Section 5

Chicopee River Watershed

SECTION 5 – CHICOPEE RIVER WATERSHED

5.1 INTRODUCTION

The Chicopee River is the largest tributary of the Connecticut River. The Chicopee watershed is the largest of the 27 major drainage basins in the State of Massachusetts. The River starts in the Town of Palmer at the confluence of the Swift, Ware and Quaboag Rivers. The Chicopee flows westward to the Connecticut River. This study includes two POTWs that discharge directly to the Chicopee River.

Image from www.mass.gov

Figure 5.1-1 shows the Chicopee River watershed and the table below lists the two facilities with their respective sizes. The impact of nitrogen removal at each of these facilities is presented in this section.

Table 5.1-1

CHICOPEE RIVER POTWs

NAME OF FACILITY	PERMITTED CAPACITY
Palmer	5.6 mgd
Ware	1.0 mgd

N

POTW Permitted Flow Range (mgd)

0.1-1.0
1.1 - 5.0
5.1 - 10.0
10.1 - 50.0
50.1 - 100.0

Watershed
MA Town Boundaries

0 2.5 5 10 Miles

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Permitted Flows for POTWs in Chicopee Subwatershed
Figure 5-1-1

\\CDMD1VR72B1\Projects\MA_DEP_TN_Study\ JPD 03/2008

5.2 PALMER

A. **Introduction.** The Palmer Water Pollution Control Facility is located at 1 Norbell Street in Palmer, MA. It has a permitted capacity of 5.6 mgd facility and serves the Towns of Palmer, Monson, and Belchertown and a section of Three Rivers which is a village of Palmer. Portions of the collection system are combined sanitary and storm pipelines. There currently are no industrial dischargers and six CSOs in the service area. The facility experiences an increase in septage deliveries in the summer and landfill leachate from Vermont.

The original facility was constructed in 1980. Changes that have occurred since 1980 include the conversion of two of the aeration tanks to fine bubble diffusers and two to coarse bubble in 1994 and the installation of belt filter presses in 1998.

B. **Existing Facilities.**

Aerial photo from www.google.com

1. **Description of Existing Facilities.** The main portion of the wastewater flow to the Palmer facility and the flow from the upper portion of Three Rivers enter the headworks building through two pipelines. This building contains the influent bar rack, aerated grit chamber and screenings grinder through which all the flow passes. From there, flow is conveyed to the two primary clarifiers. After primary clarification, the flow is pumped to the aeration tanks.

The facility has four aeration tanks. Each tank is 80 ft long by 40 ft wide with a 16 ft sidewater depth. The aeration tanks are followed by two 10 ft deep, 85 ft diameter secondary clarifiers.

PACl is added to the aeration tank effluent seasonally for phosphorus removal and year-round for metals removal. Caustic soda is added to the secondary clarifier effluent for pH adjustment.

Secondary effluent flows through a rapid mix tank and tertiary clariflocculator. It then receives chlorine disinfection and dechlorination prior to being discharged to the Chicopee River. A liquid process flow schematic is shown in Figure 5.2-1.

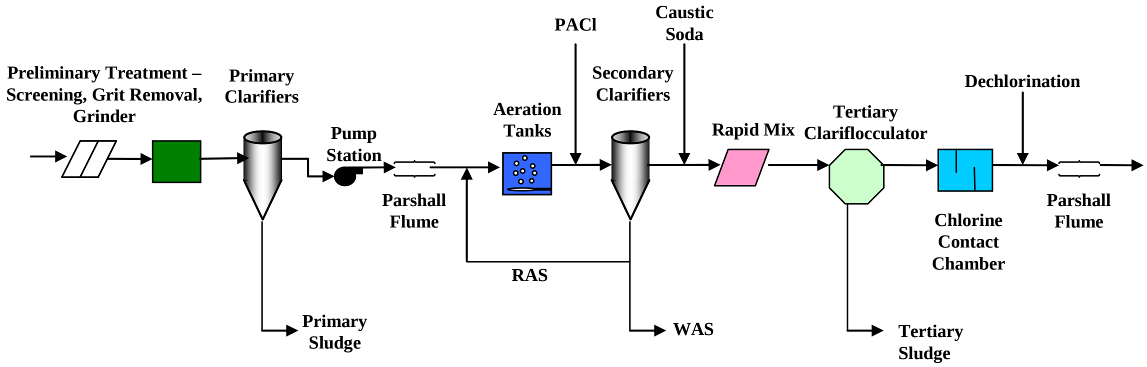


FIGURE 5.2-1: PROCESS FLOW SCHEMATIC – EXISTING FACILITY

Primary and waste activated sludge are thickened in the two gravity thickeners and dewatered with belt filter presses. Sludge cake is trucked to Synagro in Waterbury, Connecticut for incineration.

All plant recycle flows are returned to the headworks building. The influent sampler at this facility is located downstream of the grit removal facility and thus all plant flows including internal recycle flows are included in the influent loads.

Both primary clarifiers, two aeration tanks, one secondary clarifier and one chlorine contact tank are in service under normal operation. The second clarifier is utilized during rain events. Nitrification is not required, but the plant does not try to suppress nitrification at any time of the year.

The plant has ten full-time employees of which one is administrative.

Design flows and loads for the most recent upgrade were not made available.

There is space east and west of the existing aeration tanks to expand their capacity, but there is very little additional space as shown in the aerial photo. There also is some space west of the clariflocculator which could be used. It is believed that current structures are supported on piles due to the high groundwater table. Significant dewatering efforts would be required due to the high groundwater levels and proximity to the river.

2. **Summary of Plant Data.** Data from January 2004 through December 2006 was provided by the Town for this study. A summary of the monthly data is shown in Table 5.2-1. Seasonal and annual average and maximum month data is summarized in the table.

(continued)

Table 5.2-1

PALMER WPCF

Palmer, Massachusetts

Monthly Averages 2003-2006

GENERAL		INFLUENT								EFFLUENT								
DATE		INF	pH	BOD	TSS	pH	DO	TEMP	ALKALINITY	pH	BOD	TSS	FECAL	NO2	NO3	TKN	NH3	ALKALINITY
MONTH	YEAR	MGD		MG/L	MG/L		MG/L	DEG F	MMOL/L		MG/L	MG/L	COLI.	MG/L	MG/L	MG/L	MG/L	MMOL/L
January	2004	2.3	7.2	123.9	143.1	49.0	0.6	45.9	94.0	7.0	4.3	4.9	0.0	1.6	0.8	11.3	11.1	82.0
February	2004	2.1	7.1	142.3	166.8	63.8	0.6	45.8	110.0	7.0	5.7	6.3	0.0	1.7	0.4	19.8	13.2	91.0
March	2004	2.3	7.2	130.4	151.7	66.4	0.6	47.9	98.0	7.1	5.9	4.3	6.0	0.3	2.3	20.0	16.0	99.0
April	2004	2.9	7.0	98.4	130.5	51.8	0.7	49.7	68.0	6.9	5.9	3.9	0.6	0.2	1.8	16.0	12.0	63.0
May	2004	2.4	6.9	205.1	156.2	62.0	0.8	56.1	85.0	6.9	6.4	2.2	0.0	0.2	3.1	8.1	8.2	60.0
June	2004	2.0	7.2	176.9	206.7	63.2	0.7	61.0	98.0	7.0	5.7	2.7	4.5	0.6	10.0		2.3	52.0
July	2004	1.9	7.0	198.1	234.4	66.5	0.7	64.0	118.0	7.1	4.8	2.1	0.1		0.5	45.0	18.0	91.0
August	2004	1.9	7.0	204.0	296.6	64.0	0.8	65.7	127.0	7.1	5.3	2.6	0.3	0.7	16.0		1.2	48.0
September	2004	2.1	7.0	166.2	244.9	60.7	0.7	64.8	145.0	7.1	6.4	2.4	0.1	1.0	15.0	2.7	4.2	66.0
October	2004	2.0	7.2	201.0	229.6	70.0	0.7	60.4	125.0	7.1	8.6	2.6	0.0	0.1	14.0	1.2	1.6	52.0
November	2004	2.3	7.1	151.2	185.6	68.4	0.6	53.9	117.0	6.9	9.3	4.0	0.0	0.4	15.0	3.4	4.5	61.0
December	2004	2.0	7.0	185.1	188.8	64.7	0.7	51.9	111.0	6.8	9.8	3.9	0.0	0.5	5.6	15.0	13.0	74.0
January	2005	2.3	6.9	168.5	142.4	49.0	0.6	47.5	85.0	6.9	6.8	4.5	0.0	0.3	3.5	15.0	11.0	79.0
February	2005	2.3	6.8	128.3	163.3	63.8	0.6	46.4	89.0	6.8	5.2	3.7	0.0		1.4	17.0	20.0	105.0
March	2005	2.3	6.8	120.6	154.2	62.0	0.6	46.6	92.0	6.8	4.4	2.9	0.0	2.1	2.1	18.0	19.0	97.0
April	2005	3.1	6.6	99.6	135.5	57.8	0.7	49.9	71.0	6.7	6.4	3.0	0.9	0.1	1.2	7.5	8.9	79.0
May	2005	2.5	6.6	145.1	187.1	62.0	0.8	54.1	84.0	6.7	14.3	4.9	0.7	0.3	2.0	14.0	13.0	106.0
June	2005	2.0	6.7	184.4	253.4	63.8	0.7	60.2	118.0	6.9	18.2	2.6	0.1	0.2	0.1	21.0	20.0	118.0
July	2005	1.9	6.8	170.6	190.1	65.6	0.7	63.6	128.0	6.8	12.7	3.1	0.0	0.1	2.3	16.0	19.0	89.0
August	2005	1.8	7.1	171.6	227.4	62.5	0.8	66.1	123.0	7.3	5.3	1.8	0.1	0.1	15.0		3.0	61.0
September	2005	1.8	7.2	166.3	213.9	62.2	0.7	65.3	162.0	7.1	4.6	1.7	0.9	0.3	39.0		2.1	67.0
October	2005	3.7	7.1	137.3	146.8	70.0	0.7	60.5	95.0	6.9	5.4	3.8	1.7	1.2	17.0		1.5	49.0
November	2005	3.0	7.0	112.3	142.1	70.0	0.6	55.8	82.0	6.9	8.1	3.2	0.0	0.2	4.3	5.3	5.6	76.0
December	2005	2.7	7.0	115.5	129.5	63.8	0.7	50.7	72.0	7.0	8.5	3.9	0.0		2.5	9.1	9.5	86.0
January	2006	3.6	7.2	93.8	114.5	49.0	0.6	48.5	69.0	7.1	6.1	5.3	0.0	0.2	1.3	15.0	13.0	78.0
February	2006	3.5	7.2	96.8	91.3	63.8	0.6	47.1	63.0	7.1	3.5	3.9	0.0		1.7	8.0	10.0	79.0
March	2006	2.4	7.3	154.2	131.1	62.0	0.6	48.0	80.0	7.2	4.9	4.5	0.0		1.1	17.0	17.0	95.0
April	2006	2.2	7.2	180.3	154.3	57.8	0.7	51.1	118.0	7.2	5.8	3.8	0.7		0.2	23.0	21.0	121.0
May	2006	2.4	7.0	165.0	191.2	62.0	0.8	56.0	111.0	7.1	6.8	4.1	0.7	0.2	0.8	13.0	17.0	126.0
June	2006	2.8	7.1	113.3	159.9	63.8	0.7	60.0	97.0	7.2	7.0	2.9	0.9	0.1	0.3	22.0	19.0	97.0
July	2006	2.5	7.1	132.9	171.2	65.6	0.7	63.6	89.0	6.9	6.6	3.0	6.7	0.0	2.1	5.6	5.2	49.0
August	2006	2.1	7.0	158.2	203.7	62.5	0.8	65.5	120.0	7.1	4.2	2.1	1.2		20.0		0.7	66.0
September	2006	2.3	7.1	208.1	234.0	62.2	0.7	63.4	133.0	7.2	3.8	1.5	2.8	0.1	14.0		1.4	60.0
October	2006	2.4	7.2	178.6	194.4	70.0	0.7	60.2	133.0	7.1	5.8	2.0	0.2		16.0		0.4	46.0
November	2006	2.7	7.3	185.6	191.1	70.0	0.6	57.0	119.0	7.1	9.6	2.2	0.0	0.3	13.0	6.3	7.5	74.0
December	2006	2.0	7.3	173.8	195.5	63.8	0.7	53.5	121.0	7.2	11.8	4.3	0.0	0.3	15.0		1.7	103.0
Min. Month		1.8	6.6	93.8	91.3	49.0	0.6	45.8	63.0	6.7	3.5	1.5	0.0	0.0	0.1	1.2	0.4	46.0
Seasonal Average		**2.2**	**7.0**	**171.3**	**207.9**	**64.4**	**0.7**	**61.7**	**116.2**	**7.0**	**7.3**	**2.7**	**1.2**	**0.3**	**10.4**	**14.9**	**7.7**	**72.4**
Average Annual		**2.4**	**7.0**	**154.0**	**179.2**	**62.6**	**0.7**	**55.8**	**104.2**	**7.0**	**7.1**	**3.3**	**0.8**	**0.5**	**7.2**	**13.9**	**9.8**	**79.0**
Max. Month		3.7	7.3	208.1	296.6	70.0	0.8	66.1	162.0	7.3	18.2	6.3	6.7	2.1	39.0	45.0	21.0	126.0

