DILLON CONSULTING

RURAL MUNICIPALITY OF MACDONALD

Starbuck Lagoon Sludge Survey and Capacity Assessment

Final Report

November 2025 – 24-9319

November 7, 2025

Rural Municipality of Macdonald
161 Mandan Drive
Sanford, Manitoba
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Attention: Daryl Hrehirchuk, CMMA
Chief Administrative Officer

Starbuck Lagoon Sludge Survey and Capacity Assessment – Final Report

Dillon Consulting Limited (Dillon) is pleased to present the Starbuck Lagoon Sludge Survey and Capacity Assessment Draft Report for the Rural Municipality (RM) of Macdonald for your review and comment.

Should you have any questions or comments regarding this report, please contact the undersigned at (204) 453-2301, or via email at cpogue@dillon.ca.

Sincerely,

DILLON CONSULTING LIMITED

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1.0 Introduction

The Rural Municipality of Macdonald (RM) retained Dillon Consulting Limited (Dillon) to complete a lagoon sludge survey and updated capacity assessment of the Starbuck Wastewater Treatment Lagoon, located in the community of Starbuck, Manitoba. The purpose of the assignment was to determine if there is sufficient process treatment capacity in the lagoon to accept additional wastewater from 17 new residential homes as part of a proposed residential development on the west side of Starbuck. This information will be used to evaluate the feasibility of the housing development and next steps for the community.

Starbuck is located along the La Salle River in the RM of Macdonald, approximately 40 km west of Winnipeg. All homes in Starbuck are serviced by a Septic Tank Effluent Pumping (STEP) type, low pressure sewer (LPS) system, which includes 166 holding tanks for solids storage. The LPS system conveys wastewater to a lift station located immediately north of St. Paul's Roman Catholic Cemetery. From this lift station, wastewater is pumped via a 2 km forcemain to the lagoon. The holding tanks within the community are pumped out by a septic truck once a year and discharged to the lagoon. The lagoon consists of two treatment cells, including a primary and a secondary cell.

Following the submission of the draft report, Dillon attended an RM Council meeting on September 23, 2025, to address questions and comments from council members. Key issues raised during the meeting included:

- Rationale for differences between the 2021 Starbuck Passive Filter Feasibility Study and the updated 2025 Capacity Assessment, specifically regarding the remaining hydraulic capacity.
- Justification for selecting two different wastewater generation rates: 270 L/c/d in the 2025 report (the rate selected in the 2025 study, based on the City of Winnipeg residential wastewater generation guidelines) and 174 L/c/d (the rate selected in the 2021 study, based on annual community water usage).

Dillon has since updated the draft report to provide additional background information and address the comments received from the RM Council.

1.1 Capacity Assessment Updates

Dillon completed a capacity assessment of the Starbuck Lagoon in 2021 as part of a larger study looking at the feasibility of adding a passive filtration system to the lagoon titled *Starbuck Passive Filter Feasibility Study*. The conclusion from the capacity assessment was that the facility was nearing its hydraulic capacity. The key recommendations from this study were as follows:

- **Sludge Build-up:** Investigate the sludge accumulation in both the primary and secondary cells of the lagoon. It is understood that the sludge has not been removed from the lagoon since construction in 1979. There is potential for sludge build up to impede the hydraulic storage capacity of the lagoon if thick enough (0.3 to 0.5 m depth). A sludge survey was recommended to be completed by a qualified contractor to determine current sludge depths.
- **Operations:** Improve winter storage capacity by discharging the full capacity of the secondary cell and half the primary cell prior to the end of the summer discharge period on November 1 to provide the largest possible buffer for the winter storage period.
- **Population Growth Rate:** Investigate the population projection in further detail. The future population growth rate has a significant impact on the future hydraulic capacity of the lagoon. Dillon looked at Statistics Canada population growth rates from 2011 to 2016 for both Starbuck and the RM.
    - Considering a population growth rate in line with the Starbuck growth rate of 0.85%, there is an estimated additional 10 to 15 years of lagoon capacity; and
    - Considering a population growth rate in line with the RM growth rate of 2.80%, the lagoon will only have hydraulic capacity for another one to two years.
- **Wastewater Generation:** Wastewater flow data was not available at the time of the 2021 study. A wastewater generation rate of 174 L/c/d was estimated in the 2021 study, based on metered water consumption in 2020. It was recommended to record flows to the lagoon from the upstream lift station from November 1 to June 15 to validate assumptions and hydraulic capacity calculations.
- **Estimated Capacity**: The hydraulic capacity and organic capacity were estimated at 15,958 m^3 and 4,752 m^2 based on record drawing information.

As part of the 2025 study, Dillon revisited the recommendations from the 2021 study to update the capacity assessment. The following updates have occurred since the 2021 study:

- **Sludge Build-up**: Based on the recommendations in the 2021 study, the RM retained a third party (Hydrasurvey) to complete a sludge survey of the lagoon in May 2025 to measure the sludge build-up in the both the primary and secondary cells.
- **Operations**: The RM is working to improve winter storage by discharging the full volume of the secondary cell and half the volume of the primary cell prior to the end of the summer discharge period on November 1st.
- **Wastewater Generation**: RM operations staff have been unable to retrieve flow data from the upstream lift station flow meter between 2021 and the time of this study. Wastewater generation was instead estimated using annual water consumption data and typical Infill and Infiltration (I&I). Recognizing that the annual water consumption data likely underrepresents the community's actual wastewater generation—based on data from similarly sized communities—Dillon established a range of wastewater generation rates. This range runs from a low end of 155 L/c/d (derived from 2021–2024 water consumption data) to a high end of 270 L/c/d (based on the City of Winnipeg residential wastewater generation guidelines).

- **Population Growth Rate**: Updated Statistics Canada data for the Town of Starbuck was available between 2016 and 2021, indicating a population growth rate of 1.22%, up from 0.85%.
- **Estimated Capacity**: A LiDAR drone survey, conducted as part of the sludge survey revealed that the lagoon's actual construction dimensions (specifically berm elevations) does not match the record drawings. The record drawings indicate a depth of close to 2.4 m in the primary and secondary cells. The sludge survey measured depths of approximately 2.28 m (primary cell) and 1.98 m (secondary cell). This discrepancy results in a 40% reduction in available hydraulic capacity compared to the 2021 study, totaling 10,570 m^3 (previous estimate of 15,938 m^3). The estimated organic capacity remains relatively similar to the 2021 findings at 4,887 m^2 (previous estimate of 4,752 m^2).

The RM retained Hydrasurvey to complete a sludge survey at the lagoon. Hydrasurvey utilizes autonomous survey vessels (ASC) equipped with sonar and Global Navigation Satellite System (GNSS) technology to accurately measure water elevations and sludge depths within the lagoon cells. Additionally, Hydrasurvey collected sludge samples to determine the composition of the sludge. This information will be required should the next steps include sludge removal and land application.

1.2 Background Documents

The following background documents were reviewed and referenced as part of the lagoon capacity assessment:

- Starbuck Lagoon Design Drawings, August 1978, Manitoba Water Services Board;
- Wastewater Engineering – Treatment and Recovery 5th Edition, 2014, Metcalf and Eddy (*Metcalf and Eddy 5th Edition*);
- Information Bulletin – Design Objectives for Wastewater Treatment Lagoons, March 2022, Manitoba Environment and Climate Change;
- Starbuck Passive Filter Feasibility Study Letter Report – Final Report, 2021, Dillon Consulting; and,
- Wastewater Flow Estimation and Servicing Guidelines, December 2024, City of Winnipeg.

1.3 Scope of Work and Objectives

The scope of work and objectives of the lagoon capacity assessment were as follows:

- **Sludge Survey:** Complete a sludge survey and lab analysis to determine the extent of sludge build-up in the primary and secondary cells of the lagoon;
- **Capacity Assessment:** Establish current (2025) and projected future hydraulic and organic loading to the lagoon, considering the contribution from 17 additional homes. Assess the remaining hydraulic and organic capacity of the lagoon considering the sludge volume quantified during the sludge survey, and the impact on hydraulic capacity if the sludge is removed;
- **Class D Cost Estimate**: Complete a Class D cost estimate for removal of sludge by dredging, truck hauling, land application and environmental licensing; and,
- **Conclusions and Recommendations:** Provide conclusions on the sludge survey and capacity assessment and make recommendations on next steps.

2.0 Sludge Survey

Hydrasurvey completed a hydrographic sludge survey of the Starbuck lagoon site on May 25th, 2025. The sludge survey was completed using an autonomous survey vessel (ASV) equipped with sonar and Global Navigation Satellite System (GNSS) technology to generate a sludge blanket thickness map that shows the sludge distribution within each cell surveyed, as well as water depth and liner depth. For the capacity assessment, Dillon primarily used the measurements of water depth, sludge depth, and clay liner depth. This data was used for determining both the available and remaining hydraulic and organic capacities, accounting for the accumulated sludge within the lagoon cells. Additionally, Hydrasurvey collected one sludge sample from each of the primary and secondary cells. These samples were analyzed by an accredited lab to determine the percent total solids, and the nutrient and metals composition of the sludge. Understanding these characteristics provides valuable information for quantifying the sludge volume, as well as assessing its quality. **Table 2-1** presents the dimensions and operating levels of the lagoon as measured during the sludge survey. The complete sludge survey report is appended in **Appendix A**.

Table 2-1: Measured Lagoons Dimensions and Operating Levels from Sludge Survey

Parameters	Sludge Survey Measurements	
	Primary Cell	*Secondary Cell*
Top of Cell Dimensions	76 x 56 m	131 x 76 m
Interior Side Slopes	4:1	4:1
Berm Height	2.28 m	1.98 m
Freeboard	0.24 m	0.38 m
Operating Depth	2.04 m	1.6 m
Total Volume (at operating depth)	10,164 m^3	17,844 m^3
Surface Area (at mid-liquid depth)	4,887 m^2	N/A
Total Sludge Volume	2,318 m^3	2,164 m^3

Table 2-2 presents the results of the sludge survey including the average sludge depth, total estimated sludge volume, and the potential hydraulic capacity increase of the lagoon. The hydraulic capacity of the primary cell is limited to one half of its actual operating volume, while the hydraulic capacity of the secondary cell is based on the volume of liquid above the bottom 0.3 m of the cell (i.e. the invert of the interconnection and discharge piping, assumed to be 0.3 m from the cell floor as lagoon profile drawings were not available). Although a plan-view drawing of the lagoon was available, detailed drawings of the lagoon profile and interconnection pipe were not. As shown visually on **Figure 2-1**, sludge accumulated above the 0.3 m elevation in the secondary cell is considered accessible and represents the volume that could be removed to increase hydraulic capacity.

Table 2-2: Starbuck Sludge Volumes

Cell	Average Sludge Depth (m)	Total Estimated Sludge Volume (m^3)	Sludge Volume Above 0.3 m (m^3)	Potential Hydraulic Capacity Increase with Sludge Removal (m^3)
Primary Cell	0.36	2,318	N/A	2,318
Secondary Cell	0.16	2,164	19	19

[1]Hydraulic storage capacity of the secondary cell is limited to the actual operating capacity above 0.3 m depth at a freeboard of 1.0 m, based on *Design Objectives for Wastewater Treatment Lagoons*.

