Rural Municipality of Brokenhead

Pre-Design Report
for the
Wastewater Lagoon Expansion and Upgrading

December 2014

DRAFT

ENGINEERING CONSULTANTS

RURAL MUNICIPALITY OF BROKENHEAD

Pre-Design Report

for the

Wastewater Lagoon Expansion and Upgrading

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December 2014

ENGINEERING CONSULTANTS

ACKNOWLEDGMENTS

To prepare this preliminary design report, various sources of information were investigated and researched. JR Cousin Consultants Ltd. thanks the RM of Brokenhead who contributed data and content for this pre-design report.

REMARKS

The findings and recommendations in this report were prepared in accordance with generally accepted professional engineering principles and practices. The findings and recommendations were based upon objective data available to us at the time of forming our opinions and the accuracy of the report depends upon the accuracy of this data.

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1.0 INTRODUCTION

1.1 Background

The RM of Brokenhead retained JR Cousin Consultants Ltd. (JRCC) to address wastewater lagoon upgrading to accommodate new wastewater quality regulations and the future proposed growth in the communities of Garson, Tyndall, and Henryville as well as the truck haul loadings from the rural residents in the RM of Brokenhead.

An Environment Act Proposal application was submitted to upgrade the lagoon. Environment Act Licence 2646 RR was received on April 9, 2014.

1.2 Project Scope and Description

The scope of work is to provide engineering services to prepare the design, plans, specifications and tender documents for the wastewater lagoon expansion and upgrading project.

The lagoon expansion works include construction of two new primary cells and a new storage cell. The cells will be constructed with a total dike height of 3.5 m. The cells will be operated as facultative lagoon cells in Phase 1 (current phase) with a maximum liquid level of 1.5 m. In Phase 2, an aeration system will be added and the cells will be operated at a maximum liquid level of 2.5 m.

New environmental guidelines were released by Manitoba Conservation on November 28, 2011 that included requirements for phosphorus reduction. The RM decided to address phosphorus reduction by chemical addition and settling in the primary and storage cells as part of a nutrient management program. It was decided to "try" this approach without a filtration stage to lower total phosphorus to less than 1.0 mg/L. Chemical will be added to the piped wastewater from the communities of Garson, Tyndall, and Henryville whereas the trucked wastewater direct to the lagoon will not receive chemical treatment. The trucked wastewater will impact the overall chemical effectiveness; hence more chemical will have to be added at the chemical feed building.

As stated in the feasibility study, the effectiveness of simple chemical addition methodology as a Phase 1 is relatively unknown and in future as a subsequent phase up-flow sand filters may have to be added to obtain sufficient reduction of phosphorous. If the chemical addition and settling system is insufficient at reducing the phosphorus concentration, chemical can be surface applied on a case by case basis, but preferably a filtration system should be added as a long term solution.

For the Phase 1 selected phosphorus reduction method of chemical addition and settling in the cells, a building will be constructed at the lagoon site to house the chemical storage and injection system.

A brief listing of the works consists of:

- Implementing works to construct new primary cells and storage cell.
- Implementing works to add the injection of alum on a flow paced basis.

- Constructing a new access road, truck turnaround and concrete spillway for the new primary cells and to providing access to the chemical feed building.
- Extending the forcemain from the existing primary cell to the new primary cells.
- Constructing the dikes higher than currently required so in the future the primary cells and storage cell can be converted to add an aeration system.

Optional works that were discussed but not selected by the RM are listed below:

- Options to provide enhanced wastewater treatment to lower BOD below typical facultative lagoon normal parameters and to address nitrogen reduction were discussed.
- Installation of up-flow sand filters with chemical feed to reduce the phosphorous.
- Options to limit erosion of the dikes by adding rip rap on the dikes of the proposed new cells. As rip rap is not included with the lagoon expansion, there will be some risk of dike erosion. Cost estimates for rip rap on the new cells were included as an extra.
- The EAP recommended re-working and re-compacting the soils under the new dikes to reduce the risk of having to re-build the dikes if the liner did not pass Manitoba Conservation regulations. Upon further review, re-working of soils under the dikes could be removed to reduce capital costs. The cost estimates include re-working soils under the dikes as an extra.

1.3 Project Report

The pre-design report herein contains a description of our proposed design complete with capital cost estimates of required works. Overall, the report presents our investigation, which includes information from meetings, engineering knowledge of the present system, office computations and summarization.

2.0 LAGOON REGULATORY REQUIREMENTS AND LICENSE #2646 RR

2.1 License and Provincial Design Objectives

For the Environmental Submission, the Province of Manitoba *Design Objectives for Standard Sewage Lagoons* was used to solicit a license. The impact of the issued Environmental Act License No. 2646 RR, April 9, 2014 and the provincial design objectives are reviewed below.

Organic Loading

The new license has been issued with the typical average organic treatment capacity of 56 kg BOD_5/ha/day in the primary cell.

Hydraulic Loading

The license states that the lagoon cannot be discharged between November 1 and June 15 (230 day winter storage period) as per the Provincial Design Objectives. Therefore, the lagoon will have the storage capacity for this time period based upon half the volume of the primary cell and the storage cell volume from the invert of the discharge pipe (0.3 m) to the maximum liquid level (1.5 m).

Lagoon Liner

In accordance to the license, the lagoon cells will be designed 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.

Effluent Quality Requirements

The license stipulates the lagoon is required to meet the *Manitoba Water Quality Standards, Objectives and Guidelines - Tier 1 Water Quality Standards* at a minimum, for discharged effluent. The effluent standards specific to the RM of Brokenhead lagoon are not to exceed:

- 200 fecal coliforms/100 mL or 200 E. coli/100 mL
- 1500 total coliform/100 mL
- 25 mg/L BOD
- 25 mg/L TSS
- 1 mg/L Total Phosphorus
- 1.25 mg/L unionized ammonia.

2.2 Nutrient Management Plan

The new nutrient reduction guidelines require a 1.0 mg/L phosphorus limit, which was identified in the Environmental Act License No. 2646 RR.

2.2.1 Phosphorous Concentrations in Lagoon and Options for Reduction

The total phosphorous concentrations found in the cells from five samples tested by ALS Laboratories Ltd., between March and October 2012 are summarized in the following table.

Table 1: Phosphorous concentrations in the existing lagoon

Location	Total Phosphorus Concentration (mg/L)				
	Mar	Apr	Jun	Aug	Oct
Cell 1 Intercell	1.37	4.68	7.27	10.40	9.57
Cell 1 Discharge	2.73	3.83	2.69	2.65	3.37
Cell 2 Intercell	0.349	3.99	7.72	9.93	8.44
Cell 2 Discharge	0.583	4.03	3.20	3.45	3.10

As shown in the table, there is some natural phosphorus reduction occurring in the existing storage cells as generally the phosphorus concentration is lower at the discharge location compared to the intercell location (from the primary cell). The phosphorus concentration was greater than 1.0 mg/L in all samples except for two and therefore phosphorus reduction measures will be required.

The options considered to address phosphorus reduction for the RM of Brokenhead lagoon were:

- phosphorus reduction by filtration
- phosphorus reduction by surface chemical treatment
- phosphorus reduction by chemical addition in the forcemain followed by settling in the lagoon
- constructed wetlands
- public awareness.

2.2.2 Selected Phosphorous Reduction Option by Chemical Addition in Forcemain

Upon review of the options and budgets for phosphorus reduction the RM decided to address phosphorus reduction by chemical addition and settling in the primary and storage cells as part of a nutrient management program. For budget reasons, Council decided to “try” this approach without the subsequent filtration stage to lower total phosphorus to less than 1.0 mg/L. As stated in the feasibility study, the effectiveness of simple chemical addition methodology is relatively unknown and up-flow sand filters at the lagoon site, the subsequent phase, may have to be added to obtain sufficient reduction of phosphorous.

The chemical feed rate required to reduce phosphorus to 1.0 mg/L depends on many parameters of the raw sewage including the incoming phosphorus concentration, the amount of solids, alkalinity and the pH, among others. The quality of mixing between alum and the wastewater will also affect phosphorus reduction. Chemical will be added to the piped wastewater from the communities of Garson, Tyndall, and Henryville whereas the trucked wastewater direct to the lagoon will not receive alum. The trucked wastewater will impact the overall chemical effectiveness; hence more alum will have to be added to the piped wastewater.

A chemical feed rate can be estimated based on theoretical removal rates and past experience at other sites. In practice, the chemical feed rate will have to be adjusted based on operational experience from actual test results in the lagoon cells and record keeping of chemical feed rates. There is a chance that the phosphorus will not meet the 1.0 mg/L limit and surface chemical application from a boat would be required prior to discharge, especially in the first years when experimental test results are not available.

The subsequent phase, the addition of a filtration system, would be the long-term solution if surface applied chemical addition is required annually.

Summary 1: The feasibility study reviewed various options for phosphorous reduction that were discussed with Council. The selected option by chemical addition and settling can be initially used and if surface application is still required it can be followed by a subsequent project phase of adding a filtration system at the lagoon site.

2.2.3 Sludge Management

The existing primary cell has been in operation for approximately 10 years and likely has some sludge accumulation. The primary cell will be converted to a storage cell when the lagoon expansion and upgrade is complete. The sludge could be removed to gain some additional capacity in the cell, but the additional capacity would likely be very minimal and the costs for sludge removal would be high. It is not recommended to remove sludge from the existing primary cell.

The sludge containing the phosphorus would accumulate in the lagoon cells and require removal after approximately 20 - 25 years. Based on file data, facultative lagoons in Manitoba without phosphorus reduction systems have some natural phosphorus reduction by settling in the lagoon. With the chemical addition and settling system, additional phosphorus will bind with the alum and settle out. When sludge is removed from the lagoon, some of the phosphorus would likely remain bound to the alum in the sludge potentially causing difficulty for plant uptake if the sludge was land applied. The sludge would also contain the phosphorus not chemically bound, which would be available for plant uptake.

When sludge removal is required, a complete Environment Act Proposal would be submitted to obtain an Environment Act Licence from Manitoba Conservation. At the time of sludge removal, the best practice technology for use of nutrients, organic matter and energy will be reviewed and evaluated. Methods for sludge removal include land application or sludge drying and hauling to an acceptable landfill.

3.0 POPULATION, WASTEWATER PRODUCTION, AND LAGOON EXPANSION SIZING

3.1 Population Contributing Effluent

The current and future design year 20 (year 2032 from the initial study used for licensing) populations contributing effluent to the lagoon are discussed. Wastewater production rates are based on actual water meter readings from the water treatment plant (WTP) and the lift station to the lagoon from 2008 - 2014. The data is discussed below.

Population projections and organic and hydraulic loading from 2012 (year study completed) to design year 20 (2032) are shown on Table 1 attached in Appendix A. The lagoon was sized to utilize the maximum available land area (Parcel 1) east of the existing lagoon in the NW ¼ and SW ¼ of 15-13-06 E, as per the RM of Brokenhead Council resolution passed on February 1, 2012. Since February 1, 2012, the RM of Brokenhead Council has purchased more land (Parcel 2) in the SE ¼ of 15-13-06 E that is located east of Parcel 1. JRCC recently conducted a geotechnical investigation on the Parcel 2 land purchase, results are discussed herein. Parcel 1 and Parcel 2 are shown on Plan L1 attached in Appendix C.

3.1.1 Existing Lagoon Design Parameters

The 2004 total population of Garson, Tyndall, and Henryville used in the original lagoon design was 1,025 people which included the 37 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.

The 2004 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 of 56 kg BOD5/ha/day and was decreased so that odours from the lagoon would not become an issue. This decision was made following the Clean Environment Commission hearing.

3.1.2 Current and Projected 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. There were 157 building permits issued in Garson and Tyndall over that time period. No building permits were issued for Henryville.

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.

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 that 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 three subdivisions in the planning stage that 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.

Prior to the Revised May 2013 Environmental Submission the municipality owned land east of the existing lagoon (Parcel 1) amounting to 24 ha, hence the lagoon expansion was to be constructed to utilize the maximum available land area.

For that land (Parcel 1) the lagoon expansion would accommodate an additional 758 people in Garson, Tyndall, and Henryville. This results in an additional 216 lots that are available for development once the lagoon expansion is complete. Since the Environmental Submission and subsequent license, the municipality purchased additional land further east (Parcel 2). There was no discussion on further increasing the size of the lagoon but discussion ensued on a possible re-orientation of the proposed lagoon to possibly obtain more consistent geotechnical conditions than what existed in the northern portion of Parcel 1. Any possible re-orientation of the proposed lagoon is dependent upon suitable geotechnical conditions in Parcel 2. The additional geotechnical investigation, of October 2014, is discussed further in this report.

Table 2: 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

Time	Development	Population
Future Available	216 lots are available for development based on constructing the lagoon for the maximum available land	758
Total	990 houses are to be serviced by the water and sewer system upon completion of the committed and proposed development and 216 lots are available for development	3,753

From the above information, correspondence with Council and follow up discussion the above table reflecting a future population of 3,753 people by the design year 20 (2032) was to be used for the growth in Garson, Tyndall, and Henryville. The growth rate from 2012 - 2032 will be approximately 4.56% over the 20 year time period. This is a decrease of 1.84% from the population growth rate of 6.4% observed from 2005 - 2011.

Summary 2: The design year 20 (2032) population of Garson, Tyndall, and Henryville used in design was 3,753 people which results in an average growth rate of 4.56% from 2012 to 2032.

3.1.3 Population of the RM of Brokenhead

The lagoon will also service the remainder of the RM of Brokenhead rural residents by truck haul from a combination of septic and holding tanks. The population of the RM of Brokenhead is estimated based on Canada Census data provided by Statistics Canada. The values below for RM of Brokenhead population **include** the populations of Garson, Tyndall, and Henryville.

Table 3: 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

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 2011 population and the projected 2012 and 2032 RM populations and the portion of the population serviced by septic tanks and holding tanks.

Table 4: 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 3: The design year 20 (2032) Population of RM of Brokenhead is projected to be 4,230; Population using Septic Tanks is 3,172;and Population using Holding Tanks is 1,058.

3.2 Wastewater Production

3.2.1 Reported Water Consumption of Garson/Tyndall/Henryville

Raw water usage and water consumption data from 2008 – 2014 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 5: Actual Water Usage from the RM of Brokenhead WTP

Year	2008	2009	2010	2011	2012	2013	2014
Average Daily Raw Water Usage (m^3/day)	155	245	286	335	359	360	384
Average Daily Water Consumption (m^3/day)	115	171	205	237	252	256	267
Percentage Reject (Reject Water/Raw Water Intake)	25.1%	29.9%	28.3%	29.3%	30.0%	28.8%	30.4%
Estimated Population (Calculated based on building permits issued since 2004)	1,254	1,286	1,342	1,405	1,538	1,609	1,689
Actual Average Per Capita Water Consumption (L/person/day)	91	133	153	169	164	159	158

As shown in Table 5, the per capita water usage increased from 2008 to 2011 and has slightly decreased from 2011 - 2014. 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 original lagoon 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 younger families may possibly 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.

Recent water use data was obtained from 2012 to 2014 to determine if the water use per person from the communities had changed from what was previously determined. An assessment of the recent data indicates that the water use has slightly decreased from 2011 - 2014.

The previous reports used a water consumption rate of 225 L/person/day for design purposes. There have been no significant changes to the water use from 2012 - 2014 and therefore the water consumption rate of 225 L/person/day will continue to be used for design.

The percentage of reject water ranged from 25.1% to 30.4% between 2008 and 2014, 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 to determine the projected hydraulic loadings to the lagoon.

3.2.2 Reported Wastewater Production of Garson/Tyndall/Henryville

Reported effluent flows to the lagoon from 2008 - 2014 were obtained from the lagoon operator as measured from a flow meter at the lift station. The data most likely contained errors since from 2010 to 2013, less water was reportedly sent to the lagoon than was drawn from the raw water well. The amount of wastewater sent to the lagoon should be the amount drawn from the raw water well plus some amount of infiltration into the system. 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. Since the 2012 study no work had been completed on water meters regarding calibration, etc.

For the purposes of design, the infiltration percentage assumed in the original design of 15% of the per capita water usage or 34 L/person/day (15% of 225 L/person/day) will continue to be utilized.

Therefore the total wastewater production for Garson, Tyndall, and Henryville will be 355 L/person/day (225 L/p/d water consumption + 96 L/p/d reject water + 34 L/p/d infiltration).

3.2.3 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 allowable summer hauling 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 community 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.

The truck haul loadings to the lagoon from 2010 to 2014 were recorded by the RM. Each septic truck hauler has a coded key for the lagoon gate. The lock on the gate records the date and time the lock is opened so the number of truck loads to the lagoon can be recorded. Each truck load is assumed to carry a full load of 6,819 L (1,500 Igal). Some 13,638 L (3,000 Igal) trucks have started to haul to the lagoon in 2014 which are recorded separately. The septic truck records do not differentiate between septic tank pump outs and holding tank pump outs. The following table shows the annual truck haul loadings to the lagoon.

Table 6: Recorded Truck Haul Loadings to the RM of Brokenhead Lagoon

Year	2010	2011	2012	2013	2014*
Truck Loads per Year	1,159	1,168	1,318	1,457	1,069**
Volume per Year (m^3)	7,903	7,965	8,988	9,935	8,122

*2014 loads were from January to October 22 (295 days)

**In 2014 - 947 loads were delivered with 1500 Igal trucks and 122 loads with a 3,000 Igal truck

The expected volume of wastewater from truck haul was calculated from 2010 - 2014 based on a hydraulic loading rate of 200 L/person/year for populations on holding tanks and 1,730 L/person/year for populations of septic tanks (200 L of septage and 1,530 L of sewage) and the population. The following table shows the calculated truck haul volumes to the lagoon:

Table 7: Calculated Truck Haul Loadings to the RM of Brokenhead Lagoon

Year	2010	2011	2012	2013	2014*
Population on Septic Tanks	2,356	2,388	2,421	2,454	2,488
Population on Holding Tanks	786	796	807	818	830
Expected Truck Haul Loadings - Septic Tanks (m^3/year)	4,076	4,131	4,188	4,245	3,478

Year	2010	2011	2012	2013	2014*
Expected Truck Haul Loadings - Holding Tanks (m^3/year)	57,378	58,108	58,911	59,714	48,957
Total Expected Truck Haul Loadings (m^3/year)	61,454	62,239	63,099	63,959	52,435

*2014 expected loading from January to October 22 (295 days)

As shown on Table 7, the calculated truck haul loadings to the lagoon are significantly higher than the RM's truck haul records. The calculated truck haul volumes are based on the assumption that 25% of the rural residences have holding tanks and 75% have septic tanks. Residents with holding tanks will contribute significantly higher wastewater volumes compared to residents with septic tanks where the majority of the hydraulics are pumped to a septic field and only the concentrated septage is hauled to the lagoon approximately once per year. The large discrepancy between the calculated truck haul loadings and the recorded truck haul loadings could be attributed to a lower population serviced by holding tanks at this point in time.

In the past, some septic truck haulers have sent two trucks into the lagoon at once, which only get recorded as one load, thus the actual truck haul volumes could be larger than reported.

The expected truck haul loadings will not be adjusted based on the RM's actual truck haul records for the following reasons:

- In future, more residences in the RM may switch from septic tanks to holding tanks due to failing septic fields and more stringent environmental regulations.
- The RM's truck haul records may be lower than actually hauled to the lagoon.
- Using higher truck haul volumes will result in a slightly larger lagoon. If the actual truck haul volumes remain lower than calculated, the additional lagoon capacity could be used by additional residents in Garson, Tyndall and Henryville.

3.3 Lagoon Loading

The required size of the lagoon is based on the above projected wastewater production to year 20 population contributing wastewater to the lagoon.

3.3.1 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 design year 20 daily organic loading is:

- 285.2 kg BOD_5/day (i.e. 3,753 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 / 1,000) from the rural residents on septic tanks.

The total organic loading in design year 20 (2032) is 402.3 kg BOD_5/day.

Summary 4: The design year 20 (2032) organic loading is calculated to be 402.3 kg BOD_5/day.

3.3.2 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% reject water or 96 L/person/day 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 projected year 20 (2032) daily hydraulic loadings to the lagoon are:

- 1,350 m^3/day (3,803 x 355 / 1000) from the Garson, Tyndall, and Henryville populations including the bussed-in students
- 212 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 1,567 m^3/day, in summer, and in winter is 1,562 m^3/day (1,567 m^3/day - 5 m^3/day from septic tanks). The storage for the winter 230 day storage requirement is 359,183 m^3.

Summary 5: The 230 day winter storage requirement is 359,183 m^3.

3.4 Existing Lagoon Capacity

The organic and hydraulic storage capacities of the lagoon were determined from record drawings of the existing lagoon and confirmed by aerial photographs.

3.4.1 Existing Organic Treatment Capacity

The organic loading rate as per the 2004 Environmental Licence was 45.64 kg BOD_5/ha/day. 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 302.1 kg BOD_5/day less than the projected year 20 required treatment capacity of 402.3 kg BOD_5/day.

3.4.2 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 storage cell volume, between a liquid level of 0.3 m and 1.5 m above the storage cell floor. The 230 day storage capacity of the existing lagoon is:

Hydraulic Capacity of Lagoon	**178,200 m^3 or 2,182 equivalent people** **Based on a loading of 355 L/p/d**

The existing hydraulic storage capacity is currently 180,983 m^3 less than the projected design year 20 required hydraulic capacity of 359,183 m^3.

Summary 6: The lagoon is capable of treating 100.2 kg BOD_5/day. This treatment capacity corresponds to an equivalent population of 1,318 people based on a typical organic loading of 0.076 kg BOD_5/person/day.

The total hydraulic capacity of the lagoon is calculated to be 178,200 m^3. From past years of operation the average per capita wastewater production of 355 L/person/day the current lagoon is suitable for the hydraulic loadings of 2,182 people.

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 both organically and hydraulically.

3.5 Size of Expansion Required

Consideration was given by the RM of Brokenhead to construct an aerated lagoon expansion to reduce the footprint of the expansion cell, provide mitigation of potential odour generation and provide overall enhanced wastewater treatment. After review of budgets it was determined that capital costs of an aerated lagoon expansion were too high at this stage of the project. Council decided that a facultative lagoon expansion would be constructed with the intention that the new facultative lagoon cells would be converted to aerated lagoon cells in the future.

The dikes of the expansion cells will be constructed with a total height from the cell floor to top of dike of 3.5 m. The new Primary Cell #1 will have a 1.0 m weir constructed to ensure the cells are not operated above a 1.5 m liquid level with a 1.0 m freeboard while operating as a facultative lagoon. When aeration lines are added to the new cells in the future, the weir will be removed and a maximum liquid level of 2.5 m will be utilized with a 1.0 m freeboard. The location of the weir is shown on Plan L3 and the weir detail is shown on Plan L5, attached in Appendix C.

The new expansion cells will be constructed with a 5:1 inner dike slope and a 4:1 outer dike slope. The discharge pipe invert in the new storage cell will be 0.3 m above the cell floor elevation. A liquid storage period of 230 days was utilized in cell sizing as per Manitoba Conservation requirements.

A detailed description of the expansion cells are provided below.

3.5.1 New Primary Cells

The facultative lagoon expansion is designed with the intention that the new facultative lagoon cells will be converted to aeration lagoon cells in the future. One large primary cell would be sufficient for a facultative lagoon but when aeration is added, two primary cells will be required to provide sufficient treatment. Therefore, two primary cells will be constructed at this stage with a splitter manhole to provide relatively equal wastewater loadings to each cell. Following is a description of the cells:

3.5.1.1 New Primary Cells as Facultative Cells

Based on the existing ground 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 were met. To balance the cut and fill quantities, reducing the required earthwork and capital costs, the new cell top of dike would have to be constructed at a higher elevation than the existing lagoon. This will also reduce the amount of high plastic clay excavated from the floor of the lagoon, increasing the depth of the in situ clay liner.

The storage cells of a lagoon cannot be constructed at a higher elevation than the primary cells because flow from the primary cells to the storage cells is by gravity. Therefore, new primary cells will be constructed at the highest ground elevation which is on the east side of the expansion area on Parcel 2. The primary cells will be constructed at a higher elevation than the existing lagoon cells and the proposed storage cell with a total dike height of 3.5 m.

A new storage cell will be constructed east of the existing lagoon and west of the new primary cells. The storage cell top of dike elevation will be lower than the primary cell dikes and higher than the existing lagoon. The total dike height will be 3.5 m. This will allow the lagoon to operate by gravity and allow aeration to be added to the lagoon in future. A portion of the existing lagoon east dike will have to be raised to meet the new storage cell top of dike elevation.

Once aeration is added to the new lagoon cells in the future, two aerated primary cells are required to provide sufficient retention time for BOD reduction. For this reason two new primary cells will be constructed at this stage. The existing forcemain will be re-routed to a splitter manhole, which will re-direct the wastewater via a forcemain to the new Primary Cell #1 and to the new Primary Cell #2.

The existing primary cell will be converted to a storage cell and the existing truck turnaround and spillway will be abandoned. A new truck turnaround area and spillway will be constructed at the new Primary Cell #1.

The new Primary Cell #1 when operated as a facultative cell will have an area at a height of 0.75 m from the cell floor of 35,950 m^2. The new Primary Cell #2 when operated as a facultative cell will have an area at a height of 0.75 m from the cell floor of 36,130 m^2. The total combined surface area of 72,080 m^2 is sufficient to provide an organic treatment capacity of 403.6 kg BOD_5/day at an organic treatment rate of 56 kg BOD_5/ha/day. This is 1.3 kg BOD_5/day greater than the projected year 20 organic loadings. The combined hydraulic storage in the "top half" of the primary cells will be 56,450 m^3.

3.5.1.2 New Primary Cells as Aerated Cells

When aeration lines are added to the primary cells in future, the primary cells will have the capacity to treat approximately 650 kg BOD_5/day. This is approximately 60% greater than the projected design year 20 organic loading. Once the primary cells are aerated, the liquid level in the cells will be constant and no hydraulic storage will be achieved in the cells.

3.5.2 New Storage Cell

3.5.2.1 New Storage Cells as Facultative Cells

The new storage cell was to fit the remaining property in Parcel 1, which would result in a storage cell with a flat bottom area of approximately 252 m x 321 m. The clay at the north end of Parcel 1 is not consistent and would have to be re-worked and re-compacted or high plastic clay hauled in for the liner. The RM of Brokenhead Council has since purchased land (Parcel 2) to the immediate east in the SW ¼ of 15-13-6 E. A geotechnical investigation was completed on Parcel 2 to investigate the potential to re-orientate the new lagoon cells to avoid the poor soils at the north end of Parcel 1. The investigation found suitable clay soils and thus the lagoon was re-oriented as shown on Plan L2 and L3 attached in Appendix C.

The storage capacity of the new storage cell will be 115,167 m^3. The available storage is determined from the discharge pipe invert elevation (0.3 m above the cell floor) to the maximum liquid level (1.5 m above the cell floor). The existing lagoon cells with the existing primary cell converted to a storage cell have a storage capacity of approximately 187,830 m^3. The new primary cells will have a combined storage capacity in the "top half" of the cell of 56,450 m^3. Therefore, the total storage capacity in the lagoon will be approximately 359,447 m^3. This is approximately 264 m^3 greater than the required storage capacity in design year 20.

3.5.2.2 New Storage Cells as Aerated Cells

When aeration lines are added to the storage cell in future, the maximum liquid level will become 2.5 m above the cell floor. The total storage capacity of the cell will become 218,127 m^3 and the overall storage capacity of the lagoon system will become 405,957 m^3. This value takes into account that the primary cells once converted to aeration cells, will no longer provide storage capacity as the cells will always remain full.

In future, if additional hydraulic storage capacity is required, the dikes of the existing lagoon cells could be raised and aeration lines added to further increase capacity. Also, as a result of the aerated wastewater treatment and nutrient reduction a storage period reduction could be considered. With an aerated lagoon the storage period could potentially be reduced from 230 days to as little as 180 days. With the greater storage capacity and shorter storage period the lagoon would be able to accept a hydraulic load approximately 45% greater than the projected design year 20 hydraulic loading.

A layout plan of the proposed new cells is shown on Plan L2 and L3 attached in Appendix C.

Summary 6: The size of the lagoon expansion cells are as follows:

Cell	Flat Bottom Area	Storage Volume
Primary Cell #1	35,950 m^2	28,159 m^3
Primary Cell #2	36,130 m^2	28,295 m^3
Storage Cell	90,420 m^2	115,167 m^3

4.0 LINER DESIGN, LAGOON LAYOUT AND ELEVATION OF CELLS

JRCC completed a field investigation in March 2012 to determine the suitability of the proposed lagoon expansion site, Parcel 1, for construction of the lagoon cells. The report, issued in June 2012, is entitled *RM of Brokenhead – Geotechnical and Topographic Investigation for the Wastewater Treatment Lagoon Expansion*.

JRCC completed a field investigation in October 2014, to determine the suitability of Parcel 2 land for the construction of the storage cell rather than using the north part of Parcel 1. The report is entitled *RM of Brokenhead – Geotechnical and Topographic Investigation for the Wastewater Treatment Lagoon Expansion on the SE 1/4 of 15-13-6 EPM*.

Both complete geotechnical and topographic investigation reports are attached in Appendix B.

4.1 Summary of Geotechnical Investigation of Parcel 1

In situ clay liner from south end of Parcel 1 to 185 metres from the north end: As discussed in the report the 1 m thick horizontal liner of the proposed lagoon expansion cells is recommended to be constructed with an in situ clay liner starting at the cell floor elevation and extending downward 1 m. The most economical approach, in situ liner, is considered first; should Manitoba Conservation testing show the in situ liner does not meet regulations, then cell bottom re-working would be required. The location and area of the in situ liner will be approximately south of a line running through TH10, as shown on Plan L2 (approximately 185 m from the north end of Parcel 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.

Re-worked clay liner in Parcel 1 - northern 185 m of the site: Approximately north of a line running through TH10, the horizontal liner of the proposed lagoon expansion cell would have to be excavated and re-compacted with 1.0 m of suitable high plastic clay. 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.

Perimeter dikes: 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. If at any point along the vertical cut-off wall, unsuitable materials (sand seams or till material) are discovered to be within the liner elevation, the extent of the unsuitable material within the liner elevations must be excavated and re-compacted with suitable high plastic clay to ensure a minimum 1.0 m liner exists across the cell.

4.2 Summary of Geotechnical Investigation of Parcel 2

In situ clay liner on the southwest side of Parcel 2: The soil profile found during the geotechnical investigation consisted of high plastic clay over a low plastic, sandy silty till material. The high plastic clay was shown to be suitable for use as an in situ clay liner and the till material was shown to be unsuitable for a clay liner. The depth of suitable clay ranged from 1.5 m - 5.3 m below surface. Depending on the final elevation of the cells, the depth of clay from TH4, TH5, TH8 and TH9 are likely too shallow for construction of an in situ clay liner. The remainder of the test holes had a depth of clay of 3.0 m or more from the surface. The approximate line of insufficient clay depth is shown on Plan L3, attached in Appendix C.

If any layers of unsuitable material are found during construction, they will have to be excavated and replaced with high plastic clay soils. The most economical approach, in situ liner, is considered first; should Manitoba Conservation testing show the in situ liner does not meet regulations, then cell bottom re-working would be required.

Re-worked clay liner on the northeast side of Parcel 2: If a lagoon cell is constructed northeast of the line of insufficient clay depth as shown on Plan L3, excavation of the till material and re-compacting a 1.0 m thick high plastic clay liner would be required, depending on the final cell floor elevations.

Perimeter dikes: 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. If at any point along the vertical cut-off wall, unsuitable materials (sand seams or till material) are discovered to be within the liner elevation, the extent of the unsuitable material within the liner elevations must be excavated and re-compacted with suitable high plastic clay to ensure a minimum 1.0 m liner exists across the cell.

4.3 Summary of Geotechnical Investigation and Recommendations on Lagoon Layout

4.3.1 Recommendations for Lagoon Layout

Layout: Based on the geotechnical investigations at Parcel 1 and Parcel 2, the recommended location for the lagoon expansion is a combination of both Parcels. The lagoon is recommended to be constructed on Parcel 1 with the exception of the northern 185 m of the site. The lagoon is recommended to be constructed on Parcel 2, southwest of the line of unsuitable soils shown on Plan L2 and L3. The area recommended for lagoon construction is shown on Plan L2, attached in Appendix C.

If the lagoon is constructed within the recommended area, an in situ liner can be utilized. If the lagoon cells are constructed beyond the recommended area, a re-worked and re-compacted liner would likely be required, which would increase capital costs of lagoon construction.

Construction Budget Saving with Parcel 2 layout: The previous cost estimate of lagoon construction on Parcel 1 only included re-working and re-compacting approximately 40,000 m^2 of the horizontal clay liner. With the revised cell layout, only approximately 2,000 m^2 of the horizontal liner will require re-working which saves capital cost compared to the previous estimates. The revised layout requires a slightly longer access road and some additional piping to be installed which will reduce the capital cost savings of the option.

4.3.2 Summary of Soil Profile and Uses during Construction

The following table summarises the average soil profile found during the geotechnical investigation of Parcel 1 and Parcel 2 and describes the uses of each soil layer for lagoon construction.

Table 8: Utilization of Soils for Lagoon Construction

Average Depth	Soil Layer	Possible Use for Lagoon Construction
0 to 0.1 m	Black, high plastic clay topsoil silty, some sand with organics and roots	• Topsoil dressing • Mixed into outer dike slopes
0.1 to 0.3 m	Black high plastic clay, silty, some sand	• Suitable for vertical cut-off walls • Suitable for inner and outer dike slopes
0.3 to (1.5 – 5.3 m)	Brown high plastic clay, some silt inclusions, some sand, moist, stiff	• Suitable for in situ horizontal clay liner • Suitable for vertical cut-off walls • Suitable for inner and outer dike slopes
(1.5 – 5.3) to (TH termination)	Tan, low plastic sandy, silt till, clayey with some gravel, soft, wet	• Not suitable for clay liner • If discovered within the 1m thick in situ clay liner, soils must be removed and replaced with high plastic clay soils

4.3.3 Re-working Soils beneath the New Dikes

The EAP recommended that the soils 1.0 m below in the inner dike slopes of the new lagoon be re-worked and re-compacted to reduce the risk of the liner failing under the dike, causing the inner dike to be re-built. Upon final lagoon sizing and setting final elevations of the cells, the liner elevation will be within the suitable clay layer with the exception of the northeast corner of new Primary Cell #2. The risk of the suitable clay layer not meeting a hydraulic conductivity of 1 x 10^{-7} cm/s is deemed low based on three Shelby tube test results which were all in the order of 1 x 10^{-9} cm/s. The only concern would be if the unsuitable till layer extended up into the liner elevation under the inner dike slopes. A vertical cut-off wall will be constructed a minimum of 1.0 m into the horizontal liner and if at any point along the vertical cut-off wall, unsuitable materials (sand seams or till material) are discovered to be within the liner elevation, the extent of the unsuitable material within the liner elevations must replaced with high plastic clay. This procedure should be suitable to detect any potential non-suitable liner materials under the new dikes.

However, soil conditions can vary unexpectedly and the soils under the new dikes could be re-worked and re-compacted to reduce risks of not meeting Manitoba Conservation requirements i.e. risk management.

Re-working the soils under the dikes would require approximately 160,800 m^3 of earthwork resulting in a construction cost of approximately $1,286,400, depending on the final price received for earth movement during tendering. To reduce risks this extra work could be included by the RM, if desired, at a cost of approximately $1,286,400.

Summary 7: Using the most economical approach first the liner of the lagoon will be in situ clay where potentially possible within the recommended area for lagoon construction. The new lagoon cells will be lined with an in situ clay liner from the high plastic clay soils. To reduce risk (risk management) the horizontal liner soils under the inner perimeter dike slopes could be re-worked. The extra cost for this risk management is $1,286,400.

4.4 Elevations

4.4.1 Existing Ground Elevations

The existing ground at Parcel 1 is relatively flat with some low lying areas. The average ground elevation is approximately 236.25 m and varies between 234.99 m and 237.38 m.

The existing ground at Parcel 2 slopes from the northeast to the southwest at an average slope of approximately 0.88%. The existing ground elevations varied from 236.58 m to 240.01 m with an average elevation of approximately 238.08 m.

The average elevation of Parcel 2 is approximately 1.8 m higher than Parcel 1.

A review of record plans and benchmarks used in construction of the past lagoon cells were made. Existing cells (1 - 3) were constructed with the same top and floor elevation. Top of dike elevations were checked in October 2014 and found to be an average of 237.15 m.

4.4.2 Proposed New Primary Cell Elevation

The new primary cells must be constructed on Parcel 2 within the recommended area for lagoon construction because the existing ground elevations are the highest and the primary cells must be constructed higher than the storage cells as flow between the cells is by gravity. Based on cut and fill requirements to balance the earth movement, the primary cells will be constructed with a top of dike elevation of 239.5 m and a cell floor elevation of 236.0 m. Therefore the bottom of the horizontal liner elevation will be 235.0 m. The geotechnical investigation report was reviewed to determine the elevation of the top of the unsuitable material in each test hole within the proposed lagoon construction area. The following table shows the start of unsuitable material elevation for all test holes within the footprint of the proposed primary cells:

Table 9: Start of Unsuitable Material

Test Hole	Depth Below Surface	Elevation
2014-TH1	5.3 m	231.6 m
2014-TH2	3.4 m	234.0 m
2014-TH6	3.4 m	234.6 m
2014-TH7	4.0 m	233.2 m
2012-TH2	>6.1 m	<230.2 m
2012-TH3	>5.3 m	<230.9 m

As shown on the above table, all test holes taken within the primary cell footprint have a top of unsuitable material elevation below the bottom of the horizontal liner elevation (i.e. suitable depth of clay for an in situ clay liner). The top of unsuitable material elevation in TH8 (taken approximately 50 m east of the Primary Cell #2 dike) is 237.1 m. Therefore, there is potential that the NE corner of the Primary Cell #2 may require high plastic clay to be hauled in to replace the unsuitable till material. There is also potential that the start of unsuitable material is higher at a location not represented by the test holes as soil conditions can change significantly across a site.

As stated above, if at any point along the vertical cut-off wall, unsuitable materials (sand seams or till material) are discovered to be within the liner elevation, the extent of the unsuitable material within the liner elevations must replaced with high plastic clay.

Summary 8: The floor elevation of the new primary cells will be 236.0 m and the top of dike elevation will be 239.5 m since the cells are being constructed to depths required for future aeration cells.

4.4.3 Proposed New Storage Cell Elevation

The new storage cell will be constructed with a top of dike elevation of approximately 238.6 m, which is 0.9 m lower than the primary cell top of dike elevation and 1.45 m higher than the existing lagoon top of dike elevation.

With a top of dike elevation of 238.6 m the cell floor elevation will be 235.1 m and the bottom of the horizontal liner elevation will be 234.1 m. The test holes within the proposed storage cell footprint were reviewed and the start of unsuitable material elevation is shown on the following table.

Table 10: Start of Unsuitable Material

Test Hole	Depth Below Surface	Elevation
2012-TH1	>6.1 m	<230.1 m
2012-TH4	4.9 m	232.1 m
2012-TH7	4.9 m	231.1 m

Test Hole	Depth Below Surface	Elevation
2012-TH8	>6.1 m	<229.7 m
2012-TH9*	0.9 – 1.5 m	235.3 – 234.7 m
2014-TH10	>6.1 m	<229.9 m

*2012-TH9 had a layer of unsuitable material followed by suitable clay to at least 6.1 m below surface.

As shown on the above table, all test holes taken within the new storage cell footprint have a top of unsuitable material elevation well below the bottom of the horizontal liner elevation (i.e. suitable depth of clay for an in situ clay liner). The only exception is a layer of silty sandy till soil in TH9 from 0.9 - 1.5 m. The layer of till was not observed in any other test hole and is assumed to be an isolated pocket of unsuitable material. The extent of the unsuitable material within the liner elevation should be excavated and suitable high plastic clay should be hauled in to replace the unsuitable material.

Summary 9: The floor elevation of the new storage cell will be 235.1 m and the top of dike elevation will be 238.6 m since the cells are being constructed to depths required for future aeration cells.

5.0 EXISTING AND PROPOSED PIPING AND LAGOON OPERATION

As stated, the existing forcemain will be re-routed to the proposed chemical feed building for alum addition. From the building, a forcemain will be installed to a splitter manhole installed between Primary Cell #1 and #2. From the splitter manhole wastewater will be distributed evenly into both primary cells. Wastewater can flow from Primary Cell #1 through an intercell pipe into Primary Cell #2. Wastewater can flow from the Primary Cell #2 to either the new storage cell or the existing Storage Cell #2.

The primary cells will be constructed approximately 0.9 m higher than the new storage cell and the new storage cell will be approximately 1.45 m higher than the existing lagoon cells. The lagoon will have to be operated by opening and closing valves to ensure that the maximum liquid level is not exceeded in any of the cells.

5.1 Proposed Piping for Lagoon Expansion

The location of all proposed piping is shown on Plan L2 and L3 attached in Appendix C.

The proposed piping works required for the facultative lagoon expansion are:

- 880 m of 250 mm forcemain pipe to the building location
- 185 m of 250 mm forcemain pipe from the building to the splitter manhole
- 50 m of 250 mm piping into each of Primary Cell #1 and #2
- 670 m of 200 mm piping from Primary Cell #2 to the existing Storage Cell #2
- A tee installed on the above pipe with 50 m of piping to the new storage cell
- 200 mm intercell pipe between Primary Cell #1 and #2
- 300 mm discharge pipe from the new storage cell
- 200 mm intercell pipe from new storage cell to existing Storage Cell #1
- 200 mm discharge pipe from exiting Storage Cell #2
- 200 mm discharge pipe from the existing primary cell (converted to storage cell).

All proposed piping will be HDPE DR17 or heavier.

The piping from Primary Cell #2 to the existing Storage Cell #2 will be installed in a common trench with the 250 mm forcemain piping.

5.2 Piping Required for Aerated Lagoon

In future, when an aeration system is added the general flow through the lagoon system will be as follows:

> Forcemain from the existing lift station → building for potential chemical addition → Primary Cell #1 → Primary Cell #2 → building for filtration, UV disinfection and potential ammonia reduction → storage cells (aerated storage cell or existing lagoon storage cells).

The valve on the pipe from the splitter manhole to Primary Cell #2 will be closed and the flow from the forcemain will be into Primary Cell #1 only. Wastewater will flow from Primary Cell #1 to Primary Cell #2 through the intercell pipe. The pipe from the Primary Cell #2 to existing Storage Cell #2 will be re-routed into a manhole at the aeration building for treatment (filtration and UV disinfection). From the building the wastewater would be pumped into the pipe to direct treated wastewater to either the aerated storage cell or the existing Storage Cell #2.

5.3 Liquid Level Monitoring

Liquid levels in the storage cells will be monitored by piping and ultrasonic level sensors installed in the building. Three saddles and small pipes (38 mm) will be installed on the proposed piping from Primary Cell #2 to the storage cells. The saddle and pipes will be installed so that the liquid level in each cell can be monitored at the building, depending on which valves are open and closed. The 38 mm piping will transition to 100 mm stainless steel or PVC pipe at the building and three straight pieces of pipe will be installed through the building floor. An ultrasonic level sensor will be installed on each pipe and the liquid levels of all cells can be monitored and displayed with the Supervisory Control and Data Acquisition (SCADA) system. The display could record liquid level or % full or both. The vertical stainless steel pipes will be vented through the building wall to allow the liquid level inside the pipes to fluctuate.

6.0 CHEMICAL FEED SYSTEM AND MONITORING

To precipitate phosphorus from wastewater the addition of chemical i.e. alum is required. A building will be constructed and alum will be added to the wastewater from the communities of Garson, Tyndall, and Henryville, whereas the trucked rural wastewater hauled direct to the lagoon will not receive alum. The trucked wastewater will impact the overall alum effectiveness; hence more alum will have to be added at the chemical feed building.

6.1 Chemical Feed Building Location

Three options for chemical feed building location were reviewed and discussed with the RM of Brokenhead. The options and a brief description of the option are as follows:

Site 1 – At Existing Lift Station Building

An expansion to the existing lift station building was proposed to house the chemical feed system. A portion of the existing building could be re-used in the expanded building as well as the existing mag meter and piping, electrical power etc. The land for the existing lift station building is currently not owned by the RM and obtaining additional land for the building and a truck turnaround would be difficult. The capital costs of the building would likely be the lowest.

Site 2 – Along Forcemain Route North of PTH 44

A building location along the forcemain route was proposed by the RM because land was potentially available for purchase. The existing forcemain would have to be excavated and fittings and valves would have to be installed to bring piping into the proposed building while allowing continued use of the forcemain during construction. In future, when the lagoon is converted to aeration there would be three buildings to maintain and service (lift station building, chemical feed building and aeration building). The capital costs of the option would likely be the highest.

Site 3 – At Proposed Lagoon Site

The chemical feed building could be constructed at the lagoon site. In future the chemical feed building would be incorporated into the aeration building and the truck turnaround area would continue to be used for both buildings. Land acquisition would not be required as the land is currently owned by the RM. Single phase electrical power is required for the chemical feed building. In future, three phase power would be required for the aeration building. The building would likely have capital costs between Site 1 and 2 but the building location would be the best long term solution for the RM of Brokenhead.

A meeting was held between JRCC and the RM of Brokenhead on November 25, 2014 and it was decided that the chemical feed building should be located at the lagoon site.

Summary 9: The chemical feed building will be located at the lagoon site.

6.2 Chemical Feed System

The forcemain from the lift station will be re-routed from the existing location where it enters the primary cell to the chemical feed building location. Approximately 940 m of 250 mm forcemain piping would be required. A mag meter will be installed on the forcemain within the building.

The chemical feed pump will inject chemical directly into the forcemain piping that leaves the chemical feed building. A 20 mm PVC pipe will be used to inject chemical from the chemical pump to the forcemain. From the building, wastewater would be directed approximately 210 m to a splitter manhole which would evenly distribute flow into Primary Cell #1 and #2.

Peristaltic chemical feed pumps will be used and will be flow paced by the new flow meter installed in the chemical feed building. The amount of chemical pumped will be regulated by the wastewater flow that is directed through the forcemain from the lift station. The peak chemical feed will be based upon the peak flow rate from the lift station pumps.

The rate of chemical addition, concentration of alum to wastewater, can be altered based on phosphorous test results in the cells once the system is in operation. Chemical feed allowance must be incorporated for the trucked rural wastewater hauled direct to the lagoon. Initially the alum flow will be somewhat experimental but guidance will be achieved through onsite testing of the cell wastewater.

If the chemical addition is insufficient the settling will also be insufficient at reducing the phosphorus concentration below 1.0 mg/L, then chemical would have to be surface applied. Surface chemical addition may be required based upon cell test results prior to discharge. The subsequent phase, addition of a filtration system, would be the solution if surface applied chemical addition is required annually.

6.3 Mixing

The effectiveness of alum addition for phosphorus reduction depends partially on the amount of mixing provided between the chemical and the wastewater. The ideal conditions for coagulation and flocculation are rapid mix followed by slow mix. The rapid mix will allow the chemical to be evenly distributed among the wastewater and allow floc to be formed. The slow mix allows the small floc to mix together to form larger floc which will settle out of the wastewater in the lagoon cells.

The fast mix will be provided by a mixing device installed in the chemical feed building. Additional slow mixing will be provided in the forcemain, splitter manhole and piping into the primary cells.

6.4 Remote Monitoring

Alarms that would be incorporated include:

- low building temperature
- building flood
- chemical tray flood

- pump fault
- chemical feed valve fail to open.

Two options are available for remote access/remote monitoring of the chemical feed building:

Option 1

Use an MTS telephone line and telephone dialer to dial out alarms to a set of phone numbers or send an SMS text. The system would only dial alarms. Priority 1 and 2 alarms could be set such that Priority 2 alarms do no dial during night time periods.

Option 2

Use an internet based system, no telephone line. Using a fixed IP address and security software all parameters such as alarms plus info such as levels, flows and other data could be viewed remotely. Alarm notification could be by text or email rather than a phone call and a pre-recorded voice as per Option #1.

Summary 10: A building at the lagoon site will house the chemical storage and peristaltic chemical feed pumps. The chemical feed pump will pull chemical from the storage tank and discharge it to a 20 mm PVC pipe connected directly to the forcemain. A fast mix device will be provided in the building for mixing alum with the wastewater. An internet based alarm and monitoring system is recommended subject to the Operators' acceptance with alarm notification by email or text message.

7.0 CHEMICAL DOSAGE AND STORAGE FOR PHOSPHORUS REDUCTION

Alum (aluminum sulfate), a coagulant, is readily available and is proposed at this site. The factors that affect the actual quantity of alum required to reduce phosphorus include alkalinity, final pH of the wastewater, ionic constituents such as sulfate, fluoride, sodium, etc., quantity and nature of suspended solids, microorganisms, and the intensity of mixing and other physical conditions of the treatment facility. The optimum pH for phosphorus reduction with alum is 5.5 to 6.5, but in typical wastewaters, it ranges from 6.0 to 9.0.

Based upon the wastewater generated and the level of phosphorous in the wastewater the alum dosage can be calculated and the necessary storage determined.

7.1 Alum Dosage

From Table 1, in the Appendix, the average flow rate in the summer of design year 20 is 1,567 m^3/day (piped and trucked), which must be treated for phosphorus reduction.

The lift station pumps discharge wastewater into the forcemain but wastewater is also capable of siphoning after the lift station pumps stop, hence the flow in the forcemain is highly variable. The flow paced-chemical feed rate must be able to meet maximum lift station pump flow rates not the average over the day and the chemical feed pump must be flow paced by a mag meter. The maximum pumping capacity of lift station pumps with the 3.3 km of 250 mm forcemain is approximately 55 L/s for which the maximum chemical feedrate is determined. With both lift station pumps running, the increase is marginal, approximately 58 L/s.

The mole ratio for chemical phosphorus reduction is the chemical ratio of aluminum added to phosphorus ions required to be removed. The theoretical ratio is 1.0, i.e 1.0 mole of alum will remove 1.0 mole of phosphorus. In practice, the value can vary from 1.5 to 4.0. Increasing the mole ratio above 1.0 is similar to adding a safety factor to the amount of chemical being pumped. Since wastewater will also be truck hauled with no direct alum injection, the truck haul wastewater will only be exposed to alum in the primary cell when it mixes with the piped wastewater. More alum will have to be fed at the chemical feed building to consider the impact of the trucked wastewater. The quantity of flow in the summer of design year 20 of 1,567 m^3/day (piped and trucked) was used for the wastewater quantity to treat. The mole ratio was increased from 2:1 to 2.5:1 as a method of adding a safety factor due to the expected poorer mixing in the cell as compared to the alum in the forcemain. The JRCC design spreadsheet determined that a daily average alum chemical dosage was 175.9 L/day and the maximum alum solution dosing rate is 370.4 mL/min for the maximum lift station pumping rate of 55L/s. The actual level of the phosphorous in the lagoon cells determines the actual required dosing rate of the chemical which must be re-assessed with operational experience.

7.2 Chemical Storage Tank

7.2.1 Tank Size

It is not intended to have a “high” building, for aesthetic and cost reasons the interior wall height should be approximately 3.0 m. A round fibreglass tank would be the most economical tank. The most economical manner to order alum is in bulk and a typical bulk load is 24 tonne (17,400 L). One Litre of alum weighs about 1.38 kg; possible tank size options are:

1. 2.4 m ID dia x 3 m high fiberglass is 13,500 L - could accept 18.6 tonne load delivery
2. 3.0 m dia x 2.4 m high – 17,000 L could not accept a 23.5 tonne load
3. 3.6 m dia x 2.4 m high – 24,400 L could accept 33.7 tonnes hence a 24 tonne load could be delivered providing there was less than 7,000 L (approximately a 39 day supply) in the tank.
4. 3.6 m dia x 2.7 m high – 27,400 L could accept larger than 24 tonne load deliveries.

Summary 11: Since a typical bulk load is 24 tonne (17,400 L) a 3.6 m diameter tank x 2.4 m high holding 24,400 litres will be used. This will allow a building with a 3 m inside height to be used.

7.2.2 Chemical Cost

The alum cost per litre is approximately 0.37 litre based upon on bulk ordering of alum in 24 tonne (18,000 L) loads. The annual cost is estimated at $23,800 in design year 20. If the alum was ordered in smaller loads, such as 12 tonne, the cost would increase about 18% or to $28,000 per year.

7.2.3 Tank Ports

Tank ports will be required for a suction port and also a drain port. A manhole is required in the event the tank must be opened for cleaning. Without significantly increasing the building height there is insufficient space to have the tank manhole on top of the tank therefore the manhole will have to be on the wall of the tank.

The suction pump port could be at floor level then no suction line is needed in the tank. The alternative would be a port at the top of the tank but a suction line is required in the tank. The piping extending from the floor level port must be elbowed to permit movement and must be supported.

The drain port would be installed at floor level to drain the tank. All ports would be fibreglass installed during tank manufacturing.

7.2.4 Storage Tank Containment

Containment options, should the tank leak, were reviewed as per the following:

1. ***Double wall tank*** - A double walled tank with all openings through the top could be considered. This is difficult when the building height is low and there is no room to have the pump located above tank. The height makes difficult access for pump servicing.
2. ***Containment curb around single walled tank*** - Due to the volume stored the containment curb would have to be at least 2.5 m high and be 5 m by 5 m around the tank. The tank location would be in a lowered area in the small building footprint. The

curb would necessitate a ladder out and possibly in the containment area. The tank would have to be strapped down to prevent floatation during a spill event, the tank would have to be made stronger to be able to be strapped down. The concrete curb and concrete wall would have to be sealed to the building floor. This methodology would result in higher costs than a double walled tank and is more complex to construct.

3. ***Floor drain to Lagoon Cells*** - Install a floor drain and 100 mm piping that would drain a chemical spill into the proposed new storage cell. The option would be the least complex to construct but if the leakage is not stopped by the operator (SCADA would warn of leak) there could be a large concentrations of alum pumped to the lagoon cells, which would be wasteful but not harmful.

The above options were discussed with Manitoba Conservation. There was no concern with discharge from a chemical storage tank failure or the chemical leakage from the tank flowing to the lagoon as the chemical is required in the lagoon.

With the use of single walled tanks, the tank can be non-pigmented hence slightly see through which is helpful to assess visual liquid level in the tank. Non pigmented tanks are not as aesthetically pleasing; pigmented tanks have typically a white opaque finish.

