Section 4

Connecticut River Watershed

SECTION 4 – CONNECTICUT RIVER WATERSHED

4.1 INTRODUCTION

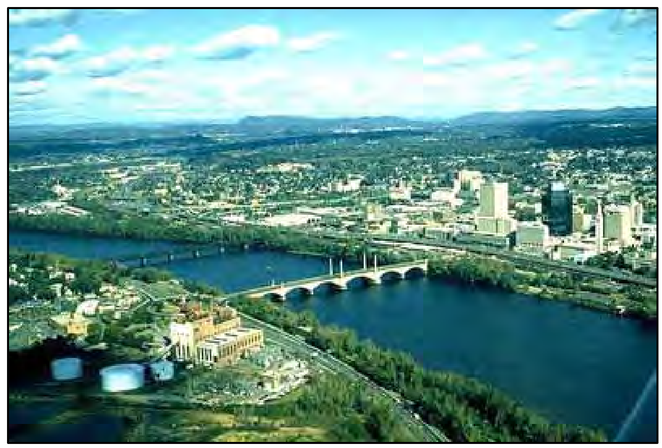

Image from www.ctriver.org

The Connecticut River is New England's longest river spanning a distance of over 400 miles. It begins in the Fourth Connecticut Lake at the Canadian border. It flows southward, bordering Vermont and New Hampshire, through central Massachusetts and Connecticut until ultimately discharging to Long Island Sound. A number of sub-watersheds discharge into this river including the following ones which are part of this study: Chicopee River (Section 5), Millers River (Section 6), Deerfield River (Section 7) and Westfield River (Section 8).

This study includes seven POTWs that discharge directly to the Connecticut River. Figure 4.1-1 shows the Connecticut River watershed and the table below lists the seven facilities with their respective sizes. The impact of nitrogen removal at each of these facilities is presented in this section.

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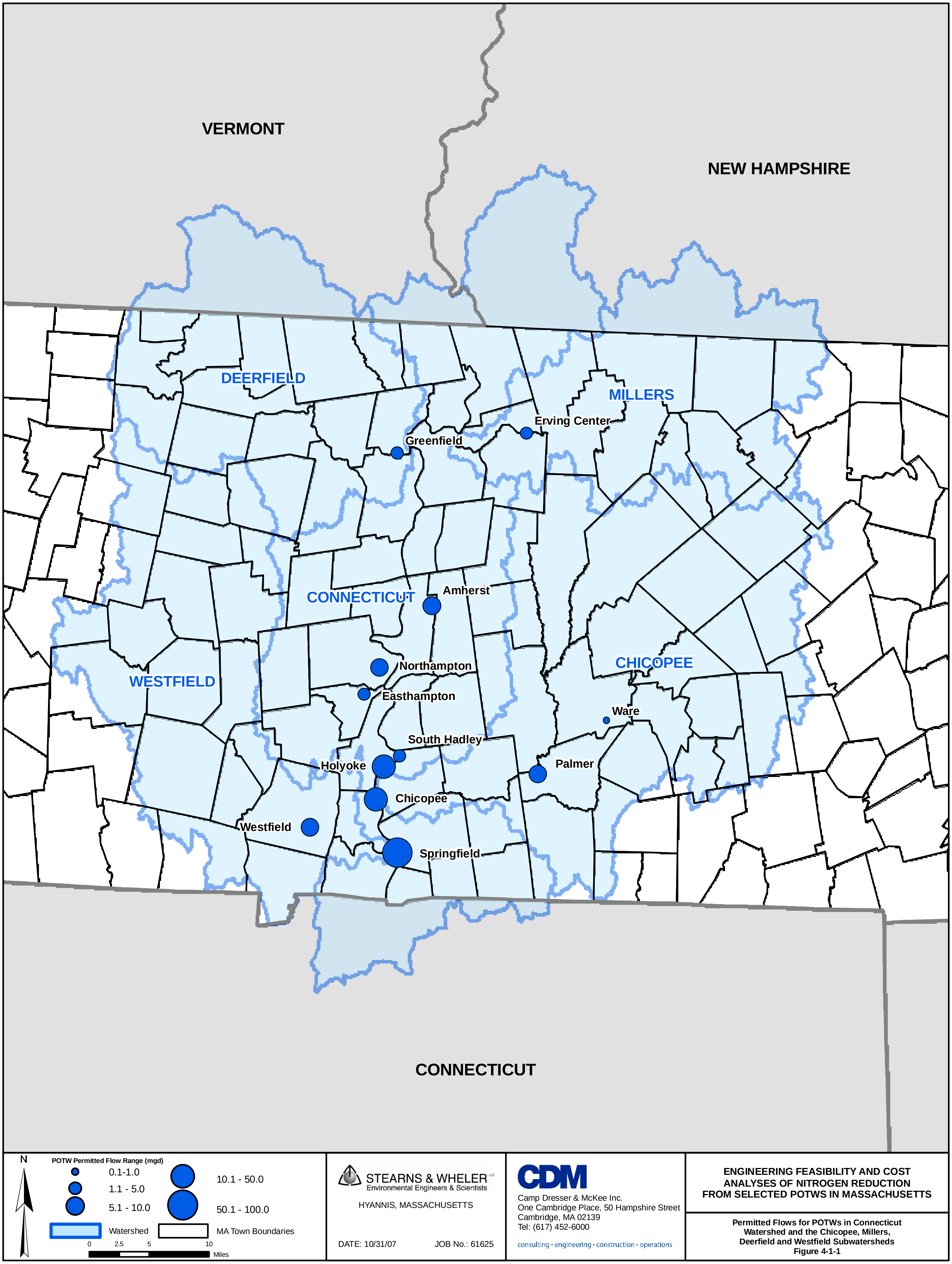

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CDM
Camp Dresser & McKee Inc.
One Cambridge Place, 50 Hampshire Street
Cambridge, MA 02139
Tel: (617) 452-6000
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ENGINEERING FEASIBILITY AND COST ANALYSES OF NITROGEN REDUCTION FROM SELECTED POTWS IN MASSACHUSETTS

Permitted Flows for POTWs in Connecticut Watershed and the Chicopee, Millers, Deerfield and Westfield Subwatersheds
Figure 4-1-1

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Table 4.1-1

CONNECTICUT RIVER POTWs

NAME OF FACILITY	PERMITTED CAPACITY
Springfield	67.0 mgd
Amherst	7.1 mgd
Northampton	8.6 mgd
Holyoke	17.5 mgd
Chicopee	15.5 mgd
Easthampton	3.8 mgd
S. Hadley	4.2 mgd

(continued)

4.2 SPRINGFIELD

A. **Introduction.** The Springfield wastewater treatment facility is located at Route 5 Bondi Island in Agawam, MA. It has a permitted average annual capacity of 67 mgd facility and serves eight communities: Springfield, Wilbraham, West Springfield, Ludlow, Longmeadow, East Longmeadow, Chicopee and Agawam. The flow comprises of 18% industrial, 49% domestic and commercial and 33% I/I. Sixty percent of Springfield's service area is served by a combined collection system.

The majority of the current facility was built in 1977. Prior to 1977, primary clarifiers and anaerobic digesters existed on the site. Changes that have occurred since 1977 include the replacement of the vacuum filters with belt filter presses, replacement of the DAFs with gravity belt thickeners and conversion of the mechanical aeration system to diffused aeration in 1997-1998. This upgrade also included installing aluminum baffle walls in the first section of the aeration tanks and installation of submersible mixers to form pre-anoxic zones.

B. **Existing Facilities.**

Aerial photo from www.google.com

1. **Description of Existing Facilities.** All flow conveyed to the Springfield Wastewater Treatment Facility (WWTF) enters the influent structure to receive preliminary treatment. Preliminary treatment consists of mechanically-cleaned coarse bar screens. Four parallel channels leave the screenings building into an influent distribution chamber. The distribution chambers direct the flow to the four primary sedimentation basins. Grit is removed from the primary clarifiers with dilute primary sludge. After primary sedimentation, primary effluent flows by gravity through closed conduit to the aeration tanks.

The facility has four aeration tanks. Each tank is 600 ft long by 100 ft wide with a 15 ft sidewater depth. The first 100 ft of each aeration basin can be operated as a pre-anoxic zone. A flocculation zone is located between the aeration basins and the secondary clarifiers. The four, 50 ft by 100 ft flocculator tank cannot be bypassed. The flocculation tanks are followed by four 12.4 ft deep, 300 ft by 100 ft rectangular clarifiers.

Secondary effluent receives chlorine disinfection and dechlorination prior to being discharged to the Connecticut River. An effluent pump station is available to pump effluent to the river if the water stage in the river is too high for the effluent to flow by gravity. A process flow schematic is shown in Figure 4.2-1.

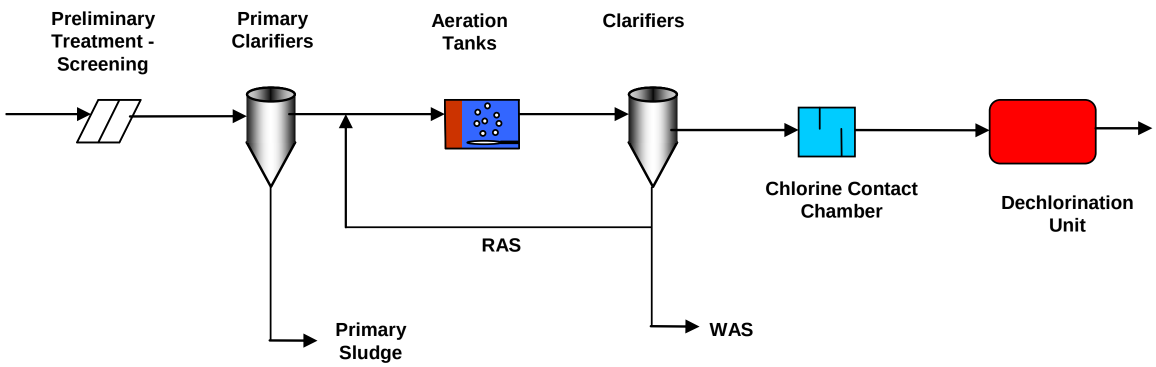


FIGURE 4.2-1: PROCESS FLOW SCHEMATIC – EXISTING FACILITY

Primary sludge and grit are separated by four cyclone degritting systems. Primary sludge is then thickened in three gravity thickeners. It is also stored in the tanks prior to being fed to blending tanks for dewatering. Waste activated sludge is pumped to the old DAFs which now serve as equalization basins prior to being pumped to the gravity belt thickeners. Thickened activated sludge normally is pumped to holding tanks used for blending the thickened waste activated and thickened primary sludges. The thickened sludge is dewatered with belt filter presses. Sludge cake is then conveyed to trucks for disposal in a landfill or into a private onsite composting facility.

The plant recycle flows (including gravity thickener overflow and BFP filtrate) are returned upstream of the primary effluent sampler. Thus, the primary effluent sampler contains all plant flows including internal recycle flows.

Two of the four primary sedimentation basins, all aeration basins, all four secondary clarifiers and all four chlorine contact tanks are on line under normal operation. Nitrification is not required, but the plant is nitrifying year-round according to the operators.

The plant is operated by United Water who has a 20-year operation and maintenance contract which began in 2000.

There is space to construct additional tankage south of the secondary system process tanks as shown in the aerial photograph. All new structures must be installed on piles since the site is located in a marsh area.

2. **Summary of Plant Data.** Data from January 2004 through December 2006 was provided by United Water for this study. A summary of the monthly data is shown in Table 4.2-1. Seasonal and annual average and maximum month data is summarized in the table.

With a current average daily flow of 46.4 mgd and a permitted capacity of 67 mgd, this facility is operating at approximately 69% of its permitted capacity. Based on the average BOD concentration of 168 mg/L and TSS concentration of 155 mg/L, this wastewater would be considered medium strength. No influent nitrogen data is available for this plant.

(continued)

Table 4.2-1
SPRINGFIELD WWTF
Springfield, Massachusetts
Monthly Averages 2003-2006

GENERAL		INFLUENT				PRIMARY EFFLUENT		FINAL EFFLUENT						
DATE		INF	BOD	TSS	TEMP	BOD	TSS	pH	BOD	TSS	NO2 + NO3	TKN	NH3	TN
MONTH	YEAR	MGD	MG/L	MG/L	DEG F	MG/L	MG/L		MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
January	2004				56.1	145.3	107.0							
February	2004	46.6	196.0	202.0	57.2	177.1	104.9	6.8	5.0	8.0	2.1	1.1	0.3	3.6
March	2004	45.9	190.0	157.0	58.3	178.3	89.5	6.8	6.0	9.0	2.2	1.4	0.4	4.0
April	2004	46.3	147.0	139.0	58.8	141.4	97.1	6.6	7.0	11.0	2.5		0.6	3.1
May	2004	46.5	163.0	162.0	64.7	168.6	100.1	6.9	5.0	5.0	3.1		0.3	3.4
June	2004	45.6	190.0	158.0	68.0	169.1	79.0	6.9	5.0	4.0	2.9	1.2	0.4	4.5
July	2004	45.4	176.0	169.0	72.1	154.4	80.4	7.0	4.0	3.0	3.2	1.8	0.3	5.3
August	2004	45.3	197.0	181.0	72.4	173.5	88.1	6.9	4.0	3.0	4.1		0.3	4.5
September	2004	45.2	207.0	199.0	71.3	156.8	78.8	6.9	4.0	3.0	4.4	1.1	0.5	6.0
October	2004	44.5	192.0	166.0	66.7	150.9	76.0	6.8	3.0	3.0	4.0		0.3	4.3
November	2004	43.7	209.0	180.0	64.4	158.1	85.3	6.9	4.0	4.0	4.9	2.0	0.4	7.3
December	2004	43.4	189.0	162.0	59.7	160.6	95.4	6.8	5.0	5.0	3.1		0.4	3.5
January	2005	43.2	170.0	176.0	56.6	142.9	85.8	7.0	11.0	12.0	3.1	1.5	0.4	4.9
February	2005	43.8	167.0	165.0	56.6	141.1	87.5	6.8	9.0	11.0	2.7	1.8	1.6	6.1
March	2005	44.2	179.0	167.0	56.6	150.3	90.5	6.7	7.0	6.0	3.6		0.5	4.0
April	2005	44.2	131.0	127.0	59.3	142.6	92.0	6.6	14.0	21.0	2.8		0.6	3.3
May	2005	44.0	173.0	142.0	63.4	145.3	77.1	6.8	6.0	7.0	2.2	1.2	0.3	3.7
June	2005	43.9	184.0	157.0	69.8	167.6	86.6	6.9	6.0	5.0	2.0	2.4	0.4	4.8
July	2005	43.8	183.0	158.0	71.8	154.9	81.3	6.8	6.0	6.0	3.8	1.6	0.7	6.1
August	2005	43.6	198.0	176.0	73.9	169.3	88.9	6.9	7.0	6.0	4.1	3.2	1.2	8.5
September	2005	43.2	210.0	189.0	72.6	188.8	94.7	6.9	5.0	4.0	2.1	1.6	0.7	4.4
October	2005	45.6	129.0	139.0	66.2	121.7	80.9	6.4	8.0	14.0	2.8		0.2	3.0
November	2005	47.0	147.0	139.0	62.9	127.2	80.5	6.7	7.0	11.0	4.2	1.6	0.9	6.8
December	2005	47.5	156.0	149.0	58.5	133.3	89.9	6.7	7.0	8.0	4.1	1.4	0.5	6.0
January	2006	48.9	123.0	122.0	56.7	112.6	80.4	6.6	9.0	13.0	1.8		0.2	2.0
February	2006	49.9	122.0	108.0	56.5	111.6	71.8	6.8	10.0	12.0	1.0		1.3	
(continued)														

GENERAL		INFLUENT				PRIMARY EFFLUENT		FINAL EFFLUENT						
DATE		INF	BOD	TSS	TEMP	BOD	TSS	pH	BOD	TSS	NO2 + NO3	TKN	NH3	TN
MONTH	YEAR	MGD	MG/L	MG/L	DEG F	MG/L	MG/L		MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
March	2006	49.7	147.0	131.0	58.4	151.6	84.3	6.9	6.0	6.0	2.0	1.8	0.5	4.2
April	2006	48.4	142.0	135.0	61.5	137.2	94.0	6.8	7.0	7.0	2.8	1.4	1.0	5.2
May	2006		130.0	124.0	64.1	132.2	86.9	6.8	7.0	5.0				
June	2006	49.8	132.0	129.0	67.8	125.1	83.2	6.8	6.0	5.0	1.6	2.9	1.5	6.1
July	2006	50.6	135.0	139.0	71.6	119.7	81.5	6.9	7.0	8.0	1.2	2.7	1.7	5.5
August	2006	51.1	165.0	156.0	72.8	145.1	89.7	6.9	4.0	3.0	3.1	2.5	1.5	7.1
September	2006	51.3	180.0	166.0	70.4	149.6	85.1	7.0	4.0	4.0	2.2	5.5	3.3	11.1
October	2006	49.2	160.0	157.0	66.4	138.0	92.0	6.7	5.0	6.0	2.8		0.7	3.5
November	2006	48.4	158.0	142.0	64.5	140.6	80.2	6.9	4.0	6.0	0.1	3.1	1.8	5.0
December	2006	47.5	199.0	161.0	61.8	181.3	86.8	7.0	10.0	13.0	1.8		0.3	2.1
Min. Month		43.2	122.0	108.0	56.1	111.6	71.8	6.4	3.0	3.0	0.1	1.1	0.2	2.0
Seasonal Average		**46.4**	**172.4**	**159.3**	**69.2**	**151.7**	**85.0**	**6.8**	**5.3**	**5.2**	**2.9**	**2.3**	**0.8**	**5.4**
Average Annual		**46.4**	**167.9**	**155.1**	**64.2**	**149.0**	**87.0**	**6.8**	**6.4**	**7.3**	**2.8**	**2.6**	**0.8**	**5.3**
Max. Month		51.3	210.0	202.0	73.9	188.8	107.0	7.0	14.0	21.0	4.9	16.0	3.3	18.2

3. **Permit Requirements and Current Performance.** The current permit for this facility has been in effect since December 8, 2000. Monthly permit limits that are relevant to this study are shown below in Table 4.2-2.

<u>Table 4.2-2</u>

SELECT MONTHLY PERMIT LIMITS

PARAMETER	LIMIT
BOD5	30 mg/L
TSS	30 mg/L
Nitrite+Nitrate Nitrogen	Report
TKN	Report

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

4. **Nitrogen Removal Performance.** The monthly data indicates that TN is generally less than 5 mg/L. The facility currently collects one sample per month; however, past studies during which nitrogen data was collected on a more frequent basis also showed that denitrification is occurring at the facility.

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 primary effluent data which correspond to maximum-month loads is shown in Table 4.2-3 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 0.21.

(continued)

Table 4.2-3

EXISTING PRIMARY EFFLUENT PARAMETERS

PERMIT CONDITION	PARAMETER	VALUE
Annual Average	Flow, mgd	46.6
	BOD, mg/L	177
	TSS, mg/L	103
	TN, mg/L	33
	Temperature, F	56
Seasonal	Flow, mgd	43.2
	BOD, mg/L	189
	TSS, mg/L	110
	TN, mg/L	35
	Temperature, F	63

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 4.2-4.

Table 4.2-4

MODEL INPUT PARAMETERS AT PERMITTED CAPACITY

PERMIT CONDITION	PARAMETER	VALUE
Annual Average		
	Flow, mgd	67.3
	BOD, mg/L	177
	TSS, mg/L	103
	TN, mg/L	33
	Temperature, F	56
Seasonal	Flow, mgd	62.4
	BOD, mg/L	189
	TSS, mg/L	110
	TN, mg/L	35
	Temperature, F	63

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. It should be noted that the baseline simulation for the facility predicted three times the concentration of total nitrogen in the effluent than reported in the effluent data. Potential reasons for this are a lower influent TKN/BOD ratio than assumed and/or biological activity occurring in the secondary clarifiers which was not captured in the ideal clarifier model. 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 has already made the modifications to the aeration system which would be considered minor modifications in this evaluation. The facility has baffled off a pre-anoxic zone to create a Ludzack-Ettinger process (anoxic followed by aerobic with no internal recycle). It also has added four submersible mixers to the anoxic zone and they have ample RAS pump capacity with 120% of average daily flow. Nitrate recycle pumps to pump MLSS from the end of the aeration zone to the anoxic zone could be added to create an MLE process to improve their nitrogen removal, but this is beyond the definition of minor modifications for this study.

2. **Modifications Required to Meet TN of 8 mg/L.** As noted, the facility is already meeting a TN of 8 mg/L at current flows; however, BioWin model runs show that the current process configuration will not be able to meet 8 mg/L at permitted flows. The modifications to the facility that are required to meet an effluent TN of 8 mg/L on a seasonal and annual average basis at permitted flows 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 4.2-2 below.

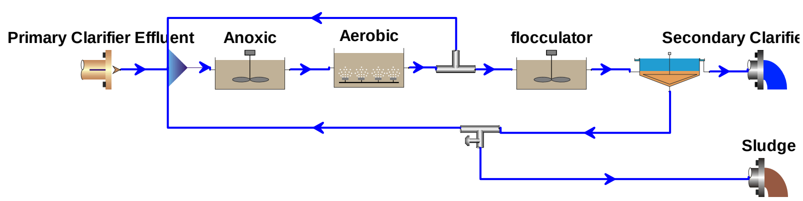
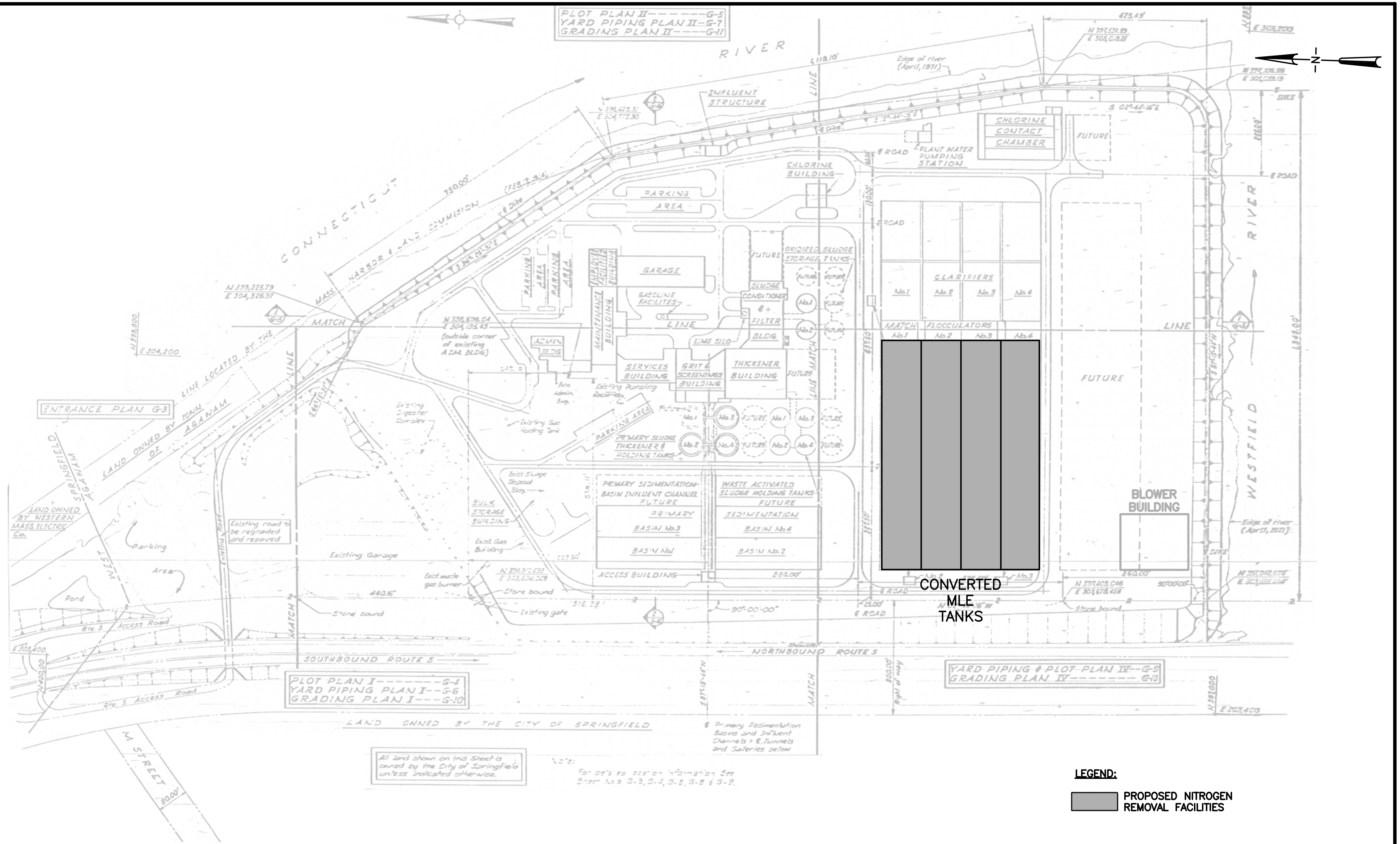


FIGURE 4.2-2: BIOWIN MODEL FOR SEASONAL TN LIMIT OF 8 mg/L

This process can fit in the existing tanks with only the addition of nitrate recycle pumps, and the existing configuration can be maintained as shown in the site plan in Figure 4.2-3.



NOTES:

1. Background is from Drawing G–2 from Contract Documents entitled "SEWAGE WORKS IMPROVEMENTS" by CDM and dated 1972.

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

SPRINGFIELD, MASSACHUSETTS
FIGURE 4.2–3

It is assumed the existing 10-yr old blowers have adequate capacity to nitrify seasonally, but this would have to be further evaluated since confirming blower capacity is outside the scope of this project. It is anticipated that no new 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 12.4 feet deep which is slightly less than the depth of 13 ft recommended in TR-16 for nitrogen removal facilities. Because the clarifiers do not meet the minimum requirements set forth in Section 2, it is recommended that they be further evaluated. It is unlikely, however, that they would require replacement or derating due to the shallower depth.

Specific information regarding the design results is shown in the following Table 4.2-5.

Table 4.2-5

RESULTS FOR SEASONAL LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Aerobic SRT	4.7 days
Total SRT	6.0 days
First Anoxic Fraction	20%
Total Anoxic Fraction	20%
Reaeration HRT	N/A
Total Volume (incl. floc tank)	29.14 MG (existing)
RAS Rate	50%
Nitrate Recycle Rate	350%
Max MLSS at Loading Rate	1,700 mg/L
Effluent TN	7.8 mg/L
Methanol Addition	No
Fixed Film Required?	No
Clarifiers?	No new clarifiers
Effluent Filtration Required?	No

b. **Annual Average.** At the assumed influent TN levels for this facility, an MLE process will accomplish an average annual effluent TN level of 8 mg/L Thus, an MLE process is recommended as shown in the BioWin model in Figure 4.2-4 below.

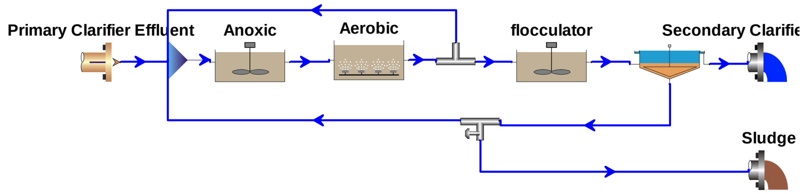

FIGURE 4.2-4: BIOWIN MODEL FOR ANNUAL AVERAGE TN LIMIT OF 8 mg/L

This process can fit in the existing tanks with only the addition of nitrate recycle pumps, and the existing configuration can be maintained, as shown in the site plan in Figure 4.2-5. It is assumed the existing 10-yr old blowers have adequate capacity to nitrify annually, but this would have to be further evaluated since confirming blower capacity is outside the scope of this project. It is also anticipated that the facility will require two additional secondary clarifiers (in addition to the existing four) to operate the facility at the resultant model MLSS concentration. It should be noted that the existing clarifiers at this facility are 12.4 feet deep. It should be noted that the existing clarifiers at this facility are 12.4 feet deep which is slightly less than the depth of 13 ft recommended in TR-16 for nitrogen removal facilities. Because the clarifiers do not meet the minimum requirements set forth in Section 2, it is recommended that they be further evaluated. It is unlikely, however, that they would require replacement or derating due to the shallower depth. It is also anticipated that two new RAS pumps will be required.

Specific information regarding the design results is shown in Table 4.2-6 below.

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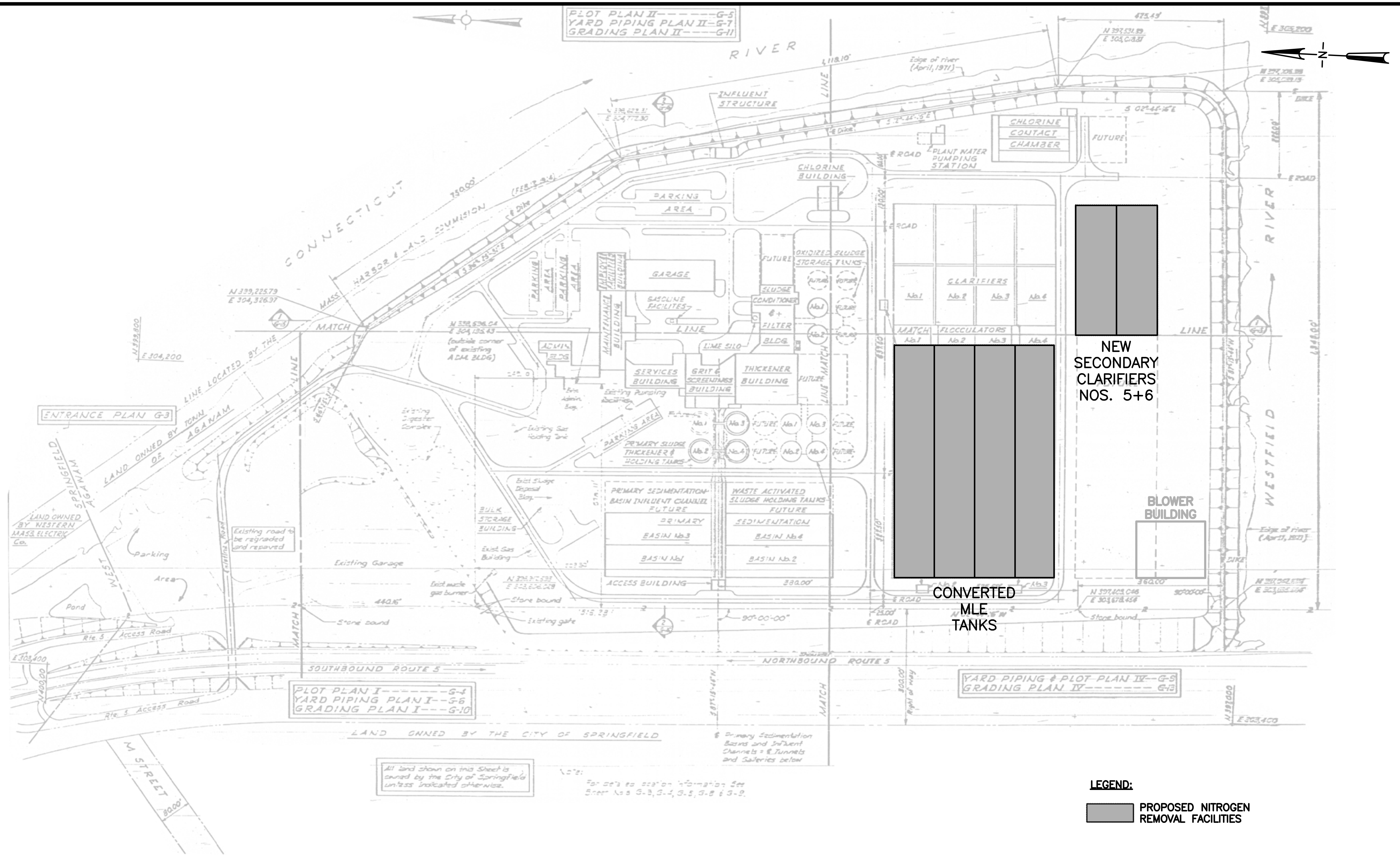

NOTES:
1. Background is from Drawing G–2 from Contract Documents entitled "SEWAGE WORKS IMPROVEMENTS" by CDM and dated 1972.

