Appendix A
Technical Documents

Appendix A. Technical Documents

A.1 Yonge Street Aquifer Well Capacity Update and Proposed Permit to Take Water Amendment Strategy

A.2 Green Lane Well Site Groundwater Resource Evaluation Report

Note: Full reports can be made accessible on request.

York Region

Public Works
Environmental Promotion and Protection

Memorandum

TO: To File

FROM: Erin Wilson, Program Manager Water Resources Monitoring

DATE: November 10, 2022

RE: **Yonge Street Aquifer Well Capacity Update and Proposed Permit to Take Water Amendment Strategy**

Introduction

This technical memorandum has been prepared with the intent of supporting York Region Operations, Maintenance and Monitoring and Capital Planning and Delivery in the decision-making process pertaining to production well asset management (well replacement and maintenance) and the need and feasibility of replacing lost groundwater production capacity in the Yonge Street Aquifer (YSA) groundwater supply system servicing the Town of Aurora, Newmarket ,and East Gwillimbury.

Background

The Regional Municipality of York (York Region) owns and operates 18 municipal water supply wells within the Town of Aurora, Town of Newmarket, and the Town of East Gwillimbury. These wells, collectively known as the YSA groundwater supply system, operate under Permit to Take Water (PTTW) No. 1736-BKZPJD, which is due for renewal on December 31, 2023. The PTTW does not specify an average daily rate for each well, but rather limits the yearly daily average taking volume from all YSA wells to 42,000 cubic meters per day (m^3/day). Additionally, during the yearly peak demand period (May to September), the maximum allowable daily average taking from all YSA wells is increased to 67,200 m^3/day, while the maximum daily taking volume from all wells during this period is permitted up to 87,656 m^3/day. The maximum permitted water taking rate for each of the production wells is included in **Table 1**.

Two new wells (East Gwillimbury Production Well (PW) 1 and PW2) are planned to be commissioned and added to the YSA groundwater system within the next 5 years and have been added to **Table 1** for information purposes.

Table 1. Summary of YSA Wells and PTTW Capacity

Production Well ID	Elevation of Screen Interval (masl)	Aquifer Unit[a]	Permitted Capacity (m^3/d)
Aurora PW1	155.6 to 161.7	Thorncliffe Channel	3,273

Production Well ID	Elevation of Screen Interval (masl)	Aquifer Unit[a]	Permitted Capacity (m^3/d)
Aurora PW2	150.2 to 162.4	Thorncliffe Channel	5,892
Aurora PW3	151.2 to 161.8	Thorncliffe Channel	5,237
Aurora PW4	154.1 to 167.6	Thorncliffe Channel	7,856
Aurora PW5	153.2 to 165.4	Thorncliffe Channel	5,892
Aurora PW6	168.5 to 179.4	Thorncliffe Channel	3,470
Aurora PW7	157.8 to 165.7	Thorncliffe Channel	4,752
Holland Landing PW1	168.2 to 177.3	Thorncliffe Channel	2,291
Holland Landing PW2	168.0 to 176.4	Thorncliffe Channel	3,600
Newmarket PW1	176.7 to 184.3	Thorncliffe Channel	2,291
Newmarket PW2	174.4 to 182.3	Thorncliffe Channel	4,583
Newmarket PW13	161.5 to 169.4	Thorncliffe Channel	5,892
Newmarket PW15	167.4 to 181.5	Thorncliffe Channel	3,273
Newmarket PW16	162.5 to 170.4	Thorncliffe Channel	5,630
Queensville PW1	171.9 to 184.1	Thorncliffe Channel	6,546
Queensville PW2	174.4 to 185.3	Thorncliffe Channel	6,546
Queensville PW3	164.5 to 177.0	Thorncliffe Channel	6,546
Queensville PW4	163.8 to 176.3	Thorncliffe Channel	6,546
East Gwillimbury PW1[b]	162.9 to 173.4	Thorncliffe Channel	9,072[c]
East Gwillimbury PW2[b]	159.2 to 173.2	Thorncliffe Channel	9,072[c]

Notes:
ID Denotes identification
m^3/day Denotes cubic meters per day
masl Denotes meters above sea level
PW Denotes production well
[a] "Thorncliffe Channel" is a term used to describe the Yonge Street Aquifer. Production and monitoring wells interpreted to be screened within the Thorncliffe Channel (as identified in this report) may have been previously identified to be screened within the "Thorncliffe Formation" and/or the "Scarborough Formation." This updated terminology is supported by the assessment completed by Gerber et al., 2018.
[b] East Gwillimbury (To Be Commissioned by 2028) – Not Permitted
[c] An application to amend PTTW for the addition of East Gwillimbury PW1 and PW2 is being proposed. The maximum permitted capacity is proposed to be 100 liters per second (L/s) per well for a combined maximum taken per day of 9,072 m^3/day (105 L/s). This assumes a peak capacity of 200 L/s for a 12-hour period.

Operational flexibility within the groundwater supply system is required to maintain adequate supply redundancy, water pressure, and water quality in the distribution system, as well as manage fluctuations in demand or respond to emergencies that are unique to each pressure district. Future growth and forecasted maximum day demands are also important considerations when assessing water supply capacity requirements. As shown in **Figure 1**, the operational capacity of the groundwater supply system is less than the current and forecasted total maximum day demand in Aurora, Newmarket, and East Gwillimbury. As such, Lake Ontario supply is required to supplement the groundwater supply and meet current and forecasted demand. Lake Ontario supply is limited by the permitted intra-basin transfer of 105,000 m^3/day, resulting in more dependency and reliance on the YSA groundwater system as demand increases and the surplus of supply within the York Water System decreases.

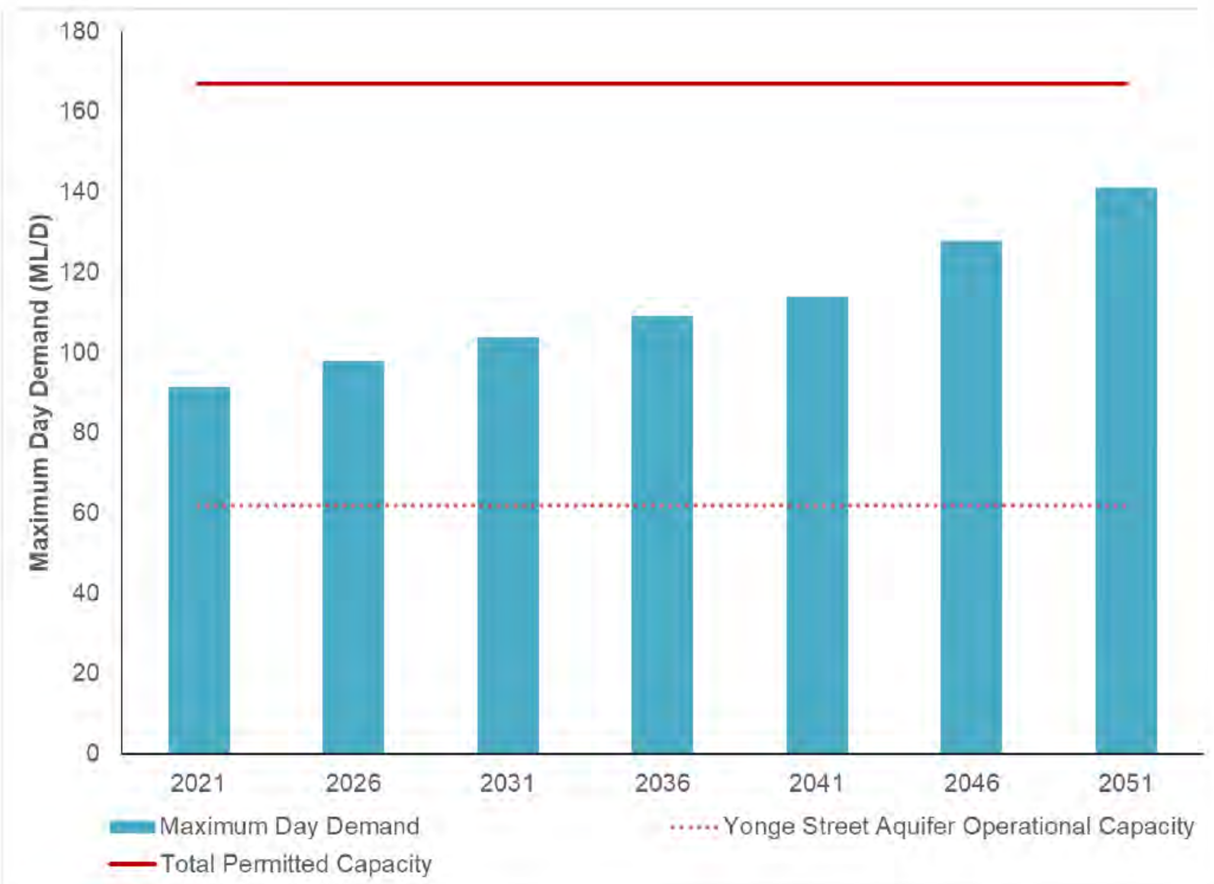

Figure 1. Forecasted Maximum Day Demand and Supply Capacity in Aurora, East Gwillimbury, and Newmarket (Source: 2022 York Region Water and Wastewater Master Plan)

Objective

This memorandum has been prepared with the following objectives:

- Review the current YSA operational capacity for each groundwater supply well previously assessed as part of the YSA Well Capacity Restoration Environmental Assessment (EA) project and identify revisions required based on the current state of supply wells permitted under the YSA PTTW.
- Provide an overview of well condition for individual production wells of concern, where operational capacity restrictions exist.
- Provide recommendation and next steps to restore YSA operational capacity.

Summary of Historical Well Capacity Assessments

In 2012, AECOM Canada Ltd. (AECOM) completed a well performance evaluation as part of the YSA Well Capacity Restoration Project. The objective of this assessment was to identify well operation constraints and quantify the capacity that has been lost due to operational issues. Results of this investigation indicated that all wells should be able to operate to their permitted capacities, except for the following:

- **Aurora PW5**: Operated below the permitted rate at 5,184 m^3/day to avoid possible premature fouling.
- **Aurora PW6**: Operated below the permitted rate at 2,420 m^3/day to avoid sand production issues.
- **Newmarket PW14**: Well not in operation due to aesthetic and operations water quality issues.
- **Newmarket PW15**: Operated below the permitted rate at 2,160 m^3/day to avoid sand production issues.

AECOM (2012) concluded that the 2012 'present-day' conditions of the wells resulted in a lost capacity in the YSA groundwater supply system of 5,161.6 m^3/day (59.7 liters per second [L/s).

In 2015, Water Resources investigated the condition of all groundwater production wells within York Region to identify wells that require replacement or that are likely to require replacement or major modification by 2035. Production wells were evaluated against key parameters, such as well age, rehabilitation rate/frequency and success, structural condition and surficial impact. Results of this investigation concluded that the following production wells within the YSA groundwater supply system require replacement or major modification within the 20-year planning horizon (2035):

- **Aurora PW1, PW2, PW3**: Identified for continued monitoring due to well age exceeding the predicted life span for a supply well in 2035.
- **Aurora PW6**: Identified for replacement due to well performance instability and loss of well capacity.
- **Newmarket PW14**: Not in operation and identified for replacement due to elevated chloride concentration.
- **Newmarket PW15**: Identified for replacement due to well performance instability and loss of well capacity.

In 2016, Water Resources completed an assessment of the feasibility of replacing those wells identified in the 2015 investigation and recommended an implementation plan for corrective action to restore lost capacity. Results of the feasibility assessment for the two existing wells identified as needing replacement within the YSA groundwater supply system (Aurora PW6 and Newmarket PW15) concluded that off-site replacement may be required due to site-specific property constraints and geological conditions contributing to the well performance issues. It was recommended that well replacement options be evaluated as part of the YSA Well Capacity Restoration EA.
York Region completed the YSA Well Capacity Restoration EA in December of 2016. The Class EA study identified the following preferred solution to restore full permitted well capacity of York Region's water system in the YSA area while ensuring that future water demands can be met, the reliability of the water supply is maintained or enhanced, and the responsible management of groundwater in the YSA is continued:

- Rehabilitate existing wells at Aurora Well No. 5, Aurora Well No. 6, and Newmarket Well No. 15 to restore up to 29 L/s
- Construct two new wells at Well Area 6 (Green Lane Site) with an estimate combined capacity of 80 to 100 L/s
- Construct new well at Well (Aurora Well No. 5 Site) with an estimated capacity of 40 to 65 L/s

YSA Well Capacity Update (2022) and Detailed Well Condition Assessment

The following provides an update to the well condition assessments previously performed for the YSA supply wells. A detailed review of well condition and performance was completed for individual production wells of concern, where operational capacity restrictions were previously identified, including Aurora PW1, PW3, PW4, PW5 and PW6, and Newmarket PW14 and PW15.

Aurora PW1, PW2, PW3, PW4

Well performance testing (step-testing) at Aurora PW1, PW2, PW3, and PW4 was completed between April 2020 and April 2021. Results indicated that there is evidence of well efficiency deterioration since the time of construction at all wells, however, performance remains stable.

With routine inspection and completion of rehabilitation, when required, all wells are expected to be capable of supplying the individual permitted capacity in the long-term (20 years). Structural integrity of the wells will need to be monitored closely as Aurora PW1, PW2 and PW3 are nearing the predicted ‘end-of-life’ of 75 years for well casing material and components.

Since it is considered feasible to replace one or more wells at the existing well site, with consideration for future treatment facility upgrades, off-site well capacity replacement is not required.

Aurora PW5

Well performance testing (step-test) at Aurora PW5 was completed in April 2021. The well performance test results indicated a decrease in specific capacity of 25% from the original construction conditions but only a 1% decrease from the 2014 conditions, following the last rehabilitation. Analysis of the step-test data predicted a drawdown of approximately 5 meters (m) from the static water level at the time of the test, at the maximum permitted rate of 68.19 L/s, which indicates nearly 55 m of available drawdown at Aurora PW5. Performance projections indicate Aurora PW5 is sustainable throughout the current 20-year planning horizon, based on historical performance and continued operation and maintenance under current conditions.

It is expected that Aurora PW5 can meet the permitted capacity as operation restrictions aimed to avoid possible premature fouling are not considered required. Integration of the new well (Aurora PW7) is expected to impact the available drawdown at Aurora PW5 under concurrent well operation scenarios, however, this is not expected to impact well performance or the ability for the well to produce up to the permitted capacity.

Aurora Well No. 6

Aurora PW6 was constructed in 1991 as a 20-inch gravel wall well with a 12-inch back off capable of producing 40 L/s instantaneously (short-term) and 20 L/s continuously (long-term). The York Region files indicate that the well was rehabilitated in 2008, 2015 and 2019, following the identification of significant performance declines. In 2008, rehabilitation was considered successful and recovered approximately 27 m of drawdown (at 19 L/s). The 2015 rehabilitation program was considered unsuccessful because it was only able to recover approximately seven metres of lost drawdown (at 19 L/s). In 2019, a third rehabilitation attempt was completed and was also considered unsuccessful, as only 9.1 m of drawdown (at 20.6 L/s) was gained. The three rehabilitation programs were conducted with similar methodologies and following industry standards/guidelines. It cannot be explained why the 2015 and 2019 rehabilitation program could not recover more of the lost drawdown. It is believed that the local aquifer formation material is finer (fine sand and clay) compared to other YSA wells, and fine sand migration through the aquifer has resulted in a permanent reduction in well transmissivity. As such, future well rehabilitation efforts are not expected to be successful at restoring lost capacity from this well. A summary of well performance for Aurora PW6 is shown in **Figure 2**.

During the well pump installation following the 2019 rehabilitation, the J-hook feature in the casing was bent inward, preventing the passing of the pump suction. Pump setting was decreased to 60.1 m from the previous pump setting of 70.1 m and a further reduction in the available drawdown for the well was observed. **Figure 3** shows the modified well diagram for Aurora PW6.

Water quality challenges, such as discolouration, water age, and chlorine residual, have been observed within the central east pressure district for which Aurora PW6 supplies water. York Region Operations, Maintenance and Monitoring and the Town of Aurora considered areas for improvement and mitigation measures required to improve overall water quality in the distribution system. One mitigation measure explored was the reduction in groundwater supply in the pressure district, resulting in a significant reduction in water production from Aurora PW6 starting in 2017. Total annual production volumes from Aurora PW6 from 1996 to 2022 is shown in **Figure 4**.

As a result of well capacity constraints, structural damage to the well casing and the need to maintain water quality in the central east pressure district of Aurora, Aurora PW6 was put offline in September 2019. Because it is more efficient to operate wells with higher yield than maintaining lower yield well, it was determined that well replacement would be required for the purposes of replacing lost capacity. As it would not be feasible to replace Aurora PW6 at the existing site due to site size limitations associated with the necessary upgrades to the treatment facility for iron and manganese removal technology, off-site well replacement is required.

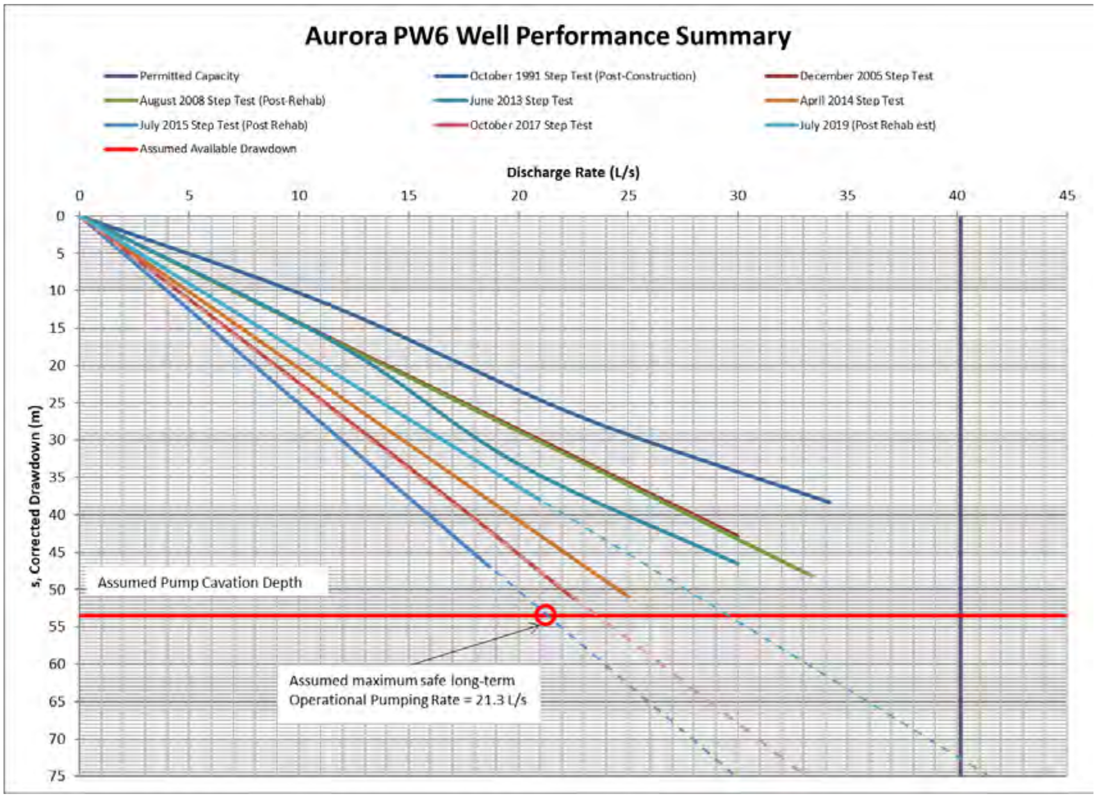

Figure 2. Aurora PW6 Well Performance Summary

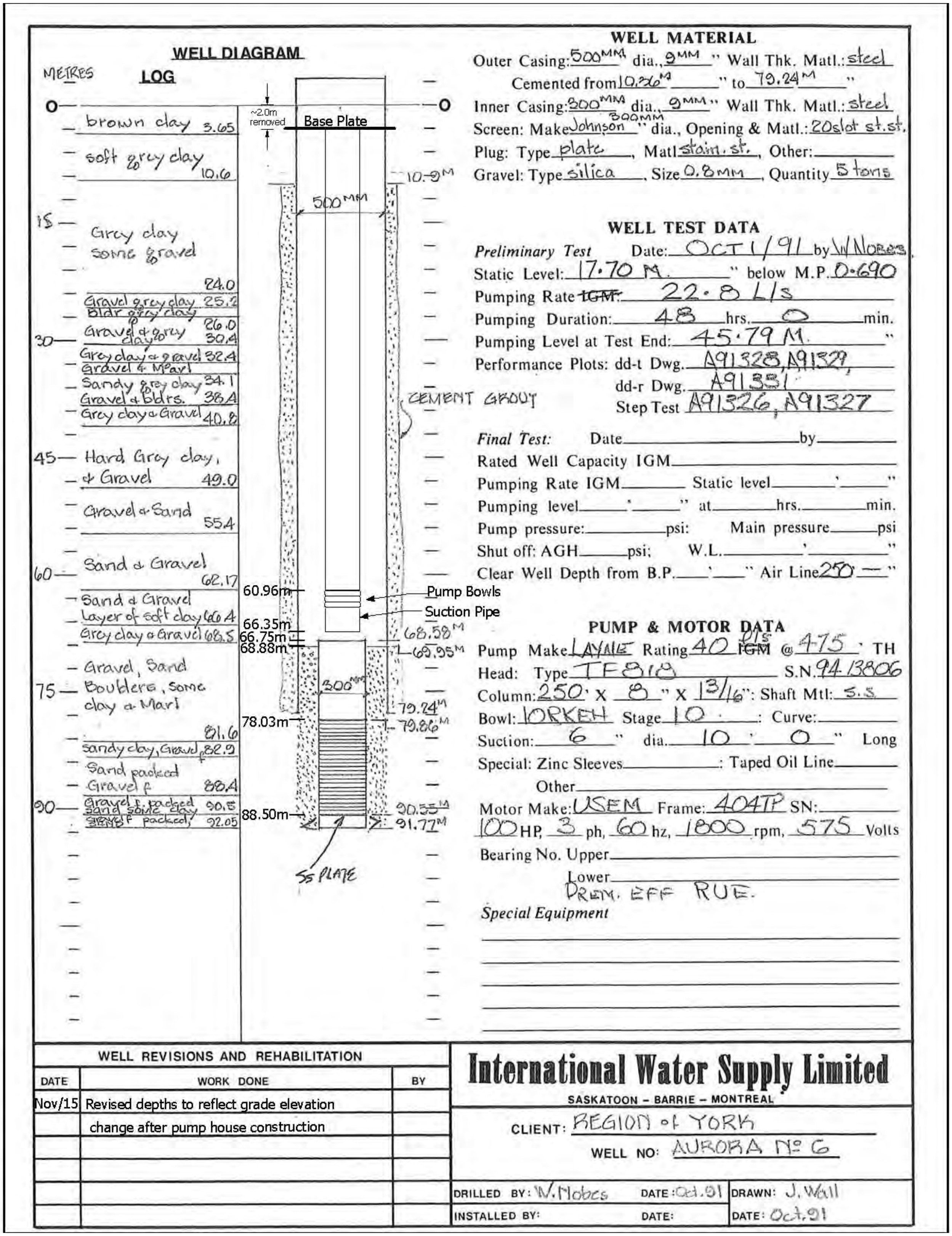

Figure 3. Aurora Well No. 6 Revised Well Diagram (IWS, 2019)

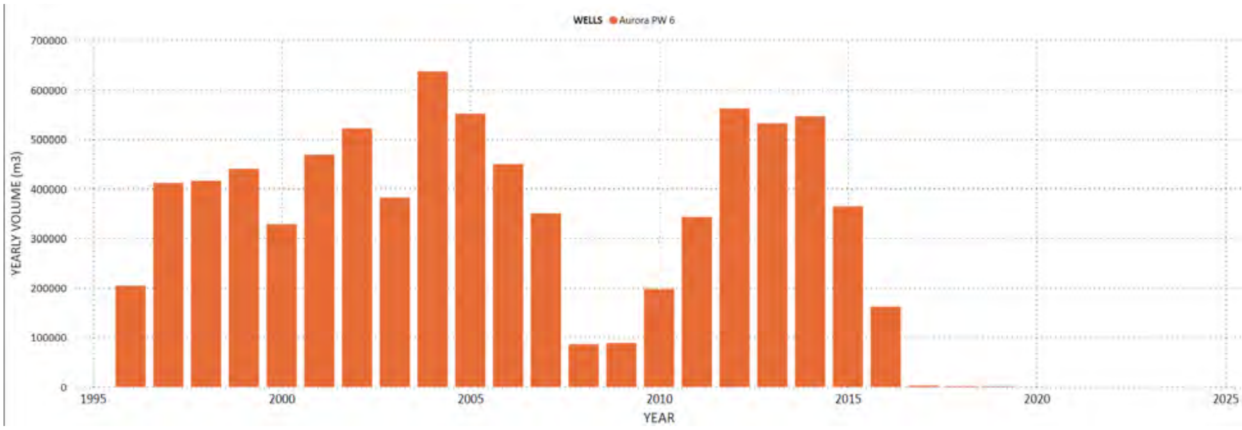

Figure 4. Aurora Well No. 6 Total Annual Production

Holland Landing Well No. 1 and No. 2

Holland Landing PW1 was constructed in 1957, has been step-tested three times and was rehabilitated once in 2010. A recent well performance test completed in March 2018 indicates Holland Landing PW1 may require rehabilitation within the next 10 years to ensure sustainable operation at the permitted capacity (26.5 L/s) throughout the current 20-year planning horizon.

Holland Landing PW2 was constructed in 1977, has been step-tested four times and has been rehabilitated once in 2007. A recent well performance test completed in February 2016 indicates Holland Landing PW2 may require rehabilitation within the next 10 years to ensure sustainable operation at the permitted capacity (41.6 L/s) throughout the current 20-year planning horizon.

With routine inspection and completion of rehabilitation, when required, Holland Landing PW1 and PW2 are expected to be capable of supplying the individual permitted capacity in the long term (20 years). It would not be feasible to replace Holland Landing PW1 (if required) at the existing site due to site limitations; off-site well replacement would be required.

Newmarket Well No. 1 and No. 2

Newmarket PW1 was constructed in 1957, has been step-tested four times and has never been rehabilitated. In 1994, the well reportedly produced sand, and well re-development was undertaken, including the installation of a liner inside the original screen. Subsequent well performance tests indicate that the well modification (screen liner) was effective at preventing sand issues and did not result in a loss of well efficiency. A recent well performance test completed in September 2020 confirmed that Newmarket PW1 well efficiency is stable and capable sustaining the permitted capacity of 26.5 L/s long term.

Newmarket PW2 was constructed in 1966 has been step-tested four times and has never been rehabilitated. A recent well performance test completed in May 2019 confirmed that Newmarket PW2 well performance is stable and capable of sustaining the permitted capacity of 53 L/s.

With routine inspection and completion of rehabilitation, when required, Newmarket PW1 and PW2 are expected to be capable of supplying the individual permitted capacity in the long term (20 years). Structural integrity of the wells will need to be monitored closely, as both wells are nearing the predicted ‘end-of-life’ of 75 years for well casing material and components. Since it is considered feasible to replace one or more wells at the existing well site, with consideration for future treatment facility upgrades, off-site well capacity replacement is not required.

Newmarket Well No. 13 and No. 16

Newmarket PW13 was constructed in 1977, has been step-tested eight times, and has been rehabilitated once in 2010. A recent well performance test completed in January 2022 indicates Newmarket PW13 may require rehabilitation within the next 10 years to ensure sustainable operation at the permitted capacity (68.2 L/s) throughout the current 20-year planning horizon.

Newmarket PW16 was constructed in 1983, has been step-tested seven times, and has been rehabilitated twice in 2006 and 2012. A recent well performance test, completed in June 2019, indicates Newmarket PW16 may require rehabilitation within the next 10 years to ensure sustainable operation at the permitted capacity (65.2 L/s) throughout the current 20-year planning horizon.

With routine inspection and completion of well rehabilitation, when required, Newmarket PW13 and PW16 are expected to be capable of supplying the individual permitted capacity in the long term (20 years). Should well replacement be necessary, it is considered feasible to replace one or more wells at the existing well site, even with consideration for future treatment facility upgrades, and therefore, off-site well capacity replacement would not be required.

Newmarket Well No. 14

Newmarket PW14 has not been in operation since mid-2009 due to adverse water quality issues. As a result, PW14 was decommissioned by a licensed Water Well Driller in February 2021 and removed from the permit in 2020. Well replacement at an alternative (off-site) location with improved water quality was required for the purposes of replacing lost capacity and has since been restored with the addition of Aurora PW7.

Newmarket Well No. 15

Newmarket PW15 is a 406-millimeter (16-inch) diameter drilled well constructed in 1978 (44 years old) with a 254-millimeter (10-inch) telescoping stainless screen with artificial sand-pack construction. This well contains a back-off coupling at the top of the screen that may be made of carbon steel. If differing metal types are indeed present, this well is more susceptible to galvanic corrosion and a reduced life expectancy.

York Region files indicate that the well has been rehabilitated four times following significant performance declines. Rehabilitation efforts occurring in 1996, 2000, 2007, and 2014 were considered successful in restoring well efficiency and performance; however, the sustainability of the rehabilitation is unknown due to the frequency of performance tests completed and observed decline in performance following rehabilitation (as shown in **Figure 5)**. Recent well performance test results, completed in October 2021, showed no loss in well performance since the time of construction, proving the well capable of producing the targeted permitted capacity of 37.9 L/s with more than 35 m of available drawdown remaining. This increase in well efficiency may be attributed to the lack of well operation over the past 6 years, and it can be expected that further declines in well performance will resume if the well is operated normally.

During the 2014 rehabilitation, approximately 65 gallons of sand were removed. Artificial sand pack material was added to bring the pack up from depths of 78.1 m to a depth of 75.5 m below ground surface. The reason for loss of sand pack could not be definitively determined, as there were no breaches in the lead pipe noted during the well video inspection, and all joints in the screen appeared to be in good condition. It is suspected that there is some movement of sand pack at the very top of the lead pipe where some ‘bubbling’ was observed that could potentially lead to sand pack over topping the lead pipe and falling into the well (**Figure 6**).

To mitigate sand-pack movement and depletion, Newmarket 15 is recommended to run at 25 L/s continuously instead of at its rated capacity of 37 L/s in order to avoid the previous practice of frequent start/stop operation.

Water quality challenges in the distribution system, such as discolouration, water age, and chlorine residual, have been observed within the Newmarket area. York Region Operations, Maintenance and Monitoring and the Town of Newmarket considered areas for improvement and mitigation measures required to improve overall water quality in the distribution system. One mitigation measure explored was the reduction in groundwater supply in the Newmarket area, resulting in a significant reduction in water production from Newmarket PW15 starting in 2016. In 2020, the well was taken offline due to operational challenges associated with maintaining well sites with reduced or restrictive production rates. Total annual production volumes from Newmarket PW15 from 1996 to 2022 is shown in **Figure 7**. Late in 2022, the Town of Newmarket requested that York Region commission Newmarket PW15 with the intended purpose of improving water age in the northeastern areas of the Newmarket distribution system as a temporary measure until the Green Lane Water Treatment Plant (WTP) is commissioned.

As a result of well capacity constraints, the need for frequent and exhaustive rehabilitation efforts, potential advanced deterioration to the well casing, and sand production issues, it was determined that well replacement would be required for the purposes of replacing lost capacity. As it would not be feasible to replace Newmarket PW15 at the existing site due to site limitations, off-site well replacement is required.

