Golder Associates Ltd.

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Golder Associates

REPORT ON

2004
GROUNDWATER MONITORING PROGRAM
COMMUNAL SEWAGE SYSTEM
NATION MUNICIPALITY
ST. BERNARDIN, ONTARIO

Submitted to:

Eastern Ontario Health Unit
Central Office
100 Pitt Street
Cornwall, Ontario
K6J 5T1

DISTRIBUTION:

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February 2005

04-1120-708

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1.0 INTRODUCTION

This report presents the results of the 2004 groundwater monitoring program undertaken by Golder Associates Ltd. (Golder Associates) at the St. Bernardin Communal Sewage System. The sewage system is located on part of Lot 12, Concession VI, in the geographic Township of Caledonia, near the Hamlet of St. Bernardin, in the Nation Municipality, Ontario (Figure 1). It is understood that the sewage system became operational in 1997. Groundwater monitoring and annual reporting were required as a condition of approval for the sewage system. Groundwater sampling was completed in the spring and fall of 2004.

1.1 Certificate of Approval

The St. Bernardin Sewage System is operating under a Certificate of Approval ("C of A") issued for the tank and tile bed system (Class 4 system) by the Eastern Ontario Health Unit on March 25, 1996. Conditions of approval required the preparation of a maintenance program (as outlined by Lascelles Engineering Ltd.) and fulfillment of conditions of approval set out by the Ministry of the Environment in a letter dated February 20, 1996. In terms of groundwater monitoring, the conditions set by the MOE are as follows:

- The two year time frame for sampling be removed while maintaining the option of changing the requirements of the program following review of the data acquired during the first two years of operation. This ensures that monitoring continues and any changes to the monitoring program would have to be specifically approved; and,

- The analytical parameter list be expanded to include nitrite and ammonia;

A Use Permit was issued for the original septic tank and tile bed installation by the Eastern Ontario Health Unit in January 1997. See Appendix B for copies of the C of A including the MOE conditions for approval and the Use Permit.

1.2 Site Description

The St. Bernardin Sewage System site consists of land owned by The Nation Municipality ("Nation") and land leased by Nation which is used as a groundwater contaminant attenuation zone ("CAZ"). Caledonia Creek runs from south to north, east of the St. Bernardin Sewage System site (Figure 2). A ditch\creek runs along the south eastern border of the CAZ. The pumping station, septic tank, and pump chamber are located off of County Road 22 near the western edge of the property owned by Nation. The leaching beds are located approximately 120 metres east of County Road 22 on the land owned by Nation. The area around the St. Bernardin Sewage system consists of agricultural fields (corn) west and south of the leaching bed, residential housing and businesses north of the leaching bed, and agricultural fields (hay) east of the leaching bed on the CAZ.

2.0 GROUNDWATER SAMPLING

Groundwater samples were collected from all groundwater monitors on May 19, 2004 and October 21, 2004. Groundwater was sampled using the dedicated samplers that were installed during monitor installation (in 2003). A minimum of three standing volumes of groundwater was purged from each monitor prior to the collection of groundwater samples. Groundwater levels were measured prior to purging. Piezometer tests were conducted in each groundwater monitor during sampling on May 19, 2004.

Temperature, pH, dissolved oxygen and conductivity of the groundwater samples were measured in the field at the time of sampling. The field conductivity, pH, temperature, and dissolved oxygen measurements were obtained using meters calibrated in the field prior to use. All sample IDs were entered on a Chain of Custody Form and the samples were placed in coolers with ice packs until they were delivered in person to PSC Analytical Services in Mississauga, Ontario for analysis of chloride, dissolved organic carbon (DOC), ammonia, nitrate, nitrite, total phosphorus, and sodium. Groundwater samples were collected, prepared, and preserved in the field using the following protocols:

Analytical Parameters	Preparation and Preservation Protocols
General chemistry	Plastic bottle, unfiltered, unpreserved
DOC	Amber glass bottle preserved to pH<4 with H_2SO_4
total phosphorous, ammonia	Plastic bottle, unfiltered, preserved to pH<2 with H_2SO_4

3.0 SUBSURFACE CONDITIONS

3.1 Geology

The geological conditions encountered during borehole drilling and groundwater monitor installation program carried out by Golder Associates in 2003 are shown on the Record of Boreholes in Appendix C. Details of the groundwater monitor installations for each of the boreholes are also included in the Record of Boreholes in Appendix C. It should be noted that the boundaries between strata on the Record of Borehole Sheets have been inferred from observations during drilling and non-continuous sampling and, as such their positions should be considered as transitional in nature rather than as an exact plane of geological change. Natural variations other than those encountered in the boreholes should also be expected to exist.

In general, the geological conditions at the site consist of a surficial topsoil layer underlain by a brown/grey fine sand to sandy silt (sand) unit with depths ranging from 0.15 to 0.40 m. The sand unit ranged in thickness from 0.67 to 1.07 m. The sand unit is underlain by a silty (clay) unit. None of the boreholes at the site encountered bedrock to a maximum depth of investigation of 4.6 metres below ground surface.

Previous studies and MOE water well records suggest that the clay unit is typically 30 to 40 m thick and is underlain by roughly 3 m of gravel overlying shale (Geo-analysis, 1992).

3.2 Hydraulic Conductivity

Piezometer test hydraulic conductivities for the sand unit were calculated using the method of Hvorslev (1951), according to the following expression:

$$K = \frac{r^2 In(L/R)}{2LT_o}$$

where: r = monitor riser radius
L = screen length
R = radius of borehole
T_o = basic time lag

The hydraulic conductivities that were calculated from the rising head tests completed in September 2003, November 2003 and May 2004 are summarized in Table 1. Note that unit conversion errors were found in the data presented in the 2003 annual report (Golder, 2004); the 2003 hydraulic conductivity values have been revised and are shown in Table 1.

The 2004 rising head data indicates that hydraulic conductivities for the sand unit below the St. Bernardin Sewage System average 1.6×10^{-4} centimetres per second (cm/s) in the area immediately around the leaching beds. These K values are in the range of historical values determined by Guelph permeameter (1.3×10^{-5} to 2.9×10^{-4} cm/s Geo-Analysis, 1992). The Guelph permeameter tests were completed in the area north east of the St. Bernardin Sewage System, close to groundwater monitor BH03-6.

The 2004 rising head data from BH03-6 indicates that the hydraulic conductivity for the clay unit below the St. Bernardin Sewage system is on the order of 1.9×10^{-6} cm/s. This estimated K value is relatively high for a clay, possibly reflecting the effects of interbedded sand and silty seams.

3.3 Groundwater Flow

Groundwater level measurements in 2004 are presented in Table 2. Elevations were referenced to a geodetic datum located at the flagpole in front of the old school on County Road 22, north of the site.

Shallow groundwater (water table) elevations and interpreted groundwater elevation contours from May and October 2004 are presented on Figure 2. The range in groundwater elevations measured during 2003-2004 compared with rainfall data for the same period indicates that the shallow groundwater flow system is influenced by infiltration (Figure 3).

The groundwater elevations in May and October 2004 suggest that there is a groundwater mound in the sand unit below the St. Bernardin leaching beds, however, the groundwater elevations also suggest that the natural groundwater flow direction is towards the east. This is consistent with the estimated groundwater flow direction determined previously (Geo-analysis, 1992). Due to the contrast between the hydraulic conductivity of the sand and the clay units, horizontal groundwater flow would be expected to occur primarily in the higher hydraulic conductivity sand unit. Groundwater flow within the clay would occur primarily in fractures and the sand/silt seams in the clay; and the amount of flow would be dependent on the connectivity of the sand and silt layers.

Using groundwater elevations at BH03-2, BH03-3 and BH03-4, the horizontal hydraulic gradient in the vicinity of the groundwater mound below the leaching beds was calculated. The horizontal hydraulic gradient was also calculated using groundwater elevations at BH03-3, BH03-4 and BH03-6, in order to estimate the gradient away from the influence of the groundwater mound. The horizontal gradient in the vicinity of the groundwater mound was approximately 0.016 in May 2004 and 0.009 in October 2004, while east of the groundwater mound (on the CAZ), the horizontal hydraulic gradient was approximately 0.011 in May 2004 and 0.017 in October 2004.

An estimate of average linear groundwater flow velocity can be calculated using the following equation:

$$v = \frac{-K}{n} i$$

Where v is the average linear groundwater velocity, K is the hydraulic conductivity, i is the horizontal hydraulic gradient and n is porosity. Using the 2004 average piezometer test hydraulic conductivity for the sand unit (1.6×10^{-4} cm/s), and assuming a porosity for the sand of 35% (Freeze and Cherry, 1979), the calculated groundwater flow velocity is estimated to range from 1.4 to 2.3 metres per year in the area close to the leaching beds in the sand unit. Using the 2004 piezometer test, hydraulic conductivity for the clay unit (1.9×10^{-6} cm/s) and assuming an effective porosity of the clay of 1 percent (representative of fractures and sand/silt seams), the calculated flow velocity is estimated to be approximately 0.6 to 1.0 metres per year in the clay unit (east of the leaching beds in the CAZ).

3.4 Groundwater Quality

Results of field and laboratory chemical and physical analyses conducted on groundwater samples, along with relevant Ontario Drinking Water Standards, Objectives, and Guidelines (MOE, 2003), are presented in Appendix E. Copies of the report of analysis sheets from Accutest Laboratories Ltd. are provided in Appendix F.

3.4.1 Background Groundwater Quality

A review of historical documents regarding this site and other sites within the Nation Municipality suggests that the overburden groundwater in the area has naturally elevated concentrations of chloride (200 to 1400 mg/L; Golder, 2003). Nitrate concentrations ranging from 0.6 mg/L to 9.0 mg/L have also been documented (Geoanalysis, 1992) in the area around the St. Bernardin Sewage System site. The elevated nitrate concentrations were attributed to agricultural activities. There are no historical data for any other parameters.

Groundwater monitor BH03-1 is located approximately 30 metres west of leaching beds and is likely upgradient from the leaching beds. BH03-5 is located approximately 40 metres north of the leaching beds and is likely cross-gradient of the leaching beds (see Figure 2). Therefore, the groundwater quality at BH03-1 and BH03-5 may be used to represent on-site background groundwater quality. The groundwater quality at BH03-1 and BH03-5 in May and October 2004 is summarized in Table 3.

Groundwater concentrations of chloride, DOC, and sodium exceeded the applicable ODWQS criteria at the background monitors in 2004, as was the case in 2003. The maximum concentration of nitrate was 0.8 mg/L and the maximum concentration of chloride was 1350 mg/L. In general, the concentrations of groundwater quality parameters in the background monitors were similar in 2003 and 2004.

3.4.2 Downgradient Groundwater Quality

Groundwater monitors BH03-2, BH03-3, BH03-4 and BH03-6 are interpreted to be downgradient of the leaching beds, therefore the groundwater quality at these monitors is interpreted to be representative of downgradient groundwater quality.

In 2004, groundwater concentrations of nitrate at the downgradient groundwater monitors ranged from less than 0.2 mg/L (BH03-6) to 16.70 mg/L (nearest downgradient monitor; BH03-3). The nitrate concentrations at BH03-2 and BH03-3 were much greater than background in the fall of 2004, but were similar to background in the spring of 2004. The nitrate concentrations at BH03-4 and BH03-6 were similar to background in both the spring and fall of 2004.

Groundwater concentrations of chloride at the downgradient groundwater monitors ranged from 2.9 to 1360 mg/L. The highest chloride concentration was found at BH03-3, immediately downgradient of the leaching beds, also the location of the highest nitrate concentration. The chloride concentrations at BH03-3 are similar to the highest background groundwater concentration. The lowest chloride concentrations were found at BH03-6, and were much lower than concentrations at the background wells.

The downgradient groundwater quality in 2004 is summarized as follows:

- Groundwater nitrate concentrations exceeded the ODWQS and background concentrations at BH03-2 and BH03-3 in the fall of 2004;

- Groundwater concentrations of sodium exceeded ODWQS at all locations with the exception of BH03-6 and exceeded the background concentrations at BH03-3 and BH03-2 (spring only);

- Groundwater concentrations of DOC exceeded ODWQS at all locations with the exception of BH03-5 and exceeded historical background concentrations at BH03-2; and

- Groundwater concentrations of chloride exceeded ODWQS at all locations with the exception of BH03-6 and did not exceed historical background concentrations at any locations.

4.0 INTERPRETATION OF GROUNDWATER QUALITY

For comparison of groundwater quality results and drinking water standards, ODWQS (MOE, 2003) non-health related objectives (i.e., aesthetic parameters) and health related parameters for which a Maximum Acceptable Concentration (MAC) or Interim Maximum Acceptable Concentration (IMAC) has been established are used.

Nitrate is commonly used as a sewage indicator parameter and since the background nitrate groundwater concentration is low (maximum historical concentration of 0.8 mg/L at BH03-1) at the St. Bernardin Sewage System site, nitrate is used as the prime indicator of sewage impact. Other parameters (e.g. chloride, DOC and phosphorus) are at elevated concentrations in background groundwater, and are therefore not as useful as nitrate as an indicator of sewage impact.

Based on 2004 reported nitrate concentrations, groundwater at BH03-2 and BH03-3 is interpreted to be impacted by effluent from the St. Bernardin Sewage System. Groundwater at the downgradient monitoring locations BH03-4 and BH03-6 (the Reasonable Use assessment location) is interpreted not to be impacted by the sewage system effluent (see Table 4).

The calculated groundwater velocity based on 2004 hydrogeological data indicates that the groundwater velocity in close proximity to the St. Bernardin Sewage System is approximately 1.4 to 2.3 metres per year. Considering that BH03-4 is approximately 40 metres downgradient of the leaching beds, no groundwater impacts at BH03-4 should be expected until 2014. Groundwater quality data for BH03-4 suggests that groundwater at this location is likely not impacted by effluent. It is also possible that the relatively thin sand unit over the clay unit results in significant changes in the saturated thickness of the sand, due to infiltration and evaporation, thus slowing the movement of effluent impacted groundwater away from the sewage system.