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
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SPRINGFIELD, MASSACHUSETTS
FIGURE 4.2–5

Table 4.2-6

RESULTS FOR ANNUAL AVERAGE LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Aerobic SRT	6.7 days
Total SRT	8.6 days
First Anoxic Fraction	20%
Total Anoxic Fraction	20%
Reaeration HRT	N/A
Total Volume (incl. floc tank)	29.14 MG (existing)
RAS Rate	50%
Nitrate Recycle Rate	350%
Max MLSS at Loading Rate	2,400 mg/L
Effluent TN	7.8 mg/L
Methanol Addition	No
Fixed Film Required?	No
Clarifiers?	2 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 Figure 4.2-6.

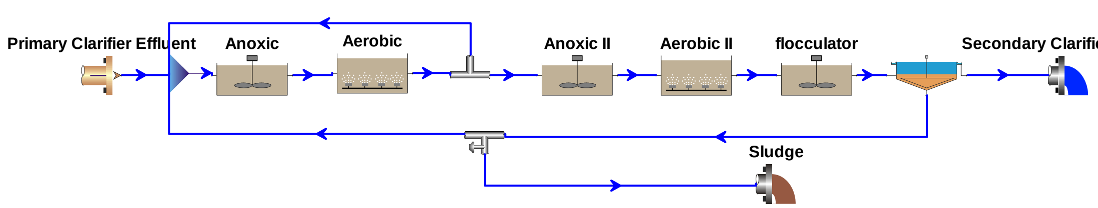


FIGURE 4.2-6: BIOWIN MODEL FOR SEASONAL TN LIMIT OF 5 mg/L

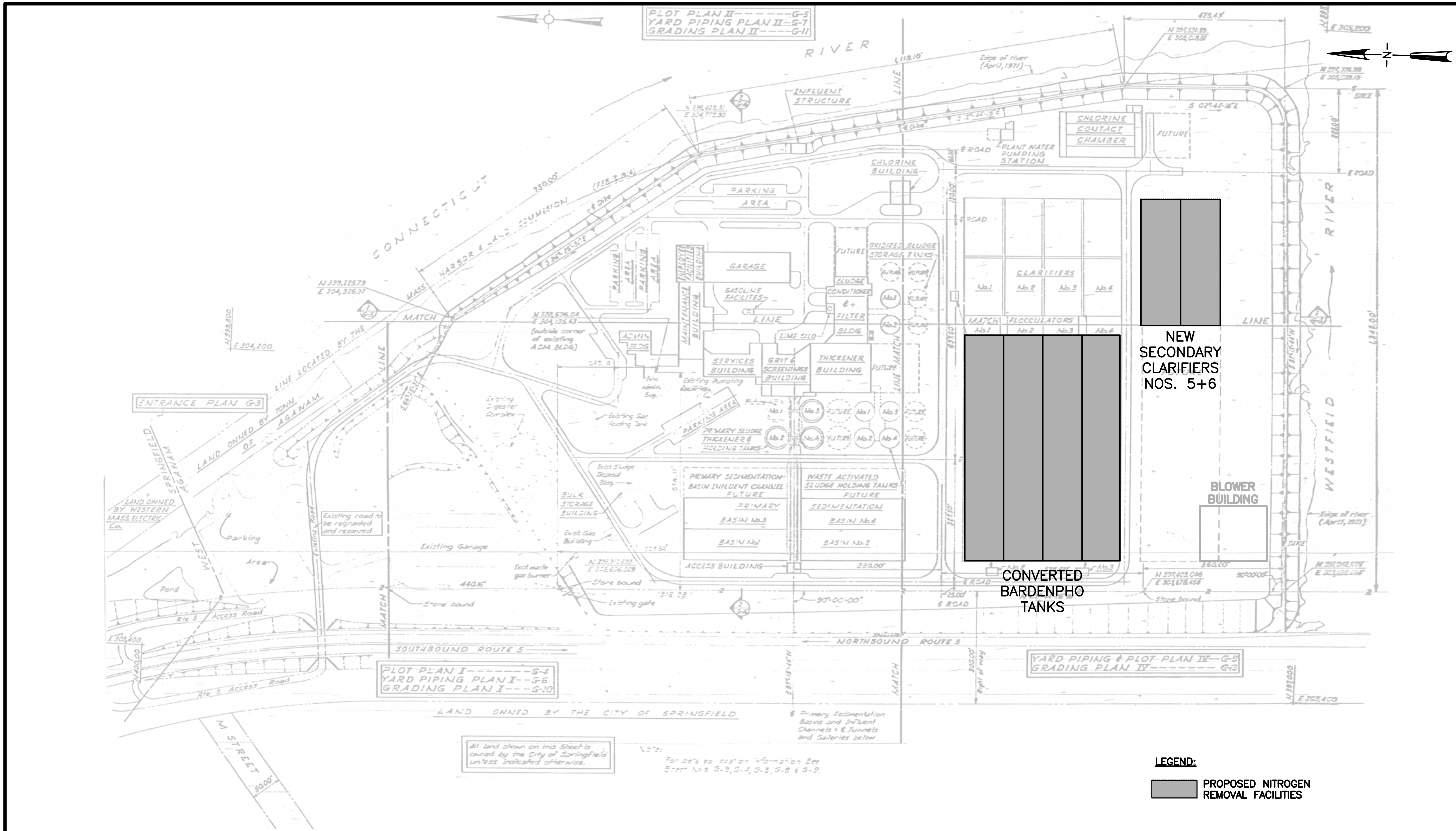
In addition to nitrate recycle pumps, this process would require partitioning of all four aeration tanks in order to achieve the configuration represented above. The process could fit within the existing tanks as shown in the site plan in Figure 4.2-7. The reconfiguration could affect the diffuser layout so piping and diffuser layout changes are assumed. It is assumed the existing 10-yr old blowers have adequate capacity to nitrify seasonally, but this would have to be further evaluated since confirming blower capacity is outside the scope of this project.

It is also anticipated that the facility will require two additional secondary clarifiers (in addition to the existing four) to operate the facility at the resultant model MLSS concentration. It should be noted that the existing clarifiers at this facility are 12.4 feet deep which is slightly less than the depth of 13 ft recommended in TR-16 for nitrogen removal facilities. Because the clarifiers do not meet the minimum requirements set forth in Section 2, it is recommended that they be further evaluated. It is unlikely, however, that they would require replacement or derating due to the shallower depth. It is also anticipated that two new RAS pumps will be required.

Specific information regarding the design results is shown in Table 4.2-7 as follows.

Table 4.2-7
RESULTS FOR SEASONAL LIMIT OF 5 mg/L TN

PARAMETER	VALUE
Aerobic SRT	4.7 days
Total SRT	8.1 days
First Anoxic Fraction	20%
Total Anoxic Fraction	42%
Reaeration HRT	20 minutes
Total Volume (incl. floc tank)	29.14 MG (existing)
RAS Rate	50%
Nitrate Recycle Rate	350%
Max MLSS at Loading Rate	2,400 mg/L
Effluent TN	4.1 mg/L
Methanol Addition	No
Fixed Film Required?	No
Clarifiers?	2 new clarifiers
Effluent Filtration Required?	No



NOTES:

1. Background is from Drawing G–2 from Contract Documents entitled "SEWAGE WORKS IMPROVEMENTS" by CDM and dated 1972.

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

Login name: BITTOVJ
Filename path: C:\Projects\CAM_CIVL\57833
Filename: FIG4–2–7.DWG
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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
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ENGINEERING FEASIBILITY AND COST ANALYSES OF NITROGEN REDUCTION FROM SELECTED POTWS IN MASSACHUSETTS

SPRINGFIELD, MASSACHUSETTS
FIGURE 4.2–7

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 an average annual effluent TN of 5 mg/L as shown in the BioWin model in Figure 4.2-8.

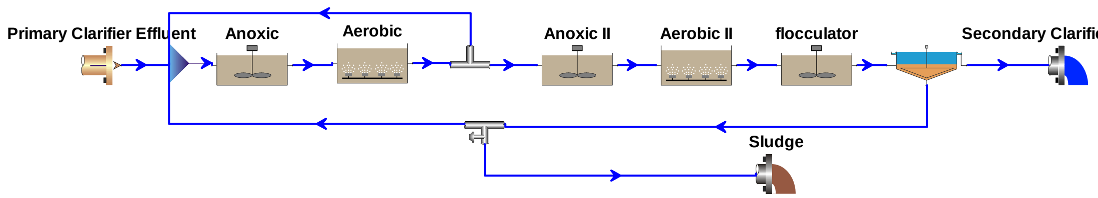
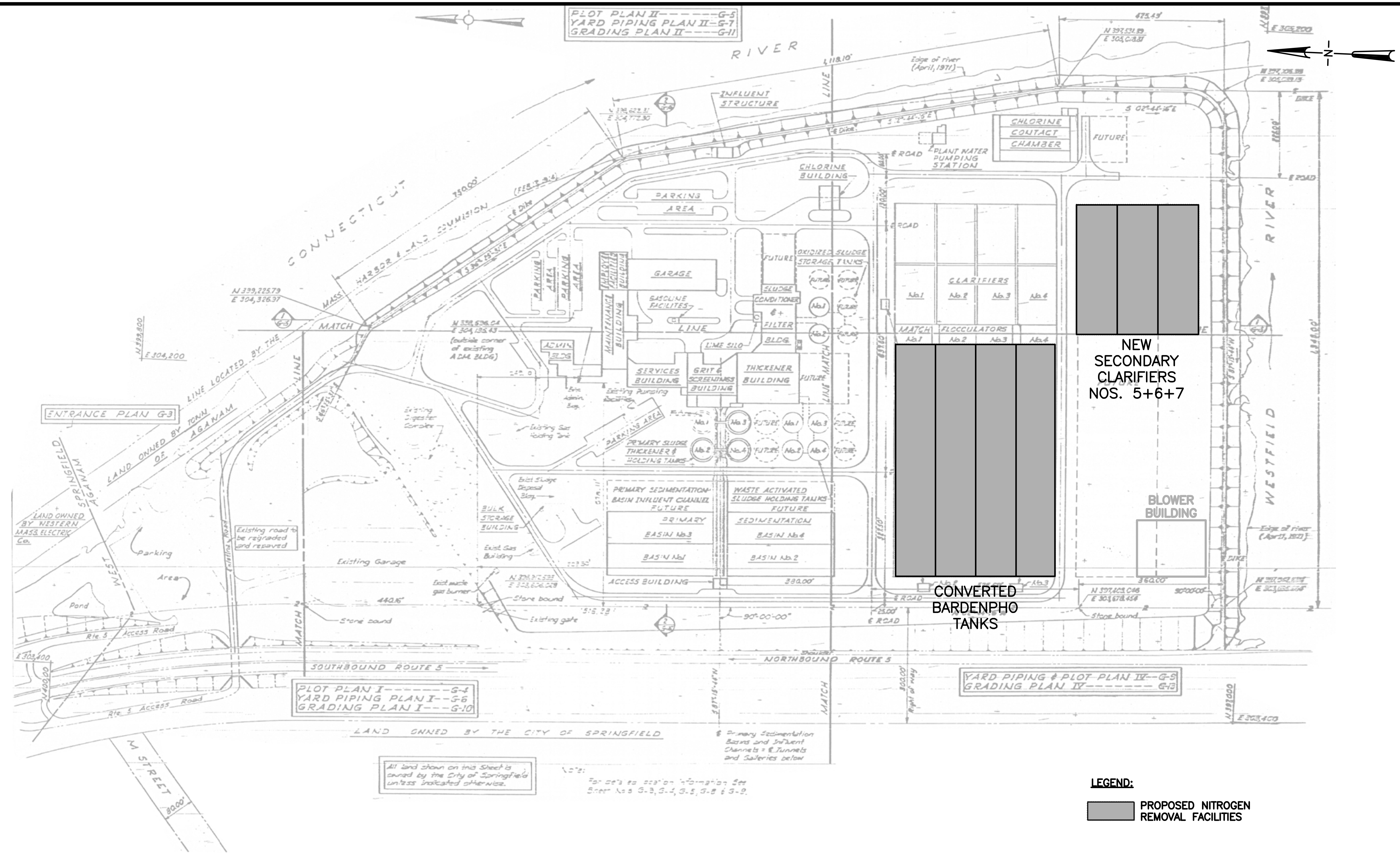


FIGURE 4.2-8:
BIOWIN MODEL FOR ANNUAL AVERAGE TN LIMIT OF 5 mg/L

In addition to nitrate recycle pumps, this process would require partitioning of all four aeration tanks in order to achieve the configuration represented above. The reconfiguration could fit within the existing tanks as shown in the site plan in Figure 4.2-9. The reconfiguration could affect the diffuser layout so piping and diffuser layout changes are assumed. It is assumed the existing 10-yr old blowers have adequate capacity to nitrify annually, but this would have to be further evaluated since confirming blower capacity is outside the scope of this project.

It is also anticipated that the facility will require three additional secondary clarifiers (in addition to the existing four) to operate the facility at the resultant model MLSS concentration. It should be noted that the existing clarifiers at this facility are 12.4 feet deep which is slightly less than the depth of 13 ft recommended in TR-16 for nitrogen removal facilities. Because the clarifiers do not meet the minimum requirements set forth in Section 2, it is recommended that they be further evaluated. It is unlikely, however, that they would require replacement or derating due to the shallower depth. It is also anticipated that at least two new RAS pumps will be required.

Specific information regarding the design results is shown in Table 4.2-8 below.



NOTES:
1. Background is from Drawing G-2 from Contract Documents entitled "SEWAGE WORKS IMPROVEMENTS" by CDM and dated 1972.

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

Login name: BITTOVJ
Filename path: C:\Projects\CAM_CIVL\57833
Filename: FIG4-2-9.DWG
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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
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CDM
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SPRINGFIELD, MASSACHUSETTS
FIGURE 4.2-9

Table 4.2-8

RESULTS FOR ANNUAL AVERAGE LIMIT OF 5 mg/L TN

PARAMETER	VALUE
Aerobic SRT	6.7 days
Total SRT	11.6 days
First Anoxic Fraction	20%
Total Anoxic Fraction	42%
Reaeration HRT	20 minutes
Total Volume (incl. floc tank)	29.14 MG (existing)
RAS Rate	50%
Nitrate Recycle Rate	350%
Max MLSS at Loading Rate	3,300 mg/L
Effluent TN	4.5 mg/L
Methanol Addition	No
Fixed Film Required?	No
Clarifiers?	3 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.**

Table 4.2-9 presents flow data for the Springfield WWTP as well as the current nitrogen removal performance of the plant. As shown, the facility is achieving nitrogen removal to almost 5 mg/L both seasonally and year-round with their current Ludzack-Ettinger process.

(continued)

Table 4.2-9

PLANT FLOW AND EFFLUENT LIMIT SUMMARY

PARAMETER	VALUE
Permitted Flow (mgd)	67.0
Existing Flow (2004-6)	46.4
% of existing capacity	69.3
Current average seasonal effluent TN (mg/L)	5.4
Current average annual effluent TN (mg/L)	5.3
Permit Limits Seasonal Nitrification (mg/L) Year-round nitrification (mg/L) Seasonal TN Limit Annual TN Limit	 No No Report Report

Table 4.2-10 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 Modified Ludzack-Ettinger process to consistently meet a TN limit of 8 mg/L at permitted capacity both seasonally and year-round. The BioWin models were run at permitted capacity (67 mgd) which is the reason a change in process mode is required. Adding the nitrate recycle pumps would also add seasonable stability. It should be noted that an assumed ammonia to BOD ratio was used since no influent nitrogen data was available. The assumed ratio and the fact that the models are uncalibrated could also contribute to the need to change nitrogen removal processes even though they seem to be meeting 8 mg/L at current flows. The modeling also predicts that the facility will have to convert to a Bardenpho process to meet 5 mg/L for the same reasons noted for 8 mg/L.

Table 4.2-10

NITROGEN REMOVAL PROCESS SUMMARY FOR SPRINGFIELD 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
Ludzack-Ettinger	MLE	MLE	Bardenpho	Bardenpho

The modifications required at Springfield to convert to a new nitrogen removal process are summarized in Table 4.2-11. As noted, no minor modifications can be made to the treatment facility to improve nitrogen removal since they currently operate in a Ludzack-Ettinger mode and achieve removal in this configuration.

Table 4.2-11

REQUIRED MODIFICATIONS SUMMARY FOR SPRINGFIELD 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
None	Nitrate recycle pumps and other minor modifications to existing aeration tanks	Nitrate recycle pumps and other minor modifications to existing aeration tanks; 2 new clarifiers	Structural modifications to 4 existing aeration tanks; new diffusers; nitrate recycle pumps; 2 new clarifiers	Structural modifications to 4 existing aeration tanks; new diffusers; nitrate recycle pumps; 3 new clarifiers	Facility has an anoxic flocculator tank between each aeration tank and clarifier

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 4.2-12.

Table 4.2-12

COST SUMMARY FOR NITROGEN REMOVAL AT SPRINGFIELD WWTF[1]

LIMIT	CAPITAL COSTS (IN MILLIONS)	TOTAL ANNUAL COSTS[2] (IN MILLLIONS)	20-YR PRESENT WORTH (IN MILLIONS)
Minor Modifications/Retrofits	minor	n/a	n/a
Seasonal Effluent TN of 8 mg/L	$4.5	$1.5	$23
Annual Average Effluent TN of 8 mg/L	$23	$2.0	$48
Seasonal Effluent TN of 5 mg/L	$56	$1.3	$72
Annual Average Effluent TN of 5 mg/L	$65	$1.7	$86

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.

4.3 AMHERST

A. **Introduction.** The Amherst Wastewater Treatment Plant (WWTP) is located at 1 Mullins Way in Amherst, MA. It has a permitted annual average capacity of 7.1 mgd and serves the Town of Amherst only. The facility also accepts septage.

Parts of the Amherst collection system date back to the 1880s. The WWTP started in the 1930s as a primary treatment facility. The current facility went online January 2, 1979. The facility decommissioned dissolved air flotation and vacuum filtration in 1993 when they started thickening and hauling sludge offsite.

B. **Existing Facilities.**

1. **Description of Existing Facilities.** All flow is conveyed to the Amherst WWTP by gravity where it enters the Influent Meter Structure. It is here that flow from Amherst, The University of Massachusetts, and North Amherst is separately metered. The flow then passes through preliminary treatment which consists of comminutors and grit removal. The University of Massachusetts represents approximately 30% of the plant flow.

Aerial photo from www.google.com

Raw sewage pumps lift the raw wastewater to the three primary clarifiers. After primary clarification, the primary effluent flows by gravity to the aeration tanks.

The facility has three aeration tanks. Each tank is 129.5 feet long by 43 feet wide with a 15 foot sidewater depth. The tanks have mechanical aerators and are each divided into two compartments – one with 1/3 of the volume and the other with the balance of the volume. The aeration tanks are followed by three secondary clarifiers which are each 15 feet deep and 82 feet in diameter.

Secondary effluent is then pumped approximately 1.8 miles to the Connecticut River. Chlorine is injected into the forcemain. A combined waste activated and primary sludge is thickened in the gravity belt thickener and then hauled off site. A process flow schematic is shown in Figure 4.3-1.

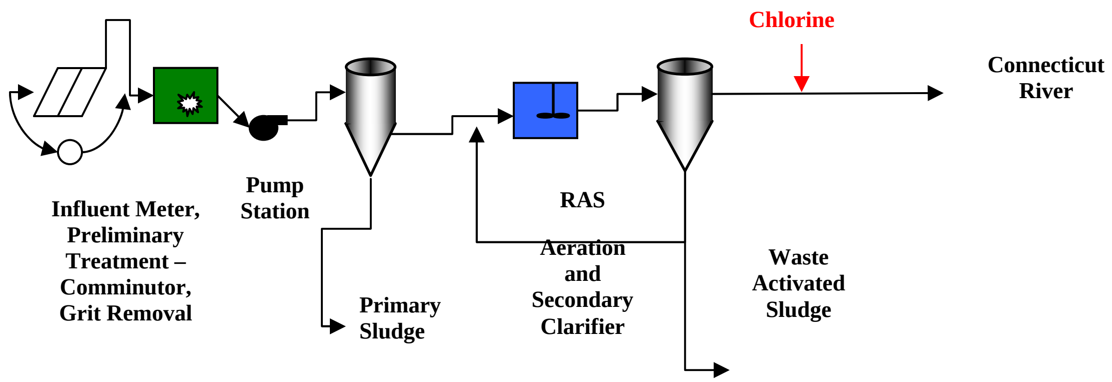


FIGURE 4.3-1: PROCESS FLOW SCHEMATIC – EXISTING FACILITY

The main plant recycle flow is filtrate from the gravity belt thickener and this is reintroduced to the waste stream prior to the primary clarifiers. Septage is introduced prior to the flow measurement. The influent sampler at this facility is located prior to the comminutors and thus it includes septage, but not plant recycle. The effluent flow meter is located after disinfection.

Because of the University of Massachusetts, this treatment facility receives most of its flow during the school year. Typically, the plant uses the two larger compartments of two of the aeration tanks (four aerators) and then during the summer and in January, one full tank is typically used. During very dry periods, the plant operates with only a single tank in use. The plant does not try to suppress nitrification at any time of the year.

The plant has thirteen full-time employees including the plant superintendent. This crew serves the plant, collection system and 20 pumping stations.

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

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 the following Table 4.3-1. Seasonal and annual average and maximum month data is summarized in the table.

With a current average annual flow of 4.22 mgd and a permitted capacity of 7.1 mgd, this facility is operating at almost 60% of its permitted capacity.

Based on the average BOD concentration of 229 mg/L, this wastewater is slightly higher than medium strength.

(continued)

<u>Table 4.3-1</u>

AMHERST WWTP

Amherst, Massachusetts

Monthly Averages 2004-2006

GENERAL		INFLUENT					EFFLUENT					
DATE		INF	pH	BOD	TSS	TEMP	BOD	TSS	NO2 + NO3	TKN	NH3	TN
MONTH	YEAR	MGD		MG/L	MG/L	DEG F	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
January	2004	3.88	7.20	211.4	174.2		17.30	2.90				
February	2004	4.05	7.50	273.1	221.3		20.20	4.00	10.1	9.50	8.35	18.48
March	2004	4.40	7.30	205.1	225.0		13.00	2.50	6.1	8.40	8.55	14.66
April	2004	5.97	7.10	183.4	211.5		9.90	3.00	10.3	5.00	7.05	17.33
May	2004	4.63	7.10	192.3	216.6		9.70	3.20	12.1		0.50	12.63
June	2004	3.39	7.00	208.0	198.6		5.50	2.50	9.1	7.10	0.40	9.48
July	2004	3.15	7.00	184.8	208.5		8.80	2.50	9.3	2.80	1.50	10.81
August	2004	3.08	7.00	157.8	191.2		15.90	2.40	5.8	7.00	2.15	7.97
September	2004	4.38	7.20	230.5	225.0		13.50	2.90	6.9	14.00	9.85	16.77
October	2004	4.45	7.24	288.3	229.0		19.91	3.53	7.3	6.30	6.30	13.55
November	2004	4.04	7.27	276.1	243.2	64	19.45	3.82	8.5	5.20	0.98	9.43
December	2004	4.57	7.16	215.9	199.5	58	14.18	3.36	10.2	12.70	2.00	12.20
January	2005	4.40	7.20	192.7	160.0	54	8.73	2.36	4.1	15.60	9.50	13.60
February	2005	4.83	7.31	239.6	199.4	55	11.50	2.63	4.1	11.00	9.90	14.00
March	2005	4.83	7.29	200.9	197.5	54	11.60	3.38	7.1	5.30	4.70	11.75
April	2005	5.45	7.20	223.6	188.6	58	10.36	4.18	8.6	4.00	3.70	12.31
May	2005	4.14	7.15	239.0	205.0	61	8.27	2.91	10.3		3.95	14.23
June	2005	3.19	7.06	193.1	199.1	66	13.45	4.82	7.5	2.90	5.00	12.47
July	2005	3.24	7.05	178.1	212.1	70	7.75	3.00	10.2		1.80	12.03
August	2005	2.91	7.06	210.8	238.1	72	11.46	2.69	8.1	3.90	9.90	17.95
September	2005	3.55	7.26	320.0	323.9	73	5.45	3.91	7.0	39.00	13.10	20.05
October	2005	6.25	7.19	244.5	199.6	67	2.91	3.48	6.2	2.00	2.55	8.73
November	2005	5.21	7.27	221.2	182.4	62	4.40	3.80	8.3	1.30	1.55	9.88
December	2005	4.75	7.30	236.2	159.8	55	4.46	3.62	19.1	3.70	3.65	22.73
January	2006	5.50	7.05	154.8	114.5	51	3.07	2.79	4.1	2.60	3.80	7.93
February	2006	5.21	7.33	253.2	157.6	53	2.30	2.50	5.2	16.00	13.30	18.47
March	2006	3.86	7.48	278.5	195.8	55	2.62	3.08	6.3	15.00	13.20	19.47
April	2006	4.04	7.46	284.9	259.0	58	2.67	2.56	5.3		10.60	15.87
May	2006	4.67	7.32	249.1	225.4	60	2.80	2.70	8.1	4.30	3.15	11.30
June	2006	3.86	7.09	208.4	168.6	64	2.75	2.33	12.0		0.30	12.34
July	2006	3.36	7.07	251.2	195.9	70	7.64	4.36	8.1	7.80	0.38	8.51
August	2006	2.80	7.14	229.8	189.4	72	14.57	4.00	7.6	5.40	4.70	12.33
September	2006	3.50	7.40	278.5	231.5	71	7.82	2.55	8.8	10.00	9.30	18.05
October	2006	4.00	7.30	260.5	251.0	66	11.27	3.82	7.5	8.90	8.90	16.39
November	2006	4.66	7.22	221.8	224.5	63	11.08	3.00		7.40	7.30	
December	2006	3.86	7.25	237.0	232.7	59	3.60	2.50	6.2	17.00	14.70	20.94
Min. Month		2.80	7.00	155	115	51.03	2	2	4.10	1.30	0.30	7.93
Seasonal Average		**3.81**	**7.15**	**229.16**	**217.14**	**67.70**	**9.41**	**3.20**	**8.44**	**8.67**	**4.65**	**13.09**
Annual Average		**4.22**	**7.21**	**228.73**	**207.09**	**62.07**	**9.44**	**3.15**	**8.10**	**8.70**	**5.90**	**13.96**
Max. Month		6.25	7.50	320.00	323.91	73.27	20.20	4.82	19.08	39.00	14.70	22.73

3. **Permit Requirements and Current Performance.** The current permit for this facility has been in effect since September 29, 2006. Monthly permit limits that are relevant to this study are shown below in Table 4.3-2.

Table 4.3-2

SELECT MONTHLY PERMIT LIMITS

PARAMETER	LIMIT
CBOD5	25 mg/L
TSS	30 mg/L
Ammonia, TKN, Nitrate, Nitrite	Report

The plant has met its permit for the above parameters for all months that are included in this study.

4. **Nitrogen Removal Performance.** This facility does not collect influent nitrogen data. However, effluent ammonia data is collected and as can be seen in Table 4.3-1, the facility reduces ammonia to low levels at times.

C. **Nitrogen Removal Alternatives.** The existing maximum month loads over the three-year data collection period were used to determine the BioWin input data; one outlier was found in the data and not included in the analysis. The influent data which correspond to maximum-month loads is shown in the following Table 4.3-3 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.

(continued)

Table 4.3-3

EXISTING INFLUENT PARAMETERS

PERMIT CONDITION	PARAMETER	VALUE
Average Annual	Flow, mgd	5.21
	BOD, mg/L	253
	TSS, mg/L	229
	TN, mg/L	46
	Temperature, F	51
Seasonal	Flow, mgd	4.45
	BOD, mg/L	288
	TSS, mg/L	261
	TN, mg/L	52
	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. This projected data is shown in Table 4.3-4.

Table 4.3-4

MODEL INPUT PARAMETERS AT PERMITTED CAPACITY

PERMIT CONDITION	PARAMETER	VALUE
Annual Average	Flow, mgd	8.75
	BOD, mg/L	253
	TSS, mg/L	229
	TN, mg/L	46
	Temperature, F	51
Seasonal	Flow, mgd	7.48
	BOD, mg/L	288
	TSS, mg/L	261
	TN, mg/L	52
	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. 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.

The existing site plan shows a space for one future tank. There appears to be at least enough space on the site for up to five more aeration tanks. The effluent forcemain runs along the western border of the facility. The actual location of any new aeration tanks would be dependent upon the location of this pipeline.

1. **Minor Modifications/Retrofits.** At the assumed influent TN levels, there are no operational or minor modifications/retrofits that could be implemented at this facility to consistently achieve nitrogen removal. The existing facility has half of the necessary volume at the current flows.

2. **Modifications Required to Meet TN of 8.** 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 approximately 10 mg/L. Because of site limitations, the option that appears to suit the site the best is to use aeration tanks to nitrify and to then use denitrification filters for nitrogen removal. The recommended option is shown in Figure 4.3-2 below.

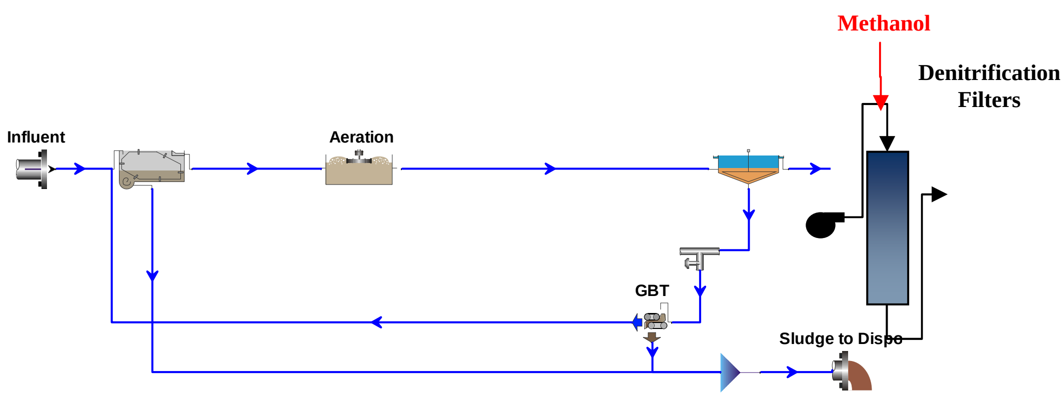


FIGURE 4.3-2: NITROGEN REMOVAL PROCESSES - SEASONAL LIMIT OF 8 mg/L

This process would require a total of 5 aeration tanks - 2 new tanks in addition to the existing three. The new tanks would be the same size as each of the three existing tanks. This volume is adequate to fully nitrify the loads at this facility and then nitrates can be removed through the use of denitrification filters. The denitrification filter complex would have a footprint of approximately 5500 square feet with six cells each at approximately 22 ft by 14 ft.

In addition to the new aeration tanks and denitrification filters, it is also anticipated that the facility will require one additional secondary clarifier (in addition to the existing three) to be able to handle the future flow and loading conditions.

As shown in the site plan in Figure 4.3-3, the site appears to have enough space for the additional aeration tanks, clarifier and the denitrification filters. Specific information regarding the results of this analysis is shown in Table 4.3-5 below.

