PINTER
& ASSOCIATES LTD

Hydrogeologic Memo

To: **The Town of Radisson**
329 Main Street
PO Box 69
Radisson, SK S0K 3L0

Attention: **Norma Stumborg - Administrator**

Date: **25 September 2024**

Re: **Radisson Lagoon Regional Hydrogeologic Characterization, Radisson, SK**

1. INTRODUCTION & BACKGROUND

PINTER & Associates Ltd. (PINTER) is pleased to provide this technical memorandum (Tech Memo) to the Town of Radisson (the Client) based on the review of the available physiographic information of the area surrounding the existing wastewater lagoon and the proposed Lagoon expansion area. The Lagoon is located approximately 400 m south of Radisson, at SW-21-40-10-3. The lagoon expansion is proposed to be developed in the land immediately to the east of the existing lagoon on the same quarter section of the land (the Site).

Based on the information provided to PINTER, the Client has encountered issues with the Lagoon due to the undersize of its current capacity, and population growth. The Client wishes to remediate this problem by expanding its wastewater treatment capacity and remediating any underlying issues with the existing Lagoon to allow future developments that will support its economic growth.

The construction of the lagoon expansion started in August 2024; however, it was interrupted due to wet soil conditions found at the site area during the soil stripping. The situation demanded a reassessment of the lagoon expansion design and location since the clay soil encountered during excavation would not achieve ideal compaction with the observed degree of saturation found at the Site. Additionally, PINTER collected groundwater samples from test pits dug in the expansion area to investigate if the lagoon cell is potentially contaminating the shallow groundwater in the area.

This report presents a review of the regional hydrology and hydrogeology of the area surrounding the proposed lagoon expansion, characterizes the subsoil conditions of the area, and serves as a guide to the design re-evaluation of the lagoon cell.

2. SITE CHARACTERIZATION

2.1 Topography and Drainage

The Site is located on the Hafford Plain of the Aspen Parkland ecoregion of the prairies. The landscape is dominated by undulating to gently rolling plains dominated by sandy and gravelly till deposits of glaciofluvial and glaciolacustrine origin. Local sand dunes occur within the landscape zone. The region has a relief of approximately 40 m, sloping southeast from over 530 metres above sea level (mASL) north of the Town of Radisson to about 490 mASL near the North Saskatchewan River.

The external regional drainage of the region is very limited, and the main natural drainage feature is Shepard Creek, located approximately 3 km southeast of the Site, which drains east towards the North Saskatchewan River. Overall, the regional drainage is controlled by wetlands that accumulate surficial drainage from precipitation and snowmelt, and that often receive contribution from shallow groundwater inflow. Unless human-made drainage ditches or structures are present, the surficial runoff from one wetland to the other is dependent on the climate and the local topography. Usually, during wet years or heavy storm events, a "fill-and-spill" process occurs where the wetland "basin" fills and the extra water spills to the next wetland following the area's topography. In drought or dry periods, these wetlands may disappear completely or be maintained only by groundwater inflow.

Locally, the lagoon expansion area is marked by a topographic low that intersects the Site from the northwest to the southeast. The Site elevations range from about 521.5 mASL at the east edge of the site adjacent to the existing lagoon to approximately 520.5 mASL at the southeast end of the topographic low at the point where a culvert is installed under the south grid road.

Historical satellite imagery and topographic charts indicate the presence of an intermittent drainage channel in this low area which likely conveys water from a wetland just north of the Site toward the land to the south of the Site. Also, the historical imagery indicates the lowland area is a wetland as suggested by the water accumulation during springtime or wet years. Figure 2.1 shows the interpreted drainage and wetland system of the Site.

