



REPORT

Hydrogeological Baseline Assessment

Markdale Treatment and Disposal Facility

Submitted to:

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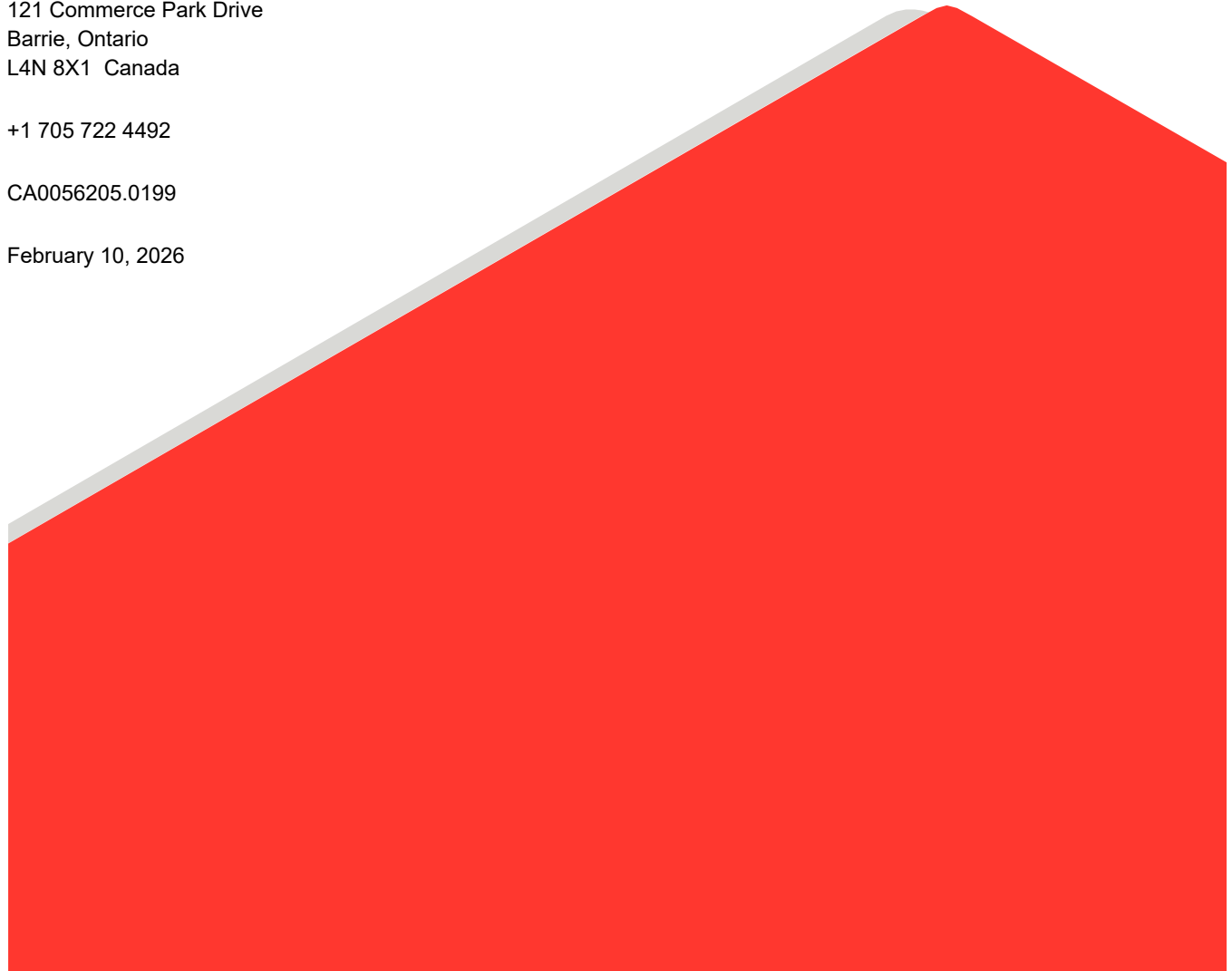
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1.0 INTRODUCTION

WSP Canada Inc. (WSP) was retained by J.L. Richards & Associates Limited (JLR) to provide hydrogeological consulting services in support of the proposed expansion of the Markdale Wastewater Treatment Plant (WWTP), referred to herein as the 'Site'. It is understood that JLR is conducting a Schedule C Municipal Class Environmental Assessment (MCEA) for the Markdale WWTP.

This report should be read in conjunction with the "Important Information and Limitations of This Report" in Appendix A, which forms an integral part of this document. The reader's attention is specifically drawn to this information, as it is essential for the proper use and interpretation of this report. The factual data, interpretations and recommendations contained in this report pertain to a specific project as described in the report and are not applicable to any other project or site location.

2.0 SCOPE OF WORK

The scope of work for the current investigation consisted of:

- Reviewing historical Site data, including groundwater level measurements, borehole and well completion logs, groundwater quality data, facility design plans, and publicly available geological and stratigraphic information;
- Conducting a field investigation at the Site, which consisted of:
 - Completing a drilling program to evaluate geology in locations of potential location of future Rapid Infiltration Basins (RIBs), particularly in areas where information was limited;
 - Install additional monitoring wells in locations near possible future RIB development;
 - Completing hydraulic conductivity testing at the newly installed monitoring wells;
 - Conducting infiltration testing of the shallow soils at the potential RIB locations;
- Updating the conceptual hydrostratigraphic model of the Site, including characterization of the seasonal groundwater fluctuations based off the ongoing field measurements of the monitoring wells on site and the previously installed automatic pressure transducers (data loggers) at select wells;
- Preparation of a report documenting the results of the field program and providing updates with regard to the hydrogeological conditions at the Site.

3.0 SITE BACKGROUND

The Markdale WWTP is owned and operated by the Municipality of Grey Highlands. In 2018, amended Environmental Compliance Approval (ECA) 9653-B5GLKM was issued to increase the Wastewater Treatment Plant's rated capacity from 1,122 m³/d to 1,722 m³/d.

Significant features of the Markdale WWTP are two aerated lagoons (Cells 1 and 2), Parshall flume for flow monitoring and an alum dosing system for phosphorous removal. The treated effluent from the lagoons is discharged to eight RIB which gradually release the treated effluent into the subsurface. Figure 1 illustrates the layout of the lagoons and RIB. The cells, flume and dosing system are located more than 100 m east of the RIB system and are not shown on Figure 1.

Cell 1 was constructed to act as a primary treatment cell, whereas Cell 2 can provide winter storage if needed. Discharge to the RIB occurs during favourable seasonal conditions (between March 1 and November 30, as permitted) and winterized basins are used after November 30. The treated sewage effluent enters each RIB, infiltrates into the underlying granular material, and enters the groundwater system. The treated effluent travels

via advective groundwater flow away from the RIB in a radial pattern to the northwest, west, and southwest (depending on the RIB in question), and emerges as groundwater discharge at or slightly above the Rocky Saugeen River. The objective of the system is to have zero “direct discharge” to the Rocky Saugeen River to protect the river as much as possible due to its high quality and fish and aquatic life habitat (WSP, 2022).

3.1 Topography and Drainage

The Site is located within the Saugeen Conservation Watershed. The topography at the Site is characterized by relatively high elevation ground in the area of the Cells, treatment area and RIB. The ground surface elevation along the RIB varies between approximately 404 to 405 masl. From the RIB the ground slopes downward southwest, west, and northwest into the Rocky Saugeen River valley (DWS 2022). The Rocky Saugeen River is at an elevation of approximately 400 masl along the western edge of the WWTP property. The ground surface elevations at the location of the existing RIB is about 404 masl based on prior surveyed monitoring well data (Novakovic, 1992) and additional surveyed data carried out during the current investigation.

3.2 Geography

Regional geological mapping indicates that the quaternary geology in the Markdale area consists of a mix of glaciofluvial ice-contact deposits (gravel and sand, minor till) and esker, kame, end moraine, ice-marginal delta and subaqueous fan deposits (Quaternary Geology of Ontario, 1991). Within the river valley it is expected that the surficial deposits will consist of organic and modern alluvial deposits associated with the Rocky Saugeen River. The Saugeen Kames are present in the Markdale area, which consist of glaciofluvial ice-contact sand and gravel (Waterloo Hydrogeologic Inc., 2003). Bedrock in the Markdale area, and at the WTP site, is expected to be the Guelph Formation composed of sandstone, shale, dolostone and/or siltstone from the Middle and Lower Silurian period (Bedrock Geology of Ontario, 1991).

Geological conditions at the Site were evaluated based on the results presented in the various historical intrusive investigation reports as well as the current field investigation. Figure 1 indicates the location of historical test pit, borehole, and monitoring well locations, as well as the borehole, monitoring well, and infiltration testing locations of the current investigation. The geological conditions described at the Site in the historical reports were generally consistent with local mapping results from the Ontario Geological Survey (OGS) and the results from the current field investigation. The surficial geology in area of the RIB system and between the RIB and the river has been reported to consist of coarse grained glaciofluvial material. Historical drilling data (Henderson and Paddon, 1981; Golder Associates, 1984) characterizes the surficial deposits at the current RIB as consisting of sand and gravel, with silt, cobbles, and occasional boulders. Deeper drilling in the RIB area notes a sandy silt unit is present underlying the surficial sand and gravel. The sandy silt is in turn underlain by silt till, which is present above the bedrock. Figures 2 through 4 present hydrostratigraphic cross sections of the Site based off information from both the historical and current field investigations.

