Waterloo Biofilter Systems Inc.
on-site wastewater treatment

October 15, 2004

Dear Engineer,

The purpose of this letter is to provide supporting documentation that shows the nitrogen removal capabilities of the Waterloo Biofilter system.

Nitrogen Removal with the Waterloo Biofilter

Introduction

Over the last few years, nitrogen removal has been a hot topic of concern in the on-site industry. Currently, under the Ontario Building Code there is no requirement for nitrogen removal. However, in systems above 10,000 L/day that are under the jurisdiction of the MOE, nitrogen removal is a factor. In order to evaluate a system's efficiency in the removal of nitrogen, it is important to understand the different forms of nitrogen that exist in wastewater.

Nitrogen in Wastewater

There are five predominant forms of nitrogen that exist in wastewater. They are:

<table>
<tr><td>• Organic – N (Organic Nitrogen)
• NH_3-N (Ammonia Nitrogen)
• NH_4-N (Ammonium Nitrogen)</td><td>TKN
(Reduced Forms of Nitrogen)</td><td rowspan="2">TN
(Total Nitrogen)</td></tr>
<tr><td>• NO_2-N (Nitrite Nitrogen)
• NO_3-N (Nitrate Nitrogen)</td><td>“Nitrates”
(Oxidized Forms of Nitrogen)</td></tr>
</table>

Sometimes the forms of nitrogen in wastewater are grouped together. The two most commonly used groups are:

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1. TKN (Total Kjedahl Nitrogen) = Organic–N + NH_3-N + NH_4-N
This form of nitrogen is referred as the total nitrogen that is in a chemically reduced form.

2. TN (Total Nitrogen) = TKN + NO_2-N + NO_3-N
This form of nitrogen is referred as the "true" total nitrogen that includes both chemically reduced and oxidized forms.

Nitrogen Removal with the Waterloo Biofilter Treatment System

Nitrogen removal with the Waterloo Biofilter Treatment System is accomplished through a series of biochemical reactions that occur in the septic tank and in the Biofilter medium. It is important to emphasize that the microbes that are responsible for nitrogen removal are very sensitive to temperature (cold weather), alkalinity (hardness) of the sewage and disinfectant chemicals that are added to the system.

The nitrogen removal process is illustrated in **Figure 1.** The process of nitrogen removal is as follows:

1. Septic tank effluent which is high in TKN (Organic-N + NH_3-N + NH_4-N) flows into a pump chamber and is dosed to the Biofilter. In this step TN ~ TKN because Nitrate and Nitrite (NO_2-N and NO_3-N) is usually very low.

2. The Biofilter medium provides an aerobic environment (high in oxygen) where the aerobic microbes use O_2 to convert TKN into Nitrate and Nitrite. This step is called **Nitrification**. Almost no TN is removed in this step; it is simply converted into different forms.

3. Biofilter effluent which is high in Nitrate and Nitrite and low in TKN is re-circulated back to the septic tank.

4. The septic tank which is high in organic carbon (BOD) allows anaerobic microbes to convert Nitrate and Nitrite into Nitrogen gas (N_2). The Nitrogen gas is released into the atmosphere, thereby removing nitrogen (TN) from the system. This step is called **Denitrification.**

