3.6 UPTON

A. **Introduction.** The Upton Wastewater Treatment Facility (WWTF) is located at 43 Maple Avenue in Upton, MA. It has a permitted annual average capacity of 0.4 mgd and serves the Town of Upton only.

The Upton WWTF was originally constructed in 1971 and included aeration tanks, secondary clarifiers and chlorination and dechlorination. It was upgraded in 1999 to include grit removal facilities, solids handling facilities, effluent filters and new secondary clarifiers.

B. **Existing Facilities.**

Aerial photo taken from www.google.com

1. **Description of Existing Facilities.** All flow is conveyed to the Upton WWTF by gravity to the former Control Building structure. All flow passes through a grinder before being pumped to the aerated grit chamber. Sodium aluminate is added to the grit chamber for phosphorus removal.

After grit removal, the flow is conveyed by gravity to the aeration tanks. The facility has two aeration tanks. Each tank is 40 ft long by 40 ft wide with a 12.5 ft sidewater depth. The tanks have internal baffles that create a serpentine path and have diffused aeration. The aeration tanks are followed by two 10 ft deep, 35 ft diameter secondary clarifiers.

Secondary effluent flows to the downflow sand filters and then to the chlorine contact tank before being discharged to an unnamed tributary to the West River. Sludge is stored in Sludge Tanks, thickened in a gravity belt thickener, and then stored again in a thickened sludge tank before being hauled off site for disposal. A process flow schematic is shown in Figure 3.6-1.

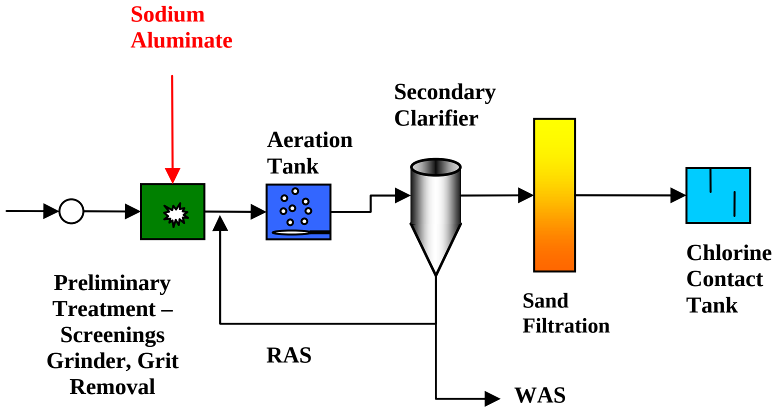


FIGURE 3.6-1: PROCESS FLOW SCHEMATIC – EXISTING FACILITY

All plant recycle flows are returned to the plant influent prior to entering the former Control Building where it is then sampled. The effluent sampler is located after dechlorination.

The grit chamber, grinder and disinfection are always in use. The facility normally operates with both aeration tanks, one of two secondary clarifiers, and both effluent filters. The plant does not try to suppress nitrification at any time of the year.

There are a total of three employees that cover the treatment facility and pump stations including the plant superintendent. The Town contracts out heavy collection system work such as collection system blockages.

Design flows and loads for the most recent upgrade are shown below in Table 3.6-1.

Table 3.6-1

DESIGN FLOWS AND LOADS

PARAMETER	VALUE
Average Monthly (design flow)	0.40 mgd
BOD	251 mg/L
TSS	263 mg/L
TKN	36 mg/L

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 3.6-2. Seasonal and annual average maximum month data are summarized in the table.

With a current average annual flow of 0.16 mgd and a permitted capacity of 0.40 mgd, this facility is operating at 40% of its permitted capacity.

Based on the average BOD concentration of 273 mg/L, this wastewater is slightly higher than medium strength.

(continued)

<u>**Table 3.6-2**</u>

UPTON WWTF

Upton, Massachusetts

Monthly Averages 2004-2006

GENERAL			**INFLUENT**				**EFFLUENT**								
DATE		**FLOW (LOCAL)**	**pH**	**BOD**	**TSS**	**RETURN TEMP**	**pH**	**BOD**	**TSS**	**F. COLI**	**NO3**	**NO2**	**TKN**	**NH3**	**TN**
MONTH	**YEAR**	**GPD**		**MG/L**	**MG/L**	**DEG C**		**MG/L**	**MG/L**	**# / 100ML**	**MG/L**	**MG/L**	**MG/L**	**MG/L**	**MG/L**
January	2004	152,461	7.0	245	350	10.0	7.2	6.1	5.5	ND	15.0	ND	1.8	7.00	16.8
February	2004	140,760	6.9	273	359	9.3	6.8	5.7	5.5	ND	20.0	13.0	20.0	16.70	53.0
March	2004	158,586	6.9	255	344	9.8	6.7	4.7	3.3	ND	18.0	22.0	18.0	8.80	58.0
April	2004	250,479	6.8	200	224	10.6	6.6	5.3	3.5	0.5	2.7	4.6	4.4	5.49	11.7
May	2004	173,034	7.0	229	241	14.7	6.9	4.6	3.3	0.7	2.2	0.7	9.2	7.00	12.1
June	2004	119,392	6.9	248	306	17.0	6.7	2.9	1.8	2.1	6.7	1.1	0.2	0.31	8.0
July	2004	93,610	6.9	197	308	20.6	6.9	2.2	1.8	0.6	23.0	ND	ND	0.12	23.0
August	2004	100,745	7.3	297	671	21.1	7.1	2.2	1.6	1.9	19.0	ND	ND	0.05	19.0
September	2004	121,209	7.6	278	534	20.2	7.4	2.8	1.5	4.3	26.0	ND	ND	0.05	26.0
October	2004	134,873	7.6	316	746	17.6	7.3	0.8	2.7	1.3	22.0	ND	ND	0.02	22.0
November	2004	138,761	7.1	333	643	15.7	6.9	2.7	2.5	ND	10.0	0.1	4.4	4.10	14.5
December	2004	181,000	7.5	266	284	12.4	7.1	6.2	1.6	ND	15.0	0.5	1.8	2.60	17.3
January	2005	214,819	7.5	203	238	10.5	7.5	5.4	2.5	ND	7.6	0.5	3.8	3.19	11.9
February	2005	186,555	7.6	248	266	9.8	7.4	7.3	3.2	ND	3.0	0.3	6.8	3.30	10.1
March	2005	208,162	7.4	303	332	9.5	7.1	2.6	2.3	ND	5.6	0.3	1.5	0.36	7.4
April	2005	234,876	7.2	263	382	11.3	7.0	1.7	5.9	ND	7.8	ND	0.3	2.70	8.1
May	2005	189,122	7.3	261	495	13.8	7.2	2.3	3.0	ND	7.2	0.1	6.0	5.80	13.3
June	2005	142,064	7.2	267	236	17.4	7.1	6.3	2.2	ND	9.3	0.3	62.0	6.93	71.6
July	2005	111,700	7.2	381	445	19.6	7.2	4.8	1.7	ND	9.2	0.3	5.8	4.77	15.3
August	2005	101,246	7.1	332	457	21.3	6.9	8.3	1.3	ND	9.4	0.4	4.4	4.50	14.2
September	2005	101,315	7.2	356	508	21.1	7.5	6.8	1.1	ND	9.6	0.3	2.5	2.30	12.4
October	2005	245,039	6.9	209	258	18.5	7.0	1.6	1.7	0.6	15.0	0.1	1.7	0.60	16.8
November	2005	215,000	ND	275	355	14.9	7.1	2.0	1.8	ND	6.4	ND	0.6	0.85	7.0
December	2005	196,287	7.2	255	404	11.6	7.1	4.5	2.0	ND	9.7	0.0	1.0	0.67	10.7
January	2006	232,750	7.1	295	394	10.2	6.9	1.7	1.7	ND	7.5	0.0	ND	0.45	7.5
February	2006	218,561	7.2	311	397	9.8	6.8	3.9	2.3	ND	6.9	0.1	2.2	1.34	9.2
March	2006	145,283	7.2	370	416	10.4	7.0	3.3	2.5	ND	7.6	0.1	3.8	2.39	11.5
April	2006	129,174	7.4	307	306	12.8	7.0	2.8	3.4	3.8	11.0	ND	1.3	0.81	12.3
May	2006	197,856	7.4	281	412	14.4	7.1	2.2	1.6	6.8	17.0	0.1	2.5	0.80	19.6
June	2006	236,735	6.9	302	335	16.7	6.9	1.4	2.4	2.4	10.0	ND	0.6	0.90	10.6
July	2006	130,418	7.3	265	470	19.8	7.0	3.9	1.6	1.1	11.0	0.0	1.8	1.23	12.8
August	2006	112,751	7.4	262	413	21.2	7.2	3.2	1.3	0.1	17.0	0.3	3.6	1.80	20.9
September	2006	118,514	7.3	234	227	19.1	7.2	1.1	0.9	4.5	14.0	0.0	1.0	0.20	15.0
October	2006	123,207	7.4	193	245	16.9	7.2	1.3	0.8	1.6	15.0	ND	ND	0.21	15.0
November	2006	176,257	7.3	317	356	14.7	7.3	1.3	0.8	ND	9.3	0.0	0.0	0.14	9.3
December	2006	160,500	7.3	194	306	12.9	7.2	2.1	0.7	ND	5.8	ND	0.5	0.42	6.3
Min. Month		93,610	6.8	193	224	9.3	6.6	0.8	0.7	0.1	2.2	0.0	0.0	0.02	6.3
Seasonal Average		**141,824**	**7**	**273**	**406**	**18**	**7**	**3**	**2**	**2**	**13**	**0**	**8**	**2**	**19**
Average		**163,697**	**7.2**	**273**	**379**	**14.9**	**7.1**	**3.6**	**2.3**	**2.1**	**11.4**	**1.8**	**5.8**	**2.75**	17.5
Max. Month		250,479	7.6	381	746	21.3	7.5	8.3	5.9	6.8	26.0	22.0	62.0	16.70	71.6

3. **Permit Requirements and Current Performance.** The current permit for this facility has been in effect since March 1, 2006. Monthly permit limits that are relevant to this study are shown below in Table 3.6-3.