Summary 12: Place the tank on the building floor without containment but with a floor drain and 100 mm piping to the new storage cell. Utilize a non pigmented tank.

7.3 Test Kits

Two types of a Hach style test kit are proposed to test the phosphorous in the wastewater on a regular basis from the primary cell. A simple color wheel type of orthophosphate (reactive) test kit HACH PO-19A (224801) has a budget of $175. This test kit does not measure total phosphorous (TP) thus will not agree with lab results (licence shows TP), however the difference between the lab and this test kit of 5-20% is expected to be consistent between samples. A more accurate TP test is to use a HACH DR-890 (now DR-900) and add a HACH DRB 200 (LTV082.53.40001) reactor and TNT test vials. If the RM has a DR-890 the extra cost for the reactor is about $1,300 plus vials and chemicals at about $3.00/test. To purchase a DR-900 the cost is about $1,800.

7.4 Chemical Feed Pump Location

Following are options and comments for the placement of the chemical feed pump:

1. The pump could be located on top of the 2.4 m high chemical storage tank. A hole on top of the tank would be utilized for the suction line. The pump would be high and difficult to service. Steps or ladders in a small building would be awkward.
2. The pump could be located on the wall near the tank and installed at a height of approximately 1.2 m. An opening in the side of the chemical storage tank would be required. The opening must be molded in place during the tank production. There is concern that the piping or connection to the tank could fail, draining the chemical above the tank tapping. To alleviate this concern an electrical actuator valve would close at the end of each chemical pumping cycle.

3. The pump could be located above the tank height but mounted on a wall rail system to service the pump at a height of approximately 1.2 m. This system involves the mechanics of a rail system and the necessity of the operator to return the pump to its upper level position upon completion of servicing.

Summary 13: Having assessed each of the above, the selected pump location is method 2 where the pump is mounted on the wall at a height of approximately 1.2 m. The suction line would be connected to the base of the chemical tank. An electrical actuator valve would close at the end of each chemical pumping cycle.

7.5 Alum Dilution

Alum storage tanks frequently have crystallization issues over time. Crystallization in a tank is typically very hard and difficult to remove. Crystallization is caused due to the alum being delivered at near saturation levels and water from the tank evaporating into the air through tank venting over time. The loss of water causes the alum to become oversaturated and the chemical will begin to precipitate out.

To mitigate crystallization, water should be added to dilute the alum 2-3% below saturation prior to shipping. For a dilution of 3% approximately 550 L of water is required for one 24 tonne truck load of alum.

An alternate method is to add water to the storage tank before a new batch of alum is delivered by truck. The alum should be "warm" and would mix as the tank is being filled. This method requires proper scheduling and hauling of water.

Summary 14: The preferred method to avoid crystallization is to have the alum hauled to the site at 2-3% below saturation.

8.0 BUILDING AND ELECTRICAL

8.1 Building

A building is required to house the chemical storage tank and chemical feed system. As discussed in Section 6.1, the building will be located at the lagoon site. Based on a 3.6 m diameter storage tank the interior building width would be about 4.88 m assuming 0.6 m clearance to the walls. The building interior length would be 7.48 m.

The building would be wood studs (38 mm x 140 mm) and truss rafters with metal roof. The exterior walls would be metal and the interior walls would be plastic. Plywood would be used behind the interior steel panels.

8.2 Foundation

The chemical storage creates a significant loading on the building foundation. A 24,400 L full tank creates a loading of approximately 34 tonnes. Foundations considered were slab on grade and piles with grade beams with structural floor.

The building foundation will likely be a thickened edge concrete slab on grade. The base for the foundation would likely be constructed with C-base gravel compacted in 200 mm lifts to 98% standard proctor density. The building floor elevation will be approximately 3.5 m above the existing ground elevation.

The building foundation type requires further assessment and will be finalized prior to final design.

8.3 Existing Electrical Power

Electrical power is required to heat the building, to operate the mag meters, chemical feed pumps, monitoring equipment and for miscellaneous purposes i.e. lights, controls, etc. The building requires single phase power. In future, three phase power will be required for the aeration building (pumps, filters, blowers, UV etc.).

There is currently no power at the existing lagoon site. Single phase power is available south of the lagoon site on Mile Road 74N (Morden Road). The power would have to be extended approximately 515 m to the proposed building. Three phase power is available on the north side of PTH 44. Approximately 2.4 km of power lines would have to be upgraded from single phase to three phase with 515 m of new three phase power to reach the building location. Manitoba Hydro was contacted to obtain budget costs estimates to bring single phase and three phase power to the site. At the time of submitting the pre-design report budgets were not available from Manitoba Hydro, but hydro did indicate that three phase power would be significantly more expensive than single phase.

Based on the high capital costs of the three phase power, an estimate to bring single phase power was included in the cost estimates for this phase of construction. If Council would prefer to bring three phase power to the building, additional costs would have to be added to the cost estimate.

Summary 15: The chemical feed building will be serviced by single phase power.

8.4 Building Access Road

Access to the building will be provided from a short access road off the existing lagoon access road. A gravelled truck turnaround area will be constructed for septic trucks to access the spillway and for building access. The access road and truck turnaround area will be designed so that a semi trailer with a turning radius of 18.3 m can access the building for delivery of chemical. The access road and turnaround area will have geotextile cloth, 0.3 m of C-base and 0.15 m of A-base.

The existing lagoon access road would remain open for access to the existing truck turnaround and spillway area throughout construction. Upon completion of construction the existing spillway would be decommissioned.

The access road and truck turnaround area are shown on Plan L8 attached in Appendix C.

9.0 DESIGN PARAMETERS

A partial listing of design parameters pertinent to the new lagoon expansion cells is provided below:

- A total equivalent design year 20 population of 3,753 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 402.3 kg BOD_5/day
- Construction of two new primary cells with a combined surface area of 72,080 m^2 at 0.75 m height from the floor, providing a daily organic treatment capacity of 403.6 kg BOD_5/day at an organic loading rate of 56 kg BOD_5/ha/day and a hydraulic storage volume in the top half of 56,450 m^3
- A design year 20 hydraulic loading to the lagoon over 230 days of 359,183 m^3
- Construction of a new storage cell with additional hydraulic storage capacity above the invert elevation of 115,167 m^3
- A total hydraulic capacity of the lagoon, with previous cells and the new storage cell, of 359,447 m^3
- The new primary and storage cells will be facultative for now with the intention that aeration will be added in the future
- The new cells will have a 3.5 m total dike height but a 1.0 m weir will be installed to ensure a maximum 1.5 m liquid level with a 1.0 m freeboard while the cells are facultative
- The inner dike slope of the new cells will be 5:1 and the outer slope will be 4:1
- Phosphorus will be reduced by a chemical addition system and settling in the lagoon cells, and the trucked wastewater direct to the lagoon will not receive alum. Trucked wastewater will only be exposed to an alum wastewater mix from the piped wastewater in the cell. The quantity of alum flow paced at chemical feed building will have to be increased to compensate for the wastewater that is trucked
- Construction of a building to house chemical storage and feed system for phosphorus reduction
- The existing primary cell will be converted to a storage cell
- The existing forcemain will be diverted to the building for chemical addition. From the building the forcemain will be directed to a manhole and two pipes will be installed to deliver wastewater evenly to each new primary cell
- A new truck turnaround area and concrete spillway will be constructed at the new Primary Cell #1
- An access road will be constructed from the existing road to the truck turnaround area and the existing access road will be maintained throughout construction. The access road will be constructed with geotextile, 0.3 m of C-base and 0.15 m of A-base
- Piping will be installed from Primary Cell #2 to the new storage cell and the existing lagoon Storage Cell #2 so that the storage cells can be isolated prior to discharge. In future the pipe can be re-routed into the aeration building for treatment and from the building to the storage cells
- The discharge pipe invert is to be 0.3 m above the cell floor elevation of the new storage cell
- 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 in situ clay liner except in the location at the northeast corner of Parcel 2, as shown on Plan L3, 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 four strand 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
- A genset for the existing lift station building was included in the capital cost estimates for this project. The genset will allow operation of the lift station pumps during dower outages to reduce the risk of sewage overflowing the lift station.

10.0 COST ESTIMATE

10.1 General

The cost estimate is based on pre-design report information. This cost estimate is an opinion of probable costs. This opinion is based on assumptions as to the actual conditions that will be encountered onsite; the specific decision and design of other design professionals engaged i.e. geotechnical soils analysis; the means and methods of construction the Contractor will utilize; 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; and other factors over which JR Cousin Consultants Ltd. has no control. Given the assumptions that must be made, JR Cousin Consultants Ltd. cannot guarantee the accuracy of our opinions of cost.

10.2 Summarized Capital Costs

An itemized budget class "C" cost estimate of construction costs is presented in Appendix D. The following is a summarization of the capital costs for the required works for a 2015 construction season. The costs for each year after this projection period should be inflated per prevailing inflation and market conditions.

Class C Cost Estimate

Description	Total
Lagoon Cells and Building	$3,049,000
15% Contingency	$457,400
Total Construction	**$3,506,400**
Extra for Rip Rap on New Dikes Only (including 15% contingency)	$673,100

APPENDIX

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, JR Cousin Consultants Ltd., June 2012

RM of Brokenhead Geotechnical and Topographic Investigation for the Wastewater Treatment Lagoon Expansion on the SE 1/4 of 15-13-6 EPM, JR Cousin Consultants Ltd., November 2014

Appendix C

Plan GI1: Drawing Legend, Abbreviation Index and Key Plan

Plan L1: Existing Lagoon Layout – Test Hole Locations and Existing Contour Lines

Plan L2: Proposed Lagoon Layout – Test Hole Locations and Existing Contour Lines

Plan L3: Proposed Lagoon Layout

Plan L4: Perimeter Dike and Intercell Dike Details

Plan L5: Existing Lagoon Dike Upgrade, Liquid Level Control Weir and Intercell Dike Details

Plan L6: Perimeter Dike at Transition between Re-Worked and In situ Liner and Splitter Manhole Details

Plan L7: Splitter Manhole, Valve, Valve Marker, Site Marker, Rip Rap, Gate, Lock, Fence and Forcemain Trench Details

Plan L8: Silt Fence, Spillway, Truck Turnaround and Access Road Details

Plan P1: Process and Instrumentation Diagram

Plan S1: Building Elevations

Plan S2: Building Layout

Appendix D

Cost Estimate

Appendix A

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

F:\200\246 Brokenhead RM\246.12 GTH Lagoon Design and Construction\03 Design\[Brokenhead Table 1 AERATE IN FUTURE.xlsx]Table 1 REVISED 13.05.02

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 1.15% Growth/year		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 56 kg BOD$_5$/ha/day (Col 12/56 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 During the Winter Storage Period *	230 Day WASTEWATER PRODUCTION Col 20 * 230
		4.56%	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	36,851	225	96	34	355	200	200	722	165,966
1	2013	1,609	120	40	2,454	818	0.076	7.0	187.5	25.4	212.9	38,025	225	96	34	355	200	200	749	172,269
2	2014	1,682	121	41	2,488	830	0.076	7.0	194.0	25.8	219.8	39,255	225	96	34	355	200	200	778	178,863
3	2015	1,759	123	41	2,522	841	0.076	7.0	200.7	26.2	226.9	40,513	225	96	34	355	200	200	807	185,656
4	2016	1,839	124	42	2,556	852	0.076	7.0	207.7	26.5	234.2	41,824	225	96	34	355	200	200	838	192,776
5	2017	1,923	125	42	2,591	864	0.076	7.0	215.0	26.9	241.9	43,192	225	96	34	355	200	200	870	200,186
6	2018	2,010	127	43	2,626	876	0.076	7.0	222.6	27.2	249.8	44,614	225	96	34	355	200	200	904	207,923
7	2019	2,102	128	43	2,662	888	0.076	7.0	230.5	27.6	258.1	46,092	225	96	34	355	200	200	939	215,987
8	2020	2,198	130	44	2,698	900	0.076	7.0	238.8	28.0	266.8	47,638	225	96	34	355	200	200	976	224,459
9	2021	2,298	131	44	2,734	912	0.076	7.0	247.3	28.4	275.7	49,224	225	96	34	355	200	200	1,014	233,176
10	2022	2,403	133	45	2,772	924	0.076	7.0	256.3	28.7	285.0	50,896	225	96	34	355	200	200	1,054	242,383
11	2023	2,512	134	45	2,809	937	0.076	7.0	265.5	29.1	294.7	52,620	225	96	34	355	200	200	1,095	251,881
12	2024	2,627	136	46	2,848	950	0.076	7.0	275.3	29.5	304.9	54,443	225	96	34	355	200	200	1,139	261,950
13	2025	2,747	137	46	2,886	962	0.076	7.0	285.4	29.9	315.3	56,305	225	96	34	355	200	200	1,184	272,300
14	2026	2,872	139	47	2,926	976	0.076	7.0	296.0	30.3	326.4	58,279	225	96	34	355	200	200	1,231	283,232
15	2027	3,003	141	47	2,965	989	0.076	7.0	307.0	30.7	337.7	60,306	225	96	34	355	200	200	1,281	294,527
16	2028	3,140	142	48	3,006	1,002	0.076	7.0	318.4	31.2	349.6	62,431	225	96	34	355	200	200	1,332	306,392
17	2029	3,283	144	48	3,046	1,016	0.076	7.0	330.4	31.6	362.0	64,636	225	96	34	355	200	200	1,386	318,712
18	2030	3,432	145	49	3,088	1,030	0.076	7.0	342.8	32.0	374.9	66,939	225	96	34	355	200	200	1,442	331,604
19	2031	3,589	147	49	3,130	1,044	0.076	7.0	355.8	32.5	388.3	69,338	225	96	34	355	200	200	1,500	345,067
20	2032	3,753	149	50	3,172	1,058	0.076	7.0	369.4	32.9	402.3	71,845	225	96	34	355	200	200	1562	359,183

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

Appendix B

RM of Brokenhead Geotechnical and Topographic Investigation for the Wastewater Treatment Lagoon Expansion, JR Cousin Consultants Ltd., June 2012

RM of Brokenhead Geotechnical and Topographic Investigation for the Wastewater Treatment Lagoon Expansion on the SE 1/4 of 15-13-6 EPM, JR Cousin Consultants Ltd., November 2014

RM of Brokenhead Geotechnical and Topographic Investigation for the Wastewater Treatment Lagoon Expansion,
JR Cousin Consultants Ltd., June 2012

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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

G. R.
COUSIN
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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.

TABLE OF CONTENTS

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 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. 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

Jun 22, 2012 – 10:31am F:\200\246 Brokenhead RM\246.09 GTH Lagoon Feasibility Study\04 Drawings\dwg\Feasibility Study\Lagoon Layout.dwg

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:
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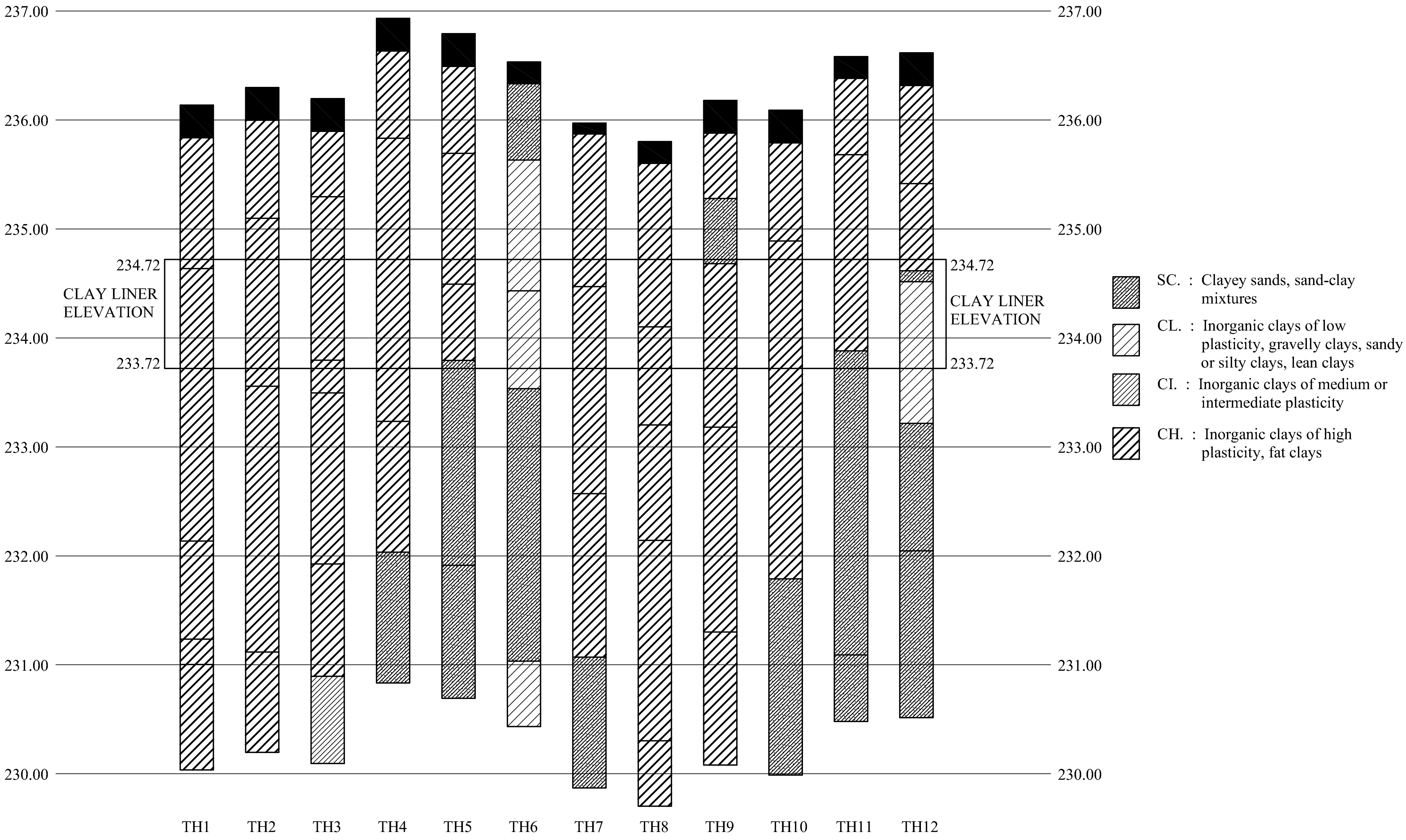

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ph: (204) 489-0474 fax: (204) 489-0487
email: info@jrcc.ca website: www.jrcc.ca

DATE: 12/06/21
SCALE: 1:50
PLAN NO.: 2

CLIENT: R.M. OF BROKENHEAD
PROJECT: GARSON/TYNDALL/HENRYVILLE LAGOON FEASIBILITY STUDY
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

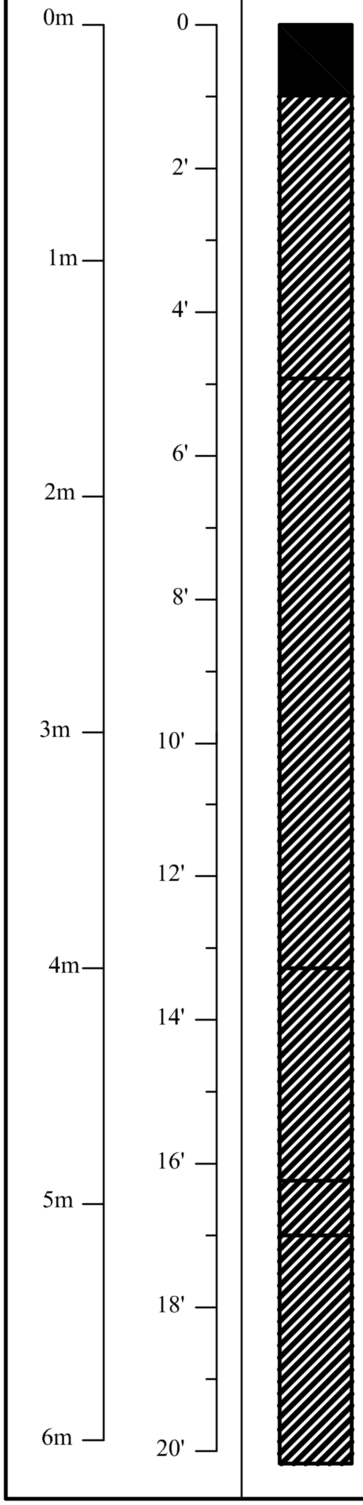
The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of an unlimited number of test holes. Every 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
DATE : March 27, 2012
ELEVATION: 236.163
PROJECT : GTH Lagoon Feasibility Study
TEST HOLE # 1

DEPTH OF SAMPLE | FIELD CLASSIFICATION



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

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

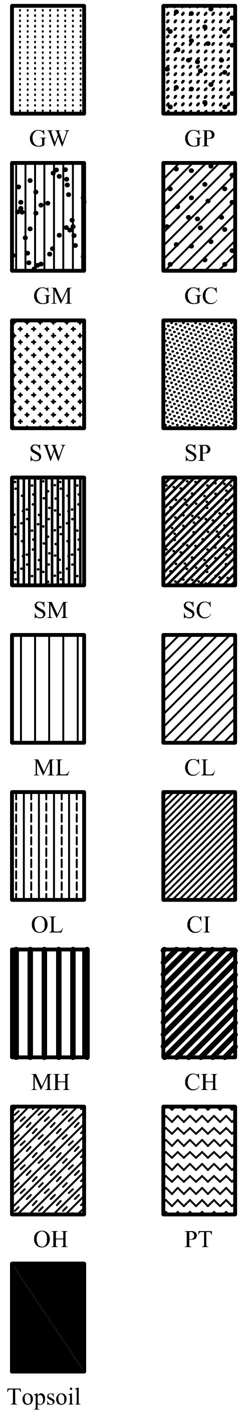
CLAY - High plastic, grey, trace silt, damp, hard, homogenous

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



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.

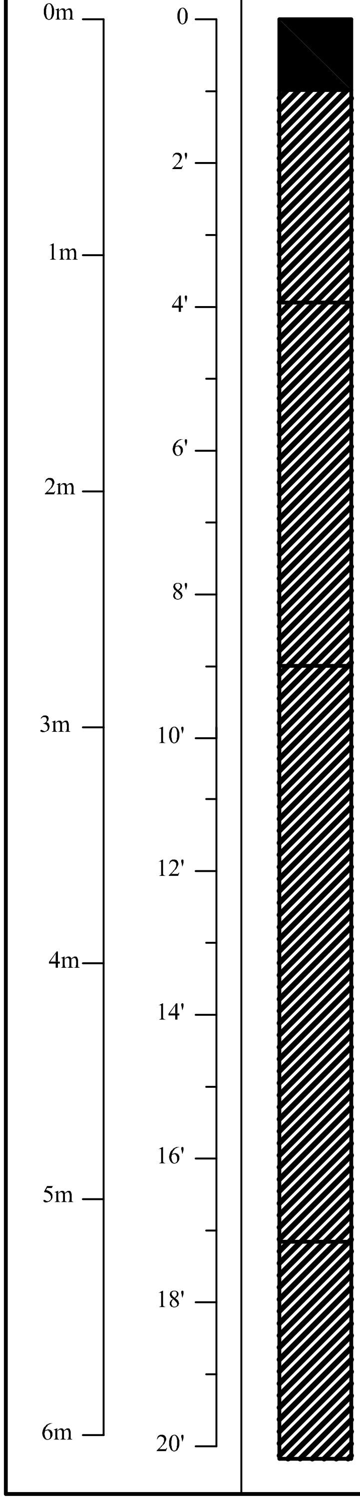
TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead

PROJECT : GTH Lagoon Feasibility Study

DATE : March 27, 2012
ELEVATION: 236.297
TEST HOLE # 2

DEPTH OF SAMPLE	FIELD CLASSIFICATION



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

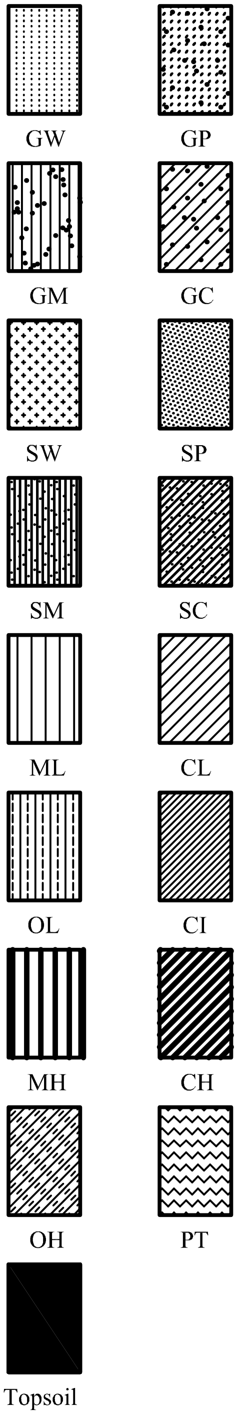
CLAY - High plastic, grey, trace silt, moist, hard, blocky

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

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

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

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

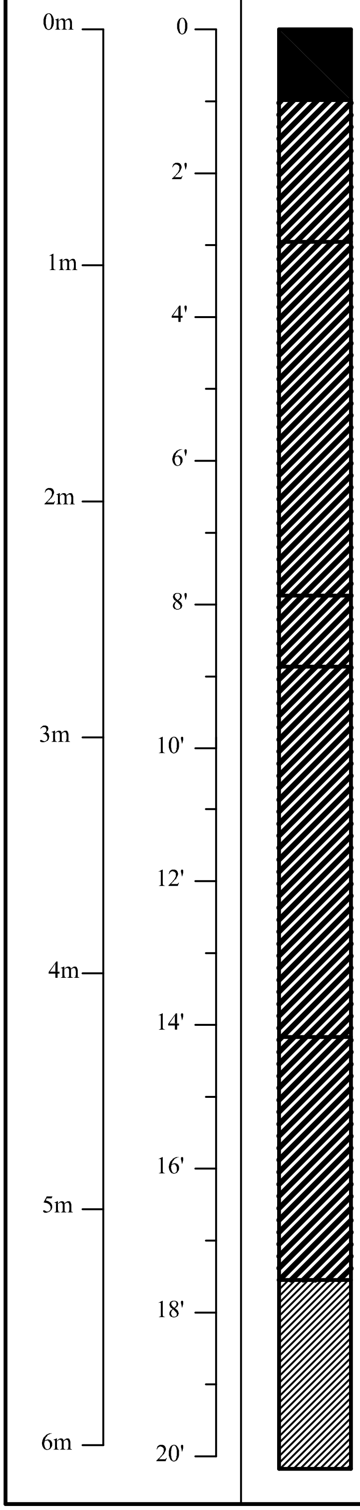
DATE : March 27, 2012

ELEVATION: 236.195

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

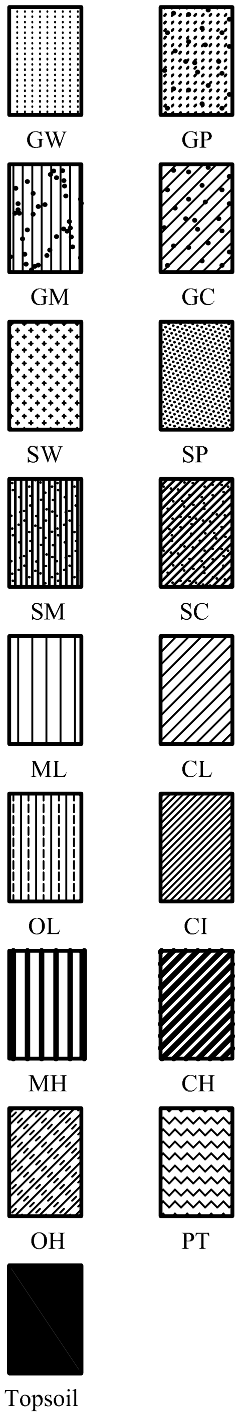
CLAY - High plastic, grey/light brown, with gravel, with silt inclusions, some sand

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



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.

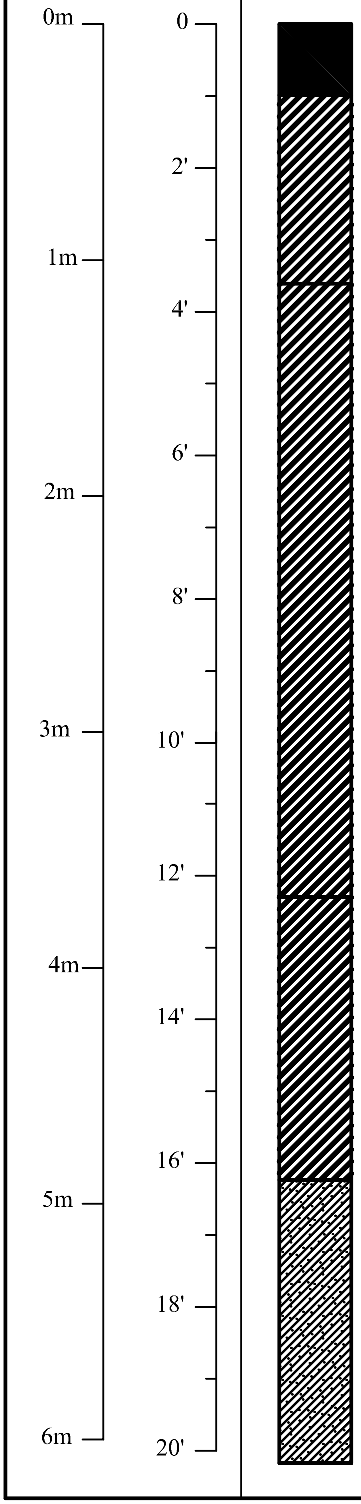
TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead

PROJECT : GTH Lagoon Feasibility Study

DATE : March 27, 2012
ELEVATION: 236.933
TEST HOLE # 4

DEPTH OF SAMPLE	FIELD CLASSIFICATION



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

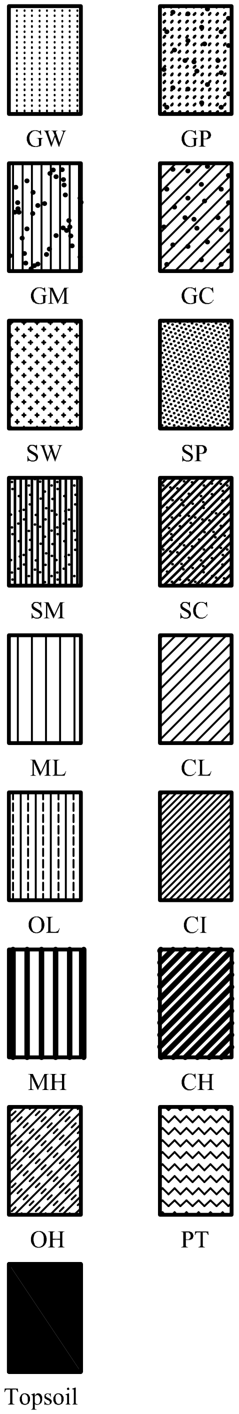
CLAY - High plastic, grey, trace silt, moist, hard, blocky

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



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

DATE : March 27, 2012

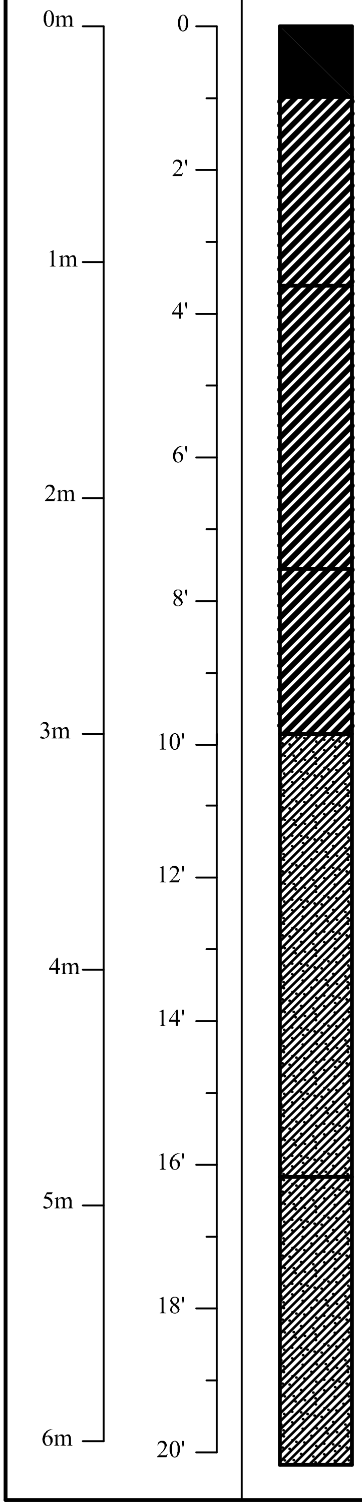
ELEVATION: 236.823

PROJECT : GTH Lagoon Feasibility Study

TEST HOLE # 5

DEPTH OF SAMPLE

FIELD CLASSIFICATION



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

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

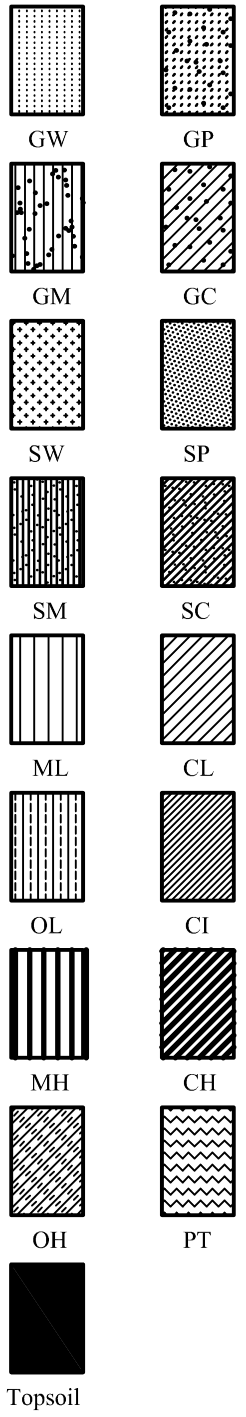
CLAY - High plastic, light brown, with silt and sand inclusions, trace gravel, moist, hard

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



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

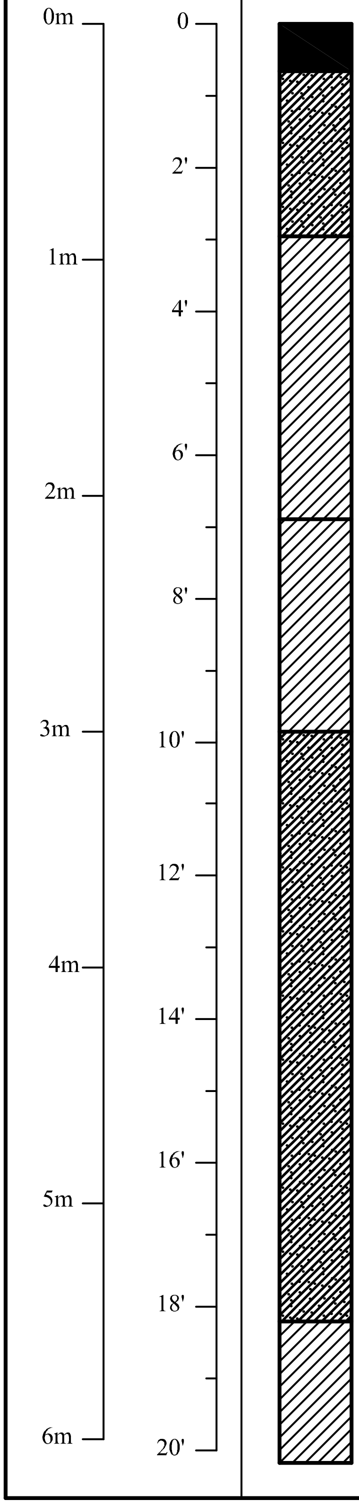
DATE : March 27, 2012

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

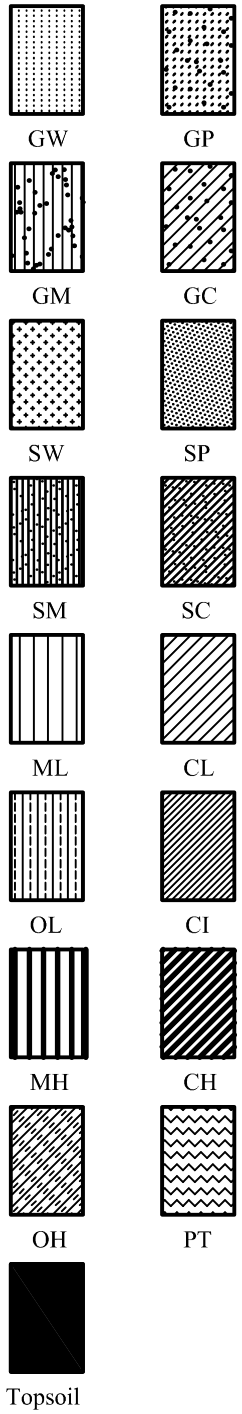
SILTY CLAY - Medium plastic, brown, with some sand, trace gravel, moist, stiff

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

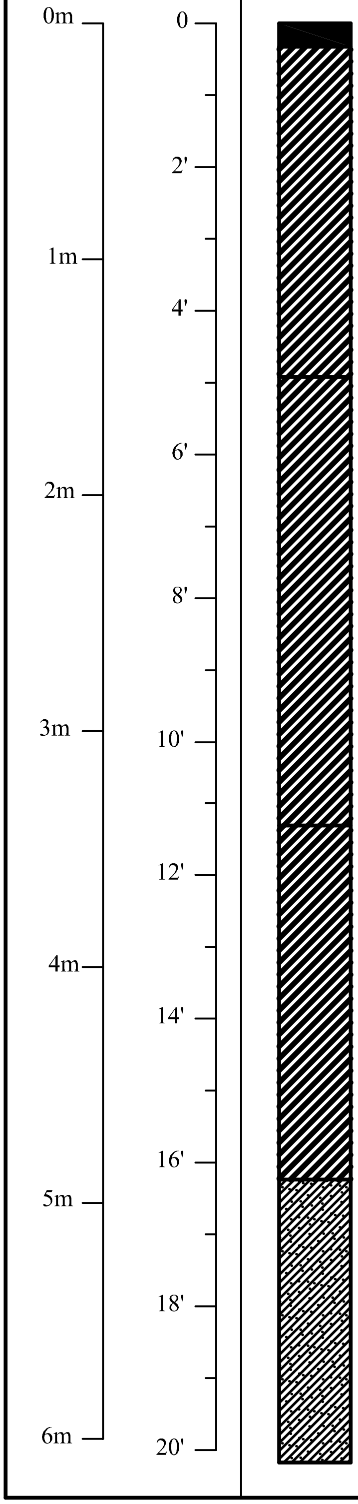
DATE : March 27, 2012

ELEVATION: 235.971

PROJECT : GTH Lagoon Feasibility Study

TEST HOLE # 7

DEPTH OF SAMPLE	FIELD CLASSIFICATION



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

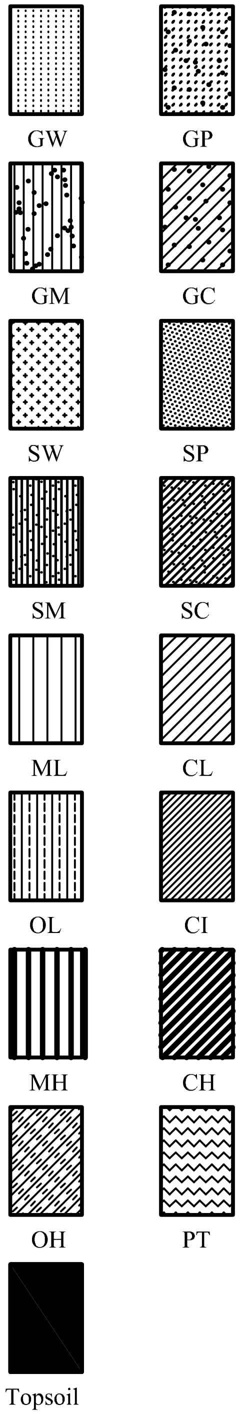
CLAY - High plastic, dark grey, some silt, wet, soft, blocky

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



J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead

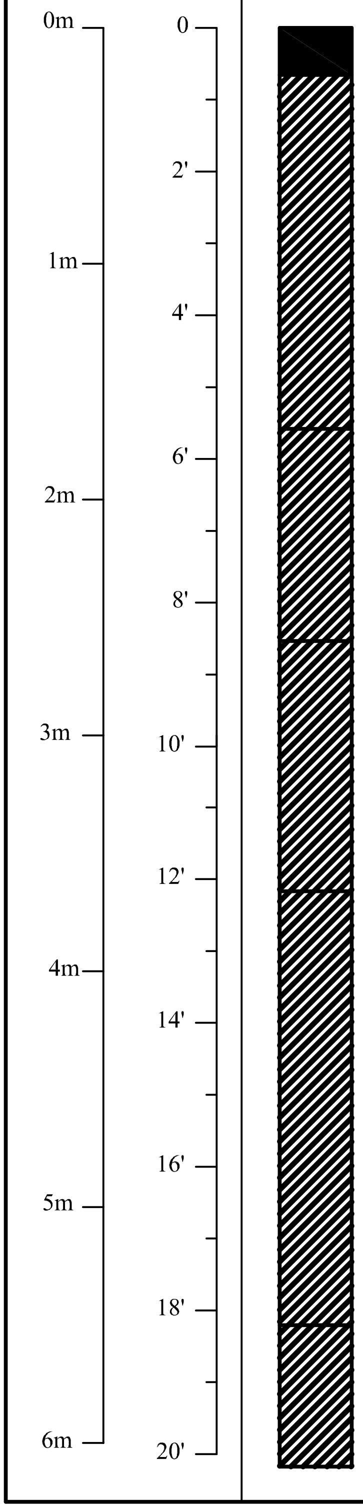
DATE : March 27, 2012

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

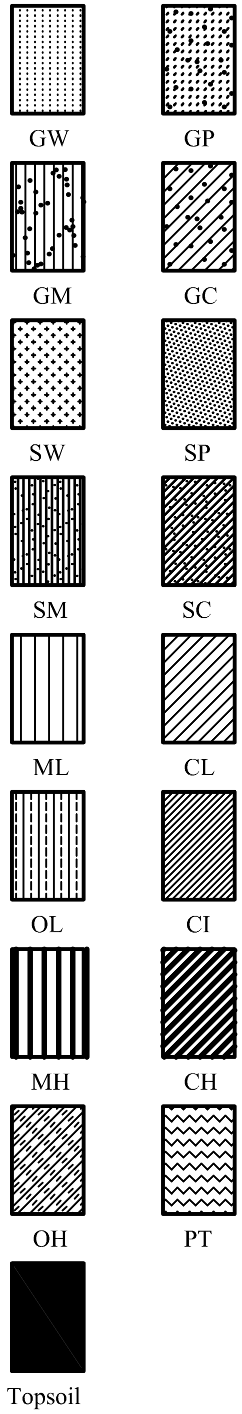
CLAY - High plastic, grey, moist, stiff, homogenous

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



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J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead

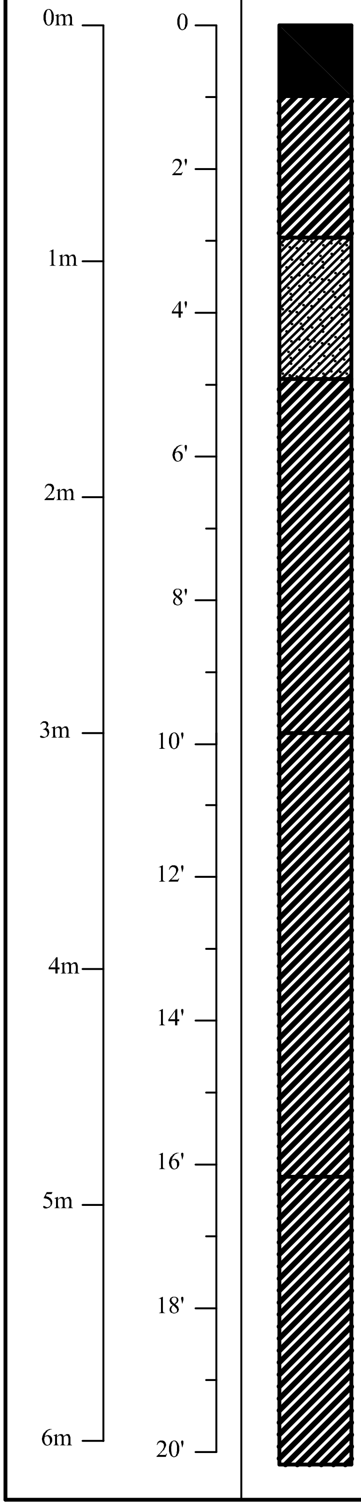
DATE : March 27, 2012

ELEVATION: 236.180

PROJECT : GTH Lagoon Feasibility Study

TEST HOLE # 9

DEPTH OF SAMPLE	FIELD CLASSIFICATION



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

CLAY - High plastic, grey, some silt, damp, hard, blocky

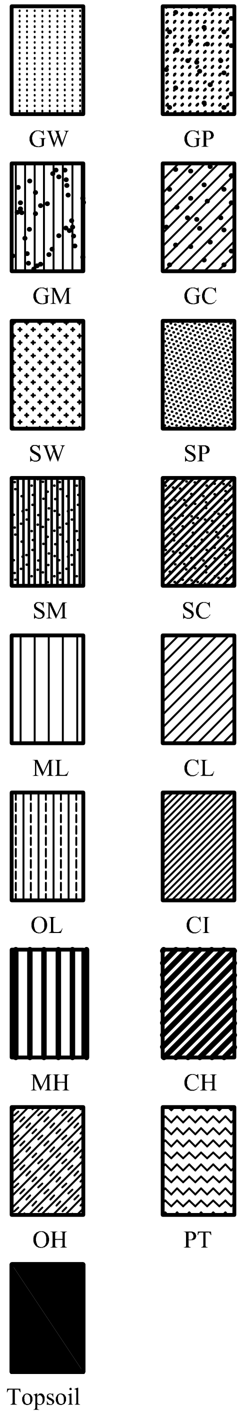
TILL - Light brown, silty, sandy, trace clay, damp, loose

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

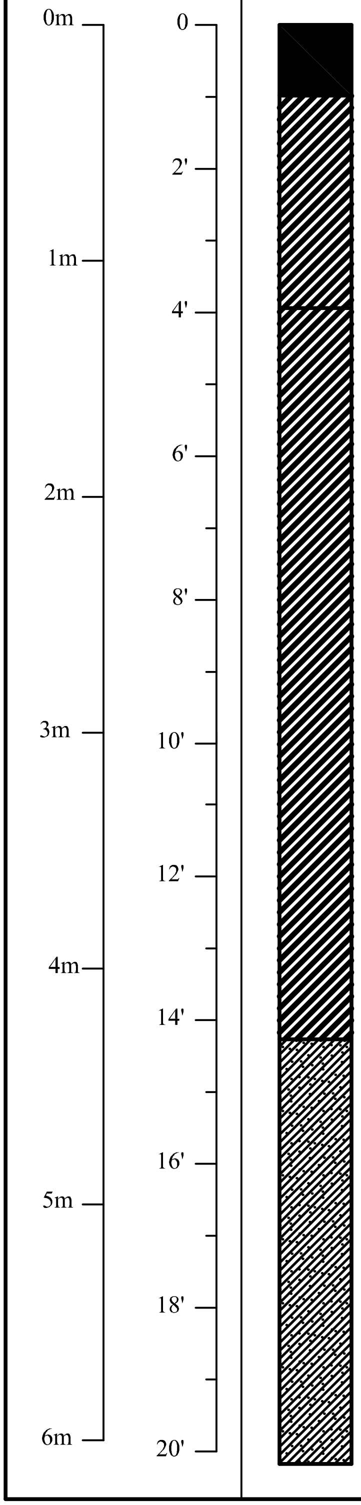
DATE : March 27, 2012

ELEVATION: 236.089

PROJECT : GTH Lagoon Feasibility Study

TEST HOLE # 10

DEPTH OF SAMPLE	FIELD CLASSIFICATION



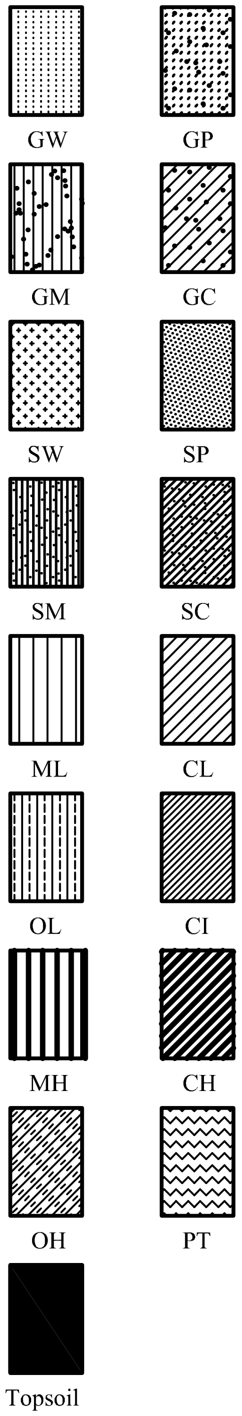
TOPSOIL - Black, clayey, organic, silty, trace sand

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

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

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

NO WATER, NO CAVING



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J. R. Cousin Consultants Ltd.

