



BURNSIDE

**2025 Biennial Groundwater Monitoring
Report - Hespeler Well Field (H5, H5A)**

The Region of Waterloo



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The Region of Waterloo

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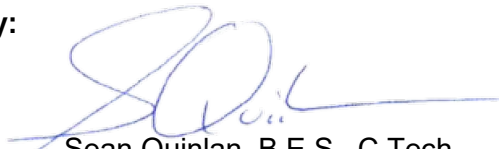
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1.0 Introduction

The Regional Municipality of Waterloo (the Region) is unique in Ontario in that it is the largest urban municipality to rely almost exclusively on groundwater supplies for its drinking-water (Region of Waterloo, 2015). Figure 1 shows the location of municipal well fields within the Region.

The Permit to Take Water (PTTW) for H5 / H5A in the Hespeler Well Field (P-300-1161883172) requires submission of a well field specific biennial report to the Ministry of Environment, Conservation and Parks (MECP) which documents production well pumping volumes and water levels in specific monitoring wells during 2024 and 2025. This report has been prepared to meet the reporting condition of the PTTW for 2024 and 2025. A copy of the PTTW is included in Appendix A.

The location of the Hespeler Well Field is shown in Figure 1 and the production wells in Cambridge are shown in Figure 2 with the monitoring network for H5 and H5A shown in Figure 3. Well records for the production and monitoring wells are found in Appendix B.

1.1 Scope of Work

The Region records water levels on a regular basis within a network of monitoring wells to satisfy the requirements of their PTTW and to confirm that water taking is sustainable in the long term. The monitoring wells are concentrated near the production wells but are also located in known aquifer recharge areas. The data from these wells and regular measurements of pumping volume obtained from the production wells are used to evaluate the impact of Region pumping on aquifers and potential impacts to private wells, other water takers and the natural environment.

The Region has developed a monitoring program for the Hespeler Well Field (H5, H5A) in accordance with PTTW P-300-1161883172 which consists of the following activities:

- Measuring the daily volume pumped from the H5 and H5A production wells (Condition 4.1 of the PTTW);
- Measuring the water levels in monitoring wells C-HP-H5OW2-10-ABC and C-HP-H5TW1-10-D (Condition 4.2 of the PTTW);
- Review of precipitation data from the nearest GRCA / Environment Canada weather station (Condition 4.3); and
- Completion of a biennial report (every 2 years) that presents data in compliance with condition 4.3 of the PTTW.

The Monitoring data (pumped volumes and hydrographs) are found in Appendix C with precipitation data in Appendix D. The monitoring program procedures and methodology are included in Appendix E.

2.0 Site Setting

2.1 Well Field Description

The H5 / H5A production well site is located north of the Speed River near the intersection of Hespeler Road and Guelph Avenue in the City of Cambridge (formerly the Town of Hespeler). Other wells in the Hespeler Well Field include H3 and H3A located about 2.5 km to the south, and the H4A wells found about 2.5 km to the southeast. Each well field is permitted under a separate PTTW. The wells are in an urban area that is municipally serviced. Each well field is permitted under a separate PTTW. The H5 and H5A wells are on the northern edge of an urban area that is municipally serviced. The closest residence not municipally serviced is 250 m northeast. The closest surface water feature to the H5 and H5A site is the Speed River located 1.5 km to the east and south (Figure 3).

2.1.1 Pumping Wells

Well records for the production wells are found in Appendix B. Well H5 was originally constructed in 1954 to a depth of 58.8 m below ground surface (mbgs) as an open hole bedrock well. It obtains the majority of its water from a solution-enhanced feature in the shallow bedrock aquifer (Gasport Formation) at a depth of approximately 23 m bgs. In 2010, the lower portion of H5 (below 30.8 mbgs) was sealed with bentonite and capped with cement to eliminate the unproductive deeper portion of the well. At the same time, a 225 mm diameter steel well liner was installed in the well with cement grout to a depth of 22.6 m bgs. The well is open from 282.2 metres above sea level (masl) (22.6 mbgs) to 274 masl (30.8 mbgs). Regular use ceased in September 2016 when the pumping water level in the well was drawn down to the pump intake.

Well H5A is a newer open hole bedrock well drilled deeper into the Gasport Aquifer. It is cased to 62 m bgs and is an open bedrock hole from 62 to 114.9 m bgs (208 to 243 masl). Well H5A draws its water from the intermediate and deep bedrock formations at the site. The primary producing interval is from a series of solution enhanced features between 94.4 and 96.0 m bgs in the Gasport Formation. This water-producing interval provides over 50% of the water to the well, while the remainder is obtained from a series of smaller features between the bottom of the casing and 94 mbgs. H5A was connected to the distribution system during the summer of 2017.

A summary of the production well construction details is provided in Table 1 below.

Table 1: Production Well Construction Details

Well Name	Year Built	Casing Diameter (mm)	Open Hole Diameter (mm)	Open Hole interval (mbgs)	Aquifer
H5	1954	305	250	22.6-30.8	Goat Island*
H5A	2010	500	300	62.1-114.9	Upper Gasport to Lower Gasport

*At the time of construction, H5A was interpreted to be completed in the Upper Gasport Formation. The recently completed Tier Three Assessment Update project (Aqua Insight et al, 2023) concluded that the Goat Island Formation is much thicker than previously interpreted and the underlying Gasport Formation is interpreted to be thinner. As a result, H5A is now interpreted to be completed in the Goat Island Formation. The water taking volumes for the Hespeler H5 and H5A Well Field are regulated by Condition 3.2 of the PTTW and are summarized in Table 2 below.

The pumping volumes are based on the total daily volumes as recorded by the Region's SCADA system and are presented in Appendix C as total monthly volumes. Production wells H5 and H5A are pumped in alternation. Pumping volumes ranged from 25,029 m³/month to 32,106 m³/month in 2024, and from 19,323 m³/month to 32,131 m³/month in 2025. In total, 329,615 m³ was produced from these wells in 2024 and 293,267 m³ was produced in 2025. These volumes are consistent with the previous five years, and below the permitted volume of 725,328 m³ per year (Table C-1).

Table 2: Annual Water Taking 2024 / 2025

	PTTW Details	2024			2025		
Well	Permitted Max. Daily Water Taking (m ³)	Avg. Daily Water Taking (m ³)	Max Taken per Day (m ³)	Total Volume Pumped (m ³)	Avg. Daily Water Taking (m ³)	Max Taken per Day (m ³)	Total Volume Pumped (m ³)
H5	1,987	481	1,037	175,980	277	865	100,931
H5A	1,987	420	864	153,635	527	855	192,336
Combined H5, H5A	1,987	901	1,037	329,615	803	865	293,267

2.1.2 Monitoring Wells

The Region recently updated their well naming protocol and as a result, the well names in EQulS vary from the names listed on the PTTW. The well names on the PTTW are shown below along with the updated name that is used by the Region. The updated Region names will be used throughout this report.

Table 3: Well Nomenclature

Monitoring well names as they appear on the PTTW	Revised well names consistent with Region nomenclature
C-HPW-H5-TW2A-10	C-HP-H5OW2-10-A
C-HPW-H5-TW2B-10	C-HP-H5OW2-10-B
C-HPW-H5-TW2C-10	C-HP-H5OW2-10-C
C-HPW-H5-TW1D-10	C-HP-H5TW1-10-D

Observation wells C-HP-H5OW2-10-A, C-HP-H5OW2-10-B, C-HP-H5OW2-10-C and C-HP-H5TW1-10-D are located adjacent to wells H5 and H5A (Figure 3).

Construction and monitoring details of C-HP-H5OW2-10-A, C-HP-H5OW2-10-B, C-HP-H5OW2-10-C and C-HPH5-TW1-10-D are described in the table below. Well records for the monitoring wells are provided in Appendix B.

Table 4: Monitoring Well Construction Details

Monitoring Well Name	Year Built	Screened Depth (mbgs)	Screened Formation	Distance to H5 (m)	Distance to H5A (m)
C-HP-H5OW2-10-A	2010	94.8-97.8	Middle Gasport	8	12
C-HP-H5OW2-10-B	2010	74.1-77.1	Upper Gasport	8	12
C-HP-H5OW2-10-C	2010	25.0-28.0	Upper Gasport	8	12
C-HP-H5TW1-10-D	2010	7.3-10.4	ATB1	4.5	3.3

2.2 Regional Geology and Hydrostratigraphy

The following sections provide a brief overview of the regional geology and hydrogeology of the study area. The surficial geology at the site based on regional Ontario Geologic Survey (OGS) mapping is provided in Figure 4. Representative cross-sections showing the stratigraphy in the vicinity of the Hespeler Well Field (H5, H5A) are included as Figures 5 and 6 to visualize the stratigraphy described in this section. The cross-section locations are provided in Figure 3.

The cross-sections are provided as a visual aid and do not necessarily contain all wells in the monitoring program for the Hespeler Well Field.

The recently completed Tier Three Assessment Update Project (Aqua Insight et al, 2023) has revised the stratigraphic (Brunton and Brintnell (2020), have indicated that the Goat Island Formation is much thicker than previously interpreted and the underlying Gasport Formation is interpreted to be thinner. Reef mounds are now interpreted to be part of the Goat Island Formation rather than the previously interpreted Gasport Formation. The lithological layers were updated in accordance with documentation provided in the Numerical Model Surface Transfer memorandum (Aqua Insight Inc, 2026).

2.2.1 Surficial Geology and Conceptual Hydrostratigraphy

The surficial geology of the Study Area has been mapped and described by Karrow (1987). Along the eastern side of the Grand River and the south side of the Speed River, the surficial geology (Figure 4) largely consists of sand and gravel outwash deposits (Units 7a and 7b in Figure 4). Ice-contact kame stratified sands and gravels (Unit 6 in Figure 4) are present east of the outwash deposits and extend towards Puslinch Lake.

The thickness of overburden deposits generally range from approximately 5 to 10 m in areas of outwash deposits, however, can be up to approximately 30 to 40 m thick in areas of the Paris and Galt moraines to the east of Cambridge. In the vicinity of the Shade's Mill, Clemens Mill and Pinebush Well Fields, the overburden thickness is generally 20 to 40 m. In the Hespeler Well Field area in northern Cambridge adjacent to the Speed River, overburden thickness is generally less than 20 m and the overburden is thin or absent in the Speed River Valley.

The key OGS model hydrostratigraphic units present in the Cambridge area are described in more detail below from youngest to oldest (Golder, 2011). The Tier 3 Update Project was focused on bedrock picks and the previous model conceptualization of the overburden remains the same (Aqua Insight et al, 2023).

Aquitard ATA2 - Wentworth Till

The Wentworth Till was deposited by the last glacier to advance in the area. It is described as a stony, sandy silt to sand textured till, and is often inter-bedded with sand and gravel. In the Cambridge area, the Wentworth Till is generally less than 10 m thick. Due to the loose, coarse-grained nature of the till, the unit behaves as a leaky aquitard or poor aquifer that is readily recharged from precipitation.

Aquifer AFA2 - Outwash Deposits

The outwash sand and gravel sediments of AFA2 are present within the Grand River Valley and vicinity, however extensive deposits have also been identified underlying the Wentworth Till in the Paris and Galt moraines. These outwash deposits are interpreted as the main production aquifer for the Shade's Mills municipal wells.

Aquitard ATB1 - Port Stanley Till

The Port Stanley Till is a sandy silt to silty sand till, with occasional stony texture. The Port Stanley Till was deposited by ice advancing from the Erie-Ontario ice lobe. In other parts of the Region, Bajc and Shirota (2007) have also used unit ATB1 to represent Tavistock, Mornington and Upper Maryhill Tills. In the Grand River and Speed River Valleys this unit has been largely removed by erosion. This unit is generally finer grained than the Wentworth Till and behaves as an aquitard.

Aquifer AFB1 - Upper Waterloo Moraine Stratified Sediments and Equivalents

Significant thicknesses of aquifer AFB1 are interpreted to occur southeast of the Speed River and west of Puslinch Lake and generally corresponds with mapped surficial ice contact sands and gravels. AFB1 is generally fine sand with some gravel and is often slightly finer grained than unit AFA2, which typically contains greater amounts of gravel. Since AFB1 and AFA2 both behave as aquifers, differentiation of these units is not critical from a hydraulic perspective, although it is necessary to represent AFB1 separately from AFA2 to allow sequential layers for aquifer units both above and below the Port Stanley Till (ATB1), where this situation occurs. Where AFB1 is not present, Port Stanley Till may directly overlie Maryhill Till and Catfish Creek Till (described below), forming a single combined aquitard unit composed of these tills.

Aquitard ATB3 - Lower Maryhill Till

Fine grained till and glaciolacustrine deposits of the Lower Maryhill Till ATB3 generally separate AFB1 from the underlying Catfish Creek Till. The Lower Maryhill Till is described as a dense, dark brown, clayey silt to silty clay till and is interpreted to be present in the Fountain Street (Well P16) well field area above the Catfish Creek and below the Port Stanley Till. Aquitard ATB3 can be difficult to distinguish from ATB1 throughout most of the study area due to the similar lithologies of these units. Lotowater (1997) grouped the Port Stanley and Maryhill Tills as a single aquitard hydrostratigraphic unit, which is a reasonable approach where no significant thickness of sand and gravel separate these units.

Aquitard ATC1 – Upper / Main Catfish Creek Till

The Catfish Creek Till was deposited by a major glacial advance from the north to northeast that covered all of southern Ontario. The Catfish Creek Till is a dense, stony, sandy silt to silty sand till with little clay content. Although originally deposited over the

entire Cambridge area, erosion, glaciations and meltwater events have removed areas of the Catfish Creek Till and it is now discontinuous. In the Cambridge Area, the thickness of this unit ranges from approximately 5 m in areas east of the Grand River, to approximately 20 m west of the Grand River, and is usually found immediately overlying bedrock and beneath clayey sediments. The hydrogeologic properties of the Catfish Creek Till are variable, ranging from a good aquitard to a poor aquifer, depending on local lithology, degree of compaction, and the presence of overlying aquitard units.

2.2.2 Bedrock Geology and Conceptual Hydrostratigraphy

The stratigraphy discussed below is consistent with the revised stratigraphic framework described by the OGS (Brunton, 2009) and is also used in the Tier 3 Study of the area (Golder, 2011). The thickness of the Goat Island and Gasport Formations in the vicinity of H5 / H5A has been revised based on the Tier Three Assessment Update Project (Aqua Insight et al, 2023). A brief description (from Stantec, 2013) of each bedrock formation and conceptual hydrostratigraphic units typically present in Cambridge is provided below (from youngest to oldest). The formations present in the vicinity of H5 / H5A are shown on the cross sections in Figures 5 and 6.

The bedrock that sub crops beneath the Hespeler area was deposited in a marine environment during the Silurian Period. The thick deposits of carbonate rock, the source of water for all of the bedrock wells in Cambridge, is referred to as the Guelph / Gasport aquifer and is subdivided into Guelph, Eramosa and Gasport Formations.

Guelph Formation

The Guelph Formation is a cream-coloured fossiliferous dolostone that represents an important aquifer in the Cambridge and Guelph area, where it is most often the uppermost bedrock unit.

Eramosa Formation

The Upper Eramosa Formation is described by Brunton (2009) as light brown to cream coloured, pseudo nodular, thickly bedded and coarsely crystalline dolostone. The formation consists of the Reformatory Quarry Member, and the Vinemount Member.

The Reformatory Quarry Member is susceptible to karstification due to its uniform fine dolomite crystallinity (Brunton, 2009), and also often contains mud-rich and microbial mat-bearing lithofacies. As a result, this unit generally represents a poor aquifer or poor aquitard. This unit was described as either the Guelph Formation or Eramosa Member in previous studies within the Region.

The Vinemount Member is comprised of thinly bedded, fine crystalline dolostone with shaley beds that give off a distinctive petroliferous odour when broken (Brunton, 2009). This unit represents an aquitard when present within the Cambridge and Guelph areas.

Goat Island Formation

The Goat Island Formation consists of the upper Ancaster Member and lower Niagara Falls Member. The Ancaster Member is a chert rich, finely crystalline dolostone that is medium to ash grey in colour. The Niagara Falls Member is a finely crystalline and cross laminated crinoidal grainstone with small reef mounds. The finely crystalline nature of these Members results in a lower hydraulic conductivity and transmissivity compared to the underlying Gasport Formation (Brunton, 2009). Conceptually, the two members of the Goat Island Formation are treated as a single hydrostratigraphic unit. Based on an updated interpretation provided by the Ontario Geological Survey (OGS; Brunton and Brintnell, 2020), the interpreted Goat Island Formation is about 50 m thicker at H5 / H5A than previously interpreted and the underlying Gasport Formation is interpreted to be thinner. Reef mounds are now interpreted to be associated with the Goat Island Formation. As a result, the highly transmissive reef mounds, crinoidal grainstones and coquina beds originally used to delineate the Upper and Middle portions of the Gasport Formation are now considered part of the Goat Island Formation.

Gasport (Amabel) Formation

The Gasport Formation is a cross-bedded crinoidal grainstone-packstone with sequences of reef mound and coquina (shell bed) lithofacies. This unit has commonly been referred to as the Amabel Formation in previous studies in the Region and is now interpreted to be much thinner than previously interpreted (Aqua Insight et al, 2023).

2.3 Local Geology

Figure 3 displays the Hespeler well plan and cross section locations. Representative cross-sections are included as Figures 5 and 6 to visualize the stratigraphy described in this section.

2.3.1 Overburden Geology

Investigations during the drilling of on-site boreholes (C-HP-H5TW1-10-D) (Burnside, 2012) indicated that the overburden is approximately 10 m thick and includes interbedded layers of sand, silty sand, silty clay and silt (ATA2) from approximately 0.7 to 4.1 metres below ground surface (m bgs). A thin layer (approximately 0.4 m thick) of silty clay till corresponding with the Maryhill Till (ATB1 / ATB2) underlies the stratified deposit. A dense silt and gravel unit (approximately 3.8 m thick) underlies the Maryhill Till. This unit is likely the Catfish Creek Till (ATC1 / ATC2) which is widespread throughout the area. A unit consisting of sand with some gravel is present under the Catfish Creek Till unit and extends to the bedrock surface at approximately 10.0 m bgs. This sequence of units generally corresponds to the stratigraphy indicated on the original borehole log for well H5. Based on observations of the recovered core, it is Burnside's interpretation that the Maryhill Till and Catfish Creek Till likely act as aquitards in the area of the H5A site.

2.3.2 Bedrock Geology

Based on the results of drilling investigations at the site, including H5, H5A, and C-HP-H5OW2-10-A, the bedrock surface is found at approximately 10 mbgs (Appendix B). The Guelph Formation is not present at the H5 well site. At the time of construction in 2009, the Eramosa Formation was identified between 10-11.5 mbgs (1.5 m thick), the Goat Island Formation between 11.5-15.3 mbgs (3.8 m thick), and the Gasport between 15.3 and 110.4 mbgs (95.1 m thick) (Burnside, 2012). The thickness of the dolostone units is approximately 102.9 m, which is consistent with a total thickness of approximately 104 m for the dolostone formations identified 1,010 m to the southwest at C-HP-OW1-95 (Lotowater, 1997).

