

Lombardo Associates, Inc.

Representative Nitrogen Removal Project Descriptions



- Cluster Nitrex™ Systems
- Test Centers & Independent Evaluations
- Groundwater & Stormwater Treatment
- Single Family Nitrex™ Systems
- Multi Family & Institutional Nitrex™ Systems

Environmental Engineers/ Consultants

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Nitrex™ Nitrogen Removal Systems - Nitrogen Removal Performance									
Site #	Location		Application	Nitrex™ Effluent Total Nitrogen Quality (mg/l)	Sampling Frequency	Total Nitrogen Percent (%) Removal	Period of Operation		
							From	To	
1	2950 Beacon Court, Lusby, MD		Single Family Residence (SFR)	1.97	quarterly	96.7%	Sep-09	present	
2	6500 Long Beach Drive, St. Leonard, MD		SFR	2.80	quarterly	95.3%	Sep-09	present	
3	6586 Long Beach Drive, St. Leonard, MD		SFR	2.95	quarterly	95.1%	Sep-09	present	
4	18040 Barnesville Road, Barnesville, MD		SFR	4.20	quarterly	93.0%	Mar-10	present	
5	1933 Clifton Road, Virginia Beach, VA		SFR	3.26	annually	94.6%	Aug-09	present	
6	Dana Drive, Crawfordville, FL		SFR	4.8	every 2 months	92.0%	Oct-11	present	
7	Mashpee, MA Main St Villages		30 unit subdivision	2.80	monthly for 1st 18 months then quarterly	95.0%	May-06	present	
8	Eastham, MA Bracket Landing		40 unit subdivision	2.03		95.5%	Oct-07	present	
9	Suffolk County NY Environmental Center Islip NY		Environmental Center	3.39	quarterly	96.6%	Aug-11	present	
10	Bogue Sound Elementary & Croatan High School Newport, NC			2.57	weekly for 1st 8 weeks, then monthly for next 9 months then quarterly	97.6%	Jan-10	present	
11	Malibu Village Plaza Malibu, CA		Shopping Center - Restaurants & Retail	2.49	weekly	96.2%	Jul-07	present	
12	Stone Residence LaPine, OR		SFR	2.2	monthly for 23 months	96.1%	Dec-00	May-03	
13	Fleming Residence LaPine, OR		SFR	2.65	monthly for 21 months	96.1%	Dec-00	Mar-03	
14	Polson, MT for MT Dept of Natural Resources		SFR	3.4	daily for 5 days once per month for 11 months then monthly for 11 months. 65 sample events total	92.6%	Oct-99	Aug-01	
15	Massachusetts Alternative Septic System Test Center Cape Cod, MA		330	4.5	Monthly for 30 months then weekly for 12	88.5%	Oct-01	Oct-05	
Environmental Engineers/ Consultants				2.47	AVERAGE OF Large Flows	96.1%			
LOMBARDO ASSOCIATES, INC.				3.28	AVERAGE OF SFR	94.2%			

Canoe Place Inn Redevelopment & Housing Development Southampton, NY - Up to 150 % Nitrogen Removal



ON-SITE WASTEWATER & GROUNDWATER NITROGEN REMOVAL

BRINGING BACK A TREASURED INN



Owner: Rechler Equity

Canoe Place Inn Property Rehabilitation - 20 unit Inn; Catering facility 350-person; Restaurant - 70-seats, 20-seat bar & 120-outdoor seating. 5 cottages - 6,670 SF

Wastewater & Groundwater Nitrogen Removal System Design Wastewater Flow = 10,175 gpd

Shinnecock Canal– 37 Townhouses Wastewater Treatment & Nitrogen Removal System
Design Flow = 11,870 gpd

Project Description:

Rechler Equity is proposing to rehabilitate the historic Canoe Place Inn (CPI) property and building 37 townhouses along the eastern shore of the Shinnecock Canal. Due to the excessive nitrogen discharges that are adversely affecting the Shinnecock and Peconic Bays, Rechler retained Lombardo Associates, Inc. to engineer the state-of-the-art, highest level of nitrogen removal Nitrex™ wastewater treatment for the Shinnecock townhouses. The Nitrex™ system has been shown to reliably and consistently achieve 93+% wastewater nitrogen removal, as validated by Suffolk County Department of Health Service testing and studies.

For the CPI property, Lombardo has prepared preliminary engineering of the Nitrex™ groundwater treatment system which will remove 93+% of wastewater nitrogen, but also remove nitrogen from the contaminated groundwater that is traversing the property and discharging to Shinnecock and Peconic Bays. With the passive Nitrex™ groundwater system and Nitrex™ wastewater nitrogen removal system for the Shinnecock Canal townhouses, approximately 150% of the nitrogen discharged from both sites will be removed. This is equivalent to removing the nitrogen discharges from 30+ homes, which would cost \$2+ million with a conventional sewerage system, in addition to removing all of the nitrogen from the proposed CPI and Canal townhouses developments. The project was unanimously approved by the Southampton Town Board in January 2015

Reference:

Kristen McCabe, Director of Planning and Land Use
Rechler Equity
85 South Service Road
Plainview, NY 11803
631-414-8438
KMCCabe@rechlerequity.com

Contact:

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PROJECT DESCRIPTION – MAIN STREET VILLAGE – MASHPEE, MA



Cluster System Producing Water with Total Nitrogen 3+/- mg/l

Project: Main Street Village
Mashpee, MA

Design Flow: 5,226 gpd

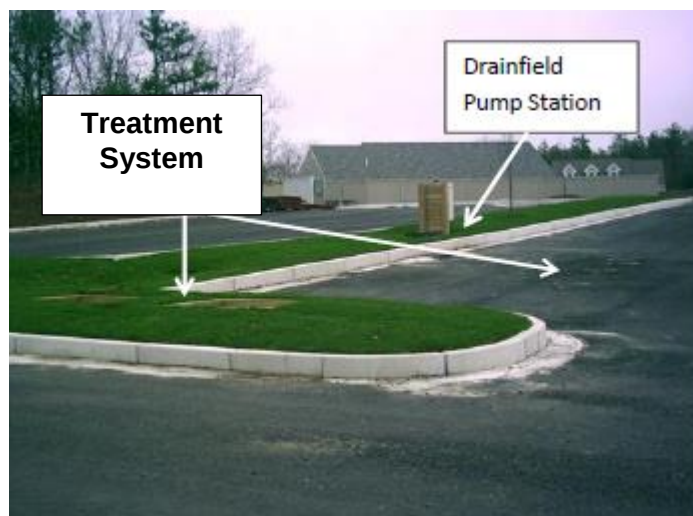
Wastewater Engineer: Pio Lombardo, P.E.
Lombardo Associates, Inc.
Boston, MA & Malibu, CA
617-964-2924
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The Main Street Village, in Mashpee, Cape Cod, MA, which has 24 housing units and small commercial space, was created with a 5,226 gpd design flow, community-sized wastewater treatment system. The wastewater system is located in a defined nitrogen sensitive area, a Zone II of a public water supply well. Zone II areas are contributing to a water supply well.

The development is served with Town water and the entire Wastewater System includes a wastewater collection system, septic tank, and Recirculating Media Biofilter followed by a Nitrex™ Filter to reduce effluent total nitrogen prior to discharge to a drainfield. Permit effluent requirements are TN must be < 10 mg/l. The Wastewater System became operational in March 2006.

Mashpee, MA Wastewater System at Completion



After the start-up period, wastewater effluent TN levels have generally been < 3 mg/l. Effluent BOD and TSS are typically < 15 mg/l and < 5 mg/l, respectively.

Operations and Maintenance requirements consist of permit required monthly visits for treatment system performance sampling. Daily electrical consumption is approximately 5 KWHr, or \$0.75/day with electric costs of \$0.15/KWHr. Telephone connection allows remote monitoring of flow and notification of alarm conditions. No chemicals and no other utilities are required.

