

**Manitoba Hydro
Kelsey Generating Station
Sewage Lagoon Project
Preliminary Design Brief**

**Manitoba Hydro
360 Portage Avenue
Winnipeg, MB R3C 0G8**

**Neegan Burnside Ltd.
106-B Scurfield Boulevard
Winnipeg MB R3Y 1G4 CANADA**

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Neegan Burnside Ltd.

Report Prepared By:



Josh Daniels, E.I.T.
Engineer in Training

Report Reviewed By:



Paul Klassen, P. Eng.
Project Engineer



Executive Summary

Neegan Burnside Ltd. (NBL) has been retained by Manitoba Hydro to provide engineering services for the design and construction of a new wastewater treatment lagoon at the Kelsey Generating Station (GS). In addition to the new lagoon itself, the project requires the installation of a new sewage lift station and forcemain and a new access road. The site is currently serviced by an SBR and a BioBrane mechanical wastewater treatment system, which will be decommissioned and removed as part of the project.

Site investigations of the potential lagoon sites were completed for this project, including topographic survey and a geotechnical investigation to determine the suitability of the soil conditions at two potential lagoon sites. Results of laboratory tests show that the in-situ clay material at both sites is suitable for use as a liner. The geotechnical engineer recommended that the top 500mm of the clay liner for the lagoon be reworked and recompacted.

Historical water and wastewater records were reviewed in order to develop wastewater generation estimates for a baseline population of 25-35 people during normal occupancy, and 120 people during maximum occupancy. A design flow during peak occupancy of 62 m³/day has been determined. This flow was used to size the lagoon for twice annual discharge during maximum occupancy, and a single annual discharge at normal occupancy.

NBL considered a facultative lagoon and an aerated SAGR lagoon to treat the wastewater produced by the Generating Station, with the facultative lagoon proving to be the more favourable option due to its lower operation and maintenance demands and seasonal discharge ability.

Two lagoon location options were considered: a North site (Option 1) and a South site (Option 2). The North site is located nearer to the developed area of the GS site, while the South site would require an access road and forcemain installation passing through a low wetland area and crossing a small creek. Both sites were found to have suitable clay soils. Both sites had moderately sloped topography, although the North site did have a slightly steeper grade from east to west. The North option was recommended due to its lower construction cost, fewer environmental concerns, and more favourable location closer to the rest of the Kelsey GS site.

Based upon the findings of the geotechnical report, risk analysis, consideration of environmental effects, safety impacts and projected project schedule, it is recommended that detailed design of the facultative lagoon be constructed at the Option 1 North site, following the conceptual design outlined in this report.

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1.0 Introduction

Neegan Burnside Ltd. (NBL) has been retained to provide engineering services for the design and construction of a new wastewater treatment lagoon at Manitoba Hydro's Kelsey Generating Station (GS). The project also requires the installation of a new sewage lift station and forcemain as well as the construction of a new access road. The two existing mechanical wastewater treatment facilities will be decommissioned and removed.

This Design Brief report will outline the existing wastewater treatment infrastructure at the GS, and present the wastewater treatment lagoon alternatives and design criteria that were considered for the project. The recommendations in this report will be used to select a preferred option to proceed to the detailed design stage.

1.1 Project Background

The Kelsey Generating Station (GS) is owned and operated by the provincial Crown Corporation of Manitoba Hydro. The GS is located on the upper arm of the Nelson River, and was the first GS to be built on the Nelson River. It is located approximately 680 km north of Winnipeg, and approximately 90 km north east of Thompson. The location of the GS is shown in Figure 1.0 of Appendix A.

The GS has a baseline staff population of approximately 25-35 people, but is capable of housing up to 120 people. That maximum population is associated with larger construction projects, such as the recent Kelsey Re-Runnering Project.

The GS town site currently relies on two mechanical wastewater treatment plants, a Sequencing Batch Reactor (SBR) and a Bio-Brane, to collectively treat the sewage. They are both south of the Service Centre and east of the 40 Man Camp, as shown in Figure 2.0 in Appendix A.

Treated water for the town site comes from the local water treatment plant, which uses a Pall Water Treatment System with chlorine disinfection, located within the Powerhouse. The system draws raw water from the Nelson River upstream of the dam.

2.0 Existing Conditions

2.1 Wastewater Generation Estimates

The Kelsey Generating Station is currently serviced by two wastewater treatment systems that treat the wastewater generated throughout the facility:

- Sequencing Batch Reactor (SBR) System (1992);
- Bio-Brane System (2012).

While both systems are in operation, the BioBrane system is used to treat most of the sewage. The SBR system is operated as required to maintain a minimum baseline flow to keep the system operational.

Historical wastewater production data has been collected by Manitoba Hydro and provided to NBL, with a total of 17 monthly data sets from February 2014 until August 2015. Manitoba Hydro also provided NBL with population records for the above noted periods, from which NBL was able to determine per capita wastewater production estimates. This information is summarized on Table 2.1.

Manitoba Hydro advised NBL during preliminary meetings that they preferred to have the lagoon sized to treat the maximum potential occupancy of 120 people, opposed to the expected average baseline staff population of approximately 25-35 people. This is because large-scale upgrade projects may bring the on-site population to the maximum level for an extended period of time, even several years.

The monthly wastewater production data shown in Table 2.1 show that the overall wastewater production does not tend to increase proportionally to the population of the GS. For example, the average effluent flow in July 2014 was 51.94 m³/day, with an average population of 98, but the average flow in July 2015 was 26.33 m³/day, with an average population of 24. While the on-site population in July 2015 was about 25% of the population in July 2014, the flow was approximately 50% as great. This is indicative of other sources of flow such as infiltration in the manholes and gravity sewer mains. MB Hydro has advised that process wastewater from the Powerhouse, including the water treatment system, does not end up in the wastewater collection system.

To establish the 'baseline' flow during normal periods, the average flow was calculated looking only at months when the population was lower than 40. This returns a value of 29 m³/day as the baseline flow.

To determine the design flow for the new wastewater treatment lagoon, it is necessary to consider the available data for high population months, notably July and August 2014. Extrapolating that data to a population of 120 people yields a design flow of approximately 59 m³/day. The design flow of the BioBrane system, which the lagoon is

intended to replace, is 60 m³/day. Adding a small additional flow to accommodate minor variations, a design flow of 62 m³/day has been selected.

Table 2.1 Kelsey Generating Station 2014-2015 Wastewater Production				
Month	Average Population	Bioclear SBR Effluent	Bio-Brane Effluent	Combined Effluent
Year 2014 (m³/day)				
January	28	-	-	-
February	28	3.78	20.01	23.79
March	27	1.62	19.25	20.27
April	36	-	-	-
May	50	5.58	23.53	28.72
June	52	-	-	-
July	98	2.24	49.70	51.94
August	90	2.80	37.63	40.43
September	52	1.88	30.85	32.73
October	30	2.14	26.69	28.83
November	25	2.13	27.78	29.91
December	25	1.96	24.53	26.49
2014 Annual Average	45	2.68	28.89	31.46
Year 2015 (m³/day)				
January	26	1.65	24.40	26.05
February	24	1.82	32.81	34.63
March	25	1.46	29.64	31.11
April	25	2.22	28.60	30.82
May	25	2.22	25.81	28.02
June	30	4.81	16.75	21.56
July	24	3.77	22.56	26.33
August	29	1.99	47.86	49.85
September	24	-	-	-
October	-	-	-	-
November	-	-	-	-
December	-	-	-	-
2015 Annual Average	26	2.49	28.55	31.05

2.2 Existing Wastewater Treatment Systems

As noted above there are two wastewater treatment systems at Kelsey which are both operational. The new facultative lagoon is intended to replace these systems, which will be decommissioned once the lagoon is in operation.

2.2.1 Sequencing Batch Reactor (SBR) System

A portion of the wastewater generated by the community is directed to an existing SBR plant, as indicated in Table 2.1. The location of this plant is shown in Figure 2.0 of Appendix A. The SBR was originally constructed in 1992. It was subsequently modified before the BioBrane sewage treatment system was installed.

An SBR system is a highly automated process that combines the principal treatment functions in a single tank. Raw wastewater enters the trash tank, a two-cell chamber, where it is collected and allowed to equalize. The wastewater first enters the primary trash tank, then flows into the secondary trash tank, with the main objective to be a primary treatment process for the removal of grit and large suspended solids. The trash tank also receives waste activated sludge that has been removed from the reactor using a submersible sludge pump.

The sewage flows from the trash tank to the transfer tank where it is stored for equalization before entering the reactor tank. The transfer tank contains two submersible centrifugal pumps that transfer the sewage through 50 mm pipes to the reactor tank, and a 100 mm PVC emergency overflow line that is connected to the effluent discharge line. The reactor tank has four stages – fill, react, settle, and decant – and receives wastewater using 50 mm diameter pipes. Biological oxidation takes place in the reactor tank, and the air required for microorganism respiration is supplied by two 5 hp rotary type blowers through PVC pipes.

The SBR has an original design capacity of 32 m³/day. A later upgrade project involved the installation of a new underground equalization tank adjacent to the original SBR tanks. With this modification, the original transfer tank was converted to a second SBR reactor basin with an additional capacity of 24 m³/day.

The SBR building is approximately 2.4m x 4.5m and is located above the tanks. A Trojan UV Disinfection unit, located in an adjacent building with dimensions approximately 6.7 m x 3.3 m, follows the system and the wastewater passes through it prior to being discharged.

2.2.2 Bio-Brane System

To increase the wastewater treatment capability of the GS to accommodate the recently completed Kelsey GS Re-Runnering Project, Manitoba Hydro purchased and installed an H2O Innovations Bio-Brane package wastewater treatment plant system. The Bio-Brane is similar to a membrane bioreactor (MBR) system, in that it uses integrated fixed-film suspended growth media as well as membrane filtration processes. Raw wastewater from the GS town site is mechanically screened for solids removal and then collected in an aerated equalization tank to allow for a uniform flow through the treatment system. The wastewater is transported through gravity through the Bio-Wheel tank, after which is

it pumped to the membrane tank where it is filtered. Air diffusers are also provided in the membrane tank which scour the membrane surface and ensure an aerobic environment for filtration.

The Bio-Brane system has a design flow of 60 m³/day, and as noted in Table 2.1 is currently being used to treat most of the wastewater produced by the GS. At the present time, both the Bio-Brane and SBR plant are in service, with the SBR Tank 1 serving as a backup to the Bio-Brane. Under typical conditions the SBR system is not required, although a small amount of sewage is diverted to that system to maintain the biological process. The design capacities of the systems are 60 m³/day (Bio-Brane) plus 32 m³/day (SBR), with an additional capacity of 24 m³/day (SBR) when required.

2.2.3 Sludge Digester Facility

The Generating Station also has a sludge disposal system, which includes a sludge digester building, digester tanks, and disposal piping and pumps. Sludge is periodically wasted from the Bio-Brane MBR tank or from the SBR reactor tanks and pumped to the sludge digester tanks. Sludge wasting is critical to the operation of both the SBR and the Bio-Brane systems to ensure that the MLSS in the system remains in a target range.

The sludge digester building is approximately 12.2 m x 5.1 m, while the sludge digester tanks are located underground, outside the building. Each tank has a volume of approximately 11.4 m³ (3000 us gal.). The sludge building consists of a Polymer Area and a Dewatering Area.

2.3 Wastewater Quality Data

While historical wastewater quality is available for effluent quality from the existing sewage treatment plants, there was no regular data available for the raw influent entering the treatment systems.

The effluent quality data indicates that the BioBrane system typically is able to achieve the required level of treatment for BOD, TSS, and Ammonia. Regular sampling data for CBOD, Phosphorus, E. coli, or Fecal Coliform was not available.

For the purpose of this report the influent characterization data was considered more relevant, as the intent of Manitoba Hydro is to decommission the SBR and BioBrane systems.

Influent data was collected as part of the commissioning process in 2013 for the BioBrane system and is included in the O&M manual for that system. These samples were taken from the transfer tank. The raw influent data is summarized below in Table 2.2.

Table 2.2
Manitoba Hydro Kelsey Generating Station
Raw Wastewater Chemical Analysis (Transfer Tank)

Parameter	Units	Sample Date											Federal/ Provincial Limit
		Sept. 4, 2013	Sept. 5, 2013	Sept. 6, 2013	Sept. 11, 2013	Sept. 12, 2013	Sept. 16, 2013	Sept. 18, 2013	Sept. 20, 2013	Sept. 23, 2013	Sept. 24, 2013	Oct. 2, 2013	
Total Hardness	mg/L	191											
Biochemical Oxygen Demand (BOD)	mg/L	254	281	269	457	330	288	115	259	450	254	98	25
Chemical Oxygen Demand (COD)	mg/L	562											
Alkalinity (Total as CaCO ₃)	mg/L	340											
Total Organic Carbon	mg/L	63.8											
pH	-	7.3											
Bicarbonate (HCO ₃)	mg/L	410											
Carbonate (CO ₃)	mg/L	<0.5											
Hydroxide (OH)	mg/L	<0.5											
Total Suspended Solids	mg/L	194	86	82	156	116	114	82	110	330	276	126	25
Nitrate plus Nitrite (N)	mg/L	0.036											
Total Nitrogen (N)	mg/L	51.8											
Ammonia-N	mg/L	42	49	38	38	42	41	27	37	31	28	27	1.25
Total Kjeldahl Nitrogen (Calc)	mg/L	51.7											
Total Phosphorus	mg/L	5.85											1.0
Total Oil and Grease	mg/L	<1.0											

NBL collected one additional raw sewage sample from the trash tank in January 2016 and submitted it for analysis. The results are summarized below in Table 2.3.

Table 2.3 Manitoba Hydro Kelsey Generating Station Raw Wastewater Chemical Analysis (Trash Tank)				
Parameter	Units	Sample Date	Typical Domestic Wastewater ¹	Federal/Provincial Guidelines Effluent Limit
		January 22, 2016		
Ammonia-N	mg/L	47.9	25	1.25
BOD	mg/L	238	190	25
Carbonaceous Biochemical Oxygen Demand (CBOD)	mg/L	176	-	25
Phosphorus	mg/L	7.80	7	1.0
Total Suspended Solids	mg/L	292	210	25

¹ Source: Metcalf & Eddy "Wastewater Engineering Treatment & Reuse v. 4" Medium Strength Untreated Domestic Wastewater, Table 3-15

The available raw influent data shows that the composition of the sewage is within the typical range for municipal sewage.

2.4 Water Treatment System

The Kelsey facility uses a Pall package water treatment system which is located in the Powerhouse structure. MB Hydro has advised that the process wastewater from the Pall system enters the powerhouse station sump and does not end up in the wastewater collection system.

The intake for the water system is located upstream of the dam.

3.0 Design Criteria

3.1 Lagoon Alternatives

The RFP issued by Manitoba Hydro requested the design of a new lagoon to treat all of the wastewater generated by the Kelsey Generating Station site, which would replace the existing SBR and BioBrane systems. The new lagoon would serve the entire GS site, and the existing mechanical treatment systems would be decommissioned and removed.

The primary motivation for the decommissioning of the mechanical treatment systems in favour of a lagoon is simplicity of operation.

The lagoon options considered were:

- New Facultative Lagoon
- New Aerated Lagoon and SAGR System.

3.1.1 New Facultative Lagoon

The preferred wastewater treatment option considered was a new facultative lagoon. Two location options were considered, based on Manitoba Hydro's preferences outlined in the RFP, which were subsequently modified in and preliminary project meetings and at the initial Chartering Site Visit.

Facultative lagoons are a popular treatment method where space is available because they have very long retention times that allow them to adequately treat large fluctuations in wastewater flow and strength without compromising effluent quality. Facultative lagoons are also popular for small remote locations because of their low operational complexity and costs. They are less susceptible to failure than other options as there are no automated parts.

Facultative lagoons typically consist of at least two cells operating in series to treat wastewater. The primary cell(s) serve to settle out solids and provide anaerobic treatment to the settled solids at the bottom of the lagoon, with wind and sun providing aerobic conditions at the surface of the lagoon. The secondary cell(s) serve to provide additional treatment to the wastewater prior to discharge of the treated effluent.

Facultative lagoons typically require the addition of an additional process such as chemical dosing in order to provide adequate nutrient removal to meet current regulations, notably for phosphorus removal.

3.1.2 New Aerated Lagoon and SAGR System

A new lagoon in combination with an aerated SAGR system was another option considered. In an aerated system oxygen is provided by mechanical aeration. The

overall land area footprint for an aerated lagoon is smaller than that of a facultative lagoon serving the same population, and the odour generated is minimized by the aeration process.

The proposed conceptual design for the aerated lagoon and SAGR option includes a non-aerated primary cell with the purpose of allowing settling of solids and facilitating sludge removal. This would be followed by an aerated cell, and then followed by flow through a Submerged Activated Growth Reactor (SAGR) bed for nutrient removal. The SAGR is a fully aerated coarse gravel bed reactor with an aggregate base, enclosed in a large cell.

An aerated system would rely on continuous effluent discharge rather than a secondary cell to hold effluent over the winter. This would require a discharge location that is protected from freezing. Risks associated with a continuous discharge system include the potential for freezing or blockage of the discharge line, and the inability to store effluent in the event that it is found not to meet effluent quality requirements for discharge.

The advantages of an aerated lagoon include the reduced land area required, and greater flexibility for reducing nutrients such as nitrogen, ammonia, and phosphorus. However, aerated lagoons have higher capital costs and annual operating and maintenance costs than facultative lagoons because they are more complex in nature.

3.1.3 Lagoon Alternative Recommendation

Due to the greater operational and maintenance costs, ongoing electrical power requirements and higher overall complexity when compared to a facultative lagoon, an aerated lagoon and SAGR system is not recommended for the Kelsey GS site.

The simplicity of the facultative lagoon option and the availability of sufficient area and suitable material makes it the preferred option.

The advantages and disadvantages of the two lagoon options are presented in greater detail below in Table 3.1.

Table 3.1 Manitoba Hydro – Kelsey Generating Station Comparison of Communal Wastewater Treatment Alternatives		
Option	Advantages	Disadvantages
Facultative Lagoon	- Simplest system with the lowest operation and maintenance requirements - Significantly lower operation and maintenance costs compared to mechanical plant or aerated SAGR lagoon - Allows for seasonal discharge so effluent requirements are less stringent - No concerns on freezing of effluent discharge route - Consistent quality of effluent	- Larger land requirement compared to SAGR system - Higher initial capital cost to implement
Aerated Lagoon/ SAGR System	- Lower land requirement compared to a facultative lagoon - Continuous discharge is acceptable based on a higher effluent quality - Lower initial capital costs	- Hydro connection and year-round access to lagoon site required - Greater complexity and greater operational and maintenance needs - Risk of freezing of effluent discharge pipe for continuous discharge - Higher annual operational cost - Higher Life Cycle Costs based on a 25 year calculation.

3.2 Provincial Design Guidelines

Manitoba Conservation and Water Stewardship (CWS) has issued Design Objectives for Wastewater Treatment Lagoons that apply to all facultative lagoons located on provincial land. Some of the key parameters specified in these guidelines are as follows:

- 227 days of storage volume (hydraulic loading);
- BOD₅ loading of 56 kg/hectare/day;
- Half of the primary cell effective volume being utilized for storage;
- The entire secondary cell effective volume used for storage;
- Minimum distance of 460 m to centre of population and 300 m to individual residences;
- Minimum top width of berm to be 3 m;
- Maximum embankment slopes:
 - Four horizontal to one vertical on inner slopes
 - Three horizontal to one vertical on outer slopes

- Minimum freeboard of 1 m;
- Minimum normal liquid depth to be 0.3 m and maximum normal liquid depth to be 1.5 m (i.e. the effective volume is the volume between these two levels);
- Soil liner to have a hydraulic conductivity of 1×10^{-7} cm/s or less, with a minimum thickness of 1 m.

3.3 Effluent Targets

The applicable wastewater effluent quality guidelines and regulations that were reviewed for this study include the following:

- Manitoba CWS Design Objectives for Wastewater Treatment Lagoons (September 2014)
- Manitoba Water Quality Standards, Objectives, and Guidelines (November 2011)

The applicability of the Provincial regulations is defined separately for each parameter, under Tier 1 (Water Quality Standards) the most generally applicable section of the Provincial Regulations.

Phosphorous: Communities with a population of 2000 or less are required to achieve 1.0 mg/L total phosphorous, or a demonstrated nutrient reduction strategy. However, the Manitoba Water Protection Act Regulation 196/2011 specifically requires that facilities owned or operated by the provincial government must have a maximum allowable concentration for phosphorous removal of 1.0 mg/L, effective January 1, 2016. Therefore, the Kelsey GS system must treat for phosphorus.

Ammonia: The provincial requirement for ammonia applies only to continuously discharging facilities, and is derived from a set of tables, using site-specific data, available within the Tier 2 Water Quality Objectives.

Nitrogen: The provincial limit of 15 mg/L total nitrogen applies to community systems servicing 10,000 or more people.

The provincial standards for Fecal Coliform, E. Coli., and Total Suspended Solids apply to all municipal wastewater effluents discharged to a water body.

The 25 mg/L limit for Biochemical Oxygen Demand (BOD) applies to all facilities without ammonia or total nitrogen limits – i.e. systems using seasonal discharge with a population below 10,000. For facilities with ammonia or total nitrogen limits, a standard of 25 mg/L Carbonaceous Biochemical Oxygen Demand is instead applicable.

The effluent quality objectives are summarized below in Table 3.1.

Table 3.2 Kelsey GS Lagoon Wastewater Effluent Quality Objectives Applicability Summary			
Parameter	Objective	Source	Notes
BOD	25 mg/L	Provincial	Applicable for Seasonal Discharge (Applicable to the Kelsey Lagoon project)
CBOD	25 mg/L	Provincial/Federal	Continuous Discharge in Provincial Regulations. Not applicable to the Kelsey Lagoon project.
TSS	25 mg/L	Provincial/Federal	Applicable to the Kelsey Lagoon project.
Fecal Coliform	200 per 100 mL	Provincial	Applicable to the Kelsey Lagoon project.
E.Coli	200 per 100 mL	Provincial	Applicable to the Kelsey Lagoon project.
Total Phosphorus	1 mg/L	Provincial	Allowance for an alternative "nutrient reduction strategy" but Provincially owned facilities must provide treatment. Applicable to the Kelsey Lagoon project.
Un-Ionized Ammonia	1.25 mg/L at 15°C +/- 1°C expressed as nitrogen (N)	Federal	Not applicable to the Kelsey Lagoon project.
Ammonia	Site Specific	Provincial	Applies to continuously discharging facilities. Not applicable to the Kelsey Lagoon project.
Nitrogen	15 mg/L total N	Provincial	Applies to new systems serving over 10,000 people. Not applicable to the Kelsey Lagoon project
Total Chlorine Residual	0.02 mg/L	Federal	Not applicable to the Kelsey Lagoon project.

4.0 Geotechnical Investigation & Lagoon Siting

A geotechnical investigation was completed by Eng-Tech Consulting Ltd. with the field work taking place January 17-22, 2016. The Geotechnical Report for the investigation is included in its entirety in Appendix B.

In addition to the geotechnical investigation completed by Eng-Tech, an earlier preliminary geotechnical investigation was completed by Manitoba Hydro. The report from that investigation is included for reference in Appendix C.

This section will present the two lagoon location options that were investigated, and will summarize the findings of the geotechnical investigation. The key objectives were to evaluate the suitability of each potential lagoon location from a geotechnical standpoint and define the geotechnical design criteria that would be required at the preferred site.

4.1 Geotechnical Report

The geotechnical report, included in Appendix B, provides recommendations from a geotechnical perspective for the lagoon construction and lift station.

The key conclusions and recommendations from the geotechnical report are as follows:

- The soil at both lagoon options is suitable for lagoon construction.
- Based on the hydraulic conductivity analysis completed, the soil at either lagoon site is suitable as a lagoon base if the top 500 mm of the liner is removed, the surface scarified and compacted, and the top 500 mm liner rebuilt with recompacted clay material. To explore the option of removing this 500 mm layer of recompacted material entirely, Eng-Tech proposed an option for 5 or more additional hydraulic conductivity tests to be completed at the preferred lagoon site.
- The berm slopes in the preliminary design, set at 4:1 inside and outside, will be adequate to avoid rotational failure according to slope stability analysis.
- The soils at the lift station will support the use of a concrete ballast slab and a raft foundation for the lift station building.

4.2 Lagoon Siting Options

4.2.1 Option 1 (Preferred Location)

Option 1 is Manitoba Hydro's preferred option, and is located west of the switchyard area on site, between the "Central" and "North" sites that had been identified in the project RFP. The location is shown on Figure 3.0 in Appendix A, while cross sections of the proposed lagoon at that site are shown in Figure 4.0.

The primary advantage of this location is that it is located nearer to the existing developed area of the site, and therefore the construction costs would be lower for this location and it will be more accessible to facility staff for operations and maintenance.

Lagoon Cell Location

This location satisfies the minimum recommended distance from the center of population as well as the minimum distance from individual residences, outlined in Manitoba CWS Design Objectives. Transport Canada Guidelines do not recommend situating a lagoon within 3.2 km of an airport reference point, which typically is the geometric center of the runway, due to the possibility of bird/airplane hazards. The Option 1 lagoon site is within approximately 2.0 km from the airport reference point, which is closer than the set-back distance as recommended by Transport Canada. Approval from regulatory agencies may be required prior to construction, and additional mitigation measures may be required.

Along the south extents of the site, there is a transmission line oriented east to west. Through discussion with MB Hydro, it was confirmed that it is necessary that the lagoon development not be within the easement for that transmission line. The width of the easement, according to information from MB Hydro, is 91.4 m (300 ft). The position of the line within the easement is not known. Therefore, it was assumed that a distance from the transmission line of 50 m on either side of the line should be followed as the transmission line easement. This line is shown on Figure 3.0. The entire lagoon berm must remain outside of these extents. This results in the lagoon location to be shifted north of the original "Central" location that was defined in the RFP.

Another challenge associated with this location is the significant elevation grade across the site, particularly from the east sloping towards the west. This was determined in the topographical survey completed in January 2016. To accommodate this slope and to control the required volume of cut and fill and the height of the berms, it is preferable to place the two lagoon cells at different elevations, with the primary cell approximately 1.5 m higher than the secondary cell. The resultant cross section of the lagoon showing the elevation difference between the two cells is shown in Figure 4.0 in Appendix A.

Based on the preliminary design for the lagoon, the cut and fill volume required for the lagoon construction is approximately 19,000 m³ of cut material and 15,000 m³ of fill material required. The cut/fill balance was completed with the object of retaining 20-25% additional cut material.

Access Road and Forcemain

The proposed forcemain route to the new site is shown on Figure 3.0. Determining the most favourable alignment for the forcemain, particularly across the open area located

between the communications tower and the switchyard, is a challenge. It is known that in the area near the proposed alignment, that concrete rubble from past construction projects was buried. Probe holes were advanced in this area to gather more information along the route. The probe holes indicate that some debris was buried to the west of the decommissioned landfill area. Therefore it is anticipated that along a segment of the forcemain route, it may be necessary to provide shallow burial for the forcemain and use cut material from the lagoon site to add additional cover.

An alternative forcemain route that was considered was to run parallel the road north of the lagoon site. The road is the access driveway to a cabin operated by a local trapper. The forcemain would then turn to the south towards the lagoon. Through discussion with MB Hydro it was determined this option was not viable due to potential concerns from the local trapper and the First Nation.

Another alternative forcemain alignment considered was to run the line across the existing maintenance yard area located to the east of the switchyard and beside the warehouse building. However, this option would place the line under a large area that will experience traffic from heavy vehicles which would be a freezing risk and would require additional insulation. This route would add significant additional length to the forcemain which increases the construction costs.

The proposed access road for the Option 1 site is shown on Figure 3.0, with cross sections shown on Figure 4.0. The road would extend west towards the lagoon from the area that is currently gravelled. The road will run over the decommissioned landfill area and will then follow the forcemain route to a truck turn-around pad adjacent to the lagoon primary cell.

Effluent Outfall

The outfall location for the proposed lagoon will be near the southwest corner of the secondary cell. A swale will be constructed to direct the treated effluent south to a natural wetland area that will serve as tertiary treatment and provide additional nutrient removal as described in Section 5.1.2. From the wetland, effluent will naturally drain to a creek to the south, which in turn drains into a larger watercourse to the west of the site.

4.2.2 Option 2 (Alternative Location)

Option 2 site was investigated in the event that Option 1 was not feasible. This site is located approximately 400 m to the south of Option 1, and is immediately to the north of a transmission line. The location is shown on Figure 5.0 in Appendix A, while cross sections of the proposed lagoon at that site are shown in Figure 6.0.

This location is further from the developed area of the site, and would therefore require a longer road and forcemain, which would increase the construction cost. Furthermore,

this road and forcemain would pass through a low area which is located between the Option 1 and Option 2 sites, and would need to cross a small creek.

Lagoon Cell Location

This location also satisfies the minimum recommended distance from the center of population as well as the minimum distance from individual residences, outlined in Manitoba CWS Design Objectives. As with Option 1, this site is within 3.2 km of the Kelsey airport, which is the set-back distance as recommended by Transport Canada. As with Option 1, approval from regulatory agencies may be required prior to construction, and additional mitigation measures may be required.

As with the Option 1 site, a transmission line is located to the south of the Option 2 site. According to historical information from MB Hydro (Right of Way Plan #5738) the easement for this line extends 24.3 m (80 ft) north of the transmission line and 21.3 m (70 ft) to the south.

The location has a slope gradient across the site, although it is less severe than at the north site. The preliminary design for this site places the primary cell elevation 0.3 m above the secondary cell.

Access Road and Forcemain

The forcemain to the Option 2 site would extend south through the open area to the west of the switchyard, and would then pass through a low and less well-drained area, including a creek crossing. The proposed route for the forcemain is shown in Figure 5.0 in Appendix A.

Through the low area, a raised section of earth would be required to support the road and the forcemain. This would require material from a borrow pit location, which would be located either adjacent to the Option 2 site, or located at the Option 1 site. Preliminary drainage calculations have been completed considering the tributary area for the stream crossing the roadway in a 50-year storm event or a spring runoff event. It has been determined that a 1.2 m diameter culvert would be adequate to prevent flooding and overtopping of the road during the spring runoff season. If Option 2 is selected this must be confirmed with more detailed runoff calculations.

An alternative forcemain route considered was to follow the west dyke located along the west shore of the forebay. However, in discussion with Manitoba Hydro at preliminary meetings it was determined that this option would involve logistical challenges related to construction work near the dyke. In addition, this forcemain route would be considerably longer, adding cost to the project.

Effluent Outfall

The effluent outfall for Option 2 would be positioned along the northern berm of the secondary cell and discharge into the low wetland area to the north of the site. As with the Option 1 site, a swale will be constructed to direct the treated effluent north to the natural wetland area, which will serve as tertiary treatment and provide additional nutrient removal. From the wetland, effluent will naturally drain to a creek to the north, which in turn drains into a larger watercourse to the west of the site.

4.2.3 Geotechnical Recommendations

A summary of the key recommendations and conclusions from the geotechnical report, from a geotechnical engineering perspective, can be found in Section **Error! Reference source not found.**

Based on the completed test hole logs from the geotechnical report and the topographic survey data, the quantity of clay material in both lagoon sites can be determined. Lagoon site option 1 (north) has a high amount of clay material therefore the recommended method for construction would be a pure cut and fill approach using in-situ clay material, and a borrow material source would not be required. Lagoon site option 2 (south) is situated in a more low-lying area on relatively flat topography and would therefore require a source of borrow material. Due to the quality of the clay material in the option 1 (north) site, this would be recommended as the source of borrow material, should the south option 2 location be selected.

The geotechnical investigation did not encounter significant groundwater seepage within the upper 4.6 m of the clay layer, and at the location of the proposed lift station ground water was encountered near an elevation of 174.5 m (6.0 m below grade). No permafrost was encountered in any of the test hole locations advanced during the geotechnical investigation between January 19 – 22, 2016.

Key geotechnical recommendations relating to the construction of the lagoon liner, lagoon embankments, all excavations and backfilling are as follows:

- Minimum compaction of 97% Maximum Dry Density (MDD)
- Maximum lift thickness for compaction of 250 mm
- Construction process for the lagoon liner:
 - Excavation of clay material to final lagoon cell elevation
 - Excavation and stockpiling of clay material to 500 mm below lagoon cell finished elevation
 - Compaction of in-situ clay material at elevation 500 mm below finished lagoon cell elevation to minimum 97% MDD.
 - Replacement, Scarification and Compaction of 500 mm clay material to finished lagoon cell base elevation. Maximum lift thickness 250 mm to 97% MDD.

- Construction process of lift station barrel slab:
 - Excavate within 100 mm below design slab elevation
 - Compact 300 mm of in-situ clay material to 97% MDD at optimum moisture content
 - Place and compact 100 mm limestone or granular “A” Base to 98% MDD at optimum moisture content
 - Place minimum 6 mil poly vapour barrier below concrete foundation slab

The geotechnical investigation recommends two options for excavation of the lift station building foundation, open excavation or drilled hole, as outlined in the Geotechnical Report.

Considering the geotechnical properties and recommendations of each lagoon site option, the lagoon option 1 site (north) is the recommended location for a facultative lagoon.

5.0 Preliminary Design

As outlined in Section 3.2, the Provincial Design Guidelines will be followed in the design of a new facultative lagoon. A facultative lagoon is the recommended option due to the lower operational and maintenance needs and the consistent treated effluent produced. The recommended location for the lagoon is Option 1, with a preliminary layout shown on Figure 3.0.

The preliminary geotechnical investigation completed by Manitoba Hydro also indicates that the existing clay material may be suitable for use as a lagoon liner at this location.

The following sections outline the preliminary design of the lagoon, forcemain, lift station, and associated works.

5.1.1 Lagoon Sizing Calculations

A facultative lagoon is typically sized according to two criteria: hydraulic loading, and BOD loading. Hydraulic loading is the capacity of the lagoon to hold the incoming sewage generated between discharge periods, and relates to the lagoon's liquid volume. BOD loading is the capacity of the lagoon to treat the biochemical oxygen demand (BOD) of the incoming sewage, and is related to the surface area of the primary treatment cell. The lagoon has been sized based on the wastewater generation projection for the GS Site of 62 m³ as outlined in Section 2.1.

The lagoon sizing calculations are based on the following assumptions, taken from available historical data and from the guidelines given in the Province of Manitoba Design Objectives for Wastewater Treatment Lagoons:

- Design population of 120 people;
- BOD₅ generation of 77 g/person/day;
- BOD₅ loading capacity of 56 kg/ha/day;
- 227-day storage volume required for secondary cell;
- Liquid depth of both lagoon cells is 1.5 m, with a minimum depth of 0.3 m to be considered when calculating storage volumes;
- Half of the primary cell effective volume being utilized for storage; and
- The entire secondary cell effective volume used for storage.

Based on these parameters the BOD₅ loading from the community is:

$$120 \text{ people} \times 77 \text{ g/person/day} = \mathbf{9.24 \text{ kg BOD}_5/\text{day}}$$

The required primary cell area is:

$$(9.24 \text{ kg BOD}_5/\text{day}) / (56 \text{ kg/ha/day}) = 0.165 \text{ ha} = \mathbf{1,650 \text{ m}^2}$$

With a maximum depth of 1.5 m and an operating depth of 1.2 m, the effective lagoon volume is 2,000 m³.

The minimum lagoon volume necessary for twice yearly discharge is:

$$62 \text{ m}^2 / \text{day} \times 227 \text{ days} = \mathbf{14,074 \text{ m}^3}$$

Half of the primary cell may be allocated for storage, so the secondary cell effective volume is:

$$14,074 \text{ m}^3 - (2,000 \text{ m}^3 / 2) = \mathbf{13,074 \text{ m}^3}$$

Thus, assuming an operating depth of 1.2 m, the minimum secondary cell area is:

$$13,074 \text{ m}^3 / 1.2 \text{ m} = \mathbf{10,895 \text{ m}^2}$$

A summary of the design volume and area for each lagoon cell is given below in Table 5.1.

Table 5.1 Kelsey GS Lagoon Lagoon Cell Design Summary					
Lagoon Cell	Volume	Surface Area	Liquid Depth	Inside Berm Slope	Outside Berm Slope
Primary Cell	2,000 m ³	1,650 m ²	1.5 m	4:1	4:1
Secondary Cell	13,100 m ³	10,900 m ²	1.5 m	4:1	4:1

5.1.2 Nutrient Removal

Facultative lagoons are typically not able to reliably provide adequate phosphorous removal. Thus, in order to meet the objective for phosphorous removal, phosphorus control with chemical dosing or natural uptake would be necessary. Chemical dosing provides nutrient removal through a precipitation method whereby the application of alum causes the formation of floc which eventually settles to the bottom of the lagoon as sludge.

Chemical dosing using a coagulant such as alum (aluminum sulphate) is commonly used to remove phosphorous. It is proposed to include an alum dosing system at the lift station which would automatically dose alum into the forcemain. In the unlikely event that phosphorus is still found to be above the 1.0 mg/L limit in the secondary cell, then additional coagulant chemical could be applied by spraying into the cell from the banks or by application from a boat with an outboard motor to facilitate mixing.

Proper personal protective equipment is required to dose chemicals, as well as a proper storage facility for the alum.

Natural uptake of phosphorous is another method to reduce phosphorous levels in the effluent, whereby ions are removed from the solution by plant uptake or soil adsorption. With the location of the outfall described in Section 4.2 recommended to be a natural wetland area, it is anticipated that additional phosphorous removal will be achieved before the effluent reaches the larger waterway. Natural nutrient removal is advantageous because it does not contribute to the accumulation of solids in the lagoon bed which require periodic removal.

Relying on natural nutrient removal is the preferred approach for the Kelsey GS Site. However, Manitoba Conservation and Water Stewardship will require that effluent samples be taken from the secondary cell discharge, and therefore will not benefit from the attenuation in the wetland area. Therefore, chemical dosing may be required at times of high occupancy. As noted above, an alum chemical dosing system will be located within the lift station so it is available as required. It is recommended that the alum dosing system be used in the first two seasons of operation prior to any experimentation with relying on the facultative lagoon process alone to control phosphorus.

5.1.3 Gravity Sewer Design

A new gravity sewer line will be connected to the existing manhole 'MH3' which discharges to the SBR trash tank. A new hole will be cored into the manhole, and the new gravity line will be connected. This line will be temporarily be plugged until the new lagoon is operational and the existing wastewater treatment facilities can be decommissioned.

One new manhole will be required to direct the gravity flow into the lift station. The gravity sewer will be 250 mm SDR 35 PVC with 50mm insulation and a minimum grade of 0.5%. The total length of pipe will be approximately 45m.

5.1.4 Lift Station Design

A new duplex sewage lift station is proposed to be located south of the existing wastewater treatment plant to receive flows from the town site. It is proposed that a 2.44 m (8 ft.) diameter prefabricated fiberglass lift station will be used for this purpose. The lift station depth of approximately 4.785 m below ground level was selected because of the hydraulic gradient of the gravity sewer service from upstream "New MH3", and to provide sufficient storage for the town site. The lift station will be designed in accordance with the requirements of the RFP and current design guidelines. The duplex control panel will be located in an adjacent electrical and controls room. The location of

the lift station is shown in Figure 3.0 in Appendix A, along with the proposed gravity sewer and forcemain routes.

Anti-Floatation Ballast

In order to resist buoyant forces, a concrete ballast will be necessary as the foundation for the sewage lift station. The adequacy of the lift station with respect to buoyant uplift forces was checked using the following assumptions:

- A minimum factor of safety of 2.0;
- The unit weight of concrete is 23.5 kN/m^3 ;
- The unit weight of soil is 18.5 kN/m^3 ;
- The water table is at the finished ground surface;
- The weight of the fibreglass barrel is negligible; and
- A square footing will be used to simplify installation in the field.

The actual inside dimension of the lift station used is 2438 mm, the thickness of the barrel wall is 13 mm, and 50 mm of insulation will cover the entire barrel. Based on these assumptions and dimensions, an overall ballast slab size of 3.464 m x 3.464 m x 0.3 m will be satisfactory.

Lift Station Building

The lift station will be contained within a heated building, to provide protection against adverse weather conditions during maintenance activities. The building will consist of a reinforced concrete slab on grade poured around the pre-packaged fiberglass barrel, complete with wood framed construction superstructure and prefinished metal roofing. All interior and exterior walls will be metal cladding. The building will have two interior rooms each with their own exterior access door, both of which will be heated. Access into the lift station will be provided in one room, while the control panel and electronic accessories will be provided in a separate room. There will be no interior door connecting each room to eliminate the need for explosion proof materials, but a window will be provided between the rooms.

The lift station will be equipped with lifting davit sockets, to facilitate the removal of pumps from the wet well using pump guide rails. The lifting davit sockets will also be compatible with the existing fall arrest system in use at the Kelsey Generating Station in the event that personnel should enter the lift station wet well.

The building will be equipped with a diesel driven backup generator, to be located adjacent to the building in a stand-alone enclosure.

Lift Station Forcemain and Pump Sizing

A 100 mm (92.2 mm ID) HDPE DR 11 forcemain will be installed to deliver the sewage flows from the lift station to the lagoon. The forcemain will be pre-insulated with 50 mm insulation, and buried to a minimum depth of 2.5 m. Where 2.5 m burial depth cannot be achieved, rigid insulation will be required in an inverted 'U' shape above the forcemain.

NBL completed an Excel-based hydraulic model of the lift station and forcemain to ensure that they will be able to handle the design flows from the town site. The sewage design flow used are as follows:

- Average daily sewage production of 62 m³/day for the town site, assumed to be concentrated over an 8-hour period.
- Total sewage flow of 6.7 L/s.
- Length of 450 m for Option 1; 875 m for Option 2.

Based on pressure loss calculations for the lift station and forcemain system, the total static and dynamic head loss at that pumping rate, for each lagoon option site would be:

- Lagoon Option 1:
 - 9.6 m
- Lagoon Option 2:
 - 12.6 m

Flygt N-type submersible sewage pumps will be used to deliver the sewage to the lagoon, with each pump expected to be in the range of 3-5 HP, depending on the location selected for the lagoon. The proposed pump model, based on the preliminary information above and lagoon Option 1 location, is a Flygt 3102 MT 3-phase Adaptive 465 5 hp submersible sewage pump. The lift station will have two submersible sewage pumps connected to a common discharge header and operating in a lead/lag sequence.

5.1.5 Access Road / Truck Dump Ramp

Year-round road access is required to the new wastewater treatment lagoon from the GS town site. Furthermore, the site must be accessible to large sewage disposal trucks when required. The access road will use the following design, with a typical cross section shown in Figure 4.0 in Appendix A.

- 250 mm Class A Base
- 350 mm Class C Base
- Non-Woven Geotextile Fabric
- Subgrade Compaction

The granular material required for the road will be transported to the site via rail, which will impact the cost of the project.

To facilitate trucked sewage disposal services, a concrete discharge ramp will be located at the lagoon. The truck dump ramp will be a 4 m x 14 m reinforced concrete slab that will allow sewage trucks to back up to the edge of the lagoon and empty their tanks, without eroding or degrading the lagoon embankments.

5.1.6 Decommissioning – Staging

The connection point to the new lift station will be at the manhole MH3. This manhole is located adjacent to the existing sewage treatment systems and currently discharges into the trash tank of the SBR.

The existing wastewater treatment systems must remain in service during the construction of the new lagoon and lift station. Once the new systems are in service, the mechanical wastewater treatment systems will be decommissioned. The buildings and tankage will be removed from the site. However, the sludge dewatering building will remain in place and may be repurposed.

A layout of the existing system with notes for the decommissioning is included in Figure 8.0 in Appendix A.

6.0 Economic Analysis

Class 'C' cost estimates have been prepared for each of the lagoon locations considered, and are included in Table G-1.0 & G-2.0 in Appendix G. The cost estimates include construction costs, with a 10% contingency, plus an estimate of operation and maintenance costs for the system. A summary of the costs for each Option are shown below in Table 6.1.

The cost estimates do not include room and board as they are based on the assumption this will be covered by Manitoba Hydro and be outside the Contractor's tendered pricing.

The cost estimates also do not include tree clearing work as that will be included in a separate contract. However, costs for grubbing of the lagoon site are included.

Operation and maintenance costs for each site include costs associated with forcemain maintenance, operator labour, training and development, lagoon maintenance and repair, laboratory sampling and analysis, effluent outfall maintenance, and access road maintenance and repair.

As shown in Table 6.1, the Option 2 South Site is expected to have a higher capital cost and operation and maintenance costs than the Option 1 North Site. This is attributed to the larger separation distance from the Generating Station Site, requiring additional lengths of forcemain piping (425 m difference) and access road construction (400 m difference). The Option 2 route for the forcemain piping and access road would also traverse through a low-lying wetland area, this would require additional fill material to achieve an adequate road bed elevation, as well as a large culvert crossing at the creek in this area. Placement of forcemain piping in a wetland area with a high groundwater table elevation would also have higher capital costs to ensure adequate cover over the forcemain piping and to allow for higher contractor effort for pipe installation.

Based on these cost estimates, the more economical option is Lagoon Option 1, as shown below in Table 6.1.

Table 6.1 Kelsey GS Lagoon Cost Estimate Summary		
Option	Capital Cost	Annual O&M Cost
Option 1 (North Site)		
Option 2 (South Site)		

Note: As per discussions with Manitoba Hydro and Manitoba Conservation and Water Stewardship, cost estimates not included for EAP Submission.

7.0 Site Operation and Maintenance Needs

Facultative lagoons are typically preferred to treat wastewater for remote locations because of their low operational and maintenance needs, simplicity of construction and operation, and their ability to produce a consistent quality of treated effluent. The ongoing operation and maintenance needs for the proposed wastewater treatment lagoon at the Kelsey GS Site will include:

- Periodic access road grading, resurfacing, and maintaining accessibility (snow clearing);
- Lift station maintenance including maintaining pump and forcemain operation;
- Maintenance of vegetation on lagoon berms;
- Periodic inspections of the berms for slope stability;
- Maintenance of discharge swale including removal of vegetation, removal of accumulated solids/debris, and maintaining proper drainage grade;
- Maintenance of lagoon inter-cell piping including inspection of level control weir and routine exercising of valves to ensure functionality; and
- Maintenance of lagoon perimeter fencing.

8.0 Risk Analysis

With any construction project of this magnitude, there is an inherent degree of risk associated with all processes throughout the project. NBL has analyzed and considered the risks associated with the lagoon development, including risks particular to each of the lagoon locations considered (Option 1 and Option 2) shown in Table 8.1.

Table 8.1 Manitoba Hydro – Kelsey Generating Station Risk Analysis For Facultative Lagoon Location Options		
Risk Area	Potential Risk	Mitigation Method
Environment Act Proposal Submission	Long time for the approval process and issuance of Environment Act License could result in construction project initiation delays.	Submit EAP immediately after completion. Minimize potential for corrections on EAP by thorough design practices.
Lagoon Operation (Either Location)	Within recommended separation distance to airport runway (less than 3.2 km). Separation distance is recommended to prevent bird/aircraft encounters.	Provide a mitigation plan and preventative measures (such as screen above lagoon cells)
Effluent Quality	At the desired time for discharge, effluent is found to not meet the provincial regulations	Proper sizing of the lagoon and flows within the anticipated range, and use of the alum dosing system anticipated to prevent this risk
Forcemain Construction	Unexpected adverse condition such as bedrock or excessive buried rubble cause delays and additional costs	Review probe hole information and ensure areas with suspected rubble are identified in the contract and that provisional items such as adding fill for mounding is included in the contract.
Lagoon Construction	- Over-excavation of clay material increasing hydraulic conductivity and reducing compaction of liner - Delay caused by unexpected geotechnical issues - Fuel or hazardous material spills causing contamination - Environmental impacts from construction activity including decommissioning and sludge handling	- Adequate geotechnical information and monitoring of excavation by Surveyor during construction period - Follow geotechnical engineer's recommendations and include adequate provisional items in contract. - Provide mitigation and monitoring measures in Construction Specifications - Provide environmental specifications in contract and inspection to ensure compliance.

Table 8.1 Manitoba Hydro – Kelsey Generating Station Risk Analysis For Facultative Lagoon Location Options		
Risk Area	Potential Risk	Mitigation Method
Option 1 Location (North)	• Closer separation distance to Generating Station town site could allow unauthorized entry into lagoon site • Location is not favourable to Tataskweyak Cree Nation members who seasonally occupy a nearby cabin	• Provide a fence complete with padlocks and signage preventing authorized entry • Ensure adequate consultation with these stakeholders prior to construction
Option 2 Location (South)	• Larger distance from existing sewage collection system and longer construction duration • Foremain and access road through wetland with high water table, could have unstable trench • Access road through wetland area could be subject to overtopping	• Efficient scheduling and design completion • Provide adequate fill material to meet elevation requirements for road; Provide dewatering methods, safe excavation techniques and adequate cover for forcemain pipe • Ensure detailed runoff calculations are completed in detailed design and a conservatively sized culvert(s) is used

9.0 Analysis of Environmental and Safety Impacts

The potential environmental and safety impacts associated with the construction and operation of the wastewater treatment lagoon are discussed in the following section. An advantage of using a facultative lagoon, as opposed to an aerated lagoon (SAGR) system or the existing mechanical wastewater treatment plants, is the low operation and maintenance requirements and consistent quality of effluent produced. For both potential lagoon site options, the environmental and safety impacts are expected to be lower than the existing systems in place, and are outlined below.

9.1 Environmental Effects

The environmental effects associated with the construction of a new facultative lagoon are primarily constant for each lagoon site option. In general, constructing a new lagoon at either site requires clearing of trees and existing vegetation that can result in loss of habitat for wildlife and the potential for erosional loss of soil. The potential for these effects has been analyzed as part of the Environment Act Proposal and has been deemed to be minor and mitigable.

Contamination of surface water during construction and operation processes, such as a fuel oil spill, could result in damage to fish habitats and the surface water supply, with the risk associated with the construction of a new lagoon at both site options. These environmental effects are expected to be minimal and will be reduced and mitigated through safe construction practices and requirements in the Construction Documents.

9.1.1 Lagoon Site Option 1

Environmental effects that are specific to the Option 1 (north) site are primarily related to the proximity of the new lagoon site to the Generating Station town site. The close proximity to the existing wastewater collection infrastructure is also one reason why this site is recommended, as it reduces amount of forcemain piping, access road construction, and borrow material required.

In contrast to this, the closer proximity to the town site also brings a higher likelihood of foul odours in the town site. This is not anticipated to be a concern or negative effect because minimum separation distances as outlined by the Province of Manitoba Lagoon Design Objectives have still been achieved, and the lagoon was sized according to Manitoba Conservation and Water Stewardship guidelines.

9.1.2 Lagoon Site Option 2

The placement of the new wastewater treatment lagoon at the Option 2 site is expected to have a larger effect on the environment than the selection of lagoon site Option 1. While this site would have the same amount of clearing required for the placement of the

lagoon, additional tree clearing would be required for the borrow pit location and the proposed access road, as shown in Figure 5.0 of Appendix A. This would result in additional loss of habitat and potential for erosional loss of soil material. In addition, the proposed route for the forcemain and access road would be through the wetland area south of the Generating Station town site. The construction of the access road would require fill material to achieve the required elevation that could alter the natural drainage course and impact animals that inhabit the wetland area.

9.2 Safety Impacts

The simplicity of operating a facultative lagoon means that there are typically less safety impacts or concerns when compared against an aerated (SAGR) lagoon or a mechanical wastewater treatment plant like the ones currently used at the Kelsey Generating Station. The project requires the installation of a new sewage lift station near the town site, regardless of the lagoon location selected. This would require excavation to an approximate depth of 5.5 m below grade, where Construction Specifications will be produced to outline safety requirements during construction and excavation. The lift station building will be equipped with a fence surrounding the exterior generator unit, as well as railings and fall arrest systems inside of the wet well room. An interior platform in the lift station barrel will also be complete with a railing system.

All process equipment will be suitable for lockout/tag out procedures to reduce the safety risks during maintenance activities. In addition, all new or altered electrical works will have an Arc Flash study done to identify the level of PPE required for personnel.

At either lagoon site, there is a risk of minor safety impacts from construction processes. Regardless of the location of the lagoon, a chain link fence completed with locked access gate and warning signs would be provided. This will reduce the likelihood of animals in the lagoon area, as well as unauthorized personnel.

With regards to the lagoon Option 1 location (North), the close proximity to the town site makes it more likely that the town site is affected during construction processes by equipment activity.

Both lagoon location options are approximately 2.0 km from the Kelsey Airport Runway, which is within the recommended separation distance of 3.2 km advised by Transport Canada. With the lagoon at this distance to the airport runway, there is a potential for bird-airplane collision. Mitigation measures and a management plan may be required to prevent such occurrences.

10.0 Scheduling

The anticipated construction schedule for each lagoon site is expected to be a comparable duration, with the Option Site 2 expected to require more time due to the longer lengths of road and forcemain to service the site.

The initiation of the construction contract for each lagoon site option is dependent on the approval of the Environment Act Proposal and issuance of an Environment Act License, by Manitoba Conservation and Water Stewardship. This is understood to require between 4 – 12 months and must be completed prior to beginning any construction activities.

With respect to the construction period, some key constraints for scheduling purposes are expected to be:

- Approval of the EAP and other regulatory approvals.
- Tree clearing of the site prior to March 31.
- Transportation of equipment to site via rail and air.
- Limited construction window due to harsh northern climate.

The proposed schedule associated with each option is presented below.

10.1 Lagoon Site Option 1 – Proposed Schedule

1. Submission of Preliminary Design Report – May 2016
2. Submission of Environment Act Proposal – May 2016
3. Acceptance of Final Detailed Design – August 2016
4. Issuance of Environment Act License – December 2016
5. Construction Contract Tender Period – February 2017
6. Construction Contract Project Award – February 2017
7. Construction Period – April 2017 – October 2017
8. Commissioning and Approval of Liner Properties – October 2017
9. End of Warranty Period and Final Inspection – November 2018

10.2 Lagoon Site Option 2 – Proposed Schedule

1. Submission of Preliminary Design Report – May 2016
2. Submission of Environment Act Proposal – July 2016
3. Acceptance of Final Detailed Design – October 2016
4. Issuance of Environment Act License – March 2017
5. Construction Contract Tender Period – April 2017
6. Construction Contract Project Award – April 2017
7. Construction Period – May 2017 – November 2017
8. Commissioning and Approval of Liner Properties – November 2017
9. End of Warranty Period and Final Inspection – December 2018

11.0 Recommendations

This section will summarize the recommendations provided in the various sections of this report, to be used in the preparation of Detailed Design and Contract Documents. Recommendations are based on an engineering perspective, considering the risk analysis, environmental effects, safety impacts, costs, and Generating Station site characteristics presented in this report.

