OLT-23-000534
OLT-23-000939
OLT-23-000940

ONTARIO LAND TRIBUNAL

PROCEEDING COMMENCED UNDER subsection 22(7) of the *Planning Act,* R.S.O. 1990, c. P.13, as amended.

Applicant and Appellant:	Caivan (Perth GC) Limited
Subject:	Request to amend the Official Plan – Failure to adopt the re-quested amendment
Description:	To permit 940 single detached dwellings and townhomes, a nine-hole golf course, park and open space areas
Reference Number:	OPA-01-2023
Property Address:	141 Peter Street, Part of Lots 26 & 27, Concession 1, Part Lots 25, 26 & 27, Concession 2, Geographic Township of Bathurst, and Part Lot 1 in Southeast Half Lot 1, Concession 1, Part Lot 1 in Southwest Half Lot 1, Concession 2, Geographic Township of Drummond, now in the Town of Perth, County of Lanark
Municipality/UT:	Town of Perth / County of Lanark
OLT Case No.:	OLT-23-000939
OLT Lead Case No.:	OLT-23-000534

PROCEEDING COMMENCED UNDER subsection 34(11) of the *Planning Act,* R.S.O. 1990, c. P.13, as amended.

Applicant and Appellant:	Caivan (Perth GC) Limited
Subject:	Application to amend the Zoning By-law – Refusal or neglect to make a decision
Description:	To permit 940 single detached dwellings and townhomes, a nine-hole golf course, park and open space areas
Reference Number:	ZBL-03-2023
Property Address:	141 Peter Street, Part of Lots 26 & 27, Concession 1, Part Lots 25, 26 & 27, Concession 2, Geographic Township of Bathurst, and Part Lot 1 in Southeast Half Lot 1, Concession 1, Part Lot 1 in Southwest Half Lot 1, Concession 2, Geographic Township of Drummond, now in the Town of Perth, County of Lanark
Municipality/UT:	Town of Perth / County of Lanark
OLT Case No.:	OLT-23-000940

PROCEEDING COMMENCED UNDER subsection 51(34) of the *Planning Act,* R.S.O. 1990, c. P.13, as amended.

Applicant and Appellant:	Caivan (Perth GC) Limited
Subject:	Proposed Plan of Subdivision – Failure of Approval Authority to make a decision
Description:	To permit 940 single detached dwellings and townhomes, a nine-hole golf course, park and open space areas
Reference Number:	09-T-22001

OLT-23-000534
OLT-23-000939
OLT-23-000940

Property Address:	141 Peter Street, Part of Lots 26 & 27, Concession 1, Part Lots 25, 26 & 27, Concession 2, Geographic Township of Bathurst, and Part Lot 1 in Southeast Half Lot 1, Concession 1, Part Lot 1 in Southwest Half Lot 1, Concession 2, Geographic Township of Drummond, now in the Town of Perth, County of Lanark
Municipality/UT:	Town of Perth / County of Lanark
OLT Case No.:	OLT-23-000534
OLT Lead Case No.:	OLT-23-000534
OLT Case Name:	Caivan (Perth GC) v Lanark County

Witness Statement of Andrius Paznekas, M.Sc., P.Geo.

Qualifications

1. I am a Professional Geoscientist (P.Geo.) as designated by Professional Geoscientists Ontario (PGO). I have more than eight years of experience as a consulting hydrogeologist and have been a practicing member of PGO since 2019 (Member 3154). I obtained my Honours Bachelor of Science degree in Earth and Environmental Science from McMaster University and my Master's Degree from the University of Calgary specializing in geology and geophysics.

2. I am currently employed as a hydrogeologist with GEMTEC Consulting Engineers and Scientists Limited (GEMTEC). GEMTEC is a consulting company of engineers and geoscientists providing consulting services to a range of clients in both the private and public sector.

3. My consulting experience includes hydrogeological assessments in support of land development on both private (well and septic) and municipal services, construction dewatering, environmental monitor programs, and peer review services for public sector clients.

4. My curriculum vitae is attached to this witness statement as Appendix "A". A copy of my Acknowledgement of Expert Duty is attached as Appendix "B".

Retainer

5. GEMTEC Consulting Engineers and Scientists Limited (GEMTEC) was retained by Caivan (Perth GC) Limited in 2021 to complete geotechnical, environmental and hydrogeological investigations for the proposed development.

6. As part of this retainer I prepared a hydrogeological investigation to characterize the geologic and hydrogeologic conditions of the subject site, prepared a pre- to post-development water balance and a hydrogeological conceptual model to assess the potential impacts of land development to nearby groundwater and surface water features, specifically Tay River and the Grants Creek Wetland Complex. I worked with J.F. Sabourin and Associated Inc. (JFSA), Kilgour & Associates Ltd. (Kilgour), and Schaeffer David Engineering Ltd (DSEL) to prepare an Integrated Hydrologic Impact Assessment, which assesses the potential impacts from the land development to Tay River and Grants Creek

Wetland Complex through a multi-disciplinary approach, i.e., jointly considering groundwater, surface water, and ecological site characterization.

7. As part of this retainer, I prepared the following reports:

   a. "Hydrogeological Investigation, Proposed Residential Development, 141 Perth Street, Perth, Ontario" dated February 22, 2023 and prepared by GEMTEC. A copy of this report is attached as Appendix "C".

   b. "Grants Creek Wetland Integrated Hydrologic Impact Assessment, Perth Western Annex Lands" dated March, 2023 and jointly prepared by J.F. Sabourin and Associated Inc. (JFSA), GEMTEC, Kilgour & Associates Ltd. (Kilgour), and Schaeffer David Engineering Ltd (DSEL). A copy of this report is attached as Appendix "D".

      i. My contributions are to Sections 2.2, 3.2, 4.1 and 5.3.

Documents Reviewed

8. As part of this retainer and in preparation for my evidence, I reviewed the following documents:

   a. GEMTEC, 2023. Geotechnical Investigation, Proposed Residential Development, 141 Peter Street, Ottawa, Ontario. Project 100737.002, February 3, 2023.

   b. GEMTEC, 2022. Phase Two Environmental Site Assessment, Perth Golf Course, 141 Peter Street, Perth, Ontario. Project 100737.002, April 8, 2022.

   c. Ontario Ministry of the Environment, Storm Water Management Planning and Design Manual, March 2003.

   d. Credit Valley Conservation (CVC), Toronto and Region Conservation Authority (TRCA). 2010. Low Impact Development Stormwater Management Planning and Design Guide.

   e. J.D. Barnes, 2024. Draft Plan of Subdivision (Sheets 1, 2 and 3 of 3). Dated June 12, 2024.

Issues

9. The issues that I will address in this witness statement include the following:

a. Have the potential impacts of the Tay River and Grant's Creek floodplains been adequately addressed for the proposed subdivision?

Hydrogeological Setting

10. GEMTEC has prepared a hydrogeological conceptual model, an illustration of which is available in Figures 5 and 6 of the hydrogeological investigation report, attached in Appendix "C". The hydrogeological setting was characterized by GEMTEC after a review of publicly available resources and a field investigation program. The resources consulted included the Ontario Data Catalogue, Ministry of the Environment, Conservation and Parks (MECP) Water Well Record Database, Ontario Geologic Survey mapping and Mississippi-Rideau Source Protection Regions Assessment Reports. The field program consisted of advancing 52 test holes across the site. GMTEC installed 24 monitoring wells at the site during the field investigation to allow for water level monitoring and hydraulic conductivity testing. The locations of the test holes are shown on Figure 1 ('Site Plan') of Hydrogeological Report for test hole and monitoring well locations, attached in Appendix "C".

11. In general, subsurface conditions on the Site consist of topsoil or peat (wetland), stiff silty clay, overlying silty sand and gravel with cobbles and boulders (glacial till), above bedrock. Surficial soil thicknesses are variable across the Site with exposed bedrock forming high points and 1 to 3 m of overburden in the low areas between bedrock knolls. The surface of the bedrock drops off to the northwest towards the Tay River where the overburden thickness exceeds 7 m.

12. The topography across the Site is variable with prominent knolls rising 4 to 6 m above low-lying areas. A west-east oriented surface water divide transects the proposed development area and surface water drainage north of the divide flows to the Tay River and the area south of the divide drains into the Grants Creek Wetland, a Provincially Significant Wetland (PSW).

13. The general local-scale site hydrogeology can be divided into three units as follows:

- Unit 1: Shallow- glacial till water table unit (including peat and clay in wetland)
- Unit 2: Upper, heterogeneously fractured bedrock (RQD 0 to 100%)
- Unit 3: Deeper relatively competent, fractured bedrock (RQD >75%)

14. The hydrogeological system at the Site is interpreted as an unconfined to leaky aquifer system (refer to 'Conceptual Site Model' Figures 5 and 6 of the Hydrogeological Investigation Report, attached in Appendix "C"). In general, the measurements of hydraulic conductivities for the glacial till and the underlying upper bedrock are comparable. The connectivity between the overburden and upper bedrock are expected to vary spatially across the Site depending on the presence and significance of bedrock fractures and the presence of any lower hydraulic conductivity confining beds above the bedrock. However, with generally similar water level elevations, the two upper geological units frequently act as one hydrostratigraphic unit, and their connection would be influenced locally by zones of higher sand content in the glacial till or fractures and weathering in the upper bedrock unit.

15. Based on hydraulic testing, calculated hydraulic conductivity values for the bedrock range from less than 1×10^{-7} to 9×10^{-5} metres per second with a geometric mean of 2×10^{-6} metres per second. The bedrock is locally weathered / fractured and is inferred to become progressively more competent with depth. The hydraulic conductivity of the overburden is similar to that of the bedrock, ranging from 2×10^{-7} to 3×10^{-6} metres per second, with a geometric mean of 8×10^{-7} metres per second.

16. Groundwater levels were monitored over a multi-season period and ranged from ground surface to approximately 4.9 m below ground surface. In general, groundwater was encountered at shallow depths and slight downward gradients (recharge conditions) were noted along the high areas and slight upward gradients (discharge conditions) were noted in lower-lying areas. Interflow pathways are likely strongly influenced by surface topography and bedrock fractures, and the surface water divides can be used as a proxy for shallow groundwater divides.

17. The lowest measured groundwater elevation is by the Grants Creek Wetland near the southeastern portion of the Site. Poorly drained native peat and clay deposits underlie the swampy areas present within the Grants Creek Wetland and will constrain or perch the shallow surface water and groundwater exchange with the underlying hydrostratigraphic units, thereby reducing direct groundwater discharge from the Site to the Grants Creek Wetland. Deeper groundwater flow may be isolated from the Grants Creek Wetland. This interpretation is corroborated by soil characterisations within the adjacent wetland area and biological species surveys.

18. The study completed by GEMTEC has sufficiently characterized the subsurface conditions at the site in order to complete an impact assessment on natural features on and adjacent to the site, including Tay River and Grants Creek Wetland Complex.

Water Balance

19. A pre to post development water balance was competed to assess the potential impacts of land development on the local groundwater conditions, which indicates that post-development surface water runoff is greater than infiltration (refer to Water Balance Summary Table 4.11 in the Hydrogeological Investigation Report, attached in Appendix "C").

20. It is our evaluation that the post-development surface water runoff will potentially increase on the order of 405 mm/year and 385 mm/year for the Tay River and Grants Creek subwatersheds, respectively. Without mitigation measures the post-development infiltration to groundwater will be reduced on the order of 102 mm/year and 86 mm/year for the Tay River and Grants Creek subwatersheds, respectively. Low Impact Development (LID) features are proposed to infiltrate groundwater post-development, which shall address this issue.

21. The hydrogeological conceptual model suggests that surface water overland flow and interflow (e.g., rapid vadose zone transport and/or exfiltration to the shallow subsurface following infiltration) are the primary contributors of water to the Grants Creek Wetland and Tay River from the Site; these flowpaths are considered together as runoff, as described by Fetter (2001). Most of the infiltration reduction post-development, much of which would otherwise go to interflow, will be captured by stormwater management ponds (SWMPs). SWMPs will be designed to control the runoff volumes and travel times to the downstream receivers to emulate pre-development function.

22. The proposed LID measures will be designed to closely reflect pre-development infiltration and are proposed throughout the site to treat, attenuate, and distribute outflows from the development to the wetland (refer to Section 5.4.1. of the Integrated Hydrologic Impact Assessment, attached in Appendix "D").

Impact Assessment

23. The proposed development, with the implementation of Low Impact Development (LID) features, will not affect the natural features and functions supported by groundwater resources.

24. The water from the subject site is primarily being received by the Grants Creek Wetland via overland surface processes or interflow pathways. Deeper groundwater pathways contributing to the wetland are likely limited by the clay base of the wetland and its low conductivity relative to its underlying materials, thus perching and separating the local groundwater flow systems. Glacial till and fractured bedrock beneath the clay layer may encourage groundwater flow paths to be horizontal beneath the Grants Creek Wetland Complex. As such, it is our interpretation that any reduction in infiltration or baseflow recharge caused by the proposed development will not significantly alter the volume of water currently sustaining the key processes of the Grants Creek Wetland.

25. Estimates of annual groundwater discharge (baseflow) into the Tay River catchment upstream of the development areas were calculated using available water level information from the stream gauge in the Tay River at Perth Station. The results fall within the upper range of published data for the region (21 percent) and are likely skewed higher by surface water released during low flow periods from dam-controlled storage reservoirs in the watershed that are designed to maintain water levels in the Rideau Canal system.

26. Long-term water level monitoring data provides evidence that notable volumes of water are draining horizontally, rather than infiltrating deeper, due to limited storage and infiltration capacity across the Site. Deep groundwater recharge will be limited by the on-site bedrock, which was identified to be locally weathered and fractured, that likely becomes progressively less vertically transmissive with depth. Further, it is believed that the extent and hydraulic capacity of fractures within the upper bedrock layers influence how water is directed horizontally over the area proposed for development. The significance of horizontal drainage is further evidenced by rapidly declining water levels in wells following infiltration events (i.e., peaks in water level) that may indicate exfiltration or horizontal migration of stormwater downgradient.

Summary Opinion to the Tribunal

27. Based on my assessment, it is my professional opinion that the proposed development will not impact the Tay River, Grants Creek Wetland Complex or hydrogeological regime of the subject site, provided that the recommended Low Impact Development (LID) measures are incorporated. Significant changes to the Grants Creek and Tay River contributions from groundwater are not anticipated with the implementation of LID measures. The proposed

stormwater management plan for the subject site, which incorporated LID measures, will maintain the pre-development infiltration to the fullest extent possible.

28. The recommended mitigation measures to preserve the pre-development hydrogeological regime include the following:

a. Stormwater management measures and LIDs that function to control rapid runoff and allow for release volumes and rates similar to the pre-development conditions will be used to supplement and support the ecologic function and long-term sustainability of the wetland and Tay River.

b. LID features with subdrains (to allow for overflow during seasonally high groundwater levels in the spring) and unlined SWMPs with naturalized outlets. This SWMP and LID design is stipulated to function analogously to the pre-development conditions, wherein deep infiltration is limited and highly localized to irregularly distributed vertical bedrock fractures, and excess water that cannot be received by the subsurface system becomes runoff.

29. A revised Draft Plan of Subdivision, prepared by J.D. Barnes dated June 12, 2024 was provided to GEMTEC following completion of the hydrogeological investigation report. The revised Draft Plan of Subdivision includes updated wetland limits and newly proposed bridge crossing, which do not change the conclusions or recommendations provided in the hydrogeological investigation report.

30. Based on the foregoing, and relying upon the hydrogeological investigations undertaken by GEMTEC, I am of the opinion that there are no hydrogeological impediments to development of the site as contemplated by the updated draft plan of subdivision. I am recommending low-impact techniques to maintain groundwater recharge in effort to reduce the impact of increased impervious surfaces on the Site as a result of the proposed development. I do not find that there will be an impact on the groundwater flows that currently feed/sustain existing wetland features on the Site. I will be in attendance before the Tribunal to answer any relevant questions concerning the attached reports (Appendix C and D), the contents of this WS and the contents of any WS or other evidence filed by parties opposite.

Andrius Paznekas, M.Sc., P.Geo. June 12, 2024

60398176.1

APPENDIX A

ANDRIUS PAZNEKAS M.SC., P.Geo.

Hydrogeologist

EDUCATION

M.Sc. Geology and Geophysics
University of Calgary
2016

Hon. B.Sc. Earth & Environmental Science
McMaster University
2012

LICENCES & REGISTRATIONS

Licensed Professional Geoscientist, Ontario

AFFILIATIONS

National Ground Water Association

Andrius Paznekas is a hydrogeologist and hydrogeological team lead in GEMTEC's Ottawa office. He is a licensed Professional Geoscientist practicing in the field of physical hydrogeology. Andrius has eight years of applied consulting experience for a broad range of hydrogeological investigations, including hydrogeological site characterizations for land development and infrastructure projects, water supply and septic impact investigations (private and communal residential and commercial/industrial systems), peer-review services, quarry investigations and construction dewatering assessments.

His role includes the coordination and completion of various hydrogeological studies, including the supervision / coordination of borehole drilling, logging, well installation, hydraulic conductivity testing, sampling, and preparation of documentation reports for the results of these studies.

Andrius has provided technical guidance and review of Permit To Take Water (PTTW) applications, and hydrogeological reporting for Environmental Activity Sector Registry (EASR).

PROJECT EXPERIENCE

Hydrogeological Investigation for Residential Development, Perth, ON - Hydrogeologist providing technical support for a hydrogeological investigation of a proposed municipally serviced residential development in Perth, Ontario. The project included a hydrogeological field program and site characterization, pre- and post-development water budget assessments on a site-wide and feature-specific basis, evaluation of baseline groundwater conditions, assessment of subsurface infiltration feature feasibility, assess groundwater contribution to rivers and wetlands, and assessment of potential hydrogeological impacts. The subsurface field program was coordinated with a geotechnical investigation.

Hydrogeological Investigation for Residential Development, Limoges, ON - Hydrogeologist and technical reviewer for a hydrogeological investigation of a proposed municipally serviced residential development in Limoges, Ontario. The project includes a hydrogeological field program and site characterization, assessment of potential hydrogeological impacts to adjacent South Indian creek and local private water wells, and evaluation of long-term and temporary construction dewatering requirements. The subsurface field program was coordinated with a geotechnical investigation.

Geotechnical Investigation for Residential Development, Petawawa, ON – Hydrogeologist for a hydrogeological assessment for a residential development on municipal water and sewage services. Providing technical input for hydrogeological site characterization, hydraulic testing, water quality with respect to discharge considerations during dewatering and infiltration potential for Low Impact Development features.

PROJECT EXPERIENCE *(continued)*

Hydrogeological Investigation for Underground Servicing, Culverts and PTTW, Ottawa, ON – Hydrogeological lead resource for a hydrogeological assessment for Permit To Take Water (PTTW) applications for temporary construction dewatering at several outfall locations along the Ottawa River, including impact assessment for surface water features and the development of a monitoring program. Construction dewatering was required to facilitate municipal services installations and outfalls replacement / rehabilitation.

Hydrogeological Investigation for Residential Development, Arnprior, ON – Hydrogeological lead resource for a hydrogeological assessment for Permit To Take Water (PTTW) applications for temporary construction dewatering to support municipal infrastructure installations (water, sanitary, sewer, stormwater management ponds), including impact assessment on local private well users and downgradient surface water sources. Construction dewatering was required to facilitate municipal services installations and outfalls replacement / rehabilitation.

Hydrogeological Investigation for Quarry PTTW, Montague, ON – Project manager and reviewer of a hydrogeological assessment for a licensed quarry in Montague, Ontario. The project included hydrogeological site characterization, hydraulic testing (slug tests and pumping tests), assessment of potential hydrogeological impacts and short-term and long-term groundwater taking rates to obtain a Category 3 Permit To Take Water (PTTW). Further, assessment of groundwater – surface water interaction with adjacent Provincially Significant Wetland (PSW) and impacts from proposed quarry water takings.

Peer Review – Category 3 Permit To Take Water, Ottawa, ON - Technical review of provided hydrogeological investigation reports and subsequent amendments to support Category 3 Permit To Take Water applications. Due to construction delays associated with groundwater pumping in excess of those permitted, a technical review was requested by the City of Ottawa to provide a professional opinion as to whether the initial investigations completed by others included sufficient site characterization to estimate the anticipated groundwater inflows.

Peer Review – Proposed Residential Subdivision Beckwith, ON – Hydrogeologist responsible for completing a peer-review for a proposed 3-lot residential subdivision on private water supply and septic services. Reviewed provided documentation for any deviations from technical and industry standards, regulations, or guidelines and provided peer review correspondence documents for the proponent.

Hydrogeological Investigation and Terrain Analysis – Proposed Chicken Processing Plan, Ottawa, ON - Hydrogeologist and reviewer for a hydrogeological assessment for a re-zoning site plan control application in support of an abattoir, including private water supply and sewage system assessments, in general accordance with MECP Procedures D-5-4 and D-5-5, and other applicable legislation.

Hydrogeological Investigation and Terrain Analysis for Residential Subdivision, Perth, ON – Project manager and hydrogeologist for a 43-lot residential subdivision development on private water and septic services, including a hydrogeological evaluation of existing groundwater sources, aquifer selection, site-specific pumping tests to confirm supply requirements, testing of water quality for potable purposes, and a nitrate loading assessment for the proposed sewage systems that considered the use of tertiary (Level IV) treatments systems with nitrate treatment capability. Proposed development located in hydrogeologically sensitive terrain with elevated background nitrate concentrations in the receiving aquifer.

PROJECT EXPERIENCE *(continued)*

Hydrogeological Investigation for Residential Development, Richmond (Ottawa), ON – Project manager and technical resource a residential development serviced with communal water supply. Hydrogeological assessment included hydrogeological site characterization coordinated with the geotechnical subsurface investigation, test well drilling, aquifer selection and 72-hour constant rate pumping test. Category 2 Permit To Take Water with associated impact assessment and monitoring program for private well users to support communal well pumping tests.

Hydrogeological Investigation and Terrain Analysis for Residential Subdivision, Calabogie, ON – Project manager and hydrogeologist for a 52-lot residential subdivision development on private water and septic services, including a hydrogeological evaluation of existing groundwater sources, aquifer selection, site-specific pumping tests to confirm supply requirements, testing of water quality for potable purposes, and a nitrate loading assessment for the proposed sewage systems. Proposed development located in hydrogeologically sensitive terrain with thin soils and low well yields.

Infiltration Rates Assessment, Parking Lot, Limoges, ON – Project manager and hydrogeologist performing an assessment of infiltration rates in surficial soils using the Guelph Permeameter apparatus for proposed low impact development features for a parking lot in Limoges, Ontario.

Hydrogeological Investigation for Underground Servicing, Kingston, ON – Hydrogeological lead resource and technical reviewer for a hydrogeological assessment for Permit To Take Water (PTTW) application for temporary construction dewatering at a Canadian Forces Base in Kingston, Ontario. Construction dewatering was required to facilitate municipal service installations out letting to the St. Lawrence River. The groundwater characterization completed as part of the hydrogeological impact assessment found contaminated groundwater associated with past site uses, to be managed through on-site treatment and/or off-site disposal.

Hydrogeological Investigation for Linear Servicing, Ottawa, ON - Hydrogeologist and reviewer for numerous hydrogeological investigations of short-term groundwater control requirements for the installation of municipal services in Ottawa, Ontario. The subsurface field programs were coordinated with a geotechnical investigation and hydrogeological investigation completed to support Environmental Activity Sector Registry (EASR) and Category 3 Permit To Take Water (PTTW) applications.

APPENDIX B

Ontario

Ontario Land Tribunal

Tribunal ontarien de l'aménagement du territoire

Acknowledgment Of Expert's Duty

OLT Case Number	Municipality
OLT-23-000534	Town of Perth / County of Lanark

1. My name is Andrius Paznekas

   I live at the City of Ottawa

   in the Regional Municipality of Ottawa-Carleton

   in the Province of Ontario

2. I have been engaged by or on behalf of Caivan (Perth GC) Limited to provide evidence in relation to the above-noted Ontario Land Tribunal (`Tribunal`) proceeding.

3. I acknowledge that it is my duty to provide evidence in relation to this proceeding as follows:

   a. to provide opinion evidence that is fair, objective and non-partisan;

   b. to provide opinion evidence that is related only to matters that are within my area of expertise;

   c. to provide such additional assistance as the Tribunal may reasonably require, to determine a matter in issue; and

   d. not to seek or receive assistance or communication, except technical support, while under cross examination, through any means including any electronic means, from any third party, including but not limited to legal counsel or client.

4. I acknowledge that the duty referred to above prevails over any obligation which I may owe to any party by whom or on whose behalf I am engaged.

Date April 15, 2024 ………………………………………………………………….

Signature

APPENDIX C

GEMTEC

www.gemtec.ca

Hydrogeological Investigation
Proposed Residential Development
141 Peter Street
Perth, Ontario

experience • knowledge • integrity   expérience • connaissance • intégrité

GEMTEC
www.gemtec.ca

Submitted to:

Caivan (Perth GC) Limited
2934 Baseline Road, Suite 302
Ottawa, Ontario
K2H 1B2

Hydrogeological Investigation Proposed Residential Development 141 Peter Street
Perth, Ontario

February 22, 2023
Project: 100737.002

experience • knowledge • integrity

GEMTEC Consulting Engineers and Scientists Limited
32 Steacie Drive
Ottawa, ON, Canada
K2K 2A9

February 22, 2023 File: 100737.002

Caivan (Perth GC) Limited
2934 Baseline Road, Suite 302
Ottawa, Ontario
K2H 1B2

Attention: Hugo Lalonde – Director, Land Development

Re: Hydrogeological Investigation
Proposed Residential Development
141 Peter Street
Perth, Ontario

Enclosed is our hydrogeological investigation report for the above noted project, in accordance with our proposal dated November 24, 2021.

Jason KarisAllen, M.A.Sc., E.I.T.

Andrius Paznekas, M.Sc., P.Geo

Steve Livingstone, M.Sc., P.Geo.

Shaun Pelkey, M.Sc.E., P.Eng.

BR/JKA/WAM/AP/SL/SP

Enclosures
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1.0 INTRODUCTION

GEMTEC Consulting Engineers and Scientists Limited (GEMTEC) was retained by Caivan (Perth GC) Limited, herein referred to Caivan, to carry out a hydrogeological investigation for a proposed residential development located at 141 Peter Street (here in referred to as the "Site") in Perth, Ontario (Figure 1, located following the text of this report).

1.1 Project Description

Plans are being prepared for a new residential development located at 141 Peter Street that will be equipped with municipal services and a new sanitary forcemain proposed to connect to the existing sanitary sewer on Rogers Road, south of South Street in Perth, Ontario

The following is known about the Site and project:

- The Site is located south of the Tay River, north of the Grants Creek Wetland and west of Peter Street in Perth, Ontario;
- The Site is currently a recreational development (the Perth Golf Club); and
- Based on the plans provided by Caivan , the proposed development will consist of single detached houses, and townhouses, stormwater management ponds, a new pumping station, and new community parks.

1.2 Study Objectives and Scope of Work

The main objectives of this hydrogeological assessment are to characterize the baseline and post development groundwater conditions within the development footprint and the surrounding area, and to evaluate the regional hydrogeological setting (watershed scale). As such, the specific objectives of the hydrogeological assessment included:

- Determine soil and groundwater conditions across the Site;
- Develop regional and local scale conceptual site models;
- Evaluate baseline groundwater conditions (water levels, vertical and horizontal groundwater gradients, and flow directions);
- Characterize the hydrostratigraphic units within the development and surrounding area (hydraulic testing and grain size analyses);
- Provide baseline information for the preparation of a Permit to Take Water (PTTW);
- Complete a preliminary water balance and assess potential impacts of the development on the groundwater regime;
- Assess the groundwater contribution to the adjacent Grants Creek Wetland; and
- Identify mitigation measures and develop recommendations to limit potential impacts on groundwater, in particular, potential impacts to the adjacent Grants Creek Wetland.

2.0 SITE BACKGROUND

This section was prepared to provide background and insight into the regional topography, surface water features and the geologic units within the general study area of the Grants Creek catchment proximal to the Site. A site plan is presented in Figure 1 for reference. Additionally, Appendix A includes maps reviewing the geological context of the Site based on public records (Figures A1 to A12).

2.1 Data Sources

Most of the data were collected from the provincial data catalogue (Ontario Data Catalogue or Ontario GeoHub). Hydrological watersheds were downloaded from a larger Ontario database on Ontario Water Basin, and smaller creek catchments, such as Grants Creek catchment, were delineated and digitized using GIS software. Urban references, roads, and built-up areas, along with locations of the registered wells were also downloaded from Ontario database specifically from Land Information Ontario Geohub. Some of the datasets used were downloaded from national scale datasets, such as the surficial geology and rivers. Those datasets were downloaded in January and February 2022 to provide insight on the geology and groundwater levels in the vicinity of the Site.

The distribution of water wells contained within the database are illustrated as yellow circles on Figures A1 and A2 in Appendix A. As illustrated, there are substantial domestic water well data for the urban areas around the Town of Perth, with many wells drilled around the residential areas. The density of water well data is significantly lower in the agricultural and golf course areas.

The 1-m resolution Digital Elevation Model (DEM) used throughout this study was derived from a local LiDAR survey (see Figure A3) provided to GEMTEC by JFSA in 2022.

2.2 Regional Topography

The Grants Creek catchment resides within part of the physiographic region known as the Algonquin Highlands within the Tay River Watershed. Based on a 1-m Digital Elevation Model (DEM), the area surrounding the Site is characterized as low to moderate relief with elevations ranging from 132.0 to 144.8 metres above sea level (m asl; See Figure A3), and an average elevation of around 135 m asl. The surface topography generally reflects the underlying profile of the bedrock. The highest elevations are found in the west, and the lower elevations generally follow the surface water features. Grants Creek and the Tay River flow along the low-lying relief and swampy depressions northeast towards the Town of Perth (see topographic cross sections, Figure A4 and A5). The Grants Creek wetland area is a prominent topographic feature to the southwest of the proposed development area. This wetland is classified as a Provincially Significant Wetland (PSW) by the Province of Ontario. On a regional scale, the land surface slopes gradually towards southeast (see topographic cross sections, Figure A4 and A5).

2.3 Regional Geology

2.3.1 Overburden Geology

Where there are no urbanization and built-up areas, the overlaying soil cover is mostly silty sands (regarded as comparable to fine sandy loam for the purpose of infiltration assessments), except in the wetland area where the soils are muck/clay (Figure A6).

The surficial geology map (Figure A7) shows the two dominant surficial geology categories, glacial deposits of till, and postglacial deposits of organic muck and peat. The glacial deposits are two types: ‘1b’, a discontinuous till veneer cover over bedrock that has an average thickness of less than one metre, except in local depressions; and ‘1a’, a generally continuous till blanket that is usually more than one metre thick, especially in proximity of the streams. The second most common surficial deposits are the postglacial organic deposits (‘7’) consisting mainly of muck and peat ranging in thickness between 1 to 5 m; these deposits are predominantly found in swamps and wetlands including the Grants Creek Wetland (Figure A8).

2.3.2 Bedrock Geology

The bedrock geology is comprised of either Precambrian metamorphic and igneous rocks or Cambrian-Ordovician age March and Nepean Formations (See Figure A9). The Paleozoic-aged bedrock units of the Ottawa area were characterized by Williams (1991) in an Ontario Geological Survey report.

The geology of the Grants Creek catchment is comprised of Precambrian metamorphic/igneous bedrock with a large area of younger Cambrian-Ordovician age sandstone/limestones found within the centre of the catchment. It consists of fine to coarse grained quartz sandstone (Nepean Formation) and interbedded quartz sandstone, sandy dolostone and dolostone, with areas of Precambrian age metamorphic and igneous rocks within the development area (Williams and Wolf, 1982).

2.3.2.1 Precambrian bedrock

Precambrian aged rocks of igneous and metamorphic origin underlie the entire Site, and form a region commonly known as the Precambrian Shield (Figure A9). The Precambrian rock is comprised of a combination of felsic, mafic to ultramafic plutonic rocks and carbonate to clastic metasedimentary rocks. The Precambrian rock is exposed at surface in areas of the Site. Along the flanks of Precambrian bedrock, the younger clastic, and then carbonate Paleozoic age sediments were deposited. These sediments lithified, and are expressed today as limestone, dolostone and sandstone.

Precambrian bedrock has been reported at the drilling locations completed across the Site. The bedrock can be described as slightly weathered to fresh, fine grained, very strong, pinkish grey amphibole gneiss (metamorphic rock) and pink granite pegmatites (a coarser grained felsic igneous rock).

2.3.2.2 Cambrian-Ordovician age, March and Nepean Formations

The uppermost bedrock formation is a limestone unit that is interpreted to be part of the Lower Ordovician March Formations and interbedded grey quartz sandstone, dolomitic quartz sandstone, and blue-grey sandy dolostone and dolostone. The unit represents a transition zone between the Oxford Formation dolostones above, and the Nepean Formation sandstone below. Dolostones of the March Formation are described as light to medium brownish to greenish grey dolostone, making it difficult to distinguish using drill cuttings.

The underlying Cambrian-Ordovician age, Nepean Formation is a quartz sandstone that is thinly bedded to massive and well sorted. The sandstone is variable in colour and can be white to light grey, brown, reddish brown and green. It underlies the March Formation beneath the Site, and the upper Nepean Formation contact is marked by the lowermost unit of (sandy) dolostone.

Figure A9 illustrates the uppermost bedrock formations mapped in the area, which were available at the regional scale; thus, uncertainty exists with the exact location of the geologic contacts and faults.

2.3.3 Depth to Top of Bedrock / Overburden Thickness

The water well information in the vicinity of the Site gives an indication of the depth to the top of the bedrock, which suggests very limited to no overburden thickness (i.e., exposed bedrock). Figure A9 presents the general overburden type, overburden thickness, and bedrock topography in the general vicinity of the Site. As shown, the depth of the overburden regionally is controlled by the topography of the underlying bedrock. Further, in topographic bedrock lows, streams and wetland areas are more pronounced, leading to the development of clay-rich and peat deposits within lower energy deposition environments.

2.3.4 Structural

The Site is located on a south to southeast strike fault, and north to northeast strike fault, forming a graben-like structure (Wolf & Williams, 1984).

2.4 Hydrostratigraphy

2.4.1 Spatial Distribution of Water Wells

Approximately 400 wells were reviewed in the vicinity of the Site (shown on Figures A1 and A2), and their depths ranged from the surface (zero metre) to the deepest being 114 m bgs, as drilled in 2019 (Government of Ontario, 2019).

There are a few wells dug in the 1940’s, but more than 50 percent of the wells were drilled between 2000 and 2020. There are 400 wells shown on the map and these are used for different purposes including, commercial, domestic, irrigation, industrial, monitoring, and public (See Figure A10). There are 32 out of the 400 wells found on the map that are used for commercial purposes and the depth of those mostly range between 15 to 25 m deep. There are a few wells (11) for industrial purposes, with the deepest well of 70 m deep reaching to clay and red granite formation.

There are 145 out of those wells that are used for domestic purposes and these wells have more varying depths ranging between 10 to 40 m deep, with an average of about 15 m. Those wells reach to mostly clay and/or loamy sand. There are around 135 wells and test holes used for monitoring purposes and those are mostly shallow, less than 5 m deep, reaching to sandy gravel deposits. There is a single well used for municipal purposes and that is only 4 m deep.

2.4.2 Hydrostratigraphic Units

Based on reported water level data from Ministry of the Environment, Conservation and Parks (MECP) well records, aquifers in the area are limited to the following bedrock formations:

- Precambrian Bedrock
- March Formation dolostones, and the underlying Nepean Formation sandstone.

The water level elevations reported in all water wells that are completed in bedrock are illustrated on Figure A11. The colour variation denotes the water levels interpolated from the well sites (yellow points).

The water levels in the shallow and deep bedrock wells are similar (Figure A12), with groundwater levels lying only a few metres below ground surface. As continuous water level data is collected onsite, the understanding of the groundwater flow variability in the upper and lower bedrock formations will be determined.

In general, water levels in the Perth area lie 1 to 2.5 metres below ground surface (m bgs) with large portions of wells recording surface water levels (zero) along the Christie Lake Road, and again around the built-up area of the Town of Perth and Caroline Village Park. There is also one anomalous water level of 36 m recorded at well No. 3506397.

Groundwater flow within the Precambrian and sedimentary rock is mainly through secondary porosity associated with fractures. In general, primary porosity within Precambrian bedrock is commonly less than two percent, whereas higher porosities are reported for dolostones, sandstones, and limestones (Freeze and Cherry, 1979). The distribution and density of fractures commonly decreases with depth. Near surface stress releases cause sedimentary bedrock “sheeting” that produces horizontal fractures parallel to the ground surface. A significant cause of sheeting was the release of stress following glaciation during glacial retreat.

Regional groundwater flow patterns are mainly controlled by both topography and the density and connectivity of horizontal and vertical fractures. Based on the lithology and hydrogeological properties of the various formations, it is postulated that the bulk permeability of the Precambrian bedrock is lower than that of the overlying sedimentary rock. It is expected that the deeper regional flow is southeast.

2.5 Background Reports

2.5.1 Mississippi-Rideau Source Protection Region Assessment Report

In review of Mississippi-Rideau Source Protection Region's Assessment Report mapping (MVRVCA, 2011), the following relevant information is provided:

- The Site is located within an area of highly vulnerable aquifer;
- The primary water supply aquifer is the Precambrian aquifer, with the sandstone aquifer located east of the Site;
- The Site is located within the Tay River Intake Protection Zone (IPZ) scored 9 (Perth IPZ 2013 map provided in Appendix B).
    - Property boundary extends into IPZ scored 10.
- The Site is located within a transitional area of potential groundwater recharge/discharge;
- The annual shallow groundwater elevations decrease to the southeast; and
- The annual deep groundwater elevations decrease to the southeast, towards the St. Lawrence River.

2.5.2 Conceptual Understanding of the Water Budget

In review of Mississippi-Rideau Source Protection Region's Tier 1 Water Budget and Water Quantity Stress Assessment, Preliminary Draft (revised) report (MVRVCA, 2009), the following relevant information is provided:

- Majority of Mississippi Valley contains Precambrian bedrock, which has limited lateral groundwater flow within discrete fractures.
    - Lateral groundwater flow in the Precambrian is considered to be negligible.
- Groundwater recharge estimated through various methods (as referenced in MVRVCA, 2009):
    - Novakowski et al. (2007) study examined daily changes in water levels in several shallow groundwater wells in the Tay River at Perth Subwatershed. The groundwater recharge was estimated to be approximately 2% of precipitation (18mm/year) and recharge is dependant on bedrock fractures. The shallow wells showed a rapid response to water level changes, which is partially controlled by bedrock fractures.
    - MOEE (1995) method estimated groundwater recharge to be as low as 40mm/year in some of the 25m x 25m cells in the Tay River at Perth Subwatershed and as high as 300 mm/year. The subject site falls within an area of low groundwater recharge – 40mm/year.

    - Baseflow separation completed using USGS BFLOW model (Neff et al. 2006) estimated baseflow in the range of 145 to 236 mm/year. It was noted that the baseflow separation results were included in the study for comparisons purposes only as the Tay River at Perth is a regulated river.

2.5.3 Grants Creek Catchment Study

The following relevant information is provided in review of the Rideau Valley Conservation Authority's Grants Creek Catchment report (RVCA, 2017):

- Figure 36 indicates that the dominant substrate type along the Grants Creek, in the vicinity of the subject site, consists of silt.
- Figure 50 indicates that the surveyed stream network did not identify any groundwater discharge indicators along Grants Creek, in the vicinity of the subject site.
    - Groundwater discharge indicators were observed approximately 1.5 to 2 km upstream of the subject site.

3.0 STUDY METHODOLOGY

3.1 Subsurface Characterization

The subsurface investigation was conducted in conjunction with the geotechnical investigation completed by GEMTEC (GEMTEC, 2022a). The fieldwork for the geotechnical investigation was carried out between January 4 and February 2, 2022. During that time, 33 boreholes (numbered 22-201, 22-202, 22-203, 22-203A, 22-205 to 22-214, 22-214A, 22-214B, 22-215, 22-216, 22-218, 22-219, 22-220, 22-221, 22-221A, 22-222, 22-222A, 22-223, 22-224, 22-225, 22-225A, 22-226, 22-227, 22-228, 22-228A, 22-229, and 22-230) were advanced at the Site. Hand auger holes (numbered 137 to 142, inclusive) and boreholes (numbered 231, 231A, 232 and 232A) were advanced within the boundary of the Grants Creek Wetland in February and March 2022. Additional boreholes (numbered 22-106, 22-107, 22-108, 22-233A, 22-233B, 22-234, and 22-235) were advanced to auger refusal in October 2022.

Details on the boreholes are provided below.

- The boreholes were advanced, within the overburden, to depths ranging from about 0.3 to 8.0 m bgs. Upon reaching practical auger refusal in boreholes 22-201, 22-203A, 22-208, 22-214, 22-216, 22-221, 22-222 to 22-225, 22-228, 231A, and 232A the boreholes were then advanced into the bedrock using rotary diamond drilling techniques while retrieving HQ sized bedrock core. These boreholes were advanced to total depths ranging from about 5.8 to 12.3 m bgs.
- Boreholes 22-214B, 22-221A, 22-225A, 22-228A, 231, and 232 were advanced adjacent to boreholes 22-214, 22-221, 22-225, 22-228, 231A, and 232A, respectively, all of which

had monitoring wells installed. These monitoring well pairs were installed at different depths to allow for the assessment of vertical hydraulic gradients.

- Hand auger holes HA137, 138, 139, 140, 141 and 142 were advanced in the Grants Creek Wetland to depths of about 1.8 m bgs.
- Detailed soil logging was not performed for boreholes 22-106, 22-107, 22-108, 22-233A, 22-233B, 22-234, and 22-235 as they were advanced primarily to characterise depths to water and bedrock.

Descriptions of the monitoring wells and subsurface conditions logged in the boreholes and grain size distribution curves from the current investigation are provided in Appendix C. Boreholes, hand auger holes, and probe holes from previous and present investigations were utilized when generating bedrock contours for the Site. The approximate locations of the advanced holes are shown on the GEMTEC Site Plan, Figure 1.

3.2 Water Quality

As part of a Phase II Environmental Assessment (GEMTEC, 2022b), groundwater samples were collected from monitoring wells installed at boreholes: 22-201, 22-203A, 22-205, 2-208, 22-214, 22-216, 22-221A, 22-222, 22-223, 22-224, and 22-225A. The samples were collected in laboratory supplied bottles using a low-flow peristaltic pump with disposable tubing on February 8 and February 9, 2022. Samples were collected following a period of stabilization, which was monitored using a multi-parameter probe. The samples were submitted to Paracel Laboratories in Ottawa, Ontario for metals, volatiles, and hydrocarbons.

Additional groundwater samples were taken from monitoring wells installed at borehole locations 22-221, 22-225 and 22-228 and submitted to a Paracel Laboratories for parameters related to the Town of Perth's municipal sewer use regulations, By-Law No. 4819. Parameters tested include microbial, general organics, dissolved and total metals, volatiles, pesticides and PCBs.

3.3 Groundwater Level Monitoring

Monitoring wells were installed in boreholes 22-201, 22-203A, 22-205, 22-208, 22-214, 22-214B, 22-216, 22-221, 22-221A, 22-222, 22-222A, 22-223, 22-224, 22-225, 22-225A, 22-228, 22-228A, 22-231, 22-231A, 22-232, 22-232A, 22-233, 22-234, and 22-235 for subsequent measurement of groundwater levels.

Long-term water level monitoring was conducted within wells 22-203A, 22-205, 22-221A, 22-221, 22-222, 22-225A, 22-225, 22-228A, 22-231, 22-231A, 22-232, and 22-232A by installing pressure transducers downhole, recording at 15-minute intervals. Well depths, screened intervals, and screen lithologies for the long-term water level monitoring wells are listed in Table 3.1.

Table 3.1: Long-Term Water Level Monitoring Wells

Well ID	Well Depth (m bgs[1])	Screened Interval (m bgs[1])	Screened Lithology
22-205	6.15	3.10 to 6.15	Glacial Till
22-221A	1.42	0.80 to 1.42	Glacial Till
22-221	6.30	3.25 to 6.30	Bedrock
22-222	6.10	4.57 to 6.10	Bedrock
22-225A	1.37	0.80 to 1.37	Glacial Till
22-225	6.02	2.97 to 6.02	Bedrock
22-228A	7.65	4.60 to 7.65	Bedrock
22-228	12.34	9.14 to 12.34	Bedrock
22-231A	10.08	8.56 to 10.08	Bedrock / Wetland
22-231	3.35	1.80 to 3.35	Clay and Till / Wetland
22-232A	4.67	3.15 to 4.67	Bedrock / Wetland
22-232	1.60	0.69 to 1.60	Clay / Wetland

Notes:
1. m bgs = metres below ground surface

3.4 Hydraulic Conductivity Assessments

Hydraulic testing was carried out in the well screens installed as part of the geotechnical investigation on February 8 and 9, 2022, as well as October 14, 2022. The hydraulic testing was performed to estimate the hydraulic conductivity of the overburden soils and the bedrock within the anticipated depth of excavations and to provide an estimate of the potential quantity of water entering future excavations. The hydraulic testing followed ASTM D4044-96, Standard Test Method (Field Procedure) for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Aquifers. Hydraulic conductivity testing was completed in monitoring wells screened in the overburden (22-201, 22-205, 22-224 and 22-233B) and bedrock (22-203A, 22-208, 22-214, 22-216, 22-221, 22-222, 22-222A, 22-223, 22-225, 22-228, 22-228A, 22-234, and 22-235).

The grain size distributions (Appendix C) of select unconsolidated soil samples collected from boreholes (i.e., 22-202 SS5, 22-207 SS3, 22-220 SS3, 22-224 SS4, and 22-230 SS4) were leveraged to estimate their hydraulic conductivity. HydrogeosieveXL (version 2.2; Devlin, 2015) was used to estimate their hydraulic conductivity by applying and evaluating the suitability of various empirical models. A range of hydraulic conductivity estimates using soil grain size analysis methods whose assumptions/conditions were met are presented, and they are typically regarded as more accurate when considering coarser soil types (i.e., sands and gravels; Devlin, 2015).

3.5 Groundwater Recharge Assessments

3.5.1 Infiltration Assessment

Infiltration rates for the Site were approximated using a relationship with hydraulic conductivity presented by the Ontario Ministry of Municipal Affairs and Housing (OMMAH, 1997) intended for stormwater management planning and design. This relationship was applied to hydraulic conductivity estimates for overburden soils derived from grain size analysis. It was assumed for the purpose of this computation that the anisotropy ratio of the Site's overburden soils was one.

3.5.2 Baseline Water Balance (MOE, 2003)

To support the conceptualization of the Site, an annual water balance was completed to approximate the partitioning of water surplus into recharge and runoff. It is noted that a water balance will be completed for the non-winter months (i.e., April to November) as part of the stormwater management plan for LID design. The water balance of the proposed development area was assessed, based on the following equation:

Mean Annual Precipitation - Change in Groundwater Storage - Evapotranspiration = Runoff + Infiltration

where:

- Mean annual precipitation is based on data provided by Environment Canada, from the Drummond Centre weather station for the period of 1985 to 2021. The Drummond Centre weather station is located approximately 11 kilometres northeast of the Site.

- Long term changes to groundwater storage are assumed to be negligible. Short term or seasonal changes are anticipated to balance out (e.g., increased groundwater recharge following spring freshet, followed by dry conditions in the summer months).

- Evapotranspiration is calculated based on the Thornthwaite and Mather (1955) model, run by Environment Canada (Johnstone, K. & Louie, P.Y.T., undated).

The hydrologic factors used to estimate infiltration, such as topography, soil, cover, and water holding capacities are based on the Ministry of Environment (MOE) Stormwater Management Planning and Design Manual Section 3.0 (MOE, 2003) and the Ministry of the Environment and

Energy (MOEE) Hydrogeological Technical Information Requirements for Land Development Applications (MOEE, 1995).

3.6 Baseflow Separation

Baseflow separation is often used to assess the proportion of rainfall that enters a stream through runoff (overland flow, interflow, return flow, and throughflow pathways; see Fetter (2001) for term definitions) relative to baseflow pathways. Consistent with Fetter (2001), interflow will be regarded as runoff due to its limited residence time within the groundwater system. For this report, runoff will be discussed in terms of overland flow (i.e., sheet and channelized surface flows) and interflow (i.e., all rapid intermediary transport process between overland flow and deep percolation / recharge). Understanding the ratio of runoff to baseflow provides insight into groundwater and surface water interactions along a river reach and at the watershed scale. In fact, determining the ratio between stream baseflow and total precipitation in its associated watershed provides a rough estimate of recharge. Continuous stream flow data from 2005 to 2016 (Station 02LA024; ECCC, 2022) was used to estimate the baseflow of the Tay River using the Chapman method (Chapman, 1991) in the SepHydro online tool (Danielescu, MacQuarrie, & Popa, 2018).

4.0 RESULTS AND DISCUSSION

The subsurface hydrogeological characterisation of the Site is discussed in this section including the results of borehole logging, groundwater monitoring, hydraulic conductivity assessments, groundwater recharge assessments, and baseflow separation. The hydrogeological characterization is provided herein to evaluate the Site's geological framework and local-scale hydrogeological conditions (i.e., hydrostratigraphic units, groundwater levels, groundwater flow directions, and recharge and discharge processes).

4.1 Topography and Drainage

The topography of the Site development area is generally gently rolling , with elevations ranging from approximately 134.0 to 142.5 m asl (average of approximately 136.1 m asl), with three distinct rises in elevation, as shown in Figure A3. Historical development activities carried out at the Site in the last few decades have likely resulted in some fill build-up in the central and eastern portions of the Site associated with the golf course construction.

The Grants Creek Wetland environment adjacent to the Site is interpreted to be primarily sustained by surface water, which is consistent with previous studies that have not identified groundwater indicators adjacent to the Site (RVCA, 2017). Groundwater contributions are likely limited by clay and/or silt sediments lining the base of the adjacent wetland and stream (refer to Conceptual Site Model Figures 5 and 6; RVCA, 2017) and the limited capacity for deep infiltration of Precambrian bedrock, estimated as 2% of annual precipitation by Novakowski et al. (2007).

The Site is bounded by the Tay River to the north, agricultural lands and rural residential properties to the west, Grants Creek Wetland to the south and the Perth Golf Course and Peter

Street bridge to the east. Surface drainage across the site flows overland towards the Tay River and Grants Creek Wetland. The Grants Creek Wetland is a dominant local drainage features in the area and will receive some runoff from the Site (approximate area of 0.22 km^2), but most of the surface flow is derived from up stream contributions in the Grants Creek catchment area (approximately catchment area of 31.1 km^2; RVCA, 2017). To contextualize the surface water contribution from the Site to the wetland, it represents only 0.5% by area of the total Grants Creek drainage area.

4.2 Site Geology

Subsurface investigations have been conducted at the Site including the completion of overburden and bedrock drilling, auger probes, and the installation of monitoring wells. The borehole and monitoring well logs are provided in Appendix C. Boreholes have penetrated to a maximum depth of approximately 12.3 m into the bedrock. Subsurface investigations completed to date have reported the following stratigraphic zones, in descending order:

- Fill (silty sand) – deposited during construction of the golf course;
- Wetland peats and clay;
- Glacial till – loose to stiff grey-brown silty clay to silty sand with cobbles and boulders; and
- Precambrian Bedrock - fine grained, very strong, pinkish grey amphibole gneiss (metamorphic rock) and pink granite pegmatites (igneous rock).

4.2.1 Fill

Discrete areas of fill were reported in the boreholes drilled, specifically around the current location of the golf course club house and entrance way. The fill thickness was on the order of about 2.1 m (boreholes 22-229 and 22-230 and consisted of loose, brown silty sand with some gravel. The fill was not found widespread and likely associated with historical golf course construction and infrastructure development.

4.2.2 Peat and Clay

Six hand auger holes (HA137 to HA142) and four boreholes (22-231, 22-231A, 22-232, 22-232A) were drilled within the Grants Creek Wetland to evaluate the soil conditions, as shown on Figure 1. The soil conditions encountered in the hand auger holes (Appendix C) consisted of up to 0.31 m of woody organics, followed by a 0.25 to 1.49 m thick layer of peat, underlain by grey silty clay that was proven to an approximate depth 1.80 m bgs. The soil conditions in the boreholes consisted of 0.07 to 0.56 m of peat, underlain by 1.06 to 2.08 m of silty clay. The mapping of the peat and clay is consistent with the regional mapping indicating organic deposits consisting mainly of mulch and peat and ranging in thickness between 1 and 5 m, found predominantly in swamps and wetlands. The peat and clay material has infilled the low-lying areas and sits above the glacial till unit.

4.2.3 Silty Clay

A discontinuous deposit of silty clay was encountered in the boreholes completed at the Site. The silty clay has generally been weathered to a stiff to very stiff grey-brown crust.

4.2.4 Glacial Till

Glacial till was encountered at most of the boreholes completed on the Site. The glacial till can generally be described as a compact to very dense, grey-brown silty sand with gravel, cobbles, and boulders.

Grain size distributions from selected boreholes are provided on Table 4.1 and indicate a relatively consistent composition of sands, silts, clays and gravel/cobbles with depth and spatial distribution.

Table 4.1: Grain Size Distribution Data from Selected Boreholes

Location	Sample Number (SS)	Sample Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
22-202	5	3.0 – 3.5	5	56	28	11
22-207	3	1.5 – 2.1	10	53	25	12
22-220	3	1.5 – 2.1	8	38	27	27
22-224	4	2.3 – 2.9	17	51	22	10
22-230	4	2.3 – 2.9	6	56	27	11
HA137	-	1.37 – 1.83	6	29	34	31

The glacial till thickness is variable across the Site. The thickness (top of bedrock) can range from less than 0.3 m (at borehole 22-208) to greater than 8 m (at borehole 22-206). The thickness of the glacial till is directly related to the elevation and topography of the underlying bedrock. As indicated on Figure 3 (bedrock contour plan), the overburden is generally thicker proximal to the Tay River along the northern portion the site.

The maximum overburden thickness noted in the drilling completed to date was at BH 22-206 with a thickness of 7.98 m. Adjacent and proximal to the Grants Creek Wetland, the glacial till thickness are generally shallow with a thickness in the range of 1.2 m (boreholes 222-222 and 22-223) to 1.4 m (boreholes 22-221). The distribution of the glacial tills is consistent with the regional mapping of the till blanket across this area. Available borehole data were interpolated to generate inferred distributions of overburden overlying bedrock across the Site (Figure 5).

4.2.5 Precambrian Bedrock

All boreholes drilled into the underlying bedrock reported the presence of fine grained, very strong, pinkish grey amphibole gneiss (metamorphic rock) and pink granite pegmatites (igneous rock). The bedrock was found to be slightly weathered in the upper metre of the bedrock profile. Measured RQD values ranging between 0 and 100% suggest frequent and irregularly distributed fracturing within the Precambrian bedrock. Generally, RQD values are anticipated to increase with depth, reducing the hydraulic conductivity and fracture connectivity of the bedrock aquifer. The depths over which changes in hydraulic properties occur may not be consistent across the site and are unlikely to be abrupt, but rather transitional. Overburden depths range significantly over the site but, for the purpose of conceptualizing site processes, a reasonable estimation of the transition to more competent bedrock based on the borehole logs (Appendix C) may be below a 6-metre more conductive upper bedrock zone.

4.3 Hydrogeological Characterization

4.3.1 Groundwater Levels

The most recent series of manual groundwater level measurements, taken between October 14 and 17, 2022, are presented in Table 4.2. An extended compilation of water level data measured over the study period (February 2022 to October 2022) is provided in Appendix D. There are 24 wells in total, nine of which are screened in the glacial till and the remainder within the Precambrian bedrock. As evident in Table 4.2, the water levels for the paired shallow and deeper wells (e.g., 22-214 and 22-214B) are generally similar. Thus, water level measurements summarized in Table 4.2 were all used to interpolate inferred groundwater elevations across the Site (Figure 4).

Pressure transducers were installed into a subset of wells as part of a long-term water level monitoring program. Available water level and elevation data are presented in Figure D1 to D6 and Table D1 to D3, Appendix D. Water level depths ranged from -0.1 to 4.9 m bgs. Water level fluctuations are associated with temperatures increasing beyond 0°C (i.e., snowmelt and soil thaw) and rainfall. Frozen soils and snowpack likely reduce the amount of infiltration seasonally. The irregular peaks in monitoring well 22-228A are likely an artifact caused by either overtopping of the well casing or freezing of water within the well. Additionally, the plateau in well 22-221A indicates that the water level within the well fell beneath the sensor.

The shallow water level elevations reported at the Site are consistent with the regional water level evaluation which indicated shallow water levels in wells across the Grants Creek Wetland area. The presented elevations reflect the conditions at the time of measurement only and demonstrate a general agreement between groundwater and surface water drainage divides. Groundwater elevations vary seasonally and in response to infiltration, as demonstrated by monitoring data presented within Appendix D.

Table 4.2: Water Level Measurements for October 14-17, 2022

Borehole/Test Pit Number	Screened Formation	Well Depth (m bgs)	Groundwater Depth (m bgs[1])	Groundwater Elevation (m asl[2])
22-201	Glacial Till	6.10	1.96	134.04
22-203A	Bedrock	6.22	2.00	133.92
22-205	Glacial Till	6.15	1.66	133.66
22-208	Bedrock	6.07	3.64	133.84
22-214	Bedrock	6.96	3.18	134.74
22-214B	Glacial Till	4.88	3.05	134.75
22-216	Bedrock	5.79	1.02	133.60
22-221	Bedrock	6.30	2.13	132.50
22-221A	Glacial Till	1.42	Dry at 1.42	Dry at 1.42
22-222	Bedrock	6.10	2.68	132.94
22-222A	Bedrock	3.73	2.77	132.96
22-223	Bedrock	12.09	1.01	133.60
22-224	Glacial Till	4.45	1.60	134.04
22-225	Bedrock	6.02	1.05	133.89
22-225A	Glacial Till	1.37	1.15	133.82
22-228	Bedrock	12.34	4.86	133.62
22-228A	Bedrock	7.65	4.58	133.86
22-231	Bedrock	10.08	0.70	132.64
22-231A	Clay/Till	3.35	0.78	132.57
22-232	Bedrock	4.67	1.36	132.38
22-232A	Clay	1.60	1.27	132.50
22-233B	Overburden	5.83	1.05	133.89
22-234	Bedrock	6.86	1.07	133.36
22-235	Bedrock	4.84	0.98	133.27

Notes:
1. m bgs: metres below ground surface
2. m asl: metres above sea level

4.3.2 Vertical Gradients

Vertical gradients were calculated for seven nested pairs of wells screened in overburden and bedrock strata. Vertical hydraulic gradients were generally low over the monitoring period (see Table 4.3) in the nested wells (locations in Figure 1), as the water levels in both the shallow and deeper wells were similar. This implies unconfined or leaky aquifer conditions over the depths monitored, apart from the conditions beneath Grants Creek Wetland, which may be more confined based on the presence of low permeability soils (clay and silt).

Based on six rounds of water level measurements, slight potential downward hydraulic gradients were observed at the locations of wells 22-228 and 22-232, and a slight potential upward gradient was measured at the location of well 22-222. The remaining nested wells did not present notable or otherwise consistent gradients across measurements. All observed gradients were small.

Table 4.3: Vertical Gradient Between Shallow and Deep Nested Monitoring Wells on Site

Nested Well Location	Screened Formations ("Shallow" - "Deep")	Hydraulic Gradients (m/m, + Downward Flow, - Upward Flow)[1]					
		Feb 9	Feb 16	Feb 23	Mar 30	May 12	Oct 14 - 17
22-214	Till - Bedrock	0.05	0.00	-0.05	0.00	0.007	0.004
22-221	Till - Bedrock	0.00	-0.01	ND[3]	ND[3]	0.003	-
22-222	Bedrock - Bedrock	-0.05	-0.02	-0.02	-0.01	-0.02	0.005
22-225	Till - Bedrock	0.00	-0.01	-0.01	ND	0.05	-0.02
22-228	Bedrock - Bedrock	0.02	0.02	0.04	0.05	0.04	0.05
22-231	Clay/Till - Bedrock	ND[2]	ND[2]	ND[2]	ND[3]	0.00	-0.01
22-232	Clay - Bedrock	ND[2]	ND[2]	ND[2]	ND[3]	0.02	0.04

Notes:
ND = No Data
1. Measurements were all taken in the year 2022.
2. Wetland wells were not installed until March 2022.
3. Wells were frozen at time of measurement.

4.3.3 Hydraulic Conductivities

Hydraulic conductivities were calculated for overburden and bedrock by performing slug tests within onsite wells. Well recovery data was analysed using Hvorslev method for unconfined aquifers. The results of the test analyses are provided in Appendix E.

As presented on Table 4.4, the hydraulic conductivity for overburden soils (in monitoring wells 22-201, 22-205, 22-224, and 22-233B was calculated to range from 2×10^{-7} to 3×10^{-6} ms^{-1}. The hydraulic conductivity calculated for granitic bedrock in boreholes 22-203A, 22-208, 22-214, 22-216, 22-221, 22-222A, 22-222, 22-223, 22-225, 22-228A, 22-228, 22-234, and 22-235 ranged from less than 1×10^{-7} to 9×10^{-5} ms^{-1}. The calculated hydraulic conductivities are generally within literature values (Freeze and Cherry, 1979) for glacial till (10^{-12} to 10^{-6} ms^{-1}) and for fractured igneous and metamorphic bedrock (10^{-9} ms^{-1} to 10^{-4} ms^{-1}). The geometric mean of the overburden and bedrock hydraulic conductivities are approximately 8×10^{-7} ms^{-1} and 2×10^{-6} ms^{-1}, respectively.

Table 4.4: Calculated Hydraulic Conductivities of Onsite Monitoring Wells

Borehole	Geological Material Monitored	Calculated Hydraulic Conductivity, k (ms^{-1})[1,2]	
		Falling Head Test by Introducing a Slug	Rising Head Test by Removing a Slug
22-201	Silty Sand (till)	6×10^{-7}	2×10^{-7}
22-203A	Bedrock	-	$< 10^{-7}$
22-205	Silty Sand (till)	-	2×10^{-7}
22-208	Bedrock	7×10^{-7}	1×10^{-6}
22-214	Bedrock	1×10^{-7}	-
22-216	Bedrock	9×10^{-7}	1×10^{-6}
22-221	Bedrock	1×10^{-7}	-
22-222A	Bedrock	1×10^{-6}	-
22-222	Bedrock	3×10^{-6}	1×10^{-6}
22-223	Bedrock	-	2×10^{-5}
22-224	Silty Sand (till)	-	3×10^{-6}
22-225	Bedrock	8×10^{-5}	9×10^{-5}
22-228A	Bedrock	2×10^{-7}	-
22-228	Bedrock	7×10^{-5}	7×10^{-5}
22-233B	Overburden	2×10^{-6}	2×10^{-6}
22-234	Bedrock	4×10^{-6}	4×10^{-6}
22-235	Bedrock	1×10^{-6}	-

Notes:
1. The hydraulic conductivities were calculated using the Hvorslev analysis.
2. Displacement volume of slug (0.6 metres) used in analysis for all boreholes.

The hydraulic conductivity of select unconsolidated soil samples was also estimated using their grain size distribution curves using HydrogeosieveXL (version 2.2; Devlin, 2015). Unprocessed results from HydrogeosieveXL are included in Appendix E. The range of hydraulic conductivity estimated for soil samples 22-202 SS5, 22-207 SS3, 22-220 SS3, 22-224 SS4, and 22-230 SS4 using this method are compiled in Table 4.5 (including only results from models whose criteria were met). These values are generally in agreement with estimates derived from overburden slug test analyses (geometric mean of 2.1×10^{-7} ms^{-1}).

Table 4.5: Calculated Hydraulic Conductivities of Select Soil Samples

Soil Sample ID	Sampling Depth Range	Calculated Hydraulic Conductivity [1], k (m/s)	Range of Hydraulic Conductivity [2], k (m/s)
22-202 SS5	3.05 - 3.48	5.40×10^{-7}	2.52×10^{-8} to 8.68×10^{-6}
22-207 SS3	1.52 - 2.13	6.05×10^{-7}	2.23×10^{-8} to 1.11×10^{-5}
22-220 SS3	1.52 - 2.13	2.10×10^{-9}	1.43×10^{-11} to 5.03×10^{-7}
22-224 SS4	2.29 - 2.90	9.51×10^{-7}	2.81×10^{-8} to 2.20×10^{-5}
22-230 SS4	2.29 - 2.90	5.69×10^{-7}	2.29×10^{-8} to 8.45×10^{-6}

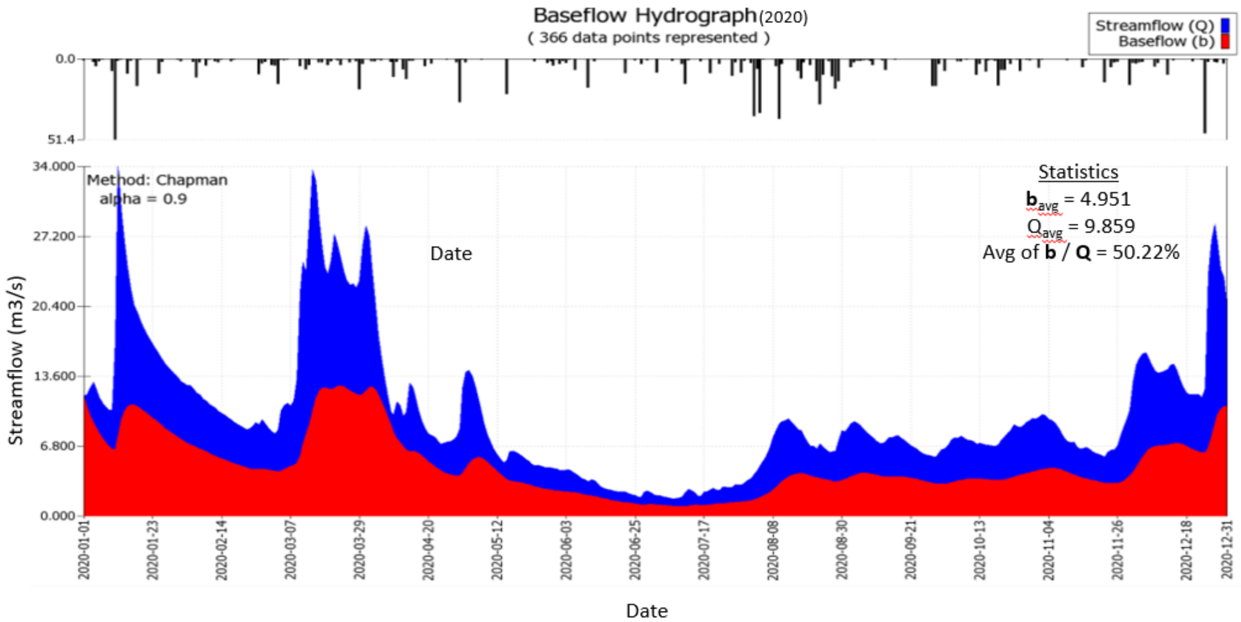
Notes:
1. Geometric mean hydraulic conductivity.
2. Includes only model outputs whose criteria were satisfied, as shown in Appendix E.

4.3.4 Groundwater Flow

The groundwater site contours for sampling conducted mid-October are shown on Figure 4. As depicted, flow directions are interpreted to mostly mirror local topographic divides. The groundwater elevations are generally the highest at the topographic highs within the central and western portions of the Site, with pseudo-radial flow away from these peaks. There appears to be a groundwater divide running roughly east-west across the Site controlled by the topographic ridges. As such, groundwater on the northern portion of the Site would flow towards the Tay River, whereas groundwater flow on the southern portion of the Site would flow towards the Grants Creek Wetland. The Site is located on the northeastern portion of the Grants Creek Wetland before the outlet to the Tay River.

4.3.5 Baseflow – Pre-Development

Baseflow separation is often used to assess the proportion of rainfall that enters a stream through overland and interflow pathways relative to deeper, relatively slow subsurface pathways (baseflow). Understanding this ratio may provide insight into groundwater and surface water interactions along a river reach and at the watershed scale. In fact, determining the ratio between stream baseflow and total precipitation in its associated watershed provides a rough estimate of recharge.



Tay River at Perth Hydrograph 2020 (Figure G1 insert from Appendix G)

This evaluation estimated baseflow to assess groundwater flow paths, recharge rates, and the potential impacts of the development (e.g., reduced infiltration post-development and temporary dewatering activities). Continuous stream flow data from 2005 to 2016 and 2018 to 2020 (Station 02LA024; ECCC Historical Hydrometric Data, 2022) were used to estimate the baseflow of the Tay River using the Chapman method (Chapman, 1991) in the SepHydro online tool (Danielescu, MacQuarrie, & Popa, 2018). The ratio of baseflow over total flow (BFI or Baseflow Index) was calculated to be approximately 50 percent (α = 0.9), potentially reflecting the impacts of river control structures (i.e., dams). The calculated BFI was then used to estimate that recharge is less than 21 percent of total precipitation within the watershed of the Tay River (annual precipitation of 960 mm and a catchment area of 661 km^2). The inputs and results of this analysis are compiled in Appendix G.

The Mississippi-Rideau Source Protection Region (2009) estimated groundwater recharge in the Tay River subwatershed using multiple techniques, including baseflow separation, conceptual water balance using the MOE 1995 method and site-specific investigations. The results are tabulated in Table 4.6 below.

Table 4.6: Baseflow Estimates Tay River at Perth Subwatershed

Data Source	Methodology	Percent of Annual Precipitation	Baseflow / Recharge Estimate (mm/year)
GEMTEC[1]	Baseflow Separation[3]	21 %	201
MVRVCA (2009)[2]	Baseflow Separation[3]	16 – 26 %	145 – 236
MVRVCA (2009)[2]	Conceptual Water Budget (MOE 1995 Method)	13 % (4 to 40%)	Average = 121 (ranges from 40 to 363)
MVRVCA (2009)[2]	Site Scale – assess shallow well water levels (Novakowski et al., 2007)	2 %	18

Notes:
1. Data period 2005 to 2016 and 2018 to 2020. Average annual precipitation of 958 mm for Drummond Centre, Climate ID 6102J13.
2. Data period 1970 to 2000. Average annual precipitation of 906 mm/yr.
3. Baseflow separation baseflow estimates provided for comparison/discussion purposes. Tay River at Perth is a regulated system.

The baseflow and conceptual water balance methods suggest regional scale recharge of the Tay River subwatershed is in the order of 4 to 40 percent of annual precipitation. The site-scale study completed by Novakowski et al. (2007) estimated significantly lower recharge rates; their study highlighted that recharge at the local scale was highly dependent on bedrock fracture location/spacing and overburden composition.

The Site appears to be located within an area of recharge as low as 40 mm/yr (Figure No. 3.1-3; MVRVCA, 2009) which is consistent with the hydrogeological characterization for the Site (i.e., low hydraulic conductivity soil and bedrock).

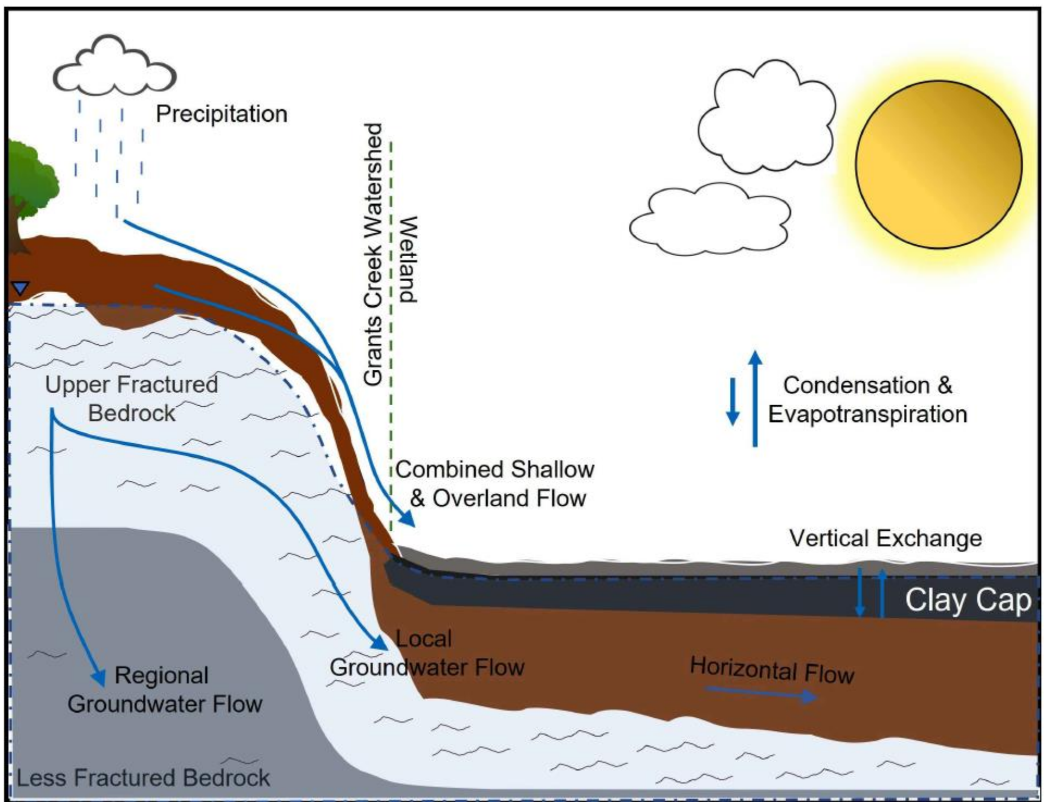
4.4 Hydrogeological Conceptual Model

The general local-scale site hydrogeology can be divided into three units as follows:

- Unit 1: Shallow- glacial till water table unit (including peat and clay in wetland)
- Unit 2: Upper, heterogeneously fractured bedrock (RQD 0 to 100%)
- Unit 3: Deeper relatively competent, fractured bedrock (RQD >75%)

The predominant hydrogeological system (Units 1 and 2) at the Site is considered to be an unconfined or leaky aquifer system, with the degree of confinement generally increasing with depth (Unit 3) in tandem with a reduction in fracture connectivity. In general, the hydraulic conductivities of the glacial till and the underlying upper bedrock are comparable. The connectivity between Unit 1 and Unit 2 are expected to vary spatially across the Site depending on the presence and significance of fractures. With generally similar water level elevations, the two upper geological units frequently act as one hydrostratigraphic unit and their connection would be influenced locally by zones of higher sand content in the glacial till or fractures and weathering in the upper bedrock unit. Based on field observations of water levels, it is believed that topography, soil properties, fractures, and/or bedrock surface encourage shallow horizontal drainage to downgradient receivers (i.e., the Tay River, onsite ponds, and Grants Creek Wetland), limiting deeper percolation of infiltrated water.

The conceptual site model is presented in Figure 6 (insert presented below).



Conceptual Site Model (insert from Figure 6, following text of this report)

4.5 Water Balance

The Site is located within an area of low groundwater recharge based on available mapping (MVRVCA, 2009). Pre-and post-development water budgets were calculated for the Site to assess potential water budget impacts resulting from the proposed development. Site-specific information was collected and incorporated into the MOE (2003) model, including estimated infiltration rates, seasonal water levels, and land cover information. For water budget analysis, the site was divided into its northern Tay River (0.23 km^2) and southern Grants Creek (0.22 km^2) watersheds.

4.5.1 Proposed Development Plans

The Site currently consists of a recreational development (golf course), forested lands and unevaluated wetlands bounded by the Tay River and the Grants Creek wetland. The development area is 0.45 km^2 and undulates with bedrock knolls across the site with three pronounced rises. The Site has an average elevation of approximately 136.1 m asl and a maximum elevation of approximately 142.5 m asl.