Environmental Engineers/ Consultants

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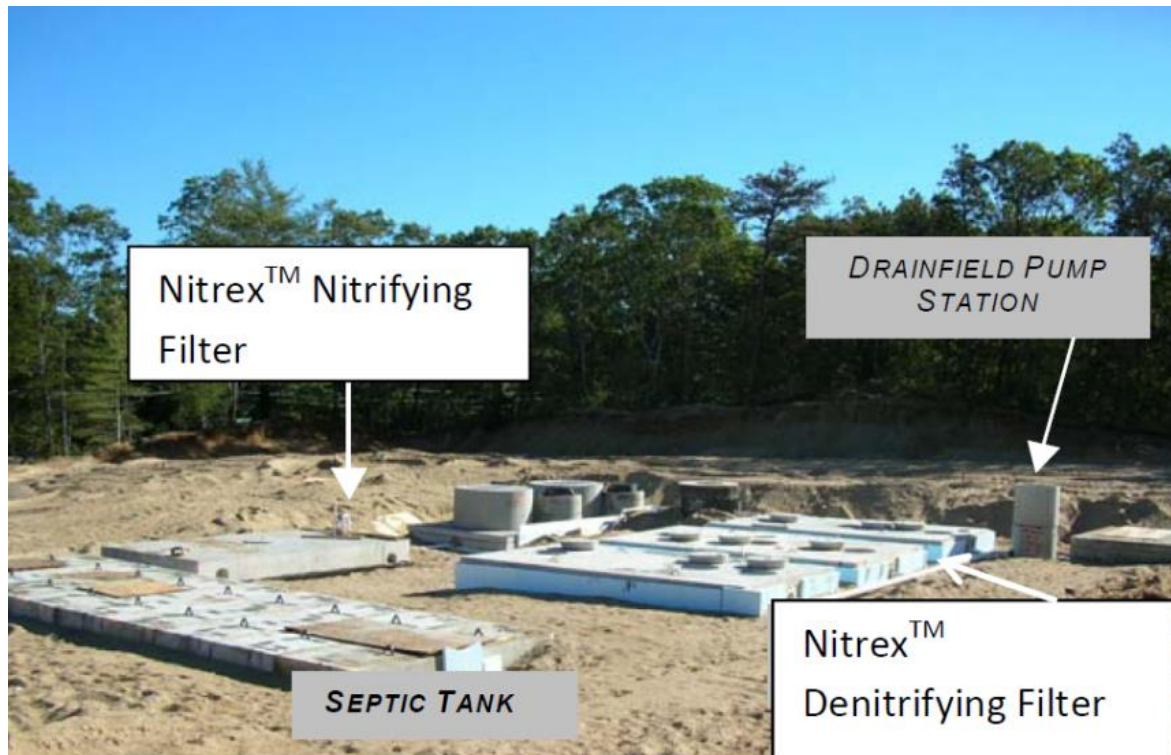
Pio@LombardoAssociates.com

<i>2006 - 2008 GeoMean</i>	<i>48.5</i>	<i>2.8</i>
<i>2007 - 2009 GeoMean</i>	<i>46.2</i>	<i>2.9</i>
<i>2008 - 2010 GeoMean</i>	<i>56.2</i>	<i>2.2</i>
<i>2009 - 2011 GeoMean</i>	<i>66.0</i>	<i>3.0</i>
<i>2010 - 2012 GeoMean</i>	<i>72.0</i>	<i>3.1</i>
<i>2011 - 2013 GeoMean</i>	<i>55.7</i>	<i>3.0</i>
Period of Record	52.7	2.8

The wastewater treatment technology demonstrates that decentralized distributed wastewater systems can be as effective as centralized facilities in achieving the accepted limit of technology of TN < 3 mg/l, and is another tool for wastewater planners and engineers in nitrogen sensitive areas.

The Mashpee project results are similar to independent testing performed in Oregon, Montana, and Massachusetts. The Nitrex™ System is an approved technology in a number of States, with installations in MA, MD, VA, MT, OR, CA and Canada.

Mashpee, MA Wastewater System at Substantial Completion



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Bogue Sound Elementary School & Croatan High School Newport, NC



ACHIEVING TOTAL NITROGEN < 3 MG/L

Project Location: Bogue Sound Elementary
School & Croatan High School
Newport, NC

Owner: Carteret County Board of Education

Wastewater Engineer: Lombardo Associates, Inc.
Boston, MA & Malibu, CA
www.LombardoAssociates.com

Nitrex™ Design Profile:

- Design Wastewater Flow: **12,000 gpd**
- Nitrex™ Influent Total Nitrogen (TN): **70 mg/l**
- Effluent Requirements:
 - TN <10 mg/l
 - cBOD₅ <15 mg/l
 - TSS <15 mg/l
 - Fecal Coliform < 200 MPN/100ML



Wastewater Treatment Process:

Septic Tank → Recirculating Sand Filter → Nitrex™ Filter → Recirc. Sand Filter → UV Disinfection → Drainfield

Lombardo Associates, Inc. (LAI) was retained by the Carteret County Board of Education (CCBoE) to design, permit and build a Nitrex™ Nitrogen Removal wastewater system serving Croatan High School and Bogue Sound Elementary School. The existing wastewater system for the School consisted of three recirculating sand filter (RSF) cells with UV disinfection prior to discharge to a drainfield. The LAI design included modifications to the piping of the RSF to optimize denitrification and construction of a Nitrex™ filter, and using one of the RSFs for polishing. The Croatan High School and Bogue Sound Elementary School On-Site Wastewater Treatment System became operational in December 2009 and was immediately performing within permit requirements. Performance data is:

Bogue Sound Elementary School & Croatan High School, Newport, NC							
Date	Start-up	Septic Tank Effluent		Nitrex™ System Effluent			
	10-Dec-09	BOD	TKN	BOD	TSS	TN Calc.	Fecal Coliform
	Units	mg/l	mg/l	mg/l	mg/l	mg/l	mpn / 100 mL
	Permit			15	15	10	200
Geometric Mean		178	104	1.2	1.3	2.52	1.2

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PROJECT DESCRIPTION - Chincoteague, Virginia

RESIDENTIAL SYSTEM PRODUCING TOTAL NITROGEN < 3 mg/l



Project: Landing at Water's Edge
Chincoteague, VA

Design Flow: 3,900 gpd

Wastewater Engineer: Pio Lombardo, P.E.
Lombardo Associates, Inc.
Malibu, CA & Boston, MA
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LAI designed the Nitrex™ component of the wastewater treatment and disposal system for the seasonally used Landings at Water's Edge site in Chincoteague, VA to reduce total nitrogen to less than 10 mg/l in the effluent after pretreatment by a recirculating peat filter aerobic treatment system. The system is designed for sanitary sewage from a residential development with approximately 15 units. The system has been operational since February 2007 and effluent total nitrogen has been <3 mg/l.

The Nitrex™ system is virtually maintenance free. The water quality data is presented below:

Date	Avg. Monthly Flow (gpd)	Nitrex™ Effluent
		TN
		mg/l
May-07	2,068	3.17
Jun-07	268	1.10
		0.96
Jul-07	703	0.20
Sep-07	299	2.05
Average	514	1.50



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PROJECT DESCRIPTION – MALIBU VILLAGE PLAZA, MALIBU, CA

Producing Water Meeting CA Title 22 Unrestricted Water Reuse Standards Achieving Total Nitrogen 2+/- mg/l and Turbidity <1 NTU

Project: Malibu Village Plaza
Shopping Plaza

Design Flow: 16,000 gpd High Strength
Equivalent to ~40,000 gpd
Residential Strength Wastewater
System – approximately 200
homes

Client: Malibu Creek Preservation Co.
c/o Soboroff Partners

**Wastewater
Engineer:** Lombardo Associates, Inc.
Malibu, CA & Boston, MA
www.LombardoAssociates.com



Project Description.

The Malibu Village Plaza is a shopping plaza consisting of both retail and commercial businesses. It is located in an environmentally sensitive area adjacent to the famous Surfrider Beach in Malibu, California. In 1999 the California Regional Water Quality Control Board (CRWQCB) and the City of Malibu conducted groundwater and surface water sampling at Malibu Village Plaza and the nearby area and determined that wastewater discharge from the Plaza and other properties using conventional septic systems were causing groundwater pollution, which adversely impacted Malibu Creek and Malibu Lagoon.

Lombardo Associates, Inc. (LAI) was retained to engineer a compliant wastewater management system to protect Malibu Lagoon and Surfrider Beach. The previous system was a conventional system consisting of grease traps, septic tanks and gravel drainfields, which provided insufficient nitrogen and bacteria removal.

LAI designed a cost-effective wastewater management system that employs a septic tank effluent pump (STEP) collection system and treatment system consisting of the NitrexTM Nitrogen Removal Technology, recirculating media pretreatment of septic tank effluent, and an ozone – UV disinfection system for bacteria removal. Treated effluent is discharged to new high capacity drainfields. The treatment system was designed to treat 16,000 gpd of the high strength wastewater (equivalent to ~40,000 gpd of residential strength wastewater) as 85% of the flow was from the Plaza's popular restaurants. Discharge is to a drainfield at 3 gpd/SF.



Water Quality Data – Nitrex™ Wastewater System – Malibu Village Plaza, Malibu, CA

The Malibu Village Plaza Wastewater Treatment System has been operational since July 2007. The Plaza's wastewater treatment effluent quality is compliant with permit requirements as well as California Title 22 unrestricted water reuse requirements as shown on the following table. An additional 125 chemicals are analyzed on a monthly basis. All are within permit requirements. All contaminants of concern are below Detection Limits, typically < 5 ppb.

