2025 Biennial Groundwater Monitoring Report - Mannheim Well Field Consolidated

The Region of Waterloo

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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 Mannheim Well Fields Consolidated Permit to Take Water (PTTW) P-300-3130244509 was issued on October 8, 2021, and includes the Mannheim West Well Field, Mannheim East Well Field, Peaking Well Field and Mannheim ASR Well Field. The Peaking Well Field has been renamed to be the Mannheim North Well Field and is referred to as for this entire report. The PTTW for the Mannheim Well Fields 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 Mannheim Well Fields are shown in Figure 1 and the production wells in Kitchener and Wilmot are shown in Figure 2. The monitoring network for the Mannheim Well Fields are shown in Figures 3 and 4. 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 Permits to Take Water (PTTW) and to confirm that water taking is sustainable in the long term. The monitoring wells are concentrated near the production wells and 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 Mannheim Well Field in accordance with Consolidated PTTW P-300-3130244509 which consists of the following activities:

- Measuring the daily volume pumped from the production wells K21, K21A, K91, K92, K93, K94, K25, K29, ASR1, ASR2, ASR3, ASR4, ASR5, RCW2, RCW3, RCW4, K23, K24, and K26 (Condition 4.1 of the PTTW)
- Measuring the water levels in monitoring wells as listed in the permit (Appendix A) and Table 2 below (Condition 4.2 of the PTTW)
- Comparison of groundwater levels to trigger levels as listed in the Stantec letter report dated July 28, 2016 (Appendix A) (Condition 4.3 of the PTTW)

- Review of precipitation data from the nearest GRCA / Environment Canada weather station
- Completion of a biennial report (every two years) that presents data in compliance with Condition 4.4 of the PTTW

There are several domestic wells in the vicinity of the Mannheim wells. Although the potential for interference from the Mannheim pumping wells is considered low, the Region has proactively developed trigger levels for several of the monitoring wells in the well field. Water levels below the trigger levels are not considered an indication of well interference but will result in additional investigations. The Region has developed an on-line EQuIS dashboard that allows them to compare water levels to trigger levels as soon as water level data is received.

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 Location

The Mannheim Well Fields are located in the western portion of Kitchener and the eastern portion of Wilmot Township (Figure 2). The Mannheim East Well Field is located east of Trussler Road between Bleams Road and the Conestoga Parkway. The Mannheim West Well Field is located south of Highway 7/8 along Mannheim Road between Bleams Road and Huron Road. The Mannheim North Well Field is located south of Highway 7/8 bordered by Trussler Road to the west and Ottawa Street to the south. The ASR Well Field is located on the Region's Mannheim Water Treatment Plant property between the Mannheim East Well Field and Mannheim West Well Field, and south of the Mannheim North Well Field. The closest municipal well fields to the Mannheim Well Fields are the Greenbrook Well Field located to the east, the New Dundee Well Field to the south, and the Wilmot Centre Well Field to the west (Figure 2).

There are no significant surface water features located near the municipal wells in the Mannheim North Well Field and Mannheim ASR Well Field. In the Mannheim East Well Field K21 and K21A are located just west of a large pond / wetland area (Figure 3). In Mannheim West, K22A, K23, K24, and K26 are near Alder Creek and its tributaries (Figure 4).

2.1 Pumping Wells

The Mannheim Well Fields Consolidated PTTW includes production wells in the Mannheim West Well Field (K23, K24, and K26), the Mannheim ASR Well Field (ASR1, ASR2, ASR3, ASR4, RCW1 / ASR5, RCW2, RCW3 and RCW4), the

Mannheim East Well Field (K21, K21A, K25 and K29) and the Mannheim North Well Field (K91, K92, K93 and K94). Well records for the production wells are found in Appendix B. Details on the construction of the production wells in each well field are provided in Section 3.0.

The water taking volumes for the Mannheim Well Fields are regulated by Condition 3.2 of the PTTW and are summarized in Table 1 below along with a summary of pumping volumes at each well field for 2024 and 2025.

Table 1: Annual Water Taking 2024 / 2025

Mannheim Well Field	PTTW	2024			2025		
	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)
Mannheim West (K23, K24 & K26)	19,354	10,019	14,063	3,656,967	9,925	13,575	3,622,704
Mannheim ASR (ASR1, ASR2, ASR3, ASR4, RCW1 / ASR5, RCW2, RCW3 and RCW4)	23,700	1,123	13,679	410,031	2,141	14,718	781,299
Mannheim East (K21, K21A, K25 & K29)	17,021	11,654	12,352	4,253,663	11,371	11,918	4,150,268
Mannheim North (K91, K92, K93 & K94)	16,416	9,123	13,580	3,329,853	9,799	13,374	3,576,775
Total Combined	76,491	31,919	52,800	11,650,514	33,236	52,130	12,131,047
Total Combined (West, East and North)	52,791	30,796	39,136	11,240,483	31,095	38,108	11,349,747

Condition 3.3 of the PTTW specifies that the taking from the Mannheim East wells, Mannheim West wells and Mannheim North wells (in any combination of the 11 listed wells) shall not exceed an annual daily average of 40,715.136 m^3/day. As shown in Table 1, this requirement was met in both 2024 and 2025.

The Region of Waterloo's SCADA system records total daily water taking volumes including the dates and times of water takings, the rates of pumping, and calculations of the total amounts of water pumped per day for each supply well, which complies with Condition 4.1 of the PTTW.

The pumping volumes are presented in Appendix C as total monthly volumes. Pumping volumes from the well fields ranged from 866,478 m^3/month to 1,708,184 m^3/month in 2024, and from 815,974 m^3/month to 1,221,679 m^3/month in 2025. In total, 11,650,514 m^3 was produced at the Mannheim Well Fields in 2024 and 12,131,047 m^3 was produced in 2025. The volumes in 2024 and 2025 were below the permitted volume of 14,861,025 m^3 per year (Table C-1).

2.2 Monitoring Wells

Groundwater level monitoring is required by the PTTW at 22 monitoring wells. The wells listed below have names on the PTTW that are slightly different than the names used by the Region. The Region names will be used throughout this report. The locations of the monitoring wells are shown in Figure 3 and Figure 4. Well records for the monitoring wells are provided in Appendix B.

Table 2: Monitoring Well Nomenclature

Monitoring well names as they appear on the PTTW	Region nomenclature
K-ASR-OW2-96-B	K-MA-ASR-OW2-96-B
K-ASR-OW2-16-A	K-MA-ASR-OW2-16-A
WT-MW-OW6-04-A	WT-MW-OW6-04-B

2.3 Regional Geology and Hydrostratigraphy

The following sections provide a brief overview of the regional geology and hydrogeology of the Mannheim Well Fields. The surficial geology based on regional OGS mapping is provided in Figure 5. The Mannheim Well Fields are in the core of the Waterloo Moraine (Figure 6). The wells obtain water from Aquifer 1(AFB1 / AFB2) with water levels in the aquifer shown on Figure 7. Representative cross-sections showing the stratigraphy in the vicinity of the Mannheim Well Fields are included as Figure 8 to Figure 16. The cross-section locations are provided in Figure 3 and Figure 4.

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

The recently completed Tier Three Assessment Update Project (Aqua Insight et al, 2023) has revised the previous (Matrix 2015) stratigraphic interpretation of the lithology around the Mannheim Well Fields. The lithological layers were updated in accordance with documentation provided in the Numerical Model Surface Transfer memorandum (Aqua Insight Inc, 2026).

The general updates to the model layers based on the updated geological picks are are described in the Tier 3 Assessment Update project (Aqua Insight Inc. et al,2023) as follows:

- The ground surface in the Mannheim Well Field was updated using the high-resolution Digital Elevation Model (DEM) to better capture the topographic relief in this area.
- A recent hydrogeologic and groundwater flow modelling study was undertaken (Matrix, 2022) that included reinterpretation of the hydrostratigraphic units present within the Mannheim Well Field. As part of that study, the ATB2 surface was interpreted to be present at an elevation of approximately 330 to 340 m asl in the vicinity of Mannheim North. As part of the current study, the upper surface of ATB2, was re-interpreted. The elevation of ATB2 is now interpreted to be at a higher elevation of approximately 350 to 360 m asl. This upper aquitard is discontinuous and lies in the unsaturated zone, the unit supports shallow water levels in AFB1 in the area. This reinterpretation resulted in an overall increase in the thickness of AFB2 by approximately 20 m, and commensurate decrease in thickness of AFB1.
- The thickness of ATB2 was also revised in an area south of Huron Road and east of Ira Needles. Lower quality domestic well logs were causing an interpreted thickening of ATB2 in this area that differed from higher quality lithologic logs in the area, and the water level elevations in the area. The thickness of ATB2 was reduced in this area relative to previous hydrostratigraphic layer interpretations.
- No changes were made to the upper surface of ATB3 or underlying units.

2.3.1 Surficial Geology and Conceptual Hydrostratigraphy

The surficial geology of the Study Area has been mapped and described by the Ontario Geological Survey (2003) and updated in Bajc and Shirota (2007). The surficial geology of the Mannheim Well Field Consolidated is characterized primarily by ice contact sand and gravel and silty to clayey till and silty to sandy till sediments (Figure 5). Modern alluvial and organic deposits are present along Alder Creek.

The Quaternary units typically present in the Waterloo Moraine area are briefly described below, in order from youngest to oldest.

Aquitard ATB1 – Port Stanley / Tavistock Till

The ATB1 unit is considered an aquitard and, where present, acts to restrict recharge to the lower aquifers. Both the Port Stanley Till and Tavistock Till are mapped in the area of the Mannheim Well Fields. The Port Stanley Till is a sandy silt to silty sand till, with occasional stony texture, that is predominantly found along the eastern flanks of the Waterloo Moraine. The Tavistock Till is a dark brown clayey silt till, mainly restricted to the western flanks of the Waterloo Moraine. ATB1 is interpreted to be thin or absent to

the east of Fischer Hallman Road (Stantec, 2009) and correlates well with the surficial regional geology mapping (Figure 5).

Aquifer AFB1 / ATB2 / AFB2 – Upper Waterloo Moraine Stratified Sediments and Equivalents

Aquifer AFB1 / AFB2 represents the main water supply aquifer in the core areas of the Waterloo Moraine, including the Mannheim Well Fields production wells. These units are generally comprised of layered silt and fine sand to coarse sand and gravel. Throughout the core areas of the Moraine (Figure 6), the unit typically exceeds 45 m in thickness. In some areas, the Upper Waterloo Moraine is interpreted to be bisected by the middle Maryhill Till (ATB2), effectively separating the aquifer into two units, AFB1 and AFB2. This aquifer is the most prolific aquifer in the Waterloo Region due to its high hydraulic conductivity and transmissivity, lateral extent, and high recharge rate.

Aquitard ATB3 – Lower Maryhill Till

The Lower Maryhill Till is described as a clayey silt to silty clay till. This unit represents one of the primary regional aquitards due to its strong influence on the groundwater flow system within the Waterloo Moraine. This unit is extensive within the core area of the Waterloo Moraine, and along the eastern flank tends to be thin, discontinuous, or re-worked and re-deposited as glaciofluvial sediments.

Aquitard ATC1 / ATC2 – 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. It is a dense, stony, sandy silt to silty sand till with little clay content. 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. The Catfish Creek Till is typically thickest in the core area of the Waterloo Moraine, and thin or absent along the eastern flank.

Aquifer AFD1 – Pre-Catfish Creek Sand and Gravel

Pre-Catfish Creek Till aquifer corresponds to sands and gravel re-worked from Catfish Creek and Pre-Catfish Creek Tills and represents the main supply aquifer in several production wells in the Cities of Kitchener and Waterloo. This unit is spatially discontinuous throughout much of the core areas of the Waterloo Moraine and pinches out beneath Alder Creek.

Aquitard ATE1 – Canning Drift

The Canning Drift is comprised of till and associated fine-textured lake deposits. It is typically found at depths of greater than 70 mbgs in the Waterloo Moraine area and is

identified to be discontinuous and limited in lateral extent and thickness. Where it is absent, a hydraulic connection is present between the deep overburden aquifers and the underlying bedrock.

Aquifer AFF1 – Pre-Canning Till

The Pre-Canning aquifer is characterized by coarse-grained sand and gravel sediments and is typically found within bedrock depressions. This unit is discontinuous throughout the Region, and where present is hydraulically connected with the upper weathered portion of the bedrock aquifer.

2.3.2 Bedrock Geology

The Paleozoic bedrock beneath the Waterloo Moraine consists of the Salina and Guelph Formations with the top of the bedrock generally encountered at about 280 metres above sea level (masl). The Salina Formation consists of interbedded brown dolostone and grey to green shale with lenses of gypsum and anhydrite. The Guelph Formation is a cream colored crystalline dolostone. In the Mannheim area, the contact between the Salina and Guelph Formations is generally encountered at approximately 240 masl.

2.4 Local Geology

Figure 3 and Figure 4 display the Mannheim Well Fields well plans and cross-section locations. Representative cross-sections are included as Figure 8 to Figure 16 to visualize the stratigraphy described in this section.

Port Stanley / Tavistock Till (ATB1) – This unit represents a relatively thin (i.e., less than 10 m in thickness) and patchy network of glacial till cover within the Mannheim area. Occurrences of ATB1 at water well locations reasonably correlate with Quaternary geology mapping (Figure 5).

Upper Waterloo Moraine (AFB1 / ATB2 / AFB2) – The Mannheim production wells are all completed in this aquifer. Aquifer AFB1 represents shallow granular soils within the Mannheim area, with thicknesses ranging from 5 m to 15 m. The AFB1 aquifer is typically unsaturated and comprised of silty fine sands to coarse sands and gravels. Based on a review of borehole logs within the area, the ATB2 aquitard is interpreted to reflect discontinuous, fine-grained soils, generally encountered between 365 and 335 masl. The thickness and composition of the ATB2 soils varies both vertically and spatially which makes it difficult to correlate ATB2 as a single hydrostratigraphic layer. The AFB2 aquifer consists of fine to coarse sand and gravel ranging in thickness from 5 to 40 m and appears to be laterally extensive throughout most of the area.

Lower Maryhill Till (ATB3) – This unit and is typically characterized as a clayey silt to silty clay till and is interpreted to be continuous across the area. The unit was identified at K-MA-ASR-OW2-16-A as silty clay to silt till from 69.5 m to 79.2 mbgs

Catfish Creek Till (ATC1 / ATC2) – This unit is interpreted to be continuous in the Manheim area. The only borehole that extended to the unit was K-ME-OW1-03-A which described it as clay with silt, gravel and cobbles from 44.2 m to 61.9 mbgs

Bedrock – The bedrock in the Mannheim area consists of the Salina and Guelph formations, with the top of the bedrock generally encountered at about 280 meters above sea level (masl). At K-MA-ASR-OW1-96-A (near ASR1) bedrock was encountered at 110.3 mbgs. At WT-MW-OW3-92-A, bedrock was encountered at 65.5 mbgs.

3.0 2024 / 2025 Results

In accordance with Conditions 4.2 and 4.4a of the PTTW, water levels were measured and recorded once a month in all listed monitoring wells. Monitoring wells are inspected regularly (see Appendix E) and well conditions were considered in the interpretation of the monitoring results.

The following sections summarize groundwater levels at monitoring wells by well field in relation to precipitation, water taking from the aquifer (in accordance with Condition 4.4a of the PTTW), and assess groundwater elevation measurements relative to the trigger levels (PTTW Conditions 4.3 and 4.4d).

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 Mannheim well fields is the University of Waterloo weather station located 7.2 km north from the Mannheim North well field. The closest Environment Canada station is Roseville located about 5.8 km southeast from the Mannheim West well field. The locations of the meteorological stations are shown on Figure 1. Annual precipitation data from the past ten years for all stations are compared with long term averages in Table D.1, Appendix D. Monthly precipitation data for the past ten years at the University of Waterloo station and Roseville station are shown on Figures D.1 and D.2, Appendix D. At the University of Waterloo (U of W) station, the long-term average was calculated from 1998 until the end of 2025. The Roseville station has “Climate Normals” calculated by Environment Canada for 1981 to 2010.

Annual 2024 / 2025 precipitation data for the closest weather station and closest Environment Canada meteorological station to the Mannheim well fields are presented in

Table 3 below. In 2024 Roseville was missing five days of data and 20 days in 2025. As a result, the precipitation totals may be under reported at this location.

Table 3: Summary of Precipitation Data

Station	2024 Precipitation (mm)	2024 Deviation (mm)	Long-Term Average (mm)	2025 Precipitation (mm)	2025 Deviation (mm)
University of Waterloo(2)	763	-108	871(B)	943	+72
Roseville Station(1)	856	-63	919(A)	786	-133

Sources: Environment Canada (1), University of Waterloo (2)
A 1981 to 2010 Normal B 1998-2025 data

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 the U of W station was 763 mm, which is 108 mm below the long-term average, indicating 2024 was a drier-than-average year at the well field. A similar above long-term average trend is noted at the Roseville station. The March 1, 2024 GRCA snow survey indicated a snowpack across the Region that was low compared to normal. In 2025, the total precipitation at the U of W station was 943 mm, which is 73 mm above the long-term average. Alternately, the total precipitation at the Roseville station was 133 mm below the long-term average, indicating 2025 was a drier-than-average year. However, Roseville was missing 25 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 Mannheim West Well Field

Production Wells

The Mannheim West Well Field consists of production wells K23, K24 and K26 which obtain water from AFB2. Well records for the production wells are found in Appendix B. A summary of the production well construction are provided in Table 4 below.

Table 4: Mannheim West Well Field Production Well Details

Well Name	Year Built	Casing/Screen Diameter (mm)	Screened Interval (mbgs)	Aquifer
K23	1950	350 / 450	21.6 – 26.2	AFB2
K24	1951	457	30.0 – 33.5	AFB2
K26	1969	450	28.4 – 37.5	AFB2

Pumping Volumes

The pumping volumes are presented in Appendix C as total monthly volumes. In total, 3,656,967 m^3 was produced at this well field in 2024 and 3,622,704 m^3 was produced in 2025. In 2024 / 2025, K26 produced 52% of the volume while K23 and K24 provided the rest. Pumping volumes from the well field ranged from 267,601 m^3/month to 357,590 m^3/month in 2024, and from 248,235 m^3/month to 365,939 m^3/month in 2025.

Monitoring Wells

Observation wells within the vicinity of the Mannheim West Well Field are shown in Figure 3. Construction and monitoring details of the monitoring wells are described in Table 5 below. Well records for the monitoring wells are provided in Appendix B.

Table 5: Mannheim West Monitoring Wells

Monitoring Well ID	Year Built	Screened Depth (mbgs)	Screened Formation	Distance to Closest Well (m)	Trigger Level (masl)
WT-MW-AC1-01-A	2001	18.3 – 21.3	ATB2	924 m to K24	-
WT-MW-AC1-01-B	2001	5.97 – 9.02	AFB1		-
WT-MW-WM20-93-A	1993	32.3 – 35.4	AFB2	1,240 m to K23	-
WT-MW-WM20-93-B	1993	5.2 – 8.2	AFB1		-
WT-MW-OW1-21-A (Replacement for WT-MW-OW01-09-A)	2021	36.0 – 39.0	AFB2	20 m to K26	-
WT-MW-OW02-10-A	2010	27.4 – 30.5	AFB2	25 m to K24	325.1

Monitoring Well ID	Year Built	Screened Depth (mbgs)	Screened Formation	Distance to Closest Well (m)	Trigger Level (masl)
WT-MW-OW2-11-A	2011	10.66 – 12.2	AFB2	360 m to K23	-
WT-MW-OW3-04-A	2004	6.3 – 6.8	AFB2	730 m to K26	326.8
WT-MW-OW6-04-B	2004	43.0 – 48.0	ATB3	1,100 m to K26	328.5
WT-MW-OW03-09-B	2009	19.5 – 22.6	AFB2	360 m to K23	-
WT-MW-OW04-09-A	2009	23.0 – 26.1	AFB2	6 m to K23	-
WT-ME-OW03-09-A	2009	35.1 – 38.1	AFB2	762 m to K23	331.0

The hydrographs showing the results of water level monitoring (Appendix C) only show data collected during the past ten years. The method used to collect the water levels (manual or electronic) is indicated on the graphs in Appendix C.

WT-MW-AC1-01-AB

Water levels at WT-MW-AC1-01-AB are collected manually monthly. Screen A is located across fine grained silt (ATB2) and Screen B is located across clay and fine sand (AFB1). The well is located in an area that AFB2 pinches out (Figure 8, Cross Section A-A') and therefore the screens show no response to pumping. The groundwater levels have seasonal variations within a 1 m range typical of shallow wells influenced by precipitation events. 2024 / 2025 late summer water levels in both screens are the lowest seen in the last ten years of monitoring.

WT-MW-OW01-09-A

Water levels at WT-MW-OW01-09-A were collected with an electronic water level meter (data logger). The well located 18 m south of well K26 is screened in AFB2 and responds to changes in pumping at K26. Monitoring well WT-MW-OW01-09-A was decommissioned in October 2021 and was replaced with WT-OW1-21-A.

WT-MW-OW1-21-A

Water levels in WT-OW1-21-A are measured with a data logger. The well was added to the monitoring program as a replacement for WT-MW-OW01-09 in October 2021. The well is located near K26 and is screened in AFB2. Similar to WT-MW-OW01-09-A, the well responds to K26 as an increase in water levels occurs in September and October 2023 when pumping at K26 is reduced. Water levels declined about 2 m below the

highest historical levels from May 2020 to the end of 2023 in correlation with increased pumping. Water levels in 2024 and 2025 are stable as a result of decreased pumping of K26, but remain about 1 m below highest historical levels observed at WT-MW-OW01-09.

WT-MW-OW02-10-A

Water levels at monitoring well WT-MW-OW02-10-A have been measured with a data logger since December 2013. The well is located 25 m from K24 and is screened in Aquifer AFB2. Groundwater level fluctuations of up to 3.5 m indicate that the well responds to pumping of K24. There is a decreasing trend in water levels beginning in April 2020 to October 2023 due to increased pumping of K24 and K26. In July 2025 water levels reached a historical low (since monitoring began in 2013) of 325.66 masl, about 0.56 m above the trigger level of 325.1 masl. Water levels have since stabilized due to reduced pumping of K26. 2024 / 2025 water levels are about 1 m below historical water levels observed before 2020 and are 1.3 m above the trigger level at the end of 2025.

WT-MW-OW04-09-A

Water levels at monitoring well WT-MW-OW04-09-A is measured with a data logger. The well is located adjacent to K23 and responds to pumping of K23 with variations of up to 1.5 m. The water levels also show some of the seasonal trends observed in the local aquifer when pumping is consistent at K23. Similar to other monitoring wells in the well field, water levels generally decline about 2.5 m from May 2020 to the end of 2025 (with some variations in response to changes in K23 pumping). 2024 / 2025 water levels are about 1 m below historical water levels observed before 2023.

WT-MW-OW2-11-A

Monitoring well WT-MW-OW2-11-A is located 360 m from K23 and adjacent to Alder Creek and monitors groundwater levels in AFB2. Manual groundwater levels have been measured monthly since January 2013. The well does not appear to be directly influenced by changes in pumping. This well also shows a declining trend declining from 333.8 masl in March 2020 to 331.3 masl at the end of 2025. The decline is interpreted to be a regional scale response in the aquifer to climatic conditions. The 2024 / 2025 water levels are about 2 m below the highest historical water levels observed between 2013 and 2020.

WT-MW-OW3-04-A

Groundwater level monitoring at WT-MW-OW3-04-A, screened in AFB2, began in September 2016. This well which is located about 730 m from K26 was assigned a trigger level designed to be protective of nearby domestic wells. The water levels show seasonal variations of less than 1 m and appear to respond to pumping at K26.

2024 / 2025 water levels are about 1.5 m lower than the highest historical water levels. A decreasing trend beginning in 2020 is similar to other monitoring wells in the well field. Water levels at the end of 2025 are 0.5 m above the trigger level of 326.8 masl.

WT-MW-OW6-04-B

Water levels at monitoring well WT-MW-OW6-04 (located 1,100 m from K26) are measured with a data logger. The well is screened in ATB3 and a trigger level was assigned that is designed to be protective of nearby domestic wells. Groundwater levels do not respond to changes in pumping at the well field and show seasonal trends. Daily fluctuations of about 0.1 m are likely related to domestic well use. 2024 / 2025 water levels are about 1.6 m lower than the highest historical water levels. Water levels follow a similar trend to WT-MW-OW3-04-A with a decreasing trend from 2020 to 2025. At the end of 2025 water levels were about 0.3 m above the trigger level of 328.5 masl.

WT-MW-WM20-93-AB

Water levels at WT-MW-WM20-93-AB located about 1,240 m from K23, are collected manually on a monthly basis. The A screen is located across AFB2 and the B screen is located across AFB1. As indicated on Cross-section B-B' (Figure 9), there is about 12 m of clay till (ATB2) between the A and B screens. Neither of the screens respond to pumping of production wells. A seasonal variation of about 1 m and 2 m is observed in the A and B screens respectively. Water levels in the A screen decline about 1 m from May 2020 to the end of 2025. The B screen water levels are more variable, but there is a 1 m decline between May 2020 and the end of 2025. Water levels at the end of 2025 are the lowest seen in the past 10 years.

WT-MW-OW03-09-B

Water levels at monitoring well WT-MW-OW3-09-B are measured with a data logger. The well is located on the K22A site and monitors groundwater levels in AFB2. Historically, the well has shown a response to pumping of K22A; however, K22A was last used in November 2011. Water levels in the well reflect climatic trends in the AFB2 aquifer and there is the same decreasing trend from 2020 to 2025 as observed in other monitoring wells within AFB2. Water levels at the end of 2025 are about 0.8 m lower than the highest levels seen in 2019/2020.

WT-ME-OW03-09-A

WT-ME-OW03-09-A is located approximately 1 km southwest from the Mannheim North Well Field, 1 km west of the Mannheim ASR Well Field and 1 km northeast of the Mannheim West Well Field and is screened in AFB2. Water level monitoring at the well has been completed with a data logger since November 2009. Since the well is an equal distance from several pumping wells, it is difficult to discern whether changes in groundwater levels can be attributed to changes in pumping or climate. WT-ME-OW03-

09A has a trigger level assigned that is designed to be protective of nearby domestic well users. Water levels declined by about 3.5 m from the highest historical levels seen in November 2020 to the end of 2025. At the end of 2025, groundwater levels are approximately 0.6 m above the well's trigger level of 331 masl.

3.3 Mannheim ASR Well Field

3.3.1 Production Wells

The Mannheim ASR Well Field consists of wells ASR1, ASR2, ASR3, ASR4, RCW1 / ASR5, RCW2, RCW3 and RCW4. The ASR / RCW wells are screened within the lower sand and gravel deposits of AFB2.

The ASR system involves the injection and storage of treated, unchlorinated drinking water from the Grand River during periods of excess water, followed by pumping as required to meet system demands. The ASR system began operating in 2005 and consists of five dual purpose injection / pumping wells, ASR1, ASR2, ASR3, ASR4, RCW1 / ASR5, and three pumping only wells (recovery wells), RCW2, RCW3 and RCW4.

Well records for the production wells are found in Appendix B. A summary of the production well construction details is provided in Table 6 below.

Table 6: Mannheim ASR Well Field Production Well Details

Well Name	Year Built	Casing / Screen Diameter (mm)	Screened Interval (mbgs)	Aquifer
ASR1	1996	406	53.7 – 66.1	AFB2
ASR2	2002	406	52.4 – 59.8	AFB2
ASR3	2003	442 / 406	51.8 – 57.0	AFB2
ASR4	2002	442 / 406	56.4 – 65.8	AFB2
RCW1/ ASR5	2002	442 / 406	68.9 – 77.1	AFB2
RCW2	2002	442 / 406	69.2 – 73.2	AFB2
RCW3	2019	304	64.5 – 68.5	AFB2
RCW4	2020	304 / 290	61.6 – 67.1	AFB2

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. A summary of the pumping volumes and injection volumes for 2024 and 2025 is provided in Table 7below.

Table 7: Mannheim ASR Well Field Pumping / Injection Volumes

Well Name	2024 Total Volume Pumped (m^3)	2024 Total Volume Injected (m^3)	2024 Total Net Taking (m^3)	2025 Total Volume Pumped (m^3)	2025 Total Volume Injected (m^3)	2025 Total Net Taking (m^3)
ASR1	4,258	131,038	-126,780	20,401	0	20,401
ASR2	20,786	150,377	-129,591	45,868	82	45,786
ASR3	31	110,705	-110,674	9,499	204	9,295
ASR4	0	14	14	0	0	0
RCW1/ ASR5	129,281	882	128,399	189,151	0	189,151
RCW2	100,124	0	100,124	180,266	0	180,266
RCW3	50,342	0	50,342	140,682	0	140,682
RCW4	105,209	0	105,209	195,433	0	195,433
2024 Total Net Taking			17,015	2025 Total Net Taking		779,177

Pumping volumes from the well field ranged from 1,509 m^3/month to 61,930 m^3/month in 2024, and from 1,761 m^3/month to 154,823 m^3/month in 2025. In total, 410,031 m^3 was produced at this well field in 2024 and 781,299 m^3 was produced in 2025. The volumes produced from the well field in 2024 / 2025 are lower than volumes in the past five years.

Injection of water occurs in ASR1, ASR2, ASR3, ASR4 and RCW1 / ASR5. Injection volumes from the well field ranged from 0 m^3/month to 155,419 m^3/month in 2024, and from 0 m^3/month to 204 m^3/month in 2025. In 2024, 393,016 m^3 was injected at the well field and 288 m^3 was injected in 2025.

3.3.2 Monitoring Wells

Observation wells within the vicinity of the Mannheim ASR Well Field are shown on Figure 4. Construction and monitoring details of the monitoring wells are described in the Table 8 below. Well records for the monitoring wells are provided in Appendix B.

Table 8: Mannheim ASR Well Field Monitoring Well Details

Monitoring Well ID	Year Built	Screened Depth (mbgs)	Screened Formation	Distance to Closest Well	Trigger Level (masl)
K-MA-ASR-OW2-96-B	1996	56.4 – 65.5	AFB2	6 m to RCW1	-
K-ASR-TW13-85-A	1985	Not available	AFB2	140 m to ASR4	-

Monitoring Well ID	Year Built	Screened Depth (mbgs)	Screened Formation	Distance to Closest Well	Trigger Level (masl)
K-MA-ASR-OW2-16-A	2016	60.96 – 64.01	AFB2	330 m to ASR4	326.3

Hydrographs showing the results of water level monitoring over the past ten 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.

K-MA-ASR-OW2-96-B

K-MA-ASR-OW2-96-B is located adjacent to RCW1 and water levels are measured with a data logger. The data logger was removed in July 2025 and monthly manual water levels were collected for the remainder of 2025. Groundwater levels at this location respond to pumping and injections at the ASR wells with water level variations typically between 2 and 3 m. Water levels at the end of 2025 are about 3.3 m lower than the highest levels in the past ten years.

K-ASR-TW13-85-A

K-ASR-TW13-85-A is located about 140 m southeast of ASR4 and water levels are measured with a data logger. There is no borehole log available for this well, but the well is estimated to be 78 m deep. A geophysical log for Mannheim TW13B-85 indicates that the Lower Maryhill Till begins at a depth of 70 m (317.61 masl); however, the groundwater levels are what would be expected for a well located in AFB2. Levels at K-ASR-TW13-85-A vary within a 1 m range in response to volumes of takings and injections. Groundwater level trends were very similar to those observed at K-OW-ASR-OW2-96-B and show water levels at the end of 2025 about 2.9 m below levels at the end of 2022.

K-MA-ASR-OW2-16-A

K-MA-ASR-OW2-16-A is located about 330 m southeast of ASR4 and water levels are measured with a data logger. This well was assigned a trigger level designed to be protective of nearby private wells. The levels appear to have a similar trend to K-ASR-OW2-96-B although more subdued indicating a minor response to pumping and injections with water levels varying within 2 m. Water levels have declined about 3.9 m since late 2020 and at the end of 2025 are about 3.3 m above the trigger level of 326.3 masl.

3.4 Mannheim East Well Field

3.4.1 Production Wells

The Mannheim East Well Field consists of production wells K21, K21A, K25 and K29 which obtain water from AFB2. Well records for the production wells are found in Appendix B. A summary of the production well construction details is provided in Table 9 below.

Table 9: Mannheim East Well Field Production Well Details

Well Name	Year Built	Casing / Screen Diameter (mm)	Screened Interval (mbgs)	Aquifer
K21	1960	460	29.6 – 35.7	AFB2
K21A	2015	324 / 286	32.0 – 38.1	AFB2
K25	1962	400	40.2 – 49.4	AFB2
K29	1988	300	42.4 – 51.5	AFB2

3.4.2 Pumping Volumes

The pumping volumes are presented in Appendix C as total monthly volumes. Pumping volumes from the Mannheim East well field ranged from 331,617 m^3/month to 369,635 m^3/month in 2024, and from 326,987 m^3/month to 362,114 m^3/month in 2025. In total, 4,253,663 m^3 was produced at this well field in 2024 and 4,150,268 m^3 was produced in 2025. These volumes are below the permitted volumes.

In 2024 and 2025, about 37% of the total volume pumped was provided by K25, 32% of the volume was from K29, 17% from K21 and 14% was from K21A.

3.4.3 Monitoring Wells

Observation wells within the vicinity of the Mannheim East Well Field are shown on Figure 4. Construction and monitoring details of the monitoring wells are described in the Table 10 below. Well records for the monitoring wells are provided in Appendix B.

Table 10: Mannheim East Well Field Monitoring Well Details

Monitoring Well ID	Year Built	Screened Depth (mbgs)	Screened Formation	Distance to K21 (m)	Distance to K25 / K29 (m)
K-ME-OW1-03-A	2003	55.8 – 58.8	ATC1/AFC1 /ATC2	1,333 m	1,630 m
K-ME-OW1-03-B	2003	32.0 – 35.1	AFB2		
K-ME-OW2-17-A	2017	52.7 – 55.8	AFB2	1,335 m	520 m
K-ME-OW1-17-A	2017	46.9 - 50	AFB2	570 m	950 m

Monitoring Well ID	Year Built	Screened Depth (mbgs)	Screened Formation	Distance to K21 (m)	Distance to K25 / K29 (m)
K-ME-OW1-21-A	2021	68.0 – 71.0	ATC1/AFC1 /ATC2	20 m	800 m
K-ME-OW1-21-B	2021	32.0 – 35.0	AFB2	20 m	800 m
K-ME-OW02-09-A	2009	45.7 – 48.8	AFB2	845 m	7 m

Hydrographs showing the results of water level monitoring over the past ten 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. When pumping at an adjacent well field has been identified as potentially impacting monitoring wells, an additional hydrograph has been provided that compares the pumping data for the adjacent well field.

K-ME-OW1-03-AB

K-ME-OW1-03-AB is located about 1,200 m east of K21, midway between the Mannheim East and Greenbrook Well Fields. The A screen is completed within stoney clay till (AFC1) just above aquifer AFD1 (Figure 12), the same aquifer utilized by the Greenbrook wells. The A screen is separated from the Mannheim East aquifer AFB2 by about 14 m of aquitard material comprised of ATB3 and ATC1 units. Groundwater levels in the A screen collected with a data logger show a response to pumping from the Greenbrook Well Field and are not influenced by pumping of the Mannheim East wells indicating the aquitards ATB3 and ATC1 provide strong hydraulic isolation of the two aquifers. Increased pumping at Greenbrook in 2024 resulted in a decline in water levels of about 3 m. Water levels rise 1.5 m after May 2025 when pumping at Greenbrook is reduced. Water levels from July 2024 to May 2025 are amongst the lowest seen in the past 10 years but after May levels recover and are similar to historical values.

The B screen is completed within AFB2 and water levels are collected manually on a monthly basis. Groundwater levels in the B screen show no impacts from pumping and vary seasonally by less than 1 m. Groundwater levels declined throughout 2024 / 2025 and at the end of 2025 were at an elevation of 332.1 masl, which is the lowest since January 2005.

K-ME-OW01-10-A

K-ME-OW1-10-A is located close to K21 and water levels are measured with a data logger. The well monitors groundwater levels in AFB2 at the same interval as the screened portion of K21 (Figure 12). It is also screened at the same interval as K29 and Mannheim North wells K91 and K92, which are located approximately 800 m from the monitoring well. Graphs comparing water levels at this well to both Mannheim East and North well fields are included in Appendix C. Groundwater levels collected at this well

indicate a response to pumping at the production wells. Due to the well's location and screened interval, it is difficult to discern whether groundwater level decreases are a result of increased pumping at the Mannheim North Well Field or the Mannheim East Well Field. The Mannheim East wells likely have the greatest impact since the volumes pumped are much larger than at the Mannheim North wells. K-ME-OW1-10-A was decommissioned in October 2021 and was replaced with K-ME-OW1-21-B.

K-ME-OW1-21-AB

K-ME-OW1-21-AB is located close to K21, about 500 m away from K29 and about 800 m away from the Mannheim North wells.

The A screen is completed in the ATC1 / AFC1 / ATC2 and water levels are collected with a data logger. There is no observed response to Manheim East Pumping Wells. Variations in water levels are similar to K-ME-OW1-03-A which is impacted by pumping at the Greenbrook well field.

The B screen is completed within AFB2 and is a replacement of K-ME-OW1-10-A. The B screen is also screened at the same interval as K29 and wells K91 and K92. Groundwater levels in the B screen collected with a data logger show a response to pumping at the production wells. Groundwater levels rose about 1.4 m in response to the K21 shutdown from February 2022 to September 2022 and decrease 2.7 m when K21 and K21A go online in October 2022. From 2021 at OW01-10-A to the end of 2025 a decreasing trend in water levels is observed. 2024/2025 water levels are about 4.8 m lower than historical water levels observed before 2021.

K-ME-OW02-09-A

K-ME-OW2-09-A is located on the K25 / K29 well site and monitors the aquifer in AFB2. Water level monitoring at K-ME-OW2-09-A has been completed with a data logger since December 2010. Changes in groundwater levels (a variation of 2 m) can be correlated to changes in pumping at the production wells. Water levels increased 1 m between September and November 2020 when K29 was shut down. An overall decreasing trend of about 1.3 m in 2024 and 2025 is consistent with trends in other monitoring wells in the AFB2 aquifer. Levels at the end of 2025 are the lowest seen in the last ten years.

K-ME-OW1-17-A

K-ME-OW1-17-A is located 570 m southwest of K21 and 375 m northeast of K91 / K92 and is screened in the aquifer AFB2. Water level monitoring at K-ME-OW1-17-A has been completed with a data logger since February 2018. Graphs comparing water levels at this well to both Mannheim East and Mannheim North well fields are included in Appendix C. Changes in groundwater levels (a variation of 2.2 m) can be correlated to changes in pumping at the production wells. It is difficult to discern whether groundwater level decreases are a result of increased pumping at the Mannheim North

Well Field or the Mannheim East Well Field. Increases in water levels observed in 2020 and 2021 correlate with decreases in pumping at the Mannheim North Wells and also with changes in pumping at K25 and K29. 2024 / 2025 water levels are about 4 m lower than the highest water levels seen in May 2020. A decreasing trend in water levels after 2021 is consistent with trends observed in other monitoring wells in the AFB2 aquifer.

K-ME-OW2-17-A

K-ME-OW2-17-A is located 500 m from the K25/K29 well site and monitors the AFB2 aquifer. Water level monitoring at K-ME-OW2-09-A has been completed with a data logger since February 2018. The water levels generally show seasonal variations within 1 m. Increases in water levels are observed when K25 is shut down in April 2020 and K29 is shut down from September to November 2020. 2024 / 2025 water levels are about 3.5 m to 4 m lower than the highest historical water levels which occurred in 2020. A decreasing trend in water levels from June 2022 to the end of 2025 is consistent with trends observed in other monitoring wells in the AFB2 aquifer.

3.5 Mannheim North Well Field

3.5.1 Pumping Wells

The Mannheim North Well Field (previously known as the Peaking Wells) consists of Wells K91, K92, K93 and K94, which obtain water from AFB2. Well records for the production wells are found in Appendix B. A summary of the production well construction details is provided in Table 11 below.

Table 11: Mannheim North Well Field Production Well Details

Well Name	Year Built	Casing / Screen Diameter (mm)	Screened Interval (mbgs)	Aquifer
K91	1989	300	55.8 – 64.0	AFB2
K92	1990	300	54.3 – 62.5	AFB2
K93	1989	300	67.1 – 75.3	AFB2
K94	1989	300	60.1 – 68.3	AFB2

3.5.2 Pumping Volumes

The pumping volumes are based are presented in Appendix C as total monthly volumes. Pumping volumes from the well field ranged from 206,884 m^3/month to 372,339 m^3/month in 2024, and from 194,558 m^3/month to 376,045 m^3/month in 2025. In total, 3,329,853 m^3 was produced at this well field in 2024 and 3,576,775 m^3 was produced in 2025. These volumes are higher than the previous five years as production

at the Mannheim North Well Field has been increasing since 2015 but remains below the permitted rates.

3.5.3 Monitoring Wells

Observation wells within the vicinity of the Mannheim North Well Field are shown on Figure 4. Construction and monitoring details of the monitoring wells are described in Table 12 below. Well records for the monitoring wells are provided in Appendix B.

Table 12: Mannheim North Well Field Monitoring Well Details

Monitoring Well ID	Year Built	Screened Depth (mbgs)	Screened Formation	Distance to K91/K92 (m)	Distance to K93/K94 (m)	Trigger Level (masl)
K-ASR-TW5-08-A	2008	58.4 – 59.9	AFB2	285 m	260 m	-
K-MP-OW9-89-A	1989	64.0 – 70.1	AFB2	485 m	64 m	-
K-MP-OW1-16-B	2016	46.9 – 50.0	AFB2	970 m	800 m	333.3
K-MP-OW1-17-A	2017	56.4 – 59.4	AFB2	40 m	515 m	-

Hydrographs showing the results of water level monitoring over the past ten 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.

K-ASR-TW5-08-A

K-ASR-TW5-08-A is located 260 m southeast of K93 and K94 and 285 m northwest of K92 and K91 and water levels are measured with a data logger. Groundwater levels at this location respond to pumping at the Mannheim North wells with water level variations within 1.5 m. A decreasing trend in water levels in 2023 and in 2025 when pumping is increased is consistent with other monitoring wells in the AFB2 aquifer. 2024 / 2025 water levels are about 3 m lower than historical water levels observed before 2021.

K-MP-OW9-89-A

K-MP-OW9-89-A is located about 64 m from wells K93 and K94 and is screened in sand and gravel (AFB2) (Figure 16). Electronic water level monitoring data starting in 2016 indicates clear responses to pumping at the production wells. Water levels at this well have a similar trend to K-ASR-TW05-08 but with a more subdued response to pumping at the Mannheim North Wells. A declining trend in water levels beginning in 2021 is observed with water levels at the end of 2025 4 m lower than historical water levels observed before 2021.

K-MP-OW1-16-B

K-MP-OW1-16-B is screened in AFB2 and monitored with an electronic water level logger. K-MP-OW1-16-B is located 970 m from K91 / K92 and 800 m from K93 / K94. Groundwater level monitoring started in August 2016 and a trigger level was assigned to be protective of domestic wells. Responses to pumping of the Mannheim North well field are much more subdued than observed at K-MP-OW9-89-A. A declining trend in water levels beginning in 2021 is observed with water levels at the end of 2025 about 2.0 m lower than historical water levels observed before 2021. Groundwater levels remain 2 m above the trigger level of 333.3 masl

K-MP-OW17-A

K-MP-OW17-A is located 40 m from wells K91 and K92 and is screened in aquifer AFB2 (Figure 15). Electronic water level monitoring data starting in 2018 indicates a clear response to pumping at the Mannheim North wells. Water levels at this well vary daily in response to pumping cycles at the production wells with a similar trend to K-ASR-TW5-08-A. Water levels decline from 333.9 masl in June 2022 to 331 masl at the end of 2023. 2024 water levels are higher than 2023 levels due to reduced pumping. Water levels in 2025 have a decreasing trend until August and then rise to 331 masl at the end of 2025. An overall declining trend in water levels from 2021 to 2025 is observed with water levels at the end of 2025 are about 4 m lower than historical water levels before 2021.

4.0 Impact Assessment

4.1 Potential for Interference with Domestic Wells

PTTW Condition 4.3 states "The Permit Holder shall adhere to the monitoring and contingency plan, including trigger levels, as detailed in the Stantec letter report dated July 28, 2016, or as updated and approved by the Director. In addition, the Permit Holder shall initiate an investigation by a Qualified Person if any of the trigger levels is reached to assess potential impacts to private water supply wells from municipal well pumping permitted in this Permit. The Permit Holder shall notify both the Manager, Guelph District Office and the Water Compliance Supervisor, Safe Drinking Water Branch, Guelph District Office within five business days of receipt of the water level data in the event the trigger level is reached".

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".

There are properties without municipal servicing within a 500 m radius of the Mannheim Well Fields that use individual wells for water supply. Trigger levels have been established in six monitoring wells that will initiate a contingency plan for investigation into potential impacts to private wells. The contingency plan is outlined in the Monitoring and Contingency Plan (Stantec, 2016b) included in Appendix A. When 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 pumping at the Mannheim Well Fields received in 2024 and 2025.

Groundwater levels in K-MP-OW9-89-A, KP-MP-OW1-16-B, WT-ME-OW03-09-A, K-MA-ASR-OW2-16-A, WT-MW-OW3-04-A, WT-MW-OW02-10-A and WT-MW-OW6-04 show a declining trend over the past three to five years. Water levels remained above trigger levels in 2024 and 2025.

4.2 Other Water Takers

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".

Groundwater and surface water takings registered in the MECP's PTTW database were reviewed and there were no PTTWs mapped within 2 km of the well fields.

4.3 Aquifer Response to Precipitation and Pumping

PTTW Condition 4.4 Conditions b and c state:

> a. The Permit Holder shall prepare and submit a report every two years by June 30th, commencing on June 30, 2022, that presents:
>
> b. Assesses changes in water levels in the supply aquifer in relation to precipitation and water taking from the aquifer,
>
> c. Provides groundwater level contour figures for Aquifer 1

(Conditions 4.4a, 4.4d, and 4.4e have been addressed in Sections 3.0 and 4.2. of this report.)

Several shallow monitoring wells in the Mannheim West Well Field screened in AFB1 / ATB1 responded to seasonal precipitation trends with highest levels typically observed in the spring and the lowest levels typically observed in the fall. The 2024 / 2025 precipitation data from the closest weather station at Roseville was reviewed and did not correlate with any specific water level response. The shallow wells in AFB1 / ATB1 did not respond to pumping since they are separated from the pumping wells installed in AFB2 by finer grained materials.

At Mannheim West, monitoring wells in the AFB2 aquifer show a decreasing trend beginning in 2020 with levels 1 m to 2 m below historical levels at the end of 2025. The trend and magnitude of water level decline is similar in wells that respond to pumping and wells that do not which suggests that the decline is a regional scale response in the aquifer to climatic conditions. Wells outside the influence of pumping show seasonal trends but no immediate response to precipitation events.

At Mannheim North, monitoring wells screened in the AFB2 aquifer show an overall declining trend from 2021 to 2025, with water levels 2 to 4 m below historical levels by the end of 2025. The magnitude of decline is up to 2 m greater than that observed at Mannheim West, indicating that the aquifer in this area is also influenced by increased pumping at the well field. However, the decline also reflects the broader regional downward trend in AFB2 water levels observed in Mannheim West monitoring wells that are not impacted by pumping.

At Mannheim East, the monitoring wells installed in ATC1 / AFC1 / ATC2 do not show a response to pumping at the Mannheim supply wells, but show a response to pumping of the Greenbrook supply wells. All monitoring wells in the AFB2 aquifer show a declining trend from 2021 to 2025. The magnitude of the decline is due to a combination of climatic effects and pumping.

At Mannheim ASR, monitoring wells screened in the AFB2 are impacted by pumping. The decreasing trend beginning in 2021 is the result of pumping and climatic conditions and has resulted in historically low water levels at the end of 2025.

The groundwater levels in the Mannheim East, North and ASR monitoring wells did not display a correlation with precipitation events. The monitoring wells are all screened in AFB2 or ATC1 / AFC1 / ATC2 at depths greater than 30 m below ground surface; therefore, no immediate response to short-term precipitation events was observed in the hydrographs.

Details on short-term responses at monitoring wells that respond to changes in pumping can be found in the Stantec report, which documents 2013 aquifer testing (Stantec, 2016) and also an assessment of K23 and K34 (Golder, 2018).

Condition 4.4c of the PTTW requires submission of groundwater level contours for Aquifer 1. The groundwater levels for November 2025 are shown on Figure 7. Groundwater flow in November 2025 was generally in a southeasterly direction, with some localized influences caused by the pumping wells. This is consistent with historical groundwater flow directions.

5.0 Conclusions

Impacts from pumping the municipal wells at the Mannheim West Well Field (K23, K24 and K26), the Mannheim ASR Well Field (ASR1, ASR2, ASR3, ASR4, RCW1 / ASR5, RCW2, RCW3 and RCW4), the Mannheim East Well Field (K21, K21A, K25 and K29) and the Mannheim North Well Field (K91, K92, K93 and K94) were evaluated through implementation of the Groundwater Monitoring Program. Based on the information contained in the report, Burnside offers the following conclusions:

- This report satisfies Condition 4.4 of PTTW P-300-3130244509
- 2024 and 2025 pumping volumes were within the permitted range
- There have been no well interference complaints arising from water taking at the Mannheim well field
- Water levels in wells screened in AFB2 show a declining trend from 2021 to 2025 that is observed across the Mannheim area as a result of climatic effects.
- Additional declines of up to 2 m are seen when the wells are also influenced by pumping with many wells having historically low water levels at the end of 2025.
- Groundwater levels remained above the trigger levels established.
- Groundwater levels in the shallow aquifer AFB1 did not respond to pumping and show seasonal trends.

6.0 References

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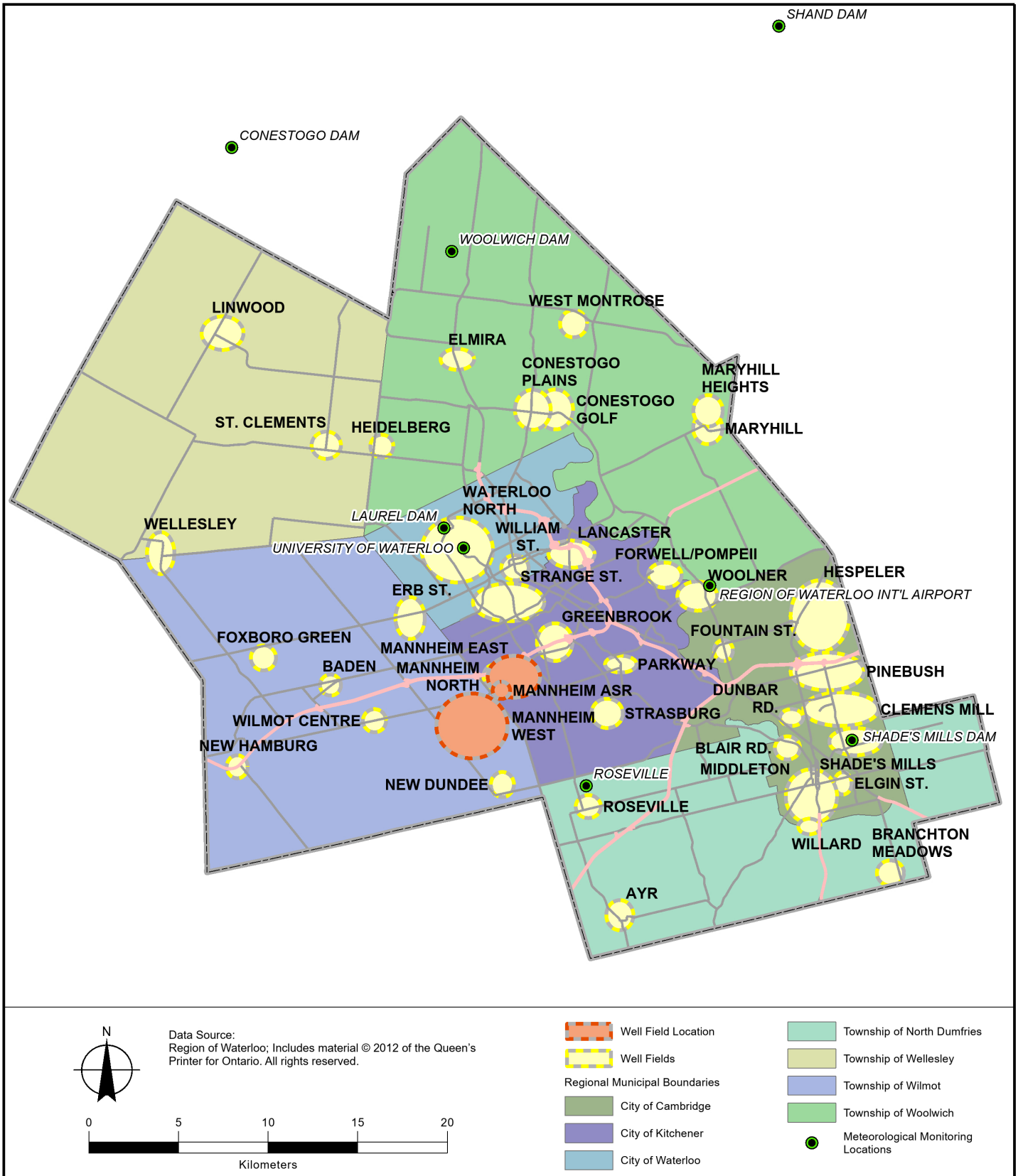
[THE DIFFERENCE IS OUR PEOPLE]

Figures



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Map Title

2025 GROUNDWATER MONITORING REPORT - MANNHEIM WELL FIELDS

WELL FIELD LOCATION MAP

Client

REGION OF WATERLOO

Drawn	Checked	Date	Figure No.
HN	SQ	February 2026	1
Scale		Project No.	
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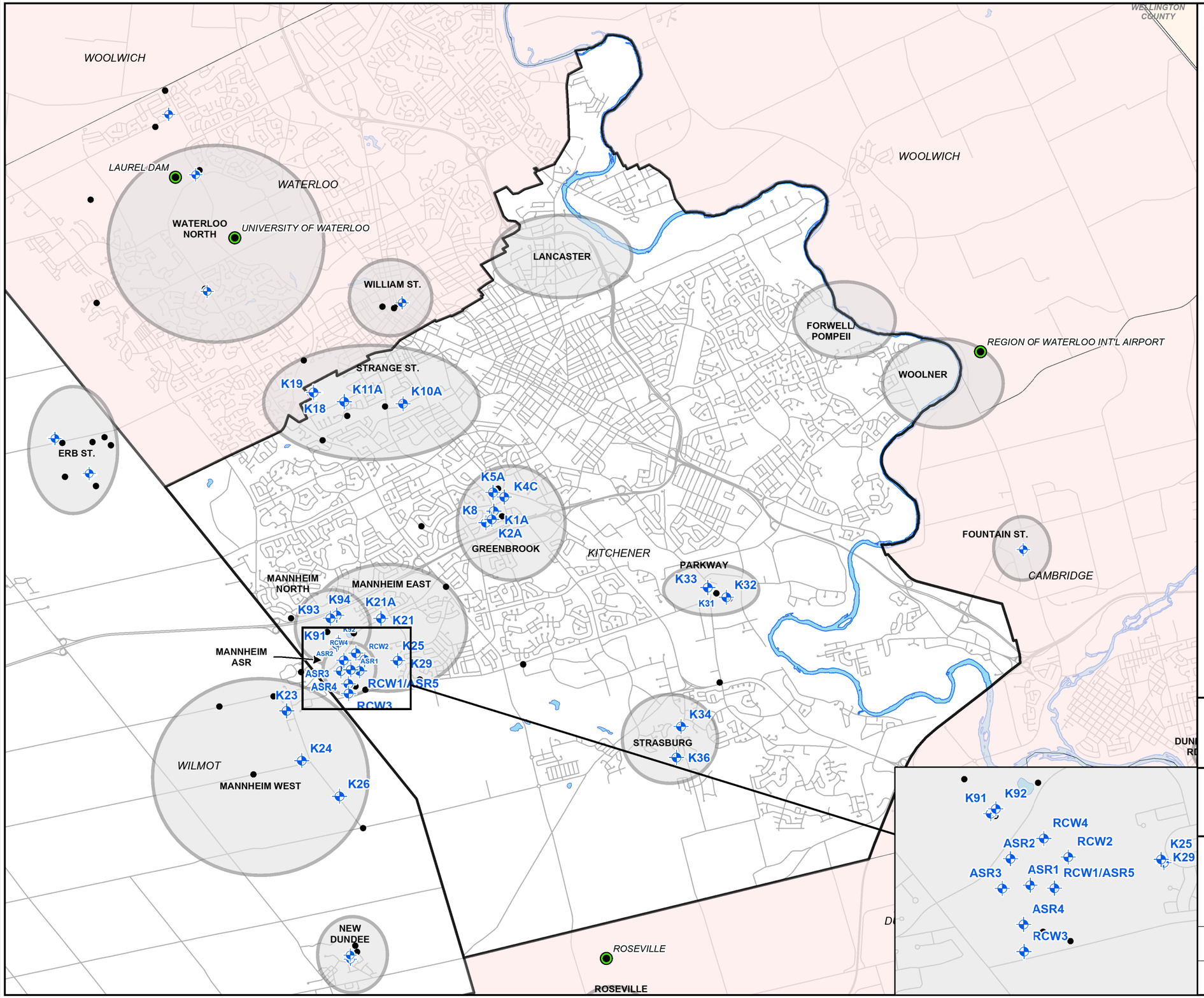

LEGEND

- Production Well Location
- Monitoring Well Location
- Municipal Boundary
- Well Fields
- 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

N

0 1 2 3 4 5

Kilometers

BURNSIDE

Client

REGION OF WATERLOO

Figure Title

2025 GROUNDWATER MONITORING REPORT - MANNHEIM WELL FIELDS

KITCHENER/WILMOT WELL FIELDS AND MONITORING NETWORK

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Legend

- PTTW Monitoring Well Location
- Production Well Location
- Nearby Monitoring Well Location
- Decommissioned Well Location
- Cross Section Orientation

Additional MECP PTTW Locations

- Surface and Ground Water
- Provincial Highway
- Municipal Roads
- Local Roads
- Stream: Permanent (OHN)
- Stream: Intermittent (OHN)
- Waterbody: Permanent (OHN)

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.

Datum: North American 1983

N

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Metres

BURNSIDE

Client

REGION OF WATERLOO

Figure Title

2025 GROUNDWATER MONITORING REPORT - MANNHEIM WEST WELL FIELD

WELL LOCATION MAP

Drawn	Checked	Date	Figure No.
HN	SQ	March 2026	3
Scale		Project No.	
1:21,000		HA0464020	

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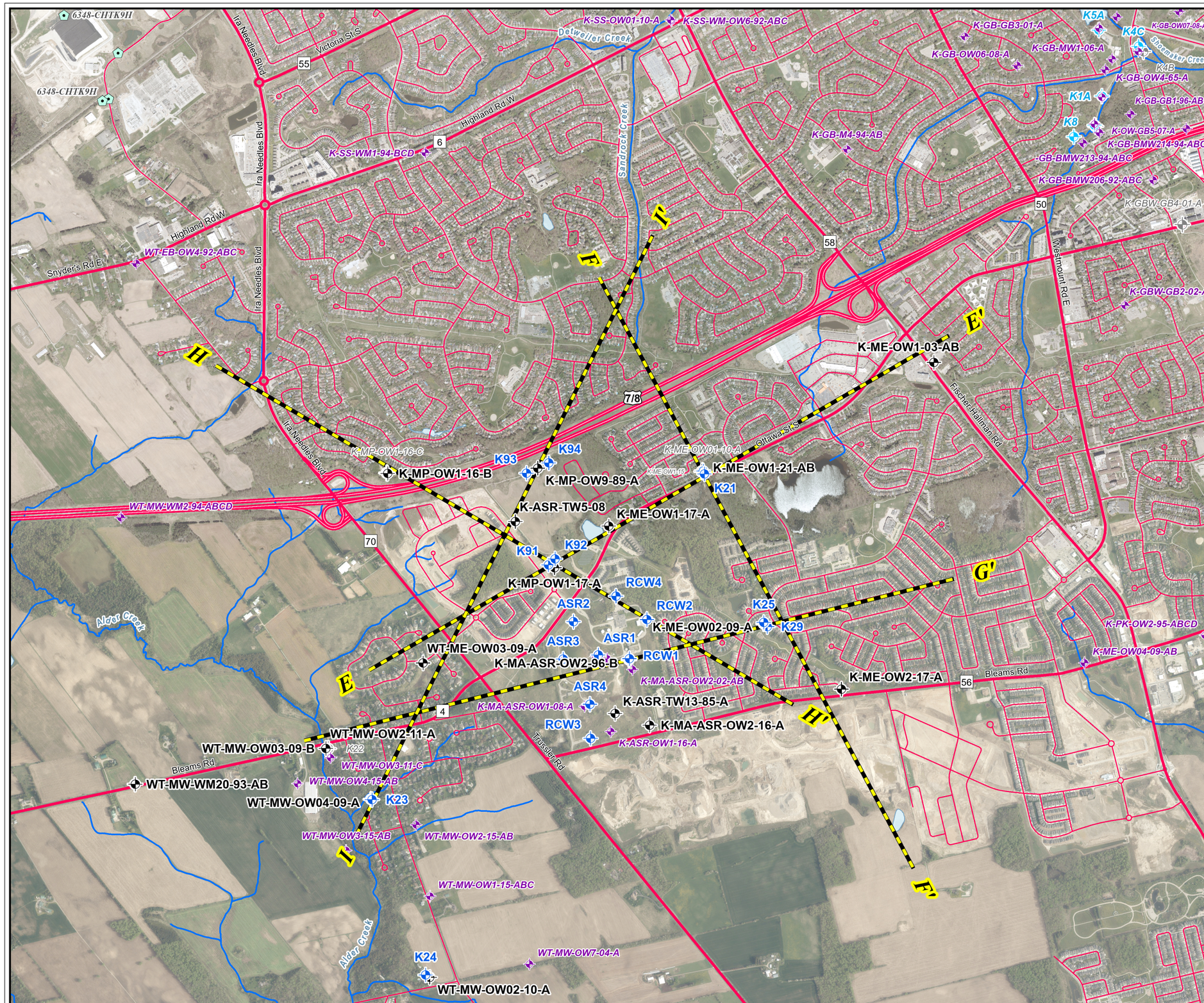

Legend

- PTTW Monitoring Well Location
- Nearby Monitoring Well Location
- Nearby Production Well Location
- Decommissioned Well Location
- Cross Section Orientation

Additional MECP PTTW Locations

- Groundwater
- Provincial Highway
- Municipal Roads
- Local Roads
- Stream: Permanent (OHN)
- Waterbody: Permanent (OHN)

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.

Datum: North American 1983

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Metres

BURNSIDE

Client

REGION OF WATERLOO

Figure Title

2025 GROUNDWATER MONITORING REPORT - MANNHEIM EAST, MANNHEIM ASR AND MANNHEIM NORTH WELL FIELD

WELL LOCATION MAP

Drawn	Checked	Date	Figure No.
HN	SQ	March 2026	4
Scale		Project No.	
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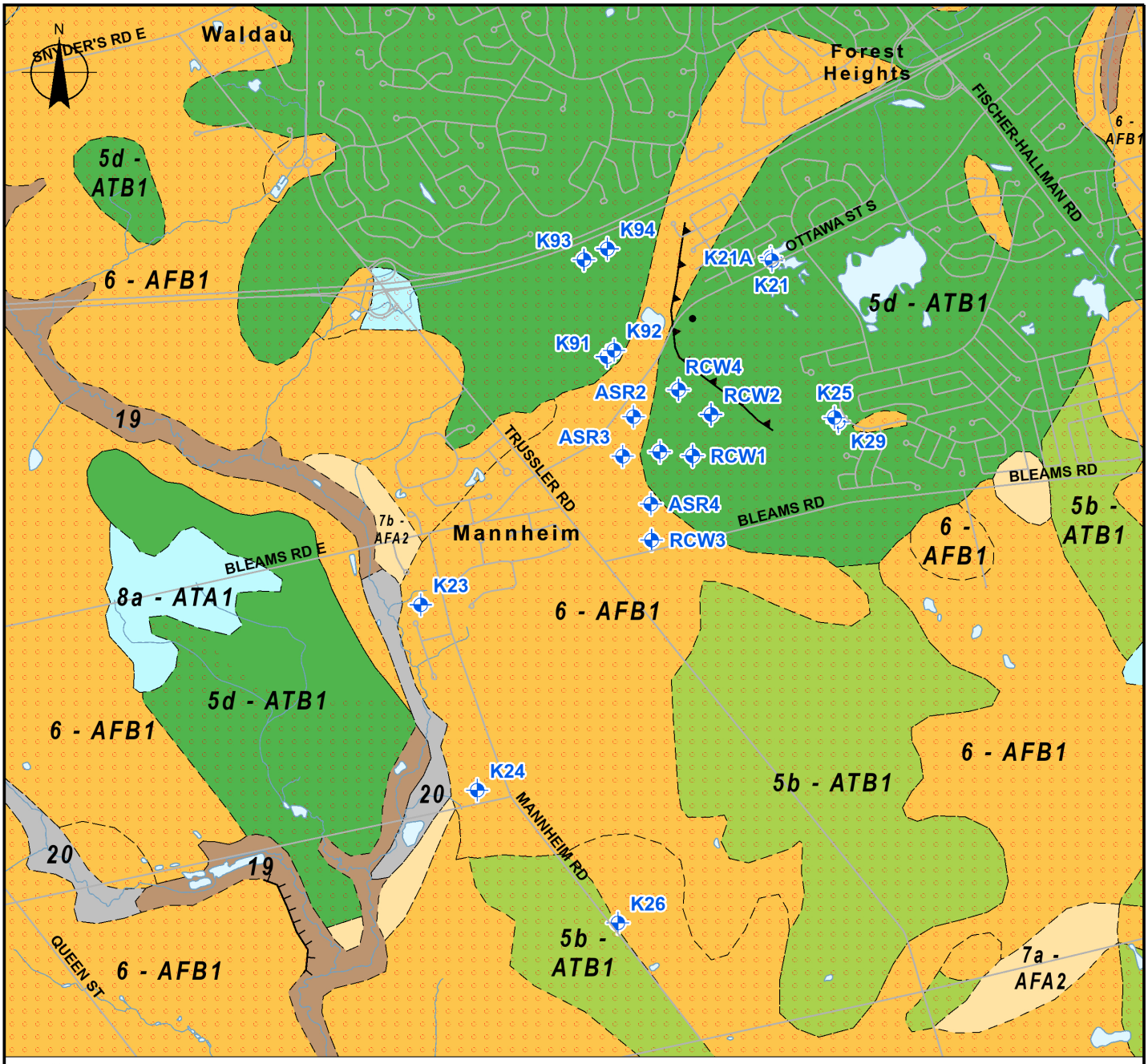

Data Source:
1. Ontario Geological Survey 2003. Surficial Geology of Southern Ontario; Ontario Geological Survey, Miscellaneous Release--Data 128.
2. Region of Waterloo GIS

0 500 1,000 1,500 2,000
Meters

- RMOW Supply Well
- Watercourse
- Waterbody

Surficial Geology

- 5b: Stone-poor, carbonate-derived silty to sandy till (ATA2 - Aquitard)
- 5d: Glaciolacustrine-derived silty to clayey till (ATB1 - Aquitard)
- 6: Ice-contact stratified deposits (AFB1 - Aquifer)
- 7a: Glaciofluvial deposits: Sandy deposits (AFA2 - Aquifer)
- 7b: Glaciofluvial deposits: Gravelly deposits (AFA2 - Aquifer)
- 8a: Fine-textured glaciolacustrine deposits: Massive-well laminated (ATA1)
- 19: Modern alluvial deposits
- 20: Organic deposits
- Unit Contact Boundary
- Sample Site
- Terrace
- Ice-Contact Slope
- Hummocky Topography

BURNSIDE

Map Title
2025 GROUNDWATER MONITORING REPORT - MANNHEIM WELL FIELDS

QUATERNARY GEOLOGY

Client
REGION OF WATERLOO

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HN	SQ	March 2026	5
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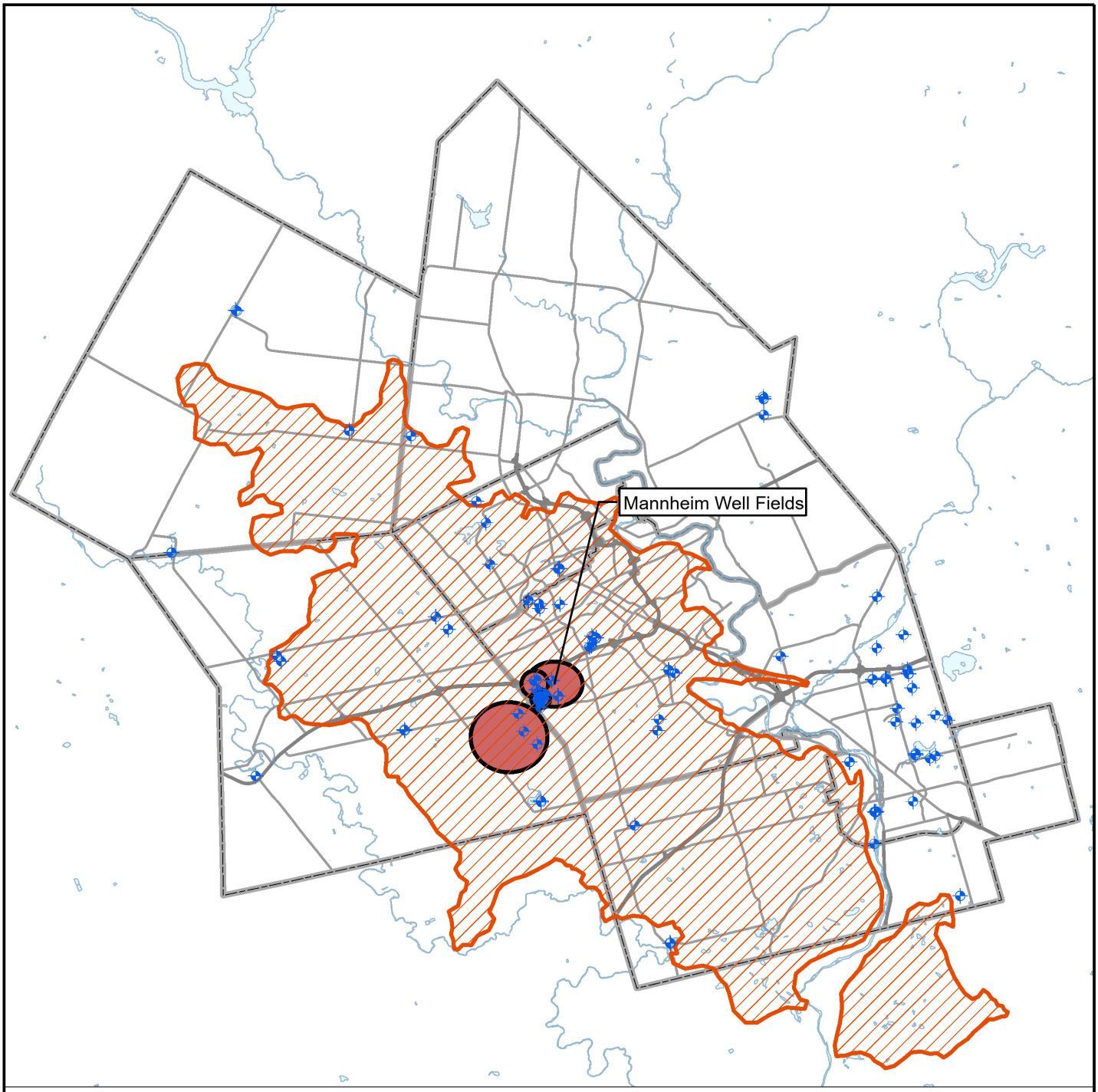

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Data Source:
1. Andy F. Bajc, Hazen A.J. Russell and David R. Sharpe (2014) A three-dimensional hydrostratigraphic model of the Waterloo Moraine area, Southern Ontario, Canada, Canadian Water Resources Journal / Revue canadienne des ressources hydriques, 39:2, 95-119
2. Region of Waterloo; Includes material © 2019 of the Queen's Printer for Ontario. All rights reserved.