11.1 Review of Advantages & Disadvantages

Two potential wastewater treatment processes were reviewed including a facultative lagoon and an aerated lagoon with a SAGR system to replace the existing mechanical wastewater treatment systems that are currently in use at the Kelsey Generating Station. Table 3.1 summarizes the advantages and disadvantages associated with facultative and aerated lagoons that were considered for this project. The remote nature of the site was considered, which emphasized the importance of having a reliable treatment system with low operation and maintenance demands. A facultative lagoon was found to be the recommended wastewater treatment method, because fewer potential risks have been identified and it is anticipated to have a lower life cycle cost based on the economic analysis presented in this report.

11.2 Recommended Lagoon Location

The advantages and disadvantages associated with the two lagoon location options are summarized below in Table 11.1. The differences between the two sites have an impact on the cost of the project. The cost estimates for each option are presented in Section 6.0, with detailed cost estimates in Appendix G.

Table 11.1 Kelsey GS Lagoon Lagoon Location Comparison		
Proposed Site	Advantages	Disadvantages
Option 1 (North Site)	• Closer to developed area • Lower construction cost • Location preferred by Manitoba Hydro • Shorter anticipated construction schedule	• Steeper topography • Closer to area used by local trapper
Option 2 (South Site)	• Less steep topography	• Further from developed area • Road and forcemain must cross wetland area and creek • Higher construction cost

The recommended location for a new facultative lagoon is the central site identified in the preliminary geotechnical investigation, referred to as Option 1.

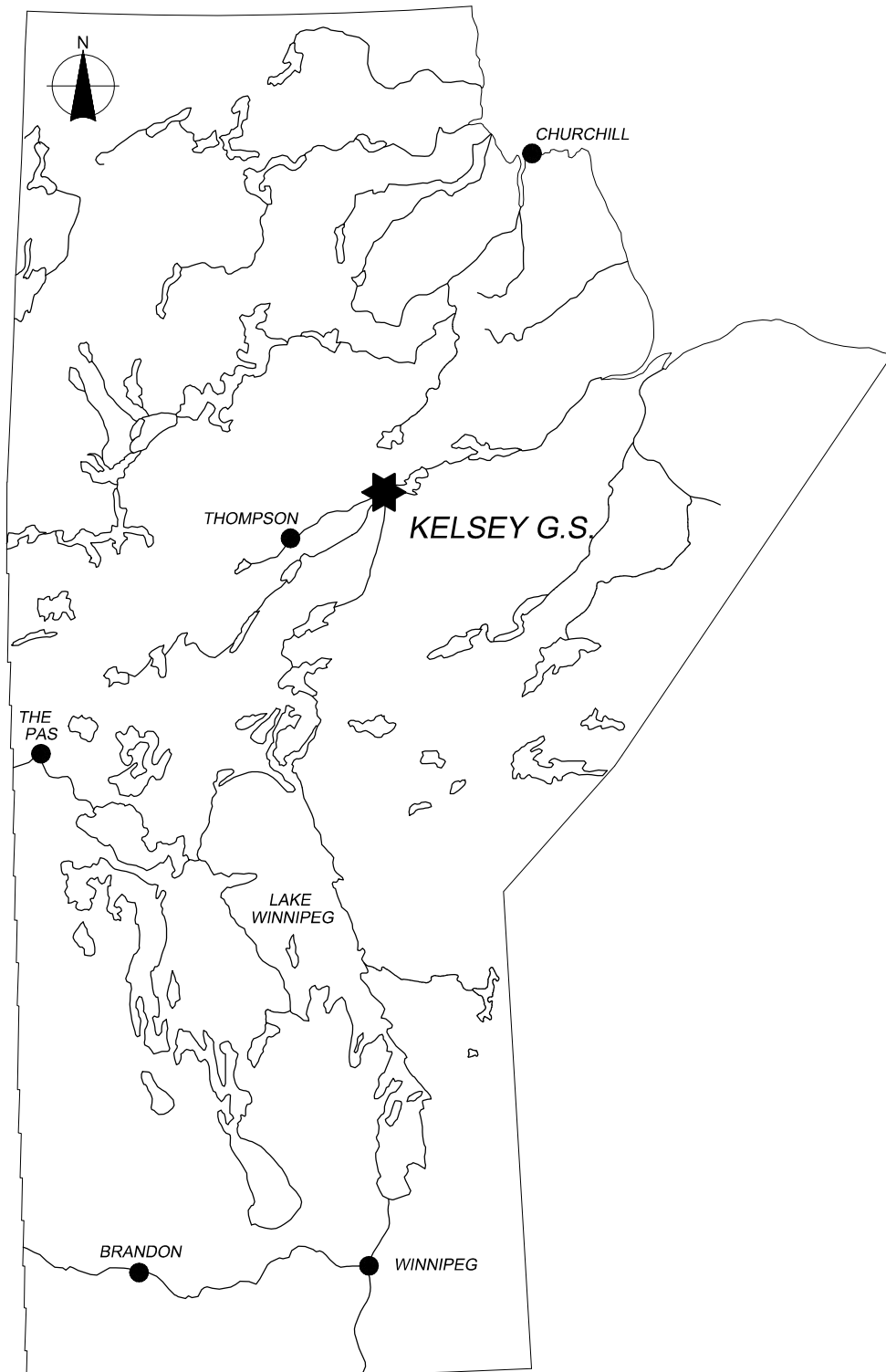
11.3 Recommended Lagoon Design

The recommended lagoon design is a new facultative lagoon at the Option 1 North site, as described in this report. To satisfy the design intent outlined in this report, the following design parameters will be used:

- Underground Servicing:
 - 45 m SDR 35 PVC deep bury Gravity Sewermain complete with 1 new manhole and 50 mm factory applied insulation, connection to existing manhole
 - 450 m DR11 HDPE deep bury Sewage Forcemain complete with 50 mm factory applied insulation and necessary valves and fittings
- Pre-Packaged Fiberglass Sewage Lift Station:
 - 2.4 m Diameter
 - Stainless steel process piping
 - 5 hp submersible sewage pumps (lead/lag operation) complete with factory programmed electrical and controls
 - 2 room building complete with separated wet well room and electrical/chemical dosing room
 - Chemical dosing system with metering pumps suitable for alum dosing directly into sewage forcemain
 - Exterior self-enclosed diesel generator
- 200 m granular access road
 - 250 mm base course
 - 350 mm sub-base course
 - Non-woven geotextile fabric
- Lagoon:
 - Primary Cell:
 - Volume = 2,000 m³
 - Cell Base Elevation = 179.8 m
 - Secondary Cell:
 - Volume = 13,100 m³
 - Cell Base Elevation = 178.3 m
 - Inside and outside slopes to be 4:1
 - Top 500 mm of in-situ clay liner to be remolded as per geotechnical recommendations (Section 4.2.3)
- Effluent discharge to existing wetland area south of proposed lagoon site

Appendix A

Figures



NEEGAN BURNSIDE

Figure Title

**KELSEY GENERATING STATION NEW
LAGOON PRELIMINARY DESIGN
GENERATING STATION LOCATION MAP**

Client

MANITOBA HYDRO

Drawn

JJ

Checked

PK

Date

2016/02/18

Scale

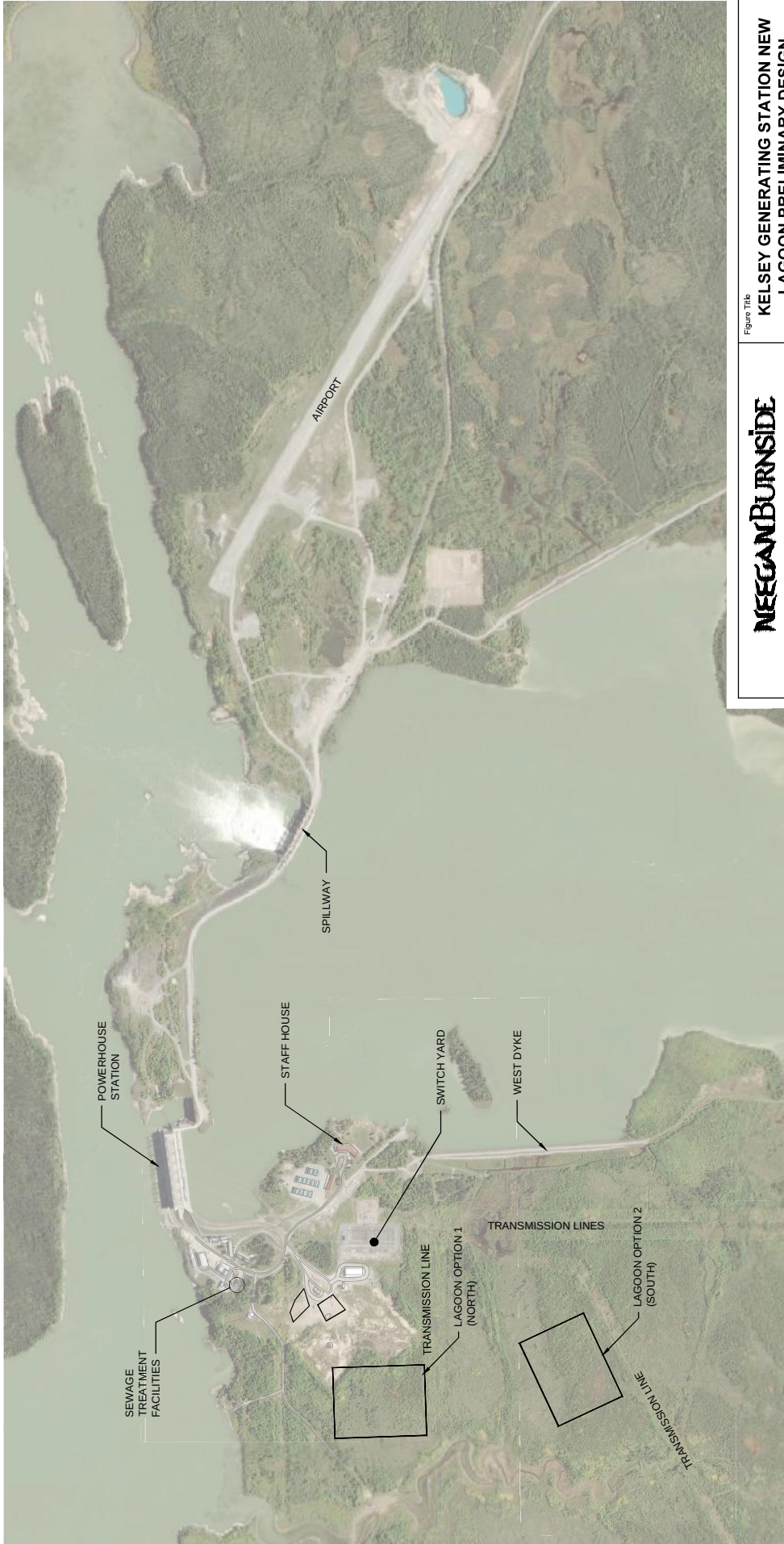
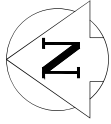
NOT TO SCALE

Project No.

300037851

Figure No.

1.0



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MANITOBA HYDRO

Client

Figure Title

**KELSEY GENERATING STATION NEW
LAGOON PRELIMINARY DESIGN
GENERAL SITE PLAN**

Figure No.

2.0

Date

2016/02/12

Checked

PK

Drawn

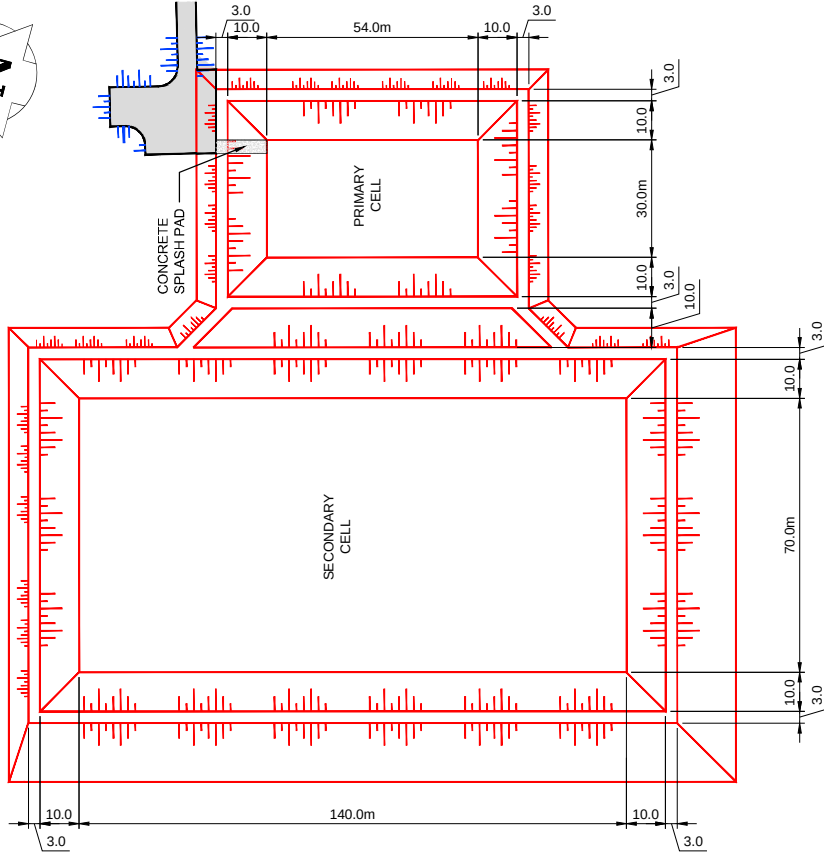
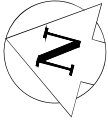
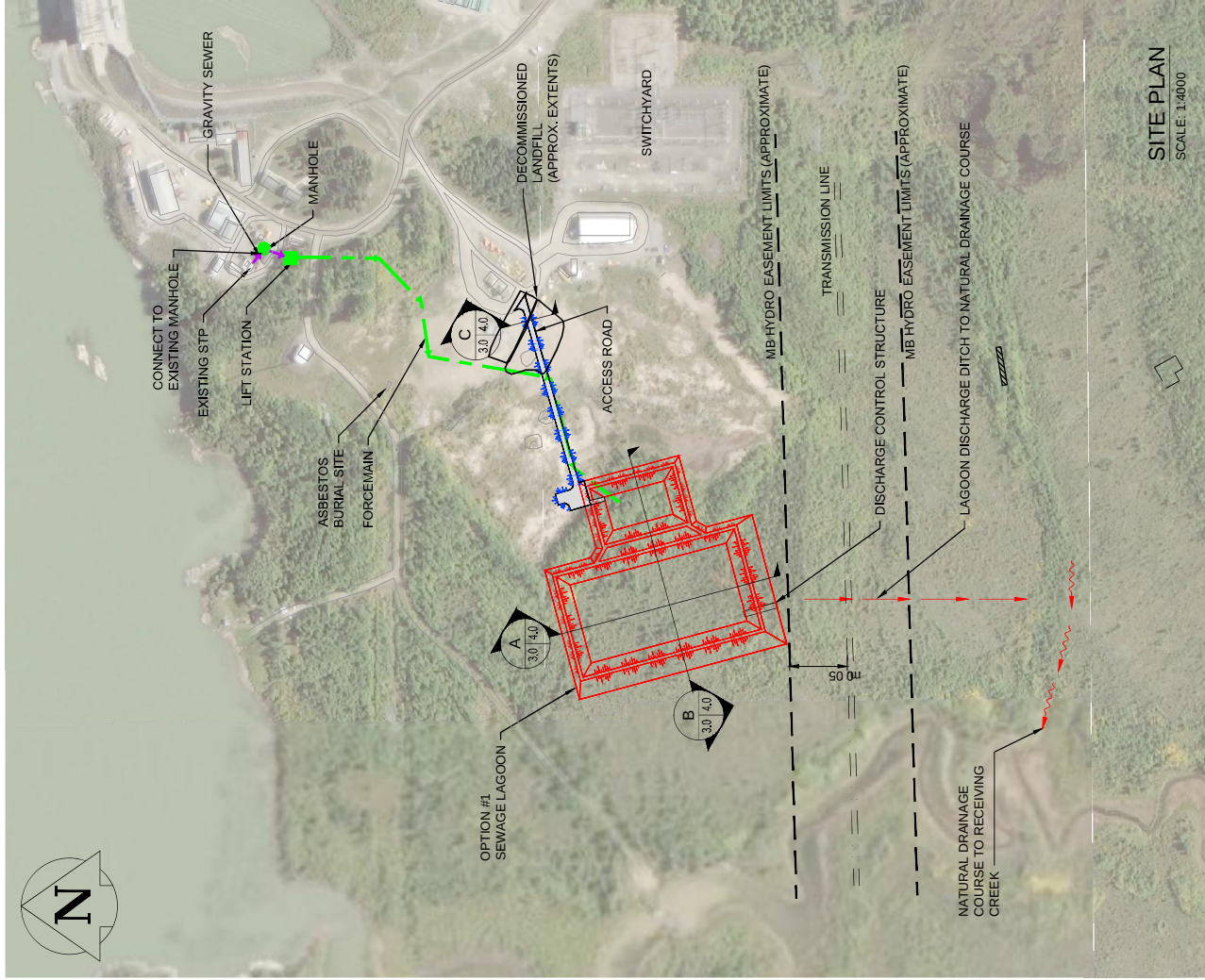
JJ

Scale

1:10000

Project No.

300037851



SEWAGE LAGOON - OPTION 1

SCALE: 1:1250

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Figure Title
**KELSEY GENERATING STATION NEW
LAGOON PRELIMINARY DESIGN
CONCEPTUAL DESIGN - OPTION 1**

Client

MANITOBA HYDRO

Drawn
JJ

Checked
PK

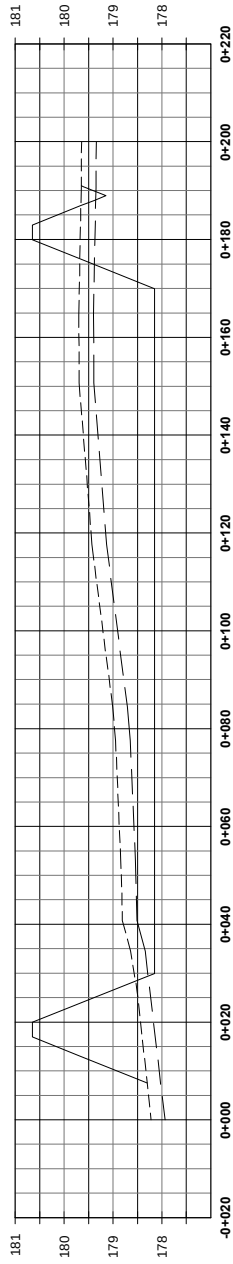
Date
2016/03/29

Project No.
300037851

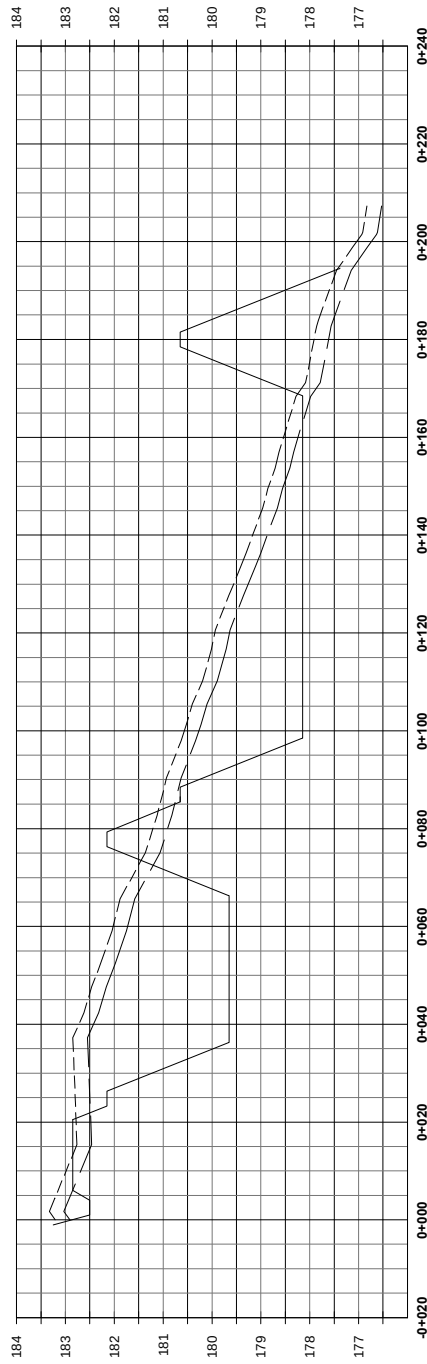
Scale
AS NOTED

Figure No.

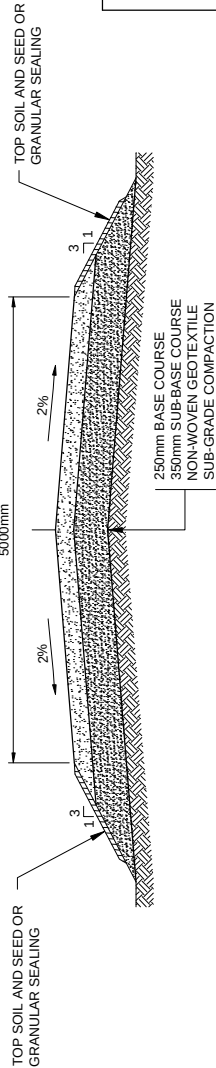
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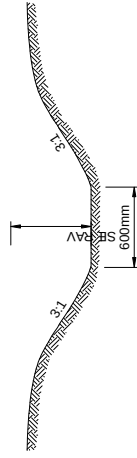
A LAGOON CROSS SECTION
SCALE: N.T.S.



B LAGOON CROSS SECTION
SCALE: N.T.S.



C ACCESS ROAD CROSS SECTION
SCALE: N.T.S.



TYPICAL DRAINAGE SWALE
SCALE: N.T.S.

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MANITOBA HYDRO

Client

Figure Title
**KELSEY GENERATING STATION NEW
LAGOON PRELIMINARY DESIGN
LAGOON AND ACCESS ROAD
CROSS SECTIONS - OPTION 1**

Figure No.

4.0

Drawn
JJ

Checked
PK

Date
2016/03/29

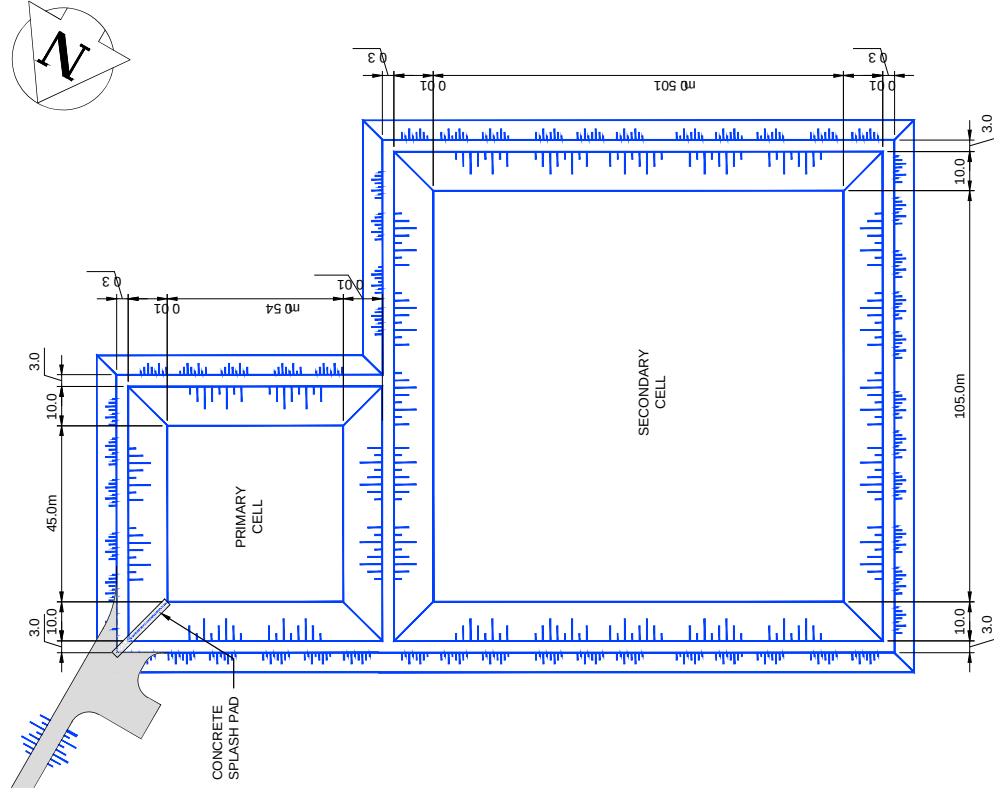
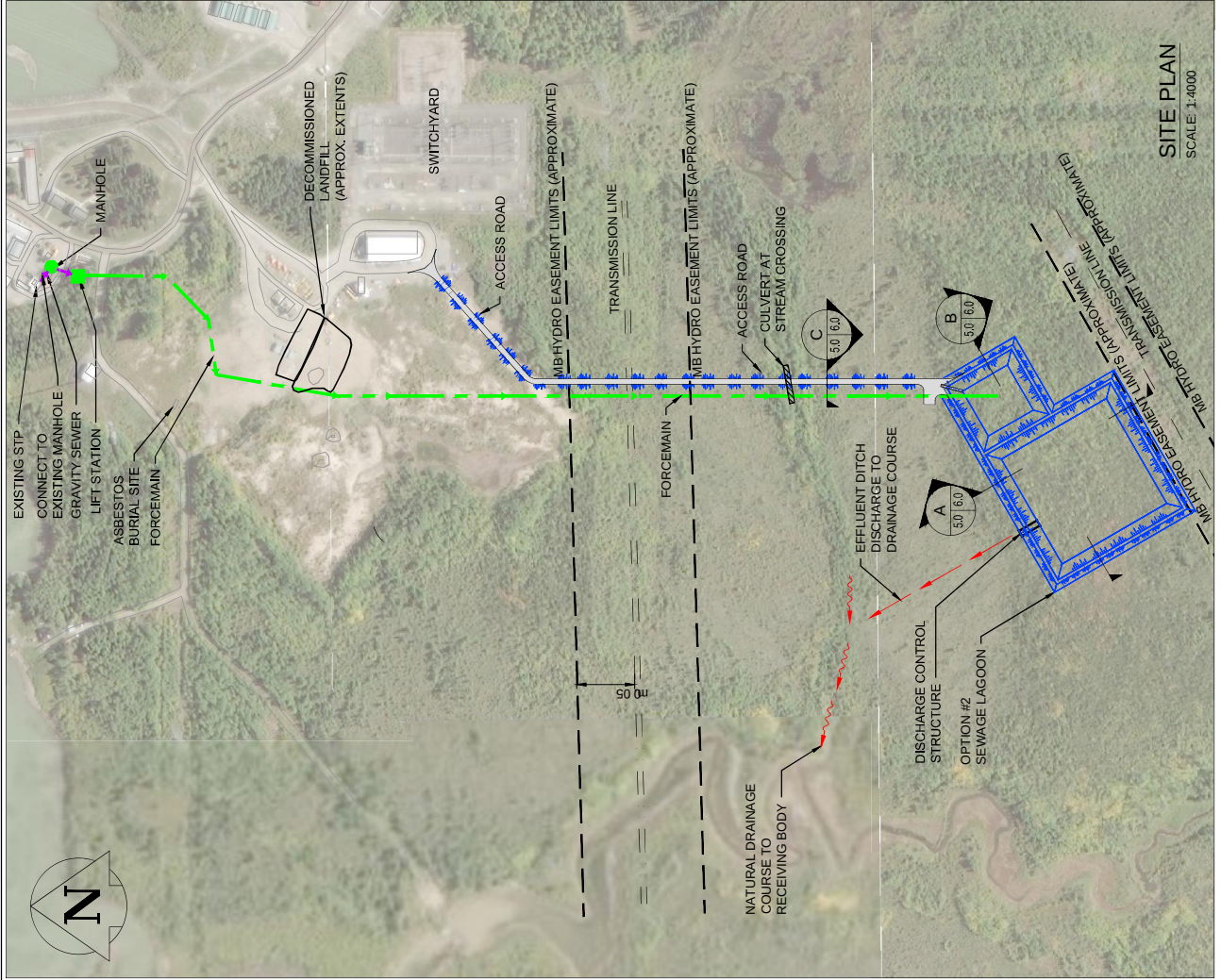
Project No.
300037851

Scale
AS NOTED

Figure No.

Project No.

Scale



SEWAGE LAGOON - OPTION 2
SCALE: 1:1250

NEEGANBURNSIDE

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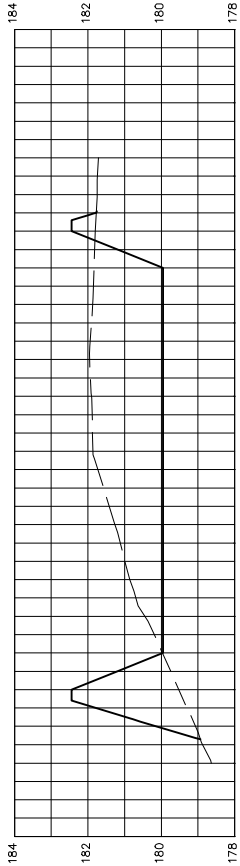
Figure Title
**KELSEY GENERATING STATION NEW
LAGOON PRELIMINARY DESIGN
CONCEPTUAL DESIGN - OPTION 2**

Client

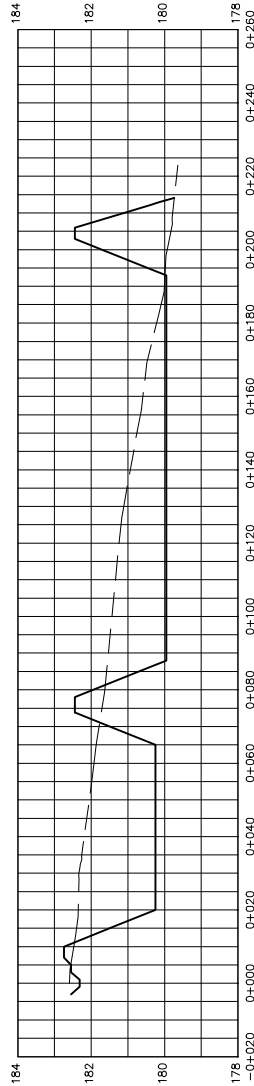
MANITOBA HYDRO

Drawn
JJ
Checked
PK
Date
2016/03/29
Project No.
300037851
Scale
AS NOTED

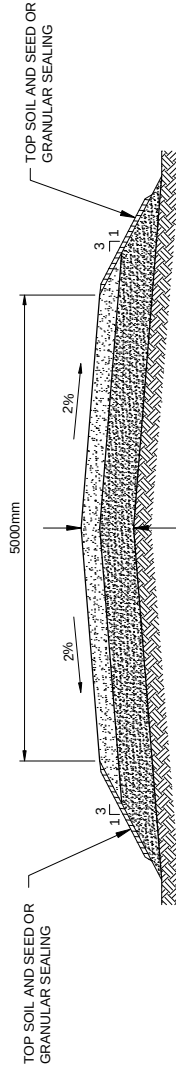
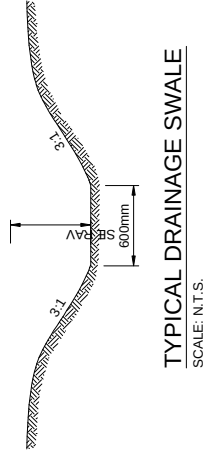
Figure No.
5.0



A LAGOON CROSS SECTION
SCALE: N.T.S.

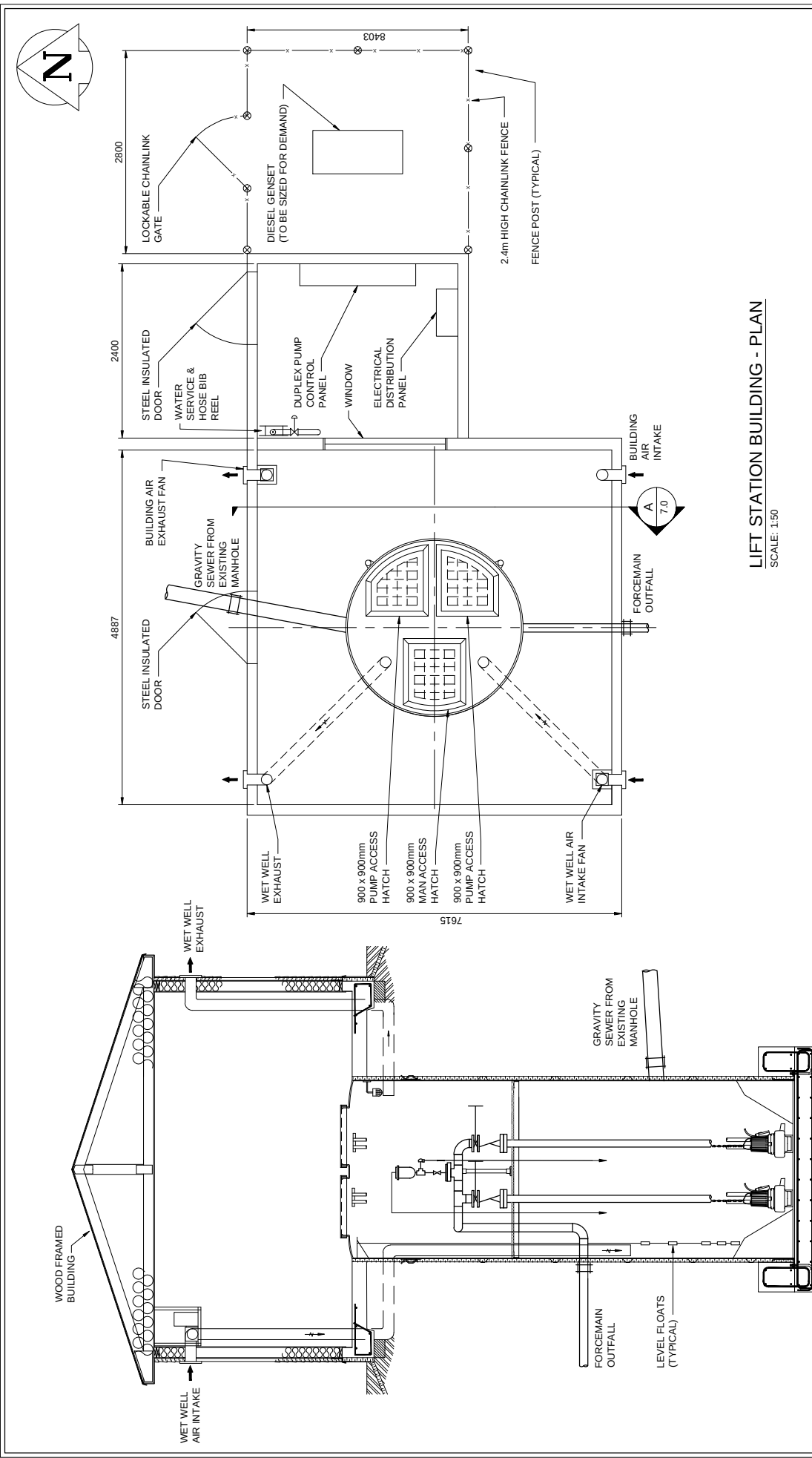


B LAGOON CROSS SECTION
SCALE: N.T.S.



C ACCESS ROAD CROSS SECTION
SCALE: N.T.S.

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	KELSEY GENERATING STATION NEW LAGOON PRELIMINARY DESIGN LAGOON AND ACCESS ROAD CROSS SECTIONS - OPTION 2			
Figure Title	Drawn	Checked	Date	Figure No.
	JJ	PK	2016/02/12	6.0
Scale	AS NOTED		Project No.	300037851

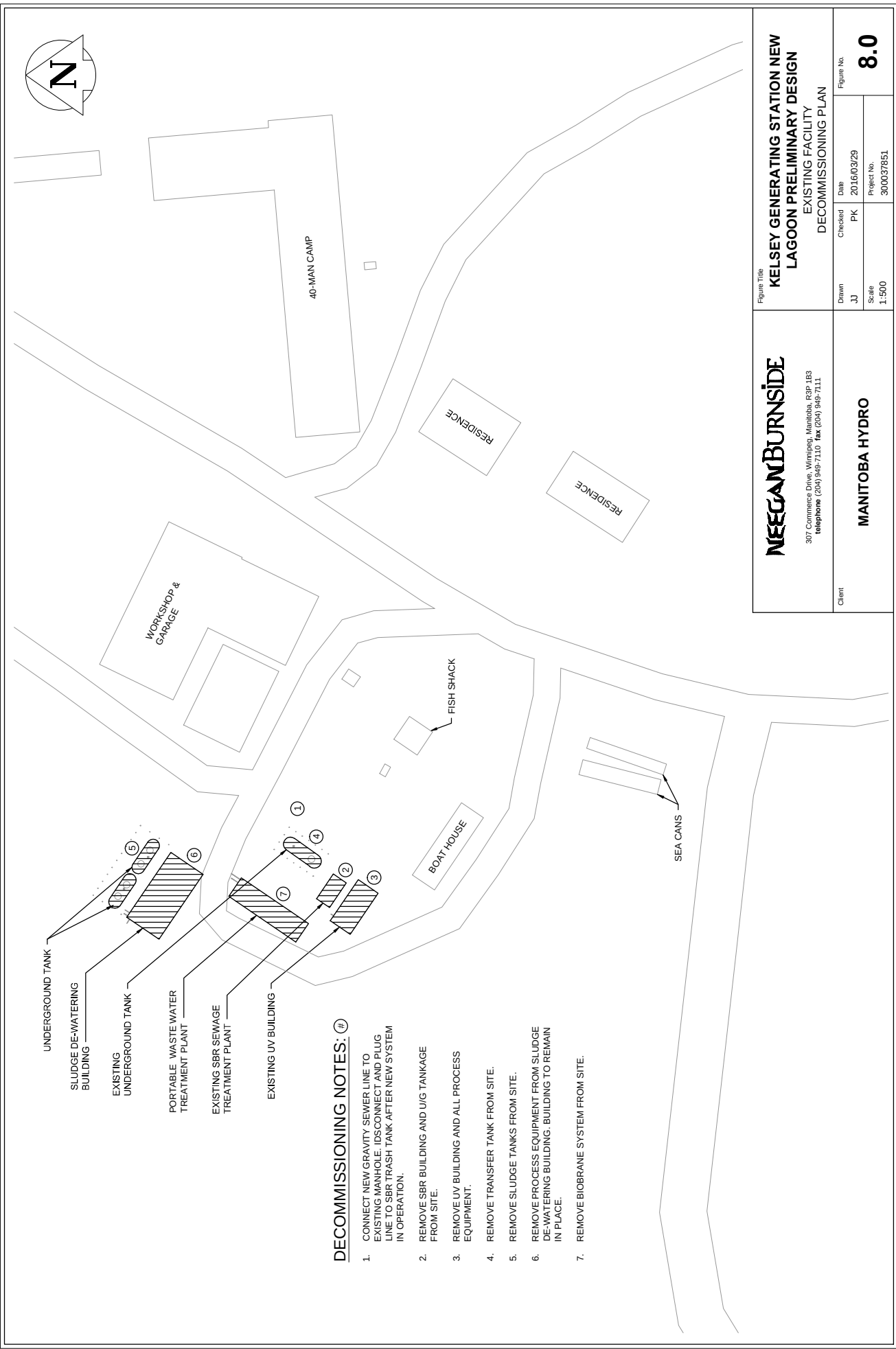


LIFT STATION BUILDING - PLAN
SCALE: 1:50

A SECTION
7.0 SCALE: 1:50

Figure Title KELSEY GENERATING STATION NEW LIFT STATION BUILDING DESIGN LAYOUT AND PROFILE		Figure No. 7.0	
Client	Drawn	Checked	Date
	CPG	GP	2016/02/18
	Scale	Project No.	300037851
MANITOBA HYDRO		AS NOTED	

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DECOMMISSIONING NOTES: ④

1. CONNECT NEW GRAVITY SEWER LINE TO EXISTING MANHOLE. DISCONNECT AND PLUG LINE TO SBR TRASH TANK AFTER NEW SYSTEM IN OPERATION.
2. REMOVE SBR BUILDING AND U/G TANKAGE FROM SITE.
3. REMOVE UV BUILDING AND ALL PROCESS EQUIPMENT.
4. REMOVE TRANSFER TANK FROM SITE.
5. REMOVE SLUDGE TANKS FROM SITE.
6. REMOVE PROCESS EQUIPMENT FROM SLUDGE DE-WATERING BUILDING. BUILDING TO REMAIN IN PLACE.
7. REMOVE BIOBRANE SYSTEM FROM SITE.

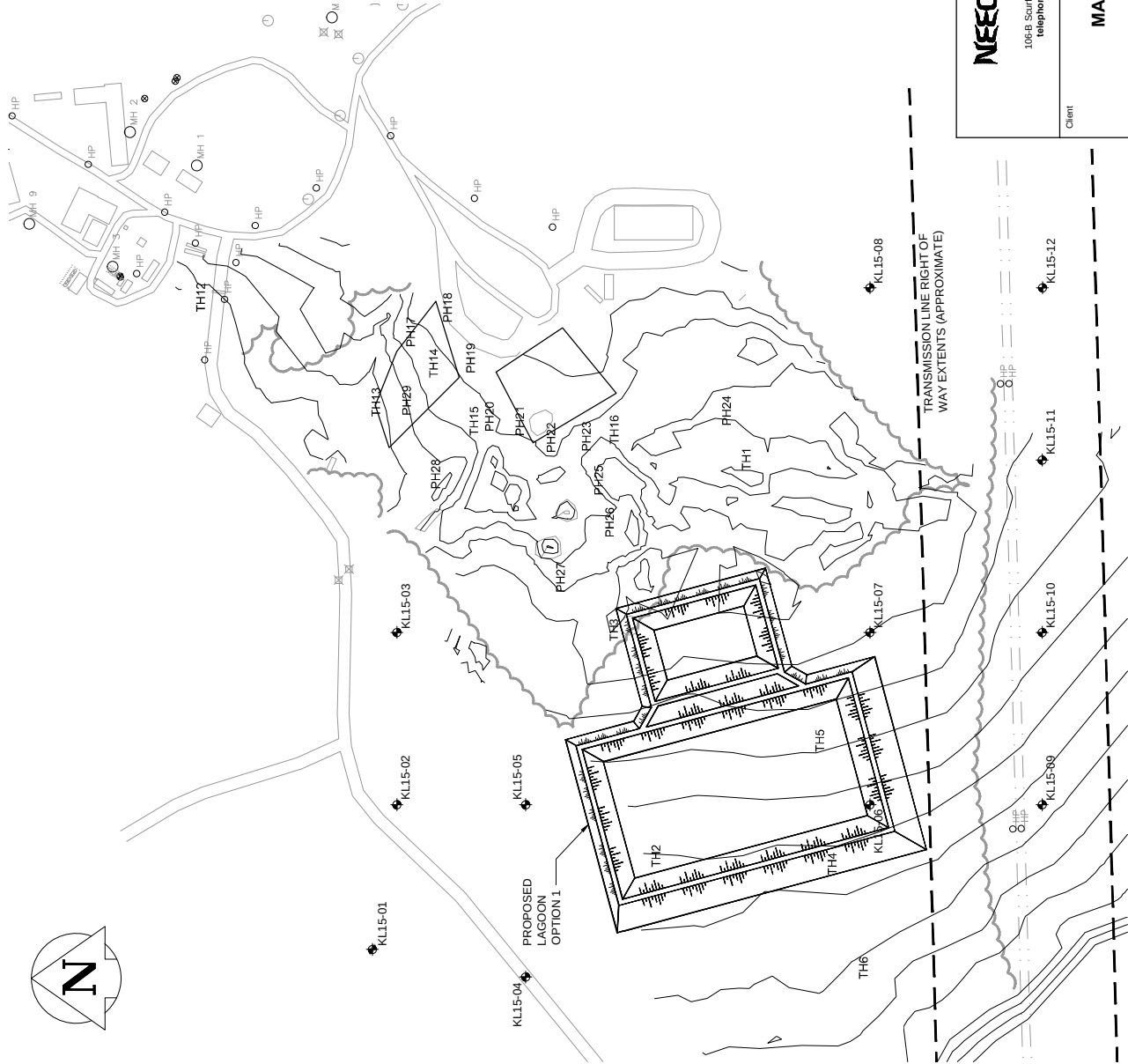
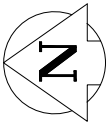
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Figure Title
KELSEY GENERATING STATION NEW
LAGOON PRELIMINARY DESIGN
EXISTING FACILITY
DECOMMISSIONING PLAN

Client
MANITOBA HYDRO

Drawn	Checked	Date	Figure No.
JJ	PK	2016/03/29	8.0
Scale	Project No.		
1:500	300037851		



PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION
Neegan Burnside Ltd.

KL	HAND-AUGERED TEST HOLE (2015)
PH	PROBE HOLE (2016)
TH	TEST HOLE (2016)
HP	HYDRO POLE
---	TRANSMISSION LINE
---	BUSH LINE
---	BUILDING
EXISTING	LEGEND - PLAN
	PROPOSED



NEEGANBURNSIDE

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**KELSEY GENERATING
STATION NEW LAGOON
NORTH TEST HOLE
LOCATION PLAN**

Client

MANITOBA HYDRO

Figure No.

9.0

Date

2016/03/04

Checked

PAK

Drawn

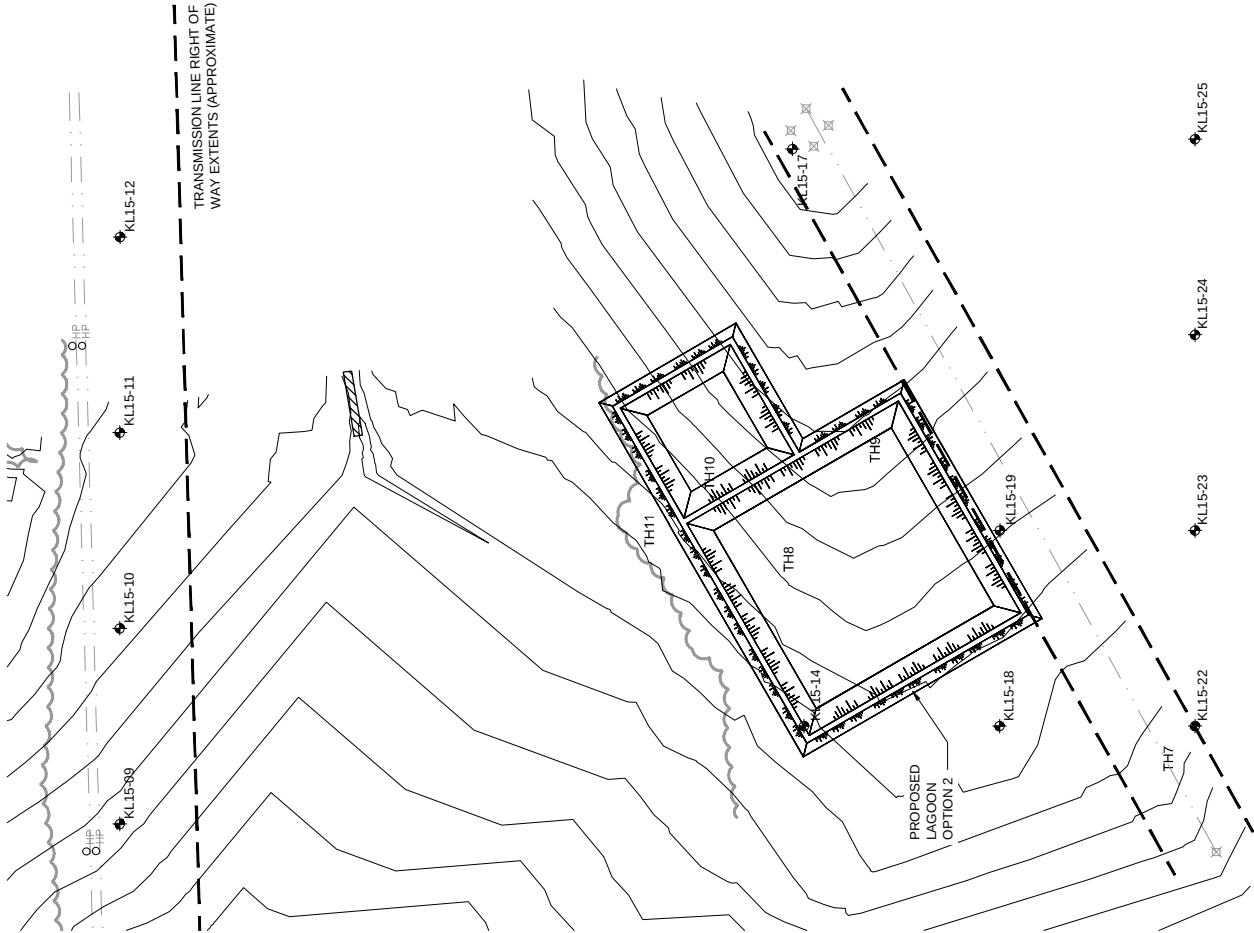
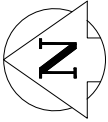
JJ

Scale

1:2500

Project No.

300037851



PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION
Neegan Burnside Ltd.