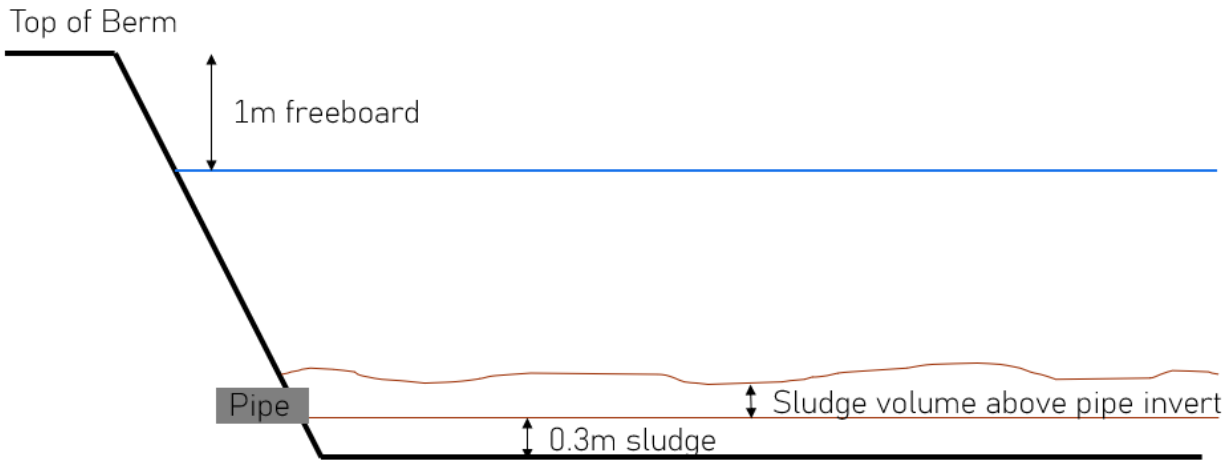


Figure 2-1: Sludge Volume in Secondary Cell Above 0.3 m depth

Table 2-3 presents the key parameters from the laboratory results of the sludge samples as summarized from the complete sludge survey report. The results for aluminum and iron are highlighted and discussed in the following paragraph.

Table 2-3: Starbuck Sludge Survey Laboratory Results Summary

Parameter	Primary Cell	Secondary Cell	Unit
Total Phosphorus (TP)	2,392	2,071	mg/kg
Total Kjeldahl Nitrogen (TKN)	10,700	4,470	mg/kg
Nitrate (as N)	<5.0	<5.0	mg/kg
Total Ammonia (as N)	411	155	mg/kg
Total Organic Nitrogen (calculated)	10,300	4,320	mg/kg
Total Solids	25.2	33.7	%
Aluminum	**15,780**	**19,780**	mg/kg
Iron	**21,709**	**24,403**	mg/kg

The following findings were identified from the sludge survey:

- There were visible signs of erosion observed along the shorelines of both cells. It's suspected that erosion may be caused by wave action over time, due to the lagoon operating with less than the recommended 1.0 m freeboard. The lagoon was built in the 1970's and has not been upgraded since.
- The primary cell has 23% of its total cell volume occupied by sludge. The sludge depth ranges from 0.2-0.6 m throughout the cell, with the largest sludge build-up located near the truck septage disposal location. The sludge elevation at the interconnection piping between the primary and secondary cells appears to be nearing the invert of the interconnection pipe which poses a risk to short circuiting and clogging.
- The secondary cell has 12% of its volume occupied by sludge. The sludge depth ranges from 0.1-0.4 m of sludge, with a higher proportion of sludge found near the west end of the cell close to the interconnection piping and at the south end of the cell close to the discharge location.
- The survey identified that the lagoon is currently operating with a freeboard significantly below the minimum provincial requirement of 1.0 m. The *Design Objectives for Wastewater Treatment Lagoons* requires that lagoons are to be designed with a minimum of 1.0 metre of freeboard allowance from the High-Water Level (HWL) to the top of the berm in both primary and secondary cells. However, survey results indicate the water level in the primary cell is currently 0.24 m below the top of berm and the secondary cell's water level is approximately 0.38 m below the top of the berm.
- Each cell is currently operating over the 1.5 m maximum operating depth for facultative lagoons as noted in the *Design Objectives for Wastewater Treatment Lagoons*. At the time of the survey, the primary cell was operating at 2.04 m depth, and the secondary cell was operating at 1.60 m depth.
- A notable discrepancy was identified between the measured and design depths of the lagoon cells. The primary cell was measured at 2.28 m depth and the secondary cell at 1.98 m depth from the top of berm to the liner. This contrasts with the 2.4 m depth indicated in the record drawings and assumed in the previous 2021 capacity assessment. Consequently, the available hydraulic capacity is less than previously estimated.
- The primary and secondary cells contain 2,318 m^3 and 2,164 m^3 of accumulated sludge, respectively. Only 19 m^3 of sludge accumulation in the secondary cell is above the 0.3 m depth, indicating a potential hydraulic capacity increase of 2,337 m^3.

High concentrations of aluminum and iron were observed in the sludge mixture. This would typically be attributed to the past use of alum or ferric-based coagulants to aid flocculation and phosphorus removal. The RM has indicated that they have not historically used alum or ferric-based coagulants at the lagoon, as their license currently has no limits for phosphorus removal. It is unclear where the build-up of aluminum and iron could be from.

3.0 Capacity Assessment

3.1 Population Projections

As per the Statistics Canada 2021 Census, Starbuck had a population of 363. Between 2016 and 2021, the community experienced an annual growth rate of 1.22%. This growth rate was used to project the 2025 population. Future development projections account for an additional 17 new homes in 2026, with an anticipated occupancy of 3.05 people per home, consistent with the *City of Winnipeg's Wastewater Flow Estimation and Servicing Guidelines*. Using this assumed occupancy, the housing development would account for 52 additional residents. Information on the design horizon and projected annual build-out for the 17 additional homes was not available during the assessment. The Starbuck population projections are presented in **Table 3-1**

Table 3-1: Starbuck Population Projections

Year	Total Population
	Starbuck Growth Rate (1.22%)
2021	*363*
2022	367
2023	372
2024	376
2025	381
2026 (Future Population with 17 Additional Home)	**433**

3.2 Lagoon Capacity

The existing hydraulic and organic loading capacities of the lagoon were calculated using data obtained from the sludge survey, as detailed in **Section 2.0**. These calculations adhere to design assumptions from the *Design Objectives for Wastewater Treatment Lagoons* and *Metcalf and Eddy 5th Edition,* including a 1.0 m freeboard and maximum operating depth of 1.5 m. The hydraulic capacity calculated using the sludge survey data was compared to the desktop capacity assessment completed as part of the 2021 *Starbuck Passive Filter Feasibility Study* which is based on lagoon dimensions from record drawings. Lagoon dimensions and volumes are presented in **Table 3-2** below.

Table 3-2: Lagoon Capacity Summary

Parameters	1978 Record Drawings		2025 Sludge Survey	
	Primary Cell	*Secondary Cell*	*Primary Cell*	*Secondary Cell*
Top of Cell Dimensions	74 x 53 m	134 x 53 m	76 x 56 m	131 x 76 m
Interior Side Slopes	4:1	4:1	4:1	4:1
Berm Height	2.4 m	2.4 m	2.28 m	1.98 m
Freeboard	1.0 m	1.0 m	1.0 m	1.0 m
Operating Depth	1.4 m	1.4 m	1.28 m	0.98 m
Total Volume (at operating depth)	6,858 m^3	16,206 m^3	6,266 m^3	10,466 m^3
Dead space volume (assumed 0.3 m above cell floor)	N/A	3,077 m^3	N/A	3,031 m^3
Storage Volume (at operating depth)	2,809 m^3	13,129 m^3	3,133 m^3	7,436 m^3
Surface Area (at mid-liquid depth)	4,752 m^2	N/A	4,887 m^2	N/A
Total Sludge Volume	N/A	N/A	2,318 m^3	2,164 m^3
Potential Hydraulic Capacity Increase by Removing Sludge	N/A	N/A	2,318 m^3	19 m^3
Remaining Hydraulic Capacity (with Current Sludge Volume)	N/A[1]		8,233 m^3	
Available Hydraulic Capacity (with Sludge Removed)	15,938 m^3		10,570 m^3	

[1]Sludge volumes were unknown during 2021 desktop lagoon capacity study.

A LiDAR drone survey, conducted as part of the sludge survey revealed that the lagoon's actual constructed dimensions (specifically berm elevation) do not match the record drawings. The record drawings indicate a depth of close to 2.4 m in the primary and secondary cells. The sludge survey measured depths of approximately 2.28 m (primary cell) and 1.98 m (secondary cell). This discrepancy results in a 40% reduction in available hydraulic capacity compared to the 2021 study, totaling 10,570 m^3 (previous estimate of 15,938 m^3). The estimated organic capacity remains relatively similar to the 2021 findings at 4,887 m^2 (previous estimate of 4,752 m^2).

The lagoon capacity is as follows:

- Hydraulic Capacity: 10,570 m^3 at 1.0 m freeboard (combined primary and secondary cell).
- Organic Mass Loading Capacity – 4,887 m^2 (surface area measured at mid liquid depth of the primary cell).

Further details of the hydraulic and organic loadings are described in the sections below.

3.2.1 Hydraulic Loading

The following assumptions were applied for estimating the hydraulic loading of the lagoon:

- Calculations are based on the winter holding period outside the seasonal discharge period of 227 days (November 1 to June 15), as referenced in the Environmental Licence No. 2506;
- The remaining hydraulic capacity considers the current sludge thickness, as surveyed by Hydrasurvey, assuming a minimum freeboard height of 1.0 m in accordance with the Design Objectives for Wastewater Treatment Lagoons;
- Storage capacity is based on half the operating volume of the primary cell and the full operating volume of the secondary cell measured 0.3 m above cell floor. This conservatively estimates the invert elevations of the interconnection and discharge piping at 0.3 m from the cell floor, as actual pipe invert elevations were not measured during the sludge survey;
- A flow meter was installed at the upstream lift station in 2020. However, the RM operations staff were unable to retrieve flow data from this meter during the background data collection stage of the project. Recognizing that the annual water consumption data likely underrepresents the community's actual wastewater generation—based on data from similarly sized communities—Dillon analyzed three distinct wastewater generation rates to bracket the potential community flow, given the lack of available flow data:
    - **Low Estimate** (155 L/c/d), estimated from the Starbuck average per capita water consumption between 2021 and 2024.
    - **High Estimate** (270 L/c/d), based on the City of Winnipeg residential wastewater generation guidelines.
    - **Mid-Range Estimate** (213 L/c/d): Calculated as the midpoint between the low (water consumption) and high (Winnipeg guideline) rates.
- In addition to municipal wastewater from the Town of Starbuck, the lagoon also accepts wastewater from Bridges Golf Course. Based on water consumption data provided by the RM from 2021-2024, Bridges Golf Course contributes an average of 5,308 L/day.

Table 3-3 summarizes the existing and future hydraulic loading, considering the contribution from 17 additional homes and the range of wastewater generation rates stated above.

Table 3-3: Starbuck Hydraulic Loading Projections (November 1 -June 15)

Scenario	Total Population	Hydraulic Loading (m^3)		
		Low Estimate (155 L/c/d)	*Mid-Range Estimate (213 L/c/d)*	*High Estimate (270 L/c/d)*
Existing (2025)	381	14,612	19,629	24,559
Future (2026) [17 Additional Homes]	433	16,436	22,136	27,737
Remaining Hydraulic Capacity (Current Sludge Volume)			**8,233**	
Available Hydraulic Capacity (Sludge Removed)			**10,570**	

Based on the existing (2025) and future (17 additional homes) population projections, and assuming a freeboard of 1.0 m, the lagoon is operating beyond its design capacity and has no remaining hydraulic capacity regardless of the per capita wastewater generation rate. The lagoon does not have sufficient hydraulic capacity to accept wastewater from additional homes. As of May 25, 2025, the primary and secondary lagoon cells were operating with freeboards of 0.24 m and 0.38 m, respectively, as measured from the lagoon water level to the berm crest. The lagoon is being operated at a water level below the minimum recommended freeboard depth of 1.0 m, offering minimal safety margin and posing an overflow risk in the event of a large rainfall event or snowmelt. The sludge survey indicated that measured berm heights are less than the berm heights indicated in the record drawings. It's suspected that erosion may be caused by wave action over time, due to the lagoon operating with less than the recommended 1.0 m freeboard. Erosion of the berms, in combination with high operating water levels could lead to berm stability issues.

