalization tank, denitrification filters, blowers and effluent filtration beds.

The leaching beds will need to be expanded to meet the revised capacity of the treatment plant. The existing bed loading rate is 2.5gpd/sqft and contains 10,500 square feet area. DEP guidelines would allow a lower rate of 2.0gpd/sqft, which results in 22,500 sqft of required leaching area. Since there is currently 10,500sqft, another 12,000sqft is required.

5.3 Recommended Collection System Expansion

The existing collection system will have to be greatly expanded to serve the entire area of the South Lincoln Sewer District. Figure 2-1 provides a rough layout of the expanded collection system, which includes gravity sewer pipes, pressure sewer force mains and pump stations.

There is an existing pump station located on the Lincoln Woods property and conveys all of the wastewater to the treatment plant. It would be a challenge for the Town to maintain and operate this station, while remaining on private property. In addition, it will be difficult to convey flow from the expanded sewer system to this existing pump station. For these reasons, CDM recommends that a new pump station, of greater capacity, be located on Town land adjacent to the Lincoln Mall. All flow from the current and future collection system would be conveyed to this pump station. Lincoln Woods Condominium would remain responsible for the existing pump station and sewer pipes on their property. The new pump station would be installed with a new force main (approximately 1,900 feet of 4-inch) to convey wastewater to the treatment plant. Once the pump station is installed, then the system expansion can proceed.

It has been assumed that the entire sewer district can flow by gravity to the new pump station. This would include approximately 3,700 feet of 8-inch polyvinyl chloride pipe. Typical pipe installation is expected with the exception of the subsurface crossing of the railroad tracks. It has been assumed that a new sleeve can be jacket under the tracks and a new sewer installed with the new crossing.

The Town also wishes to provide service to the Lincoln School. This would require that a new pump station be constructed at the school and a sewer force main (approximately 5,000 feet of 4-inch) installed from the school to the new sewer pipe in Lincoln Road.

The new collection system includes many other items besides pipe and pump station. Individual service connections will be provided to each property for connection by the owner. Also, sewer manholes will be located strategically for access when maintain the pipes.

Section 6
Recommended Plan and Conceptual Costs

6.1 Expansion Options

CDM recommends that the Town consider four options to providing wastewater service to the South Lincoln Sewer District. The general focus of each option is described below.

Option I – No Action (12,900gpd)

This option would result in the Town not purchasing the Lincoln Woods WWTP. There are no associated costs with this option and as a result, there will be limited ability to increase growth in the South Lincoln area. The existing influent flow would likely remain constant since no additional users are being considered.

Option II – Existing WWTP with Partial Collection Expansion (12,900gpd to 17,300gpd)

Option II could proceed immediately and would increase influent flows with minor plant modifications, while maintaining permit compliance (nitrogen of 10mg/l and flow limit of 26,000gpd). The option includes one suggested plant modification to replace the aeration diffusers with a more efficient system. As discussed in Section 3, there is adequate blower capacity, but low oxygen transfer efficiency in the aeration tank. This results in higher than required operation costs. In addition, CDM has included an estimate for unforeseen capital improvements since the limited plant inspection was not sufficient to reveal underlying issues.

The existing plant is comprised of several processes, each having treatment limitations, which vary. It was found that the denitrification process was designed for an average and maximum flow limit of 26,000gpd. In reality, the average daily flow limit is much less (17,300gpd), based on a current peaking factor of 1.5 (26,000 ÷ 1.5). Therefore, the existing plant cannot exceed the average daily flow limit of 17,300gpd without risk of a permit violation for nitrogen.

The current influent flow is 12,900gpd and this phase would increase the rate to 17,300gpd, resulting in an increase of 4,400gpd. This additional capacity allows for minimal expansion of the existing collection system. It was assumed that a new sewer would be installed on Lincoln Road for connection to the buildings along that roadway. As part of this option, CDM recommends that a new pump station be installed for collecting all future and existing flows. Greater detail regarding collection system expansion is provided later in this section.

Option III– WWTP Upgrade with Additional Collection Expansion (17,300gpd to 26,000gpd)

Phase II includes a process upgrade to increase flow from 17,300gpd to the permitted limit of 26,000gpd, while maintaining permit compliance (nitrogen of 10mg/l). It also includes the WWTP capital improvements described in Option II and the installation of a second disinfection unit (ultraviolet light), and a second denitrification filter, both in equal capacity of the existing units. Since the existing facility has some useful life and remaining capacity, it is recommended that these process additions be made to fully utilize the existing capacity.