KL	HAND-AUGURED TEST HOLE (2015)
PH	PROBE HOLE (2016)
TH	TEST HOLE (2016)
HP	HYDRO POLE
---	TRANSMISSION LINE
~~~~~	BUSH LINE
=====	BUILDING
EXISTING	LEGEND - PLAN
	PROPOSED



<b>NEEGANBURNSIDE</b> 106-B Scurfield Blvd., Winnipeg, Manitoba, R3Y 1G4 telephone (204) 949-7110 fax (204) 949-7111		Figure Title <b>KELSEY GENERATING STATION NEW LAGOON SOUTH TEST HOLE LOCATION PLAN</b>	
Client	MANITOBA HYDRO	Drawn JJ	Date 2016/03/04
		Checked PAK	Project No. 300037851
		Scale 1:2500	Figure No. <b>10.0</b>



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Winnipeg, Manitoba  
R2J 0K4  
eng_tech@mts.net  
www.eng-tech.ca

## PARTICLE SIZE ANALYSIS REPORT

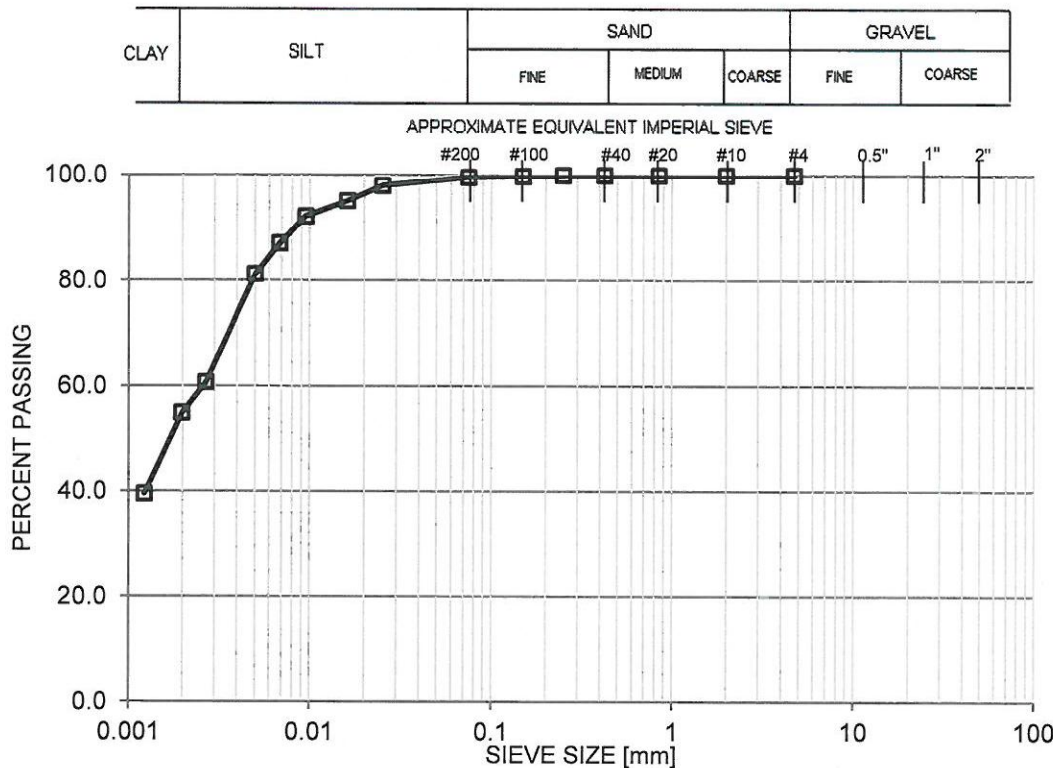
Neegan Burnside Ltd.  
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Winnipeg, Manitoba  
R3Y 1G4

File No.: 15-185-01  
Ref. No.: 15-185-1-7

ATTENTION: Paul Klassen, P. Eng

PROJECT: GEOTECHNICAL INVESTIGATION, MB HYDRO KELSEY GS SEWAGE LAGOON PROJECT

Test Hole No. 4 Sample No. S2 Depth: 1.5 - 2.1 m  
Sampled By: ENG-TECH Type of Sample: Shelby tube Source: -  
Date Sampled: Jan 20/16 Date Received: Jan 29/16 Date Tested: Feb 10/16



SIEVE SIZE (mm)	PERCENT PASSING
4.75	100.0
2.0	100.0
0.850	100.0
0.425	100.0
0.250	100.0
0.150	99.8
0.075	99.6
0.025	98.1
0.016	95.1
0.010	92.2
0.0068	87.1
0.0050	81.2
0.0027	60.7
0.0020	54.9
0.0012	39.5

Percent of: GRAVEL (0.0 %), SAND (0.4 %), SILT (44.5 %), CLAY (55.1 %)  
Sample Description:

COMMENTS:

ENG-TECH Consulting Limited

per   
Clark Hyrhoruk, M. Sc., P. Eng, President  
Ph: (204) 233-1694 Fax: (204) 235-1579

## PARTICLE SIZE ANALYSIS REPORT

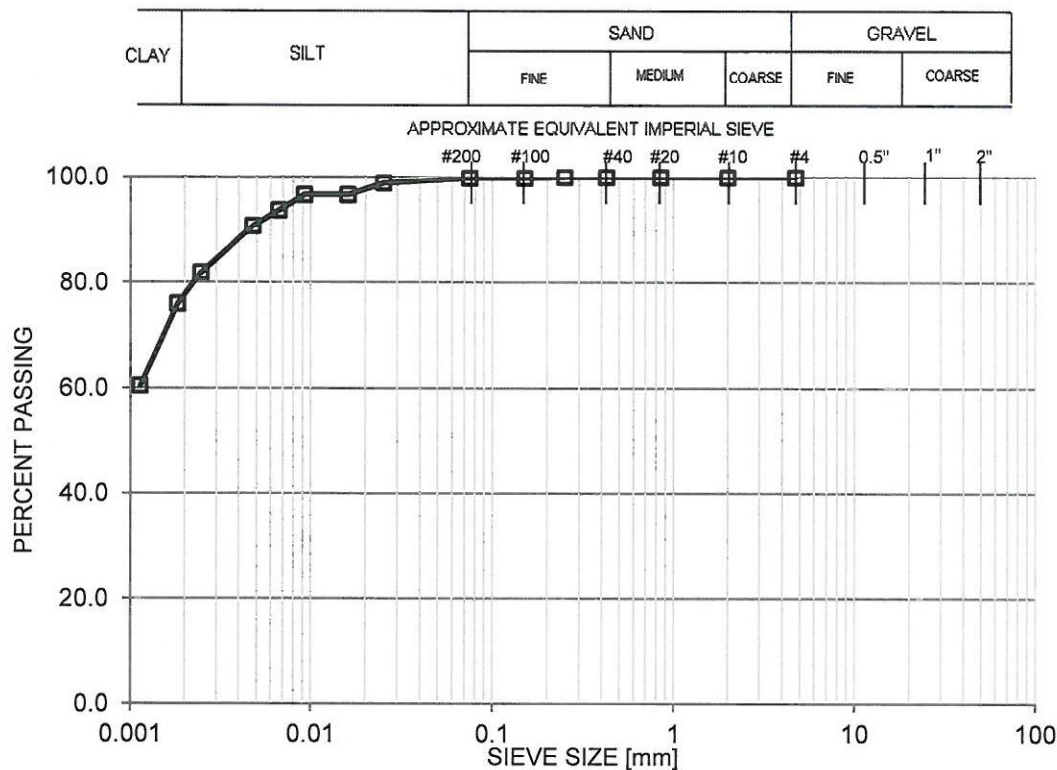
Neegan Burnside Ltd.  
106 - B Scurfield Blvd.  
Winnipeg, Manitoba  
R3Y 1G4

**File No.:** 15-185-01  
**Ref. No.:** 15-185-1-10

**ATTENTION:** Paul Klassen, P. Eng

**PROJECT:** GEOTECHNICAL INVESTIGATION, MB HYDRO KELSEY GS SEWAGE LAGOON PROJECT

<b>Test Hole No.</b>	6	<b>Sample No.</b>	S2	<b>Depth:</b>	1.5 - 2.1 m
<b>Sampled By:</b>	ENG-TECH	<b>Type of Sample:</b>	Shelby tube	<b>Source:</b>	-
<b>Date Sampled:</b>	Jan 21/16	<b>Date Received:</b>	Jan 29/16	<b>Date Tested:</b>	Feb 10/16



SIEVE SIZE (mm)	PERCENT PASSING
4.75	100.0
2.0	100.0
0.850	100.0
0.425	100.0
0.250	100.0
0.150	99.8
0.075	99.8
0.025	98.9
0.016	96.7
0.009	96.7
0.0066	93.7
0.0048	90.8
0.0025	81.9
0.0018	76.0
0.0011	60.5

**Percent of:** GRAVEL (0.0 %), SAND (0.2 %), SILT (21.9 %), CLAY (77.9 %)  
**Sample Description:**

**COMMENTS:**

**ENG-TECH Consulting Limited**

per   
Clark Hyrhoruk, M. Sc., P. Eng, President  
Ph: (204) 233-1694 Fax: (204) 235-1579



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Winnipeg, Manitoba  
R2J 0K4  
eng_tech@mts.net  
www.eng-tech.ca

## PARTICLE SIZE ANALYSIS REPORT

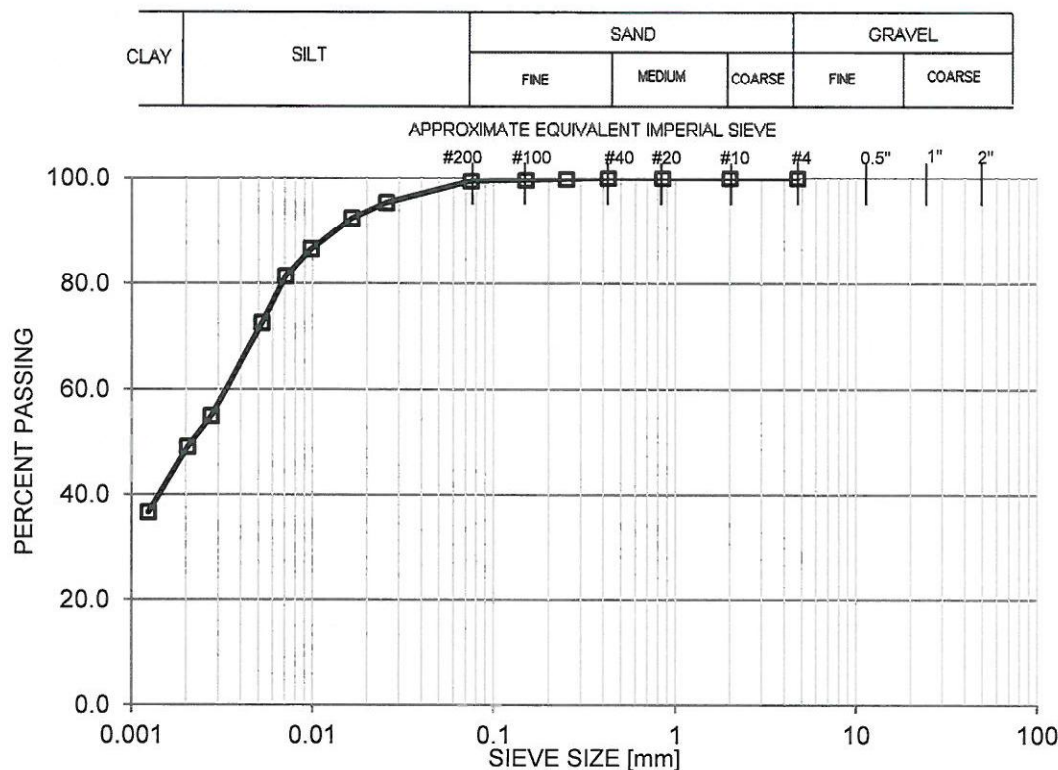
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File No.: 15-185-01  
Ref. No.: 15-185-1-11

ATTENTION: Paul Klassen, P. Eng

PROJECT: GEOTECHNICAL INVESTIGATION, MB HYDRO KELSEY GS SEWAGE LAGOON PROJECT

Test Hole No. 6 Sample No. S4 Depth: 2.4 - 3.0 m  
Sampled By: ENG-TECH Type of Sample: Shelby tube Source: -  
Date Sampled: Jan 21/16 Date Received: Jan 29/16 Date Tested: Feb 10/16



SIEVE SIZE (mm)	PERCENT PASSING
4.75	100.0
2.0	100.0
0.850	100.0
0.425	100.0
0.250	99.8
0.150	99.6
0.075	99.4
0.026	95.3
0.016	92.4
0.010	86.5
0.0071	81.4
0.0052	72.6
0.0027	55.0
0.0020	49.1
0.0012	36.7

Percent of: GRAVEL (0.0 %), SAND (0.6 %), SILT (50.7 %), CLAY (48.7 %)

Sample Description:

COMMENTS:

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R2J 0K4  
eng_tech@mts.net  
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## PARTICLE SIZE ANALYSIS REPORT

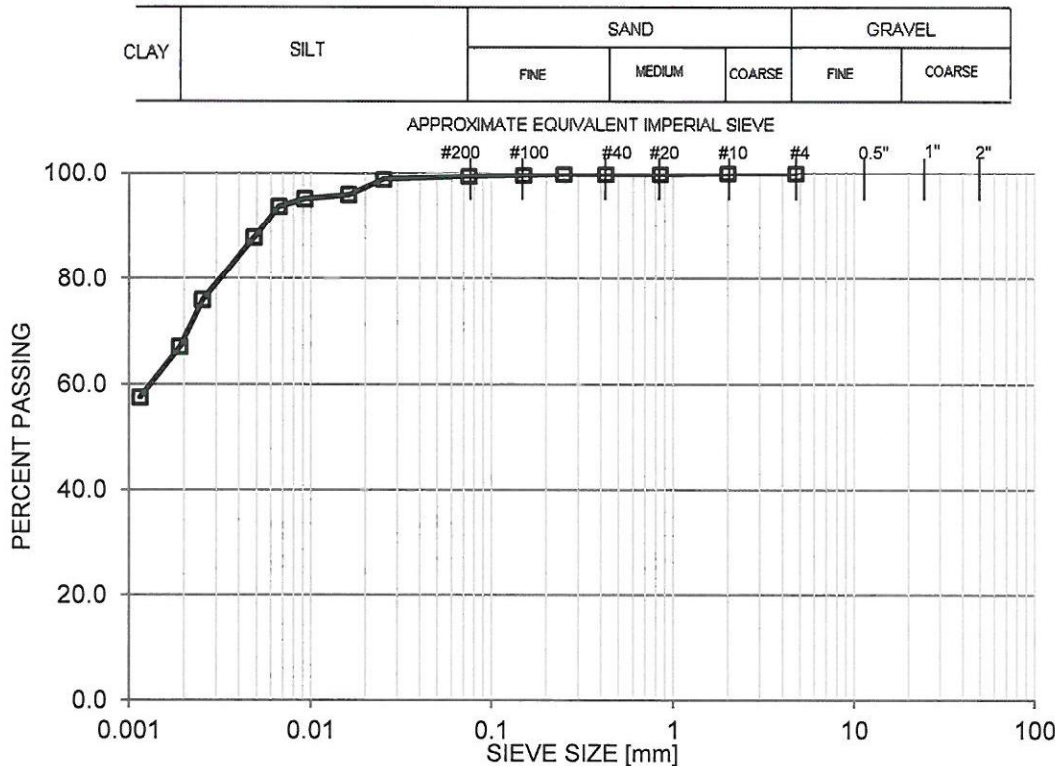
Neegan Burnside Ltd.  
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Winnipeg, Manitoba  
R3Y 1G4

File No.: 15-185-01  
Ref. No.: 15-185-1-13

**ATTENTION:** Paul Klassen, P. Eng

**PROJECT:** GEOTECHNICAL INVESTIGATION, MB HYDRO KELSEY GS SEWAGE LAGOON PROJECT

<b>Test Hole No.</b>	11	<b>Sample No.</b>	S2	<b>Depth:</b>	1.5 - 2.1 m
<b>Sampled By:</b>	ENG-TECH	<b>Type of Sample:</b>	Shelby tube	<b>Source:</b>	-
<b>Date Sampled:</b>	Jan 21/16	<b>Date Received:</b>	Jan 29/16	<b>Date Tested:</b>	Feb 10/16

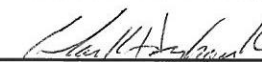


Percent of: GRAVEL (0.0 %), SAND (0.6 %), SILT (30.6 %), CLAY (68.8 %)

**Sample Description:**

**COMMENTS:**

**ENG-TECH Consulting Limited**

per   
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Ph: (204) 233-1694 Fax: (204) 235-1579





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R2J 0K4  
eng_tech@mts.net  
www.eng-tech.ca

## PARTICLE SIZE ANALYSIS REPORT

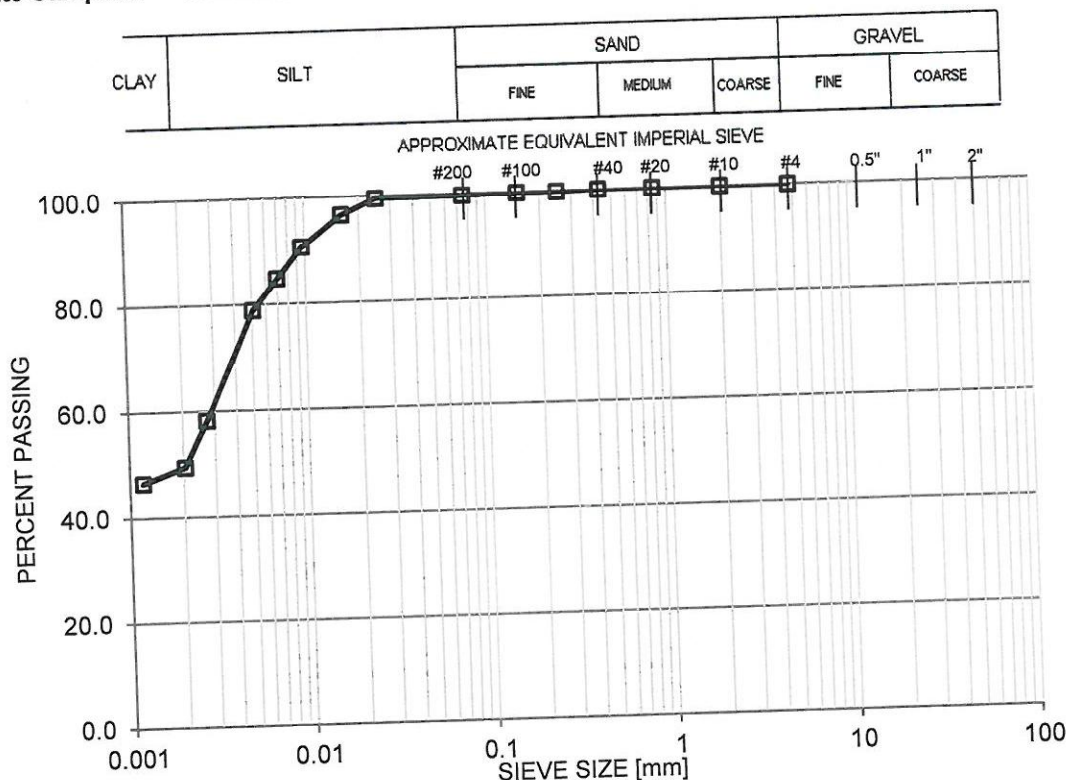
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Winnipeg, Manitoba  
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File No.: 15-185-01  
Ref. No.: 15-185-1-16

ATTENTION: Paul Klassen, P. Eng

PROJECT: GEOTECHNICAL INVESTIGATION, MB HYDRO KELSEY GS SEWAGE LAGOON PROJECT

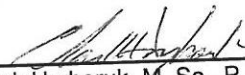
Test Hole No.	8	Sample No.	S4	Depth:	2.4 - 3.0 m
Sampled By:	ENG-TECH	Type of Sample:	Shelby tube	Source:	-
Date Sampled:	Jan 21/16	Date Received:	Jan 29/16	Date Tested:	Feb 10/16



Percent of: GRAVEL (0.0 %), SAND (0.4 %), SILT (50.3 %), CLAY (49.3 %)  
Sample Description:

COMMENTS:

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per   
Clark Hyrhoruk, M. Sc., P. Eng, President  
Ph: (204) 233-1694 Fax: (204) 235-1579





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Winnipeg, Manitoba  
R2J 0K4  
eng_tech@mts.net  
www.eng-tech.ca

## PARTICLE SIZE ANALYSIS REPORT

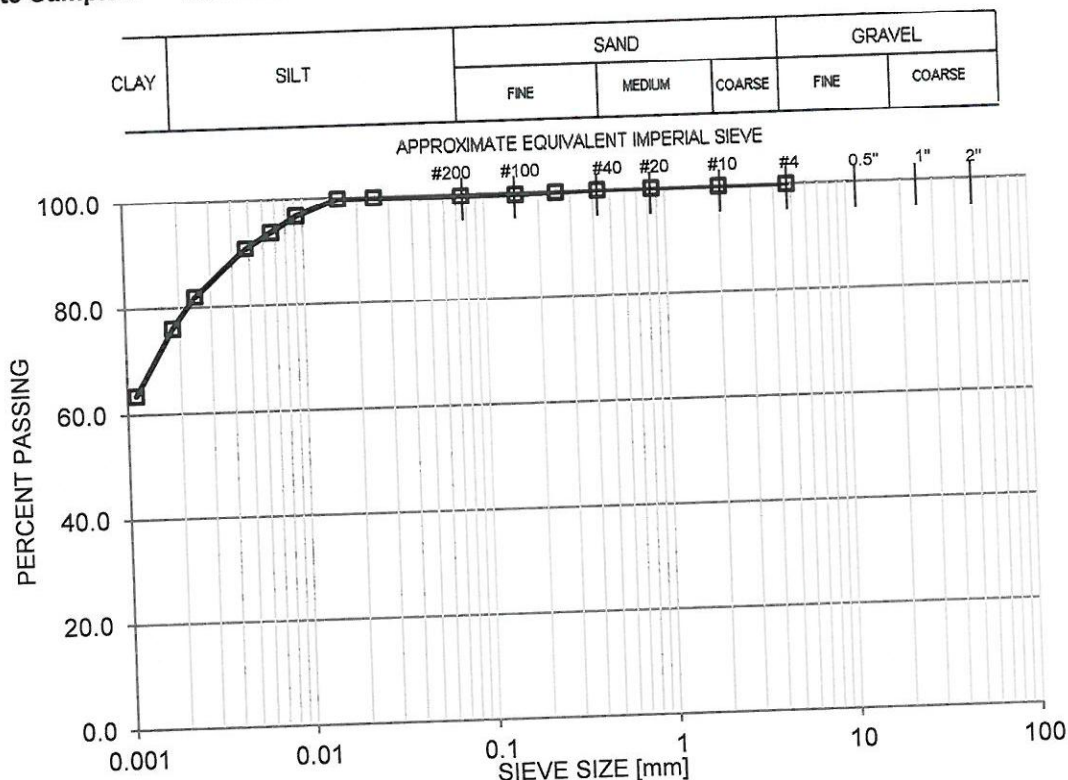
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Winnipeg, Manitoba  
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File No.: 15-185-01  
Ref. No.: 15-185-1-18

ATTENTION: Paul Klassen, P. Eng

PROJECT: GEOTECHNICAL INVESTIGATION, MB HYDRO KELSEY GS SEWAGE LAGOON PROJECT

Test Hole No. 7 Sample No. S1 Depth: 0.6 m  
Sampled By: ENG-TECH Type of Sample: Auger cutting Source: -  
Date Sampled: Jan 21/16 Date Received: Jan 29/16 Date Tested: Feb 10/16

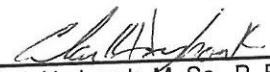


SIEVE SIZE (mm)	PERCENT PASSING
4.75	100.0
2.0	100.0
0.850	100.0
0.425	100.0
0.250	99.8
0.150	99.6
0.075	99.6
0.025	99.8
0.016	99.8
0.009	96.8
0.0066	93.9
0.0048	90.9
0.0025	82.0
0.0018	76.1
0.0011	63.6

Percent of: GRAVEL (0.0 %), SAND (0.4 %), SILT (21.6 %), CLAY (78.0 %)  
Sample Description:

COMMENTS:

ENG-TECH Consulting Limited

per   
Clark Hyrhoruk, M. Sc., P. Eng, President  
Ph: (204) 233-1694 Fax: (204) 235-1579







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Winnipeg, Manitoba  
R2J 0K4  
eng_tech@mts.net  
www.eng-tech.ca

## PARTICLE SIZE ANALYSIS REPORT

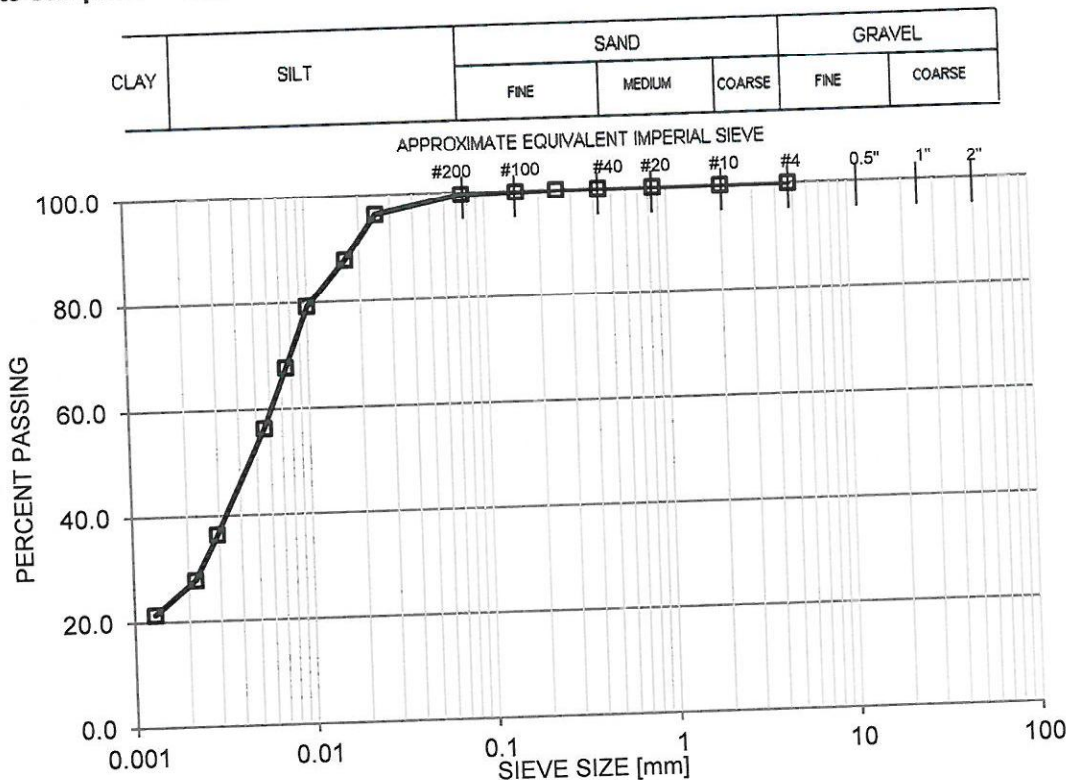
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R3Y 1G4

File No.: 15-185-01  
Ref. No.: 15-185-1-22

ATTENTION: Paul Klassen, P. Eng

PROJECT: GEOTECHNICAL INVESTIGATION, MB HYDRO KELSEY GS SEWAGE LAGOON PROJECT

Test Hole No.	12	Sample No.	S11	Depth:	4.6 - 5.2 m
Sampled By:	ENG-TECH	Type of Sample:	Shelby tube	Source:	-
Date Sampled:	Jan 19/16	Date Received:	Jan 29/16	Date Tested:	Feb 10/16

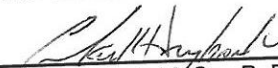


SIEVE SIZE (mm)	PERCENT PASSING
4.75	100.0
2.0	100.0
0.850	100.0
0.425	100.0
0.250	100.0
0.150	99.8
0.075	99.6
0.025	96.4
0.017	87.8
0.010	79.2
0.0075	67.8
0.0056	56.4
0.0029	36.4
0.0022	27.8
0.0013	21.4

Percent of: GRAVEL (0.0 %), SAND (0.4 %), SILT (72.8 %), CLAY (26.8 %)  
Sample Description:

COMMENTS:

ENG-TECH Consulting Limited

per   
Clark Hyrhoruk, M. Sc., P. Eng, President  
Ph: (204) 233-1694 Fax: (204) 235-1579



Unit 6 - 854 Marion Street  
Winnipeg, Manitoba  
R2J 0K4  
eng_tech@mts.net  
www.eng-tech.ca

## MOISTURE-DENSITY RELATIONSHIP

Neegan Burnside Ltd.  
106 - B Scurfield Blvd.  
Winnipeg, Manitoba  
R3Y 1G4

File No.: 15-185-01  
Ref. No.: 15-185-1-8

**Attention:** Paul Klassen, P. Eng.

**Project:** GEOTECHNICAL INVESTIGATION, MB HYDRO KELSEY GS SEWAGE LAGOON PROJECT

Compaction Standard Method

☒ ASTM D698 ☐ ASTM D1557

Dry Density kg/m³

Moisture Content (%)

1629	1678	1640	1562	
18.4	20.7	23.1	25.8	

Maximum Dry Density =

1679 kg/m³

Corrected =

Optimum Moisture =

21.0 %

Corrected =

Source:

Kelsey Lagoon,  
Test Hole 4

- kg/m³  
- %

Date Sampled: Jan 20/16

Sampled By: ENG-TECH (Clark Hyrhoruk)

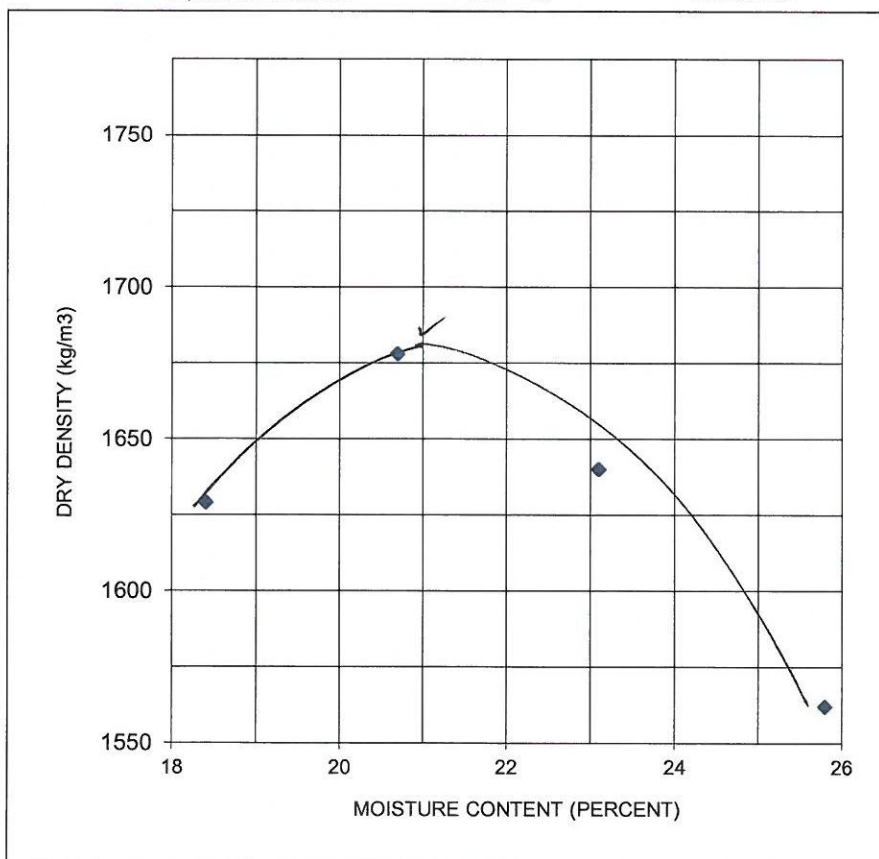
Date Received: Jan 29/16

Date Tested: Feb 8/16

Material Oversize

4.75 mm = 0.0 %  
19 mm = - %

Soil Description:  
Clay, see TH4



Comments:

ENG-TECH Consulting Limited

per

Clark Hyrhoruk, M. Sc., P. Eng, President

Ph: (204) 233-1694 Fx: (204) 235-1579





Unit 6 - 854 Marion Street  
Winnipeg, Manitoba  
R2J 0K4  
eng_tech@mts.net  
www.eng-tech.ca

## MOISTURE-DENSITY RELATIONSHIP

Neegan Burnside Ltd.  
106 - B Scurfield Blvd.  
Winnipeg, Manitoba  
R3Y 1G4

File No.: 15-185-01  
Ref. No.: 15-185-1-17

**Attention:** Paul Klassen, P. Eng.

**Project:** GEOTECHNICAL INVESTIGATION, MB HYDRO KELSEY GS SEWAGE LAGOON PROJECT

Compaction Standard Method ☒ ASTM D698 ☐ ASTM D1557

Dry Density kg/m ³	1628	1654	1639	1598	
Moisture Content (%)	18.0	20.3	22.2	24.1	

Source: Kelsey Lagoon,  
Test Hole 8

Maximum Dry Density = 1655 kg/m³ Corrected =  
Optimum Moisture = 20.5 % Corrected =

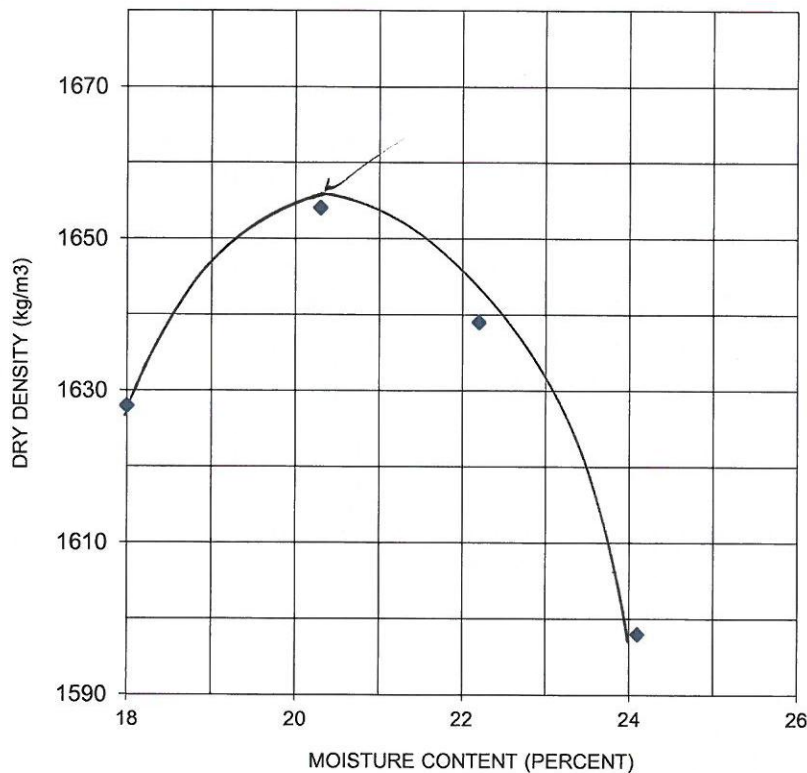
- kg/m³  
- %

Date Sampled: Jan 21/16  
Sampled By: ENG-TECH (Clark Hyrhoruk)  
Date Received: Jan 29/16  
Date Tested: Feb 8/16

Material Oversize

4.75 mm = 0.0 %  
19 mm = - %

Soil Description:  
Clay, see TH8



Comments:

ENG-TECH Consulting Limited

per

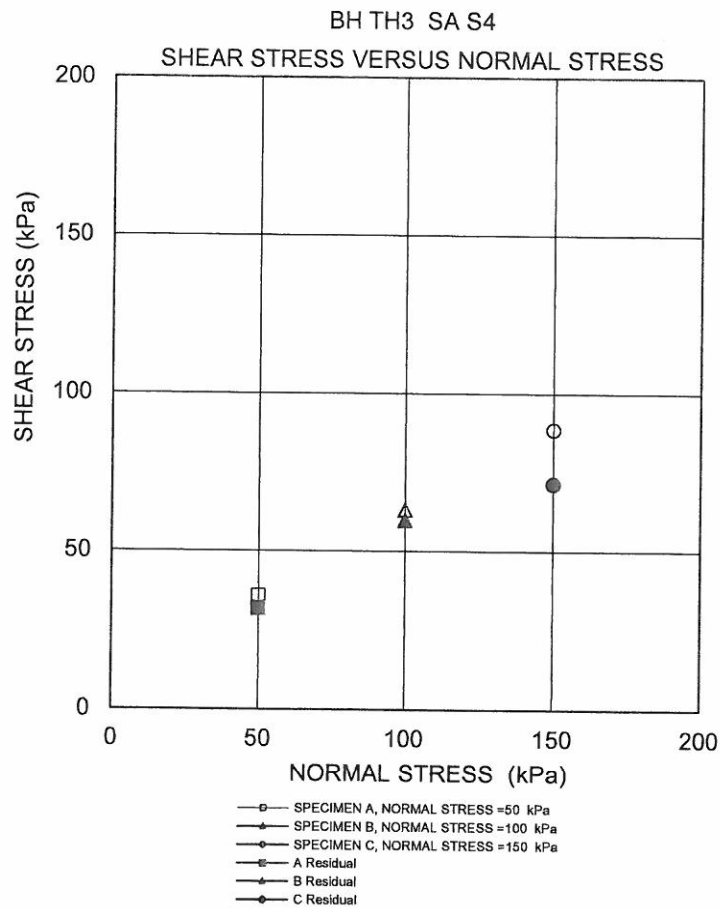
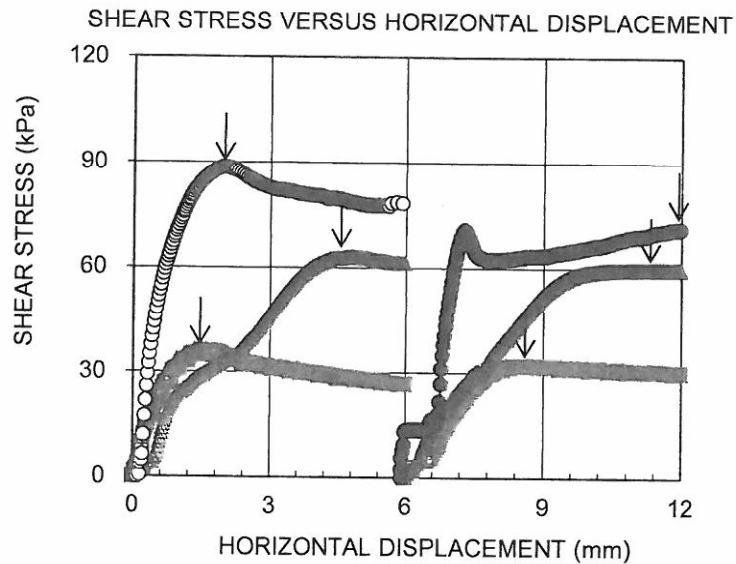
Clark Hyrhoruk, M. Sc., P. Eng, President  
Ph: (204) 233-1694 Fx: (204) 235-1579

CONSOLIDATED DRAINED DIRECT SHEAR TEST SHEET 1 OF 3		FIGURE		
TEST STAGE		A	B	C
BOREHOLE NUMBER		TH3		
SAMPLE		S4		
SAMPLE DEPTH, (m)		3.00		
SAMPLE HEIGHT, (mm)	25.79	25.607	25.83	
SAMPLE LENGTH, (mm)	60.00	60.00	60.00	
WATER CONTENT, BEFORE TEST, (%)	22.8	22.8	22.8	
NORMAL (CONSOLIDATION) STRESS, (kPa)	50	100	150	
WATER CONTENT, AFTER TEST, (%)	29.4	24.3	31.8	
DISPLACEMENT RATE, mm/min	0.0048	0.0048	0.0048	
TIME TO FAILURE, hours	6	17	7	
PEAK SHEAR STRESS ¹ , (kPa)	35.9	63.1	88.6	
HORIZONTAL DISPLACEMENT AT PEAK, (mm)	1.7	4.8	1.9	
RESIDUAL SHEAR STRESS, (kPa)	32.1	59.7	71.3	
HORIZONTAL DISPLACEMENT AT RESIDUAL, (mm)	8.4	11.5	12.0	
DRY DENSITY, initial, Mg/m ³	1.51	1.58	1.49	
WET DENSITY, initial, Mg/m ³	1.86	1.94	1.83	
TEST NOTES:				
¹ In the absence of a peak, the shear stress reported is at 10 percent relative horizontal displacement (ASTM D3080).				
Date: 3/22/2016   Project No. 1652876       Golder Associates       Prepared By: LH   Checked By: 				

**CONSOLIDATED DRAINED DIRECT SHEAR TEST**  
**SHEET 2 OF 3**

**FIGURE**

BH TH3 SA S4



Date: 3/22/2016

Project No. 1652876

**Golder Associates**

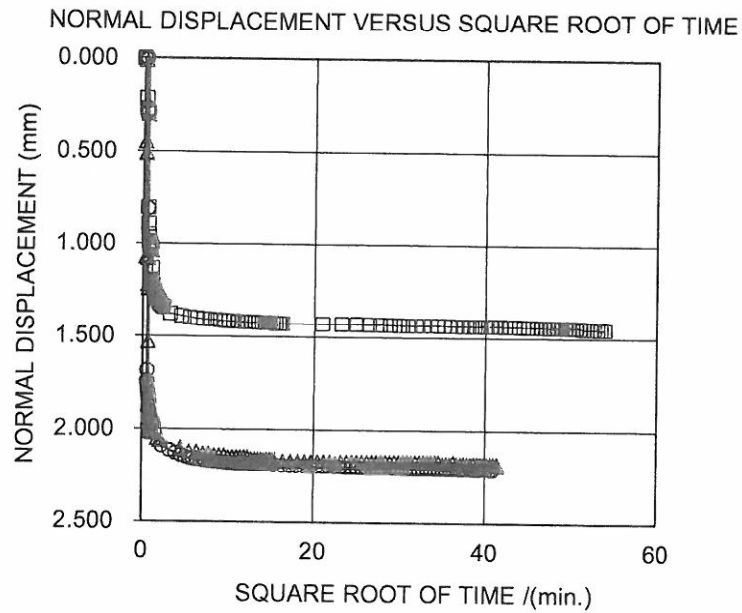
Prepared By LH

Checked By: *[Signature]*

**CONSOLIDATED DRAINED DIRECT SHEAR TEST**  
**SHEET 3 OF 3**

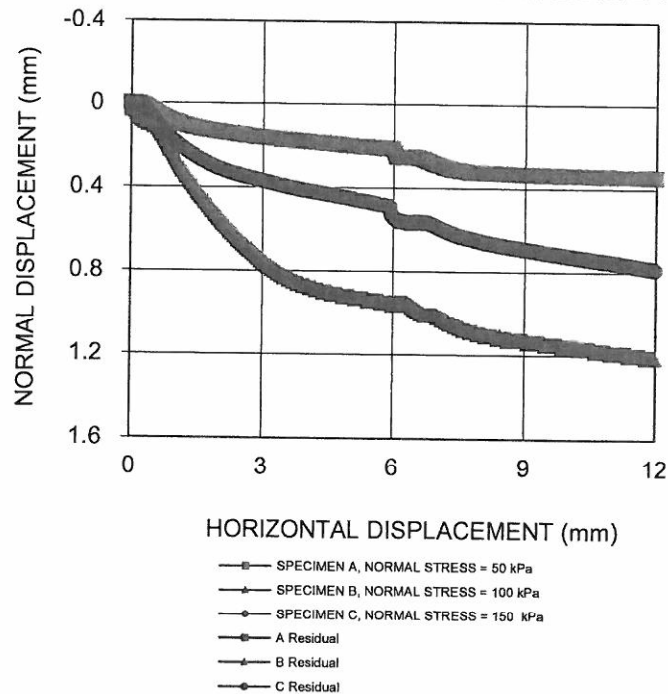
**FIGURE**

BH TH3 SA S4



BH TH3 SA S4

NORMAL DISPLACEMENT VERSUS HORIZONTAL DISPLACEMENT



Date: 3/22/2016

Project No. 1652876

**Golder Associates**

Prepared By LH

Checked By: *[Signature]*

# CONSOLIDATION TEST SUMMARY

ASTM D2435/D2435M

FIGURE

## SAMPLE IDENTIFICATION

Project Number	1652876	Sample Number	S4
Borehole Number	TH5	Sample Depth, m	3

## TEST CONDITIONS

Test Type	Laboratory Standard	Load Duration, hr	24
Oedometer Number	6		
Date Started	02/26/2016		
Date Completed	03/14/2016		

## SAMPLE DIMENSIONS AND PROPERTIES - INITIAL

Sample Height, cm	1.89	Unit Weight, kN/m ³	19.23
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m ³	14.88
Area, cm ²	31.62	Specific Gravity, measured	2.74
Volume, cm ³	59.82	Solids Height, cm	1.048
Water Content, %	29.25	Volume of Solids, cm ³	33.13
Wet Mass, g	117.32	Volume of Voids, cm ³	26.70
Dry Mass, g	90.77	Degree of Saturation, %	99.5

## TEST COMPUTATIONS

Stress kPa	Corr. Height cm	Void Ratio	Average Height cm	t ₉₀ sec	cv. cm ² /s	mv m ² /kN	k cm/s
0.00	1.892	0.806	1.892				
5.93	1.862	0.778	1.877				
10.67	1.859	0.774	1.860	1	7.34E-01	4.35E-04	3.13E-05
20.39	1.854	0.769	1.856	173	4.22E-03	2.50E-04	1.03E-07
39.79	1.845	0.761	1.850	614	1.18E-03	2.40E-04	2.77E-08
78.61	1.828	0.744	1.836	240	2.98E-03	2.37E-04	6.92E-08
156.23	1.809	0.726	1.818	163	4.30E-03	1.29E-04	5.45E-08
311.21	1.766	0.685	1.787	305	2.22E-03	1.46E-04	3.18E-08
620.18	1.711	0.633	1.739	317	2.02E-03	9.32E-05	1.85E-08
1239.94	1.656	0.580	1.684	375	1.60E-03	4.74E-05	7.45E-09
2478.67	1.593	0.520	1.624	252	2.22E-03	2.69E-05	5.85E-09
1239.94	1.606	0.533	1.599				
311.21	1.639	0.564	1.622				
78.61	1.670	0.593	1.654				
20.53	1.697	0.620	1.683				
5.96	1.717	0.639	1.707				

Note:

Consolidation loading and unloading schedule assigned by the client.  
k calculated using cv based on t₉₀ values.

## SAMPLE DIMENSIONS AND PROPERTIES - FINAL

Sample Height, cm	1.72	Unit Weight, kN/m ³	20.56
Sample Diameter, cm	6.35	Dry Unit Weight, kN/m ³	16.40
Area, cm ²	31.62	Specific Gravity, measured	2.74
Volume, cm ³	54.29	Solids Height, cm	1.048
Water Content, %	25.39	Volume of Solids, cm ³	33.13
Wet Mass, g	113.82	Volume of Voids, cm ³	21.16
Dry Mass, g	90.77		

Prepared By: LH

**Golder Associates**

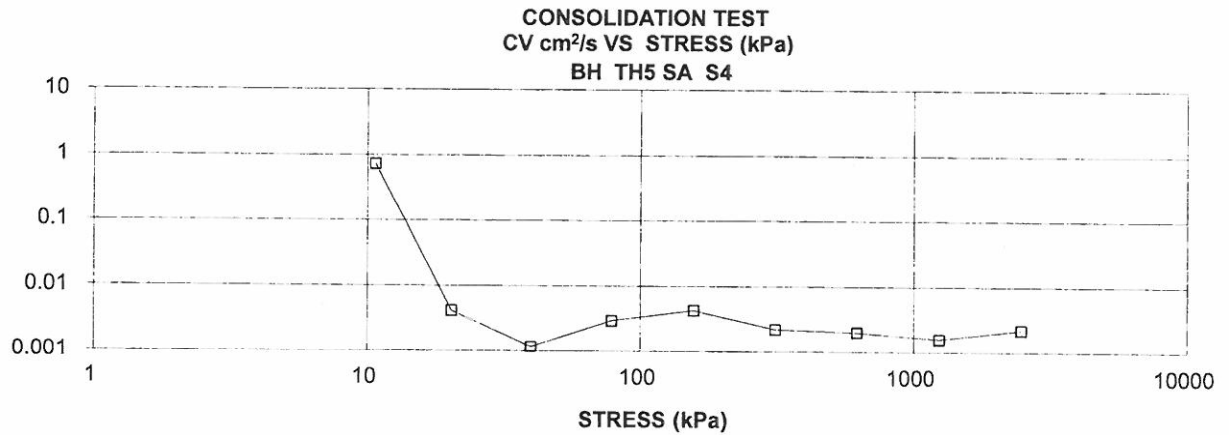
Checked By: 



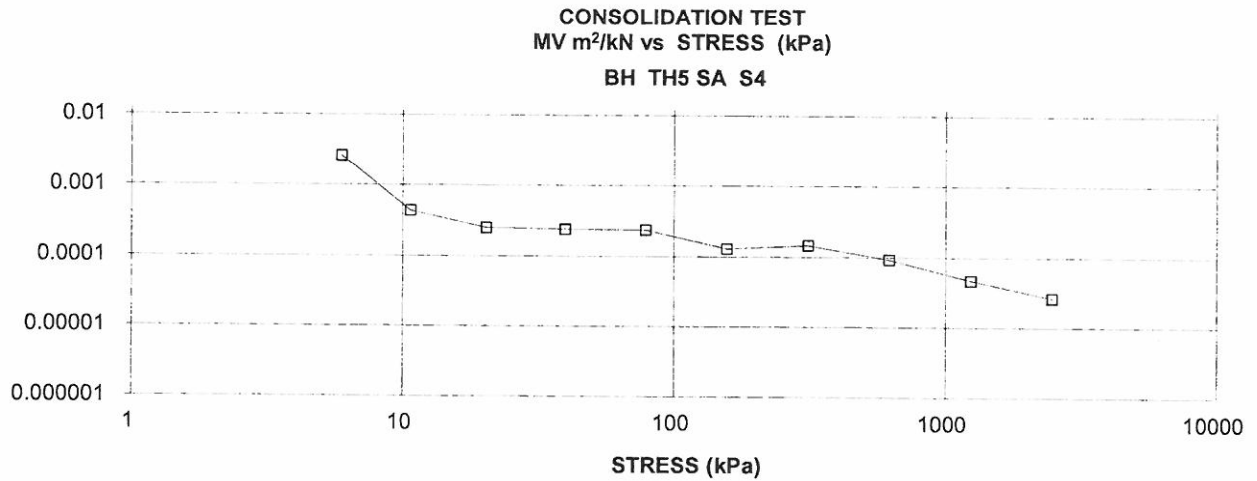
# CONSOLIDATION TEST SUMMARY

FIGURE

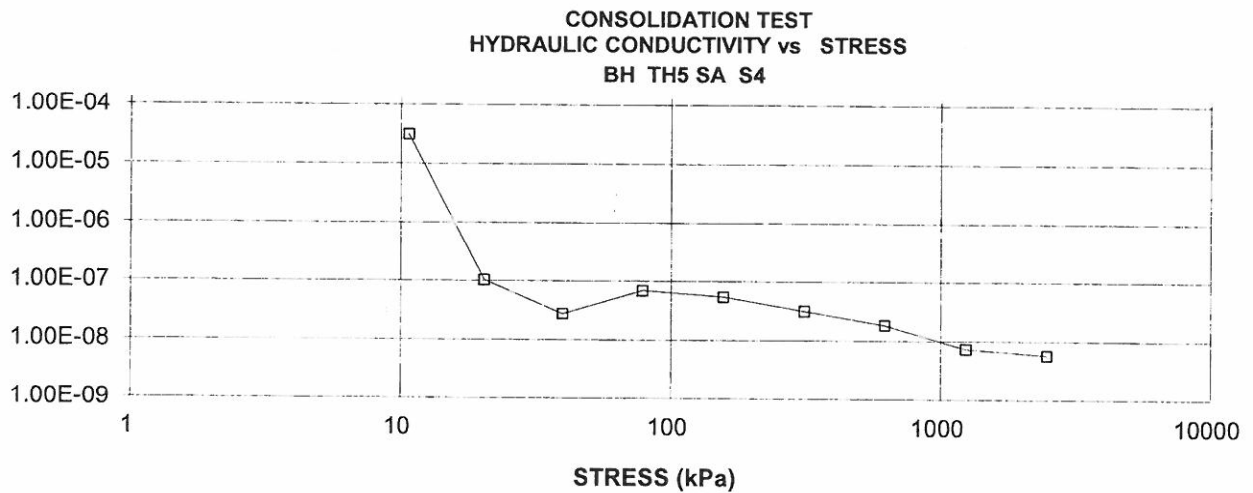
COEFFICIENT OF CONSOLIDATION,  
cm²/s



VOLUME COMPRESSIBILITY, m²/kN



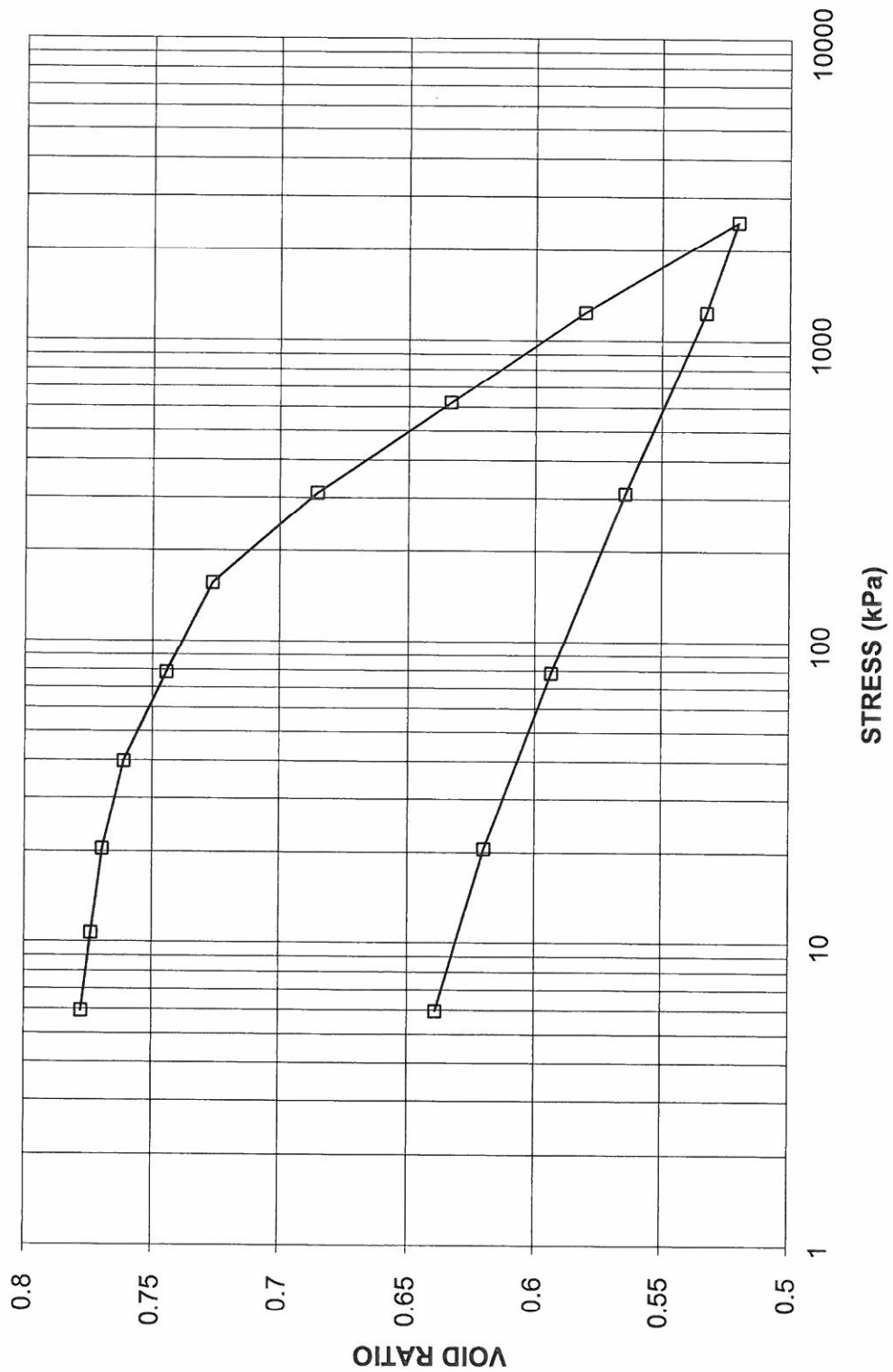
HYDRAULIC CONDUCTIVITY, cm/s



CONSOLIDATION TEST  
VOID RATIO VS LOG STRESS

FIGURE

CONSOLIDATION TEST  
VOID RATIO vs STRESS  
BH TH5 SA S4



Project No. 1652876

Prepared By: LH

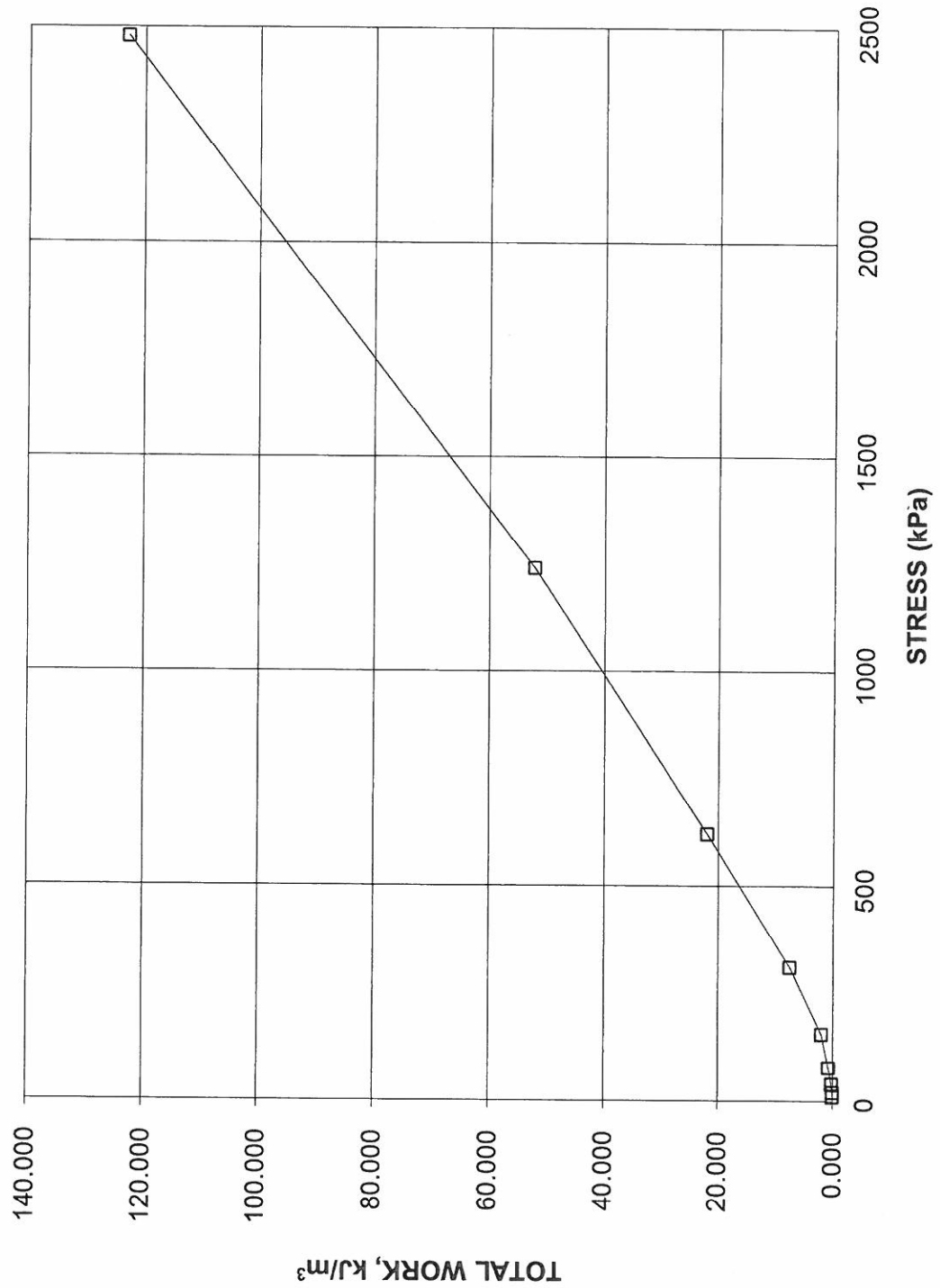
Golder Associates

Checked By: *[Signature]*

**CONSOLIDATION TEST  
TOTAL WORK VS STRESS**

**FIGURE**

**CONSOLIDATION TEST  
TOTAL WORK,  $\text{kJ/m}^3$  vs STRESS  
BH TH5 SA S4**



Project No. 1652876

Prepared By: LH

**Golder Associates**

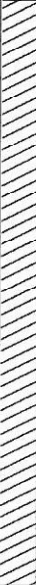
Checked By: *[Signature]*



**Engineering And Testing  
Solutions That Work For You**

**Test Hole #: TH7**  
**Client:** Neegan Burnside Ltd.  
**Site:** MB Hydro Kelsey GS  
**Location:** See Figure 1  
**Project:** Geotechnical Investigation, MB Hydro Kelsey GS Sewage Lagoon Project

**File No.:** 15-185-01  
**Date Drilled:** January 21, 2016  
**Grade Elevation:** 177.5 m  
**Water Elevation:** - -

SUBSURFACE PROFILE				SAMPLE DATA				SHEAR STRENGTH (kPa)		
Depth (m)	Soil Symbol	Description	Elevation (m)	Sample No.	Sample Type	Moisture Content (%)	Blows/300 mm			
								Moisture Content (%)		
								PL  -----X-----  LL 20 40 60 80		
0.0		Ground Surface	177.5							
		<b>Clay (CH)</b> - light to medium brown, frozen to 0.5 m, moist, firm, highly plastic, with silt.								
1.0					S1		32.5			
		- at 1.5 m, occa. silt lenses.	176.0							
					S2		26.9			
2.0										
		- below 2.4 m, soft, and silt.	175.0							
				S3		29.7				
				S4		25.2				
3.0		<b>End of Test Hole</b> - end of test hole at 3.0 m below existing grade. - no seepage or sloughing during drilling. - test hole backfilled with auger cuttings and bentonite.	174.0							
4.0										
5.0										
			172.0							

ENG- TECH Consulting Limited

Logged by: cdh

Reviewed by: *cdh*

Drilled By: Maple Leaf Drilling Ltd.

Drill Rig: B20 Cricket

Auger Size: 100 mm solid stem

Completion Depth: 3.0 m

Completion Elevation: 174.5 m

Sheet: 1 of 1

SAMPLE TYPE



SPLIT BARREL



SHELBY TUBE



AUGER CUTTINGS



SPLIT SPOON



**Engineering And Testing  
Solutions That Work For You**

**Test Hole #: TH8**

**Client:** Neegan Burnside Ltd.

**Site:** MB Hydro Kelsey GS

**Location:** See Figure 1

**Project:** Geotechnical Investigation, MB Hydro Kelsey GS Sewage Lagoon Project

**File No.:** 15-185-01

**Date Drilled:** January 21, 2016

**Grade Elevation:** 180.9 m

**Water Elevation:** - -

SUBSURFACE PROFILE				SAMPLE DATA				SHEAR STRENGTH (kPa)			
Depth (m)	Soil Symbol	Description	Elevation (m)	Sample No.	Sample Type	Moisture Content (%)	Blows/300 mm	Moisture Content (%)	P. Pen	Torvane	UC
								PL  -----X-----  LL 20    40    60    80			
0.0		Ground Surface	180.9								
		<b>Clay (CH)</b> - light brown, moist, firm to 0.75 m, highly plastic, some to with silt, organics in upper 50 mm, zones of and silt (silty) are more medium to highly plastic.									
1.0		- at 1.0 m, field vane, peak = 141 kPa, residual = 62 kPa.	180.0	S1		29.4					
		- below 1.8 m, soft, and silt.									
2.0		- at 2.3 m, field vane, peak = 115 kPa, residual = 71 kPa.	179.0	S2		25.4					
				S3		27.9					
				S4		33.6					
3.0		<b>End of Test Hole</b> - end of test hole at 3.0 m below existing grade. - no seepage or sloughing during drilling. - test hole backfilled with auger cuttings and bentonite.	178.0								
4.0			177.0								
5.0			176.0								

ENG- TECH Consulting Limited

Logged by: cdh

Reviewed by: *CDH*

Drilled By: Maple Leaf Drilling Ltd.

Drill Rig: B20 Cricket

Auger Size: 100 mm solid stem

Completion Depth: 3.0 m

Completion Elevation: 177.9 m

Sheet: 1 of 1

SAMPLE TYPE



SPLIT BARREL



SHELBY TUBE



AUGER CUTTINGS



SPLIT SPOON





**Engineering And Testing**  
Solutions That Work For You

**Test Hole #: TH9**  
**Client:** Neegan Burnside Ltd.  
**Site:** MB Hydro Kelsey GS  
**Location:** See Figure 1  
**Project:** Geotechnical Investigation, MB Hydro Kelsey GS Sewage Lagoon Project

**File No.:** 15-185-01  
**Date Drilled:** January 21, 2016  
**Grade Elevation:** 183.8 m  
**Water Elevation:** - -

SUBSURFACE PROFILE				SAMPLE DATA				SHEAR STRENGTH (kPa)						
Depth (m)	Soil Symbol	Description	Elevation (m)	Sample No.	Sample Type	Moisture Content (%)	Blows/300 mm	Moisture Content (%)			P. Pen	Torvane	UC	
								PL	X	LL				
								20	40	60	80			
0.0		Ground Surface	183.8											
		<b>Clay (CH)</b> - light to medium brown, frozen to 0.9 m, moist, firm, highly plastic, some to with silt, organics in top 50 mm.												
1.0		- below 0.9 m, trace silt inclusions & silt lenses.	183.0	S1		31.9								
			182.0	S2		25.4						60	48	
2.0		- below 1.8 m, firm to soft.												
			181.0											
3.0				S3		26.9						48	29	
			180.0											
4.0				S4		25.0						48		
			179.0											
5.0		<b>End of Test Hole</b> - end of test hole at 4.6 m below existing grade. - no seepage or sloughing during drilling. - test hole backfilled with auger cuttings and bentonite.												

ENG- TECH Consulting Limited

Logged by: cdh

Reviewed by:

Drilled By: Maple Leaf Drilling Ltd.

Drill Rig: B20 Cricket

Auger Size: 100 mm solid stem

Completion Depth: 4.6 m

Completion Elevation: 179.2 m

Sheet: 1 of 1

SAMPLE TYPE



SPLIT BARREL



SHELBY TUBE



AUGER CUTTINGS



SPLIT SPOON



**Engineering And Testing  
Solutions That Work For You**

**Test Hole #: TH10**

**Client:** Neegan Burnside Ltd.

**Site:** MB Hydro Kelsey GS

**Location:** See Figure 1

**Project:** Geotechnical Investigation, MB Hydro Kelsey GS Sewage Lagoon Project

**File No.:** 15-185-01

**Date Drilled:** January 21, 2016

**Grade Elevation:** 181.1 m

**Water Elevation:** - -

SUBSURFACE PROFILE				SAMPLE DATA								SHEAR STRENGTH (kPa)		
Depth (m)	Soil Symbol	Description	Elevation (m)	Sample No.	Sample Type	Moisture Content (%)	Blows/300 mm	Moisture Content (%)				P. Pen	Torvane	UC
								PL	LL	X				
								20	40	60	80			
0.0		Ground Surface	181.1											
		<b>Clay (CH)</b> - light to medium brown, frozen to 0.6 m, moist, firm, highly plastic, some to with silt, upper 50 mm organics.												
1.0			180.0											
2.0			179.0											
3.0		<b>End of Test Hole</b> - end of test hole at 3.0 m below existing grade. - no seepage or sloughing observed during drilling. - test hole backfilled with auger cuttings and bentonite.	178.0											
4.0			177.0											
5.0			176.0											

ENG- TECH Consulting Limited

Logged by: cdh

Reviewed by: *cdh*

Drilled By: Maple Leaf Drilling Ltd.

Drill Rig: B20 Cricket

Auger Size: 100 mm solid stem

Completion Depth: 3.0 m

Completion Elevation: 178.1 m

Sheet: 1 of 1

SAMPLE TYPE



SPLIT BARREL



SHELBY TUBE



AUGER CUTTINGS



SPLIT SPOON





**Engineering And Testing  
Solutions That Work For You**

**Test Hole #: TH11**

**Client:** Neegan Burnside Ltd.

**Site:** MB Hydro Kelsey GS

**Location:** See Figure 1

**Project:** Geotechnical Investigation, MB Hydro Kelsey GS Sewage Lagoon Project

**File No.:** 15-185-01

**Date Drilled:** January 21, 2016

**Grade Elevation:** 179.3 m

**Water Elevation:** - -

SUBSURFACE PROFILE				SAMPLE DATA				SHEAR STRENGTH (kPa)			
Depth (m)	Soil Symbol	Description	Elevation (m)	Sample No.	Sample Type	Moisture Content (%)	Blows/300 mm	Moisture Content (%)	P. Pen	Torvane	UC
								PL  -----X-----  LL 20 40 60 80			
0.0		Ground Surface	179.3								
		Clay (CH) - light brown, moist, firm, highly plastic, some to with silt, organics in upper 50 mm.	179.0								
1.0				S1		29.2					
			178.0								
2.0				S2		30.0					
			177.0								
				S3		26.3					
3.0				S4		28.2					
		End of Test Hole - end of test hole at 3.0 m below existing grade. - no seepage or sloughing during drilling. - test hole backfilled with auger cuttings and bentonite.	176.0								
4.0			175.0								
5.0			174.0								

ENG- TECH Consulting Limited

Logged by: cdh

Reviewed by:

Drilled By: Maple Leaf Drilling Ltd.

Drill Rig: B20 Cricket

Auger Size: 100 mm solid stem

Completion Depth: 3.0 m

Completion Elevation: 176.3 m

Sheet: 1 of 1

SAMPLE TYPE



SPLIT BARREL



SHELBY TUBE



AUGER CUTTINGS



SPLIT SPOON





**Engineering And Testing  
Solutions That Work For You**

**Test Hole #: TH12**

**Client:** Neegan Burnside Ltd.

**Site:** MB Hydro Kelsey GS

**Location:** See Figure 1

**Project:** Geotechnical Investigation, MB Hydro Kelsey GS Sewage Lagoon Project

**File No.:** 15-185-01

**Date Drilled:** January 21, 2016

**Grade Elevation:** 180.8 m

**Water Elevation:** - -

SUBSURFACE PROFILE				SAMPLE DATA				Moisture Content (%)		SHEAR STRENGTH (kPa)		
Depth (m)	Soil Symbol	Description	Elevation (m)	Sample No.	Sample Type	Moisture Content (%)	Blows/300 mm			P. Pen	Torvane	UC
									PL  -----X-----  LL 20    40    60    80			
0.0		Ground Surface	180.8									
1.0		<b>Clay (CH)</b> - light brown, frozen to 0.6 m, moist, firm, highly plastic, some to with silt.	180.0	S1		23.5				144	72	
2.0		- below 2.3 m, firm to soft.	179.0	S2		25.8				144	72	
3.0		- below 2.7 m, soft.	178.0	S3		25.2				144	72	
4.0		- at 3.0 m, field vane, peak = 88 kPa, residual = 44 kPa.	178.0	S4		25.5				48	24	31
5.0			177.0	S5		26.1				48	24	
6.0		- below 4.6 m, soft to very soft, and silt.	176.0	S6		23.7						33
7.0		- at 4.9 m, oxide inclusions, very soft to 5.8 m.	176.0	S7		24.8						
8.0			175.0	S8		15.0						
9.0		- at 5.5 m, silt inclusions.	175.0	S9		15.3						
10.0		- below 5.8 m, greyish.	174.0	S10		24.4						
11.0		<b>Clay Till (CI)</b> - grey, moist, very soft, medium plastic, with to and silt, some sand.	174.0									
12.0			173.0	S11		30.0						
			172.0									
			171.0									
			170.0									
			169.0									
		<b>End of Test Hole</b> - auger refusal at 9.9 m below existing grade. - seepage and sloughing observed below 6.1 m. - test hole open to 8.5 m. - test hole backfilled with auger cuttings.										

ENG- TECH Consulting Limited

Logged by: cdh

Reviewed by: CH

Drilled By: Maple Leaf Drilling Ltd.

Drill Rig: B20 Cricket

Auger Size: 100 mm solid stem

Completion Depth: 9.9 m

Completion Elevation: 170.9 m

Sheet: 1 of 1

SAMPLE TYPE



SPLIT BARREL



SHELBY TUBE



AUGER CUTTINGS



SPLIT SPOON



**Engineering And Testing**  
Solutions That Work For You

**Test Hole #: TH13**

**Client:** Neegan Burnside Ltd.

**Site:** MB Hydro Kelsey GS

**Location:** See Figure 1

**Project:** Geotechnical Investigation, MB Hydro Kelsey GS Sewage Lagoon Project

**File No.:** 15-185-01

**Date Drilled:** January 21, 2016

**Grade Elevation:** 182.4 m

**Water Elevation:** - -

SUBSURFACE PROFILE				SAMPLE DATA				SHEAR STRENGTH (kPa)		
Depth (m)	Soil Symbol	Description	Elevation (m)	Sample No.	Sample Type	Moisture Content (%)	Blows/300 mm			
								Moisture Content (%)		
								PL  -----X-----  LL 20 40 60 80		
0.0		Ground Surface	182.4							
		<b>Organics (600 mm)</b> - blackish brown, organics, rootlets, leaves.	182.0							
1.0		<b>Clay (CH)</b> - light to medium brown, frozen to 0.5 m, moist, firm to soft, highly plastic, some to with silt.			S1		32.7		24	29
					S2		27.9		24	29
2.0										
					S3		27.4		24	14
3.0					S4		27.6		24	14
4.0			- below 3.0 m, oxide inclusions, soft.	179.0						
					S5		25.4			10
			178.0							
				S6		20.8			10	
5.0		<b>End of Test Hole</b> - end of test hole at 4.6 m below existing grade. - no seepage or sloughing during drilling. - test hole backfilled with auger cuttings.	177.0							

ENG-TECH Consulting Limited

Logged by: cdh

Reviewed by: CH

Drilled By: Maple Leaf Drilling Ltd.

Drill Rig: B20 Cricket

Auger Size: 100 mm solid stem

Completion Depth: 4.6 m

Completion Elevation: 177.8 m

Sheet: 1 of 1

SAMPLE TYPE



SPLIT BARREL



SHELBY TUBE



AUGER CUTTINGS



SPLIT SPOON





**Engineering And Testing  
Solutions That Work For You**

**Test Hole #: TH14**

**Client:** Neegan Burnside Ltd.

**Site:** MB Hydro Kelsey GS

**Location:** See Figure 1

**Project:** Geotechnical Investigation, MB Hydro Kelsey GS Sewage Lagoon Project

**File No.:** 15-185-01

**Date Drilled:** January 21, 2016

**Grade Elevation:** 184.3 m

**Water Elevation:** - -

SUBSURFACE PROFILE				SAMPLE DATA								SHEAR STRENGTH (kPa)		
Depth (m)	Soil Symbol	Description	Elevation (m)	Sample No.	Sample Type	Moisture Content (%)	Blows/300 mm	Moisture Content (%)				P. Pen	Torvane	UC
								PL	LL					
								20	40	60	80			
0.0		Ground Surface	184.3											
		Clay Fill (CI-CH) - light to medium brown, frozen to 0.6 m, moist, medium to highly plastic, some silt.	184.0											
1.0		End of Test Hole - auger refusal on concrete rubble 0.8 m below existing grade. - no seepage or sloughing observed during drilling. - test hole backfilled with auger cuttings.	183.0											
2.0														

ENG-TECH Consulting Limited

Logged by: cdh

Reviewed by: *CH*

Drilled By: Maple Leaf Drilling Ltd.

Drill Rig: B20 Cricket

Auger Size: 100 mm solid stem

Completion Depth: 0.8 m

Completion Elevation: 183.7 m

Sheet: 1 of 1

SAMPLE TYPE



SPLIT BARREL



SHELBY TUBE



AUGER CUTTINGS



SPLIT SPOON



**Engineering And Testing  
Solutions That Work For You**

**Test Hole #: TH15**

**Client:** Neegan Burnside Ltd.

**Site:** MB Hydro Kelsey GS

**Location:** See Figure 1

**Project:** Geotechnical Investigation, MB Hydro Kelsey GS Sewage Lagoon Project

**File No.:** 15-185-01

**Date Drilled:** January 21, 2016

**Grade Elevation:** 183.8 m

**Water Elevation:** - -

SUBSURFACE PROFILE				SAMPLE DATA				SHEAR STRENGTH (kPa)		
Depth (m)	Soil Symbol	Description	Elevation (m)	Sample No.	Sample Type	Moisture Content (%)	Blows/300 mm	Moisture Content (%)		
								PL  -----X-----  LL 20 40 60 80	P. Pen	Torvane
0.0		Ground Surface	183.8							
		<b>Clay Fill (CI-CH)</b> - medium brown, frozen to 0.6 m, moist, medium to highly plastic, some silt.								
1.0		<b>End of Test Hole</b> - auger refusal on suspected boulder 1.0 m below existing grade. - no seepage or sloughing observed during drilling. - test hole backfilled with auger cuttings.								
2.0			182.0							

ENG- TECH Consulting Limited

Logged by: cdh

Reviewed by:

Drilled By: Maple Leaf Drilling Ltd.

Drill Rig: B20 Cricket

Auger Size: 100 mm solid stem

Completion Depth: 1.0 m

Completion Elevation: 182.8 m

Sheet: 1 of 1

SAMPLE TYPE



SPLIT BARREL



SHELBY TUBE



AUGER CUTTINGS



SPLIT SPOON



**Engineering And Testing**  
Solutions That Work For You

**Test Hole #: TH16**

**Client:** Neegan Burnside Ltd.

**Site:** MB Hydro Kelsey GS

**Location:** See Figure 1

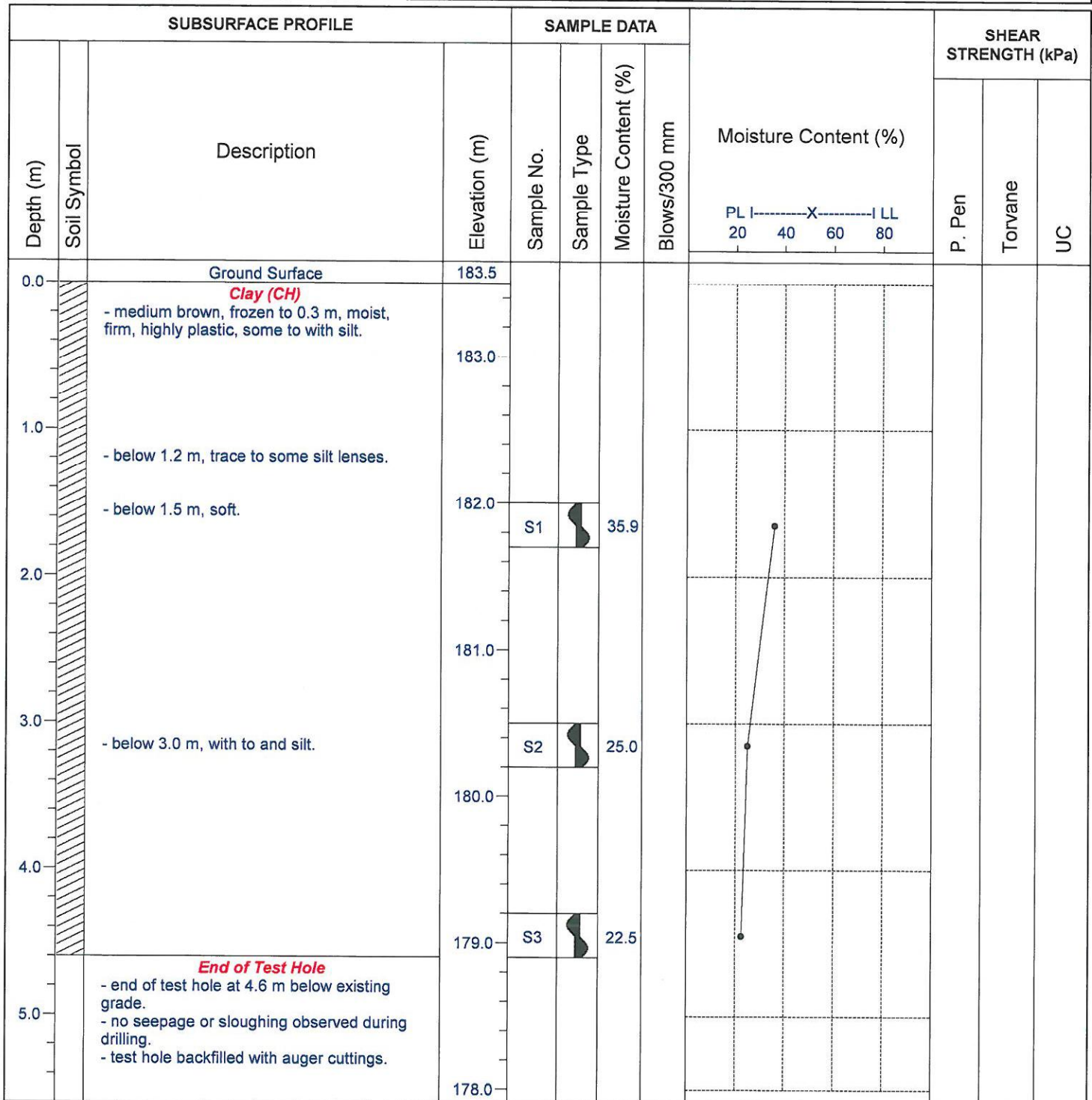
**Project:** Geotechnical Investigation, MB Hydro Kelsey GS Sewage Lagoon Project

**File No.:** 15-185-01

**Date Drilled:** January 21, 2016

**Grade Elevation:** 183.5 m

**Water Elevation:** - -



ENG- TECH Consulting Limited

Logged by: cdh

Reviewed by: *cdh*

Drilled By: Maple Leaf Drilling Ltd.

Drill Rig: B20 Cricket

Auger Size: 100 mm solid stem

Completion Depth: 4.6 m

Completion Elevation: 178.9 m

Sheet: 1 of 1

SAMPLE TYPE



SPLIT BARREL



SHELBY TUBE



AUGER CUTTINGS



SPLIT SPOON



## **APPENDIX C**

Particle Size Analysis Reports (12)

Moisture Density Reports (2)

Direct Shear Strength Test

Compressibility Test



Unit 6 - 854 Marion Street  
Winnipeg, Manitoba  
R2J 0K4  
eng_tech@mts.net  
www.eng-tech.ca

## PARTICLE SIZE ANALYSIS REPORT

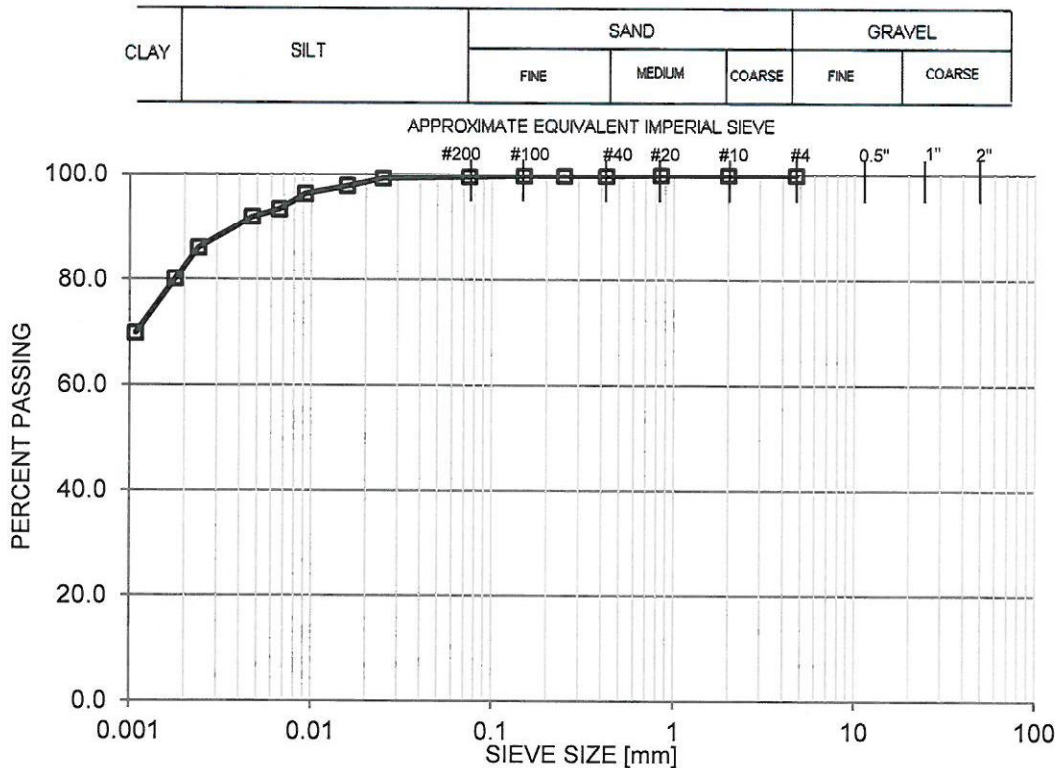
Neegan Burnside Ltd.  
106 - B Scurfield Blvd.  
Winnipeg, Manitoba  
R3Y 1G4

File No.: 15-185-01  
Ref. No.: 15-185-1-3

ATTENTION: Paul Klassen, P. Eng

PROJECT: GEOTECHNICAL INVESTIGATION, MB HYDRO KELSEY GS SEWAGE LAGOON PROJECT

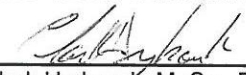
Test Hole No. 2 Sample No. S1 Depth: 0.76 m  
Sampled By: ENG-TECH Type of Sample: Auger cutting Source: -  
Date Sampled: Jan 20/16 Date Received: Jan 29/16 Date Tested: Feb 10/16



Percent of: GRAVEL (0.0 %), SAND (0.4 %), SILT (17.0 %), CLAY (82.6 %)  
Sample Description:

COMMENTS:

ENG-TECH Consulting Limited

per   
Clark Hyrhoruk, M. Sc., P. Eng, President  
Ph: (204) 233-1694 Fax: (204) 235-1579





Unit 6 - 854 Marion Street  
Winnipeg, Manitoba  
R2J 0K4  
eng_tech@mts.net  
www.eng-tech.ca

## PARTICLE SIZE ANALYSIS REPORT

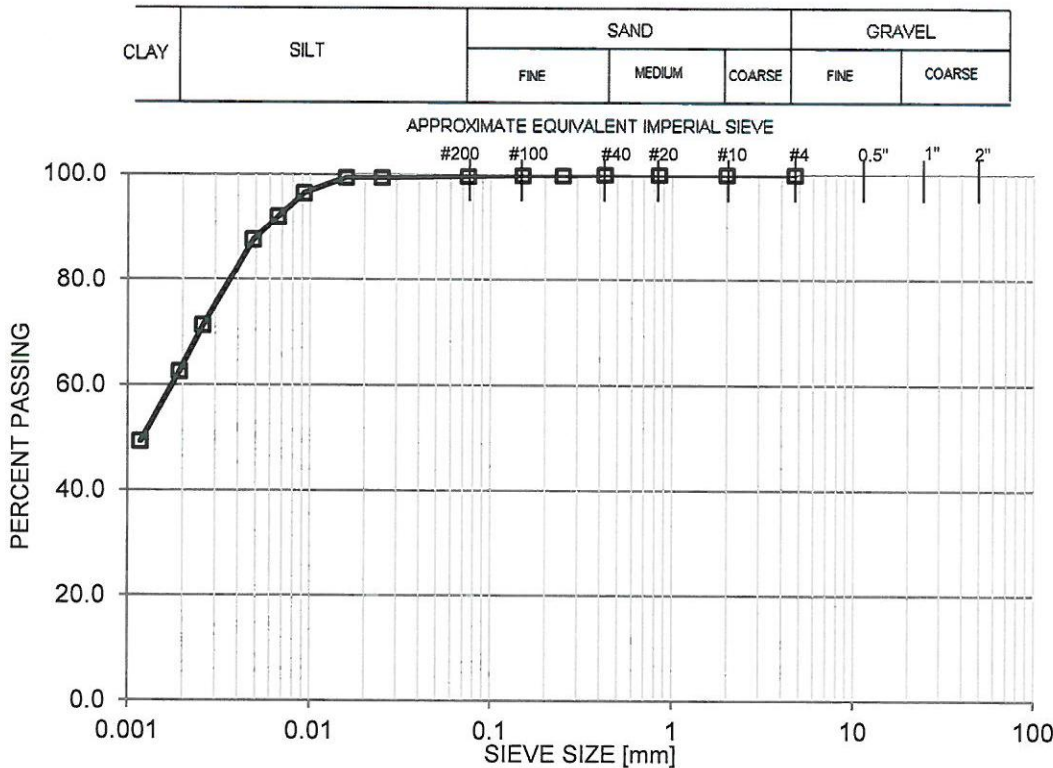
Neegan Burnside Ltd.  
106 - B Scurfield Blvd.  
Winnipeg, Manitoba  
R3Y 1G4

File No.: 15-185-01  
Ref. No.: 15-185-1-4

ATTENTION: Paul Klassen, P. Eng

PROJECT: GEOTECHNICAL INVESTIGATION, MB HYDRO KELSEY GS SEWAGE LAGOON PROJECT

Test Hole No. 2 Sample No. S2 Depth: 1.5 m  
Sampled By: ENG-TECH Type of Sample: Auger cutting Source: -  
Date Sampled: Jan 20/16 Date Received: Jan 29/16 Date Tested: Feb 10/16



Percent of: GRAVEL (0.0 %), SAND (0.4 %), SILT (35.7 %), CLAY (63.9 %)  
Sample Description:

COMMENTS:

ENG-TECH Consulting Limited

per   
Clark Hyrhoruk, M. Sc., P. Eng, President  
Ph: (204) 233-1694 Fax: (204) 235-1579



Unit 6 - 854 Marion Street  
Winnipeg, Manitoba  
R2J 0K4  
eng_tech@mts.net  
www.eng-tech.ca

## PARTICLE SIZE ANALYSIS REPORT

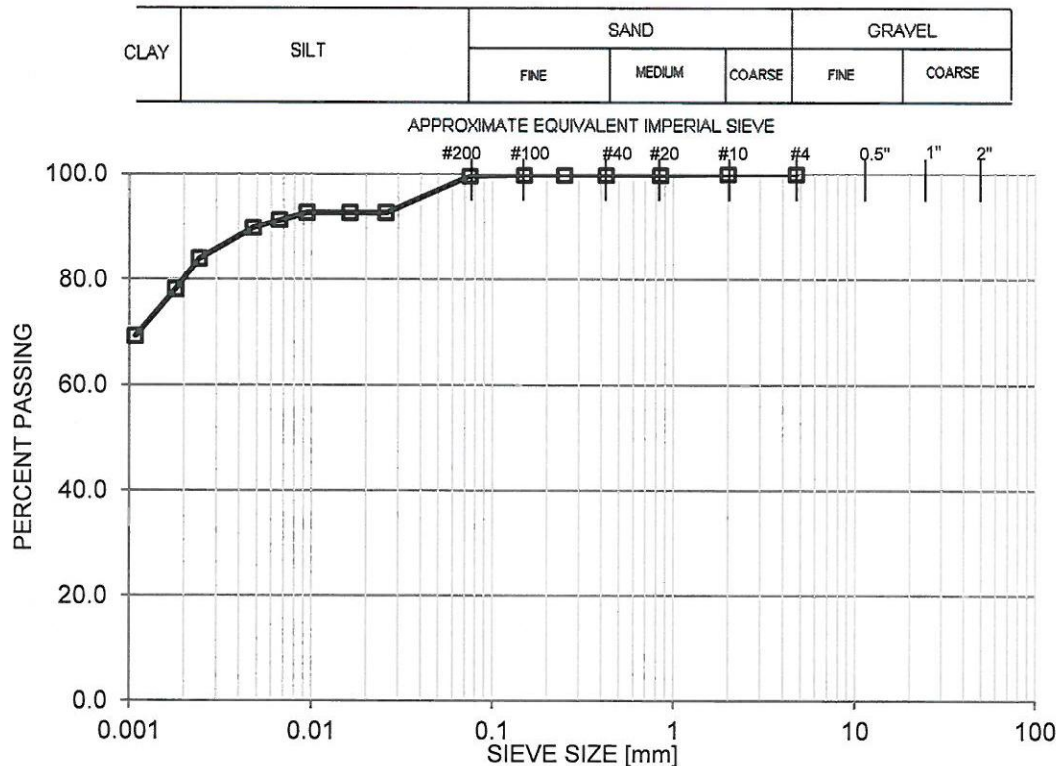
Neegan Burnside Ltd.  
106 - B Scurfield Blvd.  
Winnipeg, Manitoba  
R3Y 1G4

File No.: 15-185-01  
Ref. No.: 15-185-1-6

ATTENTION: Paul Klassen, P. Eng

PROJECT: GEOTECHNICAL INVESTIGATION, MB HYDRO KELSEY GS SEWAGE LAGOON PROJECT

Test Hole No. 3 Sample No. S2 Depth: 1.5 m  
Sampled By: ENG-TECH Type of Sample: Auger cutting Source: -  
Date Sampled: Jan 20/16 Date Received: Jan 29/16 Date Tested: Feb 10/16



Percent of: GRAVEL (0.0 %), SAND (0.4 %), SILT (19.3 %), CLAY (80.3 %)

Sample Description:

COMMENTS:

ENG-TECH Consulting Limited

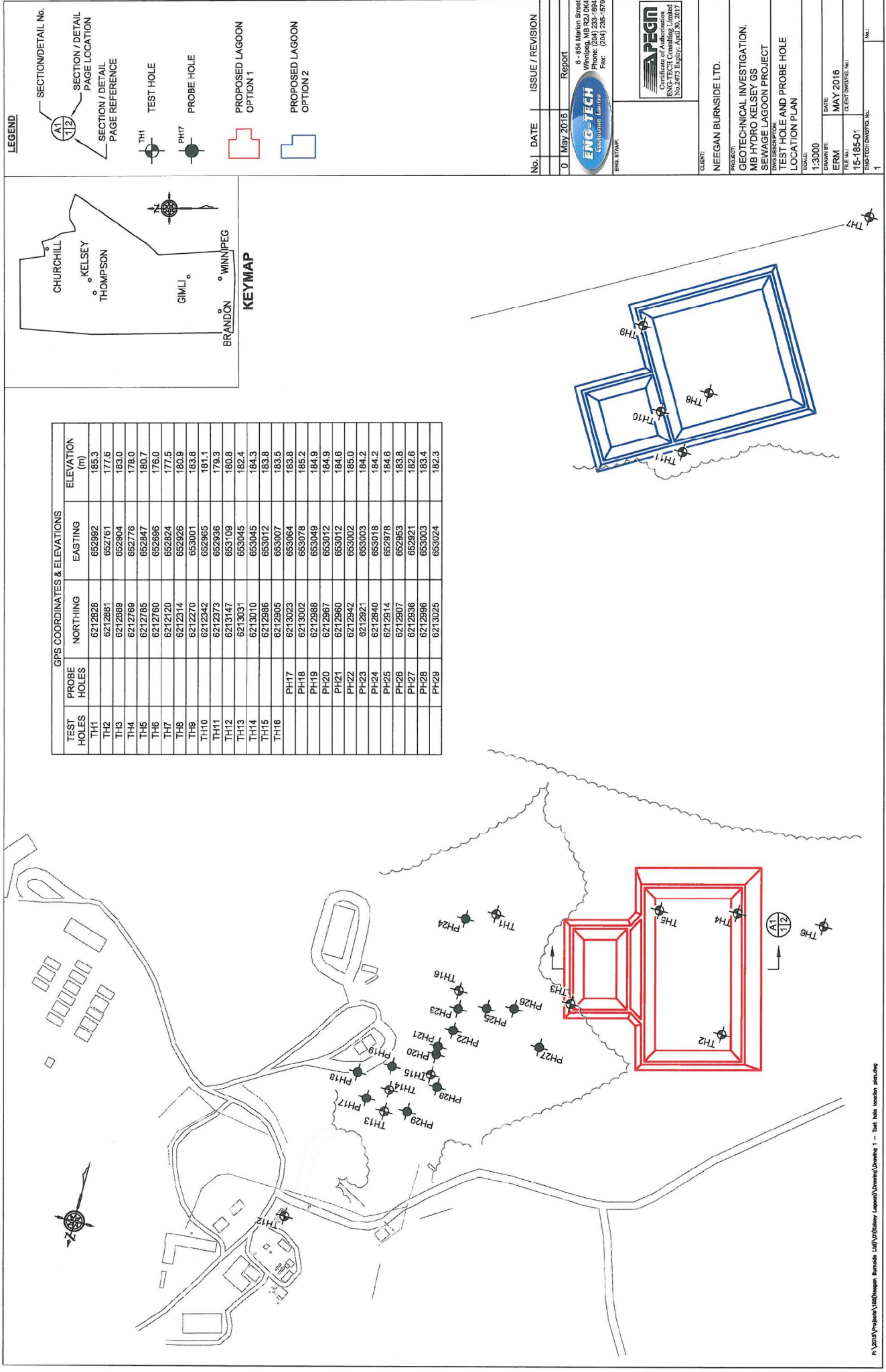
per   
Clark Hyrhoruk, M. Sc., P. Eng, President  
Ph: (204) 233-1694 Fax: (204) 235-1579

## **APPENDIX A**

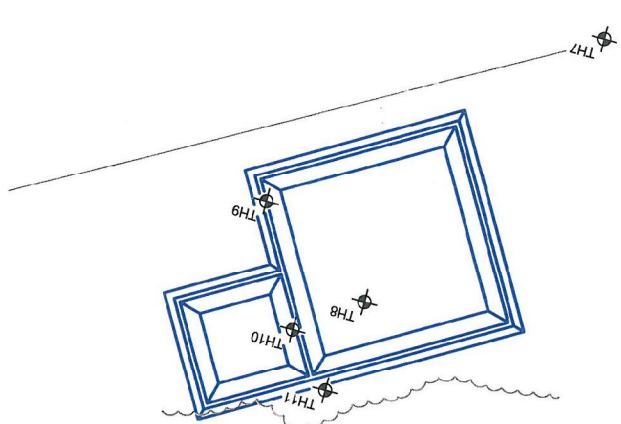
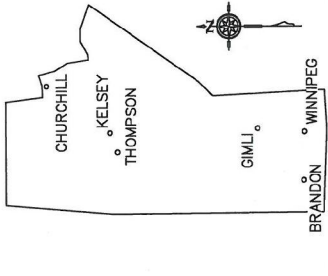
Figure 1 – Test Hole and Probe Hole Location Plan

Figure 2 – Slope Stability Analysis – Section A1

Figure 3 – Hydraulic Conductivity Results



GPS COORDINATES & ELEVATIONS			
TEST HOLES	NORTHING	EASTING	ELEVATION (m)
TH1	6212828	652992	185.3
TH2	6212881	652761	177.6
TH3	6212889	652904	183.0
TH4	6212769	652776	178.0
TH5	6212785	652847	180.7
TH6	6212760	652696	176.0
TH7	6212120	652824	177.5
TH8	6212314	652926	180.9
TH9	6212270	653001	183.8
TH10	6212342	652965	181.1
TH11	6212373	652936	179.3
TH12	6213147	653108	180.8
TH13	6213031	653045	182.4
TH14	6213010	653045	184.3
TH15	6212986	653012	183.8
TH16	6212905	653007	183.5
PH17	6213023	653064	183.8
PH18	6213002	653078	185.2
PH19	6212988	653049	184.9
PH20	6212987	653012	184.9
PH21	6212960	653012	184.6
PH22	6212942	653002	185.0
PH23	6212921	653003	184.2
PH24	6212840	653018	184.2
PH25	6212914	652978	184.6
PH26	6212907	652963	183.8
PH27	6212936	652921	182.6
PH28	6212996	653003	183.4
PH29	6213025	653024	182.3



SECTION/DETAIL No.  
A1  
12

SECTION / DETAIL  
PAGE LOCATION  
PAGE REFERENCE

TEST HOLE  
TH1

PROBE HOLE  
PH17

PROPOSED LAGOON  
OPTION 1

PROPOSED LAGOON  
OPTION 2

No.

DATE

ISSUE / REVISION

0

May 2016

Report

ENG-TECH  
Engineering Limited

6 - 854 Marion Street  
Winnipeg, MB R2L 0K4  
Phone: (204) 225-8700  
Fax: (204) 225-8701

ENG STAMP

ENG-TECH  
Engineering Limited

CLIENT:

NEEGAN BURNSIDE LTD.

PROJECT:

GEOTECHNICAL INVESTIGATION,  
MB HYDRO KELSEY GS  
SEWAGE LAGOON PROJECT

DATE OF ISSUE:

15-185-01

LOCATION PLAN

SCALE:

1:3000

DRAWN BY:

ERM

DATE:

MAY 2016

FILE NO.:

15-185-01

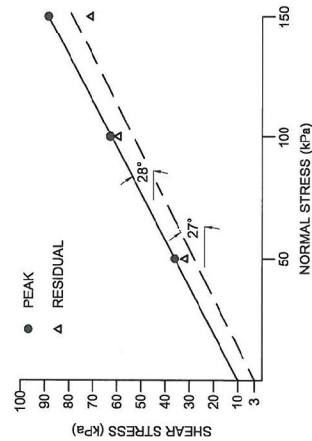
CLIENT DRAWING NO.:

1



SOIL STRENGTH PARAMETER VALUES USED IN MODELLING			
SOIL TYPE & CLASSIFICATION	BULK DENSITY $\gamma$ ( $\text{kN/m}^3$ )	EFFECTIVE COHESION $c'$ (kPa)	EFFECTIVE FRICTION ANGLE $\phi'$ (°)
BROWN CLAY (C)	20	3	27 (18)

- VALUES IN PARENTHESIS ARE A CONSERVATIVE FRICTION ANGLE BASED ON THE DIRECT SHEAR TEST.

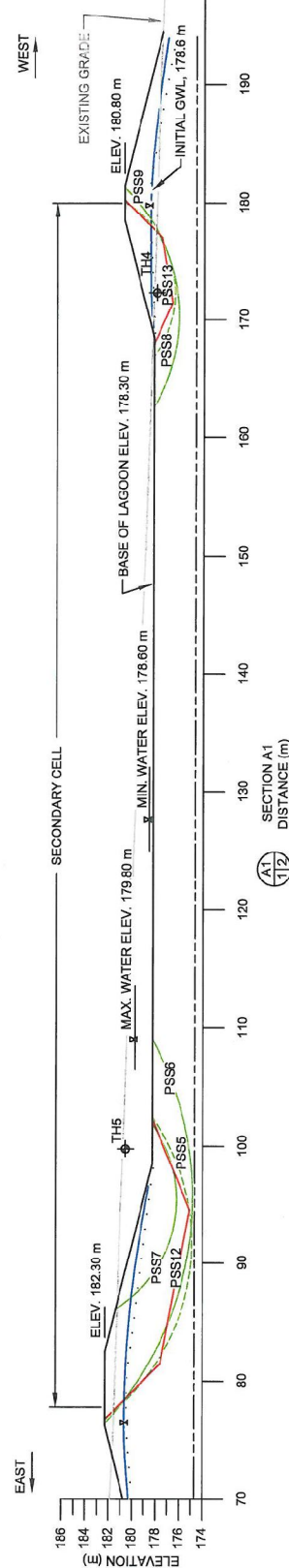
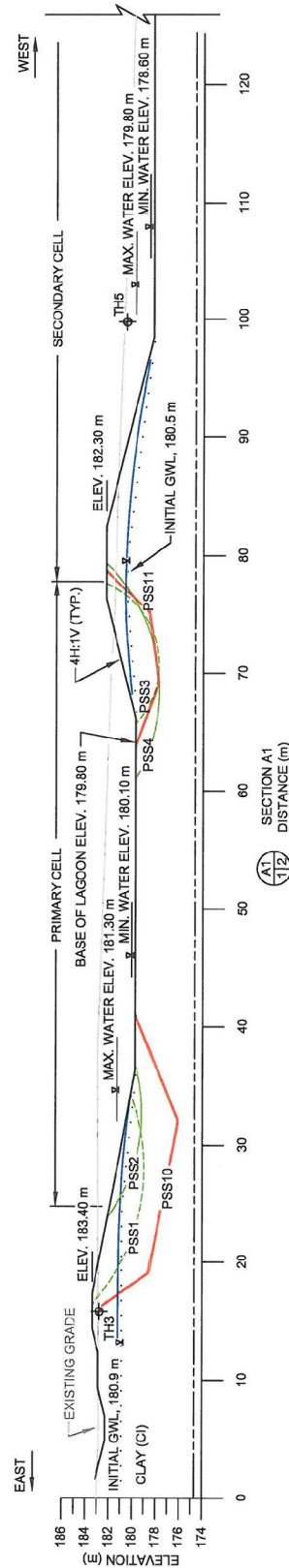


TRANSIENT SEEPAGE MODEL		
SOIL TYPE & CLASSIFICATION	HYDRAULIC CONDUCTIVITY	INITIAL GWL
BROWN CLAY (C)	$6 \times 10^{-8} \text{ cm/s}$	180.9 m

FACTOR OF SAFETY (FS) VALUES			
LAGOON CELL	POTENTIAL SLIP SURFACE (PSS)		1) PROPOSED LAGOON DESIGN
	CIRCULAR	BLOCK	
PRIMARY CELL	PSS1†	-	2.61 (1.81)
	PSS2	-	2.74 (1.95)
	PSS3†	-	2.90
	PSS4	-	2.49 (1.77)
	PSS5†	-	2.58 (1.88)
SECONDARY CELL	PSS6†	-	2.74
	PSS7	-	2.10 (1.47)
	PSS8	-	2.26 (1.60)
	PSS9	-	2.31 (1.67)
	PSS10†	-	2.47
SECONDARY CELL	PSS11†	-	2.24 (1.64)
	PSS12†	-	2.44 (1.81)
	PSS13†	-	2.75 (2.02)
	PSS14†	-	2.65
	PSS15†	-	3.08

† CRITICAL SLIP SURFACE.

- 1 USING RESIDUAL STRENGTH-VALUES, WITH INITIAL GWL AT 180.9 m.
  - 2 USING RESIDUAL STRENGTH-VALUES, WITH GWL AFTER SEEPAGE MODELING.
- VALUES IN PARENTHESIS ARE MODELED USING EFFECTIVE FRICTION ANGLE EQUAL TO 18°.



# LEGEND

SECTION/DETAIL No.  
A1  
1/2  
SECTION / DETAIL  
PAGE LOCATION  
PAGE REFERENCE



GWL LEVEL AFTER  
SEEPAGE MODELING

## NOTES

- ALL ELEVATIONS ARE IN METERS UNLESS OTHERWISE NOTED.
- GROUNDWATER LEVEL (GWL) DECREASES FROM EAST TO WEST.
- TEST HOLE LOCATIONS ARE APPROXIMATE.
- ALL BERM SLOPE ANGLES ARE 4H:1V (HORIZONTAL:VERTICLE)

No.	DATE	ISSUE / REVISION
0	May 2016	Report

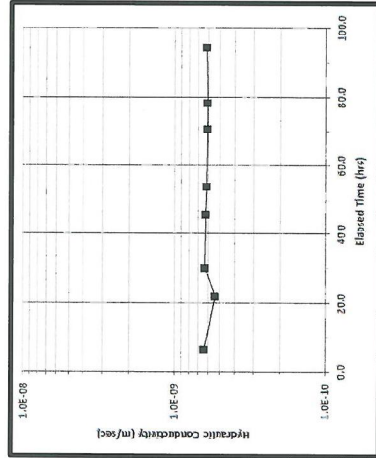


8 - 654 Marion Street  
Winnipeg, MB R2L 0K4  
Phone: (204) 233-1894  
Fax: (204) 235-1575

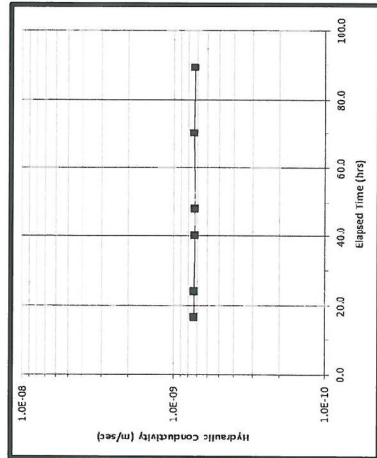


ENG-TECH Consulting Limited  
15-2475 EMBURY AVE. #101  
WILLOWDALE, ONT. M2H 3B7

CLIENT:	NEEGAN BURNSIDE LTD.
PROJECT:	GEO-TECHNICAL INVESTIGATION, MB HYDRO KELSEY GS SEWAGE LAGOON PROJECT
SECTION:	SLOPE STABILITY ANALYSIS - SECTION A1
SCALE:	1:400
DATE:	MAY 2016
PREPARED BY:	CLINT SWANSON, INC.
CHECKED BY:	15-185-01
DATE:	15-185-01
SCALE:	1:400



HYDRAULIC CONDUCTIVITY SAMPLE TH4 S2



HYDRAULIC CONDUCTIVITY SAMPLE TH6 S2