The proposed development for the Site consists of a residential subdivision with internal roadways, stormwater management ponds, and parklands (refer to preliminary Grading Plan, in Appendix B). Preliminary development plans include the installation of municipal storm, sanitary, and water services to a subdivision consisting of single and multi-residential units. Further, it is assumed that green spaces will consist mainly of landscaped urban lawns.

The Site will be regraded to accommodate the new infrastructure, and drainage from the roads will be directed to three stormwater retention ponds; two ponds will be located in the current Tay River Watershed and the other will be located adjacent to the Grants Creek Wetland (preliminary Grading Plan, Appendix B). Proposed cuts of bedrock knolls for grading the Site are not anticipated to intersect the groundwater table. Based on the preliminary grading plan by DSEL (Appendix B) the larger knolls on the site will be cut and used to fill in lower areas. Conversely, water, sewer, and other site infrastructure (e.g., stormwater management ponds) will extend below the ground surface and possibly below the groundwater table. Standard mitigation measures will be required for the water, sewer, and other infrastructure that extends below the groundwater table.

The final stormwater management (SWM) ponds are not anticipated to adversely impact the groundwater table. The highest measured groundwater elevations at these locations ranged from 134.5 m to 135.3 m. Permanent pond levels of 134.2 to 134.8 m asl are similar to the measured groundwater levels. SWM Pond design features and existing site conditions are presented in Table 4.7.

Table 4.7: Preliminary SWM Pond Design Features

	SWM Pond Design Features[1]			Data from Boreholes	
Pond No	Surface Elevation, m	Bottom Elevation, m	Permanent Pond Level[1,2], m	Borehole / Monitoring Well	Groundwater Elevation[2], m
Pond 1	135.0	132.8	134.3	BH22-225	134.5
Pond 2	134.9	133.2	134.2	BH22-223	134.4
Pond 3	135.8	133.3	134.8	BH22-205	135.3

Notes:
1. Pond design information obtained from DSEL (2023) Grading Plan for the Town of Perth.
2. Pond level and groundwater elevation to be confirmed following final design.

4.5.2 Pre-Development Scenario

Based on the site characteristics, the weighted average infiltration factor is estimated to be 0.43 for the Tay River watershed and 0.39 for the Grants Creek watershed. The hydrologic cycle components were calculated using the parameters compiled in Table 4.8, as informed by field and desktop investigations, and water surplus data for the Drummond Centre weather station (Climate ID: 6102J13). These parameters were input into the MOE (2003) model for each watershed, the results of which are provided in Appendix F. These calculations consider only infiltration processes and do not consider the interflow contributions to total runoff that would occur thereafter.

Table 4.8: MOE (2003) Parameters for Pre-Development Scenario

MOE (2003) Parameter	Land Condition	Tay River and Grants Creek Watershed
Topography Factor	Forested Silty Sand Till	0.1
	Grassed Silty Sand Till	0.1
	Exposed, Shallow, or Grassed Precambrian Bedrock	0.1
Soil Factor	Forested Silty Sand Till	0.2
	Grassed Silty Sand Till	0.2

MOE (2003) Parameter	Land Condition	Tay River and Grants Creek Watershed
	Exposed, Shallow, or Grassed Precambrian Bedrock	0.02
Cover Factor	Forested Silty Sand Till	0.2
	Grassed Silty Sand Till	0.1
	Exposed, Shallow, or Grassed Precambrian Bedrock	0.1
Infiltration Coefficient	Forested Silty Sand Till	0.5
	Grassed Silty Sand Till	0.4
	Exposed, Shallow, or Grassed Precambrian Bedrock	0.22
Runoff Coefficient[1]	Forested Silty Sand Till	0.5
	Grassed Silty Sand Till	0.6
	Exposed or Shallow Precambrian Bedrock	0.78

Notes:
1. The runoff coefficient characterises the proportion of water surplus that is directed to overland flow and is not sensitive to interflow contributions to runoff.

The estimated water holding capacity is variable across the site due to variations in overburden thickness, exposed bedrock, as well as variable vegetation types (short grasses on golf course compared to forested lands). Three land conditions were considered for the parameterisation of the MOE (2003) model: (1) forested silty sand till (i.e., “fine sandy loam”), (2) grass-covered silty sand till, and (3) shallow, grass-covered or exposed, fractured Precambrian bedrock (Appendix F). The areal coverage of land conditions 1, 2, and 3 were estimated as 50.1%, 38.8%, and 11.1% for the Tay River watershed. The areal coverage of land conditions 1, 2, and 3 were estimated as 47.4%, 19.2%, and 33.4% for the Grants Creek watershed. Based on the soil type and vegetation, the estimated water holding capacities selected from Table 3.1 of the Stormwater Management Planning and Design Manual (MOE, 2003) is 75 mm for grassed areas (i.e., “urban lawns”) and 300 mm for forested lands.

4.5.3 Post-Development Scenario

The infiltration for the proposed stormwater ponds and internal roadways were considered to be impervious with an infiltration factor of 0. The proposed residential properties were conservatively assumed to be 80% impervious, with the remainder considered as urban lawns with native soils.

Site grading and landscaping of the existing soils are anticipated to change the water holding capacity. The post-development water holding capacity of permeable lands is expected to be 75 mm, selected from Table 3.1 of the Stormwater Management Planning and Design Manual (MOE, 2003). The post-development infiltration factor is estimated to be 0.50 assuming rolling land topography and site vegetation classified as urban lawn underlain by fine sandy loam (native till soils). Thus, two land conditions were assumed for the post-development scenario: (1) impermeable surfaces and (2) urban lawns underlain by native tills. Water surplus for the impermeable surfaces were conservatively assumed to be 80% of precipitation. Table 4.9 summarizes the model inputs for the post-development conditions, as shown in Appendix F.

Table 4.9: MOE (2003) Parameters for Post-Development Scenario

MOE (2003) Parameter	Land Condition	Tay River and Grants Creek Watershed
Topography Factor	Impermeable Surfaces	-
	Urban Lawns Underlain by Native Tills	0.2
Soil Factor	Impermeable Surfaces	-
	Urban Lawns Underlain by Native Tills	0.2
Cover Factor	Impermeable Surfaces	-
	Urban Lawns Underlain by Native Tills	0.1
Infiltration Coefficient	Impermeable Surfaces	0
	Urban Lawns Underlain by Native Tills	0.5
Runoff Coefficient[1]	Impermeable Surfaces	1
	Urban Lawns Underlain by Native Tills	0.5

Notes:
1. Land condition 1 – impermeable surfaces and 2 – urban lawns underlain by native tills.
2. The runoff coefficient characterises the proportion of water surplus that is directed to overland flow and is not sensitive to interflow contributions to runoff.

4.5.4 Post-Development Scenario – With Mitigation

To offset the impact of the development on infiltration, low impact development (LID) measures can be implemented. Guelph permeameter testing was attempted at the project site to support LID design but proved ineffective due to high water tables and shallow bedrock. Typically, LID features are designed to be at least one metre above the seasonally high ground water table and bedrock. The MOE SWMP Design Manual (2003) and LID manuals published by the CVC and TRCA (2010) outline best management practices and LID strategies for maintaining groundwater recharge for residential land development.

In light of the high water tables and shallow bedrock across many portions of the site, modified LID features should be considered (e.g., infiltration features with subdrains to allow for drainage during high groundwater conditions), increased soil thickness on lawns for increased storage/infiltration potential, LID features located in areas with proposed grade raises, etc. Other examples of LIDs that can be incorporated into the development include catch basins, infiltration trenches, rear-yard infiltration trenches, bioswales, direct roof runoff to lawns/parks, increasing thickness of topsoil (e.g., increase from the typical minimum of 15cm to 30cm to increase retention), rain gardens, permeable pavers, etc.

To facilitate LID design, infiltration rates and percolation times were computed using the empirical relationship developed by the OMMAH (1997), a relationship that relates hydraulic conductivity to percolation times and infiltration rates. The hydraulic conductivities of native glacial till samples were estimated using HydrogeosieveXL in Section 4.3.3 (version 2.2; Devlin, 2015) and used for this assessment. The calculated percolation times and infiltration rates are included in Table 4.10. The grain size curves for these samples are provided in Appendix C and the results of HydrogeosieveXL are provided in Appendix E.

Table 4.10: Calculated Infiltration Capacity of Native Soils using OMMAH (1997)

Sample ID	Sample Depth Range	Hydraulic Conductivity[1] (m/s)	Percolation Time (min/cm)	Infiltration Rate[2] (mm/hour)
22-202 SS5	3.05 - 3.48	5E-07	13	46
22-207 SS3	1.52 - 2.13	6E-07	13	47
22-220 SS3	1.52 - 2.13	2E-09	47	13
22-224 SS4	2.29 - 2.90	9E-07	12	52
22-230_SS4	2.29 – 2.90	6E-07	13	46

Notes:
1. Geometric mean hydraulic conductivity
2. Infiltration rates do not include a safety factor.

4.5.5 Water Balance Summary

As summarized in Appendix F, development conditions are anticipated to result in a reduction of infiltration volume and an increase in overland flow volume for both watersheds. Based on the water balance calculations, the annual infiltration volumes will decrease from 34,166 m^3 to 10,787 m^3 and the runoff will increase from 46,612 m^3 to 139,278 m^3 post-development for the Tay River Watershed (Table 4.11; Table F3, Appendix F). Post-development for the Grants Creek Watershed, the annual infiltration volumes will decrease from 29,435 m^3 to 10,558 m^3 and the runoff will increase from 48,787 m^3 to 133,623 m^3 (Table 4.11; Table F6, Appendix F). The values are presented in Table 4.11 without mitigative factors included, such as LIDs.

Table 4.11: Water Balance Summary (without mitigative measures)

	Infiltration (mm/year)[1]	Runoff (mm/year)[1]	Infiltration (m^3/year)	Runoff (m^3/year)
Pre-Development (Tay River Watershed)	149	204	34,166	46,612
Pre-Development (Grants Creek Watershed)	134	222	29,435	48,787
Post-Development[2] (Tay River Watershed)	47	609	10,787	139,278
Post-Development[2] (Grants Creek Watershed)	48	607	10,558	133,623
Change (Tay River Watershed)	-102	405	-23,379	92,666
Change (Grants Creek Watershed)	-86	385	-18,877	84,837

Notes:
1. Area-weighted averages (refer to Appendix F).
2. Assume watershed divide remains the same as pre-development conditions.

Infiltration in the MOE (2003) empirical model may be regarded as one-dimensional surface model; therefore, the volumes presented in Appendix F do not distinguish between shallow infiltration processes (e.g., interflow) and deeper groundwater recharge, some of which discharges to streams and wetlands as baseflow. Factors reducing infiltration at the site include shallow bedrock, shallow water tables, and low-permeability Precambrian bedrock.

As summarized in Table 4.6, baseflow estimates vary significantly between methods, ranging from 2 to 40% of annual precipitation (18 to 363mm/year). The hydrogeological conceptual model presented in Section 4.4, suggests that the majority of pre-development infiltration (149 mm/year and 134 mm/year for Tay River and Grants Creek respectively) will be limited to the glacial till overburden and upper fractured bedrock. Deeper groundwater recharge is expected to be limited by the low permeability, competent Precambrian bedrock. Quantifying the deep groundwater contribution in Precambrian bedrock is difficult to achieve due to preferential fracture flow pathways, fracture morphology, unknown vertical connections, etc.

The MOE (1995) water balance approach estimates that infiltration in Precambrian bedrock is less than that for clay, with an infiltration factor of 0.02 (compared to clay – 0.1, till – 0.2 and sand – 0.4). Site specific studies in the Tay River subwatershed suggest rapid recharge processes are localized to areas of thin soils and primarily controlled by the hydraulic conductivity of the bedrock (Gleeson et al., 2009) and is dependant on fracture location and spacing (Novakowski et al., 2007). The Novakowski (2007) site scale study estimated baseflow contribution to be approximately 2% of annual precipitation, equal to 18 mm/year. If baseflow contribution was taken to be 18mm/year, that would represent 12 to 13% of the Tay River and Grants Creek pre-development infiltration or approximately 5% of the total pre-development surplus (infiltration and runoff). More conservative baseflow estimates based on the MOE (1995) method of 40 mm/year, as presented in MVRVCA (2009) would result in baseflow contribution of 27 to 30% of the Tay River and Grants Creek pre-development infiltration or 11% of the total pre-development surplus (infiltration and runoff). In summary, the groundwater contribution to baseflow is a very small component of the available water surplus.

4.6 Wetland Assessment

Water levels of vertically paired wells across the Site appear to respond to infiltration near-simultaneously (e.g., Figure D1, Appendix D), suggesting predominantly unconfined to leaky aquifer conditions. Although the peak and recession behaviours occur simultaneously, the magnitude of the peaks within the deeper wells are often attenuated relative to their shallower counterparts (e.g., well 22-225A compared to 22-225, Figure D2, Appendix D). This is interpreted as evidence that notable volumes of water are draining horizontally, contributing to runoff, rather than infiltrating deeper, due to limited storage and infiltration capacity across the Site. The significance of horizontal drainage is further evidenced by rapidly declining water levels in wells following infiltration events (i.e., peaks in water level) that may indicate exfiltration or horizontal migration of stormwater/meltwater downgradient (e.g., 22-221/221A and 22-232/232A). The extent and limited hydraulic capacity of fractures within the upper bedrock layers influence how water is directed horizontally over the area proposed for development.

Due to the inferred predominance of runoff processes, contributions of groundwater to the Grants Creek Wetland from the Site are likely minor. Ecological surveys performed by Kilgour & Associates Ltd. (Kilgour, February 2023) did not identify indicator biological species of significant groundwater influence within the wetland, supporting the conceptual understanding of the wetland system as surface water dominated. Poorly drained native peat and clay deposits that form the swampy areas within the Grants Creek Wetland sit above the glacial till unit and receive a minor contribution of groundwater discharge from the Site. These clay deposits are interpreted to restrict vertical groundwater flow to and from the underlying hydrostratigraphic unit comprised of till and fractured bedrock (refer to Conceptual Model, Figure 6). Thus, the clay deposits are likely to reduce groundwater discharge originating from the Site to the wetland vertically, while more conductive underlying till and upper fractured bedrock will encourage horizontal groundwater transport beneath the wetland as a flow through component.

The relatively low permeability of the clay layer is most pronounced in monitoring wells 22-232 and 22-232A (relatively upgradient wetland wells) on August 29, 2022, where a rainfall event creates a large response in the overburden well relative to the bedrock underlying the clay layer (Figure D6, Appendix D); this may be interpreted as some water infiltrating downward beneath the wetland, while a greater amount travels horizontally downgradient. Paired monitoring wells 22-231 and 22-231A in the lower wetland span the bedrock and overburden system, and the comparable magnitudes of their responses (Figure D5, Appendix D) to infiltration appear to indicate a flow through system (horizontal transport) capped by the clay of the surface water dominated wetland. Vertical flow through the clay base of the wetland is likely limited given the more conductive sandy materials beneath it, and the direction of the minor vertical exchange across the clay may be subject to change over the wetland hydroperiod.

To summarize, GEMTEC field observations and interpretations, previous investigations performed by others (Novakowski et al., 2007; Gleeson et al., 2009; RVCA, 2017), and ecological surveys performed by Kilgour and Associated Ltd. (Kilgour, February 2023), support the conclusion that water from the project Site is primarily being received by the wetland via overland processes or interflow pathways. Deeper groundwater pathways contributing to the wetland are likely limited by the clay base of the wetland and its low conductivity relative to its underlying materials. Till and fractured bedrock beneath the clay layer may encourage groundwater flow paths to be horizontal beneath the Grants Creek Wetland Complex, as reflected by the absence of a significant vertical gradient between wells 22-231 and 22-231A (Table 4.3 and Figure D5, Appendix D). As such, it is our interpretation that any reduction in infiltration or baseflow recharge caused by the development will not significantly alter the volume of water currently sustaining the key processes of the Grants Creek Wetland.

5.0 WATER TAKING AND DISCHARGE CONSIDERATIONS

Excavations will be required for the installation of storm sewers, sanitary sewers, watermain, SWP pond(s) and other site services. It is expected that the excavations will extend below the groundwater level and, therefore, temporary dewatering of the excavations will be required.

5.1 Sources of Water Taking

Water taking will be approximately located at the locations of the roads (municipal services) and storm water management ponds (preliminary locations shown in Figure 7). It is noted that this investigation does not include site services located at river crossings (i.e., Peter Street Bridge).

The proposed water taking sources are summarized in Table 5.1, which are subject to change following infrastructure layout and design changes.

Table 5.1: Estimated Excavation Dimensions

Source	Area (m^2)	Depth (m)	Volume (m^3)
Service utility trenches	135[1]	5	675
SWM Pond 1	4,700	3.5	16,450
SWM Pond 2	8,450	3	25,350
SWM Pond 3	9,900	3.5	34,650

Notes:
1. Assumed dimension for a single open trench (30 m long and 4.5 m wide).
2. Approximate dimensions for stormwater management ponds. It is noted that the infrastructure layout and design is not final and is subject to change.

Groundwater will be taken, as required, to achieve the required dewatering of excavations. It is expected that the proposed water taking from the above sources may be accomplished using one or more methods, which may include direct dewatering of open excavations using pumps, well point dewatering systems and/or other methods.

A combination of methods may also be used depending on the contractor's preferences and/or conditions determined in the field at the time of construction. For the purposes of this application, it is assumed that dewatering will be carried out using portable pumps within open excavations and that groundwater will be lowered to the base of the open excavations.

5.2 Discharge of Water

The groundwater taken will be discharged to vegetated ground surfaces in the vicinity of the proposed water takings, following suitable sediment and erosion control measures. Given the low permeability soils encountered on Site, overland flow is expected with the receiver being the Tay River and/or Grants Creek Wetland.

5.3 Groundwater Taking Calculations

Based on the water levels measured in February 2022, the groundwater levels in the vicinity of the proposed excavations range from approximately 0 (at ground surface) to 4.9 m bgs and may vary seasonally.

For the purposes of calculating groundwater taking needs, the Site was modeled as a single aquifer with a saturated aquifer thickness (i.e., water head outside the radius of influence) of up to 7 m (2 m below expected excavation depth of 5 m). Given the variable overburden thickness encountered on-site, excavations are likely to extend through the overburden and into the bedrock.

The maximum estimated dimensions for the excavations of the various groundwater taking sources are provided in Table 5.1. It is assumed that groundwater will be lowered to the base of the excavations during dewatering activities.

The groundwater taking needs for the proposed water takings at the Site are based on an estimated value of hydraulic conductivity, k, as discussed Section 4.3.3 of this report. The highest k value was calculated to be 9×10^{-5} ms^{-1} in the bedrock and provides a conservative estimate for maximum groundwater taking requirements.

The aquifer parameters used in the groundwater taking needs calculations are summarized in Table 5.2 below. The calculated groundwater taking needs for the open excavation and the above noted parameters are presented in Appendix H. The equations used, variable definitions, values used, and references are all given on the calculation worksheet provided in Appendix H.

For the purposes of assessing the maximum groundwater pumping requirements, a conservative estimate of hydraulic conductivity (9×10^{-5} ms^{-1}) was used. Although the values used for hydraulic conductivity and the hydraulic head calculations may be conservative, this is not considered to be problematic for the impact assessment as the calculated radius of influence and dewatering volumes will be less for lower hydraulic conductivity conditions encountered during construction. Based on the geometric mean of the overburden and bedrock k values, calculated to be 8×10^{-7} m^{-1} and 2×10^{-6} ms^{-1} respectively, the groundwater dewatering requirements are expected to be significantly lower.

The parameters used in the groundwater taking needs calculations are summarized in Table 5.2.

Table 5.2: Summary of Parameters Input for Groundwater Taking Calculations

Groundwater Source[1]	Volume (m^3)	Hydraulic Conductivity (ms^{-1})	Saturated Aquifer Thickness – H (m)	Water Head at Dewatered Excavation – h_0 (m)
Service trenches	675	9×10^{-5}	7.0	2.0
SWM Pond 1	4,700	9×10^{-5}	5.5	2.0
SWM Pond 2	8,450	9×10^{-5}	5.5	2.0

Groundwater Source[1]	Volume (m^3)	Hydraulic Conductivity (ms^{-1})	Saturated Aquifer Thickness – H (m)	Water Head at Dewatered Excavation – h_0 (m)
SWM Pond 3	9,900	9×10^{-5}	5.5	2.0

Notes:
1. Groundwater sources and input parameters should be verified with the final lot development plan.

The calculated groundwater taking needs for the various sources and the above noted parameters are given on the calculation worksheets provided in Appendix H. The calculated radius of influence and maximum calculated groundwater taking volume for each groundwater source are summarized in Table 5.3.

Table 5.3: Summary of Estimated Groundwater Taking Needs

Groundwater Source[1]	Radius of Influence (m)	Calculated Groundwater Taking Per Source (litres per day)	Calculated Groundwater Taking Per Source with Safety Factor[2] (litres per day)	Maximum Rate Per Source[3] (litres per minute)
Service trenches	142	339,000	847,500	1,766
SWM Pond 1	99.6	503,000	1,257,500	2,620
SWM Pond 2	99.6	598,000	1,495,000	3,115
SWM Pond 3	99.6	628,000	1,570,000	3,271

Notes:
1. Groundwater sources based on preliminary grading plan, to be verified with the final lot development plan.
2. A safety factor of 2.5 was applied to account for possible variations in hydrogeological conditions, transient (short-term) conditions upon initiation of pumping, and dewatering methodology by the contractor, as well as stormwater infiltrating into the open excavation.
3. Maximum rate calculated for an 8-hour period.

The calculated total groundwater taking for all sources within the proposed residential development is expected to be 5,485,000 litres per day. It is expected that multiple excavations will be open simultaneously for service utility trenches and the total daily water taking requested for the PTTW submission will be dependant upon construction sequencing.

Stormwater infiltration into the open excavations once mixed with groundwater will be considered groundwater for construction dewatering purposes. Therefore, the total stormwater and groundwater taking for large excavations (i.e., SWM ponds) were calculated. The highest reported precipitation event over the last 37 years is 114 mm (Drummond Centre weather station, ON 6102J13; climate.weather.gc.ca). A 114 mm rain event would produce corresponding water volumes of approximately 536 m^3/day (536,000 litres/day), 963 m^3/day (963,000 litres/day), and 1129 m^3/day (1,129,000 litres/day) for SWM Pond 1, SWM Pond 2 and SWM Pond 3 respectively. The volume added to the storm water ponds by extreme precipitation events are estimated to be less than the calculated groundwater taking, and a safety factor of 2.5 is sufficient to account for the likely range of precipitation events encountered. Alternatively, if construction sequencing allows, the stormwater can be pumped out (or allowed to overflow) at significantly lower pumping rates over a multi-day period.

It is noted that the calculated groundwater taking needs assume a conservative hydraulic conductivity for the overburden and bedrock of 9×10^{-5} ms^{-1}. The groundwater taking estimates would be significantly reduced if the geometric mean of hydraulic conductivity for overburden or bedrock of 8×10^{-7} ms^{-1} and 2×10^{-6} ms^{-1}, respectively, are used. The estimated dewatering requirements assuming geometric mean hydraulic conductivity are provided in Table 5.4. As described in the hydrogeological characterization of the Site, the groundwater flow in the bedrock will be controlled by the fracture density and connectivity. As such, the groundwater flow in the bedrock system may be highly variable.

Table 5.4: Groundwater Taking Estimates – Geometric Mean Hydraulic Conductivity

Groundwater Source	Hydraulic Conductivity (ms^{-1})	Radius of Influence (m)	Calculated Groundwater Taking Per Source (litres per day)
Service trenches	2×10^{-6}	21	22,000
SWM Pond 1	2×10^{-6}	8.5	33,000
SWM Pond 2	2×10^{-6}	8.5	43,000
SWM Pond 3	2×10^{-6}	8.5	46,000

5.4 Water Quality

The groundwater conditions at the Site were assessed as part of the Environmental Site Assessment (GEMTEC, 2022). Water quality samples were collected from monitoring wells 22-201, 22-203, 22-205, 2-208, 22-214, 22-216, 22-221, 22-222, 22-223, 22-224, and 22-225. Based on the Phase 2 Environmental Site Assessment (GEMTEC, 2022b), the groundwater quality did not meet the applicable MECP Table 1 Site Condition Standard (SCS) for one or more of cobalt, copper, nickel, and uranium at seven sampling locations (22-201, 22-208, 22-216, 22-221A, 22-222A, 22-223, 22-225 and 22-228A). The results were also compared to MECP Table 6 SCS for sites with thin soil in potable groundwater conditions, with exceedances of cobalt (22-224 and 22-225A) and uranium (22-228A). The analytical results are presented in Appendix I.

In addition, groundwater samples were collected from overburden and bedrock monitoring wells 22-221, 22-225 and 22-228. The water quality results were compared to the Town of Perth Municipal Storm Sewer Use By-Law No. 4819. Groundwater analytical results are presented in Appendix I along with Laboratory certificates of analysis. Total manganese concentrations of 1.92 mg/L and 1.52 mg/L were reported in wells 22-225 and 22-228, which exceeds the Town of Perth Storm Sewer Discharge By-Law No. 4819.

Due to the limited infiltration potential of surficial soils, discharged groundwater may flow into nearby surface water features (e.g., Tay River and Grants Creek Wetland) and as such, the groundwater quality was compared to Canadian Council of Ministers of the Environment (CCME) freshwater aquatic guidelines. The groundwater exceeds the CCME freshwater aquatic guidelines for copper (22-201, 22-208, 22-221, 22-222, 22-224, 22-225 and 22-228), nickel (22-201) and uranium (22-228). Given the distribution of copper across the Site and absence of any potentially contaminating activities identified in the Phase 2 ESA (GEMTEC, 2022b), the copper is likely naturally occurring and representative of background conditions.

Based on the results of the water quality sampling in monitoring wells 22-221, 22-225 and 22-228 along with the Environmental Site Assessment (GEMTEC, 2022b), the groundwater quality meets the Town of Perth Storm Sewer Use By-law No. 4819 and exceeds the applicable Site Condition Standards for multiple metals. Surface water quality sampling is recommended to assess the background metals concentrations and whether discharged groundwater would result in a significant increase in metals in surface waters. If the groundwater discharge would result in negative impacts to the environment (to be determined), on-site treatment prior to discharge and/or off-site disposal would be required. For discharge to a storm sewer, approval from the Town of Perth Public Works Office will be required.

5.5 Impact to Existing Groundwater Users

The purpose of the well survey is to identify existing water wells in the vicinity of the Site that may be susceptible to adverse impacts due to the proposed water taking.

Drinking Water Well Records were retrieved from the MECP online map of well records for an approximate 500 m radius around the proposed Site. It is noted that the well records do not include owner's names or addresses and, therefore, it is not possible to identify the exact locations of the wells provided in the search results. However, the locations of the water wells, based on the UTM coordinates provided in the MECP Water Well Record search results, were plotted on Figure 8.

A total of 39 well records were identified within 500 m of the site and are classified into the following groups:

- 26 Domestic Wells;
- 1 Public Wells;
- 2 Livestock Wells;
- 4 Monitoring and Test; and
- 6 Unknown (Not Listed).

A summary of the 39 MECP Water Well Records is provided in Appendix J. The recorded well depths range from 0.9 to 76.2 m bgs, with an average well depth of 23.2 m and an average recorded depth to bedrock of 2.2 m.

Based on aerial photographs and available MECP water well records, potential groundwater users are located along Christie Lake Road northwest of the Site. The closest residential dwellings are 200 m north (north of the Tay River) and 300 m west of the Site. Based on the maximum estimated radius of influence of 142 m, no groundwater users are anticipated within the zone of influence (Figure 8). The estimated radius of influence assuming geometric mean hydraulic conductivities ranges from 8.5 to 21 m, further reducing the potential impacts to groundwater users. Municipal water services are available within the Town of Perth, which obtains water from the Tay River.

In relation of discharged groundwater quality, given the low permeability of on-site soils, the majority of discharged groundwater will flow into surface water features (i.e., Tay River and/or Grants Creek Wetland). Therefore, the MECP Table 6 SCS or copper and uranium are not anticipated to impact deep bedrock groundwater supply wells.

5.6 Impact to Surface Water – Temporary Construction Dewatering

Surface water features located within 500 m of the Site include the Tay River and the Grants Creek Wetland. Both surface water features are located within the dewatering radius of influence, estimated to be up to 142 m. In terms of potential surface water quantity impacts from short-term dewatering, the hydraulic connection between groundwater dewatering sources and surface water features will be limited by the relatively low hydraulic conductivity soils and bedrock. Given that the annual average daily flow of the Tay River in 2020 was in the order of 750,000,000 L/day (Tay River at Perth Station No. 02LA024), dewatering estimates for the Site in the order of 5,402,000 L/day represents less than 1 percent of Tay River's daily average flows.

The overburden thickness generally increases towards the Tay River and bedrock removal is not expected for the installation of municipal services near the Tay River (upstream of the surface water intake) thereby reducing potential impacts associated with bedrock removal (e.g., blasting). Impacts to the Tay River from short-duration groundwater dewatering are not anticipated.

Based on the estimated radius of influence using the geometric mean k value, the radius of influence will not extend to the Grants Creek Wetland and impacts from groundwater lowering would not be anticipated. More conservative radius of influence estimates indicate that the radius of influence of up to 142 m from dewatering may extend into the Grants Creek Wetland; however, poorly drained native peat and clay deposits underlay the swampy areas present within the Grants Creek Wetland and will constrain exchange with the underlying hydrostratigraphic units, thus reducing the potential for short-term dewatering impacts (as evident in boreholes BH22-231, 22-231A, 22-232, 22-232A and hand auger holes HA137, 138, 139, 140, 141 and 142). Although unlikely, given the theoretical interaction of the drawdown cone with the wetland under conservative assumptions, controls should be implemented within the excavations to constrain inflow into the excavations to further mitigate risk.

5.7 Impact to Surface Water – Discharge

The Town of Perth's municipal surface water intake is located north of the proposed development area (refer to Figure 8). The property boundary is located within IPZ 9 and 10, with the Site limited to IPZ 9.

Groundwater should be discharged following appropriate erosion and sediment control measures (e.g., filter bags, settlement tanks, etc.) to the ground surface in vegetated areas more than 30 m away from the surface water bodies. Sedimentation and erosion control measures will be required to prevent excessive suspended solids and sediment to enter the river or wetland. Given the high anticipated flow rates, runoff towards the river and wetlands is anticipated. The use of straw bales and silt fences to promote settlement and reduce erosion is recommended.

In instances where discharged groundwater will reach the Tay River or Grants Creek Wetland, water quality monitoring of turbidity and total suspended solids concentrations should be conducted to ensure the discharged water quality meets the total particulate matter standards outlined in the Canadian Water Quality Guidelines for the protection of aquatic life (Canadian Environmental Quality Guidelines, 2002). In addition, multiple metals including copper, nickel, and uranium exceeded the CCME freshwater aquatic guidelines. Prior to discharge, the metals concentrations in surface water should be determined in order to assess whether the discharged groundwater will increase background conditions and negatively impact surface waters.

As a protective measure, the discharge location should be situated in an area downgradient from the Tay River surface water intake. The discharge location in proximity to the Grants Creek Wetland should consider the sensitivity of the Grants Creek Wetland species, some of which may be sensitive to groundwater discharge temperatures. The sensitivity of the wetland to temperature should be assessed prior to discharge.

The water quality should be measured at three locations: 1) upstream of the work area and Town of Perth surface water intake, 2) downstream of the discharge point, and 3) at the point of discharge. The downstream water quality and surface water discharged from the excavations should meet the following criteria:

- Turbidity (clear flow; between 8 and 80 Nephelometric Turbidity Unit; NTU): maximum increase of 8 NTUs from upstream levels;
- Turbidity (high/turbid flow; >80 NTU): maximum increase of 10 percent of upstream turbidity levels;
- Total suspended solids (clear flow): maximum increase of 25 mg/L from upstream levels for the first 24-hour period and a maximum increase of 5 mg/L from background levels for exposures exceeding 24-hours; and
- Total suspended solids (high flow): maximum increase of 25 mg/L from upstream levels at any time when background levels are between 25 and 250 mg/L and a maximum increase of 10 percent of upstream levels when background is greater than 250 mg/L.

If groundwater is discharged to the Town of Perth's municipal storm sewer, a discharge agreement will need to be obtained with the Town of Perth prior to discharge. Turbidity and total suspended solids monitoring should be performed periodically in order to avoid releasing groundwater with excessive suspended solids in the sewers. Should the groundwater quality deteriorate, and signs of impacts be observed during dewatering operations, the groundwater must be treated on Site or discharged directly to groundwater tankers and disposed of at an appropriate off-site receiver. No discharge to the environment will occur under those circumstances until water quality issues have been resolved.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Based on the results of the hydrogeological investigation, the following conclusions and professional opinions are provided:

- The topography across the Site is variable with prominent knolls rising 4 to 6 m above low-lying areas. A west-east oriented surface water divide transects the proposed development area and surface water drainage north of the divide flows to the Tay River and the area south of the divide drains into the Grants Creek Wetland, a Provincially Significant Wetland (PSW).

- In general, subsurface conditions on the Site consist of topsoil or peat (wetland), stiff silty clay, overlying silty sand and gravel with cobbles and boulders (glacial till), above bedrock. Surficial soil thicknesses are variable across the Site with exposed bedrock forming high points and 1 to 3 m of overburden in the low areas between bedrock knolls. The surface of the bedrock drops off to the northwest towards the Tay River where the overburden thickness exceeds 7 m.

- Monitoring wells were installed in 24 of the 46 boreholes drilled at the Site. Groundwater levels ranged from 0 to 4.9 m bgs. In general, groundwater was encountered at shallow depths and slight downward gradients (recharge conditions) were noted along the high areas and slight upward gradients (discharge conditions) were noted in lower-lying areas. Interflow pathways are likely strongly influenced by surface topography and bedrock fractures, and the surface water divides can be used as a proxy for shallow groundwater divides.

- The hydrogeological system at the Site is interpreted as an unconfined to leaky aquifer system. In general, the measurements of hydraulic conductivities for the glacial till and the underlying upper bedrock are comparable. The connectivity between the overburden and upper bedrock are expected to vary spatially across the Site depending on the presence and significance of fractures. However, with generally similar water level elevations, the two upper geological units frequently act as one hydrostratigraphic unit, and their connection would be influenced locally by zones of higher sand content in the glacial till or fractures and weathering in the upper bedrock unit.

- Based on hydraulic testing, calculated hydraulic conductivity values for the bedrock range from less than 1×10^{-7} to 9×10^{-5} ms^{-1} with a geometric mean of 2×10^{-6} ms^{-1}. The bedrock is locally weathered / fractured and is inferred to become progressively more competent with depth. The hydraulic conductivity of the overburden is similar to that of the bedrock, ranging from 2×10^{-7} to 3×10^{-6} ms^{-1}, with a geometric mean of 8×10^{-7} ms^{-1}.

- The lowest measured groundwater elevation is by the Grants Creek Wetland near the southeastern portion of the Site. Poorly drained native peat and clay deposits underlie the swampy areas present within the Grants Creek Wetland and will constrain exchange with the underlying hydrostratigraphic units, thereby reducing direct groundwater discharge from the Site to the Grants Creek Wetland. This interpretation is corroborated by soil characterisations within the adjacent wetland area and biological species surveys.

- The Site is located on the downstream end of Grants Creek, where it discharges into the Tay River. Based on surface water flows, wetland vegetation communities, and water balances (MVRVCA, 2009), most water supplied to the Grants Creek Wetland is likely derived from sources upgradient rather than through surface water or, to an even lesser degree, groundwater originating from the proposed development area.

  - Groundwater contribution to baseflow is a very small component of the available water surplus (estimated at 5 to 11% of available water surplus).

- The water from the project Site is primarily being received by the wetland via overland processes or interflow pathways. Deeper groundwater pathways contributing to the wetland are likely limited by the clay base of the wetland and its low conductivity relative to its underlying materials. Glacial till and fractured bedrock beneath the clay layer may encourage groundwater flow paths to be horizontal beneath the Grants Creek Wetland Complex. As such, it is our interpretation that any reduction in infiltration or baseflow recharge caused by the proposed development will not significantly alter the volume of water currently sustaining the key processes of the Grants Creek Wetland.

- The water balance completed for the Site, based on conservative assumptions to be refined during the detailed design phase, indicates that pre- and post-development runoff is greater than infiltration. The post-development runoff will increase by 405 mm/year and 385 mm/year for the Tay River and Grants Creek subwatersheds, respectively. The post-development infiltration (without mitigation measures) will be reduced by 102 mm/year and 86 mm/year for the Tay River and Grants Creek subwatersheds, respectively.

  - The hydrogeological conceptual model suggests that overland flow and interflow (e.g., rapid vadose zone transport and/or exfiltration following infiltration) are the primary contributors of water to the Grants Creek Wetland and Tay River from the Site; these flowpaths are considered together as runoff, as described by Fetter (2001). Most of the infiltration reduction post-development, much of which would otherwise go to interflow, will be captured by SWMPs. SWMPs will be designed to control the runoff volumes and travel times to the downstream receivers to emulate pre-development function.

- Estimates of annual groundwater discharge (baseflow) into the Tay River catchment upstream of the development areas were calculated using available water level information from stream gauge Tay River at Perth Station. The results fall within the upper range of published data for the region (21 percent) and are likely skewed higher by surface water released during low flow periods from dam-controlled storage reservoirs in the watershed that are designed to maintain water levels in the Rideau Canal system.

  - The MVRVCA (2009) Tier 1 Water Budget and Water Quantity Stress Assessment estimate baseflow contribution to be between 2% and 40% of annual precipitation, with the lowest baseflow estimate of 2% based on site scale studies conducted in the Tay River subwatershed (Novakowski et al., 2007).

- Long-term water level monitoring data provides evidence that notable volumes of water are draining horizontally, rather than infiltrating deeper, due to limited storage and infiltration capacity across the Site. Deep groundwater recharge will be limited by the on-site Precambrian bedrock, which was identified to be locally weathered and fractured, that likely becomes progressively less vertically transmissive with depth. Further, it is believed that the extent and hydraulic capacity of fractures within the upper bedrock layers influence how water is directed horizontally over the area proposed for development. The significance of horizontal drainage is further evidenced by rapidly declining water levels in wells following infiltration events (i.e., peaks in water level) that may indicate exfiltration or horizontal migration of stormwater downgradient (e.g., 22-221/221A and 22-232/232A).

  - This is supported by site-specific studies in the Tay River subwatershed that suggest infiltration is localized and dependant on bedrock fracture location and spacing (Gleeson et al., 2009; Novakowski et al., 2007).

- Significant changes to the Grants Creek and Tay River contributions from groundwater are not anticipated from the reduction in groundwater infiltration and could be supplemented with the proposed LIDs and stormwater management measures.

  - Stormwater management measures and LIDs that function to control rapid runoff and allow for release volumes and rates similar to the pre-development conditions will help supplement and support the ecologic function and long-term sustainability of the wetland and Tay River.

  - The type and location of LID features will be constrained by the high groundwater levels and shallow bedrock encountered on Site; however, long-term water level monitoring data suggests groundwater levels decrease to greater than one metre below ground surface seasonally.

  - LID features with subdrains (to allow for overflow during seasonally high groundwater levels in the spring) and unlined SWMPs with naturalized outlets should be considered. SWMP and LID features with overflow functions would serve to maintain groundwater levels if they permitted infiltration of retained water when the groundwater system had available storage capacity. This SWMP and LID design is stipulated to function analogously to the pre-development conditions, wherein deep infiltration is limited and highly localized to irregularly distributed vertical bedrock fractures, and excess water that cannot be received by the subsurface system becomes runoff.

- Although a grade raise may cause minor changes in groundwater levels within the developed area, groundwater flow direction in the overburden at the Site is not anticipated to change to an extent that would adversely affect the wetland water levels. The post-development grading plan indicates that topographic highs and lows will be cut and filled to accommodate internal roadways and the pre-development grading at the development boundaries will remain unchanged.

- Impacts to groundwater users in the area are not anticipated. The proposed development is situated 200 m from the nearest reported water well. The development will be serviced with municipal water, and groundwater extraction for potable water will not occur.

- No negative impacts associated with temporary construction dewatering are anticipated, provided protective measures are implemented to safeguard the Town of Perth municipal surface water intake.

    - The hydrogeological investigation indicates that dewatering of the proposed groundwater sources is not anticipated to cause significant adverse impacts on or off the Site.

    - The areas surrounding the Site are serviced by municipal water. Potential groundwater users are located greater than 200 m from the property boundary and are outside the calculated radius of influence. Based on the relatively shallow excavation depths, no impacts to groundwater users are anticipated.

    - No geotechnical concerns were identified associated with construction dewatering or soil settlement.

    - The dewatering radius of influence is calculated to be 21 m based on geometric mean bedrock hydraulic conductivity and up to 142 m based on conservative estimate of hydraulic conductivity.

    - Groundwater quality exceeds the MECP Table 1 and Table 6 SCS as well as the CCME freshwater aquatic guidelines for multiple metals. Given the low permeability of on-site soils, it is anticipated that the discharged groundwater will flow towards the Tay River and/or Grants Creek Wetland. Prior to discharge, the metals concentrations in surface water should be confirmed to assess whether the discharged groundwater will increase background conditions and negatively impact surface waters. In areas where the groundwater quality exceeds the applicable SCS and/or CCME freshwater aquatic guidelines, on-site treatment or off-site disposal may be required.

- The location of groundwater discharge should be located downgradient of the Town of Perth surface water intake. If discharged to a municipal storm sewer, the groundwater quality meets the Town of Perth Storm Sewer Use By-law No. 4819, apart from manganese (common exceedance and sewer disposal permissions are typically granted via the approval of a by-law variance).

6.2 Recommendations

The following recommendations are provided regarding potential impacts to the Tay River and Grants Creek Wetland:

- Permanent modifications to the groundwater table should be avoided. Clay seals should be placed along water and sewer infrastructure to limit groundwater flow in the permeable pipe bedding material and possible decline of groundwater levels.

- Water levels within the wetland should continue to be monitored to characterise seasonal water levels more comprehensively and to ensure that the interpretation of site processes is upheld over multiple years of data. The maintenance of the current wetland monitoring locations is recommended for this purpose.

- On-site wells paired with the wetland wells, such as 221/221A and 228/228A presently (or equivalent), should be maintained to monitor for development impacts and continue to evaluate the present interpretation of site processes.

- Once wells have outlived their usefulness for monitoring and assessment, they should be decommissioned in accordance with Ontario Regulation 903.

- The pre-development infiltration volumes and conceptual understanding of the subsurface system should be incorporated into detailed stormwater management and LID design. Infiltration capacity estimates, soil characterizations, and water table monitoring are presented within this report and in the associated surface water report prepared by JFSA to assist in detailed SWMP and LID design. It is recommended that the mitigated post-development infiltration and runoff rates are assessed at the time of detailed design.

- Groundwater taking and discharge requirements should be confirmed by a Qualified Person following a review of the final detailed design drawings.

- As part of any construction dewatering at the Site, a detailed discharge plan should be submitted for review prior to construction with specific measures to eliminate groundwater discharge to the Tay River upstream of the Town of Perth municipal surface water intake (IPZ 9).

7.0 LIMITATION OF LIABILITY

This report was prepared, and the work referred to within it, has been undertaken by GEMTEC for Caivan (Perth GC) Limited. It is intended for the exclusive use of Caivan (Perth GC) Limited. This report may not be relied upon by any other person or entity without the express written consent of GEMTEC and Caivan (Perth GC) Limited. Nothing in this report is intended to provide a legal opinion.

The investigation undertaken by GEMTEC with respect to this report and any conclusions or recommendations made in this report reflect the best judgments of GEMTEC based on the site conditions observed during the investigations undertaken at the date(s) identified in the report and on the information available at the time the report was prepared. This report has been prepared for the application noted and it is based, in part, on visual observations made at the Site, subsurface investigations at discrete locations and depths during a specific time interval, all as described in the report. Unless otherwise stated, the findings contained in this report cannot be extrapolated or extended to previous or future Site conditions, portions of the site that were unavailable for direct investigation, subsurface locations on the site that were not investigated directly, or chemical parameters, materials or analysis which were not addressed.

Should new information become available during future work, including excavations, borings or other studies, GEMTEC should be requested to review the information and, if necessary, reassess the conclusions presented herein.

8.0 CLOSURE

We trust this report provides sufficient information for your present purposes. If you have any questions concerning this report, please do not hesitate to contact our office.

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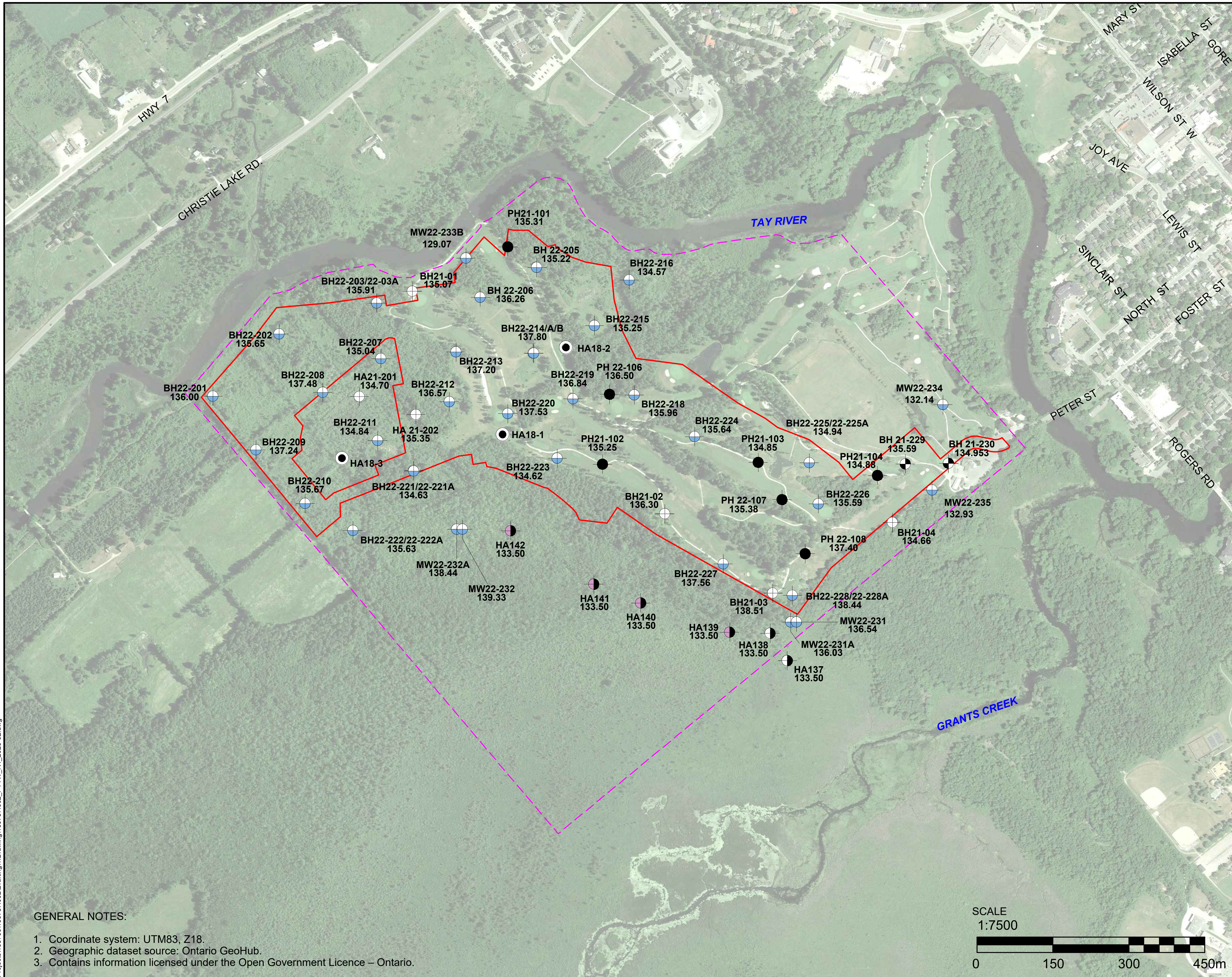

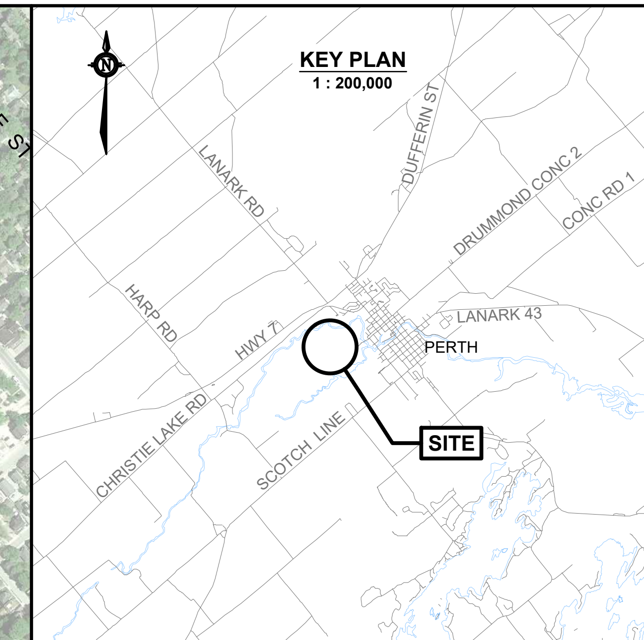

LEGEND

BH/ PH/ HA/ MW # — BOREHOLE/ PROBEHOLE/ HAND AUGERHOLE/ MONITORING WELL ID

XX.XX — GROUND SURFACE ELEVATION, IN METRES GEODETIC DATUM

- **BOREHOLE** (current investigation by GEMTEC)
- **BOREHOLE** (previous investigation by GEMTEC)
- **PROBEHOLE** (previous investigation by GEMTEC)
- **MONITORING WELL** (current investigation by GEMTEC)
- **HAND AUGER HOLE** (current investigation by GEMTEC)
- **HAND AUGERHOLE** (previous investigation by GEMTEC)
- **HAND AUGER HOLE** (previous investigation by GEMTEC, 2018)
- **HAND AUGER HOLE** (current investigation by GEMTEC,elevations are based on DEM (not surveyed data))
- APPROXIMATE PROPERTY BOUNDARY
- APPROXIMATE DEVELOPMENT BOUNDARY

DRAWING	SITE PLAN
CLIENT	CAIVAN COMMUNITIES
PROJECT	PROPOSED DEVELOPMENT PERTH GOLF 151 PETER STREET PERTH, ONTARIO

DRAWN BY S.L.	CHECKED BY A.P.
PROJECT NO. 100737.002	REVISION NO. 1
DATE FEBRUARY 2023	FIGURE NO. FIGURE 1

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GENERAL NOTES:

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2. Geographic dataset source: Ontario GeoHub.
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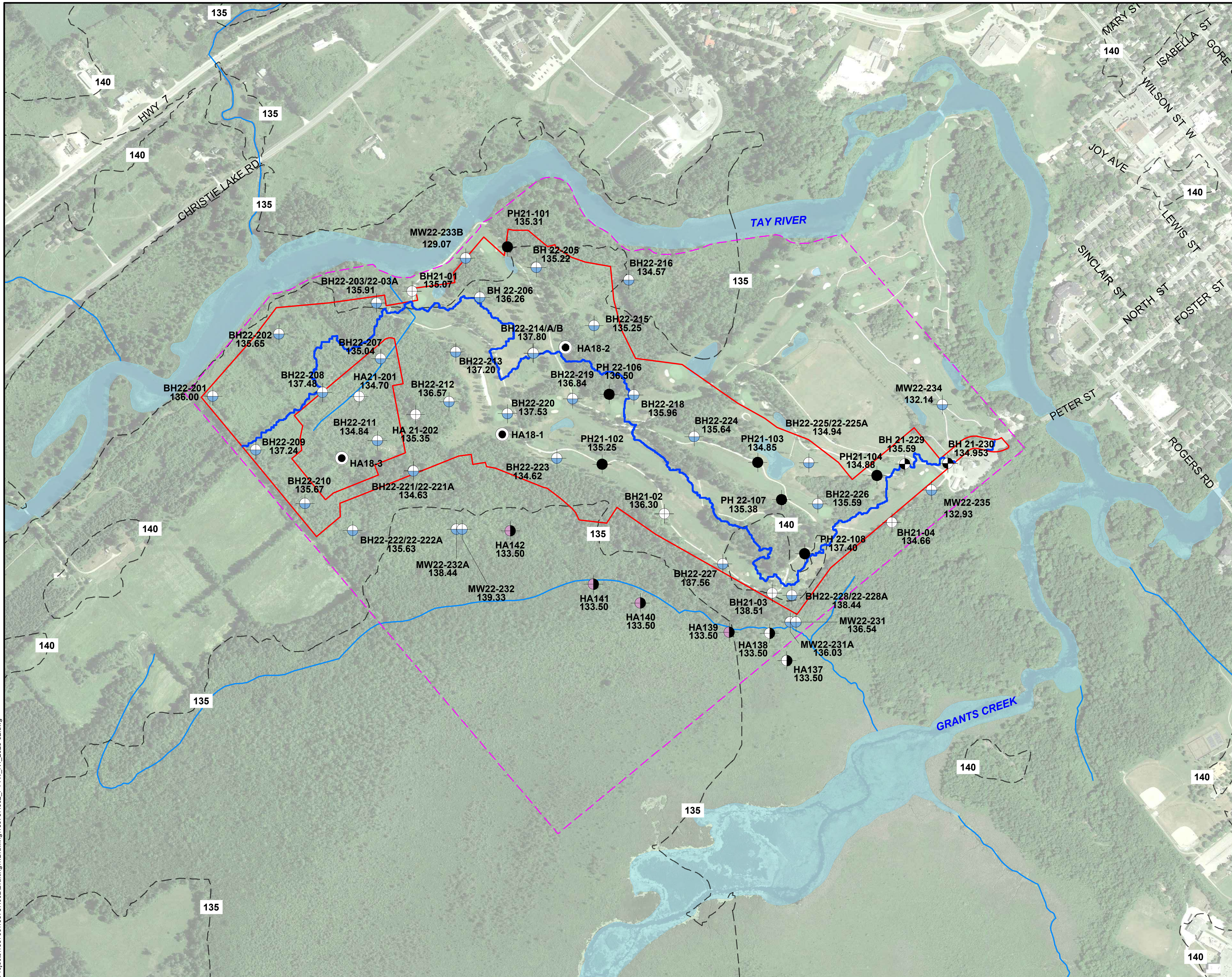

LEGEND

BH/ PH/ HA/ MW # — BOREHOLE/ PROBEHOLE/ HAND AUGERHOLE/ MONITORING WELL ID
XX.XX — GROUND SURFACE ELEVATION, IN METRES GEODETIC DATUM

- **BOREHOLE** (current investigation by GEMTEC)
- **BOREHOLE** (previous investigation by GEMTEC)
- **PROBEHOLE** (previous investigation by GEMTEC)
- **MONITORING WELL** (current investigation by GEMTEC)
- **HAND AUGER HOLE** (current investigation by GEMTEC)
- **HAND AUGERHOLE** (previous investigation by GEMTEC)
- **HAND AUGER HOLE** (previous investigation by GEMTEC, 2018)
- **HAND AUGER HOLE** (current investigation by GEMTEC,elevations are based on DEM (not surveyed data))
- APPROXIMATE PROPERTY BOUNDARY
- APPROXIMATE DEVELOPMENT BOUNDARY
- SURFACE WATER
- WATERSHED DRAINAGE DIVIDE
- WATER BODY
- 100 — ONTARIO BASE MAPPING (OBM) CONTOUR, 5 METRES INTERVAL

GENERAL NOTE(S)

1. Coordinate system: UTM83, Z18.
2. Geographic dataset source: Ontario GeoHub.
3. Contains information licensed under the Open Government Licence – Ontario.

SCALE 1:7500

0 150 300 450m

DRAWING	SITE TOPOGRAPHY AND DRAINAGE PLAN
CLIENT	CAIVAN COMMUNITIES
PROJECT	PROPOSED DEVELOPMENT PERTH GOLF 151 PETER STREET PERTH, ONTARIO

DRAWN BY: S.L.	CHECKED BY: A.P.
PROJECT NO.: 100737.002	REVISION NO.: 1
DATE: FEBRUARY 2023	FIGURE NO.: **FIGURE 2**

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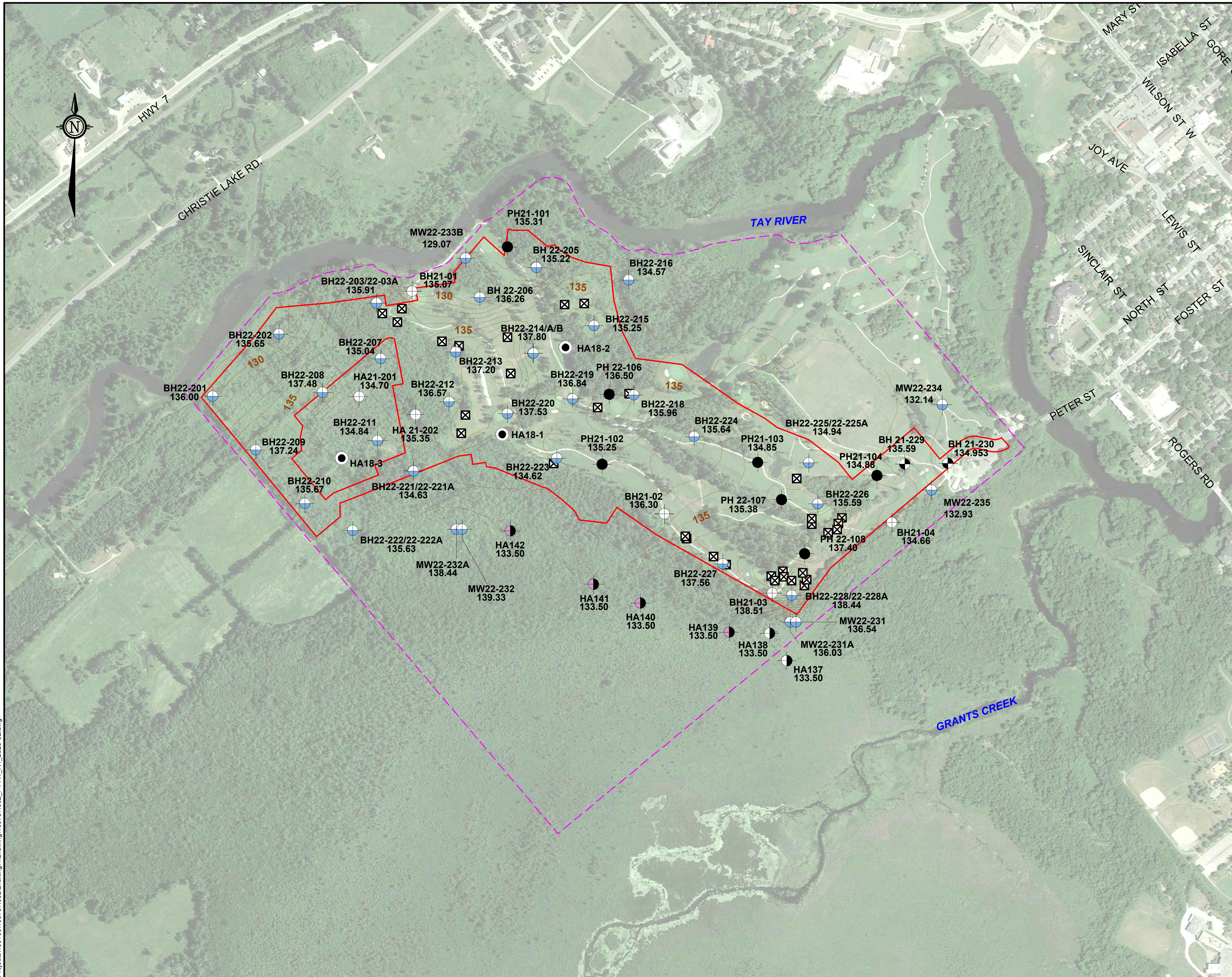

LEGEND

BH/ PH/ HA/ MW # — BOREHOLE/ PROBEHOLE/ HAND AUGERHOLE/ MONITORING WELL ID
XX.XX — GROUND SURFACE ELEVATION, IN METRES GEODETIC DATUM

- **BOREHOLE** (current investigation by GEMTEC)
- **BOREHOLE** (previous investigation by GEMTEC)
- **PROBEHOLE** (previous investigation by GEMTEC)
- **MONITORING WELL** (current investigation by GEMTEC)
- **HAND AUGER HOLE** (current investigation by GEMTEC)
- **HAND AUGERHOLE** (previous investigation by GEMTEC)
- **HAND AUGER HOLE** (previous investigation by GEMTEC, 2018)
- **HAND AUGER HOLE** (current investigation by GEMTEC,elevations are based on DEM (not surveyed data))
- **BEDROCK OUTCROPS OBSERVED**
- APPROXIMATE PROPERTY BOUNDARY
- APPROXIMATE DEVELOPMENT BOUNDARY
- 134 BEDROCK CONTOURS (1.0 metre interval)

GENERAL NOTE(S)

1. Coordinate system: UTM83, Z18.
2. Geographic dataset source: Ontario GeoHub.
3. Contains information licensed under the Open Government Licence – Ontario.

SCALE 1:7500
0 150 300 450m

DRAWING	BEDROCK CONTOUR PLAN
CLIENT	CAIVAN COMMUNITIES
PROJECT	PROPOSED DEVELOPMENT PERTH GOLF 151 PETER STREET PERTH, ONTARIO
DRAWN BY: S.L.	CHECKED BY: A.P.
PROJECT NO.: 100737.002	REVISION NO.: 1
DATE: FEBRUARY 2023	FIGURE NO.: FIGURE 3

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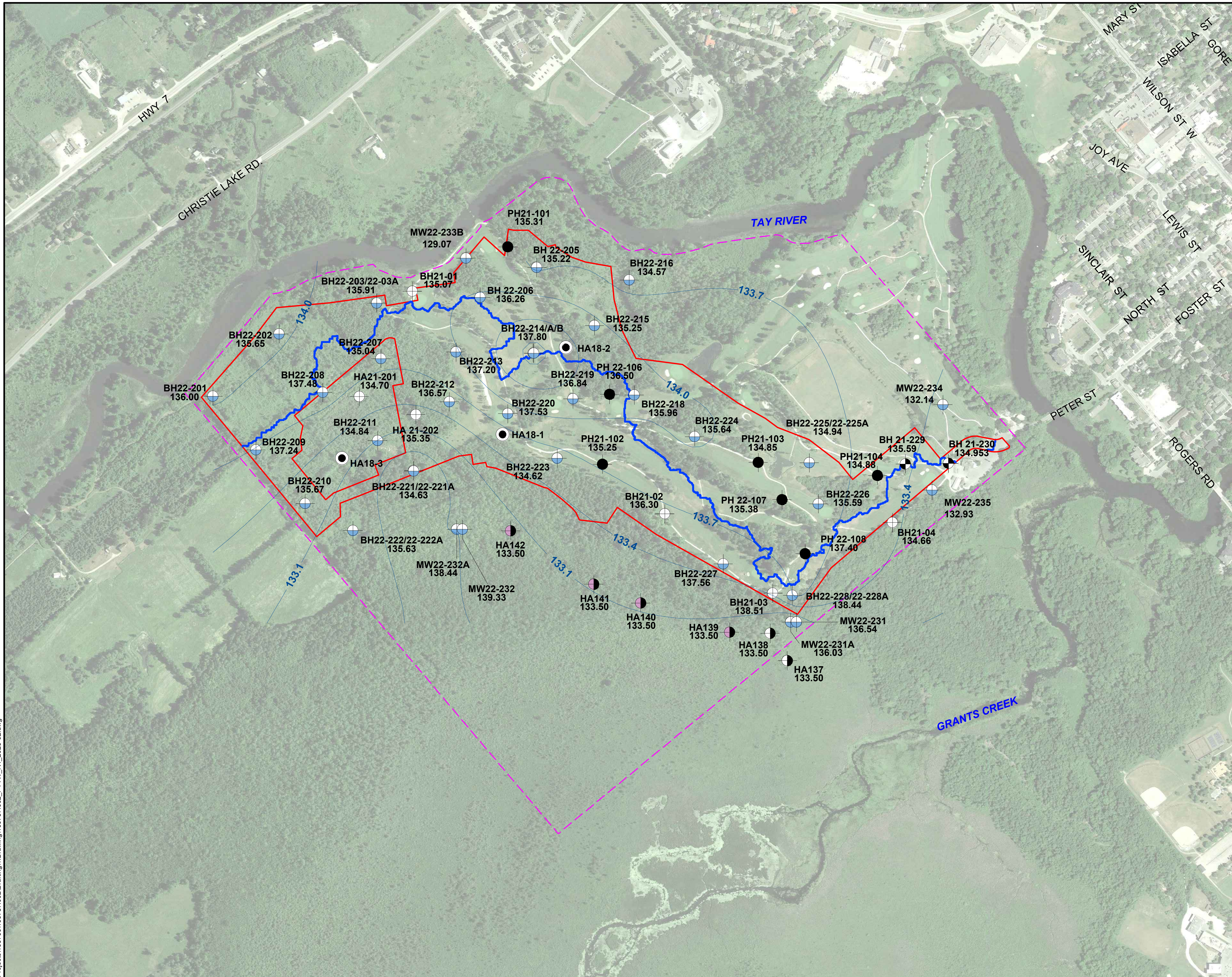

LEGEND

BH/ PH/ HA/ MW # — BOREHOLE/ PROBEHOLE/ HAND AUGERHOLE/ MONITORING WELL ID
XX.XX — GROUND SURFACE ELEVATION, IN METRES GEODETIC DATUM

- **BOREHOLE** (current investigation by GEMTEC)
- **BOREHOLE** (previous investigation by GEMTEC)
- **PROBEHOLE** (previous investigation by GEMTEC)
- **MONITORING WELL** (current investigation by GEMTEC)
- **HAND AUGER HOLE** (current investigation by GEMTEC)
- **HAND AUGERHOLE** (previous investigation by GEMTEC)
- **HAND AUGER HOLE** (previous investigation by GEMTEC, 2018)
- **HAND AUGER HOLE** (current investigation by GEMTEC,elevations are based on DEM (not surveyed data))
- APPROXIMATE PROPERTY BOUNDARY
- APPROXIMATE DEVELOPMENT BOUNDARY
- WATERSHED DRAINAGE DIVIDE
- 100 WATER LEVEL CONTOUR (in metres), MASL

GENERAL NOTE(S)

1. Coordinate system: UTM83, Z18.
2. Geographic dataset source: Ontario GeoHub.
3. Contains information licensed under the Open Government Licence – Ontario.

SCALE 1:7500

0 150 300 450m

DRAWING	GROUNDWATER ELEVATION
CLIENT	CAIVAN COMMUNITIES
PROJECT	PROPOSED DEVELOPMENT PERTH GOLF 151 PETER STREET PERTH, ONTARIO

DRAWN BY: S.L.	CHECKED BY: A.P.
PROJECT NO.: 100737.002	REVISION NO.: 1
DATE: FEBRUARY 2023	FIGURE NO.: FIGURE 4

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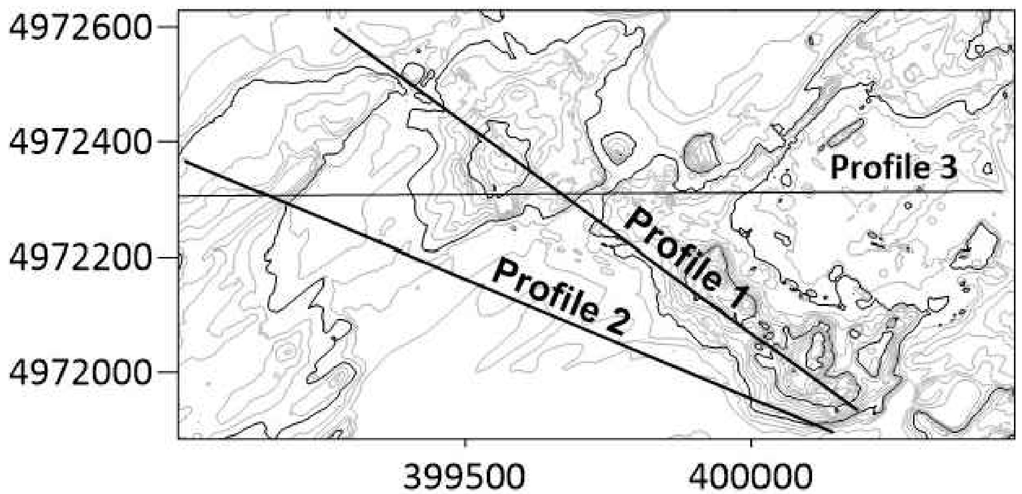

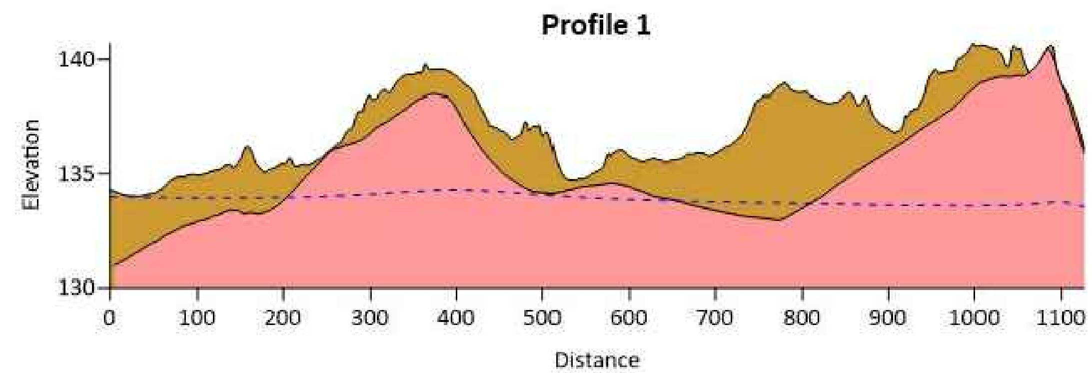

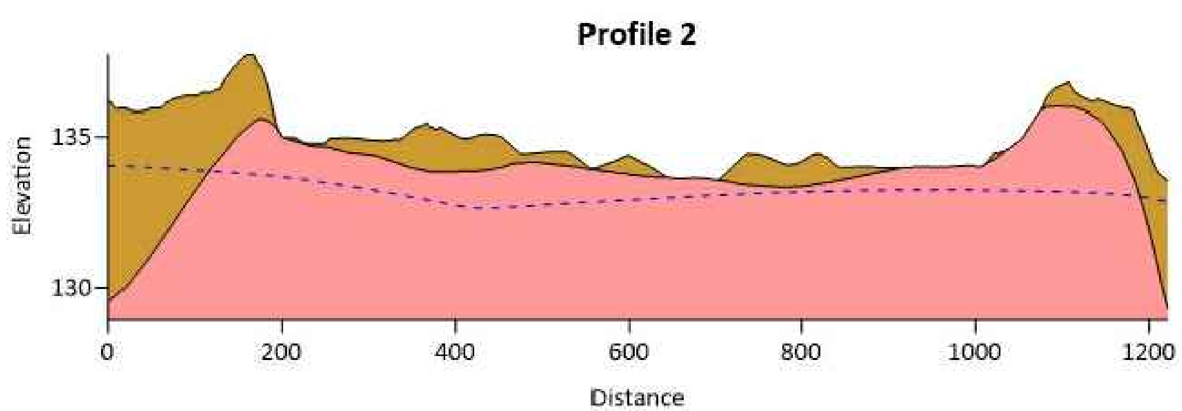

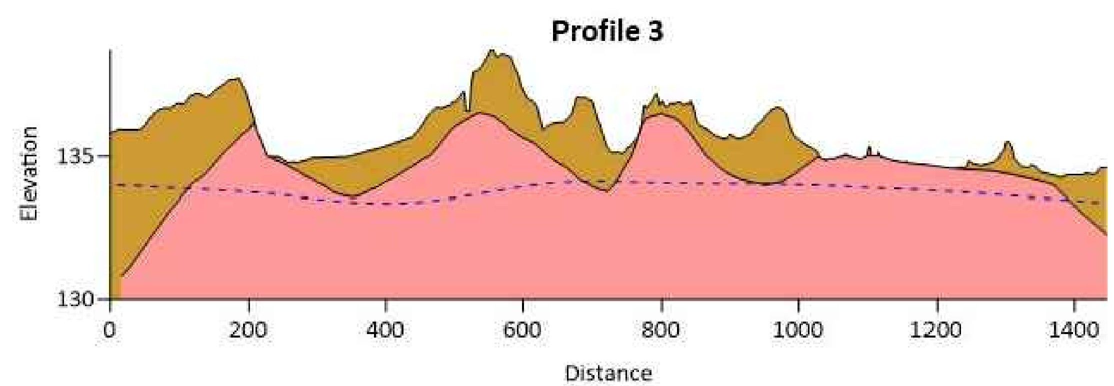

LEGEND

INFERRED BEDROCK

INFERRED OVERBURDEN

SCALE: NOT TO SCALE	
DRAWING: CONCEPTUAL SITE MODEL (1 OF 2)	
CLIENT: CAIVAN COMMUNITIES	
PROJECT: PROPOSED DEVELOPMENT PERTH GOLF 151 PETER STREET PERTH, ONTARIO	
DRAWN BY: S.L.	CHECKED BY: A.P.
PROJECT NO.: 100737.002	REVISION NO.: 1
DATE: FEBRUARY 2023	FIGURE NO.: **FIGURE 5**

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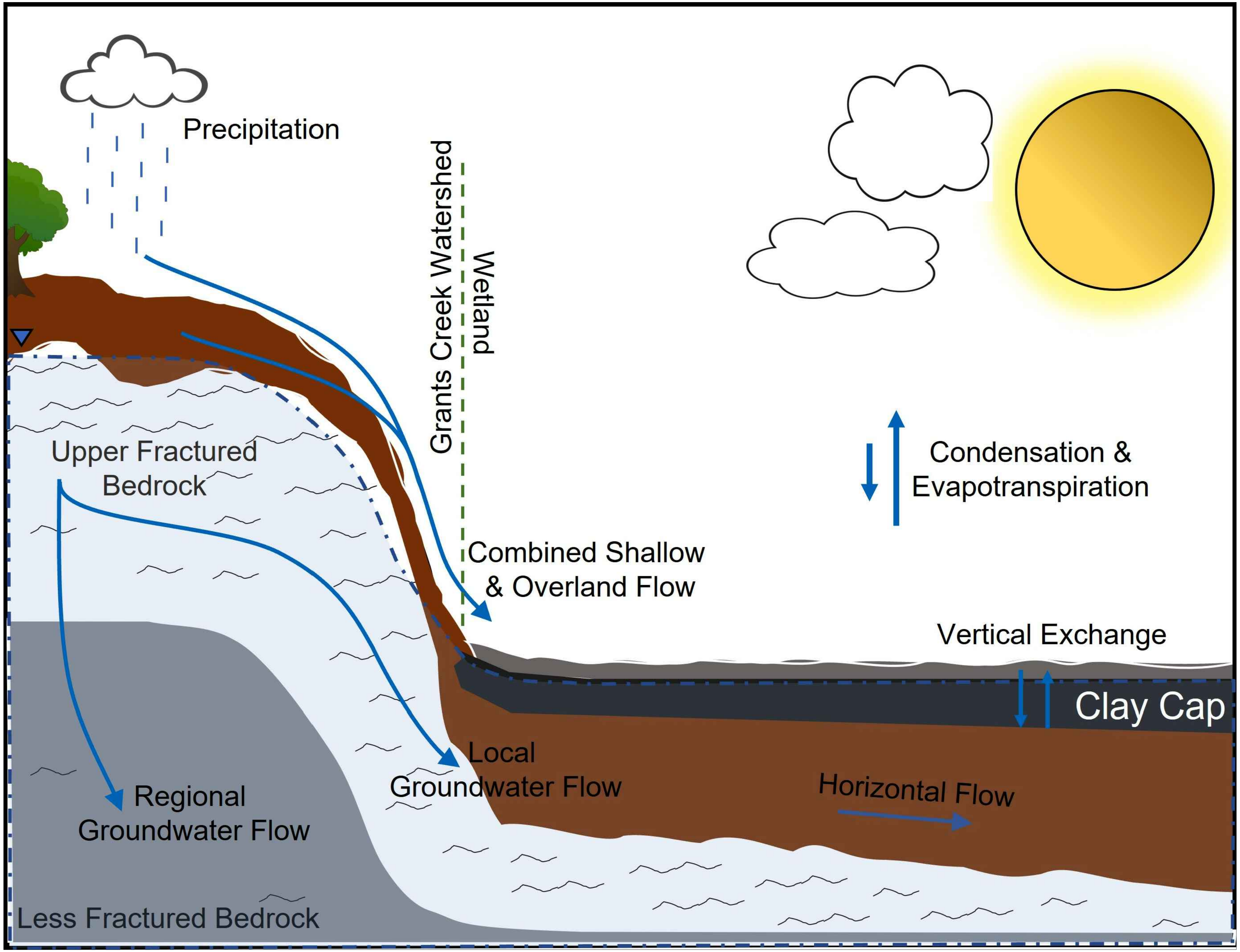

LEGEND

- WATER
- TILL
- PEAT
- CLAY
- BEDROCK
- FRACTURES
- WATER TRANSPORT

SCALE	NOT TO SCALE
DRAWING	CONCEPTUAL SITE MODEL (2 OF 2)
CLIENT	CAIVAN COMMUNITIES
PROJECT	PROPOSED DEVELOPMENT PERTH GOLF 151 PETER STREET PERTH, ONTARIO
DRAWN BY	S.L.
CHECKED BY	A.P.
PROJECT NO.	100737.002
REVISION NO.	1
DATE	FEBRUARY 2023
FIGURE NO.	FIGURE 6

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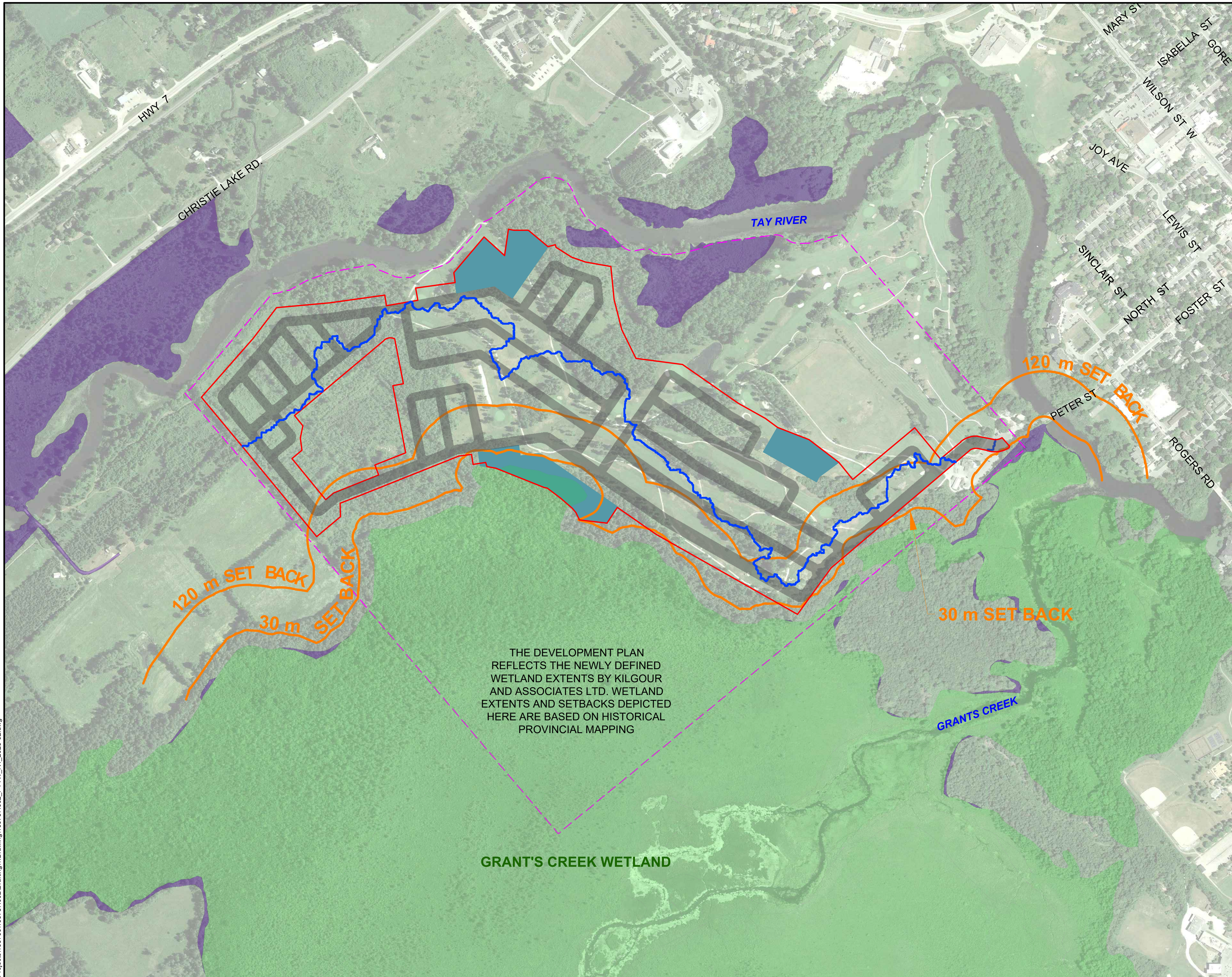

LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- APPROXIMATE DEVELOPMENT BOUNDARY
- WATERSHED DRAINAGE DIVIDE
- APPROXIMATE WETLAND SETBACKS
- PROVINCIALLY EVALUATED WETLAND (ONTARIO MINISTRY OF NATURAL RESOURCES AND FORESTRY, OMNRF)
- UNEVALUATED WETLAND (ONTARIO MINISTRY OF NATURAL RESOURCES AND FORESTRY, OMNRF)
- APPROXIMATE STORM WATER MANAGEMENT POND LOCATION
- PROPOSED ROADS

GENERAL NOTE(S)

1. Coordinate system: UTM83, Z18.
2. Geographic dataset source: Ontario GeoHub.
3. Contains information licensed under the Open Government Licence – Ontario.