Energy use, 67% of which is for disinfection, of the high strength 16,000 gpd facility (equivalent to 200 - 250 homes) is approximately \$7,400 per year (135 kwhr/day @\$0.15). Operation & Maintenance requirements are weekly visits of 2 – 4 hours for maintenance and sample collection

Year	Total Nitrogen (mg/l)	
	Annual Geo mean	3 yr Geo Mean
2009	1.72	
2010	1.90	2.25
2011	2.03	1.89
2012	2.35	2.09
2013	2.73	2.35
2014	3.40	2.80
Record	2.49	

Wastewater Treatment system below parking lot and inside fence. Small building for electrical and disinfection equipment



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PROJECT DESCRIPTION – EASTHAM, MA

Cape Cod Residential Development Producing Water with Total Nitrogen 2 - 3 mg/l

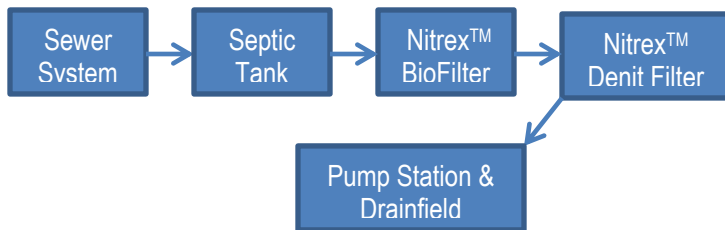
Project: Brackett Landing, Eastham, MA
40 unit subdivision

Design Flow: 8,310 gpd

Wastewater Engineer: Pio Lombardo, P.E.
Lombardo Associates, Inc.
Boston, MA & Malibu, CA
617-964-2924
Pio@LombardoAssociates.com
www.LombardoAssociates.com

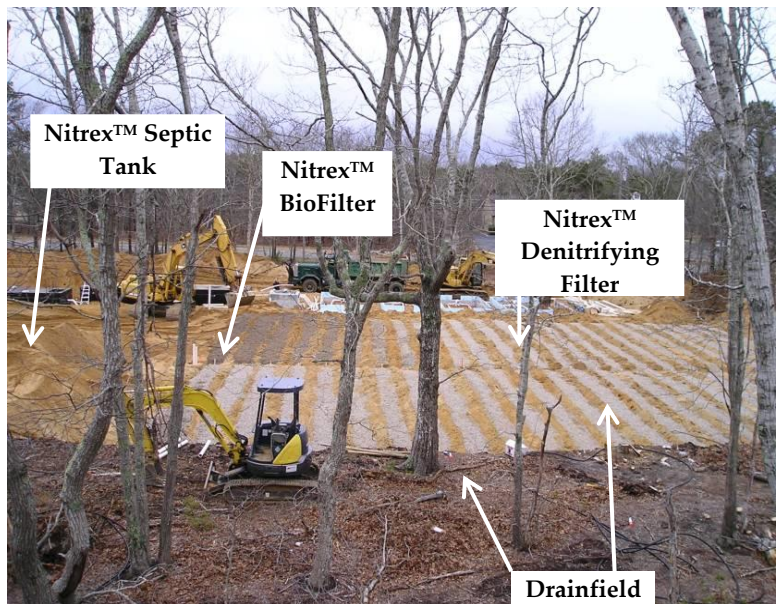


Lombardo Associates, Inc. (LAI) has provided design-build-operate services for the wastewater treatment system for the Brackett Landing development in the Town of Eastham on Cape Cod, MA utilizing the Nitrex™ System to achieve nitrogen reduction since 2006. Wastewater is purified in the Nitrex™ system by the following process as illustrated in the Figure of the installed system.



The wastewater system was designed and constructed in accordance with the Town of Eastham Board of Health regulations and the MADEP Title 5 requirements for effluent Total Nitrogen < 10 mg/l. The System has been installed and operational since September 2007. The performance to date is presented in the following table. Quarterly visits are performed for maintenance and required permit sampling.

Brackett Landing, Eastham, MA	
Nitrex™ Treatment System	
Date	Nitrex™ Effluent
	Total Nitrogen (mg/l) Geometric Mean
2007 - 2009	2.23
2008 - 2010	2.21
2009 - 2011	2.62
2010 - 2012	2.05



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Harvard, MA Residential System



ON-SITE WASTEWATER TREATMENT SYSTEM WITH ALKALINITY CHALLENGES



Project Application Data:

- Location: Harvard, MA
- Site Application: 6 bedroom residential site – 2 houses
- Installation Date: Fall 2006

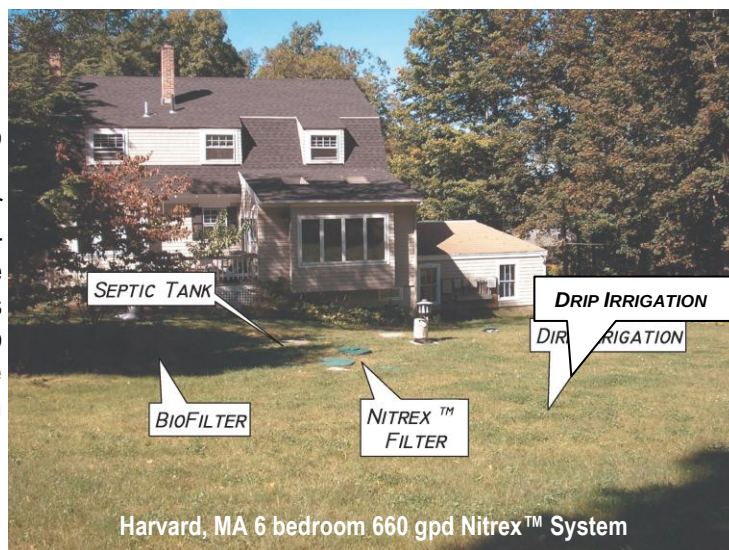
Wastewater Engineer: Lombardo Associates, Inc.
Boston, MA & Malibu, CA
www.LombardoAssociates.com

Design Profile:

- Design Wastewater Flow = 660 gpd
- Wastewater Treatment Process: Septic Tank → BioFilter → Nitrex™ → UV Disinfection → Drip Irrigation

Project Description:

Due to shallow depth to groundwater and closeness to environmentally sensitive wetlands, Lombardo Associates, Inc. was retained to engineer an innovative wastewater system for the 2 home site. The final design of Septic Tank – BioFilter – Nitrex™ – UV Disinfection – Drip Irrigation was approved by the Conservation Commission and had a construction cost savings of 40% as compared to the previously bid mound system. Due to the extremely high influent nitrogen levels, nitrogen removal were diminished due to insufficient alkalinity, which LAI solved with an automatic alkalinity feed system in summer 2011.



Harvard, MA 6 bedroom 660 gpd Nitrex™ System

Performance Data:

Date	Total Nitrogen (mg/l)	
	Septic Tank Effluent	Nitrex™ Effluent
8/16/11	110.0	2.06
9/19/11	118.0	0.63
9/22/11	102.0	0.94
3/9/12	84.0	6.60
Avg.	103.5	2.6

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Alternative Wastewater Systems Achieving TN < 10 mg/l Study Suffolk County NY



Project Application Data:

- Location: Suffolk County New York
- Testing Period: September 2011

Wastewater H2M
Engineer: Melville, NY

Project Description:

The Suffolk County Department of Health Services (SCDHS) retained the engineering firm of Hollzmacher, McLendon and Murrell (H2M) to investigate the ability of alternative on-site sewage treatment and disposal systems to meet the effluent requirement for total nitrogen of 10 mg/l or less. Upon evaluation and approval by SCDHS, these systems could be implemented in place of currently approved on-site treatment systems in residential and commercial applications. Based upon a wide-ranging comprehensive evaluation, four (4) technologies were identified by a joint panel of experts from SCDHS and H2M, as potentially capable of achieving effluent TN < 10 mg/l, with Nitrex™ system having the most promising capability.

Sampling of the candidate sites of the various technologies was then undertaken with the results for the Nitrex™ installations presented below.

On November 29, 2011, the Suffolk County Department of Health Services (SCDHS) approved the Nitrex™ system for use in Suffolk County to achieve effluent TN < 10 mg/l. As stated in the SCDHS News release:

"The Nitrex system, which was installed at Scully Estate County Park and evaluated as part of the county's study, is now available for use on other commercial projects. Health officials have completed sampling of this system and the results have been exceptional, commonly reducing nitrogen to the range of two to three milligrams per liter of wastewater discharge."

No.	Site Name	Nitrex™ EFFLUENT TN (mg/l) Sampled		
		1st sampling	2nd sampling	Average
1	Eastham MA 40 unit subdivision	1.33	1.37	1.35
2	Mashpee MA 24 unit subdivision with 5,200 sf commercial	0.54	1.57	1.055
3	Harvard MA 2 family installation	0.63	1.4	1.015
4	Malibu CA 16,000 gpd Shopping Center restaurants & retail	1.58	1.28	1.43
5	St. Leonard, MD MA single family installation	2.3	3.68	2.99
Average all sites		1.28	1.86	

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PROJECT DESCRIPTION – VIRGINIA BEACH, VA

Residential System Producing Total Nitrogen 3.26 mg/l

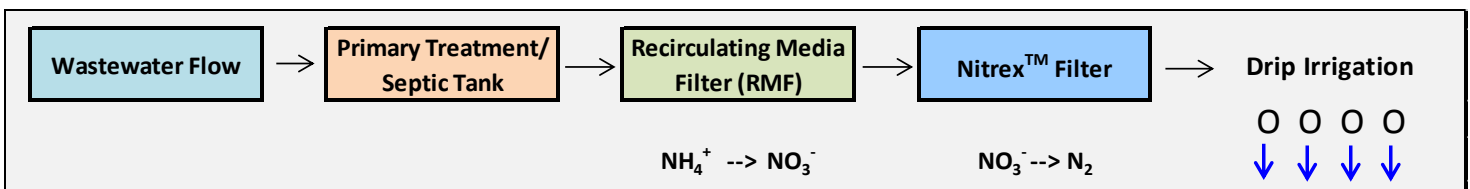
Project: 1933 Clifton Road
Virginia Beach, VA

