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June 29, 2012

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Via Mail and Email

B-246.09

Ms. Christine Hutlet
R.M. of Brokenhead
72013 Road 42 East
Box 490
Beausejour, Manitoba
R0E 0C0

Dear Ms. Hutlet,

Re: Draft RM of Brokenhead Wastewater Treatment Lagoon Expansion Feasibility Study

Enclosed are two (2) hard copies of the draft RM of Brokenhead Wastewater Treatment Lagoon Expansion Feasibility Study. As described in the e-mail a link to a digital .pdf copy of the report has also been provided.

Once the RM of Brokenhead council reviews the feasibility study report, council may wish to meet to discuss the report. Subsequently the report can be finalized.

If there are any questions, please do not hesitate to contact the undersigned.

Yours truly,

J. R. Cousin Consultants Ltd.

Brett McCormac, E.I.T.
Environmental Engineer-in-Training

Reviewed by:

Jerry Cousin, P.Eng.
President

enc. two documents

RURAL MUNICIPALITY OF BROKENHEAD

DRAFT

WASTEWATER TREATMENT

LAGOON EXPANSION

FEASIBILITY STUDY

J. R. Cousin Consultants Ltd.
June 2012

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P&R #8.178 JRCC

B-246.09

RURAL MUNICIPALITY OF BROKENHEAD

Wastewater Treatment Lagoon Expansion

Feasibility Study

Prepared by: J. R. Cousin Consultants Ltd.
91 A Scurfield Blvd.
Winnipeg, Manitoba
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June 2012

ACKNOWLEDGMENTS

To prepare this report various sources of information were investigated and researched. J. R. Cousin Consultants Ltd. (JRCC) wishes to thank the RM of Brokenhead who contributed to the data and content of this report.

REMARKS

Conclusions reached in this report are based upon the generalization of data available to us at the time of forming our opinions. Information in this document may rely on previous studies, investigative work and data by others. JRCC cannot be responsible for actual site conditions proved to be at variance with any generalized data. This report was completed in accordance with generally accepted professional engineering principles and practice. Any use of this report by a third party is the responsibility of the third party, JRCC accepts no responsibility for third party decisions or actions based on the report. No other warranty or guarantee expressed, implied or statutory is made.

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EXECUTIVE SUMMARY

General

The RM of Brokenhead wastewater treatment lagoon is overloaded and requires expansion. This feasibility study presents an outline of the works to be completed for the lagoon expansion with associated costs.

Description

The RM of Brokenhead lagoon was constructed in 2004 to service the Towns of Garson, Tyndall and Henryville. The lagoon will continue to service the Towns of Garson, Tyndall and Henryville as well as the rural residents in the RM of Brokenhead.

The proposed lagoon expansion site is located immediately east of the existing RM of Brokenhead lagoon within the NW and SW ¼ of 15-13-06 EPM.

Discharge Route

The discharge route from the expanded lagoon will follow the existing licensed discharge route from the RM of Brokenhead lagoon to the Devil's Creek.

Existing Lagoon Design Parameters

The 2004 total population of Garson, Tyndall and Henryville used in the original design was 1,025 people which includes the 37 bussed in student equivalent population. The 2024 population used in original design was 1,291 people which includes the 46 bussed in student equivalent population. The water demand used in design was 360 L/person/day with 15% added for infiltration and 33.3% of the daily raw water intake added to account for reject water from the WTP for a total wastewater production of 594 L/person/day.

Current and Projected Populations and Design Parameters

157 building permits have been issued from 2005 – 2011 increasing the Garson, Tyndall and Henryville populations by approximately 553 people (including the bussed in student equivalent population), to the 2012 population of 1,578 resulting in an average annual growth rate of 6.4% over the 7 year period.

Future development in Garson, Tyndall and Henryville will bring the total population to approximately 4,210 people by the design year 20 (2032) including the bussed in student equivalent population. The design growth rate from 2012 to 2032 is 5.1% which is 1.3% lower than the actual growth rate of 6.4% observed from 2005 – 2011.

Based on the average growth rate of 1.36% from 1991-2011, the 2012 population of the rural residents in the RM of Brokenhead is approximately 3,228 people and the projected design year 20 (2032) population is approximately 4,230 people. Approximately 75% of the rural residents are serviced by septic tanks and 25% are serviced by holding tanks.

The water consumption has increased from 91 L/person/day in 2008 to 169 L/person/day in 2011. The per capita water consumption rate that will be used for design is 225 L/person/day. The reject water from the WTP used in design will be 30.0% of the raw water intake.

The water meter in the lift station does not produce accurate results. It is recommended that the mag meter be checked and re-calibrated if required. An infiltration rate of 15% of the daily water consumption or 34 L/person/day will be used for design.

A hydraulic loading of 200 L/person/year will be used for the rural residents on septic tanks and a hydraulic loading of 200 L/person/day will be used for rural residents on holding tanks.

Lagoon Loading

The current 2012 organic loading is approximately 206.4 kg BOD_5/day and the projected year 20 design organic loading is approximately 433.3 kg BOD_5/day which provides service to 4,160 future residents of Garson, Tyndall and Henryville, 50 equivalent bussed-in students, 1,058 rural residents on holding tanks and 3,172 rural residents on septic tanks.

The current 2012 hydraulic loading to the lagoon is 725 m^3/day and the 230 day storage requirements are 166,791 m^3. The projected design year 20 (2032) daily hydraulic loading is 1,711 m^3/day and the 230 day storage requirements are 393,495 m^3 which provides service to 4,160 future residents of Garson, Tyndall and Henryville, 50 equivalent bussed-in students, 1,058 rural residents on holding tanks and 3,172 rural residents on septic tanks.

Existing Lagoon Capacity

The current organic capacity of the lagoon based on a lagoon organic treatment rate of 45.64 kg BOD_5/ha/day is 100.2 kg BOD_5/day, which is 106.2 kg BOD_5/day less than the current organic loading and 333.1 kg BOD_5/day less than the projected future organic loading to the lagoon.

The current hydraulic storage capacity of the lagoon is 178,192 m^3 which is 11,401 m^3 in excess of the current hydraulic storage requirements and 215,303 m^3 less than the projected future design year 20 (2032) hydraulic storage requirements.

Facultative Lagoon Expansion

Due to the existing elevations in the cell expansion areas, the new expansion cells will have to be constructed at a higher elevation than the existing lagoon. A new primary cell will be constructed east of the existing lagoon secondary cell #2 with an area at a 0.75 m height of 95,419 m^2. The existing primary cell will be converted to a secondary cell. A new secondary cell will be constructed north of the new primary cell and east of the existing lagoon cells with a hydraulic storage capacity of 135,026 m^3.

Discussion of Aeration

Aerated lagoon cells could be constructed which would result in a smaller lagoon footprint, less odour generation, higher effluent quality and greater flexibility to meet higher loadings in future. An aerated lagoon would result in higher capital costs and higher operating costs compared with a facultative lagoon. If the RM of Brokenhead wishes to investigate an aerated lagoon further, additional equipment research and sizing and detailed budget capital estimates would have to be completed.

Topographical Survey and Geotechnical Investigation

Based on the geotechnical investigation it is recommended the flat bottom liner of lagoon expansion cells be constructed partially with the insitu soils and partially with a re-worked and re-compacted liner. The flat bottom liner south of the line approximately through TH10, could be constructed with insitu clay 1.0 m below the cell floor elevation. The flat bottom liner north of the line approximately through TH10, would have to be excavated and re-compacted with 1.0 m of suitable high plastic clay. Any pockets of unsuitable material found in the horizontal liner would have to be replaced with suitable high plastic clay soils. The topography of the site was relatively flat with an average ground elevation of 236.23 m.

Nutrient Management Plan

New environmental guidelines require a 1.0 mg/L phosphorus limit. Based on nutrient testing by the RM, it is expected phosphorus reduction measures will be required. It is recommended an additional study be completed to investigate the feasibility of a chemical filtration system at this stage to obtain budget capital cost estimates and compare them to the costs of phosphorous reduction by surface chemical treatment.

Summarized Lagoon Construction Works

The following is a summary of the required works for the lagoon construction:

- A new primary cell and new secondary cell will be constructed east of the existing lagoon and the existing primary cell will be converted to secondary storage
- The existing forcemain will be diverted to the new primary cell
- A new truck turnaround area and concrete spillway will be constructed at the new primary cell
- The southwest top of dike of the new primary cell will be graveled to maintain road access to the existing truck turnaround area
- Discharge from the lagoon is to follow the existing licensed discharge route to the Devil's Creek
- The horizontal liner will be constructed with a minimum 1.0 m insitu clay liner except in the location at the north end of the proposed cell, as shown on Plan 1, where a minimum 1.0 m thick re-worked liner will be required

- A 3.0 m wide vertical cut-off wall constructed with re-worked clay soils will extend a minimum of 1.0 m into the horizontal clay liner and extend to the top of dike elevation
- The fencing along the east side of the existing lagoon will be removed and a 1.2 m high barbed wire fence would be installed around the perimeter of the new lagoon cells
- Valve markers will be installed at the new discharge and intercell pipe locations.

Project Costs

The following table summarizes budget capital costs for the lagoon expansion, which are based upon expected 2012 construction. The costs for each year after 2012 should be inflated per prevailing inflation. No equipment was included in the cost estimate for phosphorus or ammonia reduction, phosphorus concentration can be reduced by broadcasting alum on the surface of the secondary cell, prior to discharge. Rip Rap could be included on the inside dikes of the lagoon at an elevation 0.5 m above and 0.5 m below the high water level of the cells to reduce erosion of the dikes. An additional item in the detailed cost estimate, attached in the Appendix for rip rap on the new dikes has been provided. A 15% contingency and 15% for engineering was also included in the cost estimate.

Options	Construction	Non-Construction	Total
Facultative Lagoon Expansion	$2,091,100	$639,900	**$2,731,000**

Next Steps

The next step in the process of developing the lagoon is for the RM of Brokenhead to review this feasibility study and provide comment. The RM of Brokenhead council may wish to meet JRCC to discuss the report. Subsequently the feasibility study will be finalized. An Environment Act Proposal should be completed and submitted after the review and acceptance of this feasibility study document.

1.0 INTRODUCTION

The RM of Brokenhead wastewater treatment lagoon is overloaded and requires expansion. J. R. Cousin Consultants Ltd. (JRCC) was retained for the engineering services. This feasibility study report establishes the lagoon design criteria and the required works with associated costs.

1.1 Project Purpose

The purpose of this project is to expand the existing RM of Brokenhead lagoon to meet the projected loadings from the Towns of Garson, Tyndall and Henryville as well as the truck haul loadings from the rural residents in the RM of Brokenhead to the projected design year 20 (2032).

1.2 Scope of Project

The scope of the project is to undertake feasibility study works for the wastewater treatment lagoon expansion, which will meet demands to design year 20.

The scope of the project consists of the following:

- Review existing documentation and Environmental Licence
- Complete population assessment to design year 20
- Complete effluent projections and design year 20 organic and hydraulic loadings based on past data and projected populations
- Review existing land owned by the RM and land required for the lagoon expansion
- Complete an on-site geotechnical investigation and topographic survey
- Prepare a feasibility study complete with capital cost estimates.

1.3 Project Report

Overall, the feasibility study presents an outline of the works to be completed for the RM of Brokenhead lagoon expansion. The report herein establishes the lagoon construction criteria and the required works with associated costs.

2.0 DESCRIPTION OF THE DEVELOPMENT

2.1 Background

The RM of Brokenhead lagoon was constructed in 2004 to service the Towns of Garson, Tyndall and Henryville. A piped wastewater collection system, a water treatment plant and piped water distribution system were installed along with the lagoon construction. The lagoon will continue to service the Towns of Garson, Tyndall and Henryville as well as the rural residents in the RM of Brokenhead.

2.2 Land Description

The proposed lagoon expansion site is located immediately east of the existing lagoon cells within an agricultural field.

2.3 Description of Previous Studies

A letter report entitled *RM of Brokenhead Water and Sewer Assessment Letter Report* was completed by JRCC in June of 2011. The report assessed the capacity of the existing wastewater treatment lagoon and the water treatment plant and reviewed the current and projected loadings for a 20 year design period. The report identified the primary cell of the lagoon was organically overloaded and growth in Garson, Tyndall and Henryville should be postponed until expansion of the lagoon occurs.

2.4 Basis for Proposed Lagoon Site Selection

The proposed lagoon expansion site is located immediately east of the existing RM of Brokenhead lagoon within the NW and SW ¼ of 15-13-06 EPM. Access to the site would be from an existing access road which runs from Mile Road 74 N to the existing lagoon.

Plan 1 in the Appendix shows the proposed lagoon expansion layout.

Manitoba Conservation's guidelines for the location of a wastewater treatment lagoon *Design Objectives for Standard Sewage Lagoons, Province of Manitoba, Environmental Management, July 1985* are outlined in the following table. A description of the proposed sites in relation to each of the guidelines is also provided in the table.

Table 2.1: Proposed Lagoon Expansion Site Location in Relation to Manitoba Conservation Guidelines

Manitoba Conservation Guideline	Proposed Relation to Site
1. Lagoons must be located a minimum of 460 m from any community centre.	The proposed new lagoon is located approximately 2.0 km from the nearest community centre (Town of Tyndall).
2. Lagoons must be located a minimum of 300 m from any residence. (The distance is to be measured from the centreline of the nearest dike) , this distance is shown on Plan 1, attached in the Appendix.	The proposed new lagoon is located over 300 m from the nearest resident.
3. Consideration should be given to sites in which prevailing winds are in the direction of uninhabited areas.	The prevailing winds are from the north and west. The lagoon is located north and northwest of Garson and Tyndall.
4. Sites with an unobstructed wind sweep across the lagoon are preferred.	The site surrounding the proposed lagoon is the existing lagoon and agricultural field.
5. Areas that are habitually flooded shall be avoided.	The proposed lagoon dikes would be higher than 100 year flood elevation of the area.
6. Sewage lagoons are to be designed and constructed such that the interior surface of the proposed lagoon is underlain by at least one metre of soil having a hydraulic conductivity of 1×10^{-7} cm/sec or less. In areas sensitive to groundwater contamination, a flexible synthetic liner may be recommended.	Based on the geotechnical investigation, the in-situ soils will be capable of providing a consistent permeability of 1×10^{-7} cm/sec in most locations. Some of soils in the north portion of the new cell secondary cell will be lined with re-worked and re-compacted clay liner.

2.5 Proposed Discharge Route

The drainage route from the expanded lagoon will follow the existing licensed drainage route from the RM of Brokenhead lagoon. The drainage route from the expansion cells will flow through perimeter ditches which will meet the existing discharge route. The existing discharge route flows from the perimeter ditches of the existing lagoon to the Devil's Creek.

3.0 POPULATION AND WASTEWATER PRODUCTION

The population, for which the lagoon was originally designed, is discussed below. Also the current and future (design year 20) populations contributing effluent to the lagoon is discussed. Wastewater production rates used for design are based on actual water meter readings from the water treatment plant and the lift station to the lagoon from 2008 – 2011 and are discussed below.

Population projections and organic and hydraulic loading to lagoon to design year 20 (2032) are shown on Table 1 attached in the Appendix. The lagoon has been sized to utilize the maximum available land area east of the existing lagoon, as per the RM of Brokenhead Council resolution passed on February 1, 2012.

3.1 Existing Lagoon Design Parameters

The following information on the design population was obtained from the *RM of Brokenhead Village of Garson, Community of Tyndall, Community of Henryville Municipal Water and Sewer System Pre-Design Report* by JRCC in Feb, 2002. Populations and population growth rates from 2001 were provided by RM officials and summarized by JRCC in Technical Memorandum # 1, dated August 17, 2001. The populations and population growth rates were resolved by Council, MWSB officials and JRCC at a meeting held August 24, 2001 and JRCC received approval to proceed with design. These population growth rates were also used to determine the design populations when updated in 2004 to make 2024 the design year 20.

3.1.1 Village of Garson Design Population

The 2004 population of the Village of Garson used for design of the water and sewer system was 371 people. The chosen growth rate of 1.15% was expected to continue until 2024. Based on these projections the 2024 population for the Village of Garson used in design of the water systems was 467 people.

3.1.2 Tyndall Design Population

The 2004 population of the Community of Tyndall used for design of the water and sewer system was 570. The chosen growth rate of 1.17% was used for design until 2024. Based on these projections the 2024 population for the Community of Tyndall used in design was 719 people.

3.1.3 Henryville Design Population

The 2004 population of the Community of Henryville used for design of the water and sewer system was 47 people. The chosen growth rate of 1.17% was assumed to continue until 2024. Based on these projections, the 2024 population of the Community of Henryville used design of the water and sewer systems was 59.

3.1.4 Bussed in Students

There were 106 bussed-in students to schools in Tyndall and Garson in 2001. A chosen growth rate of 1.15% and an equivalent full time resident occupancy factor of 1/3 was assumed for the bussed-in student population. Based on these projections the 2004 bussed-in student equivalent population was 37 and the 2024 equivalent population of bussed-in students used in design of the water and sewer systems was 46.

3.1.5 Water Demand and Effluent Production

A typical water demand of 360 L/person/day was assumed for original design in 2004. An extra 15% was included in the effluent production to account for extraneous/infiltration flows. In addition, all reject water from the water treatment plant is assumed to be directed to the lagoon. The amount of reject water assumed for design was 33.3% of the daily raw water intake (50% of the daily water demand) or 180 L/person/day.

3.1.6 Organic Sizing Growth Rates

The Environmental Licence for the lagoon allows for an organic loading of 45.64 kg BOD_5/ha/day. This permissible organic loading is less than the typical loading for a lagoon and was decreased so that odours from the lagoon would not become an issue. This decision was made following the Clean Environment Commission (CEC) hearing. The lagoon loading in 2024 (design year 20) was designed to be 45.64 kg BOD_5/ha/day as opposed to the provincial guideline of 56 kg BOD_5/ha/day.

Summary: The 2004 total population of Garson, Tyndall and Henryville used in design was 1,025 people which includes the 37 bussed in student equivalent population. The 2024 population used in design was 1,291 people which includes the 46 bussed in student equivalent population. The water demand used in design was 360 L/person/day with 15% added for infiltration and 33.3% of the daily raw water intake added to account for reject water from the WTP for a total wastewater production of 594 L/person/day.

3.2 Current and Projected Year 20 Populations

3.2.1 Current Population of Garson, Tyndall and Henryville

The current population of Garson, Tyndall and Henryville was estimated based on the number of building permits issued from 2005 – 2011, provided by the Brokenhead River Planning District. The total number of building permits issued in Garson and Tyndall is provided in the following table. No building permits were issued for Henryville.

Table A – Building Permits Issued in Garson and Tyndall

Year	Garson	Tyndall	Total
2005	5	15	20
2006	5	13	18
2007	16	14	29
2008	10	18	28
2009	6	7	13
2010	12	11	23
2011	21	4	25
TOTAL	**75**	**82**	**157**

There have been 157 houses built in Garson and Tyndall from 2005 – 2011 resulting in an increase to the 2004 population of approximately 550 people (assuming an occupancy of 3.5 people/household for new developments). Therefore, the 2012 population of Garson, Tyndall and Henryville including the bussed in student equivalent population is estimated at 1,578 people (1,025 people + 553 people). This results in an average annual growth rate of 6.4% over the 7 year time period.

Summary: 157 building permits have been issued from 2005 – 2011 increasing the Garson, Tyndall and Henryville populations by approximately 553 people (including the bussed in student equivalent population), to the 2012 population of 1,578 resulting in an average annual growth rate of 6.4% over the 7 year period.

3.2.2 Future Population of Garson, Tyndall and Henryville

Future growth in Garson, Tyndall and Henryville will be based on the number of committed and proposed development lots since the 2004 mainline installation.

According to JRCC office records, 173 water services were installed to unoccupied lots in 2005. Based on the occupancy rate of 3.5 people/household for new developments, 606 people are committed to be added to the 2004 total population of Garson, Tyndall and Henryville from these lots.

There are also 79 lots in Tyndall and 62 lots in Garson which have been approved for development and are in various stages of completion. When all 141 lots become serviced and occupied at an occupancy rate of 3.5 people/household, 494 people are committed to be added to the 2004 total population of Garson, Tyndall and Henryville from these lots.

There are also 3 subdivisions in the planning stage which include a 100 lot development east of the school in Tyndall, a proposed 123 lot subdivision on the west side of Tyndall and a proposed 36 lot subdivision in the south end of Garson that the RM would like to include in the population count. Once all 259 of the proposed lots become serviced and occupied at an occupancy rate of 3.5 people/household, 907 people will be added to the 2004 total population of Garson, Tyndall and Henryville from these lots.

Lagoon will be constructed to utilize the maximum available land area which will allow an additional 1,165 people in Garson, Tyndall and Henryville to be serviced by the lagoon. This results in an additional 333 lots which are available for development once the lagoon expansion is complete.

Table B – Summary of Development in Garson and Tyndall

Time	Development	Population
2004	417 occupied houses serviced in 2004	988
2005	173 unoccupied lots serviced in 2005 (some are now occupied)	606
Future Committed	141 lots are committed to be serviced (69 currently serviced)	494
Future Proposed	259 lots are proposed to be developed and serviced in Garson and Tyndall	907
Future Available	333 lots are available for development based on constructing the lagoon for the maximum available land	1,165
Total	990 houses are to be serviced by the water and sewer system upon completion of the committed and proposed development and 333 lots are available for development	4,160

For the purposes of this study it can be assumed that Garson, Tyndall and Henryville will reach the future population of 4,160 people by the design year 20 (2032). The growth rate from 2012 to 2032 will be approximately 5.1% over the 20 year time period. This is a decrease of 1.3% from the population growth rate of 6.4% observed from 2005 – 2011.

Summary: Future development in Garson, Tyndall and Henryville will bring the total population to approximately 4,210 people by the design year 20 (2032) including the bussed in student equivalent population. The design growth rate from 2012 to 2032 is 5.1% which is 1.3% lower than the actual growth rate of 6.4% observed from 2005 – 2011.

3.2.3 Population of the RM of Brokenhead

The Garson/Tyndall/Henryville lagoon also services the remainder of the RM of Brokenhead rural residents by truck haul from a combination of septic and holding tanks. This was not included in the original design of the lagoon.

The population of the RM of Brokenhead is estimated based on Canada Census data provided by Statistics Canada.

Table C – RM of Brokenhead Populations from 1991 - 2006

Year	Population*	Annual Population Growth Rate (%)
1991	3,645	
1996	3,834	1.04
2001	3,877	0.22
2006	3,940	0.32
2011	4,635	3.53
Average Growth Rate		1.36

*Note: The RM of Brokenhead population includes the populations of Garson, Tyndall and Henryville.

The future growth will be based on the average annual growth rate of 1.36% observed between 1991 and 2011. The 2011 population of Garson, Tyndall and Henryville was 1,451 people and therefore the population of rural residents was 3,184 people (4,635 – 1,451). Applying a growth rate of 1.36% to the 2011 rural resident population of 3,184, the 2012 population would be 3,228 people and the 2032 population would be 4,230 people.

According to municipal officials from the RM of Brokenhead approximately 75% of the rural residents are serviced by septic tanks and 25% are serviced by holding tanks.

The following table indicates the 2006 population and the projected 2012 and 2032 RM populations and the portion of the population serviced by septic tanks and holding tanks.

Table D – RM of Brokenhead Projected Populations from 2011 - 2032

Year	Population of RM of Brokenhead	Population on Septic Tanks	Population on Holding Tanks
2011	3,184	2,388	796
2012	3,228	2,421	807
2032	4,230	3,172	1,058

Summary: Based on the average growth rate of 1.36% from 1991-2011, the 2012 population of the rural residents in the RM of Brokenhead is approximately 3,228 people and the projected design year 20 (2032) population is approximately 4,230 people. Approximately 75% of the rural residents are serviced by septic tanks and 25% are serviced by holding tanks.

3.3 Reported Water Consumption and Effluent Production

3.3.1 Reported Water Consumption of Garson/Tyndall/Henryville

Raw water usage and water consumption data from 2008 – 2011 was obtained from the water treatment plant operator. The actual daily per capita water usage for the Communities was calculated based on actual population information and summarized in the following table:

Table E – Actual Water Usage from the RM of Brokenhead WTP

Year	2008	2009	2010	2011
Average Daily Raw Water Usage (m^3/day)	155	245	286	335
Average Daily Water Consumption (m^3/day)	115	171	205	237
Percentage Reject (Reject Water/Raw Water Intake)	25.1%	29.9%	28.3%	29.3%
Estimated Population (Calculated based on building permits issued since 2004)	1,254	1,286	1,342	1,405
Actual Average Per Capita Water Consumption (L/person/day)	91	133	153	169

As shown in Table E, the per capita water usage has increased from 2008 to 2011. The highest per capita water usage (not including reject water) in 2011 of 169 L/person/day is still much lower than the 360 L/person/day water usage (not including reject water) assumed in the 2004 design. This low water usage could be contributed to water conservation habits of Community members who relied on well water and holding tanks in the past. As development continues in the Communities the population demographic may change as possibly younger families move in and the per capita water consumption may continue to rise. In the June 2011 Water and Sewer Assessment Letter Report a design water consumption rate of 200 L/person/day was used based on the 2010 actual value of 153 L/person/day. With the increase in actual water consumption from 2010 – 2011, a water consumption rate of 225 L/person/day will be used in design for the purposes of this study.

The percentage of reject water per raw intake water ranged from 25.1% to 29.9% between 2008 and 2011, calculated from actual water use records provided by the WTP operator. The percentage of reject water per raw intake water of 30.0% will be utilized in this study to determine the projected hydraulic loadings to the lagoon. This reject water percentage is slightly lower than the number used in the original design of 33.3%.

Summary: The water consumption has increased from 91 L/person/day in 2008 to 169 L/person/day in 2011. The per capita water consumption rate that will be used for design is 225 L/person/day. The reject water from the WTP used in design will be 30.0% of the raw water intake.

3.3.2 Reported Wastewater Production of Garson/Tyndall/Henryville

Reported effluent flows to the lagoon from 2008 – 2011 were obtained from the lagoon operator as measured from a flow meter at the lift station. The calculated daily infiltration for the Communities is summarized in the following table:

Table F – Actual Wastewater Sent to the RM of Brokenhead Lagoon

Year	2008	2009	2010	2011
Average Wastewater Flow to Lagoon (m^3/day)	193	266	286	297
Reported Average Per Capita Wastewater Production (L/person/day)	154	207	213	211
Infiltration (m^3/day) (Wastewater Flow to Lagoon - Raw Water Usage)	39	21	-1	-38
Reported Average Per Capita Infiltration (L/person/day)	31	16	-1	-27
Percentage Infiltration (Reject Water/Daily Water Usage)	34%	12%	-0.3%	-16%

As shown in Table F, the infiltration decreased from 34% of daily water usage in 2008 to -16% in 2010. This data most likely contains errors as in 2011 and 2010, less water was sent to the lagoon than was drawn from the raw water well. Every Community should experience infiltration into the sewer system, and no measures to reduce infiltration have been implemented since 2008. Errors could be introduced by inaccurate flow meters, flow meters not being properly calibrated in the lift station and/or in the WTP, power outages resulting in lower readings, truck fill and hydrant flushing.