SCALE 1:7500

0 150 300 450m

DRAWING	DEVELOPMENT PLAN
CLIENT	CAIVAN COMMUNITIES
PROJECT	PROPOSED DEVELOPMENT PERTH GOLF 151 PETER STREET PERTH, ONTARIO
DRAWN BY: S.L.	CHECKED BY: A.P.
PROJECT NO.: 100737.002	REVISION NO.: 1
DATE: FEBRUARY 2023	FIGURE NO.: **FIGURE 7**

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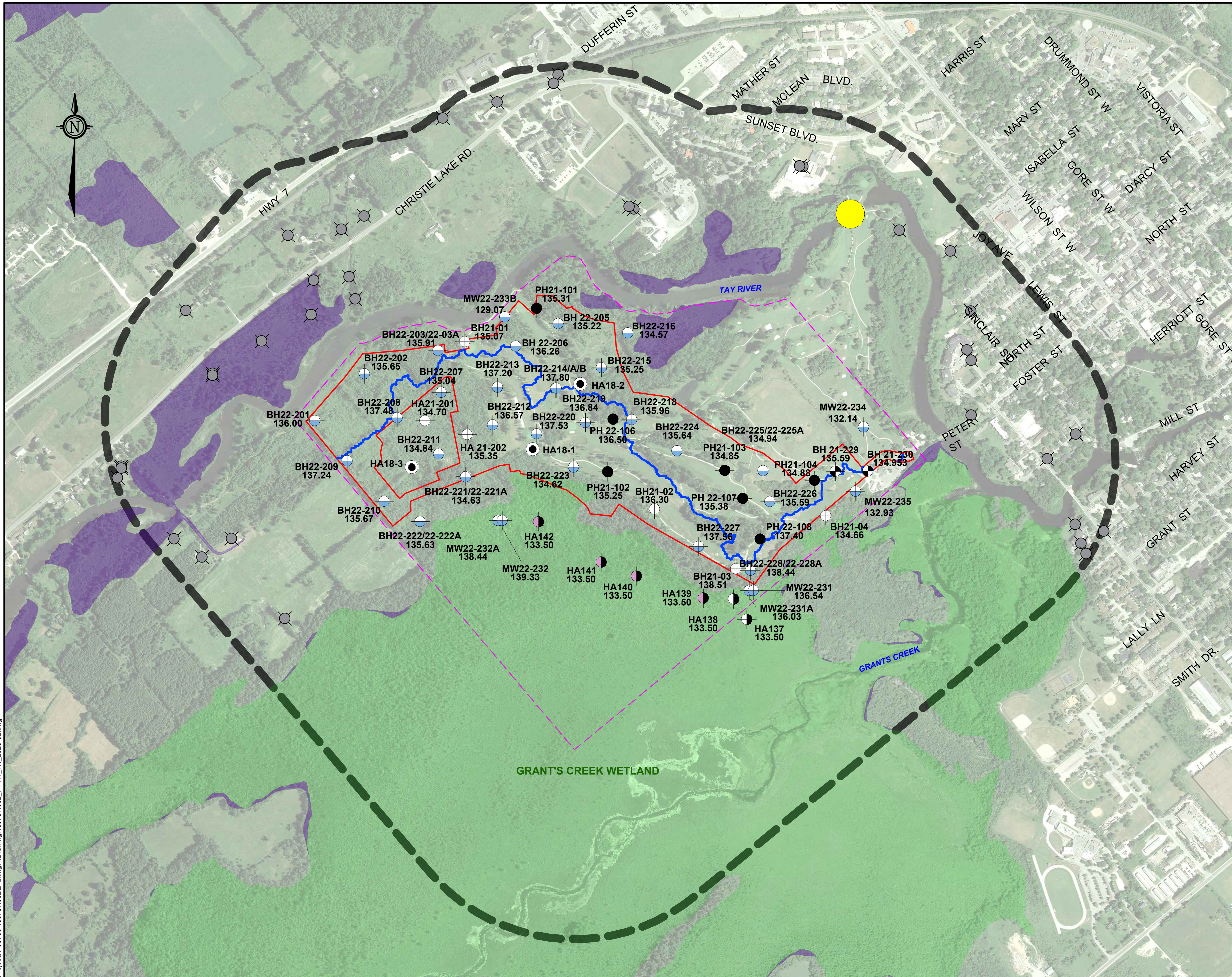

LEGEND

BH/ PH/ HA/ MW # — BOREHOLE/ PROBEHOLE/ HAND AUGERHOLE/ MONITORING WELL ID
XX.XX — GROUND SURFACE ELEVATION, IN METRES GEODETIC DATUM

- **BOREHOLE** (current investigation by GEMTEC)
- **BOREHOLE** (previous investigation by GEMTEC)
- **PROBEHOLE** (previous investigation by GEMTEC)
- **MONITORING WELL** (current investigation by GEMTEC)
- **HAND AUGER HOLE** (current investigation by GEMTEC)
- **HAND AUGERHOLE** (previous investigation by GEMTEC)
- **HAND AUGER HOLE** (previous investigation by GEMTEC, 2018)
- **HAND AUGER HOLE** (current investigation by GEMTEC,elevations are based on DEM (not surveyed data))
- APPROXIMATE PROPERTY BOUNDARY
- APPROXIMATE DEVELOPMENT BOUNDARY
- WATERSHED DRAINAGE DIVIDE
- STUDY AREA (500m RADIUS FROM PROPERTY BOUNDARY)
- PROVINCIALLY EVALUATED WETLAND (ONTARIO MINISTRY OF NATURAL RESOURCES AND FORESTRY, OMNRF)
- UNEVALUATED WETLAND (ONTARIO MINISTRY OF NATURAL RESOURCES AND FORESTRY, OMNRF)
- MECP WELL
- CITY OF PERTH SURFACE WATER INTAKE

GENERAL NOTE(S)

1. Coordinate system: UTM83, Z18.
2. Geographic dataset source: Ontario GeoHub.
3. Contains information licensed under the Open Government Licence – Ontario.

SCALE 1:10000

0 200 400 600m

DRAWING	PERMIT TO WATER TAKE WATER PLAN
CLIENT	CAIVAN COMMUNITIES
PROJECT	PROPOSED DEVELOPMENT PERTH GOLF 151 PETER STREET PERTH, ONTARIO

DRAWN BY: S.L.	CHECKED BY: A.P.
PROJECT NO.: 100737.002	REVISION NO.: 1
DATE: FEBRUARY 2023	FIGURE NO.: **FIGURE 8**

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APPENDIX A

Regional Geological Data Review (Figures A1 to A12)

Report to: Caivan (Perth GC) Limited
Project: 100737.002 (February 22, 2023)

Upper Left: 76°21'47"W 44°56'53"N

Property Boundary

Roads

Cross Sections

Rivers

Wells

Province of Ontario, Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, NPS, USDA, NRCan, Parks Canada, New York State, Earthstar Geographics
Roads: Ontario_Road_Network_(ORN)_Road_Net_Element (geohub.lio.gov.on.ca)
Wells: Ontario Data Catalogue

0 1 2 Km

N W E S

Coordinate System: GCS North American 1983

141 Peter Street, Perth, Ontario
Project: 100737.002

Site Map and Cross Sections
Zoom 1

Figure A1

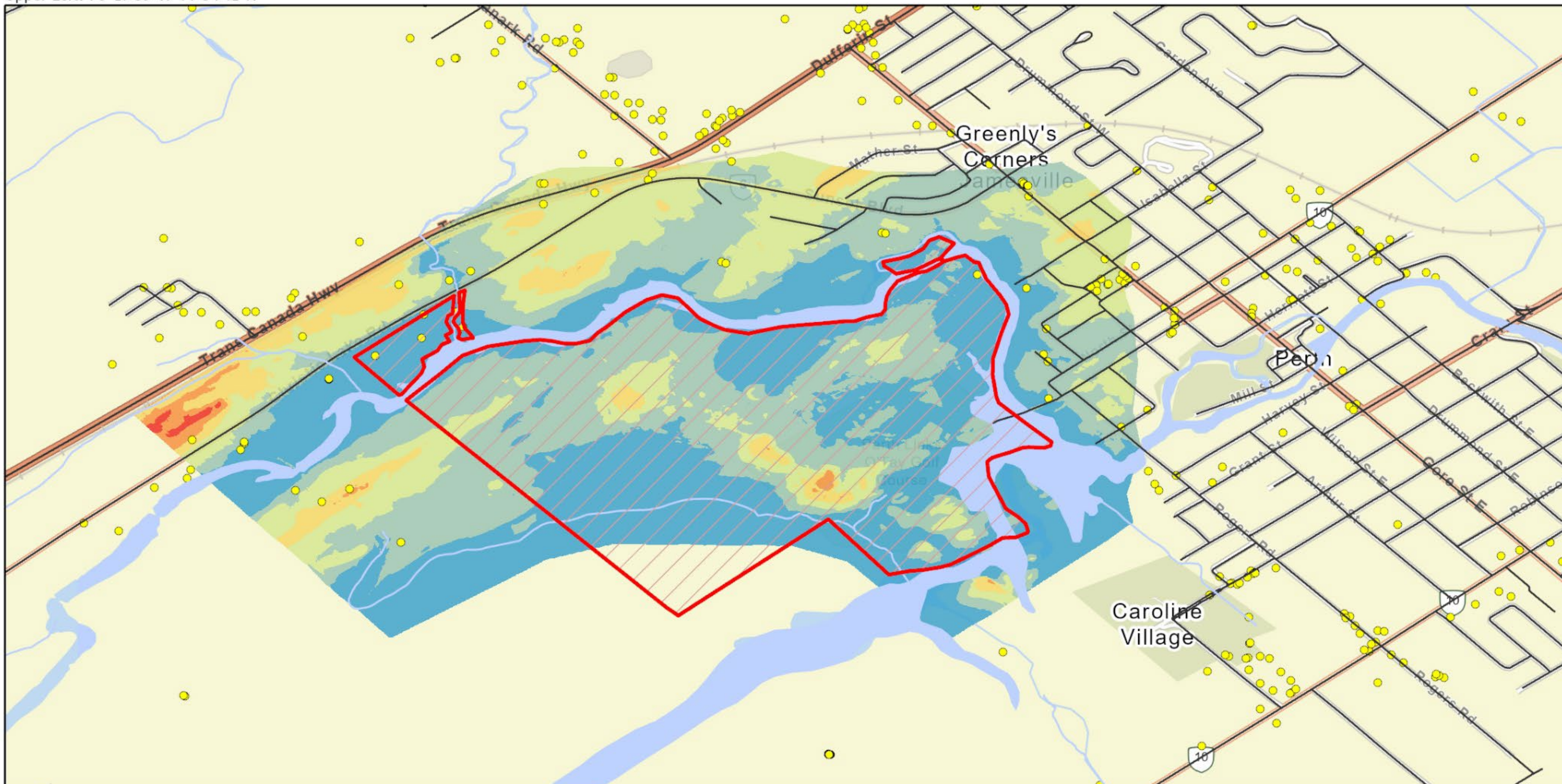
Date Saved: 2022-02-27 2:28 PM

Upper Left: 76°17'30"W 44°54'42"N

Legend	Sources	Project
Property Boundary Rivers Roads Wells Cross Sections	Province of Ontario, Esri Canada, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc., METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, NRCan, Parks Canada, New York State, Maxar Roads: Ontario_Road_Network_(ORN)_Road_Net_Element (geohub.lio.gov.on.ca) Wells: Ontario Data Catalogue 0 0.25 0.5 Km Coordinate System: GCS North American 1983	141 Peter Street, Perth, Ontario Project: 100737.002 Site Map and Cross Sections Zoom 2 **Figure A2**

Date Saved: 2022-02-27 2:36 PM

Upper Left: 76°17'39"W 44°54'41"N



Topography (m asl)

Value

- 134.8
- 136.8
- 138.8
- 140.8
- 142.8

- Property Boundary
- Wells
- Roads
- Rivers

Province of Ontario, Esri Canada, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc., METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, NRCan, Parks Canada
Roads: Ontario_Road_Network_(ORN)_Road_Net_Element (geohub.lio.gov.on.ca)
Wells: Ontario Data Catalogue

0 0.25 0.5 Km

N W E S

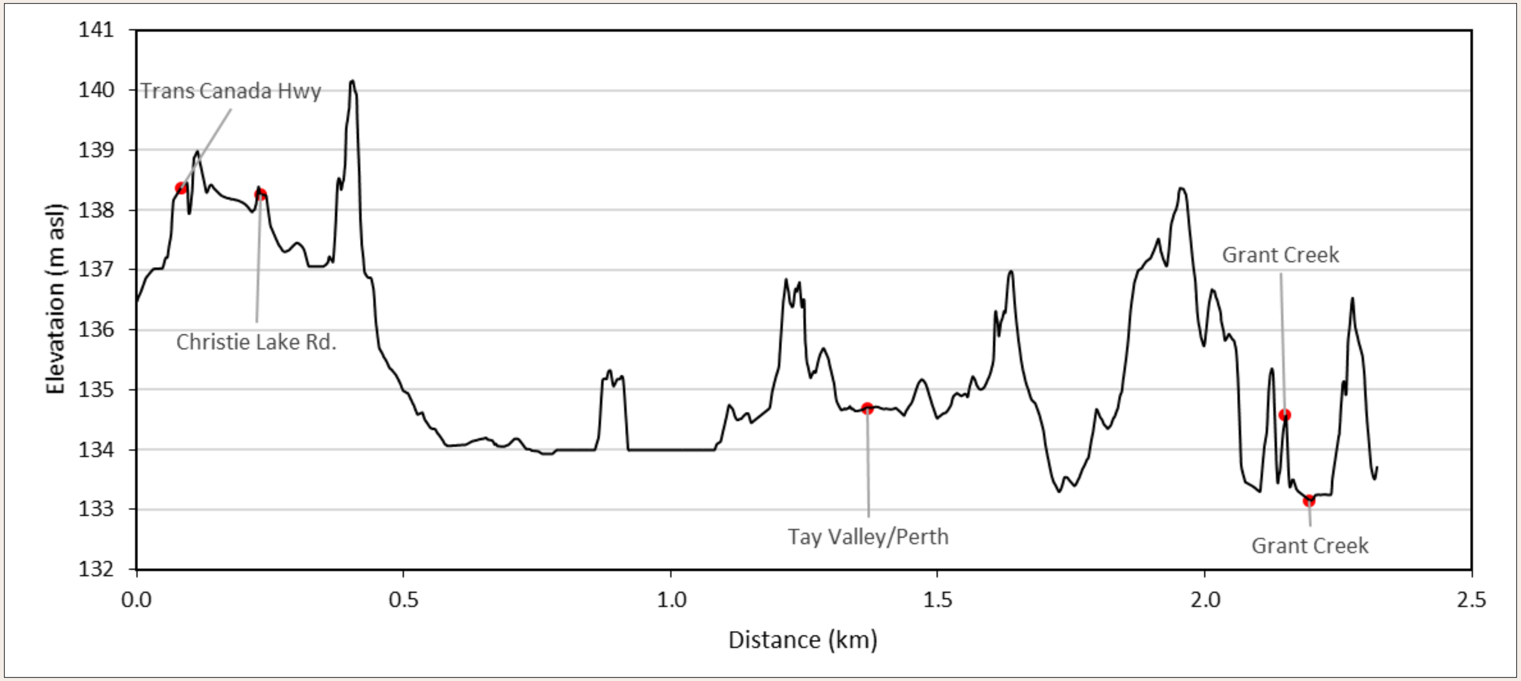
Coordinate System: GCS North American 1983

141 Peter Street, Perth, Ontario
Project: 100737.002

Topography – Surface Elevation

Figure A3

Date Saved: 2022-02-27 3:16 PM



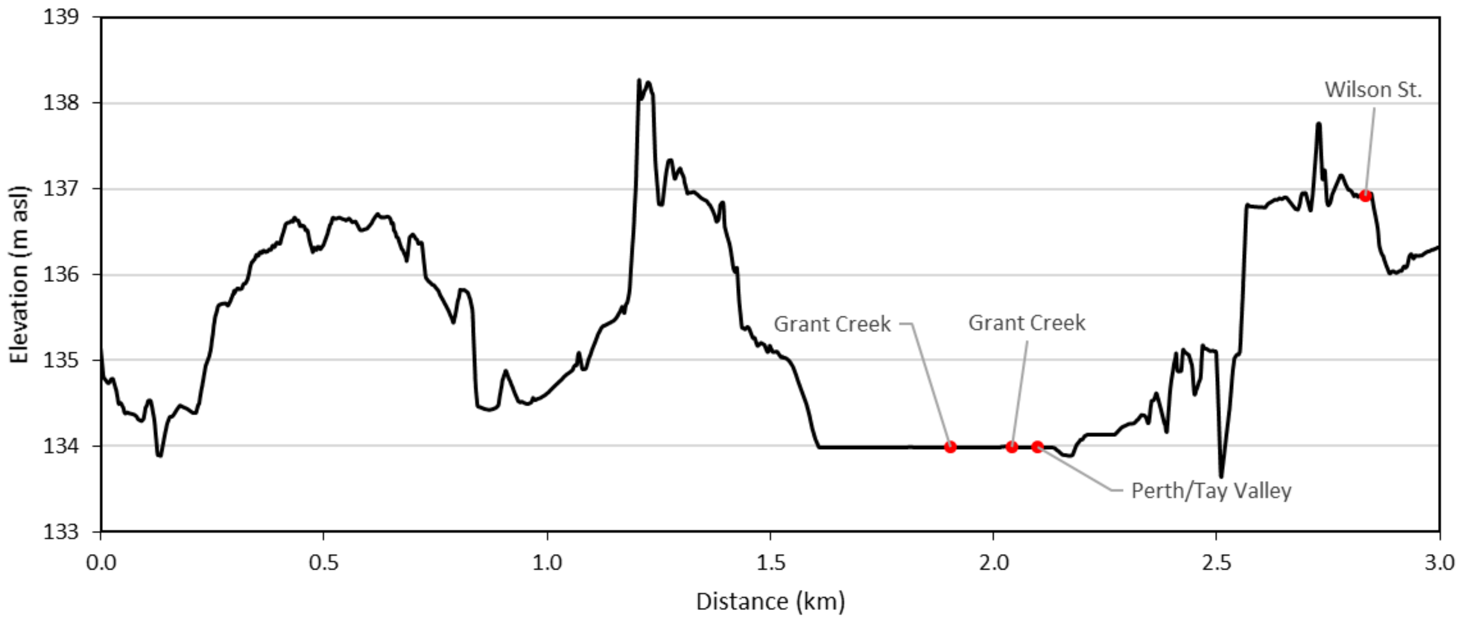
Transect goes from NW (left) to SE (right) across the project site.

Refer to Figure 1 and 2 for transect depictions.

141 Peter Street, Perth, Ontario
Project: 100737.002

Surface Elevation
Transect A-A’

Figure A4



Transect goes from SW (left) to NE (right) across the project site.

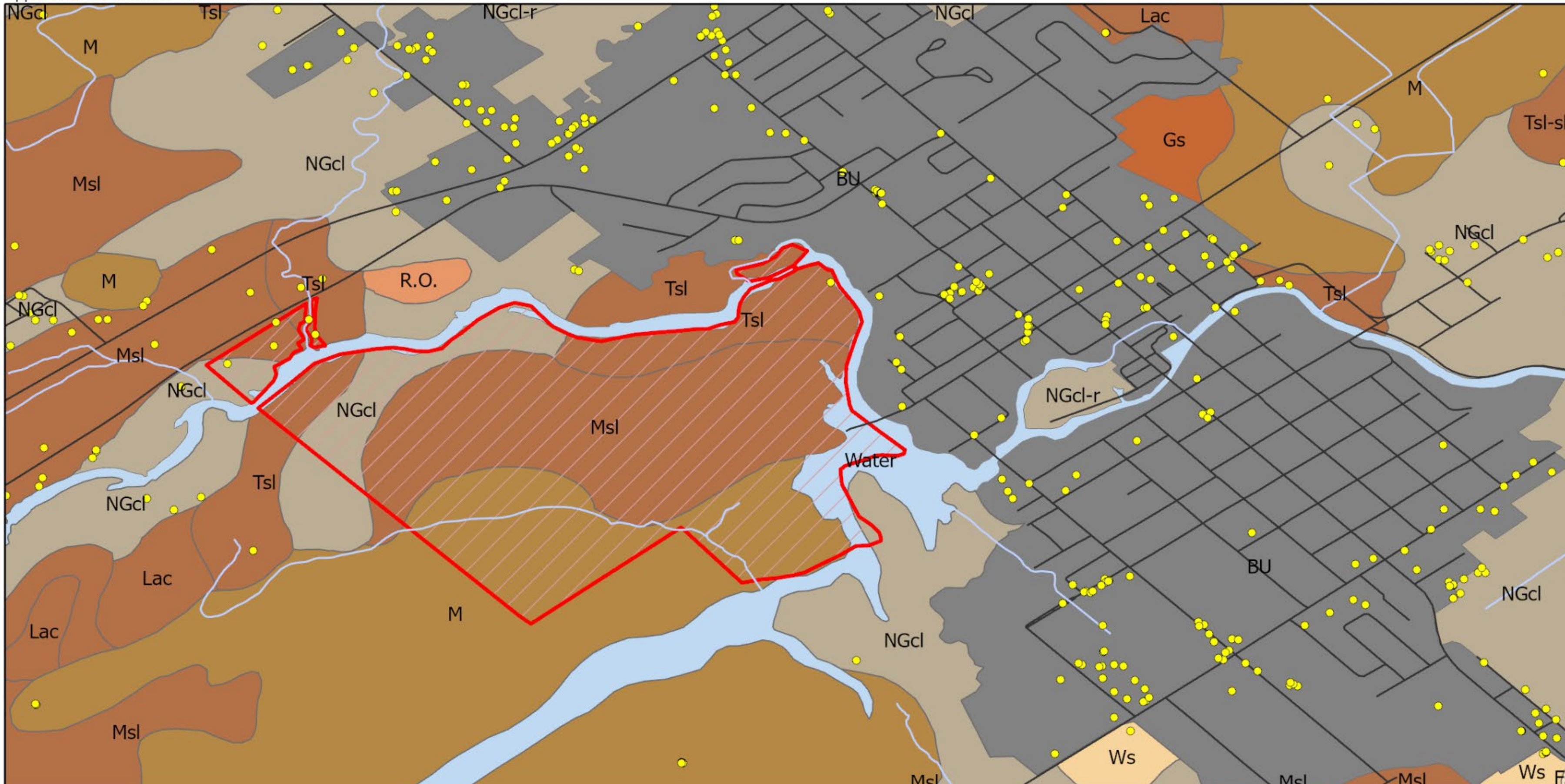
Refer to Figure 1 and 2 for transect depictions.

141 Peter Street, Perth, Ontario
Project: 100737.002

Surface Elevation
Transect B-B’

Figure A5

Upper Left: 76°17'20"W 44°54'42"N



Soil Type

- Sand (Gs)
- Clay (Lac)
- Granby Sand (Gs)
- Muck (M)
- North Grower/Rocky (NGcl-r)
- Silt Loam (Ws)
- Sandy Loam (Msl, Fsl, Bs, Tsl)
- Wiarton Silt Loam (Ws)
- Property Boundary
- Wells
- Roads
- Rivers
- Built-up area
- Water

Province of Ontario, Esri Canada, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc., METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, NRCan, Parks Canada
Open Government Licence – Ontario (2019), Access to Soil Survey
Roads: Ontario_Road_Network_(ORN)_Road_Net_Element (geohub.lio.gov.on.ca)
Rivers: National Hydro Network - NHN (open.canada.ca/)
Wells: Ontario Data Catalogue

0 0.25 0.5 Km

N W E S

Coordinate System: GCS North American 1983

141 Peter Street, Perth, Ontario
Project: 100737.002

Soil types

Figure A6

Date Saved: 2022-02-27 12:57 PM

Upper Left: 76°17'19"W 44°54'40"N

QUATERNARY

Postglacial Deposits

7 Organic deposits (muck and peat)

Proglacial & Glacial Deposits

Marine Deposits

5b Littoral & nearshore sediments

5a Offshore sediments

Glaciolacustrine Deposits

4a Offshore sediments

Glaciofluvial Deposits

2 Ice content sediments

Glacial Deposits

1b Till veneer

1a Till blanket

Property Boundary

Rivers

Esri, NASA, NGA, USGS, FEMA, Province of Ontario, Esri Canada, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc., METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, NRCan, Parks Canada

Roads: Ontario_Road_Network_(ORN)_Road_Net_Element (geohub.lio.gov.on.ca)

Geology: Ministry of Natural Resources Surficial Geology, Perth, Ontario. Geological Survey of Canada, "A" Series Map 1800A, 1992

0 0.4 0.7 Km

N W E S

Coordinate System: GCS North American 1983

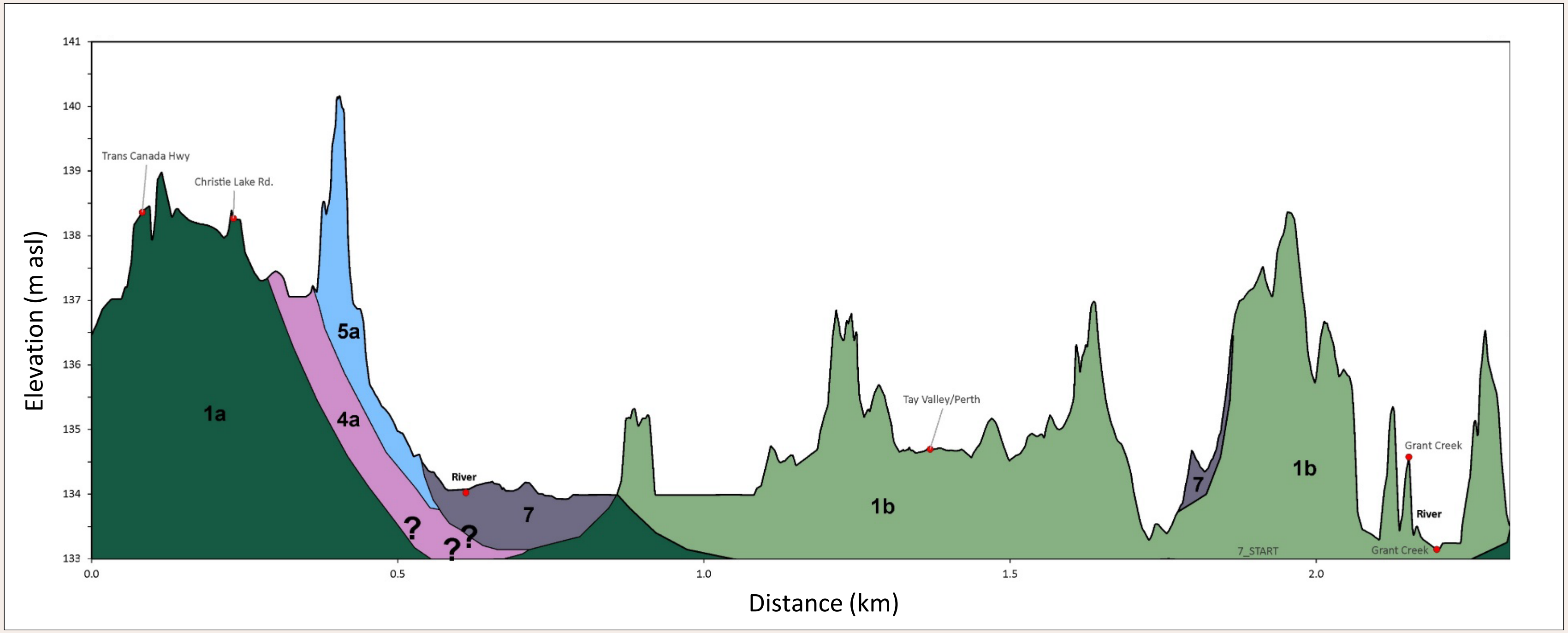
141 Peter Street, Perth, Ontario

Project: 100737.002

Surficial Geology

Figure A7

Date Saved: 2022-02-27 1:19 PM



QUATERNARY

- 7 — Postglacial Deposits, Organic deposits (much & peat)
- 5a — Marine deposits, Littoral & nearshore sediments
- 4a — Glaciolacustrine deposits, offshore sediments
- 1b — Glacial Deposits, Till veneer
- 1a — Glacial Deposits, Till blanket

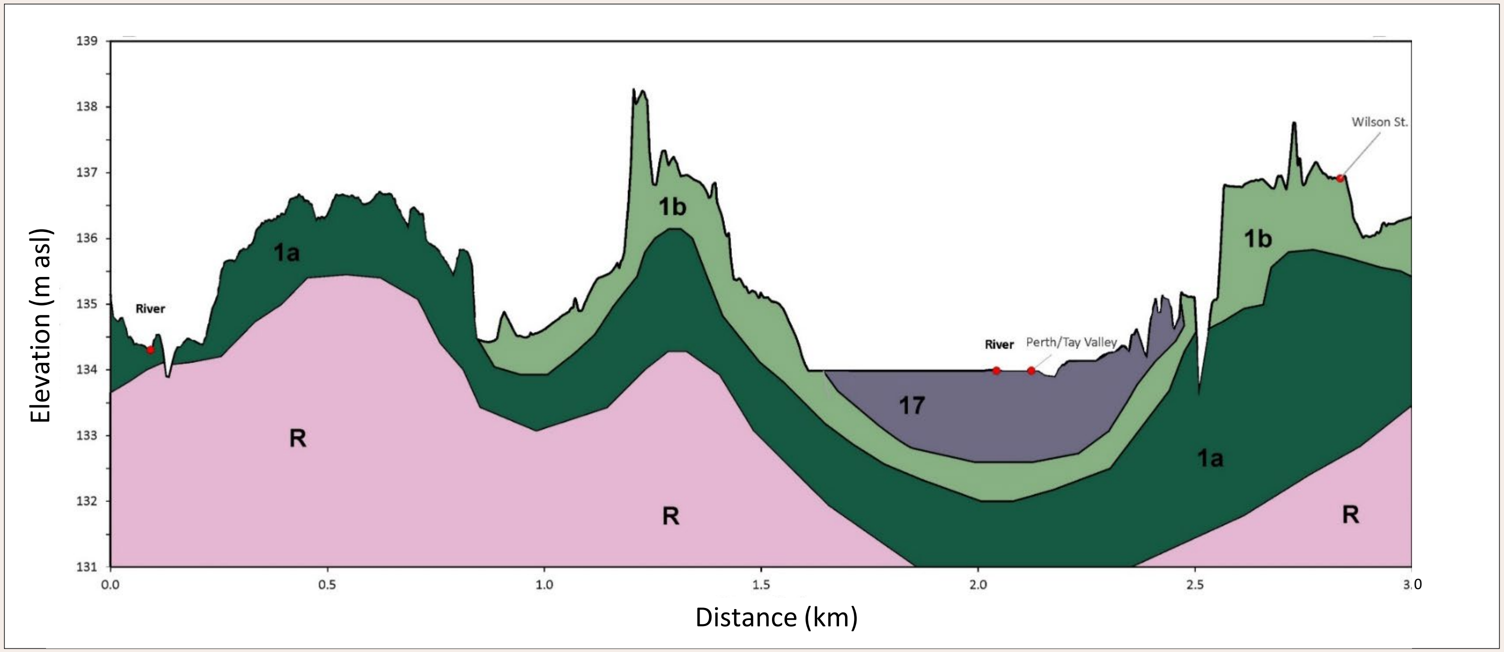
Transect goes from NW (left) to SE (right) across the project site.

Refer to Figure 7 for transects depictions.

141 Peter Street, Perth, Ontario
Project: 100737.002

Surface Elevation & Surficial Soil Types
Transect A-A’

Figure A8



QUATERNARY

7 Postglacial Deposits
Organic deposits (much & peat)

1b Glacial Deposits
Till veneer

1a Glacial Deposits
Till blanket

PRE-QUATERNARY

R Precambrian bedrock
medium to high grade gneiss

Transect goes from SW (left) to NE (right) across the project site.

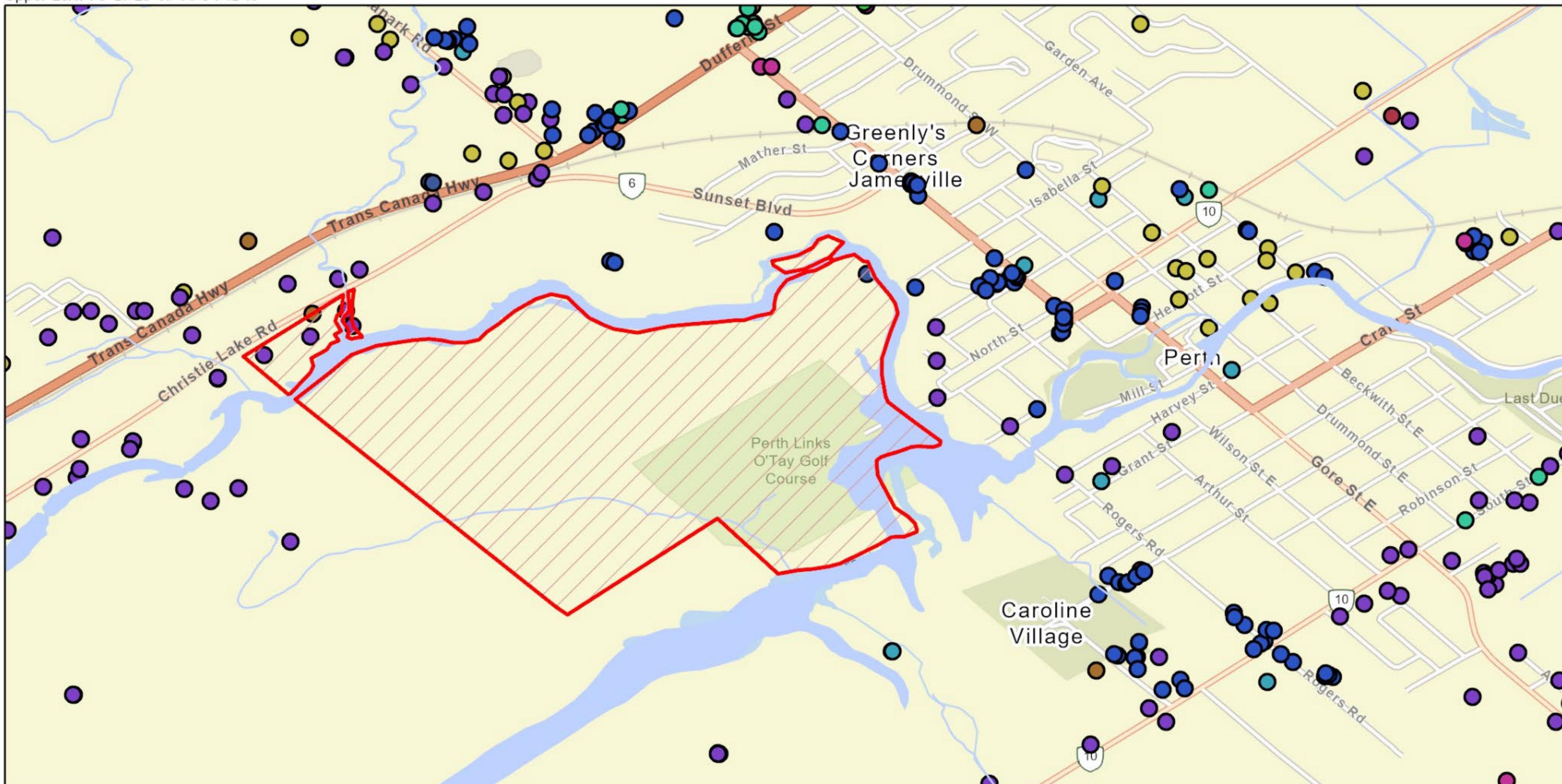
Refer to Figure 7 for transects depictions.

141 Peter Street, Perth, Ontario
Project: 100737.002

Surface Elevation & Surficial Soil Types
Transect B-B’

Figure A9

Upper Left: 76°17'25"W 44°54'41"N



Well use

- Commercial
- Domestic
- Industrial
- Irrigation
- Municipal
- Not Used
- Public
- Livestock
- Test Hole
- Monitoring
- Property Boundary
- Rivers

Province of Ontario, Esri Canada, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc., METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, NRCan, Parks Canada
Roads: Ontario_Road_Network_(ORN)_Road_Net_Element (geohub.lio.gov.on.ca)
Wells: Ontario Data Catalogue

0 0.25 0.5 Km

N E S W

Coordinate System: GCS North American 1983

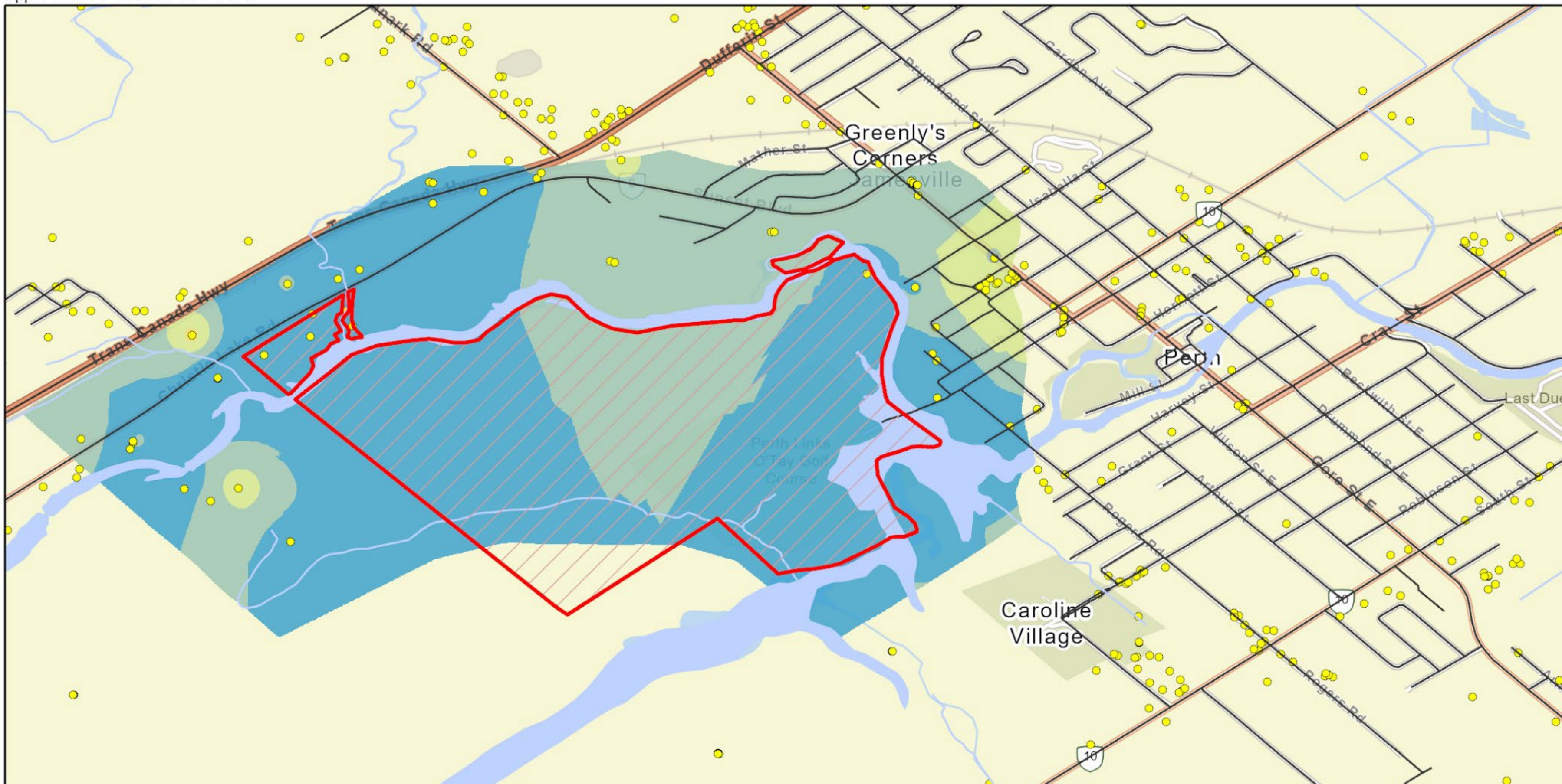
141 Peter Street, Perth, Ontario
Project: 100737.002

Well Use

Figure A10

Date Saved: 2022-02-27 1:36 PM

Upper Left: 76°17'25"W 44°54'41"N



Static water level (m asl)

Value

- 134.8
- 136.8
- 138.8
- 140.8
- 142.8

- Property Boundary
- Wells
- Roads
- Rivers

Province of Ontario, Esri Canada, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc., METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, NRCan, Parks Canada
Roads: Ontario_Road_Network_(ORN)_Road_Net_Element (geohub.lio.gov.on.ca)
Wells: Ontario Data Catalogue

0 0.25 0.5 Km

N E S W

Coordinate System: GCS North American 1983

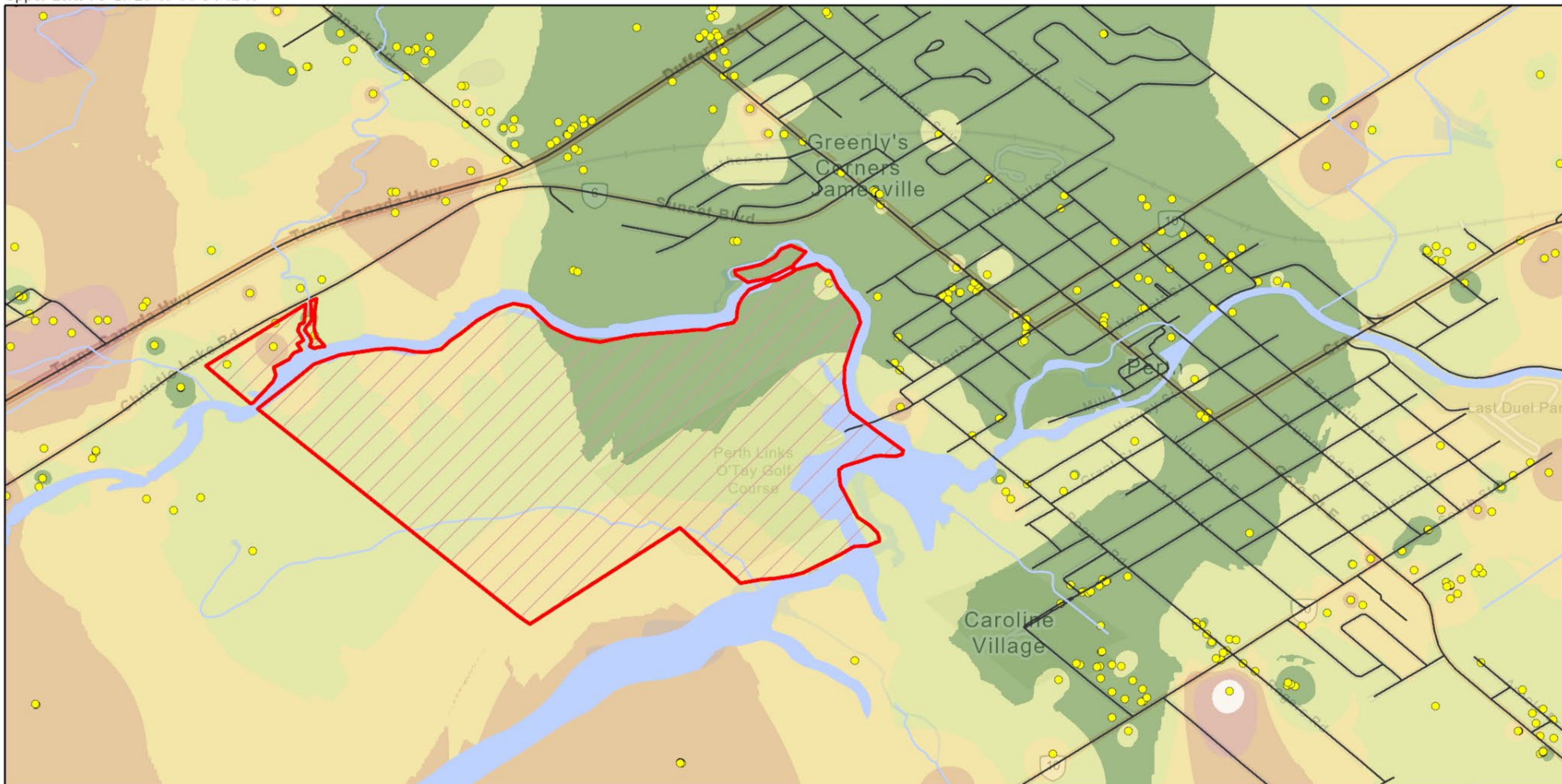
141 Peter Street, Perth, Ontario
Project: 100737.002

Water Level (m asl)

Figure A11

Date Saved: 2022-02-27 1:06 PM

Upper Left: 76°17'20"W 44°54'42"N



Static water level (m bgl)

VALUE

- 0 - 1
- 1 - 2.5
- 2.5 - 3.8
- 3.8 - 6.5
- 6.5 - 15.3

- Property Boundary
- Wells
- Roads
- Rivers

Province of Ontario, Esri Canada, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc., METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA, NRCan, Parks Canada
Roads: Ontario_Road_Network_(ORN)_Road_Net_Element (geohub.lio.gov.on.ca)
Wells: Ontario Data Catalogue

0 0.25 0.5 Km

N E S W

Coordinate System: GCS North American 1983

141 Peter Street, Perth, Ontario
Project: 100737.002

Water Level (m bgl)

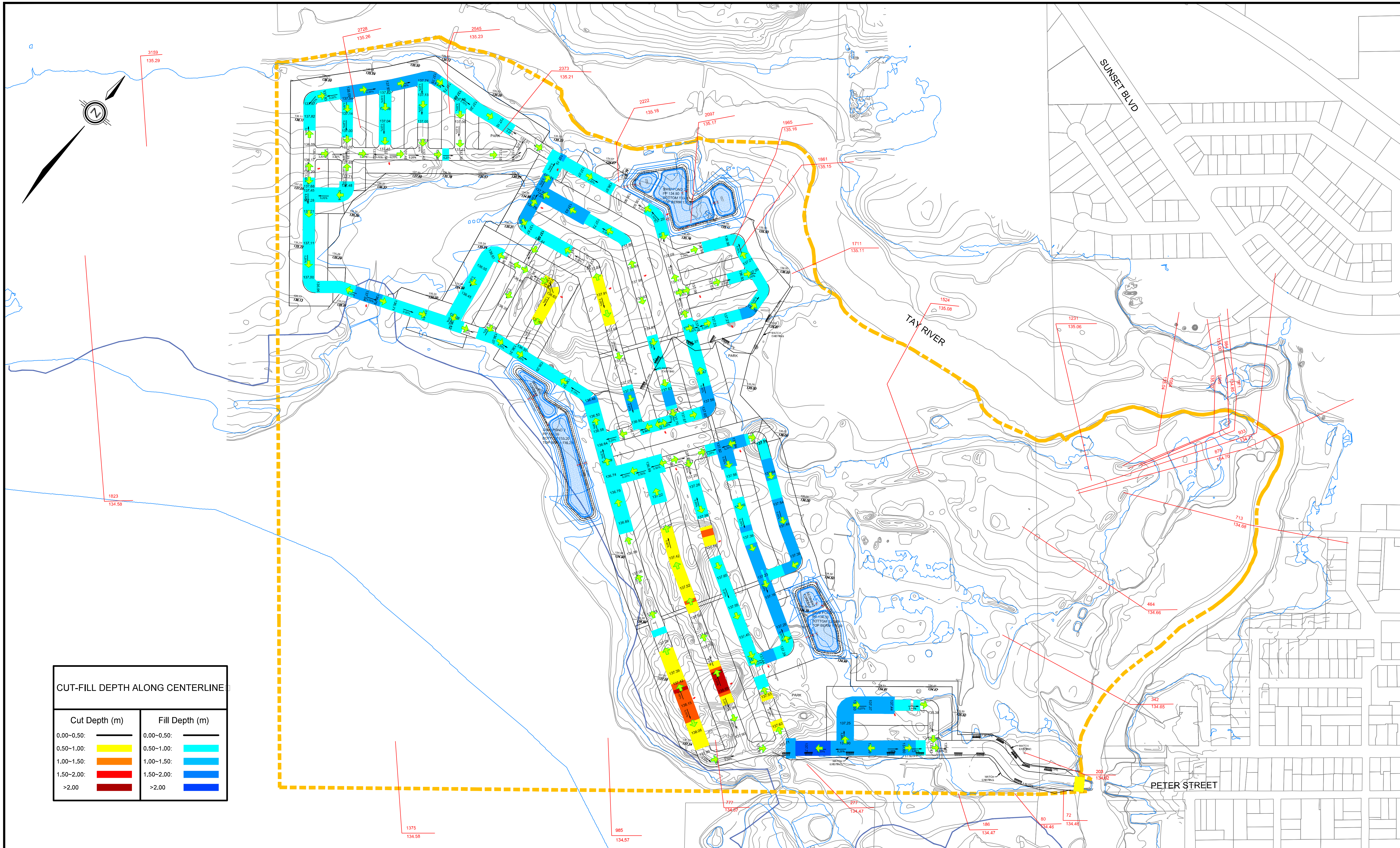
Figure A12

Date Saved: 2022-02-27 2:51 PM

APPENDIX B

Relevant Background Reports & Figures

Report to: Caivan (Perth GC) Limited
Project: 100737.002 (February 22, 2023)



LEGEND

SITE BOUNDARY

PHASE 1 BOUNDARY

STORM OVERLAND FLOW ARROW

135.45 / 135.45 PROPOSED ELEVATION / EXISTING ELEVATION

1375 / 134.58 STATION NUMBER / REGULATORY FLOOD ELEVATION (m)

DSEL
120 Iber Road, Unit 203
Stittsville, Ontario, K2S 1E9
Tel. (613) 836-0856
Fax. (613) 836-7183
www.DSEL.ca

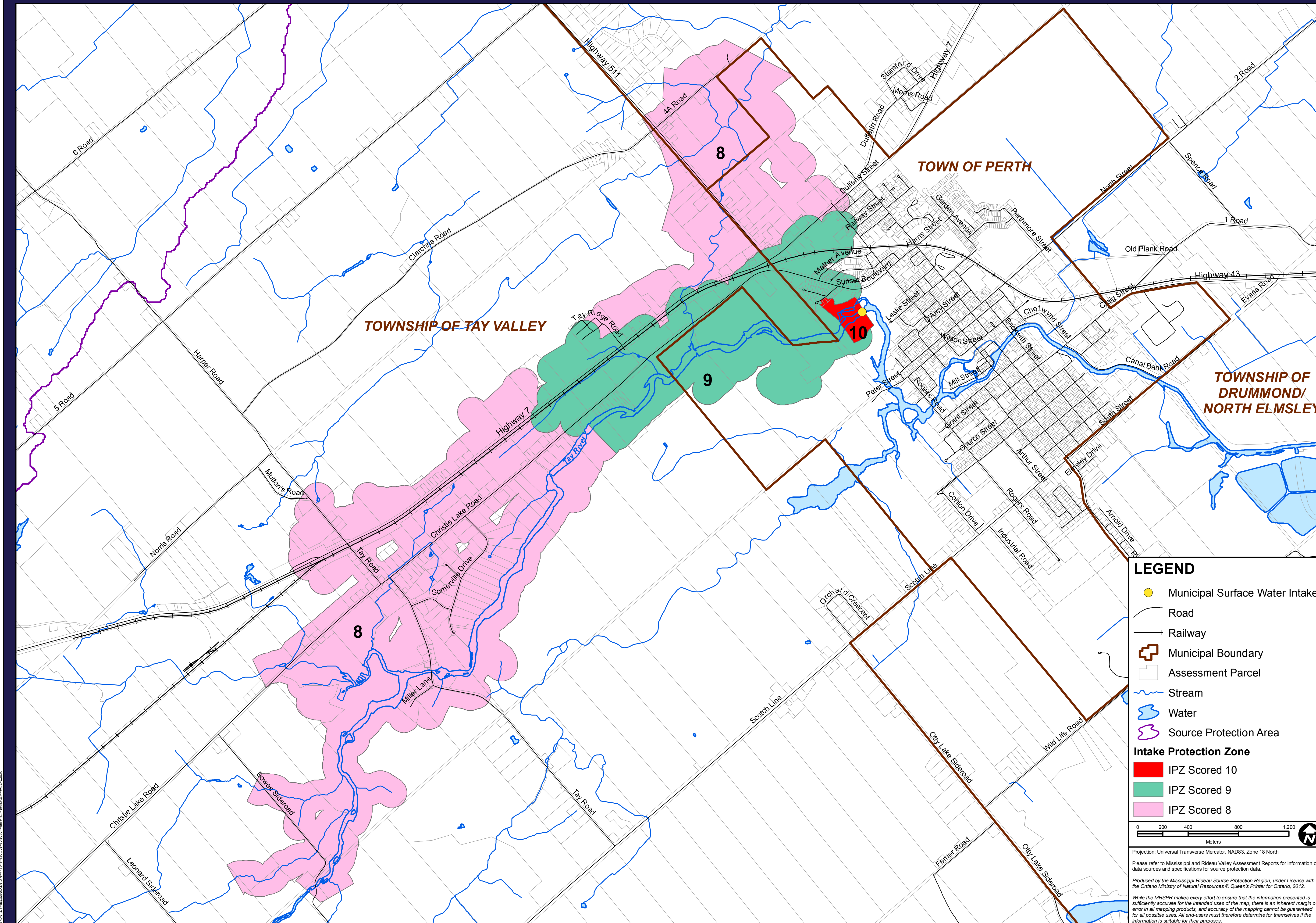
PERTH

TOWN OF PERTH

GRADING PLAN

SCALE:	1:2500	PROJECT No.:	21-1278
DATE:	FEB 2023	FIGURE:	9

Mississippi-Rideau Source Protection Plan 2013



Perth
Intake Protection Zone

Schedule J

APPENDIX C

Record of Borehole Sheets and Grain Size Curves

RECORD OF BOREHOLE 22-106

CLIENT: Caivan (Perth G.C.) Limited
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Oct 5 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m; DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED; WATER CONTENT, % W_P W W_L (10 20 30 40 50 60 70 80 90)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger, Hollow Stem Auger (210mm OD)	Ground Surface		136.50							
		Unsampled Overburden		136.14 0.36							Native backfill
		End of Borehole, Auger Refusal									
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

GEMTEC
CONSULTING ENGINEERS AND SCIENTISTS

LOGGED: A.N.
CHECKED: W.A.M.

RECORD OF BOREHOLE 22-107

CLIENT: Caivan (Perth G.C.) Limited
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Oct 5 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m; DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED; WATER CONTENT, % W_P W W_L (10 20 30 40 50 60 70 80 90)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger, Hollow Stem Auger (210mm OD)	Ground Surface		135.38							
		Unsampled Overburden									Native backfill
2.67		End of Borehole, Auger Refusal		132.71 2.67							

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

GEO - BOREHOLE LOG 100737.002_GINT_2022-10-13.GPJ GEMTEC 2018.GDT 12/15/22

GEMTEC Consulting Engineers and Scientists

LOGGED: A.N.
CHECKED: W.A.M.

RECORD OF BOREHOLE 22-108

CLIENT: Caivan (Perth G.C.) Limited
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Oct 5 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m / DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH (Cu), kPA (+ NATURAL, ⊕ REMOULDED) / WATER CONTENT, % (W_P — W — W_L) 10 20 30 40 50 60 70 80 90	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface		137.40							
	Power Auger, Hollow Stem Auger (210mm OD)	Unsampled Overburden									Native backfill
3		End of Borehole, Auger Refusal		134.22 / 3.18							

Depth scale: 0 – 10 m

GEMTEC
Consulting Engineers and Scientists

LOGGED: A.N.
CHECKED: W.A.M.

GEO - BOREHOLE LOG 100737.002_GINT_2022-10-13.GPJ GEMTEC 2018.GDT 12/15/22

RECORD OF BOREHOLE 22-201

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 18 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger, Hollow Stem Auger (210mm OD)	Ground Surface	136.00					
		TOPSOIL						Bentonite seal
		Loose, brown SILTY SAND	0.10	1	SS	150	5	
1		Very loose to compact, grey brown SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)	135.24 / 0.76	2	SS	305	2	
2				3	SS	280	18	
				4	SS	255	16	
3		Compact to very dense, grey brown to grey SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)	133.10 / 2.90					Filter sand
4–5				5	SS	150	>50 for 100 mm	50 millimetre well screen
				6	SS	125	>50 for 100 mm	
6				7	SS	230	>50 for 180 mm	
	Diamond Rotary Core, HQ (89mm OD)	Slightly weathered to fresh, fine grained, medium strong, greenish grey to pinkish grey Precambrian BEDROCK	129.57 / 6.43	8	RC		TCR = 98%; SCR = 89%; RQD = 89%	Bentonite
7		End of Borehole	128.53 / 7.47					

PENETRATION RESISTANCE (N), BLOWS/0.3m; DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED; WATER CONTENT, % W_P — W — W_L; ADDITIONAL LAB. TESTING

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/02/09	0.9 ▽	135.1

GEMTEC Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-202

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 14 2022

Boring method: Power Auger, Hollow Stem Auger (210mm OD)

Depth (m)	Description	Elev. / Depth (m)	Sample No.	Type	Recovery, mm	Blows/0.3m	Additional Lab. Testing	Piezometer or Standpipe Installation
0	Ground Surface	135.65						
	TOPSOIL	0.10						Native backfill
	Very loose, brown SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)		1	SS	150	2		
1			2	SS	255	2		
	Compact to very dense, grey SILTY SAND, some clay, trace gravel, with cobbles and boulders (GLACIAL TILL)	134.13 / 1.52	3	SS	455	18		
2			4	SS	75	>50 for 130 mm		
3			5	SS	255	>50 for 130 mm	MH	
4			6	SS	280	>50 for 100 mm		
			7	SS	150	>50 for 100 mm		
5			8	SS	75	>50 for 150 mm		
6			9	SS	205	>50 for 75 mm		
7			10	SS	180	>50 for 75 mm		
	End of Borehole Auger Refusal	128.16 / 7.49						

Legend: ● PENETRATION RESISTANCE (N), BLOWS/0.3m; ▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED; WATER CONTENT, %: W_P — W — W_L (scale 10–90)

GEMTEC Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-203

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 18 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m / SHEAR STRENGTH (Cu), kPA / WATER CONTENT, %	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger / Hollow Stem Auger (210mm OD)	Ground Surface		135.91							
		TOPSOIL		0.08							
		Loose to very dense, brown SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)			1	SS	330	7			Native backfill
				134.92	2	SS	75	>50 for 75 mm			
1		End of Borehole Auger Refusal		0.99							

Legend: ● PENETRATION RESISTANCE (N), BLOWS/0.3m; ▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; + NATURAL ⊕ REMOULDED; W_P — W — W_L

Depth scale: 0 – 10 m. Chart scale: 10 20 30 40 50 60 70 80 90

GEMTEC Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-203A

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 20 2022

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION / SHEAR STRENGTH / WATER CONTENT	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface	135.91						
	Wash Casing HW (114mm OD)	TOPSOIL	0.08						
		Brown SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)	135.15 0.76						
1	Diamond Rotary Core HQ (89mm OD)	Slightly weathered to fresh, fine grained, very strong, greenish grey to pink Precambrian BEDROCK		1	RC			TCR = 100%; SCR = 37%; RQD = 0%	Bentonite seal
2				2	RC			TCR = 100%; SCR = 91%; RQD = 91%	
3				3	RC			TCR = 100%; SCR = 87%; RQD = 95%	Filter sand
5				4	RC			TCR = 98%; SCR = 60%; RQD = 60%	50 millimetre well screen
6			129.69 6.22	5	RC			TCR = 100%; SCR = 100%; RQD = 88%	
		End of Borehole							

PENETRATION RESISTANCE (N), BLOWS/0.3m; DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED; WATER CONTENT, % W_P — W — W_L; scale 10 20 30 40 50 60 70 80 90; ADDITIONAL LAB. TESTING

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/02/09	1.2 ∇	134.7

GEMTEC Consulting Engineers and Scientists

LOGGED: BWW
CHECKED: WAM

GEO - BOREHOLE LOG 100737.002_GINT_BOREHOLE LOGS.GPJ GEMTEC 2018.GDT 12/15/22

RECORD OF BOREHOLE 22-205

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 10 2022

BORING METHOD: Power Auger – Hollow Stem Auger (210mm OD)

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m
0	Ground Surface	135.32				
	TOPSOIL	0.10				
	Stiff to very stiff, grey brown SILTY CLAY (WEATHERED CRUST)		1	SS	355	4
	Compact to very dense, grey SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)	134.56 / 0.76				
1			2	SS	100	20
			3	SS	510	20
2			4	SS	405	26
3			5	SS	455	81
4			6	SS	455	84
5			7	SS	455	77
			8	SS	510	82
6			9	SS	50	>50 for 50 mm
	End of Borehole Auger Refusal	129.17 / 6.15				

PENETRATION RESISTANCE (N), BLOWS/0.3m ● — SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED
▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m — WATER CONTENT, %: W_P — W — W_L
Scale: 10 20 30 40 50 60 70 80 90

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION:
Bentonite seal
Filter sand
Bentonite seal
Filter sand
50 millimetre well screen

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/02/09	0.5 ∇	134.9

GEMTEC Consulting Engineers and Scientists

LOGGED: CS/ML
CHECKED: WAM

RECORD OF BOREHOLE 22-206

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 20 2022

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface	136.26					
	Power Auger – Hollow Stem Auger (210mm OD)	Very loose to loose, dark brown to brown silty sand, some gravel (FILL MATERIAL)		1	SS	330	4	Native backfill
1		Loose to compact, grey brown SILTY SAND, trace to some gravel, with cobbles and boulders (GLACIAL TILL)	135.50 / 0.76	2	SS	455	5	
2				3	SS	355	10	
3		Very dense, grey brown to grey SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)	133.97 / 2.29	4	SS	610	57	
				5	SS	405	>50 for 130 mm	
4	Wash Casing – HW (114mm OD)			6	RC	150	DD	
				7	SS	50	>50 for 75 mm	
5				8	RC	255	DD	
				9	RC	150	DD	
6				10	RC	75	DD	
				11	SS	125	>50 for 50 mm	
7				12	RC	75	DD	
				13	SS	150	>50 for 75 mm	
8		End of Borehole Sampler Refusal	128.28 / 7.98					
9								
10								

Chart columns: ● PENETRATION RESISTANCE (N), BLOWS/0.3m; ▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED; WATER CONTENT, % W_P — W — W_L; scale 10 20 30 40 50 60 70 80 90. ADDITIONAL LAB. TESTING.

GEMTEC Consulting Engineers and Scientists

LOGGED: BWW/CS
CHECKED: WAM

RECORD OF BOREHOLE 22-207

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 12 2022

Boring method: Power Auger, Hollow Stem Auger (210mm OD)

DEPTH SCALE METRES	DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Ground Surface	135.04						
	TOPSOIL	134.91 / 0.13						
	Stiff to very stiff, grey brown SILTY CLAY (WEATHERED CRUST)	134.28 / 0.76	1	SS	100	9		Native backfill
1	Loose to very dense, brown SILTY SAND, some clay and gravel, with cobbles and boulders (GLACIAL TILL)		2	SS	510	8		
			3	SS	455	13	MH	
2			4	SS	50	10		
3		131.69 / 3.35	5	SS	180	>50 for 50 mm		
	End of Borehole Auger Refusal							

Legend: ● PENETRATION RESISTANCE (N), BLOWS/0.3m; ▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED; WATER CONTENT, %: W_P — W — W_L (scale 10–90)

Depth scale: 0 1 2 3 4 5 6 7 8 9 10

GEMTEC
Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-208

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 12 2022

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m / DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED / WATER CONTENT, % W_P W W_L (10 20 30 40 50 60 70 80 90)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger / Hollow Stem Auger (210mm OD)	Ground Surface		137.48							
		TOPSOIL		0.08	1	SS	100	>50			
		Very dense, brown SILTY SAND, with organics		137.18 / 0.30							
1	Diamond Rotary Core / HQ (89mm OD)	Slightly weathered to fresh, fine grained, very strong, pinkish grey Precambrian BEDROCK			2	RC		TCR = 100%; SCR = 63%; RQD = 67%			Bentonite seal
2					3	RC		TCR = 95%; SCR = 43%; RQD = 59%			Filter sand
3											
4					4	RC		TCR = 100%; SCR = 86%; RQD = 86%			50 millimetre well screen
5					5	RC		TCR = 100%; SCR = 96%; RQD = 96%			
6		End of Borehole		131.41 / 6.07							
7											
8											
9											
10											

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/02/09	2.7 ∇	134.8

GEO - BOREHOLE LOG 100737.002_GINT_BOREHOLE LOGS.GPJ GEMTEC 2018.GDT 12/15/22

GEMTEC
CONSULTING ENGINEERS AND SCIENTISTS

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-209

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 14 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger / Hollow Stem Auger (210mm OD)	Ground Surface	137.24						
		TOPSOIL	137.09 / 0.15						Native backfill
		Loose to compact, brown SILTY SAND, trace to some gravel, with cobbles and boulders (GLACIAL TILL)		1	SS	355	8	8	
1				2	SS	330	12	12	
			135.97 / 1.27						
		End of Borehole Auger Refusal							

Legend: ● PENETRATION RESISTANCE (N), BLOWS/0.3m; ▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED; WATER CONTENT, %: W_P — W — W_L; ADDITIONAL LAB. TESTING

Depth scale: 0 1 2 3 4 5 6 7 8 9 10
Plot scale: 10 20 30 40 50 60 70 80 90

GEMTEC Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

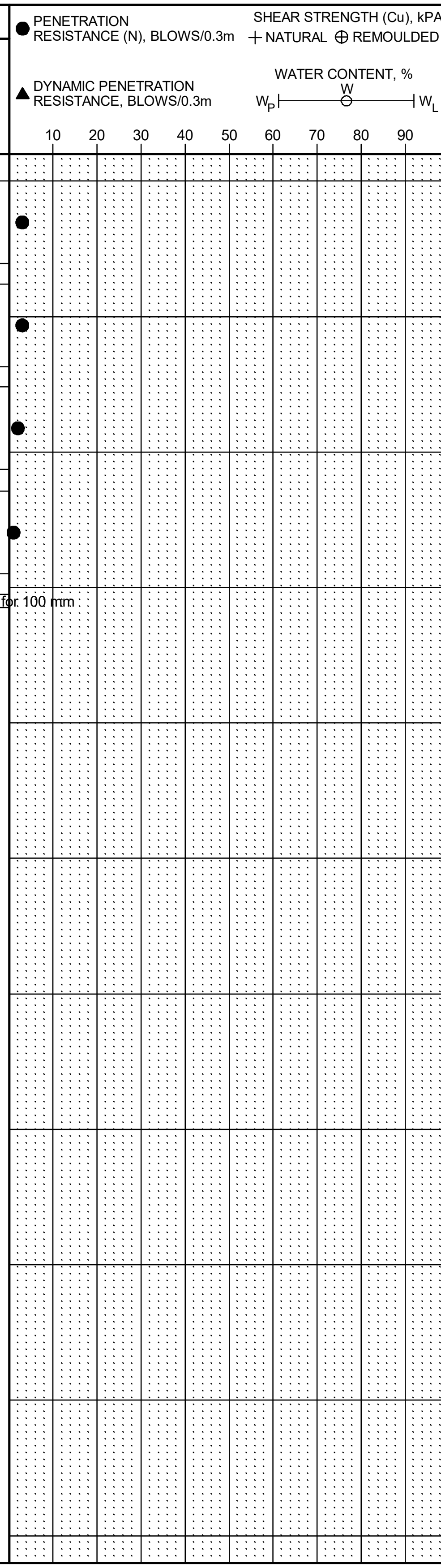
RECORD OF BOREHOLE 22-210

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 14 2022

BORING METHOD: Power Auger – Hollow Stem Auger (210mm OD)

DESCRIPTION	ELEV. / DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m
Ground Surface	135.67				
TOPSOIL					
Very loose, brown SILTY SAND, trace to some gravel, with cobbles and boulders (GLACIAL TILL)	0.10	1	SS	150	3
		2	SS	125	3
		3	SS	355	2
		4	SS	405	1
		5	SS	50	>50 for 100 mm
End of Borehole Auger Refusal	132.47 3.20				



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION: Native backfill

DEPTH SCALE METRES: 0–10

GEMTEC Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-211

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 12 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m / SHEAR STRENGTH (Cu), kPA / WATER CONTENT, %	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger, Hollow Stem Auger (210mm OD)	Ground Surface		134.84							
		TOPSOIL		134.71 / 0.13							Native backfill
		Very loose to very dense, brown SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)			1	SS	125	2	● 2		
				133.93	2	SS	100	>50 for 150 mm			
1		End of Borehole Auger Refusal		0.91							

Legend: ● PENETRATION RESISTANCE (N), BLOWS/0.3m; ▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED; WATER CONTENT, %: W_P — W — W_L; scale 10 20 30 40 50 60 70 80 90

Depth scale: 0 1 2 3 4 5 6 7 8 9 10

GEMTEC Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-212

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 11 2022

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. / DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface	136.57					
0	Power Auger, Hollow Stem Auger (210mm OD)	TOPSOIL	0.08					Native backfill
		Very loose, brown SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)	135.96 / 0.61	1	SS	430	3	
1		Dense, brown to grey SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)		2	SS	535	34	
			134.61 / 1.96	3	SS	510	45	
2		End of Borehole Auger Refusal						

PENETRATION RESISTANCE (N), BLOWS/0.3m (●); DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (▲); SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED; WATER CONTENT, %: W_P — W — W_L; scale 10 20 30 40 50 60 70 80 90; ADDITIONAL LAB. TESTING

Depth scale: 0 1 2 3 4 5 6 7 8 9 10

GEO - BOREHOLE LOG 100737.002_GINT_BOREHOLE LOGS.GPJ GEMTEC 2018.GDT 12/15/22

GEMTEC Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-213

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 11 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface	137.20					
	Power Auger / Hollow Stem Auger (210mm OD)	TOPSOIL	0.10					Native backfill
		Loose to very dense, brown SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)		1	SS	305	8	
1				2	SS	50	6	
				3	SS	330	>50 for 75 mm	
2			134.99 / 2.21					
		End of Borehole Auger Refusal						

Chart columns: PENETRATION RESISTANCE (N), BLOWS/0.3m; DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED; WATER CONTENT, % W_P — W — W_L; scale 10 20 30 40 50 60 70 80 90. ADDITIONAL LAB. TESTING.