Since it is expected that active groundwater flow is limited mainly to the sand unit and in the upper portion of the clay unit, and since groundwater impacts are interpreted not to be occurring 40 metres downgradient of the leaching beds (the approximate distance to BH03-4), it is concluded that the St. Bernardin Sewage System is not impacting local water supply wells or watercourses beyond the CAZ.

4.1 Groundwater Compliance

MOE Guideline B-7 (MOE, 1994), "Incorporation of the Reasonable Use Concept into MOE Groundwater Management", addresses the levels of off-site impact on groundwater considered acceptable by the MOE and defines the level of impact on groundwater beyond which some form of mitigation measure(s) would be warranted.

Under MOE Guideline B-7, a change in the quality of groundwater on adjacent properties will only be acceptable if the quality is not degraded in excess of fifty percent of the difference between background concentration and established water quality criteria for aesthetic related parameters, and twenty-five percent of the difference between background conditions and established water quality criteria for health related parameters, If the background concentrations of a particular parameter exceeds a given criteria, the quality of the groundwater should not be degraded further. The acceptable groundwater concentrations for the site based on the Reasonable Use Concept set forwards within MOE Guideline B-7 are known as the Reasonable Use Performance Objectives (RUPO).

At the St. Bernardin Sewage System Site, BH03-6 is used for Reasonable Use Assessment. Results for 2004 indicate that the St. Bernardin Sewage System Site has not caused ground impact at downgradient monitors BH03-4 (40 metres downgradient) or BH03-6 (the Reasonable Use Assessment monitor, 145 metres downgradient of the sewage system). Therefore, the St. Bernardin Sewage System site is in compliance with the Reasonable Use Policy.

5.0 PROPOSED 2005 MONITORING PROGRAM

The proposed 2005 monitoring program for the St. Bernardin Sewage System is based on the results of the 2004 monitoring program and the sewage system C of A. The purpose of the monitoring program will be to document groundwater impact by the St. Bernardin Sewage System. The monitoring program involves the collection of groundwater samples and measurement of groundwater levels at background and downgradient monitoring locations in the spring (April-May) and fall (September-October). The following summarizes the sampling locations, frequency, and parameters to be sampled for:

Location Type	Frequency	Monitoring Locations	Parameters
Background	Spring and Fall	BH03-1 BH03-5	Ammonia, conductivity, DOC, DO, nitrate, nitrite, pH, phosphorus, sodium
Downgradient		BH03-2 BH03-3 BH03-4	
Reasonable Use Assessment		BH03-6	

The results of the future groundwater monitoring programs will be documented in a yearly report. Future reports may include recommended changes to the monitoring program and updated interpretations of groundwater impact by the St. Bernardin Sewage System.

6.0 LIMITATIONS AND USE OF REPORT

This report was prepared for the exclusive use of Eastern Ontario Health Unit and The Nation Municipality. The report, which especially includes all tables, figures, and appendices, is based on data and information collected by Golder Associates and is based solely on the conditions of the site at the time of the work, supplemented by historical information and data obtained by Golder Associates as described in this report, and in the previous reports prepared by Golder Associates (see References for list of previous reports). Each of these reports must be read and understood collectively, and can only relied upon in their totality.

The assessment of environmental conditions and possible hazards at this site has been made using the results of physical measurements and chemical analyses of liquids from a number of locations. The site conditions between sampling locations have been inferred based on conditions observed at borehole and monitoring well locations. Subsurface conditions may vary from these sampled locations.

The services performed, as described in this report, were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to limits and financial and physical constraints applicable to the services.

Any use which a third party makes of this report, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder Associates accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The findings and conclusions of this report are valid only as of the date of this report. If new information is discovered in future work, including excavations, borings, or other studies, Golder should be requested to re-evaluate the conclusions of this report, and to provide amendments as required.

GOLDER ASSOCIATES LTD.

Caitlin Martin, M.Sc.
Environmental Scientist

Brian T. Byerley, M.Sc., P.Eng.
Hydrogeologist/Associate

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Geoanalysis, 1992. Proposed Communal Sewage Disposal System for the Hamlet of St. Bernardin, February 21, 1992.

Ministry of the Environment, 2003. Ontario Drinking Water Quality Standards, June 2003: Ontario Ministry of the Environment.

Freeze, R.A. and J.A. Cherry, 1979. Groundwater. Prentice-Hall Inc., Englewood Cliff, New Jersey, 604p.

TABLE 1

SUMMARY OF RISING HEAD DATA RESULTS (cm/s)

Monitor Location	September 2003	November 2003	May 2004
03-1 (sand)	n/a	4.9×10^{-5}	5.8×10^{-5}
03-2 (sand)	8.1×10^{-6}	n/a	3.0×10^{-4}
03-3 (sand)	9.1×10^{-5}	1.8×10^{-4}	2.3×10^{-4}
03-4 (sand)	n/a	1.3×10^{-4}	1.1×10^{-4}
03-5 (sand)	n/a	n/a	1.2×10^{-4}
03-6 (clay)	n/a	1.5×10^{-6}	1.9×10^{-6}

Notes

n/a - data not available

September 2003 and November 2003 results have been revised from the previous report.

TABLE 2

2004 GROUNDWATER ELEVATIONS

Monitoring Well	Ground Surface Elevation (masl)	Top of Casing elevation (masl)	Groundwater Elevation (masl)	
			May 19 2004	Oct 21 2004
03-1	64.746	65.456	64.5	64.1
03-2	65.086	65.906	64.8	64.4
03-3	65.286	66.066	64.7	64.3
03-4	64.746	65.571	64.5	64.2
03-5	64.806	65.636	64.6	64.1
03-6	64.541	65.331	63.2	62.0

Notes

n/a - data not available

TABLE 3
BACKGROUND GROUNDWATER QUALITY

Parameter	ODWQS	BH03-5	BH03-1	BH03-5	BH03-1	BH03-5	BH03-1
		27-Oct-03		19-May-04		21-Oct-04	
Ammonia	---	0.06	0.05	<0.03	0.03	<0.03	0.05
Chloride	250 (AO)	916	1390	826	1330	906	1350
Conductivity (us/cm)	---	3200	4300	3230	4600	3700	4900
DOC	5 (AO)	1.6	20.2	3.5	15.3	5.4	34.7
Nitrate	10	0.29	0.1	0.4	0.8	<0.2	0.4
Nitrite	1	<0.10	<0.10	<1.0	<1.0	<2.0	<2.0
pH	---	6.5	6.1	7.1	6.8	7.3	6.8
Phosphorous (total)	---	5.44	4.85	2.61	5.46	3.62	8.36
Sodium	200	387	874	321	767	387	850

Notes:

Results in mg/L except for pH and conductivity

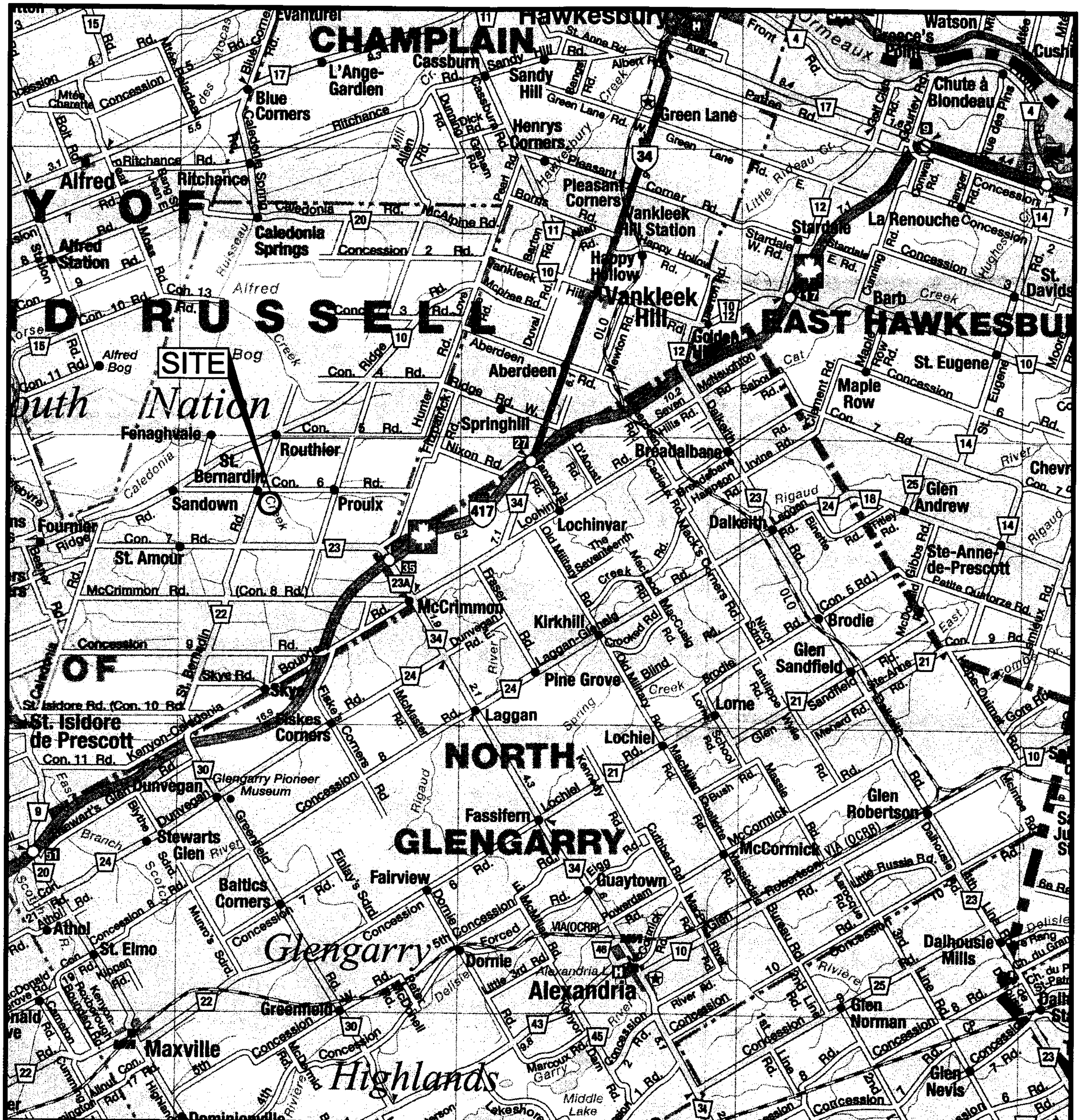
ODWQS = Ontario Drinking Water Quality Standards, Objectives and Guidelines, June 2003

(AO) – Aesthetic objective

TABLE 4

INTERPRETATION OF GROUNDWATER QUALITY DATA FROM DOWNGRADIENT GROUNDWATER MONITORS

Sampling Location	Parameters Exceeding ODWQS in 2004	Parameters Elevated Compared to Background Concentrations	Hydrogeological Interpretation
03-2	chloride, DOC, nitrate, sodium	nitrate, sodium (slightly)	• borehole 03-2 is located approximately 5 metres downgradient from leaching beds (see Figure 2); • groundwater interpreted to be impacted by sewage system based on groundwater quality;
03-3	chloride, DOC, nitrate, sodium	chloride (slightly), nitrate, sodium	• borehole 03-3 is located approximately 5 metres downgradient from leaching beds (see Figure 2) • groundwater interpreted to be impacted by sewage system based on groundwater quality;
03-4	chloride, DOC, sodium	nitrate	• borehole 03-4 is located approximately 40 metres downgradient from leaching beds (see Figure 2); • groundwater interpreted to be possibly impacted by sewage system based on groundwater;
03-6	DOC	n/a	• borehole 03-6 is located approximately 150 metres downgradient from leaching beds (see Figure 2); • groundwater is interpreted to not be impacted by septic system effluent based groundwater flow velocity;



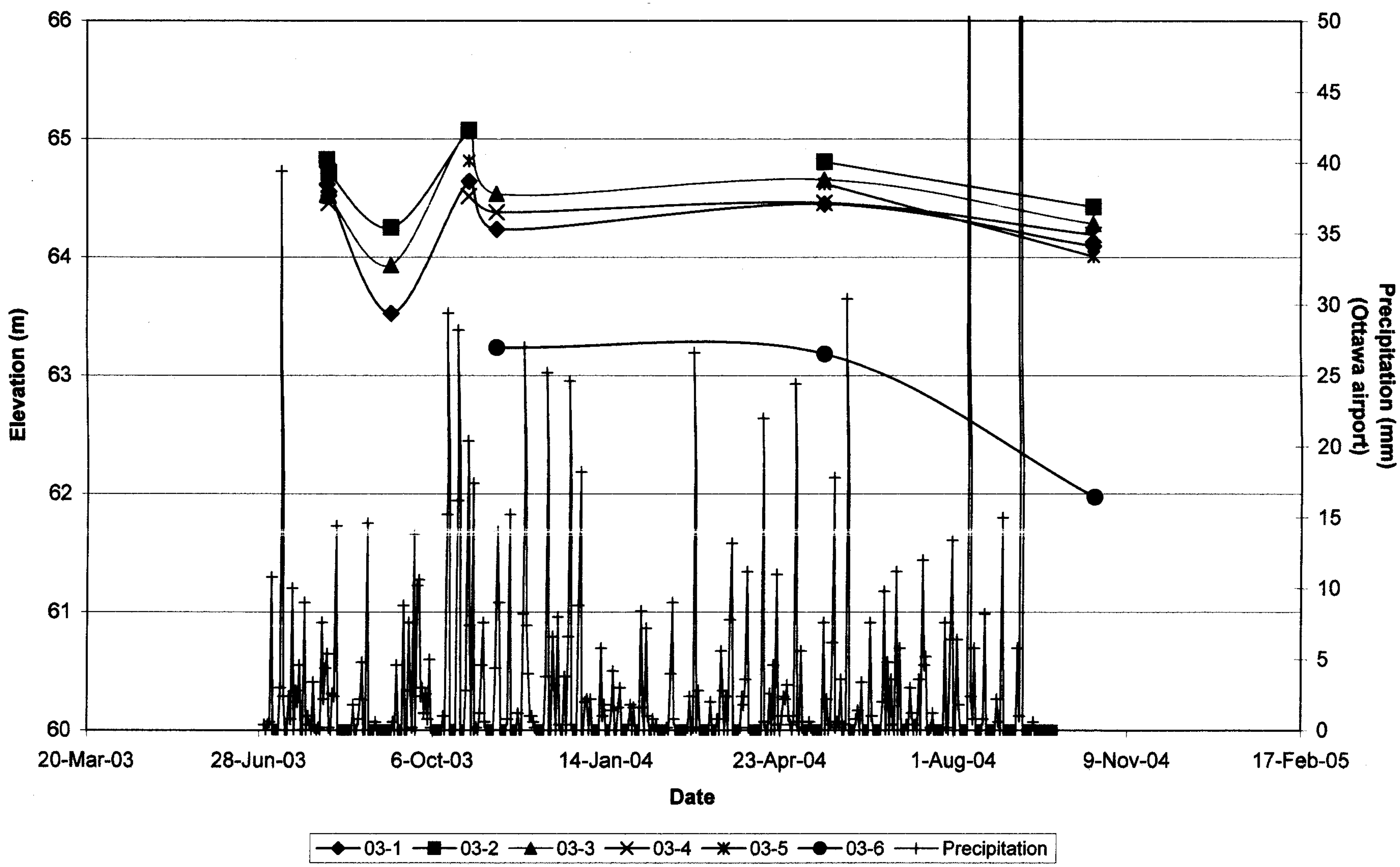
SPECIAL NOTE
THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT

Golder Associates
Ottawa, Ontario

SCALE	1: 200,000	TITLE	KEY PLAN
DATE	12/29/04		
DESIGN			
CADD	J.M.		
FILE No. 041120708-6000-01	CHECK	C.A.M.	
PROJECT No. 04-1120-708 REV.	REVIEW	K.A.M.	FIGURE 1

Drawing file: 04-1120-708-6000-01.dwg Feb 13, 2005 - 4:37pm

Figure 3 Groundwater Elevation and Precipitation Trends



APPENDIX B

CERTIFICATE OF APPROVAL (SEWAGE) NO. CAL-94-07 DATED JUNE 23, 1994 AND USE PERMIT DATED JANUARY 1997

Eastern Ontario Health · Unit
Bureau de santé de l'Est de l'Ontario

APPLICATION FORM AND CERTIFICATE OF APPROVAL FOR A CLASS 2-6 SEWAGE SYSTEM

(Please read and print clearly items 1 to 16 only)

Complete in ink.

Application No.:	CAL-94-07
Fee Receipt No.:	51368
Date Received:	24 / 6 / 94

1. Name of Owner: TOWNSHIP OF CALEDONIA — Tel. No. 678-2100
2. Installer's Name: — Tel. No.:

Owner's postal address for future correspondence: 6950 COUNTY RD No. 22, R.R. 1, ST BERNARDIN

MOE Licence Number:

Directions to Lot: Highway No., Secondary roads, Signs to Follow, etc.
310 M South on COUNTY RD No 22 FROM CONCESSION 5 & 6 ROAD ALLOWANCE, LOT IS ON EAST SIDE OF COUNTY RD 22

3. Propose to CONSTRUCT a Class 4 sewage system to serve 16 SINGLE FAMILY DWELLING.
(CONSTRUCT/INSTALL/ALTER/EXTEND/ENLARGE) (e.g. SINGLE FAMILY DWELLING OR COMMERCIAL BUILDING, ETC.)

4. County	Township	Town, Village	Lot No.	Conc. No.	Sub Lot No.	Plan No.
PRESCOTT	CALEDONIA	ST BERNARDIN	12	6		

Lot Size: 6.0 Acres

5. State No. of Bedrooms: 48; Persons: 52

Fixture Count (See Appendix A):

6. Water Supply: Dug or Bored Well [X]; Drilled Well [X]; Municipal [ ]; Other ....; Proposed [ ] or Existing [X]

7. Dwelling or building: New [ ]; Existing [X]

8. Any problems with existing sewage system? [X] Yes [ ] No

9. Relationship to Serverance if applicable:
Lot Approval Pending [X]
Lot Approved [ ]
Under Severance Application No. ________

10. The applicaton fees are the following (non-refundable)
a. Small systems servicing single family residences up to five (5) bedrooms or other establishments, having an estimated daily flow of 4,500 litres, (989 imperial gallons). ONE HUNDRED DOLLARS ($100.00)
(b.) Large systems having an estimated daily flow in excess or 4,500 litres (989 imperial gallons). TWO HUNDRED DOLLARS ($200.00)

11. **No application will be processed if a copy of the Transfer/Deed of land of the property in question is not enclosed.**

12. NOTICE: Unprocessed applications will be cancelled without further notice or refund 12 months after the application submission.

13. The Eastern Ontario Health Unit strongly recommends that fencing or equivalent protection encircle any test pit. The same is recommended for any septic/holding tank excavation until placement of backfill material. Tank access lids should always be in place. The Health Unit and its agent will not assume any responsibility for negligence relating to these safety measures.

14. I certify that the above information is true, complete and accurate. The installation of the sewage system shall conform with provincial requirements and local Municipal By-Laws. I have received the leaflet "Environment Information-Environnement". I also certify that I have read, completed, signed and attached with this application pages 2 and 3 and appendices A, B, C, D...(where necessary) and one of the following typical drawings A, B, C, D, E...

15. Under Section 139 of the Environmental Protection Act, R.S.O. 1990, an applicant may appeal a decision by writing to the Director and the Environmental Appeal Board, 112 St. clair Avenue West, Suite 502, Toronto, Ontario M4V 1N3 within 15 days of receipt of the decision.

16. The sewage system must be completed and a use permit issued within 12 months of the issuance of the certificate. When a use permit has not been issued after this time the application will be cancelled and persons wanting to proceed will be required to re-apply and pay the applicable fee.

Manon Rodrigue — le 23 juin 94
Signature of Owner and Agent — Date
for Laselle Engineering Ltd

A Certificate of Approval for this application is refused for the reasons given (attached)

Inspected by	Refused	Date
	Director	

CERTIFICATE OF APPROVAL

Based on the information provided on pages 1, 2, 3, 4 and appendices and the typical drawing of this application and pursuant to Section 77 of the Environmental Protection Act, R.S.O. 1990, this Certificate of Approval is hereby issued for the installation of a sewage disposal system with the requirements and conditions here approved. Requirements and conditions of the sewage system installation are appended.

Reviewed by	Issued by	Date
Antoine Rabbat Stephen Babb	Sylvain Thotte, Director	March 25, 1996

Central Office/Bureau chef, 1000, rue Pitt Street, CORNWALL, Ont. K6J 5T1, (613) 933-1375 ou/or 1-800-267-7120, Fax/télécopieur: (613) 933-7930, (613) 933-9916
547, rue St. Lawrence Street, P.O. Box/C.P. 618, WINCHESTER, Ont. K0C 2K0, (613) 774-2739, Fax/télécopieur: (613) 774-2898
P.O. Box/C.P. 329, Highway 34, South, Route 34 sud, ALEXANDRIA, Ont. K0C 1A0, (613) 525-1112, Fax/télécopieur: (613) 525-3534
1945, rue Laborité Street, P.O. Box/C.P. 89, CLARENCE CREEK, Ont. K0A 1N0, (613) 488-3337, Fax/télécopieur: (613) 488-3306
134, est rue Main Street East, Bureau/Suite 301, HAWKESBURY, Ont. K6A 1A3, (613) 632-4355, Fax/télécopieur: (613) 632-1607
41, rue Racine Street, P.O. Box/C.P. 338, CASSELMAN, Ont. K0A 1M0, (613) 764-2841, Fax/télécopieur: (613) 764-3685, 1-800-267-8260

Eastern Ontario Health Unit

Bureau de Santé de l'Est de l'Ontario

USE PERMIT

Permit Nº CAL-94-07

Lot 12

Concession 6

Township CALEDONIA

Date	Owner
January 31, 1997	Township of Caledonia
Installer	**MOE Licence Number**
Leroux et frères	10-4-784-93

1. Work authorized by the Certificate of Approval has been satisfactorily completed and includes:
   a) the installation of a prefabricated....tank........... having a working capacity of 45,500 ... *litres*, constructed of .... concrete .... which services .Village of St-Bernadin ....
   b) a leaching bed consisting of ..75.... *millimetre* diameter distribution pipe laid in ..72 .... runs for a total of ...1317.6........ *metres*
   c) distribution pipes fed by means of......pump system..........
   d) Other details:.................. two tanks at 45 500 litres..................

2. LOCATION: The sewage system has been installed
   - ☐ as described in section 13 of the Certificate of Approval
   - ☐ as described on the Septic Tank System Installer's AS BUILT REPORT
   - ☒ as shown below

As per the design drawings of Lascelles Engineering Ltd. 185-1

IT IS IMPORTANT TO KEEP THESE DOCUMENTS FOR FUTURE TRANSACTIONS.

3. It is the owner's responsibility to:
   - ☒ Backfill the system and stabilize all slopes
   - ☒ Shape the leaching bed to shed water
   - ☐ Other: ....

The Use Permit issued hereunder may be revoked if this work does not comply with provincial standards.

USE PERMIT

Under Section 78 of the Environmental Protection Act, 1990 and subject to the provisions of the Act and Regulations, this Use Permit is hereby issued to ....Township of Caledonia............ for the use and operation of the Class ......4........ sewage system pursuant to the Certificate of Approval No. CAL-94-07..... and any approved changes indicated in 2 above, and the system being located on Lot 12........ Concession ....6...... Township/ Municipality ....Caledonia.................. County .....Prescott.................. sub-lot............ of Plan No.................. Town, Village ....

Furthermore, the operator of the sewage system shall keep it maintained at all times so that its construction remains in accordance with the Certificate of Approval and any order made under the Act.

Inspected by	Permit issued by	Date of issue
Pierre Savard [signature]	Sylvain Diotte [signature] Director	January 31, 1997

NOTE: Section 76 of the Act stipulates that no change can be made to any building(s) or structure(s) in connection with which this sewage system is used, if the operation or effectiveness of the sewage system will or is likely to be affected by the change, unless a new Certificate of Approval is obtained.
Section 139 of the Act provides that an applicant may appeal the imposition of terms and conditions by a Director on issuing a permit. Written notice of appeal must be forwarded to the Director and to the Environmental Appeal Board, 112 St. Clair Ave. West, Suite 502, Toronto, Ontario M4V 1N3 within 15 days of receipt of the permit.

1935 Eastern Ontario Health Unit Bureau de santé de l'Est de l'Ontario 1995

Conditions of approval CAL-94-07

1. The sewage disposal system must be constructed in accordance with plans L85-1, L85-2, DC493-1, DC493-2 and DC493-3 revised Febryary 14, 1996 as prepared by Lascelles Engineering Limted and the Groundwaer Impact Assessment Report dated August 1995 as [re[ared by SauriolEnvironmental Incorporated and all addendums.

2. Thw maintenace program for the sewage disposal system must be submitted to the Eastern Ontario Health Unit for review and comment.

3. The conditions of approval set out in the MOEE letter, dated February 20, 1996, to Lascelles Engineering Limited must be fulfilled.

Part VIII Director

March 25, 1996

Date

Owner/Agent

Date

Central Office/Bureau chef
1000, rue Pitt Street
RNWALL, Ont. K6J 5T1
3) 933-1375 or/ou
00-267-7120
x/télécopieur: (613) 933-7930
(613) 933-9916

547, rue St. Lawrence Street
P.O. Box/C.P. 616
WINCHESTER, Ont. K0C 2K0
(613) 774-2739
Fax/télécopieur: (613) 774-2891

P.O. Box/C.P. 329
Highway 34, South
Route 34 sud
ALEXANDRIA, Ont. K0C 1A0
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1919, rue Labonté Street
P.O. Box/C.P. 89
CLARENCE CREEK, Ont. K0A 1N0
(613) 488-3337
Fax/télécopieur: (613) 488-3306

134, est rue Main Street East
Bureau/Suite 301
HAWKESBURY, Ont. K6A 1A3
(613) 632-4355
Fax/télécopieur: (613) 632-1607

41, rue Racine Street
P.O. Box/C.P. 338
CASSELMAN, Ont. K0A 1M0
(613) 764-2841
Fax/télécopieur: (613) 764-3695
1-800-267-8260

MEMORANDUM

Project: 2151 **Phase: 100** **Date: Feb.23/96**

From: Stephen Babb **To: E.O.H.U Attn: Sylvain Diotte**

Subject: Communal Sewage System Proposal
Hamlet of St. Bernardin
Township of Caladonia
CAL-94-07

We have reviewed the above noted proposal and have the following comments:

1. We find the proposal to be satisfactory subject to the following conditions:

   i) The sewage disposal system must be constructed in accordance with plans L85-1, L85-2, L85-3, DL493-1, DL493-2, and DL493-3 revised February 14, 1996 as prepared by Lascelles Engineering Limited, and the Groundwater Impact Assessment Report dated August 1995 as prepared by Sauriol Environmental Incorporated.

   ii) The maintenance program for the sewage disposal system must be submitted to the Eastern Ontario Health Unit for review and comment.

   iii) The conditions of approval set out in the MOEE letter, dated February 20, 1996, to Lascelles Engineering Limited must be fulfilled.