Rock core collected at the H5A site was originally logged by the OGS, who provided input on the identification and correlation of the bedrock formational characteristics. Logging of bedrock formations by the OGS at C-HP-H5-TW1-09-A is summarized below in Table 5. The values in brackets are the reinterpreted thicknesses of the Goat Island and Gasport Formations.

Table 5: Summary of Bedrock Formations at Hespeler Well Field (H5, H5A)

Formation	Description	Thickness (m)	H5A Water Production (mbgs)
Eramosa - Reformatory Quarry Member	Dolostone – dark grey, slightly to very porous with some large voids.	1.5	-
Goat Island	Dolostone – grey, slightly porous with some large voids.	3.8 (51.5)	
Gasport	Dolostone - grey, fine crystalline, slightly to very porous, moderately to richly fossiliferous, mottled, few vugs.	95.1 (47.4)	94.4 to 96.0
Irondequoit	Dolostone - dark grey, slightly porous, fine crystalline.	1.0	-
Rockway-Merritton	Dolostone - dark grey, slightly porous, finely crystalline.	2.6	-
Cabot Head	Shale – grey and red layered	> 3.0	-

3.0 2024 / 2025 Results

In accordance with condition 4.2 of the PTTW, water levels were measured and recorded once a month in all listed monitoring wells.

The following sections summarize groundwater levels in the monitoring wells in relation to precipitation, water taking from the aquifer (in accordance with condition 4.3 of the PTTW).

3.1 Precipitation

Longer term precipitation trends can have an impact on water levels in the supply aquifer. To assess the potential influence, monthly precipitation is plotted for comparison to water levels and pumping and presented in Appendix C.

Since variations in precipitation totals can occur throughout the Region due to localized events, monthly precipitation data from the GRCA and Environment Canada station located closest to the production wells are used. The closest GRCA weather station relative to the Hespeler H5, H5A wellfield is the Shades Mills Dam station located 8.3 km to the south. The closest Environment Canada station is the Waterloo International Airport (WIA) located 5.6 km to the west. The locations of the meteorological stations are shown in Figure 1.

Annual precipitation data from the past 10 years for all stations are compared with long term averages in Table D.1, Appendix D. At the Shades Mills Dam station, the long-term average was calculated from when measurements started until the end of 2025. The WIA has “Climate Normals” calculated by Environment Canada for 1971 to 2000.

Annual 2024 / 2025 precipitation data all the meteorological stations closest to the Hespeler Well H5, H5A well field are presented in Table 6 below. WIA was missing 6 days of data in 2024 and 6 days in 2025. As a result, the precipitation totals at these stations may be under reported.

Table 6: Summary of Precipitation Data

Station	2024 Precipitation (mm)	2024 Deviation (mm)	Long- Term Average (mm)	2025 Precipitation (mm)	2025 Deviation (mm)
Region of Waterloo International Airport ^(A)	874	+23	851 ^D	723	-128
Shades Mills Dam ^(B)	976	+67	909 ^A	895	-14
Sources: Environment Canada (1), GRCA (2) ^A 1991 to 2020 Normal ^B 1998-2024 data ^B Average annual precipitation since monitoring began to the end of 2025					

Water levels typically follow a seasonal trend with highest levels occurring in the spring with the depth and water content of the snowpack having a significant influence on water levels. Lowest levels occurring in July / August. Widespread synoptic rainfall events can also result in Region-wide water level responses. Summer thunderstorms tend to be short lived and occur over a smaller area resulting in short term, localized water level rises not typically seen in the monitoring wells.

The 2024 total precipitation at Shades Mills station was 976 mm, which is 67 mm above the long-term average, indicating 2024 was wetter-than-average at the well field. A similar above long-term average trend is noted at the WIA station. The March 1 GRCA snow survey indicated a snowpack across the Region that was low compared to normal.

In 2025, the total precipitation was 895 mm, which is 14 mm below the long-term average. Similarly, the total precipitation at the WIA station was 128 mm below the long-term average, indicating 2025 was a drier-than-average year. However, WIA was missing 12 days of data in 2024 / 2025 and as a result, precipitation totals may be under reported. The snow survey conducted by the GRCA on March 15, 2025, showed that the stations in the Region had a high to very high measured snow water equivalent.

3.2 Monitoring Results

Hydrographs showing the results of water level monitoring at each monitoring well over the past 10 years are provided in Appendix C. The method used to collect the water levels (manual or electronic) is indicated on the graphs in Appendix C.

C-HP-H5OW2-10-ABC

C-HP-H5OW2-10 is located on the H5 / H5A property and includes three nested bedrock wells (A, B, and C screens). Water levels have been collected at this location since December 2012. Hydrographs are presented in Appendix C.

Water level monitoring at the B screen is completed using monthly manual measurements. Monitoring in the A and C screens is completed using electronic dataloggers. The well field was off-line between September 2016 to July 2017 and levels during this time period are considered to be non-pumping water levels. Water levels in all three screens at C-HP-H5OW2-10-ABC respond to pumping of H5 and H5A.

During 2024 and 2025 water levels followed historical trends with the greatest response to H5A pumping observed in the A (lowest levels near 285 masl) and B screens (lowest levels near 287 masl). The greatest response to H5 pumping was observed in the C screen (lowest levels near 287 masl). Water levels observed in 2024 / 2025 were consistent with historical values.

The greatest response to H5 pumping occurs in C-HP-H5OW2-10-C, where the water levels decline by up to 10 m in 2023 levels to 287 masl. Water levels in screens A and B decline approximately 5 m to 289 masl during pumping of H5. Levels in the A and B screens show a greater response to pumping of H5A and rise when only H5 is pumping.

C HP-H5TW1-10-D

Monitoring well C HP-H5TW1-10-D is a 10.4 m deep overburden (ATB1) monitoring well located on the H5/H5A site (Figure 3). The well is screened from 297.7 to 294.7 masl and responds to pumping of H5 / H5A. The response to H5 pumping is greater than H5A because H5A is screened much deeper (62.1-114.9 mbgs) compared to H5 (22.6-30.8 mbgs). Water levels are now collected manually once per month which does not allow the short-term response to pumping to be discerned. Water levels in screen D are reflective of seasonal trends where water levels are typically highest in the spring, decline during the summer months, and rise in the late fall

In 2025 the lowest level occurred in October and was about 0.2 m higher than the September 2022 level. Water levels observed in 2024 / 2025 were consistent with historical values.

4.0 Impact Assessment

4.1 Well Interference

PTTW Condition 5.1 states, "The Permit Holder shall immediately notify the local District Office of any complaint arising from the taking of water authorized under this Permit and shall report any action which has been taken or is proposed with regard to such complaint. The Permit Holder shall immediately notify the local District Office if the taking of water is observed to have any significant impact on the surrounding waters. After hours, calls shall be directed to the Ministry's Spills Action Centre at 1-800-268-6060."

PTTW Condition 5.2 states: For Groundwater Takings - If the taking of water is observed to cause any negative impact to other water supplies obtained from any adequate sources that were in use prior to initial issuance of a Permit for this water taking, the Permit Holder shall take such action necessary to make available to those affected, a supply of water equivalent in quantity and quality to their normal takings, or shall compensate such persons for their reasonable costs of so doing, or shall reduce the rate and amount of taking to prevent or alleviate the observed negative impact. Pending permanent restoration of the affected supplies, the Permit Holder shall provide to those affected, temporary water supplies adequate to meet their normal requirements or shall compensate such persons for their reasonable costs of doing so. If permanent interference is caused by the water taking, the Permit Holder shall restore the water supplies of those permanently affected.

The well field has been in operation for approximately 70 years (H5A has been in service since 2017), so future domestic well interference is considered unlikely. In the event that a well interference complaint is received, the Region has a Well Interference Policy in place. A copy of the policy is presented in Appendix F of the 2019 Biennial Groundwater Monitoring Report - Multiple Well Fields (Burnside, 2020). There were no well interference complaints related to H5/H5A received in 2024 and 2025.

Other non-municipal groundwater and surface water takings registered in the MECP's PTTW database within 2 km of the well field are mapped in Figures 3 and summarized below in Table 7. The PTTW database identified three permits located north-east of H5 / H5A. The groundwater taking at Brookfield Country Club impacts groundwater levels at the production wells and water taking at the production wells impact water levels at the Brookfield Country Club.

Table 7: PTTWs (Groundwater and Surface Water) in Vicinity of Hespeler Well Field (H5, H5A)

Permit Number	Permit Holder	Purpose	Max Liters per Day	Distance (km) from H5/H5A Supply Wells	Expiry Date	Source
7318-BPHSD5	Brookfield Country Club	Golf Course Irrigation	1,637,000	2.0	2025-2-28	GW
7318-BPHSD5	Brookfield Country Club	Golf Course Irrigation	2,217,000	2.0	2025-2-28	SW
2322-BDJJ4J	Beaverdale Golf Club Limited	Golf Course Irrigation	491,000	2.7	2029-3-31	SW
5315-A5HMWN	The Greenhorizons Group of Farms Ltd.	Agricultural	1908000	1.6	2026-2-28	SW
5315-A5HMWN	The Greenhorizons Group of Farms Ltd.	Agricultural	1908000	1.6	2026-2-28	GW

4.2 Aquifer Response to Pumping and Precipitation

PTTW Condition 4.3 states: " The Permit Holder shall prepare and submit a report every two years by June 30, that presents the results of the well field water level monitoring for the two preceding calendar years, assesses changes in water levels in the supply aquifer(s) in relation to precipitation and water taking from the aquifer(s)".

The Upper and Middle Gasport Formation Aquifers in the vicinity of H5 / H5A are more responsive to trends in pumping, and less reflective of long-term precipitation over the years of 2024 to 2025. However, water levels in the shallow overburden (ATB1) show a seasonal response to long-term precipitation rather than individualized events.

5.0 Conclusions

Impacts from pumping the municipal wells at the Hespeler Well Field (H5, H5A) were evaluated through implementation of the Groundwater Monitoring Program. Based on the information contained in the report, Burnside offers the following conclusions:

- The information presented in this report satisfies condition 4.3 of PTTW P-300-1161883172;
- There were no reported well interference complaints arising from water taken at the Hespeler H5, H5A well field;
- Onsite monitoring wells completed in the bedrock respond to pumping of H5 / H5A;
- Groundwater levels at C-HP-H5OW2-10-ABC and C HP-H5TW1-10-D in 2024/2025 are in line with historical data;
- The onsite overburden monitoring well shows typical seasonal variations; and
- Water levels in monitoring wells indicate that current pumping rates have not resulted in any adverse impacts to water levels in the monitoring wells.

6.0 References

Aqua Insight Inc., Technical Memorandum Numerical Model Surface Transfer, March 2026.

Aqua Insight Inc., Stantec Consulting Ltd, S.S. Papadopoulos and Associates Inc. and WSP Canada Inc., 2023. Hydrogeologic Characterization and Conceptual Model Updates, Region of Waterloo Tier Three Update Project. Final Report, June 2023.

Aqua Insight Inc., Stantec Consulting Ltd, S.S. Papadopoulos and Associates Inc., 2024. Updates to the Moraine and Cambridge Model following Model Calibration Reporting, July 2024.

Bajc, A.F. and Shirota J., 2007. Three-dimensional mapping of surficial deposits in the Regional Municipality of Waterloo, southwestern Ontario; report in Ontario Geological Survey, Groundwater Resources Study 3, p. 42.

Brunton, F.R. and Brintnell, C. 2020. Early Silurian sequence stratigraphy and geological controls on karstic bedrock groundwater-flow zones, Niagara Escarpment region and the subsurface of southwestern Ontario; report [PDF document] in Ontario Geological Survey, Groundwater Resources Study 13.

Brunton, F.R., Preliminary Revisions to the Early Silurian Stratigraphy of Niagara Escarpment: Integration of Sequence Stratigraphy, Sedimentology and Hydrogeology to Delineate Hydrogeologic Units., Summary of Field Work and Other Activities 2008, Ontario Geological Survey, Open File Report 6226, P31-1 to 31-18.

Golder Associates, October, 2009: Revised November 2011. Tier 3 Water Budget and Local Area Risk Assessment, Cambridge East Well Field Characterization.

Karrow 1987, Quaternary geology of the Hamilton-Cambridge Area, Southern Ontario. Ontario Geological Survey, Report 255, 94 p.

Lotowater Ltd. 1997, Study of the Hydrogeology of the Cambridge Area, The Regional Municipality of Waterloo, 93p.

Matrix Solutions Inc., 2015. Technical Memorandum: Numerical Model Surfaces Data Transfer. Region of Waterloo, June 5, 2015.

Region of Waterloo, 2015. Regional Official Plan.

R.J. Burnside & Associates Limited, 2024. 2023 Biennial Groundwater Monitoring Report – Hespeler Well Field (H5, H5A), Region of Waterloo. R.J. Burnside & Associates Limited, 2023. Seasonal Water Level Report, Region of Waterloo, March 3, 2023

R.J. Burnside & Associates Limited, 2012. Production Well H5A Construction and Testing Report Regional Municipality of Waterloo.

2025 Biennial Groundwater Monitoring Report - Hespeler Well Field (H5, H5A)
June 2026

Stantec, 2013. Pinebush Road Well Field Construction and Testing of Test Wells P10A, P10B, TW1-10, and Production Wells P11 and P17.

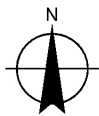
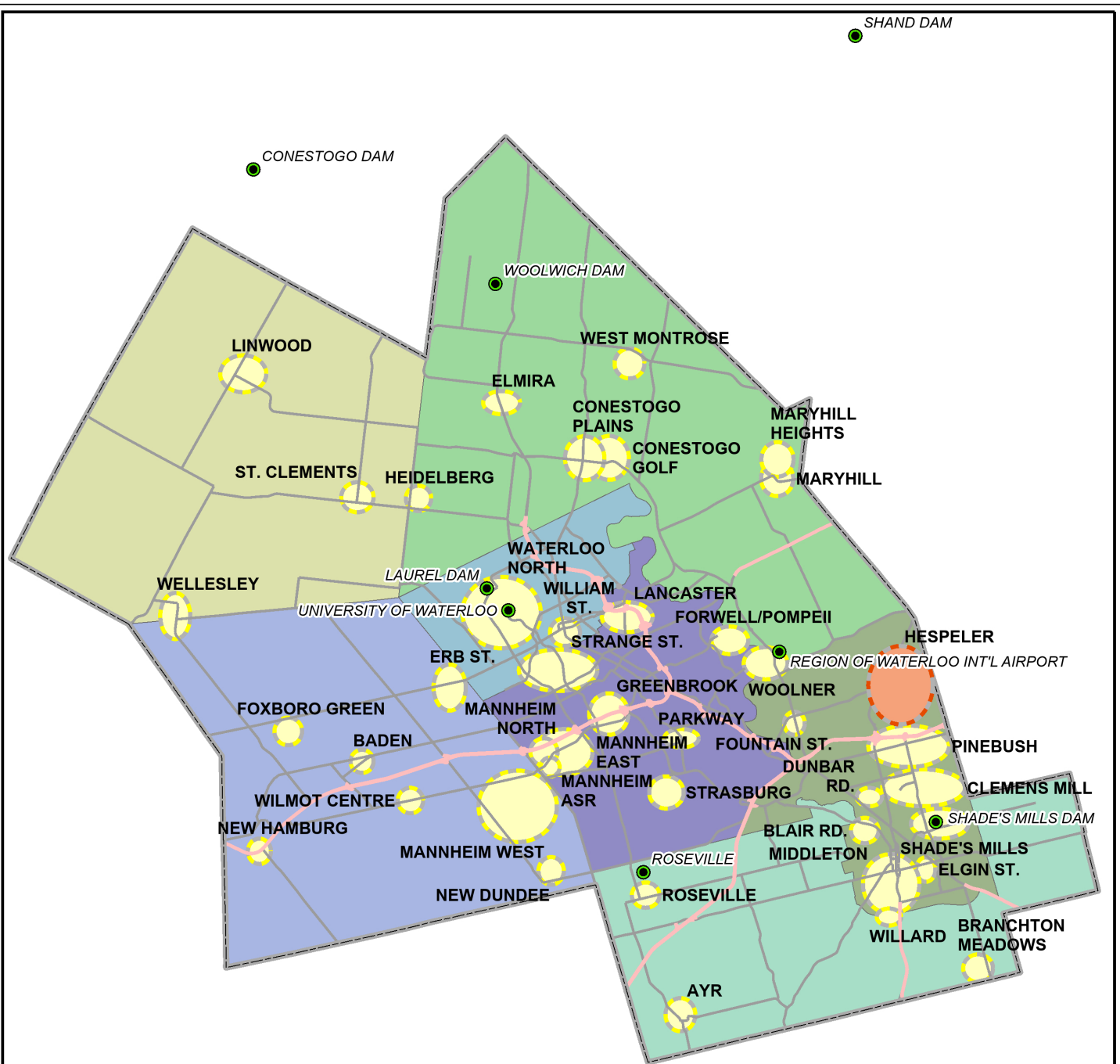


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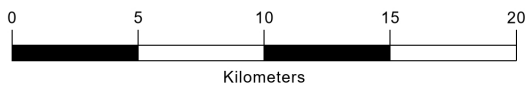
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Figures



Data Source:
Region of Waterloo; Includes material © 2012 of the Queen's
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- | | |
|-------------------------------|-------------------------------------|
| Well Field Location | Township of North Dumfries |
| Well Fields | Township of Wellesley |
| Regional Municipal Boundaries | Township of Wilmot |
| City of Cambridge | Township of Woolwich |
| City of Kitchener | Meteorological Monitoring Locations |
| City of Waterloo | |



Map Title

2025 GROUNDWATER MONITORING REPORT - HESPELER H5/H5A WELL FIELD

WELL FIELD LOCATION MAP

Client

REGION OF WATERLOO

Drawn

HN

Scale

1:300,000

Checked

SQ

Date

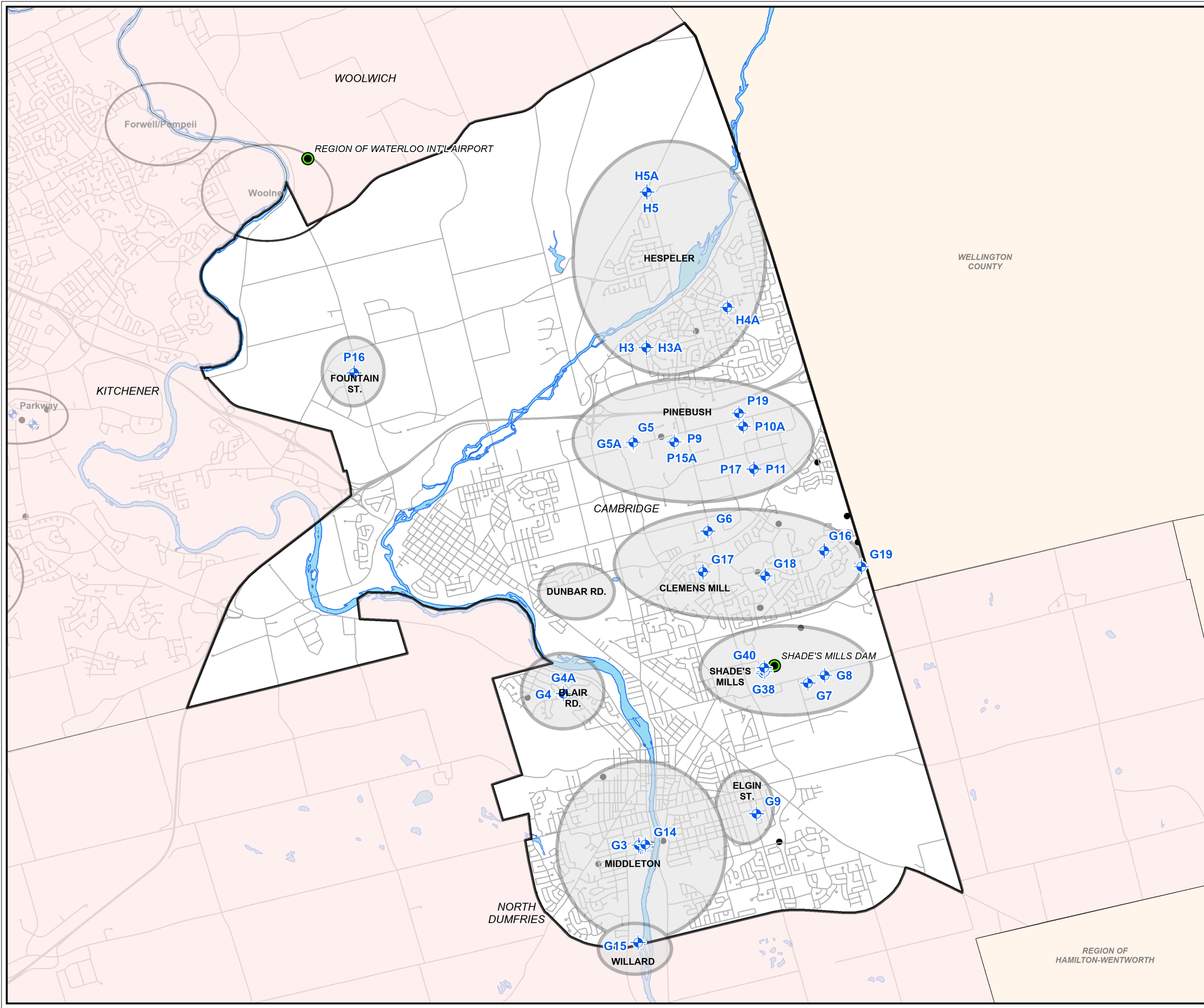
February 2026

Project No.