It is recommended that the Communities lift station mag meter be checked and re-calibrated if required. A pump draw down test should be performed to determine the pumping rates of the lift station pumps. The flow to the lagoon could then be calculated based on the pump hour readings and compared to the flow meters. When corrected, pump hour readings and flow meter readings should be recorded daily so an accurate assessment of infiltration in Communities can be completed.

For the purposes of this study we will continue to use the infiltration percentage assumed in design of 15% of the per capita water usage or 34 L/person/day (15% of 225 L/person/day).

Summary: The water meter in the lift station does not produce accurate results. It is recommended that the mag meter be checked and re-calibrated if required. An infiltration rate of 15% of the daily water consumption or 34 L/person/day will be used for design.

3.3.3 Wastewater Production from Rural Residents

The hydraulic loading from the rural residents on septic tanks is based on a typical septage contribution rate of 200 L/person/year, during the summer period of 135 days.

The rural residents from the RM of Brokenhead on holding tanks can be assumed to have a lower water consumption rate from town residents on the piped system due to water conservation habits. A water consumption of 200 L/person/day will be used for the rural residents serviced by holding tanks. Reject water and infiltration do not apply to residents on holding tanks and therefore the total wastewater production from rural residents on holding tanks will be 200 L/person/day.

Summary: A hydraulic loading of 200 L/person/year will be used for the rural residents on septic tanks and a hydraulic loading of 200 L/person/day will be used for rural residents on holding tanks.

3.4 Lagoon Loading

3.4.1 Organic Loading

The organic loading calculation is based upon the organics in typical residential wastewater. A value of 0.076 kg BOD_5/person/day was utilized to estimate the organic loading from the residents within Garson, Tyndall and Henryville that are connected to the existing piped wastewater collection system and for rural residents in the RM of Brokenhead serviced by holding tanks. An organic strength of 7.0 kg BOD_5/m^3 was utilized to calculate the organic loading from rural residents from the RM of Brokenhead serviced by septic tanks based upon a typical septage contribution rate of 200 L/person/year, during the summer period of 135 days.

The current 2012 daily organic loading is:

- 116.9 kg BOD_5/day (i.e. 1,538 x 0.076) from Garson, Tyndall and Henryville

- 3.0 kg BOD_5/day (i.e. 40 x 0.076) from the equivalent population of bussed in students
- 61.4 kg BOD_5/day (i.e. 807 x 0.076) from the rural residents on holding tanks
- 25.1 kg BOD_5/day (i.e. 200 x 2,421/135 x 7/1000) from the rural residents on septic tanks

The total organic loading is 206.4 kg BOD_5/day.

The design year 20 daily organic loading is:

- 316.2 kg BOD_5/day (i.e. 4,160 x 0.076) from Garson, Tyndall and Henryville
- 3.8 kg BOD_5/day (i.e. 50 x 0.076) from the equivalent population of bussed in students
- 80.4 kg BOD_5/day (i.e. 1,058 x 0.076) from the rural residents on holding tanks
- 32.9 kg BOD_5/day (i.e. 200 x 3,172/135 x 7/1000) from the rural residents on septic tanks

The total organic loading is 433.3 kg BOD_5/day.

Summary: The current 2012 organic loading is approximately 206.4 kg BOD_5/day and the projected year 20 design organic loading is approximately 433.3 kg BOD_5/day which provides service to 4,160 future residents of Garson, Tyndall and Henryville, 50 equivalent bussed-in students, 1,058 rural residents on holding tanks and 3,172 rural residents on septic tanks.

3.4.2 Hydraulic Loading

As stated above, the per capita water consumption rate for Garson, Tyndall and Henryville used for design will be 225 L/person/day. In addition, the total wastewater production will also include 30% of the raw water intake or 96 L/person/day to account for reject water and an additional 15% of the per capita daily water demand or 34 L/person/day to account for infiltration. In total, the wastewater production from Garson, Tyndall and Henryville is 355 L/person/day.

The total wastewater production from rural residents from the RM of Brokenhead serviced by holding tanks used in design is 200 L/person/day.

The hydraulic loading from the rural residents on septic tanks is based on a typical septage contribution rate of 200 L/person/year, during the summer period of 135 days. Therefore, hydraulic loading from septic tanks will not count towards the winter storage requirements.

The current 2012 daily hydraulic loadings to the lagoon is:

- 560 m^3/day (1,578 x 355/1000) from the Garson, Tyndall and Henryville populations including the bussed-in students
- 161 m^3/day (807 x 200/1000) from the RM of Brokenhead rural residents on holding tanks
- 4 m^3/day (2,421 x 200/135/1000) from the RM of Brokenhead rural residents on septic tanks

The current total daily hydraulic loadings to the lagoon is 725 m^3/day and the 230 day storage requirements are 166,791 m^3.

The projected year 20 (2032) daily hydraulic loadings to the lagoon is:

- 1,495 m^3/day (4,210 x 355/1000) from the Garson, Tyndall and Henryville populations including the bussed-in students
- 211 m^3/day (1,058 x 200/1000) from the RM of Brokenhead rural residents on holding tanks
- 5 m^3/day (3,172 x 200/135/1000) from the RM of Brokenhead rural residents on septic tanks

The projected year 20 (2032) total daily hydraulic loadings to the lagoon is 1,711 m^3/day and the 230 day storage requirements are 393,495 m^3.

Summary: The current 2012 hydraulic loading to the lagoon is 725 m^3/day and the 230 day storage requirements are 166,791 m^3. The projected design year 20 (2032) daily hydraulic loading is 1,711 m^3/day and the 230 day storage requirements are 393,495 m^3 which provides service to 4,160 future residents of Garson, Tyndall and Henryville, 50 equivalent bussed-in students, 1,058 rural residents on holding tanks and 3,172 rural residents on septic tanks.

4.0 EXISTING LAGOON CAPACITY

The organic and hydraulic storage capacities of the lagoon were determined from record drawings of the existing lagoon and actual water use data from 2008 – 2011 provided by the WTP operator.

4.1 Existing Organic Storage Capacity

Provincial guidelines stipulate that the organic loading of a lagoon must not exceed 56 kg BOD_5/ha/day in the primary cell. The effluent surface area at a 0.75 m depth in the primary cell is used in this calculation. Based on the results of the CEC hearing the primary cell of the Garson/Tyndall/Henryville lagoon was over designed to reduce the impact of possible odours from the lagoon. The current organic loading rate as per the Environmental Licence is 45.64 kg BOD_5/ha/day and this rate will be used for the purposes of this study. Based upon review of aerials and record plans, the effluent surface area at a depth of 0.75 m in the primary cell of the lagoon was estimated to be 21,955 m^2. The standard per capita organic loading of 0.076 kg BOD_5/person/day was assumed. Therefore, the lagoon has an organic capacity of:

Organic Capacity of Lagoon	**100.2 kg BOD_5/day or 1,318 people** **Based on 45.64 kgBOD_5/ha/day**

The existing organic capacity of 100.2 kg BOD_5/day is approximately 106.2 kg BOD_5/day less than the current required treatment capacity of 206.4 kg BOD_5/day and approximately 333.1 kg BOD_5/day less than the projected year 20 required treatment capacity of 433.3 kg BOD_5/day.

Summary: The current organic capacity of the lagoon based on a lagoon organic treatment rate of 45.64 kg BOD_5/ha/day is 100.2 kg BOD_5/day, which is 106.2 kg BOD_5/day less than the current organic loading and 333.1 kg BOD_5/day less than the projected future organic loading to the lagoon.

4.2 Existing Hydraulic Storage Capacity

Per provincial guidelines, the hydraulic storage capacity of a lagoon is determined from the volume of the top half of the primary cell and the secondary cell volume, between a liquid level of 0.3 m and 1.5 m above the secondary cell floor. The 230 day storage capacity of the existing lagoon is:

Hydraulic Storage Capacity of Existing Lagoon	**178,192 m^3**

The existing hydraulic storage capacity is currently 11,401 m^3 in excess of the current 230 day hydraulic loading of 166,791 m^3. The projected design year 20 hydraulic storage requirements of 393,495 m^3 are approximately 215,303 m^3 in excess of the current lagoon capacity. The lagoon has sufficient hydraulic capacity to meet the projected loadings to design year 1 (2013).

Summary: The current hydraulic storage capacity of the lagoon is 178,192 m^3 which is 11,401 m^3 in excess of the current hydraulic storage requirements and 215,303 m^3 less than the projected future design year 20 (2032) hydraulic storage requirements.

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5.0 EXPANSION REQUIREMENTS

The existing lagoon is currently overloaded organically and does not have sufficient hydraulic capacity to meet the 20 year design loadings. Lagoon expansion is required to meet both the current and future organic and hydraulic loading requirements.

The lagoon could be expanded with facultative cells or deep aeration cells could be constructed. A detailed description of the facultative lagoon expansion option is provided below. The possibility of aeration is discussed in more general terms.

5.1 Facultative Lagoon Expansion

Based on the existing elevations in the lagoon expansion area and cut and fill calculations completed for the proposed new cells east of the existing lagoon, a large surplus of soil would be obtained if the top of dike elevation of the existing cells was met. To balance the cut and fill quantities, reducing the required earthwork and related budget, the new cell top of dike would have to be constructed at a higher elevation than the existing lagoon. The secondary cells of a lagoon cannot be constructed at a higher elevation than the primary cells because flow from the primary cells to the secondary cells is by gravity. Therefore, a new primary cell will be constructed east of the existing lagoon at a higher elevation than the existing lagoon cells. A new secondary cell will be constructed north of the new primary cell, also at a higher elevation than the existing lagoon. This will allow the lagoon to operate by gravity. The existing lagoon east dike will have to be raised to meet the new cell top of dike elevation.

Based on the soil conditions found during the geotechnical investigation a higher lagoon liner elevation will be of benefit as the silty till layer would extend into the horizontal liner in some locations if the existing lagoon top of dike elevation was met. The north part of the cell would still require re-working and re-compacting as the soils from TH6 and TH12 did not pass the requirements of an insitu clay liner.

The existing primary cell will be converted to a secondary cell and the existing forcemain will be extended into the new primary cell. A new truck turnaround area and spillway will have to be constructed at the new primary cell.

A 4:1 slope for the inside walls of the new cell dikes and a 0.3 m invert height above the cell bottom were used in estimating the lagoon expansion size requirements. A liquid level of 1.5 m with a 1.0 m freeboard was assumed with a storage period of 230 days per current Manitoba Conservation requirements.

5.1.1 Existing Primary Cell Converted to Secondary Storage

The existing primary cell had a hydraulic storage in the top half of the cell of 17,142 m^3. When the primary cell is converted to a secondary cell the hydraulic capacity of the cell will be from the new discharge pipe invert elevation (0.3 m above the cell floor) to the maximum liquid level 1.5 m above the cell floor. The total hydraulic capacity of the cell will be 26,783 m^3.

5.1.2 New Primary Cell

The new primary cell requires a minimum area at a height of 0.75 m of 94,931 m^2 providing a minimum organic loading capacity of 433.3 kg BOD_5/day at an organic treatment rate of 45.64 kg BOD_5/ha/day. The new cell will be constructed east of the existing lagoon secondary cell #2 with a flat bottom area of 91,748 m^2 which results in an area at a height of 0.75 m of 95,419 m^2 which is 488 m^2 in excess of the minimum requirement. The new primary cell will have a hydraulic storage capacity in the top half of the cell of 72,963 m^3.

5.1.3 New Secondary Cell

The existing lagoon with the existing primary cell converted to a secondary cell will have a storage capacity of 187,833 m^3 and the additional hydraulic storage from the new primary cell will be 72,963 m^3 for a total hydraulic storage of 260,796 m^3. The total required storage of the lagoon is 393,495 m^3 and therefore the required storage in the new secondary cell is 132,699 m^3 (393,495 m^3 – 260,796 m^3). The new secondary cell will be constructed north of the new primary cell with a flat bottom area of 276 m x 390 m which results in a hydraulic storage capacity of 135,026 m^3, which is 2,327 m^3 in excess of the minimum storage requirements.

A layout plan of the proposed new cells is shown on Plan 1 attached in the Appendix.

Summary: Due to the existing elevations in the cell expansion areas, the new expansion cells will have to be constructed at a higher elevation than the existing lagoon. A new primary cell will be constructed east of the existing lagoon secondary cell #2 with an area at a 0.75 m height of 95,419 m^2. The existing primary cell will be converted to a secondary cell. A new secondary cell will be constructed north of the new primary cell and east of the existing lagoon cells with a hydraulic storage capacity of 135,026 m^3.

5.2 Discussion of Aeration

The technology of aerated lagoons is more closely related to the activated sludge process of a sewage treatment plant than it is to that of facultative lagoons. In aerated lagoons, oxygen is provided by mechanical aeration, and features to minimize algae growth are incorporated in their design. Overall land area footprints are significantly smaller than facultative lagoons and odour generation is mitigated by aeration. Aerated lagoons provide enhanced treatment compared to a facultative lagoon resulting in a higher quality effluent.

An aerated lagoon primary cell could be constructed with a deeper liquid storage depth (2.5 – 3.5 m) providing the required organic treatment of the wastewater. In future, more aeration could be added to the cell to provide more organic treatment resulting in capacity to service a higher population.

A deep aerated secondary cell could be constructed to provide the additional required hydraulic storage. If the new secondary cell is aerated, Manitoba Conservation may allow discharge of the cell earlier and later than the typical discharge dates for a facultative lagoon of June 15th to October 31st as long as there is no ice buildup in the discharge route. This would result in a higher hydraulic capacity in the lagoon, increasing the population which could be serviced by the lagoon. The deep liquid storage depth would allow for a smaller footprint of the cell compared to a facultative cell. Due to the soil conditions found at the site, the high plastic clay layer is underlain by a silty till layer especially at the north end of the lagoon expansion area. There would be some risk of vertical leakage through the deeper cells with a higher hydraulic head and a shallower horizontal liner. The horizontal liner would be shallower due to excavation of the high plastic clay to construct the deep cells. If an aerated lagoon option were selected, the dikes would have to be constructed higher above ground rather than deeper into the ground, possibly requiring soils to be obtained from a borrow pit.

Construction of new aerated lagoon cells would result in a higher capital cost compared to a facultative lagoon and would have higher operating and maintenance costs. The additional capital costs for this option compared to a facultative lagoon would include the aeration lines and blowers, a weatherproof building to house the blowers and bringing power to the site, preferably 3-phase. The operating and maintenance costs would include power, maintenance of the blowers and aeration lines and building maintenance. Also, the lagoon operator would require a higher certification class with Manitoba Conservation.

Aeration of the lagoon cells is not of great benefit for phosphorus reduction, other than increasing organic treatment in winter which would allow year-round filtration.

If the RM of Brokenhead wishes to investigate an aerated lagoon further, additional equipment research and sizing and detailed budget capital estimates would have to be completed.

Summary: Aerated lagoon cells could be constructed which would result in a smaller lagoon footprint, less odour generation, higher effluent quality and greater flexibility to meet higher loadings in future. An aerated lagoon would result in higher capital costs and higher operating costs compared with a facultative lagoon. If the RM of Brokenhead wishes to investigate an aerated lagoon further, additional equipment research and sizing and detailed budget capital estimates would have to be completed.

6.0 TOPOGRAPHY AND GEOTECHNICAL REVIEW

A field investigation was completed on March 27, 2012 to determine the suitability of the proposed lagoon expansion site for construction of the lagoon cells.

The complete Geotechnical and Topographic Investigation report with appendices is attached in Appendix B. The test hole locations and the topographic contour lines are shown on Plan 2, attached in the Appendix.

6.1 Geotechnical Review

6.1.1 Past Geotechnical Investigations

6.1.1.1 Geotechnical Investigation by JRCC

A geotechnical investigation for construction of the existing RM of Brokenhead lagoon site was performed by JRCC in January of 2002. The report found the soil profile in the test holes consisted of topsoil followed by a minimum of 4.6 m of high plastic clay with varying levels of silt. The laboratory analysis confirmed the clay would be suitable for use as a lagoon liner in the insitu conditions or when re-worked and re-compacted.

6.1.1.2 GW Driller's Well Logs

Four driller's well logs from 15-13-06 EPM were reviewed. The well logs indicated the soil profile consisted of clay followed by till underlain by gravel and limestone.

6.1.2 Test Holes

Twelve test holes (TH1 – TH12) were drilled during the geotechnical investigation. Test holes were drilled to a depth of 6.1 m (20'). The following is a summary of the soil profile at the proposed lagoon expansion site.

The soil profile consisted of an average of 0.3 m of black topsoil followed by a grey, hard, blocky high plastic clay from an average of 0.3 m – 1.2 m. The following layer varied between the test holes, in TH1, TH8 and TH10 – TH12 the layer was a high plastic, homogonous grey clay with an average depth of 1.6 m. In TH2 – TH7 the layer was a grey high plastic clay with silt inclusions, some sand and trace gravel with an average depth of 2.3 m. The final layer in TH4 – TH5, TH7 and TH10 – TH12 was a light brown silty, sandy till with trace of low plastic clay. This layer of till was also found in TH6 from 3.0 – 5.5 m, TH9 from 0.9 – 1.5 m and TH12 from 2.0 – 2.1 m.

Bedrock was not encountered in any of the test holes. Caving of the test holes was observed in TH3 at 5.8 m, TH5 at 4.1 m and TH6 at 1.9 m.

6.1.3 Groundwater

Short-term groundwater conditions were assessed in each test hole by observing standing water elevations in the holes prior to backfilling. Standing water was observed in TH5 at 5.7 m and water infiltration was observed in TH6 at a depth of 1.9 m. No water infiltration or standing water was observed in the remainder of the test holes.

Groundwater in the test holes depends on high static groundwater conditions and on seasonal conditions, i.e. snowmelt and rainy seasons. Other assumptions relating to the groundwater elevation cannot be made at this time, as water levels will normally fluctuate seasonally.

6.1.4 Laboratory Analysis

Laboratory classification analysis of the bagged soil samples indicated ten of the samples were deemed fat clay (CH), two of the samples were deemed sandy lean clay (CL) and two samples were deemed an inorganic clay and silt (CI). The Plasticity Index of the samples classified as CH varied between 38 and 64 and the percentage of clay varied between 48.8% and 86.7%. The Plasticity Index of the samples classified as CL and CI varied between 11 and 23 and the percentage of clay varied between 19.8% and 34.2%. Based on past experience, the laboratory has commented that homogeneous soils with a plasticity index greater than 25 and a clay content greater than 50% would typically be expected to have a hydraulic conductivity of 1 x 10^{-7} cm/sec or less. Plasticity Index analysis (i.e. Atterberg limits) of the soils indicated that all of the bagged soil samples submitted with the exceptions of TH5 3.0 – 6.1 m, TH6 0.9 – 2.1 m, TH6 2.1 – 3.0 m and TH12 2.1 – 3.3 m were considered to have potential for use as an insitu clay liner or a re-moulded and re-compacted clay liner.

AMEC indicates that the bagged soil samples suitability for use as a clay liner is dependent upon the soils being homogeneous with no preferential flow paths. It is also noted that estimating the hydraulic conductivity of a soil based upon classification test results (Plasticity Index and particle size analysis) alone might be misleading if the soil contains layers of sand, silt, or organic material. These silt and sand layers along with rocks, boulders or fissures in the soil can create preferential flow paths which can lead to an increased hydraulic conductivity.

A Shelby tube sample from TH2 1.5 – 2.1 m was submitted to AMEC to determine the insitu hydraulic conductivity for potential use as a lagoon liner. The sample achieved a hydraulic conductivity (k_{20}) of 8.18 x 10^{-9} cm/sec. This hydraulic conductivity is lower than the Manitoba Conservation requirement of 1 x 10^{-7} cm/sec and is therefore deemed suitable for use as an insitu clay lagoon liner.

6.1.5 Discussion

Based on laboratory analysis the entire soil profile found in TH6 would not be suitable for use as an insitu lagoon liner or when re-worked and re-compacted. The soil profile of TH12 has suitable high plastic clay from 0.3 – 2.0 m and unsuitable clay from 2.0 – 6.0 m. The unsuitable clay found in the horizontal liner would have to be excavated and suitable high plastic clay from the cell excavation would have to be hauled in and re-compacted and re-worked.

TH5 and TH11 had a top of unsuitable material 3.0 and 2.7 m below the ground surface, respectively, with suitable high plastic clay above the unsuitable material. Depending on the depth of the horizontal clay liner determined during design, there is some risk of not meeting the Manitoba Conservation requirement of a 1.0 m thick clay liner, especially if the depth to unsuitable material is higher in some locations than observed in the test holes.

TH10, completed south of TH6 and TH12, had a top of unsuitable material 4.3 m below the ground surface with suitable high plastic clay above the unsuitable material. TH4 and TH7, also taken south of TH10 each had a top of unsuitable material 4.9 m below the ground surface with suitable high plastic clay material above the unsuitable material.

Therefore the horizontal liner of the proposed lagoon expansion cells could be constructed with an insitu clay liner 1.0 m below the cell floor elevation approximately south of a line running through TH10, as shown on Plan 1. The exact location of this line would have to be determined by multiple on-site test holes completed during construction of the lagoon. Any layers of unsuitable material as found in TH9 from 0.9 – 1.5 m will have to be removed and replaced with re-worked and re-compacted high plastic clay.

The horizontal liner of the proposed lagoon expansion cells would have to be excavated and re-compacted with 1.0 m of suitable high plastic clay, approximately north of a line running through TH10. The area, which must be re-worked and re-compacted, may be larger or smaller than that shown on the plans, depending on the extent of the pockets of unsuitable material found during construction.

For all new perimeter dikes, a 3.0 m wide vertical cut-off wall will have to be constructed extending a minimum of 1.0 m into the horizontal liner surrounding the entire lagoon. Also, the clay soils 1.0 m below the cell floor elevation under the inside dike slope should be re-worked and re-compacted approximately 100 m south of the line through TH10. If the lagoon horizontal liner is tested by Manitoba Conservation and does not pass the requirements near the perimeter dikes, the dike would have to be removed to re-work and re-compact the clay soils beneath. If during lagoon construction the clay soils beneath the inside dike slope are re-worked and re-compacted, there will be little risk of not meeting the Manitoba Conservation requirements and having to remove the dikes.

6.1.6 Recommendations

Based on the soil conditions encountered during the geotechnical investigation and the results of the laboratory analysis it is recommended the flat bottom liner of the RM of Brokenhead lagoon expansion cells be constructed partially with the insitu soils and partially with a re-worked and re-compacted liner. The flat bottom liner south of the line approximately through TH10, as shown on Plan 1, could be constructed with insitu clay 1.0 m below the cell floor elevation. Any layers of unsuitable material found in the insitu portion of the liner, such as TH9 from 0.9 – 1.5 m will have to be removed and replaced with re-worked and re-compacted high plastic clay.

The flat bottom liner north of the line approximately through TH10, would have to be excavated and re-compacted with 1.0 m of suitable high plastic clay. The pockets of unsuitable clay material found in TH6 and TH12 would have to be removed and replaced with suitable high plastic clay from the cell excavation. The exact location of the line dividing the re-worked liner from the insitu liner would have to be determined by multiple on-site test holes completed during construction of the lagoon. The amount of clay material that would have to be replaced would also have to be determined on-site during construction.

It is recommended for all new perimeter dikes, a 3.0 m wide vertical cut-off wall be constructed extending a minimum of 1.0 m into the horizontal liner surrounding the entire lagoon. Also, it is recommended the clay soils 1.0 m below the cell floor elevation under the inside dike slope should be re-worked and re-compacted approximately 100 m south of the line through TH10.

6.2 Topography

A topographic GPS survey of the test hole locations and existing ground locations across the proposed lagoon expansion site was completed on March 27, 2012 along with the geotechnical investigation. The existing ground at the proposed expansion site was relatively flat with some low lying areas. From the topographic survey data, the existing ground elevations varied from 235.04 m to 237.38 m with an average elevation of approximately 236.23 m. The top of dike elevation of the existing Cell #6 was approximately 237.22 m, which is approximately 1.0 m above the average surrounding ground elevation.

Summary: Based on the geotechnical investigation it is recommended the flat bottom liner of lagoon expansion cells be constructed partially with the insitu soils and partially with a re-worked and re-compacted liner. The flat bottom liner south of the line approximately through TH10, could be constructed with insitu clay 1.0 m below the cell floor elevation. The flat bottom liner north of the line approximately through TH10, would have to be excavated and re-compacted with 1.0 m of suitable high plastic clay. Any pockets of unsuitable material found in the horizontal liner would have to be replaced with suitable high plastic clay soils. The topography of the site was relatively flat with an average ground elevation of 236.23 m.

7.0 LAGOON REGULATORY REQUIREMENTS

7.1 Province of Manitoba Design Objectives

The Province of Manitoba Design Objectives for Standard Sewage Lagoons was used as a guideline in the layout and design of the lagoon.

7.1.1 Organic Loading

Although a lagoon operates at various organic efficiencies throughout the year an average organic treatment capacity of 56 kg BOD_5/ha/day at 0.75 m depth in the primary cell has been utilized for design purposes.

7.1.2 Hydraulic Loading

The lagoon cannot be discharged between November 1 and June 15th (230 day winter storage period) as per current guidelines. Therefore, the lagoon must have the storage capacity for this time period based upon half the volume of the primary cell and the secondary cell volume from the invert of the discharge pipe (0.3 m) to the maximum liquid level (1.5 m).

7.1.3 Lagoon Liner

Sewage lagoons are to be designed and constructed such that the interior surface of the proposed lagoon is underlain by at least one metre of soil having a hydraulic conductivity of 1×10^{-7} cm/sec or less. In the absence of soils with a hydraulic conductivity of 1×10^{-7} cm/sec or less, the interior surfaces of a lagoon could be lined with a synthetic liner. In areas sensitive to groundwater contamination, a flexible synthetic liner may be recommended.

7.1.4 Nutrient Management Plan

New nutrient reduction guidelines were released in the *Manitoba Water Quality Standards, Objectives, and Guidelines, November 28, 2011*. The regulations include province wide standards for phosphorus reduction and where site-specific conditions warrant, nitrogen reduction. Under the new nutrient standards, a 1.0 mg/L phosphorus limit immediately applies for all new, expanding or modified wastewater treatment facilities. The exception being small wastewater treatment facilities which serve less than 2,000 equivalent people which have the option of implementing a nutrient reduction strategy instead of the 1.0 mg/L phosphorus limit. Nutrient reduction strategies include, but are not limited to, effluent irrigation, trickle discharge or constructed wetlands.

Nitrogen reduction to 15 mg/L is required on a site-specific basis depending on the receiving environment for new and expanding wastewater treatment facilities serving more than 10,000 equivalent people. The document also set the discharge requirements for fecal coliform at 200 organisms/100 mL sample, Total Suspended Solids at 25 mg/L and the Biochemical Oxygen Demand at 25 mg/L (facilities with ammonia or total nitrogen limits have a Carbonaceous Biochemical Oxygen Demand limit of 25 mg/L).

The RM of Brokenhead lagoon is sized to treat well over 2,000 residents and therefore it is expected the 1.0 mg/L phosphorous reduction guideline will apply to the expanded lagoon.

