ORE
Oakridge Environmental Limited
Environmental and Hydrogeological Services

March 10, 2023

1693 Casey Road
Belleville, Ontario
K8N 4Z6

Att: **Clayton Ferriman**, Owner

Re: Hydrogeological Study - Well Certification Report
Proposed Residential Severance
1693 Casey Road
Part of Lot 31, Concession 3 (Thurlow)
City of Belleville
ORE File No. 23-3222

Dear Clayton:

1.0 Introduction and Background

Oakridge Environmental Ltd is pleased to present our hydrogeological report for the above-referenced property located north of Shannoville, Ontario (Figure 1).

Based on the information provided, it is understood the owner of the above-referenced property is seeking a single residential lot severance. Although an application to sever the property has not yet been submitted, it is understood that the proponent has been advised by City staff that a hydrogeological assessment would be required. This requirement typically comes from the City of Belleville's adopted Official Plan (OP), where Section 7.2.1 c) states the following:

> *"The Municipality may require the completion of a hydrogeological study for any consent application that would result in a new development parcel on private services if the subject land is within an area of known constraint where groundwater quantity or quality may be of concern, or if it is in an area constituting 5 or more existing dwellings/lots occupying 4 hectares of land or less within 300 metres of the new lot boundary. The detailed hydrogeological study shall be undertaken by a qualified professional and shall demonstrate that an adequate water supply exists and that no adverse impacts will result to the surface and groundwater."*

Hydrogeological studies for residential developments generally follow the requirements outlined in the Ministry of the Environment, Conservation and Parks' (MECP) guidance documents intended for Plans of Subdivision applications. These are referred to as Procedures D-5-4 and D-5-5.

However, Procedures D-5-4 and D-5-5 are primarily intended for large developments and include extensive well testing requirements and impact assessments, among other things. Moreover, the MECP guidelines are utilized for determining the allowable number of lots and lot sizes within the proposed development based on the concentration of nutrients in the groundwater, resulting from the numerous sewage systems. As a consequence, applying the MECP guidelines in their entirety for a proposed severance would, in our opinion, be considered onerous and unnecessary.

Based on previous experience, it is expected that the City of Belleville also recognizes that applying the full weight of the Procedures is onerous for a simple severance application. Therefore, our study has focussed on demonstrating that the newly constructed well (on the lands to be severed) can supply a sufficient quantity of adequate quality water to sustain the proposed residential use, without impacting neighbouring groundwater supplies. This report also provides a review of shallow soil and groundwater conditions on the site to aid with the placement and construction of a future septic system on the lands to be severed.

2.0 Well Description

In preparation of the hydrogeological study, it is understood that Holmes Hydrofracturing constructed a new drilled well (referred to herein as "TW23-1") on the lands to be severed. In addition, the existing residence is supplied by a drilled well (referred to herein as "W-1"). The location of the wells are illustrated on Figure 2.

The well record for TW23-1 is provided in Appendix A and a brief description is provided below.

The well was completed on February 7, 2023 with a 6¼" (15.88 cm) diameter steel casing 0.188 inches (0.5 cm) thick with the casing extending from 2 ft (0.6 m) above grade to 10 ft (3.05 m) below the ground surface. The annulus around the casing was sealed with a bentonite slurry. Beneath the well casing, the bore represents an open hole through the limestone bedrock to a total depth of 12.8 m (42 ft) below ground surface.

The contractor intersected an overburden sequence consisting of 0.61 m (2 ft) of clay-rich soils, directly above the underlying limestone bedrock. The contractor encountered two (2) water bearing zones "aquifer" within the bedrock, occurring at depths of 2.13 m (7 ft) and 7.62 m (25 ft) from the ground surface. These aquifer conditions appear to be similar to other wells in the immediate area, with most wells obtaining water from a supply aquifer that occurs between 4.57 m (15 ft) and 9.14 m (30 ft) below the ground surface.

Upon completion, the driller estimated the theoretical yield of the well at over 15 gpm (0.95 L/s).

3.0 Well Test

3.1 Water Demand

Water consumption varies among households according to occupancy and lifestyle. However, for studies of this type, we generally assume the average water requirement for a rural residence to be 450 litres per person per day (as per MECP Procedure D-5-5). Peak domestic demand occurs over two, 60-minute periods each day (morning and evening). This is generally equivalent to a peak demand rate of 3.75 L/min/person. Based on the daily per capita demand, a four (4) bedroom dwelling with five (5) occupants would require a minimum total supply of 2,250 L/day (~500 imperial gallons per day). This estimate excludes additional water for other uses such as lawn watering, etc.

To account for some ancillary uses, a conservative target yield for a domestic well is on the order of 2,500 L/day.

3.2 Well Survey

A well survey letter and questionnaire was provided to the owner to distribute to all neighbours within 300 m of the proposed severance lot. It is understood that these were distributed on January 30th, 2023. Copies of the well survey letter and questionnaire are provided in Appendix B.

One (1) well survey respondent agreed to provide their information and participate in well monitoring as part of our study. The location of the well (referred to as "W-2") is illustrated on Figure 2. Unfortunately, upon inspection of the well on February 14, 2023, the well was observed to be constructed in a pit. As the well owner utilizes a single line jet pump with plastic fittings at the well head, it was determined that any attempt to remove the well cap would result in damaging the intake, likely requiring replacement and re-priming of the owner's pump. Therefore, the well was deemed inaccessible for monitoring and the well owner was notified by email that monitoring the well would not be possible without having it upgraded in accordance with Ontario Regulation 903, as amended.

Photos of the wells and site conditions have been included in Appendix C.

3.3 Test Data and Interpretation

Prior to conducting a pumping test for the purposes of this hydrogeological study (described below), a temporary submersible pump was supplied by the well contractor and installed in TW23-1. To disinfect the pumping equipment, bleach was circulated briefly approximately

1-hour before commencing the test.

On February 14th, 2023, ORE staff attended the site to conduct a pumping test on TW23-1. Upon arrival, the test well (TW23-1) and observation well (W-1) were outfitted with data logging pressure transducers ("dataloggers") to obtain automatic water level measurements. Immediately prior to the test, the static ("at rest") water level measured in the test well (TW23-1) was 1.67 m below the top of the well casing (btoc). Based on the aquifer depth (provided above) of 7.62 m, the resulting available drawdown prior to the test was estimated to be (7.62 m + 0.47 m for casing height - 1.67 m =) 6.42 m.

During the course of the pumping test, a manual auger borehole ("HA23-1") was advanced within 5 m of TW23-1. Upon completion, the borehole was observed to fill with shallow groundwater and was subsequently outfitted with a datalogger to monitor whether there was any direct hydraulic connection between the shallow groundwater and the supply aquifer.

Discharge water, from the pumping test, was directed to a tarp to prevent erosion and sedimentation 52 m north of the well location. The discharge waters followed a natural overland drainage swale that directed the water towards the wetland to the north.

During the pumping test, the water levels in TW23-1, HA23-1 and W-1 were also measured manually as a check on the dataloggers. Field water quality was monitored with an AquaTroll 400 series multi-parameter meter and a LaMotte 2020e turbidity meter. The flow rate was controlled with a gate valve and flow measurements were obtained from a flow meter on the discharge line and checked with a graduated pail.

The pumping test commenced at a rate of 0.86 L/s (~13.5 gpm) and was held constant for the entire pumping duration of 180 minutes (i.e., 3 hours), resulting in a total volume of approximately 9,255 L being abstracted from the well. During the test, the well exhibited a drawdown of 2.32 m, representing approximately 36% of the available drawdown. The resulting 3-hour calculated specific capacity of the well is 0.37 L/s/m.

Following the test, the well exhibited a relatively slow recovery that recovered to within 95% of the original static water level approximately 252 minutes following the cessation of pumping.

Plots of drawdown versus time for the pumped well and observation well are presented in Appendix D. From the pumped well data, the estimated near-well transmissivity is determined to be approximately 15.2 m^2/day. This value was obtained from the best fit Cooper-Jacob analysis, which is typically known to under-estimate the transmissivity in pumped wells (i.e., as opposed to analysing observation well data).

However, a Theis analysis of the observation well data provides a slightly lower

transmissivity of approximately 14.0 m^2/day. The transmissivity estimate from the observation well data is expected to be a better representation of the aquifer properties as this minimizes the pumped well loss effects. The estimated transmissivity value for the subject well is considered adequate for private supply purposes and could potential supply somewhat larger uses (Krasny, 1993).

During the pumping test, the observation well (W-1), located approximately 24 m from the pumped well, exhibited a drawdown of approximately 1.5 m. This represents approximately 25% of the available drawdown, based on the well being of similar construction to TW23-1. As the volume of water pumped from TW23-1 was almost four (4) times what a typical 4-bedroom household would use in a day, this amount of interference is negligible, and is not likely to cause a noticeable effect on neighbouring water supplies.

Water level measurements in the manual auger borehole (HA23-1) appear to show no response to the pumping portion of the test. Should there have been a direct hydraulic connection between the shallow aquifer and the supply aquifer, it is expected that there would have been a measurable response. In addition, it was noted through the course of the pumping test, that the sump in the existing residence near W-1 was periodically pumping water from the shallow aquifer, with no apparent effect on the water level in either the pumped well or observation well.

3.4 Water Quality

Prior to the end of the pumping test, a sample of raw groundwater was obtained from the discharge. The sample was forwarded to Caduceon Environmental Laboratories for analysis of the chemical and microbiological water quality parameters in general accordance with Procedure D-5-5. The analytical results are presented in Appendix E.

The Ontario Drinking Water Quality Standards (ODWQS) generally fall within the following:

- Interim and Maximum Acceptable Concentrations;
- Operational Guidelines, and/or
- Aesthetic Objectives.

The ODWQS defines these as:

> *The [Maximum Acceptable Concentration] MAC is established for parameters which when present above a certain concentration, have known or suspected adverse health effects. The length of time the MAC can be exceeded without health effects will depend on the nature and concentration of the parameter. The [Interim Maximum Acceptable Concentration] IMAC is established for parameters either when there are insufficient toxicological data to establish a MAC with reasonable certainty, or when it is not feasible, for practical*

reasons, to establish a MAC at the desired level.

[Operational Guidelines] are established for parameters that, if not controlled, may negatively effect the efficient and effective treatment, disinfection and distribution of the water.

[Aesthetic Objectives] are established for parameters that may impair the taste, odour or colour of water or which may interfere with good water quality control practices. For certain parameters, both aesthetic objectives and health-related MACs have been derived.

The analytical results indicate that there were no exceedances with regard to any of the health-related chemical parameters of the ODWQS. The reported nitrate concentration (also a health-related parameter) is reported to be below the 10 mg/L standard (and below the laboratory's detection limits), indicating pristine conditions.

The reported hardness value of 444 mg/L (as $CaCO_3$) is elevated above the maximum aesthetic objective range of 80 to 100 mg/L. However, this is typical of groundwater in southern Ontario and is not of concern. If desired by the well owner, installation of a water softener will reduce the potential effects from hardness (i.e., scale formation). It should be noted that the installation of a water softener will increase the sodium concentration in the water as a result of the ion exchange process.

The reported dissolved sodium concentration is 94.2 mg/L, which is well within the ODWQS objective of 200 mg/L, but exceeds the "warning level" of 20 mg/L (for persons on sodium restricted diets). Any perspective purchasers of the severance lot (future well owners) should be advised of the sodium concentration exceeding the warning criteria.

The associated chloride concentration is comparatively elevated, occurring at 222 mg/L, although below the MAC of 250 mg/L. The difference between the sodium and chloride concentrations, along with a low dissolved organic carbon concentration (discussed below) indicate that significant reducing conditions are occurring within the aquifer.