Table 3.6-3

SELECT MONTHLY PERMIT LIMITS

PARAMETER	LIMIT
BOD5 November – April May - October	 22 mg/L 12 mg/L
TSS November – April May - October	 22 mg/L 12 mg/L
Ammonia-Nitrogen November – April May - October	 7 mg/L 2.3 mg/L
Total Nitrogen, TKN, Nitrate, Nitrite	Report

Since the most recent permit took effect, the plant has met all of the above limits.

4. **Nitrogen Removal Performance.** This facility does not collect influent nitrogen data. However, various effluent nitrogen data is collected and can be seen in Table 3.6-2.

It should be noted that although the facility fully nitrifies, it is doing so under stressed conditions with winter MLSS levels being well above 4000 mg/L and with very long SRTs. At the time of the site visit, the facility was operating with MLSS levels above 5000 mg/L.

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 Table 3.6-4 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 0.19, and due to a lack of wastewater temperature data, the temperatures were assumed.

<u>Table 3.6-4</u>

EXISTING INFLUENT PARAMETERS

PERMIT CONDITIONS	PARAMETER	VALUE
Annual Average	Flow, mgd	0.23
	BOD, mg/L	295
	TSS, mg/L	410
	TN, mg/L	55
	Temperature, F	46
Seasonal	Flow, mgd	0.20
	BOD, mg/L	281
	TSS, mg/L	390
	TN, mg/L	53
	Temperature, F	52

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 3.6-5.

<u>Table 3.6-5</u>

MODEL INPUT PARAMETERS AT PERMITTED CAPACITY

PERMIT CONDITIONS	PARAMETER	VALUE
Annual Average	Flow, mgd	0.57
	BOD, mg/L	295
	TSS, mg/L	410
	TN, mg/L	55
	Temperature, F	46
Seasonal	Flow, mgd	0.48
	BOD, mg/L	281
	TSS, mg/L	390
	TN, mg/L	53
	Temperature, F	52

As was noted previously, this facility has recently been able to fully nitrify, but only by maintaining very long SRTs and operating at very high MLSS levels. Operation under these conditions implies that the plant is either overloaded or there may be some inhibition of the nitrification process. Currently, the facility is operating at approximately 40% of its ultimate capacity. Thus, it is possible that some type of nitrification inhibition is occurring.

As a result, we were unable to develop a model that reasonably represents the current operating conditions at the site. It should be noted that the following results are valid as long as there is no inhibition of nitrification occurring at this facility.

The site appears to have space available for at least one new aeration tank. The options below will assume that one new tank can be added.

1. **Minor Modifications/Retrofits.** With the facility only able to nitrify by maintaining very high MLSS levels in the tanks, 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 will not accomplish a seasonal effluent TN level of 8 mg/L. An MLE process is projected to yield a seasonal effluent TN of 12 mg/L. Thus, a Bardenpho process is recommended as shown in the BioWin model in Figure 3.6-2 below.

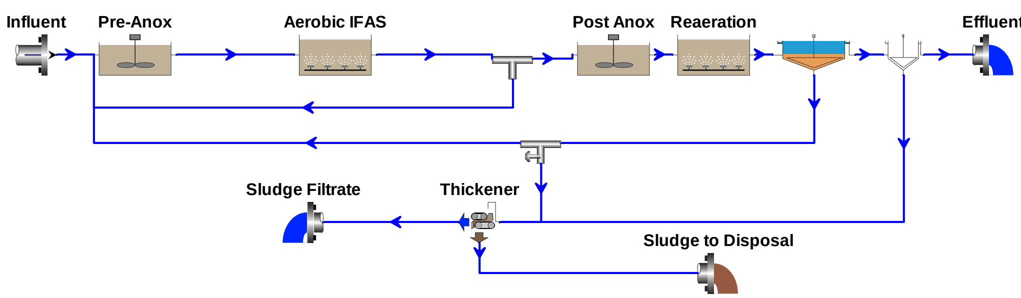


FIGURE 3.6-2: NITROGEN REMOVAL PROCESSES - SEASONAL LIMIT OF 8 mg/L

This process would require a total of 3 aeration tanks - 1 new tank in addition to the existing two. The new tank would be the same size as each of the two existing tanks.

Although the existing clarifiers appear to be adequately sized to handle the future flow and loading conditions, it should be noted that the clarifiers at this facility are only ten 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 Section 2, they will have to be further evaluated to consider if they will require replacement or derating because of the shallow depth.

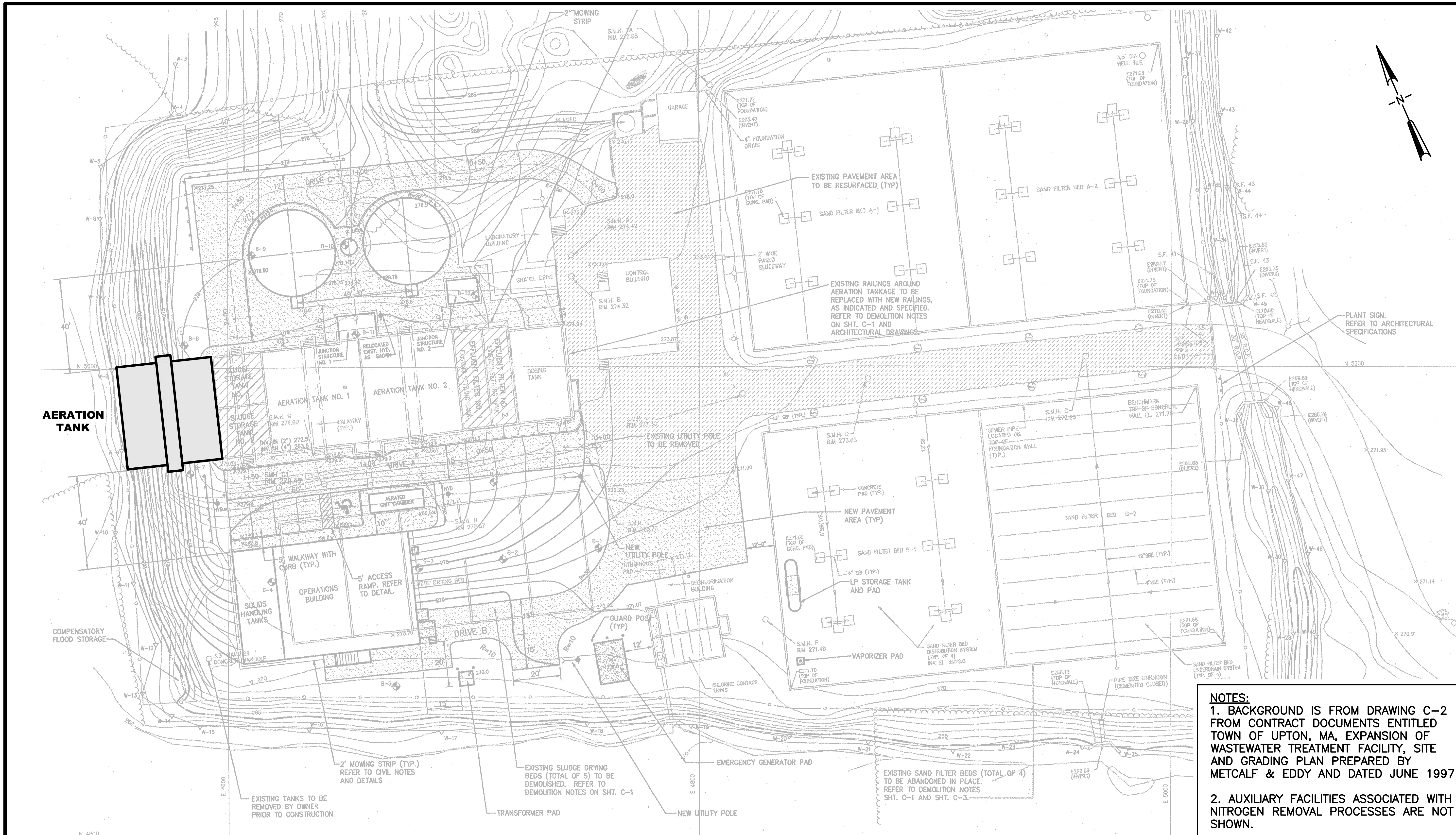
As shown in the site plan in Figure 3.6-3, the site has enough space for the additional aeration tank. Specific information regarding the results of this analysis is shown in Table 3.6-6 below.