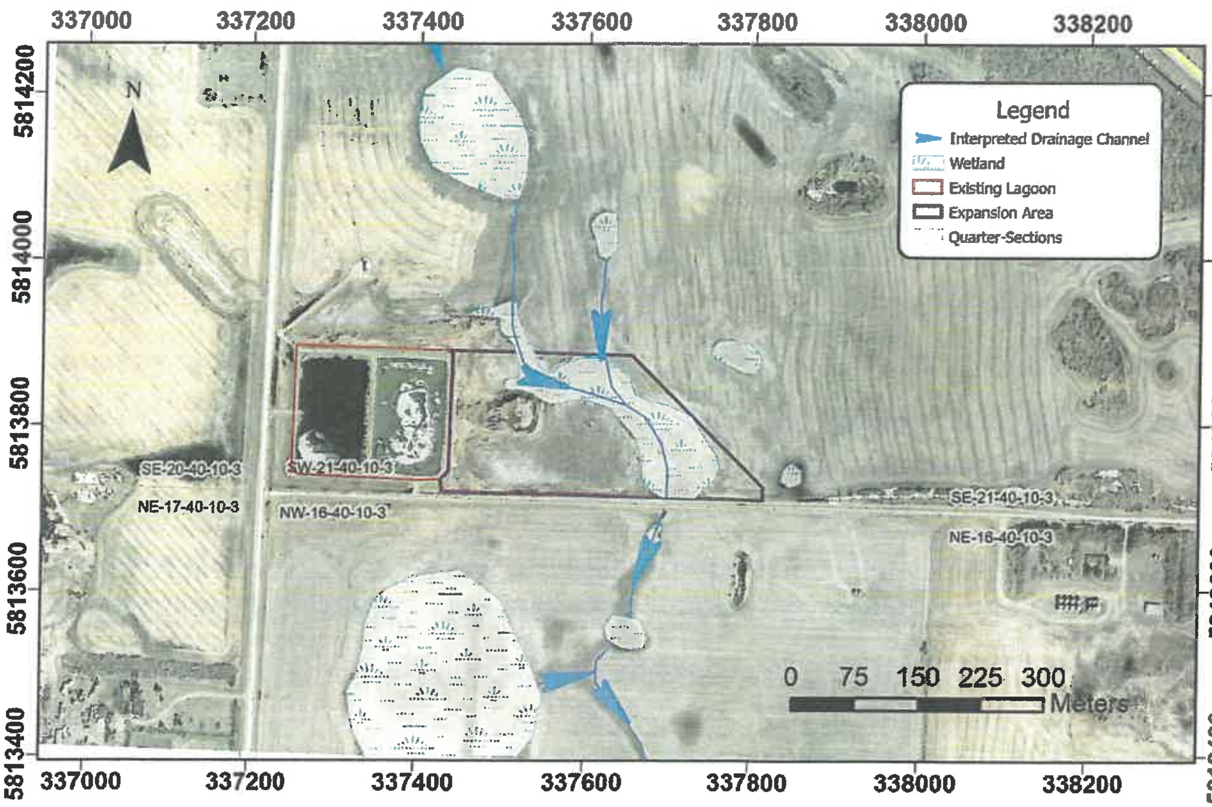

Figure 2.1 – Interpreted wetlands and drainage flow for the area surrounding the existing lagoon and proposed expansion area.

2.2 Regional Geology & Hydrogeology

The regional geology and hydrogeology were interpreted from the Hydrogeology Mapping of the NTS Mapsheet Saskatoon 73B (MDH, 2011) and the water well records available in the WSA's

Water Well Driller's Record Database (WWDR Database). The regional geology around the Site is characterized by Quaternary drift sediments deposited over Cretaceous marine deposits of the bedrock.

The Quaternary drift configures the shallow stratigraphy of the area (down to 50 m below ground surface), and these deposits represent the focus of this site characterization, as deeper stratigraphic formations are most likely not impacted by the lagoon expansion construction and operation. These deposits belong to the Saskatoon Group, which represents the portion of the drift lying between the Sutherland Group and the topographic surface. A summary of the shallow stratigraphic units identified in the region is presented below:

Surficial Stratified Deposits (SSD) – the SSD comprises the post-glacial sediments including fluvial, lacustrine, aeolian, and topsoil deposits that originate from modern depositional environments. A Glaciolacustrine Plain and a Glaciofluvial Outwash Plain configure the main environmental depositional systems of the area. Sandy and gravelly tills interbedded with coarser sediment layers associated with these depositional environments are expected to occur at surficial levels in the study area.

A complex arrangement of gravels, sands, silts, and clay deposits of the SSD configure a relatively continuous aquifer in the area. These deposits are informally named Surficial Aquifer (MDH, 2011). They have an interpreted thickness of 5 m around the Radisson area and the thickness increases eastward to more than 20 m around the outskirts of Saskatoon. Figure 2.2 shows the areal extent of the Surficial Aquifer around the study area.

The groundwater flow within the Surficial Aquifer is heavily influenced by the surficial topography, and the recharge of the aquifer is controlled by the infiltration of meteoric water. Based on the regional topography, groundwater flow in this area should occur to the east or southeast direction towards Shepards Creek and the North Saskatchewan River. The groundwater level observed in wells and boreholes completed in this formation is commonly referred to as the groundwater table.

