July 26, 2021 Project No. 12-1186-0047

Ms. Farrah Ward, P.Eng.
Claremont Developments Inc.
3190 Steeles Avenue East, Suite 300
Markham, Ontario
L3R 1G9

PRIVATE SERVICING FEASIBILITY
PROPOSED RESIDENTIAL SUBDIVISION
CLAREMONT, CITY OF PICKERING, ONTARIO

Dear Ms. Ward,

Golder Associates Ltd. (Golder) was retained by Claremont Developments Inc. (CDI) to carry out geotechnical, environmental and hydrogeological investigations for a proposed 70-lot residential subdivision at 5113 Old Brock Road in the Hamlet of Claremont, City of Pickering, Ontario.

This report serves to provide an assessment of the feasibility of private servicing, including an update of a groundwater quality impact assessment related to the proposed use of private sewage systems, in respect of the proposed zoning and subdivision of 5113 Old Brock Road, as fully described in the Planning Report by Malone Given Parsons dated July 2021.

This report draws on our attached previous letter and analysis dated August 24, 2012 for background information and where this information is applied it will be referenced.

Site and Project Description

The 38.18 ha site is located to the northeast of the existing development in Claremont, as shown on Figure 1, attached. The site is bounded to the east by Brock Road (Claremont Bypass), existing residential properties to the south, Old Brock Road to the west, and residential properties and a woodlot to the north. The southern-most portion of the site is bounded by Central Street (Durham Regional Road 5). A railroad corridor is located off-site to the north. The site primarily consists of an irregularly-shaped, agricultural parcel of land with one privately-serviced residential dwelling.

The existing lot and the proposed 70-lot development are to be privately serviced with individual water wells and sewage systems. This letter, submitted as part of the application for Draft Plan of Subdivision, provides a preliminary assessment of the feasibility of the site for private servicing.

Available Information

Golder carried out a subsurface investigation at the site as described in our concurrent preliminary water balance assessment and preliminary geotechnical investigation reports for the proposed development, referenced as follows:

- Golder Associates Ltd., July 2021. *Preliminary Hydrogeological Investigation, Proposed Residential Subdivision, 5113 Old Brock Road, Hamlet of Claremont, Pickering, Ontario*. Reference No. 12-1186-0047 (Golder 2021a); and
- Golder Associates Ltd., July 2021. *Preliminary Geotechnical Investigation, Proposed Residential Subdivision, 5113 Old Brock Road, Hamlet of Claremont, Pickering, Ontario* (Golder 2021b). Reference No. 12-1186-0047 (7000).

Previously, Golder also carried out a preliminary nitrate loading assessment and prepared conceptual sizing for private sewage systems for a portion of the site, attached and referenced as follows:

- *Preliminary Nitrate Loading Assessment, Conceptual Sewage System Sizing, In Support of Draft Plan Submission, Proposed Residential Development, Part of Lots 17 & 18, Concession 9 and Lots 47 & 48, Registered Plan No. 12, Claremont, City of Pickering, Region of Durham, Ontario*, dated August 24, 2012, Reference No. 12-1186-0047 (2000) (Golder 2012).

This letter is based in part on the subsurface data and hydrogeological assessment included in the above-referenced documents. The factual data, interpretations and recommendations contained in the above-referenced documents and this letter pertain to a specific project as described in the report and are not applicable to any other project or site location. If the project is modified in concept, location or elevation, or if the project is not initiated within eighteen months of the date of the report, Golder should be given an opportunity to confirm that the recommendations are still valid. In addition, this report should be read in conjunction with the attached *"Important Information and Limitations of This Report"*, included in Golder 2021a. The reader's attention is specifically drawn to this information, as it is essential for the proper use and interpretation of this report.

This assessment is based on *Draft Plan of Subdivision, 21T-, Part of Lots 17 & 18, Concession 9, Lots 47 & 48, Registered Plan No. 12 (Geographic Township of Pickering), City of Pickering, Regional Municipality of Durham*, prepared by Malone Givens Parsons Ltd., reference no. 12-2110, Revised March 1, 2018. A copy of the Draft Plan is attached.

Private Water Supply Potential

The site is located within the physiographic region known as the South Slope (*The Physiography of Southern Ontario*, Chapman and Putnam, 1984), which is an area of drumlinized till plains. The physiographic region known as the Oak Ridges Moraine is located approximately 125 m north of the site.

According to Sharpe and Barnett (1997) (*Surficial Geology of the Markham Area, NTS 30M14, southern Ontario*; Geological Survey of Canada, Open File 3300, Scale 1:50,000) surficial geology at the site is reported to consist of the Halton Till, a glacial deposit of clayey silt till to silt till ranging from 1 m to 15 m thick with interbedded fine sand, silt, and clay. Hummocky topography, typically associated with the Oak Ridges Moraine, is mapped just off-site to the north (i.e., from the off-site rail line and northward). Moraine deposits of fine sand to gravel outcrop approximately 1 km north of the site. The till unit is mapped as overlain by glaciolacustrine sand to silty sand in the southern-most end of the site (i.e., in the vicinity of Brock Road and Central Street). Recent relatively coarse-textured fluvial deposits of sand and gravel are reported within the floodplain of the unnamed tributary to Mitchell Creek that is located off-site to the west.

As described in Golder 2021a and 2021b, site-specific subsurface conditions were investigated through the drilling of 19 boreholes to depths ranging from 5.9 m to 9.6 m below grade. The soil conditions encountered are generally comprised of thin surficial deposits of clayey silt, sandy silt and silt underlain by a major strata of glacial till. Where encountered, the base of the surficial deposits ranged in depth from 0.2 mbgs to 1.8 mbgs, with an average of 0.9 mbgs (n = 17). The till ranged in gradation from clayey silt till to sand and silt till. Minor deposits of clayey silt, sandy silt, silty sand and sand were also locally encountered within the till unit, and typically in the southwest portion of the Site.

A review of Ontario Ministry of the Environment, Conservation and Parks (MECP) Water Well Records was carried out for 381 well records in the Claremont area. The location of the water well records is shown on Figure 1. It is noted that historically there was no requirement to register shallow dug/bored wells and that these can be under-represented in the Water Well Record database. Shallow, dug or bored wells are typically in the order of 6 m to 10 m deep, and water quality interference in shallow, unconfined aquifers from surficial sources of contamination (e.g., septic systems) is common. These can include increased concentrations of nitrate and bacteria.

The following table summarizes data from the Water Well Records that were reviewed:

Table 1: Summary of MECP Water Well Records, Claremont Area

Category	No.	(%)	Well Depth		
			Min	Max	Avg.
Shallow dug or bored wells	59	15%	5.2	15.2	9.1
Drilled overburden wells	256	67%	10.7	97.5	61.9
Drilled bedrock wells	4	1%	93.3	97.8	95.1
Observation wells	7	2%	-	-	-
Abandoned wells	40	10%	-	-	-
Records with poor or no information	15	4%	-	-	-
TOTAL	**381**	**100%**	-		

From Table 1 above, the Water Well Records indicate that drilled overburden well use predominates in the Claremont area. Golder prepared two hydrostratigraphic sections based on the reported geological conditions, attached as Figures 2 and 3. Figure 2 is a section oriented in a north-south direction along Old Brock Road (i.e., the western flank of the site). Figure 3 is a section oriented in an east-west direction through the southern end of the site.

Based on the recorded information, private water wells generally utilize three zones in the Claremont area, and the following is inferred:

i) shallow water wells – shallow dug and bored wells are inferred to utilize various shallow, thin coarse-textured units or the glacial till unit for water supply. The coarse-textured units are not recorded at all well locations, and therefore are inferred to be laterally discontinuous;

ii) intermediate aquifer(s) – drilled wells utilize a number of confined coarse-textured aquifer units within the thick glacial till unit that underlies the Claremont area. A number of records indicate the presence of a sandy unit or units from approximate elevations of 230 metres above sea level (masl) to 250 masl, which are labelled on Figures 2 and 3 as the "intermediate aquifer(s)". The intermediate aquifer(s) is/are not recorded at all locations, and is/are or may be discontinuous, depending on location; and,

iii) "target" aquifer – a deeper confined aquifer within the till unit is commonly screened for water supply at an elevation of approximately 178 m masl to 187 masl. This unit appears to be commonly screened for water supply in the Claremont area, and is the target aquifer for private water well use for the proposed residential subdivision. For the purposes of this letter, it is labelled as the "target aquifer" on Figures 2 and 3.

A fourth, deeper zone is also present, comprised of the bedrock and an immediately overlying coarse-textured unit that is seldom utilized in the Claremont area. The elevation of the bedrock is recorded at approximately 165 masl to 170 masl.

As discussed, the target aquifer is at an elevation of approximately 178 m masl to 187 masl. Approximately 117 water wells (i.e., 46% of the drilled overburden wells) have well depths within this elevation range, with well depths ranging from 63.4 m to 89.9 m, and with an average well depth of 80.2 m. The locations of these 117 well records are spread across the community of Claremont, including residences on Old Brock Road along the west flank of the site. The sections suggest a widespread lateral extent for this confined aquifer in the Claremont area.

Based on our discussions with water well drillers in the area, Golder understands that there was a historical government program in Claremont to convert shallow (dug and bored) wells and wells using the confined "intermediate aquifer(s)" to deeper confined aquifers. The Water Well Records indicate 56% of the drilled overburden wells were installed between 1986 and 1989, and 58% of the abandonment records are from the same period, and have therefore been attributed to the well replacement program. Shallow water well use and use of the intermediate aquifer(s) is not recommended for the proposed development, which is consistent with the Claremont well replacement program. An assessment of the proposed private sewage systems for the development as it relates to groundwater quality is provided below.

The presence of fresh water was reported at all 117 water well records with screened intervals within the target aquifer. Of the 117 records, a further review of 61 relatively complete records with pumping test information was carried out. Pumping tests were carried out by an air method for 43 of 61 records, and the results suggested that the tested water wells had adequate to more than adequate water supply potential for individual residential use. Of the remaining 18 records with a pumping test carried out by bailer or pump, the drawdown in the well at the end of pumping ranged from 1% to 71% of the available drawdown in the well, with an average of 21%, at pumping rates ranging from 36 L/min to 136 L/min, and averaging 54 L/min. These rates exceed the minimum test rate of 18.75 L/min required by Ministry of Environment and Energy (MOEE) (now the MECP) *Procedure D-5-5* (*Technical Guideline for Private Wells: Water Supply Assessment*) (August 1996). The driller's recommended pumping rates for all 61 wells ranged from 23 L/min to 182 L/min, and averaged 62 L/min. Overall, the data indicate adequate, and frequently more than adequate, water supply potential for individual residential use.

Average day water use can be reasonably estimated at 1,000 L/day/residence. Given the 70-lot plan, the average day water use for the proposed subdivision is estimated to 70,000 L/day, or 49 L/min. Seven of the 61 water well records discussed above were completed in 2003, or later, and include pumping test and water level recovery data. Pumping tests at these seven wells were carried out at rates of 40 L/min to 45 L/min (which is similar to the average day rate of 49 L/min for the proposed subdivision) for 2 hours to 3 hours. Water levels were drawn down 0.9 m to 7.1 m, or 1% to 13% of available drawdown in the well, and the water levels essentially recovered in less than one hour following the end of pumping. The driller's recommended pumping rates for these seven wells ranged from 40 L/min to 45 L/min. These data also suggest more than adequate water supply potential for individual residential use.

Golder has been retained to carry out an additional site-specific investigation to confirm that the site can provide adequate groundwater quantity and quality for private well use. Given the 38.18 ha size of the site, five test wells are planned. The methods and findings of this assessment will be reported under separate cover.

Conceptual Sewage System Sizing and Lot Layout

Golder 2012, attached, provides conceptual sewage system sizing based on native soil and groundwater conditions in the southwest portion of the site, in accordance with the 2006 Ontario Building Code (OBC) which was in effect at that time. The concept design provided for both (1) a conventional raised leaching bed, and (2) a tertiary treatment unit in accordance with the Building Materials Evaluation Commission (BMEC) requirements and associated area bed. Under the current 2012 OBC, the BMEC tertiary treatment system and area bed are now referred to as a Level IV treatment system and Type A Dispersal Bed. The following summary is provided. Given the soil conditions, conceptual sewage system sizing was recommended to be based on a percolation (T) time of 50 cm/min, and sewage systems (fully) raised 1.5 m over native soils were recommended. If tertiary treatment (i.e., Level IV treatment) units are used to reduce the loading area for each system, and if area beds (i.e., Type A dispersal beds) are used, the required loading area for each system is 375 m^2. Providing a 100% replacement area, although not required by the OBC, would double the area to 750 m^2. Minimum clearance distances for the sewage systems were provided in the letter.

Based on the results of the subsurface investigation for the 38.18 ha site, as reported in Golder 2021a and 2021b, it is appropriate to continue to assume the use of fully raised sewage systems with an area of 750 m^2 for each lot. Based on the proposed Draft Plan of Subdivision, adequate space is available for 750 m^2 sewage systems on each lot with appropriate setbacks. Further, adequate space is available on existing Lot 71 for the replacement of the existing sewage system with the same type of sewage system that is proposed for the remainder of the subdivision. As discussed above, the use of deep drilled wells on each lot are proposed for the subdivision. Evenly spaced drilled wells with the appropriate setback from the sewage systems can be achieved on all lots in the Draft Plan of Subdivision.

It is noted that CDI plans to convey Blocks 83, 84 and 85 (see attached Draft Plan) to three adjacent residents to accommodate existing private sewage systems for residential dwellings that are located within or near the site boundaries. Each of Blocks 83, 84 and 85 includes a 750 m^2 area plus setbacks, totalling 0.11 ha or 0.12 ha.

In summary, the 70-lot plan is feasible from a sewage system layout perspective.

Potential Groundwater Quality Impact Assessment

To confirm that the 70-lot subdivision plan (plus 1 existing lot) is viable from a groundwater quality perspective, a potential impact assessment was carried out as follows using nitrate as an indicator of groundwater impact potential.

A subsurface investigation, including monitoring well installation, was carried out at the site as detailed in Golder 2021a. Groundwater samples were collected from ten monitoring wells distributed across the site to assess background nitrate concentrations. The samples collected in 2012 were submitted to AGAT Laboratories of

Mississauga, and the samples collected in 2017 and 2018 were submitted to Maxxam Analytics of Mississauga. Laboratory certificates of analysis are attached to this letter. The following table summarizes the nitrate concentrations as sampled in shallow groundwater.

Table 2: Summary of Shallow Nitrate Concentrations in Groundwater

Location	Nitrate in Groundwater (mg/L)			
	5-Mar-12	5-Apr-12	14-Nov-17	23-Jan-18
BH12-2	0.17	-	0.83	-
BH12-4	5.76	8.40	-	18.4
BH12-6	< 0.05	-	<0.10	-
BH17-7	-	-	7.79	6.42
BH17-8	-	-	10.6	9.45
BH17-9	-	-	7.71	7.24
BH17-11	-	-	9.40	9.87
BH17-16	-	-	0.11	-
BH17-18	-	-	<0.10	-
BH17-19	-	-	<0.10	-

Notes: – = no sample collected. < = concentration less than accompany method detection limit.

The concentration of nitrate in shallow groundwater exceeded the chemical standard of 10 mg/L in Ontario Regulation 169/03, *Ontario Drinking Water Quality Standards* (ODWS) at two of ten locations: BH17-8 (November 14, 2017); and, BH12-4 (January 23, 2018). Using the maximum concentration recorded at each location to date, the average nitrate concentration in shallow groundwater at the site is 5.5 mg/L, which meets the ODWS. The source of the nitrate is considered to be the active agricultural use of the site. The agricultural sources of nitrate are expected to decline with time when the agricultural use of the site is discontinued.

Golder 2021a presents the results of a preliminary water balance assessment for the proposed development, to which the reader is referred. As presented in Golder 2021a, the post-development infiltration rate for the 38.18 ha site, including the use of soakaway pits on 36 lots as a Low Impact Development (LID) technique, is estimated to be 36,630 m^3/year (or approximately 95.9 mm/year).

The use of individual private sewage systems is proposed, comprised of tertiary treatment (i.e., Level IV treatment) systems approved under the OBC that also include nitrate removal and the use of area beds (i.e., Type A dispersal beds) that are smaller than conventional sizing. As presented in Golder 2012, it is considered reasonable to assume these systems provide an average 50% reduction in effluent nitrate concentrations. Accordingly, the concentration of nitrate in sewage effluent has been estimated at 50% of the assumption of 40 mg/L (i.e., 20 mg/L) used in a typical nitrate loading calculation.

To confirm that the 70-lot subdivision plan (plus 1 existing lot) is viable from a groundwater quality perspective, an estimate of the dilution of septic effluent by post-development infiltration was carried out using nitrate as an indicator of groundwater impact potential. The estimate assumes even mixing over the site area, such that the resulting nitrate concentration in groundwater at the property boundary is below the *Ontario Drinking Water Quality Standard* of 10.0 mg/L (Ontario Regulation 169/03). The estimate assumes that the existing sewage system on existing Lot 71 will be replaced with the same type of system utilized on the new lots.

The concentration of nitrate in groundwater at the property boundary was estimated using the following formula:

$$[NO_{3\,PL}] = ((Q_g \times [NO_{3\,bck}]) + (Q_{eff}\ x\ [NO_{3\,eff}]))\ \div (Q_g + Q_{eff})$$

where:
$[NO_{3\,PL}]$ = Resulting Nitrate Concentration at the Property Line (in mg/L);
$[NO_{3\,bck}]$ = Nitrate Concentration in Background (i.e., 0 mg/L in infiltrating precipitation);
$[NO_{3\,eff}]$ = Nitrate Concentration of Sewage Effluent (as per above, 20 mg/L, assuming 50% total nitrogen reduction through use of nitrate treatment systems);
Q_g = Volume of Infiltration (100.356 m^3/day); and
Q_{eff} = Volume of Effluent (1 m^3/day per lot).

The estimate assumes dilution by infiltrating precipitation, and no mixing with groundwater flow was considered. Based on the nitrate loading assessment method and the assumptions and sewage system design considerations provided above, a 70-lot plan plus one existing lot would result in an estimated nitrate concentration of 8.3 mg/L at the property boundary. Therefore the 70-lot plan plus 1 existing lot is technically achievable from the perspective of potential impacts to groundwater quality.

A groundwater monitoring program is recommended to be carried out, including pre-, during- and post-development components. At this time the monitoring program is recommended to include the installation of shallow monitoring wells at or near the southern and western property boundaries (i.e., sentry wells installed to monitor the water table). The sentry wells will be used to monitor groundwater quality and levels, to monitor for any changing conditions that may result from site development activities.

Additional Hydrogeological Investigation

As discussed above, CDI has retained Golder to carry out a potable water supply investigation that will be submitted under separate cover, in consideration of the following:

- MOEE (now the MECP), August 1996. *Procedure D-5-5* (*Technical Guideline for Private Wells: Water Supply Assessment*);
- Groundwater quality compared to Ontario Regulation 169/03, *Ontario Drinking Water Quality Standards*; *Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines* ("ODWSOG") (MOE, June 2003, Revised June 2006); and the water quality parameter tables in the above-referenced *Procedure D-5-5*.

The results of the water supply investigation will be used to confirm that the site can support individual private water well use from a quantity and quality perspective.

Closure

We trust this submission meets your current requirements. Please contact the undersigned with any questions.

Yours truly,

Golder Associates Ltd.

C. M. Kozuskanich, P.Geo.
Associate, Hydrogeologist

Doug Kerr, P.Eng.
Associate, Engineer

CMK/DK/lb/sv

Attachments: Figure 1: Recorded Water Wells
Figure 2: Section A – A'
Figure 3: Section B – B'

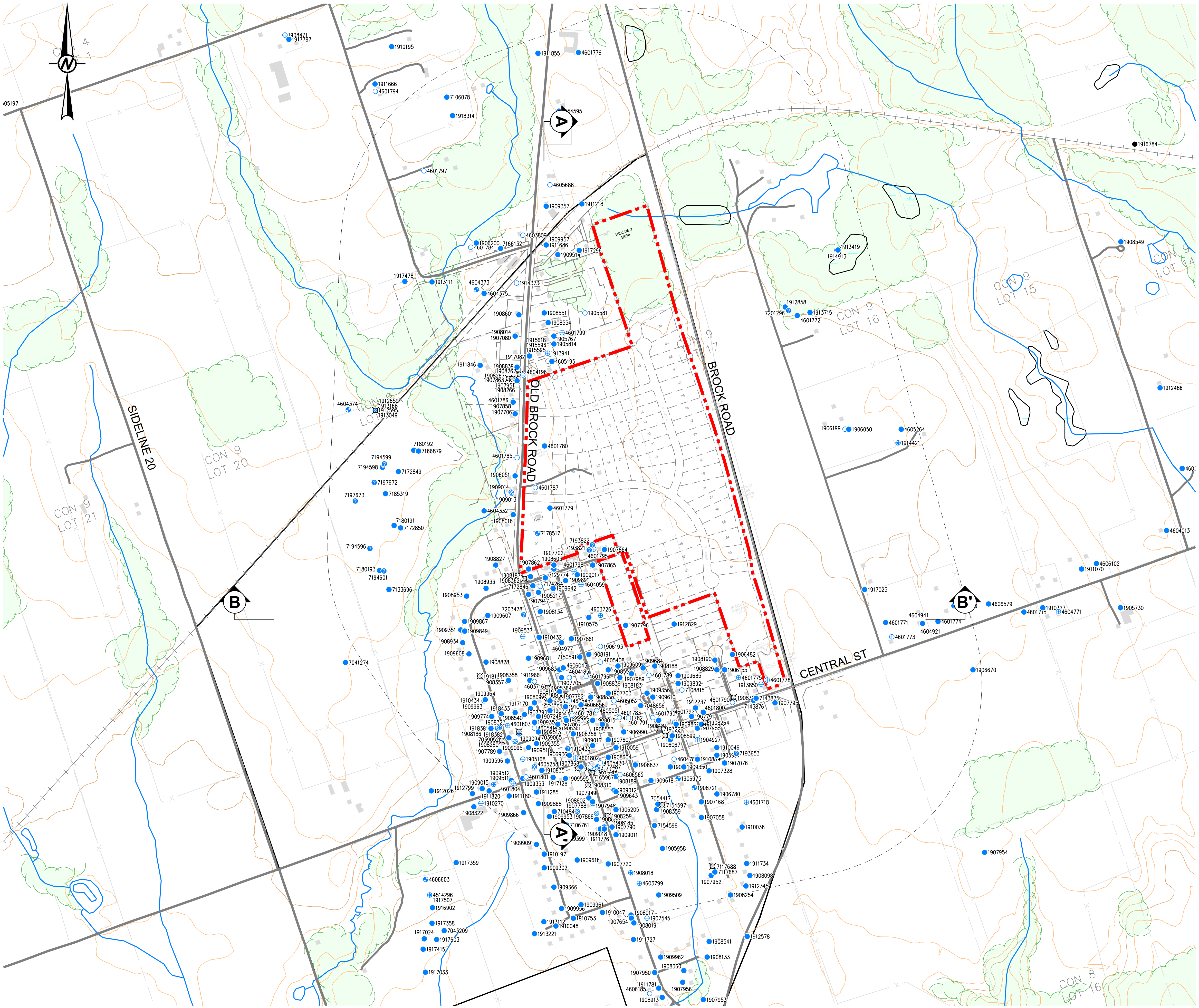
Malone Givens Parsons Ltd., January 31, 2018, revised March 1, 2018. *Draft Plan of Subdivision, 21T-, Part of Lots 17 & 18, Concession 9, Lots 47 & 48, Registered Plan No. 12 (Geographic Township of Pickering), City of Pickering, Regional Municipality of Durham*.

Golder Associates Ltd., August 24, 2012. *Preliminary Nitrate Loading Assessment, Conceptual Sewage System Sizing in Support of Draft Plan Submission, Proposed Residential Development, Part of Lots 17 & 18, Concession 9 and Lots 47 & 48, Registered Plan 12, Claremont, City of Pickering, Region of Durham, Ontario*. Reference No. 12-1186-0047 (2000).

AGAT Laboratories, Certificates of Analysis 12T580244, 12T589565
Maxxam Analytics, Certificates of Analysis B7P5848V1, B87344V1

FIGURE 1

Recorded Water Wells



LEGEND:

- Property Line

Recorded MOECC Water Well Record Number

- Shallow Dug or Bored <10 m
- Deep Bored Well >10 m
- Drilled Overburden Well
- Test or Observation Well
- Drilled Bedrock Well
- Sandpoint
- A Line of Section

NOTES:

1. DATUM IS UTM NAD 83 ZONE 17

REFERENCES:

1. MAPPING BASED ON ESRI GEOGRAPHYNETWORK OBM FEATURES
2. DRAFT PLAN OF SUBDIVISION, MALONE GIVENS PARSONS LTD., MAR. 03, 2018

0 200 400 600 m

1:10000

CLIENT
CLAREMONT DEVELOPMENTS INC.

PROJECT
PRIVATE SERVICING POTENTIAL
PROPOSED RESIDENTIAL DEVELOPMENT
5113 OLD BROCK ROAD, CLAREMONT

TITLE
RECORDED WATER WELLS

CONSULTANT

GOLDER
MEMBER OF WSP

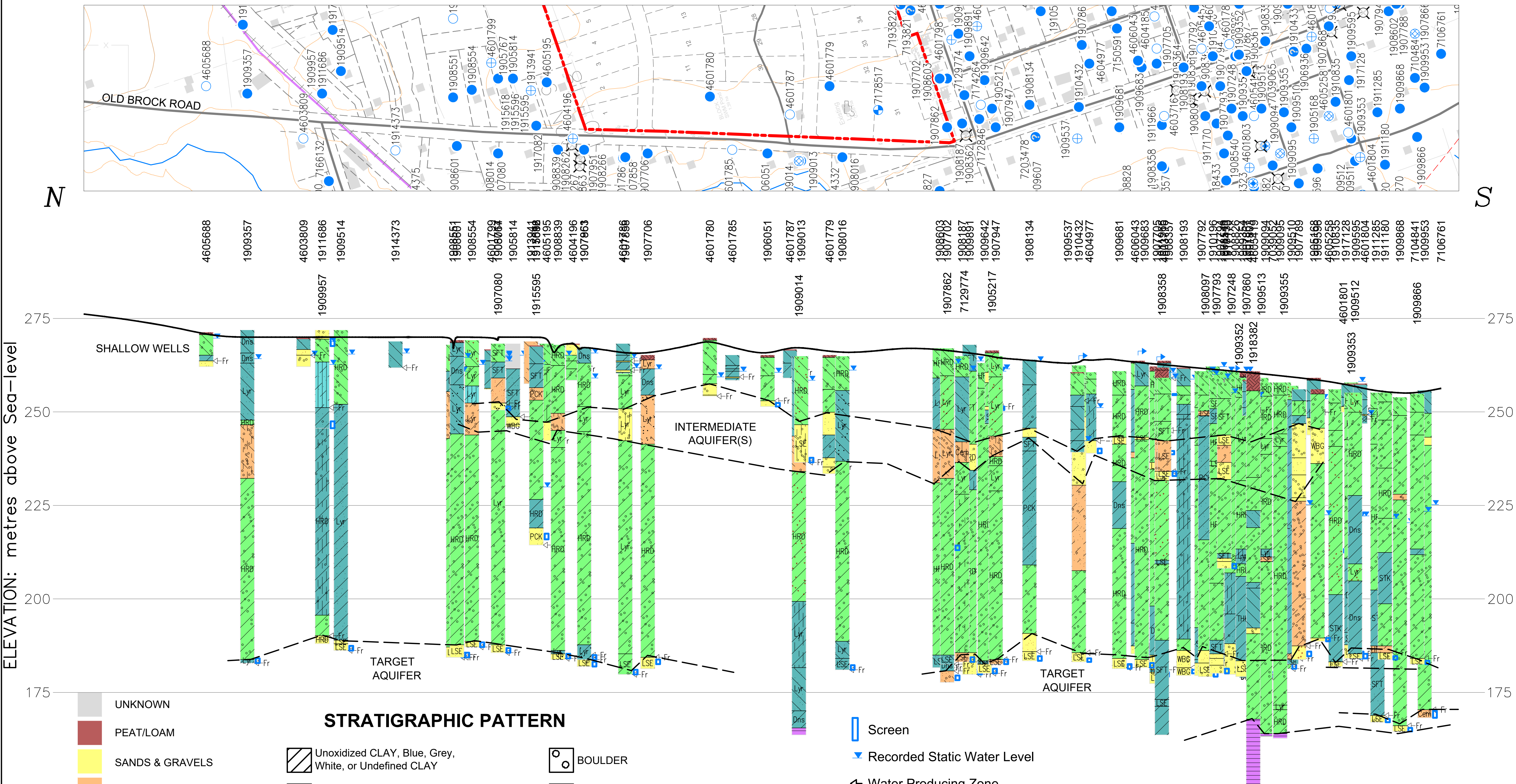
YYYY-MM-DD	2018-01-24
DESIGNED	
PREPARED	JPR
REVIEWED	KZK
APPROVED	CMK

PROJECT NO.	CONTROL	REV.	FIGURE
1211860047	0004	----	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25 mm

FIGURE 2

Section A – A’



- UNKNOWN
- PEAT/LOAM
- SANDS & GRAVELS
- GRANULAR TILL
- SILT
- SILT CLAYEY
- CLAY
- TILL
- LIMESTONES
- SHALES

STRATIGRAPHIC PATTERN

- Unoxidized CLAY, Blue, Grey, White, or Undefined CLAY
- Oxidized CLAY, Brown, Red, Yellow
- SILT
- SAND
- GRAVEL
- STONES, Rounded GRAVEL, PEBBLES
- BOULDER
- TILL
- SHALE
- DOLOSTONE
- LIMESTONE
- CRYSTALLINE ROCK

- Screen
- Recorded Static Water Level
- Water Producing Zone
- Flowing Well
- 23453 MOE Recorded Private Well

0 100 200 300 m
1:5000

CLIENT
CLAREMONT DEVELOPMENTS INC.