0 5 10 15 20 25
Kilometers

RMOW Supply Well
Waterloo Moraine (2014)
Mannheim Well Fields
Waterbody
Regional Municipal Boundaries

BURNSIDE

Map Title

2025 GROUNDWATER MONITORING REPORT - MANNHEIM WELL FIELDS

LOCATION OF THE WATERLOO MORAINE

Client

REGION OF WATERLOO

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HN	SQ	March 2026	6
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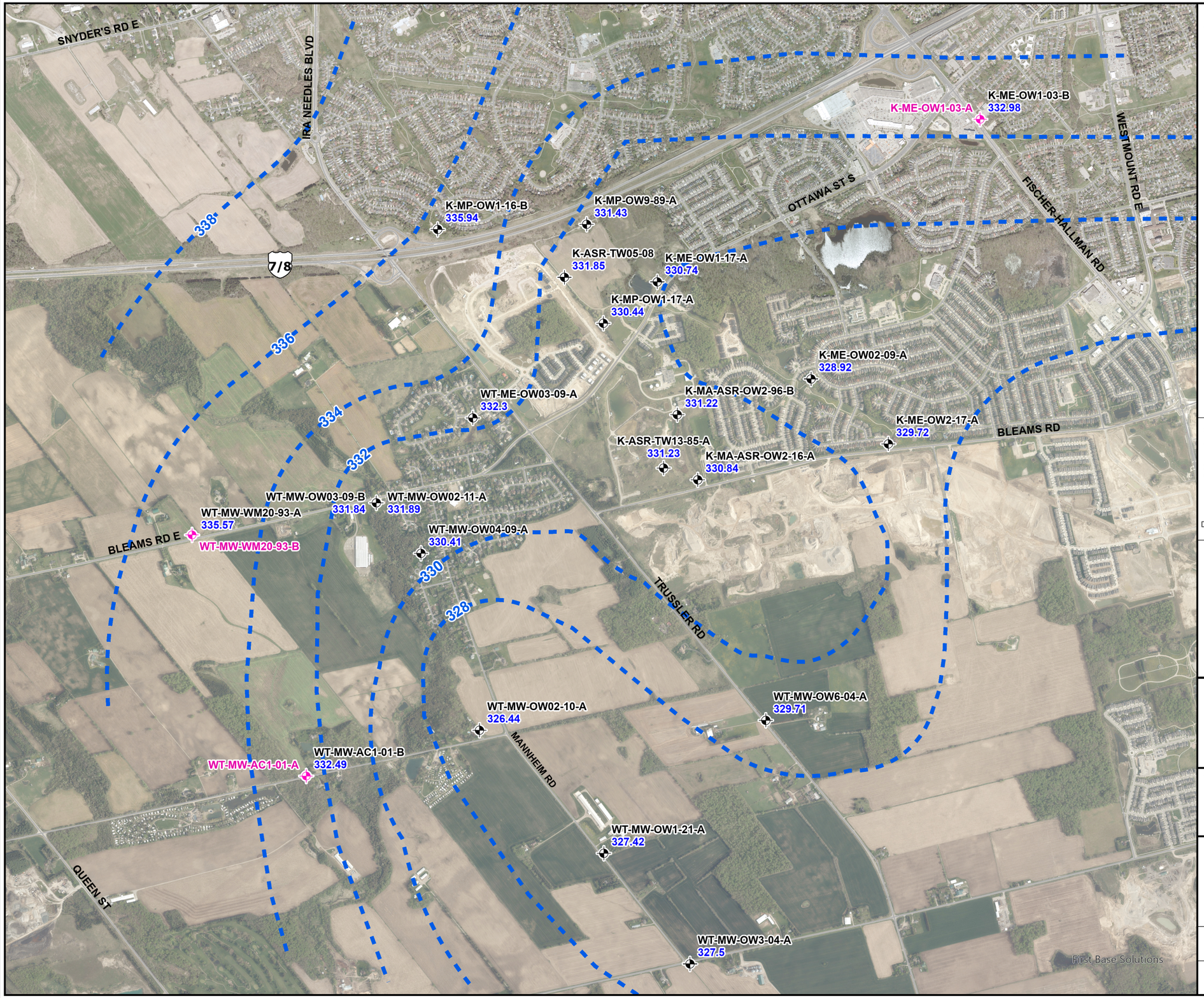

Legend

- Aquifer 1 Monitoring Well
- Other Aquifer Monitoring Well
- Interpreted Groundwater Contour (masl) - November, 2025
- Municipal Roads
- Region Roads
- Provincial Highways

Sources:

Region of Waterloo;
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2016 Air Photo: The South Western Ontario Orthoimagery Project (SWOOP) provided in Partnership with the Region of Waterloo

Datum: North American 1983

N

0 200 400 600 800 1,000 1,200 1,400
Metres

BURNSIDE

Client

REGION OF WATERLOO

Figure Title

2025 GROUNDWATER MONITORING REPORT - MANNHEIM WELL FIELDS

GROUNDWATER CONTOURS - AQUIFER 1

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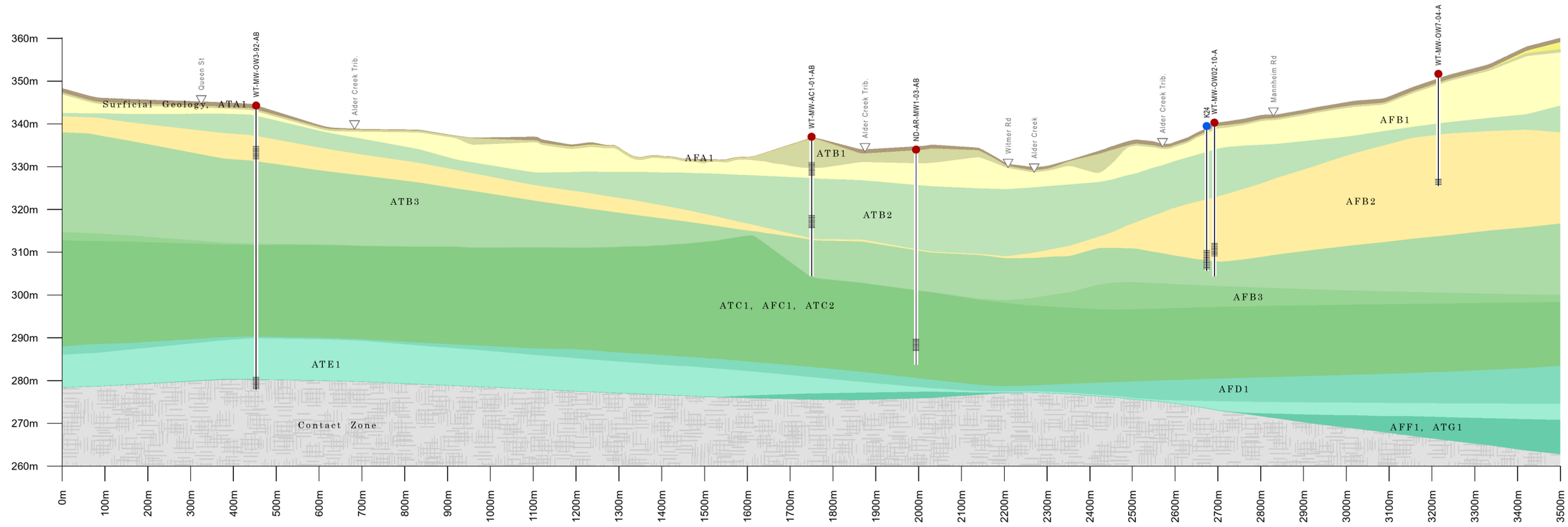

Wells

- Production Well (Active)
- Monitoring Well

Moraine Model 2026

- Surficial Geology, Whittlesey Clay (ATA1)
- Whittlesey Sand (AFA1)
- Upper Maryhill, Port Stanley, Tavistock, Mornington, & Stratford Tills (ATB1)
- 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

Wellhead

Well

Screen or Open Hole

BURNSIDE

Client

REGION OF WATERLOO

Figure Title

GEOLOGIC CROSS SECTION REGION OF WATERLOO

Mannheim West
Cross Section A - A'

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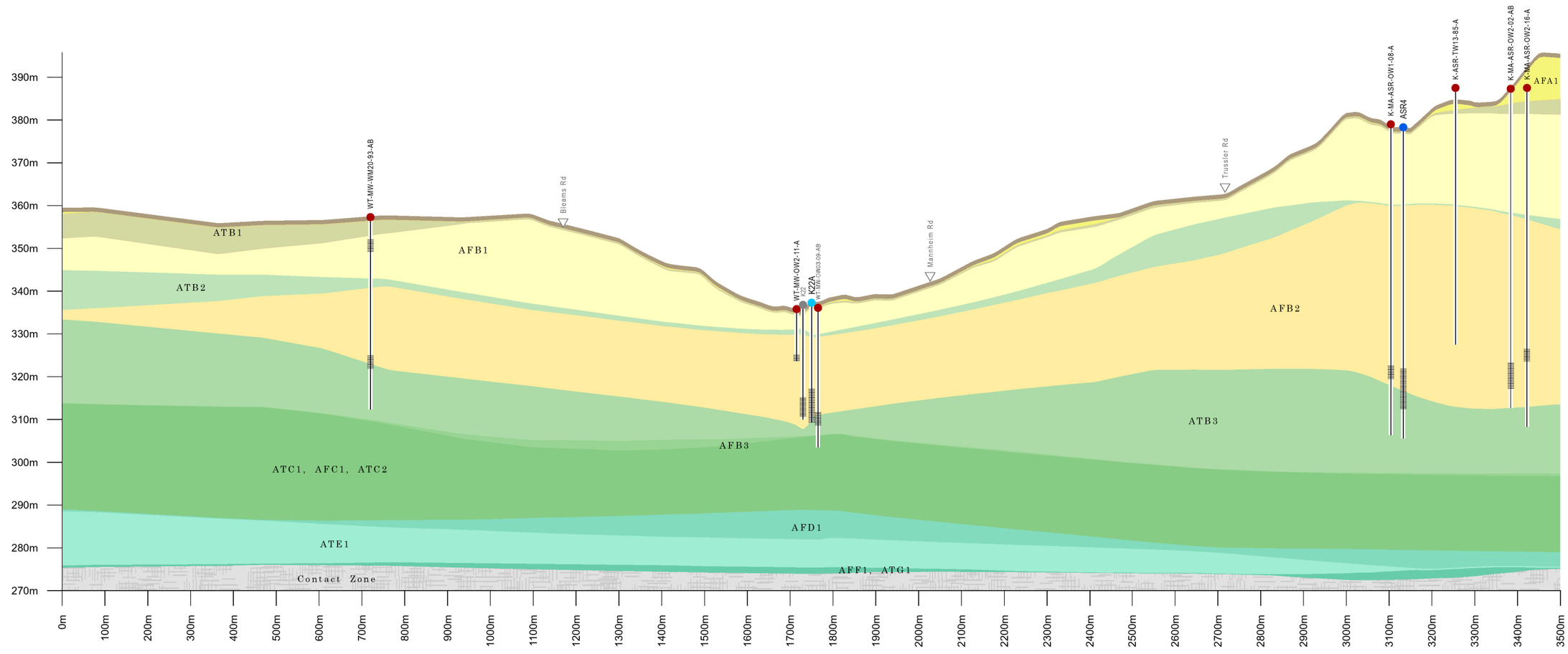

Wells

- Production Well (Active)
- Production Well (Inactive)
- Production Well (Decommissioned)
- Monitoring Well

Moraine Model 2026

Surficial Geology, Whittlesey Clay (ATA1)	Upper Waterloo Moraine Stratified Sediments & Equivalents (AFB1)	Lower Maryhill Till & Stratified Equivalents (ATB3)	Pre-Catfish Creek Coarse-Grained Glaciofluvial/Lacustrine Deposits (AFD1)
Whittlesey Sand (AFA1)	Middle Maryhill Till & Equivalents (ATB2)	Lower Waterloo Moraine Stratified Sediments or Catfish Creek Till Outwash (AFB3)	Canning Drift, Till & Fine Textured Glaciolacustrine Deposits (ATE1)
Upper Maryhill, Port Stanley, Tavistock, Mornington, & Stratford Tills (ATB1)	Middle Waterloo Moraine Stratified Sediments & Equivalents (AFB2)	Upper/Main Catfish Creek Till (ATC1), Middle Catfish Creek Stratified Deposits (AFC1), Lower Catfish Creek Till (ATC2)	Pre-Canning Coarse Textured Glaciofluvial / Glaciolacustrine Deposits (AFF1), Pre-Canning Coarse Textured Till (ATG1)

Weathered Bedrock

Wellhead

Well

Screen or Open Hole

BURNSIDE

Client

REGION OF WATERLOO

Figure Title

GEOLOGIC CROSS SECTION REGION OF WATERLOO

Mannheim West A
Cross Section B - B'

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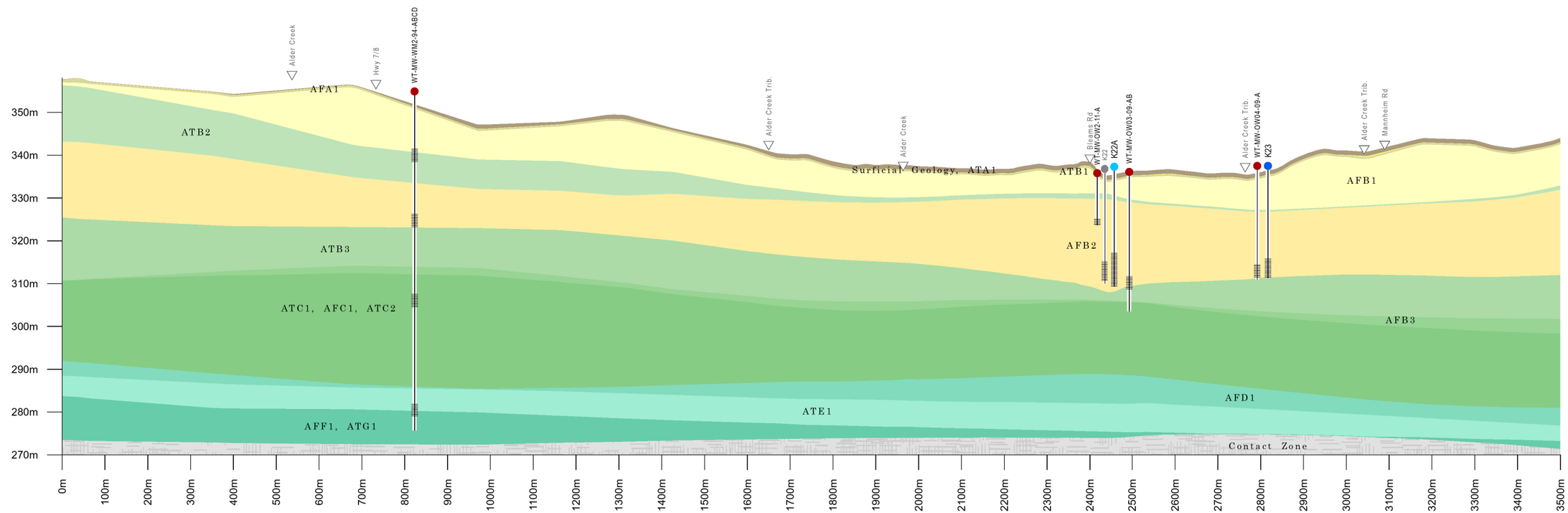

Wells

- Production Well (Active)
- Production Well (Inactive)
- Production Well (Decommissioned)
- Monitoring Well

Moraine Model 2026

- Surficial Geology, Whittlesey Clay (ATA1)
- Whittlesey Sand (AFA1)
- Upper Maryhill, Port Stanley, Tavistock, Mornington, & Stratford Tills (ATB1)
- 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

Wellhead

Well

Screen or Open Hole

BURNSIDE

Client

REGION OF WATERLOO

Figure Title

GEOLOGIC CROSS SECTION
REGION OF WATERLOO
Mannheim West A
Cross Section C - C'

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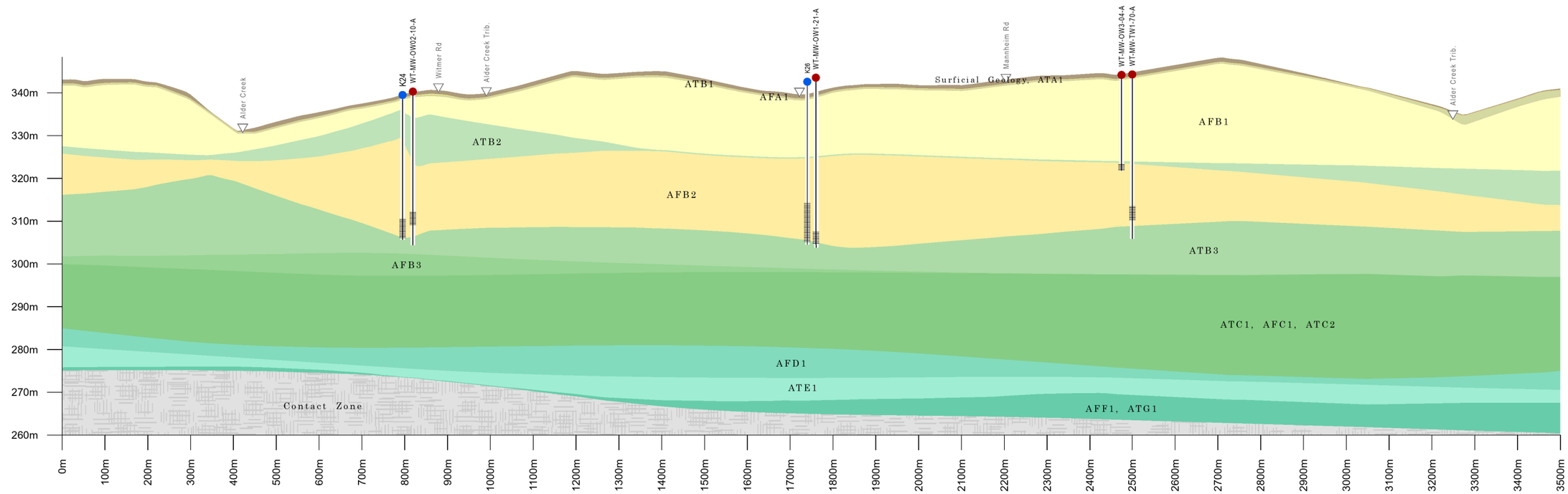

Wells

- Production Well (Active)
- Monitoring Well

Moraine Model 2026

- Surficial Geology, Whittlesey Clay (ATA1)
- Whittlesey Sand (AFA1)
- Upper Maryhill, Port Stanley, Tavistock, Mornington, & Stratford Tills (ATB1)
- 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

Wellhead

Well

Screen or Open Hole

BURNSIDE

Client

REGION OF WATERLOO

Figure Title

GEOLOGIC CROSS SECTION
REGION OF WATERLOO
Mannheim West A
Cross Section D - D'

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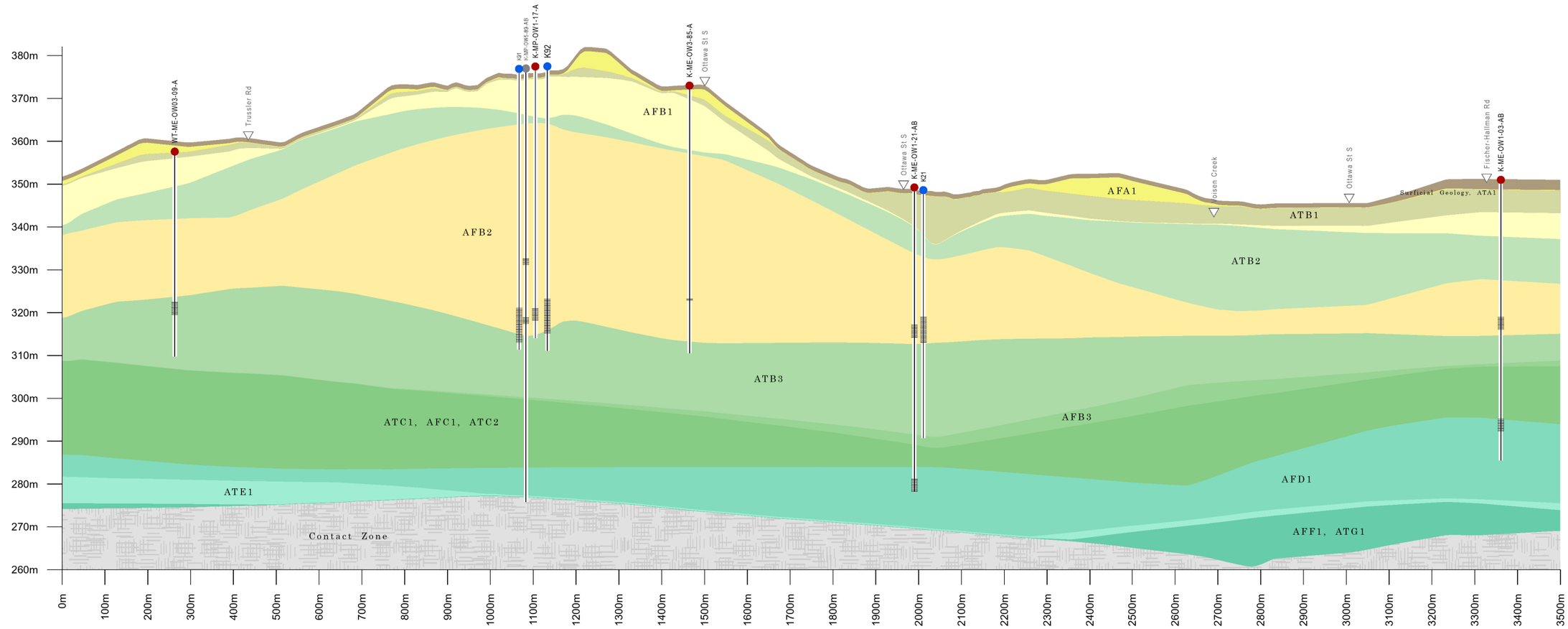

Wells

- Production Well (Active)
- Monitoring Well
- Decommissioned Monitoring Well Location

Moraine Model 2026

- Surficial Geology, Whittlesey Clay (ATA1)
- Whittlesey Sand (AFA1)
- Upper Maryhill, Port Stanley, Tavistock, Mornington, & Stratford Tills (ATB1)
- 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

Wellhead

Well

Screen or Open Hole

BURNSIDE

Client

REGION OF WATERLOO

Figure Title

GEOLOGIC CROSS SECTION
REGION OF WATERLOO
Mannheim East
Cross Section E - E'

Drawn	Checked	Date	Figure No.
PS	DH	2026/06/11	12
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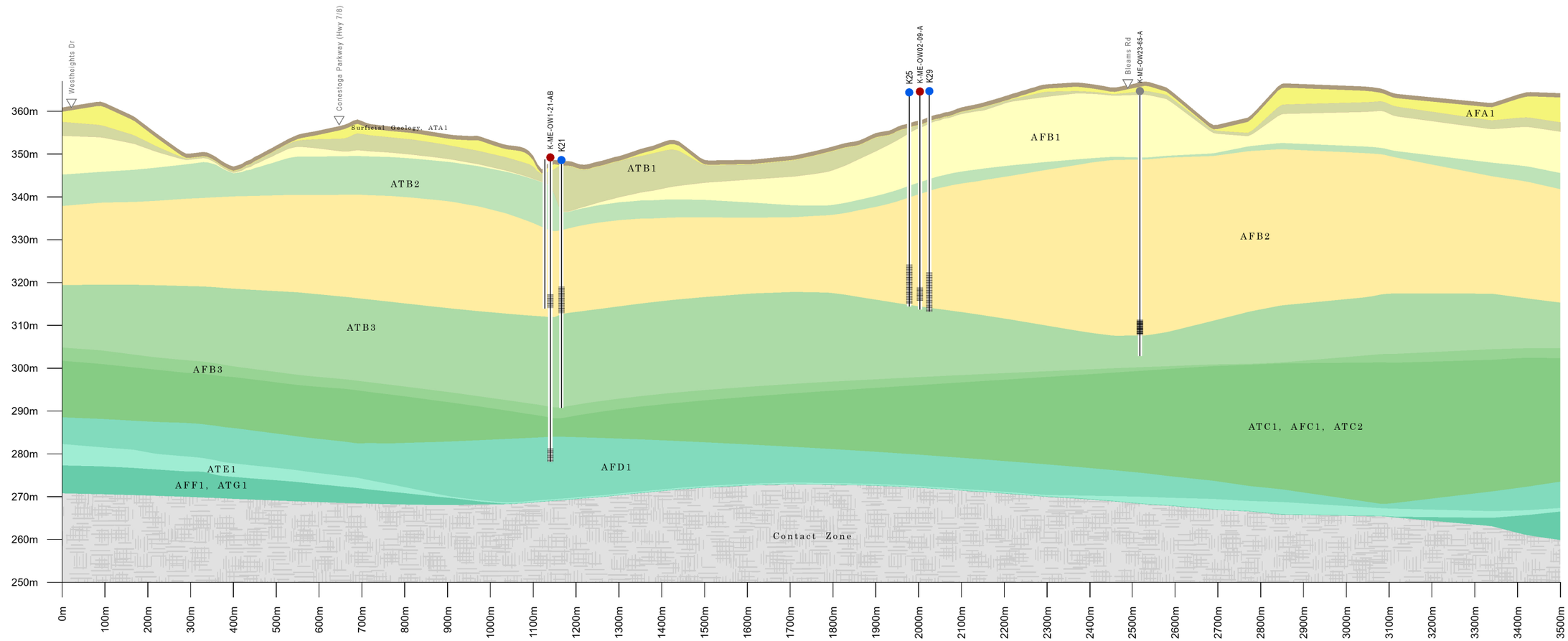

Wells

- Production Well (Active)
- Monitoring Well
- Decommissioned Monitoring Well Location

Moraine Model 2026

- Surficial Geology, Whittlesey Clay (ATA1)
- Whittlesey Sand (AFA1)
- Upper Maryhill, Port Stanley, Tavistock, Mornington, & Stratford Tills (ATB1)
- 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

Wellhead

Well

Screen or Open Hole

BURNSIDE

Client

REGION OF WATERLOO

Figure Title

GEOLOGIC CROSS SECTION
REGION OF WATERLOO
Mannheim East
Cross Section F - F'

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PS	DH	2026/06/01	13
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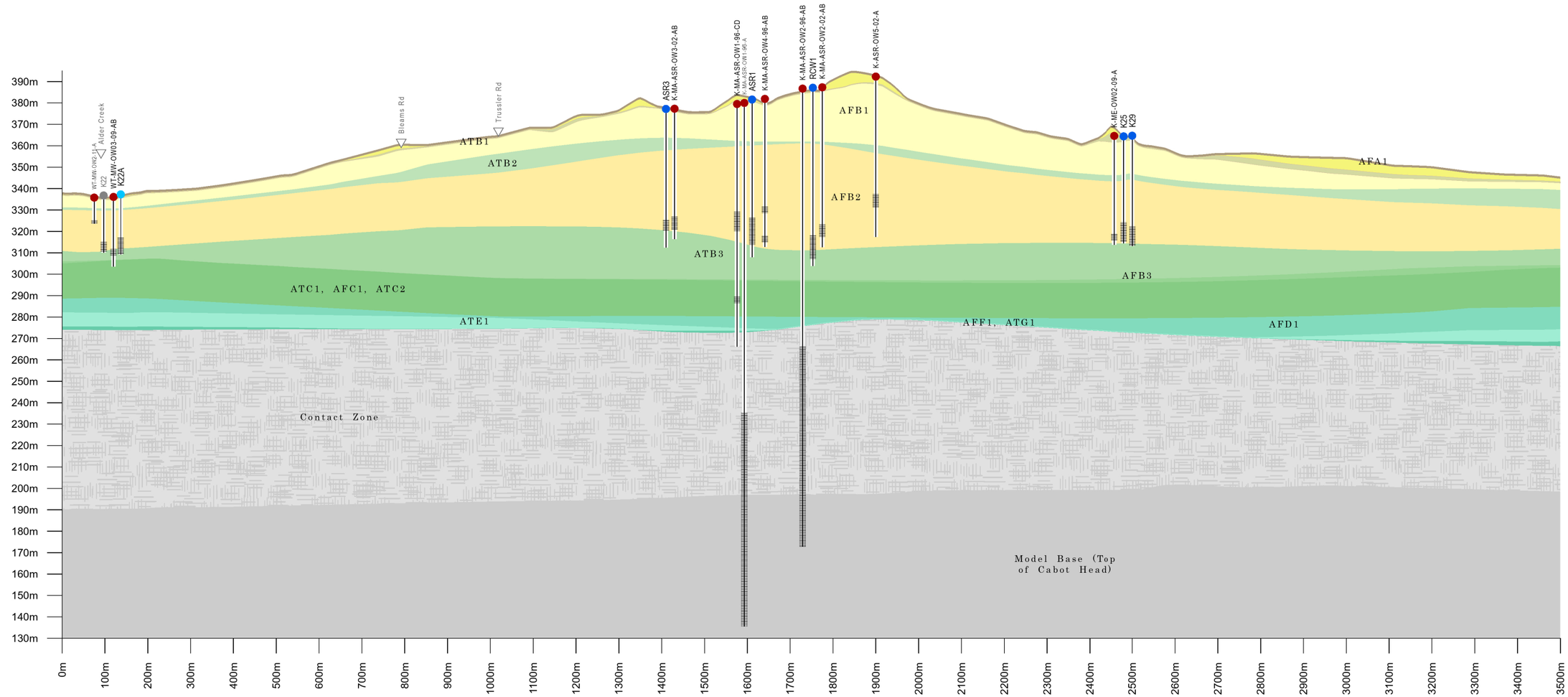

Wells

- Production Well (Active)
- Production Well (Inactive)
- Production Well (Decommissioned)
- Monitoring Well

Moraine Model 2026

- Surficial Geology, Whittlesey Clay (ATA1)
- Whittlesey Sand (AFA1)
- Upper Maryhill, Port Stanley, Tavistock, Mornington, & Stratford Tills (ATB1)
- 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
- Model Base (Top of Cabot Head)

Wellhead

Well

Screen or Open Hole

BURNSIDE

Client

REGION OF WATERLOO

Figure Title

GEOLOGIC CROSS SECTION REGION OF WATERLOO

Mannheim ASR
Cross Section G - G'

Drawn	Checked	Date	Figure No.
PS	DH	2026/06/01	14
Horizontal Scale 1:10,000		Project No.	
Vertical Ex.:5x		HA046402	

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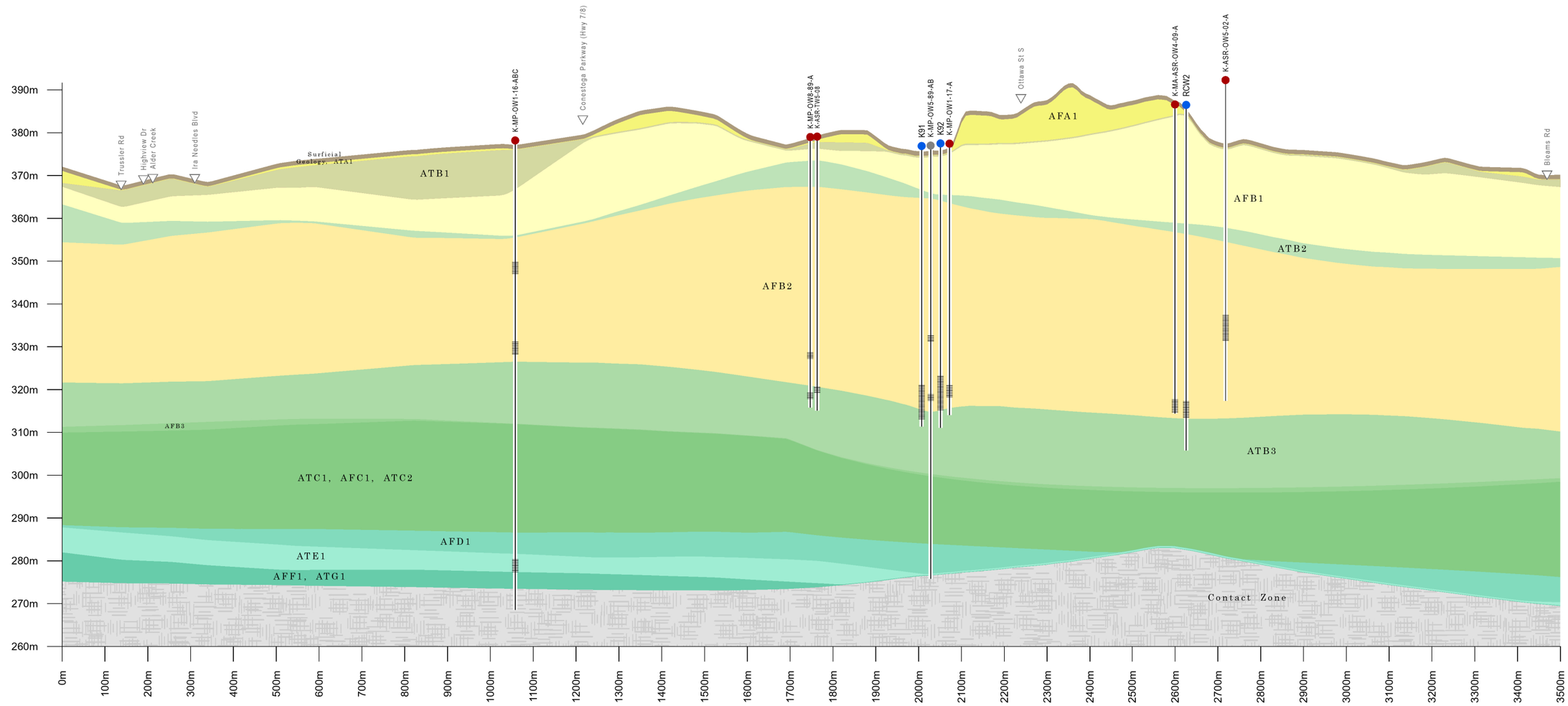

Wells

- Production Well (Active)
- Monitoring Well
- Decommissioned Monitoring Well Location

Moraine Model 2026

Surficial Geology, Whittlesey Clay (ATA1)	Upper Waterloo Moraine Stratified Sediments & Equivalents (AFB1)	Lower Maryhill Till & Stratified Equivalents (ATB3)	Pre-Catfish Creek Coarse-Grained Glaciofluvial/Lacustrine Deposits (AFD1)	Weathered Bedrock
Whittlesey Sand (AFA1)	Middle Maryhill Till & Equivalents (ATB2)	Lower Waterloo Moraine Stratified Sediments or Catfish Creek Till Outwash (AFB3)	Canning Drift, Till & Fine Textured Glaciolacustrine Deposits (ATE1)	
Upper Maryhill, Port Stanley, Tavistock, Mornington, & Stratford Tills (ATB1)	Middle Waterloo Moraine Stratified Sediments & Equivalents (AFB2)	Upper/Main Catfish Creek Till (ATC1), Middle Catfish Creek Stratified Deposits (AFC1), Lower Catfish Creek Till (ATC2)	Pre-Canning Coarse Textured Glaciofluvial / Glaciolacustrine Deposits (AFF1), Pre-Canning Coarse Textured Till (ATG1)	

Wellhead

Well

Screen or Open Hole

BURNSIDE

Client

REGION OF WATERLOO

Figure Title

GEOLOGIC CROSS SECTION
REGION OF WATERLOO
Peaking
Cross Section H - H'

Drawn	Checked	Date	Figure No.
PS	DH	2026/06/02	15
Horizontal Scale 1:10,000		Project No.	
Vertical Ex.:10x		HA046402	

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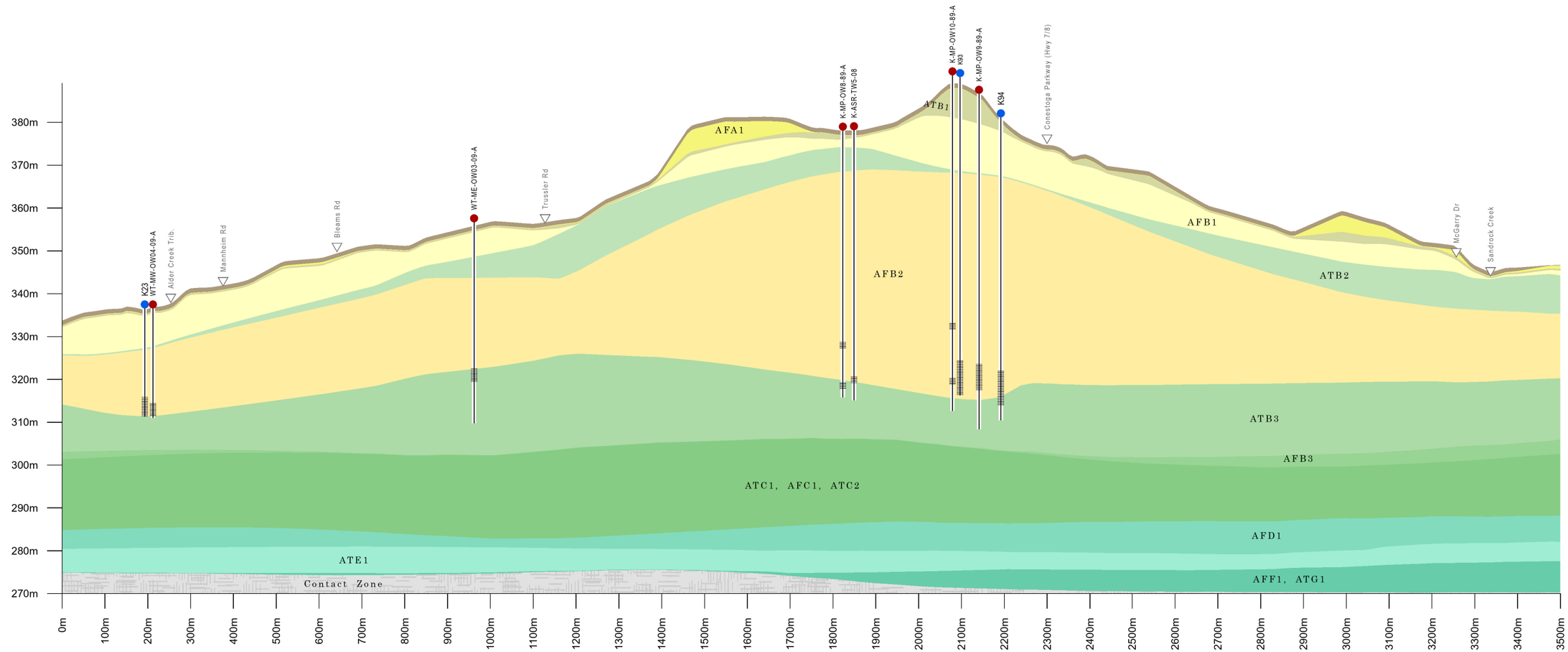


Wells

- Production Well (Active)
- Monitoring Well

Moraine Model 2026

Surficial Geology, Whittlesey Clay (ATA1)	Upper Waterloo Moraine Stratified Sediments & Equivalents (AFB1)	Lower Maryhill Till & Stratified Equivalents (ATB3)	Pre-Catfish Creek Coarse-Grained Glaciofluvial/Lacustrine Deposits (AFD1)
Whittlesey Sand (AFA1)	Middle Maryhill Till & Equivalents (ATB2)	Lower Waterloo Moraine Stratified Sediments or Catfish Creek Till Outwash (AFB3)	Canning Drift, Till & Fine Textured Glaciolacustrine Deposits (ATE1)
Upper Maryhill, Port Stanley, Tavistock, Mornington, & Stratford Tills (ATB1)	Middle Waterloo Moraine Stratified Sediments & Equivalents (AFB2)	Upper/Main Catfish Creek Till (ATC1), Middle Catfish Creek Stratified Deposits (AFC1), Lower Catfish Creek Till (ATC2)	Pre-Canning Coarse Textured Glaciofluvial / Glaciolacustrine Deposits (AFF1), Pre-Canning Coarse Textured Till (ATG1)

Weathered Bedrock

Wellhead

Well

Screen or Open Hole

BURNSIDE

Client

REGION OF WATERLOO

Figure Title

GEOLOGIC CROSS SECTION
REGION OF WATERLOO
Peaking
Cross Section I - I'

Drawn	Checked	Date	Figure No.
PS	DH	2026/06/02	16
Horizontal Scale 1:10,000		Project No.	
Vertical Ex.:10x		HA046402	

File Path: F:\GIS Working\Projects\ROW_Cross_Sections\ROW_Cross_Sections.aprx Print Date: 2026/06/02 Time: 08:34 AM

BURNSIDE

[THE DIFFERENCE IS OUR PEOPLE]

Appendix A

Permit To Take Water

PTTW A-1

Monitoring and Contingency Plan A-2

Stantec Consulting Ltd.
100-300 Hagey Boulevard, Waterloo ON N2L 0A4

July 28, 2016
File: 1609-00748/10

Attention: Mr. Richard Wootton
Regional Municipality of Waterloo
Water Services
150 Frederick Street, 7th Floor
Kitchener, ON N2G 4J3

Dear Mr. Wootton,

Reference: Monitoring and Contingency Plan
Draft PTTW MOECC Ref. No. 4354-A9DKV9
Mannheim East, Mannheim West and Peaking Wells Fields
Regional Municipality of Waterloo, Ontario

The Ministry of the Environment and Climate Change (MOECC) is currently reviewing the consolidated Permit to Take Water (PTTW) application submitted by the Regional Municipality of Waterloo (Region) for the Mannheim East, Mannheim West, Peaking and ASR Well Fields (Figure 1, Attachment A).

The following letter presents the monitoring and contingency plan to be completed by the Region in support of the consolidated PTTW. The monitoring program may be updated and amended as approved by the MOECC Director.

MONITORING TRIGGER LOCATIONS

Groundwater level monitoring will be completed at the following six (6) monitoring locations with associated trigger levels:

- WT-MW-OW3-04 – The recommended trigger level at this location is 326.8 m AMSL to be protective of RW10.
- WT-MW-OW02-10 – The recommended trigger level at this location is 325.1 m AMSL to be protective of RW22.
- WT-MW-OW6-04 – The recommended trigger level at this location is 328.5 m AMSL to be protective of RW13.
- K-MP-OW1B-16 – The recommended trigger level at this location is 333.3 m AMSL to be protective of RW29, RW28 and RW15.
- K-ASR-OW2-16 – The recommended trigger level is 326.3 m AMSL to be protective of RW12 and RW4.

Reference: Monitoring and Contingency Plan
Draft PTTW MOECC Ref. No. 4354-A9DKV9
Mannheim East, Mannheim West and Peaking Wells Fields
Regional Municipality of Waterloo, Ontario

- WT-ME-OW03-09 - The recommended trigger level at this location is 331.0 m AMSL to be protective of RW5 and RW16.

MONITORING METHOD

At these six (6) wells, groundwater level monitoring will be completed using dataloggers set to record at 1 hour intervals. The dataloggers will be installed within these six (6) wells within 60 days of the MOECC issuing the consolidated PTTW.

Manual water level measurements will be completed on a monthly basis at all six (6) wells, as a backup to the dataloggers. The dataloggers will be downloaded on a bi-monthly basis, consistent with current groundwater monitoring program procedures.

It is acknowledged that in spite of best efforts and maintenance, dataloggers will eventually fail, requiring replacement. In the event of failure, the Region will have the datalogger replaced within 14 business days of notification of the failure.

CONTINGENCY PLAN

In the event that a trigger level is reached within any of the six (6) monitoring wells, the following contingency plan would be initiated. Again, reaching a trigger level would not be considered an indication of potential private well interference, but that additional investigation is warranted. For some locations, the trigger levels are set in new monitoring wells and levels are meant to be conservative and updates are expected.

For the contingency plan, the Region proposes to complete the following:

- Retain a licensed well contractor to complete a well survey of the applicable private wells to document well construction details, pump setting details and static and pumping water levels within accessible wells with the owner's permission. An elevation survey of the private wells would be completed at each location.

- Retain a Qualified Person to review water levels and remaining available drawdown within each residential well, groundwater levels within nearby monitoring wells, precipitation data, and municipal pumping records, to evaluate influencing factors on observed water levels. The Qualified Person would assess the potential for impacts from municipal pumping, residential pumping, and seasonal variability in precipitation, on aquifer groundwater levels, as feasible. Based on the review, the Qualified Person may provide recommendations that may include, but not limited to:

Reference: Monitoring and Contingency Plan
Draft PTTW MOECC Ref. No. 4354-A9DKV9
Mannheim East, Mannheim West and Peaking Wells Fields
Regional Municipality of Waterloo, Ontario

- Update trigger level as required based on observations
- Recommend additional private well inspections
- Recommend upgrades to individual private wells, such as changing pumping rate, pump size or depth
- Recommend private well replacement
- Recommend additional monitoring wells at key locations

The results of the review will be provided to the MOECC upon completion of the assessment. The trigger levels were conservatively determined, allowing adequate time for review and comment by both the Region and the MOECC. In the event of a private well interference complaint, the Region will follow the requirements of Condition 5.2 of the PTTW.

CONCLUSION

We trust that this information is suitable for processing of the PTTW application. Please do not hesitate to contact the undersigned should you have any questions or concerns.

Regards,

STANTEC CONSULTING LTD.

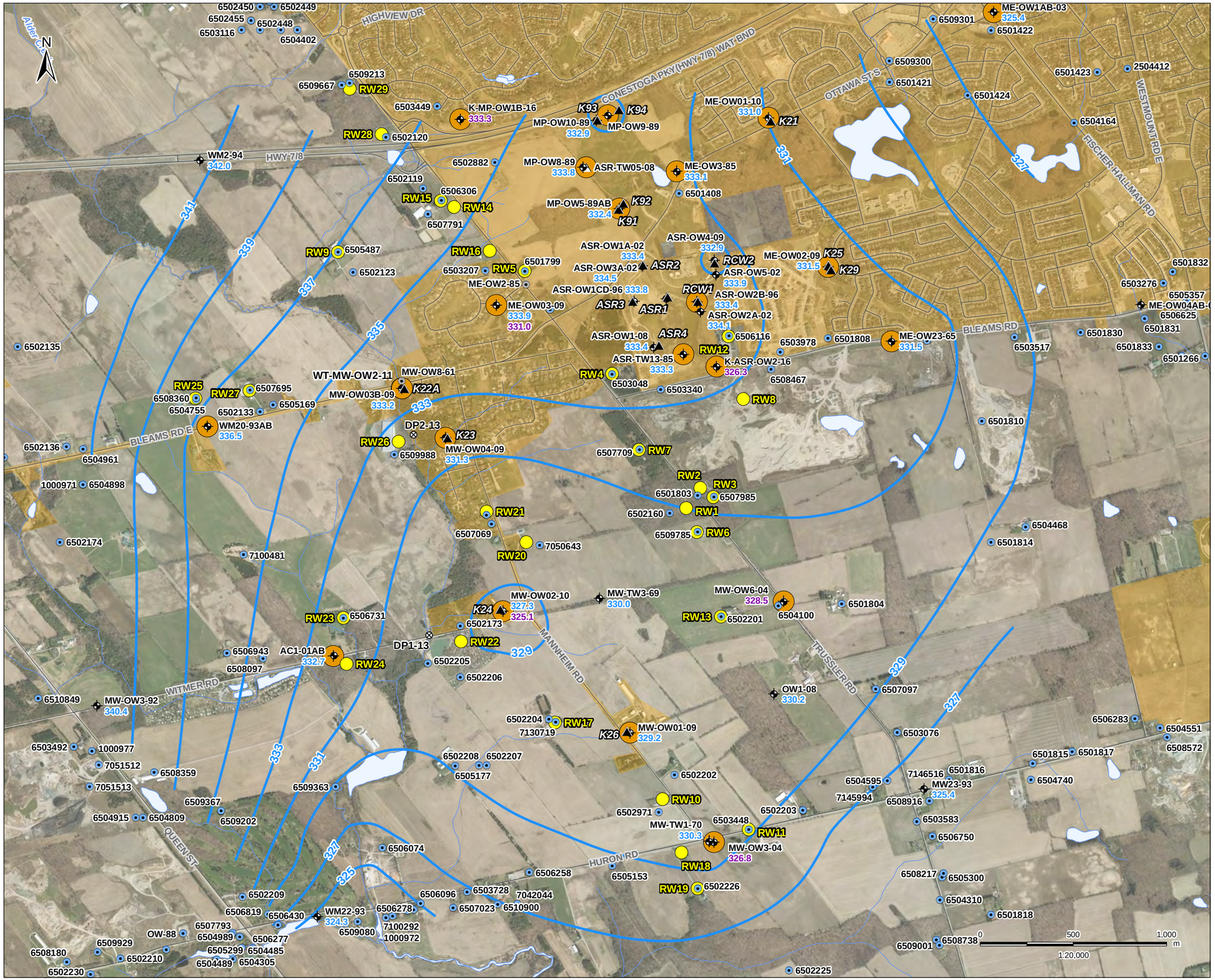
Lesley Veale, M.Sc., P.Geo.
Senior Hydrogeologist
Phone: (519) 585-7377
Fax: (519) 579-4239
lesley.veale@stantec.com

Roger Freymond, P.Eng.
Senior Hydrogeologist
Phone: (519) 585-7381
Fax: (519) 579-4239
roger.freymond@stantec.com

Attachment: A Figure 1 – Groundwater Contours and Well Locations

c. Eric Hodgins - Region

be w:\active\160900748_mannheim pumping test\preliminary\correspondence\moecc_160728\let_moecc_mannheim_pttw_160728_rev.docx



Stantec

Legend

- Production Well
- Drive-Point Piezometer (Stantec, 2013)
- Test Well
- Monitoring Well
- Abandoned Well
- Water Supply Well
- Residential Well Survey Location
- Proposed PTTW Monitoring Location
- 327.54 Observed Water Level on August 18, 2013
- 327.54 Proposed Trigger Level
- Groundwater Contour (mAMSL)
- Road
- Watercourse
- Municipal Water Servicing
- Waterbody

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2013.
3. Orthoimagery © First Base Solutions, 2010.
4. Stage 1 pumping at a combined rate of 450 L/s with Mannheim West at 157 L/s, Mannheim East at 135 L/s and Peaking at 159 L/s.
5. Ground surface elevation estimated based on topographic mapping at MW20-93, WM22-93 and MW-OW3-92.

July 2016
160900748

Client/Project

Review of Mannheim PTTW
Mannheim East, West and Peaking Well Fields
Regional Municipality of Waterloo

Figure No.

1

Title

Groundwater Contours -
August 18, 2013 (End of Stage 1 Pumping)
Mannheim Aquifer

\\Ca1004-f01\work_group\01609\active\160900748_Mannheim Pumping Test\preliminary\drawing\MXD\PumpTest_2014\PTTW_Review_Letter4\160900748_PTTWReview_Fig01_GrdwFlow2013.mxd
Revised: 2016-07-22 By: ccoghlan

Ontario

Ministry of the Environment, Conservation and Parks
Ministère de l'Environnement, de la Protection de la nature et des Parcs

PERMIT TO TAKE WATER
Ground Water
NUMBER P-300-3130244509
Version: 1.0
Effective Date: October 8, 2021
Expiry Date: May 31, 2031

Pursuant to Section 34.1 of the Ontario Water Resources Act, 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

K21

K21A

K91

K94

K93

K92

K25

K29

ASR3

ASR4

RCW3

ASR1

RCW4

RCW1/ASR5

ASR2

RCW2

K24

K26

K23

Located at:

1768 OTTAWA Street South, KITCHENER, KITCHENER,
ONTARIO, CANADA, N2E 0C6

2056 OTTAWA Street South, KITCHENER, KITCHENER,
ONTARIO, CANADA, N2E 0C4

453 ACTIVA Avenue (AVE) , KITCHENER, KITCHENER,
ONTARIO, CANADA, N2E 4B9

2069 OTTAWA Street South, KITCHENER, KITCHENER,
ONTARIO, CANADA, N2E 3K3

1024 WITMER Road , PETERSBURG, WILMOT, ONTARIO,
CANADA, N0B 2H0

1139 MANNHEIM Road , PETERSBURG, WILMOT, ONTARIO,
CANADA, N0B 2H0

1510 MANNHEIM Road , PETERSBURG, WILMOT, ONTARIO,
CANADA, N0B 2H0

This Permit cancels and replaces Permit Number 2671-AC9PFQ, issued on July 28, 2016.

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
Guelph District Office
Guelph District Office
Guelph District Office
Guelph District Office
Guelph District Office
Guelph District Office
of the Ministry.

e. "Permit" or "PTTW" means this Permit to Take Water No. P-300-3130244509 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 June 3, 2021, 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, 2031. 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	Max. Taken per minute	Max. No. of Hrs Taken per day	Max. volume per Day	Max. days in a year	Zone / Easting / Northing
1	ASR1 (ASR1)	Well	Public administration	Municipal Supply	Water Supply	20220	24	23700000	365	17 / 537950 / 4805538
2	ASR2 (ASR2)	Well	Public administration	Municipal Supply	Water Supply	20220	24	23700000	365	17 / 537818 / 4805710
3	ASR3 (ASR3)	Well	Public administration	Municipal Supply	Water Supply	20220	24	23700000	365	17 / 537764 / 4805513
4	ASR4 (ASR4)	Well	Public administration	Municipal Supply	Water Supply	20220	24	23700000	365	17 / 537904 / 4805280
5	RCW1/ASR5 (RCW1/ASR5)	Well	Public administration	Municipal Supply	Water Supply	20220	24	23700000	365	17 / 538112 / 4805517
6	RCW2 (RCW2)	Well	Public administration	Municipal Supply	Water Supply	20220	24	23700000	365	17 / 538204 / 4805721
7	RCW3 (RCW3)	Well	Public administration	Municipal Supply	Water Supply	20220	24	23700000	365	17 / 537909 / 4805100
8	RCW4 (RCW4)	Well	Public administration	Municipal Supply	Water Supply	20220	24	23700000	365	17 / 538042 / 4805844
9	K21 (K21)	Well	Public administration	Municipal Supply	Water Supply	11820	24	17021000	365	17 / 538505 / 4806484
10	K21A (K21A)	Well	Public administration	Municipal Supply	Water Supply	11820	24	17021000	365	17 / 538498 / 4806499
			Public	Municipal	Water					17 / 536768 /

11	K23 (K23)	Well	administration	Supply	Supply	13440	24	19353600	365	4804779
12	K24 (K24)	Well	Public administration	Municipal Supply	Water Supply	13440	24	19353600	365	17 / 537047 / 4803862
13	K25 (K25)	Well	Public administration	Municipal Supply	Water Supply	11820	24	17021000	365	17 / 538814 / 4805706
14	K29 (K29)	Well	Public administration	Municipal Supply	Water Supply	11820	24	17021000	365	17 / 538832 / 4805684
15	K26 (K26)	Well	Public administration	Municipal Supply	Water Supply	13440	24	19353600	365	17 / 537740 / 4803208
16	K91 (K91)	Well	Public administration	Municipal Supply	Water Supply	11400	24	16416000	365	17 / 537689 / 4806007
17	K92 (K92)	Well	Public administration	Municipal Supply	Water Supply	11400	24	16416000	365	17 / 537723 / 4806039
18	K93 (K93)	Well	Public administration	Municipal Supply	Water Supply	11400	24	16416000	365	17 / 537573 / 4806489
19	K94 (K94)	Well	Public administration	Municipal Supply	Water Supply	11400	24	16416000	365	17 / 537691 / 4806544
Total Taking								**76490600**		

3.3. Notwithstanding the Maximum Taken per Day specified in Table A of Condition 3.2, the taking from the Mannheim East wells (K21, K21A, K25 & K29), Mannheim West wells (K23, K24 & K26), and Peaking wells (K91, K92, K93 & K94) (in any combination of the 11 listed wells) shall not exceed an annual daily average of 40,715,136 L/day.

4. **Monitoring**

4.1. The Permit Holder shall maintain a record of all water takings. This record shall include the dates and times of water takings, the rates of pumping, and an estimated calculation of the total amounts of water pumped per day for each day that water is taken under the authorization of this Permit. A separate record shall be maintained for each source. The Permit Holder shall keep all required records up to date and available at or near the site of the taking and shall produce the records immediately for inspection by a Provincial Officer upon his or her request.

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

K-ME-OW2-17-A
K-ME-OW1-17-A
K-ME-OW1-03-A
K-ME-OW1-03-B
K-ME-OW1-10-A
K-ME-OW2-09-A
K-ASR-OW2-96-B
K-ASR-TW13-85-A
K-ASR-TW5-08-A
K-ASR-OW2-16-A
K-MP-OW1-17-A
K-MP-OW9-89-A
K-MP-OW1-16-B
WT-MW-AC1-01-A
WT-MW-AC1-01-B
WT-MW-OW1-09-A
WT-MW-OW2-11-A
WT-MW-OW03-09-B
WT-MW-OW4-09-A
WT-MW-WM20-93-A
WT-MW-WM20-93-B

WT-MW-OW3-04-A
WT-MW-OW2-10-A
WT-MW-OW6-04-A
WT-ME-OW3-09-A

4.3. The Permit Holder shall adhere to the monitoring and contingency plan, including trigger levels, as detailed in the Stantec letter report dated July 28, 2016, or as updated and approved by the Director. In addition, the Permit Holder shall initiate an investigation by a Qualified Person if any of the trigger levels is reached to assess potential impacts to private water supply wells from municipal well pumping permitted in this Permit. The Permit Holder shall notify both the Manager, Guelph District Office and the Water Compliance Supervisor, Safe Drinking Water Branch, Guelph District Office within 5 business days of receipt of the water level data in the event the trigger level is reached.

4.4. The Permit Holder shall prepare and submit a report every two years by June 30th, commencing on June 30, 2022, that presents:

a) the results of the well field water level monitoring for the two preceding calendar years,
b) assesses changes in water levels in the supply aquifer in relation to precipitation and water taking from the aquifer,
c) provides groundwater level contour figures for Aquifer 1,
d) assesses groundwater elevation measurements relative to the trigger levels established in Condition 4.3, and
e) 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* Ontario Land Tribunal	The Director, Section 34.1, Ministry of the Environment, Conservation and Parks

655 Bay Street, Suite 1500 Toronto ON M5G 1E5 OLT.Registrar@ontario.ca	and	5775 Yonge Street, 8th Floor Toronto, ON M2M 4J1 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 16th day of November, 2021

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-300-3130244509 Version Number 1.0, dated October 7, 2021.

BURNSIDE

[THE DIFFERENCE IS OUR PEOPLE]

Appendix B

Well Records

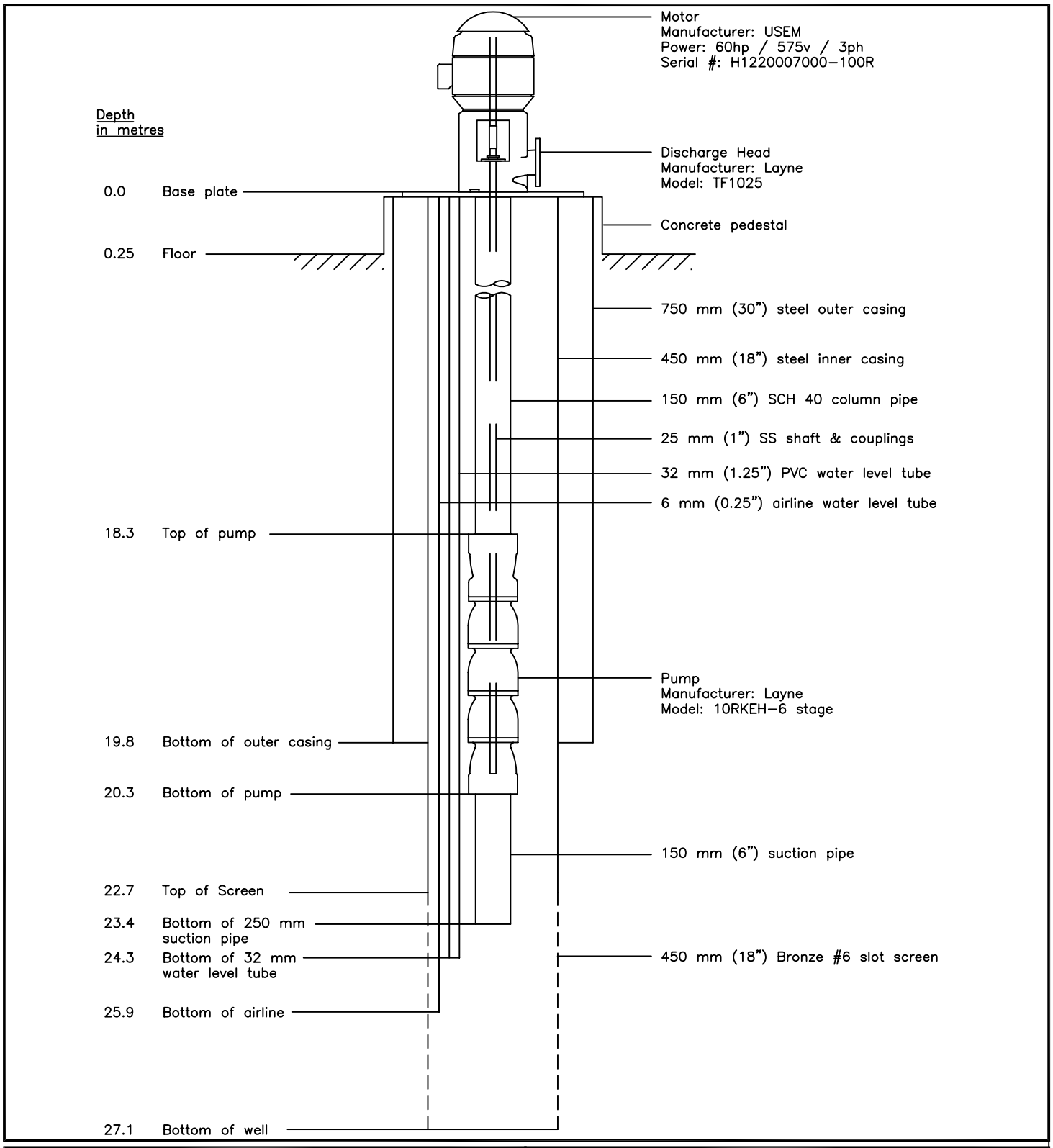
BURNSIDE

[THE DIFFERENCE IS OUR PEOPLE]

Appendix B-1

Mannheim West Well Logs

K23



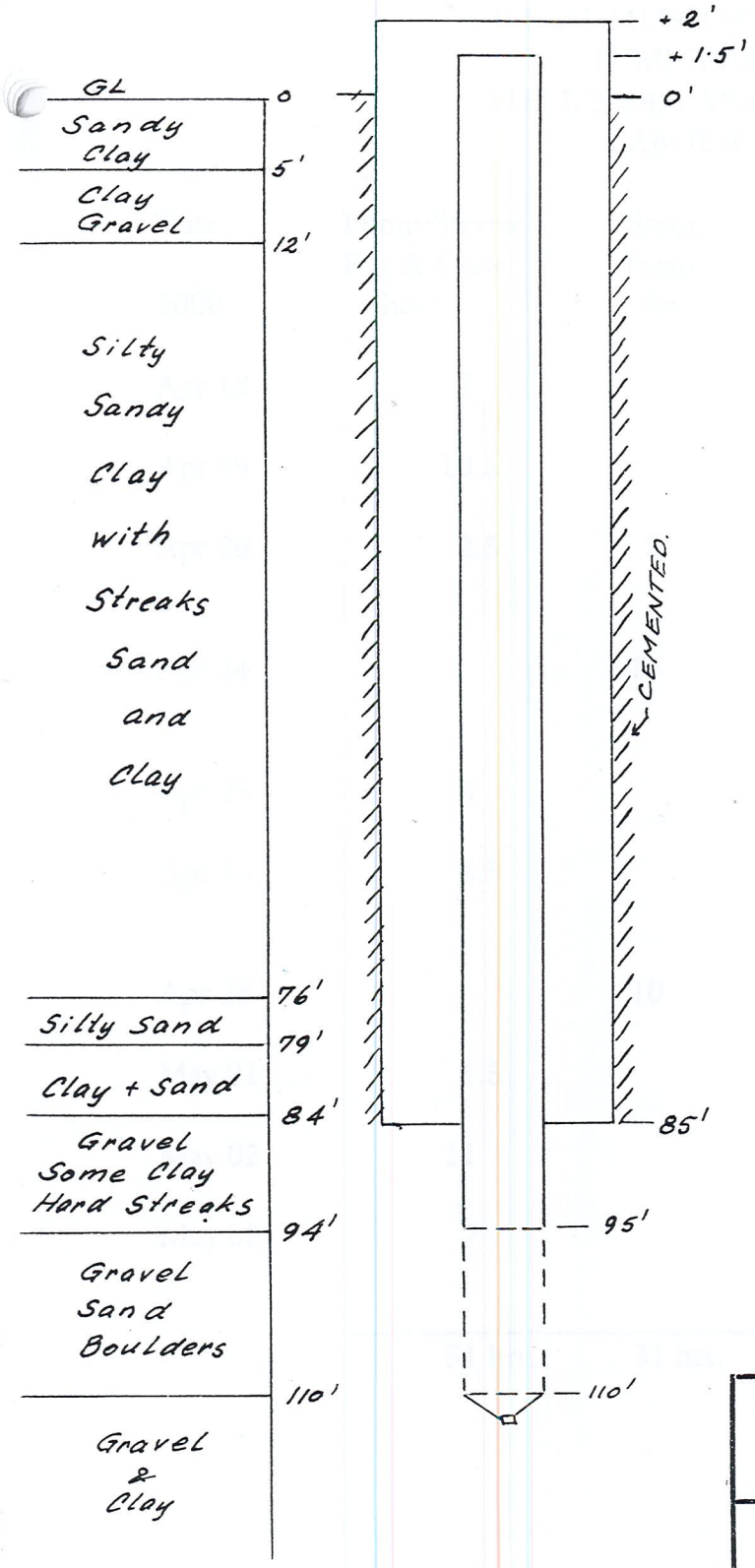
Lotowater TECHNICAL SERVICES INC.

CLIENT
Regional Municipality of Waterloo

TITLE
Well K23
Pump Installation Drawing

PROJECT No. 006-191			G:\Lotowater Projects\006 Region of Waterloo\191 K23 Rehabilitation\Lineshaft Pump Installation	FIGURE
DESIGN			REVISION No. 2011-05-31	SCALE N.T.S.	3
DRAWN	EH	2011/01/05		
CHECKED				

K24



Well Material

Outer Casing 87' of 30" rolled steel welde

Inner Casing 96.5' of 18" rolled steel welde

Screen 15' of 18" S.S. #6

Plug 18×6 swedge, 6" Baker whirler shoe, 3 ga slurr

Gravel 18 yds #5

Pump

No. 24576	Setting BP-MB 60'
No. Stages 6	Length Bowl 7'3"
Bowl 15" DRHC	Size & Lgth. Suction 10' of 10
Head TF 1025	Size Column 10'

Materials or setting details other than standard: Air line 75', 1" Line 60'

Motor

Make U.S.	Phase 3
Shaft CFU (TYPE)	Cycles 60
H. P. 100	Volts 550
R. P. M. 1200	Amps. 96.8
Type CFU	Base
Frame 587-3	Serial 927242

Special Equipment

Well

B. P. referred to original	Ground Level ~~[illegible]~~ 1'6
Started	Clear Depth 112'9"
Preliminary Test July 19, 1951	Length Air Line 70'
Final Test	Static Level 15'
Guarantee 3500 IGM from not less then 3 wells	Pumping Level 83'
Pressure	Capacity 996 IGM

Driller: L. Oliver 7/19/51

Installer: Gordon Keyes 1/27/56

INTERNATIONAL WATER SUPPLY LTD.
LONDON, CANADA
WATER SUPPLY CONTRACTORS

KITCHENER, ONT.

DRAWN BY H APPROVED BY

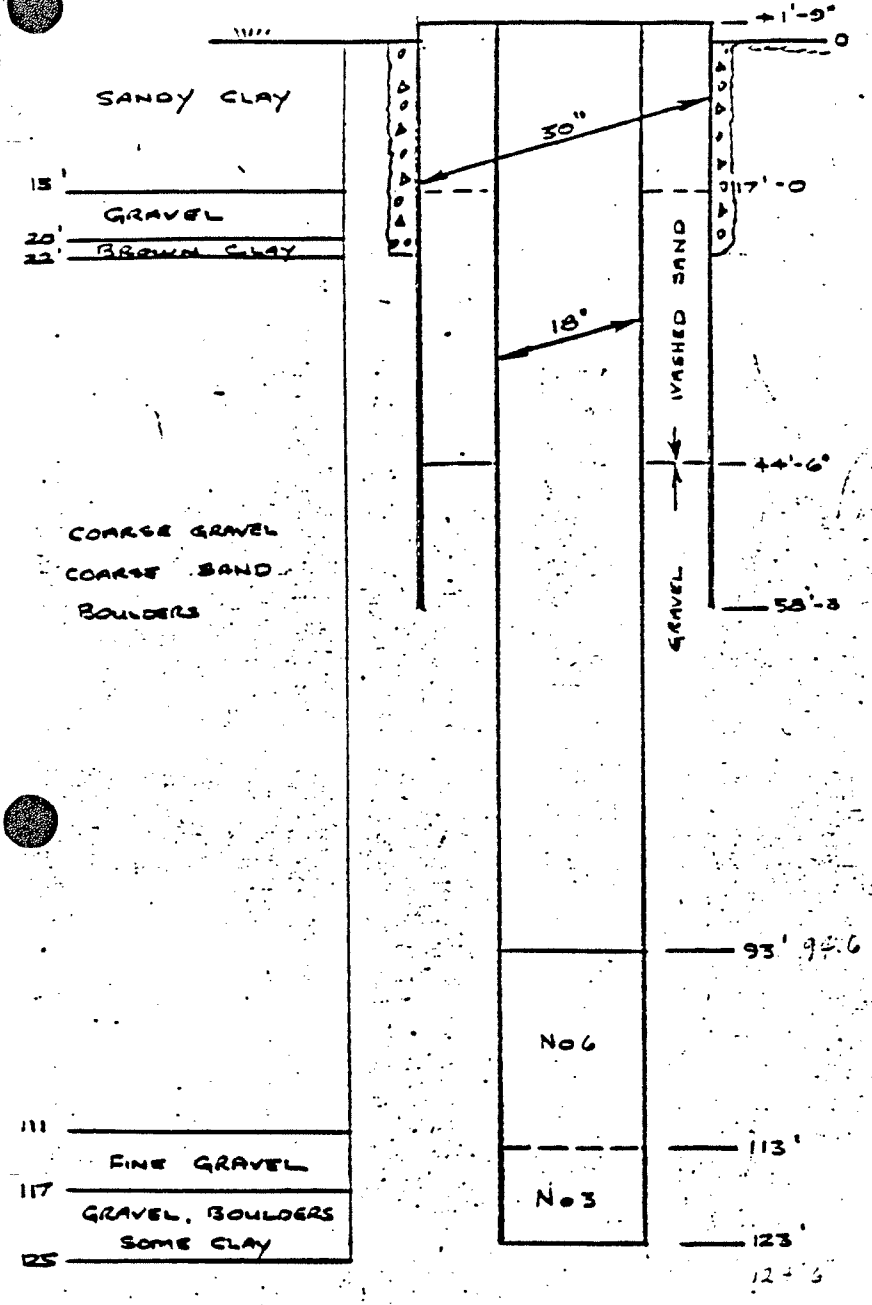
WELL NO. 4 Mannheim (Devitt) TEST HOLE # 40

K26

K26

Elev ~ 345 (1:10,000)

add 1.6



Well Material

Outer Casing 60' - 30" DIA 3/8"

Inner Casing 94'-9" - 18" DIA 3/8"

Screen 18" Φ 20' - No 6 - 10' - No 3 LAYNE

Plug 1/4" SS PLATE

Gravel 60T 1/4" x 1/8"

Pump

No. 63162	Setting BP-MB 90'-0
No. Stages 5	Length Bowl 7'-7
Bowl 14" TLC	Size & Lgth. Suction 10"
Head TF 1018	Size Column 10" x 1 1/16"

Materials or setting details other than stand

Impellers: Trim

Motor

Make WESTINGHOUSE	Phase 3
H. P. 200	Cycles 60
R. P. M. 1800	Volts 575
Type H.S.B.	Amps. 177
Frame 444-5TPH	Serial 1-195804
Bearing Nos.	

Special Equipment

1. ZINC SLEEVES

Well No. 26

B. P. referred to original ground level + 2' APP

Clear depth below B. P. 125'-9"

Started _____ Final Test Nov 27/

Preliminary Test _____ Static Level 45'-8

Final Test _____ Pumping Level 50'

Guarantee _____ I G P M Capacity 1400 I C

Contract Pressure _____ # Pressure Pump _____

Length Air Line 90' Main _____

INTERNATIONAL WATER SUPPLY L

MONTREAL LONDON, CANADA SASK
OAKVILLE WATER SUPPLY CONTRACTORS VANC

KITCHENER WATER COMMISSION

DRILLED BY J. AUGUSTINE DRAWN BY B.L.H.
INSTALLED BY HARTMAN APPROVED BY

C A 1 2 65- 537750 1125 08/69 2801 2 FR 4 43 44 25 1/30
3136 4802920 FR 7 50

001 VL C 002 GRVL
MSND GRVL BLDR 0095 MSN VL STNS 0125
MSND CLAY 0127
KITCHENER WATER COMM CLA
BRWN CLAY 0012 GRVL MSND BL 0040 BLDR
GRVL MSND 0054 GRVL MSND BLDR 0130 (S
0118 11) GREY CLAY GRVL 0144

K26

BLOC A 1 2 65- 537750 1125 12/69 2801 30 FR 45 46 50 1400 71/30 MU
3145 4802950
KITCHENER WATER COMM
BRWN CLAY MSND 0015 GRVL 0020 BRWN CLAY
0022 GRVL MSND BLDR 0111 (S 0093 15)
(S 0108 15) GRVL 0117 GRVL BLDR CLAY
0125

BLOC A 1 2 65- 537975 1150 09/58 3106 6 FR 76 45 45 15 5/00 ST DO
2202 4802750 FR 83
KNECHTEL C
CLAY 0022 GRVL 0083

BLOC A 1 2 65- 538550 1150 01/60 3106 6 FR 86 77 85 5 4/00 DO
2203 4802575
SHANTZ W
CLAY 0028 GRVL 0087

BLOC A 1 3 65- 536650 1075 04/66 3533 8 FR 45 20 40 10 3/00 PS DO
2205 4803350
SCHNEIDER G
MSND 0001 GRVL 0045 MSND CLAY 0046 MSND
0051 (S 0046 05)

BLOC A 1 3 65- 536825 1115 07/66 4719 7 FR 204 21 41 30 5/00 PS
2206 4803275
SCHNEIDER G
MUCK 0002 BRWN CLAY 0030 CLAY GRVL 0058
CLAY SILT 0082 CLAY GRVL 0102 CLAY GRVL
SILT 0146 GRVL CLAY 0185 GRVL CLAY ROCK
0197 GREY ROCK 0206

BLOC A 1 3 65- 537300 1125 10/57 3524 6 FR 50 23 48 15 15/00 DO
2204 4803050
SCHNEIDER G
PRDG 0024 CSND 0050 CSND 0062

BLOC A 1 3 65- 537890 1120 05/68 3518 6 FR 81 40 45 10 5/00 ST
2971 4802550
HYPPKE KLUS
TPSL 0001 GREY CLAY 0030 GRVL MSND 0035
BLUE CLAY 0050 HPAN 0081 MSND GRVL 0087
(S 0083 04)

BLOC A 1 4 65- 536925 1075 10/58 3122 4 FR 13 45 48 15 4/00 ST DO
2208 4802800 FR 260
WEBER S
CLAY 0012 MSND 0013 CLAY 0076 SILT MSND
0086 CLAY 0098 SILT CLAY 0167 HPAN 0178
MSND CLAY 0208 HPAN 0222 SHLE 0260

BLOC A 1 4 65- 536965 1075 06/58 3122 6 FR 77 45 48 15 4/00 ST DO
2207 4802800
WEBER A
CLAY 0024 GRVL 0079

BLOC A 1 6 65- 535655 1100 10/58 3122 6 FR 86 40 43 15 5/00 ST DO
2209 4802095
SARARAS W
CLAY 0043 HPAN 0079 GRVL 0086

BLOC A 1 7 65- 534750 1150 11/71 2519 30 FR 20 20 35 ST DO
3492 4802900
SIEBERT L
BRWN CLAY MSND 0005 BRWN MSND 0009 GREY
CLAY 0035

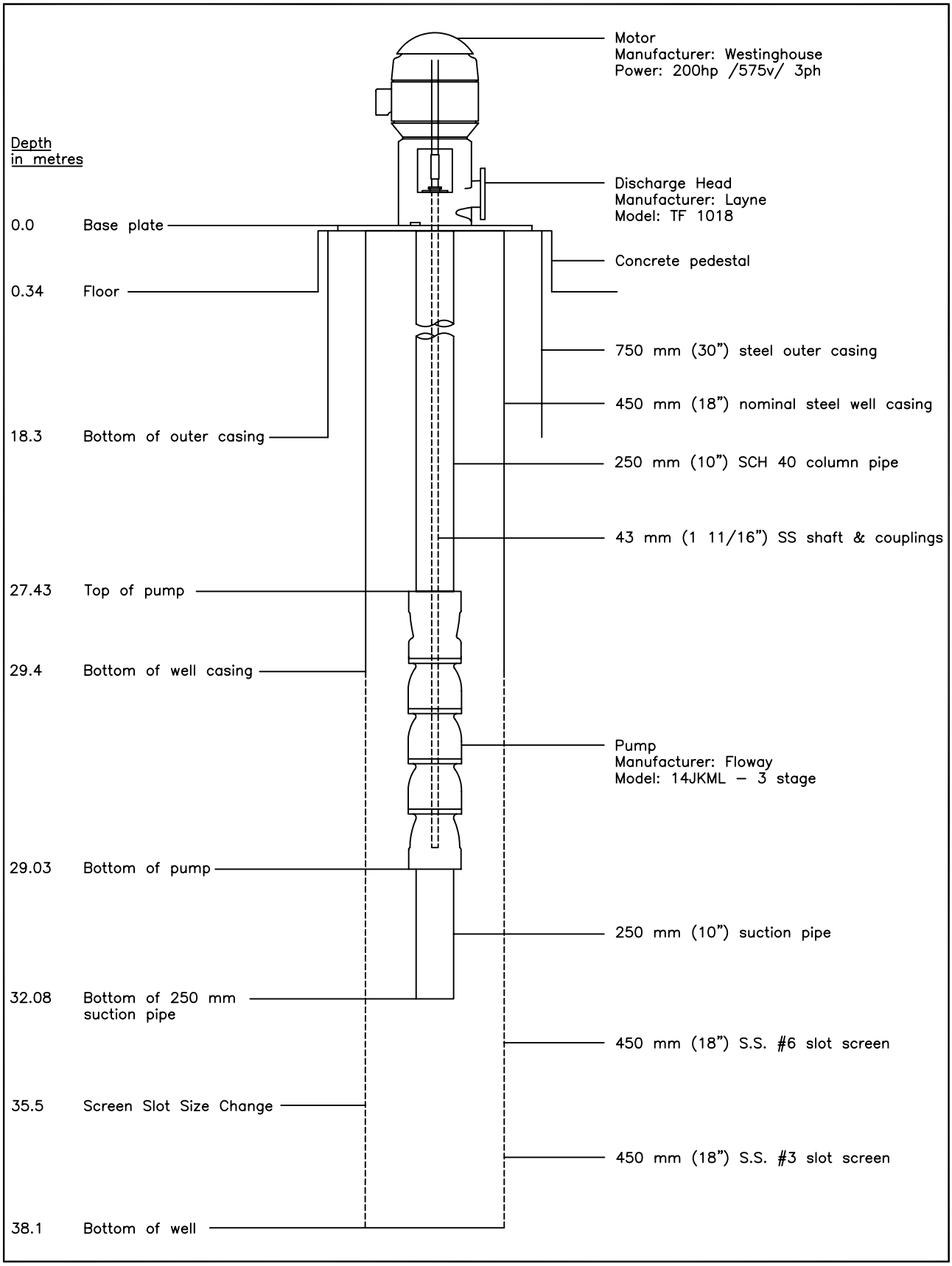
BLOC A 1 7 65- 535260 1200 10/72 2801 6
3733 4801900
MIN OF ENVIRONMENT
GRVL CSND BLDR 0021 BRWN SILT 0026 GREY
CLAY SILT STNS 0054 SAND GRVL 0055 GREY
CLAY SILT 0062 GREY SILT SAND STNS 0069
GREY CLAY SILT 0102 GREY CLAY SILT STNS
0121 SAND GRVL 0131 SAND GRVL CLAY 0143

BLOC A 1 8 65- 533950 1150 02/63 3533 5 FR 69 60 63 15 18/00 DO IR
2211 4802600
BARNES W
TPSL 0001 MSND GRVL 0068 GRVL MSND 0081
(S 0070 08)

BLOC A 1 8 65- 535000 1130 06/46 1440 3 FR 90 90 6 5/00 ST DO
2210 4801765
ROHMAN W
TPSL MSND 0090 GRVL 0091 CLAY 0190 CLAY
MSND STNS 0260 MSND 0270 GRVL 0275

BLOC A 1 9 65- 532950 1201 04/73 5469 5 FR 112 66 72 12 4/00 DO
3788 4802830
SCHAUB R
TPSL 0001 BRWN GRVL 0042 BRWN CLAY SAND
0112 BRWN SAND GRVL 0120 (S 0112 04)
BRWN CLAY 0121

BLOC A 1 9 65- 533350 1175 02/64 3533 5 FR 224 110 190 8 10/00 ST DO
2212 4802665
DEIFENBACHER N
TPSL 0002 MSND 0011 MSND GRVL 0036 HPAN
0084 MSND 0096 CLAY HPAN 0156 HPAN 0224
GRVL 0225



NOTES

(1) All measurements below top of base plate which is 0.34 m above pump house floor.

(2) Static water level = 14.03 m below base plate measured 2010/05/06

Lotowater TECHNICAL SERVICES INC.