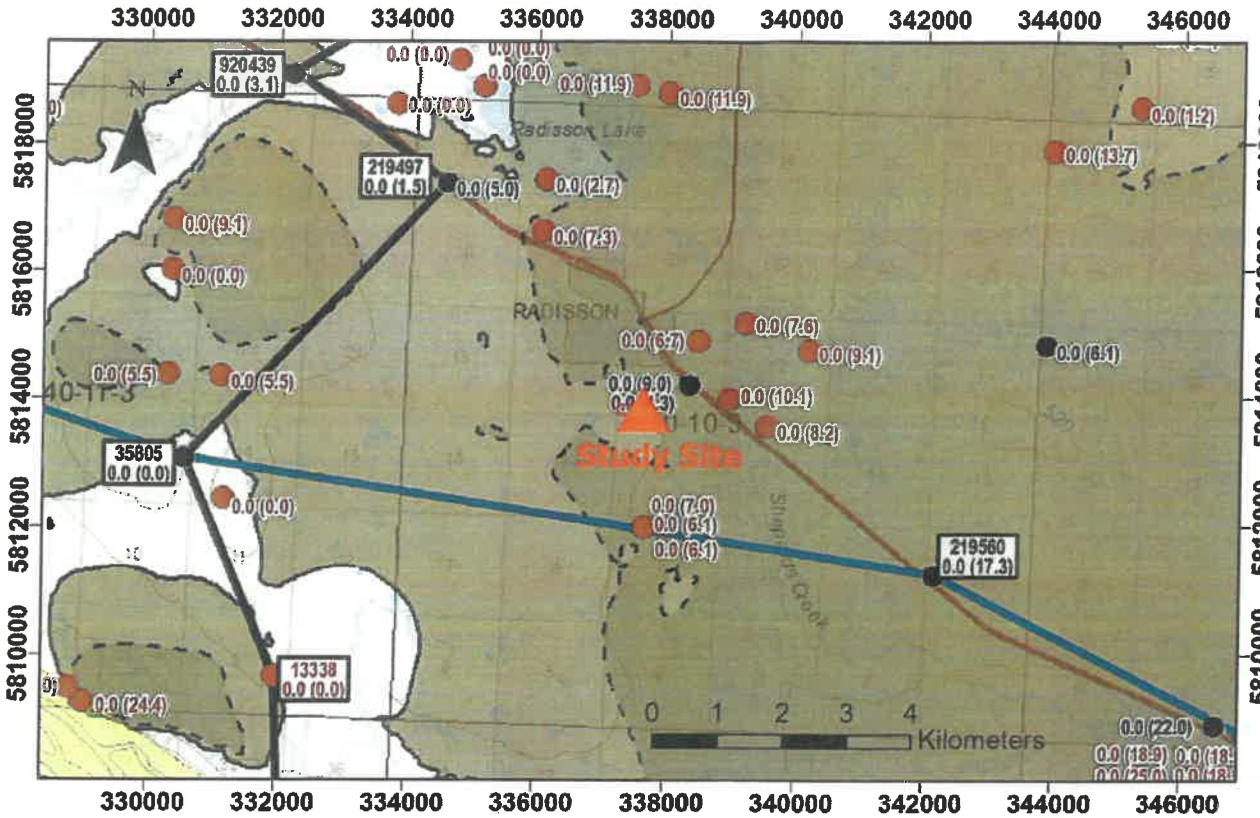

Figure 2.2 – Surficial Aquifer areal extents (in brown) around the study site. The dashed line represents the 5 m isopach for the aquifer.

Battleford Formation and Floral Formation – The Battleford Formation is composed of soft, oxidized till deposited by glacial process during the last glaciation period. The Floral Formation comprises firm, low to high plasticity, silt till layers interbedded with intertill stratified deposits of coarser sediments such as gravel, sand and silt. The upper portion of the Floral Formation is fractured and strongly oxidized and is usually differentiated from the Battleford Formation tills by its consistency and fractured nature. The bottom of the Floral Formation is interpreted to occur at approximately 35 m below the ground surface.

Stratified gravel and sand sediments at the contact of the Battleford and Floral Formation represent the Battleford Aquifer in the region (MDH, 2011). This aquifer is discontinuous over the Saskatoon Mapsheet region with some limited, localized areas tapped as a groundwater source. The groundwater flow regime of the Battleford Aquifer usually follows the local topography, and the flow direction is usually focused on local sloughs and depressions. Recharge is controlled by infiltration. An extension of the Battleford Aquifer is mapped approximately 1.5 km northwest of the proposed lagoon site (Figure 2.3). The aquifer is interpreted to occur at a depth of approximately 10 m below the surface with a thickness of approximately 2 m.