Sludge accumulation can increase the risk of short circuiting and clogging in interconnection piping when the sludge reaches 30% of total cell volume (i.e. cell floor to top of berms). From the sludge survey results, neither the primary or secondary cells have sludge volumes at more than 30% total cell volume, with sludge occupying 23% of the primary cell and 12% of the secondary cell, as described in **Section 2.0**. From sludge blanket thickness maps, it appears that the sludge elevation at the interconnection piping between the primary and secondary cells is nearing the interconnection pipe invert which poses a risk to short circuiting and clogging.

While 2,318 m^3 of sludge has accumulated in the primary cell and could be removed restoring additional hydraulic capacity, this action alone will not provide sufficient hydraulic storage capacity to meet the projected low, mid-range, and high estimates of wastewater generation or significantly extend the overall hydraulic life of the lagoon. However, removing the sludge could improve lagoon operation by improving treatment performance and reducing the risk of short circuiting and clogging.

3.2.2 Organic Load

The following assumptions were applied for estimating the organic loading of the lagoon:

- Per capita loading of BOD_5 – 77 g BOD_5/c/d (referenced from Metcalf and Eddy 5th Edition); and,

- Organic loading capacity – 56 kg BOD_5/ha/d (referenced from *Design Objectives for Wastewater Treatment Lagoons*).
- In addition to municipal wastewater from the Town of Starbuck, the lagoon also accepts wastewater from Bridges Golf Course. To estimate the golf course's contribution to the daily organic loading, a ratio was calculated by comparing its water consumption data (2021–2024) against the community's water consumption over the same period. This analysis concluded that the golf course accounts for approximately 7.8% of the total annual water consumption, and this percentage was applied when estimating the organic loading.

The environmental licence states an organic loading on the primary cell should not be in excess of 56 kg BOD_5/ha/day. The textbook, *Metcalf and Eddy 5th Edition*, references a range of per capita loading of BOD_5 of 50 to 120 g BOD_5/c/d. An organic loading per capita of 77 g BOD_5/c/d, has been selected at the lower end of this range which is typical of a community on a LPS system, with low organic strength.

Table 3-4 summarizes the existing and future organic loading, considering the contribution from 17 additional homes.

Table 3-4: Starbuck Organic Loading Projections

Scenario	Total Population	Primary Cell Area Required (m^2)		
		Town of Starbuck	*Bridges Golf Course*	*Total Area*
Existing (2025)	*381*	5,239	410	5,649
Future (2026) [17 Additional Homes]	433	5,952	466	6,418
Current Primary Cell Area		**4,887**		

Based on the existing (2025) and future (17 additional homes) population projections, the lagoon is estimated to be operating at or slightly above its design capacity in 2025 and will exceed its organic capacity with the connection of 17 additional homes. The lagoon does not have sufficient organic capacity to accept wastewater from additional homes. Currently the lagoon consistently meets effluent discharge requirements for BOD_5 and Total Suspended Solids (TSS) and is discharged in both the spring and fall.

4.0 Cost Estimate

The results of the sludge survey indicated that a large proportion of the sludge build-up is contained within the primary cell as indicated by **Figure 4-1,** which presents a 3D isometric profile of the sludge thickness in the primary cell (Cell 1) and secondary cell (Cell 2). In Manitoba, sludge is typically removed by of two methods: desludging or dredging. Desludging involved using tractor powered pumps (such as Houle pumps) to thoroughly mix, slurry and dewater the entire primary cell until the liner is visible. This method is only feasible if the primary cell can be bypassed and taken out of service. Dredging, in contrast, utilizes a floating cutterhead suction dredge to clean sludge from the bottom of the primary cell, while it remains full of water and in operation. For the Starbuck lagoon, it is assumed that sludge will be removed by dredging rather than desludging.

The following steps will be required as part of the sludge removal and land application process:

- Identify suitable land of sufficient area within a reasonable hauling distance from the lagoon and perform soil testing as required as part of an Environmental Act Proposal (EAP) submission to Manitoba Environment and Climate Change (MECC);
- Discuss this as the preferred sludge disposal option with MECC to identify other information that will be required as part of an EAP submission;
- Perform detailed nutrient and metals balance calculations based on soils and sludge analysis results; and
- Prepare and submit an EAP to MECC.

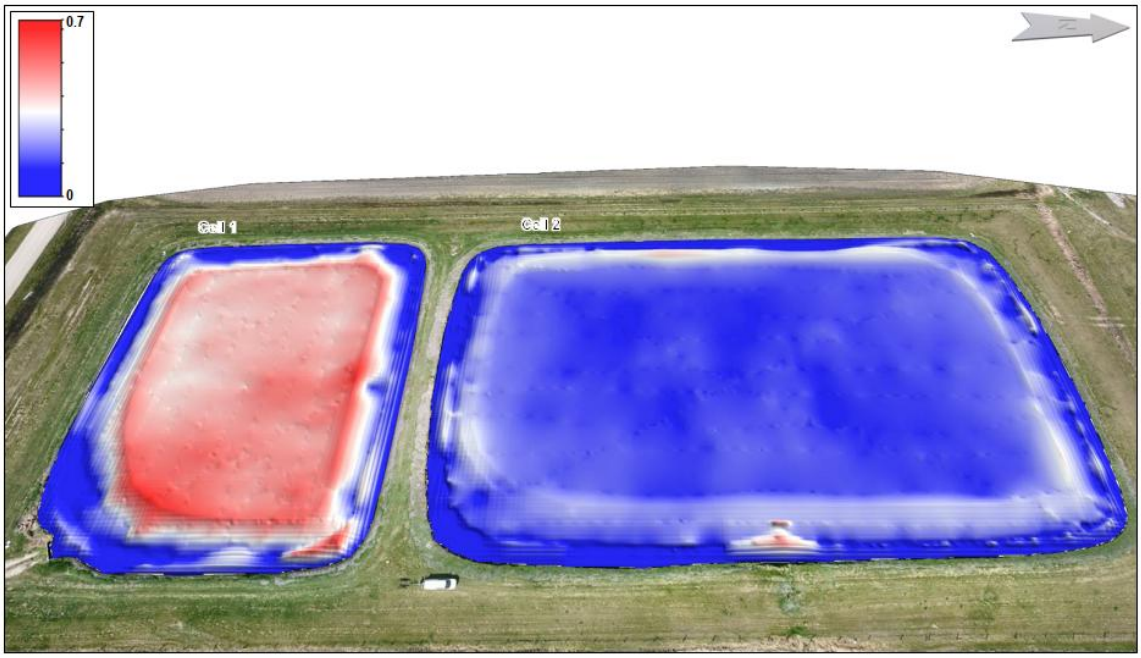


Figure 4-1: Primary Cell (Cell #1) and Secondary Cell (Cell #2) Isometric Sludge Thickness Profile

The Class D opinion of probable cost for removal of sludge by dredging, truck hauling, land application and environmental licensing is **$270,000**, excluding applicable taxes and only considers sludge removal in the primary cell. The cost estimate includes the following items:

- Sludge removal from the primary cell by dredging and truck hauling to receiving fields;
- Land application of sludge by direct injection;
- Soil sampling of receiving fields; and
- Preparation of an EAP for land application of sludge.

5.0 Conclusions and Recommendations

5.1 Conclusions

According to the *Design Objectives for Wastewater Treatment Lagoons* and based on the existing (2025) and future (17 additional homes) population projections, the lagoon is operating at or above its design capacity and has no remaining hydraulic or organic capacity. The lagoon does not have sufficient capacity to accept wastewater from additional homes. As of May 25, 2025, the primary and secondary lagoon cells were operating with freeboards of 0.24 m and 0.38 m, respectively, as measured from the lagoon water level to the berm crest elevation. The lagoon is being operated at a water level below the minimum recommended freeboard depth of 1.0 m, offering minimal safety margin and posing an overflow risk in the event of a large rainfall event or snowmelt. The sludge survey indicated that measured berm heights are less than their as-constructed heights. It's suspected that erosion may be caused by wave action over time, due to the lagoon operating with less than the recommended 1.0 m freeboard.

It is important to note that we have conservatively evaluated the lagoon capacity against the *Design Objectives for Wastewater Treatment* Lagoons, which outlines a maximum operating depth of 1.5 m and a freeboard of 1.0 m. The current operating license does not explicitly state these operating parameters. However, if a new operating licence was issued with a maximum operating depth of 1.5 m and freeboard of 1.0 m, the lagoon would be operating outside of provincial guidelines.

While 2,318 m^3 of sludge has accumulated in the primary cell and could be removed restoring additional hydraulic capacity, this action alone will not provide sufficient hydraulic storage capacity to meet the projected low, mid-range, and high estimates of wastewater generation or significantly extend the overall hydraulic life of the lagoon. However, removing the sludge could improve lagoon operation by improving treatment performance and reducing the risk of short circuiting and clogging.

High concentrations of aluminum and iron were observed in the sludge mixture. This would typically be attributed to the past use of alum or ferric-based coagulants to aid flocculation and phosphorus removal. The RM has indicated that they have not historically used alum or ferric-based coagulants at the lagoon, as their license currently has no limits for phosphorus removal.

To gain the necessary hydraulic and organic capacity, it is recommended to expand or upgrade the lagoon. The lagoon expansion should be designed for a 20-year design horizon (2045 or later), including the 17 additional homes. Given the observed erosion, re-grading of the primary and secondary cell berms is recommended to restore the cell depth to 2.5 m and to maintain outer and inner slopes of 4:1. Recommended options for lagoon upgrades could include:

- **Seasonal Discharge Facultative Lagoon System:** Expand the existing facultative lagoon to include additional secondary cells.
- **Continuous Discharge Aerated Lagoon System and Nitrification Reactor:** Conversion of the existing facultative lagoon to an aerated lagoon including a nitrification reactor to provide coliform and nitrogen removal following lagoon treatment.
- **Seasonal Discharge Aerated Lagoon System:** Conversion of the existing facultative lagoon to an aerated lagoon using submerged aerators.

As part of the upgrade, a new Environmental Act License (EAL) would be required, and new discharge objectives would be added. Currently, the lagoon does not have phosphorus or nitrogen discharge limits, however a new license would be expected to include the following requirements in place:

- Phosphorus limit of 1.0 mg/L, or a demonstrated nutrient reduction strategy for facilities discharging less than 820 kg/year of total phosphorus (a population equivalent of under 2000 people.) For facilities proposing a nutrient reduction strategy, strategies will be evaluated on a site-specific basis, and strategies which do not offer a reasonable likelihood of attaining a total phosphorus content of one milligram per litre at a significant downstream waterway will not be approved; and
- Unionized ammonia as N at 15°C of 1.25 mg/L for intermittently discharging facilities; or total ammonia as N shall not exceed a site-specific limit derived from the *Manitoba Water Quality Objectives* for continuously discharged facilities only.

5.2 Recommendations

The RM should consider the following action items as described in the conclusions above:

- Record flows to the lagoon from November 1 to June 15 to validate assumptions and hydraulic capacity calculations.
- Investigate the source of aluminum and iron in the sludge mixture. Recommended actions include:
    - Compare aluminum and iron concentrations in sludge from the Sanford and Starbuck Lagoons;
    - Review aluminum and iron concentrations in raw and treated water from the Macdonald Regional Water Treatment Plant;
    - Confirming any historical sludge transport from the Sanford Lagoon to the Starbuck Lagoon; and,
    - Repeat the sludge sampling and analysis to confirm aluminum and iron concentrations are accurate.
- Complete a preliminary design study to evaluate the most feasible lagoon upgrade option.