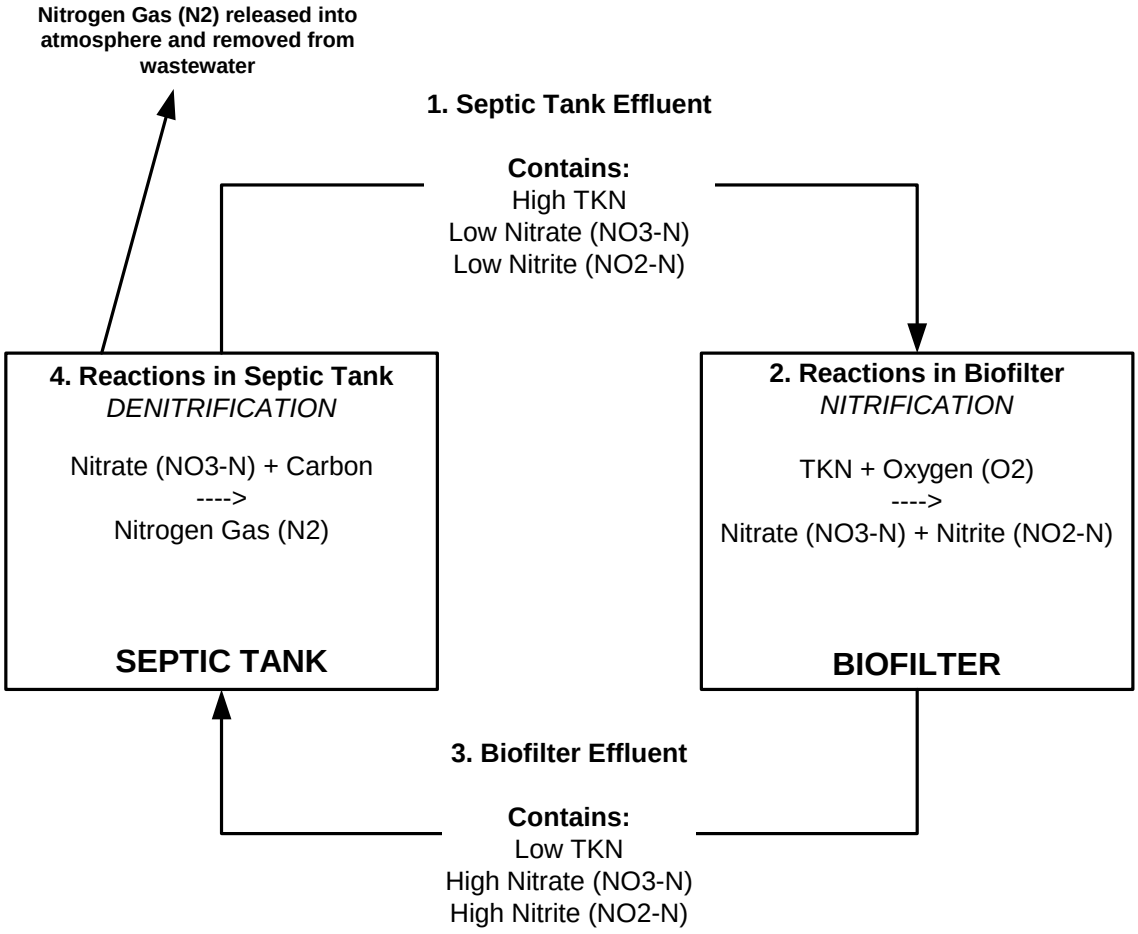

Figure 1
Nitrogen Removal in the Waterloo Biofilter System. Nitrogen is converted into different forms before it is actually removed from the wastewater

The Importance of understanding the different forms of Nitrogen

There is often a lot of confusion on the nitrogen removal efficiencies of wastewater treatment systems. The terminology that is often used to evaluate the ability of a system to remove nitrogen is the concentration of Nitrate that leaves the system. This can be confusing and misleading, since untreated septic tank effluent is low in Nitrates and high in TKN, as shown above. The job of a treatment unit is to convert TKN into Nitrate and Nitrite and a properly working treatment system should have high Nitrate and Nitrite in the effluent.

To properly evaluate how well a treatment system removes nitrogen it is important to see how much TN is removed, not just Nitrate alone.

Waterloo Biofilter Third-Party Testing Data

Waterloo Biofilter Systems Inc. has done extensive testing to prove that the Biofilter can remove TN. Attached is a Data Summary of the 14-month extensive third-party field testing carried under the NSF-EPA ETV program. This test is quite stringent and results are published no matter how well or how poorly a system performs. These results show that the Waterloo Biofilter can remove ~60% TN in a double-pass system (with 50% re-circulation).

Also attached is the ETI 24-month third party field testing results. These results show that the Waterloo Biofilter can remove ~40% TN in a single pass system (without re-circulation).

The results from these third-party testing programs are posted on the Internet. For more details you can use the following links:

ETV Program - http://www.epa.gov/etv/verifications/vcenter9-3.html

ETI Program - http://www.buzzardsbay.org/etiresults.htm

If you have any questions, please feel free to contact me.

Regards,

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Engineering Department

NSF International
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Data Summary for Waterloo Biofilter® Model 4 Bedroom Under the EPA ETV Water Quality Protection Center

The following is a preliminary summary of the test results obtained for the Waterloo Biofilter® Model 4 Bedroom for nutrient reduction under the ETV Water Quality Protection Center. These results have been QA reviewed, but will not be considered final until all EPA reviews have been completed. The testing was completed at the Massachusetts Septic Systems Test Center during the period of March 2001 through April 2002. A full report for this testing will be completed soon and posted on the EPA (www.epa.gov/etv) and NSF (www.nsf.org/etv) web sites.