The reported dissolved and total iron concentrations exceed the ODWQS aesthetic objective of 0.30 mg/L, at 1.49 and 1.51 mg/L respectively. Similarly, dissolved and total manganese also exceeds the ODWQS AO of 0.05 mg/L, at 0.051 mg/L and 0.052 mg/L, respectively. At these concentrations, iron and manganese are expected to cause staining to fixtures. Due to the reducing conditions in the aquifer, precipitates of iron and manganese are likely to readily form when the water is exposed to oxygen. This is evidenced by the laboratory turbidity (at 20 NTU), despite the water appearing clear at the point of discharge, as evidenced by consistent field turbidity values below the ODWQS AO of 5 NTU, at < 0.1 NTU throughout the pumping test. As a result, the future well owner should consider aeration with filtration

to reduce the iron and manganese[1] concentrations.

As a direct consequence of the elevated sodium, chloride and select metals, the Total Dissolved Solids (TDS) concentration was found to exceed the ODWQS AO of 500 mg/L, at 735 mg/L. At this concentration, the raw water may have an objectionable taste. Treatment through aeration and filtration may help to reduce these effects.

The dissolved organic carbon (DOC) concentration was found to be well below the ODWQS objective of 5 mg/L, occurring below the laboratory method detection limit. DOC can be an indicator of surface water intrusion into the well and/or aquifer. Despite the relatively shallow well depth and high (likely karstic) well yield, the DOC and colour (2 TCU) remained below their respective ODWQS objectives.

During the pumping test described above, spot-checks of field water quality parameters were monitored, from samples collected at the discharge, using an AquaTroll 400 Multi-parameter Meter and a LaMotte 2020e Turbidity Meter. Continuous conductivity and temperature measurements were monitored with the use of a Solinst LTC datalogger, set to 1 minute intervals throughout the testing and monitoring periods.

The compiled field water quality data are presented in Appendix F. As illustrated, the relative conductivity declined throughout the pumping test, starting at approximately 1,600 μS/cm and continued to decline throughout the test, until stabilizing at just under 1,200 μS/cm. In contrast, the temperature of the water remained fairly constant throughout the test, with a slight warming (i.e., < 0.5°C) towards the end of the test. It is likely the warming effect is related to the daytime sun warming the polyethylene pipe. The Relative Dissolved Oxygen (RDO) and Oxidation Reduction Potential (ORP) both declined throughout the test, with the ORP stabilizing in the slightly negative range, which appears to confirm reducing conditions at the time of sample collection. The pH remained relatively stable and neutral throughout the test.

Despite the relatively pristine and stable chemical water quality, the total coliform concentration (6 cfu/100 mL), occurred above the *health-related* criteria of the ODWQS and the limit suggested by Procedure D-5-5 (i.e., 5 cfu/100 mL) generally viewed as acceptable for private groundwater supplies. Despite this result, the background bacteria counts were relatively low and there was no indication of contamination by E. Coli.

It was noted during the site observations that the nearby monitoring well (W-1) did not have a vermin-proof cap. In addition, some wells in the area have been constructed in well pits,

[1] While aeration and filtration is expected to marginally reduce the manganese concentration, the well owner may need additional treatment if a concentration below the ODWQS AO is desired.

despite the area having a relatively shallow water table where the wellheads could be seasonally under water. As a result, tracing the source of the bacteria would be difficult in this environment. Therefore, to mitigate for any future low-level bacteria counts in the groundwater, it is highly recommended that the future well owner utilize an ultra-violet (UV) light system with the recommended aeration/filtration outlined above, with an additional pre-filter (i.e., cartridge filter) to provide disinfection. The well owner should also submit a water sample to the local Health Unit on a regular basis to ensure the system is achieving the desired level of disinfection.

3.5 Water Level Monitoring

Following the pumping test described above, the dataloggers remained in TW23-1 and W-1 for a period of approximately two (2) weeks to observe any seasonal trends. As illustrated in Appendix G, the water level in TW23-1 recovered following the pumping test on February 14, 2023. Similarly, W-1 also recovered following the pumping test. However, data from both wells show numerous superimposed pumping cycles, believed to be from water use at the existing residences in addition to interference from other nearby wells. The water levels in TW23-1 and W-1, show a regional decline after February 16, 2023, eventually dropping approximately 0.5 m. In contrast, temperature data suggests a prolonged warming period, where daytime high temperatures remained above freezing until February 20, 2023.

It is expected that the precipitation event (i.e., >26 mm of rain as recorded by Environment Canada - Belleville) and associated snow melt on February 9, 2023 may have contributed to the elevated water levels observed at the site between February 14th and February 16th. Following this period in the monitoring data, the water levels appear to decline and may be showing signs of stabilizing between February 25th and February 27th.

In contrast, temperature data from the well over the same period (Appendix G) shows relatively stable conditions, with a slight decrease (i.e., <0.1°C) in temperature occurring on February 17, 2023. A corresponding slight increase (i.e., ~100 μS/cm) in conductivity occurs at the same time, possibly suggesting additional "fresh" recharge moving through the aquifer. This could potentially correspond with a precipitation event recorded by Environment Canada's Belleville station on February 16th or could be associated with the end of a regional recharge event. These observations a similar to those of karst and epikarst aquifer characteristics found elsewhere.

Regardless, it is apparent from the available data that the water levels in both TW23-1 and W-1 do not appear to respond rapidly to recharge events.

4.0 Servicing Considerations

4.1 Shallow Soil and Groundwater Conditions

A series of two (2) manual (hand auger) boreholes were advanced on the property to explore the shallow soil conditions (Figure 2). The boreholes revealed a predictable sequence of overburden materials below the subject site, consisting of the following:

Topsoil

Each borehole intersected a dark brown to black, highly organic topsoil, rich in silt and clay. Evidence of mottling was also present throughout. As the area was most likely used historically for agricultural purposes, there was some evidence of mixing the underlying mineral soils. Although not encountered, occasional hummocks were observed on the ground surface, likely representing boulders and/or cobbles of limestone "floating" on the surface of the bedrock.

The site abruptly rises approximately 0.5 m in the west-northwest portion of the property following a linear definition. While this could be related to grading/infilling of neighbouring properties, borehole HA23-2 suggests this could represent the location of a subdued (erosional) bedrock scarp. Based on field observations, the scarp would be roughly perpendicular to the orientation of glacial striae observed in the area.

ML Type Soil

Borehole HA23-1 encountered a relatively thin sequence of light brown/grey, sandy silt with clay, containing a considerable amount of moisture and no appreciable gravel content. There was no clear layering of the soils, suggesting it may represent a weathered portion of the underlying till, rather than the glaciolacustrine materials that are also mapped to occur in the area. The till was found to be very moist to saturated in both boreholes, with high plasticity, exhibiting mottling throughout. Both boreholes terminated on presumed bedrock at depths of 0.76 m and 0.61 m, for HA23-1 and HA23-2, respectively. Both boreholes were observed to have a water level within 0.15 m of the ground surface prior to backfill.

Field borehole logs have are presented in Appendix H.

During the site inspection, a sump at the residence on the retained lands was observed to be constantly in use (i.e., cycling through many on-off cycles), suggesting a persistent shallow aquifer exists in the study area. Based on the groundwater encountered in the manual (hand

auger) boreholes, the typical depth to water on the site is less than 15 cm. In comparison, the depth to water in the drilled wells, referenced to ground, is 1.2 m. Based on the water level monitoring data (described above) and the difference between the hydraulic head (i.e., static water level) of the shallow aquifer, there is expected to be minimal direct hydraulic connection between the two (2) aquifers.

4.2 Karst Considerations

The site occurs near the headwater of a tributary of the Moira River, located approximately 10 km west of the site. The Moira River is well known to be associated with karst features. The river meanders through the regional geology, occasionally flowing through the subsurface of the surrounding Paleozoic limestone. Areas of interest are located along the river such as the Moira River Scuttleholes and cave structures.

Karst conditions can affect groundwater resources (positively and negatively), as karstic aquifers can yield an abundant supply of groundwater. Karst conditions can also be challenging with regard to sensitivity.

Published mapping by Brunton/Dodge (2008) provides an overview of potential, inferred and known karst in Ontario. The mapping is largely based on extrapolation of quaternary and bedrock geology mapping. The dataset also includes verified locations of karst features. The subject property is not mapped to be within a known, inferred or potential karst area. The closest area of "known" karst occurs approximately 4.5 km north of the subject site.

Although the mapping includes actual karst occurrences, it is important to recognize that much of the mapping is based on extrapolation that infers the presence of karst, based on the Paleozoic bedrock geology, surficial geology and stratigraphy in the area. As the site occurs in an area that is mapped as containing Paleozoic limestone of the Verulam Formation, the mapping is inconclusive with respect to karst occurrences in the immediate area. However, this does not imply that karst features do not exist locally. Therefore, it is important to not place too much emphasis on the karst hazard mapping. The mapping is best viewed as a general guide for investigators to assist in identifying areas that could potentially exhibit karst features, as opposed to being definitive.

The extent of the karst is expected to be highly dependant on several factors, including distance from river valley (former spillway), overburden cover and the elevation corresponding to ancient flooding adjacent to the spillway. Beyond that critical distance and above that elevation, karstic weathering is expected to be less pronounced. There is also likely a lower critical elevation, where the karst weathering was not active, either due to absence of the right conditions to promote weathering (such as absence of an outlet) or due to the rock composition.

During the site inspections, ORE staff examined the site terrain for any potential karst-related features. There were no observations of any karst hazards on the property and the continuous overburden deposits suggest active karst weathering of the surficial bedrock is unlikely. However, it is important to recognize that high yield bedrock wells are typically rare in this geological environment, unless a karst aquifer or other enhanced weathering of the bedrock is encountered. As a result, it is expected that TW23-1 and W-1 take advantage of an aquifer that has been enhanced by some karst or other enhanced weathering process (i.e., epikarst).

However, based on the compiled water level and water quality data, it appears the aquifer utilized by TW23-1 is relatively insensitive to recharge events. The nearly pristine water quality and subdued response to precipitation suggests the aquifer primarily relies on recharge that is a sufficient distance from the well to mitigate any significant water quality concerns. In addition, analysis of the pumping test data seem to suggest a best fit to confined aquifer analysis, which would not be anticipated if the well was directly utilizing the shallow aquifer.

As karst (or enhanced shallow bedrock) aquifers can be seasonally enhanced by recharge, we have attempted to analyse water level data for the 2 week period following the pumping test. While the data suggests the aquifer can experience fluctuations of 0.5 m during this relatively short monitoring period, the data suggests the water levels may reach some sort of equilibrium following a recharge event, as evidenced by the gradual “flattening” of the recession curve near the end of the monitoring period. This appears to suggest there is no dramatic recession in water levels that would indicate the potential for the well to become “dry” in the summer months.

Regardless, the importance of these karstic-type conditions with regard to groundwater supply cannot be over-stated and we are unable to say with any certainty whether prolonged periods of drought would affect the connection with the aquifer or result in a change in groundwater chemistry.

4.3 Water Supply

Based on the results of the well testing, it is clear that TW23-1 can support regular domestic use in excess of 2,500 L/day, without the need for supplemental storage (i.e., a cistern). Despite the well taking advantage of what could be a karstic aquifer, the chemical water quality and monitoring period hydrograph suggests there is sufficient separation from the recharge source for the aquifer to mitigate water quality and seasonal water quantity concerns. In addition, nitrate analysis suggests the supply aquifer on the subject site has not be influenced by nearby septic systems.

As the well exhibits an elevated Total Coliform count that could be persistent in the area due to historical well construction, it is recommended that prospective purchasers be made aware of the need for primary disinfection treatment, in the form of a UV system (at minimum). In addition, as the groundwater contains relatively high concentrations of iron and manganese, it is recommended that aeration with filtration treatment be employed prior to disinfection treatment to limit the interference that precipitates of iron and manganese can have on these systems. The well owner should confirm that the treatment system is functioning correctly by collecting and submitting samples for bacteriological analysis to the local Health Unit on a semi-annual (twice yearly) basis.

The laboratory reported concentrations of sodium and chloride are elevated. As a result, water softening with the use of a salt brine is not recommended. Prospective purchasers should be made aware that the sodium concentration (i.e., 94.2 mg/L) exceeds the "warning limit" for persons on sodium restricted diets.