With a current average daily flow of 2.4 mgd and a permitted capacity of 5.6 mgd, this facility is operating at approximately 43% of its permitted capacity. There is a possibility that a casino will be built in Palmer. The estimated water usage for the casino is 1 mgd, and there may be a further increase in flow based on population increase associated with such a project. If this were to occur, the facility would be operating at closer to 65% of its permitted capacity. Based on the average BOD concentration of 154 mg/L and TSS concentration of 179 mg/L, this wastewater would be considered medium strength. No influent nitrogen data is available for this plant.

3. **Permit Requirements and Current Performance.** The current permit for this facility has been in effect since September 29, 2000. Monthly permit limits that are relevant to this study are shown below in Table 5.2-2.

Table 5.2-2

SELECT MONTHLY PERMIT LIMITS

PARAMETER	LIMIT
BOD5	30 mg/L
TSS	30 mg/L
Ammonia Nitrogen	Report
TKN	Report
Nitrate Nitrogen	Report
Nitrite Nitrogen	Report
Total Phosphorus November –May June - October	 Report 1 mg/L

The above BOD and TSS limits have been met in all months of the data collection period.

4. **Nitrogen Removal Performance.** This facility does not collect influent nitrogen data and samples effluent data once a month. This data suggests nitrification is occurring in the summer months due to the ammonia data and reduction in alkalinity.

C. **Nitrogen Removal Alternatives.** The existing maximum month loads over the three-year data collection period were used to determine the BioWin input data. The raw influent data which correspond to maximum-month loads is shown in Table 5.2-3 below for each permitting scenario. The minimum temperature for the permit condition is also shown. In addition, due to a lack of influent nitrogen data, the TN/BOD ratio was estimated to be 0.18.

Table 5.2-3

EXISTING INFLUENT PARAMETERS

PERMIT CONDITION	PARAMETER	VALUE
Average Annual	Flow, mgd	2.2
	BOD, mg/L	208
	TSS, mg/L	242
	TN, mg/L	37
	Temperature, F	46
Seasonal	Flow, mgd	2.3
	BOD, mg/L	208
	TSS, mg/L	242
	TN, mg/L	37
	Temperature, F	54

The existing plant data was then projected to the permitted capacity of the facility to develop model input parameters for the average annual and seasonal model runs. The resultant data is shown in Table 5.2-4.

Table 5.2-4

MODEL INPUT PARAMETERS AT PERMITTED CAPACITY

PERMIT CONDITION	PARAMETER	VALUE
Average Annual	Flow, mgd	5.4
	BOD, mg/L	208
	TSS, mg/L	242
	TN, mg/L	37
	Temperature, F	466
Seasonal	Flow, mgd	5.4
	BOD, mg/L	208
	TSS, mg/L	242
	TN, mg/L	37
	Temperature, F	54

The model input data was used to run uncalibrated simulations to determine planning level, order-of-magnitude costs for implementing different levels of nitrogen reduction at the facility. A discussion of operational changes or minor modifications that can be made to the facility to improve current nitrogen reduction performance as well as a presentation of the simulation results are presented in the following sections.

1. **Minor Modifications/Retrofits.** The plant is operating at only 43% of its permitted capacity with only half the aeration tanks in operation under normal conditions. Limited data indicates that summer nitrification is occurring, and it is possible that it would occur year-round, even with coarse bubble diffusers in half the tanks, due to the extra capacity. Therefore, the first grid of diffusers per aeration tank could be turned off to create an anoxic zone if it was baffled off.

2. **Modifications Required to Meet TN of 8 mg/L.** The modifications to the facility that are required to meet an effluent TN of 8 mg/L on a seasonal and annual average basis are as follows.

a. **Seasonal.** At the assumed influent TN levels for this facility, an MLE process will not accomplish a seasonal effluent TN level of 8 mg/L. The MLE process will yield a seasonal effluent TN of 10 mg/L. Thus, a four stage Bardenpho process is recommended as shown in the BioWin model in Figure 5.2-2 below.

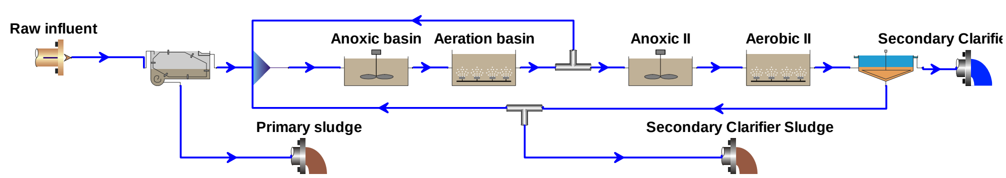


FIGURE 5.2-2: BIOWIN MODEL FOR SEASONAL TN LIMIT OF 8 mg/L

This process would require a 25% increase in volume, or the equivalent of one new aeration tank. The existing tanks would be modified with the adequate partitioning so that there would be five parallel Bardenpho tanks. The existing flow pattern may be inadequate, so the tanks may need to be operated as 2-pass tanks to provide plug flow. It is assumed that the diffusers would have to be replaced and blower capacity would have to be increased since the facility was not designed to nitrify. Nitrate recycle pumps would be added. As shown in the site plan in Figure 5.2-3, the site has enough space for the additional tank.