Table 3.6-6

RESULTS FOR SEASONAL LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Aerobic SRT	6.7 days
Total SRT	14 days
First Anoxic Fraction	21%
Total Anoxic Fraction	42%
Reaeration HRT	1.5 hrs
RAS Rate	100%
Total Volume	0.45 MG
Nitrate Recycle Rate	300%
Max MLSS at loading rate	3000 mg/L
Effluent TN	8 mg/L
Methanol Addition	No
Fixed Film Required?	No
Clarifiers?	Reuse existing
Effluent Filtration Required?	Existing

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



NOTES:
1. BACKGROUND IS FROM DRAWING C–2 FROM CONTRACT DOCUMENTS ENTITLED TOWN OF UPTON, MA, EXPANSION OF WASTEWATER TREATMENT FACILITY, SITE AND GRADING PLAN PREPARED BY METCALF & EDDY AND DATED JUNE 1997

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

40 0 40 80
1"=40'-0"

Login name: JDF
Filename path: J:\60000\61265 MADEP\10\Drawings\Fig
Filename: UPTON-CH3.dwg
Latest Revision: Friday, April 04, 2008

SITE PLAN
SCALE: 1"=40'-0"

STEARNS & WHELER LLC
Environmental Engineers & Scientists
1545 Iyannough Road, Route 132
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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

UPTON, MASSACHUSETTS

FIGURE 3.6–3

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. An MLE process is projected to yield an annual average effluent TN of about 12 mg/L. Thus, a Bardenpho process is recommended as shown in the BioWin model in Figure 3.6-4 below. It is also recommended that IFAS be added to the aerobic zone to allow the system to fully nitrify in the winter.

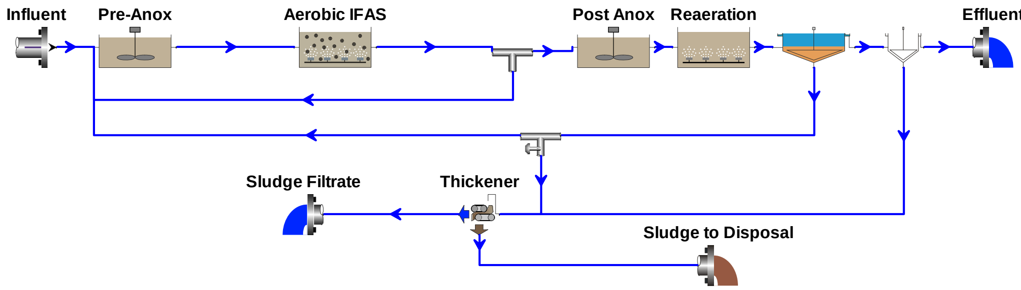


FIGURE 3.6-4:
NITROGEN REMOVAL PROCESSES – ANNUAL AVERAGE LIMIT OF 8 mg/L

This process would require a total of 3 aeration tanks - one new tank in addition to the existing two. The new tank would be the same size as each of the existing tanks. The media fill volume would be approximately 50% of the aerobic zone.

Although the existing clarifiers appear to be adequately sized to handle the future flow and loading conditions, it should be noted that the clarifiers at this facility are only ten feet deep. According to TR-16, clarifiers at nitrogen removal facilities should be a minimum of 13 feet deep. Although the clarifiers meet the minimum requirements set forth in Section 2, they should be further evaluated to consider if they will require replacement or derating because of the shallow depth.

As shown in the site plan in Figure 3.6-3, the site appears to have enough space for the additional aeration tank. Specific information regarding the results of this analysis is shown in Table 3.6-7 below.

<u>Table 3.6-7</u>

RESULTS FOR ANNUAL AVERAGE LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Aerobic SRT	6.7 days
Total SRT	14 days
First Anoxic Fraction	21%
Total Anoxic Fraction	44%
Reaeration HRT	1.5 hrs
RAS Rate	100%
Total Volume	0.45 MG
Nitrate Recycle Rate	300%
Max MLSS at loading rate	3700 mg/L
Effluent TN	8 mg/L
Methanol Addition	No
Fixed Film Required?	Yes, 50% fill
Clarifiers?	Reuse existing
Effluent Filtration Required?	Existing

The inclusion of IFAS in the activated sludge system will necessitate an upgrade to the influent screening system. In addition, other plant modifications may be needed including upgrades to sludge handling processes. 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 Bardenpho process with methanol addition is recommended to achieve a seasonal effluent TN of 5 mg/L as shown in the BioWin model in Figure 3.6-5.

(continued)

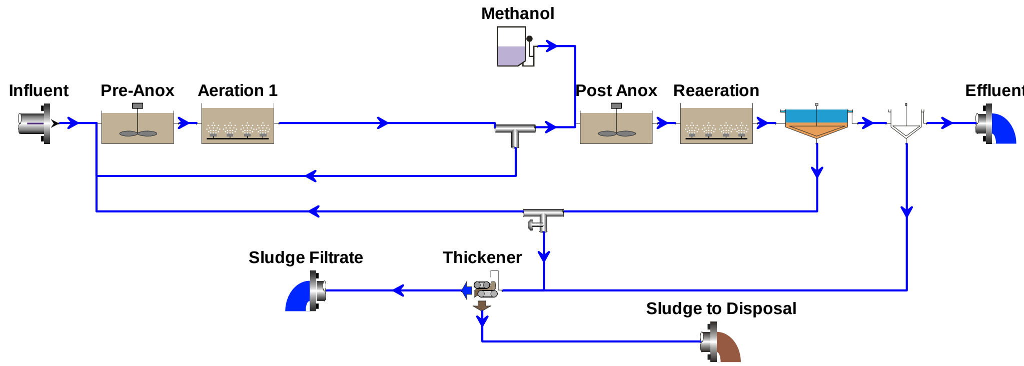


FIGURE 3.6-5: NITROGEN REMOVAL PROCESSES – SEASONAL LIMIT OF 5 mg/L

This process would require a total of three aeration tanks - one new tank in addition to the existing two. The new tank would be the same size as each of the two existing tanks.

Although the existing clarifiers appear to be adequately sized to handle the future flow and loading conditions, it should be noted that the clarifiers at this facility are only ten feet deep. According to TR-16, clarifiers at nitrogen removal facilities should be a minimum of 13 feet deep. Although the clarifiers meet the minimum requirements set forth in Section 2, they should be further evaluated to consider if they will require replacement or derating because of the shallow depth.

As shown in the site plan in Figure 3.6-3, the site appears to have enough space for the additional aeration tank. Specific information regarding the results of this analysis is shown in Table 3.6-8 below.

(continued)

Table 3.6-8

RESULTS FOR SEASONAL LIMIT OF 5 mg/L TN

PARAMETER	VALUE
Aerobic SRT	6.7 days
Total SRT	14 days
First Anoxic Fraction	21%
Total Anoxic Fraction	42%
Reaeration HRT	1.5 hrs
RAS Rate	100%
Total Volume	0.45 MG
Nitrate Recycle Rate	300%
Max MLSS at loading rate	3100 mg/L
Effluent TN	5 mg/L
Methanol Addition	Yes
Fixed Film Required?	No
Clarifiers?	Reuse existing
Effluent Filtration Required?	Existing

In addition, other plant modifications may be needed including upgrades to sludge handling processes. 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, Bardenpho process with methanol addition plus IFAS in the aerobic zone is recommended to achieve an annual average TN of 5 mg/L as shown in the BioWin model in Figure 3.6-6.

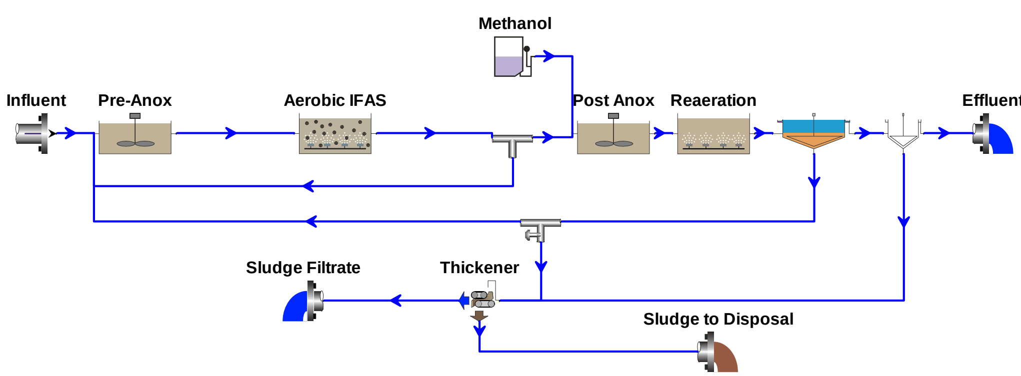


FIGURE 3.6-6:

NITROGEN REMOVAL PROCESSES – ANNUAL AVERAGE LIMIT OF 5 mg/L

This process would require a total of three aeration tanks - one new tank in addition to the existing two. The new tank would be the same size as each of the two existing tanks. The media fill volume would be approximately 50% of the aerobic zone.