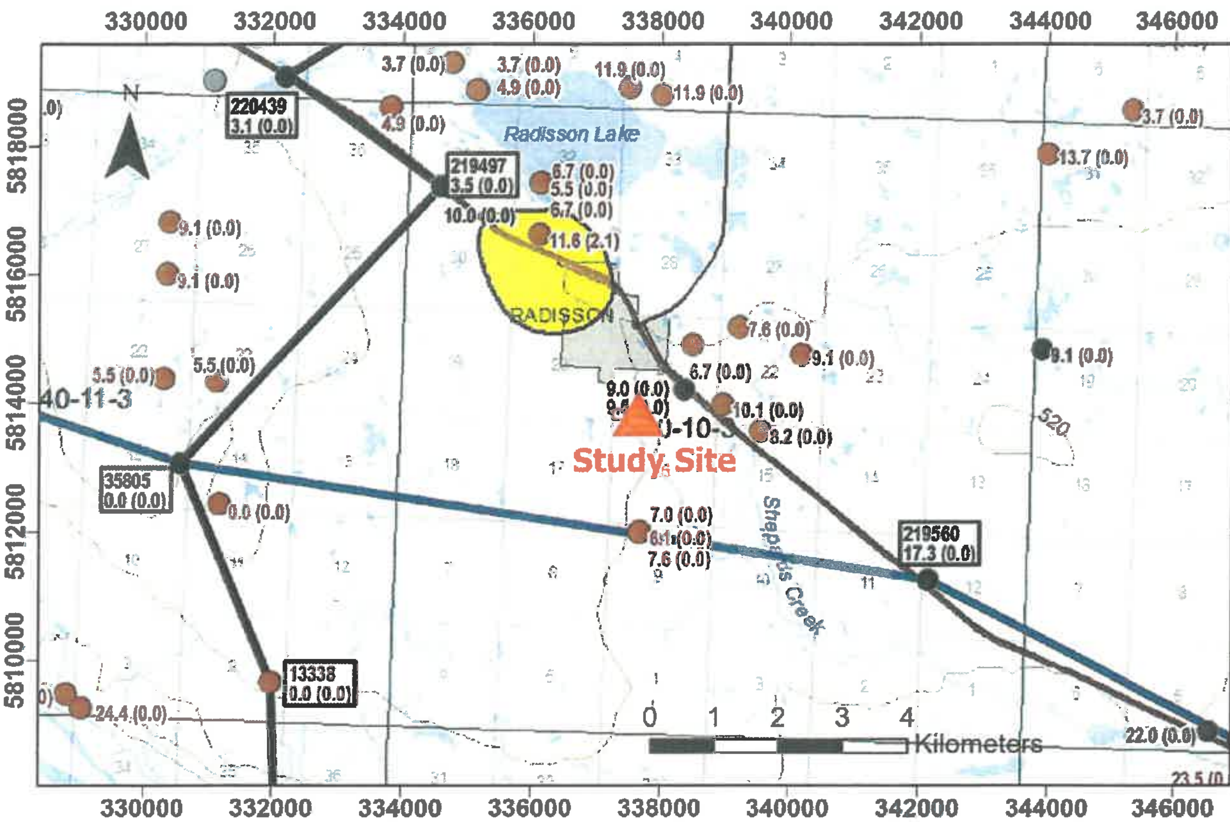

Figure 2.3 – Battleford Aquifer areal extents (in yellow) around the study site.

Interbedded stratified deposits that occur at the contact between the Sutherland and the Saskatoon Groups configure the Lower Floral Aquifer and the Upper Floral Aquifer based on their stratigraphic position relative to the interbedded till layers. At several locations in the Saskatoon Mapsheet area, these aquifers are hydraulically connected and differentiation between them is very difficult due to the lithologic similarities. At these locations, the connected aquifers form important regional aquifers formally named: the Fielding Aquifer, the Dalmeny Aquifer, the Tessier Aquifer, and the Forestry Farm Aquifer.

The regional maps show the Fielding Aquifer occurs approximately 4.5 km northwest of the study site (Figure 2.4). It is interpreted to occur at a depth of approximately 20 m in the Radisson Lake area with a thickness ranging from 5 m to more than 20 m as the aquifer extends to the northwest towards the town of Fielding.

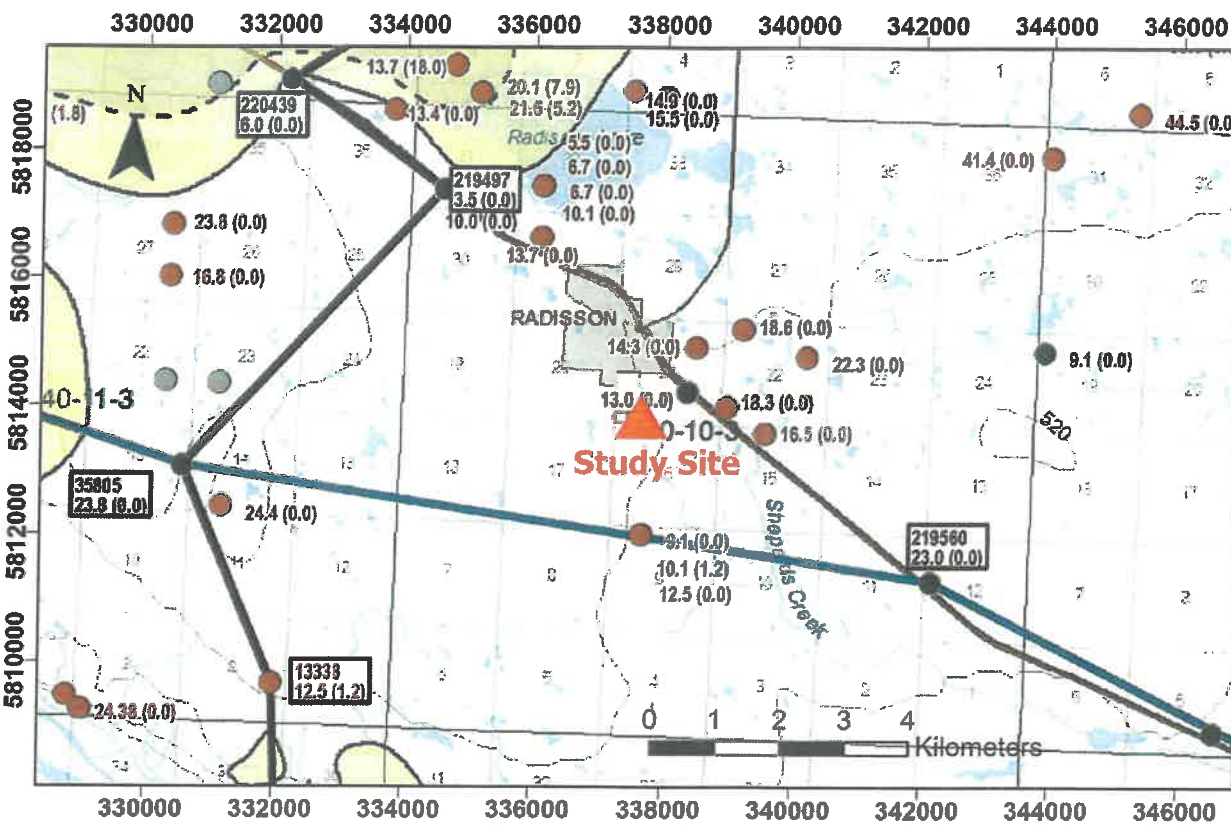

Figure 2.4 – The Fielding Aquifer areal extent (in yellow) around the study site.