3.3 Hydrogeology and Groundwater Conditions

Drilling at the Site, both historical report and the current investigation, has resulted in the completion of approximately 65 boreholes / monitoring wells (Figure 1). The majority of the boreholes advanced at the Site were originally completed as monitoring wells. However, based off initial visits to the site, it appeared a majority of the wells in the RIB area were no longer present or could not be located, but a more detailed survey through the area should be done to confirm the presence of all of the historical monitoring wells and their status. Seven groundwater monitoring wells (OW1-86, OW2 86, OW6-86, OW6A86, OW6B-86, OW13-86 and OW16-79), installed between 1979 and 1986, are currently included in the monthly monitoring program. It is understood that these seven monitoring locations were retained as part of the routine monitoring program due to the expectation that they are aligned along the anticipated flow path of the treated effluent from beneath the RIB system toward the river.

Four data loggers were installed at the Site in 2024 to collect (semi)continuous water level readings at OW1 86, OW2-85, OW4 85, and OW6B-86. Appendix B provides groundwater hydrographs for each well, along with the available manual water level readings. The manual water level measurements collected at the Site between May 1, 2024 and October 28, 2025 are provided in Appendix C. Notably, three out of the four monitored wells show regular response to the loading cycles of the RIB, while the fourth location (OW4-85) is in the covered basin operating continuously which shows a steady water level with minimal fluctuations.

Seeps have been noted in the past along the slope between the RIB and the Rocky Saugeen River (Douglas Water Services, 2022), particularly at Sta. TP3 79 and CW2 (see Figure 1). Both these seep locations are incorporated into the routine monitoring program. The seeps are considered to represent locations where the shallow groundwater table intersects the ground surface for at least a portion of the year, leading to local discharge. It is expected that the shallow groundwater flow pattern across the area roughly mimics topography, with lateral groundwater flow away from the topographic high areas toward the low-lying Rocky Saugeen River.

4.0 2025 DRILLING INVESTIGATION METHODS AND RESULTS

A drilling investigation was completed at the Site on September 25 and 26, 2025. Five boreholes (BH25-1 to BH25-5) were advanced by Altech Drilling and Investigative Service, out of Cambridge, Ontario, under the supervision of WSP field staff, using a Geoprobe 7822T track-mount drilling rig. Initially, hollow stem augers were used to drill through the material for BH25-5, however due to difficulties drilling through the material from the high cobble content, the drillers switched afterwards to percussive drilling methods to reach target depth at each location. The drillers then over drilled using solid stem augers once the target depth was reached in order to widen the hole for monitoring well installation. Representative soil samples were collected periodically during drilling at each borehole using auger cuttings or from continuous direct push sampling. At each location during drilling, groundwater was encountered between 2.7 m to 4.3 m at BH25-1 through 4, and 1.2 m at BH25-5.

Three of the boreholes, BH25-1, BH25-4, and BH25-5, were completed as monitoring wells. Each monitoring well was constructed using 50 mm diameter, schedule 40, polyvinyl chloride well screens and riser pipe. The borehole annular space was backfilled with silica filter sand around each screened interval, and the sand placed a height of at least 0.4 m above the top of the well screen. The remaining annular space was backfilled with bentonite hole plug to grade and was completed with a monument style protective well casing. The borehole logs, showing the geological information and well completion details, can be found in Appendix D. Data loggers were installed at each of the monitoring wells following completion of the drilling program.

Overburden conditions encountered during the 2025 drilling program were considered to be consistent with prior investigations and regional geological mapping of the area. To summarize the stratigraphic data from the drilling:

- Topsoil: 0.1 to 0.4 m thick present at surface, generally composed of silty sand loam. Topsoil was also noted at a depth of 2 meters at BH25-4, which was likely the original grade of that area.
- Fill: 0.8 to 1.6 m thick, when present, composed of silty sand and cobbles.
- Sand/Sand and Gravel: uppermost native material, with a thickness ranging from 0.3 m to 4.7 m, to a maximum depth of 6.1 m
- Sandy Silt: found to be located below the cobbly sand, starting from 2.10 mbgs, 2.7 mbgs, and 5.5 mbgs to the maximum depth of investigation at boreholes 25-5, 25-4, and 25-3 respectively.

The geology at each of the three investigation areas was found to be relatively similar. Area 2 featured relatively thick surficial fill deposits compared to Areas 1 and 3 (Figures 2 to 4). Groundwater levels at each of the new wells were noted to be consistent with historical readings at wells within the existing monitoring well network.

Table 1 below provides a summary of the groundwater level measurements collected to date at the newly installed monitoring wells. Appendix C provides a full list of the manual groundwater level measurements collected at the Site in support of the planned RIB expansion assessment since May 2024.

Table 1: Water Levels from 2025 Monitoring Wells

Well ID	Date	Water Level (mbtop)	Water Level (mbgs)	Water Level (masl)
BH25-1	26-Sept-25	4.25	3.20	400.68
	28-Oct-25	4.06	3.01	400.87
BH25-4	26-Sept-25	3.2	2.15	400.85
	28-Oct-25	3.73	2.68	401.37
BH25-5	26-Sept-25	1.82	0.85	400.62
	28-Oct-25	1.86	0.89	400.58

Notes: mbtop – meters below top of pipe

mbgs – meters below ground surface

masl – meters above sea level

The depth to groundwater at Areas 1 and 2 ranged from about 2 to 3 m below current grade. At Area 3 (BH25 5) the depth to groundwater was notably shallower compared to the rest of the Site, which was attributed to the lower ground surface elevation in Area 3.

4.1 Hydraulic Conductivity Testing

Single-well response testing was conducted by WSP on October 28, 2025, at each of the newly installed monitoring wells to estimate the bulk hydraulic conductivity of the soils adjacent to the screened intervals. The testing was carried out by rapidly purging the standing water in each well with a dedicated Waterra tube and foot valve and monitoring the subsequent water level recovery by collecting manual water level measurements.

The water level data was analyzed using the Bouwer-Rice (1976) method for unconfined conditions. The analysis was completed using the AQTESOLV for Windows version 4.50 Professional software. The single-well response test analyses and the AQTESOLV printouts are provided in Appendix E. The results of the hydraulic conductivity testing were:

- BH25-1 (Sand and Gravel to Cobbly Sand): 5.3×10^{-8} m/s
- BH25-4 (Cobbly Sand to Sandy Silt): 6.0×10^{-7} m/s
- BH25-5 (Cobbly Sand): 2.2×10^{-6} m/s

The geometric mean hydraulic conductivity for the cobbly sand/sand and gravel unit was calculated to be 4.1×10^{-7} m/s. The results of the hydraulic conductivity testing are lower than what might be expected based on the apparent grain size distribution of the overburden deposits (i.e., relatively coarse-grained material). One possible explanation could be that the unit is naturally cemented which would reduce the porosity of the soil in turn slowing the rate of transmissivity in the soil.

4.2 Infiltration Testing Results

Soil infiltration rate testing was conducted using a Guelph Permeameter (Soilmoisture Equipment Corp. Model 2800K1) in accordance with the procedures outlined by the manufacturer (Soilmoisture Equipment Corp., 2012) using a combined head method. Testing was conducted at the potential expansion areas 1 and 2 (Figure 1) to evaluate the infiltration capacity of the shallow native overburden deposits in these areas.

The field testing was carried out on October 28, 2025. Boreholes were advanced at GP1 and GP2 using hand tools (i.e., pickaxe, hand auger) to a depth of 0.43 m and 0.9 m, respectively. GP1 was completed at a shallower depth due to auger refusal from the large volume of cobbles in the material near surface. Groundwater was not encountered at either of the test locations. Once the Guelph Permeameter unit was installed at the testing depth (bottom of the borehole), the outflow of water was maintained until a steady state flow rate was achieved.

The field-saturated hydraulic conductivity, K_{fs} , of the soil was estimated using following equation (Elrick et. al., 1989):

$$K_{fs} = \frac{C_1 Q_1}{2 \pi H_1^2 + \pi a^2 C_1 + 2 \pi \frac{H_1}{\alpha^*}}$$

Where: C_1 = shape factor

Q_1 = flow rate (cm^3/s)

H_1 = water column height (cm)

a = well radius (cm)

α^* = alpha factor (0.04 cm^{-1} to 0.36 cm^{-1})

The infiltration rate (mm/hr) of the overburden material was estimated using the calculated K_{fs} (cm/s) and the approximate relationship and safety factors presented in the Low Impact Development Stormwater Management Planning and Design Guide (TRCA, 2010).

Infiltration testing results, presented as data reports, are provided in Appendix E and are summarized in Table 2 below. The calculated K_{fs} values ranged from $3.6 \times 10^{-4} \text{ cm/s}$ ($3.6 \times 10^{-6} \text{ m/s}$) to $5.4 \times 10^{-4} \text{ cm/s}$ ($5.4 \times 10^{-6} \text{ m/s}$) for the native cobbly silty sand. Based on the relationship comparison presented in TRCA (2010), the calculated saturated conductivity rates correspond to estimated uncorrected infiltration rates of about 35 to 39 mm/hr. In accordance with the approach outlined in TRCA (2010), applying a default safety correction factor of 2.5 to the estimated infiltration rate, the estimated design infiltration rates range from 14 to 15.6 mm/hr.