## HYDRAULIC CONDUCTIVITY TEST DATA

SAMPLE IDENTIFICATION		TH4 S2	TH6 S2	TH8 S4
Sample Elevation		176.1 m	±174.5 m	178.3 m
INITIAL VALUES				
ENG-TECH Reference No.		15-185-1-24	15-185-1-25	15-185-1-26
Location of Sample in Tube (cm)		48.3	- -	30.5
Length (cm)		630	5.97	5.59
Diameter (cm)		7.15	7.03	7.03
Area (cm²)		40.1	39.4	38.8
Volume (cm³)		252.8	235.0	216.9
Water Content (%)		24.1	27.1	22.9
Bulk Dry Density (kg/m³)		1643	1549	1671
Specific Gravity (G _s ) (assumed)		2.70	2.70	2.70
Void Ratio		0.643	0.743	0.615
Degree of Saturation (%)		~100	98.5	~100
FINAL VALUES				
Length (cm)		633	5.98	5.41
Diameter (cm)		7.15	7.07	7.12
Area (cm²)		40.1	39.2	38.8
Volume (cm³)		254.0	234.7	215.5
Water Content (%)		24.6	27.5	23.2
Bulk Dry Density (kg/m³)		1625	1555	1664
Specific Gravity (G _s ) (assumed)		2.70	2.70	2.70
Void Ratio		0.662	0.736	0.623
Degree of Saturation (%)		~100	~100	~100
CONSOLIDATION PHASE				
Confining Pressure (kPa)		103.4	103.4	103.4
Pore Water Pressure (kPa)		82.7	82.7	82.7
Effective Stress (kPa)		20.7	20.7	20.7
PERMEATION PHASE				
Confining Pressure (kPa)		103.4	103.4	103.4
Pore Water Pressure (kPa)		82.7	82.7	82.7
Effective Stress (kPa)		20.7	20.7	20.7
Hydraulic Gradient		17.8	18.8	20.8
Permeant Fluid		Distilled Water	Distilled Water	Distilled Water
HYDRAULIC CONDUCTIVITY at TEST TEMPERATURE OF 21 °C (cm/sec)		5.1 x 10 ⁻⁶	7.3 x 10 ⁻⁶	5.0 x 10 ⁻⁶
HYDRAULIC CONDUCTIVITY at TEMPERATURE OF 20 °C (K ₂₀ ) (cm/sec)		3.0 x 10 ⁻⁶	7.1 x 10 ⁻⁷	4.9 x 10 ⁻⁶



## **APPENDIX B**

Soil Classification Sheet  
Test Hole Summary Logs (16)

MODIFIED UNIFIED CLASSIFICATION SYSTEM FOR SOILS						
MAJOR DIVISION			GROUP SYMBOL	GRAPH SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA
COARSE GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 75 µm)	GRAVELS MORE THAN HALF THE COARSE FRACTION LARGER THAN 4.75 mm	CLEAN GRAVELS (TRACE OR NO FINES)	GW		WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}} > 4$ ; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ TO } 3$
			GP		POORLY GRADED GRAVELS, GRAVEL- SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS
		DIRTY GRAVELS (WITH SOME OR MORE FINES)	GM		SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	ATTERBERG LIMITS BELOW "A" LINE OR P.I. LESS THAN 4
			GC		CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES	ATTERBERG LIMITS ABOVE "A" LINE AND P.I. MORE THAN 7
	SANDS MORE THAN HALF THE COARSE FRACTION SMALLER THAN 4.75 mm	CLEAN SANDS (TRACE OR NO FINES)	SW		WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}} > 6$ ; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ TO } 3$
			SP		POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS
		DIRTY SANDS (WITH SOME OR MORE FINES)	SM		SILTY SANDS, SAND-SILT MIXTURES	ATTERBERG LIMITS BELOW "A" LINE OR P.I. LESS THAN 4
			SC		CLAYEY SANDS, SAND-CLAY MIXTURES	ATTERBERG LIMITS ABOVE "A" LINE AND P.I. MORE THAN 7
FINE GRAINED SOILS (MORE THAN HALF BY WEIGHT SMALLER THAN 75 µm)	SILTS BELOW "A" LINE NEGLECTIBLE ORGANIC CONTENT	LL ≤ 50%	ML		INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHTY PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (SEE BELOW)
		LL > 50%	MH		INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS	
	CLAYS ABOVE "A" LINE NEGLECTIBLE ORGANIC CONTENT	LL ≤ 30%	CL		INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY OR SILTY CLAYS, LEAN CLAYS	
		30% < LL ≤ 50%	CI		INORGANIC CLAYS OF MEDIUM PLASTICITY, SILTY CLAYS	
		LL > 50%	CH		INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	
	ORGANIC SILTS & CLAYS BELOW "A" LINE	LL < 50%	OL		ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	
		LL > 50%	OH		ORGANIC CLAYS OF HIGH PLASTICITY	
	HIGHLY ORGANIC SOILS			Pt		

ADDITIONAL SYMBOLS			PLASTIC SOILS						
TILL		SANDSTONE		MOISTURE	PLASTICITY	INTRUSIONS	CONSISTENCY	POCKET PEN (TSF)	(N)
FILL		GRANITE		DRY	LOW	ROOTLETS	VERY SOFT		< 2
TOPSOIL				DAMP	MEDIUM	OXIDES	SOFT	0 - 0.5	2 - 4
CONCRETE				MOIST	HIGH	MICA	FIRM	0.5 - 1.0	4 - 8
SHALE				WET		GYPSUM	STIFF	1.0 - 2.0	8 - 15
LIMESTONE						ETC.	VERY STIFF	2.0 - 4.0	15 - 30
							HARD	> 4.0	> 30
PLASTICITY CHART FOR SOILS PASSING 425 µm SIEVE				TSF x 95.8 = kPa (q _u )      S _u = 1/2 x q _u					
				SOIL DESCRIPTIONS					
TRACE: 0 - 10%		BOULDERS: > 200 mm		COARSE SAND: 2 - 4.75 mm					
SOME: 10 - 20%		COBBLES: 75 - 200 mm		MEDIUM SAND: 0.425 - 2 mm					
WITH: 20 - 35%		COURSE GRAVEL: 19 - 75 mm		FINE SAND: 0.075 - 0.425 mm					
AND: 35 - 50%		FINE GRAVEL: 4.75 - 19 mm		FINES: < 0.075 mm					
GRANULAR SOILS									
MOISTURE	DENSITY	GRADATION	INTRUSIONS	SPT (N)					
DRY	VERY LOOSE	POORLY	ROOTLETS	0 - 4					
DAMP	LOOSE	WELL	OXIDES	4 - 10					
MOIST	MED. DENSE		MICA	10 - 30					
WET	DENSE		FINES	30 - 50					
	VERY DENSE		ETC.	> 50					
DEFINITIONS					C _c = COMPRESSION INDEX				
LL = LIQUID LIMIT					PL = PLASTIC LIMIT				
P.I. = PLASTICITY INDEX									
C _u = COEFFICIENT OF UNIFORMITY									
q _u = UNCONFINED COMPRESSIVE STRENGTH									
S _u = UNDRAINED SHEAR STRENGTH									

F:\Drafting\SOIL CLASSIFICATIONS\SOIL CLASSIFICATIONS.dwg

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Winnipeg, MB R2J 0K4  
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Fax: (204) 235-1579



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**Test Hole #: TH1**

**Client:** Neegan Burnside Ltd.

**Site:** MB Hydro Kelsey GS

**Location:** See Figure 1

**Project:** Geotechnical Investigation, MB Hydro Kelsey GS Sewage Lagoon Project

**File No.:** 15-185-01

**Date Drilled:** January 21, 2016

**Grade Elevation:** 185.3 m

**Water Elevation:** - -

SUBSURFACE PROFILE				SAMPLE DATA				SHEAR STRENGTH (kPa)		
Depth (m)	Soil Symbol	Description	Elevation (m)	Sample No.	Sample Type	Moisture Content (%)	Blows/300 mm	Moisture Content (%)		
								PL  -----X-----  LL	P. Pen	Torvane
								20 40 60 80		UC
0.0		Ground Surface	185.3							
		<b>Clay (CI-CH)</b> - light to medium brown, frozen to 0.6 m, moist, medium to highly plastic, some silt, organics in upper 50 mm.	185.0							
1.0		<b>End of Test Hole</b> - auger refusal on concrete rubble 1.0 m below existing grade. - no seepage or sloughing observed during drilling. - test hole backfilled with auger cuttings.	184.0							
2.0										

ENG- TECH Consulting Limited

Logged by: cdh

Reviewed by:

Drilled By: Maple Leaf Drilling Ltd.

Drill Rig: B20 Cricket

Auger Size: 100 mm solid stem

Completion Depth: 1.0 m

Completion Elevation: 184.3 m

Sheet: 1 of 1

SAMPLE TYPE



SPLIT BARREL



SHELBY TUBE



AUGER CUTTINGS



SPLIT SPOON





**Engineering And Testing  
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**Test Hole #: TH2**

**Client:** Neegan Burnside Ltd.

**Site:** MB Hydro Kelsey GS

**Location:** See Figure 1

**Project:** Geotechnical Investigation, MB Hydro Kelsey GS Sewage Lagoon Project

**File No.:** 15-185-01

**Date Drilled:** January 20, 2016

**Grade Elevation:** 177.6 m

**Water Elevation:** - -

SUBSURFACE PROFILE				SAMPLE DATA								SHEAR STRENGTH (kPa)		
Depth (m)	Soil Symbol	Description	Elevation (m)	Sample No.	Sample Type	Moisture Content (%)	Blows/300 mm	Moisture Content (%)						
									PL	X	LL	P. Pen	Torvane	UC
								20	40	60	80			
0.0		Ground Surface	177.6											
		Clay (CH)												
		- light brown, frozen to 0.45 m, moist, firm, highly plastic, some to with silt, organics in upper 150 mm.												
1.0			177.0	S1		33.0						36	29	
			176.0	S2		32.2						48	38	
2.0		- at 1.8 m, field vane, peak = 124 kPa, residual = 44 kPa.												
		- below 2.1 m, firm to soft, with silt, occa. silt lenses.												
		- below 2.4 m, soft.		S3		28.0						36	29	
3.0			175.0	S4		26.6						36	29	
		- at 3.3 m, field vane, peak = 141 kPa, residual = 44 kPa.												
		End of Test Hole	174.0											
		- end of test hole at 3.4 m below existing grade.												
4.0		- no seepage or sloughing during drilling.												
		- test hole backfilled with auger cuttings and bentonite.	173.0											
5.0														

ENG- TECH Consulting Limited

Logged by: cdh

Reviewed by: *CA*

Drilled By: Maple Leaf Drilling Ltd.

Drill Rig: B20 Cricket

Auger Size: 100 mm solid stem

Completion Depth: 3.4 m

Completion Elevation: 174.2 m

Sheet: 1 of 1

SAMPLE TYPE



SPLIT BARREL



SHELBY TUBE



AUGER CUTTINGS



SPLIT SPOON



**Engineering And Testing  
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**Test Hole #: TH3**

**Client:** Neegan Burnside Ltd.

**Site:** MB Hydro Kelsey GS

**Location:** See Figure 1

**Project:** Geotechnical Investigation, MB Hydro Kelsey GS Sewage Lagoon Project

**File No.:** 15-185-01

**Date Drilled:** January 20, 2016

**Grade Elevation:** 183.0 m

**Water Elevation:** - -

SUBSURFACE PROFILE				SAMPLE DATA				SHEAR STRENGTH (kPa)		
Depth (m)	Soil Symbol	Description	Elevation (m)	Sample No.	Sample Type	Moisture Content (%)	Blows/300 mm			
								Moisture Content (%)		
								PL  -----X-----  LL 20    40    60    80		
0.0		Ground Surface	183.0							
		<b>Clay (CH)</b> - light brown, frozen to 0.5 m, moist, firm, highly plastic, some to with silt, organics on surface.								
1.0										
2.0										
		- below 2.1 m, soft, occa. silt inclusions. - below 2.4 m, with silt, occa. silt lenses.								
3.0										
4.0										

ENG-TECH Consulting Limited

Logged by: cdh

Reviewed by:

Drilled By: Maple Leaf Drilling Ltd.

Drill Rig: B20 Cricket

Auger Size: 100 mm solid stem

Completion Depth: 4.6 m

Completion Elevation: 178.4 m

Sheet: 1 of 1

SAMPLE TYPE



SPLIT BARREL



SHELBY TUBE



AUGER CUTTINGS



SPLIT SPOON





**Engineering And Testing  
Solutions That Work For You**

**Test Hole #: TH4**

**Client:** Neegan Burnside Ltd.

**Site:** MB Hydro Kelsey GS

**Location:** See Figure 1

**Project:** Geotechnical Investigation, MB Hydro Kelsey GS Sewage Lagoon Project

**File No.:** 15-185-01

**Date Drilled:** January 20, 2016

**Grade Elevation:** 178.0 m

**Water Elevation:** - -

SUBSURFACE PROFILE				SAMPLE DATA				SHEAR STRENGTH (kPa)		
Depth (m)	Soil Symbol	Description	Elevation (m)	Sample No.	Sample Type	Moisture Content (%)	Blows/300 mm	Moisture Content (%)		
								PL  -----X-----  LL 20 40 60 80	P. Pen	Torvane
0.0		Ground Surface	178.0							
		<b>Clay (CH)</b> - light brown, frozen to 0.6 m, moist, firm, highly plastic, some to with silt, upper 200 mm organics.								
1.0			177.0	S1		28.4			42	33
		- below 1.5 m, dark brown, occa. silt lenses & inclusions.								
2.0			176.0	S2		24.9				
		- below 2.6 m, soft.								
3.0			175.0	S3		25.9			24	16
4.0			174.0							
				S4		25.9			24	24
5.0		<b>End of Test Hole</b> - end of test hole at 4.6 m below existing grade. - no seepage or sloughing during drilling. - test hole backfilled with auger cuttings and bentonite.	173.0							

ENG- TECH Consulting Limited

Logged by: cdh

Reviewed by:

Drilled By: Maple Leaf Drilling Ltd.

Drill Rig: B20 Cricket

Auger Size: 100 mm solid stem

Completion Depth: 4.6 m

Completion Elevation: 173.4 m

Sheet: 1 of 1

SAMPLE TYPE



SPLIT BARREL



SHELBY TUBE



AUGER CUTTINGS



SPLIT SPOON





**Engineering And Testing  
Solutions That Work For You**

**Test Hole #: TH5**  
**Client:** Neegan Burnside Ltd.  
**Site:** MB Hydro Kelsey GS  
**Location:** See Figure 1  
**Project:** Geotechnical Investigation, MB Hydro Kelsey GS Sewage Lagoon Project

**File No.:** 15-185-01  
**Date Drilled:** January 20, 2016  
**Grade Elevation:** 180.7 m  
**Water Elevation:** - -

SUBSURFACE PROFILE				SAMPLE DATA				SHEAR STRENGTH (kPa)		
Depth (m)	Soil Symbol	Description	Elevation (m)	Sample No.	Sample Type	Moisture Content (%)	Blows/300 mm	Moisture Content (%)		P. Pen
								PL  -----X-----  LL 20 40 60 80		Torvane
0.0		Ground Surface	180.7							
		<b>Clay (CH)</b> - light brown, frozen to 0.6 m, below moist, firm, highly plastic, some to with silt, organics in upper 50 mm.								
1.0			180.0	S1		24.1				36
		- below 1.5 m, soft to firm, with silt, trace silt inclusions & lenses.								
2.0		- at 1.8 m, field vane, peak = 89 kPa, residual = 35 kPa.	179.0	S2		25.4				36
		- below 2.2 m, soft.								
3.0			178.0	S3		26.4				24
				S4		26.3				24
4.0		<b>End of Test Hole</b> - end of test hole at 3.7 m below existing grade. - no seepage or sloughing during drilling. - seepage and sloughing measured to 1.8 m after 1.5 hours after drilling. - test hole backfilled with auger cuttings and bentonite.	177.0							
5.0			176.0							

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Logged by: cdh

Reviewed by:

Drilled By: Maple Leaf Drilling Ltd.  
 Drill Rig: B20 Cricket  
 Auger Size: 100 mm solid stem

Completion Depth: 3.7 m  
 Completion Elevation: 177.0 m  
 Sheet: 1 of 1

SAMPLE TYPE



SPLIT BARREL



SHELBY TUBE



AUGER CUTTINGS



SPLIT SPOON



**Engineering And Testing  
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**Test Hole #: TH6**

**Client:** Neegan Burnside Ltd.

**Site:** MB Hydro Kelsey Lagoon

**Location:** See Figure 1

**Project:** Geotechnical Investigation, MB Hydro Kelsey GS Sewage Lagoon Project

**File No.:** 15-185-01

**Date Drilled:** January 21, 2016

**Grade Elevation:** 176.0 m

**Water Elevation:** - -

SUBSURFACE PROFILE				SAMPLE DATA				SHEAR STRENGTH (kPa)			
Depth (m)	Soil Symbol	Description	Elevation (m)	Sample No.	Sample Type	Moisture Content (%)	Blows/300 mm	Moisture Content (%)  PL  -----X-----  LL 20    40    60    80	SHEAR STRENGTH (kPa)		
									P. Pen	Torvane	UC
0.0		Ground Surface	176.0								
		<b>Peat (Pt)</b> - black, frozen to 0.3 m, below moist to wet, fine to medium grains.									
1.0		<b>Clay (CH)</b> - light brown, moist to firm, highly plastic, some silt.	175.0	S1		31.7					
		- below 1.8 m, occa. oxide inclusions & silt lenses.		S2		30.0					
2.0		- at 2.3 m, field vane, peak = 212 kPa, residual = 53 kPa.	174.0	S3		25.9					
				S4		33.3					
3.0		<b>End of Test Hole</b> - end of test hole at 3.0 m below existing grade. - no seepage or sloughing observed during drilling. - test hole backfilled with auger cuttings and bentonite.	173.0								
4.0			172.0								
5.0			171.0								

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Logged by: cdh

Reviewed by:

Drilled By: Maple Leaf Drilling Ltd.

Drill Rig: B20 Cricket

Auger Size: 100 mm solid stem

Completion Depth: 3.0 m

Completion Elevation: 173.0 m

Sheet: 1 of 1

SAMPLE TYPE



SPLIT BARREL



SHELBY TUBE



AUGER CUTTINGS



SPLIT SPOON



## Appendix B

### Eng-Tech Geotechnical Report



Prepared For:

**NEEGAN BURNSIDE LTD**

**GEOTECHNICAL INVESTIGATION  
KELSEY GENERATING STATION PROPOSED SEWAGE LAGOON,  
KELSEY, MANITOBA**



**DATE: MAY 2016**

**FILE NO. 15-185-01**



***"Engineering and Testing Solutions That Work for You"***

6 - 854 Marion Street  
Winnipeg, Manitoba  
Canada  
R2J 0K4

Phone: (204) 233-1694  
Facsimile: (204) 235-1579  
e-mail: [eng_tech@mts.net](mailto:eng_tech@mts.net)  
[www.eng-tech.ca](http://www.eng-tech.ca)

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### Appendices

#### Appendix A – Figures

- Figure 1 – Test Hole and Probe Hole Location Plan
- Figure 2 – Slope Stability Analysis – Section A1
- Figure 3 – Hydraulic Conductivity Results

#### Appendix B –

- Soil Classification Sheet
- Test Hole Summary Logs (16)

#### Appendix C – Laboratory Test Results

- Particle Size Analysis Reports (12)
- Moisture Density Relationship Reports (2)
- Direct Shear Strength Test
- Compressibility Test



## 1.0 INTRODUCTION

ENG-TECH Consulting Limited (ENG-TECH) completed the requested geotechnical investigation for the Kelsey Generating Station proposed sewage lagoon in Manitoba. The purpose of the investigation was to assess the soil conditions within the proposed lagoon areas in order to provide recommendations related to the lift station, soil permeability, plasticity, and overall suitability of the soil for a lagoon.

### Scope of Work

ENG-TECH completed the following scope of work:

- A laboratory testing program.
- An assessment of the field and laboratory results.
- An engineering report outlining the soils investigation and recommendations.

## 2.0 TEST HOLE DRILLING, SOIL SAMPLING, LABORATORY TESTING

### Test Hole Drilling

ENG-TECH supervised the drilling of sixteen (16) test holes (TH1 to TH16) and thirteen (13) probe holes (PH17 to PH29) between January 19 and 22, 2016 at the locations shown on Figure 1. The test holes were drilled typically 3.0 and 4.6 m below existing grade into native clay, whereas TH12 was drilled to auger refusal into clay till 9.9 m below existing grade, and TH14 and TH15 were drilled to auger refusal on concrete rubble. The probe holes were drilled to auger refusal on suspected boulders / concrete rubble. All the test holes and probe holes were drilled using a portable B20 Cricket drill rig equipped with 100 mm diameter solid stem continuous flight augers, and owned and operated by Maple Leaf Drilling Ltd. The test holes and probe holes were backfilled to existing grade either using the auger cuttings or a combination of auger cuttings mixed with bentonite. Shallow holes with refusal near the surface were only backfilled with auger cuttings. The geodetic elevations and GPS coordinates of the test holes and probe holes are shown on Figure 1 in Appendix A, with test hole summary logs shown in Appendix B.

### *Test Holes*

The test holes drilled within the footprint of the north lagoon location (Proposed Lagoon Option 1) included TH2 to TH5, and those drilled just outside of the lagoon footprint were TH1 and TH6. TH8 to TH11 were drilled at the south proposed lagoon location (Proposed Lagoon Option 2), with TH7 drilled outside of the lagoon footprint. TH12 was drilled within the footprint of the proposed lift station and TH13 to TH16 were drilled between the proposed north lagoon and lift station in areas of proposed pipe routes.

The test holes depths varied depending on location and if bedrock or rubble was encountered. The depth of all test holes in both lagoon areas extend to at least 3 m below grade and in some areas to 4.6 m below grade as reported on the test hole logs.

### *Probe Holes*

The probe holes drilled were completed to determine the type of soil and fill encountered in the proposed areas of the pipe routes from the lift station through the former land fill and bedrock

outcrop areas. The location of the probe holes is shown on Figure 1, while the grade elevation, depth drilled and soils encountered are outlined on Table 1 below.

**TABLE 1  
OVERVIEW OF PROBE HOLES**

Probe Hole No.	Date Drilled	Grade Elevation (m)	Depth Drilled (m)	Completion Elevation (m)	Soil Conditions
PH17	Jan. 22, 2016	183.3	0.6	182.7	- clay fill, refusal on concrete rubble.
PH18	Jan. 22, 2016	185.2	3.0	182.2	- clay fill, with sand & gravel fragments to 0.6 m. - traces of bags/garbage, old land fill site. - no seepage or sloughing. Suspected concrete rubble
PH19	Jan. 21, 2016	184.9	0.08	184.8	- at 80 mm, refusal on concrete rubble
PH20	Jan. 21, 2016	184.9	0.1	184.8	- at 0.1 m, refusal on concrete rubble.
PH21	Jan. 21, 2016	184.6	0.1	184.5	- at 0.1 m, refusal on concrete rubble.
PH22	Jan. 21, 2016	185.0	0.1	184.9	- at 0.1 m, refusal on concrete rubble.
PH23	Jan. 22, 2016	184.2	0.5	184.7	- clay fill, refusal on rocks and concrete rubble.
PH24	Jan. 22, 2016	184.2	2.1	182.1	- clay, light brown, moist firm, medium plastic, some silt. - refusal on suspected bedrock. Suspected concrete rubble - no seepage or sloughing.
PH25	Jan. 20, 2016	184.6	4.0	180.6	- clay, light brown, moist, firm, medium plastic, some silt. Suspected concrete rubble - at 4.0 m refusal on suspected bedrock.
PH26	Jan. 20, 2016	183.8	4.6	179.2	- clay. - at 2.1 m, boulder. new hole beside PH25
PH27	Jan. 20, 2016	182.6	0.6	182.0	- silt and fill. - at 0.6 m, refusal on suspected concrete rubble.
PH28	Jan. 21, 2016	183.4	4.0	179.4	- clay, light to medium brown, traces of peat and organics, firm to soft, with silt, trace of oxides below 7.5 m. - below 2.3 m, light brown. - below 3.7 m, wet, trace to some seepage and sloughing. Suspected concrete rubble - at 4.0 m, refusal on suspected bedrock.
PH29	Jan. 21, 2016	182.3	4.6	177.7	- clay, light to medium brown, firm to soft, with silt, no seepage or sloughing. Suspected concrete rubble

### Soil Sampling

The soil stratigraphy was visually classified at the time of drilling using the modified Unified Soil Classification System (USCS). Soil samples were collected off the auger flights, and by means of Shelby tubes at select depths at the lift station and in the area of both proposed lagoon locations. All soil samples collected were retained for testing in ENG-TECH's Winnipeg laboratory, except the direct shear strength and compression tests were completed by others.

### Laboratory Testing

The laboratory testing program consisted of the following:

- *Lift Station:* Moisture contents (11), Atterberg Limits (1), particle size analysis (2), and unconfined compressive strength (2) tests.

- *Proposed North Lagoon Option 1:* Moisture contents (21), Atterberg Limits (3), particle size analysis (6), hydraulic conductivity tests (2), a direct shear strength test, a compressibility test and a moisture density relationship test.
- *Proposed South Lagoon Option 2:* Moisture contents (16), Atterberg Limits (2), particle size analysis (4), hydraulic conductivity test (1) and a moisture density relationship test.
- *Pipe Route:* Moisture contents (9).

The hydraulic conductivity test results are shown on Figure 3 in Appendix A, while the moisture contents, Atterberg Limits, and unconfined compressive strength test results are shown on the test hole summary logs in Appendix B. The particle sizes, moisture density relationship, direct shear strength and compressibility tests results are shown on individual reports in Appendix C.

### 3.0 STRATIGRAPHY

Overall, the stratigraphy at both proposed lagoon locations consisted of a thin surface layer or organics, followed by native clay which was light to medium brown, moist, firm, highly plastic, and contained some to with silt. In a few zones with depth the silt content increased causing a reduction in the plasticity, and in some zones the plasticity of the clay would be more medium to high. Portions of the clay contained trace lenses which were not significant enough to change the classification or act as an independent layer. Also no permafrost was encountered at the test hole locations.

A clay till was encountered near 6 m below grade at TH12, the test hole drilled near the proposed lift station. The till was moist, very soft, medium plastic, contained with-to-and silt, and contained some sand sizes. Auger refusal occurred at 9.9 m below grade in the till at TH12.

Groundwater seepage was not encountered within the upper 4.6 m of the clay layer. At the location of the proposed lift station seepage and sloughing were encountered in the till below 6.0 m from grade, near elev. 174.5 m. Further details are outlined on the test hole summary logs.

### 4.0 SLOPE STABILITY

#### Seepage Analysis

An assessment of groundwater seepage was conducted using Seep/W, a 2 dimensional computer seepage program using finite element analysis. The hydraulic conductivity value used in the analysis was similar to the values obtained from the test values ( $6 \times 10^{-8}$  cm/sec). The model involved gradual filling and drawing down the lagoon no greater than 0.3 m per day, with the water levels ranging from a minimum and maximum of 0.3 and 1.5 m above the base of the lagoon, respectively. The initial static groundwater level used was a conservative estimate based on the field results. The initial groundwater level and water levels from the seepage model are shown in Figure 2.

#### Slope Stability Analyses

Slope stability analyses on the proposed lagoon dikes were completed using Slope-W, a two dimensional finite element analysis computer program. The analyses were completed to assess the stability of the proposed dikes before and after lagoon draw down. Initially, stability of the dikes were assessed using a static groundwater level then after a typical filling and draw down

cycle using residual shear strength values. Upon completion of an initial assessment lower than residual shear strength values of the native clay (and remoulded dikes) was used to show that even under these values the stability of the lagoon slopes are stable. The results are shown on Figure 2, and the direct shear strength test results are shown in Appendix C. The remoulded shear strength of the dikes and clay liner are representative since the native clays are quite uniform, and will be remoulded then compacted to densities greater than in-situ values during construction. As such, remoulding will result in shear strengths developing that will be representative of in-situ values.

Slope stability analyses were completed using the Morgenstern-Price Method of Slices for circular slip surfaces with a half-sine interslice force function to estimate the Factor of Safety (FS) of potential slip surfaces (PSSs). Block failures were also assessed to review a different mode of failure of the dikes.

A cross-sectional profile of the proposed northern lagoon was used in the assessment because this essentially represented the design of the dikes for both proposed lagoon locations. Overall, the dikes at the proposed design slope and lagoon depth are stable using low residual shear strength values both initially and after a draw down event, with all FS values over 1.44 as outlined on Figure 2.

## **5.0 LIFT STATION**

### General

ENG-TECH understands that two (2) options are being considered for the construction of the shaft for the lift station. Option 1 is an open excavation followed by construction of the shaft, backfilling the excavation and then constructing the building over the lift station. Option 2 involves drilling a larger hole than the shaft foundation, installing a steel tube followed by construction of the lift station foundation, shaft, and then the building. Either option is viable, although an open excavation will extend past the perimeter edge of the lift station building, and therefore the raft foundation for the building will be placed on fill material. If a hole is drilled for the lift station foundation and shaft the space between the shaft and hole should be filled in with a lean mix of concrete because compaction of fill in a small area may not be possible.

### Shaft for Lift Station

The below grade structurally reinforced slab for the shaft will be constructed on native clay, which has a low potential for movements due to soil swelling, and these movements can be minimized with adequate sub-grade preparation as outlined below:

- Excavate to 100 mm below the slab design elevation, approximately 5.3 m below grade. The soil at this depth will be wet of optimum moisture content and will require the removal of moisture prior to compaction.
- Compact the upper 300 mm of the native clay to 97% of its Maximum Dry Density (MDD) near optimum moisture content.
- Place 100 mm of limestone or granular "A" base immediately below the bottom of the slab and compact it to 98% of its MDD near optimum moisture content. Additional base material will be required during compaction because the granular will be driven into the clay.



- Place a vapour barrier consisting of 6 mil poly (minimum) between the granular base and underside of the slab prior to pouring the concrete.
- Some seepage at the base of the slab can be expected, although only minor swelling (if any) of the clay is anticipated.

#### Lift Station Building

ENG-TECH cautions that with shallow foundations, such as rafts, there is an increased potential for movements due to soil swelling and frost heave, however these movements can be minimized with adequate sub-grade preparation and site drainage. Preparation for the raft foundation for the building will depend on the chosen installation option of the shaft. For both options the raft foundation for the building could be constructed as outlined below using an Ultimate Limit States (ULS) bearing pressure of 200 kPa, and Serviceable Limit States (SLS) bearing pressure of 130 kPa for the perimeter load bearing thickened edge of the raft. The perimeter thickened edge must be no less than 0.61 m wide, the top of the raft located approximately 100 mm above existing grade for drainage, and the base shaped to ensure a uniform granular base layer below the raft. Settlements are not expected to exceed 25 mm and 15 mm over the life of the raft when constructed as outlined below for Option 1 and Option 2, respectively.

#### *Option 1 – Open Excavation*

The excavation will extend approximately 5.3 m below existing grade, with the side slopes of the excavation extending past the perimeter edge of the building foundation. Therefore, the fill placed back into the excavation must be compacted as outlined below:

- Compact the upper 200 mm of the base and side slopes of the excavation to a minimum of 95% of the soils MDD near optimum moisture content. Upon completion place the clay from the excavation in maximum 250 mm thick lifts with each lift compacted to at least 99% of MDD near optimum moisture content to 350 mm below the base of the raft design elevation. Compaction of the fill shall extend the full width of the excavation.
- Place 250 mm of clay and shape the clay to meet the raft design, then compact the clay layer to 100% of MDD near optimum moisture content. Compaction shall extend to the greater of 0.3 m beyond the perimeter edge of the building or the width of the excavation.
- Place 100 mm of limestone or granular "A" base immediately below the bottom of the raft and compact it to 100% of its MDD near optimum moisture content.
- Place a vapour barrier consisting of 6 mil poly (minimum) between the granular base and underside of the raft prior to pouring the concrete.

#### *Option 2 – Drilled Hole for Shaft*

The base preparation for the proposed raft shall extend 0.3 m beyond the perimeter edge and be prepared as outlined below:

- Excavate all topsoil, silt, organics, rootlets and soft soils within the foot print of the raft, including 0.3 beyond the perimeter edge. Continue to excavate as required to 100 mm below the raft design elevation. The soils at sub-grade design elevation should be native clay.



- Shape the subgrade via cut and fill as required then uniformly compact the upper 300 mm to 97% of its MDD at  $\pm 2\%$  of optimum moisture content (ASTM D 698).
- Place 100 mm of limestone or granular "A" base immediately below the bottom of the raft and compact it to 100% of its MDD at  $\pm 2\%$  optimum moisture content.
- Place a vapour barrier consisting of 6 mil poly (minimum) between the granular base and underside of the raft prior to pouring the concrete.

#### Lateral Earth Pressure on Shaft

The shaft for the lift station will be a prefabricated item, and therefore should be designed for the lateral soil pressures, including the forces generated from compacting the fill adjacent the shaft when an open excavation is used.

It is assumed that the shaft will be rigid, and therefore, the coefficient of earth pressure at rest ( $K_o$ ) can be used to determine the lateral earth pressure on the shaft. The compaction effort of the backfill placed against the shaft, backfill type and sub-drainage conditions will have an impact on the magnitude and shape of lateral earth pressures on the shaft. Lateral earth pressures induced by compaction, and groundwater will have to be accounted for in the design of the shaft. We are not aware of large surcharge loading that will be located adjacent the shaft that will need to be accounted for, and therefore surcharge loading was excluded.

#### *Option 1 – Open Excavation*

Well compacted backfills placed against the upper portions of the below grade shaft will build-up lateral stresses on the shaft. These compressive stresses depend on the force imposed by the compactor, which depends on the dead weight and centrifugal force of the compactor. Typical compactor forces can be provided by the manufacture for the compactor used by the contractor. The contractor should compact the fill starting at the shaft and compact outwards to limit the forces due to compaction on the shaft.

Well compacted backfill typically corresponds to 98% (plus) of MDD. Settlements of backfill compacted to at least 98% MDD usually does not exceed 1% of the fill height when no surcharge loads are added to the fill after compaction. When backfill is well compacted against the upper portion of the below portion of the shaft, the lateral earth pressures in the upper portion along the shaft can be determined as follows:

- (1) From: 0 (shaft at grade) to  $z_1$

$$\sigma_h = K_o \sqrt{(2 \cdot P \cdot \gamma \div \pi)}$$

Where:  $z_1 = K_o \sqrt{(2 \cdot P \div (\pi \gamma))}$

$\sigma_h$  = lateral earth pressure (kN/m²)

$K_o$  = coefficient of earth pressure at rest

$\gamma$  = total unit weight of the soil (kN/m³)

$Z_{1 \& 2}$  = depth below shaft at grade (m)

$P$  (Compactor Force, kN/m) =  $\frac{\text{Compactor Weight (kN)} + \text{Centrifugal Force (kN)}}{\text{Width of Compactor (m)}}$

- (2) From:  $z_1$  to  $z_2$

$$\sigma_h = K_o \sqrt{(2 \cdot P \cdot \gamma \div \pi)}$$

Where:  $z_2 = (1 \div K_o) \sqrt{(2 \cdot P \div (\pi \cdot \gamma))}$

(3) From: below  $z_2$

$$\sigma_h = K_o \cdot \gamma \cdot z$$

Values for the lateral earth pressure coefficient and total unit weight of well compacted soils are outlined below.

Earth Pressure Coefficients and Total Unit Weights for Well Compacted Backfill		
Soil Type	$K_o$	Total Unit Weight (kN/m ³ )
Granular (Sand or Gravel)	0.40	22
Clay	0.50	20

#### *Option 2 –Drilled Hole for Shaft*

Even if the space between the shaft and hole is filled in with a lean mix of concrete, horizontal forces will still apply to the shaft. These horizontal forces on the shaft can be determined as follows:

$$\sigma_h = K_o \cdot \gamma \cdot z_w + K_o \gamma' (z - z_w) + \gamma_w (z - z_w)$$

Where:

$\sigma_h$  = lateral earth pressure (kN/m²)

$K_o$  = coefficient of earth pressure at rest

$\gamma$  = total unit weight of the soil (kN/m³)

$\gamma'$  = buoyant unit weight of the soil (kN/m³)

$\gamma_w$  = unit weight of water (kN/m³)

$z$  = depth of shaft below grade (m)

$z_w$  = depth to the top of the water table (measured from top of final grade, m)

The recommended values for the lateral earth pressure coefficient and total unit weight of the soil are outlined below:

Earth Pressure Coefficients and Total Unit Weights		
Soil Type	$K_o$	Total Unit Weight (kN/m ³ )
Sand & Gravel fill	0.50	20
Clay	0.65	19

Even though a static water table was not recorded it is best to use  $z_w = 3.0$  m to ensure the shaft can withstand some forces due to water.

#### Lateral Earth Pressure on Temporary Below Grade Walls

Design details of a shoring system can be provided, if required, once more is known about the proposed construction scheduling. For preliminary (and conservative) design purposes the use of a design coefficient ( $K_d$ ) is recommended rather than the lateral earth pressure coefficient at

rest ( $K_0$ ). For a level grade surface the lateral earth pressures will increase linearly from zero at the top of grade to a maximum at the base as outlined below.