Groundwater recharge of the Floral Aquifers occurs through infiltration of the meteoric water and vertical flow through the sediments of the SSD and Battleford Formation, including the aquifers found in these formations. The lateral groundwater flow of the Fielding Aquifer is towards the North Saskatchewan River, where it discharges as springs along the valley walls.

2.3 Water Well Records

A neighbouring well inventory was completed using the Water Well Driller's Record Database. Table 2.1 presents the neighbouring wells and yard sites identified in a 5 km radius of the Site.

Table 2.1 – Groundwater supply wells identified within a 5 km radius of the Site and with a completion depth of less than 30 m.

WWDR	Well Name	Legal Land Location	Distance from site (km)	Water Use	Borehole Depth (m)	Water level (mbtoc)	Aquifer Completion
35694	Hamilton	20-40-10-3	1.1	Domestic	6.1	2.1	Surficial
35698	Radisson Motors	20-40-10-3	1.1	Domestic	9.8	-	Battleford
35693	Glen	20-40-10-3	1.1	Domestic	18.3	7.6	Battleford
35699	Stott	20-40-10-3	1.1	Domestic	11.0	4.9	Battleford
35701	Racine	NE-20-40-10-3	1.2	Domestic	5.5	4.3	Surficial
57217	Kindt	NE-21-40-10-3	1.3	Domestic	16.5	-	Battleford
35691	Hunter	NW-15-40-10-3	1.5	Domestic	6.1	3.4	Surficial
35709	Anglo Amer Explor	SW-28-40-10-3	1.9	Domestic	11.0	4.6	Battleford
35710	Anglo Amer Explor	SW-28-40-10-3	2.0	Domestic	11.0	6.1	Battleford
14523	Amson	SE-28-40-10-3	2.0	Domestic	11.6	2.4	Battleford
35704	Lommer	22-40-10-3	2.0	Domestic	27.4	16.8	Floral
35692	Brigham	NE-19-40-10-3	2.3	Domestic	3.7	1.5	Surficial
65285	Myers	SW-27-40-10-3	2.4	Domestic	9.1	1.2	Battleford
65297	Myers	SW-27-40-10-3	2.5	Domestic	9.1	1.2	Battleford
35690	McKellar	NW-08-40-10-3	2.5	Domestic	7.9	5.5	Surficial
49698	Harach	SW-09-40-10-3	2.9	Domestic	13.7	-	Battleford
65296	Amson	NW-27-40-10-3	3.1	Domestic	27.1	16.8	Floral
63024	Genereux	NE-30-40-10-3	3.4	Domestic	11.0	1.8	Battleford
14524	Amson	SW-33-40-10-3	3.5	Domestic	28.7	21.6	Floral
35688	Maxwell	SE-07-40-10-3	3.5	Domestic	9.1	-	Battleford
94315	Pidwerbesky	NE-05-40-10-3	3.6	Domestic	9.4	-	Battleford
35686	RM of Great Bend	NE-05-40-10-3	3.7	Municipal	3.7	1.8	Surficial
118661	Garrett	SE-14-40-10-3	4.0	Domestic	15.8	4.6	Battleford

A total of 23 groundwater supply wells with a depth of less than 30 m were identified within a 5 km radius of the Site. Of these, six (6) wells were completed in the Surficial Aquifer, 14 in the Battleford Aquifer, and three (3) in the Floral Aquifer. The groundwater level in the wells completed within the Surficial Aquifers varies between 1.5 m and 5.0 m below the surface.

2.4 Local Geology & Hydrogeology

P. Machibroda Engineering Ltd. (PMEL) completed a geotechnical study for the proposed expansion area in 2009 and a total of six (6) test holes were drilled. Later, on 29 April 2024, PINTER performed a drilling investigation on the existing lagoon berms to characterize the construction material and the lagoon substrate. On 19 July 2024, PINTER performed a field investigation to confirm the soil condition listed in PMEL report. In total, PINTER drilled three (3) boreholes around the existing lagoon berm and one (1) additional borehole in the lagoon expansion area.

In general, the shallow stratigraphy of the Site consists of a thin layer of topsoil, ranging from 50 mm to 300 mm in thickness, overlying a silty clay deposit extending to depths of 5.5 m to 6.3 m below the ground surface. A clay till unit underlies the silty clay deposit. In almost all boreholes, the clay till unit extended to the full depth of the test hole, except for one borehole, drilled by PMEL (TH 09-1), where a sand layer was found at a depth of 8.9 m.