The preliminary design study should include the following:

- Design basis including:
    - Population projections for a 20-year design horizon;
    - Future hydraulic and organic generation rates;

  - Influent wastewater quality; and
  - Regulatory review to establish effluent quality targets.
- Assessment of treatment alternatives:
  - Seasonal Discharge Facultative Lagoon System;
  - Continuous Discharge Aerated Lagoon System and Nitrification Reactor; and
  - Seasonal Discharge Aerated Lagoon System.
- Comparison of treatment alternatives including:
  - Treatment summary;
  - Operational complexity and operator qualification requirements;
  - Anticipated treatment performance;
  - Approximate footprint on a site plan;
  - Capital and operating costs for each alternative;
  - Advantages and disadvantages of each alternative; and
  - Site servicing requirements.
- Recommended upgrades to existing lagoon infrastructure including:
  - Berm repair and ditch re-grading;
  - Repair of perimeter fencing;
  - Upgrade of truck discharge concrete approach; and
  - Sludge removal from primary cell.
- Recommendation of a preferred treatment alternative:
  - Preliminary design report; and
  - 30% design drawings.

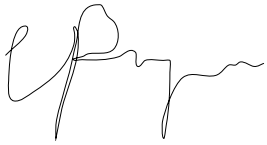
6.0 Closure

Thank you for the opportunity to work with the Rural Municipality of Macdonald throughout this assignment.

Please contact Charlie Pogue at (204) 453-2301 or via email at cpogue@dillon.ca should there be any questions or comments.

Sincerely,

DILLON CONSULTING LIMITED



Charlie Pogue, P.Eng.
Project Manager

Appendix A

Starbuck Sludge Survey

STARBUCK SLUDGE SURVEY REPORT 2025

STARBUCK, MB WASTEWATER LAGOON

Location: Starbuck, MB

Name of lagoon cell(s): Cells 1 & 2

Client: Municipality of Starbuck, Dillon Consulting Ltd

Client contact(s): Charlie Pogue

Report prepared by: R. Machado

Surveyors: J. Sinclair, M. Hillestad

Date(s) of survey: 25/05/2025

Map grid reference: Horizontal Datum: NAD83(CSRS) (2010.0), Projection: UTM, Zone 14N

Vertical datum: CGVD2013

Control points: HCP1 – (Base occupied static control point for processing with NRCAN PPP Service)

Revision number: 0

Report print size: 11x17”

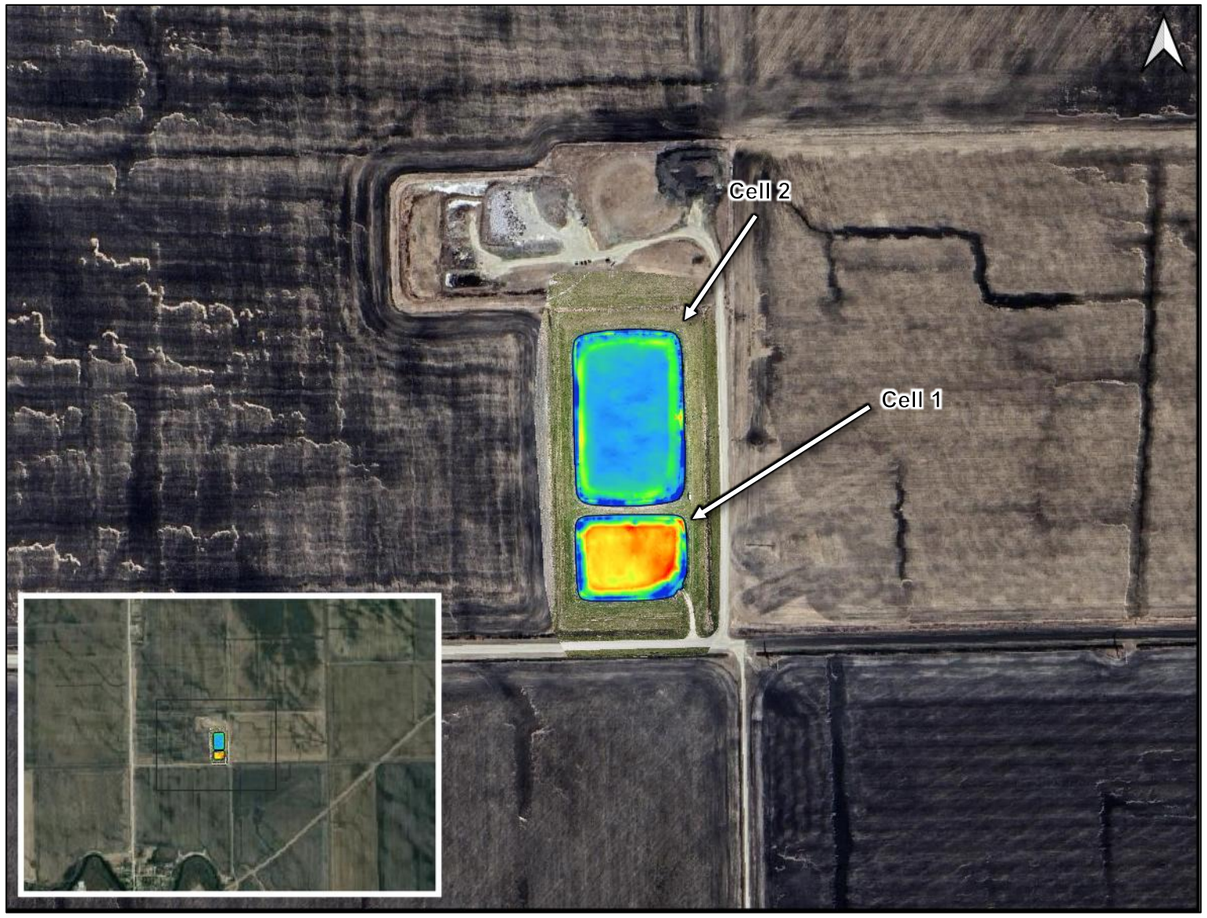


Figure 1 Starbuck, MB Wastewater Lagoon overview

This is not a legal survey document
Matrix depths and elevations are interpolated from field measurements
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Infrastructure shown on drawings is approximate.
Survey data collected on 25/05/2025.
Report any discrepancies in this report to Hydrasurvey Ltd.
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Drone aerial imagery is georeferenced.

	Name	Date
Prepared by:	RM	03-06-2025
Reviewed by:	AA	12-06-2025

Unless otherwise specified all dimensions are in meters

HYDRASURVEY

Project Title	Starbuck, MB Wastewater Lagoon Sludge Surveys 2025 Report	
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FIGURES & TABLES SUMMARY

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List of Tables

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Reviewed by:	AA	12-06-2025

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EXECUTIVE SUMMARY

Hydrasurvey conducted sludge surveys at the **Starbuck, MB Wastewater Lagoon** for the Municipality of Starbuck on 25/05/2025. The purpose of the sludge survey and this report is to map and quantify sludge accumulation in cells 1 & 2. Cells 1 & 2 were in service at the time of survey. A virtual site tour can be accessed **here**.

Cell	Date of survey	Water elevation CGVD2013 (m)	Maximum measured liner depth inside toe (m)	Current hydraulic capacity (m^3)	Freeboard (m)	Estimated sludge volume - 2025 (m^3)	*Estimated dredgeable sludge volume - 2025 (m^3)	Estimated bone dry tonnes (BDTs) of sludge to be removed	Estimated dredgeable bone dry tonnes (BDTs) of sludge to be removed	Percent of total cell volume occupied by sludge (at surveyed dimensions)
CELL 1	25-May-25	239.534	2.04	7,845	0.24	2,318	1,436	748	463	23%
CELL 2	25-May-25	239.106	1.60	15,679	0.38	2,164	402	1,007	187	12%

**Note: For details regarding dredgeable volumes please refer to Appendix A - Glossary.*

Table 1 Summary of sludge survey findings

Cells 1 & 2 findings:

- Cells 1 & 2 have 23% and 12% of their volume occupied by sludge, respectively.
- Signs of erosion along the shorelines of both cells was observed.
- Sludge sample test results show high levels of aluminum and iron in both cells.
- Cells 1 & 2 are clay lined.

Figure 3 Erosion along the eastern shoreline of Cell 2

Figure 4 Cell 1 septage dump

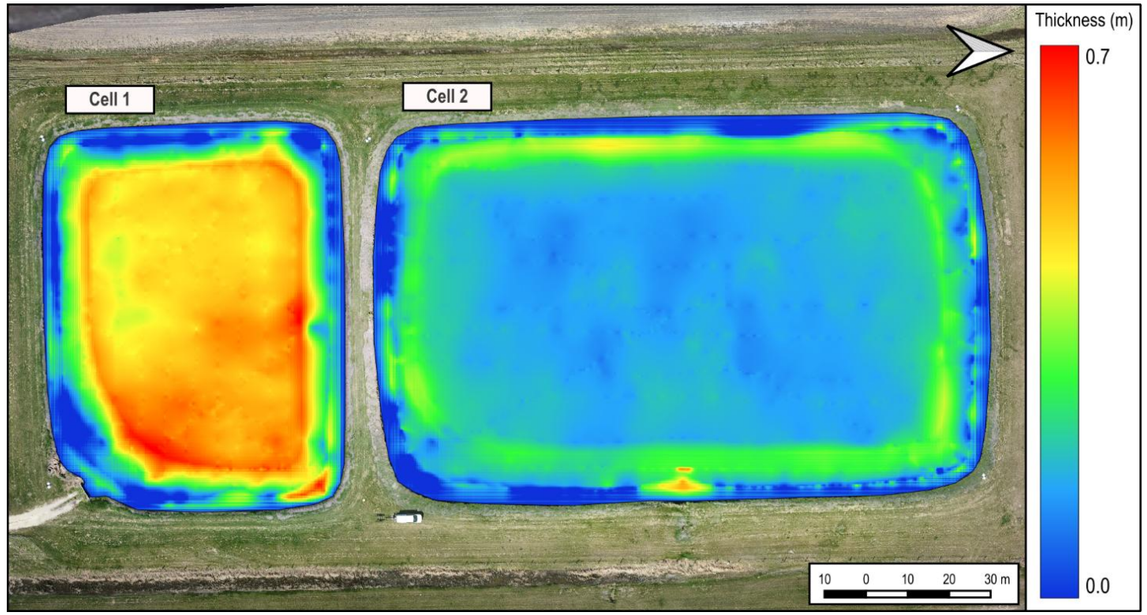

Figure 2 Starbuck, MB Wastewater Lagoon cells 1 & 2 sludge blanket thickness

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Reviewed by:	AA	12-06-2025

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CELLS 1 & 2 – SLUDGE BLANKET THICKNESS