HA0464020

Figure No.

1



LEGEND

- Production Well Location
- Monitoring Well Location
- Well Fields
- Cambridge Municipal Boundary
- Meteorological Monitoring Locations

Sources:
1. Ministry of Natural Resources, © Queen's Printer for Ontario
2. Natural Resources Canada © Her Majesty the Queen in Right of Canada.

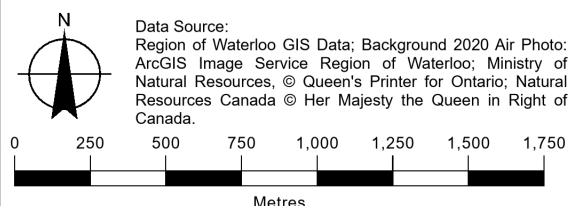
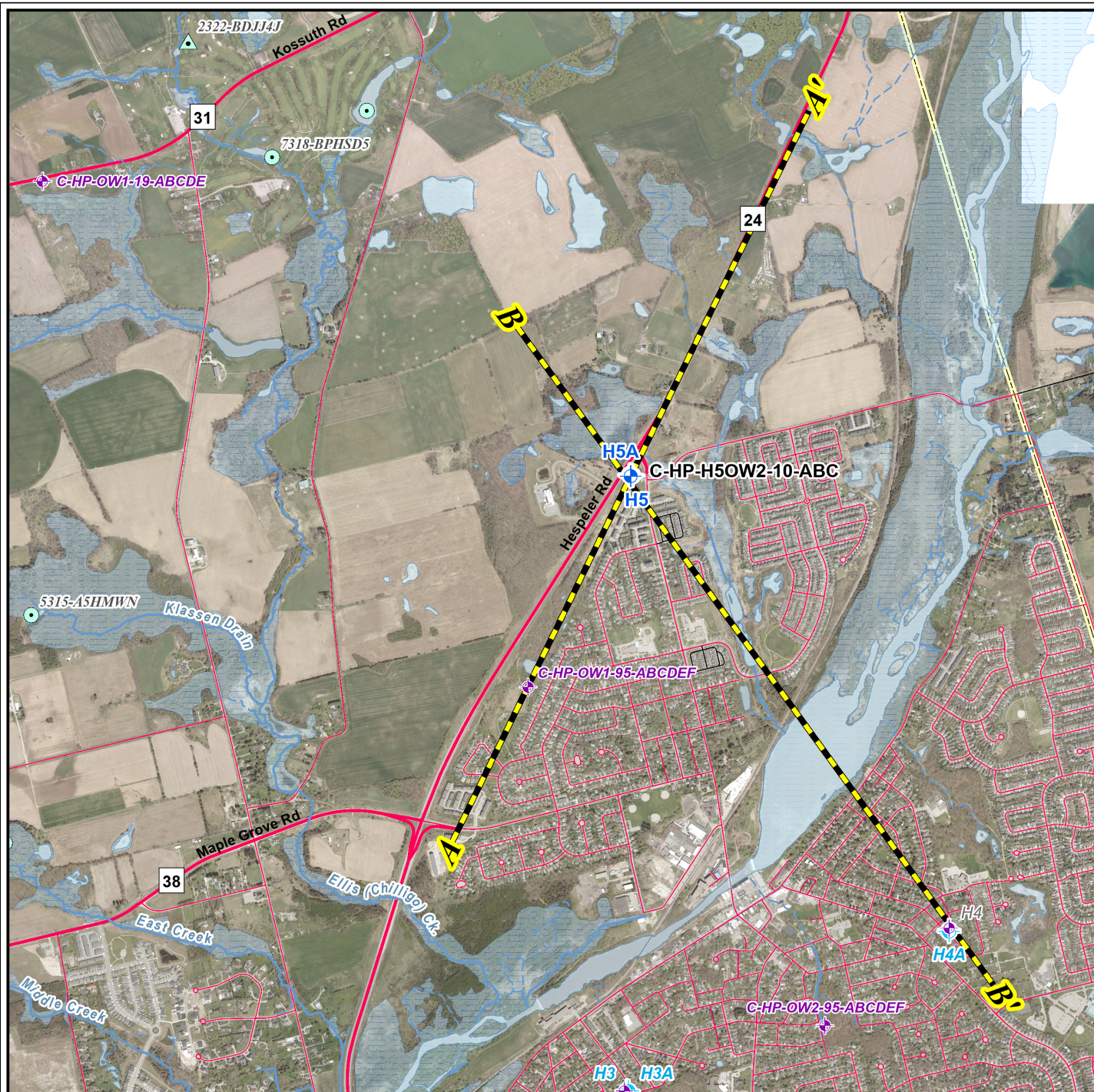
Datum: North American 1983 CSRS
Coord. System: NAD 1983 CSRS UTM Zone 17N



Client
REGION OF WATERLOO

Figure Title
**2025 GROUNDWATER MONITORING
REPORT - HESPELER H5/H5A WELL FIELD**
**CAMBRIDGE WELL FIELDS AND
MONITORING NETWORK**

Drawn	Checked	Date	Figure No. 2
HN	SQ	February 2026	
Scale 1:65,000		Project No. HA0464020	



Data Source:
Region of Waterloo GIS Data; Background 2020 Air Photo;
ArcGIS Image Service Region of Waterloo; Ministry of
Natural Resources, © Queen's Printer for Ontario; Natural
Resources Canada © Her Majesty the Queen in Right of
Canada.

- PTTW Monitoring Well Location
- Nearby Monitoring Well Location
- Nearby Production Well Location
- Abandoned Well Location

- Additional MECP PTTW Locations**
- Surface Water
 - Surface and Ground Water
 - Cross Section Orientation
 - Intermittent Creek
 - Creek

- Waterbody
- Provincially Significant Wetland (MNR)
- Regional Road
- Local Road
- Private / Other Road
- Region of Waterloo Boundary



Map Title

2025 GROUNDWATER MONITORING REPORT - HESPELER H5/H5A WELL FIELD

WELL LOCATION MAP

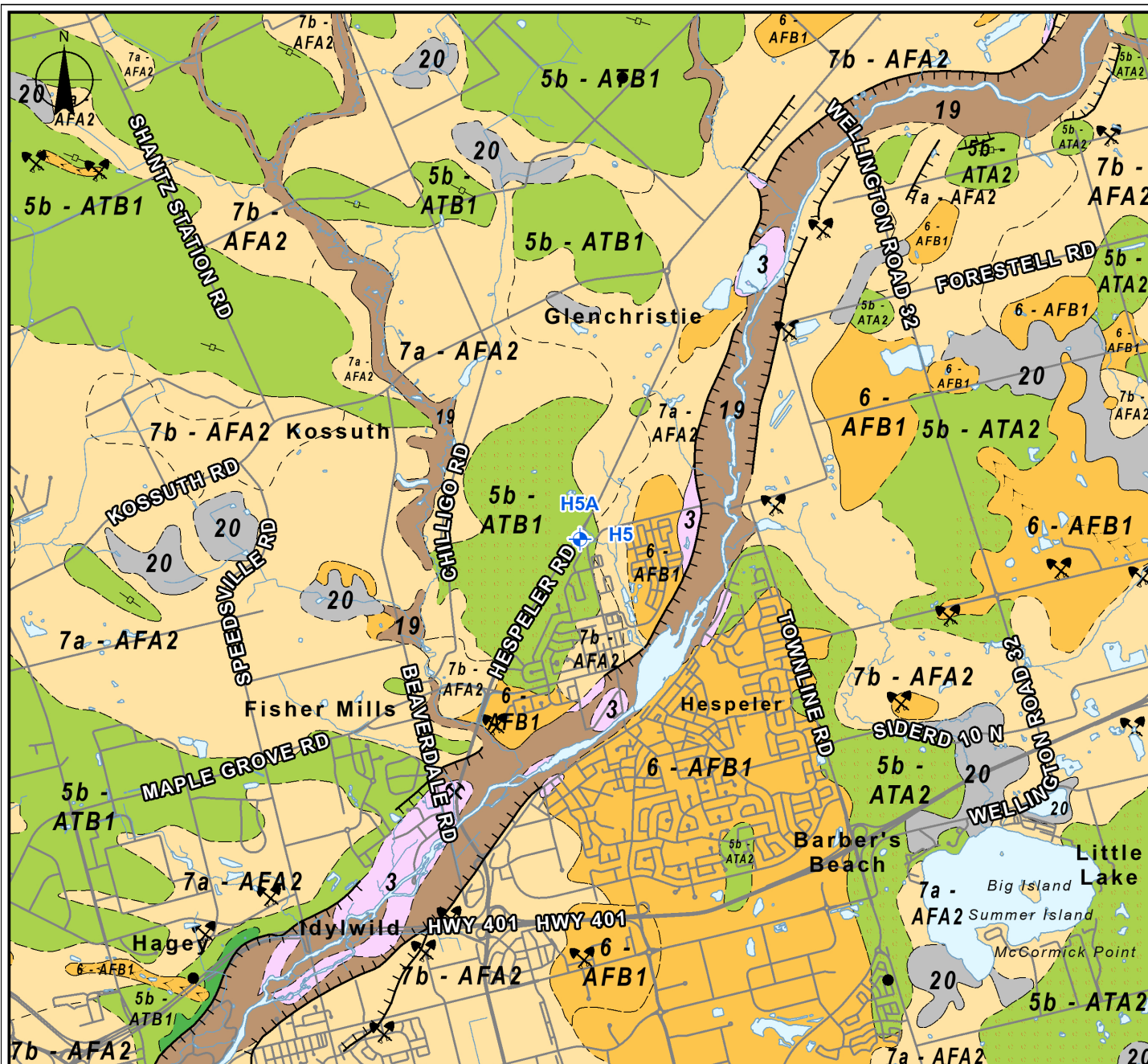
Client

REGION OF WATERLOO

Drawn	Checked	Date
HN	SQ	February 2026
Scale	Project No.	
1:25,000	HA0464020	

Figure No.

3



Data Source:
 1. Ontario Geological Survey 2003. Surficial Geology of Southern Ontario; Ontario Geological Survey, Miscellaneous Release--Data 128.
 2. Region of Waterloo GIS

- | | | | | |
|---|--|---|--|--|
| <ul style="list-style-type: none"> RMOW Supply Well Watercourse Waterbody <p>Surficial Geology</p> <ul style="list-style-type: none"> 3: Paleozoic bedrock | <ul style="list-style-type: none"> 5b: Stone-poor, carbonate-derived silty to sandy till (ATA2/ATB1 - Aquitard) 5d: Glaciolacustrine-derived silty to clayey till (ATB1 - Aquitard) 6: Ice-contact stratified deposits (AFB1 - Aquifer) | <ul style="list-style-type: none"> 7a: Glaciofluvial deposits: Sandy deposits (AFA2 - Aquifer) 7b: Glaciofluvial deposits: Gravelly deposits (AFA2 - Aquifer) 19: Modern alluvial deposits | <ul style="list-style-type: none"> 20: Organic deposits Quarry (Point) Sand and Gravel Pit Esker: Direction of Flow Known Terrace Drumlin or drumlinoid ridges (point) | <ul style="list-style-type: none"> Sample Location Hummocky Topography Unit Contact Boundary |
|---|--|---|--|--|



Map Title
**2025 GROUNDWATER MONITORING
 REPORT - HESPELER H5/H5A WELL FIELD**

SURFICIAL GEOLOGY

Client

REGION OF WATERLOO

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Date

February 2026

Project No.

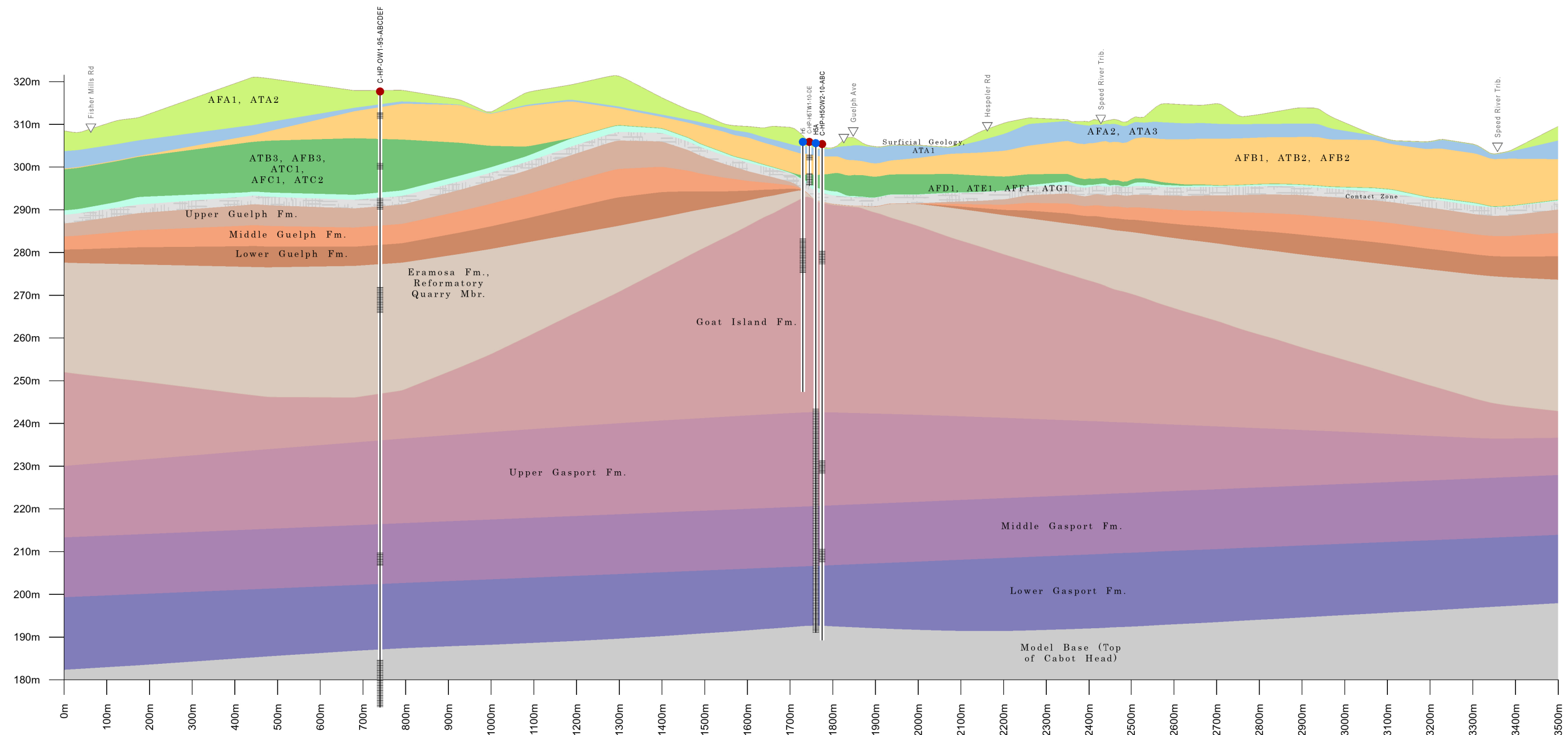
HA0464020

Figure No.

4

A

A'

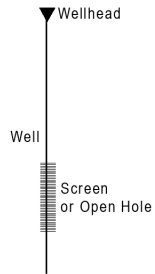


Wells

- Production Well (Active)
- Monitoring Well

Cambridge Model 2026

Surficial Geology, Whittlesey Clay (ATA1)	Upper Waterloo Moraine Stratified Sediments & Equivalents (AFB1), Middle Maryhill Till & Equivalents (ATB2), Middle Waterloo Moraine Stratified Sediments & Equivalents (AFB2)	Pre-Cattfish Creek Coarse-Grained Glaciofluvial/ Lacustrine Deposits (AFD1), Canning Drift: Till & Fine Textured Glaciolacustrine Deposits (ATE1), Pre-Canning Coarse-Textured Glaciofluvial/ Glaciolacustrine Deposits (AFF1), Pre-Canning Coarse-Textured Till (ATG1)	Bedrock: Upper Guelph Fm.	Bedrock: Eramosa Fm., Vinemount Mbr.	Bedrock: Middle Gasport Fm.
Whittlesey Sand (AFA1), Wentworth Till (ATA2)	Lower Maryhill Till & stratified Equivalents (ATB3), Lower Waterloo Moraine Stratified Sediments or Cattfish Creek Till Outwash (AFB3), Upper / Main Cattfish Creek Till (ATC1), Middle Cattfish Creek Stratified Deposits (AFC1), Lower Cattfish Creek Till (ATC2)	Weathered Bedrock	Bedrock: Middle Guelph Fm.	Bedrock: Goat Island Fm.	Model Base (Top of Cabot Head)
Grand River Valley Outwash Deposits (AFA2), Fine Grain Deposits in the Grand River Valley (ATA3)			Bedrock: Lower Guelph Fm.	Bedrock: Lower Gasport Fm.	
			Bedrock: Eramosa Fm., Reformatory Quarry Mbr.	Bedrock: Upper Gasport Fm.	