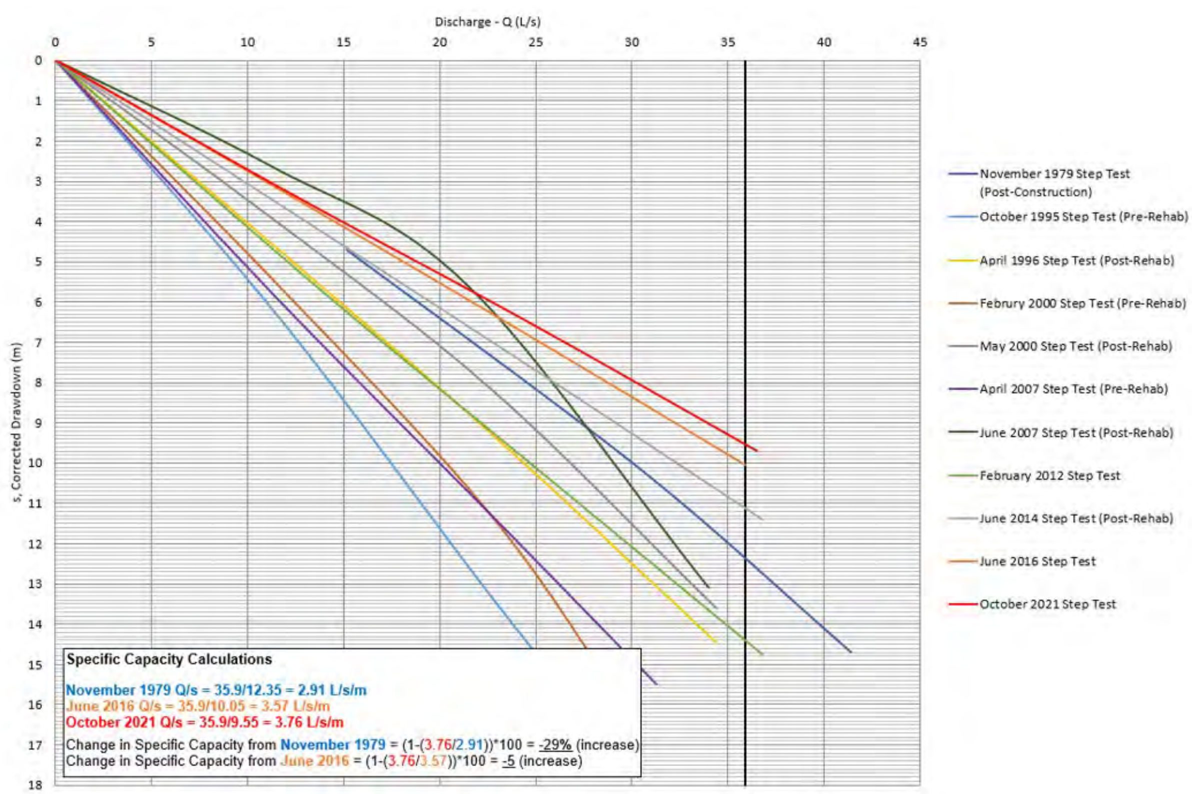

Figure 5. Newmarket PW15 Well Performance Summary

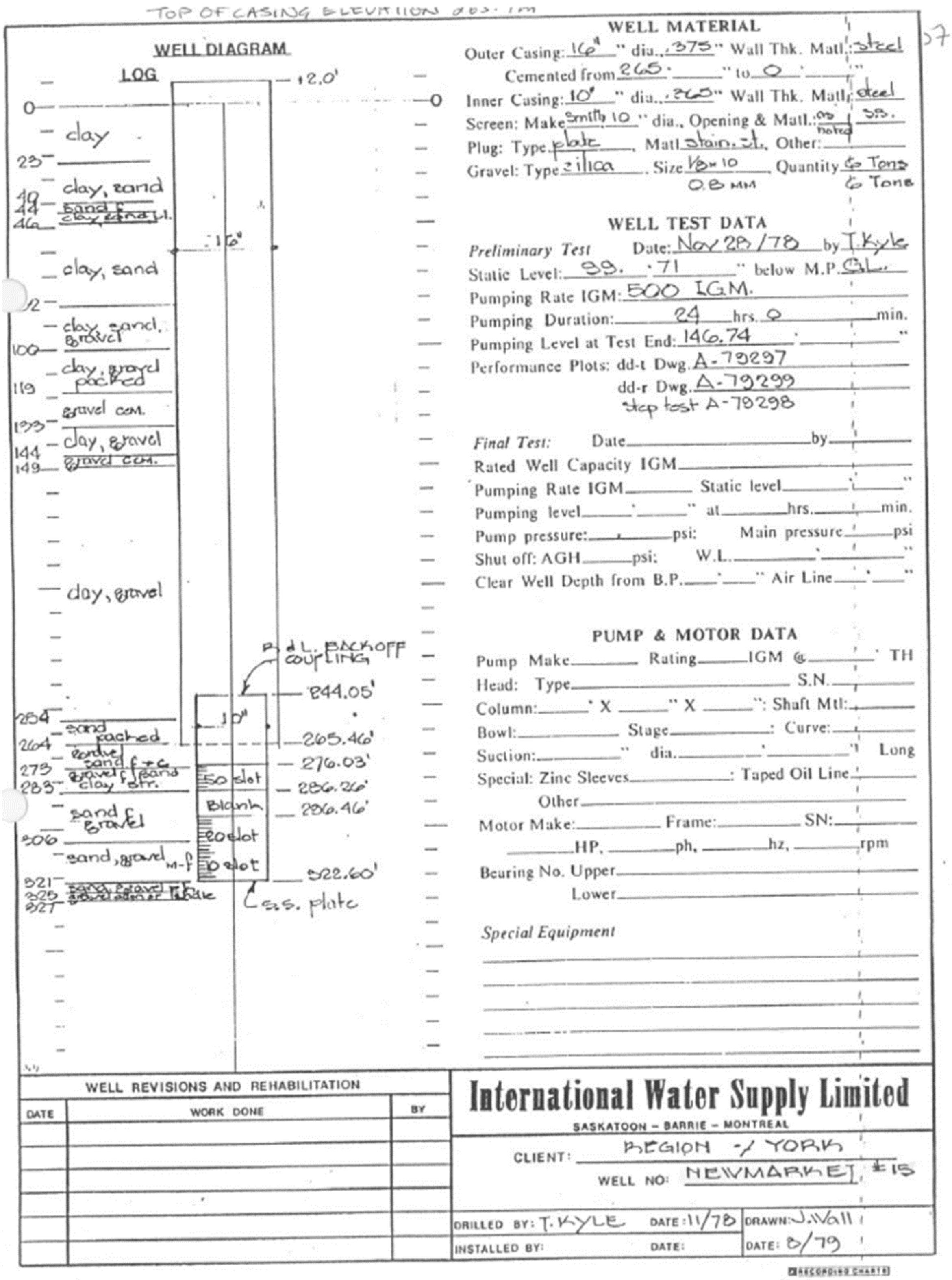

Figure 6. Newmarket Well No. 15 Well Diagram

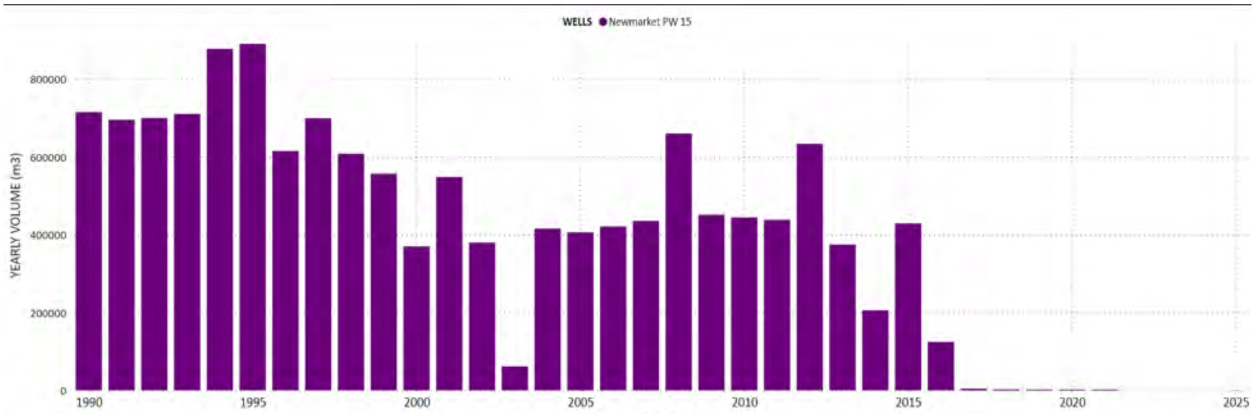

Figure 7. Newmarket Well No. 15 Total Annual Production Summary

Queensville Well No. 1 and No. 2

Queensville PW1 was constructed in 1991, has been step-tested four times, and has been rehabilitated once in 2011. The most recent well performance test was completed in October 214 and showed well performance to be stable and that the well is capable of operating at the permitted rate of 75.7 L/s.

Queensville PW2 was constructed in 1991, has been step tested four times and has never required rehabilitation. The most recent well performance test was completed in June 2016 and confirmed that Queensville PW2 well performance is stable and capable of sustaining the permitted capacity of 75.7 L/s.

With routine inspection and completion of rehabilitation, when required, Queensville PW1 and PW2 are expected to be capable of supplying the individual permitted capacity in the long-term (20-years).

Queensville Well No. 3 and No. 4

Queensville PW3 was constructed in 1990, has been step tested four times and has never required rehabilitation. The most recent well performance test was completed in September 2016 and confirmed that Queensville PW3 well performance is stable and capable of sustaining the permitted capacity of 75.7 L/s.

Queensville PW4 was constructed in 1990, has been step-tested four times and has never required rehabilitation. The most recent well performance test was completed in October 2019 and confirmed that Queensville PW4 well performance is stable and capable of sustaining the permitted capacity of 75.7 L/s

With routine inspection and completion of rehabilitation, when required, Queensville PW3 and PW4 are expected to be capable of supplying the individual permitted capacity in the long term (20 years).

Well Capacity Update Summary

As part of the YSA Well Capacity Restoration EA, AECOM completed a Well Performance Evaluation report, which concluded that the YSA system has lost 5,161,600 L/day of capacity. Since this assessment was completed in 2012, additional well capacity restrictions, water quality issues, and operational constraints have increased risk to the YSA groundwater supply due to the increase in lost capacity to 9,033,840 L/day. Considering the restoration of a portion of this lost capacity with the addition Aurora PW7 to the PTTW, the remaining lost capacity yet to be restored is 4,281,840 L/day as summarize in **Table 2**.

Table 2. Summary of Practical YSA Well Capacity and Comparison to PTTW

Well ID	Date Constructed	Permitted Maximum Rate (L/min)	Permitted Daily Maximum Taken (L/day)	Practical Daily Maximum Taking (L/day)	Lost Well Capacity (L/day)	Notes/ Considerations
Aurora PW1	May 27, 1957	2,273	3,273,120	3,273,120	0	Well is nearing predicted end-of-life but off-site well capacity replacement is not required.
Aurora PW2	June 24, 1959	4,092	5,891,760	5,891,760	0	Well is nearing predicted end-of-life but off-site well capacity replacement is not required.
Aurora PW3	July 18, 1960	3,637	5,237,136	5,237,136	0	Well is nearing predicted end-of-life but off-site well capacity replacement is not required.
Aurora PW4	November 20, 1978	5,455	7,855,632	7,855,632	0	None
Aurora PW5	February 22, 1988	4,092	5,891,760	5,891,760	0	None
Aurora PW6	July 5, 1991	2,409	3,469,536	0	3,469,536	Off-site well replacement would be required for the purposes of replacing lost capacity due to well capacity constraints, structural damage to the well casing and water quality issues.
Aurora PW7	September 15, 2016	3,300	4,752,000	4,752,000	(4,752,000)	New well added to PTTW to restore lost capacity from the removal of Newmarket PW14.

Well ID	Date Constructed	Permitted Maximum Rate (L/min)	Permitted Daily Maximum Taken (L/day)	Practical Daily Maximum Taking (L/day)	Lost Well Capacity (L/day)	Notes/ Considerations
Newmarket PW1	April 15, 1957	1,591	2,291,184	2,291,184	0	Well is nearing predicted end-of-life but off-site well capacity replacement is not required.
Newmarket PW2	October 4, 1966	3,182	4,582,512	4,582,512	0	Well is nearing predicted end-of-life but off-site well capacity replacement is not required
Newmarket PW13	May 1, 1977	4,092	5,891,760	5,891,760	0	None
Newmarket PW14	February 1, 1978	1,591	2,291,184	0	2,291,184	Well has been decommissioned and removed from the PTTW due to water quality issues.
Newmarket PW15	November 1, 1978	2,273	3,273,120	0	3,273,120	Off-site well replacement would be required for the purposes of replacing lost capacity due to well capacity constraints, the need for frequent and exhaustive rehabilitation efforts, potential advanced deterioration to the well casing and sand production issues.
Newmarket PW16	April 1, 1983	3,910	5,629,824	5,629,824	0	None
Holland Landing PW1	September 16, 1974	1,591	2,291,184	2,291,184	0	None
Holland Landing PW2	July 25, 1977	2,500	3,600,432	3,600,432	0	None

Well ID	Date Constructed	Permitted Maximum Rate (L/min)	Permitted Daily Maximum Taken (L/day)	Practical Daily Maximum Taking (L/day)	Lost Well Capacity (L/day)	Notes/ Considerations
Queensville PW1	August 1, 1991	4,546	6,546,384	6,546,384	0	None
Queensville PW2	May 22, 1991	4,546	6,546,384	6,546,384	0	None
Queensville PW3	March 17, 1990	4,546	6,546,384	6,546,384	0	None
Queensville PW4	February 8, 1990	4,546	6,546,384	6,546,384	0	None

Total Permitted Capacity (L/day)[a]	**90,116,496**
Total Practical Capacity (L/day)[b]	**83,373,840**
Total Lost Capacity (L/day)[c]	**9,033,840**
Total Remaining Lost Capacity (L/day)[d]	**4,281,840**

Notes:
[a] "Total Permitted Capacity" of 90,116,496 includes the capacity of Aurora PW7 and excludes capacity of Newmarket PW14 to represent the existing permitted capacity.
[b] "Total Practical Capacity" is the total capacity available in the YSA groundwater system as of 2022.
[c] "Total Lost Capacity" is the total capacity removed from the YSA groundwater system as a result of well performance or failure since the YSA EA was completed. Total includes the capacity of Newmarket PW14.
[d] "Total Remaining Lost Capacity" is the total lost capacity remaining after adding Aurora PW7 to the permit.

YSA PTTW Capacity Assessment

As discussed previously, the PTTW does not specify an average daily rate for each well, but rather limits the yearly daily average taking volume from all YSA wells to 42,000 m^3/day. Additionally, during the yearly peak demand period (May to September) the maximum allowable daily average taking from all YSA wells is increased to 67,200 m^3/day, while the maximum daily taking volume from all wells during this period is permitted up to 87,656 m^3/day.

As shown in **Figure 8**, a comparison of the practical well capacity of the YSA groundwater system (83,374 m^3/day) and the PTTW allowance for peak day demand (87,656 m^3/day) indicates a deficit of supply of 4,282 m^3/day. This assumes all remaining viable wells are in operation.

In the event the largest capacity well site (Aurora Wells 1-4) is impacted by well failure or unexpected well/facility maintenance work, the practical well capacity is reduced significantly. Well redundancy in the groundwater system is therefore an important consideration when calculating the surplus/deficit of supply. For example, should the highest capacity well in the YSA (Aurora PW4) require emergency well maintenance (chemical rehabilitation) during the peak demand period, the firm practical capacity of the YSA groundwater system is reduced to 61,116 m^3/day because all four wells at the well site would need to be taken offline as a preventative measure for the protection of water quality. In this worst-case scenario, the YSA groundwater system has a 26,540 m^3/day deficit compared to the maximum daily peak demand allowance under the PTTW.

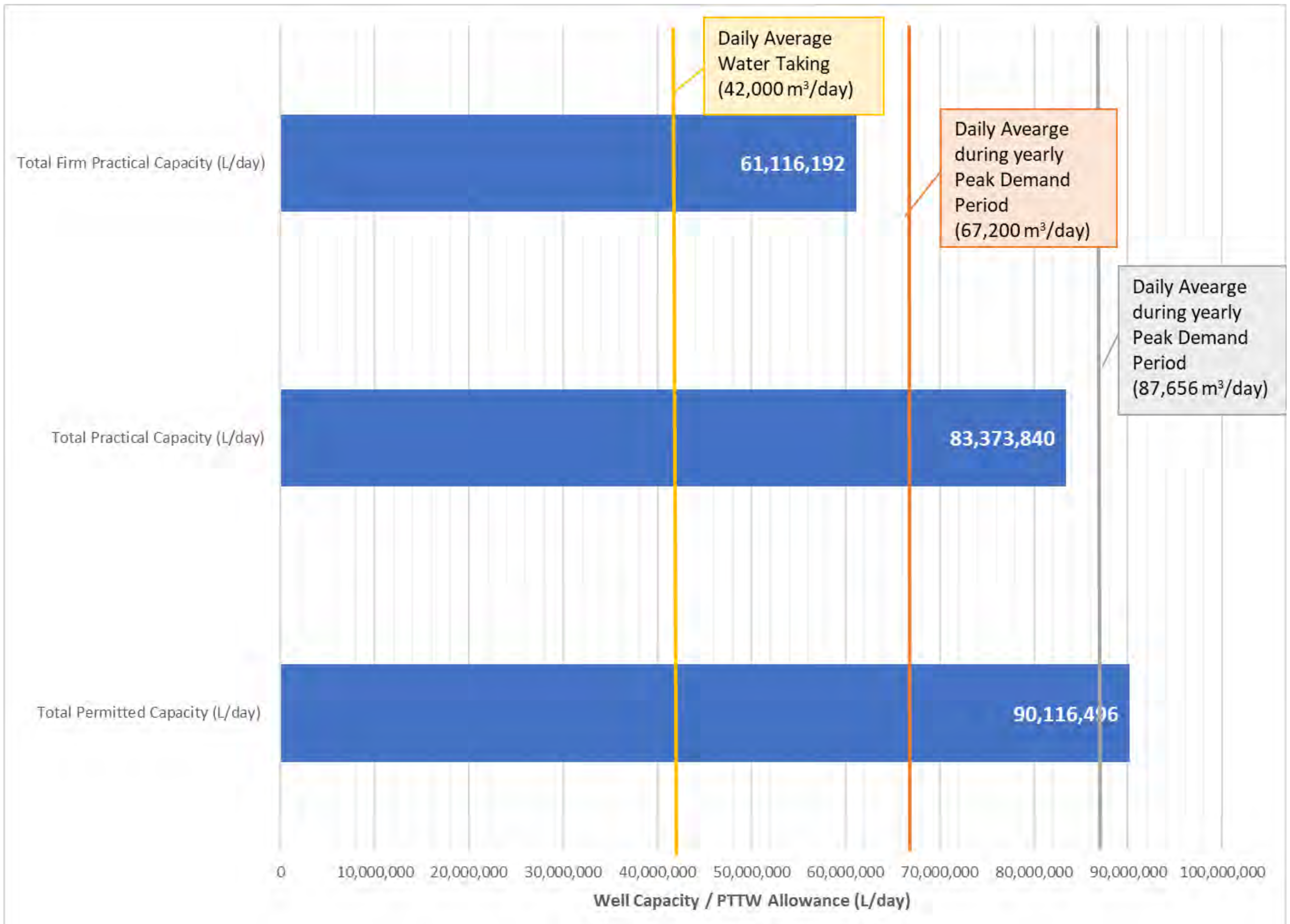

Figure 8. Comparison of YSA Well Capacity and PTTW Daily Limits

YSA PTTW Amendment Recommendation

Maintaining system capacity of the PTTW is required to sustain the existing anticipated growth in water demand and provide sufficient operational flexibility and redundancy to respond to unexpected changes in the supply system (i.e., reduction in lake-based supply, well failure, or water quality challenges) and/or system demand (i.e., emergencies such as fire flow). To replace lost capacity from Aurora PW6 and Newmarket PW15 a total of 4,282 m^3/day (50 L/s) would be required from the addition of off-site or new wells in the YSA groundwater system. To improve system redundancy, 26,540 m^3/day (307 L/s) would need to be added to the YSA groundwater system through the addition of new wells. A portion of this has been approved through the YSA Well Capacity Restoration EA. The remained firm capacity redundancy would need to be evaluated under a subsequent EA process.

The approved YSA Well Capacity Restoration EA allows for the development of three new wells at two sites with a combined capacity of 13,392 m^3/day within the YSA area to restore full permitted well capacity of York Region's water system. The EA also recommended the rehabilitation of Aurora Well PW5, Aurora PW6, and Newmarket Well PW15 to restore up to 2,505.6 m^3/day. Since the time the EA was approved York Region, attempted to rehabilitate Aurora PW6 and Newmarket PW15 to restore this lost capacity but were unsuccessful. York Region also constructed a second well (East Gwillimbury

PW2) at the Green Lane site and confirmed that the two wells could operate concurrently at a combined instantaneous pumping rate of 200 L/s with a maximum daily site capacity of 9,072 m^3/day during the peak demand period.

Based on this assessment, recommendations as presented in **Table 3** are proposed in consideration for the management of the YSA PTTW and future capital projects pertaining to groundwater supply system upgrades and/or maintenance.

Table 3. Proposed Permit to Take Water Amendment Strategy

Application Type	Schedule and Contingency	Description
Renewal	December 31, 2023	Water Resources to request a 10-yr extension of existing PTTW
Amendment #1	Following EA amendment[a] approval, prior to completion of detailed design (2026)	East Gwillimbury PW1 and PW2 to be added to the PTTW and permitted to operate concurrently at a combined instantaneous pumping rate of 200 L/s during the peak demand period and with a maximum daily site capacity of 9,072 m^3/day (105 L/s).
Amendment #2		Aurora PW6 to be decommissioned and removed from the PTTW.
Amendment #3	Following the commissioning of the Green Lane Water Treatment Plan (2028)	Newmarket PW15 to be decommissioned and removed from the PTTW following the commissioning of East Gwillimbury PW1 and PW2 as this well will be required to operate during the construction of the Green Lane WTP to maintain water quality in the distribution system.

Notes:
[a] EA amendment required to increase Green Lane WTP capacity to 200 L/s and increase production well instantaneous capacity. Amendment is planned to be completed as part of Preliminary Design by Jacobs Engineering by the end of 2022.

As summarized in **Table 3**, the existing PTTW (No. 1736-BKZPJD) is due to expire on December 31, 2023. It is recommended that a PTTW renewal application be submitted prior to, and separate from, a request for Amendment #1 and Amendment #2, which is to be submitted during detailed design of the Green Lane WTP to support the Drinking Water Works Permit application. Newmarket PW15 will be required to operate during the construction of the Green Lane WTP to maintain water quality in the distribution system. Following the commissioning of the Green Lane WTP (in approximately 2028), a request for Amendment #3 and the removal of Newmarket PW15 can be applied.

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eDOCS#14126793

Green Lane Well Site Groundwater Resource Evaluation

180 Green Lane East, East Gwillimbury, York Region, ON

York Region

The Regional Municipality of York

Green Lane Well Site Groundwater Resource Evaluation

180 Green Lane East, East Gwillimbury, York Region, ON

Prepared by the Public Works Department, Water Resources Group

February 2023

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Acronym Table

Acronym	Full Reference
AECOM	AECOM Canada Ltd.
ANSI	Areas of Natural and Scientific Interest
AWWA	American Water Works Association
$CaCO_3$	Calcium Carbonate
CAF	Chemically Assisted Filtration
CFU	Colony Forming Unit
cm	centimeters
E.coli	Escherichia coli
EA	Environmental Assessment
EG-PW1	East Gwillimbury Well No. 1
EG-PW2	East Gwillimbury Well No. 2
ESA	Environmentally Significant Area
FOI	Freedom of Information
GUDI	Groundwater Under the Direct Influence of Surface Water
L/s	Liters per second
Lotowater	Lotowater Technical Services Inc.
LSRCA	Lake Simcoe Region Conservation Authority
m	meters
m^2/day	Square meters per day
m^3	Cubic meters
m^3/day	Cubic meters per day
masl	Meters above sea level
Matrix	Matrix Solutions Inc.
mbgs	Meters below ground surface
MECP	Ministry of Environment Conservation and Parks
mg/L	milligrams per litre
mL	milliliters
MP	Mini-Piezometer
MW	Monitoring Well
N	No
N/A	Not Available
NTU	Nephelometric Turbidity Units
O. Reg.	Ontario Regulation
ODWSOG	Ontario Drinking Water Standards, Objectives and Guidelines
ORAC	Oak Ridges Aquifer Complex
ORM	Oak Ridges Moraine
ORMGP	Oak Ridges Moraine Groundwater Program
PBADs	Pigment-Bearing Algae and/or Diatoms
ppm	parts per million

Acronym	Full Reference
PTTW	Permit to Take Water
PW	Production Well
RAD	Remaining Available Drawdown
S	Storativity
SAC	Scarborough Aquifer Complex
SG	Stream Gauge
Spp	species pluralis
T	Transmissivity
TAC	Thorncliffe Aquifer Complex
ToR	Terms of Reference
TSS	Total Suspended Solids
UVT	Ultraviolet Transmittance
WCH	Water Column Height
WHPA	Wellhead Protection Area
Y	Yes
York Region	The Regional Municipality of York
YSA	Yonge Street Aquifer
ZOI	Zone of Influence

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1.0 Introduction

The Regional Municipality of York (York Region) has completed a hydrogeological investigation in the Town of East Gwillimbury as part of the Green Lane Well 2 Construction Project. The Green Lane Well 2 Construction Project has the objective to provide system redundancy and replace lost capacity from other municipal production wells permitted under the Yonge Street Aquifer (YSA) Permit to Take Water (PTTW) (Amended PTTW No. 1736-BKZPJD) by constructing a second municipal well at the Green Lane site as part of the recommendations from the *Schedule B Class Environmental Assessment (Class EA) for the Yonge Street Aquifer Well Capacity Restoration Project* completed by the Region in 2016.

This hydrogeological investigation consisted of four tasks:

- Task 1: Desktop Hydrogeological Assessment and Permits/Approvals;
- Task 2: Large Diameter Test Well Construction and Monitoring Network Establishment;
- Task 3: Aquifer Testing; and,
- Task 4: Analysis and Reporting.

As detailed in **Section 1.1**, the hydrogeological investigation was undertaken to meet the requirements of Task 2 through to Task 4 of the Green Lane Well 2 Construction Project based on the recommendations of Task 1. A temporary Category 3 Permit To Take Water (PTTW) application was prepared to support the development and aquifer testing associated with a large diameter test well. The hydrogeological report supporting the temporary Category 3 PTTW application was submitted under a separate cover in May 2021 (York Region, 2021); the issued temporary PTTW No. P-300-1131641248 is included in **Appendix A**.

Task 2 involved the procurement of services of a licensed water well driller and construction of a 30.5 centimeter (cm) diameter test well with aquifer testing being completed in Task 3.

This hydrogeological investigation report, completed under Task 2 to 4, documents the work involved in drilling, constructing and testing a 30.5 cm diameter test well as well as Task 4 requirements of the hydrogeological analyses conducted to assess the well and aquifer performance, and the potential impacts of groundwater takings on nearby groundwater receptors.

1.1 Background and Study Objective

The existing well, East Gwillimbury Well No. 1 (EG-PW1), formerly referred to as EG-MW2 (MECP Well No. 7285159), was drilled and constructed in 2016 by Gerrits Drilling & Engineering Ltd., under contract by AECOM Canada Ltd. (AECOM), as part of a groundwater exploration project that was undertaken based on the recommendations of the Schedule ‘B’ Yonge Street Aquifer Well Capacity Restoration Class Environmental Assessment (EA). The EA had the objective of identifying the preferred solution to restore the full permitted capacity of the Yonge Street Aquifer groundwater supply system while ensuring a reliable water supply that can meet future water demands (AECOM, 2016). The EA recommended that production wells permitted under the Yonge Street Aquifer PTTW (Amended PTTW No. 1736-BKZPJD) where operational issues had been identified be rehabilitated and that new production wells be installed to restore and improve redundancy of the groundwater supply system (AECOM, 2019). The 2016 groundwater exploration work was conducted to assess additional well capacity at the Yonge Street/Green Lane Area, in the Town of East Gwillimbury, as one of the areas selected for field investigation as part of the alternative municipal well area selection process completed under the EA by AECOM in 2012.

The Yonge Street Aquifer (YSA) groundwater supply system of York Region is composed of a network of 18 municipal production wells which supply potable water to the Town of Aurora, the Town of Newmarket as well as the Community of Holland Landing, and Village of Queensville in the Town of East Gwillimbury. The production wells source groundwater from the YSA which is interpreted to correspond to sand and gravel deposits associated with a Thorncliffe Formation-age channel that extends in a general north-south direction along Yonge Street from the Community of Oak Ridges to the south through the areas of Aurora, Newmarket, Queensville and Holland Landing to the north (Gerber et al., 2018). The groundwater supply in the YSA area is supplemented with surface water from Lake Ontario obtained via The Regional Municipality of Peel and/or the City of Toronto (York Region, 2019).

The 2016 groundwater investigation in the Yonge Street/Green Lane area involved the testing of EG-PW1 at a maximum pumping rate of 55 liters per second (L/s) and determined that the well would be capable of a yield of approximately 55 L/s (AECOM, 2016). Subsequently, to investigate potential additional capacity and to prove capacity requested under the EA, further aquifer testing was undertaken on EG-PW1 in late 2018 at a maximum pumping rate of 100 L/s. Based on the results of the aquifer test, it was determined that the site is capable of a yield of at least 100 L/s with acceptable water quality, with the exception of iron, which will need to be treated as part of the water supply treatment process. As such, to help restore lost capacity in the YSA groundwater supply system, while providing system redundancy, it was recommended that groundwater supply from the site be developed via two production wells with rated capacities of 55 L/s and 50 L/s, for a total site capacity of 105 L/s (AECOM, 2020). Reports prepared by AECOM on the results of pumping tests conducted on EG-PW1 in 2016 and 2018 are included in **Appendix B**.

Based on this recommendation, York Region constructed a second well on the same site as EG-PW1 (referred herein as East Gwillimbury Well No. 2 or EG-PW2). However, as this work also has the objective of informing the design of the future Green Lane Water Treatment Plant, the well construction and testing plan (outlined in **Section 3.0**) was conducted with the intent of assessing further groundwater development at the site so that the maximum proven site capacity can be built into the water treatment capabilities of the Water Treatment Plant. EG-PW1 was designed with a theoretical screen transmitting capacity of 104 L/s with a target theoretical screen transmitting capacity of the second well being 105 L/s. The objective was to construct East Gwillimbury Well No. 2 (EG-PW2), formerly referred to as EG-MW3 (MECP Well No. A315290) similarly to EG-PW1 and for the well capacities and overall site capacity to be tested at a combined target rate of 200 L/s. Should testing results indicate a maximum site yield exceeding the total site capacity of 105 L/s approved under the EA, the MECP will be consulted, and the appropriate EA evaluations completed by York Region under separate cover. This report may serve as a technical support document to this EA evaluation.

1.2 Scope of Study

The hydrogeological investigation documented in this report had the following scope to meet the objectives of the evaluation:

1. Evaluate geologic and hydrogeologic conditions at the drilling location through pilot hole advancement to facilitate the collection of soil samples for grain size analysis and comparison of results documented during the previous groundwater exploration program at the Site.

2. Finalize the well design for a large diameter test well (EG-PW2).

3. Construct a large diameter test well based on the final well design.

4. Conduct a step-drawdown test at the large diameter test well as a preliminary evaluation of well capacity. Use the test results to confirm similar or better performance than EG-PW1 and identify an appropriate discharge rate for the subsequent constant rate pumping test.

5. Conduct a 96-hour constant rate pumping test on EG-PW2 (the last 72 hours of which involving combined pumping with EG-PW1) to estimate aquifer properties, potential well and aquifer yield, and the potential for impacts to the surrounding shallow groundwater system, existing municipal wells and/or existing private wells.

6. Collect water quality samples during the step-drawdown test and constant rate pumping tests to further characterize the aquifer water quality, document the Groundwater Under the Direct Influence of Surface Water (GUDI) status of the well and further evaluate treatment requirements for municipal supply.

1.3 Study Area Description

EG-PW2 is approximately 17 meters (m) east of EG-PW1, which is situated at 180 Green Lane East, Town of East Gwillimbury, ON (the Site). More specifically, the Site is located immediately north of the Green Lane East right-of-way, and approximately 930 m east of Yonge Street. The Site location is illustrated on **Figure 1**. **Figure 2** shows the location of EG-PW1 and EG-PW2.

The Site encompasses an area of approximately 0.26 hectares and includes a crushed limestone drill pad from the previous groundwater exploration and part of an agricultural field. Four monitoring wells, including one well nest, owned by York Region are located just south and southwest of the Site within the Green Lane East right-of-way. The Site is bounded by Green Lane East to the south, and an agricultural field to the north, east and west.

The Site is in the Lake Simcoe Watershed within the East Holland River Subwatershed and falls within the Lake Simcoe Region Conservation Authority's (LSRCA's) jurisdiction. The closest surface water features to the Site include tributaries of the East Holland River to the north, west and east of the Site, as well as non-provincially significant wetlands regulated by the LSRCA to the northwest, west and southeast of the Site (**Figure 2**). The tributaries of the East Holland River are understood to be permanent warmwater features (AECOM, 2019).

2.0 Physical Setting

2.1 Topography and Drainage

The Site is in the Lake Simcoe Watershed within the East Holland River Subwatershed. At a regional scale, the topography in the Site area generally slopes northerly and northwesterly toward Lake Simcoe but is locally influenced by stream valleys. On the Site, the ground elevation ranges from approximately 254 meters above sea level (masl) in the northeastern corner of the Site to 259.5 masl in the southwestern corner. As such, surface drainage across the Site is expected to be primarily in a northeasterly direction toward the tributary of the East Holland River. The topography of the Site area is illustrated on **Figure 3**.

2.2 Physiography

The Site is located within the Schomberg Clay Plains physiographic region, just east of the boundary with the Simcoe Lowlands physiographic region. The Schomberg Clay Plains physiographic region is comprised of deposits of stratified fine-grained clay and silt sediments that overlie an irregular till plain and are typically 15 m in thickness (Chapman and Putnam, 1984).

The Simcoe Lowlands extend from the Oak Ridges Moraine (ORM) northward to Lake Simcoe and are characterized by deep valley features which generally correspond to existing flowing watercourses, including the Holland River, the Black River and the Maskinonge River. This physiographic region is thought to have been flooded by Glacial Lake Algonquin, which resulted in the deposition of lacustrine sand, silt, and clays (Chapman and Putnam, 1984). The physiography for the Site area is shown on **Figure 4.**

2.3 Regional Geology and Hydrostratigraphy

The understanding of the regional geology and hydrostratigraphy is based on the conceptual hydrogeological model of the Yonge Street Aquifer (YSA) presented in the article by Gerber et al. (2018). As previously mentioned, the YSA is the term given to the aquifer which sources 18 of York Region’s production wells in the Newmarket, Aurora, Queensville and Holland Landing areas. It extends in a general north-south direction along Yonge Street from the Community of Oak Ridges to the south through the areas of Aurora, Newmarket, Holland Landing, and Queensville to the north. It is the screened aquifer for EG-PW1 and EG-PW2. The extent of the YSA, approximated from Gerber et al., 2018, is shown on **Figure 5.**

Based on this conceptual model of the YSA, the following stratigraphic layers are understood to be present in the YSA and vicinity (from youngest to oldest):

1) Glaciolacustrine Sediments
2) Oak Ridges Moraine Aquifer Complex and Oak Ridges Moraine-Age Channel Sediments
3) Newmarket Till
4) Thorncliffe Formation and Thorncliffe-Age Channel Sediments
5) Sunnybrook Drift
6) Scarborough Formation
7) Bedrock

A brief description of each stratigraphic layer is provided in the following paragraphs. **Figure 6** illustrates geologic transects for a North-South and a West-East cross-section through the YSA area (and near the Site) developed by Gerber et al. (2018), which are provided as **Figure 6a**.