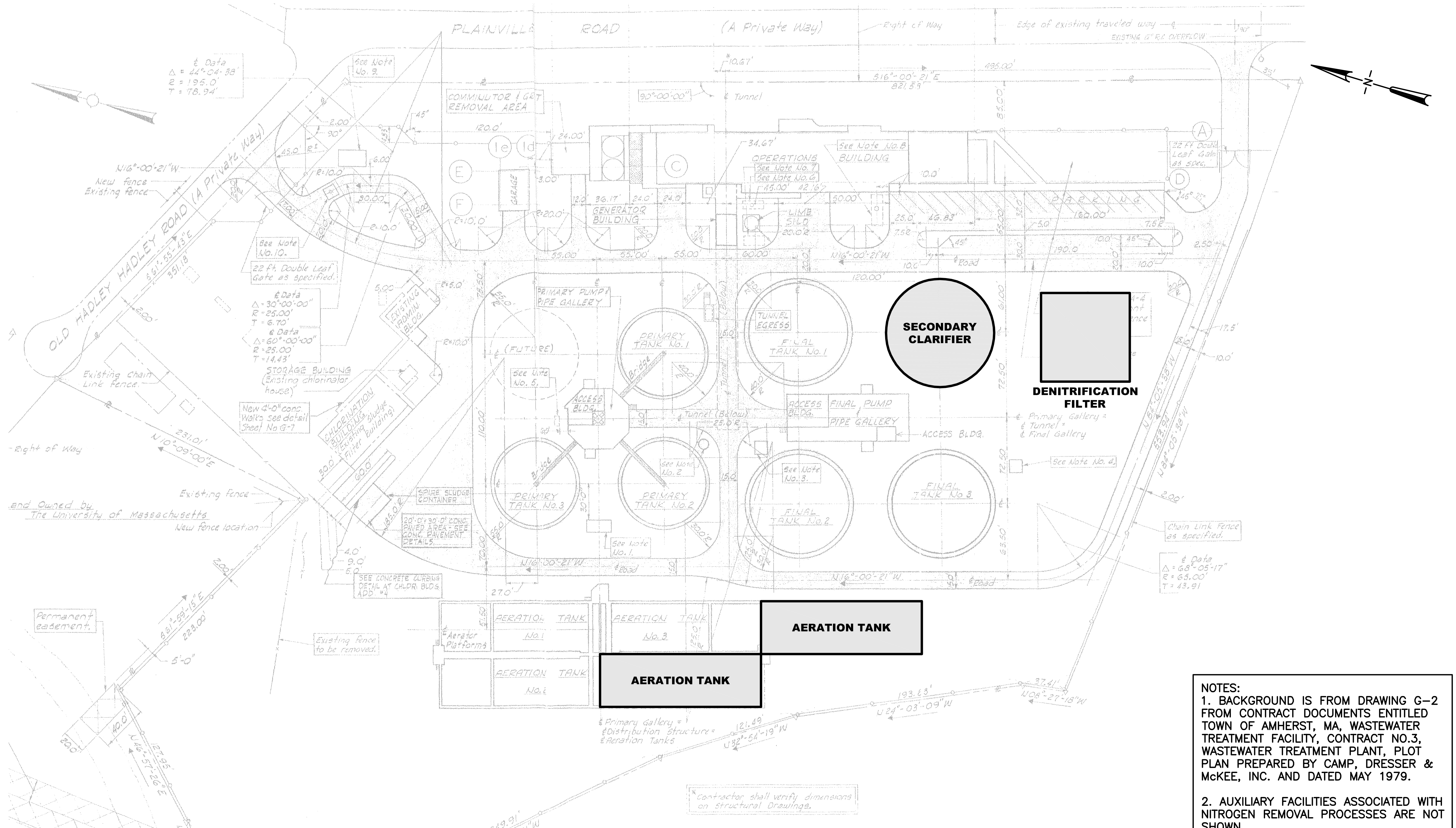
Table 4.3-5

RESULTS FOR SEASONAL LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Aerobic SRT	6 days
Total SRT	6 days
First Anoxic Fraction	n/a
Total Anoxic Fraction	n/a
Reaeration HRT	n/a
RAS Rate	100%
Total Volume	3.12 MG
Nitrate Recycle Rate	n/a
Max MLSS at Loading Rate	3800 mg/L
Effluent TN	8 mg/L
Methanol Addition	Yes, in denitrification filter
Fixed Film Required?	No
Clarifiers?	Reuse existing and add one new one
Effluent Filtration Required?	Yes, denitrification filter

The modifications related to the proposed upgrades described above do not appear to require any structure demolition. The aeration tanks, clarifier and denitrification filters can be constructed in portions of the site that are currently unused.

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.



NOTES:
1. BACKGROUND IS FROM DRAWING G-2 FROM CONTRACT DOCUMENTS ENTITLED TOWN OF AMHERST, MA, WASTEWATER TREATMENT FACILITY, CONTRACT NO.3, WASTEWATER TREATMENT PLANT, PLOT PLAN PREPARED BY CAMP, DRESSER & McKEE, INC. AND DATED MAY 1979.

2. AUXILIARY FACILITIES ASSOCIATED WITH NITROGEN REMOVAL PROCESSES ARE NOT SHOWN.

80 0 80 160
1"=80'-0"

SITE PLAN
SCALE: 1"=80'-0"

Login name: JDF
Filename path: J:\60000\61265 MADEP\10\Drawings\Fig
Filename: AMHERST-CH4.dwg
Latest Revision: Friday, April 04, 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
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AMHERST, MASSACHUSETTS

FIGURE 4.3-3

b. **Annual Average.** As indicated above, at the assumed influent TN levels for this facility, an MLE process will not accomplish an average annual effluent TN level of 8 mg/L. The MLE process will yield an annual average effluent TN of about 10 mg/L. Because of site limitations, the option that appears to suit the site the best is to use aeration tanks to nitrify and to then use denitrification filters for nitrogen removal. The recommended option is shown in Figure 4.3-4 as follows.

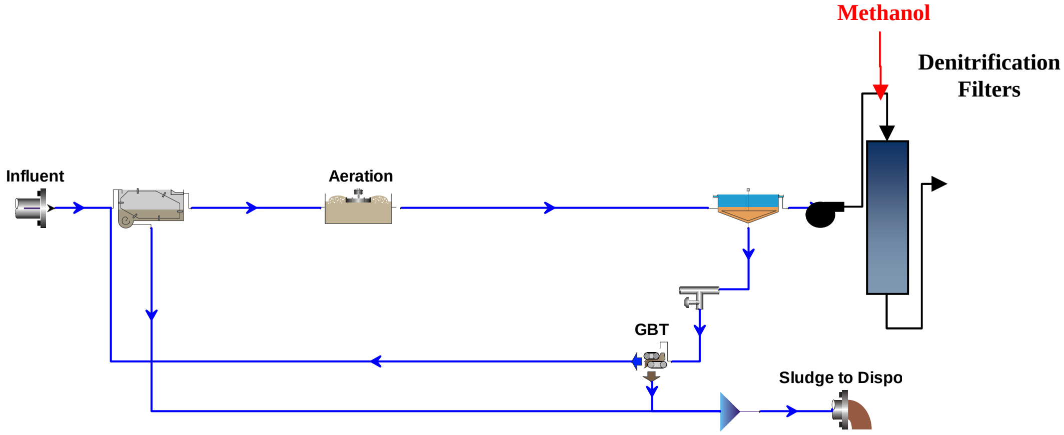
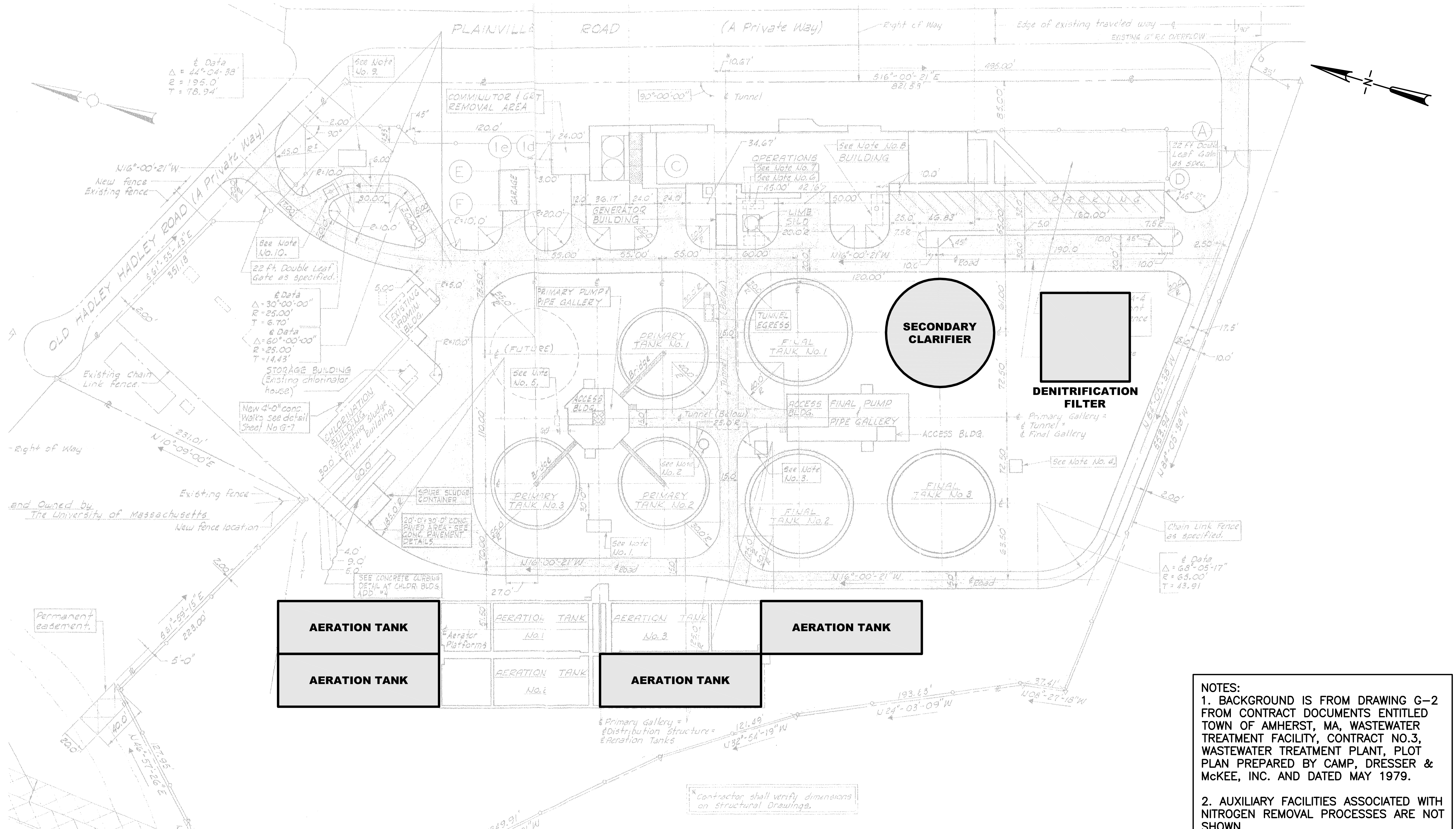


FIGURE 4.3-4:
NITROGEN REMOVAL PROCESSES – ANNUAL AVERAGE LIMIT OF 8 mg/L

This process would require a total of seven aeration tanks – four new tanks in addition to the existing three. The new tanks would be the same size as each of the three existing tanks. This volume is adequate to fully nitrify the loads at this facility and then nitrates can be removed through the use of denitrification filters. The denitrification filter complex would have a footprint of approximately 5500 square feet with six cells each at approximately 22 ft by 14 ft.

In addition to the new aeration tanks and denitrification filters, it is also anticipated that the facility will require one additional secondary clarifier (in addition to the existing three) to be able to handle the future flow and loading conditions.

As shown in the site plan in Figure 4.3-5, the site appears to have enough space for the additional aeration tanks, clarifier and denitrification filters. Specific information regarding the results of this analysis is shown in Table 4.3-6 as follows.



NOTES:

1. BACKGROUND IS FROM DRAWING G-2 FROM CONTRACT DOCUMENTS ENTITLED TOWN OF AMHERST, MA, WASTEWATER TREATMENT FACILITY, CONTRACT NO.3, WASTEWATER TREATMENT PLANT, PLOT PLAN PREPARED BY CAMP, DRESSER & McKEE, INC. AND DATED MAY 1979.

2. AUXILIARY FACILITIES ASSOCIATED WITH NITROGEN REMOVAL PROCESSES ARE NOT SHOWN.

SITE PLAN

SCALE: 1"=80'-0"

Login name: JDF
Filename path: J:\60000\61265 MADEP\10\Drawings\Fig
Filename: AMHERST-CH4.dwg
Latest Revision: Friday, April 04, 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
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ENGINEERING FEASIBILITY AND COST ANALYSES OF NITROGEN REDUCTION FROM SELECTED POTWS IN MASSACHUSETTS

AMHERST, MASSACHUSETTS

FIGURE 4.3-5

Table 4.3-6

RESULTS FOR ANNUAL AVERAGE LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Aerobic SRT	8.5 days
Total SRT	8.5 days
First Anoxic Fraction	n/a
Total Anoxic Fraction	n/a
Reaeration HRT	n/a
RAS Rate	100%
Total Volume	4.37 MG
Nitrate Recycle Rate	n/a
Max MLSS at Loading Rate	3800 mg/L
Effluent TN	8 mg/L
Methanol Addition	Yes, in denitrification filter
Fixed Film Required?	n/a
Clarifier?	Reuse existing and add one new one
Effluent Filtration Required?	Yes, denitrification filter

The modifications related to the proposed upgrades described above do not appear to require any structure demolition. The aeration tanks, clarifier and denitrification filters can be constructed in portions of the site that are currently unused.

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.** 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 and because of site limitations, the option that appears to suit the site the best is to achieve a seasonal effluent TN of 5 mg/L is to use the aeration tanks to nitrify and to then use denitrification filters for nitrogen removal. The recommended option is shown in Figure 4.3-6 as follows.

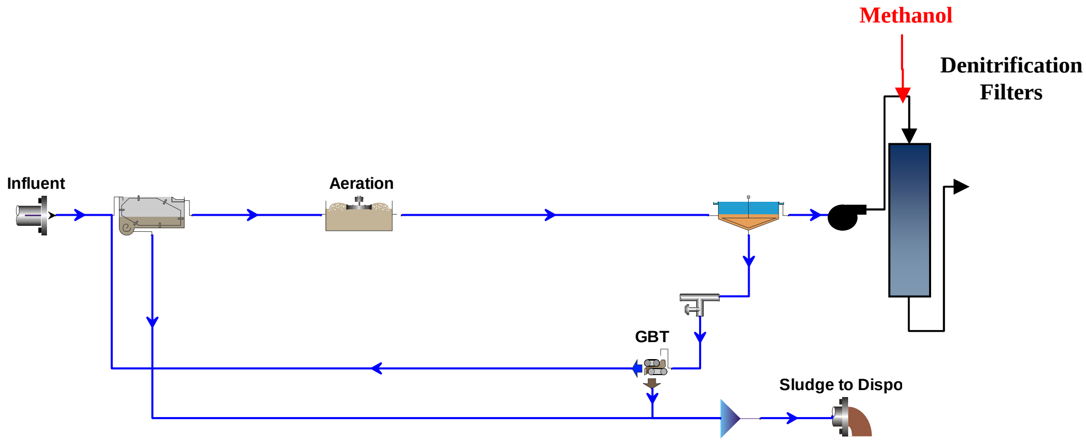


FIGURE 4.3-6: NITROGEN REMOVAL PROCESSES – SEASONAL LIMIT OF 5 mg/L

This process would require a total of 5 aeration tanks - 2 new tanks in addition to the existing three. The new tanks would be the same size as each of the three existing tanks. This volume is adequate to fully nitrify the loads at this facility and then nitrates can be removed through the use of denitrification filters. The denitrification filter complex would have a footprint of approximately 5500 square feet with six cells each at approximately 22 ft by 14 ft.

In addition to the new aeration tanks and denitrification filters, it is also anticipated that the facility will require one additional secondary clarifier (in addition to the existing three) to be able to handle the future flow and loading conditions.

As shown in the site plan in Figure 4.3-3, the site appears to have enough space for the additional aeration tanks, clarifier and denitrification filters. Specific information regarding the results of this analysis is shown in Table 4.3-7 as follows.

(continued)

Table 4.3-7

RESULTS FOR SEASONAL LIMIT OF 5 mg/L TN

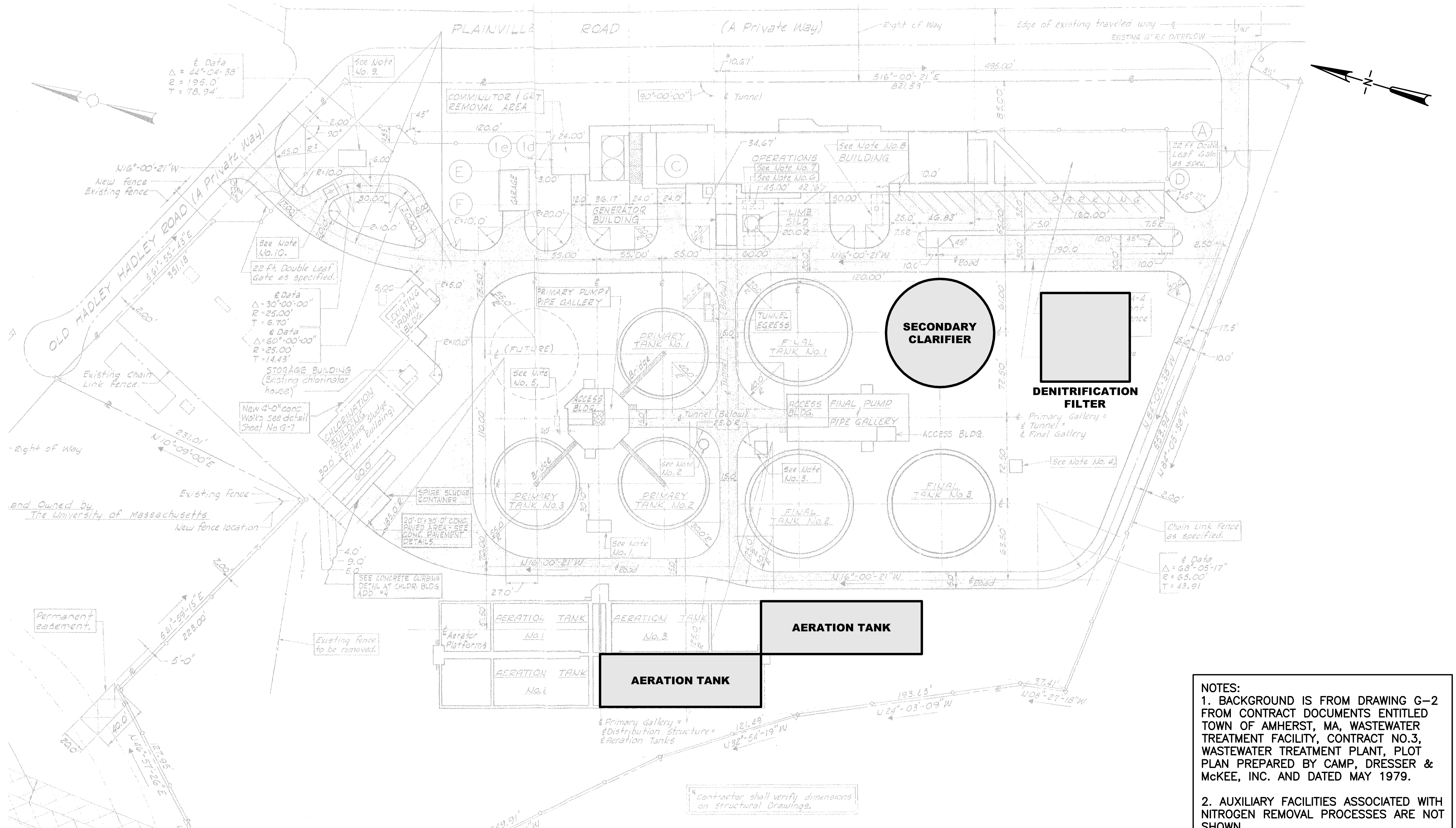
PARAMETER	VALUE
Aerobic SRT	6 days
Total SRT	6 days
First Anoxic Fraction	n/a
Total Anoxic Fraction	n/a
Reaeration HRT	n/a
RAS Rate	100%
Total Volume	3.12 MG
Nitrate Recycle Rate	n/a
Max MLSS at Loading Rate	3800 mg/L
Effluent TN	5 mg/L
Methanol Addition	Yes, in denitrification filter
Fixed Film Required?	No
Clarifiers?	Reuse existing and add one new one
Effluent Filtration Required?	Yes, denitrification filter

The modifications related to the proposed upgrades described above do not appear to require any structure demolition. The aeration tanks, clarifier and denitrification filters can be constructed in portions of the site that are currently unused.

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 and because of site limitations, the option that appears to suit the site the best is to achieve an annual average effluent TN of 5 mg/L is to use the aeration tanks to nitrify and to then use denitrification filters for nitrogen removal. The recommended option is shown in Figure 4.3-7 as follows.

(continued)



NOTES:
1. BACKGROUND IS FROM DRAWING G–2 FROM CONTRACT DOCUMENTS ENTITLED TOWN OF AMHERST, MA, WASTEWATER TREATMENT FACILITY, CONTRACT NO.3, WASTEWATER TREATMENT PLANT, PLOT PLAN PREPARED BY CAMP, DRESSER & McKEE, INC. AND DATED MAY 1979.

2. AUXILIARY FACILITIES ASSOCIATED WITH NITROGEN REMOVAL PROCESSES ARE NOT SHOWN.

80 0 80 160
1"=80'–0"

SITE PLAN
SCALE: 1"=80'–0"

Login name: JDF
Filename path: J:\60000\61265 MADEP\10\Drawings\Fig
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Latest Revision: Friday, April 04, 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
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ENGINEERING FEASIBILITY AND COST ANALYSES OF NITROGEN REDUCTION FROM SELECTED POTWS IN MASSACHUSETTS

AMHERST, MASSACHUSETTS
FIGURE 4.3–7

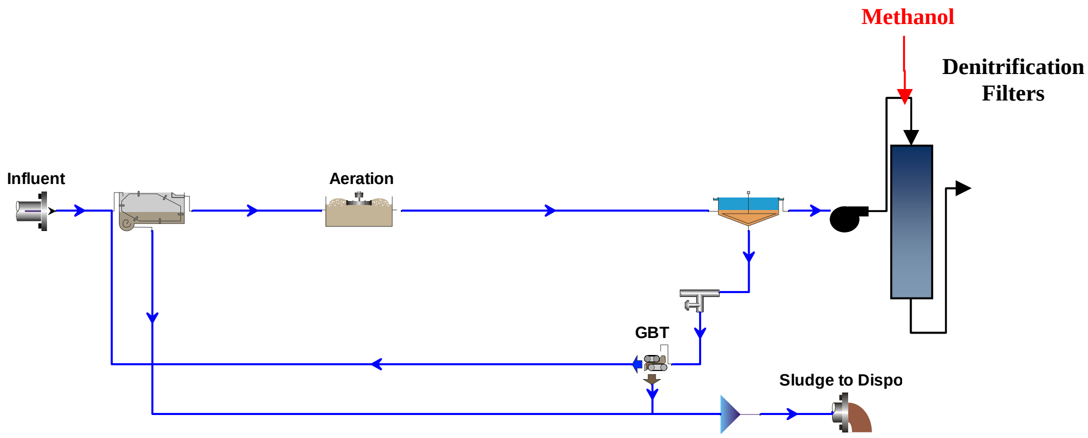


FIGURE 4.3-7:
NITROGEN REMOVAL PROCESSES – ANNUAL AVERAGE LIMIT OF 5 mg/L

This process would require a total of seven aeration tanks - four new tanks in addition to the existing three. The new tanks would be the same size as each of the three existing tanks. This volume is adequate to fully nitrify the loads at this facility and then nitrates can be removed through the use of denitrification filters. The denitrification filter complex would have a footprint of approximately 5500 square feet with six cells each at approximately 22 ft by 14 ft.

In addition to the new aeration tanks and denitrification filters, it is also anticipated that the facility will require one additional secondary clarifier (in addition to the existing three) to be able to handle the future flow and loading conditions.

As shown in the site plan in Figure 4.3-5, the site appears to have enough space for the additional aeration tanks, clarifier and denitrification filters. Specific information regarding the results of this analysis is shown in Table 4.3-8 as follows.

(continued)

Table 4.3-8

RESULTS FOR ANNUAL AVERAGE LIMIT OF 5 mg/L TN

PARAMETER	VALUE
Aerobic SRT	8.5 days
Total SRT	8.5 days
First Anoxic Fraction	n/a
Total Anoxic Fraction	n/a
Reaeration HRT	n/a
RAS Rate	100%
Total Volume	4.37 MG
Nitrate Recycle Rate	n/a
Max MLSS at Loading Rate	3800 mg/L
Effluent TN	5 mg/L
Methanol Addition	Yes, in denitrification filter
Fixed Film Required?	n/a
Clarifiers?	Reuse existing and add one new one
Effluent Filtration Required?	Yes, denitrification filter

The modifications related to the proposed upgrades described above do not appear to require any structure demolition. The aeration tanks, clarifier and denitrification filters can be constructed in portions of the site that are currently unused.

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 4.3-9 presents flow data for the Amherst WWTF as well as the current nitrogen removal performance of the plant.

(continued)

Table 4.3-9

PLANT FLOW AND EFFLUENT LIMIT SUMMARY

PARAMETER	VALUE
Permitted Flow (mgd)	7.1
Existing Flow (2004-6)	4.2
% of existing capacity	59
Current average seasonal effluent TN (mg/L)	13
Current average annual effluent TN (mg/L) [1]	14
Permit Limits Seasonal Nitrification (mg/L) Year-round nitrification (mg/L) Seasonal TN Limit Annual TN Limit	 Report Report Report Report

Table 4.3-10 presents the nitrogen removal processes identified in this section to achieve the four different permit conditions considered. Based on the loading conditions established for this facility and the subsequent BioWin modeling performed using this data, the facility improvements include adding additional aeration tanks and using these tanks for ammonia removal only. Other improvements include the installation of one additional secondary clarifier and denitrification filters for nitrate removal. It also should be noted that influent nitrogen data was assumed for this facility.

Table 4.3-10

NITROGEN REMOVAL PROCESS SUMMARY FOR AMHERST WWTP

MINOR MODIFICATIONS OR RETROFITS	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
None	Nitrification in aeration tanks followed by denitrification filters	Nitrification in aeration tanks followed by denitrification filters	Nitrification in aeration tanks followed by denitrification filters	Nitrification in aeration tanks followed by denitrification filters

The modifications required at Amherst to convert to a new nitrogen removal process are summarized in Table 4.3-11. As noted previously, no minor modifications can be made to the treatment facility to improve nitrogen removal at the assumed influent nitrogen loads.

Table 4.3-11

REQUIRED MODIFICATIONS SUMMARY FOR AMHERST WWTP

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
2 new aeration tanks, one new clarifier, denitrification filters	4 new aeration tanks, one new clarifier, denitrification filters	2 new aeration tanks, one new clarifier, denitrification filters	4 new aeration tanks, one new clarifier, denitrification filters	None

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 4.3-12.

Table 4.3-12

COST SUMMARY FOR NITROGEN REMOVAL AT AMHERST WWTP[1]

LIMIT	CAPITAL COSTS (IN MILLIONS)	TOTAL ANNUAL COSTS[2] (IN THOUSANDS)	20-YR PRESENT WORTH (IN MILLIONS)
Minor Modifications/Retrofits	None	n/a	n/a
Seasonal Effluent TN of 8 mg/L	$48	$680	$57
Annual Average Effluent TN of 8 mg/L	$61	$1,200	$76
Seasonal Effluent TN of 5 mg/L	$48	$680	$57
Annual Average Effluent TN of 5 mg/L	$61	$1,200	$76

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)

4.4 NORTHAMPTON

A. **Introduction.** The Northampton wastewater treatment facility is located at 30 Hockanum Road in Northampton, MA. It has a permitted capacity of 8.6 mgd and serves all of Northampton and portions of Williamsburg. Approximately 8% of the total flow is from industrial/commercial dischargers. Low septage loads (less than 1000 gpd) are received at the facility. The collection system is over 95% separate, and there are no regulated CSOs in the service area.

The original facility was completed in 1981. One filter press was added in 1989, and the aeration system was converted to fine bubble diffusers in 1994. Additional improvements in 1994 include construction of the gravity belt thickener (GBT) building (which houses the blowers and GBTs), a second belt filter press, an odor control system and a lime silo. Changes that have occurred since 1994 include replacement of the intermediate screw pumps with submersible pumps and converting the two digesters to sludge holding tanks.

B. **Existing Facilities.**

Aerial photo from www.google.com

1. **Description of existing facilities.** All flow conveyed to the Northampton Wastewater Treatment Facility (WWTF) receives preliminary treatment which includes screening with a manual bar rack, grit removal and screenings comminutors. The flow then passes through the influent Parshall flume to the three primary clarifiers. After primary clarification, the flow is pumped to the aeration system.

The facility has two aeration trains each of which consists of four square tanks in series. Each tank is 51.5 ft square with a 13 ft sidewater depth. The aeration tanks are followed by three 12 ft deep, 75 ft diameter secondary clarifiers.

Secondary effluent receives disinfection with hypochlorite. No dechlorination chemical is required since the effluent travels over a mile prior to being discharged to the Connecticut River during which time chlorine residual is dissipated in the pipeline. An effluent pump station is available to pump effluent to the river if the water stage in the river is too high for the effluent to flow by gravity. A process flow schematic is shown in the following Figure 4.4-1.

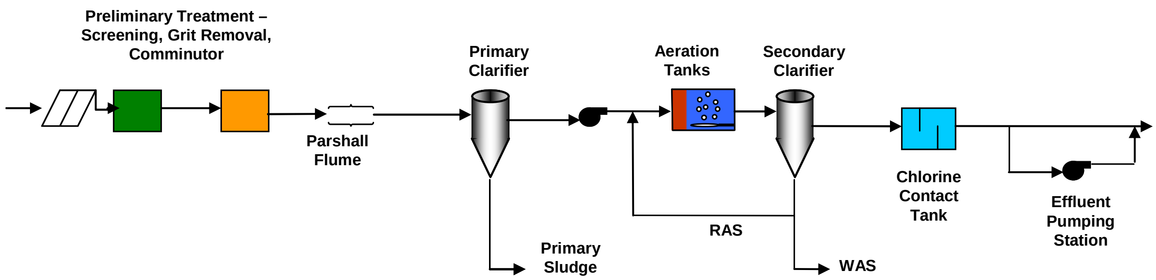


FIGURE 4.4-1: PROCESS FLOW SCHEMATIC – EXISTING FACILITY

The plant wastes activated sludge continuously from the RAS line. Primary sludge and waste activated sludge are thickened in two gravity thickeners and then dewatered with belt filter presses. Sludge cake is trucked offsite to Connecticut by private contractor. The plant has an alternative for sludge thickening and disposal. Sludge can be thickened with gravity belt thickeners and then thickened sludge can be trucked off-site. If this method of solids handling is employed, the old digesters are used as thickened sludge holding tanks.

All plant recycle flows (gravity thickener overflow and BFP filtrate) are returned upstream of the Parshall flume. Septage is introduced to the manhole upstream of the headworks. The influent sampler at this facility is located at the Parshall Flume, thus all plant flows including internal recycle flows are included in the influent loads.

Two out of three primary clarifiers, both aeration trains (all eight tanks) and two out of three secondary clarifiers are in use under normal operation. The plant currently is operating a portion of each aeration train as anoxic zones. When a storm is imminent, the blowers and RAS pumps are turned off in an attempt to maintain the biomass within the system and prevent washout. Nitrification is not required, but the plant does not try to suppress nitrification at any time of the year.

The plant has eleven full-time employees: five operators, four maintenance personnel, a lead operator and an IP officer.

There is very little room for expansion of the Northampton facility as shown in the aerial photos. There is a small area south of the maintenance building. The only other alternative is to remove one of the two modes of handling solids at the plant. Demolishing the old digesters (current storage tanks) and siting new bioreactor volume there would provide approximately 50% more aeration volume. The existing foundations are slabs on footings, and there is evidence of sinking and cracking in the slabs due to the alternating layers of sand and clay. It will be assumed that piles will be used for all new construction.

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 4.4-1. Seasonal and annual average and maximum month data is summarized in the table.