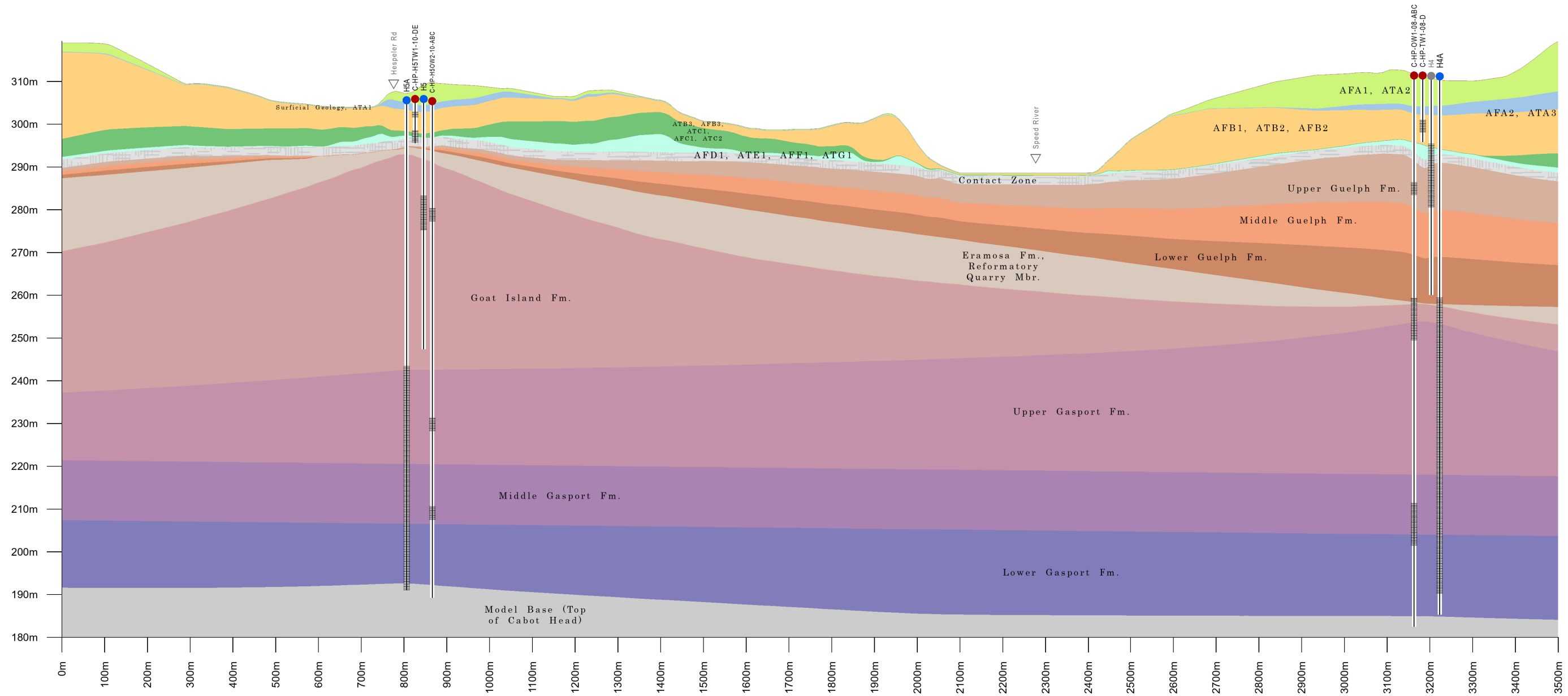
Client
REGION OF WATERLOO

Figure Title
**GEOLOGIC CROSS SECTION
REGION OF WATERLOO**
Hespeler
Cross Section A - A'

Drawn	Checked	Date	Figure No.
PS	DH	2026/06/02	5
Horizontal Scale 1:10,000		Project No.	
Vertical Ex.:10x		HA046402	

B

B'



Wells

● Production Well (Active) ● Production Well (Decommissioned) ● Monitoring Well

Cambridge Model 2026

Surficial Geology, Whittlesey Clay (ATA1) Whittlesey Sand (AFA1), Wentworth Till (ATA2) Grand River Valley Outwash Deposits (AFA2), Fine Grain Deposits in the Grand River Valley (ATA3)	Upper Waterloo Moraine Stratified Sediments & Equivalents (AFB1), Middle Maryhill Till & Equivalents (ATB2), Middle Waterloo Moraine Stratified Sediments & Equivalents (AFB2) Lower Maryhill Till & stratified Equivalents (ATB3), Lower Waterloo Moraine Stratified Sediments or Catfish Creek Till Outwash (AFB3), Upper / Main Catfish Creek Till (ATC1), Middle Catfish Creek Stratified Deposits (AFC1), Lower Catfish Creek Till (ATC2)	Pre-Catfish Creek Coarse-Grained Glaciofluvial/ Lacustrine Deposits (AFD1), Canning Drift: Till & Fine Textured Glaciolacustrine Deposits (ATE1), Pre-Canning Coarse-Textured Glaciofluvial/ Glaciolacustrine Deposits (AFF1), Pre-Canning Coarse-Textured Till (ATG1) Weathered Bedrock	Bedrock: Upper Guelph Fm. Bedrock: Middle Guelph Fm. Bedrock: Lower Guelph Fm. Bedrock: Eramosa Fm., Reformatory Quarry Mbr.	Bedrock: Eramosa Fm., Vinemount Mbr. Bedrock: Goat Island Fm. Bedrock: Lower Gasport Fm. Bedrock: Upper Gasport Fm.	Bedrock: Middle Gasport Fm. Model Base (Top of Cabot Head)	Wellhead Well Screen or Open Hole	 Client REGION OF WATERLOO	Figure Title GEOLOGIC CROSS SECTION REGION OF WATERLOO Hespeler Cross Section B - B'	<table><tr><td>Drawn</td><td>Checked</td><td>Date</td><td rowspan="3">Figure No.</td></tr><tr><td>PS</td><td>DH</td><td>2026/06/02</td></tr><tr><td colspan="2">Horizontal Scale 1:10,000</td><td>Project No.</td></tr><tr><td colspan="2">Vertical Ex.:10x</td><td>HA046402</td><td></td></tr></table>	Drawn	Checked	Date	Figure No.	PS	DH	2026/06/02	Horizontal Scale 1:10,000		Project No.	Vertical Ex.:10x		HA046402		6
Drawn	Checked	Date	Figure No.																					
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Horizontal Scale 1:10,000		Project No.																						
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Appendix A

Permit To Take Water



PERMIT TO TAKE WATER

Ground Water

NUMBER P-300-1161883172

Version: 1.0

Effective Date: July 7, 2022

Expiry Date: May 31, 2032

Pursuant to Section 34.1 of the Ontario Water Resources Act, Revised Statutes of Ontario (R.S.O.) 1990 this Permit To Take Water is hereby issued to:

REGIONAL MUNICIPALITY OF WATERLOO

150 Frederick Street
6th Floor
KITCHENER
ONTARIO
Canada
N2G 4J3

For the water taking from

H5A

H5

Located at:

500 Guelph Avenue (AVE) , Cambridge, CAMBRIDGE, ONTARIO, CANADA, N3C 2V3

This Permit cancels and replaces Permit Number 7145-8Z8QUN, issued on October 31, 2012.

DEFINITIONS

For the purposes of this Permit, and the terms and conditions specified below, the following definitions apply:

- a. "Director" means any person appointed in writing as a director pursuant to section 5 of the OWRA for the purposes of section 34.1 of the OWRA.
- b. "Provincial Officer" means any person designated in writing by the Minister as a provincial officer pursuant to section 5 of the OWRA.
- c. "Ministry" means the ministry of the government of Ontario responsible for the administration of the OWRA, currently named the Ministry of the Environment, Conservation and Parks.
- d. "District Office" means the Guelph District Office of the Ministry.
- e. "Permit" or "PTTW" means this Permit to Take Water No. P-300-1161883172 including its Schedules, if any, issued in accordance with Section 34.1 of the OWRA, as may amended.
- f. "Permit Holder" means REGIONAL MUNICIPALITY OF WATERLOO.
- g. "OWRA" means the *Ontario Water Resources Act*, R.S.O. 1990, c. O. 40.

TERMS AND CONDITIONS

You are hereby notified that this Permit is issued subject to the terms and conditions outlined below:

1. Compliance with Permit

- 1.1. Except where modified by this Permit, the water taking shall be in accordance with the application for this Permit To Take Water, attested to by Karl Belan, on February 25, 2022, and all Schedules included in this Permit.
- 1.2. The Permit Holder shall ensure that any person authorized by the Permit Holder to take water under this Permit is provided with a copy of this Permit and shall take all reasonable measures to ensure that any such person complies with the conditions of this Permit.
- 1.3. Any person authorized by the Permit Holder to take water under this Permit shall comply with the conditions of this Permit.
- 1.4. This Permit is not transferable to another person.
- 1.5. This Permit provides the Permit Holder with permission to take water in accordance with the conditions of this Permit, up to the date of the expiry of this Permit. This Permit does not constitute a legal right, vested or otherwise, to a water allocation, and the issuance of this Permit does not guarantee that, upon its expiry, it will be renewed.
- 1.6. The Permit Holder shall keep this Permit available at all times at or near the site of the taking, and shall produce this Permit immediately for inspection by a Provincial Officer upon his or her request.
- 1.7. The Permit Holder shall report any changes of address to the Director within thirty days of any such change. The Permit Holder shall report any change of ownership of the property for which this Permit is issued within thirty days of any such change. A change in ownership in the property shall cause this Permit to be cancelled.

2. General Conditions and Interpretation

2.1. Inspections

The Permit Holder must forthwith, upon presentation of credentials, permit a Provincial Officer to carry out any and all inspections authorized by the OWRA, the Environmental Protection Act, R.S.O. 1990, the Pesticides Act, R.S.O. 1990, or the Safe Drinking Water Act, S. O. 2002.

2.2. Other Approvals

The issuance of, and compliance with this Permit, does not:

- (a) relieve the Permit Holder or any other person from any obligation to comply with any other applicable legal requirements, including the provisions of the Ontario Water Resources Act, and the Environmental Protection Act, and any regulations made thereunder; or
- (b) limit in any way any authority of the Ministry, a Director, or a Provincial Officer, including the authority to require certain steps be taken or to require the Permit Holder to furnish any further information related to this Permit.

2.3. Information

The receipt of any information by the Ministry, the failure of the Ministry to take any action or require any person to take any action in relation to the information, or the failure of a Provincial Officer to prosecute any person in relation to the information, shall not be construed as:

- (a) an approval, waiver or justification by the Ministry of any act or omission of any person that contravenes this Permit or other legal requirement; or
- (b) acceptance by the Ministry of the information's completeness or accuracy.

2.4. Rights of Action

The issuance of, and compliance with this Permit shall not be construed as precluding or limiting any legal claims or rights of action that any person, including the Crown in right of Ontario or any agency thereof, has or may have against the Permit Holder, its officers, employees, agents, and contractors.

2.5. Severability

The requirements of this Permit are severable. If any requirements of this Permit, or the application of any requirements of this Permit to any circumstance, is held invalid or unenforceable, the application of such requirements to other circumstances and the remainder of this Permit shall not be affected thereby.

2.6. Conflicts

Where there is a conflict between a provision of any submitted document referred to in this Permit, including its Schedules, and the conditions of this Permit, the conditions in this Permit shall take precedence.

3. Water Takings Authorized by This Permit

3.1. Expiry

This Permit expires on May 31, 2032. No water shall be taken under authority of this Permit after the expiry date.

3.2. Amounts of Taking Permitted

The Permit Holder shall only take water from the source, during the periods and at the rates and amounts of taking specified in Table A. Water takings are authorized only for the purposes specified in Table A.

Table A (litres)

	Source Name / Description	Source Type	Purpose Category	Specific Purpose	Activity	Maximum Taken per minute	Maximum Number of Hours Taken per day	Maximum volume per Day	Maximum days in a year	Zone / Easting / Northing
1	H5 (H5)	Well	Public administration	Municipal Supply	Water Supply	1380	24	1987200	365	17 / 555318 / 4810827
2	H5A (H5A)	Well	Public administration	Municipal Supply	Water Supply	1380	24	1987200	365	17 / 555314 / 4810833
Total Taking								1987200		

4. Monitoring

4.1. Under section 9 of O. Reg. 387/04, and as authorized by subsection 34(6) of the Ontario Water Resources Act, the Permit Holder shall, on each day water is taken under the authorization of this Permit, record the date, the volume of water taken on that date and the rate at which it was taken. The daily volume of water taken shall be measured by a flow meter or calculated in accordance with the method described in the application for this Permit, or as otherwise accepted by the Director. A separate record shall be maintained for each source. The Permit Holder shall keep all records required by this condition current and available at or near the site of the taking and shall produce the records for inspection by a Provincial Officer upon his or her request. The Permit Holder, unless otherwise required by the Director, shall submit, on or before March 31st in every year, the records required by this condition to the ministry's Water Taking Reporting System.

4.2. The Permit Holder shall measure and record water levels once a month in the following monitoring wells:

C-HPW-H5-TW2ABC-10
C-HPW-H5-TW1D-10

4.3. The Permit Holder shall prepare and submit a report every two years by June 30, that presents the results of the well field water level monitoring for the two preceding calendar years, assesses changes in water levels in the supply aquifer(s) in relation to precipitation and water taking from the aquifer(s), and provides a summary for all interference complaints received by the Permit Holder related to this permit and reported in the District Office in accordance with Condition 5.1 and the manner in which the Permit Holder has dealt with the complaint.

5. Impacts of the Water Taking

5.1. Notification

The Permit Holder shall immediately notify the local District Office of any complaint arising from the taking of water authorized under this Permit and shall report any action which has been taken or is proposed with regard to such complaint. The Permit Holder shall immediately notify the local District Office if the taking of water is

observed to have any significant impact on the surrounding waters. After hours, calls shall be directed to the Ministry's Spills Action Centre at 1-800-268-6060.

5.2. Impacts for Water Situation Type

For Surface-Water Takings

The taking of water (including the taking of water into storage and the subsequent or simultaneous withdrawal from storage) shall be carried out in such a manner that streamflow is not stopped and is not reduced to a rate that will cause interference with downstream uses of water or with the natural functions of the stream.

For Groundwater Takings

If the taking of water is observed to cause any negative impact to other water supplies obtained from any adequate sources that were in use prior to initial issuance of a Permit for this water taking, the Permit Holder shall take such action necessary to make available to those affected, a supply of water equivalent in quantity and quality to their normal takings, or shall compensate such persons for their reasonable costs of so doing, or shall reduce the rate and amount of taking to prevent or alleviate the observed negative impact. Pending permanent restoration of the affected supplies, the Permit Holder shall provide, to those affected, temporary water supplies adequate to meet their normal requirements, or shall compensate such persons for their reasonable costs of doing so.

If permanent interference is caused by the water taking, the Permit Holder shall restore the water supplies of those permanently affected.

6. Director May Amend Permit

- 6.1. The Director may amend this Permit by letter requiring the Permit Holder to suspend or reduce the taking to an amount or threshold specified by the Director in the letter. The suspension or reduction in taking shall be effective immediately and may be revoked at any time upon notification by the Director. This condition does not affect your right to appeal the suspension or reduction in taking to the Environmental Review Tribunal under the Ontario Water Resources Act, Section 100 (4).

REASONS

The reasons for the imposition of these terms and conditions are as follows:

1. Condition 1 is included to ensure that the conditions in this Permit are complied with and can be enforced.
2. Condition 2 is included to clarify the legal interpretation of aspects of this Permit.
3. Conditions 3 through 6 are included to protect the quality of the natural environment so as to safeguard the ecosystem and human health and foster efficient use and conservation of waters. These conditions allow for the beneficial use of waters while ensuring the fair sharing, conservation and sustainable use of the waters of Ontario. The conditions also specify the water takings that are authorized by this Permit and the scope of this Permit.

APPEAL PROVISIONS

In accordance with Section 100 of the *Ontario Water Resources Act, R.S.O. 1990*, you may by written notice served upon me and the Ontario Land Tribunal within 15 days after receipt of this notice, require a hearing by the Tribunal. Section 101 of the *Ontario Water Resources Act, R.S.O. 1990*, as amended, provides that the notice requiring the hearing ("the Notice") shall state:

1. The portions of the Permit or each term or condition in the Permit in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

In addition to these legal requirements, the Notice should also include:

- a. The name of the appellant;
- b. The address of the appellant;
- c. The permit to take water number;
- d. The date of the permit to take water;
- e. The name of the Director;
- f. The municipality within which the works are located;

This Notice must be served upon:

Registrar*		The Director, Section 34.1,
Ontario Land Tribunal		Ministry of the Environment, Conservation and Parks
655 Bay Street, Suite 1500	and	5775 Yonge Street, 8 th Floor
Toronto ON		Toronto, ON
M5G 1E5		M2M 4J1
OLT.Registrar@ontario.ca		Fax: (416) 325-6347

*** Further information on the Ontario Land Tribunal's requirements for an appeal can be obtained directly from the Tribunal at: Tel: (416) 212-6349 or 1 (866) 448-2248, or www.olt.gov.on.ca**

Dated at Hamilton this 6th day of July, 2022



Neil Taylor

Director, Section 34.1

Ontario Water Resources Act, R.S.O. 1990

c: Karl Belan, REGIONAL MUNICIPALITY OF WATERLOO

SCHEDULE 1

This Schedule "A" forms part of Permit To Take Water P-300-1161883172 Version Number 1.0, dated July 6, 2022.