$$\sigma_h = K_d \cdot \gamma \cdot z$$

Where:

$\sigma_h$  = lateral earth pressure for depth  $z$  (kN/m²)

$K_d$  = design coefficient of earth pressure (0.60)

$\gamma$  = unit weight of soil (19 kN/m³)

$z$  = depth below soil surface (m)

### Concrete

All concrete should be designed, specified, and constructed in accordance with CSA standard A23.1-14, Concrete Materials and Methods of Concrete Construction using the Performance Specification Alternative as outlined in Table 5 of CSA A23.1-14.

Under the performance alternative, the concrete supplier shall assume responsibility for the performance of the concrete as delivered and the contractor shall assume responsibility for the concrete in place. The owner shall specify performance requirements including: the required structural criteria and concrete strength at age, the concrete exposure class for durability, and any other properties that may be required to meet the owner's performance requirements such as colour, architectural requirements, and special surface finishes. The owner reserves the right to request the supplier provide satisfactory documentation that the proposed mix design will achieve the strength, durability, and performance requirements specified by the owner, and that the mix design satisfies the requirements of CSA A23.1-14. In addition, the owner may request the contractor submit documentation demonstrating the owner's performance requirements have been met during construction and placement.

Based on Tables 1, 2, 3, and 4 of CSA A23.1-14, the concrete in contact with the local soils can be classified as an S-2 exposure class for the shaft slab, and a F-2 exposure class for the raft foundation of the building. The use of Type GU or GUb cement for the shaft slab is to ensure a life expectancy and is typical for use with similar clay soil types. The concrete can be selected as structurally required for design; however the concrete should be designed to meet the minimum specifications outlined below for durability.

#### *Shaft Slab (S-2)*

56 day minimum compressive strength of 32 MPa

Maximum water/cementing materials ratio of 0.45

Maximum nominal aggregate size of 20 mm

Type HS or HSb cement

Air content of 4-7%

#### *Raft for Building (F-2)*

28 day minimum compressive strength of 25 MPa

Maximum water/cementing materials ratio of 0.55

Maximum nominal aggregate size of 20 mm

Type GU or GUb cement

Air content of 4-7%

## 6.0 DISCUSSION

### Particle Size and Atterberg Limits

Overall, the clay is classified as highly plastic, with a typical plastic limit near 20% and a liquid limit typically near 60%, with a reduction in both when the silt content increases. The clay and silt content range typically from 60 to 80% and 20 to 30%, respectively and sand sizes less than 10%. In the areas of more silt or silt lenses, the clay content typically decreases to 50%, with the silt content increasing to over 40%. The Atterberg Limits and clay content show the Activity is near 0.6, indicating the predominant clay mineral being Kaolinite, with some Illite and Montmorillonite.

The clay content and Atterberg Limit test results show the clay in both the proposed lagoon locations would achieve a hydraulic conductivity less than  $1 \times 10^{-7}$  cm/sec after remoulding and compaction, and potentially in-situ.

### Hydraulic Conductivity

The three (3) hydraulic conductivity test results were completed on in-situ samples are shown in tabular form and graphically on Figure 3. Overall, the values averaged near  $6 \times 10^{-8}$  cm/sec, which is typical for clay which is slightly over consolidated, and which has some preferential flow paths from the silt lenses. The samples from TH4 and TH6 were collected from different elevations below the proposed north lagoon base, while the sample from TH8 was collected below the base at the south proposed lagoon area.

The existing information from the site and data from other sites in our files show the clay at the proposed lagoon areas has a moderate to high potential of having a hydraulic conductivity (vertical and horizontal) less than  $1 \times 10^{-7}$  cm/sec in its natural state, as well as when compacted to at least 95% of its MDD. Completing at least 5 more hydraulic conductivity tests just below the base of the lagoon and/or dikes at the final site location to further prove statistically that removal and compaction of the clay for the entire lagoon is not required. The above would substantially reduce construction costs of the lagoon.

### Compaction and Lagoon Construction

The moisture density relationships (standard Proctor) were completed on two clay samples, one from each proposed lagoon area as noted on the reports in Appendix C. The results show the in-situ clay moisture content is typically between 4 and 10% higher than the optimal moisture content near the base of the lagoon. With depth the clay became slightly moister and softer. Removal of some moisture (drying the clay) will be required before remoulding and compaction during construction.

Currently it is not known if additional information related to the hydraulic conductivity of the clay will be forth coming. As such, two options for construction of the lagoon exist in order to ensure the clay linear meets the required regulations as outlined below:

#### *Option A – No Additional Hydraulic Conductivity Testing*

The lagoon can be constructed by removing the upper 500 mm from final grade and compacting the top 300 mm to 95% of the MDD near optimum moisture content. The native clay removed can then be placed in maximum 250 mm thick lifts with each lift also compacted to 95% of the MDD near optimum moisture content.



Compaction should be completed using a sheeps foot roller in vibratory or non-vibratory mode to ensure the next lift is blended with the lower compacted layer. Blending can also be completed by disking then placement of clay followed by compaction. The purpose of blending the layers is to reduce the potential of the clay having individual layers and preferential flow paths between the layers. Blending by disking or compaction with a sheeps foot roller will result in a more homogeneous clay mixture, which will eliminate any thick silt lenses, should any exist, and reduce the hydraulic conductivity of zones with more silt content or lenses or varves.

#### *Option B – Additional Hydraulic Conductivity Testing Completed*

After completion of additional hydraulic conductivity testing with favorable results the lagoon could be constructed by excavating to the final grades followed by compacting the upper 300 mm of clay to 95% of the MDD near optimum moisture content. Berms which extend above existing grade can be completed as mentioned above in Option A.

#### Slope Stability

The stability analysis was completed along the center line of the lagoon (Proposed Lagoon Option 1) in an east/west orientation as shown in Figure 1. The cross section profile and results of the analyses are shown in Figure 2. Determinations of the FS values of the PSSs were not less than 1.5. This was observed after lagoon drawdown and using the reported residual shear strength values, which were obtained from the direct shear tests. In addition, a conservative lower bound estimate of the effective friction angle was also assessed and the FS values for the same PSSs were not less than 1.4, which is quite acceptable for this type of construction. Overall, this shows the proposed design with side slope of 4H:1V (Horizontal:Vertical) is acceptable.

#### Lift Station Foundation

The raft foundation for the building could be constructed as outlined herein, and would be a suitable foundation for the intended use of the building. The shaft must be separated from the floor of the building to allow for differential movement between the structures.

#### Shaft Foundation

A below grade structurally reinforced slab for the shaft is suitable, will be constructed on native clay, and based on the test results has a low potential for movements due to soil swelling.

## **7.0 CONCLUSIONS**

Based on the results ENG-TECH concludes the following:

- The soil within both proposed lagoon areas is highly plastic clay, with some-to-with silt, and is suitable for use in a clay lined lagoon.
- Blending the clay by disking or compaction with a sheeps foot roller will result in a more homogeneous mixture. Removal of 2 to 10% moisture from the clay will be required during construction in order to have the clay meet the optimum moisture content near 21% for compaction.
- The test results show the clay is most likely suitable in its natural state to meet a hydraulic conductivity value less than  $1 \times 10^{-7}$  cm/sec. Additional testing with favorable results will be needed to confirm this. The clay when remolded and compacted as



mentioned herein will be suitable to meet the required regulatory maximum hydraulic conductivity value.

- The current design shows the side slopes of the dikes will have FS values that are within keeping for similar projects, and considered stable in an extreme event using residual and lower than the reported residual shear strength values. Slope grades as shown on the figures are adequate for the construction of the lagoon.
- The use of a raft foundation to support the building over the lift station is suitable, with a reinforced slab used for the shaft foundation.
- The methods of construction of the shaft for the lift station as mentioned herein will suffice. Other methods are available and will need to be reviewed prior to construction.

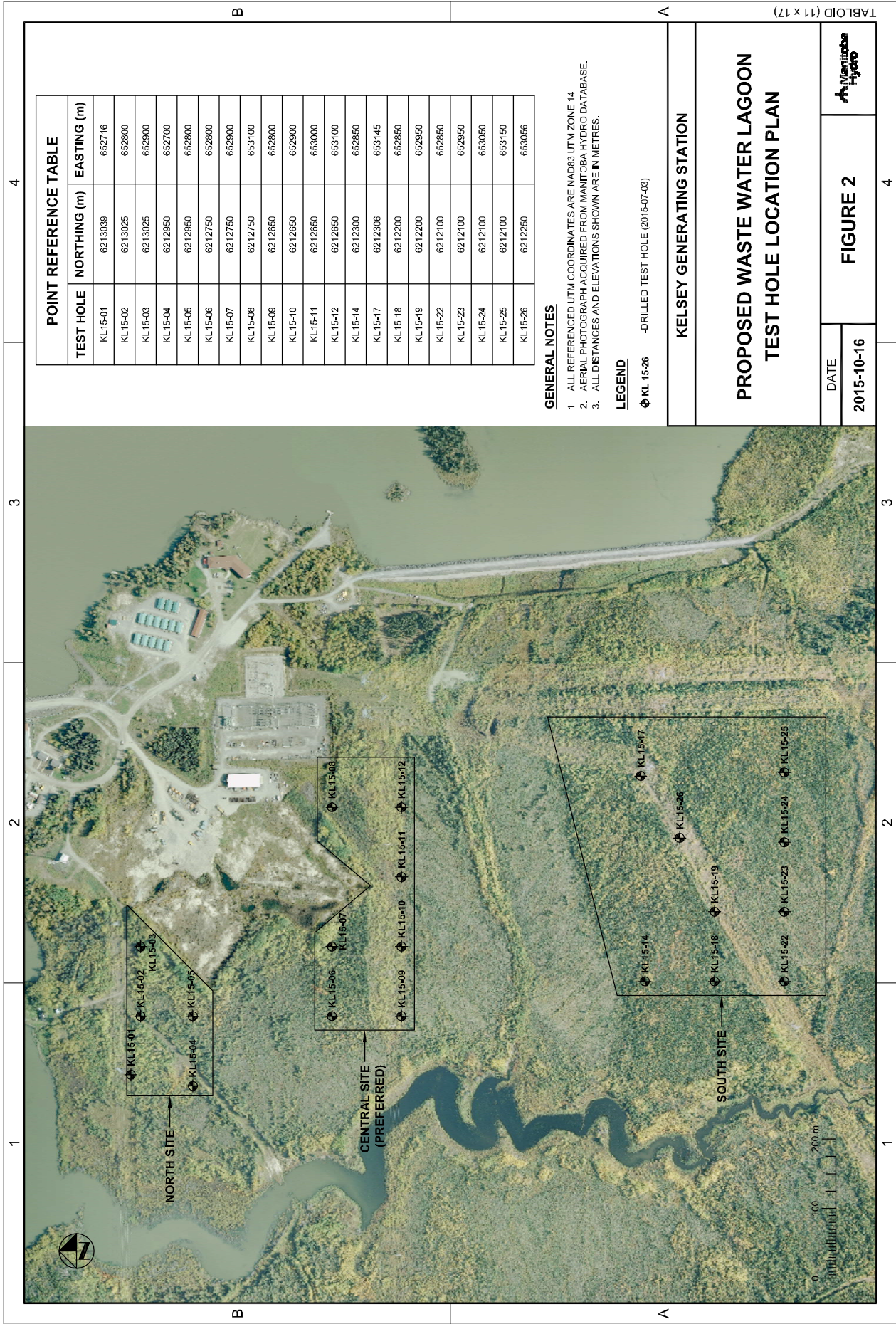
## 8.0 CLOSURE

This report was based on the scope of work outlined for the purpose of the investigation, and was prepared in accordance with acceptable professional engineering principles and practices. If you have any questions, please contact the undersigned.

Sincerely,  
ENG-TECH Consulting Limited



Clark Hryhoruk, M.Sc., P.Eng.  
Principal, Geotechnical Engineer



POINT REFERENCE TABLE		
TEST HOLE	NORTHING (m)	EASTING (m)
KL15-01	6213039	652716
KL15-02	6213025	652800
KL15-03	6213025	652900
KL15-04	6212950	652700
KL15-05	6212950	652800
KL15-06	6212750	652800
KL15-07	6212750	652900
KL15-08	6212750	653100
KL15-09	6212650	652800
KL15-10	6212650	652900
KL15-11	6212650	653000
KL15-12	6212650	653100
KL15-14	6212300	652850
KL15-17	6212306	653145
KL15-18	6212200	652850
KL15-19	6212200	652950
KL15-22	6212100	652850
KL15-23	6212100	652950
KL15-24	6212100	653050
KL15-25	6212100	653150
KL15-26	6212250	653056

GENERAL NOTES

- 1. ALL REFERENCED UTM COORDINATES ARE NAD83 UTM ZONE 14.
- 2. AERIAL PHOTOGRAPH ACQUIRED FROM MANITOBA HYDRO DATABASE.
- 3. ALL DISTANCES AND ELEVATIONS SHOWN ARE IN METRES.

LEGEND

KL 15-26 -DRILLED TEST HOLE (2015-07-03)

KELSEY GENERATING STATION

PROPOSED WASTE WATER LAGOON  
TEST HOLE LOCATION PLAN

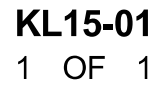
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2015-10-16

FIGURE 2

Manitoba Hydro

TABLOID (11 x 17)

## ***Appendix A: Test Hole Logs***



<b>WATER TABLE</b>  Dry Hole	NORTH: 6213039.000 EAST: 652716.000 TREND: ----- PLUNGE: (deg) ELEV G/S:	EQUIPMENT: Hand Auger CONTRACTOR: Manitoba Hydro DRILLER: Blake Holowick COMPLETION: 2015 06 29 INSPECTOR: Blake Holowick	DEPTH: 3.15 m ENGINEER: Jeff Tutkaluk APPROVED: 
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**Manitoba Hydro**

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**GEOTECHNICAL LOG****Kelsey Lagoon Preliminary  
Geotechnical Investigation****KL15-02**

1 OF 1

DEPTH (m)	SAMPLE #	SAMPLER	USCS	SOIL DESCRIPTION	Standard Penetration Uncorrected Blow Count (N)	Penetrometer Unconfined Compression (kPa)	ELEV (m)
0.0			CI	(0.00 - 0.30) CLAY (FILL) - silty, medium plastic, soft, moist, brownish grey, frequent organics			
			CI	(0.30 - 2.06) CLAY - silty, medium plastic, firm, moist, mottled brown and light brown, occasional rootlets  - frozen below 0.6 m (ice crystals < 1 mm diameter)			
0.74	ES-1						
1.37	ES-2						
2.0							
TEST HOLE TERMINATED AT 2.06 m IN FROZEN CLAY							
NOTES: - No sloughing at completion of drilling. - Test hole dry at completion of drilling. - Test hole backfilled with auger cuttings.							
UTM coordinates based on handheld GPS (+/- 3 m)							
3.0							

**WATER TABLE**

Dry Hole

NORTH: 6213025.000  
EAST: 652800.000  
TREND: -----  
PLUNGE: (deg)  
ELEV G/S:EQUIPMENT: Hand Auger  
CONTRACTOR: Manitoba Hydro  
DRILLER: Blake Holowick  
COMPLETION: 2015 06 29  
INSPECTOR: Blake HolowickDEPTH: 2.06 m  
ENGINEER: Jeff Tutkaluk

APPROVED:



**Manitoba Hydro**

Civil Engineering

**GEOTECHNICAL LOG****Kelsey Lagoon Preliminary  
Geotechnical Investigation****KL15-03**

1 OF 1

DEPTH (m)	SAMPLE #	SAMPLER	USCS	SOIL DESCRIPTION	Standard Penetration Uncorrected Blow Count (N)	Moisture M.C. PL 20 40 60 80 LL	Penetrometer Unconfined Compression (kPa) 20 40 60 80	Field Insitu Peak Residual (kPa)	Lab Torvane Disturbed	ELEV (m)
0.0			PT	(0.00 - 0.05) ORGANICS - Leaves, grass, decomposed forest matter.						
			CI	(0.05 - 0.41) CLAY (FILL) - clay mixed with roots, wood and cinders						
				(0.41 - 3.10) CLAY - silty, medium plastic, firm, moist, brown, occasional oxidation						
				- mottled brown and light brown below 0.7 m						
1.0				- firm to stiff below 1.0 m						
				- varved below 1.2 m						
				- increasing silt content below 1.8 m						
2.0				- firm below 2.3 m						
3.0										

TEST HOLE TERMINATED AT 3.10 m IN FIRM  
CLAY

## NOTES:

- No sloughing at completion of drilling.
- Test hole dry at completion of drilling.
- Test hole backfilled with auger cuttings.

UTM coordinates based on handheld GPS (+/- 3 m)

**WATER TABLE**

Dry Hole

NORTH: 6213025.000  
EAST: 652900.000  
TREND: -----  
PLUNGE: (deg)  
ELEV G/S:EQUIPMENT: Hand Auger  
CONTRACTOR: Manitoba Hydro  
DRILLER: Blake Holowick  
COMPLETION: 2015 06 30  
INSPECTOR: Blake HolowickDEPTH: 3.10 m  
ENGINEER: Jeff Tutkaluk

APPROVED:

**Manitoba Hydro**

Civil Engineering

**GEOTECHNICAL LOG****Kelsey Lagoon Preliminary  
Geotechnical Investigation****KL15-04**

1 OF 1

DEPTH (m)	SAMPLE #	SAMPLER	USCS	SOIL DESCRIPTION	Moisture M.C.		Penetrometer		ELEV (m)
					PL	LL	Unconfined	Field	
					Standard Penetration *		Vane Shear		
					Uncorrected Blow Count (N)		Insitu Peak		
							Residual		
0.0			PT CI	(0.00 - 0.05) ORGANICS - Leaves, grass, decomposed forest matter. (0.05 - 3.12) CLAY - silty, medium plastic, firm to stiff, moist, brown - mottled brown and light brown below 0.3 m  - soft to firm, varved, increasing silt content below 0.6 m  - frozen from 1.1 m to 1.5 m (ice crystals < 1mm diameter)  - occasional oxidation below 1.8 m					
0.76	ES-1								
1.0									
1.45	ES-2								
2.0									
2.90	ES-3								
3.0									
TEST HOLE TERMINATED AT 3.12 m IN SOFT TO FIRM CLAY									
NOTES: - No sloughing at completion of drilling. - Test hole dry at completion of drilling. - Test hole backfilled with auger cuttings.  UTM coordinates based on handheld GPS (+/- 3 m)									

**WATER TABLE**

Dry Hole

NORTH: 6212950.000  
EAST: 652700.000  
TREND: -----  
PLUNGE: (deg)  
ELEV G/S:EQUIPMENT: Hand Auger  
CONTRACTOR: Manitoba Hydro  
DRILLER: Blake Holowick  
COMPLETION: 2015 06 30  
INSPECTOR: Blake HolowickDEPTH: 3.12 m  
ENGINEER: Jeff Tutkaluk

APPROVED:

**Manitoba Hydro**

Civil Engineering

**GEOTECHNICAL LOG****Kelsey Lagoon Preliminary  
Geotechnical Investigation****KL15-05**

1 OF 1

DEPTH (m)	SAMPLE #	SAMPLER	USCS	SOIL DESCRIPTION	Moisture M.C.		Penetrometer		ELEV (m)
					PL	LL	Unconfined	Compression	
					20 40 60 80		20 40 60 80		
					Standard Penetration *		Vane Shear		
					Uncorrected Blow Count (N)		Insitu Peak		
					20 40 60 80		Residual		
							(kPa)		
							Laboratory		
							Torvane		
							Disturbed		

TEST HOLE TERMINATED AT 3.10 m IN SOFT  
CLAY

## NOTES:

- No sloughing at completion of drilling.
- Test hole dry at completion of drilling.
- Test hole backfilled with auger cuttings.

UTM coordinates based on handheld GPS (+/- 3 m)

**WATER TABLE**

Dry Hole

NORTH: 6212950.000  
 EAST: 652800.000  
 TREND: -----  
 PLUNGE: (deg)  
 ELEV G/S:

EQUIPMENT: Hand Auger  
 CONTRACTOR: Manitoba Hydro  
 DRILLER: Blake Holowick  
 COMPLETION: 2015 06 30  
 INSPECTOR:

DEPTH: 3.10 m  
 ENGINEER: Jeff Tutkaluk

APPROVED:



1 OF 1

Printed: 2015/10/16 14:38 2015 KEI SEYI AGOON PRELIMINARY INVESTIGATION GP

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**GEOTECHNICAL LOG****Kelsey Lagoon Preliminary  
Geotechnical Investigation****KL15-07**

1 OF 1

DEPTH (m)	SAMPLE #	SAMPLER	SAMPLER TYPES	USCS	SOIL DESCRIPTION	Moisture		Penetrometer		ELEV (m)
						PL	M.C.	Unconfined	Compression	
						Standard Penetration		Vane Shear		
						Uncorrected Blow Count (N)		Insitu Peak		
								Residual		
0.0			PT Cl		(0.00 - 0.03) ORGANICS - Leaves, grass, decomposed forest matter.  (0.03 - 3.05) CLAY - silty, medium plastic, firm, moist, brown, crumbly  - light brown and soft below 0.4 m  - frozen (seasonal) from 0.7 m to 1.6 m (ice crystals < 1mm diameter) - mottled brown and light brown, varved below 0.76 m  - firm below 1.6 m  - occasional oxidation below 2.1 m  - increasing silt content and trace fine sand below 2.3 m					
0.61	ES-1									
1.52	ES-2									
2.90	ES-3									
3.0										
TEST HOLE TERMINATED AT 3.05 m IN FIRM CLAY										
NOTES: - No sloughing at completion of drilling. - Test hole dry at completion of drilling. - Test hole backfilled with auger cuttings.										
UTM coordinates based on handheld GPS (+/- 3 m)										

**WATER TABLE**

Dry Hole

NORTH: 6212750.000  
EAST: 652900.000  
TREND: -----  
PLUNGE: (deg)  
ELEV G/S:EQUIPMENT: Hand Auger  
CONTRACTOR: Manitoba Hydro  
DRILLER: Blake Holowick  
COMPLETION: 2015 07 01  
INSPECTOR: Blake HolowickDEPTH: 3.05 m  
ENGINEER: Jeff Tutkaluk

APPROVED:



**Manitoba Hydro**

Civil Engineering

**GEOTECHNICAL LOG****Kelsey Lagoon Preliminary  
Geotechnical Investigation****KL15-08**

1 OF 1

DEPTH (m)	SAMPLE #	SAMPLER	SAMPLER TYPES				Moisture M.C.	Penetrometer Unconfined Compression (kPa)	Field Lab	ELEV (m)	
			Split Spoon	Sonic/Air	Core Barrel	Bulk Sample					
			Shelby	Split	Special Samplers	Grab Sample	Standard Penetration * Uncorrected Blow Count (N)	Vane Shear Insitu Peak Residual	Laboratory Torvane Disturbed		
			USCS		SOIL DESCRIPTION						
0.0			PT		(0.00 - 0.15) PEAT - moist, fibrous						
			PT		(0.15 - 0.30) PEAT - moist, black, amorphous						
			CI		(0.30 - 3.02) CLAY - silty, medium plastic, firm, moist, brown						
					- frozen from 0.5 m to 2.0 m (ice crystals < 5 mm diameter)						
					- mottled brown and light brown, varved below 0.6 m						
0.71	ES-1										
1.52	ES-2										
2.90	ES-3										
3.0			TEST HOLE TERMINATED AT 3.02 m IN STIFF CLAY								
NOTES: - No sloughing at completion of drilling. - Test hole dry at completion of drilling. - Test hole backfilled with auger cuttings.											
UTM coordinates based on handheld GPS (+/- 3 m)											

**WATER TABLE**

Dry Hole

NORTH: 6212750.000  
EAST: 653100.000  
TREND: -----  
PLUNGE: (deg)  
ELEV G/S:EQUIPMENT: Hand Auger  
CONTRACTOR: Manitoba Hydro  
DRILLER: Blake Holowick  
COMPLETION: 2015 06 30  
INSPECTOR:DEPTH: 3.02 m  
ENGINEER: Jeff Tutkaluk

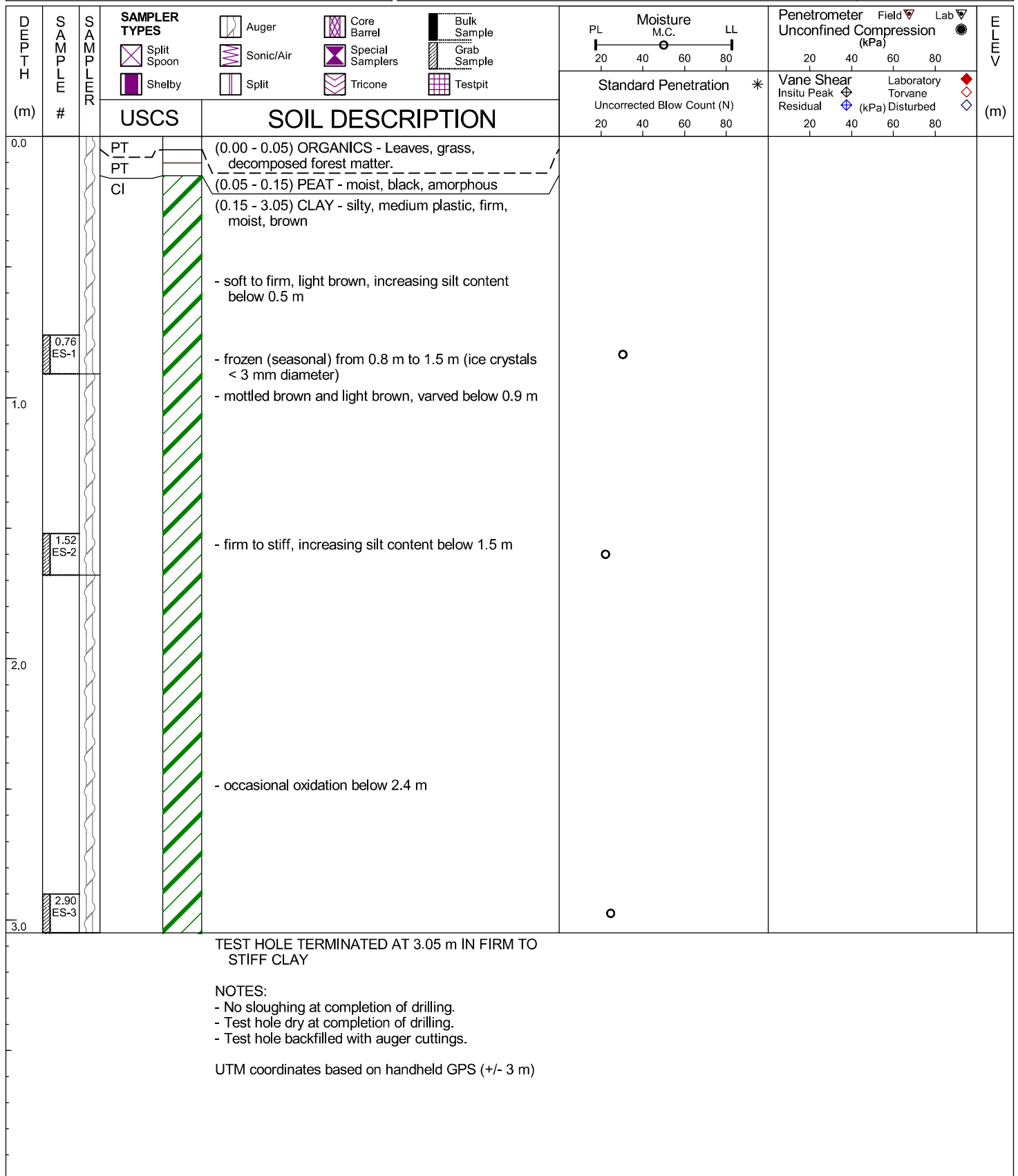
APPROVED:

**Manitoba Hydro**

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**GEOTECHNICAL LOG****Kelsey Lagoon Preliminary  
Geotechnical Investigation****KL15-09**

1 OF 1

**WATER TABLE**

Dry Hole

NORTH: 6212650.000  
EAST: 652800.000  
TREND: -----  
PLUNGE: (deg)  
ELEV G/S:

EQUIPMENT: Hand Auger  
CONTRACTOR: Manitoba Hydro  
DRILLER: Blake Holowick  
COMPLETION: 2015 07 01  
INSPECTOR: Blake Holowick

DEPTH: 3.05 m  
ENGINEER: Jeff Tutkaluk

APPROVED:



# Manitoba Hydro

Civil Engineering

## GEOTECHNICAL LOG

## Kelsey Lagoon Preliminary Geotechnical Investigation

KL15-10

1 OF 1

DEPTH (m)	SAMPLE #	SAMPLER	SAMPLER TYPES	USCS	SOIL DESCRIPTION	Moisture M.C.	Penetrometer Unconfined Compression (kPa)	Field Unconfined Compression (kPa)	Lab Unconfined Compression (kPa)	ELEV (m)
			Auger  Core Barrel  Bulk Sample  Split Spoon  Sonic/Air  Special Samplers  Shelby  Split  Tricone  Grab Sample  Testpit							
0.0				PT	(0.00 - 0.20) PEAT - moist, brown, fibrous					
				CI	(0.20 - 3.05) CLAY - silty, medium plastic, soft to firm, moist, brown, occasional rootlets					
0.76	ES-1				- frozen (seasonal) from 0.8 m to 1.0 m (ice crystals < 1 mm diameter) 0% gravel, 1% sand, 53% silt, 46% clay					
1.52	ES-2				- mottled brown and light brown, varved, increasing silt content below 1.2 m					
2.90	ES-3				- occasional oxidation below 2.4 m					
3.0					0% gravel, 1% sand, 63% silt, 36% clay					
TEST HOLE TERMINATED AT 3.05 m IN SOFT TO FIRM CLAY										
NOTES: - No sloughing at completion of drilling. - Test hole dry at completion of drilling. - Test hole backfilled with auger cuttings.										
UTM coordinates based on handheld GPS (+/- 3 m)										

### WATER TABLE



Dry Hole

NORTH: 6212650.000  
EAST: 652900.000  
TREND: -----  
PLUNGE: (deg)  
ELEV G/S:

EQUIPMENT: Hand Auger  
CONTRACTOR: Manitoba Hydro  
DRILLER: Blake Holowick  
COMPLETION: 2015 06 30  
INSPECTOR:

DEPTH: 3.05 m  
ENGINEER: Jeff Tutkaluk

APPROVED:



1 OF 1

UTM coordinates based on handheld GPS ( $\pm 3$  m)

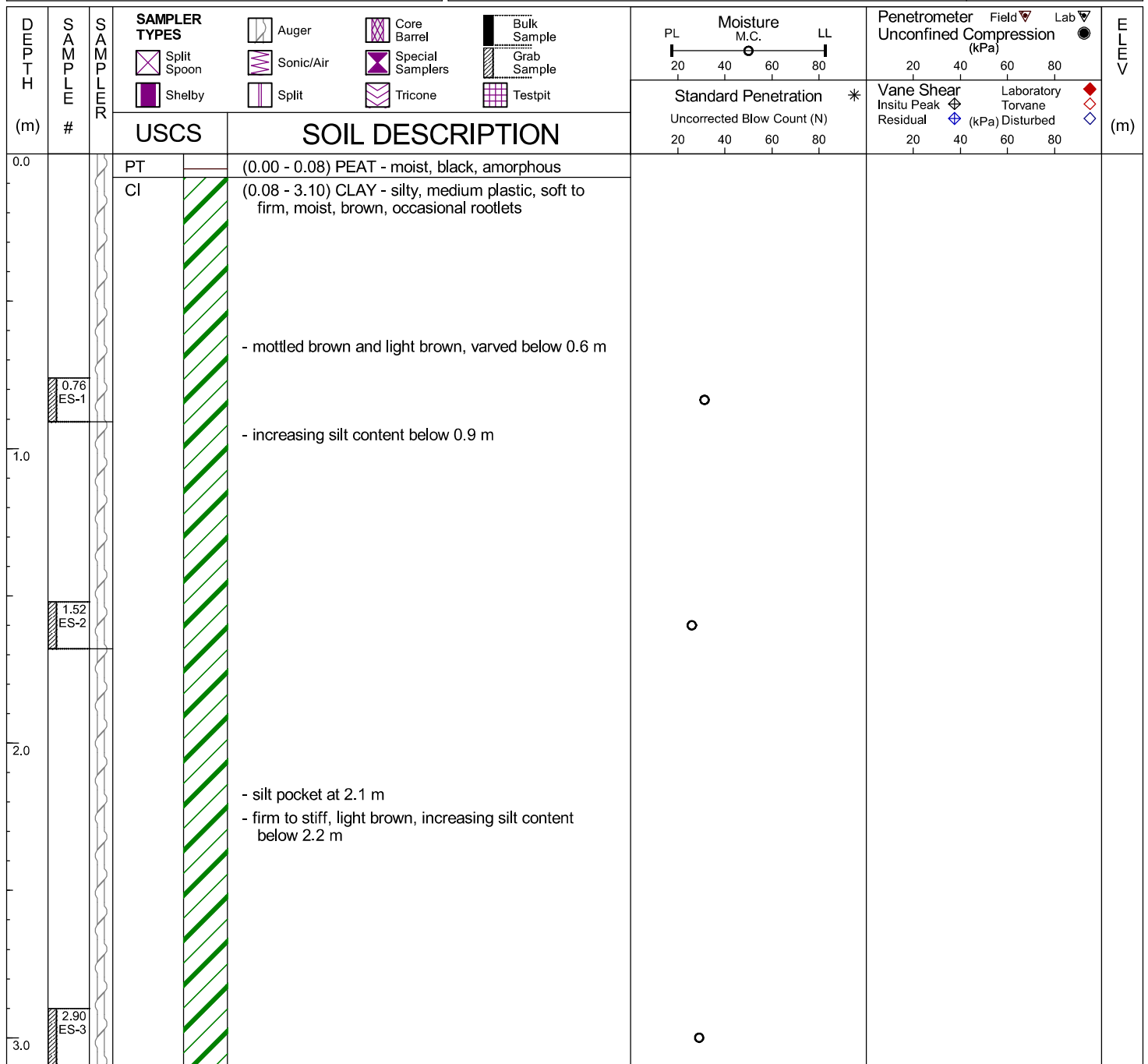
APPROVED:

**Manitoba Hydro**

Civil Engineering

**GEOTECHNICAL LOG****Kelsey Lagoon Preliminary  
Geotechnical Investigation****KL15-12**

1 OF 1

TEST HOLE TERMINATED AT 3.10 m IN FIRM TO  
STIFF CLAY

## NOTES:

- No sloughing at completion of drilling.
- Test hole dry at completion of drilling.
- Test hole backfilled with auger cuttings.

UTM coordinates based on handheld GPS (+/- 3 m)

**WATER TABLE**

Dry Hole

NORTH: 6212650.000  
EAST: 653100.000  
TREND: -----  
PLUNGE: (deg)  
ELEV G/S:EQUIPMENT: Hand Auger  
CONTRACTOR: Manitoba Hydro  
DRILLER: Blake Holowick  
COMPLETION: 2015 06 30  
INSPECTOR: Blake HolowickDEPTH: 3.10 m  
ENGINEER: Jeff Tutkaluk

APPROVED:



**Manitoba Hydro**

Civil Engineering

**GEOTECHNICAL LOG****Kelsey Lagoon Preliminary  
Geotechnical Investigation****KL15-14**

1 OF 1

DEPTH (m)	SAMPLE #	SAMPLER	USCS	SOIL DESCRIPTION	Standard Penetration Uncorrected Blow Count (N)	Penetrometer Unconfined Compression (kPa)	ELEV (m)
0.0			PT CI	(0.00 - 0.03) ORGANICS - Leaves, grass, decomposed forest matter.  (0.03 - 1.02) CLAY - silty, medium plastic, firm, moist, brown  - mottled brown and light brown, varved below 0.6 m - frozen (seasonal) below 0.7 m (ice crystals < 1 mm diameter)			
1.0				AUGER REFUSAL AT 1.02 m IN FROZEN CLAY (AUGER BIT SHEARED)			
				NOTES: - No sloughing at completion of drilling. - Test hole dry at completion of drilling. - Test hole backfilled with auger cuttings.  UTM coordinates based on handheld GPS (+/- 3 m)			
2.0							
3.0							

**WATER TABLE**

Dry Hole

NORTH: 6212300.000  
EAST: 652850.000  
TREND: _____  
PLUNGE: (deg)  
ELEV G/S:EQUIPMENT: Hand Auger  
CONTRACTOR: Manitoba Hydro  
DRILLER: Blake Holowick  
COMPLETION: 2015 07 01  
INSPECTOR: Blake HolowickDEPTH: 1.02 m  
ENGINEER: Jeff Tutkaluk

APPROVED:



# Manitoba Hydro

Civil Engineering

## GEOTECHNICAL LOG

# Kelsey Lagoon Preliminary Geotechnical Investigation

KL15-17

1 OF 1

DEPTH (m)	SAMPLER #	SAMPLER	SAMPLER TYPES				Moisture M.C.		Penetrometer Unconfined Compression (kPa)				ELEV (m)
			Split Spoon	Sonic/Air	Special Samplers	Tricone	Bulk Sample	Grab Sample	Testpit	Standard Penetration	Vane Shear	Laboratory Torvane	
			Shelby	Split						Uncorrected Blow Count (N)	Insitu Peak Residual	(kPa) Disturbed	
			USCS	SOIL DESCRIPTION									
0.0			CI	(0.00 - 2.60) CLAY - silty, medium plastic, firm to stiff, moist, brown									
				- mottled brown and light brown, varved, increasing silt content below 0.4 m									
				- firm below 0.6 m									
				- increasing silt content below 1.0 m									
				- soft to firm below 1.4 m									
				- occasional oxidation below 2.4 m									
			CL	(2.60 - 3.05) CLAY - silty, low plastic, soft to firm, moist, brown to light brown, trace fine sand, varved.									
				0% gravel, 2% sand, 74% silt, 24% clay									
TEST HOLE TERMINATED AT 3.05 m IN SOFT TO FIRM CLAY													
NOTES: - No sloughing at completion of drilling. - Test hole dry at completion of drilling. - Test hole backfilled with auger cuttings.													
UTM coordinates based on handheld GPS (+/- 3 m)													

### WATER TABLE



Dry Hole

NORTH: 6212306.000  
 EAST: 653145.000  
 TREND: -----  
 PLUNGE: (deg)  
 ELEV G/S:

EQUIPMENT: Hand Auger  
 CONTRACTOR: Manitoba Hydro  
 DRILLER: Blake Holowick  
 COMPLETION: 2015 07 01  
 INSPECTOR:

DEPTH: 3.05 m  
 ENGINEER: Jeff Tutkaluk

APPROVED:

**Manitoba Hydro**

Civil Engineering

**GEOTECHNICAL LOG****Kelsey Lagoon Preliminary  
Geotechnical Investigation****KL15-18**

1 OF 1

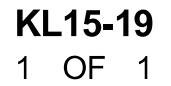
DEPTH (m)	SAMPLE #	SAMPLER	USCS	SOIL DESCRIPTION	Standard Penetration Uncorrected Blow Count (N)	Penetrometer Unconfined Compression (kPa)	Field Unconfined Compression (kPa)	Lab Unconfined Compression (kPa)	ELEV (m)
0.0			PT CI	(0.00 - 0.03) ORGANICS - Leaves, grass, decomposed forest matter.  (0.03 - 1.19) CLAY - silty, medium plastic, firm, moist, brown, trace rootlets to 0.3 m depth  - frozen below 0.7 m (ice crystals < 1 mm diameter)  - varved below 1.1 m					
1.0									
2.0									
3.0									
HAND AUGER REFUSAL AT 1.19 m IN FROZEN CLAY									
NOTES: - No sloughing at completion of drilling. - Test hole dry at completion of drilling. - Test hole backfilled with auger cuttings.									
UTM coordinates based on handheld GPS (+/- 3 m)									

**WATER TABLE**

Dry Hole

NORTH: 6212200.000  
EAST: 652850.000  
TREND: -----  
PLUNGE: (deg)  
ELEV G/S:EQUIPMENT: Hand Auger  
CONTRACTOR: Manitoba Hydro  
DRILLER: Blake Holowick  
COMPLETION: 2015 06 29  
INSPECTOR: Blake HolowickDEPTH: 1.19 m  
ENGINEER: Jeff Tutkaluk

APPROVED:



<b>WATER TABLE</b>  Dry Hole	NORTH: 6212200.000 EAST: 652950.000 TREND: ----- PLUNGE: (deg) ELEV G/S:	EQUIPMENT: Hand Auger CONTRACTOR: Manitoba Hydro DRILLER: Blake Holowick COMPLETION: 2015 06 29 INSPECTOR: Blake Holowick	DEPTH: 2.97 m ENGINEER: Jeff Tutkaluk APPROVED: 
--------------------------------------------------------------------------------------------------------------------	--------------------------------------------------------------------------------------	---------------------------------------------------------------------------------------------------------------------------------------	---------------------------------------------------------------------------------------------------------------------------------------------

**Manitoba Hydro**

Civil Engineering

**GEOTECHNICAL LOG****Kelsey Lagoon Preliminary  
Geotechnical Investigation****KL15-22**

1 OF 1

DEPTH (m)	SAMPLE #	SAMPLER	USCS	SOIL DESCRIPTION	Standard Penetration Uncorrected Blow Count (N)	Penetrometer Unconfined Compression (kPa)	Vane Shear Insitu Peak Residual (kPa)	Laboratory Torvane Disturbed	ELEV (m)
0.0			PT	(0.00 - 0.08) PEAT - moist, black, amorphous					
			CI	(0.08 - 3.05) CLAY - silty, medium plastic, firm, moist, brown					
				- frozen from 0.6 m to 1.3 m					
1.0				- brown to light brown, varved below 1.2 m					
				- stiff below 1.3 m					
				- occasional oxidation below 1.4 m					
2.0				- increasing silt content below 2.1 m					
				- mottled grey and brown below 5.3 m					
3.0									
TEST HOLE TERMINATED AT 3.05 m IN STIFF CLAY									
NOTES:									
- No sloughing at completion of drilling.									
- Test hole dry at completion of drilling.									
- Test hole backfilled with auger cuttings.									
UTM coordinates based on handheld GPS (+/- 3 m)									

**WATER TABLE**

Dry Hole

NORTH: 6212100.000  
EAST: 652850.000  
TREND: -----  
PLUNGE: (deg)  
ELEV G/S:EQUIPMENT: Hand Auger  
CONTRACTOR: Manitoba Hydro  
DRILLER: Blake Holowick  
COMPLETION: 2015 06 29  
INSPECTOR: Blake HolowickDEPTH: 3.05 m  
ENGINEER: Jeff Tutkaluk

APPROVED:



DEPTH (m)	SAMPLE #	SAMPLER	SAMPLER TYPES			Moisture M.C.		Penetrometer		ELEV (m)
			Split Spoon	Sonic/Air	Shelby	Auger	Core Barrel	Special Samplers	Grab Sample	
0.0			PT							
			(0.00 - 0.30) PEAT - moist to wet, black, amorphous							
			- frozen below 0.3 m							
			HAND AUGER REFUSAL AT 0.3 m IN FROZEN PEAT							
			NOTES:							
			- No sloughing at completion of drilling.							
			- Test hole dry at completion of drilling.							
			- Test hole backfilled with auger cuttings.							
			UTM coordinates based on handheld GPS (+/- 3 m)							

**WATER TABLE** 

Dry Hole

NORTH: 6212100.000  
EAST: 652950.000  
TREND: -----  
PLUNGE: (deg)  
ELEV G/S:

EQUIPMENT: Hand Auger  
CONTRACTOR: Manitoba Hydro  
DRILLER: Blake Holowick  
COMPLETION: 2015 06 29  
INSPECTOR: Blake Holowick

DEPTH:	0.30 m
ENGINEER:	Jeff Tutkaluk

APPROVED:



[illegible]

**WATER TABLE** 

Dry Hole

NORTH: 6212100.000  
EAST: 653050.000  
TREND: -----  
PLUNGE: (deg)  
ELEV G/S:

EQUIPMENT: Hand Auger  
CONTRACTOR: Manitoba Hydro  
DRILLER: Blake Holowick  
COMPLETION: 2015 06 29  
INSPECTOR: Blake Holowick

DEPTH:	0.81 m
ENGINEER:	Jeff Tutkaluk

APPROVED:

*Signature*



**Manitoba Hydro**

Civil Engineering

**GEOTECHNICAL LOG**

**Kelsey Lagoon Preliminary  
Geotechnical Investigation**

**KL15-25**

1 OF 1

DEPTH (m)	SAMPLE #	SAMPLER	SAMPLER TYPES	USCS	SOIL DESCRIPTION	Moisture		Penetrometer		ELEV (m)
						PL	M.C.	Unconfined	Compression	
0.0			Auger   Core Barrel   Bulk Sample   Split Spoon   Sonic/Air   Grab Sample   Shelby   Split   Special Samplers   Tricone   Testpit		(0.00 - 0.03) ORGANICS - Leaves, grass, decomposed forest matter. (0.03 - 3.05) CLAY - silty, medium plastic, firm, moist, brown - light brown below 0.3 m					
0.76	ES-1				- mottled brown and light brown, varved below 0.9 m					
1.52	ES-2				- stiff below 1.8 m					
2.90	ES-3				- occasional oxidation below 2.0 m					
3.0					- increasing silt content below 2.1 m					
					- firm to stiff below 2.4 m					
TEST HOLE TERMINATED AT 3.05 m IN FIRM TO STIFF CLAY  NOTES: - No sloughing at completion of drilling. - Test hole dry at completion of drilling. - Test hole backfilled with auger cuttings.  UTM coordinates based on handheld GPS (+/- 3 m)										

<b>WATER TABLE</b> Dry Hole	NORTH: 6212100.000 EAST: 653150.000 TREND: ----- PLUNGE: (deg) ELEV G/S:	EQUIPMENT: Hand Auger CONTRACTOR: Manitoba Hydro DRILLER: Blake Holowick COMPLETION: 2015 07 01 INSPECTOR: Blake Holowick	DEPTH: 3.05 m ENGINEER: Jeff Tutkaluk APPROVED:
--------------------------------	--------------------------------------------------------------------------------------	---------------------------------------------------------------------------------------------------------------------------------------	-------------------------------------------------------

**Manitoba Hydro**

Civil Engineering

**GEOTECHNICAL LOG****Kelsey Lagoon Preliminary  
Geotechnical Investigation****KL15-26**

1 OF 1

DEPTH (m)	SAMPLE #	SAMPLER	USCS	SOIL DESCRIPTION	Standard Penetration Uncorrected Blow Count (N)	Penetrometer Unconfined Compression (kPa)	Field Unconfined Compression (kPa)	Lab Unconfined Compression (kPa)	ELEV (m)
0.0			CI	(0.00 - 3.05) CLAY - silty, medium plastic, stiff, moist, brown, friable to 0.5 m					
				- mottled brown, light brown and greyish brown, varved below 0.5 m					
	0.71 ES-1			- firm to stiff below 0.9 m					
1.0				- increasing silt content below 1.1 m					
	1.52 ES-2			- firm below 1.5 m					
				- occasional oxidation below 1.8 m					
2.0				- increasing silt content below 2.4 m					
	2.90 ES-3								
3.0									
TEST HOLE TERMINATED AT 3.05 m IN FIRM CLAY									
NOTES: - No sloughing at completion of drilling. - Test hole dry at completion of drilling. - Test hole backfilled with auger cuttings.									
UTM coordinates based on handheld GPS (+/- 3 m)									

**WATER TABLE**

Dry Hole

NORTH: 6212250.000  
EAST: 653056.000  
TREND: -----  
PLUNGE: (deg)  
ELEV G/S:EQUIPMENT: Hand Auger  
CONTRACTOR: Manitoba Hydro  
DRILLER: Blake Holowick  
COMPLETION: 2015 07 01  
INSPECTOR: Blake HolowickDEPTH: 3.05 m  
ENGINEER: Jeff Tutkaluk

APPROVED:

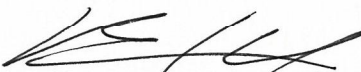


## Appendix C

### MB Hydro Geotechnical Report

**Kelsey Generating Station**  
**Proposed Wastewater Lagoon**  
**Geotechnical Site Selection Recommendations**

Prepared by:   
Jeff Tutkaluk, M.Sc., P.Eng.  
Geotechnical Engineering Section Head

Reviewed by:   
Blake Holowick, M.Sc., P.Eng.  
Geotechnical Engineer

Approved by:   
Jeff Tutkaluk, M.Sc., P.Eng.  
Geotechnical Engineering Section Head

Noted by:  for Halina  
Halina Zbigniewicz, P.Eng.  
Civil Engineering Department Manager



Date: 2015 10 16  
Report No. ESD15-47

**Geotechnical Engineering Section**  
**Civil Engineering Department**  
**Engineering Services Division**  
**Generation Operations Business Unit**

**IMPORTANT**

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## ***Statement of Limitations***

The findings and recommendations of this report were prepared in accordance with generally accepted professional engineering principles and practice. The recommendations in this report are based on the results of field and laboratory investigations, combined with an interpolation of soil and groundwater conditions between test hole locations. They do not reflect variations in the subsurface conditions which may exist between the test holes and in unexplored areas of the site. If the conditions encountered during construction appear to be different from those shown on the test hole logs, or if the assumptions stated herein are not in keeping with the design, the Civil Engineering Department should be notified so that the recommendations can be reviewed and adjusted, if necessary.

The Civil Engineering Department requests the opportunity to review drawings and specifications related to any designs based on the recommendations provided in this report to confirm that they have been correctly interpreted.

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## **1.0 Summary**

Manitoba Hydro intends to construct a wastewater lagoon at the Kelsey Generating Station. The Civil Engineering Department (CED) has completed a preliminary geotechnical investigation and determined a preferred location for the wastewater lagoon. The preferred site is southwest of the generating station and is the central site of the three areas investigated. The preferred site is a compromise between proximity to the staffhouse, dwellings and other ancillary buildings, and the required length of wastewater piping.

## **2.0 Background**

The Generation North Division (Gen North) of the Generation Operations Business Unit has determined that a wastewater lagoon is required at the Kelsey Generating Station (GS). Currently, two mechanical systems are present at the Kelsey GS for treating wastewater and consist of a Sequencing Batch Reactor (SBR) and a Bio-Brane. Several upgrades have been made to the SRB while the Bio-Brane was added to the treatment process to accommodate the increase in site personnel required for the re-running project at the Kelsey GS.