CLIENT: REGIONAL MUNICIPALITY OF WATERLOO

TITLE: Well K26 Pump Installation Drawing

PROJECT No. 006-164	G:\Lotowater Projects\006 Region of Waterloo\ 164 K26 Service\Pump Installation Drawing			
DESIGN		REVISION No. 1	SCALE N.T.S.	FIGURE 1
DRAWN	EH 2010/05/06			
CHECKED				

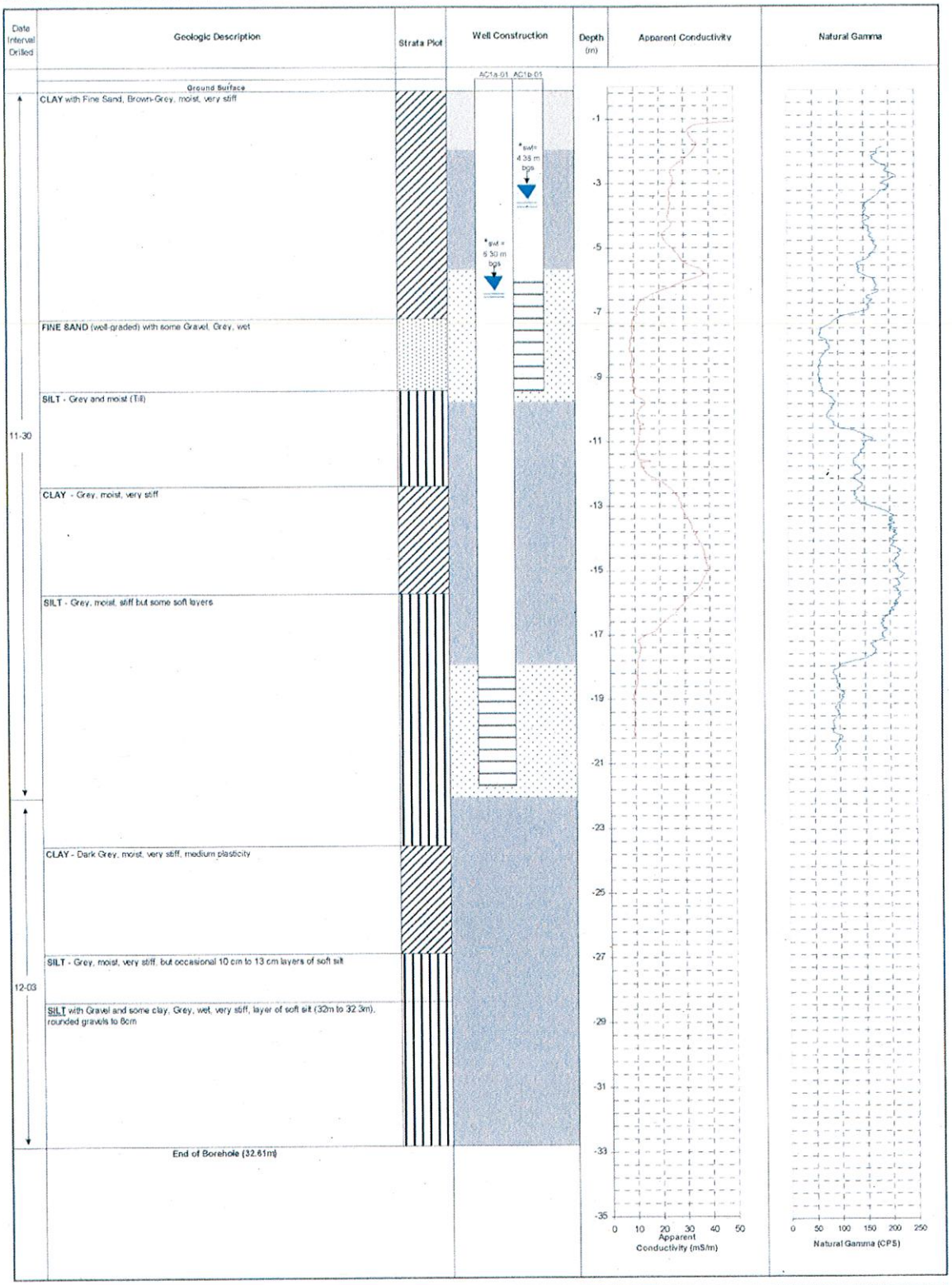
WT-MW-AC1-01-(A-B)

Figure A-1

AC1-01

Project: Alder Creek Study			**Location:** Alder Creek Watershed, Ont.
Project No.: 120868			**Northing:** 4803609.61 meters
Started Drilling: 11-30-01	**Started Well Construction:** 12-04-01	**Well Casing:** a=2", b=1.25" - SCH 40 PVC	**Easting:** 536156.22 meters
Completed Drilling: 12-03-01	**Completed Well Construction:** 12-04-01	**Screen Type:** a=2", b=1.25" - SCH 40 PVC Slot	**Ground Elevation:** a=337.32 m, b=337.33 m
Total Depth of Bore Hole: 32.61 mbgs	**Total Depth of Well:** a=21.33mbgs, b=9.02 mbgs	**Screen Interval:** a=21.33-18.29 mbgs, b=9.02-5.97 mbgs	**Well Head Stick-Up:** a=0.85 mags, b=0.90 mags
***Water Level Collected:** 12-04-01	**Drill Method :** PQ Core, Mud Rotary	**Drilling Contractor:** All Terrain Drilling Inc.	**Survey Datum:** NAD 83

Date Interval Drilled	Geologic Description
	Ground Surface
11-30	CLAY with Fine Sand, Brown-Grey, moist, very stiff
	FINE SAND (well-graded) with some Gravel, Grey, wet
	SILT - Grey and moist (Till)
	CLAY - Grey, moist, very stiff
	SILT - Grey, moist, stiff but some soft layers
12-03	CLAY - Dark Grey, moist, very stiff, medium plasticity
	SILT - Grey, moist, very stiff, but occasional 10 cm to 13 cm layers of soft silt
	SILT with Gravel and some clay, Grey, wet, very stiff, layer of soft silt (32m to 32.3m), rounded gravels to 8cm
	End of Borehole (32.61m)



CH2M HILL

CH2M Hill Canada Limited
180 King Street South
Suite 600
Waterloo, Ontario, N2J 1P8
Tel 519 579 3500

LEGEND:
= Neat Cement Grout
= #1 Sand
= 0.01" PVC Screen
= Cement Bentonite Grout
= Native Backfill, Cuttings & Slough

PROJECT: 08-1112-0150

BOREHOLE LOG OF: WT-MW-OW02-10

SHEET 1 OF 2

LOCATION: N 4803850.0 ;E 537068.0

DRILLING DATE: January 20, 2010

DATUM: NAD83

DRILL RIG: Formost DR12

DRILLING CONTRACTOR: Gerrits Well Drilling

DEPTH SCALE METRES	DESCRIPTION	ELEV. / DEPTH (m)	OGS CODE
	GROUND SURFACE	339.59	
0	TOPSOIL	0.00 / 338.98	
	Brown, medium SAND, some gravel, trace boulders	0.61 / 332.58	
	Brown, CLAYEY SILT and SAND	7.01 / 320.69	AFB1
	SA-1 (11.9-12.8 m)		
	Brown, medium SAND	18.90	
20	*CONTINUED NEXT PAGE*		

GEOPHYSICAL RECORD

GAMMA (cps): 25 50 75 100

CONDUCTIVITY (mS/m): 10 20 30 40

PIEZOMETER OR STANDPIPE INSTALLATION

Bentonite Grout

DEPTH SCALE

1 : 100

Golder Associates

LOGGED: BH

CHECKED: CM

PROJECT: 08-1112-0150

BOREHOLE LOG OF: WT-MW-OW02-10

LOCATION: N 4803850.0 ;E 537068.0

DRILLING DATE: January 20, 2010

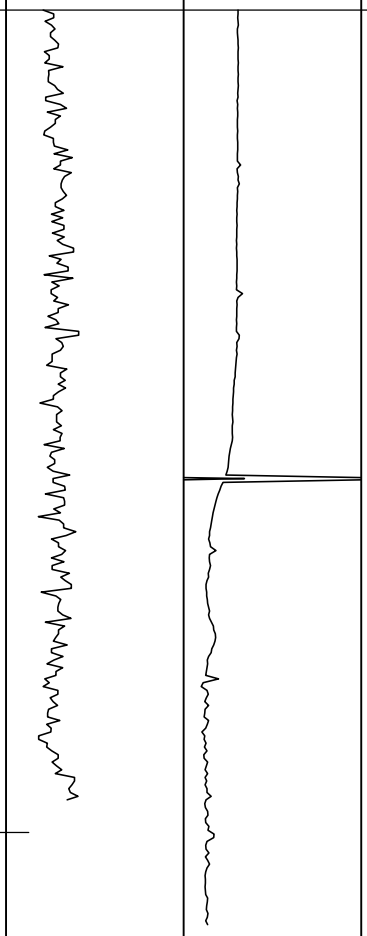
DRILL RIG: Formost DR12

DRILLING CONTRACTOR: Gerrits Well Drilling

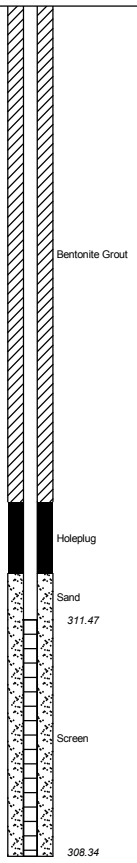
DATUM: NAD83

DEPTH SCALE METRES	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	OGS CODE
	--- CONTINUED FROM PREVIOUS PAGE ---			
20	Brown, medium SAND			AFB1
22				
24				
26				
28	SA-2 (29.0 m)			
30				
32				
34			305.22	
	Grey, CLAY, trace sand, trace silt		34.37	
			303.66	
36	END OF BOREHOLE		35.93	
38				
40				

GEOPHYSICAL RECORD



PIEZOMETER OR STANDPIPE INSTALLATION



DEPTH SCALE

1 : 100

Golder Associates

LOGGED: BH

CHECKED: CM

PROJECT: 08-1112-0150

BOREHOLE LOG OF: WT-MW-OW04-09

SHEET 1 OF 2

LOCATION: N 4804781.0 ;E 536760.0

DRILLING DATE: November 17-20, 2009

DATUM: NAD83

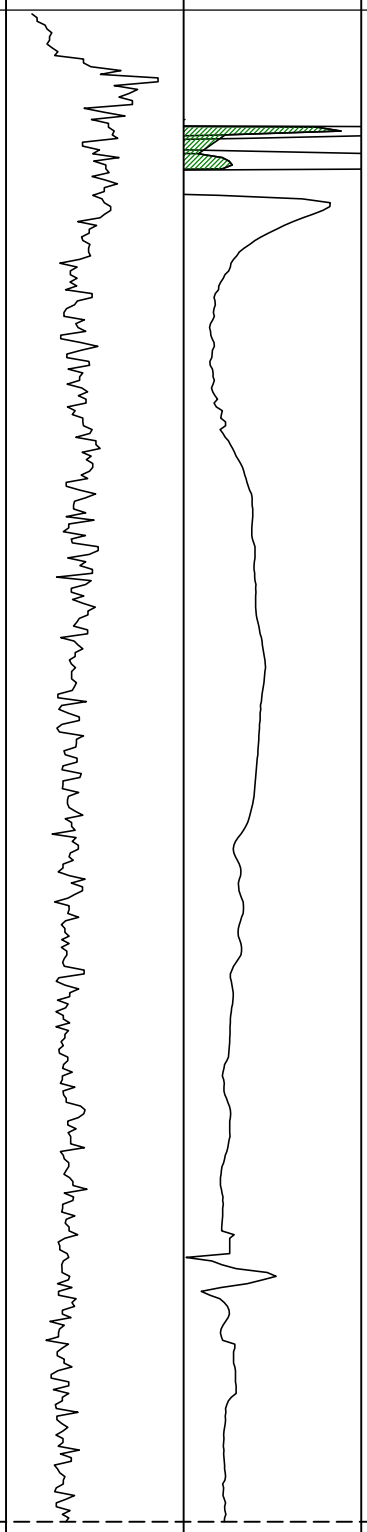
DRILL RIG: PQ Coring

DRILLING CONTRACTOR: Noll Drilling

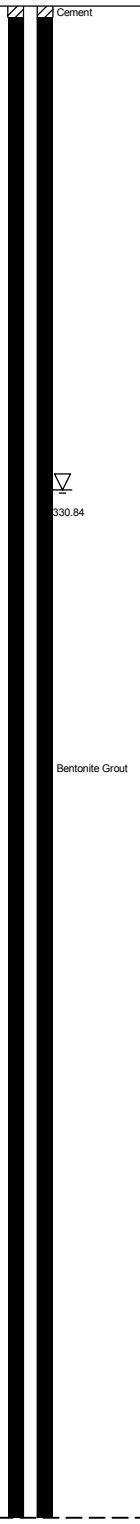
DEPTH SCALE METRES	DESCRIPTION	ELEV. / DEPTH (m)
	GROUND SURFACE	337.24
0	Dark brown, TOPSOIL with organics, trace stone	0.15
	Loose, dry, dark brown, sand, trace silt, loam (FILL)	335.72
	Dense, dry, dark brown/black, medium sand with peat, loam (FILL)	1.52 / 1.80 / 335.08
2	Loose, dry, brown, medium to fine SAND, trace gravel	2.16
	Loose, dry, reddish brown/grey, medium to fine SAND, trace gravel, stone	334.19
	Loose, dry, reddish grey, medium to fine gravelly SAND	3.05
4	Becomes wet	332.01
	Dense, moist, grey, medium to fine SAND	5.23
6		329.62
8	Dense, moist, grey, medium to fine SAND, trace gravel	7.62
10		326.32
	Compact, moist, brown/grey, medium to fine SAND	10.92 / 325.66
12	Compact, moist, brown/grey, medium to fine SAND and GRAVEL	11.58 / 325.00
	Compact, moist, black grey, medium to coarse SAND, trace gravel	12.24 / 324.54
	Compact, moist, brown grey, GRAVEL, some medium to fine sand	12.83
14	Compact, moist, black grey, medium to coarse SAND and GRAVEL	322.86
	Compact, moist, grey, GRAVEL, trace fine sand	14.38 / 14.71
	Dense, moist, light grey, medium to fine SAND, some gravel	322.00 / 15.24
	Compact, moist, brown, medium to coarse gravelly SAND	321.54 / 15.70
16	Compact, moist, grey, GRAVEL and COBBLES, some medium to coarse sand	320.02
	Core lost	17.22
18		318.95
	Compact, moist, grey, GRAVEL and COBBLES, some medium to coarse sand	18.29
20		

OGS CODE: AFB1

GEOPHYSICAL RECORD



PIEZOMETER OR STANDPIPE INSTALLATION



CONTINUED NEXT PAGE

DEPTH SCALE

1 : 100

Golder Associates

LOGGED: BH

CHECKED: CM

PROJECT: 08-1112-0150

BOREHOLE LOG OF: WT-MW-OW04-09

LOCATION: N 4804781.0 ;E 536760.0

DRILLING DATE: November 17-20, 2009

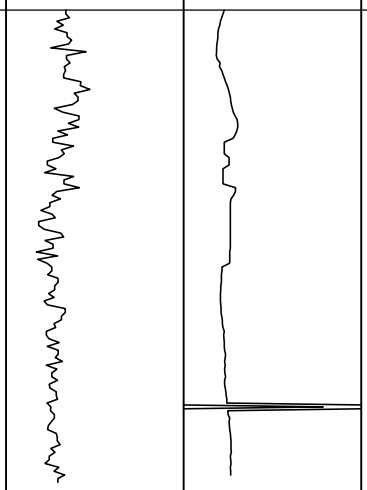
DRILL RIG: PQ Coring

DRILLING CONTRACTOR: Noll Drilling

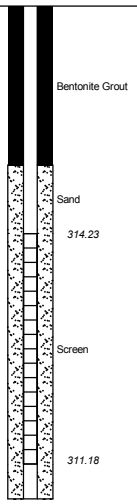
DATUM: NAD83

DEPTH SCALE METRES	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	OGS CODE
	--- CONTINUED FROM PREVIOUS PAGE ---			
20			316.87	
	Core lost		20.37	
22			314.58	
	Compact, moist, grey, GRAVEL and COBBLES, some medium to coarse sand		22.66	
	Core lost		22.86	AFB1
			313.47	
24	Compact, moist, grey, GRAVEL and COBBLES, some medium to coarse sand		23.77	
	SA1 (25.0 m)			
26			311.03	
	Dense, moist, grey, CLAYEY SILT, some fine sand		26.21	
	END OF BOREHOLE		26.52	
28				
30				
32				
34				
36				
38				
40				

GEOPHYSICAL RECORD



PIEZOMETER OR STANDPIPE INSTALLATION



DEPTH SCALE

1 : 100

Golder Associates

LOGGED: BH

CHECKED: CM

WT-MW-OW2-11-A
WT-MW-OW3-09-B

Monitoring Well: WT-MW-OW3B-09 and WT-MW-OW2-11

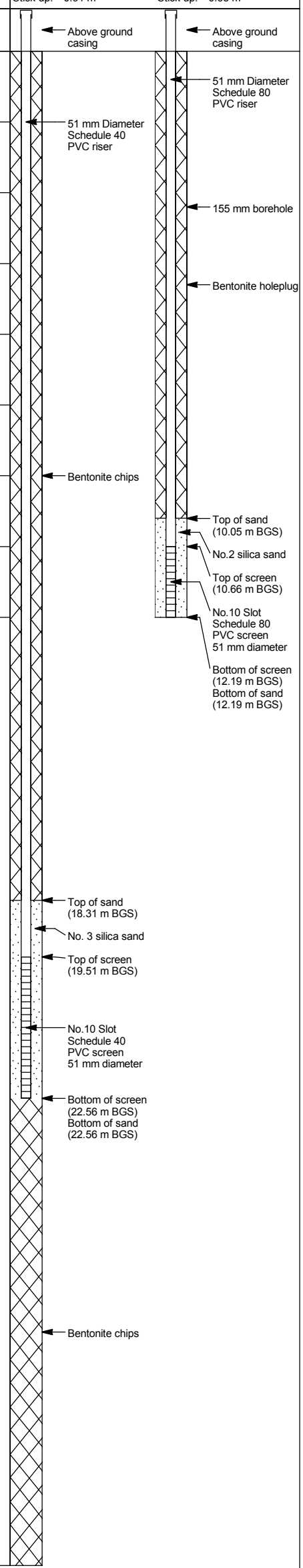
Project: 2011 Municipal Well Construction and Testing
Client: Region of Waterloo
Location: Mannhiem West Well Field
Number: 160900651

Field investigator: KS (Golder) and EH (Stantec)
Contractor: Boart Longyear / Gerrits Well Drilling
Drilling method: Sonic / Truck mount, DR 12, air rotary
Date started/completed: 01-Dec-2009 / 08-Jun-2011

SUBSURFACE PROFILE				HYDROGEOLOGY		SAMPLE DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type
			Ground Surface	336.49				
0	0		TOPSOIL	0.00				
			dark brown to black	336.19				
			SAND medium sand	0.30			1	GB
5			wet at 1.52 m BGS	334.56				
	2		SILTY SAND	1.93				
			SAND medium to coarse sand	334.36 2.13			2	GB
				333.44				
10			SAND and GRAVEL fine to medium sand, varies in colour, wet, subangular to subrounded gravel	3.05 332.83				
	4		SAND fine to medium sand	3.66			3	GB
15								
							4	GB
20	6							
							5	GB
25								
	8						6	GB
				327.65				
30			SILTY SAND	8.84				
			SANDY SILT	327.34				
			SILTY SAND	9.14				
	10		SAND medium, some fine sand, becoming coarser with depth, wet	327.19 9.30			7	GB
35				326.74 9.75				
							8	GB
40	12							
45	14							
50					AFB1/ AFB3	Upper and Lower Moraine Stratified Sediments and Equivalents		
	16							
55				319.12				
			GRAVEL medium to coarse gravel	17.37 318.96				
	18		SAND fine to coarse sand, becoming finer with depth	17.53				
60								
65	20							
70								
	22							
75				313.02				
			SAND and GRAVEL potentially till material	23.47				
	24							
80								
85	26							
90								
	28							
95				306.92				
	30		SANDY SILT (TILL)	29.57				
100					ATC1	Upper/Main Catfish Creek Till		
105	32			303.88				
			End of Borehole	32.61				
110	34							
115								

WELL DETAILS

	WT-MW-OW3B-09	WT-MW-OW2-11
Name:	WT-MW-OW3B-09	WT-MW-OW2-11
Location:	9205529	9205817
GS Elev:	336.49 m AMSL	336.62 m AMSL
TOC Elev:	337.40 m AMSL	337.57 m AMSL
Easting:	536524	536526
Northing:	4805046	4805047
Stick-up:	0.91 m	0.95 m



DRAFT

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
GB - grab sample
n/a - not available

Stratigraphic description from Golder Associates (2009) for drilling of WT-MW-OW3B-09.
Edits by Stantec based on review of cored material and drilling at WT-MW-OW2-11.
Sample details pertain to WT-MW-OW2-11.

Drawn By/Checked By: EH / LV

Stantec

STANTEC BOREHOLE AND WELL - CLUST 11X17 160900651_BOREHOLES_110909.GPJ STANTEC - DATA TEMPLATE.GDT 11/7/12 MJFRASER

Ontario Ministry of the Environment

Sticker and/or Print Below)
A112224
A112224

Well Record

Regulation 903 Ontario Water Resources Act

Measurements recorded in: [X] Metric [ ] Imperial

Page 1 of 1

Well Owner's Information

First Name	Last Name / Organization	E-mail Address	[ ] Well Constructed by Well Owner
	REGION OF WATERLOO		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
150 FREDERICK ST		ON	N2G4J3	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
1181 BLEAMS RD	WILMOT	2	GERMAN BLOCK SBR

County/District/Municipality	City/Town/Village	Province	Postal Code
WATERLOO	MANNHEIM	Ontario	

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	17	536519	4805043		

Overburden and Bedrock Materials/Abandonment Sealing Record (see instructions on the back of this form)

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	To
BLACK	TOPSOIL			0	1.52
BROWN	SAND			1.52	12.19

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m³/ft³)
0	10.05	BENTONITE CHIPS	0.21
10.05	12.19	#2 WELL SAND	0.045

Method of Construction

[ ] Cable Tool [ ] Diamond
[X] Rotary (Conventional) [ ] Jetting
[ ] Rotary (Reverse) [ ] Driving
[ ] Boring [ ] Digging
[ ] Air percussion
[ ] Other, specify

Well Use

[ ] Public [ ] Commercial [ ] Not used
[ ] Domestic [ ] Municipal [ ] Dewatering
[ ] Livestock [ ] Test Hole [ ] Monitoring
[ ] Irrigation [ ] Cooling & Air Conditioning
[ ] Industrial
[ ] Other, specify

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	To
4.85	PLASTIC	SCH 80	7 0.96	10.66

Status of Well

[ ] Water Supply
[ ] Replacement Well
[ ] Test Hole
[ ] Recharge Well
[ ] Dewatering Well
[ ] Observation and/or Monitoring Hole
[ ] Alteration (Construction)
[ ] Abandoned, Insufficient Supply
[ ] Abandoned, Poor Water Quality
[ ] Abandoned, other, specify
[ ] Other, specify

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	To
5.40	PLASTIC	10	10.66	12.19

Water Details

Water found at Depth (m/ft)	Kind of Water	
10	[ ] Fresh [X] Untested [ ] Gas [ ] Other, specify	
	[ ] Fresh [ ] Untested [ ] Gas [ ] Other, specify	
	[ ] Fresh [ ] Untested [ ] Gas [ ] Other, specify	

Hole Diameter

Depth (m/ft) From	To	Diameter (cm/in)
0	12.19	15.55

Results of Well Yield Testing

After test of well yield, water was:
[ ] Clear and sand free
[ ] Other, specify

If pumping discontinued, give reason:

Pump intake set at (m/ft)

Pumping rate (l/min / GPM)

Duration of pumping ____ hrs + ____ min

Final water level end of pumping (m/ft)

If flowing give rate (l/min / GPM)

Recommended pump depth (m/ft)

Recommended pump rate (l/min / GPM)

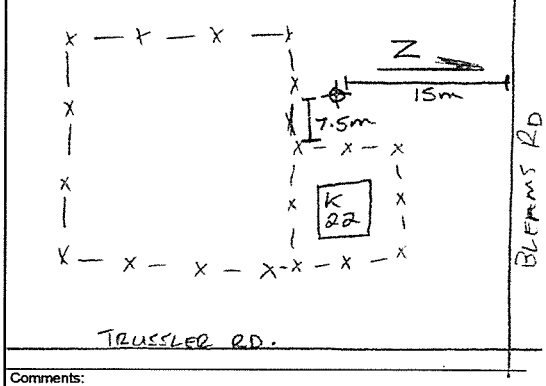
Well production (l/min / GPM)

Disinfected? [X] Yes [ ] No

Draw Down Time (min)	Water Level (m/ft)	Recovery Time (min)	Water Level (m/ft)
Static Level			
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Well Contractor and Well Technician Information

Business Name of Well Contractor: Gerrits Drilling & Engineering Ltd.
Well Contractor's Licence No.: 3406

Business Address (Street Number/Name): 215154 10th Line, R.R. #1
Municipality:

Province: Grand Valley, Ontario
Postal Code: L0N 1G0
Business E-mail Address:

Bus.Telephone No. (inc. area code):
Name of Well Technician (Last Name, First Name): DEVON BAST

Well Technician's Licence No.: 2443
Signature of Technician and/or Contractor:
Date Submitted: YYYY MM DD

Well owner's information package delivered: [ ] Yes [ ] No

Date Package Delivered: YYYY MM DD

Date Work Completed: YYYY MM DD

Ministry Use Only
Audit No.: Z127339
Received

WT-MW-OWA-11

0506E (2007/12) © Queen's Printer for Ontario, 2007

Well Owner's Copy

WT-MW-OW3-04-A

Project No: B2452-5

Project: Nitrate Pilot Study

Client: RMOW

Site Coordinates: Huron Rd. and Mannheim Rd.

Log of Borehole: WT-MW~~W~~-OW3-04

Obj # ~~9203602~~ 9203995

Field Personnel: K.Greer

SUBSURFACE PROFILE			WELL INSTALLATION	
Depth (ft / m)	Symbol	Description	Well Completion Details	Comments
0 / 0		Ground Surface		
		Silt brown, moist		above ground casing -stickup 0.74 m ags
10		***Silty Clay*** brown moist		casing locked with RMOW O lock
20		***Clay Till*** brown, wet		
30 / 10		***Sand*** brown, dry		bentonite grout schedule 40 PVC pipe
40		***Course Sand and Gravel***		
50		***Silt Till*** dense, dry		
		sand lenses less that 10 cm		water level (17.72 m)
60 / 20		***Sand Till*** less dense		
70		fluid loss at approx 63ft		#3 drilling sand 5ft, 10 slot screen backfill
		lenses of denser silt till, less that 10 cm		
80		End of Borehole		
90				
100 / 30				

Drill Method: Fluid Rotary

Drill Date: Nov 2, 2004

Datum: Relative

Checked by: T. Svensson

WESA
182 Victoria St. South
Kitchener, Ontario
Canada N2G 2B9

WT-MW-OW6-04-B

Project No: B2452-5

Project: Nitrate Pilot Study

Client: RMOW

Site Coordinates:

Log of Borehole: WT-MW~~W~~-OW6-04B

obj # 9203607

Field Personnel: K.Greer

SUBSURFACE PROFILE			WELL INSTALLATION	
Depth (ft / m)	Symbol	Description	Well Completion Details	Comments
0 / 0		Ground Surface		
		Sandy Silt dry, brown		above ground casing - stickup 1.11 m ags casing locked with RMOW O lock
10				
		Silty Caly Till some gravel		
20		***Gravel and Stones***		
30 / 10				
40				
50				
		Silty Sand Till trace clay		
60				bentonite grout
20				schedule 40 PVC pipe
70				
80				
90				
100 / 30				

Drill Method: Fluid Rotary

Drill Date: Oct 20, 2004

Datum: Relative

Checked by: T. Svensson

WESA
182 Victoria St. South
Kitchener, Ontario
Canada N2G 2B9

Project No: B2452-5

Log of Borehole: WT-MWW-OW6-04B

Project: Nitrate Pilot Study

Client: RMOW

Site Coordinates:

Field Personnel: K.Greer

SUBSURFACE PROFILE			WELL INSTALLATION	
Depth	Symbol	Description	Well Completion Details	Comments
110				
120				water level (35.61 m)
130	40			
140				
150				#3 drilling sand
				5 ft, 10 slot screen
160		***Silty Sand Till*** soft, saturated trace gravel		backfill
	50			
170		End of Borehole		
180				
190				
	60			
200				

Drill Method: Fluid Rotary

Drill Date: Oct 20, 2004

Datum: Relative

Checked by: T. Svensson

WESA
182 Victoria St. South
Kitchener, Ontario
Canada N2G 2B9

WT-MW-WM20-93-(A-B) 9200517

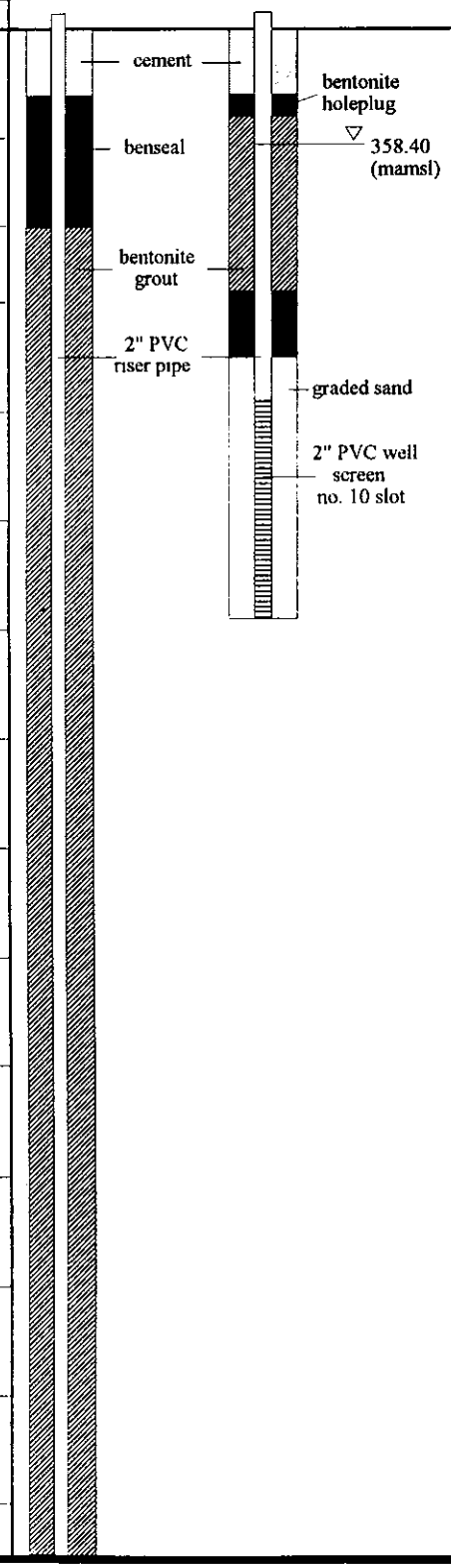
Terraqua Investigations Ltd.

BOREHOLE NO. : WM-93-20

PROJECT - CLIENT : Waterloo Moraine Study - Region of Waterloo
DATE : December 2 to December 7 1993
PROJECT NO. : TA92378
SUPERVISORS : W. Best
CONTRACTOR : All Terrain Drilling Ltd.
METHOD : Christensen PQ (5.25" O.D.) Core Barrel Wireline System and 4.25" I.D. (8" O.D.) Hollow Stem Augers

GEOLOGIC DESCRIPTION	DEPTH ft	DEPTH m	ELEV. (mAMSL)	SAMPLES #	type	rec ft	interval ft
	0	0	360				
0 to 6" - Topsoil				1	AU	2.3	5
Clay Till: little silt, minor very small to small stones, orangey-brown, fairly dense 1.83	5						
		2	358.23	2	AU	4	4
Silty Sand Till: little clay, trace very small stones, light brown with orange tinge, sl. moist			357.26				
	10			3	PQ	2.8	3.5
Sandy Clay Till/Clayey Sand Till: minor very small to small stones, brown except 10'3" to 11'7" which is grey, moist		4					
	15			4	PQ	1.8	5
5.18			354.67				
Medium Sand: minor fine sand, structureless, brown, wet	20	6		5	PQ	2.3	5
			353.14				
Fine/Medium Sand: laminated (some areas faint, others more prominent 22'6" to 23'6" - Fine Sand	25	8		6	PQ	4.75	5
29'3" to 30'10" - Fine Sand							
grey at 30'10" structureless from 30'10" to 31'9"	30			7	PQ	5	5
		10	350.09				
Fine Sand: structureless, grey, wet 11.28	35		349.33	8	PQ	4.8	5
Fine/Medium Sand: occ. stone, pseudo clay laminae			348.57				
Sandy Clay Till: little small stones, grey, dense 12.19	40	12	347.87	9	PQ	3.4	5
Very Fine to Fine Sand: occ. blebs/laminae of clay at top structureless, grey 13.72							
	45	14	346.50	10	PQ	3.4	5
Clay Till: trace very small stones, little fine sand occurring as "cracks", grey 47'6" to 48'3" - faint silt blebs 15.24							
	50		344.97	11	PQ	2.2	5
Fine Sand: little silt, lt brown, structurelesss, wet		16	344.00				
Medium Sand: structureless, grey, wet	55			12	PQ	0.8	5
		18					
	60			13	PQ	3	5
			340.49				
Fine Sand: structureless, grey, wet	65	20		14	PQ	3.5	5
65'1" to 65'7" - laminated				15	PQ	4	5
	70						

GROUND WATER MONITOR



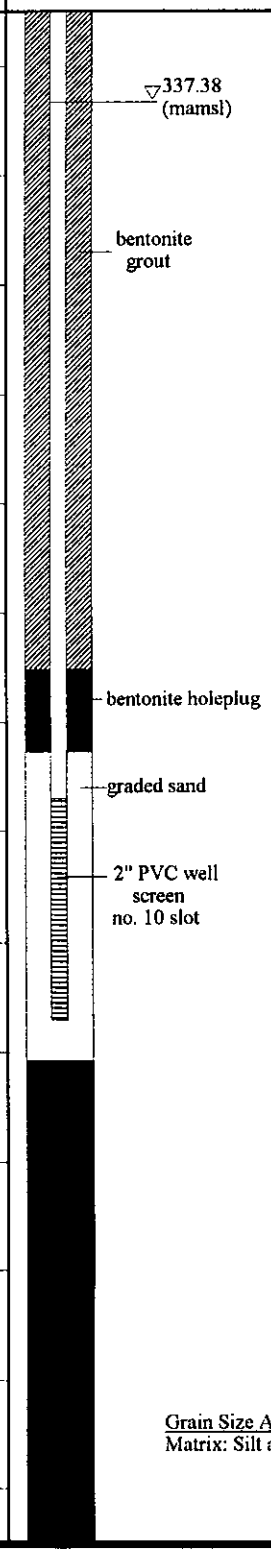
Terraqua Investigations Ltd.

BOREHOLE NO. : WM-93-20

PROJECT - CLIENT : Waterloo Moraine Study - Region of Waterloo
DATE : December 2 to December 7 1993
PROJECT NO. : TA92378
SUPERVISOR : W. Best
CONTRACTOR : All Terrain Drilling Ltd.
METHOD : Christensen PQ (5.25" O.D.) Core Barrel Wireline System and 4.25" I.D. (8" O.D.) Hollow Stem Augers

GEOLOGIC DESCRIPTION	DEPTH ft	DEPTH m	ELEV. (mAMSL)	SAMPLES #	type	rec ft	interval ft
	70						
Fine Sand: as described above		22					
	75			16	PQ	4.4	5
laminated from 76'1" to 77'8"		24					
-	80		335.80	17	PQ	4.3	5
Fine/Medium Sand: grey, structureless							
	85	26		18	PQ	4.3	5
	90			19	PQ	3.75	5
28.35		28					
			331.81				
Clay (Till?) then Silt: 28.96	95		331.14	20	PQ	4.2	5
Fine/Medium Sand: alternating between laminated and not laminated, grey-brown to grey		30					
94'8" to 95'9" - Fine Sand	100			21	PQ	4.5	5
	105	32		22	PQ	4.5	5
	110			23	PQ	4.5	5
		34	326.29				
Medium Sand: structureless, grey							
35.36	115		324.95	24	PQ	4.1	5
Coarse Sand: structureless, grey			324.49				
Silty Clay Till: trace very small stones, grey, dense mottled with silt as "cracks" and pseudo blebs from 117'6" to 124'5"		36					
	120			25	PQ	5	5
Grain Size Analysis at 119': Matrix: Silty Clay, trace fine sand 38.10		38					
	125		322.08	26	PQ	5	5
Silt and Clay: lamintaed with clay, from 127'6" to 132'6" proportions of silt and clay are almost identical, moderately dense, grey	130	40		27	PQ	5	5
129'9" to 130' 5" - Silt 132'6" to 133'9" - Silt 40.84			319.23				
Clay (Till?): mottled with tiny silt blebs or pseudo laminae, no stones except for last foot	135	42		28	PQ	5	5
			318.09				
Layered Clay: grey & red-brn			317.79	29	PQ	4.1	4
	140						

GROUND WATER MONITOR



Grain Size Analysis at 134': Matrix: Silt and Clay, trace fine sand

Terraqua Investigations Ltd.

BOREHOLE NO. : WM-93-20

PROJECT - CLIENT : Waterloo Moraine Study - Region of Waterloo
DATE : December 2 to December 7 1993
PROJECT NO. : TA92378
SUPERVISOR : W. Best
CONTRACTOR : All Terrain Drilling Ltd.
METHOD : Christensen PQ (5.25" O.D.) Core Barrel Wireline System and 4.25" I.D. (8" O.D.) Hollow Stem Augers

GEOLOGIC DESCRIPTION	DEPTH ft	DEPTH m	ELEV. (mAMSL)	SAMPLES #	type	rec ft	interval ft	GROUND WATER MONITOR
	140							
Clayey Silt: occassional to trace very small stone, grey, dense 144'9" to 145'6" - Silt: grey	145	44		30	PQ	5.8	6	bentonite holeplug
			315.65					
Clay Till:			315.04					
End of Borehole - 147'6"	150	46						
44.96	155	48						
	160	50						
	165							
	170	52						
	175	54						
	180	56						
	185							
	190	58						
	195	60						
	200	62						
	205							
	210	64						

INSTALLATION SUMMARY

Monitor	Sandpack top	Sandpack bottom	Screen top	Screen bottom	Static WL ▽	date
WM-93-20-S	355.5	351.8	354.8	351.8	358.40	05/94
WM-93-20-I	328.4	324.0	327.7	324.6	337.38	05/94

- All values are elevations (mamsl)
- Water levels given are post development statics

WT-MW-OW3-09-(A-B)

PROJECT: 08-1112-0150

BOREHOLE LOG OF: WT-MW-OW03AB-09

SHEET 1 OF 2

LOCATION: N 4804996.0 ;E 536554.0

DRILLING DATE: December 2, 2009

DATUM: NAD83

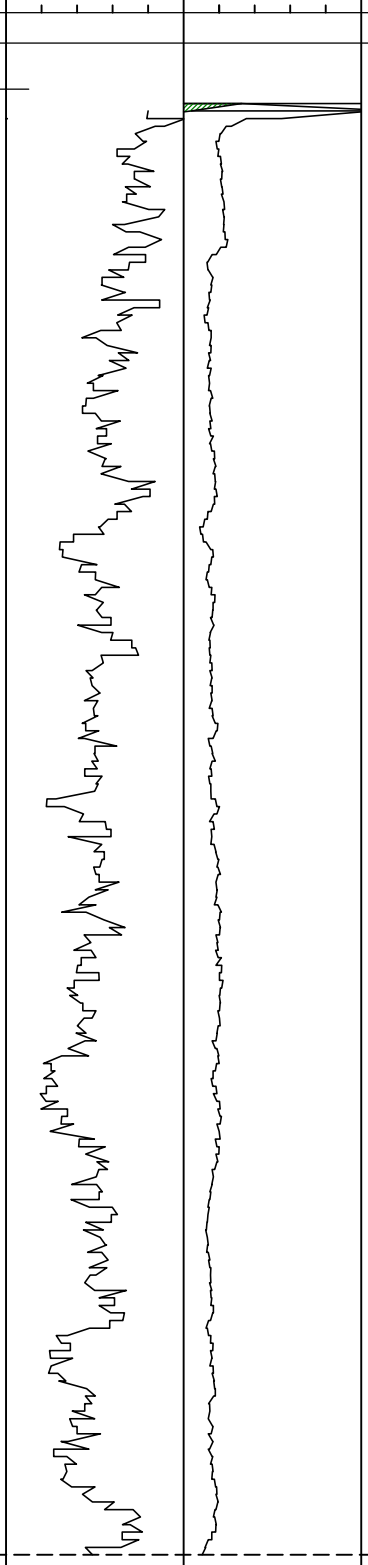
DRILL RIG: Sonic

DRILLING CONTRACTOR: Boart Longyear

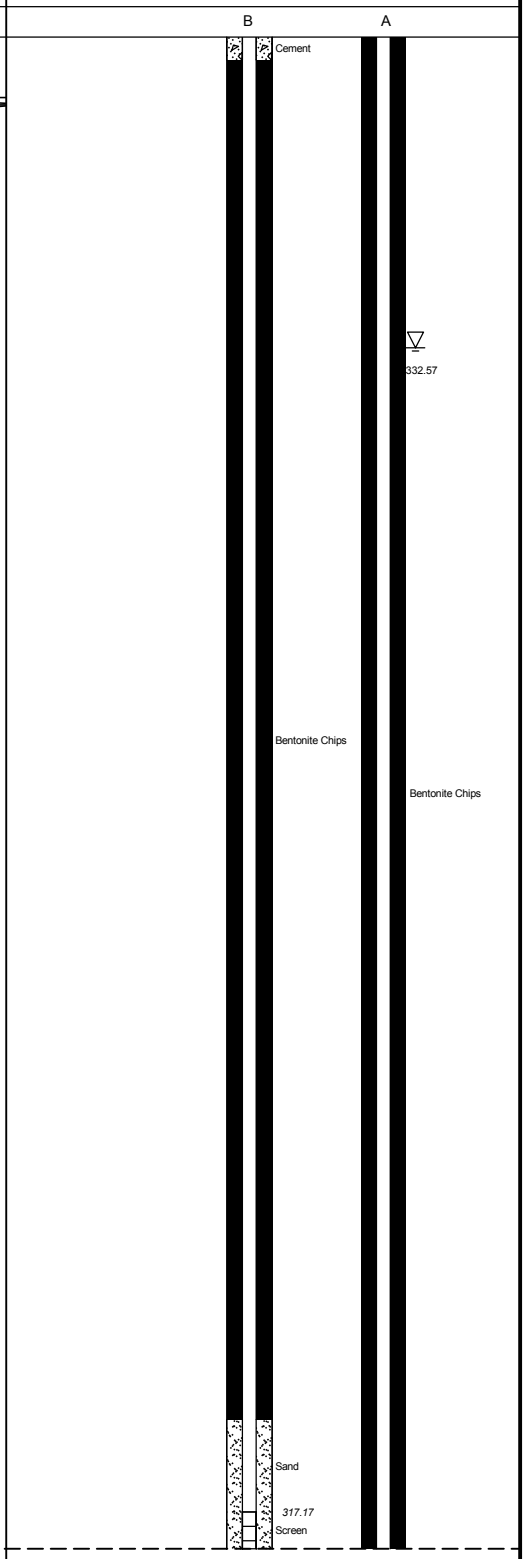
DEPTH SCALE METRES	DESCRIPTION	ELEV. / DEPTH (m)	OGS CODE
	GROUND SURFACE	336.68	
0	Very loose, moist, black, organics, peat, some rootlets, sand	0.00 / 336.07	
	Compact, moist, brown, sandy SILT, some beddings	0.61 / 335.16	
2	Loose to compact, moist, brown, medium to fine SAND, some silty sand layers throughout, trace gravel	1.52 / 333.33	
	Some gravel	3.35 / 325.40	AFB1
4			
6			
8			
10			
	Some coarse sand, trace gravel	11.28 / 319.31	
12			
14			
16			
	Loose to compact, moist to wet, brown, medium SAND, trace gravel	17.37	
18			
20			

CONTINUED NEXT PAGE

GEOPHYSICAL RECORD



PIEZOMETER OR STANDPIPE INSTALLATION



DEPTH SCALE

1 : 100

Golder Associates

LOGGED: KS

CHECKED: DN

MIS-HYD 009 08-1112-0150.GPJ GAL-MISS.GDT 2/7/11 RJ

PROJECT: 08-1112-0150

BOREHOLE LOG OF: WT-MW-OW03AB-09

LOCATION: N 4804996.0 ;E 536554.0

DRILLING DATE: December 2, 2009

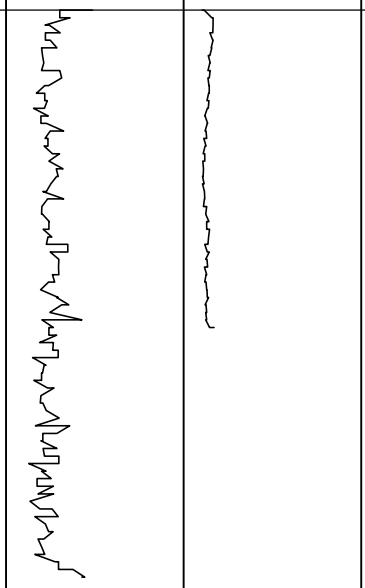
DRILL RIG: Sonic

DRILLING CONTRACTOR: Boart Longyear

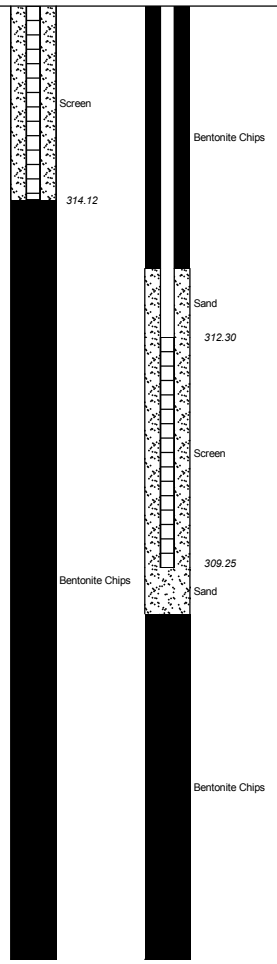
DATUM: NAD83

DEPTH SCALE METRES	DESCRIPTION	ELEV. / DEPTH (m)	OGS CODE
	--- CONTINUED FROM PREVIOUS PAGE ---		
20	Loose to compact, moist to wet, brown, medium SAND, trace gravel	315.34	AFB1
	Compact, wet, brown, medium to coarse SAND and GRAVEL, some silt	21.34	
22		313.21	
	Compact, saturated, brown, medium to coarse GRAVEL, trace sandy silt	23.47 / 23.65	
24	Compact, saturated, brown, medium SAND and GRAVEL, trace silt, trace cobbles	312.60 / 24.08	
	Compact, wet, brown to greyish brown, medium SAND, some gravel		
26	SA-1 (25.9-26.8 m)		
28		307.11	
30	Compact, moist, brown to greyish brown, sandy SILT, trace to some gravel, trace clay (TILL)	29.57	ATC1
32		304.07	
	END OF BOREHOLE	32.61	
34			
36			
38			
40			

GEOPHYSICAL RECORD



PIEZOMETER OR STANDPIPE INSTALLATION



DEPTH SCALE

1 : 100

Golder Associates

LOGGED: KS

CHECKED: DN

Monitoring Well: WT-MW-OW1-21-A

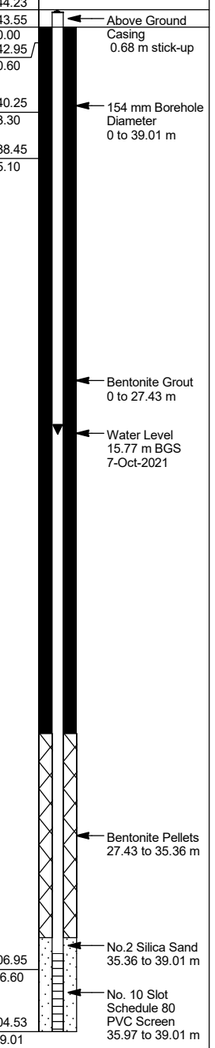
WT-MW-OW1-21-A

Project:	K21/K26 Well Replacement	**Field Investigator:**	S. Baer	**Ground surface elevation:**	343.55 m AMSL
Client:	Regional Municipality of Waterloo	**Contractor:**	Aardvark Drilling Inc.	**Top of casing elevation:**	344.23 m AMSL
Location:	Kitchener ON	**Drilling method:**	CME 75 truck mount - Hollow Stem Auger/PQ Mud Rotary	**Easting:**	537722.36
Number:	165640303	**Date started/completed:**	27-Sep-2021 / 29-Sep-2021	**Northing:**	4803202.56

SUBSURFACE PROFILE

Lithologic Description	Elevation (m AMSL) Depth (m BGS)
	344.23
Ground Surface	343.55
FILL	0.00
CLAYEY SILT	342.95 / 0.60
SILTY SAND	340.25 / 3.30
GRAVEL Coarse gravel with some cobbles and fine gravel	338.45 / 5.10
SAND	306.95 / 36.60
End of Borehole	304.53 / 39.01

WELL DETAILS



Screen Interval: 35.97 - 39.01 m BGS
Sand Pack Interval: 35.36 - 39.01 m BGS
Well Seal Interval: 0.00 - 35.36 m BGS

Stantec

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
n/a - not available/applicable

Lithologic description between 0 and 16.8 m BGS was logged in the field. Lithologic description below 16.8 m BGS was provided by the drilling contractor on the MECP Water Well Records.
KWT-MW-OW1-21-A is a replacement well for WT-MW-OW01-09-A. More detailed lithologic descriptions can be found on those borehole logs.

Drawn By/Checked By: SB/ KM

STANTEC BOREHOLE AND WELL - MASTER 17X11 165640303_K21-K26_SB.GPJ DATA TEMPLATE_ENVS_CA_140725.GDT 6/12/23 AHEALEY

BURNSIDE

[THE DIFFERENCE IS OUR PEOPLE]

Appendix B-2

Mannheim ASR Well Logs

Appendix B-2

ASR1

CH2M Gore & Storrie Ltd.

PROJECT NUMBER: 211K44073A.B4

WELL NUMBER: ASR-1

MONITORING WELL DRILLING & CONSTRUCTION LOG

CLIENT NAME: RMOW

LOCATION: Mannheim WTP- Warren Pit

DATE DRILLED: Nov.-Dec.1996

LOGGER: Peter Lamont

DRILL COMPANY: All Terrain Drilling Ltd./ IWS Ltd.

DRILLING METHOD: MR/CC/RC

ELEVATIONS: (METERS) -SURFACE ELEV.:

-TOTAL DEPTH: 72.24

EASTING:

NORTHING:

DEPTH BELOW SURFACE (METERS)	SOIL SAMPLE: INTER-VAL (METERS)	SOIL SAMPLE: TYPE AND NUMBER	SOIL SAMPLE: RE-COVERY (cm)	SOIL DESCRIPTION (NAME, COLOUR, SOIL STRUCTURE PARTICAL SIZE DISTRIBUTION, MOISTURE CONTENT, PLASTICITY, DENSITY.)	WELL CONSTRUCTION (CASING, SCREEN INTERVAL, SAND PACK, SEAL, ETC.)
		CONTINUOUS CS			
0				**Coarse Sand/Gravel** (0-3.05 m) coarse sand & gravel-well rounded	**Surface Casing** (0-6) 660 mm dia. steel casing cemented into place
5				**Sand** (3.05-6.10 m) fine to medium, trace gravel	Borehole diameter: 914 mm: 0-6.1 m 813 mm: 6.1-45.7 m
				Sand (6.10-8.22 m) fine to very fine, trace to some silt	
10				**Sand** (8.22-10.67 m) very coarse with fine gravel, some oxidation	
				Silt (10.67-14.63 m) moderate yellow brown (10YR 5/4) sandy silt with some clay	
15				**Sand** (14.63-19.20 m) medium to fine sand, trace silt, trace gravel	**Concrete Well Seal** (0-36.6) 2% bentonite:cement mix
20					

CH2M Gore & Storrie Ltd.

PROJECT NUMBER: 211K44073A.B4

WELL NUMBER: ASR-1

MONITORING WELL DRILLING & CONSTRUCTION LOG

CLIENT NAME: RMOW

LOCATION: Mannheim WTP- Warren Pit

DATE DRILLED: Nov.-Dec.1996

LOGGER: Peter Lamont

DRILL COMPANY: All Terrain Drilling Ltd./ IWS Ltd.

DRILLING METHOD: MR/CC/RC

ELEVATIONS: (METERS) -SURFACE ELEV.:

-TOTAL DEPTH: 72.24

EASTING:

NORTHING:

DEPTH BELOW SURFACE (METERS)	SOIL SAMPLE: INTER-VAL (METERS)	SOIL SAMPLE: TYPE AND NUMBER	SOIL SAMPLE: RE-COVERY (cm)	SOIL DESCRIPTION: NAME, COLOUR, SOIL STRUCTURE PARTICAL SIZE DISTRIBUTION, MOISTURE CONTENT, PLASTICITY, DENSITY.	WELL CONSTRUCTION: CASING, SCREEN INTERVAL, SAND PACK, SEAL, ETC.
		CONTINUOUS CS			
20				**Clay** (19.20-22.56 m) moderate yellow brown (10YR 5/4) clay, trace to some sand, trace silt, increasing sand % with depth to lower contact	**Gravel Supply Tubes** (0-44) 50 mm dia. steel pipe
				Sand (22.56-30.48 m) medium to coarse sand, fining with depth to some fine sand at lower contact	
25					**Well Casing** (0-53.65) 442 mm O.D. Certa-Lok™ PVC pipe
30				**Clay** (30.48-32.00) clay with fine sand, some silt, some medium to coarse sand	
				Sand (32.00-41.15 m) 32.0-36.58 m: silty medium to coarse sand, trace gravel	
35				36.58-41.15 m: fine to coarse sand, trace silt, some fine gravel at lower 1.5 m	**Well Seal** (36.6-40) bentonite chips
40					

CH2M Gore & Storrie Ltd.

PROJECT NUMBER: 211K44073A.B4

WELL NUMBER: ASR-1

MONITORING WELL DRILLING & CONSTRUCTION LOG

CLIENT NAME: RMOW

LOCATION: Mannheim WTP- Warren Pit

DATE DRILLED: Nov.-Dec.1996

LOGGER: Peter Lamont

DRILL COMPANY: All Terrain Drilling Ltd./ IWS Ltd.

DRILLING METHOD: MR/CC/RC

ELEVATIONS: (METERS) -SURFACE ELEV.:

-TOTAL DEPTH: 72.24

EASTING:

NORTHING:

DEPTH BELOW SURFACE (METERS)	SOIL SAMPLE: INTERVAL (METERS)	SOIL SAMPLE: TYPE AND NUMBER	SOIL SAMPLE: RECOVERY (cm)	SOIL DESCRIPTION: NAME, COLOUR, SOIL STRUCTURE PARTICAL SIZE DISTRIBUTION, MOISTURE CONTENT, PLASTICITY, DENSITY.	WELL CONSTRUCTION: CASING, SCREEN INTERVAL, SAND PACK, SEAL, ETC.
		CONTINUOUS CS			
40					
				Gravel (41.15-45.72 m) fine gravel with medium sand, some fine and coarse sand	**Filter Pack** (40.0-72.2) #1 W.G. silica sand
45					
				Sand (45.72-49.98) very coarse with gravel/cobbles, trace to some silt	
		R1	90		Borehole diameter 711 mm: 45.7-56.4 m
		R2	110		
50		R3	150	**Sand** (49.98-52.42 m) medium to very coarse, poorly sorted, trace to some gravel, faint H_2S odour	
		R4	150		
		R5	110	**Gravel/Cobbles** (52.42-55.84 m) gravel/cobbles, round to sub-rounded with silt and sand	**Well Screen** (53.65-55.47) 406 mm dia. #304 S.S., #35 slot wire wound
55		R6	10		
		R7	130	**Sand** (55.84-57.16 m) moderate yellow brown (10YR 5/4) fine sand, trace clay/silt	**Blank** (55.47-57.00) #304 Stainless Steel
		R8	105	**Sand** (57.16-58.52 m) medium to coarse, well sorted, trace silt/gravel	Borehole diameter 610 mm: 56.4-72.2 m
		R9	75	**Sand** (58.52-60.05 m) fine sand, well sorted, with silt	
60					

CH2M Gore & Storrie Ltd.

PROJECT NUMBER: 211K44073A.B4

WELL NUMBER: ASR-1

MONITORING WELL DRILLING & CONSTRUCTION LOG

CLIENT NAME: RMOW

LOCATION: Mannheim WTP- Warren Pit

DATE DRILLED: Nov.-Dec.1996

LOGGER: Peter Lamont

DRILL COMPANY: All Terrain Drilling Ltd./ IWS Ltd.

DRILLING METHOD: MR/CC/RC

ELEVATIONS: (METERS) -SURFACE ELEV.:

-TOTAL DEPTH: 72.24

EASTING:

NORTHING:

DEPTH BELOW SURFACE (METERS)	SOIL SAMPLE: INTERVAL (METERS)	SOIL SAMPLE: TYPE AND NUMBER	SOIL SAMPLE: RECOVERY (cm)	SOIL DESCRIPTION (NAME, COLOUR, SOIL STRUCTURE PARTICAL SIZE DISTRIBUTION, MOISTURE CONTENT, PLASTICITY, DENSITY.)	WELL CONSTRUCTION (CASING, SCREEN INTERVAL, SAND PACK, SEAL, ETC.)
		CONTINUOUS CS			
60		R10	60	**Sand** (60.05-63.49 m) moderate brown (5YR 4/4 - 3/4) medium to coarse sand, trace silt, occasional cobbles, gravel, H_2S odour at lower contact	**Well Screen** (57.0-66.14) 406 mm dia. #304 S.S., #35 slot wire wound
		R11	130		
		R12	150	**Sand** (63.49-66.68 m) moderate yellow brown (10YR 5/4) medium sand, some fine and coarse sand, well sorted, trace silt/gravel, faint H_2S odour	
65		R13	144		
		R14	80	**Silt** (66.68-69.07 m) light brown (5YR 5/6) silt, compact, layers of fine to very fine sand, strong H_2S odour at lower contact	**Well Sump** (65.84-72.2) #304 Stainless Steel
		R15	150		
70		R16	150	**Silt** (69.07-72.24 m) pale brown (5YR 5/2) to brown grey (5YR 4/1) silt, trace to some clay, trace gravel, strong H_2S odour, silt becoming medium dark grey (N4) at lower contact	
		R17	150		
				End of Drilling	
75					
80					

ASR2

9201293

Figure A-1: ASR2

Project: Mannheim ASR Project, Stage 1

Project No.: 121099

Started Drilling: 11-10-2002

Completed Drilling: 11-17-2002

Bore Hole Diameter: 660mm from 0-66.5 mbgs

Total Depth of Bore Hole: 66.5 mbgs

Geologic Log by: Boyd Pendleton, CH2M Hill

Started Well Construction: 11-17-2002

Completed Well Construction: 11-20-2002

Total Depth of Well: 65.56 mbgs

Drill Method: Conventional Mud Rotary

Grout: Type II portland cement with 8% bentonite

Drilling Contractor: Davidson Drilling Ltd.

Casing Type: 390mm ID Certa-Lok PVC (SDR 17)

Sump Type: 394mm ID 304 SS sump

Screen Type: 406mm OD 304 SS Johnson high flow wire wrap screen 0.07" slot

Screen Interval: 52.37 - 59.77 mbgs

Gravel Quantity & Type: 14.0 Metric Tonnes Red Flint Michigan #60

Notes: Pilot bore hole cored by Roto-Sonic methods on 10-03-02 to 10-4-02

Location: Mannheim, Ontario

Northing: 8907.1 m

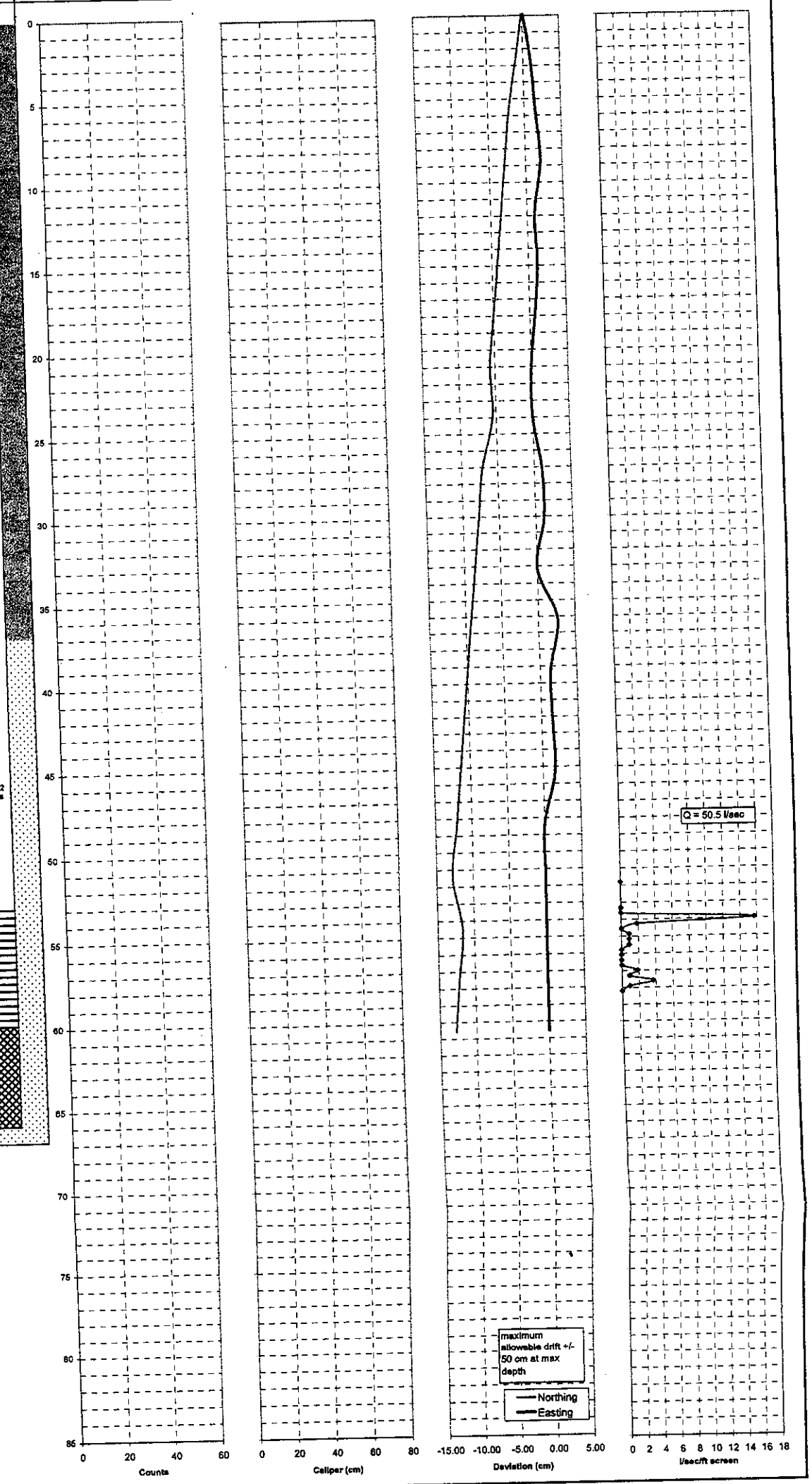
Easting: -3795.4 m

Ground Elevation: 378.30 masl

Well Head Elevation: 379.50 masl

Survey Datum: ASR site cordinates

Depth of Interval (m)	Abbreviated Geologic Description
0-2.4	Well graded sand with Gravel, dark brown, moist, dense
2.4-5.5	No Sample Recovery
5.5-6.4	Poorly Graded Fine Sand, brown, moist, loose
6.4-12.2	Fine Sand with Silt, brown, moist, loose
12.2-12.5	Clay, red-brown, moist, stiff
12.5-22.3	Silt, red-brown,moist, med-dense
22.3-24.1	Poorly Graded med Sand, grey-brown, moist, loose
24.1-26.8	Silt, red-brown,moist, med-dense
26.8-35.1	Silt with fine Sand, light brown, dry-moist, loose
35.1-36.0	Well Graded Gravel with Silt, light brown, dry-moist, loose
36.0-39.9	Poorly Graded med Sand, brown-grey, moist, loose
39.9-42.7	Well Graded Gravel with Sand, brown, wet, loose
42.7-44.8	Well Graded Gravel with Sand & Silt, brown, moist, loose
44.8-47.2	Well Graded Sand with Gravel & Silt, brown, wet, loose
47.2-47.9	Poorly Graded Coarse Gravel, grey, wet, loose
47.9-52.4	Well Graded fine-med Sand with Gravel, brown, wet, loose
52.4-53.9	Well Graded Coarse Gravel, brown, wet, loose
53.9-55.8	Well Graded Coarse Gravel with Sand, brown, wet, loose
55.8-59.7	Poorly Graded med Sand, brown, wet, loose
59.7-62.5	Lean Clay, grey, moist, stiff



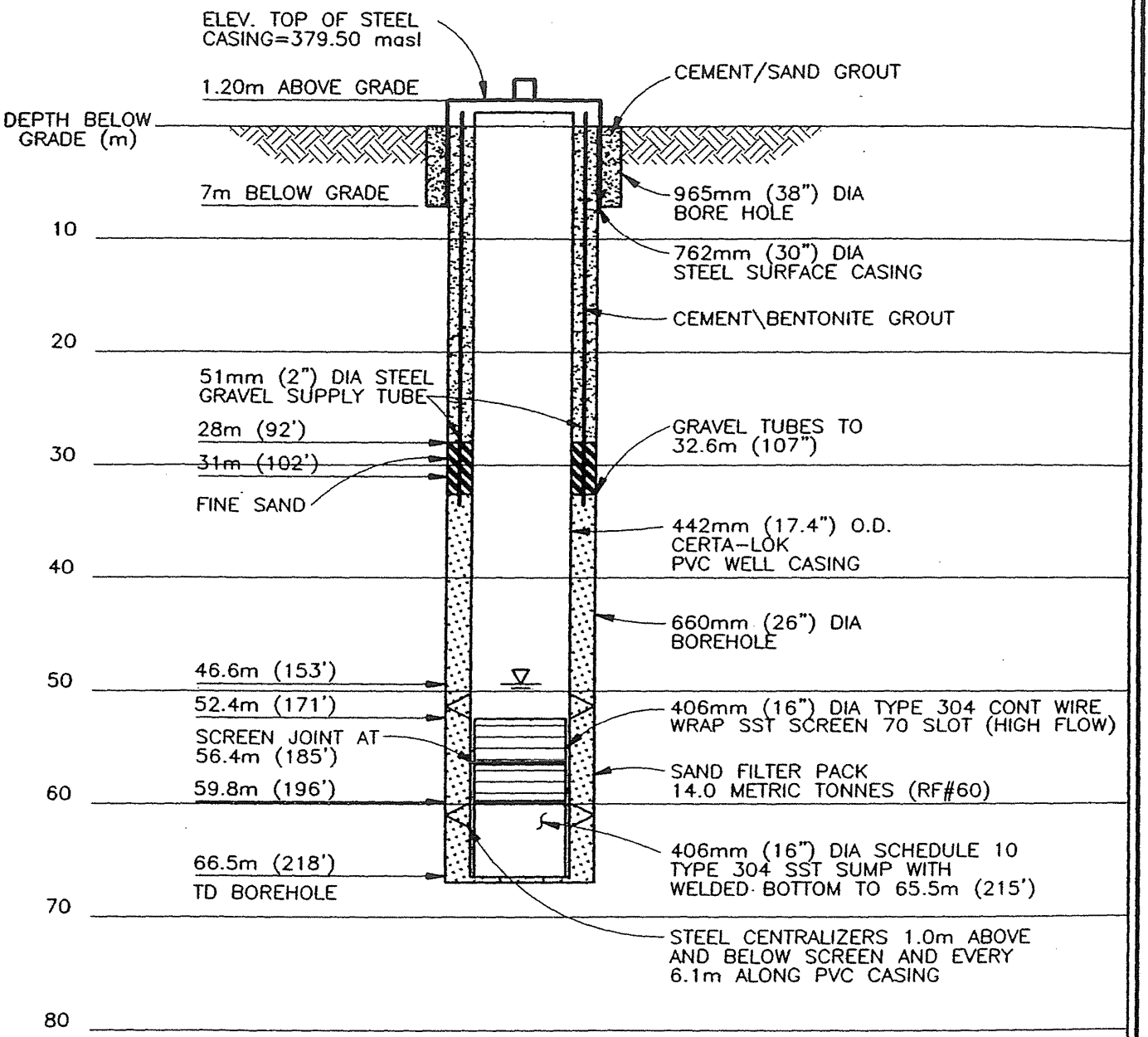
CH2M HILL

CH2M Hill Canada Limited
180 King Street South, Suite 600
Waterloo, ON N2J 1P8
519-579-3501

LEGEND:
= Cement bentonite grout
= #60 RF Sand
= 0.07" SS Screen
= SS Blank Sump

ASR2

24/FEB/2003



NOTE:
NOT TO SCALE

CH2MHILL	MANNHEIM ASR SYSTEM
DATE : 2-18-03	FIGURE A-6
PROJECT No. 121099	ASR 2 AS BUILT WELL CONSTRUCTION

121099f011B

ASR3

9201290

Project: Mannheim ASR Project, Stage 1

Project No.: 121099

Started Drilling: 01-04-2003

Completed Drilling: 01-06-2003

Bore Hole Diameter: 660mm from 0-63.4 mbgs

Total Depth of Bore Hole: 63.4 mbgs

Geologic Log by: Boyd Pendleton, CH2M Hill

Figure A-2: ASR3

Started Well Construction: 01-07-2003

Completed Well Construction: 01-09-2003

Total Depth of Well: 63.12 mbgs

Drill Method: Conventional Mud Rotary

Grout: Type II portland cement with 8% bentonite

Drilling Contractor: Davidson Drilling Ltd.

Casing Type: 390mm ID Certa-Lok PVC (SDR 17)

Sump Type: 394mm ID 304 SS sump

Screen Type: 406mm OD 304 SS Johnson high flow wire wrap screen 0.07" slot

Screen Interval: 51.82 - 57.02 mbgs

Gravel Quantity & Type: 10.35 Metric Tonnes Red Flint Michigan #60

Notes: Pilot bore hole cored by Roto-Sonic methods on 10-02-02 to 10-03-02

Location: Mannheim, Ontario

Northing: 8809.9 m

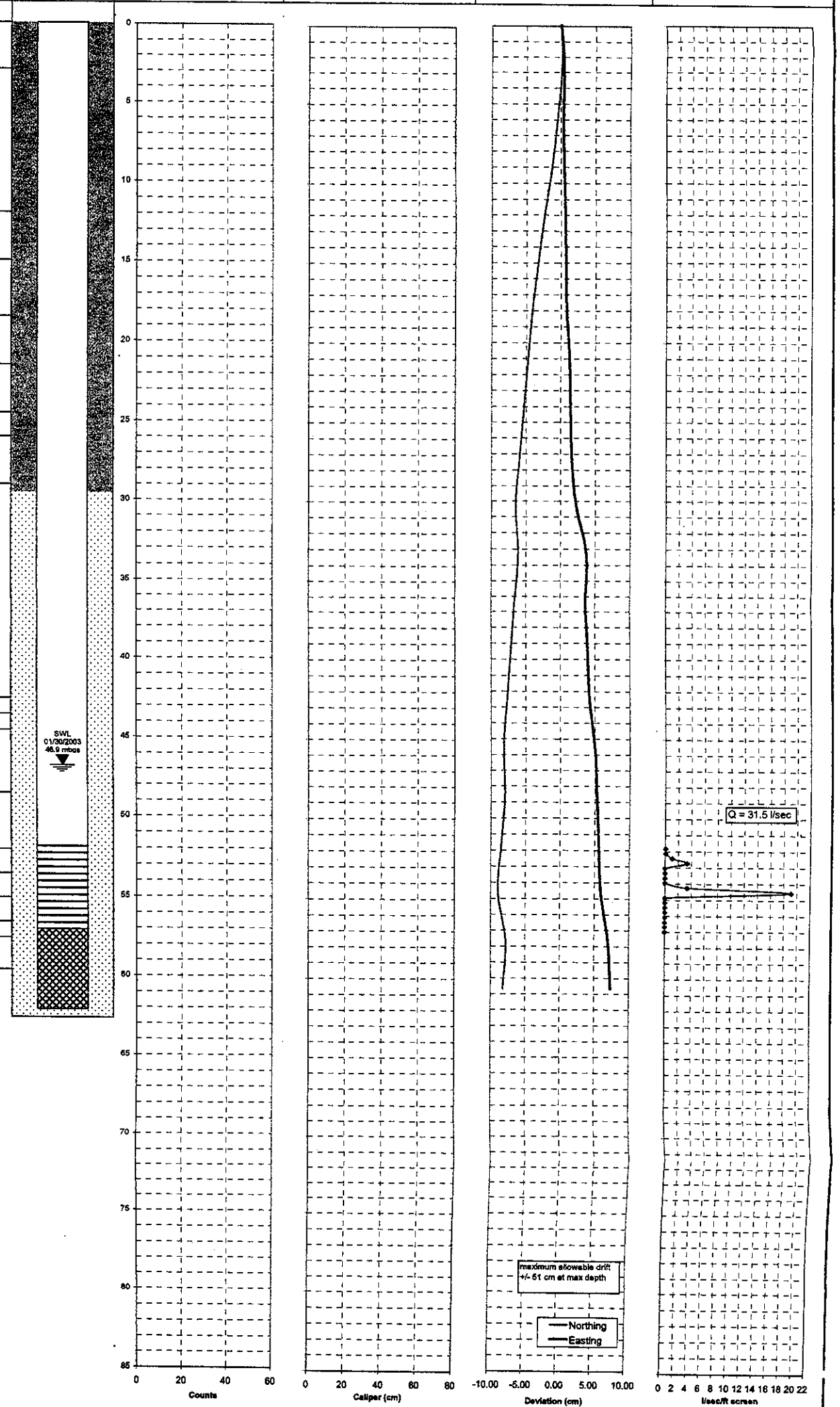
Easting: -3616.5 m

Ground Elevation: 376.94 masl

Well Head Elevation: 377.82 masl

Survey Datum: ASR site cordinates

Depth of Interval (m)	Abbreviated Geologic Description
0-3.1	Well Graded coarse Sand with Gravel, grey
3.1-12.2	Poorly Graded fine Sand, brown
12.2-15.2	Lean Clay, brown
15.2-18.3	Lean Clay with Silt, brown
18.3-21.3	Poorly Graded fine Sand with Silt, brown
21.3-24.4	Silt with fine Sand, brown
24.4-25.9	Lean Clay with Silt, brown
25.9-29.0	Fine Sand with Silt and Coarse Gravel, brown
29.0-42.7	Poorly Graded fine Sand with Silt, brown
42.7-43.6	Silty Sand with Gravel, brown, moist, med-dense
43.6-44.5	Poorly Graded med Sand, brown-orange, moist, loose
44.5-48.5	Well Graded Sand with Silt, brown, wet, loose
48.5-52.1	Well Graded Sand with Gravel & Silt, brown, wet, loose
52.1-53.3	Poorly Graded med Sand w Gravel, brown, wet, loose
53.3-55.2	Well Graded Sand with Gravel, brown, wet, loose
55.2-56.4	Well Graded Sand with Gravel, brown, wet, loose
56.4-57.6	Poorly Graded fine Sand, brown, wet, loose
57.6-59.4	Lean Clay, grey, moist, very stiff

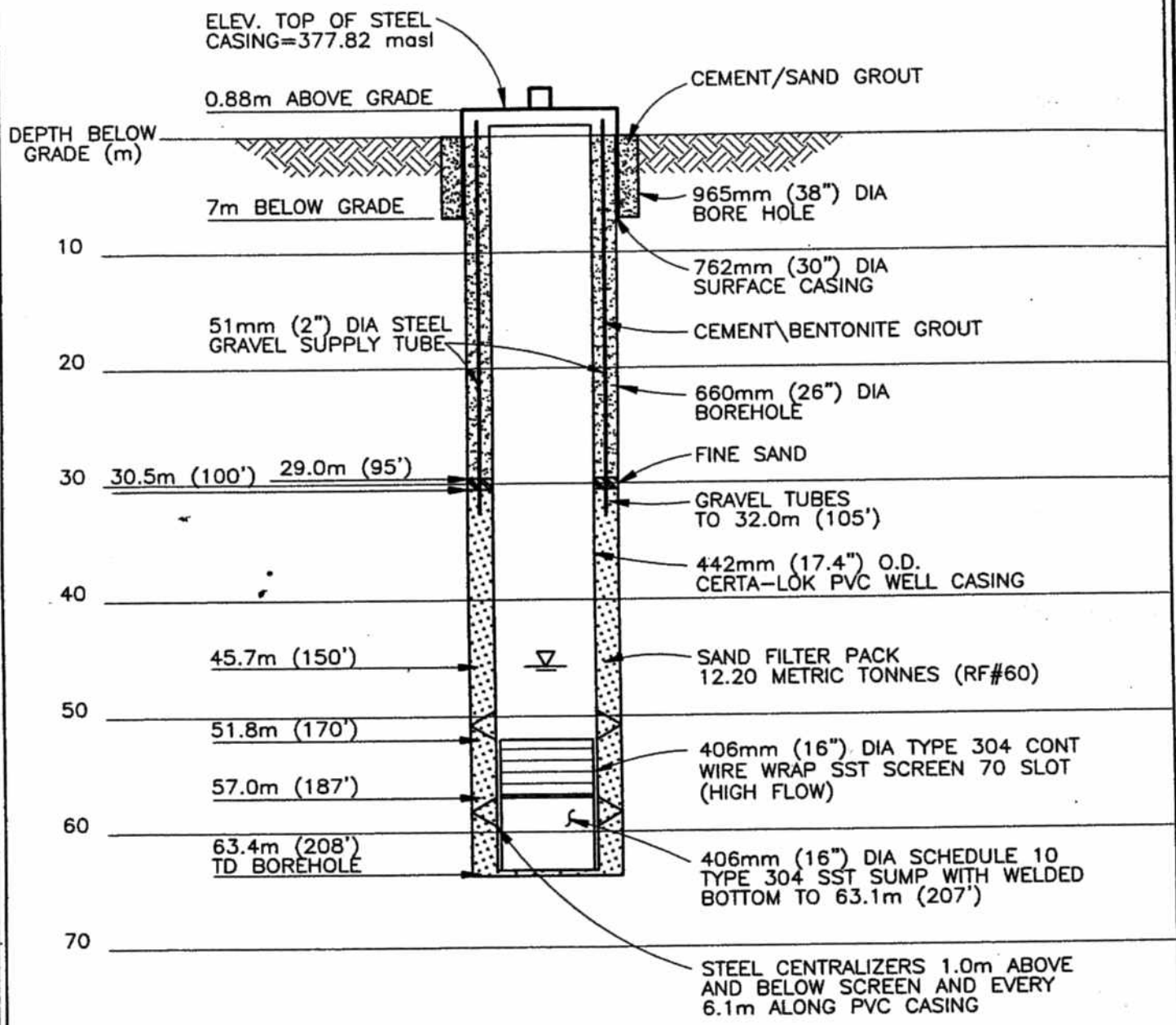


CH2M HILL

CH2M Hill Canada Limited
180 King Street South, Suite 600
Waterloo, ON N2J 1P8
519-579-3501

LEGEND:
= Cement bentonite grout
= #60 RF Sand
= 0.07" SS Screen
= SS Blank Sump

ASR3



NOTE:
NOT TO SCALE

CH2MHILL	MANNHEIM ASR SYSTEM
DATE : 2-18-03	FIGURE A-7
PROJECT No. 121099	ASR 3 AS BUILT WELL CONSTRUCTION

ASR3

Ontario Ministry of the Environment

The Ontario Water Resources Act
WATER WELL RECORD

Print only in spaces provided.
Mark correct box with a checkmark, where applicable.

County or District	Township/Borough/City/Town/Village	Con block tract survey, etc.	Lot
Region of Waterloo	City of Kitchener	Con. GCT	131
Owner's surname / First Name	Address	Date completed (Day Month Year)	
Regional Mun. of Waterloo	150 Frederick St. 4th Floor Waterloo, Ontario	13 Jan 03	

Site Easting Northing

LOG OF OVERBURDEN AND BEDROCK MATERIALS (see instructions)

General colour	Most common material	Other materials	General description	Depth - feet From	To
Grey	Coarse sand	Gravel		0	10
Brown	Fine Sand			10	40
Brown	Clay	Silt		40	60
Brown	Fine Sand	Silt, some sand		60	80
Brown	Clay	Silt		80	85
Brown	Fine Sand	Silt and some coarse gravel		85	95
Brown	Fine Sand	Silt		95	155
Dk.Grey	Med. Sand	Gravel		155	170
Brown	Gravel	Silt		170	191
Grey	Clay	Silt		191	200

WATER RECORD

Water found at - feet	Kind of water
189	☒ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas

CASING & OPEN HOLE RECORD

Inside diam inches	Material	Wall thickness inches	Depth - feet From	To
30	☒ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic	.375	+1	21
17.4	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☒ Plastic	1.024	+3	170
	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic			

SCREEN

Slot No.	Diameter	Length
70	16 inches	17 feet
Material and type	Depth at top of screen	
304 Stainless Steel	170 feet	

PLUGGING & SEALING RECORD

☒ Annular space ☐ Abandoned well

Depth set at - feet From	To	Material and type (Cement grout, bentonite, etc.)
0	95	Neat Cement

PUMPING TEST

Pumping test method ☐ Pump ☐ Bailer | Pumping rate GPM | Duration of pumping Hours Minutes

Static level feet | Water level end of pumping feet | Water levels during ☐ Pumping ☐ Recovery

15 minutes	30 minutes	45 minutes	60 minutes
see ch2M-HILL REPORT			

If flowing give rate GPM | Pump intake set at feet | Water at end of test ☐ Clear ☐ Cloudy

Recommended pump type ☐ Shallow ☐ Deep | Recommended pump setting feet | Recommended pump rate GPM

FINAL STATUS OF WELL

☒ Water supply ☐ Observation well ☐ Test hole ☐ Recharge well ☐ Abandoned, insufficient supply ☐ Abandoned, poor quality ☐ Abandoned (Other) ☐ Dewatering ☐ Unfinished ☐ Replacement well

WATER USE

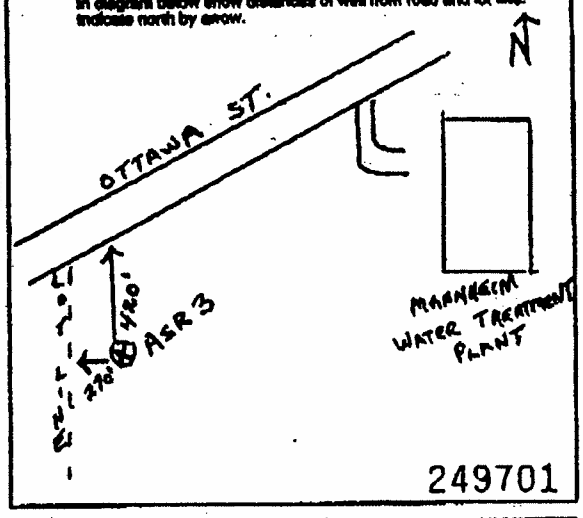
☐ Domestic ☐ Stock ☐ Irrigation ☐ Industrial ☐ Commercial ☒ Municipal ☐ Public supply ☐ Cooling & air conditioning ☐ Not used ☐ Other

METHOD OF CONSTRUCTION

☐ Cable tool ☒ Rotary (conventional) ☐ Rotary (reverse) ☐ Rotary (air) ☐ Air percussion ☐ Boring ☐ Diamond ☐ Jetting ☐ Driving ☐ Digging ☐ Other

LOCATION OF WELL

In diagram below show distances of well from road and lot line. Indicate north by arrow.