Ministry of Environment and Energy
133 Dalton Avenue
P O Box 620
Kingston ON K7L 4X6

Ministère de l'Environnement et de l'Énergie
133 avenue Dalton
C P 620
Kingston ON K7L 4X6

Ontario

1 613/549-4000 1 800/267-0974 Fax: 613/548-6908

Post-it™ Fax Note 7671 | Date 23 Nov 96 | # of pages 2
To M. Rodrigue ✓ | From B. Parks
Co./Dept | Co.
Phone # | Phone #
Fax # | Fax #

February 20, 1996

Lascelles Engineering Limited
870 James Street
HAWKESBURY, Ontario
K6A 2W8

Attention: Manon C. Rodrigue, P.Eng.

Dear Ms Rodrigue:

Re: **TOWNSHIP OF CALEDONIA - HAMLET OF ST. BERNARDIN**

Your most recent submission dated February 5, 1996 has been reviewed by Regional staff, and the following comments are offered for your consideration.

The groundwater monitoring program that you have proposed includes the installation of five new piezometers and twice yearly (June & September) sampling for sodium, nitrate, phosphorus, DOC, pH and DO for a period of two years. In addition to what is being proposed, the Ministry has the following requirements:

- the proposed locations for the piezometers (including depth/hydrostratigraphic unit) must be finalized and presented on a suitable diagram for approval

- the two year time frame for sampling be removed while maintaining the option of changing the requirements of the program following review of the data acquired during the first two years of operation. This ensures that monitoring continues and any changes to the monitoring program would have to be specifically approved

- the analytical parameter list be expanded to include nitrite and ammonia

In my previous letter of November 24, 1995, I indicated the need to address potential surface water impacts from the septic system's groundwater discharge on the "no name" creek. This information is not contained in your most recent submission, nor is there a proposed sampling program for the no name creek.

RECEIVED 26/02/96

The Region will agree to the creation of a CAZ through the acquisition of groundwater rights. It is felt that the proposed system is the best treatment that can be provided within the available economic means to correct an existing contamination problem, and has the support of both the local Health Unit and the Township Council. As the plume develops, the monitoring program will demonstrate the adequacy of the CAZ. The available contingency options include expanding the groundwater easement or providing additional effluent treatment to maintain compliance with the Reasonable Use Guideline.

As conditions of our approval of this approach however, the following additional information must be provided prior to operation of the sewage works:

- the groundwater monitoring program amended as outlined in the first part of this letter
- impacts of the groundwater discharge on "no name" creek must be addressed and submitted for review
- a surface water monitoring program be developed and submitted for approval
- a legal description of the lands affected, and a definition of the legal means by which the easement will be established and maintained

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

Yours truly,

Barry D. Burns, P.Eng.
Regional Approvals Engineer
Technical Support Section
Eastern Region
BDB/sh
cc: Sylvain Diotte, Eastern Ontario Health Unit
- Ivan Lee, OCWA
- Gerry Murphy, Cornwall District Office

RECEIVED

L'ingénierie
L·A·S·C·E·L·L·E·S
engineering limited
CONSULTING-ENGINEER INGENIEUR-CONSEIL
GAËTAN H. LASCELLES ING. P.ENG.

L89-103
December 6, 1996

Eastern Ontario Health Unit
P.O. Box 338
41 Racine Street
Casselman ON K0A 1M0

Attention: Mr. Sylvain Diotte, Part VIII Director

Dear Sir:

Re: Communal Sewage Collection and Disposal System
Hamlet of St-Bernardin, Township of Caledonia
Provincial Direct Grant Sewage System Project No. 52-0018-01

Enclosed please find a maintenance program for the above referenced project. This is resubmitted with revision as per memo from Stephen Babb,P.Eng. of DS-Lea Associates Ltd dated November 13,1996.

Operation and Maintenance

1. The sewage disposal system will be maintained and operated by the Township of Caledonia for the residents now being connected to it. A copy of the brochure entitled "Care and Feeding of your Septic System" will be distributed to all residences connected to the communal sewage disposal system.

2. The electrical panels for the pumping station and dosing chamber will be visually inspected weekly.

O JAMES ST., HAWKESBURY, ONTARIO K6A 2W8 bus. (613) 632-0241 res. (613) 632-3069 fax. (613) 632-1669

3. The septic tanks will be pumped out once every year. The sewage pumps will be visually inspected every year.

4. The sewer lines will be cleaned out every second year. The manholes will be visually inspected once a month for a period of one year to confirm the satisfactory functioning of the sewers.

5. The grass over the septic tile beds will be maintained during the growing season by mowing once per week.

6. The access road will be kept clear of snow during the winter time in order to provide access to the sewage disposal system and to the pumping station, dosing chamber and septic tanks.

7. As per conditional approval from the MOEE, 5 piezometers will be sampled twice per year and analyzed for sodium, nitrate, phosphorus, dissolved organic carbon, pH, nitrite, ammonia and dissolved oxygen.

8. As per conditional approval from the MOEE, the no-name creek will be sampled twice per year at the downgradient location and the Caledonia Creek will be sampled at the upstream side of the box culvert crossing Concession 6 road. The samples collected will be analyzed for total phosphorus, nitrogen nutrients, un-ionized ammonia, pH, chlorides, conductivity and temperature.

9. A yearly letter report will be prepared and submitted to the EOHU and MOEE.

<u>Final Inspection</u>

The final inspection of the sewage disposal system was performed by Pierre Savard of DS-Lea Associates Ltd on October 30, 1996. We are also responding to his comments.

1. Padlocks were installed on all the covers to the septic tanks, pumping station and dosing chamber.

2. Bug screens were installed on the vents to the pumping station and dosing chamber.

3. We have enclosed a copy of the "As-built" plans for the sewage disposal system.

4. The extent of the mantle was verified and was built as shown on the "As-built" plans.

5. A swale will be constructed in the spring when the site work continues. The grass seeding will also be performed in the spring.

These comments complement your final inspection and the use permit can now be issued.

We trust you will find this information to your satisfaction and we remain,

Yours truly,

L'ingénierie
LASCELLES
engineering limited

per Manon Rodrigue
Manon C. Rodrigue, P.Eng.

MCR/
encl.

cc: Joanne Bougie-Normand, Clerk-Treasurer, Township of Caledonia
Nitti Subramaniam, P.Eng., Project Engineer, OCWA
Pierre Savard, Inspector, DS-Lea Associates Ltd, Casselman
Stephen Babb, P.Eng., DS-Lea Associates Ltd, Ottawa

APPENDIX C

RECORD OF BOREHOLE SHEETS

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS -	Auger sample
BS	Block sample
CS	Chunk sample
DO	Drive open
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:
The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open Sampler for a distance of 300 mm (12 in.)

Dynamic Penetration Resistance; N_d:
The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive Uncased a 50 mm (2 in.) diameter, 60^0 cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH:	Sampler advanced by hydraulic pressure
PM:	Sampler advanced by manual pressure
WH:	Sampler advanced by static weight of hammer
WR:	Sampler advanced by weight of sampler and rod

Peizo-Cone Penetration Test (CPT):
An electronic cone penetrometer with a 60^0 conical tip and a projected end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded Electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	**N** Blows/300 mm Or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

Consistency	$C_{u2}S_u$ Kpa	Psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	Over 200	Over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limited
w_l	liquid limit
C	consolidaiton (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	modified Proctor compaction test
SPC	standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane test (LV-laboratory vane test)
γ	unit weight

Note:
1. Tests which are anisotropically consolidated prior shear are shown as CAD, CAU.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	= 3.1416
ln x; natural logarithm of x	
$\log_{10}$ x or log x, logarithm of x to base 10	
g	Acceleration due to gravity
t	time
F	factor of safety
V	volume
W	weight

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma'$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma''$-u)
σ'_{vo}	initial effective overburden stress
$\sigma_1\sigma_2\sigma_3$	principal stresses (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1+\sigma_2+\sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma'=\gamma-\gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s/\rho_w$) formerly (G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where γ=ρg(i.e. mass density x acceleration due to gravity)

(a) Index Properties (cont'd.)

w	water content
w_l	liquid limit
w_p	plastic limit
I_p	plasticity Index=(w_l-w_p)
w_s	shrinkage limit
I_L	liquidity index=$(w-w_p)/I_p$
I_c	consistency index=$(w_l-w)/I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index-$(e_{max}-e)/(e_{max}-e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (overconsolidated range)
C_s	swelling index
C_α	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	Overconsolidation ratio=σ'_p/σ'_{vo}

(d) Shear Strength

$\tau_p\tau_r$	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction=tan δ
c'	effective cohesion
c_u, s_u	undrained shear strength (ϕ=0 analysis)
p	mean total stress $(\sigma_1+\sigma_3)/2$
p'	mean effective stress $(\sigma'_1+\sigma'_3)/2$
q	$(\sigma_1-\sigma_3)/2$ or $(\sigma'_1-\sigma_3)/2$
q_u	compressive strength $(\sigma_1-\sigma_3)$
S_t	sensitivity

Notes: 1. τ=c'σ' tan □
2. Shear strength=(Compressive strength)/2

PROJECT: 03-1120-717

RECORD OF BOREHOLE: BH 03-1

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: August 6, 2003

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	64.75				
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL	0.00				Steel Protective Casing set in Bentonite Seal
		Brown fine SAND	64.60 / 0.15				
		Grey brown SILTY SAND/SANDY SILT	64.45 / 0.30				
		Very loose grey brown SILTY SAND	64.32 / 0.43	1	AS		
1				2	50 DO	3	32 mm Diam. PVC # 10 Slot Screen
		Grey brown to grey with depth SILTY CLAY, with sandy silt layers	63.53 / 1.22	3	50 DO	WH	Native Backfill
2		End of Borehole	62.62 / 2.13				Water level in screen at elev. 64.64m Oct. 2003 Water level in screen at elev. 64.24m Nov. 2003
3							
4							
5							

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - O; 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp —O W— Wl; 10 20 30 40

ADDITIONAL LAB. TESTING

DEPTH SCALE 1 : 25

Golder Associates

LOGGED: P.A.H.

CHECKED: C.D.V.

RECORD OF BOREHOLE: BH 03-2

PROJECT: 03-1120-717

LOCATION: See Site Plan

SAMPLER HAMMER, 64kg; DROP, 760mm

BORING DATE: August 6, 2003

SHEET 1 OF 1

DATUM:

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger 200mm Diam. (Hollow Stem)	GROUND SURFACE	65.09				Protective Steel Casing set in Cement Grout
		TOPSOIL	0.00				
		Loose brown fine SAND, trace silt	64.89 0.20				Bentonite Seal; Silica Sand
1		Brown SILTY SAND/SANDY SILT	64.02 1.07	1	50 DO	9	32 mm Diam. PVC # 10 Slot Screen
		Grey brown SILTY CLAY, with silty fine sand and sandy silt layers	63.87 1.22	2	50 DO	WH	Native Backfill
2		End of Borehole	62.96 2.13				Water level in screen at elev. 65.07m Oct. 2003
3							
4							
5							

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - O: 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢—O W—⊣ Wl: 10 20 30 40

ADDITIONAL LAB. TESTING

DEPTH SCALE 1 : 25

Golder Associates

LOGGED: P.A.H.

CHECKED: C.D.V.

RECORD OF BOREHOLE: BH 03-3

PROJECT: 03-1120-717
LOCATION: See Site Plan
SAMPLER HAMMER, 64kg; DROP, 760mm

BORING DATE: August 6, 2003

SHEET 1 OF 1
DATUM:
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

Boring method: Power Auger, 200 mm diam. (Hollow Stem)

DEPTH SCALE METRES	DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - O (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT Wp ⊢—O W—⊣ Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	GROUND SURFACE		65.29							
	Dark brown TOPSOIL		0.00							Protective Steel Casing set in Cement Grout
	Loose to compact brown SAND, trace silt		64.99 / 0.30							Bentonite Seal
1	Compact grey brown SILTY SAND		64.38 / 0.91	1	50 DO	12				Silica Sand
	Grey brown to grey with depth SILTY CLAY, with silty sand layers		63.74 / 1.55	2	50 DO	2				32 mm Diam. PVC # 10 Slot Screen
2				3	50 DO	WH				Bentonite Seal
	End of Borehole		62.55 / 2.74							
3										Water level in screen at elev. 65.07m Oct. 2003
										Water level in screen at elev. 64.54m Nov. 2003
4										
5										

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: P.A.H.
CHECKED: C.D.V.

RECORD OF BOREHOLE: BH 03-4

PROJECT: 03-1120-717
SHEET 1 OF 1
LOCATION: See Site Plan
BORING DATE: August 7, 2003
DATUM:
SAMPLER HAMMER, 64kg; DROP, 760mm
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - O (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT Wp ⊢—O W—⊣ Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		64.75							
0	Power Auger 200 mm Diam. (Hollow Stem)	Dark brown TOPSOIL		0.00							Bentonite Seal
		Grey brown fine SAND, trace to some silt		64.35 / 0.40							Silica Sand
		Grey brown SILTY SAND		63.99 / 0.76							32 mm Diam. PVC # 10 Slot Screen
1		Grey brown SILTY CLAY, with silty sand and sandy silt layers/seams		63.68 / 1.07	1	50 DO	3				Silica Sand
					2	50 DO	WH				Native Backfill
2		End of Borehole		62.62 / 2.13							Water level in screen at elev. 64.52m Oct. 2003 Water level in screen at elev. 64.38m Nov. 2003
3											
4											
5											

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: P.A.H.
CHECKED: C.D.V.