7.1.4.1 Phosphorous Concentrations in the Existing Lagoon

A nutrient sampling and testing program was developed for the existing RM of Brokenhead lagoon. The nutrient concentration of the lagoon wastewater was tested on a monthly basis with samples taken from the secondary cell #1 and secondary cell #2 at both the intercell pipe location and the discharge pipe location. The total phosphorous concentrations found in the cells from the months of March and April are summarized in the following table. Test results from May were not available at this time.

Table G – Phosphorous concentrations in the existing lagoon

Location	Total Phosphorus Concentration (mg/L)	
	March	April
Cell 1 Intercell	1.37	4.68
Cell 1 Discharge	2.73	3.83
Cell 2 Intercell	0.349	3.99
Cell 2 Discharge	0.583	4.03

Based on the results of the testing it is likely phosphorous reduction measures will have to be implemented for the RM of Brokenhead lagoon. It is recommended the monthly nutrient testing program be continued so more accurate phosphorus concentrations are known for future pre-design/design of a phosphorous reduction system.

Full test results from ALS laboratories Ltd. Are attached in the Appendix.

Based upon the new guidelines and the nutrient testing program results, the following options were considered to address nutrient management, with particular emphasis on phosphorus reduction for the RM of Brokenhead lagoon.

7.1.4.2 Phosphorus Reduction by Filtration

Sewage treatment plant technology, such as chemical addition and filtration systems could be utilized to reduce the phosphorus concentration in the lagoon. The effluent could be pumped from the primary cells to a filtration building and filtered through a continuous backwash sand filter or a cloth disk filter. A chemical flocculent such as alum would have to be added to the wastewater prior to filtration. Backwash containing the phosphorus would be sent back to the primary cell where it settles out into sludge. The sludge can accumulate in the lagoon for approximately 20 – 25 years and then will have to be removed.

This level of treatment is costly as equipment and housing is required as well as annual operating costs and chemical costs. An electrical power source is also required, such as a hydro line to the lagoon.

7.1.4.3 Phosphorus Reduction by Surface Chemical Treatment

This option involves application of chemicals such as alum to wastewater in the secondary cell to reduce the level of phosphorus in the treated effluent, if prior to discharge the phosphorus concentration in the wastewater is found to be greater than 1.0 mg/L. The alum is broadcast onto the surface of the secondary cell utilizing a gas driven pump and spray system from the top of the dike, or from a boat on the surface of the secondary cell. The alum creates flocculation of the turbidity and phosphorus which results in settlement to the bottom. The effluent can then be discharged from the secondary cell with a reduced level of phosphorus. This option could possibly be used for RM of Brokenhead lagoon to obtain a phosphorus upper limit of 1.0 mg/L. The phosphorus level in the treated effluent must be tested prior to discharge and if the phosphorous is not at or below 1.0 mg/L, spreading of the alum on the second cell surface may have to be repeated. Based on the large surface area of the secondary cells, this option may be very expensive and additional studies would have to be completed to determine the effectiveness of the alum addition to estimate required loading rates.

7.1.4.4 Constructed Wetlands

Constructed wetlands are used to polish treated effluent from a lagoon, and have the potential to provide nutrient reduction. However, they can require large land areas for construction, have increased odour potential, can favour mosquito breeding (due to vegetation type, very shallow effluent, and minimal wind action), can cause higher *E. coli* concentrations due to increase wildlife including mammals, waterfowl, reptiles and amphibians, and can add significant cost to the project. In addition, the use of constructed/engineered wetlands requires further investigation regarding their effectiveness under climatic conditions in Manitoba.

Constructed wetlands were investigated during design of the existing RM of Brokenhead lagoon and were deemed not feasible due to the large area required, increased odour potential, the high capital cost, the increased mosquito breeding area and the additional wildlife which would increase the *E. coli* levels.

These disadvantages are still applicable and cause the option not to be feasible.

7.1.4.5 Recommended Option

Phosphorous reduction by surface chemical treatment could be utilized and would result in an added operating cost to the lagoon as chemical spreading would occur prior to each discharge if the phosphorous concentration was found to be greater than 1.0 mg/L. Phosphorous reduction by filtration would add a capital cost to the project and would also add operating costs for the chemical feed, and pump/building maintenance.

It is recommended an additional study be completed to investigate the feasibility of a chemical filtration system at this stage to obtain budget capital cost estimates and compare them to the costs of phosphorous reduction by surface chemical treatment. This is not part of the current scope of work but could be completed by JRCC as a separate project.

Summary: New environmental guidelines require a 1.0 mg/L phosphorus limit. Based on nutrient testing by the RM, it is expected phosphorus reduction measures will be required. It is recommended an additional study be completed to investigate the feasibility of a chemical filtration system at this stage to obtain budget capital cost estimates and compare them to the costs of phosphorous reduction by surface chemical treatment.

7.2 Summarized Selected Design Criteria

The following selected criteria would be used for design purposes:

- A total equivalent design population of 4,160 residents of Garson, Tyndall and Henryville, an equivalent full time population of 50 bussed-in students, 3,172 rural residents serviced by septic tanks and 1,058 rural residents serviced by holding tanks
- A total daily organic loading of 433.3 kg BOD_5/day
- Construction of a new primary cell with surface area of 95,419 m^2 at 0.75 m height from the floor, providing a daily organic treatment capacity of 435.49 kg BOD_5/day at an organic loading rate of 45.64 kg BOD_5/ha/day and a hydraulic storage volume in the top half of 72,963 m^3
- A yearly hydraulic loading to the lagoon of 393,495 m^3

- Construction of a new secondary cell with a total hydraulic storage capacity above the invert elevation of 135,026 m^3
- A total hydraulic capacity of the lagoon of 395,823 m^3
- The existing primary cell will be converted to secondary storage
- The existing forcemain will be diverted to the new primary cell
- A new truck turnaround area and concrete spillway will be constructed at the new primary cell
- The southwest top of dike of the new primary cell will be graveled to maintain road access to the existing truck turnaround area
- The discharge pipe invert to be 0.3 m above the cell floor elevation of the secondary cells
- Discharge from the lagoon is to follow the existing licensed discharge route to the Devil's Creek
- The horizontal liner will be constructed with a minimum 1.0 m insitu clay liner except in the location at the north end of the proposed cell, as shown on Plan 1, where a minimum 1.0 m thick re-worked liner will be required
- A 3.0 m wide vertical cut-off wall constructed with re-worked clay soils will extend a minimum of 1.0 m into the horizontal clay liner and extend to the top of dike elevation
- A 4:1 slope will be used for the inner and outside dikes of the cells
- No equipment was included in the cost estimate for phosphorus or ammonia reduction, phosphorus concentration can be reduced by broadcasting alum on the surface of the secondary cell, prior to discharge, as stated, it is recommended an additional study be completed to investigate the feasibility of a chemical filtration system at this stage to obtain budget capital cost estimates
- Rip rap is not shown on the plans but can be included on the inside dikes to reduce erosion. A separate item in the detailed cost estimate, attached in the Appendix for rip rap has been provided
- The fencing along the east side of the existing lagoon will be removed and a 1.2 m high barbed wire fence would be installed around the perimeter of the new lagoon cells
- Valve markers will be installed at the new discharge and intercell pipe locations.

8.0 LAGOON CONSTRUCTION DETAILS

8.1 General, Conceptual Liner Design and Construction Techniques

A conceptual layout plan for the lagoon expansion cells is provided in the Appendix.

The organic topsoil from the lagoon expansion area would be removed and stockpiled. Approximately 50% of the outside of the dike is permitted to be constructed with topsoil. The topsoil will also be used as dressing on the dikes and perimeter ditches. The new lagoon would be excavated to the cell floor elevation. In the required areas at the north end of the expansion cell, the clay soils from 1.0 m below the cell floor elevation would be excavated and re-worked and re-compacted a sheepsfoot roller to 95% Standard Proctor Density on a maximum 150 mm (6") compacted lift. If the soils 1.0 m below the cell floor elevation are deemed unsuitable for use as a re-worked and re-compacted clay liner, suitable clay soils from a borrow area will be excavated and hauled in.

The vertical cut-off walls will be constructed with excavated clay soils from the cell area or from a borrow pit. The cut-off wall will extend from the top of dike elevation to an at least 1.0 m below the cell floor elevation. The vertical cut-off wall will be construction with similar construction techniques as the horizontal liner, as described above.

The new lagoon cell floor bottom will be 2.5 m lower than the top of dike. The inner and outer dike slopes would be constructed at 4:1 slope. A discharge pipe will be installed in the new secondary cells 0.3 m above the cell floor elevation. Rip rap would be installed at the intercell and discharge piping locations to reduce erosion. Silt fencing would be placed around the lagoon construction area at locations which are thought to drain from the site. Perimeter ditches would be constructed surrounding the new cells and tied into the existing perimeter ditches. Upon completion of construction, the excess topsoil that was stripped off the new cell area would be placed on the outside of the dikes and the area would be seeded. A barbed wire fence surrounding the new lagoon cells would be constructed and attached to the existing fence.

8.2 Construction Details

All topsoil would be removed to a depth of approximately 300 mm from the new cell area.

Construction of lagoon liner (cell bottom and cut-off walls) would be in accordance with the following specifications:

1. The liner shall be constructed of clay;
2. The liner shall be at least one metre in thickness;
3. The liner shall have a hydraulic conductivity of 1×10^{-7} cm/sec or less at all locations;

Prior to placement of the embankment material and liner material to be compacted, the foundation would be scarified to a depth of 150 mm (6 in.) compacted with a minimum of eight passes of a sheepsfoot roller. Complete foundation preparation shall be approved by the Engineer before any embankment or liner material is placed. Embankment (both common topsoil and relatively impermeable soil) and liner material (medium plastic clay soil), would be compacted with a minimum of eight passes of a sheepsfoot roller on a 150 mm (6 in.) compacted lift.

The lagoon construction specifications would indicate that the sheepsfoot roller shall have a minimum foot pressure of no less than 1,700 kPa (250 psi). The drum diameter of the sheepsfoot roller would not be less than 1,200 mm (4 ft.). Each roller would be equipped with cleaning fingers designed to prevent the accumulation of material between the tamping feet. The foot pressure would be calculated by taking the total mass of the roller and dividing it by the greater of: the area of the maximum number of tamping feet in one row parallel to the axis of the roller, or by 5 percent of the total foot area. The roller foot would be at least 200 mm (8 in.) long and would have a minimum foot area of at least 4,500 mm^2 (7 sq. in.).

A limited range of moisture content would be permitted. The material shall not be so wet nor so dry that compaction equipment cannot compact the fill into a homogeneous mass. Material too wet shall be dried or wasted as directed by the Engineer and material too dry shall be wetted as directed by the Engineer. All constructed earthen lagoon components shall be graded to a tolerance of +/- 50 mm (2 in.).

The specifications would state that the dikes and embankment are to be seeded with a grass such as brome.

The outer slope and perimeter drainage system would prevent surface drainage from entering into the lagoon and the ponding of surface drainage around the perimeter of the lagoon.

9.0 PARAMETERS AND CRITERIA

The cost estimates for the proposed wastewater treatment lagoon construction works were prepared from the following summarized information.

9.1 General

1. Total costs in the cost estimate have been rounded off to the nearest $100.
2. The unit prices listed in the cost estimate were determined from a review of prices received on similar projects. The prices attempt to reflect 2012 prices, but actual unit prices will be dependent upon tendering or negotiations between preferred contractors and owner.
3. No utility services will be provided to the site.
4. GST and PST are not included in the cost estimates.

9.2 Wastewater Treatment Lagoon

1. An insitu clay liner for the majority of the new cell horizontal liner will the north portion of the new cells constructed with a re-worked and re-compacted clay liner has been assumed.
2. The lagoon cells have been sized for a minimum 20 years of service.
3. No cost was included for land acquisition as both sites are currently owned by the RM.
4. Rip Rap could be included on the inside dikes of the lagoon at an elevation 0.5 m above and 0.5 m below the high water level of the cells to reduce erosion of the dikes. An additional item in the detailed cost estimate, attached in the Appendix for rip rap on the new dikes has been provided.
5. No equipment was included in the cost estimate for phosphorus or ammonia reduction, phosphorus concentration can be reduced by broadcasting alum on the surface of the secondary cell, prior to discharge, as stated, it is recommended an additional study be completed to investigate the feasibility of a chemical filtration system at this stage to obtain budget capital cost estimates.

9.3 Risk

1. A risk allowance is recommended to address volatility in market conditions, especially in the area of earth movement.
2. Other potential items that may be attributed to risk are adverse weather, unforeseen bedrock, unforeseen environmental concerns, etc.

10.0 COST ESTIMATES

10.1 General

The cost estimate is based on information outlined in the Parameters and Criteria. This cost estimate is an opinion of probable construction costs. This opinion is based on assumptions as to the actual conditions that will be encountered onsite, as actual site conditions may be at variance with the information obtained from onsite testing. The specific decision and design of other design professionals engaged i.e. geotechnical soils analysis; the means and methods of construction the Contractor will employ; the costs and extent of labour, equipment and materials the Contractor will employ; contractor's techniques in determining prices and market conditions at the time; may be based upon other factors over which JRCC has no control. The cost estimates herein represent the best estimates of J. R. Cousin Consultants Ltd.

In accordance to government guidelines, the cost estimate was prepared in metric units of measure. Below are the conversions required to convert the metric units of measure to imperial units of measure.

Distance and Volume

1 metre = 3.28 feet
1 cubic metre (m^3) = 1.31 cubic yards (yd^3)
1 m^3 = 1,000 litres
3.785 litres = 1 US gallon

Pipe Sizes

20 mm = 3/4 inch
32 mm = 1 1/4 inch
75 mm = 3 inch
100 mm = 4 inch
150 mm = 6 inch
200 mm = 8 inch
250 mm = 10 inch
300 mm = 12 inch

A contingency line item of 15% was included in each cost estimate to cover costs that may be incurred due to unforeseen circumstances. A line item of 15% for Engineering was also included in the cost estimate.

10.2 Capital Costs

The following table summarizes budget capital costs for the lagoon construction, which are based upon expected 2012 construction. The costs for each year after 2012 should be inflated per prevailing inflation. Details of the Cost estimates are provided in Appendix D.

Options	Construction	Non-Construction	Total
Facultative Lagoon Expansion	$2,091,100	$639,900	**$2,731,000**

11.0 CONCLUDING REMARKS

This feasibility study provides information on the proposed RM of Brokenhead lagoon expansion.

11.1 Next Step

The next step in the process of developing the lagoon is for the RM of Brokenhead to review this feasibility study and provide comment. The RM of Brokenhead council may wish to meet JRCC to discuss the report. Subsequently the feasibility study will be finalized.

An Environment Act Proposal should be completed and submitted after the review and acceptance of this feasibility study document. The environmental review process through Manitoba Conservation Environmental Assessment and Licensing Branch will determine whether there are any concerns with the development.

Once the license has been issued, final design works and tendering process should be completed to ensure an early start in the construction of the project works.

APPENDICES

Appendix A

Table 1: Population, Hydraulic and Organic Loading Projections for the RM of Brokenhead Lagoon

Appendix B

RM of Brokenhead Geotechnical and Topographic Investigation for the Wastewater Treatment Lagoon Expansion

Test Results from ALS Laboratories, dated March 26, 2012

Test Results from ALS Laboratories, dated May 07, 2012

Appendix C

Plan 1: Proposed Lagoon Expansion Site Layout

Plan 2: Proposed Lagoon Expansion Site Layout with Test Hole Locations and Topographic Contour Lines

Appendix D

Detailed Cost Estimate

Appendix A

Table 1: Population, Hydraulic and Organic Loading Projections for the RM of Brokenhead Lagoon

F:\200\246 Brokenhead RM\246.09 GTH Lagoon Feasibility Study\03 Design\[Brokenhead Table 1 REVISED.xlsx]Old Table 5 w 30% Reject

TABLE 1

POPULATION, HYDRAULIC, AND ORGANIC LOADING PROJECTIONS FOR THE RM OF BROKENHEAD LAGOON

Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10	Col 11	Col 12	Col 13	Col 14	Col 15	Col 16	Col 17	Col 18	Col 19	Col 20	Col 21
		POPULATION					ORGANIC LOADING						HYDRAULIC LOADING							
PROJECT YEAR	YEAR	POPULATION GROWTH PER YEAR Garson/Tyndall /Henryville	BUSSED-IN STUDENTS		R.M. OF BROKENHEAD RURAL RESIDENTS Serviced by Septic Tanks	R.M. OF BROKENHEAD RURAL RESIDENTS Serviced by Holding Tanks	DAILY PER CAPITA BOD Piped and Holding Tanks	BOD PRODUCTION Septic Tanks	DAILY BOD PRODUCTION Piped and Holding Tanks (Col 3 + Col 5 + Col 7)*Col 8	DAILY BOD PRODUCTION Septic Tanks (Col 6 * Col 19/ 135 days)* (Col 9/1000)	DAILY BOD PRODUCTION Total Col 10 + Col 11	SURFACE AREA REQ'RD AT 0.75 M DEPTH Based on loading rate of 45.64 kg BOD_5/ha/day (Col 12/45.64 kgBOD_5/ha)* 1000	DAILY/CAPITA WATER DEMAND Piped Systems	REJECT 30% of daily per capita raw water demand (Col 14 / 0.7) *0.3	INFILTRATION* 15% of daily per capita water demand (Piped Systems only) Col 14 * 0.15	DAILY/CAPITA WATER DEMAND Including 30% reject water and 15% infiltration Col 14 + Col 15 + Col 16	DAILY/CAPITA WATER DEMAND Rural Residents on Holding Tanks	YEARLY/CAPITA SEPTAGE PRODUCTION From Rural Residents on Septic Tanks	TOTAL DAILY WASTEWATER PRODUCTION **	230 Day WASTEWATER PRODUCTION Col 20 * 230
			1.15% Growth/year																	
		5.1%	Actual	Equivalent (1/3)	1.36% Growth/year	1.36% Growth/year	(kg)	(kg/m^3)	(kg)	(kg)	(kg)	(m^2)	(L/person/day)	(L/person/day)	(L/person/day)	(L/person/day)	(L/person/day)	(litres/year)	(m^3/day)	(m^3)
0	2012	1,538	118	40	2,421	807	0.076	7.0	181.3	25.1	206.4	45,216	225	96	34	355	200	200	725	166,791
1	2013	1,617	120	40	2,454	818	0.076	7.0	188.1	25.4	213.5	46,790	225	96	34	355	200	200	755	173,758
2	2014	1,699	121	41	2,488	830	0.076	7.0	195.3	25.8	221.1	48,449	225	96	34	355	200	200	787	181,099
3	2015	1,786	123	41	2,522	841	0.076	7.0	202.8	26.2	228.9	50,158	225	96	34	355	200	200	821	188,720
4	2016	1,877	124	42	2,556	852	0.076	7.0	210.6	26.5	237.1	51,951	225	96	34	355	200	200	855	196,749
5	2017	1,973	125	42	2,591	864	0.076	7.0	218.8	26.9	245.7	53,829	225	96	34	355	200	200	892	205,152
6	2018	2,073	127	43	2,626	876	0.076	7.0	227.4	27.2	254.6	55,790	225	96	34	355	200	200	930	213,962
7	2019	2,179	128	43	2,662	888	0.076	7.0	236.4	27.6	264.0	57,837	225	96	34	355	200	200	970	223,181
8	2020	2,290	130	44	2,698	900	0.076	7.0	245.8	28.0	273.8	59,983	225	96	34	355	200	200	1,013	232,890
9	2021	2,407	131	44	2,734	912	0.076	7.0	255.6	28.4	283.9	62,213	225	96	34	355	200	200	1,057	243,008
10	2022	2,530	133	45	2,772	924	0.076	7.0	265.9	28.7	294.7	64,564	225	96	34	355	200	200	1,103	253,697
11	2023	2,659	134	45	2,809	937	0.076	7.0	276.7	29.1	305.8	67,013	225	96	34	355	200	200	1,151	264,841
12	2024	2,794	136	46	2,848	950	0.076	7.0	288.0	29.5	317.6	69,583	225	96	34	355	200	200	1,202	276,556
13	2025	2,937	137	46	2,886	962	0.076	7.0	299.8	29.9	329.7	72,250	225	96	34	355	200	200	1,256	288,797
14	2026	3,086	139	47	2,926	976	0.076	7.0	312.3	30.3	342.6	75,072	225	96	34	355	200	200	1,312	301,702
15	2027	3,244	141	47	2,965	989	0.076	7.0	325.3	30.7	356.0	78,008	225	96	34	355	200	200	1,370	315,214
16	2028	3,409	142	48	3,006	1,002	0.076	7.0	338.9	31.2	370.1	81,082	225	96	34	355	200	200	1,432	329,380
17	2029	3,583	144	48	3,046	1,016	0.076	7.0	353.2	31.6	384.8	84,303	225	96	34	355	200	200	1,497	344,245
18	2030	3,766	145	49	3,088	1,030	0.076	7.0	368.2	32.0	400.2	87,696	225	96	34	355	200	200	1,565	359,927
19	2031	3,958	147	49	3,130	1,044	0.076	7.0	383.9	32.5	416.3	91,222	225	96	34	355	200	200	1,636	376,262
20	2032	4,160	149	50	3,172	1,058	0.076	7.0	400.4	32.9	433.3	94,931	225	96	34	355	200	200	1,711	393,495

*Based on assumed infiltration rates as mag meter in the lift station does not produce accurate readings

**(Col 3 + Col 5)*(Col 17)/1000 + Col 7 * Col 18/1000 + Col 6 * Col 19/135/1000

Appendix B

RM of Brokenhead Geotechnical and Topographic Investigation
for the Wastewater Treatment Lagoon Expansion

Test Results from ALS Laboratories, dated March 26, 2012

Test Results from ALS Laboratories, dated May 07, 2012

RM of Brokenhead Geotechnical and Topographic Investigation for the Wastewater Treatment Lagoon Expansion

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RM OF BROKENHEAD

Geotechnical and Topographic Investigation for the Wastewater Treatment Lagoon Expansion

APEGM
Certificate of Authorization
J. R. Cousin Consultants Ltd.
No. 234 Date June 22/12

PROVINCE OF MANITOBA
G. R. COUSIN
12/06/22
REGISTERED PROFESSIONAL ENGINEER

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June 2012

ACKNOWLEDGMENTS

To prepare this report various sources of information were investigated and researched. The firm of J. R. Cousin Consultants Ltd. wishes to thank the RM of Brokenhead who assisted with organization and onsite works.

REMARKS

Conclusions reached in this report are based upon the generalization of data available to us at the time of forming our opinions. Information in this document may rely on previous studies, investigative work and data by others. JRCC cannot be responsible for actual site conditions proved to be at variance with any generalized data. This report was completed in accordance with generally accepted professional engineering principles and practice. Any use of this report by a third party is the responsibility of the third party, JRCC accepts no responsibility for third party decisions or actions based on the report. No other warranty or guarantee expressed, implied or statutory is made.

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APPENDIX

1.0 INTRODUCTION

J. R. Cousin Consultants Ltd. (JRCC) conducted a topographic and geotechnical investigation for the proposed wastewater treatment lagoon expansion for the RM of Brokenhead Garson/Tyndall/Henryville lagoon. The potential lagoon expansion site investigated was east of the existing lagoon within the NW and SW ¼ of Section 15-13-06 EPM. A total of 12 test holes were drilled across the site to determine the suitability of the soils for use as a clay lagoon liner. Test hole locations are shown on Plan 1 attached in the Appendix.

This report outlines the findings of the geotechnical and topographic investigation at the proposed lagoon expansion site and evaluates the soils to determine their suitability for use as a lagoon liner as well as any potential difficulties associated with construction.

2.0 BACKGROUND

The existing RM of Brokenhead lagoon has a primary cell and two secondary cells located in the NW and SW ¼ of Section 15-13-06 EPM. The existing lagoon is overloaded and requires expansion.

2.1 Past Geotechnical Investigation

A geotechnical investigation for construction of the existing RM of Brokenhead lagoon site was performed by JRCC in January of 2002. Seven test holes were excavated and representative soil samples were sent to Eng Tech Consulting Ltd. for analysis. The report found the soil profile in the test holes consisted of topsoil followed by a minimum of 4.6 m of high plastic clay with varying levels of silt. The laboratory analysis confirmed the clay would be suitable for use as a lagoon liner in the insitu conditions or when re-worked and re-compacted.

Past test hole locations are shown on Plan 1 attached in the Appendix. Past test hole logs are also included in the Appendix.

2.2 GW Driller's Well Logs

Four driller's well logs from 15-13-06 EPM were reviewed. The well logs indicated the soil profile consisted of clay followed by till underlain by gravel and limestone. The clay layer extended to an average depth of 8.9 m below the ground surface. The layer of till extended from 8.9 m to 22.9 m below the ground surface followed by the limestone layer to a maximum observed depth of 54.9 m.

The static groundwater level recorded in the wells was 18.3 m above the ground surface in one of the wells, 0.6 m below the ground surface in two of the wells and was not reported on the fourth well.

GW Driller's Well logs are included in the Appendix.

3.0 TOPOGRAPHIC INVESTIGATION

A topographic GPS survey of the test hole locations and existing ground locations across the proposed lagoon expansion site was completed on March 27, 2012 along with the geotechnical investigation. The existing ground at the proposed expansion site was relatively flat with some low lying areas. From the topographic survey data, the existing ground elevations varied from 235.04 m to 237.38 m with an average elevation of approximately 236.23 m. The top of dike elevation of the existing Cell #6 was approximately 237.22 m, which is approximately 1.0 m above the average surrounding ground elevation.

Contour lines from the topographic survey are shown on Plan 1 in the Appendix.

4.0 GEOTECHNICAL FIELD INVESTIGATION

The onsite geotechnical investigation for the proposed lagoon expansion site was conducted on March 27, 2012. Paddock Drilling Ltd. was employed to conduct the test holes using a track-mounted drill rig under direct supervision by JRCC's field representative.

Twelve test holes (TH1 – TH12) were drilled during the geotechnical investigation. Test holes were drilled to a depth of 6.1 m (20 ft). Test hole locations are shown on Plan 1, in the Appendix.

The subsurface soil profile within each test hole was logged, water conditions were noted and representative soil samples were collected as the soils varied along the profile. The samples were visually field-classified. Fourteen selected bagged soil samples from the test holes were sealed and submitted to AMEC Earth and Environmental for testing. One Shelby tube sample (TH2 1.5 – 2.1m) was also sent to AMEC to determine the insitu hydraulic conductivity. Details of the laboratory analysis are provided in Section 5.0 of this report. Following completion of drilling, an assessment of the short term groundwater conditions was completed. All test holes were then backfilled with bentonite mixed with the auger cuttings.

4.1 Soil Profile

Details of each individual soil profile, including depth and description of each layer as well as comments on bedrock and groundwater infiltration can be found in the test hole logs attached in the Appendix. The following is a summary of the soil profile at the proposed lagoon expansion site.