Four (4) piezometers were installed in the lagoon expansion area: three (3) by PMEL and one (1) by PINTER. Groundwater levels ranged from the surface level at the southwest corner of the expansion area to 1.2 m below the surface at the northeast portion of the Site. These shallow water levels are expected to occur in lowland areas such as where the Site is located, as discussed in Section 2.1.

Given that the lagoon has been in operation for more than 50 years, the groundwater regime underneath the cells may have been changed by the lagoon. Even with a liner, wastewater lagoons will always allow some infiltration to seep into the groundwater. At locations with shallow groundwater, the infiltration may create a groundwater "mound" around the lagoon, locally increasing the groundwater level. The longer a lagoon has been in operation, the more pronounced may be the rise of the local groundwater level.

2.5 Groundwater Sampling and Lagoon Leakage Analysis

The local contractor excavated nine (9) test pits to investigate the composition of the soil and water table in the proposed expansion area. PINTER personnel completed a GPS survey of the test pit locations and collected seven (7) water samples, from selected test pits and from the lagoon secondary cell, to compare water quality composition and investigate if any potential leakage is occurring and contaminating the local groundwater. Figure 2.5 shows the location of the test pits and sampled locations.

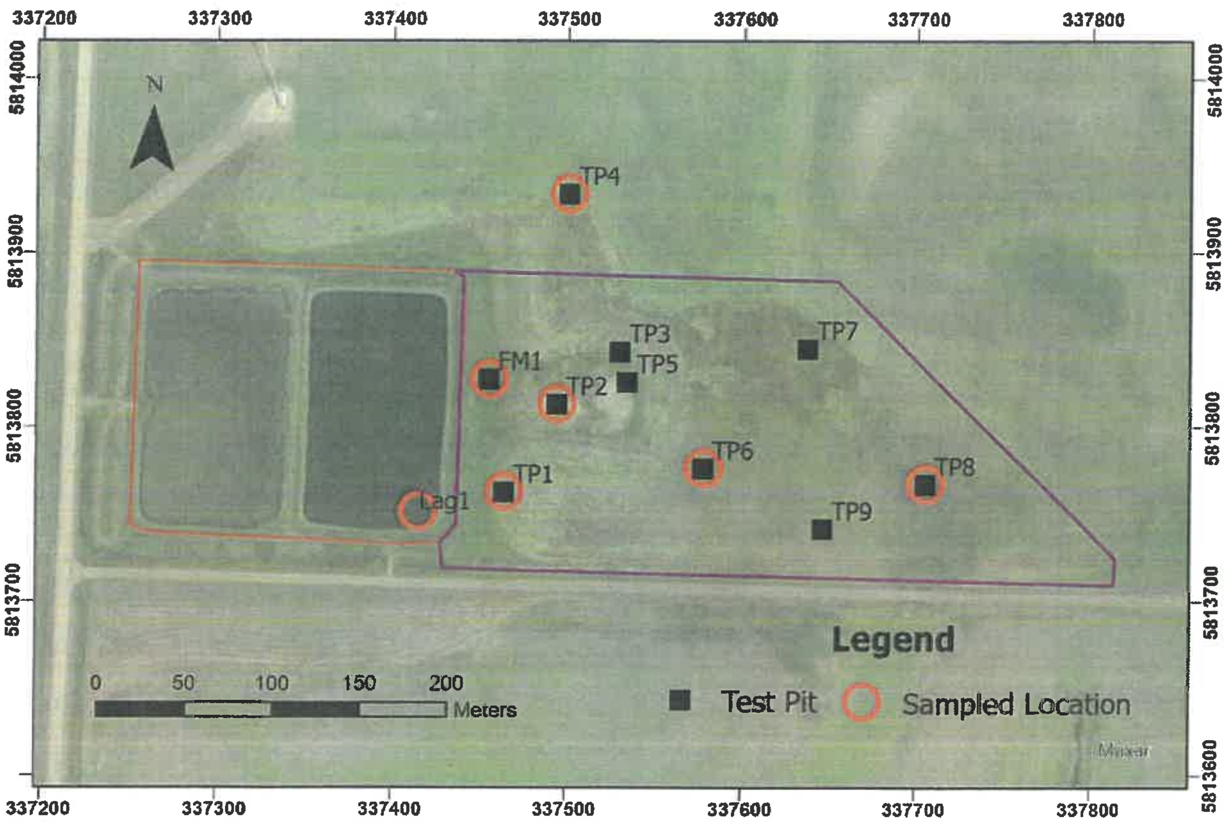

Figure 2.5 – Test pits and water sampling locations.

The samples were collected on 23 August 2024 and submitted to ALS Environmental Laboratory in Saskatoon. All samples were analyzed for Routine analysis. The laboratory certificate of analysis is available in Appendix A. The sample from the secondary lagoon cell (Lag1) was collected at a shallow level while the sampled test pits had the accumulated water collected once they were filled in. A summary of the results is presented in Table 2.2.

Table 2.2 – Summary of the water chemistry results of the samples collected on 23 August 2024.