Table 2: Infiltration Testing Results

Test Location	Test	Soil Unit	Saturated Hydraulic Conductivity (cm/s)	Estimated Infiltration Rate (mm/hr)	Safety Factor	Design Infiltration Rate (mm/hr)
GP1	Shallow	Cobbly Sandy Silt	5.4E-04	39	2.5	15.6
GP2	Shallow	Cobbly Silty Sand	3.6E-04	35	2.5	14

5.0 SUMMARY AND CONCLUSIONS

To summarize the 2025 investigation and results:

- The overburden conditions noted at the 2025 drilling locations were consistent with what had been noted during historical investigations. The stratigraphic profile was found to consist of surficial deposits of topsoil and fill, overlying native sand and gravel and sandy silt deposits.
- Groundwater conditions at the newly installed wells ranged from 0.85 meters below ground surface (400.62 masl) to 3.25 meters below ground surface (400.63 masl). It is anticipated that groundwater level fluctuations in the potential development areas will be broadly similar to the conditions noted in the existing well network.
- Single well testing results at the newly installed monitoring wells indicated the hydraulic conductivity of the test overburden material ranged from 5.3×10^{-8} m/s to 2.2×10^{-6} m/s. These values were lower than might be expected for the relatively coarse-grained material encountered, particularly at the lower end of the measured range.
- Infiltration testing results showed that the saturated hydraulic conductivity values ranged from 3.6×10^{-6} m/s to 5.4×10^{-6} m/s, which when compared against the TRCA guidelines correlate to 35 to 39 mm/hr uncorrected, or 14 to 15.6 mm/hr when a safety factor of 2.5 is applied.

The most recent groundwater level data collected at the Site shows the influence of effluent discharge at the RIB on the shallow groundwater levels, with maximum changes in groundwater level adjacent to the RIB on the order of 0.7 m. Seasonal fluctuations in the groundwater level in the shallow overburden were measured to be on the order of 1.5 m.

With regard to potential future RIB expansion at the Site:

- **Area 1** – overburden conditions in Area 1 were found to be generally similar to the conditions noted in historical reports at the location of the current RIB features. The layout in Area 1 is considered amenable to development, consisting of open, grassed spaces, with tree clusters, and occasional mounds thought to be waste piles associated with construction of the current RIB. Figure 1 provides a schematic layout of potential future RIB locations. While the actual RIB locations would be expected to depend on operational considerations and future development plans, Area 1 is considered to be the best candidate of the three investigated areas for future expansion of the RIB system.
- **Area 2** – the stratigraphic profile in Area 2 featured relatively thick fill deposits, which are understood to be associated with excavation of Lagoon Cell 1 (Figure 1). The available space in Area 2 is relatively limited, due to the presence of the rail trail and Lagoon Cell 1. As shown in Figure 1, potential RIB features in this area may need to be oriented along the slope (assuming dimensions consistent with the current RIB), which would increase in the construction requirements to maintain a horizontal bed surface.
- **Area 3** – the drilling results in Area 3 suggest the uppermost sand and gravel unit is relatively thin in this location, with a relatively small separation between current grade and the water table. The decline in topography in this area (Figure 4) would require additional fill to support any future RIB development. In addition, Area 3 currently has substantial tree cover, which would require additional effort to prepare the area for RIB construction. The existing slope in Area 3 is also the steepest of the three areas, and any RIB located in this area would be closer to the river than the current RIB. For all these reasons, Area 3 is considered the least suitable of the three areas for future development.

- The relatively low hydraulic conductivity and measured infiltration rates for the shallow coarse grained deposits suggest the native material may not be suitable for use in construction of new RIB features. This is consistent with the findings of the historical investigations supporting the design of the current RIB features. The design of the current RIB features involved over-excavation of the native material, followed by replacement with engineered design receiving soils.

As noted above, a series of data loggers were installed at the new monitoring wells to assess the long-term groundwater level fluctuations at each of the investigation Areas. It is intended that the groundwater level data be assessed following the spring freshest to provide information that will inform future RIB development (e.g., seasonal high groundwater levels, the effect of on-going effluent disposal).

6.0 CLOSURE

We trust that the information presented in this report meets your current requirements. If you have any questions or require additional information, please do not hesitate to contact the undersigned at your convenience.

Signature Page

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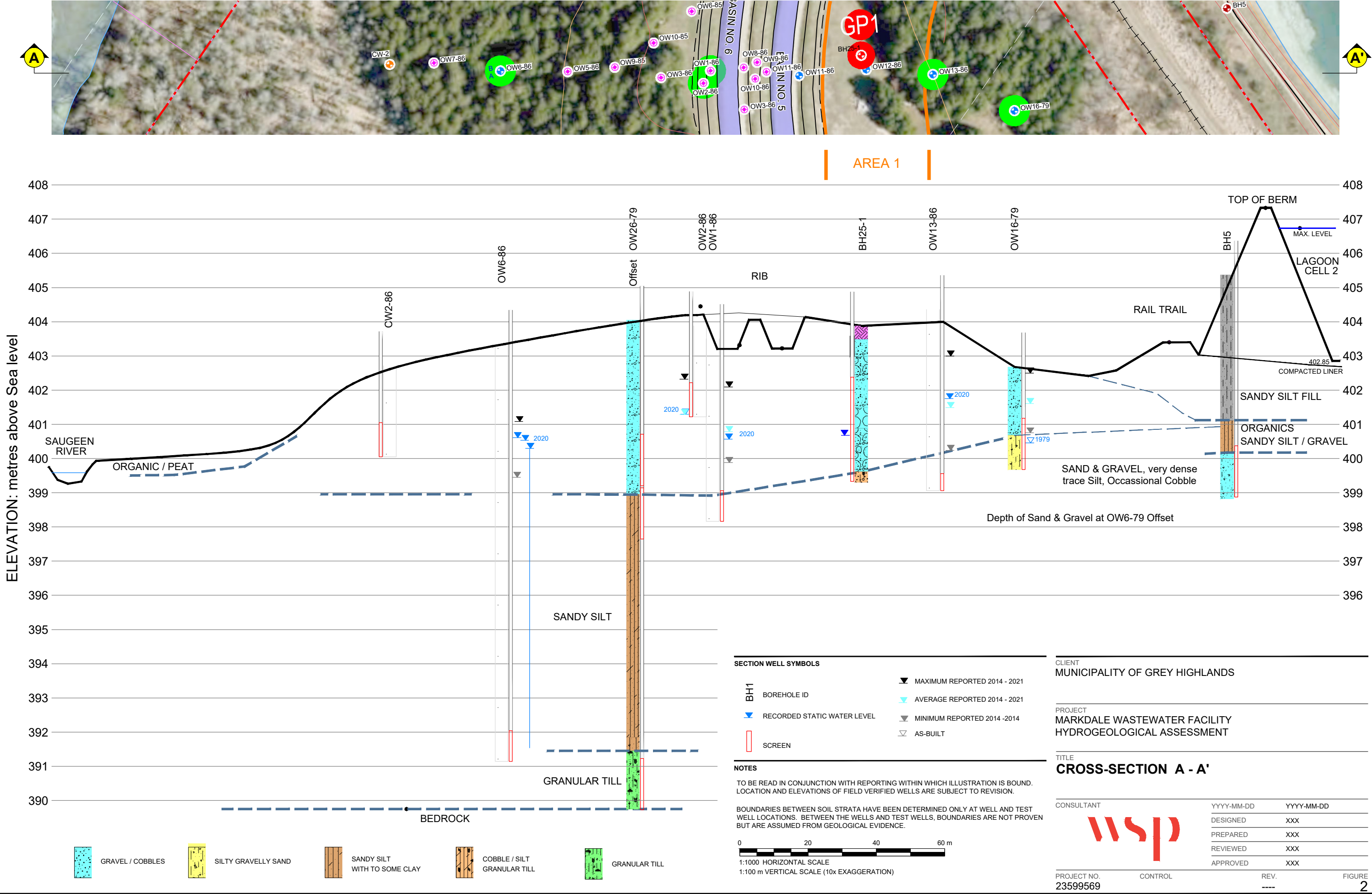
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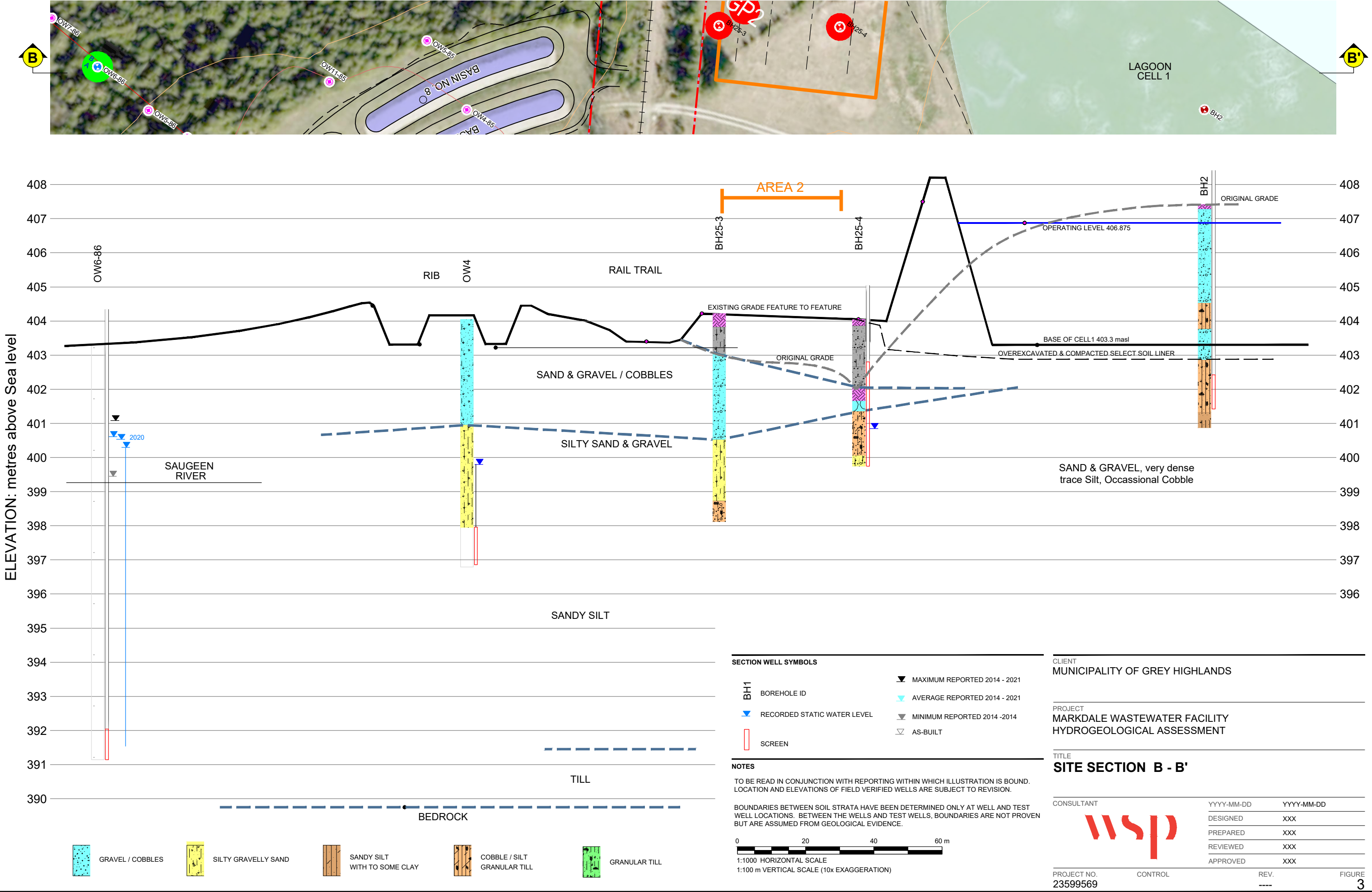
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Figures