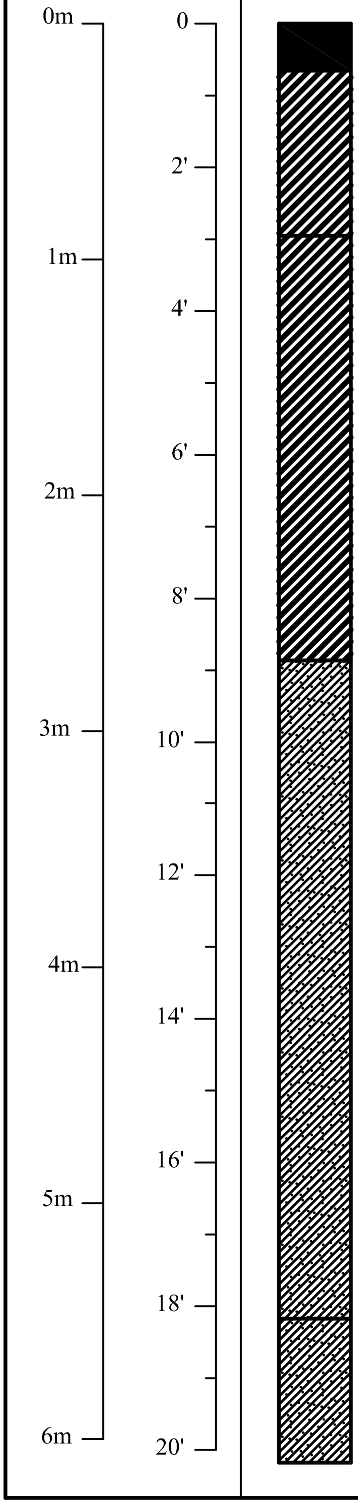
TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead

PROJECT : GTH Lagoon Feasibility Study

DATE : March 27, 2012
ELEVATION: 236.581
TEST HOLE #11

DEPTH OF SAMPLE	FIELD CLASSIFICATION



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

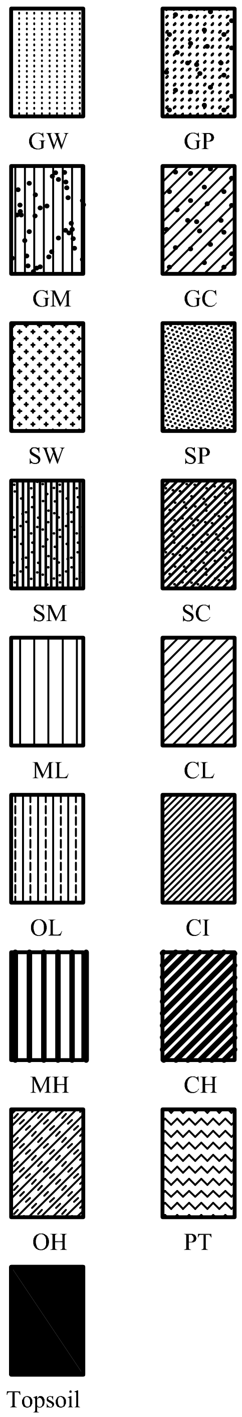
CLAY - High plastic, dark grey, with trace silt, moist, hard, blocky

CLAY - High plastic, brown, with some silt and sand, moist, hard

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

TILL - Silty, sandy, some gravel and medium 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

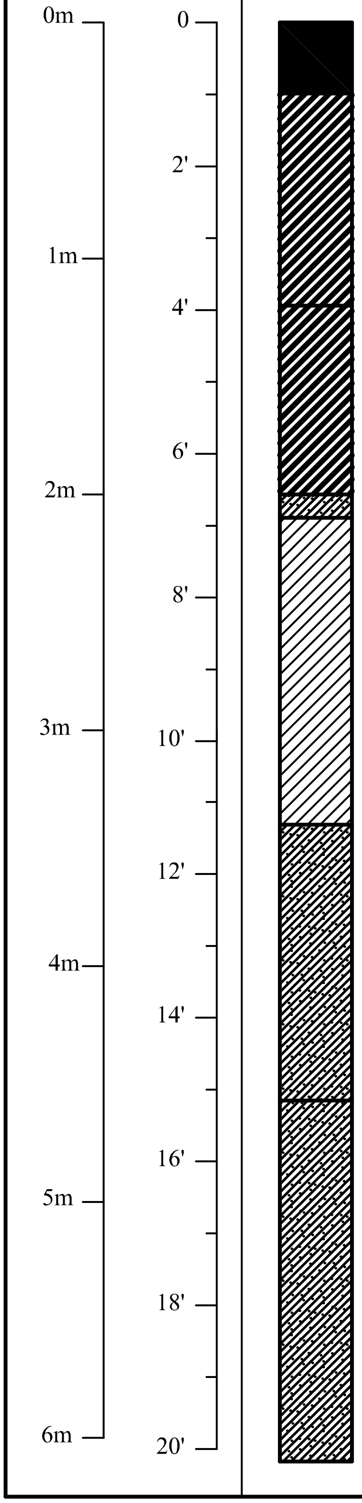
DATE : March 27, 2012

ELEVATION: 236.615

PROJECT : GTH Lagoon Feasibility Study

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

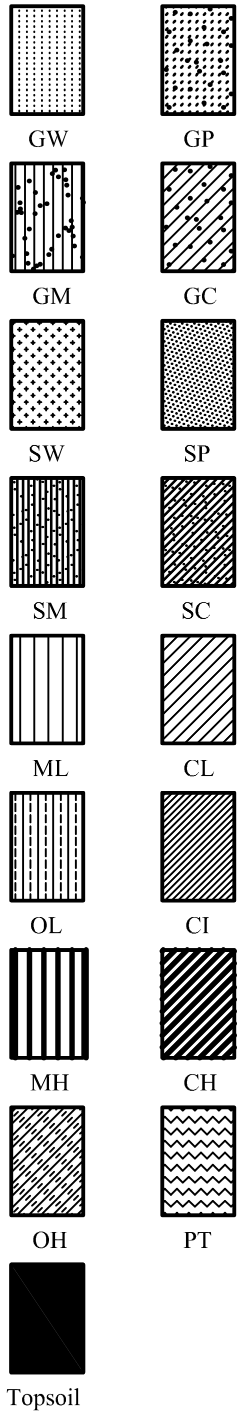
TILL - Silty, sandy, some gravel and low plastic clay, wet, soft

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

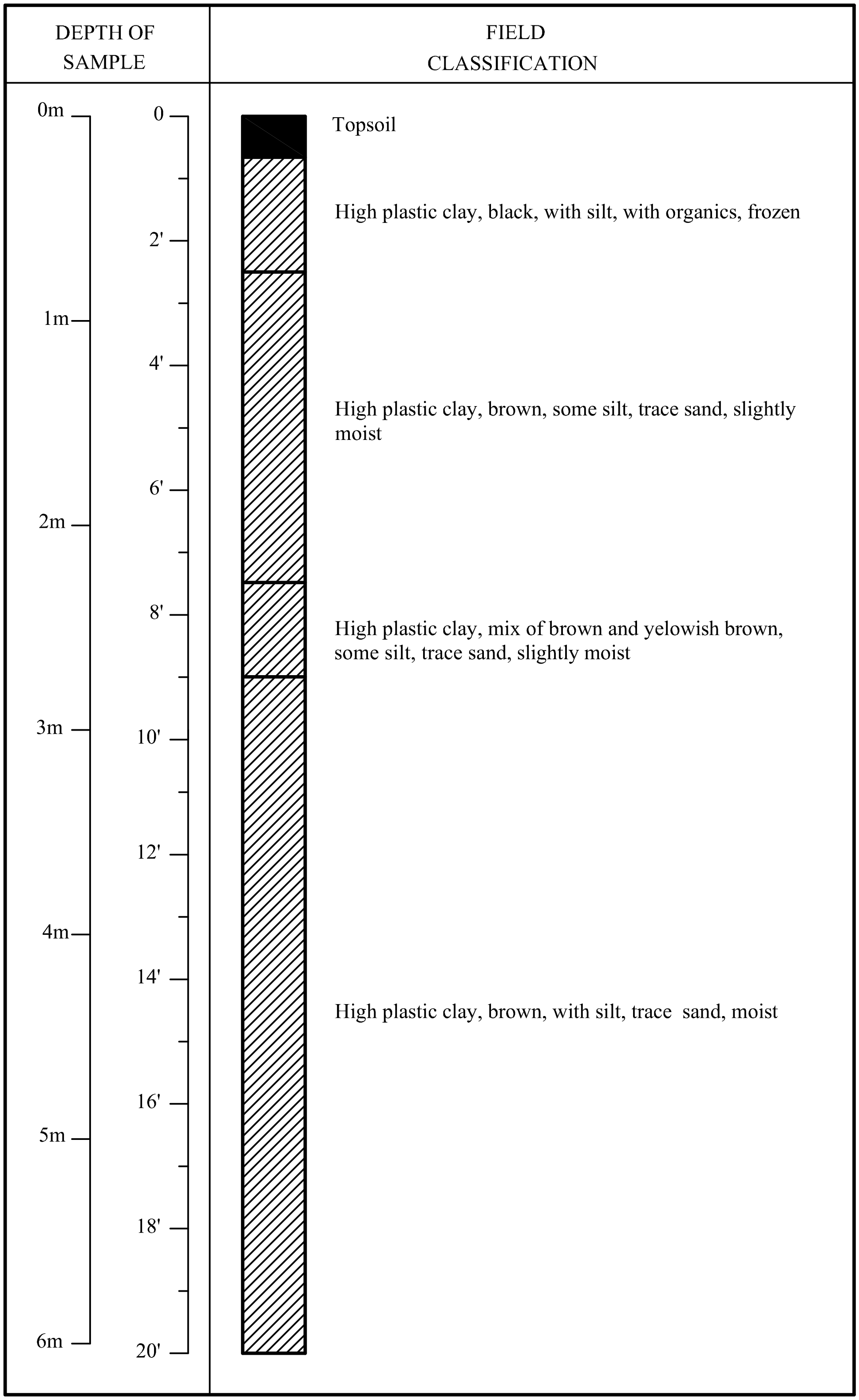
LOCATION : RM of Brokenhead

DATE : January 15, 2002

LOCATION OF BORING : NW 15-13-6E

PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02

TEST HOLE # 1



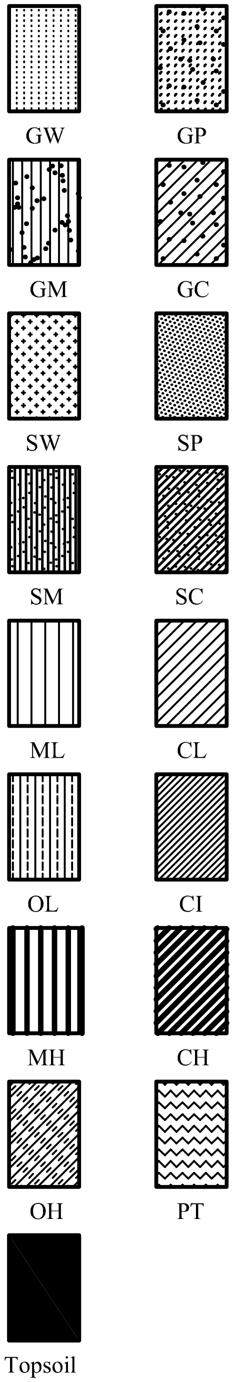
Topsoil

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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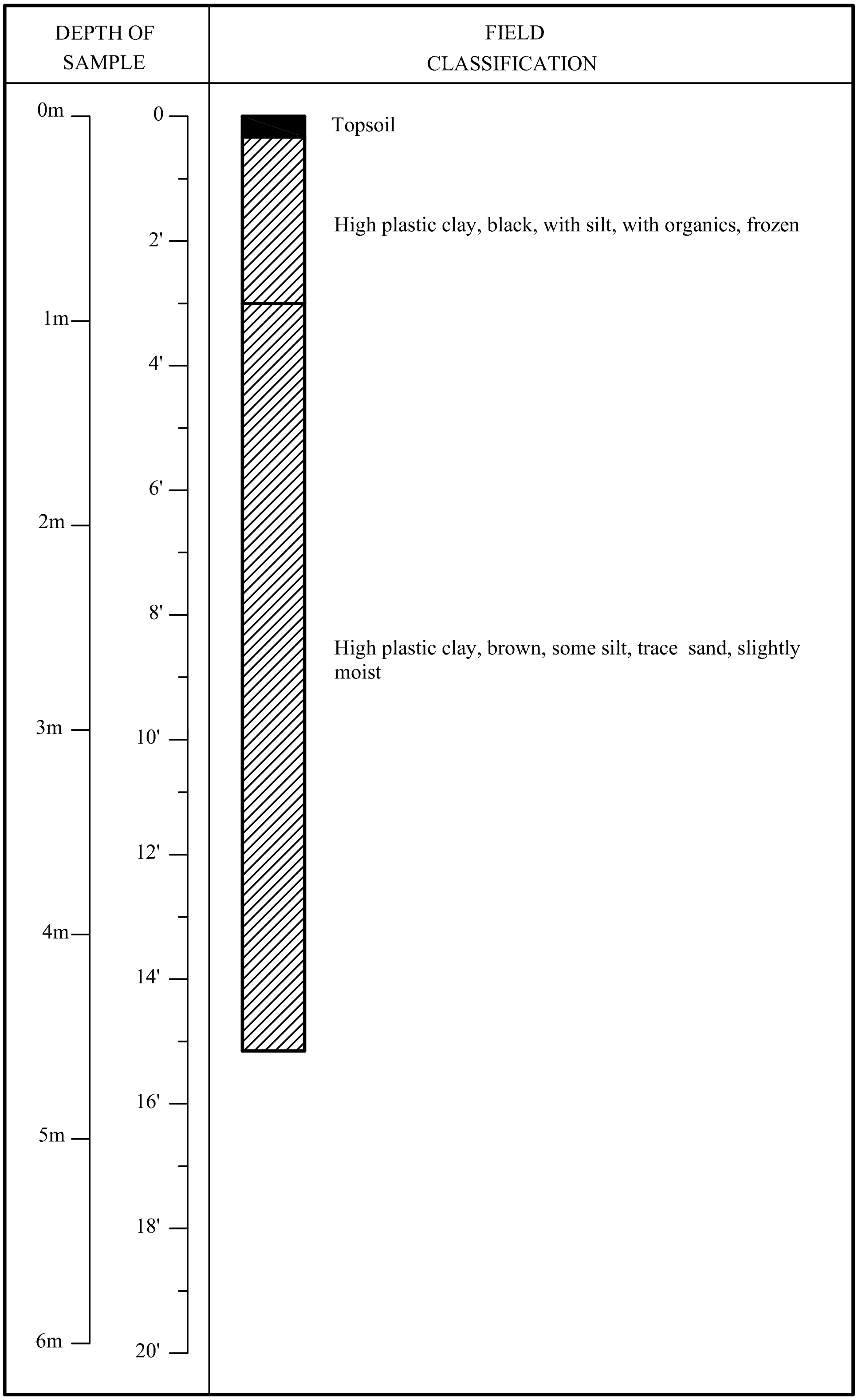
J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

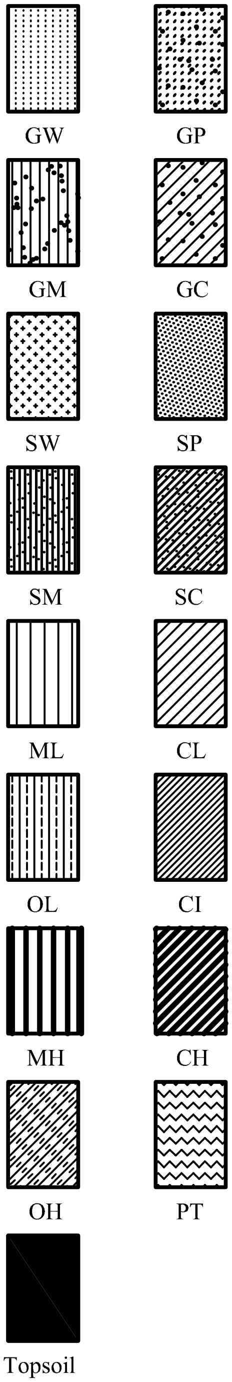
LOCATION : RM of Brokenhead
DATE : January 15, 2002
LOCATION OF BORING : NW 15-13-6E
PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02
TEST HOLE # 2



Topsoil

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

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

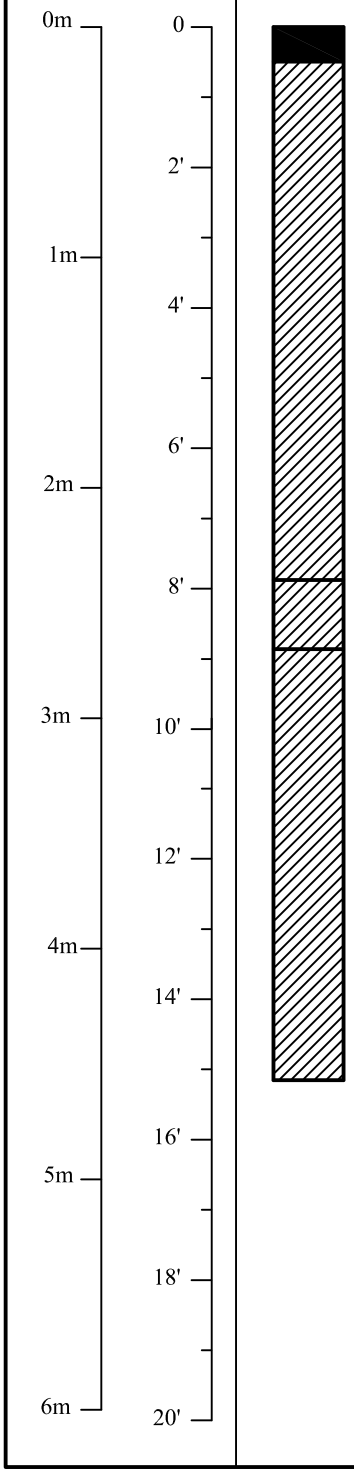
LOCATION OF BORING : NW 15-13-6E

PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02

TEST HOLE # 3

DEPTH OF SAMPLE

FIELD CLASSIFICATION

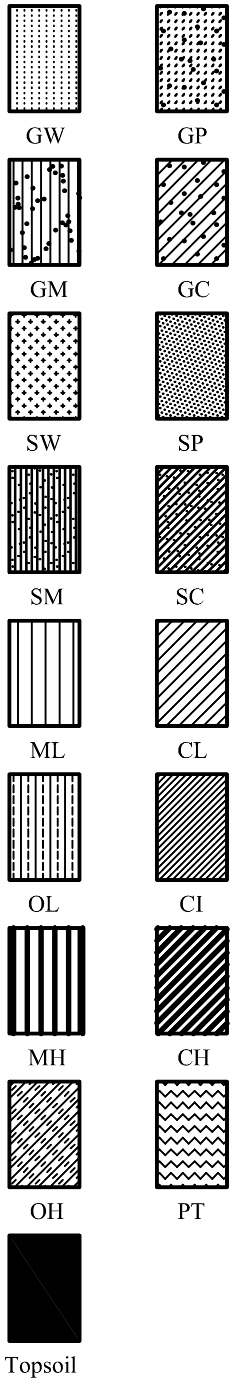


Topsoil

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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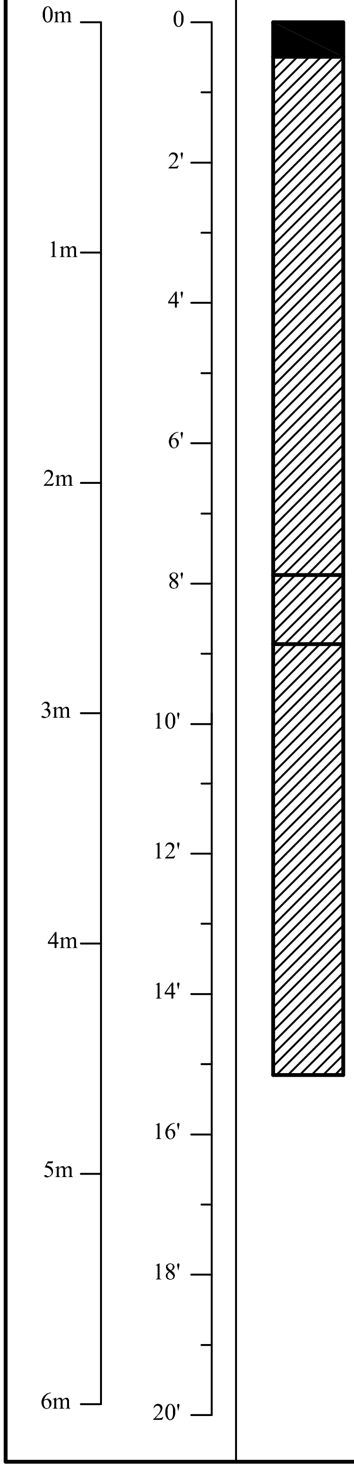
J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

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

DATE : January 15, 2002
TEST HOLE # 4

DEPTH OF SAMPLE	FIELD CLASSIFICATION

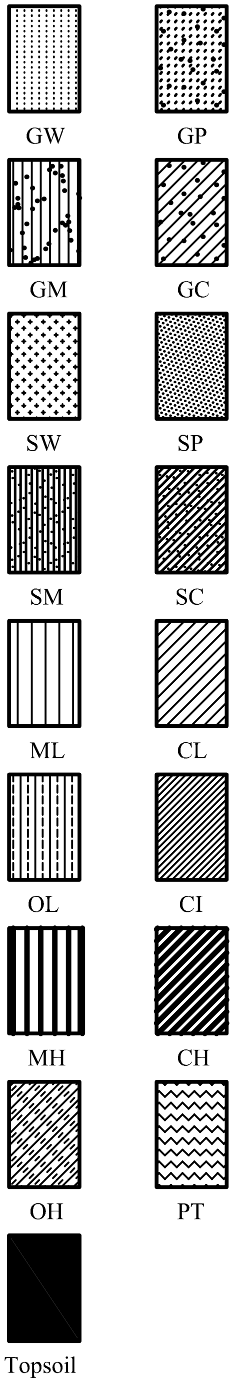


Topsoil

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

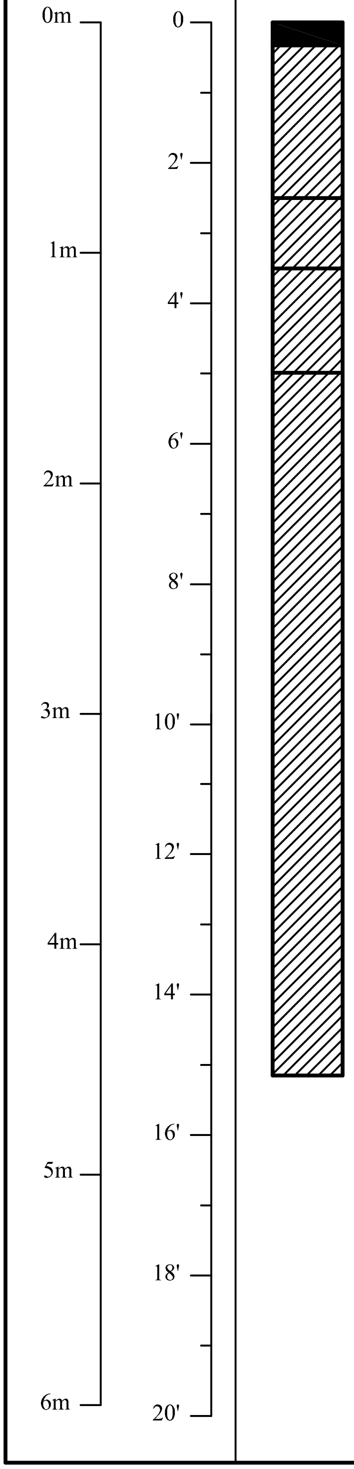
DATE : January 15, 2002

LOCATION OF BORING : NW 15-13-6E

PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02

TEST HOLE # 5

DEPTH OF SAMPLE	FIELD CLASSIFICATION



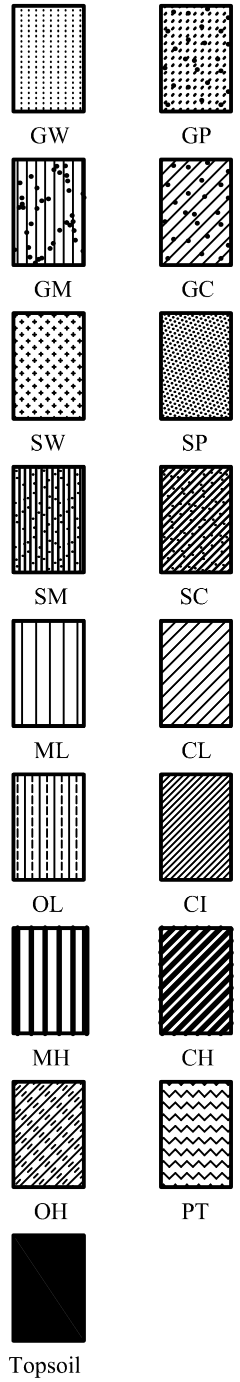
Topsoil

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

DATE : January 15, 2002

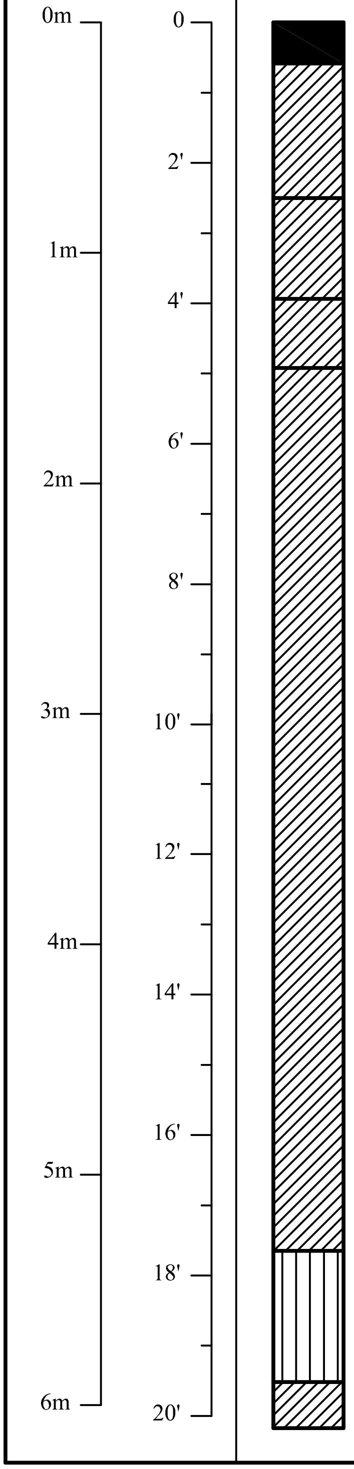
LOCATION OF BORING : NW 15-13-6E

PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02

TEST HOLE # 6

DEPTH OF SAMPLE

FIELD CLASSIFICATION



Topsoil

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

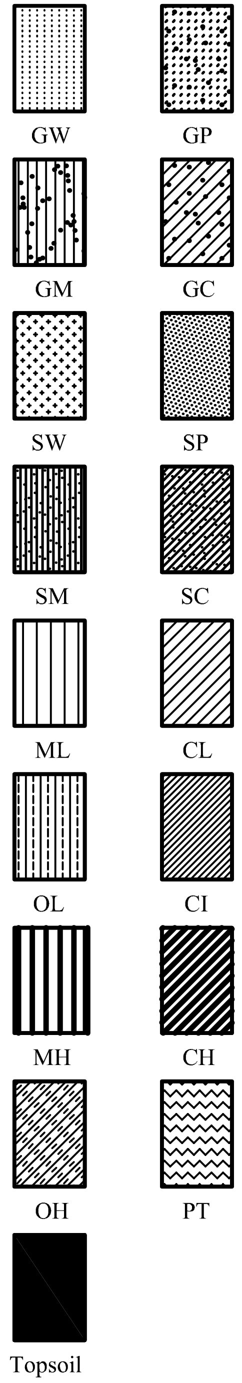
High plastic clay, brown, some silt, trace sand, slightly moist

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

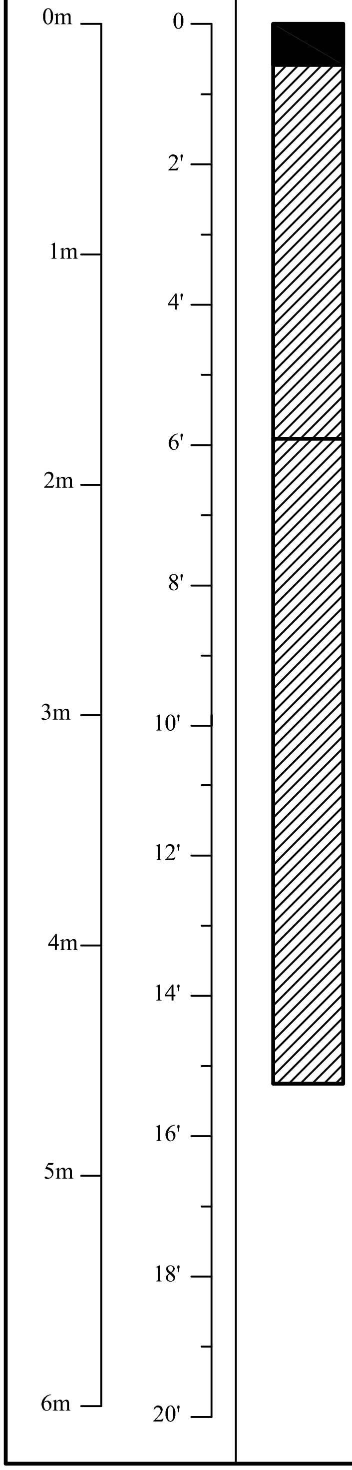
DATE : January 15, 2002

LOCATION OF BORING : NW 15-13-6E

PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02

TEST HOLE # 7

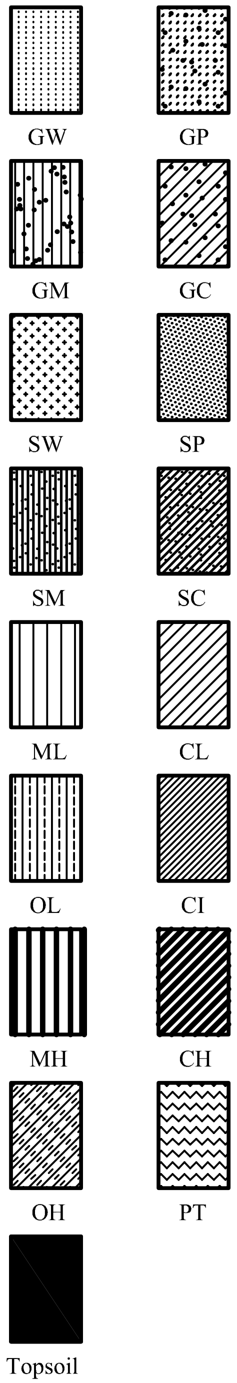
DEPTH OF SAMPLE	FIELD CLASSIFICATION



Topsoil

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

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.

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

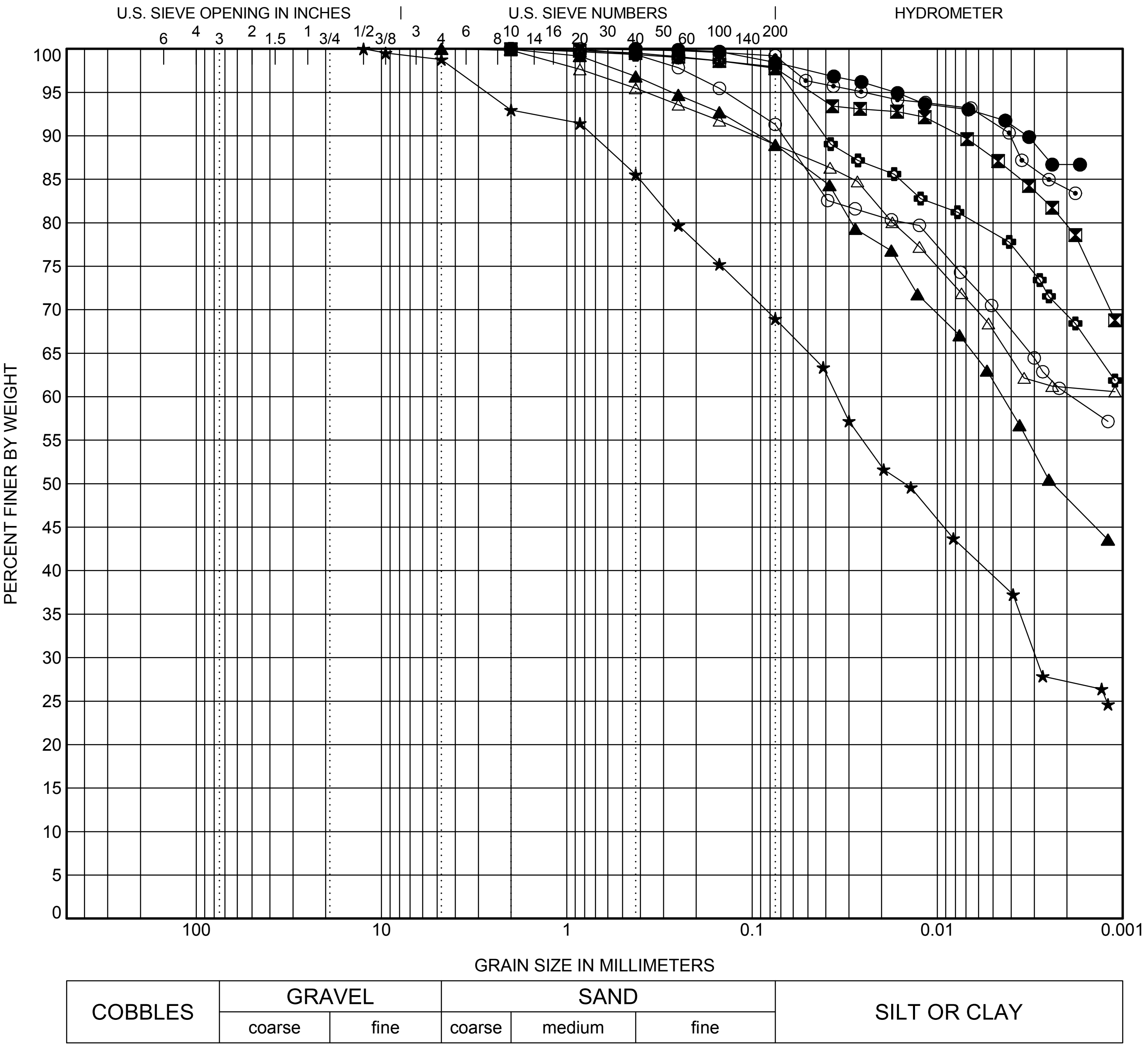
J. Wiwcharyk

T Gluck.

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

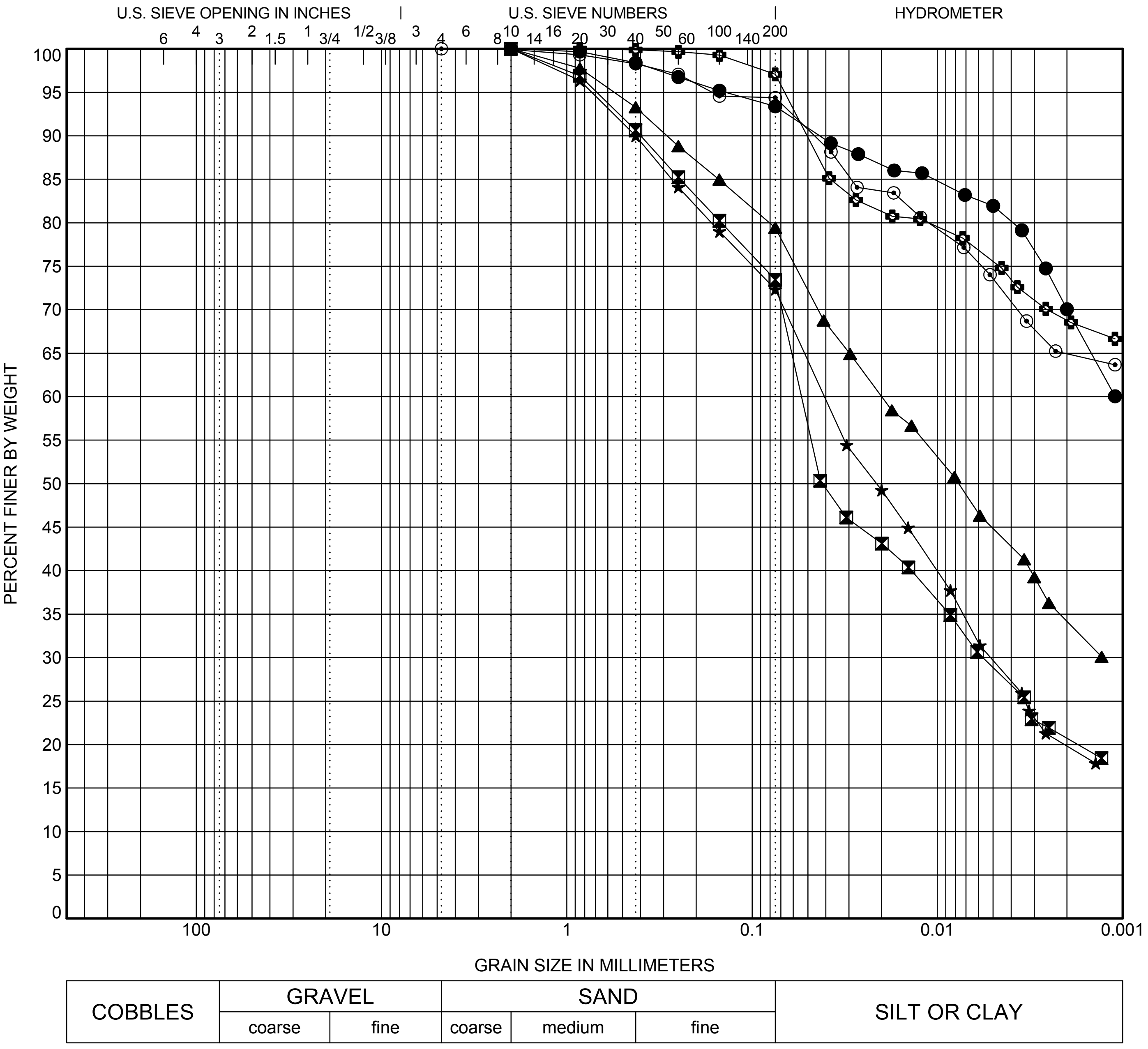
PROJECT No.: WX10949

PROJECTION: N/A

SCALE: AS SHOWN

FIGURE No.: **1**

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



	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. Corr, c	Hyd. Cond. Corrected, K
Start	End	(seconds)	Influent (ml)	Effluent (ml)		(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.

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   To       Log
  (ft.)  (ft.)
      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   To    Casing       Inside   Outside  Slot     Type        Material
  (ft.)  (ft.) Type         Dia.(in) Dia.(in) Size(in)
      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   To       Log
  (ft.)  (ft.)
     0   35.0    CLAY
   35.0   68.0    TILL
   68.0   75.0    GRAVEL
   75.0  124.9    LIMESTONE

WELL CONSTRUCTION

  From   To    Casing       Inside   Outside  Slot     Type        Material
  (ft.)  (ft.) Type         Dia.(in) Dia.(in) Size(in)
     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   To       Log
  (ft.)  (ft.)
     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   To    Casing       Inside   Outside  Slot     Type       Material
  (ft.)  (ft.) Type         Dia.(in) Dia.(in) Size(in)
     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   To       Log
  (ft.)  (ft.)
     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.

RM of Brokenhead Geotechnical and Topographic Investigation for the Wastewater Treatment Lagoon Expansion
on the SE 1/4 of 15-13-6 EPM, JR Cousin Consultants Ltd., November 2014

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RURAL MUNICIPALITY OF BROKENHEAD

Geotechnical and Topographic Investigation
for the
Wastewater Treatment Lagoon Expansion
on the SE1/4 of 15-13-6 EPM

PROVINCE OF MANITOBA
G. R.
COUSIN
14/11/13
REGISTERED PROFESSIONAL ENGINEER

Prepared by:

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

Reviewed by:

Jerry Cousin, P.Eng.
President

November 2014

APEGM
Certificate of Authorization
J. R. Cousin Consultants Ltd.
No. 234 Date: Nv 13/14

ENGINEERING CONSULTANTS

ACKNOWLEDGMENTS

To prepare this report various sources of information were investigated and researched. The firm of JR 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

JR Cousin Consultants Ltd. (JRCC) conducted a topographic and geotechnical investigation at the SE ¹/₄ of 15-13-06 EPM for the proposed wastewater treatment lagoon expansion for the Rural Municipality of Brokenhead Garson/Tyndall/Henryville lagoon. A previous geotechnical and topographic investigation was completed east of the existing lagoon within the NW and SW ¹/₄ of 15-13-06 EPM. Additional land was purchased by the RM and therefore this investigation was completed. For ease of discussion the previously tested site on the NW and SW ¹/₄ of 15-13-06 EPM will be referred to as Site 1 and the site on the SE ¹/₄ of 15-13-6 EPM will be referred to as Site 2. Nine test holes were drilled at Site 2 and one additional test hole was drilled at Site 1 to confirm the soil profile from the previous investigation. Test hole locations from Site 1 and Site 2 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 ¹/₄ of Section 15-13-06 EPM. The existing lagoon is overloaded and requires expansion.

2.1 Past Geotechnical Investigation by JRCC in 2002

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 included in the Appendix.

2.2 Past Geotechnical Investigation by JRCC in 2012

A geotechnical and topographic investigation was completed by JRCC in March of 2012 on the land east of the existing lagoon within the NW and SW ¹/₄ of 15-13-06 EPM (Site 1). Twelve test holes were drilled at the site. Test hole locations are shown on Plan 1 attached in the Appendix and past test hole logs are attached in the Appendix. The report recommended that the south end of the lagoon expansion site be lined with insitu clay soils and the north end of the site be lined with re-worked and re-compacted clay soils. The till layer at the north end of the site was observed 3.0 m below surface in TH5, 2.7 m in TH11 and 2.0 m in TH12. This would provide very little safety factor on the depth of liner, depending on the final cell floor elevations determined during final design. In addition, the entire soil profile of TH6 was deemed not suitable for use as a clay liner and would have to be excavated and replaced with suitable high plastic clay.

Based on the poor test results at the north end of the site, the current geotechnical investigation was initiated to potentially save on construction costs of re-working and re-compacting a portion of the liner.

2.3 GW Driller's Well Logs

There were four driller's well logs reviewed from 15-13-06 EPM. 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 2 was completed on October 14, 2014 along with the geotechnical investigation. Additional information was collected on October 30, 2014. The existing ground at the proposed expansion site is relatively flat. From the topographic survey data, the existing ground elevations varied from 236.58 m to 240.01 m with an average elevation of approximately 238.08 m. The ground slopes from east to west at an average slope of approximately 0.88%.

The existing ground elevation on the SW ¼ of Site 1 (directly west of Site 2) is 236.10 m. The existing ground elevation on the NW ¼ of Site 1 (northwest of Site 2) is 236.43 m. The average existing lagoon top of dike elevation is approximately 237.22 m.

The average elevation of Site 2 is approximately 2.0 m higher than Site 1.

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 October 14, 2014. Maple Leaf Drilling Ltd. was employed to conduct the test holes using a track-mounted drill rig under direct supervision by JRCC's field representative.

There were ten test holes (TH1 – TH10) drilled during the geotechnical investigation. The test holes TH1 – TH9 were drilled at Site 2 and TH10 was drilled at Site 1 to confirm the soil profile determined during the previous investigation. The test holes were drilled to a depth of 6.1 m (20 ft) or auger refusal. Test hole locations are shown on Plan 1, attached 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. Eleven selected bagged soil samples from the test holes were sealed and submitted to Stantec Consulting Ltd. for laboratory testing. There were two Shelby tube samples (TH3 2.1 m – 2.7m and TH6 0.9 m – 1.5 m) sent to the laboratory 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 groundwater infiltration and caving of the test holes 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 2 (TH1 - TH9):

• 0 to 0.1 m	Black, high plastic clay topsoil silty, some sand with organics and roots from 0 – 0.1 m
• 0.1 to 0.3 m	Black high plastic clay, silty, some sand
• 0.3 to (1.5 – 5.3 m)	Brown high plastic clay, some silt inclusions, some sand, moist, stiff
• (1.5 – 5.3) to (TH termination)	Tan, low plastic sandy, silt till, clayey with some gravel, soft, wet.

Test holes were terminated due to auger refusal from boulders in TH2 – TH6. Caving of the test holes was observed in TH1 at 3.0 m, TH5 at 4.3 m and TH6 at 4.0 m.

The soil profile of TH10 consisted of 0.05 m of black topsoil followed by brown high plastic clay from 0.05 to 6.1 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. One test hole (TH2) was left open for approximately 4.5 hours to evaluate longer term groundwater conditions. Caving and sloughing of the test hole walls was also observed and recorded. Standing water was observed in TH3 at 2.7 m, TH5 at 3.7 m, TH6 at 2.7 m and TH7 at 5.8 m. TH2 had a standing water elevation at 2.3 m below surface immediately after excavation and after 4.5 hours the standing water elevation was at 1.8 m below surface. There was no standing water 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 Stantec Consulting Ltd. 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)
- Visual Classification.

The Shelby tube samples were subjected to a Hydraulic Conductivity test (ASTM D5084).

Laboratory classification analysis of the bagged soil samples indicated that 8 of the samples were CH (fat clay), 1 sample was CH (fat clay with sand) and 2 samples were CL (sandy lean clay). The Plasticity Index of the samples classified as CH varied between 44 and 74 and the percentage of clay varied between 58.8% and 91.6%. The Plasticity Index of the samples classified as CL varied between 8 and 18 and the percentage of clay varied between 26.9% and 35.7%.

The laboratory commented *"Based upon previous testing conducted in our laboratory, homogeneous soil samples with a plasticity index greater than 25 and a clay content greater than 50% will typically have a hydraulic conductivity of 1.0 x 10^{-7} cm/sec or less."* Therefore all samples classified as CH were deemed suitable for use as a lagoon liner and all samples classified as CL were deemed not suitable for use as a lagoon liner.

The laboratory also indicated *"Our comments regarding the potential use of the material as a liner are based upon the soil being homogeneous with no preferential flow paths. It should be 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."*

The Shelby tube samples from (TH3 2.1 – 2.7 m) and (TH6 0.9 – 1.5 m) achieved hydraulic conductivities (k_{20}) of 5.8 x 10^{-9} cm/sec and 6.8 x 10^{-9} cm/sec, respectively. This hydraulic conductivity is lower than the Manitoba Conservation requirement of 1 x 10^{-7} cm/sec and therefore both samples are deemed suitable for use as an insitu clay lagoon liner.

Details of Stantec Consulting Ltd. test results and analysis, dated November 7, 2014 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 x 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 x 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 x 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 (Site 2)

Based on the laboratory analysis, all of the bagged soil samples classified as fat clay (CH) will be suitable for use as an insitu clay liner or when re-worked and re-compacted. The soils deemed unsuitable for use as a lagoon liner begin at a depth of 1.5 m – 5.3 below surface. The start of unsuitable material at each test hole and the elevation is shown on the following table:

Table 1: Start of Unsuitable Material

Test Hole	Depth Below Surface	Elevation
TH1	5.3 m	231.6 m
TH2	3.4 m	234.0 m
TH3	3.0 m	235.4 m
TH4	1.8 m	238.1 m
TH5	1.5 m	237.6 m
TH6	3.4 m	234.6 m
TH7	4.0 m	233.2 m
TH8	1.5 m	237.1 m
TH9	1.8 m	237.0 m

The highest elevation of unsuitable liner material was found in TH4, which will likely be beyond the limits of an expansion cell. The next highest elevations are found in TH5, TH8 and TH9. Depending on the final depths of cell excavation and final layout of the expansion cell, excavation and re-working a small portion of the liner compared to the north part of site 1 may be required.

It is recommended that the lagoon expansion cell be designed so that the area near TH5, TH8 and TH9 are avoided to save the capital costs of re-working and re-compacting a portion of the liner. The remainder of the site could be constructed with an insitu clay liner, depending on the final elevations of the cells.

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. If at any point along the vertical cut-off wall, the till layer is discovered to be within the liner elevation, the extent of the till material within the liner elevations must be excavated and re-compacted with suitable high plastic clay to ensure a minimum 1.0 m liner exists across the cell.

6.4 Utilization of Soils for Lagoon Construction

Based on visual soil classification during test hole drilling and subsequent laboratory analysis, the following table describes the potential use of the excavated soils for lagoon construction at the site.

Table 2: Utilization of Soils for Lagoon Construction

Average Depth	Soil Layer	Possible Use for Lagoon Construction
0 to 0.1 m	Black, high plastic clay topsoil silty, some sand with organics and roots	• Topsoil dressing • Mixed into outer dike slopes
0.1 to 0.3 m	Black high plastic clay, silty, some sand	• Suitable for vertical cut-off walls • Suitable for inner and outer dike slopes
0.3 to (1.5 – 5.3 m)	Brown high plastic clay, some silt inclusions, some sand, moist, stiff	• Suitable for insitu horizontal clay liner • Suitable for vertical cut-off walls • Suitable for inner and outer dike slopes
(1.5 – 5.3) to (TH termination)	Tan, low plastic sandy, silt till, clayey with some gravel, soft, wet	• Not suitable for clay liner • If discovered within the 1m thick insitu clay liner, soils must be removed and replaced with high plastic clay soils

The lagoon design specifications and plans should reference the above construction materials. Depth of excavation may vary based on calculated cut and fill requirements, to be determined during the detailed design phase.

7.0 RECOMMENDATIONS AND CLOSURE

7.1 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 on Site 2 be constructed with the insitu high plastic clay soils. It is recommended that the lagoon expansion cell be designed so that the area near TH5, TH8 and TH9 are avoided to save the capital costs of re-working and re-compacting a portion of the liner. Depending on the final depths of cell excavation and final layout of the expansion cell, excavation and re-working a portion of the liner may be required if till material is discovered within the 1.0 m thick insitu clay 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.

7.2 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: Test Hole Locations and Existing Contour Lines

Test Hole Logs

2002 Past Test Hole Logs

2012 Past Test Hole Logs

Stantec Consulting Ltd. Test Results, dated November 7, 2014

GW Driller's Well Logs

Plan 1: Test Hole Locations and Existing Contour Lines

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

No.	REVISIONS	DATE	INITIALS

B.M. EL.

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

JRCC ENGINEERING CONSULTANTS
JR Cousin Consultants Ltd.
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www.jrcc.ca
ENGINEERING EXCELLENCE SINCE 1981

CODE: B–246.11
DESIGNED BY: JC
DRAWN BY: BM
REVIEWED BY: JC

PROJECT:
RM OF BROKENHEAD
GTH LAGOON GEOTECHNICAL INVESTIGATION

TITLE:
TEST HOLE LOCATIONS
AND EXISTING CONTOUR LINES

SCALE: 1:2500
DATE: 14/11/13
PLAN: 1
SHEET: 1 of 1

Nov 13, 2014 – 4:05pm F:\200\246 Brokenhead RM\246.11 GTH Lagoon Geotech Investigation\04 Drawings\dwg\Geotechnical\Test Hole Locations.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 - Site 2

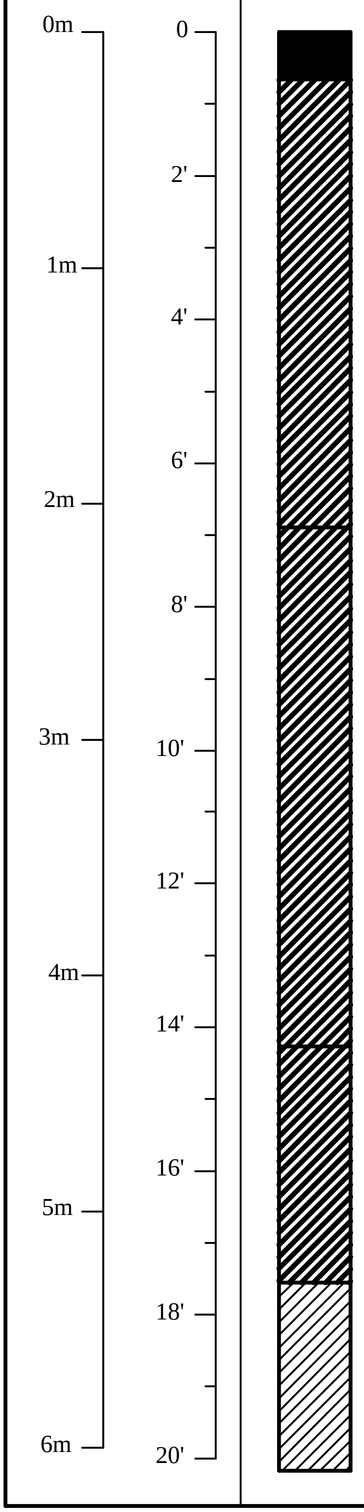
DATE : October 14, 2014

ELEVATION: 236.886 m

PROJECT : GTH Lagoon Geotechnical Investigation

TEST HOLE # 1

DEPTH OF SAMPLE	FIELD CLASSIFICATION



TOPSOIL - Black, high plastic clay, organic, silty, some sand with organics and roots from 0 - 0.1 m

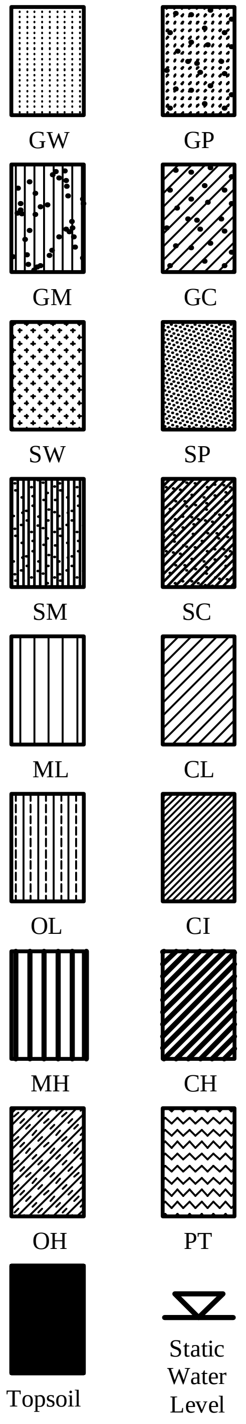
CLAY - High plastic, brown, some silt inclusions, some sand, moist, stiff

CLAY - High plastic, brown, some silt inclusions, some sand, moist-wet, soft

CLAY - High plastic, brown, trace silt, trace sand, wet, soft

TILL - Low plastic, tan, silty, sandy, clayey with some gravel, saturated, very soft

No water infiltration observed. Caving of the hole to 3.0 m.



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J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead - Site 2

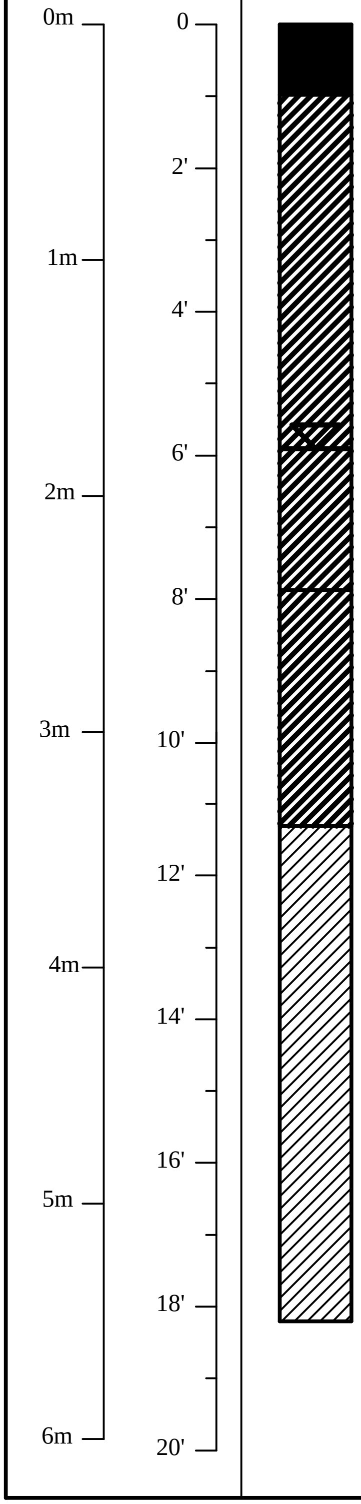
DATE : October 14, 2014

ELEVATION: 237.377 m

PROJECT : GTH Lagoon Geotechnical Investigation

TEST HOLE # 2

DEPTH OF SAMPLE	FIELD CLASSIFICATION



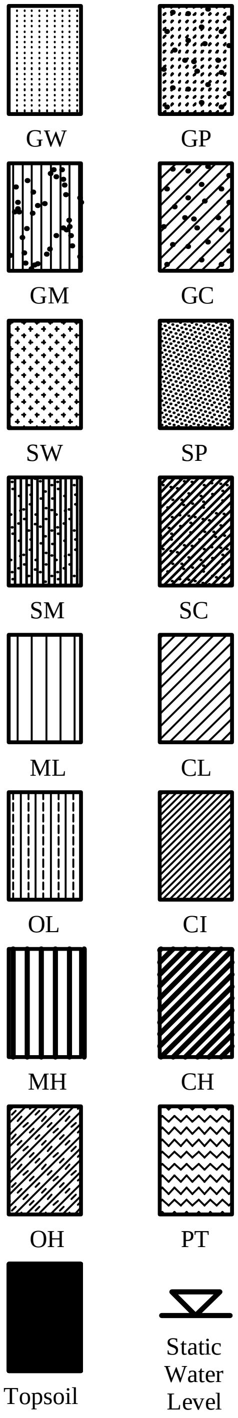
TOPSOIL - Black, high plastic clay, organic, silty, some sand with organics and roots from 0 - 0.1 m

CLAY - High plastic, brown, some silt inclusions, some sand, moist, stiff

CLAY - High plastic, brown, some silt inclusions, some sand, moist-wet, soft

TILL - Low plastic, tan, silty, sandy, clayey with some gravel, saturated, very soft

Auger refusal at 5.5 m in boulders. Standing water observed at 2.3 m after excavation. After 4.5 h standing water observed at 1.8 m.