249701

Name of Well Contractor	Well Contractor's Licence No.
Davidson Well Drilling Ltd	1737
Address	
Box 486, Wingham, Ontario N0G 2W0	
Name of Well Technician	Well Technician's Licence No.
D.Fenton	T2003
Signature of Technician/Contractor	Submission date
D.W. Davidson per D.Fenton	18 Mar 03

MINISTRY USE ONLY

1 - CONTRACTOR'S COPY

0506 (07/00) Page Form 6

ASR4

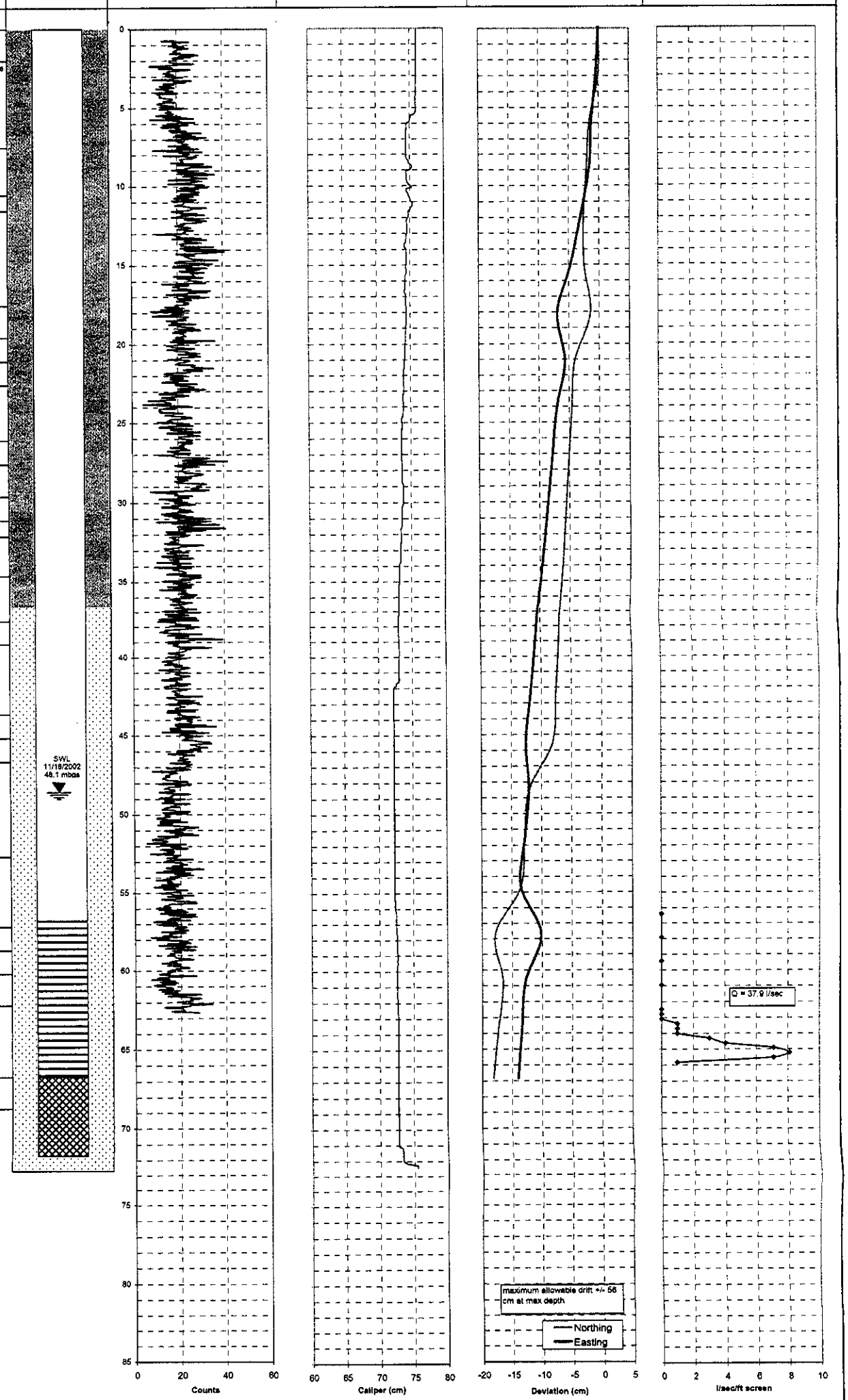
9201294
ASRPW-4A-02

ASR4

Figure A-5: ~~ASR6~~

Project: Mannheim ASR Project, Stage 1				**Location:** Mannheim, Ontario	
Project No.: 121099				**Northing:**	4,805,431 m
Started Drilling: 10-26-2002	**Started Well Construction:** 11-02-2002	**Casing Type:**	390mm ID Certa-Lok PVC (SDR 17)	**Easting:**	538,083 m
Completed Drilling: 10-31-2002	**Completed Well Construction:** 11-06-2002	**Sump Type:**	394mm ID 304 SS sump	**Ground Elevation:** 378.75 masl	
Bore Hole Diameter: 660mm from 0-41.76 mbgs 610 mm from 41.76 - 72.84 mbgs	**Total Depth of Well:** 72.50 mbgs	**Screen Type:**	406mm OD 304 SS Johnson high flow wire wrap screen 0.07" slot	**Well Head Elevation:** 379.45 masl	
Total Depth of Bore Hole: 72.84 mbgs	**Drill Method:** Conventional Mud Rotary	**Screen Interval:**	56.90 - 66.40 mbgs	**Survey Datum:**	NAD 83 (zone 17)
	Grout: Type II portland cement with 8% bentonite	**Gravel Quantity & Type:** 13.6 Metric Tonnes Red Flint Michigan #60			
Geologic Log by: Boyd Pendleton, CH2M Hill	**Drilling Contractor:** Davidson Drilling Ltd.	**Notes:** Pilot bore hole cored by Roto-Sonic methods on 10-01-02 to 10-02-02			

Depth of Interval (m)	Abbreviated Geologic Description
0-2.1	Poorly Graded medium Sand, brown, moist, loose
2.1-7.6	Well Graded Sand with Gravel, light brown, moist-dry, loose
7.6-10.7	Poorly Graded fine Sand, brown, moist, loose
10.7-11.9	Poorly Graded fine Sand, brown
11.9-17.7	Elastic Silt, brown, wet, medium dense
17.7-19.8	Poorly Graded medium Sand, brown, moist, loose
19.8-21.3	Sandy Silt, light grey, moist-dry, loose
21.3-22.9	Silt, brown, moist, loose
22.9-26.2	Well Graded Sand with Silt, light brown, moist, loose
26.2-28.0	Poorly Graded fine Sand, brown, moist, loose
28.0-29.9	Silt, brown, moist, loose
29.9-31.4	Poorly Graded fine Sand, light brown, moist, loose
31.4-32.3	Elastic Silt, brown, moist, medium dense
32.3-35.1	Well Graded Sand, light brown, moist, loose
35.1-38.1	Poorly Graded fine Sand, light brown, moist, loose
38.1-39.6	Poorly Graded medium Sand, brown, moist, loose
39.6-44.2	Poorly Graded fine Sand, light brown, moist, loose
44.2-45.7	Well Graded fine-medium Sand, brown, moist, loose
45.7-47.2	Poorly Graded fine Sand, brown, moist, loose
47.2-53.3	Poorly Graded medium Sand, brown, wet, loose
53.3-57.9	Well Graded Sand, brown, wet, loose
57.9-59.4	Well Graded Gravel with Sand, brown, wet, loose
59.4-61.0	Same as above but less gravel
61.0-63.1	Well Graded Sand, brown, wet, loose
63.1-66.4	Well Graded Gravel with Sand, brown, wet, loose
66.4-68.6	Elastic Silt, grey-brown, wet, medium stiff



CH2MHILL

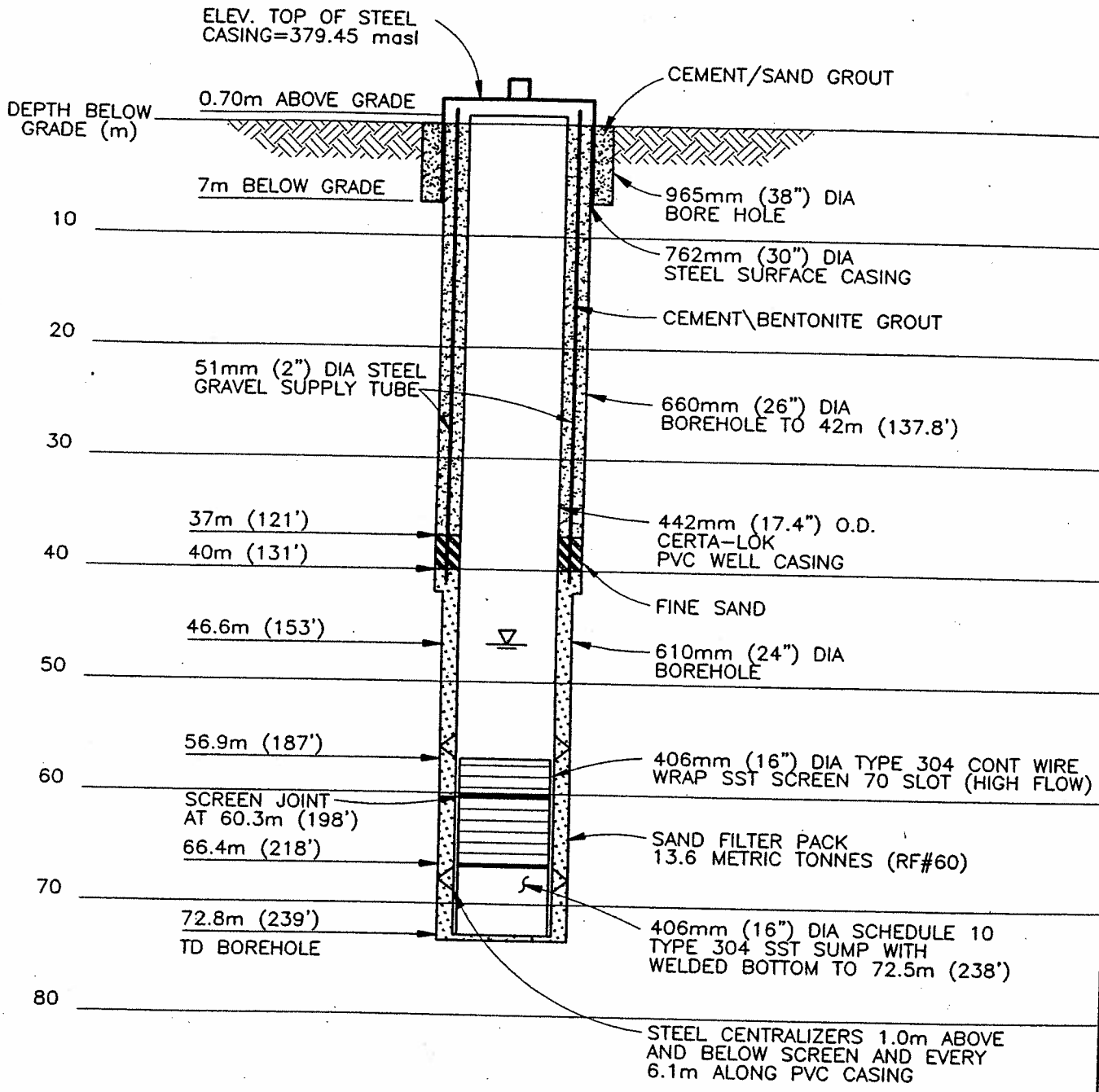
CH2M Hill Canada Limited
180 King Street South, Suite 600
Waterloo, ON N2J 1P8
519-579-3501

LEGEND:
= Cement bentonite grout
= #60 RF Sand
= 0.07" SS Screen
= SS Blank Sump

ASR4

renamed ASR4

24/FEB/2003



NOTE:
NOT TO SCALE

CH2MHILL	MANNHEIM ASR SYSTEM
DATE : 2-18-03	FIGURE A-10
PROJECT No. 121099	ASR 6 (previous 10)
	AS BUILT WELL CONSTRUCTION

121099f011A

ASR4

Ontario Ministry of the Environment

The Ontario Water Resources Act
WATER WELL RECORD

Print only in spaces provided.
Mark correct box with a checkmark, where applicable.

County or District	Township/Borough/City/Town/Village	Con block tract survey, etc.	Lot
Region of Waterloo	City of Kitchener	Con. GCT	131
Owner's surname / First Name: Reg. Mun. of Waterloo	Address: 150 Frederick St. 4th Floor Kitchener, Ontario	Date completed: 6 (day) Nov (month) 02 (year)	

Zone ☐ Easting ☐ Northing ☐

LOG OF OVERBURDEN AND BEDROCK MATERIALS (see instructions)

General colour	Most common material	Other materials	General description	Depth - feet From	To
Brown	Sand		Med.	0	7
Brown	Sand	Gravel	Med.	7	25
Brown	Sand		Fine	25	39
Brown	Silt	Clay		39	59
Brown	Silt	Sand		59	98
Brown	Sand	Silt	Fine	98	106
Brown	Sand	Silt, gravel		106	215
Brown	Silt	Clay		215	225

WATER RECORD

Water found at - feet	Kind of water
39	☒ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
175	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas

CASING & OPEN HOLE RECORD

Inside diam inches	Material	Wall thickness inches	Depth - feet From	To
30	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic	.375	+1	21
17.4	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☒ Plastic	1.024	+3	185
	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic			

SCREEN

Slots of opening (Slot No.)	Diameter	Length
70	16 inches	31 feet
Material and type: 304 Stainless Steel	Depth at top of screen: 185 feet	

PLUGGING & SEALING RECORD

☒ Annular space ☐ Abandoned

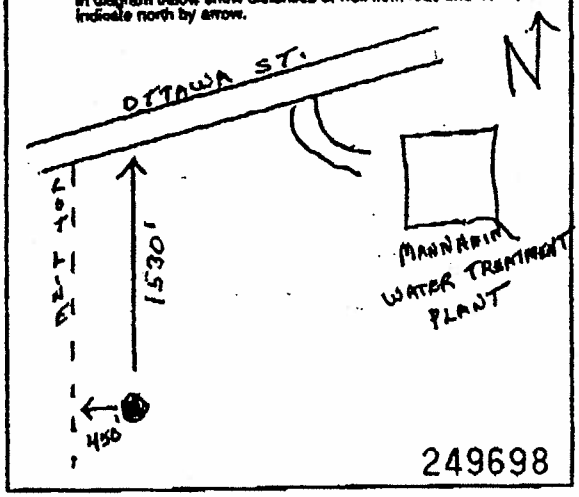
Depth set at - feet From	To	Material and type (Cement grout, bentonite, etc.)
0	121	Neat Cement

PUMPING TEST

Pumping test method: ☐ Pump ☐ Bailer
Pumping rate: GPM
Duration of pumping: Hours Mins
Static level
Water level end of pumping
Water levels during: ☐ Pumping ☐ Recovery
15 minutes 30 minutes 45 minutes 60 minutes
SEE CH2M-HILL REPORT
If flowing give rate: GPM
Pump intake set at
Water at end of test: ☐ Clear ☐ Cloudy
Recommended pump type: ☐ Shallow ☐ Deep
Recommended pump setting
Recommended pump rate: GPM

LOCATION OF WELL

In diagram below show distances of well from road and lot line. Indicate north by arrow.



249698

FINAL STATUS OF WELL
☒ Water supply ☐ Observation well ☐ Test hole ☐ Recharge well ☐ Abandoned, insufficient supply ☐ Abandoned, poor quality ☐ Abandoned (Other) ☐ Dewatering ☐ Unfinished ☐ Replacement well

WATER USE
☐ Domestic ☐ Stock ☐ Irrigation ☐ Industrial ☐ Commercial ☐ Municipal ☐ Public supply ☐ Cooling & air conditioning ☐ Not used ☐ Other

METHOD OF CONSTRUCTION
☐ Cable tool ☐ Rotary (conventional) ☐ Rotary (reverse) ☐ Rotary (air) ☐ Air percussion ☐ Boring ☐ Diamond ☐ Jetting ☐ Driving ☐ Digging ☐ Other

Name of Well Contractor	Well Contractor's Licence No.
Davidson Well Drilling Ltd.	1737
Address: Box 486, Wingham, Ontario N0G 2W0	
Name of Well Technician: D. Fenton	Well Technician's Licence No.: T2003
Signature of Technician/Contractor: D.W. Davidson per: J.C. Davidson	Submission date: 14 Mar 03

MINISTRY USE ONLY

0506 (07/00) Front Form 7

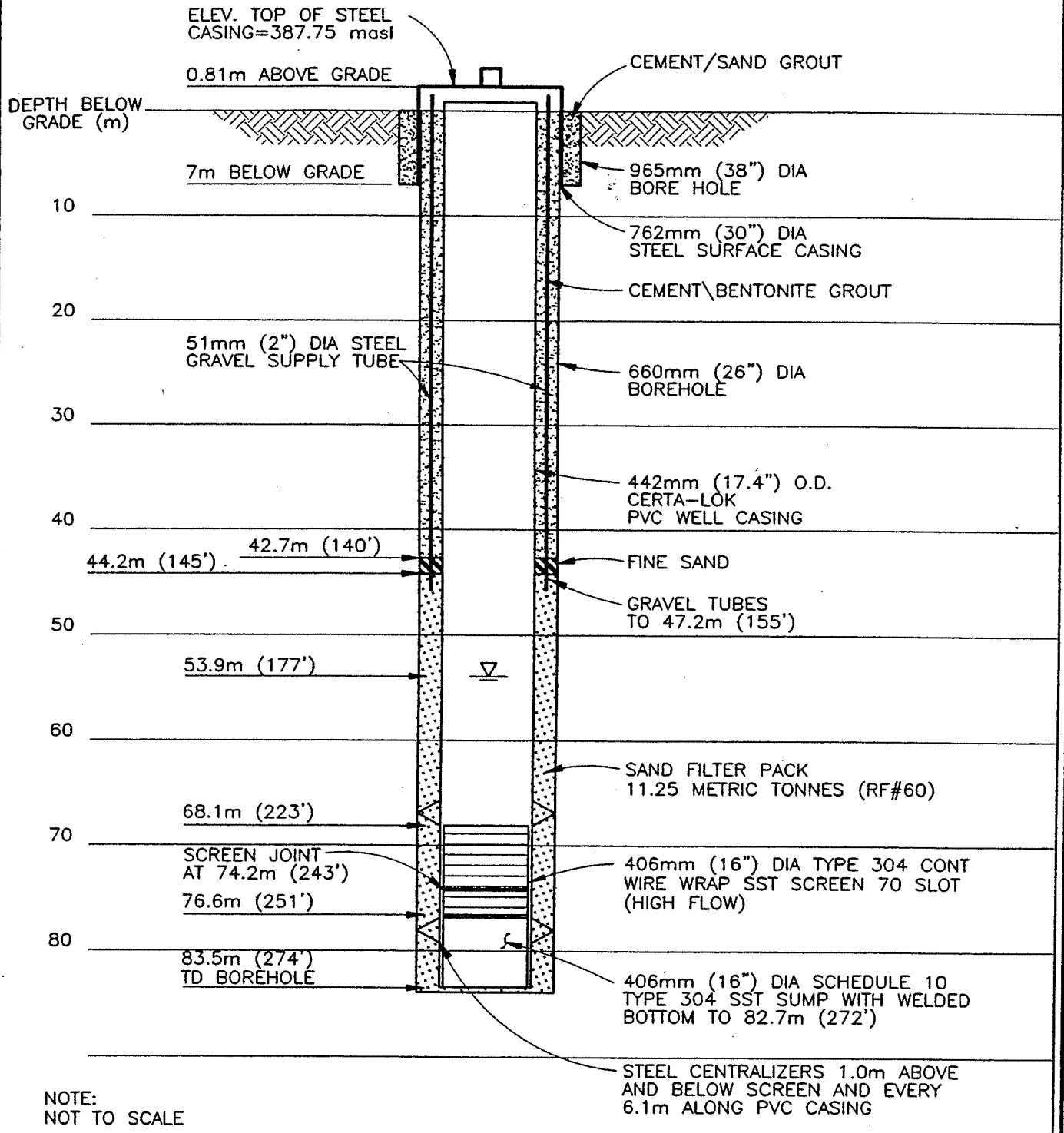
CONTRACTOR'S COPY

ASR 4

RCW1/ASR5

24/FEB/2003

renamed RCW 1



NOTE:
NOT TO SCALE

CH2MHILL	MANNHEIM ASR SYSTEM
DATE : 2-18-03	FIGURE A-9
PROJECT No. 121099	ASR 5 (previous ID)
	AS BUILT WELL CONSTRUCTION

121099f11E

RCW1/ASR5

RCW 1

Ontario Ministry of the Environment

The Ontario Water Resources Act
WATER WELL RECORD

Print only in spaces provided.
Mark correct box with a checkmark, where applicable.

County or District	Township/Borough/City/Town/Village	Con block tract survey, etc.	Lot
Region of Waterloo	City of Kitchner	Con. GCT	131

Owner's surname: Regional Mun. of Waterloo — First Name:
Address: 150 Frederick St.4th Floor Waterloo, Ontario
Date completed: 17 Day Dec Month 02 Year

Zone: Easting: Northing:

LOG OF OVERBURDEN AND BEDROCK MATERIALS (see instructions)

General colour	Most common material	Other materials	General description	Depth - feet From	To
Dk.Brn.	Fine sand & gravel			0	20
Brown	Fine to Med. sand	Silt streaks in lower zones		20	104
Brown	Med. Sand			104	153
Brown	Fine to coarse sand	Silt		153	195
Brown	Fine to Med. sand	Silt		195	230
Grey	Silt	Sand		230	274

WATER RECORD

Water found at - feet	Kind of water
130	☒ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas

CASING & OPEN HOLE RECORD

Inside diam inches	Material	Wall thickness inches	Depth - feet From	To
30	☒ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic	.375	+1	21
17.4	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☒ Plastic	1.024	+3	226
	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic			

SCREEN

Slots or opening (Slot No.)	Diameter	Length
70	16 inches	27 feet

Material and type: 304 Stainless Steel
Depth at top of screen: 226 feet

PLUGGING & SEALING RECORD

☐ Annular space ☐ Abandonment

Depth set at - feet From	To	Material and type (Cement grout, bentonite, etc.)
0	145	Neat Cement

PUMPING TEST

Pumping test method: ☐ Pump ☐ Bailer
Pumping rate: GPM
Duration of pumping: Hours Min
Static level: feet
Water level end of pumping: feet
Water levels during: ☐ Pumping ☐ Recovery
15 minutes: feet 30 minutes: feet 45 minutes: feet 60 minutes: feet

SEE CH2M-HILL REPORT

If flowing give rate: GPM
Pump intake set at: feet
Water at end of test: ☐ Clear ☐ Cloudy
Recommended pump type: ☐ Shallow ☐ Deep
Recommended pump setting: feet
Recommended pump rate: GPM

FINAL STATUS OF WELL

☒ Water supply ☐ Observation well ☐ Test hole ☐ Recharge well ☐ Abandoned, insufficient supply ☐ Abandoned, poor quality ☐ Abandoned (Other) ☐ Dewatering ☐ Unfinished ☐ Replacement well

WATER USE

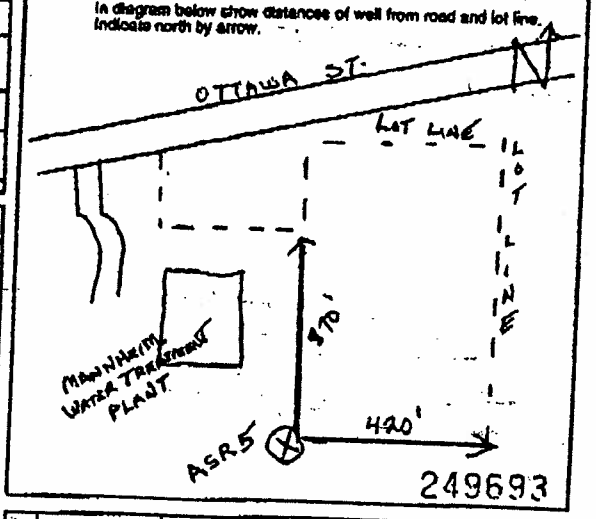
☐ Domestic ☐ Stock ☐ Irrigation ☐ Industrial ☐ Commercial ☒ Municipal ☐ Public supply ☐ Cooling & air conditioning ☐ Not used ☐ Other

METHOD OF CONSTRUCTION

☐ Cable tool ☒ Rotary (conventional) ☐ Rotary (reverse) ☐ Rotary (air) ☐ Air percussion ☐ Boring ☐ Diamond ☐ Jetting ☐ Driving ☐ Digging ☐ Other

LOCATION OF WELL

In diagram below show distances of well from road and lot line. Indicate north by arrow.



249693

Name of Well Contractor: Davidson Well Drilling Ltd. — Well Contractor's Licence No.: 1737
Address: Box 486, Wingham, Ontario NOG 2W0
Name of Well Technician: D. Fenton — Well Technician's Licence No.: T2003
Signature of Technician/Contractor: D.W. Davidson — Submission date: 17 Mar 03

MINISTRY USE ONLY

1 - CONTRACTOR'S COPY

0506 07/00b Front Form 0

9201291
ASRRCW-1A-02

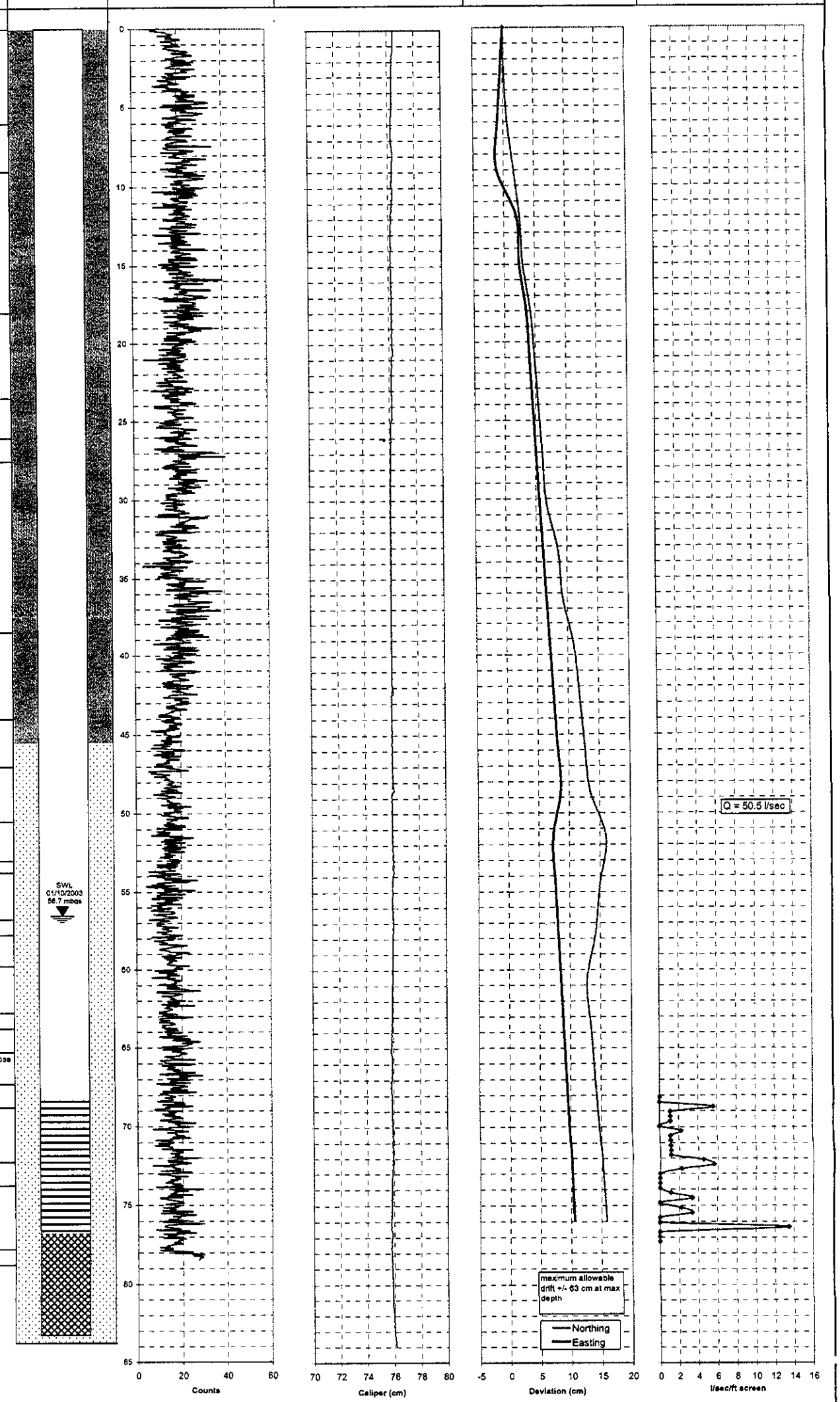
RCW1/ASR5

RCW1

Figure A-4: ~~ASR5~~

Project: Mannheim ASR Project, Stage 1				**Location:** Mannheim, Ontario	
Project No.: 121099				**Northing:**	4,805,669 m
Started Drilling: 12-08-2002	**Started Well Construction:** 12-12-2002	**Casing Type:**	390mm ID Certa-Lok PVC (SDR 17)	**Easting:**	538,293 m
Completed Drilling: 12-11-2002	**Completed Well Construction:** 12-16-2002	**Sump Type:**	394mm ID 304 SS sump	**Ground Elevation:** 386.94 masl	
Bore Hole Diameter: 660mm from 0-83.5 mbgs	**Total Depth of Well:** 82.69 mbgs	**Screen Type:**	406mm OD 304 SS Johnson high flow wire wrap screen 0.07" slot	**Well Head Elevation:** 387.75 masl	
Total Depth of Bore Hole: 83.5 mbgs	**Drill Method:** Conventional Mud Rotary	**Screen Interval:**	68.09 - 76.59 mbgs	**Survey Datum:**	NAD 83 (zone 17)
	Grout: Type II portland cement with 8% bentonite	**Gravel Quantity & Type:** 11.25 Metric Tonnes Red Flint Michigan #60			
Geologic Log by: Boyd Pendleton, CH2M Hill	**Drilling Contractor:** Davidson Drilling Ltd.	**Notes:** Pilot bore hole cored by Roto-Sonic methods on 10-09-02 to 10-10-02			

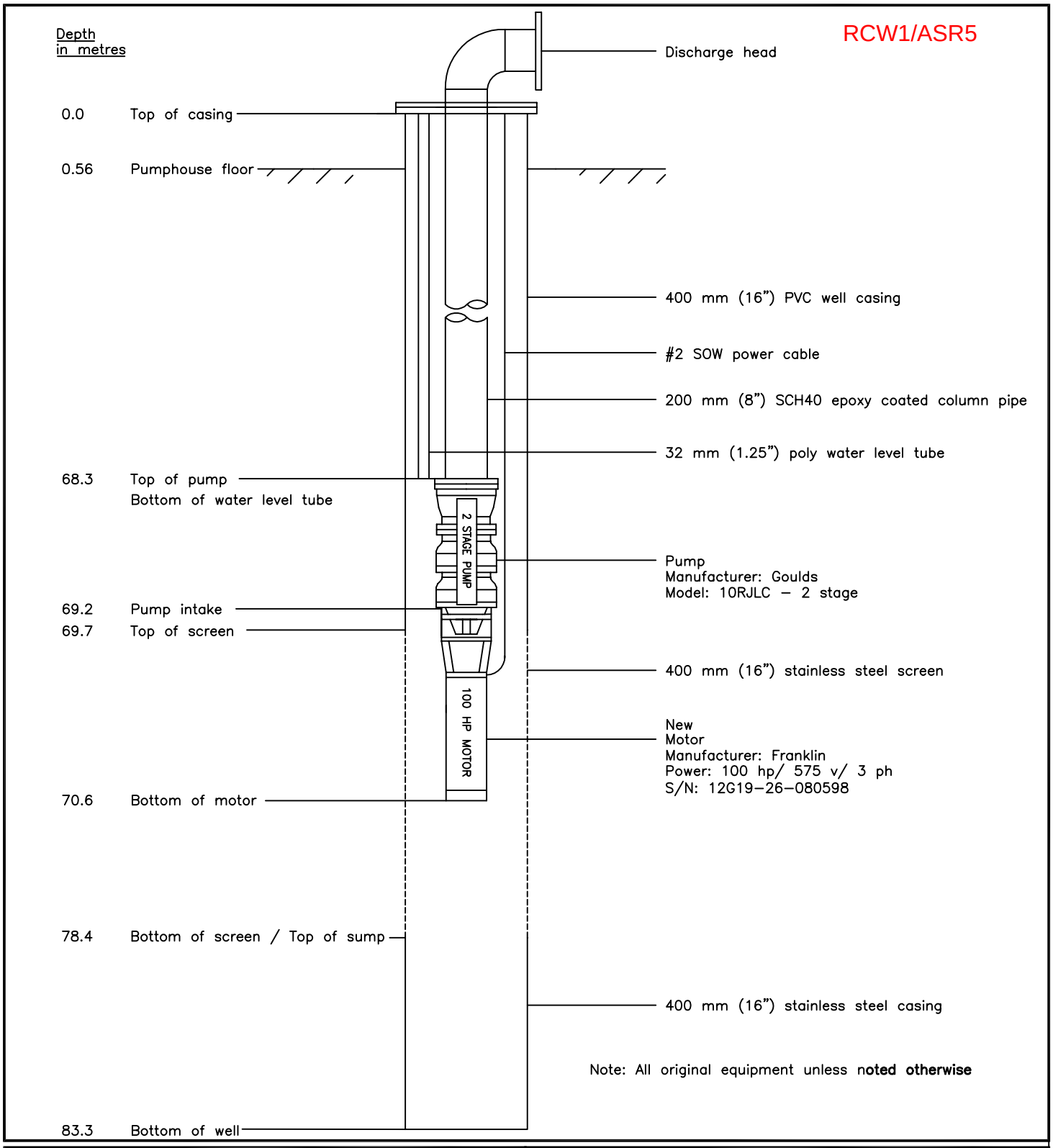
Depth of Interval (m)	Abbreviated Geologic Description
0-6.1	No Sample Recovered
6.1-9.0	Well Graded coarse Sand with Gravel, brown
9.0-18.2	Well Graded coarse Sand, grey
18.2-23.3	Well Graded fine-med Sand, brown-yellow
23.3-26.2	No Sample Recovered
26.2-27.5	Well Graded fine-coarse Sand, brown
27.5-38.5	No Sample Recovered
38.5-44.0	Well Graded fine-med Sand, brown
44.0-47.2	Well Graded Gravel w Sand & Cobbles
47.2-50.3	Silty Gravel w Sand, brown, moist, dense
50.3-53.3	Silty Gravel, brown,dry-moist, loose
53.3-53.6	Well Graded Gravel, brown, wet, loose
53.6-56.4	Silty Gravel, brown, wet, loose
56.4-57.6	Well Graded Gravel, brown, wet, loose
57.6-59.7	Well Graded Sand with Gravel, brown, wet, loose
59.7-62.5	Poorly Graded med Sand, brown, wet, loose
62.5-63.7	Well Graded Gravel with Silt & Sand, brown
63.7-64.9	Lean Clay, brown, moist, stiff
64.9-67.1	Well Graded med-fine Sand with Gravel, brown, wet, loose
67.1-68.6	Well graded med-fine Sand, brown, wet, loose
68.6-72.2	Well Graded Sand with Silt & Gravel, brown, wet, loose
72.2-73.5	Well Graded Sand with Gravel, brown, wet, loose
73.5-77.4	Well Graded fine-med Sand, brown, wet, loose
77.4-78.3	Gravely Silt & Clay with Sand, brown, wet, dense



CH2MHILL

CH2M Hill Canada Limited
180 King Street South, Suite 600
Waterloo, ON N2J 1P8
519-579-3501

LEGEND:
= Cement bentonite grout
= #60 RF Sand
= 0.07" SS Screen
= SS Blank Sump



Lotowater TECHNICAL SERVICES INC.

CLIENT
Regional Municipality of Waterloo

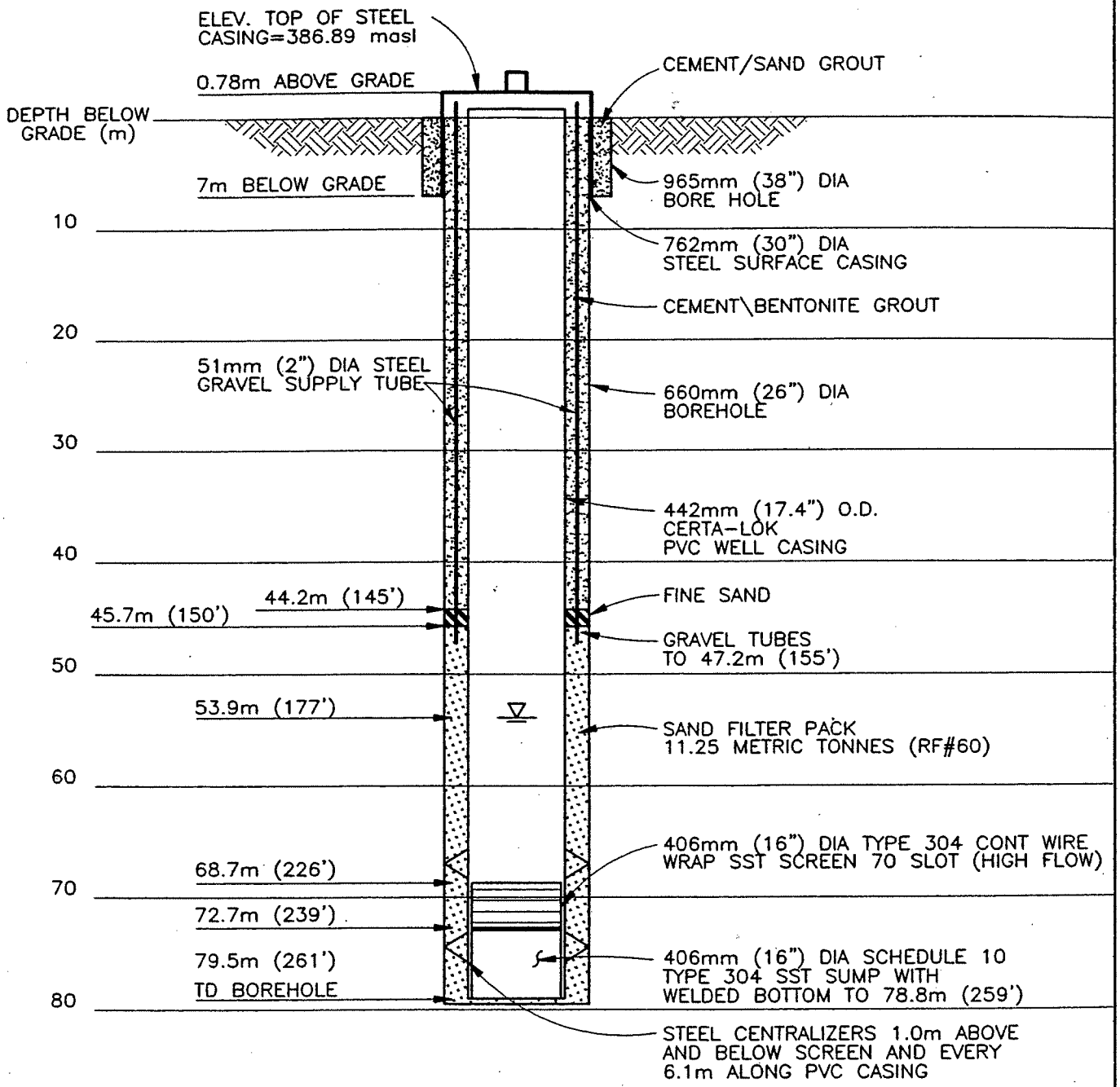
TITLE
Well RCW1
Pump Installation Drawing

PROJECT No. 006-236			G:\Lotowater Projects\006 Region of Waterloo\236 RCW1 Emergency Service\Pump Install.dwg	FIGURE 3
DESIGN			REVISION No. 2012/08/16	SCALE N.T.S.
DRAWN	EH	2012/08/16		
CHECKED				

renamed RCW 2

RCW2

24/FEB/2003



NOTE:
NOT TO SCALE

CH2MHILL	MANNHEIM ASR SYSTEM
DATE : 2-18-03	FIGURE A-8
PROJECT No. 121099	ASR 4 (previous 10)
	AS BUILT WELL CONSTRUCTION

121099f011C

RCW2

Ontario Ministry of the Environment

The Ontario Water Resources Act
WATER WELL RECORD

Print only in spaces provided.
Mark correct box with a checkmark, where applicable.

County or District	Township/Borough/City/Town/Village	Con block tract survey, etc.	Lot
Region Of Waterloo	City of Kitchener	Con. GCT	131
Owner's surname / First Name: Regional Mun. of Waterloo	Address: 150 Frederick St. 4th Floir Waterloo, Ontario	Date completed: 4 Day Dec Month 02 Year	

Zone [ ] Easting [ ] Northing [ ]

LOG OF OVERBURDEN AND BEDROCK MATERIALS (see instructions)

General colour	Most common material	Other materials	General description	Depth - feet From	To
Dk.Brn.	Silt,	Gravel/sand backfill		0	10
Brown	Med. sand	Gravel		10	15
Brown	Gravel	Silt		15	25
Brown	Fine sand	Silt		25	53
Grey	Gravel	Coarse sand		53	62
Brown	Sand	Silt		62	65
Brown	Gravel	Clay, coarse sand		65	72
Brown	Sand	Some silt		72	180
Brown	Gravel	Fine sand, some silt streaks		180	210
Brown	Silt	Some gravel and fine sand		210	215
Grey	Gravel with fine sand Some sand			215	243
~~Grey~~	~~Clay~~	~~Some silt~~		~~243~~	~~260~~

WATER RECORD

Water found at - feet	Kind of water
180	☒ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas

CASING & OPEN HOLE RECORD

Inside diam. inches	Material	Wall thickness inches	Depth - feet From	To
30	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic	.375	+1	21
17.4	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic	1.024	+3	227
	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic			

SCREEN

Slot of opening (Slot No.)	Diameter	Length
70	16 inches	13 feet
Material and type: 304 Stainless Steel	Depth at top of screen: 227 feet	

PLUGGING & SEALING RECORD
☒ Annular space ☐ Abandonment

Depth set at - feet From	To	Material and type (Cement grout, bentonite, etc.)
0	145	Neat Cement

PUMPING TEST

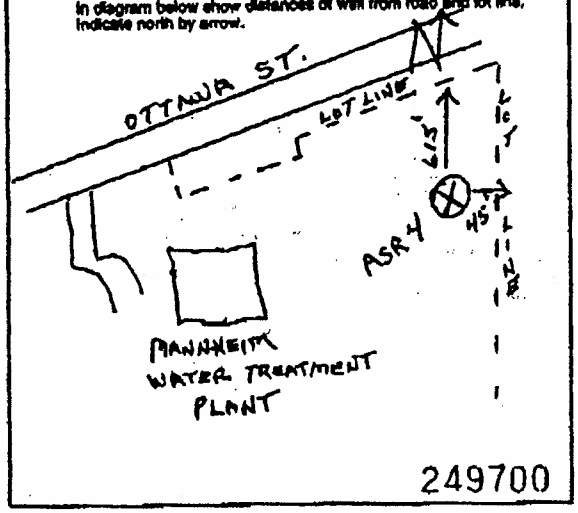
Pumping test method: ☐ Pump ☐ Bailer
Pumping rate GPM
Duration of pumping Hours Mins
Static level
Water level end of pumping
Water levels during ☐ Pumping ☐ Recovery
15 minutes feet 30 minutes feet 45 minutes feet 60 minutes feet
SEE CH2M-HILL REPORT
If flowing give rate GPM
Pump intake set at feet
Water at end of test ☐ Clear ☐ Cloudy
Recommended pump type ☐ Shallow ☐ Deep
Recommended pump setting feet
Recommended pump rate GPM

FINAL STATUS OF WELL
☒ Water supply ☐ Observation well ☐ Test hole ☐ Recharge well
☐ Abandoned, insufficient supply ☐ Abandoned, poor quality ☐ Abandoned (Other) ☐ Dewatering
☐ Unfinished ☐ Replacement well

WATER USE
☐ Domestic ☐ Stock ☐ Irrigation ☐ Industrial
☐ Commercial ☒ Municipal ☐ Public supply ☐ Cooling & air conditioning
☐ Not used ☐ Other

METHOD OF CONSTRUCTION
☐ Cable tool ☒ Rotary (conventional) ☐ Rotary (reverse) ☐ Rotary (air)
☐ Air percussion ☐ Boring ☐ Diamond ☐ Jetting
☐ Driving ☐ Digging ☐ Other

LOCATION OF WELL
In diagram below show distances of well from road and lot line. Indicate north by arrow.



249700

Name of Well Contractor: Davidson Well Drilling Ltd. — Well Contractor's Licence No.: 1737
Address: Box 486, Wingham, ONtario N0G 2W0
Name of Well Technician: D. Fenton — Well Technician's Licence No.: T2003
Signature of Technician/Contractor: D.W. Davidson per: D. Davidson — Submission date: 17 Mar 03

MINISTRY USE ONLY

0806 (07/00) Front Form 9

RCW 2

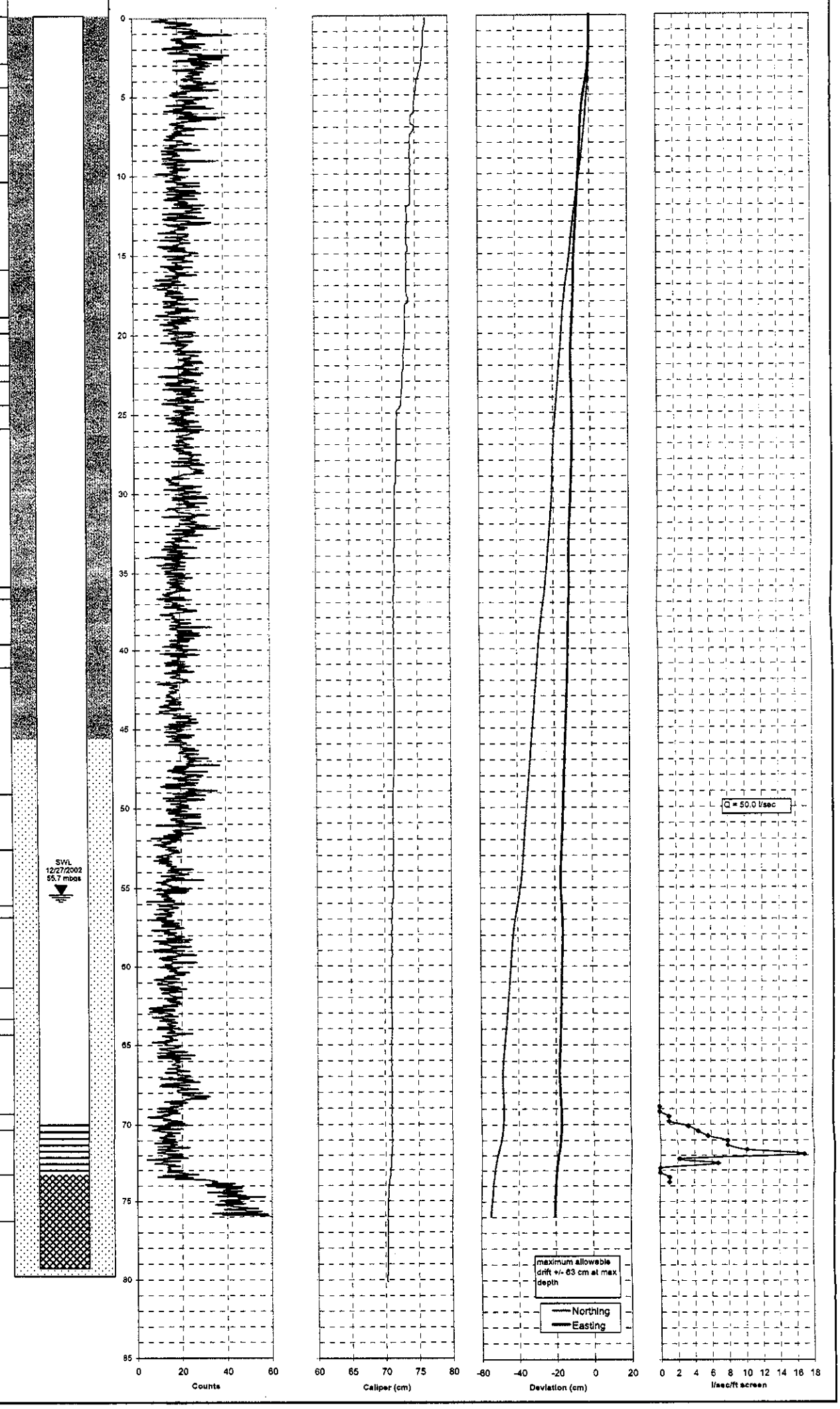
ASRPW-2A-02
9201292
RCW2

RCW2

Figure A-3 : ~~ASR4~~ RCW2

Project: Mannheim ASR Project, Stage 1				**Location:** Mannheim, Ontario	
Project No.: 121099				**Northing:**	4,805,874 m
Started Drilling: 11-25-2002	**Started Well Construction:** 11-30-2002	**Casing Type:**	390mm ID Certa-Lok PVC (SDR 17)	**Easting:**	538,384 m
Completed Drilling: 11-28-2002	**Completed Well Construction:** 12-04-2002	**Sump Type:**	394mm ID 304 SS sump	**Ground Elevation:** 386.11 masl	
Bore Hole Diameter: 660mm from 0-79.5 mbgs	**Total Depth of Well:** 78.82 mbgs	**Screen Type:**	406mm OD 304 SS Johnson high flow wire wrap screen 0.07" slot	**Well Head Elevation:** 386.89 masl	
Total Depth of Bore Hole: 79.5 mbgs	**Drill Method:** Conventional Mud Rotary	**Screen Interval:**	68.72 - 72.72 mbgs	**Survey Datum:**	NAD 83 (zone 17)
	Grout: Type II portland cement with 8% bentonite	**Gravel Quantity & Type:** 12.2 Metric Tonnes Red Flint Michigan #60			
Geologic Log by: Boyd Pendleton, CH2M Hill	**Drilling Contractor:** Davidson Drilling Ltd.	**Notes:** Pilot bore hole cored by Roto-Sonic methods on 10-07-02 to 10-08-02			

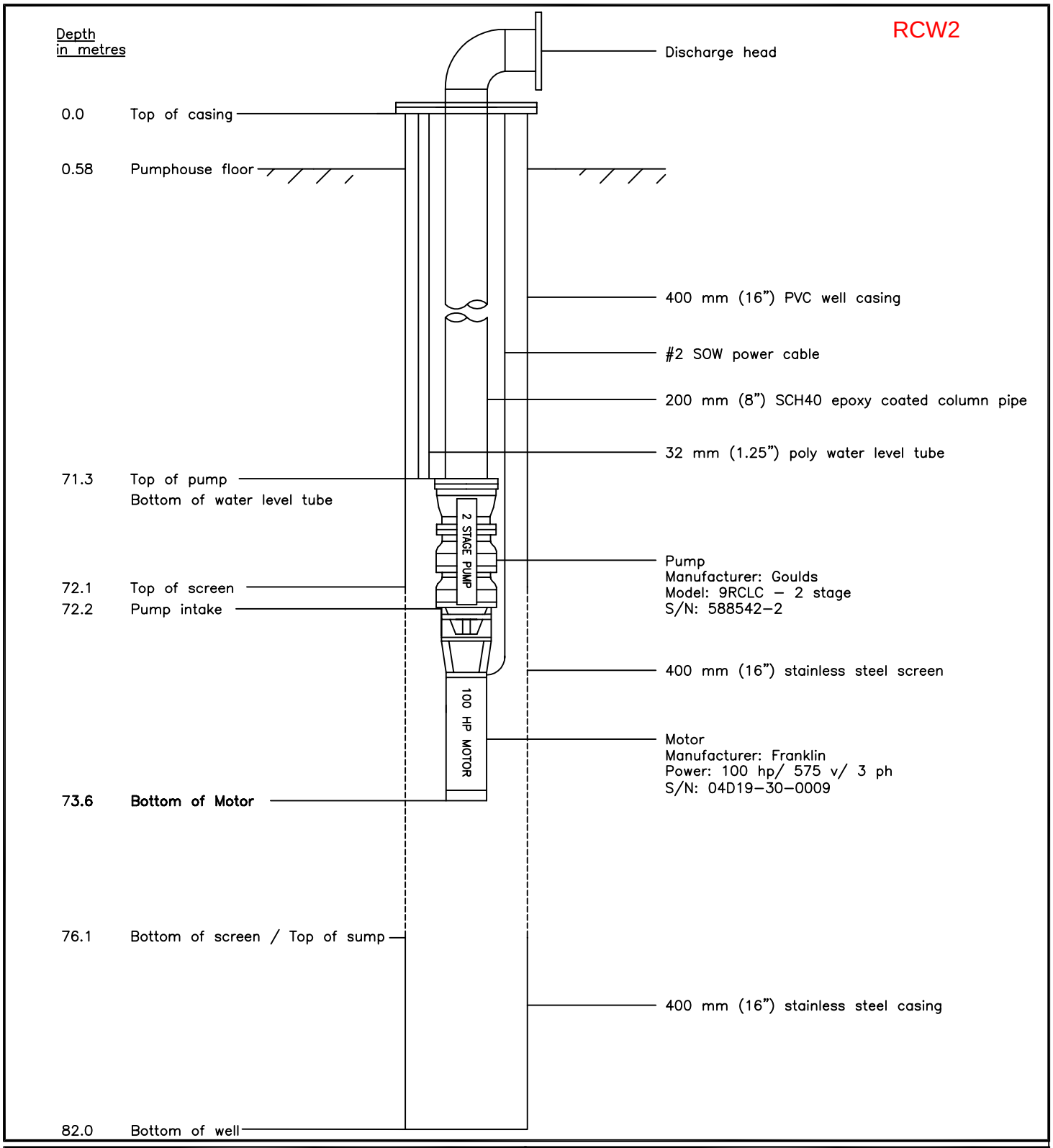
Depth of Interval (m)	Abbreviated Geologic Description
0-3.1	Well Graded Sand with Silt, brown
3.1-4.6	Well Graded Sand with Gravel, brown
4.6-7.6	Well Graded Gravel with Silt, brown
7.6-10.7	Poorly Graded fine Sand with Silt, brown
10.7-16.2	Poorly Graded fine Sand with Silt, brown
16.2-18.9	Well Graded Gravel with coarse Sand, brown
18.9-19.8	Well Graded Sand with Silt, brown
19.8-21.9	Well Graded Gravel with Clay & Sand, brown
21.9-22.9	Well Graded Sand with Silt, brown
22.9-24.4	Poorly Graded fine Sand with Silt, brown
24.4-25.9	Silt, light brown
25.9-36.3	Poorly Graded fine Sand with Silt, brown
36.3-36.6	Poorly Graded fine Sand with Silt, brown
36.6-39.6	Poorly Graded fine Sand with Silt, brown
39.6-41.2	Silt with fine sand, brown
41.2-46.6	Poorly Graded fine Sand with Silt, brown
46.6-52.7	Silt with fine Sand, light brown, moist, med-dense
52.7-55.6	Well Graded Sand with Silt, brown, moist, med-dense
55.6-56.4	Cobbles with Silt, grey, dry, hard
56.4-61.0	Well Graded Sand, brown, wet, loose
61.0-62.8	Well Graded Gravel with Sand & Silt, brown, wet, loose
62.8-64.0	Poorly Graded med Sand, brown, wet, loose
64.0-68.9	Poorly Graded fine Sand, brown, wet, loose
68.9-70.1	Poorly Graded med Sand, brown, wet, loose
70.1-73.1	Well Graded Gravel with Sand, brown, wet, loose
73.1-76.2	Lean Clay, grey, moist, very stiff



CH2MHILL

CH2M Hill Canada Limited
180 King Street South, Suite 600
Waterloo, ON N2J 1P8
519-579-3501

LEGEND:
= Cement bentonite grout
= #60 RF Sand
= 0.07" SS Screen
= SS Blank Sump



Lotowater TECHNICAL SERVICES INC.

CLIENT
Regional Municipality of Waterloo

TITLE
Well RCW2
Pump Installation Drawing

PROJECT No. 006-238			G:\Lotowater Projects\006 Region of Waterloo\238 RCW2 Emergency Service\Pump Install.dwg	FIGURE 2
DESIGN			REVISION No. 2012/08/16	SCALE N.T.S.
DRAWN	EH	2012/08/16		
CHECKED				

Production Well: RCW3

RCW3

Project: ASR Stage 1B
Client: Regional Municipality of Waterloo
Location: Kitchener, Ontario
Number: 165640252

Field Investigator: D. Smith / A. Healey
Contractor: Aardvark Drilling, Inc
Drilling method: Foremost DR 24 Air Rotary
Date started/completed: 30-May-2019 / 05-Sep-2019

SUBSURFACE PROFILE

Depth (ft)	Depth (m)	Lithologic Description	Elevation (m AMSL) / Depth (m BGS)
			385.03
		Ground Surface	384.23
0	0	SAND Fine grained, some medium to coarse grained sand, some fine subrounded gravel, trace clumps of silty clay, brown (10 YR 5/3), moist	0.00
5	2		
10		Trace coarse gravel, colour change to yellowish brown (10 YR 5/4) starting at 3.0 m	
15	4		379.66
		GRAVEL Fine and coarse, subrounded to subangular, some medium to coarse grained sand, greyish brown (10 YR 5/2), moist	4.57 378.13
20	6	SAND AND GRAVEL Medium to coarse grained sand, fine and coarse gravel, trace fine grained sand and silt	6.10
25	8		
30			375.09
		SAND Fine grained, trace medium grained sand, trace silt, brown (10 YR 5/3), moist	9.14
35	10		
40	12		372.04
		SILTY SAND Fine grained, trace fine and coarse subrounded gravel, brown (10 YR 5/3)	12.19
45	14		
50	16		
55			
60	18	Trace clumps of silty clay and coarse grained sand at 18.3 m	
65	20		
70	22		361.67
75		CLAYEY SILT Some fine grained sand, trace coarse grained sand and fine gravel, pale brown (10 YR 6/3)	22.56 360.15
80	24	SAND Fine to medium grained sand, trace silt, greyish brown (10 YR 5/2)	24.08
85	26		
90			356.80
	28	SILTY SAND Fine grained, brown (10 YR 5/3)	27.43
95			
100	30	Some medium grained sand from 30.5 m to 33.5 m	
105	32		
110	34	Trace clumps of clayey silt from 33.5 m to 36.6 m	
115	36		
120			347.65
		SAND Fine grained, trace silt and clay, trace medium grained sand, brown (10 YR 5/3)	36.58
125	38		

HYDROGEOLOGY

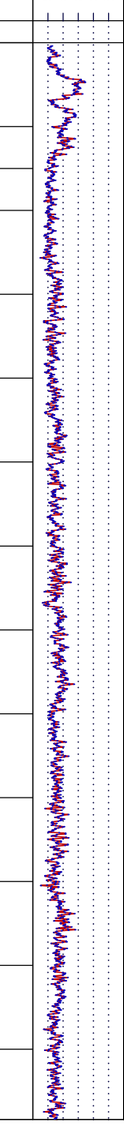
Hydro Stratigraphic Unit	Description
AFB1	Upper Waterloo Moraine stratified sediments and equivalents
ATB2	Middle Maryhill Till and equivalents

SAMPLE DETAILS

Sample Number	Sample Type	Lab Analyses
1	GB	
2	GB	
3	GB	
4	GB	
5	GB	
6	GB	
7	GB	
8	GB	
9	GB	
10	GB	
11	GB	
12	GB	
13	GB	
14	GB	

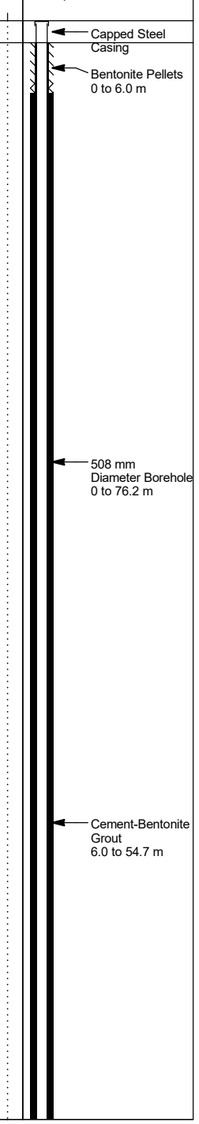
GEOPHYSIC DETAILS

Gamma (cps)



WELL DETAILS

Name: RCW3
GS Elev: 384.23 m AMSL
TOC Elev: 385.03 m AMSL
Easting: 537909
Northing: 4805100
Stick-up: 0.80 m



Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
GB - grab sample
n/a - not available/applicable

Two gravel re-supply tubes are installed from
0.59 m AGS to 62.5 m BGS and
0.57 m AGS to 62.5 m BGS
Screen depth confirmed with well video from
January 16, 2020
WRAS No.: 9207703

Stantec

Drawn By/Checked By: AH / LV

STANTEC BOREHOLE AND WELL - MASTER 17X11 20190515_RCW3_RCW4_AH.GPJ DATA TEMPLATE_ENVS_CA_140725.GDT 21/12/20 AHEALEY

Production Well: RCW3

Project: ASR Stage 1B
Client: Regional Municipality of Waterloo
Location: Kitchener, Ontario
Number: 165640252

Field Investigator: D. Smith / A. Healey
Contractor: Aardvark Drilling, Inc
Drilling method: Foremost DR 24 Air Rotary
Date started/completed: 30-May-2019 / 05-Sep-2019

SUBSURFACE PROFILE

Lithologic Description	Elevation (m AMSL) Depth (m BGS)
SILTY SAND Fine grained, trace medium grained sand, brown (10 YR 5/3) Trace clumps of clayey silt from 45.7 m to 48.8 m	344.61 39.62 335.46
SAND Fine to medium grained, trace coarse grained sand, trace fine to coarse subrounded gravel, trace silt, greyish brown (10 YR 5/2)	48.77 332.41
SILTY SAND Fine to medium grained, trace coarse grained sand and fine subrounded gravel, brown (7.5 YR 4/3) Trace medium to coarse grained sand from 53.3 m to 54.9 m Some silt starting at 56.4 m Some coarse grained sand and fine gravel starting at 57.9 m Some coarse gravel from 57.9 m to 59.4 m	51.82 321.44
GRAVELLY SAND Fine gravel, medium grained sand, trace coarse subangular gravel, some coarse grained sand and silt, trace fine grained sand, brown (7.5 YR 5/2) Seam of sand and gravel from 63.7 m to 64.6 m Fine grained sand, some medium grained sand starting at 64.6 m Seam of fine and medium grained sand, trace coarse grained sand and subangular gravel, some silt from 65.5 m to 66.4 m Trace clumps of silty clay at 66.4 m Fine to coarse gravel, fine to coarse grained sand, some silt, trace clumps of silty clay starting at 67.4 m Trace fine grained sand, colour change to greyish brown (10 YR 5/2) starting at 68.3 m	62.79 315.35
SILTY CLAY Trace fine to medium grained sand, greyish brown (10 YR 5/2) Sandy silty clay with trace fine gravel starting at 71.0 m	68.88 312.30
End of Borehole	76.20

HYDROGEOLOGY

Hydro Stratigraphic Unit	Description
AFB2	Middle Waterloo Moraine stratified sediments and equivalents
ATB3	Lower Maryhill Till

SAMPLE DETAILS

Sample Number	Sample Type	Lab Analyses
15	GB	
16	GB	
17	GB	
18	GB	
19	GB	
20	GB	
21	GB	
22	GB	
23	GB	
24	GB	
25	GB	GSA
26	GB	GSA
27	GB	GSA
28	GB	GSA
29	GB	GSA
30	GB	GSA
31	GB	GSA
32	GB	GSA
33	GB	GSA
34	GB	
35	GB	
36	GB	

GEOPHYSIC DETAILS

Gamma (cps) 20 40 60 80 100

WELL DETAILS

Name: RCW3
GS Elev: 384.23 m AMSL
TOC Elev: 385.03 m AMSL
Easting: 537909
Northing: 4805100
Stick-up: 0.80 m

- Type 316 Stainless Steel Casing 304 mm ID 0.8 m AGS to 64.5 m BGS
- Water Level 52.43 m BTOC 10-Oct-2019
- Bentonite Pellets 54.7 to 58.2 m
- K&E No. 3 Gravel Pack 58.2 to 69.8 m
- 324 mm OD No. 60 Slot Type 304 Stainless Steel Screen 64.5 to 68.5 m
- 324 mm OD Type 316 Stainless Steel Sump 68.5 to 75.5 m
- Concrete 69.8 to 71.0 m bentonite 71.0 to 71.8 m silt cave 71.8 to 76.2 m

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
GB - grab sample
n/a - not available/applicable

Two gravel re-supply tubes are installed from 0.59 m AGS to 62.5 m BGS and 0.57 m AGS to 62.5 m BGS
Screen depth confirmed with well video from January 16, 2020
WRAS No.: 9207703

Stantec

Drawn By/Checked By: AH / LV

STANTEC BOREHOLE AND WELL - MASTER 17X11 20190515_RCW3_RCW4_AH.GPJ DATA TEMPLATE_ENVS_CA_140725.GDT 21/1/20 AHEALEY

RCW4

Production Well: RCW4

Project: ASR Stage 1B
Client: Regional Municipality of Waterloo
Location: Kitchener, Ontario
Number: 165640252

Field Investigator: D. Smith
Contractor: Aardvark Drilling, Inc
Drilling method: Foremost DR 24 Air Rotary
Date started/completed: 15-Nov-2019 / 03-Jan-2020

SUBSURFACE PROFILE

Depth (ft)	Depth (m)	Lithologic Description	Elevation (m AMSL) / Depth (m BGS)
			387.73
		Ground Surface	386.76
		FILL Gravelly sand, fine to medium grained sand, fine and coarse subrounded gravel, brown (7.5 YR 4/4), dry	0.00 385.24
		SAND Fine and medium grained sand, trace silt, light brownish grey (10 YR 6/2)	1.52
		Some silt, trace medium grained sand starting at 15.2 m	365.42
		SILTY SAND to SILT AND SAND Fine grained sand, brown (10 YR 5/3)	21.34
		Some clay, trace medium sand starting at 30.5 m	353.54
		SAND AND GRAVEL Fine to coarse grained sand, fine gravel, trace coarse gravel, trace to some silt, well graded, greyish brown (10 YR 5/2)	33.22

Graphic Log

HYDROGEOLOGY

Hydro Stratigraphic Unit	Description
AFB1	Upper Waterloo Moraine stratified sediments and equivalents

SAMPLE DETAILS

Sample Number	Sample Type	Lab Analyses
1	GB	
2	GB	
3	GB	
4	GB	
5	GB	
6	GB	
7	GB	
8	GB	
9	GB	
10	GB	
11	GB	
12	GB	
13	GB	
14	GB	
15	GB	
16	GB	

WELL DETAILS

Name: RCW4
GS Elev: 386.76 m AMSL
TOC Elev: 387.73 m AMSL
Easting: 538042
Northing: 4805843
Stick-up: 0.97 m

Capped Steel Casing
457 mm Diameter Borehole 0 to 33.5 m
Cement-Bentonite Grout 0 to 33.5 m

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
GB - grab sample
n/a - not available/applicable

WRAS No.: 9207702

Stantec

Drawn By/Checked By: DS / LV

STANTEC BOREHOLE AND WELL - MASTER 17X11 20190515_RCW3_RCW4_AH.GPJ DATA TEMPLATE_ENVS_CA_140725.GDT 2/17/20 AHEALEY

Production Well: RCW4

Project: ASR Stage 1B
Client: Regional Municipality of Waterloo
Location: Kitchener, Ontario
Number: 165640252

Field Investigator: D. Smith
Contractor: Aardvark Drilling, Inc
Drilling method: Foremost DR 24 Air Rotary
Date started/completed: 15-Nov-2019 / 03-Jan-2020

SUBSURFACE PROFILE

Depth (ft)	Depth (m)	Lithologic Description	Elevation (m AMSL) / Depth (m BGS)
		SAND AND GRAVEL Fine to coarse grained sand, fine gravel, trace coarse gravel, trace to some silt, well graded, greyish brown (10 YR 5/2)	
		Coarse gravel from 42.7 to 45.7 m	
		Some silt starting at 45.7 m	
		Trace coarse gravel from 47.2 m to 51.8 m	
		Some coarse gravel at 51.8 m	
		Trace fine grained sand starting at 54.9 m	
		Trace coarse gravel starting at 59.4 m	
		Gravelly sand, fine to coarse grained sand starting at 67.1 m	
			317.88
		SAND Fine to medium grained sand, trace coarse grained sand, trace fine to coarse gravel, some silt, greyish brown (10 YR 5/2)	68.88
			312.08
		SILTY CLAY Dark grey (5 YR 4/1)	74.68 311.78
		End of Borehole	74.98

HYDROGEOLOGY

Hydro Stratigraphic Unit	Description
AFB2	Middle Waterloo Moraine stratified sediments and equivalents
ATB3	Lower Maryhill Till

SAMPLE DETAILS

Sample Number	Sample Type	Lab Analyses
17	GB	
18	GB	
19	GB	
20	GB	
21	GB	
22	GB	
23	GB	
24	GB	
25	GB	
26	GB	
27	GB	
28	GB	
29	GB	GSA
30	GB	GSA
31	GB	GSA
32	GB	GSA
33	GB	GSA
34	GB	GSA
35	GB	GSA
36	GB	GSA
37	GB	GSA
38	GB	GSA
39	GB	
40	GB	
41	GB	

WELL DETAILS

Name: RCW4
GS Elev: 386.76 m AMSL
TOC Elev: 387.73 m AMSL
Easting: 538042
Northing: 4805843
Stick-up: 0.97 m

- 324 mm Borehole Diameter 33.5 to 74.1 m
- Type 316 Stainless Steel Casing 304 mm ID 0.97 m AGS to 61.6 m
- Water Level 54.62 m BTOC 5-Feb-2020
- 3 K-packers and tight wind from 60.2 to 61.6 m
- 290 mm OD Type 304 No. 60 Slot Stainless Steel Telescopic Screen 61.6 to 67.1 m
- Natural Cave 61.6 to 75 m
- 273 mm OD Type 304 Stainless Steel Sump 67.1 to 74.1 m

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
GB - grab sample
n/a - not available/applicable

WRAS No.: 9207702

Stantec

Drawn By/Checked By: DS / LV

STANTEC BOREHOLE AND WELL - MASTER 17X11 20190515_RCW3_RCW4_AH.GPJ DATA TEMPLATE_ENVS_CA_140725.GDT 2/17/20 AHEALEY

1000983

K-MA-ASR-OW2-96-B

CH2M Gore & Storrie Ltd.

PROJECT NUMBER: 211K44073.A2	WELL NUMBER: OW2-96B Page 1 of 2

MONITORING WELL DRILLING & CONSTRUCTION LOG

CLIENT NAME: RMOW
LOCATION: Mannheim WTP-Warren Pit
DATE DRILLED: May 27,1996
LOGGER: M.Dugan
DRILL COMPANY: All-Terrain Drilling Ltd.

DRILLING METHOD: Mud Rotary/Continuous Core
ELEVATIONS: (METERS)
-SURFACE ELEV.: 386.89
-TOP OF DEEP RISER: 387.786
-TOP SHALLOW RISER: NA
-TOTAL DEPTH: 78
EASTING: 537950.33
NORTHING: 4805695.85

DEPTH BELOW SURFACE (METERS)	SOIL SAMPLE: INTER-VAL (METERS)	SOIL SAMPLE: TYPE AND NUMBER	SOIL SAMPLE: RE-COVERY (cm)	SOIL DESCRIPTION: NAME, COLOUR, SOIL STRUCTURE PARTICAL SIZE DISTRIBUTION, MOISTURE CONTENT, PLASTICITY, DENSITY.	WELL CONSTRUCTION: CASING, SCREEN INTERVAL, SAND PACK, SEAL, ETC.
		CONTINUOUS CS			
0				No Sample Recovered	Grout (0-51.82) bentonite grout
5				**Sand & Gravel** (6.7-9.14 m) coarse sand and gravel, brown	
10				**Coarse Sand** (9.14-18.90 m) very coarse sand, trace gravel, strong iron oxide staining	
15				14.94-18.90 m: cobbley	
20				**Sand** (18.90-23.47 m) fine to medium sand, dark yellowish brown (10YR 4/2)	
				fine sand, trace to some silt, pale yellowish brown (10YR 6/2), well sorted, dense	
25		R1	190	No Sample Recovered	
		R2	41	**Sand** (26.67-28.04 m) fine to coarse sand, poorly sorted, dark yellowish brown (10YR 4/2)	
30				No Sample Recovered	
35					
40					

CH2M Gore & Storrie Ltd.

PROJECT NUMBER: 211K44073.A2

WELL NUMBER: OW2-96B

MONITORING WELL DRILLING & CONSTRUCTION LOG

CLIENT NAME: RMOW
LOCATION: Mannheim WTP-Warren Pit
DATE DRILLED: May 27,1996
LOGGER: M.Dugan
DRILL COMPANY: All-Terrain Drilling Ltd.

DRILLING METHOD: Mud Rotary/Continuous Core
ELEVATIONS: (METERS)
-SURFACE ELEV.: 386.89
-TOP OF DEEP RISER: 387.786
-TOP SHALLOW RISER: NA
-TOTAL DEPTH: 78
EASTING: 537950.33
NORTHING: 4805695.85

DEPTH BELOW SURFACE (METERS)	SOIL SAMPLE: INTERVAL (METERS)	SOIL SAMPLE: TYPE AND NUMBER	SOIL SAMPLE: RECOVERY (cm)	SOIL DESCRIPTION: NAME, COLOUR, SOIL STRUCTURE PARTICAL SIZE DISTRIBUTION, MOISTURE CONTENT, PLASTICITY, DENSITY.	WELL CONSTRUCTION: CASING, SCREEN INTERVAL, SAND PACK, SEAL, ETC.
		CONTINUOUS CS			
40		R3	31	**Sand** (40.23-45.42 m) fine to medium sand, dark yellowish brown (10YR 4/2), poorly sorted, medium to coarse gravel near/at lower contact	
		R4	43		
		R5	56		
		R6	46		
		R7	81		
45		R8	0	42.98-43.28 m: very fine sand, poorly sorted	
		R9	66	43.28-43.59 m: very fine sand, fine black silt laminae, well sorted	
		R10a	15	**Gravel & Cobbles** (45.52-65.84 m) gravel and cobbles, cobbles up to 12 cm, sub-rounded some sand, dark yellowish brown (10YR 4/2), poorly sorted	
50		R10b	62		
		R11	97		**Well Seal** (52.82-53.34) bentonite
		R12	15	iron staining present	
55		R13	0	major mud loss (10 000 l) over interval	**Filter Pack** (53.34-67.06) # 1 silica sand
		R14	76		
		R15	91		**Well Screen** (56.39-65.53) #20 slot Sch80 PVC
60		R16	107		
		R17	0		
		R18	61		
65				grey silty clay seam	
		R19	137	**Sand** (65.84-69.20 m) fine to medium sand, dark yellowish brown (10YR 4/2), grading to fine sand with silt at lower contact, moderatly dense, iron staining below 66 m depth	**Well Seal** (67.06-68.58) bentonite
		R20	91		
70		R21	10		**Backfill** (68.58-78.03) sand
		R22	69	**Gravel, Cobbles & Sand** (69.2-75.59 m) as above	
75		R23	46	**Silt Clay Till** (75.59-78.03 m) silty clay till with trace sand and gravel, dark yellowish brown (10YR 4/2) grading to brownish grey (5YR 4/1), stiff to very stiff	
		R24	76		
		R25	122		
80				End of Hole	

Missing Mannheim K-ASR-TW13-85-A and K-MP-OW9-89-A

RECORD OF BOREHOLE No. K-ASR-OW2-16

Project Number:	TT163301	Drilling Method:	PQ (85mm) Continuous Sampler/Soil Coring		
Project Client:	Regional Municipality of Waterloo	Drilling Machine:	Track Mounted Drill CME 75 drill with Christiansen wireline drill		
Project Name:	Mannheim Monitoring Well Construction	Date Started:	05/18/2016	Date Completed:	05/25/2016
Project Location:	Kitchener, Ontario	Logged by:	KG	Compiled by:	KR
Drilling Location:	Mannheim WTP; As shown on the Borehole Location Plan	Reviewed by:	KG	Revision No.:	0, 08/02/2016
		Coordinates:	NAD 1983 17T 538217.4 E ; 4805168.3 N		

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LITHOLOGY PROFILE

Lithology Plot

DESCRIPTION

Stick-up of 0.91 m
Local Ground Surface Elevation: 385.69

Brown
SANDY FILL
Gravel and Boulders; Rootlets and Organics
381.69

Brown 4.0
SILTY SAND and GRAVEL or Soft STONY TILL
Trace CLAY
Cohesive
374.99

Brown 10.7
SAND
Some GRAVEL
373.49

Brown 12.2
FINE to MEDIUM SAND
Trace SILT
Stratified
Wet to saturated
371.99

Brown 13.7
SANDY SILT/ FINE SAND/ SILTY FINE SAND
Stratified
Multiple fining upwards and downwards sequences
Occasional layers of SILTY CLAY starting below 21.0m increasing in thickness with depth

SOIL SAMPLING

Sample Type	Run Number	Recovery (%)	
Soil Removed by Vaccum Truck and Auger	0	N/A	
PQ	1	50	
PQ	2	83	
PQ	3	33	
PQ	4	93	
PQ	5	40	
PQ	6	20	
PQ	7	50	Sand: 99% Silt: 1%
PQ	8	78	
PQ	9	95	Sand: 79.1% Silt: 9.9%
PQ	10	77	Sand: 47.9% Silt: 52.1%
PQ	11	60	

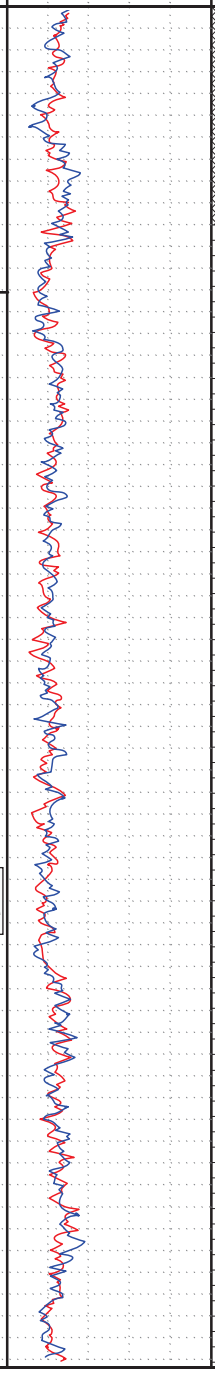
DEPTH (m): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19

INTERPRETED STRATIGRAPHY

Unit AFB1:
Upper Waterloo Moraine

GEOPHYSICS

Measuring Point: Ground Surface
Measuring Point Elevation: N/A
Logged by: J. Dion (Lotowater Tech. Services)
Logging Date: May 26, 2016
Gamma 1 (cps) 0 – 100
Gamma 2 (cps) 0 – 100



INSTRUMENTATION INSTALLATION

UNIT INTERPRETATION COMMENTS

Fill

Mixed sand and gravel with fines.

Possible ice contact deposits

Aquifer 1

Quiet water facies
Moraine deposits
Aquifer 1

Amec Foster Wheeler
Environment & Infrastructure

1-505 Woodward Avenue
Hamilton, Ontario L8H 6N6
Tel: (905) 312-0700
Fax: (905) 312-0771
www.amecfw.com

- Freestanding groundwater on 5/25/2016 measured **16.3** metres below ground surface.
- Freestanding groundwater on 6/1/2016 measured **53.43** metres below ground surface.
- Freestanding groundwater on 6/15/2016 measured **53.51** metres below ground surface.

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geoscientist. Also, borehole information should be read in conjunction withthe hydrogeological report for which it was comissioned and the accompanying 'Explanation of Borehole Log'.

Scale: 1 : 106

Continued on Next Page

RECORD OF BOREHOLE No. K-ASR-OW2-16

Project Number:	TT163301	Drilling Method:	PQ (85mm) Continuous Sampler/Soil Coring
Project Client:	Regional Municipality of Waterloo	Drilling Machine:	Track Mounted Drill CME 75 with Christiansen wireline coring
Project Name:	Mannheim Monitoring Well Construction	Date Started:	05/18/2016 — 05/25/2016
Project Location:	Kitchener, Ontario	Logged by: KG	Compiled by: KR
Drilling Location:	Mannheim WTP; As shown on Borehole Location Plan	Reviewed by: KG	Revision No.: 0, 6/27/16
		Coordinates:	NAD 1983 17T 538217.4 E ; 4805168.3 N

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LITHOLOGY PROFILE

Lithology Plot	DESCRIPTION
	Brown **SANDY SILT/ FINE SAND/ SILTY FINE SAND** Stratified Multiple fining upwards and downwards sequences Occasional layers of SILTY CLAY starting below 21.0m increasing in thickness with depth 364.69
	Brown 21.0 **SANDY SILT** with SILTY CLAY layers 360.29
	Grey to Brown 25.4 **SANDY SILT to MEDIUM SAND** Stratified Coarsening to trace GRAVEL Then fining to FINE to MEDIUM SAND Damp to wet 355.89
	Brown 29.8 **SILTY FINE SAND/ SANDY SILT** Interbedded 355.19 30.5
	Brown **FINE to MEDIUM SAND** Trace to some COARSE SAND and GRAVEL Trace to some SILT Wet 352.39
	Brown 33.3 **SILT and SILTY CLAY** Interbedded; oxidation staining 351.59 Coarsens to interbeds of stratified 34.1 SILT with oxidation staining and FINE SAND to MEDIUM SAND, Disturbed bedding
	Brown and Grey **SILTY CLAY TILL** Trace to some SAND; Trace GRAVEL Massive, dense 349.19
	Brown 36.5 **FINE to MEDIUM SAND** Wet to saturated, fining downwards to SILTY FINE SAND; Stratified and some cross-stratification Sharp upper contact 347.99 37.7 37.6 to 37.7m: interbedded with FINE SANDY SILT layers with oxidation staining

SOIL SAMPLING

Sample Type	Run Number	Recovery (%)
PQ	12	85
PQ	13	77
PQ	14	98
PQ	15	85
PQ	16	92
PQ	17	0
PQ	18	77
PQ	19	50
PQ	20	80
PQ	21	103
PQ	22	85
PQ	23	95
PQ	24	93

DEPTH (m): 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39

INTERPRETED STRATIGRAPHY

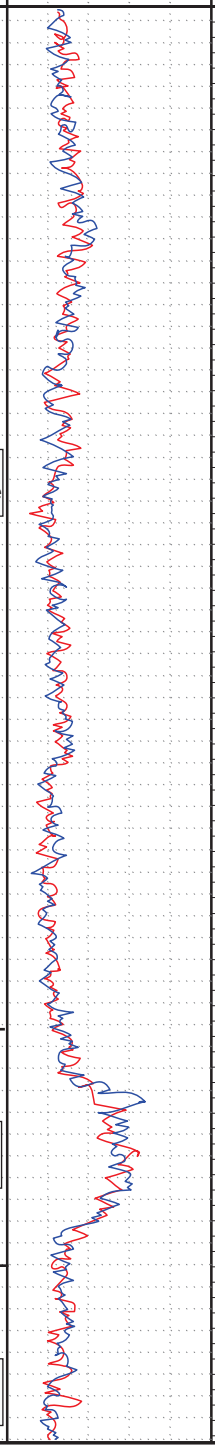
Unit AFB1: Upper Waterloo Moraine

Unit ATB2: Middle Maryhill Till

Unit AFB2: Waterloo Moraine

GEOPHYSICS

Measuring Point: Ground Surface
Measuring Point Elevation: N/A
Logged by: J. Dion (Lotowater Tech. Services)
Logging Date: May 26, 2016
Gamma 1 (cps) 0 – 100
Gamma 2 (cps) 0 – 100



INSTRUMENTATION INSTALLATION

UNIT INTERPRETATION COMMENTS

Quiet water facies Moraine deposits Aquifer 1

Aquitard 2

Quiet water facies Moraine deposits Aquifer 2

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geoscientist. Also, borehole information should be read in conjunction withthe hydrogeological report for which it was comissioned and the accompanying 'Explanation of Borehole Log'.