Although the existing clarifiers appear to be adequately sized to handle the future flow and loading conditions, it should be noted that the clarifiers at this facility are only ten feet deep. According to TR-16, clarifiers at nitrogen removal facilities should be a minimum of 13 feet deep. Although the clarifiers meet the minimum requirements set forth in Section 2, they should be further evaluated to consider if they will require replacement or derating because of the shallow depth.

As shown in the site plan in Figure 3.6-3, the site appears to have enough space for the additional aeration tank. Specific information regarding the results of this analysis is shown in Table 3.6-9 below.

Table 3.6-9

RESULTS FOR ANNUAL AVERAGE LIMIT OF 5 mg/L TN

PARAMETER	VALUE
Aerobic SRT	6.7 days
Total SRT	14 days
First Anoxic Fraction	21%
Total Anoxic Fraction	44%
Reaeration HRT	1.5 hrs
RAS Rate	100%
Total Volume	0.45 MG
Nitrate Recycle Rate	300%
Max MLSS at loading rate	4100 mg/L
Effluent TN	5 mg/L
Methanol Addition	Yes
Fixed Film Required?	Yes, 50% fill
Clarifiers?	Reuse existing
Effluent Filtration Required?	Existing

The inclusion of IFAS in the activated sludge system will necessitate an upgrade to the influent screening system. In addition, other plant modifications may be needed including upgrades to sludge handling processes. However, all facilities outside of the activated sludge process are outside of the scope of this study.

D. **Plant and Cost Summary.**

Table 3.6-10 presents flow data for the Attleboro WWTF as well as the current nitrogen removal performance of the plant.

Table 3.6-10

PLANT FLOW AND EFFLUENT LIMIT SUMMARY

PARAMETER	VALUE
Permitted Flow (mgd)	0.4
Existing Flow (2004-6)	0.16
% of existing capacity	40
Current average seasonal effluent TN (mg/L)	19
Current average annual effluent TN (mg/L)	17.5
Permit Limits	
Seasonal Nitrification (mg/L)	Yes (2.3)
Year-round nitrification (mg/L)	Yes (2.3-7)
Seasonal TN Limit	No
Annual TN Limit	No

Table 3.6-11 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 one aeration tank plus using IFAS for both annual average permit conditions.

(continued)

Table 3.6-11

NITROGEN REMOVAL PROCESS SUMMARY FOR UPTON WWTF

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	Bardenpho	Bardenpho with IFAS	Bardenpho with methanol addition	Bardenpho with IFAS and methanol addition

The modifications required at Upton to convert to a new nitrogen removal process are summarized in Table 3.6-12.

Table 3.6-12

REQUIRED MODIFICATIONS SUMMARY FOR UPTON WWTF

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
1 new aeration tank	1 new aeration tank, add IFAS to all tanks	1 new aeration tank	1 new aeration tank, add IFAS to all tanks	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 3.6-12.

Table 3.6-13

COST SUMMARY FOR NITROGEN REMOVAL AT UPTON WWTF[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
MLE Configured Tanks	$2.4	$90	$3.6
Seasonal Effluent TN of 8 mg/L	$5.1	$90	$6.2
Annual Average Effluent TN of 8 mg/L	$7.3	$120	$8.7
Seasonal Effluent TN of 5 mg/L	$5.3	$90	$6.4
MLE Configured Tanks	$4.6	$120	$6.0
Annual Average Effluent TN of 8 mg/L	$7.4	$140	$9.2

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.

3.7 UXBRIDGE

A. **Introduction.** The Uxbridge Wastewater Treatment Facility (WWTF) is located at 80 River Road in Uxbridge, MA. It has a permitted average annual capacity of 2.5 mgd and serves the Town of Uxbridge. Septage is accepted from a number of neighboring towns.

The existing facility went online in 1979 along with the collection system. The facility has not been upgraded since its original construction. Dewatering facilities ceased to operate approximately 12-13 yrs ago.

B. **Existing Facilities.**

1. **Description of Existing Facilities.** All flow is pumped to the Uxbridge WWTF from the Main Pumping Station which is located onsite. This flow first passes through an aerated grit chamber and then through a screenings grinder. The flow is then conveyed by gravity to the primary settling tanks.

Aerial photo taken from www.google.com

After primary treatment, the flow is conveyed by gravity to the aeration tanks.

The facility has three aeration tanks. Each tank is 66 ft long by 30 ft wide with a 14.5 ft sidewater depth. The aeration tanks have diffused aeration. The aeration tanks are followed by three 12 ft deep, 57 ft diameter secondary clarifiers.

Secondary effluent flows into the chlorine contact tanks and then through a cascade for aeration. After aeration, the plant flow is discharged to the Blackstone River. Primary and waste activated sludges are co-thickened in a gravity thickener prior to being hauled off site for disposal. A process flow schematic is shown in Figure 3.7-1.

This facility on average receives over 11,000 gallons of septage per day. The septage is stored in a septage storage tank and is then introduced to the waste stream at Preliminary Treatment; septage received in quantities that exceed the capacity of the storage tank will overflow to the onsite pumping station.

All plant recycle flows are conveyed to the onsite pump station where they are then introduced into the plant influent prior to sampling. Most septage is introduced to the waste stream after the influent sampler; the only septage that is present in the influent sample is septage that reaches the onsite pumping station by means of overflow. The effluent sampler is located after disinfection.

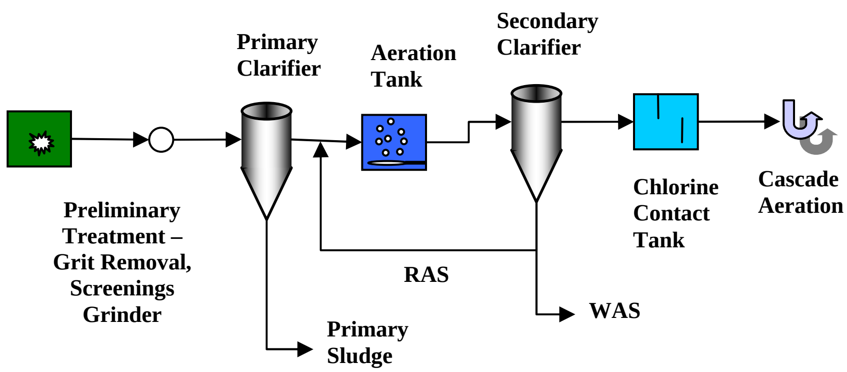


FIGURE 3.7-1:
PROCESS FLOW SCHEMATIC – EXISTING FACILITY

For the past year and a half, all aeration tanks have been online and operating in a series mode. Prior to then, only one aeration tank was operational. The tanks are set up to operate with minimal air in the first tank, full aeration in the second tank and low air in the third tank to try to remove some nitrogen.

There are four employees for the wastewater facility and collection system (plus a ½ time administrator). The pump stations have 2 employees who are responsible for their operation and maintenance.

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 Table 3.7-1. Seasonal and annual average maximum month data are summarized in the table.

<u>Table 3.7-1</u>
UXBRIDGE WWTF
Uxbridge, Massachusetts
Monthly Averages 2004-2006