<u>Glaciolacustrine Sediments</u>

The glaciolacustrine sediments are described as “rhythmically laminated silt–clay couplets and inter-bedded mud, fine sand, and silt diamicton” which were deposited in an ice-supported water body over a period of less than 100 years; possibly during waning flow to channel filling, or during events that led to the formation of the ORM ridge (Gerber et al., 2018). Based on the surficial geology map presented as **Figure 6** (captured from Gerber et al. [2018]), glaciolacustrine sediments are not expected to be present in the immediate vicinity of the Site.

<u>Oak Ridges Moraine Aquifer Complex and Oak Ridges Moraine-Age Channel Sediments</u>

The Oak Ridges Moraine Aquifer Complex (ORAC) is a sediment complex which was formed as a result of rapid sedimentation in subglacial, ice-marginal, and proglacial lacustrine environments during the Wisconsinan glaciation. It is consisted of interlobate glacial deposits whose texture ranges from silt to gravelly sand but that typically consist of sand and gravel sediments which can be up to 150 m thick (Earthfx, 2013).

Oak Ridges Moraine-Age Channel (ORM Channel) sediments are the result of the partial or full erosion of the Newmarket Till by subglacial meltwater flood events in certain areas. These erosional features are termed “tunnel channels” and were infilled with deposits as meltwater energy waned. The channel infill generally consists of a fining upward sequence whereby sand and gravel deposits (ORM Channel Sand) are overlain by bedded silts and clays (ORM Channel Silt) (Earthfx, 2013).

Although delineation of these ORM Channels in the YSA area has not been completed, they are believed to be shallow in the YSA area and to potentially be present in the Aurora, Newmarket, Holland Landing, and Queensville areas (**Figure 6a**). Locally, these tunnel channels may have incised in older Newmarket Till sediments, leading to possible hydraulic connections between ORM Channel deposits and older Thorncliffe-age Channel deposits. The tunnel channel sediments may also be overlain by ORAC sediments (Gerber et al., 2018).

The geologic cross-section featured in **Figure 6a** suggests that an ORM Channel may be present east of the Site in the area of Newmarket Monitoring Well (MW)-21D. However, its vertical and lateral extent is believed to be limited to that area. The Bradford Aquifer is situated west of the YSA and is incised into the inter-channel deposits and overlain by a thick clay and silt-confining unit. Hydrogeological studies discussed in Gerber et. al, 2018 conclude no hydraulic connection between the Bradford Aquifer and YSA was observed during a 64-day pumping test at the Bradford municipal wells, or a 19-day municipal well shut-down test in Holland Landing and Queensville (Gerber et. al., 2018).

Newmarket Till

The Newmarket Till is consisted of dense sand to silty sand diamicton sediments that were deposited when the Laurentide ice sheet was at its maximum extent approximately 20,000 years ago. The till unit can be up to 100 m thick but is typically 20 m to 30 m in thickness. It generally acts as a regional aquitard.

Around the beginning of the Mackinaw Phase, approximately 13,000 to 13,500 years ago, this unit was divided into discreet till units as a result of erosional events which created tunnel channels. In York Region, the major surface till is the Upper Newmarket Till, which is separated from the Lower Newmarket Till by Inter-Newmarket Sediments. The Inter-Newmarket Sediments form an intermediate aquifer unit consisted of glaciofluvial and glaciolacustrine sediments, including esker deposits, subaqueous fan deposits, and fine-grained lacustrine sediments (Earthfx, 2013).

Based on the surficial geology map captured from Gerber et al. (2018) (**Figure 6**), the surficial geology in the Site area is consisted of Newmarket Till.

Thorncliffe Formation and Thorncliffe-Age Channel Sediments

The Thorncliffe Formation was deposited approximately 45,000 years ago and acts as a regional aquifer. It is composed of lacustrine, fluvio-deltaic, and subaqueous fan sediments ranging from clayey silt to sand and minor gravel (Earthfx, 2013). Thorncliffe-Age Channel (Thorncliffe Channel) sediments are associated with a meltwater channel that formed late in Thorncliffe sedimentation. They are described from oldest to youngest as fining-upward infill deposits consisting of basal gravel overlain by sand underlying “rhythmically bedded mud”. These sediments are overlain by laterally extensive Thorncliffe post-channel silt-clay rhythmites referred to as a “Thorncliffe mud aquitard” (Gerber et al., 2018).

According to Gerber et al. (2018), the YSA is interpreted to correspond to sand and gravel deposits associated with the Thorncliffe Channel. It has been described as a coarse-grained aquifer up to 20 kilometers long and approximately 2 kilometers wide, with a thickness of approximately 50 m. It is a bounded, heterogenous aquifer, whereby sediments fine from north to south and laterally away from the coarse-grained sediments of the channel aquifer. This has resulted in much lower transmissivity (T) estimated from late-time pumping test data for wells screened in the YSA compared to early-time data (where T estimates are reported to range between 1,000 square meters per day (m^2/day) and 4,500 m^2/day). This suggests that lower permeability deposits are located along the limits of the higher transmissivity deposits associated with the YSA (Gerber et al., 2018). A hydraulic response (rebound) was observed within the YSA and the inter-channel sediments (both west and east of the YSA) when YSA production volumes were reduced due to the introduction of lake-based water supply (Gerber et al., 2018); therefore, a lateral hydraulic connection has been observed to exist between the YSA and the local inter-channel sediments. Additionally, a strong longitudinal response is observed along the axis of the YSA which dissipates laterally (Gerber, 2018).

There are no internal aquitards within the YSA such that no vertical hydraulic gradient exists within the channel aquifer. In the YSA area, the deep aquifer system is interpreted to be consisted entirely of sand and gravel deposits associated with the Thorncliffe Channel as the older Sunnybrook Drift and Scarborough Formation are believed to have been eroded, leaving the Thorncliffe Channel sediments to lie directly on bedrock (Gerber et al., 2018).

Sunnybrook Drift

The Sunnybrook Drift generally acts as an aquitard which separates the Thorncliffe Formation from the underlying Scarborough Formation. It is consisted of clast-poor silt and clay deposited by glacial and lacustrine processes (Earthfx, 2013). As previously indicated, the Sunnybrook Drift is interpreted to have been eroded by the Thorncliffe Channel in the YSA area but may be present beyond the YSA limits (Gerber et al., 2018).

Scarborough Formation

The Scarborough Formation marks the start of the Wisconsinan glaciations approximately 100,000 years ago and acts as a regional aquifer. The unit consists of a lower clay layer overlain by sands which were deposited as a result of fluvio-deltaic processes. It is mainly found within bedrock valleys and thins laterally away from the valleys (Earthfx, 2013). While the Scarborough Formation lies between the Sunnybrook Drift and the bedrock in some areas, it is interpreted to be absent within the YSA limits as a result of the erosional events that created the Thorncliffe Channel (Gerber et al., 2018).

Bedrock

Ontario Geological Survey (OGS) mapping indicates that the bedrock geology in the Site area is characterized primarily by Middle Ordovician limestone of the Lindsay Formation (Simcoe Group) (OGS, 2011). Bedrock elevation is reported to range between 110 masl and 190 masl across the YSA area (Gerber et al., 2018).

For the purpose of this report, the shallow aquifer system in the YSA area is considered to generally be consisted of the ORAC, the Inter-Newmarket Sediments and/or the ORM Channel Aquifer (where locally present), while the deep aquifer system is consisted of the YSA (within the YSA limits) or the Lower Sediments (Thorncliffe Formation and Scarborough Formation) (outside of the YSA limits). The Newmarket Till (and potentially underlying Thorncliffe Formation-age silt-clay rhythmites) is understood to act as the main aquitard unit which separates the shallow from the deep groundwater system. It is interpreted that the vertical hydraulic gradient between the shallow and deep groundwater systems in the YSA area is generally downward as observed in the water levels of shallow and deep well pairs introduced in **Section 2.5.2** with results and hydrograph details presented in **Section 3.3.2.1**

2.4 Local Geology and Hydrogeology

The understanding of the geologic conditions at the Site and in its immediate vicinity is primarily based on York Region's 2021 EG-PW2 well construction and testing program, AECOM's 2019 Green Lane Large Diameter Test Well Construction and Testing Report and the cored borehole log for Newmarket MW-19, which was drilled approximately 85 m southwest of EG-PW2. The borehole logs for EG-PW1 (referred to as EG-MW2 in AECOM reports) and other nearby monitoring wells (Newmarket MW-16, Newmarket MW-20S, and Newmarket MW-20D) were also reviewed and found to be generally consistent with the geologic characterization presented in the following paragraph. **Figure 2** illustrates the on-Site and nearby monitoring well locations.

The local geologic setting is understood to be characterized by 26 m of silt till (17 m of sand at EG-PW2) underlain by a 42-m thick unit consisted primarily of silt and clay rhythmites, which was characterized as consisting of fining upward sequences of fine sand to clay (AECOM, 2019). Underneath the silt and clay unit are layers of sand and gravel that appear to have been deposited in a coarsening downward sequence; ranging generally from silty fine sand near the surface of the unit between a range of 62.5 to 67.8 meters below grounds surface (mbgs), to medium to coarse sand between a range of 71.6 mbgs and 85.3 mbgs, to fine to coarse gravel deposits between range of 85.3 mbgs to 96.9 mbgs. The borehole logs for Newmarket MW-16 and EG-PW1 indicate suspected cobbles and boulders below 91.4 mbgs and 94.8 mbgs, respectively, to the terminated depth of the boreholes of 95.4 mbgs and 95.7 mbgs, respectively. Bedrock was encountered at EG-PW2 at 110.64 mbgs to the terminated depth of the borehole 111.25 mbgs, as such the approximate thickness of the local overburden was determined to be 110.64 m.

The geologic deposits encountered at the Site are summarized in **Table 2-1**. Borehole logs and well records are included in **Appendix C**.

Table 2-1. Characterization of the Local Geologic Setting

Depth Range (mbgs)[a]	Primarily Geologic Material
0 to 26.0	Silt (till)[b]
26.0 to 67.8	Silt and clay rhythmites (fining upward sequences)
67.8 to 91.4	Coarsening downward sequence of fine sand to coarse gravel
91.4 to 110.64	Medium to coarse Sand, Suspected cobbles, and boulders[c]
110.64 to 111.25 (maximum investigated depth)	Bedrock

Notes:

mbgs Denotes meters below ground surface

[a] Indicates that the depths of the geologic unit contacts are based primarily on the cored borehole log for Newmarket MW-19 and from 92.9 mbgs onwards based on Newmarket MW-16, EG-PW1 and EG-PW2 borehole logs.

b A shallow sand to silty sand layer was observed in the borehole logs of EG-PW2 (4.6 to 16.8 mbgs), Newmarket MW-16 (at 5 mbgs silt and sand observed) and Newmarket MW-20D (0 to 16.8 mbgs).

c Indicates that the suspected cobbles and boulders were identified on the borehole logs for Newmarket MW-16 and EG-MW2.

2.5 Local Hydrogeologic Setting

2.5.1 Conceptual Understanding

Based on the understanding of the regional geology and hydrogeology in the Site area, it is interpreted that the geologic overburden deposits encountered at the Site during previous drilling activities can be grouped into the hydrostratigraphic layers shown in **Table 2-2**.

Table 2-2. Interpretation of Hydrostratigraphic Layers at the Site and Vicinity

Primary Geologic Material	Interpreted Hydrostratigraphic Unit	Interpreted Thickness (meters)[a]
Silt (till)	Newmarket Till[b]	26
Silt and clay rhythmites (fining upward sequences)	Thorncliffe Formation silt-clay rhythmites (post-Thorncliffe Channel) and/or silt and clay deposits of the Thorncliffe Channel	42
Coarsening downward sequence of fine sand to coarse gravel	YSA (coarse-grained deposits associated with the Thorncliffe Channel)	42
Suspected cobbles and boulders		

Notes:

[a] The interpreted thicknesses of the hydrostratigraphic units are primarily based on the cored borehole log for Newmarket MW-19, with consideration of the logs for Newmarket MW-16, EG-PW1, and EG-PW2 in identifying deposits below the cored borehole depth of 92.9 mbgs.

[b] Possible ORAC Channel was observed in the borehole logs of EG-PW2 (4.6 to 16.8 mbgs), Newmarket MW-16 (at 5 mbgs), and Newmarket MW-20D (0 to 16.8 mbgs).

Based on the conceptual understanding, the hydrogeology at the Site is characterized by one main aquifer system, the YSA. The average thickness of the YSA is estimated to be 28 m at a minimum based on the regional geologic cross-sections presented in Gerber et al. (2018) but may be up to approximately 42 m near the Site based on previous drilling activities in the area (**Figure 6a**) and borehole logs of on-Site wells. Together, the overlying 42-m thick fine-grained unit (which may correspond to Thorncliffe Formation silt-clay rhythmites and/or silt and clay deposits of the Thorncliffe Channel) and the 26-m thick silt till unit (interpreted to correspond to the Newmarket Till) comprise the confining aquitard in the Site area, which provides protection from surface influences to the YSA. Both EG-PW1 and EG-PW2 are screened in the YSA.

2.5.2 Groundwater Monitoring Network

The YSA production wells (PWs) include seven wells in the Town of Aurora (Aurora PW1, Aurora PW2, Aurora PW3, Aurora PW4, Aurora PW5, Aurora PW6, and Aurora PW7), two wells in the Community of Holland Landing (Holland Landing PW1 and Holland Landing PW2), five wells in the Town of Newmarket (Newmarket PW1, Newmarket PW2, Newmarket PW13, Newmarket PW15, and Newmarket PW16) and four wells in the Village of Queensville (Queensville PW1, Queensville PW2, Queensville PW3, and Queensville PW4). The production well locations are illustrated on **Figure 5**. All 18 wells operate under the same PTTW (Amended PTTW No. 1736-BKZPJD), which expires on December 31, 2023. In addition to the maximum permitted water taking rate assigned to the individual wells, the PTTW limits the yearly daily average taking volume from all YSA wells to 42,000 cubic meters (m^3). During the yearly peak demand period of May to September, the maximum allowable daily average taking from all YSA wells is increased to 67,200 m^3 while the maximum daily taking volume from all wells is permitted up to 87,656 m^3.

The groundwater monitoring well network in the YSA is consisted of a total of 81 wells, of which 33 are considered shallow (screened above the Lower Newmarket Till) and the remaining 48 are screened in the deep aquifer system. The YSA monitoring well network is illustrated on **Figure 7** and **Figures 7a to 7d**. **Table 2-3** summarizes the monitoring well details. The production well details are summarized in **Table 2-4.**

Table 2-3. Yonge Street Aquifer Monitoring Well Details

York Region Well ID	MECP Well Record or Tag Number	Easting (meters)	Northing (meters)	Ground Elevation (masl)	Well Depth (mbgs)	Screened Interval (masl)	Interpreted Screened Unit
Aurora MW-1	6908518	622589	4873412	253.3	97.3	156.0 to 162.1	YSA
Aurora MW-5 (formerly Well #87-3)	N/A	622627	4875024	254.9	94.5	160.4 to 166.5	YSA
Aurora MW-6	6917481	623618	4870106	300.5	122.2	178.3 to 182.5	YSA
Aurora MW-8 (formerly OW25A-95)	N/A	625168	4871551	280.2	77.7	202.5 to 205.5	YSA

York Region Well ID	MECP Well Record or Tag Number	Easting (meters)	Northing (meters)	Ground Elevation (masl)	Well Depth (mbgs)	Screened Interval (masl)	Interpreted Screened Unit
Aurora MW-9S (formerly OW25C-95)	N/A	625172	4871558	280.9	25.6	255.3 to 258.4	ORAC
Aurora MW-9D (formerly OW25B-95)	N/A	625172	4871558	280.1	42.4	237.7 to 242.3	ORAC
Aurora MW-11	697427	623308	4870820	283.9	22.5	261.4 to 265.6	ORAC
Aurora MW-13	6918439	622625	4875031	255.0	125.6	129.4 to 133.0	YSA
Aurora MW-14D (formerly Well 86-2)	6918411	622617	4875023	255.0	124.1	130.9 to 165.1	YSA
Aurora MW-15S	6926102	626138	4871863	266.9	4.6	262.3 to 263.9	ORAC
Aurora MW-15I-A	6926102	626140	4871863	267.5	31.1	236.4 to 239.5	ORAC
Aurora MW-15I-B	6926102	626140	4871863	267.5	16.5	251.0 to 254.1	ORAC
Aurora MW-15D	6926102	626144	4871863	268.2	137.0	131.2 to 134.2	YSA
Aurora MW-16	A124709	622610	4875025	254.9	29.1	225.8 to 227.3	ORM Channel Sand
Aurora MW-18S	A124689	622491	4873912	254.1	53.5	200.6 to 203.7	ORM Channel Sand
Aurora MW-18D	A124688	622493	4873909	254.1	101.2	152.9 to 153.8	YSA
Aurora MW-19I	A124669	623974	4872672	270.7	71.0	199.7 to 202.7	YSA
Aurora MW-19D	A124786	623978	4872677	270.8	96.5	174.3 to 177.4	YSA
Aurora MW-20S	A124664	622719	4875069	247.3	10.7	236.6 to 238.2	ORAC
Aurora MW-20D	A124663	622717	4875068	247.3	83.2	164.1 to 167.1	YSA
Aurora MW-21S	A088234	624379	4875359	258.7	56.4	202.3 to 205.3	YSA

York Region Well ID	MECP Well Record or Tag Number	Easting (meters)	Northing (meters)	Ground Elevation (masl)	Well Depth (mbgs)	Screened Interval (masl)	Interpreted Screened Unit
Aurora MW-21D	A088235	624379	4875359	258.7	88.4	170.3 to 173.3	YSA
Aurora MW-22S	A169590	621753	4870444	294.1	82.9	211.1 to 214.2	ORM Channel Sand
Aurora MW-22D	A175995	621751	4870442	294.3	126.8	167.5 to 170.5	YSA
EG-MW4[a]	A315305	623127	4882609	246.47	61.0	188.5 to 185.5	YSA
Holland Landing MW-1	6912037	622193	4883503	247.4	79.9	167.5 to 169.3	YSA
Holland Landing MW-3	6920311	622791	4884206	252.1	85.8	166.3 to 172.4	YSA
Holland Landing MW-9	A124685	622387	4883801	241.6	82.1	159.5 to 162.5	YSA
Holland Landing MW-10	A247935	622354	4883967	240.1	71.6	168.5 to 171.5	YSA
Holland Landing MW-11	A041124	618982	4886769	221.4	87.0	139.1 to 141.9	SAC
Holland Landing MW-12	A041123	621076	4886155	225.0	71.9	171.0 to 174.1	YSA
Newmarket MW-2	694190	621919	4878538	268.3	94.9	173.4 to 180.1	YSA
Newmarket MW-3	6918868	628587	4881390	272.9	63.7	209.2 to 212.2	Thorncliffe Formation
Newmarket MW-4	7180847	622322	4879799	265.2	112.0	153.2 to 159.3	YSA
Newmarket MW-7	A032056	623820	4878630	241.0	71.6	169.4 to 170.2	Scarborough Formation
Newmarket MW-12	6913492	625761	4880648	285.8	53.0	232.8 to 236.6	INS
Newmarket MW-13	6913279	622291	4876462	269.8	111.9	157.9 to 161.3	YSA
Newmarket MW-14	A124698	622313	4876471	269.8	34.3	235.5 to 238.6	INS
Newmarket MW-15	A124710	621687	4879520	265.8	36.3	229.5 to 232.6	INS
Newmarket MW-16	A124671	622242	4881414	256.0	94.5	161.5 to 165.8	YSA

York Region Well ID	MECP Well Record or Tag Number	Easting (meters)	Northing (meters)	Ground Elevation (masl)	Well Depth (mbgs)	Screened Interval (masl)	Interpreted Screened Unit
Newmarket MW-17	A124684	622323	4875726	257.8	90.2	167.6 to 170.6	YSA
Newmarket MW-18S2	A102847	621852	4878218	263.4	10.7	252.7 to 254.3	Upper Newmarket Till (sand lens)
Newmarket MW-18I	A102846	621850	4878216	263.5	54.8	208.7 to 209.9	Lower Newmarket Till/YSA
Newmarket MW-18D	A124741	621850	4878219	263.6	96.3	167.3 to 170.3	YSA
Newmarket MW-19	A127808	622145	4881380	260.5	93.0	167.5 to 176.6	YSA
Newmarket MW-20S	A124746	622230	4881408	256.5	12.2	244.3 to 245.9	Upper Newmarket Till
Newmarket MW-20D	A124747	622232	4881409	256.4	68.0	188.4 to 191.4	YSA
Newmarket MW-21S	A124749	622541	4881508	250.1	31.1	219.0 to 220.5	ORM Channel Sand
Newmarket MW-21D	A124748	622539	4881508	250.1	77.7	172.4 to 173.9	YSA
Newmarket MW-22S	A169586	624220	4876697	253.3	25.9	227.4 to 230.4	INS
Newmarket MW-22D	A169585	624224	4876698	253.3	71.6	181.7 to 184.7	Thorncliffe Formation
Newmarket MW-23S	A176029	619676	4878272	280.9	79.3	201.6 to 204.7	YSA
Newmarket MW-23D	A169587	619671	4878269	280.9	129.6	151.3 to 154.4	YSA
Newmarket MW-24	A235430	621684	4879520	266.5	98.0	168.5 to 171.4	YSA
Newmarket MW-31S	A276195	621918	4878472	267.9	16.8	251.1 to 254.3	Upper Newmarket Till (sand lens)
Newmarket MW-31D	A276194	621919	4878471	267.8	89.9	177.9 to 181.1	YSA
Newmarket MW-32 (formerly BH3-12)	N/A	623662	4880787	233.5	5.0	229.2 to 231.5	Upper Newmarket Till

York Region Well ID	MECP Well Record or Tag Number	Easting (meters)	Northing (meters)	Ground Elevation (masl)	Well Depth (mbgs)	Screened Interval (masl)	Interpreted Screened Unit
Newmarket MW-33 (formerly BH10-12)	N/A	623686	4879711	236.7	12.4	225.1 to 227.4	Upper Newmarket Till
Newmarket MW-34 (formerly BH13-12)	N/A	623779	4879117	236.3	12.2	224.8-227.1	Upper Newmarket Till
Newmarket MW-35 (formerly BH17-12)	N/A	623679	4878416	242.8	12.2	231.5 to 233.6	Upper Newmarket Till
Newmarket MW-36 (formerly BH21-12)	N/A	623345	4877723	242.4	8.1	235.1 to 237.4	ORM Channel Silt / Newmarket Till
Newmarket MW-37S (formerly BH266s-16)	N/A	623420	4877502	241.4	5.0	236.4 to 237.9	Recent Deposits
Newmarket MW-37D (formerly BH266-16)	N/A	623419	4877504	241.4	22.7	218.7 to 221.7	ORM Channel Sand
EG-PW1	7285159	622218	4881432	256.2	92.9	163.3 to 164.5; 165.1 to 170.0; 170.9 to 174.0	YSA
Queensville MW-1 (formerly Test Well 3/88)	6920314	625850	4889136	253.4	81.7	171.7 to 182.4	YSA
Queensville MW-2 (formerly Test Well 8/88)	6920315	625855	4889111	254.0	77.7	176.3 to 183.0	YSA
Queensville MW-3 (formerly TW 10/89)	N/A	624252	4886630	280.1	112.2	167.9 to 176.5	YSA
Queensville MW-4	6920312	624272	4886634	280.5	114.3	166.2 to 176.8	YSA
Queensville MW-5	6920309	626163	4887023	263.0	65.5	197.5 to 202.0	Thorncliffe Formation

York Region Well ID	MECP Well Record or Tag Number	Easting (meters)	Northing (meters)	Ground Elevation (masl)	Well Depth (mbgs)	Screened Interval (masl)	Interpreted Screened Unit
Queensville MW-6S (formerly Test Well 1/91)	N/A	622295	4886248	275.1	105.2	169.9 to 173.0	YSA
Queensville MW-6D (formerly Test Well 1/91)	N/A	622295	4886248	275.2	121.6	153.6 to 156.3	YSA
Queensville MW-7	6916686	624293	4886407	269.6	104.0	165.6 to 172.3	YSA
Queensville MW-8 (formerly MW1/91)	N/A	625856	4889111	253.7	9.1	244.6 to 246.1	ORAC
Queensville MW-9 (formerly MW2/91)	N/A	627508	4891589	254.2	15.5	238.7 to 241.7	ORAC
Queensville MW-10 (formerly MW3/91)	N/A	625590	4890492	244.7	19.3	225.4 to 228.5	INS
Queensville MW-12S (formerly MW5(s))	N/A	622877	4888075	242.6	9.6	233.0 to 236.1	INS
Queensville MW-12D (formerly MW5(D))	N/A	622878	4888075	242.6	16.0	226.6 to 228.2	INS
Queensville MW13S (formerly Queensville S.R. Shallow)	7172662	626499	4889263	260.5	14.0	246.5 to 248.0	INS
Queensville MW-13D (formerly Queensville S.R.)	7172662	626500	4889264	260.6	87.2	173.4 to 174.9	YSA
Queensville MW-16	A124697	624236	4886614	279.9	13.6	266.3 to 269.4	ORAC
Queensville MW-19S	A102695	627825	4889975	263.6	10.7	252.9 to 256.0	Inter-Newmarket Sediments

York Region Well ID	MECP Well Record or Tag Number	Easting (meters)	Northing (meters)	Ground Elevation (masl)	Well Depth (mbgs)	Screened Interval (masl)	Interpreted Screened Unit
Queensville MW-19D	A102694	627825	4889973	263.6	51.2	212.4 to 224.6	Thorncliffe Formation
Queensville MW-20	A218842	626250	4887272	264.6	65.2	199.4 to 202.4	Thorncliffe Formation

Notes:
ID Denotes identification
masl Denotes meters above sea level
mbgs Denotes meters below ground surface
N/A Denotes Not Available
[a] EG-MW4 was installed as part of the Green Lane 2021 drilling program as a test hole and monitoring well, further details are provided in Section 3.1.2

Table 2-4. Yonge Street Aquifer Production Well Details

York Region Well ID	MECP Well Record No.	Easting (meters)	Northing (meters)	Ground Elevation (masl)	Well Depth (mbgs)	Screened Interval (masl)	Interpreted Screened Unit
Aurora PW1	6908523	622588	4873417	253.2	98.5	154.7 to 160.8	YSA
Aurora PW2	6908520	622576	4873385	253.0	103.7	149.3 to 161.5	YSA
Aurora PW3	6908524	622574	4873359	253.3	101.8	151.5 to 162.2	YSA
Aurora PW4	6915114	622580	4873373	253.3	102.1	151.2 to 163.4	YSA
Aurora PW5	N/A	622621	4875027	255.0	100.9	154.1 to 166.3	YSA
Aurora PW6	N/A	624234	4875380	259.0	90.6	168.4 to 179.1	YSA
Aurora PW7	A172641	622626	4875024	255.3	97.5	157.8 to 165.7	YSA
Holland Landing PW1	6912655	622148	4883524	247.5	79.3	168.2 to 177.3	YSA
Holland Landing PW2	6914319	622297	4883971	240.2	71.6	168.6 to 176.4	YSA
Newmarket PW1	N/A	621924	4878474	268.6	91.9	176.7 to 184.3	YSA
Newmarket PW2	6904204	621906	4878549	268.6	94.2	174.4 to 182.3	YSA
Newmarket PW13	6914314	622297	4876467	269.7	108.5	161.2 to 169.0	YSA

York Region Well ID	MECP Well Record No.	Easting (meters)	Northing (meters)	Ground Elevation (masl)	Well Depth (mbgs)	Screened Interval (masl)	Interpreted Screened Unit
Newmarket PW15	6915134	621800	4879502	265.7	98.4	167.3 to 181.5	YSA
Newmarket PW16	6916976	622297	4876323	269.1	106.7	162.4 to 170.3	YSA
Queensville PW1	6922338	625847	4889143	253.6	81.5	172.1 to 184.1	YSA
Queensville PW2	6921868	625850	4889114	253.9	79.6	174.3 to 187.3	YSA
Queensville PW3	6922299	624244	4886634	280.1	115.5	164.6 to 177.1	YSA
Queensville PW4	6922300	624272	4886641	280.5	116.7	163.8 to 176.3	YSA

Notes:
masl Denotes meters above sea level
mbgs Denotes meters below ground surface
N/A Denotes not available

2.5.2.1 York Region Groundwater-Surface Water Interaction Monitors

In addition to groundwater monitoring wells, York Region's monitoring network for the aquifer testing phase of this study included mini-piezometers (MPs) and stream gauges summarized in **Table 2-5** with locations are shown on **Figure 2**. The mini-piezometers were used for the assessment of potential groundwater-surface water interactions at the watercourse (the closest natural surface water feature to the Site with observed flows) during aquifer testing activities. As such, they were monitored for potential groundwater-surface water interactions during the 96-hour constant rate pumping test discussed in **Section 3.3**.

The mini-piezometers were each equipped with a pressure transducer for electronic recording of water levels. **Table 2-5** summarizes the construction details of the four mini-piezometers and installation locations of two stream gauges.

Table 2-5. Green Lane Mini-Piezometer and Stream-Gauge Details

Monitor ID	UTM Coordinates Zone 17N (Easting, Northing) (meters)	Ground Elevation (masl)	Monitor Depth (mbgs)	Monitor Type	Screened Interval (masl)	Interpreted Screened Lithologic Unit[a]	Creek
Newmarket MP-1	622387, 4881479	241.79	1.6	Shallow Piezometer	240.5 to 240.2	Modern Alluvial Deposits	Tributary of East

Monitor ID	UTM Coordinates Zone 17N (Easting, Northing) (meters)	Ground Elevation (masl)	Monitor Depth (mbgs)	Monitor Type	Screened Interval (masl)	Interpreted Screened Lithologic Unit[a]	Creek
							Holland River
Newmarket MP-2D	622417, 4881399	243.78	2.9	Deep Nested Piezometer	240.5 to 240.2	Modern Alluvial Deposits	Tributary of East Holland River
Newmarket MP-2S[b]	622417, 4881399	243.78	2.0	Shallow Nested Piezometer	242.1 to 241.8	Modern Alluvial Deposits	Tributary of East Holland River
Newmarket MP-3	621844, 4881341	262.78	2.2	Shallow Piezometer	261.0 to 260.6	Modern Alluvial Deposits	Tributary of East Holland River
Newmarket SG-1	622387, 4881479	N/A	N/A	Stream Gauge	N/A	N/A	Tributary of East Holland River
Newmarket SG-3	621844, 4881341	N/A	N/A	Stream Gauge	N/A	N/A	Tributary of East Holland River

Notes:
masl Denotes meters above sea level
SG Denotes stream gauge
[a] The screened geologic unit was interpreted from surficial geology mapping (OGS, 2003).
[b] Assuming same UTM and Ground Elevation as MP2D.

2.5.2.2 Private Groundwater Monitoring Wells

York Region obtained permission from four private well users with private water supply wells within the predicted zone of influence (ZOI) of EG-PW1 and EG-PW2 during the 96 hour pumping test and interpreted to be screened within the YSA to monitor water level and water quality **Table 2-6** presents a summary of the private well sources. **Figure 7** illustrates the locations of the pumping wells and water well records are provided in **Appendix C**.

Table 2-6. Private Production Well Details

York Region Well ID	MECP Well Record No.	UTM Coordinates Zone 17N (Easting, Northing) (meters)	Ground Elevation[a] (masl)	Well Depth (mbgs)	Screened Interval (masl)	Interpreted Screened Aquifer
Valley Trail	6916831	622848, 4883089	245.1	57.3	189 to 187.8	YSA
Lepard Crescent	6917595	621119, 4885848	226.2	50.0	177.1 to 195.1	YSA
Milne Lane	6918052	623582, 4887822	279.8	117.0	163.7 to 128.1	YSA
2nd Concession Road	6913638	622572, 4883454	243.76	67.0	178.26 to 178.1	YSA

Notes:

ID Denotes identification
masl Denotes meters above sea level
mbgs Denotes meters below ground surface
[a] Ground elevation was obtained from Oak Ridges Moraine Groundwater Program (ORMGP) interactive topographic map.

3.0 Groundwater Exploration Program

3.1 Test Well Drilling and Construction of EG-PW2

3.1.1 Pilot Hole Drilling

Pilot hole drilling for EG-PW2 was completed by Highland Water Well Drilling Inc. (Highland), under York Region supervision, to confirm local geologic and hydrogeologic conditions at the Site and to collect soil samples for analysis required to appropriately design the large diameter test well screen.

Pilot hole drilling commenced on July 21, 2021, and progressed through to July 26, 2021, using air rotary drilling method for retrieval of grab samples from ground surface into the target aquifer to a depth of 111.3 mbgs. Air rotary drilling utilizes a rotating drill bit to cut the formation into drill cuttings and allow for the advancement of a 152 millimeters (mm) (6-inch) diameter drill casing. Compressed air was used to force drill cuttings to surface where they are captured in a cyclone to allow for soil sample retrieval. Soil conditions were logged on-site by York Region staff. Grab samples retrieved from the air rotary drilling using pails and were placed in zip-lock bags and stored for future analysis and quality assurance/quality control by a Qualified Professional.

Results of the pilot hole drilling at EG-PW2 indicated that the geology generally corresponds to the local geologic conditions described in **Section 2.4**. Bedrock was encountered at a depth of 110.6 mbgs during the pilot hole drilling and, as such, a total overburden thickness was determined to be 110.6 m. As indicated on the borehole log for EG-PW1, included in **Appendix C**, drilling at this location indicated the presence of a 4.6 m-thick silty sand layer at surface, underlain by 12.2 m of a sand deposit. A 45.7 m-thick clayey silt till aquitard was encountered underneath the sand layer down to approximately 62.5 mbgs, beneath which the target aquifer formation was identified from 62.5 mbgs to 110.6 mbgs consisted of a 3.0 m silty sand layer followed by a 13.8 m coarse sand layer, underlain by a 20.6 m thick coarse sand and gravel layer followed by a second medium to coarse sand layer 10.7 m thick. Bedrock was encountered to the termination depth of the borehole (111.3 mbgs). The pilot hole was over-reamed following completion of drilling for the natural pack large diameter well construction and installation.