Depth scale: 0 1 2 3 4 5 6 7 8 9 10

GEMTEC Consulting Engineers and Scientists

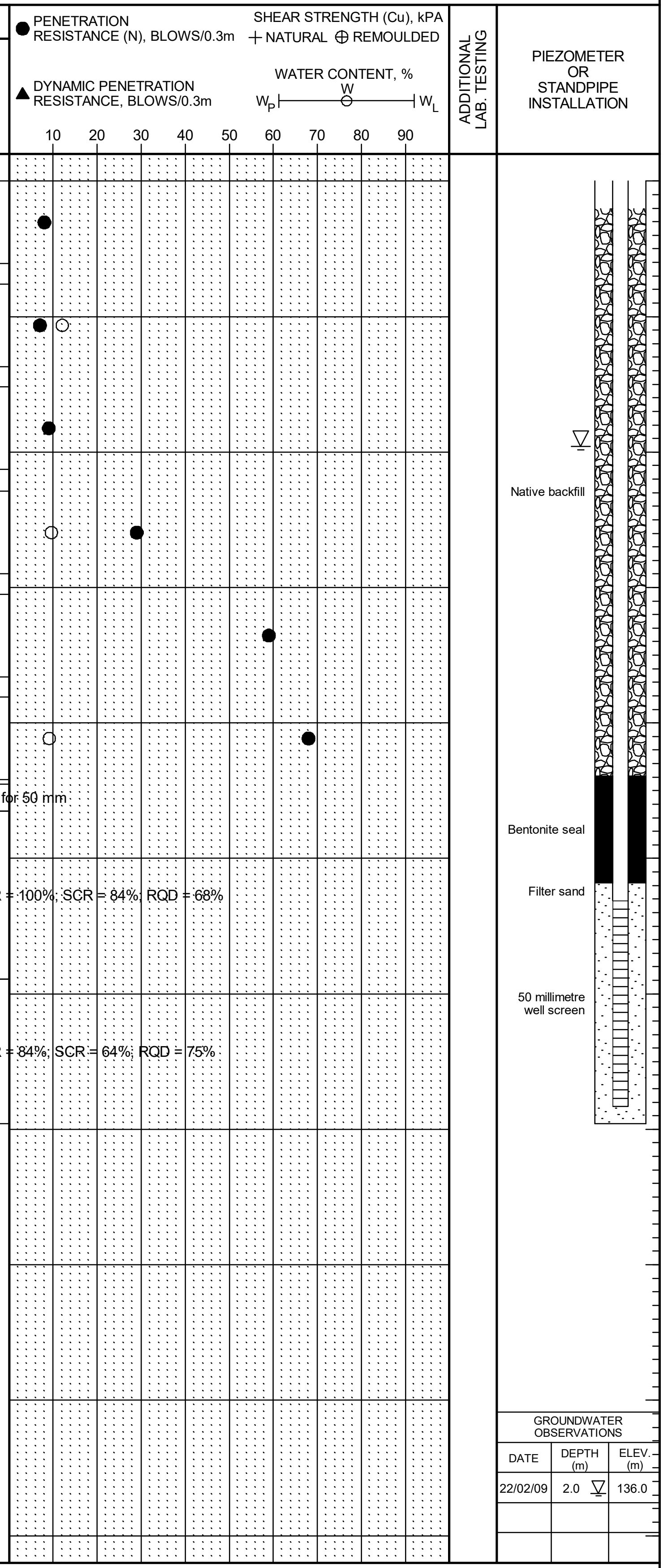
LOGGED: CS/ML
CHECKED: WAM

RECORD OF BOREHOLE 22-214

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 5 2022

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. / DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m
0	Power Auger, Hollow Stem Auger (210mm OD)	Ground Surface	137.92				
		TOPSOIL	0.08				
		Brown SILTY SAND		1	SS	480	8
1		Loose, grey brown to grey SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)	137.16 / 0.76	2	SS	305	7
2				3	SS	430	9
3		Compact to very dense, grey brown to grey SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)	135.63 / 2.29	4	SS	455	29
4				5	SS	280	59
				6	SS	535	68
				7	SS	180	>50 for 50 mm
5	Diamond Rotary Core, HQ (89mm OD)	Slightly weathered to fresh, fine grained, very strong, red to grey Precambrian BEDROCK	133.27 / 4.65	8	SS		TCR = 100%; SCR = 84%; RQD = 68%
6				9	SS		TCR = 84%; SCR = 64%; RQD = 75%
7		End of Borehole	130.96 / 6.96				



GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/02/09	2.0	136.0

GEO - BOREHOLE LOG 100737.002_GINT_BOREHOLE LOGS.GPJ GEMTEC 2018.GDT 12/15/22

GEMTEC Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-214A

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 6 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface		137.80						
	Power Auger, Hollow Stem Auger (210mm OD)	TOPSOIL								
		Brown SILTY SAND		0.08	1	SS	150	-		Native backfill
1		Grey brown to grey SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)		137.04 0.76	2	SS	455	-		
2					3	SS	305	-		
		End of Borehole Auger Refusal		135.59 2.21						

Chart legend: ● PENETRATION RESISTANCE (N), BLOWS/0.3m; ▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED; WATER CONTENT, %: W_P — W — W_L; scale 10 20 30 40 50 60 70 80 90

Depth scale: 0 1 2 3 4 5 6 7 8 9 10

GEMTEC CONSULTING ENGINEERS AND SCIENTISTS

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-214B

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 6 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m
0	Power Auger, Hollow Stem Auger (210mm OD)	Ground Surface	137.80				
		TOPSOIL	0.08				
		Brown SILTY SAND	137.04 / 0.76				
1		Grey brown to grey SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)	135.59 / 2.21				
2		Grey brown to grey SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)		4	SS	355	-
3				5	SS	355	-
4				6	SS	405	-
			132.92 / 4.88	7	SS	305	-
5		End of Borehole Auger Refusal Soil stratigraphy from 0.00 to 2.21 metres was inferred from Borehole 22-214A					

PENETRATION RESISTANCE (N), BLOWS/0.3m
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m
SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED
WATER CONTENT, % W_P — W — W_L
10 20 30 40 50 60 70 80 90

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION: Bentonite seal; Filter sand; 50 millimetre well screen

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/02/09	1.7 ∇	136.1

GEMTEC
Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-215

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 6 2022

BORING METHOD: Power Auger, Hollow Stem Auger (108mm OD)

Description	Elev. / Depth (m)	Sample Number	Type	Recovery, mm	Blows/0.3m	Piezometer or Standpipe Installation
Ground Surface	135.25					
TOPSOIL	0.05					
Stiff to very stiff, grey brown SILTY CLAY (WEATHERED CRUST)	134.64 / 0.61	1	SS	230	4	Native backfill
Very loose, brown SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)	133.88 / 1.37	2	SS	405	3	
Dense to very dense, some gravel, with cobbles and boulders (GLACIAL TILL)	132.81 / 2.44	3	SS	455	35	
		4	SS	75	>50 for 150 mm	
End of Borehole Auger Refusal						

Legend: ● PENETRATION RESISTANCE (N), BLOWS/0.3m; ▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED; WATER CONTENT, % (W_P — W — W_L); ADDITIONAL LAB. TESTING

GEMTEC Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-216

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 6 2022

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. / DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE / NOTES	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface	134.58						
	Power Auger / Hollow Stem Auger (210mm OD)	TOPSOIL	0.03						
		Stiff to very stiff, grey brown SILTY CLAY (WEATHERED CRUST)	133.97 / 0.61	1	SS	405	3	● (N = 3)	
		Very loose, brown SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)	133.56 / 1.02	2	SS	50	1	● (N = 1)	Bentonite seal; groundwater level ∇
1	Diamond Rotary Core / HQ (89mm OD)	Slightly weathered to fresh, fine grained, very strong, greenish grey to pink Precambrian BEDROCK		3	RC			TCR = 100%; SCR = 0%; RQD = 57%	
2				4	RC			TCR = 94%; SCR = 69%; RQD = 74%	Filter sand
3				5	RC			TCR = 100%; SCR = 96%; RQD = 96%	
4–5			128.79 / 5.79	6	RC			TCR = 95%; SCR = 88%; RQD = 88%	50 millimetre well screen
6		End of Borehole							

Legend: ● PENETRATION RESISTANCE (N), BLOWS/0.3m; ▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA: + NATURAL, ⊕ REMOULDED; WATER CONTENT, %: W_P — W — W_L; scale 10 20 30 40 50 60 70 80 90. ADDITIONAL LAB. TESTING.

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/02/09	0.7 ∇	133.9

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CONSULTING ENGINEERS AND SCIENTISTS

LOGGED: CS/ML
CHECKED: WAM

RECORD OF BOREHOLE 22-218

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 5 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m / SHEAR STRENGTH (Cu), kPA (+ NATURAL ⊕ REMOULDED) / DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / WATER CONTENT, % (Wp W WL) 10 20 30 40 50 60 70 80 90	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger / Hollow Stem Auger (210mm OD)	Ground Surface		135.96							
		TOPSOIL		0.05							
		Stiff to very stiff, grey brown SILTY CLAY, with roots (WEATHERED CRUST)		135.38 0.58	1	SS	205	6	● N≈6		Native backfill
		End of Borehole Auger Refusal									

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

GEMTEC
CONSULTING ENGINEERS AND SCIENTISTS

LOGGED: ML
CHECKED: WAM

RECORD OF BOREHOLE 22-219

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 5 2022

BORING METHOD: Power Auger – Hollow Stem Auger (210mm OD)

SOIL PROFILE

DESCRIPTION	ELEV. (m)	DEPTH (m)
Ground Surface	136.84	
TOPSOIL		0.08
Loose to compact, grey brown SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)	135.32	1.52
Compact to very dense, grey SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)	133.31	3.53
End of Borehole Auger Refusal		

SAMPLES

NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m
1	SS	180	5
2	SS	230	20
3	SS	280	19
4	SS	455	65
5	SS	405	84

● PENETRATION RESISTANCE (N), BLOWS/0.3m
▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m
SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED
WATER CONTENT, %: W_P — W — W_L

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION: Native backfill

DEPTH SCALE METRES: 0–10

GEMTEC Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-220

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 7 2022

Boring method: Power Auger, Hollow Stem Auger (210mm OD)

Description	Elev. (m)	Depth (m)	Sample Number	Type	Recovery, mm	Blows/0.3m	Additional Lab. Testing	Piezometer or Standpipe Installation
Ground Surface	137.53							
TOPSOIL		0.10						Native backfill
Loose, brown SILTY SAND, trace gravel, with cobbles and boulders (GLACIAL TILL)			1	SS	455	9		
			2	SS	480	9		
Loose to very dense, brown SILTY CLAYEY SAND, trace gravel, with cobbles and boulders (GLACIAL TILL)	136.01	1.52	3	SS	405	5	MH	
			4	SS	100	>50 for 100 mm		
End of Borehole Auger Refusal	134.96	2.57						

Legend: ● PENETRATION RESISTANCE (N), BLOWS/0.3m; ▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED; WATER CONTENT, %: W_P — W — W_L (scale 10–90)

Water content (approx. from plot): Sample 2 ≈ 14%; Sample 3 ≈ 28%; Sample 4 ≈ 23%

GEMTEC Consulting Engineers and Scientists

LOGGED: CS/ML
CHECKED: WAM

RECORD OF BOREHOLE 22-221

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 12 2022

BORING METHOD	DESCRIPTION	ELEV. / DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	Notes
	Ground Surface	134.63					
Power Auger, Hollow Stem Auger (210mm OD)	TOPSOIL	134.50 / 0.13					
Power Auger, Hollow Stem Auger (210mm OD)	Stiff to very stiff, grey brown SILTY CLAY (WEATHERED CRUST)	134.02 / 0.61	1	SS	255	2	
Power Auger, Hollow Stem Auger (210mm OD)	Very dense, brown SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)	133.44 / 1.19	2	SS	75	>50	
Diamond Rotary Core, HQ (89mm OD)	Slightly weathered to fresh, fine grained, medium to very strong, pinkish grey Precambrian BEDROCK	128.33 / 6.30	3	RC			TCR = 50%; SCR = 50%; RQD = 50%
			4	RC			TCR = 97%; SCR = 85%; RQD = 88%
			5	RC			TCR = 100%; SCR = 93%; RQD = 35%
			6	RC			TCR = 100%; SCR = 95%; RQD = 91%
			7	RC			TCR = 100%; SCR = 100%; RQD = 100%
	End of Borehole						

DEPTH SCALE METRES: 0 – 10

PENETRATION RESISTANCE (N), BLOWS/0.3m
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m
SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED
WATER CONTENT, %: W_P — W — W_L
10 20 30 40 50 60 70 80 90

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION: Bentonite seal; Filter sand; 50 millimetre well screen

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/02/09	0.5 ∇	134.2

GEMTEC Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

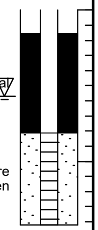
GEO - BOREHOLE LOG 100737.002_GINT_BOREHOLE LOGS.GPJ GEMTEC 2018.GDT 12/15/22

RECORD OF BOREHOLE 22-221A

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 12 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m; DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED; WATER CONTENT, % Wp W WL (10 20 30 40 50 60 70 80 90)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger; Hollow Stem Auger (210mm OD)	Ground Surface		134.72							
		TOPSOIL		134.59 0.13							
		Stiff to very stiff, grey brown SILTY CLAY (WEATHERED CRUST)		134.11 0.61							Bentonite seal
1		Very dense, brown SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)		133.30 1.42							50 millimetre well screen
		End of Borehole Soil stratigraphy from 0.00 to 1.42 metres inferred from Borehole 22-221									
2											
3											
4											
5											
6											
7											
8											
9											
10											



GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/02/09	0.6 ▽	134.1

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Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-222

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 13 2022

Boring method: Power Auger – Hollow Stem Auger (210mm OD) (0 to 1.17 m); Diamond Rotary Core – HQ (89mm OD) (1.17 to 6.10 m)

Depth (m)	Description	Elev. (m) / Depth (m)	Sample No.	Type	Recovery, mm	Blows/0.3m	Penetration / Remarks
0	Ground Surface	135.63					
	TOPSOIL	0.10					
	Loose to very loose, brown SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)		1	SS	150	9	
1		134.46 / 1.17	2	SS	380	3	
	Slightly weathered to fresh, fine grained, very strong, light grey to pinkish grey Precambrian BEDROCK		3	RC			TCR = 69%; SCR = 44%; RQD = 25%
2			4	RC			TCR = 100%; SCR = 96%; RQD = 86%
3		132.05 / 3.58					
	Slightly weathered to fresh, fine grained, very strong, greyish pink to light pink Precambrian BEDROCK		5	RC			TCR = 100%; SCR = 93%; RQD = 93%
5			6	RC			TCR = 98%; SCR = 51%; RQD = 71%
6		129.53 / 6.10	7	RC			TCR = 100%; SCR = 6%; RQD = 0%
	End of Borehole						

Legend: ● PENETRATION RESISTANCE (N), BLOWS/0.3m; ▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED; WATER CONTENT, %: W_P — W — W_L (scale 10–90)

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION: Filter sand; Bentonite seal; Filter sand; 50 millimetre well screen

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/02/09	1.1 ∇	134.5

GEMTEC Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-222A

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 13 2022

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. / DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m
0		Ground Surface	135.73				
	Power Auger / Hollow Stem Auger (210mm OD)	TOPSOIL	0.10				
		Loose to very loose, brown SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)	134.56 / 1.17				
1–3	Diamond Rotary Core / HQ (89mm OD)	Slightly weathered to fresh, fine grained, very strong, light grey to pinkish grey Precambrian BEDROCK	132.15 / 3.58				
		Slightly weathered to fresh, fine grained, very strong, greyish pink to light pink Precambrian BEDROCK	3.73				
4		End of Borehole Soil and bedrock stratigraphy from 0.00 to 3.73 metres inferred from Borehole 22-222					

PENETRATION RESISTANCE (N), BLOWS/0.3m
SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m
WATER CONTENT, % W_P W W_L
10 20 30 40 50 60 70 80 90

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION
Filter sand
Bentonite seal
Filter sand
50 millimetre well screen

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/02/09	1.3 ∇	134.4

GEMTEC
Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-223

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 2
DATUM: CGVD28
BORING DATE: Jan 25 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m / SHEAR STRENGTH (Cu), kPA / WATER CONTENT, %	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface	134.62							
	Power Auger – Hollow Stem Auger (210mm OD)	TOPSOIL	134.47 / 0.15							
		Stiff to very stiff, grey brown SILTY CLAY (WEATHERED CRUST)		1	SS	405	8	N = 8		Water level ∇
1				2	SS	355	8	N = 8		
		Slightly weathered to fresh, fine grained, pink and grey Precambrian BEDROCK	133.33 / 1.29	3	RC			TCR = 83%; SCR = 83%; RQD = 0%		
2	Diamond Rotary Core – HQ (89mm OD)			4	RC			TCR = 100%; SCR = 100%; RQD = 100%		
3–4				5	RC			TCR = 100%; SCR = 93%; RQD = 90%		
				6	RC			TCR = 97%; SCR = 97%; RQD = 97%		Bentonite seal
5				7	RC			TCR = 100%; SCR = 97%; RQD = 97%		
6				8	RC			TCR = 85%; SCR = 14%; RQD = 14%		
7				9	RC			TCR = 90%; SCR = 67%; RQD = 73%		
8		Fresh, fine grained, pink and greenish grey Precambrian BEDROCK	126.67 / 7.95	10	RC			TCR = 97%; SCR = 78%; RQD = 78%		
9				11	RC			TCR = 100%; SCR = 90%; RQD = 90%		50 millimetre well screen
10			124.62							

Legend: ● PENETRATION RESISTANCE (N), BLOWS/0.3m; ▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; + NATURAL ⊕ REMOULDED; WATER CONTENT, % (W_P — W — W_L); scale 10 20 30 40 50 60 70 80 90

GEMTEC Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-223

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 2 OF 2
DATUM: CGVD28
BORING DATE: Jan 25 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE / SHEAR STRENGTH / WATER CONTENT	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
10		Fresh, fine grained, pink and greenish grey Precambrian BEDROCK		10.00							
11					12	RC		TCR = 97%; SCR = 86%; RQD = 80%			50 millimetre well screen
12				122.53	13	RC		TCR = 100%; SCR = 22%; RQD = 0%			
		End of Borehole		12.09							
13											
14											
15											
16											
17											
18											
19											
20											

Legend: ● PENETRATION RESISTANCE (N), BLOWS/0.3m; ▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED; WATER CONTENT, %: W_P — W — W_L; scale 10 20 30 40 50 60 70 80 90

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/02/09	0.3 ∇	134.3

GEMTEC
CONSULTING ENGINEERS AND SCIENTISTS

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-224

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 5 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m
0		Ground Surface	135.64				
	Power Auger, Hollow Stem Auger (210mm OD)	TOPSOIL	0.08				
		Very loose, grey brown SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)		1	SS	255	4
1				2	SS	150	4
		Compact to very dense, grey brown to grey SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)	134.12 / 1.52	3	SS	150	13
2				4	SS	405	22
3				5	SS	380	>50
4				6	SS	330	39
	Diamond Rotary Core, HQ (89mm OD)	Slightly weathered to fresh, fine grained, very strong, pinkish grey Precambrian BEDROCK	131.19 / 4.45	7	RC		TCR = 43%; SCR = 43%; RQD = 0%
5				8	RC		TCR = 100%; SCR = 100%; RQD = 88%
6		End of Borehole	129.47 / 6.17				

PENETRATION RESISTANCE (N), BLOWS/0.3m
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m
SHEAR STRENGTH (Cu), kPA — NATURAL, REMOULDED
WATER CONTENT, % — W_P, W, W_L
10 20 30 40 50 60 70 80 90

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

Filter sand
Native backfill
Bentonite seal
Filter sand
50 millimetre well screen
Bentonite backfill

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/02/09	0.5	135.1

GEMTEC
CONSULTING ENGINEERS AND SCIENTISTS

LOGGED: CS/ML
CHECKED: WAM

GEO - BOREHOLE LOG 100737.002_GINT_BOREHOLE LOGS.GPJ GEMTEC 2018.GDT 12/15/22

RECORD OF BOREHOLE 22-225

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 4 2022

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. / DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N) / REMARKS	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface	134.94						
	Power Auger / Hollow Stem Auger (210mm OD)	TOPSOIL	134.79 / 0.15						
		Loose, grey brown SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)		1	SS	205	6	● (N = 6)	Bentonite seal
1				2	SS	150	5	● (N = 5)	
	Diamond Rotary Core / HQ (89mm OD)	Slightly weathered to fresh, fine grained, very strong, pinkish grey Precambrian BEDROCK	133.72 / 1.22	3	RC			TCR = 95%; SCR = 82%; RQD = 45%	Filter sand
2				4	RC			TCR = 98%; SCR = 96%; RQD = 86%	
3–4				5	RC			TCR = 100%; SCR = 86%; RQD = 66%	50 millimetre well screen
5				6	RC			TCR = 98%; SCR = 85%; RQD = 66%	
6		End of Borehole	128.92 / 6.02						

SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED
▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m
WATER CONTENT, %: W_P — W — W_L
ADDITIONAL LAB. TESTING

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/02/09	0.8 ∇	134.1

GEMTEC Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-225A

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 4 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION / SHEAR STRENGTH / WATER CONTENT	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger, Hollow Stem Auger (210mm OD)	Ground Surface	134.97							
		TOPSOIL	134.82 / 0.15							Filter sand
		Loose, grey brown SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)	133.60 / 1.37							Bentonite seal; Filter sand
		End of Borehole Auger Refusal Soil and bedrock stratigraphy from 0.00 to 1.37 metres inferred from Borehole 22-225								

Legend: ● PENETRATION RESISTANCE (N), BLOWS/0.3m; ▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED; WATER CONTENT, %: W_P — W — W_L; scale 10 20 30 40 50 60 70 80 90

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/02/09	0.9 ▽	134.1

GEMTEC Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-226

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 5 2022

Boring method: Power Auger, Hollow Stem Auger (210mm OD)

DESCRIPTION	ELEV. / DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m
Ground Surface	135.59				
TOPSOIL	0.08				
Stiff to very stiff, grey brown SILTY CLAY (WEATHERED CRUST)		1	SS	305	5
		2	SS	610	10
		3	SS	610	3
Compact to very dense, brown SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)	133.30 / 2.29	4	SS	25	21
		5	SS	75	>50 for 75 mm
End of Borehole Auger Refusal	132.24 / 3.35				

Depth scale: 0 to 10 metres.

PENETRATION RESISTANCE (N), BLOWS/0.3m; DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED; WATER CONTENT, % W_P W W_L (scale 10–90)

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION: Native backfill

GEMTEC Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-227

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 26 2022

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger Hollow Stem Auger (210mm OD)	Ground Surface		137.56							
		TOPSOIL		137.38 / 0.18							
		Compact to very dense, brown SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)			1	SS	355	14	● 14		Native backfill
				136.59 / 0.97	2	SS	150	>50 for 100 mm			
1		End of Borehole Auger Refusal									

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Chart axes: PENETRATION RESISTANCE (N), BLOWS/0.3m; DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED; WATER CONTENT, % W_P — W — W_L; 10 20 30 40 50 60 70 80 90

GEMTEC Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-228

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 2
DATUM: CGVD28
BORING DATE: Jan 28 2022

SOIL PROFILE

Depth (m)	Boring Method	Description	Elev. / Depth (m)
0		Ground Surface	138.48
	Power Auger, Hollow Stem Auger (210mm OD)	TOPSOIL	0.10
		Compact to very dense, brown SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)	137.54 / 0.94
1–10	Diamond Rotary Core, HQ (89mm OD)	Slightly weathered to fresh, fine grained, very strong, pinkish grey Precambrian BEDROCK	128.48 (at 10 m)

SAMPLES

Number	Type	Recovery, mm	Blows/0.3m
1	SS	255	16
2	SS	100	>50 for 75 mm
3	RC		TCR = 100%; SCR = 77%; RQD = 69%
4	RC		TCR = 100%; SCR = 19%; RQD = 0%
5	RC		TCR = 94%; SCR = 17%; RQD = 0%
6	RC		TCR = 100%; SCR = 53%; RQD = 67%
7	RC		TCR = 92%; SCR = 61%; RQD = 61%
8	RC		TCR = 100%; SCR = 74%; RQD = 54%
9	RC		TCR = 80%; SCR = 70%; RQD = 70%
10	RC		TCR = 100%; SCR = 65%; RQD = 65%
11	RC		TCR = 97%; SCR = 69%; RQD = 38%
12	RC		TCR = 100%; SCR = 95%; RQD = 95%
13	RC		TCR = 100%; SCR = 68%; RQD = 65%
14	RC		TCR = 100%; SCR = 17%; RQD = 0%
15	RC		TCR = 100%; SCR = 100%; RQD = 100%
16	RC		TCR = 96%; SCR = 94%; RQD = 94%
17	RC		TCR = 97%; SCR = 43%; RQD = 37%
18	RC		TCR = 100%; SCR = 63%; RQD = 41%
19	RC		TCR = 100%; SCR = 0%; RQD = 0%

● PENETRATION RESISTANCE (N), BLOWS/0.3m
▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m
SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED
WATER CONTENT, %: W_P — W — W_L
10 20 30 40 50 60 70 80 90

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

Native backfill
Bentonite seal
Filter sand
50 millimetre well screen

GEMTEC Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-228

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 2 OF 2
DATUM: CGVD28
BORING DATE: Jan 28 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
10		Slightly weathered to fresh, fine grained, very strong, pinkish grey Precambrian BEDROCK		10.00	20	RC		TCR = 100%; SCR = 55%; RQD = 61%		
					21	RC		TCR = 100%; SCR = 57%; RQD = 33%		
11					22	RC		TCR = 100%; SCR = 36%; RQD = 36%		50 millimetre well screen
12				126.14	23	RC		TCR = 100%; SCR = 38%; RQD = 50%		
		End of Borehole		12.34						
13										
14										
15										
16										
17										
18										
19										
20										

Chart headings: ● PENETRATION RESISTANCE (N), BLOWS/0.3m; ▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED; WATER CONTENT, %: W_P — W — W_L; 10 20 30 40 50 60 70 80 90

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/02/09	4.1 ∇	134.3

GEMTEC Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-228A

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Feb 2 2022

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m / DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED / WATER CONTENT, % Wp W WL (10 20 30 40 50 60 70 80 90)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger, Hollow Stem Auger (210mm OD)	Ground Surface		138.45							
		TOPSOIL		0.10							Native backfill
		Compact to very dense, brown SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)		137.51 / 0.94							
1	Diamond Rotary Core, HQ (89mm OD)	Slightly weathered to fresh, fine grained, very strong, pinkish grey Precambrian BEDROCK									Bentonite seal
4											∇ Filter sand
6											50 millimetre well screen
				130.80 / 7.65							
		End of Borehole Soil and bedrock stratigraphy from 0.00 to 7.65 metres inferred from Borehole 22-228									

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/02/09	4.0 ∇	134.4

GEMTEC
Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-229

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 4 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface		135.59						
	Power Auger, Hollow Stem Auger (210mm OD)	TOPSOIL		0.05						
		Loose, brown silty sand, some gravel (FILL MATERIAL)			1	SS	50	6		Native backfill
1					2	SS	405	5		
					3	SS	355	>50 for 150 mm		
2		End of Borehole Auger Refusal		133.48 2.11						

Depth scale: 0 to 10 m.

PENETRATION RESISTANCE (N), BLOWS/0.3m (●)
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (▲)
SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED
WATER CONTENT, %: W_P — W — W_L
10 20 30 40 50 60 70 80 90

GEMTEC Consulting Engineers and Scientists

LOGGED: ML
CHECKED: WAM

GEO - BOREHOLE LOG 100737.002_GINT_BOREHOLE LOGS.GPJ GEMTEC 2018.GDT 12/15/22

RECORD OF BOREHOLE 22-230

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jan 4 2022

BORING METHOD: Power Auger — Hollow Stem Auger (210mm OD)

DESCRIPTION	ELEV. / DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
Ground Surface	134.95						
TOPSOIL	0.08						Native backfill
Compact, brown silty sand, some gravel (FILL MATERIAL)	134.34 / 0.61	1	SS	230	18		
Loose, dark brown silty sand, with organics (FILL MATERIAL)	134.04 / 0.91						
Loose, grey brown silty sand (FILL MATERIAL)	132.66 / 2.29	2	SS	455	5		
		3	SS	150	5		
Loose to very dense, grey brown SILTY SAND, some clay, trace gravel, with cobbles and boulders (GLACIAL TILL)	130.91 / 4.04	4	SS	455	10	MH	
		5	SS	610	16		
		6	SS	255	>50 for 150 mm		
End of Borehole Auger Refusal							

Legend: ● PENETRATION RESISTANCE (N), BLOWS/0.3m; ▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED; WATER CONTENT, % (W_P — W — W_L); scale 10 20 30 40 50 60 70 80 90

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

GEMTEC Consulting Engineers and Scientists

LOGGED: CS
CHECKED: WAM

RECORD OF BOREHOLE 22-231

CLIENT: Caivan Communities
PROJECT: Geotechnical and Hydrological Investigation, Proposed Residential Development, Perth golf Course
JOB#: 100737.002
LOCATION: 141 Peter Street, Perth

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Mar 15 2022

BORING METHOD: Portable Drill Rig, Open Borehole

DESCRIPTION	ELEV. / DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m
Ground Surface	136.54				
Loose, black to dark brown fibrous PEAT	136.26 / 0.28	1	SS	430	3
Stiff to very stiff, grey brown SILTY CLAY, trace sand (WEATHERED CRUST)		2	SS	610	6
		3	SS	560	9
	134.18 / 2.36	4	SS	455	10
Grey SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)		5	SS	355	41
		6	SS	0	>50 for 125mm
		7	RC	5	DD
	133.19 / 3.35	8	RC	0	DD
End of Borehole					

Depth scale: 0 to 10 metres.

Chart headings: PENETRATION RESISTANCE (N), BLOWS/0.3m; DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED; WATER CONTENT, % W_P — W — W_L; scale 10 20 30 40 50 60 70 80 90.

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION: Stickup Protective Casing; Bentonite Seal; Filter Sand; 32 millimetre Diameter PVC Screen

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/10/15	0.7 ∇	135.8

GEMTEC Consulting Engineers and Scientists

LOGGED: PS

CHECKED: WAM

RECORD OF BOREHOLE 22-231A

CLIENT: Caivan Communities
PROJECT: Geotechnical and Hydrological Investigation, Proposed Residential Development, Perth golf Course
JOB#: 100737.002
LOCATION: 141 Peter Street, Perth

SHEET: 1 OF 2
DATUM: CGVD28
BORING DATE: Mar 16 2022

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. / DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface	136.03					
		Black to dark brown, fibrous PEAT	135.75 / 0.28					Stickup Protective Casing
		Grey to brown, SILTY CLAY, trace sand (WEATHERED CRUST)	133.67 / 2.36					
		Grey SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)	133.18 / 2.85					
3	Wash Casing NQ (70mm OD)	Probable SILTY SAND, some gravel, with cobbles and boulders (GLACIAL TILL)		1	RC	205	DD	Native backfill
				2	RC	75	DD	
				3	RC	155	DD	
4				4	RC	0	DD	
				5	RC	75	DD	
				6	SS	0	>50 for 25mm	
5				7	RC	815	DD	
6				8	RC	155	DD	
7			128.95 / 7.08	9	SS	0	>50 for 100mm	
	Diamond Rotary Core NQ (70mm OD)	Slightly weathered to fresh, fine grained pink to grey Precambrian BEDROCK		10	RC		TCR 76%, SCR 35%, RQD 11%	Bentonite Seal
8				11	RC		TCR 89%, SCR 44%, RQD 0%	
9		Slightly weathered to fresh, fine grained pink to grey Precambrian BEDROCK	127.03 / 9.00	12	RC	915	TCR 57%, SCR 16%, RQD 0%	Filter Sand
10								

PENETRATION RESISTANCE (N), BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED; DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; WATER CONTENT, % W_P — W — W_L; 10 20 30 40 50 60 70 80 90; ADDITIONAL LAB. TESTING

GEMTEC
Consulting Engineers and Scientists

LOGGED: PS
CHECKED: WAM

RECORD OF BOREHOLE 22-231A

CLIENT: Caivan Communities
PROJECT: Geotechnical and Hydrological Investigation, Proposed Residential Development, Perth golf Course
JOB#: 100737.002
LOCATION: 141 Peter Street, Perth

SHEET: 2 OF 2
DATUM: CGVD28
BORING DATE: Mar 16 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m; DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED; WATER CONTENT, % W_P W W_L (10 20 30 40 50 60 70 80 90)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
10				125.62	13	RC	75	TCR 37%, SCR 25%, RQD 0%			Filter Sand; 32 millimetre Diameter PVC Screen; 32 millimetre Diameter PVC Screen
		End of Borehole		10.41							
11–20											

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/10/15	0.8 ∇	135.3

GEMTEC Consulting Engineers and Scientists

LOGGED: PS
CHECKED: WAM

RECORD OF BOREHOLE 22-232

CLIENT: Caivan Communities
PROJECT: Geotechnical and Hydrological Investigation, Proposed Residential Development, Perth golf Course
JOB#: 100737.002
LOCATION: 141 Peter Street, Perth

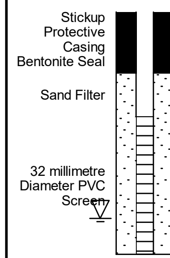
SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Mar 25 2022

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m
0		Ground Surface		138.44				
	Portable Drill Rig, Open Borehole	Black fibrous PEAT						
		Stiff to very stiff, grey brown SILTY CLAY (WEATHERED CRUST)		0.07	1	SS	280	3
					2	SS	460	9
1					3	SS	460	23
		End of Borehole Sampler Refusal		136.84 1.60				
2								
3								
4								
5								
6								
7								
8								
9								
10								

● PENETRATION RESISTANCE (N), BLOWS/0.3m
▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m
SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED
WATER CONTENT, %: W_P — W — W_L
10 20 30 40 50 60 70 80 90

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION



GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/10/17	1.4 ∇	137.1

GEMTEC Consulting Engineers and Scientists

LOGGED: PS

CHECKED: WAM

RECORD OF BOREHOLE 22-232A

CLIENT: Caivan Communities
PROJECT: Geotechnical and Hydrological Investigation, Proposed Residential Development, Perth golf Course
JOB#: 100737.002
LOCATION: 141 Peter Street, Perth

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Mar 23 2022

Depth (m)	Boring Method	Description	Elev. / Depth (m)	Number	Type	Recovery, mm	Blows/0.3m
0		Ground Surface	139.33				
	Portable Drill Rig, Open Borehole	Black fibrous PEAT		1	SS	205	4
		Stiff to very stiff, grey to brown SILTY CLAY, some sand (WEATHERED CRUST)	138.77 / 0.56	2	SS	610	12
				3	SS	355	23
	Diamond Rotary Core, NQ (70mm OD)	Slightly weathered to fresh, fine grained pink to grey Precambrian BEDROCK	137.71 / 1.62	4	RC		TCR 97%, SCR 92%, RQD 92%
				5	RC		TCR 97%, SCR 93%, RQD 93%
				6	RC		TCR 100%, SCR 75%, RQD 67%
				7	RC		TCR 100%, SCR 97%, RQD 97%
				8	RC		TCR 100%, SCR 96%, RQD 75%
				9	RC		TCR 98%, SCR 91%, RQD 84%
		End of Borehole	134.66 / 4.67				

Column headings: DEPTH SCALE METRES; BORING METHOD; SOIL PROFILE (DESCRIPTION, STRATA PLOT, ELEV. DEPTH (m)); SAMPLES (NUMBER, TYPE, RECOVERY, mm, BLOWS/0.3m); ● PENETRATION RESISTANCE (N), BLOWS/0.3m; ▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED; WATER CONTENT, % W_P — W — W_L; 10 20 30 40 50 60 70 80 90; ADDITIONAL LAB. TESTING; PIEZOMETER OR STANDPIPE INSTALLATION

Piezometer: Stickup Protective Casing; Bentonite Seal; Filter Sand; 32 millimetre Diameter PVC Screen

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/10/17	1.3 ∇	138.1

GEMTEC Consulting Engineers and Scientists

LOGGED: PS
CHECKED: WAM

RECORD OF BOREHOLE 22-233A

CLIENT: Caivan (Perth G.C.) Limited
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Oct 6 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m / DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED / WATER CONTENT, % W_P W W_L (10 20 30 40 50 60 70 80 90)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger; Hollow Stem Auger (210mm OD)	Ground Surface		134.85							
		Unsampled Overburden									Native backfill
2.87		End of Borehole, Auger Refusal		131.98 / 2.87							

GEO - BOREHOLE LOG 100737.002_GINT_2022-10-13.GPJ GEMTEC 2018.GDT 12/15/22

GEMTEC Consulting Engineers and Scientists

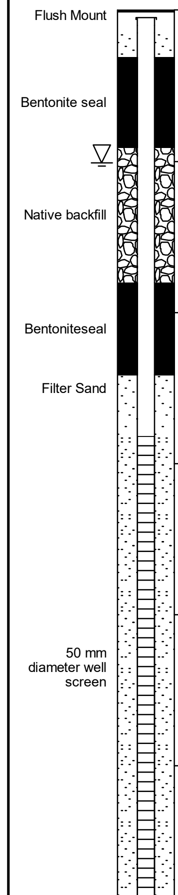
LOGGED: A.N.
CHECKED: W.A.M.

RECORD OF BOREHOLE 22-233B

CLIENT: Caivan (Perth G.C.) Limited
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Oct 6 2022

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m; DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA (+ NATURAL, ⊕ REMOULDED); WATER CONTENT, % (Wp, W, WL) 10 20 30 40 50 60 70 80 90	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger; Hollow Stem Auger (210mm OD)	Ground Surface		134.94							
		Unsampled Overburden									
5.87		End of Borehole, Auger Refusal		129.07 5.87							



GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/10/14	1.0 ∇	133.9

GEMTEC Consulting Engineers and Scientists

LOGGED: A.N.
CHECKED: W.A.M.

RECORD OF BOREHOLE 22-234

CLIENT: Caivan (Perth G.C.) Limited
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Oct 5 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m / DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED / WATER CONTENT, % W_P W W_L (10 20 30 40 50 60 70 80 90)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface		134.43							
0–2.29	Power Auger, Hollow Stem Auger (260mm OD)	Unsampled Overburden									Flush Mount; Bentonite seal; Native backfill; Bentonite seal
2.29–6.86	Air Rotary, 98.4 mm diameter	Probable Bedrock		132.14 / 2.29							Filter Sand; 50 mm well screen
6.86		End of Borehole		127.57 / 6.86							

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/10/14	1.1 ▽	133.3

GEMTEC Consulting Engineers and Scientists

LOGGED: A.N.
CHECKED: W.A.M.

RECORD OF BOREHOLE 22-235

CLIENT: Caivan (Perth G.C.) Limited
PROJECT: Proposed Residential Development, Perth Golf, 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Oct 6 2022

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m; DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA (+ NATURAL, ⊕ REMOULDED); WATER CONTENT, % (Wp, W, WL) 10 20 30 40 50 60 70 80 90	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface		134.25							
0–1.32	Power Auger, Hollow Stem Auger (210mm OD)	Unsampled Overburden									Flush Mount; Bentonite seal; Native backfill
1.32–6.10	Air Rotary, 98.4 mm diameter	Probable Bedrock		132.93 / 1.32							Bentonite seal; Filter Sand; 50 mm well screen; Native cave
6.10		End of Borehole		128.15 / 6.10							

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/10/14	1.0 ▽	133.3

GEMTEC Consulting Engineers and Scientists

LOGGED: A.N.

CHECKED: W.A.M.

RECORD OF BOREHOLE HA 137

CLIENT: Cavian Communities
PROJECT: Proposed Residential Development and Sanitoary Sewer - 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: 141 Peter Street

SHEET: 1 OF 1
DATUM: Unknown
BORING DATE: Feb 21 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m / DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED / WATER CONTENT, % W_P W W_L (10 20 30 40 50 60 70 80 90)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface		133.50							
		ICE		133.42 0.08	1						
		Roots and Woody ORGANICS		133.20	2						Native Backfill
		Highly humidified PEAT		0.31							
1					3						
		End of borehole		131.67 1.83							
2											
3											
4											
5											
6											
7											
8											
9											
10											

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/02/21	0.1 ∇	133.4

GEMTEC
Consulting Engineers and Scientists

LOGGED: M.B.
CHECKED: A.P.

RECORD OF BOREHOLE HA 138

CLIENT: Cavian Communities
PROJECT: Proposed Residential Development and Sanitoary Sewer - 141 Peter Street, Perth, Ontario
JOB#: 100737.002
LOCATION: 141 Peter Street

SHEET: 1 OF 1
DATUM: Unknown
BORING DATE: Feb 21 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE / SHEAR STRENGTH / WATER CONTENT	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface		133.50							∇
		ICE		133.20 / 0.31	1						Native backfill
		Roots, woody ORGANICS		133.04 / 0.46	2						
1		Humified PEAT		132.13 / 1.37	3						
		Grey silty CLAY		131.67 / 1.83	4					MH	
2		End of Borehole									

Legend: ● PENETRATION RESISTANCE (N), BLOWS/0.3m; ▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED; WATER CONTENT, %: W_P — W — W_L; scale 10 20 30 40 50 60 70 80 90

Depth scale: 0 – 10 m

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/02/21	0.0 ∇	133.5

GEMTEC
Consulting Engineers and Scientists

LOGGED: M.B.
CHECKED: A.P.

RECORD OF BOREHOLE Borehole HA 139

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development and Sanitary Sewer
JOB#: 100737.002
LOCATION: 141 Peter Street

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Mar 15 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m / DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED / WATER CONTENT, % Wp W WL (10 20 30 40 50 60 70 80 90)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface		142.00							
		FROST LINE		141.80							
		Dark brown humified PEAT		0.20							
1				140.90							Native Backfill
		Light grey CLAY		1.10							
				140.20 / 1.80							
2											
3											
4											
5											
6											
7											
8											
9											
10											

GEMTEC
CONSULTING ENGINEERS AND SCIENTISTS

LOGGED: BR
CHECKED: AP

RECORD OF BOREHOLE Borehole HA 140

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development and Sanitary Sewer
JOB#: 100737.002
LOCATION: 141 Peter Street

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Mar 15 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m; DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED; WATER CONTENT, % Wp W WL (10 20 30 40 50 60 70 80 90)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface		136.00							
		FROST LINE		135.85							
		Dark brown humified PEAT		0.15							Native Backfill
				134.20 1.80							
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

GEO - BOREHOLE LOG 101491.001_GEOTECH_2022-03-28.GPJ GEMTEC 2018.GDT 3/29/22

GEMTEC
CONSULTING ENGINEERS AND SCIENTISTS

LOGGED: BR
CHECKED: AP

RECORD OF BOREHOLE Borehole HA 141

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development and Sanitary Sewer
JOB#: 100737.002
LOCATION: 141 Peter Street

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Mar 15 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m; DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA (+ NATURAL, ⊕ REMOULDED); WATER CONTENT, % (W_P — W — W_L) 10 20 30 40 50 60 70 80 90	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface		136.00							
		FROST LINE		135.80							
		Dark brown humified PEAT		0.20							
1		Light grey CLAY		135.05 0.95							Native Backfill
2				134.20 1.80							
3											
4											
5											
6											
7											
8											
9											
10											

GEMTEC
CONSULTING ENGINEERS AND SCIENTISTS

LOGGED: BR
CHECKED: AP

RECORD OF BOREHOLE Borehole HA 142

CLIENT: Caivan Communities
PROJECT: Proposed Residential Development and Sanitary Sewer
JOB#: 100737.002
LOCATION: 141 Peter Street

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Mar 15 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE – DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES – NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	PENETRATION RESISTANCE (N), BLOWS/0.3m; DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA (+ NATURAL ⊕ REMOULDED); WATER CONTENT, % (W_P, W, W_L) 10 20 30 40 50 60 70 80 90	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface		147.00							
		FROST LINE		146.90 / 0.10							
		Dark brown Humified PEAT		146.75 / 0.25							
		Light brown silty CLAY									Native Backfill
1											
				145.20 / 1.80							
2											
3											
4											
5											
6											
7											
8											
9											
10											

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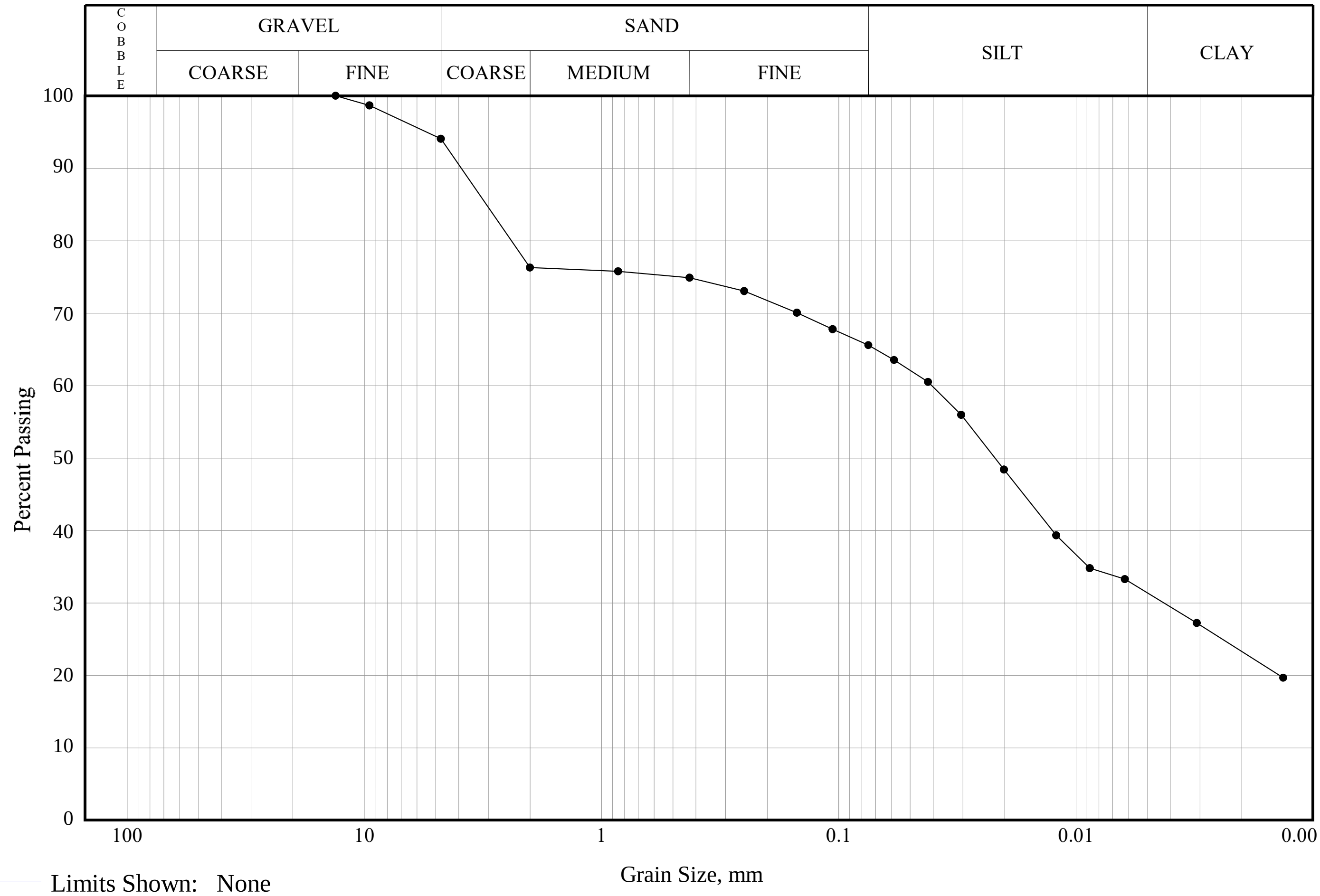
LOGGED: BR
CHECKED: AP

GEMTEC Consulting Engineers and Scientists	Client: Caivan Communities Project: Geotechnical and Hydrogeological Investigation, Propose Project #: 100737002	Soils Grading Chart (T88)

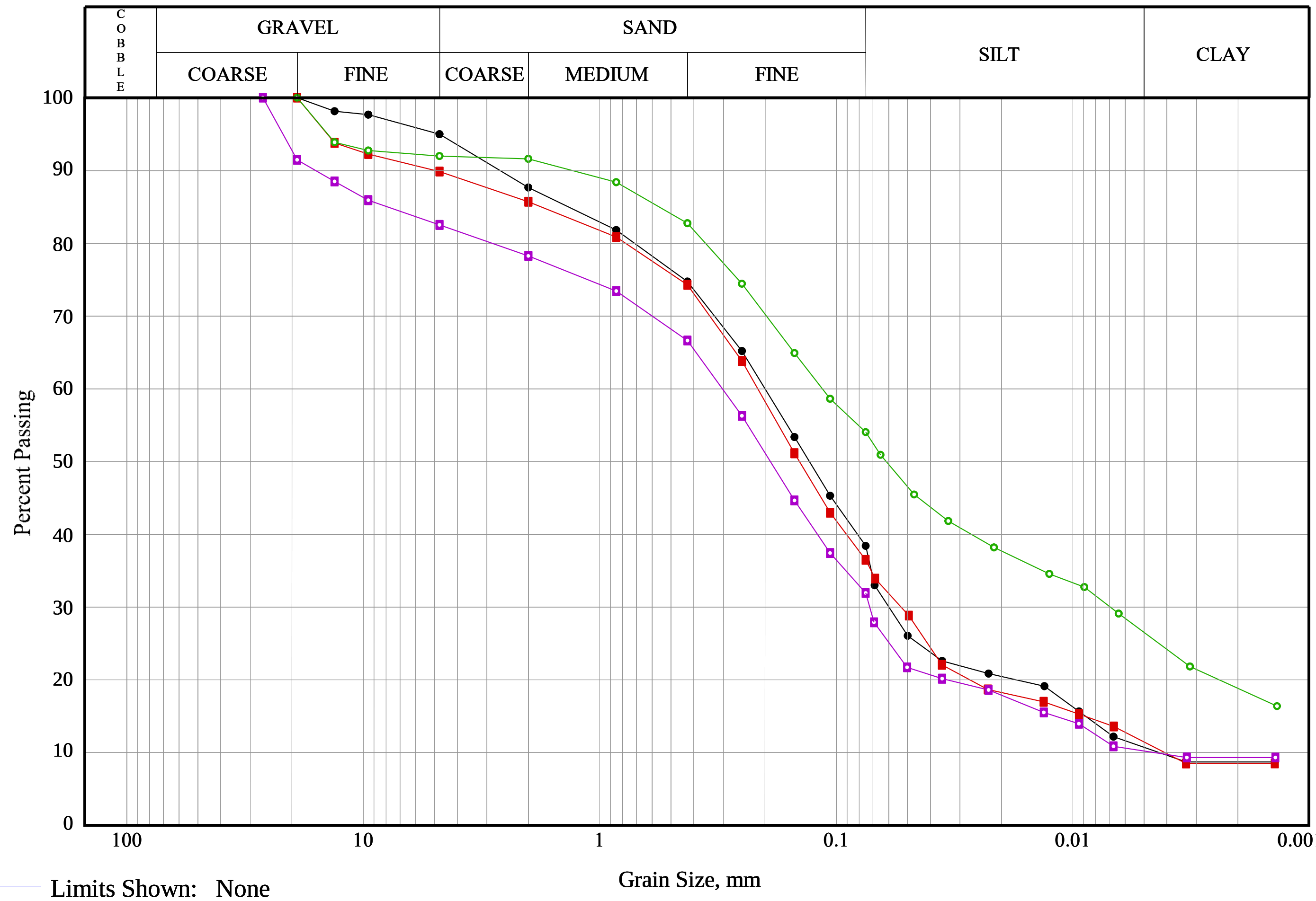


Limits Shown: None

Line Symbol	Sample	Borehole/ Test Pit	Sample Number	Depth	% Cob.+ Gravel	% Sand	% Silt	% Clay
—●—		HA138	1	1.37-1.83	5.9	28.5	34.2	31.4

Line Symbol	CanFEM Classification	USCS Symbol	D_{10}	D_{15}	D_{30}	D_{50}	D_{60}	D_{85}	% 5-75μm
—●—	Clayey sand and silt , trace gravel	N/A	---	---	0.00	0.02	0.04	3.06	34.2

GEMTEC Consulting Engineers and Scientists	Client: Caivan Communities	Soils Grading Chart (T88)
	Project: Geotechnical and Hydrogeological Investigation, Propose	
	Project #: 100737002	

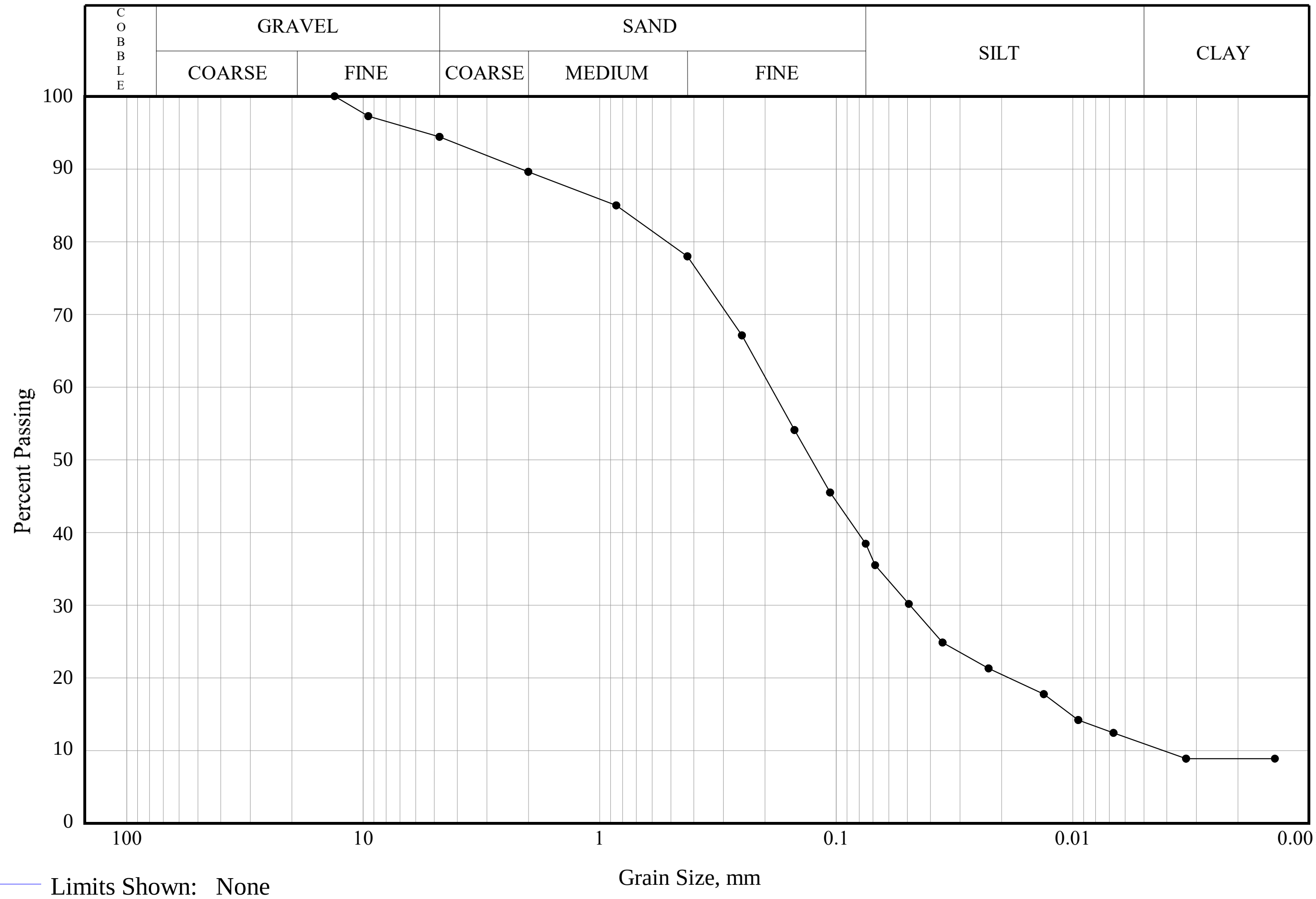


Limits Shown: None

Line Symbol	Sample	Borehole/ Test Pit	Sample Number	Depth	% Cob.+ Gravel	% Sand	% Silt	% Clay
● (black)	GLACIAL TILL	22-202	SS 5	3.05-3.48	5.0	56.6	27.7	10.7
■ (red)	GLACIAL TILL	22-207	SS 3	1.52-2.13	10.2	53.4	25.0	11.5
○ (green)	GLACIAL TILL	22-220	SS 3	1.52-2.13	8.0	38.0	27.5	26.5
□ (purple)	GLACIAL TILL	22-224	SS 4	2.29-2.90	17.5	50.6	21.7	10.2

Line Symbol	CanFEM Classification	USCS Symbol	D_{10}	D_{15}	D_{30}	D_{50}	D_{60}	D_{85}	% 5-75µm
● (black)	Silty sand , some clay , trace gravel	N/A	0.00	0.01	0.06	0.13	0.20	1.36	27.7
■ (red)	Silty sand , some gravel, some clay	N/A	0.00	0.01	0.05	0.14	0.21	1.77	25.0
○ (green)	Silty clayey sand , trace gravel	N/A	---	---	0.01	0.06	0.11	0.56	27.5
□ (purple)	Silty sand , some gravel, some clay	N/A	0.00	0.01	0.07	0.19	0.30	7.89	21.7

GEMTEC Consulting Engineers and Scientists	Client: Caivan Communities	Soils Grading Chart (T88)
	Project: Geotechnical and Hydrogeological Investigation, Propose	
	Project #: 100737002	



Limits Shown: None

Line Symbol	Sample	Borehole/ Test Pit	Sample Number	Depth	% Cob.+ Gravel	% Sand	% Silt	% Clay
—●—	GLACIAL TILL	22-230	SS 4	2.29-2.90	5.6	56.0	27.5	10.9

Line Symbol	CanFEM Classification	USCS Symbol	D_{10}	D_{15}	D_{30}	D_{50}	D_{60}	D_{85}	% 5-75μm
—●—	Silty sand , some clay , trace gravel	N/A	0.00	0.01	0.05	0.13	0.19	0.85	27.5

APPENDIX D

Water Level Monitoring

Report to: Caivan (Perth GC) Limited
Project: 100737.002 (February 22, 2023)

Table D1. Manual Groundwater Level Measurements (mbgs)

Well ID	Formation Screened	Well Depth (mbgs)	Easting[1]	Northing	Ground Elevation (m)	Measured Groundwater Levels (mbgs)							
						9-Feb-22	16-Feb-22	23-Feb-22	30-Mar-22	12-May-22	14-Oct-22	15-Oct-22	17-Oct-22
22-201	Glacial Till	6.10	399000.430	4972332.650	136.00	0.87	0.81	-	-	0.51	1.96	-	-
22-203	Bedrock	6.22	399324.950	4972517.254	135.91	1.24	1.14	0.897	0.59	0.92	-	2.00	-
22-205	Glacial Till	6.15	399642.018	4972587.767	135.32	0.45	0.34	0.056	0.13	0.26	-	1.66	-
22-208	Bedrock	6.07	399217.737	4972340.184	137.48	2.71	2.70	2.529	2.14	2.48	-	3.64	-
22-214	Bedrock	6.96	399636.118	4972417.878	137.92	1.96	1.81	1.427	0.80	1.25	-	3.18	-
22-214B	Glacial Till	4.88	399635.079	4972418.011	137.80	1.69	1.70	1.473	0.67	1.11	-	3.05	-
22-216	Bedrock	5.79	399825.166	4972563.094	134.62	0.73	0.73	0.5405	-	0.59	-	1.02	-
22-221	Bedrock	6.30	399397.921	4972184.584	134.63	0.48	0.40	-	-	0.22	-	-	2.13
22-221A	Glacial Till	1.42	399398.200	4972185.522	134.72	0.57	0.52	-	-	0.30	-	-	-
22-222	Bedrock	6.10	399277.689	4972066.449	135.63	1.09	1.04	0.738	0.42	0.74	-	2.68	-
22-222A	Bedrock	3.73	399277.817	4972067.679	135.73	1.30	1.20	0.887	0.54	0.89	-	2.77	-
22-223	Bedrock	12.09	399682.230	4972209.608	134.617	0.31	0.23	0.175	-	0.24	-	1.01	-
22-224	Glacial Till	4.45	399954.700	4972252.658	135.64	0.54	0.49	0.26	-	0.27	-	-	1.60
22-225	Bedrock	6.02	400181.841	4972200.818	134.94	0.83	0.72	0.438	-	0.81	-	1.05	-
22-225A	Glacial Till	1.37	400180.124	4972201.383	134.97	0.85	0.78	0.494	0.54	0.90	-	1.15	-
22-228	Bedrock	12.34	400147.766	4971938.274	138.48	4.15	4.12	3.861	3.52	3.88	-	4.86	-
22-228A	Bedrock	7.65	400148.520	4971938.095	138.45	4.03	3.98	3.667	3.26	3.66	-	4.58	-
22-231A	Bedrock	10.08	400145.497	4971885.441	133.34	-	-	-	-	0.04	-	0.54	-
22-231	Clay/Till	3.35	400145.520	4971883.461	133.35	-	-	-	-	0.08	-	0.54	-
22-232A	Bedrock	4.67	399484.520	4972067.769	133.74	-	-	-	-	0.11	-	-	0.95
22-232	Clay	1.60	399483.493	4972069.221	133.76	-	-	-	-	0.14	-	-	0.91
22-233B	Overburden	5.83	399496.526	4972600.749	134.94	-	-	-	-	-	1.05	-	-
22-234	Bedrock	6.86	400446.731	4972315.796	134.43	-	-	-	-	-	1.07	-	-
22-235	Bedrock	4.84	400425.387	4972146.663	134.25	-	-	-	-	-	0.98	-	-

Note: "-" denotes either frozen conditions, dry conditions, or that no data was collected.
Red font indicates ground elevations determined using lidar, whereas the remainder were measured using a high-precision Trimble GPS.

Table D2. Manual Groundwater Level Measurements (masl)

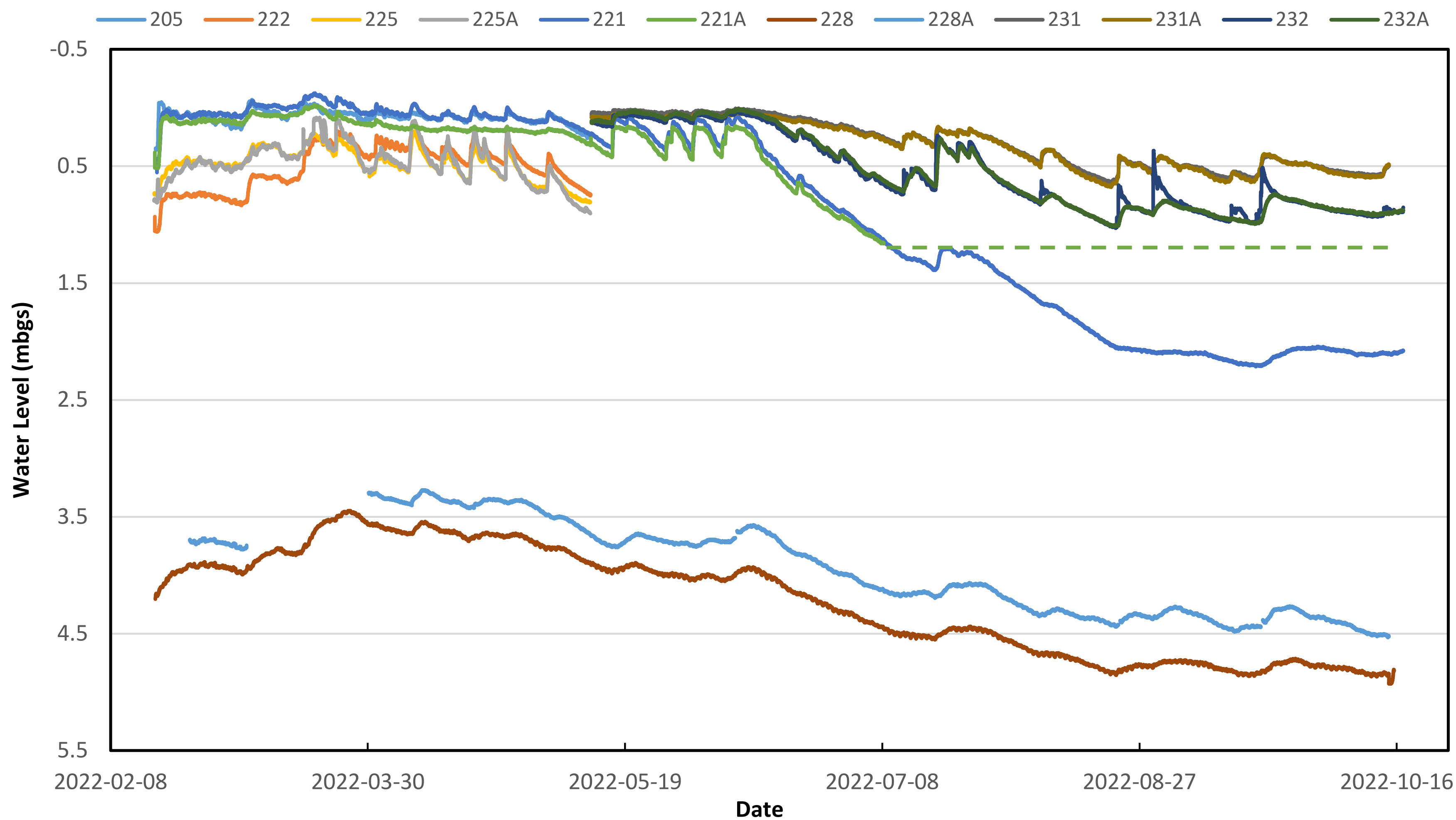
Well ID	Formation Screened	Well Depth (mbgs)	Easting[1]	Northing	Ground Elevation (m)	Measured Groundwater Levels (masl)							
						9-Feb-22	16-Feb-22	23-Feb-22	30-Mar-22	12-May-22	14-Oct-22	15-Oct-22	17-Oct-22
22-201	Glacial Till	6.10	399000.430	4972332.650	136.00	135.13	135.19	-	-	135.49	134.04	-	-
22-203	Bedrock	6.22	399324.950	4972517.254	135.91	134.68	134.78	135.016	135.33	135.00	-	133.92	-
22-205	Glacial Till	6.15	399642.018	4972587.767	135.32	134.87	134.98	135.261	135.19	135.06	-	133.66	-
22-208	Bedrock	6.07	399217.737	4972340.184	137.48	134.77	134.78	134.954	135.34	135.00	-	133.84	-
22-214	Bedrock	6.96	399636.118	4972417.878	137.92	135.96	136.11	136.49	137.12	136.67	-	134.74	-
22-214B	Glacial Till	4.88	399635.079	4972418.011	137.80	136.11	136.11	136.331	137.13	136.69	-	134.75	-
22-216	Bedrock	5.79	399825.166	4972563.094	134.62	133.89	133.89	134.08	-	134.03	-	133.60	-
22-221	Bedrock	6.30	399397.921	4972184.584	134.63	134.15	134.23	-	-	134.41	-	-	132.50
22-221A	Glacial Till	1.42	399398.200	4972185.522	134.72	134.15	134.20	-	-	134.42	-	-	-
22-222	Bedrock	6.10	399277.689	4972066.449	135.63	134.53	134.58	134.889	135.20	134.88	-	132.94	-
22-222A	Bedrock	3.73	399277.817	4972067.679	135.73	134.43	134.53	134.842	135.19	134.84	-	132.96	-
22-223	Bedrock	12.09	399682.230	4972209.608	134.617	134.30	134.38	134.442	-	134.37	-	133.60	-
22-224	Glacial Till	4.45	399954.700	4972252.658	135.64	135.10	135.15	135.379	-	135.37	-	-	134.04
22-225	Bedrock	6.02	400181.841	4972200.818	134.94	134.11	134.22	134.501	-	134.13	-	133.89	-
22-225A	Glacial Till	1.37	400180.124	4972201.383	134.97	134.12	134.19	134.476	134.43	134.07	-	133.82	-
22-228	Bedrock	12.34	400147.766	4971938.274	138.48	134.33	134.36	134.616	134.96	134.60	-	133.62	-
22-228A	Bedrock	7.65	400148.520	4971938.095	138.45	134.41	134.46	134.778	135.18	134.78	-	133.86	-
22-231A	Bedrock	10.08	400145.497	4971885.441	133.34	-	-	-	-	133.30	-	132.80	-
22-231	Clay/Till	3.35	400145.520	4971883.461	133.35	-	-	-	-	133.27	-	132.81	-
22-232A	Bedrock	4.67	399484.520	4972067.769	133.74	-	-	-	-	133.63	-	-	132.79
22-232	Clay	1.60	399483.493	4972069.221	133.76	-	-	-	-	133.62	-	-	132.85
22-233B	Overburden	5.83	399496.526	4972600.749	134.94	-	-	-	-	-	133.89	-	-
22-234	Bedrock	6.86	400446.731	4972315.796	134.43	-	-	-	-	-	133.36	-	-
22-235	Bedrock	4.84	400425.387	4972146.663	134.25	-	-	-	-	-	133.27	-	-

Note: "-" denotes either frozen conditions, dry conditions, or that no data was collected.
Red font indicates ground elevations determined using lidar, whereas the remainder were measured using a high-precision Trimble GPS.

Table D3. Manual Groundwater Level Measurements (Overburden Wells Only, mbgs)

Well ID	Formation Screened	Well Depth (mbgs)	Easting[1]	Northing	Ground Elevation (m)	Measured Groundwater Levels (mbgs)							
						9-Feb-22	16-Feb-22	23-Feb-22	30-Mar-22	12-May-22	14-Oct-22	15-Oct-22	17-Oct-22
22-201	Glacial Till	6.10	399000.430	4972332.650	136.00	0.87	0.81	-	-	0.51	1.96	-	-
22-205	Glacial Till	6.15	399642.018	4972587.767	135.32	0.45	0.34	0.056	0.13	0.26	-	1.66	-
22-214B	Glacial Till	4.88	399635.079	4972418.011	137.80	1.69	1.70	1.473	0.67	1.11	-	3.05	-
22-221A	Glacial Till	1.42	399398.200	4972185.522	134.72	0.57	0.52	-	-	0.30	-	-	-
22-224	Glacial Till	4.45	399954.700	4972252.658	135.64	0.54	0.49	0.26	-	0.27	-	-	1.60
22-225A	Glacial Till	1.37	400180.124	4972201.383	134.97	0.85	0.78	0.494	0.54	0.90	-	1.15	-
22-231	Clay/Till	3.35	400145.520	4971883.461	133.35	-	-	-	-	0.08	-	0.54	-
22-232	Clay	1.60	399483.493	4972069.221	133.76	-	-	-	-	0.14	-	-	0.91
22-233B	Overburden	5.83	399496.526	4972600.749	134.94	-	-	-	-	-	1.05	-	-

Note: "-" denotes either frozen conditions, dry conditions, or that no data was collected.
Red font indicates ground elevations determined using lidar, whereas the remainder were measured using a high-precision Trimble GPS.



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-Refer to Figure 1 for well locations and Appendix C for borehole logs.

-Water level loggers (Van Essen TD-Diver DI801) were corrected for local barometric pressure (Van Essen TD-Diver DI800).

-Data gaps in 228A are associated with artifacts due to well overtopping

-Flat dashed line (- - -) for 221A indicates the sensor is out of water

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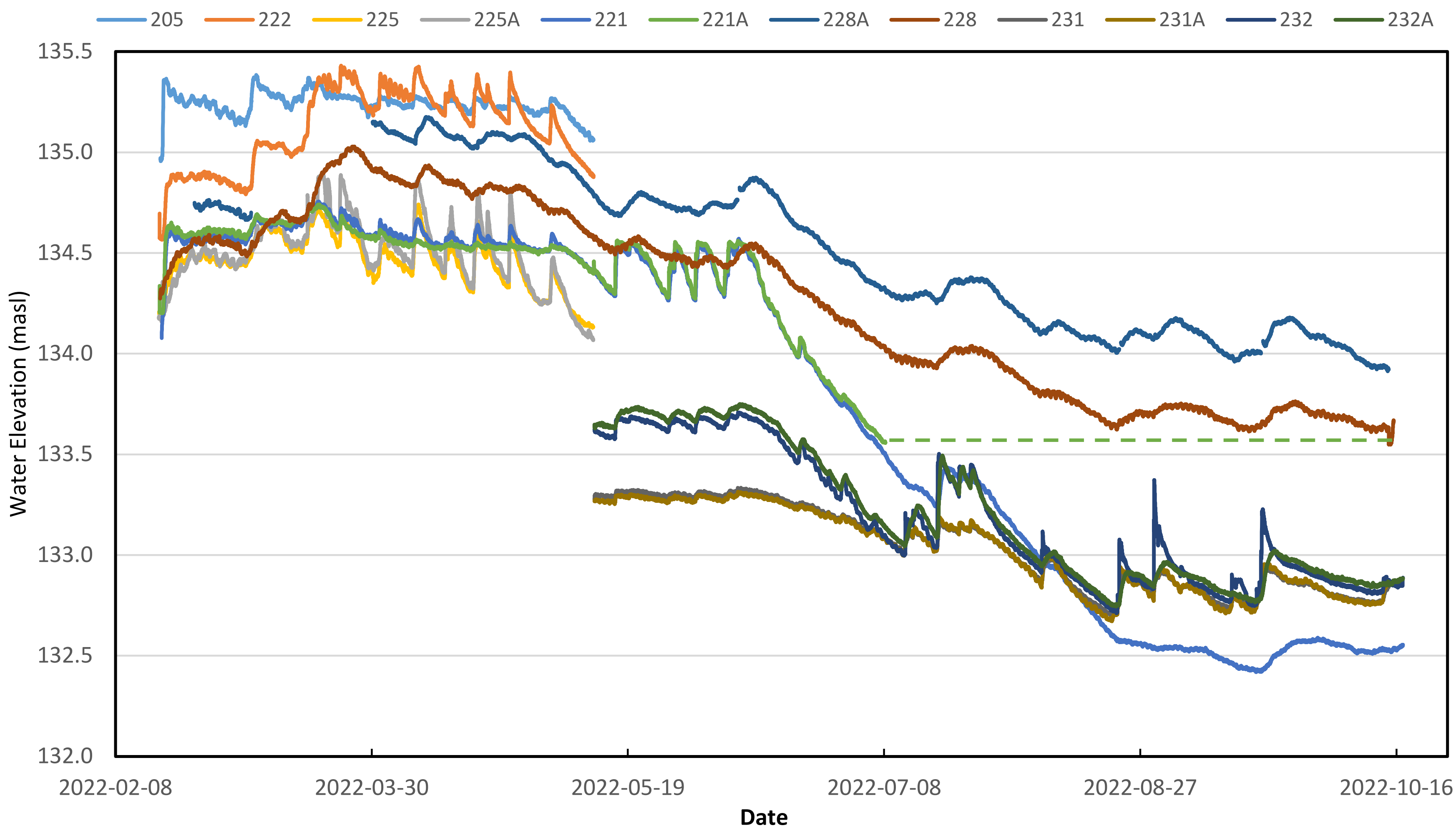
Project 100737.002

Long-term Water Level Monitoring:
All Well Data
(mbgs)

Figure D1



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-Refer to Figure 1 for well locations and Appendix C for borehole logs.