To increase reliability and reduce operating costs of the current mechanical systems, Gen North is proposing to construct a wastewater lagoon to replace the current mechanical treatment systems. The lagoon will be approximately 200 m long by 100 m wide and consist of two cells.

As requested by the Power Projects Department (PPD), the CED undertook a preliminary geotechnical investigation to determine a suitable location for the proposed lagoon. Initially, the CED reviewed aerial photography and identified three (3) potential sites (located south and southwest of the GS) for the proposed lagoon (Figure 1). Hand auger test holes were drilled in each of the three potential lagoon sites to assess the shallow soil conditions (Figure 2). The results of the geotechnical investigation have been used to determine a preferred location for the proposed lagoon.

## **3.0 Site Conditions**

With the exception of trails and transmission Right of Ways, the three potential sites are generally covered by moderate to thick vegetation consisting mostly of young evergreen trees. Topographically, all three sites gently slope to the west and are bounded by a stream/creek. The central site is bounded to the south by a low-lying area covered with organics that contained standing water at the time of the field investigation. The south site is bounded to the north by the same low-lying area situated on the south side of the central site and is also bounded to the south by another low-lying area.

Generally, the test hole locations seemed to be reasonably well drained and had only small amounts of organic material at the surface. The organic material typically consisted of a thin layer of leaves and other decomposing vegetation.

### **3.1 Field and Laboratory Investigations**

Twenty-one (21) test holes (KL15-01 to KL15-12, KL15-14, KL15-17 to KL15-19, and KL15-22 to KL15-26) were drilled from June 29 to July 1, 2015 using a 75 mm diameter hand auger; the locations of the test holes are shown on Figure 2. The test holes were generally terminated at approximately 3 m below ground surface.

All soils observed during the test hole drilling were visually classified on-site according to a modified version of the Unified Soil Classification System. Disturbed (auger grab) samples were obtained at regular intervals during drilling. The soil samples obtained during the field

investigation were transported to Manitoba Hydro's materials testing laboratory for further examination and testing. Laboratory testing consisted of moisture content determination, Atterberg limit testing and grain size analysis.

The test hole logs are included in Appendix A and show the soil profile, laboratory testing results, and comments on the groundwater and sloughing conditions encountered.

### **3.2 Subsurface Conditions**

The general soil profile, in descending order from ground surface, consisted of organic soil/peat overlying medium plastic clay. Each of the encountered stratigraphic units is discussed separately as follows.

#### Clay Fill

Clay fill was encountered in KL15-01 and KL15-02 and extended from ground surface to a depth of approximately 0.3 m. The clay fill was silty, high plastic, soft to firm, moist and brown to grayish brown.

#### Organics/Peat

Organics/peat were encountered in nearly all the test holes drilled. The organics consisted of leaves and other decomposed vegetation and generally varied in thickness from about 25 mm to 50 mm. The peat encountered in the test holes varied in thickness from about 0.05 m to 0.4 m. The peat was generally moist, black and amorphous.

#### Medium Plastic Clay

Medium plastic clay underlied the clay fill or the organics/peat in each test hole, and extended to depths varying from about 2.6 m to the end of the test holes. The medium plastic clay was generally silty, firm to stiff, moist and brown. With increasing depth, the medium plastic clay generally became siltier, varved (alternating layers of silt and clay), and brown to light brown. The *in situ* moisture content of the medium plastic clay generally varied between approximately 20% and 32%.

#### Low Plastic Clay

The medium plastic clay was underlain by low plastic clay in test hole KL15-17 based on laboratory testing completed. The low plastic clay was silty, soft to firm, moist, brown to light brown, contained trace sand and was varved. Based on a single test, the moisture content of the low plastic clay was approximately 25%.

Detailed descriptions of the soil profiles can be found on the test hole logs attached in Appendix A.

Seepage or sloughing was not observed in any test holes. It should be noted that seepage and sloughing conditions can change yearly, seasonally or as a result of construction activity.

### **4.0 Discussion and Recommendations**

Three locations were identified as being potentially suitable for a lagoon site based on favorable characteristics identified by air photo interpretation. All three sites were located on the west side of the Kelsey forebay, south and southwest of the generating station and had similar

subsurface stratigraphy which consisted of medium plastic clay from ground surface to a depth of 3 m or deeper. The primary difference between the three sites is their proximity to the staffhouse and shop buildings.

Although advanced lab testing (permeability testing) was not performed, it is assumed that the medium plastic clay encountered at all three sites would be suitable as lagoon liner material. In this regard, the GES recommends that the west end of the central site be considered as the location of the lagoon for the Kelsey GS (Figure 2). The central site is a compromise between distance from the staffhouse, dwellings and other ancillary buildings, and the required length of wastewater piping.

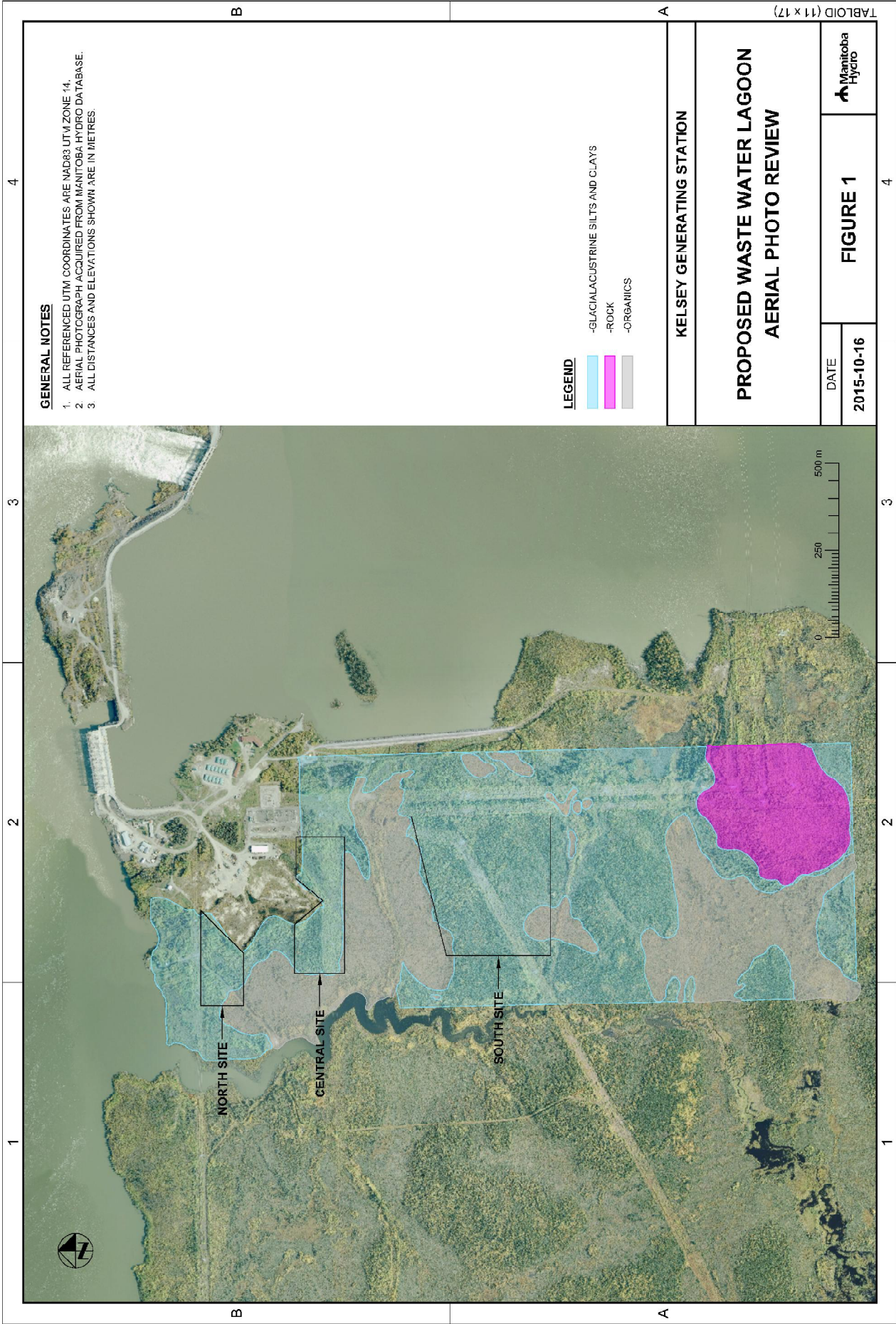
Preparation (clearing and grubbing) of the preferred site should be undertaken as early as possible in the construction process. Failure to properly clear the site will increase the risk of frozen soil (seasonal frost) being encountered during construction excavation activities.

## **5.0 Environmental Considerations**

The environmental impacts of the geotechnical investigation were considered prior to conducting the work, and all work was completed in accordance with Manitoba Hydro's Environmental Management Policy. All designs and construction based on this report should follow Manitoba Hydro's Environmental Management Policy.

## ***Figures***





**GENERAL NOTES**

- 1. ALL REFERENCED UTM COORDINATES ARE NAD83 UTW ZONE 14.
- 2. AERIAL PHOTOGRAPH ACQUIRED FROM MANITOBA HYDRO DATABASE.
- 3. ALL DISTANCES AND ELEVATIONS SHOWN ARE IN METRES.

**LEGEND**

- GLACIOLACUSTRINE SILTS AND CLAYS
- ROCK
- ORGANICS

KELSEY GENERATING STATION	
PROPOSED WASTE WATER LAGOON AERIAL PHOTO REVIEW	
DATE	FIGURE 1
2015-10-16	



TABLOID (11 x 17)

Your C.O.C. #: 408794

**Attention: FRASER KENT**

H2O INNOVATION  
5100 SOUTH SERVICE RD.  
UNIT 17  
BURLINGTON, ON  
CANADA L7L 6A5

**Report Date: 2013/09/20**

## CERTIFICATE OF ANALYSIS

**MAXXAM JOB #: B382854**
**Received: 2013/09/13, 11:30**

Sample Matrix: Water  
# Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Biochemical Oxygen Demand	2	N/A	2013/09/13	WIN SOP-00018	Based on SM-5210B
Ammonia-N (Preserved) (1)	2	N/A	2013/09/18	BBY6SOP-00009	SM-4500NH3G
Total Suspended Solids	2	N/A	2013/09/17	WIN SOP-00042	Based on SM2540 D

* Results relate only to the items tested.

(1) This test was performed by Maxxam Vancouver

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Janelle Kochan, B.Sc., Project Manager,  
Email: JKochan@maxxam.ca  
Phone# (204) 772-7276 Ext:2209

=====

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

Total cover pages: 1

## RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID	HM6670	HM6671		
Sampling Date	2013/09/12 09:00	2013/09/12 09:02		
COC#	408794	408794		
	RAW FEED	TREATED EFFLUENT	RDL	QC Batch
UNITS				
<b>Demand Parameters</b>				
Biochemical Oxygen Demand	mg/L	330	2	2
<b>Nutrients</b>				
Ammonia (N)	mg/L	42	0.050	0.0050
<b>Physical Properties</b>				
Total Suspended Solids	mg/L	116	4.0	4.0
				7181139

RDL = Reportable Detection Limit

### QUALITY ASSURANCE REPORT

QC Batch	Parameter	Date	Matrix Spike		Spiked Blank		Method Blank		RPD		Calibration Check	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
7173015	Biochemical Oxygen Demand	2013/09/13					<1	mg/L	NC	20	101	84 - 115
7177240	Ammonia (N)	2013/09/18	94	80 - 120	105	80 - 120	<0.0050	mg/L	NC	20		
7181139	Total Suspended Solids	2013/09/17	88	80 - 120	100	80 - 120	<4.0	mg/L	12.8	20		

N/A = Not Applicable

RPD = Relative Percent Difference

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

Calibration Check: A calibration standard analyzed at different times to evaluate on-going calibration accuracy.

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

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

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

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

## Validation Signature Page

**Maxxam Job #: B382854**

---

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

  
_____  
Andy Lu, Data Validation Coordinator

=====

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Your C.O.C. #: 408793

**Attention: FRASER KENT**

H2O INNOVATION  
5100 SOUTH SERVICE RD.  
UNIT 17  
BURLINGTON, ON  
CANADA L7L 6A5

**Report Date: 2013/09/20**

## CERTIFICATE OF ANALYSIS

**MAXXAM JOB #: B382875**
**Received: 2013/09/13, 11:30**

Sample Matrix: Water  
# Samples Received: 3

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Biochemical Oxygen Demand	2	N/A	2013/09/13	WIN SOP-00018	Based on SM-5210B
Ammonia-N (Preserved) (1)	2	N/A	2013/09/18	BBY6SOP-00009	SM-4500NH3G
Total Suspended Solids	3	N/A	2013/09/17	WIN SOP-00042	Based on SM2540 D

* Results relate only to the items tested.

(1) This test was performed by Maxxam Vancouver

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Janelle Kochan, B.Sc., Project Manager,  
Email: JKochan@maxxam.ca  
Phone# (204) 772-7276 Ext:2209

=====

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

Total cover pages: 1

## RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		HM6803	HM6804	HM6805	
Sampling Date		2013/09/11 18:30	2013/09/11 18:31	2013/09/11 18:32	
COC#		408793	408793	408793	
	UNITS	RAW FEED	MEMBRANE TANK MIXED LIQUOR	TREATED EFFLUENT	QC Batch
<b>Demand Parameters</b>					
Biochemical Oxygen Demand	mg/L	457		4	2
<b>Nutrients</b>					
Ammonia (N)	mg/L	38		0.055	0.0050
<b>Physical Properties</b>					
Total Suspended Solids	mg/L	156	<4.0	<4.0	4.0
					7173015
					7177240
					7181139

RDL = Reportable Detection Limit

Maxxam Job #: B382875  
Report Date: 2013/09/20

H2O INNOVATION

### QUALITY ASSURANCE REPORT

QC Batch	Parameter	Date	Matrix Spike		Spiked Blank		Method Blank		RPD		Calibration Check	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
7173015	Biochemical Oxygen Demand	2013/09/13					<1	mg/L	NC	20	101	84 - 115
7177240	Ammonia (N)	2013/09/18	94	80 - 120	105	80 - 120	<0.0050	mg/L	NC	20		
7181139	Total Suspended Solids	2013/09/17	88	80 - 120	100	80 - 120	<4.0	mg/L	12.8	20		

N/A = Not Applicable

RPD = Relative Percent Difference

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

Calibration Check: A calibration standard analyzed at different times to evaluate on-going calibration accuracy.

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

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

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

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

## Validation Signature Page

**Maxxam Job #: B382875**

---

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

  
_____  
Andy Lu, Data Validation Coordinator

=====

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Maxxam										Maxxam Analytics International Corporation o/a Maxxam Analytics										D-675 Berry Street, Winnipeg, Manitoba Canada R3H 1A7 Tel: (204) 772-2386 Toll-free: (800) 665-8566 Fax: (204) 772-2386 www.maxxam.ca										CHAIN OF CUSTODY RECORD										Page 1 of 1																			
INVOICE INFORMATION:										REPORT INFORMATION (if differs from invoice):										PROJECT INFORMATION:										Laboratory Use Only:																													
Company Name: #11201 H2O INNOVATION										Company Name:										Quotation #:										MAXXAM JOB #:										BOTTLE ORDER #:																			
Contact Name: FRASER KENT										Contact Name:										P.O. #:										P.O. #:										408793																			
Address: 5100 SOUTH SERVICE RD. UNIT 17										Address:										Project #:										Project #:																													
BURLINGTON ON L7L 6A5										BURLINGTON ON L7L 6A5										Project Name:										Project Name:																													
Phone: (289) 813-5533 x103										Phone:										Site #:										Site #:																													
Email: fraser.kent@h2oinnovation.com										Email:										Fac:										Fac:																													
REGULATORY CRITERIA:										SPECIAL INSTRUCTIONS:										ANALYSIS REQUESTED (Please be specific):										TURNAROUND TIME (TAT) REQUIRED:																													
Note: For regulated drinking water samples - please use the Drinking Water Chain of Custody Form										Regulated Drinking Water ? (Y / N)										Metals Field Filtered ? (Y / N)										Ammonia-N										Biochemical Oxygen Demand										Total Suspended Solids									
SAMPLER MUST BE KEPT COOL (< 10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM										Sample (Location) Identification										Date Sampled										Time Sampled										Matrix																			
1 197 1803										RAW FEED										13 9 11										18 30																													
2 1										BIO-WHEEL MIXED LIQUOR										13 9 11										18 30																													
3 1 04										MEMBRANE TANK MIXED LIQUOR										13 9 11										18 31																													
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Page 5 of 5										Page 5 of 5										Page 5 of 5										Page 5 of 5										Page 5 of 5																			
Laboratory Use Only										Laboratory Use Only										Laboratory Use Only										Laboratory Use Only																													
Time Sampled										Temperature (°C) on Receipt										Custody Seal Initialed on										Custody Seal Initialed on																													
10.7.10.2.10.2										10.7.10.2.10.2										10.7.10.2.10.2										10.7.10.2.10.2																													
Yes										Yes										Yes										Yes																													
No										No										No										No																													

Your Project #: KELSEY GS STP PILOT  
Your C.O.C. #: 408799

**Attention: FRASER KENT**

H2O INNOVATION  
5100 SOUTH SERVICE RD.  
UNIT 17  
BURLINGTON, ON  
CANADA L7L 6A5

**Report Date: 2013/09/24**

**CERTIFICATE OF ANALYSIS**

**MAXXAM JOB #: B384628**

**Received: 2013/09/18, 13:15**

Sample Matrix: Water  
# Samples Received: 3

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Biochemical Oxygen Demand	2	N/A	2013/09/18	WIN SOP-00018	Based on SM-5210B
Ammonia-N (Preserved) (1)	2	N/A	2013/09/20	BBY6SOP-00009	SM-4500NH3G
Total Suspended Solids	3	N/A	2013/09/23	WIN SOP-00042	Based on SM2540 D

* Results relate only to the items tested.

(1) This test was performed by Maxxam Vancouver

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Janelle Kochan, B.Sc., Project Manager,  
Email: JKochan@maxxam.ca  
Phone# (204) 772-7276 Ext:2209

=====

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Total cover pages: 1



Maxxam Job #: B384628  
Report Date: 2013/09/24

H2O INNOVATION  
Client Project #: KELSEY GS STP PILOT

## RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		HO0329	HO0330		HO0331	
Sampling Date		2013/09/16 11:59	2013/09/16 11:59		2013/09/16 11:59	
COC#		408799	408799		408799	
	UNITS	RAW FEED	BIO-WHEEL MIXED LIQUOR	RDL	TREATED EFFLUENT	RDL
						QC Batch
<b>Demand Parameters</b>						
Biochemical Oxygen Demand	mg/L	288		2	5	2
<b>Nutrients</b>						
Ammonia (N)	mg/L	41		0.50	0.069	0.0050
<b>Physical Properties</b>						
Total Suspended Solids	mg/L	114	5560	4.0	<4.0	4.0
						7185713

RDL = Reportable Detection Limit

Maxxam Job #: B384628  
Report Date: 2013/09/24

H2O INNOVATION  
Client Project #: KELSEY GS STP PILOT

### QUALITY ASSURANCE REPORT

QC Batch	Parameter	Date	Matrix Spike		Spiked Blank		Method Blank		RPD		Calibration Check	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
7182158	Ammonia (N)	2013/09/20	NC	80 - 120	102	80 - 120	<0.0050	mg/L	11.2	20		
7185107	Biochemical Oxygen Demand	2013/09/18					<1	mg/L	NC	20	106	84 - 115
7185713	Total Suspended Solids	2013/09/23	109	80 - 120	97	80 - 120	<4.0	mg/L	8.7	20		

N/A = Not Applicable

RPD = Relative Percent Difference

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

Calibration Check: A calibration standard analyzed at different times to evaluate on-going calibration accuracy.

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

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

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

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

## Validation Signature Page

**Maxxam Job #: B384628**

---

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

  
_____  
Andy Lu, Data Validation Coordinator

=====

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Your Project #: KELSEY GS H2O PILOT  
Your C.O.C. #: 408802

**Attention: FRASER KENT**  
H2O INNOVATION  
5100 SOUTH SERVICE RD.  
UNIT 17  
BURLINGTON, ON  
CANADA L7L 6A5

**Report Date: 2013/09/26**

## **CERTIFICATE OF ANALYSIS**

**MAXXAM JOB #: B385247**  
**Received: 2013/09/19, 15:45**

Sample Matrix: Water  
# Samples Received: 4

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Biochemical Oxygen Demand	2	N/A	2013/09/20	WIN SOP-00018	Based on SM-5210B
Ammonia-N (Preserved) (1)	2	N/A	2013/09/20	BBY6SOP-00009	SM-4500NH3G
Total Suspended Solids	4	N/A	2013/09/23	WIN SOP-00042	Based on SM2540 D

* Results relate only to the items tested.

(1) This test was performed by Maxxam Vancouver

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Janelle Kochan, B.Sc., Project Manager,  
Email: JKochan@maxxam.ca  
Phone# (204) 772-7276 Ext:2209

=====

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Total cover pages: 1

Maxxam Job #: B385247  
Report Date: 2013/09/26

H2O INNOVATION  
Client Project #: KELSEY GS H2O PILOT  
Sampler Initials: KS

## RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID	HO4223	HO4224	HO4225	HO4226		
Sampling Date	2013/09/18 08:10	2013/09/18 08:15	2013/09/18 08:15	2013/09/18 08:15		
COC#	408802	408802	408802	408802		
	UNITS	RAW FEED	BIO-WHEEL MIXED LIQUOR	MEMBRANE TANK MIXED LIQUOR	RDL	TREATED EFFLUENT
					RDL	QC Batch
<b>Demand Parameters</b>						
Biochemical Oxygen Demand	mg/L	115		2	<2	2
<b>Nutrients</b>						
Ammonia (N)	mg/L	27		0.50	0.047	0.0050
<b>Physical Properties</b>						
Total Suspended Solids	mg/L	82.0	5010	6170	4.0	4.3
					4.0	7186192

RDL = Reportable Detection Limit



Maxxam Job #: B385247  
Report Date: 2013/09/26

H2O INNOVATION  
Client Project #: KELSEY GS H2O PILOT  
Sampler Initials: KS

### QUALITY ASSURANCE REPORT

QC Batch	Parameter	Date	Matrix Spike		Spiked Blank		Method Blank		RPD		Calibration Check	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
7182158	Ammonia (N)	2013/09/20	NC	80 - 120	102	80 - 120	<0.0050	mg/L	11.2	20		
7185121	Biochemical Oxygen Demand	2013/09/20					<1	mg/L	NC	20	100	84 - 115
7186192	Total Suspended Solids	2013/09/23	117	80 - 120	107	80 - 120	<4.0	mg/L	NC	20		

N/A = Not Applicable

RPD = Relative Percent Difference

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

Calibration Check: A calibration standard analyzed at different times to evaluate on-going calibration accuracy.

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

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

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

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

## Validation Signature Page

**Maxxam Job #: B385247**

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

  
_____  
Andy Lu, Data Validation Coordinator

=====

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Site Location: KELSEY G.S. H2O PILOT  
Your C.O.C. #: 408801

**Attention: FRASER KENT**  
H2O INNOVATION  
5100 SOUTH SERVICE RD.  
UNIT 17  
BURLINGTON, ON  
CANADA L7L 6A5

**Report Date: 2013/10/01**

## **CERTIFICATE OF ANALYSIS**

**MAXXAM JOB #: B387328**  
**Received: 2013/09/25, 11:00**

Sample Matrix: Water  
# Samples Received: 3

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Biochemical Oxygen Demand	2	N/A	2013/09/25	WIN SOP-00018	Based on SM-5210B
Ammonia-N (Preserved) (1)	2	N/A	2013/09/27	BBY6SOP-00009	SM-4500NH3G
Total Suspended Solids	3	N/A	2013/09/26	WIN SOP-00042	Based on SM2540 D

* Results relate only to the items tested.

(1) This test was performed by Maxxam Vancouver

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Janelle Kochan, B.Sc., Project Manager,  
Email: JKochan@maxxam.ca  
Phone# (204) 772-7276 Ext:2209

=====

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Total cover pages: 1

Maxxam Job #: B387328  
Report Date: 2013/10/01

H2O INNOVATION

Site Location: KELSEY G.S. H2O PILOT  
Sampler Initials: KS

## RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID	HP8652	HP8653	HP8654		
Sampling Date	2013/09/24 07:00	2013/09/24 07:00	2013/09/24 07:05		
COC#	408801	408801	408801		
UNITS	RAW FEED	BIO-WHEEL MIXED LIQUOR	TREATED EFFLUENT	RDL	QC Batch
<b>Demand Parameters</b>					
Biochemical Oxygen Demand	mg/L	254	2	2	7192009
<b>Nutrients</b>					
Ammonia (N)	mg/L	28	0.50	0.054	0.0050
<b>Physical Properties</b>					
Total Suspended Solids	mg/L	276	4.0	<4.0	4.0
					7192032

RDL = Reportable Detection Limit

Maxxam Job #: B387328  
Report Date: 2013/10/01

H2O INNOVATION

Site Location: KELSEY G.S. H2O PILOT  
Sampler Initials: KS

### QUALITY ASSURANCE REPORT

QC Batch	Parameter	Date	Matrix Spike		Spiked Blank		Method Blank		RPD		Calibration Check	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
7192009	Biochemical Oxygen Demand	2013/09/25					<1	mg/L	NC	20	98	84 - 115
7192032	Total Suspended Solids	2013/09/26	102	80 - 120	129(1)	80 - 120	<4.0	mg/L	NC	20		
7195484	Ammonia (N)	2013/09/27	91	80 - 120	100	80 - 120	<0.0050	mg/L	NC	20		

N/A = Not Applicable

RPD = Relative Percent Difference

Calibration Check: A calibration standard analyzed at different times to evaluate on-going calibration accuracy.

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

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

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

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

(1) - Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

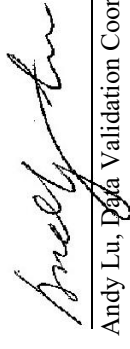


## Validation Signature Page

**Maxxam Job #: B387328**

---

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

A handwritten signature in black ink, appearing to read "Andy Lu".  
_____  
Andy Lu, Data Validation Coordinator

=====

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INVOICE INFORMATION:				REPORT INFORMATION (if differs from invoice):				PROJECT INFORMATION:				Laboratory Use Only:			
Company Name:	#11201 H2O INNOVATION	Company Name:		Quotation #:		MAXXAM JOB #:		BOTTLE ORDER #:		Project Name:		CHAIN OF CUSTODY #:		PROJECT MANAGER:	
Contact Name:	FRASER KENT	Contact Name:		P.O. #:						Project #:					
Address:	5100 SOUTH SERVICE RD. UNIT 17	Address:		Site #:						Sampled By:					
Phone:	(289)813-5533 x103	Phone:													
Email:	fraser.kent@h2oinnovation.com	Email:													
REGULATORY CRITERIA:				SPECIAL INSTRUCTIONS:				ANALYSIS REQUESTED (Please be specific):				TURNAROUND TIME (TAT) REQUIRED:			
Note: For regulated drinking water samples - please use the Drinking Water Chain of Custody Form												PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS <input checked="" type="checkbox"/> Regular (Standard) TAT: (will be applied if Rush TAT is not specified) Standard TAT = 5-7 Working days for most tests. Please note: Standard TAT for certain tests such as BOD and Dissolved Solids are > 5 days - contact your Project Manager for details. <input type="checkbox"/> Job Specific Rush TAT (if applies to entire submission) Date Required: _____ Time Required: _____ Rush Confirmation Number: _____ (call lab for #)			
Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Regulated Drinking Water ? (Y / N)	Metals Field Filtered ? (Y / N)	Ammonia-N	Biochemical Oxygen Demand	Total Suspended Solids	# Jars Used and Not Submitted	Date: (YYMMDD)	Time:	Temperature (°C) on Receipt	Custody Seal Intact on Cooler?	Yes <input type="checkbox"/> No <input type="checkbox"/>
1 HP8652	RAW FEED	13/9/24	7:00am				✓	✓	✓		203/09/25	11:00	8.2, 9.4, 8.4		
2 53	BIO-WHEEL MIXED LIQUOR	13/9/24	7:00am				✓		✓						
3 54	TREATED EFFLUENT	13/9/24	7:05am				✓		✓						
4															
5															
6															
7															
8															
9															
10															

Site Location: KELSEY G.S. STP PILOT  
Your C.O.C. #: 417576

**Attention: FRASER KENT**  
H2O INNOVATION  
5100 SOUTH SERVICE RD.  
UNIT 17  
BURLINGTON, ON  
CANADA L7L 6A5

**Report Date: 2013/10/01**

## **CERTIFICATE OF ANALYSIS**

**MAXXAM JOB #: B387343**  
**Received: 2013/09/25, 11:00**

Sample Matrix: Water  
# Samples Received: 3

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Biochemical Oxygen Demand	2	N/A	2013/09/25	WIN SOP-00018	Based on SM-5210B
Ammonia-N (Preserved) (1)	2	N/A	2013/09/27	BBY6SOP-00009	SM-4500NH3G
Total Suspended Solids	3	N/A	2013/09/26	WIN SOP-00042	Based on SM2540 D

* Results relate only to the items tested.

(1) This test was performed by Maxxam Vancouver

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Janelle Kochan, B.Sc., Project Manager,  
Email: JKochan@maxxam.ca  
Phone# (204) 772-7276 Ext:2209

=====

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Total cover pages: 1

Maxxam Job #: B387343  
Report Date: 2013/10/01

H2O INNOVATION

Site Location: KELSEY G.S. STP PILOT  
Sampler Initials: KS

## RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		HP8702	HP8703	HP8704		
Sampling Date		2013/09/23 19:30	2013/09/23 19:30	2013/09/23 19:30		
COC#		417576	417576	417576		
	UNITS	RAW FEED	BIO-WHEEL MIXED LIQUOR	RDL	TREATED EFFLUENT	RDL
<b>Demand Parameters</b>						
Biochemical Oxygen Demand	mg/L	450		2	3	2
<b>Nutrients</b>						
Ammonia (N)	mg/L	31		0.50	0.063	0.0050
<b>Physical Properties</b>						
Total Suspended Solids	mg/L	330	4630	4.0	<4.0	4.0
						7192032

RDL = Reportable Detection Limit

Maxxam Job #: B387343  
Report Date: 2013/10/01

H2O INNOVATION

Site Location: KELSEY G.S. STP PILOT  
Sampler Initials: KS

### QUALITY ASSURANCE REPORT

QC Batch	Parameter	Date	Matrix Spike		Spiked Blank		Method Blank		RPD		Calibration Check	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
7192009	Biochemical Oxygen Demand	2013/09/25					<1	mg/L	NC	20	98	84 - 115
7192032	Total Suspended Solids	2013/09/26	102	80 - 120	129(1)	80 - 120	<4.0	mg/L	NC	20		
7195484	Ammonia (N)	2013/09/27	91	80 - 120	100	80 - 120	<0.0050	mg/L	NC	20		

N/A = Not Applicable

RPD = Relative Percent Difference

Calibration Check: A calibration standard analyzed at different times to evaluate on-going calibration accuracy.

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

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

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

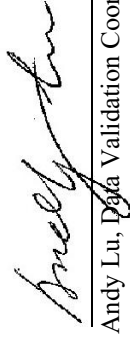
(1) - Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

## Validation Signature Page

**Maxxam Job #: B387343**

---

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

A handwritten signature in black ink, appearing to read "Andy Lu".  
_____  
Andy Lu, Data Validation Coordinator

=====

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



## INVOICE INFORMATION:

Company Name: #11201 H2O INNOVATION  
Contact Name: FRASER KENT  
Address: 5100 SOUTH SERVICE RD. UNIT 17  
BURLINGTON ON L7L 6A5  
Phone: (289) 813-5533 x103 Fax:  
Email: fraser.kent@h2oinnovation.com

## REPORT INFORMATION (if differs from invoice):

Company Name:  
Contact Name:  
Address:  
Phone:  
Email:  
Fax:

## PROJECT INFORMATION:

Quotation #: B31026  
P.O. #:  
Project #: Kelsey GS STP Pilot  
Project Name:  
Site #:  
Sampled By: Keith Sparkman  
MAXXAM JOB #: 888-7343  
BOTTLE ORDER #: 417576  
CHAIN OF CUSTODY #: PROJECT MANAGER: Janelle Kochan  
C4417576-01-01

## REGULATORY CRITERIA:

## SPECIAL INSTRUCTIONS:

Regulated Drinking Water ? (Y / N)

Metals Field Filtered ? (Y / N)

Ammonia-N

Biochemical Oxygen Demand

Total Suspended Solids

## ANALYSIS REQUESTED (Please be specific):

TURNAROUND TIME (TAT) REQUIRED:

PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS

Regular (Standard) TAT:

(will be applied if Rush TAT is not specified):

Standard TAT = 5-7 Working days for most tests

Please note: Standard TAT for certain tests such as BOD and Dissolved Solids are > 5

days - contact your Project Manager for details

Job Specific Rush TAT (if applies to entire submission)

Date Required: Time Required: Rush Confirmation Number: (Call lab for #)

# of Bottles

Comments

Time Required: Rush Confirmation Number: (Call lab for #)

Comments

Time Required: Rush Confirmation Number: (Call lab for #)

Comments

Time Required: Rush Confirmation Number: (Call lab for #)

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RECEIVED BY: (Signature/Print)

Date: (YY/MM/DD)

Time:

Temperature (°C) on Receipt

Custody Seal intact on Cooler?

Yes ☐ No ☐

Temperature (°C) on Receipt

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Yes ☐ No ☐

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Yes ☐ No ☐

Temperature (°C) on Receipt

Site Location: KELSEY G.S. H2O PILOT  
Your C.O.C. #: 408788

**Attention: Fraser Kent**  
H2O Innovation  
5100 South Service Road  
Unit 17  
Burlington, MB  
Canada L7L 6A5

**Report Date: 2013/10/02**

## **CERTIFICATE OF ANALYSIS**

**MAXXAM JOB #: B386353**  
**Received: 2013/09/23, 12:45**

Sample Matrix: Water  
# Samples Received: 4

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Biochemical Oxygen Demand	2	N/A	2013/09/25	WIN SOP-00018	Based on SM-5210B
Ammonia-N (Preserved) (1)	2	N/A	2013/09/26	BBY6SOP-00009	SM-4500NH3G
Total Suspended Solids	4	N/A	2013/09/24	WIN SOP-00042	Based on SM2540 D

* Results relate only to the items tested.

(1) This test was performed by Maxxam Vancouver

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Janelle Kochan, B.Sc., Project Manager,  
Email: JKochan@maxxam.ca  
Phone# (204) 772-7276 Ext:2209

=====

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

Total cover pages: 1

Maxxam Job #: B386353  
Report Date: 2013/10/02

H2O Innovation

Site Location: KELSEY G.S. H2O PILOT  
Sampler Initials: KS

## RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID	HP2333	HP2364	HP2365	HP2374		
Sampling Date	2013/09/20 07:20	2013/09/20 07:20	2013/09/20 07:20	2013/09/20 07:25		
COC#	408788	408788	408788	408788		
	UNITS	RAW FEED	BIO-WHEEL MIXED LIQUOR	MEMBRANE TANK MIXED LIQUOR	RDL	TREATED EFFLUENT
					RDL	QC Batch
<b>Demand Parameters</b>						
Biochemical Oxygen Demand	mg/L	259		2	<2	2
<b>Nutrients</b>						
Ammonia (N)	mg/L	37		0.50	0.032	0.0050
<b>Physical Properties</b>						
Total Suspended Solids	mg/L	110	5010	6220	<4.0	4.0
						7192001

RDL = Reportable Detection Limit

Maxxam Job #: B386353  
Report Date: 2013/10/02

H2O Innovation

Site Location: KELSEY G.S. H2O PILOT  
Sampler Initials: KS

### QUALITY ASSURANCE REPORT

QC Batch	Parameter	Date	Matrix Spike		Spiked Blank		Method Blank		RPD		Calibration Check	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
7192001	Total Suspended Solids	2013/09/24	96	80 - 120	102	80 - 120	<4.0	mg/L	NC	20		
7192009	Biochemical Oxygen Demand	2013/09/25					<1	mg/L	NC	20	98	84 - 115
7193240	Ammonia (N)	2013/09/26	NC	80 - 120	97	80 - 120	<0.0050	mg/L	1.8	20		

N/A = Not Applicable

RPD = Relative Percent Difference

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

Calibration Check: A calibration standard analyzed at different times to evaluate on-going calibration accuracy.

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

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

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

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

## Validation Signature Page

**Maxxam Job #: B386353**

---

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

  
_____  
Andy Lu, Data Validation Coordinator

=====

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Your Project #: KELSEY GS STP PILOT  
Your C.O.C. #: 417585

**Attention: FRASER KENT**

H2O INNOVATION  
5100 SOUTH SERVICE RD.  
UNIT 17  
BURLINGTON, ON  
CANADA L7L 6A5

**Report Date: 2013/10/10****CERTIFICATE OF ANALYSIS****MAXXAM JOB #: B390727****Received: 2013/10/03, 12:20**

Sample Matrix: Water  
# Samples Received: 3

Analyses	Quantity	Date	Date	Laboratory Method	Analytical Method
		Extracted	Analyzed		
Biochemical Oxygen Demand	2	N/A	2013/10/04	WIN SOP-00018	Based on SM-5210B
Ammonia-N (Preserved) (1)	2	N/A	2013/10/04	BBY6SOP-00009	SM-4500NH3G
Total Suspended Solids	3	N/A	2013/10/04	WIN SOP-00042	Based on SM2540 D

* Results relate only to the items tested.

(1) This test was performed by Maxxam Vancouver

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Janelle Kochan, B.Sc., Project Manager,  
Email: JKochan@maxxam.ca  
Phone# (204) 772-7276 Ext:2209

=====

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Total cover pages: 1



Maxxam Job #: B390727  
Report Date: 2013/10/10

H2O INNOVATION  
Client Project #: KELSEY GS STP PILOT

Sampler Initials: KS

## RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		HS1471	HS1472		HS1473	
Sampling Date		2013/10/02 08:25	2013/10/02 08:25		2013/10/02 08:30	
COC#		417585	417585		417585	
	UNITS	RAW FEED	BIO-WHEEL MIXED LIQUOR	RDL	TREATED EFFLUENT	RDL
						QC Batch
Demand Parameters						
Biochemical Oxygen Demand	mg/L	98		2	2	7211283
Nutrients						
Ammonia (N)	mg/L	27		0.50	0.045	7209382
Physical Properties						
Total Suspended Solids	mg/L	126	1370	4.0	<4.0	7206789

RDL = Reportable Detection Limit

Maxxam Job #: B390727  
Report Date: 2013/10/10

H2O INNOVATION  
Client Project #: KELSEY GS STP PILOT  
Sampler Initials: KS

### QUALITY ASSURANCE REPORT

QC Batch	Parameter	Date	Matrix Spike		Spiked Blank		Method Blank		RPD		Calibration Check	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
7206789	Total Suspended Solids	2013/10/04	108	80 - 120	84	80 - 120	<4.0	mg/L	NC	20		
7209382	Ammonia (N)	2013/10/04	96	80 - 120	101	80 - 120	0.0089, RDL=0.0050	mg/L	2.6	20		
7211283	Biochemical Oxygen Demand	2013/10/04					<1	mg/L	NC	20	100	84 - 115

N/A = Not Applicable

RDL = Reportable Detection Limit

RPD = Relative Percent Difference

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

Calibration Check: A calibration standard analyzed at different times to evaluate on-going calibration accuracy.