3.1.1.1 Grain Size Analysis

Soil samples collected from the target aquifer were submitted by Highland to Terraprobe Inc. for grain size analysis (sieve and hydrometer analysis). Results of the grain size analyses were used to assess the suitability of the aquifer for test well installation and to inform the well screen design. The grain size analysis report can be found in **Appendix D** and the results are summarized in **Table 3-1.**

Table 3-1. Summary of EG-PW2 Grain Size Analyses

Sample Box No. (Sample Number)	Sample Depth		Sample Description	Category (Unified System)			Grain Size (millimeter)			
	Sample Depth (feet)	Sample Depth (meters)		Gravel	Sand	Silt and Clay	d_{10}	d_{50}	d_{60}	Uniformity Coefficient (d_{60}/d_{10})
EG-PW2(1)	225 to 230	68.6 to 70.1	Sand, trace silt	0%	94%	6%	0.11	0.3	0.38	3.3
EG-PW2(2)	230 to 235	70.1 to 71.6	Sand, trace silt	1%	94%	5%	0.14	0.3	0.34	2.4
EG-PW2(3)	235 to 240	71.6 to 73.2	Sand, trace silt	0%	94%	6%	0.11	0.19	0.21	1.9
EG-PW2(4)	240 to 245	73.2 to 74.7	Sand, some silt	0%	84%	16%	0.07	0.15	0.17	2.3
EG-PW2(5)	245 to 250	74.7 to 76.2	Sand, trace silt	0%	92%	8%	0.1	0.2	0.23	2.3
EG-PW2(6)	250 to 255	76.2 to 77.7	Sand, trace silt, trace gravel	1%	92%	7%	0.11	0.2	0.25	2.3
EG-PW2(7)	255 to 260	77.7 to 79.3	Sand, trace silt, trace gravel	3%	89%	8%	0.12	0.23	0.27	2.3
EG-PW2(8)	260 to 265	79.3 to 80.8	Gravelly, sand, trace silt	28%	69%	3%	0.16	1.3	2.5	15.6
EG-PW2(9)	265 to 270	80.8 to 82.3	Gravelly, sand, trace silt	29%	68%	3%	0.17	1.2	2.7	15.9
EG-PW2(10)	270 to 275	82.3 to 83.8	Gravelly, sand, trace silt	28%	70%	2%	0.16	0.61	2	12.5
EG-PW2(11)	275 to 280	83.8 to 85.4	Gravelly, sand, trace silt	33%	63%	4%	0.3	2.9	4	13.3
EG-PW2(12)	280 to 285	85.4 to 86.9	Gravelly, sand, trace silt	32%	65%	3%	0.29	2.4	3.5	12.1
EG-PW2(13)	285 to 290	86.9 to 88.4	Gravelly, sand, trace silt	30%	66%	4%	0.41	2.7	3.7	9.0
EG-PW2(14)	290 to 295	88.4 to 89.9	Sand and gravel, trace silt	40%	57%	3%	0.28	3.8	5	17.9
EG-PW2(15)	295 to 300	89.9 to 91.5	Gravelly, sand, trace silt	24%	74%	2%	0.2	1.6	2.5	12.5
EG-PW2(16)	300 to 305	91.5 to 93	Sand and gravel, trace silt	39%	59%	2%	0.2	3.5	4.9	24.5
EG-PW2(17)	305 to 310	93 to 94.5	Sand and gravel, trace silt	49%	49%	2%	0.38	4.8	7	18.4
EG-PW2(18)	310 to 315	94.5 to 96	Gravelly, sand, trace silt	28%	69%	3%	0.42	2.4	3.6	8.6

Sample Box No. (Sample Number)	Sample Depth		Sample Description	Category (Unified System)			Grain Size (millimeter)			
	Sample Depth (feet)	Sample Depth (meters)		Gravel	Sand	Silt and Clay	d_{10}	d_{50}	d_{60}	Uniformity Coefficient (d_{60}/d_{10})
EG-PW2(19)	315 to 320	96 to 97.6	Gravelly, sand, trace silt	20%	75%	5%	0.15	0.5	0.65	4.3
EG-PW2(20)	320 to 325	97.6 to 99.1	Sand, trace silt	0%	95%	5%	0.13	0.29	0.31	2.4
EG-PW2(21)	325 to 330	99.1 to 100.6	Sand, trace silt	0%	95%	5%	0.12	0.27	0.3	2.4
EG-PW2(22)	330 to 335	100.6 to 102.1	Sand, trace silt	0%	93%	7%	0.13	0.24	0.44	3.4
EG-PW2(23)	335 to 340	102.1 to 103.7	Sand, trace silt	0%	94%	6%	0.13	0.39	0.47	3.6
EG-PW2(24)	340 to 345	103.7 to 105.2	Sand, trace silt	0%	95%	5%	0.14	0.42	0.5	3.6
EG-PW2(25)	345 to 350	105.2 to 106.7	Sand, trace silt	0%	93%	7%	0.1	0.27	0.34	3.4
EG-PW2(26)	350 to 355	106.7 to 108.2	Sand, trace silt, trace gravel	3%	91%	6%	0.11	0.39	0.49	4.5

3.1.1.2 Geophysics

Downhole geophysical logging of the pilot hole was conducted by Lotowater Technical Services Inc. (Lotowater), under contract with Highland, to assist with the identification of lithology and stratigraphic correlation of soil samples. The purpose of this logging was to map the relative clay content of the soils as an indication of the aquitard competency and aquifer formation depth. A wireline logging method was employed to record naturally occurring gamma rays in the formation adjacent to the wellbore with one pass descending the full length of the pilot hole and a second ascending up the pilot hole to surface.

Results of the gamma ray logging show relatively little deviation from ground surface to about 62 mbgs, where a decrease in gamma radiation (indicative of high-permeability deposits) is noted down to approximately 100 mbgs corresponding to the silty sand to sand and gravel aquifer deposit. Below this depth, the gamma readings decreased again, which corresponds to where bedrock was encountered down to the termination depth of the borehole. The gamma ray log for EG-PW1 can be found in **Appendix D.**

3.1.2 Monitoring Well Design and Installation

One monitoring well was installed as part of this exploratory program for the purpose of enhancing the existing monitoring well network and facilitating the monitoring of groundwater levels during the aquifer testing phase of the investigation. The new deep monitoring well (EG-MW4) was installed 1,473 m northeast of the test well and was interpreted to be screened in the same target aquifer as EG-PW1 and EG-PW2 (YSA) from a depth of 58.0 mbgs to 61.1 mbgs. This monitoring well was designed to monitor aquifer response and help determine the areal extent of water level drawdown during the pumping test.

Borehole drilling at the monitoring well location was conducted by Highland using air rotary drill method, similarly to that used for the EG-PW2 borehole drilling. Soil conditions from the retrieved cuttings were logged on-site by York Region staff, with a pail and subsequently placed in zip-lock bags and stored for future analysis and quality assurance/quality control by a Qualified Professional.

The borehole target depth was determined based on the soil conditions encountered during the drilling programs at EG-PW1, Newmarket MW-16, Newmarket MW-19, and the knowledge of hydrostratigraphy of the area. The well borehole was instrumented with a 76-millimeter diameter PVC riser pipe and No. 10 slot screen. A #00 filter sand pack was placed around the well screen and the annular space was backfilled with Peltonite, followed by bentonite slurry and bentonite chips. EG-MW4 was completed with an above-ground locking protective steel casing, with a J-plug fitted to the top of the well, and the well was tagged and labelled in accordance with MECP regulations. Following completion, EG-MW4 was developed to remove fine particles generated during the drilling process and establish a good hydraulic connection with the surrounding geologic formation in order to obtain representative water levels and clear water during subsequent pumping. Once development was completed, EG-MW4 was sampled for select water quality parameters and instrumented with a long-term pressure transducer.

The borehole log and MECP well record for EG-MW4 are included in **Appendix C.**

3.1.3 Large Diameter Well Design and Construction

The design of the large diameter test well was completed based on the stratigraphy encountered during pilot hole drilling and the grain size analysis results for the target aquifer, with consideration of the desired well yield. Well construction complied with Ontario Regulation (O. Reg.) 903 and American Water Works Association (AWWA) A100-20 standards and, it was completed in accordance with the MECP Draft Technical Support Document: *Determination of Minimum Microbial Treatment for Municipal Residential Drinking Water Systems Using Subsurface Raw Water Supplies* for a ‘low risk’ well.

3.1.3.1 Well Screen Design

The test well screen design was completed by Matrix Solutions Inc. (Matrix), under contract with Highland, and was reviewed and approved by York Region. The screen was designed based on the results of the grain size analysis for the EG-PW2 pilot hole soil samples to optimize the theoretical screen transmitting capacity while also (Matrix, 2021):

- Achieving a higher production potential and minimizing screen construction costs while maximizing the available drawdown in the well by having the screen extend only across the coarser sand and gravel deposits in the target aquifer;
- Promoting horizontal flow in the upper portion of the aquifer and decreasing the potential for vertical flow pulling the overlying finer-grained sand through the significantly coarser sand and gravel deposits identified herein; and
- Providing sufficient buffer/transition zones between larger slot sizes and the finer deposits identified at the top of the target aquifer and underlying the coarser sands and gravels to prevent migration of finer sediments into the screen and through the larger slot sizes.

The screen design completed by Matrix is summarized in **Table 3-2**. Custom fabricated Johnson Screens Hi-Flow telescoping 305- millimeter (nominal) diameter, continuous slot wire-wrapped 304 stainless steel well screen was designed to go through the casing. The well screen design report and As-built drawing for EG-PW2 are provided in **Appendix D.**

Table 3-2. EG-PW2 Screen Design Details

Well ID	MECP Water Well Record Number	Monitor Diameter (Internal Diameter, meters)	Ground Elevation (masl)	Screened Interval (mbgs)	Screen Diameter (Outer Diameter, meters)	Screen Slot Size (millimeter)
EG-PW2	A315290	0.27	255.01	82.0 to 96.0	0.29	1.3 (82.0 to 86.3 mbgs) 2.5 (86.3 to 90.6 mbgs) 2.0 (90.6 to 92.1 mbgs) 2.5 (92.1 to 94.0 mbgs) 3.3 (94.0 to 96.0 mbgs)

Notes:
ID Denotes identification
masl Denotes meters above sea level
mbgs Denotes meters below ground surface

Based on the well screen design, the theoretical screen transmitting capacity of EG-PW2 was calculated as 146 L/s (12,590 cubic meters per day [m^3/day]) assuming a maximum entrance velocity of 0.03 meters per second (Matrix, 2021).

3.1.3.2 Well Construction

Highland began the over-drilling and construction of EG-PW2 on August 9, 2021, and completed the well construction on October 6, 2021, using an air rotary drilling rig under supervision of York Region staff. The drilling methodology changed at 71.9 mbgs, as air pressure could no longer return cuttings and water only was used to advance the 12-inch casing and cuttings beyond this depth. The large diameter test well was constructed on the Site, 17 m east of EG-PW1 (**Figure 2**).

Drilling commenced with the installation of a 457-millimeter (18-inch) diameter surface casing to a depth of 61.9 mbgs, over drilling the decommissioned pilot hole. Following the installation of the surface casing, the 305-millimeter (12-inch) diameter carbon steel well casing was advanced to the target depth of 81.2 mbgs. Centralizers were utilized for the installation of the well casing through the surface casing to ensure adequate centralization of the 305-millimeter diameter casing inside the surface casing.

Upon completion of the installation of the 305-millimeter diameter well casing, the well's plumbness and alignment was checked to ensure that the well met the required specifications prior to installing the well screen. As detailed in **Section 3.1.3.3,** the results of the plumbness and alignment test were determined to meet AWWA A100-20 standards. Next, the well screen assembly was installed through the casing and secured using a 0.72 m double neoprene K-packer assembly and 0.038 m weld rings between screen intervals. The bottom of the well screen assembly landed at 95.8 mbgs.

Short duration well development (approximately four hours in duration) was performed following screen installation to verify that the production of large-grained particles (i.e., gravel) did not occur and that the well screen was secure before sealing the annular space and removing the surface casing.

The annular borehole space was filled with 2.1 m of bentonite chips (coated bentonite pellet) followed by Portland cement to 21 mbgs as per ANSI/AWWA A100-20 standards. The remaining 21 m of annular seal was installed the following day after placing a 1 m thick bentonite (peltonite) layer, to adjoin the two sections of cement. The remaining 20 m was sealed with Portland cement to surface. The EG-PW2 As-built well design drawing is provided in **Appendix D**.

As shown on the geologic cross-section (refer to **Figure 7a**), EG-PW2 (general location indicated with red arrow) is interpreted to have been screened in the same aquifer unit (YSA) as EG-PW1 (general location indicated with red arrow) with its screen setting (173.81 masl to 159.21 masl) overlapping with that of EG-PW1 (176.66 masl to 162.96 masl).

3.1.3.3 Well Plumbness and Alignment

Well plumbness and alignment was measured prior to well screen installation and after well construction completion by Lotowater, under Highland supervision, to ensure that the well is sufficiently plumb and aligned to allow for proper installation of the screen and for the successful installation and long-term operation of permanent pumping equipment. Results of the plumbness and alignment testing prior to well screen installation and after well completion are presented in **Appendix D**.

With respect to plumbness tolerance, the AWWA Standard A100-20 states that the maximum allowable horizontal deviation (drift) of the well from vertical shall not exceed 0.0067 times the smallest inside diameter of that part of the well being tested per 0.305 m of depth. The maximum allowable drift for the 79.1 m of 305-millimeter diameter casing was calculated to be 530 millimeters at well construction completion (Lotowater, 2021).

Well alignment was assessed using an ABI40 Slimline Acoustic Televiewer with a 3-component fluxgate magnetometer and a 3-component tilt meter to simultaneously collect data every 0.0025 m of depth. Based on the results presented in **Appendix D**, it was concluded by Lotowater that the plumbness and alignment of the large diameter test well (EG-PW2) complies with AWWA Standard A100-15 (and A100-20), with a maximum well drift of 283 millimeters recorded in the east-west and in the north-south direction.

It should be noted that the method employed to test the well for plumbness and alignment did not follow the field methodologies presented in the AWWA Standard A100-20. Tolerances presented in the AWWA Standard A100-20 apply to wells equipped with line-shaft pumps, and therefore are considered conservative for the assessment of EG-PW2 since line-shaft pumps will most likely not be used.

3.1.3.4 Well Development and Sand Content

Water produced from EG-PW1 and EG-PW2 during development and testing was conveyed through a discharge hose to the sanitary discharge point, via a manhole located approximately 530 m west of the Site. The discharge was conveyed through a 450-millimeter diameter sanitary sewer owned by the Town of East Gwillimbury, before discharging to the York Region-owned 825-millimeter diameter Green Lane Trunk Sewer where flows will be conveyed to the Newmarket Sewage Pumping Station. The required permissions from the Town of East Gwillimbury were obtained to use their infrastructure as part of the discharge plan. Total Suspended Solid (TSS) concentrations were manually measured prior to discharge point and remained compliant with York Region’s Sewer Use Bylaw (Bylaw No. 2021-102).

As per Section 4.8 of the AWWA A100-200 standard, EG-PW2 was developed to remove fine particles generated during the drilling process and to establish good hydraulic connection with the surrounding geologic formation in order to obtain representative water levels and sand-free water during subsequent pumping. EG-PW1 also underwent development to flush out sand that had accumulated since AECOM's 2018 aquifer testing program where it was developed at a rate of 100 L/s (on/off cycles for 20 minutes for 5 cycles, terminated early due to pump failure). It should be noted the development conducted in 2018 at EG-PW1 did not yield a sand test that achieved 5 parts per minute (ppm) at an increased production rate of 100 L/s as required in Section 4.8 of the AWWA A100-200 standard however, it was noted general improvement in sand production was observed with development. As such, additional development of EG-PW1 was completed as part of this project.

For the current field program, well development using airlifting was first conducted by Highland and involved developing every foot of screen by air lifting for about one hour at EG-PW1 between October 18, 2021, to October 20, 2021. On-Off cycling at 30 minutes was conducted at EG-PW1 between November 8, 2021, and December 3, 2021, intermittently at rates up to maximum rate of 130 L/s (under the maximum permitted rate of 150 L/s). Similarly, EG-PW2 was developed using air lifting and on/off cycling up to a maximum rate of up to 145 L/s (under the maximum permitted rate of 150 L/s) between October 22, 2021, and December 16, 2021, intermittently. Progress was monitored during this process by conducting sand content testing. A Rossum Sand Sampler and a water flow meter were installed to determine the amount of sand being produced by the well during the testing period and measure flow rate, respectively. The Rossum Sand Sampler was attached to the well head according to Figure E.1 of AWWA Standard A100-20.

It should be noted that EG-PW1 and EG-PW2 were developed prior to the step testing on November 16, 2021, and the 96-hour constant rate pumping test that took place November 22, 2021, to November 26, 2021, however, both did not achieve the 5 ppm as required by Section 4.8 of the AWWA A100-200 standard prior to aquifer testing. York Region decided to defer the completion of the well development and move forward with the aquifer testing as impact from observed sand production (high sand content at pump start then decline observed after first 10 minutes) was considered negligible for the purpose of the pumping test.

Further pump development of EG-PW1 and EG-PW2 ensued following the completion of the 96-hour constant rate pumping test. Two sand content tests were performed by Highland at rates of 100 L/s at EG-PW1 and 100 L/s on December 3, 2021, and December 16, 2021, respectively, that involved pumping the well at a constant rate of 100 L/s for two hours before the pump was shut off. Cumulative sand content was measured with the sampler and recorded every five minutes during the tests. The results of the sand content tests indicated that the AWWA A100-20 standard was met for both EG-PW1 and EG-PW2 at a pumping rate of 100 L/s, with average sand concentrations of 4.8 ppm and 4.4 ppm measured, respectively, over the two hours of pumping for each test. Results of the sand content tests are included in **Appendix D**.

EG-PW1 and EG-PW2 both produce an elevated sand content over the first 10 minutes of operation. It is recommended that design of the water treatment facility include provision for soft-start of the wells to ramp up to the design pumping rate. In addition, water for the first 10 minutes of operation should be pumped to waste prior to entering the treatment system.

3.2 Step-Drawdown Testing

On November 16, 2021, starting at 10:00 a.m., step-drawdown testing (step testing) was conducted on EG-PW2 to evaluate the aquifer response to variable pumping stresses and to determine a suitable long-term pumping rate for the constant rate pumping test. A combined step with EG-PW1 was run at the end to evaluate aquifer response to both wells pumping and to evaluate suitable long-term combined step for constant rate pumping test. Both EG-PW1 and EG-PW2 were equipped with a submersible pumps and associated flow control devices to facilitate the test. Power was supplied by a portable gas-powered generator and flow rates were controlled by a gate valve and monitored by a magnetic flow meter. Discharge equipment set up from development activities remained to facilitate the step test. EG-PW1 and EG-PW2 were equipped with pressure transducers, in stilling tubes within the wells, to record water level measurements at a 30-second interval over the duration of the test. Additionally, manual water level measurements were collected at regular intervals during the test to augment and verify the electronic measurements.

A quiet period was observed at production wells: Holland Landing PW1, Holland Landing PW2, Newmarket PW1, Newmarket PW2, Newmarket PW14, Newmarket PW 15, Queensville PW3, and Queensville PW4, from November 13, 2021, to November 16, 2021, where they were not operated to remove potential for water level interference in the Green Lane test data.

In addition to determining a suitable pumping rate for EG-PW1 and EG-PW2 for the constant rate pumping test, the step test was designed with the objective of confirming the well yield potential. Although the theoretical screen transmitting capacity of EG-PW2 was established as 146 L/s, it was determined that the well would be tested up to 100 L/s. Given pump equipment restrictions, the minimum achieved pumping rate from EG-PW2 was established as 40 L/s. As such, to allow for consistent pumping rate increments, the step test consisted of four steps during which EG-PW2 was pumped at progressively increasing rates of 40 L/s, 66 L/s, 100 L/s, and a combined step with EG-

PW2 and EG-PW1 both pumping 100 L/s, each for a period of 60 minutes, with no water level recovery between steps. The last step was completed at 1:00 p.m., following which the pump was turned off for monitoring of water level recovery.

Turbidity and sand content were collected from EG-PW2 and EG-PW1 toward the end of each step to track potential changes in sand production from the well with increased pumping rates. The turbidity was measured using a 2100Q Turbidimeter by Hach at the end of each step. The sand content testing was conducted using a Rossum Sand Sampler with observations collected at 5-minute intervals and averaged over a duration of 60-minutes. The observations of turbidity and sand content during the step test are summarized in **Table 3-3**.

Table 3-3. Turbidity and Sand Content Result Summary for Step Testing at EG-PW2 and EG-PW1

Step	Discharge, Q (Liters/second)	Turbidity (NTU)	Sand Content Average over 60 min (ppm)
1	40	21.4	105.7[b]
2	66	1.26	117.1
3	100	2.02	112.4
4	200	1.40[a], 1.68	12.7[a]

Notes:
ppm Denotes parts per million
[1] It should be noted full development did not occur prior to the step test at EG-PW1 or EG-PW2
a Result is measures from EG-PW1.
b Rossum Sand Sampler readings were not recorded for 5- and 10-minute intervals, value is an underestimation of actual sand content average over 60 minutes.

The results of the step test and associated analyses are presented in **Appendix E (Figure E.1 to Figure E.4)**. Based on the water level data collected from EG-PW2 during the step test, a total drawdown of 2.55 m was observed at the end of the test, with a change in drawdown of 0.63 m, 0.77 m, 1.52 m, and 2.55 m for the first, second, third, and fourth step, respectively. The drawdown with respect to time at EG-PW2 is shown on **Figure E.2** and the drawdown with respect to discharge is shown on **Figure E.3**.

No stabilization of water levels was achieved in the test well at any of the four steps. This was noted to be similar to the observations reported by AECOM during the step tests performed on EG-PW1 on July 28, 2016, at rates of 18 L/s, 36 L/s and 55 L/s (AECOM, 2016) and on EG-PW1 on November 5, 2018, at rates of 33 L/s, 66 L/s and 100 L/s (AECOM, 2019). A comparison of drawdown with respect to discharge for historical and current testing at EG-PW1 and EG-PW2 is provided in **Figure E.4**.

As noted in **Section 3.1.3.4**, EG-PW1 and EG-PW2 were not fully developed at the time of the step test. As shown in **Table 3-4**, the specific capacity at the four steps varies slightly (possibility development occurring during testing) with a general trend between discharge and drawdown for each step being almost linear (as illustrated on **Figure E.2 [Appendix E]**). This is interpreted to indicate that well efficiency losses were not significant at the tested rates.

Table 3-4. Estimated Specific Capacity Based on Step Test Results for EG-PW2

Step	Discharge, Q (Liters/second)	Drawdown, s (meters)	Specific Capacity, Q/s (Liters/seconds/meters)
Step 1	40	0.63	63.5
Step 2	66	0.77	85.4
Step 3	100	1.52	65.9
Step 4[a]	200[a]	2.55	78.5

Notes:
[a] Combined step with EG-PW1 pumping 100 Liters per second and EG-PW-2 pumping 100 Liters per second.

The target combined pumping rate of 200 L/s for EG-PW1 and EG-PW2 for the constant rate pumping test had a maximum drawdown of 2.55 m for a one-hour pumping period. The safe available drawdown at EG-PW2 is approximately 48.6 m, including 7 m clearance above EG-PW2 top of screen. It was determined from the step test results, preliminary projections of water levels, and comparison of available drawdown in the wells, that EG-PW1 and EG-PW2 would be able to sustain individual pumping rates of 100 L/s for the prescribed duration of the constant rate pumping test (96 hours).

3.3 Constant Rate Pumping Test

3.3.1 Pumping Test Details

A 96-hour constant rate pumping test was conducted on EG-PW2 from November 22, 2021, to November 26, 2021, which involved combined pumping with EG-PW1 for the last 72 hours of the test followed by a 72-hour recovery period until November 29, 2021. The purpose of the pumping test was to observe the aquifer response to pumping and thereby estimate the hydraulic properties of the tested aquifer, evaluate the potential yield of the aquifer, estimate the zone of influence of the pumping, document any changes in the water quality as pumping progressed during the test, and assess the Site drawdown at the combined target capacity of 200 L/s.

A quiet period was observed at production wells: Holland Landing PW1, Holland Landing PW2, Newmarket PW1, Newmarket PW2, Newmarket PW14, Newmarket PW 15, Queensville PW3, and Queensville PW4, from November 19, 2021, to November 28, 2021, where they were not operated to remove potential for interference in the Green Lane test data with exception of regulatory water quality sampling conducted on

November 24, 2021, at Newmarket PW1 and Newmarket PW2 (2785th minute of test), and Queensville PW3 and Queensville PW4 (2895th minute of test).

The pumping test was conducted by Highland under York Region's supervision. The same pumping apparatus and associated flow control and monitoring devices installed for the step test on EG-PW1 and EG-PW2 were used for the constant rate pumping test. The morning of the pumping test, the pressure transducers deployed in EG-PW1 and EG-PW2 were re-programmed to automatically record water levels at a 30-second frequency throughout the constant rate pumping test. Electronic water level measurements in Production Wells within the predicted ZOI were captured continuously at a five-minute frequency using a Supervisory Control and Data Acquisition probe. Electronic water level measurements in Monitoring Wells within the predicted ZOI were captured continuously at a one-minute frequency using dataloggers. Additionally, manual water level measurements were collected at nearby monitoring wells at regular intervals during the test to augment and verify the electronic measurements.

The test consisted of pumping EG-PW2 at a constant rate of 100 L/s, starting on November 22, 2021, at 10:00 a.m. and ending on November 26, 2021, at 10:00 a.m., for a total duration of 96 hours. To monitor the effects of combined pumping at the Green Lane Site, EG-PW1 began pumping at a constant rate of 100 L/s at 10:00 a.m. on November 23, 2021, and remained pumping for the last 72 hours of the pumping test. A graphical summary of the operation of EG-PW1 and EG-PW2 throughout the constant rate pumping test is presented as **Figure E.5 (Appendix E)**.

The discharge plan remained the same as for the well development and step testing. Total Suspended Solid (TSS) concentrations were periodically measured, using a YSI Quatro handheld TSS meter, through the duration of the aquifer testing and remained well below the Sewer Use Bylaw limit of 350 milligrams per liter (mg/L) (maximum reading of 8 mg/L at EG-PW2 two hours into test).

Groundwater quality samples were collected from EG-PW1 and EG-PW2 at distinct intervals during the constant rate pumping test (1 hour, 6 hours, 24 hours, 48 hours, and 72 hours for EG-PW1 and similarly for EG-PW2 with addition of a 96 hours sample) and were submitted to YD Lab for analysis of the indicator parameters listed in **Table 3-5** to assess changes in aquifer water quality throughout the test. Additional samples were also collected at the end of the test (toward the total 96-hour mark) for laboratory analysis of all parameters listed in Tables 1, 2 and 4 of the Ontario Drinking Water Standards, Objectives and Guidelines (ODWSOG) (MECP, 2006) as well as gross alpha, gross beta, and tritium and source water protection parameters listed in the Source Water Parameter List of **Table 3-5**. Groundwater and surface water samples listed in the GUDI Parameter List of **Table 3-5** were also collected from Newmarket

MW-20S, Newmarket MW-20D, at the northern tributary of East Holland River (MP/SG-3), at the wetland at eastern tributary of East Holland River south of Green Lane (MP-2S/D) before and after the constant rate pumping test and submitted to YD Lab for analysis for the purpose of assessing the relationship between surface water and groundwater sourced from EG-PW1 and EG-PW2. The groundwater and surface water sampling results are discussed in **Section 3.3.2.6.**

Table 3-5. List of Indicator Parameters, GUDI Indicator Parameters and Source Water Protection Indicator Parameters for Groundwater and Surface Water Sampling during the Constant Rate Pumping Test

Indicator Parameters[a]	GUDI Indicator Parameters[b]	Source Water Protection Indicators
• Turbidity • Total Dissolved Solids • Total Suspended Solids • Colour • Carbonate • Bicarbonate • Alkalinity • Hardness • Total Coliform Bacteria • Fecal Coliform Bacteria • Sulphate • Hydrogen Sulphide • Nitrate/Nitrite • Ammonia • Organic Nitrogen • Dissolved Organic Carbon • Methane • Phosphate • Manganese • Iron • Chloride • Magnesium • Potassium • Sodium • Calcium	• Calcium • Bicarbonate • Zinc • Aluminum • TSS • Hardness Magnesium • Carbonate • Chromium • Total Phosphorus • Iron • Alkalinity • Sodium • Sulphate • Unionized ammonia • Copper • Cadmium • Fluoride Potassium • Chloride • Lead • Phenols • pH	• 1,4 Dioxane • Acenaphthylene • Benzo(b/j)fluoranthene • Dibenzo(a,h)anthracene • MCPB • Naphthalene 1-Methylnaphthalene • Anthracene D10 (2) • Benzo(g,h,i)perylene • Fluoranthene • Mecoprop • Phenanthrene-d10 • 2-Methylnaphthalene • Benzo(a)anthracene • Benzo(k)fluoranthene • Fluorene • Acenaphthene • Benzo(a)pyrene • Chrysene • Indeno(1,2,3-cd)pyrene • Methylnaphthalene 2-(1-) • Metalaxyl • Pyrene

Notes:

[a] Indicator Parameters collected at EG-PW1 and EG-PW2.

[b] Surface Water Quality Parameters collected at Newmarket MW-20S, Newmarket MW-20D, northern tributary of East Holland River (MP/SG-3), wetland at eastern tributary of East Holland River South of Green Lane (MP-2S/D).

3.3.2 Pumping Test Data Analyses

3.3.2.1 Pumping Test Results

Select monitoring wells and mini-piezometers/stream-gauges in the Newmarket, Holland Landing, and Queensville monitoring network (Newmarket: MW-2, MW-4, MW-12, MW-16, MW-18S2/I/D, MW-19, MW-20S/D, MW-21S/D, MW-22S/D, MW-23S/D, MW-24, MW-31S/D; Holland Landing: MW-1, MW-3, MW-9, MW-10, MW-11, MW-12 (unusable data due to flowing conditions); Queensville: MW-3, MW-4, MW-6S/D, MW-7 (unusable data due to pressure transducer malfunction), MW-12S/D, MW-20; Mini-piezometers: Newmarket: MP-1, MP-2S/D, MP-3, SG-1, SG-3) were equipped with pressure transducers programmed to record water levels electronically at a one-minute intervals at monitoring wells and at two-minute intervals at mini-piezometers/stream gauges throughout the duration of the 96-hour constant rate pumping test, while the pressure transducers in the remaining monitoring wells were programmed to record water levels at a 30-minute interval. In addition, the pressure transducers deployed in the private water supply wells located at the following East Gwillimbury locations: Valley Trail, Lepard Crescent (flowing well), Milne Lane and 2nd Concession Road, were also programmed to record water levels every two-minutes. Manual water level measurements were collected from nearby groundwater monitors at a minimum frequency of once daily to allow for calibration of electronic readings.

Of the monitored wells, representative monitors were selected based on their spatial locations and interpreted screened hydrostratigraphic units and included as part of the pumping test data analyses. Hydrographs illustrating the measured groundwater levels at these monitoring wells and mini-piezometers/stream-gauges are presented in **Appendix E (Figures E.5 to E.12**.). All monitors were plotted on the hydrographs with exception of Holland Landing MW-12, Lepard Crescent, and Queensville MW-7. Holland Landing MW-12 and Lepard Crescent monitors were flowing throughout the 96-hour constant rate pumping test. The data from the pressure transducers at these monitoring wells was not used as it did not capture the actual change in potentiometric head due to pressure relief observed through overflow. Pressure transducer malfunction was observed at Queensville MW-7 making the data unusable.

A maximum drawdown of 3.63 m was observed in EG-PW2 during the first 24 hours when only EG-PW2 was pumping, while a maximum drawdown of 10.82 m was observed under the combined pumping scenario. Based on an estimated available drawdown of 48.6 m in EG-PW2 (calculated as the difference between the pre-test water level to seven meters above the top of screen), the maximum observed drawdown in the test well for 24 hours and 96 hours of the test was estimated to be equivalent to approximately 7% and 22% of the available drawdown in the well, respectively. **Table 3-6** summarizes the maximum observed drawdown in the monitors during the first 24 hours of the test when only EG-MW2 was pumping at a rate of 100 L/s, as well as the maximum observed drawdown following the combined portion of the pumping test, 96 hours into the test, when EG-PW1 and EG-PW2 were operating at a combined pumping rate of 200 L/s for a 72-hour duration.