Table 1. BOD_5/$CBOD_5$ and TSS Data Summary

	BOD_5	$CBOD_5$		TSS		
	Influent (mg/L)	Effluent (mg/L)	Removal Percent	Influent (mg/L)	Effluent (mg/L)	Removal Percent
Samples	53	53	53	53	53	52
Average	210	10	95	150	7	95
Median	200	7.4	96	130	5	97
Max	370	43	99	340	55	>99
Min	67	1.0	71	61	<1	51
Std. Dev.	73	9.0	6.0	66	8	8

Table 2. Nitrogen Data Summary

	TKN (mg/L)		NH4 (mg/L)		Total Nitrogen (mg/L)		Nitrate (mg/L)	Nitrite (mg/L)	Temperature (C)
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Effluent	Effluent	Effluent
Samples	53	53	53	53	53	53	53	53	51
Average	37	3.7	23	2.4	37	14	10	0.19	15
Median	37	1.6	23	0.7	37	13	10	0.14	14
Maximum	45	31	29	24	45	45	33	0.84	24
Minimum	24	<0.5	18	<0.2	24	6.8	0.6	<0.05	5.2
Std. Dev.	4.2	5.5	2.4	4.0	4.2	6.0	5.0	0.20	5.9

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ETI Independent 50% Re-circulation Testing in Triplicate for 24-Month Period Buzzard's Bay Test Facility, MA

Effluent average of three Waterloo Biofilters with 50% recirculation For the 24-month period of June 1999 to July 2001

Test Results: These independent tests confirm that the Waterloo Biofilter can be loaded at very high rates and still obtain tertiary quality of $_{c+n}BOD_5$ = 8 and TSS = 4 mg/L, with very low power consumption, and with ~60% total nitrogen removal. The actual loading rate is 330 USgpd dosed at household diurnal peaks, or a design of 10 gpd/ft^3 (1200 L/m^3) foam medium using a peaking factor = 2.0. Pan lysimeters showed that a 12" soil separation after the Biofilter® is equivalent to an underdrained 60" thick Title 5 sand filter system, but with much better nitrogen removal.

Benefits to Waterloo Biofilter Systems: After this testing, the Waterloo Biofilter is approved for General Use in Massachusetts and Provisional Use for Nitrogen Removal. All Massachusetts Health Departments will be advised of the test results; especially significant are the nitrogen results. Other New England states should not require multiple monitored pilots before approval, thus easing approvals for tertiary effluent credit and for nitrogen removal.

Substantial nitrogen removal in the Waterloo Biofilter® is possible by re-circulation back to the septic tank.

Biofilter organic results including start-up period (124-133 samples):

	$_{c+n}BOD_5$	TSS	Fecals cfu/100mL	NH_4-N	TN
Influent median (mg/L)	162	161	3100k	24.2	34.6
Effluent median (mg/L)	8.2	3.5	32k	0.5	13.9
% Removal	**95.2**	**97.8**	**99.0**	**97.9**	**59.8**

Fecal Coliforms are reduced by 99% in the Waterloo Biofilter®. With an additional foot of sand, the reduction is >99.99%.

Fecal coliform results for 12" lysimeter testing (25-30 samples):

	Lysimeter A1 May/00-Jul/01 cfu/100mL	Lysimeter A2 June/00-July/01 cfu/100mL	Lysimeter A3 June/00-July/01 cfu/100mL
Influent Sewage	3,700,000	3,800,000	3,700,000
After Waterloo & 12" of T=2 Sand	125	200	60
% Removal	**99.99%**	**99.99%**	**99.99%**

Independent Single-Pass Testing (No Re-circulation) On-going at Buzzard's Bay Test Facility, MA

A study on the effluent quality of a Single Pass Biofilter® is continuing at the Buzzard's Bay test site.

The single pass Biofilter is very effective at removing dissolved organics and solids in wastewater.

At peaking actor of 2.0, daily design loading rate = 10 gpd/ft^3 or 1200L/m^3 foam.

Waterloo Biofilter Single Pass Organics from Sept/01 to June/02:

	No. Samples	cBOD	TSS	DO	TN
Influent mg/L	37	214	130	0	37
Effluent mg/L	19	**6.4**	**4.0**	5.6	21.3
% Removal	**-**	**97.0**	**96.9**	**-**	**42.5**

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Project Overseers:
US Environmental Protection Agency
Massachusetts Department of Environmental Protection
Coalition for Buzzards Bay
US Department of Defense
Massachusetts Office Coastal Zone Management
Barnstable County Department of Health and the Environment
Cape Cod Commission
New England Interstate Water Pollution Control Commission
Towns of Sandwich and Falmouth
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