-Water level loggers (Van Essen TD-Diver DI801) were corrected for local barometric pressure (Van Essen TD-Diver DI800).

-Data gaps in 228A are associated with well overtopping

-Flat dashed line (- - -) for 221A indicates the sensor is out of water

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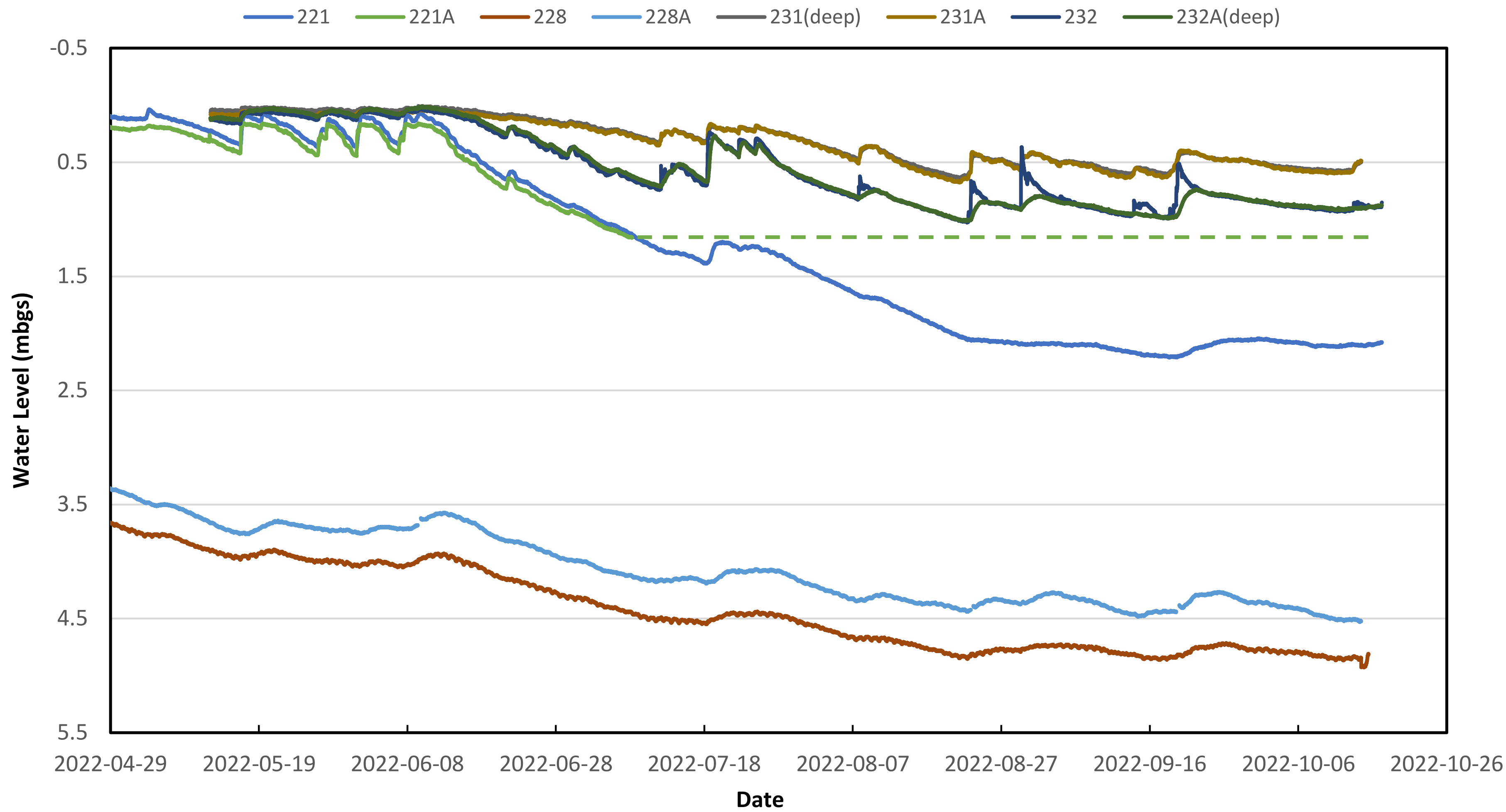
Project 100737.002

Long-term Water Level Monitoring:
All Well Data
(masl)

Figure D2



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-Refer to Figure 1 for well locations and Appendix C for borehole logs.

-Water level loggers (Van Essen TD-Diver DI801) were corrected for local barometric pressure (Van Essen TD-Diver DI800).

-Flat dashed line (- - -) for 221A indicates the sensor is out of water

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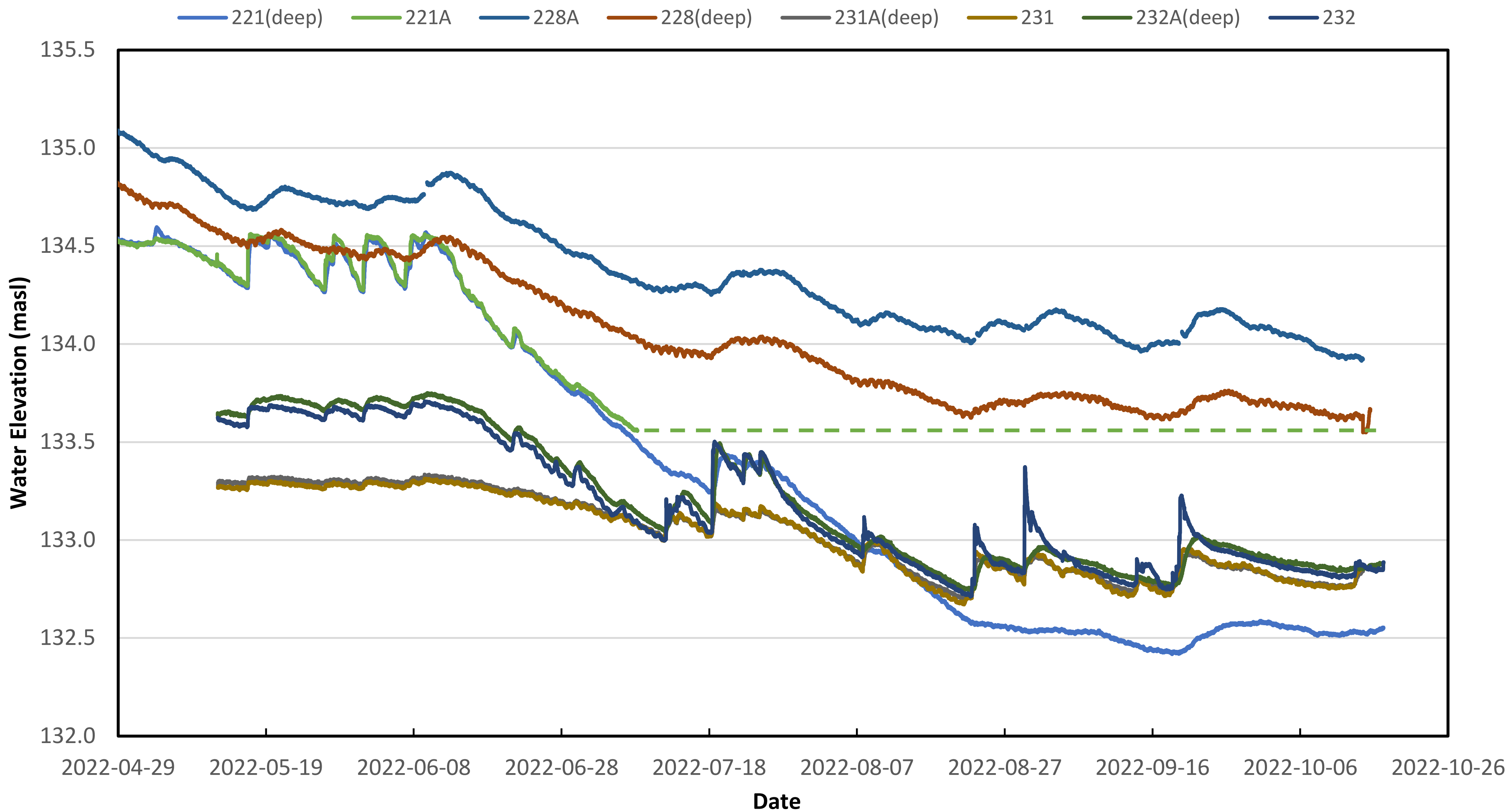
Long-term Water Level Monitoring: Wetland and Development Well Pairs (mbgs)

Figure D3



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-Refer to Figure 1 for well locations and Appendix C for borehole logs.

-Water level loggers (Van Essen TD-Diver DI801) were corrected for local barometric pressure (Van Essen TD-Diver DI800).

-Flat dashed line (- - -) for 221A indicates the sensor is out of water

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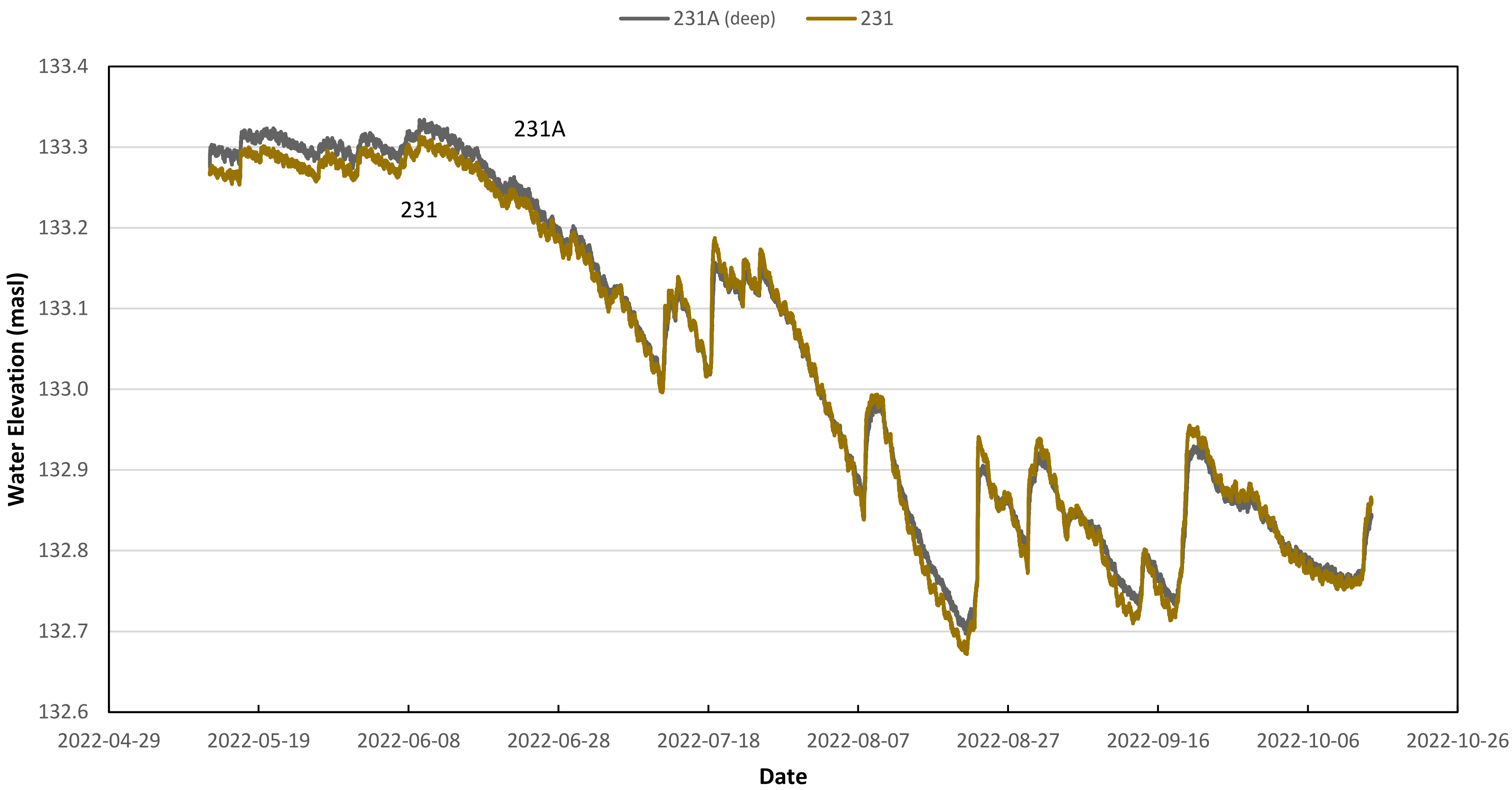
Long-term Water Level Monitoring: Wetland and Development Well Pairs (masl)

Figure D4



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-Refer to Figure 1 for well locations and Appendix C for borehole logs.

-Water level loggers (Van Essen TD-Diver DI801) were corrected for local barometric pressure (Van Essen TD-Diver DI800).

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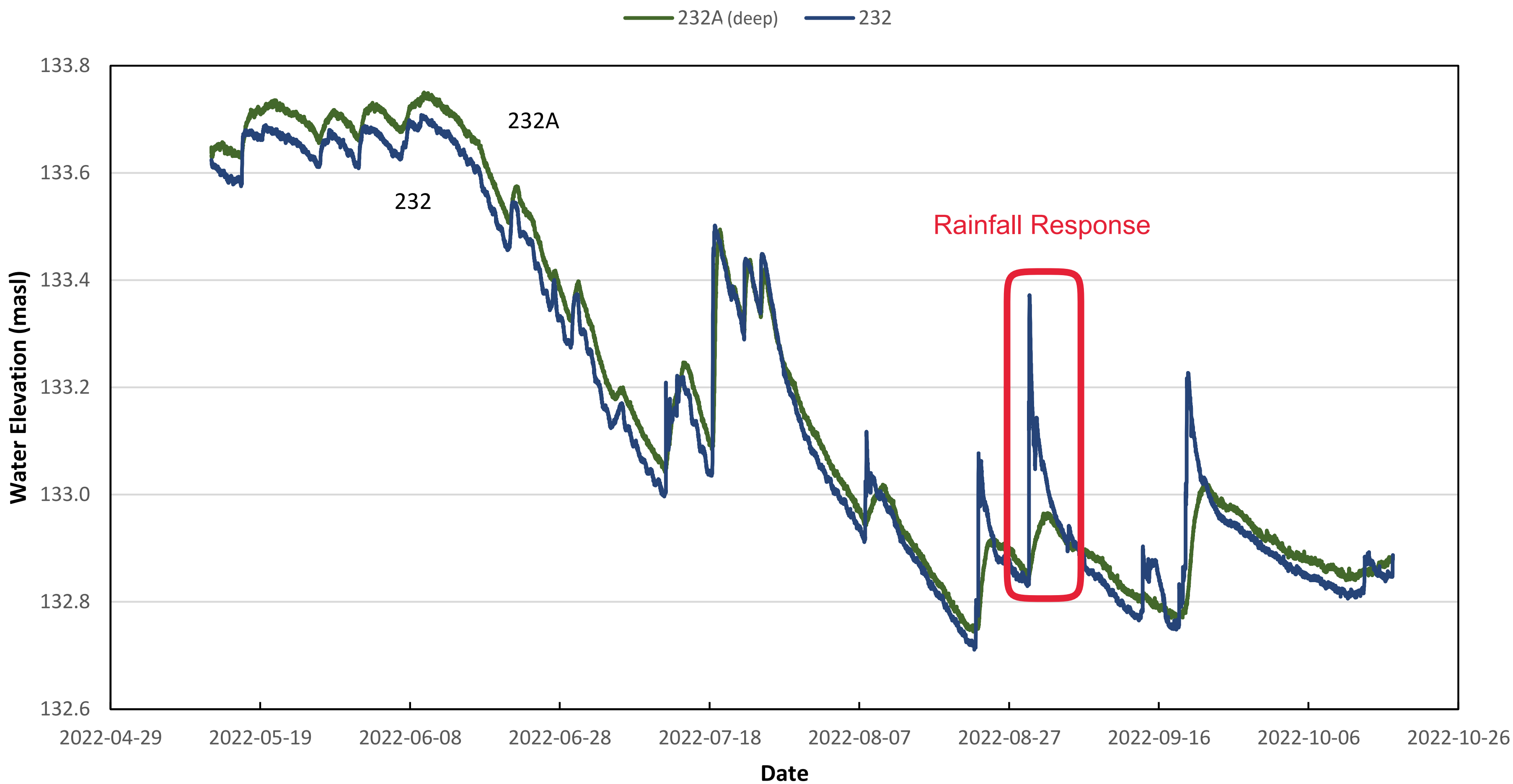
Long-term Water Level Monitoring: Nested Upgradient Wetland Wells (masl)

Figure D5



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-Refer to Figure 1 for well locations and Appendix C for borehole logs.

-Water level loggers (Van Essen TD-Diver DI801) were corrected for local barometric pressure (Van Essen TD-Diver DI800).

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Long-term Water Level Monitoring: Nested Downgradient Wetland Wells (masl)

Figure D6

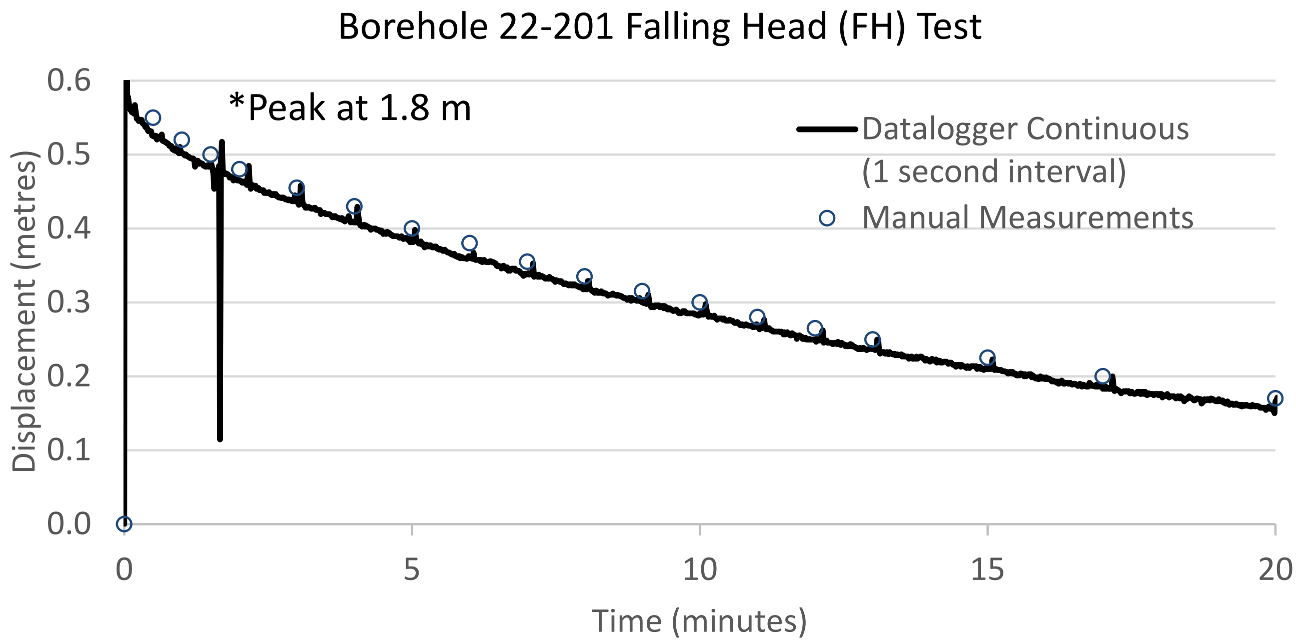
APPENDIX E

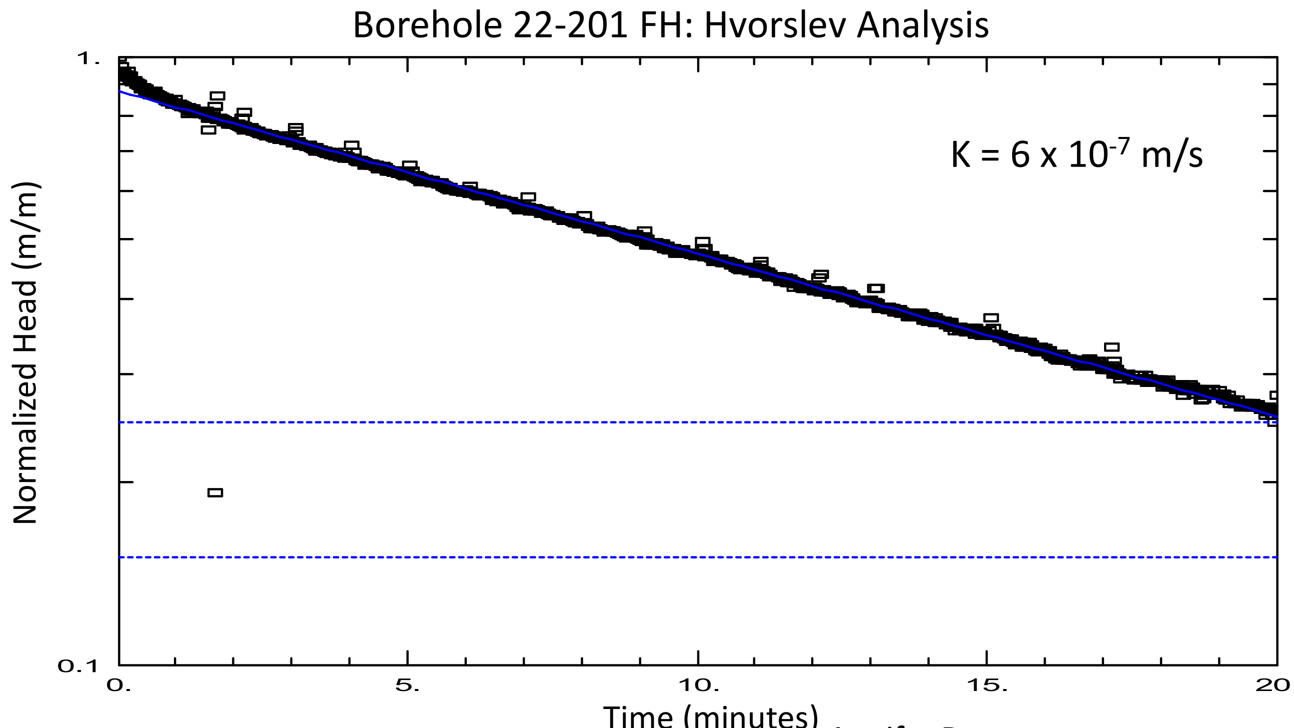
Hydraulic Conductivity Analyses

Report to: Caivan (Perth GC) Limited
Project: 100737.002 (February 22, 2023)

Slug Test Data

22-201 FH





<u>Well Data:</u>

Displacement observed (slug size): 1.81 metres (0.60 m)

Well Depth: 6.10 metres

Screen Length: 3.05 metres

Well Radius: 0.0255 metres

<u>Aquifer Data</u>

Saturated Thickness: 5.26 metres

Anisotropy Ratio (Kz/Kr): 0.1

Aquifer Model: Confined, Hvorslev

Static Water Level: 0.84 metres bgs

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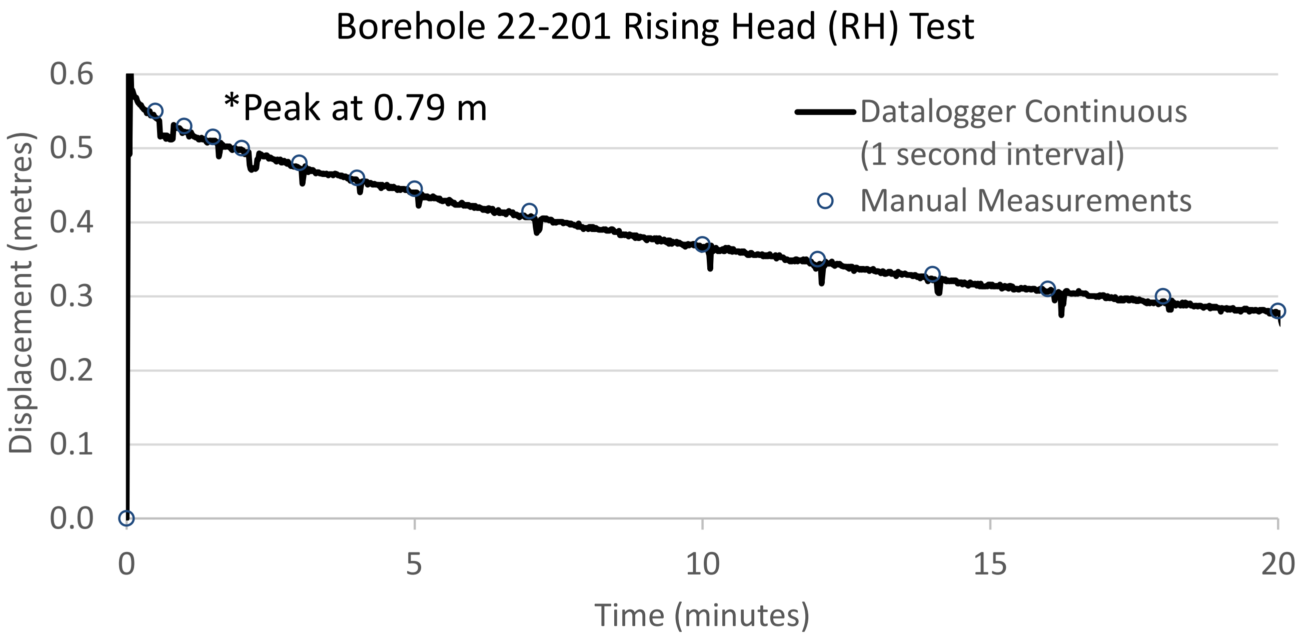
Consulting Engineers and Scientists

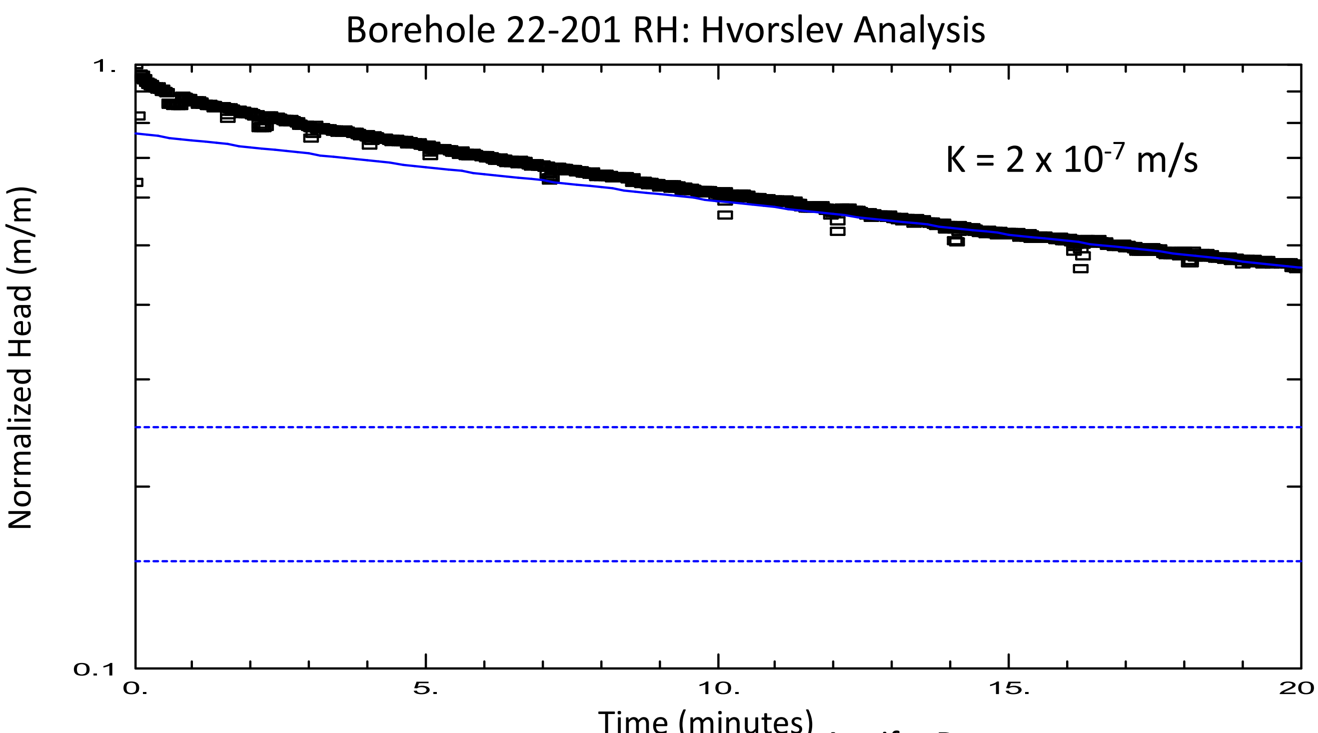
Date: February 2022

Project: 100737.002

Slug Test Data

22-201 RH





Well Data:
Displacement observed (slug size): 0.79 metres (0.60 m)
Well Depth: 6.10 metres
Screen Length: 3.05 metres
Well Radius: 0.0255 metres

Aquifer Data
Saturated Thickness: 5.26 metres
Anisotropy Ratio (Kz/Kr): 0.1
Aquifer Model: Confined, Hvorslev
Static Water Level: 0.84 metres bgs

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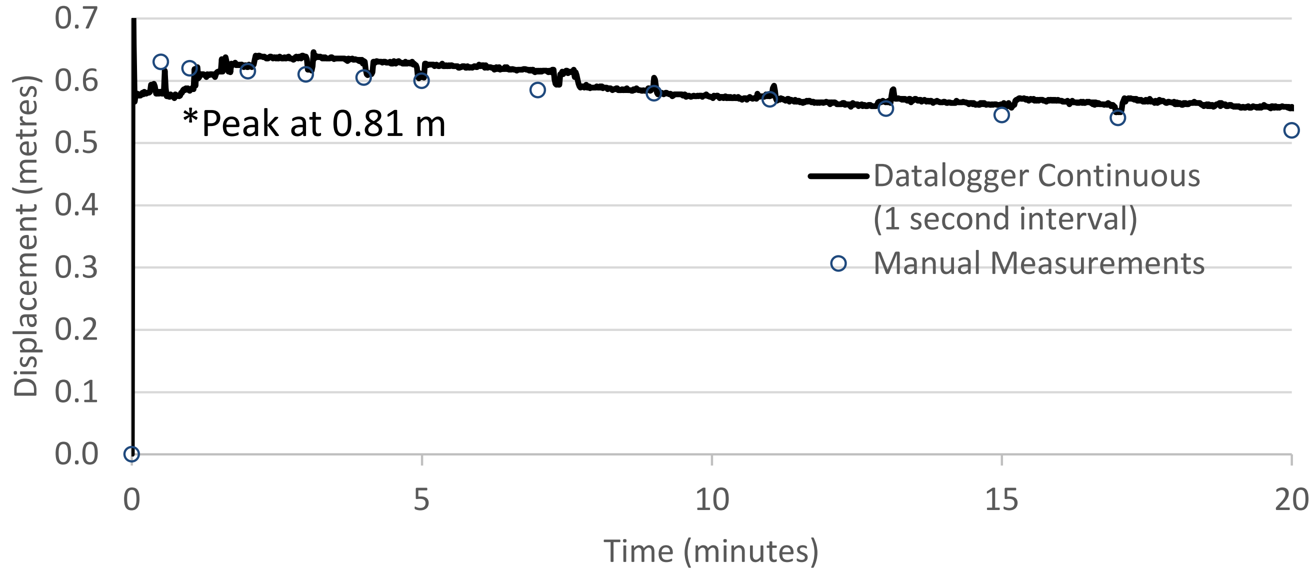
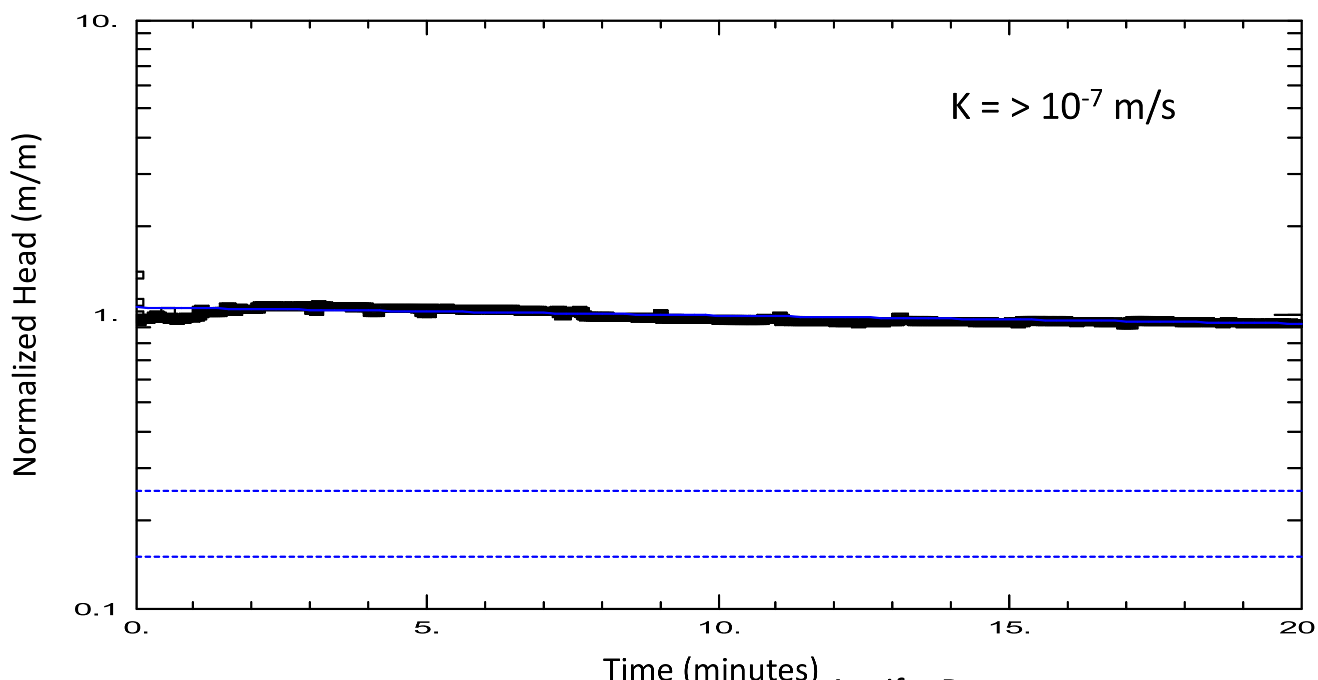
Slug Test Data

22-203A FH

Borehole 22-203A Falling Head (FH) Test



Borehole 22-203A FH: Hvorslev Analysis



<u>Well Data:</u>
Displacement observed (slug size): 0.81 metres (0.60 m)
Well Depth: 6.22 metres
Screen Length: 3.05 metres
Well Radius: 0.0255 metres

<u>Aquifer Data</u>
Saturated Thickness: 5.03 metres
Anisotropy Ratio (Kz/Kr): 0.1
Aquifer Model: Confined, Hvorslev
Static Water Level: 1.19 metres bgs

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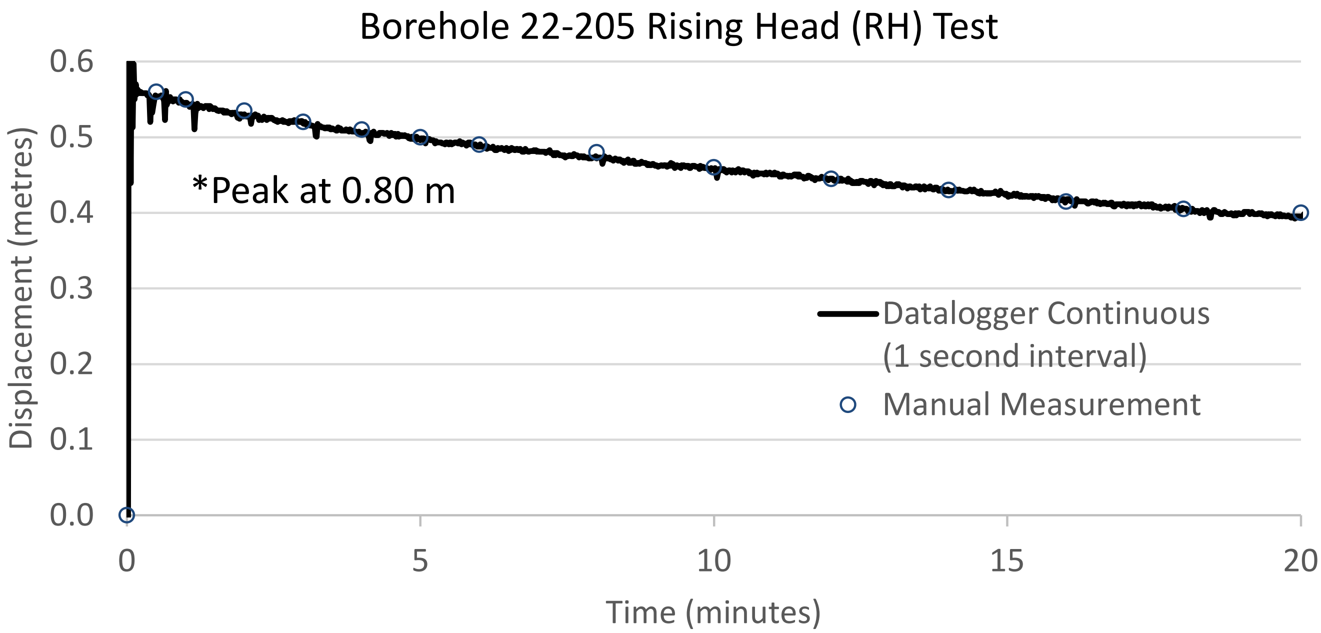
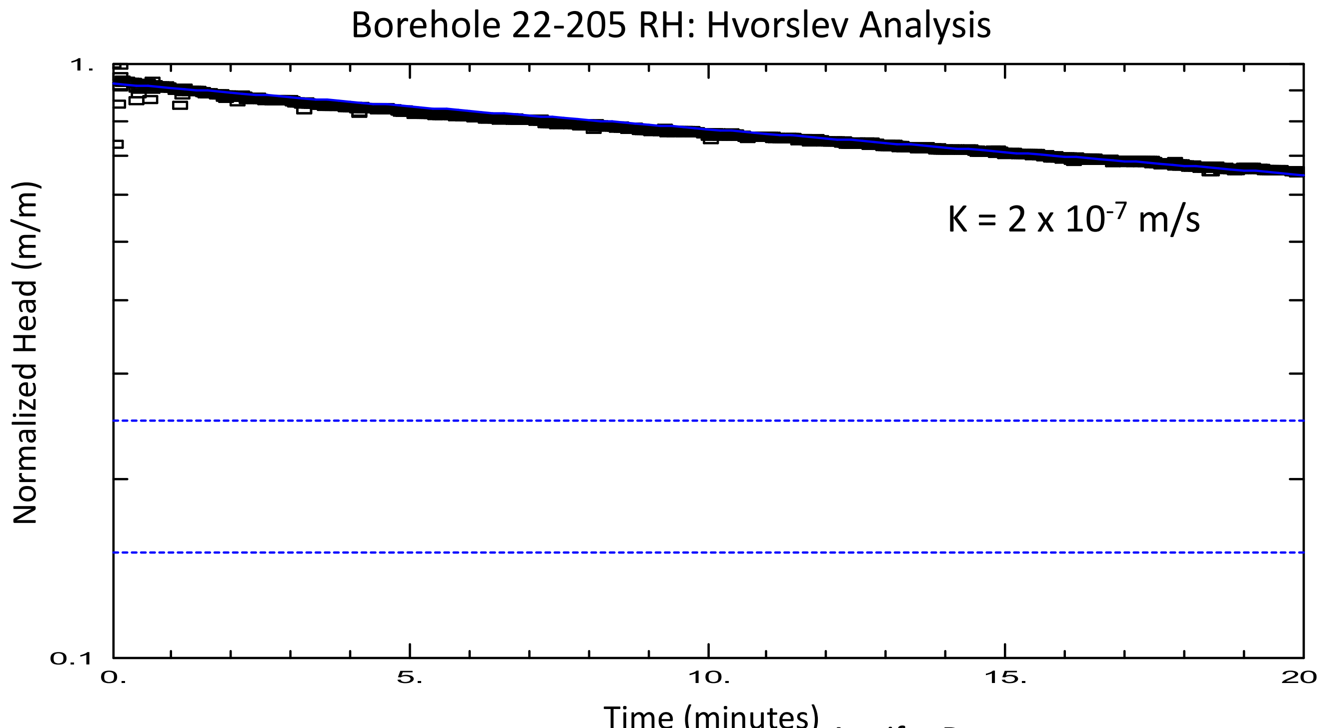
Project: 100737.002

Slug Test Data

22-205 RH





Well Data:

Displacement observed (slug size): 0.80 metres (0.60 m)

Well Depth: 6.15 metres

Screen Length: 3.05 metres

Well Radius: 0.0255 metres

Aquifer Data

Saturated Thickness: 5.85 metres

Anisotropy Ratio (Kz/Kr): 1.0

Aquifer Model: Unconfined, Hvorslev

Static Water Level: 0.30 metres bgs

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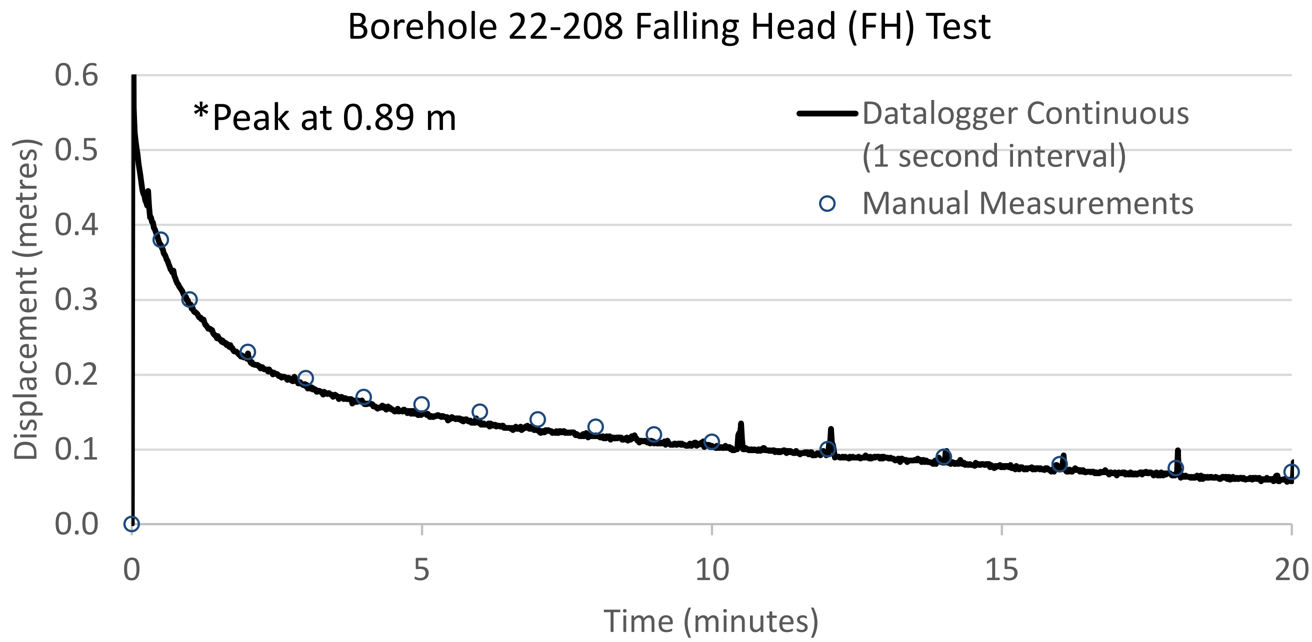
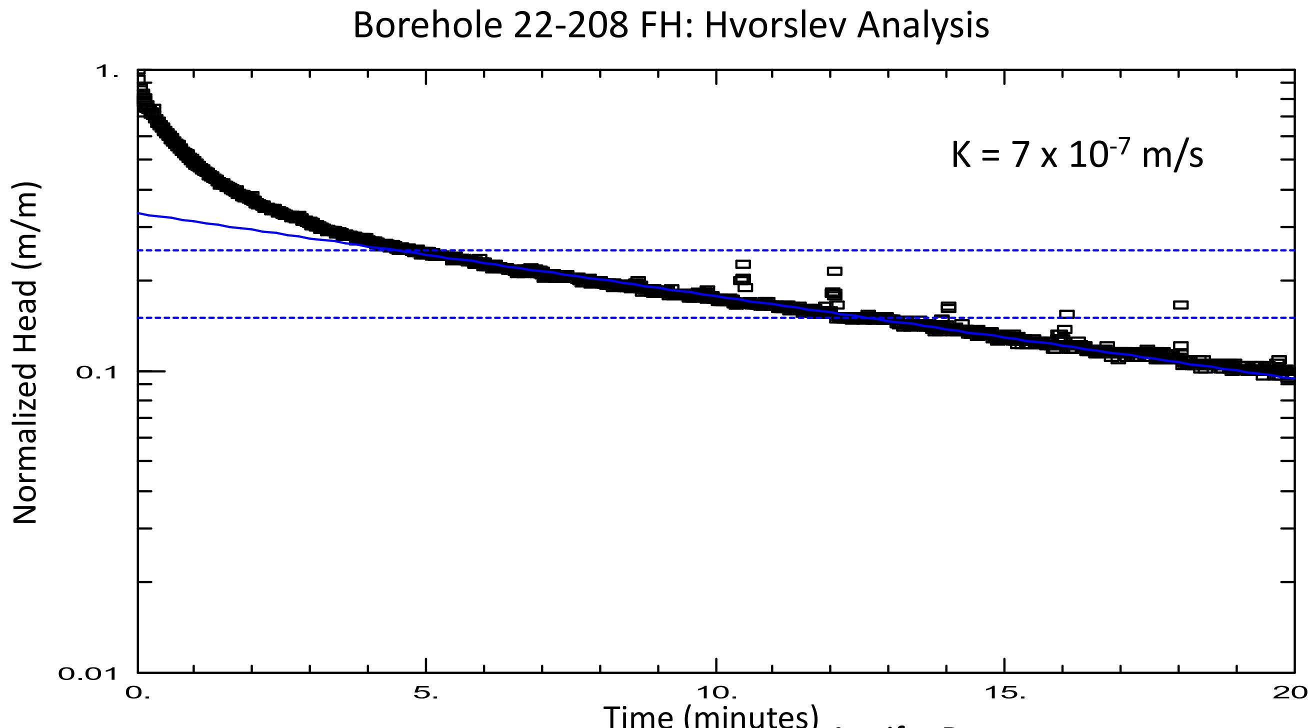
Slug Test Data

22-208 FH





Well Data:

Displacement observed (slug size): 0.80 metres (0.60 m)
Well Depth: 6.07 metres
Screen Length: 3.05 metres
Well Radius: 0.0255 metres

Aquifer Data

Saturated Thickness: 3.35 metres
Anisotropy Ratio (Kz/Kr): 0.1
Aquifer Model: Confined, Hvorslev
Static Water Level: 2.72 metres bgs

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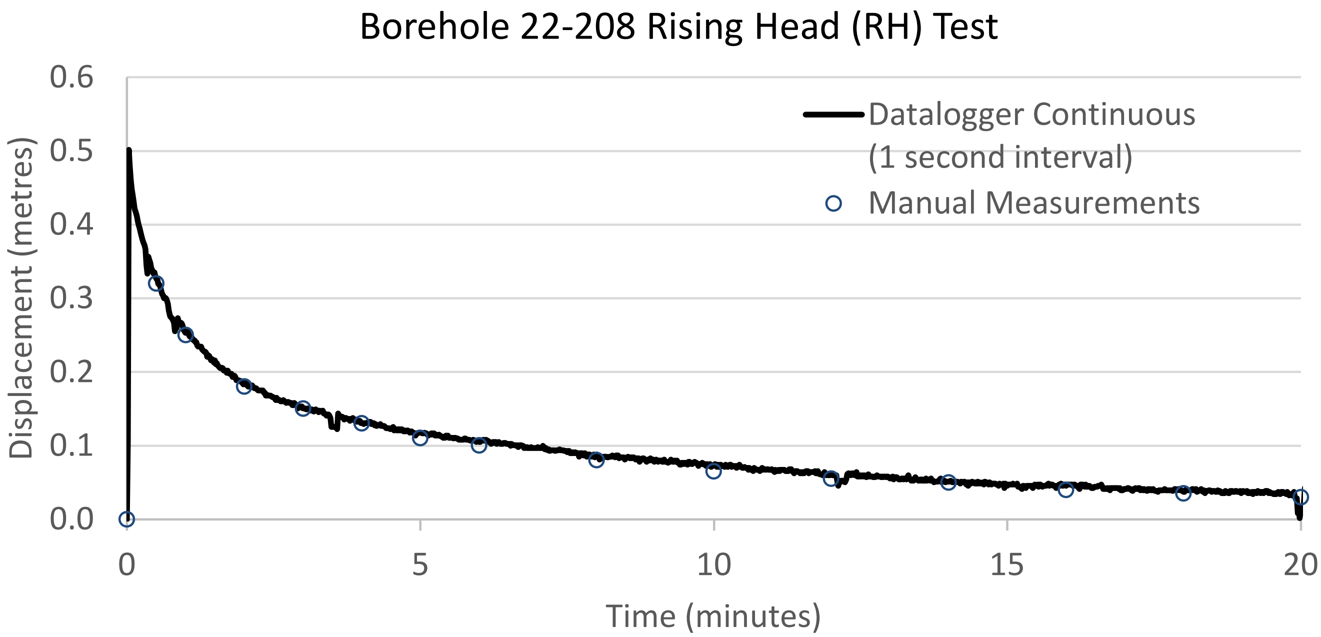
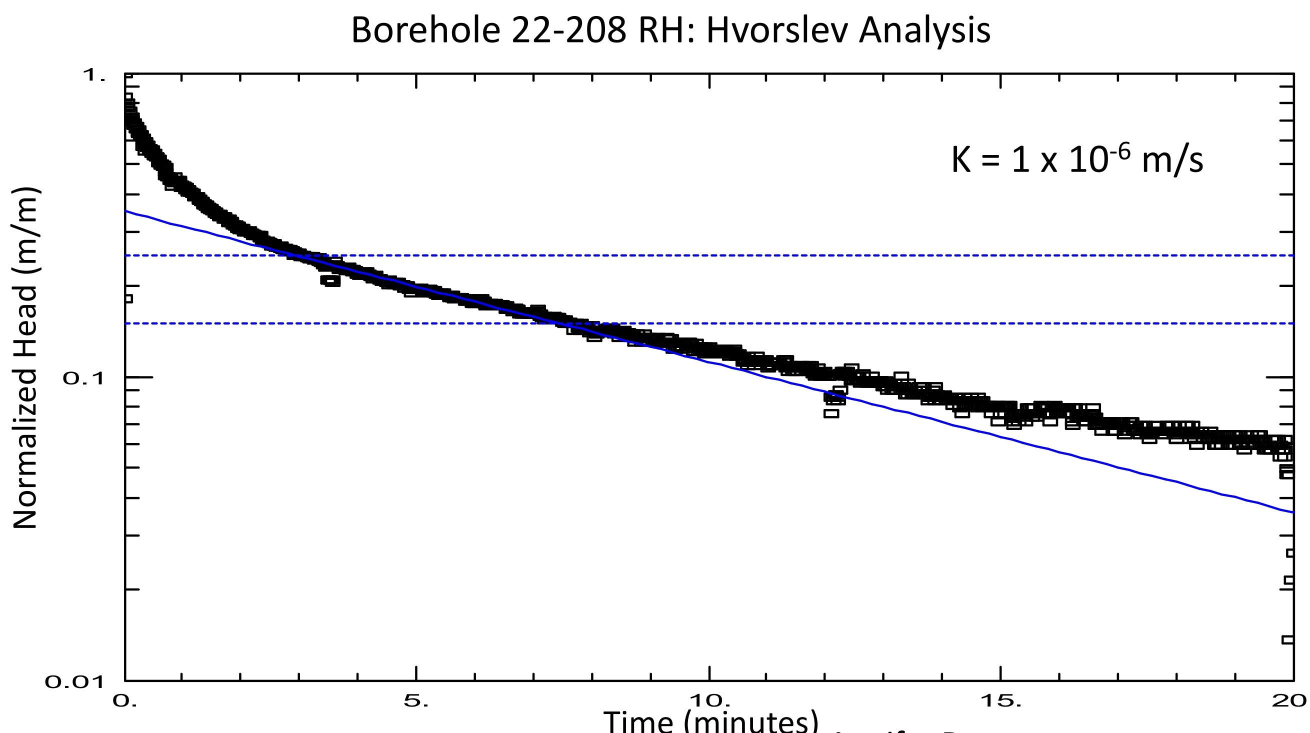
Date: February 2022

Project: 100737.002

Slug Test Data

22-208 RH





Well Data:
Displacement observed (slug size): 0.50 metres (0.60 m)
Well Depth: 6.07 metres
Screen Length: 3.05 metres
Well Radius: 0.0255 metres

Aquifer Data
Saturated Thickness: 3.35 metres
Anisotropy Ratio (Kz/Kr): 0.1
Aquifer Model: Confined, Hvorslev
Static Water Level: 2.72 metres bgs

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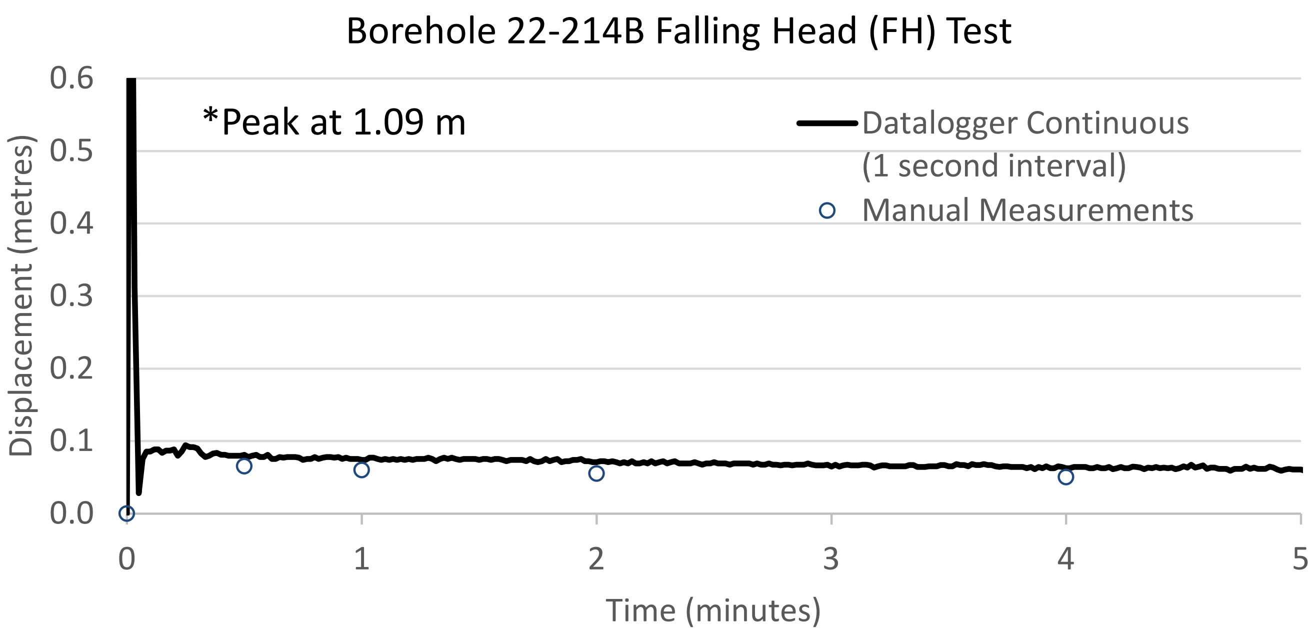
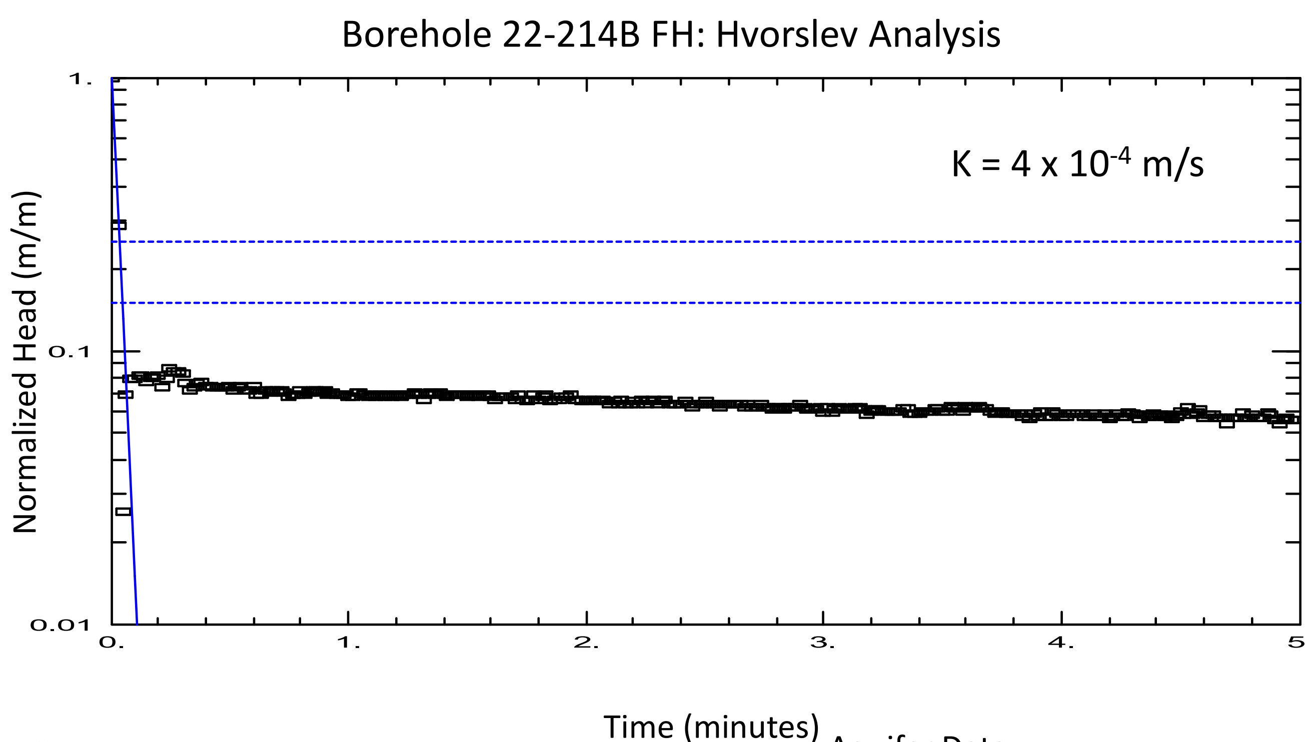
Date: February 2022
Project: 100737.002

Slug Test Data

22-214B FH





<u>Well Data:</u>

Displacement observed (slug size): 1.09 metres (0.60 m)

Well Depth: 4.88 metres

Screen Length: 3.05 metres

Well Radius: 0.0255 metres

<u>Aquifer Data</u>

Saturated Thickness: 3.20 metres

Anisotropy Ratio (Kz/Kr): 1.0

Aquifer Model: Unconfined, Hvorslev

Static Water Level: 1.68 metres bgs

GEMTEC

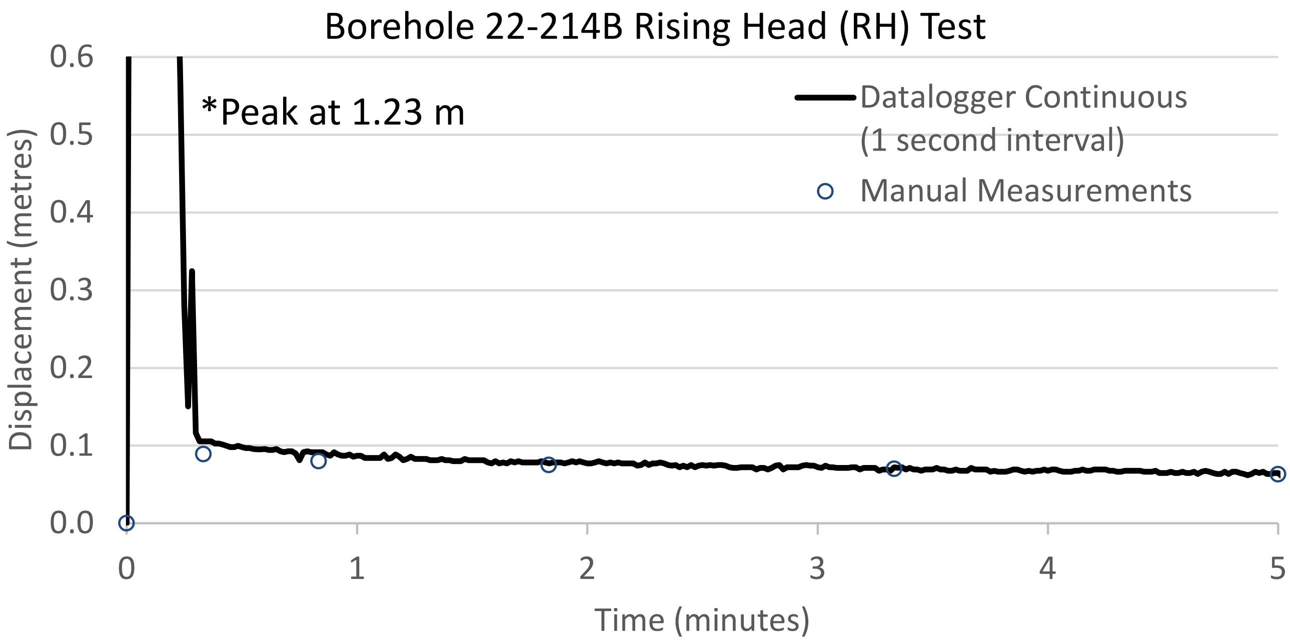
CONSULTING ENGINEERS AND SCIENTISTS

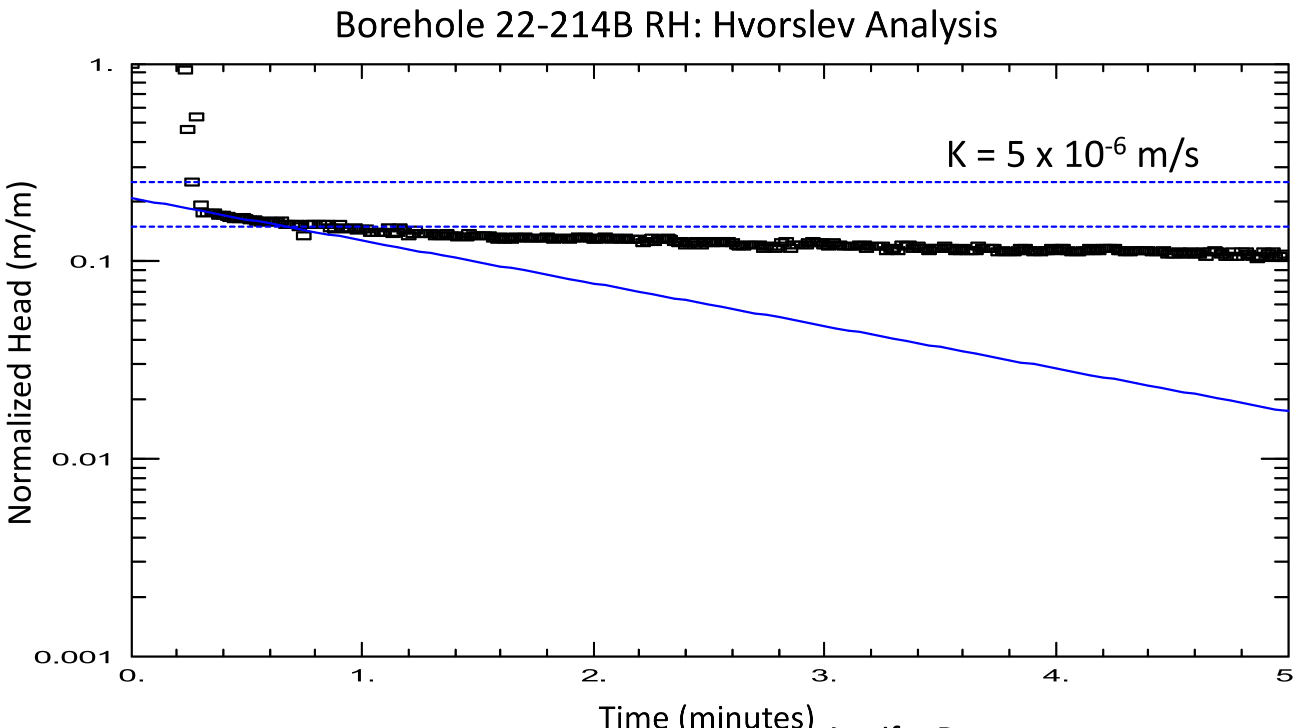
Date: February 2022

Project: 100737.002

Slug Test Data

22-214B RH





Well Data:
Displacement observed (slug size): 1.22 metres (0.60 m)
Well Depth: 4.88 metres
Screen Length: 3.05 metres
Well Radius: 0.0255 metres

Aquifer Data
Saturated Thickness: 3.20 metres
Anisotropy Ratio (Kz/Kr): 1.0
Aquifer Model: Unconfined, Hvorslev
Static Water Level: 1.68 metres bgs

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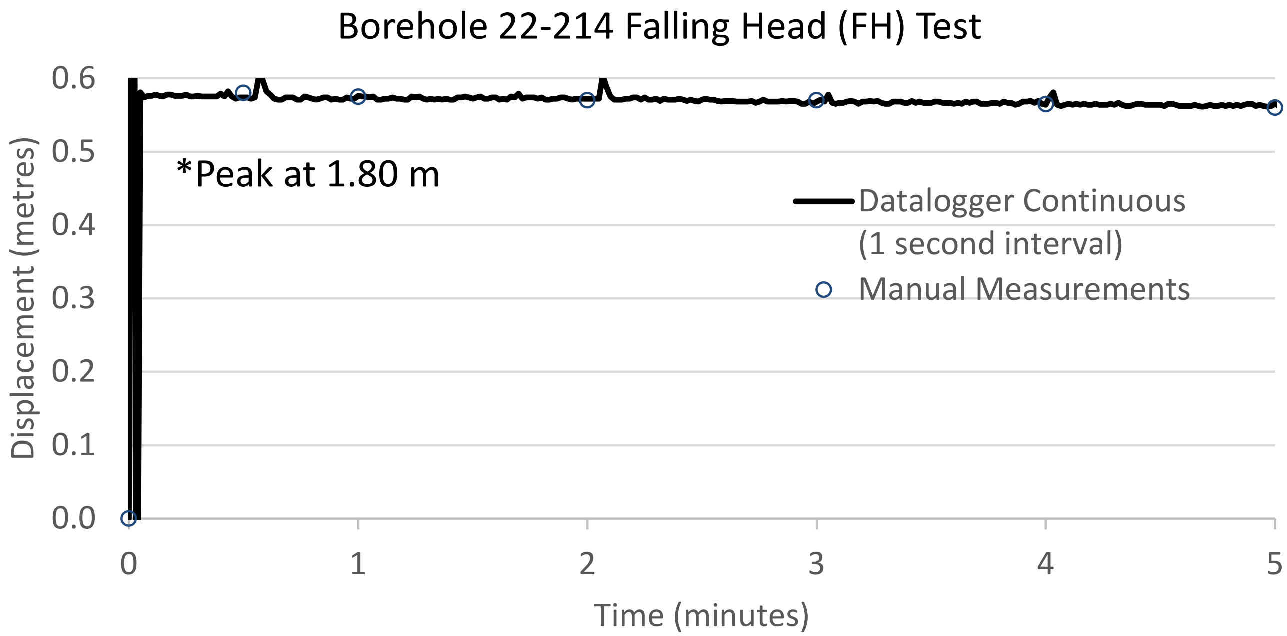
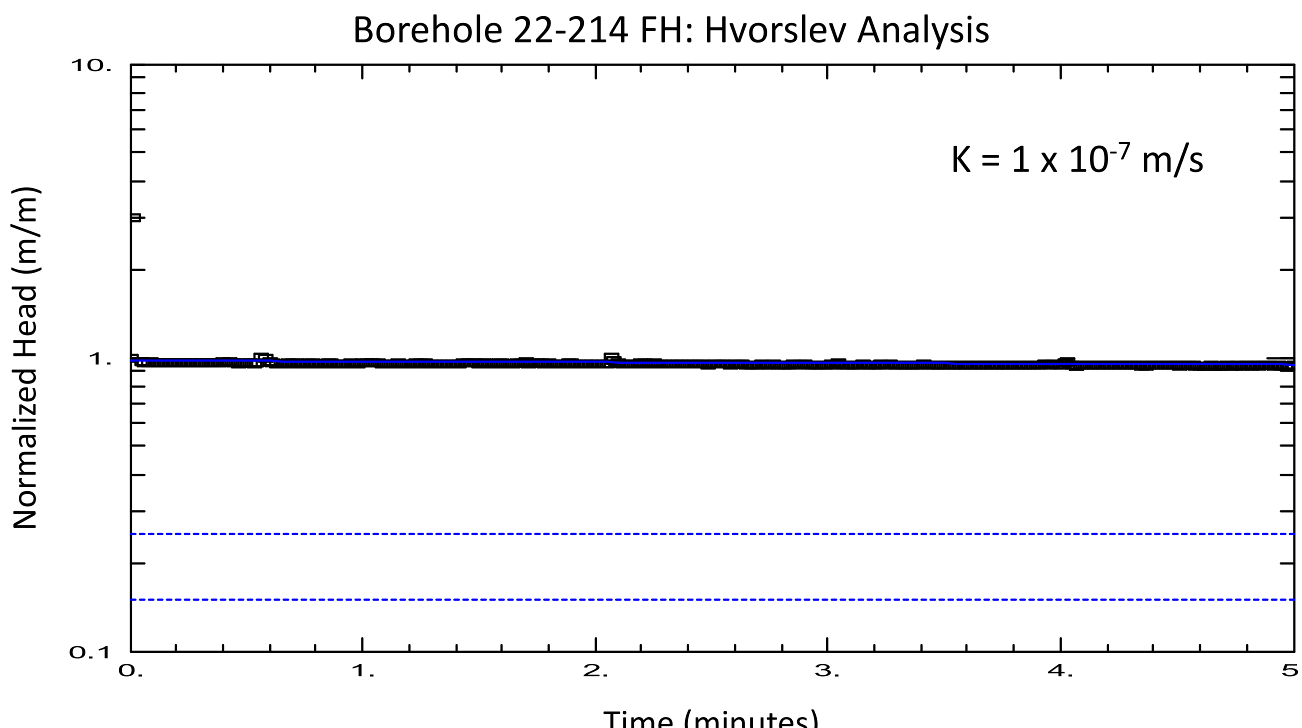
Date: February 2022

Project: 100737.002

Slug Test Data

22-214 FH





<u>Well Data:</u>

Displacement observed (slug size): 1.80 metres (0.60 m)

Well Depth: 6.83 metres

Screen Length: 1.52 metres

Well Radius: 0.0255 metres

<u>Aquifer Data</u>

Saturated Thickness: 4.90 metres

Anisotropy Ratio (Kz/Kr): 1.0

Aquifer Model: Unconfined, Hvorslev

Static Water Level: 1.93 metres bgs

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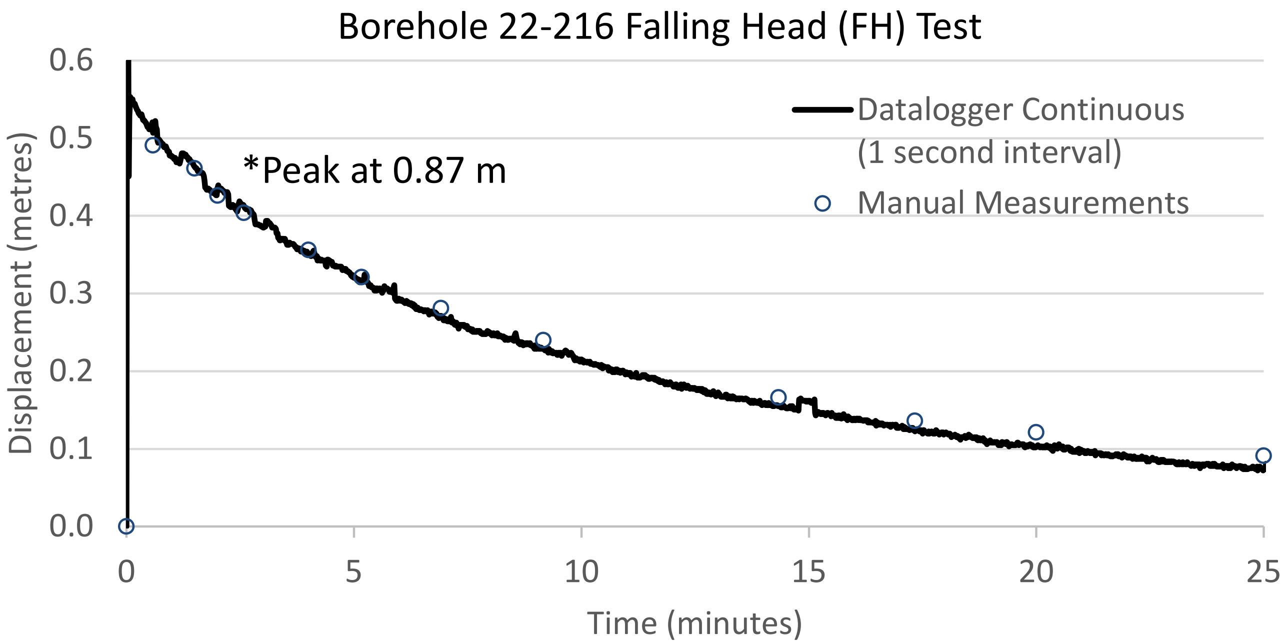
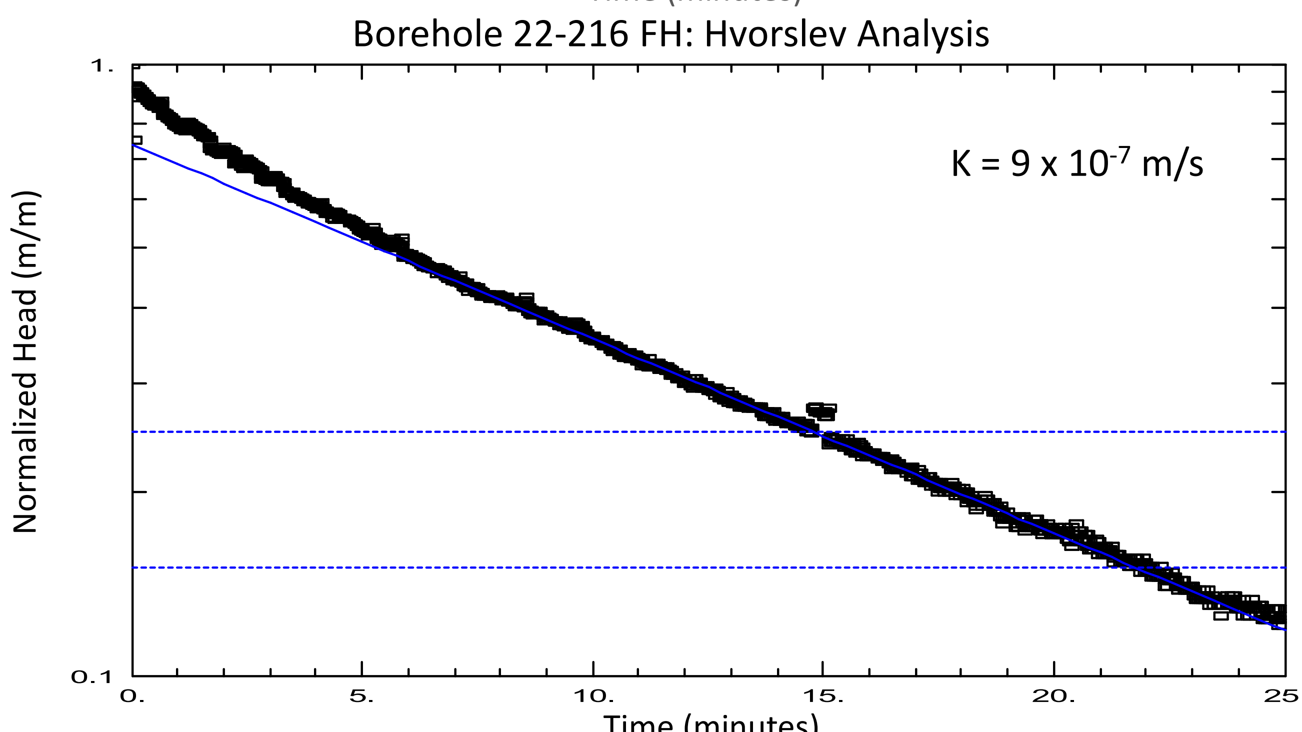
Date: February 2022