BOREHOLE 03-1120-717.GPJ GLDR_CAN.GDT 31/3/04

RECORD OF BOREHOLE: BH 03-5

PROJECT: 03-1120-717
LOCATION: See Site Plan
SAMPLER HAMMER, 64kg; DROP, 760mm

BORING DATE: August 7, 2003

SHEET 1 OF 1
DATUM:
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20, 40, 60, 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - O (20, 40, 60, 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}); WATER CONTENT PERCENT Wp —○W— Wl (10, 20, 30, 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		64.81							
0	Power Auger, 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00	1	AS					Protective Steel Casing set in Cement Grout
		Loose grey brown fine SAND, trace to some silt		64.41 0.40	2	AS					Bentonite Seal
		Grey brown SILTY SAND		64.05 0.76							Silica Sand
1		Grey brown SILTY CLAY, with silty sand layers		63.74 1.07	3	50 DO	2				32 mm Diam. PVC # 10 Slot Screen
2					4	50 DO	WH				Native Backfill
		End of Borehole		62.68 2.13							Water level in screen above ground surface at elev. 64.82m Oct. 2003
3											
4											
5											

BOREHOLE 03-1120-717.GPJ GLDR_CAN.GDT 31/3/04

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: P.A.H.
CHECKED: C.D.V.

PROJECT: 03-1120-717

LOCATION: See Site Plan

SAMPLER HAMMER, 64kg; DROP, 760mm

RECORD OF BOREHOLE: BH 03-6

BORING DATE: August 7, 2003

SHEET 1 OF 1

DATUM:

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - O (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE								
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL	64.54 / 0.00							
		Red brown to grey brown fine SAND, trace silt	64.39 / 0.15	1	AS					Protective Steel Casing set in Cement Grout
		Grey brown SILTY SAND	63.72 / 0.82							Silica Sand
1		Stiff layered grey brown SILTY CLAY, with silty sand seams/layers	63.47 / 1.07	2	50 DO	5				Bentonite Seal ∇
										Silica Sand
2				3	50 DO	2				32 mm Diam. PVC # 10 Slot Screen
				4	50 DO	WH				
3		End of Borehole	61.49 / 3.05							Water level in screen at elev. 63.24m Nov. 2003
4										
5										

DEPTH SCALE

1 : 25

Golder Associates

LOGGED: P.A.H.

CHECKED: C.D.V.

APPENDIX D

ANALYSIS OF PUMPING/RECOVERY DATA SHEETS

NOTE: ENTER DATA FOR 90% of RECOVERY 92%

ANALYSIS OF PUMPING/ RECOVERY TEST DATA

1796 Courtwood Cr.
Ottawa, Ontario
Canada K2C 2B5
Tel: (613) 224-5864
Fx: (613) 224-9928

Golder Associates

PROJECT INFORMATION

Project Name: St. Bernardin Sewage Works

Project Number: 04-1120-708

Site Location: St. Bernardin

Date of Test: 19-May-04

WELL INFORMATION

Well ID:	03-1
Static Depth to Water (m):	1.0
Screen Length (m):	0.6
Well Diameter (m):	0.0
Filter Pack Diameter (m):	0.2

ANALYTICAL METHOD

Method: Hvorslev (1951)

Reference: Freeze & Cherry, 1979

Calculations:

(1) $$q(t) = \pi r^2 \frac{dh}{dt} = FK(H-h)$$

where: q = rate of inflow
r = casing radius
h = hydraulic head
t = time
F = shape factor
K = hydraulic conductivity
H = static hydraulic head

(2) $$T_o = \frac{\pi r^2}{FK}$$

where: T_o = basic time lag

When (2) is substituted into (1), the solution to the resulting ordinary differential equation is:

(3) $$\frac{H-h}{H-H_o} = e^{-t/T_o}$$

where: H_o = hydraulic head at t = 0

For L/R > 8, Hvorslev has evaluated the shape factor, F. The resulting expression for K is:

(4) $$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

where: L = screen length
R = radius of filter pack

RAW DATA

Time (s)	Depth to Water (m)
0	1.9
15	1.82
30	1.8
60	1.77
120	1.71
180	1.655
240	1.605
300	1.555
360	1.510
480	1.300
600	1.16
720	1.12
900	1.085
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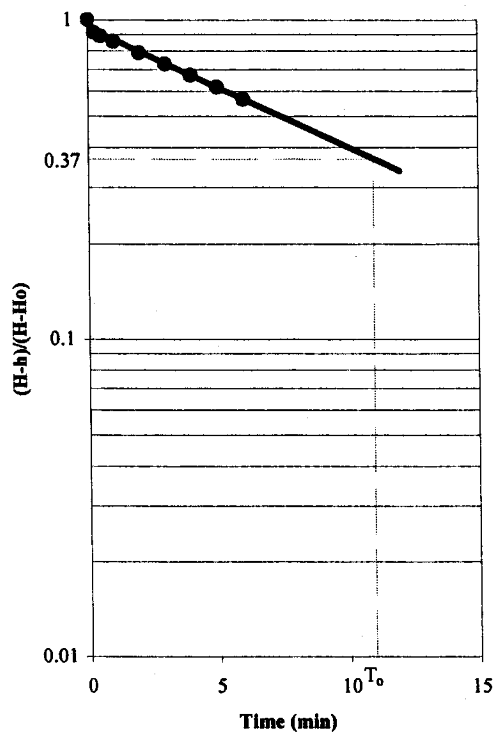
ANALYTICAL RESULTS



Casing Radius (r) = 0.016 metres
Filter Pack Radius (R) = 0.100 metres
Screen Length (L) = 0.6 metres

Basic Lag Time (T_o) = 10.96 minutes

Hydraulic Conductivity:

$$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

K Results

5.81E-07 m/s
5.02E-02 m/day
18.3 m/yr
5.8E-05 cm/s

NOTE: ENTER DATA FOR 90% of RECOVERY 97%

ANALYSIS OF PUMPING/ RECOVERY TEST DATA

1796 Courtwood Cr.
Ottawa, Ontario
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Golder Associates

PROJECT INFORMATION

Project Name: St. Bernardin Sewage Works
Project Number: 04-1120-708
Site Location: St. Bernardin
Date of Test: 19-May-04

WELL INFORMATION

Well ID:	03-2
Static Depth to Water (m):	1.1
Screen Length (m):	0.4
Well Diameter (m):	0.0
Filter Pack Diameter (m):	0.2

ANALYTICAL METHOD

Method: Hvorslev (1951)
Reference: Freeze & Cherry, 1979
Calculations:

(1) $$q(t) = \pi r^2 \frac{dh}{dt} = FK(H-h)$$

where: q = rate of inflow
r = casing radius
h = hydraulic head
t = time
F = shape factor
K = hydraulic conductivity
H = static hydraulic head

(2) $$T_o = \frac{\pi r^2}{FK}$$

where: T_o = basic time lag

When (2) is substituted into (1), the solution to the resulting ordinary differential equation is:

(3) $$\frac{H-h}{H-H_o} = e^{-t/T_o}$$

where: H_o = hydraulic head at t = 0

For L/R > 8, Hvorslev has evaluated the shape factor, F. The resulting expression for K is:

(4) $$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

where: L = screen length
R = radius of filter pack

RAW DATA

Time (s)	Depth to Water (m)
0	1.95
30	1.82
60	1.74
120	1.54
180	1.33
240	1.23
300	1.185
360	1.16
480	1.140
600	1.135
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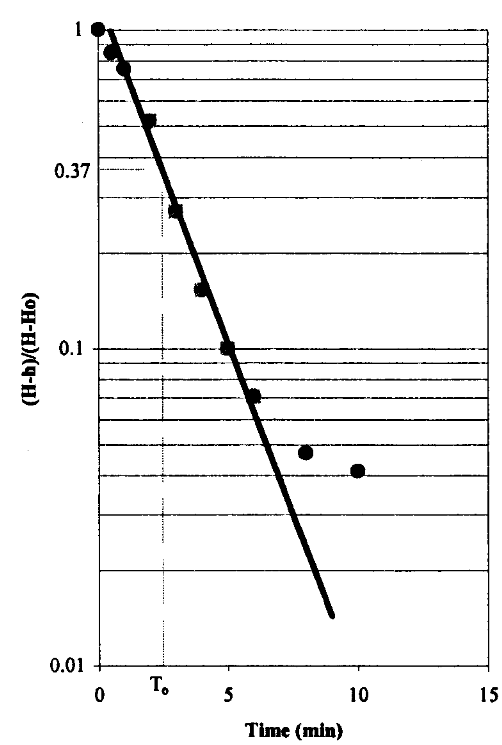
ANALYTICAL RESULTS



Casing Radius (r) =	0.016	metres
Filter Pack Radius (R) =	0.100	metres
Screen Length (L) =	0.4	metres
Basic Lag Time (T_o) =	2.48	minutes

Hydraulic Conductivity:

$$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

K Results

2.99E-06	m/s
0.25807	m/day
94.2	m/yr
0.0003	cm/s

NOTE: ENTER DATA FOR 90% of RECOVERY 95%

ANALYSIS OF PUMPING/ RECOVERY TEST DATA

1796 Courtwood Cr.
Ottawa, Ontario
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Tel: (613) 224-5864
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Golder Associates

PROJECT INFORMATION

Project Name:
St. Bernardin Sewage Works
Project Number:
04-1120-708
Site Location:
St. Bernardin
Date of Test:
19-May-04

WELL INFORMATION

Well ID:	03-3
Static Depth to Water (m):	1.4
Screen Length (m):	0.6
Well Diameter (m):	0.0
Filter Pack Diameter (m):	0.2

ANALYTICAL METHOD

Method: Hvorslev (1951)
Reference: Freeze & Cherry, 1979
Calculations:

(1) $$q(t) = \pi r^2 \frac{dh}{dt} = FK(H-h)$$

where: q = rate of inflow
r = casing radius
h = hydraulic head
t = time
F = shape factor
K = hydraulic conductivity
H = static hydraulic head

(2) $$T_o = \frac{\pi r^2}{FK}$$

where: T_o = basic time lag

When (2) is substituted into (1), the solution to the resulting ordinary differential equation is:

(3) $$\frac{H-h}{H-H_o} = e^{-t/T_o}$$

where: H_o = hydraulic head at t = 0

For L/R > 8, Hvorslev has evaluated the shape factor, F. The resulting expression for K is:

(4) $$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

where: L = screen length
R = radius of filter pack

RAW DATA

Time (s)	Depth to Water (m)
0	2.44
15	2.29
30	2.20
60	2.14
120	1.98
240	1.66
300	1.56
360	1.54
420	1.51
480	1.495
600	1.48
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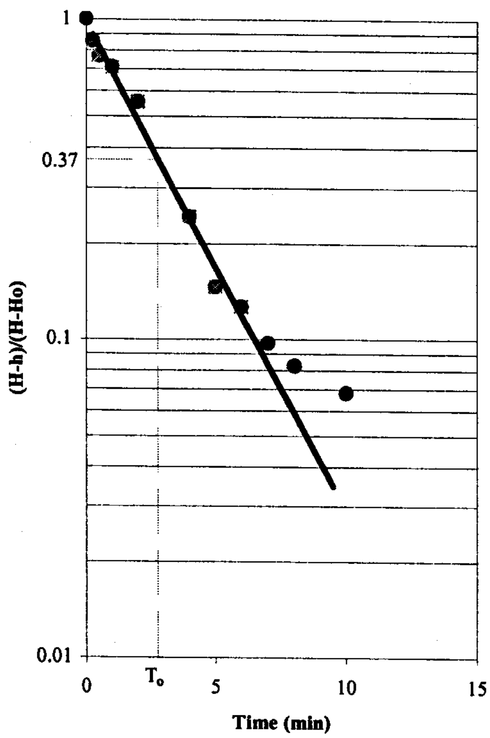
ANALYTICAL RESULTS



Casing Radius (r) =	0.016	metres
Filter Pack Radius (R) =	0.100	metres
Screen Length (L) =	0.6	metres
Basic Lag Time (T_o) =	2.77	minutes

Hydraulic Conductivity:

$$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

K Results

2.30E-06	m/s
0.19859	m/day
72	m/yr
0.00023	cm/s

NOTE: ENTER DATA FOR 90% of RECOVERY 95%

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Golder Associates

ANALYSIS OF PUMPING/ RECOVERY TEST DATA

PROJECT INFORMATION

Project Name:
St. Bernardin Sewage Works
Project Number:
04-1120-708
Site Location:
St. Bernardin
Date of Test:
19-May-04

WELL INFORMATION

Well ID:	03-4
Static Depth to Water (m):	1.1
Screen Length (m):	0.4
Well Diameter (m):	0.0
Filter Pack Diameter (m):	0.2

ANALYTICAL METHOD

Method: Hvorslev (1951)
Reference: Freeze & Cherry, 1979
Calculations:

(1) $$q(t) = \pi r^2 \frac{dh}{dt} = FK(H-h)$$

where: q = rate of inflow
r = casing radius
h = hydraulic head
t = time
F = shape factor
K = hydraulic conductivity
H = static hydraulic head

(2) $$T_o = \frac{\pi r^2}{FK}$$

where: T_o = basic time lag

When (2) is substituted into (1), the solution to the resulting ordinary differential equation is:

(3) $$\frac{H-h}{H-H_o} = e^{-t/T_o}$$

where: H_o = hydraulic head at t = 0

For L/R > 8, Hvorslev has evaluated the shape factor, F. The resulting expression for K is:

(4) $$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

where: L = screen length
R = radius of filter pack

RAW DATA

Time (s)	Depth to Water (m)
0	2.00
30	1.90
60	1.86
120	1.79
180	1.715
240	1.67
300	1.625
480	1.42
600	1.25
720	1.20
900	1.175
1200	1.160
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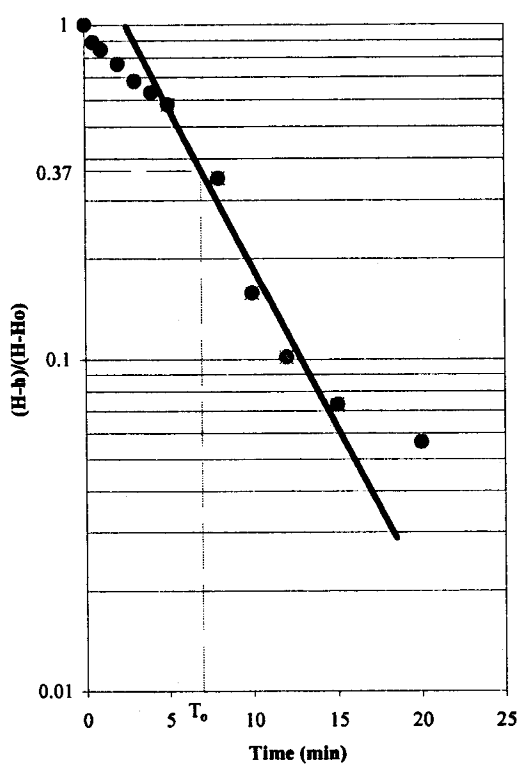
ANALYTICAL RESULTS