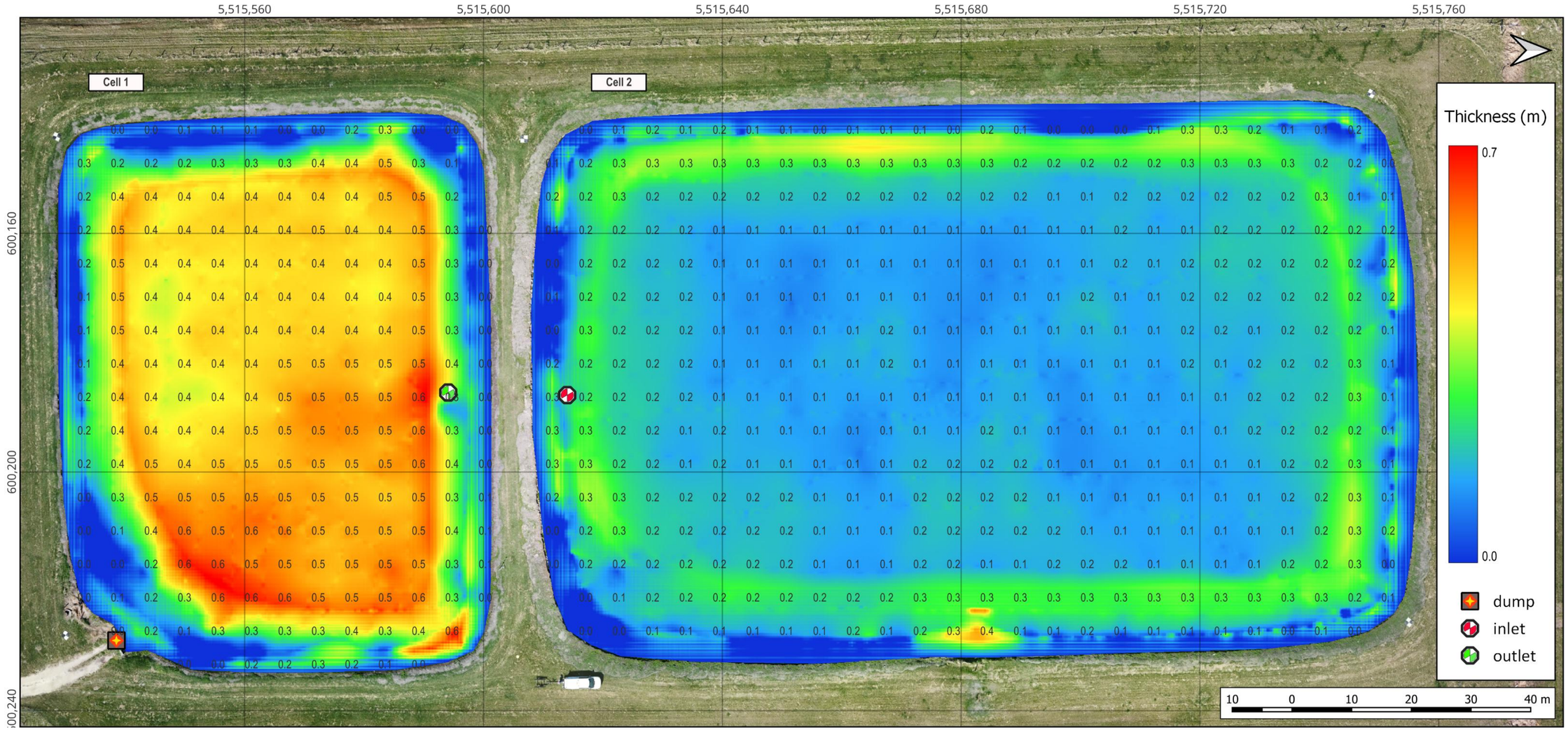

Figure 5 Cells 1 & 2 sludge blanket thickness

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CELLS 1 & 2 – TOP OF SLUDGE DEPTHS

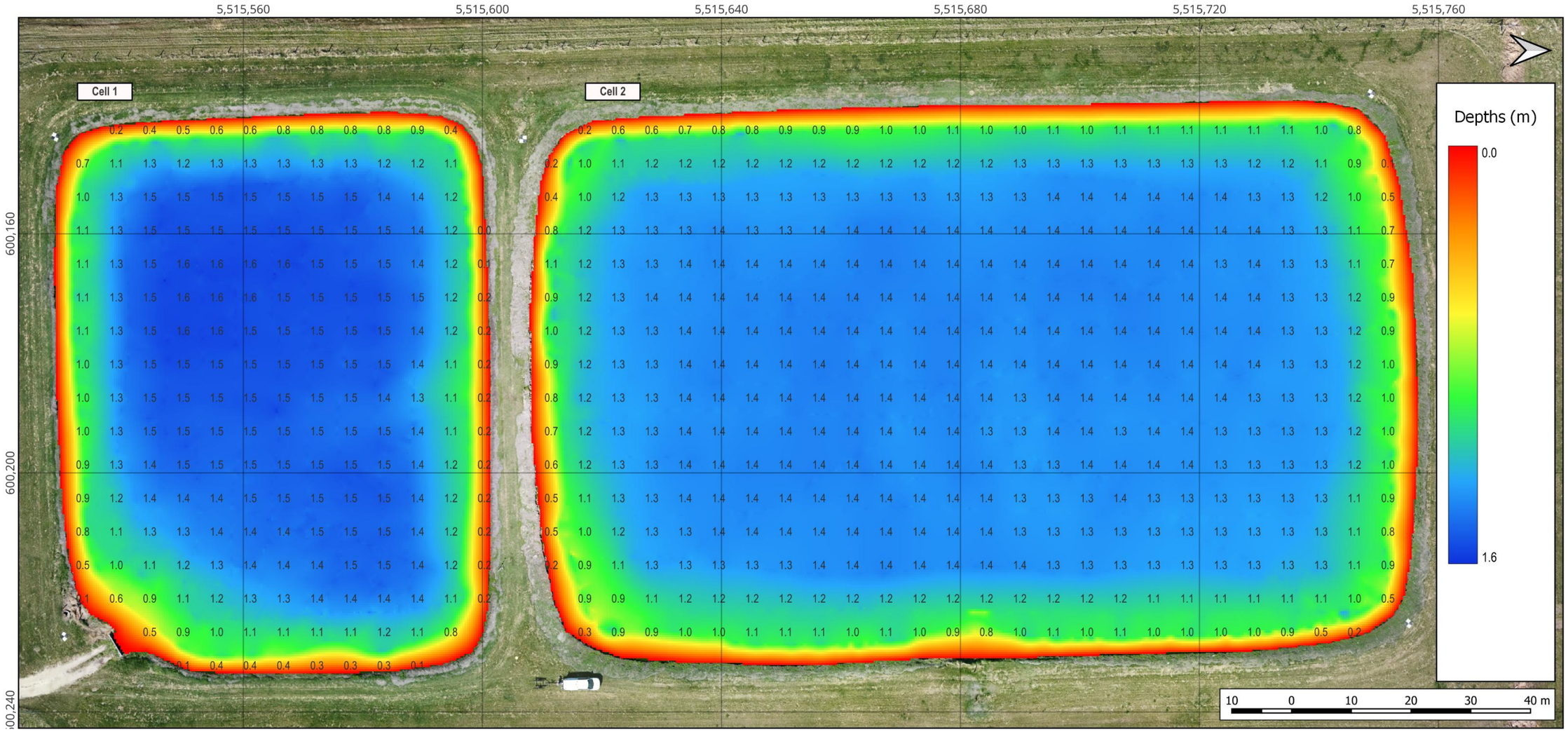

Figure 6 Cells 1 & 2 top of sludge blanket depths

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Project Title	Starbuck, MB Wastewater Lagoon Sludge Surveys 2025 Report	
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CELLS 1 & 2 – TOP OF SLUDGE ELEVATIONS

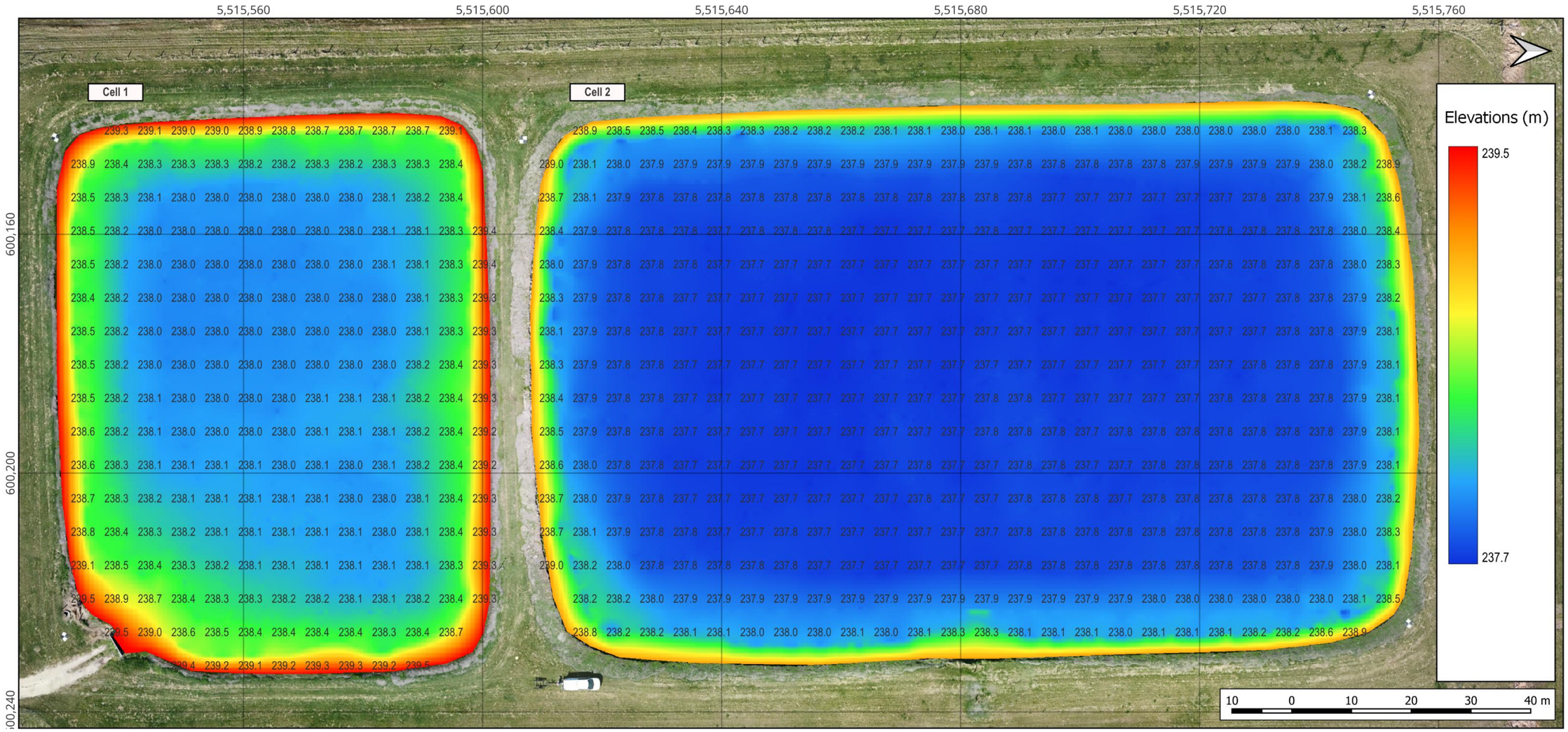

Figure 7 Cells 1 & 2 top of sludge blanket elevations

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CELLS 1 & 2 – RELEVANT FEATURES

Figure 8 Cells 1 & 2 relevant features (infrastructure locations are approximate)

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HYDRASURVEY

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CELL 1 VOLUMES

CELL 1 ESTIMATED SLUDGE QUANTITY

Estimated sludge volume is calculated using software that compares the measured and interpolated sludge depths with the depths of the lagoon liner obtained from engineered drawings and/or field measurements. A sludge sample is taken for lab analysis to determine total solids and total volatile solids and to obtain dry volume.

CELL 1:

TOTAL ESTIMATED VOLUME OF SLUDGE TO BE REMOVED (WET) =	**2,318**	**m^3**
TOTAL ESTIMATED VOLUME OF SLUDGE TO BE REMOVED (DRY) =	**584**	**m^3**
SPECIFIC GRAVITY (DRY AS SAMPLED) =	**1.28**	
TOTAL ESTIMATED MASS OF SLUDGE TO BE REMOVED =	**748**	**BDT (Bone Dry Tonnes)**
TOTAL ESTIMATED VOLATILE SOLIDS QUANTITY (DRY) =	**93**	**m^3**
IN-SITU SLUDGE DENSITY =	**1,058**	**kg/m^3**

CELL 1 HYDRAULIC CAPACITY AT PRESENT SLUDGE LOADING

Hydraulic capacity calculations for each cell are performed by comparing the water level at the time of survey to the sludge profile with results shown below.