BURNSIDE

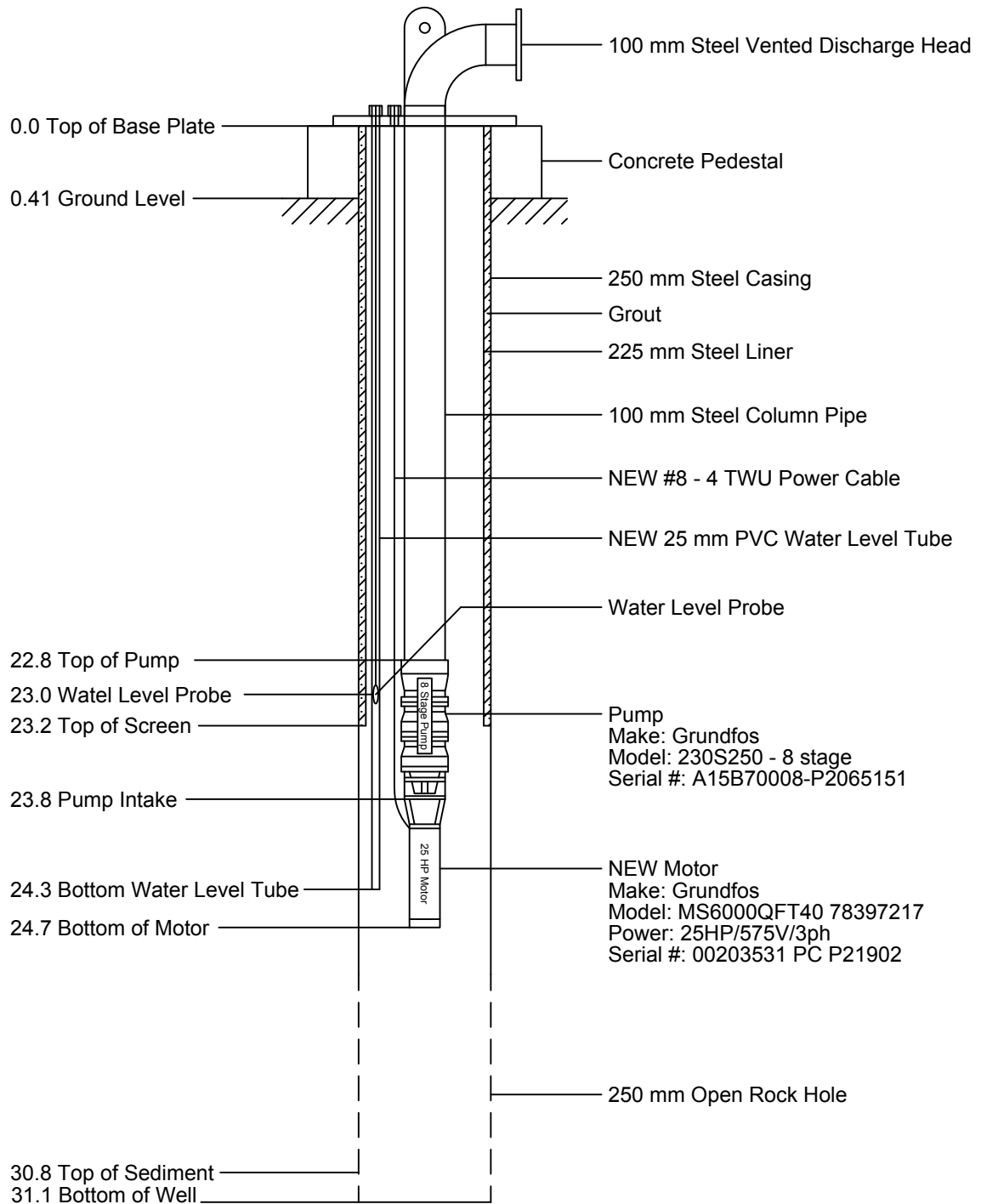
[THE DIFFERENCE IS OUR PEOPLE]

Appendix B

Well Records

WELL NO. 6 (GUELPH RD.)

Depth in Metres



CLIENT

REGIONAL MUNICIPALITY OF WATERLOO

TITLE

WELL H5
PUMP INSTALLATION DRAWING

PROJECT #: 006-458			G:\Lotowater Projects\006 Region of Waterloo\458 H5 Motor Failure\Pump Install.dwg		
DESIGN			REVISION No. 2019-06-21	SCALE N.T.S	FIGURE 1
DRAWN	EH	2019/06/21			
CHECKED	BP	2019/06/28			

9205732

H5A

LOG OF DRILLING OPERATIONS



R.J. Burnside & Associates Ltd.
15 Leavelle, Cambridge, Ontario L9H 3B4
telephone (519) 941-5331 fax (519) 941-8120

H5-TW1-09

Page 1 of 5

Client: Region of Waterloo		Project Name: H3 & H5 Test Well Construction		Logged by: S. Quinlan	
Project No.: MTA16513.0		Location: City of Cambridge		Ground (m amsl): ~305	
Drilling Co.: Gerrits Well Drilling Limited		Date Started: 4/22/2009		Static Water Level (m amsl): ~301	
Drilling Method: PQ Coring		Date Completed: 5/1/2009		Sand Pack (m amsl): N/A	

Depth Scale (ft) (m)	Stratigraphic Description	Strat. Plot	Depth (m)		SAMPLE				Depth Scale (ft) (m)
					Num.	Type	Int.	%Recov.	
	Surface Elevation (m): ~305								
1.0	SILTY SAND - with some clay and organics, dark brown, wet.	x x x x			1 OB	AR		100%	1.0
5.0			1.52		2 OB	AR		100%	5.0
2.0	FINE SAND - with some clay and slit, brown, wet	x x x x							2.0
10.0			3.05		3 OB	AR		100%	10.0
3.0	COARSE SAND - some fine sand, mixed colours (brown, white, grey), wet.	x x x x							3.0
4.0			4.57		4 OB	AR		100%	4.0
15.0	COARSE SAND - fine cobbles, mixed colours (brown, white, grey), wet	x x x x			5 OB	AR		100%	15.0
5.0			7.62		6 OB	AR		100%	5.0
8.0	FINE GRAVEL - with coarse sand, mixed colours (brown, white, grey), wet	x x x x			7 OB	AR		100%	8.0
30.0	COARSE SAND - bedrock cuttings, highly fractured, wet.	x x x x	9.14						30.0
10.0			10.00		1 Core	CORE		90%	10.0
35.0	DOLOSTONE - Eramosa Formation - grey, slightly porous, highly fractured, some clay	x x x x	11.50		2 Core	CORE		90%	35.0
12.0	DOLOSTONE - Goat Island-Niagara Falls Formation - dark grey, slightly crystalline, not very porous, medium bedding, highly fractured.	x x x x			3 Core	CORE		100%	12.0
14.0			15.26		4 Core	CORE		90%	14.0
50.0	DOLOSTONE - Gasport Formation - dark grey, fine crystalline, moderately porous, medium bedding.	x x x x			5 Core	CORE		100%	50.0
16.0			17.30		6 Core	CORE		100%	16.0
55.0	DOLOSTONE - Gasport Formation - at 17.3 m porosity and crystalline decrease	x x x x			7 Core	CORE		100%	55.0
17.0			18.60		8 Core	CORE		95%	17.0
60.0	DOLOSTONE - Gasport Formation - at 18.6 m changing to Light Grey	x x x x			9 Core	CORE		90%	60.0
18.0					10 Core	CORE		100%	18.0
65.0					11 Core	CORE		98%	65.0
20.0									20.0
21.0									21.0
22.0									22.0
23.0									23.0
24.0									24.0
25.0									25.0

Prepared By: **S. Quinlan**Checked By: **J. Baxter**Date Prepared: **7/6/2009**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND

Water found @ time of drilling

Static Water Level - 5/20/2009

MONITORING WELL DATA

Pipe: **15.9 cm dia. steel**

Screen: **15.2 cm dia. open hole**

SAMPLE TYPE

AC

Auger Cutting

CS

Continuous

RC

Rock Core

SS

Split Spoon

AR

Air Rotary

WC

Wash Cuttings



R.J. Burnside & Associates Ltd.
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LOG OF DRILLING OPERATIONS

H5-TW1-09

Page 2 of 5

Client: Region of Waterloo	Project Name: H3 & H5 Test Well Construction	Logged by: S. Quinlan
Project No.: MTA16513.0	Location: City of Cambridge	Ground (m amsl): ~305
Drilling Co.: Gerrits Well Drilling Limited	Date Started: 4/22/2009	Static Water Level (m amsl): ~301
Drilling Method: PQ Coring	Date Completed: 5/1/2009	Sand Pack (m amsl): N/A

Depth Scale (ft) (m)	Stratigraphic Description	Strat. Plot	Depth (m)	SAMPLE				Depth Scale (ft) (m)
				Num.	Type	Int.	%Recov.	
	Surface Elevation (m): ~305							
27.0	DOLOSTONE - Gasport Formation - Lost Circulation at 27.4 m		27.40	12 Core	CORE		100%	27.0
28.0				13 Core	CORE		95%	28.0
29.0				14 Core	CORE		100%	29.0
30.0	DOLOSTONE - Gasport Formation - at 30.18 becoming fine crystalline		30.18	15 Core	CORE		98%	30.0
31.0				16 Core	CORE		98%	31.0
32.0				17 Core	CORE		95%	32.0
33.0	DOLOSTONE - Gasport Formation - at 34.49 changing to Dark Grey		34.49	18 Core	CORE		98%	33.0
34.0				19 Core	CORE		90%	34.0
35.0				20 Core	CORE		98%	35.0
36.0	open hole bedrock			21 Core	CORE		98%	36.0
37.0				22 Core	CORE		90%	37.0
38.0				23 Core	CORE		85%	38.0
39.0	DOLOSTONE - Gasport Formation - at 45.9 m becoming more crystalline		45.90	24 Core	CORE		100%	39.0
40.0				25 Core	CORE		87%	40.0
41.0				26 Core	CORE		100%	41.0
42.0	DOLOSTONE - Gasport Formation - vugs starting to appear at 49.5 m		49.50	27 Core	CORE		95%	42.0
43.0				28 Core	CORE		98%	43.0
44.0				29 Core	CORE		100%	44.0
45.0			51.70					45.0
46.0								46.0
47.0								47.0
48.0								48.0
49.0								49.0
50.0								50.0
51.0								51.0
51.70								51.70

Prepared By: S. Quinlan	Checked By: J. Baxter	Date Prepared: 7/6/2009
This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.		

LEGEND	MONITORING WELL DATA	SAMPLE TYPE
Water found @ time of drilling	Pipe: 15.9 cm dia. steel	AC Auger Cutting
Static Water Level - 5/20/2009	Screen: 15.2 cm dia. open hole	CS Continuous
		RC Rock Core
		SS Split Spoon
		AR Air Rotary
		WC Wash Cuttings

B:\LOG GUELPH P:\GINT\PROJECTS\MTA16513\H5 & H3.GPJ\TEMPLATE.GDT 4/5/10



R.J. Burnside & Associates Limited
15 Tarrville, Orangeville, Ontario L9H 3R4
telephone (519) 941-5331 fax (519) 941-8129

LOG OF DRILLING OPERATIONS

H5-TW1-09

Page 3 of 5

Client: Region of Waterloo	Project Name: H3 & H5 Test Well Construction	Logged by: S. Quinlan
Project No.: MTA16513.0	Location: City of Cambridge	Ground (m amsl): ~305
Drilling Co.: Gerrits Well Drilling Limited	Date Started: 4/22/2009	Static Water Level (m amsl): ~301
Drilling Method: PQ Coring	Date Completed: 5/1/2009	Sand Pack (m amsl): N/A

Depth Scale (ft) (m)	Stratigraphic Description	Strat. Plot	Depth (m)		SAMPLE				Depth Scale (ft) (m)
					Num.	Type	Int.	% Recov.	
175.0 53.0	Surface Elevation (m): ~305				30 Core	CORE		98%	175.0 53.0
180.0 55.0	DOLOSTONE - Gasport Formation - at 51.7 m changing from dark grey to brown				31 Core	CORE		98%	180.0 55.0
185.0 56.0	DOLOSTONE - Gasport Formation - becoming porous, medium crystalline @ 55 m		55.00		32 Core	CORE		99%	185.0 56.0
190.0 57.0	DOLOSTONE - Gasport Formation - at 57.3 changing to dark grey, fine crystalline, medium bedded and not porous or vuggy.		57.30		33 Core	CORE		98%	190.0 57.0
195.0 58.0					34 Core	CORE		98%	195.0 58.0
200.0 61.0					35 Core	CORE		96%	200.0 61.0
205.0 62.0	DOLOSTONE - Gasport Formation - change to light grey at 61.3 m		61.30		36 Core	CORE		98%	205.0 62.0
210.0 64.0	DOLOSTONE - Gasport Formation - sampling changing to dark grey, porous, small fossils, medium crystalline, moderately porous at 61.8 m		61.80		37 Core	CORE		98%	210.0 64.0
215.0 65.0	DOLOSTONE - Gasport Formation - at 63.1 m changing to light grey, vugs, slightly porous, medium crystalline		63.10		38 Core	CORE		80%	215.0 65.0
220.0 67.0	DOLOSTONE - Gasport Formation - at 67.23 core is richly fossiliferous		67.23		39 Core	CORE		95%	220.0 67.0
225.0 68.0					40 Core	CORE		96%	225.0 68.0
230.0 70.0					41 Core	CORE		100%	230.0 70.0
235.0 71.0					42 Core	CORE		100%	235.0 71.0
240.0 73.0					43 Core	CORE		98%	240.0 73.0
245.0 74.0					44 Core	CORE		95%	245.0 74.0
250.0 76.0					45 Core	CORE		98%	250.0 76.0
255.0 77.0					46 Core	CORE		98%	255.0 77.0
					47 Core	CORE		98%	

Prepared By: **S. Quinlan**

Checked By: **J. Baxter**

Date Prepared: **7/6/2009**

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LEGEND

- Water found @ time of drilling
- Static Water Level - 5/20/2009

MONITORING WELL DATA

Pipe: **15.9 cm dia. steel**
Screen: **15.2 cm dia. open hole**

SAMPLE TYPE

AC Auger Cutting
CS Continuous
RC Rock Core
SS Split Spoon
AR Air Rotary
WC Wash Cuttings



R.J. Burnside & Associates Limited
15 Townsend, Orangeville, Ontario L9W 3R6
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LOG OF DRILLING OPERATIONS

H5-TW1-09

Page 4 of 5

Client: Region of Waterloo	Project Name: H3 & H5 Test Well Construction	Logged by: S. Quinlan
Project No.: MTA16513.0	Location: City of Cambridge	Ground (m amsl): ~305
Drilling Co.: Gerrits Well Drilling Limited	Date Started: 4/22/2009	Static Water Level (m amsl): ~301
Drilling Method: PQ Coring	Date Completed: 5/1/2009	Sand Pack (m amsl): N/A

Depth Scale (ft) (m)	Stratigraphic Description	Strat. Plot	Depth (m)	SAMPLE				Depth Scale (ft) (m)
				Num.	Type	Int.	%Recov.	
260.0 79.0	Surface Elevation (m): ~305			48 Core	CORE		96%	260.0 79.0
265.0 81.0				49 Core	CORE		95%	265.0 81.0
270.0 82.0				50 Core	CORE		98%	270.0 82.0
275.0 84.0				51 Core	CORE		85%	275.0 84.0
280.0 86.0				52 Core	CORE		98%	280.0 86.0
285.0 87.0				53 Core	CORE		90%	285.0 87.0
290.0 88.0				54 Core	CORE		95%	290.0 88.0
295.0 90.0				55 Core	CORE		95%	295.0 90.0
300.0 91.0				56 Core	CORE		100%	300.0 91.0
305.0 93.0				57 Core	CORE		98%	305.0 93.0
310.0 94.0				58 Core	CORE		96%	310.0 94.0
315.0 96.0				59 Core	CORE		90%	315.0 96.0
320.0 98.0				60 Core	CORE		95%	320.0 98.0
325.0 99.0				61 Core	CORE		70%	325.0 99.0
330.0 101.0				62 Core	CORE		90%	330.0 101.0
335.0 102.0				63 Core	CORE		90%	335.0 102.0
340.0 103.0				64 Core	CORE		100%	340.0 103.0
				65 Core	CORE		90%	
				66 Core	CORE		99%	

DOLOSTONE - Gasport Formation - changing to dark grey, slightly porous, slightly fossiliferous and fine crystalline @ 82.1 m

DOLOSTONE - Gasport Formation - at 90.2 m becoming more porous, vuggy, grey mottled, slightly fossiliferous, fine crystalline.

DOLOSTONE - Gasport Formation - at 95.0 m becoming richly fossiliferous, grey/brown, moderately porous, medium crystalline

DOLOSTONE - Gasport Formation - at 96.67 core changes to moderately fossiliferous and slightly porous

open hole bedrock

Prepared By: **S. Quinlan**

Checked By: **J. Baxter**

Date Prepared: **7/6/2009**

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LEGEND

- Water found @ time of drilling
- Static Water Level - 5/20/2009

MONITORING WELL DATA

Pipe: **15.9 cm dia. steel**
Screen: **15.2 cm dia. open hole**

SAMPLE TYPE

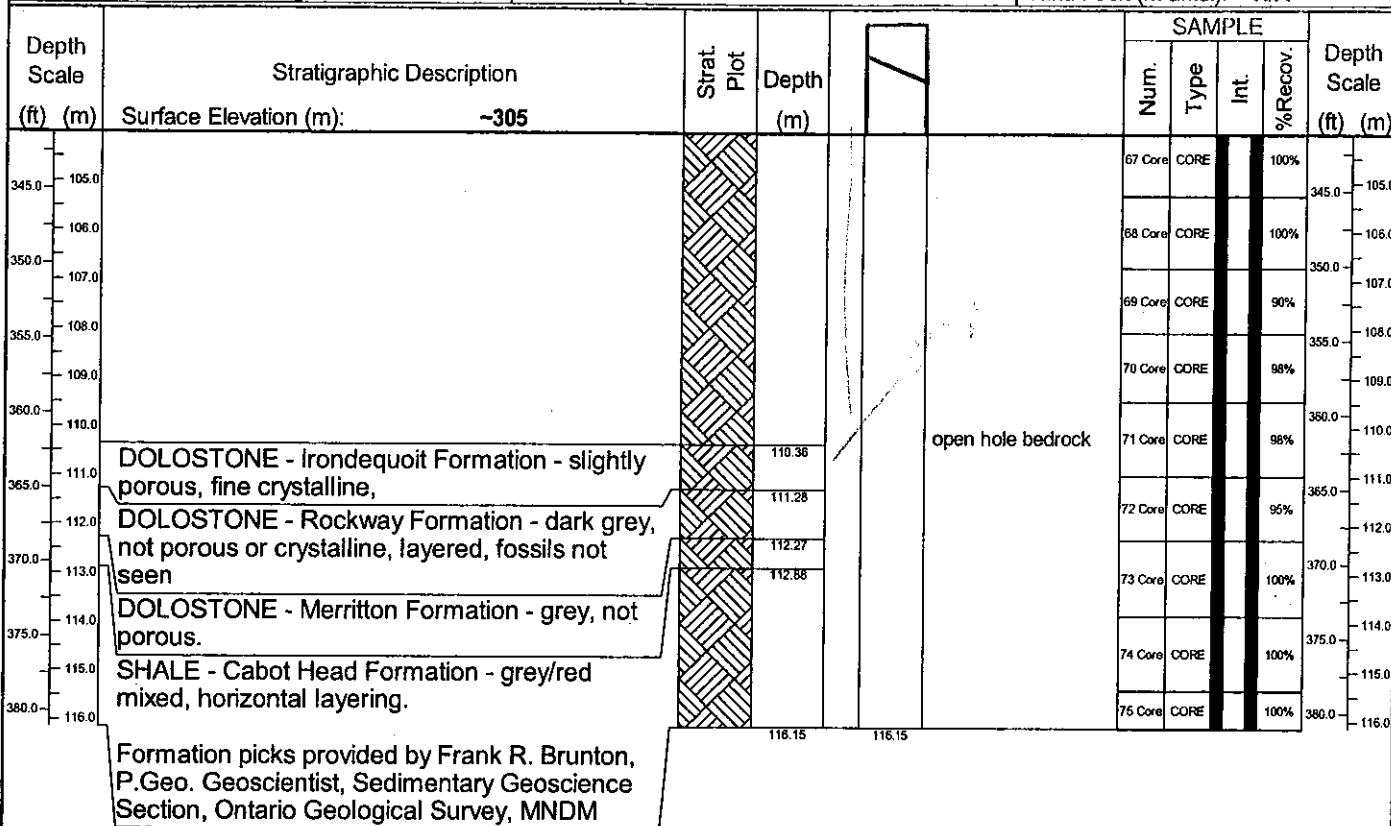
- AC Auger Cutting
- CS Continuous
- RC Rock Core
- SS Split Spoon
- AR Air Rotary
- WC Wash Cuttings