The upgrade would provide an increase in flow capacity of 8,700gpd (17,300 - 26,000). This additional capacity allows for greater expansion of the existing collection system, in addition to that recommended in Option II. It was assumed that a new sewer pipe would be installed on Ridge Road to serve the existing and future build-out in this area. Greater detail regarding collection system expansion is provided later in this section.

Phase IV – WWTP Replacement with Collection Expansion Completion (26,000 to 45,000gpd)

Phase IV is full replacement with a plant capacity to treat future build-out flow from the South Lincoln Sewer District, including the ability to remove nitrogen to 5mg/l. This would require DEP approval for the facility upgrade and discharge modification, along with a revised permit for a flow increase from 26,000gpd to 45,000gpd.

At this point, the plant would have reached its useful life and will require replacement. The additional 19,000gpd would provide service to the remaining areas not called for in the earlier phases and would accommodate expansion to the build-out limitations within the same sewer district. The major components of this collection system expansion include service to the west of the railroad tracks and service to Lincoln Schools. Greater detail regarding collection system expansion is provided later in this section.

As recommended in Section 5.2.2, CDM recommends that the existing Contact Stabilization process be replaced by a new Sequencing Batch Reactor. The SBR would provide the same treatment as the Contact Stabilization, but with additional nitrification removal. As required by DEP regulations, the SBR would have full redundancy.

This upgrade would also require that another 12,000 square feet be added to the existing filtration beds (10,500sqft). This is an increase of 114 percent from the existing beds. In addition, 22,500 square feet of reserved filtration bed area will need to be identified. The adjacent conservation land would have to be used for the leaching bed expansion and reserved bed area. Subsurface disposal options could be considered to maintain compliance with the habitat preservation requirements in the conservation area.

There are several other (existing) structures and treatment process that will remain in operation (not replaced) and be connected into the new treatment process. These include the standby generator, the process building with blowers, denitrification filters, backwash well and pump tank, UV disinfection, methanol storage and feed, equalization and pump tanks, and all of the existing filtration beds.

The challenge in completing this plant replacement involves maintaining existing service while the new plant is constructed. It is recommended that the new SBR be installed within the existing property line, just west of the underground tanks. There is sufficient space for this work while the existing plant remains in operation. The location is also close to the other processes, which simplify the cross over from old to new. When completed, the old contact stabilization tank and other abandoned tanks should be removed. This abandoned space can be used for the filtration bed expansion.

Expansion of the plant will require many environmental permits due to the location being in sensitive resource areas. The site is not within a Zone I, Zone II, or Zone A, and there are no outstanding resource waters or currently-impacted surface water bodies in the immediate down gradient area from the site. The plant is also located adjacent to an Estimated Habitat of Rare Wildlife in Wetland Areas and protected open space area. Expanding outside the current property line will require special permitting and approvals to proceed with the proposed plan.

6.2 Conceptual Capital Cost for Plant Modifications

Section 5 defines capital improvements and facility replacement options. The following provides the conceptual capital costs for the different plant modifications. These are planning level capital cost to furnish and install the equipment and materials, including all planning, design and construction services. In addition, a twenty percent contingency has been added for all capital costs provided in this report.

1. Diffused aeration system replacement: $50,000
2. Unforeseen capital improvements: $50,000
3. Ultraviolet light disinfection addition: $15,000
4. Denitrification filter addition: $80,000
5. Filtration bed expansion: $90,000
6. Plant replacement with a sequencing batch reactor type process: $2,200,000

These conceptual costs are associated with the different options described in Section 7.1 - Summary of Recommendations.

6.3 Conceptual Capital Cost for Collection System Expansion

Collection system work has been subdivided into the anticipated expansion required for each phase (capacity increase) at the plant. The sewer system work coincides with the stepped increase in allowable flow at the plant, to the point of full build-out of the service area. The following describes the collection system expansion plan and conceptual capital costs. These are planning level capital costs to furnish and install the equipment and materials, including all planning, design and construction services. In addition, a twenty percent contingency has been added for all capital costs provided in this report.

Plant improvement recommended by **Option II** requires minimal expansion of the collection system with replacement of the primary pumping station. CDM recommends that the existing pump station at Lincoln Woods Condominiums continue service to these units while future flows are directed to a new pumping station and force main. The new pump station could be constructed in the parking lot of the Mall, with a new force main leading to the treatment plant. Town operation and maintenance of the existing pump station (on private property) would become problematic and therefore, should remain the responsibility of the condominiums.