Although Ontario Regulation 903, as amended, typically requires drilled wells for supply purposes to be constructed with at least 6 m of well casing, Section 13 (15) b) makes allowances for wells to have only 2.5 m of casing below the ground surface if the only aquifer is shallower than 6 m. Based on many wells within the area being of similar construction (i.e., <6 m) of casing, it is anticipated that well contractors are aware of issues with obtaining an adequate supply of groundwater in the study area. Prospective purchasers should be provided a copy of this report and be aware that extreme seasonal variations in temperature and precipitation (i.e., drought conditions) could influence the groundwater supplies in the area.

4.4 Wastewater

In the absence of communal servicing, future development of the proposed severance lot will need to utilize a private sewage (i.e., septic) system. As the casing length and grout on TW23-1 extends to only 3.05 m (10 ft) below the ground surface, the sewage system for the lot will need to maintain a separation distance (i.e., setback) of at least 30 m (100 ft) from the well (TW23-1), in accordance with O. Reg. 903, as amended. As neighbouring wells are likely to be of similar construction, it is recommended that the sewage system be placed to be at least 30 m from any identified well near the property.

Based on the shallow soil and shallow groundwater (i.e., high water table) conditions on the site, it is expected the sewage disposal bed will need to be fully-raised with imported materials. To reduce the overall footprint of the septic system, it is expected that a filter bed configuration would be preferred.

Based on the above, Figure 3 illustrates a conceptual servicing plan to demonstrate that the lot can be serviced by private well and septic, while maintaining the required and

recommended setbacks. The development configuration shown on Figure 3 is for conceptual purposes only to demonstrate viability of the lot. It is expected that the actual configuration of the lot will be determined through the application for a Building Permit. However, it is recommended that the general area of the conceptual septic system shown on Figure 3 be utilized for actual sewage disposal bed in order to meet the required setbacks and limit potential risks to nearby wells.

5.0 Conclusions and Recommendations

5.1 This hydrogeological assessment report has been prepared in support of a proposed single lot severance at 1693 Casey Road, in the City of Belleville.

The primary objective of this report is to demonstrate that an adequate quantity of acceptable quality groundwater is available to supply the proposed lot without resulting in unacceptable impact to nearby, existing uses. In addition, our study provides supporting data and interpretations regarding the preferred approaches for private wastewater disposal.

Our study has been based on the general requirements of MECP Procedures D-5-4 and D-5-5.

5.2 The site is currently vacant, consisting of mostly open field.

5.3 A single on-site drilled well (referred to herein as "TW23-1") has been constructed and tested, revealing comparatively high-yield conditions. Based on the tested conditions, supplementary water storage should not be required for this well.

Water quality testing has verified that TW23-1 can be treated to provide acceptable quality water. Treatment to reduce iron and manganese will be required to ensure primary disinfection treatment via an ultra-violet (UV) light system is effective. Water softening and/or chlorination are not recommended based on the elevated concentrations of sodium and chloride found in the groundwater.

Prospective purchasers should be made aware that the sodium concentration (94.2 mg/L) encountered during the well testing exceeds the warning limit (20 mg/L) for persons on sodium restricted diets.

5.4 Limited exploration of the shallow soil conditions across the site has revealed that the

on-site soils consist of stone poor till near the ground surface. It is expected that the till is somewhat weathered near the surface or the coarser particles have been removed by agricultural activities. The till would be classified as an ML type soil in accordance with the Unified Soil Classification System (USCS). The Code and Guide for Sewage System (2005) suggests the corresponding percolation rate of the soil could be anywhere from 20 min/cm to 50 min/cm.

5.5 Based on a relatively high water table (i.e., within 1 m of the ground surface), any sewage system on the proposed severance lot is expected to be fully-raised. To reduce the overall footprint of the septic system, it is recommended that a filter bed configuration be utilized using appropriate fill materials. Figure 3 illustrates the recommended conceptual location for a tile bed system based on a fully-raised configuration (i.e., to demonstrate the worst-case scenario). Ultimately, a system design will need to be prepared and submitted with the required application for approval by the Engineering and Development Services Department Building & By-law Enforcement Section of the City of Belleville. One or more test pits will need to be excavated at the time of application.

5.6 The supply aquifer may be exhibiting some karstic weathering effects. While there is no evidence of *karst hazards*, we cannot rule out relatively rapid recharge in this area. In addition, as the well casing for TW23-1 does not extend a minimum of 6 m (20 ft) below the ground surface, the separation distance between TW23-1 (and any other nearby wells) and any <u>future</u> tile bed system must be at least 30 m. It is expected that this distance will maximize effluent attenuation (as shown on Figure 3).

It is important to recognize that the well (as tested) appears to meet the prescribed Ontario Building Code setback from neighbouring sewage systems.

5.7 The future well owner should be made aware that their well water can be analysed by the local Health Unit for bacteriological parameters free of charge. Given the presence of karst weathering effects and potential seasonal variations, it is recommended that the homeowner have their water checked by the Health Unit two (2) times per year, once in the spring and once in the fall.

5.8 Figure 3 illustrates an example of a viable servicing arrangement for the severance lot. Other arrangements may also be viable. The actual servicing arrangement may vary to suit other considerations, under the direction of a qualified professional, provided the 30 m separation distance from TW23-1 (and any other nearby well) is achieved.

5.9 Heat pump feasibility has not been investigated as part of this study. The use of open loop heat pump systems is not recommended for this site. Any such open loop heat pump installations should only be considered if a hydrogeologist has determined that such systems can be utilized without compromising groundwater availability and quality.

If you have any questions or concerns, we would be pleased to discuss those at your convenience.

—End of Report—

Yours truly,
Oakridge Environmental Ltd.

Dan MacIntyre, B.Sc.

Brian R. King, P.Geo.

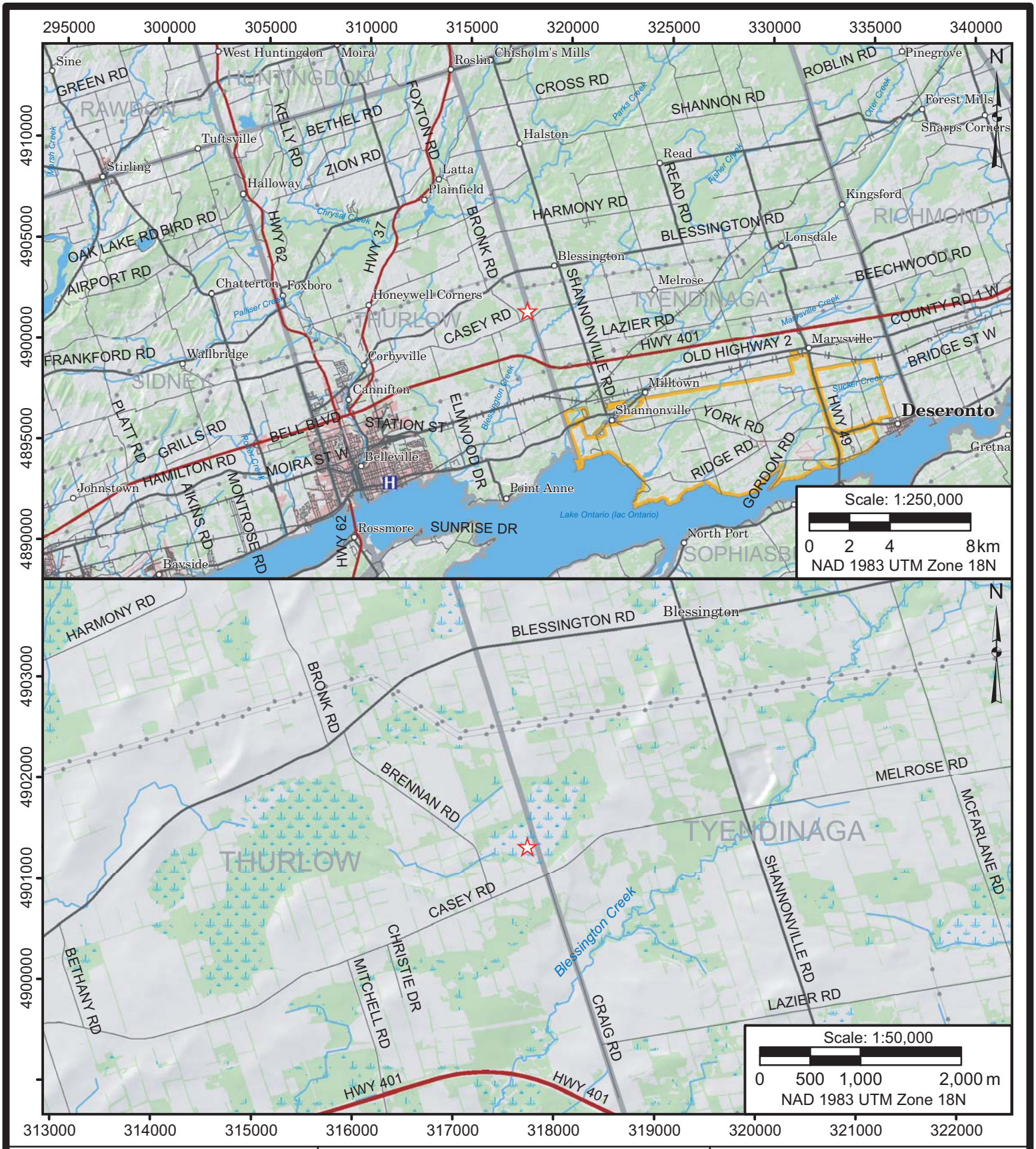
PROFESSIONAL GEOSCIENTIST
BRIAN R. KING
PRACTISING MEMBER
0396
ONTARIO

Attachments:

Figure 1 - General Location
Figure 2 - Physical Features
Figure 3 - Conceptual Servicing
Appendix A - Background Information
Appendix B - Well Survey & Questionnaire
Appendix C - Site Photos
Appendix D - Pumping Test Data
Appendix E - Water Quality Summary & Laboratory Certificate
Appendix F - Field Water Quality
Appendix G - Monitoring Period Hydrographs
Appendix H - Field Borehole Logs

cc: file

Figures



☆ Approximate Site Location

Notes: Base maps provided by Land Information Ontario and Natural Resources Canada (2023)

Optimized for Oakridge Environmental Ltd. printing

Hydrogeological Study - Well Certification
Proposed Residential Severance
1693 Casey Road, Belleville
Part of Lot 31, Concession 3 (Thurlow)
City of Belleville