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2018-01-24
DESIGNED	
PREPARED	JPR
REVIEWED	KZK
APPROVED	CMK

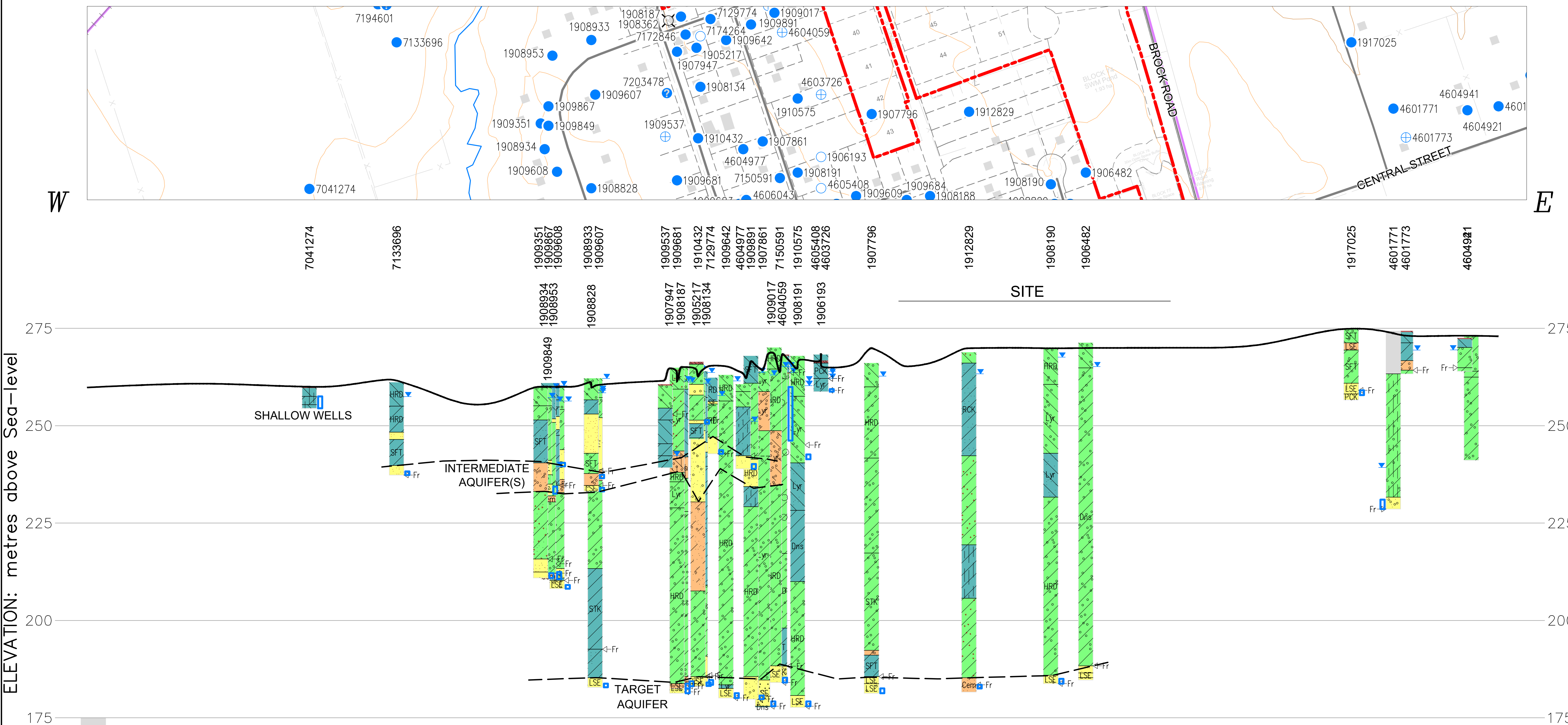
PROJECT
PRIVATE SERVICING POTENTIAL
PROPOSED RESIDENTIAL DEVELOPMENT
5113 OLD BROCK ROAD, CLAREMONT

TITLE
SECTION A - A'

PROJECT NO.	CONTROL	REV.	FIGURE
1211860047	0004	----	2

FIGURE 3

Section B – B’



UNKNOWN

PEAT/LOAM

SANDS & GRAVELS

GRANULAR TILL

SILT

SILT CLAYEY

CLAY

TILL

LIMESTONES

SHALES

STRATIGRAPHIC PATTERN

Unoxidized CLAY, Blue, Grey, White, or Undefined CLAY

Oxidized CLAY, Brown, Red, Yellow

SILT

SAND

GRAVEL

STONES, Rounded GRAVEL, PEBBLES

BOULDER

TILL

SHALE

DOLOSTONE

LIMESTONE

CRYSTALLINE ROCK

Screen

Recorded Static Water Level

Water Producing Zone

Flowing Well

23453 MOE Recorded Private Well

0 100 200 300 m

1:5000

CLIENT
CLAREMONT DEVELOPMENTS INC.

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2018-01-24
DESIGNED	
PREPARED	JPR
REVIEWED	KZK
APPROVED	CMK

PROJECT
PRIVATE SERVICING POTENTIAL
PROPOSED RESIDENTIAL DEVELOPMENT
5113 OLD BROCK ROAD, CLAREMONT

TITLE
SECTION B - B'

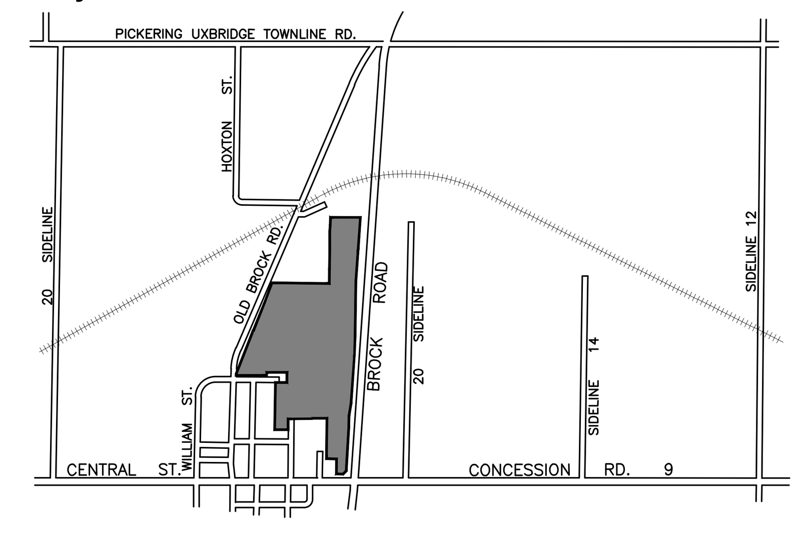
PROJECT NO.	CONTROL	REV.	FIGURE
1211860047	0004	----	3

Malone Givens Parsons Ltd., January 31, 2018, revised March 1, 2018. *Draft Plan of Subdivision, 21T-, Part of Lots 17 & 18, Concession 9, Lots 47 & 48, Registered Plan No. 12 (Geographic Township of Pickering), City of Pickering, Regional Municipality of Durham*.

Draft Plan of Subdivision
21T-

Part of Lots 17 & 18, Concession 9
Lots 47 & 48, Registered Plan No. 12
(Geographic Township of Pickering)
City of Pickering
Regional Municipality of Durham

Key Plan



Schedule of Land Use

Lot/Block	Land Use	Units	Area(ha)
1-70	Estate Residential Lots	70	22.98
71	Existing Residential	1	0.58
72	Park		1.70
73-74	SWM Pond		3.32
75-77	Open Space		4.24
78-79	30m Open Space Buffers		0.84
80	Noise Attenuation		0.89
81-82	Road Widening		0.09
83-85	to be conveyed to adjacent lot		0.33
	Roads Streets A-D (20m R.O.W.) 1,605m		3.21
Total		71	38.18

NOTES

All measurements are in metres.
All elevations refer to Geodetic Datum.
All corner roundings are 5.0mR, unless otherwise stated.

Owner's Authorization

I , ______________________, hereby authorize Malone Given Parsons Ltd. to prepare and submit this Draft Plan of Subdivision to the Town of Pickering.

______________________ ______________
Date:

Surveyor's Certificate

I hereby certify that the boundaries of the land to be subdivided and their relationship to the adjoining properties are correctly shown on this Draft Plan.

______________________ ______________
Date:

Additional Information

As required under section 51(17) of the Planning Act (R.S.O. 1990 C.P. 13)
a), e), f), j) As shown on Draft Plan.
b), g) As shown on Draft and Key Plans.
c) As shown on Key Plan.
d) Residential.
h), k) Municipal services to be provided.
i) Silt Loam soil.
l) As shown on Draft Plan.

Note: Contours relate to Canadian Geodetic Datum.

MALONE GIVEN PARSONS LTD.
140 Renfrew Drive, Suite 201
Markham, Ontario, L3R 6B3
Tel. (905) 513-0170
Fax. (905) 513-0177

Project No. 12-2110
Date: January 31, 2018
Revised: March 1, 2018

Scale:
0 50 100 150 200m

Golder Associates Ltd., August 24, 2012. *Preliminary Nitrate Loading Assessment, Conceptual Sewage System Sizing in Support of Draft Plan Submission, Proposed Residential Development, Part of Lots 17 & 18, Concession 9 and Lots 47 & 48, Registered Plan 12, City of Pickering, Region of Durham, Ontario*. Reference No. 12-1186-0047 (2000).

TECHNICAL MEMORANDUM

DATE August 24, 2012 **PROJECT No.** 12-1186-0047 (2000)

TO Mr. Nik Mracic
Geranium Corporation

CC Ms. Farrah Ward

FROM Chris Kozuskanich, P.Geo. **EMAIL** chris_kozuskanich@golder.com

PRELIMINARY NITRATE LOADING ASSESSMENT, CONCEPTUAL SEWAGE SYSTEM SIZING IN SUPPORT OF DRAFT PLAN SUBMISSION
PROPOSED RESIDENTIAL DEVELOPMENT, PART OF LOTS 17 & 18, CONCESSION 9 AND LOTS 47 & 48, REGISTERED PLAN NO. 12
CLAREMONT, CITY OF PICKERING, REGION OF DURHAM, ONTARIO

As requested by Geranium Corporation ("Geranium") on behalf of Prime "R" Management Inc., this technical memorandum provides a summary of a preliminary nitrate loading assessment and conceptual sewage system sizing carried out by Golder Associates Ltd. ("Golder") for a property located on Part of Lots 17 & 18, Concession 9 and Lots 47 & 48, Registered Plan No.12, Claremont, City of Pickering, Regional Municipality of Durham, Ontario. The location of the Site is shown on Figure 1, Key Plan, attached. It is understood that individual private sewage systems are proposed, comprised of tertiary systems approved under the Ontario Building Code that also include nitrate removal and smaller leaching beds than conventional sizing. As described in this memorandum, the preliminary nitrate loading calculation assumes a 50% reduction in nitrate concentrations in septic effluent through the use of nitrate reducing treatment systems. The Waterloo Biofilter® is an example of a nitrate reducing treatment system. A list of projects utilizing the Waterloo Biofilter® within Durham Region as provided by Waterloo Biofilter is attached. Additional comment on the use of nitrate reducing treatment systems as provided by Gunnell Engineering Ltd. is also attached.

Site and Project Description

The Site is located north of Joseph Street, between Brock Road (Claremont Bypass) and Old Brock Road, as shown on Figure 1, attached. The Site is bounded by existing residential houses to the west and south, and agricultural lands to the north and east. The Site primarily consists of an irregularly shaped, agricultural parcel of land. The terrain of the subject property is uneven; the Site topography is generally sloping downward to the southwest.

The Site is proposed to be developed into residential estate lots. A Draft Plan (Malone Given Parsons Ltd. ["MGP"], March 7, 2012, revised August 9, 2012. *Draft Plan of Subdivision, Part of Lots 17 & 18, Concession 9, Lots 47 & 48, Registered Plan No. 12, Town of Pickering, Regional Municipality of Durham*. Reference No. 11-

2041) was provided to Golder (attached). The Draft Plan illustrates a layout consisting of 27 lots and local roads on a 10.77 ha site.

From the provided plan and discussions with Geranium, we have assumed the following:

- Impermeable road surfaces totalling 0.88 ha (i.e., 60% of 1.47 ha for Streets A-B);
- Average residential building footprints of 300 m^2 (3,229 ft^2). Given 27 lots, the total building area was 0.81 ha;
- Average residential driveways of 126 m^2 (7.3 m by 17.3 m). Given 27 lots, the total driveway area was 0.34 ha; and
- The remainder of the site (8.74 ha) (including the remainder of Blocks 1 to 27 and of Streets A-B, and all of the 0.01 ha reserve Block 28) is comprised of permeable surfaces vegetated with urban lawn.

No other impermeable surfaces were assumed to be present.

Background

Golder has previously carried out a preliminary geotechnical hydrogeological investigation of the Site, summarized in the following technical memorandum:

- *Preliminary Geotechnical and Hydrogeological Investigation, In Support of Draft Plan Submission for a Proposed Residential Subdivision, Lane Street and Brock Road, Claremont, City of Pickering, Ontario,* dated August 23, 2012, reference number 12-1186-0047.

The assessment provided in this technical memorandum is based in part on the subsurface information presented in this technical memorandum.

Assessment of Post-Development Infiltration Rates

To carry out the preliminary nitrate loading calculation, the average annual post-development groundwater recharge (or infiltration) rate was estimated by means of a hydrologic budget.

Methods

The hydrologic budget assumes that the sum of the average annual precipitation (“P”) is equal to the sum of the average annual surplus (“Q”) and average annual evapotranspiration (“E”) as follows:

$$P = Q + E \qquad \text{(Freeze \& Cherry, 1979)}$$

The hydrologic budget assessment was based on climatic data, including average annual precipitation and surplus rates, obtained from Environment Canada for the Buttonville Airport (DC20492) climate station for the period of 1987 to 2010 for a variety of soil water holding capacities. The average annual precipitation (“P”) at the Buttonville Airport was 841 mm. The average annual evapotranspiration (“E”) and surplus (“Q”) values are dependant on the water holding capacity (determined by the Site specific land use and surficial soils, described below).

Based on the results of the preliminary geotechnical investigation at the Site, the surficial soil types (below the topsoil) were identified as thin, discontinuous clayey silt to silty clay, underlain by clayey silt and sand till. Based on the U.S. Bureau of Soils classification system, the silty clay to clayey silt unit was considered to be “Clay”. Based on the U.S. Bureau of Soils classification system and the results of grain size distribution testing of one soil sample of the till from our previous investigation, the till was classified as “Loam”. Water holding capacities were then assigned to these two soil types using “*Table 3.1: Hydrologic Cycle Component Values*” (“Table 3.1”) of the MOE *Stormwater Management Planning and Design Manual* (March 2003) based on soil type and vegetative cover (urban lawn). The Clay unit was assigned a water holding capacity of 75 mm, and the Loam unit was assigned a water holding capacity of 100 mm (being closest to, and hereafter referred to as “Clay Loam”, listed in Table 3.1). No infiltration was assumed to occur from impermeable surfaces (e.g., roads, roofs and driveways).

The average annual surplus data obtained from Environment Canada for the 75 mm and 100 mm water holding capacities (i.e., 319 mm and 298 mm, respectively) were split into infiltration and run-off components by applying infiltration factors based on Table 3.1.

The infiltration factors were based on a sum of Site-specific topography, surficial soil type and vegetative cover factors as summarized in Table 1, below. SCS Consulting Group Ltd. (“SCS”) indicated that average post-development lot grades would be 2%, or 20 m/km, and assigned a topographic factor of 0.12 (i.e., part way between “rolling” and “hilly”). The Clay and Clay Loam soil types were considered to be “tight impervious clay” and “medium combinations of clay and loam”, respectively, and assigned values of 0.1 and 0.2. The vegetative cover was considered to be “cultivated land” and assigned a factor of 0.1. Summing the topography, soils and cover factors, the infiltration factors shown in Table 1 (below) were applied to the average annual surplus to estimate the average annual infiltration rate. Impermeable surfaces were assigned an infiltration factor of 0 (i.e., the surplus would be entirely runoff).

Table 1: Estimation of Infiltration Factors and Rates

Soil Description	**Surplus (mm/year)**	**Topography Factor**	**Soil Factor**	**Vegetative Cover Factor**	**Infiltration Factor**	**Infiltration Rate (mm/year)**
Impermeable Surfaces	395	0	0	0	0	0
Clay	319	0.12	0.10	0.10	0.32	102
Clay Loam	298	0.12	0.20	0.10	0.42	125

Assumptions

The following assumptions were used to estimate average annual post-development infiltration rates:

- The discontinuous nature of the thin surficial Clay unit, and the partial removal of the Clay unit during grading and other site development activities would thereby result in post-development surficial soils comprised 50% of Clay and 50% of Clay Loam;
- Incident precipitation on the un-paved portion of the road network would infiltrate at the rates established for the respectively surficial soil types;
- No significant removal of groundwater from building foundation drains and the like, due to the Clay and Clay Loam soil types present; and
- No underground storm sewer or storm water management pond were assumed to be constructed at the Site.

Results

The following table summarizes the results of the hydrologic budget carried out based on the proposed preliminary development plans provided to Golder:

Table 2: Summary of Post-Development Infiltration Rates – 27 Lot Plan

Component (Soil Type – Surface Type)	Area (ha)	Infiltration Rate (m/year)	Infiltration Rate (m^3/year)
Impermeable (roads, roofs, driveways)	2.03	0	0
Clay – lawns	4.37	0.102	4,457
Clay Loam – lawns	4.37	0.125	5,463
TOTAL	**10.77**	-	**9,920**

As shown in Table 2 above, the average annual post-development infiltration rate for the 27-lot plan was estimated to be in the order of 9,920 m^3/year, or 27.2 m^3/day.

Nitrate Loading Assessment

The estimated number of viable lots able to be developed at the site was based on the dilution of septic effluent by infiltration (estimated above), assuming even mixing over the site area, such that the resulting nitrate concentration in groundwater at the property boundary was below the Ontario Drinking Water Standard of 10.0 mg/L.

Based on literature accessed from the internet, the following provides estimates of the nitrogen reducing capabilities of various alternative treatment technologies:

Table 3: Estimates of Nitrogen Reduction for Alternative Treatment Technologies

Technology	Nitrogen Reduction		Estimated Treated Nitrate Concentration	
	Lower	Upper	Lower	Upper
Waterloo Biofilter[1]	50%	65%	20 mg/L	14 mg/L
Waterloo Biofilter[2]	58.8%	58.8%	14.4 mg/L	14.4 mg/L
Recirculation[3]	40%	50%	24 mg/L	20 mg/L
FAST®[3]	55%	70%	18 mg/L	12 mg/L
RUCK®[3]	40%	80%	24 mg/L	8 mg/L
Waterloo Biofilter®[3]	21%	60%	31.6 mg/L	16 mg/L
Peat Filter[3]	30%	70%	26 mg/L	12 mg/L
Peat Filter (Golder)[4]	50%	90%	20 mg/L	4 mg/L
Ottawa Pilot Test[5]	50%	50%	20 mg/L	20 mg/L

References:

1) www.waterloo-biofilter.com. Accessed on-line April 24, 2012. (attached)

2) Massachusetts Alternative Septic System Test Center, August 2004. *US EPA Environmental Technology Initiative, Onsite Wastewater Technology Testing Report. Waterloo Biofilter®.* (attached)

3) Hagerty, P. A., Taylor, J. R., 2005. *Nitrate Removal for On-Lot Sewage Treatment Systems: The POINT™ System.* Accessed on-line at taylorgeoservices.com on April 24, 2012. (attached)

4) Golder Associates Ltd. Based on Golder's experience with an in-house peat filter system design.

5) Golder Associates Ltd. Based on Golder's experience in the Municipality of Ottawa, the municipality is proceeding with a subdivision pilot test to increase development density assuming 50% nitrogen reduction by nitrogen treatment systems.

Based on the ranges of total nitrogen reduction shown in Table 3 above, and based on our experience in the Ottawa area, an assumption of 50% nitrogen reduction is considered to be reasonable. Accordingly, the concentration of nitrate in sewage effluent has been estimated at 50% of the assumption of 40 mg/L used in a typical nitrate loading calculation.

The concentration of nitrate in groundwater at the property boundary was estimated using the following formula:

$$[NO_{3\,PL}] = ((Q_g \times [NO_{3\,bck}]) + (Q_{eff}\; x\; [NO_{3\,eff}]))\; \div (Q_g + Q_{eff})$$

where:
$[NO_{3\,PL}]$ = Resulting Nitrate Concentration at the Property Line (in mg/L);
$[NO_{3\,bck}]$ = Nitrate Concentration in Background (i.e., 0 mg/L in infiltrating precipitation);
$[NO_{3\,eff}]$ = Nitrate Concentration of Sewage Effluent (as per above, 20 mg/L, assuming 50% total nitrogen reduction through use of nitrate treatment systems);
Q_g = Volume of Infiltration (27.2 m^3/day); and
Q_{eff} = Volume of Effluent (1 m^3/day per lot).

Based on the preliminary nitrate loading assessment method, and the assumptions provided above, a 27-lot plan would result in an estimated nitrate concentration of 9.96 mg/L at the property boundary. Therefore the 27-lot plan will be technically achievable.

Conceptual Sewage System Sizing

A review of the conceptual sewage system sizing is included in an attached letter, following the text of this memorandum. Expected minimum clearances between the systems and various features are also provided in the letter.

Limitations

This technical memorandum is subject to the attached *Important Information and Limitations to This Report*. This letter is based on data and information collected during preliminary geotechnical and hydrogeological assessments of the site carried out by Golder as described above, and on the provided Draft Plan prepared by MGP as referenced above. The use of nitrate treatments systems as described in this memorandum to reduce the concentration of nitrate in septic effluent by 50% in the nitrate loading calculation is subject to acceptance by the municipality and other approving agencies. Additional assessment of the potential impact of sewage systems on existing drinking water resources in accordance with process outlined in *MOE Procedure D-5-4, Technical Guidance for Individual On-Site Sewage Systems: Water Quality Impact Risk Assessment* (August 1996) is recommended.

If the Draft Plan is altered or updated (e.g., changes or additional information is available on the number of developable lots, lot and road arrangement, lot sizing, site grading, area of impermeable surfaces, vegetative cover, and the like), or the development proceeds to detail design, Golder should be requested to re-evaluate the conclusions presented in this memorandum and provide amendments as required.

In evaluating the property, Golder has relied in good faith on information provided by others as noted in this memorandum. We assume the information is factual and accurate. We accept no responsibility for any deficiency, misstatements or inaccuracies contained in this letter as a result of omissions, misinterpretations or fraudulent acts by others.

Golder accepts no responsibility for the consequential effects of this letter report on the real or perceived value of the property, or on the ability to gain financing.

Closure

We trust this submission meets your current requirements. If you have any questions or require additional information, please do not hesitate to contact our office.

Yours truly,

GOLDER ASSOCIATES LTD.

PROFESSIONAL GEOSCIENTIST
CHRISTOPHER M. KOZUSKANICH
PRACTISING MEMBER
0315
ONTARIO

Chris Kozuskanich, P.Geo.
Associate, Senior Hydrogeologist

CMK/CLK/sv

Attachments: Important Information and Limitations to This Report

Figure 1, Key Plan.

Malone Given Parsons Ltd., March 7, 2012, updated August 9, 2012. *Draft Plan of Subdivision, Part of Lots 17 & 18, Concession 9, Lots 47 & 48, Registered Plan No. 12, Town of Pickering.* Reference No. 11-2041.

E-mail from Mr. Vimal Patel, Tuesday April 24, 2012 "Fwd: Geranium Homes Development".

E-mail from Mr. Vimal Patel, Tuesday April 24, 2012, "Fwd: Geranium Homes – Lakeshore Road, Whitchurch Stouffville".

Information and brochure from www.waterloo-biofilter.com, accessed on-line April 24, 2012.

Massachusetts Alternative Septic System Test Center, August 2004. *US EPA Environmental Technology Initiative, Onsite Wastewater Technology Testing Report. Waterloo Biofilter®.*

Hagerty, P. A., Taylor, J. R., 2005. *Nitrate Removal for On-Lot Sewage Treatment Systems: The POINT™ System.* Accessed on-line at www.taylorgeoservices.com on April 24, 2012.

Golder Associates Ltd., August 23, 2012. *Conceptual Sewage System Sizing In Support of Draft Plan Submission, Part of Lots 17 & 18, Concession 9, Lots 47 & 48, Registered Plan 12, Town of Pickering, Ontario.* Reference no. 12-1186-0047.

http://capws/sites/1211860047claremontsubdiv/reports/draft plan submission/nitrate/12-1186-0047 (2000) mem 2012'08'24 prelim nit assess and septic design (draft plan submission) final.docx

IMPORTANT INFORMATION AND LIMITATIONS TO THIS REPORT

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder can not be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder's express written consent. If the report was prepared to be included for a specific permit application process, then upon the reasonable request of the client, Golder may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client cannot rely upon the electronic media versions of Golder's report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder cannot be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report. The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

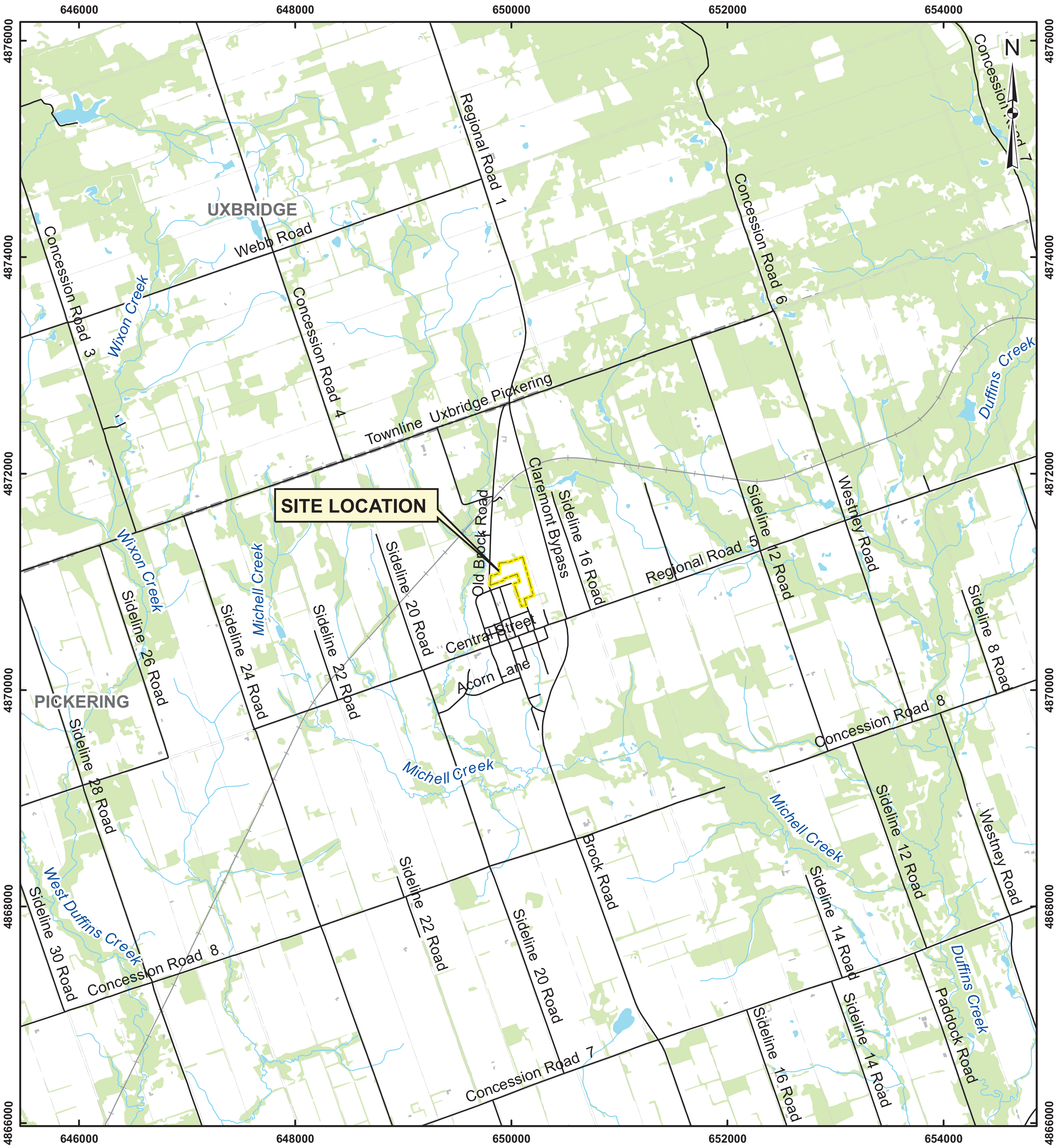
Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.



1,000 0 1,000 2,000

SCALE 1:50,000 METRES

PROJECT

PRELIMINARY GEOTECHNICAL AND HYDROGEOLOGICAL
PROPOSED RESIDENTIAL SUBDIVISION
CLAREMONT, CITY OF PICKERING, ONTARIO

TITLE

KEY PLAN

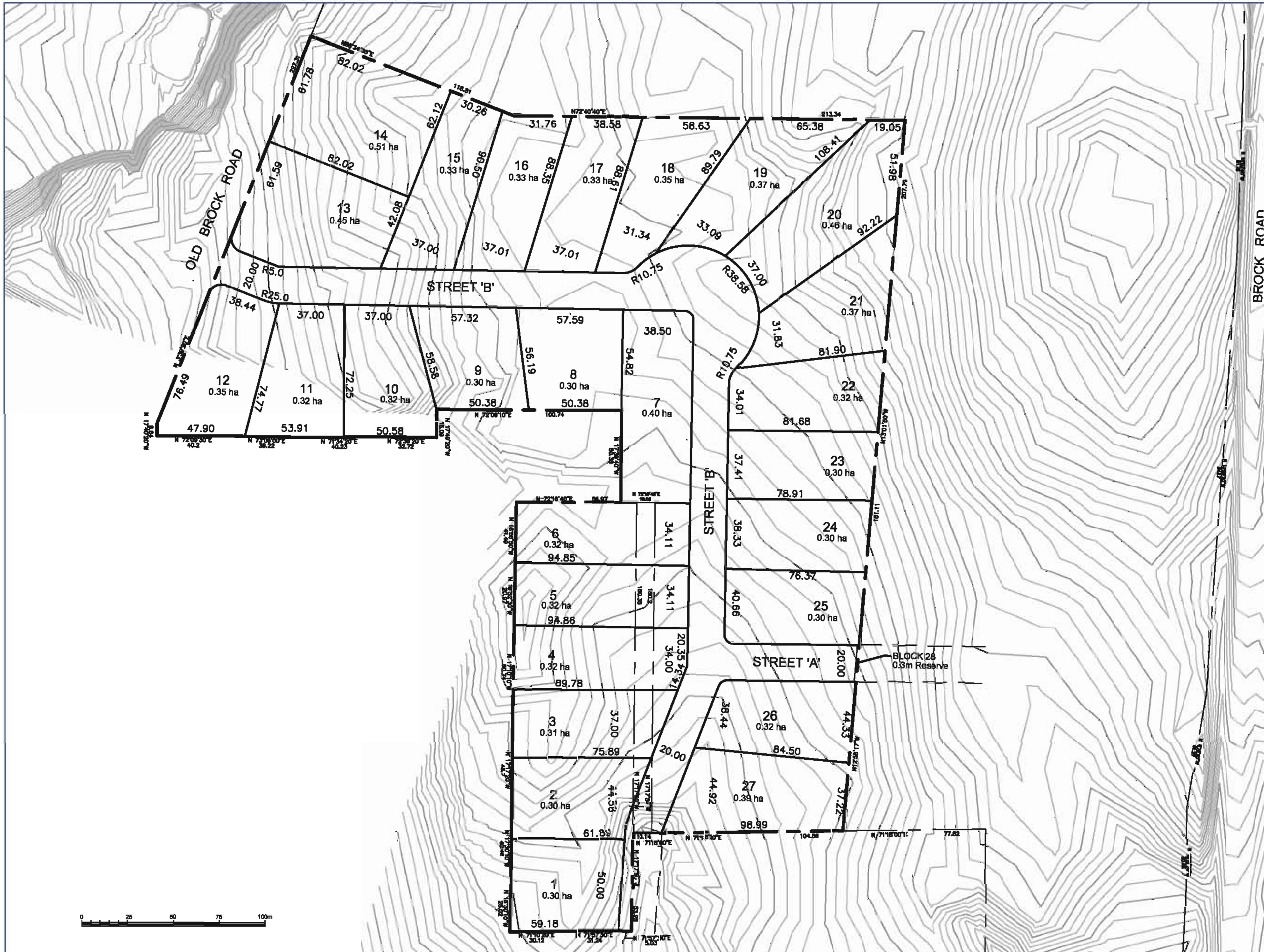
Golder Associates
Whitby, Ontario

PROJECT NO. 12-1186-0047			SCALE AS SHOWN	REV. 0.0
DESIGN			FIGURE 1	
GIS	JT	MAR. 2012		
CHECK	CMK	Aug. 2012		
REVIEW				

REFERENCE

Base Data - MNR NRVIS, obtained 2004
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2008
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 17

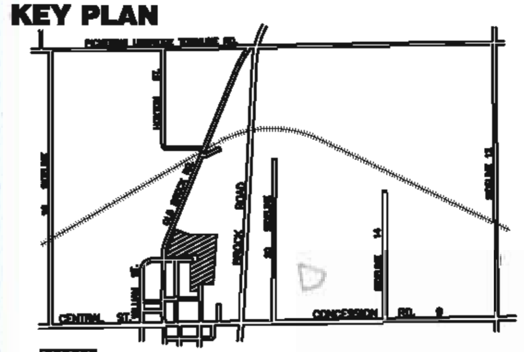
G:\Projects\2012\12-1186-0047_Geranium_Pickering\GIS\MXDs\Reporting\AA_Geotechnical\1211860047AA01.mxd



DRAFT PLAN OF SUBDIVISION

Part of Lots 17 & 18, Concession 9
Lots 47 & 48, Registered Plan No. 12
Town of Pickering
Regional Municipality of Durham

KEY PLAN



Subject Lands

SCHEDULE OF LAND USE

LOT/BLOCK	LAND USE	UNITS	AREA (ha)
1-27	Single Detached Residential	27	9.29
28	0.3m Reserves		0.01
	Roads Streets A-B @ 20.0 ROW = 643m		1.47
TOTAL		27	10.77

OWNER'S AUTHORIZATION

I hereby authorize Malone Given Parsons Ltd. to prepare and submit this Draft Plan of Subdivision to the Town of Pickering.