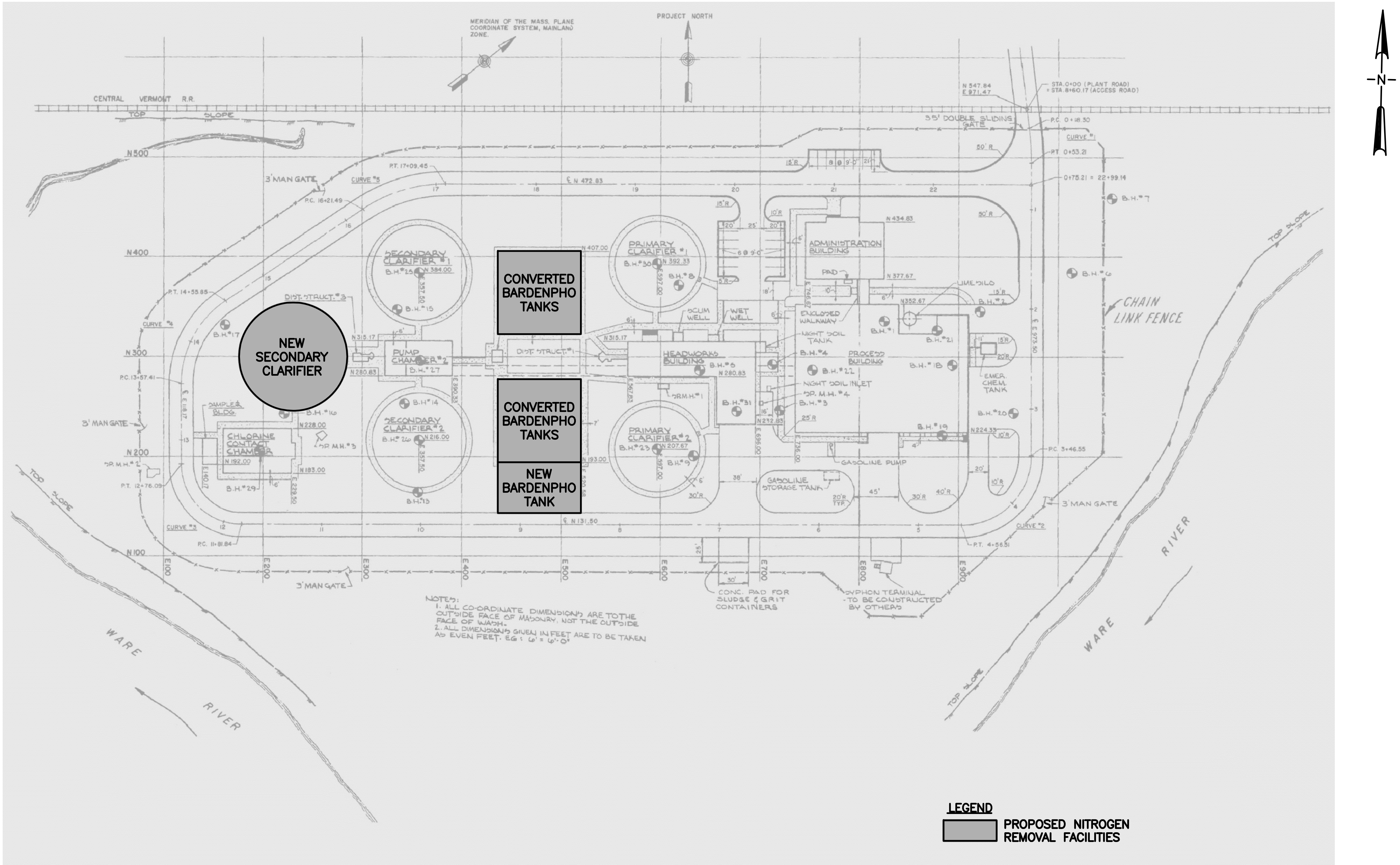
In addition to the new aeration tank, it is also anticipated that the facility will require one additional secondary clarifier (in addition to the existing two) to operate the facility at the resultant model MLSS concentration. It should be noted that the existing clarifiers at this facility are 10 feet deep. According to TR-16, clarifiers at nitrogen removal facilities should be a minimum of 13 feet deep. Because the clarifiers do not meet the minimum requirements set forth in Section 2, it is recommended that they be further evaluated to determine if they will require replacement or derating because of the shallow depth. It is assumed that the existing tertiary clariflocculator would be demolished and a new clarifier would be built in its place since the site is space-limited at that end of the plant. There is a possibility that the existing clariflocculator could be converted to a third secondary clarifier, but this would require further study. Also, an advantage of replacing the clarifier is that it can be built at a depth which meets TR-16 standards.

Specific information regarding the design results is shown in Table 5.2-5 below.

Table 5.2-5

RESULTS FOR SEASONAL LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Aerobic SRT	7.4 days
Total SRT	15.4 days
First Anoxic Fraction	19%
Total Anoxic Fraction	52%
Reaeration HRT	20 minutes
Total Volume	1.91 MG
RAS Rate	50%
Nitrate Recycle Rate	400%
Max MLSS at Loading Rate	3,300 mg/L
Effluent TN	7.6 mg/L
Methanol Addition	No
Fixed Film Required?	No
Clarifiers?	1 new clarifier
Effluent Filtration Required?	No



NOTE:

1. Background is from Drawing SITE PLAN from Contract Documents entitled "WATER POLLUTION CONTROL PROGRAM" by TIGHE & BOND and dated 1976.
2. Auxiliary facilities associated with nitrogen removal processes are not shown.

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STEARNS & WHELER
Environmental Engineers & Scientists
1545 Iyannough Road, Route 132
Hyannis, MA 02601
Tel: (508) 362-5680
Fax: (508) 362-5684
www.stearnswheler.com

CDM
Camp Dresser & McKee Inc.
One Cambridge Place, 50 Hampshire Street
Cambridge, MA 02139
Tel: (617) 452-6000
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PALMER, MASSACHUSETTS

FIGURE 5.2-3

Other plant modifications may be needed including upgrades to sludge handling. However, all facilities outside of the activated sludge process are outside of the scope of this study.

b. **Annual Average.** At the assumed influent TN levels for this facility, an MLE process will not accomplish an annual effluent TN level of 8 mg/L. The MLE process will yield an annual average effluent TN of about 10 mg/L. Thus, a four stage Bardenpho process is recommended as shown in the BioWin model in Figure 5.2-4 as follows.

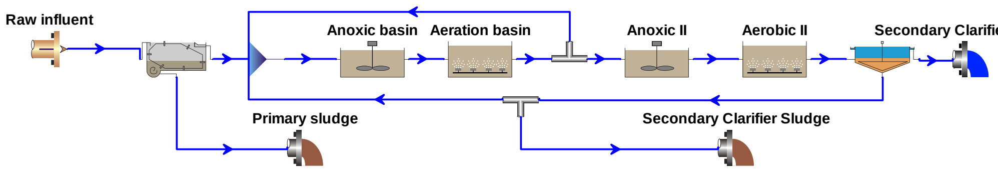
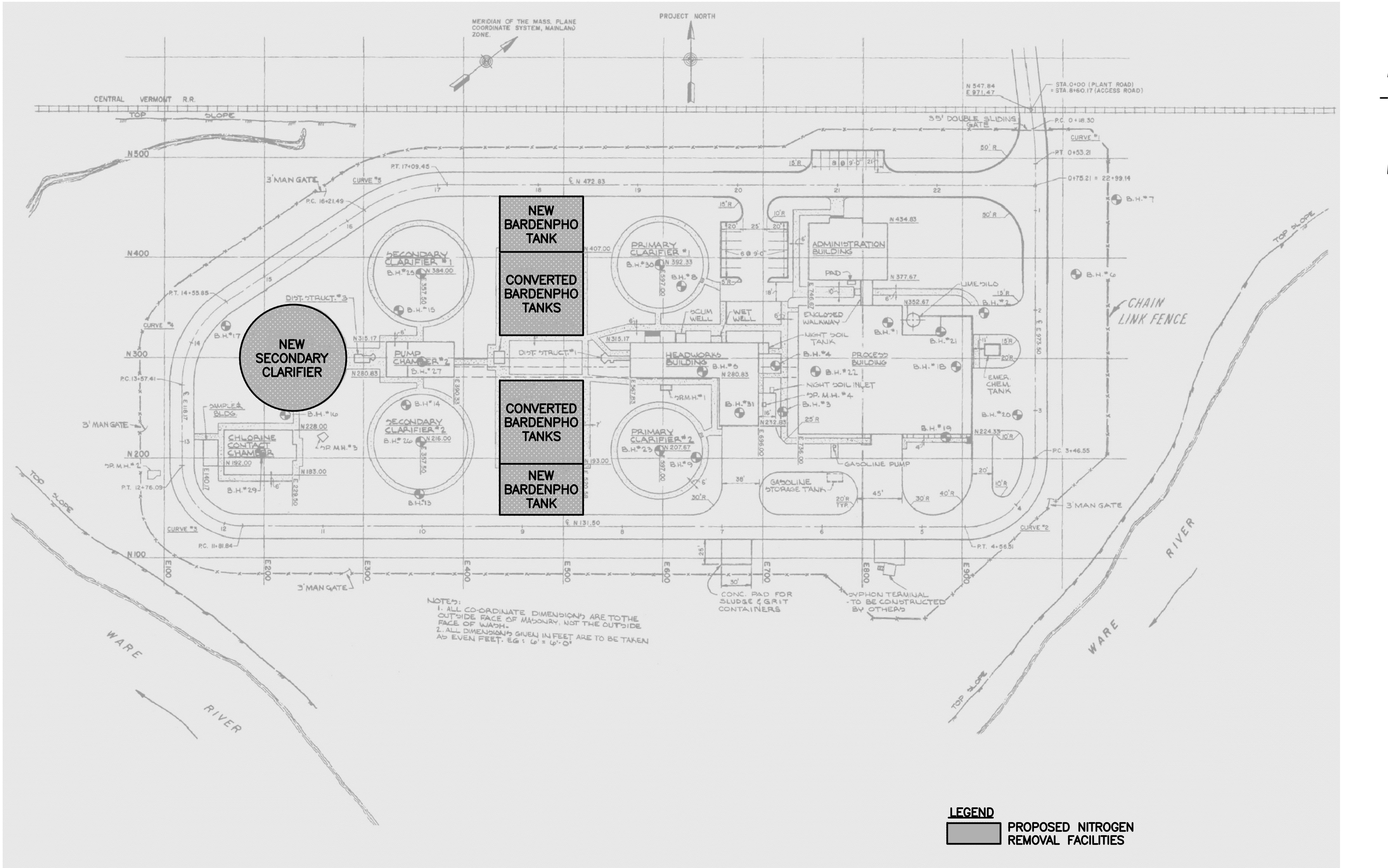


FIGURE 5.2-4: BIOWIN MODEL FOR ANNUAL AVERAGE TN LIMIT OF 8 mg/L

This process would require a 50% increase in volume, or the equivalent of two new aeration tanks. The existing tanks would be modified with the adequate partitioning so that there would be six parallel Bardenpho tanks. The existing flow pattern may be inadequate, so the tanks may need to be operated as 2-pass tanks to provide plug flow. It is assumed that the diffusers would have to be replaced and blower capacity would have to be increased since the facility was not designed to nitrify. Nitrate recycle pumps would be added. As shown in the site plan in Figure 5.2-5, the site has enough space for the additional tanks.