BURNSIDE

R.J. Barnette & Associates Inc.
15 Touraine, Orangeville, Ontario L9W 3B4
Telephone (519) 941-5331 Fax (519) 941-6129

Page 5 of 5

Client: Region of Waterloo	Project Name: H3 & H5 Test Well Construction	Logged by: S. Quinlan
Project No.: MTA16513.0	Location: City of Cambridge	Ground (m amsl): ~305
Drilling Co.: Gerrits Well Drilling Limited	Date Started: 4/22/2009	Static Water Level (m amsl): ~301
Drilling Method: PQ Coring	Date Completed: 5/1/2009	Sand Pack (m amsl): N/A



\\BHL01GUELPH.P:\GINT\PROJECTS\MMTA16513\H5 & H3.GPJ TEMPLATE.GDT 4/5/10

Date Prepared: 7/6/2009

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND

-  Water found @ time of drilling
 Static Water Level - 5/20/2009

MONITORING WELL DATA

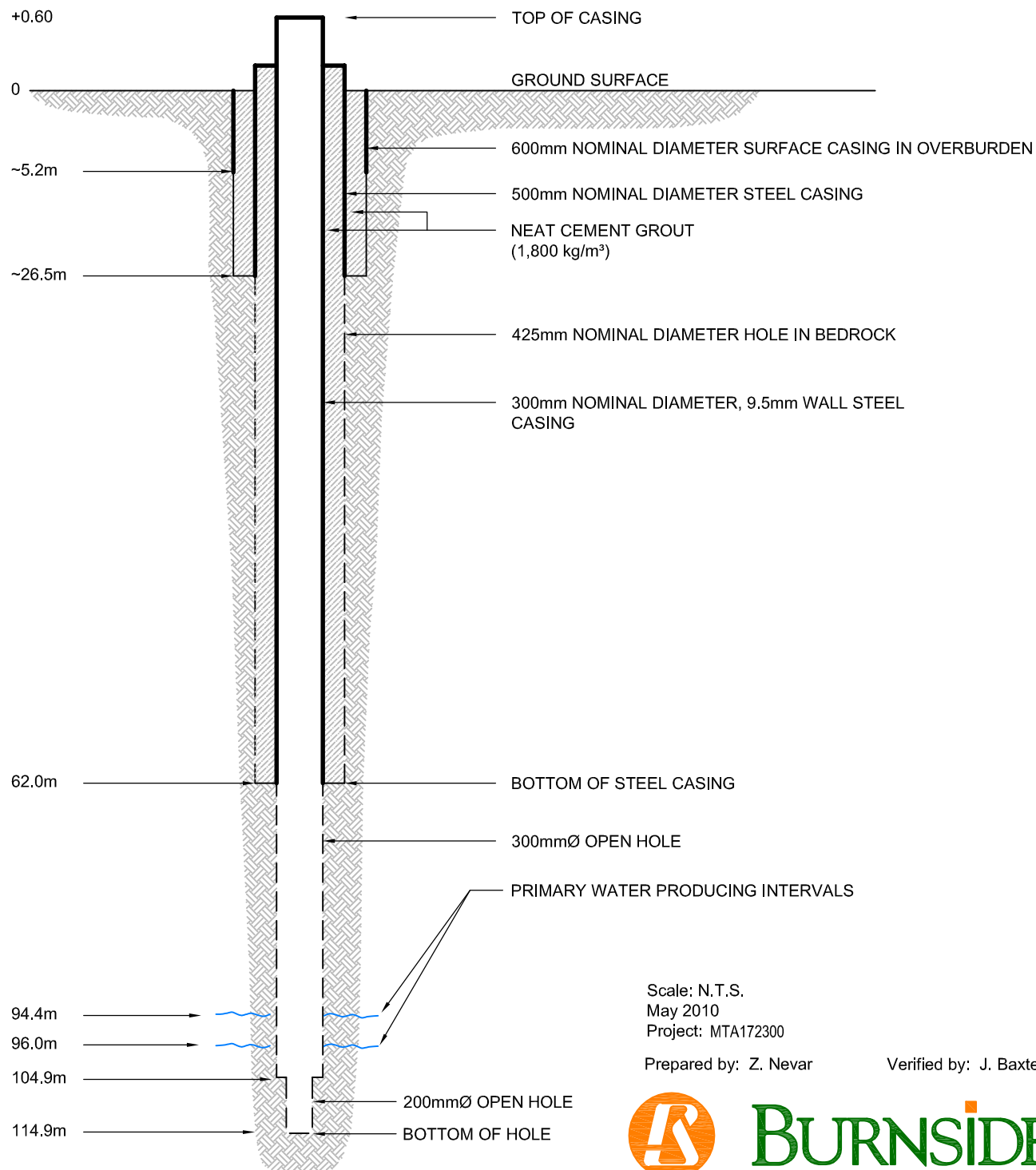
Pipe: 15.9 cm dia. steel
Screen: 15.2 cm dia. open hole

SAMPLE TYPE

- | | | | | | |
|----|--|---------------|----|--|---------------|
| AC | | Auger Cutting | SS | | Split Spoon |
| CS | | Continuous | AR | | Air Rotary |
| RC | | Rock Core | WC | | Wash Cuttings |

FIGURE 7 REGION OF WATERLOO CITY OF CAMBRIDGE H5A CONSTRUCTION AND TESTING PRODUCTION WELL H5A DETAIL

DEPTH (Meters
Below Ground Surface)



Scale: N.T.S.
May 2010
Project: MTA172300

Prepared by: Z. Nevar

Verified by: J. Baxter



BURNSIDE

17230 H5A PRODUCTION WELL DETAIL.dwg

Depths
In Metres

H5A

-0.20 Sounding tube port

0.00 Top of casing

0.91 (305.00masl) Ground level

2.7 Pitless Adapter
Discharge 150 mm steel
Flange

28.95 Bottom of transducer

36.6 Bottom of water level tubes
39.4 Top of pump

40.4 Pump intake

41.6 Bottom of motor

62.6 Bottom of casing

* main water producing intervals at 95.0 & 96.6m

105.4 Bottom of 300mm hole

115.4 Bottom of well

Boshart Well Cap

350 mm Steel pitless barrel

Pitless Adapter: Boshart IPD12FFF6M5S6NC

300 mm Steel well casing

(New)
125mm SCH 40 304SS T&C Riser

Submersible Wire: #6-4 TWU

Transducer 1 = Endress Hauser Waterpilot FMX21 (333 ft)

Transducer 2 = Diver DI605

2 x 32mm flush joint PVC sounding tube

(New) Pump
Make: Grundfos
Model: 475S400-4
Serial: 19250004

Motor
Make: Franklin
Power: 40HP/575V/3ph

300 mm Open rock hole

200 mm Open rock hole



CLIENT

Regional Municipality of Waterloo

TITLE

Well H5A
Pump Installation Drawing

PROJECT No. 006-519

L:\Lotowater Projects\006 Region of Waterloo\519 H5A Service (2021)\7. Technical

DESIGN	EH	2016/05/20
DRAWN	EH	2016/05/20
CHECKED	BP	2021/08/04

REVISION No. 2021/08/04

SCALE N.T.S.

FIGURE

3

7153479

C-HP-H5OW2-10-(A-B-C)

LOG OF DRILLING OPERATIONS

H5-TW2-10

Page 1 of 5



R. J. Burnside & Associates Inc. Ltd.
 13 Avenue, Stratford, Ontario N5A 2P4
 Telephone: 519-541-5337 Fax: 519-541-8131

Client: Region of Waterloo	Project Name: H5-TW2 Test Well Construction	Logged by: S. Quinlan
Project No.: MTA17230.2	Location: City of Cambridge	Ground (m amsl): 304.82
Drilling Co.: Davidson Drilling Limited	Date Started: 1/15/2010	Static Water Level (m amsl): 4.3
Drilling Method: Air Rotary	Date Completed: 1/21/2010	Sand Pack (m amsl): N/A

Depth Scale (ft) (m)	Stratigraphic Description	Strat. Plot	Depth (m)		SAMPLE				Depth Scale (ft) (m)
					Num.	Type	Int.	%Recov.	
	Surface Elevation (m): 304.82								
1.0	SILTY SAND - with some clay and organics, dark brown, wet.	x			1 OB	AR		100%	1.0
5.0	FINE SAND - with some clay and slit, brown, wet	x	1.52		2 OB	AR		100%	5.0
10.0	COARSE SAND - some fine sand, mixed colours (brown, white, grey), wet. Static water level 4.3 m bgs		3.05		3 OB	AR		100%	10.0
15.0	COARSE SAND - fine cobbles, mixed colours (brown, white, grey), wet		4.57		4 OB	AR		100%	15.0
20.0					5 OB	AR		100%	20.0
25.0	FINE GRAVEL - with coarse sand, mixed colours (brown, white, grey), wet		7.62		6 OB	AR		100%	25.0
30.0	COARSE SAND - bedrock cuttings, highly fractured, wet.		9.14		7 OB	AR		100%	30.0
35.0	DOLOSTONE - Eramosa Formation - grey, slightly porous, highly fractured, some clay		10.00		8 BR	AR		100%	35.0
40.0	DOLOSTONE - Goat Island-Niagara Falls Formation - dark grey, slightly crystalline, not very porous, medium bedding, highly fractured.		11.50		9 BR	AR		100%	40.0
45.0					10 BR	AR		100%	45.0
50.0	DOLOSTONE - Gasport Formation - dark grey, fine crystalline, moderately porous, medium bedding.		15.25		11 BR	AR		100%	50.0
55.0	DOLOSTONE - Gasport Formation - at 17.3 m porosity and crystalline decrease		17.30		12 BR	AR		100%	55.0
60.0	DOLOSTONE - Gasport Formation - at 18.6 m changing to Light Grey. Horizontal ring feature at 26.4 m & 27.2 m.		18.60		13 BR	AR		100%	60.0
65.0					14 BR	AR		100%	65.0
70.0					15 BR	AR		100%	70.0
75.0					16 BR	AR		100%	75.0
80.0					17 BR	AR		100%	80.0
85.0									85.0
90.0									90.0
95.0									95.0
100.0									100.0

Prepared By: **S. Quinlan**Checked By: **J. Baxter**Date Prepared: **1/24/2011**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND

- Water found @ time of drilling
 Static Water Level - 1/21/2010

MONITORING WELL DATA

Pipe: **20.3 cm dia. steel**
 Screen: **15.6 cm dia. open hole**

SAMPLE TYPE

- AC Auger Cutting
 CS Continuous
 RC Rock Core
 SS Split Spoon
 AR Air Rotary
 WC Wash Cuttings

BHLOG GUELPH PROJECT\PROJECTS\MTA17230\H5-TW2.GPJ TEMPLATE.GDT 6/10/11

LOG OF DRILLING OPERATIONS

H5-TW2-10

Page 2 of 5



R. J. Burnside & Associates Inc. 100
15000 Highway 100, Suite 100, 100
Mississauga, ON L4W 1G1

Client: Region of Waterloo	Project Name: H5-TW2 Test Well Construction	Logged by: S. Quinlan
Project No.: MTA17230.2	Location: City of Cambridge	Ground (m amsl): 304.82
Drilling Co.: Davidson Drilling Limited	Date Started: 1/15/2010	Static Water Level (m amsl): 4.3
Drilling Method: Air Rotary	Date Completed: 1/21/2010	Sand Pack (m amsl): N/A

Depth Scale (ft) (m)	Stratigraphic Description	Strat. Plot	Depth (m)	Depth Scale (ft) (m)	Num.	Type	Int.	% Recov.	Depth Scale (ft) (m)
	Surface Elevation (m): 304.82								
27.0			27.40	27.0	18 BR	AR		100%	27.0
28.0	DOLOSTONE - Gasport Formation - Lost Circulation at 27.4 m. Horizontal ring features at 27.7 m and 29.2 m.			28.0	19 BR	AR		100%	28.0
29.0				29.0	20 BR	AR		100%	29.0
30.0			30.18	30.0	21 BR	AR		100%	30.0
31.0	DOLOSTONE - Gasport Formation - at 30.18 m becoming fine crystalline. Vugs at 31.2 m. Horizontal ring features at 32.8 m and 33.2 m.			31.0	22 BR	AR		100%	31.0
32.0				32.0	23 BR	AR		100%	32.0
33.0				33.0	24 BR	AR		100%	33.0
34.0			34.49	34.0	25 BR	AR		100%	34.0
35.0	DOLOSTONE - Gasport Formation - at 34.49 m changing to Dark Grey. Extensive vugs starting at 39.9 m, Horizontal ring features at 38.4 m, 42.4 m and 43.2 m.			35.0	26 BR	AR		100%	35.0
36.0				36.0	27 BR	AR		100%	36.0
37.0				37.0	28 BR	AR		100%	37.0
38.0				38.0	29 BR	AR		100%	38.0
39.0				39.0	30 BR	AR		100%	39.0
40.0				40.0	31 BR	AR		100%	40.0
41.0				41.0	32 BR	AR		100%	41.0
42.0				42.0	33 BR	AR		100%	42.0
43.0				43.0	34 BR	AR		100%	43.0
44.0				44.0					44.0
45.0				45.0					45.0
46.0			45.90	46.0					46.0
47.0	DOLOSTONE - Gasport Formation - at 45.9 m becoming more crystalline. Extensive vugs.			47.0					47.0
48.0				48.0					48.0
49.0			49.50	49.0					49.0
50.0	DOLOSTONE - Gasport Formation - Extensive vugs.			50.0					50.0
51.0				51.0					51.0
51.70			51.70	51.70					51.70

open hole bedrock

Prepared By: **S. Quinlan**Checked By: **J. Baxter**Date Prepared: **1/24/2011**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND

Water found @ time of drilling
Static Water Level - 1/21/2010

MONITORING WELL DATA

Pipe: **20.3 cm dia. steel**
Screen: **15.6 cm dia. open hole**

SAMPLE TYPE

AC Auger Cutting
CS Continuous
RC Rock Core
SS Split Spoon
AR Air Rotary
WC Wash Cuttings

BHLOG GUELPH P:\GINT\PROJECTS\MTA17230\H5-TW2.GPJ TEMPLATE.GDT 6/10/11

LOG OF DRILLING OPERATIONS



R.J. Burnside Associates Limited
11 Fernside, Cambridge, Ontario N3H 3H4
Telephone: 519-532-7777 Fax: 519-532-7778

H5-TW2-10

Page 3 of 5

Client: Region of Waterloo	Project Name: H5-TW2 Test Well Construction	Logged by: S. Quinlan
Project No.: MTA17230.2	Location: City of Cambridge	Ground (m amsl): 304.82
Drilling Co.: Davidson Drilling Limited	Date Started: 1/15/2010	Static Water Level (m amsl): 4.3
Drilling Method: Air Rotary	Date Completed: 1/21/2010	Sand Pack (m amsl): N/A

Depth Scale (ft) (m)	Stratigraphic Description	Strat. Plot	Depth (m)		SAMPLE				Depth Scale (ft) (m)
					Num.	Type	Int.	%Recov.	
	Surface Elevation (m): 304.82								
53.0	DOLOSTONE - Gasport Formation - at 51.7 m changing from dark grey to brown, extensive vugs.				35 BR	AR		100%	53.0
54.0					36 BR	AR		100%	54.0
55.0	DOLOSTONE - Gasport Formation - becoming porous, medium crystalline @ 55 m, extensive vugs.		55.00		37 BR	AR		100%	55.0
56.0					38 BR	AR		100%	56.0
57.0	DOLOSTONE - Gasport Formation - at 57.3 m changing to dark grey, fine crystalline, medium bedded and not porous. Vugs at 57.7 m		57.30		39 BR	AR		100%	57.0
58.0					40 BR	AR		100%	58.0
59.0					41 BR	AR		100%	59.0
60.0					42 BR	AR		100%	60.0
61.0	DOLOSTONE - Gasport Formation - change to light grey at 61.3 m. Vugs at 61.9 m.		61.30		43 BR	AR		100%	61.0
62.0			61.80		44 BR	AR		100%	62.0
63.0	DOLOSTONE - Gasport Formation - sampling changing to dark grey, porous, small fossils, medium crystalline, moderately porous at 61.8 m. Horizontal ring feature. Vugs at 61.9 m and 62.9 m.		63.10		45 BR	AR		100%	63.0
64.0					46 BR	AR		100%	64.0
65.0	DOLOSTONE - Gasport Formation - at 63.1 m changing to light grey, slightly porous, medium crystalline. Vugs at 65.2 m and 66.5 m.				47 BR	AR		100%	65.0
66.0					48 BR	AR		100%	66.0
67.0	DOLOSTONE - Gasport Formation - at 67.23 m core is richly fossiliferous. Extensive Vugs.		67.23		49 BR	AR		100%	67.0
68.0					50 BR	AR		100%	68.0
69.0					51 BR	AR		100%	69.0
70.0					52 BR	AR		100%	70.0
71.0									71.0
72.0									72.0
73.0									73.0
74.0									74.0
75.0									75.0
76.0									76.0
77.0									77.0
255.0									255.0

open hole bedrock

Prepared By: **S. Quinlan**Checked By: **J. Baxter**Date Prepared: **1/24/2011**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND

- Water found @ time of drilling
 Static Water Level - 1/21/2010

MONITORING WELL DATA

Pipe: **20.3 cm dia. steel**
 Screen: **15.6 cm dia. open hole**

SAMPLE TYPE

- AC Auger Cutting
 CS Continuous
 RC Rock Core
 SS Split Spoon
 AR Air Rotary
 WC Wash Cuttings

BHLOG GUELPH P:\GINT\PROJECTS\MTA17230\H5-TW2.GPJ TEMPLATE.GDT 6/10/11

LOG OF DRILLING OPERATIONS

H5-TW2-10

Page 4 of 5



R.J. Burnside Associates Inc.
15 Lawrence Street, Suite 100, 1st Fl.
Waterloo, ON N2L 2G7 Tel: 519-841-1171

Client: Region of Waterloo	Project Name: H5-TW2 Test Well Construction	Logged by: S. Quinlan
Project No.: MTA17230.2	Location: City of Cambridge	Ground (m amsl): 304.82
Drilling Co.: Davidson Drilling Limited	Date Started: 1/15/2010	Static Water Level (m amsl): 4.3
Drilling Method: Air Rotary	Date Completed: 1/21/2010	Sand Pack (m amsl): N/A