Project: 100737.002

Slug Test Data

22-216 FH





Well Data:

Displacement observed (slug size): 0.87 metres (0.60 m)
Well Depth: 5.79 metres
Screen Length: 3.05 metres
Well Radius: 0.0255 metres

Aquifer Data

Saturated Thickness: 5.10 metres
Anisotropy Ratio (Kz/Kr): 0.1
Aquifer Model: Confined, Hvorslev
Static Water Level: 0.69 metres bgs

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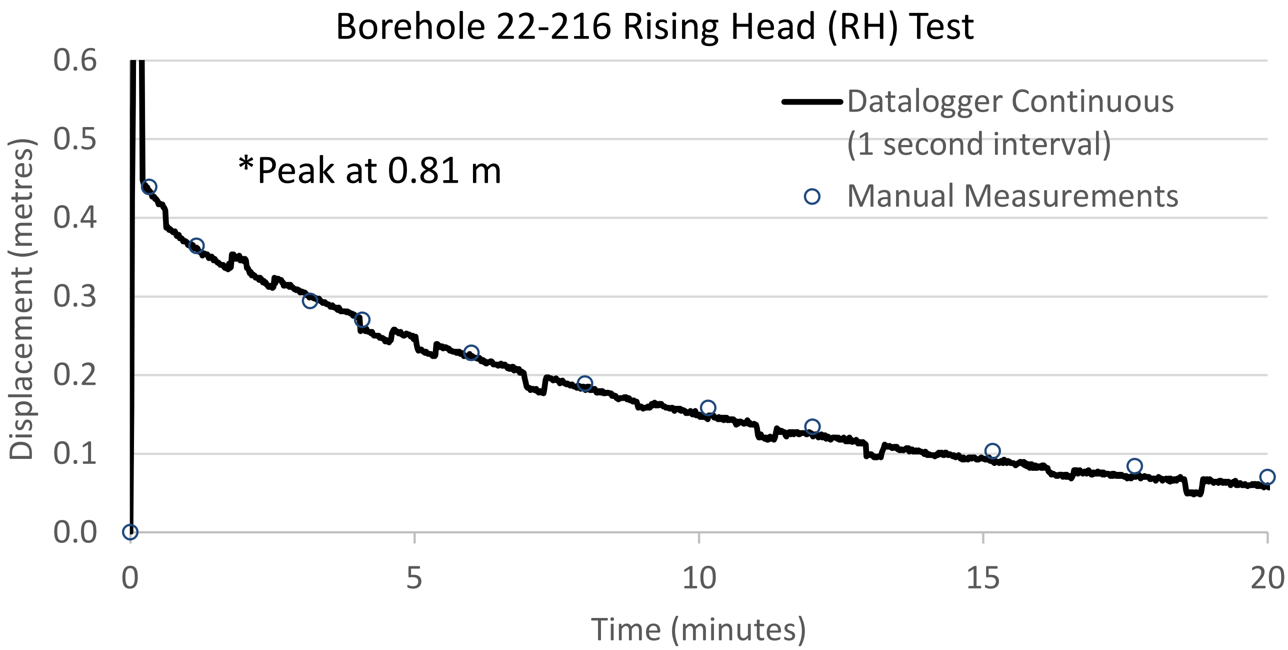
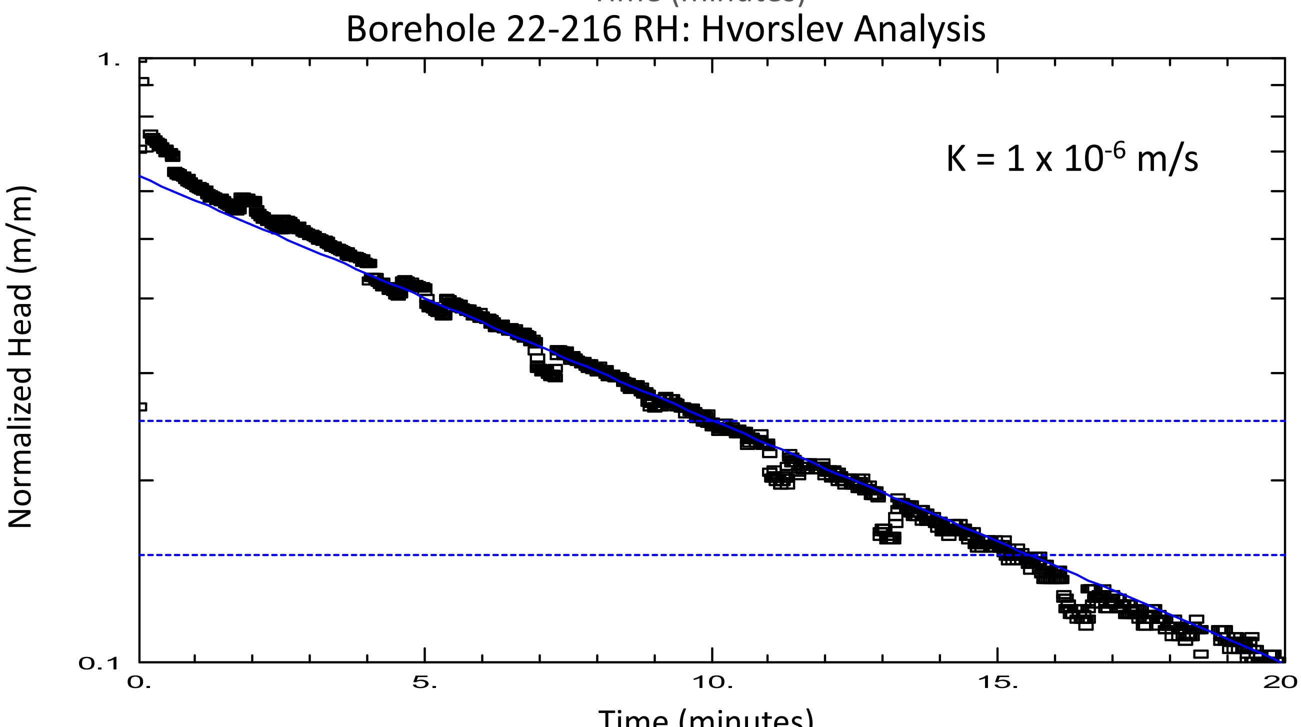
Date: February 2022
Project: 100737.002

Slug Test Data

22-216 RH





<u>Well Data:</u>
Displacement observed (slug size): 0.81 metres (0.60 m)
Well Depth: 5.79 metres
Screen Length: 3.05 metres
Well Radius: 0.0255 metres

<u>Aquifer Data</u>
Saturated Thickness: 5.10 metres
Anisotropy Ratio (Kz/Kr): 0.1
Aquifer Model: Confined, Hvorslev
Static Water Level: 0.69 metres bgs

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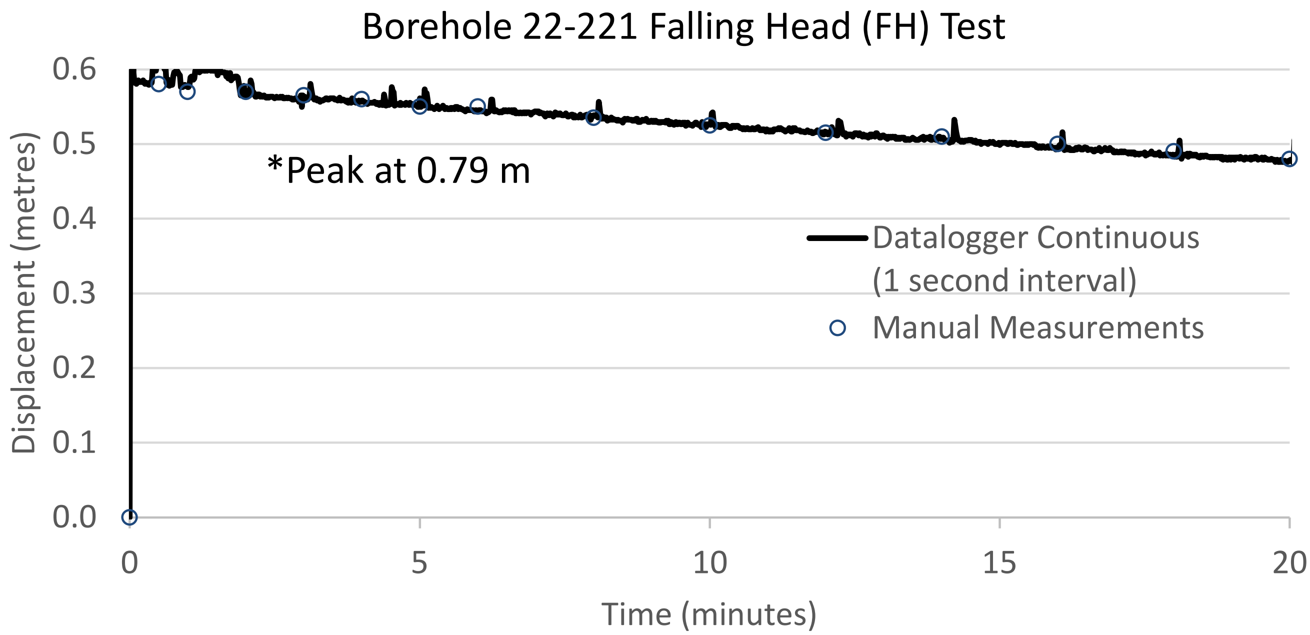
CONSULTING ENGINEERS AND SCIENTISTS

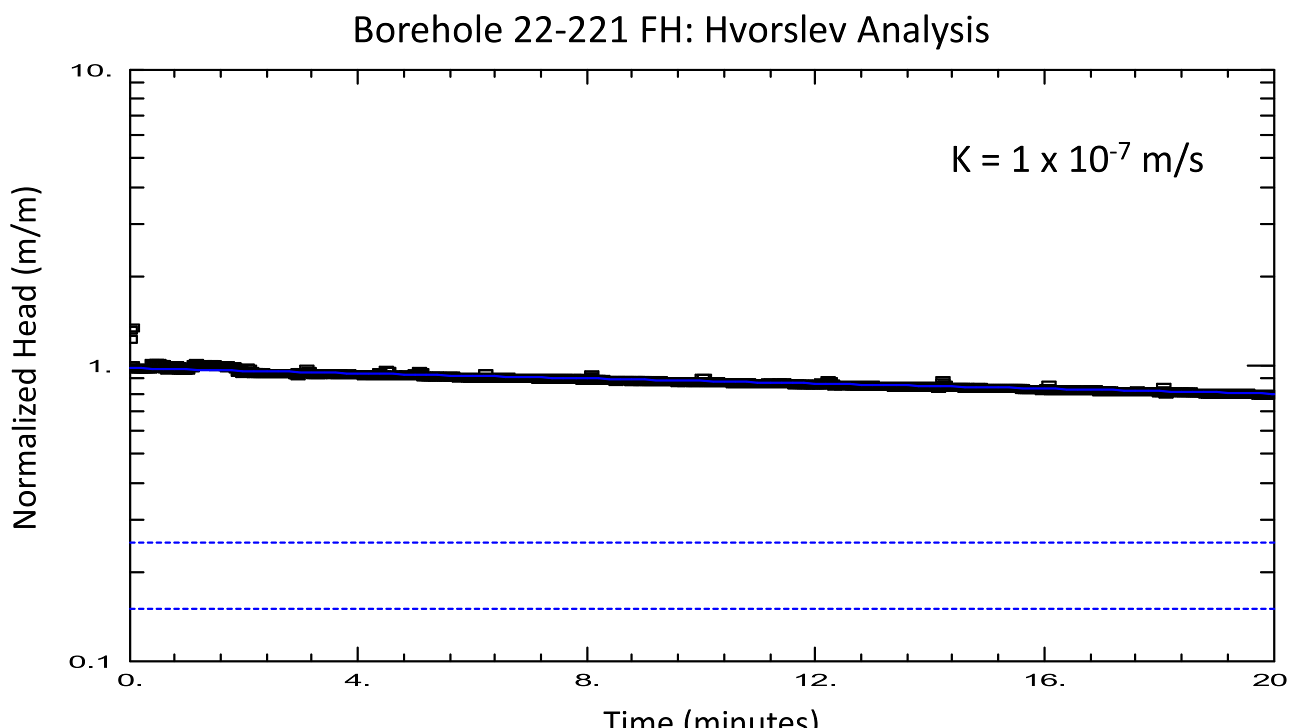
Date: February 2022

Project: 100737.002

Slug Test Data

22-221 FH





Well Data:

Displacement observed (slug size): 0.79 metres (0.60 m)

Well Depth: 6.30 metres

Screen Length: 3.05 metres

Well Radius: 0.0255 metres

Aquifer Data

Saturated Thickness: 5.87 metres

Anisotropy Ratio (Kz/Kr): 0.1

Aquifer Model: Confined, Hvorslev

Static Water Level: 0.433 metres bgs

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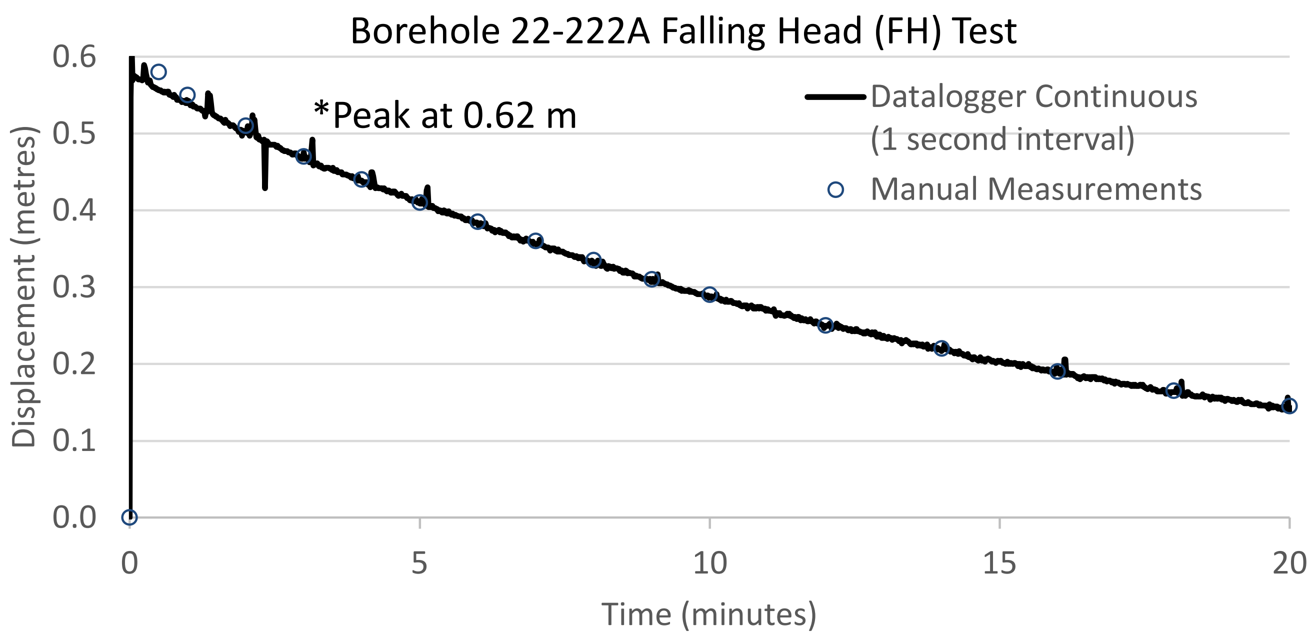
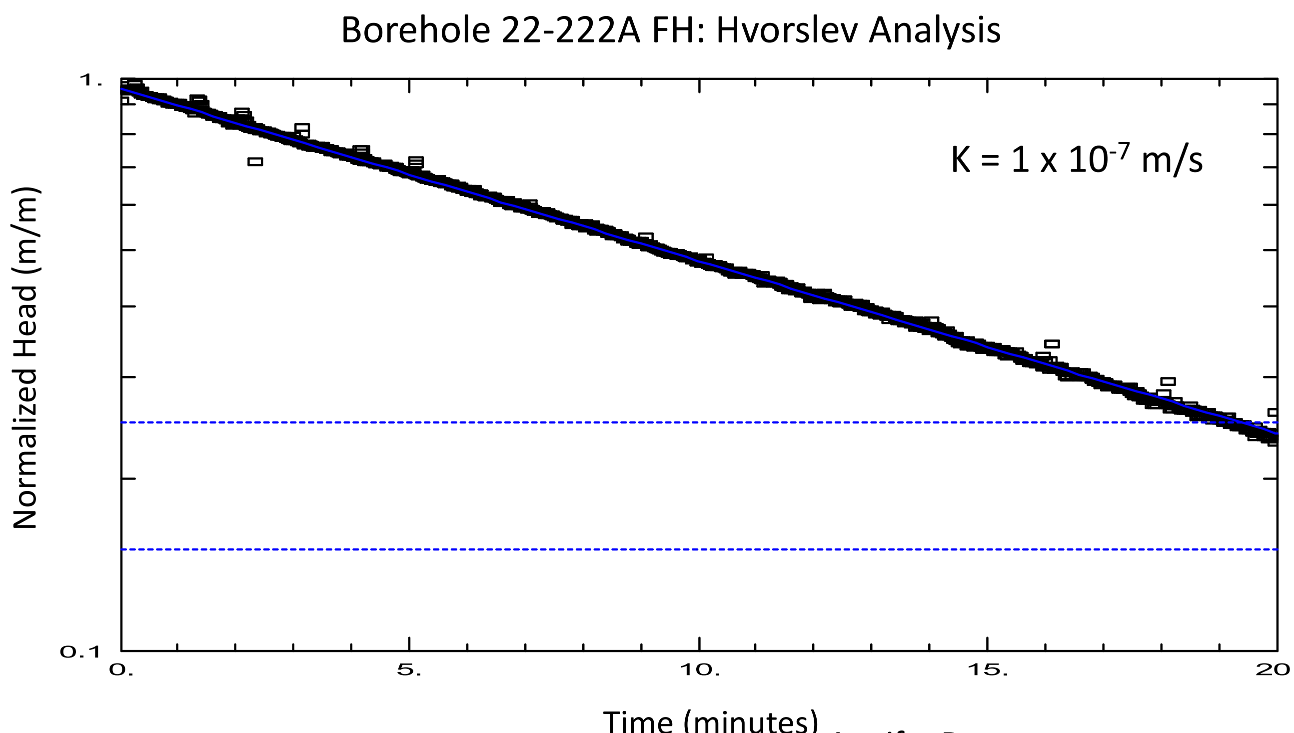
Date: February 2022

Project: 100737.002

Slug Test Data

22-222A FH





<u>Well Data:</u>
Displacement observed (slug size): 0.62 metres (0.60 m)
Well Depth: 3.73 metres
Screen Length: 1.52 metres
Well Radius: 0.0255 metres

<u>Aquifer Data</u>
Saturated Thickness: 2.51 metres
Anisotropy Ratio (Kz/Kr): 1.0
Aquifer Model: Unconfined, Hvorslev
Static Water Level: 1.22 metres bgs

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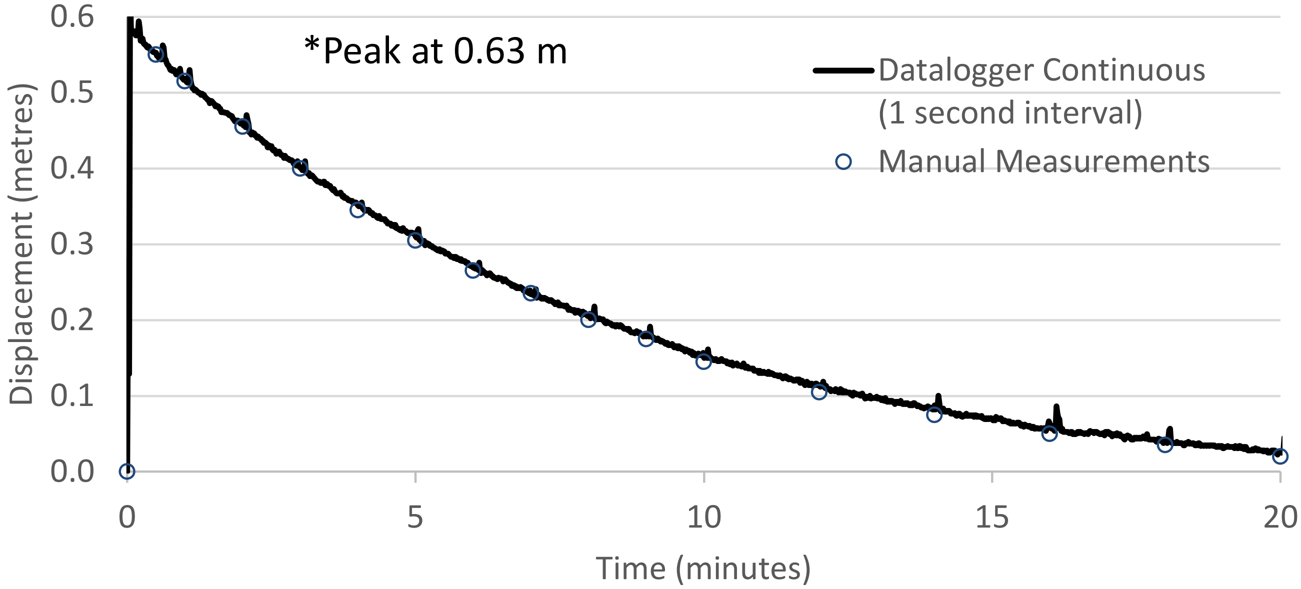
Date: February 2022

Project: 100737.002

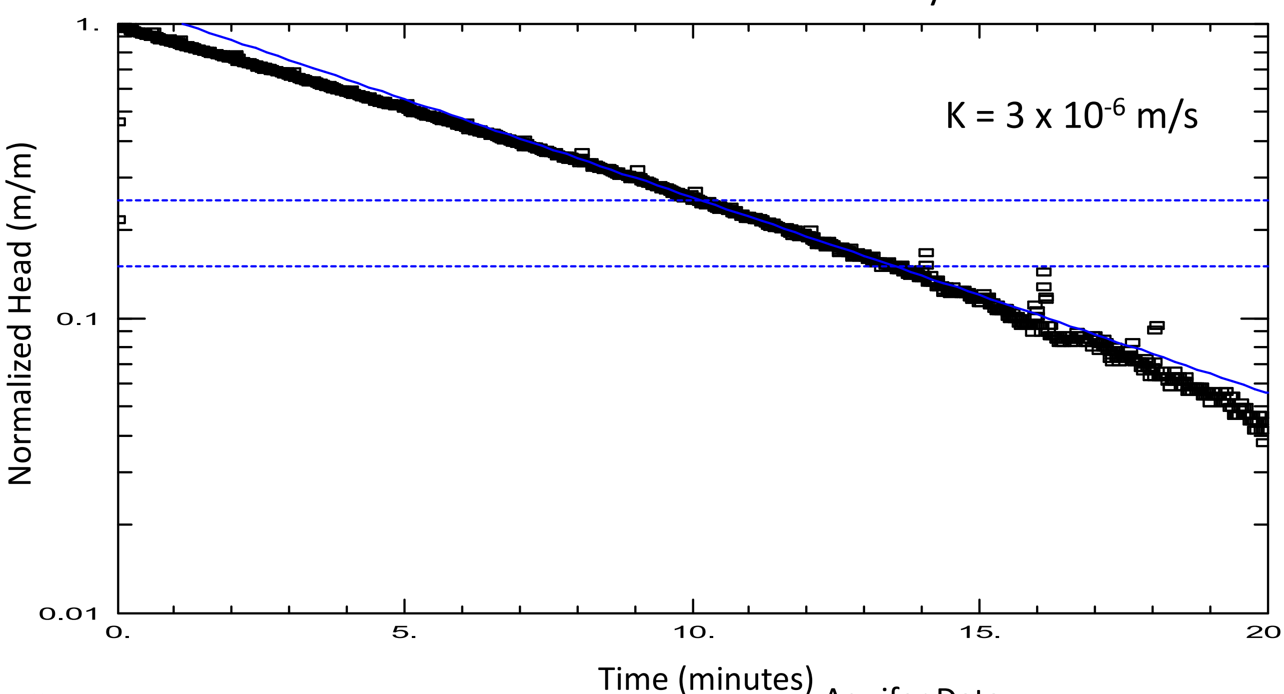
Slug Test Data

22-222 FH

Borehole 22-222 Falling Head (FH) Test



Borehole 22-222 FH: Hvorslev Analysis



Well Data:

Displacement observed (slug size): 0.63 metres (0.60 m)

Well Depth: 6.10 metres

Screen Length: 3.05 metres

Well Radius: 0.0255 metres

Aquifer Data

Saturated Thickness: 5.02 metres

Anisotropy Ratio (Kz/Kr): 0.1

Aquifer Model: Confined, Hvorslev

Static Water Level: 1.08 metres bgs

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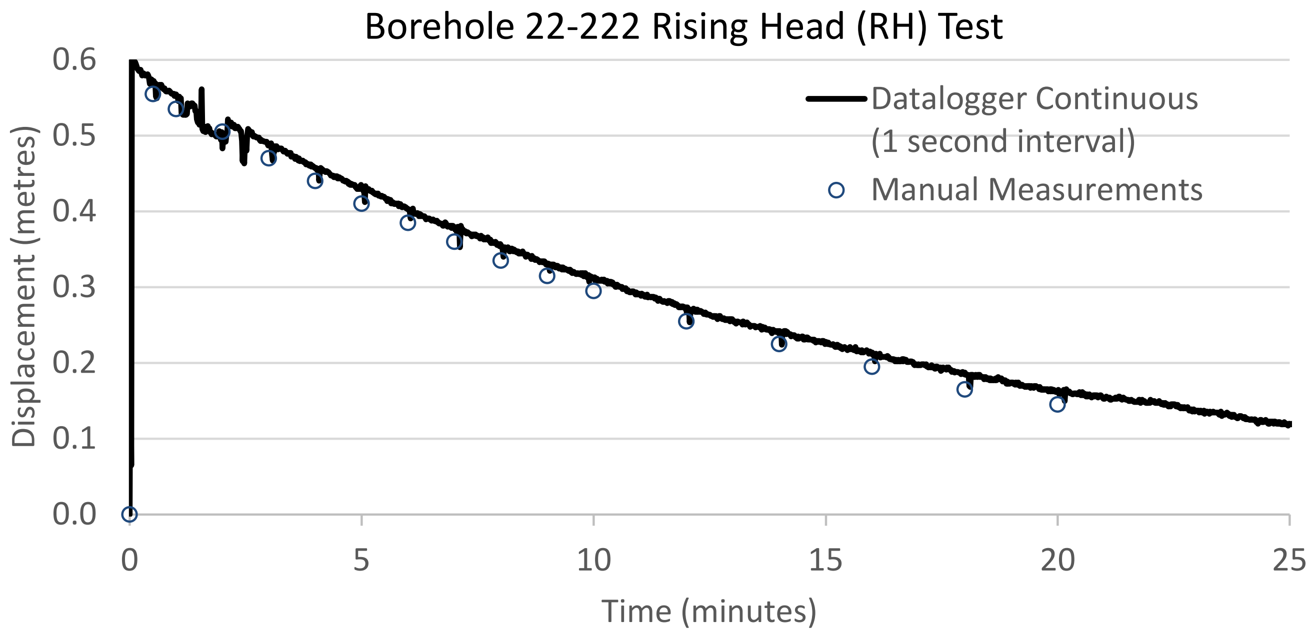
CONSULTING ENGINEERS AND SCIENTISTS

Date: February 2022

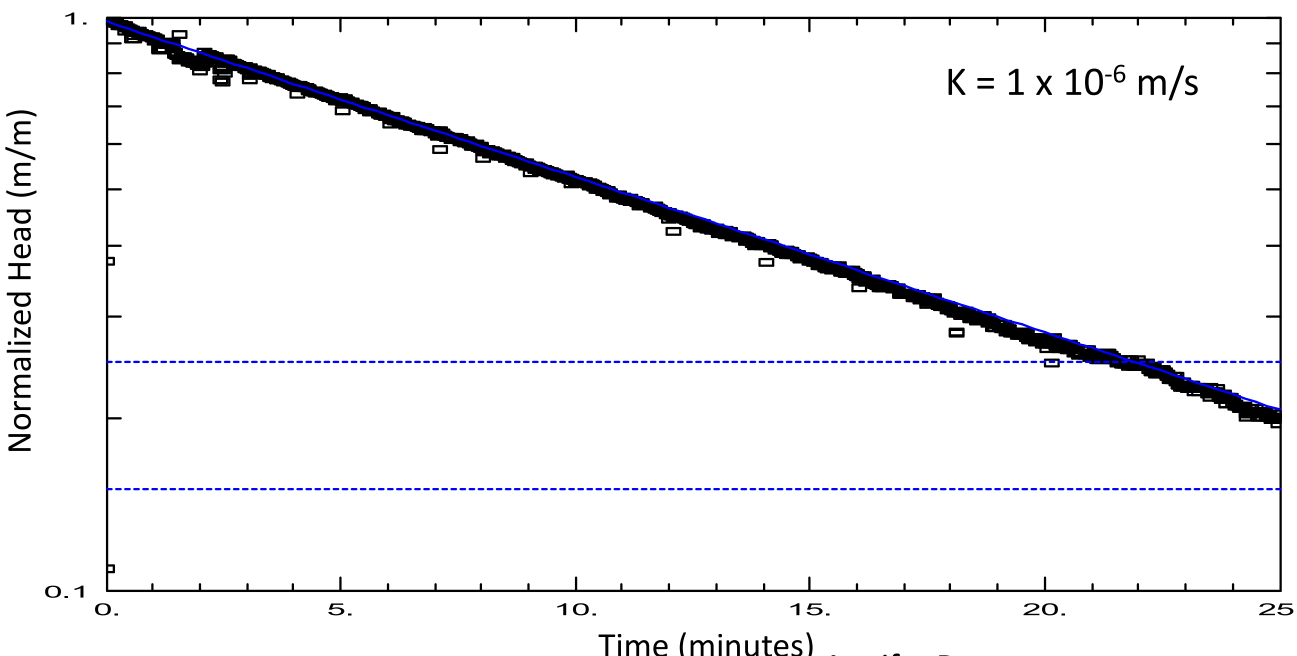
Project: 100737.002

Slug Test Data

22-222 RH



Borehole 22-222 RH: Hvorslev Analysis



<u>Well Data:</u>

Displacement observed (slug size): 0.60 metres (0.60 m)

Well Depth: 6.10 metres

Screen Length: 3.05 metres

Well Radius: 0.0255 metres

<u>Aquifer Data</u>

Saturated Thickness: 5.02 metres

Anisotropy Ratio (Kz/Kr): 0.1

Aquifer Model: Confined, Hvorslev

Static Water Level: 1.08 metres bgs

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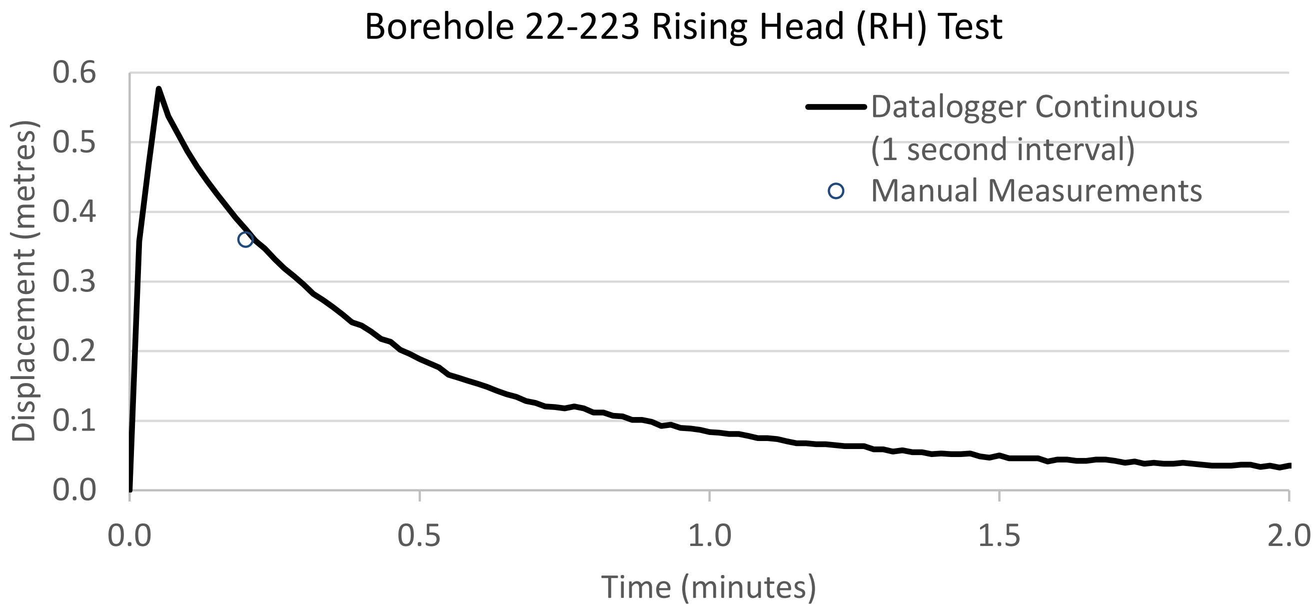
CONSULTING ENGINEERS AND SCIENTISTS

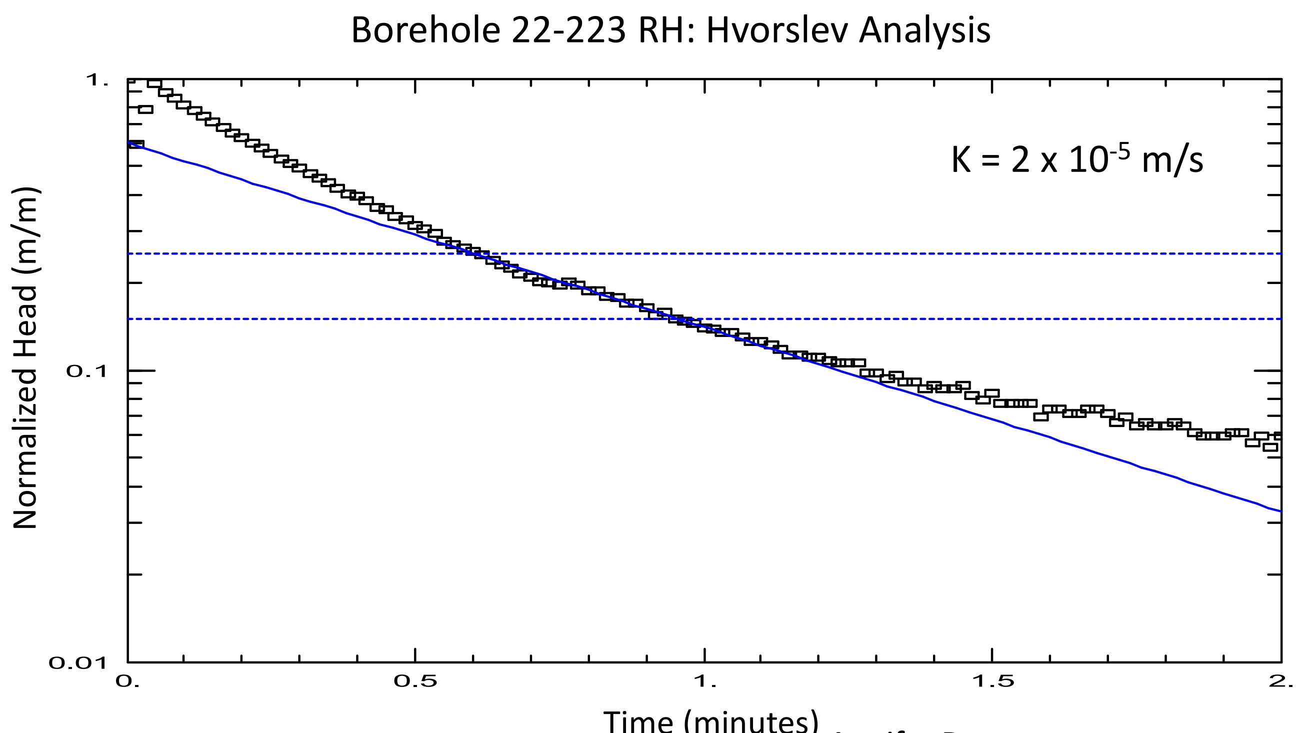
Date: February 2022

Project: 100737.002

Slug Test Data

22-223 RH





Well Data:

Displacement observed (slug size): 0.58 metres (0.60 m)
Well Depth: 12.09 metres
Screen Length: 3.05 metres
Well Radius: 0.0255 metres

Aquifer Data

Saturated Thickness: 11.80 metres
Anisotropy Ratio (Kz/Kr): 0.1
Aquifer Model: Confined, Hvorslev
Static Water Level: 0.29 metres bgs

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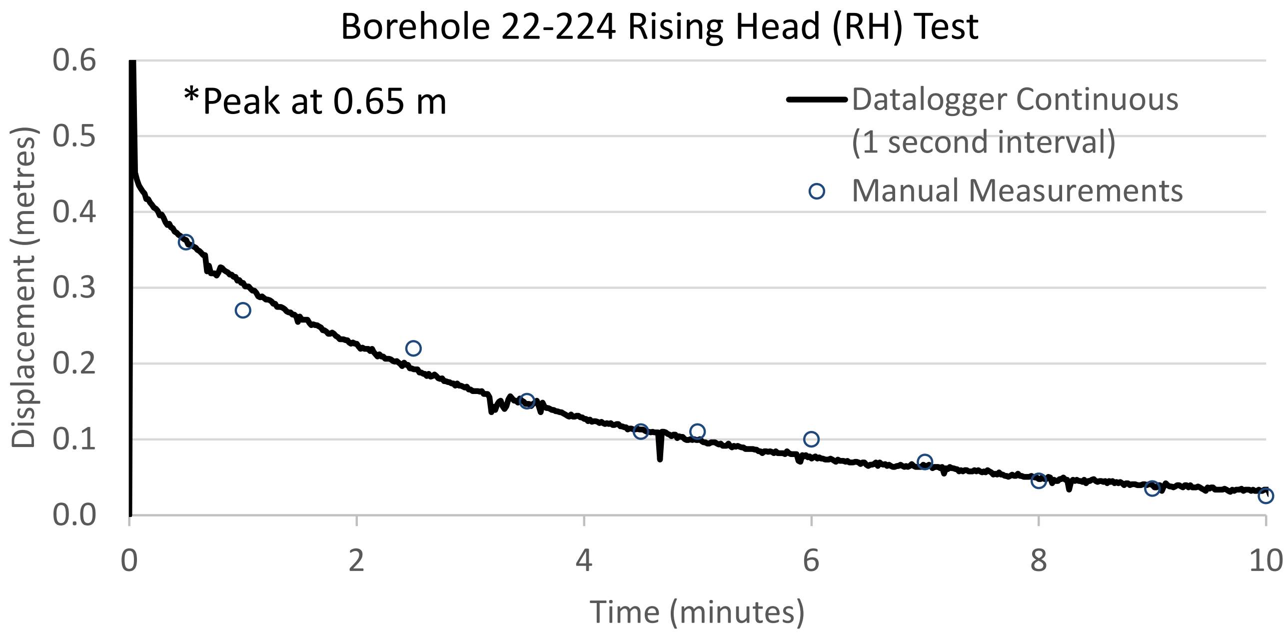
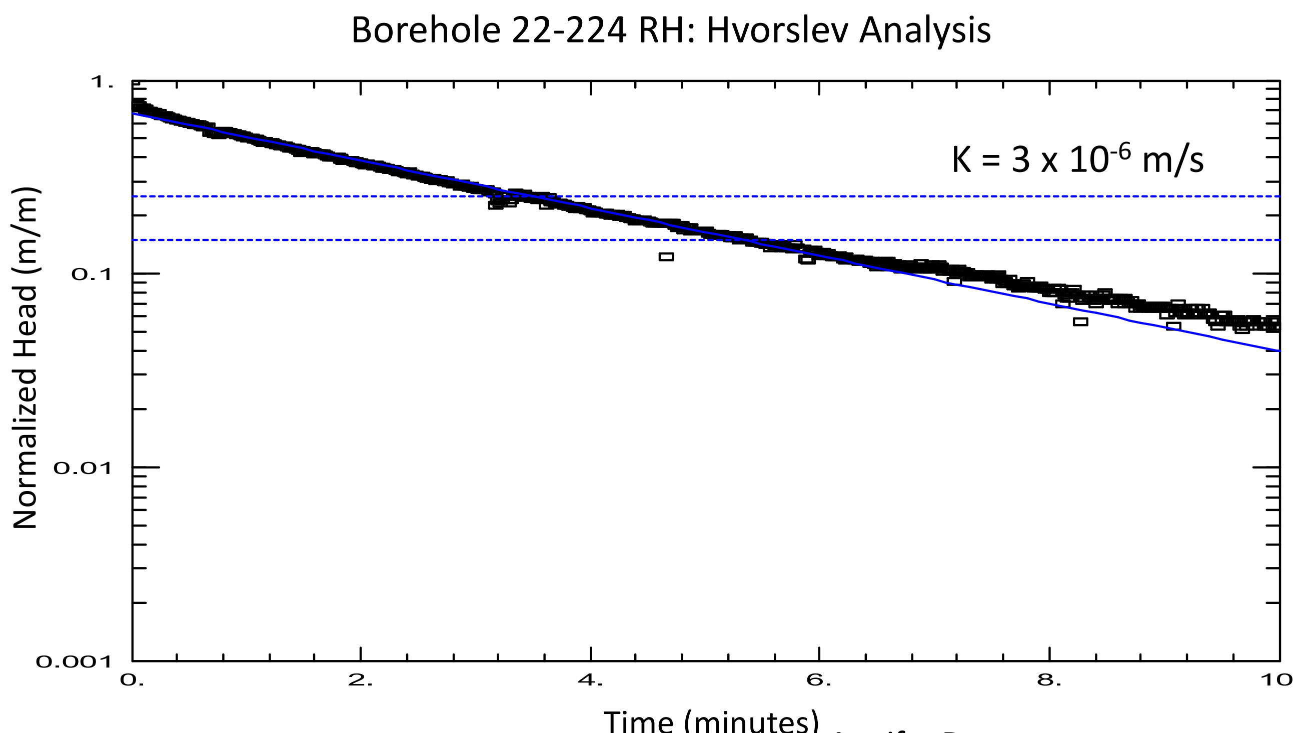
Date: February 2022

Project: 100737.002

Slug Test Data

22-224 RH





Well Data:
Displacement observed (slug size): 0.65 metres (0.60 m)
Well Depth: 4.45 metres
Screen Length: 3.05 metres
Well Radius: 0.0255 metres

Aquifer Data
Saturated Thickness: 3.91 metres
Anisotropy Ratio (Kz/Kr): 0.1
Aquifer Model: Confined, Hvorslev
Static Water Level: 0.54 metres bgs

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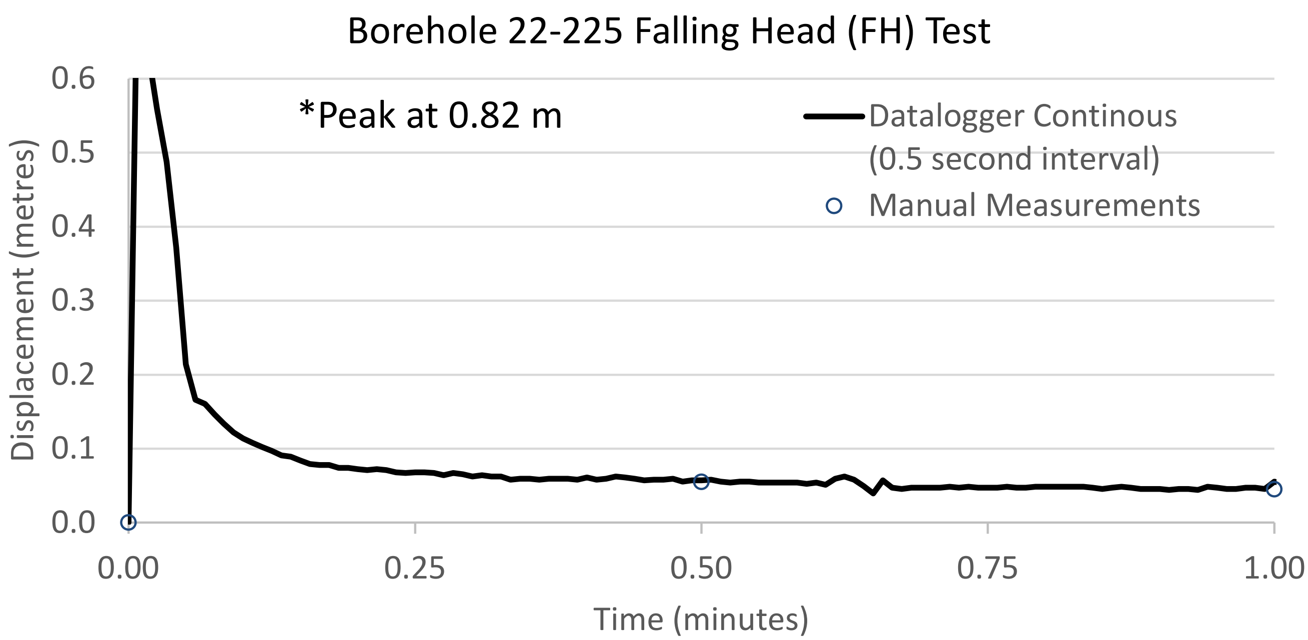
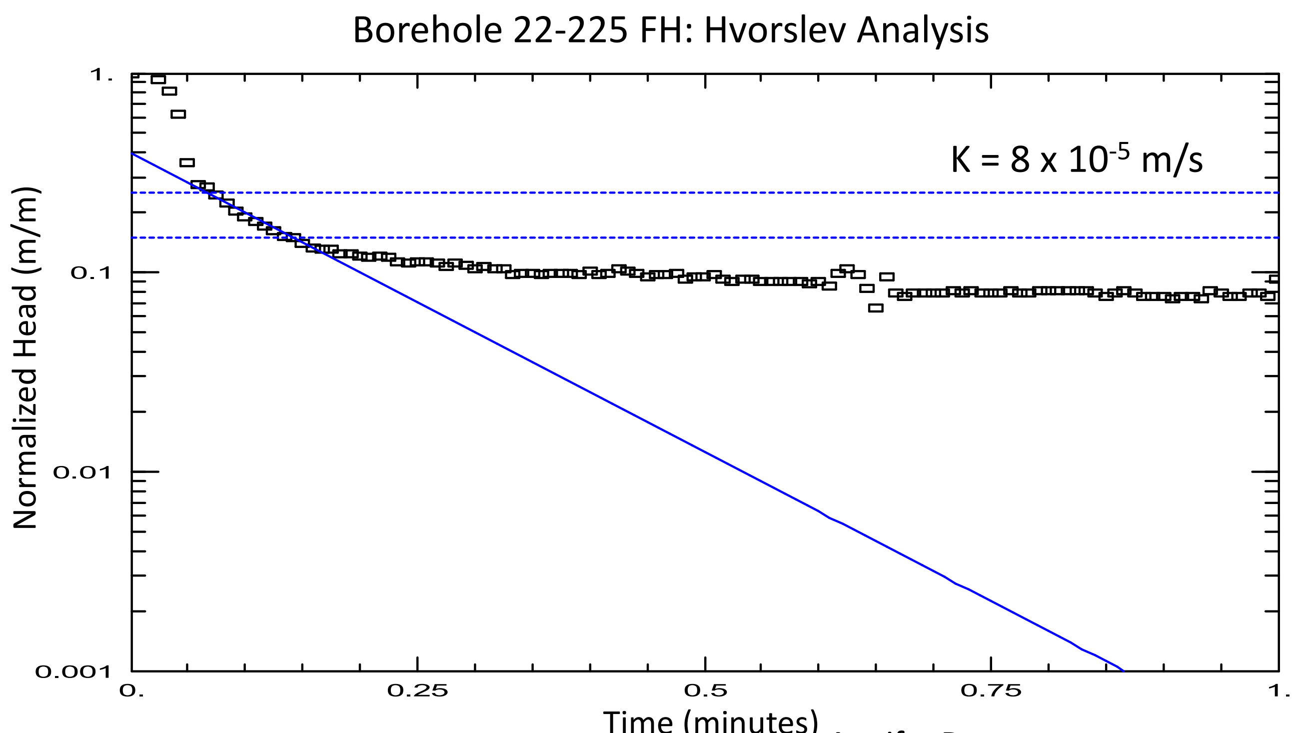
Date: February 2022
Project: 100737.002

Slug Test Data

22-225 FH





Well Data:

Displacement observed (slug size): 0.82 metres (0.60 m)

Well Depth: 6.02 metres

Screen Length: 3.05 metres

Well Radius: 0.0255 metres

Aquifer Data

Saturated Thickness: 5.30 metres

Anisotropy Ratio (Kz/Kr): 0.1

Aquifer Model: Confined, Hvorslev

Static Water Level: 0.72 metres bgs

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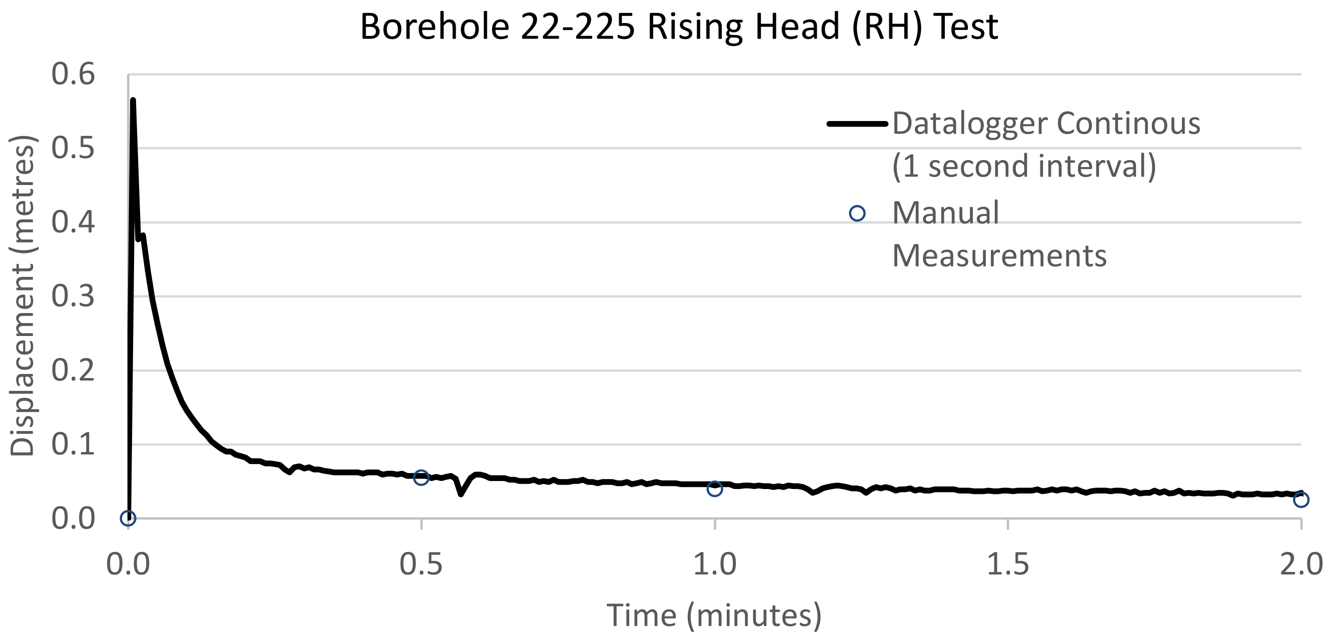
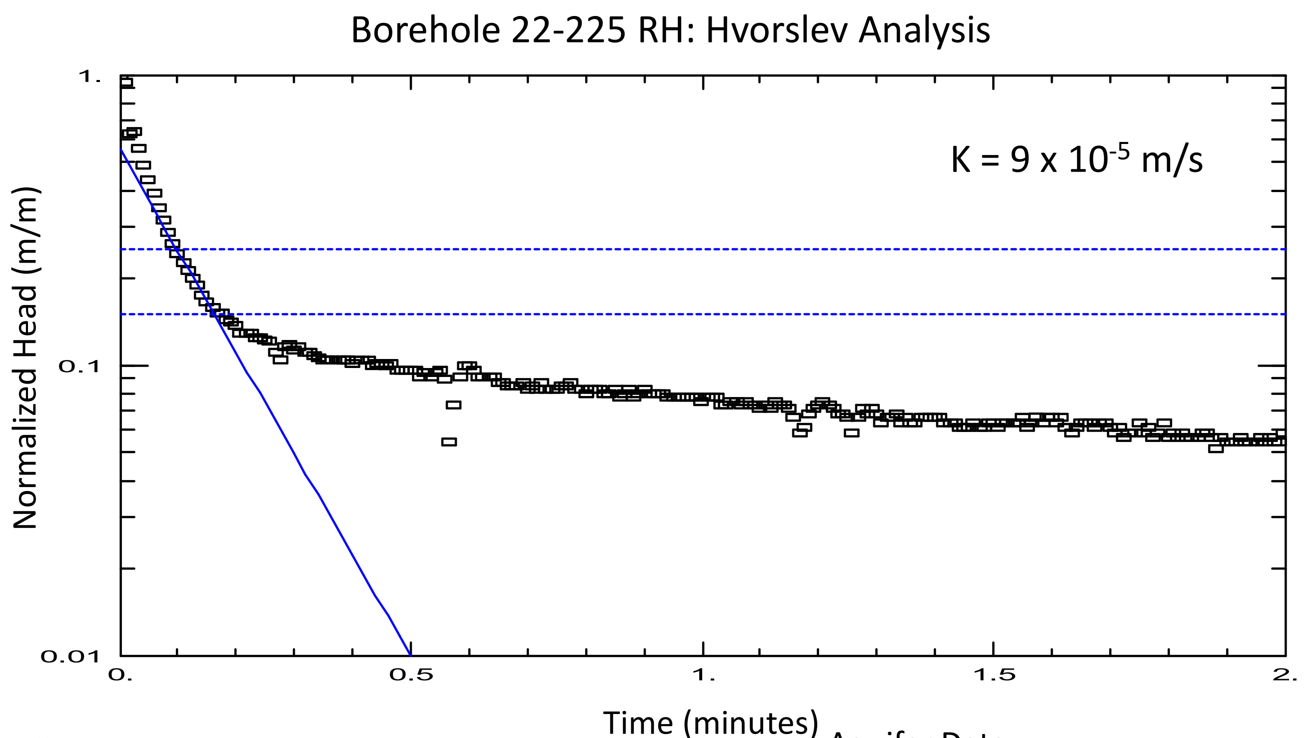
Date: February 2022

Project: 100737.002

Slug Test Data

22-225 RH





<u>Well Data:</u>

Displacement observed (slug size): 0.56 metres (0.60 m)

Well Depth: 6.02 metres

Screen Length: 3.05 metres

Well Radius: 0.0255 metres

<u>Aquifer Data</u>

Saturated Thickness: 5.30 metres

Anisotropy Ratio (Kz/Kr): 0.1

Aquifer Model: Confined, Hvorslev

Static Water Level: 0.72 metres bgs

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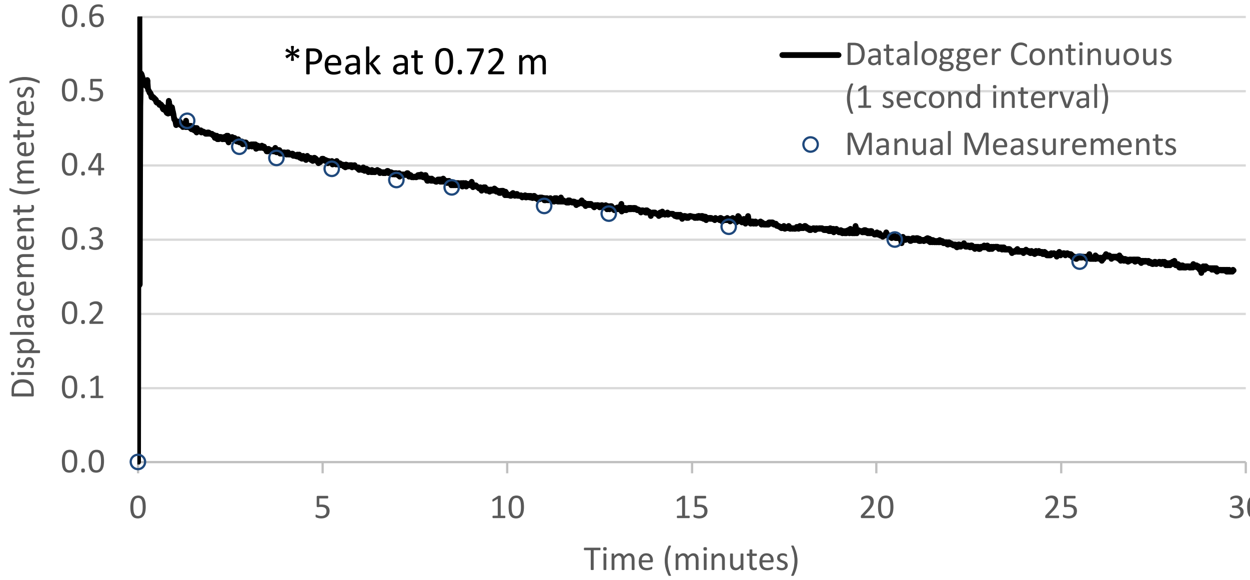
Date: February 2022

Project: 100737.002

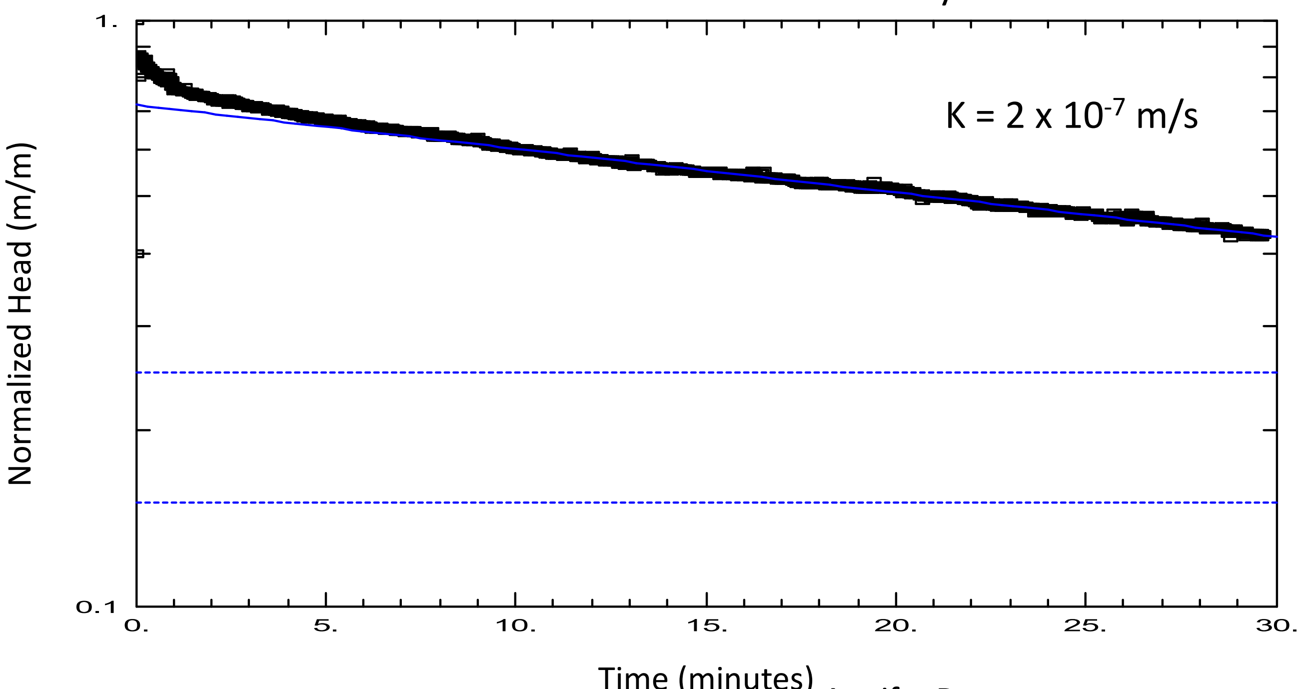
Slug Test Data

22-228A FH

Borehole 22-228A Falling Head (FH) Test



Borehole 22-228A FH: Hvorslev Analysis



Well Data:

Displacement observed (slug size): 0.72 metres (0.60 m)

Well Depth: 7.65 metres

Screen Length: 3.05 metres

Well Radius: 0.0255 metres

Aquifer Data

Saturated Thickness: 3.70 metres

Anisotropy Ratio (Kz/Kr): 0.1

Aquifer Model: Confined, Hvorslev

Static Water Level: 3.95 metres bgs

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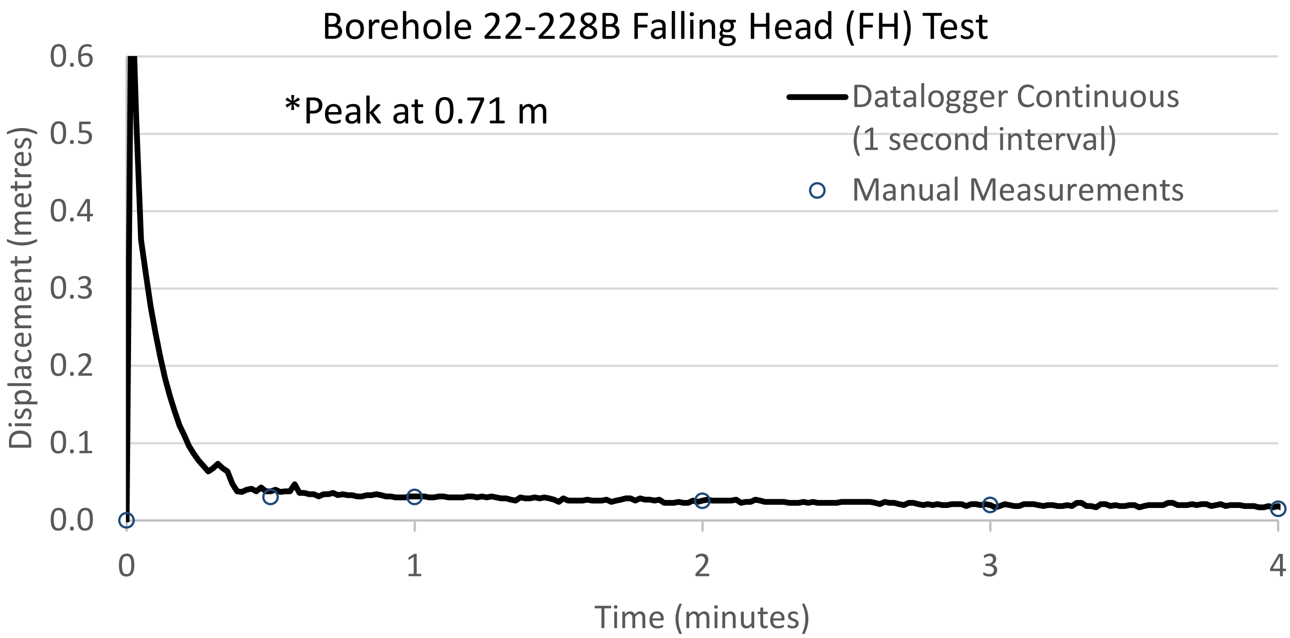
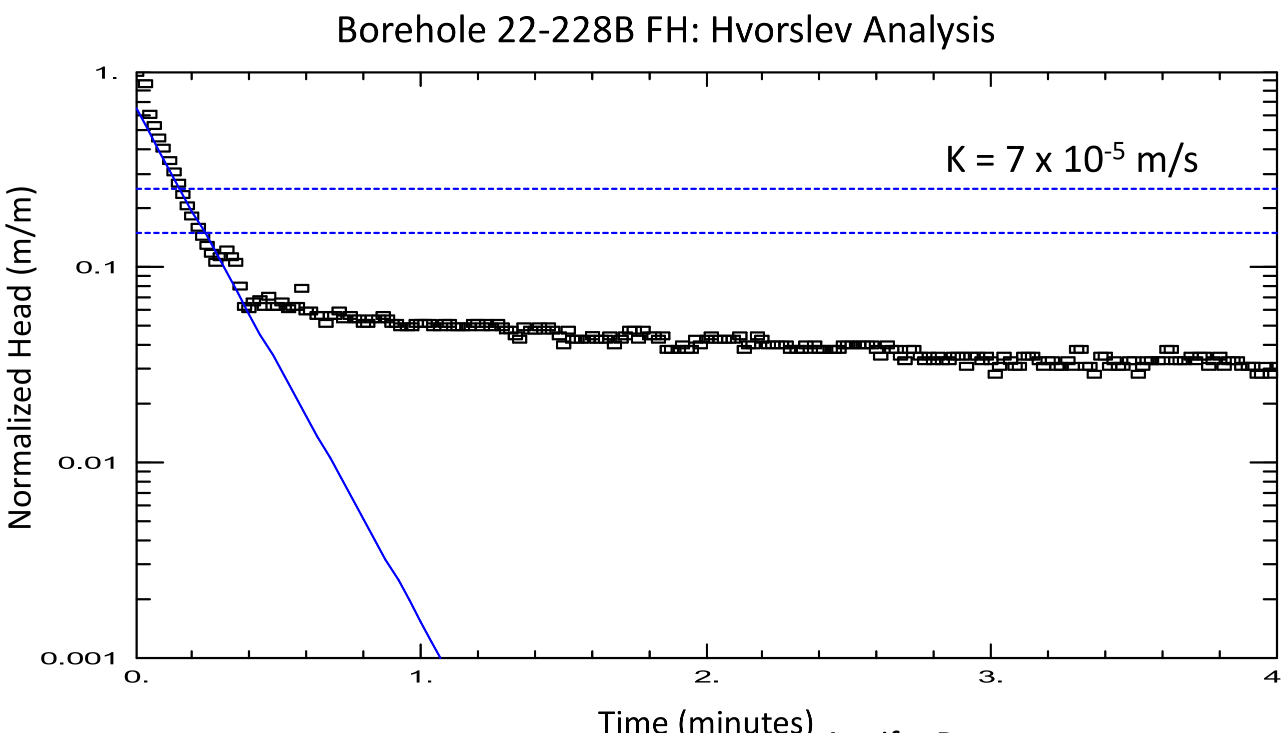
Date: February 2022

Project: 100737.002

Slug Test Data

22-228B FH





Well Data:
Displacement observed (slug size): 0.71 metres (0.60 m)
Well Depth: 12.34 metres
Screen Length: 3.05 metres
Well Radius: 0.0255 metres

Aquifer Data
Saturated Thickness: 8.22 metres
Anisotropy Ratio (Kz/Kr): 0.1
Aquifer Model: Confined, Hvorslev
Static Water Level: 4.12 metres bgs

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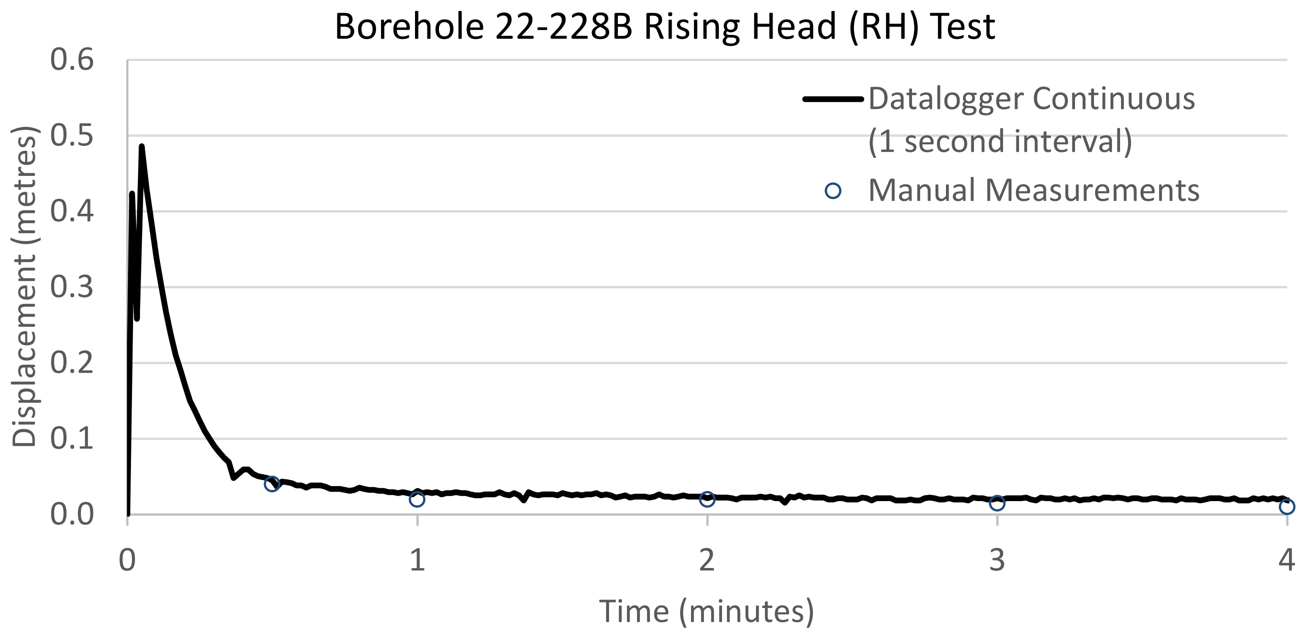
CONSULTING ENGINEERS AND SCIENTISTS

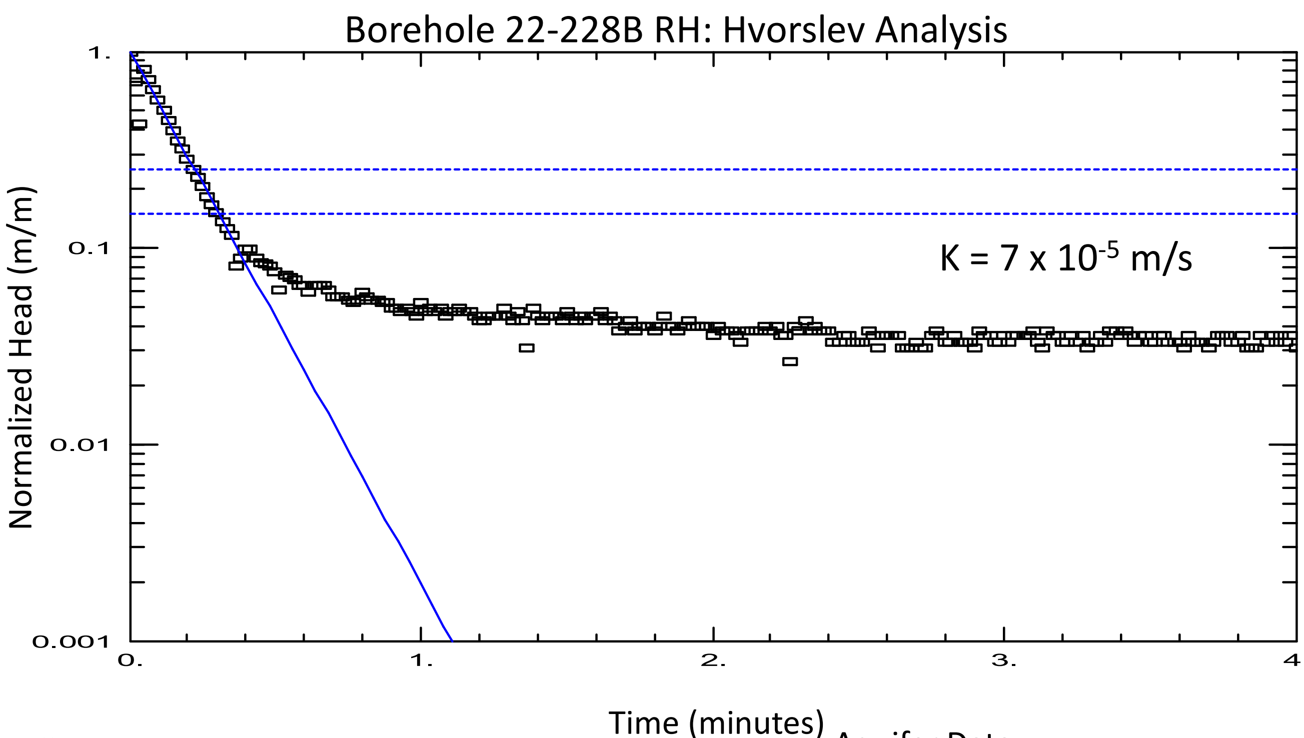
Date: February 2022

Project: 100737.002

Slug Test Data

22-228 RH





Well Data:

Displacement observed (slug size): 0.71 metres (0.60 m)

Well Depth: 12.34 metres

Screen Length: 3.05 metres

Well Radius: 0.0255 metres

Aquifer Data

Saturated Thickness: 8.22 metres

Anisotropy Ratio (Kz/Kr): 0.1

Aquifer Model: Confined, Hvorslev

Static Water Level: 4.12 metres bgs

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CONSULTING ENGINEERS AND SCIENTISTS

Date: February 2022

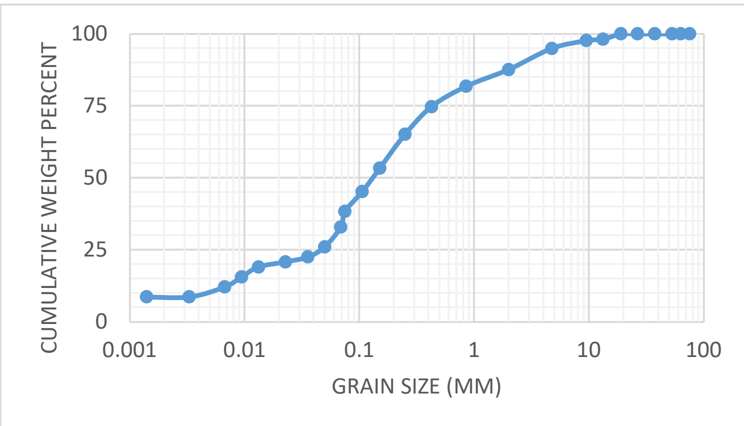
Project: 100737.002

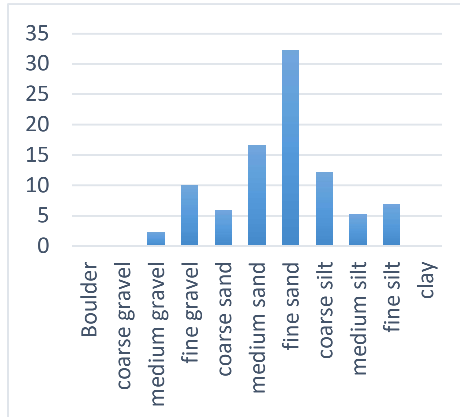
Grain Size Analysis Report | Date: 20-Feb-23

Sample Name: 22-202-SS5

Mass Sample (g): - | T (oC) 20

Poorly sorted gravelly sand low in fines





Sieve opening (ps) di (mm)	Mass of retained (mr) (g)	mass fraction (mf)	Percent Passing (pp)
75	0	0	100
63	0	0	100
53	0	0	100
37.5	0	0	100
26.5	0	0	100
19	0	0	100
13.2	1.85	0.0185	98.15
9.5	0.48	0.0048	97.67
4.75	2.69	0.0269	94.98
2	7.33	0.0733	87.65
0.85	5.85	0.0585	81.8
0.425	7.08	0.0708	74.72
0.25	9.54	0.0954	65.18
0.15	11.83	0.1183	53.35
0.106	8.07	0.0807	45.28
0.075	6.9	0.069	38.38
0.0687	5.4	0.054	32.98
0.0498	6.95	0.0695	26.03
0.0356	3.47	0.0347	22.56
0.0227	1.73	0.0173	20.83
0.0132	1.74	0.0174	19.09
0.0094	3.47	0.0347	15.62

Data continue, additional pages required ...