Scale: 1 : 106

Continued on Next Page

RECORD OF BOREHOLE No. K-ASR-OW2-16

Project Number:	TT163301	Drilling Method:	PQ (85mm) Continuous Sampler/Soil Coring
Project Client:	Regional Municipality of Waterloo	Drilling Machine:	Track Mounted Drill CME 75 with Christiansen wireline coring
Project Name:	Mannheim Monitoring Well Construction	Date Started:	05/18/2016 — 05/25/2016
Project Location:	Kitchener, Ontario	Logged by: KG	Compiled by: KR
Drilling Location:	Mannheim WTP; As shown on Borehole Location Plan	Reviewed by: KG	Revision No.: 0, 6/27/16
		Coordinates:	NAD 1983 17T 538217.4 E ; 4805168.3 N

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LITHOLOGY PROFILE

Lithology Plot	DESCRIPTION	Elevation	Depth
	Brown **FINE to MEDIUM SAND** Trace to some SILT Stratified Wet to saturated	345.69	40.0
	Brown **FINE SANDY SILT to SILTY FINE SAND** Trace MEDIUM SAND; SILT interbeds, SILTY CLAY seams common from 40.2m to 43.6m and 49.4m to 50.5m	334.59	51.1
	Brown **FINE SAND** Trace to some SILT Stratified Sharp upper contact	331.99	53.7
	Brown **FINE to MEDIUM SAND** Stratified Wet to saturated Coarsening downwards to MEDIUM to COARSE SAND Increasing GRAVEL and COBBLE content with depth		

SOIL SAMPLING

Sample Type	Run Number	Recovery (%)
PQ	25	80
PQ	26	87
PQ	27	85
PQ	28	88
PQ	29	77
PQ	30	90
PQ	31	93
PQ	32	75
PQ	33	88
PQ	34	77
PQ	35	22
PQ	36	60
PQ	37	20

DEPTH (m): 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59

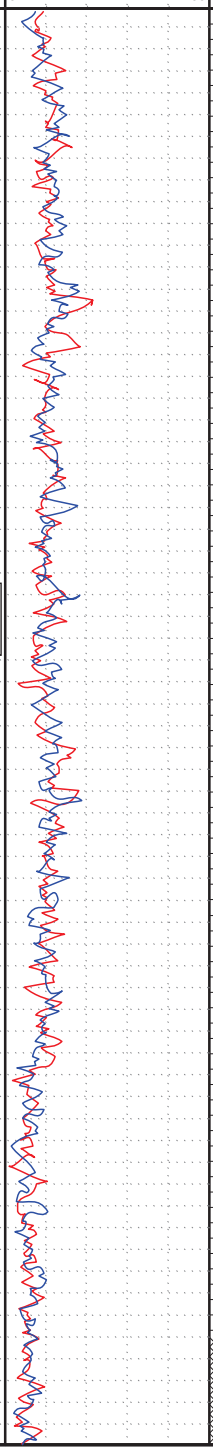
6/2/2016 — 1/6/2016

INTERPRETED STRATIGRAPHY

Unit AFB2: Waterloo Moraine

GEOPHYSICS

Measuring Point: Ground Surface
Measuring Point Elevation: N/A
Logged by: J. Dion (Lotowater Tech. Services)
Logging Date: May 26, 2016



INSTRUMENTATION INSTALLATION

UNIT INTERPRETATION COMMENTS

Quiet water facies
Moraine deposits
Aquifer 2

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geoscientist. Also, borehole information should be read in conjunction withthe hydrogeological report for which it was comissioned and the accompanying 'Explanation of Borehole Log'.

Scale: 1 : 106

Continued on Next Page

RECORD OF BOREHOLE No. K-ASR-OW2-16

Project Number:	TT163301	Drilling Method:	PQ (85mm) Continuous Sampler/Soil Coring
Project Client:	Regional Municipality of Waterloo	Drilling Machine:	Track Mounted Drill CME75 drill with Christiansen wireline coring
Project Name:	Mannheim Monitoring Well Construction	Date Started:	05/18/2016 — 05/25/2016
Project Location:	Kitchener, Ontario	Logged by: KG	Compiled by: KR
Drilling Location:	Mannheim WTP; As shown on Borehole Location Plan	Reviewed by: KG	Revision No.: 0, 08/05/2016
		Coordinates:	NAD 1983 17T 538217.4 E ; 4805168.3 N

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LITHOLOGY PROFILE

DESCRIPTION

Brown
FINE to MEDIUM SAND
Some SILT
Stratified
Wet to saturated
Coarsening downwards to MEDIUM to COARSE SAND
Increasing GRAVEL and COBBLE content with depth

317.10 — 69.5

Grey
SILTY CLAY and FINE SANDY SILT or SILT TILL
Layered
Fines slightly to SILTY CLAY and CLAYEY SILT interbeds
Bedding highly disturbed

313.70 — 72.9

Grey
FINE SANDY SILT or SILT TILL
Occasional SILTY CLAY seams; occasional ripples
Bedding highly disturbed
Soft

SILTY CLAY to SILT TILL
Trace to some SAND, occasional GRAVEL
Some disturbed bedding
Dense

308.20 — 78.6

SOIL SAMPLING

Sample Type	Run Number	Recovery (%)	
PQ	38	93	
PQ	39	60	
PQ	40	70	
PQ	41	48	Sand: 94.7% Silt: 5.3%
PQ	42	82	Sand: 95.4% Silt: 4.0%
PQ	43	98	Gravel: 29.9% Sand: 65.9% Silt: 4.2%
PQ	44	80	Sand: 42.3% Silt: 7.7%
PQ	45	107	
PQ	46	88	
PQ	47	92	
PQ	48	83	
PQ	49	90	
PQ	50	107	

DEPTH (m): 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79

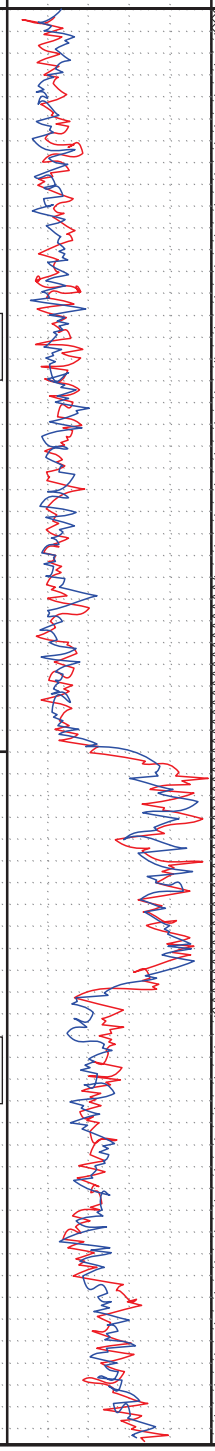
INTERPRETED STRATIGRAPHY

Unit AFB2: Waterloo Moraine

Unit ATB3: Lower Maryhill Till

GEOPHYSICS

Measuring Point: Ground Surface
Measuring Point Elevation: N/A
Logged by: J. Dion (Lotowater Tech. Services)
Logging Date: May 26, 2016
Gamma 1 (cps) 0 – 100
Gamma 2 (cps) 0 – 100



INSTRUMENTATION INSTALLATION

UNIT INTERPRETATION COMMENTS

Quiet water facies deposits grading to nearshore/ glaciofluvial/ice contact deposits with depth

Aquifer 2

Aquitard 2

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geoscientist. Also, borehole information should be read in conjunction withthe hydrogeological report for which it was comissioned and the accompanying 'Explanation of Borehole Log'.

Scale: 1 : 106

RECORD OF BOREHOLE No. K-ASR-OW2-16

Project Number:	TT163301	Drilling Method:	PQ (85mm) Continuous Sampler/Soil Coring		
Project Client:	Regional Municipality of Waterloo	Drilling Machine:	Track Mounted Drill CME 75 drill with Christiansen wireline coring		
Project Name:	Mannheim Monitoring Well Construction	Date Started:	05/18/2016		05/25/2016
Project Location:	Kitchener, Ontario	Logged by:	KG	Compiled by:	KR
Drilling Location:	Mannheim WTP; As shown on Borehole Location Plan	Reviewed by:	KG	Revision No.:	0, 08/05/2016
		Coordinates:	NAD 1983 17T 538217.4 E ; 4805168.3 N		

amec foster wheeler

LITHOLOGY PROFILE		SOIL SAMPLING					INTERPRETED STRATIGRAPHY	GEOPHYSICS	INSTRUMENTATION INSTALLATION	UNIT INTERPRETATION COMMENTS
Lithology Plot	DESCRIPTION	Sample Type	Run Number	Recovery (%)		DEPTH (m)		Measuring Point: Ground Surface Measuring Point Elevation: N/A Logged by: J. Dion (Lotowater Tech. Services) Logging Date: May 26, 2016 Gamma 1 (cps) 0 – 100 Gamma 2 (cps) 0 – 100		
	End of BOREHOLE at 79.2m. 307.40									
	WELL CONSTRUCTION DETAILS Stick-up of 0.87m Bentonite Holeplug: 0 m - 3.0 m Bentonite Grout: 3.0 m - 57.6 m Bentonite Holeplug: 57.6 m - 59.4 m Sand: 59.4 m - 67.1 m Screen: 61.0 m - 64.0 m Bentonite Holeplug: 67.1 m - 73.2 m Sand: 73.2 m - 79.2 m									

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geoscientist. Also, borehole information should be read in conjunction withthe hydrogeological report for which it was comissioned and the accompanying 'Explanation of Borehole Log'.

Scale: 1 : 106

BURNSIDE

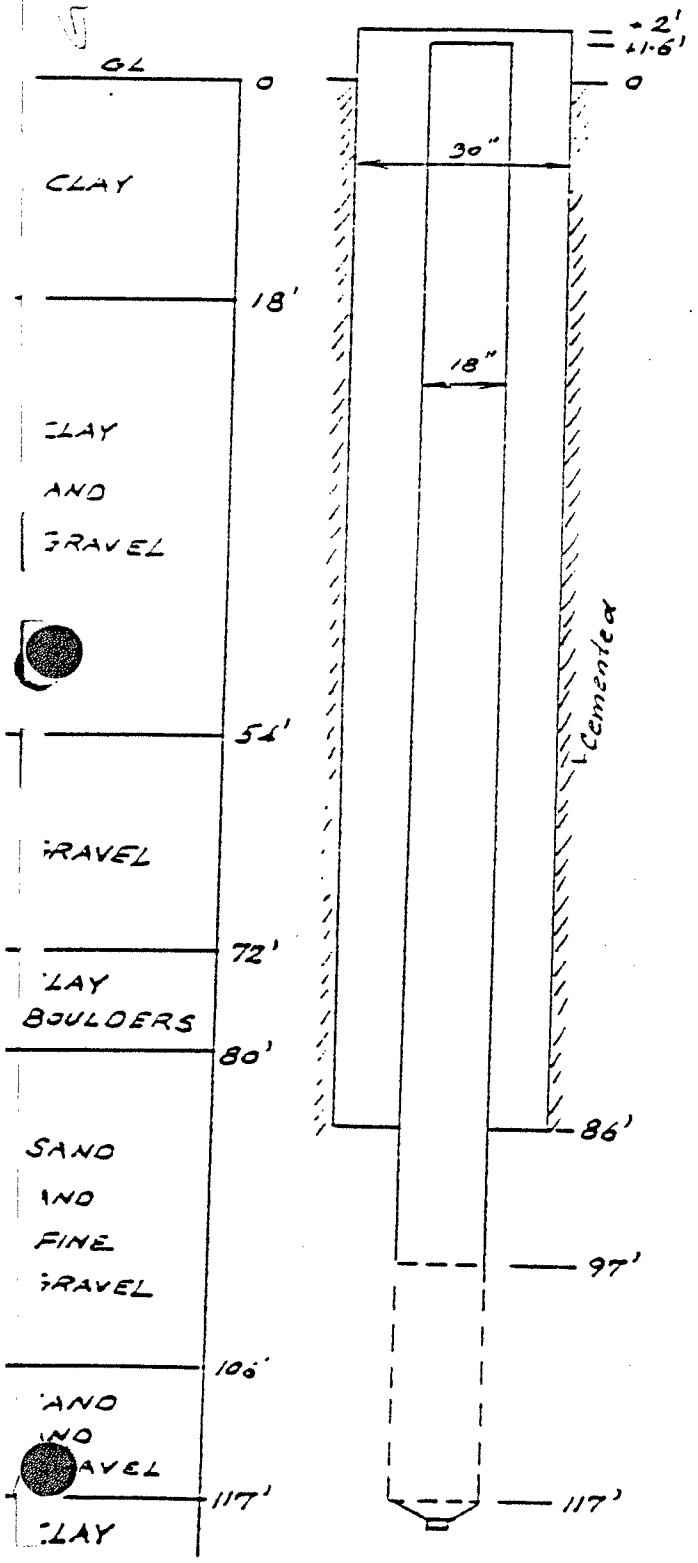
[THE DIFFERENCE IS OUR PEOPLE]

Appendix B-3

Mannheim East Well Logs

K21

K-21



idized May 2, 1960 - G. Keyes

Well Material

Outer Casing 30" x 88' rolled welded

Inner Casing 18" x 98'-6" rolled welde

Screen 18" x 20' Layne S.S. # 6

Plug 18 x 6 swedge - o" Baker & whirler

Gravel 16 Yds # 5

Pump

No. ~~24673~~ Setting BP-MB (90) ~~E~~

No. Stages 6 Length Bowl 7'-3"

Bowl 15" RKHC ~~Size & Lgth~~ Suction 10" x

Head ~~TF 1025~~ Size Column 10" x 5"

Materials or setting details other than standar
1200 IGPM @ 262' TDH

Motor

Make ~~US~~ Phase 3

Shaft VHS Cycles 60

H. P. 125 Volts 550

R. P. M. ~~1170/1800~~ Amps. 121

Type CFU Base

Frame ~~5B7-6~~ Serial ~~92 72 86~~

Type ~~CHU~~

Special Equipment

N.B. - SEE ATTACHED DIAGRAM WITH AMPS OF PUMP & MOTOR DETAIL

21

Well

B. P. referred to original Ground Level 4'

Started Clear Depth (120)-2 121

Preliminary Test 7/19/51 Length Air Line 105

Final Test Oct 7 1953 — Static Level (32'

Guarantee 3000 IGPM Pumping Level 67

Not less than 3 wells, 4 wells maximum

Pressure 92 psi Capacity 1200 G

Driller: L. OLIVER, Jun 26, 1951

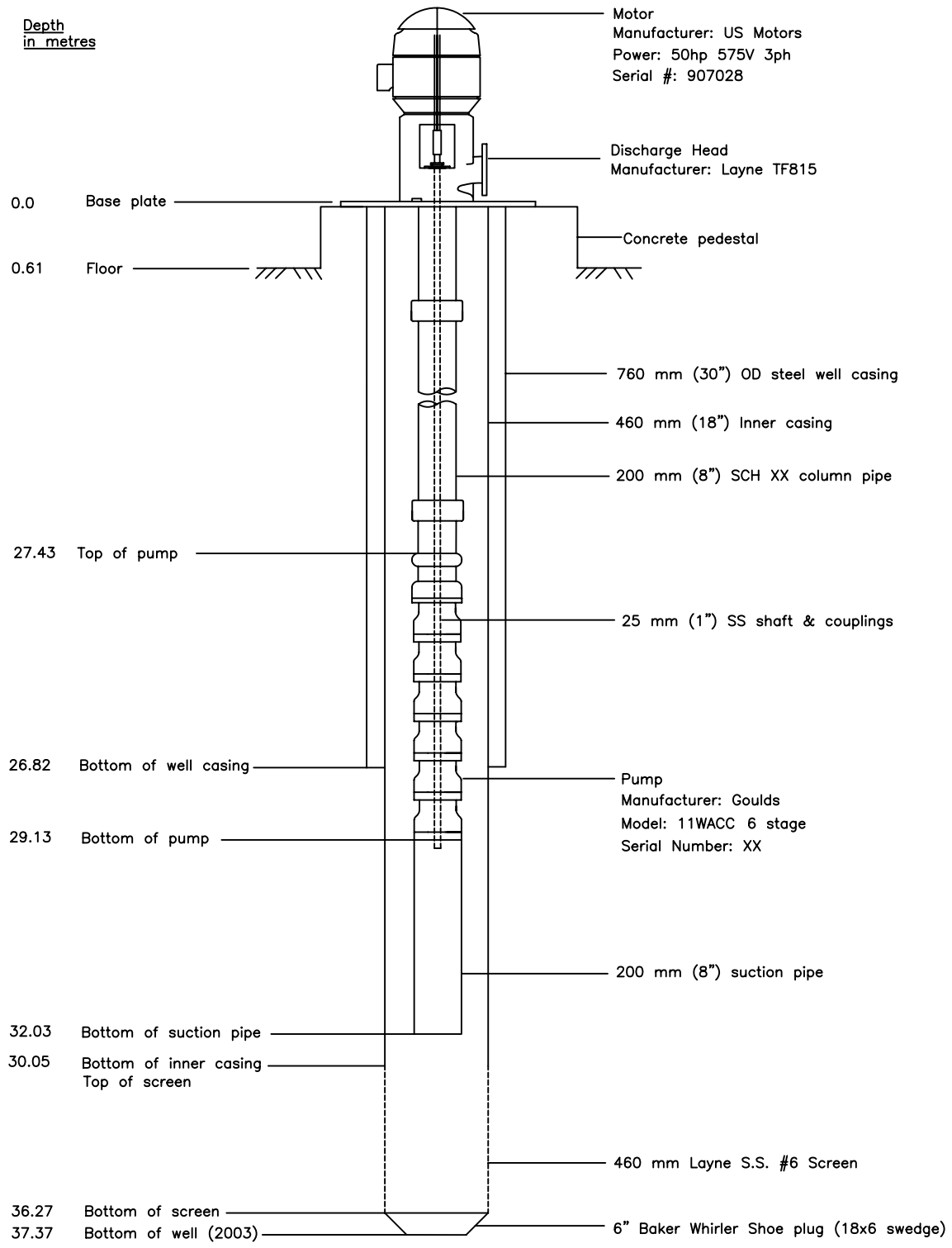
Installer: B. S. ABBOTT 5/21/53 Gordon Ke

INTERNATIONAL WATER SUPPLY LTD.
LONDON, CANADA
WATER SUPPLY CONTRACTORS

KITCHENER, ONT.

DRAWN BY HL. APPROVED BY

WELL NO. 1 MANNHEIM, (FEICK) TESTHOLE #46



NOTES

All measurements below pump baseplate in metres.

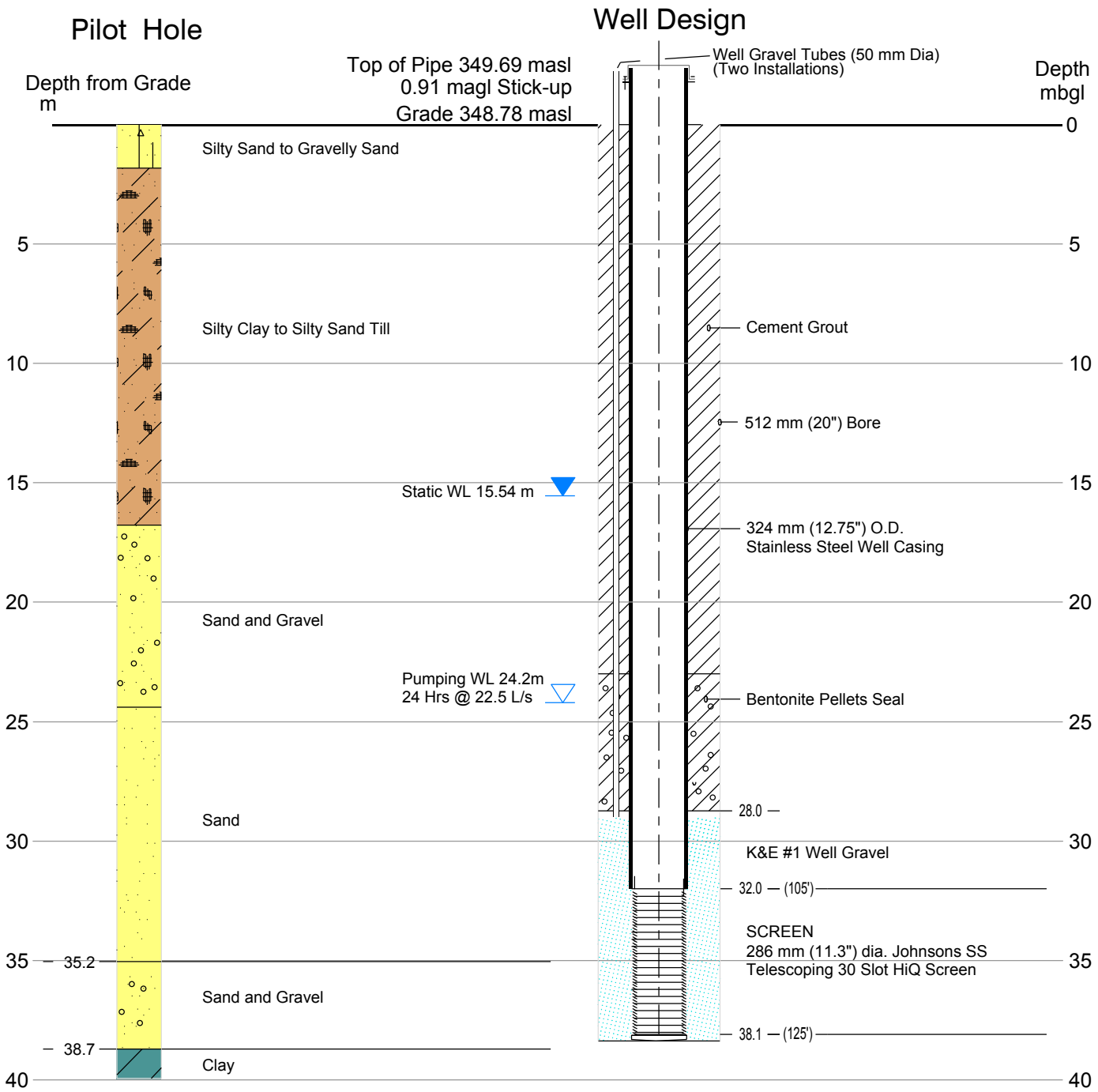
Drawing not to scale.

Lotowater TECHNICAL SERVICES INC.

CLIENT
Regional Municipality of Waterloo

TITLE
K21 Well
Pump and Motor Installation

PROJECT No. 006-115			Lotowater Projects\006 Region of Waterloo\115 RMOW 2008 Well Maintenance Program\Lineshaft Pump Installation Drawing\K21.dwg		
DESIGN			REVISION No. DRAFT	SCALE N.T.S.	FIGURE 2
DRAWN	MO	08/10/28	SCALE (m) 0 X X		
CHECKED					



*Note:
All depths are metres below ground level unless otherwise stated.

CLIENT
REGION OF WATERLOO

PROJECT
2015 NEW WELL CONSTRUCTION AND TESTING AT K21
MANNHEIM EAST WELL FIELD

CONSULTANT

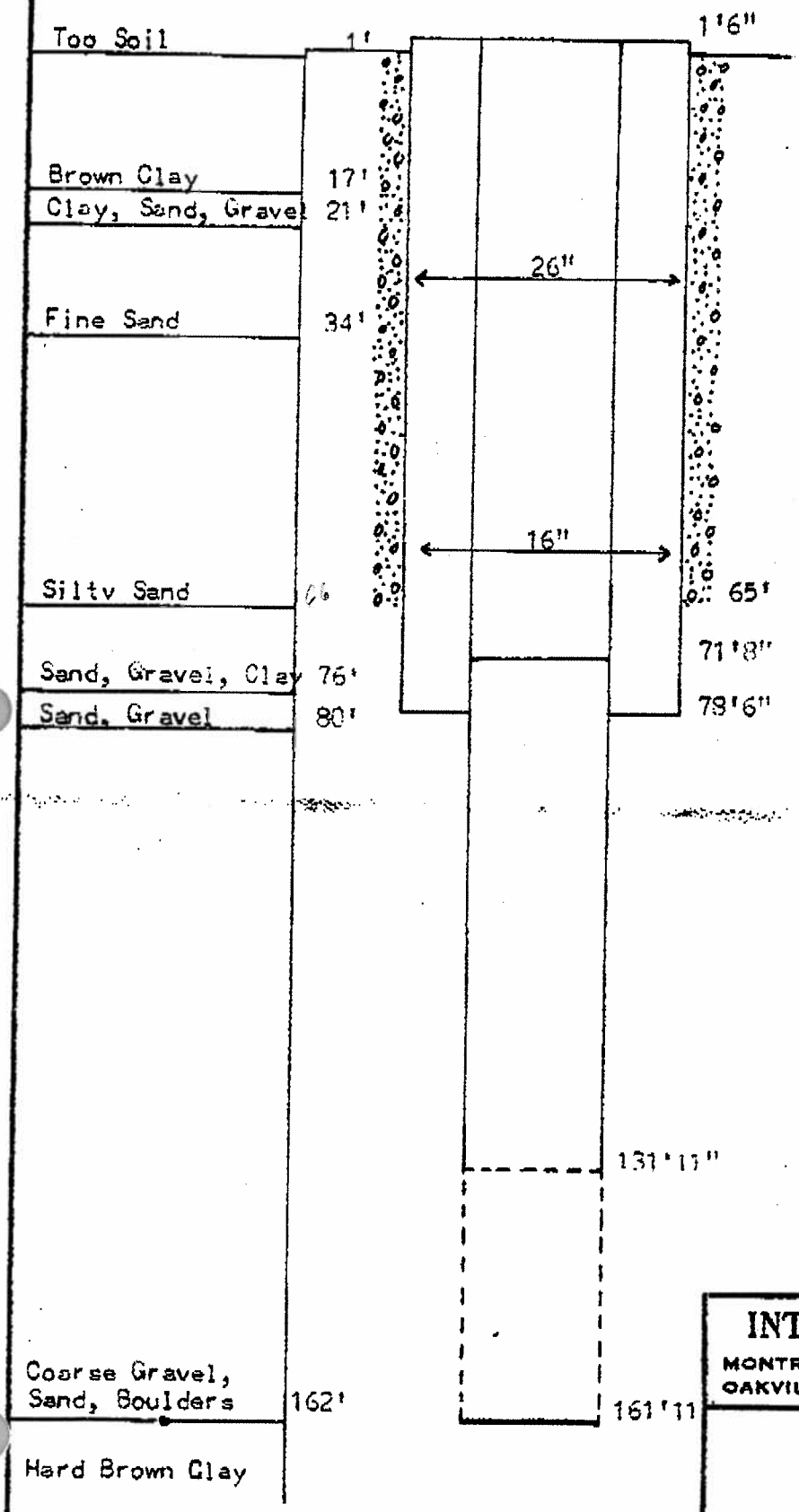
Golder Associates

YYYY-MM-DD	2016-02-22
PREPARED	JPR / GWS
DESIGN	JAE
REVIEW	JAE
APPROVED	GWS

TITLE
K21A WELL CONSTRUCTION DETAILS

PROJECT No.	Phase	Rev.	Figure
1520338	-	A	10

Path: \\golder.gds\gal\barrie\CAD. rojects\2016\1520338 (Region of Waterloo, Greenbrook)\-B A-Cambridge\ | File Name: 1520338BAMAP.dwg
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
25 mm
0



Well Material

Outer Casing 80' of 26"

Inner Casing 73'2" of 16", 60'3" of 16

Screen 30' of 16" SS, No. 6 opening

Plug Stainless steel plate

Gravel 64 T 1/4 x 1/8, 18 T #5

Pump

No. 47592	Setting BP-MB 130'
No. Stages 4	Length Bowl 5'1"
Bowl 12" RKAH	Size & Lgth. Suction
Head TF	Size Column 8" x 1-11

Materials or setting details other than sta

Impellers: Trim

Motor

Make U.S.E.M.	Phase 3
H. P. 100	Cycles 60
R. P. M. 1800	Volts 550
Type HU	Amps. 96.8
Frame 244 UPY	Serial 1184044

Bearing Nos. Upper - 7322.K Lower -

Special Equipment

14 zinc sleeves installed.

Well No. 25 - Mannheim

B.P. referred to original ground level 4'

Clear depth below B.P. 165'9"

Started Nov. 13/62 Final Test Nov. 4/

Preliminary Test Dec. 5 Static Level 97'

Final Test Pumping Level

Guarantee IGPM Capacity I

Contract Pressure # Pressure Pump

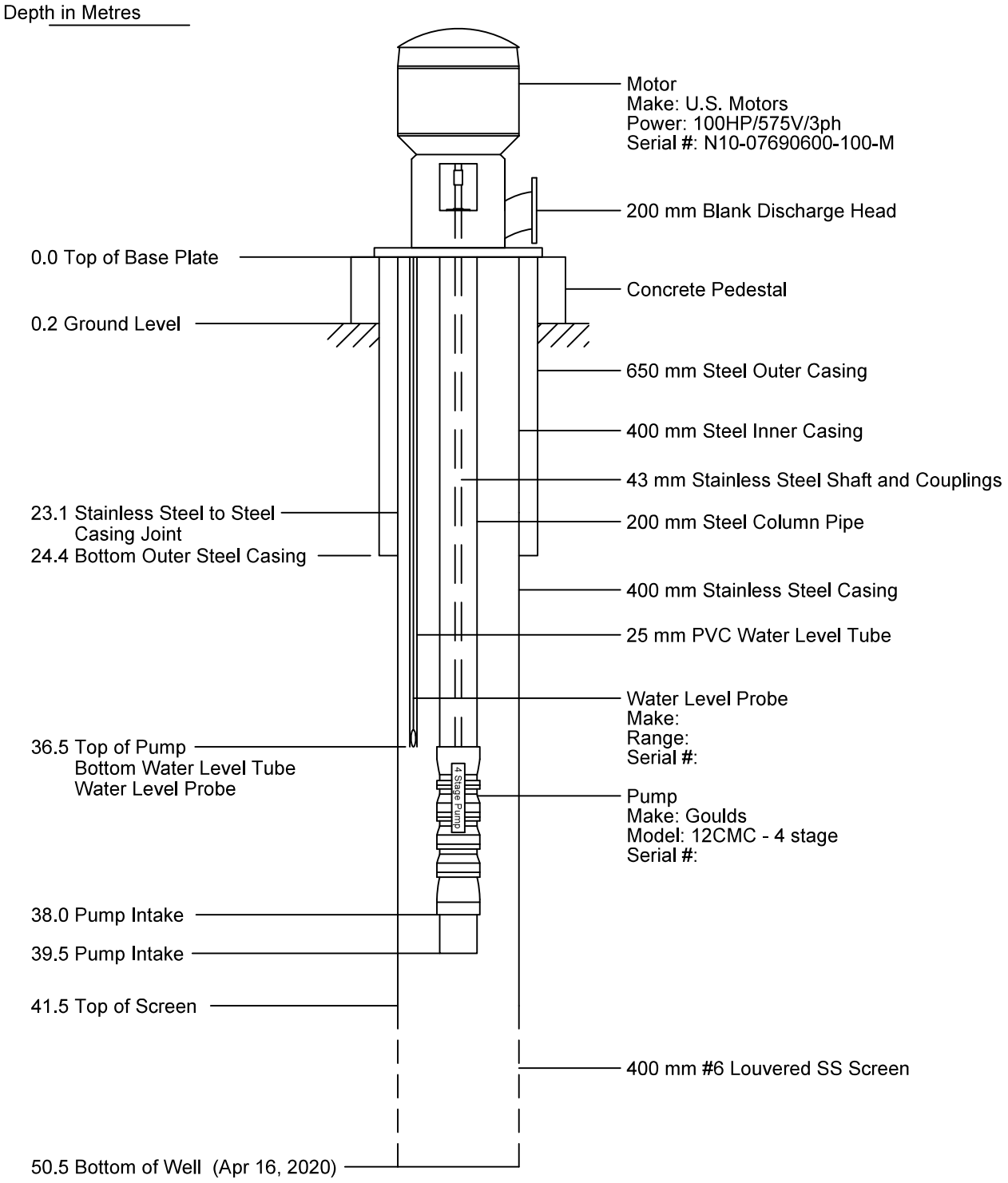
Length Air Line 145' Main

INTERNATIONAL WATER SUPPLY L

MONTREAL LONDON, CANADA SASK
OAKVILLE WATER SUPPLY CONTRACTORS VANC

KITCHENER WATER COMMISSION, KITCHENER
(Mannheim)

DRILLED BY K. McCutchen DRAWN BY MS
INSTALLED BY G. Keyes APPROVED BY



Lotowater TECHNICAL SERVICES INC.

CLIENT
REGIONAL MUNICIPALITY OF WATERLOO

TITLE
WELL K25
PUMP INSTALLATION DRAWING

PROJECT #:	006-473	G:\Lotowater Projects\006 Region of Waterloo\473 Well K25 Service\Install Drawing.dwg			
DESIGN			REVISION No.	SCALE	FIGURE
DRAWN	EH	2020/04/28	2020-06-03	N.T.S	3
CHECKED	BP	2020/04/28			

K29

WELL DIAGRAM

LOG

0 — brown clay
10 — sand
17 — coarse sand
15
22 — sand f-m
28 — Gravel f-c sand
24" — 12"
40 — sand f-m
some Gravel packed
58 — Gravel f-c some clay
62 — brown silty sand
67 — Gravel m-c
70 — sand + gravel f-c
74 — Gravel m-c
Boulders
88 — Gravel coarse.
Boulders
100 — Gravel pkd.
109 — Sand
Gravel coarse
116 — Boulders
120 — Marl & Gravel
126 — Gravel & boulders
Gravel & sand
odd boulder
136 — Gravel & sand
139 — Gravel sand
Boulders
151 — Gravel, Sand
Boulders & clay
169

+1.58' — 0 — 21' — 40' — 59 — 60 — 78 — 79 — 100 — 139' — 169

Bentonite Seals

WELL MATERIAL

Outer Casing: 24 " dia. .500 " Wall Thk. Matl.: steel
Cemented from 40 ' " to 0 ' "
Inner Casing: 12 " dia. .375 " Wall Thk. Matl.: steel
Screen: Make Johnson 12 " dia.. Opening & Matl.: 50 slot ss.
Plug: Type ____ Matl stain. ss. Other: ____
Gravel: Type silica Size 1/8 x 10 Quantity 30 bags

WELL TEST DATA

Preliminary Test Date: June 28/88 by W/M
Static Level: 110.00 ' " below M.P. + 1.58
Pumping Rate IGM: 700
Pumping Duration: 24 hrs. ____ min.
Pumping Level at Test End: 126.57 ' "
Performance Plots: dd-t Dwg. A88211
dd-r Dwg. A88212
Step Test B.88204 255.502.751

Final Test: Date ____ by ____
Rated Well Capacity IGM ____
Pumping Rate IGM ____ Static level ____ ' "
Pumping level ____ ' " at ____ hrs. ____ min.
Pump pressure: ____ psi: Main pressure ____ psi
Shut off: AGH ____ psi: W.L. ____ ' "
Clear Well Depth from B.P. ____ ' " Air Line ____ ' "

PUMP & MOTOR DATA

Pump Make ____ Rating ____ IGM @ ____ ' TH
Head: Type ____ S.N. ____
Column: ____ ' X ____ " X ____ ": Shaft Mtl: ____
Bowl: ____ Stage ____ Curve: ____
Suction: ____ " dia. ____ ' ____ " Long
Special: Zinc Sleeves ____ Taped Oil Line ____
Other ____
Motor Make: ____ Frame: ____ SN: ____
____ HP. ____ ph. ____ hz. ____ rpm. ____ Volts
Bearing No. Upper ____
Lower ____

Special Equipment

WELL REVISIONS AND REHABILITATION

DATE	WORK DONE	BY

International Water Supply Limited

SASKATOON – BARRIE – MONTREAL

CLIENT: REGION of WATERLOO
WELL NO: K-29

DRILLED BY: W. Noble DATE:
INSTALLED BY: DATE:
DRAWN: J. Wall
DATE: July 12, 1988

RECORDING CHARTS

K29

Ministry of the Environment
Ontario

The Ontario Water Resources Act

WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

COUNTY OR DISTRICT	TOWNSHIP BOROUGH CITY TOWN VILLAGE	CON BLOCK TRACT SURVEY ETC	LOT
Waterloo	Kitchener	G.C.T.	138

OWNER (SURNAME FIRST)	ADDRESS	DATE COMPLETED
Region of Waterloo	Marsland Center	DAY 28 MO 6 YR 88

Pg 1 of 2

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	TO
rown	clay			0	6
	sand			6	13
	sand		packed	13	15
	Sand f-m			15	22
	Gravel f-c	sand		22	28
	Sand f-m	some gravel	packed	28	58
	Gravel f-c	some clay		58	62
rown	clay	some gravel		62	67
	Gravel m-c			67	70
	Sand	gravel	packed	70	74
	Gravel m-c	boulders		74	88
	Gravel	& boulders	cemented	88	100

WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
20	☑ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS

CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	TO
24	☑ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC	.500	+1.58	100
12	☑ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC	.375	+1'	139
	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC			

SCREEN

SIZE(S) OF OPENING (SLOT NO.)	DIAMETER	LENGTH
50 slot	12 INCHES	30 FEET

MATERIAL AND TYPE	DEPTH TO TOP OF SCREEN
Wire wrapped Johnson	139 FEET

PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT LEAD PACKER ETC.)
0	40	Cement Grout

PUMPING TEST

PUMPING TEST METHOD	PUMPING RATE	DURATION OF PUMPING
☑ PUMP ☐ BAILER	700 GPM	24 HOURS ___ MINS

STATIC LEVEL	WATER LEVEL END OF PUMPING	WATER LEVELS DURING ☑ PUMPING ☐ RECOVERY 15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
110. FEET	FEET	126.57 FEET	126.54 FEET	FEET	126.54 FEET

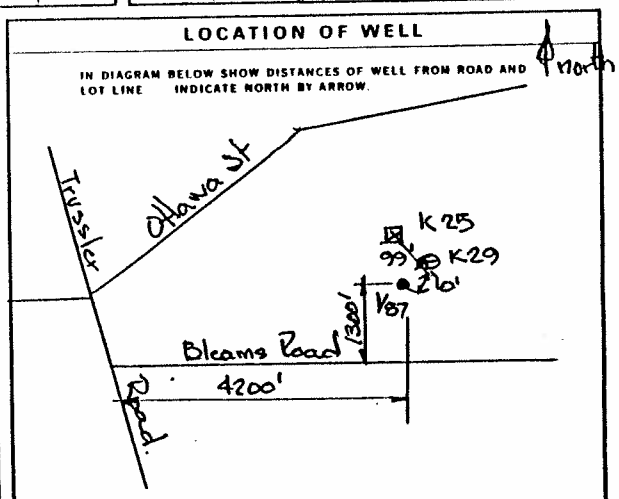
IF FLOWING, GIVE RATE	PUMP INTAKE SET AT	WATER AT END OF TEST
GPM	FEET	☐ CLEAR ☐ CLOUDY

RECOMMENDED PUMP TYPE	RECOMMENDED PUMP SETTING	RECOMMENDED PUMPING RATE
☐ SHALLOW ☐ DEEP	FEET	GPM

API ___ ST

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



30999

DRILLERS REMARKS

FINAL STATUS OF WELL	☑ WATER SUPPLY ☐ OBSERVATION WELL ☐ TEST HOLE ☐ RECHARGE WELL ☐ ABANDONED, INSUFFICIENT SUPPLY ☐ ABANDONED POOR QUALITY ☐ UNFINISHED ☐ DEWATERING
WATER USE	☐ DOMESTIC ☐ STOCK ☐ IRRIGATION ☐ INDUSTRIAL ☐ OTHER ☐ COMMERCIAL ☑ MUNICIPAL ☐ PUBLIC SUPPLY ☐ COOLING OR AIR CONDITIONING ☐ NOT USED
METHOD OF CONSTRUCTION	☑ CABLE TOOL ☐ ROTARY (CONVENTIONAL) ☑ ROTARY (REVERSE) ☐ ROTARY (AIR) ☐ AIR PERCUSSION ☐ BORING ☐ DIAMOND ☐ JETTING ☐ DRIVING ☐ DIGGING ☐ OTHER

NAME OF WELL CONTRACTOR	WELL CONTRACTOR'S LICENCE NUMBER
International Water Supply	2801
ADDRESS: P.O. Box 310 Barrie	
NAME OF WELL TECHNICIAN: W Nobes	WELL TECHNICIAN'S LICENCE NUMBER: T-0115
SIGNATURE OF TECHNICIAN/CONTRACTOR: [signature]	SUBMISSION DATE: DAY 12 MO 7 YR 88

OFFICE USE ONLY

CONTRACTOR'S COPY

FORM NO. 0506 (11 88) FORM 9

K29

Ministry of the Environment

The Ontario Water Resources Act

WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

COUNTY OR DISTRICT	TOWNSHIP BOROUGH CITY TOWN VILLAGE	CON BLOCK TRACT SURVEY ETC	LOT
Waterloo	Kitchener	GCT	138

OWNER (SURNAME FIRST)	ADDRESS	DATE COMPLETED
Region of Waterloo	Marsland Center	DAY 28 MO 6 YR 88

Pg 2 of 2

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	TO
	Gravel	sand	packed	100	109
	gravel	& boulders	cemented	109	116
	Marl	gravel		116	120
	gravel	boulders		120	126
	gravel	sand odd boulder		126	136
	gravel &	sand		136	138
	Gravel	sand boulders		138	151
	Gravel	sand boulders & clay		151	169

WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS
	☐ FRESH ☐ SALTY ☐ SULPHUR ☐ MINERALS ☐ GAS

CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	TO
	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC			
	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC			
	☐ STEEL ☐ GALVANIZED ☐ CONCRETE ☐ OPEN HOLE ☐ PLASTIC			

SCREEN

SIZE(S) OF OPENING (SLOT NO.)	DIAMETER INCHES	LENGTH FEET
MATERIAL AND TYPE	DEPTH TO TOP OF SCREEN FEET	

PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT LEAD PACKER ETC.)

PUMPING TEST

PUMPING TEST METHOD	PUMPING RATE	DURATION OF PUMPING
☐ PUMP ☐ BAILER	GPM	HOURS MINS

STATIC LEVEL	WATER LEVEL END OF PUMPING	WATER LEVELS DURING ☐ PUMPING ☐ RECOVERY			
		15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
FEET	FEET	FEET	FEET	FEET	FEET

IF FLOWING, GIVE RATE	PUMP INTAKE SET AT	WATER AT END OF TEST
GPM	FEET	☐ CLEAR ☐ CLOUDY

RECOMMENDED PUMP TYPE	RECOMMENDED PUMP SETTING	RECOMMENDED PUMPING RATE
☐ SHALLOW ☐ DEEP	FEET	GPM

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.

See Pg #1

31201

DRILLERS REMARKS

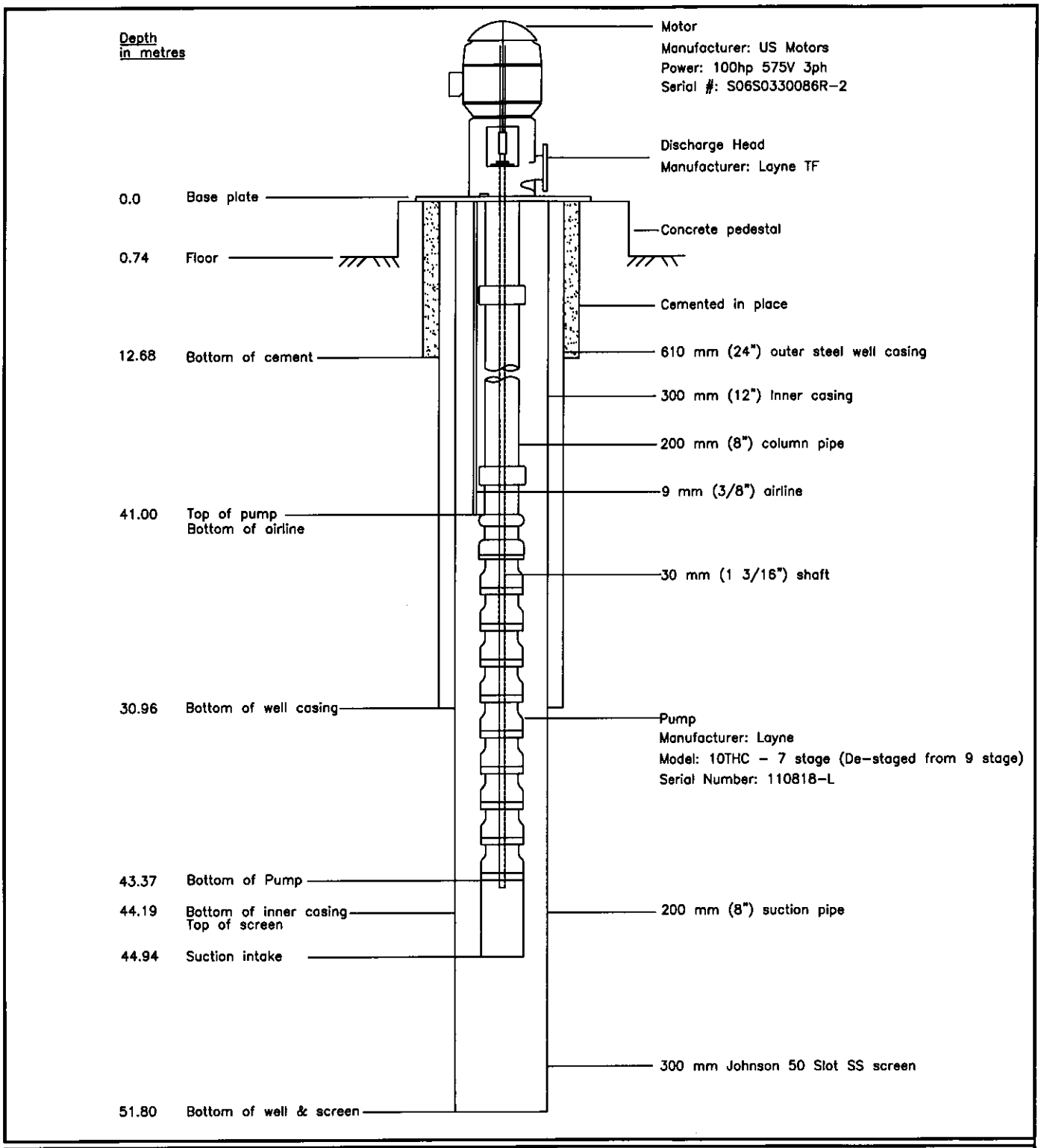
FINAL STATUS OF WELL	☑ WATER SUPPLY ☐ OBSERVATION WELL ☐ TEST HOLE ☐ RECHARGE WELL ☐ ABANDONED INSUFFICIENT SUPPLY ☐ ABANDONED POOR QUALITY ☐ UNFINISHED ☐ DEWATERING
WATER USE	☐ DOMESTIC ☐ STOCK ☐ IRRIGATION ☐ INDUSTRIAL ☐ OTHER ☐ COMMERCIAL ☑ MUNICIPAL ☐ PUBLIC SUPPLY ☐ COOLING OR AIR CONDITIONING ☐ NOT USED
METHOD OF CONSTRUCTION	☑ CABLE TOOL ☐ ROTARY (CONVENTIONAL) ☑ ROTARY (REVERSE) ☐ ROTARY (AIR) ☐ AIR PERCUSSION ☐ BORING ☐ DIAMOND ☐ JETTING ☐ DRIVING ☐ DIGGING ☐ OTHER

NAME OF WELL CONTRACTOR	International Water Supply
WELL CONTRACTOR'S LICENCE NUMBER	2801
ADDRESS	PO Box 310 Barrie
NAME OF WELL TECHNICIAN	W. Nobes
WELL TECHNICIAN'S LICENCE NUMBER	T-0115
SIGNATURE OF TECHNICIAN/CONTRACTOR	
SUBMISSION DATE	DAY 12 MO 7 YR 88

CONTRACTOR'S COPY

OFFICE USE ONLY

FORM NO. 0506 (11/86) FORM 9

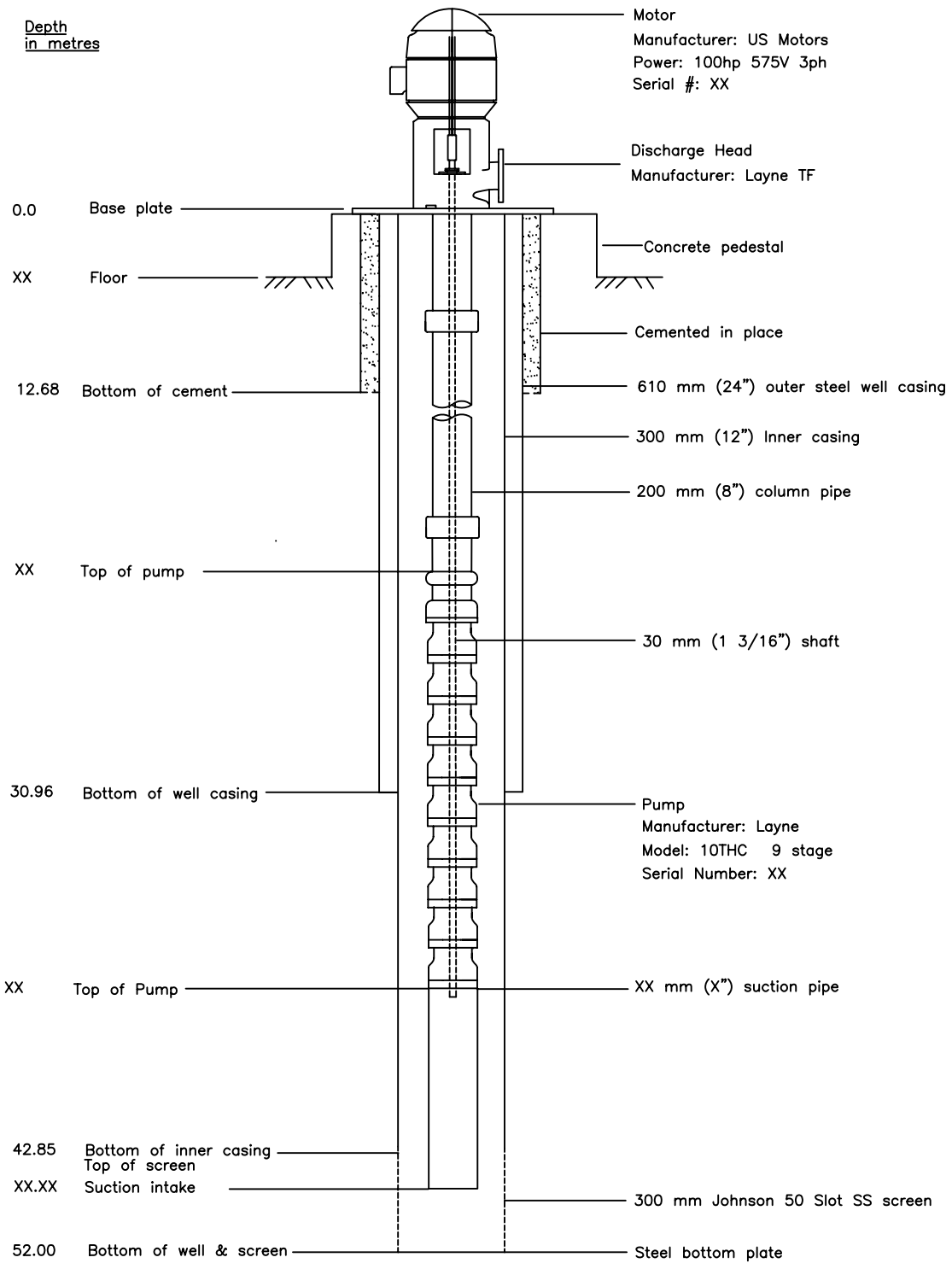


Lotowater
TECHNICAL SERVICES INC.

CLIENT
Regional Municipality of Waterloo

TITLE
K29
Pump Installation Drawing

PROJECT No.	006-153		\\Poweredge\...\Lotowater Projects\006 Region of Waterloo\153 K29 Pump Maintenance\7. Technical		FIGURE
DESIGN			REVISION No. 2013-02-27	SCALE N.T.S.	4
DRAWN	EH	2008/10/06			
CHECKED	BP	2013/03/01			



NOTES

All measurements below pump base plate in metres.
Drawing not to scale.

Lotowater TECHNICAL SERVICES INC.

CLIENT
Regional Municipality of Waterloo

TITLE
K29 Well
Pump and Motor Installation

PROJECT No.	006-115	Lotowater Projects\006 Region of Waterloo\115 RMOW 2008 Well Maintenance Program\Lineshaft Pump Installation Drawing\K29.dwg			
DESIGN			REVISION No. 1	SCALE N.T.S.	FIGURE 2
DRAWN	EH	08/10/06	SCALE (m) 0 X X		
CHECKED					

PROJECT: 08-1112-0150

BOREHOLE LOG OF: WT-ME-OW03-09

SHEET 1 OF 3

LOCATION: N 4805494.0 ;E 537033.0

DRILLING DATE: November 17, 2009

DATUM: NAD83

DRILL RIG: Air Rotary

DRILLING CONTRACTOR: Gerrits Well Drilling

DEPTH SCALE METRES	DESCRIPTION	ELEV. / DEPTH (m)	OGS CODE
	GROUND SURFACE	369.76	
0	Brown TOPSOIL, trace sand, trace gravel	0.00	AFB1
	Brown SAND, some silt, trace gravel	365.50 / 4.26	
	Brown, medium to coarse SAND, some gravel	350.56 / 19.20	

GEOPHYSICAL RECORD: GAMMA (cps) 25 50 75 100; CONDUCTIVITY (mS/m) 10 20 30 40

PIEZOMETER OR STANDPIPE INSTALLATION: Bentonite Grout

CONTINUED NEXT PAGE

DEPTH SCALE 1 : 100

Golder Associates

LOGGED: BH

CHECKED: CM

PROJECT: 08-1112-0150

BOREHOLE LOG OF: WT-ME-OW03-09

LOCATION: N 4805494.0 ;E 537033.0

DRILLING DATE: November 17, 2009

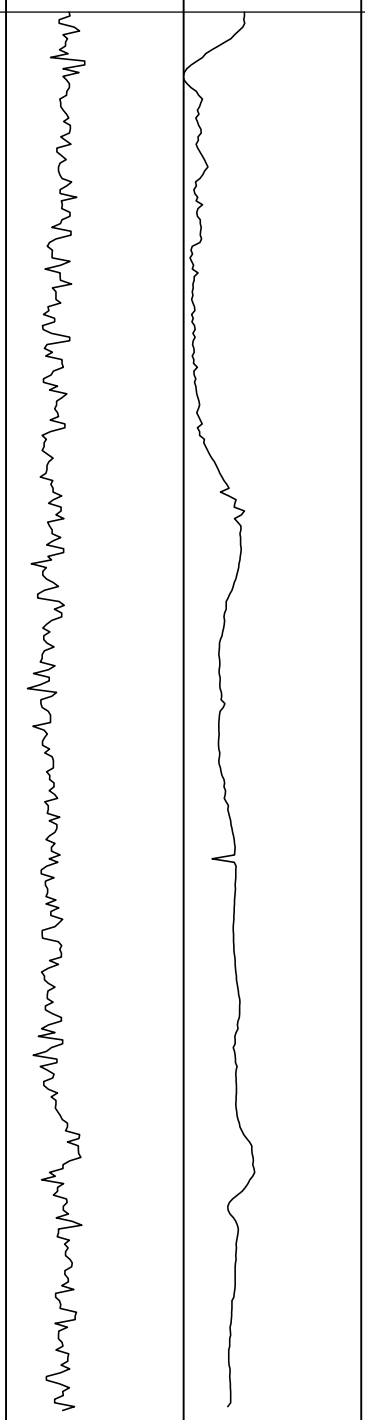
DRILL RIG: Air Rotary

DRILLING CONTRACTOR: Gerrits Well Drilling

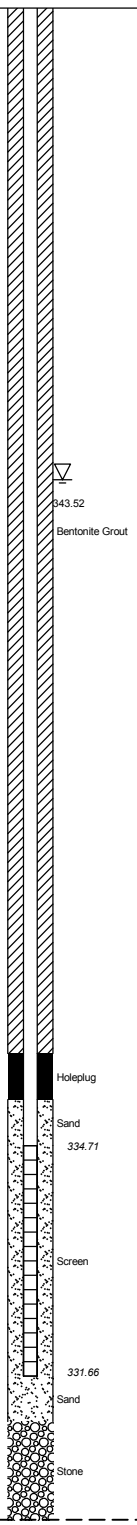
DATUM: NAD83

DEPTH SCALE METRES	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	OGS CODE
	--- CONTINUED FROM PREVIOUS PAGE ---			
20	Brown, medium to coarse SAND, some gravel			AFB1
24	Brown, coarse SAND with GRAVEL		345.76 / 24.00	AFB1
40	Dense, brown CLAY, some silt		331.06 / 38.70	ATB2
	CONTINUED NEXT PAGE			

GEOPHYSICAL RECORD



PIEZOMETER OR STANDPIPE INSTALLATION



DEPTH SCALE

1 : 100

LOGGED: BH

CHECKED: CM

PROJECT: 08-1112-0150

BOREHOLE LOG OF: WT-ME-OW03-09

LOCATION: N 4805494.0 ;E 537033.0

DRILLING DATE: November 17, 2009

DATUM: NAD83

DRILL RIG: Air Rotary

DRILLING CONTRACTOR: Gerrits Well Drilling

DEPTH SCALE METRES	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	OGS CODE	GEOPHYSICAL RECORD: GAMMA (cps) 25 50 75 100	GEOPHYSICAL RECORD: CONDUCTIVITY (mS/m) 10 20 30 40	PIEZOMETER OR STANDPIPE INSTALLATION
	--- CONTINUED FROM PREVIOUS PAGE ---						
40	Dense, brown CLAY, some silt			ATB2			Stone
42							
44							
46							
			321.91				
48	END OF BOREHOLE		47.85				
50							
52							
54							
56							
58							
60							

DEPTH SCALE

1 : 100

Golder Associates

LOGGED: BH

CHECKED: CM

K-ME-OW02-09-A

PROJECT: 08-1112-0150

BOREHOLE LOG OF: K-ME-OW02-09

SHEET 1 OF 3

LOCATION: N 4805684.0 ;E 538813.0

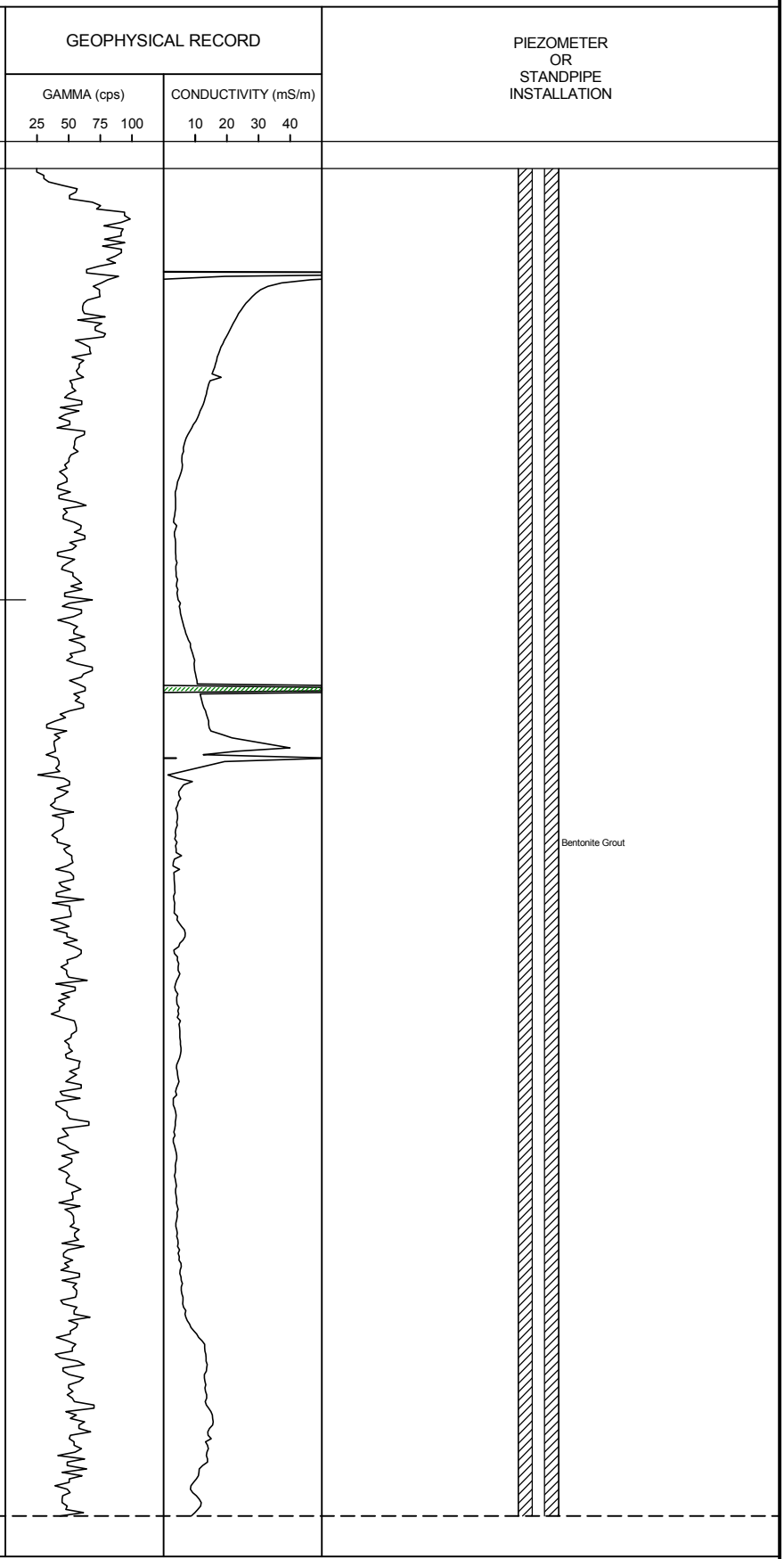
DRILLING DATE: December 3, 2009

DATUM: NAD83

DRILL RIG: Air Rotary

DRILLING CONTRACTOR: Gerrits Well Drilling

DEPTH SCALE METRES	DESCRIPTION	ELEV. / DEPTH (m)	OGS CODE
	GROUND SURFACE	364.21	
0	TOPSOIL	0.00	ATB1
	Brown, CLAY	0.30	ATB1
		358.93	
	Brown, CLAY, some medium sand, trace gravel	5.28	ATB1
		357.81	
	Brown, fine SAND	6.40	AFB1
		353.85	
	Brown, medium SAND, some silt	10.36	AFB1
20	*CONTINUED NEXT PAGE*		



DEPTH SCALE

1 : 100

Golder Associates

LOGGED: BH

CHECKED: CM

MIS-HYD 009 08-1112-0150.GPJ GAL-MISS.GDT 2/7/11 RJ

PROJECT: 08-1112-0150

BOREHOLE LOG OF: K-ME-OW02-09

LOCATION: N 4805684.0 ;E 538813.0

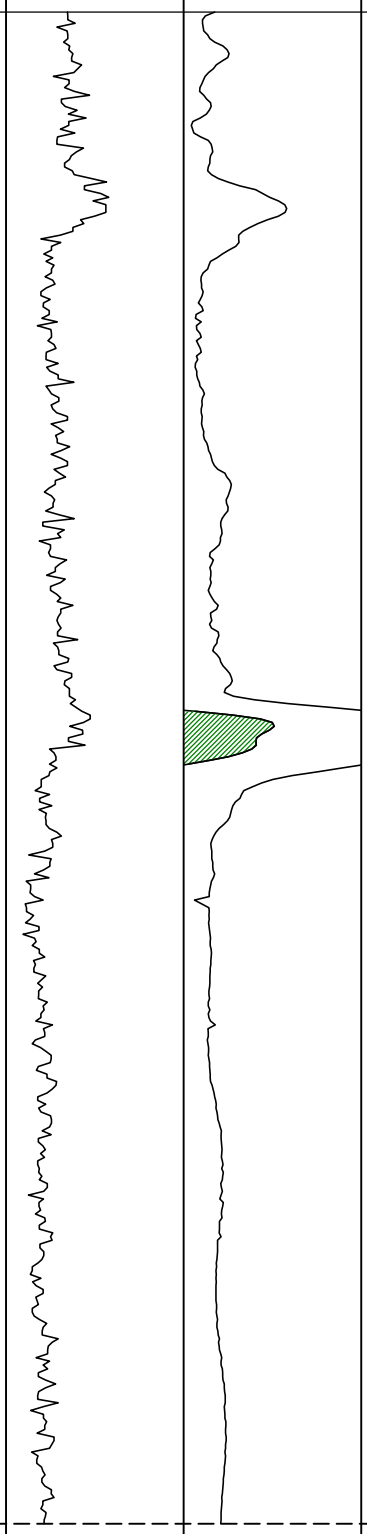
DRILLING DATE: December 3, 2009

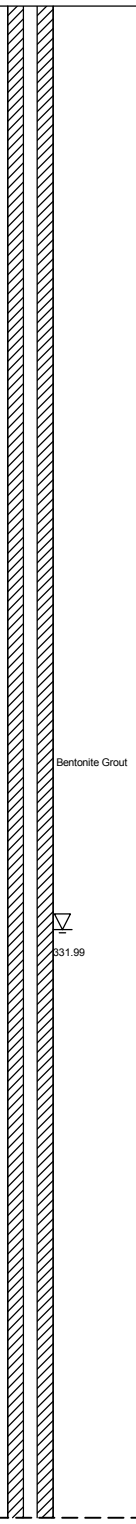
DRILL RIG: Air Rotary

DRILLING CONTRACTOR: Gerrits Well Drilling

DATUM: NAD83

DEPTH SCALE METRES	DESCRIPTION	ELEV. / DEPTH (m)	OGS CODE
	--- CONTINUED FROM PREVIOUS PAGE ---		
	Brown, medium SAND, some gravel, trace clay	344.09 / 20.12	AFB1
	Moist, brown, medium SAND, some gravel	341.04 / 23.17	
	Wet, brown, GRAVEL, some medium sand, trace boulders	339.83 / 24.38	
	CONTINUED NEXT PAGE		





DEPTH SCALE

1 : 100

LOGGED: BH

CHECKED: CM

PROJECT: 08-1112-0150

BOREHOLE LOG OF: K-ME-OW02-09

LOCATION: N 4805684.0 ;E 538813.0

DRILLING DATE: December 3, 2009

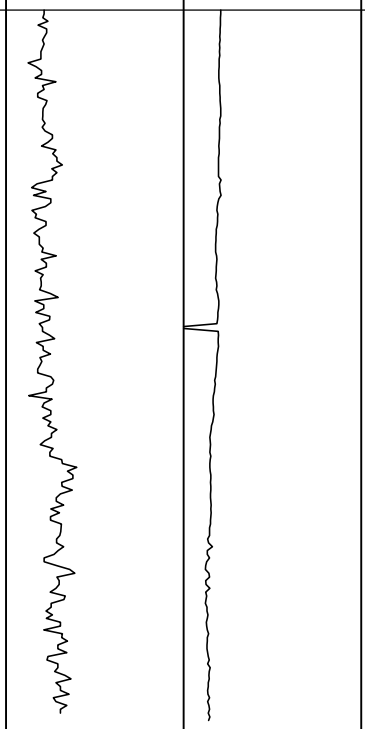
DRILL RIG: Air Rotary

DRILLING CONTRACTOR: Gerrits Well Drilling

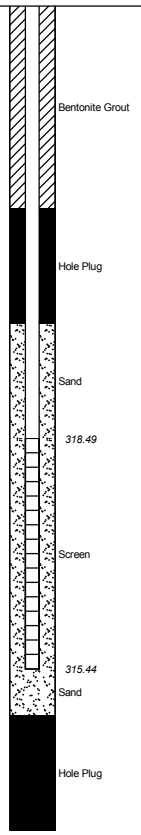
DATUM: NAD83

DEPTH SCALE METRES	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	OGS CODE
	--- CONTINUED FROM PREVIOUS PAGE ---			
40	Wet, brown, GRAVEL, some medium sand, trace boulders			AFB1
42				
44				
46	(SA-1 46.9 m)			
48				
			314.81	
	Dense, Grey, CLAY		49.40	
50				
			313.31	
	END OF BOREHOLE		50.90	
52				
54				
56				
58				
60				

GEOPHYSICAL RECORD



PIEZOMETER OR STANDPIPE INSTALLATION



DEPTH SCALE

1 : 100

LOGGED: BH

CHECKED: CM

9201363 K-ME-OW1-03-(A-B)

Borehole No.: OW1BC-03

Project: OW1-92 Replacement well

Project No: 609-00133

Location: Intersection of Fisher Hallman Road and Ottawa St.

Contractor: Davidson Well Drilling Ltd.

Drilling Method: mud rotary

Date: 12-May-03

Field Investigator: James Pickering(Davidson Well Drilling Ltd.)

Ground Surface: 355.39 m AMSL

Top of Casing: 356.45 m AMSL(A); 356.405 m AMSL(B)

SUBSURFACE PROFILE				SAMPLE DETAILS					WELL DETAILS
Depth (ft / m)	Lithologic Symbol	Lithologic Description	Elevation (m AMSL)	Sample Number	Type	N-Value	Recovery	Lab Analyses	Well
		Ground Surface	355.39						
		TOPSOIL	354.78	0.61					Cement
		CLAY some silt, brown	350.82	4.57					
		SILT some sand, brown	347.16	8.23					
		CLAY some sand and gravel, brown	346.55	8.84					Bentonite
		grey, little sand or gravel	342.89	12.5					
		some gravel, cobbles and boulders, brown	339.54	15.85					
		GRAVEL some fine to coarse sand, grey							

Depth scale: ft: -3, 2, 7, 12, 17, 22, 27, 32, 37, 42, 47, 52, 57, 62, 67, 72, 77; m: 5, 10, 15, 20

Screen interval: 32 to 35.1 m BGS; 55.8 to 58.8 m BGS

Well seal interval: 0.3 to 31.4 m;35.4 to 54.9 m; 58.8 to 65.5 m

Sand pack interval: 31.4 to 35.4 m; 54.9 to 58.8 m BGS

Notes:
mAMSL- metres above mean sea level
mBGS - metres below ground surface

Drawn By/Checked By: OR/RF

Stantec Consulting Ltd.
49 Frederick Street
Kitchener, Ontario
N2H 6M7

Stantec

9201363

Borehole No.: OW1BC-03

Project: OW1-92 Replacement well

Project No: 609-00133

Location: Intersection of Fisher Hallman Road and Ottawa St.

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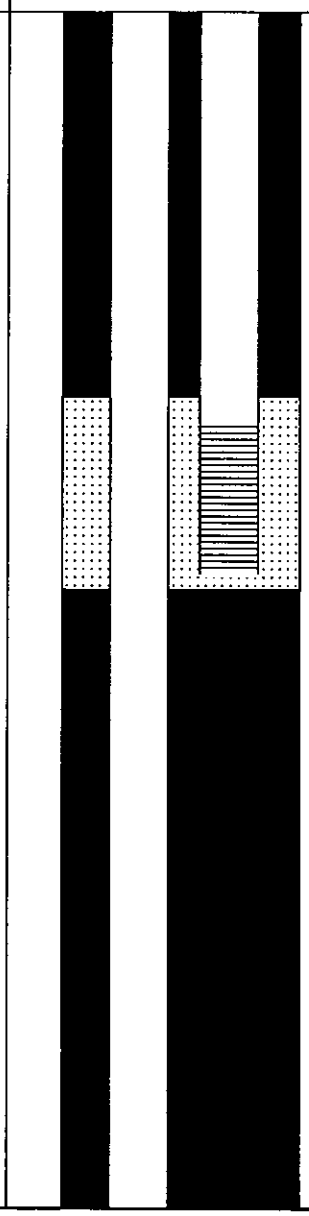
SUBSURFACE PROFILE				SAMPLE DETAILS					WELL DETAILS
Depth	Lithologic Symbol	Lithologic Description	Elevation (m AMSL)	Sample Number	Type	N-Value	Recovery	Lab Analyses	Well
			331.31	27.98					
		SILT some medium sand, brown							
81, 86, 91, 96, 101, 106, 111, 116									
28, 33									
			318.81	36.58					
121, 126, 131, 136, 141		CLAY some silt, grey							
38, 43									
			311.19	44.2					
146, 151, 156		CLAY some silt, gravel, cobbles and boulders, grey							



Screen interval: 32 to 35.1 m BGS; 55.8 to 58.8 m BGS

Well seal interval: 0.3 to 31.4 m;35.4 to 54.9 m; 58.8 to 65.5 m

Sand pack interval: 31.4 to 35.4 m; 54.9 to 58.8 m BGS

Notes:
mAMSL- metres above mean sea level
mBGS - metres below ground surface

Drawn By/Checked By: OR/RF

Stantec

Stantec Consulting Ltd.
49 Frederick Street
Kitchener, Ontario
N2H 6M7

9201363

Borehole No.: OW1BC-03

Project: OW1-92 Replacement well

Project No: 609-00133

Location: Intersection of Fisher Hallman Road and Ottawa St.

Contractor: Davidson Well Drilling Ltd.