__________________ Date ________

SURVEYOR'S CERTIFICATE

The boundaries of the lands to be subdivided and their relationship to the adjacent lands are correctly shown.

__________________ Date ________

ADDITIONAL INFORMATION

AS REQUIRED UNDER SECTION 51(17) OF THE PLANNING ACT CHAPTER P.13 (R.S.O. 1990.)
(a),(e),(f),(g),(j),(l) - As shown on the Draft Plan.
(b),(c) - As shown on the Draft and Key Plan.
(d) - Land to be used in accordance with the Schedule of Land Use.
(i) - Soil is
(h),(k) - Full municipal services to be provided.
NOTE: Contours relate to Canadian Geodetic Datum.
Contour interval is 1m with .25m interpolated.

Date: March 7, 2012	Project No.: 11-2041
Revised: August 9, 2012	MALONE GIVEN PARSONS LTD. 140 Renfrew Drive, Suite 201 Markham, Ontario, L3R 6B3 Tel: (905) 513-0170 Fax: (905) 513-0177 www.mgp.ca

Kozuskanich, Chris

From: Kellestine, Chris
Sent: April 24, 2012 2:22 PM
To: Kozuskanich, Chris
Subject: FW: Geranium Homes Development

fyi

Chris Kellestine (A.Sc.T.) | Principal, Ground Engineering| **Golder Associates Ltd.**
100 Scotia Court, Whitby, Ontario, Canada L1N 8Y6
T: [+1] (905) 723 2727 (ext 6620)| **F:** [+1] (905) 723 2182 | **C:** [+1] (905) 424 0192 | **E:** ckellestine@golder.com |
www.golder.com

Work Safe, Home Safe

From: Patel, Vimal [mailto:vimalp@geraniumcorporation.com]
Sent: April 24, 2012 2:21 PM
To: Kellestine, Chris
Cc: Shauna Dudding
Subject: Fwd: Geranium Homes Development

Chris,

Please see email below re septics in Durham region

vP.

Sent from my iPhone

Begin forwarded message:

> **From:** john@waterloo-biofilter.com
> **Date:** 24 April, 2012 2:18:40 PM EDT
> **To:** vimalp@geraniumcorporation.com
> **Subject: Fw: Geranium Homes Development**
> **Reply-To:** john@waterloo-biofilter.com
>
> Sent wirelessly from my BlackBerry device on the Bell network.
> Envoyé sans fil par mon terminal mobile BlackBerry sur le réseau de Bell.
>
> **From:** "Greg Corman" <greg@waterloo-biofilter.com>
> **Date:** Tue, 24 Apr 2012 14:27:55 -0400
> **To:** <john@waterloo-biofilter.com>
> **Subject:** RE: Geranium Homes Development
>
> Durham Region ~50+ systems listed in LooWare (Very Rough Estimate on low end):

Roselawn Avenue (Oshawa)
Grandview Avenue (Oshawa)
Lauas Court (Oshawa)
Simcoe St. (Oshawa)
Switzer Drive (Oshawa)

Rossland Road East (Whitby)
Evensong Drive (Whitby)
Baldwin St. N (Whitby)
Hialeah Cres. (Whitby)
Ennisclave Place (Whitby)

Nicholson Drive (Uxbridge)
Testa Rd. (Uxbridge)
Joseph St (Uxbridge)
Confederation Drive (Uxbridge)

Fralicks Beach Road (Port Perry)
Lakeridge Road N. (Port Perry)
Chalk Lake Rd. (Port Perry)

Nancy Avenue (Beaverton)
Alsop Beach Road (Beaverton)
Maple Beach Road (Beaverton)
Bay Street (Beaverton)
Howard Avenue (Beaverton)

ETC…ETC…

Greg Corman, B.Eng., EIT
Engineering Department

Waterloo Biofilter Systems Inc.
143 Dennis Street, P.O. Box 400
Rockwood, ON N0B 2K0
Tel: (519) 856-0757
Fax: (519) 856-0759
www.waterloo-biofilter.com

Is Yours a Waterloo?

From: john@waterloo-biofilter.com [mailto:john@waterloo-biofilter.com]
Sent: Tuesday, April 24, 2012 1:51 PM
To: Greg Corman
Subject: Re: Geranium Homes Development

Kozuskanich, Chris

From: Kellestine, Chris
Sent: April 24, 2012 1:54 PM
To: Kozuskanich, Chris
Subject: FW: Geranium Homes - Lakeshore Road, Whitchurch Stouffville

fyi

Chris Kellestine (A.Sc.T.) | Principal, Ground Engineering| **Golder Associates Ltd.**
100 Scotia Court, Whitby, Ontario, Canada L1N 8Y6
T: [+1] (905) 723 2727 (ext 6620)| **F:** [+1] (905) 723 2182 | **C:** [+1] (905) 424 0192 | **E:** ckellestine@golder.com |
www.golder.com

Work Safe, Home Safe

From: Patel, Vimal [mailto:vimalp@geraniumcorporation.com]
Sent: April 24, 2012 1:52 PM
To: Kellestine, Chris
Cc: Shauna Dudding
Subject: Fwd: Geranium Homes - Lakeshore Road, Whitchurch Stouffville

Chris,

FYI - Please see email below from Gunnell. I have requested a list of specific projects as well and will send it as soon as I receive.

Thanks,

vP.

Sent from my iPhone

Begin forwarded message:

> **From:** Eric Gunnell <eric@gunnellengineering.com>
> **Date:** 24 April, 2012 1:12:42 PM EDT
> **To:** Vimal Patel <vimalp@geraniumcorporation.com>
> **Cc:** Liz Lew <liz@gunnellengineering.com>
> **Subject: Geranium Homes - Lakeshore Road, Whitchurch Stouffville**
>
> Vimal,
> We talked this morning about tertiary treatment sewage systems.

Tertiary treatment units are typically small packaged sewage plants. As we have discussed, a number of these treatment units provide inherent nitrate reduction (i.e. Waterloo Biofilter, Bionest, and others).

The use of these treatment units in the Province of Ontario is regulated through the Ontario Building Code. Approved treatment units are detailed in Supplementary Standard SB-5 of the OBC.

We have designed numerous tertiary treatment sewage systems in Whitchurch Stouffville. In our experience, the building department accepts all OBC treatment systems, that are approved in the OBC, and certainly Waterloo Biofilter and Bionest treatment units.

With regard to increasing the lot density on the basis of providing treatment systems with nitrate reduction, this has occurred in many municipalities in Ontario. I can provide that information to you. We are currently working on a similar project in the Region of Durham to increase the lot density on the basis of providing nitrate reduction with tertiary treatment sewage systems.

With regard to the Region of Durham, septic systems are permitted by the Durham Health Unit. Again we have designed many tertiary treatment sewage systems in the Region of Durham, and there has never been a situation where Health Unit has not accepted an OBC approved treatment unit.

Cheers,

Eric

Eric Gunnell, P.Eng.

Gunnell Engineering Ltd.
1110 Stellar Drive, Unit 106
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Waterloo Biofilter Systems Inc.
on-site wastewater treatment

Search

Home

About Us

Technology

The Waterloo Process

Testing & Verification

The Waterloo Biofilter Advantage

Applications

Products

Information

Why Treatment?

Info for Homeowners

Info for Installers

Info for Engineers

Info for Regulators

Frequently Asked Questions (FAQs)

Downloads

Installers

Contact Us

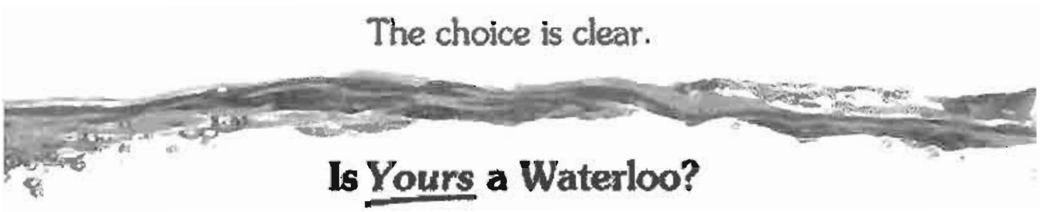
Waterloo Biofilter Systems Inc. > Technology > The Waterloo Biofilter Advantage

The Waterloo Biofilter Advantage

Please use the following comparison chart to see why the Waterloo Biofilter is the best solution for your wastewater treatment application.

Criteria	The Waterloo Biofilter® Advantage
Permanent Filter Medium	Filter medium is warranted for up to 20 years and will likely last much longer
Low Power Consumption	Uses very little electricity; up to 85% less power than competing aeration systems, and even less energy than recirculating sand filters. Our siphon-dosed Flat Bed treatment units require no electricity at all!
High Nitrogen Removal	Typically removes 50-65% total nitrogen in recirculation mode – even in cold climates! Higher removal rates are possible with the WaterNOx BAF
Small System Footprint	Has the smallest system footprint fully approved in Ontario, Manitoba, and Massachusetts, allowing you to make the most use of your property
Lowest Long Term Operating Costs	A permanent filter medium and very low power consumption means your Waterloo Biofilter costs less to operate than any other advanced treatment unit
Minimizes Tree Removal	A compact footprint with no distribution piping (Cedar Shed and Flat Bed Biofilters) means tree removal on your property is minimized
Low Maintenance	Few moving parts with only high-quality, cast iron effluent pumps used; maintenance on a Waterloo Biofilter is reduced to a simple inspection
Minimizes Mounding	Low-profile Flat Bed Biofilters and above-ground Cedar Shed Biofilters minimize unsightly raised mounds commonly found with filter beds (sand filters) and other treatment units – even in difficult bedrock and high water table sites!
Wide Product Selection	Our technology is available in many different configurations to suit your site conditions and personal tastes
Excellent Winter Performance	Achieves and maintains excellent, documented treatment levels even in temperatures down to -50°C, without the need to heat raw sewage
No Air Compressor	Air circulates passively to maintain aerobic conditions, without the need for loud, high maintenance, high energy air compressors and diffusers
Robust & Sustainable	Filtration technology recovers more quickly from system abuse (i.e. dead septic tank, chemicals poured into system, etc.) especially when compared to suspended sludge systems
Our Experience	We are pioneers and problem solvers in the on-site wastewater industry, having actively developed successful technologies for difficult sites since 1991
No Aerobic Sludge Management	Provides aerobic treatment without producing aerobic sludge. Suspended sludge technologies typically require annual pump outs of accumulated activated sludge in order to maintain treatment levels.
Consistent Over Time	Maintains treatment levels over time with no filter medium degradation and no accumulation of aerobic sludge found with other systems
Excellent Seasonal Use Performance	Absorbent filter medium retains moisture during periods of no use allowing beneficial bacteria to go dormant instead of desiccating or starving. When the system is used again the bacteria population is reactivated and starts degrading contaminants immediately.
Handles Surge Flows	Filter medium absorbs excess flows during the day, can handle much higher organic and hydraulic loads without plugging, and does not wash out solids during high flows like suspended sludge systems

Ongoing Innovative Research	Waterloo Biofilter is a world leader in performing innovative research to advance the process and technological knowledge in our industry, and is continually bringing new technologies to the market that help to protect our water supplies for future generations.
No Short Circuiting	Biological treatment combined with physical filtration of wastewater ensures that no sewage can short-circuit treatment, unlike submerged media technologies



Recent News

- Ontario Cottages & Sewage System Nutrients – Part III
- Ontario Cottages and Sewage System Nutrients - Part 2
- Ontario Cottages and Sewage System Nutrients – Part 1
- Sewage Treatment Key to a Healthy Environment
- Ontario GreenFIT Strategy Showcases Waterloo Biofilter Installation at Provincial Park

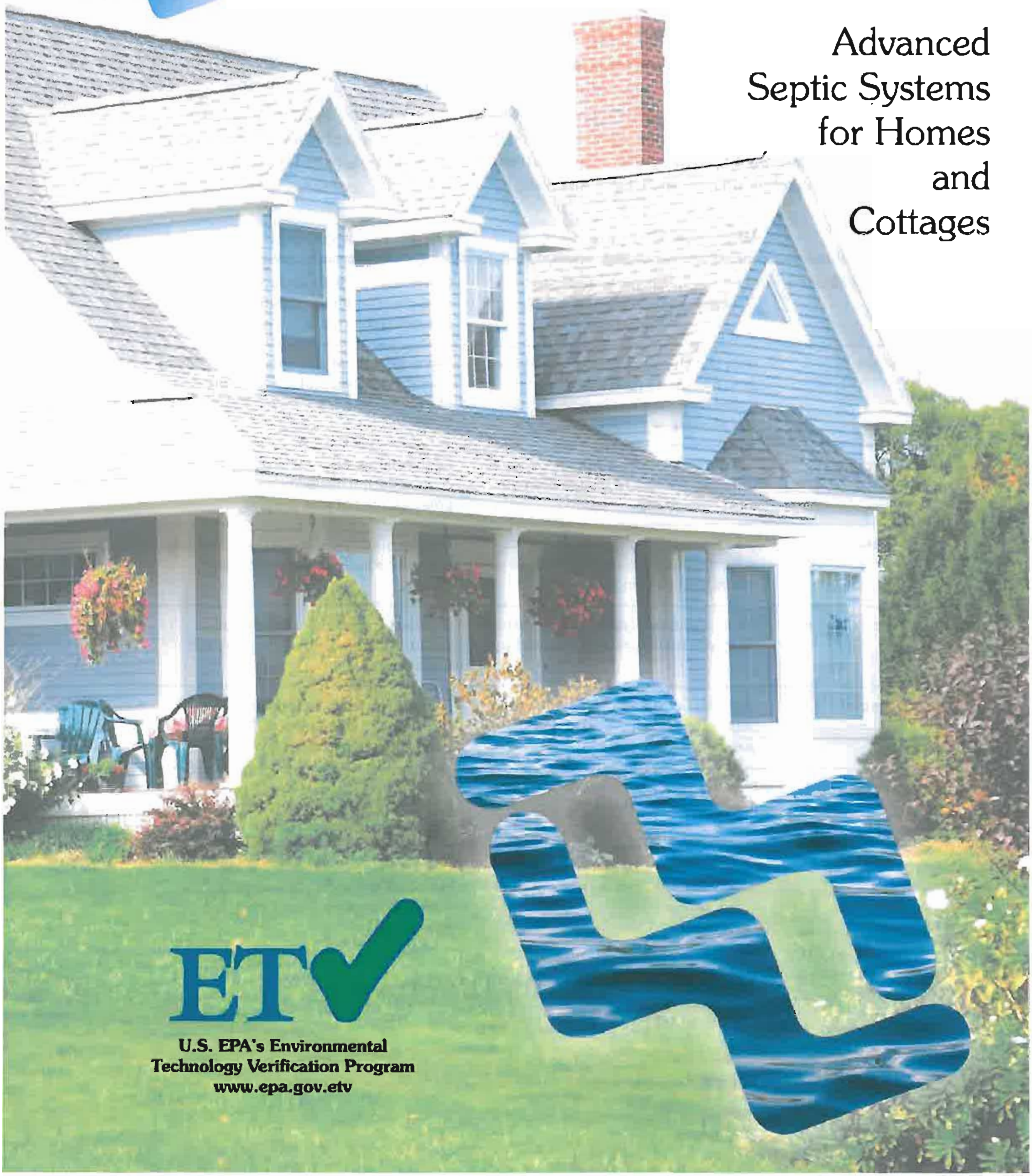
Upcoming Events

- April 25, 2012:
  - Installers' Refresher Courses
- May 1, 2012:
  - Installers' Refresher Courses
- May 16, 2012:
  - Designers' Course

Waterloo Biofilter Systems Inc.

on-site wastewater treatment

Advanced Septic Systems for Homes and Cottages



ETV

U.S. EPA's Environmental Technology Verification Program
www.epa.gov.etv

Is Yours a Waterloo?

Developed at the University of Waterloo in Ontario, the Waterloo Biofilter® is an advanced septic system ideal for use in individual homes and cottages. Since 1991 the Waterloo Biofilter has proven itself to be the most reliable wastewater treatment system available. The key to its success is the engineered filter medium that is optimized to be stable over long periods of time, accept very high loading rates without plugging, provide an aerobic treatment environment passively, and absorb wastewater thereby increasing retention time and treatment levels.

Waterloo Biofilter filter medium provides an ideal environment for beneficial bacteria to thrive and degrade contaminants found in wastewater

Advantage	Waterloo Biofilter	Other Technologies
Permanent Filter Medium	Filter medium is warranted to last 20 years and will likely last much longer	Can require periodic replacement of filter medium at your cost, significantly increasing the cost of ownership
Energy Efficient	Uses less electricity than a recirculating sand filter, and in some cases can be dosed by siphon eliminating all electrical needs	Can require huge amounts of electricity to operate, significantly increasing the cost of ownership
Smallest Footprint	Has the smallest footprint approved in Ontario – can be installed in even the most difficult sites	Require larger disposal beds increasing costs, reducing flexibility, and reducing potential uses of your property
Property Aesthetics	Blends in naturally with your site, minimizes unsightly raised mounds and minimizes tree removal	Require more trees be cut down and can often leave large, unexpected raised mounds
Wide Product Selection	Offers numerous system configurations each with their own unique advantages	Offer less choice in finding a solution suited to your individual property and preferences
Nitrogen Removal	Removes up to 65% of Total Nitrogen, helping to protect our lakes and source waters	Remove less or no Nitrogen, which can contribute to algae blooms, fish kills and human health problems
No Air Compressor	Provides an aerobic treatment environment passively without the need for forced aeration	Can require the use of loud, high-maintenance, high-energy air compressors and diffusers
No Activated Sludge	Provides aerobic treatment without producing activated sludge	Can produce activated sludge that must periodically (typically annually) be pumped out or treatment levels fall dramatically

Engineered & Manufactured in Ontario!

Waterloo Biofilters are known in the onsite industry for their outstanding treatment consistency, longevity, low power consumption and Nitrogen removal capabilities.

Four Flexible Solutions

Blends into Your Garden

Modular and very lightweight, **Flat Bed Biofilters™** follow the natural contours of your land for a pleasing and easily landscaped installation. Flat Beds are ideal for cottages and can be dosed with an electricity-free siphon pump where site elevation allows.

Smallest Footprint in Ontario

Ideal for small lots, minimizing raised mounds, and minimizing tree removal, **Cedar Shed Biofilters™** naturally blend in with a rural setting. These discrete systems can be located away from your house as the Shed itself contains no electrical equipment.

Below Ground and Out of Sight

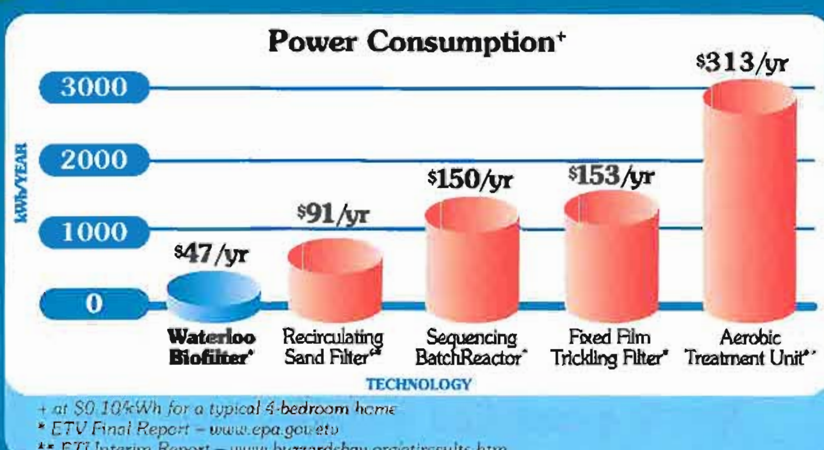
Basket Biofilter™ systems are completely below ground and can be scaled up for use with any size home. Configured for enhanced Nitrogen removal, Basket systems are ideal for environmentally sensitive areas, high water tables, and clay soils.

Lightweight and Easily Transported

HDPE Tank Biofilters™ are completely below ground, offer enhanced Nitrogen removal, and have a faster and easier installation. These lightweight tanks can be barged to islands, easily maneuvered onto remote sites, and are corrosion resistant in high-sulphur areas.

20 Year Warranty!
We've always claimed our filter medium would last for over 20 years.
Now We Guarantee It!

Waterloo Biofilters use very little energy; up to 85% less power than aeration technologies using air compressors!



A Waterloo Biofilter® is the ideal septic solution for your home or cottage

Waterloo Biofilters provide a permanent combination of biological treatment and physical filtration of wastewater not matched by any other treatment technology. Our unique and patented process uses a filter medium that is highly resistant to clogging, has the highest surface area-to-volume ratio in the industry, and is warranted to last at least 20 years!

Designed to work in even the most difficult sites, Waterloo Biofilters are the ideal solution for clay soils, bedrock, high water table, small lots, remote locations, and environmentally sensitive areas. Waterloo Biofilters work like a low-pressure membrane, providing a physical barrier that wastewater must pass through for treatment before entering the environment. Even when the power supply is interrupted, the Waterloo Biofilter's design ensures no untreated sewage enters the environment, so you can feel confident you are protecting your family, your property, and your water supplies from contamination.

Time-Proven Technology

The Waterloo Biofilter has been proven in many thousands of installations across North America since 1991. No other technology can match the Waterloo Biofilter's:

- Very low energy usage
- Few moving parts & low maintenance requirements
- Tertiary quality treatment even in very cold climates
- High level of Nitrogen removal
- Aesthetically pleasing impact on your property

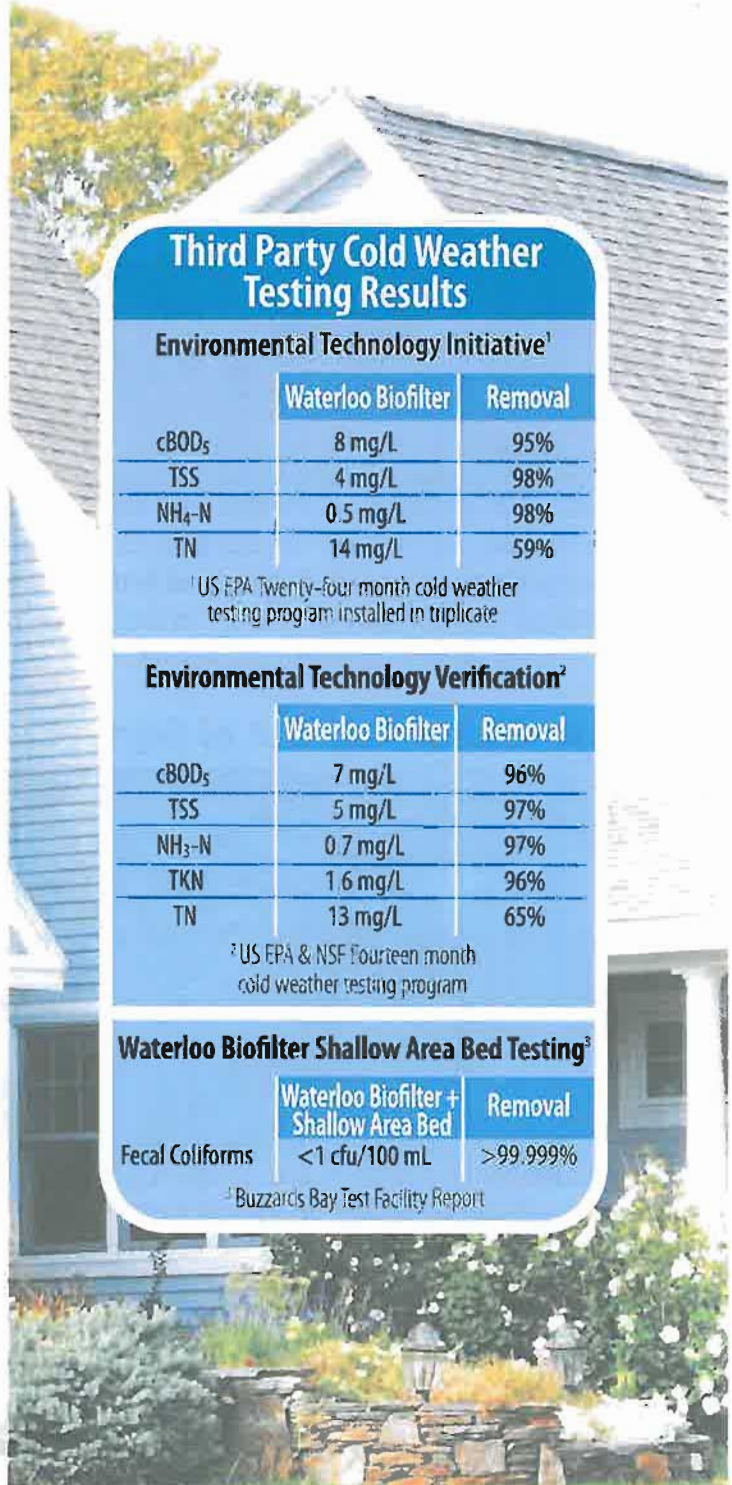
No other septic system preserves the value of your property by naturally blending in with your site like a Waterloo Biofilter. Waterloo Biofilters have the smallest system footprint approved in Ontario, and help to minimize unsightly raised mounds and tree removal.

Other benefits of the Waterloo Biofilter include:

- The lowest long-term operating costs
- One of the best warranties in the industry
- Easily handles surge flows and seasonal use
- Quickly recovers from system abuse or neglect
- Air filters block potential odours

The Choice is Clear
Is Yours a Waterloo?

Please call us or visit our website to locate a certified installer near you!



Third Party Cold Weather Testing Results

Environmental Technology Initiative[1]

	Waterloo Biofilter	Removal
$cBOD_5$	8 mg/L	95%
TSS	4 mg/L	98%
NH_4-N	0.5 mg/L	98%
TN	14 mg/L	59%

[1] US EPA Twenty-four month cold weather testing program installed in triplicate

Environmental Technology Verification[2]

	Waterloo Biofilter	Removal
$cBOD_5$	7 mg/L	96%
TSS	5 mg/L	97%
NH_3-N	0.7 mg/L	97%
TKN	1.6 mg/L	96%
TN	13 mg/L	65%

[2] US EPA & NSF Fourteen month cold weather testing program

Waterloo Biofilter Shallow Area Bed Testing[3]

	Waterloo Biofilter + Shallow Area Bed	Removal
Fecal Coliforms	<1 cfu/100 mL	>99.999%

[3] Buzzards Bay Test Facility Report

Waterloo Biofilter Systems Inc.

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www.waterloo-biofilter.com

Ball's Falls CONSERVATION AREA

NIAGARA PENINSULA CONSERVATION AUTHORITY

LEED®-NC Gold Certified

Owner:
Niagara Peninsula Conservation Authority

Architect:
MacDonald Zuberec Ensslen Architects Inc.

LEED Consultant, M/E Engineers, Commissioning Agent, Monitoring & Verification:
Enermodal Engineering Ltd.

Structural Engineer:
Lee Yung & Associates

Civil Engineer:
MTE Consultants Inc

Contractor:
Merit Contractors

Landscape Architect:
Niagara Peninsula Conservation Authority

Ball's Falls Centre for Conservation

Jordan, Ontario

PHOTO CREDIT MZE/STEPHEN DOMINICK

Ball's Falls Conservation Area is one of the premier parks in the Niagara Peninsula Conservation Authority's open space system, and is frequented by thousands of visitors each year. The Centre for Conservation is part of the Ball's Falls experience. Through design features and day-to-day operations, this building is a living demonstration of conservation initiatives, a place where visitors can observe energy and water conservation in action.

The building design is sensitive to the natural environment and yet meets all the requirements of a contemporary education centre. Key design features include the following:

- three 44 m^3 cisterns
- on-site sewage treatment
- extensive landscaping using local plant species
- a ground source heat pump system for heating and cooling
- non-polluting materials, finishes, and furnishings

Reducing the Impact of Urban Development

The Centre for Conservation is a protected natural area within a rapidly urbanizing region. Many measures were taken to reduce the impact of building construction and operation on local habitats. Exterior lighting will not spill onto neighbouring properties or into natural areas. A reflective metal roof and a gravel parking lot will not contribute to the warming urban atmosphere.

Several measures on the construction site prevented soil erosion and thus sedimentation impacts in the nearby river. Stormwater runoff is reduced by the use of three 44 m^3 rainwater cisterns. Cistern overflow is directed through a grassy swale and into a nearby wooded area where the water is filtered and absorbed by the soil.

ENERMODAL ENGINEERING
Creating energy and resource efficient buildings

From Source to Treatment, Not a Drop is Wasted

Water conservation is a vital concern in the Niagara Region, where water supplies can be scarce, and thus careful water use was a guiding principle during building design. An outdoor irrigation system was eliminated through the use of native landscaping plants. Indoors, water-conserving plumbing fixtures were used throughout the Centre. Rainwater stored in cisterns is used for toilet flushing, further reducing the use of treated water.

All wastewater is treated by an innovative sewage treatment system called a Waterloo Biofilter. The environmental impacts of the system are significantly less than those associated with conventional septic systems. The resulting effluent is of higher quality, requires less space, and does not require a sand bed.

These measures result in a remarkable 87% reduction in water use.

Ground Source Heat Pump System

The earth itself is an integral part of the Centre's mechanical system. Ground source heat pumps use the latent warmth of the earth in winter to heat the building. There are many times when the air in one section of the Centre will be warmed by sunlight entering through large windows. At these times, the heat pump system will move this warmed air to cool parts of the building, and this eliminates the need for mechanical heating.

During the summer, excess heat from the building will be exhausted to the underground heat pump tubing instead of to the outdoors. This eliminates much of the need for a mechanical air conditioning system.

Other energy conservation measures include high efficiency lighting, energy recovery ventilators, and a well-insulated building envelope. The Centre is expected to achieve a 62% annual energy savings.

The Environment Indoors

The Centre for Conservation is primarily a public education centre, and thus the quality of the indoor environment—air quality, daylighting, temperature and humidity control—is very important.

Measures taken during construction prevented contaminants from entering the indoor air stream. Construction materials and furnishings were selected for low toxicity. These materials include adhesives, sealants, paints, carpet, composite wood, and laminates. Furnishings are GREENGUARD certified.

Adjustable air inlets allow for individual control over workplace air temperature and volume, and over light levels (from natural and artificial lighting). The Centre has abundant natural lighting through large windows that also provide wide-angle views of beautiful landscaping. Light levels are controlled by both occupancy and daylighting sensors.

For more information, contact
Enermodal Engineering Limited
LEED Consultant
info@enermodal.com

ENERMODAL ENGINEERING
Creating energy and resource efficient buildings

US EPA Environmental Technology Initiative

Onsite Wastewater Technology Testing Report

Massachusetts
Alternative
Septic
System
Test
Center

Massachusetts Alternative Septic System Test Center
Air Station Cape Cod, Massachusetts 02542
Telephone: 508-563-6757
MASSTC@cape.com

-- August, 2004 --

Waterloo Biofilter®

Technology Vendor

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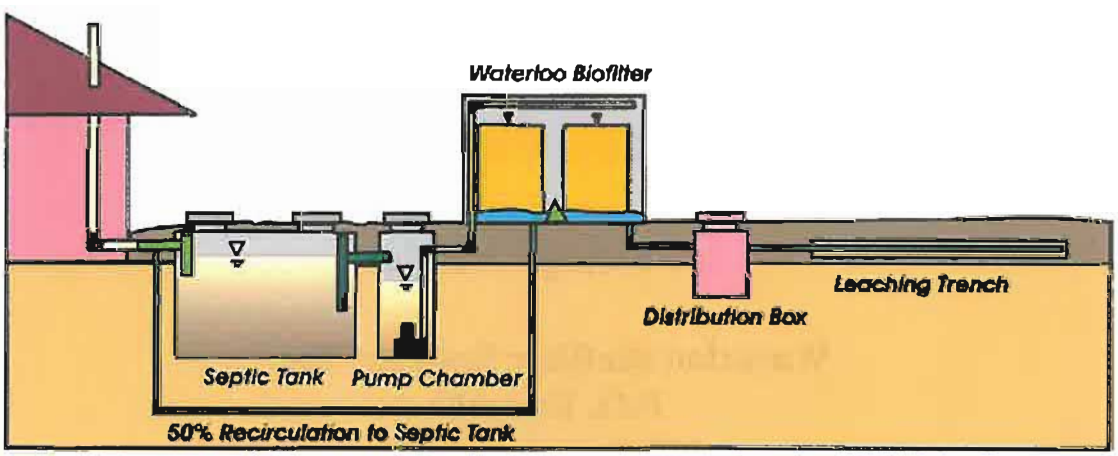
Rockwood, ON N0B 2K0 Canada
Telephone: 519-856-0757
Facsimile: 519-856-0759
www.waterloo-biofilter.com

1. Technology description

General
The Waterloo Biofilter® belongs to a broad class of treatment units called trickling filters. When used in denitrifying systems, the filters are generally configured so as to return a portion of the filtrate to the septic tank, while the remaining portion flows forward to a soil absorption system.