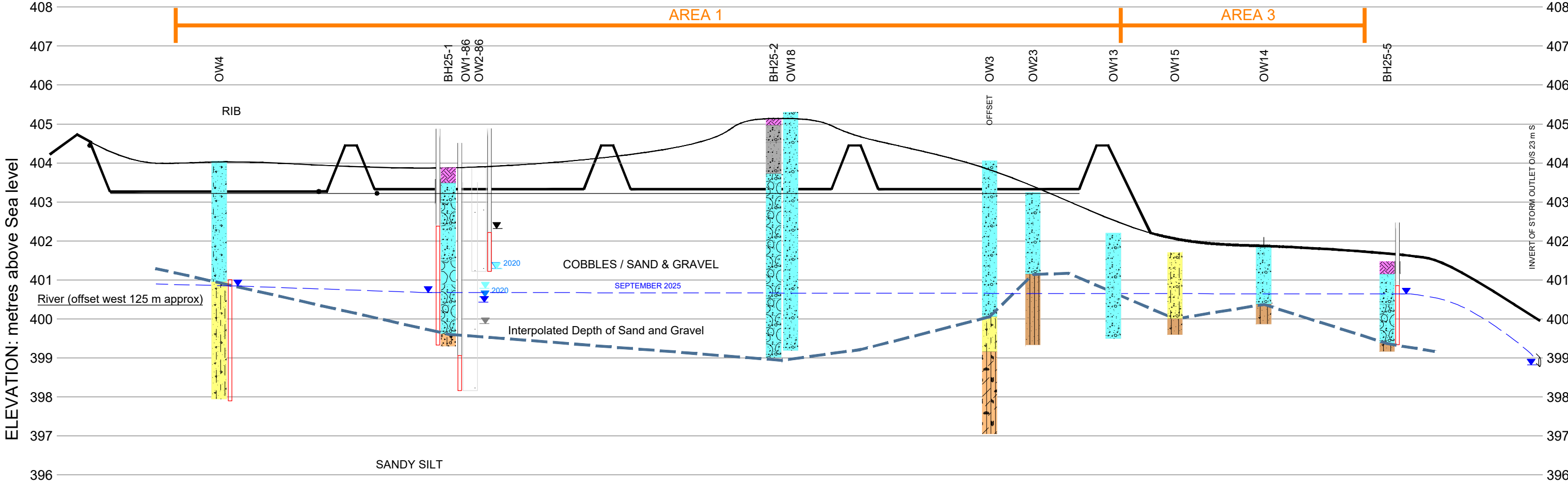
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SECTION WELL SYMBOLS

BH1 BOREHOLE ID

RECORDED STATIC WATER LEVEL

SCREEN

FLOWING WELL

AS BUILT / PREVIOUS STATIC

NOTES

TO BE READ IN CONJUNCTION WITH REPORTING WITHIN WHICH ILLUSTRATION IS BOUND. LOCATION AND ELEVATIONS OF FIELD VERIFIED WELLS ARE SUBJECT TO REVISION.

BOUNDARIES BETWEEN SOIL STRATA HAVE BEEN DETERMINED ONLY AT WELL AND TEST WELL LOCATIONS. BETWEEN THE WELLS AND TEST WELLS, BOUNDARIES ARE NOT PROVEN BUT ARE ASSUMED FROM GEOLOGICAL EVIDENCE.

CLIENT

MUNICIPALITY OF GREY HIGHLANDS

PROJECT

MARKDALE WASTEWATER FACILITY
HYDROGEOLOGICAL ASSESSMENT

TITLE

SITE SECTION C - C'

CONSULTANT	YYYY-MM-DD	YYYY-MM-DD
DESIGNED	XXX	
PREPARED	XXX	
REVIEWED	XXX	
APPROVED	XXX	

PROJECT NO. 23599569 **CONTROL** **REV.** **FIGURE** 4

LEGEND

GRAVEL / COBBLES

SILTY GRAVELLY SAND

SANDY SILT WITH TO SOME CLAY

COBBLE / SILT GRANULAR TILL

GRANULAR TILL

SCALE

0 20 40 60 m

1:1000

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM A4 (210 x 297 mm) TO A3 (297 x 420 mm)

APPENDIX A

**Important Information and
Limitations of this Report**



IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

WSP Canada Inc. ("WSP") prepared this report solely for the use of the intended recipient, J.L. Richards & Associates Limited, the (Client), in accordance with the professional services agreement between the parties. In the event a contract has not been executed, the parties agree that the WSP General Terms for Consultant shall govern their business relationship which was provided to you prior to the preparation of this report.

The report is intended to be used in its entirety. No excerpts may be taken to be representative of the findings in the assessment.

The conclusions presented in this report are based on work performed by trained, professional and technical staff, in accordance with their reasonable interpretation of current and accepted engineering and scientific practices at the time the work was performed.

The content and opinions contained in the present report are based on the observations and/or information available to WSP at the time of preparation, using investigation techniques and engineering analysis methods consistent with those ordinarily exercised by WSP and other engineering/scientific practitioners working under similar conditions, and subject to the same time, financial and physical constraints applicable to this project.

WSP disclaims any obligation to update this report if, after the date of this report, any conditions appear to differ significantly from those presented in this report; however, WSP reserves the right to amend or supplement this report based on additional information, documentation or evidence.

WSP makes no other representations whatsoever concerning the legal significance of its findings.

The intended recipient is solely responsible for the disclosure of any information contained in this report. If a third party makes use of, relies on, or makes decisions in accordance with this report, said third party is solely responsible for such use, reliance or decisions. WSP does not accept responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken by said third party based on this report.

WSP has provided services to the intended recipient in accordance with the professional services agreement between the parties and in a manner consistent with that degree of care, skill and diligence normally provided by members of the same profession performing the same or comparable services in respect of projects of a similar nature in similar circumstances. It is understood and agreed by WSP and the recipient of this report that WSP provides no warranty, express or implied, of any kind. Without limiting the generality of the foregoing, it is agreed and understood by WSP and the recipient of this report that WSP makes no representation or warranty whatsoever as to the sufficiency of its scope of work for the purpose sought by the recipient of this report.

In preparing this report, WSP has relied in good faith on information provided by others, as noted in the report. WSP has reasonably assumed that the information provided is correct and WSP is not responsible for the accuracy or completeness of such information.

Benchmark and elevations used in this report are primarily to establish relative elevation differences between the specific testing and/or sampling locations and should not be used for other purposes, such as grading, excavating, construction, planning, development, etc.