Effective Grain Diameters (mm)		Other Useful Parameters	
d10	0.005	Uniformity Coef.	44.89
d17	0.011	n computed	0.26
d20	0.018	g (cm/s^2)	980.00
d50	0.132	ρ (g/cm^3)	0.9981
d60	0.206	μ (g/cm s)	0.0098
de (Kruger)	0.047	ρg/μ (1/cm s)	9.9327E+04
de (Kozeny)	0.013	tau (Sauerbrei)	1.053
de (Zunker)	0.013	$d_{geometric\ mean}$	0.212
de (Zamarin)	0.014	σ_ϕ	3.657
Io (Alyameni)	-0.027		

mm	0	% in sample
>64	Boulder	0
16 - 64	coarse gravel	0
8 - 16	medium gravel	2.33
2 - 8	fine gravel	10.02
0.5 - 2	coarse sand	5.85
0.25 - 0.5	medium sand	16.62
0.063 - 0.25	fine sand	32.2
0.016 - 0.063	coarse silt	12.15
0.008 - 0.016	medium silt	5.21
0.002 - 0.008	fine silt	6.94
<0.002	clay	0

K from Grain Size Analysis Report

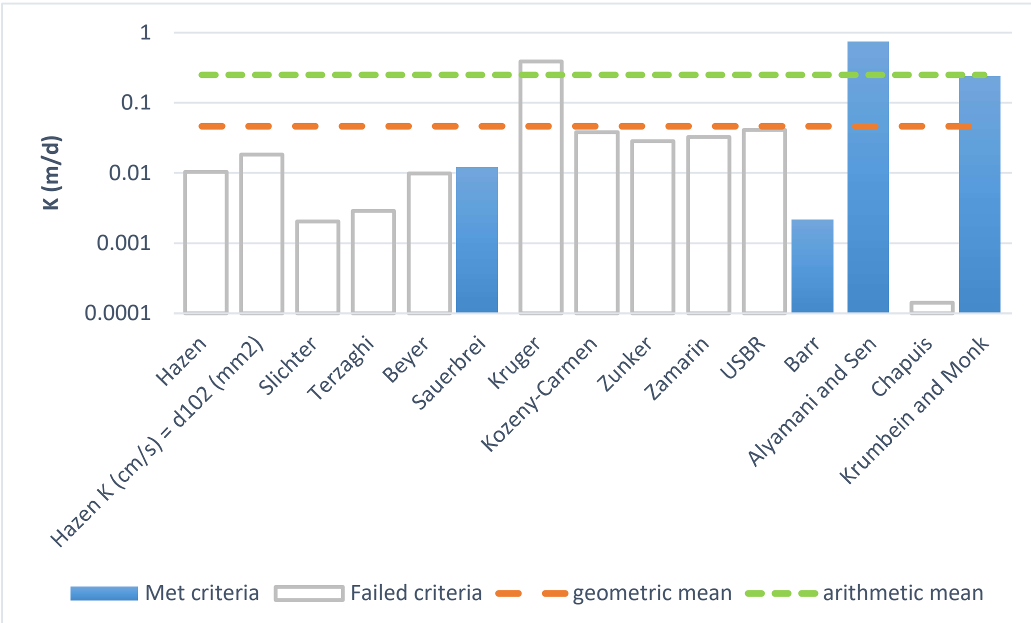
Date: 20-Feb-23

Sample Name: 22-202-SS5

Mass Sample (g): -

T (oC) 20

Poorly sorted gravelly sand low in fines



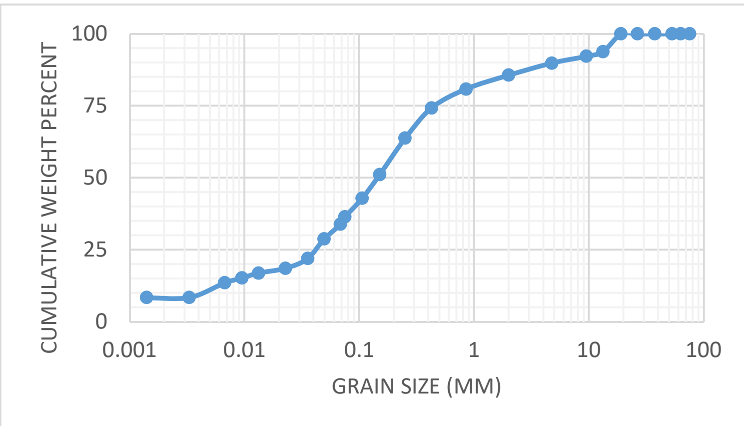
Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.120E-04	.120E-06	0.01	
Hazen K (cm/s) = d_{10} (mm)	.211E-04	.211E-06	0.02	
Slichter	.235E-05	.235E-07	0.00	
Terzaghi	.335E-05	.335E-07	0.00	
Beyer	.114E-04	.114E-06	0.01	
Sauerbrei	.140E-04	.140E-06	0.01	
Kruger	.447E-03	.447E-05	0.39	
Kozeny-Carmen	.443E-04	.443E-06	0.04	
Zunker	.329E-04	.329E-06	0.03	
Zamarin	.378E-04	.378E-06	0.03	
USBR	.473E-04	.473E-06	0.04	
Barr	.252E-05	.252E-07	0.00	
Alyamani and Sen	.868E-03	.868E-05	0.75	
Chapuis	.163E-06	.163E-08	0.00	
Krumbein and Monk	.279E-03	.279E-05	0.24	
geometric mean	.540E-04	.540E-06	0.05	
arithmetic mean	.291E-03	.291E-05	0.25	

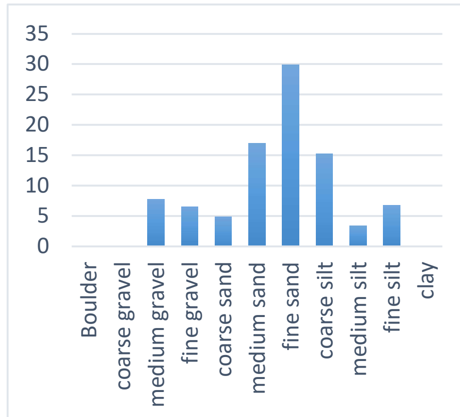
Grain Size Analysis Report Date: 20-Feb-23

Sample Name: 22-207_SS3

Mass Sample (g): 100 T (oC) 20

Poorly sorted gravelly sand low in fines





Sieve opening (ps) di (mm)	Mass of retained (mr) (g)	mass fraction (mf)	Percent Passing (pp)
75	0	0	100
63	0	0	100
53	0	0	100
37.5	0	0	100
26.5	0	0	100
19	0	0	100
13.2	6.22	0.0622	93.78
9.5	1.53	0.0153	92.25
4.75	2.4	0.024	89.85
2	4.15	0.0415	85.7
0.85	4.86	0.0486	80.84
0.425	6.56	0.0656	74.28
0.25	10.47	0.1047	63.81
0.15	12.69	0.1269	51.12
0.106	8.18	0.0818	42.94
0.075	6.48	0.0648	36.46
0.0684	2.57	0.0257	33.89
0.0493	5.08	0.0508	28.81
0.0355	6.78	0.0678	22.03
0.0227	3.39	0.0339	18.64
0.0132	1.69	0.0169	16.95
0.0095	1.7	0.017	15.25

Data continue, additional pages required ...

Effective Grain Diameters (mm)		Other Useful Parameters	
d10	0.004	Uniformity Coef.	50.90
d17	0.013	n computed	0.26
d20	0.028	g (cm/s^2)	980.00
d50	0.144	ρ (g/cm^3)	0.9981
d60	0.220	μ (g/cm s)	0.0098
de (Kruger)	0.047	ρg/μ (1/cm s)	9.9327E+04
de (Kozeny)	0.014	tau (Sauerbrei)	1.053
de (Zunker)	0.014	$d_{geometric\ mean}$	0.242
de (Zamarin)	0.014	σ_ϕ	3.925
Io (Alyameni)	-0.031		

mm	0	% in sample
>64	Boulder	0
16 - 64	coarse gravel	0
8 - 16	medium gravel	7.75
2 - 8	fine gravel	6.55
0.5 - 2	coarse sand	4.86
0.25 - 0.5	medium sand	17.03
0.063 - 0.25	fine sand	29.92
0.016 - 0.063	coarse silt	15.25
0.008 - 0.016	medium silt	3.39
0.002 - 0.008	fine silt	6.78
<0.002	clay	0

K from Grain Size Analysis Report

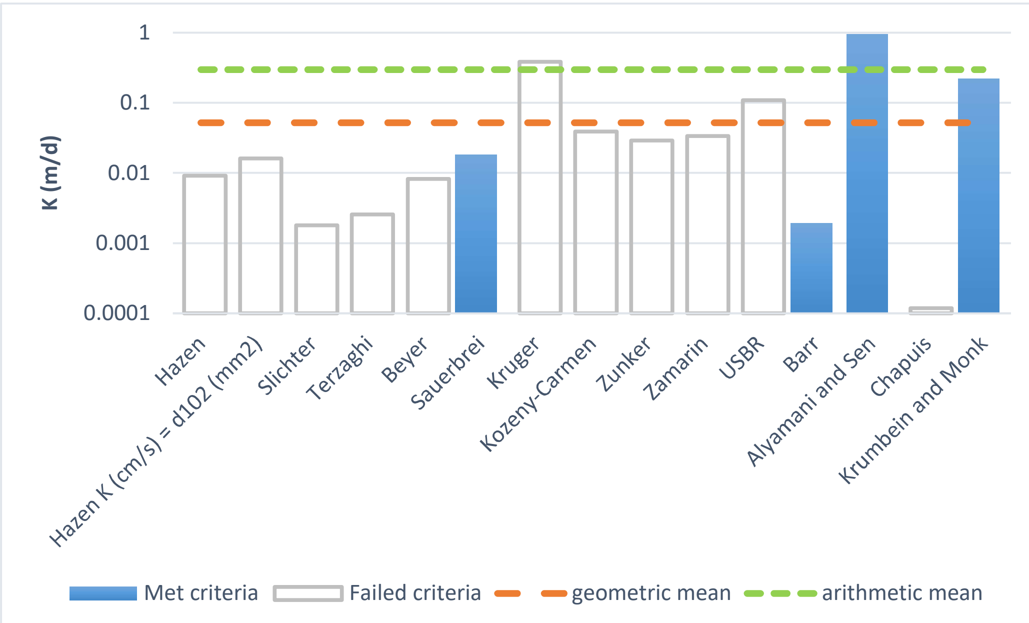
Date: 20-Feb-23

Sample Name: 22-207_SS3

Mass Sample (g): -

T (oC) 20

Poorly sorted gravelly sand low in fines



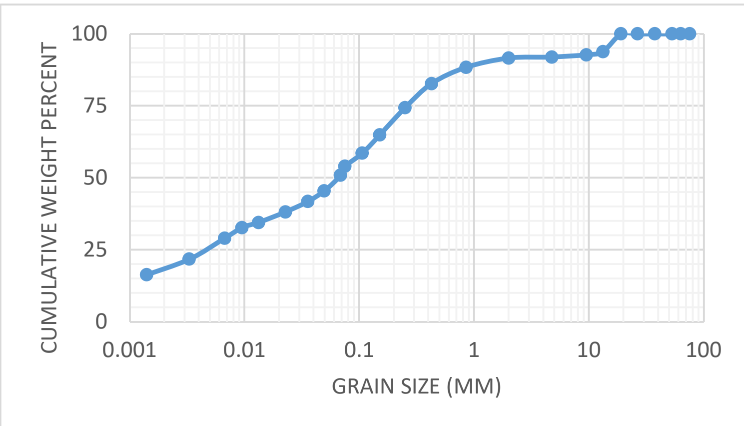
Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.106E-04	.106E-06	0.01	
Hazen K (cm/s) = d_{10} (mm)	.187E-04	.187E-06	0.02	
Slichter	.208E-05	.208E-07	0.00	
Terzaghi	.296E-05	.296E-07	0.00	
Beyer	.957E-05	.957E-07	0.01	
Sauerbrei	.213E-04	.213E-06	0.02	
Kruger	.444E-03	.444E-05	0.38	
Kozeny-Carmen	.453E-04	.453E-06	0.04	
Zunker	.337E-04	.337E-06	0.03	
Zamarin	.389E-04	.389E-06	0.03	
USBR	.126E-03	.126E-05	0.11	
Barr	.223E-05	.223E-07	0.00	
Alyamani and Sen	.111E-02	.111E-04	0.95	
Chapuis	.137E-06	.137E-08	0.00	
Krumbein and Monk	.255E-03	.255E-05	0.22	
geometric mean	.605E-04	.605E-06	0.05	
arithmetic mean	.346E-03	.346E-05	0.30	

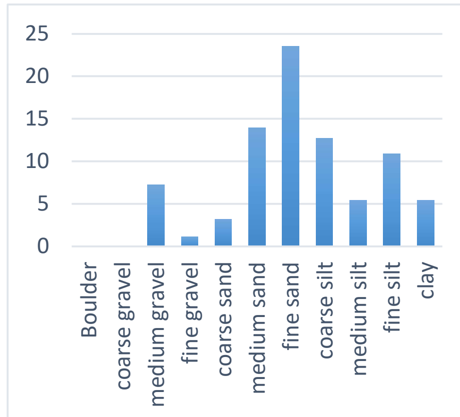
Grain Size Analysis Report   Date: 20-Feb-23

Sample Name: 22-220_SS3

Mass Sample (g): -   T (oC) 20

Poorly sorted sand with fines





Sieve opening (ps) di (mm)	Mass of retained (mr) (g)	mass fraction (mf)	Percent Passing (pp)
75	0	0	100
63	0	0	100
53	0	0	100
37.5	0	0	100
26.5	0	0	100
19	0	0	100
13.2	6.13	0.0613	93.87
9.5	1.13	0.0113	92.74
4.75	0.76	0.0076	91.98
2	0.38	0.0038	91.6
0.85	3.22	0.0322	88.38
0.425	5.64	0.0564	82.74
0.25	8.31	0.0831	74.43
0.15	9.54	0.0954	64.89
0.106	6.28	0.0628	58.61
0.075	4.59	0.0459	54.02
0.0684	3.12	0.0312	50.9
0.0493	5.45	0.0545	45.45
0.0355	3.64	0.0364	41.81
0.0227	3.64	0.0364	38.17
0.0132	3.63	0.0363	34.54
0.0095	1.82	0.0182	32.72

Data continue, additional pages required ...

Effective Grain Diameters (mm)		Other Useful Parameters	
d10	0.001	Uniformity Coef.	135.25
d17	0.002	n computed	0.26
d20	0.003	g (cm/s^2)	980.00
d50	0.065	ρ (g/cm^3)	0.9981
d60	0.116	μ (g/cm s)	0.0098
de (Kruger)	0.020	ρg/μ (1/cm s)	9.9327E+04
de (Kozeny)	0.006	tau (Sauerbrei)	1.053
de (Zunker)	0.006	$d_{geometric\ mean}$	0.148
de (Zamarin)	0.007	σ_ϕ	4.419
Io (Alyameni)	-0.015		

mm	0	% in sample
>64	Boulder	0
16 - 64	coarse gravel	0
8 - 16	medium gravel	7.26
2 - 8	fine gravel	1.14
0.5 - 2	coarse sand	3.22
0.25 - 0.5	medium sand	13.95
0.063 - 0.25	fine sand	23.53
0.016 - 0.063	coarse silt	12.73
0.008 - 0.016	medium silt	5.45
0.002 - 0.008	fine silt	10.91
<0.002	clay	5.45

K from Grain Size Analysis Report

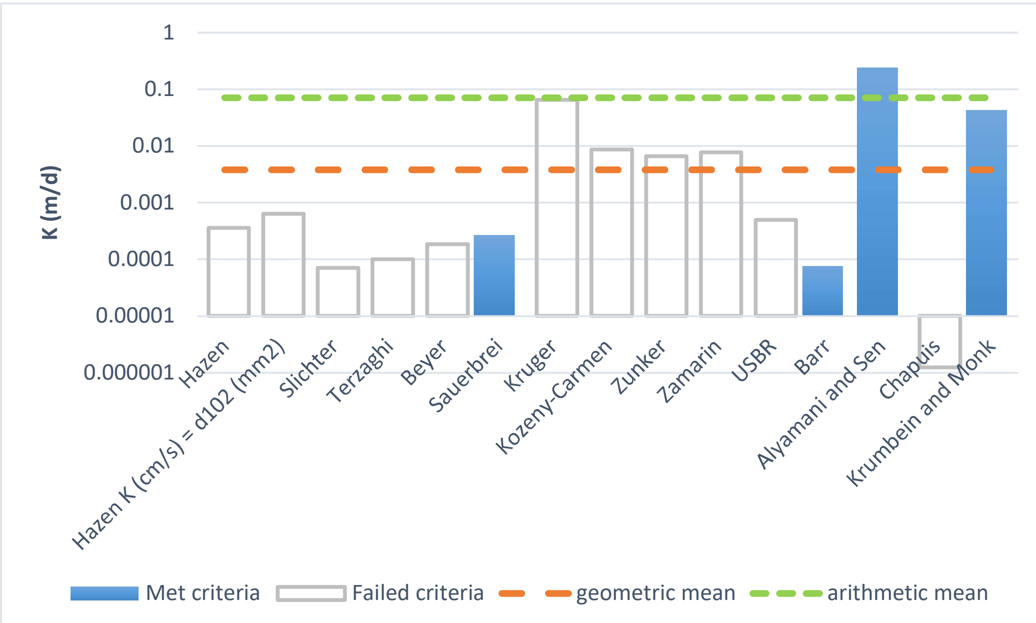
Date: 20-Feb-23

Sample Name: 22-220_SS3

Mass Sample (g): -

T (oC) 20

Poorly sorted sand with fines



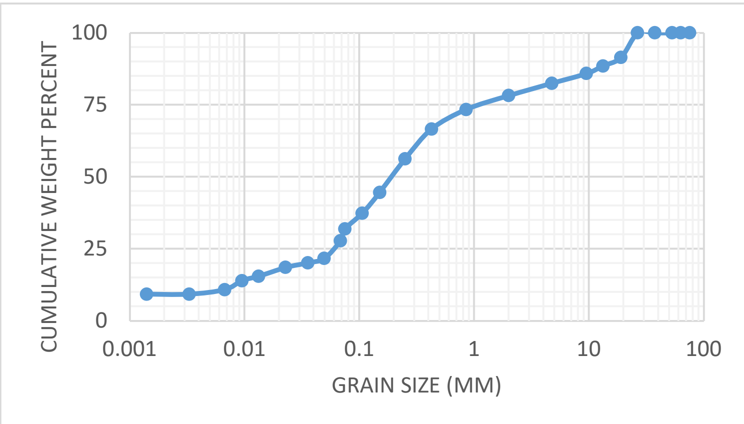
Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.415E-06	.415E-08	0.00	
Hazen K (cm/s) = d_{10} (mm)	.732E-06	.732E-08	0.00	
Slichter	.815E-07	.815E-09	0.00	
Terzaghi	.116E-06	.116E-08	0.00	
Beyer	.215E-06	.215E-08	0.00	
Sauerbrei	.309E-06	.309E-08	0.00	
Kruger	.758E-04	.758E-06	0.07	
Kozeny-Carmen	.101E-04	.101E-06	0.01	
Zunker	.762E-05	.762E-07	0.01	
Zamarin	.891E-05	.891E-07	0.01	
USBR	.574E-06	.574E-08	0.00	
Barr	.874E-07	.874E-09	0.00	
Alyamani and Sen	.280E-03	.280E-05	0.24	
Chapuis	.143E-08	.143E-10	0.00	
Krumbein and Monk	.503E-04	.503E-06	0.04	
geometric mean	.441E-05	.441E-07	0.00	
arithmetic mean	.826E-04	.826E-06	0.07	

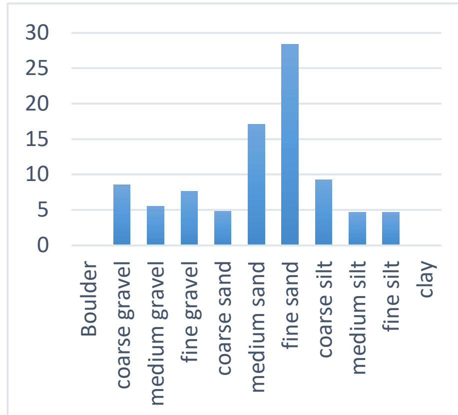
Grain Size Analysis Report Date: 20-Feb-23

Sample Name: 22-224_SS4

Mass Sample (g): - T (oC) 20

Poorly sorted gravelly sand low in fines





Sieve opening (ps) di (mm)	Mass of retained (mr) (g)	mass fraction (mf)	Percent Passing (pp)
75	0	0	100
63	0	0	100
53	0	0	100
37.5	0	0	100
26.5	0	0	100
19	8.54	0.0854	91.46
13.2	2.97	0.0297	88.49
9.5	2.58	0.0258	85.91
4.75	3.4	0.034	82.51
2	4.27	0.0427	78.24
0.85	4.83	0.0483	73.41
0.425	6.79	0.0679	66.62
0.25	10.35	0.1035	56.27
0.15	11.64	0.1164	44.63
0.106	7.24	0.0724	37.39
0.075	5.48	0.0548	31.91
0.0684	4.04	0.0404	27.87
0.0493	6.19	0.0619	21.68
0.0355	1.55	0.0155	20.13
0.0227	1.55	0.0155	18.58
0.0132	3.09	0.0309	15.49
0.0095	1.55	0.0155	13.94

Data continue, additional pages required ...

Effective Grain Diameters (mm)		Other Useful Parameters	
d10	0.005	Uniformity Coef.	64.45
d17	0.018	n computed	0.26
d20	0.034	g (cm/s^2)	980.00
d50	0.196	ρ (g/cm^3)	0.9981
d60	0.313	μ (g/cm s)	0.0098
de (Kruger)	0.068	ρg/μ (1/cm s)	9.9327E+04
de (Kozeny)	0.014	tau (Sauerbrei)	1.053
de (Zunker)	0.014	$d_{geometric\ mean}$	0.405
de (Zamarin)	0.014	σ_ϕ	4.462
Io (Alyameni)	-0.043		

mm	0	% in sample
>64	Boulder	0
16 - 64	coarse gravel	8.54
8 - 16	medium gravel	5.55
2 - 8	fine gravel	7.67
0.5 - 2	coarse sand	4.83
0.25 - 0.5	medium sand	17.14
0.063 - 0.25	fine sand	28.4
0.016 - 0.063	coarse silt	9.29
0.008 - 0.016	medium silt	4.64
0.002 - 0.008	fine silt	4.65
<0.002	clay	0

K from Grain Size Analysis Report

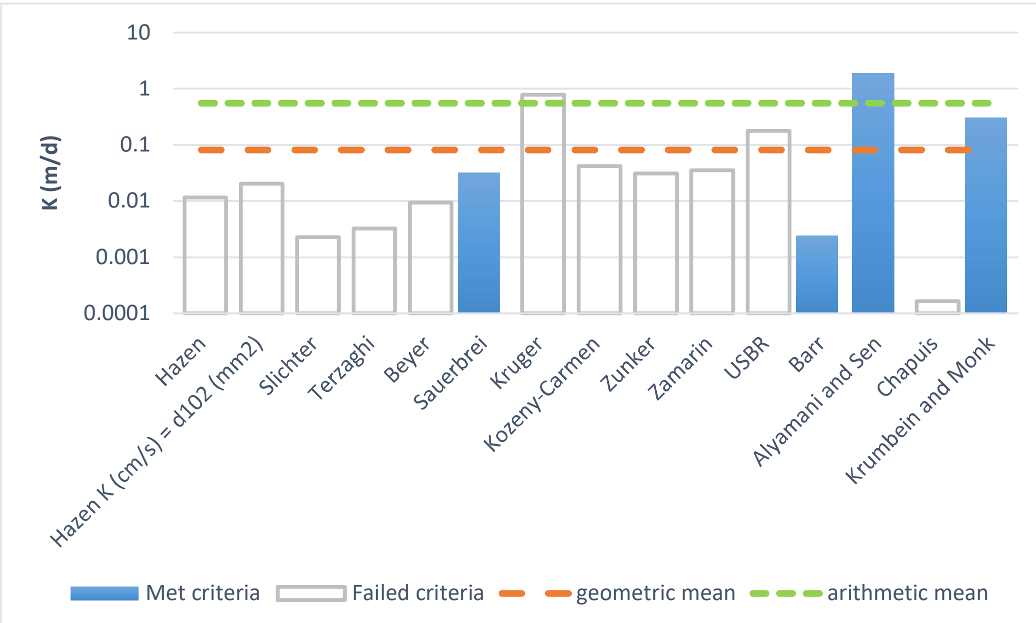
Date: 20-Feb-23

Sample Name: 22-224_SS4

Mass Sample (g): -

T (oC) 20

Poorly sorted gravelly sand low in fines



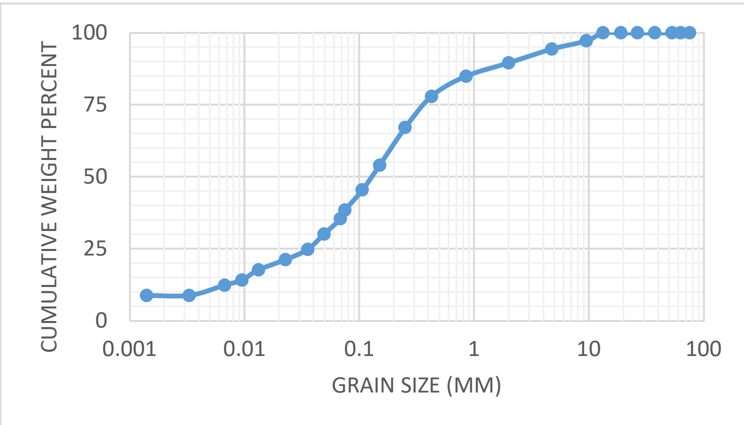
Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.134E-04	.134E-06	0.01	
Hazen K (cm/s) = d_{10} (mm)	.236E-04	.236E-06	0.02	
Slichter	.263E-05	.263E-07	0.00	
Terzaghi	.374E-05	.374E-07	0.00	
Beyer	.108E-04	.108E-06	0.01	
Sauerbrei	.373E-04	.373E-06	0.03	
Kruger	.912E-03	.912E-05	0.79	
Kozeny-Carmen	.484E-04	.484E-06	0.04	
Zunker	.357E-04	.357E-06	0.03	
Zamarin	.408E-04	.408E-06	0.04	
USBR	.206E-03	.206E-05	0.18	
Barr	.281E-05	.281E-07	0.00	
Alyamani and Sen	.219E-02	.219E-04	1.90	
Chapuis	.190E-06	.190E-08	0.00	
Krumbein and Monk	.354E-03	.354E-05	0.31	
geometric mean	.950E-04	.950E-06	0.08	
arithmetic mean	.647E-03	.647E-05	0.56	

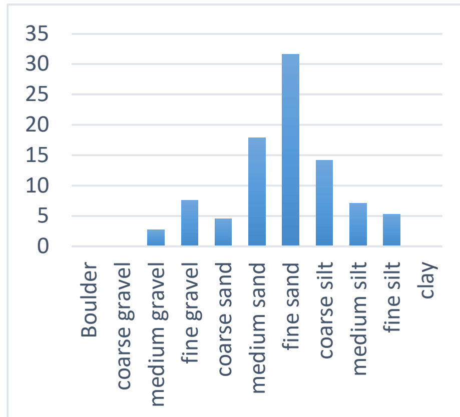
Grain Size Analysis Report   Date: 20-Feb-23

Sample Name: 22-230_SS4

Mass Sample (g): -   T (oC) 20

Poorly sorted gravelly sand low in fines





Sieve opening (ps) di (mm)	Mass of retained (mr) (g)	mass fraction (mf)	Percent Passing (pp)
75	0	0	100
63	0	0	100
53	0	0	100
37.5	0	0	100
26.5	0	0	100
19	0	0	100
13.2	0	0	100
9.5	2.74	0.0274	97.26
4.75	2.85	0.0285	94.41
2	4.81	0.0481	89.6
0.85	4.62	0.0462	84.98
0.425	7	0.07	77.98
0.25	10.87	0.1087	67.11
0.15	13.04	0.1304	54.07
0.106	8.59	0.0859	45.48
0.075	7.04	0.0704	38.44
0.0684	2.96	0.0296	35.48
0.0493	5.32	0.0532	30.16
0.0355	5.32	0.0532	24.84
0.0227	3.55	0.0355	21.29
0.0132	3.55	0.0355	17.74
0.0095	3.55	0.0355	14.19

Data continue, additional pages required ...

Effective Grain Diameters (mm)		Other Useful Parameters	
d10	0.004	Uniformity Coef.	44.61
d17	0.012	n computed	0.26
d20	0.019	g (cm/s^2)	980.00
d50	0.129	ρ (g/cm^3)	0.9981
d60	0.195	μ (g/cm s)	0.0098
de (Kruger)	0.048	ρg/μ (1/cm s)	9.9327E+04
de (Kozeny)	0.013	tau (Sauerbrei)	1.053
de (Zunker)	0.013	$d_{geometric\ mean}$	0.195
de (Zamarin)	0.013	σ_ϕ	3.473
Io (Alyameni)	-0.027		

mm	0	% in sample
>64	Boulder	0
16 - 64	coarse gravel	0
8 - 16	medium gravel	2.74
2 - 8	fine gravel	7.66
0.5 - 2	coarse sand	4.62
0.25 - 0.5	medium sand	17.87
0.063 - 0.25	fine sand	31.63
0.016 - 0.063	coarse silt	14.19
0.008 - 0.016	medium silt	7.1
0.002 - 0.008	fine silt	5.32
<0.002	clay	0

K from Grain Size Analysis Report

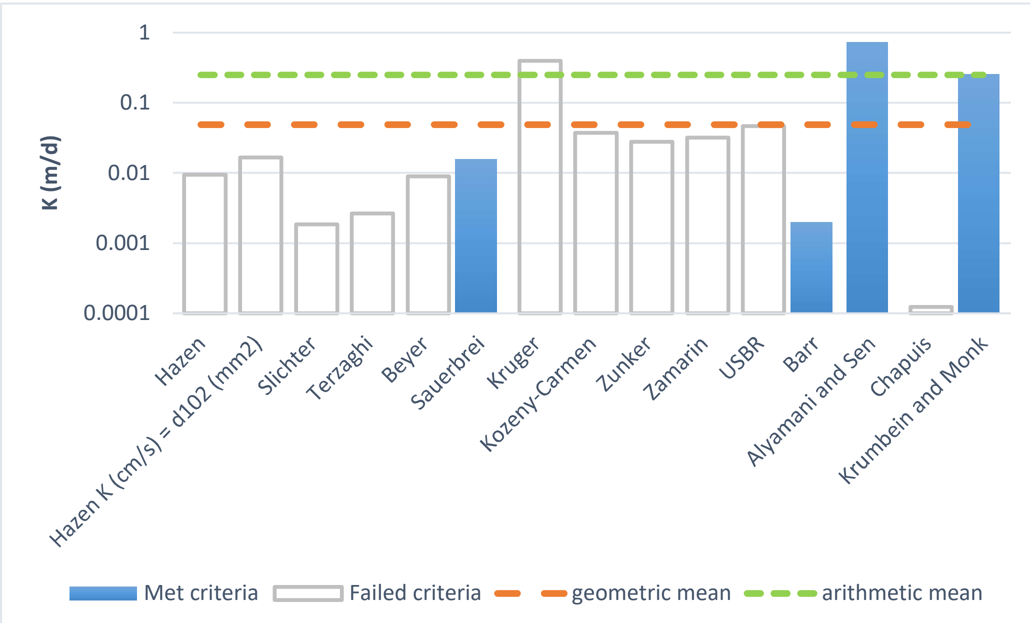
Date: 20-Feb-23

Sample Name: 22-230_SS4

Mass Sample (g): -

T (oC) 20

Poorly sorted gravelly sand low in fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d	de
Hazen	.109E-04	.109E-06	0.01	
Hazen K (cm/s) = d_{10} (mm)	.192E-04	.192E-06	0.02	
Slichter	.214E-05	.214E-07	0.00	
Terzaghi	.305E-05	.305E-07	0.00	
Beyer	.104E-04	.104E-06	0.01	
Sauerbrei	.181E-04	.181E-06	0.02	
Kruger	.460E-03	.460E-05	0.40	
Kozeny-Carmen	.433E-04	.433E-06	0.04	
Zunker	.321E-04	.321E-06	0.03	
Zamarin	.369E-04	.369E-06	0.03	
USBR	.540E-04	.540E-06	0.05	
Barr	.229E-05	.229E-07	0.00	
Alyamani and Sen	.844E-03	.844E-05	0.73	
Chapuis	.143E-06	.143E-08	0.00	
Krumbein and Monk	.298E-03	.298E-05	0.26	
geometric mean	.569E-04	.569E-06	0.05	
arithmetic mean	.291E-03	.291E-05	0.25	

APPENDIX F

Water Balance Calculations

Report to: Caivan (Perth GC) Limited
Project: 100737.002 (February 22, 2023)

Water Budget -141 Peter Street

Table F1. Pre-Development Conditions (Tay River Watershed)

Geology	Land Use[1]	Water Holding Capacity (mm)[1]	Area (%)	Area (m2)	Surplus[2] (mm/yr)	Topography Factor	Soil Factor	Cover Factor	Infiltration Coefficient	Runoff Coefficient	Infiltration (mm/yr)	Runoff (mm/yr)	Infiltration Volume (m3/yr)	Runoff Volume (m3/yr)
Silty Sand Till	Forested	300	50.1%	114,628	317	0.1	0.2	0.2	0.5	0.5	159	159	18,169	18,169
Silty Sand Till	Short Grasses (Golf Course)	75	38.8%	88,604	390	0.1	0.2	0.1	0.4	0.6	156	234	13,822	20,733
Precambrian Bedrock	Short Grasses (Golf Course)	75	11.1%	25,347	390	0.1	0.02	0.1	0.22	0.78	86	304	2,175	7,711
		Total Development Area		228,579							-	-	34,166	46,612
										Weighted Average	149	204	-	-

1. Table 3.1 MOE SWMP Planning and Design Manual (2003)
2. Surplus data from Environment Canada Water Budget Means for Drummond Centre 1985-2021.

Table F2. Post-Development Conditions (Tay River Watershed)

Geology	Land Use[1]	Water Holding Capacity (mm)[1]	Area (%)	Area (m2)	Surplus[2] (mm/yr)	Topography Factor	Soil Factor	Cover Factor	Infiltration Coefficient	Runoff Coefficient	Infiltration (mm/yr)	Runoff (mm/yr)	Infiltration Volume (m3/yr)	Runoff Volume (m3/yr)
Silty Sand Till	Urban Lawn	75	24%	55,316	390	0.2	0.2	0.1	0.5	0.5	195	195	10,787	10,787
Hard Surface (building and roadway)	Impermeable[3]	0	76%	173,263	742[4]	-	-	-	0	1	0	741.6	0	128,492
		Total Development Area		228,579							-	-	10,787	139,278
										Weighted Average	47	609	-	-

1. Table 3.1 MOE SWMP Planning and Design Manual (2003)
2. Surplus data taken to be average of Environment Canada Water Budget Means for Carleton-Appleton 1984-2020.
3. Residential properties where assumed to be 65% impermeable by area, and stormwater management ponds were assumed as impermeable.
4. Hard Surface surplus calculated to be average precipitation - 20% evaporation (conservative estimate as per Cuddy et al., 2013)

Table F3. Water Budget Summary (Tay River Watershed)

Summary	Infil mm/yr	Runoff mm/yr	Infil m^3/yr	Runoff m^3/yr
Pre-Development	149	204	34,166	46,612
Post-Development	47	609	10,787	139,278
Change	**-102**	**405**	**- 23,379**	**92,666**

Water Budget -141 Peter Street

Table F4. Pre-Development Conditions (Grant's Creek Watershed)

Geology	Land Use[1]	Water Holding Capacity (mm)[1]	Area (%)	Area (m2)	Surplus[2] (mm/yr)	Topography Factor	Soil Factor	Cover Factor	Infiltration Coefficient	Runoff Coefficient	Infiltration (mm/yr)	Runoff (mm/yr)	Infiltration Volume (m3/yr)	Runoff Volume (m3/yr)
Silty Sand Till	Forested	300	47.4%	104,289	317	0.1	0.2	0.2	0.5	0.5	159	159	16,530	16,530
Silty Sand Till	Short Grasses (Golf Course)	75	19.2%	42,298	390	0.1	0.2	0.1	0.4	0.6	156	234	6,598	9,898
Precambrian Bedrock	Short Grasses (Golf Course)	75	33.4%	73,501	390	0.1	0.02	0.1	0.22	0.78	86	304	6,306	22,359
		Total Development Area		220,088							-	-	29,435	48,787
										Weighted Average	134	222	-	-

1. Table 3.1 MOE SWMP Planning and Design Manual (2003)
2. Surplus data from Environment Canada Water Budget Means for Drummond Centre 1985-2021.

Table F5. Post-Development Conditions (Grant's Creek Watershed)

Geology	Land Use[1]	Water Holding Capacity (mm)[1]	Area (%)	Area (m2)	Surplus[2] (mm/yr)	Topography Factor	Soil Factor	Cover Factor	Infiltration Coefficient	Runoff Coefficient	Infiltration (mm/yr)	Runoff (mm/yr)	Infiltration Volume (m3/yr)	Runoff Volume (m3/yr)
Silty Sand Till	Urban Lawn	75	25%	54,142	390	0.2	0.2	0.1	0.5	0.5	195	195	10,558	10,558
Hard Surface (building and roadway)	Impermeable[3]	0	75%	165,946	742 [4]	-	-	-	0	1	0	741.6	0	123,066
		Total Development Area		220,088							-	-	10,558	133,623
										Weighted Average	48	607	-	-

1. Table 3.1 MOE SWMP Planning and Design Manual (2003)

2. Surplus data taken to be average of Environment Canada Water Budget Means for Carleton-Appleton 1984-2020.

3. Residential properties where assumed to be 65% impermeable by area, and stormwater management ponds were assumed as impermeable.

4. Hard Surface surplus calculated to be average precipitation - 20% evaporation (conservative estimate as per Cuddy et al., 2013)

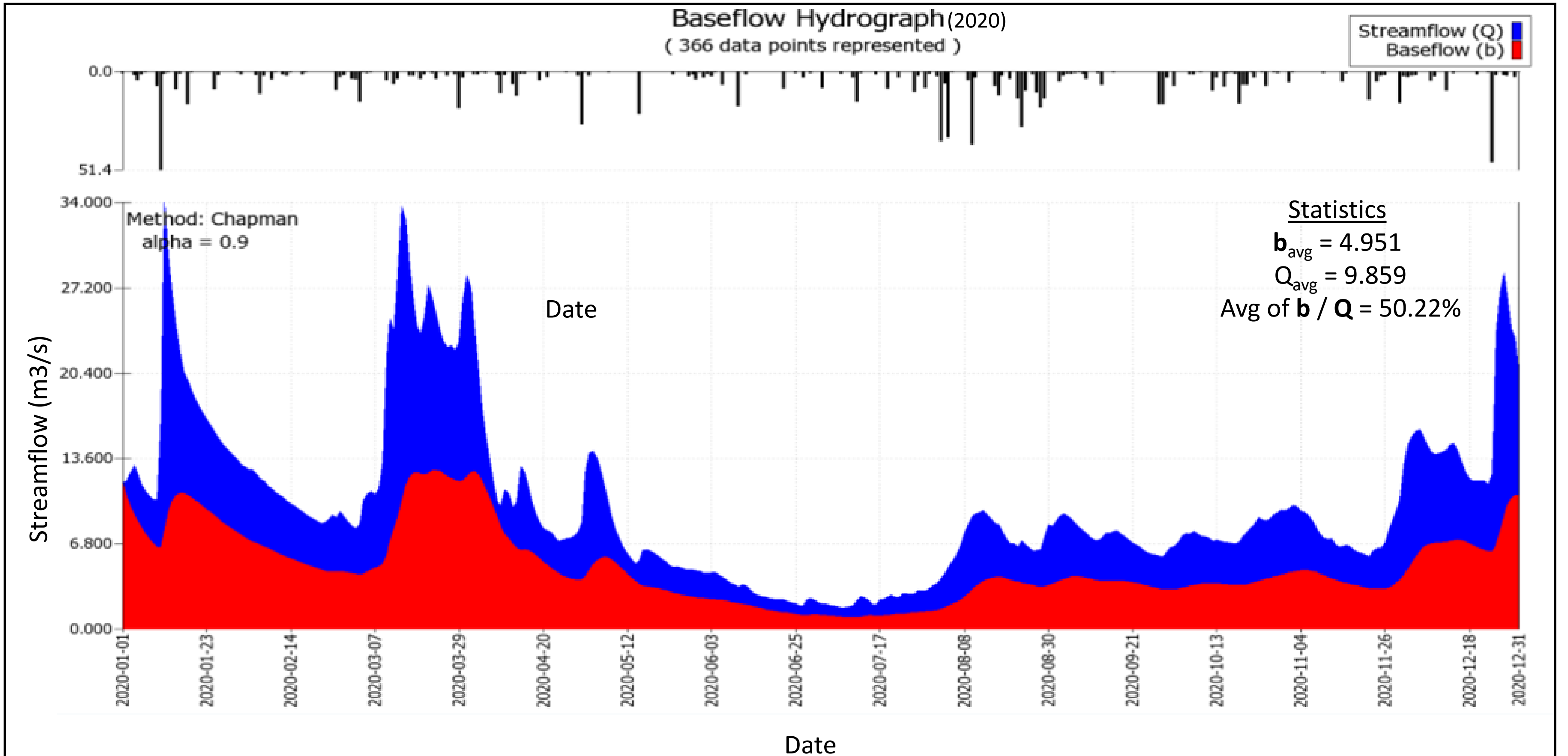
Table F6. Water Budget Summary (Grant's Creek Watershed)

Summary	Infil mm/yr	Runoff mm/yr	Infil m^3/yr	Runoff m^3/yr
Pre-Development	134	222	29,435	48,787
Post-Development	48	607	10,558	133,623
Change	**-86**	**385**	**- 18,877**	**84,837**

APPENDIX G

Tay River Baseflow Calculations

Report to: Caivan (Perth GC) Limited
Project: 100737.002 (February 22, 2023)



GEMTEC
CONSULTING ENGINEERS AND SCIENTISTS

SepHydro online tool (Danielescu, MacQuarrie, & Popa, 2018)

Streamflow Hydrograph Tay River at Perth (Station ID: 02LA024). Dataset for 2020. Weather station: Drummond Centre, ID: 6102J13.

141 Perth Street
Project 100737.002

Streamflow Hydrograph

Figure G1

Streamflow Analysis Summary Table

Data Descriptor	Value	Unit
Baseflow Separation Method	Chapman	-
Alpha Value	0.9	-
Data Period	2005-2016, 2018-2020	-
Total Years	15	years
Average Streamflow	8.6	m3/s
Average Annual Streamflow	272,220,778	m3/yr
Average Annual Runoff	136,024,547	m3/yr
Average Annual Baseflow	136,196,231	m3/yr
Average Annual BFI	50	%
Watershed Area	661	km2
Average Annual Precipitation	967	mm
Annual Infiltration	21.3	%

GEMTEC
CONSULTING ENGINEERS AND SCIENTISTS

SepHydro online tool (Danielescu, MacQuarrie, & Popa, 2018)

Streamflow Hydrograph Tay River at Perth (Station ID: 02LA024). Data Period: 2005-2016, 2018-2020.

141 Perth Street
Project 100737.002

Baseflow Calculations

Figure G2

APPENDIX H

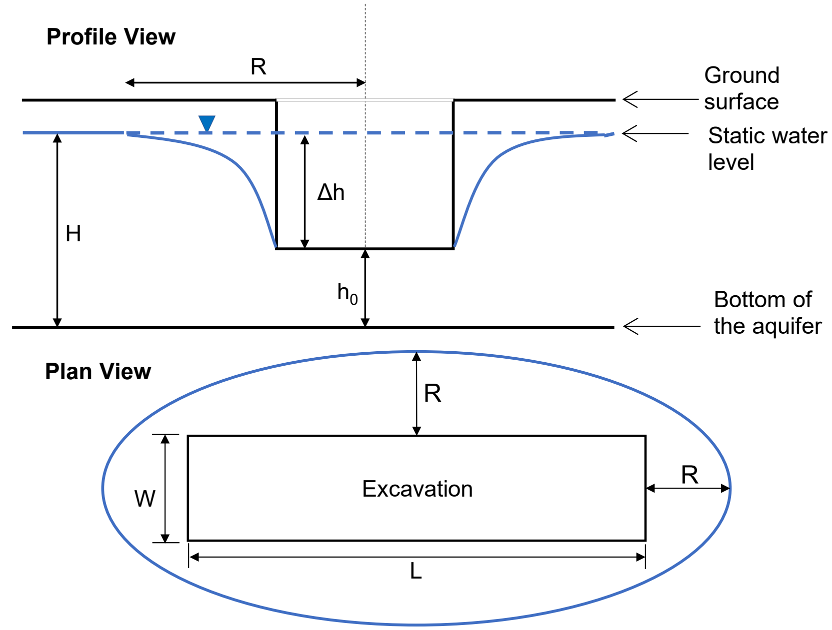
Dewatering Estimates

Report to: Caivan (Perth GC) Limited
Project: 100737.002 (February 22, 2023)

Groundwater Flow Estimates To Open Excavation - Source 1

Project: 100737.002

Date: Feb 2023



Radius of Influence Equation
(Leonards, 1962)

$$R=100\cdot C\cdot(H-h_0)\cdot\sqrt{k}$$

Variables and Units

- R = Distance from edge of excavation where drawdown is negligible (m)
- C = Situation Factor (C = 3 for flow to a well; C = 1.5 to 2 for single line of well points)
- H = Water head outside distance R from open slot excavation (m)
- h_0 = Water head inside open slot excavation (m)
- k = Coefficient of permeability (cm/sec)

Gravity flow to Slot/Open Trench Equation (Driscoll, 1986)

Gravity flow to Slot/Open Trench Equation (Powers, 2007)

$$Q=\frac{\pi k(H^2-h_0^2)}{\ln(L/r_s)}+2\left(\frac{xk(H^2-h_0^2)}{2L}\right)$$

Variables and Units

- Q = Groundwater flow rate (m^3/day)
- k = hydraulic conductivity m/s
- x = Length of open excavation (m)
- L = Radius of influence (m)
- H = Water table at L (m)
- h_0 = target groundwater level at excavation (m)
- rs = Radius of the well approximation (half of excavation width) (m)

Data Entry

Radius of Influence Equation		Flow to Open Trench Equation	
Variable	Input	Variable	Input
C	3.0	k	7.8 m/day
H	7.0 m	x	30.0 m
h_0	2.0 m	w	4.5 m
k	0.009 cm/sec		

Results

Radius of Influence (L)	**142 m**
Flow to Open Trench Equation	**339 (m^3/day)**

GEMTEC
Consulting Engineers and Scientists

Groundwater Flow Estimates - SWMP 1

Radius of Influence Equation
(Leonards, 1962)

$$R = 100 \cdot C \cdot (H - h_0) \cdot \sqrt{k}$$

Variables and Units

R = Distance from edge of excavation where drawdown is negligible (m)

C = Situation Factor (C = 3 for flow to a well; C = 1.5 to 2 for single line of well points)

H = Water head outside distance R from open circular excavation (m)

h_0 = Water head inside open circular excavation (m)

k = Coefficient of permeability (cm/sec)

Gravity flow to Open Circular Excavation/Well (Driscoll, 1986)

$$Q = \frac{k(H^2 - h_0^2)}{0.733\log(R/r)}$$

Variables and Units

Q = Flow into open excavation (m^3/day)

k = Coefficient of permeability (m/day)

R = Radius of influence (m)

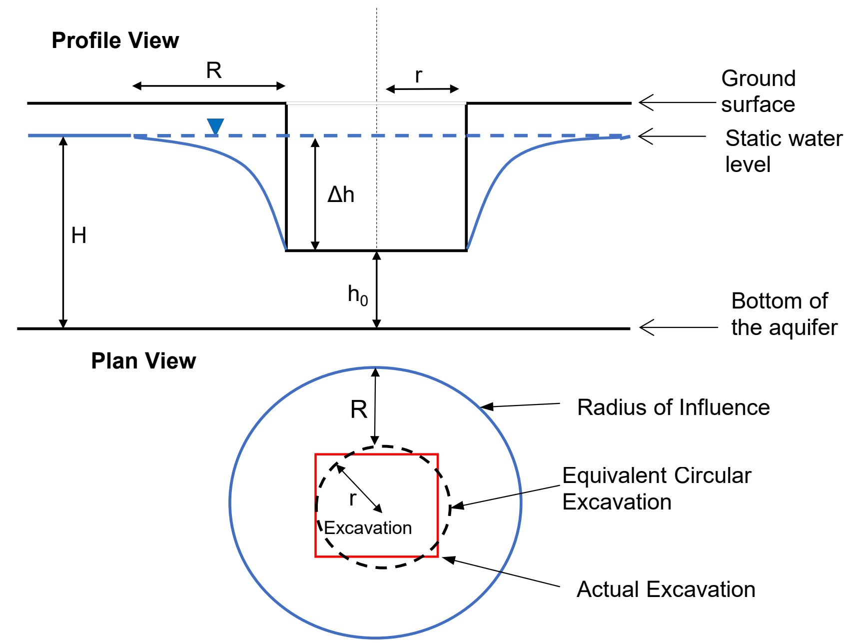
H = Water head outside distance R from open excavation (m)

h_0 = Water head at base of excavation (m)

r = Radius of equivalent circular excavation/well (m)

L = Length of excavation (m)

W = Width of excavation (m)



Data Entry

Radius of Influence Equation		Flow to Open Equation	
Variable	Input	Variable	Input
C	3.0	k	7.8 m/day
H	5.5 m	L	69 m
h_0	2.0 m	W	69 m
k	0.009 cm/sec		

Results

Radius of Equivalent Circular Excavation (r)	**38.7 m**
Radius of Influence From Edge of Excavation	**99.6 m**
Flow to Open Excavation	**503 (m^3/day)**

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Consulting Engineers and Scientists

Groundwater Flow Estimates - SWMP 2

Radius of Influence Equation
(Leonards, 1962)

$$R = 100 \cdot C \cdot (H - h_0) \cdot \sqrt{k}$$

Variables and Units

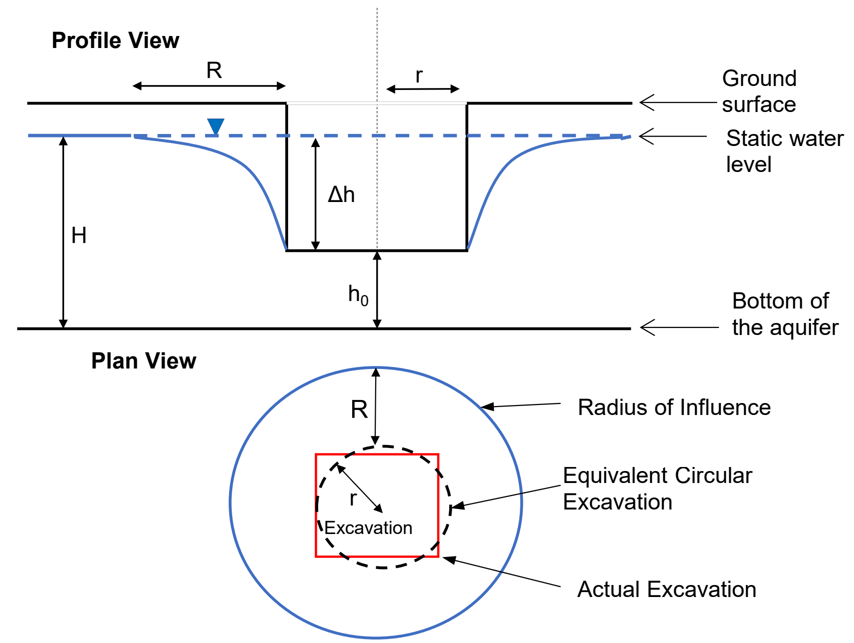
R = Distance from edge of excavation where drawdown is negligible (m)
C = Situation Factor (C = 3 for flow to a well; C = 1.5 to 2 for single line of well points)
H = Water head outside distance R from open circular excavation (m)
h_0 = Water head inside open circular excavation (m)
k = Coefficient of permeability (cm/sec)

Gravity flow to Open Circular Excavation/Well (Driscoll, 1986)

$$Q = \frac{k(H^2 - h_0^2)}{0.733 \log(R/r)}$$

Variables and Units

Q = Flow into open excavation (m^3/day)
k = Coefficient of permeability (m/day)
R = Radius of influence (m)
H = Water head outside distance R from open excavation (m)
h_0 = Water head at base of excavation (m)
r = Radius of equivalent circular excavation/well (m)
L = Length of excavation (m)
W = Width of excavation (m)



Data Entry

Radius of Influence Equation		Flow to Open Equation	
Variable	Input	Variable	Input
C	3.0	k	7.8 m/day
H	5.5 m	L	92 m
h_0	2.0 m	W	92 m
k	0.009 cm/sec		

Results

Radius of Equivalent Circular Excavation (r)	**51.9 m**
Radius of Influence From Edge of Excavation	**99.6 m**
Flow to Open Excavation	**598 (m^3/day)**

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Consulting Engineers and Scientists

Groundwater Flow Estimates - SWMP 3

Radius of Influence Equation
(Leonards, 1962)

$$R = 100 \cdot C \cdot (H - h_0) \cdot \sqrt{k}$$

Variables and Units

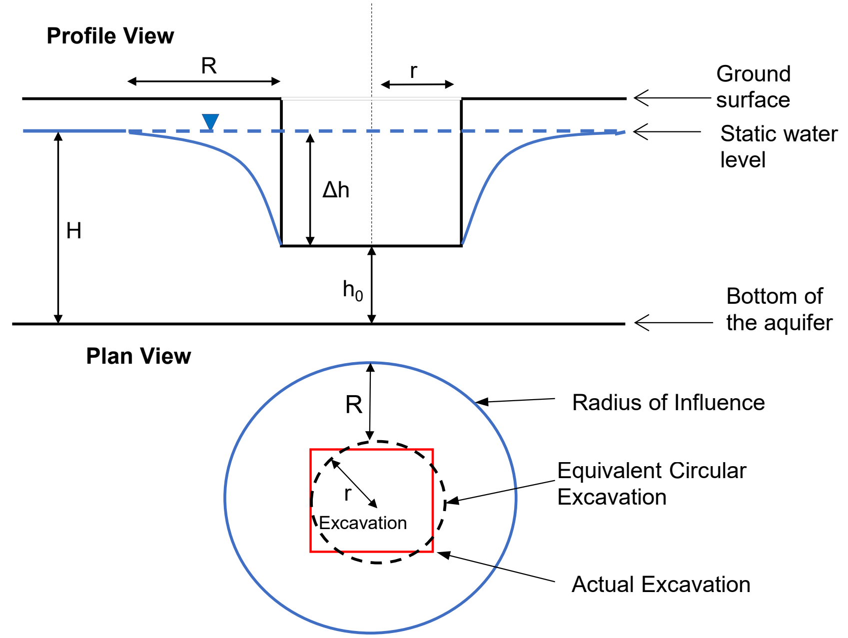
R = Distance from edge of excavation where drawdown is negligible (m)
C = Situation Factor (C = 3 for flow to a well; C = 1.5 to 2 for single line of well points)
H = Water head outside distance R from open circular excavation (m)
h_0 = Water head inside open circular excavation (m)
k = Coefficient of permeability (cm/sec)

Gravity flow to Open Circular Excavation/Well (Driscoll, 1986)

$$Q = \frac{k(H^2 - h_0^2)}{0.733 \log(R/r)}$$

Variables and Units

Q = Flow into open excavation (m^3/day)
k = Coefficient of permeability (m/day)
R = Radius of influence (m)
H = Water head outside distance R from open excavation (m)
h_0 = Water head at base of excavation (m)
r = Radius of equivalent circular excavation/well (m)
L = Length of excavation (m)
W = Width of excavation (m)



Data Entry

Radius of Influence Equation		Flow to Open Equation	
Variable	Input	Variable	Input
C	3.0	k	7.8 m/day
H	5.5 m	L	100 m
h_0	2.0 m	W	100 m
k	0.009 cm/sec		

Results

Radius of Equivalent Circular Excavation (r)	**56.1 m**
Radius of Influence From Edge of Excavation	**99.6 m**
Flow to Open Excavation	**628 (m^3/day)**

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Groundwater Flow Estimates To Open Excavation - Source 1 (geometric mean k)

Project: 100737.002

Date: Feb 2023

Radius of Influence Equation
(Leonards, 1962)

$$R=100 \cdot C \cdot (H-h_0) \cdot \sqrt{k}$$

Variables and Units

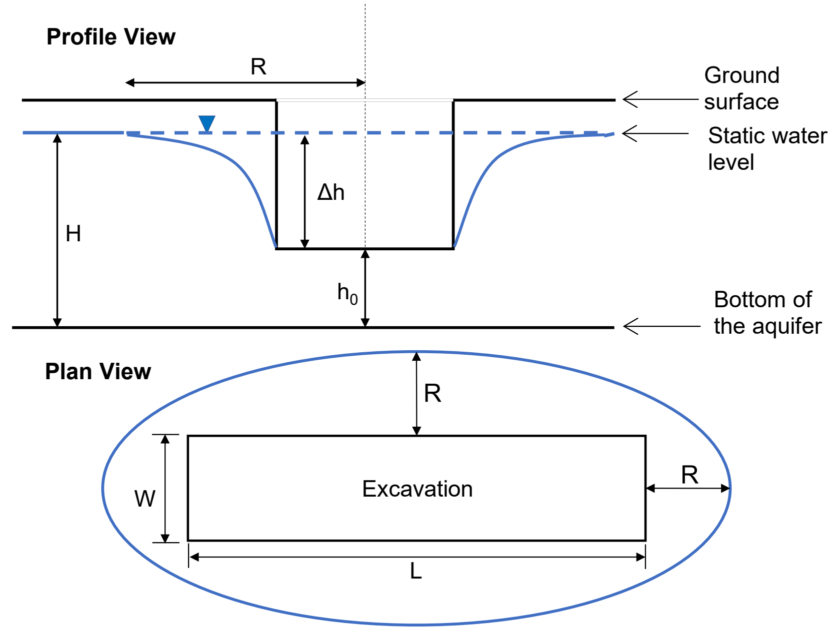
R = Distance from edge of excavation where drawdown is negligible (m)

C = Situation Factor (C = 3 for flow to a well; C = 1.5 to 2 for single line of well points)

H = Water head outside distance R from open slot excavation (m)

h_0 = Water head inside open slot excavation (m)

k = Coefficient of permeability (cm/sec)



Gravity flow to Slot/Open Trench Equation (Driscoll, 1986)

Gravity flow to Slot/Open Trench Equation (Powers, 2007)

$$Q=\pi k(H^2-h_0^2)/\ln(L/r_s) +2(xk(H^2-h_0^2)/2L)$$

Variables and Units

Q = Groundwater flow rate (m^3/day)

k = hydraulic conductivity m/s

x = Length of open excavation (m)

L = Radius of influence (m)

H = Water table at L (m)

h_0 = target groundwater level at excavation (m)

rs = Radius of the well approximation (half of excavation width) (m)

Data Entry

Radius of Influence Equation		Flow to Open Trench Equation	
Variable	Input	Variable	Input
C	3.0	k	0.2 m/day
H	7.0 m	x	30.0 m
h_0	2.0 m	w	4.5 m
k	0.0002 cm/sec		

Results

Radius of Influence (L)	**21 m**
Flow to Open Trench Equation	**22 (m^3/day)**

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Groundwater Flow Estimates - SWMP 1 (geometric mean k)

Radius of Influence Equation
(Leonards, 1962)

$$R = 100 \cdot C \cdot (H - h_0) \cdot \sqrt{k}$$

Variables and Units

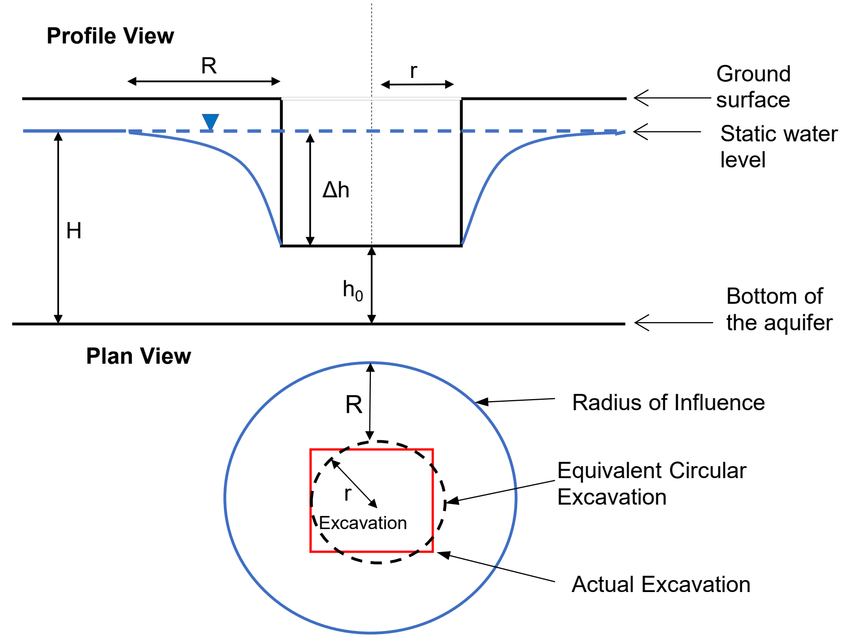
R = Distance from edge of excavation where drawdown is negligible (m)
C = Situation Factor (C = 3 for flow to a well; C = 1.5 to 2 for single line of well points)
H = Water head outside distance R from open circular excavation (m)
h_0 = Water head inside open circular excavation (m)
k = Coefficient of permeability (cm/sec)

Gravity flow to Open Circular Excavation/Well (Driscoll, 1986)

$$Q = \frac{k(H^2 - h_0^2)}{0.733 \log(R/r)}$$

Variables and Units

Q = Flow into open excavation (m^3/day)
k = Coefficient of permeability (m/day)
R = Radius of influence (m)
H = Water head outside distance R from open excavation (m)
h_0 = Water head at base of excavation (m)
r = Radius of equivalent circular excavation/well (m)
L = Length of excavation (m)
W = Width of excavation (m)



Data Entry

Radius of Influence Equation		Flow to Open Equation	
Variable	Input	Variable	Input
C	3.0	k	0.2 m/day
H	4 m	L	69 m
h_0	2.0 m	W	69 m
k	0.0002 cm/sec		

Results

Radius of Equivalent Circular Excavation (r)	**38.7 m**
Radius of Influence From Edge of Excavation	**8.5 m**
Flow to Open Excavation	**33 (m^3/day)**

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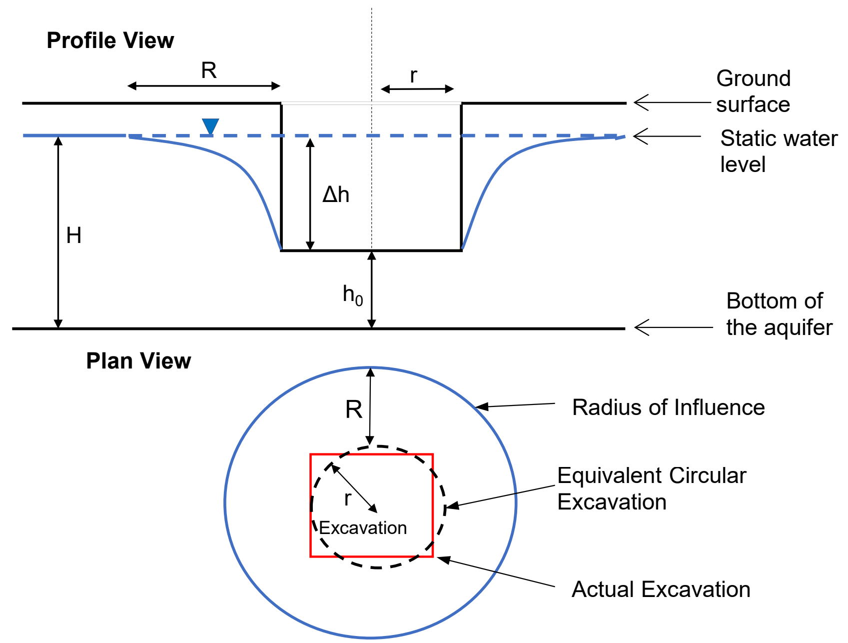
Groundwater Flow Estimates - SWMP 2 (geometric mean k)



Radius of Influence Equation
(Leonards, 1962)

$$R = 100 \cdot C \cdot (H - h_0) \cdot \sqrt{k}$$

Variables and Units

R = Distance from edge of excavation where drawdown is negligible (m)

C = Situation Factor (C = 3 for flow to a well; C = 1.5 to 2 for single line of well points)

H = Water head outside distance R from open circular excavation (m)

h_0 = Water head inside open circular excavation (m)

k = Coefficient of permeability (cm/sec)

Gravity flow to Open Circular Excavation/Well (Driscoll, 1986)

$$Q = \frac{k(H^2 - h_0^2)}{0.733 \log(R/r)}$$

Variables and Units

Q = Flow into open excavation (m^3/day)

k = Coefficient of permeability (m/day)

R = Radius of influence (m)

H = Water head outside distance R from open excavation (m)

h_0 = Water head at base of excavation (m)

r = Radius of equivalent circular excavation/well (m)

L = Length of excavation (m)

W = Width of excavation (m)

Data Entry

Radius of Influence Equation		Flow to Open Equation	
Variable	Input	Variable	Input
C	3.0	k	0.2 m/day
H	4 m	L	92 m
h_0	2.0 m	W	92 m
k	0.0002 cm/sec		

Results

Radius of Equivalent Circular Excavation (r)	**51.9 m**
Radius of Influence From Edge of Excavation	**8.5 m**
Flow to Open Excavation	**43 (m^3/day)**

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Groundwater Flow Estimates - SWMP 3 (geometric mean k)

Radius of Influence Equation
(Leonards, 1962)

$$R = 100 \cdot C \cdot (H - h_0) \cdot \sqrt{k}$$

Variables and Units

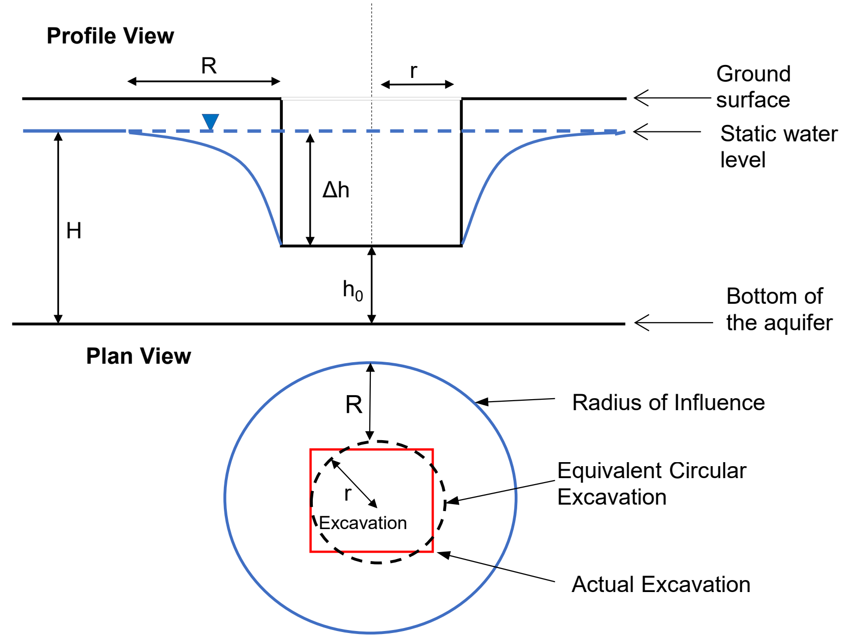
R = Distance from edge of excavation where drawdown is negligible (m)

C = Situation Factor (C = 3 for flow to a well; C = 1.5 to 2 for single line of well points)

H = Water head outside distance R from open circular excavation (m)

h_0 = Water head inside open circular excavation (m)

k = Coefficient of permeability (cm/sec)



Gravity flow to Open Circular Excavation/Well (Driscoll, 1986)

$$Q = \frac{k(H^2 - h_0^2)}{0.733 \log(R/r)}$$

Variables and Units

Q = Flow into open excavation (m^3/day)

k = Coefficient of permeability (m/day)

R = Radius of influence (m)

H = Water head outside distance R from open excavation (m)

h_0 = Water head at base of excavation (m)

r = Radius of equivalent circular excavation/well (m)

L = Length of excavation (m)

W = Width of excavation (m)

Data Entry

Radius of Influence Equation		Flow to Open Equation	
Variable	Input	Variable	Input
C	3.0	k	0.2 m/day
H	4 m	L	100 m
h_0	2.0 m	W	100 m
k	0.0002 cm/sec		

Results

Radius of Equivalent Circular Excavation (r)	**56.1 m**
Radius of Influence From Edge of Excavation	**8.5 m**
Flow to Open Excavation	**46 (m^3/day)**

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APPENDIX I

Water Quality Results and Laboratory Certificates

Report to: Caivan (Perth GC) Limited
Project: 100737.002 (February 22, 2023)

Labratory Analytical Results
141 Peter Street

Parameter	City of Perth Storm Sewer Discharge By-Law 4819	City of Perth Sanitary and Combined Sewer By-Law 4819	MDL	Sample ID: Laboratory ID: Date (mm/dd/yyyy): Units	BH22-221 2208363-01 02/16/2022	BH-225 2208363-02 02/16/2022	BH-228 2208363-03 02/16/2022	BH22-221 Filtered 2208363-04 02/16/2022	BH22-225 Filtered 2208363-05 02/16/2022	BH22-228 Filtered 2208363-06 02/16/2022
Microbiological Parameters										
E. Coli		-	1	CFU/100mL	ND (10)	ND (10)	ND (10)	-	-	-
General Inorganics										
BOD	15	300	2	mg/L	14	ND (2)	180	-	-	-
Cyanide, total	0.008	2	0.01	mg/L	ND (0.01)	ND (0.01)	ND (0.01)	-	-	-
pH	NV	NV	0.1	pH Units	8.0	7.7	7.8	-	-	-
Phenolics	0.008	1	0.001	mg/L	ND (0.001)	ND (0.001)	ND (0.001)	-	-	-
Phosphorus, total	0.4	10	0.01	mg/L	0.03	0.01	0.05	-	-	-
Total Suspended Solids	NV	NV	2	mg/L	12	23	26	-	-	-
Metals - Filtered										
Arsenic	NV	NV	10	ug/L	-	-	-	ND (10)	ND (10)	ND (10)
Cadmium	NV	NV	1	ug/L	-	-	-	ND (1)	ND (1)	ND (1)
Chromium	NV	NV	50	ug/L	-	-	-	ND (50)	ND (50)	ND (50)
Copper	NV	NV	5	ug/L	-	-	-	ND (5)	ND (5)	ND (5)
Lead	NV	NV	1	ug/L	-	-	-	ND (1)	ND (1)	ND (1)
Manganese	NV	NV	50	ug/L	-	-	-	56	1310	812
Nickel	NV	NV	5	ug/L	-	-	-	ND (5)	ND (5)	7
Selenium	NV	NV	5	ug/L	-	-	-	ND (5)	ND (5)	ND (5)
Silver	NV	NV	1	ug/L	-	-	-	ND (1)	ND (1)	ND (1)
Zinc	NV	NV	20	ug/L	-	-	-	ND (20)	ND (20)	ND (20)
Metals - Total										
Arsenic	0.02	1	0.01	mg/L	ND (0.01)	ND (0.01)	ND (0.01)	-	-	-
Cadmium	0.008	0.2	0.001	mg/L	ND (0.001)	ND (0.001)	ND (0.001)	-	-	-
Chromium	0.08	0.5	0.05	mg/L	ND (0.05)	ND (0.05)	ND (0.05)	-	-	-
Copper	0.04	2	0.005	mg/L	ND (0.005)	ND (0.005)	0.006	-	-	-
Lead	0.12	1	0.001	mg/L	ND (0.001)	ND (0.001)	ND (0.001)	-	-	-
Manganese	0.05	5	0.05	mg/L	0.08	**1.92**	**1.53**	-	-	-
Mercury	0.0004	0.1	0.0001	mg/L	ND (0.0001)	ND (0.0001)	ND (0.0001)	-	-	-
Nickel	0.08	2	0.005	mg/L	ND (0.005)	ND (0.005)	0.010	-	-	-
Selenium	0.02	1	0.005	mg/L	ND (0.005)	ND (0.005)	ND (0.005)	-	-	-
Silver	0.12	5	0.001	mg/L	ND (0.001)	ND (0.001)	ND (0.001)	-	-	-
Zinc	0.04	2	0.02	mg/L	0.02	0.03	0.03	-	-	-
Volatiles										
Benzene	0.002	0.01	0.0005	mg/L	ND (0.0005)	ND (0.0005)	ND (0.0005)	-	-	-
Chloroform	0.002	0.04	0.0005	mg/L	0.0014	ND (0.0005)	ND (0.0005)	-	-	-
1,2-Dichlorobenzene	0.005	0.05	0.0005	mg/L	ND (0.0005)	ND (0.0005)	ND (0.0005)	-	-	-
1,4-Dichlorobenzene	0.008	0.08	0.0005	mg/L	ND (0.0005)	ND (0.0005)	ND (0.0005)	-	-	-
cis-1,2-Dichloroethylene	0.006	0.4	0.0005	mg/L	ND (0.0005)	ND (0.0005)	ND (0.0005)	-	-	-
trans-1,3-Dichloropropylene	0.006	0.14	0.0005	mg/L	ND (0.0005)	ND (0.0005)	ND (0.0005)	-	-	-
Ethylbenzene	0.002	0.06	0.0005	mg/L	ND (0.0005)	ND (0.0005)	ND (0.0005)	-	-	-
Methyl Ethyl Ketone (2-Butanone)	NV	8	0.0050	mg/L	ND (0.0050)	ND (0.0050)	ND (0.0050)	-	-	-

Labratory Analytical Results
141 Peter Street

Parameter	City of Perth Storm Sewer Discharge By-Law 4819	City of Perth Sanitary and Combined Sewer By-Law 4819	MDL	Sample ID: Laboratory ID: Date (mm/dd/yyyy): Units	BH22-221 2208363-01 02/16/2022	BH-225 2208363-02 02/16/2022	BH-228 2208363-03 02/16/2022	BH22-221 Filtered 2208363-04 02/16/2022	BH22-225 Filtered 2208363-05 02/16/2022	BH22-228 Filtered 2208363-06 02/16/2022
Methylene Chloride	0.006	0.21	0.0050	mg/L	ND (0.0050)	ND (0.0050)	ND (0.0050)	-	-	-
Styrene	NV	0.04	0.0005	mg/L	ND (0.0005)	ND (0.0005)	ND (0.0005)	-	-	-
1,1,2,2-Tetrachloroethane	0.017	0.9	0.0005	mg/L	ND (0.0005)	ND (0.0005)	ND (0.0005)	-	-	-
Tetrachloroethylene	0.004	0.5	0.0005	mg/L	ND (0.0005)	ND (0.0005)	ND (0.0005)	-	-	-
Toluene	0.002	0.016	0.0005	mg/L	ND (0.0005)	ND (0.0005)	ND (0.0005)	-	-	-
Trichloroethylene	0.007	0.07	0.0005	mg/L	ND (0.0005)	ND (0.0005)	ND (0.0005)	-	-	-
Xylenes, total	0.004	0.94	0.0005	mg/L	ND (0.0005)	ND (0.0005)	ND (0.0005)	-	-	-
Pesticides, OC										
Aldrin	0.08	0.2	0.01	ug/L	ND (0.01)	ND (0.01)	ND (0.01)	-	-	-
Dieldrin	0.08	0.2	0.01	ug/L	ND (0.01)	ND (0.01)	ND (0.01)	-	-	-
Hexachlorobenzene	0.04	0.1	0.01	ug/L	ND (0.01)	ND (0.01)	ND (0.01)	-	-	-
PCBs										
PCBs, total	0.4	1	0.05	ug/L	ND (0.05)	ND (0.05)	0.26	-	-	-

Notes:
'NV' - No Standard Established
'MDL' - Method Detection Limit
'-' - No Value Available
'ND" - Non-Detect Sample
Bolded - Exceeds City of Perth Storm Sewer Discharge By-Law 4819

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Summary of Analytical Results in Groundwater
Metals and Inorganics
Proposed Residential Development
Perth, Ontario

Sample ID / Sampling Date	CCME Fresh Water Aquatic	MECP TABLE 6 STANDARD	MECP TABLE 1 STANDARD	REPORTING LIMIT	UNITS	BH22-201 8-Feb-2022	BH22-203A 8-Feb-2022	DUP 1 Duplicate of BH22-203A 8-Feb-2022	BH22-205 8-Feb-2022	BH22-208 8-Feb-2022	BH22-214 8-Feb-2022
Metals and Inorganics											
Antimony	NV	6	1.5	0.5	µg/L	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Arsenic	5	25	13	1	µg/L	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)
Barium	NV	1,000	610	1	µg/L	106	113	114	125	67	130
Beryllium	NV	4	0.5	0.5	µg/L	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Boron (Total)	1500	5,000	1,700	10	µg/L	104	59	59	48	23	ND (10)
Cadmium	0.017	2	0.5	0.1	µg/L	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Chromium	NV	50	11	1	µg/L	ND (1)	ND (1)	ND (1)	ND (1)	1	ND (1)
Cobalt	NV	4	3.8	0.5	µg/L	2.3	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Copper	2	69	5	0.5	µg/L	4.2	1.7	3.2	ND (0.5)	**7.8**	1.2
Lead	1	10	1.9	0.1	µg/L	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	0.2	ND (0.1)
Molybdenum	73	70	23	0.5	µg/L	5.6	3.5	3.5	9.9	0.6	2
Nickel	NV	100	14	1	µg/L	**29**	2	2	ND (1)	2	ND (1)
Selenium	1	10	5	1	µg/L	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)
Silver	0.25	1	0.3	0.1	µg/L	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Thallium	0.8	2	0.5	0.1	µg/L	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Vanadium	NV	6	3.9	0.5	µg/L	ND (0.5)	1.5	1.5	0.6	1.5	ND (0.5)
Zinc	30	890	160	5	µg/L	8	5	6	ND (5)	9	ND (5)
pH	NV	5 to 9	7-9	0.1	pH Units	7.7	N/A	N/A	N/A	N/A	N/A
Sodium	NV	490,000	490,000	200	µg/L	36,400	12,900	12,400	13,700	5,600	6,630
Uranium	15	20	8.9	0.1	µg/L	0.8	8	8.1	0.4	1	0.7

Notes:
'NV ' : No Standard established
'NA': Parameter not analyzed

CCME Fresh Water Aquatic Standards: "Guidelines are intended to protect all forms of aquatic life and all aspects of aquatic life cycles, including the most senstivie life stage of the most sensitive species over the long term from anthropogenic stressors such as checmical inputs or changes to physical components."