In addition to the new aeration tanks and in accordance, it is also anticipated that the facility will require one additional secondary clarifier (in addition to the existing two) to operate the facility at the resultant model MLSS concentration. It should be noted that the existing clarifiers at this facility are 10 feet deep. According to TR-16, clarifiers at nitrogen removal facilities should be a minimum of 13 feet deep. Because the clarifiers do not meet the minimum requirements set forth in Section 2, it is recommended that they be further evaluated to determine if they will require replacement or derating because of the shallow depth. It is assumed that the existing tertiary clariflocculator would be demolished and a new clarifier would be built in its place since the site is space-limited at that end of the plant. There is a possibility that the existing clariflocculator could be converted to a



NOTE:

1. Background is from Drawing SITE PLAN from Contract Documents entitled "WATER POLLUTION CONTROL PROGRAM" by TIGHE & BOND and dated 1976.

2. Auxiliary facilities associated with nitrogen removal processes are not shown.

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STEARNS & WHELER
Environmental Engineers & Scientists
1545 Iyannough Road, Route 132
Hyannis, MA 02601
Tel: (508) 362-5680
Fax: (508) 362-5684
www.stearnswheler.com

CDM
Camp Dresser & McKee Inc.
One Cambridge Place, 50 Hampshire Street
Cambridge, MA 02139
Tel: (617) 452-6000
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PALMER, MASSACHUSETTS

FIGURE 5.2-5

third secondary clarifier, but this would require further study. Also, an advantage of replacing the clarifier is that it can be built at a depth which meets TR-16 standards.

Specific information regarding the design results is shown in the following Table 5.2-6.

Other plant modifications may be needed including upgrades to sludge handling. However, all facilities outside of the activated sludge process are outside of the scope of this study.

Table 5.2-6

RESULTS FOR ANNUAL AVERAGE LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Aerobic SRT	11.3 days
Total SRT	22.6 days
First Anoxic Fraction	26%
Total Anoxic Fraction	49%
Reaeration HRT	20 minutes
Total Volume	2.3 MG
RAS Rate	50%
Nitrate Recycle Rate	400%
Max MLSS at Loading Rate	3,700 mg/L
Effluent TN	7.1 mg/L
Methanol Addition	No
Fixed Film Required?	No
Clarifiers?	1 new clarifier
Effluent Filtration Required?	No

3. **Modifications Required to Meet a TN of 5 mg/L.** The modifications to the facility that are required to meet an effluent TN of 5 mg/L on a seasonal and annual average basis are as follows.

a. **Seasonal.** At the assumed influent TN levels for this facility, a four stage Bardenpho process with methanol addition to the second anoxic zone is recommended to achieve a seasonal effluent TN of 5 mg/L as shown in the BioWin model in Figure 5.2-6.

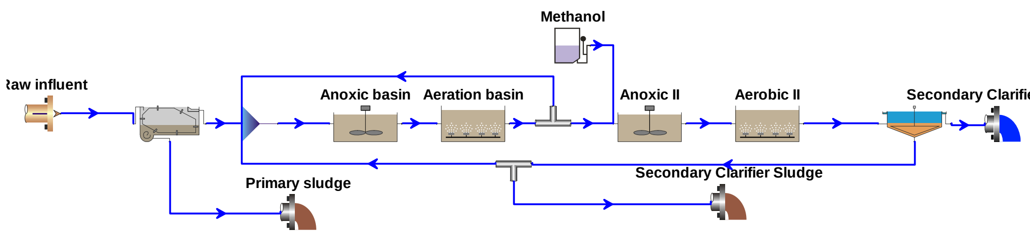


FIGURE 5.2-6: BIOWIN MODEL FOR SEASONAL TN LIMIT OF 5 mg/L

This process would require a 25% increase in volume, or the equivalent of one new aeration tank. The existing tanks would be modified with the adequate partitioning so that there are five parallel Bardenpho tanks. The existing flow pattern may be inadequate, so the tanks may need to be operated as 2-pass tanks to provide plug flow. It is assumed that the diffusers would have to be replaced and blower capacity would have to be increased since the facility was not designed to nitrify. Nitrate recycle pumps would be added as well as a methanol feed facility. As shown in the site plan in Figure 5.2-3, the site has enough space for the additional tanks.

In addition to the new aeration tank, it is also anticipated that the facility will require one additional secondary clarifier (in addition to the existing two) to operate the facility at the resultant model MLSS concentration. It should be noted that the existing clarifiers at this facility are 10 feet deep. According to TR-16, clarifiers at nitrogen removal facilities should be a minimum of 13 feet deep. Because the clarifiers do not meet the minimum requirements set forth in the QA/QC procedures in Section 2, it is recommended that they be further evaluated to determine if they will require replacement or derating because of the shallow depth. It is assumed that the existing tertiary clariflocculator would be demolished and a new clarifier would be built in its place since the site is space-limited at that end of the plant. There is a possibility that the existing clariflocculator could be converted to a third secondary clarifier, but this would require further study. Also, an advantage of replacing the clarifier is that it can be built at a depth which meets TR-16 standards.

(continued)

Specific information regarding the design results is shown in Table 5.2-7 below.

Table 5.2-7

RESULTS FOR SEASONAL LIMIT OF 5 mg/L TN

PARAMETER	VALUE
Aerobic SRT	7.4 days
Total SRT	15.4 days
First Anoxic Fraction	19%
Total Anoxic Fraction	52%
Reaeration HRT	20 minutes
Total Volume	1.82 MG
RAS Rate	50%
Nitrate Recycle Rate	400%
Max MLSS at Loading Rate	3,900 mg/L
Effluent TN	4.6 mg/L
Methanol Addition	Yes; 250 gpd (seasonal)
Fixed Film Required?	No
Clarifiers?	1 new clarifier
Effluent Filtration Required?	No

Other plant modifications may be needed including upgrades to sludge handling. However, all facilities outside of the activated sludge process are outside of the scope of this study.

b. **Annual Average.** At the assumed influent TN levels for this facility, a four stage Bardenpho process with methanol addition to the second anoxic zone is recommended to achieve an average annual effluent TN of 5 mg/L as shown in the BioWin model in Figure 5.2-7.

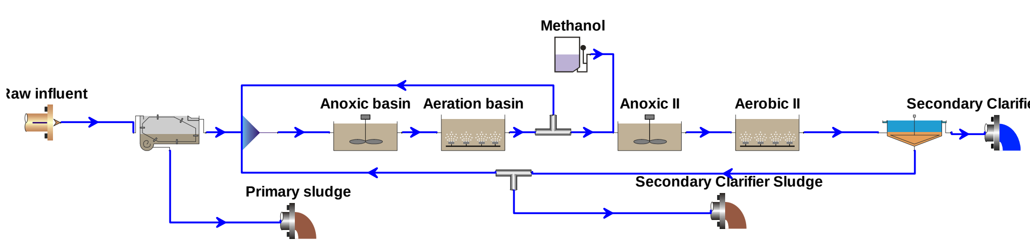


FIGURE 5.2-7: BIOWIN MODEL FOR ANNUAL AVERAGE TN LIMIT OF 5 mg/L

This process would require a 50% increase in volume, or the equivalent of two new aeration tanks. The existing tanks would be modified with the adequate partitioning so that there are six parallel Bardenpho tanks. The existing flow pattern may be inadequate, so the tanks may need to be operated as 2-pass tanks to provide plug flow. It is assumed that the diffusers would have to be replaced and blower capacity would have to be increased since the facility was not designed to nitrify. Nitrate recycle pumps would be added as well as a Methanol feed facility. As shown in the site plan in Figure 5.2-5, the site has enough space for the additional aeration tanks.

In addition to the new aeration tanks, it is also anticipated that the facility will require one additional secondary clarifier (in addition to the existing two) to operate the facility at the resultant model MLSS concentration. It should be noted that the existing clarifiers at this facility are 10 feet deep. According to TR-16, clarifiers at nitrogen removal facilities should be a minimum of 13 feet deep. Because the clarifiers do not meet the minimum requirements set forth Section 2, it is recommended that they be further evaluated to determine if they will require replacement or derating because of the shallow depth. It is assumed that the existing tertiary clariflocculator would be demolished and a new clarifier would be built in its place since the site is space-limited at that end of the plant. There is a possibility that the existing clariflocculator could be converted to a third secondary clarifier, but this would require further study. Also, an advantage of replacing the clarifier is that it can be built at a depth which meets TR-16 standards.

(continued)

Specific information regarding the design results is shown in Table 5.2-8 below.

Table 5.2-8

RESULTS FOR ANNUAL AVERAGE LIMIT OF 5 mg/L TN

PARAMETER	VALUE
Aerobic SRT	11.3 days
Total SRT	18.8 days
First Anoxic Fraction	22%
Total Anoxic Fraction	40%
Reaeration HRT	20 minutes
Total Volume	2.3 MG
RAS Rate	50%
Nitrate Recycle Rate	400%
Max MLSS at Loading Rate	4,000 mg/L
Effluent TN	4.7 mg/L
Methanol Addition	400 gpd
Fixed Film Required?	No
Clarifiers?	1 new clarifier
Effluent Filtration Required?	No

Other plant modifications may be needed including upgrades to sludge handling. However, all facilities outside of the activated sludge process are outside of the scope of this study.

D. **Plant and Cost Summary.**

Table 5.2-9 presents flow data for the Palmer WWTP as well as the current nitrogen removal performance of the plant. As shown, the facility is achieving minimal nitrogen removal with their current activated sludge process.

(continued)

Table 5.2-9

PLANT FLOW AND EFFLUENT LIMIT SUMMARY

PARAMETER	VALUE
Permitted Flow (mgd)	5.6
Existing Flow (2004-6)	2.4
% of permitted capacity	42.9
Current average seasonal effluent TN (mg/L)[1]	21.6
Current average annual effluent TN (mg/L) [1]	25.6
Permit Limits Seasonal Nitrification (mg/L) Year-round nitrification (mg/L) Seasonal TN Limit Annual TN Limit	 Report Report Report Report

Table 5.2-10 presents the nitrogen removal processes required to meet the four different permit conditions considered. Based on the BioWin modeling performed, the facility will need to convert to a 4-stage Bardenpho process with methanol additional to consistently meet 8 mg/L TN both seasonally and annually. The BioWin models were run at permitted capacity with an assumed ammonia to BOD ratio since no influent nitrogen data was available. The modeling also predicts that the facility will have to convert to a Bardenpho process with methanol addition to meet 5 mg/L TN in the space available at the facility.