Design recommendations given in this report are applicable only to the project and areas as described in the text and then only if constructed in accordance with the details stated in this report. The comments made in this report on potential construction issues and possible methods are intended only for the guidance of the designer. The number of testing and/or sampling locations may not be sufficient to determine all the factors that may affect construction methods and costs. We accept no responsibility for any decisions made or actions taken as a result of this report unless we are specifically advised of and participate in such action, in which case our responsibility will be as agreed to at that time.

Overall conditions can only be extrapolated to an undefined limited area around these testing and sampling locations. The conditions that WSP interprets to exist between testing and sampling points may differ from those that actually exist. The accuracy of any extrapolation and interpretation beyond the sampling locations will depend on natural conditions, the history of Site development and changes through construction and other activities. In addition, analysis has been carried out for the identified chemical and physical parameters only, and it should not be inferred that other chemical species or physical conditions are not present. WSP cannot warrant against undiscovered environmental liabilities or adverse impacts off-Site.

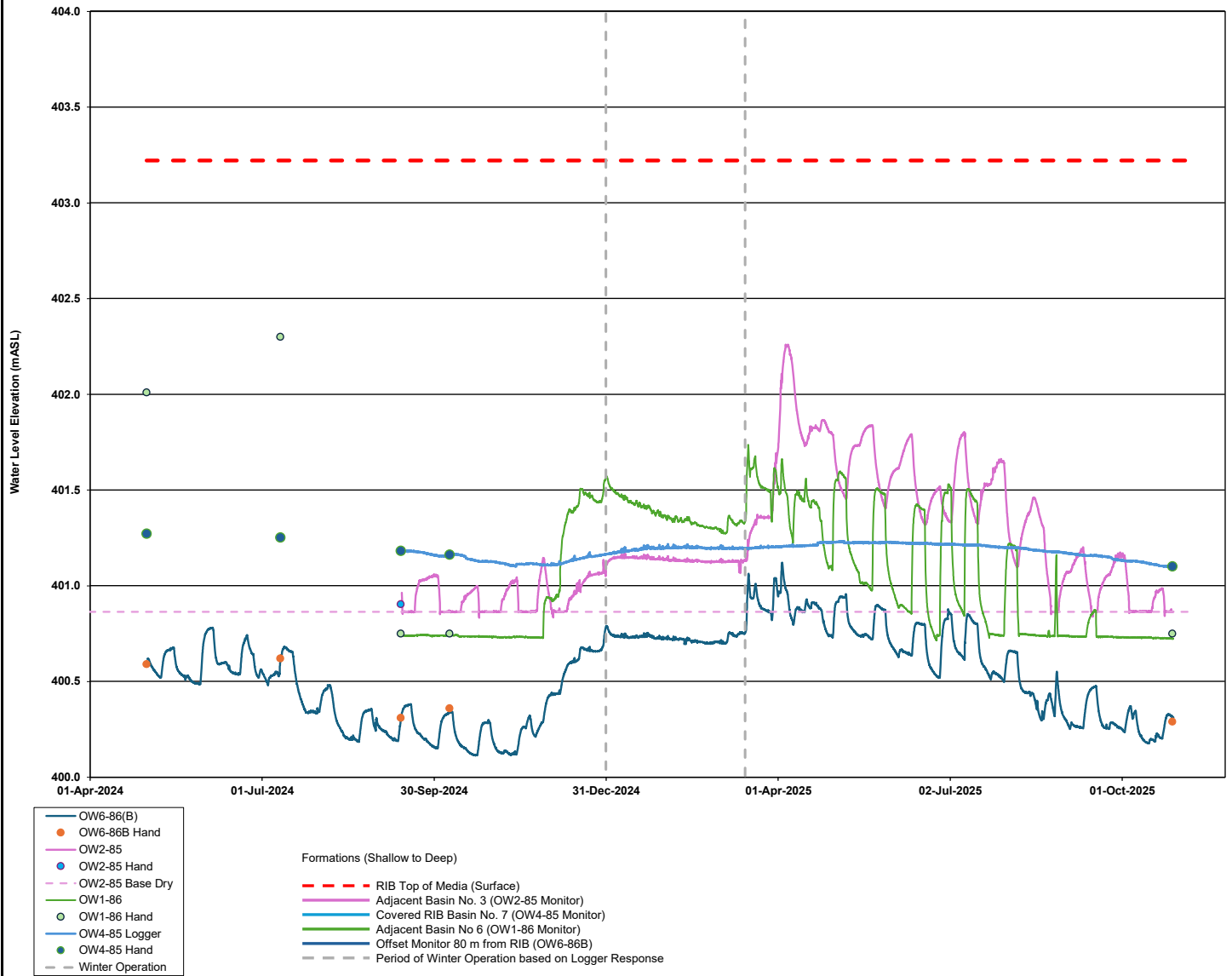
The original of this digital file will be kept by WSP for a period of not less than 10 years. As the digital file transmitted to the intended recipient is no longer under the control of WSP, its integrity cannot be assured. As such, WSP does not guarantee any modifications made to this digital file subsequent to its transmission to the intended recipient.

This limitations statement is considered an integral part of this report.

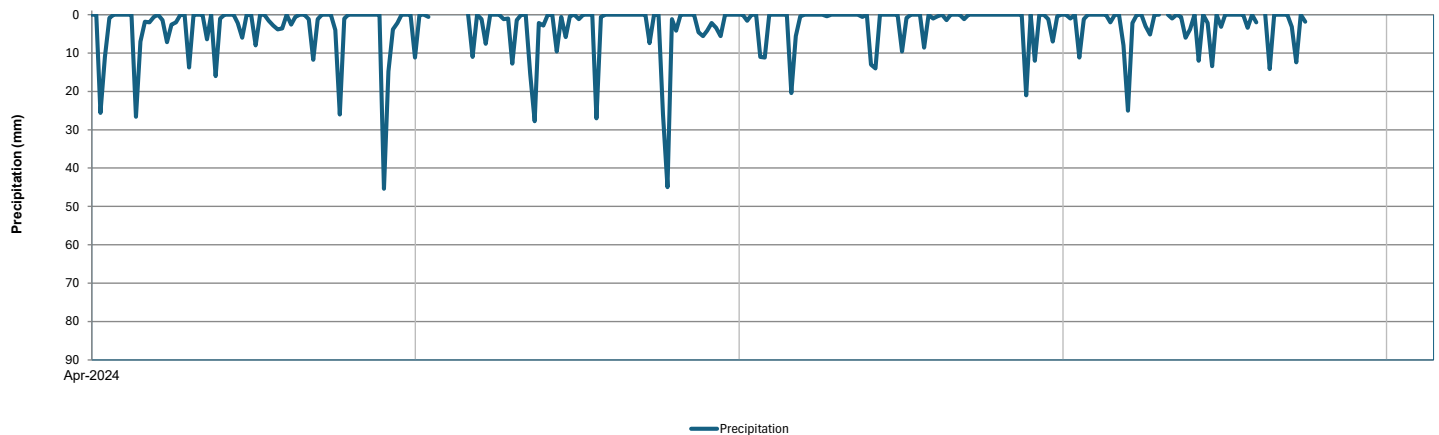
APPENDIX B

Groundwater Hydrograph

Water Level Hydrograph: Selected Monitors by Elevation



Graph of Precipitation



CLIENT MARKDALE SEWAGE LAGOONS		PROJECT HYDROGEOLOGICAL INVESTIGATIONS	
CONSULTANT 	YYYY-MM-DD	2025-03-30	TITLE GROUNDWATER ELEVATIONS AT MONITORING WELLS:
	PREPARED		
	DESIGN	JPR	
	REVIEW		
	APPROVED		
	PROJECT No.	CA0024804.6519	Task: 2100
			Rev
			FIGURE
			4

APPENDIX C

Water Level Table

Well ID	Borehole Depth (mbgs)	Top of Casing Elevation (masl)	Stick up (m)	Measurement Date	Water Level (mbtoc)	Water Level (mbgs)	Water Level (masl)
OW6-86A	7.61	404.0	0.67	01-May-24	3.26	2.59	400.71
				11-Jul-24	3.48	2.81	400.49
				13-Sep-24	3.74	3.07	400.23
				09-Oct-24	3.71	3.04	400.26
				28-Oct-25	3.76	3.09	400.21
OW6-86B	4.55	404.0	0.72	01-May-24	3.47	2.75	400.54
				11-Jul-24	3.44	2.72	400.57
				13-Sep-24	3.75	3.03	400.26
				09-Oct-24	3.7	2.98	400.31
				28-Oct-25	3.77	3.05	400.24
OW6-86	12.04	403.9	0.63	01-May-24	3.68	3.05	400.24
				11-Jul-24	3.71	3.08	400.21
				13-Sep-24	4.05	3.42	399.87
				09-Oct-24	3.94	3.31	399.98
				28-Oct-25	3.97	3.34	399.95
OW2-86	3.01	404.5	0.31	01-May-24	3.32	3.01	401.14
				11-Jul-24	2.08	1.77	402.38
				13-Sep-24	Dry	>3.01	-
				09-Oct-24	Dry	>3.01	-
				28-Oct-25	Dry	>3.01	-
OW1-86	3.52	405.4	1.05	01-May-24	4.36	3.31	401.06
				11-Jul-24	4.07	3.02	401.35
				13-Sep-24	Dry	>3.52	-
				09-Oct-24	Dry	>3.52	-
				28-Oct-25	Dry	>3.52	-
OW4-85	3.61	405.6	1.06	01-May-24	4.17	3.11	401.42
				11-Jul-24	4.19	3.13	401.40
				13-Sep-24	4.26	3.20	401.33
				09-Oct-24	4.28	3.22	401.31
				28-Oct-25	4.34	3.28	401.25
OW6-86C	2.59	404.2	0.84	01-May-24	3.29	2.45	400.86
				11-Jul-24	Dry	>2.59	-
				13-Sep-24	Dry	>2.59	-
				09-Oct-24	Dry	>2.59	-
				28-Oct-25	Dry	>2.59	-
OW2-85	3.00	404.0	0.10	13-Sep-24	2.92	2.82	401.06
				09-Oct-24	Dry	>3.00	-
				28-Oct-25	Dry	>3.00	-
BH25-1	4.57	404.9	1.05	26-Sep-25	4.25	3.20	400.68
				28-Oct-25	4.06	3.01	400.87
BH25-4	4.30	405.1	1.05	26-Sep-25	4.25	3.20	400.85
				28-Oct-25	3.73	2.68	401.37
BH25-5	2.30	402.4	0.97	26-Sep-25	1.82	0.85	400.62
				28-Oct-25	1.86	0.89	400.58