ESTIMATED HYDRAULIC CAPACITY - WATER LEVEL @ 239.534 m = **7,845 m^3**

CELL 1 APPROXIMATE DIMENSIONS AND VOLUMES
(AS SURVEYED)

Shape / sides	Rectangular	
Length	95	**m**
Width	75	**m**
Area	6454	**m^2**
Maximum liner depth	2.04	**m**
Total volume	10164	**m^3**
Total potential volume (high water level)	11713	**m^3**
Average sludge thickness	0.36	**m**
Average top of liner depths	1.58	**m**
Average top of sludge depths	1.22	**m**

REMAINING CAPACITY OF CELL BASED ON SURVEYED SLUDGE VOLUME

Stage	Depth (m)	Volume (m^3)	Area (m^2)
1	0.0	7,845	6,454
2	0.4	5,359	5,988
3	0.8	3,053	5,539
4	1.2	1,012	4,210
5	1.6	-	-

Figure 9 Cell 1 volumes

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Reviewed by:	AA	12-06-2025

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HYDRASURVEY

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CELL 2 VOLUMES

CELL 2 ESTIMATED SLUDGE QUANTITY

Estimated sludge volume is calculated using software that compares the measured and interpolated sludge depths with the depths of the lagoon liner obtained from engineered drawings and/or field measurements. A sludge sample is taken for lab analysis to determine total solids and total volatile solids and to obtain dry volume.

CELL 2:

TOTAL ESTIMATED VOLUME OF SLUDGE TO BE REMOVED (WET) =	**2,164**	**m^3**
TOTAL ESTIMATED VOLUME OF SLUDGE TO BE REMOVED (DRY) =	**729**	**m^3**
SPECIFIC GRAVITY (DRY AS SAMPLED) =	**1.38**	
TOTAL ESTIMATED MASS OF SLUDGE TO BE REMOVED =	**1,007**	**BDT (Bone Dry Tonnes)**
TOTAL ESTIMATED VOLATILE SOLIDS QUANTITY (DRY) =	**65**	**m^3**
IN-SITU SLUDGE DENSITY =	**1,102**	**kg/m^3**

CELL 2 HYDRAULIC CAPACITY AT PRESENT SLUDGE LOADING

Hydraulic capacity calculations for each lagoon are performed by comparing the water level at the time of survey to the sludge profile with results shown below.

ESTIMATED HYDRAULIC CAPACITY - WATER LEVEL @ 239.106 m = **15,679 m^3**

CELL 2 APPROXIMATE DIMENSIONS AND VOLUMES
(AS SURVEYED)

Shape / sides	Rectangular	
Length	150	**m**
Width	95	**m**
Area	13243	**m^2**
Maximum liner depth	1.60	**m**
Total volume	17844	**m^3**
Total potential volume (high water level)	22836	**m^3**
Average sludge thickness	0.16	**m**
Average top of liner depths	1.35	**m**
Average top of sludge depths	1.18	**m**

REMAINING CAPACITY OF CELL BASED ON SURVEYED SLUDGE VOLUME

Stage	Depth (m)	Volume (m^3)	Area (m^2)
1	0.0	15,679	13,243
2	0.4	10,520	12,549
3	0.8	5,638	11,857
4	1.2	1,289	9,021
5	1.6	-	-

Figure 10 Cell 2 volumes

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CELLS 1 & 2 – TOP OF SLUDGE 3D PROFILE

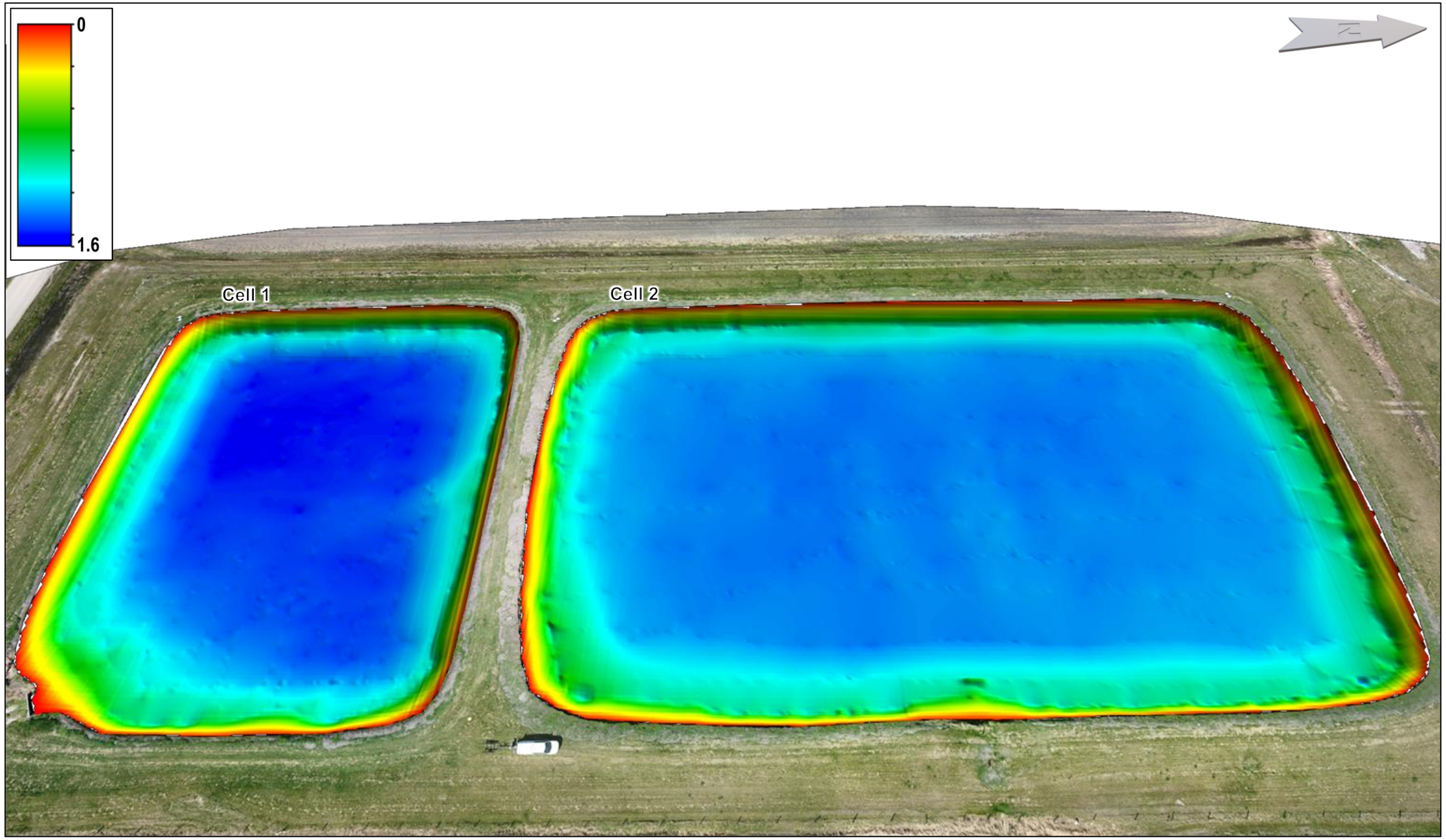

Figure 11 Cells 1 & 2 top of sludge 3D isometric drawing – east to west

A 3x vertical exaggeration has been applied to the 3D isometric drawing to highlight bottom features.

Top of sludge depths are evenly distributed across both cells with a shallow region near the septage dump in Aell 1.

The average top of sludge depths for Cells 1 & 2 are, respectively, 1.22 m & 1.18 m.

	Name	Date
Prepared by:	RM	03-06-2025
Reviewed by:	AA	12-06-2025

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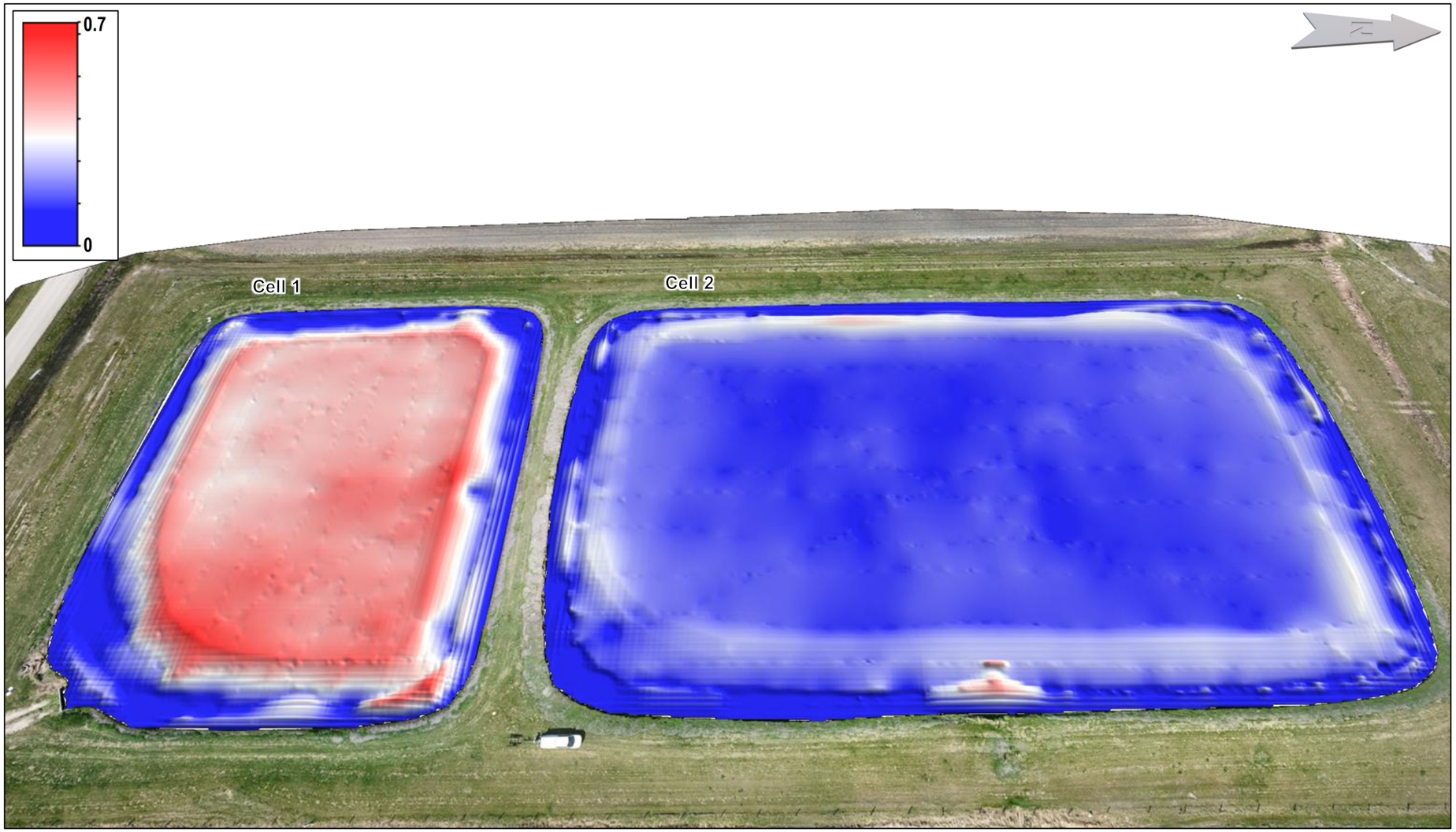
CELLS 1 & 2 – SLUDGE THICKNESS 3D PROFILE



A 3x vertical exaggeration has been applied to the 3D isometric drawing to highlight bottom features.

Sludge build-up is more significant throughout the bottom of Cell 1.

In Cell 2, sludge accumulation is low and parallel to the shorelines.

The average sludge thickness for Cells 1 & 2 are, respectively, 0.36 m & 0.16 m.