Casing Radius (r) =	0.016	metres
Filter Pack Radius (R) =	0.100	metres
Screen Length (L) =	0.35	metres
Basic Lag Time (T_o) =	6.96	minutes

Hydraulic Conductivity:

$$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

K Results

1.10E-06	m/s
0.09478	m/day
35	m/yr
0.00011	cm/s

NOTE: ENTER DATA FOR 90% of RECOVERY 91%

ANALYSIS OF PUMPING/ RECOVERY TEST DATA

1796 Courtwood Cr.
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Golder Associates

PROJECT INFORMATION

Project Name: St. Bernardin Sewage Works
Project Number: 04-1120-708
Site Location: St. Bernardin
Date of Test: 19-May-04

WELL INFORMATION

Well ID:	03-5
Static Depth to Water (m):	1.0
Screen Length (m):	0.4
Well Diameter (m):	0.0
Filter Pack Diameter (m):	0.2

ANALYTICAL METHOD

Method: Hvorslev (1951)
Reference: Freeze & Cherry, 1979
Calculations:

(1) $$q(t) = \pi r^2 \frac{dh}{dt} = FK(H-h)$$

where: q = rate of inflow
r = casing radius
h = hydraulic head
t = time
F = shape factor
K = hydraulic conductivity
H = static hydraulic head

(2) $$T_o = \frac{\pi r^2}{FK}$$

where: T_o = basic time lag

When (2) is substituted into (1), the solution to the resulting ordinary differential equation is:

(3) $$\frac{H-h}{H-H_o} = e^{-t/T_o}$$

where: H_o = hydraulic head at t = 0

For L/R > 8, Hvorslev has evaluated the shape factor, F. The resulting expression for K is:

(4) $$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

where: L = screen length
R = radius of filter pack

RAW DATA

Time (s)	Depth to Water (m)
0	2.16
15	2.09
30	2.06
60	2.02
120	1.94
180	1.85
240	1.77
300	1.68
360	1.45
420	1.30
480	1.22
600	1.14
720	1.11
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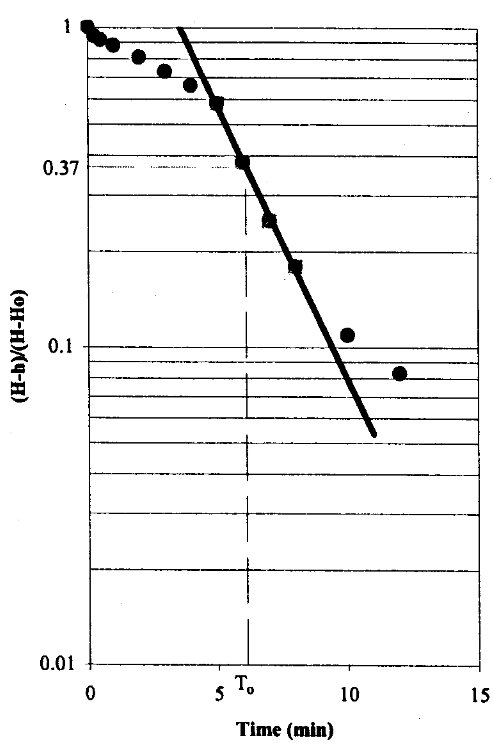
ANALYTICAL RESULTS



Casing Radius (r) = 0.016 metres
Filter Pack Radius (R) = 0.100 metres
Screen Length (L) = 0.4 metres

Basic Lag Time (T_o) = 6.11 minutes

Hydraulic Conductivity:

$$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

K Results

1.21E-06 m/s
0.10461 m/day
38.2 m/yr
0.00012 cm/s

NOTE: ENTER DATA FOR 90% of RECOVERY 53%

ANALYSIS OF PUMPING/ RECOVERY TEST DATA

1796 Courtwood Cr.
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Golder Associates

PROJECT INFORMATION

Project Name: St. Bernardin Sewage Works
Project Number: 03-1120-717
Site Location: St. Bernardin
Date of Test: 19-May-04

WELL INFORMATION

Well ID:	03-6
Static Depth to Water (m):	2.2
Screen Length (m):	1.5
Well Diameter (m):	0.0
Filter Pack Diameter (m):	0.2

ANALYTICAL METHOD

Method: Hvorslev (1951)
Reference: Freeze & Cherry, 1979
Calculations:

(1) $$q(t) = \pi r^2 \frac{dh}{dt} = FK(H-h)$$

where: q = rate of inflow
r = casing radius
h = hydraulic head
t = time
F = shape factor
K = hydraulic conductivity
H = static hydraulic head

(2) $$T_o = \frac{\pi r^2}{FK}$$

where: T_o = basic time lag

When (2) is substituted into (1), the solution to the resulting ordinary differential equation is:

(3) $$\frac{H-h}{H-H_o} = e^{-t/T_o}$$

where: H_o = hydraulic head at t = 0

For L/R > 8, Hvorslev has evaluated the shape factor, F. The resulting expression for K is:

(4) $$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

where: L = screen length
R = radius of filter pack

RAW DATA

Time (s)	Depth to Water (m)
0	3.48
30	3.43
60	3.41
120	3.40
180	3.39
300	3.38
600	3.35
900	3.32
1200	3.30
1800	3.255
3000	3.16
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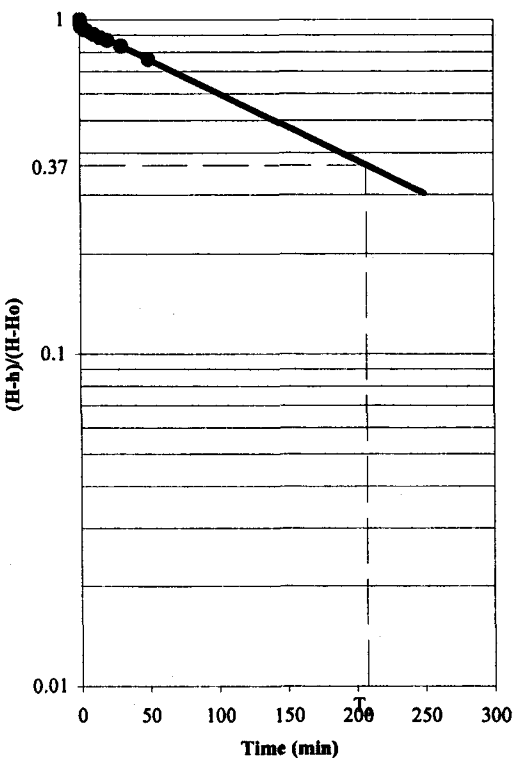
ANALYTICAL RESULTS



Casing Radius (r) =	0.016	metres
Filter Pack Radius (R) =	0.100	metres
Screen Length (L) =	1.5	metres
Basic Lag Time (T_o) =	207.34	minutes

Hydraulic Conductivity:

$$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

K Results

1.86E-08 m/s
0.0016 m/day
1 m/yr
1.9E-06 cm/s

NOTE: ENTER DATA FOR 90% of RECOVERY

ANALYSIS OF PUMPING/ RECOVERY TEST DATA

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Golder Associates

PROJECT INFORMATION

Project Name:
St. Bernardin Sewage Works
Project Number:
03-1120-717
Site Location:
St. Bernardin
Date of Test:
12-Sep-03

WELL INFORMATION

Well ID:	03-2
Static Depth to Water (m):	1.7
Screen Length (m):	0.2
Well Diameter (m):	0.0
Filter Pack Diameter (m):	0.2

ANALYTICAL METHOD

Method: Hvorslev (1951)
Reference: Freeze & Cherry, 1979
Calculations:

(1) $$q(t) = \pi r^2 \frac{dh}{dt} = FK(H-h)$$

where: q = rate of inflow
r = casing radius
h = hydraulic head
t = time
F = shape factor
K = hydraulic conductivity
H = static hydraulic head

(2) $$T_o = \frac{\pi r^2}{FK}$$

where: T_o = basic time lag

When (2) is substituted into (1), the solution to the resulting ordinary differential equation is:

(3) $$\frac{H-h}{H-H_o} = e^{-t/T_o}$$

where: H_o = hydraulic head at t = 0

For L/R > 8, Hvorslev has evaluated the shape factor, F. The resulting expression for K is:

(4) $$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

where: L = screen length
R = radius of filter pack

RAW DATA

Time (s)	Depth to Water (m)
0	2.15
10	2.147
20	2.145
30	2.14
40	2.138
50	2.137
60	2.136
70	2.136
80	2.135
90	2.135
100	2.134
110	2.133
120	2.133
140	2.132
160	2.13
180	2.126
210	2.124
240	2.122
270	2.12
300	2.118
360	2.12
420	2.11
480	2.11
540	2.1
600	2.1
720	2.09
840	2.08
960	2.07
1080	2.06
1200	2.05
1500	2.03
1800	2.01
2100	1.99
2400	1.97
2700	1.95
3000	1.94
3300	1.92
3600	1.9
4200	1.86
4800	1.82
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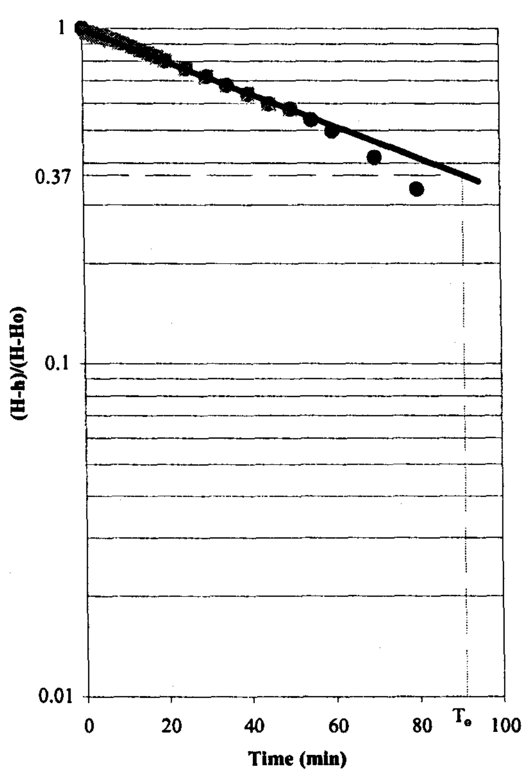
ANALYTICAL RESULTS



Casing Radius (r) = 0.016 metres
Filter Pack Radius (R) = 0.100 metres
Screen Length (L) = 0.2 metres

Basic Lag Time (T_o) = 90.97 minutes

Hydraulic Conductivity:

$$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

K Results

8.13E-08 m/s
0.00702 m/day
3 m/yr
8.1E-06 cm/s

NOTE: ENTER DATA FOR 90% of RECOVERY

ANALYSIS OF PUMPING/ RECOVERY TEST DATA

1796 Courtwood Cr.
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Golder Associates

PROJECT INFORMATION

Project Name: St. Bernardin Sewage Works
Project Number: 03-1120-717
Site Location: St. Bernardin
Date of Test: 12-Sep-03

WELL INFORMATION

Well ID:	03-3
Static Depth to Water (m):	2.1
Screen Length (m):	0.2
Well Diameter (m):	0.0
Filter Pack Diameter (m):	0.2

ANALYTICAL METHOD

Method: Hvorslev (1951)
Reference: Freeze & Cherry, 1979
Calculations:

(1) $$q(t) = \pi r^2 \frac{dh}{dt} = FK(H-h)$$

where: q = rate of inflow
r = casing radius
h = hydraulic head
t = time
F = shape factor
K = hydraulic conductivity
H = static hydraulic head

(2) $$T_o = \frac{\pi r^2}{FK}$$

where: T_o = basic time lag

When (2) is substituted into (1), the solution to the resulting ordinary differential equation is:

(3) $$\frac{H-h}{H-H_o} = e^{-t/T_o}$$

where: H_o = hydraulic head at t = 0

For L/R > 8, Hvorslev has evaluated the shape factor, F. The resulting expression for K is:

(4) $$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

where: L = screen length
R = radius of filter pack

RAW DATA

Time (s)	Depth to Water (m)
0	2.605
10	2.581
20	2.569
30	2.56
40	2.55
50	2.542
60	2.534
70	2.518
80	2.508
90	2.501
100	2.496
110	2.49
120	2.476
140	2.466
160	2.447
180	2.438
210	2.422
240	2.405
270	2.389
300	2.373
360	2.348
420	2.336
480	2.308
540	2.291
600	2.279
720	2.252
840	2.232
960	2.216
1080	2.188
1200	2.182
1500	2.169
1800	2.16
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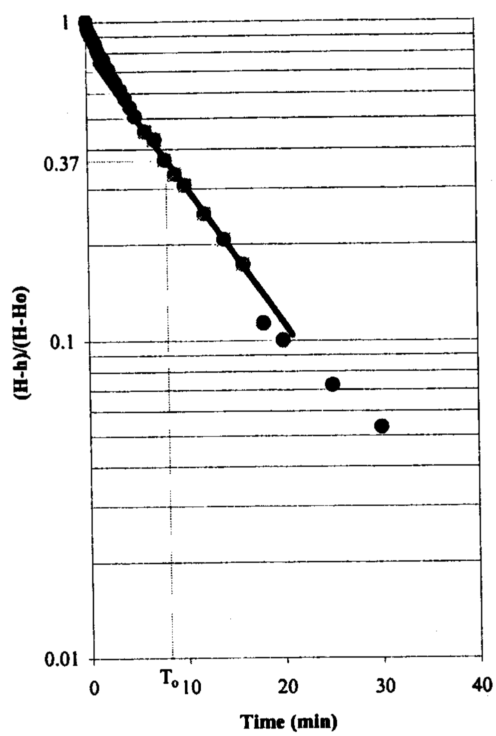
ANALYTICAL RESULTS