Notes:

1. mbtoc meters below top of casing
2. masl meters above sea level
3. mbgs meters below ground surface
4. Table to be read in conjunction with accompanying report

APPENDIX D

Borehole Logs

PROJECT: CA0056205
LOCATION: N 4907539.60; E 526594.00

RECORD OF BOREHOLE: BH25-1

SHEET 1 OF 1
DATUM: Geodetic

BORING DATE: 26-Sep-2025
DRILL RIG: Geoprobe

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION										
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT PERCENT														
								20		40		60		80				10 ⁻⁶		10 ⁻⁵		10 ⁻⁴		10 ⁻³		
								SHEAR STRENGTH Cu, kPa		nat V. rem V.		+ ⊕		Q - U -				● ○		Wp		W		Wi		
								20	40	60	80					10	20	30	40							
0		GROUND SURFACE		403.88																						
	2" DP & 4" SS Geoprobe	TOPSOIL, silty, soft; brown (LOAM)		0.00																						
		SAND & COBBLES / Granular Stone, coarse		403.48 0.40																						
				402.98 0.90																						
1		COBBLES / Granular Stone, sand, coarse		402.38 1.50																						
		SAND and GRAVEL, Stone, coarse		401.48 2.40																						
		COBBLES, Crushed Granular Stone in DP Sleeve, sand and trace silt; White		400.88 3.00																						
3		COBBLES / Granular Stone, sand, coarse; grey		399.61 4.27																						
				399.31 4.57																						
		End of Direct Push Sampling																								
5																										
6																										
7																										
8																										
9																										
10																										

26-Sep-2025



PROJECT: CA0056205
LOCATION: N 4907469.60; E 526599.40

RECORD OF BOREHOLE: BH25-2

SHEET 1 OF 1
DATUM: Geodetic

BORING DATE: 25-Sep-2025
DRILL RIG: Geoprobe

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES			DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m										
								20 40 60 80				10 ⁻⁶ 10 ⁻⁵ 10 ⁻⁴ 10 ⁻³					
								SHEAR STRENGTH Cu, kPa		nat V. + Q - rem V. ⊕ U - ●		WATER CONTENT PERCENT					
0	6" HS Geoprobe	GROUND SURFACE		405.12													
		TOPSOIL - silty sandy LOAM; brown		0.00													
		FILL - Sand and COBBLES / Granular Stone, with organics, large cobble		0.16													
		FILL - Sand and COBBLES / Granular Stone, with organics		404.52 0.60													
1	2" DP Geoprobe	COBBLES, Sand and Granular Stone, coarse grained		403.72													
				1.40													
2																	
3																	
4																	
5		COBBLES, Sand and Granular Stone, finer at depth		400.52 4.60													
6																	
6		End of Direct Push Sampling		399.02 6.10													
7																	
8																	
9																	
10																	



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PROJECT: CA0056205
LOCATION: N 4907658.50; E 526630.60

RECORD OF BOREHOLE: BH25-3

SHEET 1 OF 1
DATUM: Geodetic

BORING DATE: 26-Sep-2025
DRILL RIG: Geoprobe

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m										
				DEPTH (m)				SHEAR STRENGTH		WATER CONTENT PERCENT							
								Cu, kPa	nat V. rem V.	+ ⊕	Q - U -	● ○	Wp	W			Wi
							20	40	60	80		10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³		
0		GROUND SURFACE		404.22													
	2" DP Geoprobe	TOPSOIL - silty sandy LOAM; brown		0.00													
		FILL - Silty COBBLES / Granular Stone, sand and gravel		403.82 0.40													
1																	
		COBBLES / Granular Stone & Sand, coarse grained; lens of silt at 3.6 m		403.02 1.20													
2																	
3																	
		SAND / Cobbly Granular Stone, some to trace fines		400.52 3.70													
4																	
5																	
		SANDY SILT / Silty sandy, Granular Stone		398.72 5.50													
6																	
		End of Direct Push Sampling		398.12 6.10													
7																	
8																	
9																	
10																	

DEPTH SCALE
1 : 50



LOGGED: JPR
CHECKED:

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PROJECT: CA0056205
LOCATION: N 4907678.60; E 526659.90

RECORD OF BOREHOLE: BH25-4

SHEET 1 OF 1
DATUM: Geodetic

BORING DATE: 26-Sep-2025
DRILL RIG: Geoprobe

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT PERCENT																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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								SHEAR STRENGTH Cu, kPa		nat V. rem V.		+ ⊕		Q - U -			● ○		Wp		W		Wi																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										

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PROJECT: CA0056205
LOCATION: N 4907372.20; E 526704.60

RECORD OF BOREHOLE: BH25-5

SHEET 1 OF 1
BORING DATE: 25-Sep-2025
DATUM: Geodetic

DRILL RIG: Geoprobe

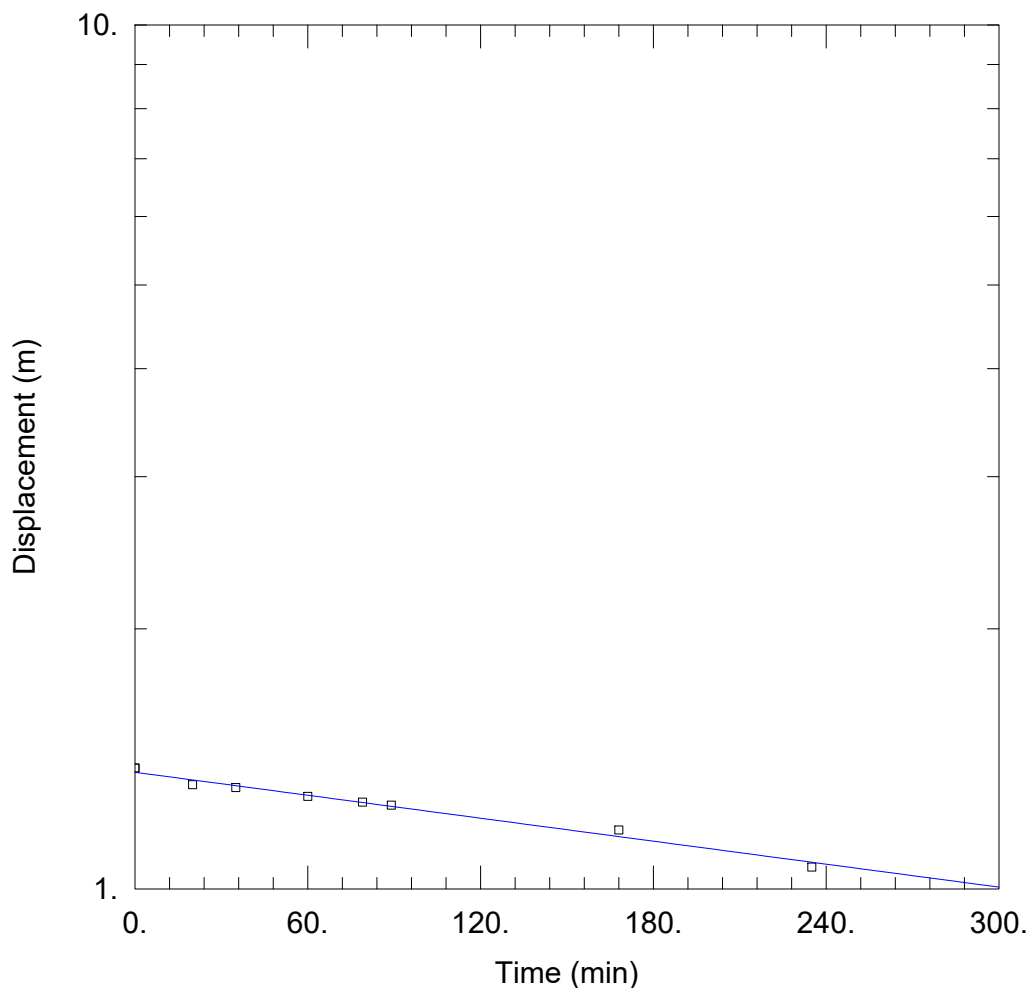
DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV.	NUMBER	TYPE	BLOWS/0.3m	20 40 60 80				10 ⁻⁶ 10 ⁻⁵ 10 ⁻⁴ 10 ⁻³					
				DEPTH (m)				SHEAR STRENGTH Cu, kPa	nat V. rem V.	+ ⊕	Q - U -	● ○	WATER CONTENT PERCENT Wp — W — WI				
								20	40	60	80		10	20	30	40	
0	6" HS Geoprobe	GROUND SURFACE		401.47													
		TOPSOIL (33 cm), Silty LOAM; brown		0.00													
				401.14													
		SILTY SAND, cobbles / granular stone; Grey		0.33													
				400.37													
1		COBBLES / Granular Stone, sand trace silt, coarse		1.10													
2				399.37													
		SANDY SILT, Occasional cobble / granular stone; brown		2.10													
		End of Borehole		399.17													
				2.30													
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