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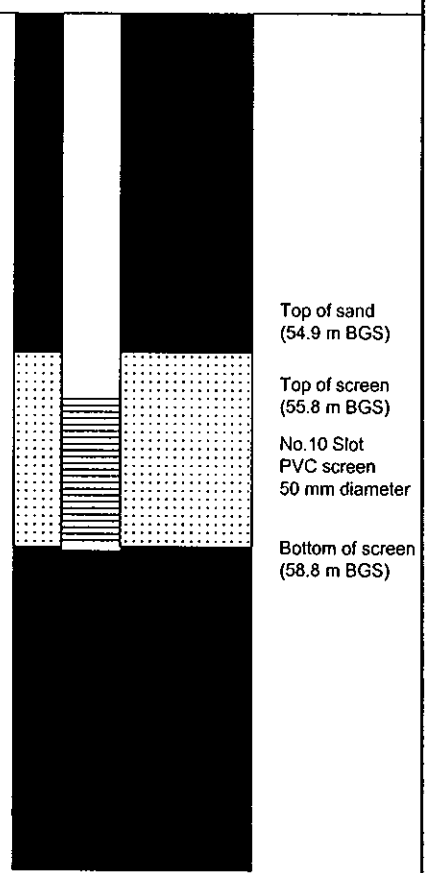
Ground Surface: 355.39 m AMSL

Top of Casing: 356.45 m AMSL(A); 356.405 m AMSL(B)

SUBSURFACE PROFILE				SAMPLE DETAILS					WELL DETAILS
Depth	Lithologic Symbol	Lithologic Description	Elevation (m AMSL)	Sample Number	Type	N-Value	Recovery	Lab Analyses	Well
161									
166									
171 – 52									
176									
181									
186 – 57									
191									
196									
201			293.52	61.87					
62		CLAY grey							
206									
211			289.86	65.53					
216		End of Borehole							
221 – 67									
226									
231									
236 – 72									



Screen interval: 32 to 35.1 m BGS; 55.8 to 58.8 m BGS

Well seal interval: 0.3 to 31.4 m;35.4 to 54.9 m; 58.8 to 65.5 m

Sand pack interval: 31.4 to 35.4 m; 54.9 to 58.8 m BGS

Notes:
mAMSL- metres above mean sea level
mBGS - metres below ground surface

Drawn By/Checked By: OR/RF

Stantec

Stantec Consulting Ltd.
49 Frederick Street
Kitchener, Ontario
N2H 6M7

Monitoring Well: K-ME-OW1-17

K-ME-OW1-17-A

Project: Monitoring Well Construction
Client: Regional Municipality of Waterloo
Location: Kitchener, Waterloo, ON
Number: 160900870

Field Investigator: AV
Contractor: Choice Sonic
Drilling method: Rotosonic
Date started/completed: 10-Aug-2017 / 14-Aug-2017

Ground surface elevation: 371.00 m AMSL
Top of casing elevation: 371.91 m AMSL
Easting: 538004.323
Northing: 4806209.648

SUBSURFACE PROFILE				HYDROGEOLOGY		SAMPLE DETAILS			GEOPHYSIC DETAILS	WELL DETAILS
Depth (ft) (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	Lab Analyses	Gamma (cps) 20 40 60 80	
			371.81							
		Ground Surface	371.00							Above ground Casing 0.820 m stick-up
		HYDROVAC	0.00							Cement Surface Seal 0 to 0.6 m; Bentonite chips 0.6 to 1.1 m
			368.71							
		SAND loose, yellowish brown (10 YR 5/4), medium sand, little fine and coarse sand, moist	2.29							
		sand fines downward, trace fine gravel rounded				1	CC			
						2	CC			
		trace fine to coarse gravel beginning at 5.8 m				3	CC			168 mm diameter Borehole
		silt seam 0.08 m thick at 7.6 m fine sand from 7.9 to 10.1 m		AFB1	Upper Waterloo Moraine stratified sediments and equivalents					
						4	CC			

Depth (m): -0.5, 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5

Screen Interval: 46.94 - 49.99 m BGS
Sand Pack Interval: 46.33 - 50.90 m BGS
Well Seal Interval: 0.61 - 46.33 m BGS

Stantec

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
CC - continuous core sample
n/a - not available/applicable

Geophysics performed by Lotowater Technical Services Ltd. August 14, 2017, completed through temporary steel casing
Monitoring well installed as a replacement for K-ME-OW3-85
WRAS No.: 9207338A
GSA - Grain Size Analysis

Drawn By/Checked By: CD/LV

STANTEC BOREHOLE AND WELL - MASTER 17X11 20170831_RMOW_MONITORING WELLS.GPJ DATA TEMPLATE_ENVS_CA_140725.GDT 30/11/17 AHEALEY

Monitoring Well: K-ME-OW1-17

Project: Monitoring Well Construction
Client: Regional Municipality of Waterloo
Location: Kitchener, Waterloo, ON
Number: 160900870

Field Investigator: AV
Contractor: Choice Sonic
Drilling method: Rotosonic
Date started/completed: 10-Aug-2017 / 14-Aug-2017

Ground surface elevation: 371.00 m AMSL
Top of casing elevation: 371.91 m AMSL
Easting: 538004.323
Northing: 4806209.648

SUBSURFACE PROFILE				HYDROGEOLOGY		SAMPLE DETAILS			GEOPHYSIC DETAILS	WELL DETAILS
Depth (ft) (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	Lab Analyses	Gamma (cps) 20 40 60 80	
33 10.0		SAND loose, yellowish brown (10 YR 5/4), medium sand, little fine and coarse sand, moist								
34 10.5										
35										
36 11.0						5	CC			
37										
38 11.5										
39 12.0		sand becomes stratified fine sand, trace silt, and fine/medium sand, trace coarse sand brown to yellowish brown (10 YR 5/3 - 10 YR 5/4)								
40										
41 12.5										
42										
43 13.0										
44 13.5						6	CC	Sample at 14 m for GSA		
45										
46 14.0										
47										
48 14.5										
49 15.0										
50										
51 15.5										
52			355.15							
16.0		SAND brown to greyish brown (10 YR 5/3 to 2.5 Y 5/2), some fine to coarse gravel, trace silt, subrounded to rounded, well graded, trace oxidation staining, moist	15.85							
53										
54 16.5						7	CC			
55										
56 17.0										
57										
58 17.5										
59 18.0			353.01							
		GRAVELLY SAND greyish brown (2.5 Y 5/2), medium/coarse sand, rounded gravel, well graded, moist	17.98							
60										
61 18.5										
62										
63 19.0										
64 19.5						8	CC			
65										
66 20.0										
67										

Screen Interval: 46.94 - 49.99 m BGS
Sand Pack Interval: 46.33 - 50.90 m BGS
Well Seal Interval: 0.61 - 46.33 m BGS

Notes:
m AMSL - metres above mean sea level
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m BTOC - metres below top of casing
CC - continuous core sample
n/a - not available/applicable

Geophysics performed by Lotowater Technical Services Ltd. August 14, 2017, completed through temporary steel casing
Monitoring well installed as a replacement for K-ME-OW3-85
WRAS No.: 9207338A
GSA - Grain Size Analysis

Stantec

Drawn By/Checked By: CD/LV

STANTEC BOREHOLE AND WELL - MASTER 17X11 20170831_RMOW_MONITORING WELLS.GPJ DATA TEMPLATE_ENVS_CA_140725.GDT 30/11/17 AHEALEY

Monitoring Well: K-ME-OW1-17

Project: Monitoring Well Construction
Client: Regional Municipality of Waterloo
Location: Kitchener, Waterloo, ON
Number: 160900870

Field Investigator: AV
Contractor: Choice Sonic
Drilling method: Rotosonic
Date started/completed: 10-Aug-2017 / 14-Aug-2017

Ground surface elevation: 371.00 m AMSL
Top of casing elevation: 371.91 m AMSL
Easting: 538004.323
Northing: 4806209.648

SUBSURFACE PROFILE				HYDROGEOLOGY		SAMPLE DETAILS			GEOPHYSIC DETAILS	WELL DETAILS
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	Lab Analyses	Gamma (cps) 20 40 60 80	
68			GRAVELLY SAND greyish brown (2.5 Y 5/2), medium/coarse sand, rounded gravel, well graded, moist								
69	21.0										
70							9	CC			
71	21.5		gravel content decreasing with depth								
72	22.0										
73				348.75 22.25							
74	22.5		SAND AND GRAVEL light greyish brown (10 YR 5/2 to 10 YR 6/2), medium to coarse sand, some fine sand, fine to coarse gravel, rounded, moist								
75	23.0										Bentonite Grout 1.1 to 44.5 m
76							10	CC			
77	23.5										
78											
79	24.0			346.92 24.08							
80			SAND greyish brown to light greyish brown (10 YR 6/2 to 2.5 Y 5/2), little to some fine gravel, well graded, moist								
81	24.5										
82	25.0										
83											
84	25.5						11	CC			
85	26.0										
86											
87	26.5										
88											
89	27.0			343.87 27.13							
90	27.5		SAND AND GRAVEL light browninsh grey (10 YR 6/2), trace silt, medium sand, fine to coarse gravel, rounded, trace to some cobbles, rounded, moist								
91											
92	28.0										
93											
94	28.5						12	CC			
95	29.0										
96											
97	29.5										
98											
99	30.0										
100	30.5										
101											
102	31.0						13	CC			

Screen Interval: 46.94 - 49.99 m BGS
Sand Pack Interval: 46.33 - 50.90 m BGS
Well Seal Interval: 0.61 - 46.33 m BGS

Stantec

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
CC - continuous core sample
n/a - not available/applicable

Geophysics performed by Lotowater Technical Services Ltd. August 14, 2017, completed through temporary steel casing
Monitoring well installed as a replacement for K-ME-OW3-85
WRAS No.: 9207338A
GSA - Grain Size Analysis

Drawn By/Checked By: CD/LV

STANTEC BOREHOLE AND WELL - MASTER 17X11 20170831_RMOW_MONITORING WELLS.GPJ DATA TEMPLATE_ENVS_CA_140725.GDT 30/11/17 AHEALEY

Monitoring Well: K-ME-OW1-17

Project: Monitoring Well Construction
Client: Regional Municipality of Waterloo
Location: Kitchener, Waterloo, ON
Number: 160900870

Field Investigator: AV
Contractor: Choice Sonic
Drilling method: Rotosonic
Date started/completed: 10-Aug-2017 / 14-Aug-2017

Ground surface elevation: 371.00 m AMSL
Top of casing elevation: 371.91 m AMSL
Easting: 538004.323
Northing: 4806209.648

SUBSURFACE PROFILE				HYDROGEOLOGY		SAMPLE DETAILS			GEOPHYSIC DETAILS	WELL DETAILS
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	Lab Analyses	Gamma (cps) 20 40 60 80	
103	31.5		SAND AND GRAVEL light browninsh grey (10 YR 6/2), trace silt, medium sand, fine to coarse gravel, rounded, trace to some cobbles, rounded, moist		AFB2	Middle Waterloo Moraine stratified sediments and equivalents				
104										
105	32.0									
106										
107	32.5									
108	33.0						14	CC		
109										
110	33.5									
111										
112	34.0									
113	34.5									
114										
115	35.0									
116	35.5						15	CC		
117										
118	36.0									
119										
120	36.5									
121	37.0									
122			fine sand and fine gravel seam at 37.2 m, 0.3 m thick							
123	37.5									
124	38.0									
125										
126	38.5									
127							16	CC		
128	39.0									
129			stratified sediments, sand, some silt to gravel, 0.3 to 0.9 m thick at 39 to 42 m							
130	39.5									
131	40.0									
132										
133	40.5									
134	41.0						17	CC		
135										
136	41.5									
137										

Screen Interval: 46.94 - 49.99 m BGS
Sand Pack Interval: 46.33 - 50.90 m BGS
Well Seal Interval: 0.61 - 46.33 m BGS

Stantec

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
CC - continuous core sample
n/a - not available/applicable

Geophysics performed by Lotowater Technical Services Ltd. August 14, 2017, completed through temporary steel casing
Monitoring well installed as a replacement for K-ME-OW3-85
WRAS No.: 9207338A
GSA - Grain Size Analysis

Drawn By/Checked By: CD/LV

STANTEC BOREHOLE AND WELL - MASTER 17X11 20170831_RMOW_MONITORING WELLS.GPJ DATA TEMPLATE_ENVS_CA_140725.GDT 30/11/17 AHEALEY

Monitoring Well: K-ME-OW1-17

Project: Monitoring Well Construction
Client: Regional Municipality of Waterloo
Location: Kitchener, Waterloo, ON
Number: 160900870

Field Investigator: AV
Contractor: Choice Sonic
Drilling method: Rotosonic
Date started/completed: 10-Aug-2017 / 14-Aug-2017

Ground surface elevation: 371.00 m AMSL
Top of casing elevation: 371.91 m AMSL
Easting: 538004.323
Northing: 4806209.648

Depth (ft)	Depth (m)	Graphic Log	Lithologic Description (SUBSURFACE PROFILE)	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit (HYDROGEOLOGY)	Description	Sample Number (SAMPLE DETAILS)	Sample Type	Lab Analyses
138	42.0		SAND AND GRAVEL light browninsh grey (10 YR 6/2), trace silt, medium sand, fine to coarse gravel, rounded, trace to some cobbles, rounded, moist						
139	42.5								
140									
141	43.0								
142			oxidation staining at 43.3 m						
143	43.5								
144				327.11					
	44.0		SAND medium grained, trace silt, trace fine to coarse gravel, well graded, wet	43.89			18	CC	
145			coarsens downward						
146	44.5								
147									
148	45.0								
149	45.5								
150									
151	46.0								
152									
153	46.5								
154	47.0		sand becomes fine to medium grained				19	CC	Sample at 47 m for GSA
155									
156	47.5								
157			silt clasts within the sand 0.01 to 0.05 m thick beginning at 47.9 m						
158	48.0								
159	48.5								
160			stratified sediments, 0.3 to 0.6 m thick starting at 48.8 m consisting of light olive brown (10 YR 5/3) fine, little medium, trace silt to brown (2.5 Y 5/3) medium, little coarse, trace gravel						
161	49.0								
162	49.5								
163									
164	50.0								
165							20	CC	
166	50.5								
167	51.0								
168									
169	51.5								
170									
171	52.0								
172									

GEOPHYSIC DETAILS: Gamma (cps) 20 40 60 80

WELL DETAILS:
- Bentonite pellets 44.5 to 46.3 m
- No. 1 Silica Sand 46.3 to 51 m
- No. 10 slot Schedule 80 PVC Screen 51 mm OD 46.9 to 50 m
- No. 1 Silica Sand 46.3 to 51 m

Screen Interval: 46.94 - 49.99 m BGS
Sand Pack Interval: 46.33 - 50.90 m BGS
Well Seal Interval: 0.61 - 46.33 m BGS

Stantec

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
CC - continuous core sample
n/a - not available/applicable

Geophysics performed by Lotowater Technical Services Ltd. August 14, 2017, completed through temporary steel casing
Monitoring well installed as a replacement for K-ME-OW3-85
WRAS No.: 9207338A
GSA - Grain Size Analysis

Drawn By/Checked By: CD/LV

STANTEC BOREHOLE AND WELL - MASTER 17X11 20170831_RMOW_MONITORING WELLS.GPJ DATA TEMPLATE_ENVS_CA_140725.GDT 30/11/17 AHEALEY

Monitoring Well: K-ME-OW1-17

Project: Monitoring Well Construction
Client: Regional Municipality of Waterloo
Location: Kitchener, Waterloo, ON
Number: 160900870

Field Investigator: AV
Contractor: Choice Sonic
Drilling method: Rotosonic
Date started/completed: 10-Aug-2017 / 14-Aug-2017

Ground surface elevation: 371.00 m AMSL
Top of casing elevation: 371.91 m AMSL
Easting: 538004.323
Northing: 4806209.648

SUBSURFACE PROFILE				HYDROGEOLOGY		SAMPLE DETAILS			GEOPHYSIC DETAILS	WELL DETAILS
Depth (ft) (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	Lab Analyses	Gamma (cps) 20 40 60 80	
173 (ft); 53.0 (m)		SAND medium grained, trace silt, trace fine to coarse gravel, well graded, wet coarsens downward				21	CC			
53.5										
54.0										
54.5										
55.0										
55.5						22	CC			Bentonite chips 51 to 60.7 m
56.0										
56.5										
57.0										
57.5										
58.0		CLAYEY SILT TILL hard, dark grey to dark greyish brown (10 YR 4/1 to 10 YR 4/2), silt, trace medium to coarse sand, blocky	313.09 57.91	ATB3	Lower Maryhill Till	23	CC	Sample at 59 m for GSA		
58.5										
59.0										
59.5										
60.0										
60.5			310.34							
		End of Borehole	60.66							
61.0										
61.5										
62.0										
62.5										
63.0										

Screen Interval: 46.94 - 49.99 m BGS
Sand Pack Interval: 46.33 - 50.90 m BGS
Well Seal Interval: 0.61 - 46.33 m BGS

Stantec

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
CC - continuous core sample
n/a - not available/applicable

Geophysics performed by Lotowater Technical Services Ltd. August 14, 2017, completed through temporary steel casing
Monitoring well installed as a replacement for K-ME-OW3-85
WRAS No.: 9207338A
GSA - Grain Size Analysis

Drawn By/Checked By: CD/LV

STANTEC BOREHOLE AND WELL - MASTER 17X11 20170831_RMOW_MONITORING WELLS.GPJ DATA TEMPLATE_ENVS_CA_140725.GDT 30/11/17 AHEALEY

Monitoring Well: K-ME-OW2-17

K-ME-OW2-17-A

Project: Monitoring Well Construction
Client: Regional Municipality of Waterloo
Location: Kitchener, Waterloo, ON
Number: 160900870

Field Investigator: AV
Contractor: Choice Sonic
Drilling method: Rotosonic
Date started/completed: 18-Aug-2017 / 23-Aug-2017

Ground surface elevation: 362.83 m AMSL
Top of casing elevation: 363.77 m AMSL
Easting: 539220.335
Northing: 4805357.486

SUBSURFACE PROFILE				HYDROGEOLOGY		SAMPLE DETAILS			GEOPHYSIC DETAILS	WELL DETAILS
Depth (ft) (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	Lab Analyses	Gamma (cps) 20 40 60 80	
			363.64							
		Ground Surface	362.83							Above ground Casing 0.94 m stick-up
		HYDROVAC	0.00							Cement Surface Seal 0 to 0.6 m
			360.54							
		CLAYEY SILT soft, brown (7.5 YR 4/3), some fine grained sand, trace coarse sand, trace fine gravel, moist	2.29			1	CC			
			358.87							
		SILTY SAND brown (7.5 YR 4/3), fine sand, trace medium to coarse sand, trace fine gravel, moist to wet, trace oxidation staining till material, 0.25 m thick at 5.1 m trace cobbles	3.96			2	CC	Sample at 4.9 m for GSA		
			356.73							
		SAND brown (10 YR 5/3), stratified deposits of fine sand, little to some silt and fine and medium sand, trace to some gravel layers 0.02 to 0.08 m thick till material, 0.10 m thick at 7.3 m	6.10			3	CC			177.8 mm diameter Borehole
						4	CC			

Screen Interval: 52.73 - 55.78 m BGS
Sand Pack Interval: 50.90 - 57.91 m BGS
Well Seal Interval: 0.61 - 50.90 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
CC - continuous core sample
n/a - not available/applicable

Geophysics performed by Lotowater Technical Services Ltd. August 23, 2017, completed through temporary steel casing
WRAS No.: 9207339A
GSA - Grain Size Analysis

Stantec

Drawn By/Checked By: CD/LV

STANTEC BOREHOLE AND WELL - MASTER 17X11 20170831_RMOW_MONITORING WELLS.GPJ DATA TEMPLATE_ENVS_CA_140725.GDT 30/11/17 AHEALEY

Monitoring Well: K-ME-OW2-17

Project: Monitoring Well Construction
Client: Regional Municipality of Waterloo
Location: Kitchener, Waterloo, ON
Number: 160900870

Field Investigator: AV
Contractor: Choice Sonic
Drilling method: Rotosonic
Date started/completed: 18-Aug-2017 / 23-Aug-2017

Ground surface elevation: 362.83 m AMSL
Top of casing elevation: 363.77 m AMSL
Easting: 539220.335
Northing: 4805357.486

SUBSURFACE PROFILE				HYDROGEOLOGY		SAMPLE DETAILS			GEOPHYSIC DETAILS	WELL DETAILS
Depth (ft) (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	Lab Analyses	Gamma (cps) 20 40 60 80	
33 10.0		SAND brown (10 YR 5/3), stratified deposits of fine sand, little to some silt and fine and medium sand, trace to some gravel layers 0.02 to 0.08 m thick								
34 10.5						5	CC			
35		some gravel and silt clasts from 10.7 to 11.3 m								
36 11.0										
37										
38 11.5										
39 12.0										
40										
41 12.5		fine to coarse gravel seam at 12.5 m, 0.05 m thick								
42										
43 13.0										
44 13.5						6	CC			
45										
46 14.0										
47 14.5										
48										
49 15.0										
50										
51 15.5										Bentonite Grout 0.6 to 30.5 m
52 16.0										
53										
54 16.5						7	CC	Sample at 15.2 m for GSA		
55										
56 17.0										
57 17.5										
58										
59 18.0										
60										
61 18.5		silt clasts in sand layers starting at 18.3 m				8	CC			
62 19.0										
63			343.63							
64 19.5		SAND light olive brown (2.5 Y 5/3), fine grained, trace to some silt, moist to wet	19.20							
65										
66 20.0						9	CC			
67										

Screen Interval: 52.73 - 55.78 m BGS
Sand Pack Interval: 50.90 - 57.91 m BGS
Well Seal Interval: 0.61 - 50.90 m BGS

Stantec

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
CC - continuous core sample
n/a - not available/applicable

Geophysics performed by Lotowater Technical Services Ltd. August 23, 2017, completed through temporary steel casing
WRAS No.: 9207339A
GSA - Grain Size Analysis

Drawn By/Checked By: CD/LV

STANTEC BOREHOLE AND WELL - MASTER 17X11 20170831_RMOW_MONITORING WELLS.GPJ DATA TEMPLATE_ENVS_CA_140725.GDT 30/11/17 AHEALEY

Monitoring Well: K-ME-OW2-17

Project: Monitoring Well Construction
Client: Regional Municipality of Waterloo
Location: Kitchener, Waterloo, ON
Number: 160900870

Field Investigator: AV
Contractor: Choice Sonic
Drilling method: Rotosonic
Date started/completed: 18-Aug-2017 / 23-Aug-2017

Ground surface elevation: 362.83 m AMSL
Top of casing elevation: 363.77 m AMSL
Easting: 539220.335
Northing: 4805357.486

SUBSURFACE PROFILE				HYDROGEOLOGY		SAMPLE DETAILS			GEOPHYSIC DETAILS	WELL DETAILS
Depth (ft) (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	Lab Analyses	Gamma (cps) 20 40 60 80	
68, 69 (21.0)		SAND light olive brown (2.5 Y 5/3), fine grained, trace to some silt, moist to wet								
		clayey silt at 21.2 to 21.5 m	341.65 21.18							
70, 71 (21.5), 72 (22.0), 73, 74 (22.5), 75, 76 (23.0), 77 (23.5), 78, 79 (24.0)		SAND stratified deposits of fine sand, some medium and well graded sand, trace fine and coarse gravel layers 0.15 to 0.91 m thick				10	CC	Sample at 21.3 m for GSA		
80 (24.5), 81, 82 (25.0), 83, 84 (25.5), 85, 86 (26.0), 87 (26.5), 88, 89 (27.0)		trace brown (10 YR 5/3) silt at 24.4 m				11	CC			
90 (27.5), 91		trace dark gray (GLEY 1 4/4) clay, 0.15 m thick, wet at 27.7 m								
92 (28.0), 93										
94 (28.5), 95 (29.0), 96, 97 (29.5), 98 (30.0)		silty fine sand, wet, 0.15 to 0.2 m thick at 28.3 m				12	CC			
		SAND AND GRAVEL medium to coarse sand, trace fine sand, rounded gravel and sand, well graded, wet	332.65 30.18		Upper Waterloo Moraine stratified					
99, 100 (30.5), 101, 102 (31.0)										

Screen Interval: 52.73 - 55.78 m BGS
Sand Pack Interval: 50.90 - 57.91 m BGS
Well Seal Interval: 0.61 - 50.90 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
CC - continuous core sample
n/a - not available/applicable

Geophysics performed by Lotowater Technical Services Ltd. August 23, 2017, completed through temporary steel casing
WRAS No.: 9207339A
GSA - Grain Size Analysis

Stantec

Drawn By/Checked By: CD/LV

STANTEC BOREHOLE AND WELL - MASTER 17X11 20170831_RMOW_MONITORING WELLS.GPJ DATA TEMPLATE_ENVS_CA_140725.GDT 30/11/17 AHEALEY

Monitoring Well: K-ME-OW2-17

Project: Monitoring Well Construction
Client: Regional Municipality of Waterloo
Location: Kitchener, Waterloo, ON
Number: 160900870

Field Investigator: AV
Contractor: Choice Sonic
Drilling method: Rotosonic
Date started/completed: 18-Aug-2017 / 23-Aug-2017

Ground surface elevation: 362.83 m AMSL
Top of casing elevation: 363.77 m AMSL
Easting: 539220.335
Northing: 4805357.486

SUBSURFACE PROFILE				HYDROGEOLOGY		SAMPLE DETAILS			GEOPHYSIC DETAILS	WELL DETAILS
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	Lab Analyses	Gamma (cps) 20 40 60 80	
103	31.5		SAND AND GRAVEL medium to coarse sand, trace fine sand, rounded gravel and sand, well graded, wet		AFB1/AFB2	sediments and equivalents/Middle Waterloo Moraine stratified sediments and equivalents	13	CC			
104											
105	32.0										
106											
107	32.5										
108	33.0		trace silt at 32.9 m	329.61							
109			GRAVEL little medium to coarse sand, little cobble, well graded, stratified, wet	33.22							
110	33.5										
111											
112	34.0										
113	34.5										
114							14	CC			
115	35.0										
116											
117	35.5										
118	36.0			326.56							
119			SAND AND GRAVEL stratified deposits of gravel, little sand, little cobble and sand, some gravel, medium to coarse layers 0.05 to 0.08 m thick	36.27							
120	36.5										
121											
122	37.0										
123	37.5										
124											
125	38.0						15	CC			
126											
127	38.5										
128	39.0										
129											
130	39.5										
131											
132	40.0										
133	40.5										
134							16	CC			Bentonite chips 30.5 to 50.9 m
135	41.0										
136											
137	41.5										

Screen Interval: 52.73 - 55.78 m BGS
Sand Pack Interval: 50.90 - 57.91 m BGS
Well Seal Interval: 0.61 - 50.90 m BGS

Stantec

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
CC - continuous core sample
n/a - not available/applicable

Geophysics performed by Lotowater Technical Services Ltd. August 23, 2017, completed through temporary steel casing
WRAS No.: 9207339A
GSA - Grain Size Analysis

Drawn By/Checked By: CD/LV

STANTEC BOREHOLE AND WELL - MASTER 17X11 20170831_RMOW_MONITORING WELLS.GPJ DATA TEMPLATE_ENVS_CA_140725.GDT 30/11/17 AHEALEY

Monitoring Well: K-ME-OW2-17

Project: Monitoring Well Construction
Client: Regional Municipality of Waterloo
Location: Kitchener, Waterloo, ON
Number: 160900870

Field Investigator: AV
Contractor: Choice Sonic
Drilling method: Rotosonic
Date started/completed: 18-Aug-2017 / 23-Aug-2017

Ground surface elevation: 362.83 m AMSL
Top of casing elevation: 363.77 m AMSL
Easting: 539220.335
Northing: 4805357.486

SUBSURFACE PROFILE				HYDROGEOLOGY		SAMPLE DETAILS			GEOPHYSIC DETAILS	WELL DETAILS
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	Lab Analyses	Gamma (cps) 20 40 60 80	
138	42.0		SAND AND GRAVEL stratified deposits of gravel, little sand, little cobble and sand, some gravel, medium to coarse layers 0.05 to 0.08 m thick sand layers becoming finer grained at 42.1 m				17	CC			
139	42.5										
140											
141	43.0										
142											
143	43.5										
144	44.0										
145											
146	44.5										
147											
148	45.0										
149	45.5		SAND stratified deposits of fine sand, trace to little silt, medium to coarse sand, some gravel, well graded, layers 0.15 to 0.9 m thick	317.41 45.42			18	CC			
150											
151	46.0										
152											
153	46.5										
154	47.0										
155											
156	47.5										
157											
158	48.0										
159	48.5										
160											
161	49.0										
162											
163	49.5										
164	50.0						19	CC	Sample at 50.3 m for GSA		
165											
166	50.5										
167											
168	51.0										
169	51.5		coarser material at 51.5 to 52.7 m								
170											
171	52.0										
172											

Screen Interval: 52.73 - 55.78 m BGS
Sand Pack Interval: 50.90 - 57.91 m BGS
Well Seal Interval: 0.61 - 50.90 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
CC - continuous core sample
n/a - not available/applicable

Geophysics performed by Lotowater Technical Services Ltd. August 23, 2017, completed through temporary steel casing
WRAS No.: 9207339A
GSA - Grain Size Analysis

Stantec

Drawn By/Checked By: CD/LV

STANTEC BOREHOLE AND WELL - MASTER 17X11 20170831_RMOW_MONITORING WELLS.GPJ DATA TEMPLATE_ENVS_CA_140725.GDT 30/11/17 AHEALEY

Monitoring Well: K-ME-OW2-17

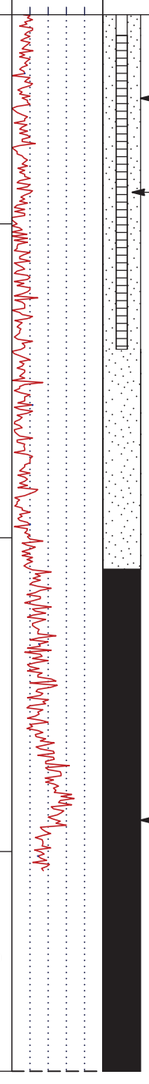
Project: Monitoring Well Construction
Client: Regional Municipality of Waterloo
Location: Kitchener, Waterloo, ON
Number: 160900870

Field Investigator: AV
Contractor: Choice Sonic
Drilling method: Rotosonic
Date started/completed: 18-Aug-2017 / 23-Aug-2017

Ground surface elevation: 362.83 m AMSL
Top of casing elevation: 363.77 m AMSL
Easting: 539220.335
Northing: 4805357.486

Depth (ft)	Depth (m)	Lithologic Description	Elevation (m AMSL) / Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	Lab Analyses
173		SAND stratified deposits of fine sand, trace to little silt, medium to coarse sand, some gravel, well graded, layers 0.15 to 0.9 m thick						
174	53.0					20	CC	
175								
176	53.5							
177	54.0							
178								
179	54.5							
180	55.0							
181								
182	55.5							
183		sandy silt till clasts 0.1 m thick as inclusions in the matrix from 55.8 to 56.4 m						
184	56.0					21	CC	
185								
186	56.5							
187	57.0							
188								
189	57.5		305.07					
		SANDY SILT soft to very stiff, pale brown to very dark greyish brown (10 YR 6/2 to 10 YR 4/2), mottled with clay, wet	57.76					
190								
191	58.0							
192	58.5							
193								
194	59.0		303.55			22	CC	
		SILT TO SILTY SAND dense, grey (10 YR 5/1), wet	59.28					
195								
196	59.5							
197	60.0							
198			302.33					
	60.5	SILTY CLAY TILL hard, very dark greyish brown (10 YR 3/2), trace medium to coarse sand, blocky	60.50					
199								
200	61.0							
201								
202	61.5							
203	62.0			ATB3	Lower Maryhill Till	23	CC	Sample at 61.0 for GSA
204								
205	62.5							
206			300.04					
		End of Borehole	62.79					
207	63.0							

Gamma (cps): 20 40 60 80



Screen Interval: 52.73 - 55.78 m BGS
Sand Pack Interval: 50.90 - 57.91 m BGS
Well Seal Interval: 0.61 - 50.90 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
CC - continuous core sample
n/a - not available/applicable

Geophysics performed by Lotowater Technical Services Ltd. August 23, 2017, completed through temporary steel casing
WRAS No.: 9207339A
GSA - Grain Size Analysis

Stantec

Drawn By/Checked By: CD/LV

STANTEC BOREHOLE AND WELL - MASTER 17X11 20170831_RMOW_MONITORING WELLS.GPJ DATA TEMPLATE_ENVS_CA_140725.GDT 30/11/17 AHEALEY

Monitoring Well: K-ME-OW1-21

K-ME-OW1-21-A
K-ME-OW1-21-B

Project: K21/K26 Well Replacement
Client: Regional Municipality of Waterloo
Location: Kitchener ON
Number: 165640303

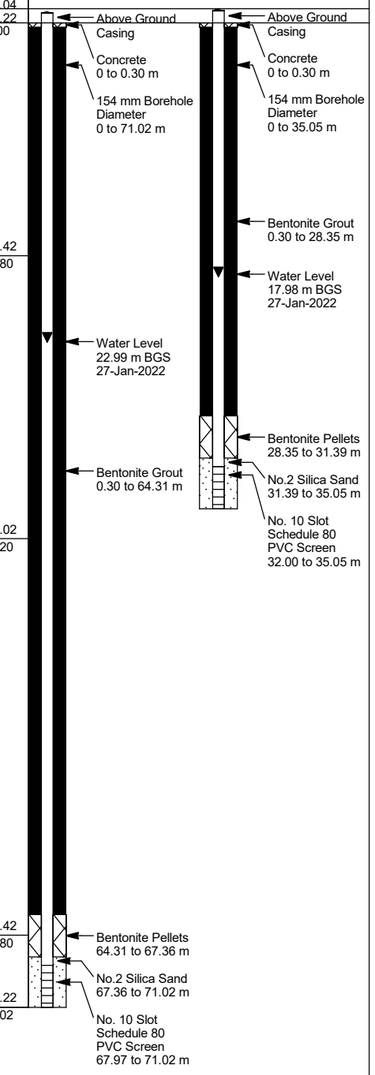
Field Investigator: S. Baer
Contractor: Aardvark Drilling Inc.
Drilling method: CME 75 truck mount - Hollow Stem Auger/PQ Mud Rotary
Date started/completed: 06-Oct-2021 / 15-Oct-2021

SUBSURFACE PROFILE

Lithologic Description	Elevation (m AMSL) / Depth (m BGS)
Ground Surface	350.04
SILT WITH CLAY	349.22 / 0.00
SAND WITH GRAVEL	332.42 / 16.80
CLAY WITH SILT	312.02 / 37.20
SAND WITH GRAVEL	283.42 / 65.80
End of Borehole	278.22 / 71.02

WELL DETAILS

	K-ME-OW1-21-A	K-ME-OW1-21-B
Name:	K-ME-OW1-21-A	K-ME-OW1-21-B
GS Elev:	349.22 m AMSL	348.96 m AMSL
TOC Elev:	350.04 m AMSL	349.98 m AMSL
Easting:	538488.37	538489.95
Northing:	4806497.71	4806498.35
Stick-up:	0.82 m	1.02 m



Screen Interval: 67.97 - 71.02; 32.00 - 35.05 m BGS
Sand Pack Interval: 67.36 - 71.02 m BGS
Well Seal Interval: 0.30 - 67.36 m BGS

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
n/a - not available/applicable

Lithologic description was provided by the drilling contractor on the MECP Water Well Records. K-ME-OW1-21-A is a replacement well for K-ME-OW1-15 and K-MW-OW1-21-B is a replacement well for -K-MW-OW01-10-A. More detailed lithologic descriptions can be found on those borehole logs.

Stantec

Drawn By/Checked By: SB/ KM

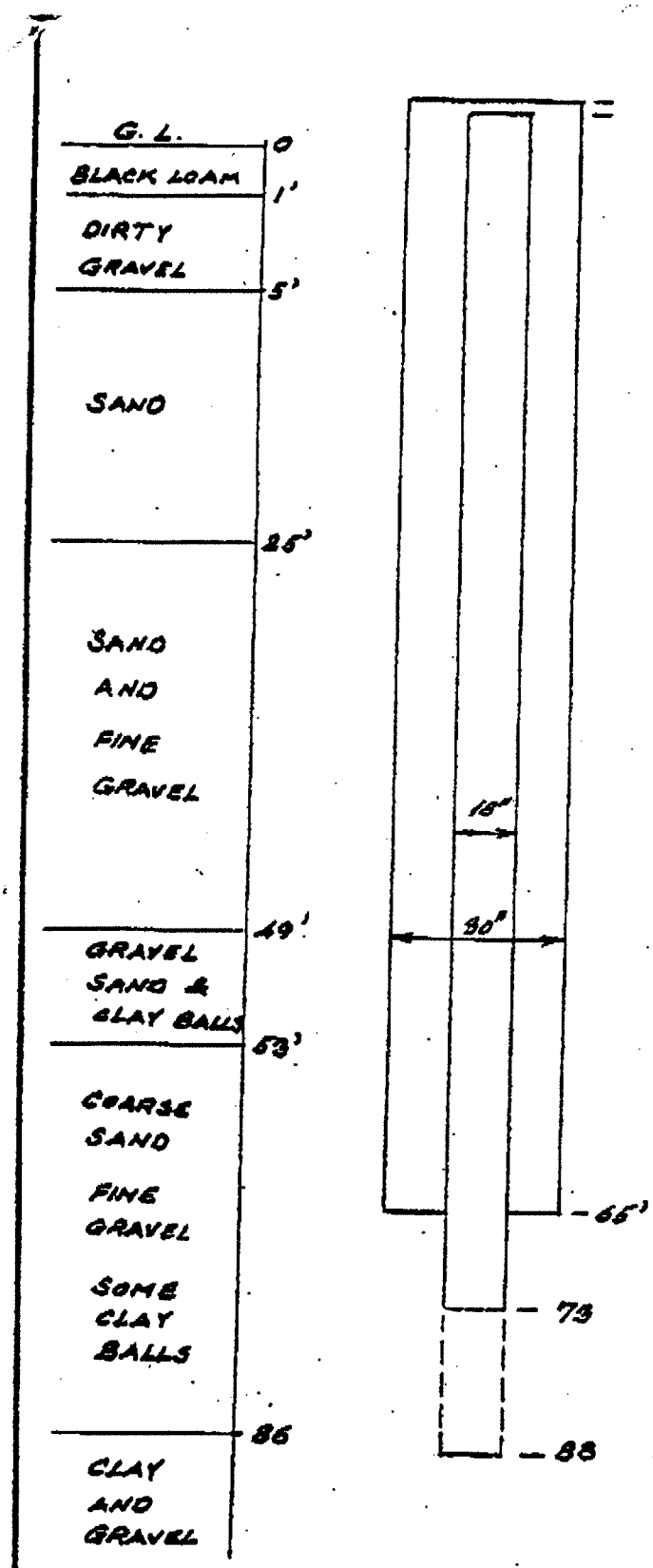
STANTEC BOREHOLE AND WELL - MASTER 17X11 165640303_K21-K26_SB.GPJ DATA TEMPLATE_ENVS_CA_140725.GDT 6/12/23 AHEALEY

BURNSIDE

[THE DIFFERENCE IS OUR PEOPLE]

Appendix B-4

Mannheim North Well Logs



Well Material

Outer Casing 30'
Inner Casing 18'
Screen # 6 Bronze
Plug Steel plate
Gravel —

Pump

No. 24575 — Setting BP-MB 60'
No. Stages 6 — Length Bowl 7' 6"
Bowl 15" DRHC — Size & Lgth. Suction 9' 7
Head TF1025 — Size Column 10" × 3" ×
Materials or setting details other than stand

Motor

Make USEM — Phase 3
Shaft — Cycles 60
H. P. 100 — Volts 550
R. P. M. 1200 — Amps. 96.8
Type CFU — Base
Frame 587-3 — Serial 927248

Special Equipment

Well

B. P. referred to original Ground Level
Started Sept 26/50 — Clear Depth
Preliminary Test 10/19/50 — Length Air Line
Final Test — Static Level
Guarantee 3500 IGM from not less than 5 wells — Pumping Level
Pressure — Capacity
Driller: MC Geachy.
Installer:

INTERNATIONAL WATER SUPPLY LT
LONDON, CANADA
WATER SUPPLY CONTRACTORS

#23

KITCHENER, ONT.

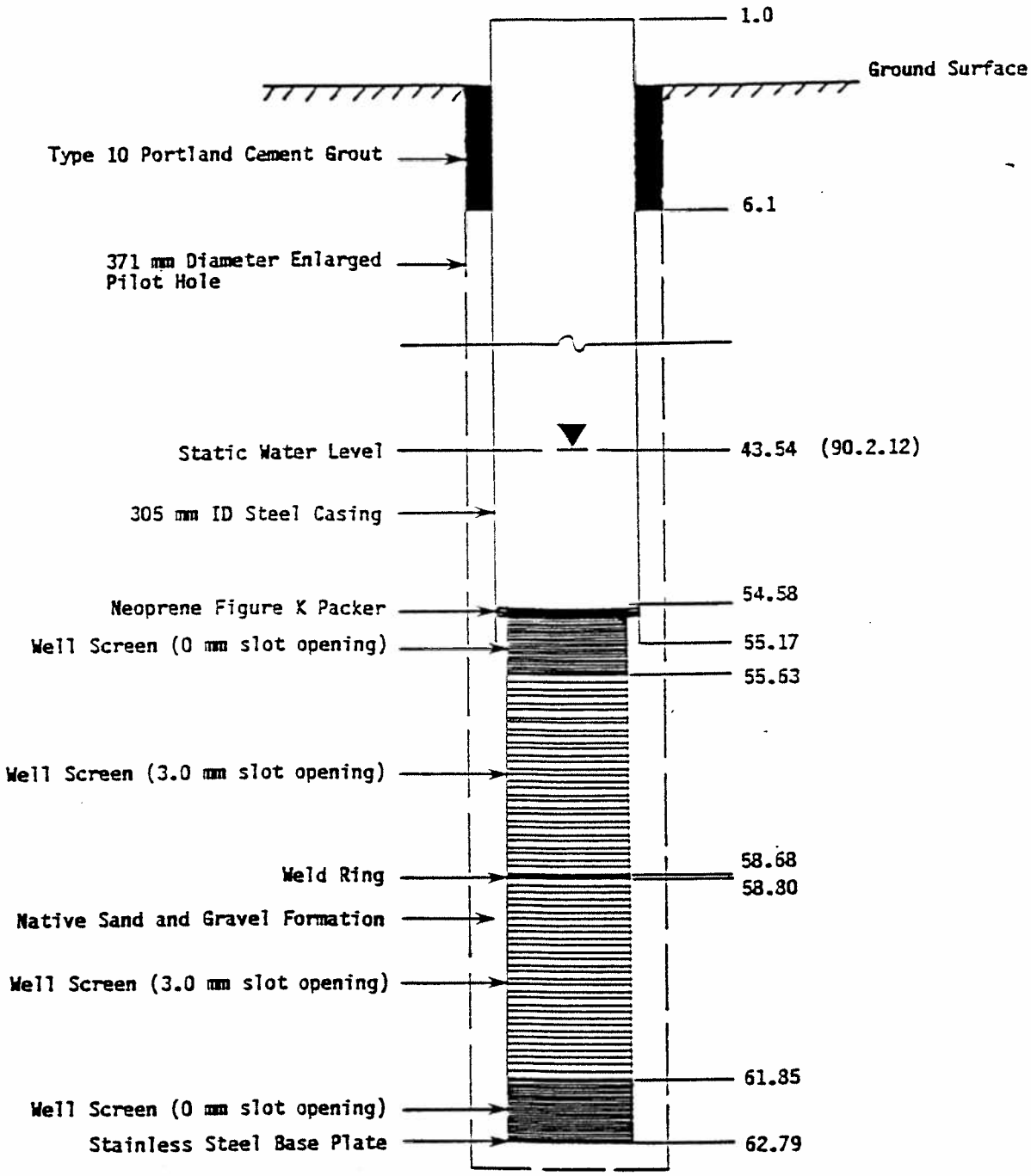
DRAWN BY M. — APPROVED BY

WELL NO. 3 MANNHEIM (ERB) TESTHOLE # 38.

MANNHEIM NO. 23

K91

PEAKING WELL K-91



Notes:

1. Depths are reported in metres above/below ground surface.
2. Hole backfilled (or allowed to collapse) with native granular materials.
3. Stainless steel well screen manufactured by Johnson Screens, Ajax, Ontario.

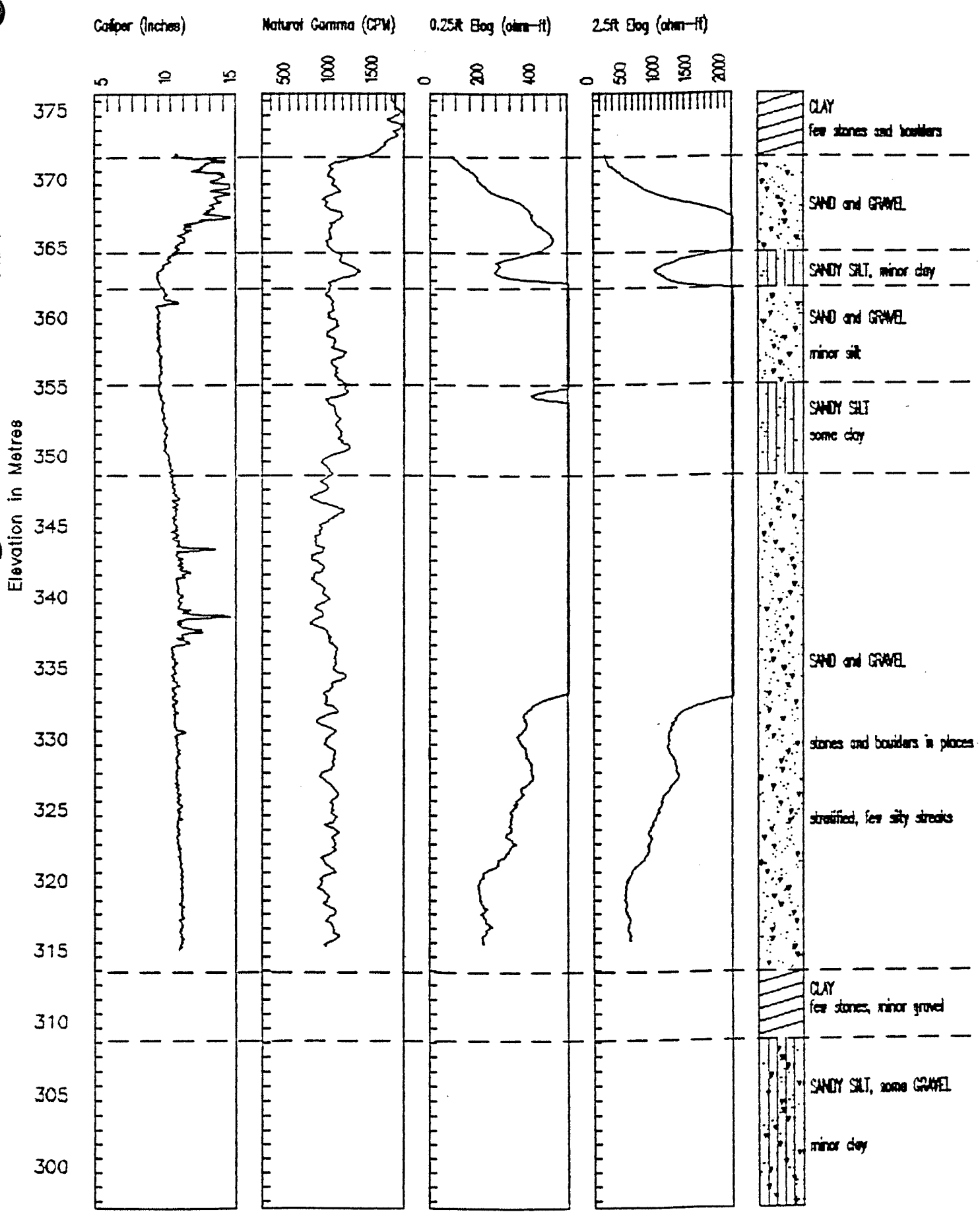
TROW, DAMES & MOORE

PEAKING WELL K-91
"AS-CONSTRUCTED" DRAWING

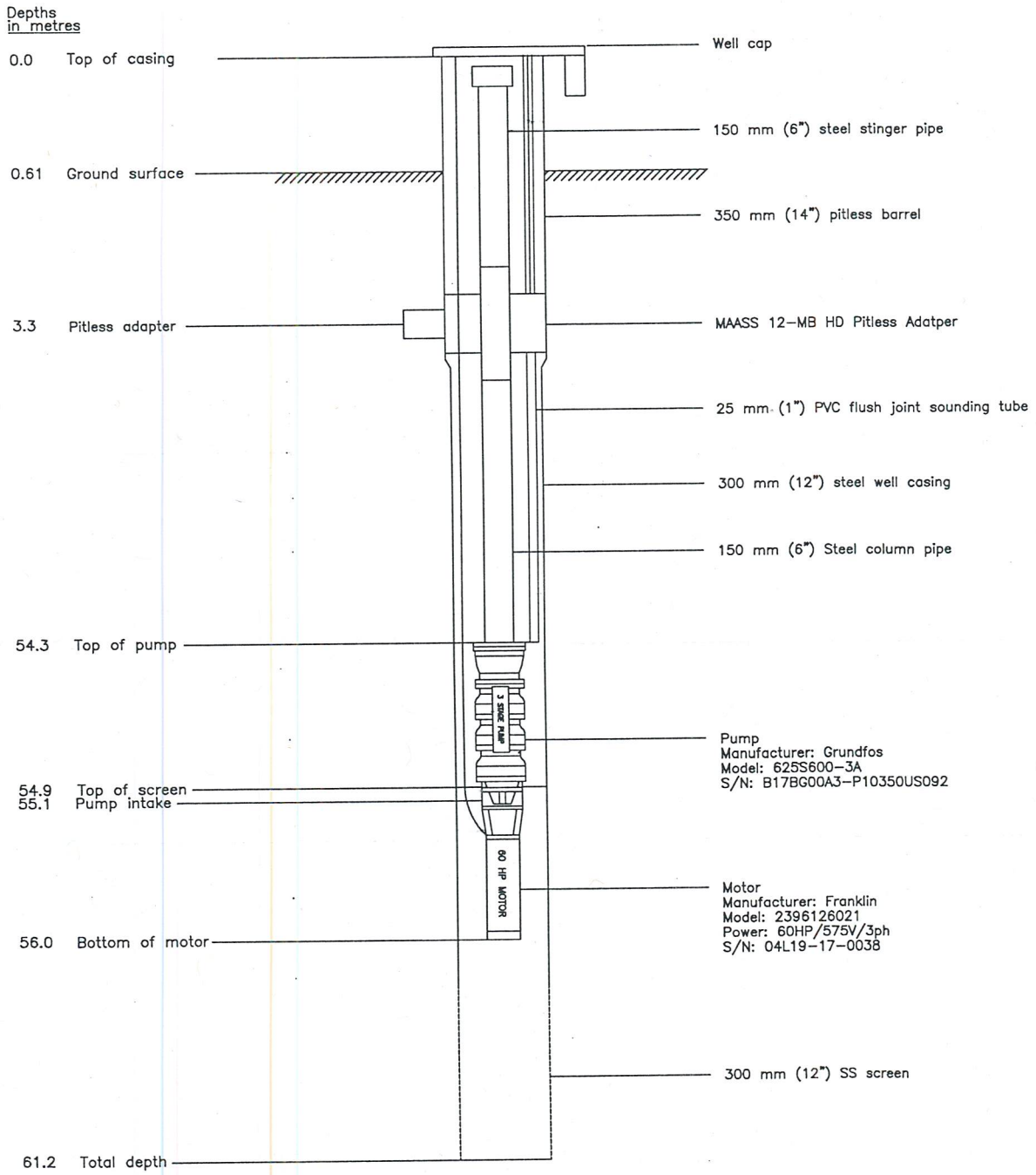
Proj. No.	16857-026
Scale	NTS
Drwn. by	PAG
Appr. by	
Revised	
Date	90.03.13

K91

Wellname Mannheim Produ n Well No. K-91
Filename MANK91A
Location Mannheim Reservoir Site, Ottawa Street, Mannheim, Ontario
Elevation 376.5 Reference Ground Surface
Well drilled by Wayne Renwick, Olympic Drilling Company Ltd., 89/11/24



K91



Lotowater TECHNICAL SERVICES INC.

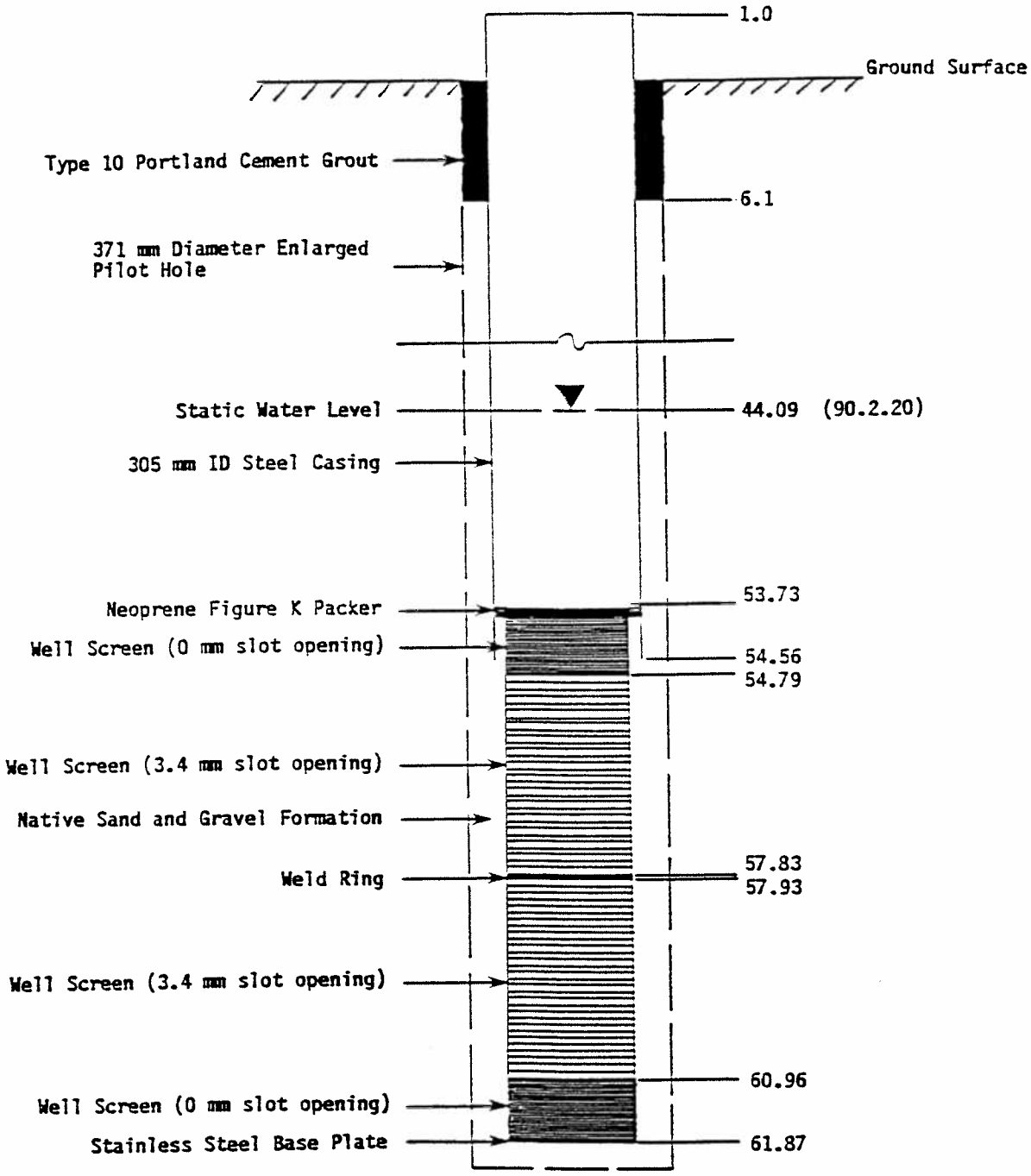
CLIENT
Regional Municipality of Waterloo

TITLE
K91
Pump Installation Drawing

PROJECT No.	006-244	\\Poweredge\...\Lotowater Projects\006 Region of Waterloo\244 K91 Inspection\7. Technical		FIGURE
DESIGN				
DRAWN	RS	2012/12/13	REVISION No. 2013-02-12	SCALE N.T.S.	4
CHECKED				

K92

PEAKING WELL K-92



Notes:
1. Depths are reported in metres above/below ground surface.
2. Hole backfilled (or allowed to collapse) with native granular materials.
3. Stainless steel well screen manufactured by Johnson Screens, Ajax, Ontario.

TROW, DAMES & MOORE

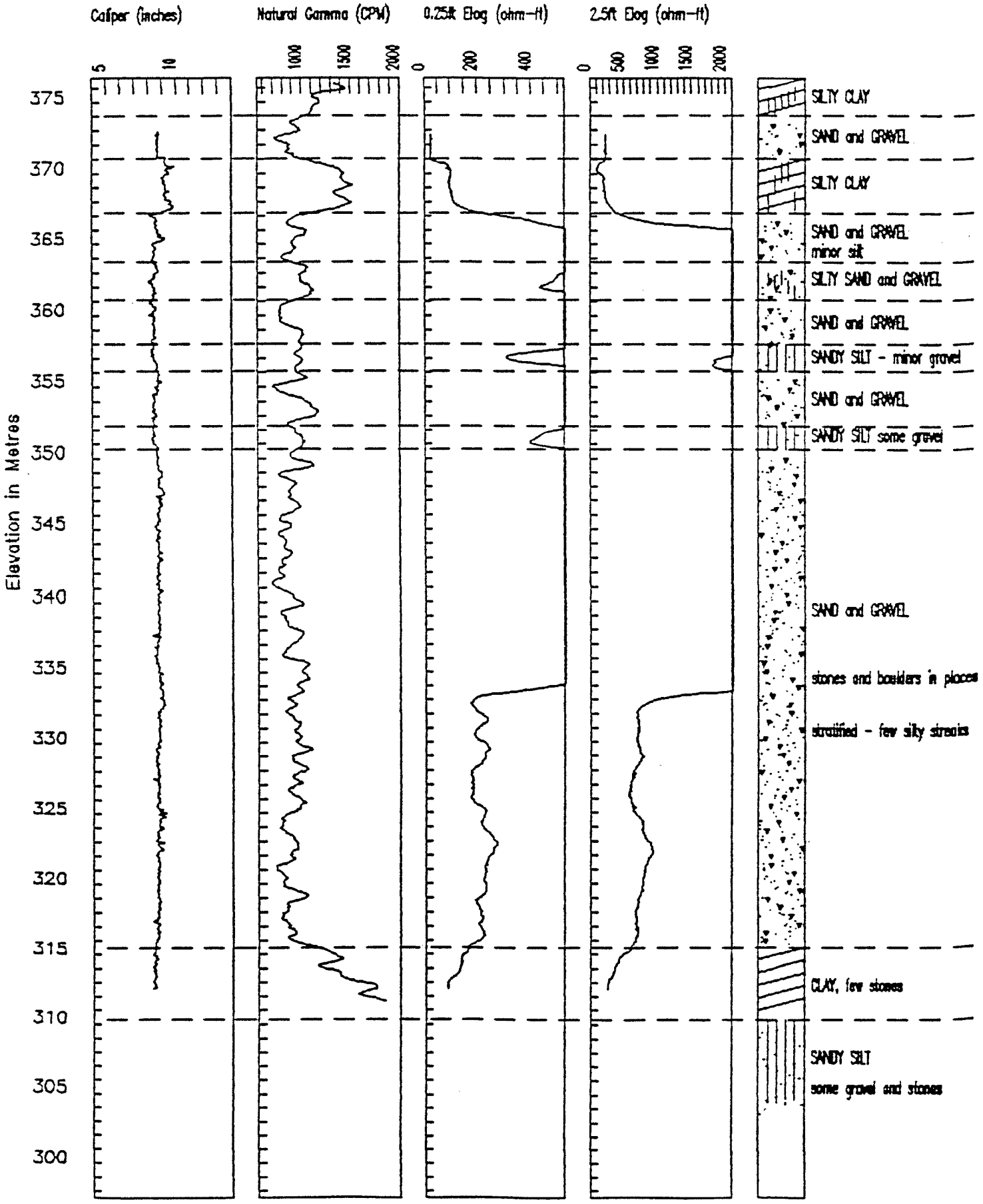
PEAKING WELL K-92

"AS-CONSTRUCTED" DRAWING

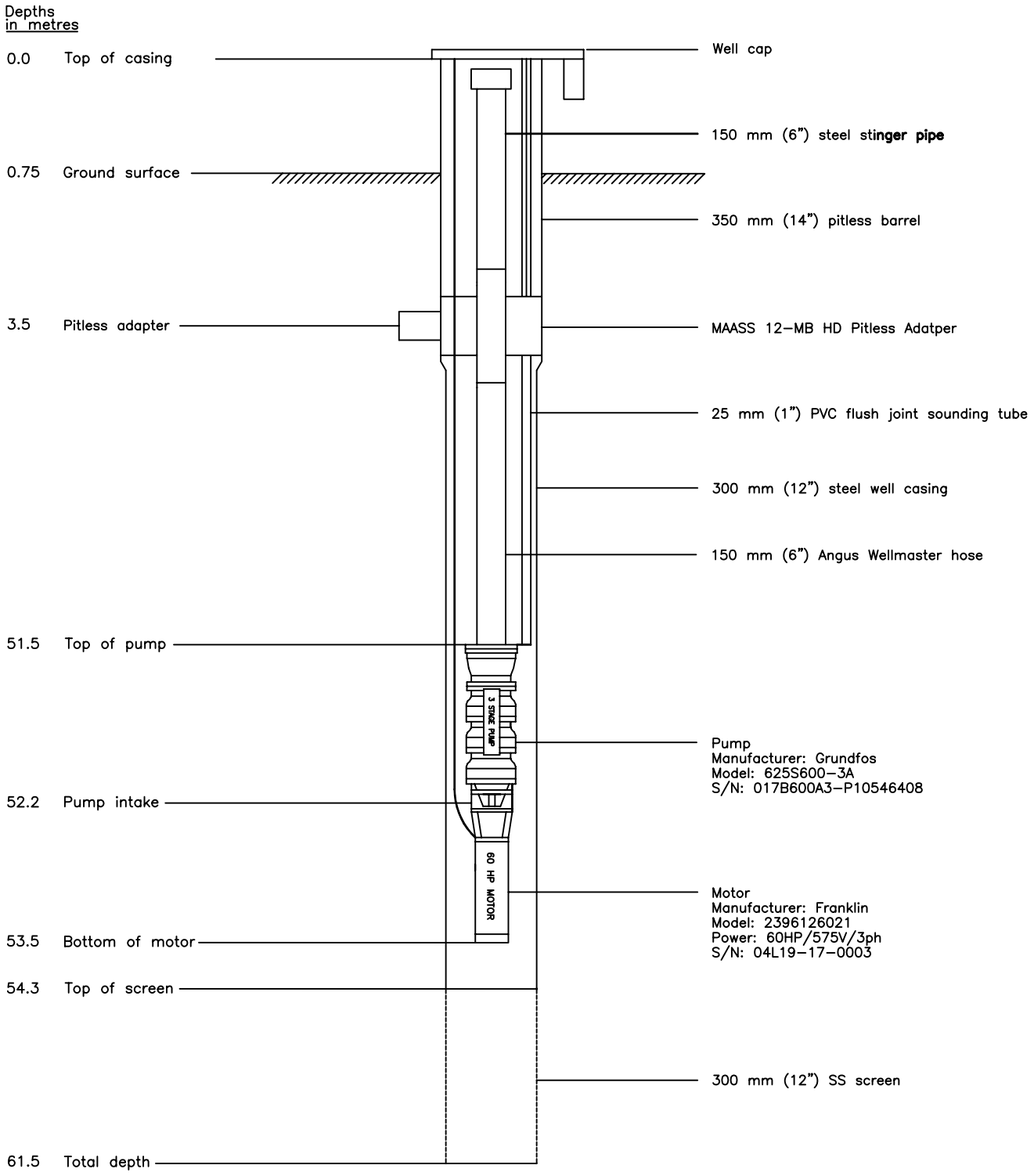
Proj. No.	16857-026
Scale	NTS
Drwn. by	PAG
Appr. by	
Revised	
Date	90.03.13

K92

Wellname Mannheim Produ on Well No. K-92
Filename MANK92A
Location Mannheim Reservoir site, Ottawa Street, Mannheim, Ontario
Elevation 376.8 Reference Ground Surface
Well drilled by Wayne Renwick, Olympic Drilling Company Ltd., 90/1/3



K92



Lotowater TECHNICAL SERVICES INC.

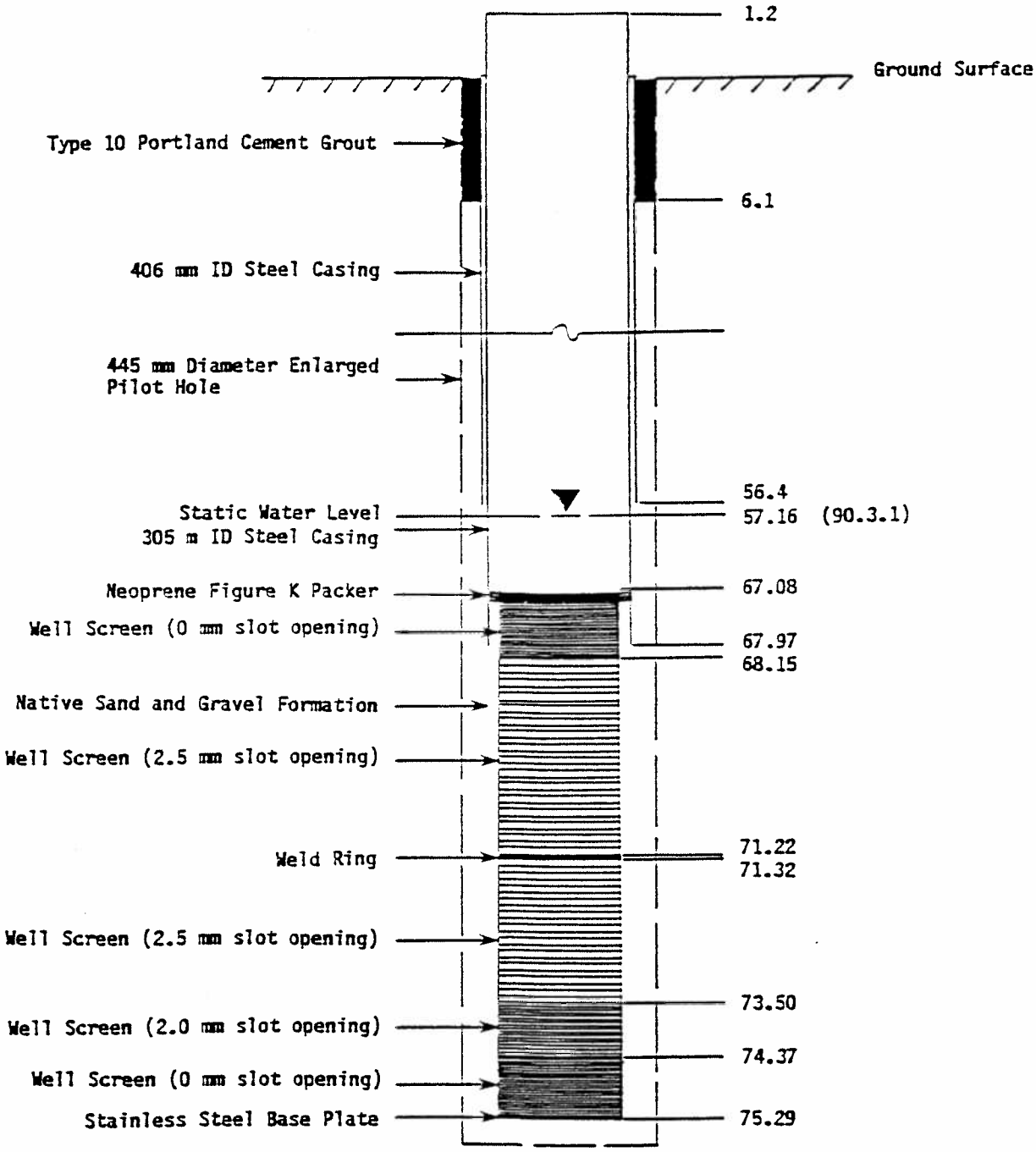
CLIENT
Regional Municipality of Waterloo

TITLE
K92
Pump Installation Drawing

PROJECT No.	006-243		\\Poweredge\...\Lotowater Projects\006 Region of Waterloo\243 K92 Inspection\7. Technical		FIGURE
DESIGN					
DRAWN	RS	2012/11/13	REVISION No. 2012-11-13	SCALE N.T.S.	4
CHECKED					

K93

PEAKING WELL K-93



Notes:

1. Depths are reported in metres above/below ground surface.
2. Hole backfilled (or allowed to collapse) with native granular materials.
3. Stainless steel well screen manufactured by Johnson Screens, Ajax, Ontario.

TROW, DAMES & MOORE

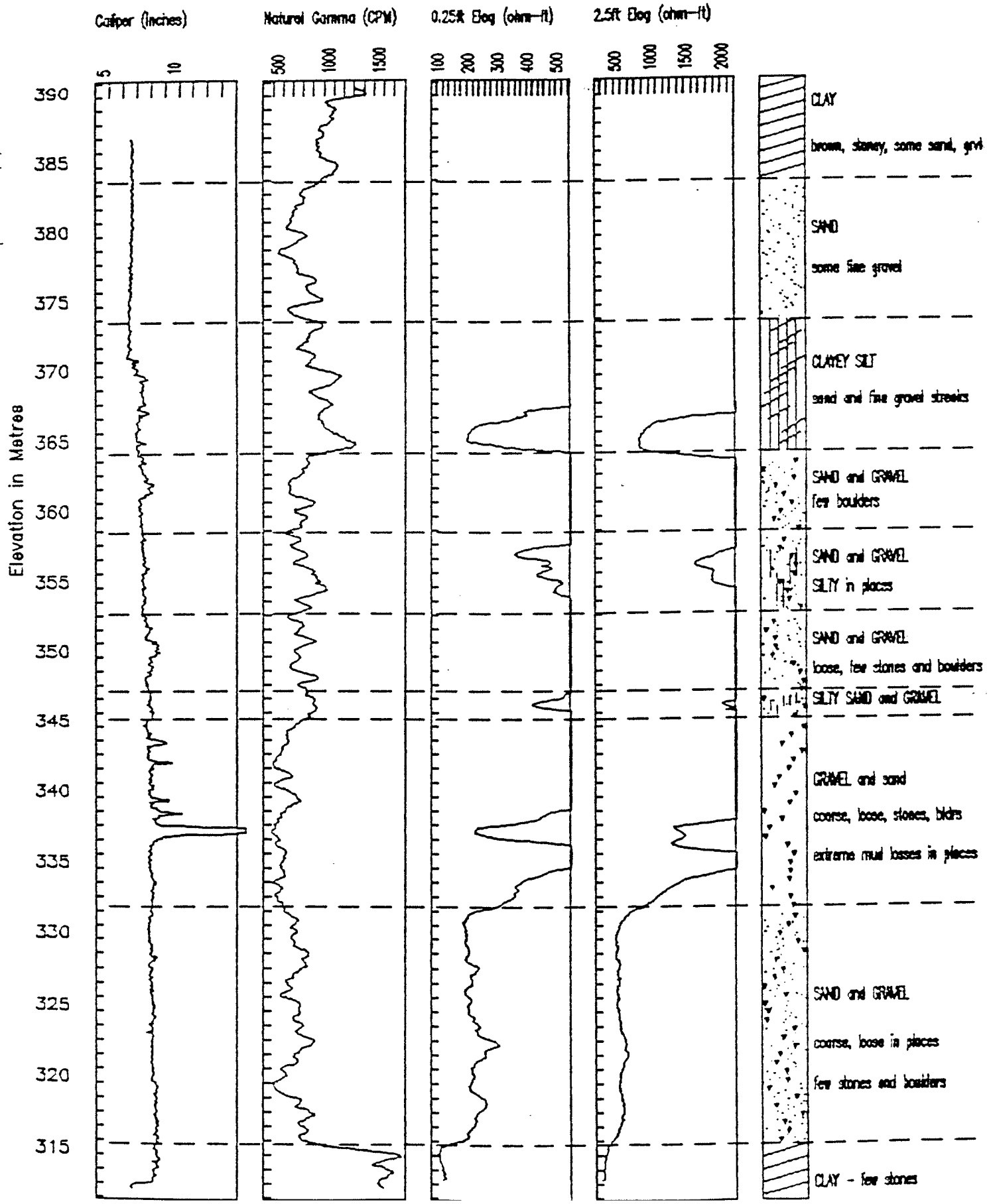
PEAKING WELL K-93

"AS-CONSTRUCTED" DRAWING

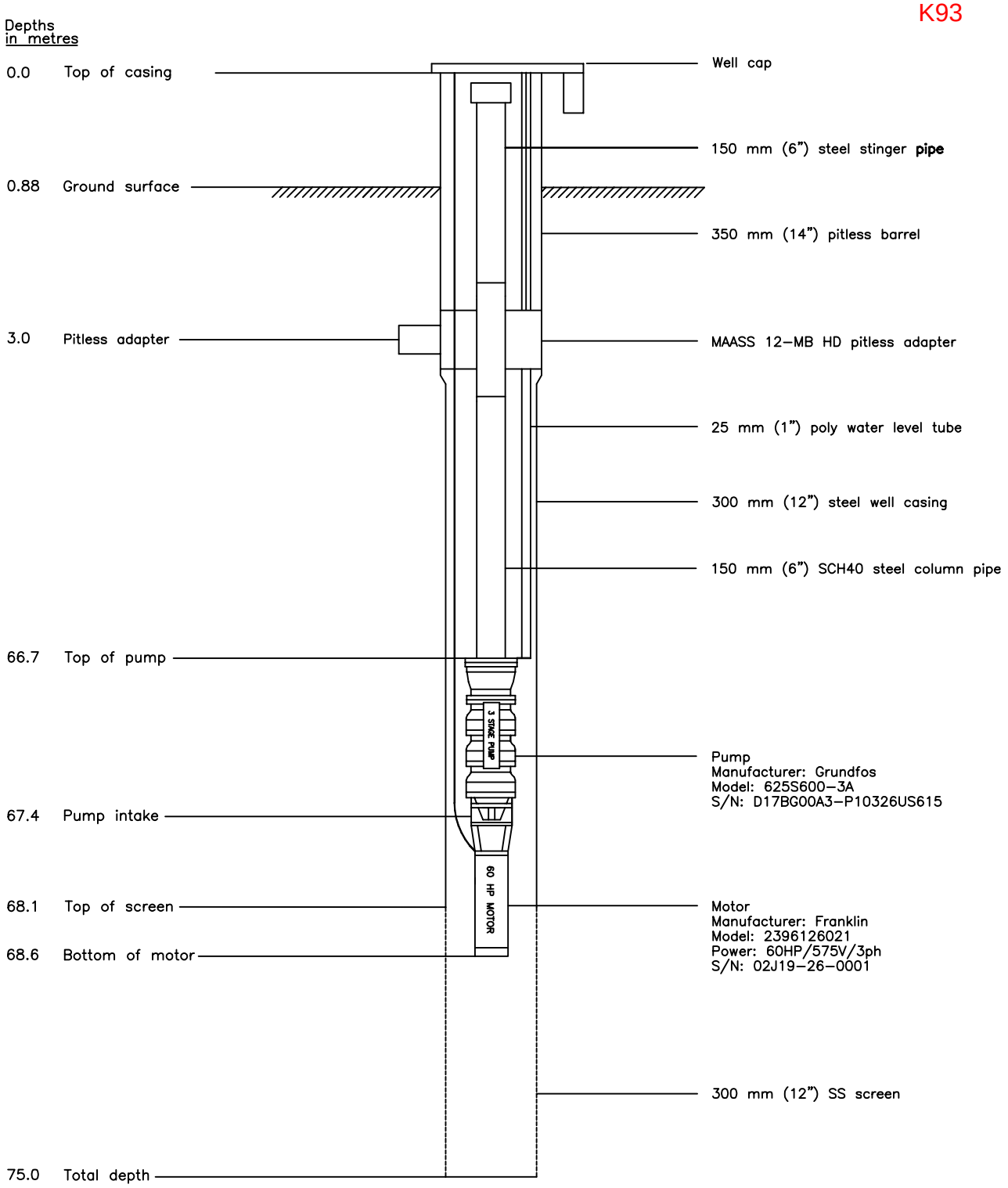
Proj. No.	16857-026
Scale	NTS
Drwn. by	PAG
Appr. by	
Revised	
Date	90.03.13

K93

Wellname Mannheim Production Well No. K-93
Filename MANK93A
Location Highway 7 & 8, Mannheim, Ontario
Elevation 391.2 Reference Ground Surface
Well drilled by Wayne Renwick, Olympic Drilling Company Ltd., 89/11/8



K93



Lotowater TECHNICAL SERVICES INC.

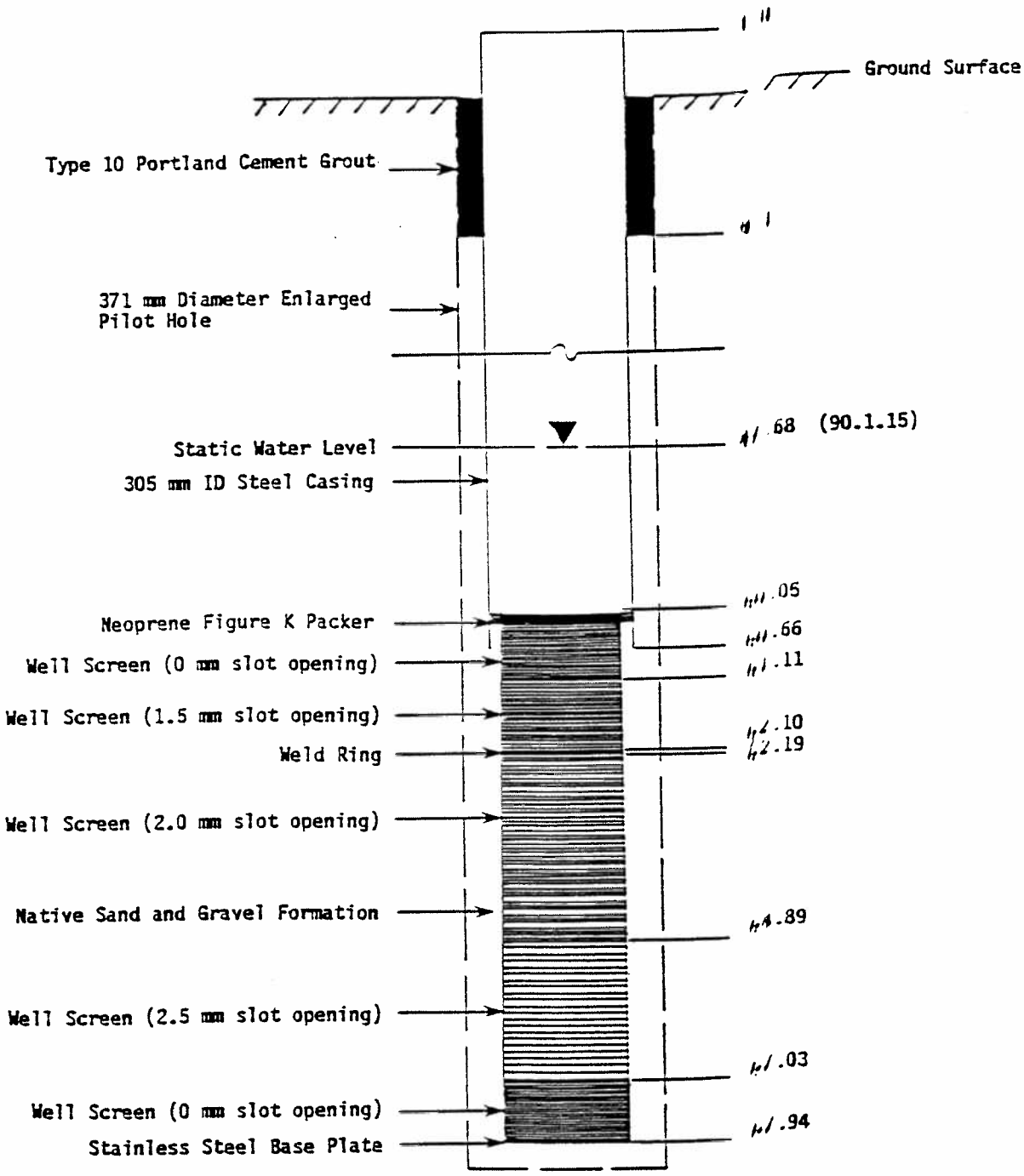
CLIENT
Regional Municipality of Waterloo

TITLE
Well K93
Pump Installation Drawing

PROJECT No. 006-229			\\Lotowater Projects\006 Region of Waterloo\229 K90's Peaking Wells Testing\7. Technical\K93	FIGURE 4
DESIGN			REVISION No. 2012-08-27	SCALE N.T.S.
DRAWN	RS	2012/08/27		
CHECKED				

K94

PEAKING WELL K-94



Notes:

1. Depths are reported in metres above/below ground surface.
2. Hole backfilled (or allowed to collapse) with native granular materials.
3. Stainless steel well screen manufactured by Johnson Screens, Ajax, Ontario.

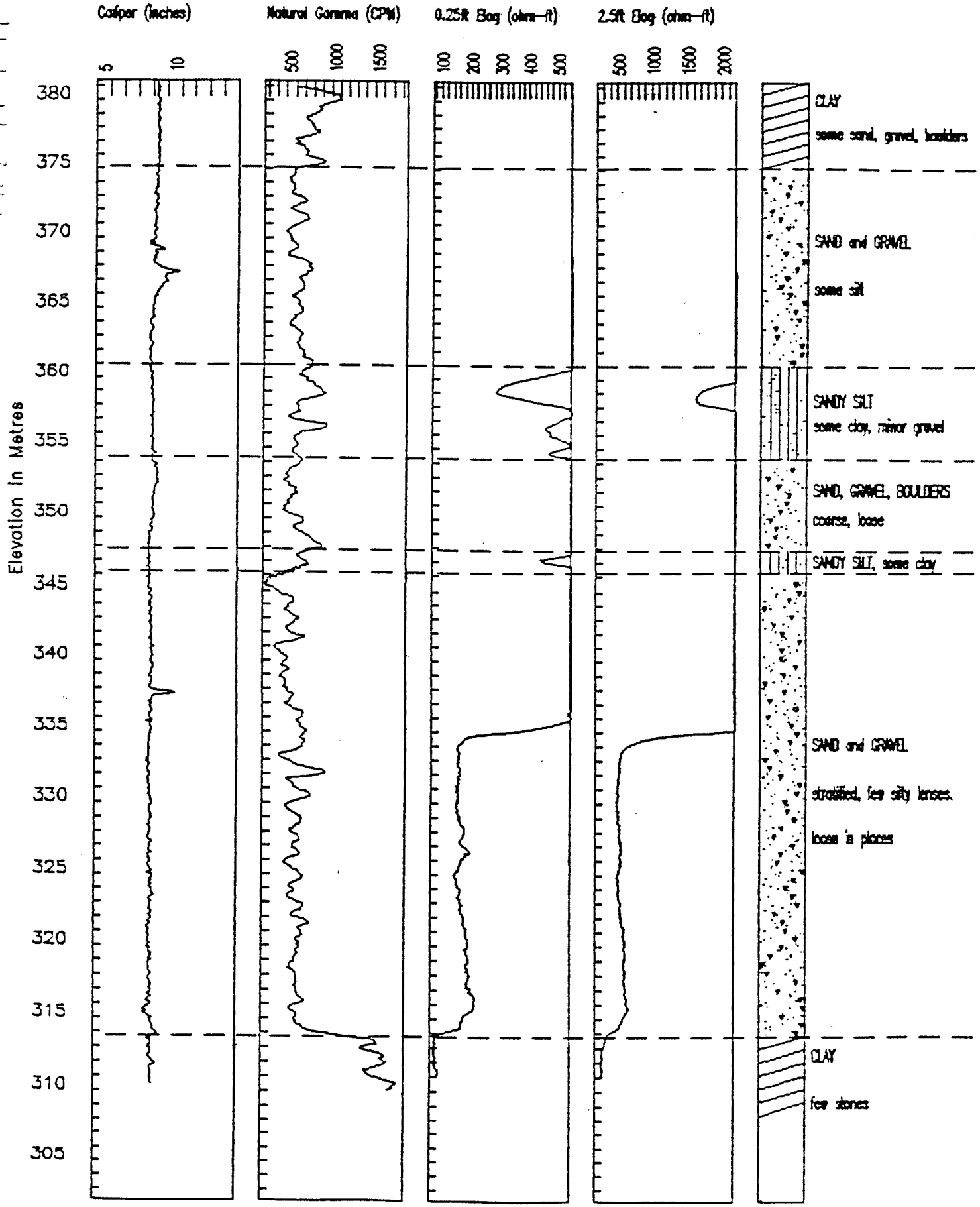
TROW, DAMES & MOORE

PEAKING WELL K 94
"AS-CONSTRUCTED" DRAWING

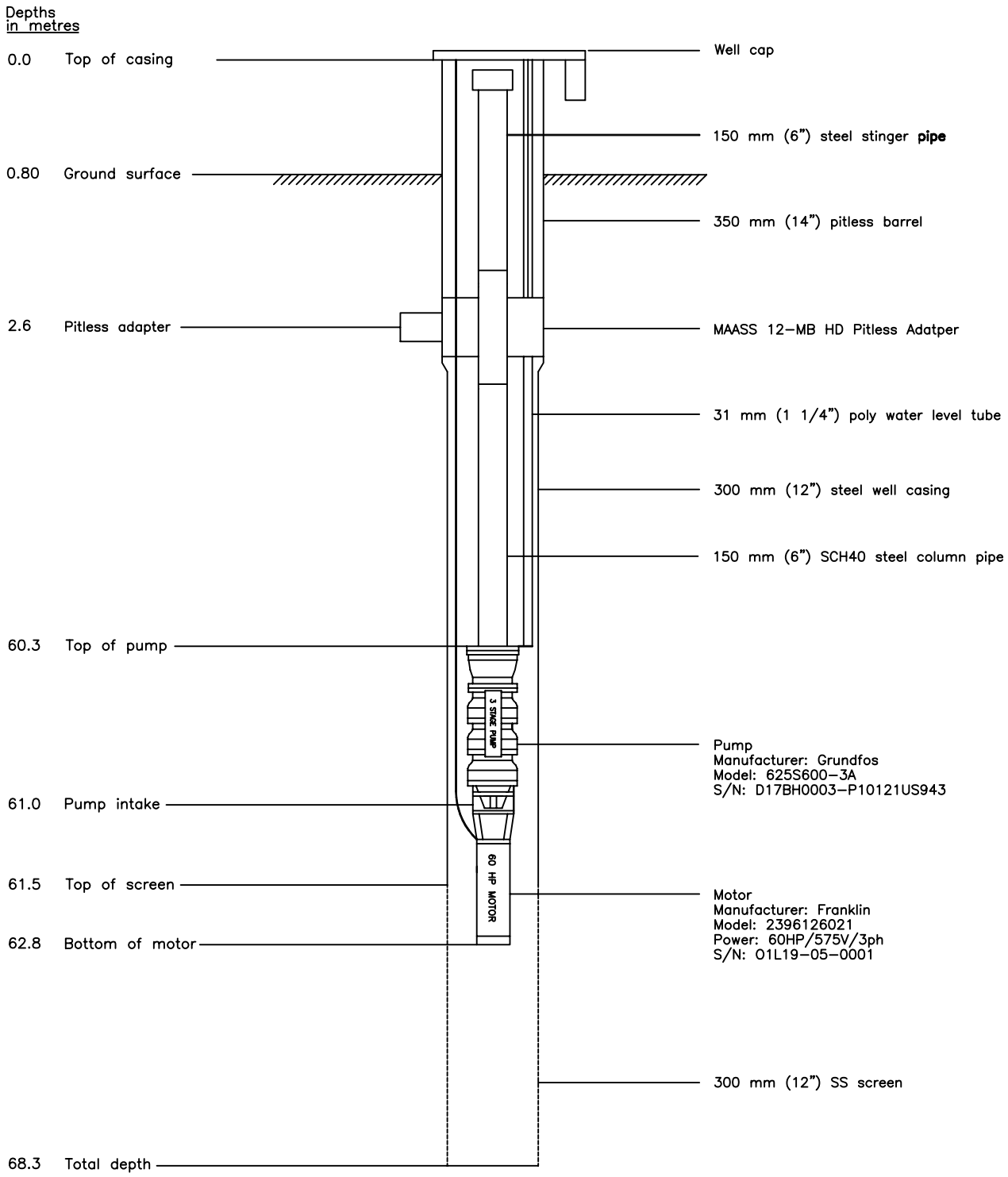
Proj. No.	16857-026
Scale	NTS
Drwn. by	PAG
Appr. by	
Revised	
Date	90.03.13

K94

Wellname Mannheim Production Well No. K-94
Filename MANK94A
Location Highway 7 & 8, Mannheim, Ontario
Elevation 381.4 Reference Ground Surface
Well drilled by Wayne Renwick, Olympic Drilling Company Ltd., 89/11/15



K94



Lotowater TECHNICAL SERVICES INC.