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J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead - Site 2

DATE : October 14, 2014

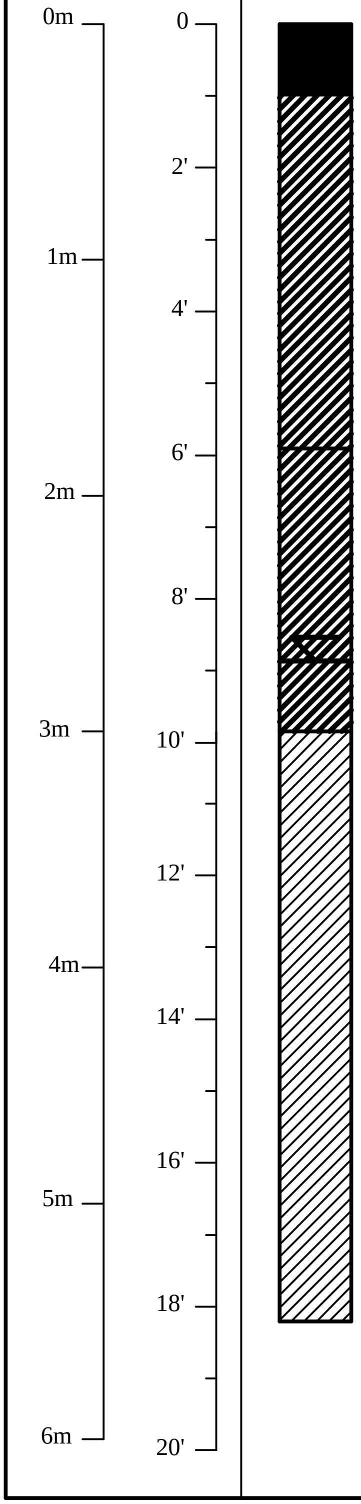
ELEVATION: 238.440 m

PROJECT : GTH Lagoon Geotechnical Investigation

TEST HOLE # 3

DEPTH OF SAMPLE

FIELD CLASSIFICATION



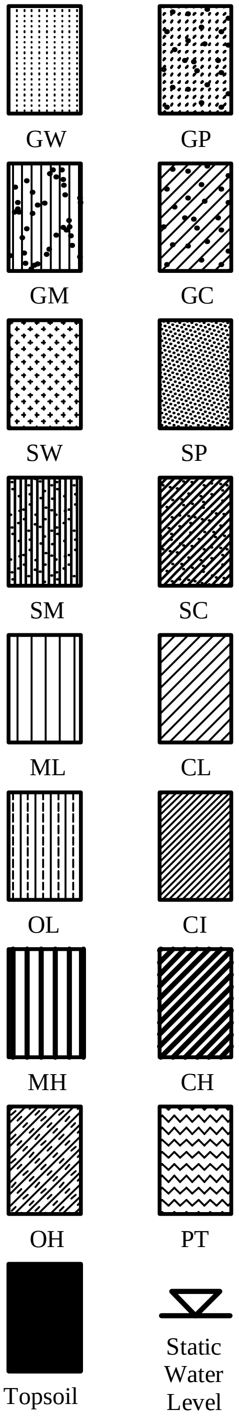
TOPSOIL - Black, high plastic clay, organic, silty, some sand with organics and roots from 0 - 0.1 m

CLAY - High plastic, brown, some silt inclusions, some sand, moist, stiff

CLAY - High plastic, brown, some silt inclusions, some sand, moist-wet, soft

TILL - Low plastic, tan, silty, sandy, clayey with some gravel, saturated, very soft

Auger refusal at 5.5 m in boulders. Standing water observed at 2.7 m after excavation.



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J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead - Site 2

DATE : October 14, 2014

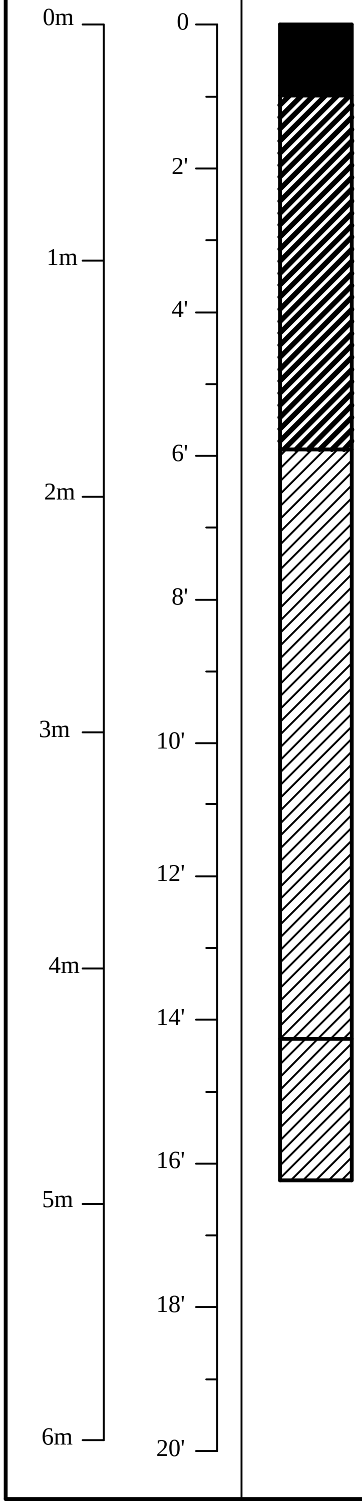
ELEVATION: 239.925 m

PROJECT : GTH Lagoon Geotechnical Investigation

TEST HOLE # 4

DEPTH OF SAMPLE

FIELD CLASSIFICATION



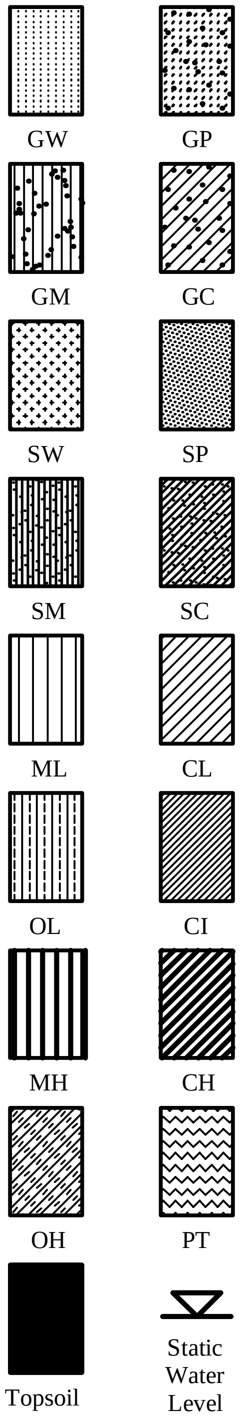
TOPSOIL - Black, high plastic clay, organic, silty, some sand with organics and roots from 0 - 0.1 m

CLAY - High plastic, brown, some silt inclusions, some sand, moist, stiff

TILL - Low plastic, tan, silty, sandy, clayey with some gravel, damp, soft, loose

TILL - Low plastic, tan, silty, sandy, clayey with gravel, damp, soft, loose

Auger refusal at 4.9 m in boulders. No water infiltration observed.



J. R. Cousin Consultants Ltd.

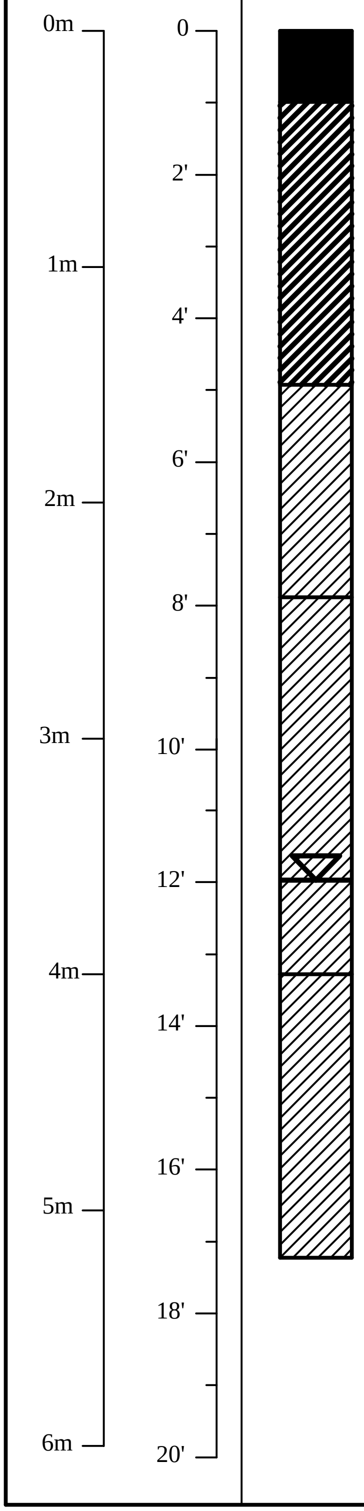
TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead - Site 2

PROJECT : GTH Lagoon Geotechnical Investigation

DATE : October 14, 2014
ELEVATION: 239.171 m
TEST HOLE # 5

DEPTH OF SAMPLE	FIELD CLASSIFICATION



TOPSOIL - Black, high plastic clay, organic, silty, some sand with organics and roots from 0 - 0.1 m

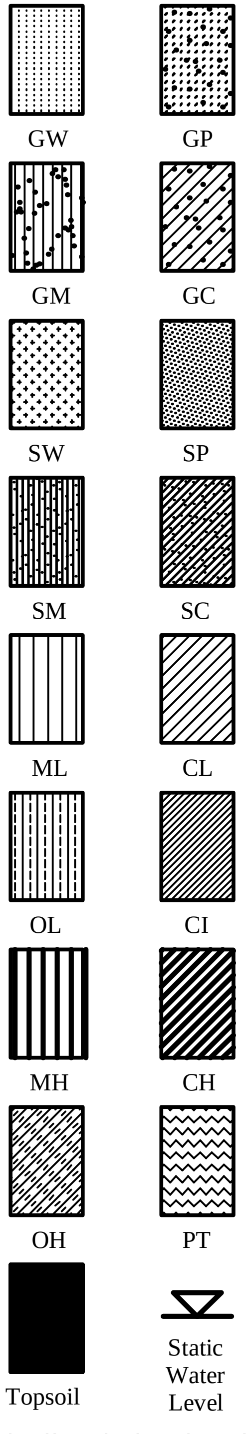
CLAY - High plastic, brown, some silt inclusions, some sand, moist, stiff

TILL - Low plastic, tan, silty, sandy, clayey with some gravel, moist, soft

TILL - Low plastic, tan, silty, sandy, clayey with some gravel, damp, soft

TILL - Low plastic, tan, silty, sandy, clayey with some gravel, saturated, soft

Auger refusal at 5.2 m in boulders. Standing water observed at 3.6 m after excavation. Caving of the test hole to 4.3 m.



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.

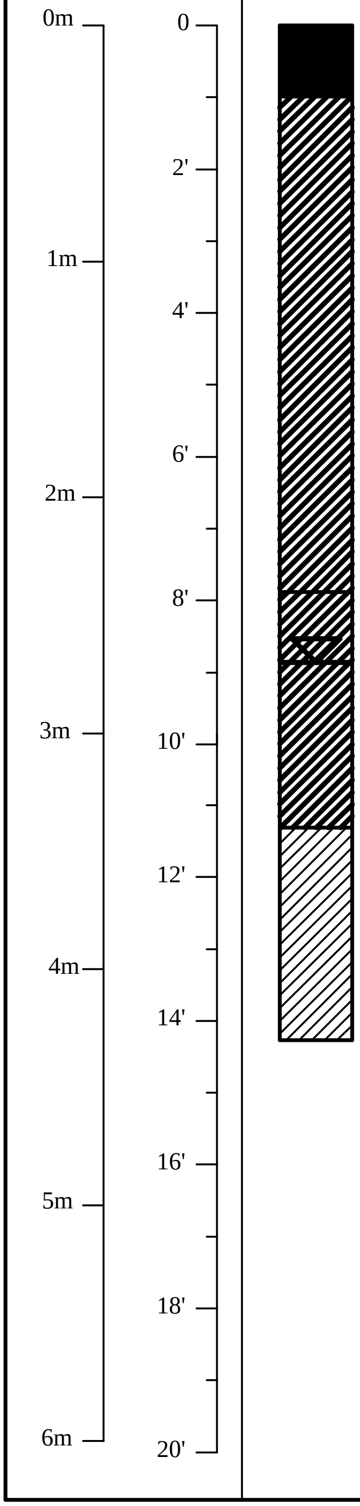
J. R. Cousin Consultants Ltd.

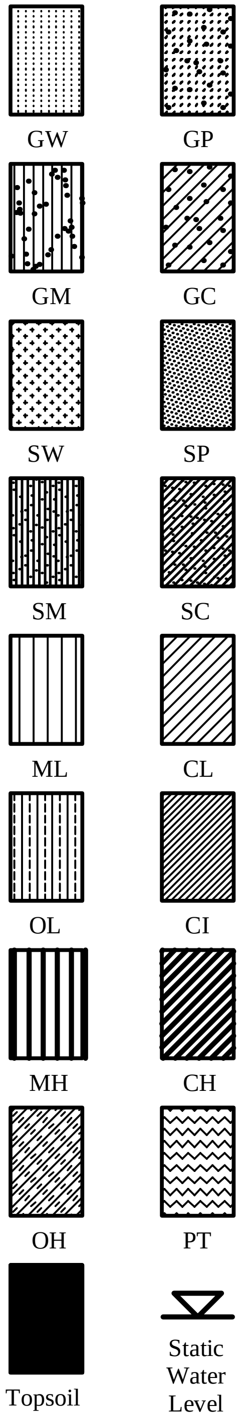
TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead - Site 2

PROJECT : GTH Lagoon Geotechnical Investigation

DATE : October 14, 2014
ELEVATION: 237.988 m
TEST HOLE # 6

DEPTH OF SAMPLE	FIELD CLASSIFICATION
	TOPSOIL - Black, high plastic clay, organic, silty, some sand with organics and roots from 0 - 0.1 m CLAY - High plastic, brown, some silt inclusions, some sand, moist, stiff CLAY - High plastic, brown, some silt inclusions, some sand, moist-wet, soft TILL - Low plastic, tan, silty, sandy, clayey with some gravel, saturated, soft Auger refusal at 4.3 m in boulders. Standing water observed at 2.7 m after excavation. Caving of the test hole to 4.0 m.



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J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead - Site 2

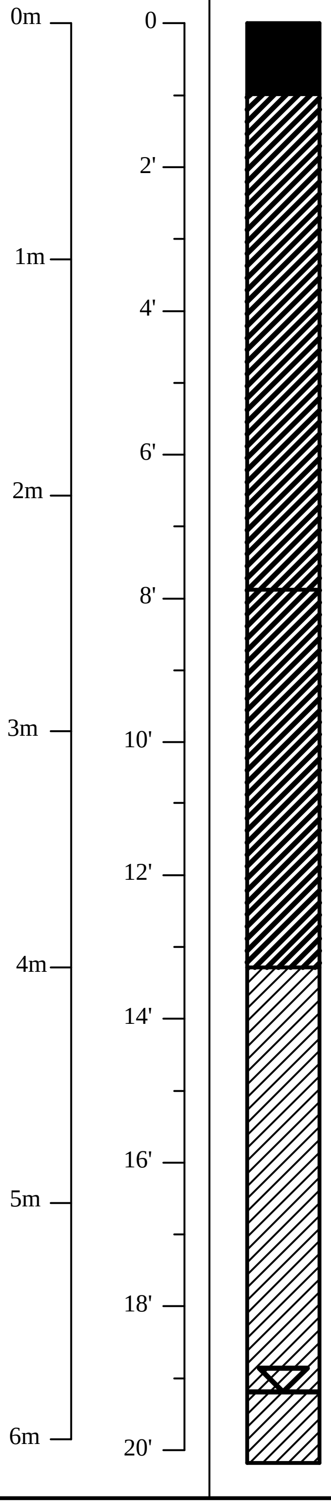
DATE : October 14, 2014

ELEVATION: 237.172 m

PROJECT : GTH Lagoon Geotechnical Investigation

TEST HOLE # 7

DEPTH OF SAMPLE	FIELD CLASSIFICATION



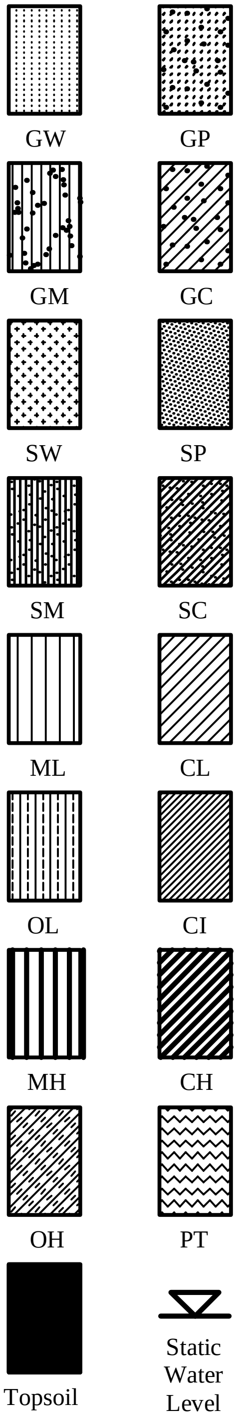
TOPSOIL - Black, high plastic clay, organic, silty, some sand with organics and roots from 0 - 0.1 m

CLAY - High plastic, brown, some silt inclusions, some sand, moist, stiff

CLAY - High plastic, brown, some silt inclusions, some sand, moist-wet, soft

TILL - Low plastic, tan, silty, sandy, clayey with some gravel, saturated, soft

Test hole terminated in till layer. Standing water observed at 5.8 m after excavation. No caving.



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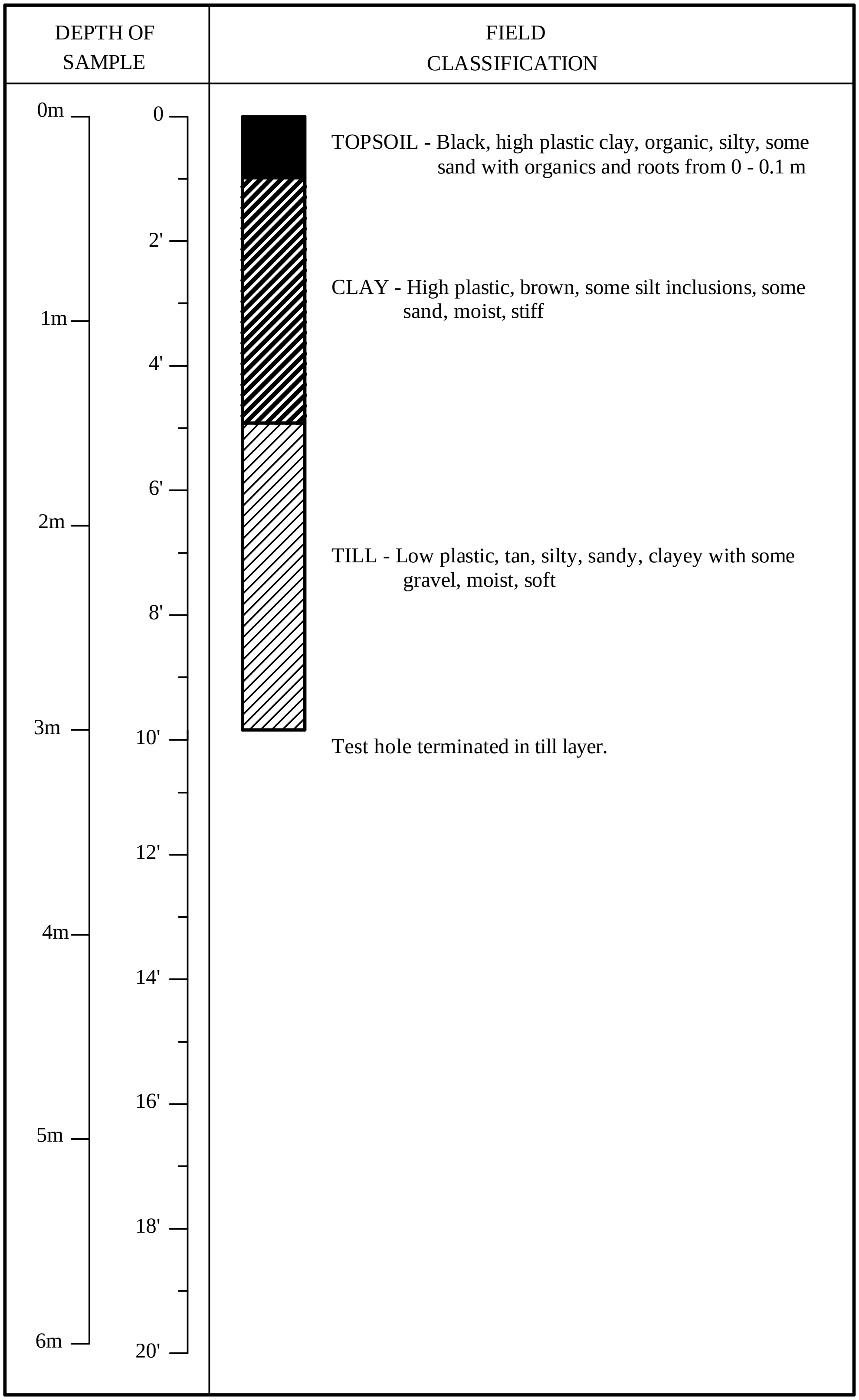
J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead - Site 2

PROJECT : GTH Lagoon Geotechnical Investigation

DATE : October 14, 2014
ELEVATION: 238.625 m
TEST HOLE # 8

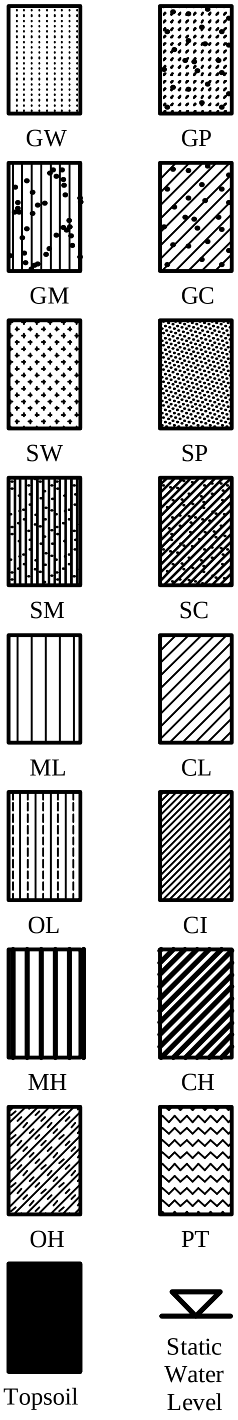


TOPSOIL - Black, high plastic clay, organic, silty, some sand with organics and roots from 0 - 0.1 m

CLAY - High plastic, brown, some silt inclusions, some sand, moist, stiff

TILL - Low plastic, tan, silty, sandy, clayey with some gravel, moist, soft

Test hole terminated in till layer.



J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead - Site 2

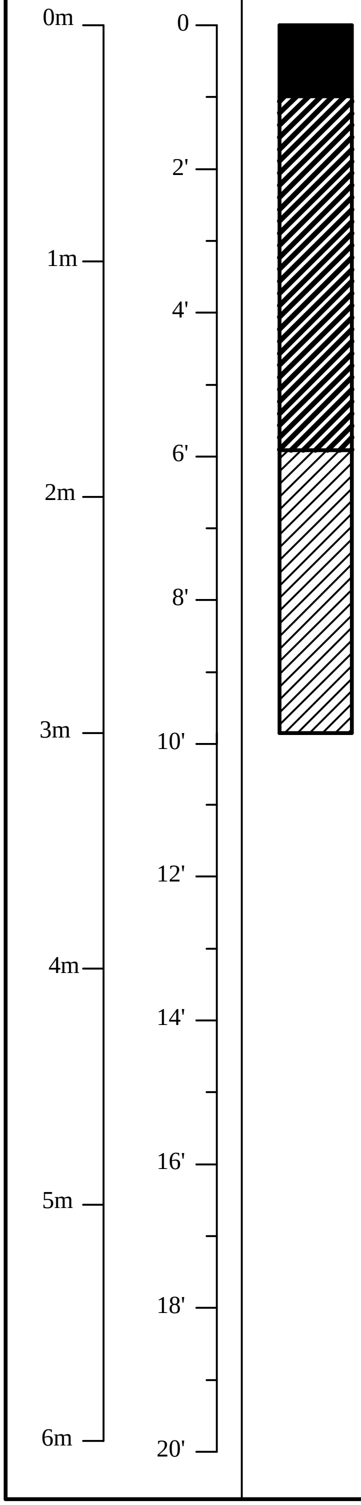
PROJECT : GTH Lagoon Geotechnical Investigation

DATE : October 14, 2014

ELEVATION: 238.798 m

TEST HOLE # 9

DEPTH OF SAMPLE	FIELD CLASSIFICATION

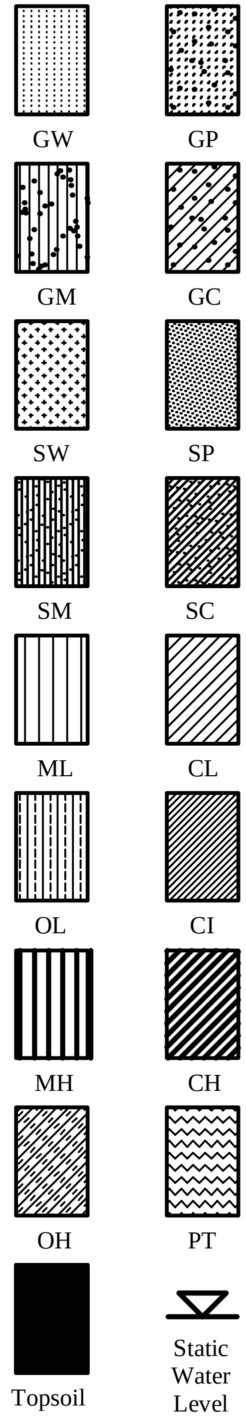


TOPSOIL - Black, high plastic clay, organic, silty, some sand with organics and roots from 0 - 0.1 m

CLAY - High plastic, brown, some silt inclusions, some sand, moist, stiff

TILL - Low plastic, tan, silty, sandy, clayey with some gravel, moist, soft

Test hole terminated in till layer.



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J. R. Cousin Consultants Ltd.

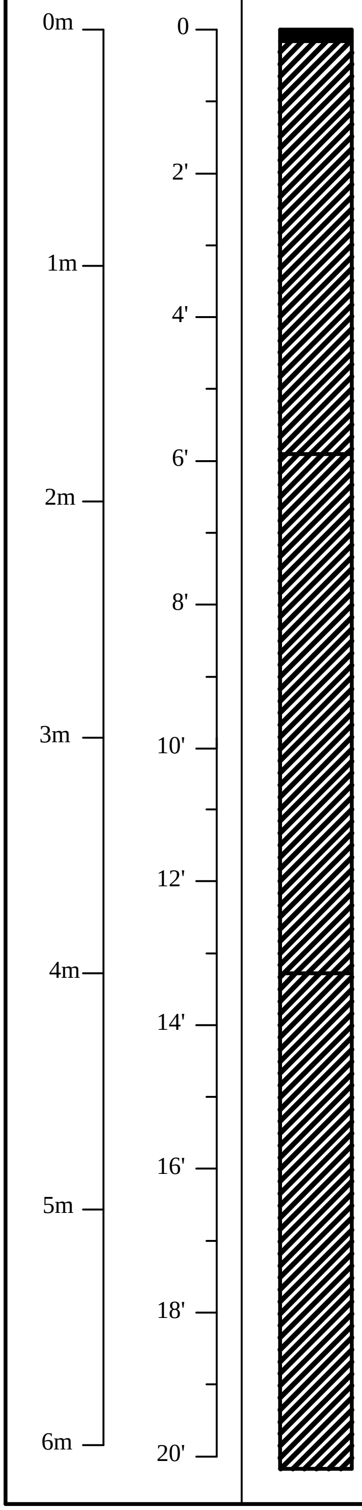
TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead - Site 2

PROJECT : GTH Lagoon Geotechnical Investigation

DATE : October 14, 2014
ELEVATION: 235.994 m
TEST HOLE # 10

DEPTH OF SAMPLE	FIELD CLASSIFICATION



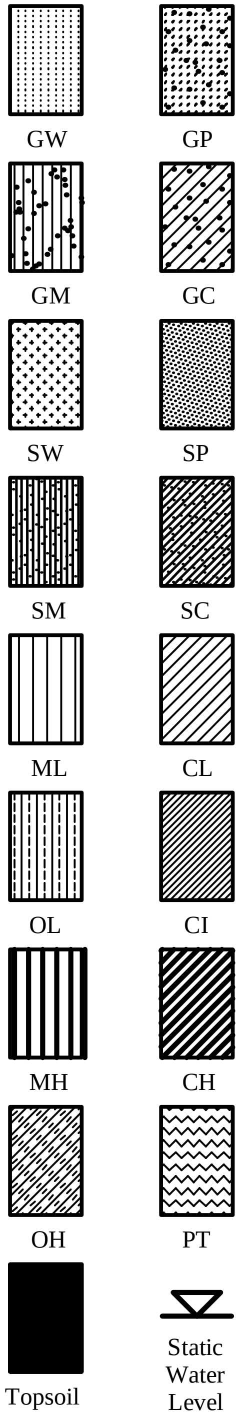
TOPSOIL - Black, high plastic clay, organic, silty, some sand

CLAY - High plastic, dark grey, some silt inclusions, some sand, moist, stiff

CLAY - High plastic, brown, some silt inclusions, some sand, trace gravel, moist, stiff

CLAY - High plastic, brown, trace silt, moist, stiff

Test hole terminated in high plastic clay layer. No water infiltration. No caving.



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2002 Past Test Hole Logs

J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : RM of Brokenhead

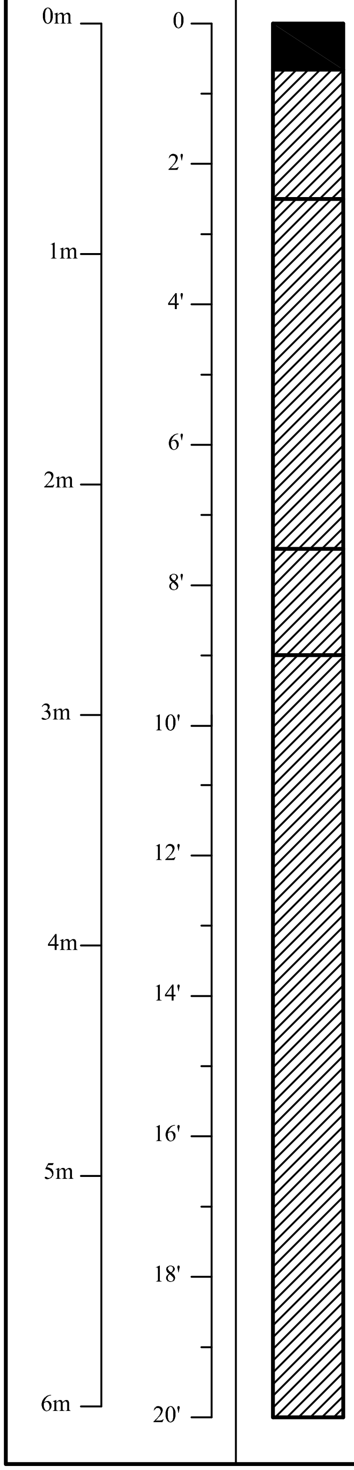
LOCATION OF BORING : NW 15-13-6E

PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02

DATE : January 15, 2002

TEST HOLE # 1

DEPTH OF SAMPLE	FIELD CLASSIFICATION



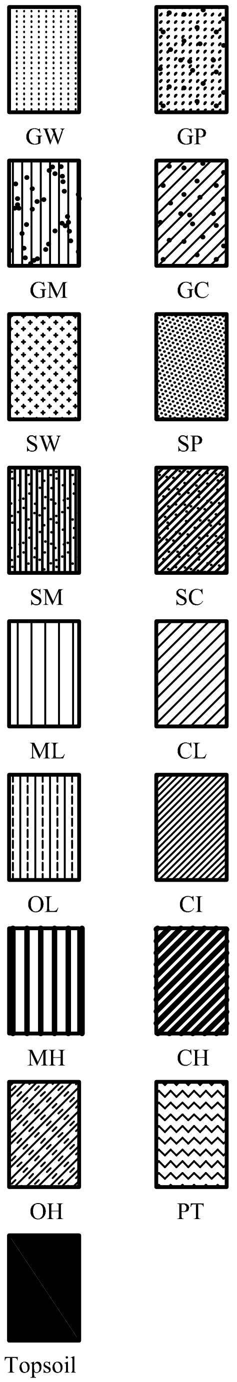
Topsoil

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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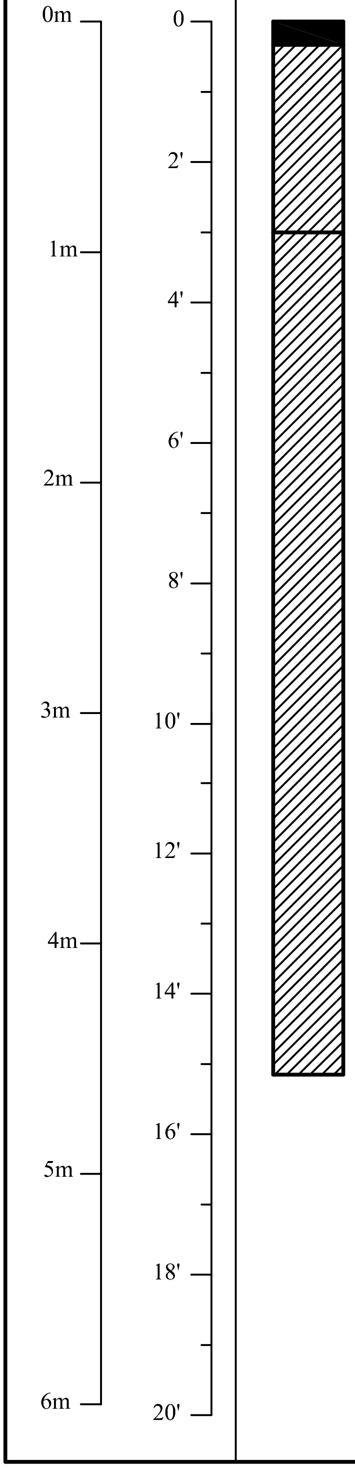
J. R. Cousin Consultants Ltd.

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

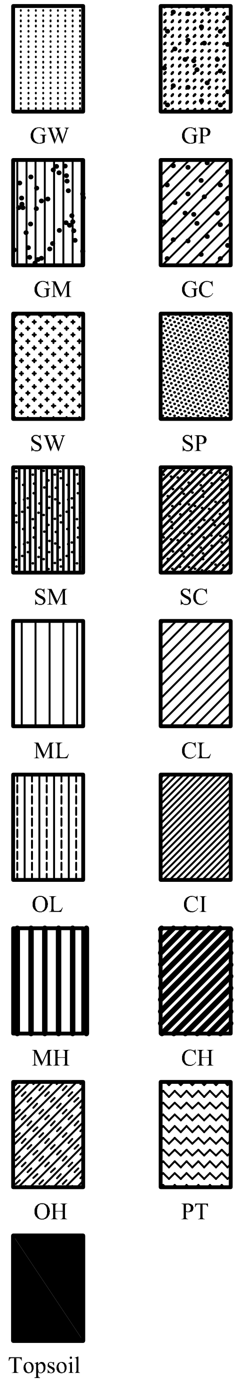
DEPTH OF SAMPLE	FIELD CLASSIFICATION



Topsoil

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

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



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 do 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

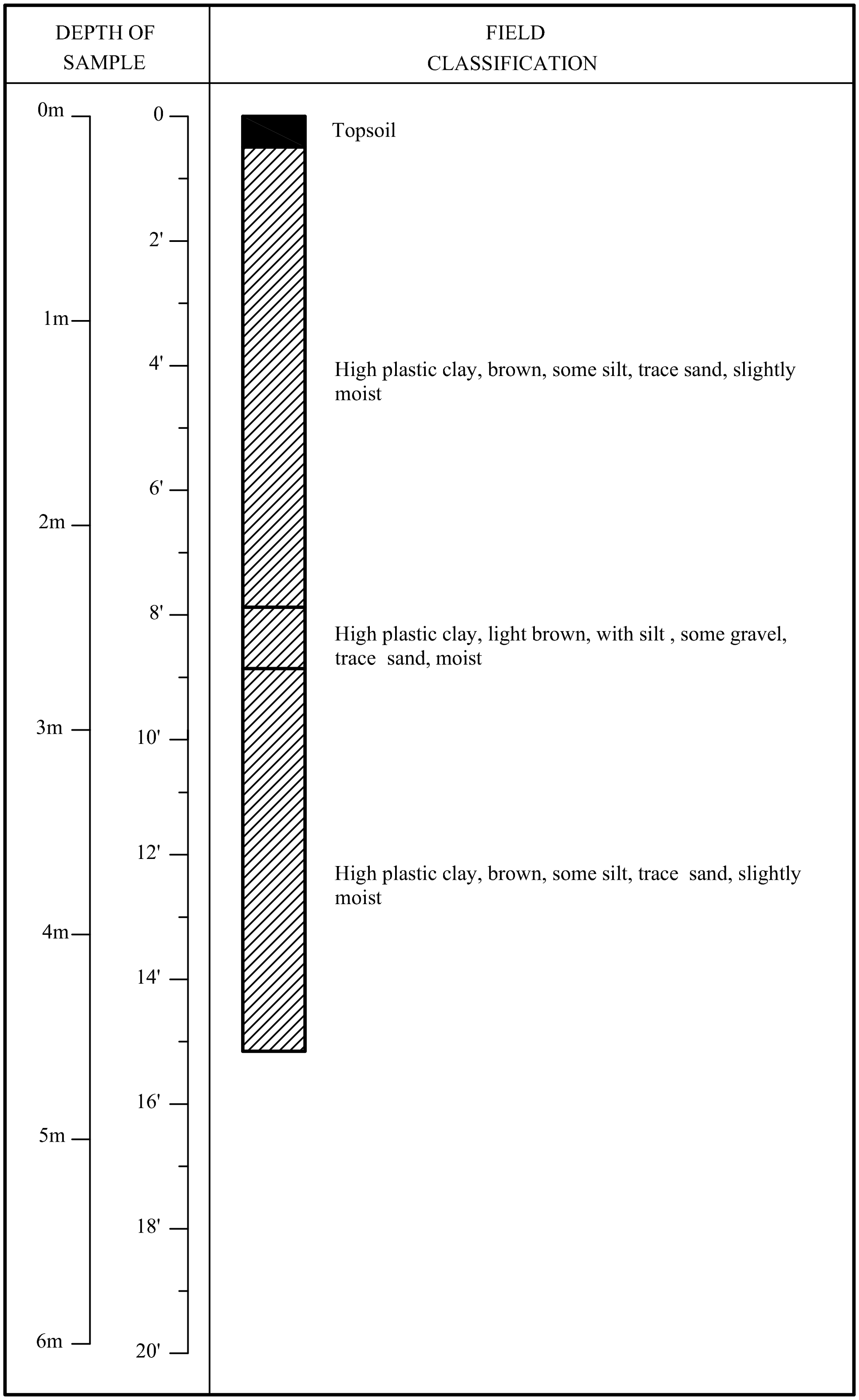
LOCATION : RM of Brokenhead

DATE : January 15, 2002

LOCATION OF BORING : NW 15-13-6E

PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02

TEST HOLE # 3

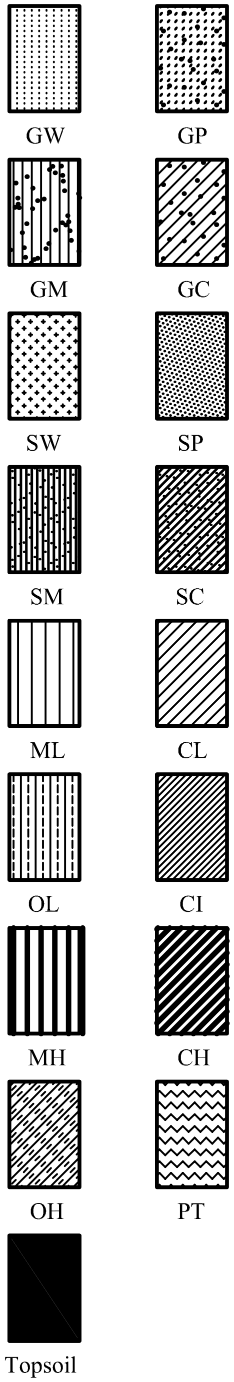


Topsoil

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

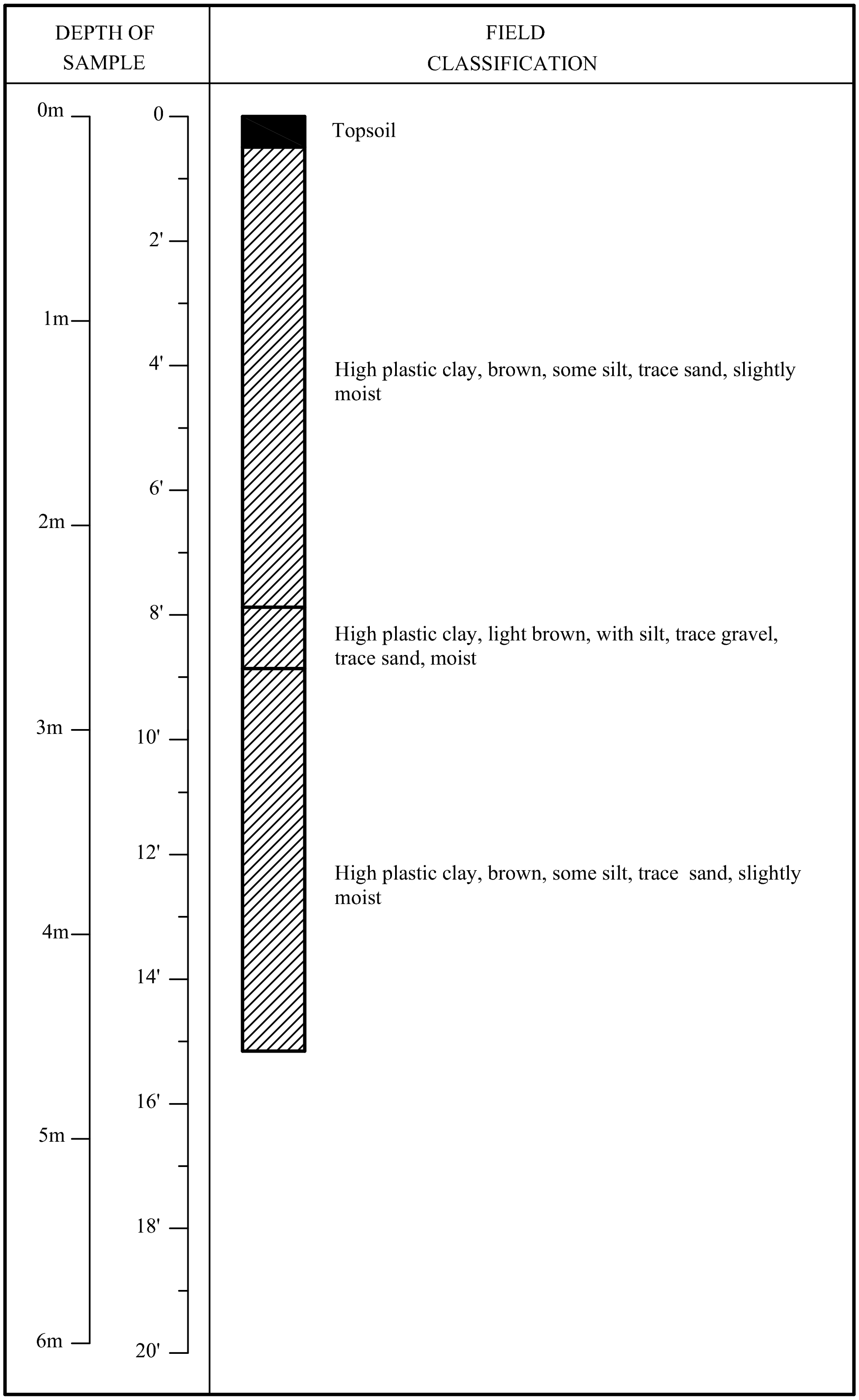
LOCATION : RM of Brokenhead

LOCATION OF BORING : NW 15-13-6E

PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02

DATE : January 15, 2002

TEST HOLE # 4

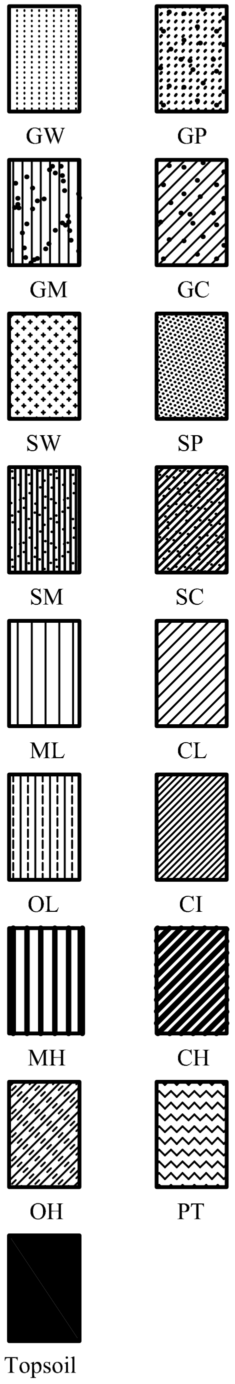


Topsoil

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



J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : RM of Brokenhead

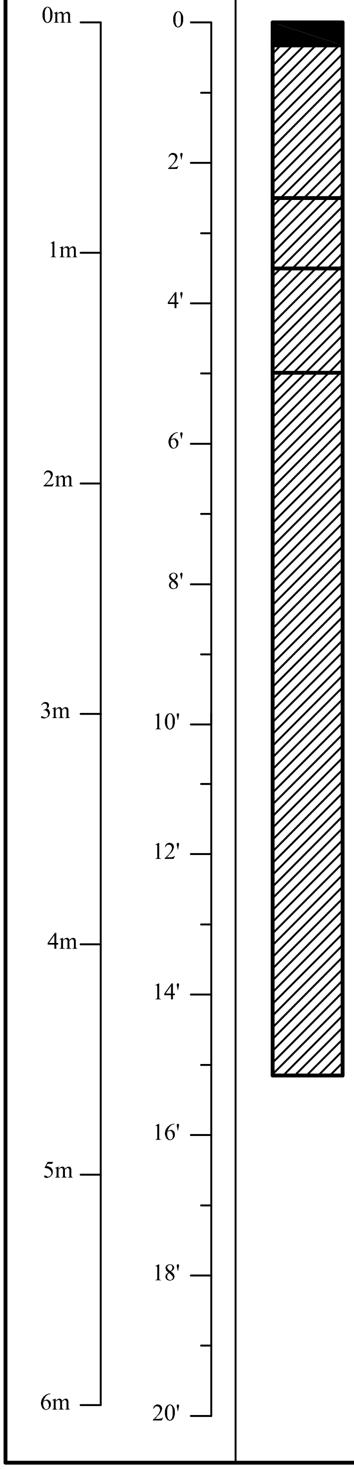
LOCATION OF BORING : NW 15-13-6E

PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02

DATE : January 15, 2002

TEST HOLE # 5

DEPTH OF SAMPLE	FIELD CLASSIFICATION



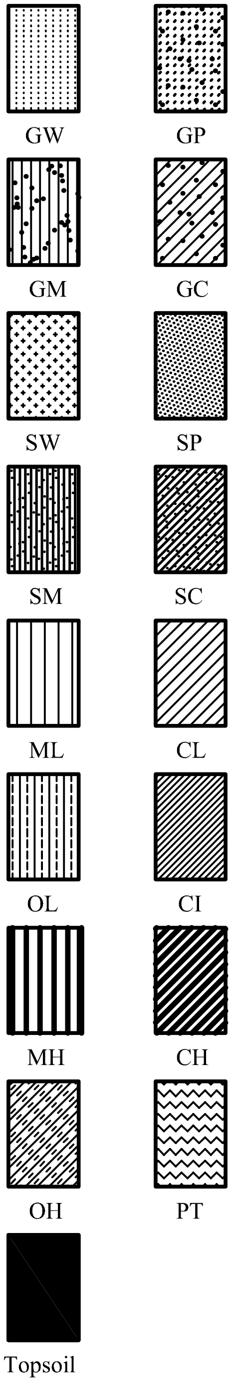
Topsoil

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

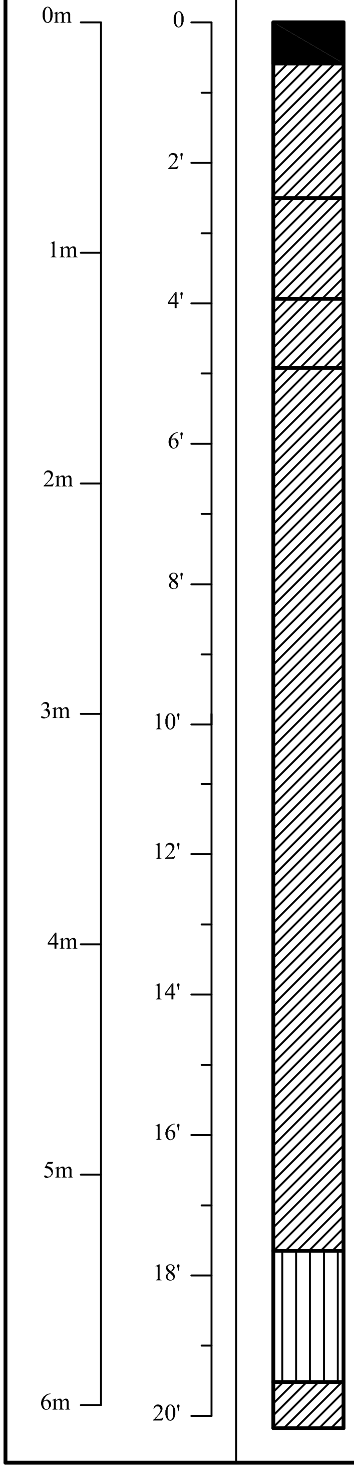
DATE : January 15, 2002

LOCATION OF BORING : NW 15-13-6E

PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02

TEST HOLE # 6

DEPTH OF SAMPLE	FIELD CLASSIFICATION



Topsoil

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

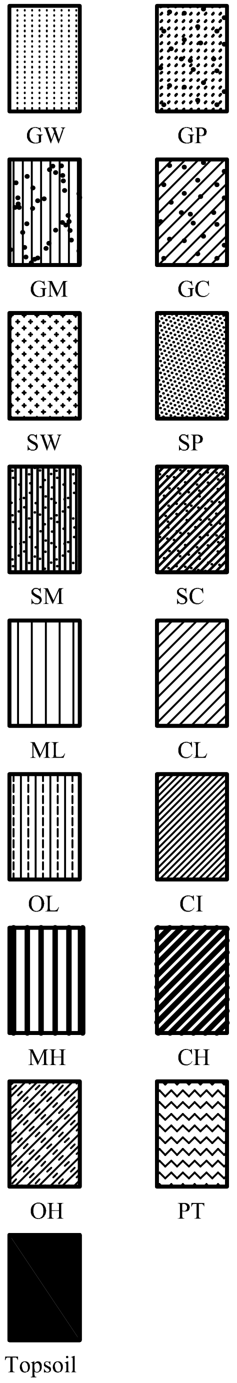
High plastic clay, brown, some silt, trace sand, slightly moist

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



J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : RM of Brokenhead

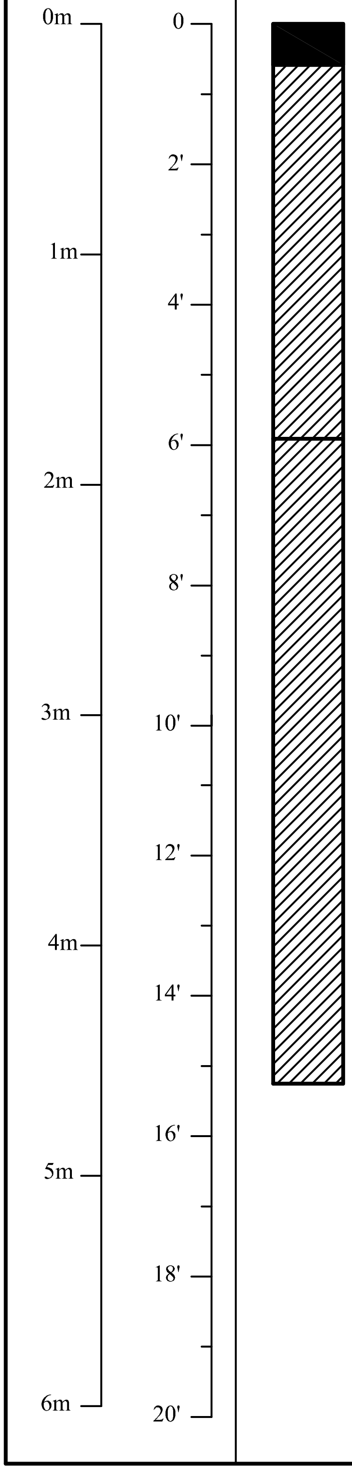
DATE : January 15, 2002

LOCATION OF BORING : NW 15-13-6E

PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02

TEST HOLE # 7

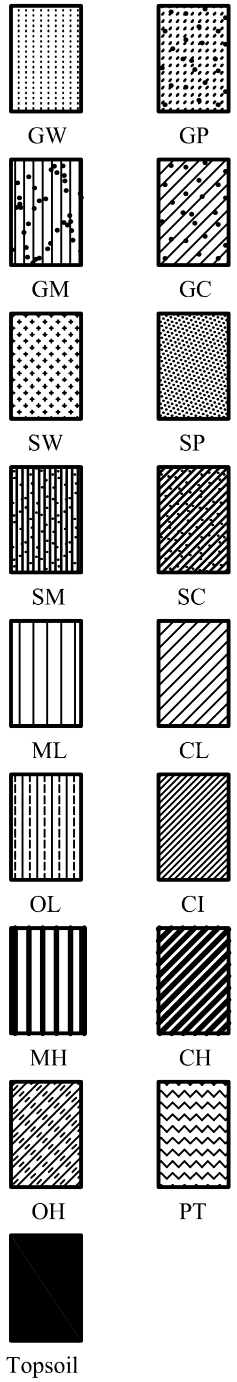
DEPTH OF SAMPLE	FIELD CLASSIFICATION



Topsoil

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

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



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2012 Past 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