Table 5.2-10

NITROGEN REMOVAL PROCESS SUMMARY FOR PALMER WPCF

EXISTING PROCESS	PROCESS TO ACHIEVE SEASONAL TN OF 8 MG/L	PROCESS TO ACHIEVE ANNUAL AVERAGE TN OF 8 MG/L	PROCESS TO ACHIEVE SEASONAL TN OF 5 MG/L	PROCESS TO ACHIEVE ANNUAL AVERAGE TN OF 5 MG/L
Activated sludge w/ fine and coarse bubble aeration	Bardenpho	Bardenpho	Bardenpho w/ methanol addition	Bardenpho w/ methanol addition

The modifications required at Palmer to convert to a new nitrogen removal process are summarized in Table 5.2-11. As noted, a Ludzack-Ettinger process could be created by turning off the air to the first grid of diffusers. The removal would be significantly less than what would be expected from an MLE or Bardenpho process. A calibrated model could be run to determine the amount of removal possible at this facility.

Table 5.2-11

REQUIRED MODIFICATIONS SUMMARY FOR PALMER WPCF

Minor Modifications/ Retrofits	Modifications to Achieve Seasonal TN of 8 mg/L	Modifications to Achieve Annual Average TN of 8 mg/L	Modifications to Achieve Seasonal TN of 5 mg/L	Modifications to Achieve Annual Average TN of 5 mg/L	Special Conditions
Create Ludzack-Ettinger configuration	1 new aeration tank; conversion of existing to plug flow; aeration equipment; nitrate recycle pumps; 1 new clarifier	2 new aeration tanks; conversion of existing to plug flow; aeration equipment; nitrate recycle pumps; 1 new clarifier	1 new aeration tank; conversion of existing to plug flow; aeration equipment; nitrate recycle pumps; 1 new clarifier; methanol feed facility	2 new aeration tanks; conversion of existing to plug flow; aeration equipment; nitrate recycle pumps; 1 new clarifier; methanol feed facility	Space-limited site

The cost estimating procedures established in Section 2 were used to estimate capital, annual O&M, and 20-year present worth costs associated with the process changes and facility modifications summarized above. The cost estimates for the process modifications described above are included in Table 5.2-12.

The table also includes costs for a potential MLE configuration. As noted in Section 2, the first anoxic and aerobic volumes from the Bardenpho configuration are assumed to be the volume for the MLE process. This cost is included since it is unknown whether permitted flows will ever be reached and since no nitrogen data or influent characterization was available to calibrate the model. The sizing is not based on model runs; it is included only to give a relative cost for a potentially smaller MLE system. At Palmer, the decreased volume means that one fewer new aeration tank is required for annual permit conditions and no additional bioreactor volume for is required for seasonal permit conditions. Everything else is assumed to be the same between the process alternatives.

Table 5.2-12

COST SUMMARY FOR NITROGEN REMOVAL AT PALMER WPCF[1]

LIMIT	CAPITAL COSTS (IN MILLIONS)	TOTAL ANNUAL COSTS[2] (IN THOUSANDS)	20-YR PRESENT WORTH (IN MILLIONS)
Minor Modifications/Retrofits	minor	n/a	n/a
Seasonal Effluent TN of 8 mg/L	$18	$340	$22
Seasonal MLE Configured Tanks	$13	$330	$18
Annual Average Effluent TN of 8 mg/L	$22	$380	$27
Annual MLE Configured Tanks	$18	$370	$22
Seasonal Effluent TN of 5 mg/L	$18	$400	$23
Annual Average Effluent TN of 5 mg/L	$23	$570	$30

1. It should be noted that these costs represent one method by which this facility can achieve the stated TN goals. It is not intended to be the most cost effective method nor the recommended method, but it represents a planning tool for MassDEP to estimate the fiscal impacts of establishing total nitrogen limits.
2. Represents incremental increase over current conditions.

(continued)

5.3 WARE

A. **Introduction.** The Ware wastewater treatment facility is located on Robbins Road in Ware, MA. It has a permitted capacity of 1 mgd and serves the Town of Ware. There is only one remaining industrial discharger to the facility which contributes highly variable flows and loads to the facility. The discharger does not pre-treat their wastewater contribution to the facility.

The original facility included a primary clarifier and an anaerobic digester with sludge drying beds. Between 1981 and 1983, the facility was converted to extended aeration activated sludge designed for 2 mgd average daily flow. Changes that have occurred since 1983 include updating the facility for chemical addition, decommissioning the belt filter presses, and other minor modifications. The facility also was derated to 1 mgd during the Year 2000 permitting cycle due to the reduced industrial flow.

B. **Existing Facilities.**

1. **Description of Existing Facilities.** Flow is conveyed to the treatment facility via gravity sewers at which point it is pumped to the grit removal units. A Total Maximum Daily Load for the headworks is currently being established for the facility.

Aerial photo from www.google.com

There are no primary clarifiers at the facility, so after grit removal, the flow enters the aeration tanks. The facility has two 3-chamber aeration tanks with each chamber 60 ft square with a 13 ft sidewater depth. Mechanical aerators are used for aeration. The two secondary clarifiers are 56 feet in diameter and 15 feet in depth.

Secondary effluent receives chlorine disinfection seasonally and then flows by gravity to the Ware River. A liquid process flow schematic of the existing facility is shown in Figure 5.3-1.

Liquid sludge is stored in the former anaerobic digester which has been converted to a sludge storage tank. Liquid sludge is then trucked off site for incineration. Therefore, there are no recycle flows.

One aeration tank is in service at a time, and both secondary clarifiers and both chlorine contact tanks are in service. Nitrification is only required in the summer months, but the plant does not try to suppress nitrification at any time of the year. The summertime nitrification is accompanied by a significant drop in alkalinity. Soda ash is added to keep the alkalinity up in the summer through the end of October.

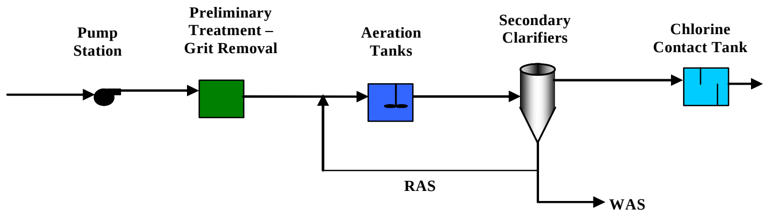


FIGURE 5.3-1: PROCESS FLOW SCHEMATIC – EXISTING FACILITY

The plant has three full-time operators.

The open space west of the aeration tanks is where the old sludge drying beds are located. The surrounding area is undeveloped, as shown in the aerial photo, and this land is owned by the town. New structures would be supported by footings since the soil in the area is good.

2. **Summary of Plant Data.** Data from January 2004 through December 2006 were provided by the Town for this study. A summary of the monthly data is shown in Table 5.3-1. Seasonal and annual average and maximum month data is summarized in the table.

(continued)