CLIENT
Regional Municipality of Waterloo

TITLE
Well K94
Pump Installation Drawing

PROJECT No.	006-229		\\Lotowater Projects\006 Region of Waterloo\229 K90's Peaking Wells Testing\7. Technical\K94		FIGURE
DESIGN					
DRAWN	RS	2012/07/23	REVISION No. 2012-07-24	SCALE N.T.S.	4
CHECKED					

K-ASR-TW5-08

PROJECT: 07-1112-0090

RECORD OF DRILLHOLE: ASRTW05-08

SHEET 1 OF 2

LOCATION: N 4806234.1 ;E 537514.3

DRILLING DATE: August 8-11, 2008

DATUM: Geodetic

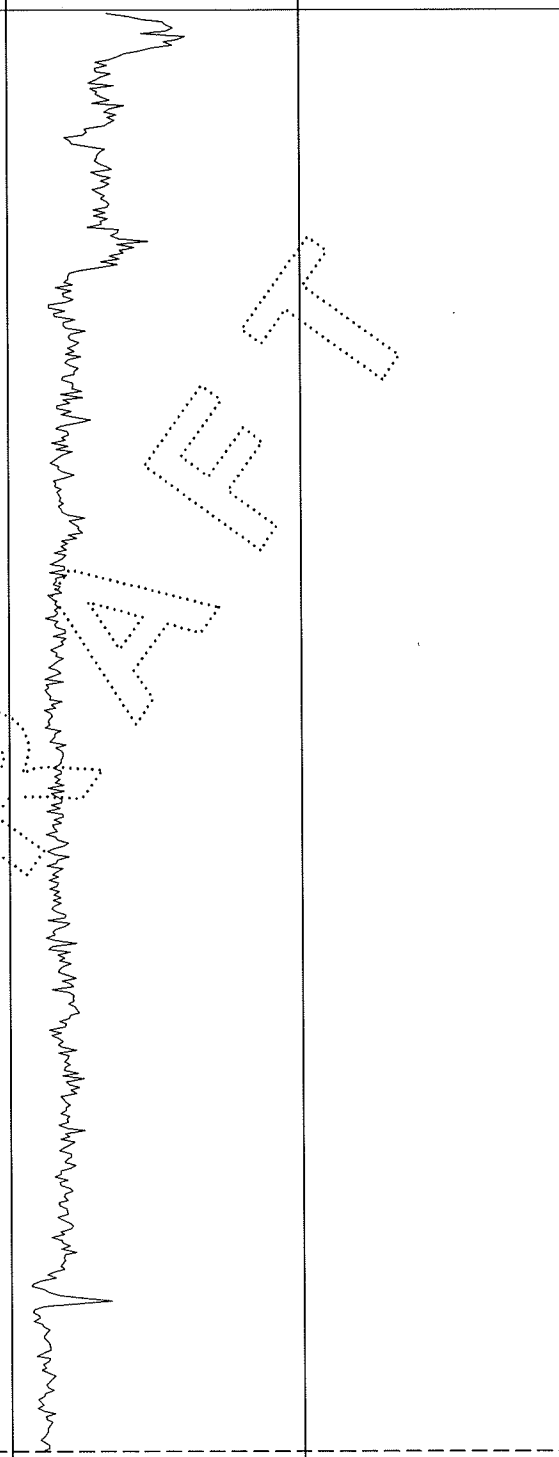
INCLINATION: -90° AZIMUTH: —

DRILL RIG: Foremost DR-12

DRILLING CONTRACTOR: Gerrits Drilling & Engineering Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m
		GROUND SURFACE	378.56			
0	Dual Rotary, 168 mm O.D. and 155 mm I.D.	light to dark brown/grey, CLAYEY SAND, slight organic odour	0.00	139	CS	
5		light to dark brown/grey, CLAYEY SAND with trace gravel	373.38 / 5.18	140	CS	
		Light to dark reddish brown, GRAVEL composed of Quartzite with mica flakes	370.64 / 8.23			
10		light to dark brown/grey, CLAYEY SAND with trace silt and gravel	367.28 / 11.28	141	CS	
		light to dark brown, SAND with trace silt and gravel		142	CS	
15				143	CS	
				144	CS	
20		Increasing gravel content with depth		145	CS	
		light to dark brown, GRAVELLY SAND	355.09 / 23.47	146	CS	
25				147	CS	
		light to dark brown, SAND with trace silt and gravel	348.99 / 29.57	148	CS	
30				149	CS	
35				150	CS	
				151	CS	
40		light to dark brown, GRAVELLY SAND with trace silt	336.80 / 41.76	152	CS	
45				153	CS	
				154	CS	
50		CONTINUED NEXT PAGE				

GEOPHYSICAL RECORD



NOTES WATER LEVELS INSTRUMENTATION

Top of Casing Elevation: 379.759 masl

9/16/2008

DEPTH SCALE 1 : 250

Golder Associates

LOGGED: SC

CHECKED: SD

MIS-GEO 001 07-1112-0090.GPJ GAL-MISS.GDT 3/5/09 DD/RJ

PROJECT: 07-1112-0090

RECORD OF DRILLHOLE: ASRTW05-08

SHEET 2 OF 2

LOCATION: N 4806234.1 ;E 537514.3

DRILLING DATE: August 8-11, 2008

DATUM: Geodetic

INCLINATION: -90° AZIMUTH: —

DRILL RIG: Foremost DR-12

DRILLING CONTRACTOR: Gerrits Drilling & Engineering Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	GEOPHYSICAL RECORD GAMMA (cps) 30 60 90 120	GEOPHYSICAL RECORD CONDUCTIVITY (mS/m) 10 20 30 40	NOTES WATER LEVELS INSTRUMENTATION
		— CONTINUED FROM PREVIOUS PAGE —								
50	Dual Rotary 168 mm O.D. and 155 mm I.D.	light to dark brown, GRAVELLY SAND with trace silt			154	CS				
					155	CS				Hole Plug
				324.61						
55		light to dark brown, medium to coarse SAND with some gravel		53.95	156	CS				18 Slot
					157	CS				45 Slot
				321.56						45 Slot
		light to dark brown, GRAVELLY SAND		57.00	158	CS				40 Slot
				320.04						
		light to dark brown, medium to coarse SAND with some gravel		58.52	159	CS				18 Slot
60				318.51						
		light to dark brown, GRAVELLY SAND		60.05	160	CS				
		light to dark grey, CLAY with some sand and trace silt		60.66	161	CS				Hole Plug
				314.55	162	CS				
		END OF BOREHOLE		64.01						
65										
70										
75										
80										
85										
90										
95										
100										

DRAFT

DEPTH SCALE

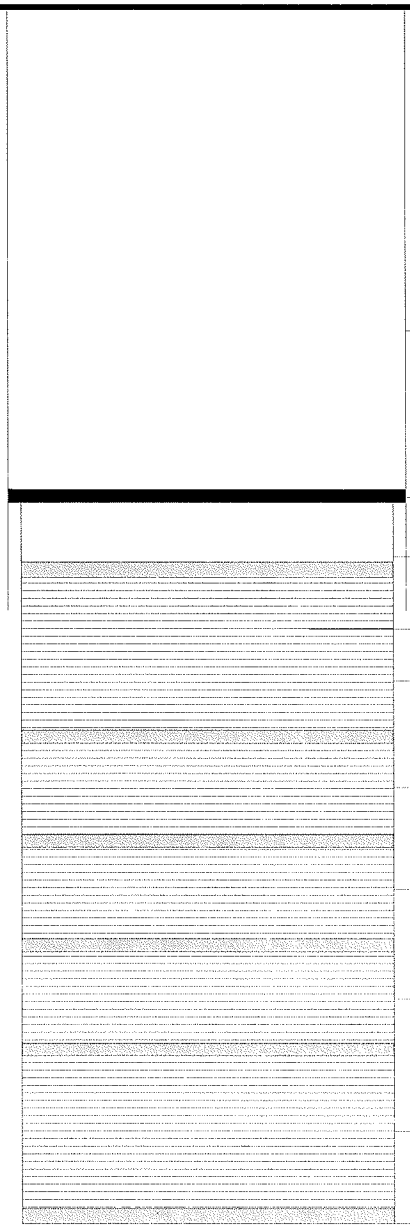
1 : 250

Golder Associates

LOGGED: SC

CHECKED: SD

Geologic Description Based on Grain Size Analysis	Depth Below Ground Surface (m)	(ft)
GRAVELLY SAND with trace silt	52.73	173
	53.05	174
	53.65	176
medium to coarse SAND with some gravel	54.25	178
	54.86	180
	55.47	182
	56.08	184
	56.69	186
GRAVELLY SAND	57.30	188
	57.91	190
	58.52	192
medium to coarse SAND with some gravel and trace silt	59.13	194
	59.74	196
GRAVELLY SAND	60.35	198
SILTY CLAY	60.96	200
	61.57	202



- $6\frac{1}{8}$" (155 mm) ID Steel Casing
- Neoprene K-packer
- 5" (127 mm) Lead Pipe 3' (0.91 m) Overall Length
- $5\frac{1}{2}$" (140 mm) OD Stainless Steel Wire Wound Screen
- 18 Slot Size from 175'$10\frac{3}{4}$" to 180'$10\frac{3}{4}$" (53.61 m to 55.14 m)
- 45 Slot Size from 181'4" to 184'4" (55.27 m to 56.19 m)
- 45 Slot Size from 184'9" to 187"9" (56.31 m to 57.23 m)
- 40 Slot Size from 188'$2\frac{1}{4}$" to 191'$2\frac{1}{4}$" (57.36 m to 58.27 m)
- 18 Slot Size from 191'$7\frac{1}{4}$" to 196'$7\frac{1}{2}$" (58.40 m to 59.93 m)
- Threaded end plug

Golder Associates
Mississauga, Ontario, Canada

SCALE	AS SHOWN	TITLE	OVERBURDEN WELL CONSTRUCTION DETAILS FOR ASRTW5-08
DATE	Mar. 5, 2009		
DESIGN	KD		
CAD	KD		
CHECK	SC	MUNICIPALITY OF WATERLOO STAGE 2 ASR EXPANSION	FIGURE A-2.5
REVIEW	SD		

FILE No. ASRTW5-08.dwg
PROJECT No. 07-1112-0090 REV. B

PLOT DATE: March 05, 2009
FILENAME: T:\Projects\2007\07-1112-0090 (ASR, Guelph)\-06- Shop Drawings\ASRTW5-08.dwg

K-PKW-OW9-89 TROW, DAMES & MOORE

MANNHEIM EAST (PEAKING WELL FIELD)

K-MP-OW9-89-A

E 537608
N 4806272

9170019

Near K93

LOG OF BOREHOLE TW9-89

Project: MANNHEIM- HIGHWAY 7/8 SITE
Client: REGIONAL MUNICIPALITY OF WATERLOO
Project No: 16857-009
Geologist/Engineer: P.A. GRAY
Technologist:

Date: 89/7/24
Depth of Borehole:
Elevation - Ground Surface: 387.5 m.a.m.s.l.
- Top of Instr: SEE BELOW
Drilling Equipment: MUD ROTARY

PROFILE			MONITOR INSTALLATION	SAMPLE	
STRATIGRAPHY DESCRIPTION AND REMARKS	Depth bgl.	ELEV. (m)	388.0	DEPTH	GRAIN SIZE
CLAY - brown, stoney, few boulders.		379.9	Bentonite.		
CLAYEY SAND AND GRAVEL	10m	378.2			
SILTY CLAY		374.7			
SAND - some gravel, trace clay.	20m	367.5			
CLAYEY SILT - sand streaks, minor gravel.		361.4			
SAND AND GRAVEL - stratified, few silty streaks. - very loose in places. - extreme mud losses in places. - stones and boulders. - packed in places.	30m				
	40m				
	50m		▼	54.6	X
				56.1	X
				57.6	X
				59.1	X
				60.7	X
	60m			62.2	X
			64.0	63.7	X
				65.2	X
				66.8	X
				68.3	X
	70m		70.1	69.8	X
CLAY - grey, few stones, firm.		314.3		71.3	X
				72.8	X
				74.4	X
TERMINATED 79.25	80m	308.6			X
	90m				
	100m				
	110m				

NOTE: Borehole data requires interpretation assistance from TDM personnel before use by others.
(1) Pipe is 203 mm. I.D. steel. (2) Screen is Stainless Steel with 2.0 mm slot opening.
(3) Hole is backfilled with native material, well screen naturally developed.
(4) ▼ Static water level measured 90/1/2; 53.2 m.b.g.l., 334.3 m.a.m.s.l.

RECORD OF BOREHOLE No. K-PK-OW1B-16

Project Number:	TT163301	Drilling Method:	PQ (85mm) Continuous Sampler/Soil Coring		
Project Client:	Regional Municipality of Waterloo	Drilling Machine:	Track Mounted Drill CME75 drill with Christiansen wireline coring		
Project Name:	Mannheim Monitoring Well Construction	Date Started:	14/04/2016	Date Completed:	14/04/2016
Project Location:	Kitchener, Ontario	Logged by:	NS/KG	Compiled by:	KR
Drilling Location:	Yellow Birch Park, Kitchener, Ontario	Reviewed by:	KG	Revision No.:	0, 05/08/2016
		Coordinates:	NAD 1983 17T 536848.3 E ; 4806485.5 N		

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LITHOLOGY PROFILE

Lithology Plot

DESCRIPTION

Stick-up of 0.88 m
Local Ground Surface Elevation: 377.18

Brown
CLAYEY SILT to SILT TILL
Trace SAND and GRAVEL
Trace organics
Dense

369.58 / 7.6

Grey
CLAYEY SILT TILL
Trace sand and gravel
Dense
Stone at 13.4m
Sharp basal contact

363.08 / 14.1

Brown
FINE TO MEDIUM and MEDIUM TO COARSE SAND
Multiple fining and coarsening downwards sequences
Moist to Saturated
Becomes stratified with depth

SOIL SAMPLING

Sample Type	Run Number	Recovery (%)	
CS	1	100	
CS	2a	60	
PQ	2b	33	
PQ	3	53	
PQ	4	18	
PQ	5	27	
PQ	6	40	
PQ	7	45	
PQ	8	92	Gravel: 3.7% Sand: 29.1% Silt: 54.7% Clay: 12.5%
PQ	9	85	
PQ	10	57	
PQ	11	95	
PQ	12	75	Gravel: 9.8%
PQ	13	100	Sand: 88.4% Silt: 1.8%

DEPTH (m): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19

5/4/2016

INTERPRETED STRATIGRAPHY

Unit ATB1: Upper Maryhill Till or equivalent

Unit AFB1: Upper Waterloo Moraine

GEOPHYSICS

Measuring Point: Ground Surface
Measuring Point Elevation: N/A
Logged by: J. Dion (Lotowater Tech. Services)
Logging Date: April 28, 2016
Gamma 1 (cps) 0 – 100
Gamma 2 (cps) 0 – 100

INSTRUMENTATION INSTALLATION

UNIT INTERPRETATION COMMENTS

Brown clay silt, trace sand and gravel, hard/dense

Aquitard 1

Nearshore/ Ice contact facies Moraine deposits

Aquifer 1

- Freestanding groundwater on 04/05/2016 measured **13.34** metres below ground surface.
- Freestanding groundwater on 01/06/2016 measured **39.84** metres below ground surface.
- Freestanding groundwater on 15/06/2016 measured **39.65** metres below ground surface.

Amec Foster Wheeler
Environment & Infrastructure

1-505 Woodward Avenue
Hamilton, Ontario L8H 6N6
Tel: (905) 312-0700
Fax: (905) 312-0771
www.amecfw.com

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geoscientist. Also, borehole information should be read in conjunction with the hydrogeological report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

Continued on Next Page

Scale: 1 : 106

RECORD OF BOREHOLE No. K-PK-OW1B-16

Project Number:	TT163301	Drilling Method:	PQ (85mm) Continuous Sampler/Soil Coring
Project Client:	Regional Municipality of Waterloo	Drilling Machine:	Track Mounted drill CME 75 drill with Christiansen wireline coring
Project Name:	Mannheim Monitoring Well Construction	Date Started:	14/04/2016 — Date Completed: Oct 13, 15
Project Location:	Kitchener, Ontario	Logged by:	NS/KG — Compiled by: KR
Drilling Location:	Yellow Birch Park, Kitchener, Ontario	Reviewed by:	KG — Revision No.: 0, 05/08/2016
		Coordinates:	NAD 1983 17T 536848.3 E ; 4806485.5 N

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Lithology Plot	DESCRIPTION	Sample Type	Run Number	Recovery (%)		DEPTH (m)	INTERPRETED STRATIGRAPHY	GEOPHYSICS (Measuring Point: Ground Surface; Measuring Point Elevation: N/A; Logged by: J. Dion (Lotowater Tech. Services); Logging Date: April 28, 2016; Gamma 1 (cps) 0–100; Gamma 2 (cps) 0–100)	INSTRUMENTATION INSTALLATION	UNIT INTERPRETATION COMMENTS
	Brown **FINE TO MEDIUM and MEDIUM TO COARSE SAND** Multiple fining and coarsening downwards sequences Heterogeneous below Moist to saturated Stratified with depth									Ice contact facies Moraine sediments Aquifer 1
		PQ	14	70		20				
		PQ	15	83		21, 22				
	Large stone at 22.1 m 354.42									
	Brown to grey 22.8 **FINE TO MEDIUM SAND** Multiple fining and coarsening downwards sequences Finer grained at depth with laminae	PQ	16	90		23, 24				Change to more uniform sands Starts at medium to coarse at top and appears to fine downwards to fine medium sand Upper part appears as a massive unit with very little lamination; lower fine grained component shows laminae
		PQ	17	97		25				
		PQ	18	95	Sand: 96.4% Silt & Clay: 3.6%	26, 27				
		PQ	19	100		28	Unit AFB1: Upper Waterloo Moraine			
		PQ	20	100		29, 30				
		PQ	21	100		31				
		PQ	22	100		32, 33				
		PQ	23	98		34				Quiet water facies Moraine deposits Aquifer 1
		PQ	24	92		35, 36				
		PQ	25	92		37				
		PQ	26	90	Sand: 92.8% Silt & Clay: 7.2%	38, 39				

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geoscientist. Also, borehole information should be read in conjunction with the hydrogeological report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

Scale: 1 : 106

Continued on Next Page

RECORD OF BOREHOLE No. K-PK-OW1B-16

Project Number:	TT163301	Drilling Method:	PQ (85mm) Continuous Sampler/Soil Coring		
Project Client:	Regional Municipality of Waterloo	Drilling Machine:	Track Mounted Drill CME 75 drill with Christiansen wireline coring		
Project Name:	Mannheim Monitoring Well Construction	Date Started:	14/04/2016	Date Completed:	14/04/2016
Project Location:	Kitchener, Ontario	Logged by:	NS/KG	Compiled by:	KR
Drilling Location:	Yellow Birch Park, Kitchener, Ontario	Reviewed by:	KG	Revision No.:	0, 05/08/2016
		Coordinates:	NAD 1983 17T 536848.3 E ; 4806485.5 N		

amec foster wheeler

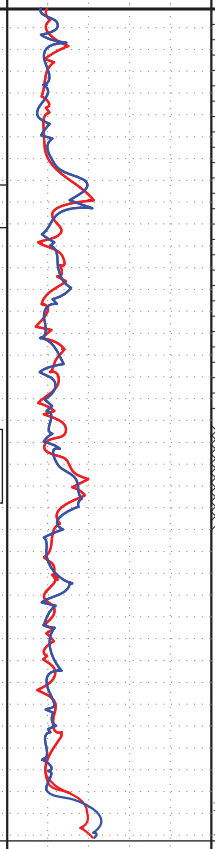
LITHOLOGY PROFILE / SOIL SAMPLING

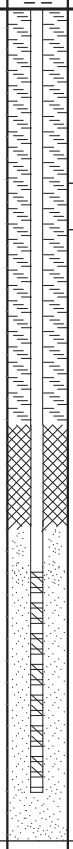
Lithology Plot	DESCRIPTION	Sample Type	Run Number	Recovery (%)	DEPTH (m)	INTERPRETED STRATIGRAPHY	INSTRUMENTATION INSTALLATION	UNIT INTERPRETATION COMMENTS
	FINE TO MEDIUM and MEDIUM TO COARSE SAND Multiple fining and coarsening downwards sequences Moist to saturated Stratified with depth	PQ	27	100	40			See above
	335.68				41			
	Brown **CLAYEY SILT to SILTY CLAY TILL** Trace to some GRAVEL 41.5 **334.98**	PQ	28	97	42	Unit ATB2: Middle Maryhill Till		Brown Till Aquitard 2
	Brown **FINE TO COARSE SAND** Trace to some GRAVEL Layered; occasional interveds of FINE SANDY SILT to SILTY FINE SAND GRAVEL layers 43.6 m - 46.3 m 42.2	PQ	29	75	43			
		PQ	30	40	44			Heterogeneous layers of sand and cobbles
	SILT layer with CLAY seams 45.7 m - 47.2 m				45	Unit AFB2: Waterloo Moraine		Near ice to ice contact moraine deposits
		PQ	31	97	46			Aquifer 2
		PQ	32	85	47			
		PQ	33	95	48			
	326.92				49			
	CLAYEY SILT to SILTY CLAY TILL 50.3				50			
	End of BOREHOLE at 50.7 m. **327.11**							
	WELL CONSTRUCTION DETAILS Stick-up of 0.88 m Bentonite Holeplug: 0 m - 3.0 m Bentonite Grout: 3.0 m - 44.8 m Bentonite Holeplug: 44.8 m - 46.3 m Sand: 46.3 m - 50.7 m Screen: 46.9 m - 50.0 m							

6/15/2016
6/1/2016

GEOPHYSICS

Measuring Point: Ground Surface
Measuring Point Elevation: N/A
Logged by: J. Dion (Lotowater Tech. Services)
Logging Date: April 28, 2016
Gamma 1 (cps) 0 – 100
Gamma 2 (cps) 0 – 100





Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geoscientist. Also, borehole information should be read in conjunction with the hydrogeological report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

Scale: 1 : 106

Monitoring Well: K-MP-OW1-17

K-MP-OW1-17-A

Project: Monitoring Well Construction
Client: Regional Municipality of Waterloo
Location: Kitchener, Waterloo, ON; Adjacent to Production Wells K91/K92
Number: 160900870

Field Investigator: AH,CD,AV
Contractor: Choice Sonic
Drilling method: Rotosonic
Date started/completed: 08-Aug-2017 / 10-Aug-2017

Ground surface elevation: 376.64 m AMSL
Top of casing elevation: 377.46 m AMSL
Easting: 537719.769
Northing: 4805992.117

SUBSURFACE PROFILE				HYDROGEOLOGY		SAMPLE DETAILS			GEOPHYSIC DETAILS	WELL DETAILS
Depth (ft) (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	Lab Analyses	Gamma (cps) 20 40 60 80	
			377.45							
0 (0)		Ground Surface HYDROVAC	376.64 0.00							Above ground Casing 0.82 m stick-up Cement Surface Seal 0 to 0.6 m
5			374.81							
(2)		GRAVELLY SAND loose, brown, (10 YR 5/3), some silt, fine to coarse sand, fine to coarse gravel, trace to some cobbles, subrounded to rounded, moist sandy clay layer 0.1 m thick at 2.1 m	1.83 374.40							
		SAND brown (7.5 YR 5/3), trace silt, trace gravel, well graded	2.23			1	CC			
10		medium to coarse sand, trace fine gravel, beginning at 3.2 m								
(4)		layers of fine sand beginning at 4 m				2	CC			
15		coarse sand beginning at 4.6 m fine to medium sand, some silt beginning at 5.3 m				3	CC			
20 (6)		increased gravel content at 6.1 m medium to coarse sand, trace gravel beginning at 6.5 m fine to medium sand beginning at 7.2 m fine sand, some silt beginning at 7.4 m		AFB1	Upper Waterloo Moraine stratified sediments and equivalents	4	CC			168 mm diameter Borehole
25 (8)						5	CC	Sample at 8.5 m for GSA		
30		coarse sand, trace coarse gravel beginning at 9.1 m medium to coarse sand, trace silt beginning at 9.6 m				6	CC			
(10)										

Screen Interval: 56.39 - 59.44 m BGS
Sand Pack Interval: 55.78 - 60.35 m BGS
Well Seal Interval: 0.61 - 55.78 m BGS

Stantec

Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
CC - continuous core sample
n/a - not available/applicable

Geophysics performed by Lotowater Technical Services Ltd. August 14, 2017, through PVC casing following well construction
WRAS No.: 9207337A
GSA - Grain Size Analysis

Drawn By/Checked By: CD/LV

STANTEC BOREHOLE AND WELL - MASTER 17X11 20170831_RMOW_MONITORING WELLS.GPJ DATA TEMPLATE_ENVS_CA_140725.GDT 30/11/17 AHEALEY

Monitoring Well: K-MP-OW1-17

Project: Monitoring Well Construction
Client: Regional Municipality of Waterloo
Location: Kitchener, Waterloo, ON; Adjacent to Production Wells K91/K92
Number: 160900870

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Drilling method: Rotosonic
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SUBSURFACE PROFILE				HYDROGEOLOGY		SAMPLE DETAILS			GEOPHYSIC DETAILS	WELL DETAILS
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	Lab Analyses	Gamma (cps) 20 40 60 80	
35			SILTY SAND dark yellowish brown (10 YR 4/4) to greyish brown (10 YR 5/2), fine sand	366.32 10.31			7	CC			
40	12		0.05 m layer of silty clay, compact at 12.4 m becomes wet at 13.1 m	363.32			8	CC			
45	14		SILTY SAND WITH CLAY TILL firm, brown (10 YR 5/3), fine sand, moist to wet	13.32	Potentially ATB2	Middle Maryhill Till and equivalents	9	CC			
50	16		pockets of fine to medium sand pockets of fine and medium sand starting at 15.5 m 0.10 m thick clay layer at 15.8 m	360.33			10	CC	Sample at 15.2 m for GSA		
55			SAND loose, greyish brown (10 YR 5/2), fine to coarse sand, trace silt	16.31 358.81			11	CC			
60	18		SILTY SAND compact, brown (10 YR 4/3), fine sand, clay in clumps silty sand layer 0.1 m thick, wet	17.83 357.43			12	CC			
65	20		SAND brown (10 YR 4/3), fine to coarse sand, trace silt, moist some fine to coarse gravel at 20.7 to 21.3 m	19.20			13	CC			
							14	CC			

Screen Interval: 56.39 - 59.44 m BGS
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Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	Lab Analyses	Gamma (cps) 20 40 60 80	
70			SAND brown (10 YR 4/3), fine to coarse sand, trace silt, moist medium to coarse sand, trace silt beginning at 21.3 m								
	22						15	CC			
75			fine sand, trace silt beginning at 22.9 m				16	CC			
	24			352.65 23.99			17	CC			
80			SANDY SILT brown (10 YR 5/3), fine sand, trace clay, moist								Bentonite Grout 0.6 to 48.2 m
							18	CC			
			becomes wet, some clay, firm at 25.5 m								
85	26						19	CC			
			becomes silty sand, some gravel at 26.8 m seam of coarse sand at 24.6 m, moist								
90							20	CC			
	28		SAND brown (10 YR 5/3), fine to medium sand, trace silt, trace clay	348.80 27.84							
			clasts of grey sandy silt beginning at 28.5 m				21	CC			
95											
			becoming fine sand, trace silt at 29.7 m				22	CC			
	30										
100											
105	32										

Screen Interval: 56.39 - 59.44 m BGS
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Well Seal Interval: 0.61 - 55.78 m BGS

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Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	Lab Analyses	Gamma (cps) 20 40 60 80	
			SAND brown (10 YR 5/3), fine to medium sand, trace silt, trace clay	343.41							
			SAND AND GRAVEL brown (10 YR 4/3), fine to coarse sand, fine to coarse gravel, rounded, trace silt in clumps, wet	33.22							
110	34						23	CC			
			light brownish grey (10 YR 6/2), some silt from 34.7 to 35.1 m, dry								
115	36						24	CC			
120			color change to light brownish grey/light yellowish brown (2.5 Y 6/2 to 2.5 Y 6/3)								
125	38						25	CC			
			SAND greyish brown (2.5 Y 5/2), medium to coarse grained, trace silt, trace gravel, subrounded to rounded, moist	337.62 39.01	AFB2	Middle Waterloo Moraine stratified sediments and equivalents					
130	40						26	CC			
135											
	42										
140							27	CC			

Screen Interval: 56.39 - 59.44 m BGS
Sand Pack Interval: 55.78 - 60.35 m BGS
Well Seal Interval: 0.61 - 55.78 m BGS

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CC - continuous core sample
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Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	Lab Analyses	Gamma (cps) 20 40 60 80	
			SAND greyish brown (2.5 Y 5/2), medium to coarse grained, trace silt, trace gravel, subrounded to rounded, moist	332.44							
145	44		SAND AND GRAVEL greyish brown, fine to coarse sand, trace silt, well graded, wet	44.20							
150	46						28	CC			
155	48		medium sand at 48.2 to 49.4 m								
160							29	CC			
165	50		medium sand 50.9 to 52.1 m, wet								
170	52						30	CC			Bentonite chips 48.2 to 55.8 m
175	54										

Screen Interval: 56.39 - 59.44 m BGS
Sand Pack Interval: 55.78 - 60.35 m BGS
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Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Elevation (m AMSL) Depth (m BGS)	Hydro Stratigraphic Unit	Description	Sample Number	Sample Type	Lab Analyses	Gamma (cps) 20 40 60 80	
180			SAND AND GRAVEL greyish brown, fine to coarse sand, trace silt, well graded, wet medium to coarse sand, trace gravel at 54.9 to 56.7 m				31	CC			
	56										
185							32	CC	Sample at 57.0 m for GSA		No. 1 Silica Sand 55.8 to 60.4 m No. 10 slot Schedule 80 PVC Screen 51 mm OD 56.4 to 59.4 m
190	58										
195							33	CC			No. 1 Silica Sand 55.8 to 60.4 m
	60			315.98 60.66							
200			SILT stiff, brown (10 YR 5/3), trace coarse sand, blocky, moist	315.37 61.26							
			CLAYEY SILT stiff to very hard, grey (10 YR 5/1) to (10 YR 6/1) mottled, trace coarse sand, trace fine gravel, blocky, moist		ATB3	Lower Maryhill Till	34	CC	Sample at 62.8 m for GSA		Bentonite pellets 60.4 to 63.4 m
	62										
205				313.24 63.40							
			End of Borehole								
210	64										

Screen Interval: 56.39 - 59.44 m BGS
Sand Pack Interval: 55.78 - 60.35 m BGS
Well Seal Interval: 0.61 - 55.78 m BGS

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BURNSIDE

[THE DIFFERENCE IS OUR PEOPLE]

Appendix C

Monitoring Data
(Pumped Volumes and Hydrographs)

Region of Waterloo

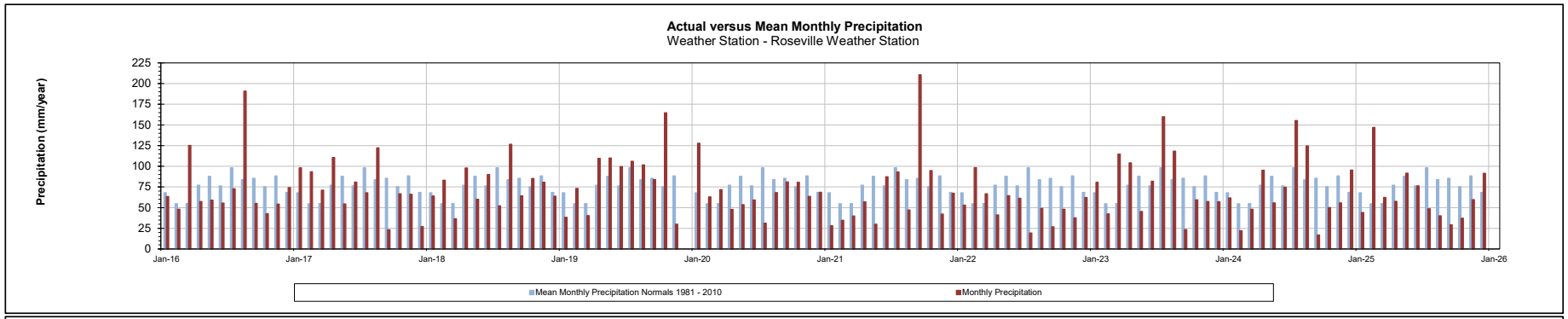
TABLE C-1
WELL FIELD WATER PRODUCTION SUMMARY
REGION OF WATERLOO - 2025 GROUNDWATER MONITORING REPORT

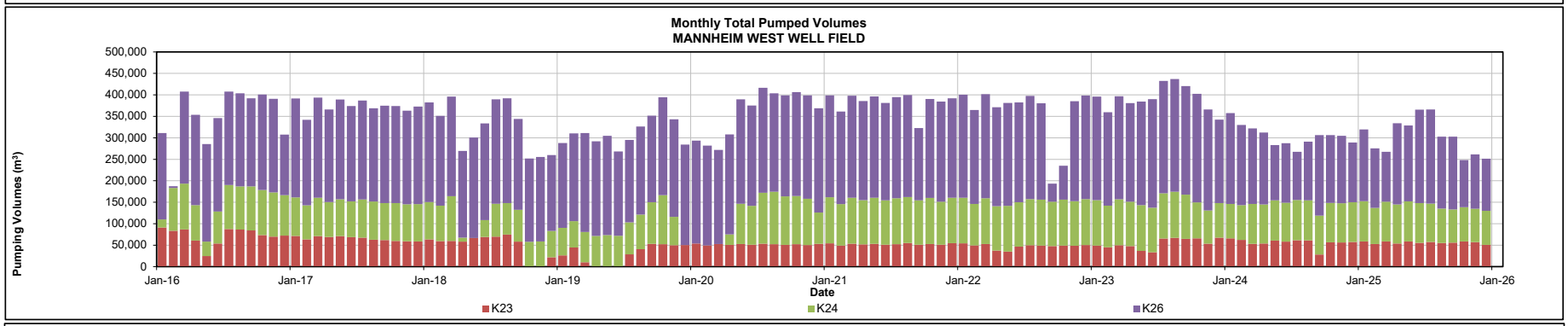
BURNSIDE

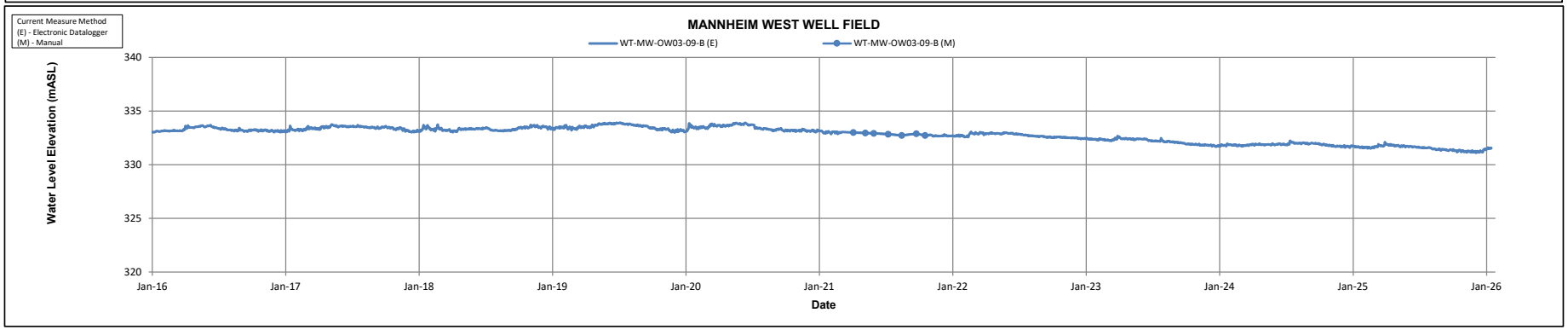
Well Field	Major or Minor Supply	Production Well Name	Status	Permit to Take Water Details			2021 Production Summary			2022 Production Summary			2023 Production Summary			2024 Production Summary			2025 Production Summary		
				MOE Permit Number[1]	Permitted Capacity (total m^3/year)*	Permitted Rate (L/s)*	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)
Mannheim Consolidated:																					
Mannheim East	Major	K21	Supply		6,212,665	197.0	873,197	2,392	27.7	196,414	538	6.2	786,132	2,154	24.9	754,207	2,066	23.9	653,266	1,790	20.7
		K21A	Supply		6,212,665	197.0	0	0	0	120,313	0	0	628,474	0	0	616,818	1,690	0.0	592,720	1,624	18.8
		K25	Supply		6,212,665	197.0	1,513,323	4,146	48.0	1,529,366	4,190	48.5	1,599,629	4,383	50.7	1,547,231	4,239	49.1	1,553,102	4,255	49.2
		K29	Supply		6,212,665	197.0	1,248,553	3,421	39.6	1,211,984	3,321	38.4	971,656	2,662	30.8	1,335,407	3,659	42.3	1,351,180	3,702	42.8
Peaking	Major	K91	Supply		5,991,840	190.0	402,322	1,102	12.8	518,744	1,421	16.4	901,718	2,470	28.6	782,974	2,145	24.8	874,982	2,397	27.7
		K92	Supply		5,991,840	190.0	571,938	1,567	18.1	466,953	1,279	14.8	873,777	2,394	27.7	860,887	2,359	27.3	939,042	2,573	29.8
		K93	Supply		5,991,840	190.0	460,209	1,261	14.6	412,689	1,131	13.1	691,378	1,894	21.9	825,153	2,261	26.2	838,555	2,297	26.6
		K94	Supply		5,991,840	190.0	454,176	1,244	14.4	450,787	1,235	14.3	915,126	2,507	29.0	860,839	2,358	27.3	924,196	2,532	29.3
Mannheim ASR	Major	ASR1	Recharge/Recovery		8,650,500	337.0	94,119	258	3.0	64,810	178	2.1	75,370	206	2.4	4,258	12	0.1	20,401	56	0.6
		ASR2	Recharge/Recovery	P-300-3130244509	8,650,500	337.0	61,138	168	1.9	30,996	85	1.0	96,317	264	3.1	20,786	57	0.7	45,868	126	1.5
		ASR3	Recharge/Recovery		8,650,500	337.0	17,566	48	0.6	77,324	212	2.5	90,178	247	2.9	31	0	0.0	9,499	26	0.3
		ASR4	Recharge/Recovery		8,650,500	337.0	112,260	308	3.6	59,163	162	1.9	188,044	515	6.0	0	0	0.0	0	0	0.0
		RCW1	Recovery		8,650,500	337.0	298,945	819	9.5	181,739	498	5.8	213,678	585	6.8	129,281	354	4.1	189,151	518	6.0
		RCW2	Recovery		8,650,500	337.0	249,879	685	7.9	254,859	698	8.1	296,357	812	9.4	100,124	274	3.2	180,266	494	5.7
		RCW3	Recovery		8,650,500	337.0	0	0	0.0	155,380	0	0	196,774	0	0	50,342	138	1.6	140,682	385	4.5
		RCW4	Recovery		8,650,500	337.0	0	0	0	203,386	0	0	307,352	0	0	105,209	288	3.3	195,433	535	6.2
Mannheim West	Major	K23	Supply		7,064,064	224.0	630,122	1,726	20.0	570,732	1,564	18.1	646,012	1,770	20.5	675,341	1,850	21.4	673,497	1,845	21.4
		K24	Supply		7,064,064	224.0	1,254,423	3,437	39.8	1,258,310	3,447	39.9	1,180,624	3,235	37.4	1,082,280	2,965	34.3	1,030,652	2,824	32.7
		K26	Supply		7,064,064	224.0	2,721,273	7,456	86.3	2,462,337	6,746	78.1	2,882,069	7,896	91.4	1,899,346	5,204	60.2	1,918,555	5,256	60.8
						Well Field Total	***10,963,443***	***30,037***	***347.6***	***10,226,286***	***28,017***	***324.3***	***13,540,665***	***37,098***	***429.4***	***11,650,514***	***31,919***	***369.4***	***12,131,047***	***33,236***	***384.7***
				Annual taking from Mannheim East, Mannheim West and Peaking Well Fields not to exceed a daily average of 40,715,136 L/day																	

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

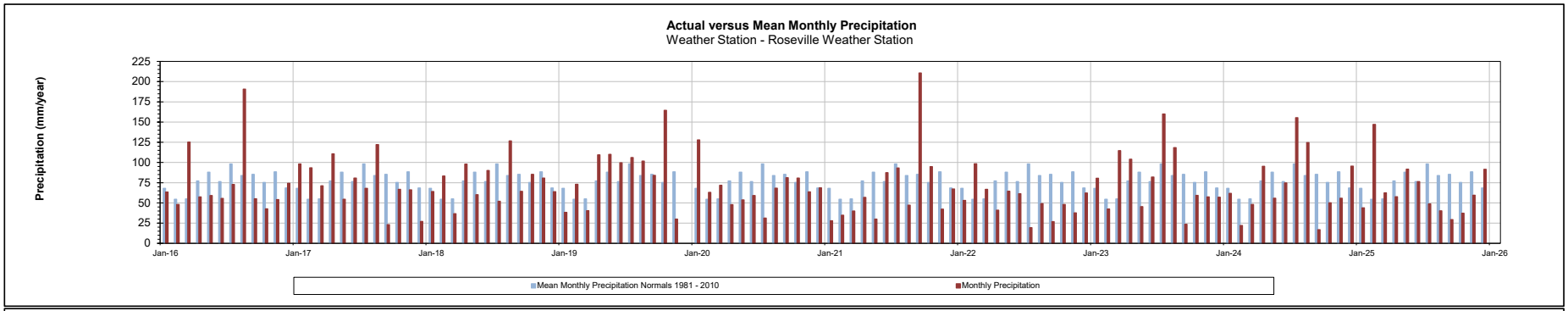
REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
MANNHEIM WELL FIELDS

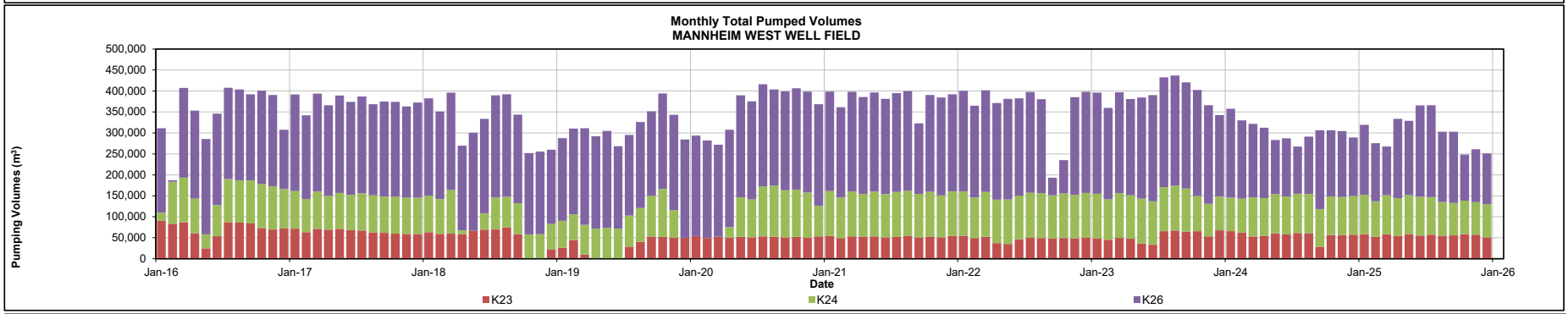


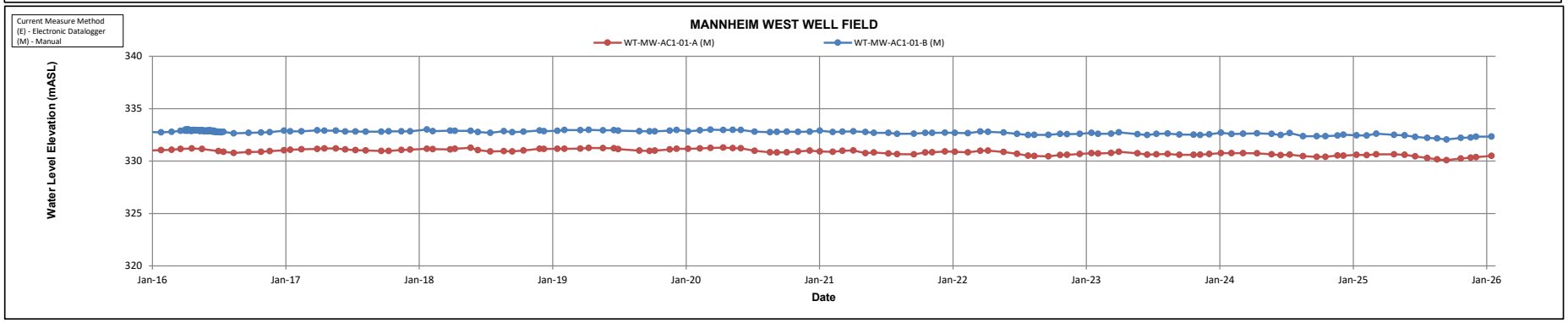




REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
MANNHEIM WELL FIELDS







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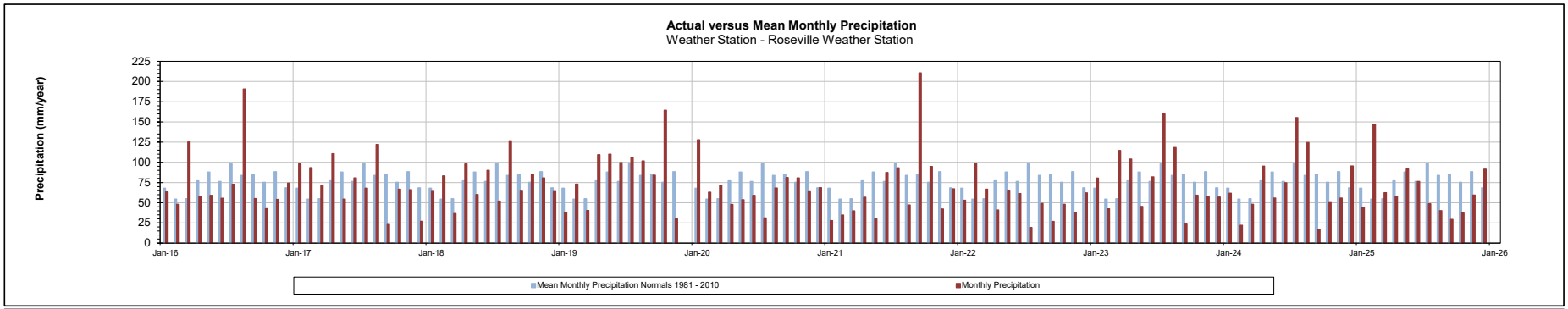
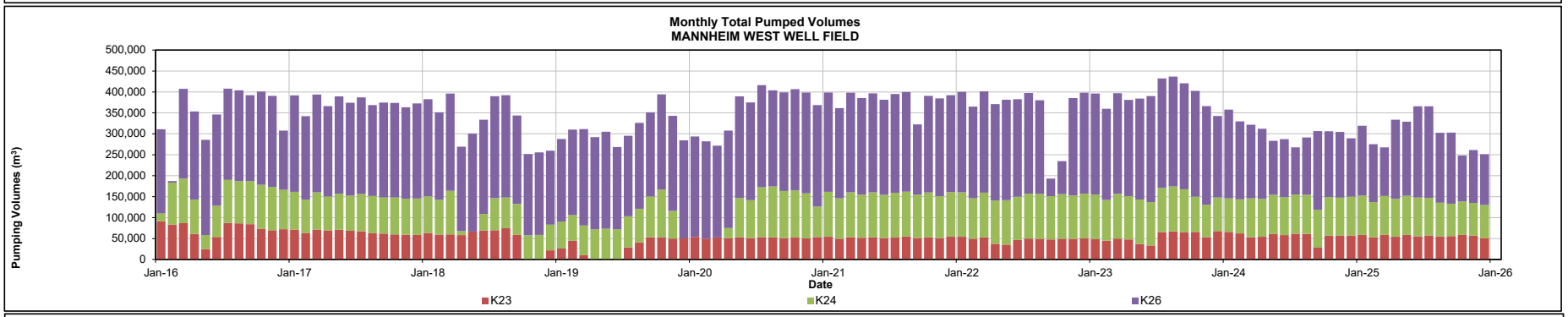
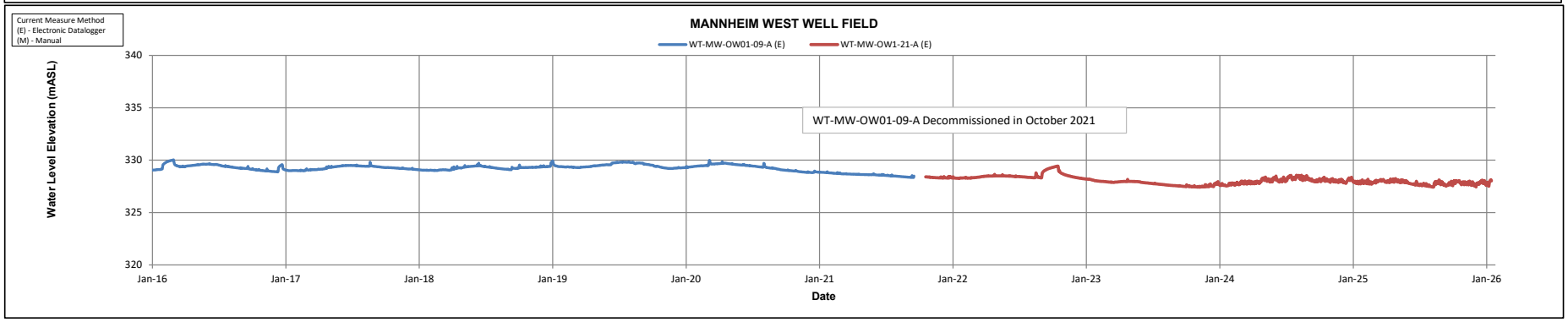
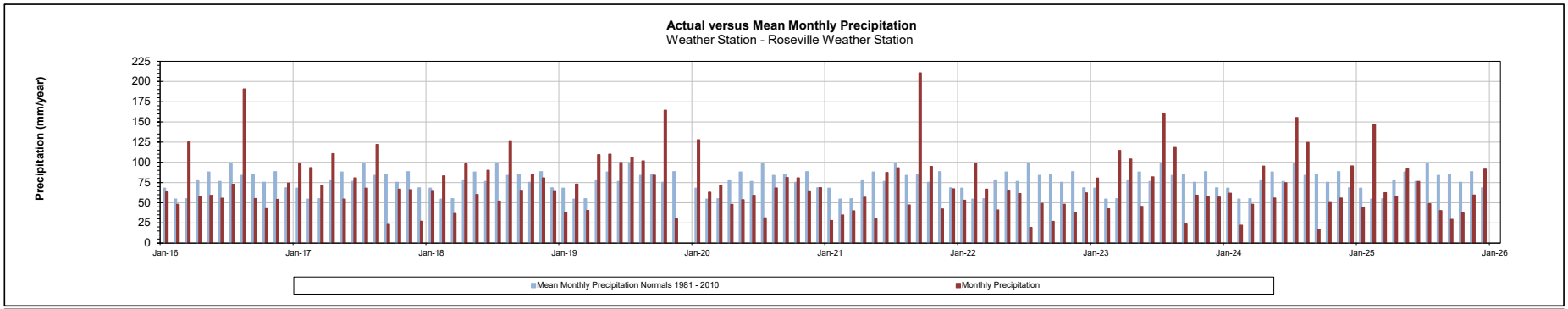
2025 GROUNDWATER MONITORING REPORT -
MANNHEIM WELL FIELDS

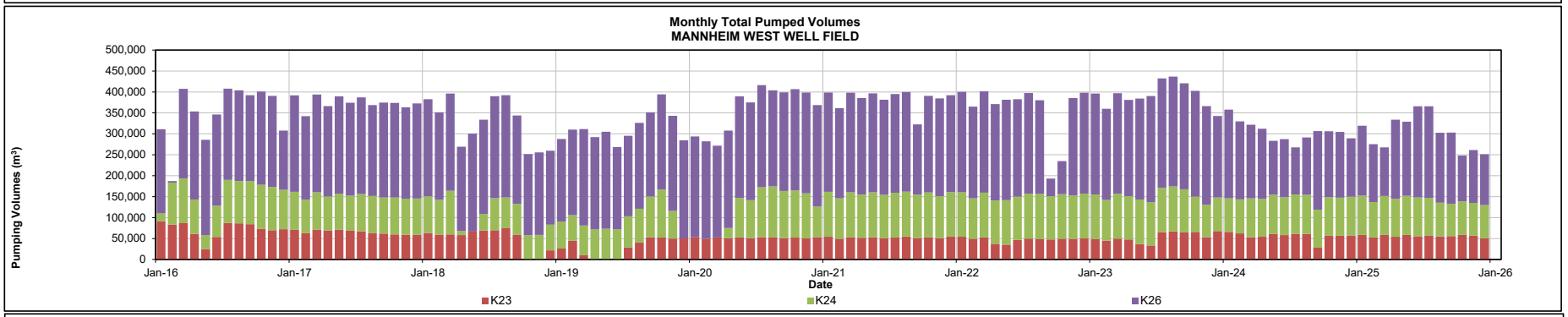


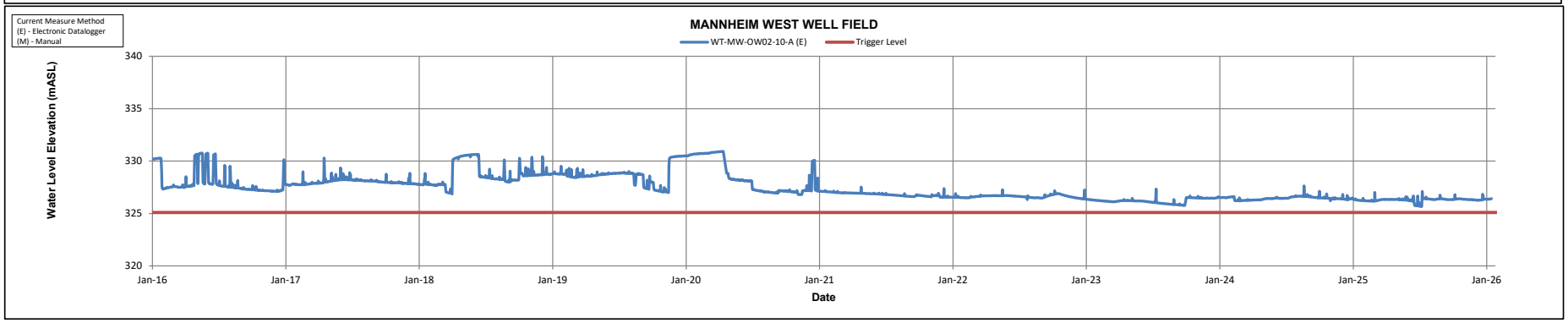




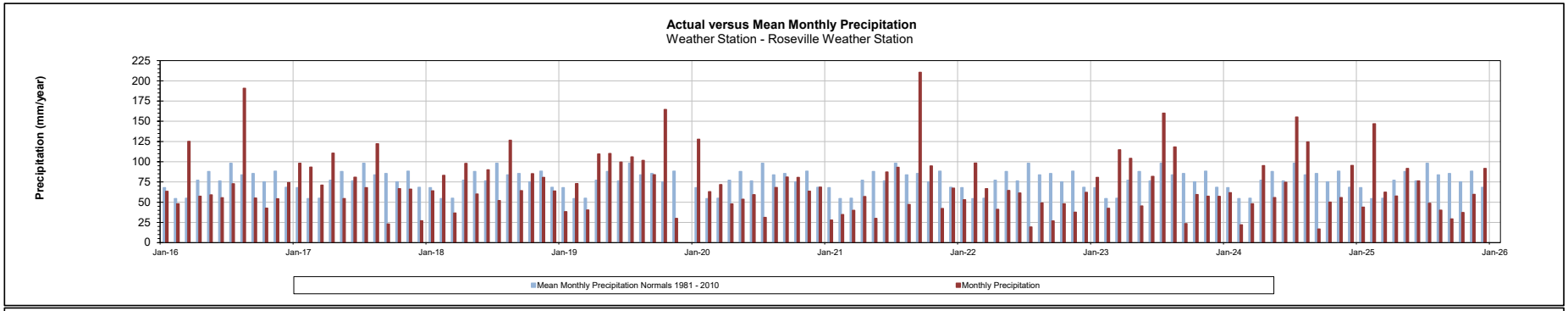
REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
MANNHEIM WELL FIELDS

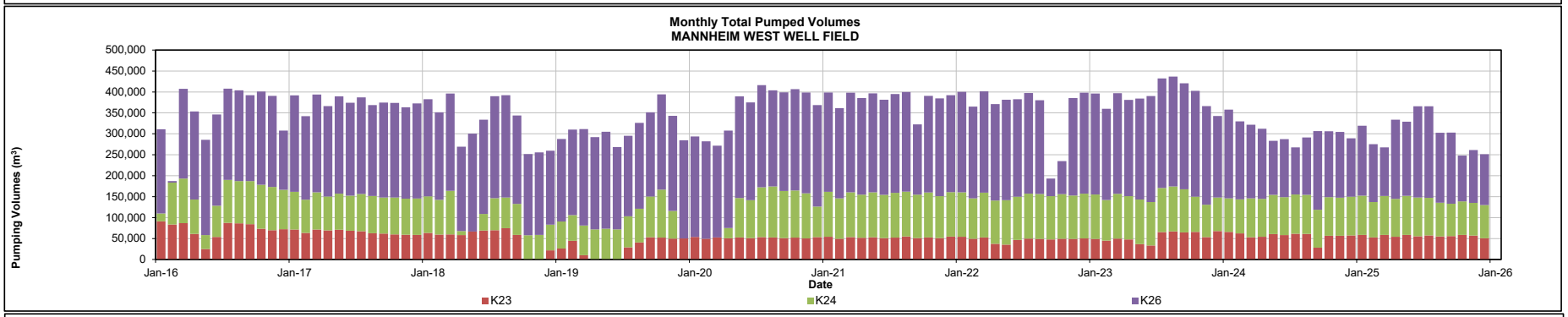


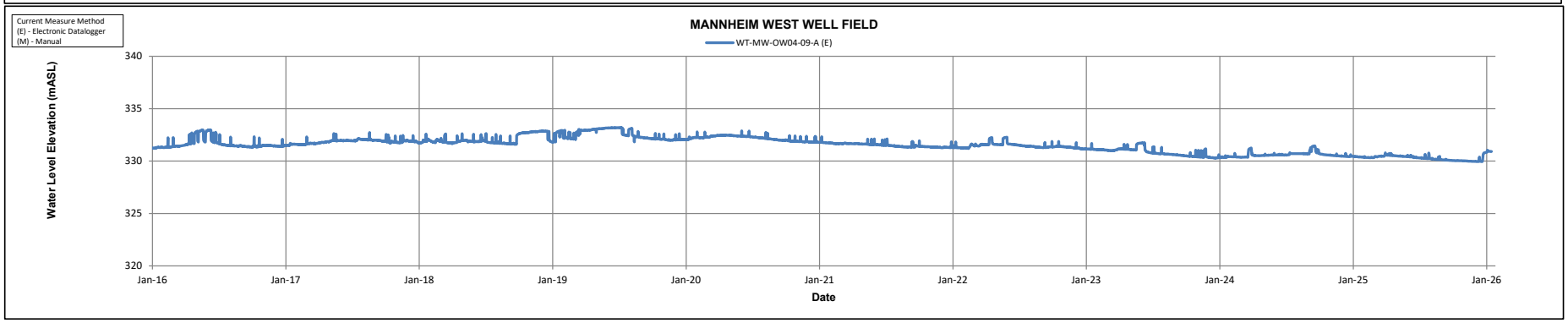




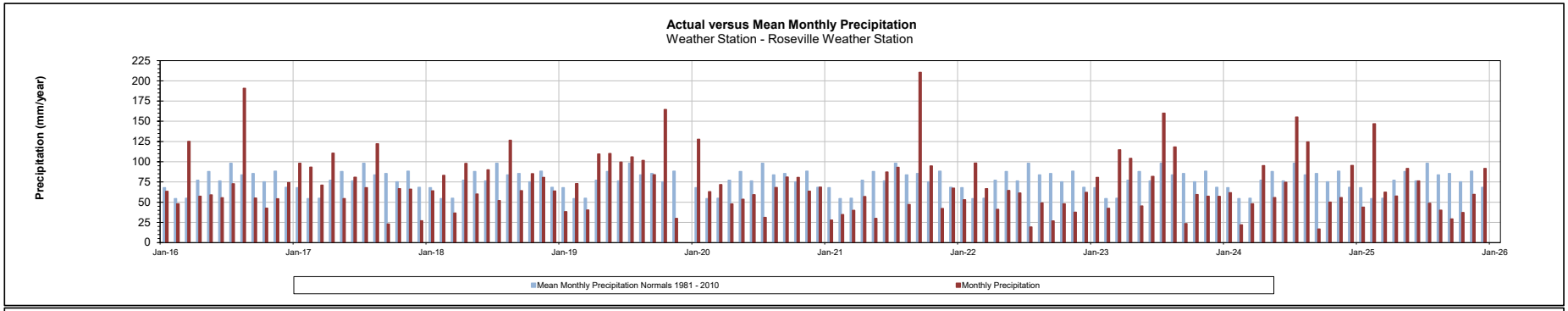
REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
MANNHEIM WELL FIELDS

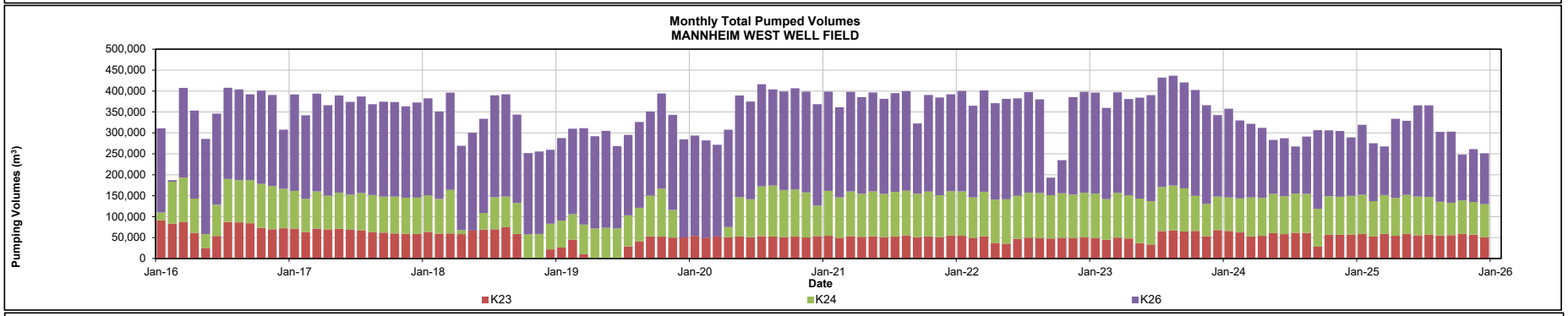


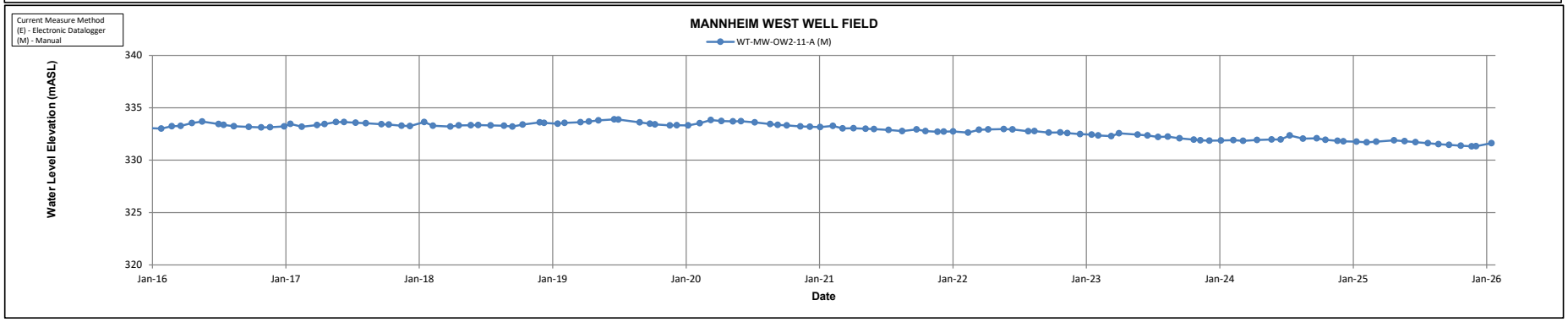




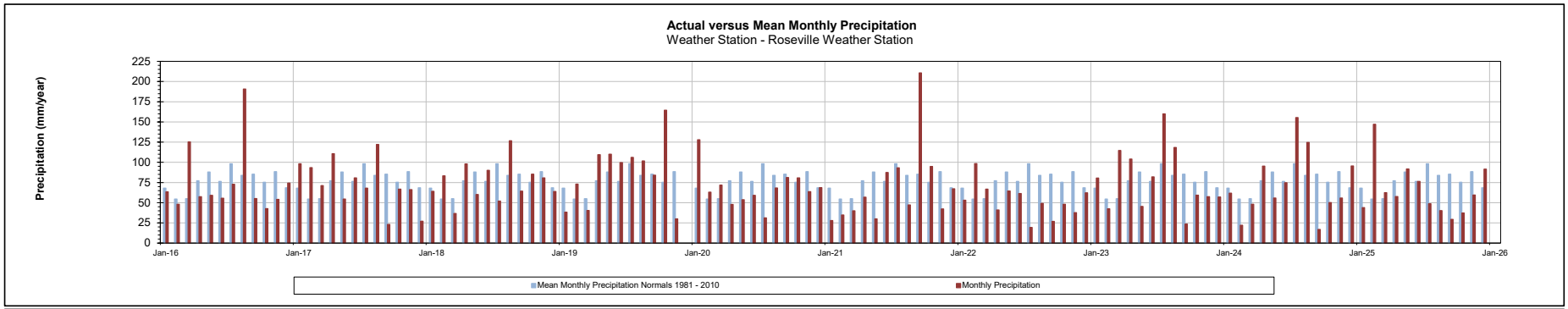
REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
MANNHEIM WELL FIELDS

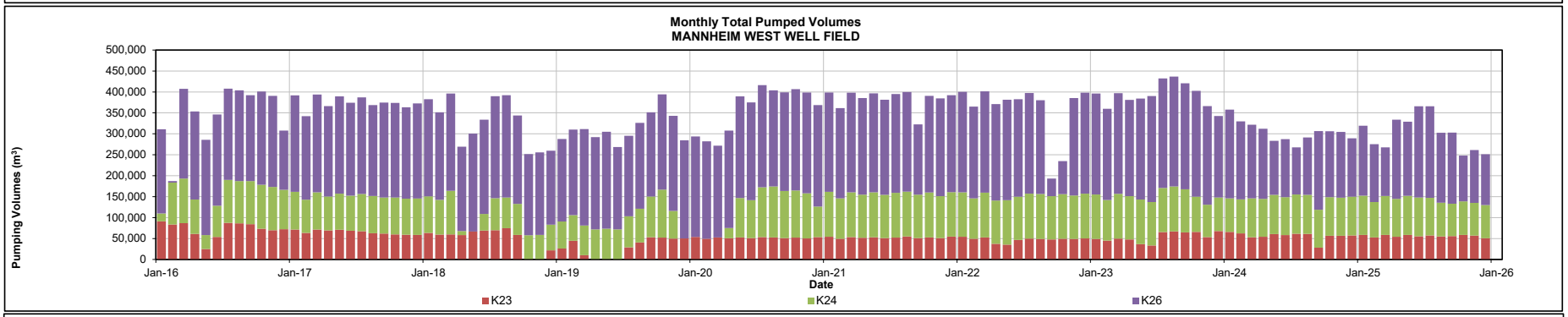


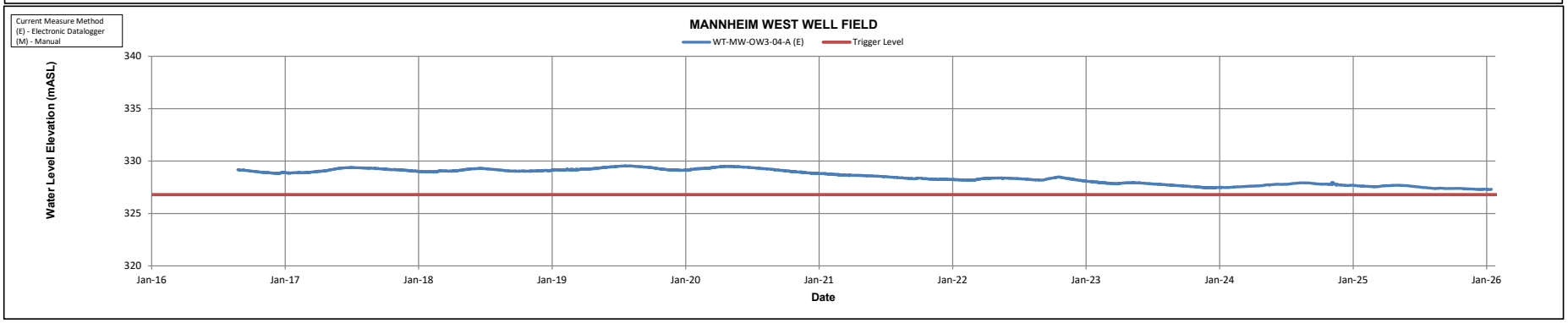




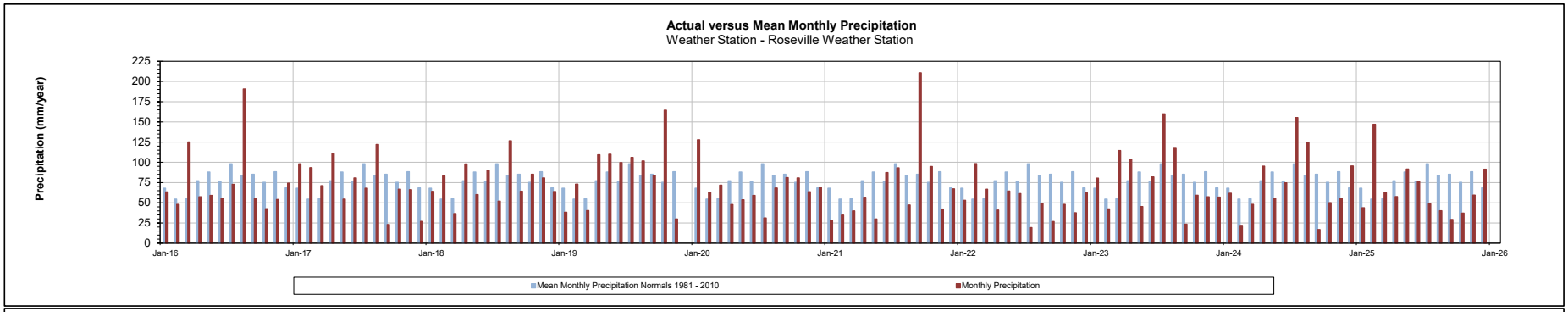
REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
MANNHEIM WELL FIELDS

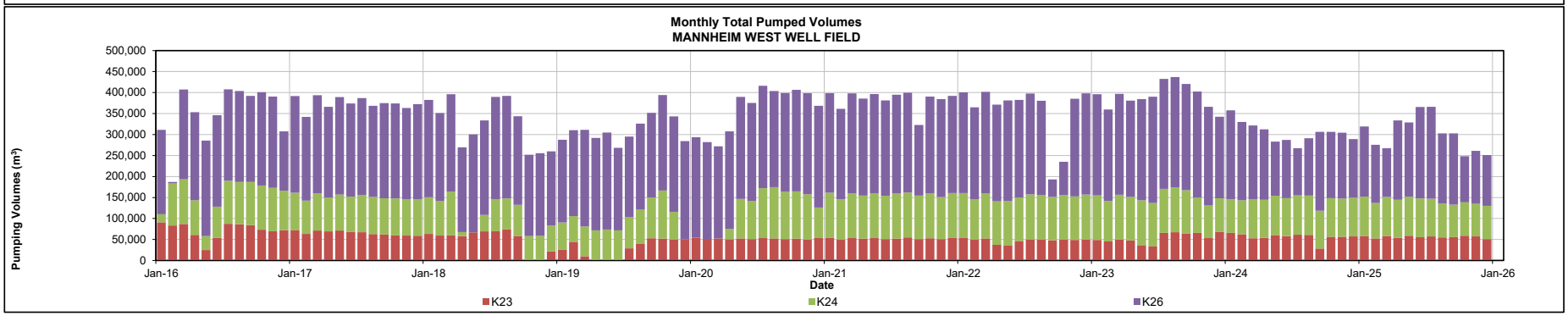


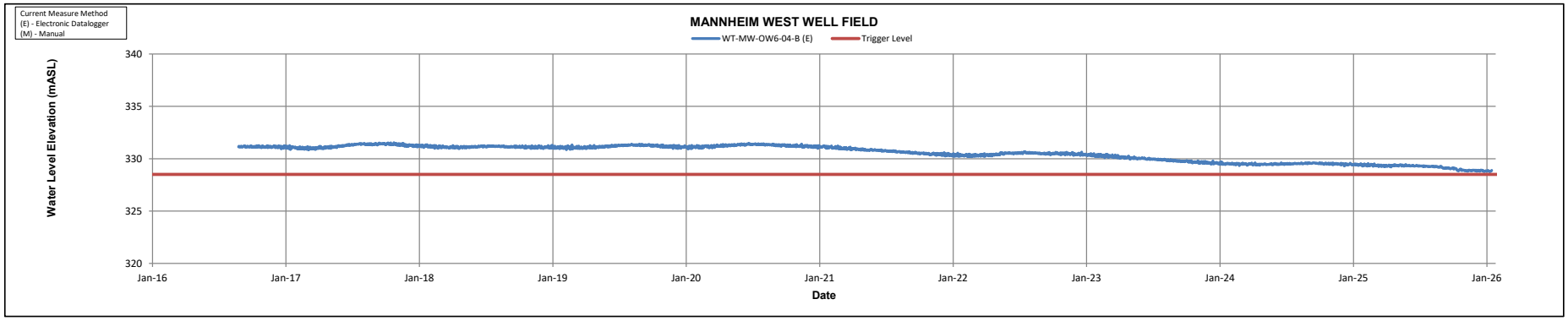




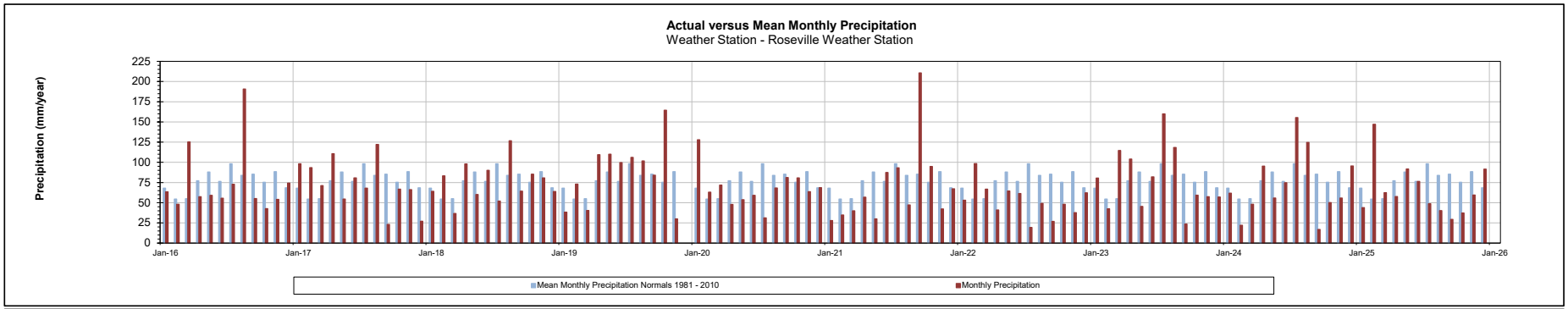
REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
MANNHEIM WELL FIELDS

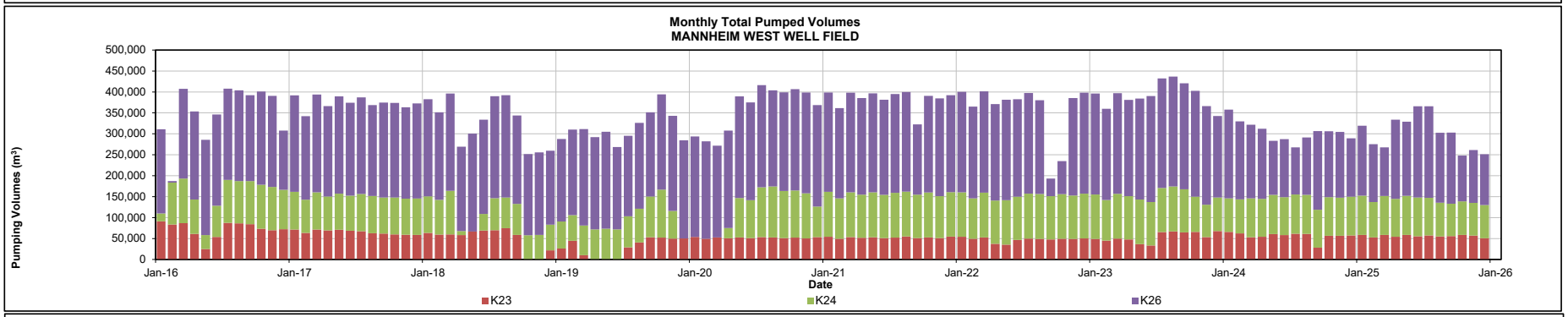


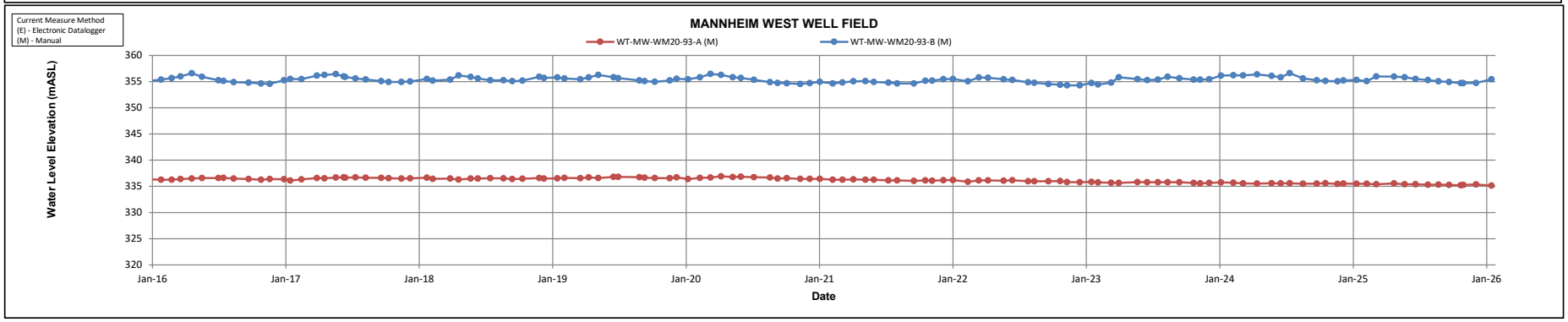




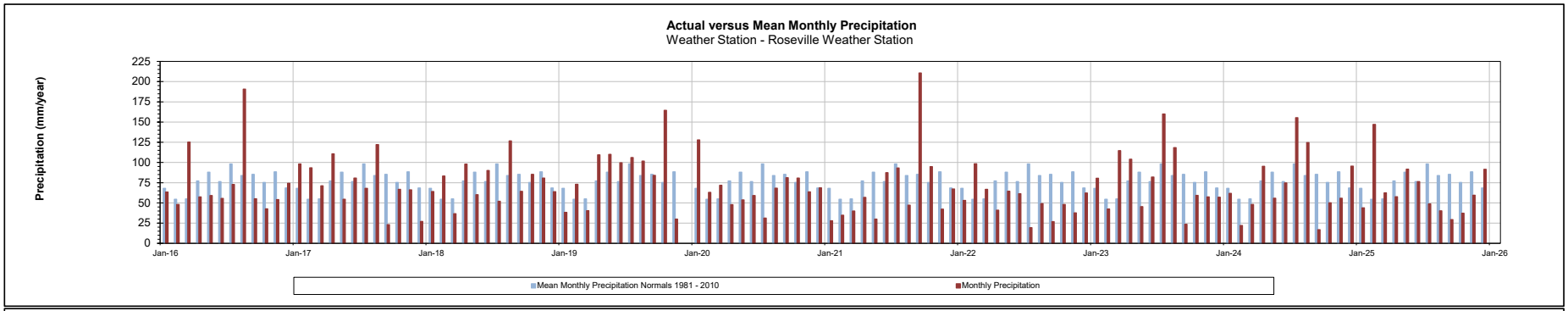
REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
MANNHEIM WELL FIELDS