ORE Oakridge Environmental Ltd.
Environmental and Hydrogeological Services

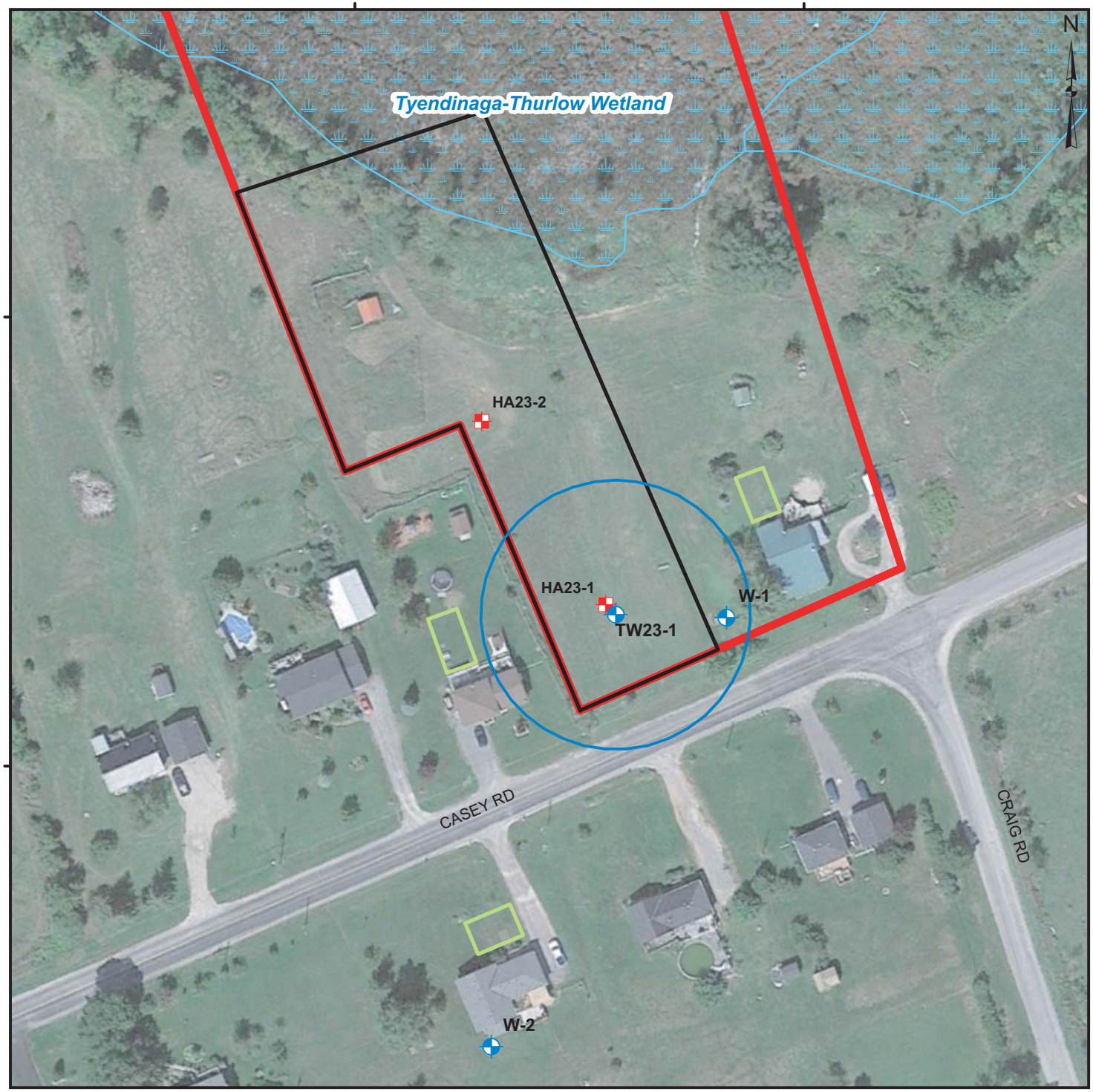
North American Datum (NAD) 1983

TITLE
General Location

PROJECT # 23-3222

DATE March 2023

FIGURE NO. **1**



NAD 1983 UTM Zone 18N

Hydrogeological Study - Well Certification
Proposed Residential Severance
1693 Casey Road, Belleville
Part of Lot 31, Concession 3 (Thurlow)
City of Belleville

- Approximate Property Boundary
- Approximate Proposed Severance
- Drilled Well with 30 m Setback
- Manual (Hand) Auger Borehole
- Sewage Disposal Bed (as confirmed by well contractor or as provided by well survey)
- Evaluated Wetland (locally significant)

Scale: 1:1,250

0 12.5 25 50 m

Notes: Base maps provided by Land Information Ontario and Natural Resources Canada (2023)

Imagery provided by GoogleEarth (2015)

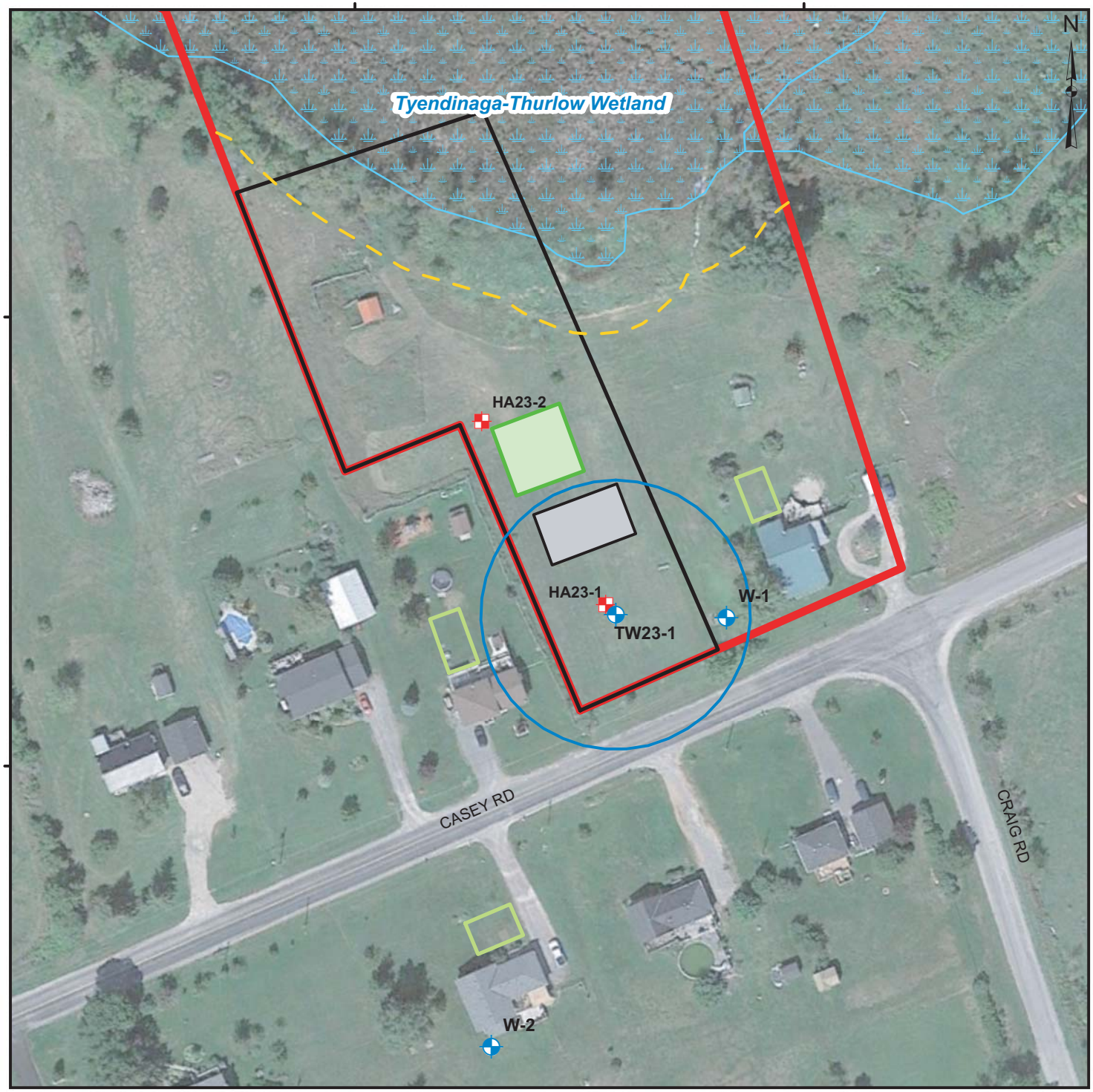
Optimized for Oakridge Environmental Ltd. printing

TITLE

Physical Features

ORE Oakridge Environmental Ltd.
Environmental and Hydrogeological Services

PROJECT #	FIGURE NO.
23-3222	**2**
DATE	
March 2023	



NAD 1983 UTM Zone 18N

Hydrogeological Study - Well Certification
Proposed Residential Severance
1693 Casey Road, Belleville
Part of Lot 31, Concession 3 (Thurlow)
City of Belleville

- Approximate Property Boundary
- Approximate Proposed Severance
- Drilled Well with 30 m Setback
- Manual (Hand) Auger Borehole
- Sewage Disposal Bed (as confirmed by well contractor or as provided by well survey)
- Evaluated Wetland (locally significant)
- Conceptual Residence (2,500 sq. ft.)
- Conceptual Filter Bed (based on a fully-raised configuration, Q = 3,000 L/day, assumed T = 50 min/cm for native soils to represent worst-case)
- Wetland Setback (15 m based on Ontario Building Code)

Scale: 1:1,250

0 12.5 25 50 m

Notes: Base maps provided by Land Information Ontario and Natural Resources Canada (2023)

Imagery provided by GoogleEarth (2015)

Optimized for Oakridge Environmental Ltd. printing

TITLE

Conseptual Servicing Plan

ORE Oakridge Environmental Ltd.
Environmental and Hydrogeological Services

PROJECT #	FIGURE NO.
23-3222	3
DATE	
March 2023	

Appendix A

Background Information

Ontario — Ministry of the Environment, Conservation and Parks

Measurements recorded in: ☐ Metric ☒ Imperial

Well Tag No. (Place Sticker and/or Print Below) A308459

Well Record

Regulation 903 Ontario Water Resources Act

Page ____ of ____

Well Owner's Information

First Name	Last Name/Organization	E-mail Address	☐ Well Constructed by Well Owner
Clayton	Fenman		

Mailing Address (Street Number/Name)	Municipality	Province	Postal Code	Telephone No. (inc. area code)
1643 Casey Road	Belleville	Ont	K8N 4Z6	

Well Location

Address of Well Location (Street Number/Name)	Township	Lot	Concession
1493 Casey Road	Quinte west	31	3

County/District/Municipality	City/Town/Village	Province	Postal Code
Hastings County	Belleville	Ontario	K8N 4Z6

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	18	317877	4919009		

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	Depth (m/ft) To
Brown	clay			0	2
Grey	Limestone			2	42

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m^3/ft^3)
0	10	30% Solids Bentonite Slurry	

Method of Construction

☐ Cable Tool ☐ Diamond
☐ 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	Depth (m/ft) To
6¼	Steel	.188	2	10

Construction Record - Screen

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

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

Water Details

Water found at Depth (m/ft)	Gas	Kind of Water	Other, specify
	☐	☐ Fresh ☒ Untested	
25	☐	☐ Fresh ☒ Untested	
	☐	☐ Fresh ☐ Untested	

Hole Diameter

Depth (m/ft) From	Depth (m/ft) To	Diameter (cm/in)
0	10	10¼
10	42	6¾

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): 35

Pumping rate (l/min / GPM): 11

Duration of pumping: 3 hrs + ____ min

Final water level end of pumping (m/ft): 13'11

If flowing give rate (l/min/GPM)

Recommended pump depth (m/ft): 30

Recommended pump rate (l/min/GPM): 15

Well production (l/min/GPM): 15+

Disinfected? ☒ Yes ☐ No

	Draw Down Time (min)	Draw Down Water Level (m/ft)	Recovery Time (min)	Recovery Water Level (m/ft)
Static Level		36"		
1		7'4"	1	
2		7'10"	2	
3		8'3"	3	
4		8'6"	4	
5		8'7"	5	
10		9'2"	10	
15		9'7"	15	
20		10'2"	20	
25		10'3"	25	
30		10'6"	30	
40		10'10"	40	
50		11'4"	50	
60		11'7"	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	Well Contractor's Licence No.
Holmes Industrial Supply Ltd	7145

Business Address (Street Number/Name)	Municipality
5548 County Rd. 9	Napanee

Province	Postal Code	Business E-mail Address
ON	K7R 3K8	

Bus. Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)
613 539 2911	Holmes, Sean

Well Technician's Licence No.	Signature of Technician and/or Contractor	Date Submitted
13516		

Well owner's information package delivered: ☐ Yes ☐ No

Date Package Delivered

Date Work Completed

Ministry Use Only

Audit No. Z392589

Received

Z392564

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Well Owner's Copy

Appendix B

Well Survey & Questionnaire

ORE
Oakridge Environmental Limited
Environmental and Hydrogeological Services

Reference #23-3222

Dear Homeowner or Occupant:

Oakridge Environmental Ltd. (ORE) has been commissioned to conduct a door-to-door well survey in your area. The purpose of the survey is to obtain information about local water supply and sewage disposal conditions. The information is being collected in accordance with provisions of the Ministry of the Environment, Conservation and Parks' (MECP's) Procedure D-5-5 guidelines for a neighbouring property owner proposing to create a residential lot by severance/consent.

Your water supply and sewage disposal information is an important part of our study and is requested to ensure that we will have an accurate database. The information will be included in our hydrogeological study and will only be used for scientific purposes. Personal information (i.e., contact information) will not be disseminated and will only be utilized in the event we need to contact you directly.