Table 3-6. Summary of Drawdown Observed in Monitoring Wells during the 96-Hour Constant Rate Pumping Test

Well ID	Interpreted Screened Unit	Distance from Test Well EG-PW1 (meters)	Distance from Test Well EG-PW2 (meters)	Maximum Change in Water Level (100 Liters/second) (24 hours of Pumping Test) (meters)	Maximum Change in Water Level (200 Liters/second) (96 hours into test) (meters)
EG-PW2	YSA	17	-	3.63	10.82
EG-PW1	YSA	-	17	2.84	11.05
Newmarket MW-16	YSA	30	25	2.9	10.03
Newmarket MW-20D	YSA	27	28	2.77	10.05
Newmarket MW-20S	Upper Newmarket Till	27	29	0.02	-0.06
Newmarket MW-19	YSA	89	105	2.8	10.15
Newmarket MP-1	Modern Alluvial Deposits[a]	175	159	-0.02	-0.19
Newmarket SG-1	N/A	175	159	0.04	0.01
Newmarket MP-2D	Modern Alluvial Deposits[a]	202	187	0.03	-0.19
Newmarket MP-2S	Modern Alluvial Deposits[a]	202	187	0.01	0
Newmarket MW-21D	YSA	330	314	2.67	9.75
Newmarket MW-21S	ORM Channel Sand	332	315	0.01	0.02
Newmarket MP-3	Modern Alluvial Deposits[a]	385	402	-0.04	-0.11
Newmarket SG-3	N/A	385	402	0.05	0
EG-MW4	YSA	1,487	1,473	1.7	8.04
Newmarket MW-4	YSA	1,637	1,641	0.37	3.24
Valley Trail	YSA	1,773	1,762	1.91	8.65
Newmarket PW15	YSA	1,975	1,984	0.11	1.75
Newmarket MW-24	YSA	1,985	1,994	0.14	1.8
2nd Concession Rd	YSA	2,053	2,045	1.25	7.98

Well ID	Interpreted Screened Unit	Distance from Test Well EG-PW1 (meters)	Distance from Test Well EG-PW2 (meters)	Maximum Change in Water Level (100 Liters/second) (24 hours of Pumping Test) (meters)	Maximum Change in Water Level (200 Liters/second) (96 hours into test) (meters)
Holland Landing MW-1	YSA	2,071	2,066	1.91	8.68
Holland Landing Well No. 1	YSA	2,093	2,088	1.9	8.67
Holland Landing MW-9	YSA	2,375	2,369	1.83	8.54
Holland Landing MW-10	YSA	2539	2532	1.81	8.5
Holland Landing PW2	YSA	2,540	2,534	1.81	8.51
Holland Landing MW-3	YSA	2,833	2,824	1.68	8.27
Newmarket PW2	YSA	2,900	2,907	-0.03	2.86
Newmarket MW-2	YSA	2,909	2,916	-0.03	0.76
Newmarket Well No. 1	YSA	2,972	2,979	-0.03	0.75
Newmarket MW-31S	Upper Newmarket Till (sand lens)	2,975	2,982	0.02	-0.03
Newmarket MW-31D	YSA	2,976	2,983	-0.04	0.72
Newmarket MW-18D	YSA	3,234	3,241	0.02	0.82
Newmarket MW-18S2	Upper Newmarket Till (sand lens)	3,235	3,242	0.01	-0.02
Newmarket MW-18I	Lower Newmarket Till / YSA	3,237	3,244	0.03	-0.13
Newmarket MW-12	INS	3,629	3,614	0.07	-0.05
Newmarket MW-23S	YSA	4,056	4,070	-0.14	-0.32
Newmarket MW-23D	YSA	4,061	4,075	-0.17	-0.37

Well ID	Interpreted Screened Unit	Distance from Test Well EG-PW1 (meters)	Distance from Test Well EG-PW2 (meters)	Maximum Change in Water Level (100 Liters/second) (24 hours of Pumping Test) (meters)	Maximum Change in Water Level (200 Liters/second) (96 hours into test) (meters)
Lepard Crescent	YSA	4,551	4,549	Flowing[b]	Flowing[b]
Queensville MW-6S	YSA	4,816	4,811	-0.16	-0.70
Queensville MW-6D	YSA	4,817	4,811	0.03	2.31
Holland Landing MW-12	YSA	4,859	4,858	Flowing[b]	Flowing[b]
Newmarket PW13	YSA	4,966	4,971	-3.97	-2.91
Newmarket PW16	YSA	5,109	5,115	-1.08	8.98
Newmarket MW-22S	INS	5,141	5,140	-0.04	-0.21
Newmarket MW-22D	Thorncliffe Formation	5,141	5,140	-0.02	-0.18
Queensville MW-7	YSA	5,390	5,379	N/A[c]	N/A[c]
Queensville MW-3	YSA	5,582	5,571	1.06	7
Queensville MW-4	YSA	5,593	5,582	0.32	5.76
Queensville PW3	YSA	5,582	5,572	1.1	7.16
Queensville PW4	YSA	5,600	5,589	1.1	7.08
Holland Landing MW-11	Scarborough Formation	6,241	6,245	0.23	0
Milne Lane	YSA	6,534	6,525	-0.34	0.42
Queensville MW-12S	INS	6,676	6,669	0.03	0.06
Queensville MW-12D	INS	6,676	6,669	0	-0.12
Queensville MW-20	Thorncliffe Formation	7,097	7,084	0	1.5
Queensville PW2	YSA	8,497	8,486	-5.13	-0.55

Well ID	Interpreted Screened Unit	Distance from Test Well EG-PW1 (meters)	Distance from Test Well EG-PW2 (meters)	Maximum Change in Water Level (100 Liters/second) (24 hours of Pumping Test) (meters)	Maximum Change in Water Level (200 Liters/second) (96 hours into test) (meters)
Queensville PW1	YSA	8,523	8,511	-2.41	2.16

Notes:

a The screened geologic unit for mini-piezometers were interpreted from surficial geology mapping (Ontario Geological Survey, 2003).

b Unable to capture representative data from flowing wells as hydraulic pressure being relieved by spilling over top of casing or t-connection.

c Data is unusable due to pressure transducer malfunction.

\- Negative value indicates water level observation is higher than that measured on November 22, 2021, at 10:00 a.m. (Start of 96-hour constant rate pumping test).

As illustrated on **Figure E.5 (Appendix E)**, the water levels observed at EG-PW1 and EG-PW2 during the combined portion of the constant rate pumping test continued to decline throughout the test with no stabilization of water levels achieved. This is similar to observations made by AECOM based on the 2016 72-hour constant rate pumping test that was performed on EG-PW1 at 55 L/s (AECOM, 2016) and again in 2018 during a 48-hour constant rate pumping test that was performed on EG-PW1 at 100 L/s (AECOM, 2019). Furthermore, it was noted that the observed water levels in EG-PW1 and EG-PW2 showed an almost identical response, which confirms that the wells source the same aquifer and reflects their close proximity to one another.

As shown in **Table 3-6**, the maximum drawdown observed in EG-PW1 and EG-PW2 during the combined portion of the pumping test was 11.05 m and 10.82 m, respectively. During the first 24 hours of the test when only EG-PW2 was pumping at 100 L/s, a maximum drawdown of 2.84 m was observed in EG-PW1, which represents the maximum observed interference in the production well from pumping of EG-PW2. The maximum drawdown observed in monitoring wells interpreted to be screened in the YSA (see **Table 3-6**) during the combined portion of the pumping test ranged from no response at Newmarket Well No. 13, Newmarket Well MW-23D and Queensville Well No. 2 to a very strong response in nearby Newmarket MW-19, Newmarket MW-20D, and Newmarket MW-16 at 10.15 m, 10.05 m, and 10.03 m, respectively.

It was also interpreted that a greater influence from the pumping test was observed at northern pumping and monitoring wells than those compared to the south of the Site. No influence from the pumping test was observed in the nearby shallow monitoring wells interpreted to be screened in the ORAC channel (Newmarket MW-21S), Upper Newmarket Till sand lens (Newmarket MW-18S2 and Newmarket MW-31S), Inter-Newmarket Sediments (Newmarket MW-12 and Newmarket MW-22S), Lower Newmarket Till (Newmarket MW-18I), or in the mini-piezometers/stream-gauges (MP-1, MP-2S/D, MP-3, SG-1 and SG-3).

3.3.2.2 Drawdown at the Private Water Wells

To assess the drawdown influence at private water wells during the constant rate pumping test, approval was sought from the private well owners to further monitor their respective private water supply wells screened in the YSA (further detailed in the section that follows). The MECP well records for the following private wells are included in **Appendix B**, and their location is illustrated on **Figure 7**:

- Valley Trail (MECP WELL ID: 6916831)
- Lepard Crescent (MECP WELL ID: 6917595)
- Milne Lane (MECP WELL ID: 6918052): and,
- 2nd Concession Road (MECP WELL ID: 6913638)

Permission was obtained from the private well owners to deploy/re-deploy pressure transducers programmed to record water level measurements electronically every two minutes in four private wells for the duration of the 96-hour constant rate pumping test. During this time, the private wells were operated concurrently and intermittently over a period of testing however did not interfere with drawdown or recovery trends within the test monitoring network. An influence from pumping EG-PW2 and combined pumping was observed at Valley Trail (1,778 m from EG-PW2) and 2nd Concession Road (1,974 m from EG-PW2) with a delayed response observed at Milne Lane (6,555 m from EG-PW2). Observations collected from Lepard Crescent were not considered representative of the potentiometric surface as the well was passively being depressurized from flowing conditions during the test. It should be noted, the water level observations at Lepard Crescent indicated the well continued to flow throughout the 96-hour constant rate test. A hydrograph showing the water levels at EG-PW1 and EG-PW2 along with the water level observations from the private wells is provided on **Figure E.11 of Appendix E.**

<u>Private Well Survey</u>

York Region conducted a private water well survey for properties within the predicted ZOI for the 96-hour constant rate pumping test (details regarding predicted ZOI provided in York Region, 2021). The objective of the private water well survey was to notify well users who could potentially be affected of the upcoming pumping activities and to develop a better understanding of the local groundwater use, a survey of private water wells within occupied and non-municipally serviced properties in the predicted ZOI ahead of the proposed aquifer testing activities. As a result of COVID-19 concerns and related safety precautions, a door-to-door in-person well survey was not completed. Instead, the well survey notification letter and well survey form was distributed to the properties with instructions to complete the form online.

Of the 63 online participants, 12 private wells were shortlisted for site visits based on potential for impact during the 96-hour constant rate pumping test. Of the 12 short-listed properties, 10 survey participants responded to an initial inspection for their private wells where only 4 private wells were acceptable for further monitoring based on permissions granted and well accessibility. The 4 private wells were monitored for microbiological parameters before and after the 96-hour constant rate pumping test and water levels throughout the duration of aquifer testing. No exceedances against the ODWSOG standard were found for the microbiological parameters sampled at the private wells with exception of total coliform where pre-test levels were found to be higher than post-test. The residents were notified of the exceedances with 24 hours of receiving the laboratory results and were guided on how to disinfect their wells. The monitoring of the private wells during the 96-hour constant rate pumping (discussed in **Section 3.3.2.2**) indicated no adverse impact to private water supply for the 4 private wells.

The results of the private well survey interpreted to be screened in the YSA are provided in **Table F-1 (Appendix F)** with locations of all participating private well surveys shown on **Figure 8**. A summary of the microbiological water quality results for the documentation of monitored private wells is provided in **Table F-2 (Appendix F)** with lab results attached in **Appendix F**. A hydrograph of the private wells monitoring during the 96-hour constant rate pumping test is provided on **Figure E.11 (Appendix E)**. The field sheets documenting the site visits for the private well survey Site Visits are attached in **Appendix F.**

3.3.2.3 Aquifer Characteristics

AQTESOLV's Pumping Test wizard for a multi-well test was used to estimate aquifer properties for the YSA based on drawdown observed in Newmarket MW-16, Newmarket MW-19, Newmarket MW-20D, Newmarket MW-21D, EG-MW4, Holland Landing MW-1, Holland Landing MW-3, Holland Landing MW-9, and Holland Landing MW-10 during the 96-hour pumping test. Well parameters and aquifer input parameters for the AQTESOLV Pumping Test simulation were determined from borehole and well logs as well as the Geologic Cross-Section (**Figure 6a**).

The entirety of the drawdown dataset for the previously noted observation wells covering the pumping test was analyzed using the composite plot tool with the Theis

(1935)/Hantush (1961) method and incorporation of boundaries to estimate transmissivity (T) and storativity (S) values.

Key assumptions of the Theis solution are as follows: the aquifer is homogenous and isotropic; the pumping well draws in groundwater from an infinite extent; the source of groundwater is solely from the aquifer's confined storage; and the aquifer is bound by impervious overlying aquitard (no leakage).

Further refinement to the AQTESOLV Pumping Test simulation was conducted by incorporating boundary conditions to the solution. The following simplifications have been assumed in characterizing the western and eastern channel walls for the analytical solution: The Site is located in the middle of the channel; the YSA channel walls trend exactly north and south; and the YSA channel walls are no flow boundaries running north south. The YSA channel delineated by Gerber et.al 2018 was used to estimate the distance of the Site to the channel walls. The western and eastern channel walls are located approximately 2,625 m west and east of the Green Lane Site. The addition of the YSA Channel boundaries to the Theis solution modeled in AQTESOLV improved the late time fit of the drawdown data observed.

The output of the AQTESOLV solution indicated the aquifer is complex. The solutions of the observation wells closest to the Green Lane Site: Newmarket MW-16, Newmarket MW-19, Newmarket MW-20D, and Newmarket MW-21D, conveyed the local area around EG-PW1 and EG-PW2 inferred a higher transmissivity (shallower slope) than the observation wells located north of the Green Lane Site: EG-MW4, Holland Landing MW-1, Holland Landing MW-3, Holland Landing MW-9, and Holland Landing MW-10.

For the local observation wells T and S values are estimated to be 24,000 m^2/day and $4x10^{-6}$ (unitless), respectively. These values are only valid for the Site and are suited to assess the impact of pumping within the pumping wells themselves. The output of the AQTESOLV analysis for local T and S is provided in **Figure E.13 (Appendix E)**. For the observation wells north of the Green Lane Site T and S values are estimated to be 1,060 m^2/day and $7x10^{-5}$ (unitless), respectively. These values are more representative of a bulk T and S and better suited to assess impacts on local wells. The output of the AQTESOLV analysis for the bulk T and S is provide in **Figure E.14 (Appendix E)**.

The typical range for storativity for a confined aquifer is 5^{-5} to 5^{-3} (Todd,1980) whereas unconfined aquifers release more water from storage for each unit decline of hydraulic head ranging from 0.1 to 0.3 (Lohman, 1972). The interpreted local and bulk storativity is indicative of a confined aquifer.

3.3.2.4 Sustainable Yield

To assess the sustainability of the groundwater takings from EG-PW1 and EG-PW2, the potential long-term drawdown in the two pumping wells was predicted by extrapolating the pumping test drawdown data beyond the testing period for two scenarios:

1. Peak Demand Scenario –pumping of EG-PW1 and EG-PW2 at the target combined rate of 200 L/s during the peak demand period (defined as the 153-day period from May 1 to September 30 in a given year, when the water demand is highest):

    - Rationale for pumping rate:

      The pumping rate of 200 L/s was determined to be the maximum redundancy requirement under potential loss of capacity in the YSA PTTW. It was quantitatively established by turning off the largest well in the system, Aurora Well No. 4, and only pumping from water supply wells planned to undergo water treatment facility enhancements with respect to iron and manganese removal, these included: Aurora: PW1, PW2, PW3, PW4, PW5, PW7; Newmarket: PW1, PW2, PW13, PW16; and Queensville-PW1, PW2, PW3, PW4. Production wells that will not have enhanced water filtration treatment systems: Aurora PW6, Newmarket PW15, Holland Landing PW1 and PW2 were assumed to be off in this scenario. By subtracting the total firm capacity of wells along with enhanced water filtration systems (69,626,592 liters per day or 805.9 L/s) from the maximum daily water taking limit during the peak demand period (permitted rate of 87,656,000 L/s or 1,014.5 L/s), a deficit of 18,029,408 liters per day or 209 L/s was calculated. As the constant rate pumping test pumped at a combined rate of 200 L/s, it was used to interpolate the peak demand scenario informed by the hydraulic response observed in the system at that rate.

2. Average Day Demand Scenario – constant pumping from EG-PW1 and EG-PW2 at combined rate of 105 L/s for 20 years until 2041.

    - Rationale for pumping rate:

    The pumping rate of 105 L/s reflects the approved pumping rate from the *Schedule B Class Environmental Assessment (Class EA) for the Yonge Street Aquifer Well Capacity Restoration Project* completed by the Region in 2016.

It is acknowledged that the Average Day Demand Scenario, in particular, is conservative as typical combined operation of the wells at this pumping rate would be limited to days (rather than weeks), with some interruption to pumping to allow aquifer recovery. However, although not expected to be realized in normal operation of the wells, this conservative scenario was assessed to fully evaluate the potential of the aquifer.

The sustainability of long-term pumping under the two scenarios was evaluated by comparing the projected drawdown at the end of the pumping period to the available drawdown in each of the two wells.

Two main factors were considered in estimating the available drawdown in EG-PW1 and EG-PW2 under each scenario:

1. Seasonal variations (in particular, the typically lower water levels in the summer between July and September of each year); and,

2. Lost capacity due to well efficiency loss.

An additional factor was considered under the Peak Demand Scenario

3. Production Well interference from other YSA water supply wells pumping maximum permissible rates during peak demand period. This is not considered for the Average Day Demand scenario, as it is assumed that Green Lane production wells will be preferred over Holland Landing production wells and Newmarket PW15 due to superior water quality post treatment and hence Holland Landing production wells and Newmarket PW15 will not be operating in the Average Day Demand Scenario.

The sustainability assessment for both the Peak Demand Scenario and the Average Day Demand Scenario focused on the Site capacity, equally combined pumping rates for EG-PW1 and EG-PW2.

<u>Peak Demand Scenario</u>

In assessing the sustainability of the groundwater takings for the first scenario (Peak Demand Scenario), EG-PW1 and EG-PW2 were assumed to be continuously pumping at the target combined rate of 200 L/s for the duration of the peak demand period (153 days). As previously noted, this is a conservative approach as it is not anticipated that the wells would realistically be operated continuously for such an extended period time; instead, pumping cycles would be driven based on storage levels and water demands.

To evaluate if the Peak Demand Scenario was sustainable a safe available drawdown trigger level was calculated based the factors 1 to 3 discussed previously and a safe water level accommodating the installed pump assembly. Using historical data available local to the Site, climatic, well loss, and production well interference buffers were applied to the available drawdown for the Peak Day Demand Scenario to account for factors 1 to 3. The adjusted available drawdown for EG-PW1 and EG-PW2 for the Peak Demand Scenario is summarized in **Table 3-7**.

Table 3-7. EG-PW1 and EG-PW2 Assumed Available Drawdown for Peak and Average Day Demand Scenarios

Well Details					Buffers			Available Drawdown with Buffers	
Well ID	Static Water Level (November 22, 2021, at 10 a.m. [masl])	Top of Screen (masl)	Safe Water Level[1] (masl)	Safe Available Drawdown without Buffer Applied (meters)	Climatic[2] (meters)	Well Loss[3] (meters)	PW Interference[4] (meters)	Peak Demand (meters)	Average Day Demand (meters)
EG-PW1	230.01	176.7	183.7	46.3	4.5	0.4	5.5	35.9	41.4
EG-PW2	229.46	173.8	180.8	48.7	4.5	0.8	5.5	37.8	43.3

Notes:
masl Denotes meters above sea level
1. The safe water level is assumed to be 7 m above the top of screen to accommodate the pump assembly and pump head to avoid pumping air:
2. Climatic buffer based on water level fluctuations observed at EG-PW1 (aka EG-MW2) from August 2016 to November 2021;
3. Well loss buffer based on 33% loss in well efficiency based on maximum capacity loss observed at nearby production wells prior to rehab scheduled;
4. Production well interference buffer based on historical changes in water level observed at EG-PW1 and nearby YSA wells from pumping rate changed at Holland Landing, Newmarket and Queensville production wells.

To assess sustainable yield of the Peak Day Demand Scenario, the Hantush-Jacob Model for a Leaky Aquifer (AQTESOLV Pumping Test Wizard) was used to extrapolate a predicted water level to 153 days.

Hantush and Jacob (1955) derived an analytical solution for predicting water-level changes in response to pumping in a homogeneous, isotropic leaky confined aquifer assuming steady flow (no storage) in the aquitard:

$$s = \frac{Q}{4\pi T}\int_u^\infty e^{-y-r^2/4B^2y}\frac{dy}{y}$$

$$u = \frac{r^2S}{4Tt}$$

$$B = \sqrt{\frac{Tb'}{K'}}$$

$$s_D = \frac{4\pi T}{Q}s$$

$$t_D = \frac{Tt}{r^2S}$$

Where:

b' is aquitard thickness [L]

K' is vertical hydraulic conductivity in the aquitard [L/T]

Q is pumping rate [L^3/T]

r is radial distance [L]

s is drawdown [L]

S is storativity [dimensionless]

t is time [T]

T is transmissivity [L^2/T]

(Note: Meters (m) were used for “L” and seconds (s) were used for “T”)

As the sustainability assessment was focused on determination of predicted available drawdown remaining within the pumping wells for each scenario, the local transmissivity was inferred to be more representative and more conservative compared to the bulk transmissivity and was used in the Hantush-Jacob solution.

Similar to **Section 3.3.2.3**, no flow boundaries trending north-south were applied based on the YSA channel walls delineated in Gerber et. al 2018.

Gerber and Howard (2000) reported a range of vertical hydraulic conductivities of the Northern Till (Newmarket Till) of $3 \times 10^{-11}\frac{m}{s}$ to $3 \times 10^{-7}\frac{m}{s}$. Assuming that the aquitard materials overlying the YSA are 45 m thick, a value of $\frac{1}{B}$ = $2.3 \times 10^{-5}\frac{1}{m}$ was back calculated using a value from the middle of the Newmarket Till range for aquitard vertical hydraulic conductivity:

$$K' = Tb'^{\left(\frac{1}{B}\right)^2} = 6.7 \times 10^{-9}\frac{m}{s}$$

Using the inputs mentioned above a solution for the Hantush-Jacobs (1955) was run in AQTESOLV.

The available drawdown is not exceeded for the Peak Demand Scenario. The pumping rate of 200 L/s is considered sustainable over a period of 153 days. The AQTESOLV solution for Hantush and Jacob (1955) is provided in **Appendix E (Figure E.15).** The solution shows a drawdown trend at both test wells until the 116 day mark (shown as 10^7 on the logarithmic axis) where stabilization between water taking at 200 L/s and the leakage from the overlying aquitard reaches equilibrium at a drawdown of 33.8 m.

The available drawdowns with buffers applied for the peak demand scenario were inferred to be 35.9 m and 37.8 m at EG-PW1 and EG-PW2, respectively, as detailed in **Table 3-7**. As such, an estimated approximate drawdown of 2.1 m and 4.0 m at EG-PW1 and EG-PW2, respectively, remains available in the solution at 153 days.

<u>Average Day Demand Scenario</u>

In assessing the sustainability of the groundwater takings for the second scenario (Average Day Demand Scenario), EG-PW1 and EG-PW2 were assumed to be continuously pumping at the target combined rate of 105 L/s for the duration of the Average Day Demand period (20 years). As previously noted, this is a conservative approach as it is not anticipated that the wells would realistically be operated continuously for such an extended period time; instead, pumping cycles would be driven based on storage levels and water demands.

To evaluate if the Average Day Demand Scenario was sustainable, a safe available drawdown trigger level was calculated based the factors 1 and 2 discussed previously and a safe water level accommodating the installed pump assembly. Using historical data available local to the Site, climatic and well loss buffers were applied to the available drawdown for the Average Day Demand Scenario to account for factors 1 and 2. The adjusted available drawdown for EG-PW1 and EG-PW2 for the Average Day Demand Scenario is summarized in **Table 3-7**.

The Hantush-Jacob Leakage solution for continuous operation at 200 L/s (with inputs discussed previously) was used to justify combined pumping of 105 L/s was sustainable at the Green Lane Site.

The available drawdown is not exceeded for the Average Day Demand Scenario. The pumping rate of 200 L/s is considered sustainable over a period of 20 years (found between 10^8 and 10^9 on the logarithmic axis). The AQTESOLV solution for Hantush and Jacob (1955) is provided in **Appendix E (Figure E.15).** The solution shows a drawdown trend at both test wells until the 116 day mark (shown as 10^7 on the logarithmic axis) where stabilization between water taking at 200 L/s and the leakage from the overlying aquitard reaches equilibrium at a drawdown of 33.8 m.

The available drawdowns with buffers applied for the peak demand scenario were inferred to be 41.4 m and 43.3 m at EG-PW1 and EG-PW2, respectively, as detailed in **Table 3-7**. As such, an estimated approximate drawdown of 7.6 m and 9.5 m at EG-PW1 and EG-PW2, respectively, remains available in the solution at 20 years. As the system is sustainable over 20 years at 200 L/s therefore it is assumed sustainable at 105 L/s.

3.3.2.5 Range of Influence

The zone of influence (ZOI) for the YSA was estimated to determine the areal extent of the anticipated drawdown cone under two pumping scenarios (Peak Demand Scenario and Average Day Demand Scenario), and to identify potential groundwater receptors which may experience influence from prolonged pumping at the Site. As noted previously, although the Peak Demand Scenario, in particular, is conservative in nature and unlikely to be realized under normal required operations of the wells, it has been reviewed as part of this evaluation to fully understand the potential of the aquifer at the Site.

Given the complex nature of the YSA, its lateral hydraulic connection to the inter-channel sediments both east and west of the YSA, and the hydraulic disconnect between the YSA and the Bradford Aquifer, it was determined that a traditional distance-drawdown analysis would not provide a realistic prediction of the ZOI. As such, a simple 3D groundwater flow “box” model (herein referred to as the box model) was constructed to reflect the conceptual understanding described in **Section 2.3**, for the purposes of predicting the ZOI under both pumping scenarios. For this analysis, the ZOI is defined as the radius of influence around the pumping wells where the estimated drawdown was expected to be approximately 1 m, which is within the range of natural groundwater fluctuations in a given year.

The box model area encompassed the entire YSA extent and beyond, spanning from Stouffville Road (south) to Ravenshoe Road (north) and from Highway 400 (west) to Kennedy Road (east). A 2-layer numerical structure was employed to reflect the deep aquifer system, which was assigned fully confined conditions; this approach enhanced computational efficiency as it eliminated the numerical challenges surrounding cell drying and rewetting nonlinearities within unconfined numerical layers (most often representing a shallow aquifer system). Further details regarding the box model parameterization can be found in **Appendix G**.

The transient calibration effort for the box model was focused on 'reasonably' matching simulated and observed drawdown estimates, from York Region monitoring wells screened near the Site. The calibration approach considered the 96-hour combined pumping test at EG-PW1 and EG-PW2 (refer to **Section 3.3** for combined pumping test details).

The calibrated groundwater flow model was used to forecast the drawdown prediction in the YSA and inter-channel sediments under both the Peak Demand Scenario (153-day constant rate pumping conditions with a combined water taking of 200 L/s at the Site) and the Average Day Demand Scenario (20-year constant rate pumping conditions with a combined water taking rate of 105 L/s at the Site). *Note: The Average Day Demand Scenario reflects the approved pumping rate from the Schedule B Class Environmental Assessment (Class EA) for the Yonge Street Aquifer Well Capacity Restoration Project completed by the Region in 2016*.

Review of the simulated water balance, for the Peak Demand Scenario, indicated some uncertainty related to the model domain's northern extent; this uncertainty was accounted for by applying a 10% extension to the north from the 1-m simulated drawdown contour for the Peak Demand Scenario (only). Water balance for the Average Day Demand Scenario did not indicate any uncertainty with respect to the model domain extents and therefore no adjustments were required. The resulting ZOI for both pumping scenarios are presented on **Figure 9**. As depicted on **Figure 9**, the ZOI for the Average Day Demand Scenario is generally larger than that of the Peak Demand Scenario with exception to the northern boundary due to the uncertainty adjustment (as previously noted).

The simulated drawdown contours for the Average Day Demand and Peak Demand Scenarios are provided on **Figure 9a** and **Figure 9b**, respectively. As expected, the drawdown contours and ZOI alignment follows the interpreted YSA extent in the north/south direction. The extent of the ZOI is limited to the west at the interpreted hydraulic disconnect between the YSA and the Bradford Aquifer.

It is important to note that the predicted ZOI for each scenario was intended to estimate the potential extent of drawdown impacts from the water takings at the Site only and does not account for potential drawdown effects from other YSA production wells or other groundwater users.

Limitations pertaining to the calibration approach and simulated ZOI are included within **Appendix G**. It is important to note that the box model was developed as a tool for estimating the approximate ZOI extent. It should also be noted that these estimates of ZOI are considered conservative on the basis that the pumping wells are not likely to be operated continuously for these extended periods of time; instead pumping cycles would be driven based on storage and water demands.

3.3.2.6 Water Quality Analysis and Characteristics

Groundwater Quality Results

Results of the indicator parameters and ODWS groundwater quality samples collected during the pumping test (as described in **Section 3.3.1**) showed minimal change in parameter concentration throughout the pumping test at EG-PW1 and EG-PW2. Parameters tested met ODWSOG standards with the exception of colour, hardness, iron, manganese and methane for which exceedances of the ODWSOG were noted at EG-PW1 and EG-PW2 (**Table 3-8 and Table 3-9**).

The complete tabulated results are found in **Tables H-1ab to H-3** (**Appendix H)** along with in-situ field chemistry measurements collected during sampling events and laboratory reports for each analysis.

Table 3-8. Summary of Groundwater Quality Exceedance Results for EG-PW1 for the 96-Hour Constant Rate Pumping Test

Water Quality Parameter	Units	Water Quality Criteria		EG-PW1					
		AO/OG[a]	MAC/ IMAC[b]	1-Hour	6-Hour	24-Hour	48-Hour	72-Hour	ODWSOG
Colour	TCU	5	-	7[d]	15[d]	7[d]	13[d]	13[d]	8[d]
Hardness as $CaCO_3$	mg/L	80-100	-	182[d]	185[d]	187[d]	188[d]	187[d]	186[d]
Iron as Fe	mg/L	0.3	-	0.45[d]	0.46[d]	0.51[d]	0.52[d]	0.52[d]	0.526[d]
Manganese as Mn	mg/L	0.05 (0.02)[c]	(0.12)[c]	0.027[e]	0.028[e]	0.026[e]	0.025[e]	0.025[e]	0.0248[e]
Methane	L/m^3	3	-	3.40[d]	3.70[d]	3.40[d]	3.60[d]	3.40[d]	2.9

Notes:

[a] AO = Aesthetic Objective; OG = Operational Guideline

[b] MAC = Maximum Acceptable Concentration; IMAC = Interim Maximum Acceptable Concentration based on Guidelines Canadian Drinking Water Quality (Health Canada, 2022)

[c] *Health Canada guideline for Canadian Drinking Water Quality: Guideline Technical Document – Manganese* (Health Canada, 2019)

[d] Exceeds water quality criteria.

[e] Exceeds Health Canada guideline for Canadian Drinking Water Quality for Manganese.

Water quality criteria are based on Ontario Regulation 169/03 and the Ontario Drinking Water Standards, Objectives and Guidelines (MECP, 2006).

Table 3-9. Summary of Groundwater Quality Exceedance Results for EG-PW2 for the 96-Hour Constant Rate Pumping Test

Water Quality Parameter	Units	Water Quality Criteria		EG-PW2						
		AO/OG [a]	MAC /IMAC[b]	1-Hour	6-Hour	24-Hour	48-Hour	72-Hour	96-Hour	ODWS OG
Colour	TCU	5	-	7[c]	6[c]	6[c]	13[c]	10[c]	14[c]	10[c]
Hardness as $CaCO_3$	mg/L	80-100	-	187[c]	188[c]	188[c]	186[c]	187[c]	192[c]	191[c]
Iron as Fe	mg/L	0.3	-	0.49[c]	0.50[c]	0.51[c]	0.54[c]	0.54[c]	0.54[c]	0.534[c]
Manganese as Mn	mg/L	0.05 (0.02[HC])	(0.12[HC])	0.035	0.030	0.026	0.025	0.024	0.024	0.023
Methane	L/m³	3	-	3.30[c]	3.10[c]	2.80	1.10	3.00[c]	3.00[c]	2.6

Notes:

[a] AO = Aesthetic Objective; OG = Operational Guideline

[b] MAC = Maximum Acceptable Concentration; IMAC = Interim Maximum Acceptable Concentration based on Guidelines Canadian Drinking Water Quality (Health Canada, 2022)

[c] Exceeds water quality criteria.

[d] Exceeds Health Canada guideline for Canadian Drinking Water Quality for Manganese.

Water quality criteria are based on Ontario Regulation 169/03 and the Ontario Drinking Water Standards, Objectives and Guidelines (MECP, 2006).

Hardness is a result of high amounts of calcium and magnesium in water and is expressed as the equivalent quantity of calcium carbonate ($CaCO_3$). The ODWSOG for hardness is an operational guideline and is set between 80 and 100 mg/L. This operational guideline is considered an acceptable range that prevents corrosion of water pipes caused by soft water and incrustation caused by hard water. Water supplies with hardness greater than 500 mg/L are considered unacceptable for most domestic purposes. The results of the water quality analysis indicate that hardness is in the range of 182 mg/L to 192 mg/L. This range is above the ODWSOG but tolerable and can be treated by residential water softening systems.

Iron and manganese removal will be part of the water treatment for the Site which in turn is expected to remove colour from the groundwater as the source of colour is likely the result of iron and manganese oxidation. In addition, provisions for including future methane removal are being considered in the Preliminary Design phase of the project.

<u>Production Well Water Quality Comparison</u>

A comparison of water quality results for the groundwater sample which was collected from EG-PW1 on November 26, 2021, and submitted for laboratory analysis of Tables 1, 2 and 4 of the ODWSOG with that for a groundwater sample collected from EG-PW2 on November 26, 2021, shows very similar water quality between the two wells. This provides further evidence that the wells are screened in the same aquifer. The complete tabulated results are presented in **Table H-2 (Appendix H)** with exceedances shown on **Table 3-8** and **Table 3-9**.

Furthermore, water quality results from EG-PW1, collected after 24 and 48 hours of continuous pumping, were compared to historical water quality results from EG-PW1 in November 13 and 14 of 2018 (during a 48-hour pumping test performed by AECOM). Select indicator parameters were used in this analysis, and it was determined that all parameter concentrations at EG-PW1 November 2021 were generally similar to the concentrations reported November 2018, with the exception of colour, methane and Total Kjedhal Nitrogen for which increased concentrations were observed at EG-PW1 in 2021. The complete tabulated results comparing historical EG-PW1 water quality are found in **Appendix H** (**Table H-4a**).