Sample Location	LAG1	FM1	TP2	TP1	TP4	TP6	TP8
Physical Tests							
Conductivity	3030	4930	8000	5660	8930	9180	5240
Alkalinity, bicarbonate (as HCO3)	552	988	922	1050	856	652	346
Alkalinity, carbonate (as CO3)	9.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Alkalinity, hydroxide (as OH)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Alkalinity, total (as CaCO3)	468	810	755	860	701	534	283
Hardness (as CaCO3), dissolved	998	1890	3070	2450	4640	4190	2640
Solids, total dissolved [TDS], calculated	1980	3370	6390	4190	7940	8540	3960
pH	8.42	7.76	7.99	7.84	7.91	8.09	7.77
Anions and Nutrients							
Chloride	449	911	886	936	1130	535	941
Nitrate (as N)	<0.400	<0.400	<1.00	<1.00	<1.00	<1.00	0.876
Nitrate + Nitrite (as N)	<0.447	<0.447	<1.12	<1.12	<1.12	<1.12	0.876
Nitrite (as N)	<0.200	<0.200	<0.500	<0.500	<0.500	<0.500	<0.200
Sulfate (as SO4)	600	904	3150	1490	4190	5320	1680
Metals							
Calcium, dissolved	154	317	454	314	508	410	561
Iron, dissolved	0.102	<0.050	<0.100	<0.050	<0.100	<0.100	<0.050
Magnesium, dissolved	149	267	470	404	820	768	300
Manganese, dissolved	0.678	1.45	0.348	0.00126	0.0325	0.00875	0.00964
Potassium, dissolved	21.3	7.50	42.3	9.14	12.1	14.3	41.7
Sodium, dissolved	288	460	916	503	822	1140	238

Figure 2.6 shows a Stiff diagram comparing the major ion components tested in the water samples collected at the site. In general, Figure 2.6 and Table 2.2 indicate that there is no correlation between the water in the storage cell and the water collected from the test pits. However, these results represent a snapshot of the water quality when the samples were connected and should not be taken as an indication that the lagoon is leaking.

The water from the storage cell is likely affected by dilution caused by precipitation over the cell and from the deposition of solids at the bottom of the lagoon. Groundwater usually has high amounts of total dissolved solids due to its nature; as the water moves through the soil, it dissolves the minerals and organic compounds of the soil and adds them to the water composition in the form of ions and organic molecules. Therefore, the parameters analyzed in this investigation do not provide sufficient information to indicate if the lagoon is leaking or contaminating the local groundwater. The results are inconclusive on that matter.

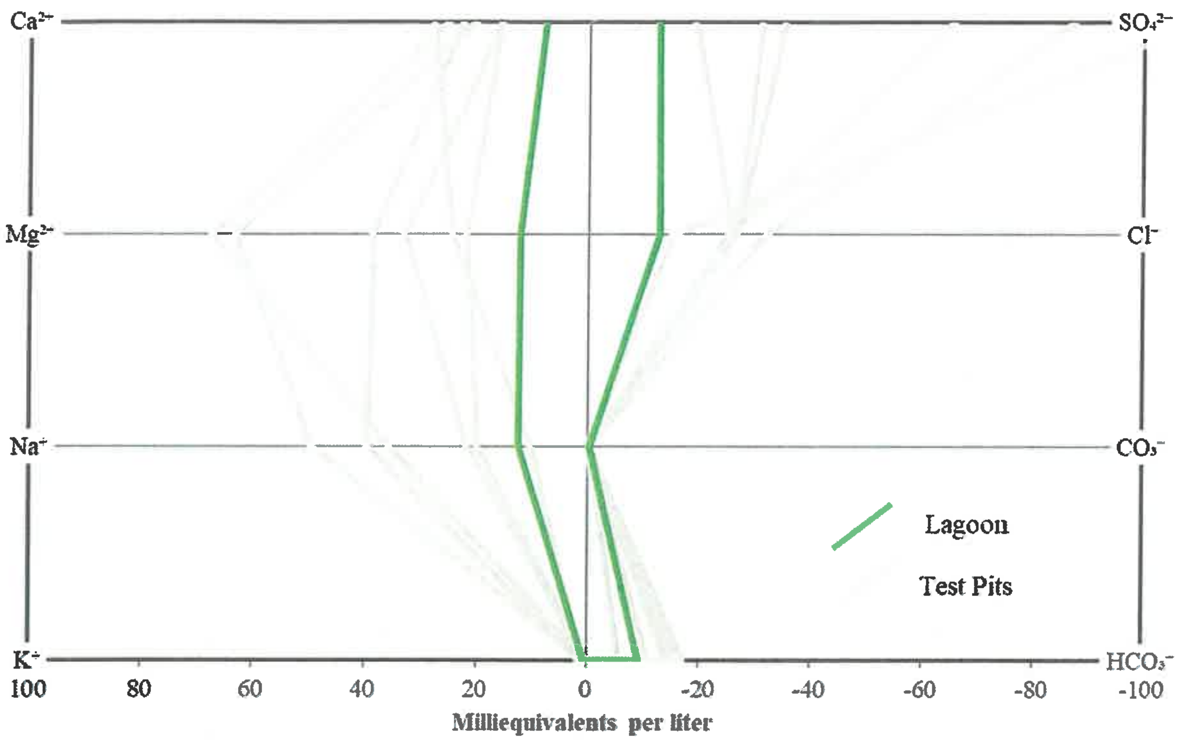

Figure 2.6 – Stiff diagram comparing the composition of the water collected in the lagoon and test pits.