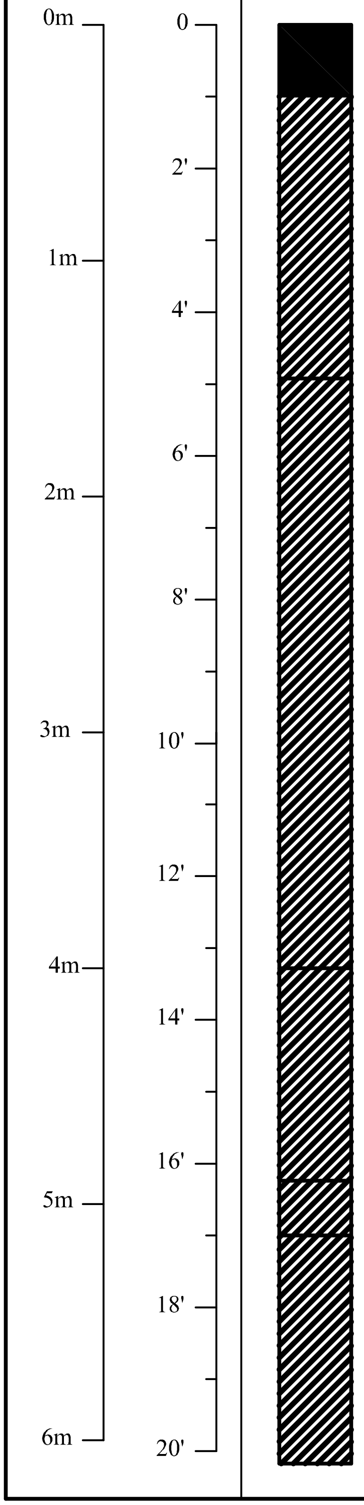
DATE : March 27, 2012

ELEVATION: 236.163

PROJECT : GTH Lagoon Feasibility Study

TEST HOLE # 1

DEPTH OF SAMPLE	FIELD CLASSIFICATION



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

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

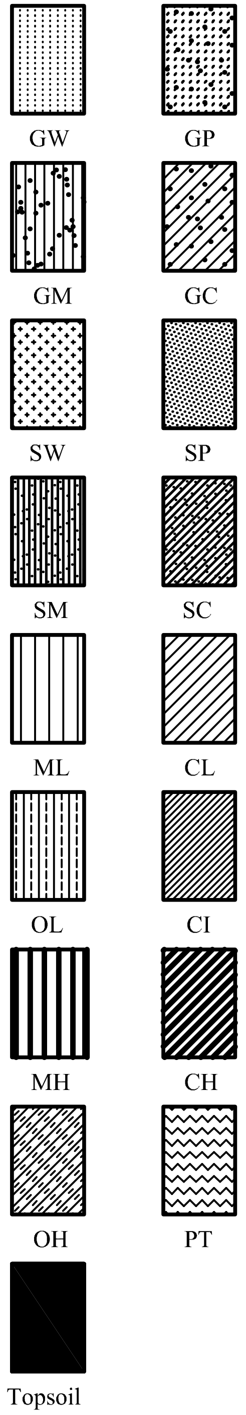
CLAY - High plastic, grey, trace silt, damp, hard, homogenous

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

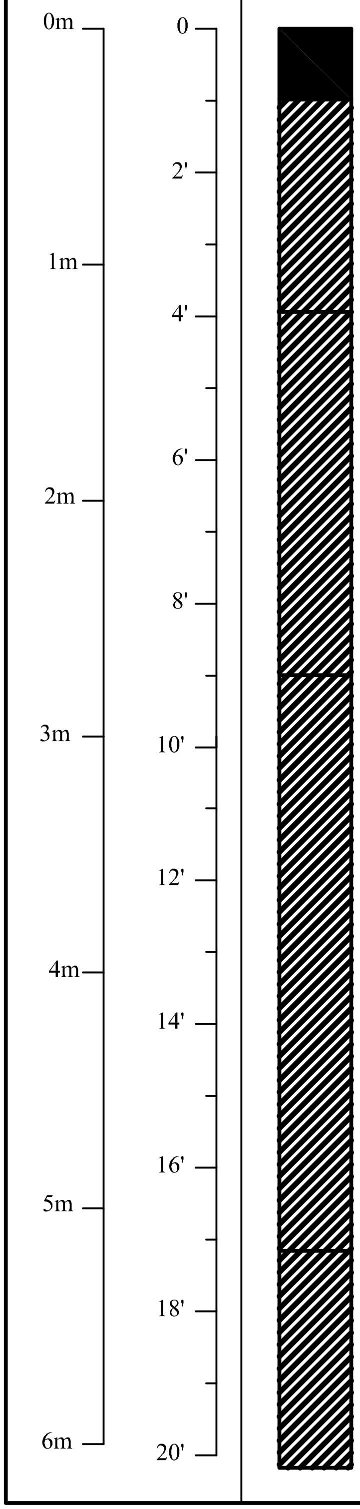
DATE : March 27, 2012

ELEVATION: 236.297

PROJECT : GTH Lagoon Feasibility Study

TEST HOLE # 2

DEPTH OF SAMPLE	FIELD CLASSIFICATION



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

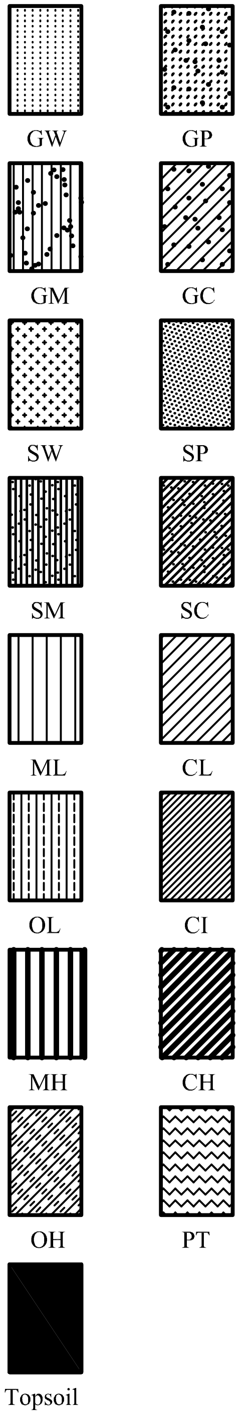
CLAY - High plastic, grey, trace silt, moist, hard, blocky

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

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

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

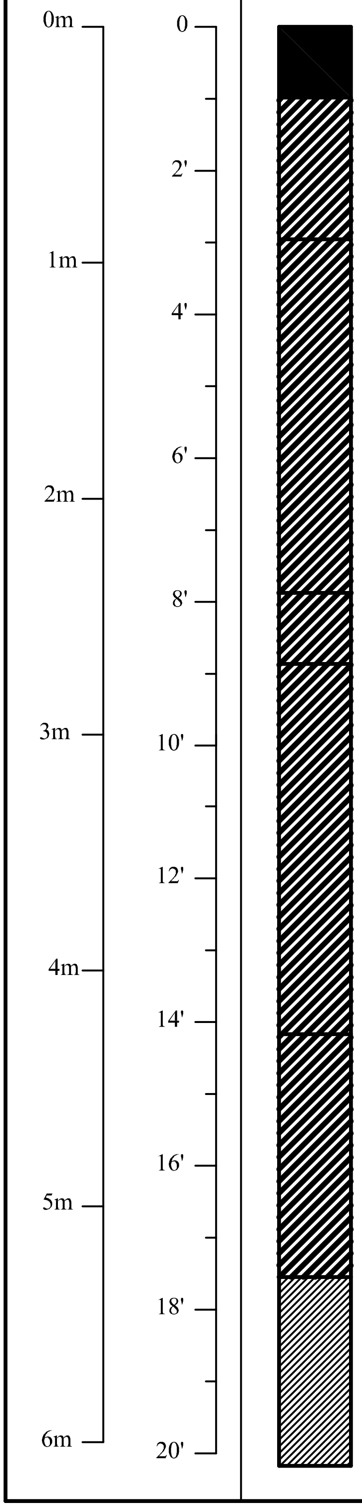
DATE : March 27, 2012

ELEVATION: 236.195

PROJECT : GTH Lagoon Feasibility Study

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

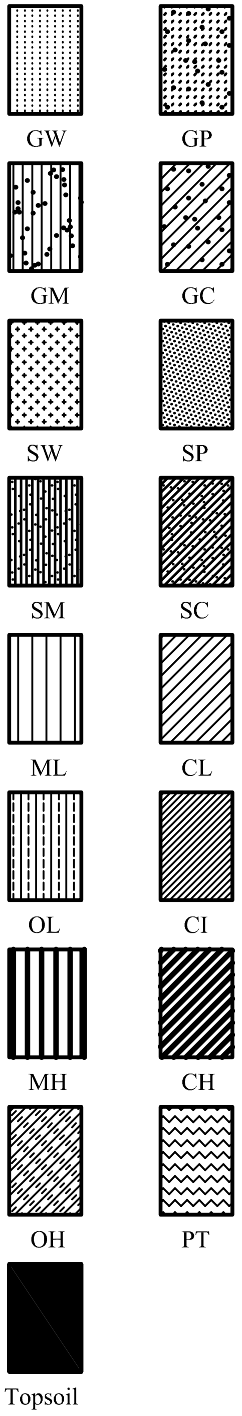
CLAY - High plastic, grey/light brown, with gravel, with silt inclusions, some sand

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.

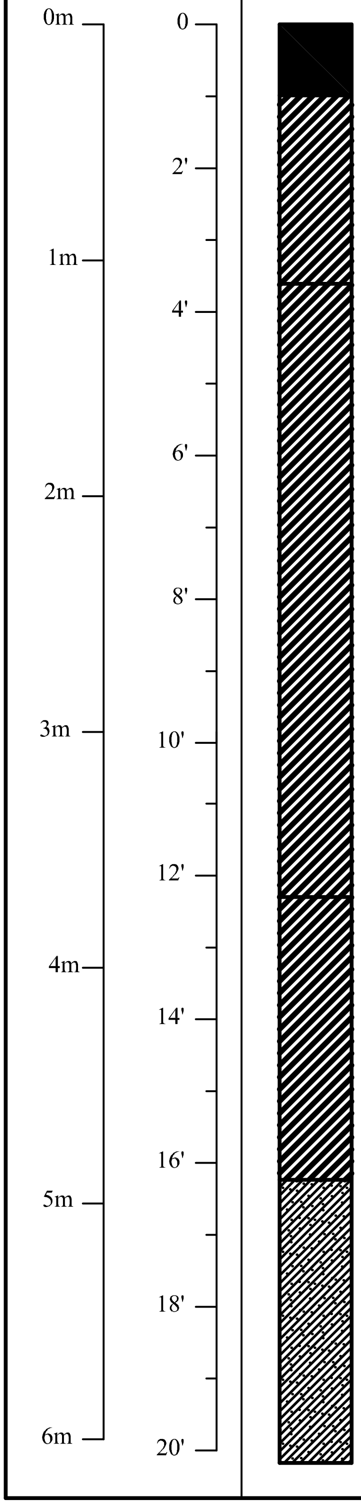
TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead

PROJECT : GTH Lagoon Feasibility Study

DATE : March 27, 2012
ELEVATION: 236.933
TEST HOLE # 4

DEPTH OF SAMPLE	FIELD CLASSIFICATION



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

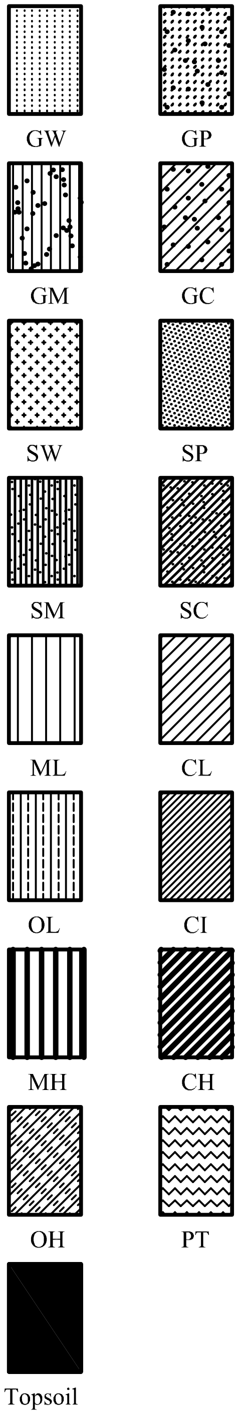
CLAY - High plastic, grey, trace silt, moist, hard, blocky

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

DATE : March 27, 2012

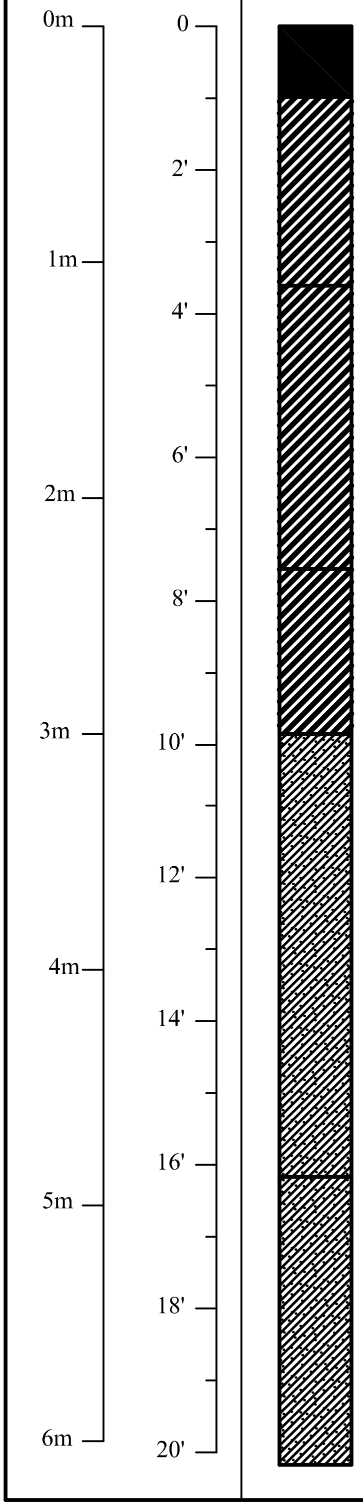
ELEVATION: 236.823

PROJECT : GTH Lagoon Feasibility Study

TEST HOLE # 5

DEPTH OF SAMPLE

FIELD CLASSIFICATION



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

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

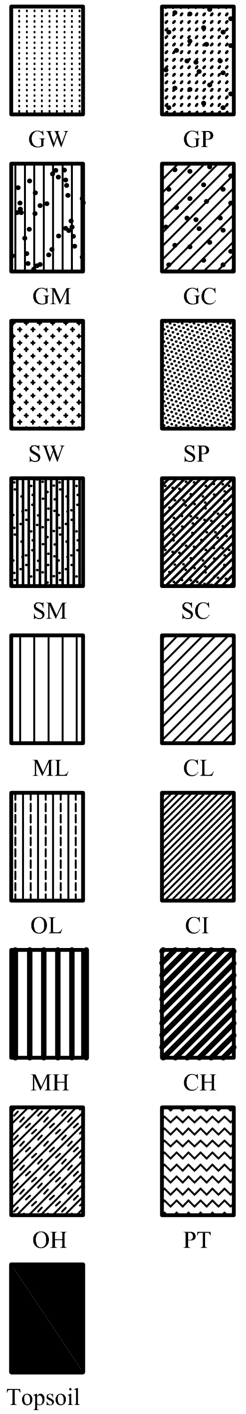
CLAY - High plastic, light brown, with silt and sand inclusions, trace gravel, moist, hard

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

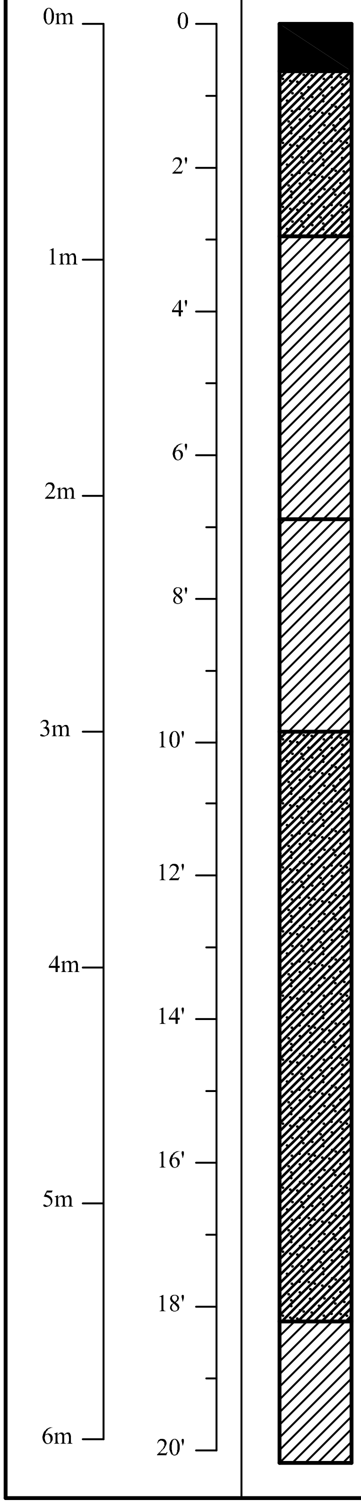
PROJECT : GTH Lagoon Feasibility Study

DATE : March 27, 2012

ELEVATION: 236.533

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

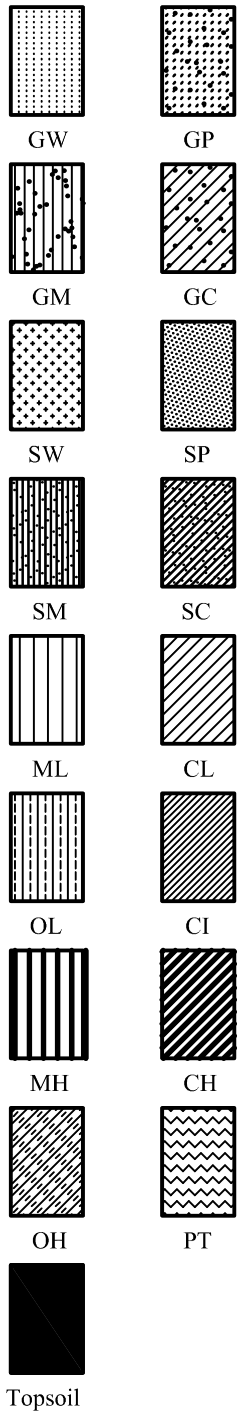
SILTY CLAY - Medium plastic, brown, with some sand, trace gravel, moist, stiff

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



J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead

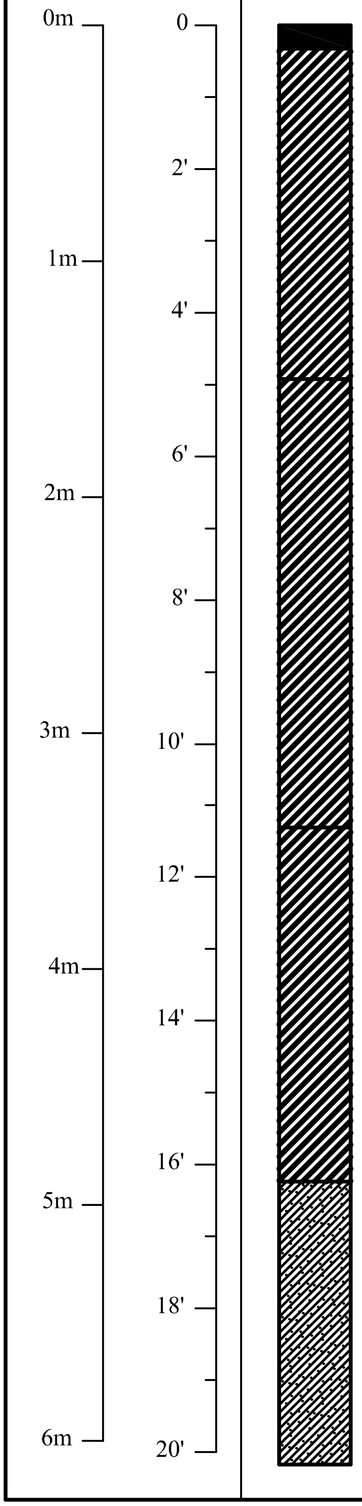
PROJECT : GTH Lagoon Feasibility Study

DATE : March 27, 2012

ELEVATION: 235.971

TEST HOLE # 7

DEPTH OF SAMPLE	FIELD CLASSIFICATION



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

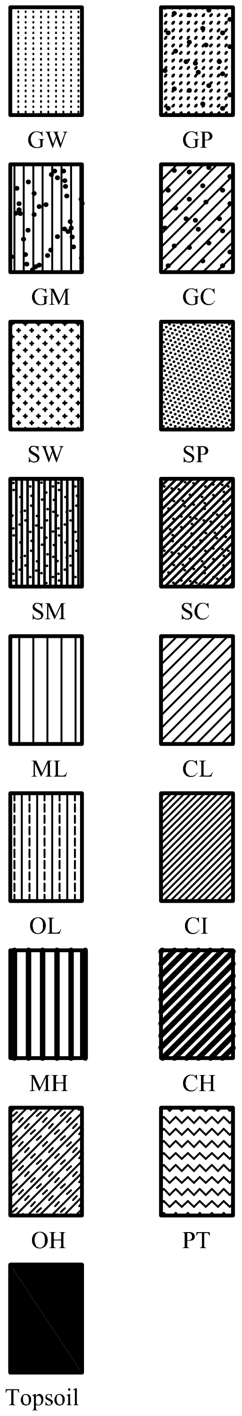
CLAY - High plastic, dark grey, some silt, wet, soft, blocky

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



J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead

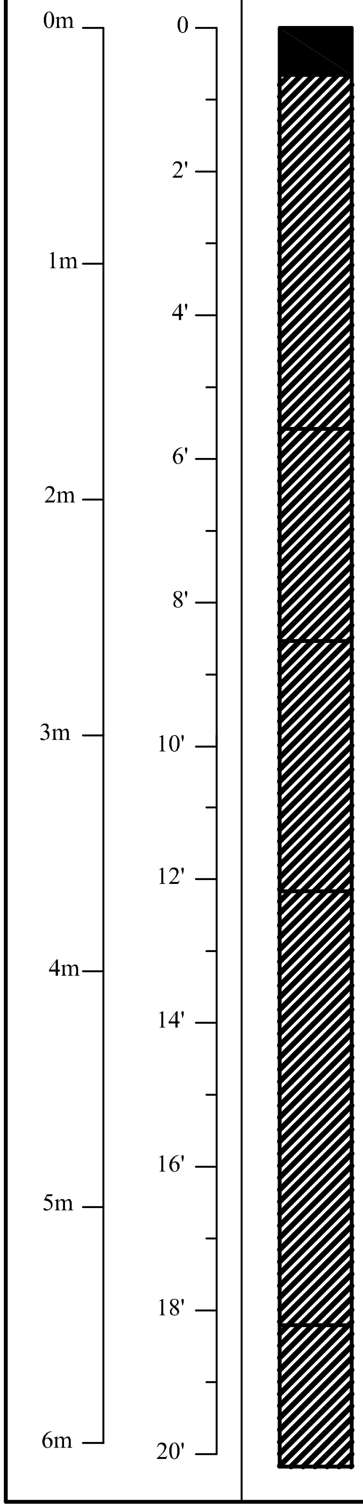
PROJECT : GTH Lagoon Feasibility Study

DATE : March 27, 2012

ELEVATION: 235.802

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

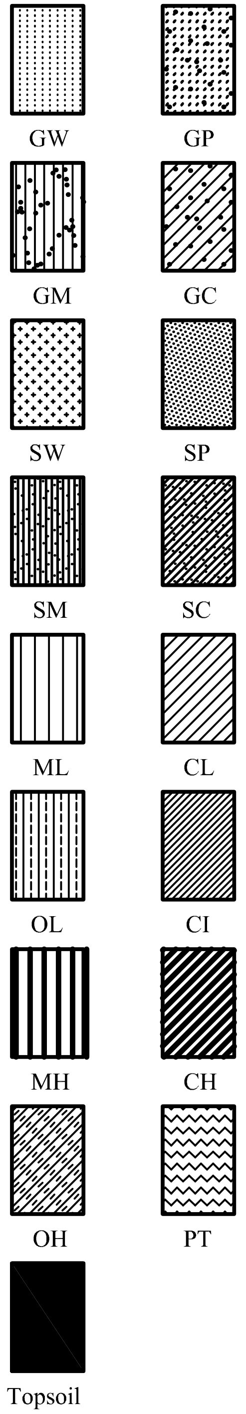
CLAY - High plastic, grey, moist, stiff, homogenous

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



J. R. Cousin Consultants Ltd.

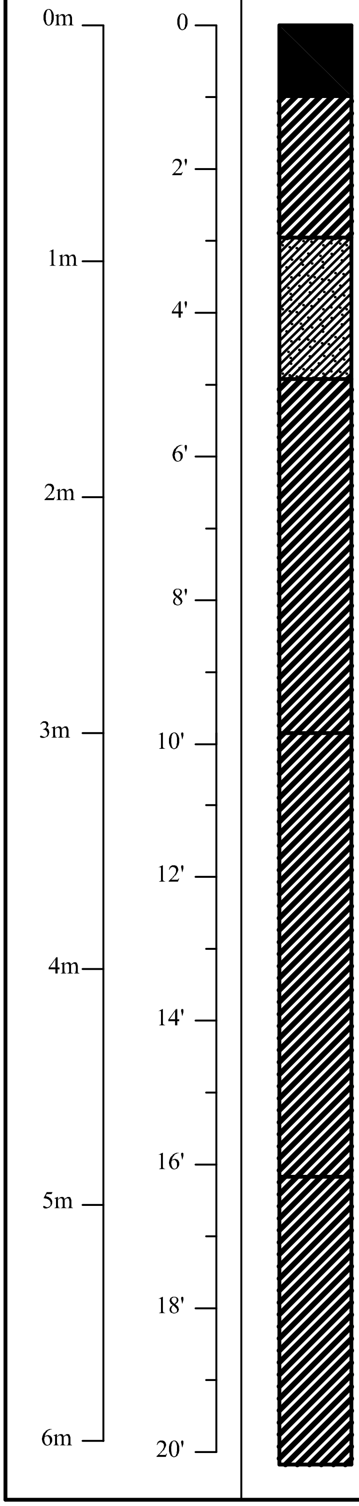
TEST HOLE LOG SHEET

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

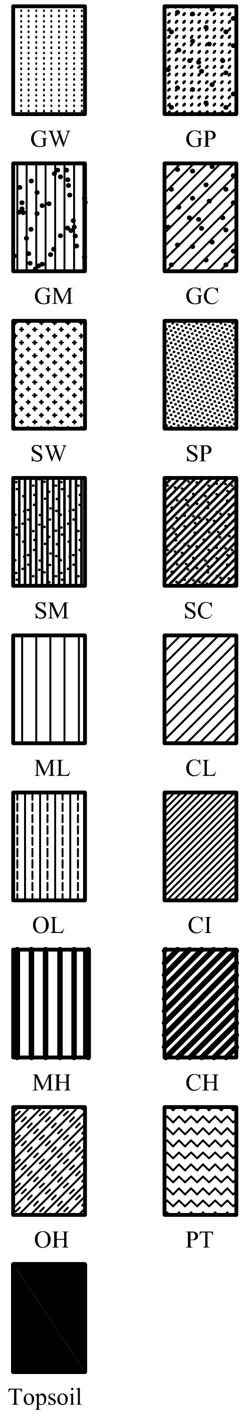
TILL - Light brown, silty, sandy, trace clay, damp, loose

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.

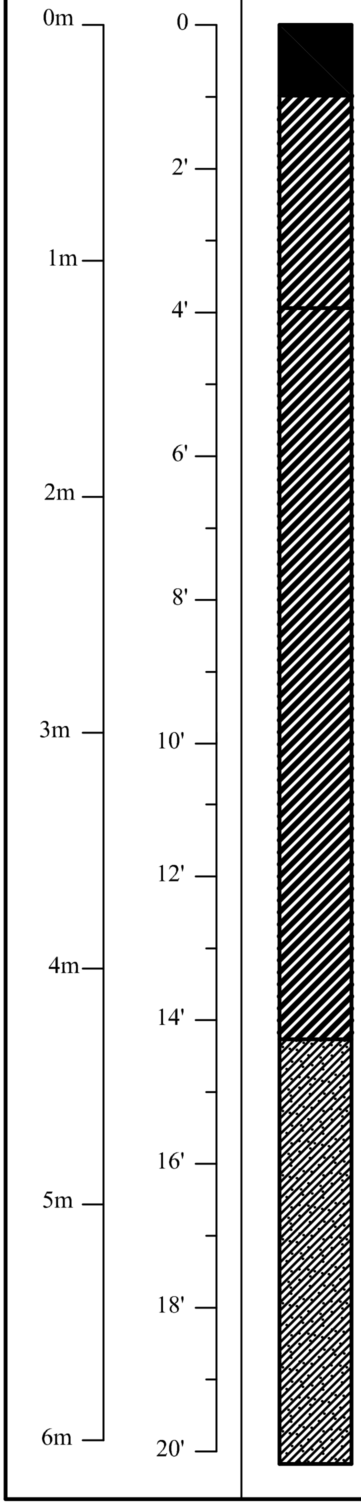
TEST HOLE LOG SHEET

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



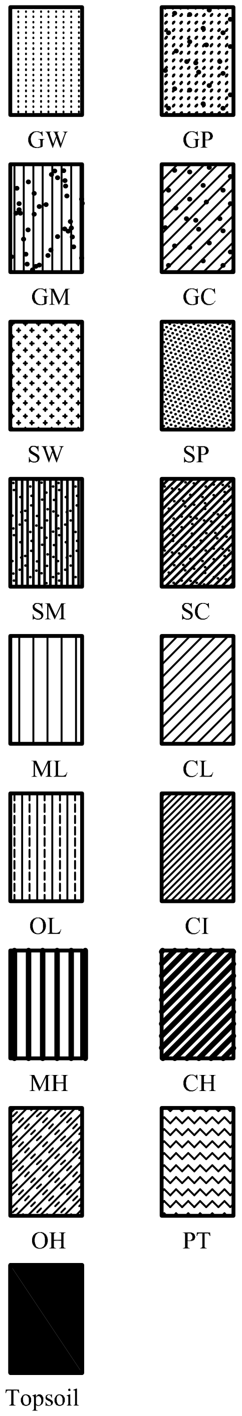
TOPSOIL - Black, clayey, organic, silty, trace sand

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

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

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

NO WATER, NO CAVING



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J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

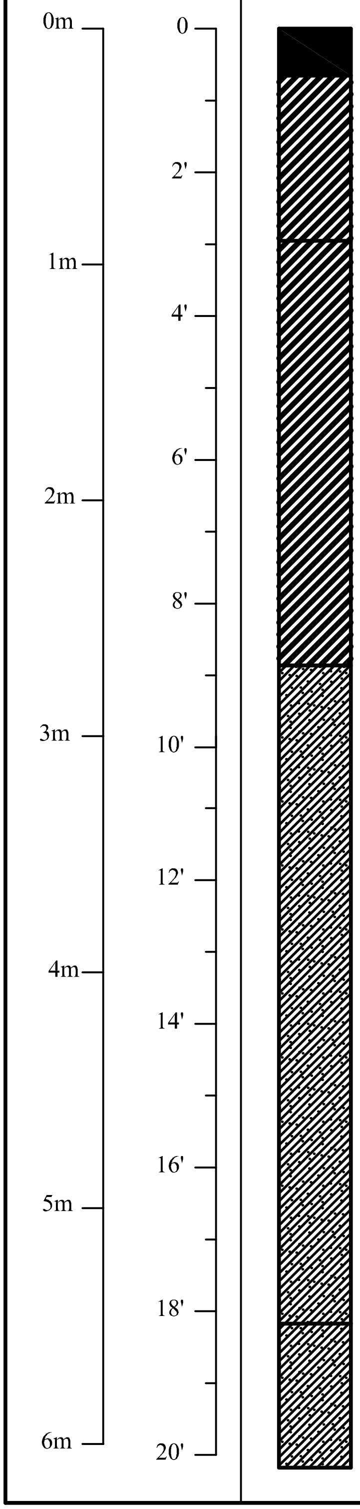
LOCATION : R.M. of Brokenhead

PROJECT : GTH Lagoon Feasibility Study

DATE : March 27, 2012
ELEVATION: 236.581
TEST HOLE #11

DEPTH OF SAMPLE

FIELD CLASSIFICATION



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

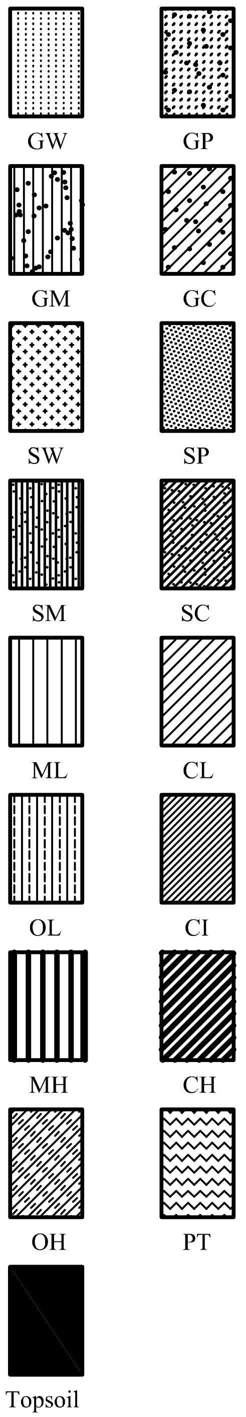
CLAY - High plastic, dark grey, with trace silt, moist, hard, blocky

CLAY - High plastic, brown, with some silt and sand, moist, hard

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

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

NO WATER, NO CAVING



J. R. Cousin Consultants Ltd.

TEST HOLE LOG SHEET

LOCATION : R.M. of Brokenhead

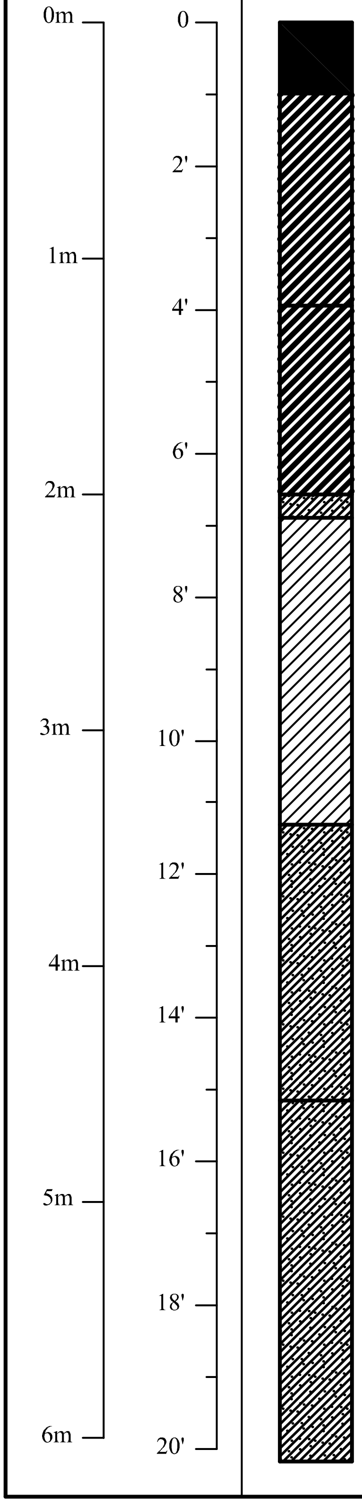
PROJECT : GTH Lagoon Feasibility Study

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

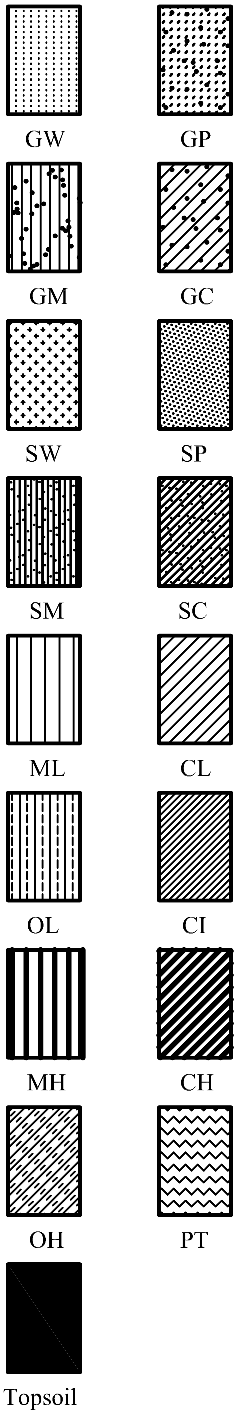
TILL - Silty, sandy, some gravel and low plastic clay, wet, soft

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



Stantec Consulting Ltd. Test Results, dated November 7, 2014

Stantec Consulting Ltd.
199 Henlow Bay, Winnipeg MB R3Y 1G4

November 7, 2014
File: 123311627

Attention: Mr. Brett McCormac
JR Cousin Consultants Ltd.
91A Scurfield Blvd.
Winnipeg, MB R3Y 1G4

Dear Brett,

Reference: RM of Brokenhead – GTH Lagoon Expansion

Soil samples were submitted to our laboratory on October 22, 2014. The following tests were conducted on selected soil samples:

- Water content (ASTM D2216)
- Particle-Size Analysis (ASTM D422)
- Liquid Limit (one-point), plastic limit, and plasticity index (ASTM D4318)
- Soil Classification (ASTM D2487)
- Hydraulic Conductivity (ASTM D5084)
- Visual Classification

The test results for the soil samples are summarized in the following table and in the attached particle size analysis, Atterberg limits and hydraulic conductivity reports.

An assessment of the bagged soil samples was conducted to determine whether the soil represented by the bagged samples could be used in-situ as a lagoon liner and would obtain a permeability of less than 1.0 x 10^{-7} cm/sec without being reworked, and when re-moulded and re-compacted.

Based upon previous testing conducted in our laboratory, homogeneous soil samples with a plasticity index greater than 25 and a clay content greater than 50% will typically have a hydraulic conductivity of 1.0 x 10^{-7} cm/sec or less. Sample TH2 at 3.4-5.5 m had a plasticity index of 18 and a clay content of 24.9% and sample TH7 at 4.0-6.1 m had a plasticity index of 8 and a clay content of 26.9%, which does not fall within this range and are considered not suitable to be used as a lagoon liner. The remaining bagged samples were considered suitable to be used as a lagoon liner. Our comments regarding the potential use of the material as a liner are based upon the soil being homogeneous with no preferential flow paths. It should be 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.

Reference: RM of Brokenhead – GTH Lagoon Expansion

We appreciate the opportunity to assist you in this project. Please call if you have any questions regarding this report.

Regards,

STANTEC CONSULTING LTD.

Jason Thompson, CET
Associate - Manager, Materials Testing Services
Phone: (204) 928-4004
Fax: (204) 488-6947
Jason.Thompson@stantec.com

Attachment: Table 1 – Summary of Water Content, Particle Size, Atterberg Limits, Soil Classification Test Data
11x Particle Size Analysis Report
7 x Atterberg Limits Report
2 x Hydraulic Conductivity Report

Stantec Consulting Ltd.
199 Henlow Bay, Winnipeg MB R3Y 1G4

TABLE 1
SUMMARY OF WATER CONTENT, PARTICLE SIZE, ATTERBERG LIMITS, SOIL CLASSIFICATION TEST DATA

Testhole	Depth (m)	Visual Classification	Water Content (%)	Gravel (%) 75 to 4.75 mm	Sand (%)			Silt (%) <0.075 to 0.005 mm	Clay (%) <0.005 mm	Liquid Limit	Plastic Limit	Plasticity Index	Soil Classification ASTM D2487	Potential use as a lagoon liner when re-moulded and re-compacted	Potential use as a lagoon liner without being reworked
					Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm								
TH1	0.2-2.1	brown, stiff, moist, high plasticity clay with trace silt, trace sand and trace gravel	32.3	0.4	0.2	0.4	2.0	9.7	87.3	88	24	64	CH(Fat Clay)	Yes	Yes
TH1	2.1-4.3	brown, stiff, moist, high plasticity clay with some silt, trace sand and trace gravel	40.2	0.5	0.4	1.1	3.2	15.2	79.6	80	23	57	CH(Fat Clay)	Yes	Yes
TH2	0.3-2.4	brown, stiff, moist, high plasticity clay with trace silt, trace sand and trace gravel	36.6	0.1	0.2	0.2	3.0	8.5	88.0	85	27	58	CH(Fat Clay)	Yes	Yes
TH2	3.4-5.5	brown, firm, moist, medium plasticity sandy clay, with some silt and trace gravel	12.0	7.2	5.3	12.4	14.5	24.9	35.7	30	12	18	CL(Sandy Lean Clay)	No	No
TH3	2.1-2.7	brown, stiff, moist, high plasticity clay with some silt, trace sand and trace gravel	44.5	2.0	0.8	2.2	4.0	11.9	79.1	82	23	59	CH(Fat Clay)	Yes	Yes
TH6	0.0-0.3	black, stiff, moist, high plasticity silty clay with some sand and trace gravel	40.1	0.8	0.8	4.2	10.5	24.9	58.8	75	31	44	CH(Fat Clay with Sand)	Yes	Yes
TH6	0.3-2.4	brown, stiff, moist, high plasticity clay with some silt, trace sand and trace gravel	29.9	0.6	0.8	0.9	4.7	19.3	73.7	73	19	54	CH(Fat Clay)	Yes	Yes

Reference: RM of Brokenhead – GTH Lagoon Expansion

TH6	2.4-3.4	brown, stiff, moist, high plasticity clay with trace silt, trace sand and trace gravel	46.5	0.2	0.3	0.4	2.1	6.1	90.9	101	27	74	CH(Fat Clay)	Yes	Yes
TH7	0.3-2.4	brown, stiff, moist, high plasticity clay with some silt, trace sand and trace gravel	29.7	1.3	1.5	2.1	5.0	17.5	72.6	66	19	47	CH(Fat Clay)	Yes	Yes
TH7	2.4-4.0	brown, stiff, moist, high plasticity clay with trace silt, trace sand and trace gravel	50.0	0.3	0.1	0.4	0.9	6.7	91.6	100	28	72	CH(Fat Clay)	Yes	Yes
TH7	4.0-6.1	tan, soft, moist, low plasticity sandy silt, clayey with some gravel	12.7	10.0	5.5	7.2	15.4	35.0	26.9	19	11	8	CL(Sandy Lean Clay)	No	No

Notes:

1. The soil samples were air-dried during sample preparation for Atterberg limits and particle size analysis
2. A high speed stirring device was used for 1 minute to disperse the test samples for particle size analysis
3. Atterberg limits conducted in accordance with ASTM D4318 Method B (one-point liquid limit)

LABORATORY
199 Henlow Bay
Winnipeg MB R3Y 1G4
Tel: (204) 488-6999

PARTICLE SIZE ANALYSIS
ASTM D422

JR Cousin Consultants Ltd.
91A Scurfield Blvd.
Winnipeg, Manitoba
R3Y 1G4

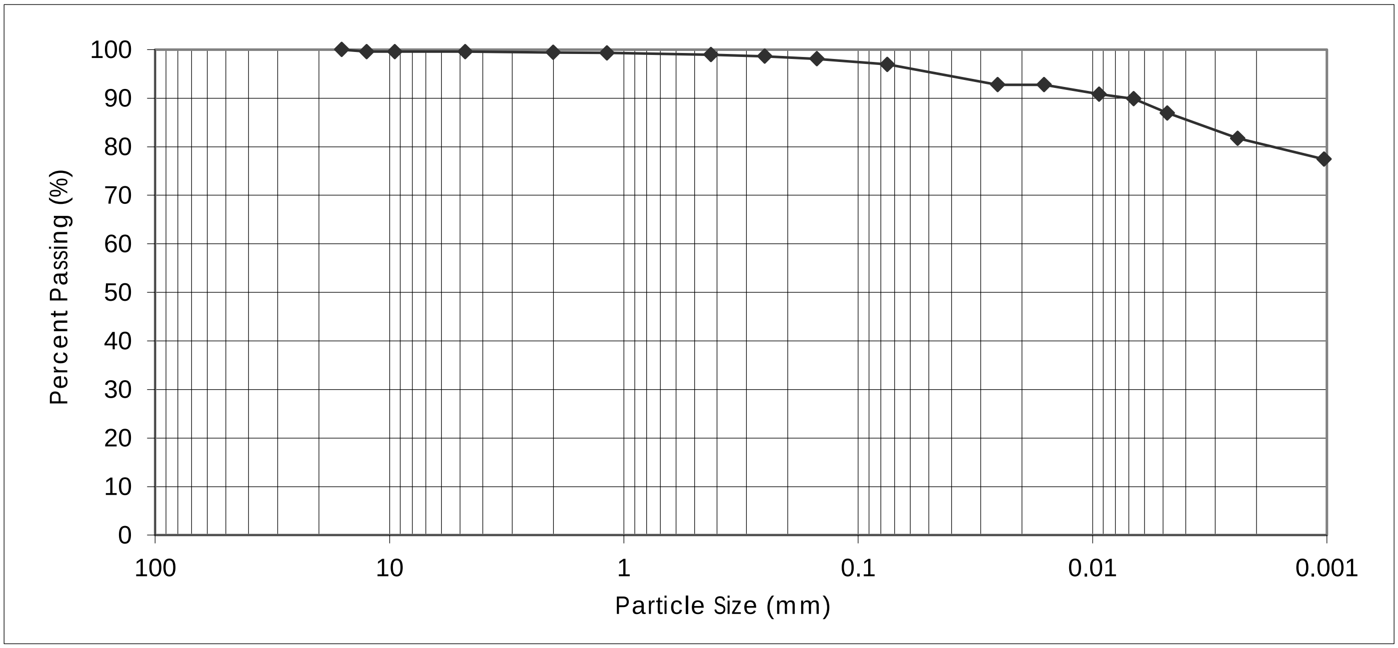
PROJECT: RM of Brokenhead
GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLED BY: Client
SAMPLE ID: TH1 at 0.2m - 2.1m

DATE RECEIVED: October 22, 2014
TESTED BY: Sothea Bun



PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0
25.00 mm	100.0
19.00 mm	100.0
16.00 mm	100.0
12.50 mm	99.6
9.50 mm	99.6
4.75 mm	99.6
2.00 mm	99.4

PARTICLE SIZE	PERCENT PASSING
1.18 mm	99.3
0.425 mm	99.0
0.250 mm	98.6
0.150 mm	98.1
0.075 mm	97.0
0.005 mm	87.3
0.002 mm	80.5
0.001 mm	NT*

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
0.4	0.2	0.4	2.0	9.7	87.3	NT*

NT* Sample not tested for colloids

October 27, 2014

REVIEWED BY: Jason Thompson, CET

Stantec

LABORATORY
199 Henlow Bay
Winnipeg MB R3Y 1G4
Tel: (204) 488-6999

PARTICLE SIZE ANALYSIS
ASTM D422

JR Cousin Consultants Ltd.
91A Scurfield Blvd.
Winnipeg, Manitoba
R3Y 1G4

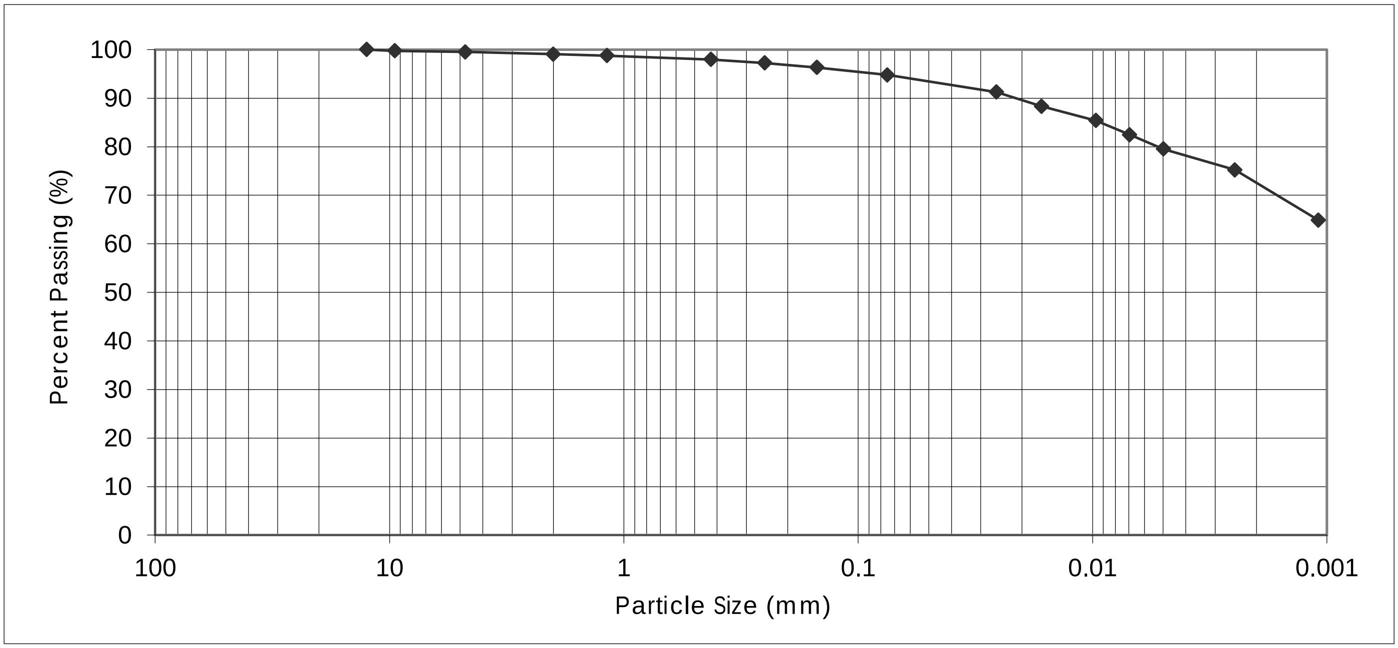
PROJECT: RM of Brokenhead
GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLED BY: Client
SAMPLE ID: TH1 at 2.1m - 4.3m

DATE RECEIVED: October 22, 2014
TESTED BY: Sothea Bun



PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0
25.00 mm	100.0
19.00 mm	100.0
16.00 mm	100.0
12.50 mm	100.0
9.50 mm	99.8
4.75 mm	99.5
2.00 mm	99.1

PARTICLE SIZE	PERCENT PASSING
1.18 mm	98.7
0.425 mm	98.0
0.250 mm	97.2
0.150 mm	96.3
0.075 mm	94.8
0.005 mm	79.6
0.002 mm	71.7
0.001 mm	NT*

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
0.5	0.4	1.1	3.2	15.2	79.6	NT*

NT* Sample not tested for colloids

October 27, 2014

REVIEWED BY: Jason Thompson, CET

LABORATORY
199 Henlow Bay
Winnipeg MB R3Y 1G4
Tel: (204) 488-6999

PARTICLE SIZE ANALYSIS
ASTM D422

JR Cousin Consultants Ltd.
91A Scurfield Blvd.
Winnipeg, Manitoba
R3Y 1G4

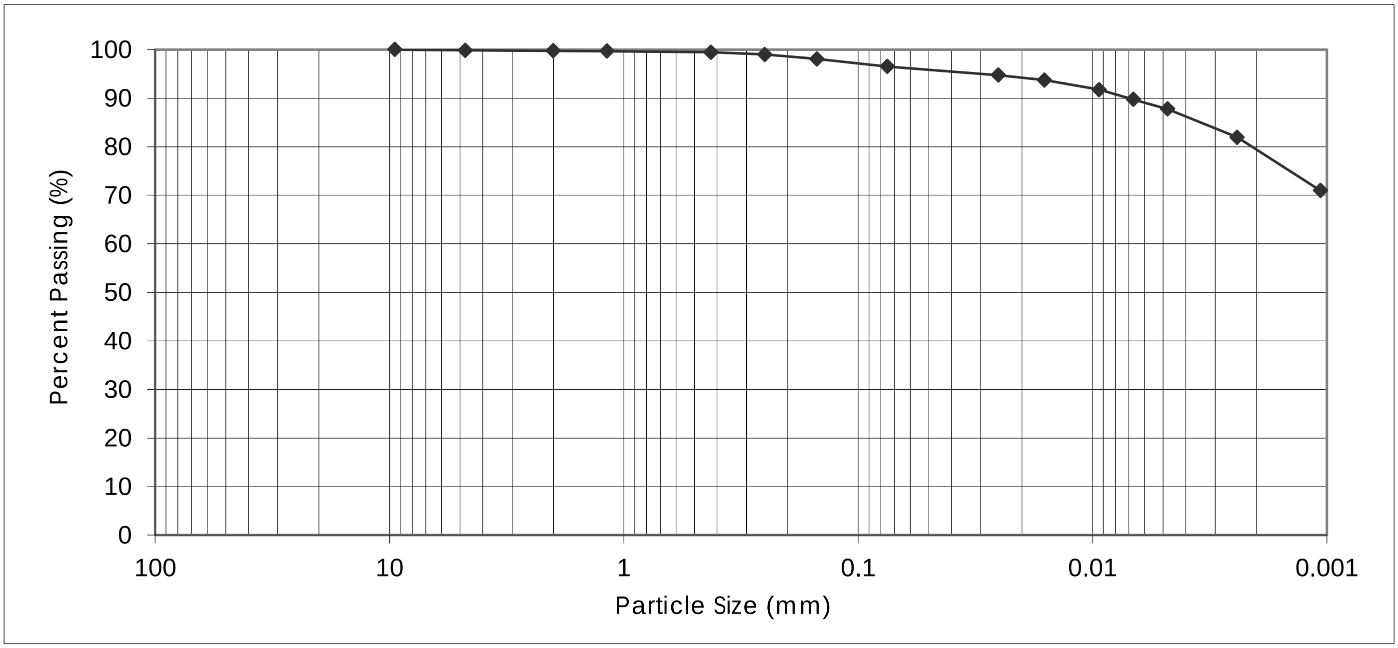
PROJECT: RM of Brokenhead
GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLED BY: Client
SAMPLE ID: TH2 at 0.3m - 2.4m

DATE RECEIVED: October 22, 2014
TESTED BY: Larry Presado



PARTICLE SIZE	PERCENT PASSING	PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0	1.18 mm	99.7
25.00 mm	100.0	0.425 mm	99.5
19.00 mm	100.0	0.250 mm	99.0
16.00 mm	100.0	0.150 mm	98.1
12.50 mm	100.0	0.075 mm	96.5
9.50 mm	100.0	0.005 mm	88.0
4.75 mm	99.9	0.002 mm	78.6
2.00 mm	99.7	0.001 mm	NT*

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
0.1	0.2	0.2	3.0	8.5	88.0	NT*