Depth Scale (ft) (m)	Stratigraphic Description	Strat. Plot	Depth (m)		SAMPLE				Depth Scale (ft) (m)
					Num.	Type	Int.	%Recov.	
	Surface Elevation (m): 304.82								
260.0 - 79.0					53 BR	AR		100%	260.0 - 79.0
265.0 - 81.0					54 BR	AR		100%	265.0 - 81.0
270.0 - 82.0					55 BR	AR		100%	270.0 - 82.0
275.0 - 84.0	DOLOSTONE - Gasport Formation - changing to dark grey, slightly porous, slightly fossiliferous and fine crystalline @ 82.1 m. Cavern 80.2 to 80.7 m. small cavern at 86.3 m. Vugs at 87.3 m and 87.9 m. Verticle fracture at 88.9 m.		82.10		56 BR	AR		100%	275.0 - 84.0
280.0 - 85.0					57 BR	AR		100%	280.0 - 85.0
285.0 - 87.0					58 BR	AR		100%	285.0 - 87.0
290.0 - 88.0					59 BR	AR		100%	290.0 - 88.0
295.0 - 90.0					60 BR	AR		100%	295.0 - 90.0
300.0 - 91.0	DOLOSTONE - Gasport Formation - at 90.2 m becoming more porous, grey mottled, slightly fossiliferous, fine crystalline. Vugs at 92.5 m. Horizontal ring feature at 93.2 m.		90.20		61 BR	AR		100%	300.0 - 91.0
305.0 - 93.0					62 BR	AR		100%	305.0 - 93.0
310.0 - 94.0					63 BR	AR		100%	310.0 - 94.0
315.0 - 96.0	DOLOSTONE - Gasport Formation - at 95.0 m becoming richly fossiliferous, grey/brown, moderately porous, medium crystalline		95.00		64 BR	AR		100%	315.0 - 96.0
320.0 - 97.0	DOLOSTONE - Gasport Formation - at 96.67 m core changes to moderately fossiliferous and slightly porous. Horizontal ring features at 97.2 m, 105.7 m, 106.5 m, 107.1 m, 107.7 m, 109.2 m, 109.4 m. Vugs at 102.7 m and 104.1 m.		96.67		65 BR	AR		100%	320.0 - 97.0
325.0 - 99.0					66 BR	AR		100%	325.0 - 99.0
330.0 - 101.0					67 BR	AR		100%	330.0 - 101.0
335.0 - 102.0					68 BR	AR		100%	335.0 - 102.0
340.0 - 103.0					69 BR	AR		100%	340.0 - 103.0

open hole bedrock

Prepared By: **S. Quinlan** Checked By: **J. Baxter** Date Prepared: **1/24/2011**

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LEGEND

- Water found @ time of drilling
- Static Water Level - 1/21/2010

MONITORING WELL DATA

Pipe: **20.3 cm dia. steel**
Screen: **15.6 cm dia. open hole**

SAMPLE TYPE

- AC Auger Cutting
- CS Continuous
- RC Rock Core
- SS Split Spoon
- AR Air Rotary
- WC Wash Cuttings

BHLOG QUELPH P:\GINT\PROJECTS\MTA17230\H5-TW2.GPJ TEMPLATE.GDT 8/10/11

LOG OF DRILLING OPERATIONS



R.J. Burnside & Associates Limited
13 Spence Street, Suite 200
Mississauga, ON L4V 1P1

H5-TW2-10

Page 5 of 5

Client: Region of Waterloo		Project Name: H5-TW2 Test Well Construction		Logged by: S. Quinlan	
Project No.: MTA17230.2		Location: City of Cambridge		Ground (m amsl): 304.82	
Drilling Co.: Davidson Drilling Limited		Date Started: 1/15/2010		Static Water Level (m amsl): 4.3	
Drilling Method: Air Rotary		Date Completed: 1/21/2010		Sand Pack (m amsl): N/A	

Depth Scale (ft) (m)	Stratigraphic Description	Strat. Plot	Depth (m)		SAMPLE				Depth Scale (ft) (m)
					Num.	Type	Int.	% Recov.	
	Surface Elevation (m): 304.82								
345.0 105.0				open hole bedrock	70 BR	AR		100%	345.0 105.0
350.0 106.0			71 BR		AR		100%	350.0 106.0	
355.0 107.0			72 BR		AR		100%	355.0 107.0	
360.0 108.0			73 BR		AR		100%	360.0 108.0	
365.0 109.0	DOLOSTONE - Irondequoit Formation - slightly porous, fine crystalline, horizontal ring feature at 110.6 m.		110.36		74 BR	AR		100%	365.0 109.0
370.0 110.0	DOLOSTONE - Rockway Formation - dark grey, not porous or crystalline, layered, fossils not seen, horizontal ring feature 112.1 m.		111.28		75 BR	AR		100%	370.0 110.0
375.0 111.0	DOLOSTONE - Merritton Formation - grey, not porous.		112.27		76 BR	AR		100%	375.0 111.0
380.0 112.0	SHALE - Cabot Head Formation - grey/red mixed, horizontal layering.		115.02		77 BR	AR		100%	380.0 112.0
	Formation picks for H5-TW1-09 provided by Frank R. Brunton, P.Geo. Geoscientist, Sedimentary Geoscience Section, Ontario Geological Survey, MNM		116.13	116.13					

Prepared By: **S. Quinlan**Checked By: **J. Baxter**Date Prepared: **1/24/2011**

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LEGEND

▼ Water found @ time of drilling
 ▽ Static Water Level - 1/21/2010

MONITORING WELL DATA

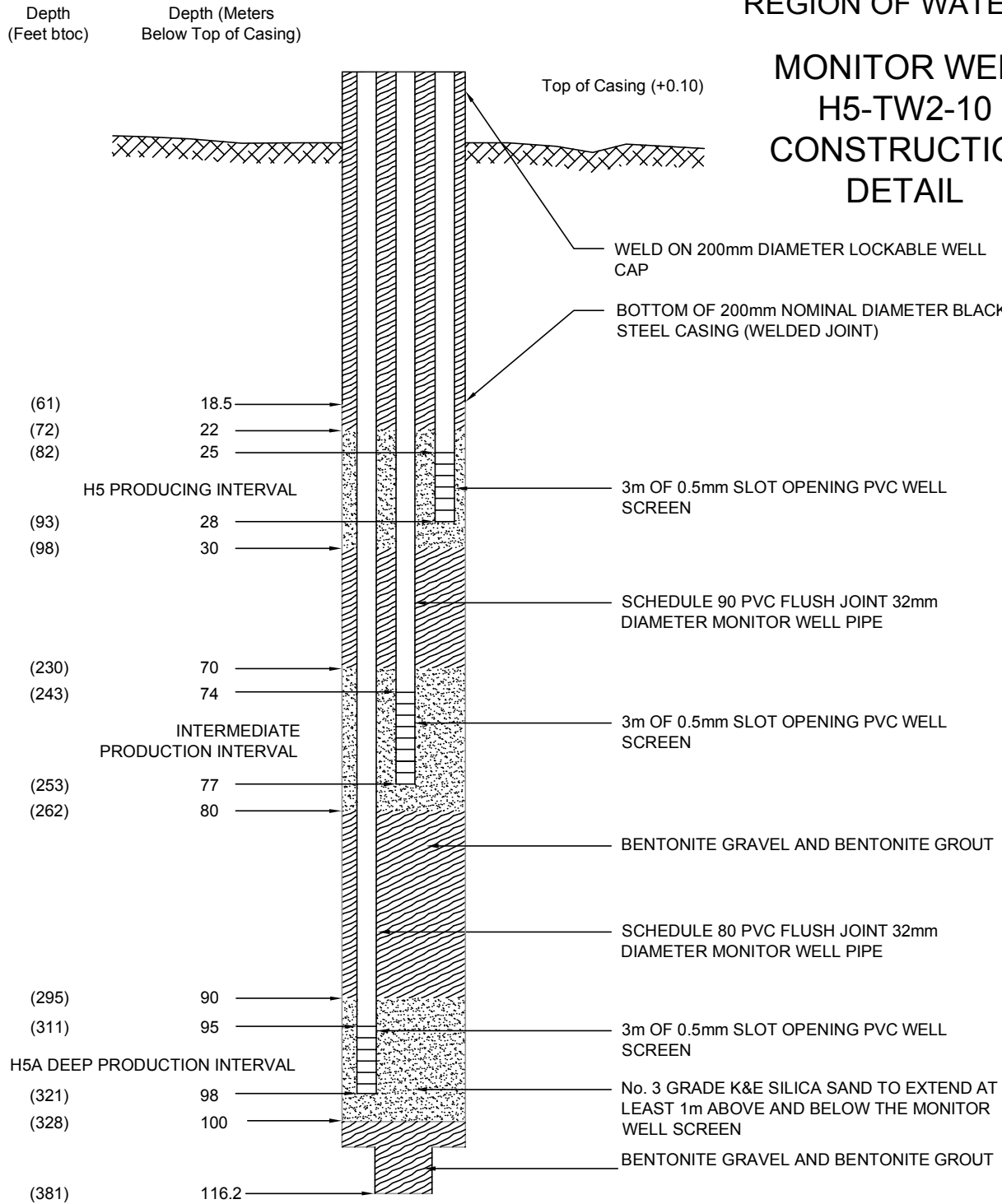
Pipe: **20.3 cm dia. steel**
 Screen: **15.6 cm dia. open hole**

SAMPLE TYPE

AC Auger Cutting
 CS Continuous
 RC Rock Core
 SS Split Spoon
 AR Air Rotary
 WC Wash Cuttings

REGION OF WATERLOO

MONITOR WELL H5-TW2-10 CONSTRUCTION DETAIL



April 2010
N.T.S.
FILE NO.: MTA172300

NOTES:
DEPTHS SHOWN ARE NOT TO SCALE



BURNSIDE

LOG OF DRILLING OPERATIONS

H5-TW1D-10

Page 1 of 1



R.J. Burnside & Associates Limited
15 Taveline, Wexford, Ontario L9W 2H4
Telephone 519 941 0331 Fax 519 941 0120

Client: Region of Waterloo	Project Name: Cambridge Well Optimization	Logged by: S. Quinlan
Project No.: MTA17230	Location: Cambridge	Ground (m amsl):
Drilling Co.: Pro Core Drilling	Date Started: 4/20/2010	Static Water Level (m amsl):
Drilling Method: Split Spoon	Date Completed: 4/22/2010	Sand Pack (m amsl):

Depth Scale (ft) (m)	Stratigraphic Description	Strat. Plot	Depth (m)		SAMPLE				Depth Scale (ft) (m)
					Num.	Type	Int.	%Recov.	
	TOPSOIL - organics, brown fine sand, dry.				1	CORE		50	
1.0	SILTY SAND - brown, wet at 1.32 m.		0.68		2	CORE		50	1.0
5.0	FINE SAND - trace gravel and silt, brown, wet.		1.45		3	CORE		50	5.0
2.0	SILTY SAND - fine sand, trace gravel and clay, brown, wet.		2.21		4	CORE		15	2.0
10.0	GRAVEL - coarse with coarse sand, brown, wet		2.97		5	SS	X	100	10.0
4.0	SAND - coarse, fine gravel, brown, wet.		3.73		6	SS	X	100	4.0
15.0	SILTY CLAY - dense with some gravel, dark grey/brown, wet.		4.11		7	SS	X	95	15.0
6.0	SAND - fine, with some silt.		4.50		8	SS	X	90	6.0
20.0	SILT - dense with some gravel, sand and clay.		4.70		9	SS	X	90	20.0
8.0					10	SS	X	50	8.0
25.0					11	SS	X	75	25.0
8.0					12	SS	X	75	8.0
30.0					13	SS	X	50	30.0
	SAND - medium, brown, wet.		8.31						
	SILT - dense with gravel and fine sand trace clay, brown, wet.		8.42						
	SAND - fine to medium with gravel and some silt and clay.		8.90						

Prepared By: **S. Quinlan** Checked By: **J. Baxter** Date Prepared: **5/19/2010**

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LEGEND

Water found @ time of drilling
Static Water Level -

MONITORING WELL DATA

Pipe: 51 mm dia. PVC
Screen: 51 mm dia. PVC #10 slot

SAMPLE TYPE

AC Auger Cutting CS Continuous RC Rock Core SS Split Spoon AR Air Rotary WC Wash Cuttings

B:\LOG GUELPH P\GINT\PROJECTS\WMTA17230P10ANDH5OVERBURDEN.GPJ TEMPLATE.GDT 25/1/11

LOG OF DRILLING OPERATIONS

H5-TW1E-10

Page 1 of 1



R.J. Burnside & Associates Limited
15 Tremblay, Ormouthe, Quebec H2W 3M4
Telephone (514) 941-5331 Fax (514) 941-8129

Client: Region of Waterloo	Project Name: Cambridge Well Optimization	Logged by: S. Quinlan
Project No.: MTA17230	Location: Cambridge	Ground (m amsl):
Drilling Co.: Pro Core Drilling	Date Started: 4/22/2010	Static Water Level (m amsl):
Drilling Method: Split Spoon	Date Completed: 4/22/2010	Sand Pack (m amsl):

Depth Scale (ft) (m)	Stratigraphic Description	Strat. Plot	Depth (m)		SAMPLE				Depth Scale (ft) (m)
					Num.	Type	Int.	% Recov.	
	TOPSOIL - organics, brown fine sand, dry.				1	CORE		50	
1.0	SILTY SAND - brown, wet at 1.32 m.		0.89		2	CORE		50	1.0
5.0	FINE SAND - trace gravel and silt, brown, wet.		1.45		3	CORE		50	5.0
2.0	SILTY SAND - fine sand, trace gravel and clay, brown, wet.		2.21		4	CORE		15	2.0
10.0	GRAVEL - coarse with coarse sand, brown, wet		2.87		5	SS	X	100	10.0
3.0	SAND - coarse, fine gravel, brown, wet.		3.75		6	SS	X	100	3.0
4.0	SILTY CLAY - dense with some gravel, dark grey/brown, wet.		4.11						4.0
			4.27						

Prepared By: **S. Quinlan**Checked By: **J. Baxter**Date Prepared: **5/19/2010**

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LEGEND

Water found @ time of drilling
Static Water Level -

MONITORING WELL DATA

Pipe: **51 mm dia. PVC**
Screen: **51 mm dia. PVC #10 slot**

SAMPLE TYPE AC



Auger Cutting



Continuous



Rock Core



Split Spoon



Air Rotary



Wash Cuttings



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Appendix C

Monitoring Data (Pumped Volumes and Hydrographs)



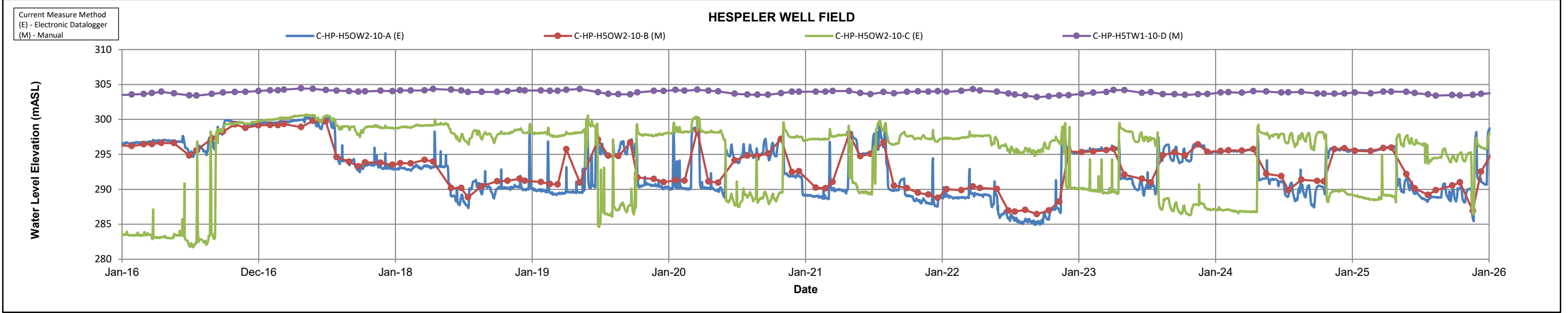
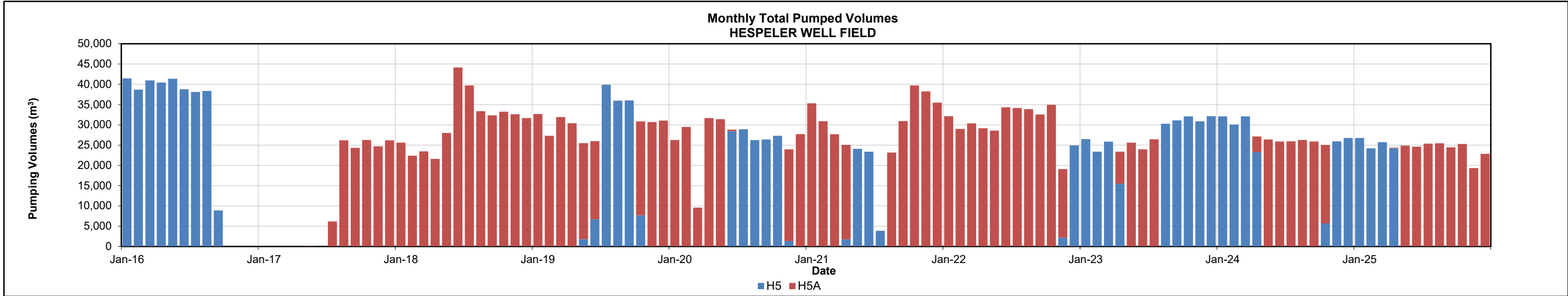
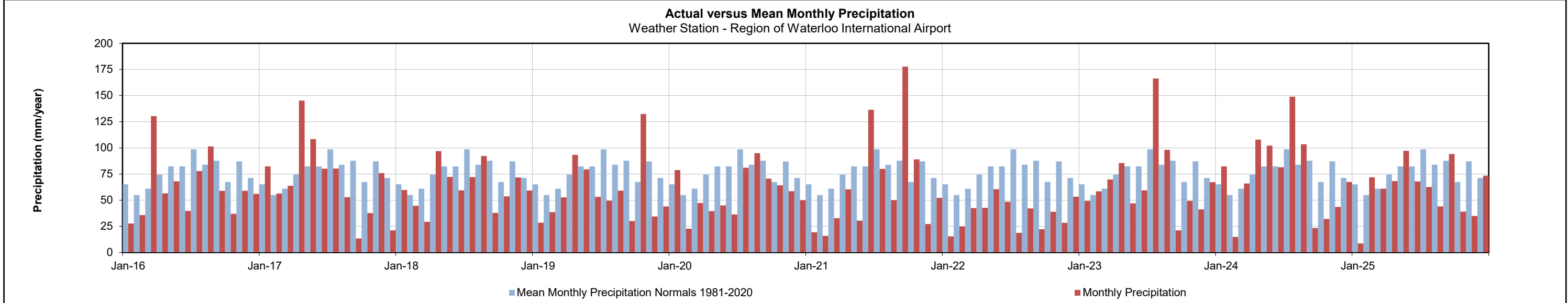
TABLE C-1
WELL FIELD WATER PRODUCTION SUMMARY
REGION OF WATERLOO - 2025 GROUNDWATER MONITORING REPORT