(continued)

Table 4.4-1

NORTHAMPTON WWTF

Northampton, Massachusetts

Monthly Averages 2003-2006

GENERAL		INFLUENT						EFFLUENT						
DATE		FLOW (AVG)	FLOW (MAX)	BOD	TSS	TEMP	RAW ALK	BOD	TSS	F. COLI	NO3 + NO2	TKN	PH	PH
MONTH	YEAR	MGD	MGD	MG/L	MG/L	DEG C	MG/L	MG/L	MG/L	# / 100ML	MG/L	MG/L	MIN	MAX
January	2004	5.2	6.1	232.5	167.1	10.3	120.2	13.2	11.5	ND		34.4	6.8	7.1
February	2004	5.2	4.5	310.0	225.1	10.1	136.8	20.0	13.8	ND		30.4	6.8	7.1
March	2004	5.1	10.2	256.5	171.1	9.6	118.2	11.0	6.8	ND		49.0	6.8	7.1
April	2004	5.1	20.0	153.1	101.9	10.1	84.4	56.3	108.8	1.1	0.1	15.0	6.6	6.9
May	2004	5.1	6.0	200.7	151.0	13.8	94.0	14.6	8.5	1.5	0.3	15.0	6.7	7.0
June	2004	5.0	7.5	239.2	173.1	17.1	117.8	16.0	6.4	2.3	0.2	30.0	6.8	7.2
July	2004	4.9	14.7	234.9	188.9	19.4	144.0	13.9	7.8	1.3	0.2	33.0	6.9	7.2
August	2004	4.9	4.9	293.4	232.2	20.7	130.9	11.6	7.0	9.1	0.2	33.0	6.4	7.3
September	2004	4.8	7.6	269.0	207.4	20.6	130.0	11.4	5.8	2.0	7.4	13.0	6.4	7.0
October	2004	4.7	5.6	319.3	268.4	18.5	123.5	18.0	14.8	2.2	2.9	15.0	6.5	7.1
November	2004	4.5	5.8	235.7	159.4	16.1	128.4	13.5	10.8	ND	0.8	27.0	6.8	7.1
December	2004	4.4	6.2	255.4	298.7	12.9	116.4	11.1	9.8	ND	0.3	14.0	6.7	7.1
January	2005	4.4	8.7	208.0	159.4	10.6	136.0	18.5	13.3	ND	0.5	22.0	6.7	7.0
February	2005	4.5	5.7	183.6	143.9	9.0	121.3	15.1	15.1	ND	0.3	22.0	6.7	7.1
March	2005	4.5	9.9	185.3	122.0	9.3	100.8	16.5	10.5	ND	0.2	18.0	6.7	7.1
April	2005	4.4	10.3	166.1	119.5	10.8	97.3	13.6	7.2	0.9	0.5	8.6	6.7	7.0
May	2005	4.4	6.2	225.2	170.0	13.9	110.7	14.9	7.5	0.9	0.1	16.0	6.7	7.2
June	2005	4.4	4.9	275.6	211.9	17.5	131.6	19.5	12.3	1.0	0.2	22.0	6.9	7.2
July	2005	4.4	4.8	303.1	374.0	20.1	127.8	19.0	3.5	1.0	1.6	31.0	6.7	7.2
August	2005	4.4	4.0	376.0	416.2	22.0	146.4	11.4	4.5	1.6	7.1	7.3	6.6	7.1
September	2005	4.3	3.6	356.5	291.4	22.2	136.2	16.9	14.3	1.4	2.7	27.0	6.7	7.1
October	2005	4.4	14.6	177.1	141.0	18.8	106.8	11.4	8.3	2.8	3.4	18.0	6.4	7.1
November	2005	4.5	6.3	208.1	195.4	15.5	103.1	18.9	24.0	ND	0.4	12.0	6.6	7.0
December	2005	4.5	6.4	206.8	149.7	12.8	112.0	21.7	16.3	ND	0.2	17.0	6.6	7.1
January	2006	4.7	13.7	132.6	126.1	10.1	94.2	48.8	24.0	ND	0.4	21.0	6.7	7.1
February	2006	4.8	9.4	166.3	107.1	10.2	95.0	21.2	12.6	ND	0.5	8.6	6.7	7.0
March	2006	4.7	4.2	227.1	155.0	10.6	122.0	21.9	9.8	ND	0.5	22.0	6.7	7.0
April	2006	4.5	4.7	248.4	185.1	12.5	123.0	22.9	10.5	0.8	0.3	22.0	6.7	7.0
May	2006	4.5	5.0	206.4	168.7	14.3	112.4	17.8	10.3	1.0	0.3	20.0	6.6	7.0
June	2006	4.6	6.1	182.2	141.1	16.3	105.6	17.5	5.5	1.0	1.8	15.0	6.5	6.9
July	2006	4.6	12.8	267.6	240.5	19.5	126.0	8.8	2.8	1.1	8.7	3.8	6.0	6.7
August	2006	4.6	4.3	330.4	335.3	21.6	131.0	17.9	8.5	1.3	7.7	7.4	5.9	6.6
September	2006	4.6	4.0	286.9	239.5	20.9	155.0	14.6	4.8	ND	7.3	2.0	5.8	6.5
October	2006	4.4	7.3	232.1	189.9	18.5	128.0	8.1	4.0	0.9	6.5	8.0	6.0	6.6
November	2006	4.4	6.7	158.9	138.8	15.2	98.7	9.6	5.8	ND	6.1	4.2	5.8	6.5
December	2006	4.4	4.6	193.9	145.8	13.2	107.8	16.4	8.8	ND	6.0	3.5	5.8	6.4
Min. Month		4.3	3.6	132.6	101.9	9.0	84.4	8.1	2.8	0.8	0.1	2.0	5.8	6.4
Seasonal Average		**4.6**	**6.9**	**265.3**	**230.0**	**18.6**	**125.4**	**14.6**	**7.6**	**1.9**	**3.2**	**17.6**	**6.5**	**7.0**
Average Annual		**4.6**	**7.4**	**236.2**	**194.8**	**15.1**	**118.7**	**17.6**	**12.7**	**1.8**	**2.3**	**18.5**	**6.5**	**7.0**
Max. Month		5.2	20.0	376.0	416.2	22.2	155.0	56.3	108.8	9.1	8.7	49.0	6.9	7.3

With a current average daily flow of 4.6 mgd and a permitted capacity of 8.6 mgd, this facility is operating at approximately 53% of its permitted capacity. Based on the average BOD concentration of 236 mg/L and TSS concentration of 195 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 May 23, 2002. Monthly permit limits that are relevant to this study are shown below in Table 4.4-2.

Table 4.4-2
SELECT MONTHLY PERMIT LIMITS

PARAMETER	LIMIT
BOD5	30 mg/L
TSS	30 mg/L
TKN	Report
Nitrite+Nitrate Nitrogen	Report

The above BOD, TSS and ammonia limits have been met in most months of the data collection period although there are three exceedances.

4. **Nitrogen Removal Performance.** This facility does not collect influent nitrogen data, and the majority of the effluent nitrogen data collected show little nitrification until July of 2006. However, the one sample collected from July 2006 to December 2006 indicates a substantial reduction in TKN with a corresponding increase in nitrate and nitrite indicating that nitrification is occurring. The effluent data also is based on only 1 sample per month as required by the permit.

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 4.4-3 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 4.4-3

EXISTING INFLUENT PARAMETERS

PERMIT CONDITION	PARAMETER	VALUE
Average Annual	Flow, mgd	5.2
	BOD, mg/L	310
	TSS, mg/L	256
	TN, mg/L	56
	Temperature, F	48
Seasonal	Flow, mgd	4.3
	BOD, mg/L	357
	TSS, mg/L	294
	TN, mg/L	64
	Temperature, F	57

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 4.4-4.

Table 4.4-4

MODEL INPUT PARAMETERS AT PERMITTED CAPACITY

PERMIT CONDITION	PARAMETER	VALUE
Average Annual	Flow, mgd	9.7
	BOD, mg/L	310
	TSS, mg/L	256
	TN, mg/L	56
	Temperature, F	48
Seasonal	Flow, mgd	8.0
	BOD, mg/L	357
	TSS, mg/L	294
	TN, mg/L	64
	Temperature, F	57

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.** Since the plant is already operating a portion of its tank as an anoxic zone, there are no additional minor modifications that could be made to improve nitrogen removal.

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 at the permitted flow. The MLE process will yield a seasonal effluent TN of 13 mg/L in the space available on the site. A 4-stage Bardenpho process is recommended as shown in the BioWin model in Figure 4.4-2 below.

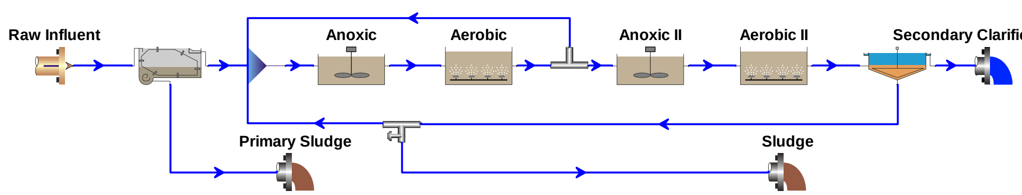
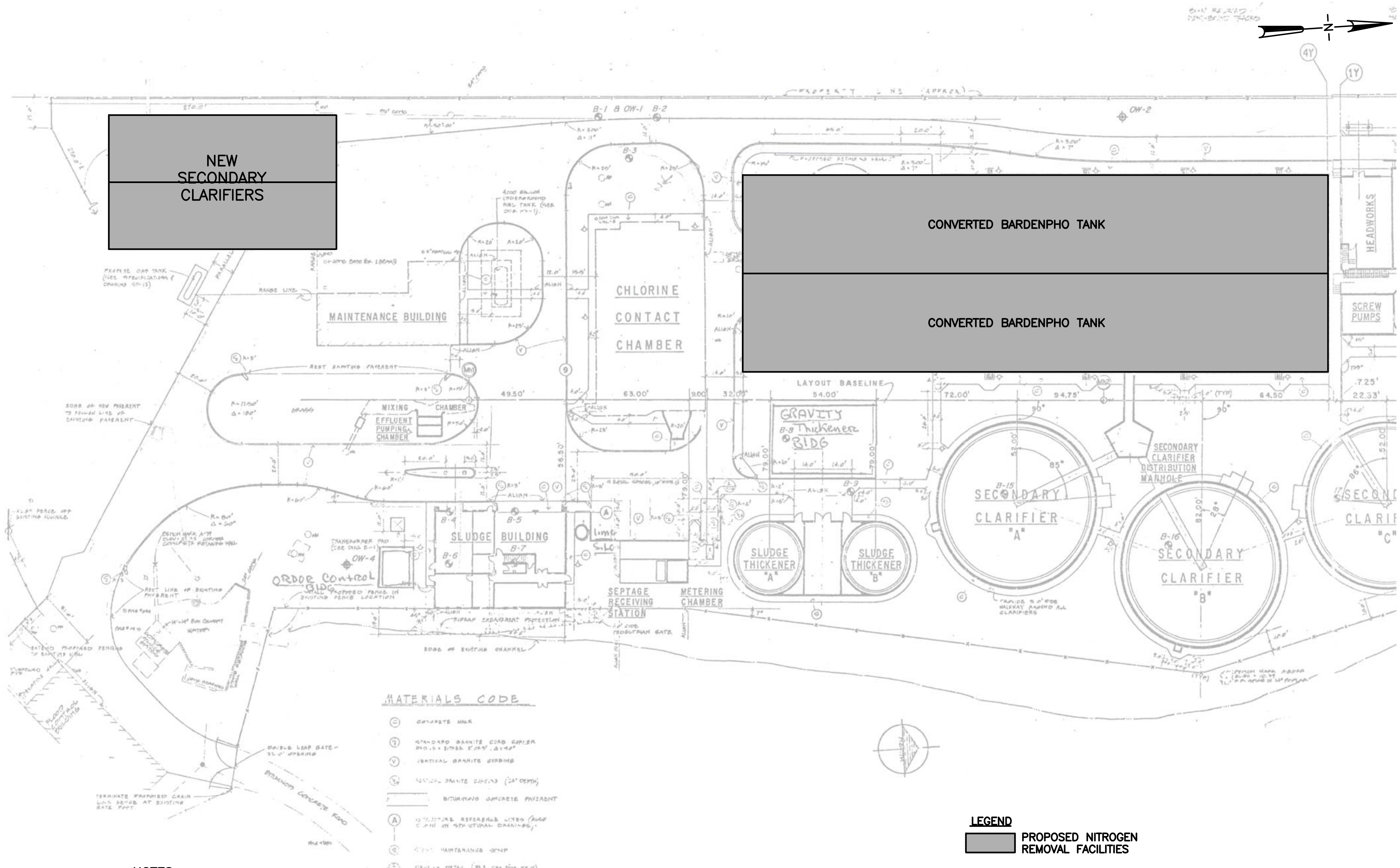


FIGURE 4.4-2: BIOWIN MODEL FOR SEASONAL TN LIMIT OF 8 mg/L

In order to meet the 8 mg/L target, 50% more bioreactor volume is required. As shown in the site plan in Figure 4.4-3, the site has enough space for the additional bioreactor volume if the existing digesters and digester building are demolished. The existing two tanks would be modified to form two parallel Bardenpho trains in a plug flow configuration and the additional tankage would be added on to the end of the tanks. Nitrate recycle pumps would be added. Structural modifications would be required to partition the tanks. It is assumed that the diffuser layout would have to be replaced and blower capacity would have to be increased since the equipment is 14 years old.



NOTES:

1. Background is from Drawing 7 from Contract Documents entitled "WASTEWATER TREATMENT FACILITY" by WHITMAN & HOWARD INC and dated 1978.
2. Auxiliary facilities associated with nitrogen removal processes are not shown.
3. Digesters and building would have to be demolished to expand bioreactors as 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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NORTHAMPTON, MASSACHUSETTS
FIGURE 4.4-3

In addition to the aeration tank modifications, it is also anticipated that two new clarifiers (in addition to the existing two) 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 12 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. The new clarifiers would be stacked and located in the open space south of the maintenance building. Intermediate pumping would be required.

Specific information regarding the design results is shown in Table 4.4-5 below.

Table 4.4-5

RESULTS FOR SEASONAL LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Aerobic SRT	6.4 days
Total SRT	14.5 days
First Anoxic Fraction	24%
Total Anoxic Fraction	56%
Reaeration HRT	12 minutes
Total Volume	3.1 MG
RAS Rate	50%
Nitrate Recycle Rate	400%
Max MLSS at Loading Rate	3,200 mg/L
Effluent TN	7.0 mg/L
Methanol Addition	No
Fixed Film Required?	No
Clarifiers?	2 new clarifiers
Effluent Filtration Required?	No

Other plant modifications may be needed including screening and 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 average annual effluent TN level of 8 mg/L at the permitted flow. An MLE process will yield an annual average effluent TN of about 12 mg/L in the space available on the site. A 4-stage Bardenpho process with both methanol addition to the second anoxic zone and IFAS in the aerobic zone is recommended as shown in the BioWin model in Figure 4.4-4 as follows.

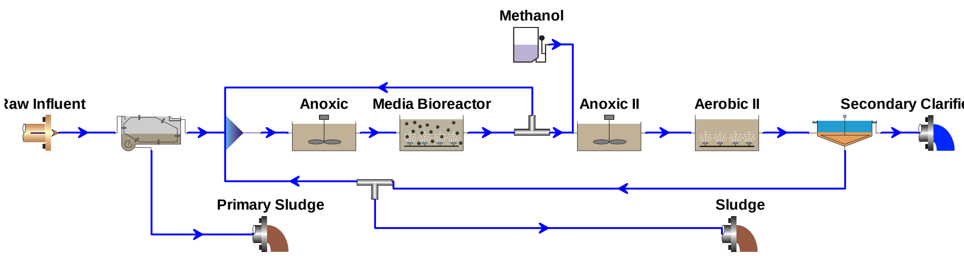
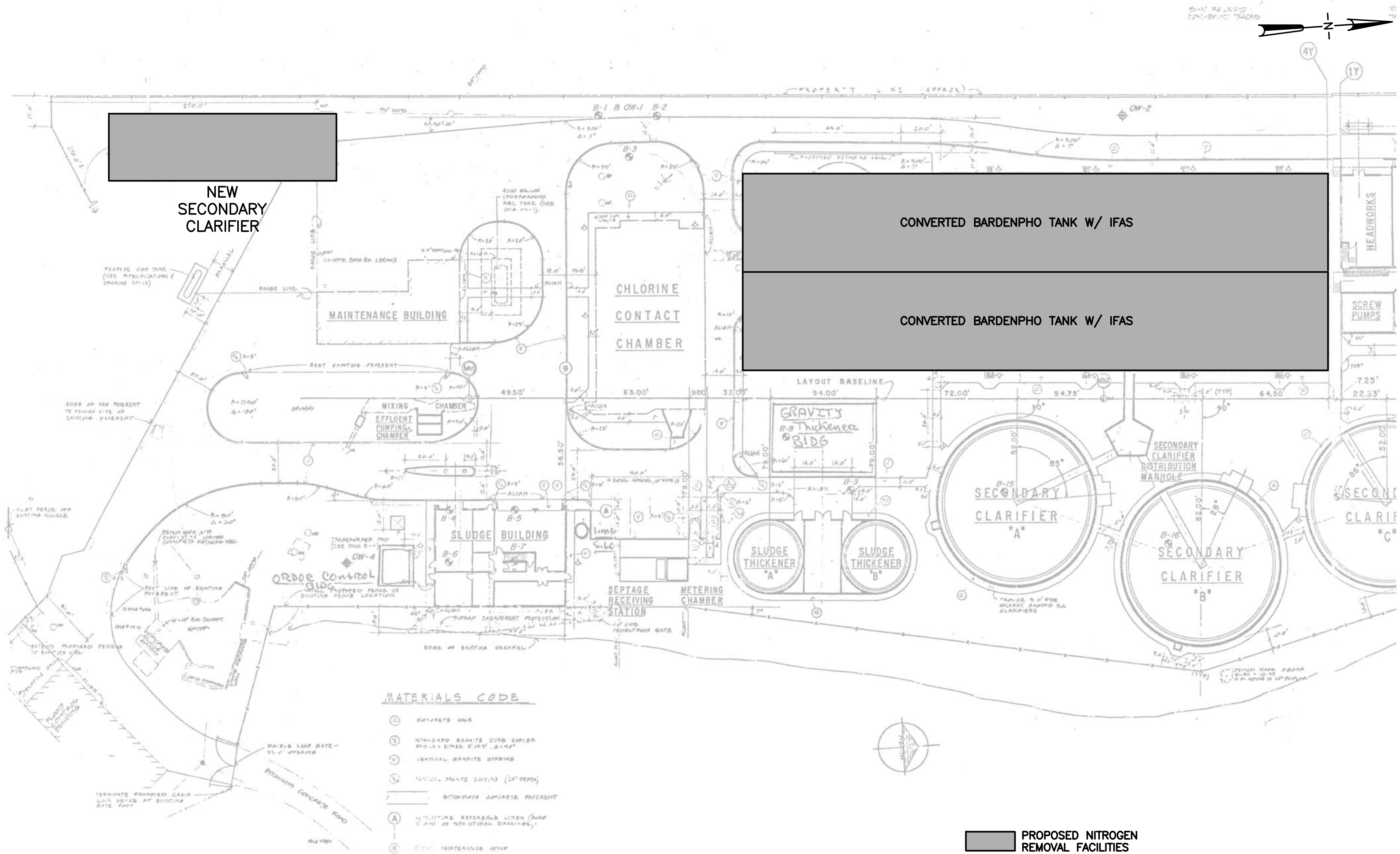


FIGURE 4.4-4: BIOWIN MODEL FOR ANNUAL AVERAGE TN LIMIT OF 8 mg/L

In order to meet the 8 mg/L target, 50% more reactor volume is required. As shown in the site plan in Figure 4.4-5, the site has enough space for the additional bioreactor volume if the existing digesters and digester building are demolished. The existing two tanks would be modified to form two parallel Bardenpho trains in a plug flow configuration and the additional tankage would be added on to the end of the tanks. IFAS media would also be required to meet the TN limit since the MLSS concentration estimated for Bardenpho without IFAS exceeds the upper limit of 4,000 mg/L established for this study in the design criteria. Additional blower capacity would be required due to the IFAS system. Nitrate recycle pumps would be added as well as a methanol feed facility. Structural modifications would be required to partition the tanks.

In addition to the aeration tank modifications, it is also anticipated that one new clarifier (in addition to the existing two) 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 12 feet deep. According to TR-16, clarifiers at nitrogen removal facilities should be a minimum of 13 feet deep. Because the clarifiers 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. The new clarifier would be located in the open space south of the maintenance building. It is anticipated that



NOTES:

1. Background is from Drawing 7 from Contract Documents entitled "WASTEWATER TREATMENT FACILITY" by WHITMAN & HOWARD INC and dated 1978.
2. Auxiliary facilities associated with nitrogen removal processes are not shown.
3. Digesters and building would have to be demolished to expand bioreactors as 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

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One Cambridge Place, 50 Hampshire Street
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NORTHAMPTON, MASSACHUSETTS
FIGURE 4.4-5

WAS pumping capacity would have to be added to maintain the design SRT with the IFAS system.

Specific information regarding the design results is shown in Table 4.4-6 as follows.

Table 4.4-6
RESULTS FOR ANNUAL AVERAGE LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Aerobic SRT	N/A
Total SRT	9.0 days
First Anoxic Fraction	16%
Total Anoxic Fraction	32%
Reaeration HRT	12 minutes
Total Volume	3.1 MG
RAS Rate	50%
Nitrate Recycle Rate	400%
Max MLSS at Loading Rate	2,600 mg/L
Effluent TN	7.4 mg/L
Methanol Addition	Yes; 600 gpd
Fixed Film Required?	Yes; 50% fill
Clarifiers?	1 new clarifier
Effluent Filtration Required?	No

Other plant modifications may be needed including screening and 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 4-stage Bardenpho process with both methanol addition to the second anoxic zone and IFAS in the aerobic zone is recommended to achieve a seasonal effluent TN of 5 mg/L as shown in the BioWin model in the following Figure 4.4-6.

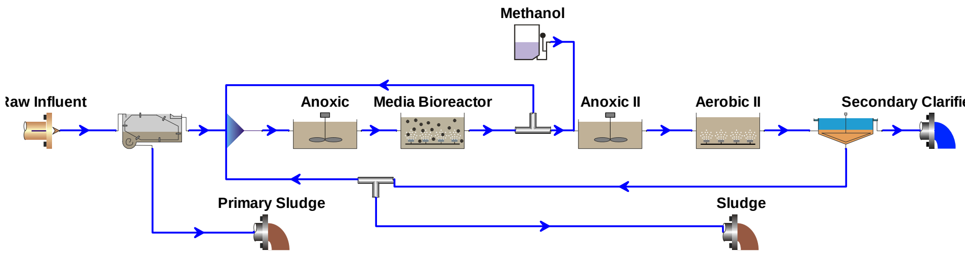


FIGURE 4.4-6: BIOWIN MODEL FOR SEASONAL TN LIMIT OF 5 mg/L

In order to meet the 5 mg/L target, 50% more bioreactor volume is required. As shown in the site plan in Figure 4.4-5, the site has enough space for the additional volume if the existing digesters and digester building are demolished. The existing two tanks would be modified to form two parallel Bardenpho trains in a plug flow configuration and the additional tankage would be added on to the end of the tanks. IFAS media would also be required to meet the TN limit. Additional blower capacity would be required due to the IFAS system. Nitrate recycle pumps would be added as well as a methanol feed facility. Structural modifications would be required to partition the tanks.

In addition to the aeration tank modifications, it is also anticipated that one new clarifier (in addition to the existing two) 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 12 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. The new clarifiers would be located in the open space south of the maintenance building. It is anticipated that WAS pumping capacity would have to be added to maintain the design SRT with the IFAS system.

Specific information regarding the design results is shown in Table 4.4-7 below.

Table 4.4-7

RESULTS FOR SEASONAL LIMIT OF 5 mg/L TN

PARAMETER	VALUE
Aerobic SRT	N/A
Total SRT	10.1
First Anoxic Fraction	16%
Total Anoxic Fraction	46%
Reaeration HRT	24 minutes
Total Volume	3.1 MG
RAS Rate	50%
Nitrate Recycle Rate	400%
Max MLSS at Loading Rate	3,000 mg/L
Effluent TN	4.6 mg/L
Methanol Addition	Yes; 1,200 gpd (6 months)
Fixed Film Required?	Yes; 50% fill
Clarifiers?	1 new clarifier
Effluent Filtration Required?	No

Other plant modifications may be needed including screening and 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 4-stage Bardenpho process with both methanol addition to the second anoxic zone and IFAS in the aerobic zone is recommended to achieve an average annual effluent TN of 5 mg/L as shown in the BioWin model in Figure 4.4-7.

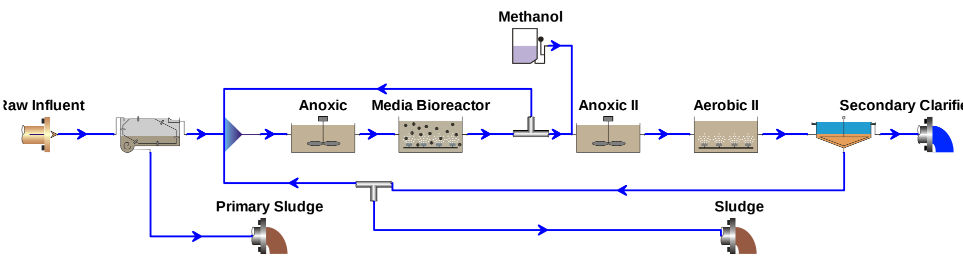


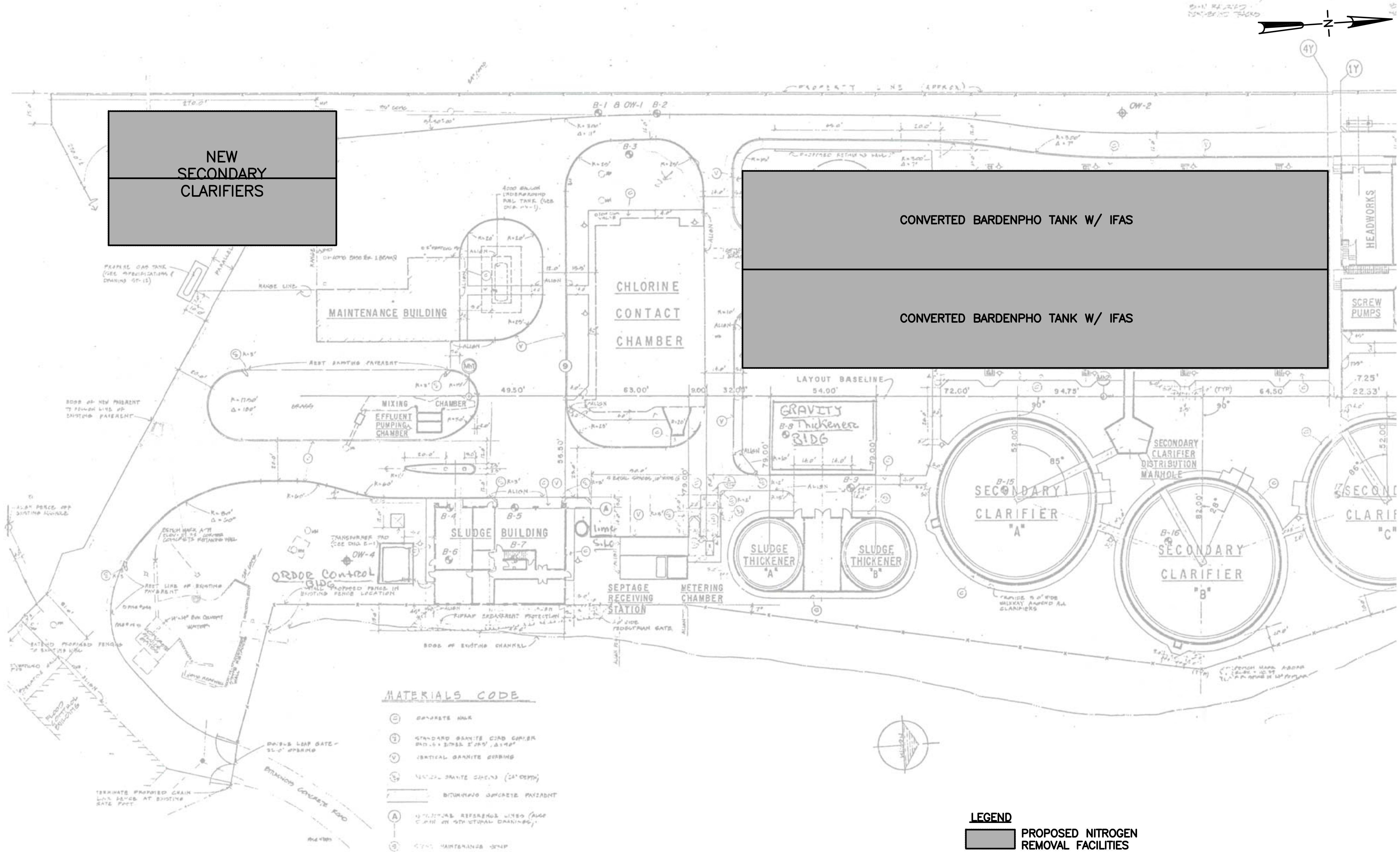
FIGURE 4.4-7: BIOWIN MODEL FOR ANNUAL AVERAGE TN LIMIT OF 5 mg/L

In order to meet the 5 mg/L target, 50% more volume is required. As shown in the site plan in Figure 4.4-8, the site has enough space for the additional volume if the existing digesters and digester building are demolished. The existing two tanks would be modified to form two parallel Bardenpho trains in a plug flow configuration and the additional tankage would be added on to the end of the tanks. IFAS media would also be required to meet the TN limit. Additional blower capacity would be required due to the IFAS system. Nitrate recycle pumps would be added as well as a methanol feed facility. Structural modifications would be required to partition the tanks.

In addition to the aeration tank modifications, it is also anticipated that two new clarifiers (in addition to the existing two) 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 12 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. The new clarifiers would be located in the open space south of the maintenance building. It is anticipated that WAS pumping capacity would have to be added to maintain the design SRT with the IFAS system.

Specific information regarding the design results is shown in Table 4.4-8 as follows.

(continued)



NOTES:

1. Background is from Drawing 7 from Contract Documents entitled "WASTEWATER TREATMENT FACILITY" by WHITMAN & HOWARD INC and dated 1978.
2. Auxiliary facilities associated with nitrogen removal processes are not shown.
3. Digesters and building would have to be demolished to expand bioreactors as 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

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Camp Dresser & McKee Inc.
One Cambridge Place, 50 Hampshire Street
Cambridge, MA 02139
Tel: (617) 452-6000
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NORTHAMPTON, MASSACHUSETTS
FIGURE 4.4-8

Table 4.4-8

RESULTS FOR ANNUAL AVERAGE TN LIMIT OF 5 mg/L

PARAMETER	VALUE
Aerobic SRT	N/A
Total SRT	8.6 days
First Anoxic Fraction	16%
Total Anoxic Fraction	32%
Reaeration HRT	20 minutes
Total Volume	3.1 MG
RAS Rate	50%
Nitrate Recycle Rate	400%
Max MLSS at Loading Rate	3,200 mg/L
Effluent TN	4.7 mg/L
Methanol Addition	Yes; 2,000 gpd
Fixed Film Required?	Yes; 50 % fill
Clarifiers?	2 new clarifiers
Effluent Filtration Required?	No

Other plant modifications may be needed including screening and 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 4.4-9 presents flow data for the Northampton WWTP as well as the current nitrogen removal performance of the plant. As shown, the facility is achieving minimal nitrogen removal both seasonally and year-round with their current Ludzack-Ettinger process.

(continued)

Table 4.4-9

PLANT FLOW AND EFFLUENT LIMIT SUMMARY

PARAMETER	VALUE
Permitted Flow (mgd)	8.6
Existing Flow (2004-6)	4.6
% of permitted capacity	53.5
Current average seasonal effluent TN (mg/L)[1]	20.8
Current average annual effluent TN (mg/L) [1]	20.8
Permit Limits Seasonal Nitrification (mg/L) Year-round nitrification (mg/L) Seasonal TN Limit Annual TN Limit	 No No Report Report

Table 4.4-10 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 Bardenpho process to consistently meet a seasonal TN permit of 8 mg/L. It will need to convert to a Bardenpho process with IFAS and methanol addition to consistently meet an annual average TN limit of 8 mg/L both 5 mg/L TN limits. The BioWin models were run at permitted capacity in the available room for expansion with an assumed ammonia to BOD ratio since no influent nitrogen data was available.

Table 4.4-10

NITROGEN REMOVAL PROCESS SUMMARY FOR NORTHAMPTON 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
Ludzack-Ettinger	Bardenpho	Bardenpho w/ IFAS and methanol addition	Bardenpho w/ IFAS and methanol addition	Bardenpho w/ IFAS and methanol addition

The modifications required at Northampton to convert to a new nitrogen removal process are summarized in Table 4.4-11. As noted, no minor modifications can be made to the treatment facility to improve nitrogen removal since they currently operate in a Ludzack-Ettinger mode.

Table 4.4-11

REQUIRED MODIFICATIONS SUMMARY FOR NORTHAMPTON 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
None	50% more volume added to end of existing tanks; conversion to plug flow; aeration equipment; nitrate recycle pumps; 2 new clarifiers; demolition existing digesters	50% more volume added to end of existing tanks; conversion to plug flow; aeration equipment; nitrate recycle pumps; IFAS system; 1 new clarifier; methanol feed facility; demolition existing digesters	50% more volume added to end of existing tanks; conversion to plug flow; aeration equipment; nitrate recycle pumps; IFAS system; 1 new clarifier; methanol feed facility; demolition existing digesters	50% more volume added to end of existing tanks; conversion to plug flow; aeration equipment; nitrate recycle pumps; IFAS system; 2 new clarifiers; methanol feed facility; demolition existing digesters	Extremely space-limited site; would have to remove one of the sludge processing methods to fit necessary tankage

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 4.4-12.