Design Flow: 330 gpd

Wastewater Engineer: Pio Lombardo, P.E.
Lombardo Associates, Inc.
Boston, MA
617-964-2924
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www.LombardoAssociates.com



Lombardo Associates, Inc. (LAI) designed a residential Nitrex™ wastewater nitrogen removal system to serve a 3 bedroom residence in Virginia Beach. The Nitrex™ system is virtually maintenance free. The process flow diagram is shown below. The system was installed in 2008, and is currently achieving an average effluent TN 3.26 mg/l. The water quality data is presented below:



Date	Nitrex™			
	BOD	TSS	TN	Fecal Coliform
21-Aug-09	18	15	1.87	40
4-Nov-09	16	5.3	1.61	<1
21-Jul-10	3	4	2.83	<1
27-Jan-11	8	5.1	6.72	<1
			3.26	
Total N % Removal			94.6%	

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Scully Estate – Environmental Center Suffolk County, Islip, NY



ON-SITE WASTEWATER TREATMENT SYSTEM

Project Application Data:

- **Location:** Scully Estate –
Suffolk County Environmental Center
- **Site Application:** Islip, NY
- **Installation Date:** November 2008
- **Start-up:** Summer 2011

Wastewater Engineer: Lombardo Associates, Inc.
Boston, MA & Malibu, CA
www.LombardoAssociates.com

Design Profile:

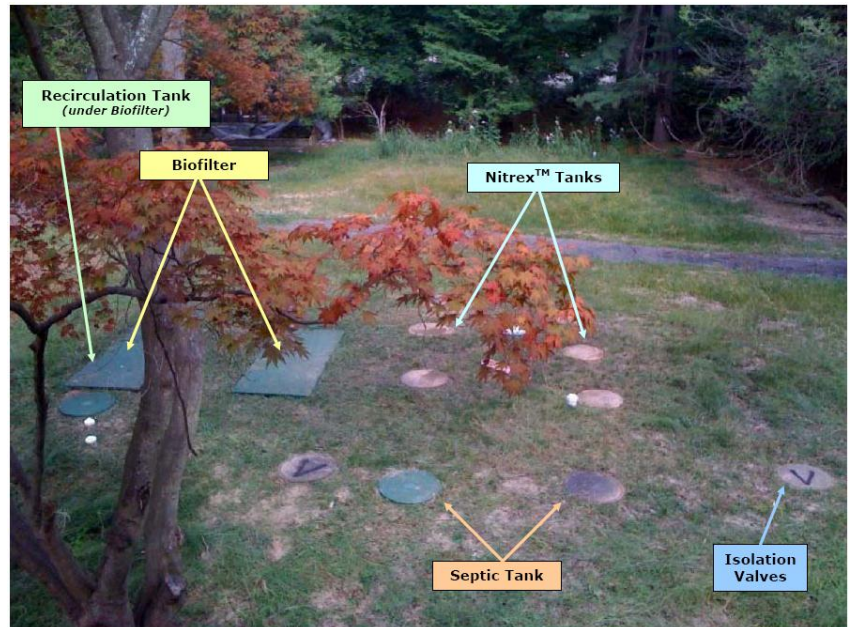
- Design Wastewater Flow = 1,300 gpd
- Wastewater Treatment Process:
Septic Tank → BioFilter → Nitrex™ →
Drainfield

Project Description:

The Scully Estate is located on South Bay Avenue in Bay Shore, Islip, NY, approximately 6,500 feet south of Montauk Highway. Daily design flow is 1,300 gpd. Because of the small flow and the distance and expense involved in connecting to the municipal sewer, an on-site treatment and disposal system was selected by Suffolk County.

Nitrogen removal was the critical wastewater issue due to the groundwater sole source aquifer and coastal embayment environmental sensitivity to nitrogen. For this reason, the Nitrex™ system was sole source selected by Suffolk County.

The entire project is LEED compliant. The basic treatment process is nitrification followed by the Nitrex™ denitrification reactor, then to the drainfield. Due to the low alkalinity water supply and high nitrogen strength wastewater, an alkalinity feed system is part of the system which enables full nitrification to occur.



Date	Wastewater Influent	Nitrex™ Effluent	Nitrex™ TN % Removal
	Total Nitrogen (TN) (mg/l)	TN (mg/l)	
10/04/11	70.4	1.6	97.8%
03/21/12	81.3	5.1	94.6%
04/03/12	81.0	5.2	93.6%
04/10/12	81.0	4.8	94.1%
04/12/12	90.0	3.8	95.8%
04/17/12	81.0	3.4	95.8%
04/24/12	81.0	5.2	93.6%
08/21/12	85.2	4.9	94.3%
Geometric Mean		4.0	94.9%

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PROJECT DESCRIPTION – CALVERT COUNTY, MARYLAND



Cost Competitive Nitrex™ Technology Systems on \$ / lb Nitrogen Removed – Residential Systems $TN < 3 \text{ mg/l}$, averaging $TN = 2.93 \text{ mg/l}$

Project: Calvert County, MD
3 Sites

Design Flow: 450 gpd

Wastewater Engineer: Pio Lombardo, P.E.
Lombardo Associates, Inc.
Boston, MA & Malibu, CA
617-964-2924
Pio@LombardoAssociates.com
www.LombardoAssociates.com

The Board of County Commissioners of Calvert County, MD, awarded Lombardo Associates, Inc. (LAI) three project sites for the installation of the Nitrex™ Technology Nitrogen Removal Systems.

The systems were installed in 2008, and are currently achieving $TN < 3 \text{ mg/l}$.



% Denitrification Rate = 93.3%





System Performance:

Date	2950 Beacon Court, Lusby, MD - Farmer & Neal						6500 Long Beach Drive, St. Leonard, MD - Rockhill						6586 Long Beach Drive, St. Leonard, MD - Aboulhosn					
	Average Monthly Flow		Nitrex™ Effluent				Average Monthly Flow		Nitrex™ Effluent				Average Monthly Flow		Nitrex™ Effluent			
	Month	Flow ⁽²⁾ (gpd)	NO ₃	NO ₂	TKN	TN ⁽¹⁾	Month	Flow ⁽²⁾ (gpd)	NO ₃	NO ₂	TKN ⁽¹⁾	TN ⁽¹⁾	Month	Flow ⁽²⁾ (gpd)	NO ₃	NO ₂	TKN	TN ⁽¹⁾
			1.0	0.1	0.5	1.10			1.0	0.1	0.5	1.10			1.0	0.1	0.5	1.10
09/16/09	16-Sep-09	102.1	<0.10	<0.10	2.0	2.0	16-Sep-09	145.1			1.01	1.01	16-Sep-09	37.1	<1.00	<0.10	1.7	1.7
01/29/10	1-Jan-10	73.6	<1.00	<0.10	0.8	0.8	1-Jan-10	100.0	<1.00	<0.10	2.2	2.2	1-Jan-10	59.1	<1.00	<0.10	4.3	4.3
05/14/10	14-May-10	88.0	<1.00	<0.10	1.3	1.4	14-May-10	174.0	<1.00	<.10	1.0	1.1	14-May-10	25.0	<1.00	<.10	1.5	1.5
05/02/11	2-May-11	83.6	<1.00	<0.10	2.9	3.7	2-May-11	185.0	<1.00	<.10	5.1	5.1	2-May-11	55.0	<1.00	<.10	2.1	2.1
08/18/11	18-Aug-11				2.5	2.5	18-Aug-11				10.4	10.4	18-Aug-11		0.6		4.2	4.2
	Average					2.1						4.0						2.8
						AVERAGE ALL SITES			2.93									
% Nitrogen Removal			96.5%				93.4%				95.4%							

All Systems/Data Average TN = 2.93 mg/l

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PROJECT DESCRIPTION – CRAWFORDVILLE, FL

Residential System Producing Total Nitrogen < 5 mg/l

Project: Dana Drive
Crawfordville, FL

Design Flow: 300 gpd

Wastewater

Engineer: Pio Lombardo, P.E.
Lombardo Associates, Inc.
Boston, MA
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The Nitrex™ system was first selected system by the Florida Department of Health (FL DoH) for evaluation as part of the multi-year FL DoH study of passive nitrogen removal systems in which only up to one pump is allowed in the treatment system.