Components
As installed and tested at MASSTC the technology consisted of a 1,500 gallon concrete septic tank, a 20-in diameter pump chamber and a Waterloo Biofilter. As Tested, a cylindrical, plastic mesh basket containing man-made fibers was suspended in the septic tank liquid. One Zabel model A100 effluent filter was fitted to the septic tank outlet tee. The pump chamber was Zabel cylindrical 50-gallon polyethylene unit, containing a pump and two control floats. The demand control panel was fitted with visual and audible



alarms. The Biofilter® was a foam-insulated cedar, above-ground unit, 8'l x 4'w x 5'h, of 160 cu ft total volume and contained approximately 108 cu ft of filter medium. The five foot tall containment of the trickling filter was buried to a depth of one foot with four feet exposed. The trickling filter was insulated on the interior surfaces and contained two, five-foot high reinforced plastic mesh cylinders about forty-five inches in diameter. These cylinders contained and supported a column of foam media. The volume of each foam cylinder was approximately 54 cu ft. A schema of a general installation is given below.

Siting Considerations and Installation Notes
The Biofilter® may be installed above grade, as it was for this testing, or the Biofilter® may be installed flush to grade at sites which have suitable topography and depth to the water table so the septic tank may be set deeply enough to permit gravity return flow from the Biofilter®. Below ground installations may use concrete tanks with a proper access opening, 2' x 4'. Alternately, a pump may be used in the Biofilter tank to maintain

a free-draining condition. The pressure manifold atop the filter must be self-draining to prevent freezing. Above ground wooden enclosure installations should consider treatment for carpenter ants and burrowing insects. An approved effluent tee filter should be installed in the septic tank. Above-ground units can have varying heights of the containment structure exposed above grade depending on land topography. The units include an electrical panel with a visual and audible alarm. Configuration of the installed system will depend upon the individual site characteristics and the manufacturer's recommendations. Dosing of the filter can be on demand, as tested, or by timer. If the system is designed for timed dose, a larger pump chamber is required.

Theory of Operation

Wastewater from a source (in most instances a residence) enters a standard septic tank. The septic tank effluent then flows by gravity to a pump chamber which is variously sized. An effluent filter on the outlet of the septic tank prevents the passage of large solids (>1/16") from entering the pump chamber. Within the septic tank, a portion of the solids are settled out, and the organic nitrogen is converted to the reduced mineral form of ammonium (NH_4^+). From the pump chamber the effluent is dispersed over the foam media. The foam is proprietary open-cell foam cut into 2" x 2" blocks and placed in random attitude in the containment structure.

As the effluent percolates through the foam media, the consumption of the organic matter by microbes occurs. An overall reduction in the Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS) occurs and the ammonium is oxidized into first nitrite (NO_2^-) and then nitrate (NO_3^{-2}). Some microzones within the foam cubes that have the prerequisite anoxic conditions for denitrification result in the conversion of some of the nitrate to nitrogen gas (N_2). At the bottom of the foam-media containment structure the percolate is divided by a dam that diverts approximately 50% of the percolate forward toward the soil absorption system. The reminder of the percolate (again approximately 50 %) is diverted back to the septic tank. Within the septic tank, the prerequisite anoxic conditions results in further denitrification of the wastewater. The process is purportedly enhanced by the substrate provided within the cylindrical basket containing man-made fiber.

2. Costs

Installation

The manufacturer claims that the Waterloo Biofilter® components including installation as installed at the MASSTC are $7,350 and to these costs should be added other conventional system costs for this installation of approximately $7,000. The cost of installation for any treatment technology is very dependent upon the particular site conditions, so readers should use the above estimates as approximations of average costs.

Design and permitting costs vary with the site conditions.

Electric usage
Average electric usage by the three units was 2.43 kW per day per unit or about $.27 per day at $.10 per kW; monthly this comes to $7.20 per month, and $86.20 per year. By comparison with other technologies at MASSTC, this electric cost is the lowest cost of the technologies tested at MASSTC (generally $8-$30 /month).

Maintenance
Massachusetts requires that all alternative technologies have a service contract in force for the life of the installation. Costs for this service vary but are approximately $400 per year. The service includes inspection of pumps, alarms, controls, fan, effluent filter, and septic tank sludge depth. Septic tanks are pumped at a frequency based on usage, but an approximate cost is $60 per annum.

Replacement parts
Pumps have a one year warranty; replacement cost is about $300. The medium is claimed to last 30 years, but may require cleaning at 10-15 year intervals ($300-$800 cost to add or replace media).

Other costs
Quarterly effluent quality monitoring is required for some permits at a cost of $300 or more annually, however this cost ends after 18 months of operation for residential installations.

3. ETI Testing Protocols Synopsis

The testing duration was for two years. The technology was installed in triplicate, with identical components. The Waterloo Biofilter® received wastewater at the rate of 330 gallons per day, throughout the two-year testing period. The 330 gallon per day volume is the Massachusetts Department of Environmental Protection (MA DEP) minimum design flow for a new residential house of three bedrooms or less.

Delivery of the wastewater was apportioned into fifteen equal doses of 22 gallons each, on a schedule which was designed to mimic the pattern of wastewater use in a typical residence (see ETI QAPP and NSFI/AJNSI Standard 40). Periodic calibration of dose volumes delivered to each technology ensured equal dosing to each replicate and to different technologies.

Effluent from the technology flowed to a distribution box with four outlets. Three of the four outlets directed effluent to a facility sewer, and the fourth conveyed treated effluent to a one-quarter sized soil absorption system (SAS), designed to MA DEP rules. Lysimeters were installed at depths of one, two and five feet beneath the SAS to collect leachate for analysis. A polyethylene liner with sump collected all leachate from the three technology replicates.

The technologies were sampled at two-week intervals. During each sampling event, technology influent wastewater was sampled at the common dosing channel. Technology effluent was sampled at the distribution box. Influent wastewater and technology effluent were sampled using automated samplers, programmed to obtain fifteen flow-weighted samples composited over a twenty four hour period. Initiation of the individual samples was timed with a delay, to the influent wastewater dosing schedule for each technology.

Composite samples were kept refrigerated at 4 degrees centigrade either by ice packed in the sampler or by use of a refrigerated sampler. Upon completion of the sampling schedule samples were processed at the MASSTC. Analysis for pH and specific conductance were conducted at MAASTC during sample processing. Subsamples for BOD_5 and fecal coliform were sent to the Barnstable County Department of Health and the Environment laboratory. Subsamples for nitrogen and phosphorus analysis: ammonium (NH_4), nitrate plus nitrite (NO_x), dissolved organic nitrogen, (DON), particulate organic nitrogen (PON), alkalinity, orthophosphate (PO_4), total suspended solids (TSS) and total phosphorus (TP); were sent to the School for Marine Science University of Massachusetts, Dartmouth (SMAST).

Electrical usage by each technology was measured by an electric meter and recorded monthly.

Mechanical and other non-quantitative performance monitoring
Alarms, mechanical failures, unusual sounds, smells were recorded in a log book as they occurred. Restorative measures taken by the technology vendor to address non-normal conditions were also recorded and appear in the Section 6 of this report.

Technology operating history
The three Waterloo Biofilter® units were started up on June 7, 1999. Units 1 and 2 were operated continuously for the two-year test period with a last sampling date of June 5, 2001. Data was not collected from Unit 3 after November 28,2001, as Unit 3 was removed from service in December 2000, in order to begin another testing protocol US EPA ETV in February 2001.

4. Testing Objectives

The Waterloo Biofilter® was tested to demonstrate nitrogen removal for use in Massachusetts watersheds which are nitrogen sensitive. Technologies must be able to demonstrate reduction of average total nitrogen levels to below 19 mg/l. Waterloo Biofilter® systems also sought to obtain Massachusetts approvals for higher hydraulic loading rates in soil absorption systems (SAS) which are granted to technologies able to achieve average BOD_5 and TSS levels below 30 mg/l. Waterloo Biofilter® also sought to obtain Massachusetts approvals for reduction in the groundwater separation distance for SAS which are also based upon average BOD_5 and TSS levels below 30 mg/l.

5. Contaminant Removal Performance Summary for the Waterloo Biofilter®

Note: Technologies were allowed a start-up period, when measures of removal performance would be excluded from the test period. We define the start-up period as ending when the technology attains effluent levels below 30 mg/l BOD_5; 30 mg/l TSS; and 19 mg/l TN. These levels are performance thresholds for alternative systems set by MA DEP.

The data from all three units from the second sampling event attained levels below 30/30/19 mg/l, so that only the first sample event was excluded under the start-up period rules.

Biochemical Oxygen Demand (BOD_5) removal

BOD_5 measured in the technology effluent averaged 9.3 mg/l (median, 8.0 mg/l) over the monitoring period, versus 175 mg/l for influent wastewater, representing a removal rate of 95 per cent (Table 1, Appendix 1 & 2)). Measurements exceeded the threshold 30 mg/l level only 2% of the time (3 samples out of 124 taken). Standard deviation, reflection of the variability of the performance was relatively low; an indication that the technology was able to provide good removal performance consistently over the testing period.

Table 1. Biochemical Oxygen Demand (5-day) removal performance of the Waterloo Biofilter® system during testing at the Massachusetts Alternative Septic System Test Center - June 1999- June 2001.

BOD (mg/l)	Replicate 1	Replicate 2	Replicate 3	Influent	Mean	%Removal
Average	9.7	8.9	9.1	174.5	9.3	94.7%
Median	9.0	7.5	8.0	162.0		
Standard Deviation	6.0	6.7	8.1	59.8		
Maximum	28.0	36.0	36.0	385.0		
Minimum	1.0	1.0	1.0	83.0		
Count	46	46	32	46		
Count> 30 mg/l	0	1	2			

The three maximum values occurred in May 2000. At that time, in all three units the baskets supporting the foam cube media tilted and slumped. This movement displaced the distribution manifold, causing some of the spray of septic tank effluent to miss the media column and hit the enclosure walls and short-circuit to the discharge point. Thus with each pressure dose, a portion of the technology effluent was not fully treated by the filter media, with resultant poorer effluent quality. Waterloo Biofilter® personnel repaired the baskets and subsequent samples show an improvement in the effluent quality (Appendix 1 &2) until the period January – March 2001 when levels rose above 20 mg/l. We interpret this decline as a seasonal effect: lower influent wastewater temperature and ambient air temperature slow biological activity and thus degrade performance. Waterloo Biofilter now uses rigid baskets or bulk filter tanks to avoid problematic slumping.

Total Suspended Solids (TSS) removal.

Total Suspended Solids (TSS) measured in the technology effluent averaged 6.2 mg/l (median 4.0 mg/l) over the monitoring period, versus 160 mg/l for influent wastewater, representing a removal rate of 96 per cent (Table 2).). Measurements exceeded the threshold 30 mg/l level less than 2% of the time (2 out of 118 samples taken). Standard deviation, a reflection of the variability of the performance was relatively low, an indication that the technology was able to provide good removal performance consistently over the testing period.

Table 2. Total Suspended Solids (TSS) removal performance of the Waterloo Biofilter® system during testing at the Massachusetts Alternative Septic System Test Center - June 1999- June 2001.

TSS (mg/l)	Replicate 1	Replicate 2	Replicate 3	Influent	Mean	%Removal
Average	6.7	6.1	5.5	160	6.2	96.2%
Median	3.5	4.0	3.0	161		
Standard Deviation	6.6	7.6	6.7	55		
Maximum	26.0	46.0	31.0	323		
Minimum	0.0	1.0	0.0	47		
Count	44	45	29	44		
Count> 30 mg/l	0	1	1	44		

As with the BOD results above, the three maximum values occurred in May 2000 and the causes were also basket slumping. When the baskets were repaired subsequent samples show an improvement in the effluent quality (Figure 2) until the period January–April 2001 when levels rose to level of 20-21 mg/l. Again this decline in efficiency appears to be a seasonal effect: lower influent wastewater temperature and ambient air temperature slow biological activity and thus degrade performance.

Nitrogen removal

Total nitrogen (TN) measured in the technology effluent averaged 14.4 mg/l (median, 13.9 mg/l) over the monitoring period, versus 35.0 mg/l for influent wastewater, representing a removal rate of 59 per cent (Table 3). TN measurements exceeded the threshold 19 mg/l level 13% of the time (16 out of 124 samples taken), principally in Unit 2.

Units 1&3 had very good nitrogen removal performance, 11.9 and 13.2 mg/l TN respectively, with only one sample above 19 mg/l. While the performance of Unit 2 was similar to Units 1&3 through the first 14 months of testing (Table 4), performance deteriorated for the final 10 months (Appendix 1 &2). The single high value of 46.30 mg/l for Unit 2 recorded September 6, 2000 was higher than average influent TN, of 35.21 and deserves comment. Upon rechecking the data source, we found no reason to

Table 3. Total Nitrogen removal performance of the Waterloo Biofilter® system during testing at the Massachusetts Alternative Septic System Test Center - June 1999- June 2001.

Total Nitrogen (mg/l)	Replicate 1	Replicate 2	Replicate 3	Influent	Mean	%Removal
Average	11.9	17.8	13.2	35.0	14.4	58.8%
Median	12.6	16.7	12.5	34.4	13.9	
Standard Deviation	3.4	6.3	2.5	3.6		
Maximum	19.8	46.3	18.7	46.3		
Minimum	4.8	7.5	9.9	28.4		
Count	46	46	32	46		
Count > 19 mg/l	1	15	0			

exclude this value. Another higher value, 54.56 mg/l for Unit 2 TN was measured on July 2, 2001 (after the 2 year testing cycle was complete) so the value was not an anomaly. Both BOD and TSS data for Unit 2 were consistent with the other units throughout the test period.

The NH_4 data for all three units for the testing period show a seasonal rise in ammonium in both years, but both Units 1&2 showed higher NH_4 values in the second winter, with Unit 2 showing variably elevated NH_4 levels during the final ten months. The higher levels in the second winter indicate increasingly incomplete nitrification in the Biofilter®. Higher NH_4 levels can indicate flow short-circuiting within or without the media column, poor distribution of spray on the filter, or poor oxygenation of spray and of liquid on the media surface. Spray nozzles were changed to a new design October 14, 2000 in all three units and this may have affected the nitrification in the filter units.

Fecal Coliform Removal
Fecal coliform is often used as a surrogate measure of public health significance. Wastewater treatment systems that remove fecal coliform are thought to concurrently reduce the discharge of human pathogens. In general, the Waterloo Biofilter removed >99% of the fecal coliform in the influent (Table 4).

Table4. Fecal Coliform removal performance of the Waterloo Biofilter® system during testing at the Massachusetts Alternative Septic System Test Center. June 1999- June 2001.

Fecal Coliform CFU/100 ml	Replicate 1	Replicate 2	Replicate 3	Influent	Mean	%Removal
Log Mean	2.6E+04	3.0E+04	1.3E+04	2.7E+06	2.2E+04	99.2
Maximum	7.5E+05	4.3E+05	2.4E+05	2.6E+07		
Minimum	8.0E+02	5.0E+02	2.0E+02	1.0E+04		

6. Operation and Maintenance Monitoring – Waterloo Biofilter®

Slumping of the basket support structures:
Slumping of the basket support structures occurred in all three units at about the same time, month ten. This problem did not recur during the rest of the test period. Waterloo Biofilter® claimed that the filter enclosures were shipped with incorrectly sized baskets. Some of the support for the baskets is provided by the enclosure. Since the baskets were too small, the added space around the baskets allowed the baskets to lean and then slump. Waterloo Biofilter® units are now all equipped with rigid support for the foam media as a response to this problem.

Spray nozzle clogging
Clogging of the plastic spray nozzles occurred on seven occasions between start-up and October 14, 2000 when the spray nozzle design was changed from a helical spray head to a splash plate design similar to a fire sprinkler. After that alteration, clogging of nozzles did not recur. A high water alarm typically announced a problem with the nozzles.

Septic tank effluent filters
The Zabel effluent filters needed cleaning on August 28,2000, about 14 months after start-up. There was about a 1.5-inch fall in the septic tank level after removing the filter for cleaning on August 28, 2000, confirming the need to clean the Zabel filter. The 14-month interval between filter cleaning is consistent with the hydraulic load of 330 gallons per day. This volume is about 1.5 to 2 times higher than the average household usage of 100-200 gallons per day, and should also shorten the maintenance interval for cleaning the effluent filter. In Massachusetts servicing is required at quarterly intervals, and we

recommend that checking and cleaning the effluent filter should normally be a part of the service/maintenance procedure.

Biofilter® Enclosure integrity

Enclosures were fitted with hinged wooden access covers. The hinge fasteners (screws) were inadequate to the stresses placed upon them and stripped out on Unit 1 (August 4, 2000).

Noise

The primary source of noise from the system is the sound of water being sprayed upon the filter media. Noise levels were measured on 2/27/00 using a quest Model 2700 Sound Level Meter calibrated by factor on 2/23/00 (NIST Traceable) using slow response and A weighting. Levels were recorded 20 feet from the unit 4 feet above grade. Recorded levels averaged 38.9 db. Some of the sound measured was contributed by an adjacent technology. These levels were equivalent to background levels at the test site at the time of measurement.

Ease of maintenance

Components which may require maintenance, such as the pump, the fan, the filter media, the spray heads and spray manifold and the effluent filter were relatively easy to access for servicing with one exception. The Biofilter® unit access cover was heavy because of its size, and had to be propped open with a stick or other object, and due to its weight presented a hazard to the service person. Waterloo Biofilter now uses smaller, lighter-weight covers with large hinges secured by bolts to address these problems.

APPENDIX 1

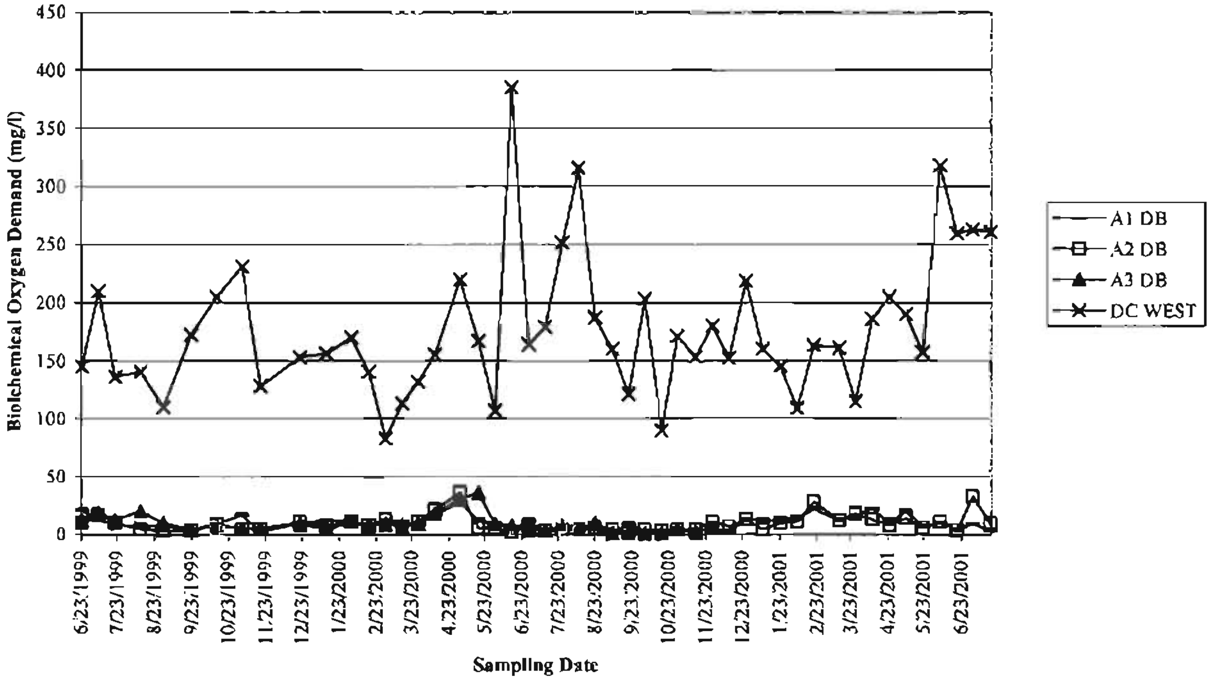
Graphs of Major Wastewater Constituents At Discharge

Waterloo Biofilter®

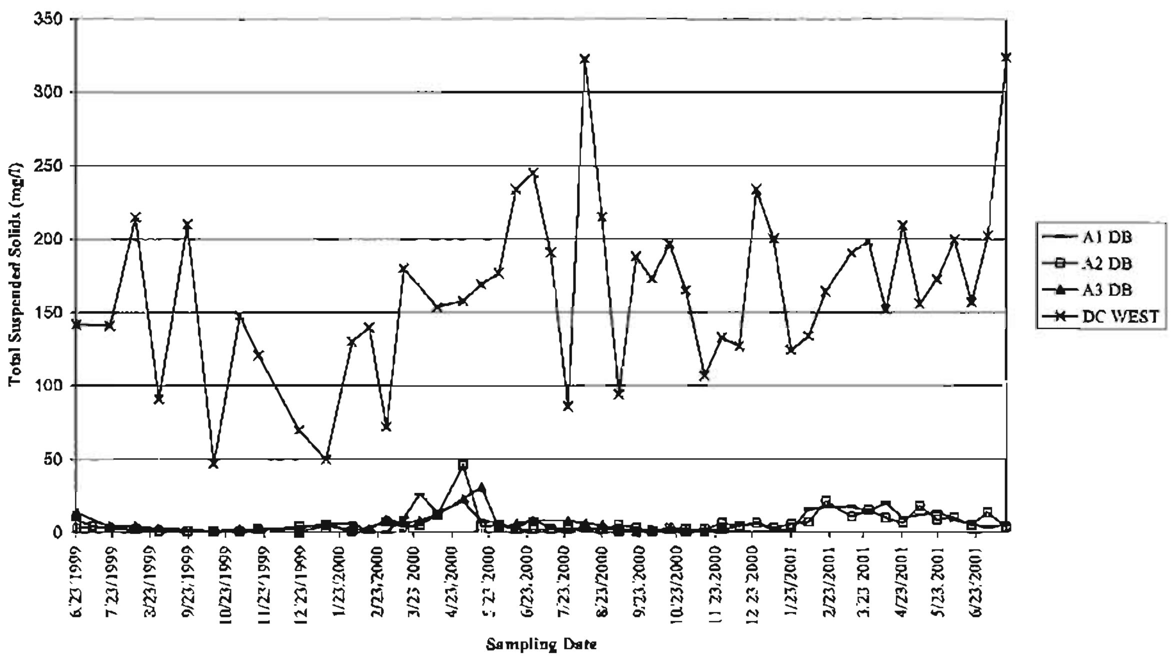
Technology Vendor

Waterloo Biofilter Systems, Inc.
P.O. Box 400
143 Dennis Street
Rockwood, ON N0B 2K0 Canada
Tel: 519-856-0757
Facsimile: 519-856-0759
www.waterloo-biofilter.com

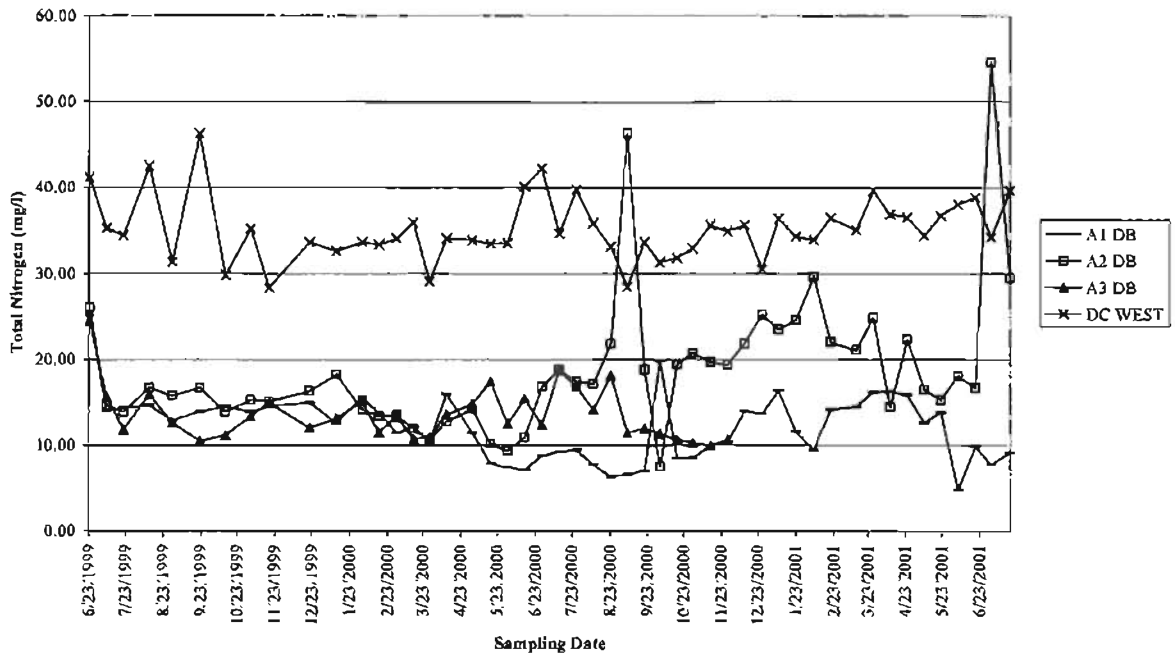
BOD(5day) Concentrations of Waterloo Biofilter Discharge vs. Influent During Testing at the Massachusetts Alternative Septic System Test Center June 1999 - June 2001. A1 DB, A2 DB, A3 DB = Replicates 1-3 respectively, DCWEST = Influent



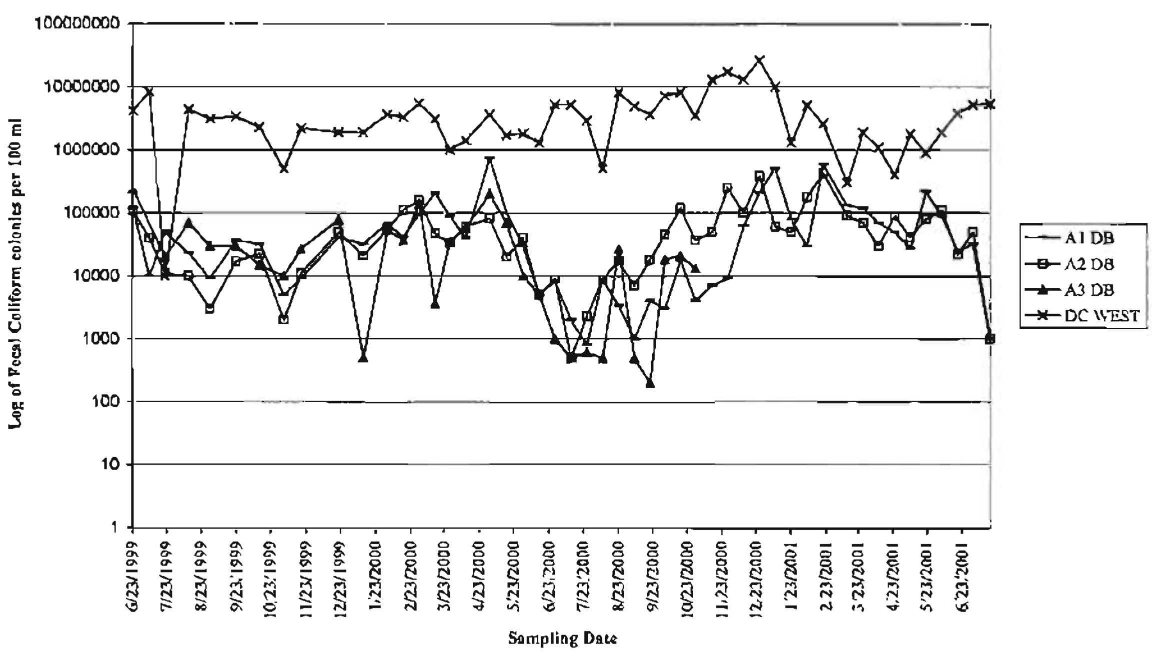
Total Suspended Solids Concentrations of Waterloo Biofilter Discharge vs. Influent During Testing at the Massachusetts Alternative Septic System Test Center June 1999 - June 2001. A1 DB, A2 DB, A3 DB = Replicates 1-3 respectively, DCWEST = Influent



Total Nitrogen Concentrations of Waterloo Biofilter Discharge vs. Influent During Testing at the Massachusetts Alternative Septic System Test Center June 1999 - June 2001. A1 DB, A2 DB, A3 DB = Replicates 1-3 respectively, DCWEST = Influent



Fecal Coliform Densities of Waterloo Biofilter Discharge vs. Influent During Testing at the Massachusetts Alternative Septic System Test Center June 1999 - June 2001. A1 DB, A2 DB, A3 DB = Replicates 1-3 respectively, DCWEST = Influent



APPENDIX 2

Tables of All Wastewater Constituents Monitored in Conjunction with Testing

Waterloo Biofilter®

Technology Vendor
Waterloo Biofilter Systems, Inc.
P.O. Box 400
143 Dennis Street
Rockwood, ON N0B 2K0 Canada
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Key:

A1DB, A2DB, and A3DB represent the discharges of units #1-3 accordingly
ASU = Sump data – a composite collection in a sump situated beneath all three soil absorption systems.

A1 1 FT, A1 2 FT, A1 5 FT – Pan lysimeters collections beneath the A1 soil absorption system at 1 ft, 2 ft, and 5 ft respectively. Similar for system A2 and A3.

DCWEST – samples at the relevant influent location.