In addition, as part of the study, we will be testing a newly constructed well on the proposed residential lot and are seeking permission to monitor any accessible neighbouring wells within 300 m of the proposed lot. If you have received this letter, it means that your property or a portion of your property is within the 300 m radius, and we would welcome the opportunity to monitor the water level in your well during our study. The purpose of the well monitoring is to determine if the newly constructed well has any influence over neighbouring wells.

If you are interested in participating in the well survey and/or are interested in having your well monitored, we have a brief questionnaire that we can complete with you by telephone, fax, or e-mail (whichever is most convenient for you). A copy of the survey questionnaire is attached.

The success of our survey depends on obtaining accurate information. You are under no obligation to participate in our survey, however, if you are interested in participating please contact our office at your earliest convenience. We would appreciate receiving your response on or before February 3rd, 2023.

If you have any questions, please feel free to contact our office using the contact information found below. We thank you for your time.

Dan MacIntyre, BSc.
Oakridge Environmental Ltd.
647 Neal Drive, Suite 3
Peterborough, Ontario
K9J 6X7

Telephone: (705) 745-1181
1-888-OAKRIDGE (625-7434)
Fax: (705) 745-4163
1-877-796-7781
Email: dan@oakenv.com

WATER SUPPLY SUMMARY

For Office Use Only
By:_____
Project No:_____
MECP #:_____
Ref. No:_____

Township:_____
Hamlet/Town:_____
Lot:_____ Concession:_____
Well Owner:_____
Mailing Address:_____
Phone: _____ Date:_____
Type of Residence: (house, seasonal cottage, business, etc.)_____

WATER SUPPLY SOURCE

Dug Well: ❑ Drilled Well: ❑ Lake/River: ❑ Other:_____
Well Depth:_____ Diameter: _____
Well Construction:_____
Well Drilled by: _____Date:_____

WATER QUANTITY

Never Dry: ❑ Occasionally Dry: ❑ Often Dry: ❑ Last Date:_____
Ever hauled water? _____ Last Date:_____ Contractor:_____

WATER QUALITY

Odour Problems (describe):_____
Taste Problems (describe):_____
Turbidity Problems (describe):_____
Staining (describe):_____
Bacteria Problems (describe): _____
Other:_____
Ever had water sampled? Bacteria? ❑ Chemical? ❑ Last Date:_____

WATER TREATMENT

Water Softener:_____
Chlorinator:_____
Filter:_____
Other:_____

PROPERTY AND WATER USE

Lot Size:_____ No. of Washrooms:_____ No. of Bedrooms:_____

No. of Fixture Units:_____

SEWAGE DISPOSAL

Tile Bed: Raised: ❑ In-ground: ❑

Problems: Odours: ❑ Breakouts: ❑ No problems: ❑

System Age:_____ Constructed By:_____

Distance to Well:_____ Direction: (eg. Upgradient) _____

Distance to Building:_____

PROPERTY SKETCH

(showing house, well, and tile bed locations)

Are you interested in having my well monitored during the hydrogeological study?

Yes No

(Please note, only representative, readily accessible wells may be monitored)

Appendix C

Site Photos

Photo A (above): Wellhead of W-2

Photo B (above): Looking northwest with W-1 in the foreground

Photo C (above): Sump outfall

Photo D (above): Looking south at TW23-1, with HA23-1 in the foreground

Photo E (right): Looking south at pumping test discharge location

APPENDIX C
Photos taken February 14, 2023

ORE
Oakridge Environmental Ltd.
Environmental and Hydrogeological Services

Appendix D

Pumping Test Data

Oakridge Environmental Ltd.
647 Neal Drive
Peterborough, Ontario
K9J 6X7
ore@oakenv.com

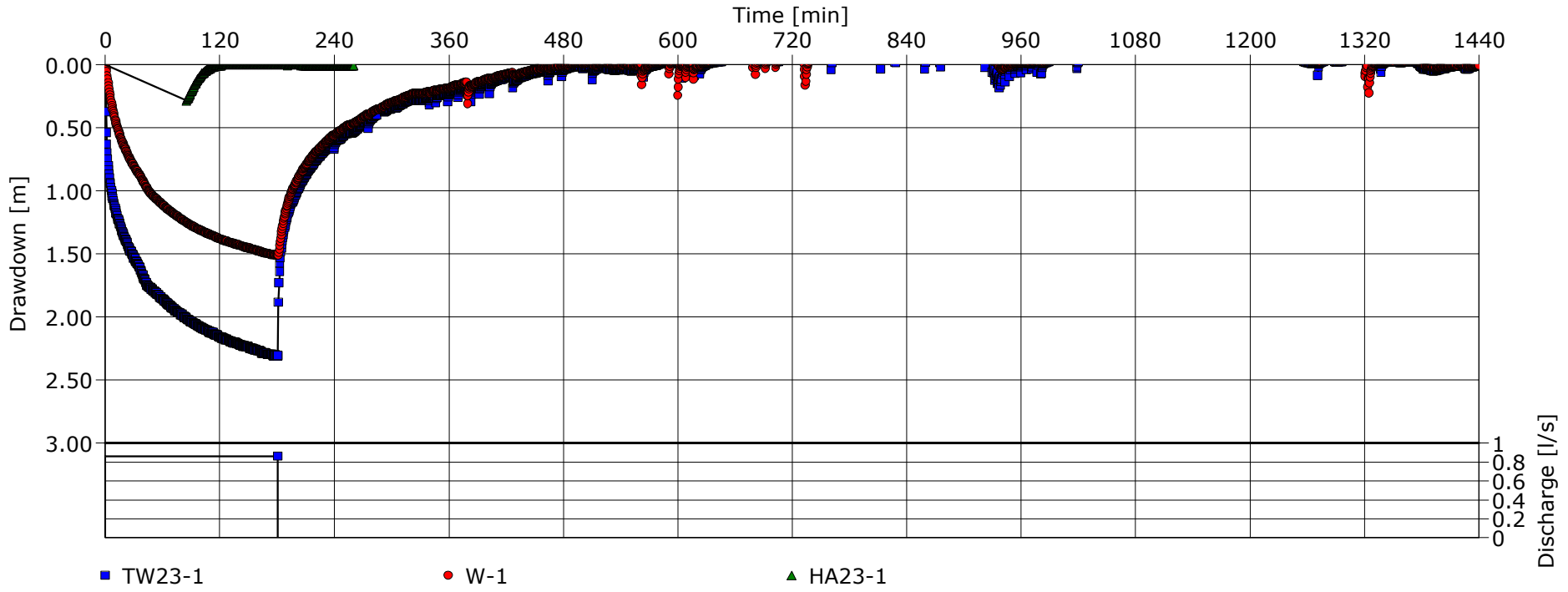
Pumping Test Analysis Report

Project: 1693 Casey Road

Number: 23-3222

Client: C. Ferriman

Location: Belleville, Ontario	Pumping Test: TW23-1	Pumping Well: TW23-1
Test Conducted by: DM		Test Date: 2023-02-14
Analysis Performed by: DM/BK	Time-Drawdown (all wells)	Analysis Date: 2023-03-01
Aquifer Thickness: 1.00 m	Discharge: variable, average rate 0.857 [l/s]	



Oakridge Environmental Ltd.
647 Neal Drive
Peterborough, Ontario
K9J 6X7
ore@oakenv.com

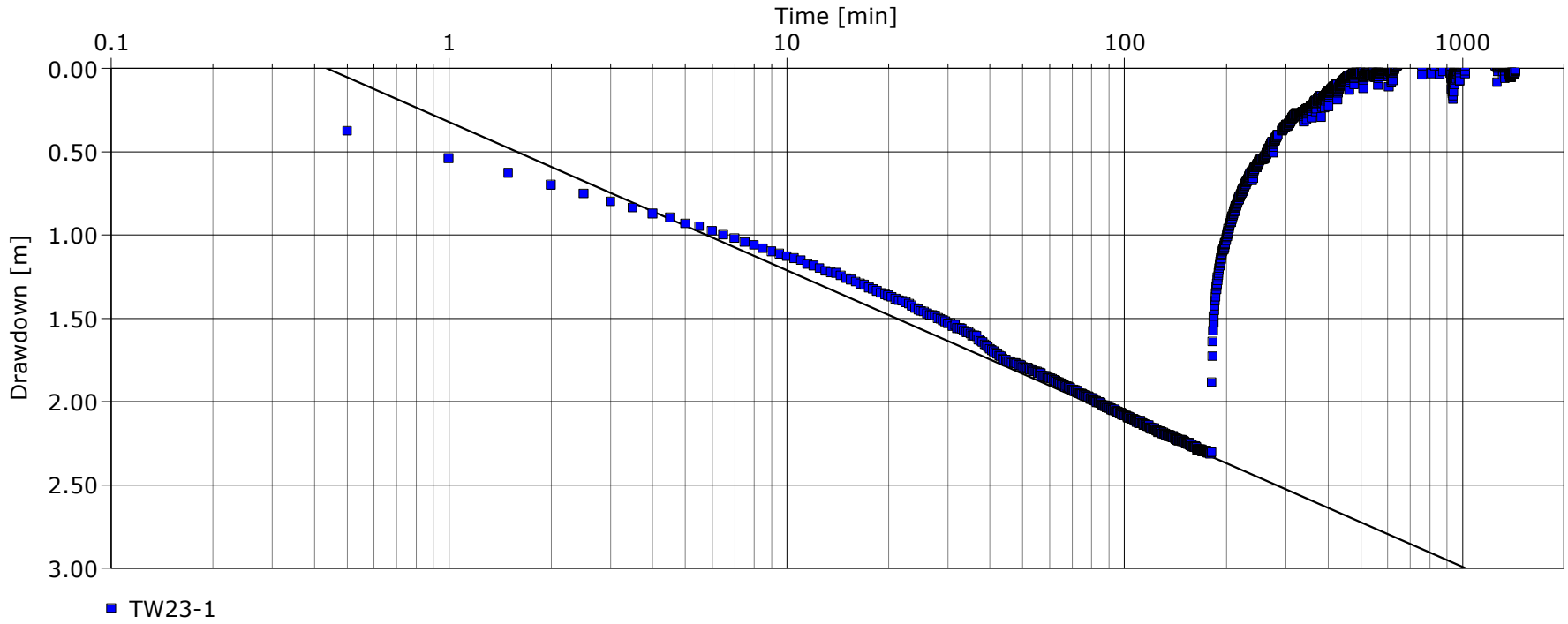
Pumping Test Analysis Report

Project: 1693 Casey Road

Number: 23-3222

Client: C. Ferriman

Location: Belleville, Ontario	Pumping Test: TW23-1	Pumping Well: TW23-1
Test Conducted by: DM		Test Date: 2023-02-14
Analysis Performed by: DM/BK	Cooper-Jacob, pumped well	Analysis Date: 2023-03-02
Aquifer Thickness: 1.00 m	Discharge: variable, average rate 0.857 [l/s]	



Calculation using COOPER & JACOB

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	Radial Distance to PW [m]	
TW23-1	1.52×10^{1}	1.52×10^{1}		0.08	

Oakridge Environmental Ltd.
647 Neal Drive
Peterborough, Ontario
K9J 6X7
ore@oakenv.com