The most common parameters associated with wastewater quality are Biochemical Oxygen Demand (BOD5), Total Suspended Solids (TSS), Total Phosphorous (Total P), Total Nitrogen (Total N), and microorganisms such as bacteria, viruses, and parasites which are usually identified by testing the groundwater for Total and Fecal coliforms content. At least some of these parameters, if not all, should be tested from samples collected from both lagoon cells and the groundwater.

The groundwater samples should be collected at additional locations surrounding the lagoon cells in every direction, so a groundwater gradient can be established and potential changes to the chemical composition of the groundwater after passing through the lagoon can be identified, if any. Also, shallow monitoring wells should be installed to conduct groundwater sampling and measure water levels.

3. SUMMARY AND RECOMMENDATIONS

A summary of the findings of this desktop study is presented as follows:

- The Site is located at a regional topographic low. Historical satellite images suggest that the eastern portion of the Site is a wetland and part of an intermittent creek channel that conveys water from other wetlands to the north of the Site towards Shepard Creek, which is approximately 3 km southeast of the Site.
- The region's geology is mainly comprised of topsoil and interbedded deposits of clay, silt, and sand overlying glacial till. Glacial silt, sand, and gravel stratified deposits within the till layers may form local and regional aquifers which are used as groundwater supply sources in the area.
    - A total of 23 groundwater supply wells with a depth of less than 30 m were identified within a 5 km radius of the Site. Eight (8) of these are within a 2 km radius. The aquifers in the completion zone of these wells may be affected by contamination caused by the wastewater stored in the lagoon cells.
- The water table in the study area was measured at different dates, and it is interpreted to occur at a range varying from surface level to 1.2 m below the surface.
    - The water table is not a static water level and will fluctuate according to the seasons and the weather; high water table levels are expected during spring melt and following long periods of precipitation, and lower levels are expected during winter or drought periods.
    - The local water table is potentially affected by the lagoon operation. A groundwater "mound" may have been developed around the lagoon caused by seepage over more than 50 years of operation.
- The water samples collected to investigate if there is contamination of groundwater were inconclusive.

The shallow groundwater table and low topographic elevations of the proposed expansion area are the main challenges for the construction of the expansion cell. Ideally, a location with a deeper water table, i.e., deep enough that the bottom of the lagoon cells is above the water table level, would be recommended since the lagoon design would be simpler and potentially less expensive. However, the construction of the expansion cell at the proposed location would be possible if considering the following:

- The lagoon design requires dewatering of the local soil to lower the water table at the lagoon location during construction and operation of the lagoon.
  - Temporary dewatering is recommended during construction to keep the site dry allowing the operation of equipment and providing dry soil conditions to build the lagoon and liner (if using a clay liner).
  - A permanent dewatering system would be recommended to keep the water table levels at a safer distance from the bottom of the lagoon to avoid flotation of the membrane liner or introducing additional water to the lagoon, affecting the required storage volume and treatment efficiency.
- The lagoon expansion cell should be built with a liner to reduce seepage into the shallow groundwater table and potential contamination of the shallow aquifers in the area.
  - The liner can be built with clay or synthetic materials as long as it can meet the maximum exfiltration (seepage) rate of 150 mm per year per WSA guidelines.
- A piezometer monitoring network should be established around the existing and proposed lagoon cells to monitor the seasonal fluctuations of the groundwater, as well as to establish baseline information for the groundwater quality around the area. Also, the groundwater monitoring would provide information on existing contamination, if any.
  - A minimum of four (4) piezometers should be installed around the treatment lagoon. One (1) piezometer should be located upstream of the groundwater gradient to establish the baseline groundwater conditions. A minimum of three (3) piezometers should be

installed downstream of the lagoon to monitor for potential contamination and groundwater level changes.

  - At least three (3) additional piezometers may be necessary to fully comprehend the local groundwater table and geochemistry.

- Groundwater samples should be collected at each lagoon cell and piezometers. The samples should be tested for Biochemical Oxygen Demand (BOD5), Total Suspended Solids (TSS), Total Phosphorous (Total P), Total Nitrogen (Total N), and Total and Fecal Coliforms to monitor potential contamination.

- The expansion lagoon design should include recommendations for a runoff drainage diversion to convey the runoff from the north side of the area around the lagoon cell towards the lowland area to the east, and eventually to the culvert under the southern grid road.

  - A hydrologic study to evaluate the Site's drainage and flood potential may be required if flooding is expected to occur in the area adjacent to the proposed expansion area. Building the new cell will change the existing topography which may affect the current drainage system around the Site.

  - Erosion protection considerations should be included in the lagoon design to prevent damage in the event of flooding.

4. STATEMENT OF LIMITATIONS

This memorandum has been prepared for the exclusive use of **The Town of Radisson**. Any use of this report by a third party or any reliance on or decisions to be made based on it is the responsibility of such third parties. PINTER & Associates Ltd. accepts no responsibility for damages, if any, suffered by any third parties as a result of decisions made or actions taken based on this memorandum.

Sincerely,

PINTER & Associates Ltd.

Per:

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Date: 25 September 2024