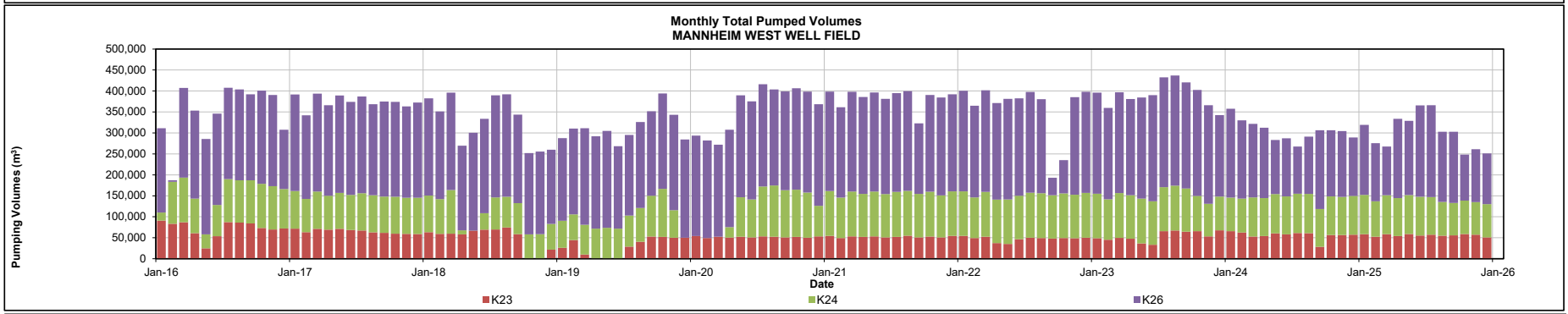


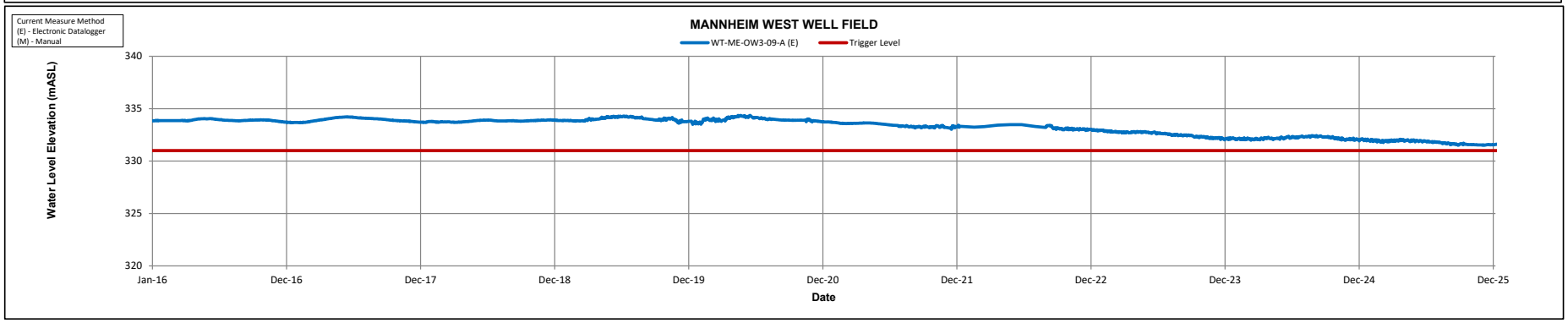


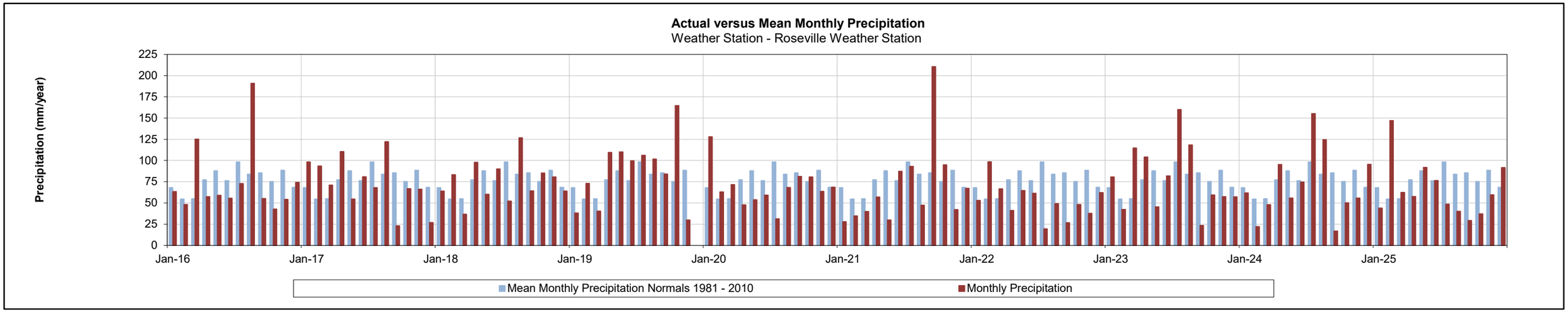


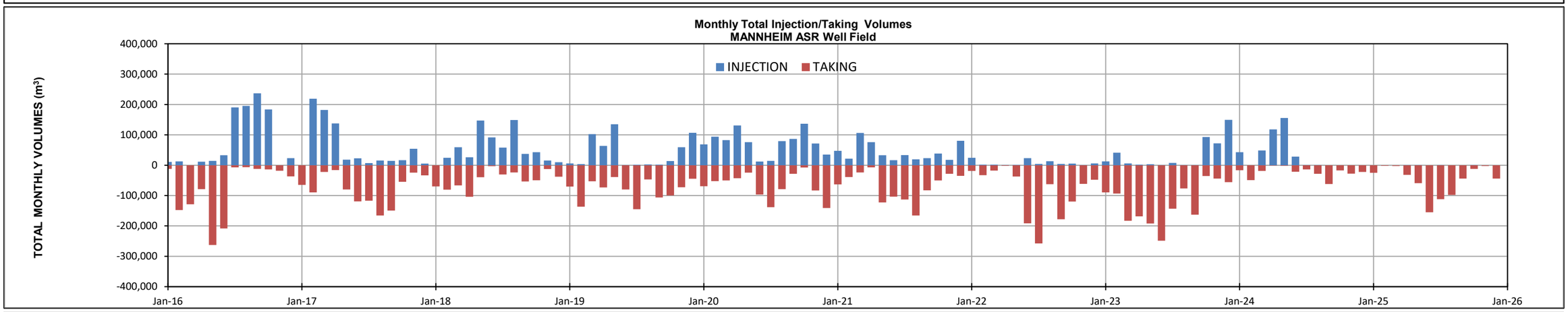
REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
MANNHEIM WELL FIELDS

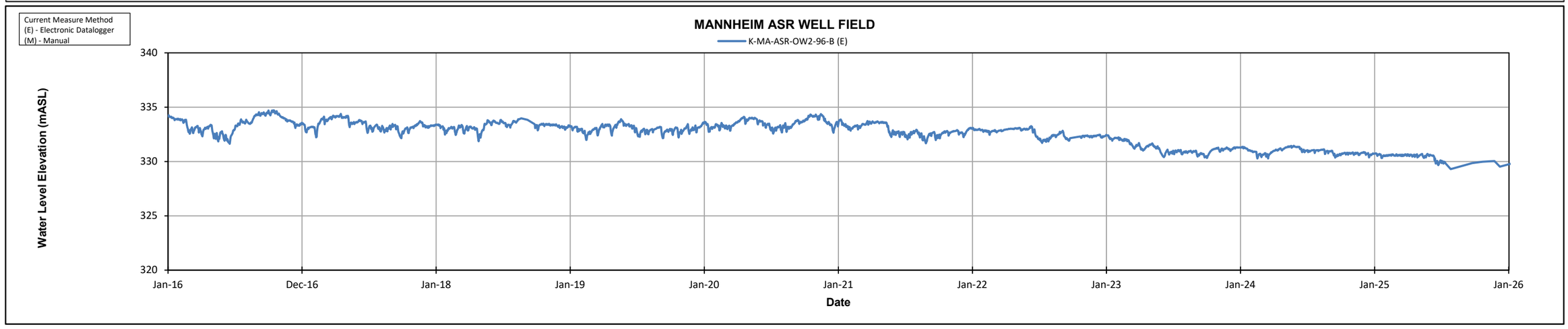




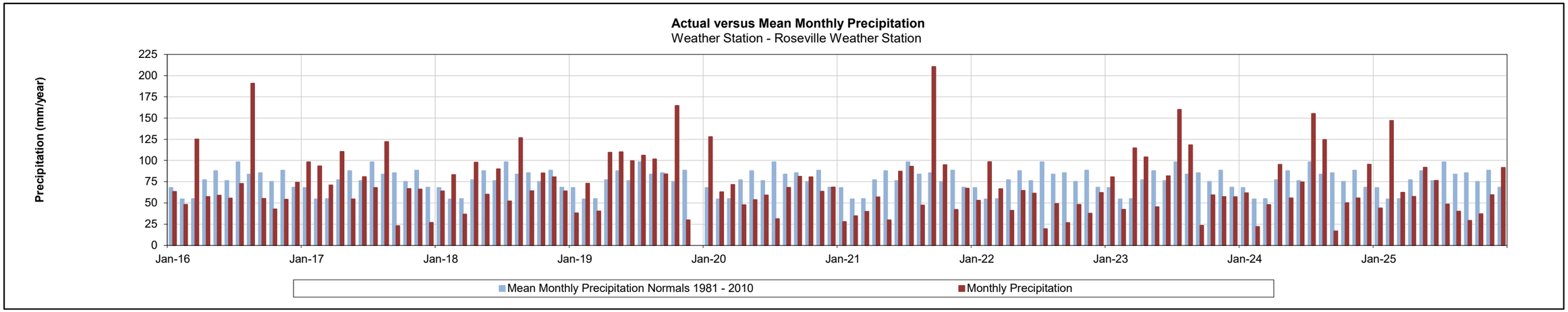


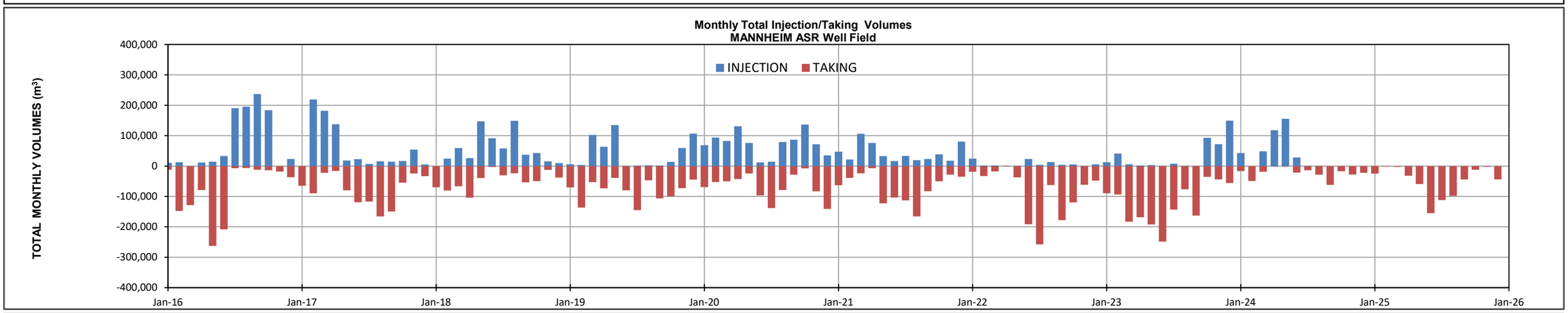

Actual versus Mean Monthly Precipitation
Weather Station - Roseville Weather Station
Precipitation (mm/year)
225
200
175
150
125
100
75
50
25
0
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
Jan-25
Mean Monthly Precipitation Normals 1981 - 2010
Monthly Precipitation

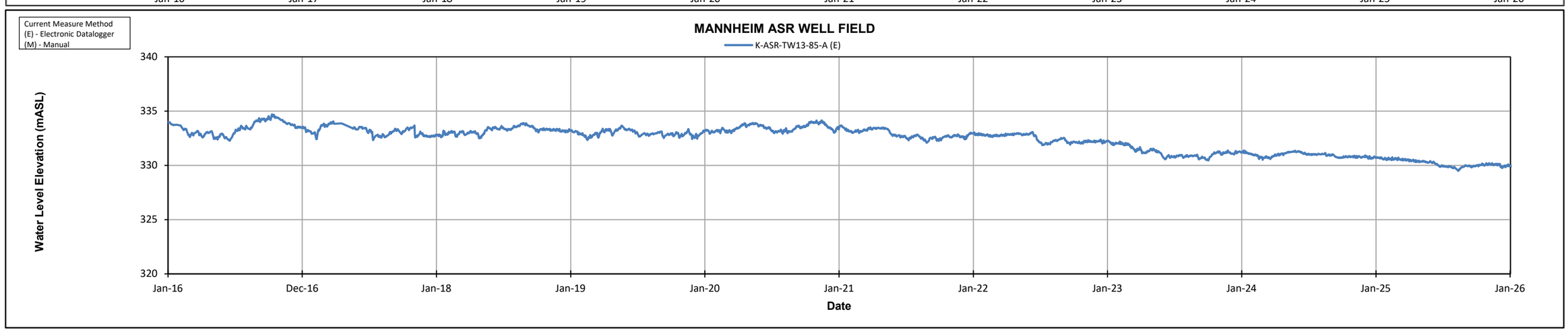

Monthly Total Injection/Taking Volumes
MANNHEIM ASR Well Field
TOTAL MONTHLY VOLUMES (m³)
INJECTION
TAKING
400,000
300,000
200,000
100,000
0
-100,000
-200,000
-300,000
-400,000
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
Jan-25
Jan-26

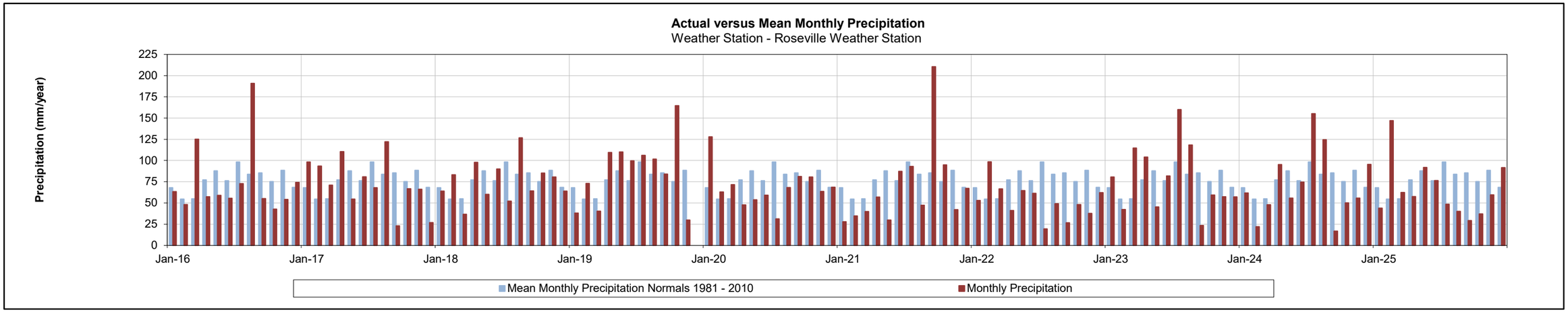

Current Measure Method
(E) - Electronic Datalogger
(M) - Manual
MANNHEIM ASR WELL FIELD
K-MA-ASR-OW2-96-B (E)
Water Level Elevation (mASL)
340
335
330
325
320
Jan-16
Dec-16
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
Jan-25
Jan-26
Date

REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
MANNHEIM WELL FIELDS





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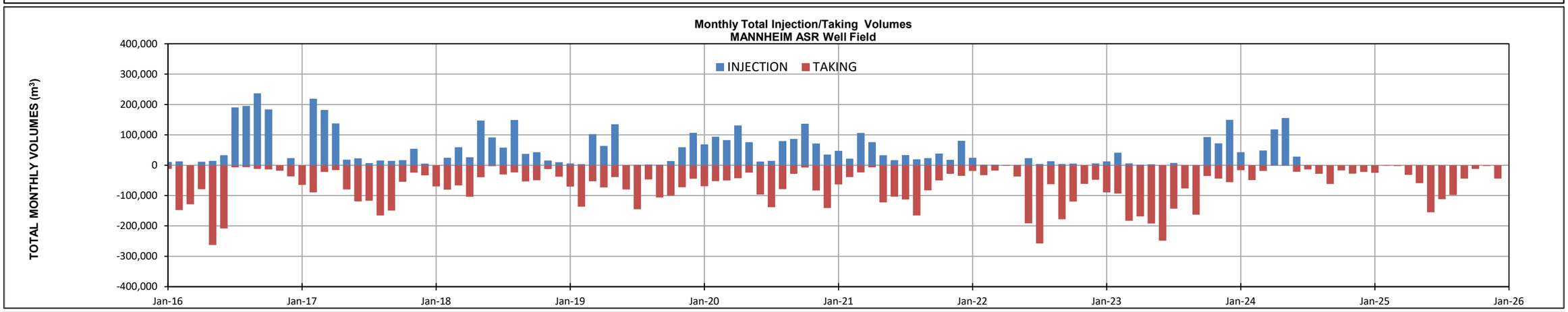
Mean Monthly Precipitation Normals 1981 - 2010
Monthly Precipitation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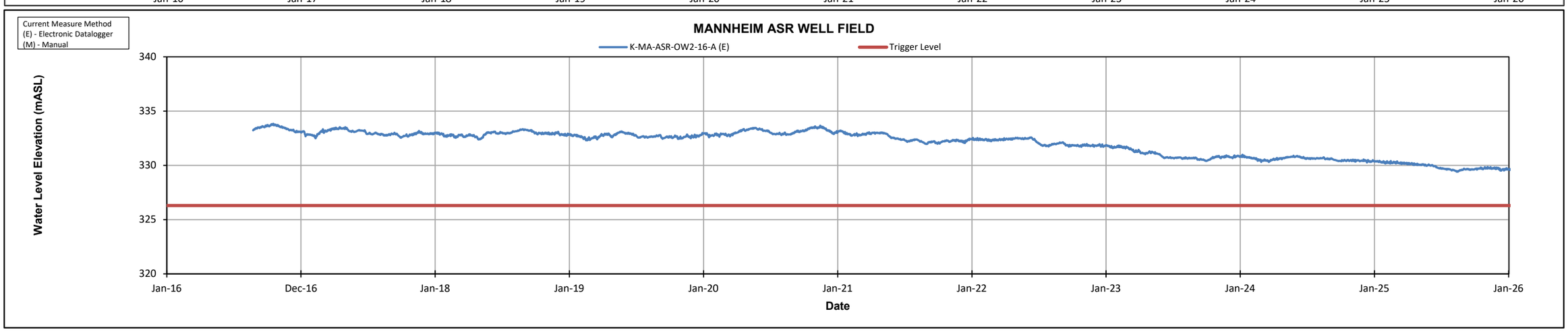
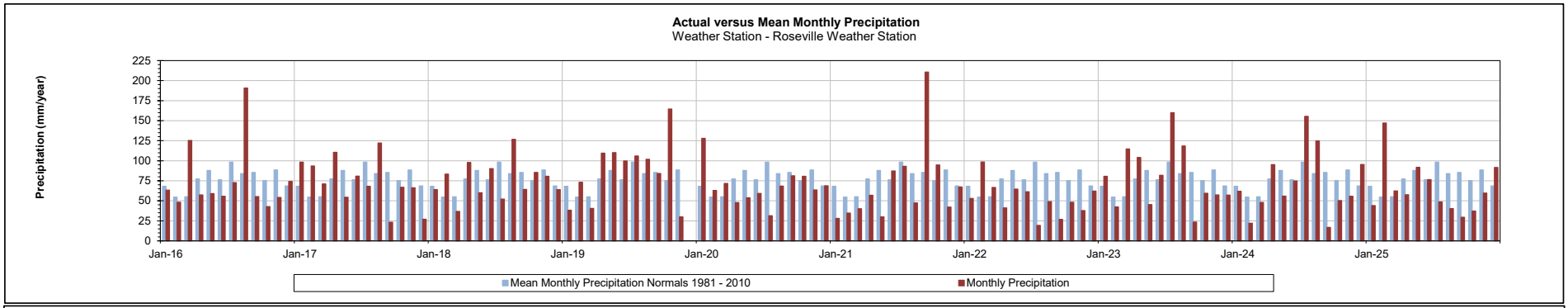
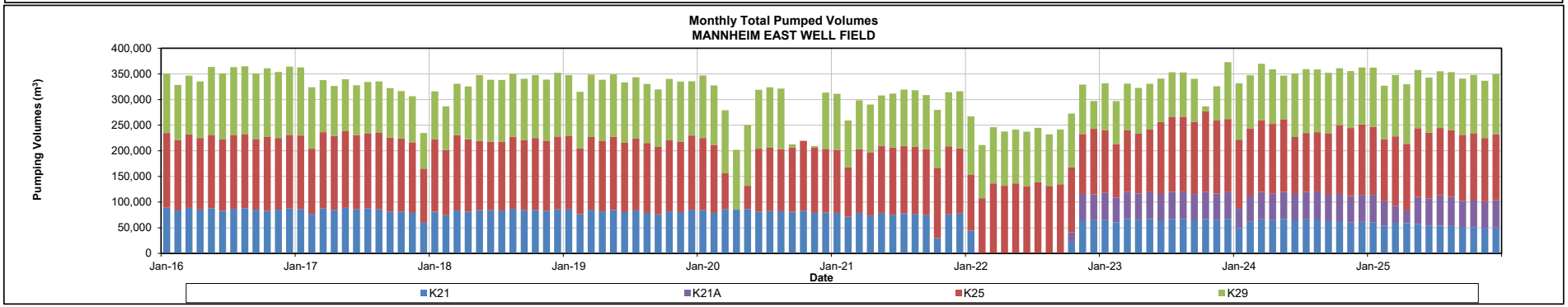
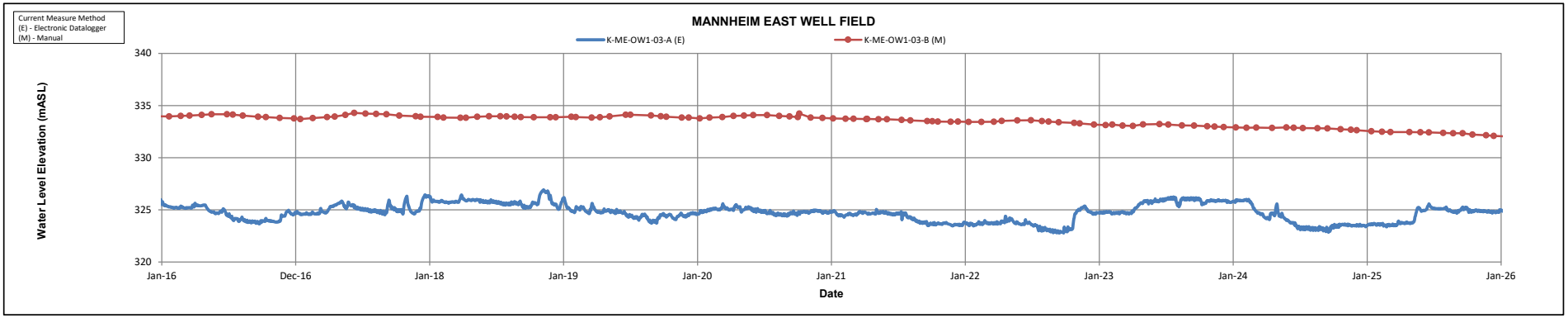
200,000
100,000
0
-100,000
-200,000
-300,000
-400,000
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
Jan-25
Jan-26


Current Measure Method
(E) - Electronic Datalogger
(M) - Manual
MANNHEIM ASR WELL FIELD
K-MA-ASR-OW2-16-A (E)
Trigger Level
Water Level Elevation (mASL)
340
335
330
325
320
Jan-16
Dec-16
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
Jan-25
Jan-26
Date

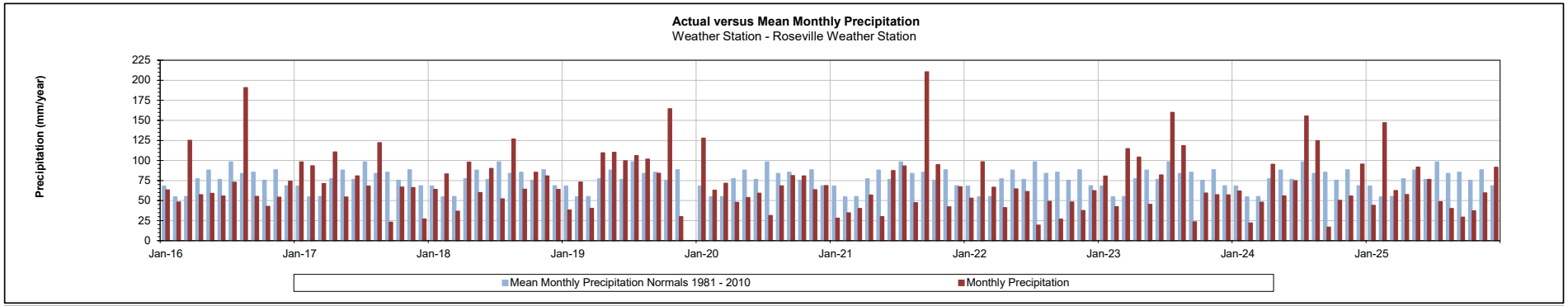
REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
MANNHEIM WELL FIELDS

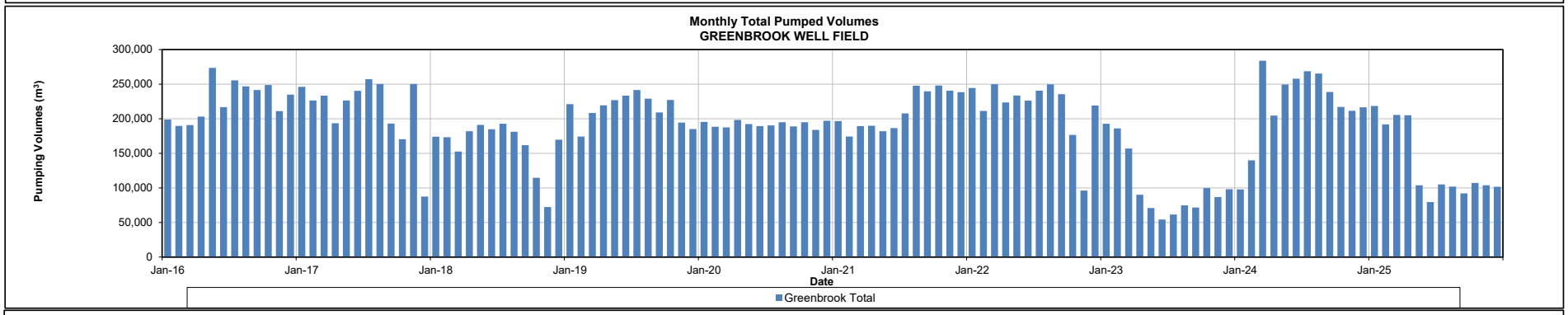


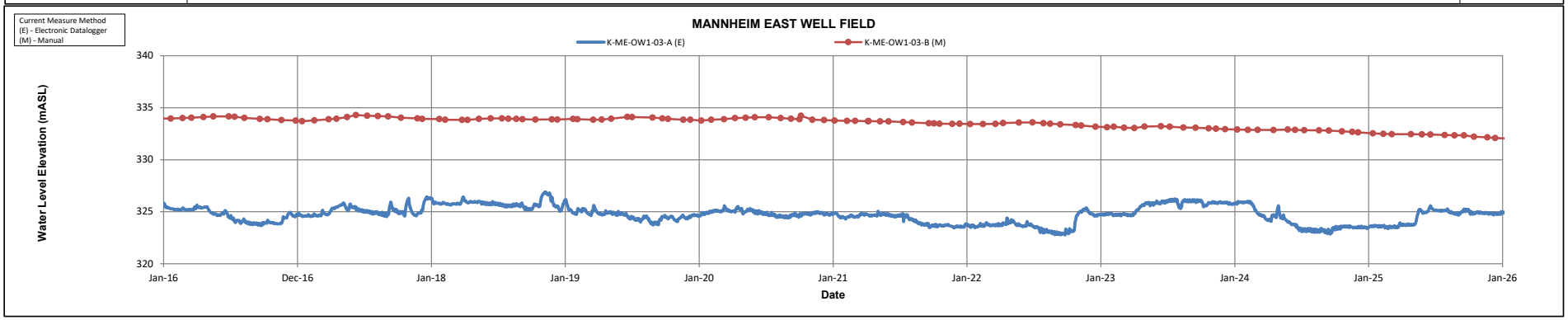




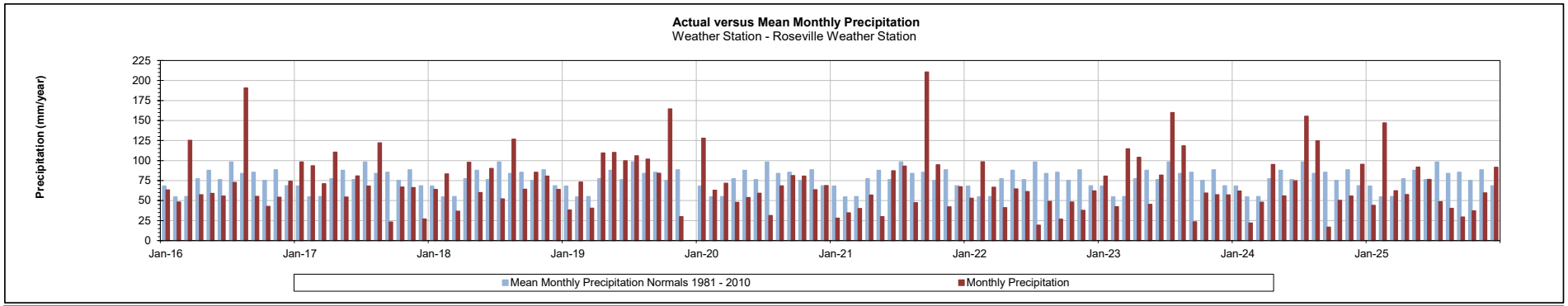
REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
MANNHEIM WELL FIELDS

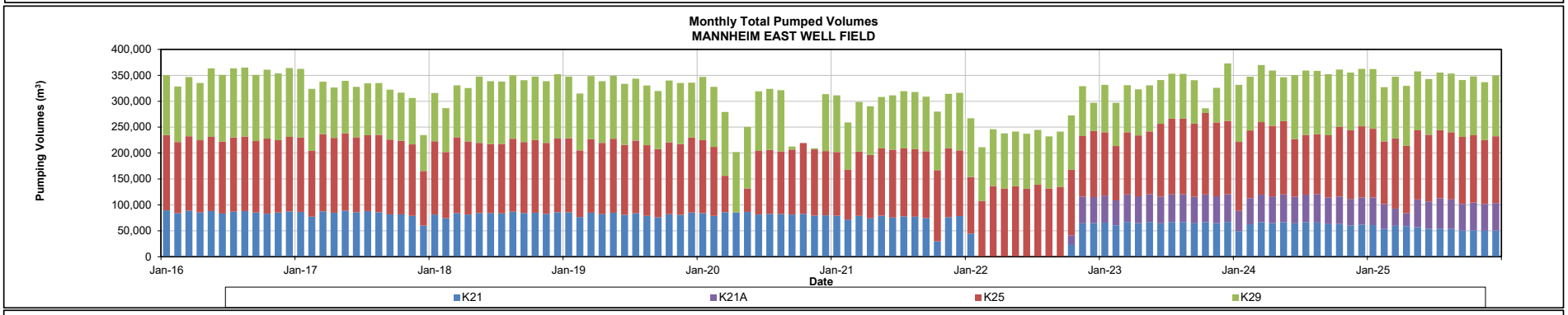


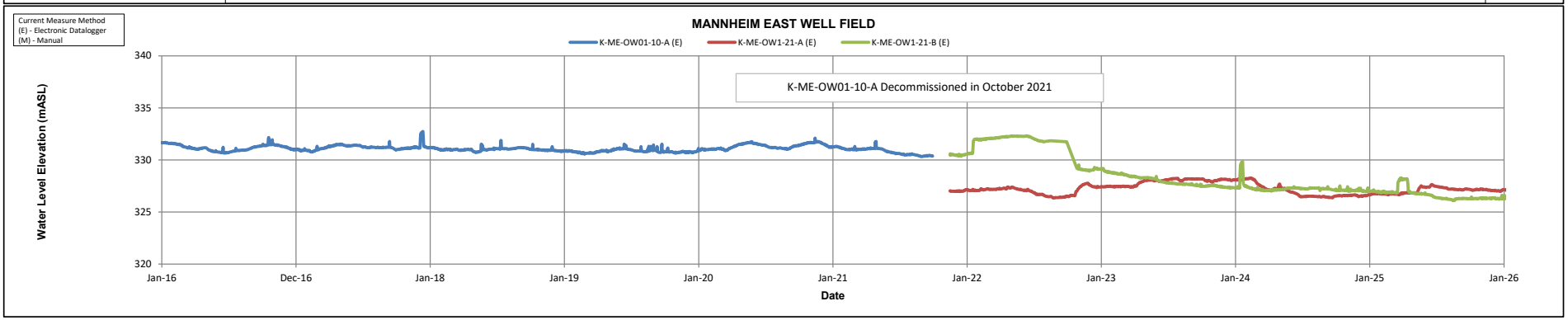




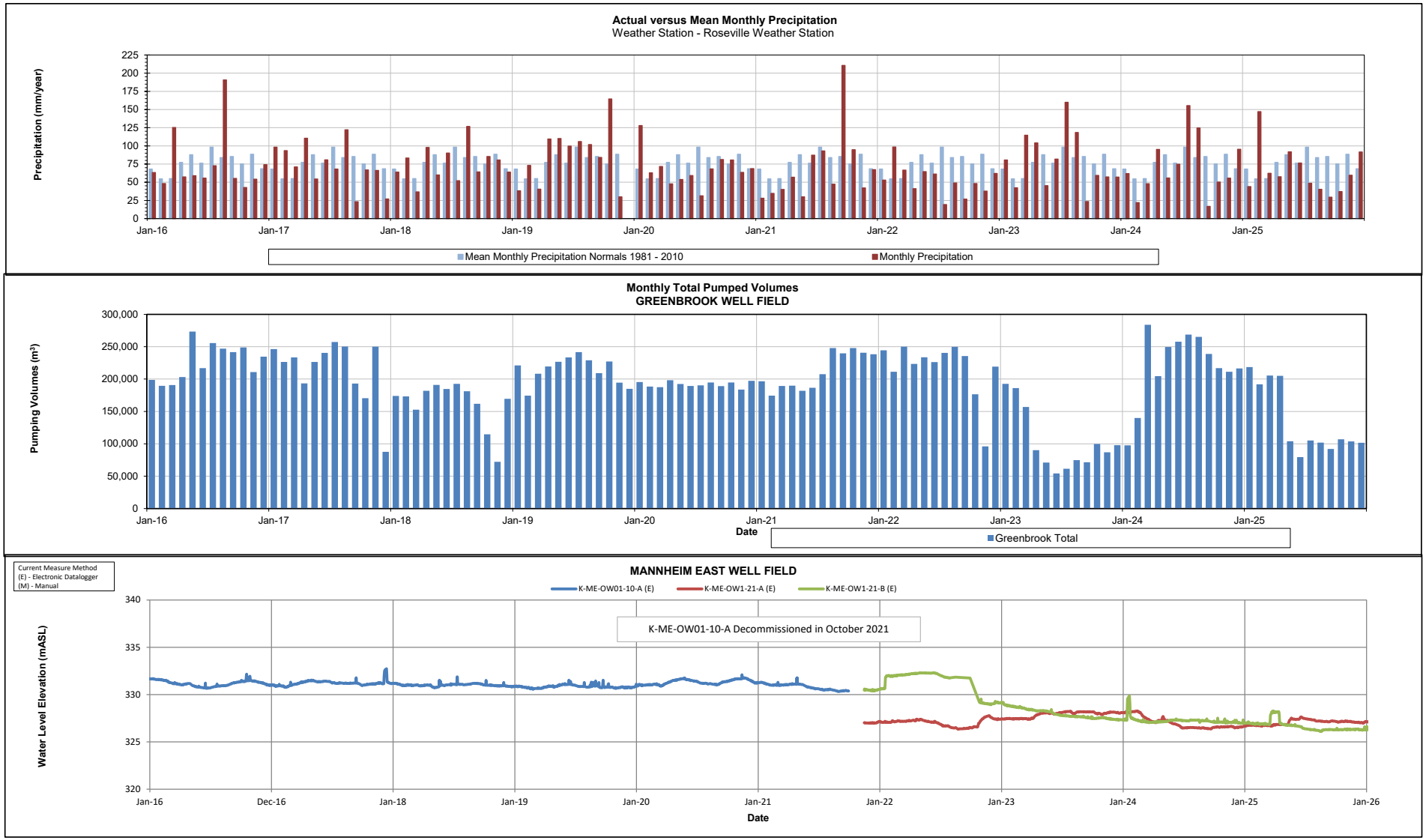
REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
MANNHEIM WELL FIELDS







REGION OF WATERLOO
2025 GROUNDWATER MONITORING REPORT -
MANNHEIM WELL FIELDS



REGION OF WATERLOO
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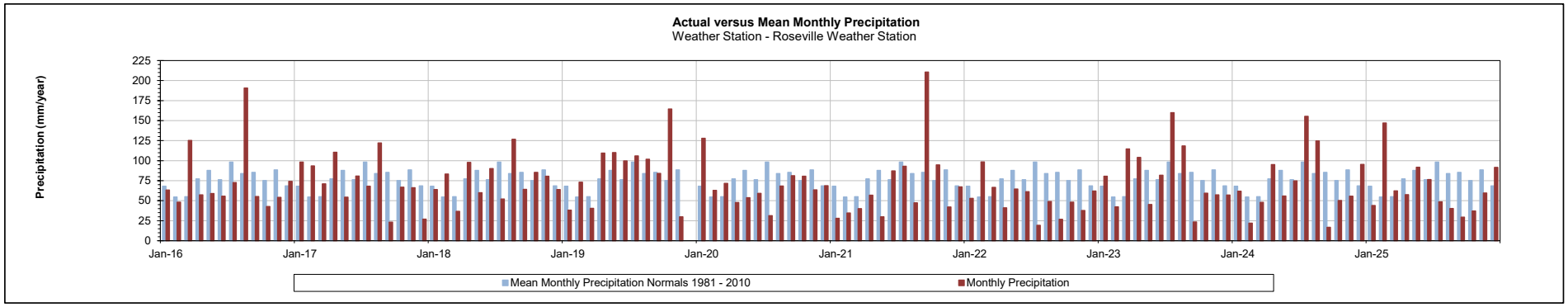
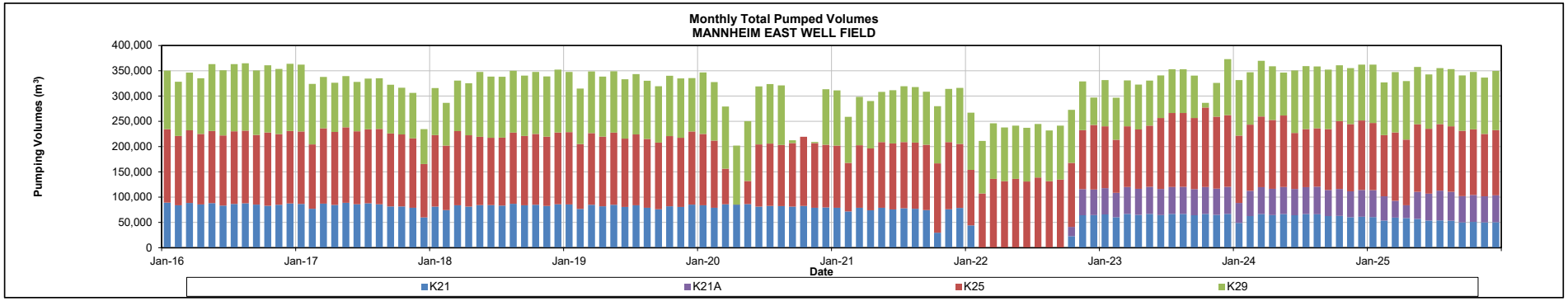
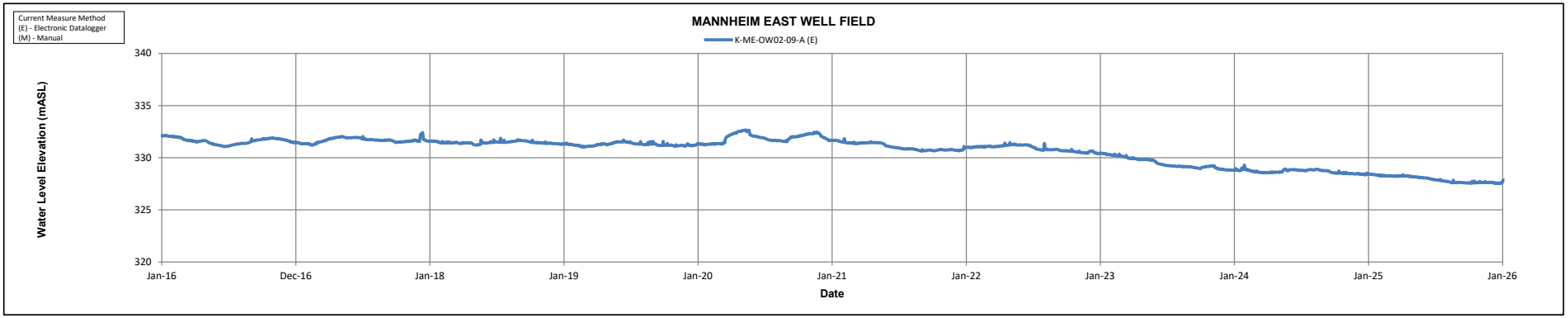
MANNHEIM WELL FIELDS







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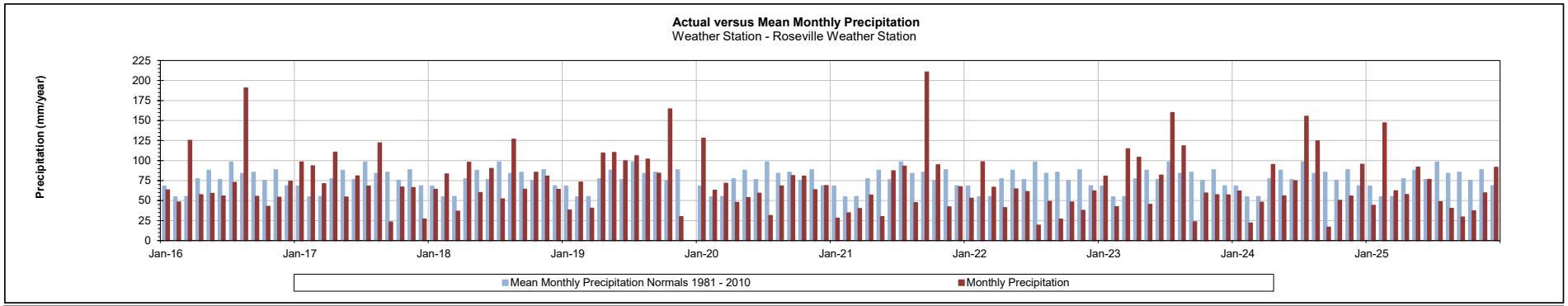
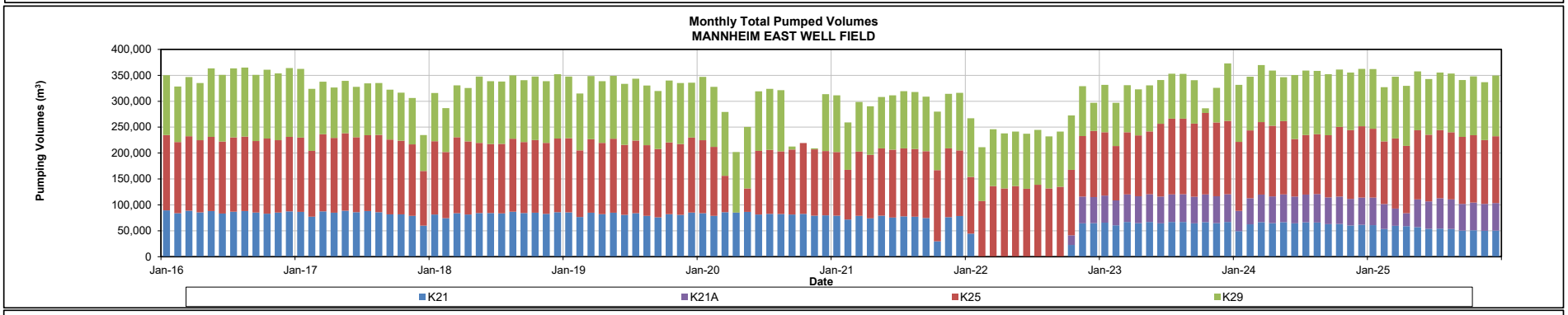
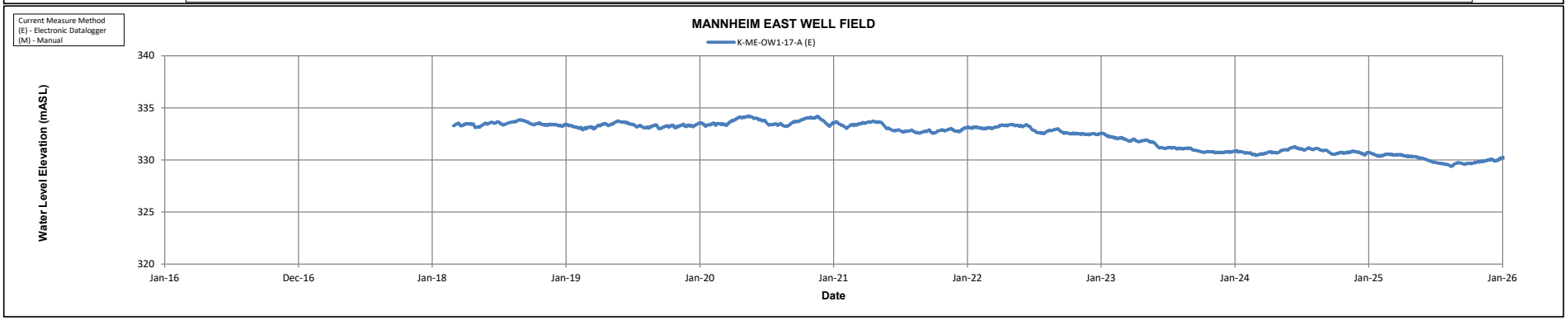
MANNHEIM WELL FIELDS







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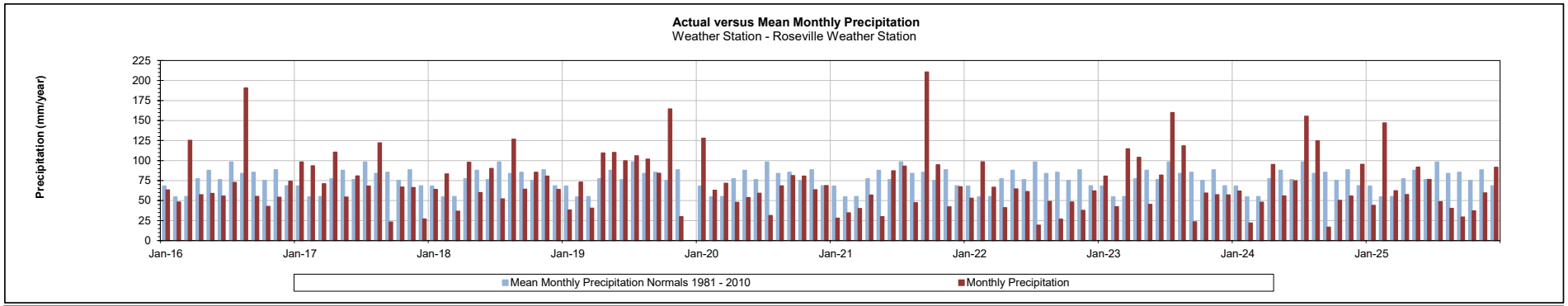
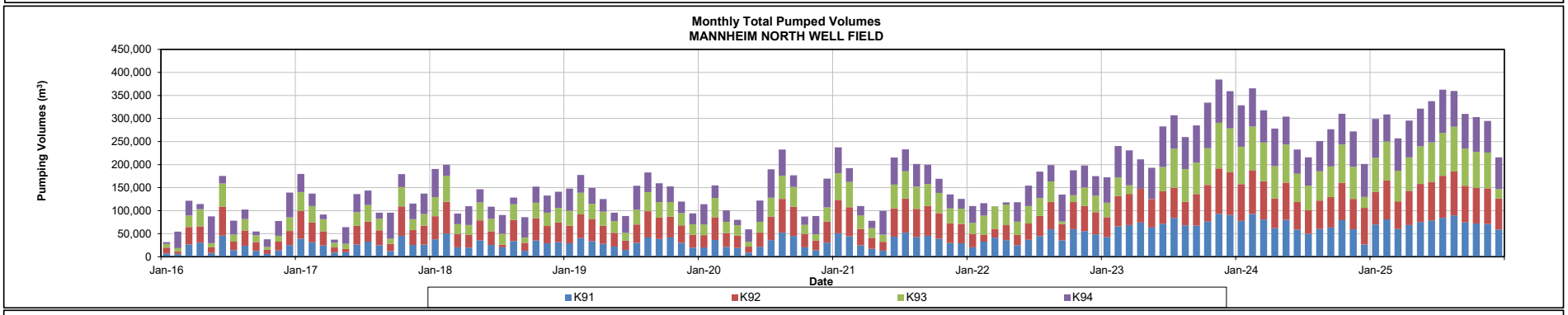
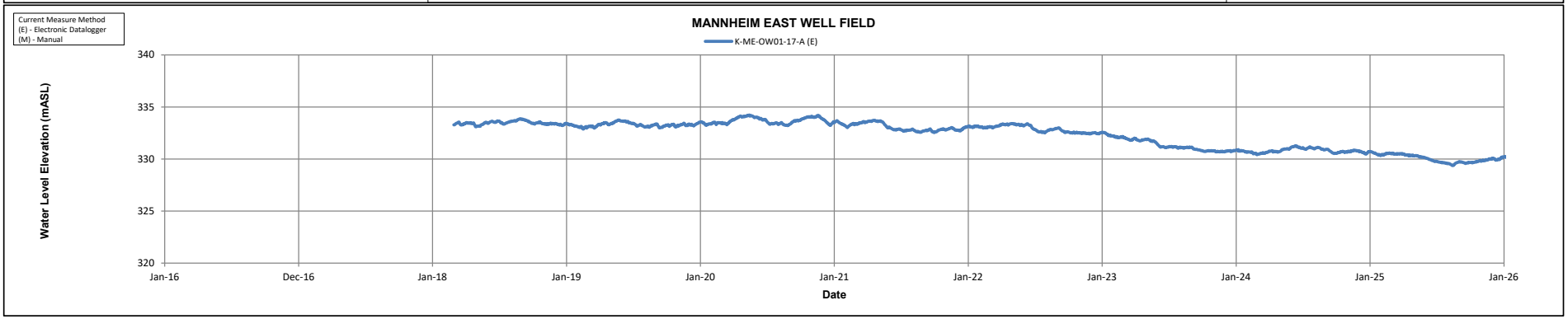
MANNHEIM WELL FIELDS







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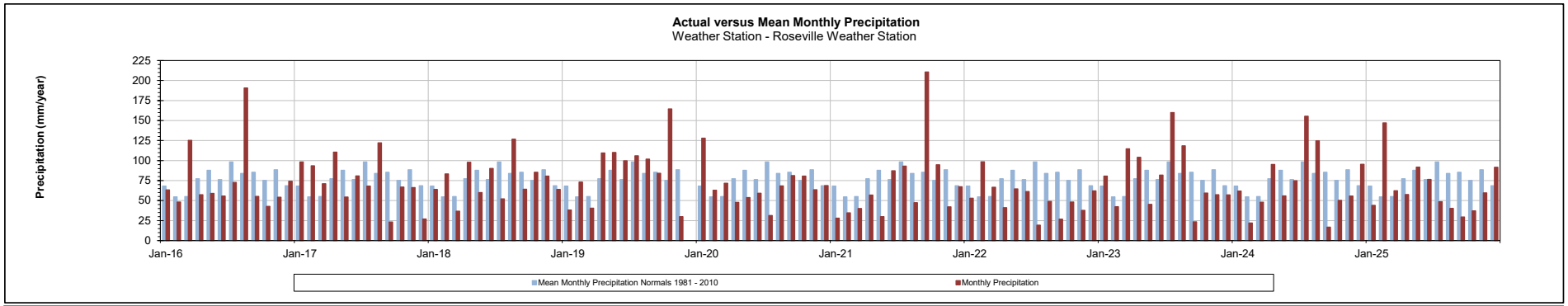
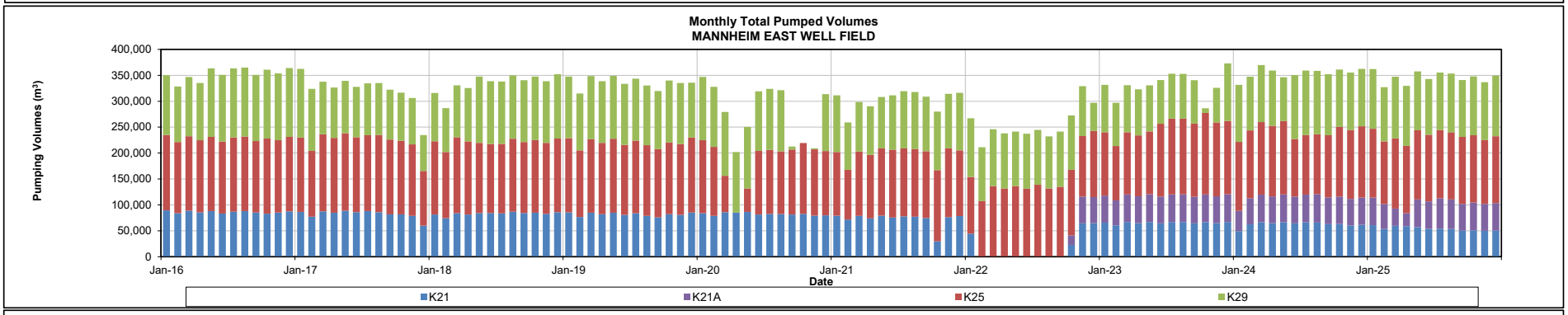
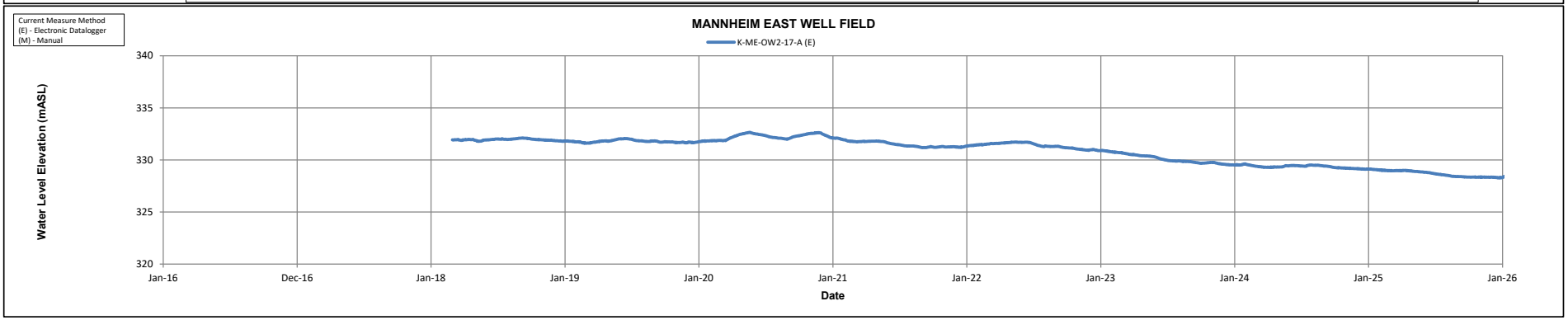
MANNHEIM WELL FIELDS







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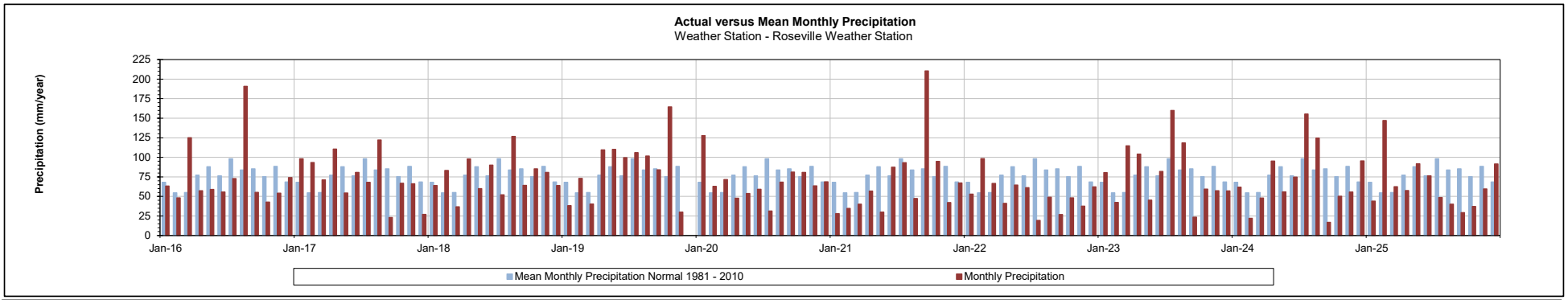
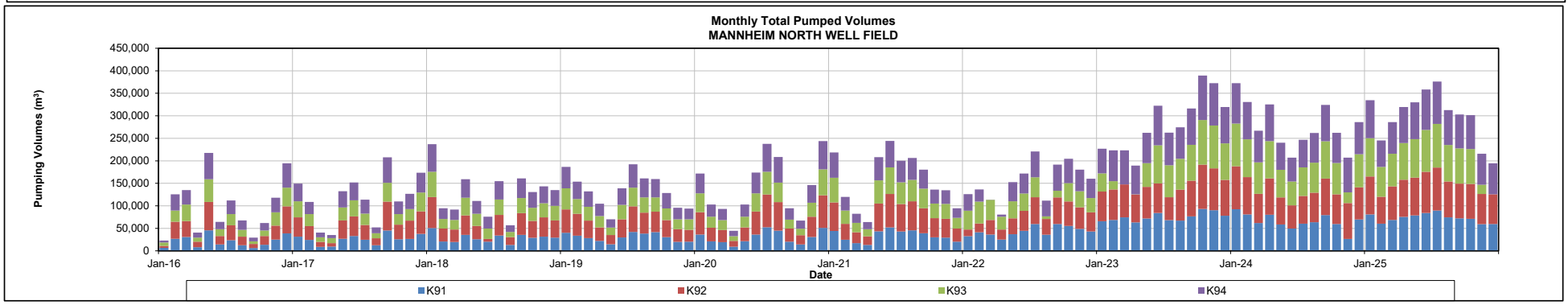
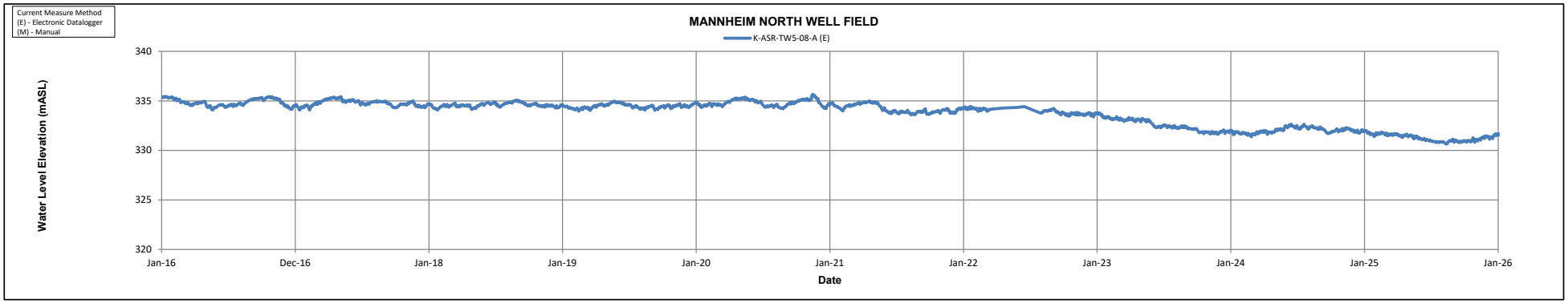
2025 GROUNDWATER MONITORING REPORT -
MANNHEIM WELL FIELDS







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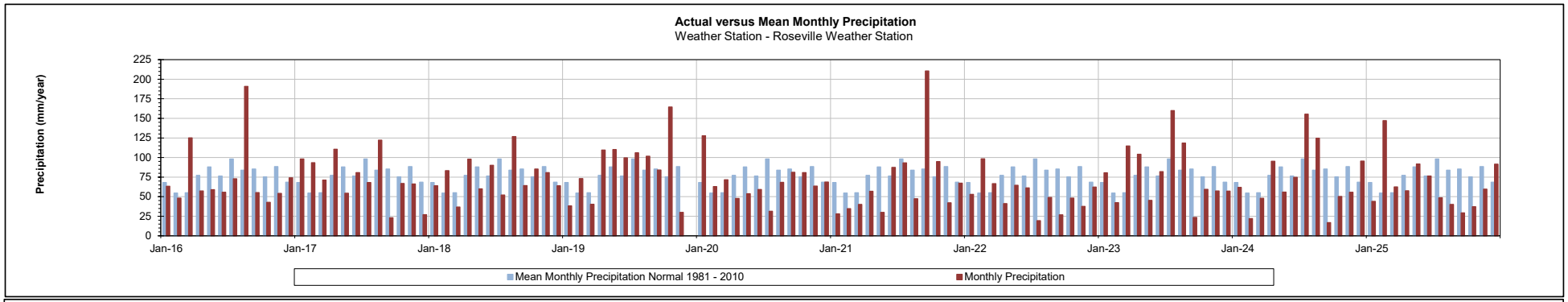
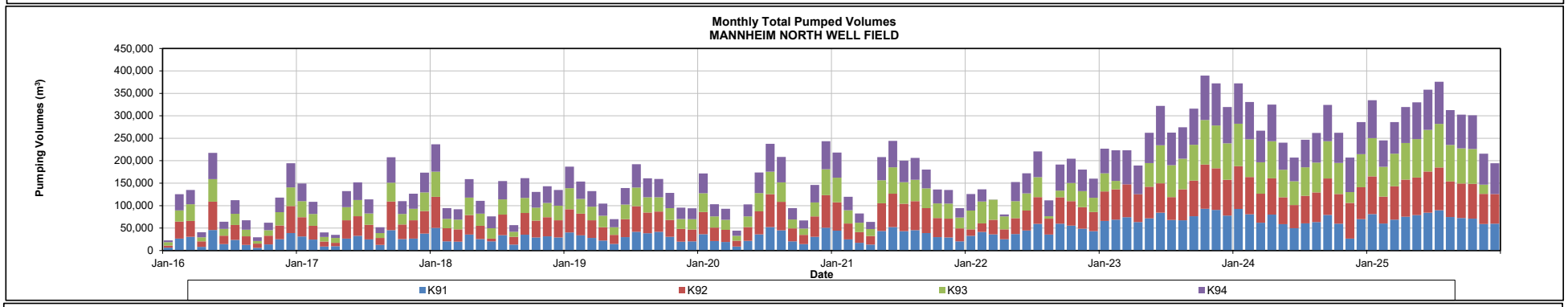
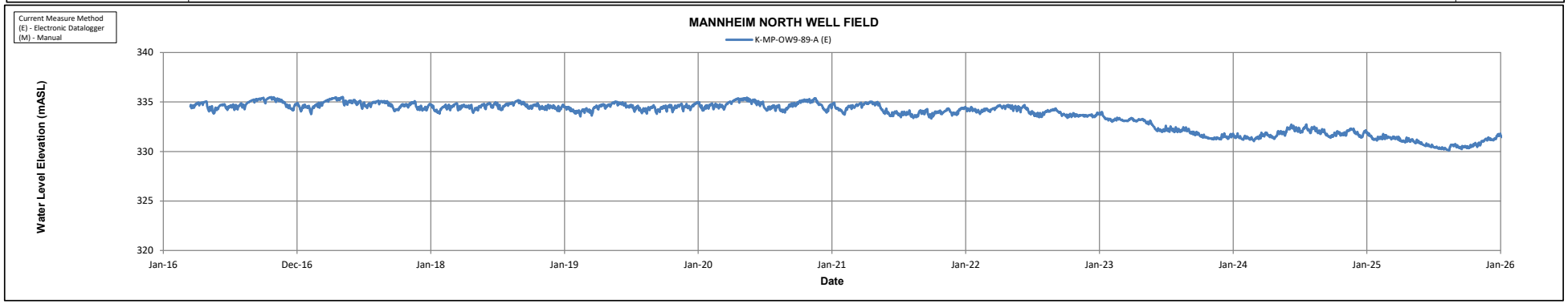
2025 GROUNDWATER MONITORING REPORT -
MANNHEIM WELL FIELDS







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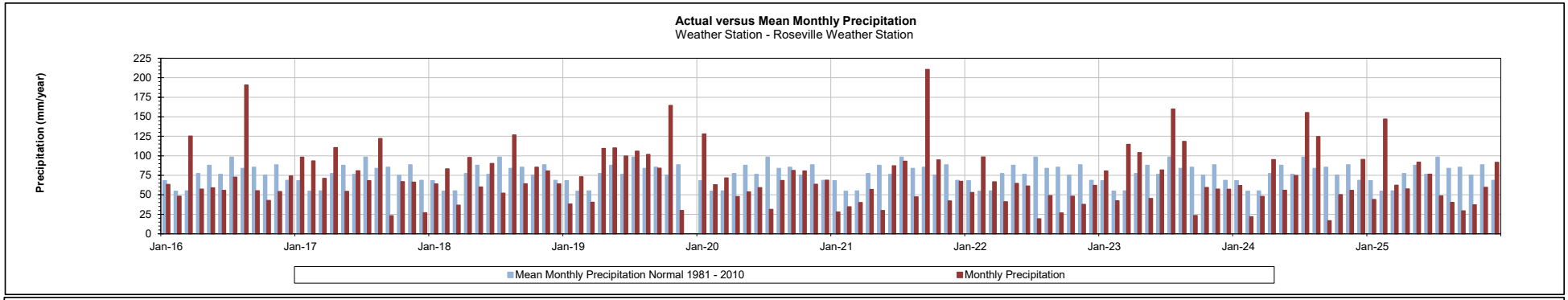

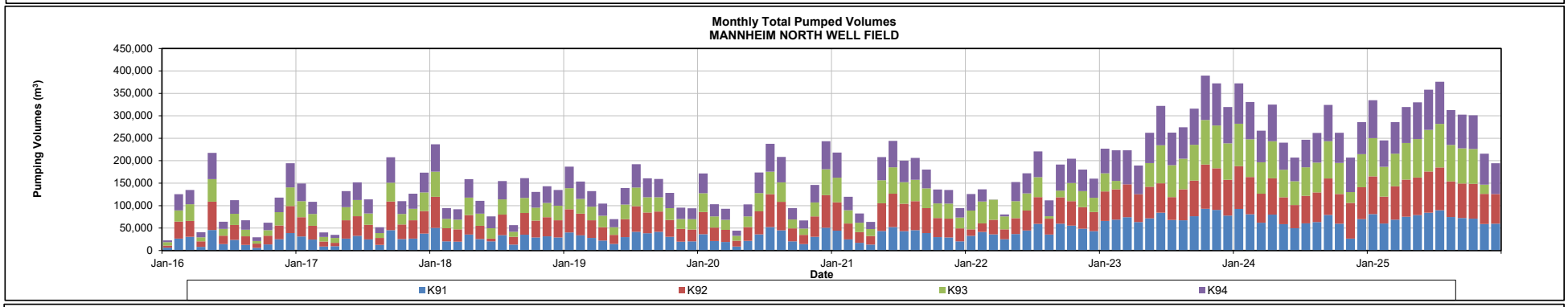

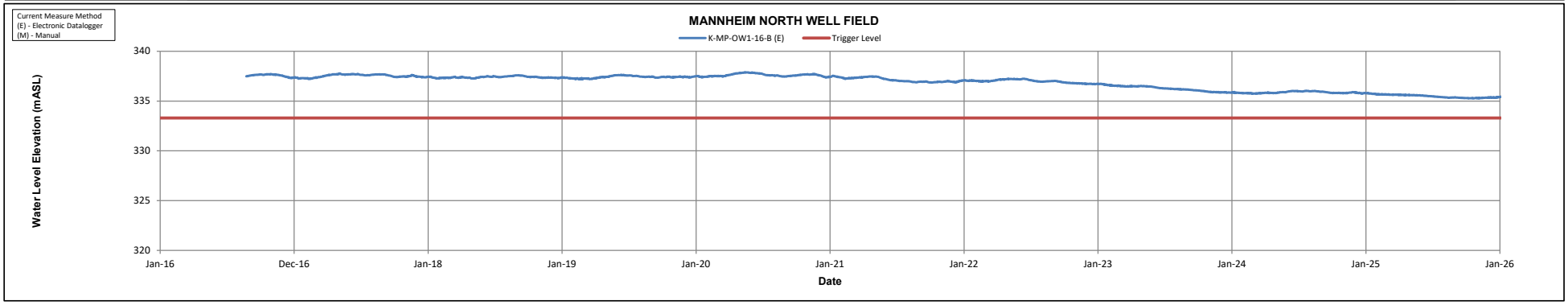

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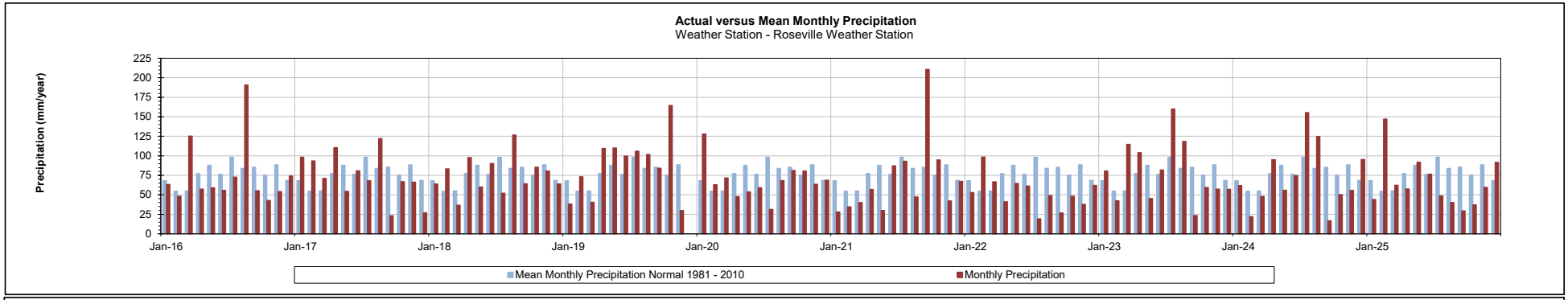
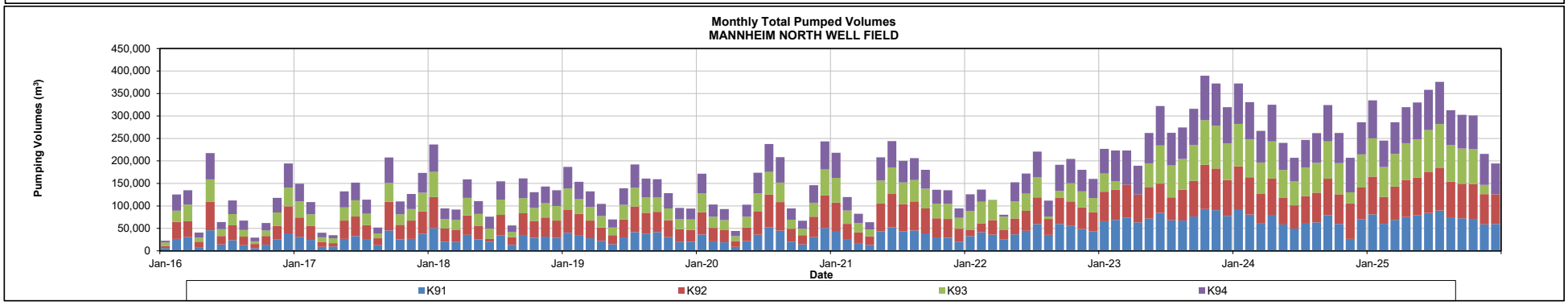
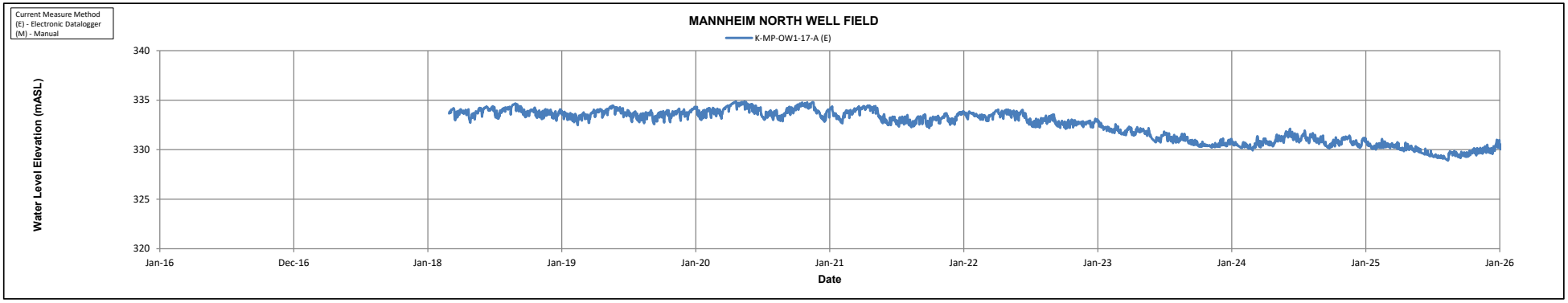
2025 GROUNDWATER MONITORING REPORT -
MANNHEIM WELL FIELDS







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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**

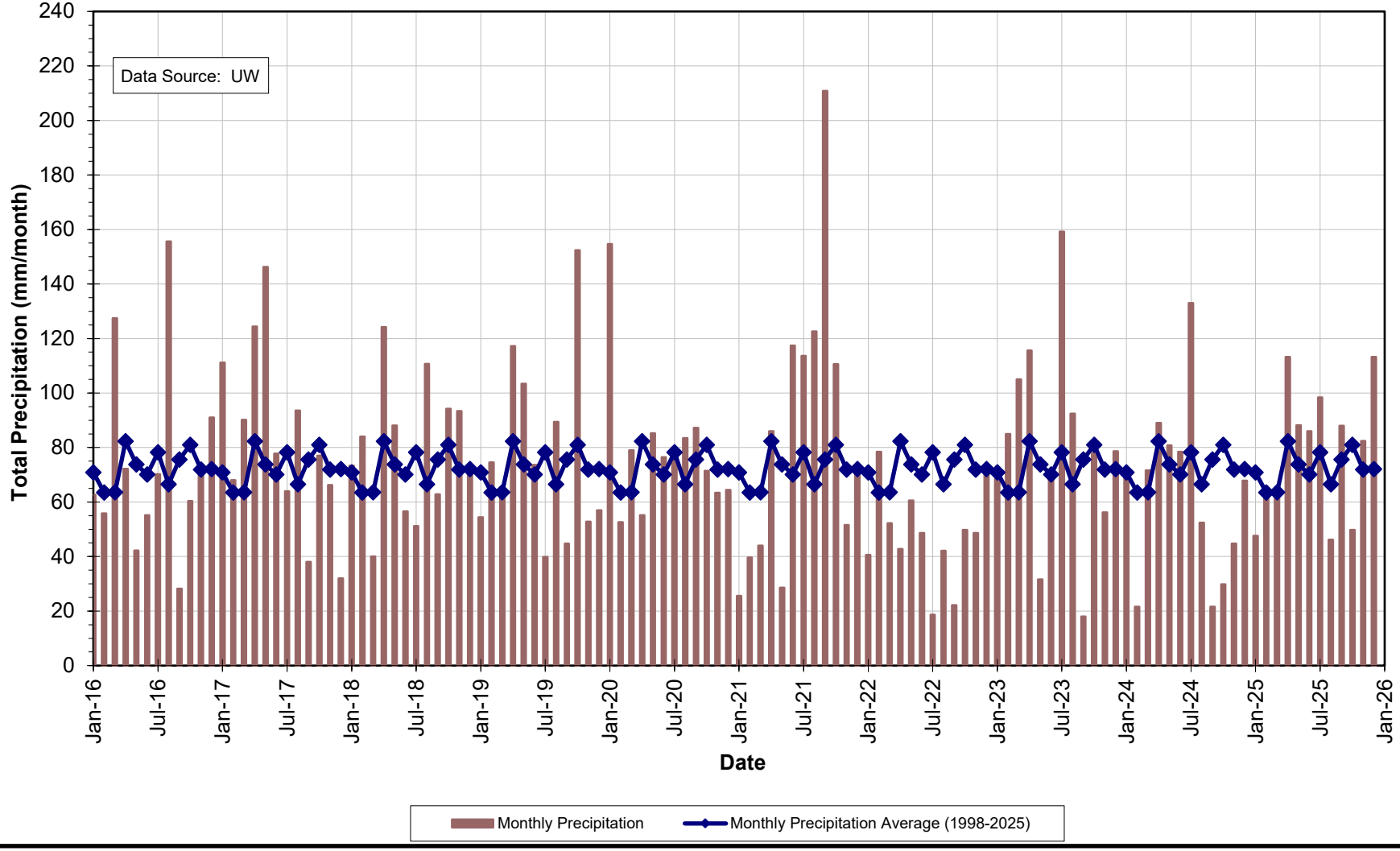
Year	Laurel Dam Established 1960		
	Annual Precipitation (mm)	Average Precipitation 1960-2025 (mm)	Difference (mm)
2016	985	938	**47**
2017	1062	938	**124**
2018	1071	938	**133**
2019	940	938	**2**
2020	938	938	**0**
2021	1027	938	**89**
2022	689	938	**-249**
2023	921	938	**-17**
2024	907	938	**-31**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

Figure D.1
University of Waterloo Weather Station
Monthly Precipitation



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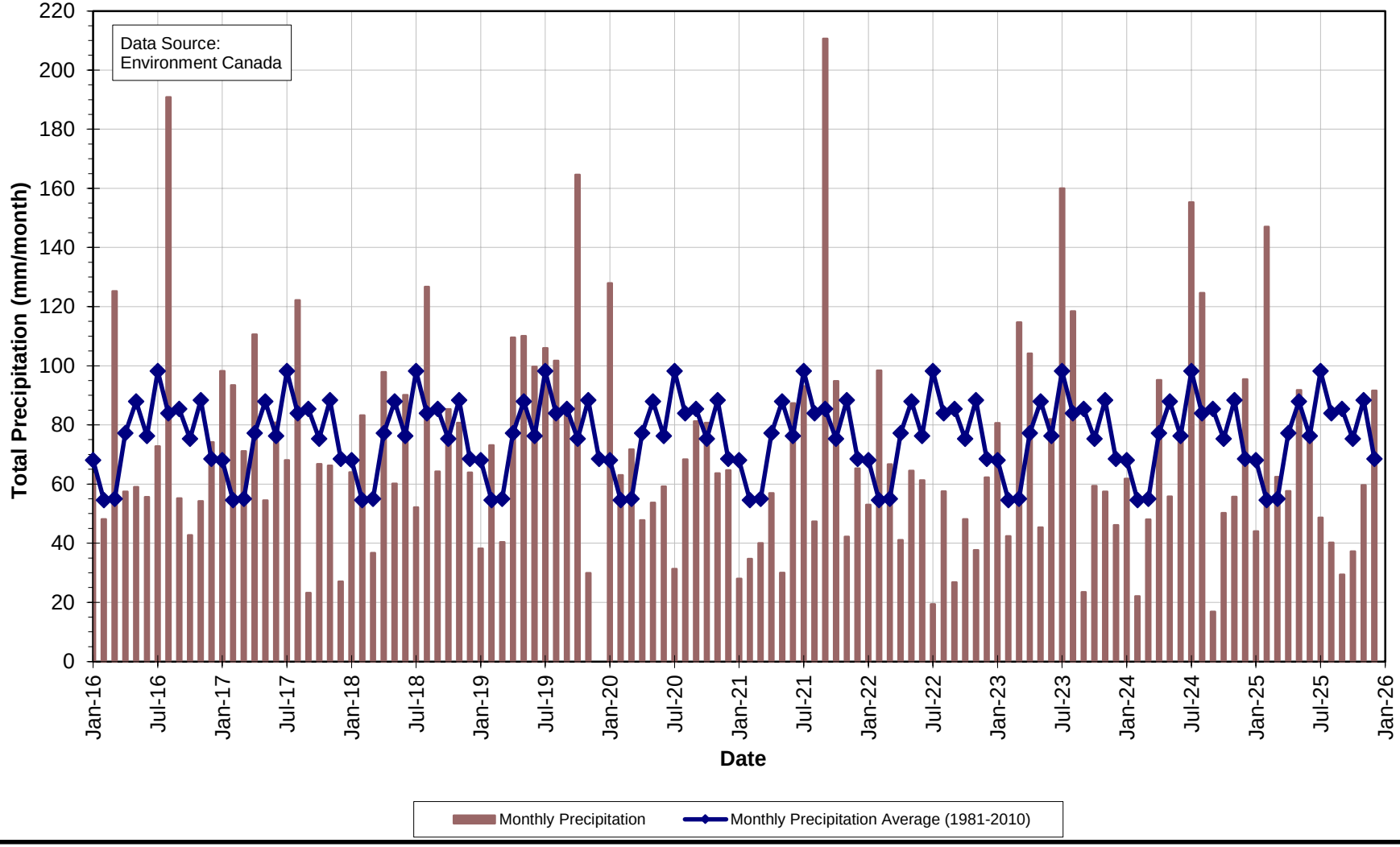
Prepared By: C.D.
Printed On: 2/13/2026
File: Appendix D Precipitation Data/Monthly UW

Figure D.2
Roseville Weather Station
Monthly Precipitation



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Prepared By: C.D.
Printed On: 3/6/2026
File: Appendix D Precipitation Data.xlsx/Monthly Roseville

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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*® Leveloggers®. 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 unconnected 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.

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