GENERAL			INFLUENT						EFFLUENT								
DATE		FLOW (TOTAL)	pH	BOD	TSS	NH3	TEMP	ALKALINITY	DO	pH	ALKALINITY	BOD	TSS	F. COLI.	NO2	NO3	NH3
MONTH	YEAR	MGD		MG/L	MG/L	MG/L	DEG C	MG/L CACO3	MG/L		MG/L CACO3	MG/L	MG/L	# / 100 ML	MG/L	MG/L	MG/L
January	2004	0.796145	6.81	272.3	539.0	26.65	7.6	7.6	6.85	6.45	16.8	7.3	5.2	ND	0.87	17.63	0.45
February	2004	0.748500	7.09	380.9	531.8	28.35	8.5	138.4	5.37	6.56	22.7	8.5	4.8	ND	1.39	17.34	0.39
March	2004	0.800032	7.21	349.7	524.4	26.80	9.9	130.6	6.38	7.13	103.5	22.1	7.8	ND	3.84	8.11	8.79
April	2004	1.172600	6.87	543.2	496.8	16.15	11.7	70.0	6.77	7.28	90.6	15.7	6.8	116.5	2.13	3.79	7.83
May	2004	0.986435	6.95	617.8	523.4	19.04	14.6	99.0	6.31	7.24	85.6	8.6	4.5	132.1	2.19	8.56	0.27
June	2004	0.831883	7.03	326.9	483.5	24.79	16.8	115.1	5.92	7.29	67.3	3.2	3.7	6.1	0.05	21.64	0.07
July	2004	0.726565	7.04	344.0	451.5	28.53	18.4	132.7	5.88	7.46	69.0	4.2	2.0	ND	0.05	23.74	0.06
August	2004	0.695097	7.04	424.9	615.3	29.09	19.3	178.2	5.39	7.45	77.2	3.4	1.5	33.1	0.04	24.89	0.14
September	2004	0.690820	7.09	367.4	499.9	28.04	18.5	152.8	5.80	7.40	71.4	2.5	2.7	182.8	0.10	25.88	0.17
October	2004	0.823532	7.00	356.1	573.0	25.73	16.4	135.7	6.43	7.42	71.8	3.0	2.0	3.9	0.05	23.18	0.06
November	2004	0.788303	7.07	444.6	499.6	27.31	14.5	140.9	6.76	7.10	52.4	2.7	2.1	ND	0.04	22.89	0.04
December	2004	0.966550	6.91	376.3	575.8	20.55	11.7	93.6	7.21	7.06	59.7	4.6	4.8	ND	0.04	17.61	0.05
January	2005	1.145758	6.87	234.8	336.2	17.83	9.7	84.9	8.48	7.20	67.0	2.2	2.4	ND	0.01	10.49	0.03
February	2005	1.070018	6.84	239.2	397.9	17.84	9.6	9.6	7.42	7.05	81.8	7.3	4.5	ND	3.37	6.69	1.30
March	2005	1.083081	6.87	222.9	332.2	18.41	9.6	84.9	7.89	7.01	65.8	4.3	3.2	ND	1.26	14.81	0.88
April	2005	1.376253	6.75	342.2	371.4	13.17	12.0	73.3	7.85	7.00	56.1	2.8	2.0	5.2	0.02	14.87	0.04
May	2005	1.023887	6.81	362.7	412.6	16.85	ND	88.4	7.38	7.27	86.0	1.5	1.0	8.5	0.01	11.92	0.04
June	2005	0.817517	6.90	380.3	440.0	20.49	17.0	121.6	6.47	7.37	107.6	3.9	1.3	1.9	0.03	11.05	0.05
July	2005	0.677516	6.89	378.0	442.3	23.53	19.3	154.1	6.06	7.47	129.8	3.3	1.8	18.5	0.05	7.99	0.07
August	2005	0.640968	7.11	409.6	483.0	31.98	20.3	182.7	5.66	7.73	128.4	2.5	1.2	69.3	0.05	7.64	0.08
September	2005	0.640250	7.15	430.8	640.5	30.27		195.1	5.71	7.67	125.3	1.7	1.3	15.1	0.05	9.22	0.06
October	2005	1.160903	6.94	257.5	396.7	20.66	17.0	119.4	6.41	7.54	95.5	1.7	1.2	55.1	0.01	7.63	0.05
November	2005	1.126117	6.86	332.8	483.6	17.55	15.0	82.6	7.00	7.35	78.5	2.7	1.2	ND	0.01	8.40	0.06
December	2005	1.002242	6.92	313.1	364.4	19.51	11.0	84.1	7.59	7.23	68.9	1.8	0.6	ND	0.01	11.05	0.08
January	2006	1.145758	6.87	234.8	336.2	15.54	10.4	75.8	8.48	7.20	67.0	2.2	2.4	ND	0.01	10.49	0.03
February	2006	1.220446	6.81	253.8	382.3	13.61	9.0	68.1	8.44	7.03	51.2	2.7	2.5	ND	0.01	11.78	0.03
March	2006	0.998032	6.98	313.4	432.2	18.73	10.1	90.5	7.98	7.14	63.0	4.9	2.3	ND	0.07	13.86	0.19
April	2006	0.841050	7.11	410.2	597.7	23.42	11.7	109.4	6.98	7.11	100.1	5.9	5.8	11.2	0.15	7.71	0.97
May	2006	1.034968	7.01	378.1	468.6	17.04	13.3	95.1	7.02	7.36	82.7	4.5	1.4	40.1	0.02	8.52	0.08
June	2006	1.414683	6.71	298.7	476.2	11.79	16.6	74.1	7.23	7.27	81.3	2.0	1.4	17.8	0.01	7.42	0.03
July	2006	0.992032	6.72	271.4	709.5	18.33	19.8	96.4	7.41	7.36	87.8	2.0	1.5	9.5	0.02	8.59	0.05
August	2006	0.776952	6.84	351.8	751.8	24.99	20.3	133.4	6.31	7.29	96.8	2.0	3.5	70.8	0.02	9.74	0.04
September	2006	0.792383	6.94	365.0	546.4	25.72	18.6	136.8	7.28	7.28	92.2	2.1	2.7	98.0	0.02	9.84	0.04
October	2006	0.734297	7.11	619.8	992.3	28.41	16.5	166.6	6.06	7.38	93.3	2.0	2.7	36.0	0.03	10.98	0.06
November	2006	0.959185	6.92	505.8	638.8	21.79	15.2	109.5	6.43	7.40	88.4	2.4	2.2	ND	0.02	10.05	0.05
December	2006	0.926645	6.99	351.9	472.8	20.37	12.7	99.1	6.79	7.31	86.3	2.0	0.9	ND	0.01	8.78	0.05
Min. Month		0.640250	6.71	222.9	332.2	11.79	7.6	7.6	5.37	6.45	16.8	1.5	0.6	1.9	0.01	3.79	0.03
Seasonal Average		**0.858927**	**6.96**	**385.6**	**550.4**	**23.63**	**17.7**	**132.1**	**6.37**	**7.40**	**91.6**	**3.0**	**2.1**	**47.0**	**0.16**	**13.25**	**0.08**
Average		**0.934095**	**6.94**	**362.8**	**506.1**	**21.91**	**14.2**	**109.2**	**6.82**	**7.25**	**79.7**	**4.3**	**2.7**	**46.6**	**0.45**	**12.63**	**0.63**
Max. Month		1.414683	7.21	619.8	992.3	31.98	20.3	195.1	8.48	7.73	129.8	22.1	7.8	182.8	3.84	25.88	8.79

With a current average annual flow of 0.93 mgd and a permitted capacity of 2.5 mgd, this facility is operating at almost 40% of its permitted capacity.

Based on the average BOD concentration of 363 mg/L, this wastewater could almost be considered a "strong" concentration waste. The high concentration is due to the contribution of septage.

3. **Permit Requirements and Current Performance.** The current permit for this facility has been in effect since September 30, 1999. Monthly permit limits that are relevant to this study are shown below in Table 3.7-2.

Table 3.7-2
SELECT MONTHLY PERMIT LIMITS

PARAMETER	LIMIT
(C) BOD_5	
November – May	30 mg/L
June - October	20 mg/L
TSS	
November – May	30 mg/L
June - October	20 mg/L
Ammonia-Nitrogen	
December – April	15 mg/L
May, November	10 mg/L
June - October	5 mg/L
Nitrate, Nitrite	Report

Over the period of time that data was reviewed for this study, the plant has performed exceptionally well and has met all of the above limits.

4. **Nitrogen Removal Performance.** This facility collects influent ammonia data. In addition, various effluent nitrogen data is collected and can be seen in Table 3.7-2.

The data shows the success of the nitrogen removal system that has been implemented by the personnel at the treatment facility with nitrate concentrations dropping to less than 10 in the warmer months.

C. **Nitrogen Removal Alternatives.** The existing maximum month loads over the three-year data collection period were used to determine the BioWin input data; two outliers were found in the data and not included in the analysis. The influent data which correspond to maximum-month loads is shown in Table 3.7-4 below for each permitting scenario. The minimum temperature for the permit condition is also shown. The data includes actual data collected from the onsite pumping station as well as estimated contributions from septage (there are no flow composite samples of influent that include septage). In addition, nitrogen was estimated by using actual influent ammonia concentrations and adding an estimated load from the septage.

Table 3.7-3

EXISTING INFLUENT PARAMETERS

PERMIT CONDITIONS	PARAMETER	VALUE
Annual Average	Flow, mgd	0.96
	BOD, mg/L	506
	TSS, mg/L	705
	TN, mg/L	40
	Temperature, F	46
Seasonal	Flow, mgd	0.73
	BOD, mg/L	620
	TSS, mg/L	864
	TN, mg/L	51
	Temperature, F	56

It should be noted that the model input parameters for this facility were developed differently than those for other facilities in this study. First, the Uxbridge WWTF collects a significant amount of septage; this septage impacts the influent concentrations of the facility. It was determined that using ratios (permitted flow to average flow) to estimate the future loads at the design capacity of this facility would result in too much of an error since it would also include a significant increase in the estimated septage load at the facility. Thus, in an attempt to maintain existing loads and project an increase in wastewater loads only, the average characteristics of the influent were estimated and then applied to the net increase in flow between the current flow and the capacity of the facility to determine an increase in the loads at this facility. The resulting concentrations were more dilute than the ones shown above. The result of this analysis yielded the model inputs shown in Table 3.7-4.

Table 3.7-4

MODEL INPUT PARAMETERS AT PERMITTED CAPACITY

PERMIT CONDITIONS	PARAMETER	VALUE
Annual Average	Flow, mgd	2.57
	BOD, mg/L	375
	TSS, mg/L	523
	TN, mg/L	46
	Temperature, F	46
Seasonal	Flow, mgd	1.97
	BOD, mg/L	474
	TSS, mg/L	661
	TN, mg/L	35
	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.

For the purposes of this study, it was assumed that septage would continue to be combined with the incoming wastewater and treated as a liquid waste. However, septage tends to have a high concentration of soluble organic nitrogen and thus how this waste stream is handled in the future should receive careful consideration. One option is that it could be taken out of the liquid process stream and combined with and treated with sludge.