Lombardo Associates, Inc. (LAI) implemented a residential Nitrex™ wastewater nitrogen removal system to serve this 2 bedroom, 300 gpd residence in Crawfordville FL, near Tallahassee. The system was installed in the summer of 2011, and is currently achieving an effluent TN < 5 mg/l with no O&M. The water quality data is presented below:



Crawfordville, FL 32327								
Date	Septic Tank Effluent	Effluent						
	TKN	BOD	TKN	NH ₄ -N	NO ₃ /NO ₂ - N	TN (calc)	%NO ₃ -N Removal	% TN Removal
10/26/11	48		4.0		0.1	4.1	97.0%	91.5%
01/30/12	77		4.75		0.15	4.9	99.7%	93.6%
03/27/12	71		7.0	6.2	0.1	7.1	99.8%	90.0%
5/24/2012 ⁽¹⁾	95	20	20.0	15.0	0.03	20.0	99.9%	78.9%
08/06/12	73	ND	3.0	1.5	0.1	3.1	99.7%	95.8%
09/26/12	81	17	2.7	0.9	0.3	3.0	98.8%	96.3%
11/28/12	94	13	3.9	2.20	0.06	4.0	99.8%	95.8%
01/24/13	100		2.6	1.49	0.024	2.6	99.9%	97.4%
Average	79.9	16.7	6.0	4.5	0.1	6.1	99.3%	92.4%
Average ⁽²⁾	76.7	14.3	4.2	2.5	0.1	4.3	99.8%	94.1%
Geomean	75.4	16.4	5.05	3.08	0.10	4.8	99.2%	91.5%
Geomean ⁽²⁾	75.3	0.0	4.0	2.1	0.1	4.1	99.8%	94.1%

⁽¹⁾ 5-24-12 influent strength unusually high and pretreatment system did not remove 25 mg/l of TKN which caused high Nitrex effluent TN

⁽²⁾ Without 5-24-12 data

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Passive Groundwater Treatment for Nitrogen, Phosphorus & Perchlorate Removal

Nitrate Nitrogen < 0.1 -0.6 mg/l

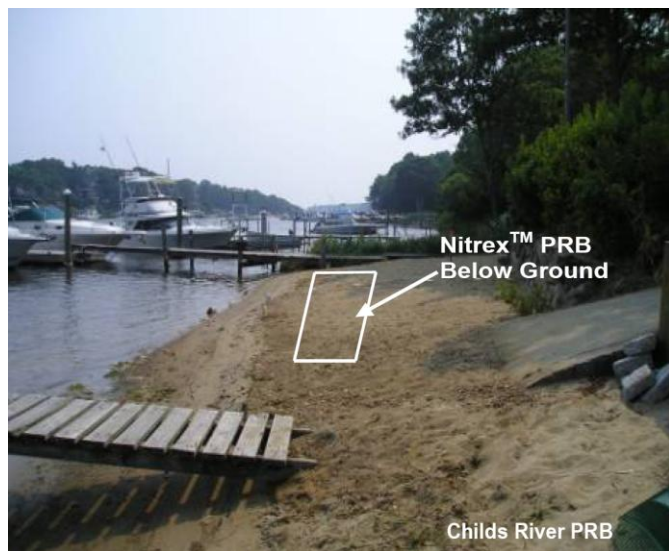
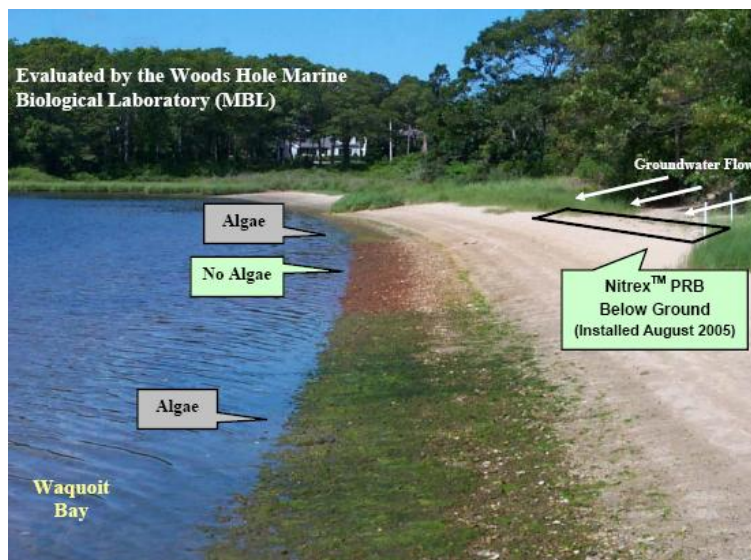
Total Phosphorus < 0.1 mg/l

Total Perchlorate < 0.2 ug/l

Project: Permeable Reactive Barrier (PRB)
Passive Groundwater Treatment
Nitrogen Removal

Wastewater Engineer: Pio Lombardo, P.E.
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Site 1 – Nitrogen Removal – Cape Cod, MA

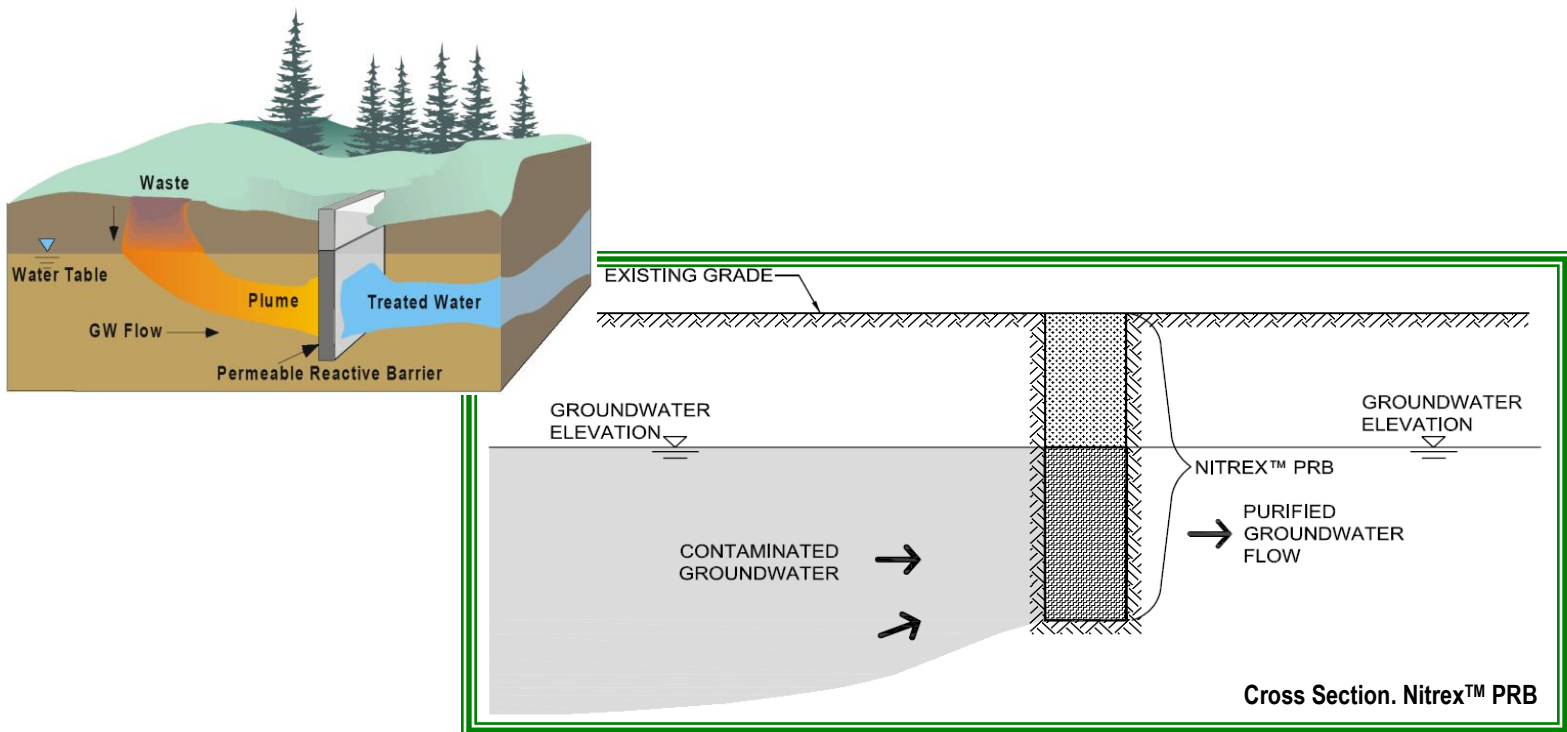


As part of a Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET) funded demonstrated project, the Woods Hole Marine Biological Lab (MBL) retained Lombardo Associates, Inc. (LAI) for installation of the patented Nitrex™ groundwater nitrogen removal technology at two locations on Cape Cod, MA in the Waquoit Bay watershed. The above photograph illustrates the dramatic water quality improvement with the installation.

Performance

Site	Influent Nitrate – N (mg/l)	Effluent Nitrate – N (mg/l)
Waquoit Bay, MA	1.74	0.007
Childs River, MA	7.19	0.568





Site 2 – Nitrogen Removal – Southern New England

Two Nitrex™ PRBs were installed in a Rhode Island coastal watershed. Upstream and downstream concentrations of nitrate, ammonia, and dissolved organic nitrogen in the groundwater were monitored over two annual cycles. The dissolved inorganic nitrogen (DIN) levels are presented below.