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

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

## Validation Signature Page

**Maxxam Job #: B390727**

---

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

  
_____  
Andy Lu, Data Validation Coordinator

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## CHAIN OF CUSTODY RECORD

<b>INVOICE INFORMATION:</b> Company Name: #11201 H2O INNOVATION Contact Name: FRASER KENT Address: 5100 SOUTH SERVICE RD. UNIT 17 BURLINGTON ON L7L 6A5 Phone: (289)813-5533 x103 Email: fraser.kent@h2oinnovation.com Fax:				<b>REPORT INFORMATION (if differs from invoice):</b> Company Name: Contact Name: Address: Phone: Email: Fax:				<b>PROJ. INFORMATION:</b> Quotation #: B31026 P.O. #: Project #: Kelsey GS STP Pilot Project Name: Site #: Sampled By: Keith Sparkman				<b>Laboratory Use Only:</b> MAXXAM JOB #: B390727 BOTTLE ORDER #: 417535 CHAIN OF CUSTODY #:  PROJECT MANAGER: Janelle Kochan C#417535-01-01																															
<b>REGULATORY CRITERIA:</b> Note: For regulated drinking water samples - please use the Drinking Water Chain of Custody Form SAMPLES MUST BE KEPT COOL (< 10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM				<b>SPECIAL INSTRUCTIONS</b>				<b>ANALYSIS REQUESTED (Please be specific):</b>				<b>TURNAROUND TIME (TAT) REQUIRED:</b> PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS Regular (Standard) TAT: <input checked="" type="checkbox"/> (will be applied if Rush TAT is not specified) Standard TAT = 5-7 Working days for most tests Please note: Standard TAT for certain tests such as BOD and Dissolved Solids are > 5 days - contact your Project Manager for details. Job Specific Rush TAT (if applies to entire submission) <input type="checkbox"/> Date Required: _____ Time Required: _____ Rush Confirmation Number: _____ (call lab for #)																															
Sample Barcodes Label 1 #5 1471 2 1 72 3 73				Sample (Location) Identification RAW FEED BIO-WHEEL MIXED LIQUOR TREATED EFFLUENT				Date Sampled 13/10/2 13/10/2 13/10/2				Time Sampled 8:25am 8:25am 8:30am				Matrix   				Regulated Drinking Water ? (Y / N)   				Ammonia-N ✓ ✓ ✓				Biochemical Oxygen Demand ✓ ✓ ✓				Total Suspended Solids ✓ ✓ ✓				# Jars Used and Not Submitted Time: 12:20 Date: (YYMMDD) 10/10/13				Laboratory Use Only Temperature (°C) on Receipt: 15.2, 16.0, 13.4 Cockey Seal Intact on Code? <input type="checkbox"/> Yes <input type="checkbox"/> No Time Sampled <input checked="" type="checkbox"/>			

Appendix G

Cost Estimates



**Appendix E**

**Historical Water and Wastewater Flow Data**



Number of People in Kelsey - 2014

	January	February	March	April	May	June	July	August	September	October	November	December
1	29	26		28	54	44	24+ppd	94	87	42	27	23
2	23	28		28	52	43	74	94		41	27	25
3	24	31		29	52	43	87	93		33	27	25
4	24	36		25	52	44	86	95	66	33	24	28
5	24			25	52	49	90	88	64	33	26	30
6	24	38	31	25	49	50	90	80	64	33	24	27
7	27	30	27	25	49	50	91	82	66	34	21	27
8	27	44	27	28	50	49	90	80	67	34	24	26
9	29	30	26	30	52	46	110	80	65	32	24	26
10	29	33	26	32	51	43	102	80	67	32	24	28
11	37	37	32	30	51	38	97	78	64	32	25	27
12	29	33	32	30	52	34	97	89	62	32	29	23
13	34	26	26	30	43	30	94	97	62	32	26	22
14	30	24	25	30	51	30	95	85	62	26	22	22
15	30	24	24	26	38	30	96	85	65	26	22	22
16	25	24	23	31	37	30	104	84	63	30	21	28
17	28	22	23	33	37	37	106	85	47	30	22	26
18	28	20	29	33	38	68	104	102	50	30	22	23
19	28	22	32	34	42	63	104	108	46	30	22	23
20	26	21	27	33	42	63	104	107	46	32	29	23
21	26	24	27	36	53	63	109	100	43	26	29	23
22		24	27	44	55	69	113	98	46	25	27	23
23	26	24	26	55	55	70	106	98	44	25	27	25
24	26	24	29	51	55	63	104	99	31	25	27	25
25	31	25	33	50	55	72	102	84	29	25	27	27
26	29	25	34	50	54	72	102	87	27	25	29	27
27	31	24	25	50	59	70	102		27	24	24	27
28	30		25	53	26 +PPD	69	107	89	27	23	24	27
29	30		23	52	58	67	96	87	36	23	23	27
30	31		23	55	51	75	91	87	43	27	26	27
31	29		23		52		95	87		24		27

Number of People in Kelsey - 2015

2015	January	February	March	April	May	June	July	August	September	October	November	December
1	29	22	23	31	24	26	33	21	29	21		
2	29	22	23	24	24	25	28	21	33	23		
3	29	23	24	24	24	23	28	21	32	23		
4	29	22	25	24	20	27	28	22	31	22		
5	36	24	25	24	21	25	28	22	28	22		
6	35	24	24	25	21	25	29	25	28	23		
7	29	27	24	28	21	24	31	23	28	23		
8	26	24	24	28	23	24	30	22	31	29		
9	26	24	24	34	23	32	27	28	28	46		
10	26	30	29	28	23	27	27	28	27	46		
11	26	27	29	24	23	34	23	30	27	46		
12	26	27	27	23	28	28	23	33	27	46		
13	25	26	25	23	22	28	22	40	27	49		
14	25	26	20	21	26	28	21	40	26	52		
15	24	26	20	21	26	28	21	40	23	52		
16	24	25	20	21	26	33	27	40	24	49		
17	24	22	27	21	26	33	25	40	21	44		
18	24	22	32	21	26	32	25	36	21	44		
19	24	27	29	21	24	31	25	37	21	46		
20	27	26	28	25	24	31	26	30	21	46		
21	27	24	28	29	24	30	24	27	21	47		
22	25	24	28	39	26	29	24	27	17	48		
23	25	24	27	37	26	39	22	27	17	24		
24	30	20	19	24	27	39	21	27	19			
25	24	20	19	24	33	36	21	19	19			
26	24	21	21	24	30	31	21	19	20			
27	27	21	21	24	29	31	21	29	23			
28	27	23	20	24	29	31	18	25	20			
29	22		21	24	29	31	18	28	22			
30	22		25	24	27	34	21	27	22			
31	22		31		27		21	30				



KELSEY G.S. WWTP										March 2014.																																																	
DATE	H2O Total M3	H2O Yesterday M3	H2O M3	DATE	SBR Total M3	SBR Yesterday M3	SBR Effluent M3	Combined Effluent M3	H2O LPM	INFL PH	Denite D.O. mg/L	BIOWHEEL RPM.	BIOWHEEL TEMP. Celsius	BIOWHEEL D.O. mg/L	EFFLUENT PH	EFFLUENT TEMP. Celsius	EFFLUENT D.O. mg/L																																										
1	607	588.69	18.31	1	52230.14	52230.14	0	18.31	26	8.11	0.41	1000	13.4	6.82	7.61	15.1	6.71																																										
2	626.01	607	19.01	2	52235.12	52230.14	4.98	23.99	26	7.18	0.41	1000	13.6	7.82	7.82	15.4	6.47																																										
3	641.38	626.01	15.37	3	52235.12	52235.12	0	15.37	26	8.19	0.39	1000	13.9	6.17	7.82	15.3	6.45																																										
4	661.55	641.38	20.17	4	52235.12	52235.12	0	20.17	24	8.12	0.36	1000	14.2	6.35	7.76	15.4	6.46																																										
5	680.44	661.55	18.89	5	52235.12	52235.12	0	18.89	24	8.24	0.67	1000	14	5.84	7.85	14.8	6.64																																										
6	696.42	680.44	15.98	6	52240.14	52235.12	5.02	21	24	8.1	0.78	1000	14.7	6.21	7.76	15.1	6.64																																										
7	717.27	696.42	20.85	7	52240.14	52240.14	0	20.85	24	8.12	0.41	1000	14.7	6.33	7.78	15.1	6.81																																										
8	749.88	717.27	32.61	8	52240.14	52240.14	0	32.61	24	8.04	0.32	1000	15.3	5.67	7.82	15.9	5.84																																										
9	776.71	749.88	26.83	9	52245.22	52240.14	5.08	31.91	24	7.96	0.36	1000	15.5	5.41	7.79	16.2	6.03																																										
10	804.27	776.71	27.56	10	52245.22	52245.22	0	27.56	24	8.01	0.31	1000	16	5.38	7.79	16.7	5.91																																										
11	836.17	804.27	31.9	11	52245.22	52245.22	0	31.9	24	8.01	0.33	1000	15.1	5.33	7.69	16.6	5.81																																										
12	854.17	836.17	18	12	52245.22	52245.22	0	18	24	8.2	0.34	1000	15.2	5.31	7.66	13.01	5.71																																										
13	867.1	854.17	12.93	13	52250.3	52245.22	5.08	18.01	24	8.11	0.37	1000	15.1	5.37	7.65	15.2	5.65																																										
14	882.35	867.1	15.25	14	52250.3	52250.3	0	15.25	24	8.38	0.33	1000	13.9	5.49	7.61	14.2	5.84																																										
15	897.77	882.35	15.42	15	52250.3	52250.3	0	15.42	24	8.01	0.38	1000	13.6	5.91	7.63	14.4	5.71																																										
16	920.21	897.77	22.44	16	52250.3	52250.3	0	22.44	24	7.99	0.36	1000	13.2	5.81	7.66	14.4	5.66																																										
17	939.11	920.21	18.9	17	52250.3	52250.3	0	18.9	24	8.01	0.33	1000	13.1	5.71	6.68	14.2	5.56																																										
18	962.33	939.11	23.22	18	52255.4	52250.3	5.1	28.32	24	8.18	0.27	1000	12.6	5.78	7.88	13.3	6.29																																										
19	975.18	962.33	12.85	19	52255.4	52255.4	0	12.85	24	8.13	0.73	1000	13.1	5.64	7.89	15.1	5.51																																										
20	986.82	975.18	11.64	20	52255.4	52255.4	0	11.64	19	8.07	0.74	1000	13.8	5.42	7.81	16.4	4.79																																										
21	999.31	986.82	12.49	21	52260.45	52255.4	5.05	17.54	19	8.01	0.41	1000	14.1	5.65	7.77	15	5.72																																										
22	1024.23	999.31	24.92	22	52260.45	52260.45	0	24.92	19	7.93	0.71	1000	13.8	5.67	7.82	14.6	5.89																																										
23	1041.35	1024.23	17.12	23	52260.45	52260.45	0	17.12	19	8.14	0.46	1000	13.8	5.74	7.84	15	5.74																																										
24	1053.23	1041.35	11.88	24	52265.48	52260.45	5.03	16.91	19	8.11	0.27	1000	14.1	5.57	7.94	14.9	6.21																																										
25	1066.35	1053.23	13.12	25	52265.48	52265.48	0	13.12	19	8.27	0.48	1000	14.1	5.16	7.99	15.6	5.75																																										
26	1079.89	1066.35	13.54	26	52265.48	52265.48	0	13.54	19	8.12	0.37	1000	14.5	5	7.92	16	5.44																																										
27	1100.47	1079.89	20.58	27	52265.48	52265.48	0	20.58	19	8.14	0.38	1000	14.4	5.16	7.86	13.5	5.95																																										
28	1115.73	1100.47	15.26	28	52270.67	52265.48	5.19	20.45	19	8.23	1.46	1000	14.5	5.26	7.72	15.5	6.69																																										
29	1132.41	1115.73	16.68	29	52270.67	52270.67	0	16.68	19	8.04	0.61	1000	14.7	5.14	7.58	15.5	6.25																																										
30	1158.62	1132.41	26.21	30	52270.67	52270.67	0	26.21	19	7.88	1.02	1000	14.3	6.32	7.72	15.4	5.62																																										
31	1185.38	1158.62	26.76	31	52280.34	52270.67	9.67	36.43	19	7.8	1.01	1000	14	6.15	7.77	15.2	5.89																																										
AVG			19.24806				1.61935	20.8674194	22.2580645	8.0590323	0.509032258			5.7183871	7.7383871		5.9916129																																										
Totals m3			596.69				50.2	646.89																																																			
			Average flow																																																								
			Min flow		20.86741935																																																						
			Max flow		36.43																																																						
	BOD Avg		0																																																								
	BOD Kg/D		0.152687																																																								
	TSS Avg		305373.8																																																								
	TSS Kg/D		305373.8																																																								
	E.Coli		#NUM!																																																								









KELSEY G.S. WWTP										September 2014.																																																	
DATE	H2O Total M3	H2O Yesterday M3	H2O M3	DATE	SBR Total M3	SBR Yesterday M3	SBR Effluent M3	Combined Effluent M3	H2O LPM	INFL PH	Denite D.O. mg/L	BIOWHEEL RPM.	BIOWHEEL Temp. Celsius	BIOWHEEL D.O. mg/L	EFFLUENT PH	EFFLUENT TEMP. Celsius	EFFLUENT D.O. mg/L																																										
1	5977.93	5938.08	39.85	1	52818.15	52818.15	0	39.85	34	8.05	0.23	1000	24.5	3.1	7.6	23.6	3.91																																										
2	6020.45	5977.93	42.52	2	52818.15	52818.15	0	42.52	34	7.68	0.24	1000	25.3	3.14	7.63	25.5	3.61																																										
3	6054.41	6020.45	33.96	3	52823.55	52818.15	5.4	39.36	29	7.76	0.32	1000	25.6	2.56	7.63	25.7	3.84																																										
4	6089.51	6054.41	35.1	4	52823.55	52823.55	0	35.1	29	7.68	0.24	1000	25.8	3.21	7.58	25.9	3.41																																										
5	6121.95	6089.51	32.44	5	52823.55	52823.55	6.79	32.44	29	7.84	0.29	1000	25.6	3.26	7.63	25.8	3.47																																										
6	6147.38	6121.95	25.43	6	52830.34	52823.55	6.79	32.22	29	7.74	0.32	1000	23.7	3.18	7.62	23.9	3.88																																										
7	6184.26	6147.38	36.88	7	52830.34	52830.34	0	36.88	29	7.91	0.27	1000	23.6	3.2	7.66	23.9	3.96																																										
8	6222.07	6184.26	37.81	8	52830.34	52830.34	0	37.81	29	7.73	0.24	1000	23.3	3.46	7.73	23.5	4.17																																										
9	6252.69	6222.07	30.62	9	52830.34	52830.34	0	30.62	29	7.73	0.24	1000	23.1	3.44	7.71	23.4	4.21																																										
10	6288.93	6252.69	36.24	10	52835.92	52830.34	5.58	41.82	30	7.88	0.27	1000	23.1	3.42	7.77	23.6	4.21																																										
11	6323.36	6288.93	34.43	11	52835.92	52835.92	0	34.43	30	7.81	0.29	1000	23.1	3.41	7.76	23.5	4.21																																										
12	6356.63	6323.36	33.27	12	52835.92	52835.92	0	33.27	30	7.5	0.31	1000	20.5	5.51	7.7	21.4	5.63																																										
13	6374.76	6356.63	18.13	13	52841.45	52835.92	5.53	23.66	30	7.79	0.33	1000	20.8	5.51	7.65	20.8	6.36																																										
14	6406.12	6374.76	31.36	14	52841.45	52841.45	0	31.36	30	7.71	0.31	1000	20.8	5.22	7.76	21.1	6.61																																										
15	6440.96	6406.12	34.84	15	52841.45	52841.45	0	34.84	30	7.7	0.37	1000	22.5	4.04	7.64	22.4	4.06																																										
16	6466.61	6440.96	25.65	16	52846.99	52841.45	5.54	31.19	29	7.67	0.38	1000	22.1	3.91	7.6	22.1	4.56																																										
17	6498.9	6466.61	32.29	17	52846.99	52846.99	0	32.29	29	7.68	0.31	1000	22.1	3.75	7.53	22.1	4.57																																										
18	6527.3	6498.9	28.4	18	52846.99	52846.99	0	28.4	29	7.49	0.54	1000	21.8	5.01	7.61	22.3	4.46																																										
19	6551.07	6527.3	23.77	19	52846.99	52846.99	0	23.77	29	7.73	0.39	1000	22.5	2.56	7.39	22.6	2.68																																										
20	6579.94	6551.07	28.87	20	52852.48	52846.99	5.49	34.36	24	7.74	0.43	1000	22.7	2.53	7.76	23	2.46																																										
21	6607.01	6579.94	27.07	21	52852.48	52852.48	0	27.07	24	7.74	0.34	1000	22.8	2.97	7.71	23.1	3.56																																										
22	6633.39	6607.01	26.38	22	52852.48	52852.48	0	26.38	29	7.89	0.37	1000	23.4	2.54	7.88	23.7	2.81																																										
23	6666.24	6633.39	32.85	23	52858	52852.48	5.52	38.37	29	7.77	0.37	1200	21.3	7.52	7.81	23.2	2.71																																										
24	6699.68	6666.24	33.44	24	52858	52858	0	33.44	29	7.88	0.33	1200	23.5	2.81	7.81	23.1	2.81																																										
25	6728.96	6699.68	29.28	25	52858	52858	0	29.28	29	7.86	0.31	1200	22.8	2.41	7.32	22.9	2.83																																										
26	6753.48	6728.96	24.52	26	52863.48	52858	5.48	30	29	7.88	0.36	1200	22.8	2.44	7.34	22.7	2.89																																										
27	6778.97	6753.48	25.49	27	52868.96	52863.48	5.48	30.97	29	8.06	1.17	1200	22.5	3.75	7.18	22.8	6.69																																										
28	6809.92	6778.97	30.95	28	52868.96	52868.96	0	30.95	30	8.01	1.01	1200	22.4	3.74	7.11	22.8	6.66																																										
29	6833.94	6809.92	24.02	29	52874.47	52868.96	5.51	29.53	30	8.02	0.97	1200	22.5	3.61	7.22	22.8	6.61																																										
30	6863.53	6833.94	29.59	30	52874.47	52874.47	0	29.59	34	7.96	1.12	1200	21.8	4.64	8.03	21.9	4.03																																										
31			0	31			0					1200																																															
AVG			29.85323				1.81677	31.67	29.43333333	7.799	0.4223333333			3.645333333	7.612333333		4.195666667																																										
Totals m3			925.45				56.32	981.77																																																			
			Average flow																																																								
			Min flow		31.67																																																						
			Max flow		0																																																						
					42.52																																																						
			BOD Avg												BOD mg/l																																												
			BOD Kg/D												31190		3																																										
			TSS Avg												TSS mg/l		3																																										
			TSS Kg/D												0.03119		0.043																																										
															NH3 mg/l																																												
															MAX																																												
															7.11	8.03																																											
			E.Coli		0									MIN																																													
													</																																														













KELSEY G.S. WWTP										Mar-15																																																			
DATE	H2O Total M3	H2O Yesterday M3	H2O M3	DATE	SBR Total M3	SBR Yesterday M3	SBR Effluent M3	Combined Effluent M3	H2O LPM	INFL PH	Denite D.O. mg/L	BIOWHEEL RPM.	BIOWHEEL Temp. Celsius	BIOWHEEL D.O. mg/L	EFFLUENT PH	EFFLUENT TEMP. Celsius	EFFLUENT D.O. mg/L																																												
1	10998.1	10978.96	19.14	1	53167.49	53167.49	0	19.14	25	8.28	1.04	1200	13.6	8.82	8.08	14.5	7.84																																												
2	11014.41	10998.1	16.31	2	53167.49	53167.49	0	16.31	25	8.29	1.05	1200	13.6	8.02	8.09	14.5	7.85																																												
3	11027.95	11014.41	13.54	3	53167.49	53167.49	0	13.54	25	8.01	0.89	1200	13.9	8.11	8.05	14.4	7.92																																												
4	11057.97	11027.95	30.02	4	53172.51	53167.49	5.02	35.04	25	8.07	0.93	1200	13.8	6.5	7.93	14.4	8.18																																												
5	11088.35	11057.97	30.38	5	53172.51	53172.51	0	30.38	25	8.13	0.36	1200	14.2	6.8	8	15	7.42																																												
6	11120.06	11088.35	31.71	6	53172.51	53172.51	5.04	32.58	25	8.16	0.6	1200	14.5	7.18	8.06	15.2	8.16																																												
7	11147.6	11120.06	27.54	7	53177.55	53172.51	0	34	25	8.13	0.52	1200	14.6	6.92	8.04	15.4	7.81																																												
8	11181.6	11147.6	34	8	53177.55	53177.55	0	34	25	8.15	0.45	1200	15.2	6.54	8.06	16	6.63																																												
9	11209.42	11181.6	27.82	9	53177.55	53177.55	0	27.82	25	8.07	0.78	1200	15.8	6.28	7.78	16.7	7.66																																												
10	11231.4	11209.42	21.98	10	53177.55	53177.55	0	21.98	25	8.2	1.15	1200	16.3	7.23	8.06	17.2	7.63																																												
11	11261.1	11231.4	29.7	11	53182.61	53177.55	5.06	34.76	25	8.19	0.41	1200	16.2	6.67	8.08	16.8	7.71																																												
12	11292.22	11261.1	31.12	12	53182.61	53182.61	0	31.12	25	8.17	0.49	1200	16.1	6.24	7.86	15.3	8.4																																												
13	11320.88	11292.22	28.66	13	53182.61	53182.61	0	28.66	25	8.15	0.45	1200	16.3	6.16	7.88	15.6	8.14																																												
14	11361.55	11320.88	40.67	14	53182.61	53182.61	0	40.67	25	8.17	0.32	1200	17.3	5.6	8.15	15.9	8.14																																												
15	11404.08	11361.55	42.53	15	53182.61	53182.61	0	42.53	25	8.13	0.4	1200	18.1	6.19	7.92	17.7	7.2																																												
16	11427.8	11404.08	23.72	16	53187.64	53182.61	5.03	28.75	25	8.22	0.34	1200	17	6.66	8.01	16.2	7.97																																												
17	11461.99	11427.8	34.19	17	53187.64	53187.64	0	34.19	25	8.18	0.28	1200	16.1	7.05	8.03	15.3	8.17																																												
18	11494.72	11461.99	32.73	18	53187.64	53187.64	0	32.73	25	8.17	0.48	1200	16	6.73	8.61	15.2	8.61																																												
19	11525.16	11494.72	30.44	19	53192.69	53187.64	5.05	35.49	25	8.15	0.54	1200	16.4	7.06	7.85	16.6	7.58																																												
20	11556.72	11525.16	31.56	20	53197.71	53192.71	5	36.56	30	8.13	0.38	1200	15.3	6.53	7.98	15.8	6.93																																												
21	11588.65	11556.72	31.93	21	53197.71	53197.71	0	31.93	25	8.2	0.71	1200	14.9	8.8	8.01	15.4	9.6																																												
22	11620.82	11588.65	32.17	22	53197.71	53197.71	0	32.17	25	8.21	0.37	1200	15	7.01	8.19	15.6	8.4																																												
23	11731.77	11620.82	110.95	23	53202.75	53197.71	5.04	115.99	35	8.23	2.55	1200	14.5	6.07	8.11	15.7	7																																												
24	11776.55	11731.77	44.78	24	53202.75	53202.75	0	44.78	25	8.23	0.36	1200	15.4	8.15	8	16	7.44																																												
25	11811.07	11776.55	34.52	25	53202.75	53202.75	0	34.52	25	8.26	0.98	1200	15.1	6.27	8.12	16.4	7.46																																												
26	11824.96	11811.07	13.89	26	53202.75	53202.75	0	13.89	25	8.2	0.52	1200	14.1	6.31	8.13	15.3	7.52																																												
27	11846.93	11824.96	21.97	27	53207.81	53202.75	5.06	27.03	25	8.26	1.87	1200	14.3	2.02	8.07	15.2	1.87																																												
28	11864.97	11846.93	18.04	28	53207.81	53207.81	0	18.04	25	8.21	0.22	1200	15.3	1.91	8.12	16.1	1.92																																												
29	11884.51	11864.97	19.54	29	53207.81	53207.81	0	19.54	25	8.2	1.49	1200	15.1	7.01	8.2	16	7.77																																												
30	11889.27	11884.51	8.63	30	53207.81	53207.81	0	4.76	25	8.52	3.12	1200	14.7	6.82	8.08	15.4	5.3																																												
31	11897.9	11889.27	4.76	31	53212.89	53207.81	5.08	13.71	25	8.48	5.63	1200	13.9	8.57	8.13	12.9	9.76																																												
AVG		29.64323					1.46387	31.1070968	25.483871	8.1267742	2.143870968			6.59290323	8.05903226		7.41903226																																												
Totals m3		918.94					45.38	964.32																																																					
			Average flow																																																										
			Min flow		31.10709677																																																								
			Max flow		4.76																																																								
					115.99																																																								

KELSEY G.S. WWTP										April 2015.																																																	
DATE	H2O Total M3	H2O Yesterday M3	H2O M3	DATE	SBR Total M3	SBR Yesterday M3	SBR Effluent M3	Combined Effluent M3	H2O LPM	INFL PH	Denite D.O. mg/L	BIOWHEEL RPM.	BIOWHEEL TEMP. Celsius	BIOWHEEL D.O. mg/L	EFFLUENT PH	EFFLUENT TEMP. Celsius	EFFLUENT D.O. mg/L																																										
1	11908.2	11897.9	10.3	1	53212.89	53212.89	0	10.3	25	8.49	1.61	1000	14.4	6.3	8.84	15.8	9.2																																										
2	11920.91	11908.2	12.71	2	53212.89	53212.89	0	12.71	25	8.52	2.52	1000	13.3	8.11	7.84	14	7.8																																										
3	11925.95	11920.91	5.04	3	53217.99	53212.89	5.1	10.14	25	8.54	4.36	1000	12.4	8.14	7.77	14.5	9.56																																										
4	11950.16	11925.95	24.21	4	53217.99	53217.99	0	24.21	25	8.23	1.05	1000	11.8	7.09	7.73	12.2	9.83																																										
5	11967.67	11950.16	17.51	5	53217.99	53217.99	0	17.51	25	8.58	6.27	1200	11.2	9.51	7.87	12	6.87																																										
6	11975.3	11967.67	7.63	6	53217.99	53217.99	0	7.63	25	8.62	6.83	1000	11.1	9.65	7.87	12.2	7.01																																										
7	11983.5	11975.3	8.2	7	53223.02	53217.99	5.03	13.23	25	8.61	1.08	1000	11.2	9.55	7.23	11.9	7.71																																										
8	11996.13	11983.5	12.63	8	53223.02	53223.02	0	12.63	25	8.32	2.12	1000	12.4	7.24	7.98	13.4	8.56																																										
9	12010.35	11996.13	14.22	9	53223.02	53223.02	0	14.22	25	8.32	2.11	1000	12.3	7.22	7.81	13.3	8.51																																										
10	12029.75	12010.35	19.4	10	53226.04	53223.02	3.02	22.42	25	8.14	0.81	1000	12.6	7.01	9.44	13.5	9.44																																										
11	12058.27	12029.75	28.52	11	53233.13	53226.04	7.09	35.61	25	8.14	0.67	1000	12.9	7.07	7.83	13.6	9.47																																										
12	12090.2	12058.27	31.93	12	53235.05	53233.13	1.92	33.85	25	8.24	1.12	1000	12.8	6.85	8.14	12.5	9.75																																										
13	12253.89	12090.2	163.69	13	53236.74	53235.05	1.69	165.38	25	8.13	1.91	1000	11.4	8.13	8.13	12.5	9.18																																										
14	12301.45	12253.89	47.56	14	53245.39	53236.74	8.65	56.21	25	8.23	2.56	1000	10.8	6.65	8.25	11.7	10.16																																										
15	12433.95	12301.45	132.5	15	53245.39	53245.39	0	132.5	25	8.25	3.15	1000	10.9	8.76	8.3	11.7	9.88																																										
16	12492.16	12433.95	58.21	16	53245.39	53245.39	0	58.21	25	8.4	3.07	1200	11.3	8.66	8.22	12.4	8.93																																										
17	12525.89	12492.16	33.73	17	53245.39	53245.39	0	33.73	25	8.2	4.32	1200	11.7	7.31	8.21	13.4	9.31																																										
18	12558.09	12525.89	32.2	18	53254.19	53245.39	8.8	41	25	8.5	5.55	1200	11.8	7.34	8.28	13.1	9.5																																										
19	12591.63	12558.09	33.54	19	53254.19	53254.19	0	33.54	25	8.48	4.54	1200	11.4	7.25	8.32	12.5	10.05																																										
20	12612.65	12591.63	21.02	20	53254.19	53254.19	0	21.02	25	8.4	4.64	1200	11	7.15	8.35	12	9.29																																										
21	12631.1	12612.65	18.45	21	53254.19	53254.19	0	18.45	25	8.7	4.28	1200	11.2	7.53	8.37	12.3	9.98																																										
22	12646.65	12631.1	15.55	22	53260.1	53254.19	5.91	21.46	25	8.61	1.23	1200	10.8	7.51	8.13	11.6	9.81																																										
23	12659.78	12646.65	13.13	23	53260.1	53260.1	0	13.13	25	8.61	1.11	1200	10.6	7.81	8.01	10.2	8.11																																										
24	12673.66	12659.78	13.88	24	53260.1	53260.1	0	13.88	25	8.51	2.22	1200	11.4	7.55	8.2	12.3	9.99																																										
25	12685.17	12673.66	11.51	25	53260.1	53260.1	0	11.51	25	8.41	2.67	1200	11.3	7.25	8.22	12.1	10.21																																										
26	12694.84	12685.17	9.67	26	53265.59	53260.1	5.49	15.16	25	8.41	2.31	1200	11.2	7.51	8.21	11.9	9.99																																										
27	12709.92	12694.84	15.08	27	53272.71	53265.59	7.12	22.2	25	8.44	1.01	1200	10.9	7.41	8.2	11.2	9.81																																										
28	12724.49	12709.92	14.57	28	53272.71	53272.71	0	14.57	25	8.74	1.21	1200	11.1	7.57	8	11	8.9																																										
29	12745.23	12724.49	20.74	29	53272.71	53272.71	0	20.74	25	8.88	1.05	1200	11	7.95	8.01	11	8.88																																										
30	12755.84	12745.23	10.61	30	53279.6	53272.71	6.89	17.5	25	8.37	1.87	1200	14.4	6.75	8	15.3	8.17																																										
31			0	31			0		25			1200																																															
AVG			27.67548																																																								
Totals m3			857.94						25	8.434	2.641666667			7.63666667	8.124		9.12866667																																										
			Average flow		29.82741935																																																						
			Min flow		0																																																						
			Max flow		165.38																																																						
			BOD Avg																																																								
			BOD Kg/D																																																								
			TSS Avg																																																								
			TSS Kg/D																																																								
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KELSEY G.S. WWTP										August 2013.																																																	
DATE	H2O Total M3		H2O Yesterday M3	H2O M3	DATE	SBR Total M3	SBR Yesterday M3	SBR Effluent M3	Combined Effluent M3	H2O LPM	INFL PH	Denite D.O. mg/L	BIOWHEEL RPM.	BIOWHEEL TEMP. Celsius	BIOWHEEL D.O. mg/L	EFFLUENT PH	EFFLUENT TEMP. Celsius	EFFLUENT D.O. mg/L																																									
1	14967.15	14751.33		215.82	1	53610.18	53610.18	0	215.82	25	8.21	3.31	1200	17.5	7.05	8.23	17.8	7.68																																									
2	15016.54	14967.15		49.39	2	53610.18	53610.18	0	49.39	25	8.21	2.59	1200	16.9	7.91	8.23	17.6	7.6																																									
3	15115.37	15016.54		98.83	3	53617.02	53610.18	6.84	105.67	25	8.22	2.67	1200	17	7.89	7.58	17.6	7.58																																									
4	15146.73	15115.37		31.36	4	53617.02	53617.02	0	31.36	25	8.09	2.16	1200	17.5	7.3	8.18	18	7.29																																									
5	15181.51	15146.73		34.78	5	53617.02	53617.02	0	34.78	25	8.14	1.88	1200	17.8	7.16	8.26	18.4	6.48																																									
6	15282.28	15181.51		107.77	6	53623.95	53617.02	6.93	107.77	25	8.28	1.47	1200	18.3	7.03	8.03	19	6.48																																									
7	15313.07	15282.28		30.79	7	53623.95	53623.95	0	30.79	25	8.21	1.67	1200	18.3	7.22	8.26	18.8	7.94																																									
8	15342.09	15313.07		29.02	8	53623.95	53623.95	0	29.02	25	8.22	1.82	1200	19	6.88	8.2	19.6	7.34																																									
9	15372.98	15342.09		30.89	9	53623.95	53623.95	0	30.89	25	8.29	0.94	1200	19.5	6.82	8.12	21.8	6.04																																									
10	15400.47	15372.98		27.49	10	53630.78	53623.95	6.83	34.32	25	8.13	1.84	1200	19.7	6.37	8.15	20	7.18																																									
11	15431.71	15400.47		31.24	11	53630.78	53630.78	0	31.24	25	8.07	0.81	1200	19.8	6.37	8.12	20.4	6.66																																									
12	15470.94	15431.71		39.23	12	53630.78	53630.78	0	39.23	25	8.23	0.88	1200	21	4.21	8.12	21.8	3.15																																									
13	15504.45	15470.94		33.51	13	53636.62	53630.78	5.84	39.35	25	8.22	0.89	1200	19.2	4.71	7.91	21.9	6.21																																									
14	15534.23	15504.45		29.78	14	53637.62	53636.62	1	30.78	25	8.22	0.88	1200	21.7	4.77	7.89	22.1	5.11																																									
15	15563.21	15534.23		28.98	15	53637.62	53637.62	0	28.98	25	8.21	0.78	1200	19.7	4.71	7.89	21.4	5.22																																									
16	15584.24	15563.21		21.03	16	53644.46	53637.62	6.84	27.87	25	8.22	0.79	1200	19.7	4.77	7.88	20.9	5.22																																									
17	15616.37	15584.24		32.13	17	53644.46	53644.46	0	32.13	25	8.01	0.81	1200	19.8	6.37	8.12	20.4	6.96																																									
18	15643.16	15616.37		26.79	18	53644.46	53644.46	0	26.79	25	8.23	1	1200	19.7	6.97	8.01	20.1	7.01																																									
19	15666.79	15643.16		23.63	19	53644.46	53644.46	0	23.63	25	8.02	0.87	1200	20.7	4.85	7.9	21.3	7.9																																									
20	15700.99	15666.79		34.65	20	53651.34	53644.46	6.88	41.08	25	8.21	0.35	1200	19.9	5.95	8	20.3	3																																									
21	15745.64	15700.99		44.65	21	53651.34	53651.34	0	44.65	25	8.11	0.37	1200	19.8	7.02	8.08	20.5	5.57																																									
22	15784.88	15745.64		39.24	22	53651.34	53651.34	0	39.24	25	8.08	7.71	1200	20.1	5.63	8.05	20.5	6.41																																									
23	15814.53	15784.88		29.65	23	53658.15	53651.34	6.81	36.46	25	8.09	0.25	1200	20	6.02	8.12	20.2	7.32																																									
24	15842.42	15814.53		27.89	24	53658.15	53658.15	0	27.89	25	8.07	1.03	1200	19.5	4.88	8.07	19.9	7.51																																									
25	15929.59	15842.42		87.17	25	53658.15	53658.15	0	87.17	25	8.01	0.28	1200	19.9	4.76	8.03	20.2	4.87																																									
26	16009.38	15929.59		79.79	26	53665.1	53658.15	6.95	86.74	25	8.04	0.48	1200	20.6	3.08	8.03	21.1	2.31																																									
27	16065.36	16009.38		55.98	27	53665.1	53665.1	0	55.98	25	8.22	0.98	1200	20.1	4.98	8.1	21.1	4.55																																									
28	16135.47	16065.36		70.11	28	53665.1	53665.1	0	70.11	25	8.23	1.04	1200	20.8	5.56	8.01	20.9	5.55																																									
29	16178.72	16135.47		43.25	29	53665.1	53665.1	0	43.25	25	7.99	0.74	1200	21.2	5.98	7.98	20.9	6.21																																									
30	16205.87	16178.72		27.15	30	53671.94	53665.1	6.84	33.99	25	6.56	0.82	1200	20.1	4.99	8.01	21	5.78																																									
31	16235.01	16205.87		29.14	31	53671.94	53671.94	0	29.14	25	6.47	0.98	1200	20.3	5.01	8.05	21	5.98																																									
AVG				47.86065				1.99226	49.8529032	25	8.0487097	1.39			5.91516129	8.05193548			6.06516129																																								
Totals	m3			1483.68				61.76	1545.44																																																		
				Average flow																																																							
				Min flow																																																							
				Max flow																																																							
				0																																																							
	BOD Avg			0.1014																																																							
	TSS Avg			304200.5																																																							
	TSS Kg/D			304200.5																																																							

Appendix F

Wastewater Quality Data



Neegan Burnside Ltd (Winnipeg)  
ATTN: PAUL KLASSEN  
106B Scurfield Blvd  
Winnipeg MB R3Y 1G4

Date Received: 24-JAN-16  
Report Date: 02-FEB-16 13:30 (MT)  
Version: FINAL

Client Phone: 204-949-7110

## Certificate of Analysis

Lab Work Order #: L1726579  
Project P.O. #: NOT SUBMITTED  
Job Reference: 300 037851  
C of C Numbers:  
Legal Site Desc: Kelsey GS Lagoon

Hua Wo  
Chemistry Laboratory Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ADDRESS: 1329 Niakwa Road East, Unit 12, Winnipeg, MB R2J 3T4 Canada | Phone: +1 204 255 9720 | Fax: +1 204 255 9721  
ALS CANADA LTD Part of the ALS Group A Campbell Brothers Limited Company

# ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L1726579-1	KELSEY GS RAW SEWAGE							
Sampled By: Paul Klassen on 22-JAN-16 @ 18:00								
Matrix: WASTE WATER								
Miscellaneous Parameters								
Ammonia, Total (as N)		47.9		5.0	mg/L		25-JAN-16	R3385219
Biochemical Oxygen Demand		238	DLA	50	mg/L		25-JAN-16	R3392251
BOD Carbonaceous		176	DLA	50	mg/L		25-JAN-16	R3392251
Phosphorus (P)-Total		7.80		0.050	mg/L		27-JAN-16	R3387231
Total Suspended Solids		292		5.0	mg/L		29-JAN-16	R3392602

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

## Reference Information

## Sample Parameter Qualifier Key:

Qualifier	Description
DLA	Detection Limit adjusted for required dilution

## Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
BOD-CBOD-WP	Water	Carbonaceous BOD	APHA 5210 B
Samples are diluted and seeded, have TCMP added to inhibit nitrogenous demands, and then are incubated in airtight bottles at 20 C for 5 days. Dissolved oxygen is measured initially and after incubation, and results are computed from the difference between initial and final DO.			
BOD-WP	Water	Biochemical Oxygen Demand (BOD)	APHA 5210 B
Samples are diluted and seeded and then incubated in airtight bottles at 20 C for 5 days. Dissolved oxygen is measured initially and after incubation, and results are computed from the difference between initial and final DO.			
NH3-COL-WP	Water	Ammonia by colour	APHA 4500 NH3 F
Ammonia in water samples forms indophenol when reacted with hypochlorite and phenol. The intensity is amplified by the addition of sodium nitroprusside and measured colourmetrically.			
P-T-COL-WP	Water	Phosphorus, Total	APHA 4500 P PHOSPHORUS
This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourmetrically after persulphate digestion of the sample.			
SOLIDS-TOTSUS-WP	Water	Total Suspended Solids	APHA 2540 D (modified)
Total suspended solids in aqueous matrices is determined gravimetrically after drying the residue at 103 105 C.			

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

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

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