Casing Radius (r) = 0.016 metres
Filter Pack Radius (R) = 0.100 metres
Screen Length (L) = 0.2 metres

Basic Lag Time (T_o) = 8.15 minutes

Hydraulic Conductivity:

$$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

K Results

9.07E-07 m/s
7.84E-02 m/day
29 m/yr
9.1E-05 cm/s

NOTE: ENTER DATA FOR 90% of RECOVERY

ANALYSIS OF PUMPING/ RECOVERY TEST DATA

1796 Courtwood Cr.
Ottawa, Ontario
Canada K2C 2B5
Tel: (613) 224-5864
Fx: (613) 224-9928

Golder Associates

PROJECT INFORMATION

Project Name: St. Bernardin Sewage Works

Project Number: 03-1120-717

Site Location: St. Bernardin

Date of Test: 11-Nov-03

WELL INFORMATION

Well ID:	03-1
Static Depth to Water (m):	1.2
Screen Length (m):	0.6
Well Diameter (m):	0.0
Filter Pack Diameter (m):	0.2

ANALYTICAL METHOD

Method: Hvorslev (1951)

Reference: Freeze & Cherry, 1979

Calculations:

(1) $$q(t) = \pi r^2 \frac{dh}{dt} = FK(H-h)$$

where: q = rate of inflow
r = casing radius
h = hydraulic head
t = time
F = shape factor
K = hydraulic conductivity
H = static hydraulic head

(2) $$T_o = \frac{\pi r^2}{FK}$$

where: T_o = basic time lag

When (2) is substituted into (1), the solution to the resulting ordinary differential equation is:

(3) $$\frac{H-h}{H-H_o} = e^{-t/T_o}$$

where: H_o = hydraulic head at t = 0

For L/R > 8, Hvorslev has evaluated the shape factor, F. The resulting expression for K is:

(4) $$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

where: L = screen length
R = radius of filter pack

RAW DATA

Time (s)	Depth to Water (m)
0	1.82
5	1.81
10	1.8
15	1.795
20	1.795
25	1.7904
30	1.785
35	1.78
40	1.78
45	1.775
50	1.77
55	1.765
60	1.76
70	1.755
80	1.75
90	1.74
100	1.73
110	1.725
120	1.72
140	1.71
160	1.695
180	1.68
210	1.67
240	1.65
270	1.635
300	1.62
360	1.595
420	1.565
480	1.54
540	1.52
600	1.495
900	1.405
1200	1.29
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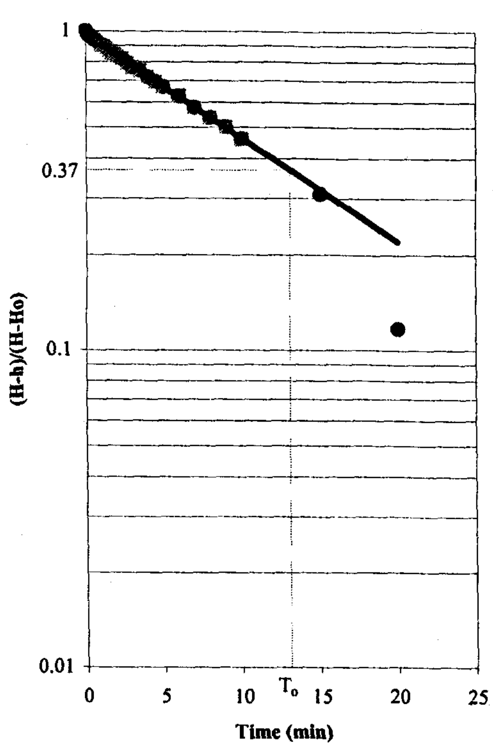
ANALYTICAL RESULTS



Casing Radius (r) =	0.016	metres
Filter Pack Radius (R) =	0.100	metres
Screen Length (L) =	0.6	metres
Basic Lag Time (T_o) =	13.03	minutes

Hydraulic Conductivity:

$$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

K Results

4.89E-07	m/s
0.04224	m/day
15	m/yr
4.9E-05	cm/s

NOTE: ENTER DATA FOR 90% of RECOVERY

ANALYSIS OF PUMPING/ RECOVERY TEST DATA

1796 Courtwood Cr.
Ottawa, Ontario
Canada K2C 2B5
Tel: (613) 224-5864
Fx: (613) 224-9928
Golder Associates

PROJECT INFORMATION

Project Name: St. Bernardin Sewage Works
Project Number: 03-1120-717
Site Location: St. Bernardin
Date of Test: 11-Nov-03

WELL INFORMATION

Well ID:	03-3
Static Depth to Water (m):	1.5
Screen Length (m):	0.6
Well Diameter (m):	0.0
Filter Pack Diameter (m):	0.2

ANALYTICAL METHOD

Method: Hvorslev (1951)
Reference: Freeze & Cherry, 1979
Calculations:

(1) $$q(t) = \pi r^2 \frac{dh}{dt} = FK(H-h)$$

where: q = rate of inflow
r = casing radius
h = hydraulic head
t = time
F = shape factor
K = hydraulic conductivity
H = static hydraulic head

(2) $$T_o = \frac{\pi r^2}{FK}$$

where: T_o = basic time lag

When (2) is substituted into (1), the solution to the resulting ordinary differential equation is:

(3) $$\frac{H-h}{H-H_o} = e^{-t/T_o}$$

where: H_o = hydraulic head at t = 0

For L/R > 8, Hvorslev has evaluated the shape factor, F. The resulting expression for K is:

(4) $$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

where: L = screen length
R = radius of filter pack

RAW DATA

Time (s)	Depth to Water (m)
0	2.4
5	2.39
10	2.38
15	2.36
20	2.34
25	2.33
30	2.32
35	2.31
40	2.3
45	2.29
50	2.28
55	2.65
70	2.225
80	2.2
90	2.175
100	2.13
110	2.11
120	2.09
140	2.05
160	2.01
180	1.95
210	1.85
240	1.81
270	1.695
300	1.67
330	1.65
360	1.63
390	1.62
420	1.61
450	1.6
480	1.6
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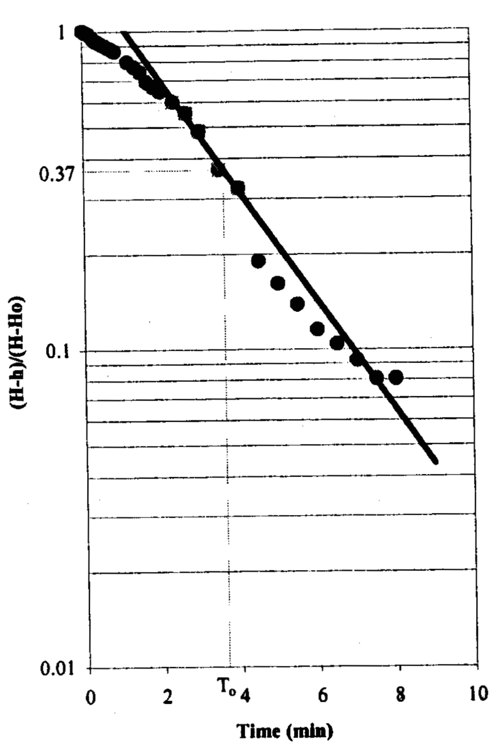
ANALYTICAL RESULTS



Casing Radius (r) =	0.016	metres
Filter Pack Radius (R) =	0.100	metres
Screen Length (L) =	0.6	metres
Basic Lag Time (T_o) =	3.62	minutes

Hydraulic Conductivity:

$$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

K Results

1.76E-06 m/s
0.15208 m/day
56 m/yr
0.00018 cm/s

April 2004

03-1120-717

NOTE: ENTER DATA FOR 90% of RECOVERY

ANALYSIS OF PUMPING/ RECOVERY TEST DATA

1796 Courtwood Cr.
Ottawa, Ontario
Canada K2C 2B5
Tel: (613) 224-5864
Fx: (613) 224-9928

Golder Associates

PROJECT INFORMATION

Project Name: St. Bernardin Sewage Works

Project Number: 03-1120-717

Site Location: St. Bernardin

Date of Test: 11-Nov-03

WELL INFORMATION

Well ID:	03-4
Static Depth to Water (m):	1.2
Screen Length (m):	0.4
Well Diameter (m):	0.0
Filter Pack Diameter (m):	0.2

ANALYTICAL METHOD

Method: Hvorslev (1951)

Reference: Freeze & Cherry, 1979

Calculations:

(1) $$q(t) = \pi r^2 \frac{dh}{dt} = FK(H-h)$$

where: q = rate of inflow
r = casing radius
h = hydraulic head
t = time
F = shape factor
K = hydraulic conductivity
H = static hydraulic head

(2) $$T_o = \frac{\pi r^2}{FK}$$

where: T_o = basic time lag

When (2) is substituted into (1), the solution to the resulting ordinary differential equation is:

(3) $$\frac{H-h}{H-H_o} = e^{-t/T_o}$$

where: H_o = hydraulic head at t = 0

For L/R > 8, Hvorslev has evaluated the shape factor, F. The resulting expression for K is:

(4) $$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

where: L = screen length
R = radius of filter pack

RAW DATA

Time (s)	Depth to Water (m)
0	1.9
5	1.88
10	1.86
15	1.85
20	1.84
25	1.83
30	1.825
35	1.82
40	1.81
45	1.8
50	1.8
55	1.79
60	1.79
70	1.775
80	1.765
90	1.755
100	1.75
110	1.745
120	1.73
140	1.705
160	1.69
180	1.675
210	1.66
240	1.64
270	1.625
300	1.565
360	1.44
390	1.375
420	1.34
450	1.31
480	1.29
510	1.275
540	1.25
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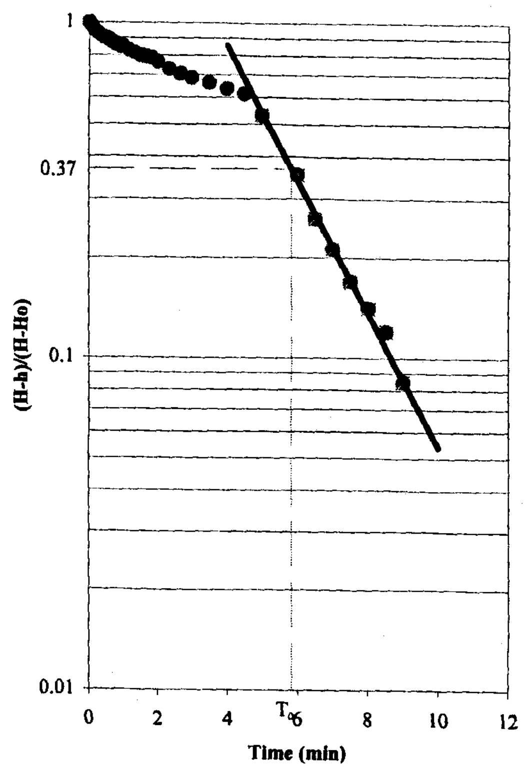
ANALYTICAL RESULTS



Casing Radius (r) =	0.016	metres
Filter Pack Radius (R) =	0.100	metres
Screen Length (L) =	0.35	metres
Basic Lag Time (T_o) =	5.83	minutes

Hydraulic Conductivity:

$$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

K Results

1.31E-06	m/s
0.11321	m/day
41	m/yr
0.00013	cm/s

NOTE: ENTER DATA FOR 90% of RECOVERY

ANALYSIS OF PUMPING/ RECOVERY TEST DATA

1796 Courtwood Cr.
Ottawa, Ontario
Canada K2C 2B5
Tel: (613) 224-5864
Fx: (613) 224-9928

Golder Associates

PROJECT INFORMATION

Project Name: St. Bernardin Sewage Works
Project Number: 03-1120-717
Site Location: St. Bernardin
Date of Test: 11-Nov-03

WELL INFORMATION

Well ID:	03-6
Static Depth to Water (m):	2.1
Screen Length (m):	1.5
Well Diameter (m):	0.0
Filter Pack Diameter (m):	0.2

ANALYTICAL METHOD

Method: Hvorslev (1951)
Reference: Freeze & Cherry, 1979
Calculations:

(1) $$q(t) = \pi r^2 \frac{dh}{dt} = FK(H-h)$$

where: q = rate of inflow
r = casing radius
h = hydraulic head
t = time
F = shape factor
K = hydraulic conductivity
H = static hydraulic head

(2) $$T_o = \frac{\pi r^2}{FK}$$

where: T_o = basic time lag

When (2) is substituted into (1), the solution to the resulting ordinary differential equation is:

(3) $$\frac{H-h}{H-H_o} = e^{-t/T_o}$$

where: H_o = hydraulic head at t = 0

For L/R > 8, Hvorslev has evaluated the shape factor, F. The resulting expression for K is:

(4) $$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

where: L = screen length
R = radius of filter pack

RAW DATA

Time (s)	Depth to Water (m)
0	3.32
5	3.32
10	3.3305
15	3.295
20	3.3305
25	3.3
35	3.295
45	3.29
50	3.285
45	3.29
50	3.285
60	3.285
70	3.28
80	3.27
90	3.27
100	3.26
110	3.26
120	3.26
140	3.255
160	3.245
180	3.245
210	3.235
240	3.23
270	3.225
300	3.22
360	3.2
420	3.19
480	3.18
540	3.17
600	3.17
900	3.15
1200	3.13
1800	3.1
3600	3
7200	2.87
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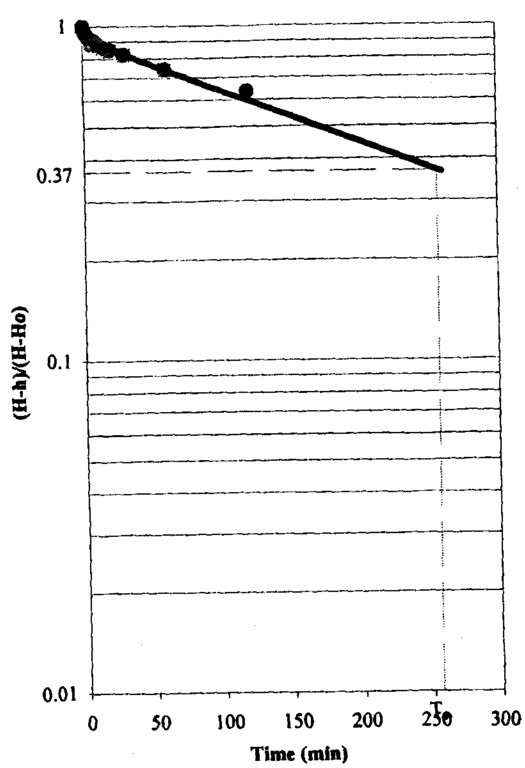
ANALYTICAL RESULTS



Casing Radius (r) =	0.016	metres
Filter Pack Radius (R) =	0.100	metres
Screen Length (L) =	1.5	metres
Basic Lag Time (T_o) =	256.34	minutes

Hydraulic Conductivity:

$$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

K Results

1.50E-08	m/s
1.30E-03	m/day
0.5	m/yr
1.5E-06	cm/s

APPENDIX E

GROUNDWATER CHEMICAL ANALYSES DATA

Golder Associates

ST. BERNARDIN - REPORT OF MONITORING RESULTS **Project: 031120717**

Sample Source: **BH03-1**

Sheet: 1

Date Sampled:		12-Sep-2003	27-Oct-2003	27-Oct-2003(2)	19-May-2004	21-Oct-2004
Parameter	ODWQS					
1 Comment		dry				
Ammonia (as N)			0.05	0.34	0.03	0.05
Chloride	250		1390.0	1400.0	1330.0	1350.0
Conductivity (uS/cm)			4300		4600	4900
Dissolved Oxygen					4.0	6.6
DOC	5		20.2	18.1	15.3	34.7
Nitrate (as N)	10		0.10	<0.10	0.80	0.40
Nitrite (as N)	1		<0.10	<0.10	<1.00	<2.00
pH (pH units)	6.5-8.5		6.1		6.8	6.8
Phosphorus (total)			4.850	4.330	5.460	8.360
Sodium	200		874.0	861.0	767.0	850.0
Temperature (C)	15		10.3		10.0	10.3

All values reported in mg/L unless otherwise noted.

Golder Associates

ST. BERNARDIN - REPORT OF MONITORING RESULTS **Project: 031120717**

Sample Source: **BH03-2** Sheet: 1

Date Sampled:		12-Sep-2003	27-Oct-2003	19-May-2004	21-Oct-2004
Parameter	ODWQS				
Ammonia (as N)		<0.02	0.03	0.09	0.68
Chloride	250	1370.0	1060.0	1130.0	1130.0
Conductivity (uS/cm)		>1990	4000	4040	4500
Dissolved Oxygen		6.8		5.4	5.6
DOC	5	31.5	32.2	104.3	54.2
Nitrate (as N)	10	4.17	5.95	1.20	12.70
Nitrite (as N)	1	<0.10	<0.10	<1.00	<2.00
pH (pH units)	6.5-8.5	7.1	6.5	7.1	7.1
Phosphorus (total)		1.010	4.130	3.660	2.300
Sodium	200	1140.0	955.0	886.0	872.0
Temperature (C)	15	18.7	9.7	10.5	9.8

All values reported in mg/L unless otherwise noted.

Golder Associates

ST. BERNARDIN - REPORT OF MONITORING RESULTS **Project: 031120717**

Sample Source: **BH03-3** Sheet: 1

Date Sampled:		12-Sep-2003	12-Sep-2003(2)	27-Oct-2003	19-May-2004	21-Oct-2004
Parameter	ODWQS					
Ammonia (as N)		0.04	0.03	<0.02	<0.03	<0.03
Chloride	250	1450.0	1510.0	1710.0	1190.0	1360.0
Conductivity (uS/cm)		>1990		>5000	4430	>5000
Dissolved Oxygen		4.6			3.8	4.6
DOC	5	19.9	17.9	12.7	16.0	21.5
Nitrate (as N)	10	2.24	2.72	16.80	1.20	16.40
Nitrite (as N)	1	<0.10	<0.10	<0.10	<1.00	<2.00
pH (pH units)	6.5-8.5	7.1		6.4	7.2	7.3
Phosphorus (total)		1.960	2.780	1.960	1.410	2.050
Sodium	200	1130.0	1410.0	1310.0	937.0	960.0
Temperature (C)	15	16.4		10.2	7.5	9.4

All values reported in mg/L unless otherwise noted.

Golder Associates

ST. BERNARDIN - REPORT OF MONITORING RESULTS **Project: 031120717**

Sample Source: **BH03-3**

Sheet: 2

Date Sampled:		21-Oct-2004(2)
Parameter	ODWQS	
Ammonia (as N)		<0.03
Chloride	250	1450.0
Conductivity (uS/cm)		
Dissolved Oxygen		5.3
DOC	5	20.2
Nitrate (as N)	10	16.70
Nitrite (as N)	1	<2.00
pH (pH units)	6.5-8.5	
Phosphorus (total)		
Sodium	200	981.0
Temperature (C)	15	

All values reported in mg/L unless otherwise noted.

Golder Associates

ST. BERNARDIN - REPORT OF MONITORING RESULTS **Project: 031120717**

Sample Source: **BH03-4** Sheet: 1

Date Sampled:		12-Sep-2003	27-Oct-2003	19-May-2004	19-May-2004(2)	21-Oct-2004
Parameter	ODWQS					
1 Comment		dry				
Ammonia (as N)			0.18	<0.03	<0.03	<0.03
Chloride	250		894.0	977.0	956.0	1080.0
Conductivity (uS/cm)			2500	3350		3800
Dissolved Oxygen				6.5		6.0
DOC	5		10.5	8.2	8.5	11.8
Nitrate (as N)	10		0.33	1.10	1.00	0.80
Nitrite (as N)	1		<0.10	<1.00	<1.00	<2.00
pH (pH units)	6.5-8.5		6.3	7.1		6.9
Phosphorus (total)			3.760	2.790	2.470	4.050
Sodium	200		308.0	293.0	290.0	360.0
Temperature (C)	15		10.1	9.5		9.8

All values reported in mg/L unless otherwise noted.

Golder Associates

ST. BERNARDIN - REPORT OF MONITORING RESULTS **Project: 031120717**

Sample Source: **BH03-5** Sheet: 1

Date Sampled:		12-Sep-2003	27-Oct-2003	19-May-2004	21-Oct-2004
Parameter	ODWQS				
1 Comment		dry			
Ammonia (as N)			0.06	<0.03	<0.03
Chloride	250		916.0	826.0	906.0
Conductivity (uS/cm)			3200	3230	3700
Dissolved Oxygen				4.4	8.4
DOC	5		1.6	3.5	5.4
Nitrate (as N)	10		0.29	0.40	<0.20
Nitrite (as N)	1		<0.10	<1.00	<2.00
pH (pH units)	6.5-8.5		6.5	7.1	7.3
Phosphorus (total)			5.440	2.610	3.620
Sodium	200		387.0	321.0	387.0
Temperature (C)	15		10.0	7.0	10.5

All values reported in mg/L unless otherwise noted.

Golder Associates

ST. BERNARDIN - REPORT OF MONITORING RESULTS **Project: 031120717**

Sample Source: **BH03-6** Sheet: 1

Date Sampled:		12-Sep-2003	27-Oct-2003	19-May-2004	21-Oct-2004
Parameter	ODWQS				
1 Comment		dry	dry		
Ammonia (as N)				<0.03	<0.03
Chloride	250			2.0	2.9
Conductivity (uS/cm)				220	310
Dissolved Oxygen				7.4	10.6
DOC	5			16.7	21.2
Nitrate (as N)	10			<0.20	<0.20
Nitrite (as N)	1			<0.20	<0.20
pH (pH units)	6.5-8.5			7.2	7.8
Phosphorus (total)				1.880	1.770
Sodium	200			12.6	11.7
Temperature (C)	15			8.0	8.6

All values reported in mg/L unless otherwise noted.

APPENDIX F

REPORT OF ANALYSES SHEETS
PSC ANALYTICAL SERVICES

PSC

ANALYTICAL SERVICES

8-Nov-2004

Page: 1
Copy: 1 of 2

GOLDER ASSOCIATES LTD.
1796 Courtwood Crescent
Ottawa, ON
K2C 2B5

Attn: Carolyn Van Delste/Caitlin Martin
Received: 23-Oct-2004 09:45

Project: 04-1120-708 T-5000 PO #:

Job: 2461117 Status: Final

Ground Water Samples

Sample Id	Cl- SM 4110B mg/L	NO2-N SM 4110B mg/L	NO3-N SM 4110B mg/L	NH3-N SM 4500H mg/L	Total P SM 4500-P F mg/L	DOC SM 5310C mg/L	DO SM 4500G mg/L	Na ICAP mg/L
MW03-1	1350.	<2.0	0.4	0.05	8.36	34.7	4.6	850.
MW03-2	1130.	<2.0	12.7	0.68	2.30	54.2	6.2	872.
MW03-3	1360.	<2.0	16.4	<0.03	2.05	21.5	7.0	960.
MW03-4	1080.	<2.0	0.8	<0.03	4.05	11.8	5.9	360.
MW03-5	906.	<2.0	<0.2	<0.03	3.62	5.4	6.3	387.
MW03-6	2.9	<0.2	<0.2	<0.03	1.77	21.2	8.5	11.7
MW03-8	1450.	<2.0	16.7	<0.03	2.11	20.2	5.3	981.
Blank	<0.5	<0.2	<0.2	<0.03	<0.002	<0.2	---	<0.1
QC Standard (found)	25.4	1.0	1.0	1.52	0.143	9.8	---	49.7
QC Standard (expected)	25.0	1.0	1.0	1.50	0.140	10	---	50.0
Repeat MW03-1	1380.	<2.0	0.3	0.05	8.52	34.6	---	850.

PSC
ANALYTICAL SERVICES

8-Nov-2004

GOLDER ASSOCIATES LTD.
1796 Courtwood Crescent
Ottawa, ON
K2C 2B5

Attn: Carolyn Van Delste/Caitlin Martin   Received: 23-Oct-2004 09:45
Project: 04-1120-708 T-5000   PO #:

Job: 2461117   Status: Final

All work recorded herein has been done in accordance with normal professional standards using accepted testing methodologies and QA/QC procedures. PSC Analytical is limited in liability to the actual cost of the pertinent analyses done unless otherwise agreed upon by contractual arrangement. Your samples will be retained by PSC Analytical for a period of 30 days following reporting or as per specific contractual arrangements.

Job approved by:

Signed:
....
Malgorzata Danczyger
Project Manager

PSC

ANALYTICAL SERVICES

8-Jun-2004

GOLDER ASSOCIATES LTD.
1796 Courtwood Crescent
Ottawa, ON
K2C 2B5

Page: 1
Copy: 1 of 2

GOLDER ASSOCIATES RECEIVED JUN 17 2004 OTTAWA

Attn: Carolyn VanDelst
Project: 04-1120-708

Received: 21-May-2004 09:30
PO #: 04-1120-708

Job: 2454545

Status: Final

Water Samples

Sample Id	Cl- SM 4110B mg/L	NO2-N SM 4110B mg/L	NO3-N SM 4110B mg/L	DOC SM 5310C mg/L	NH3-N SM 4500H mg/L	Total P SM 4500-P F mg/L	Na ICAP mg/L
S-1	1330.	<1.0	0.8	15.3	0.03	5.46	767.
S-2	1130.	<1.0	1.2	104.3	0.09	3.66	886.
S-3	1190.	<1.0	1.2	16	<0.03	1.41	937.
S-4	977.	<1.0	1.1	8.2	<0.03	2.79	293.
S-5	826.	<1.0	0.4	3.5	<0.03	2.61	321.
S-6	2.0	<0.2	<0.2	16.7	<0.03	1.88	12.6
S-7	956.	<1.0	1.0	8.5	<0.03	2.47	290.
Blank	<0.5	<0.2	<0.2	<0.2	<0.03	<0.002	<0.1
QC Standard (found)	2.0	1.0	1.0	9.9	1.52	0.133	48.3
QC Standard (expected)	2.0	1.0	1.0	10	1.50	0.144	50.0
Repeat S-1	1330.	<1.0	0.9	16.3	0.03	5.29	754.

PSC
ANALYTICAL SERVICES

8-Jun-2004

GOLDER ASSOCIATES LTD.
1796 Courtwood Crescent
Ottawa, ON
K2C 2B5

Attn: Carolyn VanDelst
Project: 04-1120-708

Received: 21-May-2004 09:30
PO #: 04-1120-708

Job: 2454545 Status: Final

IC Analysis of Water:
Some samples for NO2-N were analyzed at an extra dilution due to matrix interference. EQLs were adjusted accordingly.

All work recorded herein has been done in accordance with normal professional standards using accepted testing methodologies and QA/QC procedures. Philip Analytical is limited in liability to the actual cost of the pertinent analyses done unless otherwise agreed upon by contractual arrangement. Your samples will be retained by PASC for a period of 30 days following reporting or as per specific contractual arrangements.

Job approved by:

Signed:
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Malgorzata DanczIger
Project Manager