Site	Influent DIN (mg/l)	Effluent DIN (mg/l)
Coastal Site #1	3.9	0.2
Coastal Site #2	3.7	0.1

DIN = Dissolved Inorganic Nitrogen = Ammonium + Nitrate + Nitrite

Site 3 – Perchlorate and Nitrogen Removal – Ontario, Canada

Ontario, Canada Site	Nitrate - N (mg/l)	Perchlorate (ug/l)
Influent	50	50
Effluent	<0.1	<0.2

Site 4 – Phosphorus Removal –Massachusetts Site

Massachusetts Site	Influent Phosphorus (mg/l)	Effluent Phosphorus (mg/l)
Site #1	1.7	0.1

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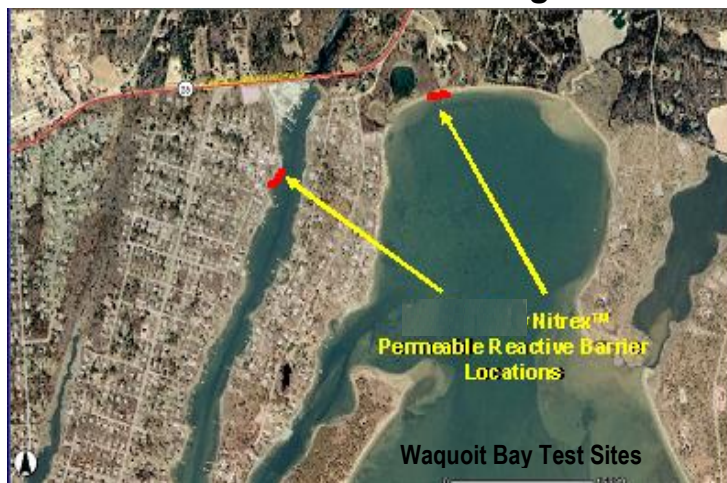


PROJECT DESCRIPTION – WAQUOIT BAY, MA – PASSIVE GROUNDWATER TREATMENT FOR NITROGEN REMOVAL

Treating Groundwater to Produce Nitrate – N Levels < 0.1 mg/l

Project: Waquoit Bay, MA
Permeable Reactive Barrier (PRB)
Passive Groundwater Treatment
Nitrogen Removal

Wastewater Engineer: Pio Lombardo, P.E.
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Malibu, CA & Boston, MA
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Waquoit Bay is located in the towns of Falmouth and Mashpee on the south side of Cape Cod. It is part of the Waquoit Bay National Estuarine Research Reserve (WBNERR), which has about 3,000 acres of bays, ponds and uplands. As part of a Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET) funded demonstrated project, the Woods Hole Marine Biological Lab (MBL) retained Lombardo Associates, Inc. (LAI) for installation of the patented Nitrex™ groundwater nitrogen removal technology at two locations in the Waquoit Bay watershed.

The two installations constructed in summer 2005 are:

- Childs River
- Waquoit Bay Reserve Property –
149 Waquoit Highway, East Falmouth, MA

Performance.

Site	Influent Nitrate – N (mg/l)	Effluent Nitrate – N (mg/l)
Waquoit Bay	1.74	0.007
Childs River	7.19	0.568





Algae

No Algae

Waquoit
Bay

Algae

Groundwater Flow

Nitrex™ PRB Below Ground
(Installed August 2005)

Nitrex™ Permeable Reactive Barrier (PRB)
For Nitrogen Removal

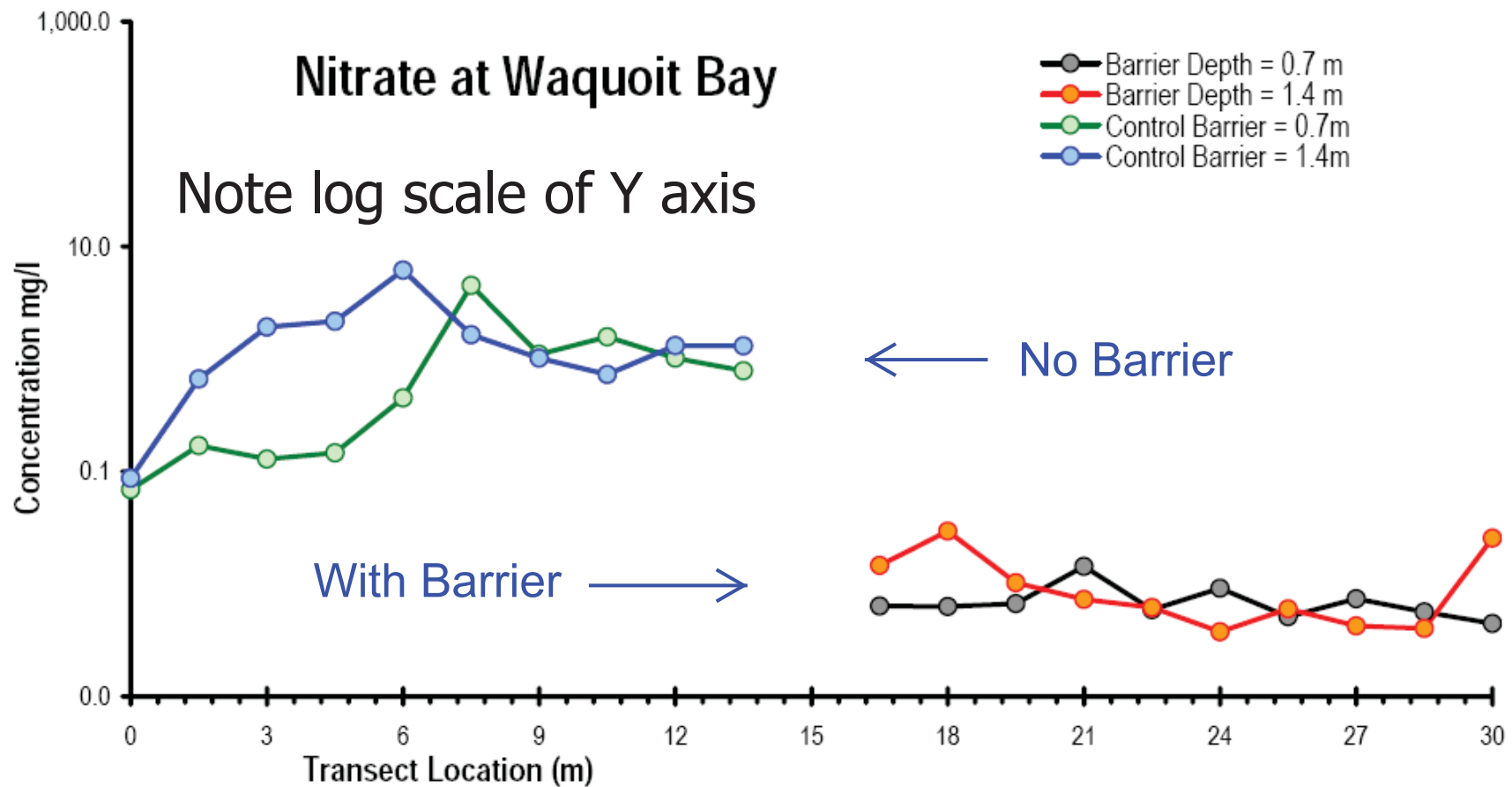
Waquoit Bay National Estuarine Research
Reserve (WBNERR), Falmouth, MA

Evaluated by the Woods Hole Marine
Biological Laboratory (MBL)

Environmental Engineers/Consultants
LOMBARDO ASSOCIATES, INC.

Photo Taken July 2009 by
Chris Weidman (WBNERR)

Groundwater Quality at Waquoit Bay - Data Collected by Woods Hole MBL



Environmental Engineers/Consultants

LOMBARDO ASSOCIATES, INC.



PROJECT DESCRIPTION – MAYO PENINSULA, MD

Integrated Decentralized Wastewater Management System

Project: Mayo Peninsula Wastewater Management System - 900,000 gpd
8,000 people

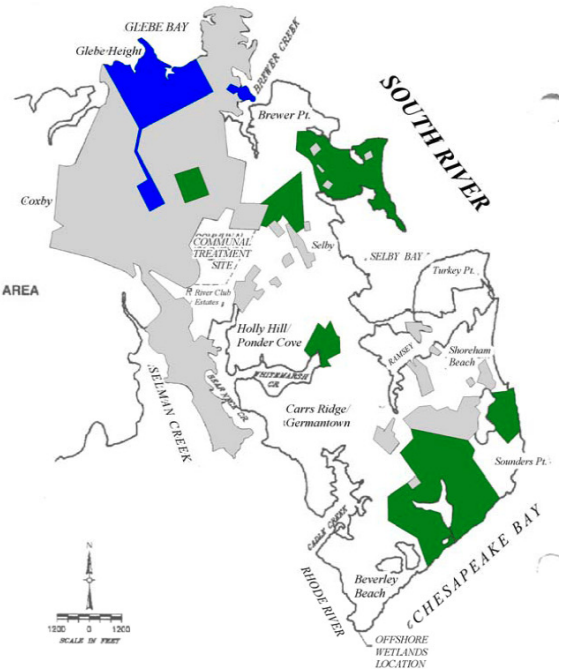
Client: Anne Arundel County
Department of Public Works
2662 Riva Road
Annapolis, MD 21401

Wastewater

Engineer: Pio Lombardo, P.E.
Lombardo Associates, Inc.
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SERVICE AREA MAP