Bentonite Holeplug
Well Sand
26-Sep-2025
10 Slot PVC Screen



APPENDIX E

Hydraulic Conductivity Results



WELL TEST ANALYSIS

Data Set: C:\Users\gld_cimrie\OneDrive - WSP O365\Documents\Markdale\BH25-1.aqt

Date: 10/31/25

Time: 12:13:52

PROJECT INFORMATION

Company: WSP Canada Inc

Client: J.L. Richards & Associates Ltd

Project: CA0056205.0199

Location: Markdale

Test Date: 28-October-2025

AQUIFER DATA

Saturated Thickness: 1.49 m

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (BH25-1)

Initial Displacement: 1.38 m

Static Water Column Height: 1.49 m

Total Well Penetration Depth: 4.49 m

Screen Length: 3. m

Casing Radius: 0.03 m

Well Radius: 0.1 m

Gravel Pack Porosity: 0.3

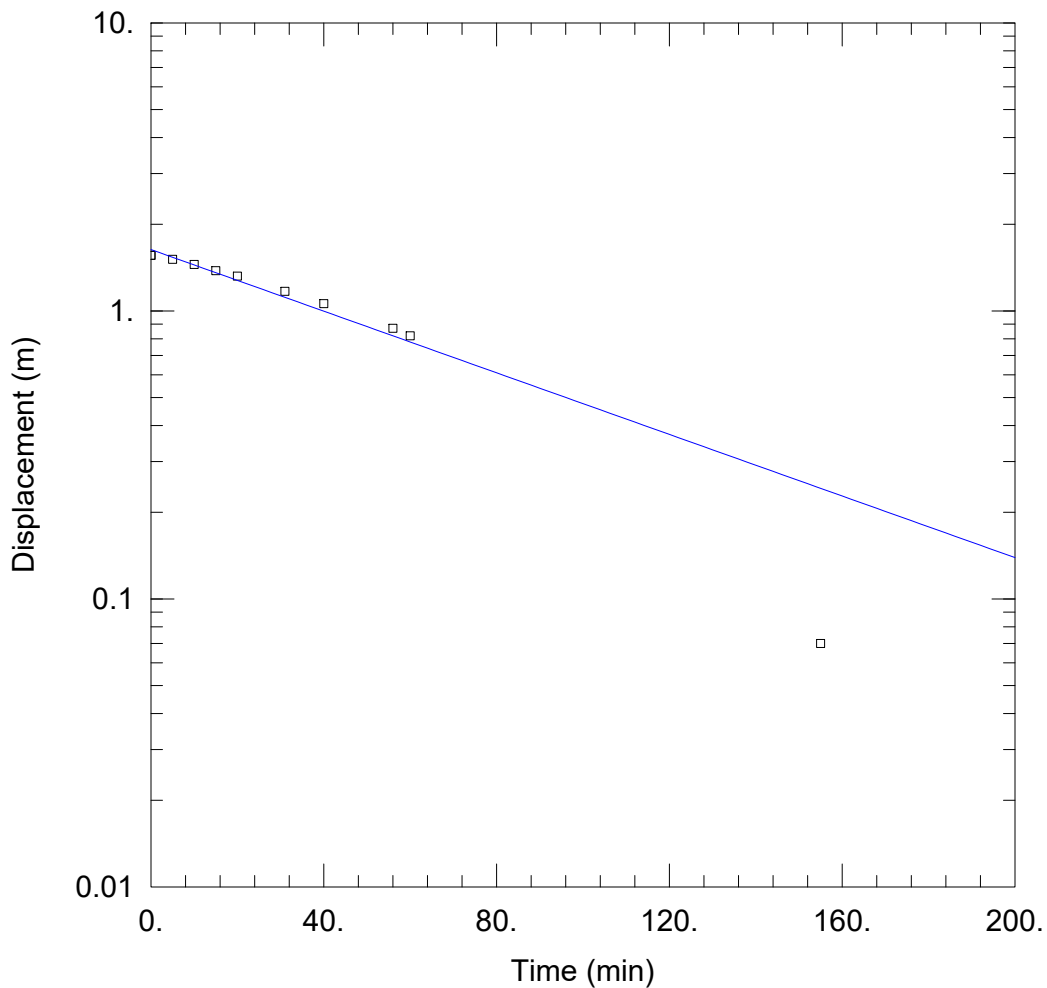
SOLUTION

Aquifer Model: Unconfined

Solution Method: Bouwer-Rice

$K = 5.319E-8$ m/sec

$y_0 = 1.365$ m



WELL TEST ANALYSIS

Data Set: C:\Users\gld_cimrie\OneDrive - WSP O365\Documents\Markdale\BH25-4.aqt
 Date: 10/31/25 Time: 12:17:50

PROJECT INFORMATION

Company: WSP Canada Inc
 Client: J.L. Richards & Associates Ltd
 Project: CA0056205.0199
 Location: Markdale
 Test Date: 28-October-2025

AQUIFER DATA

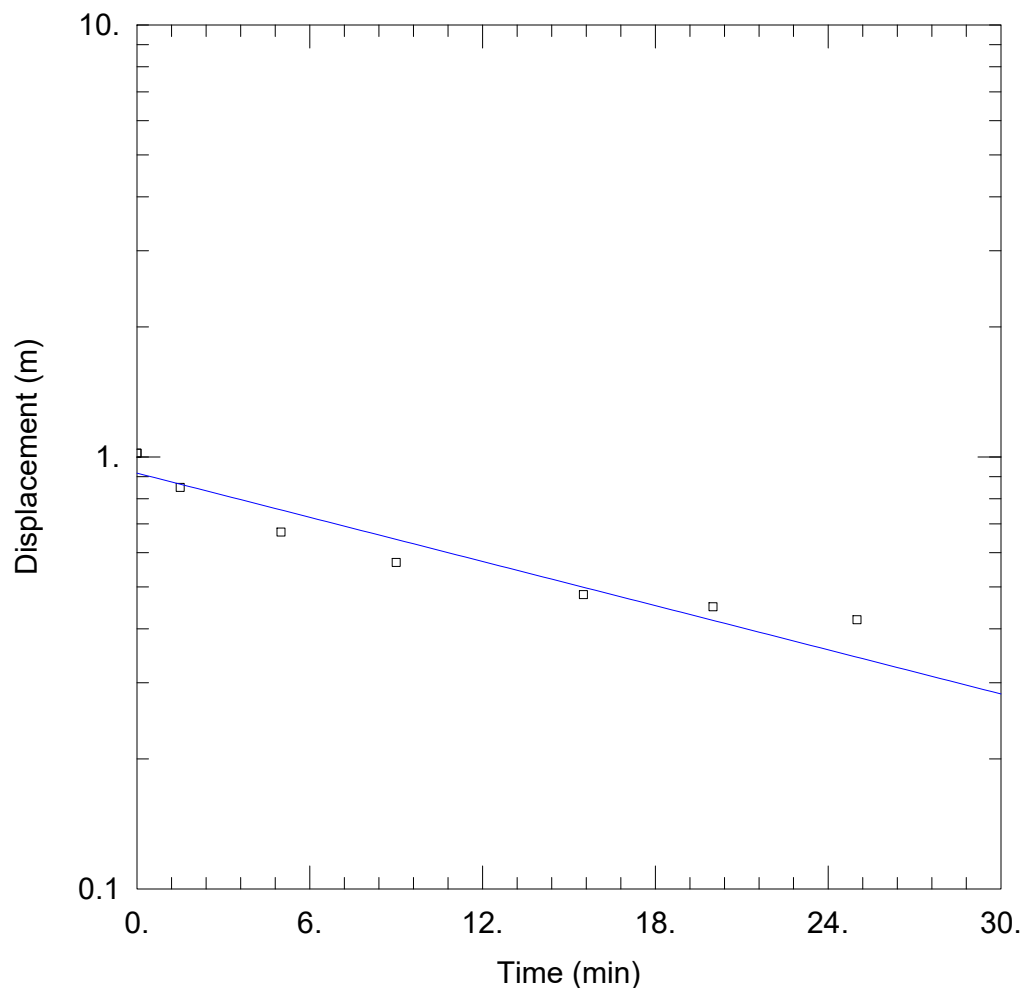
Saturated Thickness: 1.62 m Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (BH25-4)

Initial Displacement: 1.56 m Static Water Column Height: 1.62 m
 Total Well Penetration Depth: 4.72 m Screen Length: 3.1 m
 Casing Radius: 0.03 m Well Radius: 0.1 m
 Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice
 $K = 6.044E-7$ m/sec $y_0 = 1.633$ m



WELL TEST ANALYSIS

Data Set: C:\Users\gld_cimrie\OneDrive - WSP O365\Documents\Markdale\BH25-5.aqt

Date: 10/31/25

Time: 12:21:13

PROJECT INFORMATION

Company: WSP Canada Inc

Client: J.L. Richards & Associates Ltd

Project: CA0056205.0199

Location: Markdale

Test Date: 28-October-2025

AQUIFER DATA

Saturated Thickness: 1.21 m

Anisotropy Ratio (K_z/K_r): 1.