Also part of **Option II** would be a new sewer, installed in Lincoln Road to serve the properties opposite the Mall at Lincoln Center. Approximately 1,300 feet of 8-inch sewer pipe would be installed from the rail road tracks to the entrance of Lincoln Woods Condominiums. The following is a summary of collection system capital cost for Option I:

• Pump station		$280,000
• Force main (pump station to plant)		$239,000
• Sewer pipe in Lincoln Road		$364,000
	Total:	$1,153,000

The collection system expansion for the **Option III** plant work includes a new sewer pipe installed on Ridge Road, Ridge Lane and Green Ridge Lane to serve the existing and future build-out in this area. Approximately 1,300 feet of 8-inch sewer pipe would be installed from Lincoln Road to Ridge Court and other multi-unit housing. The following is a summary of collection system capital cost for Option III:

- Sewer pipe in Ridge Road $364,000

The collection system expansion for the **Option IV** plant work includes new sewer pipes installed on Lincoln Road (west of the MBTA tracks) and Lewis Street, to serve the existing and future build-out in the area west of the railroad tracks. Approximately 1,100 feet of 8-inch sewer pipe would be installed. This work includes a sewer pipe crossing of the railroad tracks. In addition, a new pump station and force main would be installed from the Lincoln School to the new sewer pipe on Lincoln Road, at the entrance to Lincoln Woods Condominiums. The following is a summary of collection system capital cost for Phase IV:

• Sewer pipe in Lewis Street		$388,000
• Lincoln School pump station and pipe		$730,000
	Total:	$1,118,000

6.4 Present and Future Annual Operating and Maintenance Costs

The operations estimate is based on current owner O&M costs and the anticipated facility discharge permit for future operations. The current owner's 2009 budget for operation of the treatment plant was $73,000.

Annual operation costs have been subdivided into the following categories. These are based on a licensed operator performing the day-to-day duties required to meet performance and maintain the Town's assets.

Labor. Labor is based on servicing the facility for a minimum of two hours per day, five days a week inclusive on non-major maintenance such as lubrication, laboratory sampling, instrumentation adjustments and site maintenance. Labor also includes travel time allowance, service vehicle time, insurance and mobile phone. It is estimated that the annual labor cost will be $40,000.

Materials. Materials are based on lubricants and oils, tools and parts for non-major repairs. CDM has assumed an annual allowance of $3,000.

Sludge Removal. Solids must be occasionally removed from the system. Currently, solids are removed from the system every two months for an annual disposal fee of $6,500. CDM proposes an escalation to $7,000 to remove solids to a registered off site facility.

Chemicals. Chemical use is typically limited to additional carbon sources (sugar or methanol) and alkalinity adjustment. The plant consumes approximately 55 gallons per month of methanol for an annual total of 715 gallons. At an average price of $6.25 per gallon, the annual methanol cost is $4,500. Adding $500 for alkalinity chemicals, results in an annual chemical cost of $5,000.

Laboratory Testing. Testing and monitoring is typically specified in the discharge permit. This operations item may include testing of the facility influent and effluent and area wells. CDM has carried an allowance of $18,000 per year for testing.

Supervision and monthly reporting is included at $7,000 per year.

Utilities such as electrically and diesel are estimated to be $20,000 per year.

Reserve Accounts. The Massachusetts Department of Environmental Protection has a Watershed Management Policy titled "Financial Security Provisions for Groundwater Discharge Permits". The policy number is BRP/DWM/WPeP/P03-1 and has an effective date of June 23, 2003. This policy requires the owner of the permitted treatment facility to establish a capital reserve account for repair and/or replacement. The current permit defines the initial sum and annual contributions to this account. An escrow account must be established with an initial balance of $54,000 and annual contributions of $18,000 made for every year. These reserved funds could be used toward the recommended facility replacement as defined by Phase III. A reserve account will still be required thereafter and has been carried in the annual operation and maintenance costs. The first year O&M includes the one-time fee ($54,000) to establish the required reserve account. The remaining years include the annual contribution of $18,000 to slowly build the required replacement funds.

In summary, the above annual costs include annual fees for all insurance required for private operation of the facility. Property taxes are not included since these shall be covered by the Town.