NT* Sample not tested for colloids

October 27, 2014

REVIEWED BY: Jason Thompson, CET

Stantec

LABORATORY
199 Henlow Bay
Winnipeg MB R3Y 1G4
Tel: (204) 488-6999

PARTICLE SIZE ANALYSIS
ASTM D422

JR Cousin Consultants Ltd.
91A Scurfield Blvd.
Winnipeg, Manitoba
R3Y 1G4

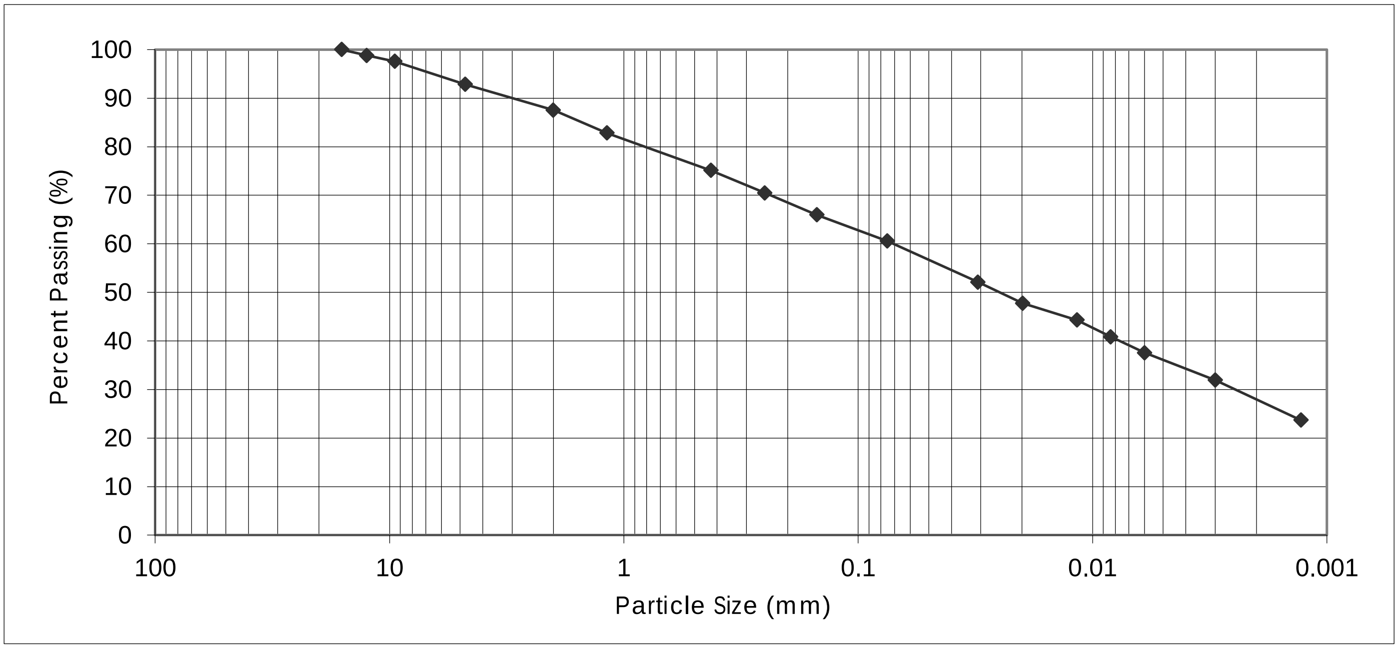
PROJECT: RM of Brokenhead
GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLED BY: Client
SAMPLE ID: TH2 at 3.4m - 5.5m

DATE RECEIVED: October 22, 2014
TESTED BY: Sothea Bun



PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0
25.00 mm	100.0
19.00 mm	100.0
16.00 mm	100.0
12.50 mm	98.8
9.50 mm	97.6
4.75 mm	92.8
2.00 mm	87.5

PARTICLE SIZE	PERCENT PASSING
1.18 mm	82.8
0.425 mm	75.1
0.250 mm	70.5
0.150 mm	66.0
0.075 mm	60.6
0.005 mm	35.7
0.002 mm	27.1
0.001 mm	NT*

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
7.2	5.3	12.4	14.5	24.9	35.7	NT*

NT* Sample not tested for colloids

October 27, 2014

REVIEWED BY: Jason Thompson, CET

LABORATORY
199 Henlow Bay
Winnipeg MB R3Y 1G4
Tel: (204) 488-6999

PARTICLE SIZE ANALYSIS
ASTM D422

JR Cousin Consultants Ltd.
91A Scurfield Blvd.
Winnipeg, Manitoba
R3Y 1G4

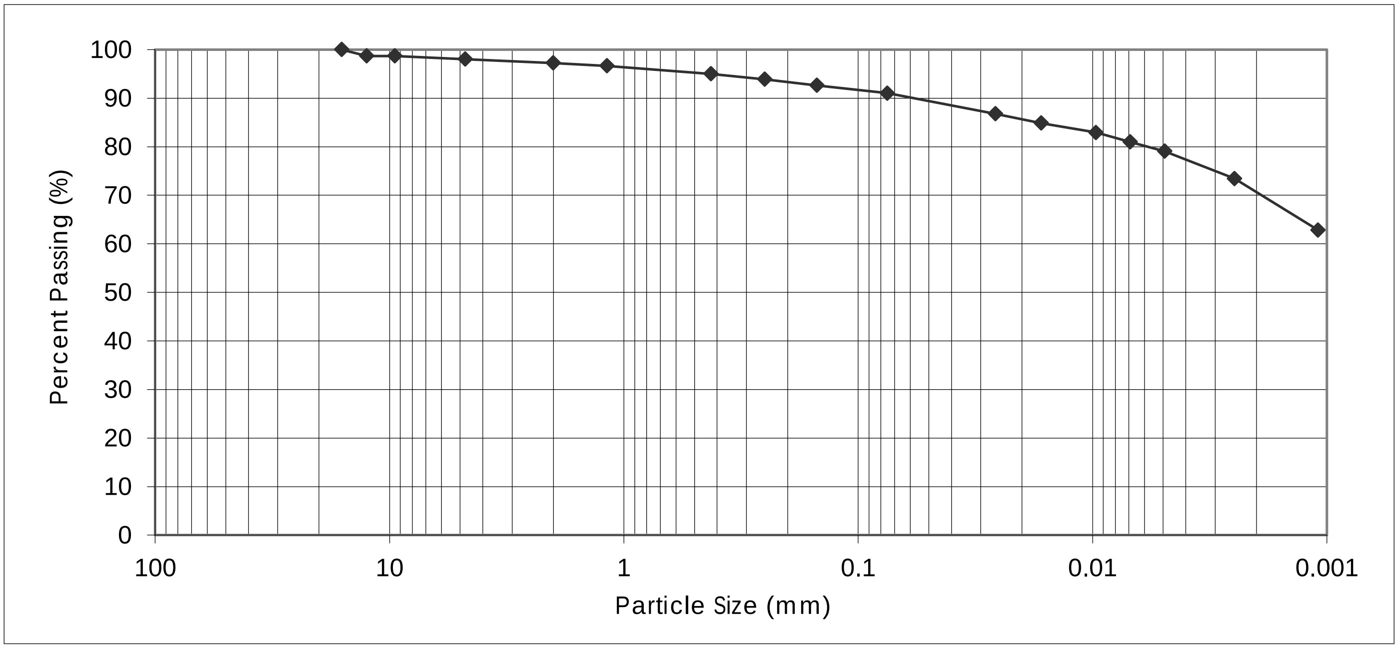
PROJECT: RM of Brokenhead
GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLED BY: Client
SAMPLE ID: TH3 at 2.1m - 2.7m

DATE RECEIVED: October 22, 2014
TESTED BY: Larry Presado



PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0
25.00 mm	100.0
19.00 mm	100.0
16.00 mm	100.0
12.50 mm	98.7
9.50 mm	98.7
4.75 mm	98.0
2.00 mm	97.2

PARTICLE SIZE	PERCENT PASSING
1.18 mm	96.6
0.425 mm	95.0
0.250 mm	93.9
0.150 mm	92.7
0.075 mm	91.0
0.005 mm	79.1
0.002 mm	69.8
0.001 mm	NT*

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
2.0	0.8	2.2	4.0	11.9	79.1	NT*

NT* Sample not tested for colloids

October 27, 2014

REVIEWED BY: Jason Thompson, CET

LABORATORY
199 Henlow Bay
Winnipeg MB R3Y 1G4
Tel: (204) 488-6999

PARTICLE SIZE ANALYSIS
ASTM D422

JR Cousin Consultants Ltd.
91A Scurfield Blvd.
Winnipeg, Manitoba
R3Y 1G4

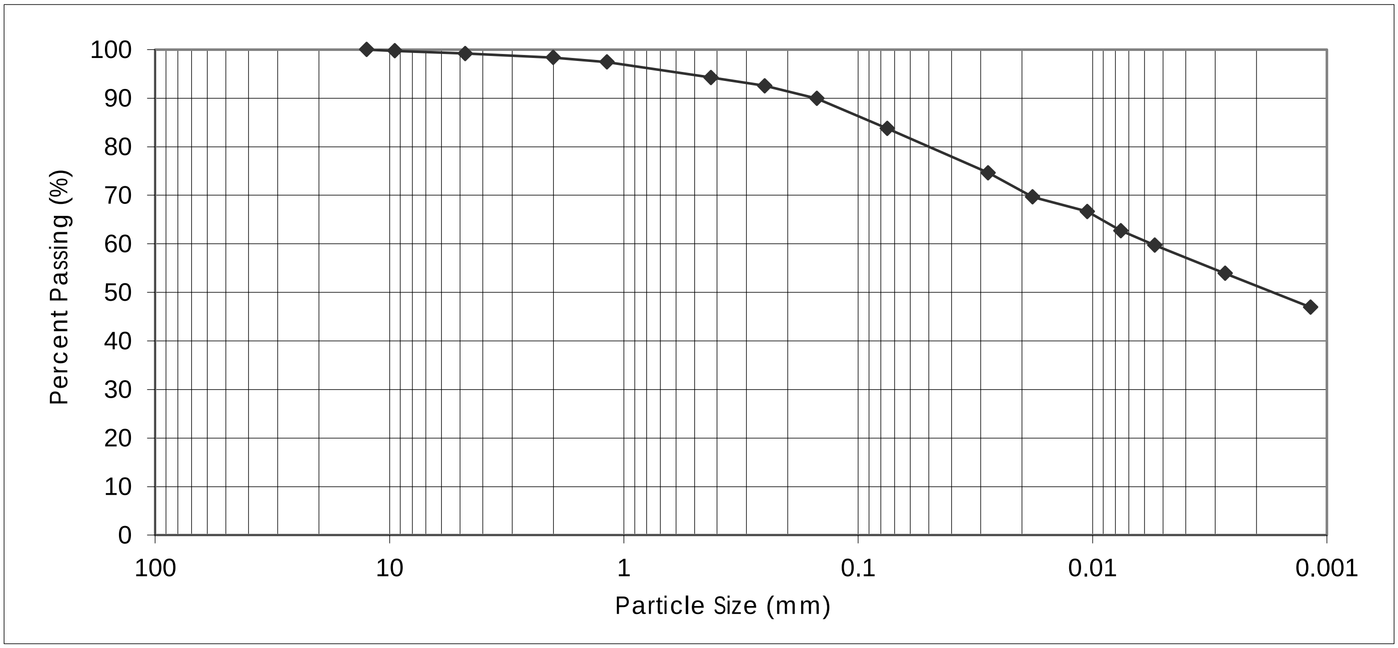
PROJECT: RM of Brokenhead
GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLED BY: Client
SAMPLE ID: TH6 at 0.0m - 0.3m

DATE RECEIVED: October 22, 2014
TESTED BY: Larry Presado



PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0
25.00 mm	100.0
19.00 mm	100.0
16.00 mm	100.0
12.50 mm	100.0
9.50 mm	99.7
4.75 mm	99.2
2.00 mm	98.4

PARTICLE SIZE	PERCENT PASSING
1.18 mm	97.4
0.425 mm	94.2
0.250 mm	92.5
0.150 mm	90.0
0.075 mm	83.7
0.005 mm	58.8
0.002 mm	50.7
0.001 mm	NT*

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
0.8	0.8	4.2	10.5	24.9	58.8	NT*

NT* Sample not tested for colloids

October 27, 2014

REVIEWED BY: Jason Thompson, CET

LABORATORY
199 Henlow Bay
Winnipeg MB R3Y 1G4
Tel: (204) 488-6999

PARTICLE SIZE ANALYSIS
ASTM D422

JR Cousin Consultants Ltd.
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Winnipeg, Manitoba
R3Y 1G4

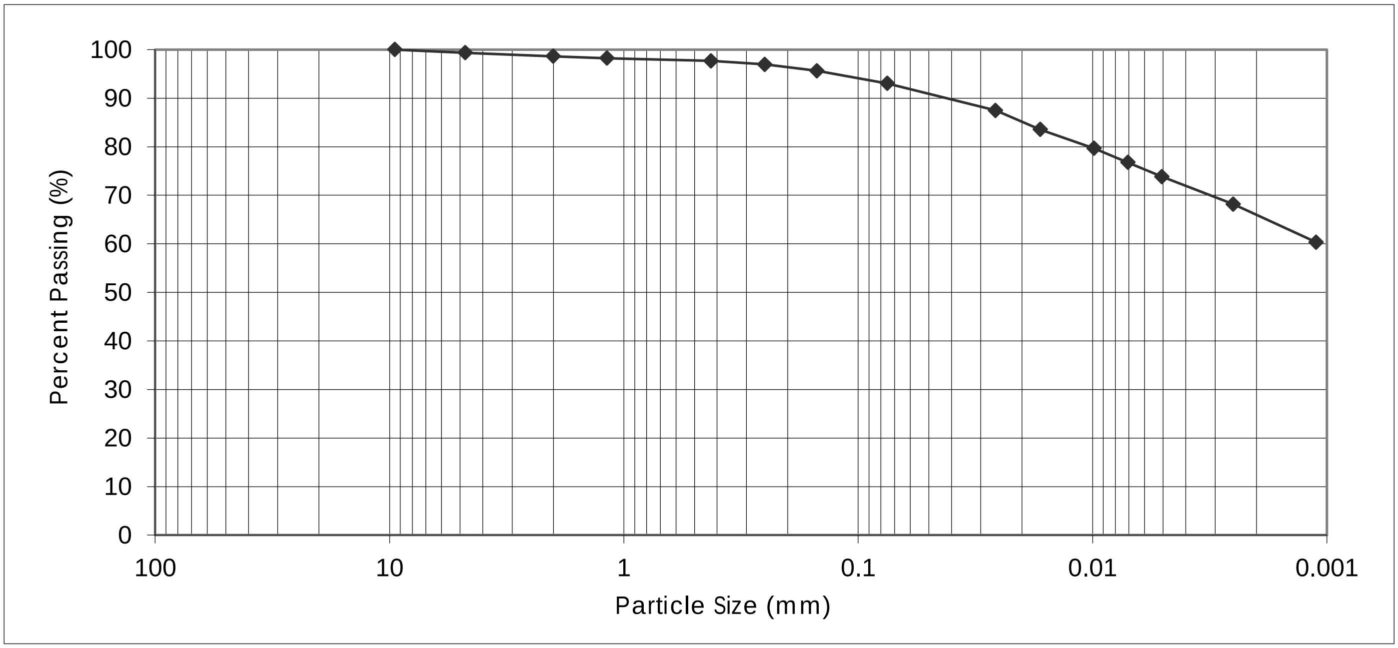
PROJECT: RM of Brokenhead
GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLED BY: Client
SAMPLE ID: TH6 at 0.3m - 2.4m

DATE RECEIVED: October 22, 2014
TESTED BY: Larry Presado



PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0
25.00 mm	100.0
19.00 mm	100.0
16.00 mm	100.0
12.50 mm	100.0
9.50 mm	100.0
4.75 mm	99.4
2.00 mm	98.6

PARTICLE SIZE	PERCENT PASSING
1.18 mm	98.2
0.425 mm	97.7
0.250 mm	97.0
0.150 mm	95.6
0.075 mm	93.0
0.005 mm	73.7
0.002 mm	65.3
0.001 mm	NT*

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
0.6	0.8	0.9	4.7	19.3	73.7	NT*

NT* Sample not tested for colloids

October 27, 2014

REVIEWED BY: Jason Thompson, CET

LABORATORY
199 Henlow Bay
Winnipeg MB R3Y 1G4
Tel: (204) 488-6999

PARTICLE SIZE ANALYSIS
ASTM D422

JR Cousin Consultants Ltd.
91A Scurfield Blvd.
Winnipeg, Manitoba
R3Y 1G4

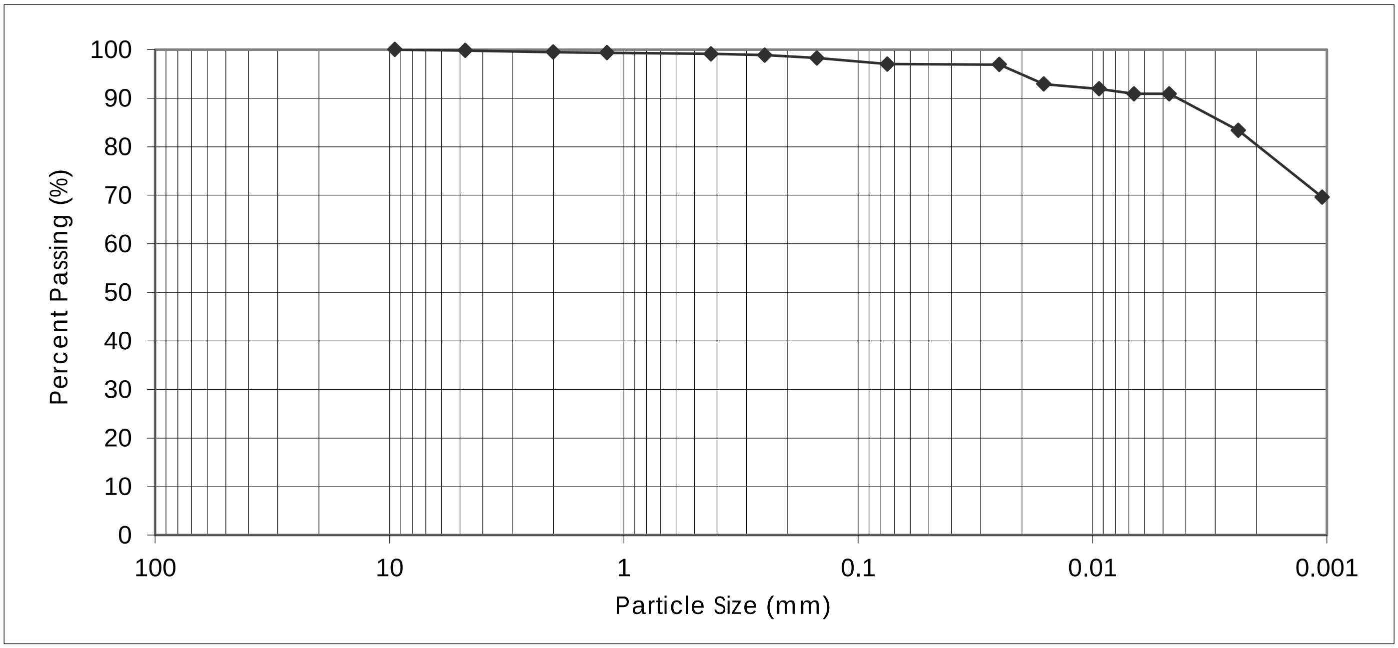
PROJECT: RM of Brokenhead
GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLED BY: Client
SAMPLE ID: TH6 at 2.4 m - 3.4 m

DATE RECEIVED: October 22, 2014
TESTED BY: Larry Presado



PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0
25.00 mm	100.0
19.00 mm	100.0
16.00 mm	100.0
12.50 mm	100.0
9.50 mm	100.0
4.75 mm	99.8
2.00 mm	99.5

PARTICLE SIZE	PERCENT PASSING
1.18 mm	99.3
0.425 mm	99.1
0.250 mm	98.9
0.150 mm	98.3
0.075 mm	97.0
0.005 mm	90.9
0.002 mm	79.4
0.001 mm	NT*

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
0.2	0.3	0.4	2.1	6.1	90.9	NT*

NT* Sample not tested for colloids

October 27, 2014

REVIEWED BY: Jason Thompson, CET

LABORATORY
199 Henlow Bay
Winnipeg MB R3Y 1G4
Tel: (204) 488-6999

PARTICLE SIZE ANALYSIS
ASTM D422

JR Cousin Consultants Ltd.
91A Scurfield Blvd.
Winnipeg, Manitoba
R3Y 1G4

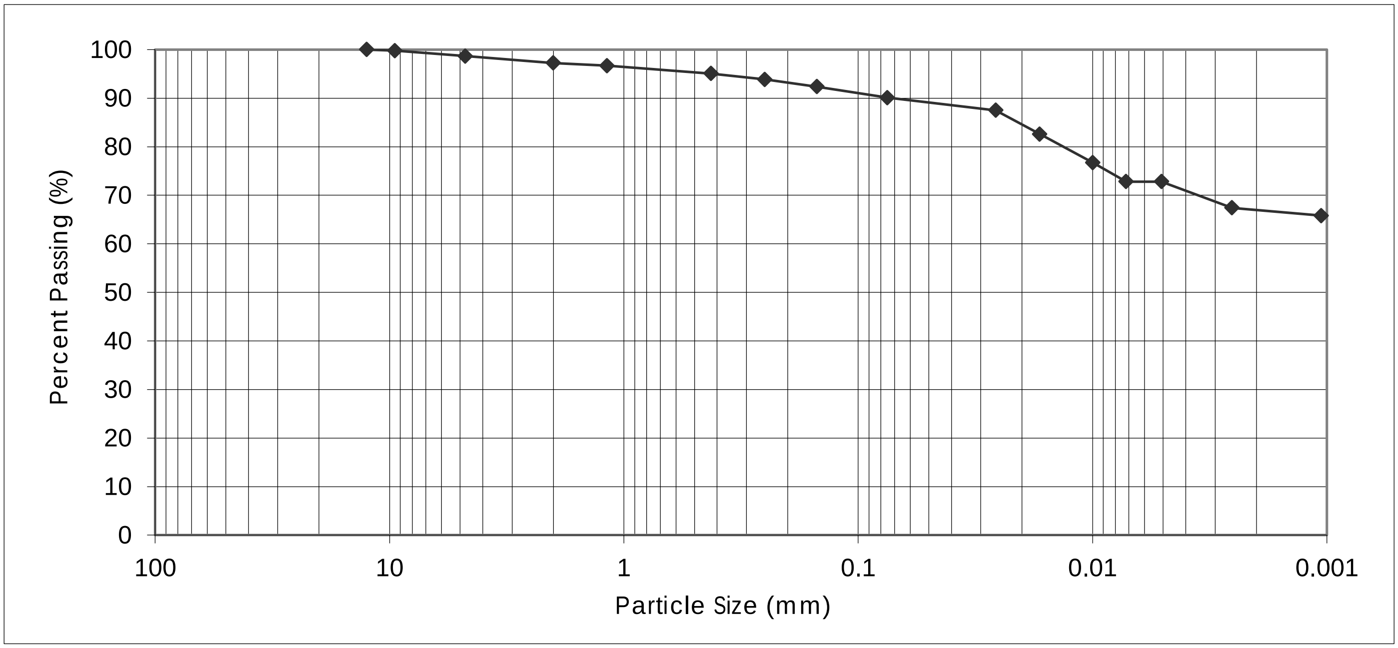
PROJECT: RM of Brokenhead
GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLED BY: Client
SAMPLE ID: TH7 at 0.3 m - 2.4 m

DATE RECEIVED: October 22, 2014
TESTED BY: Larry Presado



PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0
25.00 mm	100.0
19.00 mm	100.0
16.00 mm	100.0
12.50 mm	100.0
9.50 mm	99.8
4.75 mm	98.7
2.00 mm	97.2

PARTICLE SIZE	PERCENT PASSING
1.18 mm	96.7
0.425 mm	95.1
0.250 mm	93.8
0.150 mm	92.4
0.075 mm	90.1
0.005 mm	72.6
0.002 mm	66.8
0.001 mm	NT*

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
1.3	1.5	2.1	5.0	17.5	72.6	NT*

NT* Sample not tested for colloids

October 27, 2014

REVIEWED BY: Jason Thompson, CET

LABORATORY
199 Henlow Bay
Winnipeg MB R3Y 1G4
Tel: (204) 488-6999

PARTICLE SIZE ANALYSIS
ASTM D422

JR Cousin Consultants Ltd.
91A Scurfield Blvd.
Winnipeg, Manitoba
R3Y 1G4

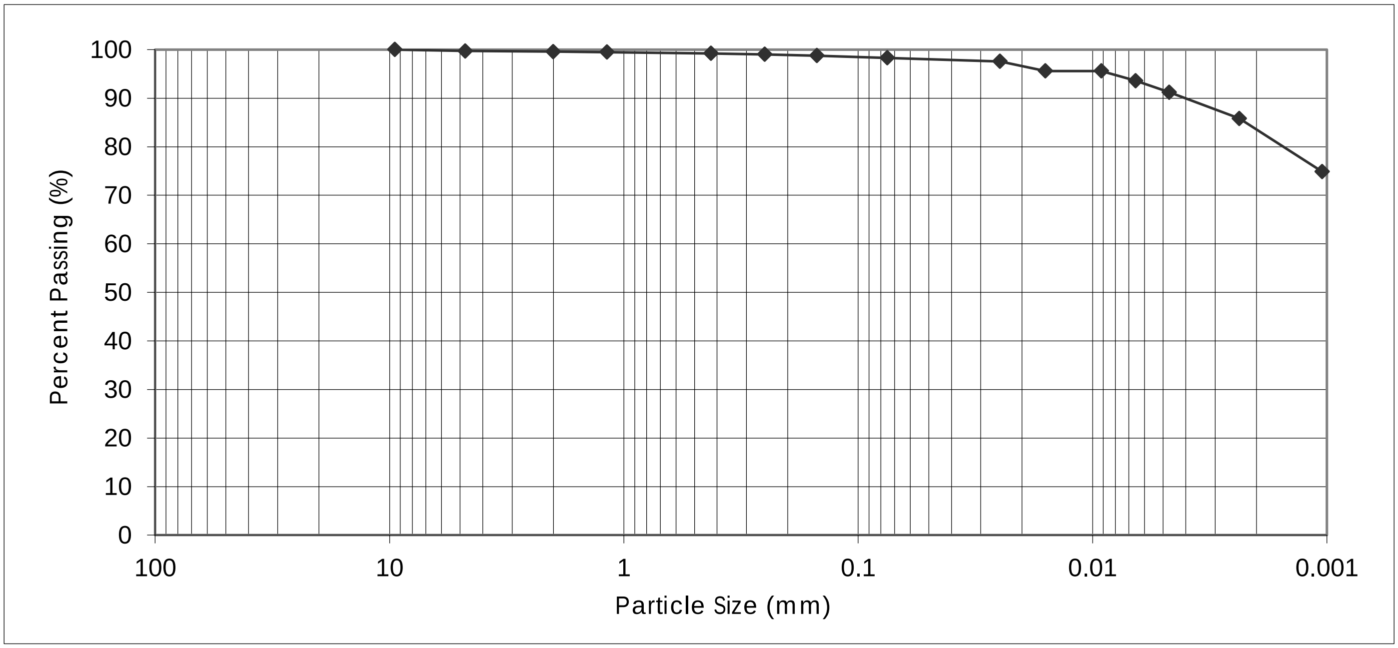
PROJECT: RM of Brokenhead
GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLED BY: Client
SAMPLE ID: TH7 at 2.4m - 4.0m

DATE RECEIVED: October 22, 2014
TESTED BY: Larry Presado



PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0
25.00 mm	100.0
19.00 mm	100.0
16.00 mm	100.0
12.50 mm	100.0
9.50 mm	100.0
4.75 mm	99.7
2.00 mm	99.6

PARTICLE SIZE	PERCENT PASSING
1.18 mm	99.5
0.425 mm	99.2
0.250 mm	99.0
0.150 mm	98.8
0.075 mm	98.3
0.005 mm	91.6
0.002 mm	82.8
0.001 mm	NT*

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
0.3	0.1	0.4	0.9	6.7	91.6	NT*

NT* Sample not tested for colloids

October 27, 2014

REVIEWED BY: Jason Thompson, CET

Stantec

LABORATORY
199 Henlow Bay
Winnipeg MB R3Y 1G4
Tel: (204) 488-6999

PARTICLE SIZE ANALYSIS
ASTM D422

JR Cousin Consultants Ltd.
91A Scurfield Blvd.
Winnipeg, Manitoba
R3Y 1G4

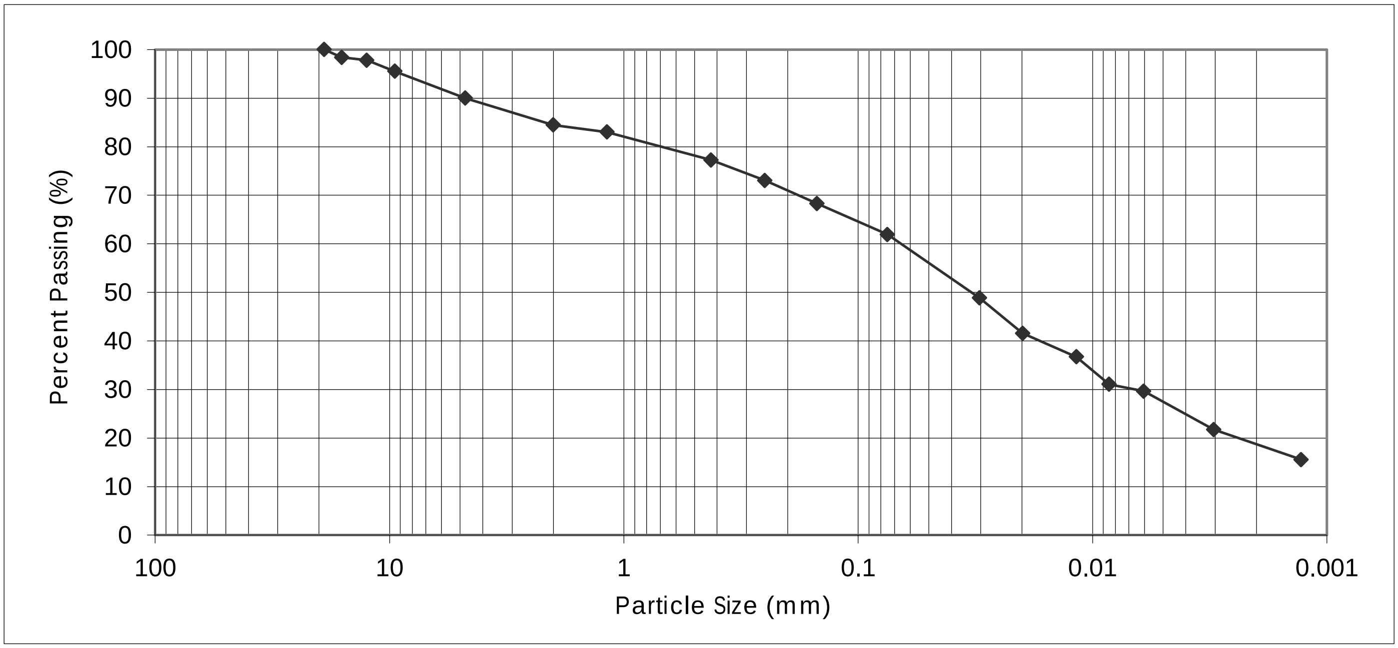
PROJECT: RM of Brokenhead
GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLED BY: Client
SAMPLE ID: TH7 at 4.0 m - 6.1 m

DATE RECEIVED: October 22, 2014
TESTED BY: Larry Presado



PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0
25.00 mm	100.0
19.00 mm	100.0
16.00 mm	98.4
12.50 mm	97.8
9.50 mm	95.5
4.75 mm	90.0
2.00 mm	84.5

PARTICLE SIZE	PERCENT PASSING
1.18 mm	83.0
0.425 mm	77.3
0.250 mm	73.1
0.150 mm	68.3
0.075 mm	61.9
0.005 mm	26.9
0.002 mm	18.1
0.001 mm	NT*

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
10.0	5.5	7.2	15.4	35.0	26.9	NT*

NT* Sample not tested for colloids

October 27, 2014

REVIEWED BY: Jason Thompson, CET

Stantec

Atterberg Limits

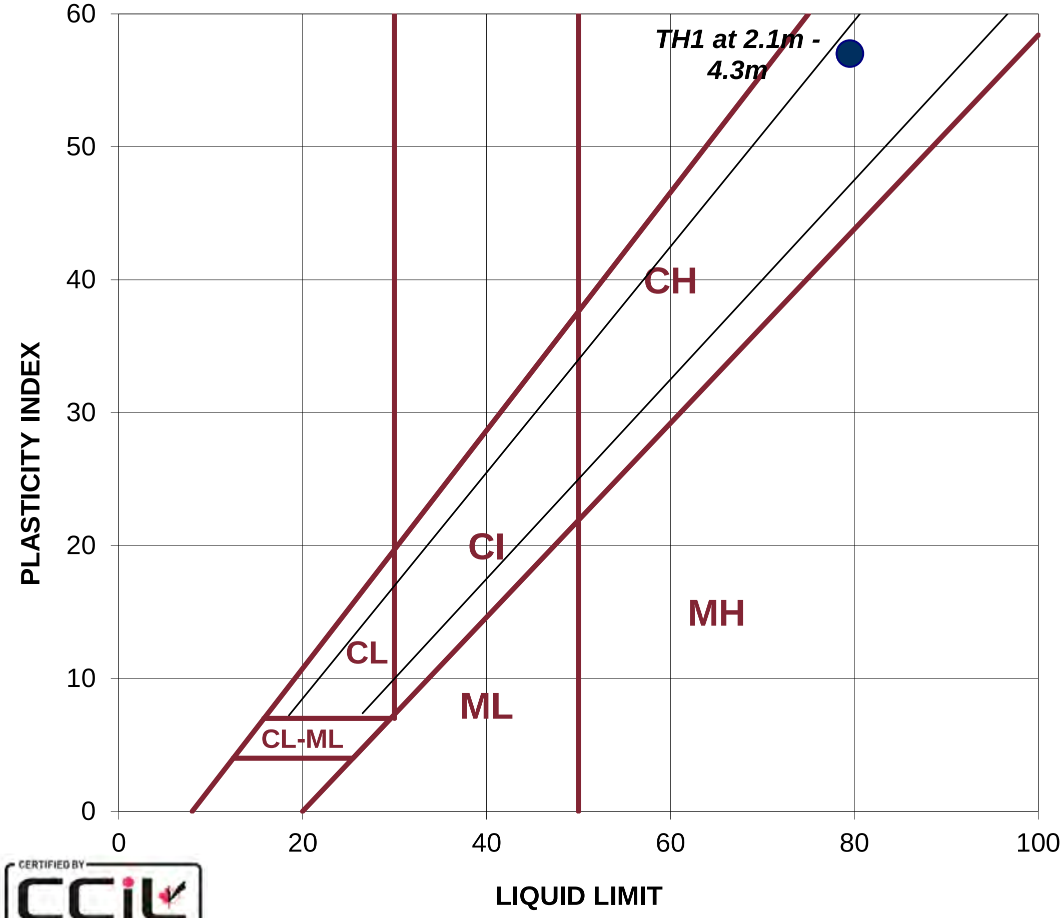
ASTM D4318
Method B- One Point

Client: JR Cousin Consultants Ltd.
Project Name: RM of Brokenhead-GTH Lagoon Expansion
Project No: 123311627
Date Received: October 22, 2014
Date Tested: October 29, 2014
Tested By: Nestor Abarca

LABORATORY
199 Henlow Bay
Winnipeg, Manitoba
Canada R3Y 1G4

Tel: (204) 488-6999

Sample:			Sample:	
TH1 at 2.1m - 4.3m			TH1 at 0.2m - 2.1m	
LIQUID			LIQUID	
1	2	Trial No.	1	2
20	20	Number of Blows	24	24
242	237	Container Number	281	153
38.17	36.71	Wt. Sample (wet+tare)(g)	40.35	37.91
30.19	29.44	Wt. Sample (dry+tare)(g)	31.23	29.40
20.43	20.54	Wt. Tare (g)	20.93	19.74
9.8	8.9	Wt. Dry Soil (g)	10.3	9.7
8.0	7.3	Wt. Water (g)	9.1	8.5
81.8%	81.7%	Water Content (%)	88.5%	88.1%
79.6%	79.5%	Corrected Water Content (%)	88.1%	87.7%
PLASTIC			PLASTIC	
1	2	Trial No.	1	2
304	173	Container Number	136	260
29.39	29.62	Wt. Sample (wet+tare)(g)	28.94	29.07
27.67	27.7	Wt. Sample (dry+tare)(g)	27.15	27.4
20.31	19.47	Wt. Tare (g)	19.69	20.54
7.4	8.2	Wt. Dry Soil (g)	7.5	6.9
1.7	1.9	Wt. Water (g)	1.8	1.7
23.4%	23.3%	Water Content (%)	24.0%	24.3%
AVERAGE VALUES			AVERAGE VALUES	
1	2		1	2
LL	80		LL	88
PL	23		PL	24
PI	57		PI	64
CLASSIFICATION			CLASSIFICATION	
CH ●			**CH** ◆	



Reviewed By: Jason Thompson, CET

Stantec

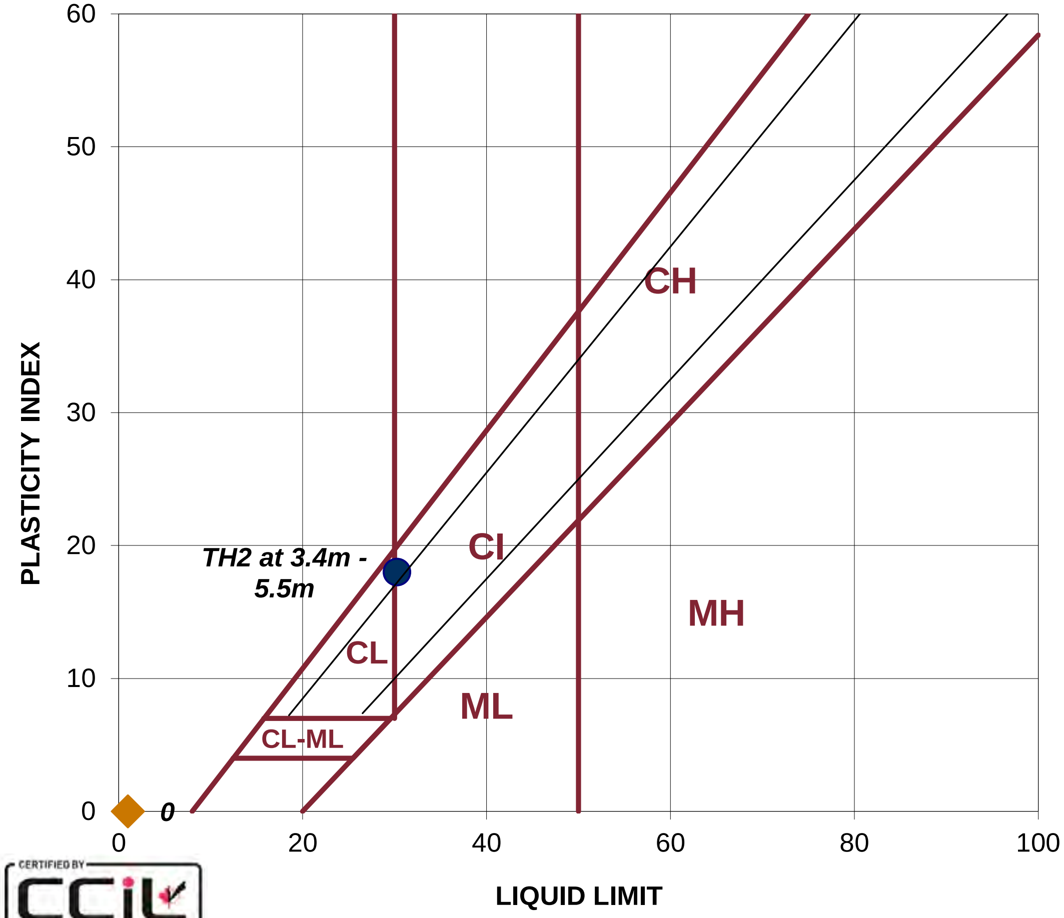
Atterberg Limits
ASTM D4318
Method B- One Point

Client: JR Cousin Consultants Ltd.
Project Name: RM of Brokenhead-GTH Lagoon Expansion
Project No: 123311627
Date Received: October 22, 2014
Date Tested: October 29, 2014
Tested By: Nestor Abarca

LABORATORY
199 Henlow Bay
Winnipeg, Manitoba
Canada R3Y 1G4

Tel: (204) 488-6999

Sample:			Sample:	
TH2 at 3.4m - 5.5m				
LIQUID			LIQUID	
1	2	Trial No.	1	2
21	21	Number of Blows		
282	262	Container Number		
41.94	45.68	Wt. Sample (wet+tare)(g)		
36.95	39.78	Wt. Sample (dry+tare)(g)		
20.81	20.67	Wt. Tare (g)		
16.1	19.1	Wt. Dry Soil (g)		
5.0	5.9	Wt. Water (g)		
30.9%	30.9%	Water Content (%)		
30.3%	30.2%	Corrected Water Content (%)		
PLASTIC			PLASTIC	
1	2	Trial No.	1	2
310	312	Container Number		
32.82	31.93	Wt. Sample (wet+tare)(g)		
31.55	30.72	Wt. Sample (dry+tare)(g)		
20.7	20.47	Wt. Tare (g)		
10.9	10.3	Wt. Dry Soil (g)		
1.3	1.2	Wt. Water (g)		
11.7%	11.8%	Water Content (%)		
AVERAGE VALUES			AVERAGE VALUES	
1	2		1	2
LL	30		LL	
PL	12		PL	
PI	18		PI	
CLASSIFICATION			CLASSIFICATION	
CI-CL ●			***NON-PLASTIC*** ◆	



CERTIFIED BY CCIL

Reviewed By: Jason Thompson, CET

Stantec

Atterberg Limits

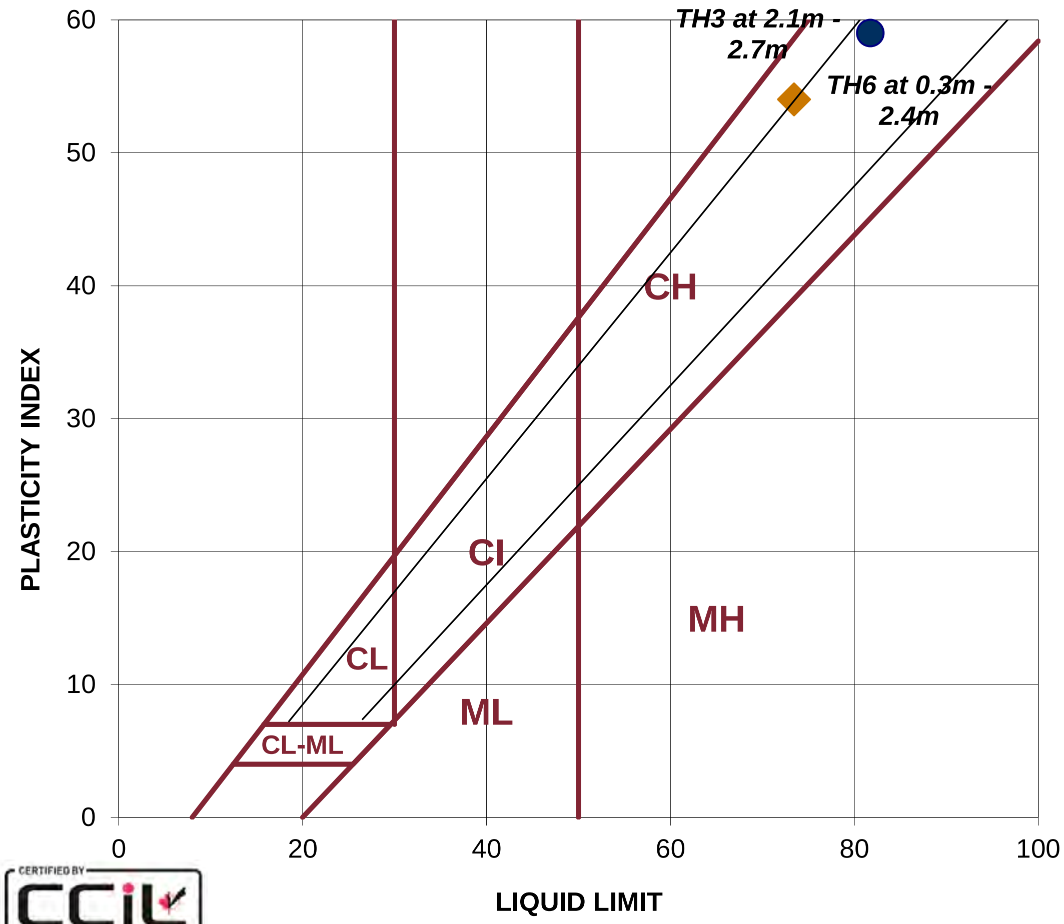
ASTM D4318
Method B- One Point

Client: JR Cousin Consultants Ltd.
Project Name: RM of Brokenhead-GTH Lagoon Expansion
Project No: 123311627
Date Received: October 22, 2014
Date Tested: October 28, 2014
Tested By: Nestor Abarca

LABORATORY
199 Henlow Bay
Winnipeg, Manitoba
Canada R3Y 1G4

Tel: (204) 488-6999

Sample:			Sample:	
TH3 at 2.1m - 2.7m			TH6 at 0.3m - 2.4m	
LIQUID			LIQUID	
1	2	Trial No.	1	2
23	22	Number of Blows	22	22
265	232	Container Number	220	259
39.65	39.43	Wt. Sample (wet+tare)(g)	38.04	38.18
31.07	30.67	Wt. Sample (dry+tare)(g)	30.18	30.70
20.68	20.12	Wt. Tare (g)	19.64	20.68
10.4	10.6	Wt. Dry Soil (g)	10.5	10.0
8.6	8.8	Wt. Water (g)	7.9	7.5
82.6%	83.0%	Water Content (%)	74.6%	74.7%
81.8%	81.8%	Corrected Water Content (%)	73.4%	73.5%
PLASTIC			PLASTIC	
1	2	Trial No.	1	2
320	152	Container Number	249	166
32.31	29.75	Wt. Sample (wet+tare)(g)	31.09	31.27
30.14	27.9	Wt. Sample (dry+tare)(g)	29.35	29.37
20.87	20.03	Wt. Tare (g)	20.3	19.76
9.3	7.9	Wt. Dry Soil (g)	9.1	9.6
2.2	1.9	Wt. Water (g)	1.7	1.9
23.4%	23.5%	Water Content (%)	19.2%	19.8%
AVERAGE VALUES			AVERAGE VALUES	
1	2		1	2
LL	82		LL	73
PL	23		PL	19
PI	59		PI	54
CLASSIFICATION			CLASSIFICATION	
CH ●			**CH** ◆	



Reviewed By: Jason Thompson, CET

Stantec

Atterberg Limits

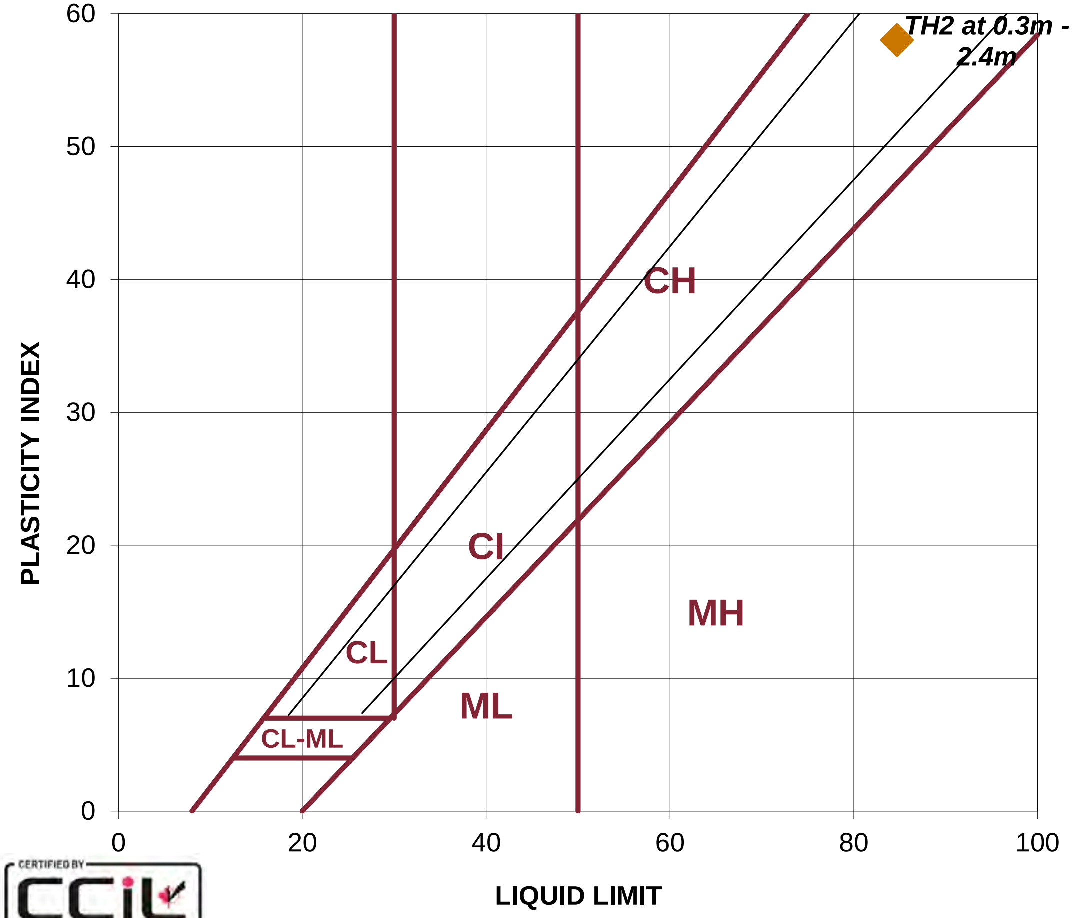
ASTM D4318
Method B- One Point

Client: JR Cousin Consultants Ltd.
Project Name: RM of Brokenhead-GTH Lagoon Expansion
Project No: 123311627
Date Received: October 22, 2014
Date Tested: October 28, 2014
Tested By: Nestor Abarca

LABORATORY
199 Henlow Bay
Winnipeg, Manitoba
Canada R3Y 1G4

Tel: (204) 488-6999

Sample:			Sample:	
TH7 at 2.4m - 4.0m			TH2 at 0.3m - 2.4m	
LIQUID			LIQUID	
1	2	Trial No.	1	2
24	23	Number of Blows	22	23
165	276	Container Number	275	158
36.55	36.92	Wt. Sample (wet+tare)(g)	39.16	39.50
28.03	28.61	Wt. Sample (dry+tare)(g)	30.71	30.57
19.59	20.42	Wt. Tare (g)	20.82	20.21
8.4	8.2	Wt. Dry Soil (g)	9.9	10.4
8.5	8.3	Wt. Water (g)	8.5	8.9
100.9%	101.5%	Water Content (%)	85.4%	86.2%
100.5%	100.4%	Corrected Water Content (%)	84.1%	85.3%
PLASTIC			PLASTIC	
1	2	Trial No.	1	2
255	217	Container Number	298	296
27.71	28.38	Wt. Sample (wet+tare)(g)	31.84	30.86
26.21	26.35	Wt. Sample (dry+tare)(g)	29.42	28.77
20.75	19.17	Wt. Tare (g)	20.25	20.96
5.5	7.2	Wt. Dry Soil (g)	9.2	7.8
1.5	2.0	Wt. Water (g)	2.4	2.1
27.5%	28.3%	Water Content (%)	26.4%	26.8%
AVERAGE VALUES			AVERAGE VALUES	
1	2		1	2
LL	100		LL	85
PL	28		PL	27
PI	72		PI	58
CLASSIFICATION			CLASSIFICATION	
CH ●			**CH** ◆	



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Reviewed By: Jason Thompson, CET

Stantec

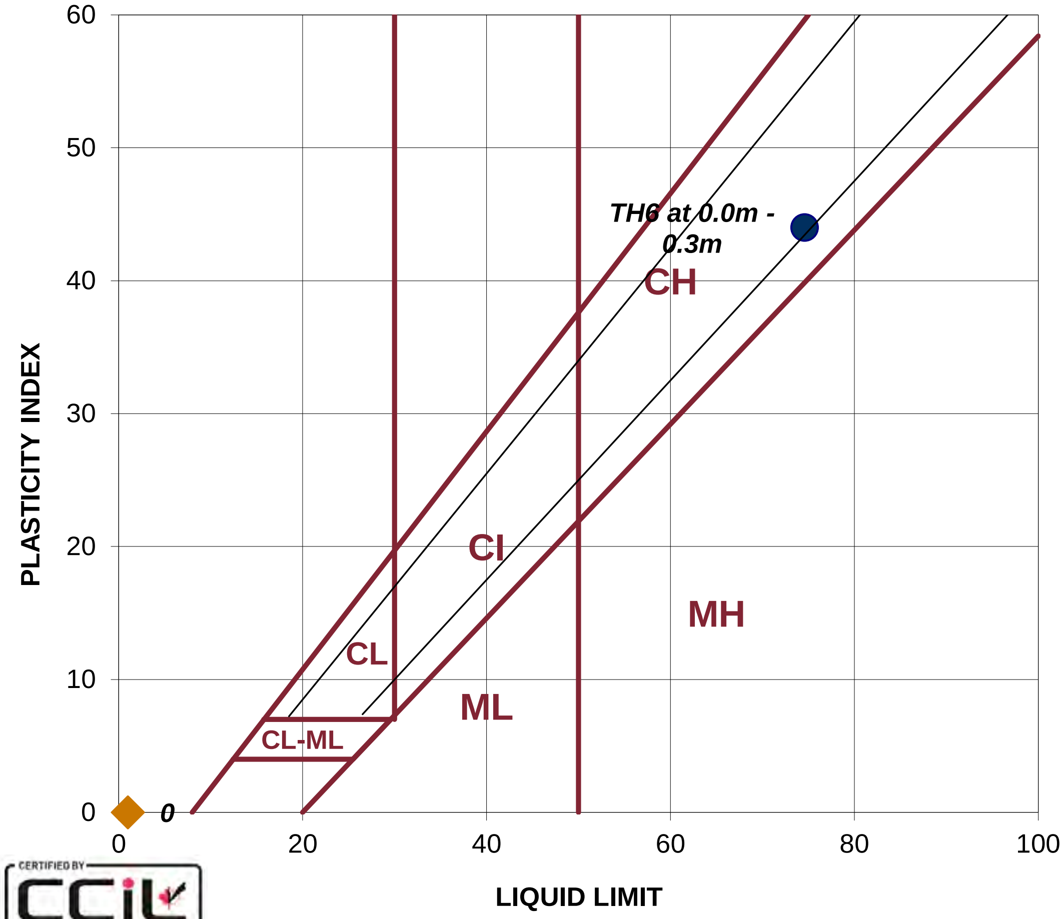
Atterberg Limits
ASTM D4318
Method B- One Point