A water quality comparison of the results of select ODWSOG parameters for samples collected at the end of the constant rate pumping tests for EG-PW1 and EG-PW2 in November of 2021 and EG-PW1 in November of 2018. The comparison showed similar parameter concentrations for both November 2021 and November 2018 sampling events with exception of increased concentrations observed for methane, colour with minor increase observed in hardness and iron. The tabulated results of select parameter results comparing historical EG-PW1 water quality are found in **Appendix H** (**Table H-4b**).

No detections or ODWSOG exceedances were observed for source water protection parameters tested at the 96-hour mark of the constant rate pumping test at EG-PW2. The full list of source water parameter sampling results for EG-PW2 is provided in **Appendix H (Table H-5)**.

4.0 Impact Assessment

Potential impacts of prolonged pumping from EG-PW1 and EG-PW2 on nearby groundwater receptors were evaluated to assess the potential for significant adverse effects. Groundwater receptors, which could potentially be impacted by the proposed activities, were identified based on the MECP PTTW and ORMGP (well record) database as well as Ministry of Northern Development, Mines, Natural Resources and Forestry natural heritage and LSRCA mapping. As discussed in the following sections, the identified potential receptors include groundwater users, surface water features, as well as other natural features.

It is important to reiterate that the objective of commissioning EG-PW1 and EG-PW2 is to provide system redundancy and restore lost capacity from other municipal production wells permitted under the Yonge Street Aquifer (YSA) Permit to Take Water (PTTW) (Amended PTTW No. 1736-BKZPJD). There will be no increase in total water taking from the existing Amended PTTW No. 1736-BKZPJD, and therefore potential impacts are limited to the localized takings from EG-PW1 and EG-PW2.

The following sections provide the methodology used to delineate a localized area of influence (referred herein as the “Impact Assessment Area of Focus”) and the results of the impact assessment for potential groundwater receptors.

4.1 Impact Assessment Area of Focus

4.1.1 Delineation Methodology

The Impact Assessment Area of Focus considered the following data and information sources:

- Groundwater Flow Box Model (**Appendix G**)
  - Simulated results from the Average Day Demand Scenario
- York Region’s production and operational data, specifically:
  - Observed production reduction in 2008 (Aurora) and 2012 (Queensville) after lake-based water supply introduction
  - Trends in private well user complaints (1990 to present day)
- York Region’s monitoring data, specifically:
  - Observed response in YSA water levels after the reduction in production volumes

Review of the above-noted data and information allowed for delineation of the Impact Assessment Area of Focus, as described in the following sections.

4.1.2 Starting Point: Average Day Demand Scenario

Recognizing that the Peak Demand Scenario is conservative in nature and unlikely to be realized under normal well operations, it was not considered as part of this impact assessment. As such, the starting point for the Impact Assessment Area of Focus delineation was to refine the estimated ZOI and simulated drawdown from the Average Day Demand Scenario, which is likely to reflect future Site operations (although wells will cycle on/off).

The extent of the Average Day Demand ZOI and subsequent simulated drawdown contours are provided on **Figure 9a**. The drawdown follows the interpreted YSA extent in the north/south direction (a distance of approximately 30 kilometers), stretches approximately 10 kilometers in the eastern direction within the inter-channel sediments (indicating a hydraulic connection between the YSA and inter-channel sediments), and truncates to the west due to intersecting the confining material overlying the Bradford Aquifer.

Local to the Site, the Average Day Demand Scenario produced a simulated drawdown of approximately 30 m. A strong response to abstraction at the Site was simulated in the northern portion of the YSA (this was also observed during the 96-hour combined pumping test) but with only a slightly weaker response to the south (a weak response was observed during the 96-hour combined pumping test). While the box model was transiently calibrated to the 96-hour combined pumping test, there is invariable uncertainty pertaining to a system's hydraulic properties (both estimated from the field and assigned within a numerical tool) due to the complexity of geologic formations and an insufficiency to understand it comprehensively. As such, this uncertainty will port with any extrapolation.

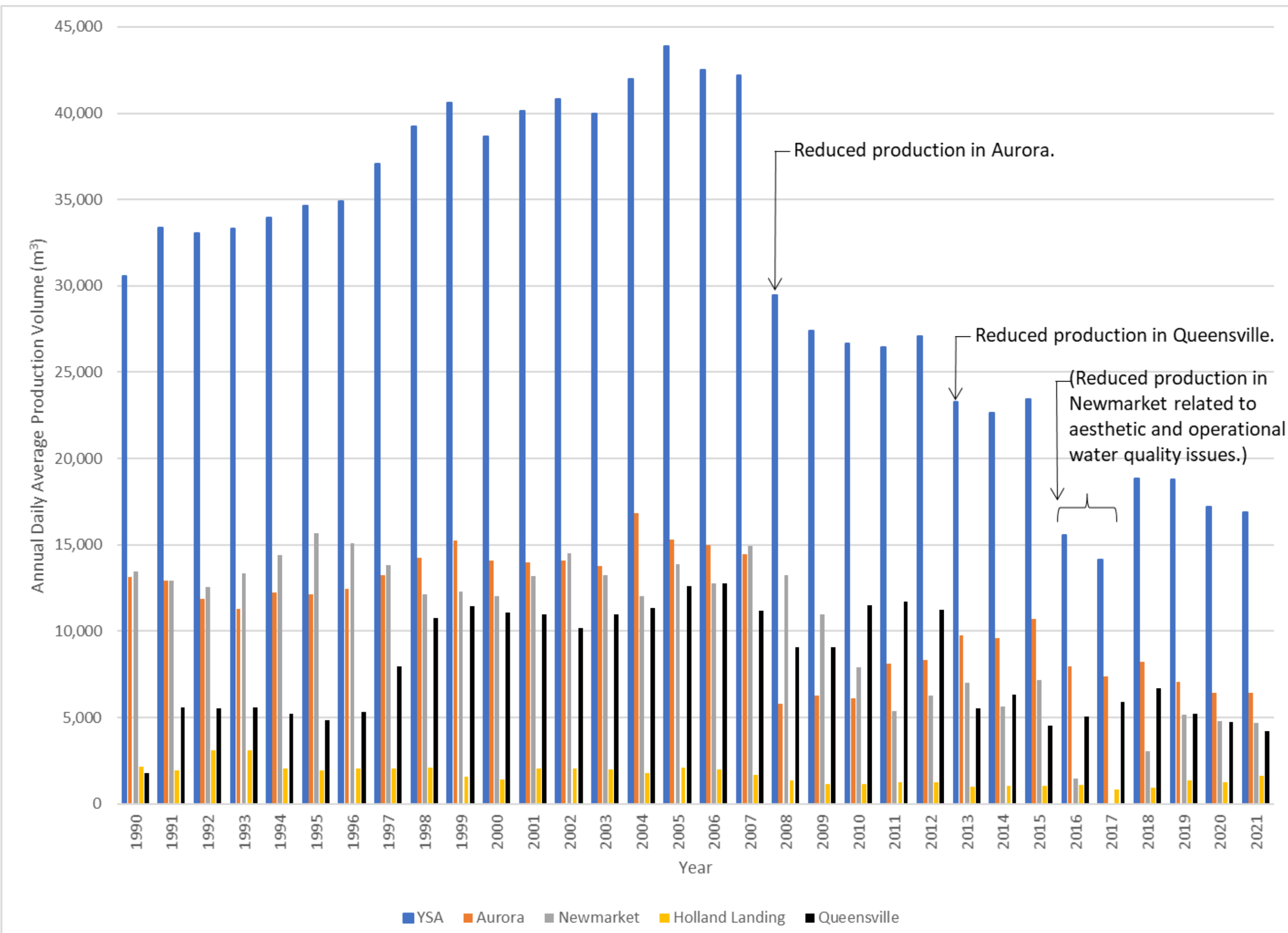
Water level influence from the operation of the Aurora production wells have been observed in Richmond Hill and King City (Gerber et al., 2018). While the Average Day Demand Scenario indicates a potential drawdown within these southern regions, there is some uncertainty regarding the magnitude of this response. The following sub-sections pertain to refining the Average Day Demand ZOI to define the Impact Assessment Area of Focus.

4.1.3 Step 1: Review of YSA Production Well Operations

4.1.3.1 Historical YSA Production Volumes

From 2004 through to 2007 the YSA system recorded its largest historical water taking volumes with annual daily average takings exceeding 40,000 m^3. After 2007, significant changes in YSA water taking volumes occurred due to lake-based water supply introduction, which resulted in decreased production at Aurora (2008), Newmarket (2010), Holland Landing (2008), and Queensville (late 2012). **Histogram 1** shows the trend of annual daily average production volume takings between 1990 and 2021.

Histogram 1 Annual Daily Average Production Volumes



A review of **Histogram 1** allows for the following observations:

- The largest annual daily average water takings occurred in 2005 (approximately 43,800 m^3).

- Following lake-based water supply introduction, production within the various YSA well systems reduced (between 2008 and end of 2012).
- 2013 was the first year to record reduced production across the entire YSA well system (i.e., Queensville production volumes were reduced in late 2012 as a result of lake-based water supply).
- The annual daily average water takings during 2013 was approximately 23,300 m^3; this is a reduction of approximately 20,000 m^3 from its largest recorded takings.

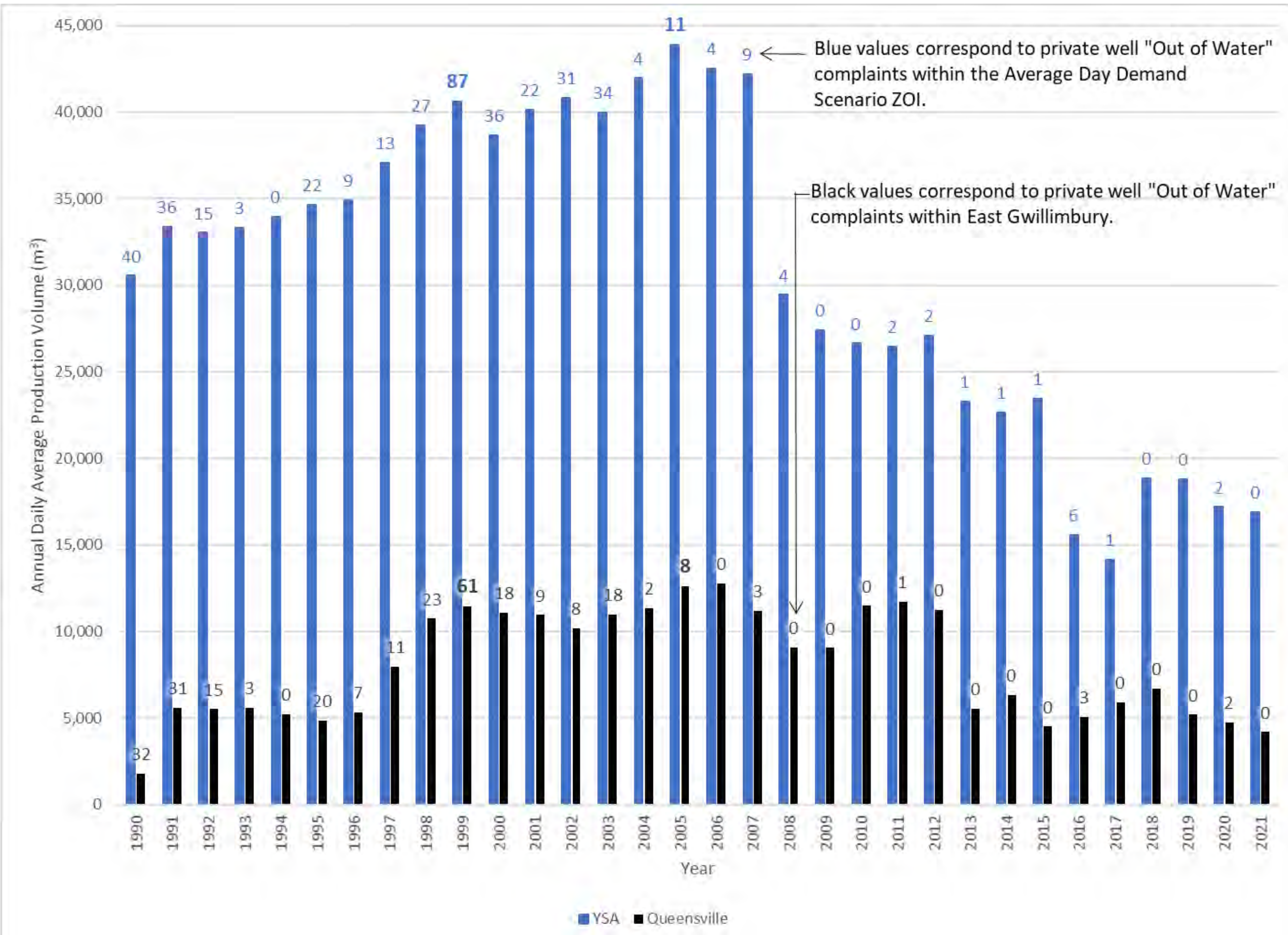
Note: Reduced production in Newmarket from 2016 through to 2018 was related to aesthetic and operational water quality issues. Newmarket production has gradually been restored over the last few years.

4.1.3.2 Historical Private Well Interference Complaints

A review of York Region's historical private well interference complaints (documentation required under Condition 5 of the amended PTTW No. 1736-BKZPJD) allowed for temporal correlation of the dataset to YSA production volumes. Within the Average Day Demand ZOI, there were 423 private well complaints pertaining to "Out of Water" issues (i.e., a dry well or low water level) over the 1990 to 2020 period (no "Out of Water" complaints were received in 2021). Approximately 65% of those complaints (i.e., 275) were sourced from locations within the Town of East Gwillimbury.

A distribution of the YSA and Queensville annual daily average production volumes are provided on **Histogram 2** along with the total annual private well "Out of Water" complaints within the Average Day Demand ZOI as well as within the Town of East Gwillimbury; a spatial distribution of the datasets are presented on **Figure 10**.

Histogram 2 Annual Daily Average Production Volumes with Private Well "Out of Water" Complaints



A review of **Histogram 2** allows for the following observations:

- An increasing incidence of private well "Out of Water" complaints were reported from 1996 to 1999, with the largest number of complaints (87) occurring in 1999. Approximately 61 of the 87 complaints occurring in 1999 were sourced from locations within the Town of East Gwillimbury, indicating that the number of complaints corresponded to increased water takings from the Queensville production wells. (*Note: The Queensville annual daily average production volume in 1999 was more than double the 1996 volume.*)
- Since all of the private well "Out of Water" complaints were addressed and resolved by York Region, the number of private well complaints drastically reduced after 1999 even though Queensville takings were maintained.

- As noted in **Section 4.1.3.1**, in 2005 the entire YSA system and the Queensville production wells reported their largest extraction volumes (annual daily average production of approximately 43,800 m^3 and 12,000 m^3, respectively); however, the total number of private well "Out of Water" complaints was 11 (8 of which were within the Town of East Gwillimbury). This provides evidence that the majority of private well issues reported due to increased YSA production had previously been resolved by York Region.

4.1.4 Step 2: Review of YSA Water Level History

4.1.4.1 Queensville

Learnings from the temporal correlation between private well complaints and YSA production volume changes (**Section 4.1.3.2**) prompted an investigation related to water level responses, specifically within the Queensville area.

As noted in **Section 4.1.3.2**, Queensville production volumes more than doubled when comparing the 1999 and 1996 datasets (annual daily average production volumes of 11,500 m^3 and 5,300 m^3, respectively). As such, the observed hydraulic response (drawdown) at the Queensville monitoring wells (Queensville MW-2, Queensville MW-3, Queensville MW-6D, and Queensville MW-7) from 1996 to 1999 ranged from 8.3 m (Queensville MW-6D) to 12.5 m (Queensville MW-2) with an average drawdown of 9.8 m from the four monitoring well locations. The approximate drawdowns, based on annual average water elevations in 1996 and 1999, are summarized in **Table 4-1**.

Table 4-1 Summary of Drawdown at Queensville Monitoring Wells in Response to Increased Production Volumes from 1996 to 1999

Location	1996 Annual Average Water Elevation (masl)	1999 Annual Average Water Elevation (masl)	Drawdown (meters)
Queensville MW-2	226.7	214.2	12.5
Queensville MW-3	220.1	210.7	9.4
Queensville MW-6D	220.8	212.5	8.3
Queensville MW-7	220.2	211.4	8.8

Notes:
masl denotes meters above sea level

The observed average drawdown of 9.8 m was used to define the northern extent of the Impact Assessment Area of Focus such that it corresponded with the Average Day Demand simulated 10 m drawdown contour. The rationale is that any predicted influence from Site operations resulting in 10 m or less, of drawdown, would be in the historical range of influence, which had already been observed during peak Queensville production periods (1997 to 2007, refer to **Histogram 1**). Furthermore, well interference complaints resulting from increased abstraction at the Queensville production wells were addressed and resolved by York Region; this provides assurance that any private wells seemingly vulnerable to impact due to Site operations were previously managed. Therefore, in the vicinity of Queensville, drawdown of 10 m or less is assumed to be tolerable at private well locations.

4.1.4.2 Entire YSA

To further refine the Impact Assessment Area of Focus all YSA monitoring well data, from years prior to- and after- production volume reduction, were compared to derive a spatial recovery estimate of the YSA's potentiometric surface. This recovery was then compared to the simulated drawdown produced by the Average Day Demand Scenario to determine the potential impact extent realized under proposed Site operations. Further details are provided in the following sub-sections.

YSA Rebound Response Due to YSA Production Reduction

The difference between annual average water levels from 2013 (first year to record reduced production across the entire YSA well system) and 2005 (highest annual daily average water takings) was calculated for YSA monitoring well locations, and is summarized in **Table 4-2**. These calculated head differences represent the magnitude in YSA rebound response; this data was used to interpolate a spatial rebound map across the study area, which is provided on **Figure 11a**. The resulting rebound map corresponds with that described in Gerber et al, 2018, "*the magnitude of the groundwater level rise [was] greatest along the axis of the Thorncliffe channel denoted by the YSA pumping centres, and dissipated laterally as the response emanated outwardly within inter-channel sediments*".

Table 4-2. Summary of Rebound at YSA Monitoring Wells in Response to Reduced Production Volumes from 2005 to 2013

Location	2005 Annual Average Water Elevation (masl)	2013 Annual Average Water Elevation (masl)	Rebound (meters)
Queensville MW-2	209.7	225.8	16.2
Queensville MW-3	207.8	226.3	18.5
Queensville MW-6D	210.5	223.7	13.2
Queensville MW-7	208.3	225.7	17.4
Holland Landing MW-1	208.5	225.7	17.2
Newmarket MW-2	209.0	227.8	18.8

Location	2005 Annual Average Water Elevation (masl)	2013 Annual Average Water Elevation (masl)	Rebound (meters)
Newmarket MW-3	260.2	263.3	3.1
Newmarket MW-4	210.6	226.6	16.0
Newmarket MW-6	219.0	232.4	13.4
Newmarket MW-10	209.0	227.6	18.6
Newmarket MW-13	213.7	232.6	18.9
Aurora MW-1	220.7	237.4	16.7
Aurora MW-2	226.0	240.1	14.1
Aurora MW-3I	233.8	243.4	9.6
Aurora MW-3D	225.7	235.7	10.0
Aurora MW-4	235.5	244.1	8.6
Aurora MW-5	218.2	235.0	16.8
Aurora MW-6	242.4	250.7	8.3
Aurora MW-7	241.5	250.2	8.7
Aurora MW-8	244.3	252.5	8.2

Notes:
masl denotes meters above sea level

Comparison of YSA Rebound Response to Average Day Demand Scenario Drawdown

A grid math approach was applied in order to compare the interpolated rebound surface to the simulated drawdown from the Average Day Demand Scenario. The purpose was to determine if there would be any potentially impacted areas due to Site operations that had not been realized during historical peak YSA water takings.

Figure 11b provides a spatial comparison between the rebound and simulated drawdown. The “0” contour line indicates a net zero change between rebound and simulated drawdown. A positive difference in Aurora indicates that there is greater observed rebound than simulated drawdown. This demonstrates that in the vicinity of Aurora, the YSA is likely more sensitive to local well operations than Site operations. As such, this region was used to delineate the Impact Assessment Area of Focus for the southern portion of the YSA.

4.1.5 Step 3: Assignment of Impact Assessment Area of Focus

The Impact Assessment Area of Focus was delineated based on the following:

- The observed drawdown response in Queensville as a result of increased production operations (as described in **Section 4.1.4.1**), which coincided with the Average Day Demand 10 m simulated drawdown contour; and,
- The difference in aquifer rebound response (due to YSA production reduction) and Average Day Demand simulated drawdown (as described in **Section 4.1.4.2**), in particular where the rebound exceeded the drawdown. The final delineated Impact Assessment Area of Focus is provided on **Figure 12**.

The final delineated Impact Assessment Area of Focus was the extent used for assessing impact to receptors, which is discussed in the following sections.

4.2 Groundwater Users

4.2.1 Private Well Users

The ORMGP water well records database (ORMGP, 2022) was used to extract well records across a footprint that exceeded the extent of the Impact Assessment Area of Focus. The well records were reviewed to filter out locations that were not pertinent to the impact assessment (i.e., non-water supply wells, wells screened within the shallow aquifer system, wells outside the Area of Focus, etc.); the following was completed:

- Determined well record aquifer assignment using top of screen elevation (or borehole bottom information, if screen data was unavailable) and the Tier 3 Water Budget Conceptual Model Surfaces (Earthfx, 2013), which represents the current conceptual understanding. Since the shallow aquifer system indicated minimal to no response to the 96-hour combined rate pumping test (**Section 3.3.2.1**), wells screened within the shallow system were filtered out.
- Determined well record primary purpose. Well records that did not have a primary purpose of “Water Supply” or “Unknown” were excluded. Any location related to municipal water supply, monitoring or exploration were also excluded.
- Excluded any location where the well status did not correspond to “Active”, “Active Pumping Well” or “Unknown”.
- Excluded any location residing within a municipally serviced area, as delineated by York Region.
- Excluded any location that was likely a non-municipal PTTW user.
- Excluded any location residing outside of the Impact Assessment Area of Focus (as delineated in **Section 4.1.5**).

A review of the filtered dataset identified a total of 555 potentially active (or unknown status) water supply well records within the Impact Assessment Area of Focus. **Figure**

13a presents the locations of the active (or unknown status) water supply users and **Table 4-3** provides a breakdown of their secondary purposes. The filtered dataset is included in **Table I-1a (Appendix I)**.

Table 4-3 Summary of Potentially Active Water Supply Well Users within the Impact Assessment Area of Focus

Well Record Primary and Secondary Purpose	Number of Well Records	Percent of Total Well Records
Water Supply – Campgrounds or Trailer Park	1	0.2%
Water Supply - Communal	5	0.9%
Water Supply - Domestic	537	96.8%
Water Supply - Hotel	2	0.4%
Water Supply - Nursery	1	0.2%
Water Supply – Other (Commercial)	3	0.5%
Water Supply – Other (Industrial)	3	0.5%
Water Supply – Other (Water Supply)	1	0.2%
Water Supply - School	1	0.2%
Unknown	1	0.2%
Total	**555**	**100%**

Active (or unknown status) private water supply users (screened within the YSA or TAC) that did not experience peak YSA production operations (i.e., wells drilled later than the end of 2007), which reside outside of the Impact Assessment Area of Focus (but inside the Average Day Demand ZOI) were identified and included as part of the impact assessment. **Figure 13b** presents their spatial locations and **Table 4-4**. provides a breakdown of their secondary purposes. The filtered dataset is included in **Table I-1b (Appendix I)**.

Table 4-4. Summary of Recently Drilled Potentially Active Water Supply Well Users Outside the Impact Assessment Area of Focus

Well Record Primary and Secondary Purpose	Number of Well Records	Percent of Total Well Records
Water Supply - Domestic	20	64.5%
Water Supply – Other (Commercial)	3	9.7%
Water Supply – Other (Industrial)	5	16.1%
Water Supply – Other (Water Supply)	1	3.2%
Unknown	2	6.5%
Total	**31**	**100%**

4.2.1.1 Private Well User Impact Assessment

Potential well interference was assessed for the locations summarized in **Table 4-3** and **Table 4-4**.; the methodology is provided as follows:

For each location, where the top of screen and static water level data were available:

- Determined the Water Column Height (WCH): Static Water Level – Top of Screen
- Determined the Estimated Available Drawdown, calculated as 60% of WCH (this approach was applied in the impact assessment for the YSA PTTW amendment [AECOM, 2019b])
- Determined the Remaining Available Drawdown (RAD): Estimated Available Drawdown – Average Day Demand simulated drawdown
- Assigned Potential Impact based on the results from RAD:
  - If RAD was negative (i.e., simulated drawdown was greater than the estimated available drawdown), assigned “Yes” as potential impact
  - If RAD was positive (i.e., simulated drawdown was less than the estimated available drawdown), assigned “No” as potential impact

Note: If top of screen and/or static water level data were unavailable, then the potential impact could not be assigned.

A summary of the resulting impact is provided in **Table 4-5** with a spatial distribution provided on **Figure 14a**.

Table 4-5. Potential Impact Results for Private Well Users

Location	Potential Impact	Number of Well Records	Percent of Total Well Records
Locations Residing Inside the Impact Assessment Area of Focus	Yes	200	36.0%
	No	310	55.9%
	Unassigned	45	8.1%
	Total	**555**	**100%**
Recently Drilled Locations Residing Outside the Impact Assessment Area of Focus	Yes	1	3.2%
	No	30	96.8%
	Unassigned	0	0%
	Total	**31**	**100%**

The 201 potentially impacted locations were further investigated to statistically ‘bin’ and spatially represent the drawdown ‘deficit’ (i.e., where the simulated drawdown was greater than the estimated available drawdown). This ‘deficit’ investigation has been summarized in **Table 4-6** with spatial locations provided on **Figure 14b**.

Table 4-6. Drawdown Deficit Summary

Location	Deficit 'Bin'	Number of Well Records	Percent of Total Well Records
Locations Residing Inside the Impact Assessment Area of Focus	Less than 0 to 5 m	92	46.0%
	Less than 5 to 10 m	53	26.5%
	Less than 10 to 20 m	37	18.5%
	Less than 20 m	18	9%
	Total	**200**	**100%**
Recently Drilled Locations Residing Outside the Impact Assessment Area of Focus	Less than 0 to 5 m	1	100%
	Less than 5 to 10 m	0	0%
	Less than 10 to 20 m	0	0%
	Less than 20 m	0	0%
	Total	**1**	**100%**

The results presented in **Table 4-6** and on **Figure 14b** indicate that the majority (72.5% of the potentially impacted private wells) have a resulting deficit of available drawdown of less than 10 m, which is considered to be within the relative large margin of error inherent with the data sources used to support the impact assessment and the conservative approach utilized to determine the predicted drawdown at each location. In addition, locations with a drawdown deficit less than 10 m (a total of 146 locations) reside within the Town of East Gwillimbury, an area which will likely be the focus of a detailed (future) private well investigation (further detailed in **Section 5.0**).

It is important to note the conservatism with the methodology used to determine potential well interference:

- It assumes 40% of the water column is continuously utilized due to well operation; the reality is such that well use will vary diurnally.
- The YSA and inter-channel sediments (TAC) are highly transmissive and as such a minimal amount of drawdown (within the private wells) is expected due to well operation; therefore, 40% of water column reduction is likely a conservative estimate.

As such, the methodology applied may be yielding a greater volume of potentially impacted locations than what will be realized during Site operation.

4.2.1.2 Private Well User Impact Assessment Summary

The private well user impact assessment included water supply locations within the Impact Assessment Area of Focus, as well as newly drilled water supply locations outside the Area of Focus (but within the Average Day Demand ZOI). To identify locations that would potentially be impacted due to Site operations, the methodology assumed that 40% of the water column is utilized continuously (i.e., constant well operation). The number of impacted wells (i.e., where there is a drawdown deficit) for locations within and outside the Area of Focus is 200 and 1, respectively.

A summary of the potential impact, for the filtered datasets, are contained in **Table I-2a** and **Table I-2b** (**Appendix I)**.

It is important to note that the determined impact is based on a desktop assessment, which has the potential to be affected by database entry errors specific to spatial coordinates and well construction details. Investigation is required to confirm a well's spatial location, depth, pump setting, and available drawdown during usage, such that potential impact can be appropriately determined due to Site operations. Locations that are confirmed to be impacted will be evaluated and appropriately mitigated (e.g., pump lowering), if required. Refer to **Section 5.0** for a monitoring and mitigation discussion.

4.2.2 Non-Municipal Permitted Groundwater Takers

Permitted groundwater takers pertain to locations that have been issued a PTTW, by the MECP, to actively pump over 50,000 L/d of groundwater from a source well (for non-dewatering purposes) or over 400,000 L/d for the purpose of dewatering.

The MECP PTTW database (MECP, 2022) was used to extract PTTW users across a footprint that exceeded the extent of the Impact Assessment Area of Focus. The PTTW users were reviewed to filter out locations that were not pertinent to the impact assessment (i.e., municipal water supply wells, wells screened within the shallow aquifer system, wells outside the Area of Focus, etc.); the following was completed:

- Removed any water taking location where the 'origin of water taking' was not groundwater (i.e., removed surface water sources).
- For each groundwater taking location, assumed an appropriate well record number (based on review of reports previously provided to York Region, or by matching the spatial location of water taking to nearby well records) in order to determine an aquifer assignment. The aquifer was assigned using the well record's screen elevations and the Tier 3 Water Budget Conceptual Model Surfaces (Earthfx, 2013), which represents the current conceptual understanding. Since the shallow aquifer system indicated minimal to no response to the 96-hour combined rate pumping test (**Section 3.3.2.1**), wells screened within this aquifer system were filtered out (this includes dugout wells or PTTW users categorized as dewatering construction).
- Reviewed the PTTW user primary purpose category and removed any location identified as municipal water supply use.

- Excluded any location where the permit was no longer "Active".
- Excluded any location residing outside of the Impact Assessment Area of Focus (as delineated in **Section 4.1.5**).

A review of the filtered dataset identified a total of 6 active non-municipal PTTW sources within the Impact Assessment Area of Focus. **Figure 15a** presents the spatial locations of the active PTTW locations and **Table 4-7** provides a summary of their permit and well details.

Table 4-7. Details of Identified Non-Municipal Permitted Groundwater Sources within the Impact Assessment Area of Focus

Source ID	PTTW Owner	PTTW No.	MECP Well Record	Purpose Category	Easting (meters)	Northing (meters)	Borehole Depth (mbgs)	Aquifer Assignment
North Well 1	Don Chapman Farms Limited	3220-94MQZA	6924124	Agricultural	623480	4890900	83.5	YSA or TAC
South Well 2	Don Chapman Farms Limited	3220-94MQZA	6921933	Agricultural	623550	4890820	76.5	YSA or TAC
Well 3	Don Chapman Farms Limited	3220-94MQZA	7308808	Agricultural	623499	4890828	54.3	YSA or TAC
PW-1 (WWR: 6921962)	Queensville Sod Farms Limited	8143-B39PYN	6921962	Agricultural	623140	4891200	45.1	YSA or TAC
PW1	Lakhani Holdings Ltd.	1802-8TRR56	6923555	Commercial	627338	4883705	43.0	YSA or TAC
TW1	Lakhani Holdings Ltd.	1802-8TRR56	6923553	Commercial	627338	4883705	107.0	YSA or TAC

Notes:
ID Denotes identification
mbgs Denotes meters below ground surface

Active non-municipal PTTW locations (screened within the YSA, TAC or SAC) that did not experience peak YSA production operations (i.e., wells drilled later than the end of 2007), which reside outside of the Impact Assessment Area of Focus (but inside the Average Day Demand ZOI), were identified and included as part of the impact assessment. **Figure 15b** presents their spatial locations and **Table 4-8** provides a summary of the permit and well details for these active locations.

Table 4-8. Details of Identified Non-Municipal Permitted Groundwater Sources Outside the Impact Assessment Area of Focus

Source ID	PTTW Owner	PTTW No.	MECP Well Record	Purpose Category	Easting (meters)	Northing (meters)	Borehole Depth (mbgs)	Aquifer Assignment
Irrigation Well	ClubLink Corporation ULC (King Valley Golf Club)	8454-BMNPEB	7121096	Commercial	619094	4872808	195.9	Scarborough Aquifer Complex
Irrigation Well	ClubLink Corporation ULC (King's Riding Golf Course)	5350-C2JQC6	7253625	Commercial	620744	4870876	136.4	YSA
New Steam Well (A241699)	Miller Paving Limited operating as Miller Concrete	2434-BFPHSC	7326814	Industrial	619094	4872808	213.9	Thorncliffe Aquifer Complex
House and Shop Well	Pheasant Golf Inc.	1042-AA9N8G	7253512	Commercial	620744	4870876	208.1	Thorncliffe Aquifer Complex
Supplemental Clubhouse Well	Westview Golf Club Limited	4648-BV3T59	7291776	Commercial	630612	4883511	222.1	Thorncliffe Aquifer Complex

Notes:
ID Denotes identification
mbgs denotes meters below ground surface

4.2.2.1 Non-Municipal PTTW User Impact Assessment

Potential well interference was assessed for the locations summarized in **Table 4-7** and **Table 4-8**; the methodology is provided as follows:

For locations, where York Region did not have access to historical water takings and/or monitored water levels:

- Determined the Water Column Height (WCH): Static Water Level – Top of Screen
- Determined the Estimated Available Drawdown, calculated as 60% of WCH (this approach was applied in the impact assessment for the YSA PTTW amendment [AECOM, 2019b])
- Determined the Remaining Available Drawdown (RAD): Estimated Available Drawdown – Average Day Demand simulated drawdown
- Assigned Potential Impact based on the results from RAD:
    - If RAD was negative (i.e., simulated drawdown was greater than the estimated available drawdown), assigned “Yes” as potential impact
    - If RAD was positive (i.e., simulated drawdown was less than the estimated available drawdown), assigned “No” as potential impact

Note: In September 2022, York Region completed a Freedom of Information (FOI) request for obtaining hydrogeological reports associated with local permit applications, whereby water takings and/or monitored water levels would be provided. It is expected that the FOI request will be fulfilled in early 2023, as such, hydrogeological reports associated with permit applications were not reviewed at the time of this report.