- First year O&M $100,000 + $54,000 = $154,000
- Second year O&M $100,000 + $18,000 = $118,000
- Third year and forward O&M should include 6% for annual inflation

6.5 Value of Existing Facility

Estimating the value of an existing wastewater treatment facility is not similar to residential homes where recent purchase and sales help define the value. Some of the existing structures and equipment are original and have been operating since the mid-1970s. While other equipment was installed within past few years and therefore, still retains some value.CDM has estimated that the current value of the existing plant, excluding the land, is $425,000. Based on the current assessed value of the Lincoln Woods Cooperative property, it has been estimated that the access road and plant site are worth approximately $300,000. The total current value of land and property is approximately $725,000.

6.6 Approximate User Fees

If the Town were to proceed with ownership of the WWTP, then a user fee system would be required to provide funding for wastewater conveyance and disposal. The wastewater fee would be similar to the current water fee, at a rate of dollars per 100 cubic feet, and billed quarterly. Typically the wastewater fee is measured as a portion (90%) of the water consumed.

Wastewater user fees vary significantly in Massachusetts. For similar populations serve, these fees range from $2.45 to $13.60 per one hundred cubic feet. Based on a typical homeowner's water consumption rate of 120 hundred cubic feet, the annual fees range from $294 to $1,632. Section 7 provides an estimate for the wastewater fee required to fund the present worth expenses for the different options being considered for Lincoln.

Section 7
Summary

7.1 Summary of Recommendations

The following paragraphs summarize each option and the associated capital and annual costs. In addition, an annual debt service estimate is provided and based on bonding of capital improvements over 20 years at a discount rate of 2 percent. Costs from each option are not cumulative since each represents an independent approach.

Option I has no associated cost because the town would not purchase the existing Lincoln Woods WWTP.

Option II would increase influent flows with minor plant modifications, while maintaining permit compliance (nitrogen of 10mg/l and flow limit of 26,000gpd). The flow would increase from 12,900gpd to 17,300gpd and there would be minimal collection system additions. The anticipated costs for Option II are:

Table 7-1, Summary of Capital and Annual Costs for Option II

Capital and Annual Expenses	Costs
Purchase of existing treatment plant and land	$725,000
Diffused air system replacement	$50,000
Unforeseen capital improvements	$50,000
Collection system expansion	$1,153,000
DEP required reserved account	$54,000
Total capital cost:	$2,032,000
Debt service on bonding capital	$124,400
Annual O&M	$118,000
Total annual debt service:	$242,400

Option III is to perform a process upgrade to increase flow from 17,300gpd to the permitted limit of 26,000gpd, while maintaining permit compliance (nitrogen of 10mg/l). There would be more significant collection system improvements. The anticipated costs for Phase II are:

Table 7-2, Summary of Capital and Annual Costs for Option III

Capital and Annual Expenses	Costs
Purchase of existing treatment plant and land	$725,000
Diffused air system replacement	$50,000
Unforeseen capital improvements	$50,000
Ultraviolet light disinfection addition	$15,000
Denitrification filter addition:	$80,000
Collection system expansion	$1,517,000
DEP required reserved account	$54,000
Total capital cost:	$2,491,000
Debt service on bonding capital	$152,400
Annual O&M	$118,000
Total annual debt service:	$270,400

Option IV is full replacement with a plant capacity to treat future build-out flow from the South Lincoln District, including the ability to remove nitrogen to 5mg/l. This would require DEP approval for the facility upgrade and disposal modification, along with a revised permit for a flow increase from 26,000gpd to 45,000gpd. Collection system expansion would serve the entire South Lincoln District. The anticipated costs for Phase III are:

Table 7-3, Summary of Capital and Annual Costs for Option IV

Capital and Annual Expenses	Costs
Purchase of existing treatment plant and land	$725,000
Plant replacement value	$2,200,000
Ultraviolet light disinfection addition	$15,000
Denitrification filter addition	$80,000
Filtration bed expansion	$90,000

Collection system expansion	$1,905,000
Lincoln School pump station and sewer pipe	$730,000
DEP required reserved account	$54,000
Total capital cost:	$5,799,000
Debt service on bonding capital	$354,900
Annual O&M	$118,000
Total annual debt service:	$472,900

Table 7-4 summarizes the annual debt service for all options and the resulting annual fees. The annual debt service is based on a 20 year bonding of the capital improvements at a discount rate of 2 percent. Project options are independent of each other and costs are not cumulative.