Location	Date	pH	Alkalinity (mg/l)	BOD5 (mg/l)	FC #/100 ml	DON (mg/l)	NH_4 (mg/l)	NO_x (mg/l)	PON (mg/l)	Total Nitrogen (mg/l)	POC (mg/l)	PO_4 (mg/l)	TP (mg/l)	Sp Cond (uS)	TSS (mg/l)
DC WEST	6/9/99	7.30	205.0	108	1.9E+06	0.5	27.0	0.10	6.5	34.1	64.6	3.4	5.3	518	135
DC WEST	6/23/99	7.39	192.0	145	4.2E+06	2.4	30.8	0.03	8.0	41.2	63.8	3.9	5.5	485	142
DC WEST	7/7/99	7.21	171.0	210	8.4E+06	1.0	23.1	0.03	11.2	35.3	97.0	3.9	5.0	418	
DC WEST	7/21/99	7.24	190.0	136	1.0E+04	1.4	26.7	0.08	6.4	34.4	63.1	3.7	5.4	503	141
DC WEST	8/11/99	7.31	185.0	140	4.4E+06	0.5	31.6	0.13	10.3	42.5	95.3	4.2	6.1	573	215
DC WEST	8/30/99	7.28	172.0	110	3.1E+06	1.6	24.7	0.06	5.0	31.3	43.7	3.7	4.8	516	91
DC WEST	9/22/99	7.47	195.0	172	3.4E+06	0.3	35.9	0.00	10.1	46.3	92.9	4.3	5.7	569	210
DC WEST	10/13/99	7.18	163.0	205	2.3E+06	1.8	24.7	0.00	3.3	29.8	31.6	3.4	4.8	488	47
DC WEST	11/3/99	7.33	175.0	231	5.0E+05	3.9	24.3	0.04	7.0	35.2	65.2	3.3	4.9	594	148
DC WEST	11/18/99	7.48		128	2.2E+06		23.0	0.05	5.3	28.4	52.2			585	121
DC WEST	12/14/99	7.33	173.0	168	3.4E+06	0.0	29.2	0.09	5.2	34.5	58.2	3.6	5.3	550	151
DC WEST	12/21/99	7.38	182.0	153	1.9E+06	3.5	26.2	0.04	3.8	33.6	35.9	3.6	5.8	582	70
DC WEST QA	12/21/99	7.36	179.0	182	2.0E+06	1.3	27.9	0.05	3.9	33.1	32.4	3.7	5.8	514	64
DC WEST	1/12/00	7.46	180.0	156	1.9E+06	1.0	27.9	0.07	3.7	32.6	28.0	3.8	5.3	552	50
DC WEST	2/2/00	7.35	147.0	170	3.7E+06	3.2	24.9	0.02	5.6	33.7	72.5	3.7		514	130
DC WEST QA	2/2/00		149.0	127	1.5E+06	2.1	26.4	0.04	5.7	34.1	58.9	3.3			96
DC WEST	2/16/00	7.54	168.0	140	3.3E+06	3.6	22.8	0.06	6.9	33.4	70.3	3.0		548	140
DC WEST	2/23/00	7.35	164.0	107	9.0E+05	2.9	22.3	0.10	5.3	30.6	50.2	2.9		1000	112
DC WEST	3/1/00	7.43	171.0	83	5.4E+06	3.1	23.5	0.02	7.4	34.0	78.5	3.1	5.9	575	72
DC WEST	3/8/00	7.31	176.0	146	1.8E+06	2.2	25.5	0.01	8.5	36.2	94.9	3.0	5.2	540	200
DC WEST	3/15/00	7.28	179.0	113	3.1E+06	3.0	23.1	0.12	9.7	35.9	91.9	3.4	4.5	595	180
DC WEST	3/28/00	7.45	157.0	132	1.0E+06	2.8	22.0	0.04	4.1	29.1	33.4	2.9	5.5	555	
DC WEST	4/11/00	7.47	170.0	155	1.4E+06	2.6	22.7	0.12	8.7	34.0	72.1	2.7	5.6	561	154
DC WEST	4/19/00	7.81	159.0	345	1.2E+06	3.8	22.7	0.09	7.3	33.9	71.4	3.5		552	232
DC WEST	5/2/00	7.47	158.0	220	3.7E+06	3.8	22.7	0.09	7.3	33.8	71.4	3.5	5.7	552	158
DC WEST	5/17/00	7.43	167.0	167	1.7E+06	3.6	22.1	0.07	7.6	33.4	74.1	2.8	3.9	561	169
DC WEST QA	5/17/00		147.0	180	1.5E+06	4.3	21.8	0.06	8.2	34.3	78.5	2.8	3.9		172
DC WEST	5/31/00	7.50	170.0	107	1.8E+06	5.1	20.3	0.14	8.0	33.5	80.0	2.7	4.9	566	177
DC WEST	6/14/00	7.13	129.0	385	1.3E+06	0.1	30.0	0.19	9.8	40.1	106.9	3.7	5.4	577	234
DC WEST	6/28/00	7.27	163.0	164	5.2E+06	6.1	24.5	0.21	11.4	42.3	112.9	3.7	5.8	655	245
DC WEST	7/12/00	7.04	60.4	179	5.2E+06	1.4	23.9	0.05	9.3	34.7	93.2	2.4	3.5	528	191
DC WEST	7/26/00	7.46	189.0	252	2.9E+06	4.2	29.0	0.03	6.6	39.8	58.3	4.4	6.1	657	86
DC WEST QA	7/26/00		188.0	283	4.0E+05	6.1	26.0	0.06	7.9	40.0	63.7	4.1	6.5		141
DC WEST	8/9/00	7.25	169.0	316	5.0E+05	4.9	19.7	0.10	11.1	35.8	162.5	3.2		592	323
DC WEST	8/23/00	7.30	151.0	187	8.0E+06	0.0	23.1	0.04	10.0	33.1	109.2	3.4	5.5	606	215

Location	Date	pH	Alkalinity (mgl)	BOD5 (mg/l)	FC #/100 ml	DON (mg/l)	NH_4 (mg/l)	NO_x (mg/l)	PON (mg/l)	Total Nitrogen (mg/l)	POC (mg/l)	PO_4 (mg/l)	TP (mg/l)	Sp Cond (uS)	TSS (mgl)
DC WEST QA	8/23/00	7.38	158.0	174	8.5E+06	6.5	24.4	0.04	11.5	42.5	139.3	3.2	4.9	650	272
DC WEST	9/6/00	7.50	144.0	160	4.9E+06	0.2	21.1	0.02	7.1	28.4	54.9	2.6	4.2	610	94
DC WEST	9/20/00	7.36	127.0	121	3.6E+06	2.6	21.4	0.00	9.7	33.7	86.7	3.0	5.3	544	188
DC WEST	10/3/00	7.24	139.0	203	7.1E+06	0.6	23.0	0.04	7.8	31.3	82.4	3.5	5.3	604	173
DC WEST QA	10/3/00	7.51	137.0	150	7.2E+06	0.4	25.7	0.02	8.6	34.6	86.7	3.7	5.3	608	184
DC WEST	10/17/00	7.09	189.0	90	8.1E+06	0.6	21.5	0.09	9.6	31.8	85.8	2.7	4.9	549	197
DC WEST	10/30/00	7.32	156.5	171	3.5E+06	3.6	21.1	0.08	8.1	32.9	80.3	2.9	3.4	463	165
DC WEST	11/14/00	7.29	163.5	153	1.3E+07	4.7	23.8	0.03	7.1	35.6	53.1	3.0	5.1	486	107
DC WEST	11/28/00	7.45	184.5	180	1.7E+07	3.8	24.5	0.01	6.6	34.9	65.0	3.2	4.8	538	133
DC WEST	12/12/00	7.57	183.5	152	1.3E+07	1.8	27.1	0.03	6.7	35.7	60.5	3.1	4.6	558	127
DC WEST QA	12/12/00	7.59	185.0	144	1.5E+07	0.3	27.2	0.04	6.0	33.5	52.3	3.3	4.4	565	112
DC WEST	1/9/01	7.56	180.0	160	1.0E+07	5.5	22.6	0.08	8.2	36.4	84.9	3.6	4.6	555	200
DC WEST	1/23/01	7.56	184.5	138	1.3E+06		27.1	0.05	7.1	34.3	69.9	3.6	4.9	514	123
DC WEST	2/6/01	7.53	179.5	109	5.1E+06	3.2	24.0	0.05	6.7	33.9	71.5	3.3	4.5	775	134
DC WEST	2/20/01	7.45	185.5	163	2.6E+06	5.5	23.5	0.05	7.5	36.5	74.2	3.5	4.9	526	164
DC WEST	3/13/01	7.43	169.5	114	3.0E+05	2.6	24.0	0.08	8.4	35.1	84.9	3.6	5.8	977	191
DC WEST QA	3/13/01	7.45	171.5	168	7.0E+05	2.9	24.0	0.08	8.4	35.4	85.0	3.6	5.7	993	191
DC WEST	3/27/01	7.48	177.5	115	1.9E+06	3.3	26.9	0.06	9.3	39.6	89.1	3.6	5.4	837	199
DC WEST	4/10/01	7.48	181.5	186	1.1E+06	4.1	24.9	0.05	7.8	36.9	72.3	3.9	5.0	501	152
DC WEST	4/24/01	7.54	195.0	205	4.0E+05	1.0	26.6	0.06	8.9	36.5	88.0	3.2	5.1	533	210
DC WEST	5/8/01	7.60	174.0	190	1.8E+06	1 8	25.3	0.07	7.3	34.4	77.0	3.0	5.1	514	156
DC WEST	5/22/01	7.46	173.0	157	9.0E+05	2.1	27.0	0.04	7.6	36.7	83.1	3.8	3.9	526	173
DC WEST	6/5/01	7.59	187.0	318	1.9E+06	1.0	28.1	0.10	8.8	38.0	87.4	3.3	4.5	507	200
DC WEST	6/19/01	7.46	183.5	260	3.8E+06	1.5	29.6	0.02	7.7	38.9	71.6	3.3		526	157
DC WEST QA	6/19/01	7.47	186.0	281	1.0E+07	1.6	29.8	0.06	7 9	39 3	72.2	3.2		508	164
DC WEST	7/2/01	7.27	185.0	263	5.2E+06	5.2	19.9	0.04	9.0	34.2	88.5	3.2	3.8	539	202
DC WEST	7/17/01	7.22	188.0	261	5.4E+06	1.7	25.3	0.06	12.6	39.7	148.8	3.3	6.1	515	288

Location	Date	pH	Alkalinity (mgl)	BOD5 (mg/l)	FC #/100 ml	DON (mg/l)	NH_4 (mg/l)	NO_x (mg/l)	PON (mg/l)	Total Nitrogen (mg/l)	POC (mg/l)	PO_4 (mg/l)	TP (mg/l)	Sp Cond (uS)	TSS (mgl)
A1 DBOX															
A1 DB	6/23/99	7.65	150.0	21.0	1.2E+05	0.7	18.1	5.6	0.7	25.1	4.0	3.8	5.4	471	9.0
A1 DB	7/7/99	7.32	48.0	13.0	1.0E+04	0.2	0.3	13.2	0.3	14.0	1.6	3.7	4.8	349	4.0
A1 DB	7/21/99	7.28	57.0	8.0	5.0E+04	0.4	0.2	13.6	0.2	14.3	1.4	4.5	4.8	359	3.0
A1 DB	8/11/99	7.28	50.3	7.0	2.3E+04	0.4	0.1	14.0	0.2	14.6	1.0	4.3	4.8	407	2.0
A1 DB QA	8/11/99	7.36	50.0	8.0	2.8E+04	0.3	0.1	14.0	0.2	14.6	1.1	4.1	4.5	424	3.0
A1 DB	8/30/99	7.26	54.7	7.0	9.0E+03	0.2	0.2	12.5		12.9		4.4	5.3	412	
A1 DB	9/22/99	7.36	54.0	4.0	3.7E+04	0.5	0.1	13.3		13.9		4.1	4.4	418	1.0
A1 DB	10/13/99	7.29	63.0	9.0	3.2E+04	1.2	1.0	12.2	0.1	14.5	0.7	4.1	4.1	388	1.0
A1 DB	11/3/99	7.49	106.0	17.0	5.0E+03	0.7	0.2	12.9	0.0	13.8	0.2	4.0	4.1	446	
A1 DB	11/18/99	7.12	65.0	2.0	9.0E+03	0.6	0.4	13.5	0.1	14.6	0.9	4.0	4.0	446	2.0
A1 DB	12/21/99	7.21	65.0	10.0	4.1E+04	0.2	1.7	12.7	0.3	14.9	2.4	4.1	4.3	438	3.0
A1 DB	1/12/00	7.35	83.6	12.0	3.2E+04	1.1	3.2	7.6	0.6	12.5	3.2	4.4	4.6	462	6.0
A1 DB	2/2/00	7.09	50.4	12.0	6.6E+04	2.4	1.1	11.5	0.5	15.6	3.1	3.3		462	6.0
A1 DB	2/16/00	7.25	64.8	6.0	4.1E+04	1.9	1.7	9.9	0.2	13.7	1.8	4.2		462	1.0
A1 DB	3/1/00	7.34	71.6	12.0	9.5E+04	1.2	1.9	7.7	0.6	11.4	3.2	3.8	4.1	476	0.0
A1 DB	3/15/00	7.28	80.0	10.0	2.1E+05	0.5	2.5	8.4	0.7	12.1	4.5	4.2	4.7	404	10.0
A1 DB	3/28/00	7.41	78.4	8.0	9.0E+04	0.8	2.4	6.5	0.7	10.4	4.2	3.9	4.5	523	26.0
A1 DB	4/11/00	7.35	74.4	17.0	4.0E+04	1.3	1.6	12.2	0.9	16.0	5.7	5.2	5.8	464	14.0
A1 DB	5/2/00	7.38	70.4	28.0	7.5E+05	0.8	0.6	8.1	1.9	11.4	9.3	4.2		467	21.0
A1 DB	5/17/00	7.40	66.8	12.0	1.0E+05	1.5	0.1	5.7	0.6	7.8	3.3	4.2	5.4	417	8.0
A1 DB	5/31/00	7.52	80.0	9.0	3.0E+04	0.6	0.1	6.7		7.4		4.6	5.3	450	6.0
A1 DB	6/14/00	7.46	104.4	5.0	5.0E+03	0.7	0.3	5.9	0.2	7.1	1.2	4.7	5.1	427	3.0
A1 DB	6/28/00	7.27	82.0	11.0	8.0E+03	0.6	0.6	6.8	0.8	8.8	4.1	5.6	5.8	499	9.0
A1 DB	7/12/00	7.02	59.6	3.0	2.0E+03	0.7	0.1	8.2	0.2	9.2	1.2	5.0	5.0	419	3.0
A1 DB QA	7/12/00		58.8	4.0	2.0E+03	1.5	0.0	7.5	0.2	9.2	1.1	5.0	5.3		2.0
A1 DB	7/26/00	7.38	88.8	3.0	8.0E+02	0.9	0.0	8.3	0.1	9.4	0.7	5.2	5.4	426	2.0
A1 DB	8/9/00	7.38	98.8	4.0	8.8E+03	0.8	0.0	6.8	0.2	7.7	1.1	4.6		512	1.0

Location	Date	pH	Alkalinity (mgl)	BOD5 (mg/l)	FC #/100 ml	DON (mg/l)	NH_4 (mg/l)	NO_x (mg/l)	PON (mg/l)	Total Nitrogen (mg/l)	POC (mg/l)	PO_4 (mg/l)	TP (mg/l)	Sp Cond (uS)	TSS (mgl)
A1 DB	8/23/00	7.36	402.8	5.0	3.4E+03	1.8	0.5	3.8	0.2	6.3	1.3	3.9	4.2	490	3.0
A1 DB	9/6/00	7.77	89.2	1.0	1.0E+03	0.3	0.0	6.1	0.1	6.6	0.7	3.6	3.6	469	2.0
A1 DB	9/20/00	7.59	89.2	9.0	4.0E+03	0.1	0.0	6.8	0.1	7.0	0.5	3.8	3.8	402	1.0
A1 DB	10/3/00	7.38	87.6	2.0	3.0E+03	0.8	1.3	17.7	0.1	19.8	0.6	4.4	4.4	455	1.0
A1 DB	10/17/00	7.60	96.0	2.0	1.8E+04	0.5	0.0	7.8	0.1	8.4	0.5	3.6	3.9	451	1.0
A1 DB	10/30/00	7.45	68.5	4.0	4.0E+03	0.6	0.0	7.8	0.1	8.5	0.4	4.0	4.2	385	1.0
A1 DB	11/14/00	7.18	52.5	4.0	7.0E+03	0.5	0.0	9.4	0.0	9.9	0.3	3.0	3.5	362	0.0
A1 DB	11/28/00	7.31	72.5	3.0	9.0E+03	1.0	0.0	9.3	0.1	10.3	0.4	3.5	3.6	390	1.0
A1 DB	12/12/00	7.23	58.5	3.0	6.2E+04	0.7	0.8	12.4	0.2	14.0	0.9	3.2	3.2	465	5.0
A1 DB	12/26/00	7.26	81.5	12.0	2.1E+05	1.4	2.5	9.3	0.5	13.7	2.8	3.5	3.7	419	6.0
A1 DB	1/9/01	7.05	83.5	12.0	5.2E+05	1.7	4.9	9.6	0.2	16.4	1.0	3.7	4.0	456	1.9
A1 DB	1/23/01	7.09	82.5	12.0	8.0E+04	0.8	3.1	7.5	0.2	11.6	1.0	4.1	4.2	433	1.8
A1 DB	2/6/01	7.36	88.0	14.0	3.0E+04	1.1	3.4	3.7	1.2	9.4	6.7	3.8	3.8	450	15.9
A1 DB	2/20/01	7.29	100.0	22.0	5.9E+05	2.8	5.0	6.2	0.2	14.1	1.0	3.8	3.8	438	17.2
A1 DB QA	2/20/01	7.35	100.0	21.0	7.8E+04	2.3	4.6	6.9	1.7	15.4	8.9	3.9	4.0	454	18.1
A1 DB	3/13/01	7.17	92.0	12.0	1.3E+05	1.9	5.0	6.0	1.5	14.5	8.0	2.7	4.0	591	17.6
A1 DB	3/27/01	7.39	92.0	16.0	1.2E+05	1.7	5.3	7.6	1.6	16.2	8.3	3.9	4.1	400	14.5
A1 DB	4/10/01	7.56	89.0	22.0	7.0E+04	1.8	5.6	7.3	1.5	16.3	8.5	4.3	4.3	419	19.7
A1 DB	4/24/01	7.41	68.0	10.0	5.0E+04	2.5	0.8	11.9	0.6	15.9	4.0	4.5	4.7	422	9.8
A1 DB	5/8/01	7.21	70.0	20.0	2.8E+04	0.4	1.1	9.9	1.2	12.6	9.1	5.0	5.3	412	11.8
A1 DB	5/22/01	7.30	61.5	7.0	2.2E+05	1.0	0.4	11.6	0.8	13.8	6.3	4.9	4.9	388	14.3
A1 DB	6/5/01	7.37	84.5	10.0	9.0E+04	1.2	0.4	2.5	0.6	4.8	3.8	4.5	4.6	393	8.6
A1 DB	6/19/01	7.22	73.5	4.0	2.5E+04	3.2	0.3	6.1	0.3	9.9	2.4	5.4		373	5.8
A1 DB	7/2/01	7.14	85.0	9.2	3.2E+04	0.1	0.8	6.6	0.2	7.7	1.4	6.9	7.1	401	3.4
A1 DB	7/17/01	6.95	78.0	3.5	1.0E+03	0.6	0.0	7.9	0.5	9.1	2.2	4.9	5.0	399	5.5
A1 DB QA	7/17/01	6.97	74.5	3.8	2.0E+03	0.9	0.0	8.1	0.5	9.5	2.3	4.9	4.9	406	3.5

Location	Date	pH	Alkalinity (mgl)	BOD5 (mg/l)	FC #/100 ml	DON (mg/l)	NH_4 (mg/l)	NO_x (mg/l)	PON (mg/l)	Total Nitrogen (mg/l)	POC (mg/l)	PO_4 (mg/l)	TP (mg/l)	Sp Cond (uS)	TSS (mgl)
A2 DBOX															
A2 DB	6/23/99	7.60	148.0	10.0	1.1E+05	0.3	16.8	8.7	0.3	26.0	1.6	4.0	5.0	460	3.0
A2 DB	7/7/99	7.11	54.0	17.0	4.0E+04	0.1	0.3	13.9	0.3	14.7	1.7	3.9	4.7	344	4.0
A2 DB	7/21/99	7.30	62.0	10.0	1.1E+04	0.0	0.1	13.5	0.2	13.9	1.4	4.2	4.7	364	3.0
A2 DB	8/11/99	7.45	45.9	5.0	1.0E+04	0.0	0.0	16.6	0.1	16.7	0.6	4.3	4.5	437	2.0
A2 DB	8/30/99	7.30	49.6	3.0	3.0E+03	0.6	0.1	15.0	0.1	15.8	0.6	4.2	4.5	413	1.0
A2 DB	9/22/99	7.40	49.0	3.0	1.7E+04	0.7	0.0	15.9	0.1	16.7	0.4	4.0	4.4	428	1.0
A2 DB	10/13/99	7.34	58.0	9.0	2.2E+04	0.6	0.3	12.9	0.1	13.9	0.5	4.1	4.3	386	1.0
A2 DB	11/3/99	7.47	65.0	5.0	2.0E+03	1.0	0.1	14.1	0.1	15.3	0.7	4.2	4.2	467	1.0
A2 DB	11/18/99	7.31	66.0	5.0	1.1E+04	1.6	0.3	13.1	0.1	15.1	0.7	4.1	4.1	436	2.0
A2 DB QA	11/18/99	7.16	62.8	2.0	1.7E+05	0.3	0.3	13.8	0.2	14.6	1.2	4.1	4.1	436	2.0
A2 DB	12/21/99	7.09	53.0	11.0	4.9E+04	0.0	0.9	15.1	0.3	16.3	1.9	4.2	4.6	448	4.0
A2 DB	1/12/00	7.20	62.4	8.0	2.1E+04	1.2	1.9	14.8	0.4	18.2	2.1	5.0	5.1	464	5.0
A2 DB	2/2/00	7.18	58.0	11.0	5.3E+04	2.6	2.9	8.3	0.3	14.1	3.2	3.7		509	1.0
A2 DB	2/16/00	7.24	75.2	8.0	1.1E+05	0.8	3.0	9.1	0.4	13.3	2.5	4.0		477	
A2 DB	3/1/00	7.20	68.0	13.0	1.6E+05	1.2	2.0	9.7	0.5	13.5	3.1	4.0	4.4	478	7.0
A2 DB	3/15/00	7.21	72.0	7.0	4.7E+04	1.3	1.3	9.0	0.3	11.9	2.0	4.3	4.7	449	4.0
A2 DB	3/28/00	7.42	70.8	11.0	3.3E+04	0.9	1.3	8.0	0.4	10.6	2.2	4.1	5.0	470	5.0
A2 DB	4/11/00	7.45	89.2	21.0	6.1E+04	1.4	2.3	8.1	0.9	12.7	5.2	3.4	4.2	517	12.0
A2 DB	5/2/00	7.51	72.4	36.0	8.2E+04	1.3	0.0	9.8	3.1	14.2	17.9	4.1		461	46.0
A2 DB	5/17/00	7.28	60.8	6.0	2.0E+04	0.5	0.1	9.3	0.3	10.1	1.7	4.3	5.1	434	4.0
A2 DB	5/31/00	7.42	66.4	5.0	4.0E+04	0.6	0.1	8.4	0.3	9.3	1.7	4.6	5.0	445	5.0
A2 DB QA	5/31/00	7.42	96.0	4.0	4.6E+03	0.4	0.1	8.5	0.2	9.3	1.5	4.3	4.9	445	2.0
A2 DB	6/14/00	7.28	68.4	2.0	5.0E+03	0.1	0.1	10.6	0.1	10.9	0.9	4.8	5.1	460	2.0
A2 DB	6/28/00	7.12	56.0	8.0	9.0E+03	0.2	0.1	16.4	0.1	16.8	0.9	5.4	5.8	529	2.0
A2 DB	7/12/00	6.83	45.2	3.0	5.0E+02	0.8	0.1	17.8	0.1	18.8	0.8	5.3	5.4	471	2.0
A2 DB	7/26/00	7.15	53.2	4.0	2.3E+03	0.8	0.1	16.4	0.1	17.4	0.7	4.9	5.2	447	2.0
A2 DB	8/9/00	7.38	70.0	4.0	8.9E+03	0.1	0.3	16.5	0.2	17.1	1.5	4.8		512	3.0

Location	Date	pH	Alkalinity (mg/l)	BOD5 (mg/l)	FC #/100 ml	DON (mg/l)	NH_4 (mg/l)	NO_x (mg/l)	PON (mg/l)	Total Nitrogen (mg/l)	POC (mg/l)	PO_4 (mg/l)	TP (mg/l)	Sp Cond (uS)
A2 DB	8/23/00	7.08	240.0	6.0	1.7E+04	1.4	0.4	19.9	0.2	21.9	1.2	4.1	4.6	490
A2 DB	9/6/00	6.88	60.0	4.0	7.0E+03	8.4	0.2	37.2	0.5	46.3	2.1	7.0	7.0	652
A2 DB	9/20/00	7.23	63.6	1.0	1.8E+04	0.1	0.6	17.9	0.2	18.8	1.3	3.7	4.5	476
A2 DB	10/3/00	7.14	65.6	4.0	4.5E+04	0.2	0.0	6.9	0.4	7.5	2.0	4.3	4.3	508
A2 DB	10/17/00	7.02	65.2	3.0	1.2E+05	0.4	0.8	18.0	0.3	19.4	1.2	3.4	3.6	483
A2 DB	10/30/00	7.00	13.5	4.0	3.7E+04	1.1	0.2	19.2	0.1	20.7	0.9	3.9	4.0	397
A2 DB	11/14/00	6.56	27.5	4.0	4.9E+04	0.9	0.4	18.2	0.2	19.7	1.2	3.2	3.7	388
A2 DB	11/28/00	6.81	64.0	11.0	2.5E+05	1.5	3.3	14.1	0.4	19.3	2.7	3.2	3.4	415
A2 DB	12/12/00	6.75	40.0	7.0	1.0E+05	1.5	1.8	18.3	0.2	21.9	1.7	3.8	3.8	488
A2 DB	12/26/00	7.02	49.0	13.0	3.8E+05	1.2	4.5	19.1	0.4	25.2	2.6	4.1	4.4	453
A2 DB	1/9/01	6.86	45.0	4.0	6.0E+04	1.7	3.2	18.4	0.2	23.5	1.5	4.4	4.5	471
A2 DB QA	1/9/01	6.97	45.0	4.0	8.0E+04	0.1	3.2	13.2	0.1	16.5	0.7	4.2	4.4	464
A2 DB	1/23/01	6.90	65.0	10.0	5.0E+04		6.0	18.1	0.4	24.6	3.1	4.3	4.4	466
A2 DB	2/6/01	6.94	55.5	11.0	1.8E+05	7.7	4.3	17.2	0.5	29.7	3.4	4.3	4.3	472
A2 DB	2/20/01	7.24	114.5	28.0	4.3E+05	1.9	10.2	8.2	1.7	22.0	10.3	3.4	3.7	477
A2 DB	3/13/01	7.23	97.5	12.0	9.0E+04	2.4	9.7	8.1	0.9	21.1	5.4	2.7	4.0	653
A2 DB QA	3/13/01	7.26	99.5	11.0	5.3E+04	3.3	9.5	6.9	1.1	20.8	7.0	3.8	3.9	650
A2 DB	3/27/01	7.18	77.0	18.0	7.0E+04	0.3	5.6	17.7	1.2	24.8	6.9	4.8	5.3	443
A2 DB	4/10/01	7.18	69.5	13.0	3.0E+04	2.3	1.6	9.9	0.6	14.4	3.9	4.5	4.5	412
A2 DB	4/24/01	7.34	86.0	8.0	9.0E+04	2.5	11.8	7.7	0.4	22.4	2.3	4.2	4.4	418
A2 DB	5/8/01	7.06	50.5	14.0	4.1E+04	1.0	0.4	14.7	0.4	16.4	2.7	6.0	6.3	422
A2 DB	5/22/01	7.09	46.0	6.0	8.0E+04	1.5	4.7	8.5	0.5	15.3	3.3	5.3	5.4	416
A2 DB	6/5/01	7.03	48.0	11.0	1.1E+05	2.4	0.6	14.3	0.8	18.1	4.6	4.9	4.9	398
A2 DB	6/19/01	6.96	45.0	3.8	2.2E+04	1.8	0.3	14.3	0.3	16.7	2.2	4.7		395
A2 DB	7/2/01	6.54	26.0	32.9	5.0E+04	6.4	6.0	40.6	1.7	54.6	9.8	8.9	8.9	619
A2 DB QA	7/2/01	6.54	26.0	41.0	3.0E+04	13.1	5.6	33.9	3.6	56.2	19.1	8.8	9.0	593
A2 DB	7/17/01	6.29	28.0	9.7	1.0E+03	1.4	0.3	27.5	0.3	29.5	1.8	5.3	5.4	461

Location	Date		Alkalinity (mgl)	BOD5 (mg/l)	FC #/100 ml	DON (mg/l)	NH_4 (mg/l)	NO_x (mg/l)	PON (mg/l)	Total Nitrogen (mg/l)	POC (mg/l)	(mg/l)	TP (mg/l)	Sp Cond (uS)	TSS (mgl)
A 3 DBOX															
A3 DB	6/23/99	7.69	173.0	12.0	2.4E+05	0.0	20.7	2.8	1.0	24.5	5.4	4.0	5.3	473	14.0
A3 DB	7/7/99	7.63	93.0	19.0		0.9	4.5	10.3		15.7		4.0	4.8	356	
A3 DB	7/21/99	7.26	75.0	13.0	2.0E+04	0.7	0.7	10.1	0.3	11.8	1.8	4.3	4.9	360	4.0
A3 DB	8/11/99	7.34	63.8	20.0	7.0E+04	0.0	2.2	13.4	0.3	15.9	1.8	4.3	4.4	449	4.0
A3 DB	8/30/99	7.27	58.4	10.0	3.0E+04	0.7	0.4	11.3	0.2	12.6	1.2	4.2	4.2	404	3.0
A3 DB	9/22/99	7.06		4.0	3.0E+04	0.7	0.1	9.7		10.5		3.8		461	
A3 DB	10/13/99	7.39	63.0	8.0	1.5E+04	0.4	0.2	10.4	0.1	11.1	0.7	4.1	4.1	370	1.0
A3 DB	11/3/99	7.39	59.0	5.0	1.0E+04	1.0	0.2	12.1	0.1	13.3	0.6	4.0	4.0	436	2.0
A3 DB	11/18/99	7.39	60.8	5.0	2.7E+04	0.1	1.0	13.8	0.1	14.9	1.0	4.1	4.1	419	2.0
A3 DB	12/21/99	7.28	74.0	9.0	7.7E+04	0.4	1.8	9.6	0.2	12.0	1.7	4.2	4.6	444	0.0
A3 DB	1/12/00	7.56	68.8	5.0	5.0E+02	0.9	1.4	10.4	0.4	13.1	2.1	5.2	5.4	434	5.0
A3 DB	2/2/00	7.10	54.4	11.0	5.3E+04	1.9	3.9	8.8	0.5	15.1	3.3	3.4		485	2.0
A3 DB	2/16/00	7.38	86.4	8.0	3.7E+04	1.0	3.7	6.4	0.4	11.5	2.8	4.0		471	2.0
A3 DB	3/1/00	7.32	70.8	9.0	1.4E+05	1.3	2.5	9.1	0.5	13.3	2.6	3.9	4.1	520	9.0
A3 DB	3/15/00	7.28	75.0	8.0	3.6E+03	0.5	1.6	8.1	0.5	10.7	2.9	4.2		458	6.0
A3 DB	3/28/00	7.42	80.4	9.0	3.4E+04	1.0	2.7	6.8	0.5	10.9	3.1	4.2	5.2	479	8.0
A3 DB	4/11/00	7.33	97.0	18.0	5.7E+04	2.3	5.2	6.0		13.5		4.3		472	12.0
A3 DB	5/2/00	7.32	67.6	31.0	2.0E+05	0.9	0.9	11.4	1.7	14.8	10.0	4.4	5.5	469	23.0
A3 DB	5/17/00	7.22	42.4	36.0	7.0E+04	0.7	0.3	14.4	2.0	17.4	12.2	4.3	5.6	434	31.0
A3 DB	5/31/00	7.37	74.8	9.0	1.0E+04	0.8	0.5	11.2		12.5		4.8	5.2	457	3.0
A3 DB	6/14/00	7.31	57.2	8.0	5.0E+03	0.6	0.2	14.5	0.1	15.4	0.9	5.5	5.8	443	6.0
A3 DB	6/28/00	7.34	60.0	4.0	1.0E+03	0.4	0.1	11.6	0.2	12.4	1.4	5.5	5.9	479	8.0
A3 DB	7/12/00	6.84	38.4	3.0	5.0E+02	0.2	0.4	17.5	0.6	18.7	4.6	6.0	6.1	462	
A3 DB	7/26/00	7.20	57.6	8.0	6.0E+02	1.7	0.3	14.4	0.5	16.9	3.4	5.2	5.6	447	8.0
A3 DB	8/9/00	7.26	77.2	5.0	5.0E+02	0.3	0.5	13.0	0.4	14.1	2.6	4.7		503	6.0
A3 DB QA	8/9/00	7 43	74.4	3.0	1.0E+03	0.8	0.3	12.9	0.0	14.0	2.6	4.6		496	6.0
A3 DB	8/23/00	7.19	331.2	10.0	2.7E+04	0.5	1.4	15.9	0.4	18.1	2.5	4.9	5.1	526	5.0