Figure 12 Cells 1 & 2 top of sludge 3D isometric drawing – east to west

	Name	Date
Prepared by:	RM	03-06-2025
Reviewed by:	AA	12-06-2025

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APPENDIX A – GLOSSARY

Bone dry tonnes (BDT): The in-situ sludge volume reduced to an ideal dry mass in metric tonnes (all moisture removed).

CGVD2013: Canadian Geodetic Vertical Datum of 2013

CGVD28: Canadian Geodetic Vertical Datum of 1928

Dredgeable area: The area of a lagoon or pond that is accessible to be cleaned by a floating dredge. Features that restrict dredge access include excessive shoreline vegetation (cattails), riprap,

infrastructure, etc.

Dredgeable volume: The volume of sludge in the dredgeable area adjusted to account for the cutterhead guard and sludge-liner interface by raising the liner surface by 15 cm and by applying an offset from the shoreline of 3 m for cells 1 and 2.

Echogram: A visualization of acoustic returns displayed as a vertical cross section (elevation view) or ‘slice’ of the entire water column (waterline down to sludge) that shows the bottom profile and basic underwater features.

Floating crust: A layer of material (made up of biosolids and synthetic debris) which is less dense and therefore floats on the surface of the effluent and forms a crust.

Freeboard: Distance from the surveyed cell water elevation to the cell level of capacity or overflow.

In-situ sludge density: The calculated density of the in-situ sludge.

Sludge accumulation: The amount of sludge (in depth or volume) that accumulates over a period of time.

Sludge blanket thickness: The amount of sludge that has accumulated on the bottom of the pond.

Sludge volume: The in-situ sludge volume that exists between the liner and the top of the sludge surface.

Top of sludge depths: The vertical measurement from the water surface down to the top of the sludge layer.

Top of sludge elevations: The elevations mapped at the top of the sludge layer. By tracking these elevations overtime sludge accumulation can be accurately monitored or dredging progress can be assessed even with varying pond levels.

Water volume / hydraulic capacity: Volume of water/effluent in the pond at the time of survey. This value represents the hydraulic capacity on top of the settled sludge blanket.

APPENDIX B – A NOTE ON VOLUME CALCULATIONS

This Sludge Survey Report has been prepared by Hydrasurvey Ltd. (“HS”) for the Municipality of Starbuck and Dillon Consulting Ltd. (herein collectively referred to as the “Client”). It is intended to provide the Client with an estimate of sludge quantity and lagoon or pond hydraulic capacity.

This report is based on data and information obtained by measuring pond depths with the Single Beam Echosounder, or Infrared Sludge Interface Detector and verified using manual checks. Estimated sludge volumes and dry tonne amounts are calculated using software that creates interpolations between the sounding lines measured in the field.

The Client recognizes and acknowledges that estimated sludge volumes will vary from actual sludge volumes and that this report should be used only as a general guideline for planning maintenance desludging or dredging and should not be assumed to be an exact quantification of sludge volume. HS shall not be liable for any damages resulting from any difference between estimated sludge volumes and actual sludge volumes.

Furthermore, the liability of HS to the Client and to all third parties shall be limited to injury or loss caused by the negligent acts, errors or omissions of HS. Notwithstanding the foregoing, the total aggregate liability of HS shall not exceed the lesser of the actual damages incurred, or the total fee of HS for services rendered on this project.

The Client agrees to defend, indemnify, and hold harmless HS, its affiliates, officers, directors, employees, and agents from any and all liabilities, in excess of the limits of HS’ entire liability set out above, incurred by HS or any other party, in connection with the services provided. Such indemnity shall include the costs of the time spent and expenses incurred by HS and its affiliates in connection with the defence of any claims.

	Name	Date
Prepared by:	RM	03-06-2025
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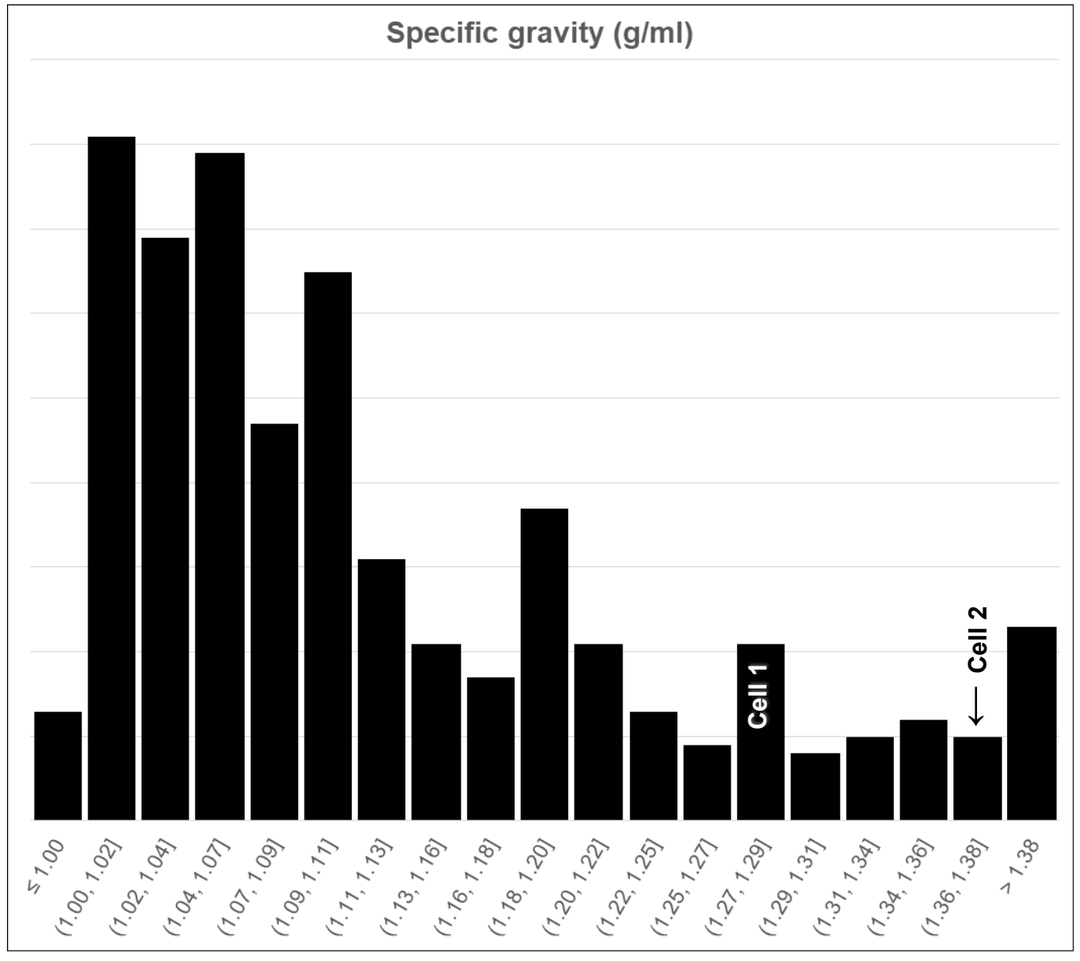
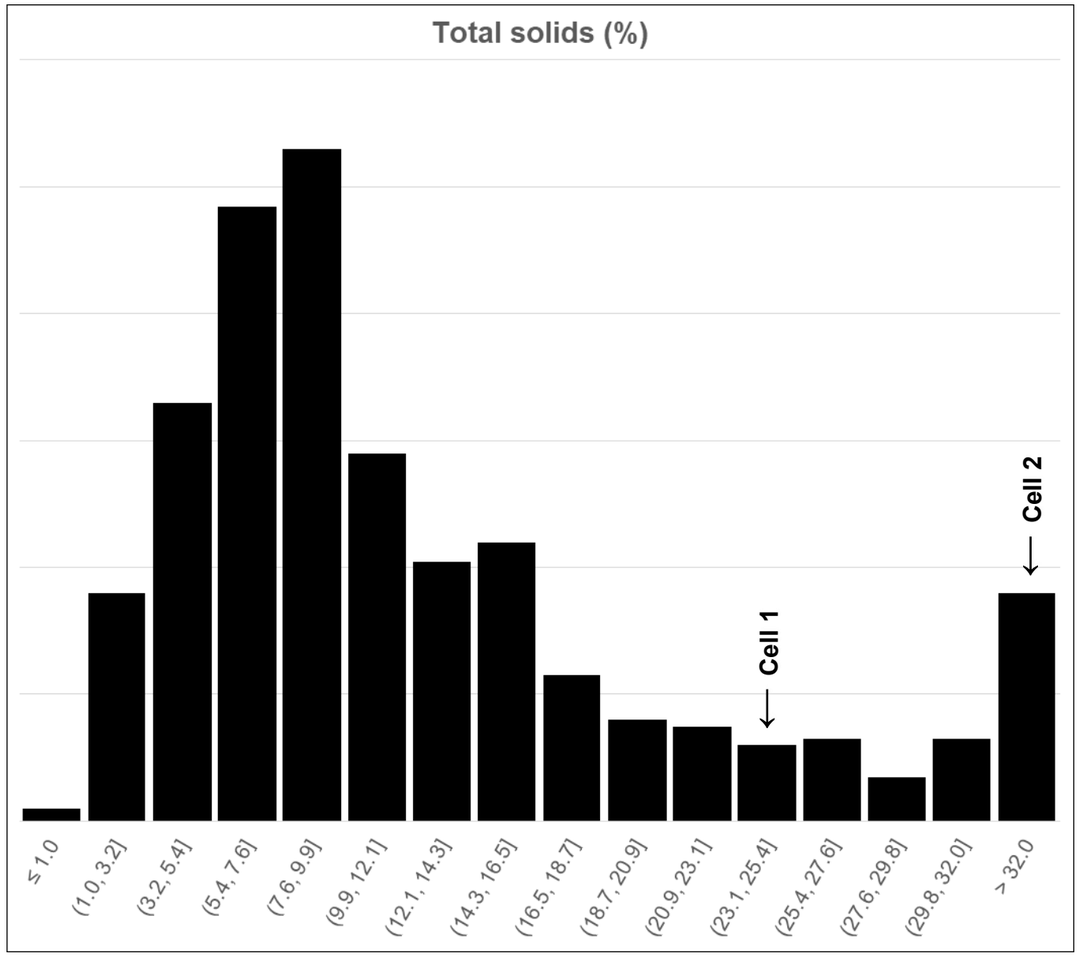
APPENDIX C – STARBUCK, MB WASTEWATER LAGOON SLUDGE SAMPLE TEST RESULTS AND COMPARISON WITH HYDRASURVEY'S DATABASE





Histogram of sludge sample test results for Specific Gravity (g/ml) and Total Solids (%)

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Sheet	14	OF 23

Unit# 288, 2880 45 Ave S.E.
Calgary, AB, T2B 3M1
Phone (403) 297-0868
Fax: (403) 297-0869

KaizenLAB

ANALYTICAL REPORT

Client: Hydrasurvey Ltd.
4030 8 Street SE
Calgary T2G 3A7

Attention: Andrew Ambrocichuk

KaizenLAB JOB #:	**345087**
DATE RECEIVED:	29-May-2025
DATE REPORTED:	05-Jun-2025
PROJECT ID:	25014 Starbuck
LOCATION:	Starbuck

KaizenLAB Sample #: 345087_001 **Sample ID:** Cell 1
Date Sampled: 24-May-2025 **Matrix:** SLUDGE