It should be noted that there is a significant difference in temperature between the seasonal and annual average data. The low winter temperature is quite low, but does not appear to be an outlier. The temperature difference combined with the strong wastewater concentrations make this facility apparently very undersized for achieving the permit conditions at permitted capacity. The number of tanks required to accomplish the permit conditions under review in this study will be significant.

To the east of the existing aeration tanks is a capped sludge landfill. It is assumed that part of this landfill can be used for additional tanks and that the excavated material would be hauled away to another landfill. The additional tanks proposed for the site will be limited to eight to maintain the tanks in the general vicinity of the existing tanks.

1. **Minor Modifications/Retrofits.** As was noted previously, the plant has already modified the facility to optimize nitrogen removal through operational changes. There are no additional minor improvements to suggest.

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 estimated future TN load at this facility, the MLE process will achieve a seasonal average TN of 8 mg/L. The BioWin model for this process is shown in Figure 3.7-2 below.

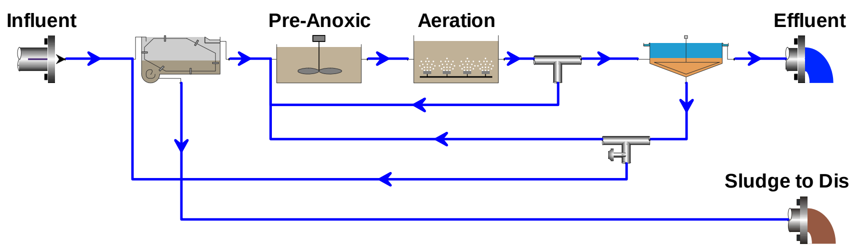


FIGURE 3.7-2: NITROGEN REMOVAL PROCESSES - SEASONAL LIMIT OF 8 mg/L

This configuration would require five additional aeration tanks. Each of the new tanks would be the same size as the three existing tanks.

Although the existing clarifiers appear to be adequately sized to handle the future flow and loading conditions, it should be noted that the clarifiers at this facility are twelve 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 Section 2, they will have to be further evaluated to consider if they will require replacement or derating because of the shallow depth.

As shown in the site plan in Figure 3.7-3, the site has enough space for the additional aeration tanks. Specific information regarding the results of this analysis is shown in Table 3.7-5 below.

Table 3.7-5

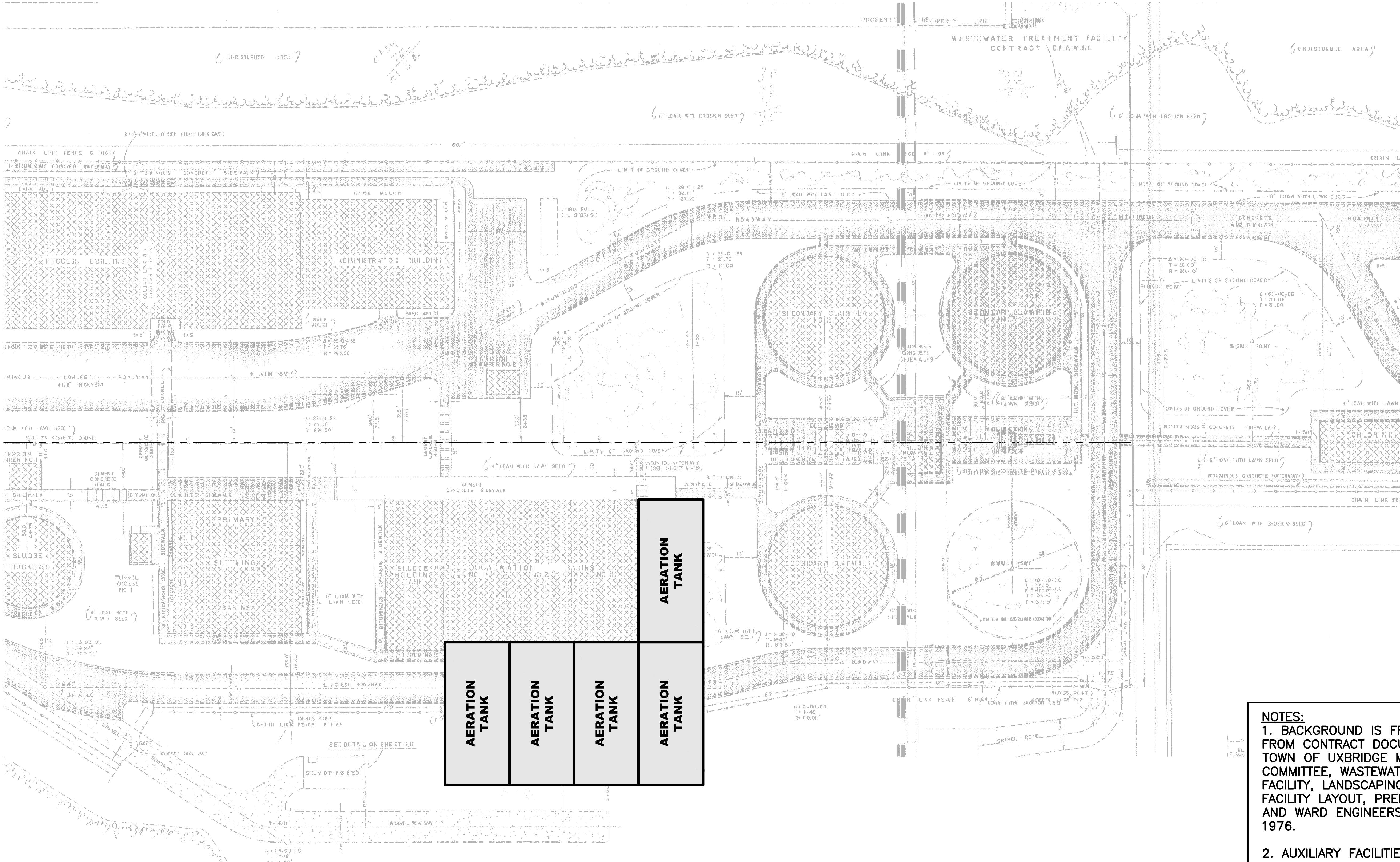
RESULTS FOR SEASONAL LIMIT OF 8 mg/L TN

Parameter	Value
Aerobic SRT	6.5 days
Total SRT	8 days
First Anoxic Fraction	20%
Total Anoxic Fraction	20%
Reaeration HRT	n/a
RAS Rate	100%
Total Volume	1.74 MG
Nitrate Recycle Rate	400%
Max MLSS at loading rate	4000 mg/L
Effluent TN	8 mg/L
Methanol Addition	No
Fixed Film Required?	No
Clarifiers?	Reuse existing
Effluent Filtration Required?	No

The modifications related to the proposed upgrade described above do not appear to require any structure demolition. The aeration tanks 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.** Although the facility would be able to accomplish a TN of 8 on an average annual basis with the MLE process, the number of tanks required to accomplish this would be fourteen. With so many tanks required, the approach taken was to use the aeration volume for nitrification only and to denitrify using a denitrification filter. This approach reduces the number of additional tanks required to eight. These nitrogen removal processes are shown in Figure 3.7-4 as follows.



NOTES:

1. BACKGROUND IS FROM DRAWING G–7 FROM CONTRACT DOCUMENTS ENTITLED TOWN OF UXBRIDGE MA, SEWER COMMITTEE, WASTEWATER TREATMENT FACILITY, LANDSCAPING PAVEMENT AND FACILITY LAYOUT, PREPARED BY HALEY AND WARD ENGINEERS AND DATED JULY 1976.

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

50 0 50 100

1"=50'–0"

SITE PLAN

SCALE: 1"=50'–0"

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Filename path: J:\60000\61265 MADEP\10\Drawings\Fig
Filename: UXBRIDGE-CH3.dwg
Latest Revision: Friday, April 04, 2008