Location	Date	pH	Alkalinity (mgl)	BOD5 (mg/l)	FC #/100 ml	DON (mg/l)	NH_4 (mg/l)	NO_x (mg/l)	PON (mg/l)	Total Nitrogen (mg/l)	POC (mg/l)	PO_4 (mg/l)	TP (mg/l)	Sp Cond (uS)	TSS (mgl)
A3 DB	9/6/00	7.66	81.2	1.0	5.0E+02	0.1	0.0	11.3	0.1	11.4	0.6	3.9	4.1	463	1.0
A3 DB	9/20/00	7.34	76.8	2.0	2.0E+02	0.1	0.0	11.8	0.1	11.9	0.5	4.0	4.1	460	1.0
A3 DB QA	9/20/00	7.55	78.8	1.0	5.0E+02	0.5	0.0	11.5	0.1	12.1	0.6	4.2	4.3	461	1.0
A3 DB	10/3/00	7.30	78.0	1.0	1.8E+04	0.4	0.2	10.6	0.1	11.3	0.6	4.4	4.4	478	1.0
A3 DB	10/17/00	7.47	84.8	1.0	2.1E+04	0.4	0.2	10.0	0.1	10.7	0.6	3.6	3.9	459	2.0
A3 DB	10/30/00	7.48	53.0	4.0	1.3E+04	0.6	0.0	9.6	0.0	10.3	0.3	3.9	4.1	381	1.0
A3 DB	11/14/00	7.19	50.5	2.0	4.3E+04	0.4	0.0	9.4	0.1	9.9	0.5	3.1	3.4	356	1.0
A3 DB	11/28/00	7.19	71.0	6.0	1.0E+05	0.9	0.2	9.4	0.1	10.6	0.7	3.2	3.4	391	2.0

Location	Date	pH	FC #/100 ml	DON (mg/l)	NH_4 (mg/l)	NO_x (mg/l)	Total Nitrogen (mg/l)	PO_4 (mg/l)	TDP (mg/l)	Sp Cond (uS)
A1 1FT	8/30/99	6.87	1.3E+04	0.5	0.0	13.3	13.8	4.6		420
A1 1FT	9/22/99	6.88		0.6	0.0	13.9	14.5	4.1		
A1 1FT	10/13/99	6.74	7.4E+03	0.0	0.3	13.5	13.8	4.1		
A1 1FT	11/3/99		6.0E+02	0.7	0.0	13.1	13.8	3.9		
A1 1FT	11/18/99	6.77	1.4E+03	0.5	0.1	14.1	14.8	4.1		
A1 1FT	12/21/99	6.75	3.4E+03	0.0	0.6	0.0	0.6	4.0		387
A1 1FT	1/12/00	6.74	2.8E+03	1.1	2.3	8.5	11.8	4.3		461
A1 1FT	2/2/00	6.68	1.0E+04	0.7	0.8	11.9	13.4	3.4		488
A1 1FT	2/16/00	6.60	1.0E+03	0.0	0.7	15.3	16.0	4.2		524
A1 1FT	3/1/00	6.74		1.0	1.1	8.5	10.5	3.7		522
A1 1FT	3/15/00	6.38	1.0E+03	1.0	0.1	9.9	11.0	4.3		434
A1 1FT	3/28/00	6.56	4.0E+02	0.7	0.1	9.6	10.3	3.7		495
A1 1FT	4/11/00	6.72	3.0E+02	1.4	0.0	9.9	11.3	3.6		442
A1 1FT	5/2/00	6.31	2.0E+04	1.8	0.0	41.5	43.3	5.2		595
A1 1FT	5/17/00	6.84	1.0E+03	1.6	0.1	6.3	8.0	4.2	4.8	437
A1 1FT	5/31/00	7.01	3.0E+02	0.6	0.0	7.3	7.9	4.6	4.8	444
A1 1FT	6/14/00	6.98	8.0E+02	0.9	0.0	5.9	6.8	4.6	4.7	452
A1 1FT	6/28/00	6.90		0.5	0.0	7.0	7.5	5.2	5.3	439
A1 1FT	7/12/00	6.94	2.0E+02	0.8	0.0	6.5	7.3	5.0	5.3	420
A1 1FT	7/26/00	6.72	5.0E+01	1.1	0.0	9.6	10.7	4.9		487
A1 1FT	8/9/00	7.02	1.4E+02	0.5	0.0	8.6	9.1	4.3	4.4	519
A1 1FT	8/23/00	6.83	1.1E+02	0.2	0.0	5.6	5.9	4.3	4.6	483
A1 1FT	9/6/00	7.00	1.0E+01	0.5	0.0	5.1	5.6	3.7	3.8	483
A1 1FT	9/20/00	7.01	6.5E+02	0.2	0.0	5.1	5.3	3.7	3.7	438
A1 1FT	10/3/00	6.94	9.0E+01	0.4	0.0	7.4	7.8	4.1	4.1	470
A1 1FT	10/17/00	7.07	4.0E+01	0.5	0.0	7.4	7.9	3.4		413
A1 1FT	10/30/00	7.10	5.0E+00	0.9	0.0	6.9	7.8	3.2	4.3	403
A1 1FT	11/14/00	6.99	7.0E+01	0.7	0.0	5.0	5.6	2.7		259
A1 1FT	11/28/00	7.03	1.1E+02	0.4	0.0	8.0	8.4	3.0		369
A1 1FT	12/12/00	6.81	1.4E+03	0.5	0.1	12.7	13.3	3.3		469
A1 1FT	12/26/00	6.82	1.9E+04	1.4	0.2	10.9	12.5	3.4		410
A1 1FT	1/9/01	6.30	2.7E+04	1.6	0.0	23.2	24.8	4.3		470
A1 1FT	1/23/01	6.58	1.0E+03	0.3	1.1	10.4	11.8	4.1		430
A1 1FT	2/6/01	6.52	1.0E+02	2.6	1.5	8.2	12.3	3.9		450
A1 1FT	2/20/01	6.52	4.0E+01	1.3	0.9	9.5	11.7	3.8		468
A1 1FT	3/13/01	6.77	2.8E+02	1.5	0.1	9.1	10.7	3.1		494
A1 1FT	4/10/01	6.60	8.0E+01	0.1	0.0	11.7	11.8	4.1		313
A1 1FT	4/24/01	6.63	3.3E+02	0.2	0.0	17.9	18.2	3.7		397
A1 1FT	5/8/01	6.51	1.7E+03	2.5	0.0	13.1	15.6	5.4		408
A1 1FT	5/22/01	6.58	1.3E+03	2.8	0.0	18.9	21.7	4.8		422
A1 1FT	6/5/01	6.61	4.0E+02	0.9	0.0	8.6	9.5	4.5		384
A1 1FT	6/19/01	6.71	5.0E+01	0.8	0.0	3.1	3.9	4.9		370
A1 1FT	7/2/01	6.76	5.0E+00	1.4	0.0	9.6	11.0	6.3		393
A1 1FT	7/17/01	6.56	5.0E+00	0.8	0.0	6.8	7.6	5.2		362

A1 5FT

Location	Date	pH	FC #/100 ml	DON (mg/l)	NH_4 (mg/l)	NO_x (mg/l)	Total Nitrogen (mg/l)	PO_4 (mg/l)	TDP (mg/l)	Sp Cond (uS)
A1 5FT	5/31/00	7.30	5.0E+01	0.6	0.3	6.9	7.8	4.0	4.2	487
A1 5FT	6/14/00	7.29	2.0E+02	0.6	0.0	5.4	6.0	4.0	4.4	479
A1 5FT	7/12/00		5.0E+01				0.0			
A1 5FT	8/23/00	7.01	1.0E+01	2.2	0.0	4.0	6.2	3.8	3.9	499
A1 5FT	9/6/00	7.54	5.0E+00				0.0			509
A1 5FT	12/12/00	7.49	5.0E+01	0.7	0.0	10.2	10.9	3.3		410
A1 5FT	12/26/00	7.24	5.0E+01	1.2	0.2	10.7	12.1	3.4	3.4	419
A1 5FT	1/9/01	6.86	2.2E+02	1.0	1.2	10.3	12.4	3.3	3.9	447
A1 5FT	1/23/01	6.87	5.0E+00				0.0			309
A1 5FT	2/20/01		5.0E+00				0.0			
A1 5FT	3/27/01		1.0E+01				0.0			
A1 5FT	4/10/01	6.91	5.0E+00	1.4	0.0	9.1	10.6	3.3	3.3	309
A1 5FT	4/24/01	6.73	2.0E+00				0.0			
A1 5FT	5/22/01	6.53	5.0E+01	1.8	0.1	30.6	32.5	5.2	5.3	459
A1 5FT	6/19/01	6.57	5.0E+00	1.1	0.0	5.6	6.7	4.3	4.5	376
A1 5FT	7/17/01	6.67	5.0E+00	1.9	0.0	5.2	7.2	5.1	5.5	397

A2 1FT

Location	Date	pH	FC #/100 ml	DON (mg/l)	NH_4 (mg/l)	NO_x (mg/l)	Total Nitrogen (mg/l)	PO_4 (mg/l)	TDP (mg/l)	Sp Cond (uS)
A2 1FT	8/30/99	6.75	5.1E+03	0.5	0.0	14.6	15.1	4.4		403
A2 1FT	9/22/99	6.80		0.3	0.0	16.5	16.8	4.0		
A2 1FT	10/13/99	6.77	1.3E+04	0.7	0.1	13.9	14.7	4.1		
A2 1FT	11/3/99		1.0E+03	0.6	0.0	14.4	15.0	4.0		
A2 1FT	11/18/99	6.92	3.0E+03	0.5	0.1	14.2	14.8	4.1		
A2 1FT	12/21/99	6.81	8.0E+03	0.5	0.2	16.4	17.1	4.2		393
A2 1FT	1/12/00	6.63	2.0E+03	0.8	0.0	15.9	16.8	5.1		
A2 1FT	2/2/00	6.69	1.3E+03	3.1	0.0	10.7	13.8	3.6		[illegible]
A2 1FT	2/16/00	6.48	3.0E+02	1.0	0.3	14.9	16.2	4.5		567
A2 1FT	3/1/00	6.52		0.5	0.1	12.1	12.7	3.9		576
A2 1FT	3/15/00	6.32	3.0E+02	0.5	0.0	11.0	11.5	4.2		426
A2 1FT	3/28/00	6.66	5.0E+01	0.1	0.0	11.3	11.4	4.1		454
A2 1FT	4/11/00	6.84	5.0E+01	0.7	0.0	11.0	11.7	4.2		452
A2 1FT	5/2/00	6.47	2.0E+03	1.5	0.1	39.1	40.7	6.3		611
A2 1FT	5/17/00	6.79	1.0E+02	0.7	0.0	17.5	18.2	4.9		464
A2 1FT	5/31/00	7.01	5.0E+01	0.5	0.0	7.6	8.1	4.4	4.6	454
A2 1FT	6/14/00	6.97	1.7E+03	1.1	0.0	9.6	10.7	4.5		462
A2 1FT	6/28/00	6.85	2.0E+02	0.8	0.0	9.6	10.4	3.9	4.0	425
A2 1FT	7/12/00	6.88	1.0E+02	0.4	0.0	25.0	25.4	3.6	3.6	554
A2 1FT	7/26/00	6.95	5.0E+01	0.9	0.1	15.8	16.8	4.3	4.3	497
A2 1FT	8/23/00	6.60	5.0E+00	1.0	0.0	15.4	16.5	3.7	3.9	514
A2 1FT	9/7/00	6.68					0.0			664

A2 1FT

Location	Date	pH	FC #/100 ml	DON (mg/l)	NH_4 (mg/l)	NO_x (mg/l)	Total Nitrogen (mg/l)	PO_4 (mg/l)	TDP (mg/l)	Sp Cond (uS)
A2 1FT	9/20/00	6.90	5.0E+00	0.2	0.0	18.0	18.3	3.5	4.1	488
A2 1FT	10/3/00	6.85	3.0E+01	0.1	0.0	17.7	17.8	3.9	4.0	495
A2 1FT	10/17/00	6.75	1.0E+01	0.3	0.1	18.4	18.8	3.1		438
A2 1FT	10/30/00	6.74	2.0E+02	1.0	0.0	18.8	19.8	3.5	4.0	414
A2 1FT	11/14/00	6.59	5.0E+02	0.7	0.0	17.8	18.4	3.1		386
A2 1FT	11/28/00	6.66	1.3E+03	0.7	0.5	15.6	16.8	3.1		399
A2 1FT	12/12/00	6.53	8.0E+02	0.5	0.0	20.3	20.8	3.8		439
A2 1FT	12/26/00	6.43	1.2E+04	2.6	0.1	24.5	27.1	4.6		443
A2 1FT	1/9/01	6.47	1.4E+03	0.7	0.0	22.7	23.4	4.2		465
A2 1FT	1/23/01	6.22	1.0E+02		0.8	24.4	25.3	4.2		444
A2 1FT	2/6/01	6.20	5.0E+01	1.5	0.7	22.6	24.8	4.2		455
A2 1FT	2/20/01	6.51	6.8E+03	4.2	0.4	14.5	19.1	3.8		428
A2 1FT	3/27/01	6.59	3.3E+02	1.2	0.1	19.2	20.4	3.6		337
A2 1FT	4/10/01	6.59	2.9E+02	0.8	0.0	24.6	25.3	4.8		451
A2 1FT	4/24/01	6.52	3.1E+02	1.6	0.0	23.9	25.6	4.9		510
A2 1FT	5/8/01	6.24	2.8E+03	8.4	0.1	43.1	51.6	7.6		660
A2 1FT	5/22/01	6.56	5.0E+01	8.0	0.0	25.5	33.5	5.3		458
A2 1FT	6/5/01	6.27	1.1E+02	2.3	0.0	19.4	21.7	5.1		397
A2 1FT	6/19/01	6.24	2.4E+02	1.9	0.0	27.3	29.2	4.7		474
A2 1FT	7/2/01	6.15	5.0E+00	2.0	0.0	42.9	44.9	6.4		445
A2 1FT	7/17/01	6.16	5.0E+00	0.1	0.0	25.7	25.8	4.9		452

A2 2FT

Location	Date	pH	FC #/100 ml	DON (mg/l)	NH_4 (mg/l)	NO_x (mg/l)	Total Nitrogen (mg/l)	PO_4 (mg/l)	TDP (mg/l)	Sp Cond (uS)
A2 2FT	4/11/00	7.32	1.8E+03	0.2	0.3	8.5	9.1	3.7		452
A2 2FT	6/28/00	6.96	9.0E+02	0.6	0.0	10.0	10.6	3.9	4.0	453
A2 2FT	7/12/00	6.84	2.0E+02	1.1	0.0	17.0	18.1	4.7	4.9	465
A2 2FT	7/26/00	6.89	1.3E+04	0.8	0.0	15.4	16.2	4.5	4.5	488
A2 2FT	8/9/00	6.97	5.0E+02	0.0	0.0	15.2	15.2	4.6	4.6	526
A2 2FT	8/23/00	6.50	1.2E+02	0.3	0.0	31.3	31.6	4.5	4.5	500
A2 2FT	9/6/00	6.59	1.0E+01	0.6	0.0	33.7	34.3	4.2	4.4	611
A2 2FT	9/7/00	6.64					0.0			680
A2 2FT	9/20/00	6.83	5.0E+00	0.4	0.0	18.8	19.2	4.0	4.0	487
A2 2FT	10/3/00	6.84	5.0E+00	0.1	0.0	17.9	18.0	3.9	3.9	494
A2 2FT	10/17/00	6.78	4.0E+01	0.0	0.0	18.7	18.7	3.3		439
A2 2FT	10/30/00	6.72	6.0E+02	1.6	0.0	19.2	20.8	3.6	4.2	419
A2 2FT	11/14/00	6.59	2.2E+03	0.3	0.0	18.8	19.2	3.3	3.9	386
A2 2FT	11/28/00	6.60	3.4E+03	1.0	1.4	15.9	18.2	3.2	3.9	407
A2 2FT	12/12/00	6.42	6.2E+03	1.0	0.0	19.8	20.8	3.9	4.1	460
A2 2FT	12/26/00	6.48	3.9E+04	2.9	0.1	21.3	24.3	4.3	4.4	420
A2 2FT	1/9/01	6.74	1.8E+03	0.7	3.6	10.5	14.8	3.7	3.7	451
A2 2FT	1/23/01	6.01	9.0E+02	4.2	1.2	17.4	22.8	4.4	4.4	450

A2 5FT

Location	Date	pH	FC #/100 ml	DON (mg/l)	NH_4 (mg/l)	NO_x (mg/l)	Total Nitrogen (mg/l)	PO_4 (mg/l)	TDP (mg/l)	Sp Cond (uS)
A2 5FT	6/5/01	6.32	5.0E+00	0.8	0.1	21.2	22.1	4.9	5.3	434
A2 5FT	6/19/01	6.23	1.0E+01	3.3	0.0	22.4	25.7	4.8	5.0	428
A2 5FT	7/2/01	6.36	5.0E+00	2.7	0.0	32.9	35.6	5.5	5.6	442
A2 5FT	7/17/01	6.01	5.0E+00	2.2	0.0	33.0	35.2	5.3	5.6	448

A3 1FT

Location	Date	pH	FC #/100 ml	DON (mg/l)	NH_4 (mg/l)	NO_x (mg/l)	Total Nitrogen (mg/l)	PO_4 (mg/l)	TDP (mg/l)	Sp Cond (uS)
A3 1FT	11/3/99			0.8	0.0	15.0	15.9	3.7		
A3 1FT	12/21/99	6.36	5.0E+00	0.5	0.0	1.4	1.9	0.0		[illegible]
A3 1FT	1/12/00	6.67	3.1E+02	1.2	0.0	4.5	5.7	2.4		
A3 1FT	2/2/00	6.75	1.0E+03	1.9	3.0	9.2	14.1	3.2		435
A3 1FT	2/16/00	6.44	1.0E+02	0.7	3.4	8.4	12.5	3.9		503
A3 1FT	3/1/00	6.62	5.0E+01	0.7	1.1	9.0	10.8	3.1		501
A3 1FT	3/28/00	6.83	1.4E+03	0.4	0.1	8.3	8.8	3.7		454
A3 1FT	4/11/00	7.01	3.0E+02	1.1	0.0	10.1	11.3	4.0		447
A3 1FT	5/17/00		4.4E+02				0.0			
A3 1FT	6/14/00	7.06	3.0E+02	0.4	0.0	9.7	10.1	4.4		436
A3 1FT	6/28/00	6.94	3.3E+02	0.4	0.0	9.4	9.8	4.6	4.7	435
A3 1FT	7/12/00	6.96	6.0E+01	1.4	0.0	11.6	13.1	4.9	5.0	438
A3 1FT	7/26/00	6.78	5.0E+01	1.1	0.0	15.1	16.2	4.8	4.9	493
A3 1FT	8/9/00	6.98	5.0E+00	0.9	0.0	11.7	12.6	4.4	4.4	504
A3 1FT	8/23/00	6.72	2.6E+02	0.2	0.0	13.4	13.6	4.4	4.6	496
A3 1FT	9/6/00	6.86	5.0E+00	0.5	0.0	8.4	8.9	3.7	3.8	473
A3 1FT	9/20/00	7.06	5.0E+00	0.5	0.0	8.0	8.5	3.7	3.7	450
A3 1FT	10/3/00	7.07	5.0E+00	0.1	0.0	10.3	10.4	4.3	4.4	
A3 1FT	10/17/00	7.01	5.0E+00	0.3	0.1	9.8	10.1	3.6		[illegible]
A3 1FT	11/14/00	7.17	1.0E+01	0.4	0.0	4.1	4.5	2.9		279
A3 1FT	11/28/00	7.25	6.0E+01	0.4	0.0	7.2	7.7	3.0		350

A3 2FT

Location	Date	pH	FC #/100 ml	DON (mg/l)	NH_4 (mg/l)	NO_x (mg/l)	Total Nitrogen (mg/l)	PO_4 (mg/l)	TDP (mg/l)	Sp Cond (uS)
A3 2FT	6/14/00	7.47	1.0E+02	1.0	1.0	7.5	9.5	2.4	2.5	535
A3 2FT	9/6/00	6.97	5.0E+00	0.5	0.0	9.4	9.9	3.9	3.9	497
A3 2FT	11/28/00	7.19	2.2E+03	0.6	0.0	8.8	9.4	3.3	3.9	380

A3 5FT

Location	Date	pH	FC #/100 ml	DON (mg/l)	NH_4 (mg/l)	NO_x (mg/l)	Total Nitrogen (mg/l)	PO_4 (mg/l)	TDP (mg/l)	Sp Cond (uS)
A3 5FT	6/14/00	7.07	2.0E+02	0.2	0.0	10.4	10.6	3.3		456
A3 5FT	6/28/00	6.84	6.0E+01	0.3	0.0	10.0	10.3	4.6	4.6	439
A3 5FT	7/12/00		1.4E+02				0.0			
A3 5FT	9/6/00	6.86	1.0E+01	0.7	0.0	10.2	10.9	3.7	3.8	506
A3 5FT	9/20/00	6.97	5.0E+00	0.4	0.0	10.1	10.5	3.9	3.9	468
A3 5FT	10/3/00	7.18	5.0E+00	0.0	0.0	10.6	10.6	4.1	4.2	485
A3 5FT	10/17/00	7.28	5.0E+00	0.5	0.0	10.0	10.6	3.6		428
A3 5FT	10/30/00	6.95	5.0E+00	0.9	0.0	10.1	11.0	3.8	4.5	392
A3 5FT	11/28/00	7.23	2.0E+01	0.6	0.0	9.3	9.9	3.2	3.9	387

A SUMP

Location	Date	pH	FC #/100 ml	DON (mg/l)	NH_4 (mg/l)	NO_x (mg/l)	Total Nitrogen (mg/l)	PO_4 (mg/l)	TDP (mg/l)	Sp Cond (uS)
A SUMP	9/22/99	6.58	5.0E+00	0.3	0.0	11.7	12.0	2.2		368
A SUMP	10/13/99	6.52	1.0E+01	0.0	0.0	11.3	11.3	2.4		
A SUMP	11/3/99	6.68	5.0E+00		0.0	11.9	11.9	2.4		
A SUMP	11/18/99	6.68	5.0E+00	2.7	0.0	9.7	12.4	2.9		334
A SUMP	12/21/99	6.71	5.0E+00	0.3	0.0	11.7	12.1	2.5		336
A SUMP	1/12/00	6.68	5.0E+00	0.0	0.0	6.8	6.8	2.7		303
A SUMP	2/2/00	6.67	3.0E+01	0.6	0.1	11.3	11.9	2.9		429
A SUMP	2/16/00	6.66	5.0E+00	5.0	0.3	11.9	17.2	3.2		464
A SUMP	3/1/00	6.46	4.0E+01	1.3	0.0	9.3	10.6	2.6		430
A SUMP	3/15/00	6.20	5.0E+00	1.7	0.0	9.4	11.1	3.2		404
A SUMP	3/28/00	6.58	5.0E+00	0.1	0.0	9.0	9.0	3.0		426
A SUMP	4/11/00	6.85	1.0E+01	0.6	0.0	10.7	11.3	2.9		398
A SUMP	5/2/00	6.48	1.7E+02	0.0	0.0	12.4	12.4	1.8		317
A SUMP	5/17/00	6.68	5.0E+00		0.0		0.0	2.9	3.2	366
A SUMP	5/31/00	6.77	5.0E+00	0.1	0.0	7.6	7.7	3.1	3.4	381
A SUMP	6/14/00	6.74	1.0E+01	0.3	0.0	7.7	7.9	3.1		391
A SUMP	6/28/00	6.68	1.3E+02	2.3	0.0	8.0	10.3	3.8		412
A SUMP	7/12/00	6.65	5.0E+00	0.7	0.0	11.2	11.9	3.5	3.5	416
A SUMP	7/26/00	6.59		1.1	0.0	13.5	14.6	3.7		479
A SUMP	8/9/00	6.63	5.0E+00	0.2	0.0	10.9	11.1	3.4	3.5	425

A SUMP

Location	Date	pH	FC #/100 ml	DON (mg/l)	NH_4 (mg/l)	NO_x (mg/l)	Total Nitrogen (mg/l)	PO_4 (mg/l)	TDP (mg/l)	Sp Cond (uS)
A SUMP	8/23/00	6.55	5.0E+00	0.3	0.0	9.3	9.6	2.8	2.8	387
A SUMP	9/6/00	6.75	5.0E+00	0.4	0.0	8.8	9.2	3.1	3.1	449
A SUMP	9/20/00	6.78	5.0E+00	0.1	0.0	13.4	13.5	2.9		433
A SUMP	10/3/00	6.82	5.0E+00	0.4	0.0	11.3	11.7	3.1	3.1	442
A SUMP	10/17/00	6.80	5.0E+00	0.1	0.0	12.5	12.6	2.8		404
A SUMP	10/30/00	6.80	5.0E+00	0.5	0.0	13.8	14.3	3.1	3.5	394
A SUMP	11/14/00	6.72	5.0E+00	0.5	0.0	11.2	11.8	2.4	2.9	316
A SUMP	11/28/00	6.71	4.0E+01	0.7	0.1	12.2	13 1	2.4	3.1	355
A SUMP	12/12/00	6.58	1.0E+01	0 8	0.2	16.9	17.9	2.8	3.0	379
A SUMP	12/26/00	6 53	1.0E+01	1.0	0.0	13.5	14.5	2.1	2.1	319
A SUMP	1/9/01	6.59	3.0E+01	0.7	0.0	15.5	16.3	2.8	2.7	399
A SUMP	1/23/01	6.28	5.0E+00		0.0	17.6	17.6	3.2	3 5	408
A SUMP	2/6/01	6.75	5.0E+00	2.0	3.6	10.0	15.6	2.8	2.9	
A SUMP	2/20/01	6.77	5.2E+03	2.1	8.6	8.1	18.8	3.1	3 4	446
A SUMP	3/13/01	6.89	5.0E+01	1.4	8.0	7.0	16.4	1.9	2.7	445
A SUMP	3/27/01	6.58	5.0E+00	0.7	6.0	7.6	14.2	2.0	2.3	248
A SUMP	4/10/01	6.31	1.6E+01			6.3	6.3	2.3	2.4	283
A SUMP	4/24/01	6.18	2.0E+00	2.5	0.4	12.5	15.3	2.4	2.9	345
A SUMP	5/8/01	6.21	1.0E+00	1.5	0.0	11.6	13.1	3.3	3.4	370
A SUMP	5/22/01	6.50	1 0E+00	11.5	0.0	14.8	26.3	3.6	3.7	401
A SUMP	6/5/01	6.40	1.0E+00	2.9	0.0	3.6	6 5	3.0	3.5	339
A SUMP	6/19/01	6.40	1.0E+00	1.2	0.1	5.8	7.1	3.2	3.5	293
A SUMP	7/2/01	6.34	1.0E+00	7.1	0.0	20.1	27.3	3.8	3.8	365
A SUMP	7/17/01	6.49	1.0E+00	6.5	0.0	8.7	15.2	3.8	4.2	392

Nitrate Removal for On-Lot Sewage Treatment Systems: The POINT™ System

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1.0 INTRODUCTION

1.1 OVERVIEW OF THE PROBLEM

Nitrate-nitrogen (NO_3-N) in groundwater is becoming a ubiquitous problem, particularly in rural and suburban areas where domestic water supplies are obtained from individual on-lot water supply wells. Nitrate in groundwater can come from natural sources such as soil, bedrock and organic material; however, the overwhelming loading of nitrate originates from anthropogenic sources, particularly agricultural practices and residential on-lot sewage treatment systems (a.k.a. "septic systems"). As residential subdivisions expand into previously undeveloped or agricultural areas, homeowners, developers, planners and township regulators are increasingly challenged with balancing sustained growth with a safe drinking water supply. Prevalent concerns are with high-density developments that utilize on-lot drinking water supply wells that draw from the same groundwater which is being impacted by the conventional nitrate-yielding on-lot septic systems. Unfortunately, the current solution implemented by most municipalities under the State's (PA) sewage planning permit process is to require larger developable lot sizes, which only encourages sprawl.

On-lot septic systems contribute a significant nitrate load to groundwater: a problem that can be addressed through innovative nitrate treatment within the septic systems. This paper provides a detailed description of the POINT™ (Passive Organic In-situ Nitrate Treatment) System; a passive, in-situ biological treatment system that augments traditional on-lot septic systems to effectively reduce nitrate levels in the effluent to below drinking water standards. This simple and cost effective technology can help prevent groundwater degradation and can easily be installed and operated for the life of the septic system with little or no maintenance.

1.2 MAGNITUDE OF THE PROBLEM

Of the estimated 11.8 million residents of Pennsylvania (U.S. Census Bureau, 2000), more than one third use on-lot sewage treatment systems (PSATS, 1998) and groundwater as their sewage disposal and primary source of drinking water, respectively (Hamlet, 1995). Drinking water containing elevated nitrate has been attributed to several adverse health effects and can be particularly severe or fatal to small infants through a condition known as methemoglobinemia, or blue baby syndrome. The U.S. Environmental Protection Agency (USEPA) currently sets a limit or maximum

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contaminant level (MCL) under the Safe Drinking Water Act for nitrate in public drinking water supplies of 10 milligrams per liter (mg/L) reported as nitrate-nitrogen (NO_3-N). Median nitrate concentrations above 10 mg/L NO_3-N are commonly reported in groundwater beneath unsewered residential subdivisions, with levels in excess of 130 mg/L NO_3-N (MPCA, 1999; Yates, 1985) in some cases. Once in groundwater, nitrate attenuates very slowly and can persist for years or decades, and improving the water quality becomes expensive or even technically infeasible (Nolan, 1996).

1.3 SOLUTIONS TO THE PROBLEM

Three primary means of addressing the nitrate-in-groundwater problem exist: 1) isolation distance, 2) on-lot sewage treatment system density, and 3) treatment. Most states, including Pennsylvania, require a minimum separation distance between the septic system and drinking water supply wells to minimize the septic system effluent contaminants, including nitrate, from entering the adjacent drinking water supply. However, nitrate in groundwater does not generally degrade and is principally reduced through dilution from the natural recharge of infiltrating precipitation. Therefore, location of on-lot sewage treatment systems vis-à-vis adjacent drinking water supply wells has little bearing on nitrate concentrations from other sources, especially when multiple sources of nitrate are located in close proximity to one another (e.g., high-density developments).

The second approach to controlling nitrate in groundwater is to balance the input of nitrate into the groundwater with the amount of dilution that occurs. This is accomplished by controlling the density of development per area, most commonly by requiring minimum lot sizes or open space. Most municipalities require minimum lot sizes, which typically range from ½ to 1 acre (Yates, 1985). Several recent studies involving groundwater sampling beneath unsewered residential communities suggest lot sizes larger than 1 acre may be needed (Brown, 1987; Yates, 1985). The Pennsylvania Department of Environmental Protection (PADEP) reports a lot size of 1.4 acres is needed for each sewage treatment system based on empirical studies and/or statewide generalizations (PADEP, 1997). On a macro-scale, this minimum lot size policy often results in more land being destroyed per unit (i.e., sprawl).

The third and most effective means of addressing the nitrate issue, and the focus of this paper, is to reduce the nitrate concentration in the on-lot sewage treatment system effluent. In many impacted groundwater areas (e.g., farmland, overdeveloped areas), prior to any development, the groundwater can already be impacted above the drinking water standard of 10 mg/L NO_3-N. In these cases, isolation distance and dilution through increased lot size do not solve the problem and the only alternative is to install on-lot sewage treatment systems that reduce the amount of nitrate discharged from the system. Several treatment technologies have been proposed to reduce this nitrate concentration from on-lot sewage treatment systems. Most of these technologies have resulted in only marginal nitrate reductions or have shown to be economically or technically impractical in individual on-lot settings. The POINT™ System presented herein overcomes the economic and technical shortcomings of the previously-developed technologies as discussed below.

2.0 ORIGIN AND FATE OF NITROGEN

2.1 NITROGEN IN THE TRADITIONAL SEWAGE TREATMENT SYSTEM

Liquid and solid waste generated in the household is partially treated in a traditional on-lot sewage treatment system in stages. Untreated household waste, which contains urea (CON_2H_4) and organic nitrogen, is first discharged to a septic tank. In the septic tank, the solid and liquid phases are separated through gravity settling. The liquid material is converted to ammonia (NH_3) and ammonium (NH_4^+) via anaerobic bacteria and the solid material settles to the bottom of the tank for eventual degradation and/or removal. Following the separation and primary treatment stage, the liquid is discharged either by gravity or by pump to the absorption field. In the absorption field, the ammonia nitrogen in the waste water is quickly converted sequentially to nitrite (NO_2^-) and then nitrate (NO_3^-) through biological aerobic nitrification processes within the shallow soil horizon. Conventional on-lot sewage treatment systems are a cost effective means of treating the solids, organic pollutants and microorganisms in waste water; however they are not specifically designed to remove nitrogen and it (the nitrogen) tends to pass directly through the absorption field with the liquid effluent and into the receiving (groundwater) (Mooers, 1996; MPCA, 1999).