For the Lakhani Holdings Ltd. water taking locations, York Region was provided access to historical water takings and/or monitored water levels. As such operating data was used to estimate the potential impact at these locations using the following methodology:

- Determined the Available Drawdown during well operation (AD): Minimal Operating Water Level (2013-2021 period) – Top of Screen
- Determined Remaining Available Drawdown (RAD): AD - Average Day Demand simulated drawdown
- Assigned Potential Impact based on the results from RAD:
  - If RAD was negative (i.e., simulated drawdown was greater than the available drawdown), assigned "Yes" as potential impact
  - If RAD was positive (i.e., simulated drawdown was less than the estimated available drawdown), assigned "No" as potential impact

A summary of the resulting impact is provided in **Table 4-9** with a spatial distribution provided on **Figure 16**.

Table 4-9. Potential Impact Results for Non-Municipal PTTW Users

Source ID	PTTW Owner	Average Day Demand Simulated Drawdown[a] (meters)	Available Drawdown[b] (meters)	Estimated Available Drawdown[c] (meters)	Estimated Available Drawdown Minus Average Day Demand Simulated Drawdown (meters)	Potential Impact
Locations Residing inside the Impact Assessment Area of Focus						
North Well 1	Don Chapman Farms Limited	17.6	64.3	38.6	21.0	No
South Well 2	Don Chapman Farms Limited	17.7	40.8	24.5	6.8	No
Well 3	Don Chapman Farms Limited	17.7	32.4	19.5	1.7	No

Source ID	PTTW Owner	Average Day Demand Simulated Drawdown[a] (meters)	Available Drawdown[b] (meters)	Estimated Available Drawdown[c] (meters)	Estimated Available Drawdown Minus Average Day Demand Simulated Drawdown (meters)	Potential Impact
PW-1 (WWR: 6921962)	Queensville Sod Farms Limited	17.5	34.4	20.7	3.2	No
PW1	Lakhani Holdings Ltd.	17.5	19.5[d]	N/A	2.0[e]	No
TW1	Lakhani Holdings Ltd.	17.5	38.4[d]	N/A	20.9[e]	No
Recently Drilled Locations Residing Outside the Impact Assessment Area of Focus						
Irrigation Well	ClubLink Corporation ULC (King Valley Golf Club)	13.5	38.1	22.9	9.4	No
Irrigation Well	ClubLink Corporation ULC (King's Riding Golf Course)	11.1	102.0	61.2	50.1	No
New Steam Well (A241699)	Miller Paving Limited operating as Miller Concrete	6.7	45.4	27.2	20.5	No
House and Shop Well	Pheasant Golf Inc.	6.7	46.9	28.1	21.5	No
Supplemental Clubhouse Well	Westview Golf Club Limited	8.5	32.0	19.2	10.7	No

Notes:

mbgs denotes meters below ground surface

[a] Simulated drawdown under average day demand scenario (continuous pumping at 105 L/s for 20 years).

[b] Available drawdown represents the static water level minus the top of the screen.

[c] Estimated available drawdown represents 60% of the available drawdown, where determined using the static water level and the top of the screen.

[d] The PW1 and TW1 hydrographs, presented in Geo Kamp (2021), indicate a response to YSA well operations. The chosen operating water level represents an observed minimum value over the 2013 to 2021 period.

[e] These values represent the Available Drawdown Minus Average Day Demand Simulated Drawdown.

Based on the potential impact assessment methodology noted above, none of the locations have been identified to be negatively impacted (i.e., there was no drawdown deficit) as a result of Site operations.

It is important to note the conservatism with the methodology used to determine potential well interference:

- It assumes 40% of the water column is continuously utilized due to well operation; the reality is such that well use will vary diurnally.
- The YSA and inter-channel sediments (TAC) are highly transmissive and as such a minimal amount of drawdown (within the private wells) is expected due to well operation; therefore, 40% of water column reduction is likely a conservative estimate.

4.2.2.1 Non-Municipal PTTW User Impact Assessment Summary

The non-municipal PTTW user impact assessment included locations within the Impact Assessment Area of Focus, as well as newly drilled PTTW locations outside the Area of Focus (but within the Average Day Demand ZOI). Where historical water takings and operating water levels were not known, the potential impact methodology assumed that 40% of the water column is utilized continuously (i.e., constant well operation regardless of permitted water taking days per year). The assessment indicated that none of the reviewed water taking locations would be negatively impacted as a result of Site operations.

A summary of the potential impact, for the filtered datasets, are contained in **Table I-3a** and **Table I-3b** (**Appendix I)**.

It is important to note that the determined impact is based on a desktop assessment, which has the potential to be affected by MECP well record assignments (assumed by York Region), database entry errors specific to spatial coordinates and well construction details. Investigation is required to confirm a well's spatial location, depth, pump setting, and available drawdown during usage, such that potential impact can be appropriately determined due to Site operations. Locations that are confirmed to be impacted will be evaluated and appropriately mitigated (e.g., pump lowering), if required. As noted earlier, in September 2022 York Region completed an FOI request for obtaining hydrogeological reports associated with local permit applications, whereby water takings and/or monitored water levels would be provided for each of the permitted users; it is expected that the FOI will be fulfilled in early 2023.

4.2.3 Municipal Permitted Groundwater Takers

4.2.3.1 Municipal PTTW User Impact Assessment

For the purposes of the municipal PTTW user impact assessment, municipal permitted groundwater takers were identified as the York Region production wells on the YSA amended PTTW No. 1736-BKZPJD. The data sources used for determining potential impact at these municipal water supply locations are contained within the following bullets:

- Production well construction and minimum pump intake information.
- Production well annual average operational water levels during 2008. The 2008 period was chosen for the following reasons:
  - The YSA's annual daily average production volume reflected approximately 29,500 m^3. Consideration of future Site operations, Average Day Demand of 105 L/s (9,072 m^3/d), would total a YSA annual daily average production volume of 38,500 m^3/d; this value approaches the annual daily average permitted volume of 42,000 m^3, allowing for maximum utilization of the YSA system.
  - This period reflects when Newmarket and Queensville production wells were operating at their greatest historical abstraction volumes.
- Review of monitoring data collected during AECOM's 72-hr constant rate pumping test at the Aurora PW5 and PW7 site (AECOM, 2019b) for determining an appropriate operational water level for both Aurora PW5 and PW7 (as Aurora PW7 was not operating during the 2008 period).

The methodology for determining potential impact, at each YSA production well, is as follows:

- Determined Safe Available Drawdown: 2008 Annual Water Level at the production well (when pump was on) – Current Pump Intake
- Determined Safe Additional Available Drawdown: 2008 Annual Water Level at the production well (when pump was on) - Minimum Pump Intake (based on well construction details) with 3 m reduction (to accommodate pump operation)
- Compared the Average Day Demand simulated drawdown to Safe Available Drawdown and Safe Additional Available Drawdown, and assigned Potential Impact:
  - If the simulated drawdown was greater than Safe Available Drawdown and also greater than Safe Additional Available Drawdown, assigned "Yes" as potential impact
  - If the simulated drawdown was less than Safe Available Drawdown and also less than Safe Additional Available Drawdown, assigned "No" as potential impact
  - If the simulated drawdown was greater than Safe Available Drawdown but less than Safe Additional Available Drawdown, assigned "No – If Minimum Pump Intake is Applied"

A summary of the resulting impact is provided in **Table 4-10** and displayed on **Figure 17**.

Table 4-10. Summary of Potential Interference from the Average Day Demand Scenario at YSA Permitted Groundwater Takers based on Available Drawdown from 2008 Pumping Water Levels and Pump Intake Information

Municipal Well	Average Day Demand Simulated Drawdown[a] (meters)	Safe Available Drawdown[b] (meters)	Safe Additional Available Drawdown[c] (meters)	Potential Impact
Aurora PW1	14.3	23.4	42.8	No
Aurora PW2	14.2	17.0[d]	46.7[d]	No
Aurora PW3	14.2	19.4	53.0	No
Aurora PW4	14.2	25.6[d]	44.5[d]	No
Aurora PW5	16.7	24.9	38.1	No
Aurora PW6[e][f]	16.9[e]	-2.3[e]	-5.3[e][g]	Yes[e]
Aurora PW7	16.7	No Pump	46.2	No
Newmarket PW1[e]	22.6[e]	21.9[e]	23.6	No – If Minimum Pump Intake is Applied
Newmarket PW2[e]	22.8[e]	12.4[e]	14.5[e]	Yes[e]
Newmarket PW13	19.1	24.5	25.9	No
Newmarket PW15[e][f]	24.6[e]	13.7[e]	14.8[e]	Yes[e]
Newmarket PW 16	18.9	24.4	25.0	No
Holland Landing PW1	28.0	30.5[h]	33.7[h]	No
Holland Landing PW2	27.7	34.3	34.1	No
Queensville PW1[e]	20.2[e][i]	14.4[e]	14.3[e]	Yes[e]
Queensville PW2[e]	20.2[e][i]	18.4[e]	18.5[e]	Yes[e]
Queensville PW3[e]	27.3[e][i]	22.6[e]	27.6	No – If Minimum Pump Intake is Applied
Queensville PW4[e]	27.3[e][i]	27.2[e]	26.9[e]	Yes[e]

Notes:

[a] Simulated drawdown at the municipal production well site under average day demand scenario (continuous pumping at 105 L/s for 20 years).

[b] Assumes an average annual pumping water level from 2008 and existing pump setting depth.

[c] Assumes an average annual pumping water level from 2008 and the minimum allowable pump intake depth reduced by 3 m to allow for proper pump operation.

[d] 2008 water levels were limited at this location. The pumped water level reflects water levels observed at Aurora MW-1 including a historical observed water level difference between Aurora MW-1 and the production well.

[e] Simulated drawdown exceeds the safe available drawdown or the safe additional available drawdown, as such, potential well interference has been identified.

[f] To be decommissioned following the commissioning of EG-PW1 and EG-PW2 and therefore not considered negatively impacted.

[g] Pump cannot be lowered to offer additional available drawdown.

[i] During the box model's calibration, it was noted that the simulated drawdown (at these locations) was slightly under-represented. As such, an additional 2 m of drawdown was included to compensate for the forecast model's underprediction.

[h] 2008 water levels were limited at this location. The pumped water level reflects water levels observed at Holland Landing MW-1 including a historical observed water level difference between Holland Landing MW-1 and the production well.

Based on the potential impact assessment methodology noted previously, the following has been observed:

- 8 production wells may be negatively impacted due to Average Day Demand Site operations if the current pump intake depth is not adjusted (i.e., the Average Day Demand simulated drawdown exceeds a location's safe available drawdown). These wells include:
    - Aurora PW6
    - Newmarket PW1, PW2 and PW15
    - Queensville PW1, PW2, PW3, and PW4
- 6 production wells may be negatively impacted due to Average Day Demand Site operations if the minimum pump intake is considered (including a 3 m buffer to accommodate a pump) (i.e., the Average Day Demand simulated drawdown exceeds a location's safe additional available drawdown). These wells included:
    - Aurora PW6
    - Newmarket PW2 and PW15
    - Queensville PW1, PW2, and PW3

However, it should be noted that Aurora PW6 and Newmarket PW15 are likely to be decommissioned following the commissioning of EG-PW1 and EG-PW2 due to water quality and operational challenges. Should it be realized that Site operations negatively impact any of the production wells, the existing pump setting depths will be increased and/or water supply operations will be modified.

4.2.3.2 Municipal PTTW User Impact Assessment Summary

The municipal PTTW user impact assessment included York Region production wells on the YSA amended PTTW No. 1736-BKZPJD. To identify locations that would potentially be impacted due to Site operations, the methodology compared the Average Day Demand simulated drawdown to a location's safe available drawdown and safe additional available drawdown. The available drawdowns were based on 2008 water levels (during pump operation) and pump intake options (current or minimum based on well construction details). A summary of the potential impact is contained in **Table I-4** (**Appendix I**).

The assessment indicated a potential for 8 production wells to be negatively impacted by prolonged Site operations should the current pump intake not be adjusted. The assessment also indicated a potential for 6 production wells to be negatively impacted should a minimum pump intake be applied.

It is important to note that the determined impact is based on a desktop assessment using operational assumptions (i.e., 2008 water level conditions were applied), which introduces significant uncertainty. The impact to production wells, due to prolonged Site operations, will be determined after system monitoring once EG-PW1 and EG-PW2 have been commissioned and in operation. Refer to **Section 5.0** for a monitoring and mitigation discussion.

4.3 Surface Water Features and Other Natural Features

The Impact Assessment Area of Focus encompasses several surface water features as well as other natural features; their spatial locations are provided on **Figure 18**. These features include: tributaries of the East Holland River, West Holland River, Maskinonge River and Black River; hydrological, physical and biological environmentally significant areas (ESAs); provincially significant wetlands; and areas of natural and scientific interest (ANSIs). **Table 4-11** summarizes identified features within the Impact Assessment Area of Focus.

Table 4-11. Identified Surface Water Features and Other Natural Features within the Impact Assessment Area of Focus

Feature Name	Feature Type / Classification
Holland Landing Fen & Wetlands	Candidate ANSI - Life Science
Holland Landing Prairie	ANSI – Life Science
Holland River Marsh	ANSI - Life Science
Glenville Hills	ANSI - Life Science, Biological ESA
Glenville Hills Kames	ANSI - Life Science, Provincial ANSI - Earth Science, Biological ESA
Cedar Valley	Biological ESA
Holland Landing	Biological ESA
Kettleby	Biological ESA
Ground Water Recharge Area	Hydrological ESA
Maskinonge River Significant Groundwater Recharge	Hydrological ESA
Dike Pond	Lake
Holland Landing Marsh L	Physical ESA
Holland Landing Prairie	Provincial ANSI - Life Science
Holland River Marsh	Provincial ANSI - Life Science
Holland Landing Fen & Wetlands	Provincial Candidate ANSI - Life Science
Ansnorveldt Wetland Complex	Provincially Significant Wetland
Aurora (McKenzie) Marsh Wetland Complex	Provincially Significant Wetland
Black River Headwater Wetland Complex	Provincially Significant Wetland

Feature Name	Feature Type / Classification
Bogart Creek Wetland Complex	Provincially Significant Wetland
East Aurora Wetland Complex	Provincially Significant Wetland
Holland Marsh Wetland Complex	Provincially Significant Wetland
Maskinonge River Wetland Complex	Provincially Significant Wetland
Tributaries and Main branch of Black River	Watercourse
Tributaries and Main branch of East Holland River	Watercourse
Tributaries and Main branch of Maskinonge River	Watercourse
Tributaries and Main branch of West Holland River	Watercourse
Black River Wetland #3	Wetland - Evaluated Other
Black River Wetland Complex #2	Wetland - Evaluated Other
Holland Landing Wetland Complex	Wetland - Evaluated Other
Newmarket Wetland	Wetland - Evaluated Other
Rogers Reservoir	Wetland - Evaluated Other
Snowball Wetland Complex	Wetland - Evaluated Other

To determine if these features would be impacted by future Site operations, the following data was reviewed to assess if the shallow aquifer system is hydraulically connected to the YSA:

- Water levels collected at mini-piezometers (installed in close proximity to the Site: Newmarket MP-1, MP-2S/D, MP-3) during the 96-hour constant rate pumping test (as discussed in **Section 2.5.2.1** and **Section 3.3.2.1)**
- Water levels collected during the 2016 and 2018 aquifer testing, at EG-PW1, performed by AECOM (**Appendix B**)
- Borehole logs from local monitoring and production wells.

The lithology indicates that the YSA and TAC are overlain by continuous low permeability unit(s) (Newmarket Till, and potentially underlying Thorncliffe Formation-age silt-clay rhythmites), as described in **Section 2.5.1**. Additionally, the water level data indicates little to no hydraulic connection between the shallow aquifer system and the YSA, as such, it is considered unlikely that features identified in **Table 4-11** are hydraulically connected to the YSA. Little to no impact is expected to occur on surface water features and/or natural features as a result of future Site operations.

4.4 Potential for Contaminant Migration

Potential contaminant sources in the Site area were reviewed to assess the likelihood of the proposed water taking causing a migration of potential contaminants. A review of land use within the Impact Assessment Area of Focus (mixture of residential, commercial, industrial, institutional and agricultural), and the confirmed significant drinking water quality threats identified within the wellhead protection areas (WHPAs) (for the YSA production wells), yielded the following potential contaminant sources:

- The handling and storage of a fuel and/or dense non-aqueous phase liquid associated with commercial or automotive operations,
- The handling and storage of agricultural source material, commercial fertilizer and/or pesticide
- The application of agricultural source material, fertilizer and/or pesticide to land related to agricultural practices.

Figure 19 provides the YSA production well WHPAs with the overlain Impact Assessment Area of Focus.

The WHPA delineation for EG-PW1 and EG-PW2 along with the source water protection vulnerability scoring will be completed under separate cover. This work is currently being completed by York Region and Golder Associates.

5.0 Monitoring and Mitigation

As discussed in **Section 4.0**, estimates of potential well interference at private and permitted groundwater supply sites is considered highly conservative due to limitations in the analysis resulting from missing or inaccurate information within the data sources, assumption that the predicted aquifer response (simulated drawdown) is conservative on the basis of limitations and uncertainties related to numerical flow modelling (see **Appendix G**) and the assumption that long-term continuous production well operation will occur as opposed to typical cyclical well operation controlled by demand. As such, further investigation, field verification and monitoring are required to confirm the potential impact to private and non-municipal PTTW wells and confirm the simulated aquifer response and desktop impact assessment results.

The following section provides the recommended monitoring and mitigation plan to be implemented by York Region to better refine the results of the impact assessment and ensure proactive water supply mitigation is implemented with the least amount of disturbance to residents and business owners.

5.1 Monitoring Plan

5.1.1 Detailed Private and Non-Municipal PTTW Water Well Investigation

Results of the impact assessment identified potential for the operation of EG-PW1 and EG-PW2 to have a localized influence on other groundwater users (private water wells and permitted groundwater takers) within the Assessment Area of Focus. York Region is responsible for ensuring all well interference confirmed to be a result of municipal well operation are fairly and consistently remedied. A proactive approach, whereby potential well interference issues are identified and mitigated prior to an impact being observed, will be implemented through the completion of a detailed water well investigation/verification program. The objective of the water well investigation is to verify preliminary impact assessment results based on site-specific information and to develop a unique monitoring and mitigation plan, if determined necessary, and shall be completed prior to the commissioning of the Green Lane Water Treatment Plant.

The detailed water well investigation will target potentially impacted water supply wells within the Assessment Area of Focus and seek to reinforce and supplement site-specific information collected through previously completed Water Well Surveys, available technical reports and the MECP water well record database. Investigations will focus on confirming water well location, well status (active/in-active), construction characteristics (i.e., depth to top of screen and pump setting depth), and operation details (i.e., typical well usage and pumping water level). A door-to-door well survey is to be conducted at properties identified as potentially impacted to complete initial information and data gathering based on an in-person interview with the water well owner. Should additional investigations be required, an intrusive well inspection will be considered if the condition and/or construction of the well permits and permission is granted by the well owner. Intrusive well inspections may include the measurement of water level and/or well depth, complete a well video and/or conduct a short-duration pumping test. Participation in the York Region-led door-to-door well survey and intrusive well inspection is contingent on the permission from the well owner and will be strictly voluntary.

Results of the detailed well investigation will confirm if there is potential for the well to be impacted by the proposed operation of EG-PW1 and EG-PW2 based on the simulated drawdown modelled as part of the analysis reported herein. Information collected as part of this investigation will inform the development of the groundwater level monitoring program detailed in **Section 5.1.2** and assist in the determination of corrective or mitigative options that best resolves well interference issues specific for each private well.

5.1.2 Monitoring and Monitoring Network Optimization

After obtaining the results of the private well survey and field truthing, a monitoring network will be established (prior to commissioning of EG-PW1 and EG-PW2) to continuously monitor groundwater levels across the areas flagged in the impact assessment. If gaps occur within York Region's existing monitoring network, new monitors will be added to capture required groundwater level data.

Once a comprehensive monitoring network is established, specific groundwater level trigger elevations will be assigned based on the outcomes of the detailed private well assessment. The trigger levels will provide a monitoring threshold for a proactive mitigation plan to be implemented. Review of the monitoring data will be complete at a frequency that allows for the detection of the groundwater level triggers prior to an observed impact at a private water well or permitted water taker well site.

5.2 Mitigation

The groundwater monitoring program will aim to provide advance warning of potential well interference where a mitigation plan can be executed proactively. Implementation of corrective/remedial action to prevent well interference will be dependent on the unique mitigation plan developed for each well through the detailed water well investigation, as described in **Section 5.1**. Potential mitigation options may include one or a combination of options and have been described in detail in the following sections.

5.2.1 Municipal Well Operation Strategy

It is expected that following the completion of the detailed well assessment (detailed in Section 5.1) uncertainty in the anticipated aquifer response from operation of EG-PW1 and EG-PW2 will remain. It is recommended that a gradual increase in production, up to the targeted average day rate of 105 L/s (9,072 m^3/day), is implemented for a minimum of one-year following commissioning of the water treatment plant. Groundwater level monitoring data will inform a well operation strategy with the objective of keeping groundwater level response within safe operating levels to prevent impact to other groundwater users.

Should the observed groundwater level response to pumping reach assigned trigger elevations in the monitoring network, the YSA production well operation strategy will be reviewed, and York Region will explore the feasibility of reduced pumping and/or cyclic pumping options for EG-PW1 and EG-PW2 and/or at other municipal production sites in areas where the well interference needs to be managed (i.e., Queensville, Holland Landing, and Newmarket).

5.2.2 Private Water Well Interference Investigation and Resolution Procedure

In the event a well interference complaint is received because of the operation of the Green Lane wells or actions, despite best efforts to monitor and mitigate ahead of time, a well interference complaint protocol will be triggered, and an investigation will ensue to determine the cause of the adverse impact and recommend necessary corrective measures to resolve the complaint. Where results of the investigation indicate private water well interference has occurred as a result of Region activities and/or actions the complainant will be compensated by York Region for cost incurred during the well interference investigation and through the implementation of corrective/remedial action required to restore the private water supply.

Corrective or mitigative options that best resolves the well interference issue, considering the duration and cost of the solution, will be determined through the well complaint investigation or will be implemented pursuant to the mitigation measures assigned as part of the detailed well investigation. Available mitigation options may include one or a combination of the following options:

- Modification of operational strategy for Green Lane Production Wells and/or other YSA production wells
- Lowering of existing pump
- Drilling a deeper well on the property
- Connecting to a municipal watermain

6.0 Groundwater Under Direct Influence of Surface Water Assessment

6.1 Regulatory Context

Existing guidance for the determination of GUDI is documented in the October 2001 Terms of Reference (ToR) for *Hydrogeological Study to Examine Groundwater Sources Potentially Under Direct Influence of Surface Water,* published by the MECP in 2001. The MECP is currently in the process of revising the 2001 ToR to incorporate current consensus of science in the evaluation of groundwater sources to ensure that appropriate water treatment for communal supplies is provided. York Region has been provided the *Draft Technical Support Document: Determination of Minimum Microbial Treatment for Municipal Residential Drinking Water Systems Using Subsurface Raw Water Supplies* (DRAFT Technical Support Document [2019]) from which field activities conducted during the constant rate pumping test at EG-PW1 and EG-PW2 were modelled.

For the purposes of assessing the relationship between surface water and groundwater sourced from aquifer source at EG-PW1 and EG-PW2, a collation of the field monitoring activities described in the existing 2001 ToR and the newly proposed draft guidance document was performed to provide an assessment of the GUDI status of t EG-PW1 and EG-PW2 that would determine the appropriate treatment requirements for a future production well at the Site.

The following is a summary of these two guidance documents.

<u>Terms of Reference (2001)</u>

In the October 2001 ToR, the MECP state that well water is considered under the direct influence of surface water (GUDI) if it has:

- Physical evidence of surface water contamination (e.g., insect parts, high turbidity), and/or;
- Surface water organisms (e.g., campylobacter, aerobic spores, Cryptosporidium, Giardia).

The ToR further state that communal wells are flagged as potentially GUDI if they:

i) Regularly contain Total Coliforms and/or periodically contain *Escherichia coli (E.coli); or*

ii) Are located within approximately 50 days horizontal saturated travel time from surface water or are within 100 m (overburden wells) or 500 m (bedrock wells) of surface water (whichever is greater) and meet one or more of the following criteria:

a. Wells may be drawing water from an unconfined aquifer;
b. Wells may be drawing water from formations within approximately 15 m of surface;
c. Wells are part of an enhanced recharge/infiltration project;
d. When the well is pumped, water levels in surface water rapidly change or hydraulic gradients beside the surface water significantly increase in a downward direction;
e. Chemical water quality parameters are more consistent with nearby surface water than local groundwater and/or they fluctuate significantly and rapidly in response to climatological or surface water conditions.

DRAFT Technical Support Document (2019)

The draft 2019 technical support document (Draft ToR) provides a procedure for determining whether a subsurface water supply requires treatment beyond a minimum level of disinfection to inactivate or remove viruses and bacteria caused by the direct influence of surface water on the groundwater supply. The draft guidance document defines the need for disinfection of protozoan pathogens Cryptosporidium spp. oocysts (Cryptosporidium) and Giardia spp. cysts (Giardia), based on:

1. Evidence of Cryptosporidium and/or Giardia contamination, or;
2. Evidence of both fecal contamination (*E. coli*) and the presence of an adequately sized or relatively rapid pathway connecting the subsurface and above ground or near surface areas.

A well is deemed vulnerable to contamination by protozoa if it meets the following assessment criteria:

a) If Cryptosporidium or Giardia are detected, or;
b) If the following water quality threshold is met: there are greater than or equal to 4 detections of *E. coli.* during any 12-month running period, and there are greater than or equal to 2 detections of photosynthetic, pigment-bearing algae and/or diatoms (PBADs) at any point in time.

Well classification is based on whether further disinfection for protozoa is required and whether particulate removal is required.

A well is determined to require further particulate removal (i.e., Chemically Assisted Filtration [CAF]) if it meets the following criterion:

a) If the turbidity ever exceeds 10 Nephelometric Turbidity Units (NTU) in two consecutive samples collected continuously and/or the 95th percentile is above 5 NTU.

Table 6-1 provides a guide of updated terms for well classification.

Table 6-1. Draft Well Classification and Treatment Requirements

Source Water Category		Minimum Required Treatment Level	
Existing Term	**Updated Term**	**Overall**	**Particulate Removal**
Groundwater	Category 1	4-log virus or as mandated by the current version of the Procedure for Disinfection of Drinking Water in Ontario	None
Groundwater Under the Direct Influence of Surface Water (GUDI) With Effective Filtration	Category 2	4-log virus 3-log Giardia spp. cysts 2-log Cryptosporidium spp. oocysts or as mandated by the current version of the Procedure for Disinfection of Drinking Water in Ontario	None
GUDI	Category 3		Chemically Assisted Filtration (CAF)
	Category 3E		Approved alternative to CAF

To assess their vulnerability to contamination by protozoa, new wells are suggested to undergo a hydrogeological study incorporating a preliminary hydrogeological evaluation and pumping test. The preliminary hydrogeological evaluation is a review of the hydrogeologic and physical site setting, which has largely been completed as part of this investigation and presented in **Section 2.0** of this report.

As prescribed in the draft guidance document, the pumping test evaluation is conducted to collect the following:

- Key water quality data that can be used to inform water well supply vulnerability to contamination by protozoa under conditions as similar as possible to the anticipated well production conditions; and,
- Hydrogeological data to confirm the setting and conceptual model of the aquifer and well, and to plan for data collection requirements during any operational confirmation period for the well.

Minimum requirements of the pumping test evaluation include:

a) Continuous water level monitoring from an appropriately designed monitoring well network;
b) Meteorological data;
c) Water sampling from pumping well, including:
    i. At least five samples for *E. coli*, including one sample at the end of the pumping test, to assess trends or changing water quality during pumping,
    ii. At least three samples for general chemistry (i.e., major anions/cations, alkalinity or bicarbonate, and dissolved organic carbon), including one sample at the end of the pumping test,
    iii. Dissolved oxygen, temperature, conductivity, and pH measured in the field when the general chemistry samples are collected, and
    iv. At least two (2) samples for Cryptosporidium, Giardia, and PBADs, including one (1) sample collected within the last 24 hours of the pumping test;
d) Pumping rates and volumes;
e) Design parameter monitoring at pumping well, including:
    i. Continuous turbidity measurements (15-minute intervals),
    ii. Continuous ultraviolet transmittance (UVT) measurements (hourly minimum intervals), and
    iii. A chlorine demand test at the end of the pumping test;
f) Water sampling from monitoring wells;
g) Water sampling from surface water; and,
h) Additional analysis at the discretion of the proponent.

6.2 Evaluation of GUDI (ToR, 2001)

Table 6-2 summarizes the GUDI criteria for EG-PW1 and EG-PW2 under the existing 2001 ToR. Based on this evaluation EG-PW1 and EG-PW2 is considered a ‘non-GUDI’ well.

Table 6-2. EG-PW1 and EG-PW2 GUDI Assessment Summary Based on 2001 ToR Criteria

GUDI Criteria (MECP, 2001)	EG-PW1 and EG-PW2
Water from the well regularly contains Total Coliforms and/or periodically contains *E.coli.*	Although the sampling record is limited, there have been no detections of these parameters in the well, with the exception of a detection of Total Coliforms that is considered anomalous and likely attributed to the sample collection method.
OR	
The well is located within approximately 50 days horizontal saturated travel time from surface water.	The supply aquifer is separated from surface water by a thick aquitard sequence; therefore vertical travel from surface to aquifer is significantly greater than 50 days.

GUDI Criteria (MECP, 2001)	EG-PW1 and EG-PW2
OR	
The well is within 100 m of surface water.	No
AND	
The well may be drawing water from an unconfined aquifer.	No. The well is screened in a confined overburden aquifer.
The well may be drawing water from formations within approximately 15 m of surface.	No. The well screen is isolated in a confined overburden aquifer (top of source formation >80 mbgs).
The well is part of an enhanced recharge/infiltration project.	No.
When the well is pumped, water levels in surface water rapidly change or hydraulic gradients beside the surface water significantly increase in a downward direction.	No.
Chemical water quality parameters are more consistent with nearby surface water than local groundwater and/or if they fluctuate significantly and rapidly in response to climatological or surface water conditions.	No. The results of analysis of surface water and groundwater quality samples do not indicate similar chemical signatures between the surface water sources and the screened aquifer unit (YSA) or between the shallower aquifer unit (Upper Newmarket Till) and the screened aquifer unit (YSA). Refer to **Section 6.3.3.2** for further details.

6.3 Evaluation of GUDI (Draft ToR, 2019)

6.3.1 Well Integrity and Structural Assessment

New wells are required to be constructed in accordance with current regulations (O. Reg. 903) and with the guidance provided in the draft ToR to classify the well as ‘low risk’. Low risk wells are classified as such when the following structural criteria are satisfied:

a) The well casing height should be higher than the 100-year storm flood line or 40 cm above ground, whichever is greater.

b) The well should be equipped with a commercially manufactured vermin-proof well cap.

c) The well air vent should be screened.

d) The ground at the base of the wellhead should be mounded to prevent the ponding of surface water, or the well should be situated within a pump house.

e) There should be no annular voids visible at ground level adjacent to the well casing.

f) There should be no visible penetrations into the well casing.

A review of the As-Built Well Diagrams for EG-PW1 and EG-PW2 (included in **Appendix D**) provide evidence that the well has been constructed using the appropriate materials and has an adequate annular seal around the well casing to prevent the movement of water from the surface to the source aquifer. As such, EG-PW1 and EG-PW2 is considered at 'low risk' for the transport of pathogens from surface to the supply aquifer.

6.3.2 Microbiological Water Quality Evaluation

6.3.2.1 Indicators of Fecal Contamination

E.coli is a widely used indicator of fecal contamination. As discussed in **Section 3.3.1**, water quality sampling for fecal indicators (*E. coli*) was completed at EG-PW1 and EG-PW2 at all sampling intervals during the constant rate pumping test (1 hour, 6 hours, 24 hours, 48 hours, 72 hours and additional sample for EG-PW2 at 96 hours). Results indicate no detection of *E.coli* in any of the samples collected. The complete tabulated water quality results are found in **Appendix H** (**Tables H-1ab and H-2**), along with laboratory reports for each analysis.

6.3.2.2 Enteric Protozoa and Microorganism Analysis

Groundwater quality sampling at EG-PW1 and EG-PW2 was conducted during the constant rate pumping test at the 6-hour and 48-hour marks on November 23, 2021, and November 24, 2021, at EG-PW2 and, November 23, 2021, and November 25, 2021, at EG-PW1, to obtain representative samples for Cryptosporidium spp., Giardia spp. and PBADs. Cryptosporidium, Giardia and PBAD samples. Sampling was conducted in accordance with the USEPA Method 1623, as outlined in the York-Durham Regional Environmental Laboratory Sampling Instruction guide for Cryptosporidium and Giardia. Samples were collected by filtering between 404 and 410 L of raw well water through an Envirocheck HV capsule in the field at a flow rate of 1.5 L/min. The sample supernatant, after Giardia and Cryptosporidium extraction by immunomagnetic separation, was examined microscopically for the presence of PBAD. The collected groundwater samples were submitted to the YD Lab for microscopic particulate analysis.

Results of this analysis are summarized in **Table 6-3**, and indicate an absence of Cryptosporidium, Giardia and PBADs. Full laboratory analytical reports can be found in **Appendix J**.