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

UXBRIDGE, MASSACHUSETTS

FIGURE 3.7–3

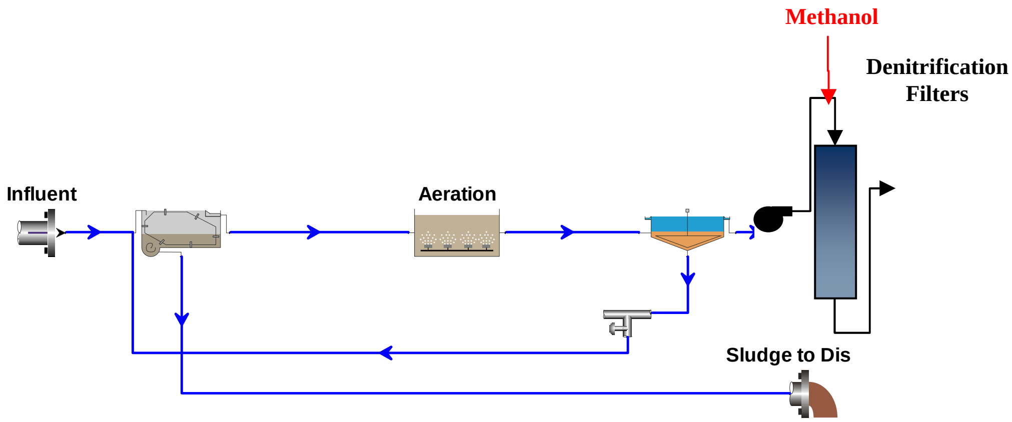


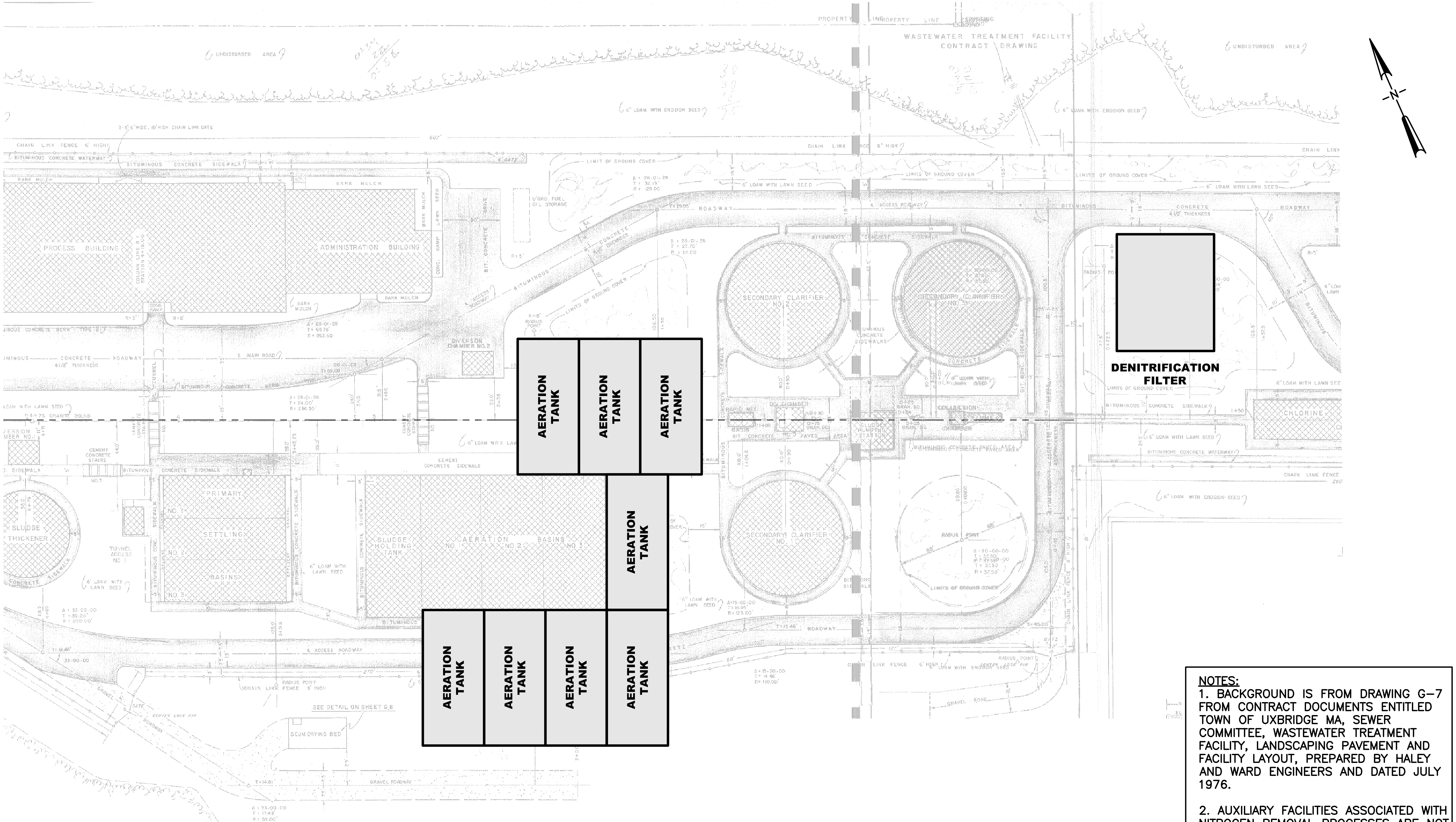
FIGURE 3.7-4:
NITROGEN REMOVAL PROCESSES – ANNUAL AVERAGE LIMIT OF 8 mg/L

The new aeration tanks would be the same size as the existing tanks. The denitrification filter complex would have a footprint of approximately 2750 square feet and four cells each approximately sixteen feet by twelve feet.

Although the existing clarifiers appear to be adequately sized to handle the future flow and loading conditions, it should be noted that the clarifiers at this facility are twelve 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 Section 2, they will have to be further evaluated to consider if they will require replacement or derating because of the shallow depth.

As shown in the site plan in Figure 3.7-5, the site has enough space for the additional aeration tanks and the denitrification filter. Specific information regarding the modeling results are shown in Table 3.7-6 as follows.

(continued)



NOTES:

1. BACKGROUND IS FROM DRAWING G–7 FROM CONTRACT DOCUMENTS ENTITLED TOWN OF UXBRIDGE MA, SEWER COMMITTEE, WASTEWATER TREATMENT FACILITY, LANDSCAPING PAVEMENT AND FACILITY LAYOUT, PREPARED BY HALEY AND WARD ENGINEERS AND DATED JULY 1976.

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

50 0 50 100
1"=50'–0"

SITE PLAN

SCALE: 1"=50'–0"

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

UXBRIDGE, MASSACHUSETTS

FIGURE 3.7–5

Table 3.7-6

RESULTS FOR ANNUAL AVERAGE LIMIT OF 8 mg/L TN

PARAMETER	VALUE
Aerobic SRT	11 days
Total SRT	11 days
First Anoxic Fraction	n/a
Total Anoxic Fraction	n/a
Reaeration HRT	n/a
RAS Rate	100%
Total Volume	2.4 MG
Nitrate Recycle Rate	n/a
Max MLSS at loading rate	3900 mg/L
Effluent TN	8 mg/L
Methanol Addition	Yes, in denitrification filter
Fixed Film Required?	No
Clarifiers?	Reuse existing
Effluent Filtration Required?	Yes, denitrification filter

The modifications related to the proposed upgrade described above do not appear to require any structure demolition. The aeration tanks and denitrification filter 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 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 estimated future TN load at this facility, the Bardenpho process will achieve a seasonal average TN of 5 mg/L. The BioWin model for this process is shown in Figure 3.7-6 as follows.

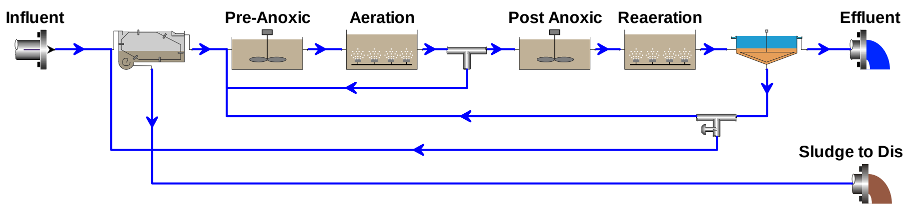


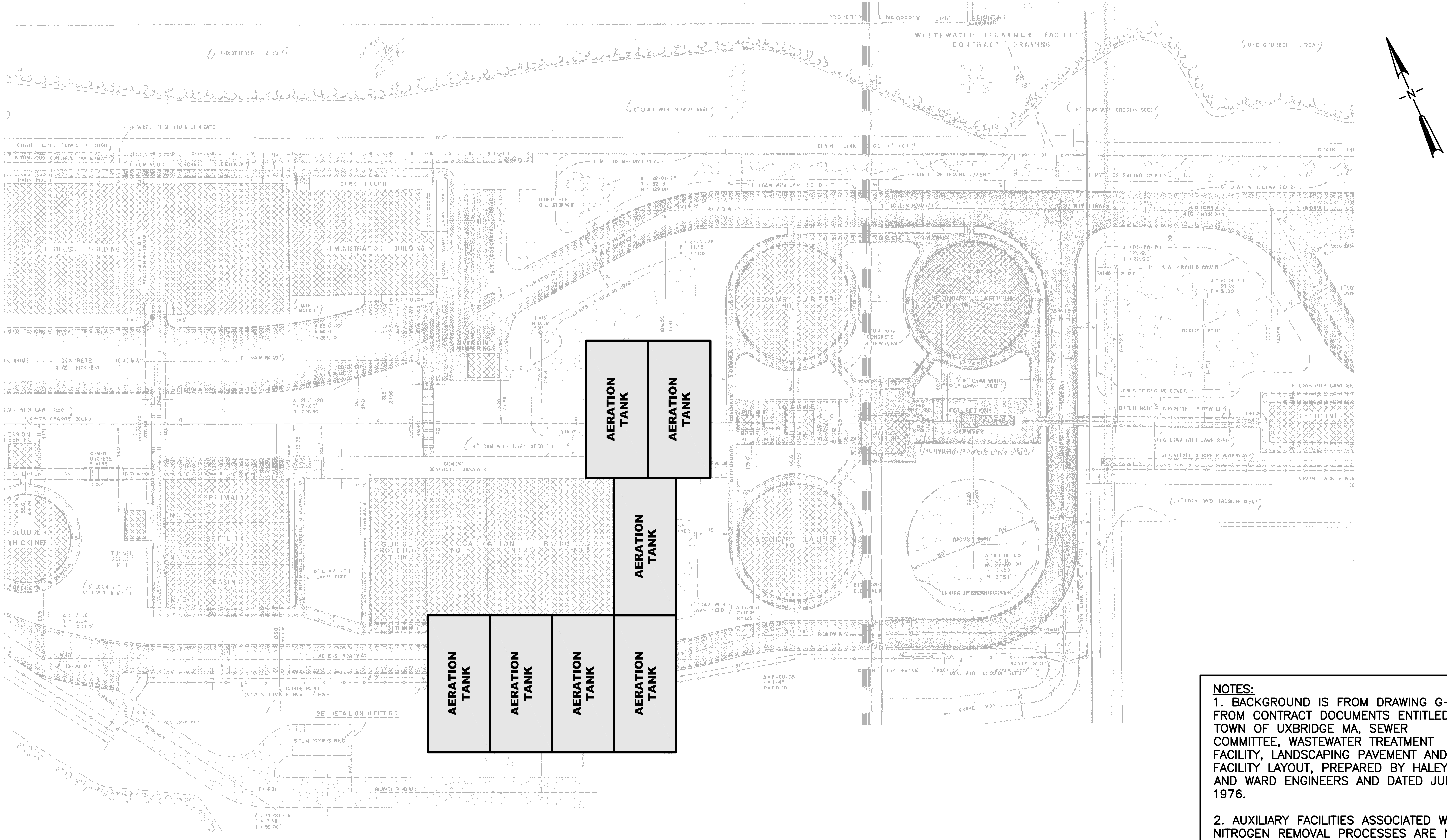
FIGURE 3.7-6: NITROGEN REMOVAL PROCESSES – SEASONAL LIMIT OF 5 mg/L