The soil profile consisted of an average of 0.3 m of black topsoil followed by a grey, hard, blocky high plastic clay from an average of 0.3 m – 1.2 m. The following layer varied between the test holes, in TH1, TH8 and TH10 – TH12 the layer was a high plastic, homogonous grey clay with an average depth of 1.6 m. In TH2 – TH7 the layer was a grey high plastic clay with silt inclusions, some sand and trace gravel with an average depth of 2.3 m. The final layer in TH4 – TH5, TH7 and TH10 – TH12 was a light brown silty, sandy till with trace of low plastic clay.

This layer of till was also found in TH6 from 3.0 – 5.5 m, TH9 from 0.9 – 1.5 m and TH12 from 2.0 – 2.1 m.

Bedrock was not encountered in any of the test holes. Caving of the test holes was observed in TH3 at 5.8 m, TH5 at 4.1 m and TH6 at 1.9 m.

4.2 Groundwater

Short-term groundwater conditions were assessed in each test hole by observing standing water elevations in the holes prior to backfilling. Caving and sloughing of the test hole walls was also observed and recorded. Standing water was observed in TH5 at 5.7 m and water infiltration was observed in TH6 at a depth of 1.9 m. No water infiltration or standing water was observed in the remainder of the test holes.

Groundwater in the test holes depends on high static groundwater conditions and on seasonal conditions, i.e. snowmelt and rainy seasons. Other assumptions relating to the groundwater elevation cannot be made at this time, as water levels will normally fluctuate seasonally.

Contractors will be made aware of the geotechnical conditions encountered onsite, as dewatering and trench stabilization may be required during construction, depending on the depth of excavation determined during final design.

5.0 LABORATORY TESTING AND ANALYSIS AND DISCUSSION

Representative soil samples from the proposed lagoon site were submitted to AMEC Earth and Environmental for testing and analysis. The testing and analysis included determining the following:

- Atterberg Limits (plastic limit, liquid limit, and plasticity index, ASTM D4318)
- Soil Classification (ASTM D2487)
- Moisture Content (ASTM D2216)
- Particle Size Analysis (Hydrometer test, ASTM D422).

The Shelby tube sample was subjected to a Hydraulic Conductivity test (ASTM D5084-03).

Laboratory classification analysis of the bagged soil samples indicated ten of the samples were deemed fat clay (CH), two of the samples were deemed sandy lean clay (CL) and two samples were deemed an inorganic clay and silt (CI). The Plasticity Index of the samples classified as CH varied between 38 and 64 and the percentage of clay varied between 48.8% and 86.7%. The Plasticity Index of the samples classified as CL and CI varied between 11 and 23 and the percentage of clay varied between 19.8% and 34.2%. Based on past experience, the laboratory has commented that homogeneous soils with a plasticity index greater than 25 and a clay content greater than 50% would typically be expected to have a hydraulic conductivity of 1×10^{-7} cm/sec or less. Plasticity Index analysis (i.e. Atterberg limits) of the soils indicated that all of the bagged soil samples submitted with the exceptions of TH5 3.0 – 6.1 m, TH6 0.9 – 2.1 m, TH6 2.1 – 3.0 m and TH12 2.1 – 3.3 m were considered to have potential for use as an insitu clay liner or a re-moulded and re-compacted clay liner. See Table 1 of the AMEC Test Results, attached in the Appendix.

AMEC indicates that the bagged soil samples suitability for use as a clay liner is dependent upon the soils being homogeneous with no preferential flow paths. It is also noted that estimating the hydraulic conductivity of a soil based upon classification test results (Plasticity Index and particle size analysis) alone might be misleading if the soil contains layers of sand, silt, or organic material. These silt and sand layers along with rocks, boulders or fissures in the soil can create preferential flow paths which can lead to an increased hydraulic conductivity.

A Shelby tube sample from TH2 1.5 – 2.1 m was submitted to AMEC to determine the insitu hydraulic conductivity for potential use as a lagoon liner. The sample achieved a hydraulic conductivity (k_{20}) of 8.18×10^{-9} cm/sec. This hydraulic conductivity is lower than the Manitoba Conservation requirement of 1×10^{-7} cm/sec and is therefore deemed suitable for use as an insitu clay lagoon liner. The bagged soil sample from the same layer had a clay content of 79.7% and a Plasticity Index of 61 and was deemed to have potential for use as an insitu lagoon liner or when re-worked and re-compacted. The hydraulic conductivity analysis confirms that the soil layer could be used as an insitu clay lagoon liner.

Details of AMEC Earth and Environmental test results and analysis, dated June 20, 2012 are attached in the Appendix.

6.0 LAGOON LINER REQUIREMENTS

6.1 Current Guidelines

Manitoba Conservation guidelines require that a standard wastewater treatment lagoon clay liner be 1.0 metre in thickness and have a hydraulic conductivity (i.e. the potential rate of fluid movement through the soil) of 1×10^{-7} cm/sec or less. This low rate is to protect the underlying groundwater from lagoon seepage. Generally, the higher a soil's plasticity the more likely a soil can achieve a hydraulic conductivity of 1×10^{-7} cm/sec.

6.2 Typical Lagoon Liner Construction Options

The liner of a lagoon can be constructed by using the insitu (undisturbed) soils if the soils can consistently achieve a hydraulic conductivity of 1×10^{-7} cm/sec or less in their insitu conditions.

If the insitu soils cannot be used the liner can be constructed by excavating and re-compacting suitable high plastic clay soils to form the liner.

If the clay content of the soils is so low that even when excavated and re-compacted, the soils cannot consistently achieve a hydraulic conductivity of 1 x 10^{-7} cm/sec, a liner constructed of high plastic clay from a borrow pit, or a synthetic geomembrane liner would be required.

6.3 Liner for the RM of Brokenhead Lagoon Expansion

Based on the laboratory Plasticity Index analysis, all of the bagged soil samples deemed a fat clay (CH) will be suitable for use as an insitu clay liner or when re-worked and re-compacted. This was confirmed by the insitu Shelby tube sample from TH2 1.5 – 2.1 m that achieved a hydraulic conductivity of 8.18 x 10^{-9} cm/sec. The bagged soil samples which were deemed a sandy lean clay (CL) or an inorganic clay and silt (CI) are not suitable for use as a clay lagoon liner. The similar layer of soils which are not suitable for a lagoon liner were found in TH4 – TH5, TH7 and TH10 – TH12 from a starting depth ranging from 2.7 to 4.9 m below ground to the termination of the test holes at 6.1 m. The layer of unsuitable soil was also found in TH9 from 0.9 – 1.5 m and TH12 from 2.0 – 3.4 m. The entire soil profile found in TH6 would not be suitable for use as an insitu lagoon liner or when re-worked and re-compacted.

The maximum elevation of the start of the unsuitable till material is approximately 233.8 m observed in TH5 and TH11. If the lagoon expansion were designed to meet the existing lagoon top of dike elevations, the top of dike would be at an elevation of approximately 237.22 m, the cell floor would be at an elevation of 234.72 m and the bottom of the insitu liner would be at an elevation of 233.72 m. The start of the till material in TH5 and TH11 is higher than the bottom of the insitu liner, providing less than 1.0 m of liner material at TH5 and TH11. See Plan 2, attached in the Appendix for a summary of the test hole logs showing the elevation of the proposed liner.

The entire soil profile found in TH6 would not be suitable for use as an insitu lagoon liner or when re-worked and re-compacted. The soil profile of TH12 has suitable high plastic clay from 0.3 – 2.0 m and unsuitable clay from 2.0 – 6.0 m. The clay liner would be approximately 1.9 m – 2.9 m below the ground surface at TH12, which is in the unsuitable clay material. The unsuitable clay found would have to be excavated and suitable high plastic clay from a borrow area would have to be hauled in and re-compacted and re-worked.

TH10, completed just south of TH5, TH6, TH11 and TH12, had a top of unsuitable material elevations of 231.8 m with suitable high plastic clay above the unsuitable material. This results in an insitu clay liner depth of 2.9, which is greater than the Manitoba Conservation requirement of 1.0 m. TH4 and TH7, also taken south of TH10 would have suitable clay liner depths of 2.6 m and 3.6 m, respectively.

Therefore the horizontal liner of the proposed lagoon expansion cells could be constructed with an insitu clay liner 1.0 m below the cell floor elevation approximately south of a line running through TH10, as shown on Plan 1. The exact location of this line would have to be determined by multiple on-site test holes completed during construction of the lagoon. Any layers of unsuitable material as found in TH9 from 0.9 – 1.5 m will have to be removed and replaced with re-worked and re-compacted high plastic clay.

The horizontal liner of the proposed lagoon expansion cells would have to be excavated and re-compacted with 1.0 m of suitable high plastic clay, approximately north of a line running through TH10. The area, which must be re-worked and re-compacted, may be larger than that shown on the plans, depending on the extent of the pockets of unsuitable material found during construction.

For all new perimeter dikes, a 3.0 m wide vertical cut-off wall will have to be constructed extending a minimum of 1.0 m into the horizontal liner surrounding the entire lagoon. Also, the clay soils 1.0 m below the cell floor elevation under the inside dike slope should be re-worked and re-compacted approximately 100 m south of the line through TH10. If the lagoon horizontal liner is tested by Manitoba Conservation and does not pass the requirements near the perimeter dikes, the dike would have to be removed to re-work and re-compact the clay soils beneath. If during lagoon construction the clay soils beneath the inside dike slope are re-worked and re-compacted, there will be little risk of not meeting the Manitoba Conservation requirements and having to remove the dikes.

7.0 SUMMARY AND RECOMMENDATIONS

7.1 Summary

The topography of the proposed site was relatively flat with an average elevation of approximately 236.23 m. The top of dike elevation of the existing RM of Brokenhead lagoon was 237.22 m.

Soils at the proposed lagoon expansion site were investigated by JRCC. Representative soil samples were analyzed by AMEC Earth and Environmental to determine their suitability for use as an insitu lagoon liner or a re-worked and re-compacted lagoon liner.

Based on the laboratory Plasticity Index analysis of the bagged soil samples submitted, ten of the samples were a fat clay (CH) and were deemed to have potential for use as an insitu lagoon liner or a re-worked and re-compacted lagoon liner. The remaining four samples were sandy lean clay (CL) and inorganic clay and silt (CI) and were not deemed suitable for use as an insitu liner or when re-worked and re-compacted. The Shelby tube sample from TH2 1.5 – 2.1 m achieved a hydraulic conductivity of 8.18×10^{-9} cm/sec showing it would be suitable for use as an insitu clay lagoon liner.

7.2 Recommendations

Based on the soil conditions encountered during the geotechnical investigation and the results of the laboratory analysis it is recommended the flat bottom liner of the RM of Brokenhead lagoon expansion cells be constructed partially with the insitu soils and partially with a re-worked and re-compacted liner. The flat bottom liner south of the line approximately through TH10, as shown on Plan 1, could be constructed with insitu clay 1.0 m below the cell floor elevation. Any layers of unsuitable material found in the insitu portion of the liner, such as TH9 from 0.9 – 1.5 m will have to be removed and replaced with re-worked and re-compacted high plastic clay.

The flat bottom liner north of the line approximately through TH10, would have to be excavated and re-compacted with 1.0 m of suitable high plastic clay. The pockets of unsuitable clay material found in TH6 and TH12 would have to be removed and replaced with suitable high plastic clay from a borrow area. The exact location of the line dividing the re-worked liner from the insitu liner would have to be determined by multiple on-site test holes completed during construction of the lagoon. The amount of clay material that would have to be replaced from a borrow area would also have to be determined on-site during construction. The area, which must be re-worked and re-compacted, may be larger than that shown on the plans, depending on the extent of the pockets of unsuitable material found during construction. See Plan 1 attached in the Appendix for the approximate location of the line dividing the insitu liner and the re-worked and re-compacted liner. See Plan 2 for a summary of the test hole logs showing the elevation of the proposed liner.

It is recommended for all new perimeter dikes, a 3.0 m wide vertical cut-off wall be constructed extending a minimum of 1.0 m into the horizontal liner surrounding the entire lagoon. Also, it is recommended the clay soils 1.0 m below the cell floor elevation under the inside dike slope should be re-worked and re-compacted approximately 100 m south of the line through TH10.

7.3 Closure

The conclusions and recommendations in this report are based on the results of the site investigation and laboratory analysis. In addition, soil and groundwater conditions between test hole locations were generalized to provide an overall assessment of the geotechnical site conditions. If conditions that appear different from those encountered at the test hole locations as described in this report, or if the assumptions stated herein are not in agreement with the design, JRCC should be informed so the recommendations can be reviewed and adjusted as required.

The geotechnical investigation and topographic review was conducted for identifying geotechnical and topographic conditions suitable for construction of the RM of Brokenhead lagoon expansion. Although no environmental issues were identified during the geotechnical investigation and topographic review, it does not necessarily follow that such issues do not exist. If the client or any other parties have any environmental concerns regarding the proposed site and works, an appropriate environmental assessment must be conducted.

It is not uncommon for soil conditions to be highly variable across a site. Previous construction activities and placement of fill at a site can augment the variability of soil conditions, especially surficial soil conditions. A contingency must be included in any construction budget to allow for potential variations in soil conditions, which may result in modification of the design and construction procedures.

APPENDIX

Plan 1: Proposed Lagoon Expansion Site with Test Hole Locations and Topographic Contour Lines

Plan 2: Summary of Test Hole Logs with Elevations

Test Hole Logs

2002 Past Test Hole Logs

AMEC Earth and Environmental Test Results, dated June 20, 2012

GW Driller's Well Logs

Plan 1: Proposed Lagoon Expansion Site with Test Hole Locations and Topographic Contour Lines

Plan 2: Summary of Test Hole Logs with Elevations

SCALE BAR
(IN METRES)
50 0 25 50 100 150 200 250
1:2500

No.	REVISIONS	DATE	INITIALS

B.M. ELEV.

LOCATIONS OF UNDERGROUND STRUCTURES/UTILITIES AS SHOWN ARE BASED ON AVAILABLE INFORMATION BUT NO GUARANTEE IS GIVEN OR IMPLIED THAT ALL EXISTING UNDERGROUND STRUCTURES/UTILITIES ARE SHOWN OR THAT THE GIVEN LOCATIONS ARE EXACT. CONFIRMATION OF EXISTENCE AND EXACT LOCATION OF ALL UNDERGROUND STRUCTURES/UTILITIES MUST BE OBTAINED FROM THE APPROPRIATE AUTHORITY/OWNER, BY THE CONTRACTOR, BEFORE PROCEEDING WITH CONSTRUCTION.

ENGINEER'S SEAL

PRELIMINARY

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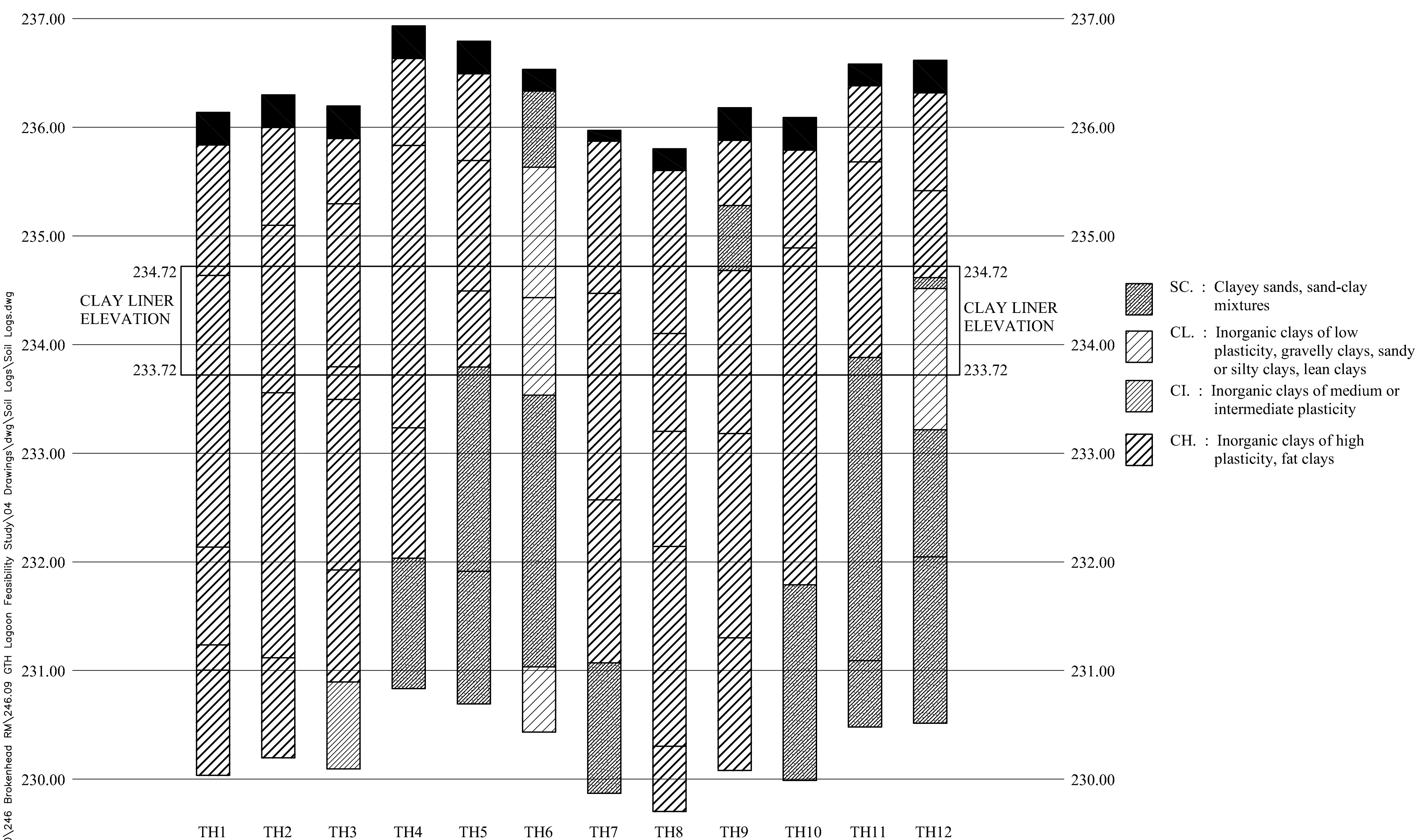
Engineering Excellence since 1981

CODE: B–246.09
DESIGNED BY: JC
DRAWN BY: BM
REVIEWED BY: JC

PROJECT:
RM OF BROKENHEAD – GARSON/TYNDALL/HENRYVILLE LAGOON FEASIBILITY STUDY

TITLE:
PROPOSED LAGOON EXPANSION SITE WITH TEST HOLE LOCATIONS AND TOPOGRAPHIC CONTOUR LINES

SCALE:	DATE:	PLAN:	SHEET:
1:2500	12/06/07	1	1 of 2



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email: info@jrcc.ca website: www.jrcc.ca

DATE: 12/06/21	CLIENT: R.M. OF BROKENHEAD
SCALE: 1:50	PROJECT: GARSON/TYNDALL/HENRYVILLE LAGOON FEASIBILITY STUDY
PLAN NO.: 2	TITLE: SUMMARY OF TEST HOLE LOGS WITH ELEVTATIONS

Jun 22, 2012 – 10:36am F:\200\246 Brokenhead RM\246.09 GTH Lagoon Feasibility Study\04 Drawings\dwg\Soil Logs\Soil Logs.dwg

Test Hole Logs

J. R. Cousin Consultants Ltd.

TEST HOLE LOGS

SYMBOL INDEX

GW. : Well graded gravels and gravel sand mixtures, little or no fines

GP. : Poorly graded gravels, gravel - sand mixtures, little or no fines

GM. : Silty gravels, gravel-sand-silt mixtures

GC. : Clayey gravels, gravel-sand-clay mixtures

SW. : Well graded sands, gravelly sands, little or no fines

SP. : Poorly graded sands, or gravelly sands, little or no fines

SM. : Silty sands, sand-silt mixtures

SC. : Clayey sands, sand-clay mixtures

ML. : Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity

CL. : Inorganic clays of low plasticity, gravelly clays, sandy or silty clays, lean clays

OL. : Organic silts and organic silty clays of low plasticity

CI. : Inorganic clays of medium or intermediate plasticity

MH. : Inorganic silts, fine sandy or silty soils

CH. : Inorganic clays of high plasticity, fat clays

OH. : Organic clays of medium to high plasticity, organic silts

Pt. : Peat, humus, swamp soils with high organic contents

TOPSOIL

The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of an unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil logs represent our opinions. J. R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

J. R. Cousin Consultants Ltd.

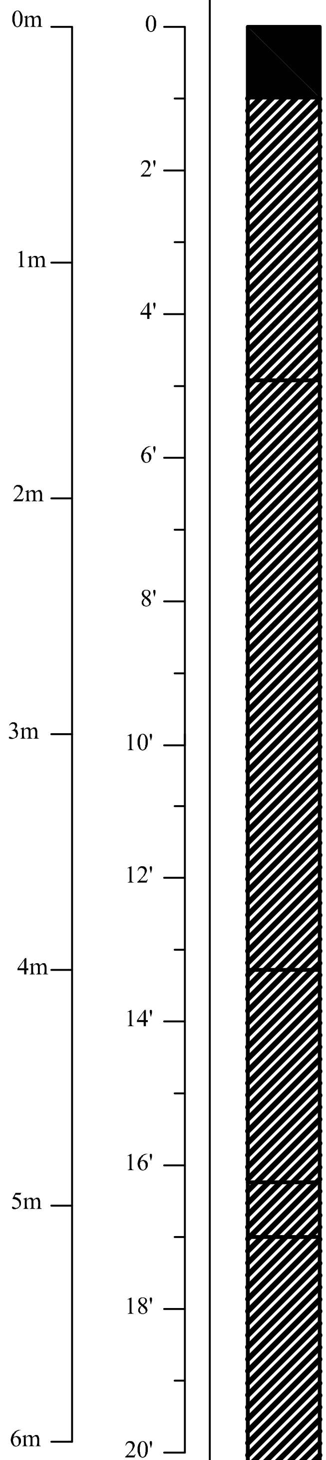
TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead

PROJECT : GTH Lagoon Feasibility Study

DATE : March 27, 2012
ELEVATION: 236.163
TEST HOLE # 1

DEPTH OF SAMPLE	FIELD CLASSIFICATION



TOPSOIL - Black, clayey, organic, silty, trace sand

CLAY - High plastic, grey, trace silt, moist, hard, blocky

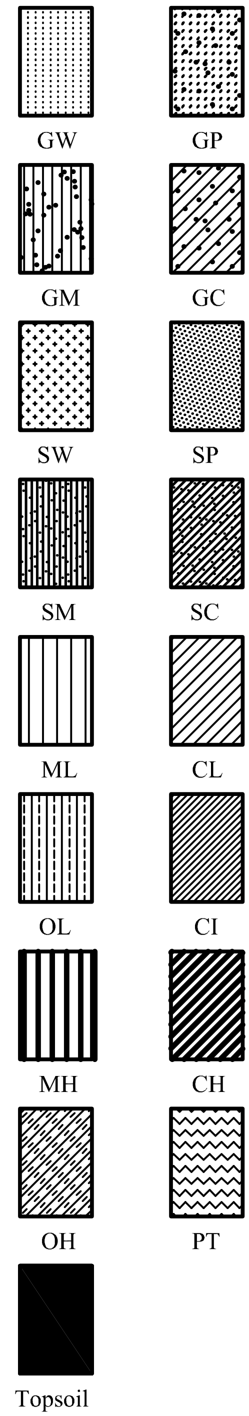
CLAY - High plastic, grey, trace silt, damp, hard, homogenous

CLAY - High plastic, grey, trace sand, moist, hard, silt inclusions

CLAY - High plastic, grey, wet, soft, silt and sand inclusions

CLAY - High plastic, grey, wet, soft, silt inclusions

NO WATER, NO CAVING



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J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead

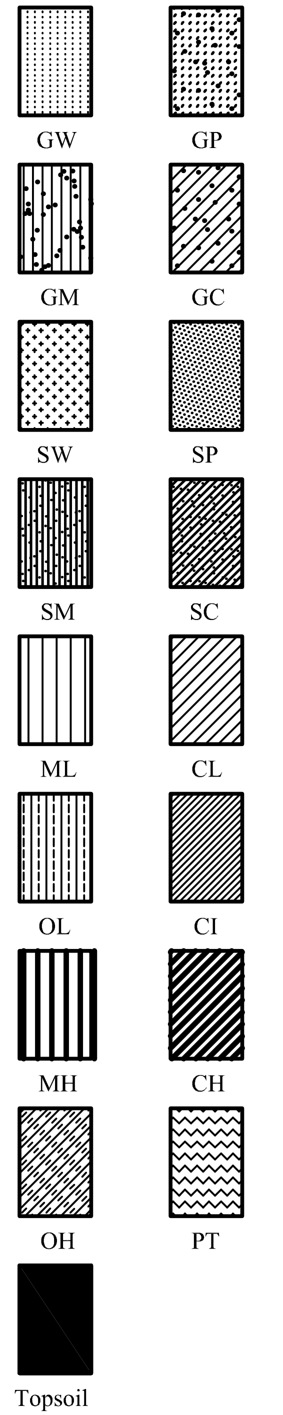
DATE : March 27, 2012

ELEVATION: 236.297

PROJECT : GTH Lagoon Feasibility Study

TEST HOLE # 2

DEPTH OF SAMPLE	FIELD CLASSIFICATION
0m / 0	TOPSOIL - Black, clayey, organic, silty, trace sand
2' / 1m	CLAY - High plastic, grey, trace silt, moist, hard, blocky
4' / 6' / 2m / 8'	CLAY - High plastic, grey, with silt inclusions, trace sand and gravel, moist, hard
3m / 10' / 12' / 4m / 14' / 16' / 5m	CLAY - High plastic, grey, some silt inclusions, trace sand, moist, hard
18' / 6m / 20'	CLAY - High plastic, grey, trace silt, wet, soft NO WATER, NO CAVING



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J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead

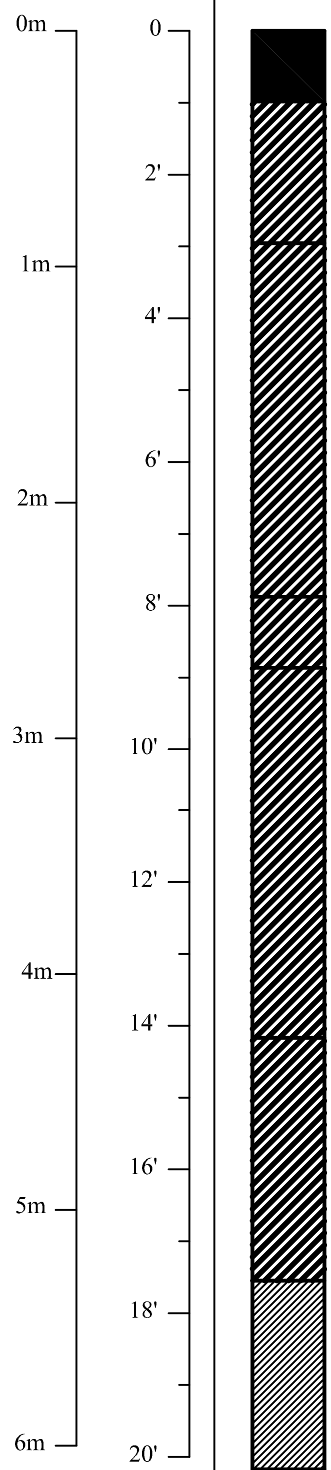
PROJECT : GTH Lagoon Feasibility Study

DATE : March 27, 2012

ELEVATION: 236.195

TEST HOLE # 3

DEPTH OF SAMPLE	FIELD CLASSIFICATION



TOPSOIL - Black, clayey, organic, silty, trace sand

CLAY - High plastic, grey, trace silt, moist, hard, blocky

CLAY - High plastic, grey/light brown, with silt inclusions, some sand

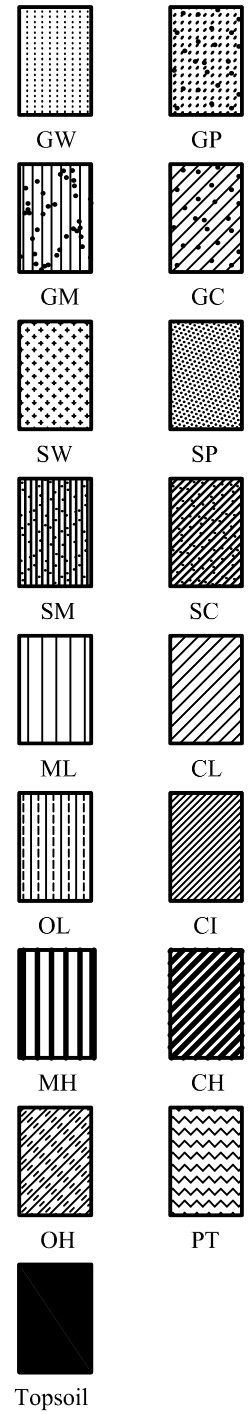
CLAY - High plastic, grey/light brown, with gravel, with silt inclusions, some sand

CLAY - High plastic, grey, some silt, wet, soft, very sticky

CLAY - High plastic, grey, wet, soft, homogenous

CLAY - High plastic, grey, with silt, trace sand, very wet, very soft

NO WATER, CAVING 5.8 m



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J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

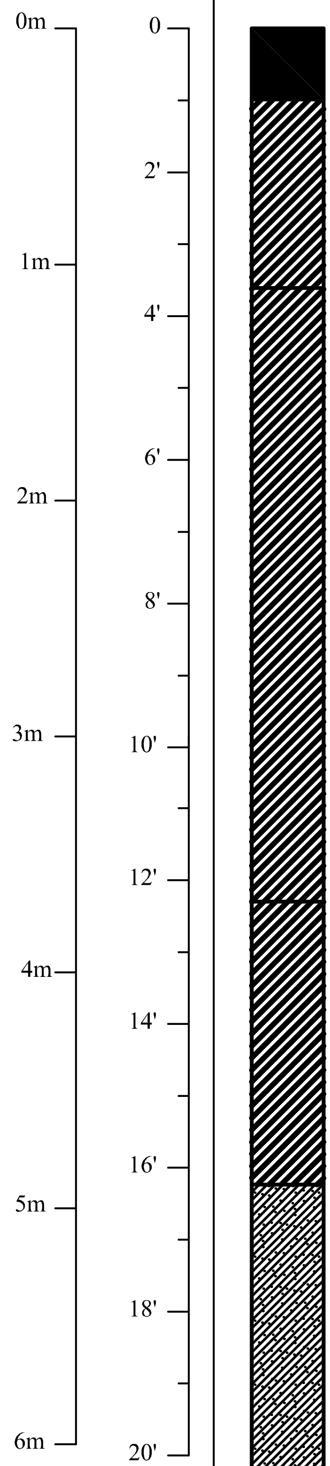
LOCATION : R.M. of Brokenhead

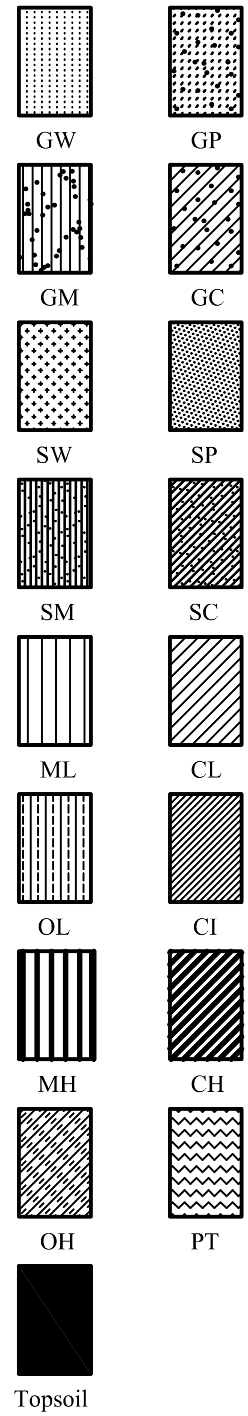
DATE : March 27, 2012

ELEVATION: 236.933

PROJECT : GTH Lagoon Feasibility Study

TEST HOLE # 4

DEPTH OF SAMPLE	FIELD CLASSIFICATION
	TOPSOIL - Black, clayey, organic, silty, trace sand CLAY - High plastic, grey, trace silt, moist, hard, blocky CLAY - High plastic, grey/brown, some silt inclusions, trace sand, damp, hard CLAY - High plastic, grey, wet, soft, homogenous TILL - Light brown, silty, sandy, some gravel and low plastic clay, very wet, very soft NO WATER, NO CAVING



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J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead

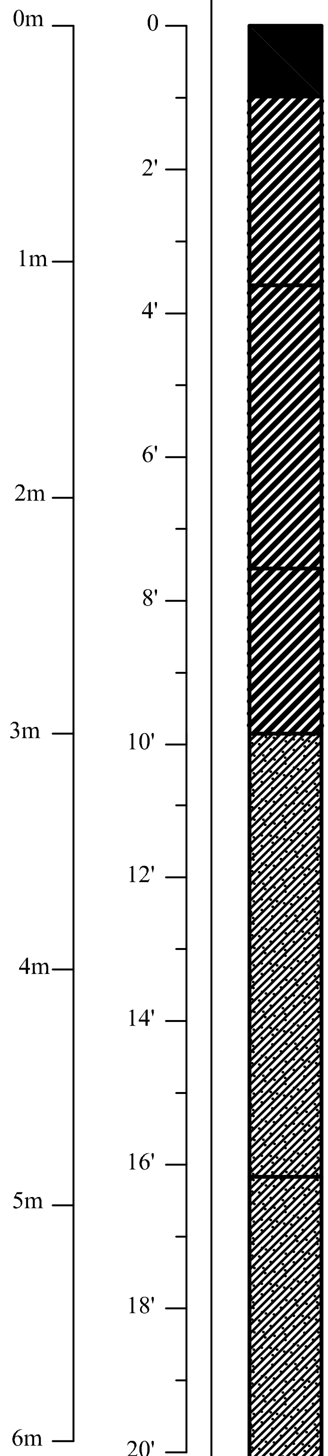
PROJECT : GTH Lagoon Feasibility Study

DATE : March 27, 2012

ELEVATION: 236.823

TEST HOLE # 5

DEPTH OF SAMPLE	FIELD CLASSIFICATION



TOPSOIL - Black, clayey, organic, silty, trace sand

CLAY - High plastic, grey, trace silt, moist, hard, blocky

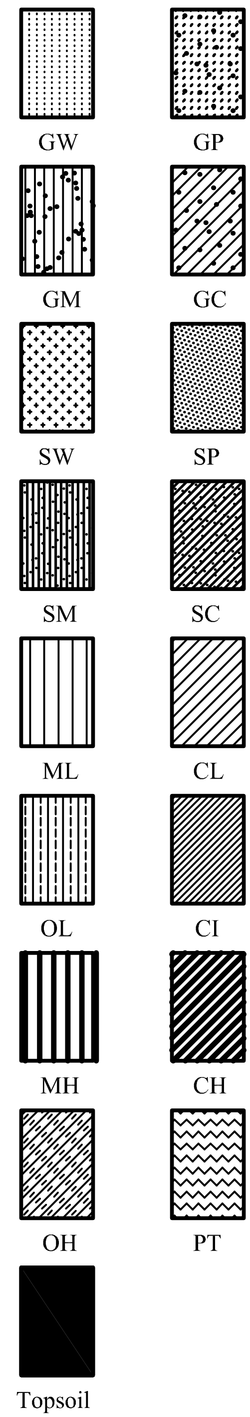
CLAY - High plastic, light brown, with silt and sand inclusions, trace gravel, moist, hard

CLAY - High plastic, grey, trace silt, moist, stiff, homogenous

TILL - Light brown, sandy, silty, gravelly, some low plastic clay, wet, soft

TILL - Light brown, sandy, silty, some gravel, trace low plastic clay, very wet, soft

0.3 m STANDING WATER, 4.1 m CAVING



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J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead

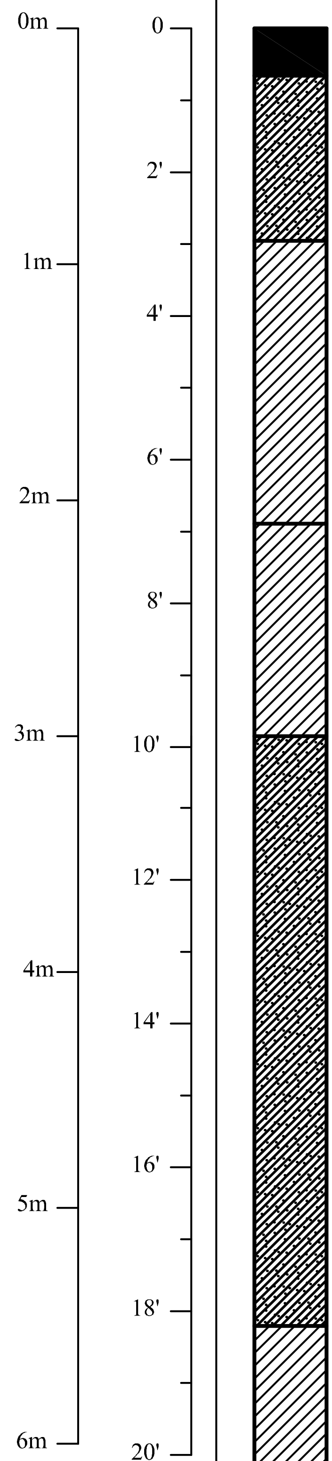
DATE : March 27, 2012

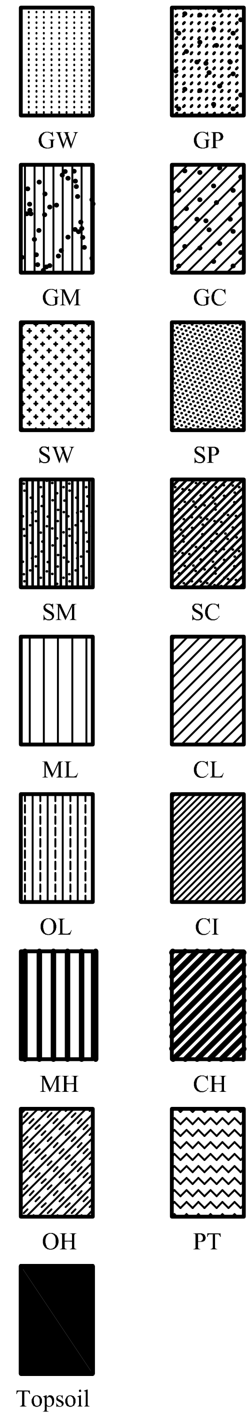
ELEVATION: 236.533

PROJECT : GTH Lagoon Feasibility Study

TEST HOLE # 6

DEPTH OF SAMPLE	FIELD CLASSIFICATION
	TOPSOIL - Black, clayey, organic, silty, trace sand
	TILL - Silty, sandy, with trace gravel, trace medium plastic clay, moist, hard
	SILTY CLAY - Medium plastic, brown, with some sand, trace gravel, moist, stiff
	SILTY CLAY - Medium plastic, light brown, some sand and gravel, wet, stiff
	TILL - Light brown, sandy, silty, some gravel and low plastic clay, very soft, very wet
	CLAY - Medium plastic, light brown, with silt, sand, gravel, wet, stiff
	WATER SEEPAGE AT 1.9 m, CAVING AT 1.9 m





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J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

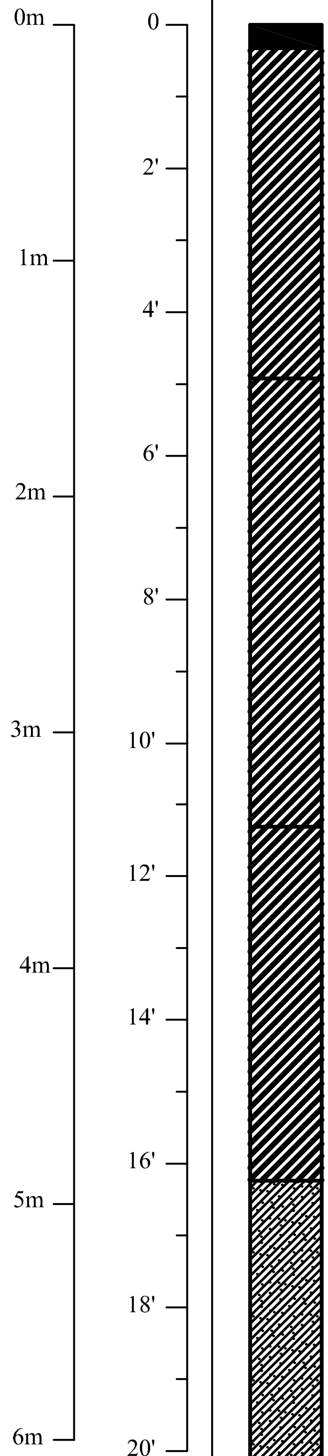
LOCATION : R.M. of Brokenhead

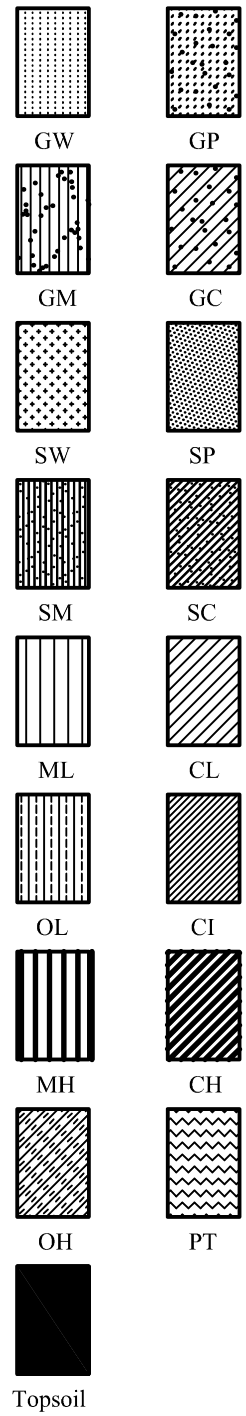
PROJECT : GTH Lagoon Feasibility Study

DATE : March 27, 2012

ELEVATION: 235.971

TEST HOLE # 7

DEPTH OF SAMPLE	FIELD CLASSIFICATION
	TOPSOIL - Black, clayey, organic, silty, trace sand CLAY - High plastic, dark grey, some silt, wet, soft, blocky CLAY - High plastic, brown, with silt, trace gravel, sand inclusions CLAY - High plastic, brown, moist, firm, homogenous TILL - Sandy, silty, with medium-high plastic clay, wet, soft NO WATER, NO CAVING



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J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead

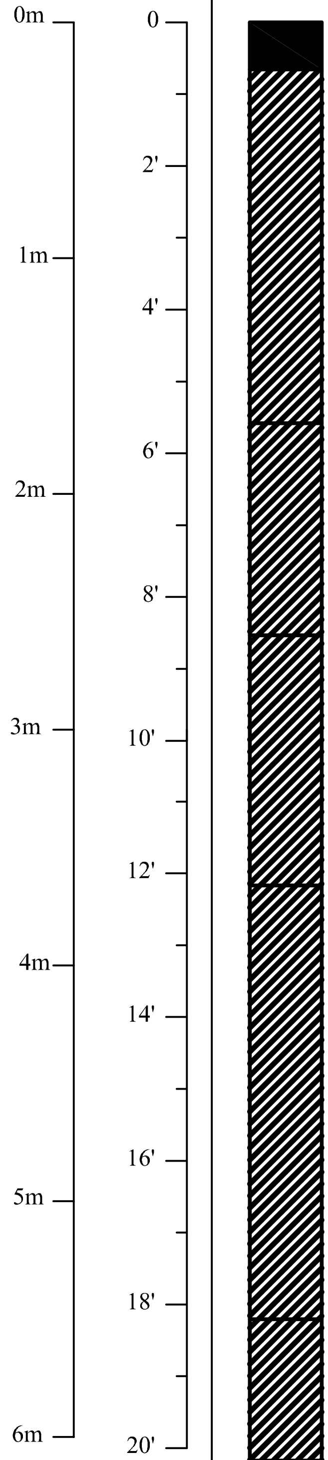
DATE : March 27, 2012

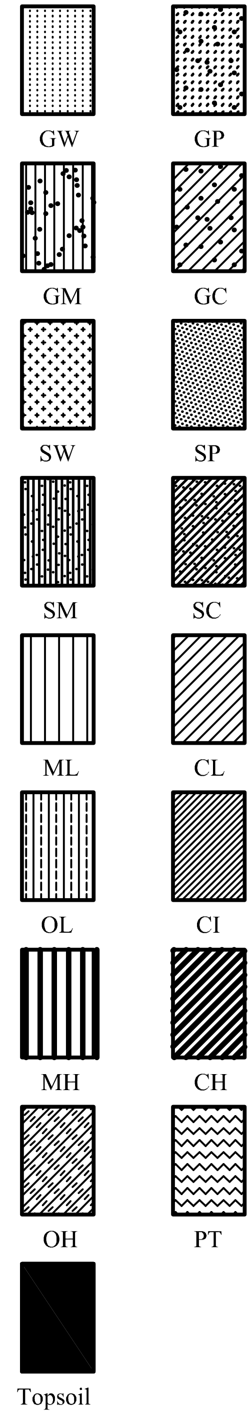
ELEVATION: 235.802

PROJECT : GTH Lagoon Feasibility Study

TEST HOLE # 8

DEPTH OF SAMPLE	FIELD CLASSIFICATION
	TOPSOIL - Black, clayey, organic, silty, trace sand
	CLAY - High plastic, dark grey, trace silt, moist, hard, blocky
	CLAY - High plastic, grey, moist, stiff, homogenous
	CLAY - High plastic, grey, with silt and sand inclusions, trace gravel, moist
	CLAY - High plastic, grey, with silt and sand inclusions, wet, soft
	CLAY - High plastic, grey, wet, soft, homogenous NO WATER, NO CAVING





The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of a unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead

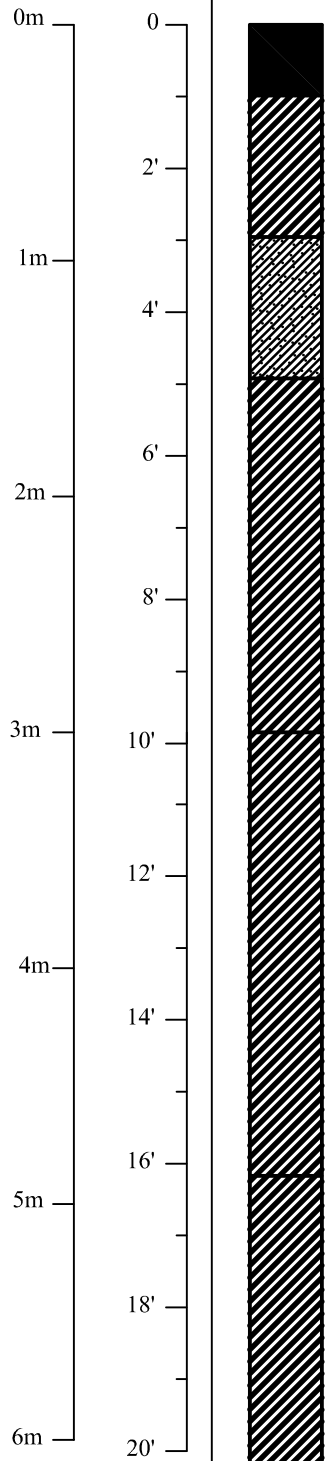
PROJECT : GTH Lagoon Feasibility Study

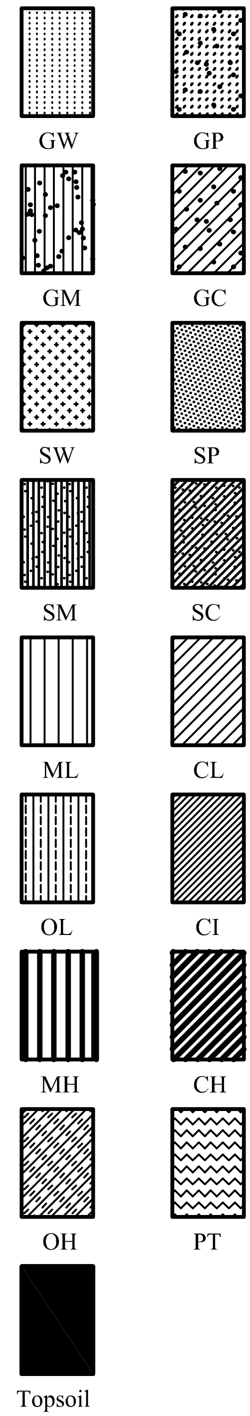
DATE : March 27, 2012

ELEVATION: 236.180

TEST HOLE # 9

DEPTH OF SAMPLE	FIELD CLASSIFICATION
	TOPSOIL - Black, clayey, organic, silty, trace sand
	CLAY - High plastic, grey, some silt, damp, hard, blocky
	TILL - Light brown, silty, sandy, trace clay, damp, loose
	CLAY, High plastic, grey, with silt inclusions, damp, hard
	CLAY - High plastic, grey, moist, stiff, homogenous
	CLAY - High plastic, grey, some silt inclusions, moist, soft
	NO WATER, NO CAVING





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J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead

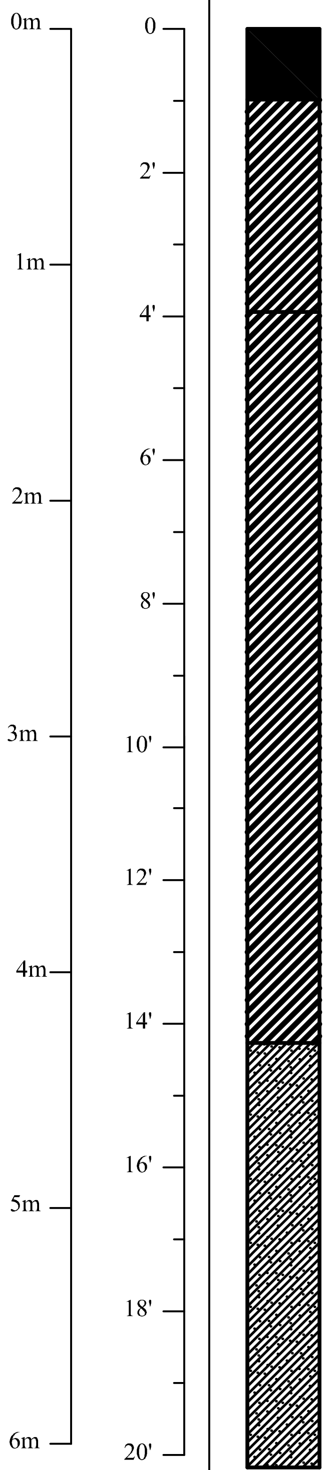
PROJECT : GTH Lagoon Feasibility Study

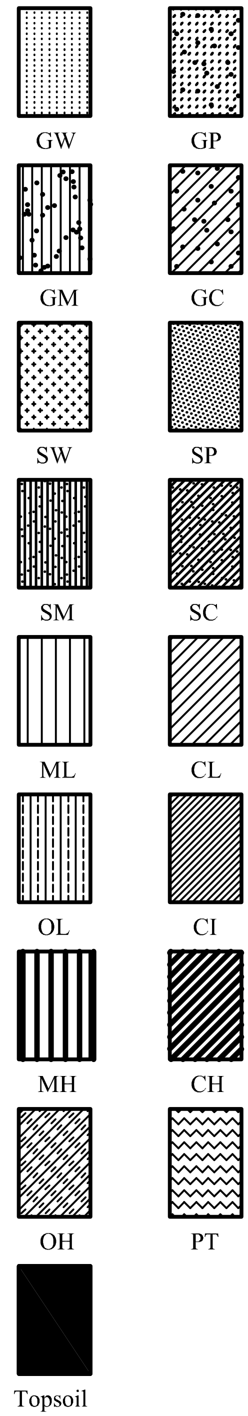
DATE : March 27, 2012

ELEVATION: 236.089

TEST HOLE # 10

DEPTH OF SAMPLE	FIELD CLASSIFICATION
0m / 0	TOPSOIL - Black, clayey, organic, silty, trace sand
2'	CLAY - High plastic, grey, some silt and sand, moist, hard, blocky
8'–10'	CLAY - High plastic, grey, trace silt, moist, stiff
5m / 16'–18'	TILL - Light brown, silty, sandy, some gravel and low plastic clay, wet, soft
6m / 20'	NO WATER, NO CAVING





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J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead

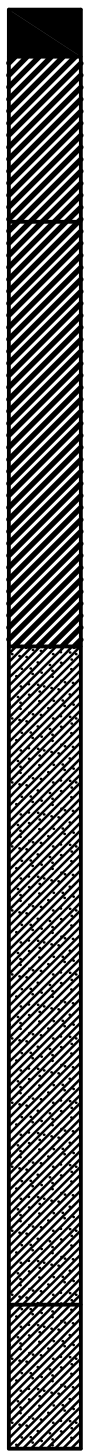
PROJECT : GTH Lagoon Feasibility Study

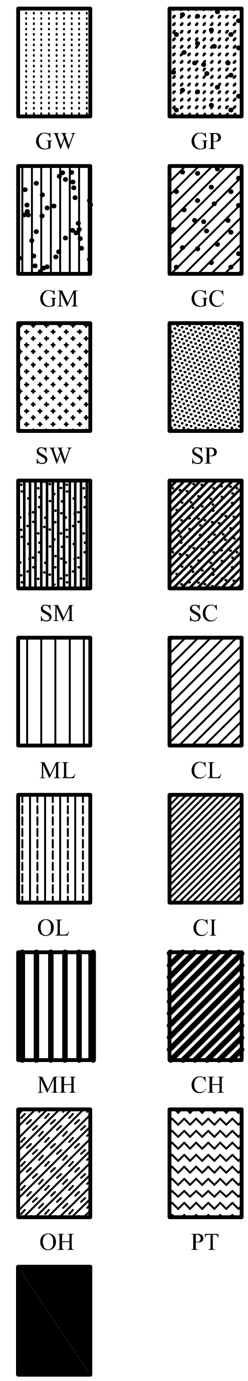
DATE : March 27, 2012

ELEVATION: 236.581

TEST HOLE #11

DEPTH OF SAMPLE (m)	DEPTH OF SAMPLE (ft)	FIELD CLASSIFICATION
0m	0	TOPSOIL - Black, clayey, organic, silty, trace sand
	2'	CLAY - High plastic, dark grey, with trace silt, moist, hard, blocky
1m	4'	
2m	6'	CLAY - High plastic, brown, with some silt and sand, moist, hard
	8'	
3m	10'	
	12'	
4m	14'	TILL - Silty, sandy, some gravel and medium plastic clay, wet, soft
5m	16'	
	18'	TILL - Silty, sandy, some gravel and medium plastic clay, very wet, very soft
6m	20'	NO WATER, NO CAVING