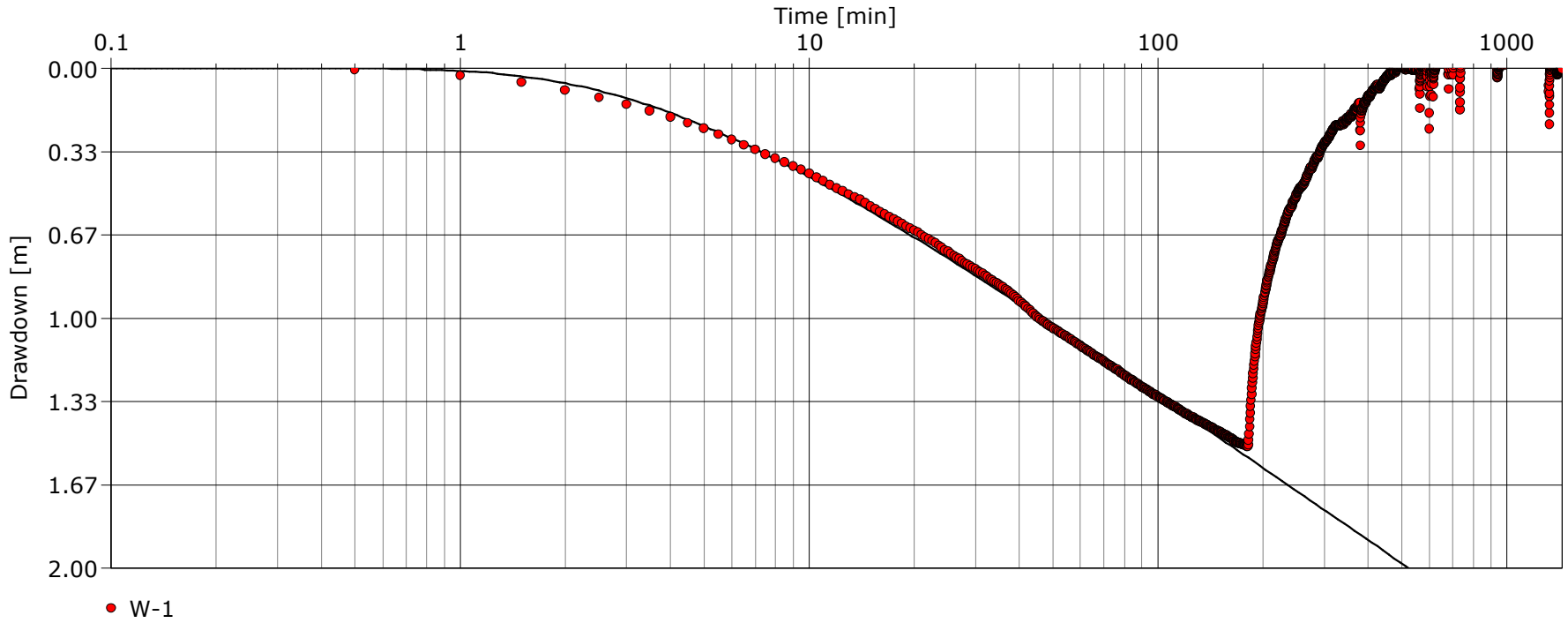
Pumping Test Analysis Report

Project: 1693 Casey Road

Number: 23-3222

Client: C. Ferriman

Location: Belleville, Ontario	Pumping Test: TW23-1	Pumping Well: TW23-1
Test Conducted by: DM		Test Date: 2023-02-14
Analysis Performed by: DM/BK	Theis, W-1 obs	Analysis Date: 2023-03-02
Aquifer Thickness: 1.00 m	Discharge: variable, average rate 0.857 [l/s]	



Calculation using Theis

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	Radial Distance to PW [m]	
W-1	1.40×10^{1}	1.40×10^{1}	1.61×10^{-4}	24.84	

Appendix E

Water Quality Summary &
Laboratory Certificate

		Client I.D.	TW23-1	ODWQS	
		Sample I.D.	B23-01943-1	Concentration	Type
		Date Collected	14-Feb-23		
Parameter	**Units**	**R.L.**			
Total Coliform	cfu/100mL	1	6	0	MAC
E. Coli	cfu/100mL	1	0	0	MAC
Background	cfu/100mL	1	5		
Heterotrophic Plate Count	cfu/mL	10	20		
Akalinity ($CaCO_3$) to pH 4.5	mg/L	5	328	30 - 500	OG
Carbonate (as $CaCO_3$)	mg/L	5	< 5		
Bicarbonate (as $CaCO_3$)	mg/L	5	328		
pH @ 25°C	pH Units		7.79	6.5 - 8.5	OG
Conductivity @ 25°C	µmho/cm	1	1340		
Colour	TCU	2	2	5	AO
Turbidity	NTU	0.1	20.0	5 (1)	AO
Turbidity (field)	NTU		< 0.1	5 (1)	AO
Fluoride	mg/L	0.1	< 0.1	1.5	MAC
Chloride	mg/L	0.5	222	250	AO
Nitrate (as N)	mg/L	0.1	< 0.1	1	MAC
Nitrite (as N)	mg/L	0.1	< 0.1	10	MAC
Sulphate	mg/L	1	46	500	AO
Total Kjeldahl Nitrogen	mg/L	0.1	0.5		
o-Phosphate (as P)	mg/L	0.002	0.015		
Total Ammonia (as N)	mg/L	0.01	0.26		
Dissolved Organic Carbon	mg/L	0.2	< 0.2	5	AO
Sulphide	mg/L	0.01	< 0.01	0.05	AO
Hardness (as $CaCO_3$)	mg/L	1	444	80 - 100	OG
Calcium	mg/L	0.02	145		
Total Calcium	mg/L	0.002	140		
Copper	mg/L	0.005	< 0.002	1	AO
Total Copper	mg/L	0.02	< 0.002	1	AO
Iron	mg/L	0.001	1.49	0.3	AO
Total Iron	mg/L	0.1	1.51	0.3	AO
Magnesium	mg/L	0.2	23.7		
Total Magnesium	mg/L	0.00005	22.7		
Manganese	mg/L	0.005	0.051	0.05	AO
Total Manganese	mg/L	0.02	0.052	0.05	AO
Potassium	mg/L	0.002	5.2		
Total Potassium	mg/L	0.005	4.8		
Sodium	mg/L	0.02	94.2	200 (20)	AO
Total Sodium	mg/L	0.001	90.6	200 (20)	AO
Uranium	mg/L	0.1	0.00061	0.02	MAC
Zinc	mg/L	0.2	< 0.005	5	AO
Total Zinc	mg/L	0.005	0.023	5	AO
Anion Sum	meq/L		13.8		
Cation Sum	meq/L		13.5		
% Difference	%		0.885		
Ion Ratio	AS/CS		1.02		
TDS (ion sum calc.)	mg/L	1	735	500	AO
Conductivity (calc.)	µmho/cm		1327		
Langelier Index (25°C)	S.I.		0.986		

MAC - Maximum Acceptable Concentration
IMAC - Interim Maximum Acceptable Concentration
AO - Aesthetic Objective
OG - Operational Guideline
Blue highlighted values exceed MAC, IMAC, AO or OG
Yellow highlighted values exceed the warning limit for persons on sodium restricted diets
Field turbidity (LaMotte 2020e) derived from sample collected immediately prior to collecting samples for laboratory analysis

CADUCEON™ ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

C.O.C.: G89599 **REPORT No. B23-01943**

Report To:

Oakridge Environmental
PO Box 431 ,
Peterborough ON K9J 6Z3 Canada
Attention: Dan MacIntyre

Caduceon Environmental Laboratories
285 Dalton Ave
Kingston Ontario K7K 6Z1
Tel: 613-544-2001
Fax: 613-544-2770

DATE RECEIVED: 15-Feb-23
DATE REPORTED: 24-Feb-23
SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: Casey
P.O. NUMBER: 23-3222
WATERWORKS NO.

			Client I.D.		TW23-1			
			Sample I.D.		B23-01943-1			
			Date Collected		14-Feb-23			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Total Coliform	cfu/100mL	1	MOE E3407	15-Feb-23/K	6			
E coli	cfu/100mL	1	MOE E3407	15-Feb-23/K	0			
Background	cfu/100mL	1	MOE E3407	15-Feb-23/K	5			
Heterotrophic Plate Count	cfu/mL	10	SM9215D	15-Feb-23/K	20			
Alkalinity(CaCO3) to pH4.5	mg/L	5	SM 2320B	15-Feb-23/O	328			
Carbonate (as CaCO3)	mg/L	5	SM 2320B	15-Feb-23/O	< 5			
Bicarbonate(as CaCO3)	mg/L	5	SM 2320B	15-Feb-23/O	328			
pH @25°C	pH Units		SM 4500H	15-Feb-23/O	7.79			
Conductivity @25°C	µmho/cm	1	SM 2510B	15-Feb-23/O	1340			
Colour	TCU	2	SM 2120C	16-Feb-23/O	2			
Turbidity	NTU	0.1	SM 2130	16-Feb-23/O	20.0			
Fluoride	mg/L	0.1	SM4110C	15-Feb-23/O	< 0.1			
Chloride	mg/L	0.5	SM4110C	15-Feb-23/O	222			
Nitrite (N)	mg/L	0.1	SM4110C	15-Feb-23/O	< 0.1			
Nitrate (N)	mg/L	0.1	SM4110C	15-Feb-23/O	< 0.1			
Sulphate	mg/L	1	SM4110C	15-Feb-23/O	46			
Total Kjeldahl Nitrogen	mg/L	0.1	E3516.2	16-Feb-23/K	0.5			
o-Phosphate (P)	mg/L	0.002	PE4500-S	16-Feb-23/K	0.015			
Ammonia (N)-Total	mg/L	0.01	SM4500-NH3-H	16-Feb-23/K	0.26			
Dissolved Organic Carbon	mg/L	0.2	EPA 415.2	15-Feb-23/O	< 0.2			
Sulphide	mg/L	0.01	SM4500-S2	15-Feb-23/K	< 0.01			
Hardness (as CaCO3)	mg/L	1	SM 3120	21-Feb-23/O	444			
Calcium	mg/L	0.02	SM 3120	21-Feb-23/O	145			
Copper	mg/L	0.002	SM 3120	21-Feb-23/O	< 0.002			
Iron	mg/L	0.005	SM 3120	21-Feb-23/O	1.49			
Magnesium	mg/L	0.02	SM 3120	21-Feb-23/O	23.7			
Manganese	mg/L	0.001	SM 3120	21-Feb-23/O	0.051			

R. Lecompte

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

Richard Lecompte
Laboratory Supervisor

CADUCEON ENVIRONMENTAL LABORATORIES
Client committed. Quality assured.

CERTIFICATE OF ANALYSIS

Final Report

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Peterborough ON K9J 6Z3 Canada
Attention: Dan MacIntyre

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Fax: 613-544-2770

DATE RECEIVED: 15-Feb-23
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SAMPLE MATRIX: Groundwater

JOB/PROJECT NO.: Casey
P.O. NUMBER: 23-3222
WATERWORKS NO.

			Client I.D.		TW23-1			
			Sample I.D.		B23-01943-1			
			Date Collected		14-Feb-23			
Parameter	**Units**	**R.L.**	**Reference Method**	**Date/Site Analyzed**				
Potassium	mg/L	0.1	SM 3120	21-Feb-23/O	5.2			
Sodium	mg/L	0.2	SM 3120	21-Feb-23/O	94.2			
Uranium	mg/L	0.00005	EPA 200.8	23-Feb-23/O	0.00061			
Zinc	mg/L	0.005	SM 3120	21-Feb-23/O	< 0.005			
Calcium	mg/L	0.02	SM 3120	17-Feb-23/O	140			
Copper	mg/L	0.002	SM 3120	17-Feb-23/O	< 0.002			
Iron (Total)	mg/L	0.005	SM 3120	17-Feb-23/O	1.51			
Magnesium	mg/L	0.02	SM 3120	17-Feb-23/O	22.7			
Manganese (Total)	mg/L	0.001	SM 3120	17-Feb-23/O	0.052			
Potassium	mg/L	0.1	SM 3120	17-Feb-23/O	4.8			
Sodium	mg/L	0.2	SM 3120	17-Feb-23/O	90.6			
Zinc	mg/L	0.005	SM 3120	17-Feb-23/O	0.023			
Anion Sum	meq/L		Calc.	16-Feb-23/O	13.8			
Cation Sum	meq/L		Calc.	16-Feb-23/O	13.5			
% Difference	%		Calc.	16-Feb-23/O	0.885			
Ion Ratio	AS/CS		Calc.	16-Feb-23/O	1.02			
TDS(ion sum calc.)	mg/L	1	Calc.	16-Feb-23/O	735			
Conductivity (calc.)	µmho/cm		Calc.	16-Feb-23/O	1327			
Langelier Index(25°C)	S.I.		Calc.	16-Feb-23/O	0.986			