<u>**Table 5.3-1**</u>

WARE WWTF

Ware, Massachusetts

Monthly Averages 2003-2006

GENERAL		INFLUENT							EFFLUENT								
DATE		INF	pH	BOD	TSS	TVSS	TEMP	DO	DO	pH	BOD	TSS	NO2	NO3	TKN	AMMONIA NITROGEN
MONTH	YEAR	MGD		MG/L	MG/L	MG/L	DEG F	MG/L	MG/L		MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
January	2004	0.7	7.2	157.9	136.9	100.0	52.9	4.8	4.8	7.1	14.4	11.0			7.4	5.4
February	2004	0.6	7.3	173.4	256.0	180.0	52.4	4.0	4.4	7.2	14.9	15.0			17.4	
March	2004	0.7	7.3	207.0	135.4	74.9	54.2	4.9	4.2	7.2	13.4	11.2		2.3	12.9	
April	2004	1.0	7.1	162.5	129.4	105.6	55.9	5.2	4.0	6.9	10.7	10.8	3.2			1.5
May	2004	0.8	7.1	155.0	209.8	127.5	60.3	4.4	3.5	6.8	12.1	13.3		0.2		0.6
June	2004	0.6	7.2	184.7	216.5	185.8	64.8	3.0	3.4	6.7	17.2	10.8		5.8	4.2	0.6
July	2004	0.5	7.3				67.5	2.4	3.5	6.8			3.4	3.4	3.1	0.5
August	2004	0.6	7.3	208.8	250.4	205.3	69.1	3.1	4.1	6.6	15.4	10.3		2.0	1.7	0.4
September	2004	0.6	7.3	199.7	271.2	208.8	68.8	4.5	4.8	6.8	10.8	13.8		9.8	0.2	0.4
October	2004	0.6	7.4	189.2	246.0	161.0	64.7	4.5	4.6	6.9	11.1	13.8		12.0	2.2	0.8
November	2004	0.6	7.5	217.1	234.8	174.0	62.0	5.3	5.4	7.0	15.9	12.5		6.0	3.6	1.0
December	2004	0.7	7.5	207.3	171.2	134.0	57.9	6.0	6.2	7.0	15.7	13.6		8.4	3.6	3.6
January	2005	0.8	7.3	187.9	189.0	157.0	55.5	6.7	6.7	7.1	19.3	15.5		6.3	6.3	1.1
February	2005	0.8	7.3	195.9	178.0	138.0	53.8	7.2		7.3	17.4	12.0		22.0	22.0	12.0
March	2005	0.8	7.4	150.7	170.4	146.0	55.6	7.0	6.7	7.4	16.7	13.8		12.0	12.0	8.0
April	2005	1.2	7.1	150.4	135.0	88.0	57.4	7.2	6.4	7.1	12.5	12.3		5.0	5.0	3.4
May	2005	0.8	7.3	169.2	159.0	100.0	60.1	6.3	6.2	7.2	18.3	13.3		11.0	11.0	
June	2005	0.6	7.4	233.7	220.0	156.0	67.3	4.6	5.1	6.8	15.6	11.8		1.9	1.9	0.5
July	2005	0.6	7.4	255.8	257.5	207.5	70.1	4.5	5.2	6.9	19.8	15.5		1.1	1.1	0.3
August	2005	0.5	7.4	237.7	217.6	155.7	72.1	4.0	5.2	6.8	20.2	12.8		2.2	2.2	0.8
September	2005	0.5	7.5	242.5	257.8	200.3	70.8	4.2	5.3	6.8	14.1	9.0		2.0	2.0	0.7
October	2005	1.1	7.1	188.4	190.0	161.7	64.9	6.1	6.4	6.8	17.6	9.0		1.2	1.2	0.6
November	2005	1.0	7.0	183.3	172.0	143.2	61.8	6.4	6.8	6.9	15.0	9.6		4.4	4.4	1.2
December	2005	0.9	7.0	171.2	144.0	134.0	57.1	6.9	7.1	6.9	15.2	16.8		4.0	4.0	1.4
January	2006	1.2	6.9	187.9	203.0	95.0	53.5	7.4	7.4	6.9	15.9	15.3	10.0	10.0	10.0	2.0
February	2006	1.1	7.0	143.4	194.0	148.0	53.3	7.2	7.3	6.9	14.4	13.3	5.0	5.0	5.0	2.8
March	2006	0.7	7.1	248.3	242.0	157.0	54.0	6.9	6.8	7.0	22.2	19.2	14.0	14.0	14.0	
April	2006	0.6	7.1	242.9	231.4	190.6	57.2	6.8	5.9	6.7	19.2	16.0	14.0	14.0	14.0	
May	2006	0.7	7.1	238.3	188.2	166.2	60.4	6.1	5.6	6.8	17.6	11.4	15.0	15.0	15.0	
June	2006	0.8	7.0	198.3	231.0	142.0	65.8	5.4	4.8	6.7	14.2	12.5	12.0	12.0	12.0	1.3
July	2006	0.6	6.9	178.8	238.3	153.3	69.0	4.8	4.6	6.7	15.0	18.5	8.8	8.8	8.8	0.8
August	2006	0.5	7.1	237.7	288.7	199.7	70.0	4.8	5.1	6.9	22.2	12.0	18.0	18.0	18.0	1.4
September	2006	0.5	7.1	258.0	312.9	235.8	67.3	4.9	5.1	6.9	24.7	11.5	14.0	14.0	14.0	0.8
October	2006	0.5	7.1	273.8	245.8	150.9	63.8	5.3	5.1	6.9	24.7	10.3	14.0	14.0	14.0	0.7
November	2006	0.6	7.0	268.7	288.0	213.0	61.7	5.7	5.4	6.8	22.9	9.4	1.5	1.5	1.5	1.5
December	2006	0.6	7.0	273.3	251.0	200.0	58.5	6.3	5.7	6.9	15.0	15.6	12.0	12.0	12.0	1.3
Min. Month		0.5	6.9	143.4	129.4	74.9	52.4	2.4	3.4	6.6	10.7	9.0	1.5	0.2	0.2	0.3
Seasonal Average		**0.7**	**7.0**	**229.1**	**235.3**	**171.6**	**66.5**	**4.6**	**4.9**	**6.8**	**17.1**	**12.3**	**12.2**	**7.5**	**6.6**	**0.7**
Average Annual		**0.7**	**7.2**	**205.1**	**213.2**	**157.0**	**61.4**	**5.4**	**5.4**	**6.9**	**16.6**	**12.9**	**10.4**	**7.9**	**7.9**	**1.9**
Max. Month		1.2	7.5	273.8	312.9	235.8	72.1	7.4	7.4	7.4	24.7	19.2	18.0	22.0	22.0	12.0

With a current average daily flow of 0.678 mgd and a permitted capacity of 1 mgd, this facility is operating at approximately 68% of its permitted hydraulic capacity. The facility was designed for an average daily flow of 2 mgd before being derated to 1 mgd, therefore it is operating at approximately 34% of its design average daily flow. Based on the average BOD concentration of 205 mg/L and TSS concentration of 213 mg/L, this wastewater would be considered medium strength. With these concentrations, the facility is operating over 50% of its design BOD and solids capacity. No influent nitrogen data is available for this plant.

3. **Permit Requirements and Current Performance.** The current permit for this facility has been in effect since September 29, 2000. Monthly permit limits that are relevant to this study are shown below in Table 5.3-2.

Table 5.3-2

SELECT MONTHLY PERMIT LIMITS

PARAMETER	LIMIT
BOD5	25 mg/L
TSS	25 mg/L
TKN	Report
Nitrite+Nitrate Nitrogen	Report
Ammonia Nitrogen June - October	1 mg/L

The above BOD and TSS limits have been met in all months of the data collection period.

4. **Nitrogen Removal Performance.** This facility is nitrifying during the months required, so ammonia limits are being met. In addition, the effluent data seem to indicate that nitrification is happening in other months as well although not year-round.

C. **Nitrogen Removal Alternatives.** The existing maximum month loads over the three-year data collection period were used to determine the BioWin input data. The raw influent data which correspond to maximum-month loads is shown in Table 5.3-3 below for each permitting scenario. The minimum temperature for the permit condition is also shown. In addition, due to a lack of influent nitrogen data, the TN/BOD ratio was estimated to be 0.18.

Table 5.3-3

EXISTING INFLUENT PARAMETERS

PERMIT CONDITION	PARAMETER	VALUE
Average Annual	Flow, mgd	1.1
	BOD, mg/L	188
	TSS, mg/L	196
	TN, mg/L	34
	Temperature, F	53
Seasonal	Flow, mgd	1.1
	BOD, mg/L	188
	TSS, mg/L	196
	TN, mg/L	34
	Temperature, F	60

The existing plant data was then projected to the permitted capacity of the facility to develop model input parameters for the average annual and seasonal model runs. The resultant data is shown in Table 5.3-4.

Table 5.3-4

MODEL INPUT PARAMETERS AT PERMITTED CAPACITY

PERMIT CONDITION	PARAMETER	VALUE
Average Annual	Flow, mgd	3.1
	BOD, mg/L	188
	TSS, mg/L	196
	TN, mg/L	34
	Temperature, F	53
Seasonal	Flow, mgd	3.1
	BOD, mg/L	188
	TSS, mg/L	196
	TN, mg/L	34
	Temperature, F	60

The model input data was used to run uncalibrated simulations to determine planning level, order-of-magnitude costs for implementing different levels of nitrogen reduction at the facility. The baseline model for the facility predicted lower BOD and TKN effluent concentrations than the plant data reports. This is likely due to the effects of the industrial discharger which are not adequately captured in the uncalibrated model. The SIU discharge contains inert solids and heavy metals which can hinder nitrification, and the discharge can also be nutrient (phosphorus) limited which can effect biological performance. A discussion of operational changes or minor modifications that can be made to the facility to improve current nitrogen reduction performance as well as a presentation of the simulation results are presented in the following sections.

1. **Minor Modifications/Retrofits.** The facility is already nitrifying consistently in the summer and is operating with an SRT that should be sufficient to nitrify in the winter (if inhibition is not occurring). Since the partition walls already exist, the first portion of the aeration tanks could be operated in an anoxic mode if mechanical aerators are turned off. Timers could be added to aid the operation. The anoxic zone most likely will become anaerobic once the nitrate available is used up.

2. **Modifications Required to Meet TN of 8 mg/L.** The modifications to the facility that are required to meet an effluent TN of 8 mg/L on a seasonal and annual average basis are as follows.

a. **Seasonal.** At the assumed influent TN levels for this facility, an MLE process will accomplish a seasonal effluent TN level of 8 mg/L. Thus, an MLE process is recommended as shown in the BioWin model in Figure 5.3-2 below.

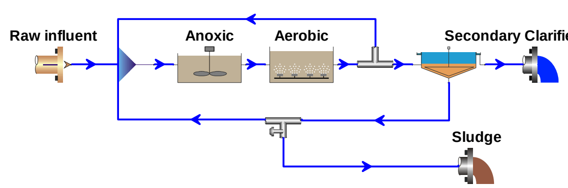
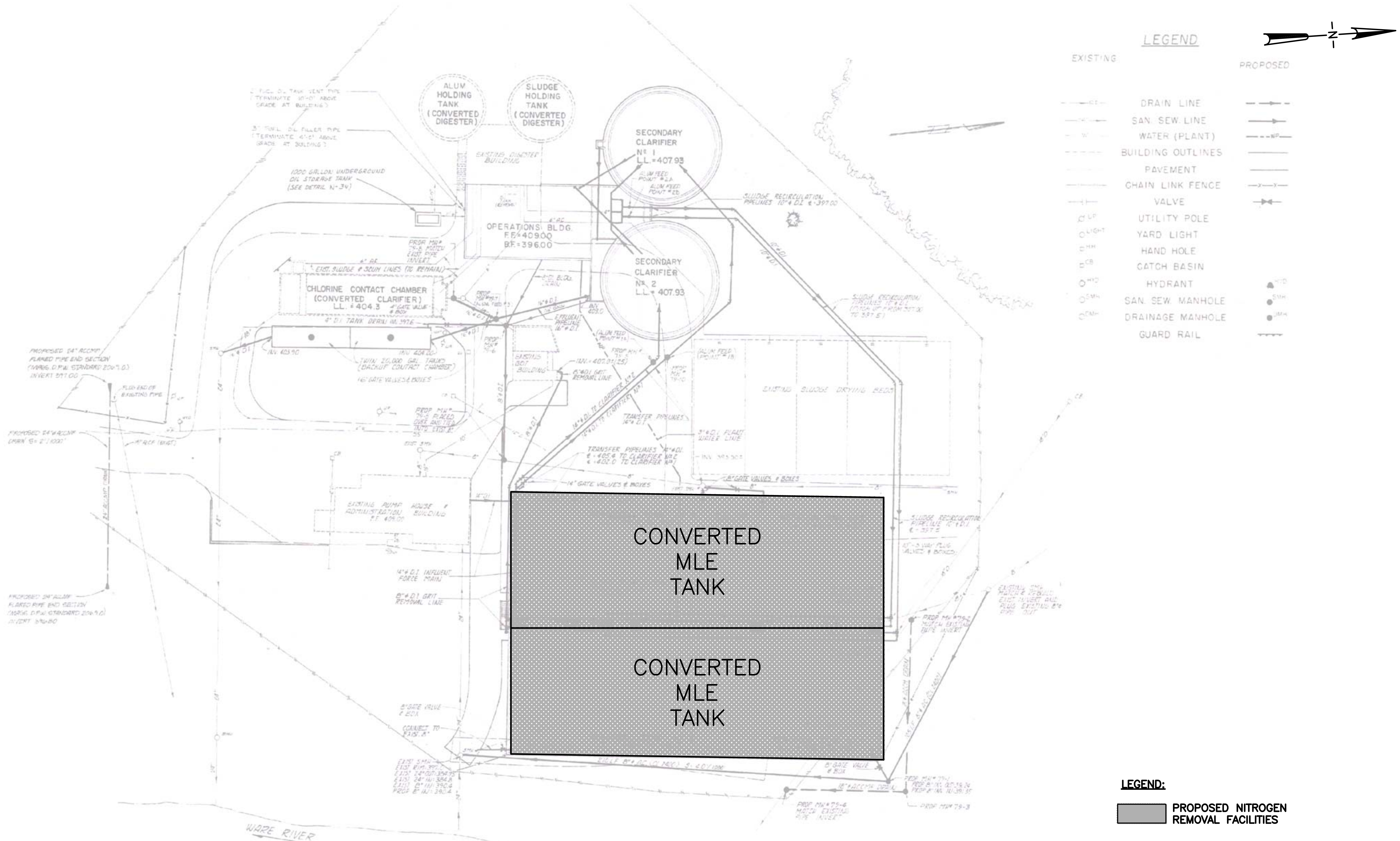