WELL DATA (BH25-5)

Initial Displacement: 1.02 m

Static Water Column Height: 1.21 m

Total Well Penetration Depth: 2.71 m

Screen Length: 1.5 m

Casing Radius: 0.03 m

Well Radius: 0.1 m

Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined

Solution Method: Bouwer-Rice

$K = 2.191E-6$ m/sec

$y_0 = 0.9173$ m

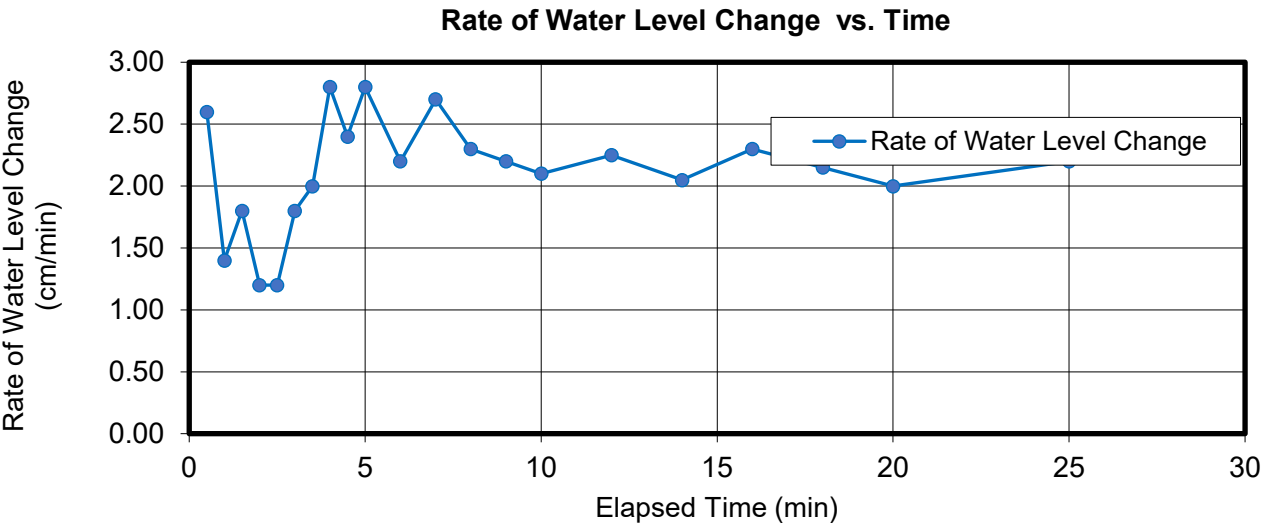
APPENDIX F

Infiltration Testing Results

Constant Head Permeameter Test Report - INF25-1

Test Depth: 0.43 m

Figure F-1



Elapsed Time (min)	Water Level in Reservoir (cm)	Water Level Change (cm)	Infiltration (cm/min)
0	11.00	-	-
0.5	12.30	1.30	2.60
1.0	13.00	0.70	1.40
1.5	13.90	0.90	1.80
2.0	14.50	0.60	1.20
2.5	15.10	0.60	1.20
3.0	16.00	0.90	1.80
3.5	17.00	1.00	2.00
4.0	18.40	1.40	2.80
4.5	19.60	1.20	2.40
5.0	21.00	1.40	2.80
6.0	23.20	2.20	2.20
7.0	25.90	2.70	2.70
8.0	28.20	2.30	2.30
9.0	30.40	2.20	2.20
10.0	32.50	2.10	2.10
12.0	37.00	4.50	2.25
14.0	41.10	4.10	2.05
16.0	45.70	4.60	2.30
18.0	50.00	4.30	2.15
20.0	54.00	4.00	2.00
25.0	65.00	11.00	2.20

Soil Type -Sandy Silt and cobbles

Interpreted Rate of:

Water Level Change (R_1) = 3.6.E-02 cm/s

Steady Intake Water Rate (Q_1) = 1.3E+00 cm³/s

hole radius (a) = 3 cm

Water column height in hole (H_1) = 15 cm

Shape factor for H_1/a = (C_1) = 1.63 -

soil type: Type 2 α^* = 0.04 cm⁻¹

Single Head Analysis

$$K_{fs} = \frac{C_1 Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi \frac{H_1}{a^2}}$$

Field Saturated Hydraulic Conductivity (K_{fs})

K_{fs} = 5.4E-04 cm/s

=input data

Reservoir type: Combined

DATE: 28 Oct 2025

PROJECT: CA0056205.0199



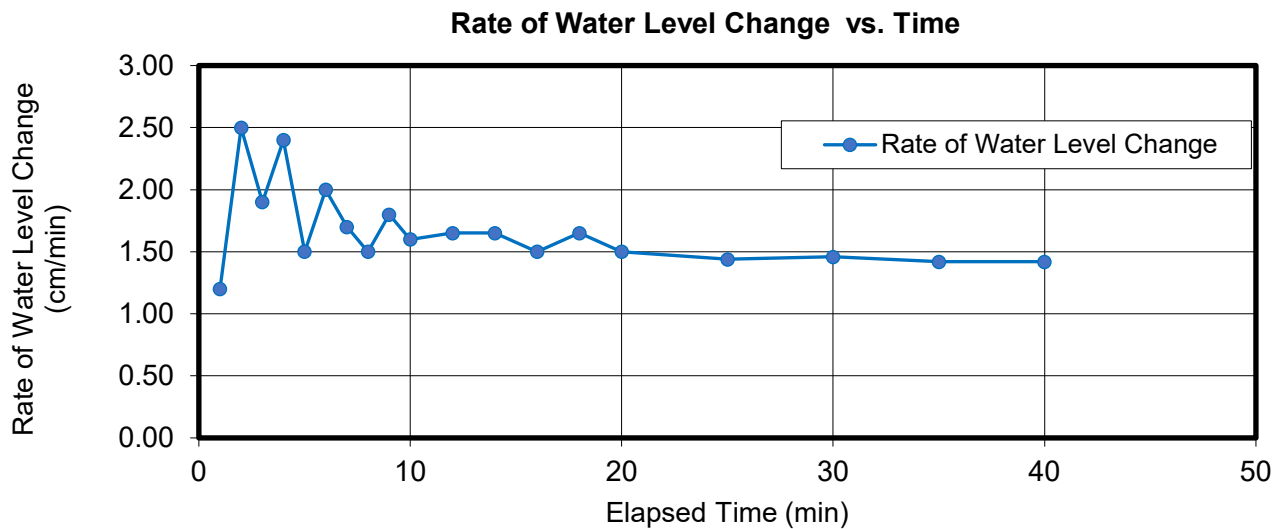
DRAWN: CI

REVIEW: DD

Constant Head Permeameter Test Report - INF25-2

Test Depth: 0.9m

Figure F-2



Elapsed Time (min)	Water Level in Reservoir (cm)	Water Level Change (cm)	Infiltration (cm/min)
0.0	11.50	-	-
1.0	12.70	1.20	1.20
2.0	15.20	2.50	2.50
3.0	17.10	1.90	1.90
4.0	19.50	2.40	2.40
5.0	21.00	1.50	1.50
6.0	23.00	2.00	2.00
7.0	24.70	1.70	1.70
8.0	26.20	1.50	1.50
9.0	28.00	1.80	1.80
10.0	29.60	1.60	1.60
12.0	32.90	3.30	1.65
14.0	36.20	3.30	1.65
16.0	39.20	3.00	1.50
18.0	42.50	3.30	1.65
20.0	45.50	3.00	1.50
25.0	52.70	7.20	1.44
30.0	60.00	7.30	1.46
35.0	67.10	7.10	1.42
40.0	74.20	7.10	1.42

Soil Type - Silty sand, some cobbles

Interpreted Rate of:

Water Level Change (R_1) = 2.4.E-02 cm/s

Steady Intake Water Rate (Q_1) = 8.5E-01 cm³/s

hole radius (a) = 3 cm

Water column height in hole (H_1) = 15 cm

Shape factor for H_1/a = (C_1) = 1.63 -

soil type: Type 2 α^* = 0.04 cm⁻¹

Single Head Analysis

$$K_{fs} = \frac{C_1 Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi \frac{H_1}{\alpha^*}}$$

Field Saturated Hydraulic Conductivity (K_{fs})

K_{fs} = 3.6E-04 cm/s

=input data

Reservoir type: Combined

DATE: 28 Oct 2025

PROJECT: CA0056205.0199



DRAWN: CI

REVIEW: DD