## Chain of Custody Numbers:

## GLOSSARY OF REPORT TERMS

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

mg/kg - milligrams per kilogram based on dry weight of sample

mg/kg ww - milligrams per kilogram based on wet weight of sample

mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight

mg/L - unit of concentration based on volume, parts per million.

< - Less than.

D.L. - The reporting limit.

N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.



# PERFORMANCE TEST REPORT

## H2O INNOVATION BIO-BRANE™

### WASTEWATER TREATMENT PLANT

Project Reference: Kelsey Generating Station  
Portable Sewage Treatment Plant

October, 2013

**Submitted to**

Trevor Ouellette, P.E.  
Manitoba Hydro,  
Power Projects Dept., Civil Projects  
Engineering Services Division  
360 Portage Ave, 20th Floor  
Winnipeg, MB R3C 2P4  
(204) 360-7217

**Submitted by**

Ryan Waldie & Fraser Kent  
H2O Innovation Inc.  
Calgary, AB  
403-540-0558



# 1 EXECUTIVE SUMMARY

## 1.1.INTRODUCTION

H2O Innovation was contracted by Manitoba Hydro to provide an enclosed, portable membrane sewage treatment plant for their Kelsey Generating Station facility located downstream of Split Lake in Manitoba, Canada. This unit is intended to replace the existing SBR system and as such receives the flow from the SBR Transfer Tank and discharges into the existing UV system. As part of this installation, a performance test was required to ensure that the commissioned and accepted facility meets the requirement of Manitoba Hydro's Specification 029794 "Kelsey Generating Station Design, Manufacture and supply New Portable Sewage Treatment Plant" Dated May 5th, 2009. The methodology used to ensure that the testing is performed in an acceptable manner is outlined within this protocol.

## 1.2.SUMMARY OF RESULTS

The results of the performance testing shows that the Bio-BraneTM treatment system was able to maintain the average and peak design flow rates and consistently achieve the required effluent criteria. **As such the performance test was passed.** The effluent water quality results were, in fact much better than the requirements and the details are given in the sections below.

# 2 PERFORMANCE TESTING REQUIREMENTS

The Performance Test requirements are outlined in Section 4.3 of the Technical Specification of Manitoba Hydro's Specification 029794 dated May 5th, 2009. These requirements are outlined below:

1. The contractor shall be responsible to arrange and undertake the performance testing of the plant. Manitoba Hydro staff and representatives will witness the performance testing.
2. The performance test will extend for a one month period and will consist of the contractor taking and analyzing daily composite samples of the treated sewage. The contractor shall pay for all costs associated with performance testing. The engineer shall determine when the performance test can commence.
3. If the performance test shows that the plant does not meet the treated effluent requirements per Table 2, the contractor shall undertake whatever changes are needed to the plant and then re-do the performance test.

Table 2: Treated Effluent Requirements

Item	Parameter	Average Monthly Concentration not to exceed	Maximum concentration never to exceed.
1.	BOD5	20 mg/l	25 mg/l
2.	TSS	20 mg/l	25 mg/l
3.	Total Ammonia – Summer (May 1 to September 30)	5 mg/l	10 mg/l

4.	Total Ammonia – Winter (October 1 to April 30)	15 mg/l	20 mg/l
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Attainment of the Effluent Requirements is predicated on the influent parameters provided for design of the system not being exceeded. These values were provided in Table 1 in Section 3.1 Raw Wastewater Influent Characteristics in the Technical Specification.

Table 1: Raw Wastewater Flows and Parameters

Item	Raw Wastewater Component	Value
1.	Average Daily Flow	60 m ³ /d (43LPM; 48LPM*)
2.	Peak Day Flow	70 m ³ /d (50 LPM; 56LPM*)
3.	Peak Hour Flow	120 m ³ /d (83 LPM)
4.	Average Bod5 Loading	22 kg/d
5.	Peak BOD5 Loading	50kg/d
6.	Average TSS Loading	22 kg/d
7.	Peak TSS Loading	50kg/d
8.	Average Total Ammonia Concentration	40 mg/l

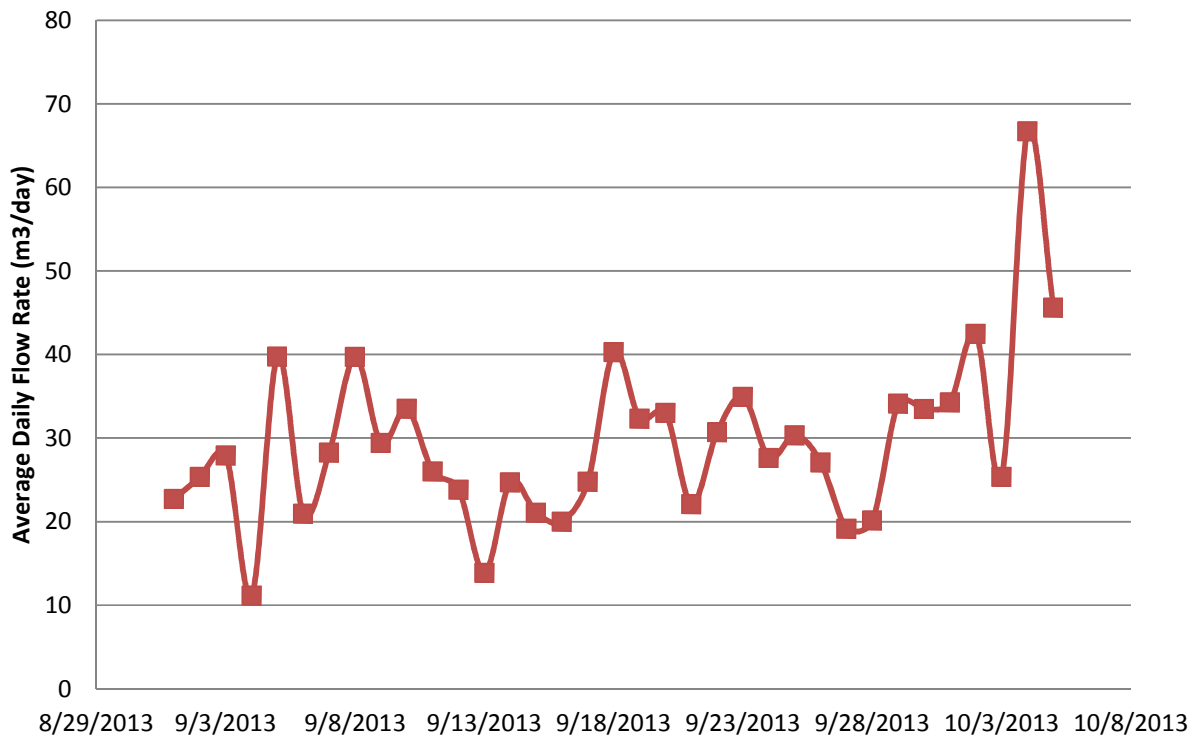
**Actual instantaneous flow rate that accounts for relaxation time between cycles*

### **3 FLOW TESTING**

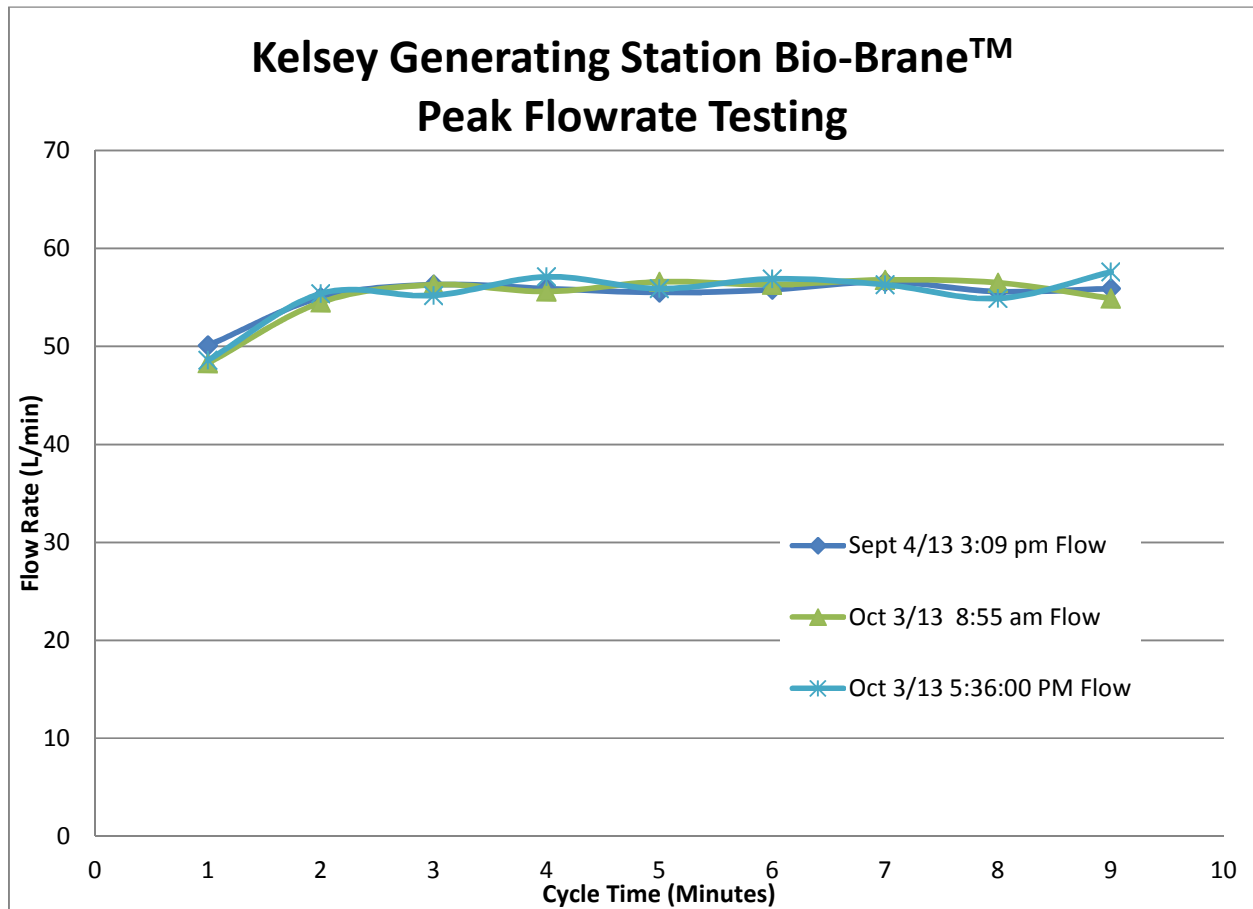
Flow testing of the package was accomplished in two ways.

First the package was tested to meet the day to day instantaneous flow rates, which involved running the system per the “average day” sewage production rates and letting the system function as it is programmed, working on the volume within the EQ tank in a normal scenario. The sewage production rates during the performance testing were below the average design flow rate of the system. Figure 1 below shows the flow rate of the system over the duration of the performance test.

## Kelsey Generating Station Bio-Brane™ Average Daily Flow Rate - Performance Test



Secondly, to simulate the peak day flow of 56 LPM instantaneous flow rate the EQ pumps were disabled to allow the EQ tank to fill with sewage. This stored sewage was then be pumped to the system by turning the EQ pumps back on. The membrane permeation rate was set at 56 LPM to ensure this flow rate was maintained. This peak event was carried out both at the beginning of the performance testing period, and for a 24 hour duration at the end of the performance testing period. Figure 2 below shows the flow rates for several cycles that were recorded for these periods. The trans-membrane pressure remained near zero for all flow testing conducted, indicating that the membrane system was easily able to handle the flow rates.



The system has been designed to handle the Peak Hour Flow of 83LPM through the use of the EQ tank for storage of excess flow. If a peak feed flow rate of 83 LPM (~5 m³/hr) is sent to the system, the flow rate that is actually sent to the bio-reactor will remain 50 LPM (3 m³/hr) with the excess feed being stored in the EQ tank. This results in an accumulation of 2 m³/hr, which can easily be stored in the EQ basin which has a volume of 12m³.

## 4 SAMPLING REQUIREMENTS

The sampling requirements for this performance test were outlined below. As part of this testing regime H2O Innovation sampled the influent and effluent of the Bio-Brane™ wastewater treatment system.

1. Required Samples:
  - a. BOD5 – Influent and Effluent
  - b. TSS – Influent and Effluent
  - c. Ammonia – Influent and Effluent
2. Sample Collection Method:

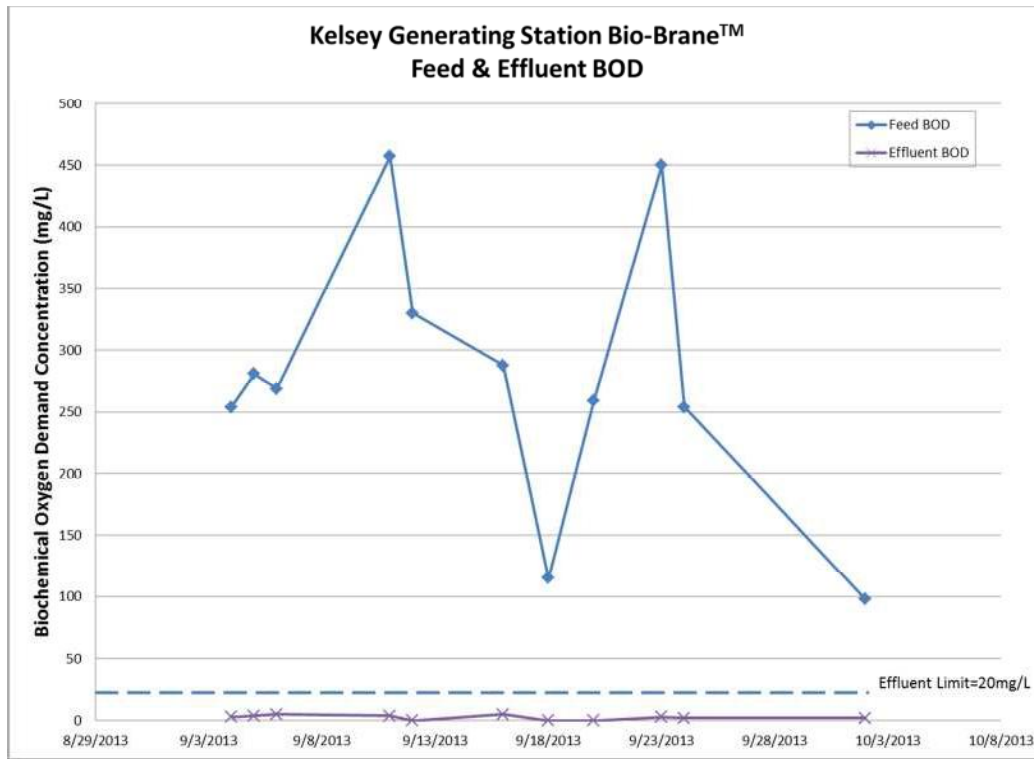
- a. Influent samples
    - i. These were Grab samples.
    - ii. These were collected from the SBR Transfer Tank at the same time that the influent samples are collected.
    - iii. These grab samples were preserved as noted in 3.3. Sample Preservation.
  - b. Effluent Samples
    - i. These were Composite Samples.
    - ii. Composite time frame was approximately 24 hours.
    - iii. These composite samples were collected from the composite sampler located in the UV Building.
    - iv. The composite sampler collected the samples from the discharge side of the UV system.
    - v. These composite samples were preserved as noted in 3.3. Sample Preservation.
3. Sample Preservation:
- a. All Samples upon collection were stored at or below 4°C.
  - b. When shipping the samples in the provided coolers, the samples should be covered in ice.

#### 4.1. SAMPLE RESULTS

The results of the sample testing is given in the sections below for BOD, TSS and NH₃, respectively. The results indicated excellent removals for the entire sampling period with BOD, TSS and NH₃ effluent values well below the effluent criteria for the system.

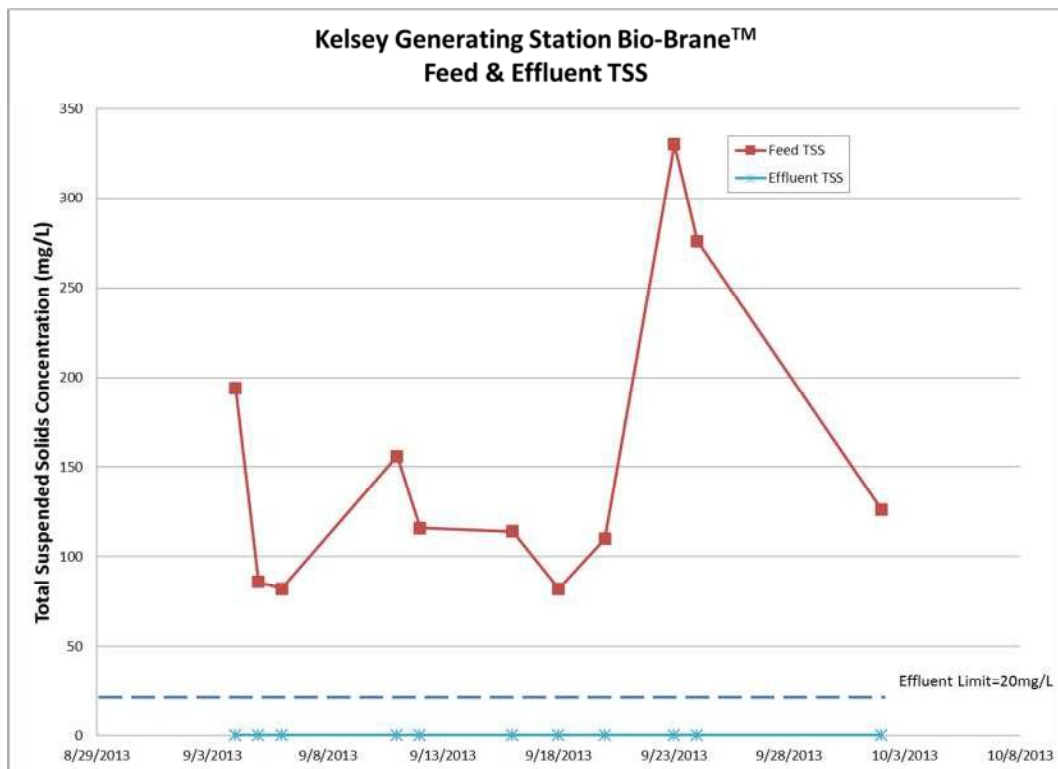
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#### 4.1.1. BOD Sampling Results



As shown above, the BOD in the effluent was consistently below the required value of 20mg/L.

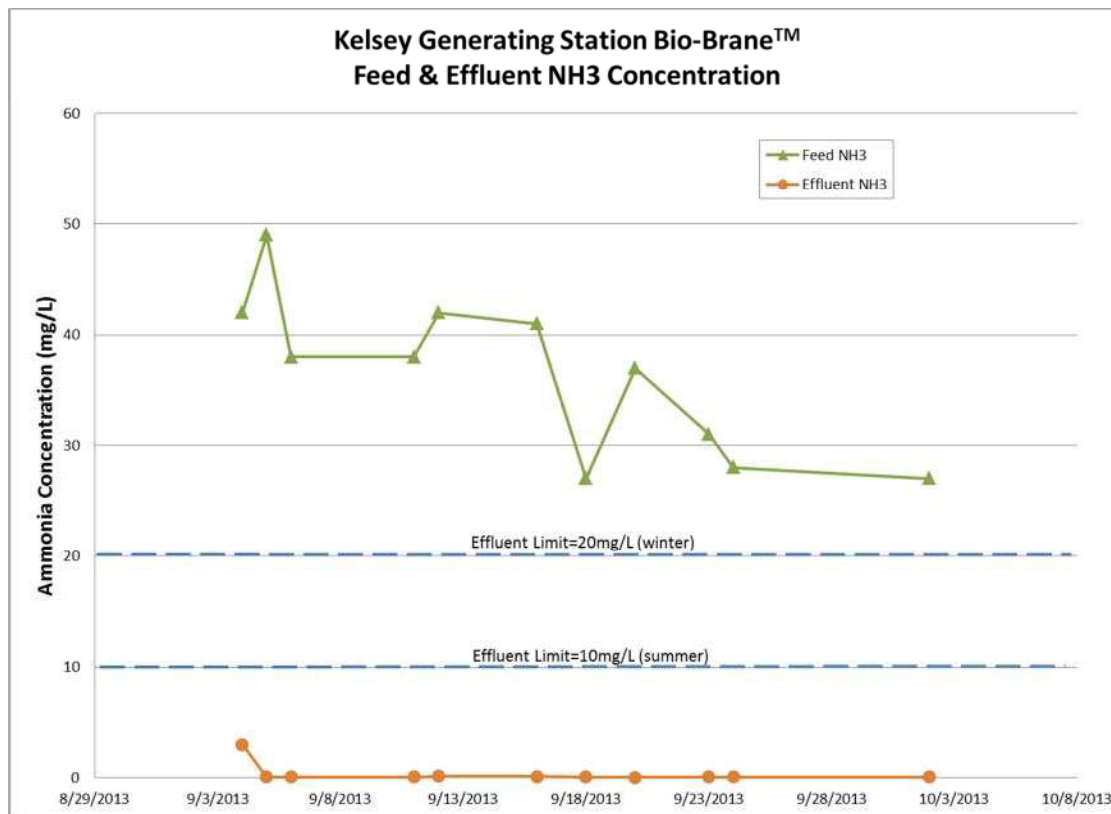
#### 4.1.2. TSS Sampling Results



As shown above, the TSS in the effluent was consistently below the required value of 20 mg/L.



#### 4.1.3. NH3 Sampling Results



As shown above, the NH₃ in the effluent was consistently below the required value of 10 mg/L, which is the more stringent requirement for the summer months despite the fact that this testing was conducted in the fall.

## 5 CONCLUSIONS

The data presented above shows that the Bio-Brane™ system operating at the Kesley Generating Station was consistently able to achieve the flow rates and removals required for this application. **This performance test was passed.**

## 6 RAW SAMPLING DATA FROM MAXXAM LABORATORY

Site Location: KELSEY STP PILOT  
Your C.O.C. #: C408786

**Attention: FRASER KENT**  
H2O INNOVATION  
5100 SOUTH SERVICE RD.  
UNIT 17  
BURLINGTON, ON  
CANADA L7L 6A5

Report Date: 2013/09/12

## CERTIFICATE OF ANALYSIS

**MAXXAM JOB #: B379111**  
**Received: 2013/09/04, 14:30**

Sample Matrix: Water  
# Samples Received: 4

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity	2	N/A	2013/09/07	WIN SOP-00014	Based on SM-2320B
Biochemical Oxygen Demand	2	N/A	2013/09/05	WIN SOP-00018	Based on SM-5210B
COD by Colorimeter (1)	2	2013/09/05	2013/09/06	BBY6SOP-00024	SM - 5220D
Hardness Total (calculated as CaCO ₃ ) (1)	2	N/A	2013/09/12	BBY7SOP-00002	EPA 6020A
Mercury (Total) by CVAf (1)	2	2013/09/11	2013/09/11	BBY7SOP-00015	EPA 245.7
Na, K, Ca, Mg, S by CRC ICPMS (total) (1)	2	2013/09/04	2013/09/12	BBY7SOP-00002	EPA 6020A
Elements by CRC ICPMS (total) (1)	2	2013/09/12	2013/09/12	BBY7SOP-00002	EPA 6020A
Nitrogen (Total) (1)	1	2013/09/06	2013/09/09	BBY6SOP-00022	SM-4500N C
Nitrogen (Total) (1)	1	2013/09/10	2013/09/11	BBY6SOP-00022	SM-4500N C
Ammonia-N (Preserved) (1)	2	N/A	2013/09/05	BBY6SOP-00009	SM-4500NH3G
Nitrate + Nitrite (N) - Preserved (1)	2	N/A	2013/09/06	BBY6SOP-00010	USEPA 353.2
pH (2)	2	N/A	2013/09/04	WIN SOP-00009	SM4500 H+B
TKN (Calc. TN, N/N) total (1)	2	N/A	2013/09/11	BBY6SOP-00022	SM 4500N-C
Carbon (Total Organic) (1)	2	N/A	2013/09/05	BBY6SOP-00003	SM-5310C
Total Oil and Grease (1)	2	N/A	2013/09/12	BBY8SOP-00004	BC Lab Manual
Total Phosphorus (1)	2	N/A	2013/09/06	BBY6SOP-00013	SM 4500 PE
Total Suspended Solids (1)	2	N/A	2013/09/10	BBY6SOP-00034	SM - 2540 D
Total Suspended Solids (1)	2	N/A	2013/09/11	BBY6SOP-00034	SM - 2540 D
Total Suspended Solids(Fixed & Volatile) (1)	4	N/A	2013/09/12	BBY6SOP-00034	SM2540 E

* Results relate only to the items tested.

(1) This test was performed by Maxxam Vancouver

(2) The APHA Standard Method requires pH to be analysed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the APHA Standard Method holding time.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Janelle Kochan, B.Sc., Project Manager,  
Email: JKochan@maxxam.ca  
Phone# (204) 772-7276 Ext:2209

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Maxxam Job #: B379111  
Report Date: 2013/09/12

H2O INNOVATION

Site Location: KELSEY STP PILOT  
Sampler Initials: TH

-2-

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

Total cover pages: 2

Maxxam Job #: B379111  
Report Date: 2013/09/12

H2O INNOVATION

Site Location: KELSEY STP PILOT  
Sampler Initials: TH

## RESULTS OF CHEMICAL ANALYSES OF WATER

	Maxxam ID		HK0763 2013/09/04 07:48		HK0764 2013/09/04 07:45	HK0765 2013/09/04 07:45			HK0766 2013/09/04 07:40		
	Sampling Date		C408786 RAW FEED	QC Batch	BIO-WHEEL MIXED LIQUOR	C408786 MEMBRANE TANK MIXED LIQUOR	RDL	QC Batch	TREATED EFFLUENT	RDL	QC Batch
	COC#	UNITS									
Calculated Parameters											
	Total Hardness (CaCO ₃ )	mg/L	191	7143413			0.50		190	0.50	7143413
Demand Parameters											
	Biochemical Oxygen Demand	mg/L	254	7149164			2		3	2	7149164
	Chemical Oxygen Demand	mg/L	562	7144266			10		43	10	7144266
Misc. Inorganics											
	Alkalinity (Total as CaCO ₃ )	mg/L	340	7152914			1		120	1	7152914
	Total Organic Carbon (C)	mg/L	63.8	7145555			2.5		10.3	0.50	7145555
	pH	pH Units	7.3	7144020					7.7		7144020
	Bicarbonate (HCO ₃ )	mg/L	410	7152914			0.5		150	0.5	7152914
	Carbonate (CO ₃ )	mg/L	<0.5	7152914			0.5		<0.5	0.5	7152914
	Hydroxide (OH)	mg/L	<0.5	7152914			0.5		<0.5	0.5	7152914
	Total Suspended Solids (Fixed)	mg/L	12.0	7161732	786	812	1.0	7161732	<1.0	1.0	7161732
	Total Suspended Solids (Volatile)	mg/L	182	7161732	3150	3270	1.0	7161732	2.0	1.0	7161732
Nutrients											
	Ammonia (N)	mg/L	42	7145979			0.50		0.037	0.0050	7145979
	Total Total Kjeldahl Nitrogen (Calc)	mg/L	51.7	7141758			2.0		1.91	0.40	7141758
	Nitrate plus Nitrite (N)	mg/L	0.036	7153955			0.020		22.2	0.40	7153955
	Total Nitrogen (N)	mg/L	51.8	7154287			2.0		24.1	0.40	7162354
	Total Phosphorus (P)	mg/L	5.85	7151905			0.10		4.75	0.050	7151905
OIL & GREASE											
	Total Oil and grease	mg/L	<1.0	7162885			1.0		<1.0	1.0	7162885
Physical Properties											
	Total Suspended Solids	mq/L	194	7149745	3940	4090	4.0	7156220	<4.0	4.0	7149745

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RDL = Reportable Detection Limit

Maxxam Job #: B379111  
Report Date: 2013/09/12

H2O INNOVATION

Site Location: KELSEY STP PILOT  
Sampler Initials: TH

# MERCURY BY COLD VAPOR (WATER)

Maxxam ID	HK0763	HK0766	
Sampling Date	2013/09/04 07:48	2013/09/04 07:40	
COC#	C408786	C408786	
	RAW FEED	TREATED EFFLUENT	RDL
UNITS			QC Batch
ug/L	<0.010	<0.010	0.010
Total Mercury (Hg)			7160142

RDL = Reportable Detection Limit

Maxxam Job #: B379111  
Report Date: 2013/09/12

H2O INNOVATION

Site Location: KELSEY STP PILOT  
Sampler Initials: TH

# ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID	HK0763	HK0766		
Sampling Date	2013/09/04 07:48	2013/09/04 07:40		
COC#	C408786	C408786		
	UNITS	RAW FEED	TREATED EFFLUENT	RDL
<b>Total Metals by ICPMS</b>				
Total Aluminum (Al)	ug/L	269	17.7	3.0
Total Antimony (Sb)	ug/L	0.85	0.51	0.50
Total Arsenic (As)	ug/L	1.88	1.58	1.0
Total Barium (Ba)	ug/L	45.8	18.5	1.0
Total Beryllium (Be)	ug/L	<0.10	<0.10	0.10
Total Bismuth (Bi)	ug/L	2.0	<1.0	1.0
Total Boron (B)	ug/L	244	222	50
Total Cadmium (Cd)	ug/L	0.201	0.131	0.010
Total Chromium (Cr)	ug/L	3.6	1.0	1.0
Total Cobalt (Co)	ug/L	1.11	<0.50	0.50
Total Copper (Cu)	ug/L	156	36.7	0.20
Total Iron (Fe)	ug/L	1060	91.1	5.0
Total Lead (Pb)	ug/L	12.4	0.20	0.20
Total Lithium (Li)	ug/L	14.0	14.2	5.0
Total Manganese (Mn)	ug/L	48.6	8.3	1.0
Total Molybdenum (Mo)	ug/L	1.5	<1.0	1.0
Total Nickel (Ni)	ug/L	5.1	4.5	1.0
Total Selenium (Se)	ug/L	0.56	0.21	0.10
Total Silicon (Si)	ug/L	2730	2840	100
Total Silver (Ag)	ug/L	0.186	0.078	0.020
Total Strontium (Sr)	ug/L	167	155	1.0
Total Thallium (Tl)	ug/L	<0.050	<0.050	0.050
Total Tin (Sn)	ug/L	<5.0	<5.0	5.0
Total Titanium (Ti)	ug/L	8.3	<5.0	5.0
Total Uranium (U)	ug/L	1.38	1.44	0.10
Total Vanadium (V)	ug/L	<5.0	<5.0	5.0
Total Zinc (Zn)	ug/L	137	134	5.0
Total Zirconium (Zr)	ug/L	5.75	<0.50	0.50
Total Calcium (Ca)	mg/L	45.5	44.8	0.050
Total Magnesium (Mg)	mg/L	18.8	18.9	0.050
Total Potassium (K)	mg/L	18.4	19.4	0.050
Total Sodium (Na)	mg/L	68.5	73.1	0.050
Total Sulphur (S)	mg/L	16.2	20.5	3.0

RDL = Reportable Detection Limit

## H2O INNOVATION

Maxxam Job #: B379111  
Report Date: 2013/09/12

Site Location: KELSEY STP PILOT  
Sampler Initials: TH

### QUALITY ASSURANCE REPORT

QC Batch	Parameter	Date	Matrix Spike		Spiked Blank		Method Blank		RPD		Calibration Check	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
7144266	Chemical Oxygen Demand	2013/09/06	NC	80 - 120	99	80 - 120	<10	mg/L	2.1	20		
7145555	Total Organic Carbon (C)	2013/09/05	105	80 - 120	106	80 - 120	<0.50	mg/L	14.1	20		
7145979	Ammonia (N)	2013/09/05	NC	80 - 120	100	80 - 120	<0.0050	mg/L	NC	20		
7149164	Biochemical Oxygen Demand	2013/09/05					<1	mg/L	NC	20	100	84 - 115
7149745	Total Suspended Solids	2013/09/10	89	80 - 120	98	80 - 120	<4.0	mg/L	NC	20		
7151905	Total Phosphorus (P)	2013/09/06	NC	80 - 120	98	80 - 120	<0.0050	mg/L	5.6	20		
7152914	Alkalinity (Total as CaCO3)	2013/09/07					<1	mg/L	0	9	93	85 - 115
7152914	Bicarbonate (HCO3)	2013/09/07										
7152914	Carbonate (CO3)	2013/09/07							NC	20		
7152914	Hydroxide (OH)	2013/09/07							NC	20		
7153955	Nitrate plus Nitrite (N)	2013/09/06	NC	80 - 120	99	80 - 120	<0.020	mg/L	1.5	25		
7154287	Total Nitrogen (N)	2013/09/09	NC	80 - 120	100	80 - 120	<0.020	mg/L	0.8	20		
7156220	Total Suspended Solids	2013/09/11	NC	80 - 120	98	80 - 120	<4.0	mg/L	NC	20		
7160142	Total Mercury (Hg)	2013/09/11	96	80 - 120	98	80 - 120	<0.010	ug/L	NC	20		
7161732	Total Suspended Solids (Fixed)	2013/09/12					<1.0	mg/L				
7161732	Total Suspended Solids (Volatile)	2013/09/12					<1.0	mg/L				
7162354	Total Nitrogen (N)	2013/09/11	NC	80 - 120	92	80 - 120	<0.020	mg/L	1.9	20		
7162885	Total Oil and grease	2013/09/12			97	70 - 130	<1.0	mg/L				
7163482	Total Aluminum (Al)	2013/09/12	NC	80 - 120	106	80 - 120	<3.0	ug/L	8.2	20		
7163482	Total Antimony (Sb)	2013/09/12	102	80 - 120	104	80 - 120	<0.50	ug/L	NC	20		
7163482	Total Arsenic (As)	2013/09/12	108	80 - 120	106	80 - 120	<0.10	ug/L	0.3	20		
7163482	Total Barium (Ba)	2013/09/12	NC	80 - 120	99	80 - 120	<1.0	ug/L	1.0	20		
7163482	Total Beryllium (Be)	2013/09/12	98	80 - 120	100	80 - 120	<0.10	ug/L	NC	20		
7163482	Total Bismuth (Bi)	2013/09/12	107	80 - 120	99	80 - 120	<1.0	ug/L	NC	20		
7163482	Total Cadmium (Cd)	2013/09/12	101	80 - 120	100	80 - 120	<0.010	ug/L	0	20		
7163482	Total Chromium (Cr)	2013/09/12	109	80 - 120	101	80 - 120	<1.0	ug/L	NC	20		
7163482	Total Cobalt (Co)	2013/09/12	103	80 - 120	102	80 - 120	<0.50	ug/L	NC	20		
7163482	Total Copper (Cu)	2013/09/12	104	80 - 120	102	80 - 120	<0.20	ug/L	5.2	20		
7163482	Total Iron (Fe)	2013/09/12	NC	80 - 120	103	80 - 120	<5.0	ug/L	3.0	20		
7163482	Total Lead (Pb)	2013/09/12	101	80 - 120	100	80 - 120	<0.20	ug/L	NC	20		
7163482	Total Lithium (Li)	2013/09/12	NC	80 - 120	100	80 - 120	<5.0	ug/L	NC	20		
7163482	Total Manganese (Mn)	2013/09/12	NC	80 - 120	103	80 - 120	<1.0	ug/L	1.3	20		
7163482	Total Molybdenum (Mo)	2013/09/12	NC	80 - 120	88	80 - 120	<1.0	ug/L	NC	20		
7163482	Total Nickel (Ni)	2013/09/12	99	80 - 120	104	80 - 120	<1.0	ug/L	NC	20		
7163482	Total Selenium (Se)	2013/09/12	98	80 - 120	105	80 - 120	<0.10	ug/L	5.6	20		
7163482	Total Silver (Ag)	2013/09/12	80	80 - 120	102	80 - 120	<0.020	ug/L	NC	20		
7163482	Total Strontium (Sr)	2013/09/12	NC	80 - 120	100	80 - 120	<1.0	ug/L	3.7	20		
7163482	Total Thallium (Tl)	2013/09/12	89	80 - 120	82	80 - 120	<0.050	ug/L	NC	20		
7163482	Total Tin (Sn)	2013/09/12	100	80 - 120	100	80 - 120	<5.0	ug/L	NC	20		
7163482	Total Titanium (Ti)	2013/09/12	91	80 - 120	118	80 - 120	<5.0	ug/L	NC	20		



Maxxam Job #: B379111  
Report Date: 2013/09/12

H2O INNOVATION

Site Location: KELSEY STP PILOT  
Sampler Initials: TH

### QUALITY ASSURANCE REPORT

QC Batch	Parameter	Date	Matrix Spike		Spiked Blank		Method Blank		RPD		Calibration Check	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
7163482	Total Uranium (U)	2013/09/12	98	80 - 120	96	80 - 120	<0.10	ug/L	0.9	20		
7163482	Total Vanadium (V)	2013/09/12	111	80 - 120	113	80 - 120	<5.0	ug/L	NC	20		
7163482	Total Zinc (Zn)	2013/09/12	NC	80 - 120	104	80 - 120	<5.0	ug/L	NC	20		
7163482	Total Boron (B)	2013/09/12					<50	ug/L	NC	20		
7163482	Total Silicon (Si)	2013/09/12					<100	ug/L	0.7	20		
7163482	Total Zirconium (Zr)	2013/09/12					<0.50	ug/L	NC	20		

N/A = Not Applicable

RPD = Relative Percent Difference

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

Calibration Check: A calibration standard analyzed at different times to evaluate on-going calibration accuracy.

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

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

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

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.

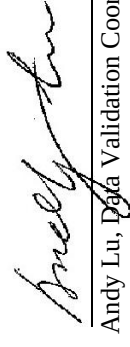
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

## Validation Signature Page

Maxxam Job #: B379111

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

  
_____  
Andy Lu, Data Validation Coordinator

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

INVOICE INFORMATION:				REPORT INFORMATION (if differs from invoice):				PROJECT INFORMATION:				Laboratory Use Only:			
Company Name: #11201 H2O INNOVATION				Company Name:				Quotation #:				MAXXAM JOB #:			
Contact Name: FRASER KENT				Contact Name:				P.O. #:				BOTTLE ORDER #:			
Address: 5100 SOUTH SERVICE RD. UNIT 17				Address:				Project #:				408735			
BURLINGTON ON L7L 6A5				Phone:				Project Name:				CHAIN OF CUSTODY #:			
(289) 813-5533 x103 Fax: fraser.kent@h2oinnovation.com				Fax:				Site #:				PROJECT MANAGER:			
Email: fraser.kent@h2oinnovation.com				Email:				Sampled By: Tyler Hawiger / Keith Sackerson				Janelle Kochan			
REGULATORY CRITERIA:				SPECIAL INSTRUCTIONS:				ANALYSIS REQUESTED (Please be specific):				TURNAROUND TIME (TAT) REQUIRED:			
Note: For regulated drinking water samples - please use the Drinking Water Chain of Custody Form				Regulated Drinking Water ? (Y / N)				Metals Field Filtered ? (Y / N)				pH			
SAMPLES MUST BE KEPT COOL   < 10°C   FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM				Matrix				Time Sampled				Date Sampled			
1	HK-0763	RAW FEED	13/04/04	07:48 AM	07:48 AM	07:48 AM	13/04/04								
2	64	BIO-WHEEL MIXED LIQUOR													
3	65	MEMBRANE TANK MIXED LIQUOR													
4	66	TREATED EFFLUENT	13/04/04	07:00 AM	07:00 AM	07:00 AM	13/04/04								composite sample
5															
6															
7															
8															
9															
10															

RELINQUISHED BY: (Signature/Print)		Date: (YY/MM/DD)		Time:		RECEIVED BY: (Signature/Print)		Date: (YY/MM/DD)		Time:		# Jars Used and Not Submitted		Time Sensitive		Temperature (°C) on Receipt		Custody Seal Intact on Cooler?	
Tyler Hawiger / Keith Sackerson		13/04/04		9:00 AM		Tyler Hawiger		13/04/04		14:30		11/2, 14.6, 8.0		11/2, 14.6, 8.0		Yes		No	

<b>INVOICE INFORMATION:</b> Company Name: #11201 H2O INNOVATION Contact Name: FRASER KENT Address: 5100 SOUTH SERVICE RD. UNIT 17 BURLINGTON ON L7L 6A5 Phone: (289) 813-5533 x103 Fax: Fraser.kent@h2oinnovation.com Email:		<b>REPORT INFORMATION (if differs from invoice):</b> Company Name: Contact Name: Address: Phone: Email:		<b>PROJECT INFORMATION:</b> Quotation #: P.O. #: Project #: Project Name: Kelkey SIP Pilot Site #: Taylor Hanger / Keith Spackman Sampled By:		<b>Laboratory Use Only:</b> MAXXAM JOB #: 8379111 BOTTLE ORDER #: 495786 CHAIN OF CUSTODY #: PROJECT MANAGER: Janelle Kochan C#408786-01-01	
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<b>REGULATORY CRITERIA:</b> SPECIAL INSTRUCTIONS: Note: For regulated drinking water samples - please use the Drinking Water Chain of Custody Form SAMPLES MUST BE KEPT COOL (< 10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM		<b>ANALYSIS REQUESTED (Please be specific):</b> Turnaround Time (TAT) REQUIRED: PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS Regular (Standard) TAT: (will be applied if Rush TAT is not specified) Standard TAT = 5-7 Working days for most tests. Please note: Standard TAT for certain tests such as BOD and DO and Dissolved Organics are > 5 days - contact your Project Manager for details. Job Spec for Rush TAT (if applies to entire submission) Date Required: Time Required: Rush Confirmation Number: (call lab for #) # of Bottles: Comments:									
-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	--	----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	--	--	--	--	--	--	--	--	--

Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Regulated Drinking Water? (Y/N)	Metals Field Filtered? (Y/N)	Biochemical Oxygen Demand	Ammonia-N	Total Suspended Solids	ICP-MS Total Metals in Water	Total Phosphorus	Total Oil and Grease	Total TKN (includes TN and N+N)	Carbon (Total Organic)	COD by Colorimeter	Total Suspended Solids (Fixed & Volatile)
1 HK0763	RAW FEED	13/09/04	07:48 AM													
2 64	BIO-WHEEL MIXED LIQUOR	13/09/04	07:45 AM													
3 65	MEMBRANE TANK MIXED LIQUOR	13/09/04	07:45 AM													
4 66	TREATED EFFLUENT	13/09/04	07:40 AM													
5																
6																
7																
8																
9																
10																

<b>RELINQUISHED BY: (Signature/Print)</b> Taylor Hanger		<b>RECEIVED BY: (Signature/Print)</b> [Signature]		<b>Date: (YYMMDD)</b> 13/09/04		<b>Time:</b> 9:00 AM		<b>Date: (YYMMDD)</b> 13/09/04		<b>Time:</b> 14:50		<b># Jars Used and Not Submitted</b>		<b>Laboratory Use Only</b> Temperature (°C) on Receipt: 11.2, 14.6, 8.0 Custody Seal Intact on Cooler? Yes <input type="checkbox"/> No <input type="checkbox"/>	
------------------------------------------------------------	--	------------------------------------------------------	--	-----------------------------------	--	-------------------------	--	-----------------------------------	--	-----------------------	--	--------------------------------------	--	-----------------------------------------------------------------------------------------------------------------------------------------------------------------------	--



Your Project #: KELSEY GS STP PILOT  
Your C.O.C. #: 408789

**Attention: FRASER KENT**  
H2O INNOVATION  
5100 SOUTH SERVICE RD.  
UNIT 17  
BURLINGTON, ON  
CANADA L7L 6A5

**Report Date: 2013/09/17**

## **CERTIFICATE OF ANALYSIS**

**MAXXAM JOB #: B379866**  
**Received: 2013/09/06, 09:45**

Sample Matrix: Water  
# Samples Received: 3

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Biochemical Oxygen Demand	2	N/A	2013/09/06	WIN SOP-00018	Based on SM-5210B
Ammonia-N (Preserved) (1)	2	N/A	2013/09/10	BBY6SOP-00009	SM-4500NH3G
Total Suspended Solids	3	N/A	2013/09/06	WIN SOP-00042	Based on SM2540 D

* Results relate only to the items tested.

(1) This test was performed by Maxxam Vancouver

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Janelle Kochan, B.Sc., Project Manager,  
Email: JKochan@maxxam.ca  
Phone# (204) 772-7276 Ext:2209

=====

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

Total cover pages: 1

Maxxam Job #: B379866  
Report Date: 2013/09/17

H2O INNOVATION  
Client Project #: KELSEY GS STP PILOT  
Sampler Initials: TH

## RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID	HK5138	HK5139	HK5140	
Sampling Date	2013/09/05 09:40	2013/09/05 09:30	2013/09/05 09:20	
COC#	408789	408789	408789	
UNITS	RAW FEED	BIO-WHEEL MIXED LIQUOR	RDL	QC Batch
<b>Demand Parameters</b>				
Biochemical Oxygen Demand	mg/L	281	2	4
<b>Nutrients</b>				
Ammonia (N)	mg/L	49	0.50	0.045
<b>Physical Properties</b>				
Total Suspended Solids	mg/L	86.0	4.0	<4.0
			4.0	7152943

RDL = Reportable Detection Limit

Maxxam Job #: B379866  
Report Date: 2013/09/17

H2O INNOVATION  
Client Project #: KELSEY GS STP PILOT  
Sampler Initials: TH

### QUALITY ASSURANCE REPORT

QC Batch	Parameter	Date	Matrix Spike		Spiked Blank		Method Blank		RPD		Calibration Check	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
7152943	Total Suspended Solids	2013/09/06	89	80 - 120	98	80 - 120	<4.0	mg/L	NC	20		
7153001	Biochemical Oxygen Demand	2013/09/06					<1	mg/L	NC	20		
7156544	Ammonia (N)	2013/09/10	98	80 - 120	98	80 - 120	<0.0050	mg/L	0.9	20	100	84 - 115

N/A = Not Applicable

RPD = Relative Percent Difference

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

Calibration Check: A calibration standard analyzed at different times to evaluate on-going calibration accuracy.

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

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

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

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.



## Validation Signature Page

**Maxxam Job #: B379866**

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



_____  
Rob Reinert, Data Validation Coordinator

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

INVOICE INFORMATION:		REPORT INFORMATION (if differs from invoice):		PROJECT INFORMATION:		Laboratory Use Only:	
Company Name:	#11201 H2O INNOVATION	Company Name:		Quotation #:		MAXXAM JOB #:	BOTTLE ORDER #:
Contact Name:	FRASER KENT	Contact Name:		P.O. #:			408789
Address:	5100 SOUTH SERVICE RD. UNIT 17	Address:		Project #:		CHAIN OF CUSTODY #:	PROJECT MANAGER:
	BURLINGTON ON L7L 6A5			Project Name:			Janele Kochan
Phone:	(289)813-5533 x103	Phone:		Site #:			
Email:	fraser.kent@h2oinnovation.com	Email:		Sampled By:	Tyler Hanger		

REGULATORY CRITERIA:		SPECIAL INSTRUCTIONS:		ANALYSIS REQUESTED (Please be specific):		TURNAROUND TIME (TAT) REQUIRED:	
Note: For regulated drinking water samples - please use the Drinking Water Chain of Custody Form						PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS	
						Regular (Standard) TAT: (will be applied if Rush TAT is not specified) Standard TAT = 5-7 Working days for most tests. Please note: Standard TAT for certain tests such as BOD and Dissolved Solids are > 5 days - contact your Project Manager for details.	
						Job Specific Rush TAT (if applies to entire submission) Date Required: Time Required: Rush Confirmation Number: (call lab for #)	

SAMPLES MUST BE KEPT COOL (< 10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM							
Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Regulated Drinking Water ? (Y / N)	Metals Field Filtered ? (Y / N)	Ammonia-N
1 HC 5738	RAW FEED	09/05/13	09:40		✓	✓	✓
2 39	BIO-WHEEL MIXED LIQUOR	09/05/13	09:30		✓	✓	✓
3 40	TREATED EFFLUENT	09/05/13	09:20		✓	✓	✓
4							
5							
6							
7							
8							
9							
10							

RECEIVED BY: (Signature/Print)		Date: (YY/MM/DD)	Time:	RECEIVED BY: (Signature/Print)		Date: (YY/MM/DD)	Time:
Tyler Hanger		13/09/15	10:00	Tyler Hanger		20/09/06	09:45
RELINQUISHED BY: (Signature/Print)		Date: (YY/MM/DD)	Time:	RELINQUISHED BY: (Signature/Print)		Date: (YY/MM/DD)	Time:
Tyler Hanger		13/09/15	10:00	Tyler Hanger		20/09/06	09:45

Your Project #: KELSEY G.S. STP PILOT  
Your C.O.C. #: C408790

**Attention: FRASER KENT**

H2O INNOVATION  
5100 SOUTH SERVICE RD.  
UNIT 17  
BURLINGTON, ON  
CANADA L7L 6A5

**Report Date: 2013/09/17****CERTIFICATE OF ANALYSIS****MAXXAM JOB #: B380019****Received: 2013/09/06, 12:10**

Sample Matrix: Water  
# Samples Received: 3

Analyses	Quantity	Date	Date	Laboratory Method	Analytical Method
		Extracted	Analyzed		
Biochemical Oxygen Demand	2	N/A	2013/09/06	WIN SOP-00018	Based on SM-5210B
Ammonia-N (Preserved) (1)	2	N/A	2013/09/10	BBY6SOP-00009	SM-4500NH3G
Total Suspended Solids	3	N/A	2013/09/06	WIN SOP-00042	Based on SM2540 D

* Results relate only to the items tested.

(1) This test was performed by Maxxam Vancouver

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Janelle Kochan, B.Sc., Project Manager,  
Email: JKochan@maxxam.ca  
Phone# (204) 772-7276 Ext:2209

=====

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

Total cover pages: 1

Maxxam Job #: B380019  
Report Date: 2013/09/17

H2O INNOVATION  
Client Project #: KELSEY G.S. STP PILOT

Sampler Initials: KS

## RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID	HK5912	HK5913	HK5914		
Sampling Date	2013/09/06 08:00	2013/09/06 08:00	2013/09/06 08:00		
COC#	C408790	C408790	C408790		
UNITS	RAW FEED	BIO-WHEEL MIXED LIQUOR	TREATED EFFLUENT	RDL	QC Batch
<b>Demand Parameters</b>					
Biochemical Oxygen Demand	mg/L	269	2	5	2
<b>Nutrients</b>					
Ammonia (N)	mg/L	38	0.50	0.044	0.0050
<b>Physical Properties</b>					
Total Suspended Solids	mg/L	82.0	4.0	<4.0	4.0
					7152943

RDL = Reportable Detection Limit

Maxxam Job #: B380019  
Report Date: 2013/09/17

H2O INNOVATION  
Client Project #: KELSEY G.S. STP PILOT  
Sampler Initials: KS

### QUALITY ASSURANCE REPORT

QC Batch	Parameter	Date	Matrix Spike		Spiked Blank		Method Blank		RPD		Calibration Check	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
7152943	Total Suspended Solids	2013/09/06	89	80 - 120	98	80 - 120	<4.0	mg/L	NC	20		
7153001	Biochemical Oxygen Demand	2013/09/06					<1	mg/L	NC	20		
7156544	Ammonia (N)	2013/09/10	98	80 - 120	98	80 - 120	<0.0050	mg/L	0.9	20	100	84 - 115

N/A = Not Applicable

RPD = Relative Percent Difference

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

Calibration Check: A calibration standard analyzed at different times to evaluate on-going calibration accuracy.

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

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

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

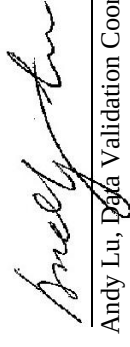
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

## Validation Signature Page

Maxxam Job #: B380019

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

  
_____  
Andy Lu, Data Validation Coordinator

=====  
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## CHAIN OF CUSTODY RECORD

[illegible]



Appendix D

Photos

# Kelsey Generating Station

## Sewage Lagoon Project Preliminary Design Report

### EXISTING WASTEWATER TREATMENT SYSTEM



1.1 SBR building and underground transfer tank



1.2 Interior of SBR building with sewage influent transfer piping



1.3 UV Building and fuel tank



1.4 UV Building entrance and conduits to SBR building



1.5 Interior of UV building



1.6 Electrical service to UV building

# Kelsey Generating Station

## Sewage Lagoon Project Preliminary Design Report

### EXISTING WASTEWATER TREATMENT SYSTEM



1.7 BioBrane exterior view from NE



1.8 BioBrane exterior view from SW



1.9 Sludge digester building



1.10 Sludge digestion underground tanks



1.11 Manhole MH3 view from SW



1.12 Manhole MH view from NW looking along proposed gravity sewer line route



# Kelsey Generating Station

## Sewage Lagoon Project Preliminary Design Report

### PROPOSED FORCEMAIN ROUTE



2.1 Road between boathouse and proposed lift station location (proposed gravity sewer line crossing)



2.2 Borehole drilling (TH-12) at proposed lift station location



2.3 Road to Communication Tower (proposed forcemain tower)



2.4 View North of Communication Tower from Probe Hole PH-19



2.5 View NE from Probe Hole PH-17



2.6 View South from Test Hole TH-15

# Kelsey Generating Station

## Sewage Lagoon Project Preliminary Design Report

### PROPOSED FORCEMAIN ROUTE



2.7 View East from Test Hole TH-14



2.8 View North from Test Hole TH-16



2.9 View West from Test Hole TH-16 looking towards Lagoon Site 1



2.10 View South from Test Hole TH-16



2.11 View South along proposed FM route to Lagoon Site 2, under transmission line approximately 150m south of TH-1



2.12 Small creek crossing along FM route to Lagoon Site 2



# Kelsey Generating Station

## Sewage Lagoon Project Preliminary Design Report

### LAGOON SITE 1 (NORTH)



3.1 View West towards Lagoon Site 1



3.2 Drill rig mobilization in open area East of Lagoon Site 1



3.3 View West along Cut Line from Test Hole TH-3



3.4 Lagoon Site 1 viewed from West from location near Test Hole TH-1



3.5 View East from Test Hole TH-6, low area east of proposed lagoon site



3.6 Creek East of Lagoon Option 1, proposed ultimate destination for effluent discharge

# Kelsey Generating Station

## Sewage Lagoon Project Preliminary Design Report

### LAGOON SITE 2 (SOUTH)



4.1 Transmission line right of way East of Lagoon Option 2



4.2 Brush looking North towards Lagoon Option 2 site



4.3 Southern extents of Lagoon Option 2 site along transmission line right of way



4.4 Geotechnical investigation at Test Hole TH-8



4.5 Low area looking North from Lagoon Option 2 near Test Hole TH-11



4.6 Creek East of Lagoon Option 2, proposed ultimate destination for effluent discharge