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 Northampton, the decreased volume equates to 25% less new bioreactor volume for annual permit conditions and not requiring any additional bioreactor volume for seasonal permit conditions. Everything else is assumed to be the same between the process alternatives.

(continued)

Table 4.4-12

COST SUMMARY FOR NITROGEN REMOVAL AT NORTHAMPTON WWTF[1]

LIMIT	CAPITAL COSTS (IN MILLIONS)	TOTAL ANNUAL COSTS[2] (IN MILIONS)	20-YR PRESENT WORTH (IN MILLIONS)
Minor Modifications/Retrofits	None	N/A	N/A
Seasonal Effluent TN of 8 mg/L	$20	$0.15	$21
MLE Configured Tanks	$11	$0.13	$13
Annual Average Effluent TN of 8 mg/L	$35	$0.83	$46
MLE Configured Tanks	$32	$0.82	$42
Seasonal Effluent TN of 5 mg/L	$36	$0.83	$46
Annual Average Effluent TN of 5 mg/L	$39	$1.40	$57

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)

4.5 HOLYOKE

A. **Introduction.** The Holyoke Water Pollution Control Faclity (WPCF) is located at One Berkshire Street in Holyoke, MA. It has a permitted average annual capacity of 17.5 mgd and serves the City of Holyoke only.

The first facility was built in the 1950s. The last major upgrade was in 1977.

B. **Existing Facilities.**

Aerial photo from www.google.com

1. **Description of Existing Facilities.** All flow is conveyed to the Holyoke WPCF by gravity where it enters the Headworks Building. This structure contains bar screens and aerated grit removal. The flow is then pumped to the primary clarifiers.

Primary effluent is then conveyed by gravity to the two Oxygenation Tanks. The oxygenation tanks are supplied with high purity oxygen for a high rate BOD removal process. The oxygenation tanks are each 144 ft long by 48 ft wide with an 11.25 ft sidewater depth. Four secondary clarifiers follow the Oxygenation Tanks. The clarifiers are each 100 ft diameter and 12 feet deep.

Secondary effluent is conveyed by gravity to the chlorine contact tank before being discharged to the Connecticut River. Plant effluent normally is discharged by gravity, but the facility is equipped with flood pumps in the event of high water elevations in the receiving water body.

Primary sludge is thickened in gravity thickeners and waste activated sludge is thickened in a rotary drum thickener. After thickening, the two sludges are combined in a pipe before being fed to a belt filter press. A process flow schematic is shown in Figure 4.5-1.

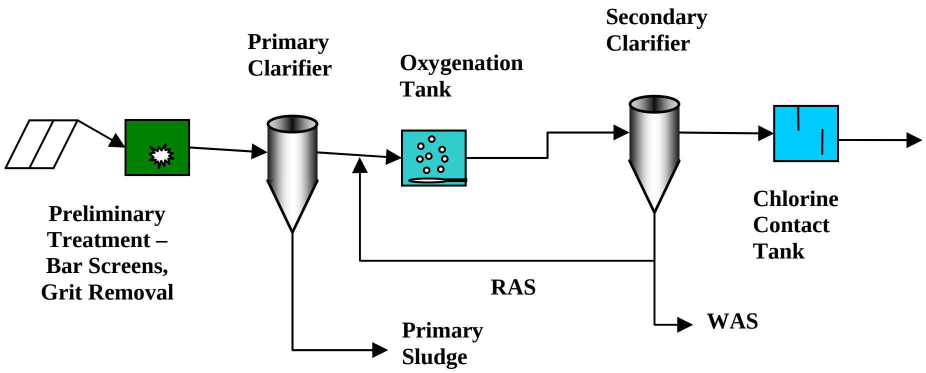


FIGURE 4.5-1: PROCESS FLOW SCHEMATIC – EXISTING FACILITY

The main plant recycle flow from the sludge processes is reintroduced to the waste stream prior to the Headworks Building, but after the influent sampler. The effluent sampler is located after disinfection.

The City of Holyoke has combined sewer overflows (CSO) and is in the process of reducing them. In 2007, a new CSO facility is being constructed adjacent to the existing WPCF. This CSO facility includes a pump station, disinfection and dechlorination facilities.

In addition, the facility receives flow from five industries with pretreatment programs. A local paper plant contributes to occasional high TSS loads. In addition, the paper plant discharges various colors to the wastewater.

Since October 1, 2005, both Oxygenation Tanks have been in operation. For the six years prior to that, only one tank was in use.

The plant is operated by Aquarion and includes nineteen full-time employees including the plant superintendent. This crew serves the plant, collection system, flood pumping facilities, the new CSO facility and street sweeping.

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

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 the following Table 4.5-1. Seasonal and annual average and maximum month data is summarized in the table.

(continued)

Table 4.5-1

HOLYOKE WPCF

Holyoke, Massachusetts

Monthly Averages 2004-2006

GENERAL			INFLUENT								EFFLUENT							
DATE		INF	pH	BOD	TSS	NO3	NO2	TKN	NH3	Temp	DO	BOD	TSS	Fecal	NO2 + NO3	TKN	NH3	TN
Month	Year	MGD		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Deg F	mg/L	mg/L	mg/L	Coli.	mg/L	mg/L	mg/L	mg/L
January	2004	9.50	6.7	155	168	0.81	0.08	20.0	8.0	54	6.3	10.1	6.3		1.4	4.60	3.58	5.98
February	2004	8.00	6.7	189	175	0.05	0.01	26.8	7.4	56	5.0	15.1	9.1		0.7	6.70	3.46	7.40
March	2004	8.60	6.7	181	207	0.05	0.01	20.0	7.6	55	4.9	14.7	8.9		0.9	8.30	4.30	9.18
April	2004	12.10	6.6	120	155	0.25	0.02	12.0	3.5	51	8.0	11.2	11.7	9	0.9	9.50	2.90	10.44
May	2004	9.60	6.6	204	185	0.05	0.22	9.2	4.9	62	5.8	12.5	9.8	6	0.6	5.10	1.80	5.68
June	2004	8.00	6.4	219	243	0.05	0.07	30.0	14.0	63	6.6	9.8	8.5	1	1.5	6.40	4.40	7.87
July	2004	7.50	6.1	217	201	0.05	0.01	64.0	11.0	71	6.1	9.7	8.9	7	2.1	13.00	5.70	15.05
August	2004	6.00	5.9	232	201	0.05	0.01	24.0	10.0	76	5.2	10.3	14.6	1	0.8	7.80	3.60	8.63
September	2004	8.40	5.8	150	211	0.05	0.01	66.0	13.0	75	5.8	8.4	11.4	0	2.5	22.00	12.00	24.45
October	2004	8.10	6.2	131	178	0.05	0.03	23.0	5.3	71	5.1	12.2	15.8	1	1.0	9.10	4.20	10.09
November	2004	7.70	6.3	188	211	0.05	0.01	22.0	7.2	69	5.7	12.3	9.5		0.8	5.30	3.20	6.07
December	2004	10.10	6.4	151	143	0.21	0.17	18.0	9.2	61	7.5	13.9	7.6		1.1	4.60	2.90	5.66
January	2005	8.00	6.6	110	111	0.05	0.01	12.0	4.9	55	7.0	9.1	6.3		0.9	3.90	2.60	4.84
February	2005	9.60	6.5	117	136	0.63	0.01	6.4	3.0	57	6.4	11.5	8.3		0.9	6.90	5.40	7.82
March	2005	9.60	6.5	105	123	0.05	0.03	14.0	3.9	56	5.3	12.2	8.0		1.3	6.10	4.10	7.36
April	2005	13.40	6.4	80	109	0.08	0.15	9.2	3.6	56	7.1	8.0	10.9	6	1.0	4.60	3.10	5.61
May	2005	9.10	6.3	110	139	0.05	0.01	14.0	5.4	61	6.2	7.0	7.9	3	0.5	3.90	3.00	4.39
June	2005	7.40	6.2	98	149	0.05	0.03	13.0	3.5	67	5.9	6.9	6.0	1	0.6	1.60	2.40	2.21
July	2005	7.10	6.1	131	213	0.05	0.01	18.0	5.0	73	5.6	8.7	8.5	7	0.9	33.00	5.00	33.94
August	2005	6.90	6.1	133	264	0.05	0.01	18.0	5.0	74	4.9	8.8	10.5	28	1.1	7.60	5.90	8.71
September	2005	6.20	6.2	169	227	0.05	0.01	33.0	6.3	73	5.1	10.8	12.9	9	0.7	6.10	3.80	6.81
October	2005	15.00	6.3	109	158	0.05	0.01	8.0	2.8	73	8.1	5.6	7.8	1	0.8	1.90	0.36	2.73
November	2005	10.30	6.7	130	119	0.05	0.01	13.0	5.0	66	5.8	6.9	6.3		0.6	4.40	3.30	4.95
December	2005	9.60	7	155	179	0.05	0.01	17.0	10.0	59	6.5	7.4	6.2		0.6	5.30	3.60	5.87
January	2006	12.90	7.1	140	204	0.05	0.01	9.6	4.7	64	7.6	10.5	6.3		0.9	2.60	1.60	3.52
February	2006	9.90	7.2	162	167	0.22	0.01	15.0	8.6	56	4.8	12.7	8.2		0.7	6.30	4.70	6.97
March	2006	7.40	7.2	234	230	0.05	0.01	21.0	12.0	57	4.4	24.2	16.3		0.7	11.00	8.20	11.73
April	2006	7.40	7.1	236	247	0.05	0.01	20.0	11.3	61	5.3	27.7	15.4	8	1.3	10.20	11.60	11.48
May	2006	10.10	7.2	187	213	0.30	0.01	16.5	4.6	64	6.0	18.0	9.6	24	1.0	4.79	3.26	5.78
June	2006	9.80	7.1	174	234	0.05	0.01	24.0	6.3	66	5.5	13.8	8.7	17	1.3	6.30	5.20	7.58
July	2006	8.60	7	180	248	0.05	0.10	28.0	7.5	69	5.8	14.1	11.2	74	0.8	12.30	5.80	13.06
August	2006	8.20	7	214	280	0.05	0.01	20.0	8.7	73	5.4	14.7	16.3	74	0.7	4.59	4.36	5.33
September	2006	8.30	7	273	376	0.05	0.01	31.0	11.7	70	5.5	9.8	10.2	18	1.0	38.50	9.07	39.47
October	2006	9.70	7	225	255	0.36	0.23	19.0	14.1	66	5.4	10.3	13.4	8	0.9	3.93	2.88	4.78
November	2006	10.90	7	179	210					65	5.2	18.5	27.1			4.74	2.74	
December	2006	8.70	6.9	259	314	0.05	0.01	23.0	9.6	64	5.2	11.5	14.7		1.2	6.08	3.47	7.29
Min. Month		6.00	5.80	80	109	0.05	0.01	6.40	2.80	51.0	4.40	6	6.0	0	0.49	1.60	0.36	2.21
Seasonal Average		**8.56**	**6.47**	**175.33**	**220.83**	**0.08**	**0.04**	**25.48**	**7.73**	**69.28**	**5.78**	**10.63**	**10.67**	**15.56**	**1.04**	**10.44**	**4.60**	**11.48**
Average		**9.10**	**6.61**	**167.97**	**199.53**	**0.12**	**0.04**	**21.08**	**7.39**	**64.1**	**5.89**	**11.91**	**10.5**	**14.43**	**0.98**	**8.31**	**4.37**	**9.39**
Max. Month		15.00	7.20	273.00	376.00	0.81	0.23	66.00	14.10	76.0	8.10	27.70	27.1	74.00	2.45	38.50	12.00	39.47

With a current average annual flow of 9.1 mgd and a permitted capacity of 17.5 mgd, this facility is operating at approximately 50% of its permitted capacity.

Based on the average BOD concentration of 168 mg/L and TN concentration of 21 mg/L, this wastewater has a BOD concentration that is between weak and medium strength wastewater, but a TN concentration that is clearly weak. Thus, the TN/BOD ratio is 0.13 which is low (a more typical TN/BOD ratio is 0.18).

3. **Permit Requirements and Current Performance.** The current permit for this facility has been in effect since September 29, 2006. Monthly permit limits that are relevant to this study are shown below in Table 4.5-2.

Table 4.5-2

SELECT MONTHLY PERMIT LIMITS

PARAMETER	LIMIT
CBOD5	30 mg/L
TSS	30 mg/L
Ammonia, TKN, Nitrate, Nitrite	Report

The plant has met its permit for the above parameters for all months that are included in this study.

4. **Nitrogen Removal Performance.** This facility collects a limited number of influent nitrate, nitrite, TKN and ammonia data. In addition, the same parameters are measured in the plant effluent as can be seen in Table 4.5-1, the facility does not fully nitrify.

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 influent data which correspond to maximum-month loads is shown in the following Table 4.5-3 for each permitting scenario. The minimum temperature for the permit condition is also shown.

Table 4.5-3

EXISTING INFLUENT PARAMETERS

Permit Condition	Parameter	Value
Annual Average	Flow, mgd	8.30
	BOD, mg/L	273
	TSS, mg/L	324
	TN, mg/L	31
	Temperature, F	51
Seasonal	Flow, mgd	8.30
	BOD, mg/L	273
	TSS, mg/L	324
	TN, mg/L	31
	Temperature, F	61

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. This projected data is shown in Table 4.5-4.

Table 4.5-4

MODEL INPUT PARAMETERS AT PERMITTED CAPACITY

Permit Condition	Parameter	Value
Annual Average	Flow, mgd	15.96
	BOD, mg/L	273
	TSS, mg/L	324
	TN, mg/L	31
	Temperature, F	51
Seasonal	Flow, mgd	15.96
	BOD, mg/L	273
	TSS, mg/L	324
	TN, mg/L	31
	Temperature, F	61

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.

The existing site is extremely limited and is nearly at its full build-out condition. There appears to be space for one more aeration (oxygenation) tank and very limited space elsewhere on the site.

1. **Minor Modifications/Retrofits.** At the current influent TN levels, there are no operational or minor modifications/retrofits that could be implemented at this facility to consistently achieve nitrogen removal.

2. **Modifications Required to Meet TN of 8.** This site is too limited to expand the existing process. For example, the site would require twelve additional aeration tanks in addition to the two existing tanks in order to be able to merely achieve the seasonal limit of 8 mg/L TN. Thus, the facility is a candidate for either expansion on another site or use of newer technologies such as membrane or biological aerated filters (BAF). Figure 4.5-2 shows a proposed layout of BAFs and denitrification filters on the existing site and Figure 4.5-3 shows the schematic of the facility with the new processes. The BAF would consist of a footprint of approximately 30,200 square feet and would consist of twelve cells each at approximately 48 ft by 27 ft. The denitrification filter complex would have a footprint of approximately 9900 square feet with six cells, each at approximately 30 ft by 20 ft.

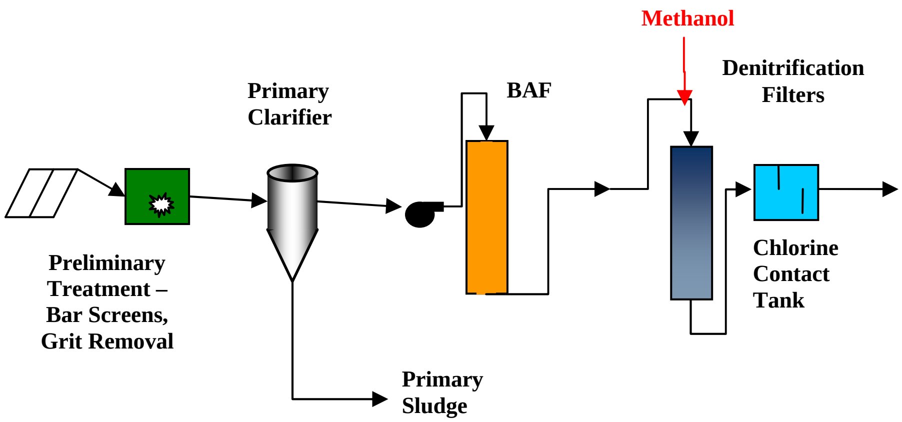
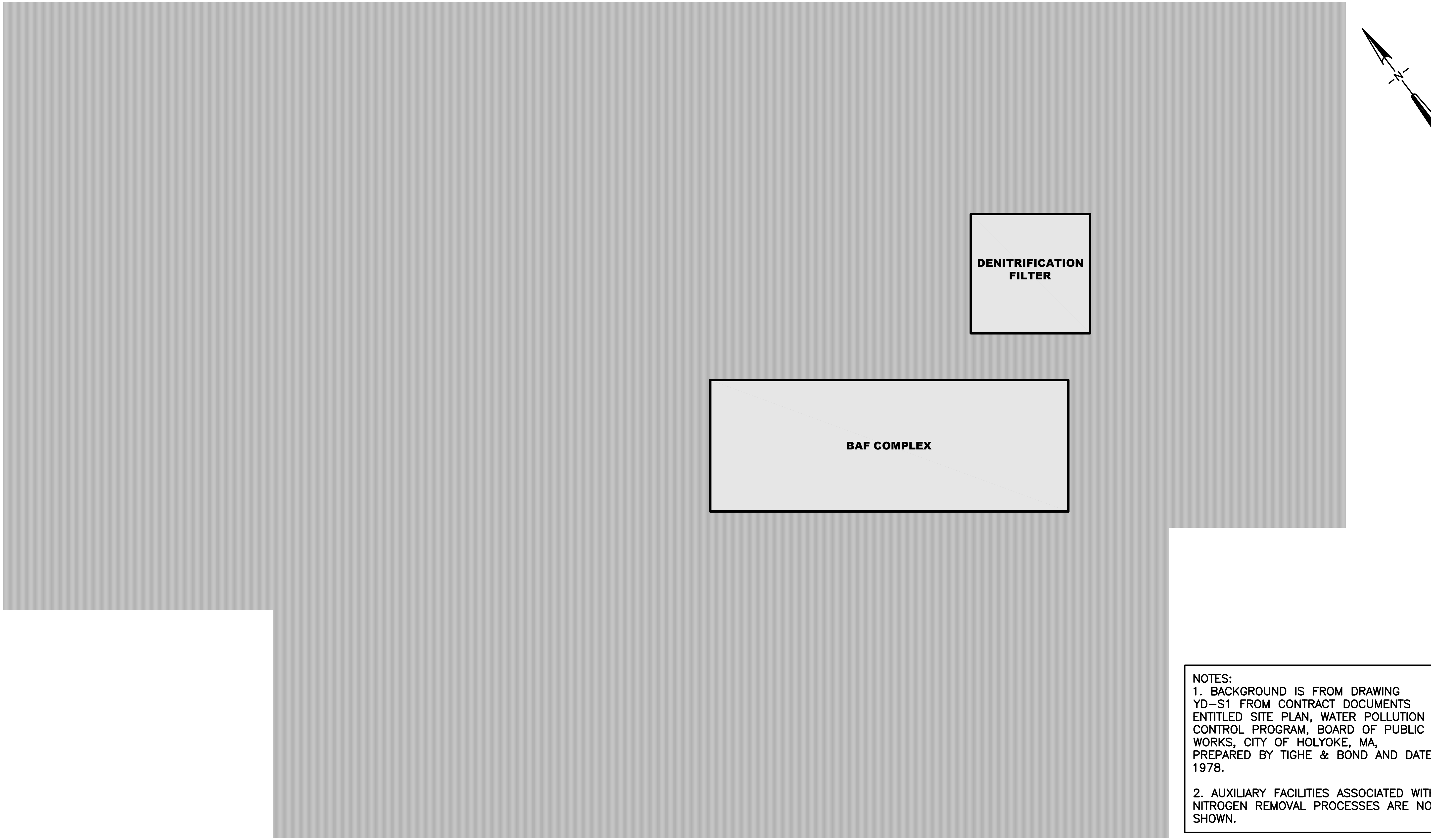


FIGURE 4.5-3:
PLANT FLOW SCHEMATIC FOR TN LIMIT OF 8 mg/L



NOTES:
1. BACKGROUND IS FROM DRAWING YD–S1 FROM CONTRACT DOCUMENTS ENTITLED SITE PLAN, WATER POLLUTION CONTROL PROGRAM, BOARD OF PUBLIC WORKS, CITY OF HOLYOKE, MA, PREPARED BY TIGHE & BOND AND DATED 1978.

2. AUXILIARY FACILITIES ASSOCIATED WITH NITROGEN REMOVAL PROCESSES ARE NOT SHOWN.

80 0 80 160
1"=80'–0"

SITE PLAN
SCALE: 1"=80'–0"

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
consulting • engineering • construction • operations

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

HOLYOKE, MASSACHUSETTS
FIGURE 4.5–2

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Filename: HOLYOKE–CH4.dwg
Latest Revision: Monday, March 31, 2008

The modifications related to the proposed upgrades described above would require the demolition of the oxygenation tanks and secondary clarifiers. 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.** Meeting a lower limit will require the same type of technology that was presented above.

D. **Plant and Cost Summary.**

The following Table 4.5-5 presents flow data for the Holyoke WPCF as well as the current nitrogen removal performance of the plant.

Table 4.5-5

PLANT FLOW AND EFFLUENT LIMIT SUMMARY

PARAMETER	VALUE
Permitted Flow (mgd)	17.5
Existing Flow (2004-6)	9.1
% of existing capacity	52
Current average seasonal effluent TN (mg/L)	11.5
Current average annual effluent TN (mg/L)	9.4
Permit Limits Seasonal Nitrification (mg/L) Year-round nitrification (mg/L) Seasonal TN Limit Annual TN Limit	 Report Report Report Report

Table 4.5-6 presents the nitrogen removal processes identified in this section to achieve the four different permit conditions considered. Based on the loading conditions established for this facility and due to extreme space limitations, modifications to the existing facility are not possible to be able to achieve the permit conditions in this study. A biological aerated filter is one technology that could be used at this site to achieve TN limits of 5 and 8 mg/L.

Table 4.5-6

NITROGEN REMOVAL PROCESS SUMMARY FOR HOLYOKE WPCF

MINOR MODIFICATIONS OR RETROFITS	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
None	Biological aerated filters followed by denitrification filters	Biological aerated filters followed by denitrification filters	Biological aerated filters followed by denitrification filters	Biological aerated filters followed by denitrification filters

The modifications required at Holyoke to convert to a new nitrogen removal process are summarized in Table 4.5-7. As noted previously, no minor modifications can be made to the treatment facility to improve nitrogen removal.

Table 4.5-7

REQUIRED MODIFICATIONS SUMMARY FOR HOLYOKE WPCF

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
New biological aerated filters and denitrification filters	New biological aerated filters and denitrification filters	New biological aerated filters and denitrification filters	New biological aerated filters and denitrification filters	Extremely 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 are included in Table 4.5-8.

(continued)

Table 4.5-8

COST SUMMARY FOR NITROGEN REMOVAL AT HOLYOKE WPCF[1]

LIMIT	CAPITAL COSTS (IN MILLIONS)	TOTAL ANNUAL COSTS[2] (IN THOUSANDS)	20-YR PRESENT WORTH (IN MILLIONS)
Minor Modifications/Retrofits	None	N/A	N/A
Seasonal Effluent TN of 8 mg/L	$99	$2,800	$130
Annual Average Effluent TN of 8 mg/L	$99	$3,400	$140
Seasonal Effluent TN of 5 mg/L	$99	$2,800	$130
Annual Average Effluent TN of 5 mg/L	$99	$3,400	$140

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)

4.6 CHICOPEE

A. **Introduction.** The Chicopee wastewater treatment facility is located at 80 Medina Street in Chicopee, MA. It has a permitted average annual capacity of 15.5 mgd and serves the City of Chicopee and two small portions of neighboring towns Granby and South Hadley. Approximately 5% of the influent flow is from industrial sources. The collection system is combined and there are 22 CSOs in the service area. The secondary system is designed to treat up to 25 mgd, and any influent above this rate is treated in the CSO facility at the plant.

The first phase of the facility was built in 1970 and consisted of a primary treatment plant. The second phase upgraded the plant to a high purity oxygen secondary treatment facility in 1977 and included disinfection. Changes that have occurred since 1977 include the addition of filter presses, a new oxygen compressor, new sludge conveyors, a new sludge garage and a new support equipment. A 15 mgd CSO facility was completed in the summer of 2006.

B. **Existing Facilities.**

Aerial photo from www.google.com

1. **Description of Existing Facilities.** The Chicopee River Interceptor and its five pump stations and the Connecticut River Interceptor and its seven pump stations convey wastewater to the Chicopee facility. All wastewater passes through a manual bar screen upon entering the plant. The flow then enters two aerated grit chambers, after which flow passes through three comminutors.

Ferric chloride is added to the headworks for seasonal phosphorus removal.

After primary clarification, the flow passes through a Parshall Flume and is pumped to the aeration tanks. Ferric chloride also is added to the pump station effluent for better sludge blanket control. The high purity oxygen aeration system consists of two 3-stage trains, with each stage 44 ft square with a side water depth of 14 ft. Oxygen is generated on-site. The four square secondary clarifiers are 75 ft by 75 ft with a 13 ft sidewater depth. PACl is added to the third chamber of the aeration tanks in the winter and during rain events when turbidity is high.

Secondary effluent receives chlorine disinfection and dechlorination with sodium bisulfite prior to being discharged in the Connecticut River. An effluent pump station is available to pump effluent to the river if the water stage in the river is too high for the effluent to flow by gravity. A liquid process flow schematic of the existing facility is shown in Figure 4.6-1.

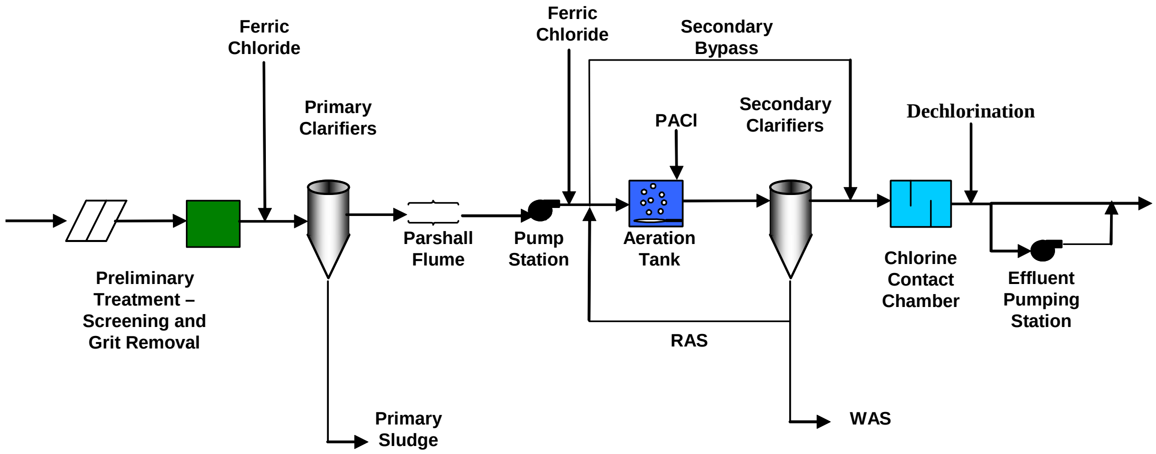


FIGURE 4.6-1: PROCESS FLOW SCHEMATIC – EXISTING FACILITY

Primary and waste activated sludge are thickened in four gravity thickeners and dewatered with centrifuges. Sludge cake is then transported to a landfill in Maine for disposal.

All plant recycle flows are returned downstream of the influent sampled but upstream of the Parshall flume and primary effluent sampler. Thus all plant flows are part of the primary effluent loads.

All clarifiers are in use at all times. One aeration train is in use at a time, and the train in operation is alternated every few years. Nitrification is not required, but the plant does not try to suppress nitrification at any time of the year.

The plant has thirty-nine employees. These include specialists for the collection system (6), flood control (3), CSO facility (1) and industrial pretreatment (3) in addition to the actual plant staff (26).

As shown in the aerial photo, there is very little space available on the site. An area that could be utilized is the location of the abandoned sludge storage/thickening tanks on the east side of the site. All new structures would be constructed on footings.

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 the following Table 4.6-1. Seasonal and annual average and maximum month data is summarized in the table.

(continued)

Table 4.6-1
CHICOPEE WWTF
Chicopee, Massachusetts
Monthly Averages 2003-2006

GENERAL		INFLUENT						PRIMARY EFFLUENT			FINAL EFFLUENT	
DATE		INF	pH	BOD	TSS	TEMP	ALKALINITY	BOD	TSS	ALKALINITY	BOD	TSS
MONTH	YEAR	MGD		MG/L	MG/L	DEG F	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
January	2004	11.0	15.9	98.4	111.6	54.8	72.5	79	46	0	19.5	15.9
February	2004	8.8	15.8	129.3	123.7	53.7	84.5	105	62	0	22.8	15.8
March	2004	8.9	16.2	127.6	129.7	54.6	87.7	103	63	0	21.5	16.2
April	2004	13.2	13.1	79.8	96.5	55.9	64.1	65	43	0	19.6	13.1
May	2004	11.4	14.3	92.3	109.3	60.4	75.9	73	48	93	20.3	14.3
June	2004	8.6	18.4	109.8	134.7	63.9	95.0	97	59	96	22.1	18.4
July	2004	8.0	13.3	124.5	155.5	67.0	103.9	87	78	106	17.1	13.3
August	2004	8.1	11.1	125.9	164.6	68.5	132.0	83	82	135	17.3	11.1
September	2004	9.1	12.4	133.8	159.7	67.6	120.3	104	70	114	17.5	12.4
October	2004	8.4	13.7	126.8	133.0	64.2	124.2	113	61	123	19.3	13.7
November	2004	8.2	17.7	141.8	151.4	61.2	137.7	119	68	0	20.2	17.7
December	2004	9.7	20.5	107.4	132.0	57.4	105.4	91	59	0	20.7	20.5
January	2005	10.3	21.6	88.8	133.4	55.8	81.5	80	66	0	22.6	21.6
February	2005	10.2	22.8	105.1	143.5	55.3	76.4	77	60	0	27.2	22.8
March	2005	10.0	20.4	95.3	130.1	56.7	87.5	85	66	0	23.1	20.4
April	2005	13.3	16.3	77.5	98.7	56.6	83.6	64	56	0	18.5	16.3
May	2005	10.6	14.8	91.2	116.9	59.9	88.6	77	63	82	17.4	14.8
June	2005	8.6	17.9	109.5	175.1	64.9	103.2	97	81	110	15.8	17.9
July	2005	8.2	17.6	107.8	146.6	68.1	106.1	99	85	116	18.1	17.6
August	2005	7.1	17.3	141.7	181.3	69.3	113.8	114	81	121	21.3	17.3
September	2005	6.8	14.8	146.2	172.3	68.9	120.2	118	68	117	19.6	14.8
October	2005	16.0	17.1	88.4	89.3	64.5	90.8	76	62	85	21.9	17.1
November	2005	12.9	18.6	81.6	89.9	61.3	81.2	74	51	0	19.9	18.6
December	2005	12.1	15.4	100.3	109.1	57.3	85.5	92	59	0	17.0	15.4
January	2006	16.2	20.3	77.4	102.0	55.9	72.0	74	71	0	23.8	20.3
February	2006	14.5	18.1	81.3	101.3	54.7	72.5	66	59	0	20.9	18.1
March	2006	9.8	15.6	112.3	121.3	56.0	83.0	92	76	0	21.0	15.6

(continued)

GENERAL		INFLUENT						PRIMARY EFFLUENT			FINAL EFFLUENT	
DATE		INF	pH	BOD	TSS	TEMP	ALKALINITY	BOD	TSS	ALKALINITY	BOD	TSS
MONTH	YEAR	MGD		MG/L	MG/L	DEG F	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L
April	2006	9.4	15.9	129.3	146.0	57.0	85.7	122	105	73	23.1	15.9
May	2006	11.3	14.7	95.0	126.7	61.3	85.7	92	79	109	16.6	14.7
June	2006	12.3	11.4	91.3	131.0	64.7	77.6	85	90	82	11.8	11.4
July	2006	9.2	10.3	99.0	119.0	67.5	87.2	77	64	92	14.9	10.3
August	2006	8.1	10.5	124.4	166.7	68.4	95.5	101	77	106	14.8	10.5
September	2006	7.6	12.0	131.0	165.6	67.2	112.2	110	69	110	14.3	12.0
October	2006	9.2	12.7	129.8	148.1	63.8	106.5	98	59	103	15.4	12.7
November	2006	11.0	21.2	94.7	157.1	61.9	91.8	69	42	0	22.2	21.2
December	2006	9.0	18.0	133.7	131.6	58.9	82.9	100	63	0	18.3	18.0
Min. Month		6.8	10.3	77.4	89.3	53.7	64.1	64.1	41.8	0.0	11.8	10.3
Seasonal Average		**9.4**	**14.1**	**114.9**	**144.2**	**65.6**	**102.1**	**94.6**	**71.0**	**105.5**	**17.5**	**14.1**
Average Annual		**10.2**	**16.0**	**109.2**	**133.5**	**61.3**	**93.7**	**90.5**	**66.5**	**54.8**	**19.4**	**16.0**
Max. Month		16.2	22.8	146.2	181.3	69.3	137.7	121.6	105.2	134.7	27.2	22.8

With a current average daily flow of 10.2 mgd and a permitted capacity of 15.5 mgd, this facility is operating at approximately 66% of its permitted capacity. Based on the average BOD concentration of 109 mg/L and TSS concentration of 134 mg/L, this wastewater would be considered low 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 May 17, 2005. Monthly permit limits that are relevant to this study are shown below in Table 4.6-2.