Well Field	Major or Minor Supply	Production Well Name	Status	Permit to Take Water Details			2021 Production Summary			2022 Production Summary			2023 Production Summary			2024 Production Summary			2025 Production Summary		
				MOE Permit Number ¹	Permitted Capacity (total m ³ /year)*	Permitted Rate (L/s)*	Total Production Well Volume (total m ³ /year)	Average Daily Rate (m ³ /day)	Average Rate (L/s)	Total Production Well Volume (total m ³ /year)	Average Daily Rate (m ³ /day)	Average Rate (L/s)	Total Production Well Volume (total m ³ /year)	Average Daily Rate (m ³ /day)	Average Rate (L/s)	Total Production Well Volume (total m ³ /year)	Average Daily Rate (m ³ /day)	Average Rate (L/s)	Total Production Well Volume (total m ³ /year)	Average Daily Rate (m ³ /day)	Average Rate (L/s)
Hespeler	Minor	H5 H5A	Connected Connected	P-300-1161883172	725,328	23.0	53,102	145	1.7	27,090	74	0.9	247,700	679	7.9	175,980	482	5.6	100,931	277	3.2
				P-300-1161883172	725,328	23.0	284,721	780	9.0	335,991	921	10.7	83,870	230	2.7	153,635	421	4.9	192,336	527	6.1
				Well Field Total	725,328	23.0	337,823	926	10.7	363,081	995	11.5	331,570	908	10.5	329,615	903	10.5	293,267	803	9.3
				Combined Rate not to exceed 1,987,200 L/day																	

Notes:
- = no applicable data
n/a = data not available
* = rates and volumes based on permitted L/day
¹ = Current Permit

REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
HESPELER





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Appendix D

Precipitation Data

Table D-1
Precipitation Variation from Average
Region of Waterloo - 2025 Groundwater Monitoring Report

Year	Kitchener/Waterloo Weather Station Established 1966		
	Annual Precipitation (mm)	30-yr NORMAL Precipitation 1981-2010 (mm)	Difference (mm)
2016	748	851	-103
2017	818	851	-33
2018	749	851	-102
2019	695	851	-156
2020	689	851	-162
2021	772	851	-79
2022	438	851	-413
2023	813	851	-38
2024	874	851	23
2025	723	851	-128

Year	University of Waterloo Station Established 1988		
	Annual Precipitation (mm)	Average Precipitation 1998-2024 (mm)	Difference (mm)
2016	891	871	20
2017	989	871	118
2018	950	871	79
2019	923	871	52
2020	953	871	82
2021	1022	871	151
2022	578	871	-293
2023	959	871	88
2024	763	871	-108
2025	943	871	72

Year	Shand Dam Established 1939		
	Annual Precipitation (mm)	Average Precipitation 1940-2025 (mm)	Difference (mm)
2016	976	926	50
2017	1093	926	167
2018	849	926	-77
2019	1081	926	155
2020	1017	926	91
2021	876	926	-50
2022	798	926	-128
2023	1015	926	89
2024	994	926	68
2025	995	926	69

Year	Conestogo Dam Established 1961		
	Annual Precipitation (mm)	Average Precipitation 1961-2025 (mm)	Difference (mm)
2016	983	990	-7
2017	1210	990	220
2018	962	990	-28
2019	992	990	2
2020	1021	990	31
2021	975	990	-15
2022	907	990	-83
2023	1053	990	63
2024	972	990	-18
2025	1025	990	35

Year	Woolwich Dam Established 1960		
	Annual Precipitation (mm)	Average Precipitation 1960-2025 (mm)	Difference (mm)
2016	844	835	9
2017	986	835	151
2018	869	835	34
2019	824	835	-11
2020	862	835	27
2021	649	835	-186
2022	668	835	-167
2023	859	835	24
2024	793	835	-42
2025	732	835	-103

Year	Shade's Mills Dam Established 1960		
	Annual Precipitation (mm)	Average Precipitation 1960-2025 (mm)	Difference (mm)
2016	934	909	24
2017	1092	909	183
2018	1042	909	133
2019	1059	909	150
2020	848	909	-62
2021	1020	909	111
2022	682	909	-227
2023	982	909	73
2024	976	909	67
2025	895	909	-14

Year	Laurel Dam Established 1960		
	Annual Precipitation (mm)	Average Precipitation 1960-2025 (mm)	Difference (mm)
2016	985	938	47
2017	1062	938	124
2018	1071	938	133
2019	940	938	2
2020	938	938	0
2021	1027	938	89
2022	689	938	-249
2023	921	938	-17
2024	907	938	-31
2025	894	938	-44

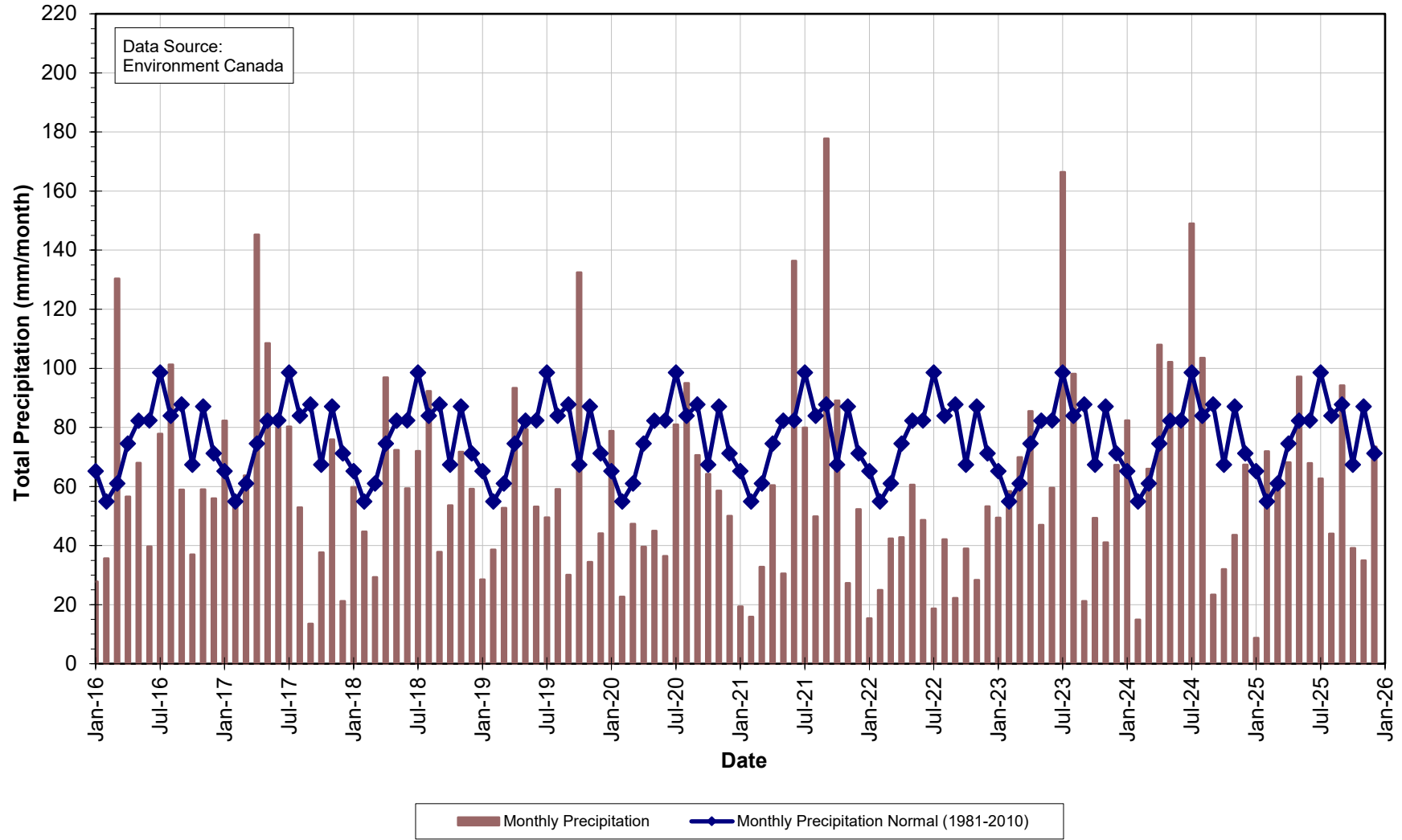
Year	Roseville Weather Station Established 1972		
	Annual Precipitation (mm)	30-yr NORMAL Precipitation 1981-2010 (mm)	Difference (mm)
2016	899	919	-20
2017	882	919	-37
2018	905	919	-14
2019	957	919	38
2020	817	919	-102
2021	832	919	-87
2022	637	919	-282
2023	945	919	26
2024	856	919	-63
2025	786	919	-133

NOTES:

WIA station data is not subject to review by the National Climate Archives, therefore, undergoes very limited quality checking.
 GRCA Dam stations data is not reviewed extensively and undergoes limited quality checking.

Region of Waterloo – 2025 Groundwater Monitoring Report

Figure D.1
Waterloo International Airport
Monthly Precipitation





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Appendix E

Monitoring Program Overview

GROUNDWATER LEVEL MONITORING PROGRAM PROCEDURES

E.1 Overview

The Region of Waterloo (Region) collects water level measurements at specific monitoring wells to ensure sustainable long-term water supply and to meet monitoring and reporting requirements for the Region's water-taking permits. The goal of the program is to manage and protect the Region's groundwater supply and to assess the potential impact of municipal pumping on the groundwater and surface water resources in the Region. The ongoing collection and assessment of groundwater level data is integral to assess any changes to the water resources that may occur due to pumping.

E.1.1 Production Well Pumping and Water Levels

In 2023 the Region managed approximately 132 production wells with status defined as:

- Commissioned – Active wells
- New Not-Commissioned – Well are inactive or locked out until future demand or repairs/maintenance of other wells requires activating them

The well fields are referred to as Urban (Kitchener, Waterloo, and Cambridge) and Rural (North Dumfries, Woolwich, Wilmot, and Wellesley). Well fields in Kitchener, Waterloo, and Cambridge are referred to as the Integrated Urban System (IUS).

The Region's active production wells are monitored through the Region's SCADA (Supervisory Control and Data Acquisition) system, which reads and records the volume pumped on a daily basis. A few wells do not have their own meter but are combined with other nearby well(s) in the well field and the combined flow is divided into a record for each source. Water level measurements are obtained from the production wells where required. All manual measurements are obtained using either an air line or a water level tape.

E.1.2 Monitoring Wells and Surface Water levels

Water levels are measured at monitoring wells and at some surface water features. The objective of this monitoring is to collect data to ensure that the Region's water taking has minimal impact on the environment and on private water takers.

Water levels in the Region's monitoring wells are measured either electronically or manually. Most of the wells that are monitored electronically use datalogger equipment manufactured by *In-Situ Inc.*® LevelTROLLs® and RuggedTROLLs®, as well as, by *Van Essen Instruments (formerly Schlumberger Water Services)* Mini-Divers®, Micro-Divers®, and TD-Divers®; or by *Solinst*® Levelloggers®. The datalogger pressure sensor models used may be either vented (gauged) or non-vented (absolute) for *In-Situ Inc.*®; whereas, for *Van Essen Instruments* and for *Solinst*®, non-vented (absolute) models are used. Barometric dataloggers by each manufacturer suspended in select well locations are also used with the non-vented (absolute) models to provide the required barometric pressure compensation necessary in producing the water level data. Manual monitoring is done using a *Solinst*® and/or *Heron Instruments Inc.* electronic water level meter with both visual and audio indicators.

The electronically monitored wells are typically measured every hour, with increased frequency as required. At the hourly frequency, the following trends can be distinguished in an individual monitoring well:

- Seasonal climate trends;
- Water level changes in the aquifer that is being pumped;
- Water level changes in aquifers connected to the pumped aquifer; and
- Individual precipitation events in unconfined aquifers.

The manually monitored wells are measured once per month. At this frequency only the first three responses listed above can be distinguished.

E.1.3 Climatological Data

To evaluate the reaction of water levels to changes in climatic conditions, precipitation data are monitored at various locations throughout the Region. Within the Region of Waterloo, climate data is collected by Environment Canada at the Region of Waterloo International Airport (WIA) and the Roseville weather station, by the Grand River Conservation Authority (GRCA) at various Dam locations and by the University of Waterloo at a weather station located on the north campus.

E.2 Groundwater Level Collection Protocols

E.2.1 Groundwater Level Monitoring Network Summary Well Checklist

A well checklist and data entry spreadsheet are prepared of all the measuring points where water levels will be collected on a monthly basis. The checklist and spreadsheet are organized by well field so wells in close proximity are grouped together and indicates whether locations are measured with electronic dataloggers or manual measurements only. Once a well is visited, data is entered in the spreadsheet and the well is checked off the list; thus, the checklist and spreadsheet provides an obvious indication that work is unfinished if a location is unchecked and has no data.

E.2.2 Well Inspection

Upon visiting a well for the first time, the well/casing/equipment details are noted, photos taken, and GPS coordinates are recorded in a field book and/or in the monthly data entry spreadsheet. Well/casing/equipment details includes: location, access, condition, materials, diameters, casing security, surface seal condition, requiring repair or not, well/casing stickup measurements from ground level, well total depth, and the type of datalogger and/or sampling equipment installed. Any notable deficiencies, concerns, problems, or changes in the well condition are recorded in a field book and/or in the monthly data entry spreadsheet, as well as, photos are taken. Also, any observed activities taking place around or near the well that are worth noting are recorded in a field book and/or in the monthly data entry spreadsheet.

E.2.3 Monitoring Well Manual Water Level Measurement Procedure

- Unlock well casing and open well casing lid.
- Remove well cap (if present).
- Use an Electronic Water Level meter and lower the probe down the well until the meter beeps to indicate the probe has encountered water.
- The probe is raised up until the beep of the meter stops, indicating the probe is now above the water.
- Then the probe is slowly lowered down until the probe just contacts the water level surface causing the meter to beep.
- At this point the depth (in meters) is read off the water level meter tape from the measuring point of the well (in most cases is the top of the casing or pipe) and this provides the water level depth below the measuring point.
- The date, time, and water level depth measured is recorded in a field book and/or in the monthly data entry spreadsheet.
- This procedure is repeated for each of the well screens inside the well casing.

- Replace well caps.
- Close well casing lid and lock well casing.

E.2.4 Downloading of Water Levels from Electronic Dataloggers Procedure

For Non-Vented (Absolute) Datalogger Models:

In-Situ Inc.® LevelTROLLs® and RuggedTROLLs®, *Van Essen Instruments* Divers®, and *Solinst*® Leveloggers®

- Prior to downloading data from the datalogger, a manual water level is measured in each well screen containing a datalogger.
- The datalogger is pulled out of the well, unthreaded from the cap that is attached to a wire cable and connected to (or placed in) the corresponding datalogger communication device. The communication device is connected to a laptop/tablet PC or a RuggedReader® Handheld PC and the associated datalogger software is started.
- Water level data stored in the datalogger is subsequently downloaded and viewed using the datalogger software and saved on the hard drive/memory.
- Note: downloading data from the datalogger does not automatically stop the datalogger from recording.
- The status of the datalogger is viewed and checked for correct operation and to confirm that the datalogger is hanging in the well water within its operating range.
- Select datalogger details such as the battery level and free/used memory are recorded in a field book and/or in the monthly data entry spreadsheet.
- If the datalogger does not require restarting to free up memory or to change the sample rate, then the datalogger is removed from the communication device and is threaded back onto its cap and lowered back down the well on the wire cable.
- If the datalogger does require restarting to free up memory or to change the sample rate, then the datalogger is stopped, reprogrammed, and restarted using the datalogger software and, as a result, erases the previous data stored in memory on the datalogger.
- This procedure is repeated for each datalogger within each of the well screens inside the well casing.
- After all the non-vented (absolute) dataloggers have been downloaded then the Barometric dataloggers are downloaded following the same procedure as above.

For Vented (Gauged) Datalogger Models:*In-Situ Inc.*® LevelTROLLs®

- Prior to downloading data from the datalogger, a manual water level is measured in each well screen containing a datalogger.
- The desiccant tube is disconnected from the datalogger cable.
- The datalogger cable is connected to a communication cable device that is connected to a laptop/tablet PC or a RuggedReader® Handheld PC and the datalogger software is started.
- Water level data stored in the datalogger is subsequently downloaded and viewed using the datalogger software and saved on the hard drive/memory.
- Note: downloading data from the datalogger does not automatically stop the datalogger from recording.
- The status of the datalogger is viewed and checked for correct operation and to confirm that the datalogger is hanging in the well water within its operating range.
- Select datalogger details such as the battery level, free/used memory, and desiccant condition (colour) are recorded in a field book and/or in the monthly data entry spreadsheet.
- The desiccant tube condition is checked and replaced if necessary.
- If the datalogger does not require restarting to free up memory or to change the sample rate, then the communication cable device is disconnected from the datalogger cable and the desiccant tube is reconnected.
- If the datalogger does require restarting to free up memory or to change the sample rate, then the datalogger is stopped, reprogrammed, and restarted using the datalogger software and, as a result, erases the previous data stored in memory on the datalogger.
- This procedure is repeated for each datalogger within each of the well screens inside the well casing.

E.2.5 Data Entry and Processing into the Burnside MS ACCESS/SQL® Database

- All field data collected (i.e. date, time, manual water level depth measured, comments) and recorded for each well screen and datalogger in a field book is entered into the monthly data entry spreadsheet, unless already entered in the field using a laptop/tablet PC.
- The monthly data entry spreadsheet is checked and reviewed prior to importing the data into a database table using Burnside Water Level Data Tools software. Manual water level depth values are converted into water level elevation values using the software during this import process.
- Any associated well notes, comments, and datalogger details are entered into a database table under the appropriate well and screen.

- Water level data from the dataloggers downloaded to a laptop/tablet PC or a RuggedReader® Handheld PC are transferred to Burnside file folder network upon returning to the office.
- These datalogger water level data files are subsequently read and the data is imported into a database table using Burnside Water Level Data Tools software.
- Using Burnside Water Level Data Tools software, the datalogger water level data are reviewed and processed (as described below) resulting in corrected water level depth values and corrected water level elevation values that are stored in a database table.
- *For Non-Vented (Absolute) Datalogger Models:*
Datalogger water level data is first barometric pressure compensated using selected Barometric datalogger data, then a manual water level depth value measured at the time of the most recent download is applied and used to convert the barometric compensated water level data into corrected water level depth values, which are converted into water level elevation values that are appended to a database table.
- *For Vented (Gauged) Datalogger Models:*
A manual water level depth value measured at the time of the most recent download is applied to the datalogger water level data to convert the water level data into corrected water level depth values, which are converted into water level elevation values that are appended to a database table.
- Temperature data recorded by the dataloggers are also imported into a database table.
- Hydrographs are subsequently created for each well and screen from the water level elevation data in the database for review and presentation. If there are some data points that are erroneous, then these data points are marked as non-reportable (invalid) within the database and/or are removed resulting in them not being plotted on the hydrographs.
- An updated data file is provided to the Region on a quarterly basis for upload into their eWRAS EQUIS database.