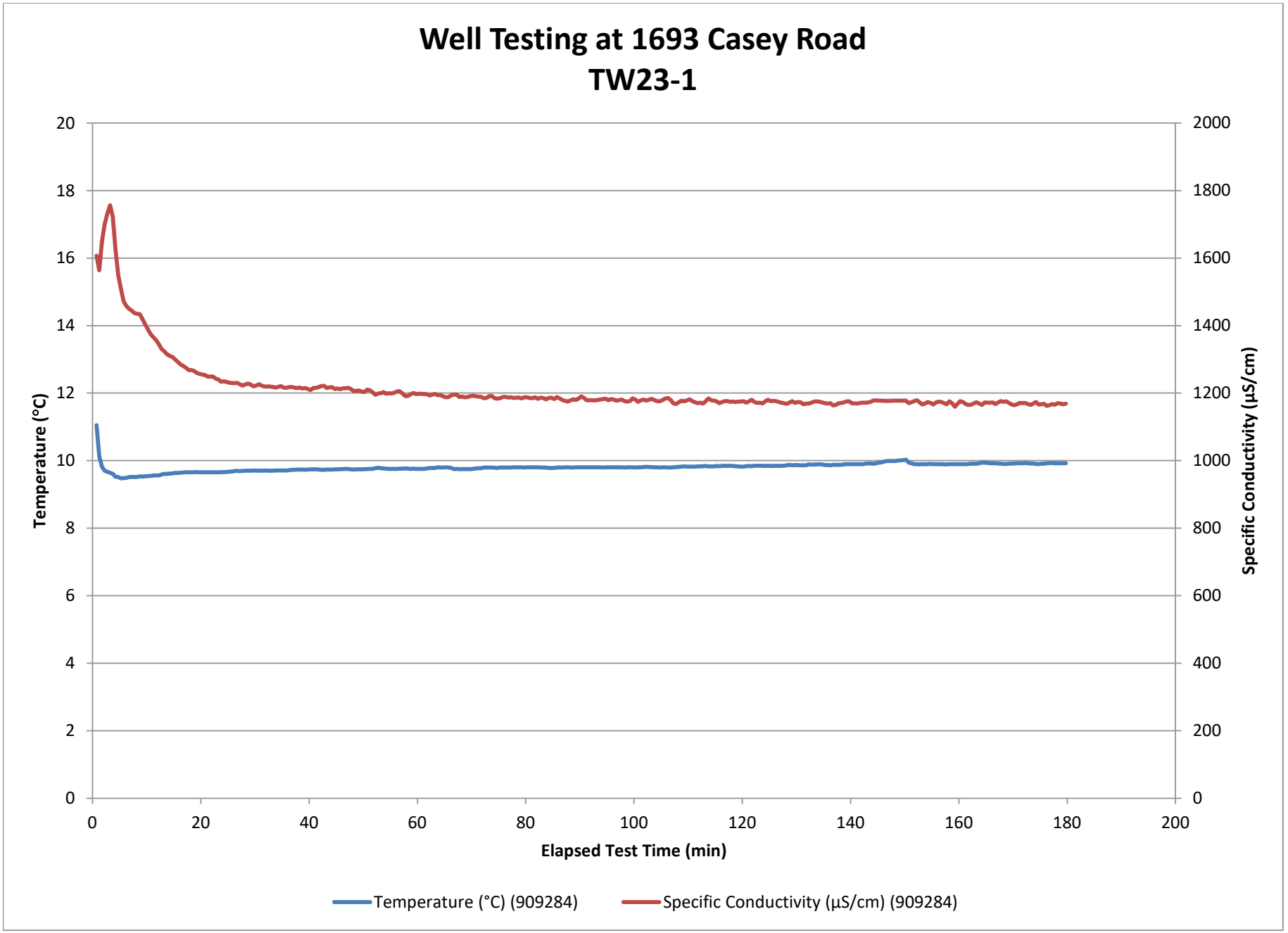
R. Lecompte

R.L. = Reporting Limit
Test methods may be modified from specified reference method unless indicated by an *
Site Analyzed=K-Kingston,W-Windsor,O-Ottawa,R-Richmond Hill,B-Barrie

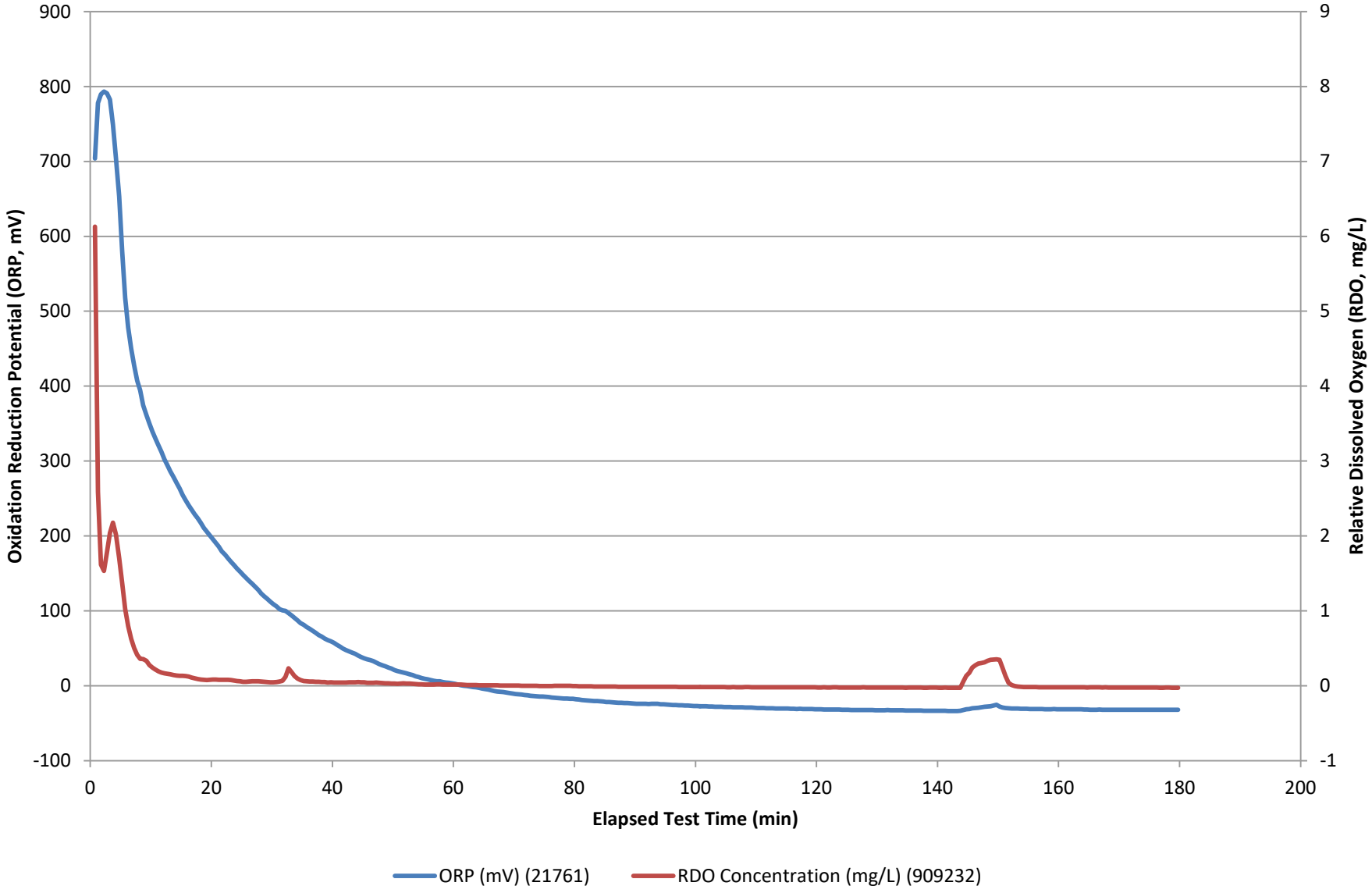
Richard Lecompte
Laboratory Supervisor

Appendix F

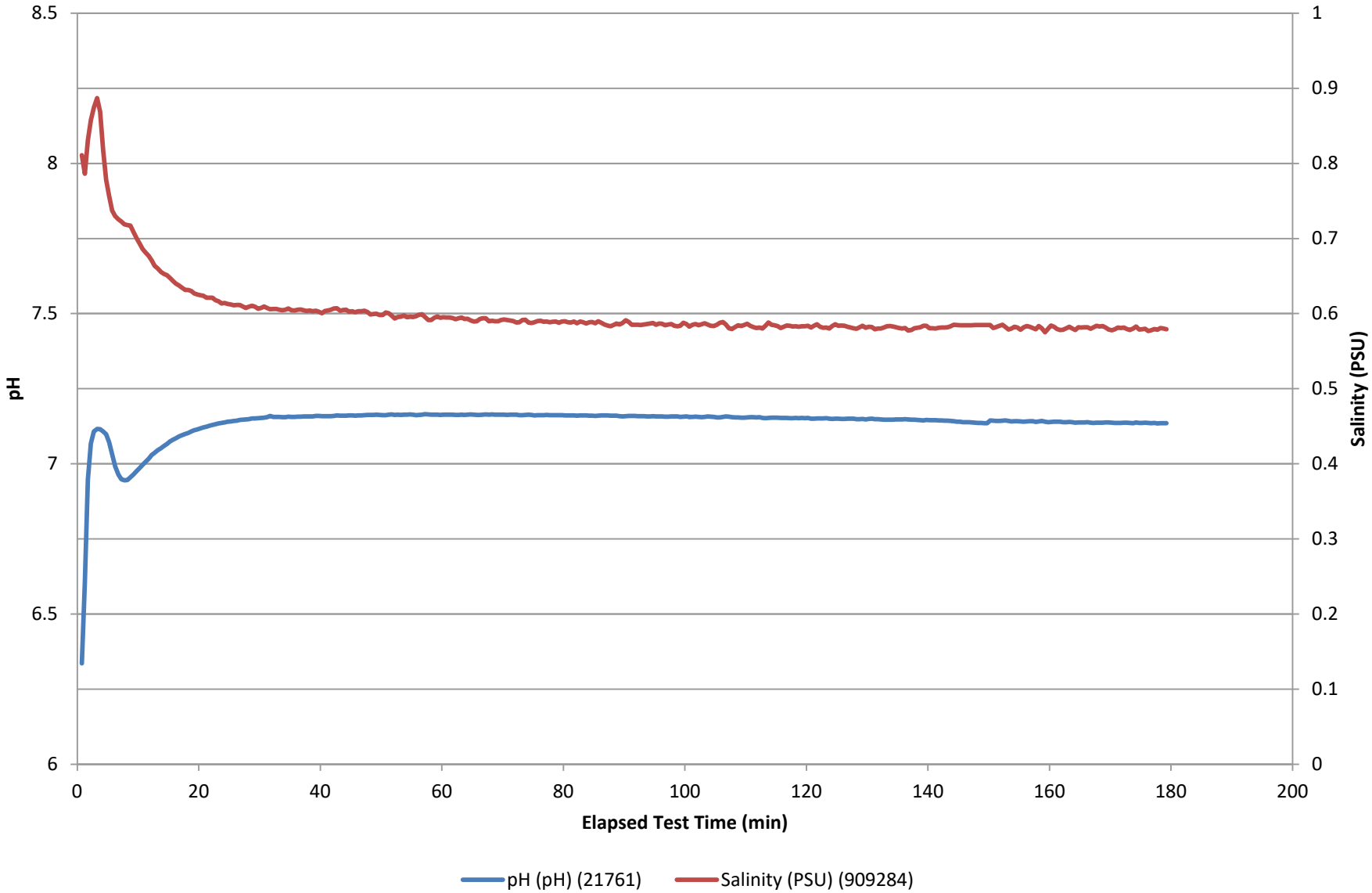
Field Water Quality


Well Testing at 1693 Casey Road
TW23-1
Temperature (°C)
Specific Conductivity (µS/cm)
Elapsed Test Time (min)
0
2
4
6
8
10
12
14
16
18
20
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0
20
40
60
80
100
120
140
160
180
200
Temperature (°C) (909284)
Specific Conductivity (µS/cm) (909284)