Table 4.6-2

SELECT MONTHLY PERMIT LIMITS

PARAMETER	LIMIT
BOD5	30 mg/L
TSS	30 mg/L
TKN	Report
Ammonia Nitrogen	Report
Nitrite Nitrogen	Report
Nitrate Nitrogen	Report

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 the effluent data is sampled at most once a month. This limited data indicates that minimal nitrification is occurring at the current flows.

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 primary effluent data which correspond to maximum-month loads is shown in the following Table 4.6-3 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.

(continued)

Table 4.6-3

EXISTING PRIMARY EFFLUENT PARAMETERS

PERMIT CONDITION	PARAMETER	VALUE
Average Annual	Flow, mgd	9.4
	BOD, mg/L	122
	TSS, mg/L	89
	TN, mg/L	21
	Temperature, F	54
Seasonal	Flow, mgd	12.3
	BOD, mg/L	85
	TSS, mg/L	63
	TN, mg/L	15
	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 4.6-4.

Table 4.6-4

MODEL INPUT PARAMETERS AT PERMITTED CAPACITY

PERMIT CONDITION	PARAMETER	VALUE
Average Annual	Flow, mgd	14.3
	BOD, mg/L	122
	TSS, mg/L	89
	TN, mg/L	21
	Temperature, F	54
Seasonal	Flow, mgd	18.7
	BOD, mg/L	85
	TSS, mg/L	63
	TN, mg/L	15
	Temperature, F	60

The model input data was used to run uncalibrated simulations for the seasonal permit limit and to size alternative treatment processes for the average annual permit limit in order 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 evaluation results are presented in the following sections.

1. **Minor Modifications/Retrofits.** Since this plant was designed only for BOD removal, nitrification cannot be expected to occur on a regular basis in the existing tankage. It would be even less likely if the tank volume was reduced to form an anoxic zone. Therefore, there are no operational or minor modifications/retrofits that could be implemented at this facility to achieve any appreciable level of nitrogen removal.

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 is not adequate for achieving a seasonal effluent TN level of 8 mg/L. It is recommended that IFAS be implemented in the existing pure oxygen process tanks for complete nitrification and denitrification filters be added for denitrification. The IFAS component is shown in the BioWin portion of the process schematic in Figure 4.6-2 below.

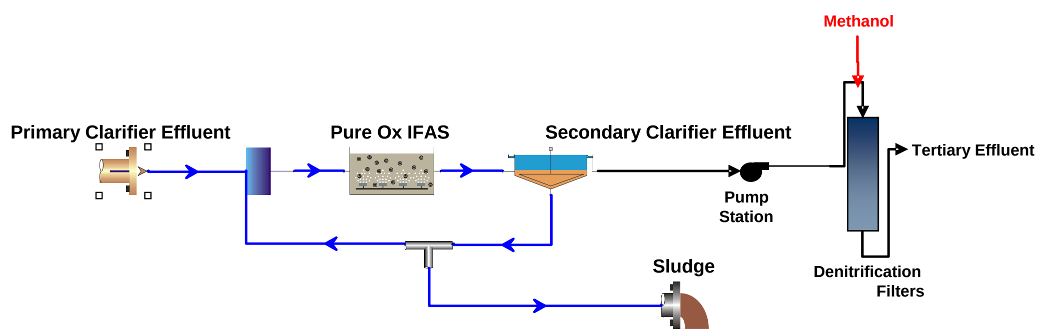
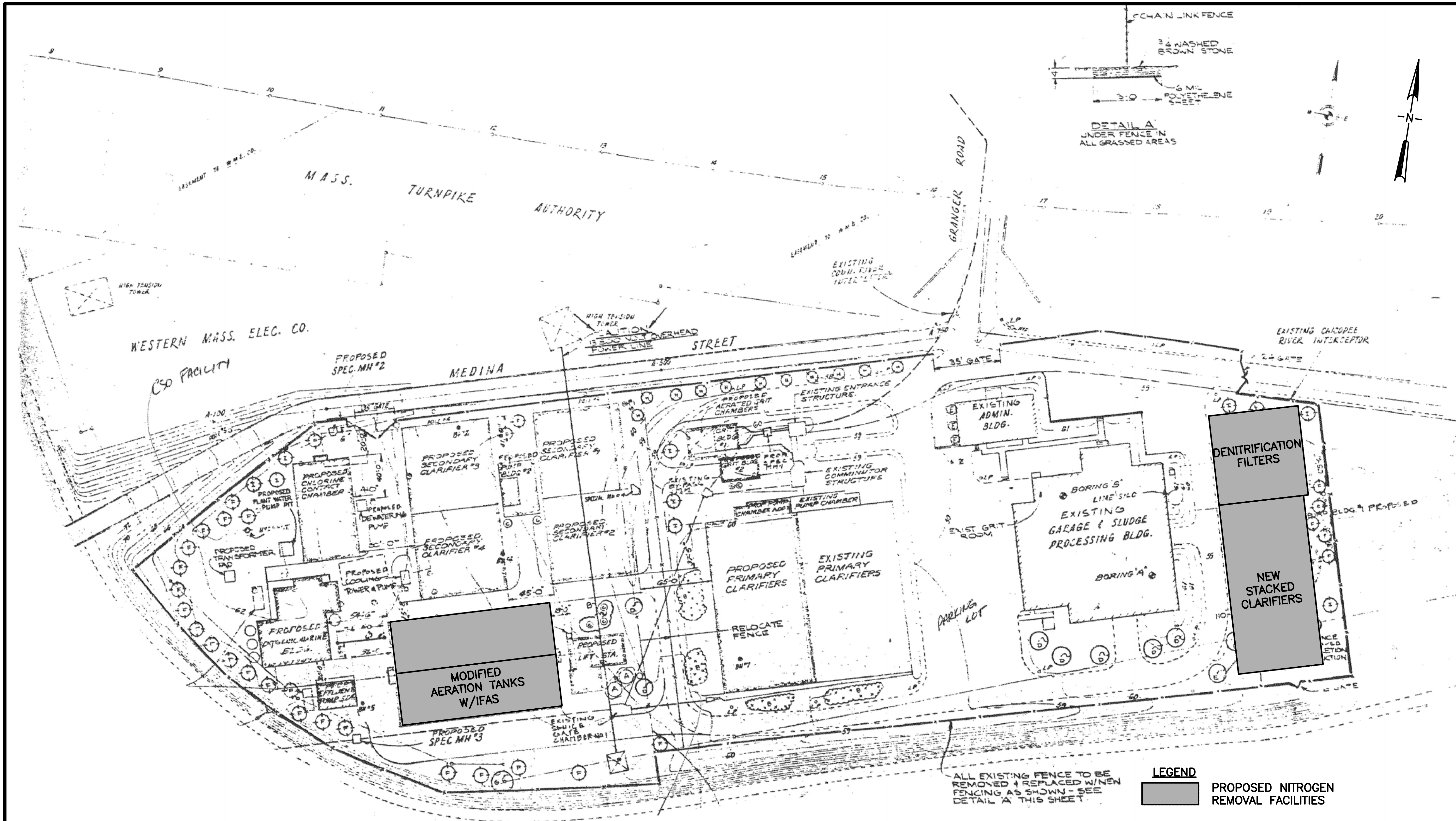


FIGURE 4.6-2: PROCESS SCHEMATIC FOR SEASONAL TN LIMIT OF 8 mg/L

This process would require that the existing aeration system be converted to from high purity oxygen aeration to aeration by air. The conversion would include new blowers, fine bubble diffusers and associated piping. A new methanol feed facility also is required. As shown in the site plan in Figure 4.6-3, the site appears to have enough space for the additional denitrification tanks if the abandoned sludge thickeners are demolished.



NOTE:

1. Background is from SITE LAYOUT Drawing from Contract Documents entitled "EXPANSION OF WWTP" by TIGHE & BOND and dated 1973.
2. Auxiliary facilities associated with nitrogen removal processes are not shown.
3. Existing sludge thickeners will have to be demolished to accomodate new facilities.

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Filename path: C:\Projects\CAM_CIVL\57833
Filename: FIG4-6-3.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

CHICOPEE, MASSACHUSETTS
FIGURE 4.6-3

In addition to the modified aeration tanks and denitrification filters, it is also anticipated that the facility will require four additional secondary clarifiers (in addition to the existing four) to operate the facility at the resultant model MLSS concentration. These would be stacked clarifiers and intermediate pumping would be required to get through them. They also would be located in the space occupied by the abandoned digesters. It should be noted that the existing clarifiers at this facility are 13 feet deep which meets the TR-16 minimum requirement. It is anticipated that WAS pumping capacity would have to be added to maintain the design SRT with the IFAS system.

Specific information regarding the process design is shown in Table 4.6-5 below.

Table 4.6-5

PROCESS DESIGN FOR SEASONAL LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Aerobic SRT	N/A
Total SRT	5.2 days
First Anoxic Fraction	N/A
Total Anoxic Fraction	N/A
Reaeration HRT	N/A
Total Volume	1.22 MG (IFAS); 0.28 MG (Effluent Filters – 4 cells)
RAS Rate	50%
Nitrate Recycle Rate	N/A
Max MLSS at Loading Rate	3,200 mg/L
Effluent TN	8 mg/L
Methanol Addition	Yes; 550 gpd
Fixed Film Required?	Yes; 60% fill
Clarifiers?	4 new clarifiers
Effluent Filtration Required?	Yes; 6,500 square feet (total footprint)

Other plant modifications may be needed including upgrades to screening or 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 is not adequate for achieving a seasonal effluent TN level of 8 mg/L. The same process configuration as proposed for the seasonal condition was investigated for the annual condition. However, the model predicted an effluent ammonia concentration of approximately 1 mg/L at an MLSS of 3,800 mg/L with an IFAS fill percentage of 60%. At this MLSS concentration, seven new secondary clarifiers are required, and there is not enough space on the site for all these clarifiers.

Thus, the facility is a candidate for either expansion on another site or use of alternative technologies such as membrane or biological aerated filters (BAF). Figure 4.6-4 shows a plant flow schematic with the new technologies, and Figure 4.6-5 shows a proposed layout of BAFs and a denitrification filters on the existing site.

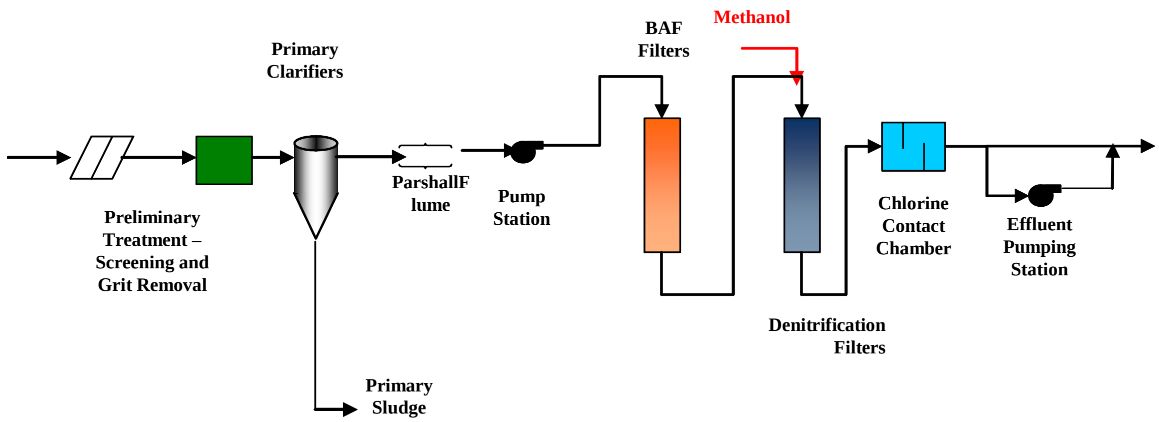
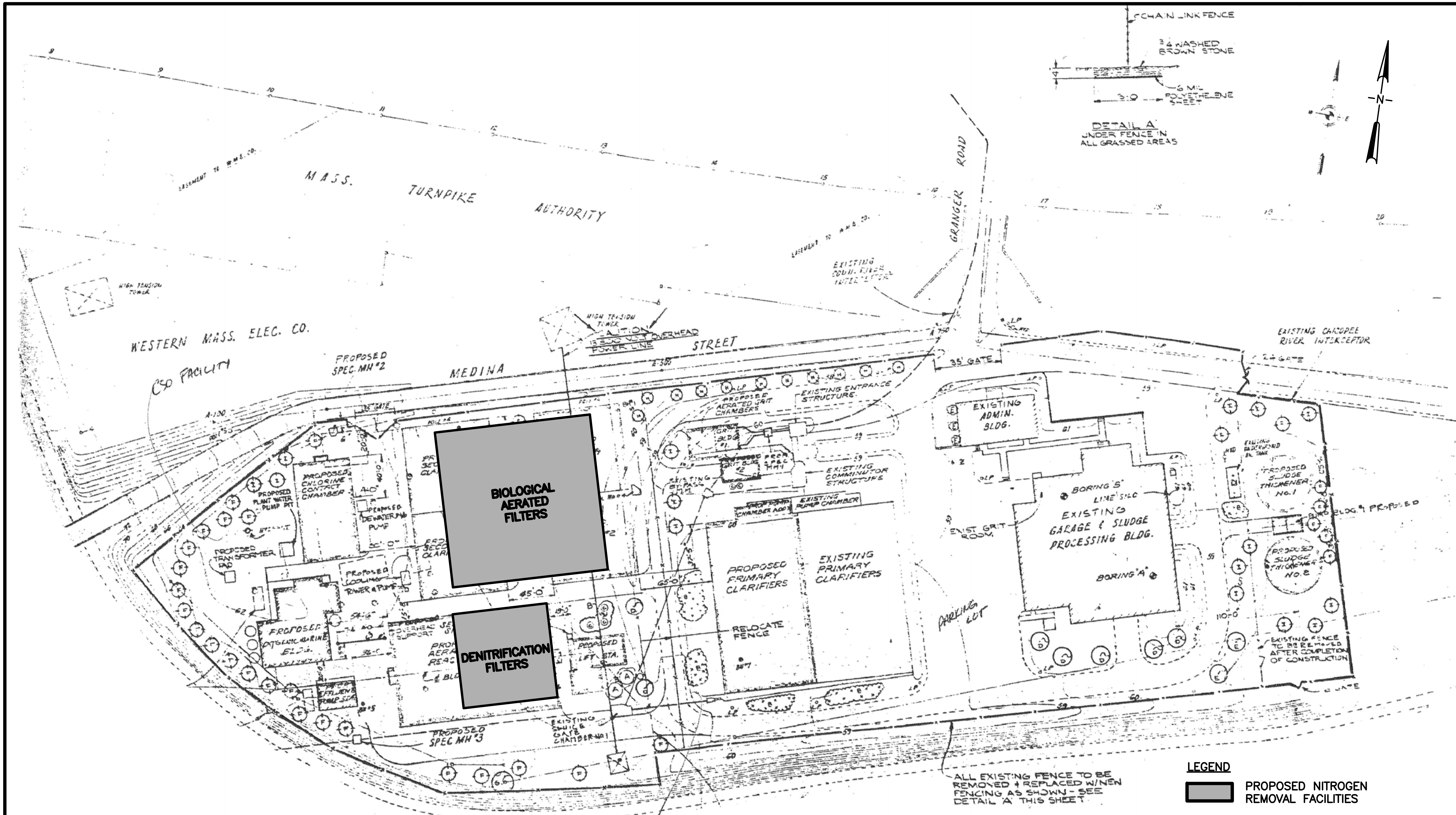


FIGURE 4.6-4:
PLANT FLOW SCHEMATIC FOR ANNUAL AVERAGE TN LIMIT OF 8 mg/L

The modifications related to the proposed upgrades described above would require the demolition of the oxygenation tanks and secondary clarifiers. The modifications also require an intermediate pump station to overcome the headloss through the filtration systems and a new methanol feed facility also is required. Other plant modifications may be needed including upgrades to sludge handling. Facilities outside of the activated sludge process are outside of the scope of this study.



NOTE:
1. Background is from SITE LAYOUT Drawing from Contract Documents entitled "EXPANSION OF WWTP" by TIGHE & BOND and dated 1973.
2. Auxiliary facilities associated with nitrogen removal processes are not shown.
3. Existing Aeration tanks and secondary clarifiers will have to be demolished to accomodate new facilities.

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Filename: FIG4-6-5.DWG
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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

CHICOPEE, MASSACHUSETTS
FIGURE 4.6–5

<u>Table 4.6-6</u>

PROCESS DESIGN FOR ANNUAL AVERAGE LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Aerobic SRT	N/A
Total SRT	N/A
First Anoxic Fraction	N/A
Total Anoxic Fraction	N/A
Reaeration HRT	N/A
Total BAF Volume and Area	1.4 MG (8 cells) 18,000 square feet (total footprint)
RAS Rate	N/A
Nitrate Recycle Rate	N/A
Max MLSS at Loading Rate	N/A
Effluent TN	8 mg/L
Methanol Addition	Yes; 550 mgd
Fixed Film Required?	No
Clarifiers?	N/A
Effluent Filtration Required?	Yes; 0.28 MG (4 cells) 6,500 square feet (total footprint)

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 traditional Bardenpho process is not applicable for achieving a seasonal effluent TN level of 8 mg/L. It is recommended that IFAS be implemented in the existing pure oxygen process tanks for adequate nitrification and denitrification filters be added for denitrification. The IFAS component is shown in the process schematic in Figure 4.6-6.

(continued)

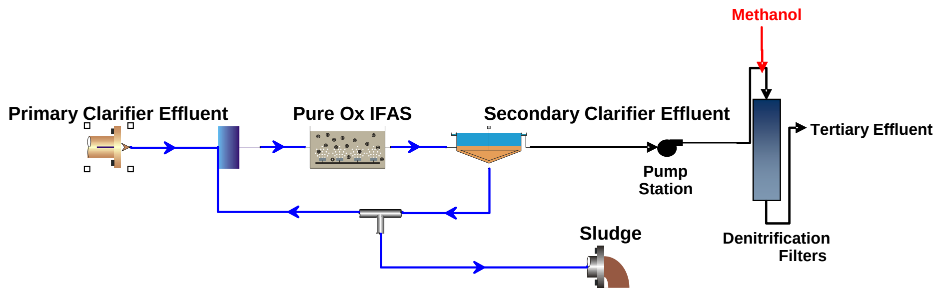


FIGURE 4.6-6: PROCESS SCHEMATIC FOR SEASONAL TN LIMIT OF 5 mg/L

This process would require that the existing aeration system be converted to from high purity oxygen aeration to aeration by air. The conversion would include new blowers, fine bubble diffusers and associated piping. A new methanol feed facility also is required. As shown in the site plan in Figure 4.6-3, the site appears to have enough space for the additional denitrification tanks if the abandoned sludge thickeners are demolished.

In addition to the modified aeration tanks and denitrification filters, it is also anticipated that the facility will require four additional secondary clarifiers (in addition to the existing four) to operate the facility at the resultant model MLSS concentration. These would be stacked clarifiers and intermediate pumping would be required to get through them. They also would be located in the space occupied by the abandoned digesters. It should be noted that the existing clarifiers at this facility are 13 feet deep which meets the TR-16 minimum requirement. It is anticipated that WAS pumping capacity would have to be added to maintain the design SRT with the IFAS system.

(continued)

Specific information regarding the process design is shown in Table 4.6-7 below.

Table 4.6-7

PROCESS DESIGN FOR SEASONAL LIMIT OF 5 mg/L TN

PARAMETER	VALUE
Aerobic SRT	N/A
Total SRT	5.2 days
First Anoxic Fraction	N/A
Total Anoxic Fraction	N/A
Reaeration HRT	N/A
Total Volume	1.22 MG (IFAS); 0.28 MG (Effluent Filters – 4 cells)
RAS Rate	50%
Nitrate Recycle Rate	N/A
Max MLSS at Loading Rate	3,200 mg/L
Effluent TN	5 mg/L
Methanol Addition	Yes; 740 gpd
Fixed Film Required?	Yes; 60% fill
Clarifiers?	4 new clarifiers
Effluent Filtration Required?	Yes; 6,500 square feet (total footprint)

Other plant modifications may be needed including upgrades to screening or 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 is not adequate for achieving a seasonal effluent TN level of 8 mg/L. The same process configuration as proposed for the seasonal condition was investigated for the annual condition. However, the model predicted an effluent ammonia concentration of approximately 1 mg/L at an MLSS of 3,800 mg/L with an IFAS fill percentage of 60%. At this MLSS concentration, seven new secondary clarifiers are required, and there is not enough space on the site for all these clarifiers.

Thus, the facility is a candidate for either expansion on another site or use of alternative technologies such as membrane or biological aerated filters (BAF). Figure 4.6-7 shows the plant flow diagram, and Figure 4.6-5 shows a proposed layout of BAFs and a denitrification filters on the existing site.

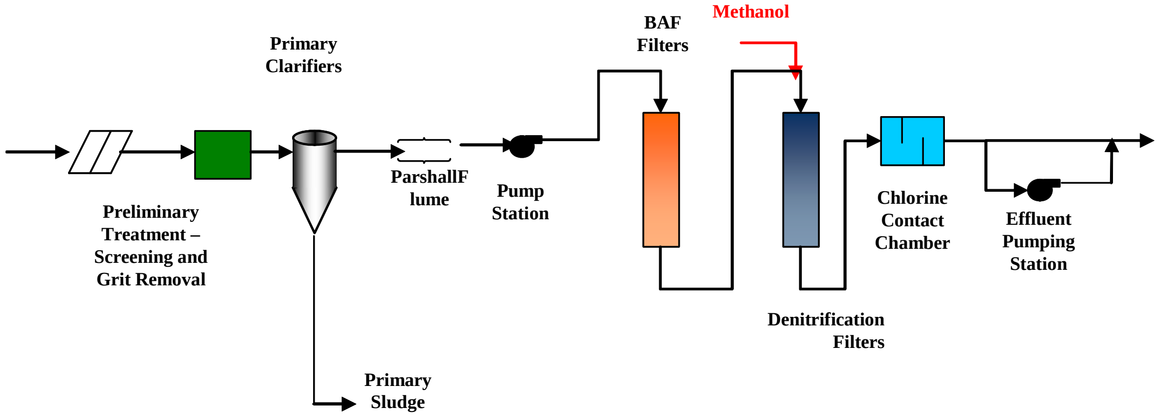


FIGURE 4.6-7:

PLANT FLOW SCHEMATIC FOR ANNUAL AVERAGE TN LIMIT OF 5 mg/L

The modifications related to the proposed upgrades described above would require the demolition of the oxygenation tanks and secondary clarifiers. The modifications also require an intermediate pump station to overcome the headloss through the filtration systems and a new Methanol feed facility also is required. 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.

(continued)

<u>Table 4.6-8</u>

PROCESS DESIGN FOR ANNUAL AVERAGE LIMIT OF 5 mg/L TN

PARAMETER	VALUE
Aerobic SRT	N/A
Total SRT	N/A
First Anoxic Fraction	N/A
Total Anoxic Fraction	N/A
Reaeration HRT	N/A
Total BAF Volume and Area	1.4 MG (8 cells) 18,000 square feet (total footprint)
RAS Rate	N/A
Nitrate Recycle Rate	N/A
Max MLSS at Loading Rate	N/A
Effluent TN	8 mg/L
Methanol Addition	Yes; 740 gpd
Fixed Film Required?	No
Clarifiers?	N/A
Effluent Filtration Required?	Yes; 0.28 MG (4 cells) 6,500 square feet (total footprint)

D. **Plant and Cost Summary.**

The following Table 4.6-9 presents flow data for the Chicopee WWTP as well as the current nitrogen removal performance of the plant. As shown, the facility is achieving minimal nitrogen removal with the current high purity oxygen activated sludge system.

(continued)

Table 4.6-9

PLANT FLOW AND EFFLUENT LIMIT SUMMARY

Parameter	Value
Permitted Flow (mgd)	15.5
Existing Flow (2004-6)	10.2
% of permitted capacity	65.8
Current average seasonal effluent TN (mg/L)	20
Current average annual effluent TN (mg/L)	20
Permit Limits Seasonal Nitrification (mg/L) Year-round nitrification (mg/L) Seasonal TN Limit Annual TN Limit	 Report Report Report Report

Table 4.6-10 presents the nitrogen removal processes required to meet the four different permit conditions considered. Based on the BioWin modeling performed, the facility can convert to a single-stage nitrification system with fine bubble diffused aeration and IFAS during the seasonal permit condition. This would be followed by denitrification filters to both seasonal TN limits. A biological aerated filter followed by a denitrification filter is recommended for each annual average scenario.

Table 4.6-10

NITROGEN REMOVAL PROCESS SUMMARY FOR CHICOPEE 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
High purity oxygen activated sludge	Single-stage nitrification w/ fine bubble aeration and IFAS plus a denitrification filter	Biological aerated filter and denitrification filter	Single-stage nitrification w/ fine bubble aeration and IFAS plus a denitrification filter	Biological aerated filter and denitrification filter

The modifications required at Chicopee to convert to a new nitrogen removal process are summarized in Table 4.6-11. As noted, no minor modifications can be made to the treatment facility to improve nitrogen removal.

Table 4.6-11

REQUIRED MODIFICATIONS SUMMARY FOR CHICOPEE 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
None	IFAS system in aeration tanks; replace aeration equipment; denitrification filters; methanol feed facility; 4 new stacked clarifiers; intermediate pump station; demolition of old digesters	Demolition of oxygenation tanks and clarifiers; nitrification and denitrification filters; intermediate PS; methanol feed facility	IFAS system in aeration tanks; replace aeration equipment; denitrification filters; methanol feed facility; 4 new stacked clarifiers; intermediate pump station; demolition of old digesters	Demolition of oxygenation tanks and clarifiers; nitrification and denitrification filters; intermediate PS; 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. O&M costs for the annual condition include all power requirements for the new secondary treatment system and not a cost differential from the existing secondary treatment system. The cost estimates are included in Table 4.6-12.

Table 4.6-12

COST SUMMARY FOR NITROGEN REMOVAL AT CHICOPEE WWTF[1]

LIMIT	CAPITAL COSTS (IN MILLIONS)	TOTAL ANNUAL COSTS[2] (IN MILLIONS)	20-YR PRESENT WORTH (IN MILLIONS)
Minor Modifications/Retrofits	n/a	n/a	n/a
Seasonal Effluent TN of 8 mg/L	$65	$0.3	$68
Annual Average Effluent TN of 8 mg/L	$87	$1.5	$106
Seasonal Effluent TN of 5 mg/L	$65	$0.3	$68
Annual Average Effluent TN of 5 mg/L	$87	$1.6	$107

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.

4.7 EASTHAMPTON

A. **Introduction.** The Easthampton wastewater treatment facility is located at 90 Ferry Street in Easthampton, MA. It has a permitted annual average capacity of 3.8 mgd and serves only the Town of Easthampton. There are sixteen pump stations in the collection system, and the collection system is entirely separate. Total industrial flow is less than 10%. The facility receives very little septage (approximately 26,000 gallons per year).

The current facility was built in 1971. Prior to 1971, primary clarifiers, a primary and secondary digester and sludge drying beds existed on the site. Changes that have occurred since 1971 include the addition of a belt filter press in the early 1980's and additional sludge processing upgrades in 2001.

B. **Existing Facilities.**

Aerial photo from www.google.com

1. **Description of Existing Facilities.** Flow is pumped to the Easthampton Wastewater Treatment Facility (WWTF) where it enters the headworks structure. This structure contains a mechanically cleaned bar screen and aeration grit chambers. From there, flow is conveyed through the Parshall flume to four rectangular primary clarifiers.

After primary clarification, the primary effluent flows by gravity to the aeration tanks. The facility has two aeration tanks. Each tank is 100 ft long by 50 ft wide with a 12 ft sidewater depth. Mechanical aerators are used for aeration. The aeration tanks are followed by two 11 ft deep, 65 ft diameter secondary clarifiers.

Secondary effluent receives chlorine disinfection and dechlorination prior to discharge. Treated flows up to 3.8 mgd are discharged to the Connecticut River and higher flows are diverted to the Manham River. A liquid process flow schematic is shown in the following Figure 4.7-1.

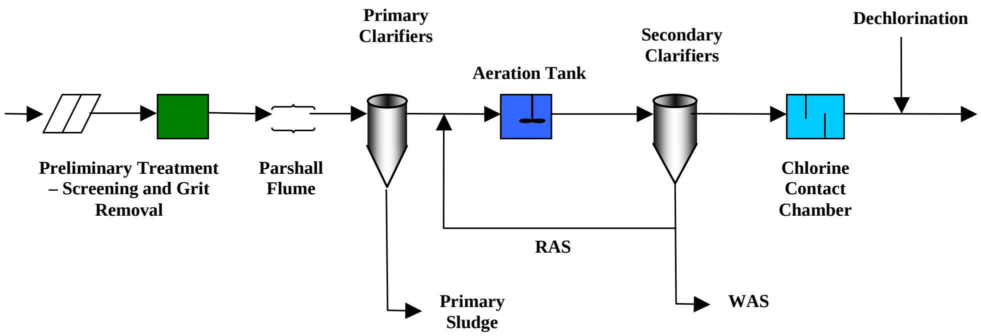


FIGURE 4.7-1: PROCESS FLOW SCHEMATIC – EXISTING FACILITY

Primary and secondary sludge are thickened in one of the gravity thickeners; the other thickener is used for storage. A belt filter press is used for sludge dewatering, and sludge cake is then trucked off site for disposal at the Synagro facility in Waterbury, Connecticut.

The influent sampler at this facility is located in the headworks building and does not include side stream loads. All plant recycles (gravity thickener overflow and BFP filtrate) are returned upstream of the primary effluent sampler.

All four primary clarifiers, one aeration tank and both secondary clarifiers are in use under normal operation. To handle high flows, the second aeration tank is used as an overflow tank but it is available for treatment if necessary. Nitrification is not required, but the plant does not try to suppress nitrification at any time of the year.

The plant has nine full-time employees, including the chief operator, assistant chief operator, two shift operators, a shift operator/pump station operator, a shift operator/pre-treatment coordinator, a mechanic, a repairman and an attendant.

There is space to construct additional tankage south and east of the aeration tanks, as well as northeast of the chlorine contact chambers and east of the existing secondary clarifiers as shown in the aerial.

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 the following Table 4.7-1. Seasonal and annual average and maximum month data is summarized in the table.