FIGURE 5.3-2: BIOWIN MODEL FOR SEASONAL TN LIMIT OF 8 mg/L

The MLE process can fit within the existing tanks as shown in the site plan in Figure 5.3-3. In order to modify the existing tanks to an MLE process, it is assumed that the two tanks will be converted to parallel plug flow tanks so some structural modifications will be required. It also is assumed that fine bubble diffusers and blowers will be installed as well as nitrate recycle pumps. It is anticipated that no new secondary clarifiers will be required to operate the facility at the resultant model MLSS concentration. It should be noted that the existing clarifiers at this facility are 15 feet deep which is greater than the minimum listed in TR-16.



LEGEND:

PROPOSED NITROGEN REMOVAL FACILITIES

NOTE:
1. Background is from Drawing 2 from Contract Documents entitled "ADVANCED WW TREATMENT WORKS" by ALMER HUNTLEY JR & ASSOCIATES and dated 1979.

2. Auxiliary facilities associated with nitrogen removal processes are not shown.

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Filename: FIG5-3-3.DWG
Latest Revision: Tuesday, June 03, 2008

STEARNS & WHELER LLC
Environmental Engineers & Scientists
1545 Iyannough Road, Route 132
Hyannis, MA 02601
Tel: (508) 362-5680
Fax: (508) 362-5684
www.stearnswheler.com

CDM
Camp Dresser & McKee Inc.
One Cambridge Place, 50 Hampshire Street
Cambridge, MA 02139
Tel: (617) 452-6000
consulting • engineering • construction • operations

ENGINEERING FEASIBILITY AND COST ANALYSES OF NITROGEN REDUCTION FROM SELECTED POTWS IN MASSACHUSETTS

WARE, MASSACHUSETTS
FIGURE 5.3-3

Specific information regarding the design results is shown in Table 5.3-5 below.

Table 5.3-5

RESULTS FOR SEASONAL LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Aerobic SRT	5.5 days
Total SRT	7.2 days
First Anoxic Fraction	30%
Total Anoxic Fraction	30%
Reaeration HRT	N/A
Total Volume	2.1 MG (existing)
RAS Rate	50%
Nitrate Recycle Rate	400%
Max MLSS at Loading Rate	1,800 mg/L
Effluent TN	7.7 mg/L
Methanol Addition	No
Fixed Film Required?	No
Clarifiers?	No new clarifiers
Effluent Filtration Required?	No

Other plant modifications may be needed including upgrades to sludge handling. However, all facilities outside of the activated sludge process are outside of the scope of this study.

b. **Annual Average.** At the assumed influent TN levels for this facility, an MLE process will accomplish an annual effluent TN level of 8 mg/L. Thus, an MLE process is recommended as shown in the BioWin model in Figure 5.3-4 below.

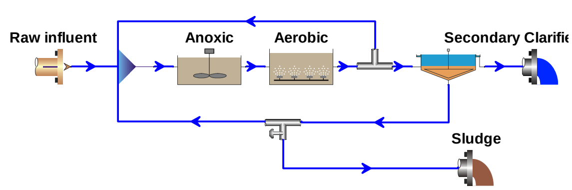


FIGURE 5.3-4: BIOWIN MODEL FOR ANNUAL AVERAGE TN LIMIT OF 8 mg/L

The MLE process can fit within the existing tanks as shown in the site plan in Figure 5.3-3. In order to modify the existing tanks to an MLE process, it is assumed that the two tanks will be converted to parallel plug flow tanks so some structural modifications will be required. It also is assumed that fine bubble diffusers and blowers will be installed as well as nitrate recycle pumps. It is anticipated that no new secondary clarifiers will be required to operate the facility at the resultant model MLSS concentration. It should be noted that the existing clarifiers at this facility are 15 feet deep which is greater than the minimum listed in TR-16.

Specific information regarding the design results is shown in Table 5.3-6 below.

Table 5.3-6

MODELING RESULTS FOR ANNUAL AVERAGE LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Aerobic SRT	8.0 days
Total SRT	11.4 days
First Anoxic Fraction	30%
Total Anoxic Fraction	30%
Reaeration HRT	N/A
Total Volume	2.1 MG (existing)
RAS Rate	50%
Nitrate Recycle Rate	400%
Max MLSS at Loading Rate	2,700 mg/L
Effluent TN	7.9 mg/L
Methanol Addition	No
Fixed Film Required?	No
Clarifiers?	No new clarifiers
Effluent Filtration Required?	No

Other plant modifications may be needed including upgrades to sludge handling. However, all facilities outside of the activated sludge process are outside of the scope of this study.

3. **Modifications Required to Meet a TN of 5 mg/L.** The modifications to the facility that are required to meet an effluent TN of 5 mg/L on a seasonal and annual average basis are as follows.

a. **Seasonal.** At the assumed influent TN levels for this facility, a four stage Bardenpho process is recommended to achieve a seasonal effluent TN of 5 mg/L as shown in the BioWin model in the following Figure 5.3-5.

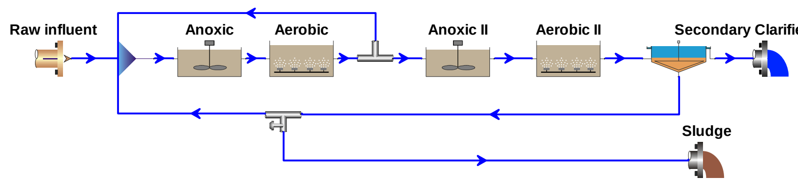
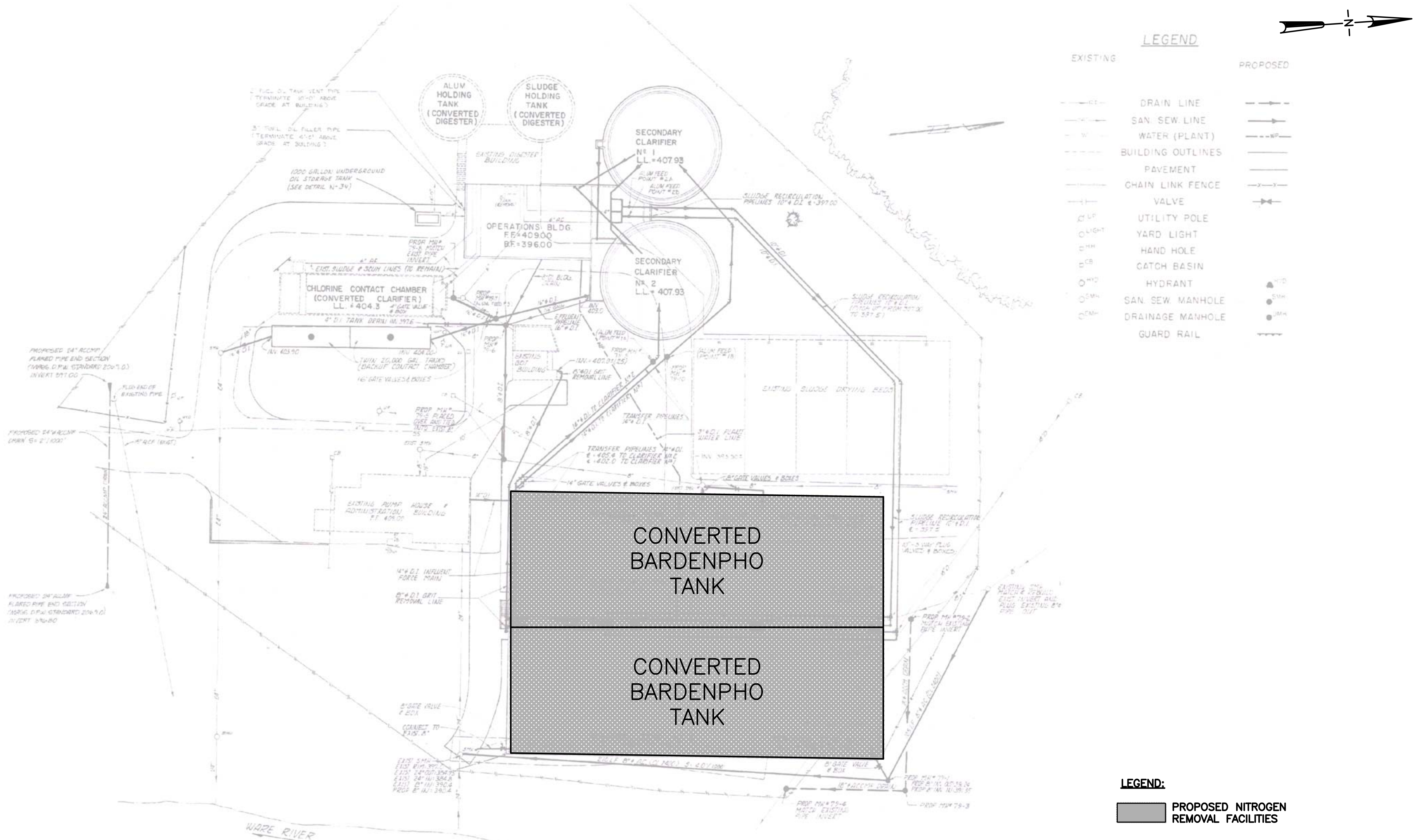