This configuration would require seven additional aeration tanks. The new tanks would be the same size as each of the existing tanks.

Although the existing clarifiers appear to be adequately sized to handle the future flow and loading conditions, it should be noted that the clarifiers at this facility are twelve 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 Section 2, they will have to be further evaluated to consider if they will require replacement or derating because of the shallow depth.

As shown in the site plan in Figure 3.7-7, the site has enough space for the additional aeration tanks. Specific information regarding the results of this analysis is shown in Table 3.7-7 as follows.

(continued)



NOTES:
1. BACKGROUND IS FROM DRAWING G-7 FROM CONTRACT DOCUMENTS ENTITLED TOWN OF UXBRIDGE MA, SEWER COMMITTEE, WASTEWATER TREATMENT FACILITY, LANDSCAPING PAVEMENT AND FACILITY LAYOUT, PREPARED BY HALEY AND WARD ENGINEERS AND DATED JULY 1976.

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

50 0 50 100
1"=50'-0"

SITE PLAN
SCALE: 1"=50'-0"

Login name: JDF
Filename path: J:\60000\61265 MADEP\10\Drawings\Fig
Filename: UXBRIDGE-CH3.dwg
Latest Revision: Friday, April 04, 2008

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

UXBRIDGE, MASSACHUSETTS
FIGURE 3.7-7

Table 3.7-7

RESULTS FOR SEASONAL LIMIT OF 5 mg/L TN

PARAMETER	VALUE
Aerobic SRT	7 days
Total SRT	10 days
First Anoxic Fraction	12%
Total Anoxic Fraction	29%
Reaeration HRT	1.5 hr
RAS Rate	100%
Total Volume	2.18 MG
Nitrate Recycle Rate	300%
Max MLSS at Loading Rate	3800 mg/L
Effluent TN	5 mg/L
Methanol Addition	No
Fixed Film Required?	No
Clarifiers?	Reuse existing
Effluent Filtration Required?	No

The modifications related to the proposed upgrade described above do not appear to require any structure demolition. The aeration tanks 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.** Although the facility would be able to accomplish a TN of 5 on an average annual basis with the Bardenpho process, the number of tanks required to accomplish this would be sixteen. With so many tanks required, the approach taken was to use the aeration volume for nitrification only and to denitrify using a denitrification filter. This approach reduces the number of additional tanks required to eight. These nitrogen removal processes are shown in Figure 3.7-8 as follows.

(continued)

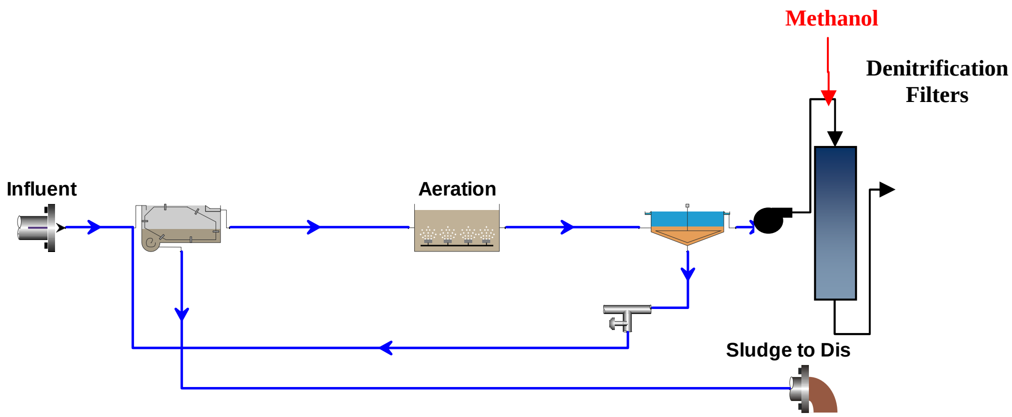

FIGURE 3.7-8:
NITROGEN REMOVAL PROCESSES – ANNUAL AVERAGE LIMIT OF 5 mg/L

The new aeration tanks would be the same size as the existing ones. The denitrification filter complex would have a footprint of approximately 2750 square feet and four cells each approximately sixteen feet by twelve feet.

Although the existing clarifiers appear to be adequately sized to handle the future flow and loading conditions, it should be noted that the clarifiers at this facility are twelve 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 Section 2, they will have to be further evaluated to consider if they will require replacement or derating because of the shallow depth.

As shown in the site plan in Figure 3.7-5, the site appears to have enough space for the additional aeration tanks and the denitrification filter. Specific information regarding the results of this analysis is shown in Table 3.7-8 as follows.

(continued)

Table 3.7-8

RESULTS FOR ANNUAL AVERAGE LIMIT OF 5 mg/L TN

PARAMETER	VALUE
Aerobic SRT	11 days
Total SRT	11 days
First Anoxic Fraction	n/a
Total Anoxic Fraction	n/a
Reaeration HRT	n/a
RAS Rate	100%
Total Volume	2.4 MG
Nitrate Recycle Rate	n/a
Max MLSS at loading rate	3900 mg/L
Effluent TN	5 mg/L
Methanol Addition	Yes, in denitrification filter
Fixed Film Required?	No
Clarifiers?	Reuse existing
Effluent Filtration Required?	Yes, denitrification filter

The modifications related to the proposed upgrade described above do not appear to require any structure demolition. The aeration tanks and denitrification filter 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.**

Table 3.7-9 presents flow data for the Uxbridge WWTF as well as the current nitrogen removal performance of the plant.

(continued)

Table 3.7-9

PLANT FLOW AND EFFLUENT LIMIT SUMMARY

PARAMETER	VALUE
Permitted Flow (mgd)	2.5
Existing Flow (2004-6)	0.93
% of existing capacity	37
Current average seasonal effluent TN (mg/L)	15.1
Current average annual effluent TN (mg/L)	13.7
Permit Limits Seasonal Nitrification (mg/L) Year-round nitrification (mg/L) Seasonal TN Limit Annual TN Limit	 Yes (5-10) Yes (5-15) No No

Table 3.7-10 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 a number of additional aeration tanks and, for the annual average limits, a denitrification filter. It should be noted that the plant has a wastewater concentration that would be considered a medium to high strength waste and has cold winter temperatures that together lead to significant upgrade requirements.

Table 3.7-10

NITROGEN REMOVAL PROCESS SUMMARY FOR UXBRIDGE WWTF

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
Currently implemented	MLE	Nitrification in aeration tanks with denitrification filters	Bardenpho	Nitrification in aeration tanks with denitrification filters

The modifications required at Uxbridge to convert to a new nitrogen removal process are summarized in Table 3.7-11.

Table 3.7-11

REQUIRED MODIFICATIONS SUMMARY FOR UXBRIDGE WWTF

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
5 new aeration tanks	8 new aeration tanks and a denitrification filter	7 new aeration tanks	8 new aeration tanks and a denitrification filter	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 3.7-11.

Table 3.7-12

COST SUMMARY FOR NITROGEN REMOVAL AT UXBRIDGE WWTF[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	\$25	\$300	\$29
Annual Average Effluent TN of 8 mg/L	\$44	\$500	\$50
Seasonal Effluent TN of 5 mg/L	\$32	\$310	\$36
Annual Average Effluent TN of 5 mg/L	\$44	\$500	\$50

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)

Section 3b

Blackstone River Watershed