2.2 DENITRIFICATION

Once nitrogen is in an aqueous nitrate form, it is generally stable except under concurrent anoxic and carbonaceous conditions, which support the biological conversion of nitrate to nitrogen gas in a process known as denitrification. Unlike nitrifying microorganisms which can only use oxygen as an electron acceptor, denitrifying bacteria are capable of using nitrate as an electron acceptor in the absence of oxygen (dissimalatory denitrification). If given a preference, the microorganisms prefer oxygen as the terminal electron acceptor due to its higher energy yield, therefore, for denitrification to occur, an anoxic environment must be present. When the microorganisms reduce (break apart) the nitrate (NO_3^-) to liberate the oxygen, nitrogen gas (N_2) and nitrous oxide (N_2O) are produced and harmlessly lost to the atmosphere. Denitrification also requires the presence of an organic carbon source (electron donor) for microbial metabolism. In traditional large-scale wastewater treatment plants employing a denitrification step, the carbon source is normally methanol or raw wastewater, both of which contain organic carbon.

These two concurrent conditions are not generally present in on-lot sewage treatment systems where unsaturated sandy soils are needed for proper filtration and percolation. In the POINT™ System, natural organic substrates such as sawdust, peat, and culm are used as the carbon source and the engineered mixture, content and placement of the organic layer create the appropriate anoxic conditions.

3.0 CURRENT NITRATE REMOVAL METHODS

Several individual on-lot nitrate treatment systems have been proposed in recent years in response to the growing concern over nitrate in groundwater. To date, none of these systems have proven to consistently reduce nitrate nor have they been approved for use in Pennsylvania via Alternate Guidance or PA Title 25, Chapter 73. The following is a brief overview of some of the commonly accepted nitrate treatment systems. This overview is not meant to be exhaustive or technically detailed but rather is meant to establish a comparative baseline by which to compare and evaluate the POINT™ System. Information used to summarize these technologies was collected from publicly- and readily-available sources.

3.1 TRADITIONAL TREATMENT METHODS

Several traditional treatment methodologies have been developed and implemented to treat nitrate either in wastewater or drinking water applications. These treatment methodologies are normally applied to large wastewater flow conditions (e.g., municipal) or to remove nitrate from drinking water. Some of the methodologies are as follows:

- Biological Denitrification – Biological denitrification is the most common means of removing nitrate from large-flow wastewater conditions. Following conversion of ammonia to nitrate in a precursor process, the nitrate is exposed to an anoxic and carbon-rich environment. The organic carbon is normally supplied by recirculating some of the wastewater sludge to the anoxic treatment vessel or by introducing an external carbon source such as ethanol, methanol, glucose, lactic acid, or acetic acid are added. Biological treatment in this form is very expensive, labor- and equipment-intensive, and not well suited for individual on-lot sewage treatment system applications.
- Ion Exchange – Ion exchange is a reversible chemical reaction whereby an ion in the fluid to be treated is replaced with a different ion on the exchange media. This process is similar to a water softener, also known as a cation exchange unit. In the case of nitrate, however, the process is an anion exchange unit as nitrate is negatively charged. As with a water softener, the exchange medium requires frequent regeneration, whereby the captured nitrate is eventually washed away, and there is generally a limited amount of resins with high selectivity for nitrate. Ion exchange is typically limited to drinking water applications and not wastewater treatment.
- Reverse Osmosis – Reverse osmosis (RO) uses a membrane that is semi-permeable, allowing the fluid that is being purified to pass through it, while rejecting the contaminants that remain. The downside to RO is the low selectivity of the membranes used for nitrate treatment and the generation and disposal of the reject fluid, not to mention the O&M cost of such a process. RO is typically limited to drinking water applications and not wastewater treatment.

3.2 NEW OR INNOVATIVE TREATMENT SYSTEMS

Several new nitrate treatment technologies have been developed over the years. The following is a literature search summary of some commonly-tried technologies when nitrate removal is required:

- Recirculation – In this process, a portion of the fluid waste stream from an aerobic treatment unit, in most cases a sand filter, is returned to the septic tank where the anoxic and carbon-rich environment biologically converts the nitrate to nitrogen gas (denitrification). These systems require installation of an additional treatment unit (sand filter), additional piping and pumps, and only treat a portion of the waste water. USEPA reports an average total nitrogen removal of between 40 and 50 percent (USEPA, 2002)
- FAST® - This technology involves installation of a large (5' x 2' x 4') fixed-film reactor vessel within an existing or new septic tank to provide both nitrification and denitrification within the vessel and the septic tank. The supplier claims a nitrogen removal rate of 70%; however, pilot-scale studies have shown average removal rates of about 55% (Costa, et. al.). The downside of this technology is the capital cost of the unit, the septic tank volume reduction resulting from the vessel, the aesthetics and additional power demands from the electric blower unit, the low nitrate removal efficiency, and the technology's performance fluctuations due to ambient temperatures. Recent experience by PADEP indicates that this process is not approved for nitrate treatment.
- RUCK – The RUCK system is a sand filter and denitrification unit where black water is sent to the septic tank, then to a sand filter (the RUCK filter). Sand filter effluent and gray water are discharged to a second septic tank where anaerobic conditions create denitrification. This effluent is then sent to a traditional absorption area. Total nitrogen removal rates are reportedly in the 40-80% range (Winkler, 2000). The downside to this system is the need for two additional treatment units (the RUCK filter and the second septic tank), necessary pumps and piping, and separate household plumbing for the grey and black water.
- Waterloo Biofilter – The Waterloo Biofilter is a trickling filter (fixed-film) using medium-density foam blocks in an above-ground or below-ground structure (the biofilter). This structure is placed between the traditional septic tank and the absorption field and operates primarily in aerobic conditions. Data from previous studies as well as manufacturer's literature report wide ranges in nitrogen removal from 21% (Winkler, 2000) to as high as 60% (Costa, et. al.) with slightly higher rates (~65%) when in conjunction with additional recirculation or denitrification components. As with the other treatment technologies, this technology requires additional capital and O&M costs for the additional treatment units and provides only marginal decreases in nitrogen levels.
- Wetlands – Both surface and subsurface flow wetlands have been designed and implemented in pilot and full-scale applications to treat for nitrate using

sequential nitrification and denitrification. Wetlands systems have not garnered widespread approval mainly due to the land area they consume and the aesthetics of such a system (e.g., the "swamp" perception). Wetlands are also susceptible to performance fluctuations based on seasonal ambient temperatures.

- Peat Filter – Peat filters are trickling filters using peat moss as the filter media. Effluent from the primary septic tank is discharged to the peat filter, followed by discharge to the soil absorption area. Total nitrogen removal rates of between 35% and 70% have been reported (McKee, 1998). Removal efficiencies of up to 70% in aerobic conditions provide support for the potential denitrification when in the presence of organics, most likely occurring in micro-environments within the peat pore spaces. The downsides of this technology are the need for the additional treatment vessel, the required O&M performed by the manufacturer, and the need for periodic substrate replacement.
- NITREX – NITREX uses "nitrate-reactive media" (wood by-products) to promote denitrification. The nitrate-reactive medium is contained in a tank, or in larger cases a lined excavation. Pretreatment is required to convert ammonia to nitrate prior to entry into the NITREX system. This technology is reportedly sensitive to low temperatures and has a higher capital cost due to the need for additional treatment vessels (pre-treatment and NITREX units).

All of the above-listed systems have at least one significant downside; whether it be costly, overly burdensome from an O&M standpoint, inefficient nitrate removal, or inapplicable to site-specific conditions (e.g., size, new plumbing). Conversely, the POINT™ System presented herein does not require additional treatment units, is in-situ and passive, and uses recycled products as its primary treatment medium.

4.0 POINT™ SYSTEM OVERVIEW AND BACKGROUND

4.1 SYSTEM OVERVIEW

The POINT™ System consists of a traditional two-chamber septic tank, distribution network, and a modified absorption area consisting of two layers for the sequential treatment of traditional wastewater parameters and nitrate. Like a conventional septic system, the upper layer consists of natural soil that is excavated for installation of the underlying nitrate treatment layer and then replaced. This layer is generally 2 feet thick and provides treatment of the traditional treatment parameters (e.g., total suspended solids [TSS], biological oxygen demand [BOD], nutrients, pathogens, and miscellaneous parameters). The nitrate treatment layer consists of a one to two foot thick layer of natural soil or imported material augmented with carbon-rich material for biological nitrate treatment (denitrification). Figure 1 provides a cross-section of a typical system. Effluent from the septic tank is distributed to the modified absorption area through a series of perforated pipes similar to a traditional system. Treatment occurs as the effluent travels by gravity through the traditional absorption area and the carbon-rich layer. The effluent is nitrate-reduced as it leaves the absorption area. Nitrogen gas generated from the denitrification is harmlessly lost to the atmosphere as it migrates upward through the air voids in the absorption field.

4.2 REGULATORY SUPPORT

It should be noted that USEPA recognizes passive in-situ biological denitrification as a viable treatment process for removal of nitrate in onsite wastewater treatment systems. Specifically, USEPA's Onsite Wastewater Treatment Systems Technology Fact Sheet 9 [Enhanced Nutrient Removal – Nitrogen] (USEPA, 2002) states that "The use of beds of carbon-rich materials below [subsurface wastewater infiltration system] leach lines could be a promising concept if the hydraulic matching problems are solved and the bed service life can be extended for 10 years or more." Both of these design considerations have been addressed by the author on previous applications and are discussed (along with several other aspects of the treatment system) in the following sections.

USEPA's Onsite Wastewater Treatment System Manual provides further support and justification for a denitrification system with an organic-rich component in the following statements: "...nitrogen removal below the infiltration field can be enhanced by placing the system high in the soil profile, where organic matter in the soil is more likely to be present,..." and "Denitrification can also occur if ground water enters surface water bodies through organic-rich bottom sediments." (USEPA, 2002).

PADEP has evaluated several "experimental" on-lot sewage treatment technologies over the years; some of which have included denitrification technologies. It appears from personal discussions and review of multiple sources that there is not a PADEP-approved (i.e., "alternate") technology for the treatment of nitrate in spite of several experimental systems which have undergone evaluation. In fact, PADEP has recently established a Technology Verification Protocol (TVP) for evaluation of on-lot sewage treatment technologies which it believes warrant evaluation. Any evaluations conducted on the POINT™ System will be performed in accordance with the TVP.

4.3 TECHNICAL JUSTIFICATION

Treatment schemes similar to the POINT™ System have been studied and field-tested by the author and other researchers for treatment of high-nitrate water and for other parameters with similar treatment removal mechanisms as nitrate. This information is summarized below as technical justification for the POINT™ System.

4.3.1 Denitrification Applications

Permeable Reactive Barriers (Australia, New Zealand)

Permeable reactive barriers, or PRBs, are trenches excavated below the groundwater table and perpendicular to the groundwater flow direction to intercept impacted groundwater. The PRBs are filled with a reactive medium to treat the groundwater as it passes through the PRB. Several PRBs have been installed in recent years, but only a handful are known to exist for the treatment of nitrate-impacted groundwater. Two such pilot-scale PRBs, one in Australia and one in New Zealand, used sawdust as the reactive medium. Both showed successful reduction in groundwater nitrate concentrations from upgradient of the PRB to downgradient (Fahrner, 2002: Schipper, circa 2001).

Subsurface On-site Waste Water Treatment System (Canada)

An on-site wastewater treatment system was installed in 1996 below a parking lot of a restaurant in Ontario, Canada. The system contained (top to bottom) polyethylene leaching chambers over a sand filter bed. Sawdust was added to one-half of the bed as a comparison to the unaugmented half. Results show a significant reduction in nitrate at the bottom of the augmented half (effluent NO_3=0.6 mg/L) as compared to the unaugmented half (8.6 mg/L) (St. Marseille, 2001).

Nitrate-Containing Landfill Leachate: Pilot Test (Canada)

A three-year pilot-scale field trial was conducted using a two-layer absorption area to treat landfill leachate containing high levels of ammonia. The absorption area contained a 95 centimeter (cm) thick (3.1 feet) layer of unsaturated sand underlain by a 20 cm (0.66 feet) thick layer of coarse hardwood sawdust. The pilot-system was able to sequentially convert ammonium to nitrate in the upper layer followed by nitrate to nitrogen gas within the sawdust layer. Average total nitrogen removal was 89% over the life of the test, with a third-year average of 96% (Robertson, 1999).

In-situ Denitrification Field Trials (Canada)

Three field trials using a variety of configurations to examine oxygen diffusion and nitrate reduction using different porous media were installed at sites in Canada. Two of the field trials used organic layers below leaching fields and one was a cut-off wall

(PRB). The two sites involving horizontal layers included an organic layer augmented with 15% sawdust and the PRB was constructed of a sand/sawdust mixture (20% sawdust). The results of these trials that are germane to the POINT™ System are four-fold: 1) coarse silt to fine sand will remain saturated via surface tension, 2) augmentation of such a layer with organics helps retain saturation levels, 3) nitrate reduction due to denitrification in an organic-augmented layer occurs rapidly, and 4) 15% organic augmentation is adequate to support denitrification over the life of the test (Robertson, 1995).

4.3.2 Similar Treatment Applications

Organic media such as peat moss, sawdust, hay, and brewery waste have been used in several passive and semi-passive treatment systems, including those researched, designed, and implemented by the primary author. In the primary author's experience, the systems have involved using sawdust as an organic substrate to promote an anaerobic environment conducive to sulfate-reducing bacteria (SRB). SRB are similar to the denitrifiers in that both require an anaerobic (anoxic) environment and a constant carbon source for metabolism. The SRB technology has been successfully applied to acid mine drainage (AMD) and metals-removal projects in a similar fashion as the POINT™ System.

Specific applications by the primary author have included: 1) Pilot study for metals removal from a wastewater influent whereby a 35-foot by 35-foot basin was constructed, filled with an organic treatment media (sawdust and manure), and operated for 3 months to successfully demonstrate metals removal using SRB in an anaerobic environment (AGC, 2004), and: 2) Column study for acid mine drainage whereby a sawdust-based substrate was successful in supporting the biological activity in an anaerobic environment, thus buffering the acidity and removing metals from the influent (Hagerty, 2002).

These systems, and many others not directly associated with the author, have been designed and implemented to provide an anaerobic, carbon-rich environment for the promotion of biological activity similar to the POINT™ System. In addition, these systems have been developed with similar long-term hydraulic and longevity design constraints as those associated with proposed nitrate treatment systems.

5.0 POINT™ SYSTEM CONSIDERATIONS

The following sections provide a technical review of the physical and biological characteristics of the POINT™ system.

5.1 CARBON SOURCE

Several sources of carbon are available for denitrification. In the POINT™ System, manufacturing byproducts such as sawdust or culm are normally used since they are high in carbon content and would otherwise be waste products. When evaluating carbon sources for use in biological degradation, the carbon is typically expressed in terms of its relative ratio to nitrogen; known as the carbon-to-nitrogen (C:N) ratio. Most sources list sawdust as the highest C:N ratio, at between 400 and 600. Sawdust generally contains about 0.1% nitrogen. Assuming sawdust has an average C:N ratio of 500:1 and 0.1% nitrogen, the sawdust is approximately 50% carbon, or about 1,000 pounds (lbs) of carbon per ton of sawdust (Jenkins, 1999: MDOC, 1994).

5.2 SYSTEM LONGEVITY

The logical follow-up question to Section 5.1 is, how long will the carbon source in the sawdust last before it requires replacement? EPA's Technology Fact Sheet 9 (USEPA, 2002) provides a design benchmark of 10 years for this type of technology to be viable, although the authors believe that applicable systems should last 20 years or more. As shown below, under normal operating conditions, the organic-carbon component is expected to last for more than 100 years. To calculate the longevity of the carbon component, the following assumptions are provided:

- Nitrate concentration into carbon layer - 45 milligrams per liter (mg/L) (PADEP, 1997)
- Daily flow rate into the absorption area - 500 gallons per day (gpd) assuming 4 bedroom residential dwelling (PADEP, 2004)
- Percolation rate - 30 minutes per inch (mpi)
- Factor of Safety (FS) added to perc rate - 1.5, or a design rate of 45 mpi (see Section 5.4.1 for explanation of FS)
- Denitrification layer thickness – two (2) feet
- Stoichiometry: $5CH_2O + 4NO_3^- \rightarrow 5CO_2 + 2N_2 + 3H_2O + 4OH^-$
- Dry bulk density of sawdust - 20 pounds per cubic foot (pcf) (Robertson, 1999: Hagerty project experience)
- 50% carbon content sawdust (by weight) (Jenkins, 1999: MDOC, 1994)

Using these assumptions results in a carbon longevity of 279 years. In reality, all of the carbon in the sawdust may not be available for metabolism and the denitrification layer is not 100% organic. Even so, a conservative FS of 4 (2 for carbon availability and 2 for 50% soil/50% organic mix) would maintain the longevity over 50 years, which is more than twice the typical life expectancy of a normal on-lot sewage treatment system and more than five times the EPA design benchmark.

As additional evidence of the ample longevity of the carbon source, the author's experience with SRB systems, which also use sawdust as the carbon source, has indicated that longevity is not an issue. One such SRB system has been in operation since 1996 with no visible signs of substrate breakdown or physical reduction. Furthermore, long-term performance evaluations of field-scale studies referenced earlier indicate only minimal carbon consumption, on the order of less than 0.5% per year (Robertson, 2000).

5.3 ANAEROBIC PROPERTIES AND SATURATION

A primary consideration in the effectiveness of any denitrification system is for the treatment unit, in this case the organic-augmented layer, to contain a low level of oxygen for the promotion of anaerobic microbial activity. Three common characteristics of the POINT™ System, infiltration zone organic loading, soil-water holding capacity, and depth of organic layer, ensure that the organic layer remains in an anoxic environment for denitrification to occur. Each of the characteristics is discussed below.

5.3.1 Infiltration Zone Organic Loading

It is well understood that the infiltration layer of a traditional on-lot sewage treatment system is responsible for the removal or reduction of the organic load (BOD) in the wastewater and also the conversion of ammonium to nitrate. Both of these processes are oxygen-demanding, and as such, DO levels a couple of feet into the infiltration layer are typically low. EPA recognizes this condition when it states "Anaerobic conditions are created when the applied oxygen demand exceeds what the soil is able to supply by diffusion through the vadose zone." (USEPA, 2002). Furthermore, research has provided data supporting the same conclusion. For example, field pilot studies conducted in the early 1990's concluded that "[g]reatest O_2 declines were noted immediately below the weeping tiles indicating that this was the zone where oxidation of effluent organic matter and NH_4^+ was most intense." (Robertson, 1995). Similarly, data cited by EPA in its Onsite Wastewater Treatment System Manual show total removal of BOD (93.5 mg/L to <1 mg/L) within the first two feet of the absorption area, indicating that O_2 was consumed in this region (USEPA, 2002). These observations and studies confirm that, even when properly designed, anaerobic conditions are likely to occur in the lower portions of an absorption area following treatment for BOD and NH_4^+ in the upper layers of an absorption area.

It is also believed that the iron content in substrates assists denitrification possibly via increased oxygen consumption rates (McFarland, 1996). This theory will be evaluated further with respect to its impact on the absorption area's overall characteristics and effectiveness of the treatment system.

5.3.2 Soil-Water Holding Capacity

It is well documented that a soil layer containing a high amount of moisture generally has a low level of DO and does not allow the diffusion of oxygen (e.g., re-aeration from the surface to the underlying soil). The presence of organics such as sawdust within the soil increase the soil's water holding capacity. These high-moisture conditions in turn create (and maintain) anaerobic conditions for denitrification. Field studies previously cited provide data whereby sawdust-augmented soil layers were placed at a prescribed depth within a septic system absorption area. Discrete DO and moisture content measurements were then taken above and below the sawdust-augmented layer, and in all cases, significant reductions in DO were experienced within and directly below the augmented layer (Robertson, 1995).

Other studies have indicated that, even when water samples from organic soil layers indicate aerobic conditions, denitrification still occurs due to microenvironments within soil pores containing denitrifying microorganisms in intra-aggregate water-filled pores (Fahrner, 2002).

5.3.3 Depth of Organic Layer

The depth of the denitrification treatment layer will normally be at least 4 feet below the ground surface. At this depth, oxygen diffusion from the surface (atmosphere) to the subsurface is limited. This is supported by EPA literature that states "The maximum depth [of the infiltration surface] should be limited to no more than 3 to 4 feet below grade to adequately re-aerate the soil and satisfy the daily oxygen demand of the applied wastewater." (USEP, 2002). Additionally, EPA states "Maximum delivery of oxygen to the infiltration zone is most likely when soil components are shallow..." (USEPA, 2002).

These observations and data provide further evidence of the ability of an organic-augmented layer directly below a traditional septic system absorption area to maintain anaerobic conditions and thus provide denitrification.

5.4 REACTION RATES AND HYDRAULICS

On-lot sewage treatment system design is based on the anticipated flow from an individual dwelling and the ability of the absorption area to accept this flow on a daily basis. To determine this ability, a percolation (or "perc") test is conducted in the proposed absorption area to determine the rate of infiltration, and hence the required absorption area. Perc rates are based on the average rate of drop in water levels in a series of test holes within the proposed absorption area and are expressed in terms of minutes per inch (mpi). This average perc rate can be expressed as the absorption area's hydraulic capacity. When determining the denitrification layer dimensions, hydraulic capacity is evaluated in two ways; 1) the ability of the organic layer to accommodate the daily flow without impacting the overall perc rate of the system, and 2) the required residence time of water within the organic layer to allow for complete denitrification. Each of these design characteristics is discussed below.

5.4.1 Hydraulic Capacity

As stated previously, EPA's Onsite Wastewater Treatment Systems Manual states that "The use of beds of carbon-rich materials below [subsurface wastewater infiltration system] leach lines could be a promising concept if the hydraulic matching problems are solved..." These hydraulic problems have been successfully addressed by the author on other similar projects (i.e., SRB projects). In reality, it is not a "matching" problem but rather a flow restriction issue. Specifically, the hydraulic properties of the overlying re-compacted soil and the underlying denitrification layer do not have to be matched, but they have to be designed such that the denitrification layer is more permeable than the overlying soil, thus creating a free-flowing system. It is only when the underlying denitrification layer is less permeable than the overlying soil layer that hydraulic failures occur. In this case, the failures would result in a collection of water at the soil/organic interface which would create the potential for an anaerobic zone into the overlying recompacted soil zone. In most cases, the grain size of the organic amendments in the denitrification layer is greater than the grain size of the overlying virgin soil. When larger-grained material is added to a soil, the permeability increases. Therefore, adding the organic amendments to the soil will create a more permeable denitrification layer, which will not cause system hydraulic flow problem.

As with a traditional system, the POINT™ System is first designed using the data from the perc test to determine the size of the absorption area. The average perc rate is increased by 1.5 (FS) to account for potential temporary hydraulic conductivity loss due to excavation and replacement of the absorption area to install the denitrification layer. It is believed that the 1.5 FS is a conservative approach to accommodate the short-term potential of the recompacted soil layer to temporarily decrease in hydraulic conductivity until a steady-state, higher conductivity is re-established. Post-installation perc tests may be conducted to confirm that the factor of safety adequately overcame the temporary permeability reductions, if any.

5.4.2 Residence Time

Residence time is defined as the time a given quantity of water resides in a treatment unit. In traditional wastewater treatment, residence time is calculated by dividing the volume of the treatment unit by the flow rate of effluent into the unit. This assumes that influent flow equals effluent flow (steady state) and that the treatment unit remains full. In on-lot sewage treatment systems including the POINT™ System, these assumptions do not always hold. Rather, residence time is a direct function of the hydraulic conductivity of the treatment media, in this case the organic layer for denitrification.

Several residence times from several column, pilot, and full-scale studies referenced above were evaluated. When calculated using hydraulic conductivity as the controlling factor, the residence times ranged from 3 to 9 hours for adequate removal of nitrate. Based on the assumptions from Section 5.2 for an average absorption field, and applying a porosity of 0.4 to determine seepage velocity, the residence time for a two-foot thick organic layer would be 7.2 hours. This is well within the range of successful residence times from other studies and indicates that the denitrification layer will adequately denitrify the effluent in a 2 foot thick layer.

5.4.3 Fill Stabilization

Disturbance of the absorption area for installation of the denitrification layer is not consistent with PADEP's on-lot sewage disposal system design standards. Specifically, disturbance of the absorption area is not permitted. However, PADEP acknowledges the soil disturbance as a temporary condition in §73.12(b) (Site location) where it states "Absorption areas or spray fields may not be placed in or on fill unless the fill has remained in place for a minimum of 4 years to allow restoration of natural permeability." Therefore, it is expected that the disturbed soil will return to pre-disturbed hydraulic conditions, or equilibrate at some other rate, relatively shortly after the installation of the system.

PADEP's Experimental Guidance Document (PADEP, 2003) provides several provisions for the early evaluation of "controlled fill" prior to the 4-year period. These provisions, both during placement of the POINT™ System and during the evaluation period, will be followed in any future pilot or full-scale applications, as appropriate, including the use of a certified Sewage Enforcement Officer (SEA) and a certified soil scientist. The TVP will be the final determination on testing and monitoring procedures.

In the event that the disturbed fill condition is not acceptable to the governing agency, the POINT™ System can be installed using several PADEP-approved treatment units. For example, a free access sand filter (§73.162(b)) or a subsurface sand filter (§73.54) can be modified with the denitrification layer to be consistent with PADEP regulations.

5.5 pH

Two primary pH concerns are typically raised when considering a system similar to the POINT™ System. First, one needs to confirm that microbial denitrification is not overly sensitive to pH fluctuations from the incoming effluent. Second, one should confirm that the denitrification process does not cause unacceptable pH conditions to the receiving body. Research indicates that denitrification operates optimally in the 6.0 to 8.0 pH range, which is typical of on-lot sewage treatment systems, therefore, denitrification efficiencies are not expected to be compromised by pH.

Impacts on the receiving body as a result of denitrification are not expected based on the byproducts of the reaction. As shown in Section 5.2, the denitrification reaction produces alkalinity (OH^-). This alkalinity is expected to be beneficial based on the slightly acidic nature of groundwater in many areas of Pennsylvania. Additionally, nitrification, which occurs directly above the denitrification layer, produces minor amounts of acidity (H^+) which will then be buffered by the denitrification process.

5.6 Temperature

Temperature fluctuations and their impact on treatment efficiencies are often a concern in biological treatment scenarios. This is witnessed in some of the treatment technologies listed in Section 3.2 where treatment efficiencies are reduced in winter months. This is not the case for the POINT™ System as the denitrification layer is normally positioned greater than 4 feet below ground surface in a horizon that does not experience significant temperature fluctuations. Furthermore, several researchers have shown that biological denitrification, although more rapid at higher temperatures, will still occur at acceptable rates down to as low as 0°C (Brown, 2002). As the geothermal temperature 4 to 5 feet below ground surface is about 55°F and stable, denitrification in the POINT™ System should be effective and stable.

5.7 Traditional Treatment Parameters

The following section is provided in support of how the POINT™ System will be able to maintain the removal efficiencies of a traditional on-lot sewage treatment system while still treating for nitrate. Generally, the traditional treatment parameters consist of solid constituents (total suspended solids [TSS]), organic substances (typically measured in terms of biological oxygen demand [BOD]), nutrients (primarily nitrogen and phosphorous), pathogens (bacteria and viruses), and miscellaneous parameters (surfactants, inorganics [metals], toxic organics). Each grouping is summarized below including how the POINT™ System will continue to treat the traditional parameters.

5.7.1 Solid Constituents

Solid constituents consist of large to small diameter particulate which generally settle out in a properly-sized septic tank. Particulate remaining in the septic tank effluent is generally small (in most cases colloidal) and is measured in terms of TSS. The POINT™ System employs the same septic tank design parameters as a traditional septic system, therefore, no increase or decrease in the removal efficiency would be experienced at this stage. It is generally accepted that the remaining TSS which is introduced into the absorption area is removed to acceptable levels within the first 1 foot of the infiltrative surface (EPA, 2002: OSU, 2002). As the top portion of the POINT™ System will be compacted native soil, TSS is expected to continue to be easily removable within the first foot of soil under the distribution piping.

5.7.2 Organic Substances

A host of organic substances, most dissolved, are present within septic tank effluent which is delivered to the leaching field. These substances collectively create an oxygen demand on the receiving body. Primarily through biological activity in upper portions of the absorption area soil, the organic matter is normally removed within the first two feet of soil. This is supported by case studies cited by EPA (EPA, 2002: Anderson et al., 1994) and also by OSU (OSU, 2002). As the top portion of the POINT™ System will be compacted native soil, BOD is expected to continue to be easily removable within the first two feet of soil under the distribution piping.

5.7.3 Nutrients

Nitrogen removal is not normally achieved in a traditional on-lot sewage treatment system. Instead, nitrogen is simply converted from organic nitrogen to ammonia (septic tank) to nitrate (absorption field). The POINT™ System provides significant nitrogen removal as detailed above.

The other main nutrient constituent is phosphorous. Phosphorous is removed in the absorption area primarily via adsorption and secondarily via precipitation (EPA, 2002).

The adsorptive capacity of soil is highly dependent on several soil characteristics. An increase in organic matter in soil increases the adsorptive capacity for phosphorous (Florida, 2003), therefore, the POINT™ System's denitrification layer is expected to increase the phosphorous removal rate over traditional on-lot sewage treatment systems.

5.7.4 Pathogens

Pathogens in on-lot sewage treatment systems generally include bacteria and viruses. Bacteria are normally removed by filtration (physical) in the first 1-2 feet of soil. The bacteria then typically do not survive long due to the hostile environment unlike the host environment (EPA, 2002). Viruses are smaller than bacteria and are removed by adsorption, also then followed by mortality due to hostile conditions. Both of these removal mechanisms are a function of the adsorption area soil of a traditional on-lot sewage disposal system. The POINT™ System is installed in a similar fashion and therefore should not impact its ability to remove pathogens at a similar rate as a traditional system.

6.0 CONCLUSIONS

Groundwater degradation by nitrate is an increasingly-important regulatory issue. Unfortunately, the current approach to addressing the issue is inversely proportional to land preservation goals, resulting in more land destruction per acre to achieve density requirements established for nitrate. A more balanced approach is to *limit* the discharge of nitrate to groundwater, as opposed to spreading it out. The POINT™ System is a passive, in-situ method of reducing the mass of nitrate discharged to groundwater while continuing to treat sewage at levels consistent with current technology. This system is conceptually simple, easy to install, has a long operating life, and requires little or no maintenance. With advanced on-lot sewage treatment systems such as the POINT™ System, land planners, developers, and regulators will have a much-needed tool to reduce nitrates to the environment while balancing development and land preservation.

The technology in the POINT™ System has been shown through bench- and pilot-scale testing to be effective at reducing nitrate concentrations by more than 90% via denitrification. As with any innovative technology, additional data and full-scale trials will be beneficial to confirm the effectiveness of the technology and to develop design standards for future installations. These data collection activities will be pursued through partnerships with regulatory agencies and their respective assessment protocols, such as PADEP's Technology Verification Protocol (TVP).

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August 23, 2012 Project No. 12-1186-0047

Greg Meek
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CONCEPTUAL SEWAGE SYSTEM SIZING
IN SUPPORT OF DRAFT PLAN SUBMISSION
PART OF LOTS 17 & 18, CONCESSION 9
LOTS 47 & 48, REGISTERED PLAN 12
TOWN OF PICKERING, ONTARIO

Dear Mr. Meek:

This letter provides the conceptual sewage system sizing for a proposed subdivision located on the above noted land, along Old Brock Road in the Town of Pickering, Ontario.