(continued)

Table 4.7-1

EASTHAMPTON WWTF

Easthampton, Massachusetts

Monthly Averages 2004-2006

GENERAL		INFLUENT					PRIMARY EFFLUENT			FINAL EFFLUENT		
DATE		INF	pH	BOD	TSS	TEMP	pH	BOD	TSS	pH	BOD	TSS
MONTH	YEAR	MGD		MG/L	MG/L	DEG F		MG/L	MG/L		MG/L	MG/L
January	2004	2.8	6.9	137.1	135.2	54.7	6.8	113.7	60.4	6.4	22.5	9.7
February	2004	2.0	7.4	221.5	257.0	54.1	7.3	132.1	92.4	7.1	12.9	8.1
March	2004	2.4	7.4	160.3	171.3	54.1	7.3	108.3	82.0	7.2	7.2	6.0
April	2004	4.1	7.1	94.4	100.2	55.6	7.0	68.9	48.4	7.0	9.1	9.7
May	2004	2.8	7.1	128.5	145.3	57.2	7.0	88.8	70.1	7.1	9.0	7.7
June	2004	2.2	7.1	172.1	191.7	59.9	6.9	113.8	70.9	7.0	10.5	7.2
July	2004	1.8	7.2	222.1	238.6	61.3	6.9	126.4	71.6	7.1	13.0	7.8
August	2004	1.8	7.3	214.7	210.4	69.1	7.0	146.7	63.8	7.1	17.6	16.3
September	2004	2.1	7.3	179.6	198.7	66.2	7.1	122.3	67.7	7.2	10.3	10.1
October	2004	2.4	7.2	133.9	166.6	63.5	7.0	106.9	73.3	7.1	7.5	4.8
November	2004	1.9	7.4	177.3	172.2	59.5	7.1	135.7	82.8	7.3	12.4	9.0
December	2004	2.7	7.2	152.8	156.8	56.7	7.1	114.3	87.9	7.0	38.4	9.4
January	2005	2.7	7.3	136.3	148.0	53.6	7.2	106.2	89.6	7.0	17.8	9.3
February	2005	2.5	7.2	155.3	153.0	54.0	7.2	115.1	87.3	7.1	12.1	11.4
March	2005	2.7	7.2	140.8	166.0	53.8	7.1	121.4	79.2	7.1	15.4	14.2
April	2005	3.7	7.0	110.3	105.7	53.1	7.0	87.8	60.2	7.0	13.0	6.6
May	2005	2.6	7.1	154.7	155.9	56.3	7.0	115.8	89.0	7.2	9.4	5.8
June	2005	1.9	7.2	188.6	211.5	62.4	6.9	151.7	88.7	7.1	13.6	8.9
July	2005	1.7	7.3	186.4	210.3	66.7	7.0	143.2	81.3	7.0	11.3	9.7
August	2005	1.5	7.3	209.5	219.6	70.5	7.0	145.6	76.4	7.1	12.5	7.8
September	2005	1.4	7.2	209.7	212.2	67.6	6.9	152.0	68.2	6.7	13.7	6.9
October	2005	3.9	6.9	106.8	116.0	63.5	6.7	82.3	39.1	6.5	14.3	11.7
November	2005	3.1	6.9	93.8	103.5	58.5	6.9	70.4	39.1	6.9	12.5	6.3
December	2005	2.7	7.0	121.2	108.3	54.7	6.9	88.2	51.1	7.0	9.7	6.6
January	2006	3.9	6.8	94.2	98.9	52.2	6.8	68.8	45.8	6.8	9.7	7.4
February	2006	3.4	6.7	106.0	96.9	51.8	6.7	76.6	46.1	6.7	11.7	7.2
March	2006	2.1	7.1	169.9	147.7	52.7	7.0	113.1	74.3	7.0	16.2	6.2
(continued)												

GENERAL		INFLUENT					PRIMARY EFFLUENT			FINAL EFFLUENT		
DATE		INF	pH	BOD	TSS	INF	pH	BOD	TSS	pH	BOD	TSS
MONTH	YEAR	MGD		MG/L	MG/L	DEG F		MG/L	MG/L		MG/L	MG/L
April	2006	2.0	7.0	191.8	172.4	54.0	7.0	129.3	80.5	7.1	15.3	5.4
May	2006	2.6	6.9	162.6	144.5	56.8	6.8	104.1	66.8	6.9	13.4	7.1
June	2006	2.4	6.9	164.2	162.0	61.5	6.8	106.5	66.9	6.8	20.8	13.8
July	2006	1.9	7.1	213.6	228.8	66.9	6.8	134.1	83.9	7.0	13.8	10.4
August	2006	1.5	7.2	243.6	252.0	69.1	6.9	131.1	85.1	7.1	20.7	12.9
September	2006	1.5	7.2	236.3	261.3	66.9	6.9	147.1	95.6	7.3	21.7	9.4
October	2006	1.9	7.2	190.9	221.2	63.0	7.0	128.2	80.7	7.2	13.6	11.9
November	2006	2.8	7.0	139.0	192.9	59.0	6.9	97.2	65.2	7.0	17.9	10.4
December	2006	2.1	7.1	169.2	174.4	56.3	6.9	123.0	76.8	7.1	32.4	30.2
Min. Month		1.4	6.7	93.8	96.9	51.8	6.7	68.8	39.1	6.4	7.2	4.8
Seasonal Average		**2.1**	**7.2**	**184.3**	**197.0**	**63.8**	**6.9**	**124.8**	**74.4**	**7.0**	**13.7**	**9.4**
Average Annual		**2.4**	**7.1**	**163.6**	**172.4**	**59.4**	**7.0**	**114.4**	**71.9**	**7.0**	**14.8**	**9.5**
Max. Month		4.1	7.4	243.6	261.3	70.5	7.3	152.0	95.6	7.3	38.4	30.2

With a current average daily flow of 2.4 mgd and a permitted capacity of 3.8 mgd, this facility is operating at approximately 63% of its permitted capacity. Based on the average BOD concentration of 164 mg/L and TSS concentration of 172 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 December 1, 2007. Monthly permit limits that are relevant to this study are shown below in Table 4.7-2.

Table 4.7-2

SELECT MONTHLY PERMIT LIMITS

PARAMETER	LIMIT
BOD5	30 mg/L
TSS	30 mg/L
TN	Report
TKN	Report
Ammonia Nitrogen	Report
Nitrite+Nitrate Nitrogen	Report
TP	Report

The above BOD and TSS limits have been met in most months of the data collection period; however, there was a BOD exceedence in December 2004 and December 2006. There also was one TSS exceedence in December 2006.

4. **Nitrogen Removal Performance.** This facility does not collect influent or effluent nitrogen data.

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 primary effluent data which correspond to maximum-month loads is shown in the following Table 4.7-3 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 4.7-3

EXISTING PRIMARY EFFLUENT INFLUENT PARAMETERS

PERMIT CONDITION	PARAMETER	VALUE
Average Annual	Flow, mgd	2.7
	BOD, mg/L	121
	TSS, mg/L	76
	TN, mg/L	23
	Temperature, F	52
Seasonal	Flow, mgd	3.9
	BOD, mg/L	82
	TSS, mg/L	52
	TN, mg/L	17
	Temperature, F	56

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 4.7-4.

Table 4.7-4

MODEL INPUT PARAMETERS AT PERMITTED CAPACITY

PERMIT CONDITION	PARAMETER	VALUE
Average Annual	Flow, mgd	4.2
	BOD, mg/L	121
	TSS, mg/L	76
	TN, mg/L	23
	Temperature, F	52
Seasonal	Flow, mgd	6.1
	BOD, mg/L	82
	TSS, mg/L	52
	TN, mg/L	17
	Temperature, F	56

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/Retrofit.** The plant is currently operating at 63% of its permitted capacity. The operators believe they are nitrifying year-round, although there is no data to confirm this. The plant is operating at a fairly low MLSS of 1,500-2,000 mg/L. The secondary clarifiers can handle up to 2,700 mg/L MLSS. Maintaining a higher MLSS and operating at a higher solids retention time would provide enough volume to nitrify year round, especially at the current average daily flow. Timers could be installed on the mechanical aerators so individual tanks can be cycled between anoxic and aerobic conditions to achieve denitrification. Submersible pumps could be installed in the aeration tanks to keep solids in suspension and maximize nitrogen removal.

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 below 8 mg/L. Thus an MLE process is recommended as shown in the BioWin model in Figure 4.7-2 below.

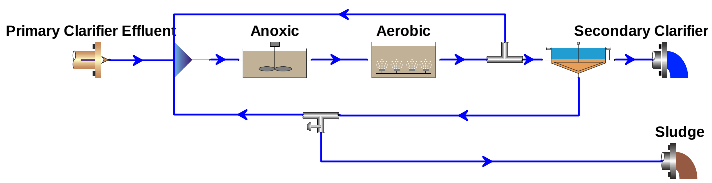


FIGURE 4.7-2: BIOWIN MODEL FOR SEASONAL TN LIMIT OF 8 mg/L

In order to meet the 8 mg/L target, the existing two aeration tanks would be modified to form two parallel MLE trains in a plug flow configuration. The existing mechanical aeration system would be converted to a fine bubble aeration system. Nitrate recycle pumps would be added. While the MLE process can fit in the existing tanks, the resulting MLSS would be nearly 4,000 mg/L, which would require an additional two clarifiers. By adding the equivalent of one new aeration tank (a 50% increase in volume), the need for additional clarifiers can be avoided as the MLSS would be around 2,300 mg/L. Therefore a third aeration tank is recommended as shown in the site plan in Figure 4.7-3. An analysis could be done during design to determine which approach (adding an aeration tank or clarifiers) is more cost-effective.

It is anticipated that no new 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 11 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.

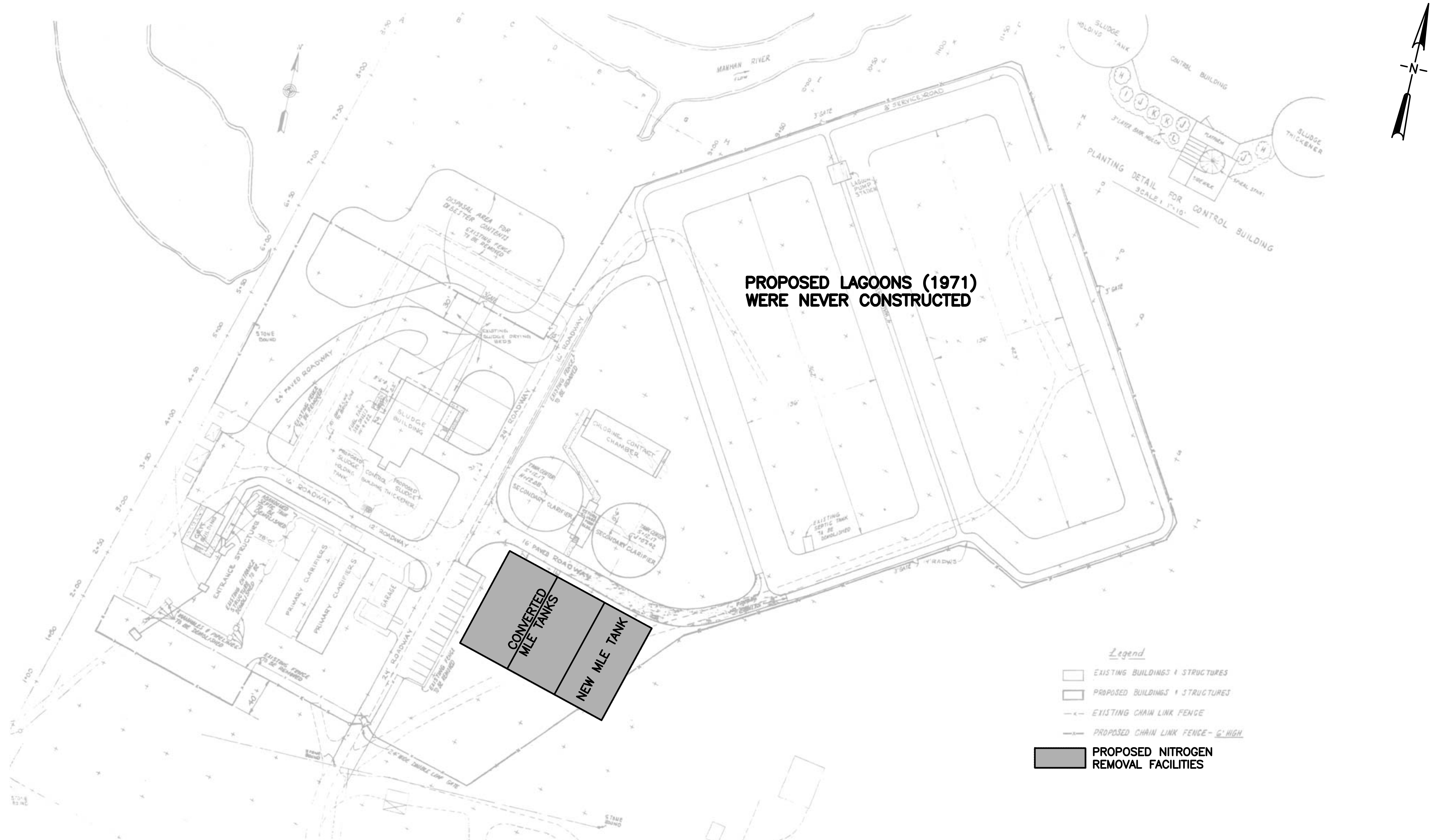
Specific information regarding the design results is shown in Table 4.7-5 below.

Table 4.7-5

RESULTS FOR SEASONAL LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Aerobic SRT	6.6 days
Total SRT	10.2 days
First Anoxic Fraction	35%
Total Anoxic Fraction	35%
Reaeration HRT	N/A
Total Volume	1.35 MG
RAS Rate	50%
Nitrate Recycle Rate	300%
Max MLSS at Loading Rate	2,300 mg/L
Effluent TN	5.7 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.



NOTES:

1. Background is from Drawing GENERAL PLANT LAYOUT from Contract Documents entitled "EXPANSION OF WWTP" by TIGHE & BOND and dated 1971.

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

EASTHAMPTON, MASSACHUSETTS
FIGURE 4.7-3

b. **Annual Average.** At the assumed influent TN levels for this facility, an MLE process will accomplish an average annual effluent TN level of 8 mg/L. Thus, an MLE process is recommended as shown in the BioWin model in the following Figure 4.7-4.

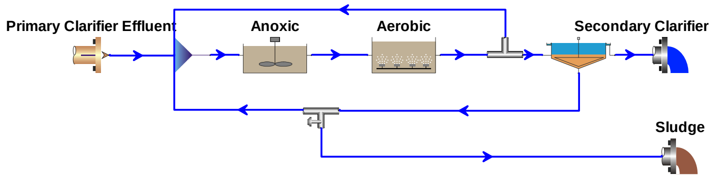


FIGURE 4.7-4: BIOWIN MODEL FOR ANNUAL AVERAGE TN LIMIT OF 8 mg/L

In order to meet the 8 mg/L target, the existing two tanks would be modified to form two parallel MLE trains in a plug flow configuration. The existing mechanical aeration system would be converted to a fine bubble aeration system. Nitrate recycle pumps would be added. While the MLE process can fit in the existing tanks, the resulting MLSS would be nearly 4,000 mg/L, which would require an additional two clarifiers. By adding the equivalent of one new aeration tank (a 50% increase in volume), the need for additional clarifiers can be avoided as the MLSS would be around 2,500 mg/L. Therefore a third aeration tank is recommended as shown in the site plan in Figure 4.7-3. An analysis could be done during design to determine which approach (adding an aeration tank or clarifiers) is the more cost-effective solution.

It is anticipated that no new 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 11 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.

Specific information regarding the design results is shown in the following Table 4.7-6.

(continued)

Table 4.7-6

RESULTS FOR ANNUAL AVERAGE LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Aerobic SRT	8.3 days
Total SRT	11.1 days
First Anoxic Fraction	25%
Total Anoxic Fraction	25%
Reaeration HRT	N/A
Total Volume	1.35 MG
RAS Rate	50%
Nitrate Recycle Rate	300%
Max MLSS at Loading Rate	2,500 mg/L
Effluent TN	7.0 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 4- stage Bardenpho process is recommended to achieve a seasonal effluent TN of 5 mg/L as shown in the BioWin model in Figure 4.7-5.

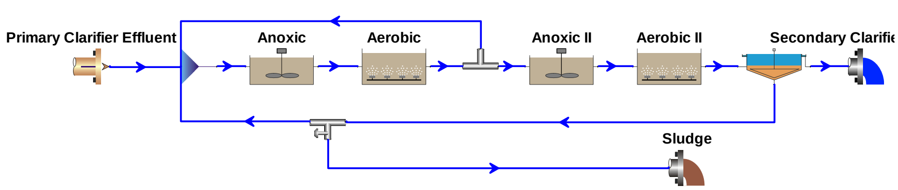


FIGURE 4.7-5: BIOWIN MODEL FOR SEASONAL TN LIMIT OF 5 mg/L

This process would require a 50% increase in tank volume. This adds a third tank to the east side of the existing tanks for three parallel four-stage Bardenpho trains in a plug flow configuration. The existing tanks would have to be modified for plug flow configuration and with the proper partitioning. The existing mechanical aeration system would be converted to a fine bubble aeration system. Nitrate recycle pumps would be added. Partitioning would be required to separate the four zones. As shown in the site plan in Figure 4.7-6, the site has enough space for the additional aeration tank.

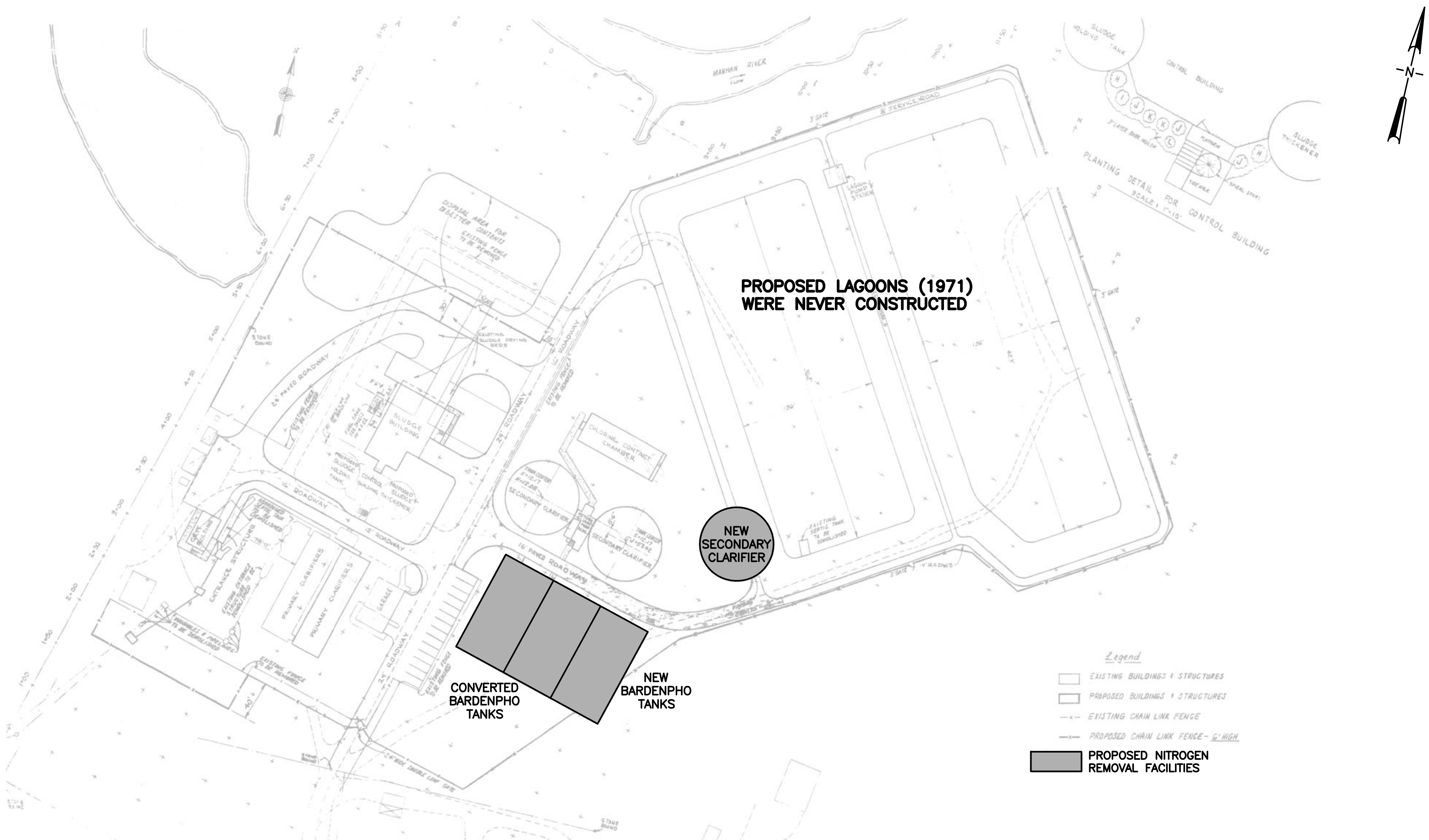
In addition to the new aeration tank, it is also anticipated that the facility will require one additional secondary clarifier (in addition to the existing two) to operate the facility at the resultant model MLSS concentration. It should be noted that the existing clarifiers at this facility are 11 feet 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.

Specific information regarding the design results is shown in Table 4.7-7 below.

Table 4.7-7

RESULTS FOR SEASONAL LIMIT OF 5 mg/L TN

PARAMETER	VALUE
Aerobic SRT	6.6 days
Total SRT	12 days
First Anoxic Fraction	20%
Total Anoxic Fraction	45%
Reaeration HRT	20 minutes
Total Volume	1.35 MG
RAS Rate	50%
Nitrate Recycle Rate	300%
Max MLSS at Loading Rate	2,700 mg/L
Effluent TN	4.1 mg/L
Methanol Addition	No
Fixed Film Required?	No
Effluent Filtration Required?	No



NOTES:

1. Background is from Drawing GENERAL PLANT LAYOUT from Contract Documents entitled "EXPANSION OF WWTP" by TIGHE & BOND and dated 1971.

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

EASTHAMPTON, MASSACHUSETTS
FIGURE 4.7-6

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.

b. **Annual Average.** At the assumed influent TN levels for this facility, a 4- stage Bardenpho process is recommended to achieve an average annual effluent TN of 5 mg/L as shown in the BioWin model in Figure 4.7-7.

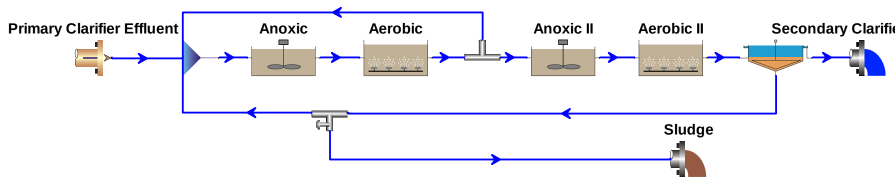


FIGURE 4.7-7: BIOWIN MODEL FOR ANNUAL AVERAGE TN LIMIT OF 5 mg/L

This process would require a 50% increase in tank volume. This adds a third tank to the east side of the existing tanks for three parallel four-stage Bardenpho trains in a plug flow configuration. The existing aeration tanks would have to be modified for plug flow configuration with the proper partitioning. The existing mechanical aeration system would be converted to a fine bubble aeration system. Nitrate recycle pumps would be added. Partitioning would be required to separate the four zones. As shown in the site plan in Figure 4.7-6, the site has enough space for the additional aeration 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 11 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.

(continued)

Specific information regarding the design results is shown in Table 4.7-8 below.

Table 4.7-8

RESULTS FOR ANNUAL AVERAGE LIMIT OF 5 mg/L TN

PARAMETER	VALUE
Aerobic SRT	8.3 days
Total SRT	15.1 days
First Anoxic Fraction	22%
Total Anoxic Fraction	45%
Reaeration HRT	20 minutes
Total Volume	1.35 MG
RAS Rate	50%
Nitrate Recycle Rate	400%
Max MLSS at Loading Rate	3,300 mg/L
Effluent TN	4.3 mg/L
Methanol Addition	No
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 4.7-9 presents flow data for the Easthampton WWTP as well as the current nitrogen removal performance of the plant. The facility does not collect influent or effluent nitrogen data.

(continued)

Table 4.7-9

PLANT FLOW AND EFFLUENT LIMIT SUMMARY

PARAMETER	VALUE
Permitted Flow (mgd)	3.8
Existing Flow (2004-6)	2.4
% of permitted capacity	63.2
Current average seasonal effluent TN (mg/L)	N/A
Current average annual effluent TN (mg/L)	N/A
Permit Limits Seasonal Nitrification (mg/L) Year-round nitrification (mg/L) Seasonal TN Limit Annual TN Limit	 Report Report Report Report

Table 4.7-10 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 an MLE process to achieve an 8 mg/L TN both seasonally and year-round. The uncalibrated BioWin models were run at permitted capacity with an assumed ammonia to BOD ratio since no influent nitrogen data was available.

Table 4.7-10

NITROGEN REMOVAL PROCESS SUMMARY FOR EASTHAMPTON 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 Easthampton to convert to a new nitrogen removal process are summarized in Table 4.7-11. 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 Easthampton.

Table 4.7-11

REQUIRED MODIFICATIONS SUMMARY FOR EASTHAMPTON 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	1 new aeration tank; conversion of existing to plug flow; aeration equipment; nitrate recycle pumps	1 new aeration tank; conversion of existing to plug flow; aeration equipment; nitrate recycle pumps	1 new aeration tank; 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	

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 4.7-12.

Table 4.7-12

COST SUMMARY FOR NITROGEN REMOVAL AT EASTHAMPTON 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	$11	$210	$13
Annual Average Effluent TN of 8 mg/L	$11	$240	$14
Seasonal Effluent TN of 5 mg/L	$13	$210	$16
Annual Average Effluent TN of 5 mg/L	$13	$220	$16

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)

4.8 SOUTH HADLEY

A. **Introduction.** The South Hadley wastewater treatment facility is located at 2 James Street in Chicopee, MA. It has a permitted average annual capacity of 4.2 mgd facility and serves the Town of South Hadley and small portions of the Town of Granby and the City of Chicopee. Less than 1% of the influent flow is from industrial discharges. The service area is comprised of 75 miles of sewer lines, with 90% separate sanitary sewer and 10% combined storm and sanitary sewer, and five pump stations. As of December 31, 2007 all of the permitted combined sewer overflows have been removed from the collection system.

The current facility was built between 1979 and 1980. Prior to 1980, two primary clarifiers, digesters and drying beds existed on the site. Changes that have occurred since 1980 include the addition of a belt filter press and conversion to sodium hypochlorite for disinfection in 2004.

B. **Existing Facilities.**

Aerial photo from www.google.com

1. **Description of Existing Facilities.** All flow conveyed to the South Hadley Wastewater Treatment Facility (WWTF) enters the Influent Pump Station which contains channel monsters upstream of the pumps. Flow is then pumped to the aerated grit chamber. From there, flow is conveyed to primary clarifiers by gravity.

After primary clarification, the primary effluent flows by gravity to the aeration tanks.

The facility has four square aeration tanks. Two tanks operate in series to form two parallel 2-tank trains. Each tank is 60 ft long by 60 ft wide with a 13.23 ft sidewater depth. Mechanical aerators are used for aeration. The aerators were recently replaced and VFDs were included to adjust the speed of the units. The aeration tanks are followed by two 10 ft deep, 75 ft diameter secondary clarifiers.

Secondary effluent then receives disinfection with sodium hypochlorite prior to being discharged to the Connecticut River. A process flow schematic is shown in the following Figure 4.8-1.

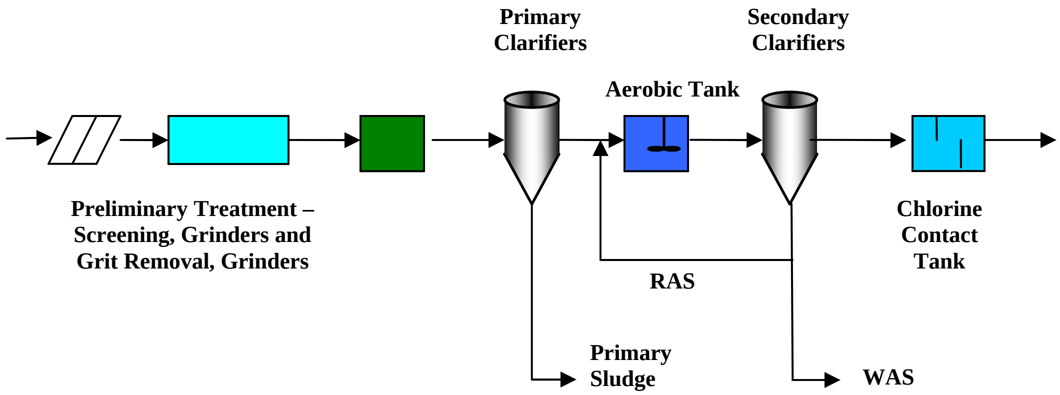


FIGURE 4.8-1: PROCESS FLOW SCHEMATIC – EXISTING FACILITY

Primary sludge and waste activated sludge are thickened in gravity thickeners and dewatered with a belt filter press. Sludge cake is trucked off site to a landfill.

All plant recycle flows (gravity thickener overflow and BFP filtrate) are returned into the influent channel of the primary clarifier. Thus, the primary effluent sample includes the recycle streams.

All three primary clarifiers, two of the four aeration tanks and both secondary clarifiers, chlorine contact tanks and gravity thickeners are in operation under normal conditions. Additional aeration tanks are brought on line during high flows to try to minimize washout of the biomass. Nitrification is not required, but the plant does not try to suppress nitrification at any time of the year.

The plant has eight full-time employees.

There is space available for expansion to the east and west of the existing aeration tanks as shown in the aerial photo. There is little available open space beyond that. There is a small open space south of the primary clarifiers, and the two, abandoned digesters could be demolished to fit necessary process tankage.

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 the following Table 4.8-1. Seasonal and annual average and maximum month data is summarized in the table.