Table 7-4, Approximate Annual Debt Service and User Fees

Option	Maximum Flow (gpd)	Number of Users	Annual Debt Service	User Fee ($/100CF)	Annual Fee ($/year)
I	12,900	234	$0	$0	$0
II	17,300	315	$242,400	$28.72	$1,550
III	26,000	473	$270,400	$21.31	$1,151
IV	45,000	818	$472,900	$21.54	$1,163
IV No School	39,400	716	$428,200	$22.27	$1,200

* Number of users based on 55 gallons per day of wastewater generated per capita.
* User fee equals annual debt service divided by maximum flow.
* Annual fee equals user fee multiplied by 54 (100 CF)/year.

7.2 Governance

The Town of Lincoln currently has Department of Public Works and a Water Department. There is no sewer department because all wastewater is disposed of locally by onsite treatment systems. If the town pursues ownership of the Lincoln Woods WWTP, then a municipal department would have to be created for the purpose of maintaining these services. It is suggested that the town consider the consolidation of all municipal infrastructure services (except schools) under the Department of Public Works. Water treatment and distribution would be included in the same department as sewer system maintenance and wastewater treatment. This allows for shared use of resources and staff between the different municipal systems.

Rather than take the risk of operating the WWTP, it is recommended that the town seek the services of a private firm to handle all maintenance, operation, and permit compliance for the plant. A long term (usually ten years) Contract Operations Agreement would be executed for these services. The town would have a designated municipal employee with responsibility for contract services. This could be the Director of Public Works.

This report makes reference to the South Lincoln Sewer District, which only serves residents of the town and does not cross the corporate boundary. Not required are agreements with other towns and legislative approval for the creation of an inter-municipal district. The town will have to renegotiate (or void) the existing contract between Lincoln Woods and the Mall at Lincoln Center.

7.3 Supplemental Recommendations

It's suggested that the Town meet with State regulators to review this report and the desires of the Town. They will have significant influence over the future use of this plant and can explain regulatory challenges in the recommended plan.

It is suggested that Lincoln Woods Condominiums and the Mall at Lincoln Center remain responsible for all wastewater collection and conveyance assets located on their respective properties. This includes all operations, maintenance, and capital improvements of the sewer pipes and pumping facilities.

7.4 Risk and Reward in Treatment Facility Purchase

7.4.1 Risk

The following are the anticipated risk in purchasing (or not purchasing) the existing Lincoln Woods Wastewater Treatment Plant:

1. The discharge limit for nitrogen could soon be reduced from 10mg/l to 5mg/l by the Massachusetts Department of Environmental Protection. The recent average discharge concentration is 6mg/l, which is much less than the current limit but would not meet the future limit. Adding more Methanol would lower the effluent nitrogen concentration but is pushing the limits of the existing treatment capacity. If the limit is reduced while operating the existing plant, then it is possible that a process upgrade might be necessary. The upgrade would likely be the addition of more denitrification filters. Adding these filters is already included in the Phase II plan.

2. Implementation of all three phases requires approval from DEP for collection system expansion and a significant increase in discharge capacity. There is a possibility that DEP will limit or even reject the planned expansion of the treatment plant and sewer system.

3. A Draft Administrative Consent Order was issued in 1997 and a Notice of Noncompliance in 2009. It should be confirmed that both legal documents has been satisfied and closed out prior to taking over ownership. Outstanding enforce issues would subject the Town to additional work and expense to achieve compliance.

4. A capacity increase and replacement of the existing plant will require additional land for these structures and leaching field. Since the surrounding property is environmentally protected, this expansion will be difficult and could be denied.

5. As owner, the Town would be liable for any violations of the discharge permit, which may include legal enforcement and penalties.

6. If Lincoln does not take ownership of the WWTP and the current owner abandons the facility, then the town and the Massachusetts Department of Environmental Protection will have an obligation to assist residents of Lincoln Woods.

7.4.2 Reward

The following are the potential rewards in purchasing the existing Lincoln Woods Wastewater Treatment Plant:

1. Where there are failing on-site septic systems (private and school), an expanded treatment plant and collection system could provide relief to these property owners.

2. Maintain and expand affordable housing requirements.

3. Eliminate the potential for the privately owned facility to become discarded if the cooperation falls into financial hardship.

4. Overall protection of the environment. The expansion of the existing and eventual installation of the new plant will redirect wastewater from the many onsite (septic) systems to an advanced treatment plant. This has an overall beneficial effect on the water quality because onsite systems provide little treatment. This urgency is noted in the Town's ***Annual Water Quality Report 2008*** which states "One of the biggest threats to the Town's water supply is improperly maintained septic systems."