Parameter Description	Units	Result	Detection Limit	
Metals in Soil, Full Scan including Mercury				
Mercury	mg/kg	0.137	0.030	*
Metals in Soil by ICP-MS				
Aluminum	mg/kg	15780	50.0	
Antimony	mg/kg	<1.0	1.0	
Arsenic	mg/kg	6.0	2.0	
Barium	mg/kg	171	15.0	
Beryllium	mg/kg	1.1	0.4	
Bismuth	mg/kg	5.3	0.5	
Boron	mg/kg	20.9	15.0	
Cadmium	mg/kg	1.1	0.5	
Chromium	mg/kg	44.0	2.0	
Cobalt	mg/kg	9.2	0.5	
Copper	mg/kg	150	2.0	
Iron	mg/kg	21709	50.0	
Lanthanum	mg/kg	16.5	3.0	
Lead	mg/kg	19.0	1.0	
Lithium	mg/kg	18.7	3.0	
Manganese	mg/kg	292	25.0	
Molybdenum	mg/kg	3.0	1.0	
Nickel	mg/kg	33.6	2.0	
Selenium	mg/kg	1	0.5	
Silver	mg/kg	<1.0	1.0	
Strontium	mg/kg	61.2	2.0	
Thallium	mg/kg	<0.5	0.5	
Tin	mg/kg	9.3	2.0	
Titanium	mg/kg	114	15.0	
Tungsten	mg/kg	<2.0	2.0	

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Calgary, AB, T2B 3M1
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KaizenLAB Sample #: 345087_001 **Sample ID:** Cell 1
Date Sampled: 24-May-2025 **Matrix:** SLUDGE

Parameter Description	Units	Result	Detection Limit	
Uranium	mg/kg	3.7	0.5	
Vanadium	mg/kg	50.3	2.0	
Zinc	mg/kg	218	10.0	
Zirconium	mg/kg	<6.0	6.0	
Total Metals in Soil by ICP-OES				
Calcium	mg/kg	35560	150	
Magnesium	mg/kg	15450	150	
Phosphorus	mg/kg	2392	45	
Potassium	mg/kg	4297	150	
Sodium	mg/kg	656.3	150.0	
Sulphur	mg/kg	6380	10.0	
Silicon	mg/kg	2320	5.0	
Available Ammonium (NH4-N) and Ammonia (NH3-N) in soil				
Available Ammonia in Soil				
Available Ammonia-N	mg/kg	1510	1.0	
Available Ammonium-N (calculated)	mg/kg	1510	1.0	
Nitrate/Nitrite in soil				
Anions in Soil by IC				
Nitrite	mg/kg	1.1	1.0	
Nitrate	mg/kg	<5.0	5.0	
TKN, Ammonia and Organic Nitrogen in soil				
Ammonia-N	mg/kg	411	20.00	*
Total Kjeldahl Nitrogen in Soil				
Total Kjeldahl Nitrogen	mg/kg	10700	100	
Organic Nitrogen (calculated)	mg/kg	10300	100	
Basic Salinity in soil				
pH (in 0.01M CaCl2)		7.7		
EC	dS/m	3.13	0.01	
Saturation Percentage	%	130		
Cations in Soil by ICP-OES				
Calcium	mg/L	151.5	5.0	
Magnesium	mg/L	81.1	5.0	
Potassium	mg/L	101.7	5.0	
Sodium	mg/L	168.9	5.0	
Sodium Adsorption Ratio (calculated)		2.75		
Specific Gravity (Dry)	g/mL	1.28		
Volatile and Total Solids (gravimetric) in soil				
Total and Volatile Solids in Soil				

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KaizenLAB Sample #: 345087_001 **Sample ID:** Cell 1

Date Sampled: 24-May-2025 **Matrix:** SLUDGE

Parameter Description	Units	Result	Detection Limit
Total Solids	%	25.2	0.1
Volatile Solids	%	4.0	0.1

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KaizenLAB Sample #: 345087_002 **Sample ID:** Cell 2
Date Sampled: 24-May-2025 **Matrix:** SLUDGE

Parameter Description	Units	Result	Detection Limit
Metals in Soil, Full Scan including Mercury			
Mercury	mg/kg	0.030	0.030 *
Metals in Soil by ICP-MS			
Aluminum	mg/kg	19780	50.0
Antimony	mg/kg	<1.0	1.0
Arsenic	mg/kg	6.5	2.0
Barium	mg/kg	189	15.0
Beryllium	mg/kg	1.3	0.4
Bismuth	mg/kg	<0.5	0.5
Boron	mg/kg	28.6	15.0
Cadmium	mg/kg	<0.5	0.5
Chromium	mg/kg	39.2	2.0
Cobalt	mg/kg	12.1	0.5
Copper	mg/kg	38.4	2.0
Iron	mg/kg	24403	50.0
Lanthanum	mg/kg	20.9	3.0
Lead	mg/kg	13.0	1.0
Lithium	mg/kg	23.0	3.0
Manganese	mg/kg	453	25.0
Molybdenum	mg/kg	13.7	1.0
Nickel	mg/kg	36.3	2.0
Selenium	mg/kg	<0.5	0.5
Silver	mg/kg	<1.0	1.0
Strontium	mg/kg	73.6	2.0
Thallium	mg/kg	<0.5	0.5
Tin	mg/kg	4.1	2.0
Titanium	mg/kg	127	15.0
Tungsten	mg/kg	<2.0	2.0
Uranium	mg/kg	1.4	0.5
Vanadium	mg/kg	58.5	2.0
Zinc	mg/kg	88.7	10.0
Zirconium	mg/kg	<6.0	6.0
Total Metals in Soil by ICP-OES			
Calcium	mg/kg	28730	150
Magnesium	mg/kg	12330	150
Phosphorus	mg/kg	2071	45
Potassium	mg/kg	5375	150
Sodium	mg/kg	753.2	150.0
Sulphur	mg/kg	3960	10.0

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KaizenLAB Sample #: 345087_002 **Sample ID:** Cell 2
Date Sampled: 24-May-2025 **Matrix:** SLUDGE

Parameter Description	Units	Result	Detection Limit	
Silicon	mg/kg	2830	5.0	
Available Ammonium (NH4-N) and Ammonia (NH3-N) in soil				
Available Ammonia in Soil				
Available Ammonia-N	mg/kg	619	1.0	
Available Ammonium-N (calculated)	mg/kg	617	1.0	
Nitrate/Nitrite in soil				
Anions in Soil by IC				
Nitrite	mg/kg	1.1	1.0	
Nitrate	mg/kg	<5.0	5.0	
TKN, Ammonia and Organic Nitrogen in soil				
Ammonia-N	mg/kg	155	10.00	*
Total Kjeldahl Nitrogen in Soil				
Total Kjeldahl Nitrogen	mg/kg	4470	100	
Organic Nitrogen (calculated)	mg/kg	4320	100	
Basic Salinity in soil				
pH (in 0.01M CaCl2)		8.2		
EC	dS/m	3.24	0.01	
Saturation Percentage	%	100		
Cations in Soil by ICP-OES				
Calcium	mg/L	219.7	5.0	
Magnesium	mg/L	105.9	5.0	
Potassium	mg/L	119.9	5.0	
Sodium	mg/L	218.3	5.0	
Sodium Adsorption Ratio (calculated)		3.03		
Specific Gravity (Dry)	g/mL	1.38		
Volatile and Total Solids (gravimetric) in soil				
Total and Volatile Solids in Soil				
Total Solids	%	33.7	0.1	
Volatile Solids	%	3.0	0.1	

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* The detection limit has been adjusted due to sample matrix type and/or insufficient sample volume.

SAR results: "Incalculable" means calcium and magnesium concentrations are less than detection limits (zero), therefore the ratio is undefined and cannot be applied; "<DL" means the sodium concentration is less than detection limits and the ratio may only be calculated as less than the maximum of this limit.

Test Methodologies

Ammonia in Soil (Non-Accredited): Modified from Soil Sampling & Methods of Analysis, M.R. Carter, 2008 and SM 4500-NH3 F

Anions in Soil: Modified from Soil Sampling & Methods of Analysis, M.R. Carter, 2008 and SM 4110 B

Available Ammonia in Soil (Non-Accredited): Modified from Soil Sampling & Methods of Analysis, M.R. Carter, 2008 and SM 4500-NH3 F

Cations in Soil by ICP-OES: Modified from Soil Sampling & Methods of Analysis, M.R. Carter, 2008 and SM 3120 B

Electrical Conductivity in Soil: Modified from SM 2510 B and CCME Guidance Manual Volume 4, 2016

Mercury in Soil: Modified from EPA 3050B and EPA 1631 Revision E

Metals in Soil by ICP-MS: Modified from EPA 3050B and SM 3125 B

Metals in Soil by ICP-OES (Non-Accredited): Modified from EPA 3050B and SM 3120 B

Moisture Content in Soil: Modified from Canada-wide Method for Petroleum Hydrocarbons in Soil, CCME 2001

pH in Soil: Modified from Soil Sampling & Methods of Analysis, M.R. Carter, 2008 and SM 4500-H+ B

Saturation Percentage of Soil: Modified from Soil Sampling & Methods of Analysis, M.R. Carter, 2008

Specific Gravity / Bulk Density in Soil/Sludge (Non-Accredited): Modified from Soil Sampling & Methods of Analysis, M.R. Carter, 2008 and Directive 05(of the Alberta Energy Regulator, August 2019

Total and Volatile Solids in Soil (Non-Accredited): Modified from SM 2540 B and E

Total Kjeldahl Nitrogen in Soil (Non-Accredited): Modified from SM 4500-N(org) B and D

Final Review by:

Ivory Ringor
Client Services Representative

Test methodologies are accredited in accordance with ISO/IEC 17025 via CALA, unless otherwise specified in the description of the methods .

[1]This analyte is not accredited, even though analyzed by an accredited methodology.

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Analytical Report

Bill To: KaizenLab Inc
#288-2880 - 45 Avenue SE
Calgary, AB, Canada
T2B 3M1
Attn: Accounts Payable
Sampled By: MP
Company:

Project ID: 345087_SUB1
Project Name:
Project Location:
LSD:
P.O.: 126493
Proj. Acct. code:

Lot ID: **1817514**
Control Number:
Date Received: May 29, 2025
Date Reported: Jun 1, 2025
Report Number: 3142614
Report Type: Final Report

Reference Number	1817514-1	1817514-2
Sample Date	May 24, 2025	May 24, 2025
Sample Time	NA	NA
Sample Location		
Sample Description	Cell 1 (345087-1) / 23.5 °C	Cell 2 (345087-2) / 23.5 °C
Matrix	Sludge	Sludge

Analyte		Units	Results	Results	Results	Nominal Detection Limit
Microbiological Analysis						
Thermotolerant (Fecal) Coliforms	MPN	MPN/g	460	3.6		3.0

Approved by:

Mike Yohemas, BSc
General Manager

Data have been validated by Analytical Quality Control and Element's Integrated Data Validation System (IDVS).
Generation and distribution of the report, and approval by the digitized signature above, are performed through a secure and controlled automatic process.

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Quality Control

Bill To: KaizenLab Inc
#288-2880 - 45 Avenue SE
Calgary, AB, Canada
T2B 3M1
Attn: Accounts Payable
Sampled By: MP
Company:

Project ID: 345087_SUB1
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P.O.: 126493
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SPK Value = Spike Value
Ref Value = Reference Value

%REC = Percent Recovery
RPD = Relative Percent Difference

Abs = Absolute Difference

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Methodology and Notes

Bill To:	KaizenLab Inc #288-2880 - 45 Avenue SE Calgary, AB, Canada T2B 3M1	Project ID:	345087_SUB1	Lot ID:	**1817514**
		Project Name:		Control Number:	
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		LSD:		Date Reported:	Jun 1, 2025
Attn:	Accounts Payable	P.O.:	126493	Report Number:	3142614
Sampled By:	MP	Proj. Acct. code:		Report Type:	Final Report
Company:					

Method of Analysis

Method Name	Reference		Method	Date Analysis Started	Location
Coliforms- MPN (Enviro)	APHA	*	Thermotolerant (Fecal) Coliform Procedure, 9221 E	May 29, 2025	Element Calgary

** Reference Method Modified*

References

APHA	Standard Methods for the Examination of Water and Wastewater

Comments:

- Samples received past recommended hold time. Proceeding with analysis as per client note.