MECP Table 1: Ontario Ministry of the Environment, "Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act, " March 2004, amended July 1, 2011. Full Depth Background Site Condition Standards for Soil for Residential/Parkland/Institutional/Industrial/Commercial/Community Property Use.

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100	Exceeds CCME Fresh W Standards
100	Exceeds MECP Table 1 Standards
100	Exceeds MECP Table 6 Standards

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Summary of Analytical Results in Groundwater
Metals and Inorganics
Proposed Residential Development
Perth, Ontario

Sample ID / Sampling Date	CCME Fresh Water Aquatic	MECP TABLE 6 STANDARD	MECP TABLE 1 STANDARD	REPORTING LIMIT	BH22-216 8-Feb-2022	BH22-221A 8-Feb-2022	BH22-222A 8-Feb-2022	BH22-223 8-Feb-2022	BH22-224 8-Feb-2022	DUP 2 Duplicate of BH22-224 8-Feb-2022	BH22-225A 9-Feb-2022
Metals and Inorganics											
Antimony	NV	6	1.5	0.5	ND (0.5)	ND (0.5)	ND (0.5)	1.2	ND (0.5)	ND (0.5)	ND (0.5)
Arsenic	5	25	13	1	ND (1)	ND (1)	ND (1)	1	2	1	ND (1)
Barium	NV	1,000	610	1	76	32	55	80	320	316	365
Beryllium	NV	4	0.5	0.5	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Boron (Total)	1500	5,000	1,700	10	24	ND (10)	21	183	13	12	ND (10)
Cadmium	0.017	2	0.5	0.1	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Chromium	NV	50	11	1	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)
Cobalt	NV	4	3.8	0.5	ND (0.5)	1.2	0.9	0.6	**6.1**	**6.3**	**6.8**
Copper	2	69	5	0.5	1.5	**12.5**	**5.9**	2	2.5	ND (0.5)	4.4
Lead	1	10	1.9	0.1	ND (0.1)	ND (0.1)	0.2	ND (0.1)	ND (0.1)	ND (0.1)	0.1
Molybdenum	73	70	23	0.5	1.4	2.3	5.5	8.6	2.8	2.8	1.7
Nickel	NV	100	14	1	ND (1)	2	1	4	10	10	6
Selenium	1	10	5	1	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)	ND (1)
Silver	0.25	1	0.3	0.1	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Thallium	0.8	2	0.5	0.1	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
Vanadium	NV	6	3.9	0.5	1.1	ND (0.5)	ND (0.5)	2	ND (0.5)	ND (0.5)	ND (0.5)
Zinc	30	890	160	5	ND (5)	ND (5)	6	12	ND (5)	ND (5)	ND (5)
pH	NV	5 to 9	7-9	0.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sodium	NV	490,000	490,000	200	6,320	13,100	15,500	40,900	18,700	18,000	4,700
Uranium	15	20	8.9	0.1	**14**	1.4	**12.8**	**9.7**	2.1	2.2	1.6

Notes:
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Summary of Analytical Results in Groundwater
Metals and Inorganics
Proposed Residential Development
Perth, Ontario

Sample ID / Sampling Date	CCME Fresh Water Aquatic	MECP TABLE 6 STANDARD	MECP TABLE 1 STANDARD	REPORTING LIMIT	BH22-228A 8-Feb-2022
Metals and Inorganics					
Antimony	NV	6	1.5	0.5	1
Arsenic	5	25	13	1	3
Barium	NV	1,000	610	1	454
Beryllium	NV	4	0.5	0.5	ND (0.5)
Boron (Total)	1500	5,000	1,700	10	69
Cadmium	0.017	2	0.5	0.1	ND (0.1)
Chromium	NV	50	11	1	ND (1)
Cobalt	NV	4	3.8	0.5	0.7
Copper	2	69	5	0.5	**5.6**
Lead	1	10	1.9	0.1	0.2
Molybdenum	73	70	23	0.5	7
Nickel	NV	100	14	1	3
Selenium	1	10	5	1	ND (1)
Silver	0.25	1	0.3	0.1	ND (0.1)
Thallium	0.8	2	0.5	0.1	ND (0.1)
Vanadium	NV	6	3.9	0.5	0.5
Zinc	30	890	160	5	11
pH	NV	5 to 9	7-9	0.1	N/A
Sodium	NV	490,000	490,000	200	23,300
Uranium	15	20	8.9	0.1	**295**

Notes:
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Summary of Analytical Results in Groundwater
PHCs and BTEX
Proposed Residential Development
Perth, Ontario

Sample ID / Sampling Date	CCME Fresh Water Aquatic	MECP TABLE 6 STANDARD	MECP TABLE 1 STANDARD	REPORTING LIMIT	UNITS	BH22-201 8-Feb-2022	BH22-203A 8-Feb-2022	DUP 1 Duplicate of BH22-203A 8-Feb-2022	BH22-205 8-Feb-2022	BH22-208 8-Feb-2022
Petroleum Hydrocarbon Compounds (PHCs)										
F1 (C6-C10)	NV	420	420	25	µg/L	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)
F2 (C10-C16)	NV	150	150	100	µg/L	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)
F3 (C16-C34)	NV	500	500	250	µg/L	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)
F4 (C34-C50)	NV	500	500	250	µg/L	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)
Volatile Organic Compounds (VOCs)										
Benzene	370	0.5	0.5	0.5	µg/L	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Ethylbenzene	90	2.4	0.5	0.5	µg/L	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Toluene	2	24	0.8	0.5	µg/L	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
m-Xylene & p-Xylene	NV	NV	NV	0.4	µg/L	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
o-Xylene	NV	NV	NV	0.3	µg/L	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Total Xylenes	NV	72	72	0.5	µg/L	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)

Notes:
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'NA': Parameter not analyzed
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Summary of Analytical Results in Groundwater
PHCs and BTEX
Proposed Residential Development
Perth, Ontario

Sample ID / Sampling Date	CCME Fresh Water Aquatic	MECP TABLE 6 STANDARD	MECP TABLE 1 STANDARD	REPORTING LIMIT	UNITS	BH22-214 8-Feb-2022	BH22-216 8-Feb-2022	BH22-221A 8-Feb-2022	BH22-222A 8-Feb-2022	BH22-223 8-Feb-2022
Petroleum Hydrocarbon Compounds (PHCs)										
F1 (C6-C10)	NV	420	420	25	µg/L	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)
F2 (C10-C16)	NV	150	150	100	µg/L	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)
F3 (C16-C34)	NV	500	500	250	µg/L	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)
F4 (C34-C50)	NV	500	500	250	µg/L	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)
Volatile Organic Compounds (VOCs)										
Benzene	370	0.5	0.5	0.5	µg/L	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Ethylbenzene	90	2.4	0.5	0.5	µg/L	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Toluene	2	24	0.8	0.5	µg/L	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
m-Xylene & p-Xylene	NV	NV	NV	0.4	µg/L	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
o-Xylene	NV	NV	NV	0.3	µg/L	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Total Xylenes	NV	72	72	0.5	µg/L	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)

Notes:

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Summary of Analytical Results in Groundwater
PHCs and BTEX
Proposed Residential Development
Perth, Ontario

Sample ID / Sampling Date	CCME Fresh Water Aquatic	MECP TABLE 6 STANDARD	MECP TABLE 1 STANDARD	REPORTING LIMIT	UNITS	BH22-224 8-Feb-2022	DUP 2 Duplicate of BH22-224 8-Feb-2022	BH22-225A 9-Feb-2022	BH22-228A 8-Feb-2022	Trip Blank 8-Feb-2022
Petroleum Hydrocarbon Compounds (PHCs)										
F1 (C6-C10)	NV	420	420	25	µg/L	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)
F2 (C10-C16)	NV	150	150	100	µg/L	ND (100)	ND (100)	ND (100)	ND (100)	N/A
F3 (C16-C34)	NV	500	500	250	µg/L	ND (100)	ND (100)	ND (100)	ND (100)	N/A
F4 (C34-C50)	NV	500	500	250	µg/L	ND (100)	ND (100)	ND (100)	ND (100)	N/A
Volatile Organic Compounds (VOCs)										
Benzene	370	0.5	0.5	0.5	µg/L	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Ethylbenzene	90	2.4	0.5	0.5	µg/L	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Toluene	2	24	0.8	0.5	µg/L	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
m-Xylene & p-Xylene	NV	NV	NV	0.4	µg/L	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
o-Xylene	NV	NV	NV	0.3	µg/L	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)
Total Xylenes	NV	72	72	0.5	µg/L	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)

Notes:

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100		Exceeds MECP Table 1 Standards
100		Exceeds MECP Table 6 Standards

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Summary of Analytical Results in Groundwater
PHCs and BTEX
Proposed Residential Development
Perth, Ontario

Sample ID / Sampling Date	CCME Fresh Water Aquatic	MECP TABLE 6 STANDARD	MECP TABLE 1 STANDARD	REPORTING LIMIT	UNITS	Trip Blank / 8-Feb-2022
Petroleum Hydrocarbon Compounds (PHCs)						
F1 (C6-C10)	NV	420	420	25	µg/L	ND (25)
F2 (C10-C16)	NV	150	150	100	µg/L	N/A
F3 (C16-C34)	NV	500	500	250	µg/L	N/A
F4 (C34-C50)	NV	500	500	250	µg/L	N/A
Volatile Organic Compounds (VOCs)						
Benzene	370	0.5	0.5	0.5	µg/L	ND (0.5)
Ethylbenzene	90	2.4	0.5	0.5	µg/L	ND (0.5)
Toluene	2	24	0.8	0.5	µg/L	ND (0.5)
m-Xylene & p-Xylene	NV	NV	NV	0.4	µg/L	ND (0.5)
o-Xylene	NV	NV	NV	0.3	µg/L	ND (0.5)
Total Xylenes	NV	72	72	0.5	µg/L	ND (0.5)

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100 (blue)	Exceeds CCME Fresh Water Aquatic Standards
100	Exceeds MECP Table 1 Standards
100 (red)	Exceeds MECP Table 6 Standards

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Table : Summary of Analytical Results in Groundwater
OC Pesticides

Sample ID / Sampling Date	CCME Fresh Water Aquatic	MECP TABLE 6 STANDARD	MECP TABLE 1 STANDARD	REPORTING LIMIT	UNITS	BH22-214 8-Feb-2022	BH22-223 8-Feb-2022	BH22-224 8-Feb-2022	DUP 2 Duplicate of BH22-224 8-Feb-2022	BH22-228A 8-Feb-2022
Organochlorine Pesticides										
Aldrin	NV	0.35	0.01	0.008	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
gamma-hexachlorocyclohexane	NV	0.95	0.01	0.008	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
a-chlordane	NV	NV	NV	0.008	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Chlordane (Total)	NV	0.06	0.06	0.011	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
g-chlordane	NV	NV	NV	0.008	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
op-DDD	NV	NV	NV	0.004	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
pp-DDD	NV	NV	NV	0.004	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Total DDD	NV	1.8	1.8	0.0057	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
o,p-DDE	NV	NV	NV	0.004	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
pp-DDE	NV	NV	NV	0.004	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Total DDE	NV	10	10	0.0057	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
op-DDT	NV	NV	NV	0.004	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
pp-DDT	NV	NV	NV	0.004	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Total DDT	NV	0.05	0.05	0.0057	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Dieldrin	NV	0.35	0.05	0.008	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Endosulfan I	NV	NV	NV	0.007	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Endosulfan II	NV	NV	NV	0.007	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Endosulfan (Total)	NV	0.56	0.05	0.0099	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Endrin	NV	0.36	0.05	0.01	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Heptachlor	NV	0.038	0.01	0.008	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Heptachlor Epoxide	NV	0.038	0.01	0.008	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Hexachlorobenzene	NV	1	0.01	0.008	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Hexachlorobutadiene	1.3	0.012	0.01	0.008	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Hexachloroethane	NV	0.17	0.01	0.008	µg/L	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Methoxychlor	NV	0.3	0.05	0.019	µg/L	ND (0.01)	ND (0.01)	0.03	ND (0.01)	ND (0.01)

Notes:

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100		Exceeds CCME Fresh Water Aquatic Standards
100		Exceeds MECP Table 1 Standards
100		Exceeds MECP Table 6 Standards

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Subcontracted Analysis

GEMTEC Consulting Engineers and Scientists Limited
32 Steacie Drive
Kanata, ON K2K 2A9
Attn: Andrius Paznekas

Paracel Report No.	**2208363**	Order Date:	17-Feb-22
Client Project(s):	**100737.002**	Report Date:	01-Mar-22
Client PO:			
Reference:	**Standing Offer - 2015**		
CoC Number:	**53281**		

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor's report is attached

Paracel ID	**Client ID**	**Analysis**
2208363-01	BH22-221	Perth - Storm Nonylphenols + Ethoxolates SU - Storm: PAHs
2208363-02	BH22-225	Perth - Storm Nonylphenols + Ethoxolates SU - Storm: PAHs
2208363-03	BH22-228	Perth - Storm Nonylphenols + Ethoxolates SU - Storm: PAHs

PARACEL LABORATORIES LTD (Ottawa-London-Kingston)
ATTN: Mark Foto
300-2319 St. Laurent Blvd.
Ottawa ON K1G 4J8

Date Received: 18-FEB-22
Report Date: 25-FEB-22 11:51 (MT)
Version: FINAL

Client Phone: 613-731-9577

Certificate of Analysis

Lab Work Order #: L2687137
Project P.O. #: NOT SUBMITTED
Job Reference: 2208363
C of C Numbers:
Legal Site Desc:

Costas Farassoglou
Account Manager

2208363

ANALYTICAL GUIDELINE REPORT

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits #1	#2
L2687137-1 BH22-221								
Sampled By: CLIENT on 16-FEB-22 @ 14:40								
Matrix: WATER							#1	#2
Organic Parameters								
	Nonylphenol	9.7		1.0	ug/L	23-FEB-22		
	Nonylphenol Diethoxylates	<0.10		0.10	ug/L	23-FEB-22		
	Total Nonylphenol Ethoxylates	<2.0		2.0	ug/L	23-FEB-22	200	
	Nonylphenol Monoethoxylates	<2.0		2.0	ug/L	23-FEB-22		
L2687137-2 BH22-225								
Sampled By: CLIENT on 16-FEB-22 @ 11:50								
Matrix: WATER							#1	#2
Organic Parameters								
	Nonylphenol	<1.0		1.0	ug/L	23-FEB-22		
	Nonylphenol Diethoxylates	<0.10		0.10	ug/L	23-FEB-22		
	Total Nonylphenol Ethoxylates	<2.0		2.0	ug/L	23-FEB-22	200	
	Nonylphenol Monoethoxylates	<2.0		2.0	ug/L	23-FEB-22		
L2687137-3 BH22-228								
Sampled By: CLIENT on 16-FEB-22 @ 16:40								
Matrix: WATER							#1	#2
Organic Parameters								
	Nonylphenol	33	DLHC	10	ug/L	23-FEB-22		
	Nonylphenol Diethoxylates	<0.10		0.10	ug/L	23-FEB-22		
	Total Nonylphenol Ethoxylates	<2.0		2.0	ug/L	23-FEB-22	200	
	Nonylphenol Monoethoxylates	<2.0		2.0	ug/L	23-FEB-22		

** Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
* Analytical result for this parameter exceeds Guideline Limit listed on this report. Guideline Limits applied:

Ontario Perth Sanitary and Storm Sewer By-Law 4819 (AUG,2019) = [Suite] - Ontario Perth-Sanitary and Storm Sewer Use Limits

#1: Ontario Town of Perth Sanitary Sewer By-Law 4819 (AUG,2019) **#2: Ontario Town of Perth Storm Sewer By-Law 2066 (OCT, 2008)**

Reference Information

Sample Parameter Qualifier key listed:

Qualifier	Description
DLHC	Detection Limit Raised: Dilution required due to high concentration of test analyte(s).

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Method Reference***
NP,NPE-LCMS-WT	Water	Nonylphenols and Ethoxylates by LC/MS-MS	J. Chrom A849 (1999) p.467-482

Water samples are filtered and analyzed on LCMS/MS by direct injection.

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

Chain of Custody numbers:

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

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA		

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Application of guidelines is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to, fitness for a particular purpose, or non-infringement. ALS assumes no responsibility for errors or omissions in the information. Guideline limits are not adjusted for the hardness, pH or temperature of the sample (the most conservative values are used). Measurement uncertainty is not applied to test results prior to comparison with specified criteria values.

Quality Control Report

Client: PARACEL LABORATORIES LTD (Ottawa-London-Kingston)
300-2319 St. Laurent Blvd.
Ottawa ON K1G 4J8

Contact: Mark Foto

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NP,NPE-LCMS-WT	**Water**							
Batch R5728992								
WG3698923-3 DUP		**L2687062-8**						
Nonylphenol		<1.0	<1.0	RPD-NA	ug/L	N/A	30	24-FEB-22
Nonylphenol Monoethoxylates		<2.0	<2.0	RPD-NA	ug/L	N/A	30	24-FEB-22
Nonylphenol Diethoxylates		<0.10	<0.10	RPD-NA	ug/L	N/A	30	24-FEB-22
WG3698923-2 LCS								
Nonylphenol			96.4		%		75-125	24-FEB-22
Nonylphenol Monoethoxylates			95.9		%		75-125	24-FEB-22
Nonylphenol Diethoxylates			91.3		%		75-125	24-FEB-22
WG3698923-1 MB								
Nonylphenol			<1.0		ug/L		1	24-FEB-22
Nonylphenol Monoethoxylates			<2.0		ug/L		2	24-FEB-22
Nonylphenol Diethoxylates			<0.10		ug/L		0.1	24-FEB-22
WG3698923-4 MS		**L2687062-8**						
Nonylphenol			109.4		%		60-140	24-FEB-22
Nonylphenol Monoethoxylates			132.2		%		60-140	24-FEB-22
Nonylphenol Diethoxylates			103.3		%		60-140	24-FEB-22

Client: PARACEL LABORATORIES LTD (Ottawa-London-Kingston)
300-2319 St. Laurent Blvd.
Ottawa ON K1G 4J8
Contact: Mark Foto

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

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Subcontract Order

SENDING LABORATORY:

Paracel Laboratories Ltd.
300-2319 St. Laurent Blvd.
Ottawa, ON K1G 4J8
Phone: 613-731-9577
Fax: 613-731-9064

RECEIVING LABORATORY:

ALS Laboratory Group (Ottawa)
7-190 Colonnade Rd
Ottawa, ON K2E7J5
Phone: (613) 225-8279
Fax: (613) 225-2801

INVOICE TO:

Paracel Laboratories Ltd.
300-2319 St. Laurent Blvd.
Ottawa, ON K1G 4J8
Phone: 613-731-9577
Fax: 613-731-9064

Date Requested: **17-Feb-22**
Project Number: **2208363**
Submitted By: **Bernice Samuel**

Required Regulation	SU - Perth
Turnaround Time	standard

Sample ID	Matrix	Analyses Requested:	Sampled	Comments
BH22-221	Water	Perth - Storm Nonylphenols + Ethoxolates	16-Feb-22 14:40	
BH22-225	Water	Perth - Storm Nonylphenols + Ethoxolates	16-Feb-22 11:50	
BH22-228	Water	Perth - Storm Nonylphenols + Ethoxolates	16-Feb-22 16:40	

L2687137

L2687137-COFC

Please email all results to mfoto@paracellabs.com, dbloom@paracellabs.com, drobertson@paracellabs.com

Released By: [signature] Date / Time: Feb 18 2022 8:10 Received By: [signature] Date: 2/18/22

Temperature prior to Shipping: 5.8°C 7.6°C 10:00AM

AP 22-Feb-22 9:00 4.6°C

TESTMARK Laboratories Ltd.
Committed to Quality and Service

CERTIFICATE OF ANALYSIS

Client:	Dale Robertson	Work Order Number:	455542
Company:	Paracel Laboratories Ltd. - Ottawa	PO #:	
Address:	300-2319 St. Laurent Blvd. Ottawa, ON, K1G 4J8	Regulation:	Sewer Use By-Law - Perth Schedule A Sanitary and Combined Sewers
		Project #:	2208363
Phone/Fax:	(613) 731-9577 / (613) 731-9064	DWS #:	
Email:	drobertson@paracellabs.com	Sampled By:	
Date Order Received:	2/18/2022	Analysis Started:	3/1/2022
Arrival Temperature:	6 °C	Analysis Completed:	3/1/2022

WORK ORDER SUMMARY

ANALYSES WERE PERFORMED ON THE FOLLOWING SAMPLES. THE RESULTS RELATE ONLY TO THE ITEMS TESTED.

Sample Description	Lab ID	Matrix	Type	Comments	Date Collected	Time Collected
BH22-221	1730100	Water	None		2/16/2022	2:40 PM
BH22-225	1730101	Water	None		2/16/2022	11:50 AM
BH22-228	1730102	Water	None		2/16/2022	4:40 PM

METHODS AND INSTRUMENTATION

THE FOLLOWING METHODS WERE USED FOR YOUR SAMPLE(S):

Method	Lab	Description	Reference
PAH TO SU Water SIM (A41)	Garson	Determination of PAH in Water by GC/MS	Modified from SW846-8270D

This report has been approved by:

Mahesh Patel, B.Sc.
Laboratory Director

CERTIFICATE OF ANALYSIS

Paracel Laboratories Ltd. - Ottawa

Work Order Number: 455542

TESTMARK Laboratories Ltd.
Committed to Quality and Service

CERTIFICATE OF ANALYSIS

Paracel Laboratories Ltd. - Ottawa

Work Order Number: 455542

WORK ORDER RESULTS

Sample Description	BH22 - 221		BH22 - 225		BH22 - 228			
Sample Date	2/16/2022 2:40 PM		2/16/2022 11:50 AM		2/16/2022 4:40 PM			
Lab ID	1730100		1730101		1730102			
PAH	Result	MDL	Result	MDL	Result	MDL	Units	Criteria: Sewer Use By-Law - Perth Schedule A Sanitary and Combined Sewers
Total PAH (Calc.)	<2	2	<2	2	<3	3	ug/L	5

LEGEND

Dates: Dates are formatted as mm/dd/year throughout this report.

MDL: Method detection limit or minimum reporting limit.

Quality Control: All associated Quality Control data is available on request.

Field Data: Reports containing Field Parameters represent data that has been collected and provided by the client. Testmark is not responsible for the validity of this data which may be used in subsequent calculations.

Sample Condition Deviations: A noted sample condition deviation may affect the validity of the result. Results apply to the sample(s) as received.

Reproduction of Report: Report shall not be reproduced, except in full, without the approval of Testmark Laboratories Ltd.

APPENDIX J

MECP Water Well Record Summary

Report to: Caivan (Perth GC) Limited
Project: 100737.002 (February 22, 2023)

MECP Water Well Record Compilation
(141 Peter Street- 500 m search radius)

Well ID	Depth (m)	Depth to Bedrock (m)	Static Water Level (m bgs)	Water Found (m)	Well Use
3500065	13.4	3.7	1.5	11.0	DO
3500066	24.4	2.4	5.5	21.9	DO
3500067	8.2	0.9	2.1	7.0	DO
3500068	17.4	2.1		14.6	DO
3500112	8.8	0.0	1.2	8.5	DO
3500113	24.4	1.5	0.0	18.3	DO
3500114	15.8	0.0	-	4.6	DO
3500118	30.5	0.0	2.1	30.5	DO
3501948	39.6	0.9	1.2	39.6	PS
3501954	14.0	1.8	4.6	12.2	DO
3502293	18.3	1.2	2.4	9.8, 14.6	DO
3502328	18.0	2.4	1.8	11.6	DO
3502505	11.0	1.8	3.4	7.9	DO
3502763	29.9	2.4	2.4	29.9	DO
3504349	42.7	3.7	0.9	16.8, 38.1	DO
3503227	41.5	1.5	2.4	39.3	DO
3503298	25.0	0.0	3.4	23.2	ST
3504468	24.1	5.5	1.2	22.3	DO
3505109	28.3	0.6	4.0	25.9	DO
3505291	29.0	6.7	4.3	14.6, 23.2	DO
3506354	39.6	10.1	3.4	22.6	DO
3506408	12.8	1.2	3.7	10.7	DO
7121404	15.8	-	2.4	8.2, 12.5	DO
3507551	30.5	1.8	1.5	29.3	DO
3507895	61.0	1.5	6.1	54.8	DO
3509202	33.5	2.4	2.4	12.1, 29.6	DO
3511364	29.0	2.1	2.4	9.1	ST
3511370	61.0	0.0	3.7	-	DO
Geometric Mean (supply wells)	23.4	0.4	1.8	17.1	-
7163410	3.5	-	-	-	MT
7204601	4.0	-	-	-	MT
7201902	-	-	3.6	-	-
7201903	-	-	2.1	-	DO
7201905	-	-	3.7	-	-
7201906	-	-	-	-	-
7222339	-	-	-	-	-
7226127	6.6	-	-	-	MT
7279875	10.7	-	-	-	-
7279876	10.7	-	-	-	MO
7310687	4.2	-	-	-	-

https://www.ontario.ca/page/map-well-records; accessed February 2022.

Notes:
1. m bgs - meters below ground surface
2. Well Use:

DO	Domestic	AC	Cooling and A/C
ST	Livestock	NU	Not Used
IR	Irrigation	OT	Other
IN	Industrial	TH	Test Hole
CO	Commercial	DE	Dewatering
MN	Municipal	MO	Monitoring
PS	Public	MT	Monitoring Test

experience • knowledge • integrity

civil	civil
geotechnical	géotechnique
environmental	environnementale
field services	surveillance de chantier
materials testing	service de laboratoire des matériaux

expérience • connaissance • intégrité

APPENDIX D

Grants Creek Wetland Integrated Hydrologic Impact Assessment

Perth Western Annex Lands

March, 2023

Prepared For:

CAIVAN COMMUNITIES

Prepared By:

JFSA WATER RESOURCES ENGINEERING, ENVIRONMENTAL MANAGEMENT AND LAND PLANNING CONSULTANTS

GEMTEC CONSULTING ENGINEERS AND SCIENTISTS

Kilgour & Associates Ltd. Environmental Consultants

DSEL

GRANTS CREEK WETLAND INTEGRATED HYDROLOGIC IMPACT ASSESSMENT

Perth GC, Ontario

MARCH 2023

Prepared for: Caivan Communities

Prepared by:

Steve Livingstone, M.Sc., P.Geo.
GEMTEC Consulting Engineers & Scientists

Andrius Paznekas, M.Sc., P.Geo
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Jason KarisAllen, MASc, EIT,
GEMTEC Consulting Engineers & Scientists

Jonathon Burnett, B.Eng, P.Eng
J.F. Sabourin and Associates Inc.

Anthony Francis, PhD,
Kilgour & Associates Ltd.

TABLE OF CONTENTS:

FIGURES:

1 Introduction

An Integrated Hydrologic Impact Assessment (IHIA) is required to ensure the form and function of the Grants Creek Provincially Significant Wetland (PSW) is maintained as the development of the Perth Western Annex Lands site advances. The following report and accompanying technical studies (provided under separate covers) provide the data, analysis and reporting required to support the proposed Perth Western Annex Lands servicing and development design, as well as satisfy tests under the CA Act (where applicable), and local and provincial policies related to wetland protection. This work has been undertaken in consideration of the following documents:

- TCRA (2016) Wetland Water Balance Monitoring Protocol
- TCRA (2017) Wetland Water Balance Risk Evaluation
- RVCA (2018) Wetland Policies Board Approved
- MVCA (2019) Regulation Policies > HIA Sections
- RVCA Technical Memorandum Western Annex (Golf Course) Lands, Town of Perth dated March 1, 2022. This document indicated that the water budget, HIS for the wetland, and part of the hydrogeological study should not be distinct investigations. These should be included in an integrated hydrological impact assessment for the full site. The interpretations and findings must be aligned with the EIS interpretations and findings.

1.1 Background

The site is located on the south side of the Tay River, across from downtown Perth and is municipally known as 141 Peter Street. It is legally described as Part of Lots 25, 26 and 27, Concessions 1 and 2 in the Geographic Township of Bathurst and Part of Lot 1 in Concessions 1 and 2 in the Geographic Township of Drummond.

A large portion of the site will be developed in and around the existing golf course to create a new primarily residential community. The development will be composed of homes, streets, stormwater facilities, parks, and municipal water and sanitary services. Portions of the existing golf course will be reconfigured.

An Infrastructure Master Plan (IMP) was prepared in 2019 to consider transportation, water supply, sanitary sewer, and stormwater servicing for these lands and other areas. The IMP sought agency and public input and reported high-level discussion related to the flood plains and wetland constraints on and adjacent to the site. Since that time, the owners undertaking the development of the site have retained professional consultants to investigate, evaluate, and refine the guidance that was reported on by the IMP. Site-specific data collection and analysis have been undertaken to support the proposed development design and relationship with the adjacent Provincially Significant Wetland, Grants Creek.

The Rideau Valley Conservation Authority (RVCA) prepared a subwatershed report on the Tay River in 2011 and 2017, and a catchment area report on Grants Creek in 2017. General considerations within the Grants Creek catchment area included water quality occasionally influenced by high nutrient concentrations, occasional bacterial and metal exceedances, concern regarding low flow impacts on fish and wildlife habitat, and consideration of Low Impact Development (LIDs) to improve quality and reduce stormwater runoff. Recommendations emphasized the retention of wetland, increases to shoreline vegetation, and restoration of forest cover.

1.2 Objectives

The integrated hydrological impact assessment work synthesizes the information collected and analyzed by various technical investigations to establish the on-site environmental conditions and functions, identify any potential impacts related to the proposed development, and devise strategies (if required) to support the wetland environment. This work was performed by the following qualified professionals:

- GEMTEC Consulting Engineers and Scientists (geological and hydrogeological),
- David Schaeffer Engineering Ltd. (civil engineering),
- JF Sabourin and Associates Inc. (surface water), and
- Kilgour and Associates Ltd (Environmental and biological).

2 Existing Conditions

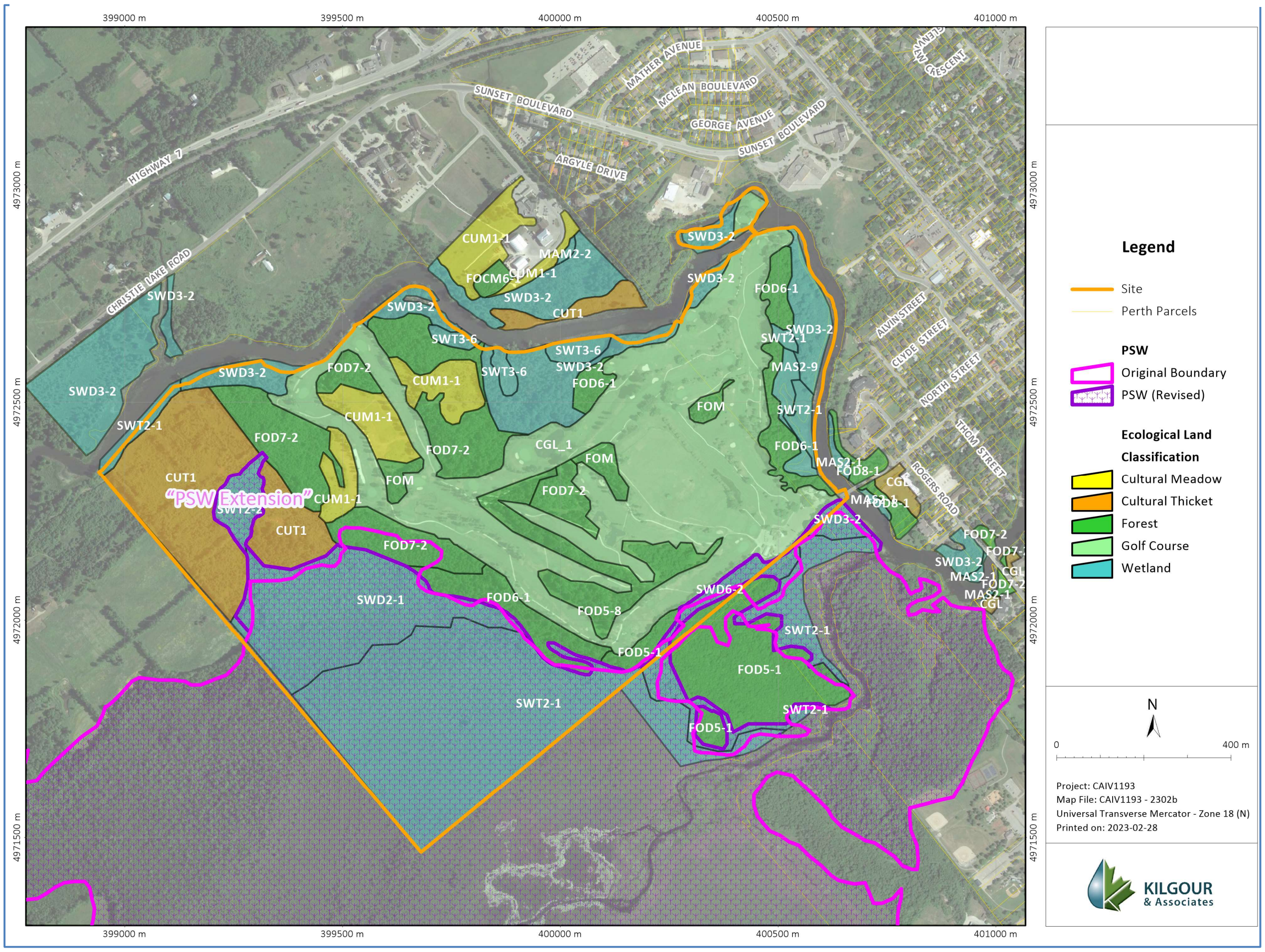
Each of the above consulting teams has prepared a standalone report that provides the data, analysis and findings related to their discipline in the context of the development proposal. The proponent seeks to establish a development envelope 30 metres or greater from the boundary of the Grants Creek Provincially Significant Wetland. The boundary used in this project has been surveyed and refined by qualified OWES assessors. A summary of existing conditions on the site, based on field studies as well as desktop research is presented below.

Figure 1: Existing Site Overview

2.1 Biological

Land cover on the site comprises nineteen distinct ELC units (ecosites and vegetation types). Ten of these ELC units are terrestrial classifications and nine are wetland (swamp and marsh) classifications. The golf course constitutes approximately 26% of the Site, while the remaining 74% is mainly natural or naturalizing habitat. Of this natural habitat approximately 40% is wetland, 23% is forested (non-wetland), 8% is cultural thicket, and 3% is cultural meadow. The peripheral areas, situated on lands adjacent to the Site, constitute swamp and marsh wetlands, deciduous forest, cultural thicket, coniferous plantation, and cultural meadows, as well as small areas of constructed green lands and residential properties (lawns). Wetland features along the south side of the site collectively constitute Provincially Significant Wetland. Wetland features along the north side of the site consist of scattered, smaller riparian pockets of wetland that are not considered provincially significant.

Figure 2: ELC Ecosites with PSW boundary



An extension of wetland contiguous with Grants Creek PWS (the "PSW Extension") was identified in the western portion of the Site. As this feature represents a contiguous wetland area, it is considered part of Grants Creek Provincially Significant Wetland. Based on historical imagery, the PSW Extension was likely not present during the evaluation of Grants Creek Provincially Significant Wetland in the 1980s, as land cover here was dominated by agricultural uses at that time. The PSW Extension represents natural regeneration by hydrophilic vegetation, as the land has been left fallow in recent years. The updated PSW boundary reflects this PSW Extension, as well as several minor adjustments along the south edge of the site based on ELC and OWES-type assessments of plant cover.

Wetland features occurring within the riparian edge of the Tay River consist mostly of Silver Maple Swamps interspersed with pockets of Sweet Gale Organic Thicket Swamp.

The south edge of the golf course within the PSW consists mostly of Silver Maple Swamp (not dissimilar to that along the Tay) with some shorter sections of Black Ash Mineral Deciduous

Swamp. The majority of the PSW, however, south of the swamp edges abutting the golf course, is dominated by Alder Mineral Thicket Swamp.

The PSW Extension, previously disturbed as an agricultural area, is vegetatively different. It is a Willow Mineral Thicket Swamp Type that is impacted by a dense cover of invasive European Buckthorn. The interior of this wetland contained patches of shallow standing water up until early summer.

All wetland areas around the periphery of the golf course provide habitat for several local turtle species including Blanding's Turtle (listed as Threatened, provincially). The wetland areas (and associated headwater features) will provide water and allochthonous material to fish habitats within the Tay River and Grants Creek, but do not provide fish habitat directly.

Six types of habitat that meet the criteria of Significant Wildlife Habitat were identified on the Site, including Bat Maternity Colonies, Turtle Nesting Areas, Woodland Amphibian Breeding Habitat, Wetland Amphibian Breeding Habitat, Woodland Area-sensitive Bird Breeding Habitat, and Special Concern and Rare Wildlife Species. These SWH categories apply, to some degree, to all woodland and wetland areas across the site and there is no portion of the site that does not correspond with at least one potential SWH category. The utility of lands within the proposed development footprint as SWH, however, is generally limited compared to the SWH-qualifying areas outside of the development footprint. Suitable, if not more ideal ecosites for all six types of confirmed Significant Wildlife Habitat exist elsewhere on the site and would be retained, such as in Grants Creek Provincially Significant Wetland and with 30 metres of the Tay River.

2.2 Hydrogeological and Geotechnical

Subsurface investigations performed at the site included the completion of overburden and bedrock boreholes, auger probes, and the installation of monitoring wells to a maximum depth of approximately 12.3 metres into the bedrock. Subsurface data informed the definition of the following stratigraphic zones for the Site, in descending order:

- Fill (silty sand) – deposited during construction of the golf course; Peats and clay – located exclusively in the wetland areas;
- Glacial till – loose to stiff grey-brown silty clay to silty sand with cobbles and boulders (0.3 to 7.2 metres thick, with an average thickness of approximately 2.2 metres)
- Precambrian Bedrock - fine grained, very strong, pinkish grey amphibole gneiss (metamorphic rock) and pink granite pegmatites (igneous rock).

The surface topography of the Site generally reflects the underlying profile of the bedrock with the highest ground elevations found to the west sloping towards the southeast, and the lower elevations associated with surface water features. There is a groundwater divide running roughly east to west across the Site, as dictated by the topographic ridges. Thus, groundwater flow directions are interpreted to mostly mirror local topographic divides (Figure 3). The groundwater elevations are highest at the topographic highs within the central and western portions of the Site, with flow trending away from these peaks. As such, groundwater north of the divide flows towards the Tay River, whereas groundwater south of the divide flows towards the Grants Creek Wetland.

Water level monitoring was performed over the proposed development site and within the wetland. Data analysis suggest that the glacial till and upper fractured bedrock in the development area operate together as an unconfined or leaky aquifer, with the degree of confinement generally increasing with depth. Based on water levels and geology, it is believed that topography, soil, properties, fractures, and/or bedrock surface encourages shallow interflow, towards downgradient receivers (i.e., the Tay River, onsite ponds, and Grants Creek Wetland), limiting deeper percolation of water.

. Due to the inferred predominance of runoff processes over the development area, contributions of groundwater to the Grants Creek Wetland from the development site are interpreted to be relatively minor. Clay and silt underlying the Grants Creek Wetland increase the confinement of the underlying system and further restrict groundwater exchange between the wetland and proposed development Site.

The conceptual site model for local wetland processes is presented below:

Figure 3: Conceptual Site Model (insert from Figure 6, from the GEMTEC hydrogeological report)

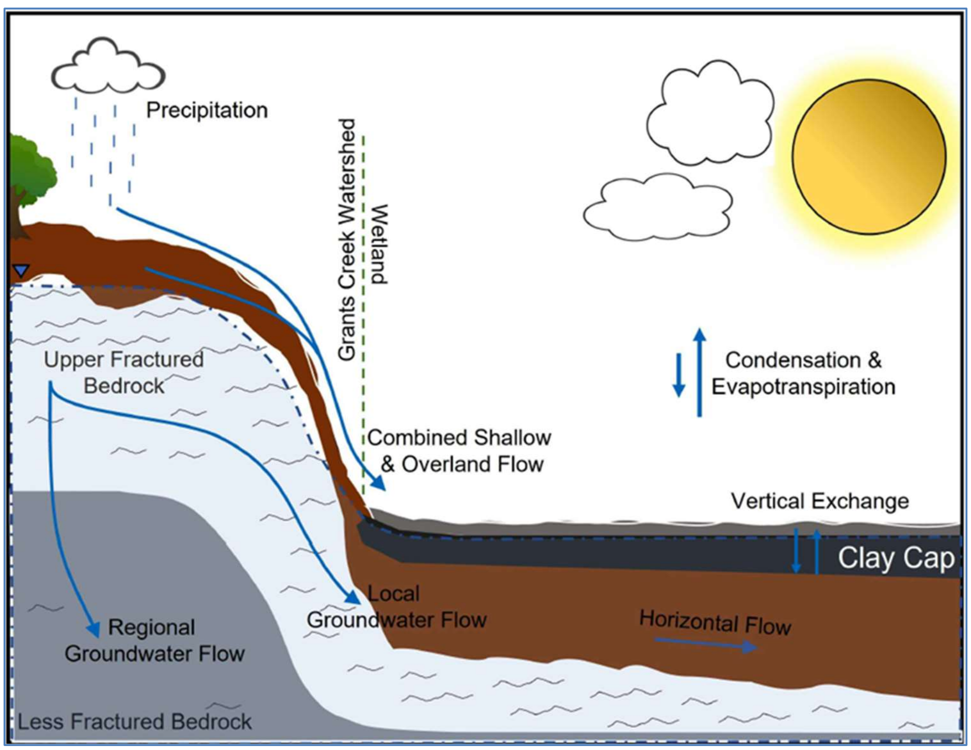


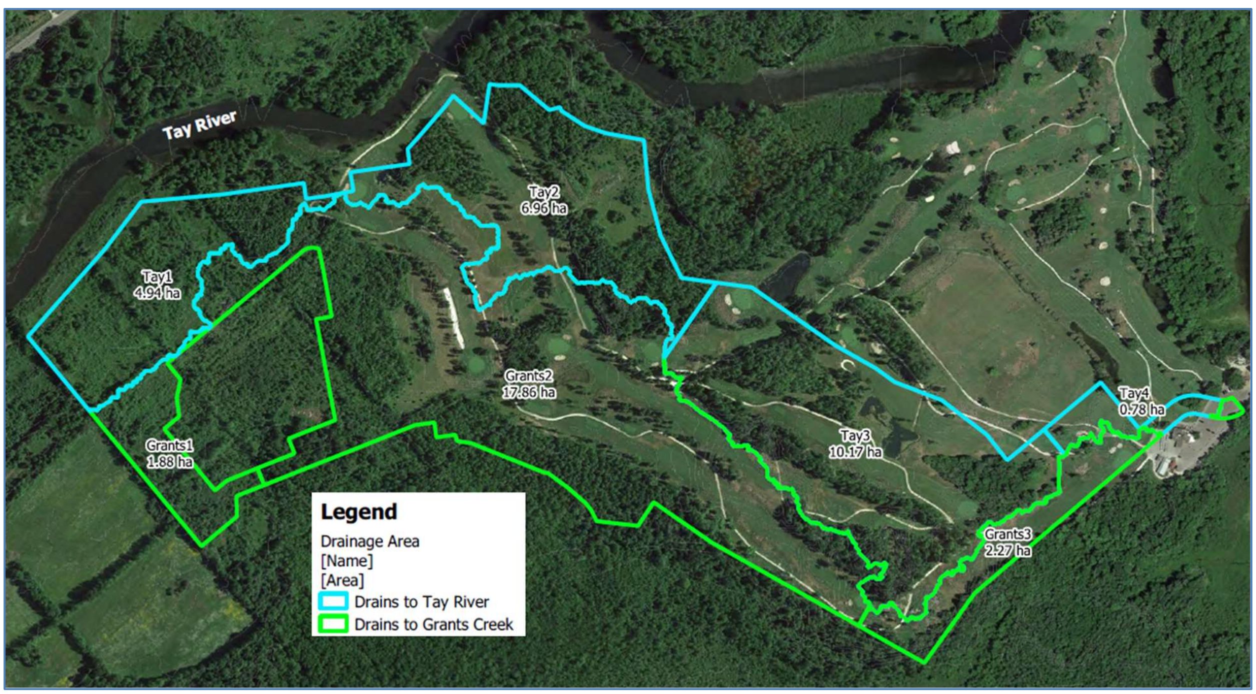
Figure 4: Groundwater Flow Direction

2.3 Surface Water

2.3.1 Drainage Area

A pre-development drainage area analysis has been completed for the Grants Creek watershed which includes the Grants Creek wetland in the tailwaters of the watershed near the confluence with the Tay River. Under existing conditions, the total existing drainage area of Grants Creek is approximately 9351.78 ha, primarily consisting of natural features, agricultural lands, and open water, with the Perth GC development lands making up 22.01 ha of the total drainage area to the wetland. The Perth GC under existing conditions consists primarily of a golf course with well-maintained lawns, surrounded by irregular forest patches. It has been assumed that the site will have an average runoff coefficient of 0.25. The site discharges to the Grants Creek wetland, via sheet flow, with very little to no defined watercourses/streams within the future development site to the wetland. Under existing conditions, the Perth GC development makes up 0.2% of the total drainage area to the wetland. The JFSA February 2023 report titled "Caivan Perth Development - Hydrologic And Hydraulic Conditions Report" provides the pre-development drainage divide between the development drainage area and the greater watershed, as shown below. Figure A3 of the same report outlines the greater Grants Creek watershed relative to the proposed development.

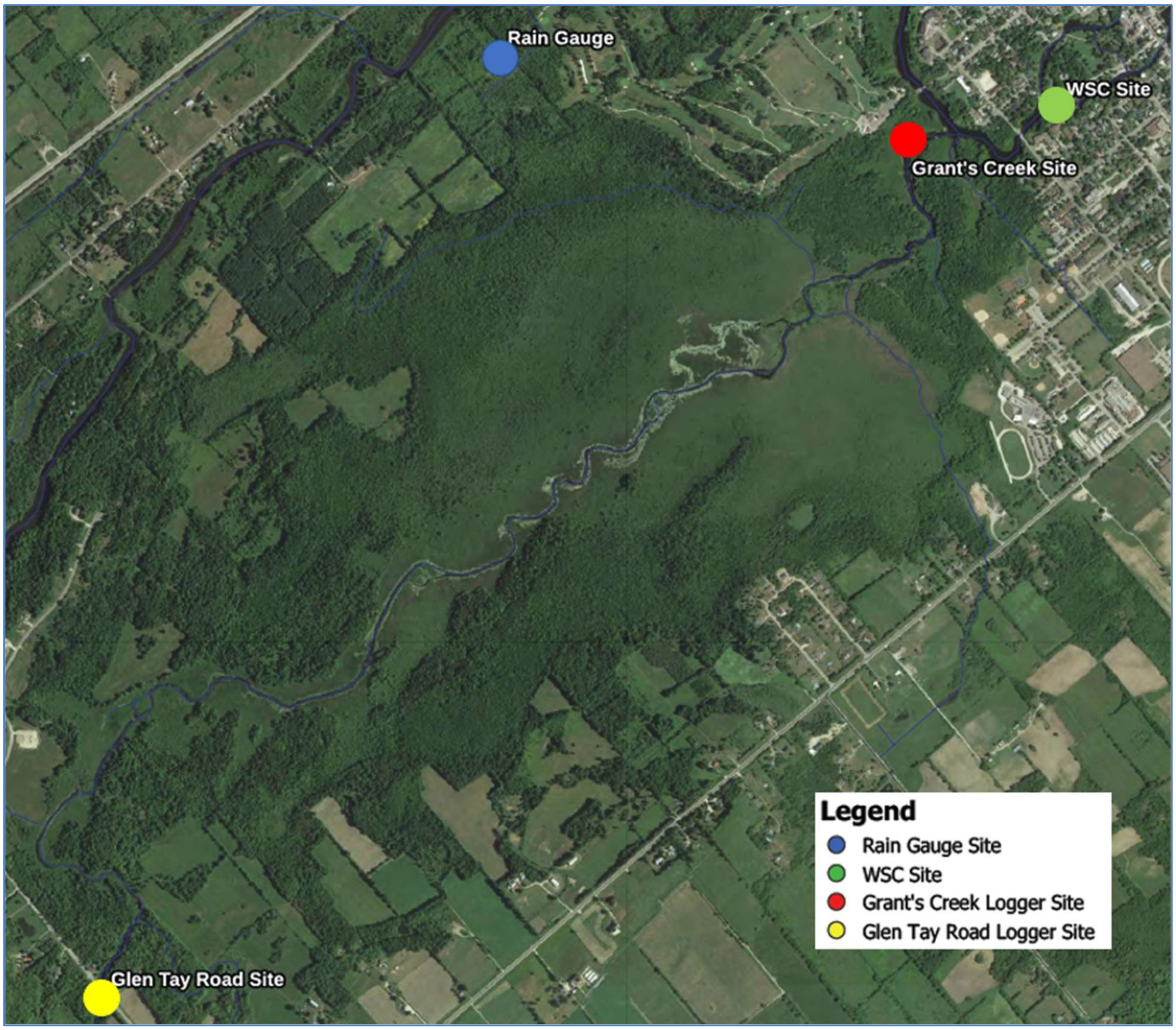
Figure 5: Pre-Development Drainage Divide



2.3.2 Surface Water Monitoring

JFSA conducted surface water monitoring around the Perth GC development area to gain a better understanding of how watercourses react to various environmental conditions, and how water flows and levels at key locations within the surrounding lands relate and fluctuate throughout the year. The surface water and precipitation monitoring were carried out from June 2022 to November 2022, refer to the map below for the location of the monitoring. Throughout the monitoring period, a total of 325.3 mm of rainfall was recorded. Based on the rainfall data obtained during this window, 18 significant rainfall events were identified. The largest event recorded over this duration had a total rainfall volume of 38.3 mm, the maximum rainfall intensity recorded over this duration equated to less than a 5-year event. The data obtained from the surface water monitoring and precipitation monitoring helps develop a better understanding of the water flow and levels in the study area.

Figure 6: Surface Water Monitoring Sites



3 Proposed Conditions / Post Development

3.1 Servicing

The proposed development area is approximately 37.44 ha not including open space/park, SWMF and wetland areas. Overland stormwater runoff on the subject property is currently to the Tay River to the north and the Grant's Creek PSW to the south.

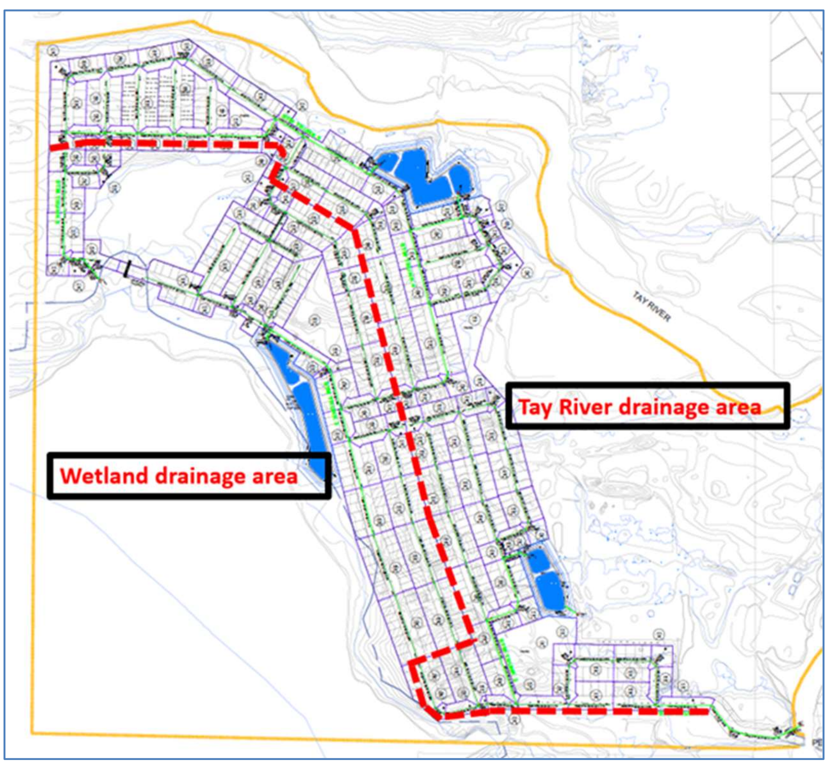
Drainage area pre and post development conditions

Condition	Grants Creek	Tay River
Pre-Development	22.01 ha	22.86 ha
Post-Development	16.32 ha	28.54 ha

The stormwater strategy for these lands proposes to establish the drainage areas such that flows to the wetland and Tay River are maintained to support the form and function of these features.

The concept design provides for two stormwater management wet ponds to discharge to the Tay River and one discharging to the Grants Creek wetland. Low Impact Design measure swill be implemented upstream of the SWMF, where practical and functional. Two additional small areas, one draining to the river and one to the wetland, are proposed to be serviced with a combination of Low Impact Development (LID) measures and an end of pipe oil grit separator. Rear yards

Figure 7: Post Development Drainage Areas



abutting the Tay River and Grants Creek Wetland will drain towards those features and will not be captured in the stormwater conveyance system.

The proposed stormwater management system will provide water quality treatment, peak flow attenuation, and flood control for the project site, maintaining pre-development peak flows to the Tay River and Grants Creek PSW. A preliminary SWM facility sizing has been completed to approximate the amount of storage volume that will be needed to ensure that sufficient land is set aside under post-development conditions to meet the above objectives. Major events in excess of the 100-year event will also outlet to the Tay River and Grant's Creek PSW.

A treatment train approach will be designed where Low Impact Development (LID) measures will be implemented upstream of the wet ponds. The wet ponds will be designed to achieve enhanced total suspended solids removal or better to protect water quality in the Tay River and Grants Creek PSW.

The LID measures provide additional quality control and support the water budget for the site. These are expected to include:

- Infiltration features with subdrains to allow for drainage during high groundwater conditions),
- Increased soil thickness on lawns for increased storage/infiltration potential,
- LID features located in areas with proposed grade raises,
- Catchbasins with infiltration trenches,
- Rear-yard infiltration trenches,
- Direct roof runoff to lawns/parks, increasing thickness of topsoil (e.g., increase from the typical minimum of 15cm to 30cm to increase retention),
- Construction dewatering installation of services and basement construction in accordance with recommendations in geotechnical and hydrogeological reports.

Detailed design on the stormwater facilities will also relate to the abutting natural features by considering outlet design as a way to support the receivers. In particular, the wet pond adjacent Grants Creek Wetland will be designed with a level spreader filtering flows through a permeable material onto a wide area in the buffer lands, rather than creating a concentrated outlet.

Figure 8: Proposed SWMF Outlets

3.2 Hydrogeological and Geotechnical

3.2.1 Conceptual Water Budget

The water balance completed for the Site indicates that pre- and post-development runoff is greater than infiltration. The post-development runoff will increase by 405 mm/year and 385 mm/year for the north (discharges to the Tay River) and south (discharges to the Grants Creek) subwatersheds of the Site, respectively. o The post-development infiltration (without mitigation measures) will be reduced by 102 mm/year and 86 mm/year for the north and south subwatersheds, respectively. Accordingly, the post-development runoff will increase by 405 mm/year and 385 mm/year for the north and south subwatersheds, respectively. The post-development infiltration reductions are considered minimal in comparison to runoff and excess surface water which will be effectively managed through SWMP and LID measures.

The hydrogeological conceptual model suggests that overland flow and interflow (e.g., rapid vadose zone transport and/or exfiltration following infiltration) and not groundwater discharge as baseflow are the primary contributors of water to the Grants Creek Wetland and Tay River from the Site; these flowpaths are considered together as runoff, as described by Fetter (2001). The infiltration calculated from the water balance does not distinguish between infiltration lost to shallow subsurface runoff processes (e.g., interflow) and infiltration that contributes to the deeper groundwater system (i.e., recharge). The Mississippi Rideau Source Protection Region’s Tier 1 Water Budget and Water Quantity Stress Assessment estimated baseflow contributions to range from as low as 2% in shallow bedrock settings (site-specific study in Tay River Subwatershed) to 40%. Based on boreholes advanced on-site as part of the geotechnical investigation, the degree of fracturing of the Precambrian bedrock decreased with depth. As such, limited deep groundwater recharge (pre- and post-development) is anticipated on-site.

3.3 Surface Water

3.3.1 Drainage Area

Under proposed conditions, approximately 16.32 ha of the 44.86 ha development will drain south to the nearby wetland and Grants Creek. This is a drainage area reduction of 5.69 ha to the Grant Creek watershed from the pre-development conditions. This results in a 0.06% reduction in the total drainage area to the Grants Creek watershed from pre-development conditions. Note that efforts have been made to maintain the existing drainage areas within the development site as much as possible with consideration for grading and servicing limitations. It is also important to note that the development will result in an increase in surface runoff volume due to the increase in impervious area (see section 3.1.1), so although the drainage area to the Grants Creek watershed will be reduced, the total annual runoff volume may increase. It has been assumed that post-development the site will have an average runoff coefficient close to 0.7. The implementation of various LID measures through out the development, where practical, will provide additional mitigation in terms of improved water quality, quantity moderation and subsurface water inputs. Given the overall size of the Grants Creek watersheds in comparison to the discrete development site, the linear reach of the watershed system and upgradient headwaters feeding the Grant Creek watershed, and the location of the drainage area change (at the confluence of the two watersheds) it is unlikely that this change under post-development conditions will have a quantifiable impact on the hydraulic and hydrologic conditions of the surrounding watercourses.

3.3.2 Grants Creek PSW Extension

As a part of Kilgour's study, a small pocket of wetland (1.48 ha) has been identified within the western extent of development lands, referred to as the PSW Extension. The proposed development will be built around this wetland with a 30m buffer applied and the wetland will be maintained by clean surface water runoff from rear yard lots and, if required, additional clean water from the development. The exact drainage area contributions for these lands will be assessed during detailed design and designed to support proposed restoration and enhancements to the wetland community. The existing vegetation community within the area – early-successional thicket with an abundance of invasive species (primarily buckthorn) – is proposed to be enhanced through a buckthorn removal program and extensive planting of deciduous wetland tree species. These enhancements will naturalize the former agricultural feature to match existing mature wetland in the vicinity.

4 Summary

4.1 Ground and surface water systems

- There will be minor changes to the total drainage area contributing to the wetland although this change is negligible and equates to a 0.06% reduction in the total drainage area to the Grants Creek Wetland. This slight change in drainage area will have no impact on wetland hydroperiod.

- The wetland is primarily surface water-fed, as indicated by the conceptual water balance where runoff is greater than infiltration pre- and post-development.
- The water from the project site is primarily being received by the wetland via overland processes or interflow pathways.
- The groundwater flows are dictated by the topography and corresponding surface water divides. The receivers include localized depressions, PSW Extension, Grants Creek Wetland and Tay River.
- Deeper groundwater pathways contributing to the wetland are limited by the clay base of the wetland and its low conductivity relative to its underlying materials.
- Glacial till and fractured bedrock beneath the clay layer may encourage groundwater flow paths to be horizontal beneath the Grants Creek Wetland. As such, it is our interpretation that any reduction in infiltration or baseflow recharge caused by the proposed development, can be effectively offset through stormwater management and low impact development features, sustaining the key processes of the Grants Creek Wetland.
- Site-specific studies conducted by others in the Tay River subwatershed suggest rapid groundwater recharge processes are localized to areas of thin soils, primarily controlled by the hydraulic conductivity of the bedrock, and are dependent on fracture location and spacing.
- The post-development conditions will include a significant increase in impermeable surface area compared to pre-development conditions, which will decrease the infiltration volumes and increase runoff volumes. Assuming an average runoff coefficient of 0.25 for pre pre-development, and a coefficient closer to 0.7 for post development. This results in 21 ha x 0.25 = 5.2516 ha of area contributing runoff to the wetland under existing conditions, compared with 16 ha x 0.7 = 11.2 ha contributing to the wetland under post development conditions The total volume of runoff will be further increased post-development due to the reduction in evapotranspiration potential associated with a decrease in vegetated area.
- SWM measures will be designed to closely reflect pre-development inflow locations. LID measures will be implemented throughout the site and flow from main SWM pond will be distributed by a level spreader rather than concentrated outlet.
- Runoff processes (i.e., overland flow and interflow) are inferred to account for most of the water surplus of the site under pre- and post-development conditions, with a minor component being transported to deeper recharge.

4.2 Wetland form and function

- The wetland across the site is a mix of palustrine (intermittent/no inflow and intermittent/permanent outflow), and riparian features.

- Wetland enhancements are proposed through restoration of vegetation from thicket swamp to deciduous (maple) swamp within the PSW Extension.

- Animal species present with wetland areas include several species of turtles common to the area (including Blanding's Turtles [Threatened), snakes (including Gray Ratsnake [Threatened]), bats (including Little Brown Myotis and Tri-colored Bat [both Endangered]), and Birds (including Eastern Wood-Pewee, Wood Thrush and, to a limited extent, Rusty Blackbird [all Special Concern]. There are extensive existing wetland areas surrounding the site which also support this type of habitat.

- Wetland swamp and thicket-swamp ecosites along the Tay River and composing the Grants Creek PSW are comprised of tree and shrub species that are generally tolerant of a range of fluctuating water conditions. The flora is unlikely be affected by small changes in water levels.

- No modifications are proposed to the outlet of the PSW.

5 Potential Impacts and Mitigation

Based on the weight of evidence from the studies completed by the consulting team to date and regional scientific studies conducted by others, it is the team's professional opinion that the potential impacts of the development on the Grant Creek Wetland will be minimal. Further, proposed monitoring and mitigative measures will be designed and in place to ensure the health, sustainability and function of this wetland system. The following sections provide an integrated summary of the study evaluations completed by the consulting team.

5.1 Wetland Impacts

- Potential for a range of fluctuating water conditions in limited locations where storm outlets are located. The flora is unlikely to be affected by this water level fluctuation.

- Potential for erosive flows to affect existing soils.

- Animal species present within wetland are expected to remain in the area and continue to using the existing/improved wetland areas as habitat.

- No change to the wetland type is expected: a mix of palustrine (intermittent/no inflow and intermittent/permanent outflow), and riparian features.

- Potential for contaminants from stormwater impacts on wetland veg ie chlorides/nutrients.

- Invasive species may be imported from nearby development. Garden waste and litter may be more proximate to the wetland boundary.

- Removal of 635 m^2 of wetland at the Peter Street Bridge Road alignment, and impacts on a further 308 m^2 from proposed road crossing.

- Minor changes are proposed to the shape and size of the wetland where the road access from the Peter Street bridge encroaches by up to 11 m for a distance of 78 m, removing 635 m^2 of PSW. The PSW Extension is connected to the main portion of the PSW by a narrow (20 m wide) isthmus thicket swamp. This strand of wetland will be the crossing point for a new road corridor. The corner of one block in the northwest corner of the site removes 233 m^2 of Tay River riparian deciduous swamp with (<0.2% of the total Tay River riparian wetland on the site), where that feature briefly extends >70 m from the riverbank.

5.2 Surface Water Impacts

- Minor changes to the total drainage area to the Grants Creek catchment under post development conditions with a reduction in total area of 0.06%.
- Approximately 23% reduction of land in the development area contributing surface water flows to the adjacent Grants Creek Wetland.
- Due to the development an increase in impervious area will increase surface water volumes available.

5.3 Hydrological Impacts

- Most water supplied to the Grants Creek Wetland is derived from headwater sources upstream rather than through local surface water or, to an even lesser degree, groundwater originating from the proposed development area. Since the groundwater contribution to the nearby area of the Grants Creek Wetland is small, post-development mitigation measures should focus on runoff volume management and water quality controls to ensure the health and function of the wetland.
- Shallow groundwater to the wetland was deemed to represent a minor contribution to the wetland, relative to surface water (including interflow) discharges. The pre-development factors controlling recharge to the deep bedrock system (i.e., shallow water table, low-conductivity bedrock, and horizontal drainage) are unlikely to be significantly altered by the proposed development, as the shallow system functionality is maintained.
- Excavations below the water table and associated dewatering will be required for municipal services (storm, sanitary, and water) and stormwater management ponds. Minimal groundwater taking is anticipated given the low hydraulic conductivity of overburden and bedrock encountered on-site. The estimated groundwater pumping rates for individual service trenches and stormwater management ponds are low, estimated to be less than 50,000 litres per day per source, with a radius of influence less than 21 metres.
- Temporary and transient groundwater pumping for the installation of municipal services is not anticipated to negatively impact groundwater users, surface waters, or wetlands. Groundwater taking and discharge will be completed subject to MECP approvals (Environmental Activity Sector Registry or Category 3 Permit To Take Water).

5.4 Mitigation

5.4.1 Stormwater Management and Low Impact Development (LID) Measures

Under post development conditions the increase in impervious area will offset reductions from the reduced drainage area, in annual flow contributions to the wetland. SWM and LID measures will be designed to closely reflect pre-development inflow locations and SWM outlets will be designed to replicate outflow locations under pre-development conditions.

Outflows from the main SWM pond will use a level spreader to distribute outflows across the site instead of having a single piped outlet location.

A treatment train approach of LIDs, Oil and Grit Separators (OGS) and or conventional SWM ponds will be implemented to ensure runoff is clean and will not adversely impact the wetland. SWM facilities have be sized to ensure post development peak flows do not exceed pre-development conditions. LIDs are proposed throughout the site to treat, attenuate, and distribute outflows from the development to the wetland.

5.4.2 Restoration

Invasive Reed-canary Grass and European Buckthorn were abundant within the PSW Extension as well more broadly along parts of the riparian edge of the Tay River in the northwest corner of the site. A re-naturalization/enhancement program, including invasive species removal and extensive plantings of native deciduous wetland trees (e.g. Silver and Red Maple) will be completed within these areas.

5.4.3 Development and Servicing Design

For the road ROW along the southern site boundary with the PSW, the intervening area is to be raised to form a wide, gently sloping berm of sufficient width and gradient, and constructed of sufficiently impervious fill, such that meltwater from salt-laden snow accumulations (windrows) from winter plowing drain fully towards the stormwater collection system of the roadway, and not towards the wetland. The top and backside of the berm are to be fully revegetated with dense trees of similar species to those of the adjacent band of forest including Sugar Maple, Basswood, Bitternut Hickory, and Black Cherry.

5.4.4 Education

Homeowner educational information will be provided to ensure good stewardship of the natural features in the community. In particular, information on fertilizer and other nutrient contaminant management, the location of the stormwater outlets, and control of invasive ornamental vegetation and disposal of yard wastes will be covered.

Flora within the PSW Extension is early successional regrowth including invasive buckthorn. Removal of Buckthorn here and replanting with locally appropriate deciduous wetland tree species (Silver Maple in the wet center with Red Maple around the periphery) is recommended.

5.4.5 Proposed Future Monitoring

Monitoring upstream and within Grants Creek PSW has been completed for the year 2022. Monitoring will continue in future years to develop a greater understanding of the wetlands hydrologic operations (hydroperiod) under existing conditions.

Monitoring of the PSW Extension to demonstrate it is being effectively used as habitat. Invasive species and PSW boundary condition will be surveyed over a ten year period.

6 CONCLUSIONS

This Integrated Hydrologic Impact Analysis has been prepared to ensure the form and function of Grants Creek Provincially Significant Wetland (PSW) is maintained as the development of the Perth Western Annex Lands site advances. The CA Act (where applicable), states the Authority may grant permission for development in or on the areas described in subsection 2 (1) if, in its opinion, the control of flooding, erosion, dynamic beaches, pollution or the conservation of land will not be affected by the development. O. Reg. 174/06, s. 3 (1).

The local policies of the RVCA under O.Reg 174/06 state that proposed development within the regulated area shall not have an adverse effect on the control of flooding, erosion, pollution or the conservation of land and, in the case of wetlands, the hydrologic function of the wetland.

Section 2.1.4 of the 2020 Provincial Policy Statement states that development and site alteration shall not be permitted in: a) significant wetlands in Ecoregions 5E, 6E and 7E1.

Further, Section 2.1.8 states that *development* and *site alteration* shall not be permitted on adjacent lands to the natural heritage features and areas identified in policies 2.1.4, 2.1.5, and 2.1.6 unless the ecological function of the adjacent lands has been evaluated and it has been demonstrated that there will be no negative impacts on the natural features or on their ecological functions.

Development: means the creation of a new lot, a change in land use, or the construction of buildings and structures requiring approval under the Planning Act, but does not include:

a) activities that create or maintain infrastructure authorized under an environmental assessment process;

Infrastructure: means physical structures (facilities and corridors) that form the foundation for development. Infrastructure includes: sewage and water systems, septage treatment systems, stormwater management systems, waste management systems, electricity generation facilities, electricity transmission and distribution systems, communications/telecommunications, transit and transportation corridors and facilities, oil and gas pipelines and associated facilities.

It is understood that to remove 635 m^2 of wetland, and impact a further 308 m^2 with a road crossing, the proposed transportation corridors shall be subject to a EA process, or a Ministerial Zoning Order shall be required.

It is the professional opinion of the consultants responsible for the preparation of this report, that the wetland is part of a significant continuous system that supports the form and function of Grants Creek Wetland and is not significantly influenced by changes to the adjacent land use at the downstream end. Appropriate mitigation through the design and construction of the community shall maintain the hydrologic function of the wetland, and its related form and functions. Grants Creek Wetland shall not be adversely affected by the Perth GC development project.

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End Page