Client: JR Cousin Consultants Ltd.
Project Name: RM of Brokenhead-GTH Lagoon Expansion
Project No: 123311627
Date Received: October 22, 2014
Date Tested: October 28, 2014
Tested By: Nestor Abarca

LABORATORY
199 Henlow Bay
Winnipeg, Manitoba
Canada R3Y 1G4

Tel: (204) 488-6999

Sample:			Sample:	
TH6 at 0.0m - 0.3m				
LIQUID			LIQUID	
1	2	Trial No.	1	2
25	25	Number of Blows		
215	212	Container Number		
35.98	39.45	Wt. Sample (wet+tare)(g)		
29.06	31.15	Wt. Sample (dry+tare)(g)		
19.76	20.05	Wt. Tare (g)		
9.3	11.1	Wt. Dry Soil (g)		
6.9	8.3	Wt. Water (g)		
74.4%	74.8%	Water Content (%)		
74.4%	74.8%	Corrected Water Content (%)		
PLASTIC			PLASTIC	
1	2	Trial No.	1	2
292	285	Container Number		
33.41	32.75	Wt. Sample (wet+tare)(g)		
30.45	30.02	Wt. Sample (dry+tare)(g)		
20.84	21.26	Wt. Tare (g)		
9.6	8.8	Wt. Dry Soil (g)		
3.0	2.7	Wt. Water (g)		
30.8%	31.2%	Water Content (%)		
AVERAGE VALUES			AVERAGE VALUES	
1	2		1	2
LL	75		LL	
PL	31		PL	
PI	44		PI	
CLASSIFICATION			CLASSIFICATION	
CH ●			***NON-PLASTIC*** ◆	



Reviewed By: Jason Thompson, CET

Stantec

Atterberg Limits

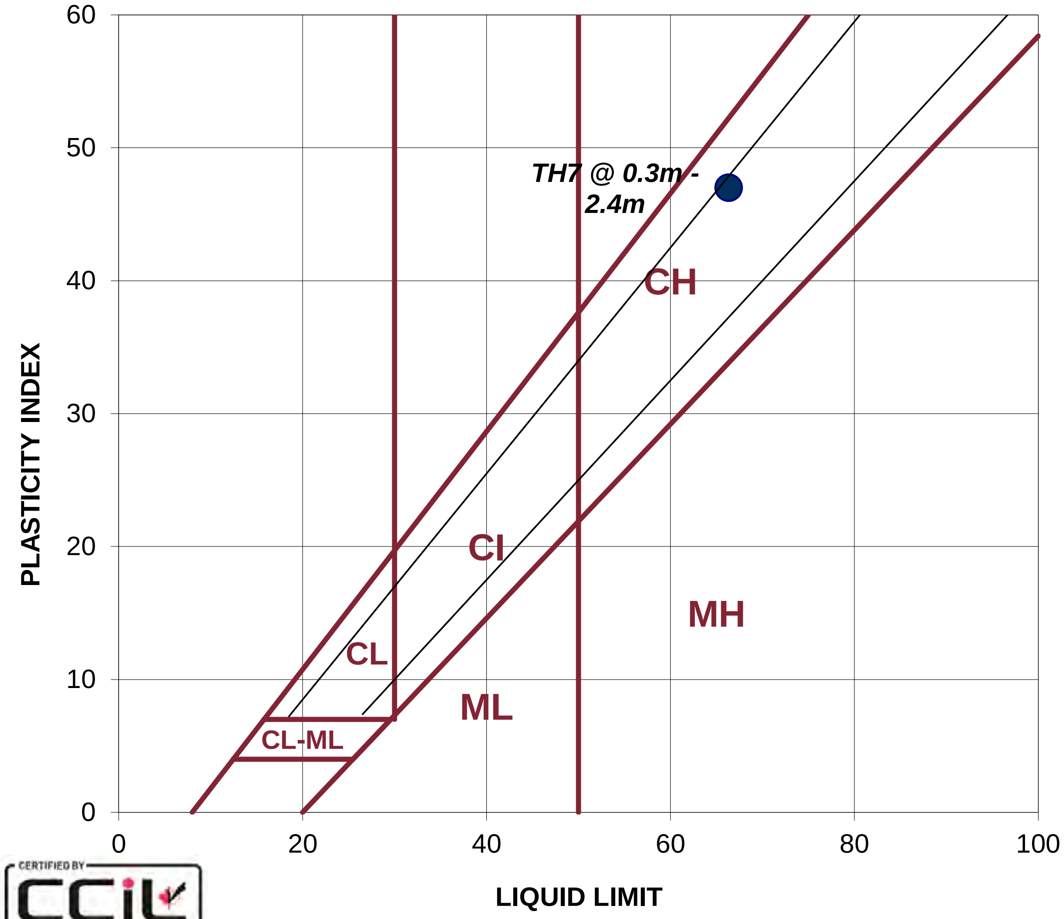
ASTM D4318
Method B- One Point

Client: JR Cousin Consultants Ltd.
Project Name: RM of Brokenhead-GTH Lagoon Expansion
Project No: 123311627
Date Received: October 22, 2014
Date Tested: October 27, 2014
Tested By: Larry Presado

LABORATORY
199 Henlow Bay
Winnipeg, Manitoba
Canada R3Y 1G4

Tel: (204) 488-6999

Sample:			Sample:	
TH7 @ 0.3m - 2.4m			TH6 @ 2.4m - 3.4m	
LIQUID			LIQUID	
1	2	Trial No.	1	2
24	24	Number of Blows	24	25
281	242	Container Number	262	282
39.47	39.17	Wt. Sample (wet+tare)(g)	41.65	45.10
32.05	31.67	Wt. Sample (dry+tare)(g)	31.10	32.87
20.92	20.42	Wt. Tare (g)	20.67	20.83
11.1	11.3	Wt. Dry Soil (g)	10.4	12.0
7.4	7.5	Wt. Water (g)	10.6	12.2
66.7%	66.7%	Water Content (%)	101.2%	101.6%
66.3%	66.3%	Corrected Water Content (%)	100.7%	101.6%
PLASTIC			PLASTIC	
1	2	Trial No.	1	2
237	304	Container Number	173	153
31.11	31.36	Wt. Sample (wet+tare)(g)	30.29	31.58
29.39	29.59	Wt. Sample (dry+tare)(g)	27.99	29.06
20.56	20.31	Wt. Tare (g)	19.48	19.76
8.8	9.3	Wt. Dry Soil (g)	8.5	9.3
1.7	1.8	Wt. Water (g)	2.3	2.5
19.5%	19.1%	Water Content (%)	27.0%	27.1%
AVERAGE VALUES			AVERAGE VALUES	
1	2		1	2
LL	66		LL	101
PL	19		PL	27
PI	47		PI	74
CLASSIFICATION			CLASSIFICATION	
CH ●			**CH** ◆	



Reviewed By: Jason Thompson, CET

Stantec

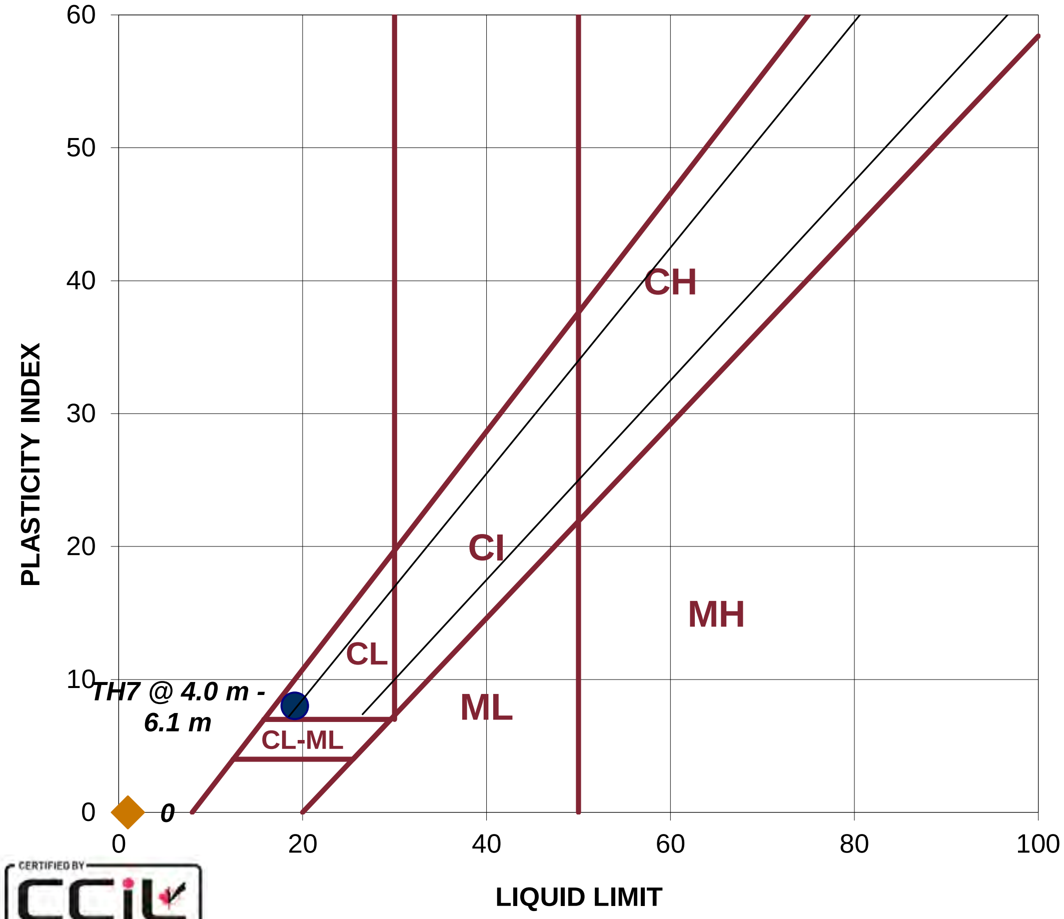
Atterberg Limits
ASTM D4318
Method B- One Point

Client: JR Cousin Consultants Ltd.
Project Name: RM of Brokenhead-GTH Lagoon Expansion
Project No: 123311627
Date Received: October 22, 2014
Date Tested: October 27, 2014
Tested By: Larry Presado

LABORATORY
199 Henlow Bay
Winnipeg, Manitoba
Canada R3Y 1G4

Tel: (204) 488-6999

Sample:			Sample:	
TH7 @ 4.0 m - 6.1 m				
LIQUID			LIQUID	
1	2	Trial No.	1	2
24	23	Number of Blows		
312	310	Container Number		
53.37	54.13	Wt. Sample (wet+tare)(g)		
48.04	48.73	Wt. Sample (dry+tare)(g)		
20.48	20.67	Wt. Tare (g)		
27.6	28.1	Wt. Dry Soil (g)		
5.3	5.4	Wt. Water (g)		
19.3%	19.2%	Water Content (%)		
19.2%	19.1%	Corrected Water Content (%)		
PLASTIC			PLASTIC	
1	2	Trial No.	1	2
136	260	Container Number		
38.03	38.67	Wt. Sample (wet+tare)(g)		
36.18	36.84	Wt. Sample (dry+tare)(g)		
19.69	20.57	Wt. Tare (g)		
16.5	16.3	Wt. Dry Soil (g)		
1.9	1.8	Wt. Water (g)		
11.2%	11.2%	Water Content (%)		
AVERAGE VALUES			AVERAGE VALUES	
1	2		1	2
LL	19		LL	
PL	11		PL	
PI	8		PI	
CLASSIFICATION			CLASSIFICATION	
CL ●			***NON-PLASTIC*** ◆	



CERTIFIED BY CCIL
Canadian Council of Independent Laboratories
For specific tests as listed on www.ccil.com

Reviewed By: Jason Thompson, CET

Stantec

LABORATORY
199 Henlow Bay
Winnipeg MB R3Y 1G4
Tel: (204) 488-6999

HYDRAULIC CONDUCTIVITY
ASTM D5084

JR Cousin Consultants Ltd.
91A Scurfield Blvd.
Winnipeg, Manitoba
R3Y 1G4

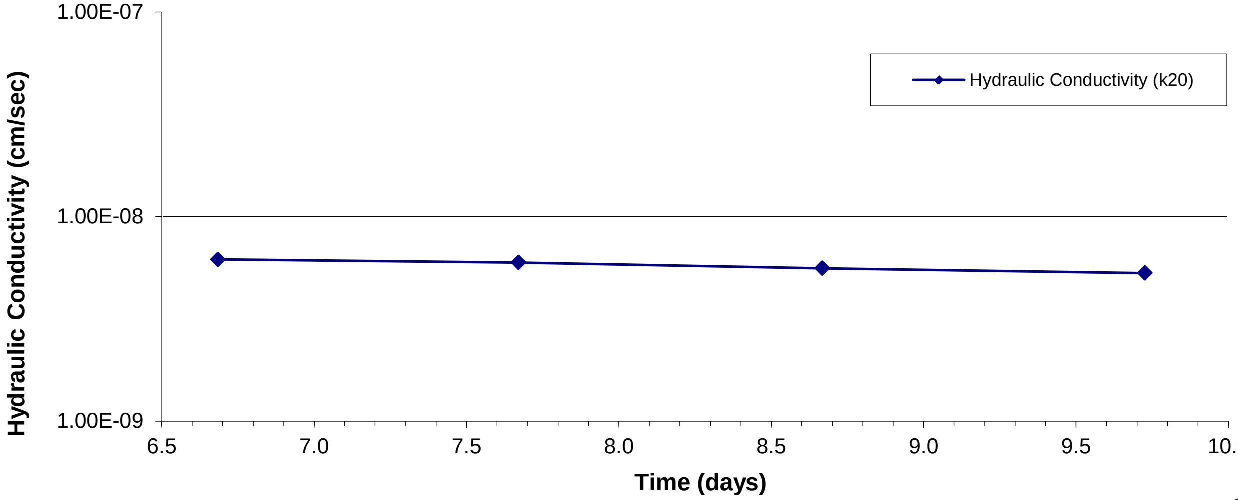
PROJECT: RM of Brokenhead
GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLE I.D.:	**TH3 @ 2.1 m - 2.7 m**
SOIL DESCRIPTION:	Brown, stiff, moist, high plasticity sand clay some silt and trace gravel
DATE TESTED:	October 22 to November 1, 2014
CONFINING PRESSURE (kPa):	137.9
EFFECTIVE SATURATION STRESS (kPa):	34.5
ASSUMED SPECIFIC GRAVITY:	2.72
HYDRAULIC GRADIENT:	20.4
TYPE OF PERMEANT LIQUID:	De-aired Water
HYDRAULIC CONDUCTIVITY, "k" (cm/s):	5.8E-09
HYDRAULIC CONDUCTIVITY, "k_{20}" (cm/s):	**5.8E-09**

	Height (mm)	Diameter (mm)	Wet Mass (g)	Dry Density (g/cm^3)	Water Content (%)	Saturation (%)
Initial Reading	73.1	72.5	531.0	1.297	35.8	88.8
Final Reading	72.3	72.1	535.1	1.242	46.1	105.4



November 6, 2014

REVIEWED BY: Jason Thompson, CET

LABORATORY
199 Henlow Bay
Winnipeg MB R3Y 1G4
Tel: (204) 488-6999

HYDRAULIC CONDUCTIVITY
ASTM D5084

JR Cousin Consultants Ltd.
91A Scurfield Blvd.
Winnipeg, Manitoba
R3Y 1G4

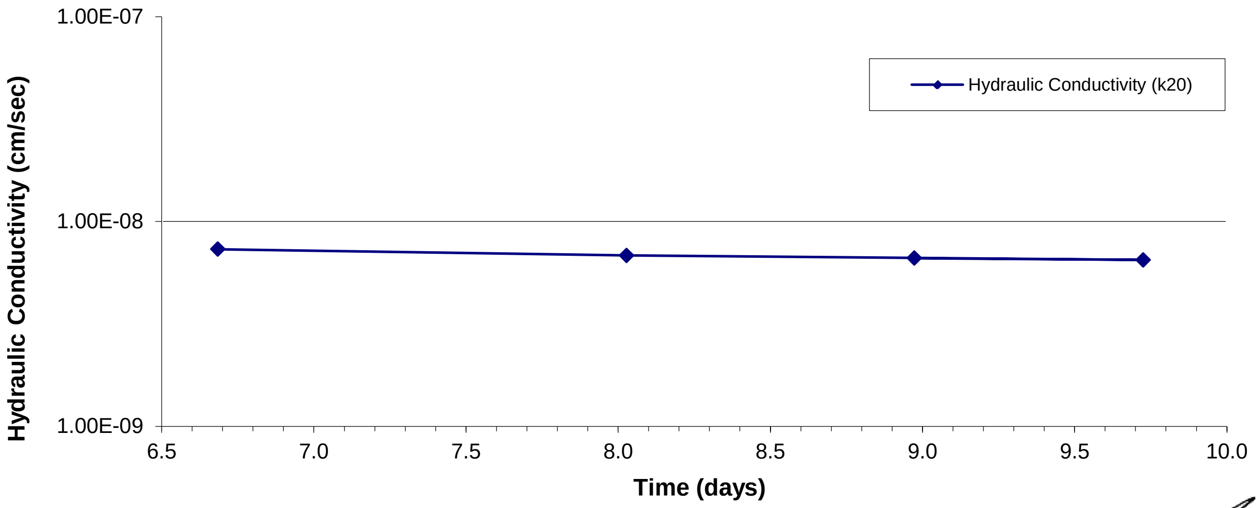
PROJECT: RM of Brokenhead
GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLE I.D.:	**TH6 @ 0.9 m - 1.5 m**
SOIL DESCRIPTION:	Brown, stiff, moist, high plasticity clay some silt, trace sand and trace gravel
DATE TESTED:	October 22 to November 1, 2014
CONFINING PRESSURE (kPa):	137.9
EFFECTIVE SATURATION STRESS (kPa):	34.5
ASSUMED SPECIFIC GRAVITY:	2.72
HYDRAULIC GRADIENT:	20.3
TYPE OF PERMEANT LIQUID:	De-aired Water
HYDRAULIC CONDUCTIVITY, "k" (cm/s):	7.0E-09
HYDRAULIC CONDUCTIVITY, "k_{20}" (cm/s):	**6.8E-09**

	Height (mm)	Diameter (mm)	Wet Mass (g)	Dry Density (g/cm^3)	Water Content (%)	Saturation (%)
Initial Reading	72.2	72.4	595.5	1.590	26.0	99.3
Final Reading	72.9	72.0	601.1	1.587	27.6	105.0



November 6, 2014

REVIEWED BY: Jason Thompson, CET

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   To       Log
  (ft.)  (ft.)
      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   To    Casing       Inside   Outside  Slot     Type       Material
  (ft.)  (ft.) Type         Dia.(in) Dia.(in) Size(in)
      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   To       Log
  (ft.)  (ft.)
      0   35.0    CLAY
   35.0   68.0    TILL
   68.0   75.0    GRAVEL
   75.0  124.9    LIMESTONE

WELL CONSTRUCTION

  From   To    Casing       Inside   Outside  Slot     Type       Material
  (ft.)  (ft.) Type         Dia.(in) Dia.(in) Size(in)
      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   To    Casing       Inside   Outside  Slot     Type       Material
  (ft.)  (ft.) Type         Dia.(in) Dia.(in) Size(in)
      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.

Appendix C

Plan GI1: Drawing Legend, Abbreviation Index and Key Plan

Plan L1: Existing Lagoon Layout – Test Hole Locations and Existing Contour Lines

Plan L2: Proposed Lagoon Layout – Test Hole Locations and Existing Contour Lines

Plan L3: Proposed Lagoon Layout

Plan L4: Perimeter Dike and Intercell Dike Details

Plan L5: Existing Lagoon Dike Upgrade, Liquid Level Control Weir and Intercell Dike Details

Plan L6: Perimeter Dike at Transition between Re-Worked and In situ Liner and Splitter Manhole Details

Plan L7: Splitter Manhole, Valve, Valve Marker, Site Marker, Rip Rap, Gate, Lock, Fence and Forcemain Trench Details

Plan L8: Silt Fence, Spillway, Truck Turnaround and Access Road Details

Plan P1: Process and Instrumentation Diagram

Plan S1: Building Elevations

Plan S2: Building Layout

RM OF BROKENHEAD

GTH LAGOON EXPANSION

PRE-DESIGN PLAN SET

PLAN INDEX

GENERAL INFORMATION

PLAN GI1.	DRAWING LEGEND, ABBREVIATION INDEX AND KEY PLAN

LAGOON

PLAN L1.	EXISTING LAGOON LAYOUT - TEST HOLE LOCATIONS AND EXISTING CONTOUR LINES
PLAN L2.	PROPOSED LAGOON LAYOUT - TEST HOLE LOCATIONS AND EXISTING CONTOUR LINES
PLAN L3.	PROPOSED LAGOON LAYOUT
PLAN L4.	PERIMETER DIKE AND INTERCELL DIKE DETAILS
PLAN L5.	EXISTING LAGOON DIKE UPGRADE, LIQUID LEVEL CONTROL WEIR AND INTERCELL DIKE DETAILS
PLAN L6.	PERIMETER DIKE AT TRANSITION BETWEEN RE-WORKED AND INSITU LINER AND AT SPLITTER MANHOLE DETAILS
PLAN L7.	SPLITTER MANHOLE, VALVE, VALVE MARKER, SITE MARKER, RIP RAP, GATE, LOCK, FENCE AND FORCEMAIN TRENCH DETAILS
PLAN L8.	SILT FENCE, SPILLWAY, TRUCK TURNAROUND AND ACCESS ROAD DETAILS

CHEMICAL FEED BUILDING PROCESS

PLAN P1.	PROCESS AND INSTRUMENTATION DIAGRAM

CHEMICAL FEED BUILDING STRUCTURAL

PLAN S1.	BUILIDNG ELEVATIONS
PLAN S2.	BUILIDNG LAYOUT

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DRAWING LEGEND:

PIPING:

- EXISTING WATERMAIN
- PROPOSED WATERMAIN
- FUTURE WATERMAIN
- EXISTING SEWERMAIN
- PROPOSED SEWERMAIN
- FUTURE SEWERMAIN
- EXISTING FORCEMAIN
- PROPOSED FORCEMAIN
- FUTURE FORCEMAIN
- EXISTING RAW WATERMAIN
- PROPOSED RAW WATERMAIN
- FUTURE RAW WATERMAIN
- EXISTING LAND DRAINAGE SEWER
- PROPOSED LAND DRAINAGE SEWER
- FUTURE LAND DRAINAGE SEWER
- FH EXISTING FIRE HYDRANT
- FH PROPOSED FIRE HYDRANT
- EXISTING VALVE
- PROPOSED VALVE
- CO EXISTING CLEANOUT
- CO PROPOSED CLEANOUT
- MH EXISTING MANHOLE
- MH PROPOSED MANHOLE
- EXISTING CURBSTOP
- PROPOSED CURBSTOP
- CB EXISTING CATCH BASIN
- CB PROPOSED CATCH BASIN

ROADS AND DRAINAGE:

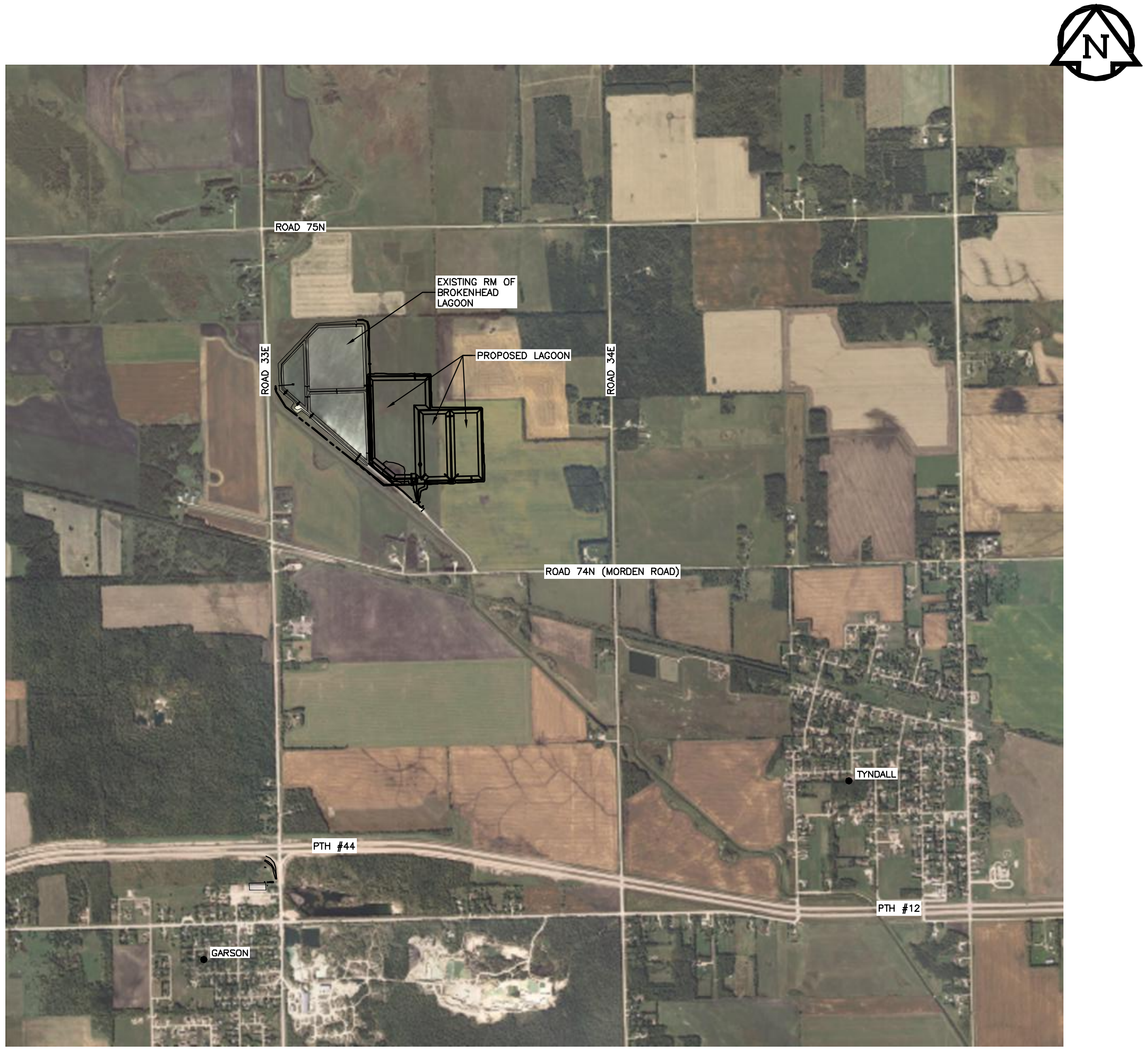
- EXISTING ROAD CENTERLINE
- PROPOSED ROAD CENTERLINE
- FUTURE ROAD CENTERLINE
- EXISTING ROAD SHOULDER
- PROPOSED ROAD SHOULDER
- EXISTING ROAD EDGE
- PROPOSED ROAD EDGE
- FUTURE ROAD EDGE
- EXISTING SIDEWALK
- PROPOSED SIDEWALK
- EXISTING DITCH
- PROPOSED DITCH
- EXISTING CULVERT
- PROPOSED CULVERT
- EXISTING DRAINAGE DIRECTION
- PROPOSED DRAINAGE DIRECTION
- 100 CONTOURS – MAJOR INTERVALS
- 100.5 CONTOURS – MINOR INTERVALS
- ×100.00 EXISTING GROUND ELEVATION
- (100.00) PROPOSED GROUND ELEVATION
- (100.00) EXISTING ROAD ELEVATION
- (100.00) PROPOSED ROAD ELEVATION
- TOP / BOTTOM EXISTING SLOPE
- TOP / BOTTOM PROPOSED SLOPE
- ASPHALT
- GRAVEL

MISCELLANEOUS:

- —X— EXISTING FENCE LINE
- —X— PROPOSED FENCE LINE
- —P— EXISTING PROPANE LINE
- —P— PROPOSED PROPANE LINE
- —H— EXISTING HYDRO LINE
- —H— PROPOSED HYDRO LINE
- —G— EXISTING GAS LINE
- —MTS— EXISTING MTS LINE
- EXISTING BUILDING
- PROPOSED BUILDING
- LEGAL/LOT LINE
- RAILWAY LINE
- MATCH LINE
- HP EXISTING HYDRO POLE
- HP PROPOSED HYDRO POLE
- Ⓦ WATER HOLDING TANK
- Ⓢ SEPTIC TANK
- Ⓗ SEWAGE HOLDING TANK
- SURVEY BAR
- SURVEY MONUMENT/BENCHMARK
- EXISTING VEGETATION
- PROPOSED VEGETATION
- D1 DOOR CONSTRUCTION TYPE
- W1 WALL CONSTRUCTION TYPE
- EASEMENT
- N NORTH ARROW

ABBREVIATIONS:

@	AT
A/C	AIR CONDITIONING
ALUM	ALUMINUM
ASPH	ASPHALT
AVE	AVENUE
AVG	AVERAGE
BD	BOTTOM OF DITCH
BLDG	BUILDING
BLVD	BOULEVARD
BM	BENCHMARK
BOT	BOTTOM
BP	BACKWASH PUMP
B/W	BOTHWAYS
CB	CATCH BASIN
CI	CAST IRON
CHKD	CHECKED
CNR	CANADIAN NATIONAL RAILWAY
CO	CLEANOUT
COL	COLUMN
CONC	CONCRETE
CONST	CONSTRUCTION
CONT	CONTINUOUS
COORD	COORDINATE
CPR	CANADIAN PACIFIC RAILWAY
C/W	COMPLETE WITH
DCW	DOMESTIC COLD WATER
DEG	DEGREE
DHW	DOMESTIC HOT WATER
DIA	DIAMETER
DIM	DIMENSION
DIST	DISTANCE
DN	DOWN
DP	DUTY PUMP
DR	DRIVE
DWG	DRAWING
E	EAST
EC	END OF CURVE
EL	ELEVATION
ELEC	ELECTRICAL
EP	EDGE OF PAVEMENT
ER	EDGE OF ROAD
E/W	EACHWAY
EXT	EXTERIOR
FAX	FAX MACHINE STAND
FC	FILE CABINET
FD	FLOOR DRAIN
F/F	FACE TO FACE
FH	FIRE HYDRANT
FM	FORCEMAIN
FP	FIRE PUMP
FT	FOOT, FEET
GA	GAUGE
GALV	GALVANIZED
HA	HECTARE
HB	HOSE BIBB
HDPE	HIGH DENSITY POLYETHYLENE
HI	HEIGHT OF INSTRUMENT
HPW	HIGH PRESSURE WATER LINE
HORIZ	HORIZONTAL
HP	HYDRO POLE
HR	HOUR
HVAC	HEATING, VENTILATING AND AIR CONDITIONING
HW	HOT WATER TANK
HWL	HIGH WATER LEVEL
ID	INSIDE DIAMETER
IL	ICE LEVEL
INCL	INCLUDE
INT	INTERIOR
INV	INVERT
JCT	JUNCTION
JP	JOCKEY PUMP
LAB	LABORATORY
LAM	LAMINATE
LAT	LATITUDE
LDS	LAND DRAINAGE SEWER
LFS	LEVEL FLOAT SWITCH
LONG	LONGITUDE
LWL	LOW WATER LEVEL
M	METRE
MAX	MAXIMUM
MCC	MOTOR CONTROL CENTER
MECH	MECHANICAL
MEMB	MEMBRANE
MH	MANHOLE
MIN	MINIMUM
MM	MILLIMETRE
N	NORTH
NAT	NATURAL
NBC	NATIONAL BUILDING CODE
NTS	NOT TO SCALE
NWL	NORMAL WATER LEVEL
O/C	ON CENTRE
O/D	OUTSIDE DIAMETER
O/F	OUTSIDE FACE
O/H	OVER HEAD
OD	OUTSIDE DIAMETER
ORIG	ORIGINAL
OWSJ	OPEN WEB STEEL JOIST
PLYWD	PLYWOOD
POLY	POLYETHYLENE
PROP	PROPERTY
PS	PRESSURE SEWER
PVC	POLY VINYL CHLORIDE
RAD	RADIUS
RD	ROAD
REV	REVISION
ROW	RIGHT OF WAY
RM	ROOM
S	SOUTH
SCH	SCHEDULE
SECT	SECTION
SHT	SHEET
SIB	STEEL IRON BAR
SPEC	SPECIFICATION
SQ	SQUARE
SSL	SEWER SERVICE LINE
ST	STREET
STD	STANDARD
SUSP	SUSPENDED
SW	SIDEWALK
TEL	TELEPHONE
TEMP	TEMPORARY
TP	TRUCKFILL PUMP
TYP	TYPICAL
VERT	VERTICAL
VOL	VOLUME
US	ULTRASONICS TRANSDUCER
VAR	VARIES
VB	VAPOUR BARRIER
VERT	VERTICAL
VFD	VARIABLE FREQUENCY DRIVE
W	WEST
W/O	WITHOUT
WL	WATER LEVEL
WM	WATERMAIN
WSL	WATER SERVICE LINE
WWS	WASTEWATER SEWER
WT	WEIGHT



KEY PLAN

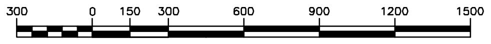
SCALE 1:15000

NOTE:

DECIMALIZED NUMBERS INDICATE METRES.
WHOLE NUMBERS INDICATE MILLIMETRES.

A – DETAIL NUMBER
B – PLAN WHERE DETAIL EXPANDED
C – PLAN WHERE DETAIL ORIGINATES

SCALE BAR
(IN METRES)



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No.	REVISIONS	DATE	INITIALS

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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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CODE: B-246.12
DESIGNED BY: BM
DRAWN BY: OT
REVIEWED BY: JC

PROJECT:
RM OF BROKENHEAD
GTH LAGOON EXPANSION

TITLE:
DRAWING LEGEND, ABBREVIATION INDEX AND KEY PLAN

SCALE: 1:15000
DATE: 14/12/17
PLAN: GI1
SHEET: 1 of 12

Dec 19, 2014 – 1:43pm F:\200\246 Brokenhead RM\246.12 GTH Lagoon Design and Construction\04 Drawings\dwg\Pre-Design Plans\GI1.dwg

Dec 19, 2014 – 11:35am F:\200\246 Brokenhead RM\246.12 GTH Lagoon Design and Construction\04 Drawings\dwg\Pre-Design Plans\L1 – Existing Lagoon Layout and Test Hole Locations.dwg

SCALE BAR
(IN METRES)

50 0 25 50 100 150 200 250

1:2500

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DESIGNED BY: JC

DRAWN BY: BM

REVIEWED BY: JC

PROJECT:
RM OF BROKENHEAD
GTH LAGOON EXPANSION

TITLE:
EXISTING LAGOON LAYOUT
TEST HOLE LOCATIONS
AND EXISTING CONTOUR LINES

SCALE: 1:2500

DATE: 14/11/13

PLAN: L1

SHEET: 2 of 12

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

No.	REVISIONS	DATE	INITIALS

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DESIGNED BY: JC
DRAWN BY: BM
REVIEWED BY: JC

PROJECT:
RM OF BROKENHEAD
GTH LAGOON EXPANSION

TITLE:
PROPOSED LAGOON LAYOUT
TEST HOLE LOCATIONS
AND EXISTING CONTOUR LINES

SCALE: 1:2500
DATE: 14/11/13
PLAN: L2
SHEET: 3 of 12

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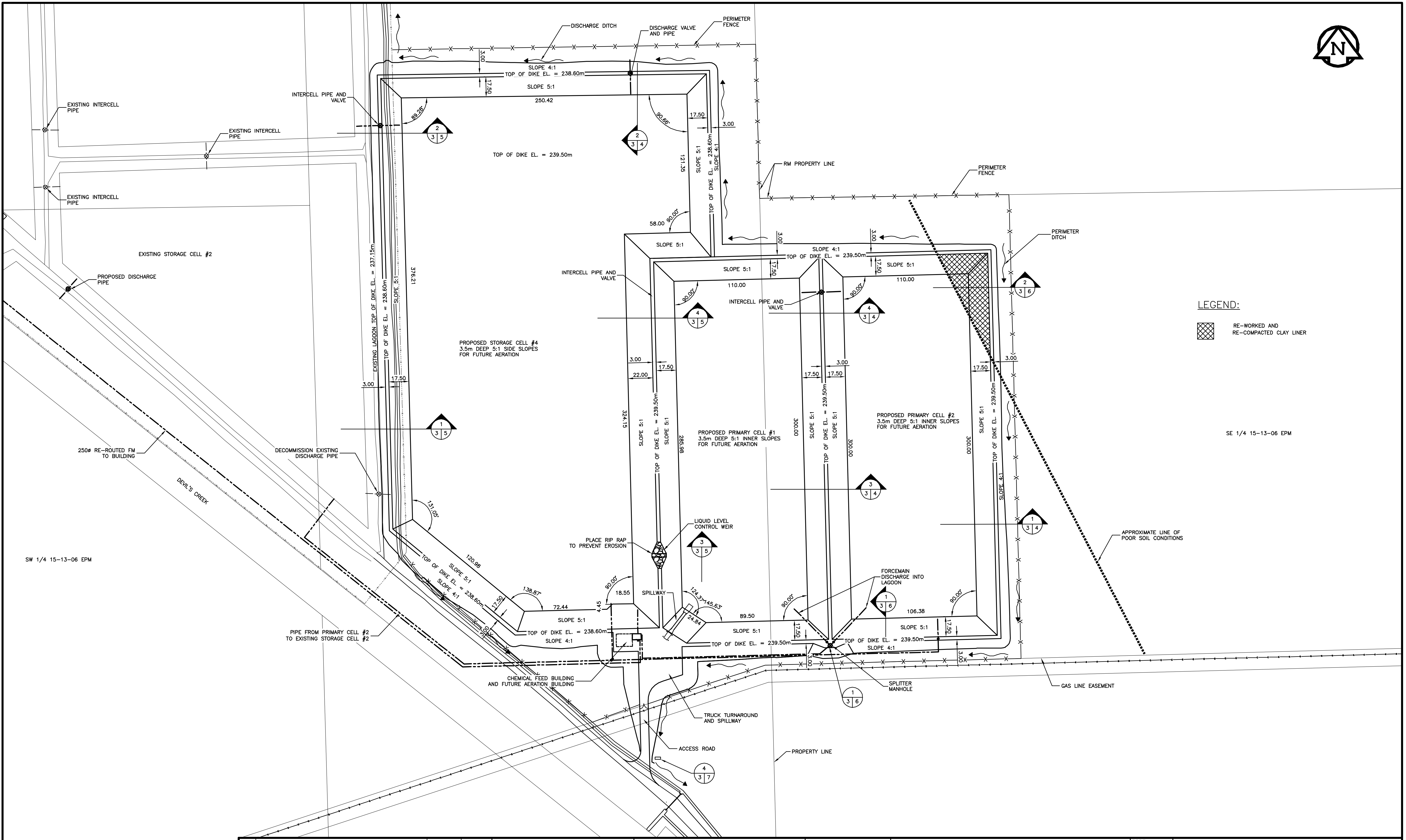

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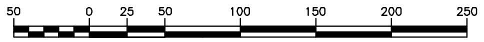

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No.	REVISIONS	DATE	INITIALS

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DRAWN BY: BM
REVIEWED BY: JC

PROJECT:
RM OF BROKENHEAD
GTH LAGOON EXPANSION

TITLE:
PROPOSED LAGOON LAYOUT

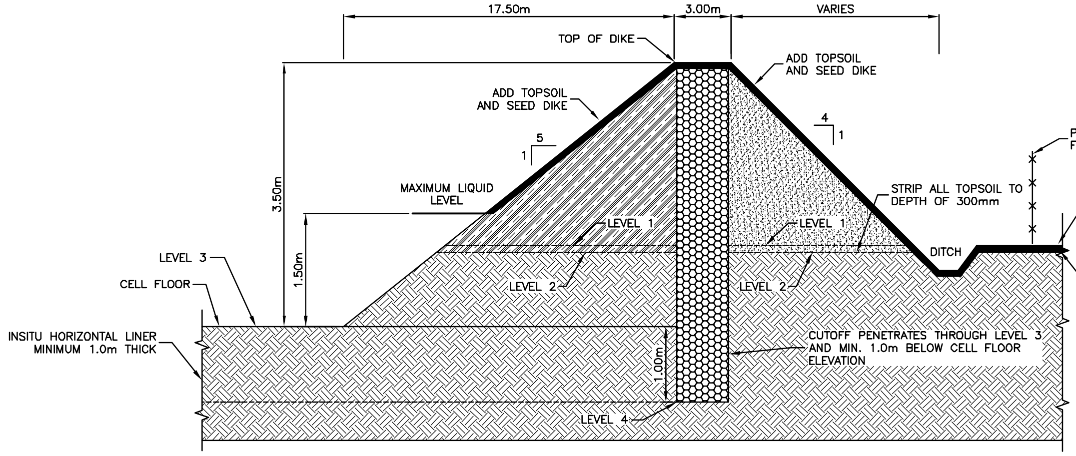
SCALE: 1:1500
DATE: 14/11/27
PLAN: L3
SHEET: 4 of 12

Dec 19, 2014 – 2:12pm F:\200\246 Brokenhead RM\246.12 GTH Lagoon Design and Construction\04 Drawings\dwg\Pre-Design Plans\L3 – Proposed Lagoon Layout.dwg

LEGEND:

⬡	EXCAVATED AND COMPACTED MEDIUM–HIGH PLASTIC CLAY TYPE SOIL	●	RIP RAP
░	EXCAVATED AND COMPACTED MIXTURE OF SOILS	■	TOPSOIL
▩	INSITU HIGH PLASTIC CLAY TYPE SOIL	▨	EXCAVATED AND COMPACTED MEDIUM–HIGH PLASTIC CLAY TYPE SOIL
▦	INSITU LOW PLASTIC SILTY CLAY TYPE SOIL		

LEVEL 1 – PRE–CONSTRUCTION EXISTING GROUND ELEVATION
LEVEL 2 – ELEVATION FOLLOWING TOPSOIL REMOVAL 0.1m
LEVEL 3 – FINISHED CELL BOTTOM ELEVATION
LEVEL 4 – BOTTOM OF HORIZONTAL LINER AND CUTOFF WALL



1 / 3 | 4 PERIMETER DIKE

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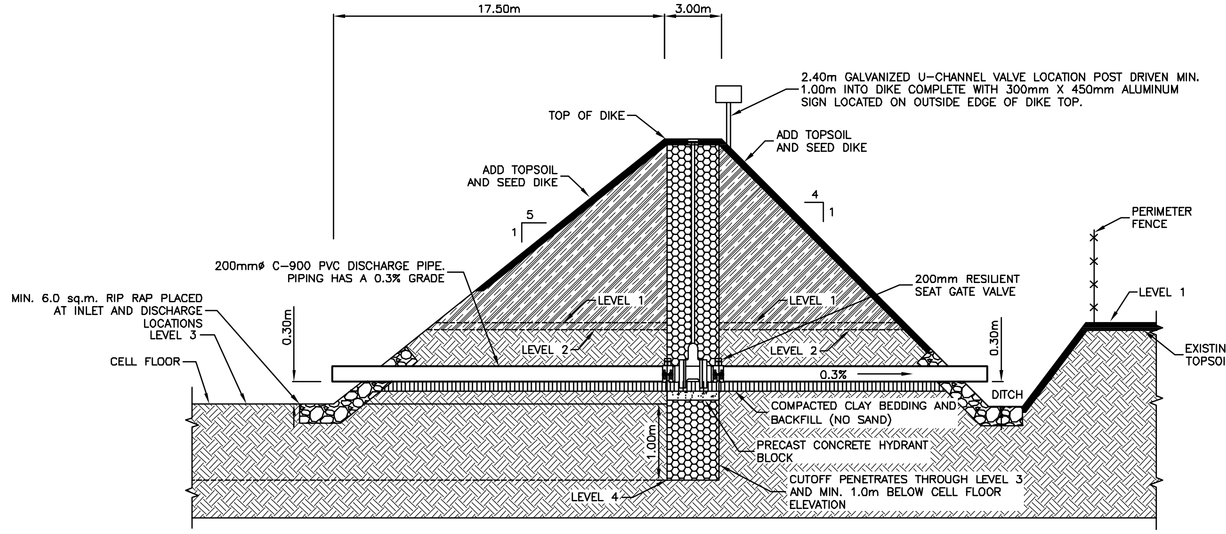
VER = 1:50



2 / 3 | 4 STORAGE CELL DIKE AT DISCHARGE PIPE

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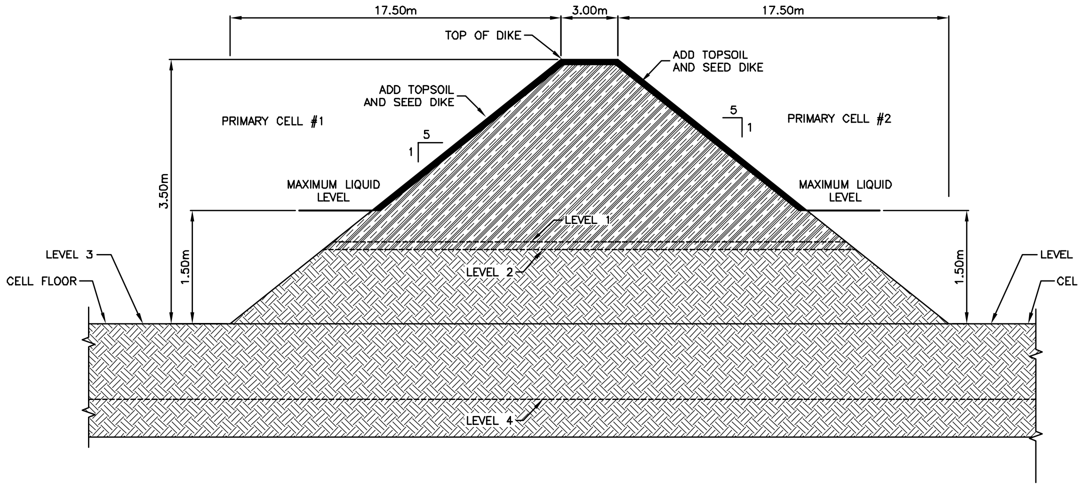
VER = 1:50



3 / 3 | 4 INTERCELL DIKE

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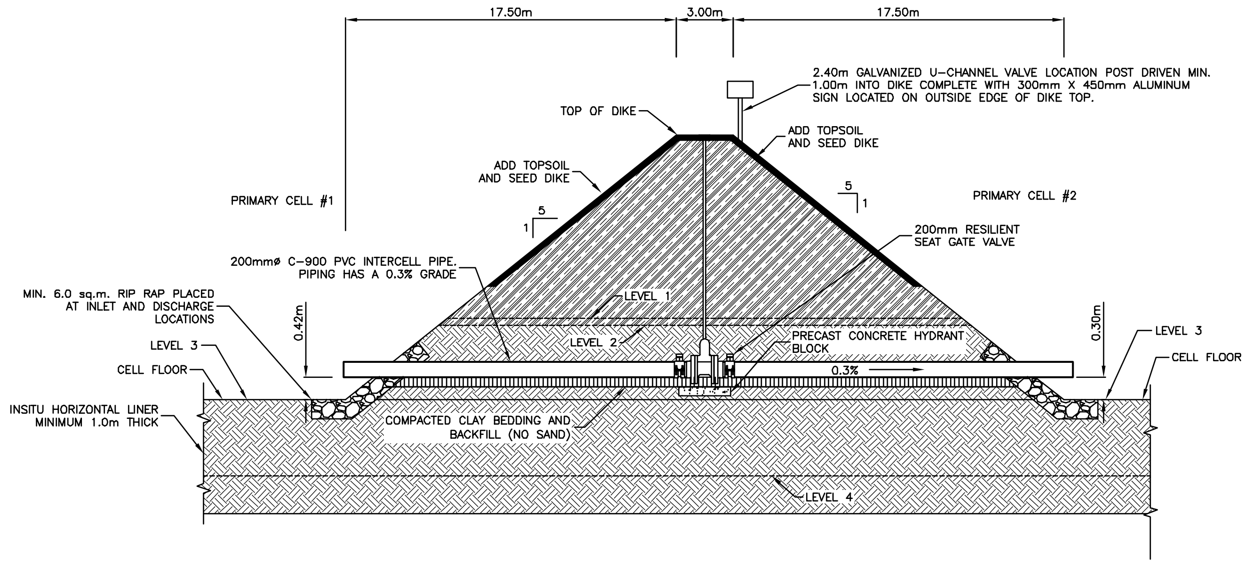

4 / 3 | 4 INTERCELL DIKE AT INTERCELL PIPE

HOR = 1:200
VER = 1:50

No.	REVISIONS	DATE	INITIALS

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CODE: B–246.12
DESIGNED BY: JC
DRAWN BY: OT
REVIEWED BY: JC

PROJECT:
RM OF BROKENHEAD
GTH LAGOON EXPANSION

TITLE:
PERIMETER DIKE AND
INTERCELL DIKE DETAILS

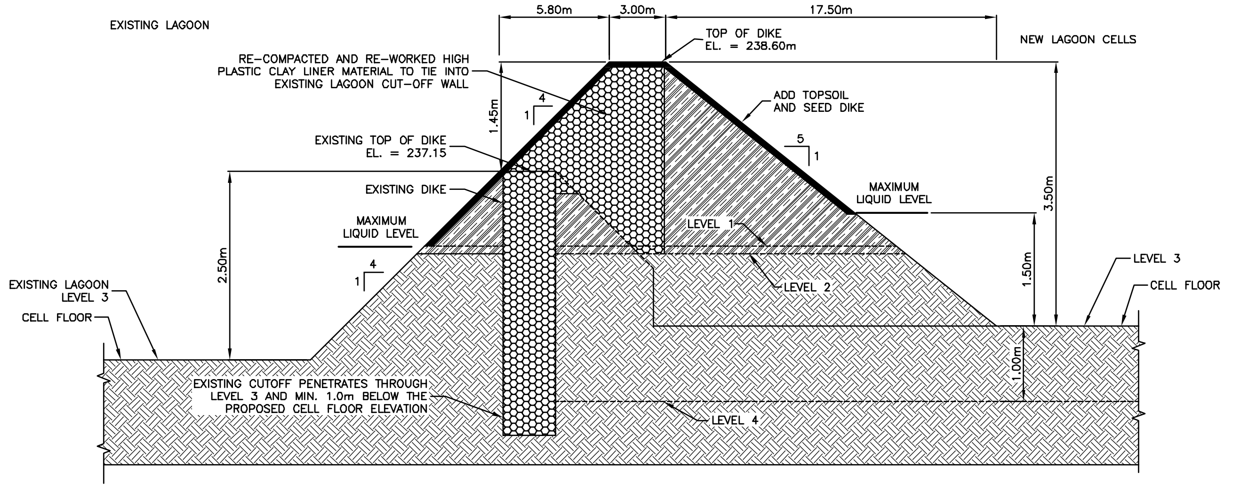
SCALE: AS NOTED
DATE: 14/12/11
PLAN: L4
SHEET: 5 of 12

Dec 19, 2014 – 2:15pm F:\200\246 Brokenhead RM\246.12 GTH Lagoon Design and Construction\04 Drawings\dwg\Pre-Design Plans\L4-L7 Lagoon Details.dwg

LEGEND:

- ⬢ EXCAVATED AND COMPACTED MEDIUM–HIGH PLASTIC CLAY TYPE SOIL
- ░ EXCAVATED AND COMPACTED MIXTURE OF SOILS
- ▩ INSITU HIGH PLASTIC CLAY TYPE SOIL
- ▒ INSITU LOW PLASTIC SILTY CLAY TYPE SOIL
- ⬭ RIP RAP
- ■ TOPSOIL
- ▨ EXCAVATED AND COMPACTED MEDIUM–HIGH PLASTIC CLAY TYPE SOIL

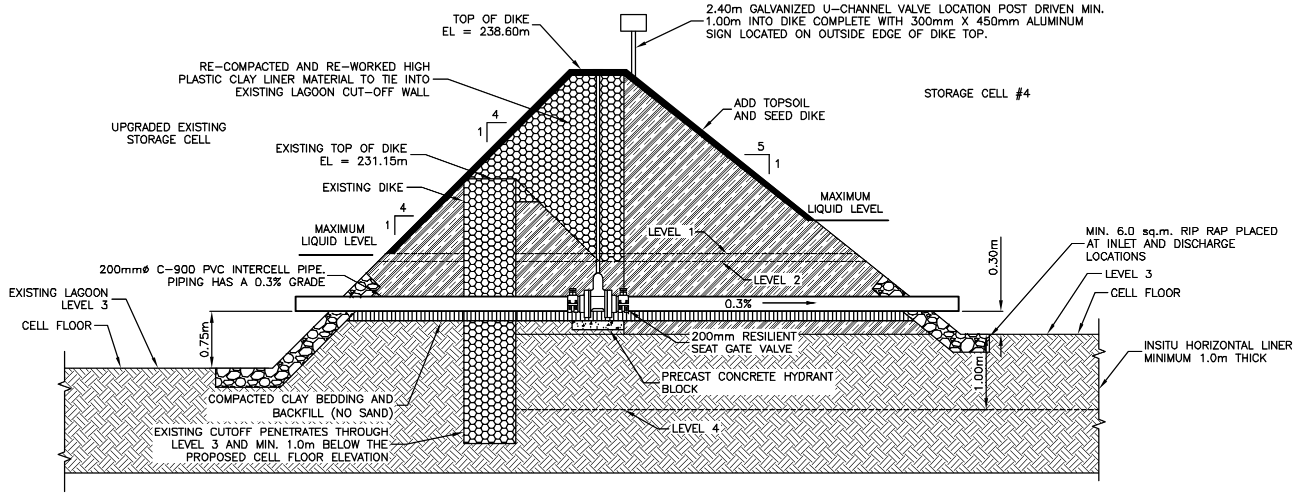
LEVEL 1 – PRE–CONSTRUCTION EXISTING GROUND ELEVATION
LEVEL 2 – ELEVATION FOLLOWING TOPSOIL REMOVAL 0.1m
LEVEL 3 – FINISHED CELL BOTTOM ELEVATION
LEVEL 4 – BOTTOM OF HORIZONTAL LINER AND CUTOFF WALL



EXISTING LAGOON PERIMETER DIKE UPGRADE TO BECOME NEW INTERCELL DIKE

1 / 3 | 5

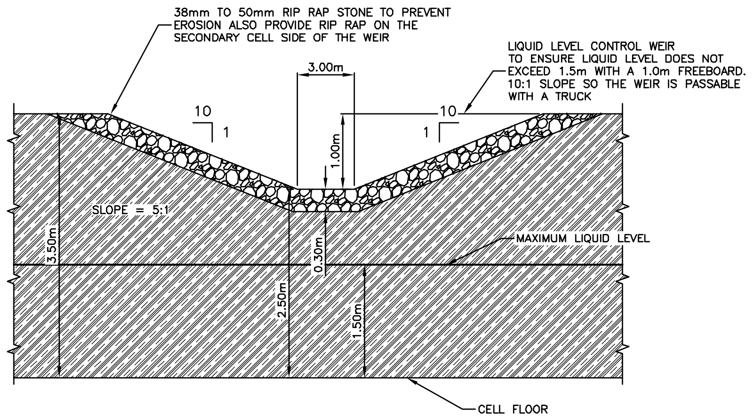
HOR = 1:200
VER = 1:50



EXISTING LAGOON PERIMETER DIKE UPGRADE TO BECOME NEW INTERCELL DIKE AT INTERCELL PIPE

2 / 3 | 5

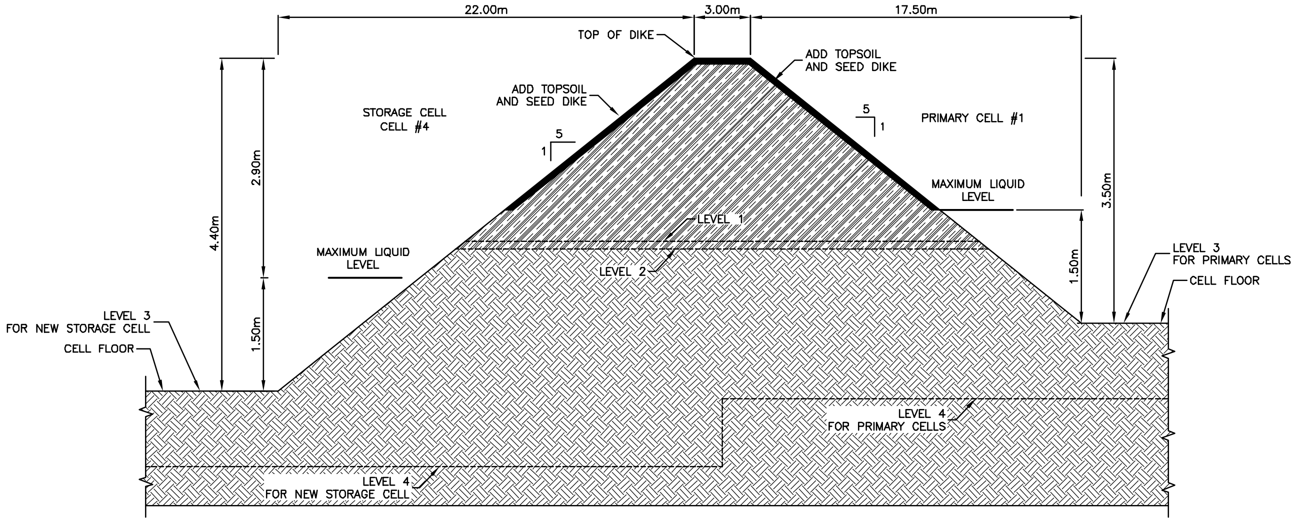
HOR = 1:200
VER = 1:50



FRONT VIEW OF LIQUID LEVEL CONTROL WEIR

3 / 3 | 5

HOR = 1:200
VER = 1:50



INTERCELL DIKE BETWEEN PRIMARY AND STORAGE CELL

4 / 3 | 5

HOR = 1:200
VER = 1:50

No.	REVISIONS	DATE	INITIALS

B.M. EL.