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J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead

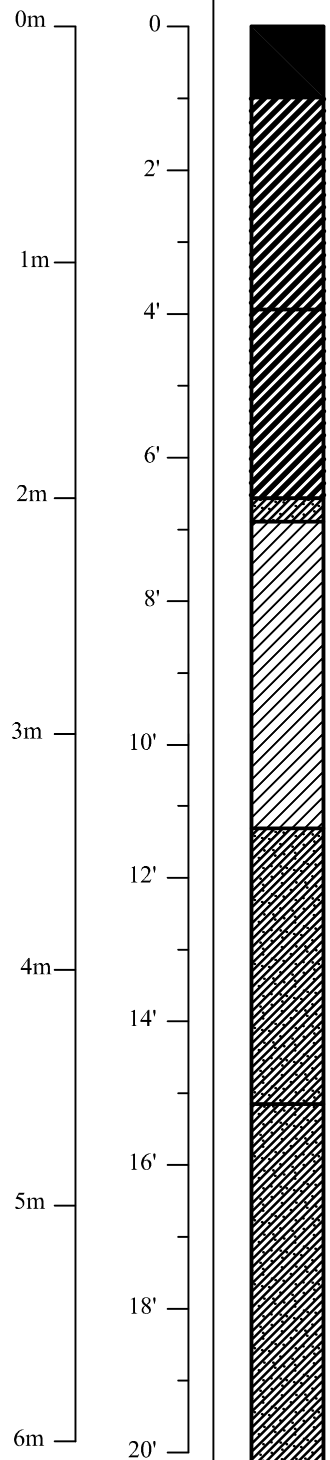
PROJECT : GTH Lagoon Feasibility Study

DATE : March 27, 2012

ELEVATION: 236.615

TEST HOLE # 12

DEPTH OF SAMPLE	FIELD CLASSIFICATION



TOPSOIL - Black, clayey, organic, silty, trace sand

CLAY - High plastic, grey, with silt and sand inclusions, moist, hard, blocky

CLAY - High plastic, brown, moist, hard

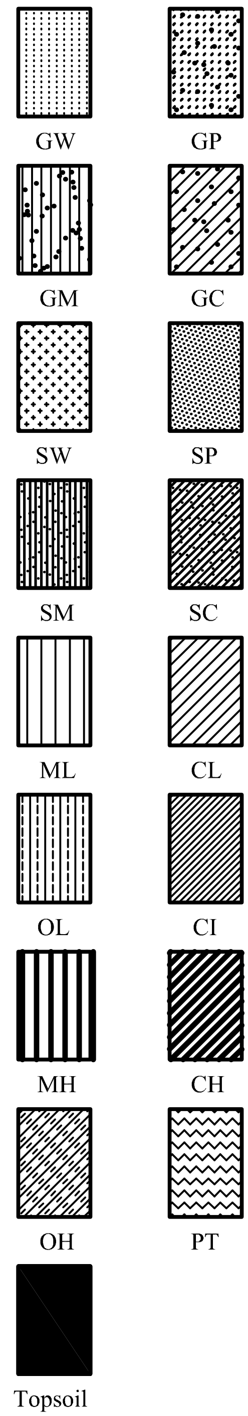
TILL - Silty, sandy, some gravel and low plastic clay, wet, soft

CLAY - Medium plastic, dark grey, some silt and sand inclusions, moist, hard

TILL - Very sandy, silty, trace low plastic clay, very wet, soft, loose

TILL - Very sandy, silty, trace low plastic clay, wet, soft, loose

NO WATER, NO CAVING



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2002 Past Test Hole Logs

J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : RM of Brokenhead

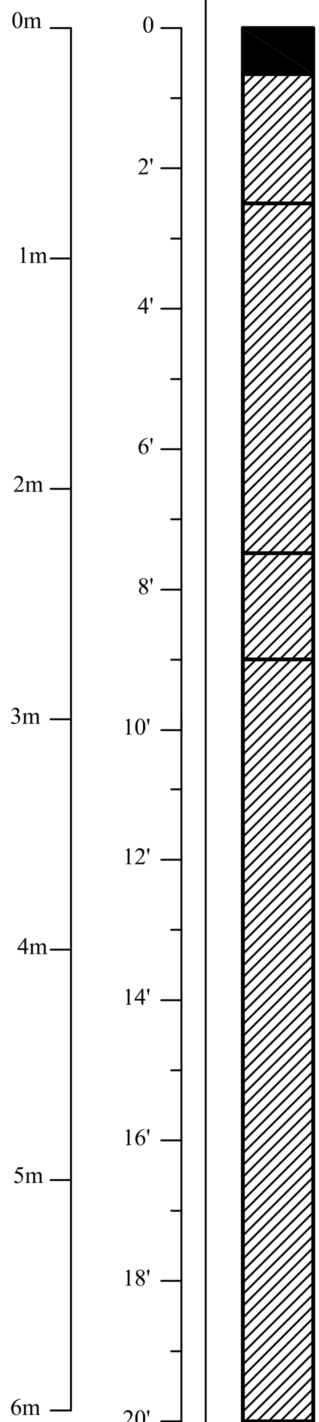
DATE : January 15, 2002

LOCATION OF BORING : NW 15-13-6E

PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02

TEST HOLE # 1

DEPTH OF SAMPLE	FIELD CLASSIFICATION



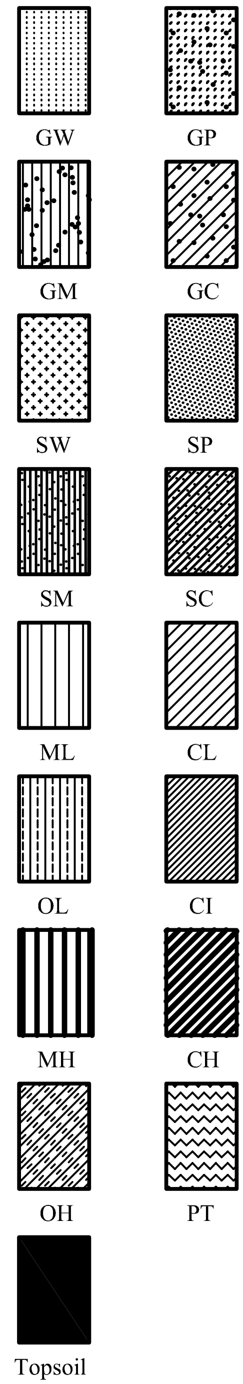
Topsoil

High plastic clay, black, with silt, with organics, frozen

High plastic clay, brown, some silt, trace sand, slightly moist

High plastic clay, mix of brown and yelowish brown, some silt, trace sand, slightly moist

High plastic clay, brown, with silt, trace sand, moist



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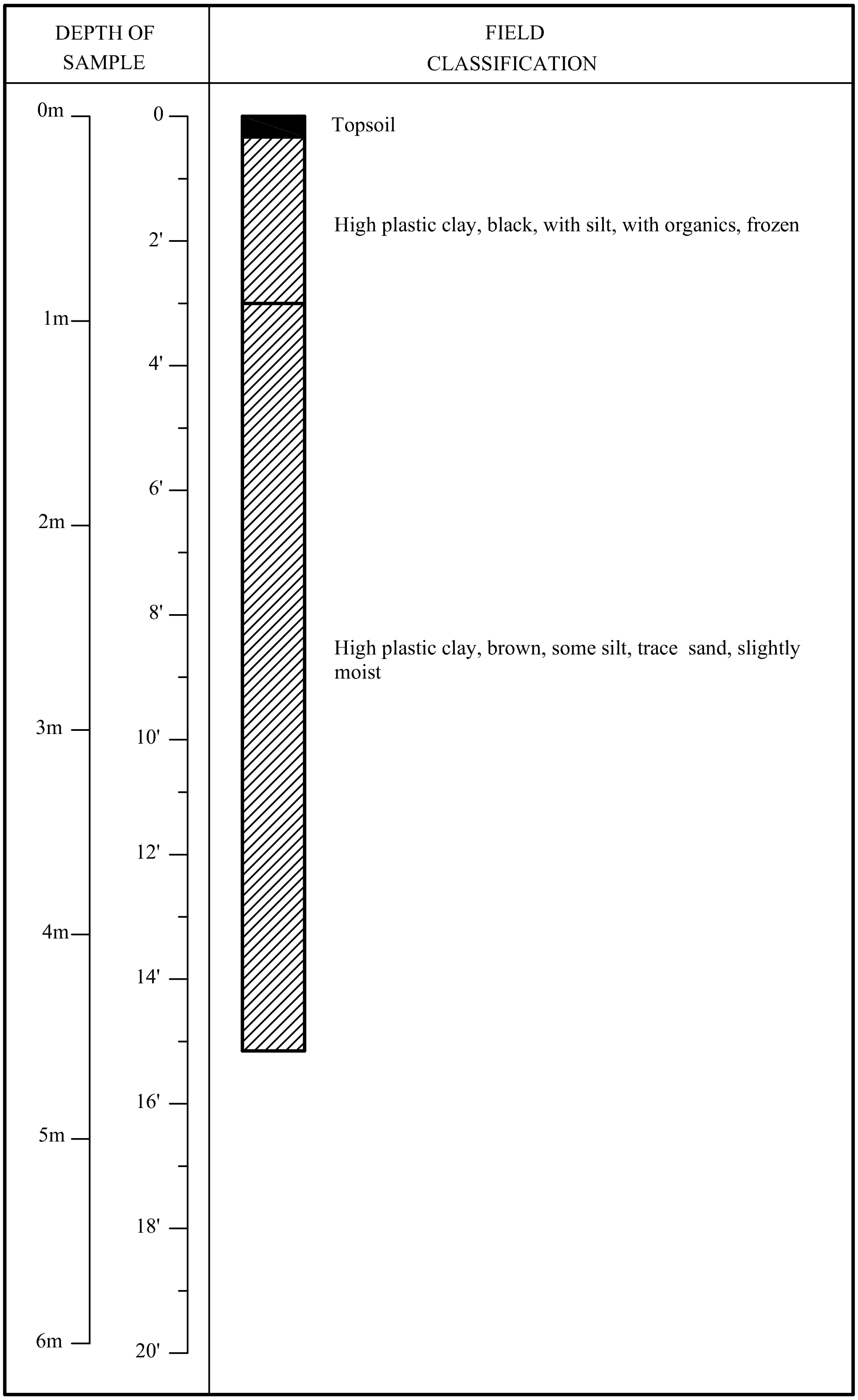
J. R. Cousin Consultants Ltd.

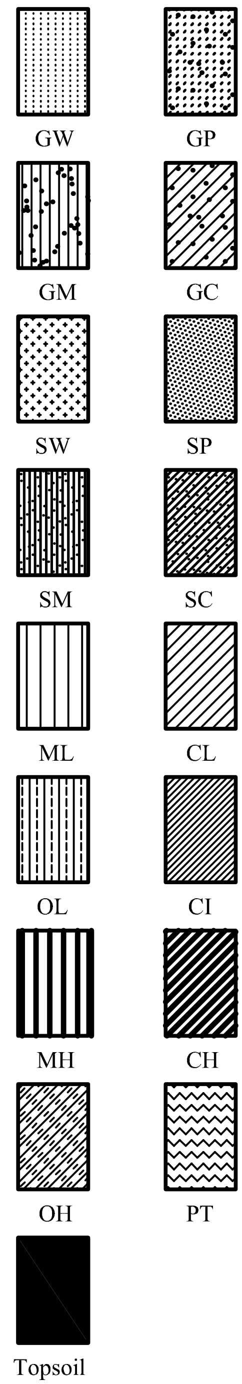
TEST HOLE LOG SHEET

LOCATION : RM of Brokenhead
DATE : January 15, 2002

LOCATION OF BORING : NW 15-13-6E

PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02
TEST HOLE # 2





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J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : RM of Brokenhead

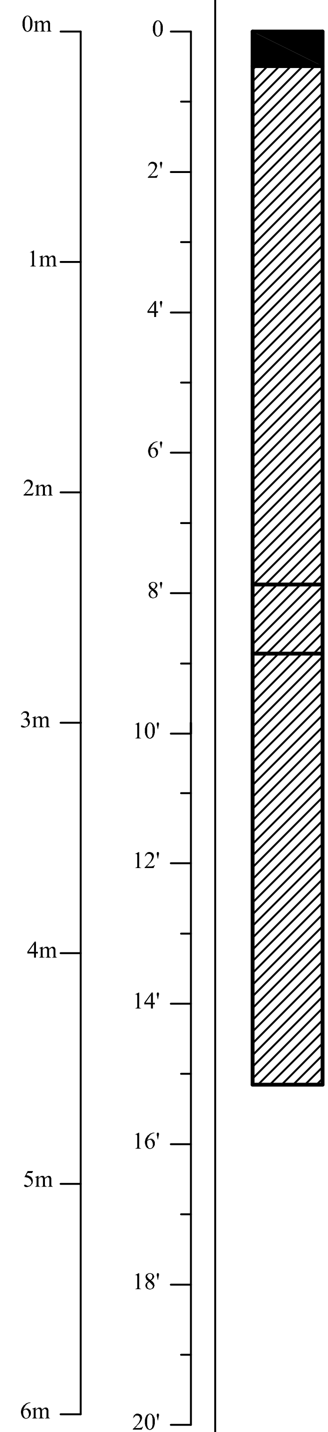
LOCATION OF BORING : NW 15-13-6E

PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02

DATE : January 15, 2002

TEST HOLE # 3

DEPTH OF SAMPLE	FIELD CLASSIFICATION

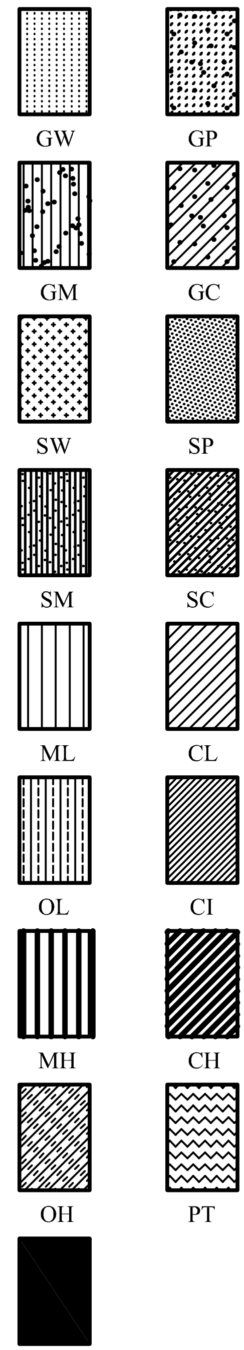


Topsoil

High plastic clay, brown, some silt, trace sand, slightly moist

High plastic clay, light brown, with silt , some gravel, trace sand, moist

High plastic clay, brown, some silt, trace sand, slightly moist



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J. R. Cousin Consultants Ltd.

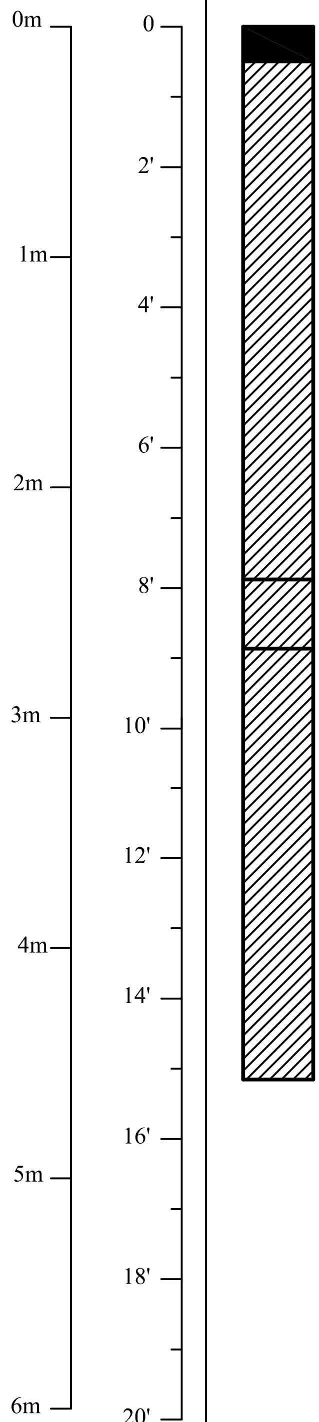
TEST HOLE LOG SHEET

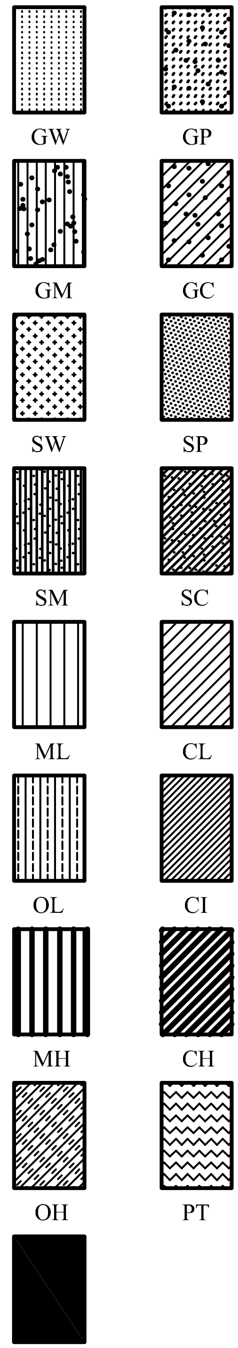
LOCATION : RM of Brokenhead — DATE : January 15, 2002

LOCATION OF BORING : NW 15-13-6E

PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02 — TEST HOLE # 4

DEPTH OF SAMPLE	FIELD CLASSIFICATION
	Topsoil
	High plastic clay, brown, some silt, trace sand, slightly moist
	High plastic clay, light brown, with silt, trace gravel, trace sand, moist
	High plastic clay, brown, some silt, trace sand, slightly moist





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J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : RM of Brokenhead

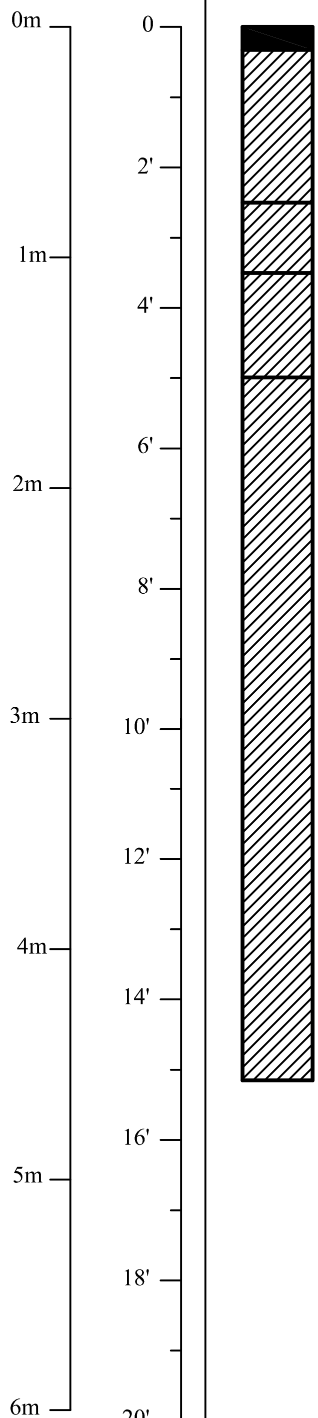
DATE : January 15, 2002

LOCATION OF BORING : NW 15-13-6E

PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02

TEST HOLE # 5

DEPTH OF SAMPLE	FIELD CLASSIFICATION



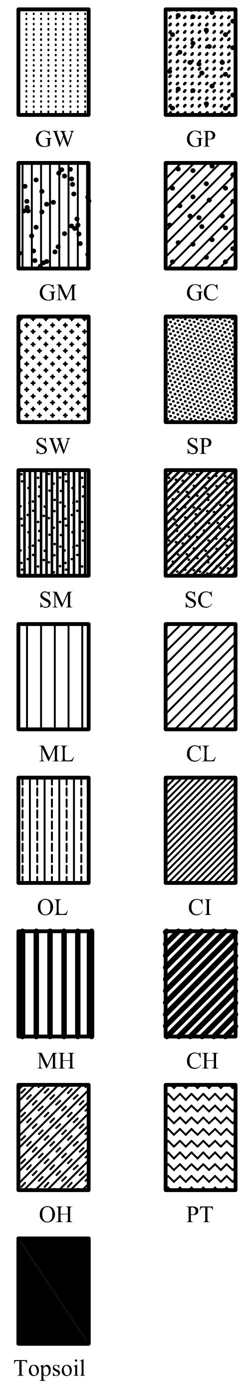
Topsoil

High plastic clay, black, some silt, trace sand, frozen

High plastic clay, brown, some silt, trace sand, slightly moist

High plastic clay, light brown, trace silt and sand, moist

High plastic clay, brown, some silt, trace sand, slightly moist



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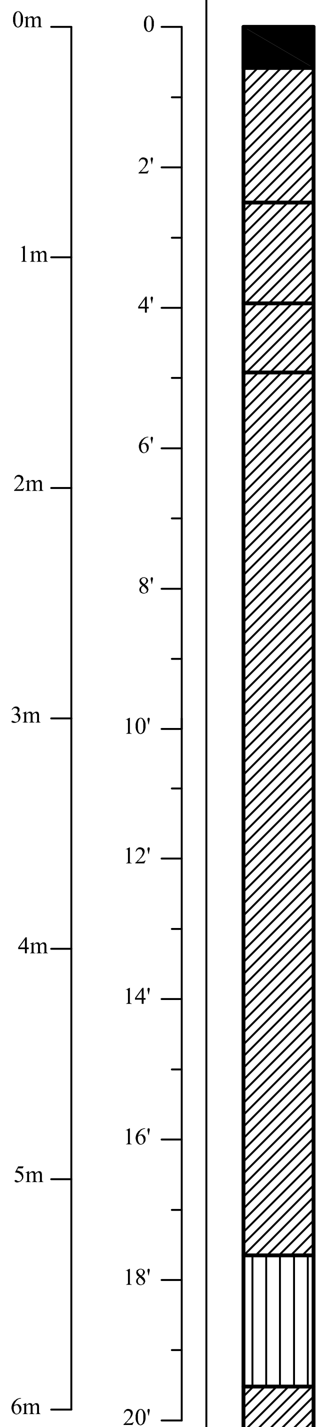
J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : RM of Brokenhead
LOCATION OF BORING : NW 15-13-6E
PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02

DATE : January 15, 2002
TEST HOLE # 6

DEPTH OF SAMPLE	FIELD CLASSIFICATION



Topsoil

High plastic clay, black, some silt, trace sand, frozen

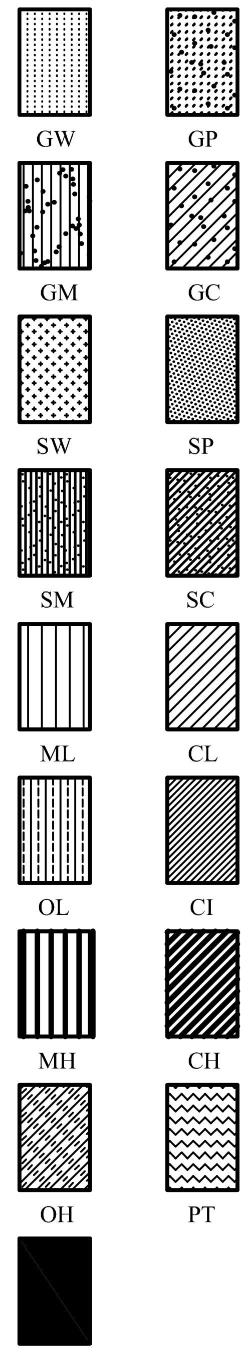
High plastic clay, brown, some silt, trace sand, slightly moist

High plastic clay, light brown, trace silt and sand, moist

High plastic clay, brown, some silt, trace sand, slightly moist

Silt, clayey, light brown, trace sand, trace gravel, wet

High plastic clay, light brown, with silt, trace sand, slightly moist



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J. R. Cousin Consultants Ltd.

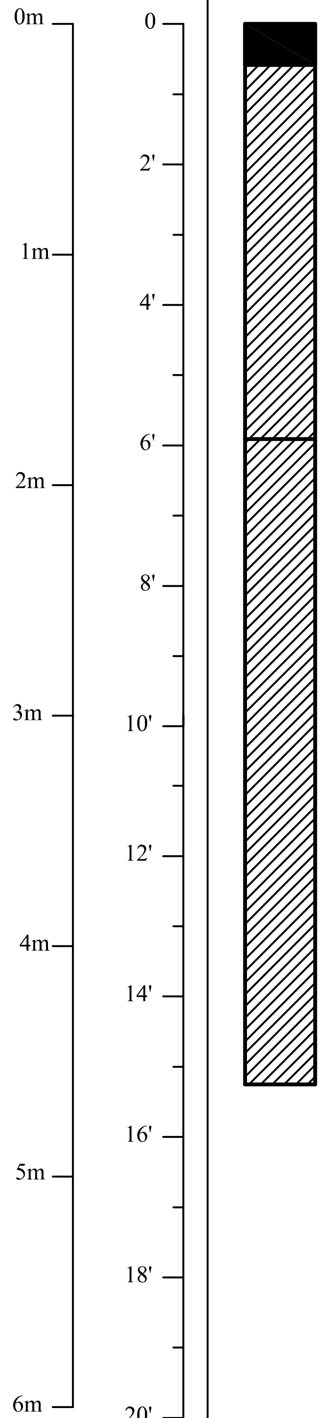
TEST HOLE LOG SHEET

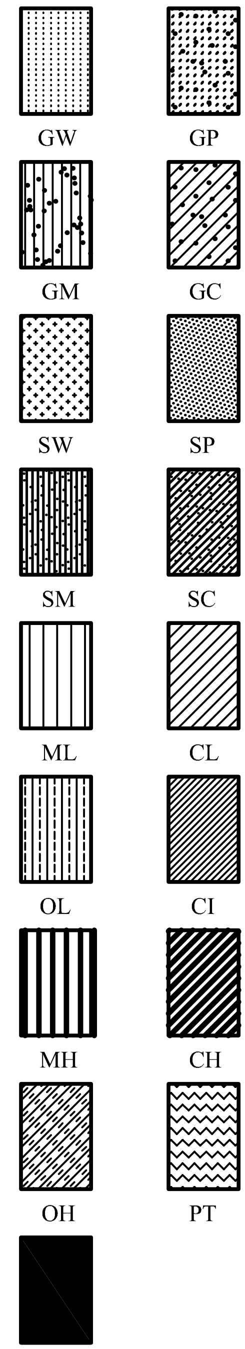
LOCATION : RM of Brokenhead — DATE : January 15, 2002

LOCATION OF BORING : NW 15-13-6E

PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02 — TEST HOLE # 7

DEPTH OF SAMPLE	FIELD CLASSIFICATION
0	Topsoil
~1m (3')	High plastic clay, brown, some silt, trace sand, slightly moist
~3m (10')	High plastic clay, brown, some silt, trace sand, slightly moist





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AMEC Earth and Environmental Test Results, dated June 20, 2012

20 June 2012
Project No. WX10949-02

J.R. Cousin Consultants Ltd.
91 Scurfield Boulevard
Winnipeg, Manitoba
R3Y 1G4

Attention: **Mr. Brett McCormac**

Re: Soils Analysis
Lagoon Feasibility Study
RM of Brokenhead, Manitoba

1.0 INTRODUCTION

As authorized by Mr. Brett McCormac, of J.R. Cousin Consultants Ltd. (JRCC), AMEC Environment and Infrastructure, a division of AMEC Americas Ltd. (AMEC), has completed an evaluation of 15 soil samples (15 grab samples and one Shelby tube sample) that were submitted to our office by JRCC. In addition to the testing, comments with respect to suitability of the submitted soil samples for lagoon liner construction were also requested.