-  COMMUNAL SERVICE AREA
-  CLUSTER SERVICE AREA
-  ON-SITE SEPTIC SYSTEM SERVICE AREA
-  PARKS/OPEN SPACE



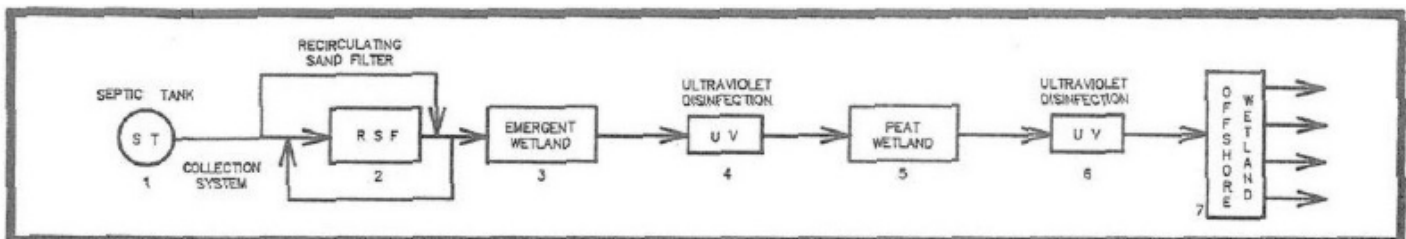
Lombardo Associates, Inc. (LAI) was the Engineer of Record for the **Mayo Peninsula Wastewater Collection System** which serves **3,000 connections** within a 9 square mile area adjacent to Annapolis, MD, with a population of approximately 8,000, where integration of growth management and use of wetlands for wastewater treatment were key attributes. Construction completion occurred in 1992 for the \$60 million project.

LAI designed & implemented an innovative decentralized wastewater management project using:

1. **On-site systems**
2. **Cluster wastewater system**
3. **Large communal system using:**

- 40 miles of septic tank effluent collection system (50% gravity & 50% pressure)
- 900,000 gallons per day (gpd) Treatment Process of:
 - recirculating sand filters,
 - constructed bulrush wetlands for nitrogen removal,
 - constructed peat wetland for phosphorus removal
 - UV disinfection
- Ultimate disposal through an off-shore, submerged aquatic vegetation wetland

Figure A: Process Flow Diagram



Integrated Phase Implementation:

The Mayo Peninsula Wastewater Collection System was completed in stages, with the Collection System and 20% of the construction occurring in year 1. Thereafter, an additional 20% of construction occurred each year until completion. Modular development allowed gradual investment and improved operational efficiency.

Table 1: Historical Performance

Average Data from 01/93 to 08/05				
	<u>Septic Tank Influent</u>	<u>Treatment Plant Effluent</u>	<u>Reduction % of Influent</u>	
BOD (mg/l)	85.8	4.4	94.8%	
TSS (mg/l)	55.7	2.1	96.3%	
TN (mg/l)	33.7	7.4	78.0%	

- Table 1 (*right*) presents the treatment performance.
- Figures 1-5 (*below*) illustrate the process demonstrated in the process flow diagram of Figure A.

Figure 1A: Typical House Septic Tank – Effluent Collection



Figure 1B: Typical Small Pump Station

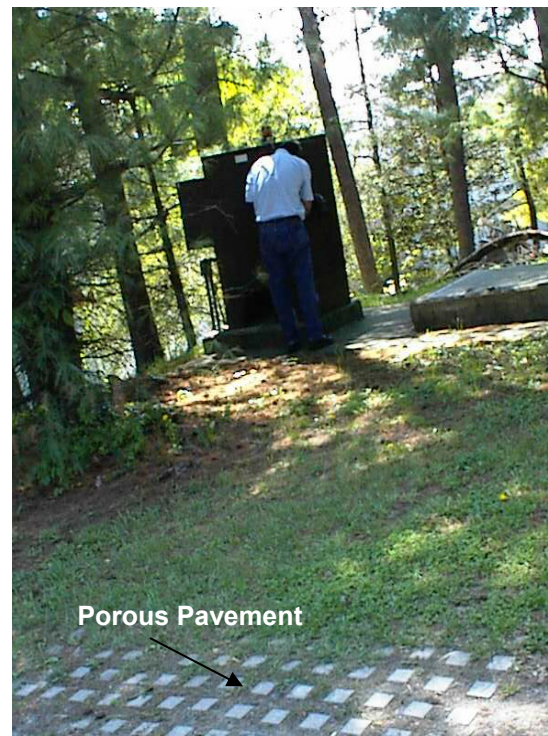


Figure 1C: Typical Large Pump Station



Figure 2: Aerial View of Communal Wastewater Treatment System

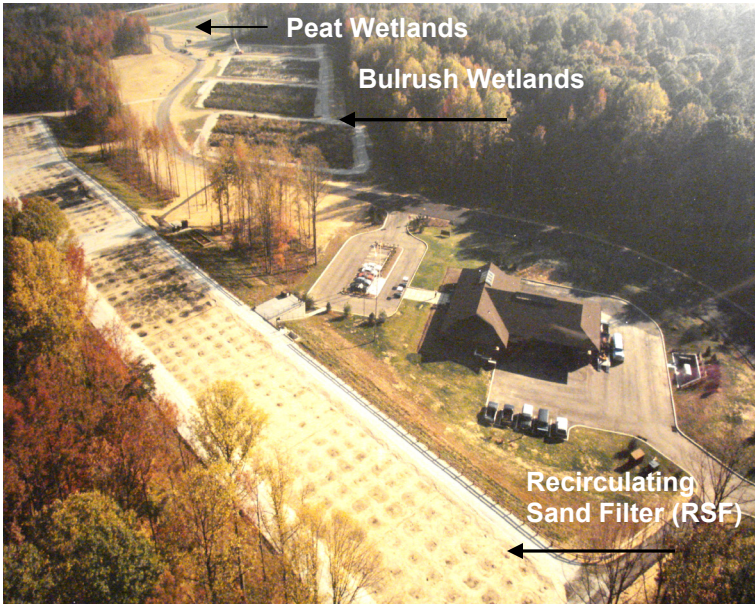


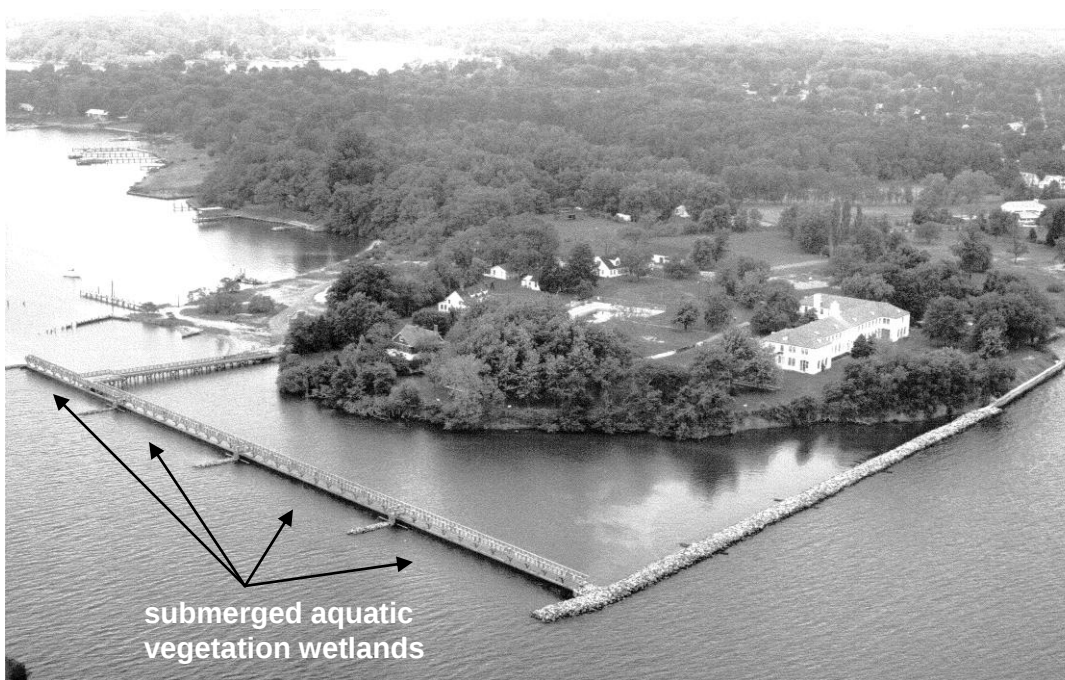
Figure 3: Bulrush Wetland



Figure 4: Peat Wetland During Operation



Figure 5: Aerial View of Constructed Offshore



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WATER REUSE – NO DISCHARGE SYSTEM MALIBU – LA PAZ DEVELOPMENT MALIBU, CALIFORNIA

No-Discharge Nitrex™ Wastewater Treatment System – 1st of its kind in California – unanimously approved

Project: La Paz Development
Malibu, CA

Code Design Flow: 37,120 gpd

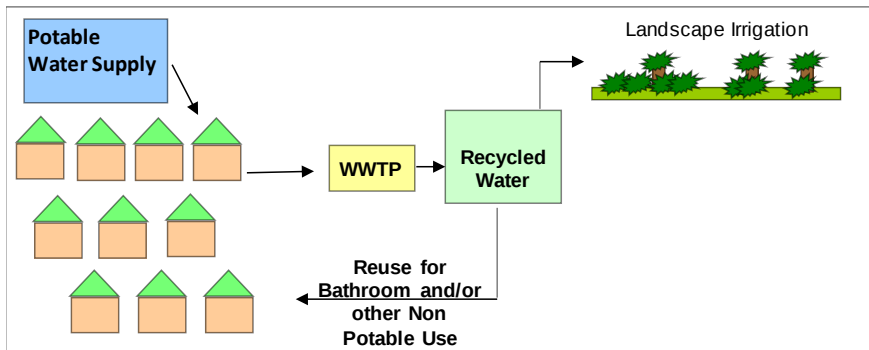
Wastewater Engineer: Lombardo Associates, Inc.
Malibu, CA & Boston, MA
www.LombardoAssociates.com

Client Reference: Mr. Don Schmitz, AICP
Schmitz & Associates, Inc.
DonS@schmitzandassociates.net



The La Paz Development, located in an environmentally sensitive area adjacent to the famous Malibu Surfrider Beach, consists of eleven (11) commercial buildings with two 175 seats restaurants and a municipal facility.