Background Review

The following information was reviewed and forms the basis of the assessment:

- Record of Boreholes, 12-1 to 12-6 (Preliminary Geotechnical and Hydrogeological Investigation, in Support of Draft Plan Submission for a Proposed Residential Subdivision, Lane Street and Brock Road, Claremont, City of Pickering, Ontario, dated August 23, 2012, reference number 12-1186-0047)
- Grain Size Distribution, Figure 3 (Preliminary Geotechnical and Hydrogeological Investigation, in Support of Draft Plan Submission for a Proposed Residential Subdivision, Lane Street and Brock Road, Claremont, City of Pickering, Ontario, dated August 23, 2012, reference number 12-1186-0047)
- Plasticity Chart, Figure 4 (Preliminary Geotechnical and Hydrogeological Investigation, in Support of Draft Plan Submission for a Proposed Residential Subdivision, Lane Street and Brock Road, Claremont, City of Pickering, Ontario, dated August 23, 2012, reference number 12-1186-0047)
- Draft Plan of Subdivision, Part of Lots 17 & 18, Concession 9, Lots 47 & 48, Registered Plan No. 12, Town of Pickering (Malone Given Parsons Ltd., March 7, 2012, updated August 9, 2012, Reference No. 11-2041)

It is assumed that each dwelling unit will consist of the following:

- 4 bedrooms;
- Floor area of 3,000 sq ft; and
- 20 fixture units.

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Sewage System Sizing

Given the above dwelling, the maximum daily sewage flow is 3,000 L/d, as per Table 8.2.1.3.A of the Ontario Building Code (OBC). This is consistent with the Region of Durham Subdivision/Severance Policy for Lands Requiring On-Site Private Sewage Systems (RofD Policy), which states that the minimum daily sewage flow used in the design shall be 3,000 L/d. The minimum septic tank size for a conventional Class 4 sewage system would be 6,000 L. The minimum septic tank size for tertiary treatment systems varies depending on the type of system selected; however, would not be greater than 6,000 L.

The borehole records indicate that the native soils consist of clayey silt within 1.5 m of existing grade. Using the Unified Soil Classification System in the OBC, the grain size distribution for this soil characterizes it as soil group ML (clayey silts with slight plasticity). However, the plasticity chart indicates that the soil would fall into the transition zone between ML and CL (clayey silts with low to high plasticity) soils.

Table 2 in the Supplementary Guidelines to the OBC provides percolation (T) times ranging from 20 to 50 min/cm for ML soils and greater than 50 min/cm for CL soils. Conservatively, we have selected greater than 50 min/cm, resulting in a loading rate of 4 L/m^2/d, based on Table 8.7.4.1.A of the OBC. For a design flow of 3,000 L/d, the loading area of the system would need to be 750 m^2. A reserve area would double the above area to 1,500 m^2. Since the soils are within the transition zone between Ml and CL soils, we recommend, when the sewage systems are designed that in-situ percolation tests be performed to determine the percolation rate of the native soil.

If tertiary treatment units are used to reduce the required loading area for each sewage system, the Building Materials Evaluation Commission (BMEC) provides requirements for the installation of these systems. There are a number of different systems approved by BMEC; however, we have focused on those that discharge to an area bed. The BMEC approval for these systems states that the loading rate, for the above soils, would be 8 L/m^2/d. This results in a required loading area of 375 m^2 for the system. A reserve area would double the above area to 750 m^2.

Groundwater was encountered at varying depths during drilling on February 23, 2012, ranging from 1.5 m to 7.3 m below ground surface (bgs). Monitoring wells were installed in BH 12-2, 12-4 and 12-6. The depth to groundwater was measured in BH 12-2 at 0.92 m bgs on March 2, 2012. The monitoring wells installed in BH 12-4 and 12-6 indicated groundwater levels of 4.50 m and 5.53 m bgs on March 2, 2012, respectively. Based on this information, the expected maximum height that any given sewage system will be raised above existing grade due to the groundwater elevation is 0.58 m.

Since the site has a percolation rate greater than 20 min/cm, the construction of in ground sewage systems relying on the native soils would not be considered practical. Therefore, all systems are assumed to be raised by 1.5 m over native soils. This will vary depending on lot configuration and topography and should be determined during the detailed design. As per 8.7.4.2.(9) of the OBC, the minimum clearance distances for the sewage system shall be increased by 3.0 m.

Therefore, the minimum clearance distances for the sewage systems are expected to be:

Description	Distance (m)
Structure	8.0
Well with watertight casing to a depth of 6 m	18.0
Any other well	33.0

Description	Distance (m)
Lake	18.0
Pond	18.0
Reservoir	18.0
River	18.0
A spring not used as a source of potable water	18.0
Stream	18.0
Property Line	6.0

The above clearance distances apply to the distribution piping. The minimum clearances for treatment units will be as per Table 8.2.1.6.A of the OBC.

The lot sizes will vary depending on lot configuration, loading area, reserve area, clearance distances, zoning setbacks, dwelling footprint and other factors. The above criteria will be used to determine the lot configuration and number of lots for the proposed subdivision.

CLOSURE

We trust that the information presented above addresses your current requirements. If you have any questions concerning our recommendations please call us at your convenience.

GOLDER ASSOCIATES LTD.

Scott Taylor, P.Eng.
Civil Engineer

SWT/DGM/lc
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AGAT Laboratories, Certificates of Analysis 12T580244, 12T589565
Maxxam Analytics, Certificates of Analysis B7P5848V1, B87344V1

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CLIENT NAME: GOLDER ASSOCIATES LTD.
100 SCOTIA COURT
WHITBY, ON L1N8Y6

ATTENTION TO: WilliamRichard Zavitz

PROJECT NO: 12-1186-0047

AGAT WORK ORDER: 12T580244

WATER ANALYSIS REVIEWED BY: Elizabeth Polakowska, MSc (Animal Sci), PhD (Agri Sci), Inorganic Lab Supervisor

DATE REPORTED: Mar 06, 2012

PAGES (INCLUDING COVER): 4

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

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Certificate of Analysis

AGAT WORK ORDER: 12T580244

PROJECT NO: 12-1186-0047

CLIENT NAME: GOLDER ASSOCIATES LTD.

ATTENTION TO: WilliamRichard Zavitz

Anion Scan

DATE SAMPLED: Mar 05, 2012 | **DATE RECEIVED: Mar 05, 2012** | **DATE REPORTED: Mar 06, 2012** | **SAMPLE TYPE: Water**

Parameter	Unit	G / S	RDL	MW2 3163571	MW4 3163572	MW6 3163573
Nitrate as N	mg/L		0.05	0.17	5.76	<0.05

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

Certified By: Elizabeth Rolakowska

Results relate only to the items tested

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Quality Assurance

CLIENT NAME: GOLDER ASSOCIATES LTD. **AGAT WORK ORDER: 12T580244**

PROJECT NO: 12-1186-0047 **ATTENTION TO: WilliamRichard Zavitz**

Water Analysis

RPT Date: Mar 06, 2012			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
Anion Scan															
Nitrate as N	1	3163572	5.76	5.48	5.0%	< 0.05	92%	90%	110%	94%	90%	110%	98%	80%	120%

Certified By: Elizabeth Polakowska

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Method Summary

CLIENT NAME: GOLDER ASSOCIATES LTD. **AGAT WORK ORDER: 12T580244**

PROJECT NO: 12-1186-0047 **ATTENTION TO: WilliamRichard Zavitz**

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Water Analysis			
Nitrate as N	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH

3pm

AGAT Laboratories

5835 Coopers Avenue
Mississauga, Ontario
L4Z 1Y2
www.agatlabs.com · webearth.agatlabs.com
Ph.: 905.712.5100 · Fax: 905.712.5122 · Toll Free: 800.856.6261

Chain of Custody Record

Laboratory Use Only
Arrival Temperature: 3.9
AGAT WO #: 12T580244
Lab Temperature: 2.1
Notes:

Client Information:
Company: Golder Associates.
Contact: Richard Zavitz.
Address: 100 Scotia Court. Whitby L1N 8Y6.
Phone: 905 723 2727 Fax:
Project: 12-1186-0047. PO:
AGAT Quotation #:
Please note, if quotation number is not provided, client will be billed full price for analysis.

Regulatory Requirements:
☐ Regulation 153/09 (reg. 511 Amend.)
Table ___ Indicate one
☐ Ind/Com
☐ Res/Park
☐ Agriculture
Soil Texture (check one)
☐ Coarse ☐ Fine
☐ Sewer Use
Region ___ Indicate one
☐ Sanitary
☐ Storm
☐ Regulation 558
☐ CCME
☐ Other (specify)
☐ Prov. Water Quality Objectives (PWQO)
☐ None

Turnaround Time Required (TAT) Required*
Regular TAT
☐ 5 to 7 Working Days
Rush TAT (please provide prior notification)
Rush Surcharges Apply
☐ 3 Working Days
☐ 2 Working Days
☒ 1 Working Day
OR
Date Required (Rush surcharges may apply): 2012 MAR 06.
*TAT is exclusive of weekends and statutory holidays

Invoice To: Same: Yes ☒ No ☐
Company:
Contact:
Address:

Is this a drinking water sample? (potable water intended for human consumption) ☐ Yes ☒ No
If "Yes", please use the *Drinking Water Chain of Custody Form*

Is this submission for a **Record of Site Condition**? ☐ Yes ☐ No

Legend Matrix
GW Ground Water O Oil
SW Surface Water P Paint
SD Sediment S Soil

Report Information – reports to be sent to:
1. Name: Richard Zavitz.
Email: RZavitz@Golder.com.
2. Name:
Email:

Sample Identification	Date Sampled	Time Sampled	Sample Matrix	# of Containers	Comments Site/Sample Information	Metals and Inorganics	Metal Scan	Hydride Forming Metals	Client Custom Metals	ORPs: ☐ B-HWS ☐ CN ☐ Cl ☐ SAR ☐ EC ☐ FOC ☐ Cr+6 ☐ Hg ☐ pH ☐ NO_3/NO_2 ☐ N-Total	Nutrients: ☐ TP ☐ NH_3 ☐ TKN ☒ NO_3 ☐ NO_2 ☐ NO_3/NO_2	VOC: ☐ VOC ☐ THM ☐ BTEX	CCME Fractions 1 to 4	ABNs	PAHs	Chlorophenols	PCBs	Organochlorine Pesticides	TCLP Metals/Inorganics	TCLP:	Sewer Use
MW2	2012MAR05	13h30	GW	1																	
MW4	2012MAR05	13h15	GW	1																	
MW6	2012MAR05	13h02	GW	1																	

Samples Relinquished by (print name & sign): MR Zavitz [signature] Date/Time: 2012MAR05
Samples Received by (Print name & sign): [signature] Mar 5/12 Date/Time: 3:15
Samples Relinquished by (print name & sign): Date/Time:
Samples Received by (Print name & sign): Date/Time: 4:40

Pink Copy – Client
Yellow + Golden Copy – AGAT
White Copy – AGAT

Page 1 of 1
NO: 170740

Document ID: DIV-78-1511.006
Date Issued: July 20, 2011

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: GOLDER ASSOCIATES LTD.
100 SCOTIA COURT
WHITBY, ON L1N8Y6

ATTENTION TO: WilliamRichard Zavitz

PROJECT NO: 12-1186-0047

AGAT WORK ORDER: 12T589565

WATER ANALYSIS REVIEWED BY: Inesa Alizarchyk, Inorganic Lab Supervisor

DATE REPORTED: Apr 16, 2012

PAGES (INCLUDING COVER): 4

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: GOLDER ASSOCIATES LTD.

ATTENTION TO: WilliamRichard Zavitz

Nitrate (water)

DATE SAMPLED: Apr 05, 2012 | DATE RECEIVED: Apr 05, 2012 | DATE REPORTED: Apr 16, 2012 | SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	MW4 3246165
Nitrate as N	mg/L		0.05	8.40

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

Certified By:

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Quality Assurance

CLIENT NAME: GOLDER ASSOCIATES LTD.

AGAT WORK ORDER: 12T589565

PROJECT NO: 12-1186-0047

ATTENTION TO: WilliamRichard Zavitz

Water Analysis

RPT Date: Apr 16, 2012			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
Nitrate (water)															
Nitrate as N	1	3246165	8.40	8.25	1.8%	< 0.05	96%	90%	110%	99%	90%	110%	100%	80%	120%

Certified By:

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Method Summary

CLIENT NAME: GOLDER ASSOCIATES LTD.

AGAT WORK ORDER: 12T589565

PROJECT NO: 12-1186-0047

ATTENTION TO: WilliamRichard Zavitz

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Water Analysis			
Nitrate as N	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH

SR12

AGAT Laboratories

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Mississauga, Ontario
L4Z 1Y2
www.agatlabs.com · webearth.agatlabs.com

Ph.: 905.712.5100 · Fax: 905.712.5122 · Toll Free: 800.856.6261

Chain of Custody Record

Laboratory Use Only

Arrival Temperature: 7.8
AGAT WO #: 12T589565
Lab Temperature: 6.9
Notes:

Client Information:

Company: GOLDER ASSOCIATES.
Contact: RICHARD ZAVITZ.
Address: 100 SCOTIA COURT.

Phone: 905-723-2727. Fax:
Project: 12-1186-0047. PO:
AGAT Quotation #:

Please note, if quotation number is not provided, client will be billed full price for analysis.

Regulatory Requirements:

- ☐ Regulation 153/09 (reg. 511 Amend.)
  - Table ____ Indicate one
  - ☐ Ind/Com
  - ☐ Res/Park
  - ☐ Agriculture
  - Soil Texture (check one): ☐ Coarse ☐ Fine
- ☐ Sewer Use
  - Region ____ Indicate one
  - ☐ Sanitary
  - ☐ Storm
- ☐ Regulation 558
- ☐ CCME
- ☐ Other (specify)
- ☐ Prov. Water Quality Objectives (PWQO)
- ☐ None

Turnaround Time Required (TAT) Required*

Regular TAT
☒ 5 to 7 Working Days

Rush TAT (please provide prior notification)
Rush Surcharges Apply
☐ 3 Working Days
☐ 2 Working Days
☐ 1 Working Day

OR

Date Required (Rush surcharges may apply):

*TAT is exclusive of weekends and statutory holidays

Invoice To: Same: Yes ☒ No ☐

Company:
Contact:
Address:

Is this a drinking water sample? (potable water intended for human consumption) ☐ Yes ☐ No
If "Yes", please use the *Drinking Water Chain of Custody Form*

Is this submission for a **Record of Site Condition?** ☐ Yes ☐ No

Legend Matrix

GW Ground Water **O** Oil
SW Surface Water **P** Paint
SD Sediment **S** Soil

Report Information – reports to be sent to:

1. Name: WR ZAVITZ.
   Email: RZAVITZ@GOLDER.COM.
2. Name:
   Email:

Sample Identification	Date Sampled	Time Sampled	Sample Matrix	# of Containers	Comments Site/Sample Information	Metals and Inorganics	Metal Scan	Hydride Forming Metals	Client Custom Metals	ORPs: ☐ B-HWS ☐ Cl ☐ CN ☐ EC ☐ FOC ☐ Cr+6 ☐ SAR ☐ NO_3/NO_2 ☐ N-Total ☐ Hg ☐ pH	Nutrients: ☐ TP ☐ NH_3 ☐ TKN ☐ NO_3 ☐ NO_2 ☐ NO_3/NO_2	VOC: ☐ VOC ☐ THM ☐ BTEX	CCME Fractions 1 to 4	ABNs	PAHs	Chlorophenols	PCBs	Organochlorine Pesticides	TCLP Metals/Inorganics	TCLP:	Sewer Use	NITRATE.
MW4.	20 APR 5	10h00	GW	1																		X

Samples Relinquished by (print name & sign): WR ZAVITZ. Date/Time: 20 APR 5
Samples Received by (Print name & sign): [signature] April 5/12 Date/Time: 1:40
Samples Relinquished by (print name & sign): Date/Time
Samples Received by (Print name & sign): Date/Time: 5:10

Pink Copy – Client
Yellow + Golden Copy – AGAT
White Copy – AGAT

Page 1 of 1

NO: 171076

Document ID: DIV-78-1511.006
Date Issued: July 20, 2011

Your Project #: 12-1186-0047 (6000)
Your C.O.C. #: 601028-06-01

Attention:Zen Keizars

Golder Associates Ltd
100 Scotia Crt
Whitby, ON
L1N 8Y6

Report Date: 2017/11/17
Report #: R4862822
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B7P5848
Received: 2017/11/14, 15:59

Sample Matrix: Water
Samples Received: 9

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Nitrate (NO3) and Nitrite (NO2) in Water (1)	9	N/A	2017/11/16	CAM SOP-00440	SM 22 4500-NO3I/NO2B

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported: unless indicated otherwise, associated sample data are not blank corrected.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) Values for calculated parameters may not appear to add up due to rounding of raw data and significant figures.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Ema Gitej, Senior Project Manager
Email: EGitej@maxxam.ca
Phone# (905)817-5829
==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Job #: B7P5848
Report Date: 2017/11/17

Golder Associates Ltd
Client Project #: 12-1186-0047 (6000)
Sampler Initials: AV

RESULTS OF ANALYSES OF WATER

Maxxam ID		FNZ122	FNZ123	FNZ124	FNZ125	FNZ126	FNZ127		
Sampling Date		2017/11/14 12:00	2017/11/14 12:00	2017/11/14 12:00	2017/11/14 12:00	2017/11/14 12:00	2017/11/14 12:00		
COC Number		601028-06-01	601028-06-01	601028-06-01	601028-06-01	601028-06-01	601028-06-01		
	UNITS	BH12-2(MW)	MW17-8	MW17-9	MW17-7	MW17-11	BH12-6(MW)	RDL	QC Batch
Inorganics									
Nitrate (N)	mg/L	0.83	10.6	7.71	7.79	9.40	<0.10	0.10	5267547

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam ID		FNZ128	FNZ129	FNZ130		
Sampling Date		2017/11/14 12:00	2017/11/14 12:00	2017/11/14 12:00		
COC Number		601028-06-01	601028-06-01	601028-06-01		
	UNITS	BH17-16	MW17-19	MW17-18	RDL	QC Batch
Inorganics						
Nitrate (N)	mg/L	0.11	<0.10	<0.10	0.10	5267547

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B7P5848
Report Date: 2017/11/17

Golder Associates Ltd
Client Project #: 12-1186-0047 (6000)
Sampler Initials: AV

TEST SUMMARY

Maxxam ID: FNZ122
Sample ID: BH12-2(MW)
Matrix: Water

Collected: 2017/11/14
Shipped:
Received: 2017/11/14

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5267547	N/A	2017/11/16	Chandra Nandlal

Maxxam ID: FNZ123
Sample ID: MW17-8
Matrix: Water

Collected: 2017/11/14
Shipped:
Received: 2017/11/14

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5267547	N/A	2017/11/16	Chandra Nandlal

Maxxam ID: FNZ124
Sample ID: MW17-9
Matrix: Water

Collected: 2017/11/14
Shipped:
Received: 2017/11/14

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5267547	N/A	2017/11/16	Chandra Nandlal

Maxxam ID: FNZ125
Sample ID: MW17-7
Matrix: Water

Collected: 2017/11/14
Shipped:
Received: 2017/11/14

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5267547	N/A	2017/11/16	Chandra Nandlal

Maxxam ID: FNZ126
Sample ID: MW17-11
Matrix: Water

Collected: 2017/11/14
Shipped:
Received: 2017/11/14

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5267547	N/A	2017/11/16	Chandra Nandlal

Maxxam ID: FNZ127
Sample ID: BH12-6(MW)
Matrix: Water

Collected: 2017/11/14
Shipped:
Received: 2017/11/14

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5267547	N/A	2017/11/16	Chandra Nandlal

Maxxam ID: FNZ128
Sample ID: BH17-16
Matrix: Water

Collected: 2017/11/14
Shipped:
Received: 2017/11/14

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5267547	N/A	2017/11/16	Chandra Nandlal

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Maxxam Job #: B7P5848
Report Date: 2017/11/17

Golder Associates Ltd
Client Project #: 12-1186-0047 (6000)
Sampler Initials: AV

TEST SUMMARY

Maxxam ID: FNZ129
Sample ID: MW17-19
Matrix: Water

Collected: 2017/11/14
Shipped:
Received: 2017/11/14

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5267547	N/A	2017/11/16	Chandra Nandlal

Maxxam ID: FNZ130
Sample ID: MW17-18
Matrix: Water

Collected: 2017/11/14
Shipped:
Received: 2017/11/14

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5267547	N/A	2017/11/16	Chandra Nandlal

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	4.0°C

Results relate only to the items tested.

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Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B7P5848
Report Date: 2017/11/17

Golder Associates Ltd
Client Project #: 12-1186-0047 (6000)
Sampler Initials: AV

QUALITY ASSURANCE REPORT

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
5267547	C_N	Matrix Spike	Nitrate (N)	2017/11/16		97	%	80 - 120
5267547	C_N	Spiked Blank	Nitrate (N)	2017/11/16		102	%	80 - 120
5267547	C_N	Method Blank	Nitrate (N)	2017/11/16	<0.10		mg/L	
5267547	C_N	RPD	Nitrate (N)	2017/11/16	2.7		%	20

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Cristina Carriere, Scientific Service Specialist

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam RUSH!

Maxxam Analytics International Corporation o/a Maxxam Analytics
6740 Campobello Road, Mississauga, Ontario Canada L5N 2L8 Tel:(905) 817-5700 Toll-free:800-563-6266 Fax:(905) 817-5777 www.maxxam.ca

CHAIN OF CUSTODY RECORD

Page 1 / 1

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:		Laboratory Use Only:	
Company Name:	#2292 Golder Associates Ltd	Company Name:		Quotation #:	~~B70018~~	Maxxam Job #:	Bottle Order #: 601028
Attention:	Accounts Payable	Attention:	~~Kevan Browne~~ Zen Keizars	P.O. #:			
Address:	100 Scotia Crt	Address:		Project:	~~1628348 (6000)~~ 12-1186-0047 (6000)	COC #: C#601028-06-01	Project Manager: Ema Gitej
	Whitby ON L1N 8Y6			Project Name:			
Tel:	(905) 723-2727 x Fax: (905) 723-2182 x	Tel:	Fax:	Site #:			
Email:	AP_CustomerService@golder.com	Email:	kevan_browne@golder.com Zen Keizars@golder.com	Sampled By:	A VANROON		

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY

Regulation 153 (2011): ☐ Table 1 ☐ Res/Park ☐ Medium/Fine; ☐ Table 2 ☐ Ind/Comm ☐ Coarse; ☐ Table 3 ☐ Agri/Other ☐ For RSC; ☐ Table ___

Other Regulations: ☐ CCME ☐ Sanitary Sewer Bylaw; ☐ Reg 558 ☐ Storm Sewer Bylaw; ☐ MISA Municipality ___; ☐ PWQO; ☑ Other ODWS

Special Instructions

Include Criteria on Certificate of Analysis (Y/N)? Y

ANALYSIS REQUESTED (PLEASE BE SPECIFIC): Field Filtered (please circle): Metals / Hg / Cr VI; ~~Ajax Storm Sewer By-Law (90-2012)~~; ~~O.Reg 153 PHCs BTEX/F1-F4~~; Nitrate

Turnaround Time (TAT) Required:
Please provide advance notice for rush projects

Regular (Standard) TAT: ☐
(will be applied if Rush TAT is not specified)
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
Date Required: EOD Nov 17/17 Time Required: 5pm ☒
Rush Confirmation Number: ___ (call lab for #)

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Nitrate	# of Bottles	Comments
1		BH12-2(mw)	Nov14/17	12pm	GW	X	1	
2		MW17-8	↓	↓	↓	X	1	
3		MW17-9	↓	↓	↓	X	1	- limited sample (⅓ bottle)
4		MW-17-7	↓	↓	↓	X	1	
5		MW 17-11	↓	↓	↓	X	1	
6		BH12-6(mw)	↓	↓	↓	X	1	
7		BH17-16	↓	↓	↓	X	1	14-Nov-17 15:59 Ema Gitej
8		MW17-19	↓	↓	↓	X	1	B7P5848
9		MW 17-18	↓	↓	↓	X	1	TLI ENV-1334
10								

RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted	Time Sensitive	Temperature (°C) on Receipt	Custody Seal	Yes	No
[signature]	17/11/14	2:30	[signature] Pardeep K. Purewal	2017/11/14	15:59			4/4/4	Present	✓	
									Intact	✓	

White: Maxxam Yellow: Client

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO MAXXAM'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.MAXXAM.CA/TERMS.

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT HTTP://MAXXAM.CA/WP-CONTENT/UPLOADS/ONTARIO-COC.PDF.

SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

Maxxam Analytics International Corporation o/a Maxxam Analytics

Maxxam
A Bureau Veritas Group Company

Your Project #: 12-1186-0047 (6000)
Site Location: 5113 OLD BROCK RD.
Your C.O.C. #: 647515-01-01

Attention: Zen Keizars

Golder Associates Ltd
100 Scotia Crt
Whitby, ON
L1N 8Y6

Report Date: 2018/01/30
Report #: R4958663
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B817344
Received: 2018/01/24, 13:17

Sample Matrix: Water
Samples Received: 5

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Nitrate (NO3) and Nitrite (NO2) in Water (1)	5	N/A	2018/01/26	CAM SOP-00440	SM 22 4500-NO3I/NO2B

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) Values for calculated parameters may not appear to add up due to rounding of raw data and significant figures.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Ema Gitej, Senior Project Manager
Email: EGitej@maxxam.ca
Phone# (905)817-5829
==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B817344
Report Date: 2018/01/30

Golder Associates Ltd
Client Project #: 12-1186-0047 (6000)
Site Location: 5113 OLD BROCK RD.
Sampler Initials: AV

RESULTS OF ANALYSES OF WATER

Maxxam ID			FYV313		FYV314	FYV315	FYV316	FYV317		
Sampling Date			2018/01/18 09:45		2018/01/18 10:05	2018/01/18 10:25	2018/01/18 10:35	2018/01/18 09:30		
COC Number			647515-01-01		647515-01-01	647515-01-01	647515-01-01	647515-01-01		
	UNITS	**MAC**	**MW17-11**	**QC Batch**	**MW17-8**	**MW17-9**	**MW17-7**	**BH12-4**	**RDL**	**QC Batch**
Inorganics										
Nitrate (N)	mg/L	**10**	9.87	5370199	9.45	7.24	6.42	**18.4**	0.10	5369734

RDL = Reportable Detection Limit

QC Batch = Quality Control Batch

MAC: Ontario Drinking Water Standards - Maximum Acceptable Concentration [MAC], Interim Maximum Acceptable Concentration [IMC] & Table 4-Chemical/Physical Objectives [A/O] - Not Health Related, respectively
(Made under the Ontario Safe Drinking Water Act, 2002)

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B817344
Report Date: 2018/01/30

Golder Associates Ltd
Client Project #: 12-1186-0047 (6000)
Site Location: 5113 OLD BROCK RD.
Sampler Initials: AV

TEST SUMMARY

Maxxam ID: FYV313
Sample ID: MW17-11
Matrix: Water

Collected: 2018/01/18
Shipped:
Received: 2018/01/24

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5370199	N/A	2018/01/26	Chandra Nandlal

Maxxam ID: FYV314
Sample ID: MW17-8
Matrix: Water

Collected: 2018/01/18
Shipped:
Received: 2018/01/24

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5369734	N/A	2018/01/26	Chandra Nandlal

Maxxam ID: FYV315
Sample ID: MW17-9
Matrix: Water

Collected: 2018/01/18
Shipped:
Received: 2018/01/24

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5369734	N/A	2018/01/26	Chandra Nandlal

Maxxam ID: FYV316
Sample ID: MW17-7
Matrix: Water

Collected: 2018/01/18
Shipped:
Received: 2018/01/24

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5369734	N/A	2018/01/26	Chandra Nandlal

Maxxam ID: FYV317
Sample ID: BH12-4
Matrix: Water

Collected: 2018/01/18
Shipped:
Received: 2018/01/24

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5369734	N/A	2018/01/26	Chandra Nandlal

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GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	-1.0°C

Results relate only to the items tested.

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Maxxam Job #: B817344
Report Date: 2018/01/30

Golder Associates Ltd
Client Project #: 12-1186-0047 (6000)
Site Location: 5113 OLD BROCK RD.
Sampler Initials: AV

QUALITY ASSURANCE REPORT

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
5369734	C_N	Matrix Spike	Nitrate (N)	2018/01/26		NC	%	80 - 120
5369734	C_N	Spiked Blank	Nitrate (N)	2018/01/26		94	%	80 - 120
5369734	C_N	Method Blank	Nitrate (N)	2018/01/26	<0.10		mg/L	
5369734	C_N	RPD	Nitrate (N)	2018/01/26	NC		%	20
5370199	C_N	Matrix Spike	Nitrate (N)	2018/01/26		106	%	80 - 120
5370199	C_N	Spiked Blank	Nitrate (N)	2018/01/26		105	%	80 - 120
5370199	C_N	Method Blank	Nitrate (N)	2018/01/26	<0.10		mg/L	
5370199	C_N	RPD	Nitrate (N)	2018/01/26	NC		%	20

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

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Golder Associates Ltd
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Site Location: 5113 OLD BROCK RD.
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VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Cristina Carriere, Scientific Service Specialist

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

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Exceedence Summary Table – ODWS (2002)

Result Exceedences

Sample ID	Maxxam ID	Parameter	Criteria	Result	DL	Units
BH12-4	FYV317-01	Nitrate (N)	10	18.4	0.10	mg/L

The exceedence summary table is for information purposes only and should not be considered a comprehensive listing or statement of conformance to applicable regulatory guidelines.

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CHAIN OF CUSTODY RECORD

Page 1 of 1

INVOICE TO:		REPORT TO:		PROJECT INFORMATION:		Laboratory Use Only:	
Company Name:	#2292 Golder Associates Ltd	Company Name:	Golder	Quotation #:	B70916	Maxxam Job #:	Bottle Order #: 647515
Attention:	Accounts Payable	Attention:	Zen Keizars	P.O. #:			
Address:	100 Scotia Crt	Address:	100 Scotia Crt	Project:	12-1186-0047 (6000)	COC #: C#647515-01-01	Project Manager: Ema Gitej
	Whitby ON L1N 8Y6		Whitby, ON	Project Name:	5113 Old Brock Rd		
Tel:	(905) 723-2727 x Fax: (905) 723-2182 x	Tel:	Fax:	Site #:			
Email:	AP_CustomerService@golder.com	Email:	zen_keizars@golder.com	Sampled By:	AVANROON		

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY

Regulation 153 (2011): ☐ Table 1 ☐ Res/Park ☐ Medium/Fine ☐ Table 2 ☐ Ind/Comm ☐ Coarse ☐ Table 3 ☐ Agri/Other ☐ For RSC ☐ Table ___

Other Regulations: ☐ CCME ☐ Sanitary Sewer Bylaw ☐ Reg 558 ☐ Storm Sewer Bylaw ☐ MISA Municipality ___ ☐ PWQO ☒ Other ODWS

Special Instructions:

Include Criteria on Certificate of Analysis (Y/N)? Y

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

Turnaround Time (TAT) Required: Please provide advance notice for rush projects

Regular (Standard) TAT: ☒
(will be applied if Rush TAT is not specified):
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
Date Required: ___ Time Required: ___
Rush Confirmation Number: ___ *(call lab for #)*

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Field Filtered (please circle): Metals / Hg / Cr VI	Nitrate	# of Bottles	Comments
1	SID#390428	MW17-11	Jan 23/18	9:45	GW	No	X	1	
2	SID#390429	MW17-8	↓	10:05	GW	↓	X	1	
3	SID#390430	MW17-9	↓	10:25	GW	↓	X	1	
4	SID#390431	MW17-7	↓	10:35	GW	↓	X	1	
5	SID#390432	BH12-4	↓	9:30	GW	↓	X	1	
6									
7									
8									
9									
10									

24-Jan-18 13:17
Ema Gitej
B817344
TLI ENV-1378

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
[signature]	18/01/23	2pm	[signature] PARAMJEET SINGH	2018/01/23	13:17	Ø

Laboratory Use Only

Time Sensitive	Temperature (°C) on Receipt	Custody Seal	Yes	No
	1/2/2	Present	✓	
		Intact		

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO MAXXAM'S STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.MAXXAM.CA/TERMS.

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

** SAMPLE CONTAINER, PRESERVATION, HOLD TIME AND PACKAGE INFORMATION CAN BE VIEWED AT HTTP://MAXXAM.CA/WP-CONTENT/UPLOADS/ONTARIO-COC.PDF.

SAMPLES MUST BE KEPT COOL (< 10° C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

White: Maxxam Yellow: Client

MW# 417589

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