FIGURE 5.3-5: BIOWIN MODEL FOR SEASONAL TN LIMIT OF 5 mg/L

This process can fit within the existing tanks as shown in the site plan in Figure 5.3-6. In order to modify the existing tanks to a four-stage Bardenpho process, it is assumed that the two tanks will be converted to parallel plug flow tanks. More substantial structural modifications will be required for Bardenpho since there are more stages in the Bardenpho process. It also is assumed that fine bubble diffusers and blowers will be installed as well as nitrate recycle pumps. It is anticipated that no new secondary clarifiers will be required to operate the facility at the resultant model MLSS concentration. It should be noted that the existing clarifiers at this facility are 15 feet deep which is greater than the minimum listed in TR-16.

(continued)



NOTE:

1. Background is from Drawing 2 from Contract Documents entitled "ADVANCED WW TREATMENT WORKS" by ALMER HUNTLEY JR & ASSOCIATES and dated 1979.
2. Auxiliary facilities associated with nitrogen removal processes are not shown.

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STEARNS & WHELER LLC
Environmental Engineers & Scientists
1545 Iyannough Road, Route 132
Hyannis, MA 02601
Tel: (508) 362-5680
Fax: (508) 362-5684
www.stearnswheler.com

CDM
Camp Dresser & McKee Inc.
One Cambridge Place, 50 Hampshire Street
Cambridge, MA 02139
Tel: (617) 452-6000
consulting • engineering • construction • operations

ENGINEERING FEASIBILITY AND COST ANALYSES OF NITROGEN REDUCTION FROM SELECTED POTWS IN MASSACHUSETTS

WARE, MASSACHUSETTS
FIGURE 5.3-6

Specific information regarding the design results is shown in Table 5.3-7 below.

<u>Table 5.3-7</u>

RESULTS FOR SEASONAL LIMIT OF 5 mg/L TN

PARAMETER	VALUE
Aerobic SRT	5.5 days
Total SRT	9.2 days
First Anoxic Fraction	23%
Total Anoxic Fraction	43%
Reaeration HRT	20 minutes
Total Volume	2.1 MG (existing)
RAS Rate	50%
Nitrate Recycle Rate	300%
Max MLSS at Loading Rate	2,300 mg/L
Effluent TN	4.6 mg/L
Methanol Addition	No
Fixed Film Required?	No
Clarifiers?	No new clarifiers
Effluent Filtration Required?	No

Other plant modifications may be needed including upgrades to sludge handling. However, all facilities outside of the activated sludge process are outside of the scope of this study.

b. **Annual Average.** At the assumed influent TN levels for this facility, a four stage Bardenpho process is recommended to achieve a seasonal effluent TN of 5 mg/L as shown in the BioWin model in Figure 5.3-7.

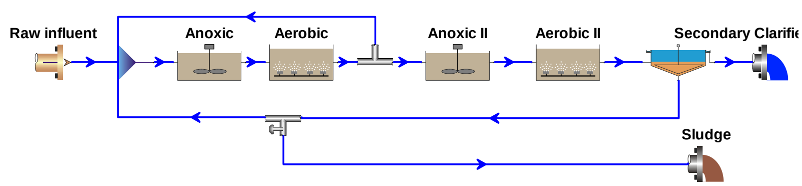

FIGURE 5.3-7: BIOWIN MODEL FOR ANNUAL AVERAGE TN LIMIT OF 5 mg/L

This process can fit within the existing tanks as shown in the site plan in Figure 5.3-6. In order to modify the existing tanks to a four-stage Bardenpho process, it is assumed that the two tanks will be converted to parallel plug flow tanks. More substantial structural modifications will be required for Bardenpho since there are more stages in the Bardenpho process. It also is assumed that fine bubble diffusers and blowers will be installed as well as nitrate recycle pumps. It is anticipated that no new secondary clarifiers will be required to operate the facility at the resultant model MLSS concentration. It should be noted that the existing clarifiers at this facility are 15 feet deep which is greater than the minimum listed in TR-16.

Specific information regarding the modeling results is shown in Table 5.3-8 below.

Table 5.3-8

RESULTS FOR ANNUAL AVERAGE LIMIT OF 5 mg/L TN

PARAMETER	VALUE
Aerobic SRT	8.0 days
Total SRT	13.3 days
First Anoxic Fraction	25%
Total Anoxic Fraction	40%
Reaeration HRT	20 minutes
Total Volume	2.1 MG (existing)
RAS Rate	50%
Nitrate Recycle Rate	300%
Max MLSS at Loading Rate	3,000 mg/L
Effluent TN	4.8 mg/L
Methanol Addition	No
Fixed Film Required?	No
Clarifiers?	No new clarifiers
Effluent Filtration Required?	No

Other plant modifications may be needed including upgrades to sludge handling. However, all facilities outside of the activated sludge process are outside of the scope of this study.

D. Plant and Cost Summary.

The following Table 5.3-9 presents flow data for the Ware WWTP as well as the current nitrogen removal performance of the plant. As shown, the facility seems to be achieving some nitrogen removal with their current configuration. The facility currently is permitted at 1 mgd, but it used to be permitted for 2 mgd so there is excess hydraulic capacity. The facility has one significant industrial user with no pre-treatment. Pre-treatment of the industrial discharge may be required in order to achieve consistent biological nutrient removal.

Table 5.3-9

PLANT FLOW AND EFFLUENT LIMIT SUMMARY

PARAMETER	VALUE
Permitted Flow (mgd)	1.0
Existing Flow (2004-6)	0.7
% of permitted capacity	67.8
Current average seasonal effluent TN (mg/L)[1]	14.1
Current average annual effluent TN (mg/L)[1]	15.8
Permit Limits Seasonal Nitrification (mg/L) Year-round nitrification (mg/L) Seasonal TN Limit Annual TN Limit	 Yes (1) Report Report Report

Table 5.3-10 presents the nitrogen removal processes required to meet the four different permit conditions considered. Based on the BioWin modeling performed, the facility will need to convert to a Modified Ludzack-Ettinger process to consistently meet a TN limit of 8 mg/L both seasonally and year-round. The BioWin models were run at permitted capacity and with an assumed ammonia to BOD ratio since no influent nitrogen data was available. The modeling also predicts that the facility will have to convert to a Bardenpho process to meet 5 mg/L.

Table 5.3-10

NITROGEN REMOVAL PROCESS SUMMARY FOR WARE WWTF

EXISTING PROCESS	PROCESS TO ACHIEVE SEASONAL TN OF 8 MG/L	PROCESS TO ACHIEVE ANNUAL AVERAGE TN OF 8 MG/L	PROCESS TO ACHIEVE SEASONAL TN OF 5 MG/L	PROCESS TO ACHIEVE ANNUAL AVERAGE TN OF 5 MG/L
Activated sludge w/ mechanical aerators	MLE	MLE	Bardenpho	Bardenpho

The modifications required at Ware to convert to a new nitrogen removal process are summarized in Table 5.3-11. As noted, timers could be added to the mechanical aerators so that cyclical aeration could be instituted for nitrogen removal. A calibrated model could be run to indicate how effective this technique would be at Ware.

Table 5.3-11
REQUIRED MODIFICATIONS SUMMARY FOR WARE WWTF

MINOR MODIFICATIONS/ RETROFITS	MODIFICATIONS TO ACHIEVE SEASONAL TN OF 8 MG/L	MODIFICATIONS TO ACHIEVE ANNUAL AVERAGE TN OF 8 MG/L	MODIFICATIONS TO ACHIEVE SEASONAL TN OF 5 MG/L	MODIFICATIONS TO ACHIEVE ANNUAL AVERAGE TN OF 5 MG/L	SPECIAL CONDITIONS
Install timers for cyclical aeration	Modify 2 existing aeration tanks to plug flow; aeration equipment; nitrate pumps	Modify 2 existing aeration tanks to plug flow; aeration equipment; nitrate pumps	Modify 2 existing aeration tanks to plug flow; aeration equipment; nitrate pumps	Modify 2 existing aeration tanks to plug flow; aeration equipment; nitrate pumps	Establishing a TMDHL for the facility due to SIU with no pre-treatment

The cost estimating procedures established in Section 2 were used to estimate capital, annual O&M, and 20-year present worth costs associated with the process changes and facility modifications summarized above. The cost estimates are included in Table 5.3-12.

Table 5.3-12
COST SUMMARY FOR NITROGEN REMOVAL AT WARE WWTF[1]

LIMIT	CAPITAL COSTS (IN MILLIONS)	TOTAL ANNUAL COSTS[2] (IN THOUSANDS)	20-YR PRESENT WORTH (IN MILLIONS)
Minor Modifications/Retrofits	minor	n/a	n/a
Seasonal Effluent TN of 8 mg/L	$6.6	$210	$9.2
Annual Average Effluent TN of 8 mg/L	$6.6	$220	$9.3
Seasonal Effluent TN of 5 mg/L	$6.6	$200	$9.2
Annual Average Effluent TN of 5 mg/L	$6.6	$210	$9.3

1. It should be noted that these costs represent one method by which this facility can achieve the stated TN goals. It is not intended to be the most cost effective method nor the recommended method, but it represents a planning tool for MassDEP to estimate the fiscal impacts of establishing total nitrogen limits.
2. Represents incremental increase over current conditions.