La Paz Development, Malibu, CA - No Discharge Wastewater Reuse System



The wastewater management plan includes a CA Department of Public Health approved Title 22 Disinfected Tertiary Recycled Water Treatment system that will beneficially reuse all recycled water for in-building non-potable water use purposes and landscape irrigation and will have No Discharge to the ground or surface waters. An effluent storage tank is provided for seasonal periods when recycled water generation is greater than reuse requirements.

No Discharge is achieved by:

1. In-Building Bathroom Non-Potable Water Reuse Purposes
2. Landscape Irrigation

The integrated wastewater-recycled water-irrigation system will achieve a 57% reduction of water use.

The LaPaz Wastewater Management Engineering Plan was unanimously approved by the Los Angeles Regional Water Quality Control Board (LARWQCB), which has issued a WRR/WDR permit for the project - the first such system approved in California. The California Department of Public Health (DPH) has determined that the LaPaz wastewater reuse project is compliant with CA Title 22 Disinfected Tertiary Treatment Standards. The City of Malibu has approved the LaPaz Wastewater Management – Water Reuse System.

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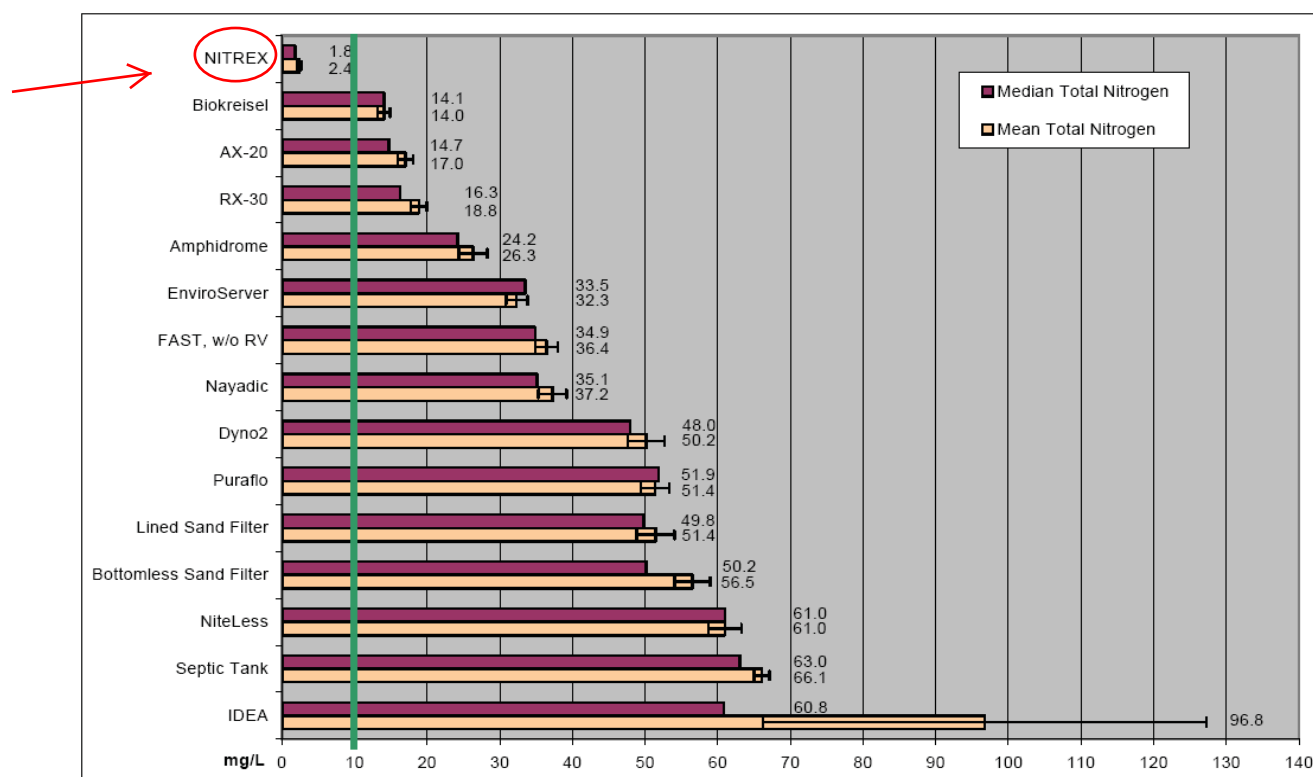
Fax: 617-332-5477

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Guidance for Federal Land Management in the Chesapeake Bay Watershed

Chapter 6. Decentralized Wastewater Treatment Systems

Nonpoint Source Pollution
Office of Wetlands, Oceans, and Watersheds
U.S. Environmental Protection Agency



Source: Rich 2005.

Figure 6-2. Effluent TN concentrations for systems tested in the La Pine Project.

Table 6-1. System components and type classifications for Figure 6-2

System component/type	General classification
Septic Tank	Primary treatment vessel
Lined Sand Filter	Attached growth, sand media
Bottomless Sand Filter	Attached growth, sand media
AdvanTex AX-20	Attached growth, textile media
AdvanTex RX-30	Attached growth, textile media
Puraflo	Attached growth, peat media
Dyno2	Attached growth, gravel media, wetland polishing
Amphidrome	Attached growth/suspended growth hybrid
Biokreisel	Attached growth/suspended growth hybrid
EnviroServer	Attached growth/suspended growth hybrid
FAST Bio-Microbics	Attached growth/suspended growth hybrid
IDEA	Suspended growth
Nayadic	Suspended growth
NiteLess	Suspended growth with add-on anoxic filter
NITREX	Add-on anoxic filter

Table 6-2. Examples of biological N removal performance from the literature

Technology examples	TN removal efficiency (%)	Effluent TN (mg/L)
Suspended growth		
Aerobic units w/ pulse aeration	25%–61% ^a	37–60 ^a
Sequencing batch reactor	60% ^b	15.5 ^b
Attached growth		
Single-Pass Sand Filters (SPSF)	8%–50% ^c	30–60 ^c
Recirculating Sand/Gravel Filters (RSF)	15%–84% ^d	10–47 ^d
Multi-Pass Textile Filters (AdvanTex AX20)	64%–70% ^e	3–55 ^e
RSF w/ Anoxic Filter	40%–90% ^f	7–23 ^f
RSF w/ Anoxic Filter & external carbon source	74%–80% ^g	10–13 ^g
RUCK system	29%–54% ^h	18–53 ^h
NITREX	96%ⁱ	2.2^j

Source: Adapted from Washington Department of Health 2005

Notes: Overall performance can vary, depending on system configuration and other factors. For detailed descriptions of treatment processes and technologies, see

http://www.psparchives.com/publications/our_work/hood_canal/hood_canal/n_reducing_technologies.pdf.

a. California Regional Water Quality Control Board 1997; Whitmeyer et al. 1991

b. Ayres Associates 1998

c. Converse 1999; Gold et al. 1992; Loomis et al. 2001; Nolte & Associates 1992; Ronayne et al. 1982

d. California Regional Water Quality Control Board 1997; Gold et al. 1992; Loomis et al 2001; Nolte & Associates 1992; Oakley et al. 1999; Piluk and Peters 1994; Ronayne et al. 1982

e. NSF International 2009

f. Ayres Associates 1998; Sandy et al. 1988

g. Gold et al. 1989

h. Brooks 1996; Gold et al. 1989

j. Rich et al. 2003

4.6 Composting Toilet Systems

Composting toilet systems that contain and treat toilet wastes can reduce watershed N discharges significantly, because such wastes account for 70–80 percent of the TN load in domestic wastewater. Composting systems have been used successfully in both private and public facility settings. Like all systems, they require appropriate design and ongoing maintenance. A graywater treatment system is needed if the facility generates sink, laundry, or other graywater, therefore adding to the cost. Capital costs for composting systems (and excluding the cost of graywater systems) range from \$2,500 to \$10,000, with O&M expenses of \$50 to \$100 per year (USEPA 1999). The single-house viability of such systems depends on local codes and the owner's attitude, though acceptance and use of composting systems is