2.0 LABORATORY TESTING

The Shelby tube and 11 grab samples obtained by JRCC were submitted to AMEC's office on 29 March 2012, with 4 additional grab samples submitted on 8 June 2012. On receipt, the grab samples were visually classified by AMEC staff in accordance with the Modified Unified Soil Classification System and were tested for moisture content, particle size (hydrometer method) and Atterberg limits. The visual classification and laboratory testing results are summarized in Table 1 with the laboratory data summary also appended to this report.

AMEC Earth & Environmental
A Division of AMEC Americas Limited
440 Dovercourt Drive
Winnipeg, Manitoba
Canada R3Y 1N4
Tel +1 (204) 488-2997
Fax +1 (204) 489-8261
www.amec.com

Table 1: Lab Results

Sample Number	Depth	Water Content (%)	Atterberg Limits			Particle Size Analysis			
			Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	% Gravel	% Sand	% Silt	% Clay
TH1	0.3 – 1.5m	35.8	93	29	64	0	1.6	11.7	86.7
	Classification: CLAY (CH) - some silt, highly plastic, moist, firm, grey, trace sand								
TH2	1.2 – 2.7m	42.1	95	34	61	0	2.2	18	79.7
	Classification: CLAY (CH) - some silt, highly plastic, moist, firm, dark brown, trace sand								
TH2	2.7 – 5.1m	50.8	70	23	47	0	2.1	28.5	69.4
	Classification: CLAY (CH) - some silt, highly plastic, moist, firm, dark brown, trace sand								
TH3	0.0 – 0.3m	31.8	83	32	51	0	8.7	30.9	60.4
	Classification: CLAY (CH) - silty, highly plastic, moist, firm, black, trace sand and organics								
TH5	1.1 – 2.3m	24.4	69	22	47	0	11.0	27.9	61.1
	Classification: CLAY (CH) - silty, high plastic, moist, firm, black, trace sand and organics								
TH5	2.3 – 3.0m	44.5	85	28	57	0	6.6	23.3	70.1
	Classification: CLAY (CH) - some silt, highly plastic, moist, firm, dark brown, trace sand								
TH5	3.0 – 6.1m	18.2	26	11	15	0	26.5	52.7	20.7
	Classification: SILT (CL) – some clay and sand, low plastic, moist to very moist, soft, light brown								
TH6	0.9 – 2.1m	18.9	36	13	23	0	20.6	45.2	34.2
	Classification: CLAY and SILT (CI) – some sand, medium plastic, moist, soft, brown								
TH6	2.1 – 3.0m	13.2	21	10	11	0	27.7	52.5	19.8
	Classification: SILT (CL) – sandy, some clay, low plastic, moist, soft, light brown								
TH7	1.5 – 3.4m	33.8	66	18	48	0	5.6	29.4	64.9
	Classification: CLAY (CH) - silty , trace sand, high plastic, moist, soft, brown								
TH9	0.3 – 0.9m	29.3	80	26	54	0	2.9	28.3	68.8
	Classification: CLAY (CH) **–** some silt, highly plastic, moist, firm, grey, trace sand								
TH10	1.2 – 4.3m	43.1	95	32	63	0	2.2	18.0	79.7
	Classification: CLAY (CH) **–** some silt, highly plastic, moist, firm, brown, trace sand								
TH11	0.3 – 2.7m	35.2	57	19	38	0	11.0	40.6	48.4
	Classification: CLAY & SILT (CH) **–**highly plastic, moist, firm brown, trace sand								
TH12	2.1 – 3.3m	16.1	32	11	21	1.2	29.8	41.7	27.3
	Classification: SILT (CI) **–** some sand and clay, medium plastic, moist, firm, brown, trace gravel								

A hydraulic conductivity test was completed on the Shelby tube sample (TH2 @ 1.5 – 2.1m). The hydraulic conductivity of the soil sample was 8.18 x 10^{-9} cm/sec.

3.0 DISCUSSION

AMEC was also requested to comment on the suitability of the soils for use as a liner in their in-situ condition, based on the visual assessment and the test results. It is expected that the soils which were tested and are classified as medium to high plastic clays (Samples TH1 (0.3 to 1.5 and 1.2 to 2.7 m), TH2 (2.7 to 5.1 m), TH3 (0.0 to 0.3 m), TH5 (1.1 to 2.3 m and 2.3 to 3.0 m), TH6 (0.9 to 2.1 m), TH7 (1.5 to 3.4 m), TH9 (0.3 to 0.9 m), TH10 (1.2 to 4.3 m) and TH1 (0.3 to 2.7 m)), will have a hydraulic conductivity of less than 1 x 10^{-7} cm/sec in their natural condition. It should be noted that the hydraulic conductivity is subject to the in-situ soil structure including the amount of fissuring, the inter-connectivity of the fissures and effects of freeze thaw and as a result, shallower soils generally have a greater likelihood of having a higher in-situ hydraulic conductivity.

For samples tested and determined to be low plastic silt, a permeability greater than 1 x 10^{-7} cm/sec is expected, even if remoulded and compacted.

Ultimately permeability testing at the final lagoon liner elevation should be undertaken to determine the hydraulic conductivity of the soil and to verfiy whether remoulding of the clay is necessary.

4.0 CLOSURE

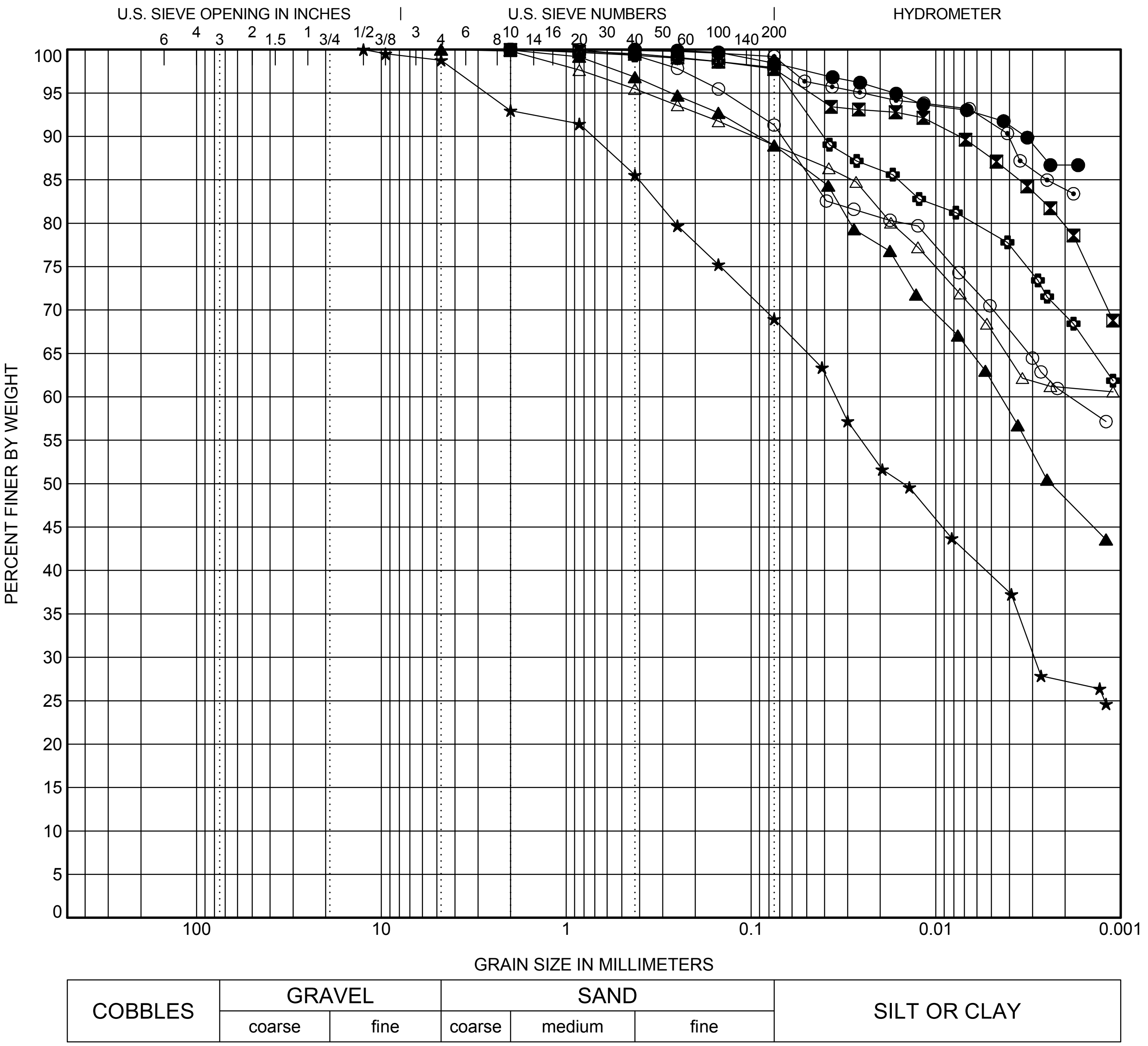
AMEC trusts that the forgoing is sufficient for your present requirements. Should you require additional information, please contact Mr. Gluck at this office.

Sincerely,
AMEC EARTH & ENVIRONMENTAL

Jorden Wiwcharyk, EIT
Geotechnical Engineer-In-Training

Trevor Gluck, P. Eng.
Senior Geotechnical Engineer

Reviewed By:
Harley Pankratz, P. Eng.
VP; Eastern Prairies/Northern Alberta



	Sample ID	Depth	MC	LL	PL	PI	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**TH1**	**0.3 m**	**35.8**	**93**	**29**	**64**	**0.425**				**0.0**	**1.6**	**11.7**	**86.7**
⧗	**TH10**	**1.2 m**	**43.1**	**95**	**32**	**63**	**2**					**2.2**	**18.0**	**79.7**
▲	**TH11**	**0.9 m**	**35.2**	**57**	**19**	**38**	**4.75**	**0.004**			**0.0**	**11.0**	**40.6**	**48.4**
★	**TH12**	**2.1 m**	**16.1**	**32**	**11**	**21**	**12.5**	**0.035**	**0.003**		**1.2**	**29.8**	**41.7**	**27.3**
⊙	**TH2**	**1.2 m**	**42.1**	**95**	**34**	**61**	**2**				**0.0**	**0.8**	**15.3**	**83.9**
✠	**TH2**	**2.7 m**	**50.8**	**70**	**23**	**47**	**2**				**0.0**	**2.1**	**28.5**	**69.4**
○	**TH3**	**0 m**	**31.8**	**83**	**32**	**51**	**2**	**0.002**			**0.0**	**8.7**	**30.9**	**60.4**
△	**TH5**	**1.1 m**	**24.4**	**69**	**22**	**47**	**4.75**				**0.0**	**11.0**	**27.9**	**61.1**

AMEC Earth & Environmental

PHONE: FAX:

CLIENT LOGO:

CLIENT: **JRCC**

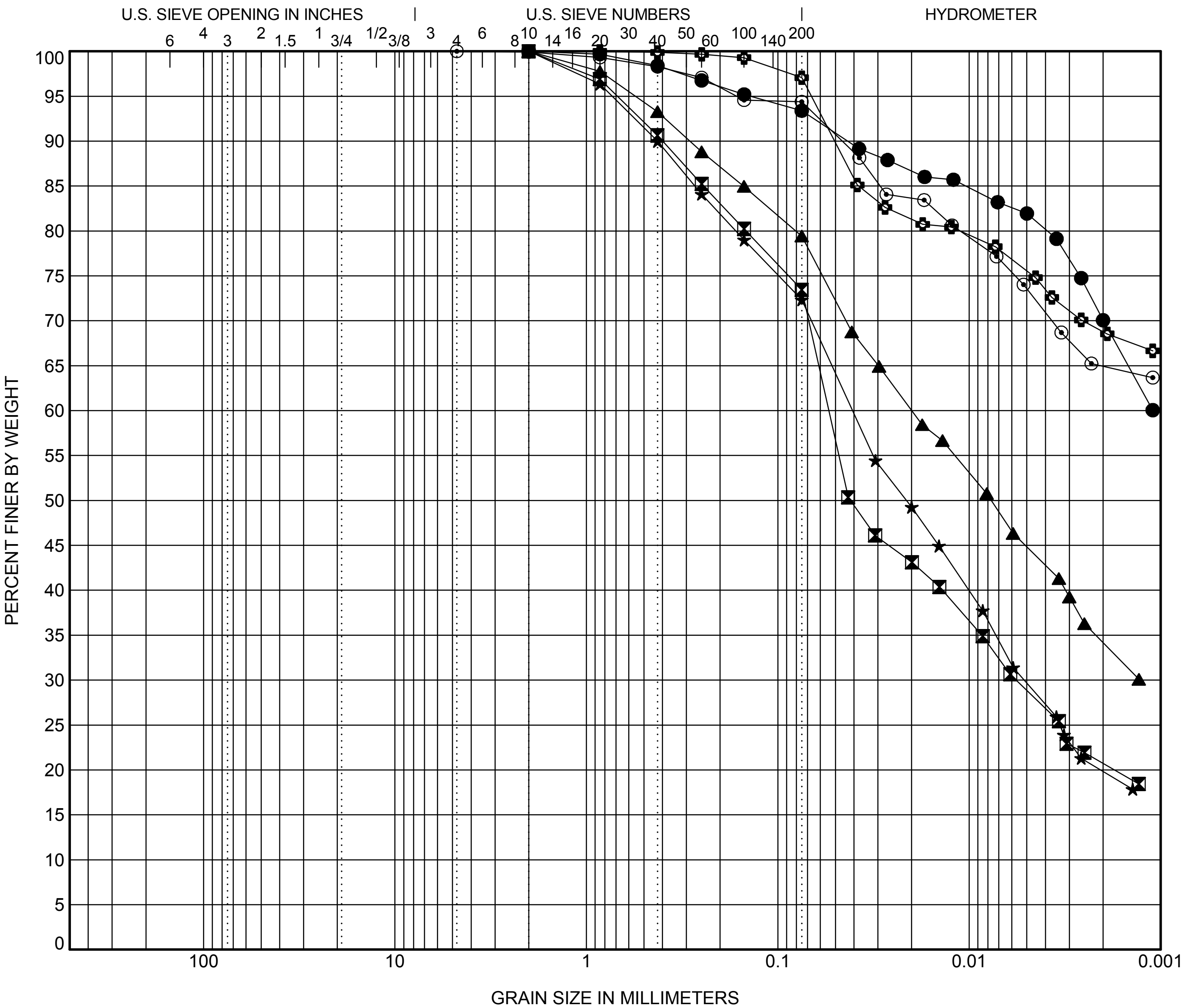
PROJECT: RM of Brokenhead Lagoon Feasibility Study

DRAWN BY: TG | DATUM: N/A | DATE: June 19, 2012

TITLE: PARTICLE SIZE DISTRIBUTION

CHK'D BY: TG | REV. NO.: 0 | PROJECT No.: WX10949

PROJECTION: N/A | SCALE: AS SHOWN | FIGURE No.: **1**



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample ID	Depth	MC	LL	PL	PI	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**TH5**	**2.3 m**	**44.5**	**85**	**28**	**57**	**2**				**0.0**	**6.6**	**23.3**	**70.1**
⧗	**TH5**	**3 m**	**18.2**	**26**	**11**	**15**	**2**	**0.054**	**0.006**		**0.0**	**26.5**	**52.7**	**20.7**
▲	**TH6**	**0.9 m**	**18.9**	**36**	**13**	**23**	**2**	**0.02**			**0.0**	**20.6**	**45.2**	**34.2**
★	**TH6**	**2.1 m**	**13.2**	**21**	**10**	**11**	**2**	**0.041**	**0.005**		**0.0**	**27.7**	**52.5**	**19.8**
⊙	**TH7**	**1.5 m**	**33.8**	**66**	**18**	**48**	**4.75**				**0.0**	**5.6**	**29.4**	**64.9**
✿	**TH9**	**0.3 m**	**29.3**	**80**	**26**	**54**	**2**				**0.0**	**2.9**	**28.3**	**68.8**

AMEC Earth & Environmental

PHONE: FAX:

CLIENT LOGO:

CLIENT: **JRCC**

PROJECT: RM of Brokenhead Lagoon Feasibility Study

TITLE: PARTICLE SIZE DISTRIBUTION

DRAWN BY: TG	DATUM: N/A	DATE: June 19, 2012
CHK'D BY: TG	REV. NO.: 0	PROJECT No.: WX10949
PROJECTION: N/A	SCALE: AS SHOWN	FIGURE No.: **1**

10949.GPJ 12/06/19 12:15 PM (WPG - GRAIN SIZE WITH ATTERBERG & MC)

HYDRAULIC CONDUCTIVITY REPORT

CSA CERTIFIED CONCRETE TESTING LABORATORY IN ACCORDANCE WITH STD A 283

amec

ASTM D 5084

TO:	JR Cousin 91 Scurfield Boulevard Winnipeg, Manitoba R3Y 1G4	**PROJECT NO:** **CLIENT:** **DATE SUBMITTED:**	WX10949 JRCC 29-Mar-12

PROJECT: RM of Brokenhead

TEST HOLE:	TH2	**PERMEANT:**	De-Aired Tap Water
SAMPLE NO.:	Not Provided	**HYDRAULIC GRADIENT:**	19.10
SAMPLE DEPTH:	1.5 to 2.1m		

CONSTANT HEAD METHOD (K = cQL/thA)

	Sample Height, L (cm)	Sample Dia. (cm)	Water Content (%)	Dry Density (kg/m^3)	Degree of Saturation (%)	Cell Pressure (kPa)	Back Pressure (kPa)	Differential Pressure, h (kPa)
Initial	7.36	7.24	32.5%	1450	99.8%	241.4	200.0	13.8
Final	7.48	7.28	35.4%	1413	102.8%			

Date & Time		Time, t	Flow (Q)		Temp.	Hyd. Cond.
Start	End	(seconds)	Influent (ml)	Effluent (ml)	Corr, c	Corrected, K (cm/s)
4/18/12 8:23 AM	4/19/12 9:58 AM	92100	0.50	0.80		1.34E-08
4/19/12 9:58 AM	4/20/12 12:34 PM	95760	0.30	0.50		7.94E-09
4/20/12 12:34 PM	4/22/12 1:00 PM	174360	0.60	0.90		8.18E-09
4/22/12 1:00 PM	4/23/12 6:00 PM	104400	0.30	0.50		7.28E-09
4/23/12 6:00 PM	4/24/12 11:00 AM	61200	0.30	0.30		9.32E-09

Soil Description: Clay (CH) - silty, high plastic

Average Temperature Corrected Value (cm/s): 8.18E-09

AMEC Earth & Environmental
A Division of AMEC Americals Limited

Per:

Brad Wiebe, M.Sc., P.Eng.
Associate Geotechnical Engineer

Reporting of these results constitutes a testing service only.
Engineering interpretation or evaluation of the test results is provided only on written request.

AMEC Earth Environmental Limited
440 Dovercourt Drive
Winnipeg, Manitoba
R3Y 1N4

Tel +1 (204) 488-2997
Fax +1 (204) 489-8261

GW Driller's Well Logs

LOCATION: NW15-13-6E

```
Well_PID:          47683
Owner:          J KOROLEWICH
Driller:        Stasiuk & Sons Drilling Inc.
Well Name:
Well Use:       PRODUCTION
Water Use:      Domestic,Livestock
UTMX:      664609.113
UTMY:      5552607.24
Accuracy XY:      UNKNOWN
UTMZ:
Accuracy Z:
Date Completed: 1983 May 09
```

WELL LOG

From (ft.)	To (ft.)	Log
0	18.0	BROWN CLAY
18.0	64.0	BROWN TILL
64.0	66.0	GRAVEL AND SAND
66.0	82.9	BROWN ROCK

WELL CONSTRUCTION

From (ft.)	To (ft.)	Casing Type	Inside Dia.(in)	Outside Dia.(in)	Slot Size(in)	Type	Material
0	67.0	casing	4.30				GALVANIZED
67.0	82.9	open hole	4.00				

Top of Casing: 1.0 ft. below ground

PUMPING TEST

```
Date:                           1983 May 09
Pumping Rate:                    30.0 Imp. gallons/minute
Water level before pumping:      2.0 ft. below ground
Pumping level at end of test:    4.0 ft. below ground
Test duration:                   hours,  minutes
Water temperature:              ?? degrees F
```

LOCATION: SE15-13-6E

```
Well_PID:          36953
Owner:          A PAWLICK
Driller:        Paul Slusarchuk Well Drilling LTd.
Well Name:
Well Use:       PRODUCTION
Water Use:      Domestic
```

UTMX: 665432.607
UTMY: 5551810.46
Accuracy XY: UNKNOWN
UTMZ:
Accuracy Z:
Date Completed: 1979 Aug 30

WELL LOG

From (ft.)	To (ft.)	Log
0	35.0	CLAY
35.0	68.0	TILL
68.0	75.0	GRAVEL
75.0	124.9	LIMESTONE

WELL CONSTRUCTION

From (ft.)	To (ft.)	Casing Type	Inside Dia.(in)	Outside Dia.(in)	Slot Size(in)	Type	Material
0	77.2	casing	4.00			T & C	GALVANIZED
77.2	124.9	open hole	3.90				

Top of Casing: 1.0 ft. below ground

PUMPING TEST

Date: 1979 Aug 30
Pumping Rate: 12.0 Imp. gallons/minute
Water level before pumping: ft. below ground
Pumping level at end of test: ?? ft. below ground
Test duration: 1 hours, minutes
Water temperature: ?? degrees F

LOCATION: SW15-13-6E

Well_PID: 155399
Owner: DARYL GROSSER
Driller: Perimeter Drilling Ltd.
Well Name:
Well Use: PRODUCTION
Water Use: Domestic
UTMX: 664939
UTMY: 5551472
Accuracy XY: 1 EXACT [<5M] [GPS]
UTMZ: 234
Accuracy Z: 4 FAIR - Shuttle at Centroid
Date Completed: 2009 Jul 15

WELL LOG

From (ft.)	To (ft.)	Log
0	2.0	TOP SOIL
2.0	34.0	CLAY
34.0	84.0	TILL
84.0	85.0	BROKEN LIMESTONE
85.0	180.0	LIMESTONE

WELL CONSTRUCTION

From (ft.)	To (ft.)	Casing Type	Inside Dia.(in)	Outside Dia.(in)	Slot Size(in)	Type	Material
0	88.0		5.00			INSERT	PVC
88.0	180.0	OPEN HOLE	4.50				
		CASING GROUT					CEMENT

Top of Casing: 2.5 ft. above ground

PUMPING TEST

Date: 2009 Jul 15
Pumping Rate: ?? Imp. gallons/minute
Water level before pumping: 60.0 ft. above ground
Pumping level at end of test: 3.0 ft. above ground
Test duration: ??? hours, ?? minutes
Water temperature: ?? degrees F

LOCATION: SW15-13-6E

Well_PID: 140056
Owner: TERRY PANISIAK
Driller: Maple Leaf Enterprises LTd.
Well Name:
Well Use: PRODUCTION
Water Use: Domestic
UTMX: 664637.297
UTMY: 5551793.04
Accuracy XY:
UTMZ:
Accuracy Z:
Date Completed: 2006 Sep 07

WELL LOG

From (ft.)	To (ft.)	Log
0	30.0	CLAY
30.0	35.0	CLAY WITH STONES
35.0	55.0	BROWN TILL
55.0	57.0	GREY TILL

57.0	85.0	GREY SILT WITH BOULDERS
85.0	88.0	LIMESTONE
88.0	91.0	SOFT WHITE LIMESTONE OR SHALE
91.0	160.0	LIMESTONE (SAND LAYERS IN LIMESTONE AFTER 135')

WELL CONSTRUCTION

From (ft.)	To (ft.)	Casing Type	Inside Dia.(in)	Outside Dia.(in)	Slot Size(in)	Type	Material
0	87.0	CASING	5.00			WELDED	PVC
82.0	92.0	CASING	4.00			WELDED	PVC
92.0	160.0	CASING	3.90				
0	70.0						

BENTONITE

Top of Casing: 4.0 ft. above ground

PUMPING TEST

Date: 2006 Sep 07
Pumping Rate: 20.0 Imp. gallons/minute
Water level before pumping: 2.0 ft. below ground
Pumping level at end of test: 40.0 ft. below ground
Test duration: 1 hours, minutes
Water temperature: ?? degrees F

REMARKS

GARSON, PUMPED WITH AIR. 4 GPM AT 130', 20 GPM AT 160. GLUED 5"
EXTENSION TO 4' ABOVE GRD, WELL MAY FLOW IN WET YEARS.