(continued)

Table 4.8-1

SOUTH HADLEY WWTF

South Hadley, Massachusetts

Monthly Averages 2004-2006

GENERAL		INFLUENT								PRIMARY EFFLUENT			FINAL EFFLUENT						
DATE		INF	pH	BOD	TSS	TEMP	ALKALINITY	NH3	DO	pH	BOD	TSS	DO	BOD	TSS	F. COLI	NO2 + NO3	TKN	NH3
MONTH	YEAR	MGD		MG/L	MG/L	DEG F	MG/L	MG/L	MG/L		MG/L	MG/L	MG/L	MG/L	MG/L	# / 100ML	MG/L	MG/L	MG/L
January	2004	2.3	7.0	114.8	210.6	50.5			4.6	7.1	81.6	96.4	6.9	16.1	9.3	0.0	12.1	19.1	
February	2004	1.9	7.2	132.0	228.0	50.9			4.7	7.2	108.7	120.4	8.0	8.4	8.4	0.0	11.7	28.9	
March	2004	2.5	7.2	107.4	201.5	50.3			5.6	7.2	81.1	101.6	7.5	15.2	7.5	0.0	18.6	22.5	
April	2004	3.9	7.1	105.1	255.4	50.6			5.9	7.1	55.1	84.2	8.4	15.9	6.6	15.0	5.3	6.5	
May	2004	2.5	7.0	184.3	305.9	57.7			4.0	7.0	63.1	98.5	7.2	22.0	11.3	4.3			
June	2004	1.9	6.8	252.3	351.1	62.6			3.3	6.8	84.6	117.4	6.7	21.3	12.0	16.6	3.1	15.8	
July	2004	1.8	7.2	220.1	481.1	66.9			1.1	7.1	88.7	123.3	6.4	17.6	7.0	19.1	4.9	39.5	
August	2004	2.1	7.2	234.9	438.8	69.3			1.0	7.2	85.1	111.4	6.4	22.7	7.0	20.3	7.7	41.6	
September	2004	2.6	7.2	185.5	256.7	68.7			2.2	7.2	86.2	101.8	6.8	22.5	8.8	58.1	9.1	29.9	
October	2004	2.5	7.0	148.7	266.7	65.6			1.8	6.9	96.3	123.6	6.7	21.8	7.7	55.0	5.9	16.8	
November	2004	2.3	7.2	366.5	271.7	61.9			2.3	7.2	92.7	107.9	6.8	18.5	9.3	0.0	4.5	33.7	
December	2004	3.3	7.0	252.4	209.2	56.1			6.0	7.0	75.5	86.9	7.9	17.3	7.7	0.0	13.1	26.0	
January	2005	3.4	7.2	232.2	180.9	51.5			6.1	7.2	76.4	100.3	8.4	20.5	11.4	0.0	11.2	20.2	
February	2005	3.5	7.3	178.9	190.2	49.9			6.4	7.3	78.1	81.9	8.4	22.3	16.2	0.0	9.5	38.1	
March	2005	3.9	7.1	176.2	133.5	49.7	92.2	17.8	6.9	7.2	85.2	98.4	8.8	17.6	16.0	0.0	8.4	22.9	15.7
April	2005	4.5	7.1	146.1	122.6	51.8	190.9		6.1	7.1	69.1	75.3	9.3	13.1	7.2	45.3	5.5	6.7	
May	2005	3.1	7.1	198.9	196.0	56.3	135.7	37.7	4.1	7.0	77.4	67.3	7.7	20.6	7.1	30.8	4.1	12.0	10.2
June	2005	2.1	7.1	193.8	256.8	62.8	160.3	32.9	2.2	7.1	105.0	92.9	6.7	28.5	9.8	62.2	5.0	30.7	19.5
July	2005	2.0	7.2	206.6	306.4	67.5	175.0		1.1	7.2	123.2	94.0	6.4	20.1	4.8	69.0	3.4	11.3	
August	2005	1.8	7.2	377.2	346.2	69.5	151.9		0.9	7.1	137.0	89.1	6.4	23.1	8.0	17.0	2.4	13.1	
September	2005	1.7	7.2	219.3	297.6	68.9	215.3	33.6	1.1	7.2	78.0	71.4	6.1	15.3	6.0	17.8	4.2	13.8	16.7
October	2005	5.2	7.0	157.8	217.7	63.8	232.8		2.3	7.0	90.0	85.1	6.6	20.1	9.0	17.4	5.6	32.8	
November	2005	4.0	7.1	121.9	154.8	58.8			2.8	7.1	85.9	77.5	6.1	14.0	5.7	0.0	10.1	6.7	
December	2005	3.8	7.2	150.2	123.0	54.2			4.2	7.1	88.8	76.7	6.9	22.3	7.0	0.0	10.2	9.5	
January	2006	5.5	7.0	152.5	105.4	50.3			5.8	7.0	94.5	90.8	6.8	10.3	8.4	0.0	1.7	4.6	
February	2006	4.5	7.0	144.0	210.1	49.5			6.2	7.0	79.8	80.5	8.1	17.2	5.5	0.0	1.5	7.5	
March	2006	2.9	7.1	164.8	213.2	50.8			4.9	7.1	99.3	80.8	7.6	11.0	5.2	0.0	6.7	16.5	

(continued)

GENERAL		INFLUENT								PRIMARY EFFLUENT			FINAL EFFLUENT						
DATE		**INF**	**pH**	**BOD**	**TSS**	**TEMP**	**ALKALINITY**	**NH3**	**DO**	**pH**	**BOD**	**TSS**	**DO**	**BOD**	**TSS**	**F. COLI**	**NO2 + NO3**	**TKN**	**NH3**
MONTH	**YEAR**	**MGD**		**MG/L**	**MG/L**	**DEG F**	**MG/L**	**MG/L**	**MG/L**		**MG/L**	**MG/L**	**MG/L**	**MG/L**	**MG/L**	**# / 100ML**	**MG/L**	**MG/L**	**MG/L**
April	2006	3.0	7.1	216.3	263.7	53.3			4.0	7.0	107.4	94.0	6.6	16.7	5.4	15.3	2.6	36.8	
May	2006	4.4	7.0	232.2	221.9	57.0			3.8	7.0	94.8	80.3	6.7	21.8	8.4	44.6	2.0	22.1	
June	2006	2.7	7.2	203.0	262.5	62.6			3.6	6.9	82.4	107.3	6.4	14.4	6.2	108.5	4.6	14.8	
July	2006	2.1	7.2	181.6	264.7	67.1			1.4	7.1	94.2	85.9	6.0	9.8	4.6	37.6	5.0	25.1	
August	2006	1.8	7.1	280.1	287.6	68.9			0.8	7.0	137.6	140.6	5.9	23.3	10.5	82.6	3.1	29.2	
September	2006	1.9	7.2	275.3	328.5	67.8			1.3	7.2	112.4	120.8	5.9	20.6	4.9	14.6	3.3	30.0	
October	2006	2.5	7.2	211.7	204.2	64.2			1.9	7.2	111.4	76.5	6.0	17.8	4.2	40.9	1.7	17.0	
November	2006	3.3	7.1	172.2	158.2	60.0			3.2	7.2	89.4	59.6	7.1	25.0	5.8	0.0	0.1	7.1	
December	2006	2.4	7.2	225.6	202.2	57.4			3.2	7.1	126.4	80.2	6.5	20.7	3.8	0.0	2.9	5.4	
Min. Month		1.7	6.8	105.1	105.4	49.5	92.2	17.8	0.8	6.8	55.1	59.6	5.9	8.4	3.8	0.0	0.1	4.6	10.2
Seasonal Average		**2.5**	**7.1**	**220.2**	**293.9**	**64.8**	**178.5**	**34.7**	**2.1**	**7.1**	**97.1**	**99.3**	**6.5**	**20.2**	**7.6**	**39.8**	**4.4**	**23.3**	**15.5**
Average Annual		**2.9**	**7.1**	**197.8**	**242.3**	**59.0**	**169.3**	**30.5**	**3.5**	**7.1**	**92.3**	**93.9**	**7.0**	**18.5**	**7.9**	**22.0**	**6.0**	**20.4**	**15.5**
Max. Month		5.5	7.3	377.2	481.1	69.5	232.8	37.7	6.9	7.3	137.6	140.6	9.3	28.5	16.2	108.5	18.6	41.6	19.5

With a current average daily flow of 2.9 mgd and a permitted capacity of 4.2 mgd, this facility is operating at approximately 69% of its permitted capacity. Based on the average BOD concentration of 198 mg/L, this wastewater would be considered medium strength. Influent BOD can fall below 100 mg/L which makes it difficult to meet the required 85% permitted removal. 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 June 12, 2006. Monthly permit limits that are relevant to this study are shown below in Table 4.8-2.

Table 4.8-2

SELECT MONTHLY PERMIT LIMITS

PARAMETER	LIMIT
BOD_5	30 mg/L
TSS	30 mg/L
TKN	Report

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 regular influent nitrogen data, and only collects effluent TKN once per month. The data indicates that nitrification is not occurring the majority of the time.

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 primary effluent data which correspond to maximum-month loads is shown in Table 4.8-3 as follows 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.

(continued)

Table 4.8-3

EXISTING PRIMARY EFFLUENT PARAMETERS

Permit Condition	Parameter	Value
Annual Average	Flow, mgd	4.5
	BOD, mg/L	95
	TSS, mg/L	80
	TN, mg/L	37
	Temperature, F	50
Seasonal	Flow, mgd	4.4
	BOD, mg/L	95
	TSS, mg/L	80
	TN, mg/L	37
	Temperature, F	38

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 4.8-4.

Table 4.8-4

MODEL INPUT PARAMETERS AT PERMITTED CAPACITY

Permit Condition	Parameter	Value
Annual Average	Flow, mgd	6.3
	BOD, mg/L	95
	TSS, mg/L	62
	TN, mg/L	37
	Temperature, F	50
Seasonal	Flow, mgd	6.3
	BOD, mg/L	95
	TSS, mg/L	62
	TN, mg/L	37
	Temperature, F	63

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 currently operating at 69% of its permitted capacity. The secondary clarifiers can handle up to 2,800 mg/L MLSS at maximum-day flows. Maintaining a higher MLSS and solids retention time could provide enough volume to nitrify year round, especially at the current average daily flow. Therefore, the new aerators can be controlled via the VFDs to cycle between anoxic and aerobic conditions to achieve nitrification. No new equipment has to be added since the aerators were recently replaced and VFDs were included with the new units.

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. An MLE process will yield a seasonal effluent TN of 13 mg/L in the space available on the site. Thus, a four stage Bardenpho process with methanol addition to the second anoxic zone is recommended as shown in the BioWin model in Figure 4.8-2 below.

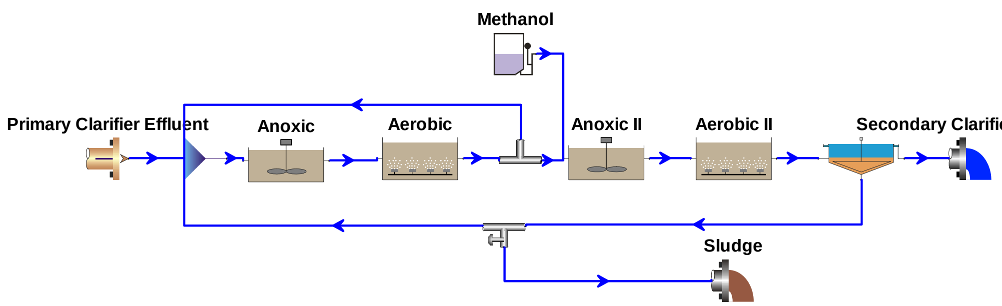


FIGURE 4.8-2: BIOWIN MODEL FOR SEASONAL TN LIMIT OF 8 mg/L

This process would require 50% more reactor volume. The existing tanks would be converted to two parallel plug flow reactors with flow moving in the east/west direction. The additional volume would be added to the front and back of the tanks to improve plug flow conditions. Structural modifications would be required to partition the tanks. The existing mechanical aeration system would be converted to a fine bubble aeration system.

Nitrate recycle pumps would be added as well as a methanol feed facility. As shown in the site plan in Figure 4.8-3, the site appears to have enough space for the additional reactor volume.

It is also anticipated that no new 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 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.

Specific information regarding the design results is shown in Table 4.8-5 below.

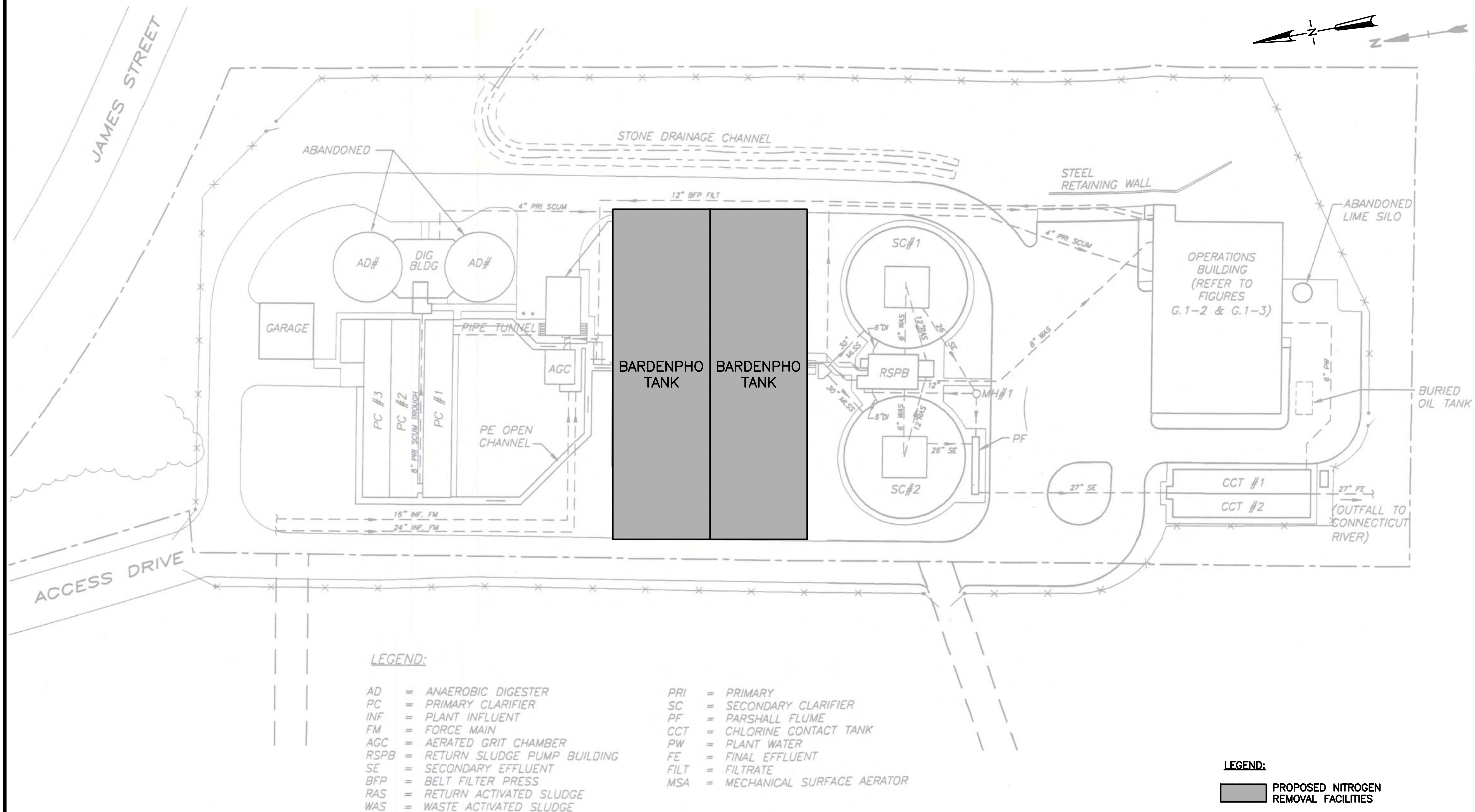
Table 4.8-5

RESULTS FOR SEASONAL LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Aerobic SRT	6.6 days
Total SRT	13.5 days
First Anoxic Fraction	15%
Total Anoxic Fraction	51%
Reaeration HRT	20 minutes
Total Volume	2.23 MG
RAS Rate	50%
Nitrate Recycle Rate	400%
Max MLSS at Loading Rate	2,800 mg/L
Effluent TN	6.7 mg/L
Methanol Addition	Yes; 200 gpd (6 months)
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.** As indicated above, at the assumed influent TN levels for this facility, an MLE process will not accomplish an average annual effluent TN level of 8



NOTE:

1. Background is from Drawing EXISTING FACILITY SITE PLAN from Contract Documents entitled "TOWN OF S. HADLEY WWTF" by TIGHE & BOND and dated 2001.
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
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ENGINEERING FEASIBILITY AND COST ANALYSES OF NITROGEN REDUCTION FROM SELECTED POTWS IN MASSACHUSETTS

SOUTH HADLEY, MASSACHUSETTS
FIGURE 4.8-3

mg/L. An MLE process will yield an annual average effluent TN of about 13 mg/L in the space available. Thus, a four stage Bardenpho process with methanol addition to the second anoxic zone is recommended as shown in the BioWin model in Figure 4.8-4 as follows.

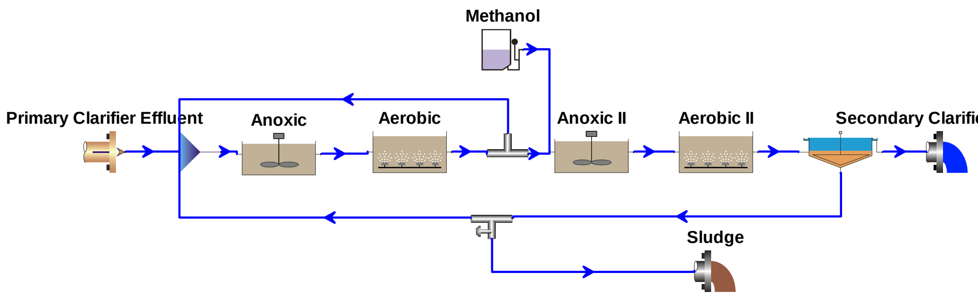
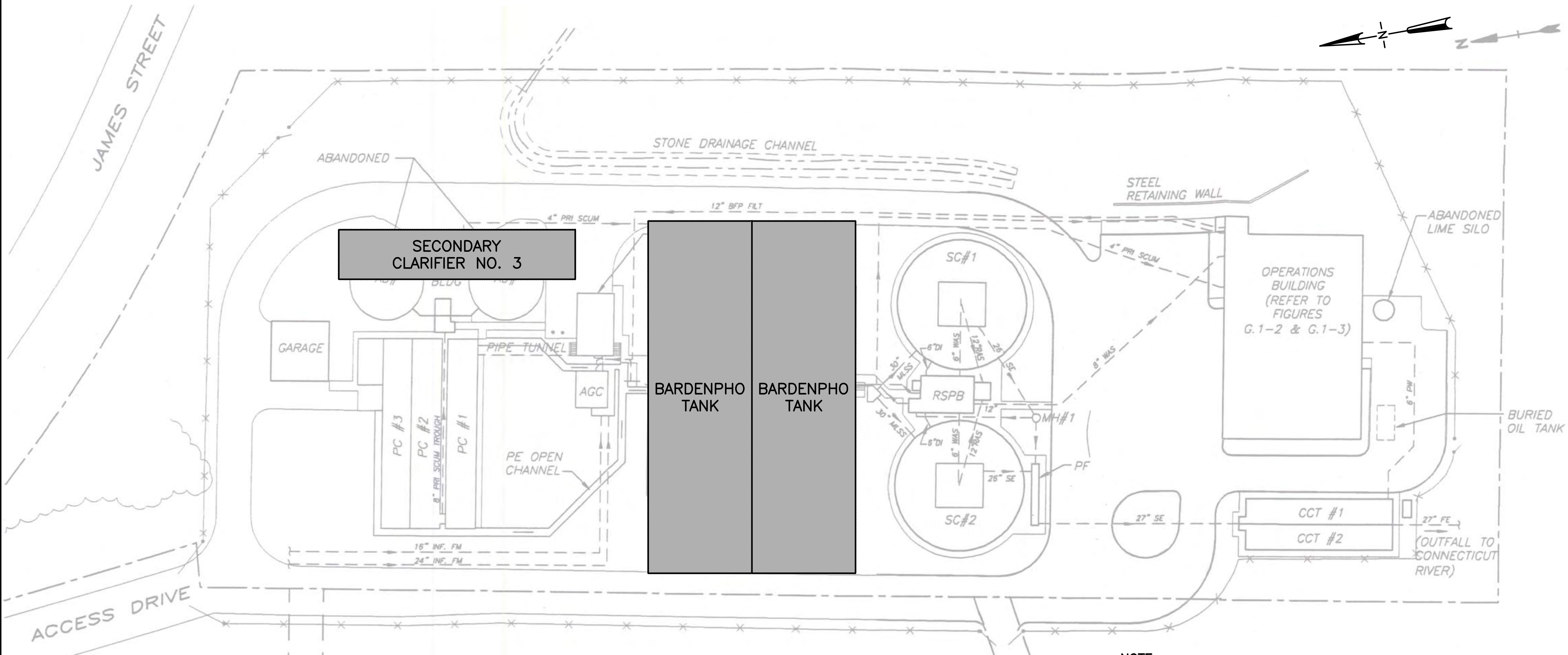


FIGURE 4.8-4: BIOWIN MODEL FOR ANNUAL AVERAGE TN LIMIT OF 8 mg/L

This process would require 50% more reactor volume. The existing tanks would be converted to two parallel plug flow reactors with flow moving in the east/west direction. The additional volume would be added to the front and back of the tanks to improve plug flow conditions. Structural modifications would be required to partition the tanks. The existing mechanical aeration system would be converted to fine bubble aeration. Nitrate recycle pumps would be added as well as a methanol feed facility. As shown in the site plan in Figure 4.8-5, the site appears to have enough space for the additional volume.

In addition to the aeration tank modifications and additional volume, 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 11 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 revaluated to determine if they will require replacement or derating because of the shallow depth. The abandoned digesters would be demolished to fit the new clarifier.

(continued)



LEGEND:

AD = ANAEROBIC DIGESTER
PC = PRIMARY CLARIFIER
INF = PLANT INFLUENT
FM = FORCE MAIN
AGC = AERATED GRIT CHAMBER
RSPB = RETURN SLUDGE PUMP BUILDING
SE = SECONDARY EFFLUENT
BFP = BELT FILTER PRESS
RAS = RETURN ACTIVATED SLUDGE
WAS = WASTE ACTIVATED SLUDGE
PRI = PRIMARY
SC = SECONDARY CLARIFIER
PF = PARSHALL FLUME
CCT = CHLORINE CONTACT TANK
PW = PLANT WATER
FE = FINAL EFFLUENT
FILT = FILTRATE
MSA = MECHANICAL SURFACE AERATOR

NOTE:

1. Background is from Drawing EXISTING FACILITY SITE PLAN from Contract Documents entitled "TOWN OF S. HADLEY WWTF" by TIGHE & BOND and dated 2001.

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

3. Existing digesters would be demolished to to install new clarifier.

LEGEND:

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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

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

SOUTH HADLEY, MASSACHUSETTS
FIGURE 4.8-5

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Filename: FIG4-8-5.DWG
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Specific information regarding the design results is shown in Table 4.8-6 below.

Table 4.8-6

RESULTS FOR ANNUAL AVERAGE LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Aerobic SRT	9.3 days
Total SRT	23.25 days
First Anoxic Fraction	15%
Total Anoxic Fraction	42%
Reaeration HRT	20 minutes
Total Volume	2.23 MG
RAS Rate	50%
Nitrate Recycle Rate	400%
Max MLSS at Loading Rate	3,500 mg/L
Effluent TN	7.8 mg/L
Methanol Addition	Yes; 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.

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 4.8-6 as follows.

(continued)

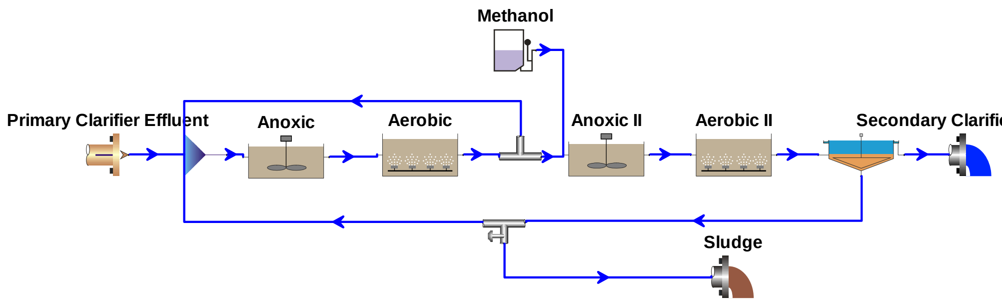


FIGURE 4.8-6: BIOWIN MODEL FOR SEASONAL TN LIMIT OF 5 mg/L

This process would require 50% more reactor volume. The existing tanks would be converted to two parallel plug flow reactors with flow moving in the east/west direction. The addition volume would be added to the front and back of the tanks to improve plug flow conditions. Structural modifications would be required to partition the tanks. The existing mechanical aeration system would be converted to fine bubble aeration. Nitrate recycle pumps would be added as well as a methanol feed facility. As shown in the site plan in Figure 4.8-5, the site appears to have enough space for the additional reactor volume.

In addition to the aeration tank modifications and additional volume, 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 11 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. The abandoned digesters would be demolished to fit the new clarifier.

(continued)

Specific information regarding the design results is shown in Table 4.8-7 below.

TABLE 4.8-7
MODELING RESULTS FOR SEASONAL LIMIT OF 5 mg/LTN

PARAMETER	VALUE
Aerobic SRT	6.6 days
Total SRT	13.5 days
First Anoxic Fraction	15%
Total Anoxic Fraction	51%
Reaeration HRT	20 minutes
Total Volume	2.23 MG
RAS Rate	50%
Nitrate Recycle Rate	400%
Max MLSS at Loading Rate	3,000 mg/L
Effluent TN	3.9 mg/L
Methanol Addition	Yes; 500 gpd (6 months)
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, 4-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 4.8-7.

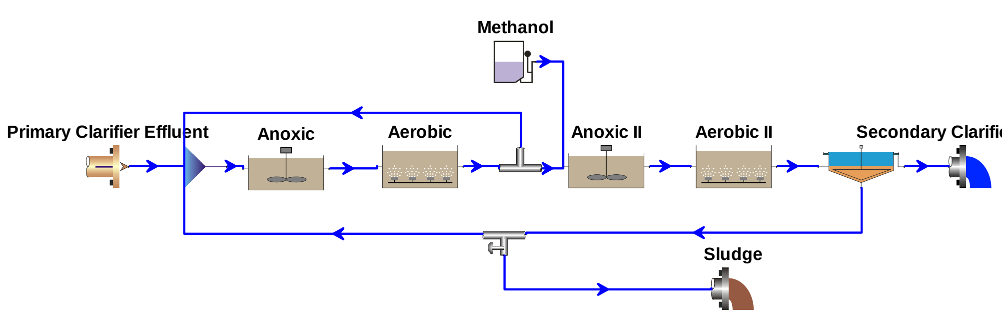


FIGURE 4.8-7: BIOWIN MODEL FOR ANNUAL AVERAGE TN LIMIT OF 5 mg/L

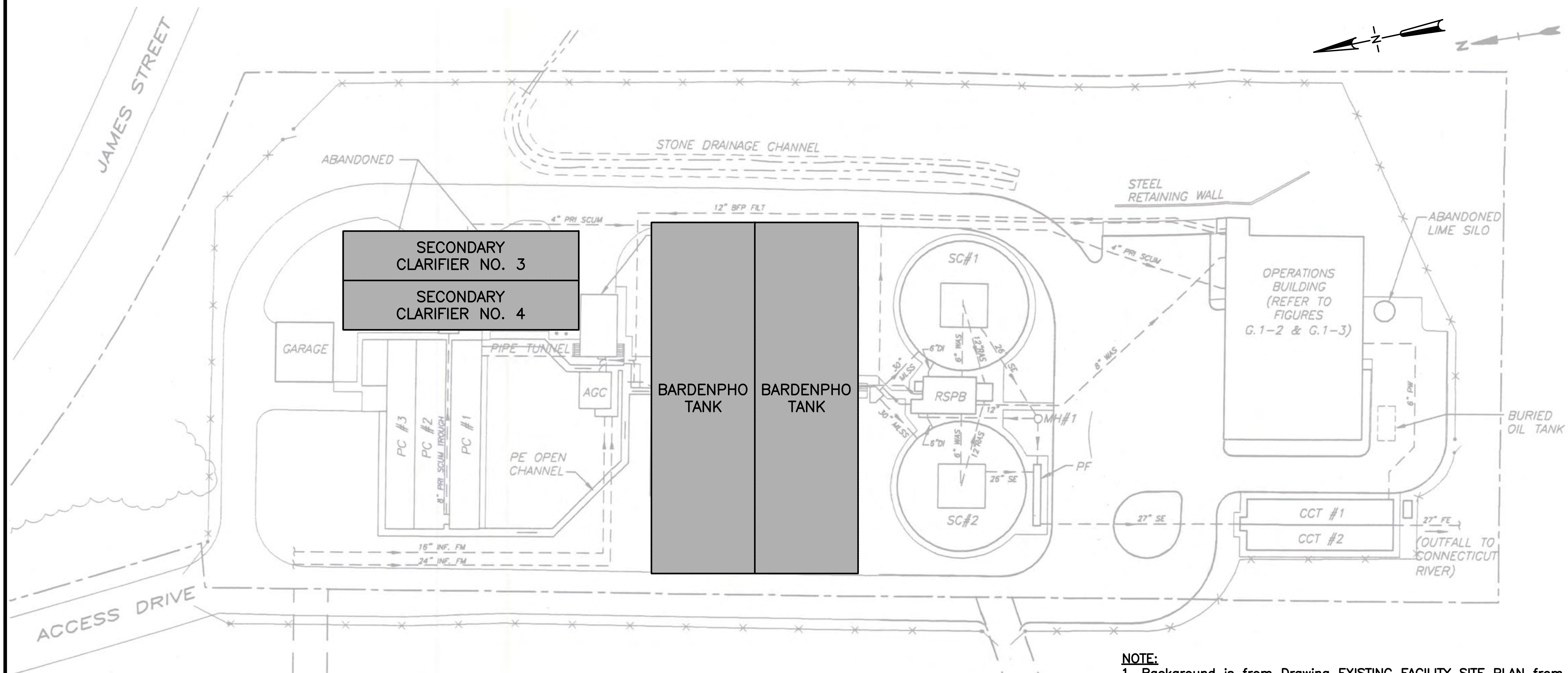
This process would require 50% more reactor volume. The existing tanks would be converted to two parallel plug flow reactors with flow moving in the east/west direction. The additional volume would be added to the front and back of the tanks to improve plug flow conditions. Structural modifications would be required to partition the tanks. The existing mechanical aeration system would be converted to fine bubble aeration. Nitrate recycle pumps would be added as well as a methanol feed facility. As shown in the site plan in Figure 4.8-8, the site appears to have enough space for the additional reactor volume. Specific information regarding the modeling results is shown in Table 4.8-8 below.

In addition to the aeration tank modifications and additional volume, it is also anticipated that the facility will require two additional secondary clarifiers (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 11 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. The abandoned digesters would be demolished to fit the new clarifiers.

Table 4.8-8

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

PARAMETER	VALUE
Aerobic SRT	9.3 days
Total SRT	16 days
First Anoxic Fraction	15%
Total Anoxic Fraction	42%
Reaeration HRT	20 minutes
Total Volume	2.23 MG
RAS Rate	50%
Nitrate Recycle Rate	400%
Max MLSS at Loading Rate	3,600 mg/L
Effluent TN	4 mg/L
Methanol Addition	Yes; 600 gpd
Fixed Film Required?	No
Clarifiers?	2 new clarifiers
Effluent Filtration Required?	No



LEGEND:

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BFP	=	BELT FILTER PRESS
RAS	=	RETURN ACTIVATED SLUDGE
WAS	=	WASTE ACTIVATED SLUDGE
PRI	=	PRIMARY
SC	=	SECONDARY CLARIFIER
PF	=	PARSHALL FLUME
CCT	=	CHLORINE CONTACT TANK
PW	=	PLANT WATER
FE	=	FINAL EFFLUENT
FILT	=	FILTRATE
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NOTE:

1. Background is from Drawing EXISTING FACILITY SITE PLAN from Contract Documents entitled "TOWN OF S. HADLEY WWTF" by TIGHE & BOND and dated 2001.
2. Auxiliary facilities associated with nitrogen removal processes are not shown.
3. Existing digesters would be demolished to to install new clarifiers.

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

SOUTH HADLEY, MASSACHUSETTS
FIGURE 4.8-8

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Filename: FIG4-8-8.DWG
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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 4.8-9 presents flow data for the South Hadley WWTF 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 system.

Table 4.8-9

PLANT FLOW AND EFFLUENT LIMIT SUMMARY

PARAMETER	VALUE
Permitted Flow (mgd)	4.2
Existing Flow (2004-6)	2.9
% of permitted capacity	69.0
Current average seasonal effluent TN (mg/L)	27.7
Current average annual effluent TN (mg/L)	26.4
Permit Limits	
Seasonal Nitrification (mg/L)	No
Year-round nitrification (mg/L)	No
Seasonal TN Limit	No
Annual TN Limit	No

Table 4.8-10 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 Bardenpho process with methanol addition to consistently meet both TN limits both seasonally and year-round. The uncalibrated BioWin models were run at permitted capacity with an assumed ammonia to BOD ratio since no influent nitrogen data was available.

(continued)

Table 4.8-10

NITROGEN REMOVAL PROCESS SUMMARY FOR SOUTH HADLEY 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 w/ VFDs	Bardenpho w/ methanol addition	Bardenpho w/ methanol addition	Bardenpho w/ methanol addition	Bardenpho w/ methanol addition

The modifications required at South Hadley to convert to a new nitrogen removal process are summarized in Table 4.8-11. 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 South Hadley.

Table 4.8-11

REQUIRED MODIFICATIONS SUMMARY FOR SOUTH HADLEY 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
Utilize new VFDs to simulate cyclical aeration	50% more bioreactor volume; convert 2 existing aeration tanks to plug flow; nitrate recycle pumps aeration equipment; methanol feed facility	50% more bioreactor volume; convert 2 existing aeration tanks; nitrate recycle pumps aeration equipment; 1 clarifier; methanol feed facility; demolition of digesters	50% more bioreactor volume; convert 2 existing aeration tanks; nitrate recycle pumps aeration equipment; 1 clarifier; methanol feed facility; demolition of digesters	50% more bioreactor volume; convert 2 existing aeration tanks; nitrate recycle pumps aeration equipment; 2 clarifiers; methanol feed facility; demolition of digesters	

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 4.8-12.

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 South Hadley, the decrease in volume means that no additional bioreactor volume is required for both the annual and seasonal conditions. Everything else is assumed to be the same between the process alternatives.

Table 4.8-12

COST SUMMARY FOR NITROGEN REMOVAL AT SOUTH HADLEY 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	$16	$320	$20
Seasonal MLE Configured Tanks	$8.8	$310	$13
Annual Average Effluent TN of 8 mg/L	$19	$500	$25
Annual MLE Configured Tanks	$12	$480	$18
Seasonal Effluent TN of 5 mg/L	$19	$390	$24
Annual Average Effluent TN of 5 mg/L	$22	$570	$29

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.