Well Testing at 1693 Casey Road
TW23-1

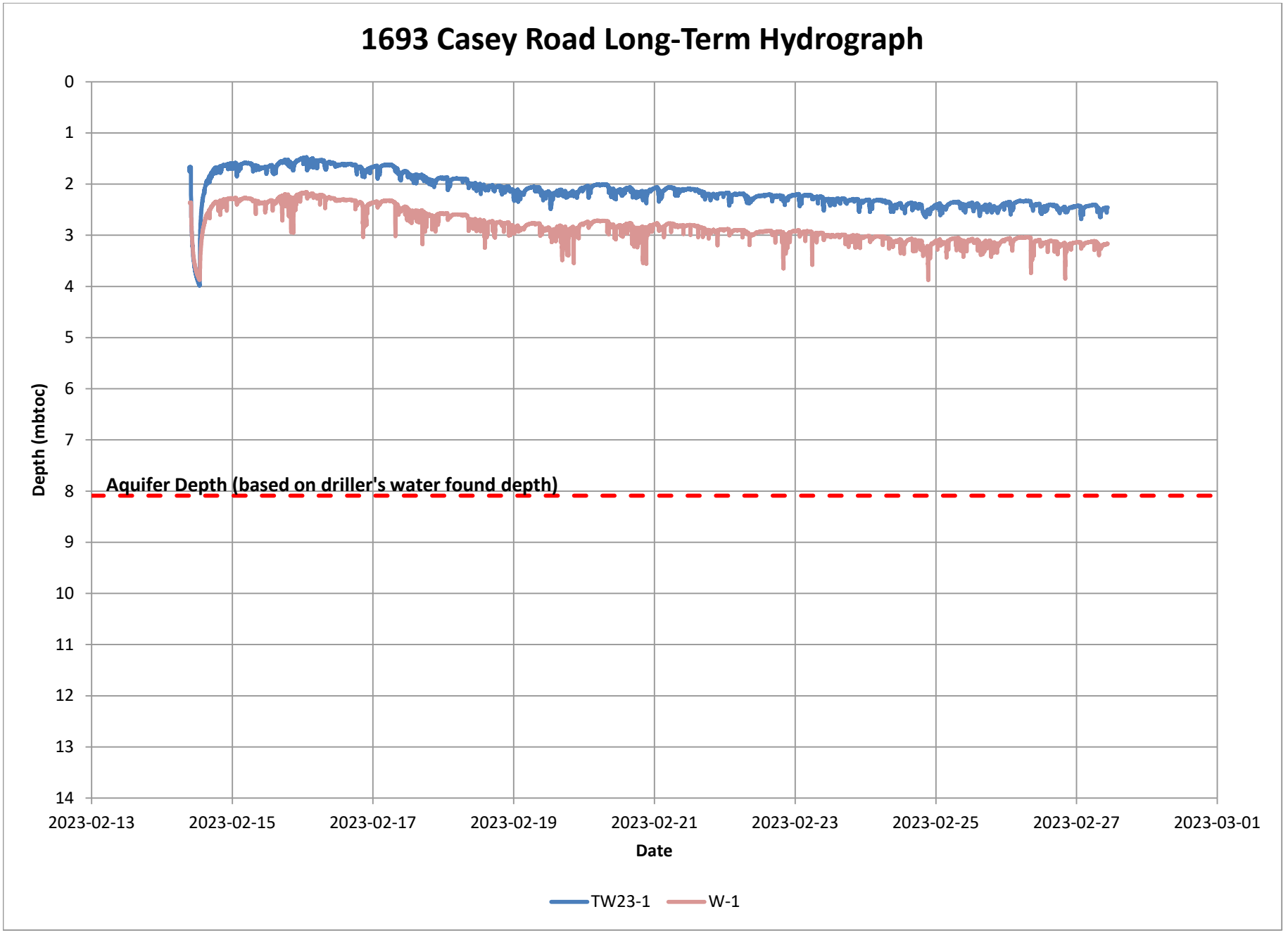


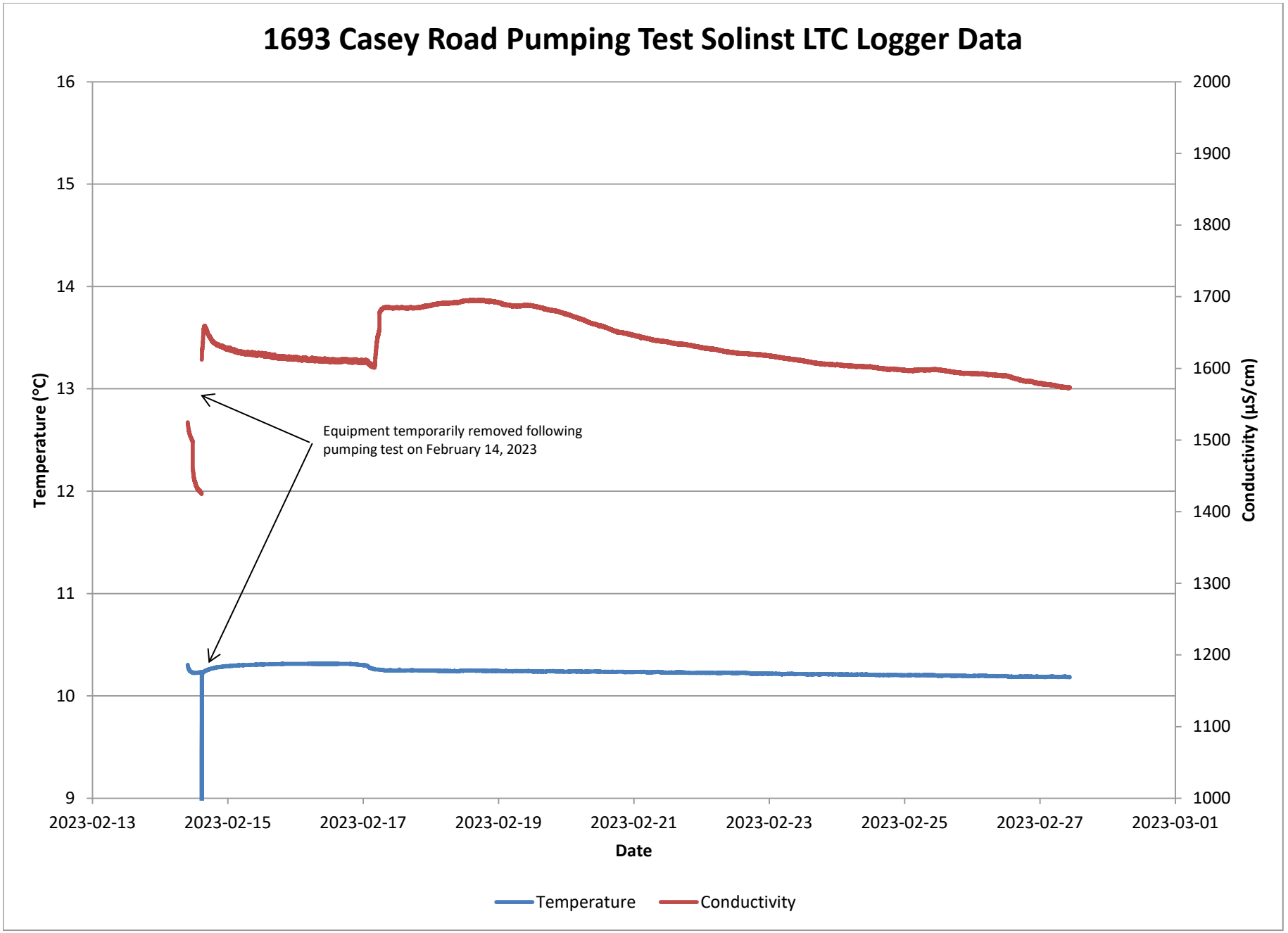
Well Testing at 1693 Casey Road
TW23-1



Appendix G

Monitoring Period Hydrographs


1693 Casey Road Long-Term Hydrograph
Depth (mbtoc)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Aquifer Depth (based on driller's water found depth)
2023-02-13
2023-02-15
2023-02-17
2023-02-19
2023-02-21
2023-02-23
2023-02-25
2023-02-27
2023-03-01
Date
TW23-1
W-1


1693 Casey Road Pumping Test Solinst LTC Logger Data
Temperature (°C)
Conductivity (µS/cm)
16
15
14
13
12
11
10
9
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
2023-02-13
2023-02-15
2023-02-17
2023-02-19
2023-02-21
2023-02-23
2023-02-25
2023-02-27
2023-03-01
Date
Equipment temporarily removed following pumping test on February 14, 2023
Temperature
Conductivity

Appendix H

Field Borehole Logs

ORE
Oakridge Environmental Ltd.
Environmental and Hydrogeological Services
647 Neal Drive, Suite 3, Peterborough, Ontario K9J 6X7
Phone: 705-745-1181 | Fax: 705-745-4163 | www.oakridgeenvironmental.com

HAND AUGER I.D.: **HA23-1**

TOTAL DEPTH: **0.762 m**

UTM Coordinates:	Elevation (masl):
317856,4901036	125.0

PROJECT INFORMATION

PROJECT NO: **23-3222**
SITE LOCATION: **Belleville, Ontario**
LOGGED BY: **DM**
DATES ASSESSED: **February 14, 2023**

CONTRACTOR INFORMATION

CONTRACTOR: **Provided by ORE**
EQUIPMENT: **Manual (Hand) Auger**
STANDPIPE/PIEZOMETERS: **Not Installed**
SAMPLING METHODS: **Composite Grab**

▽ Seepage ▼ Water Level △ Moist

FIELD AUGER LOG

Depth (m)	Water	Piezometer Installation	Special Notes	Sample #	Depth	Soil Symbol	Soil Description
0.00	△						
0.05							TOPSOIL: Brown/black silty topsoil, very moist with rootlets
0.10	▼		Water level at 0.1 m prior to backfill				
0.15					0.15		ML: Brown/grey silt with sand and clay. Mottled, with high plasticity and low toughness. Sample very moist, becoming saturated with depth.
0.20							
0.25							
0.30							
0.35							
0.40							
0.45							
0.50							
0.55							
0.60	▽				0.61		ML (TILL): Brown, mottled grey sandy silt with occasional gravel and clay. Medium plasticity with no toughness. Saturated with increased gravel content with depth.
0.65							Refused on presumed bedrock.
0.70							Saturated @ 0.6 m
0.75							END @ 0.762 m

NOTES: Minor snow pack, temperature +5 degrees

ORE
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HAND AUGER I.D.: **HA23-2**

TOTAL DEPTH: **0.61 m**

UTM Coordinates:	Elevation (masl):
317828,4901077	125.5

PROJECT INFORMATION

PROJECT NO: **23-3222**
SITE LOCATION: **Belleville, Ontario**
LOGGED BY: **DM**
DATES ASSESSED: **February 14, 2023**

CONTRACTOR INFORMATION

CONTRACTOR: **Provided by ORE**
EQUIPMENT: **Manual (Hand) Auger**
STANDPIPE/PIEZOMETERS: **Not Installed**
SAMPLING METHODS: **Composite Grab**

▽ Seepage ▼ Water Level △ Moist

FIELD AUGER LOG

Depth (m)	Water	Piezometer Installation	Special Notes	Sample #	Depth	Soil Symbol	Soil Description
0.00							TOPSOIL: Brown silty topsoil, moist with rootlets
0.05							
0.10	△						
0.15							
0.20							
0.25							
0.30					0.30		ML (TILL): Brown, mottled grey sandy silt with occasional gravel and clay. Medium plasticity with no toughness. Saturated with increased gravel content with depth.
0.35							
0.40							Refused on presumed bedrock.
0.45							
0.50							Saturated @ 0.55 m
0.55	▼ ▽		Water level at 0.54 m prior to backfill				END @ 0.61 m
0.60							

NOTES: Minor snow pack, temperature +5 degrees