Test Results from ALS Laboratories, dated March 26, 2012

RM of Brokenhead
ATTN: GRANT PLISCHKE
PO Box 490
Beausejour MB R0E 0C0

Date Received: 20-MAR-12
Report Date: 26-MAR-12 12:39 (MT)
Version: FINAL

Client Phone: 204-268-5581

Certificate of Analysis

Lab Work Order #: L1125670

Project P.O. #: NOT SUBMITTED
Job Reference: RM OF BROKENHEAD
C of C Numbers:
Legal Site Desc:

Robert S. Kitlar
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1125670-1 CELL 1, INTERCELL							
Sampled By: GRANT PLISCHKE on 19-MAR-12 @ 15:00							
Matrix: SEWAGE/WASTE WATER							
Nitrate + Nitrite							
Nitrate as N							
Nitrate-N	0.062		0.050	mg/L		20-MAR-12	R2341149
Nitrate+Nitrite							
Nitrate and Nitrite as N	<0.071		0.071	mg/L		20-MAR-12	
Nitrite as N							
Nitrite-N	<0.050		0.050	mg/L		20-MAR-12	R2341149
Miscellaneous Parameters							
Phosphorus (P)-Total	1.37		0.010	mg/L		21-MAR-12	R2340701
pH	8.45		0.10	pH units		20-MAR-12	R2340361
Un-ionized ammonia							
Ammonia by colour							
Ammonia, Total (as N)	1.61	DLA	0.10	mg/L		24-MAR-12	R2342112
Temperature supplied by Client							
Temperature, Client Provided	5.0		0.1	Degree C		22-MAR-12	R2341321
Un-ionized ammonia							
Ammonia, Un-ionized (as N)	0.076		0.010	mg/L		25-MAR-12	
pH supplied by Client							
pH, Client Supplied	8.60		0.10	pH		22-MAR-12	R2341321
L1125670-2 CELL 2 INTERCELL							
Sampled By: GRANT PLISCHKE on 19-MAR-12 @ 15:00							
Matrix: SEWAGE/WASTE WATER							
Nitrate + Nitrite							
Nitrate as N							
Nitrate-N	<0.050		0.050	mg/L		20-MAR-12	R2341149
Nitrate+Nitrite							
Nitrate and Nitrite as N	<0.071		0.071	mg/L		20-MAR-12	
Nitrite as N							
Nitrite-N	<0.050		0.050	mg/L		20-MAR-12	R2341149
Miscellaneous Parameters							
Phosphorus (P)-Total	0.349		0.010	mg/L		21-MAR-12	R2340701
pH	8.36		0.10	pH units		20-MAR-12	R2340361
Un-ionized ammonia							
Ammonia by colour							
Ammonia, Total (as N)	0.82	DLA	0.10	mg/L		24-MAR-12	R2342112
Temperature supplied by Client							
Temperature, Client Provided	2.0		0.1	Degree C		22-MAR-12	R2341321
Un-ionized ammonia							
Ammonia, Un-ionized (as N)	0.059		0.010	mg/L		25-MAR-12	
pH supplied by Client							
pH, Client Supplied	8.90		0.10	pH		22-MAR-12	R2341321
L1125670-3 CELL 1, DISCHARGE							
Sampled By: GRANT PLISCHKE on 19-MAR-12 @ 15:00							
Matrix: SEWAGE/WASTE WATER							
Nitrate + Nitrite							
Nitrate as N							
Nitrate-N	0.062		0.050	mg/L		20-MAR-12	R2341149
Nitrate+Nitrite							
Nitrate and Nitrite as N	<0.071		0.071	mg/L		20-MAR-12	
Nitrite as N							
Nitrite-N	<0.050		0.050	mg/L		20-MAR-12	R2341149
Miscellaneous Parameters							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1125670-3 CELL 1, DISCHARGE							
Sampled By: GRANT PLISCHKE on 19-MAR-12 @ 15:00							
Matrix: SEWAGE/WASTE WATER							
Phosphorus (P)-Total	2.73		0.010	mg/L		21-MAR-12	R2340701
pH	8.38		0.10	pH units		20-MAR-12	R2340361
Un-ionized ammonia							
Ammonia by colour							
Ammonia, Total (as N)	3.41	DLA	0.10	mg/L		24-MAR-12	R2342112
Temperature supplied by Client							
Temperature, Client Provided	2.0		0.1	Degree C		22-MAR-12	R2341321
Un-ionized ammonia							
Ammonia, Un-ionized (as N)	0.065		0.010	mg/L		25-MAR-12	
pH supplied by Client							
pH, Client Supplied	8.30		0.10	pH		22-MAR-12	R2341321
L1125670-4 CELL 2, DISCHARGE							
Sampled By: GRANT PLISCHKE on 19-MAR-12 @ 15:00							
Matrix: SEWAGE/WASTE WATER							
Nitrate + Nitrite							
Nitrate as N							
Nitrate-N	<0.050		0.050	mg/L		20-MAR-12	R2341149
Nitrate+Nitrite							
Nitrate and Nitrite as N	<0.071		0.071	mg/L		20-MAR-12	
Nitrite as N							
Nitrite-N	<0.050		0.050	mg/L		20-MAR-12	R2341149
Miscellaneous Parameters							
Phosphorus (P)-Total	0.583		0.010	mg/L		21-MAR-12	R2340701
pH	8.27		0.10	pH units		20-MAR-12	R2340361
Un-ionized ammonia							
Ammonia by colour							
Ammonia, Total (as N)	1.75	DLA	0.10	mg/L		24-MAR-12	R2342112
Temperature supplied by Client							
Temperature, Client Provided	3.0		0.1	Degree C		22-MAR-12	R2341321
Un-ionized ammonia							
Ammonia, Un-ionized (as N)	0.088		0.010	mg/L		25-MAR-12	
pH supplied by Client							
pH, Client Supplied	8.70		0.10	pH		22-MAR-12	R2341321

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Sample Parameter Qualifier Key:

Qualifier	Description
DLA	Detection Limit Adjusted For required dilution

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
NH3-COL-WP	Water	Ammonia by colour	APHA 4500 NH3 F

Ammonia in water samples forms indophenol when reacted with hypochlorite and phenol. The intensity is amplified by the addition of sodium nitroprusside and measured colourmetrically.

ALS Test Code	Matrix	Test Description	Method Reference**
NH3-UNION-CALC-WP	Water	Un-ionized ammonia	Calculation
NO2+NO3-CALC-WP	Water	Nitrate+Nitrite	CALCULATION
NO2-IC-WP	Water	Nitrite as N	EPA 300.1 IC
NO3-IC-WP	Water	Nitrate as N	EPA 300.1 IC
P-T-COL-WP	Water	Phosphorus, Total	APHA 4500 P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorous is determined colourimetrically after persulphate digestion of the sample.

ALS Test Code	Matrix	Test Description	Method Reference**
PH-CLIENT-WP	Water	pH supplied by Client	Supplied by client
PH-WP	Water	pH	APHA 4500H

The pH of a sample is the determination of the activity of the hydrogen ions by potentiometric measurement using a standard hydrogen electrode and a reference electrode.

ALS Test Code	Matrix	Test Description	Method Reference**
TEMP-CLIENT-WP	Water	Temperature supplied by Client	Result supplied by Client

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WP	ALS ENVIRONMENTAL - WINNIPEG, MANITOBA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.

mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

12 - 1329 Niakwa Rd. E.
Winnipeg, Manitoba R2J 3T4

Chain of Custody / Analytical Request Form
CHEMISTRY INFO: (204) 255 9739
MICRO INFO: (204) 255 9740 OR (204) 255 9737

WORK ORDER NO: L1125670

FOR LABORATORY USE ONLY
Sample Condition Upon Receipt: ☐
☐ Frozen ☐ Cold ☐ Ambient ☐ Broken ☐ Leakage ☐ Incorrect Sample Container
COMMENT:

LAB NO.:
DATE RECEIVED: 20mar12
TIME RECEIVED: 10:20
BY: 12°

Date Sampled: 19/03/2012 Time: 3 : 00 A.M. ☐ P.M. ☑ Date Required:

Location: RM OF BROKENHEAD (Town, Community, City)

Submitter's Name Printed: GRANT PLISCHKE

Sample Submitted By: GRANT PLISCHKE

Community Code Number: 29.31

Rural Municipality/LGC/UVD: BROKENHEAD

PLEASE PRINT & PRESS FIRMLY

SAMPLE TYPE

DRINKING WATER
- ☐ Untreated Well
- ☐ Treated Well
- ☐ Treated Municipal
- ☐ Non-Treated Municipal
- ☐ Water-Surface-Raw
- ☐ Water-Surface-Treated

PURPOSE OF TEST
☐ Private ☐ Real Estate ☐ Water Main

NON-DRINKING WATER
- ☑ Sewage/Waste Water
- ☐ Lake/River
- ☐ Swimming Pool
- ☐ Whirl Pool
- ☐ Other

NOTES & CONDITIONS
1. Quote number must be provided to insure proper pricing.
2. Failure to properly complete all portions of this form may delay analysis.
3. ALS's liability limited to cost of analysis.

SERVICE REQUESTED
☐ REGULAR ☐ PRIORITY (50% SURCHARGE) ☐ EMERGENCY (100% SURCHARGE)

LAB NUMBER	SAMPLE IDENTIFICATION
	#1 CELL 1, INTERCELL
	#2 CELL 2, INTERCELL
	#3 CELL 1, DISCHARGE
	#4 CELL 2 DISCHARGE
	#5 CELL 1, INTERCELL
	#6 CELL 1, DISCHARGE
	#7 CELL 2, INTERCELL
	#8 CELL 2 DISCHARGE
	CELL 1 INTERCELL 5°C 8.6 PH / DISCHARGE 2°C 8.3 pH
	CELL 2 INTERCELL 2°C 8.9 pH / DISCHARGE 3°C 8.7 pH

ALS CUSTOMER #: *QUOTE #:*

REPORT TO BE SENT TO

NAME: GRANT PLISCHKE
COMPANY: RM OF BROKENHEAD
ADDRESS: BOX 490, BEAUSEJOUR, MB
CITY/TOWN: BEAUSEJOUR / PROV.: MB
POSTAL CODE: R0E 0C0
PHONE: 268-5581
BY: MAIL ☐ FAX ☐ (FAX NUMBER)
PICKUP ☐ E-MAIL ☑ gtwater@xplornet.com (EMAIL ADDRESS)

CC
NAME:
ADDRESS:
CITY/TOWN: / PROV.:
POSTAL CODE:
PHONE:
BY: MAIL ☐ FAX ☐ (FAX NUMBER)
PICKUP ☐ E-MAIL ☐ (EMAIL ADDRESS)

Analyses required AMMONIA (NH3) DISSOLVED
NITRATE + NITRATE - N - DISSOLVED
CALCULATION FOR UN-IONIZED AMMONIA
PHOSPHORUS TOTAL, PH, TEMPERTURE

BILLING ADDRESS SAME AS REPORT TO ☐
NAME:
COMPANY:
ADDRESS:
CITY/TOWN: / PROV.:
POSTAL CODE:

SAMPLING INSTRUCTIONS ON REVERSE SIDE

PAYMENT PARTICULARS
- ☐ INVOICE NEEDED / CLIENT'S P.O. NO.
- ☐ INTERAC
- ☐ CASH — Subtotal $
- ☐ CHEQUE — G.S.T. $
- ☐ VISA / MASTERCARD — Total $

* OUR POLICY IS NOT TO ACCEPT SAMPLES FROM THE PRIVATE CITIZEN WITHOUT PREPAYMENT

ENTERED IN LIMS BY:

Manitoba Technology Centre Ltd.
Part of the ALS Laboratory Group
12 - 1329 Niakwa Rd. E., Winnipeg, MB Canada R2J 3T4
Phone: +1 204 255 9720 Fax: +1 204 255 9721 www.alsglobal.com
A Campbell Brothers Limited Company

ACCOUNT COPY

Test Results from ALS Laboratories, dated May 07, 2012

RM of Brokenhead
ATTN: GRANT PLISCHKE
PO Box 490
Beausejour MB R0E 0C0

Date Received: 25-APR-12
Report Date: 07-MAY-12 14:46 (MT)
Version: FINAL

Client Phone: 204-268-5581

Certificate of Analysis

Lab Work Order #: L1138943

Project P.O. #: NOT SUBMITTED
Job Reference: BROKENHEAD
C of C Numbers:
Legal Site Desc:

Robert S. Kitlar
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1138943-1 CELL #1 - INTERCELL							
Sampled By: GRAND PLISCHKE on 24-APR-12 @ 15:00							
Matrix: SEWAGE / WASTEWATER							
Nitrate + Nitrite							
Nitrate as N by Ion Chromatography							
Nitrate-N	<0.25	DLM	0.25	mg/L		25-APR-12	R2356904
Nitrate+Nitrite							
Nitrate and Nitrite as N	<0.35		0.35	mg/L		25-APR-12	
Nitrite as N by Ion Chromatography							
Nitrite-N	<0.25	DLM	0.25	mg/L		25-APR-12	R2356904
Miscellaneous Parameters							
Ammonia, Total (as N)	0.041		0.010	mg/L		27-APR-12	R2357424
Phosphorus (P)-Total	4.68		0.010	mg/L		30-APR-12	R2357838
Un-ionized ammonia							
Temperature supplied by Client							
Temperature, Client Provided	10.0		0.1	Degree C		25-APR-12	R2355991
Un-ionized ammonia							
Ammonia, Un-ionized (as N)	<0.010		0.010	mg/L		28-APR-12	
pH supplied by Client							
pH, Client Supplied	8.60		0.10	pH		25-APR-12	R2355991
L1138943-2 CELL #2 - INTERCELL							
Sampled By: GRAND PLISCHKE on 24-APR-12 @ 15:00							
Matrix: SEWAGE / WASTEWATER							
Nitrate + Nitrite							
Nitrate as N by Ion Chromatography							
Nitrate-N	0.30		0.25	mg/L		25-APR-12	R2356904
Nitrate+Nitrite							
Nitrate and Nitrite as N	<0.35		0.35	mg/L		25-APR-12	
Nitrite as N by Ion Chromatography							
Nitrite-N	<0.25	DLM	0.25	mg/L		25-APR-12	R2356904
Miscellaneous Parameters							
Ammonia, Total (as N)	8.3	DLA	1.0	mg/L		03-MAY-12	R2359521
Phosphorus (P)-Total	3.99		0.010	mg/L		30-APR-12	R2357838
Un-ionized ammonia							
Temperature supplied by Client							
Temperature, Client Provided	10.0		0.1	Degree C		25-APR-12	R2355991
Un-ionized ammonia							
Ammonia, Un-ionized (as N)	0.296		0.010	mg/L		03-MAY-12	
pH supplied by Client							
pH, Client Supplied	8.30		0.10	pH		25-APR-12	R2355991
L1138943-3 CELL #1 - DISCHARGE							
Sampled By: GRAND PLISCHKE on 24-APR-12 @ 15:00							
Matrix: SEWAGE / WASTEWATER							
Nitrate + Nitrite							
Nitrate as N by Ion Chromatography							
Nitrate-N	<0.25	DLM	0.25	mg/L		25-APR-12	R2356904
Nitrate+Nitrite							
Nitrate and Nitrite as N	<0.35		0.35	mg/L		25-APR-12	
Nitrite as N by Ion Chromatography							
Nitrite-N	<0.25	DLM	0.25	mg/L		25-APR-12	R2356904
Miscellaneous Parameters							
Ammonia, Total (as N)	0.056		0.010	mg/L		04-MAY-12	R2360636
Phosphorus (P)-Total	3.83		0.010	mg/L		30-APR-12	R2357838
Un-ionized ammonia							
Temperature supplied by Client							

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1138943-3 CELL #1 - DISCHARGE							
Sampled By: GRAND PLISCHKE on 24-APR-12 @ 15:00							
Matrix: SEWAGE / WASTEWATER							
Temperature supplied by Client							
Temperature, Client Provided	9.0		0.1	Degree C		25-APR-12	R2355991
Un-ionized ammonia							
Ammonia, Un-ionized (as N)	<0.010		0.010	mg/L		07-MAY-12	
pH supplied by Client							
pH, Client Supplied	8.80		0.10	pH		25-APR-12	R2355991
L1138943-4 CELL #2 - DISCHARGE							
Sampled By: GRAND PLISCHKE on 24-APR-12 @ 15:00							
Matrix: SEWAGE / WASTEWATER							
Nitrate + Nitrite							
Nitrate as N by Ion Chromatography							
Nitrate-N	0.30		0.25	mg/L		25-APR-12	R2356904
Nitrate+Nitrite							
Nitrate and Nitrite as N	<0.35		0.35	mg/L		25-APR-12	
Nitrite as N by Ion Chromatography							
Nitrite-N	<0.25	DLM	0.25	mg/L		25-APR-12	R2356904
Miscellaneous Parameters							
Ammonia, Total (as N)	8.3	DLA	1.0	mg/L		03-MAY-12	R2359521
Phosphorus (P)-Total	4.03		0.010	mg/L		30-APR-12	R2357838
Un-ionized ammonia							
Temperature supplied by Client							
Temperature, Client Provided	9.0		0.1	Degree C		25-APR-12	R2355991
Un-ionized ammonia							
Ammonia, Un-ionized (as N)	0.425		0.010	mg/L		03-MAY-12	
pH supplied by Client							
pH, Client Supplied	8.50		0.10	pH		25-APR-12	R2355991

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Sample Parameter Qualifier Key:

Qualifier	Description
DLA	Detection Limit Adjusted For required dilution
DLM	Detection Limit Adjusted For Sample Matrix Effects

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
NH3-COL-WP	Water	Ammonia by colour	APHA 4500 NH3 F
Ammonia in water samples forms indophenol when reacted with hypochlorite and phenol. The intensity is amplified by the addition of sodium nitroprusside and measured colourmetrically.			
NH3-UNION-CALC-WP	Water	Un-ionized ammonia	Calculation
NO2+NO3-CALC-WP	Water	Nitrate+Nitrite	CALCULATION
NO2-IC-WP	Water	Nitrite as N by Ion Chromatography	EPA 300.1 (modified)
Anions in aqueous matrices are analyzed using ion chromatography with conductivity and/or UV absorbance detectors.			
NO3-IC-WP	Water	Nitrate as N by Ion Chromatography	EPA 300.1 (modified)
Anions in aqueous matrices are analyzed using ion chromatography with conductivity and/or UV absorbance detectors.			
P-T-COL-WP	Water	Phosphorus, Total	APHA 4500 P PHOSPHORUS
This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorous is determined colourimetrically after persulphate digestion of the sample.			
PH-CLIENT-WP	Water	pH supplied by Client	Supplied by client
TEMP-CLIENT-WP	Water	Temperature supplied by Client	Result supplied by Client

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WP	ALS ENVIRONMENTAL - WINNIPEG, MANITOBA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Laboratory Group
ANALYTICAL CHEM

12 - 1329 Niakwa Rd. E.
[illegible]peg, Manitoba R2J 3T4
[illegible]04) 255-9720
[illegible]204) 255-9721
[illegible]ee: 1 800 607 7555

Chain of Custody / Analytical Request For[m]

CHEMISTRY INFO: (204) 255 9739
MICRO INFO: (204) 255 9740 OR (204) 255 [illegible]

Environme[nt]

L1138943-COFC

WORK ORDER NO:
LAB NO: L1138943

FOR L[AB USE ONLY]
Sample Condition Upon Receipt: ☐ ACCEPTABLE ☐ NON ACCEPTABLE
☐ Frozen ☐ Cold ☐ Ambient ☐ Broken ☐ Leakage ☐ Incorrect Sample Container
COMMENT: 17°

DATE RECEIVED: 25Apr12
TIME RECEIVED: 11:00
BY: [illegible]

Date Sampled: 24/04/2012 Time: 3 : 00 A.M. ☐ P.M. ☑
Date Required: REGULAR

Location: RM OF BROKENHEAD
(Town, Community, City)

Submitter's Name Printed: GRANT PLISCHKE
Sample Submitted By: GRANT PLISCHKE

Community Code Number: 29.31
Rural Municipality/LGC/UVD: BROKENHEAD

SAMPLE TYPE

PLEASE PRINT & PRESS FIRMLY

DRINKING WATER
- ☐ Untreated Well
- ☐ Treated Well
- ☐ Treated Municipal
- ☐ Non-Treated Municipal
- ☐ Water-Surface-Raw
- ☐ Water-Surface-Treated

PURPOSE OF TEST
☐ Private ☐ Real Estate ☐ Water Main

NON-DRINKING WATER
- ☑ Sewage/Waste Water
- ☐ Lake/River
- ☐ Swimming Pool
- ☐ Whirl Pool
- ☐ Other

NOTES & CONDITIONS
1. Quote number must be provided to insure proper pricing.
2. Failure to properly complete all portions of this form may delay ana[lysis]
3. ALS's liability limited to cost of analysis.

SERVICE REQUESTED
☐ REGULAR ☐ PRIORITY (50% SURCHARGE) ☐ EMERGENCY (100% SURCHA[RGE])

LAB NUMBER	SAMPLE IDENTIFICATION	
	#1 - CELL 1 INTERCELL	
	#2 - CELL 1 INTERCELL	
	#3 - CELL 2 INTERCELL	
	#4 - CELL 2 INTERCELL	
	#5 - CELL 1 DISCHARGE	
	#6 - CELL 1 DISCHARGE	
	#7 - CELL 2 DISCHARGE	
	#8 - CELL 2 DISCHARGE	
	CELL 1	
	INTER CELL	DISCHARGE
	PH 8.6 TEMP 10c	PH 8.8 TEMP 9c
	CELL 2	
	INTERCELL	DISCHARGE
	PH 8.3 TEMP 10c	PH 8.5 TEMP 9c

ALS CUSTOMER #: QUOTE #:

REPORT TO BE SENT TO

NAME: GRANT PLISCHKE
COMPANY: RM OF BROKENHEAD
ADDRESS: BOX 490
CITY/TOWN: BEAUSEJOUR / PROV.: MB
POSTAL CODE: R0E 0C0
PHONE: 268-5581
BY: MAIL ☐ FAX ☑ 204-268-4169 (FAX NUMBER)
PICKUP ☐ E-MAIL ☑ gtwater@xplornet.c[om] (EMAIL ADDRESS)

CC
NAME:
ADDRESS:
CITY/TOWN: / PROV.:
POSTAL CODE:
PHONE:
BY: MAIL ☐ FAX ☐ (FAX NUMBER)
PICKUP ☐ E-MAIL ☐ (EMAIL ADDRESS)

Analyses required: AMONIA (NH3) DISSOLVED
NITRATE + NITRATE - N - DISSOLVED
CALCULATION FOR UN-IONIZED AMMONIA
PHOSPHORUS TOTAL

BILLING ADDRESS SAME AS REPORT TO ☑
NAME:
COMPANY:
ADDRESS:
CITY/TOWN: / PROV.:
POSTAL CODE:

PAYMENT PARTICULARS
- ☐ INVOICE NEEDED / CLIENT'S P.O. NO.
- ☐ INTERAC
- ☐ CASH Subtotal $
- ☐ CHEQUE G.S.T. $
- ☐ VISA / MASTERCARD Total $

* OUR POLICY IS NOT TO ACCEPT SAMPLES FROM THE PRIVATE CITIZEN WITHOUT PREPAYMEN[T]

SAMPLING INSTRUCTIONS ON REVERSE SIDE

Manitoba Technology Centre Ltd.
Part of the ALS Laboratory Group
12 - 1329 Niakwa Rd. E., Winnipeg, MB Canada R2J 3T4
Phone: +1 204 255 9720 Fax: +1 204 255 9721 www.alsglobal.com
A Campbell Brothers Limited Company

SUBMITTER COPY

ENTERED IN LIMS BY: [signature]

Appendix C

Plan 1: Proposed Lagoon Expansion Site Layout

Plan 2: Proposed Lagoon Expansion Site Layout with Test Hole Locations and Topographic Contour Lines

SCALE BAR
(IN METRES)
50 0 25 50 100 150 200 250
1:2500

No.	REVISIONS	DATE	INITIALS

B.M. ELEV.

LOCATIONS OF UNDERGROUND STRUCTURES/UTILITIES AS SHOWN ARE BASED ON AVAILABLE INFORMATION BUT NO GUARANTEE IS GIVEN OR IMPLIED THAT ALL EXISTING UNDERGROUND STRUCTURES/UTILITIES ARE SHOWN OR THAT THE GIVEN LOCATIONS ARE EXACT. CONFIRMATION OF EXISTENCE AND EXACT LOCATION OF ALL UNDERGROUND STRUCTURES/UTILITIES MUST BE OBTAINED FROM THE APPROPRIATE AUTHORITY/OWNER, BY THE CONTRACTOR, BEFORE PROCEEDING WITH CONSTRUCTION.

ENGINEER'S SEAL

PRELIMINARY

J. R. Cousin Consultants Ltd.
Consulting Engineers and Project Managers
91A Scurfield Blvd. Winnipeg, MB R3Y 1G4
ph: (204) 489-0474 fax: (204) 489-0487
email: info@jrcc.ca website: www.jrcc.ca
Engineering Excellence since 1981

CODE:	PROJECT:
B-246.09	RM OF BROKENHEAD – GARSON/TYNDALL/HENRYVILLE LAGOON FEASIBILITY STUDY
DESIGNED BY: JC	TITLE: PROPOSED LAGOON EXPANSION SITE LAYOUT
DRAWN BY: BM	
REVIEWED BY: JC	SCALE: 1:2500 · DATE: 12/06/28 · PLAN: 1 · SHEET: 1 of 2

SCALE BAR
(IN METRES)

50 0 25 50 100 150 200 250

1:2500

No.	REVISIONS	DATE	INITIALS

B.M. ELEV.

LOCATIONS OF UNDERGROUND STRUCTURES/UTILITIES AS SHOWN ARE BASED ON AVAILABLE INFORMATION BUT NO GUARANTEE IS GIVEN OR IMPLIED THAT ALL EXISTING UNDERGROUND STRUCTURES/UTILITIES ARE SHOWN OR THAT THE GIVEN LOCATIONS ARE EXACT. CONFIRMATION OF EXISTENCE AND EXACT LOCATION OF ALL UNDERGROUND STRUCTURES/UTILITIES MUST BE OBTAINED FROM THE APPROPRIATE AUTHORITY/OWNER, BY THE CONTRACTOR, BEFORE PROCEEDING WITH CONSTRUCTION.

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Engineering Excellence since 1981

CODE: B–246.09

DESIGNED BY: JC

DRAWN BY: BM

REVIEWED BY: JC

PROJECT: RM OF BROKENHEAD – GARSON/TYNDALL/HENRYVILLE LAGOON FEASIBILITY STUDY

TITLE: PROPOSED LAGOON EXPANSION SITE LAYOUT WITH TEST HOLE LOCATIONS AND TOPOGRAPHIC CONTOUR LINES

SCALE:	DATE:	PLAN:	SHEET:
1:2500	12/06/28	2	2 of 2

Appendix D

Detailed Cost Estimate

COST ESTIMATE FOR RM OF BROKENHEAD LAGOON EXPANSION

F:\200\246 Brokenhead RM\246.09 GTH Lagoon Feasibility Study\18 Cost Estimate\[Brokenhead Cost Estimate.xlsx]LAGOON EXPANSION

RM OF BROKENHEAD LAGOON EXPANSION B-246.09

Summary of Lagoon Expansion

		Construction	Non Const	Total
0.1	Forcemain to Lagoon	$202,200	$60,600	$262,800
0.2	Land Aquisition	$0	$0	$0
0.3	General Costs	$54,000	$16,200	$70,200
0.4	Access Road, Truck Turnaround and Truck Dump	$68,900	$20,600	$89,500
0.5	Underground Piping	$111,000	$33,400	$144,400
0.6	Landscaping & Fencing	$49,100	$14,800	$63,900
0.7	Earthwork, Ditches and Seeding	$1,554,200	$466,200	$2,020,400
0.8	Geotechnical During Construction	$45,700	$13,800	$59,500
0.9	Miscellaneous	$6,000	$1,800	$7,800
0.10	Borrow Pit	$0	$0	$0
0.11	Geotechnical Studies and Environmental Contingency	$0	$12,500	$12,500
	Lagoon Subtotals:	$2,091,100	$639,900	**$2,731,000**
0.12	Rip Rap for New Dikes Only	$328,600	$98,600	$427,200
	Total with Rip Rap:	$2,419,700	$738,500	**$3,158,200**