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ENGINEER'S SEAL
PRELIMINARY

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www.jrcc.ca
ENGINEERING EXCELLENCE SINCE 1981

CODE: B–246.12
DESIGNED BY: JC
DRAWN BY: OT
REVIEWED BY: JC

PROJECT:
RM OF BROKENHEAD
GTH LAGOON EXPANSION

TITLE:
EXISTING LAGOON DIKE UPGRADE, LIQUID LEVEL CONTROL WEIR AND INTERCELL DIKE DETAILS

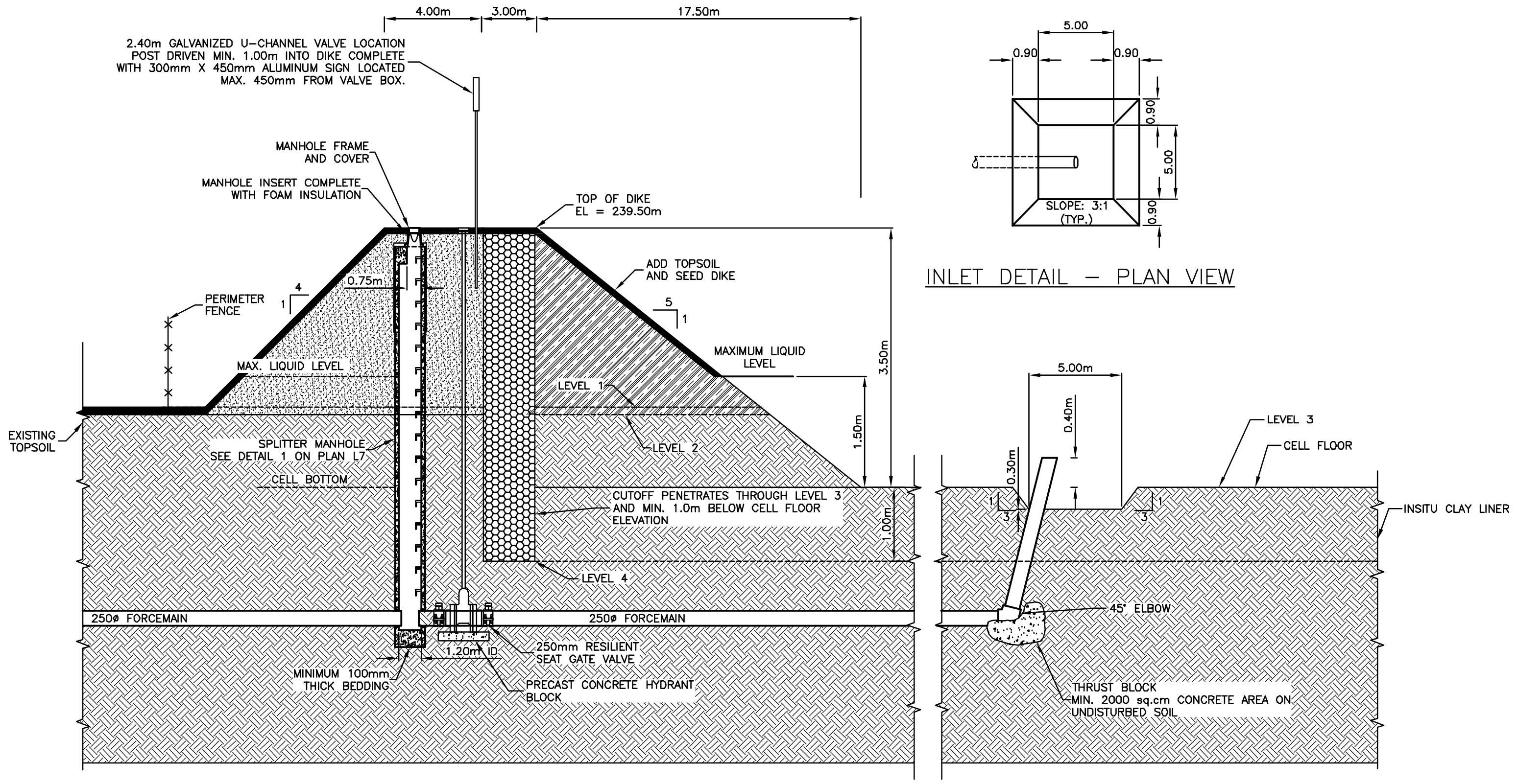
SCALE: AS NOTED
DATE: 14/12/11
PLAN: L5
SHEET: 6 of 12

Dec 19, 2014 – 2:17pm F:\200\246 Brokenhead RM\246.12 GTH Lagoon Design and Construction\04 Drawings\dwg\Pre–Design Plans\L4–L7 Lagoon Details.dwg

LEGEND:

- ▩ EXCAVATED AND COMPACTED MEDIUM–HIGH PLASTIC CLAY TYPE SOIL
- ▒ EXCAVATED AND COMPACTED MIXTURE OF SOILS
- ▧ INSITU HIGH PLASTIC CLAY TYPE SOIL
- ▨ INSITU LOW PLASTIC SILTY CLAY TYPE SOIL
- ▦ RIP RAP
- ■ TOPSOIL
- ▨ EXCAVATED AND COMPACTED MEDIUM–HIGH PLASTIC CLAY TYPE SOIL

LEVEL 1 – PRE–CONSTRUCTION EXISTING GROUND ELEVATION
LEVEL 2 – ELEVATION FOLLOWING TOPSOIL REMOVAL 0.1m
LEVEL 3 – FINISHED CELL BOTTOM ELEVATION
LEVEL 4 – BOTTOM OF HORIZONTAL LINER AND CUTOFF WALL

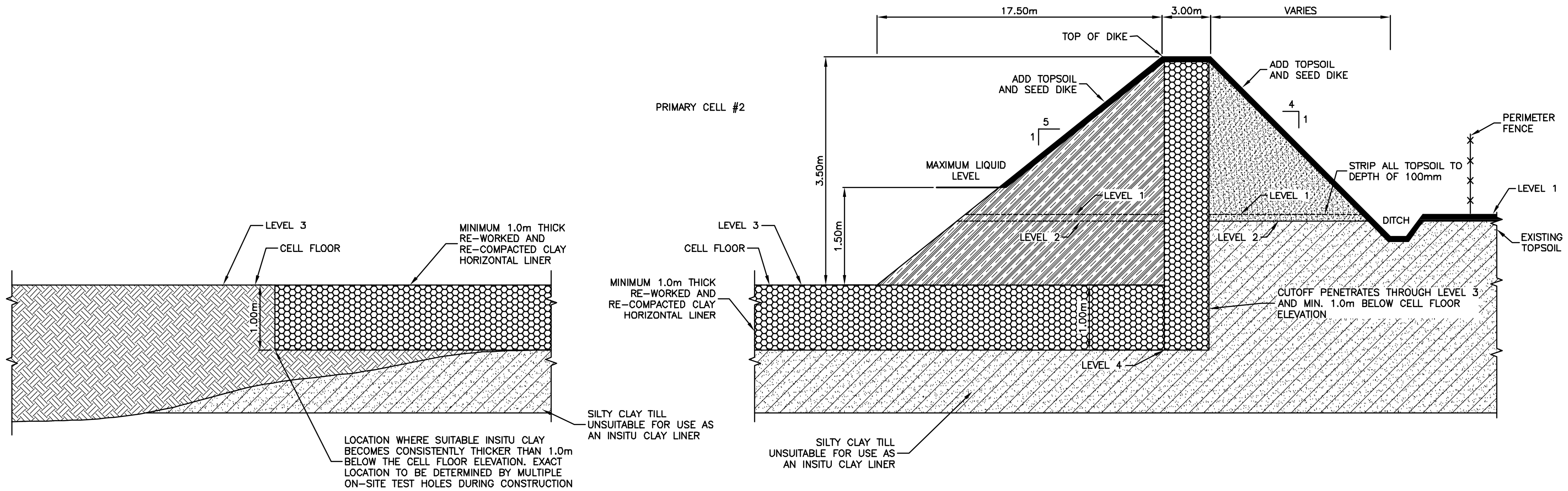


INLET DETAIL – PLAN VIEW

PERIMETER DIKE AT SPLITTER MANHOLE AND FORCEMAIN INLET

1 / 3 | 6

HOR = 1:200
VER = 1:50



PERIMETER DIKE AT TRANSITION BETWEEN RE–WORKED AND INSITU LINER

2 / 3 | 6

HOR = 1:200
VER = 1:50

No.	REVISIONS	DATE	INITIALS

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ENGINEERING EXCELLENCE SINCE 1981

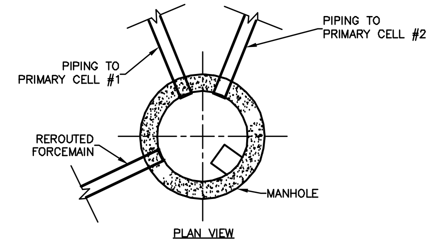
CODE: B–246.12
DESIGNED BY: JC
DRAWN BY: OT
REVIEWED BY: JC

PROJECT:
RM OF BROKENHEAD
GTH LAGOON EXPANSION

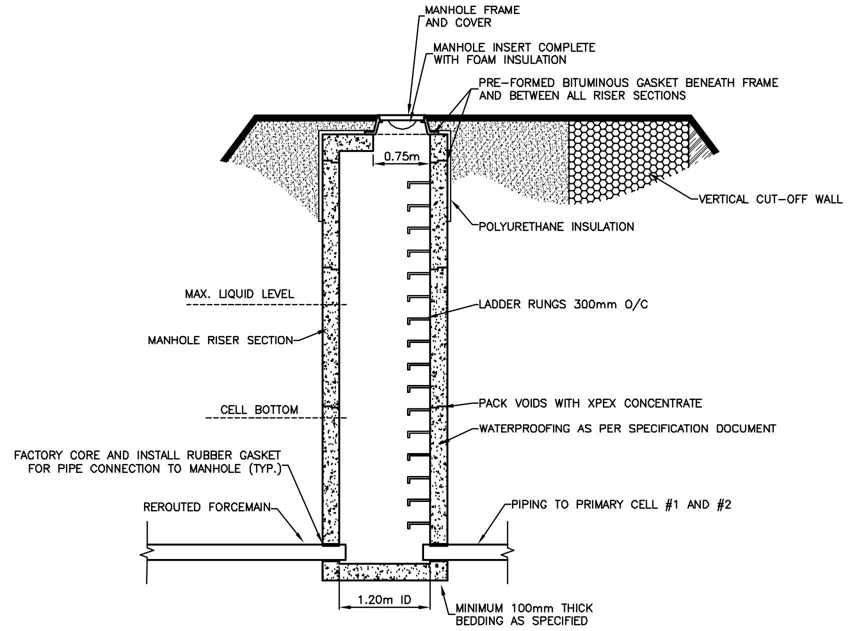
TITLE:
PERIMETER DIKE AT TRANSITION BETWEEN
RE–WORKED AND INSITU LINER AND
AT SPLITTER MANHOLE DETAILS

SCALE: AS NOTED
DATE: 14/12/11
PLAN: L6
SHEET: 7 of 12

Dec 19, 2014 – 11:03am F:\200\246 Brokenhead RM\246.12 GTH Lagoon Design and Construction\04 Drawings\dwg\Pre-Design Plans\L4–L7 Lagoon Details.dwg



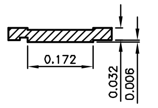
PLAN VIEW



SECTION VIEW

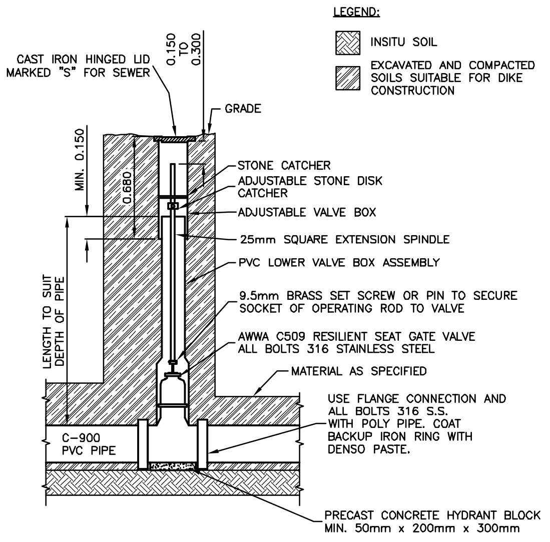
1/7 SPLITTER MANHOLE

SCALE = 1:200



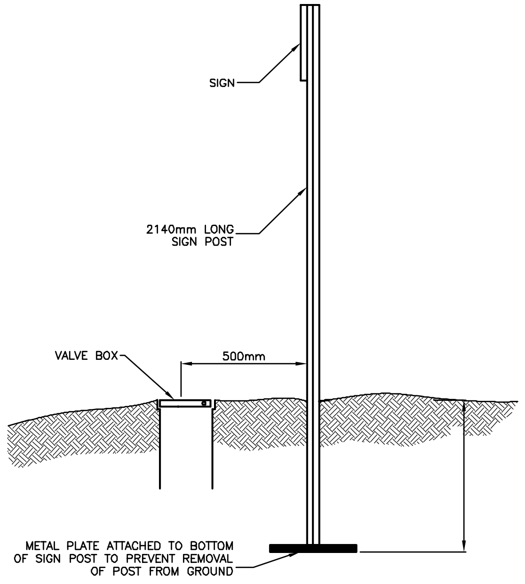
COVER DETAIL

SCALE = 1:10



2/7 TYPICAL VALVE DETAIL

SCALE = 1:25

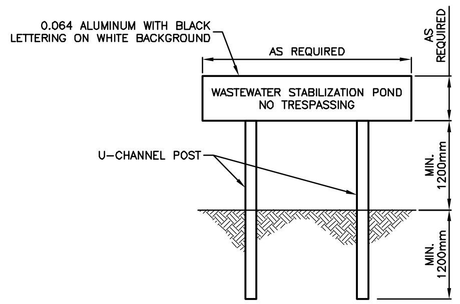


NOTES:

- MINIMUM SIGN SIZE: 300mm X 450mm
- MINIMUM POST LENGTH: 2140mm
- CROSSING MARKERS TO BE SET IN 200mmø X 1.0m CONCRETE AS PER SPECIFICATIONS

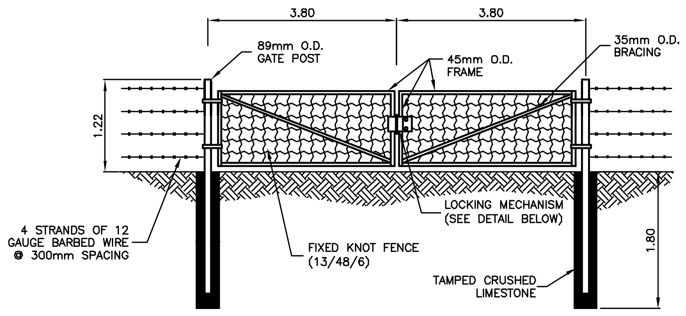
3/7 VALVE MARKER DETAIL

SCALE = 1:15



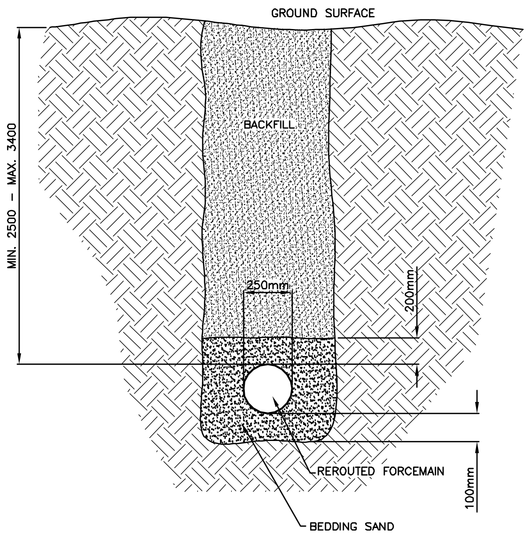
4/3 7 LAGOON SITE MARKER DETAIL

SCALE = 1:50



7/8 7 GATE DETAIL

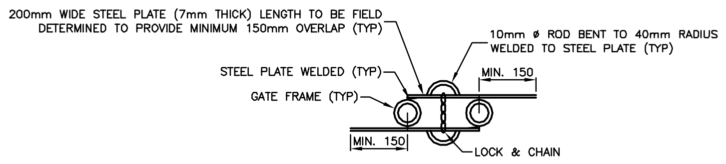
Scale = 1:50



6/7 REROUTED FORCEMAIN TRENCH PIPING DETAIL

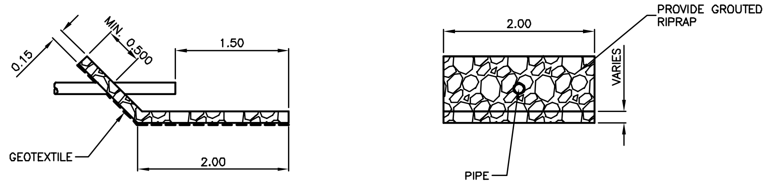
TYPICAL EXCAVATION AND CLASS "B" BEDDING

SCALE = NTS



8/7 LOCK DETAIL

SCALE = 1:10



SIDE VIEW

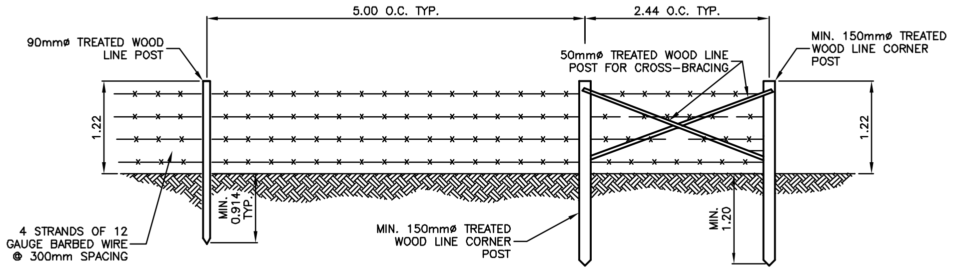
FRONT VIEW

NOTE:

-RIPRAP MATERIAL SHALL BE WELL GRADED 125mm TO 150mm HARD, DENSE, ROUNDED & DURABLE FIELD STONE.

5/7 RIPRAP DETAIL

SCALE = 1:50



NOTE:

- PROVIDE CROSS BRACING AT CORNERS POSTS IN BOTH DIRECTIONS.
- SHOWN DIAMETER REFERS TO SMALLEST END OF POST.

9/7 FENCE DETAIL

SCALE = 1:50

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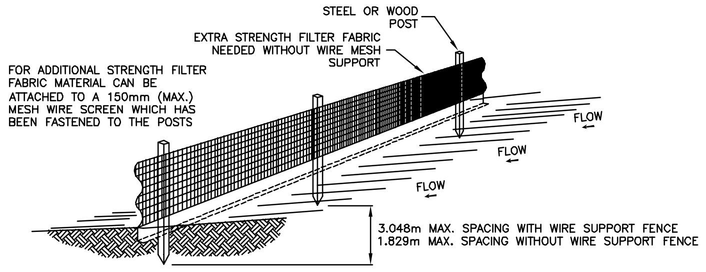
CODE: B-246.12
DESIGNED BY: JC
DRAWN BY: OT
REVIEWED BY: JC

PROJECT:
RM OF BROKENHEAD
GTH LAGOON EXPANSION

TITLE:
SPLITTER MANHOLE, VALVE, VALVE MARKER, SITE MARKER, RIP RAP, GATE, LOCK, FENCE AND FORCEMAIN TRENCH DETAILS

SCALE: AS NOTED
DATE: 14/12/11
PLAN: L7
SHEET: 8 of 12

Dec 19, 2014 - 2:19pm F:\200\246 Brokenhead RM\246.12 GTH Lagoon Design and Construction\04 Drawings\dwg\Pre-Design Plans\L4-L7 Lagoon Details.dwg

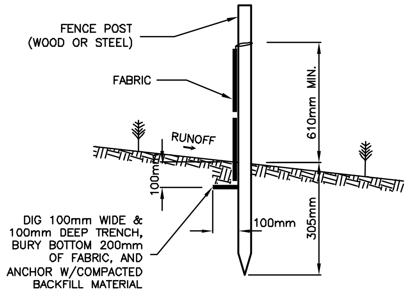


NOTES:

1. THE HEIGHT OF A SILT FENCE SHALL NOT EXCEED 914mm.
2. THE FILTER FABRIC SHALL BE PURCHASED IN A CONTINUOUS ROLL CUT TO THE LENGTH OF THE BARRIER TO AVOID THE USE OF JOINTS.
3. POSTS SHALL BE SPACED A MAXIMUM OF 3.048m APART AT THE BARRIER LOCATION AND DRIVEN SECURELY INTO THE GROUND A MINIMUM OF 300mm. WHEN EXTRA STRENGTH FABRIC IS USED WITHOUT THE WIRE SUPPORT FENCE, POST SPACING SHALL NOT EXCEED 1.829m.
4. A TRENCH SHALL BE EXCAVATED APPROXIMATELY 100mm WIDE AND 100mm DEEP ALONG THE LINE OF POSTS AND UPSLOPE FROM THE BARRIER.
5. WHEN STANDARD STRENGTH FILTER FABRIC IS USED, A WIRE MESH SUPPORT FENCE SHALL BE FASTENED SECURELY TO THE UPSLOPE SIDE OF THE POSTS USING HEAVY DUTY WIRE STAPLES AT LEAST 25mm LONG, TIE WIRES, OR HOG RINGS. THE WIRE SHALL EXTEND INTO THE TRENCH A MINIMUM OF 50mm AND SHALL NOT EXTEND MORE THAN 914mm ABOVE THE ORIGINAL GROUND SURFACE.
6. THE STANDARD STRENGTH FILTER FABRIC SHALL BE STAPLED OR WIRED TO THE FENCE, AND 200mm OF THE FABRIC SHALL BE EXTENDED INTO THE TRENCH. THE FABRIC SHALL NOT EXTEND MORE THAN 914mm ABOVE THE ORIGINAL GROUND SURFACE.
7. THE TRENCH SHALL BE BACKFILLED AND THE SOIL COMPACTED OVER THE FILTER FABRIC.
8. SILT FENCING TO BE POLYPROPYLENE SYNTHETIC FIBRE WITH ULTRAVIOLET STABILIZERS. AMOCO 1198 OR APPROVED EQUAL.
9. WOOD POSTS TO BE 38mm X 89mm (2" X 4"), POINTED AT ONE END AND FABRICATED.
10. INSTALL ALL SUPPORTING POSTS ON THE DOWN SLOPE SIDE OF THE FENCING.
11. MAINTAIN SILT FENCE THROUGHOUT CONSTRUCTION AND UNTIL REVEGETATION OCCURS.

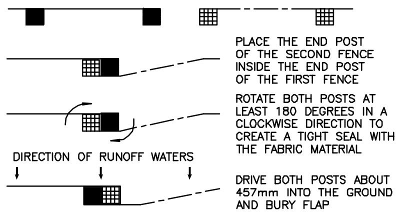
1/8 SILT FENCE DETAIL

SCALE = NTS



2/8 SILT FENCE SECTION

SCALE = NTS



3/8 ATTACHING TWO SILT FENCES

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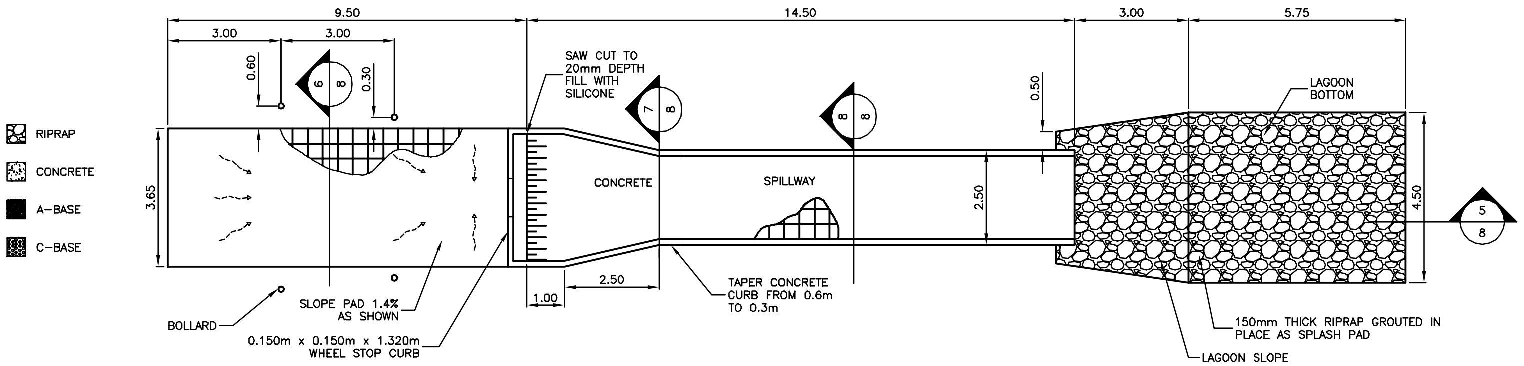


4/8 SPILLWAY PLAN VIEW

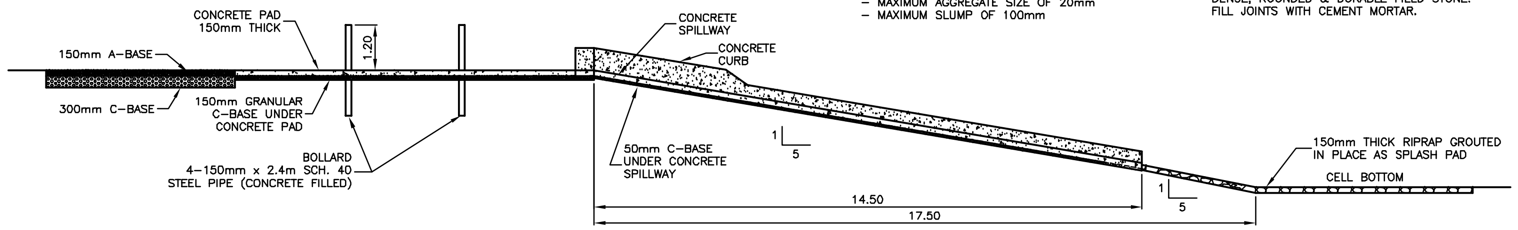
SCALE = 1:100

CONCRETE NOTE:

CONCRETE SHALL BE:
- TYPE GU PORTLAND CEMENT MINIMUM 28 DAY COMPRESSION OF 20 MPa
- 5–7% AIR CONTENT
- MAXIMUM AGGREGATE SIZE OF 20mm
- MAXIMUM SLUMP OF 100mm

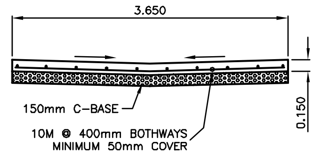
RIPRAP NOTE:

- RIPRAP MATERIAL SHALL BE WELL GRADED 125mm TO 200mm HARD, DENSE, ROUNDED & DURABLE FIELD STONE. FILL JOINTS WITH CEMENT MORTAR.



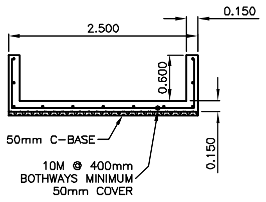
5/8 SPILLWAY SECTION

SCALE = 1:100



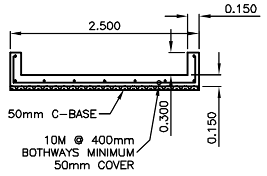
6/8 CONCRETE PAD SECTION

SCALE = 1:50



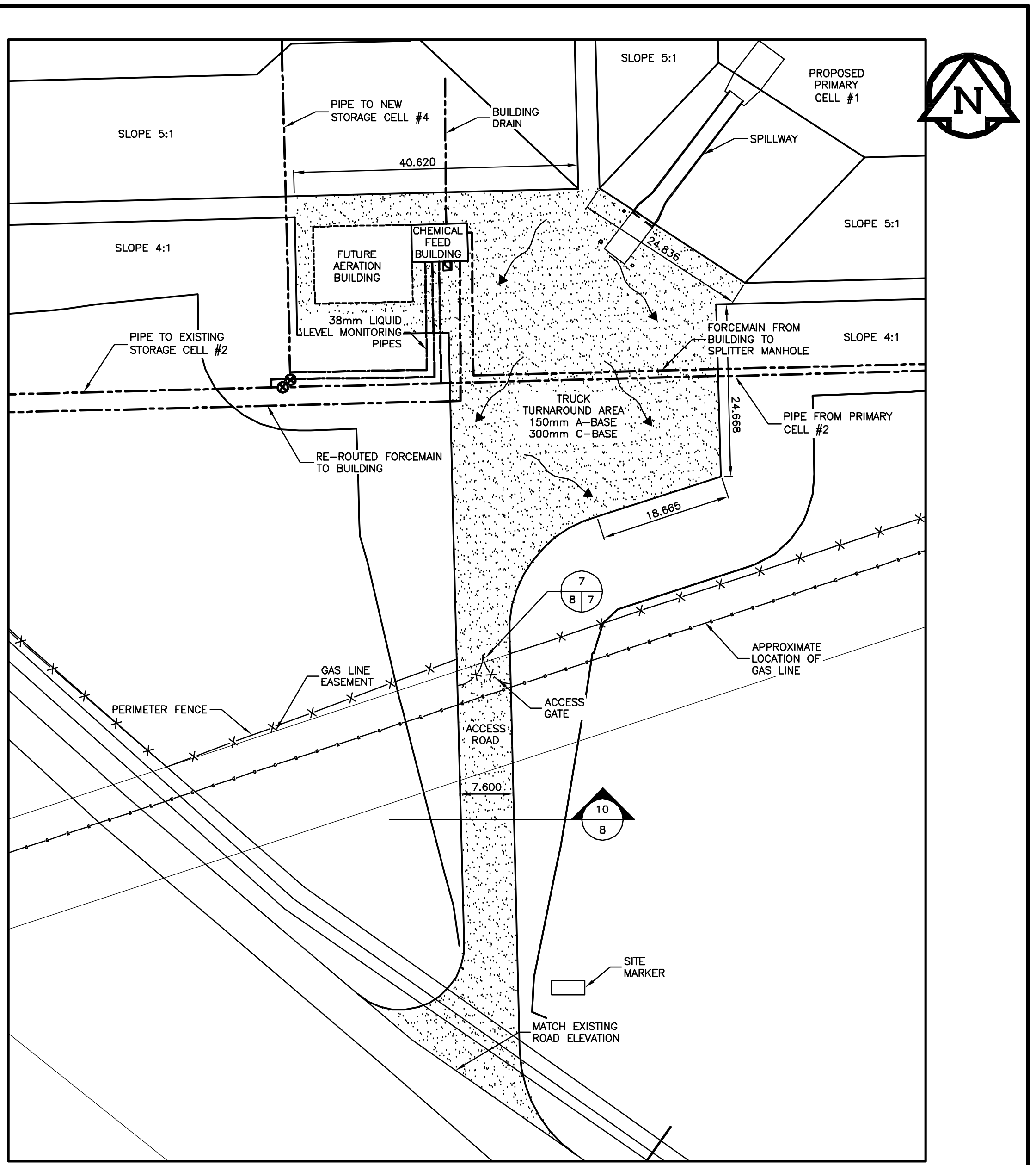
7/8 CONCRETE SPILLWAY SECTION

SCALE = 1:50



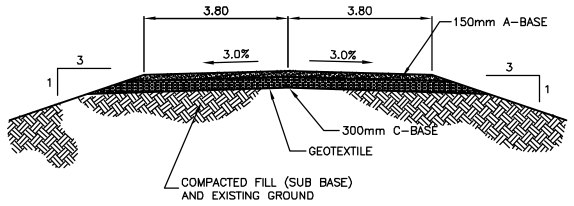
8/8 CONCRETE SPILLWAY SECTION

SCALE = 1:50



9/8 TRUCK TURNAROUND DETAIL

SCALE = 1:500



NOTE:

- TOP SOIL AND ORGANICS TO BE REMOVED FOR ROAD BED PREPARATION.

10/8 LAGOON ACCESS ROAD CROSS-SECTION

SCALE = 1:100

No.	REVISIONS	DATE	INITIALS

B.M. EL.

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ENGINEERING EXCELLENCE SINCE 1981

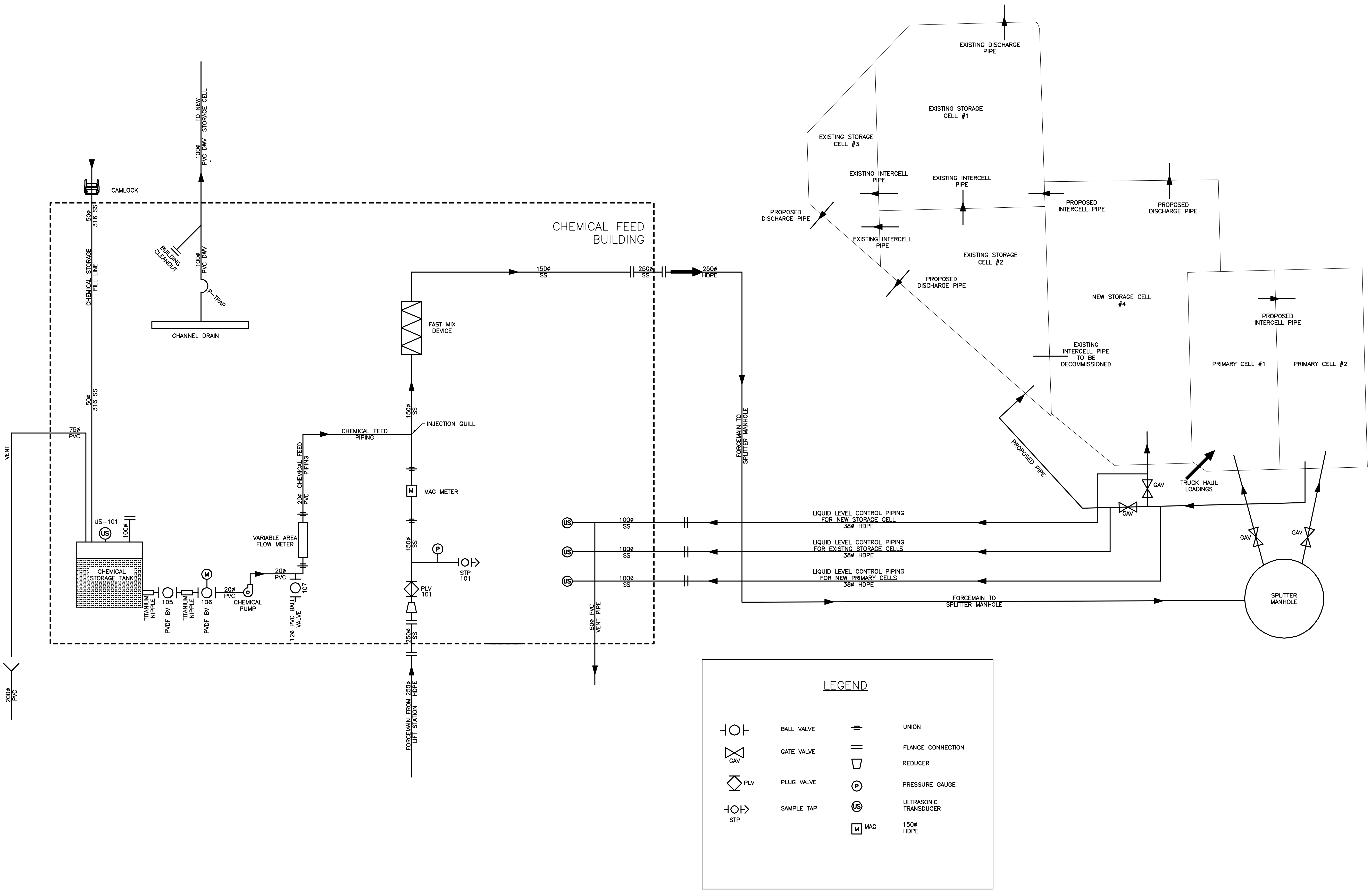
CODE: B-246.12
DESIGNED BY: JC
DRAWN BY: OT
REVIEWED BY: JC

PROJECT:
RM OF BROKENHEAD
GTH LAGOON EXPANSION

TITLE:
SILT FENCE, SPILLWAY, TRUCK TURNAROUND AND ACCESS ROAD DETAILS

SCALE: AS SHOWN
DATE: 14/12/15
PLAN: L8
SHEET: 9 of 12

Dec 15, 2014 - 2:22pm F:\320\246 Brokenhead RM\246.12 GTH Lagoon Design and Construction\04 Drawings\Dwg\Pre-Design Plans\L8 - Details.dwg



No.	REVISIONS	DATE	INITIALS

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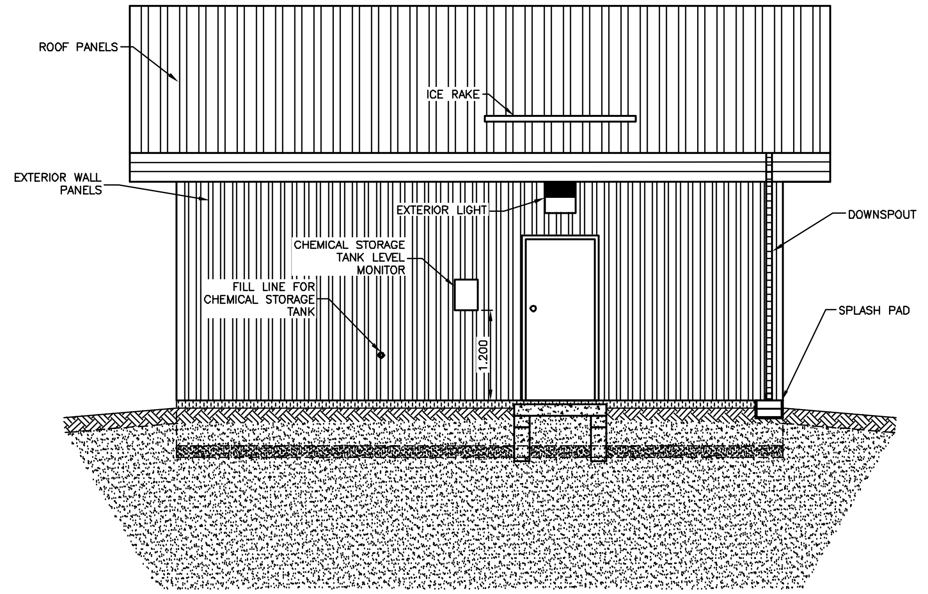
CODE: B-246.12
DESIGNED BY: BM
DRAWN BY: RH
REVIEWED BY: JC

PROJECT:
RM OF BROKENHEAD
GTH LAGOON EXPANSION

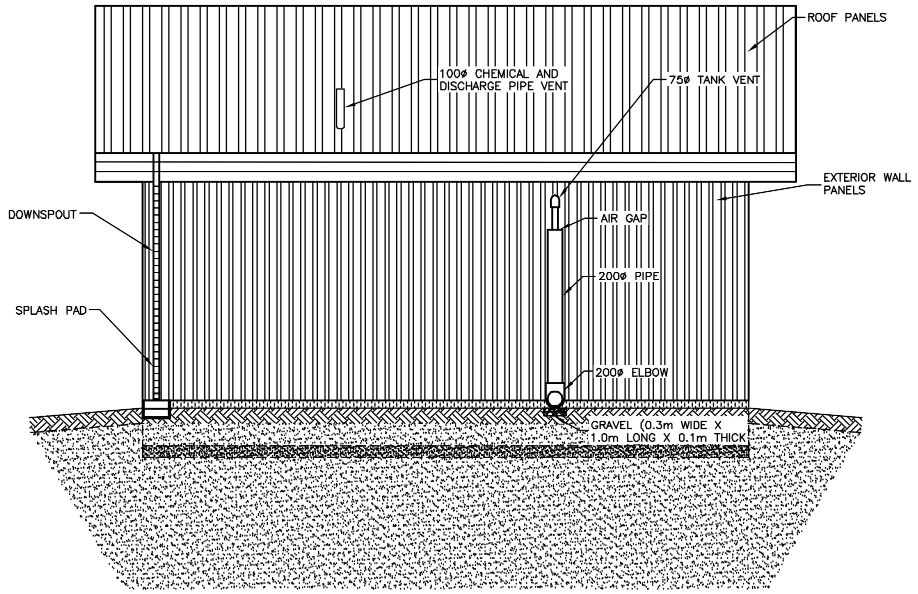
TITLE:
PROCESS AND INSTRUMENTATION DIAGRAM

SCALE: AS NOTED
DATE: 14/12/16
PLAN: P1
SHEET: 10 of 12

Dec 19, 2014 - 11:26am F:\200\246 Brokenhead RM\246.12 GTH Lagoon Design and Construction\04 Drawings\dwg\Pre-Design Plans\P1.dwg



SOUTH ELEVATION
SCALE = 1:50



NORTH ELEVATION
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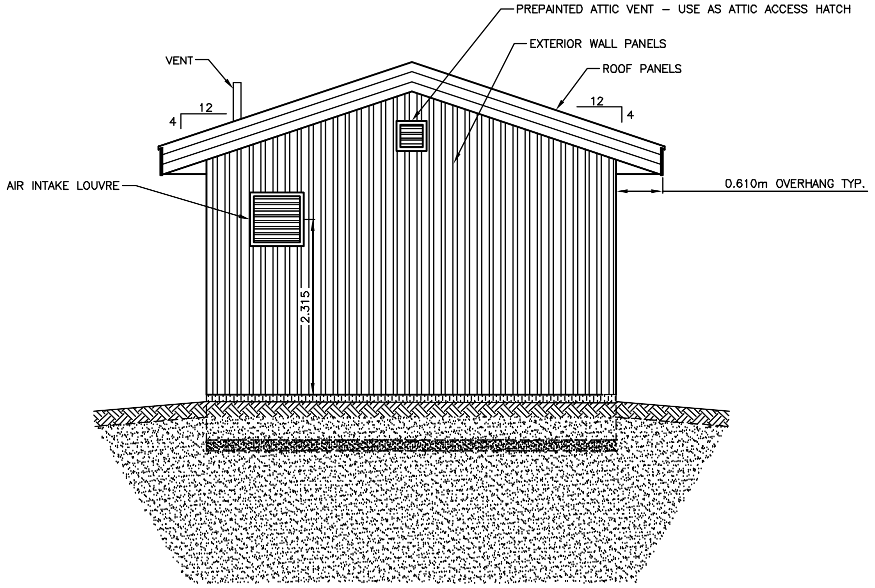

WEST ELEVATION
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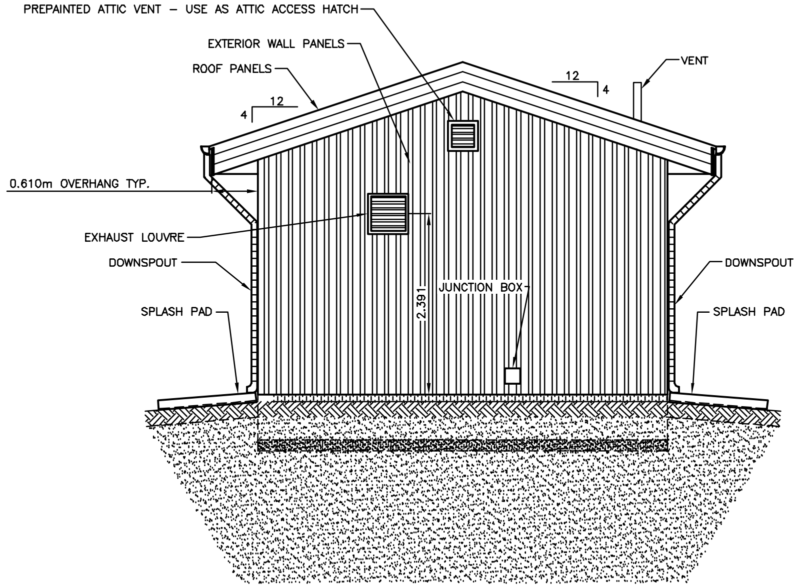

EAST ELEVATION
SCALE = 1:50

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CODE: B–246.12
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DRAWN BY: OT
REVIEWED BY: JC

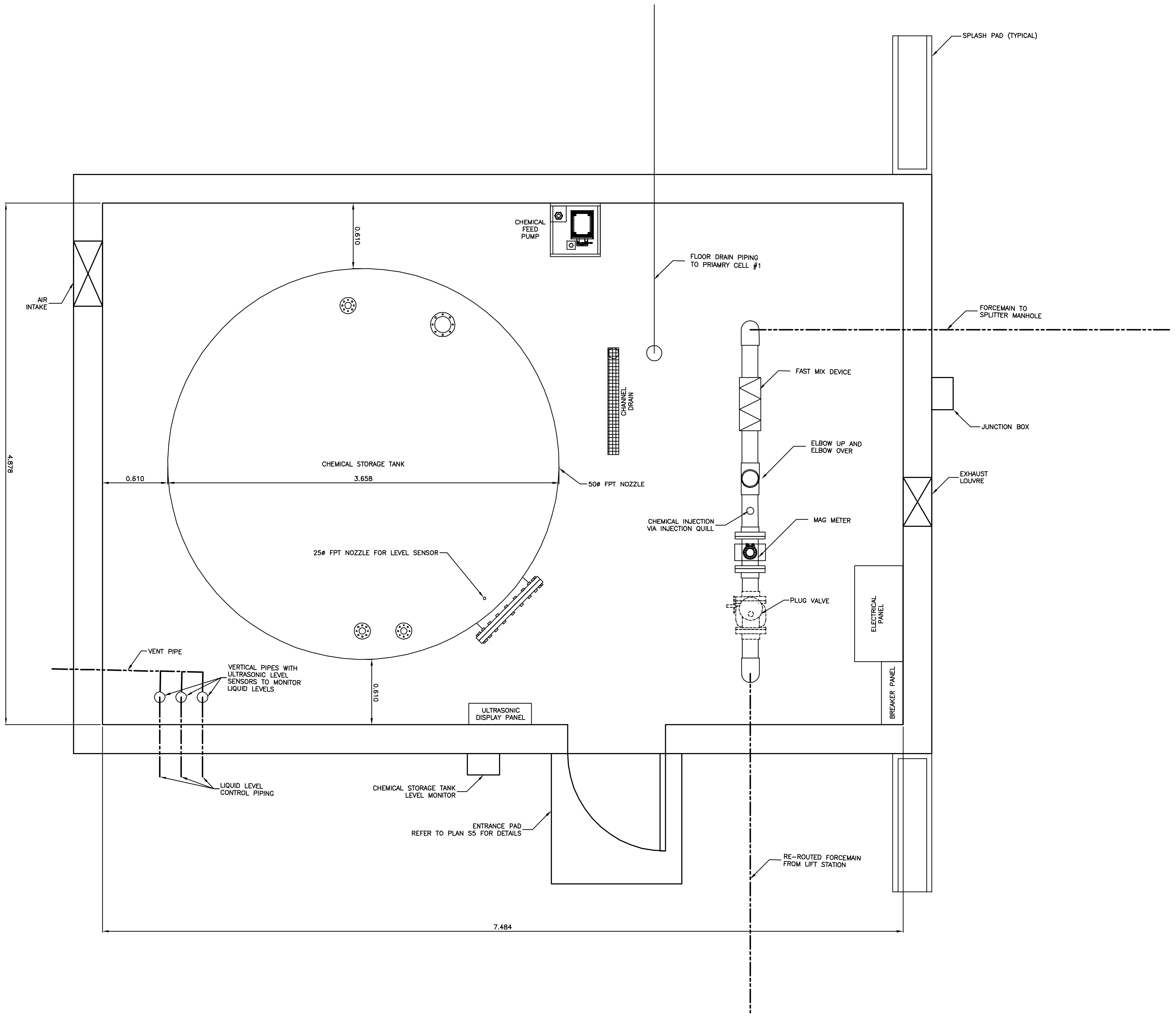
PROJECT:
RM OF BROKENHEAD
GTH LAGOON EXPANSION

TITLE:
BUILDING ELEVATIONS

SCALE: 1:50
DATE: 14/12/17
PLAN: S1
SHEET: 11 of 12

Dec 19, 2014 – 11:24am F:\300\246 Brokenhead RM\246.12 GTH Lagoon Design and Construction\04 Drawings\dwg\Pre-Design Plans\S1.dwg

Dec 19, 2014 - 11:23am F:\200\246 Brokenhead RM\246.12 GTH Lagoon Design and Construction\04 Drawings\dwg\Pre-Design Plans\S2.dwg



SCALE BAR
(IN METRES)
0.4 0 0.2 0.4 0.8 1.2 1.6 2
1:20

No.	REVISIONS	DATE	INITIALS

B.M. EL.

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CODE: B-246.12
DESIGNED BY: BM
DRAWN BY: BM
REVIEWED BY: JC

PROJECT:
RM OF BROKENHEAD
GTH LAGOON EXPANSION

TITLE:
BUILDING LAYOUT

SCALE: 1:20
DATE: 14/12/15
PLAN: S2
SHEET: 12 of 12

Appendix D

Cost Estimate

RM of BROKENHEAD - GTH LAGOON EXPANSION B-246.12

PRELIMINARY DESIGN REPORT COST ESTIMATE

Summary of Lagoon Expansion and Upgrades

		Construction
0.1	Forcemain to Chemical Feed Building	$176,700
0.2	Land Acquisition	$0
0.3	Mob/demob Insurance and Bonding	$101,700
0.4	Access Road, Truck Turnaround and Spillway	$285,600
0.5	Underground Piping	$341,200
0.6	Fencing and Gate	$46,200
0.7	Cell Excavation, Dike Construction, Ditches and Seeding	$1,604,500
0.8	Geotechnical and Density Testing During Construction	$22,200
0.9	Silt Fence, Signage and O&M Manuals	$7,000
0.10	Chemical Feed Building	$149,300
0.11	Chemical Feed Building - Electrical	$176,300
0.12	Chemical Feed Building - Mechanical	$138,300
	Construction Sub-Total:	$3,049,000
	15% Construction Contingency:	$457,400
	Total Construction:	**$3,506,400**

Extras

0.13	Rip Rap for New Dikes Only	$673,100
	Total Construction with Rip Rap:	**$4,179,500**