Table 6-3. Microscopic Particulate Analysis Results for EG-PW1 and EG-PW2

Parameter	Units	Reporting Limit	EG-PW1 23-Nov-21	EG-PW1 25-Nov-21	EG-PW2 22-Nov-21	EG-PW2 24-Nov-21
Cryptosporidium spp. oocysts (Cryptosporidium)	N/A	1	0	0	0	0
Giardia spp. cysts (Giardia)	N/A	1	0	0	0	0
Pigment-Bearing Algae and/or Diatoms (PBADs)	N/A	N/A	Absent	Absent	Absent	Absent

6.3.3 Assessment of Well Vulnerability to Contamination

6.3.3.1 Design Parameter Monitoring

A water turbidity analyzer was installed from a sampling port at EG-PW1 and EG-PW2. Continuous raw water turbidity measurements were recorded at a ten-minute interval for the duration of the pumping test. It should be noted no turbidity was measured at EG-PW1 during the first 24 hours of the constant rate test as it was not pumping. Once EG-PW1 did begin pumping, initial data was not captured for a period of 40 minutes between November 23, 2021, to November 23, 2021, 10:40 a.m. due to analyzer malfunction. A representative of York Region's Operation and Maintenance Team was promptly on-Site to address the issue and EG-PW1 turbidity data was able to be collected after November 23, 2021, 10:40 a.m. for the duration of the constant rate pumping test without issue. Results of this analysis, presented in **Appendix J (Figure J.1**), were compared to the treatment thresholds provided in the draft ToR of 5 NTU for the 95th percentile and of 10 NTU for any two consecutive samples collected continuously. Results of the turbidity analysis indicate that the turbidity of raw water from EG-PW1 and EG-PW2 were below 5 NTU. The 95th percentile over the course of the pumping test was estimated to be 0.09 NTU and 0.36 NTU, respectively, which are both below the 5 NTU water quality threshold. Further, no turbidity measurements exceeded 10 NTU.

A continuous ultraviolet 254-nanometer organic testing monitor (Real UV254 M3000) was installed on the EG-PW1 and EG-PW2 discharge pipe as a flow-through cell. This unit recorded the percentage of UVT at a ten-minute interval for the duration of the pumping test. It should be noted UVT data was not available for EG-PW1 for the first 24 hours of the constant rate pumping test as the pump was turned off. Issues were encountered capturing continuous UVT measurements at EG-PW2 as a result of leaks in the discharge lines. Data was unavailable for the following time periods: November 23, 2021, 3:50 p.m. to November 23, 2021, 4:50 p.m.; and, November 23, 2021, 6:30 p.m. to November 23, 2021, 6:40 p.m. The UVT analyzer for EG-PW2 was also effected by moisture resulting in unreliable data collection suspected to start from November 23, 2021 8:50 p.m. and continued through to November 25, 2021 8:00 a.m. when York Region's Operations and Maintenance staff were able to resolve issue for remainder of test after November 25, 2021 9:30 a.m. Results of this analysis are presented in **Appendix J** (**Figure J.2**), and show recordings generally in the range of 94 to 96 percent UVT during the intervals of reliable instrument function. Given the reliable function of the UTV analyzer at EG-PW1, it is inferred the raw water quality from EG-PW2 is similar during periods of equipment malfunction given both wells are sourcing groundwater from the same aquifer.

Chlorine is commonly used in drinking water to achieve primary disinfection whether by sodium hypochlorite or hypochlorous acid (gas). To appropriately design and size the chlorine equipment, testing needs to be done to determine the raw water demand. Testing was completed on Site according to Standard Methods 2350B to prevent oxidation of the raw water. Testing was conducted during the last few hours of the 72-hour pumping test, when the water quality is at its most stable and sourced from the aquifer. Based on the results of the testing, the raw water chlorine demand was estimated to be between 3.00 and 3.50 mg/L at EG-PW1 (referred to as East Gwillimbury Monitoring Well # 2 in appended memo) and between 3.25 and 3.50 for EG-PW2 (referred to as East Gwillimbury Monitoring Well # 3 in appended memo). A complete description of the methodology and results are provided in **Appendix J**.

6.3.3.2 Water Quality Sampling from Monitoring Network

Groundwater quality samples were collected from Newmarket MW-20D and Newmarket MW-20S on October 20, 2021, and December 1, 2021 (prior to and following the 96-hour pumping test) to assess for any change in groundwater chemistry due to continuous pumping from the supply aquifer. In addition, samples were collected from the northern tributary of East Holland River (MP/SG-3) and the wetland at the eastern tributary of East Holland River south of Green Lane (MP-2S/D) on October 21, 2021, and November 30, 2021 (prior to and following the 96-hour pumping test) to characterize the quality of nearby surface water sources. Samples were submitted to YD Lab for analysis of the indicator parameters identified in **Table 3-5**.

The water quality results were reviewed to assess potential hydraulic connections between the pumped aquifer (YSA) and the overlying water-bearing unit (Upper Newmarket Till) as well as to identify any hydraulic interaction between groundwater and surface water sources in proximity to the Site. This assessment was performed by comparing the composition or geochemical signatures of the YSA and Upper Newmarket Till and of surface water from the northern tributary of the East Holland River and eastern tributary of the East Holland River by illustrating the relative percentage concentration of major cations and anions on a piper plot. In general, differences in geochemical signature can be attributed to differences in origin, the path along which the water travelled, and the chemical composition of the deep aquifer system and the shallow overburden system. For the purpose of this assessment, the results of raw water quality sampling from Newmarket MW-20D, Newmarket MW-20S, MP 2S/D, and MP SG-3 (prior to and following the pumping test), together with the results of raw samples collected from EG-PW1 after 72 hours of pumping and EG-PW2 after 96 hours of pumping, were illustrated on the piper plot to compare the geochemical signatures of groundwater from the YSA (EG-PW1, EG-PW2 and Newmarket MW-20D) and Upper Newmarket Till (Newmarket MW-20S). Samples collected from the northern tributary of the East Holland River (MP/SG-3) and eastern tributary of the East Holland River (MP 2D/S) prior to and following the pumping test were also included in the piper plot analysis to compare the geochemical signatures of groundwater and surface water sources near the Site. Results of the piper plot analysis are presented in **Appendix J** (**Figure J.3**).

As shown on **Figure J.3 (Appendix J),** the water quality results for EG-PW1 and EG-PW2 show near identical chemical signatures, which provides evidence that the wells are screened in the same aquifer. It should be noted the chemical signatures were near identical for the following samples collected at EG-PW1 and EG-PW2: 1 hour, 6 hours, 24, hours and, 72 hours. Water quality from Newmarket MW-20D (also screened in the YSA) was consistent prior to and following the 96-hour pumping test. The water quality at Newmarket 20D has a higher percentage of sodium (mid 70% versus Mid 30% at test wells) with other ions in similar concentration. As Newmarket MW-20D is adjacent to the road, there is a chance road salt may have affected this monitoring well. No similarities in chemical signature were noted between EG-PW1/EG-PW2 (YSA) and Newmarket MW-20S (Upper Newmarket Till) or between EG-PW1/EG-PW2 (YSA) and MP 2S/D and MP SG-3 (Surface Water), which confirms the absence of a hydraulic connection between the YSA and shallower Upper Newmarket Till water-bearing unit near the Site, as also interpreted from the lack of water level response observed in these shallow wells during the 96-hour pumping test.

The piper plot (**Figure J.3 of Appendix J)** illustrates differences in chemical signature between the surface water quality samples (MP 2S/D and MP SG-3) and the groundwater samples (collected from EG-PW1, EG-PW2 and Newmarket MW-20D). Results indicate some similarity in water quality between the tributary of the East Holland River at MP 2S/D, MP SG-3 and the Upper Newmarket Till (Newmarket MW-20S) at the Site. Although this may suggest that the uppermost aquifer system at the Site is connected to the nearby surface water source. Conversely, the results indicate an absence of hydraulic connection between the Upper Newmarket Till and YSA at/near the Site and the nearby surface water sources.

6.4 Evaluation of GUDI Conclusions

Results of the 96-hour constant rate pumping test and water quality analyses presented in this report were considered to determine if groundwater sourced from EG-PW1 and EG-PW2 is influenced by surface water. Results of this assessment indicate that there is no observed hydraulic connection between the source aquifer (YSA) and surface water and that there is no presence of microbiological indicators suggesting surface water contamination of groundwater. Therefore, EG-PW1 and EG-PW2 are considered non-GUDI wells.

7.0 Summary

The following is a summary of the results presented in this report:

- York Region has completed a hydrogeological investigation as part of the Green Lane Well 2 Construction Project, which had the objective of building redundancy in municipal water supply sourced from the YSA and improving overall municipal water supply quality in the local distribution area by designing a 200 L/s capacity water treatment system for manganese and iron water filtration.
- Testing of EG-PW1 and PW-2 has demonstrated that the wells can operate concurrently at rates up to 200 L/s. Given the uncertainty of aquifer response over long duration pumping it is recommended that the average day withdrawal from the Site be limited to 105 L/s. A gradual increase in production, up to the targeted 105 L/s should be implemented for a minimum of one-year following commissioning of the water treatment plant.
- The water supply from the Green Lane production wells will undergo filtration and disinfection treatment at the proposed Green Lane Water Treatment Plant prior to being distributed to end users. An update to the Yonge Street Aquifer Well Capacity Restoration Class EA is being prepared by Jacobs under separate cover.
- The area of study for this hydrogeological investigation was the ZOI for existing EG-PW1 and newly constructed EG-PW2 at 180 Green Lane, East Gwillimbury (the Site).
- A large diameter (30.5 cm) test well (EG-PW2) was constructed in the YSA to a depth of 95.8 mbgs to facilitate aquifer testing. The well construction was completed in compliance with O. Reg. 903 and AWWA A100-20 standards, and in accordance with the MECP Draft Technical Support Document: *Determination of Minimum Microbial Treatment for Municipal Residential Drinking Water Systems Using Subsurface Raw Water Supplies* for a 'low risk' well. EG-PW2 was installed 17 m east of EG-PW1 and is interpreted to be screened in the same aquifer and at a similar setting as EG-PW1.
- Based on the well screen design, the theoretical screen transmitting capacity of EG-PW2 was calculated as 146 L/s (12,590 m^3/day) assuming a maximum entrance velocity of 0.03 meters per second.

- A monitoring well (EG-MW4) was installed as part of this exploratory program for the purposes of enhancing the existing monitoring well network.
- A private well survey was conducted prior to the 96-hour pumping test that yielded 63 participants. Of the 63 participants, 23 had private wells interpreted to be screened in the YSA. 4 locations were instrumented with pressure transducers and monitored during the 96 hour constant rate pumping test with no adverse impact to available drawdown.
- A step test was completed on EG-PW2 on November 16, 2021, which consisted of three steps during which the test well was pumped at progressively increasing rates of 40 L/s, 66 L/s, 100 L/s with a fourth combined step of 200 L/s with EG-PW1 and EG-PW2 pumping at 100 L/s, each for a period of 60 minutes, with no water level recovery between steps. Results of the step test suggest similar performance to EG-PW1.
- A 96-hour constant rate pumping test was conducted on EG-PW2 from November 22, 2021, to November 26, 2021, the last 72 hours of which involved combined pumping with EG-PW1. The purpose of the pumping test was to estimate the hydraulic properties of the tested aquifer, evaluate the potential yield of the aquifer, estimate the ZOI of the pumping, and document any changes in the water quality as pumping progressed during the test. The results from this investigation are summarized as follows:
    - The constant rate pumping test showed that EG-PW2 is capable of producing a combined 100 L/s on a long-term basis.
    - The combined portion of the pumping test, performed by pumping EG-PW2 at 100 L/s and EG-PW1 at 100 L/s, showed that the Site is capable of producing 200 L/s sustainably.
    - Maximum drawdown in the monitoring wells screened in the YSA was observed to range from 10.15 m at Newmarket MW-19 (near Site) to 0.42 m at Milne Lane (located 3,011 m northwest of EG-PW2) during the pumping test.
    - No influence was observed in the nearby shallow monitoring wells interpreted to be screened in the ORAC channel, Upper Newmarket Till lens, INS, Lower Newmarket Till or in the mini-piezometers/stream-gauges.
- Results of the sand content tests indicated that the AWWA A100-20 standard was met for both EG-PW1 and EG-PW2 at a pumping rate of 100 L/s, with average sand concentrations of 4.8 ppm and 4.4 ppm measured, respectively, over the two hours of pumping for each test. Both wells produce an elevated

sand content over the first 10 minutes of operation. It is recommended that design of the water treatment facility include provision for soft-start of the wells to ramp up to the design pumping rate. In addition, water for the first 10 minutes of operation should be pumped to waste prior to entering the treatment system. [*Note: The pump-to waste time can be modified should turbidity and sand content readings, during well startup, reflect an acceptable level.*]

- AQTESOLV's Pumping Test wizard for a multi-well test was used to estimate aquifer properties for the YSA based on drawdown observed during the 96-hour pumping test and subsequent water level recovery period. The aquifer was complex based on analytic interpretations and exhibited an area of higher transmissivity at the monitoring wells local to the Site and lower transmissivity for wells northwest of the Site. Using the composite plot tool with the Theis (1935)/Hantush (1961) method, the T was estimated as 24,000 m^2/day locally and 1,060 m^2/day as a bulk T. The S values were estimated to be $4x10^{-6}$ (unitless) and $7x10^{-5}$ (unitless), respectively, indicative of a confined aquifer formation
- Results of water quality sampling performed at EG-PW1 and EG-PW2 for the current aquifer testing program were compared to the ODWSOG, and it was determined that all parameters met the corresponding criteria limit/range, with the notable exception of colour, hardness, iron and methane. Concentration of manganese was observed to exceed the Health Canada's guideline for Canadian Drinking Water Quality. Comparison of raw water quality at the newly constructed EG-PW2 with that existing EG-PW1 showed very similar water quality.
  - A water treatment system is being designed for the Green Lane Site with provisions considered for methane removal in the pre-design phase.
- Drawdowns observed in EG-PW1 and EG-PW2 over the duration of the 96-hour constant rate pumping test were analyzed and extrapolated to assess the sustainability of the groundwater takings from the Site under two pumping scenarios:

  (1) Peak Demand Scenario (pumping of EG-PW1 and EG-PW2 at a combined 200 L/s) during the peak demand period for the local distribution area (defined as the 153-day period from May 1 to September 30, when the water demand is highest); and

  (2) Average Day Demand Scenario (constant pumping from EG-P1 and EG-PW2 at a combined rate of 105 L/s until 2041) as a conservative means of confirming sustainability of the demands outside of the peak period. It is acknowledged that these scenarios are conservative as it is unlikely that

continuous operation of the wells would occur over these extended durations without pause for aquifer recovery.

- Based on the projection analyses, it was estimated that a maximum drawdown of 35.9 m and 41.4 m would be observed in EG-PW1 and EG-PW2, respectively, under the Peak Demand Scenario, while a maximum drawdown of 37.8 m and 43.3 m was predicted in EG-PW1 and EG-PW2, respectively under the Average Day Demand Scenario. Given conservatively estimated safe available drawdowns of 46.3 m and 48.7 m for EG-PW1 and EG-PW2, respectively, it was concluded that both wells have sufficient available drawdown to sustain pumping from the YSA at the Site under the two pumping scenarios.

- A 3D groundwater flow model was used to predict the ZOI under the two pumping scenarios: Peak Demand Scenario and Average Day Demand Scenario. The ZOI was defined as the radius of influence around the pumping wells where the estimated drawdown was expected to be approximately 1 m. The ZOI for the Average Day Demand Scenario was predicted to be larger than that for the Peak Demand Scenario.
- It is acknowledged that the Peak Demand and Average Day Demand Scenarios are conservative as typical combined operation of the wells at this pumping rate would be limited to days (rather than weeks), with some interruption to pumping to allow aquifer recovery.
- The objective of commissioning EG-PW1 and EG-PW2 is to provide system redundancy and restore lost capacity from other municipal production wells permitted under the Yonge Street Aquifer Permit to Take Water. There will be no increase in total water taking from the existing PTTW, and therefore potential impacts are limited to the localized takings from EG-PW1 and EG-PW2.
- The impact assessment was completed for private water supply users, permitted groundwater takers, and surface water features within an Area of Focus (Area of Focus, a spatial extent, was delineated based on historical responses to changes in YSA production volumes). However, wells constructed after January 1, 2008, which reside outside the Area of Focus but within the Average Day Demand ZOI were included (in the impact assessment) on the basis that these wells had not experienced potential well interference due to peak production volumes from the YSA well systems (prior to production decreases due to lake-based water supply introduction).
- The results of the impact assessment carried out on private water supply users identified: 200 negatively impacted wells within the Area of Focus, and 1 negatively impacted well between the Area of Focus and Average Day Demand

ZOI. Of these negatively impacted wells, 146 locations had a drawdown deficit of 10 m (or less) and resided within the Town of East Gwillimbury (an area which will likely be the focus of a detailed future private well investigation). There are an additional 45 wells with impact ‘unassigned’ as the well records provided insufficient information to assess.

- The results of the impact assessment carried out on permitted non-municipal groundwater takers identified no negatively impacted wells either inside or outside the Area of Focus.
- The results of the impact assessment carried out on permitted municipal groundwater takers identified a negative potential impact to the following YSA production wells (based on current pump intakes): Aurora PW6, Newmarket PW1, Newmarket PW2, Newmarket PW15, Queensville PW1, Queensville PW2, Queensville PW3, and Queensville PW4. However, Aurora PW6 and Newmarket PW15 are likely to be decommissioned following the commissioning of EG-PW1 and EG-PW2. Should it be realized that Site operations negatively impact any of the production wells, the existing pump setting depths will be increased and/or production rates reduced and water supply supplemented to the area through another source.
- The impact assessment also indicated that identified surface water and other natural features with the Area of Focus, which can be considered potential groundwater receptors, will not likely experience negative long-term influences from Site operations given the hydraulic disconnect between the shallow system and the YSA.
- Further investigation, field verification and monitoring is required to confirm the potential impacts to private and on municipal PTTW wells and confirm the simulated aquifer response and desktop impact assessment results.
- A proactive approach, whereby potential well interference issues are identified and mitigated prior to an impact being observed, will be implemented through the completion of a detailed water well investigation/verification program. The objective of the water well investigation is to verify preliminary impact assessment results based on site-specific information and to develop a unique monitoring and mitigation plan, if determined necessary, and shall be completed prior to the commissioning of the Green Lane Water Treatment Plant. This will initially include a door-to-door well survey to gather additional well details from the well owner. Results will be used to confirm if there is potential for the well to be impacted by the proposed operation of EG-PW1 and EG-PW2 and help inform the development of a groundwater level monitoring program.

- A monitoring network will be established prior to commissioning the wells to monitor groundwater levels across the areas flagged in the impact assessment. Gaps will be filled with new monitors as required to capture required groundwater level data. Specific groundwater level trigger elevations will be assigned based on the outcomes of the detailed private well assessment. The levels will provide a monitoring threshold for proactive mitigation to be implemented as required.
- The gradual increase in production up to the targeted 105 L/s will allow for detailed monitoring of groundwater levels. Should groundwater level response to pump reach assigned trigger levels a possible mitigation step would include exploring the feasibility of reduced pumping and/or cyclical pumping options for EG-PW1 and EG-PW2 and/or at other municipal production sites.
- In the event a well interference complaint is received because of the operation of the Green Lane wells or actions, despite best efforts to monitor and mitigate ahead of time, a well interference complaint protocol will be triggered, and an investigation will ensue to determine the cause of the adverse impact and recommend necessary corrective measures to resolve the complaint.
  - The corrective or mitigative options that best resolves the well interference issue and considers the duration and cost of the solution will be established after the initial private well survey and site visit. Available mitigation options include:
    - Modification of operational strategy for Green Lane Production Wells and/or other YSA production wells
    - Lowering of existing pump
    - Drilling a deeper well on the property
    - Connecting to a municipal watermain
- The completed GUDI assessment concluded that EG-PW1 and EG-PW2 are groundwater wells (non-GUDI wells).

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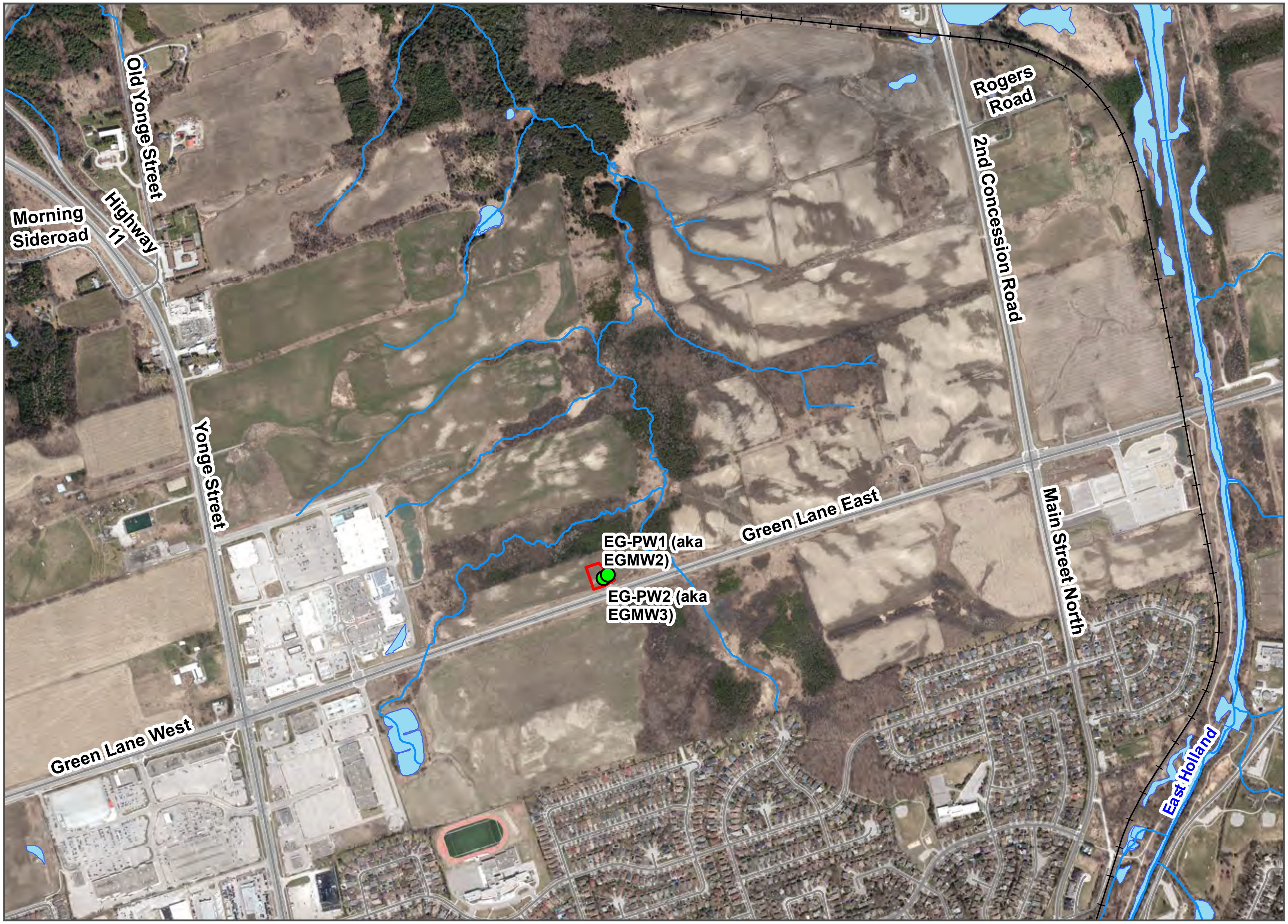
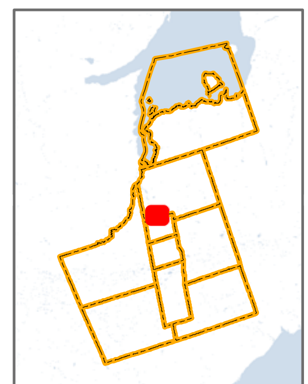
Figures

Figure 1 - Site Location



Legend

- Site
- Green Lane Test Well
- Road
- Railway
- Watercourse
- Waterbody



Meters
0 250 500

York Region

Green Lane Well Site Groundwater Resource Evaluation

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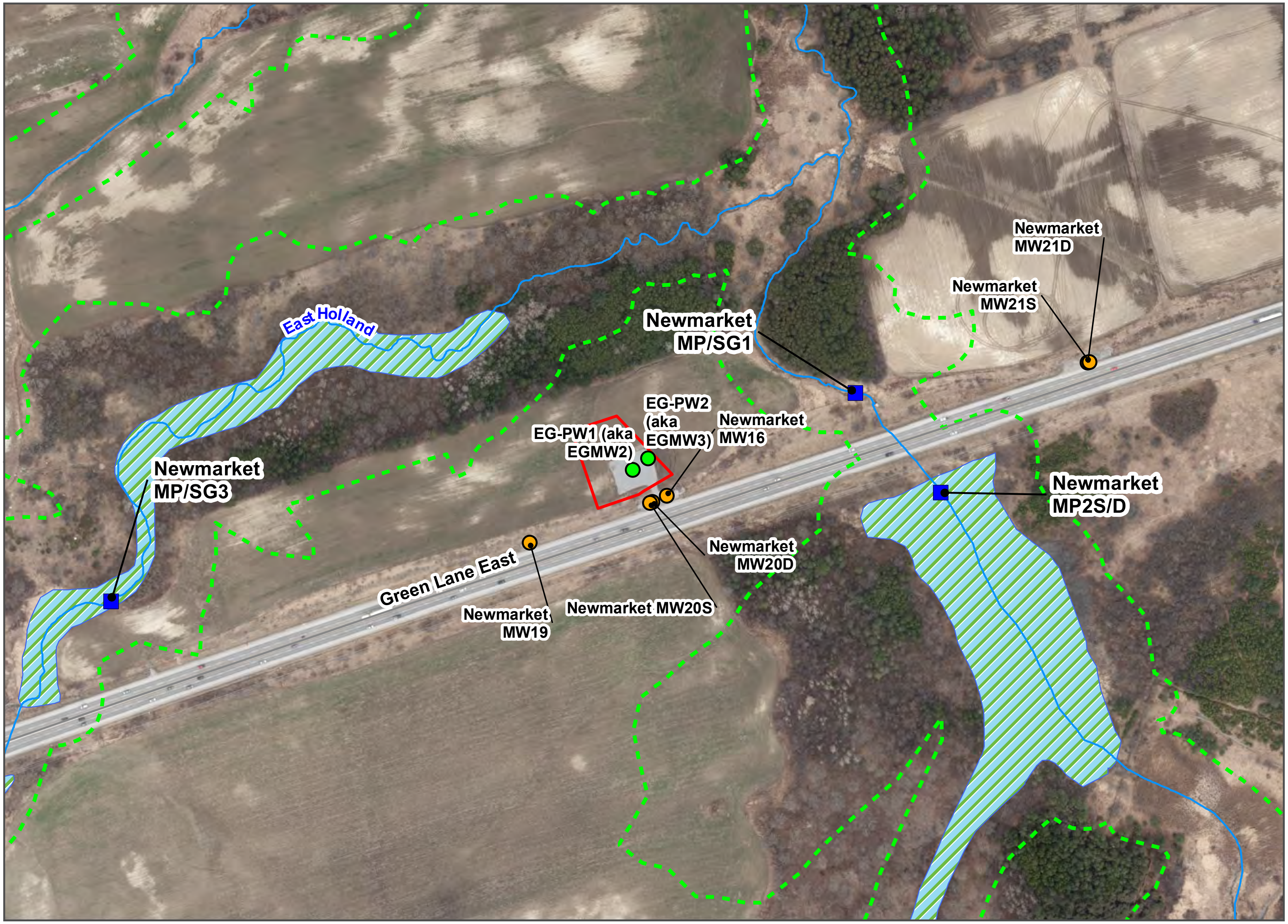
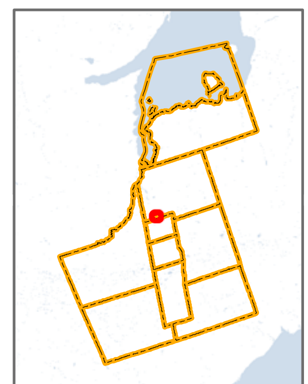
Figure 2 - Site and Local Features



Legend

- Site
- Road
- Watercourse
- Waterbody
- Test Well
- Monitoring Well
- Mini-Piezometer Nest
- LSRCA Regulation Limits



Meters
0 50 100

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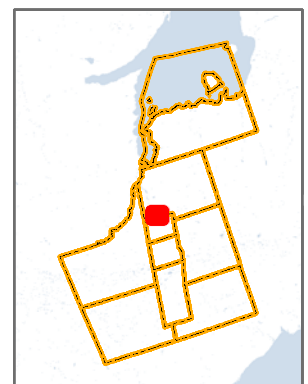
Figure 3 - Topography of the Site Area

Legend

- Site
- Road
- Railway
- Watercourse
- Waterbody
- Test Well
- Topographic Contour (5 m Interval)



Meters
0 250 500

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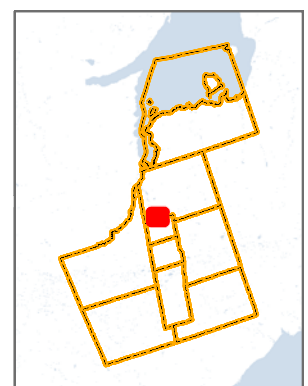
Figure 4 - Regional Physiography

Legend

- Site
- Road
- Railway
- Watercourse
- Waterbody
- Test Well

Physiographic Region

- Schomberg Clay Plains
- Simcoe Lowlands



Meters
0 250 500

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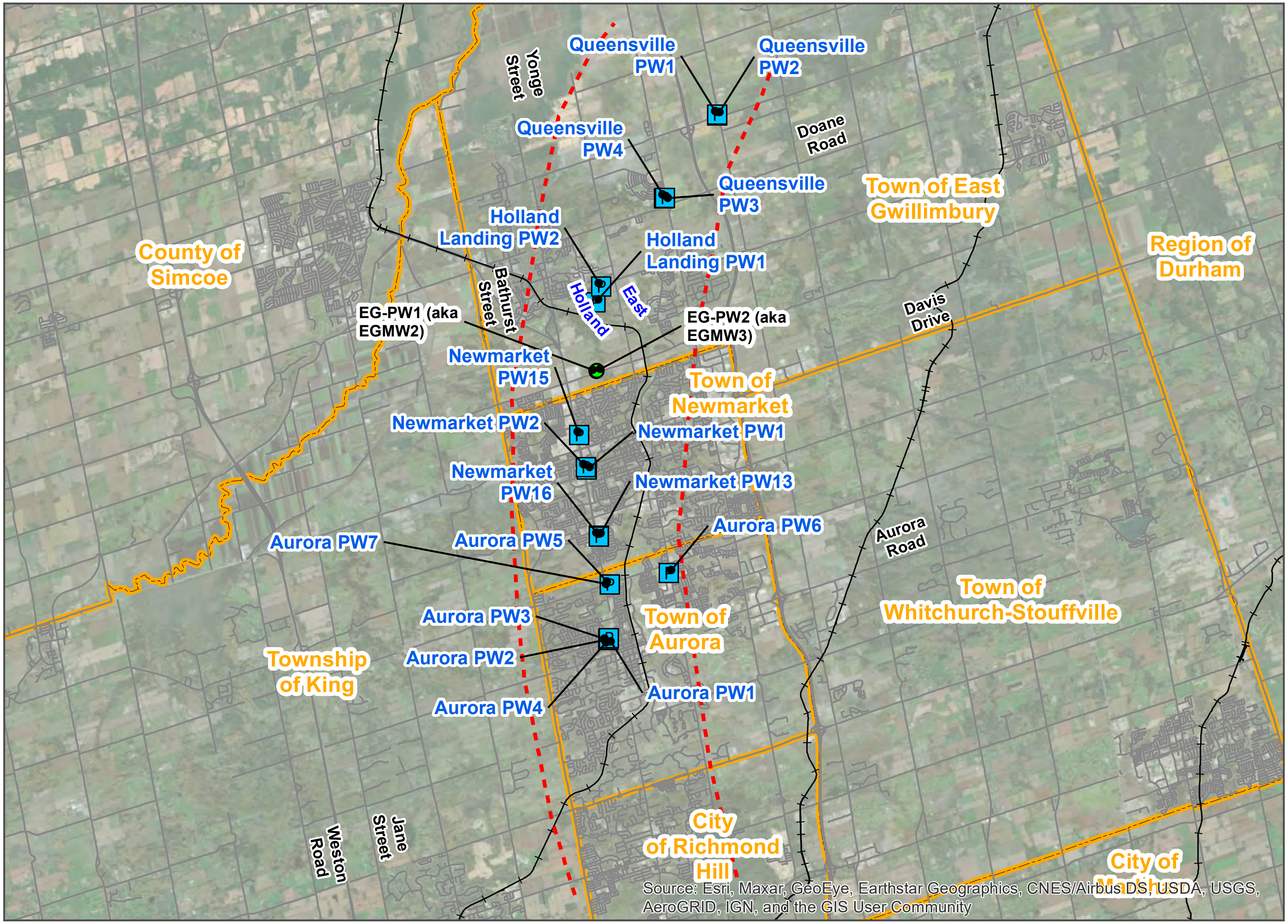
Chapman, L.J. and Putnam, D.F. 2007.
Physiography of Southern Ontario;
Ontario Geological Survey, Miscellaneous Release
--Data 228 ISBN 978-1-4249-5158-1

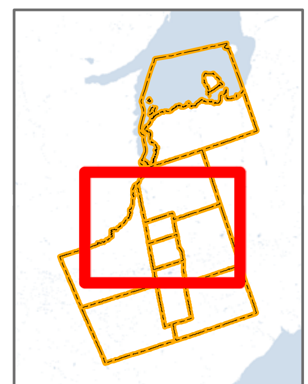
Figure 5 - Lateral Extent of the Yonge Street Aquifer



Legend

- Road
- Railway
- Municipal Boundary
- Production Well
- Test Well
- Yonge Street Aquifer (Approx. limits)

Note: The Yonge Street Aquifer (YSA) limits are approximated from Gerber et al. (2018).



Kilometers
0 2.5 5

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http://www.nrcresearchpress.com/doi/pdf/10.1139/cjes-2017-0172.

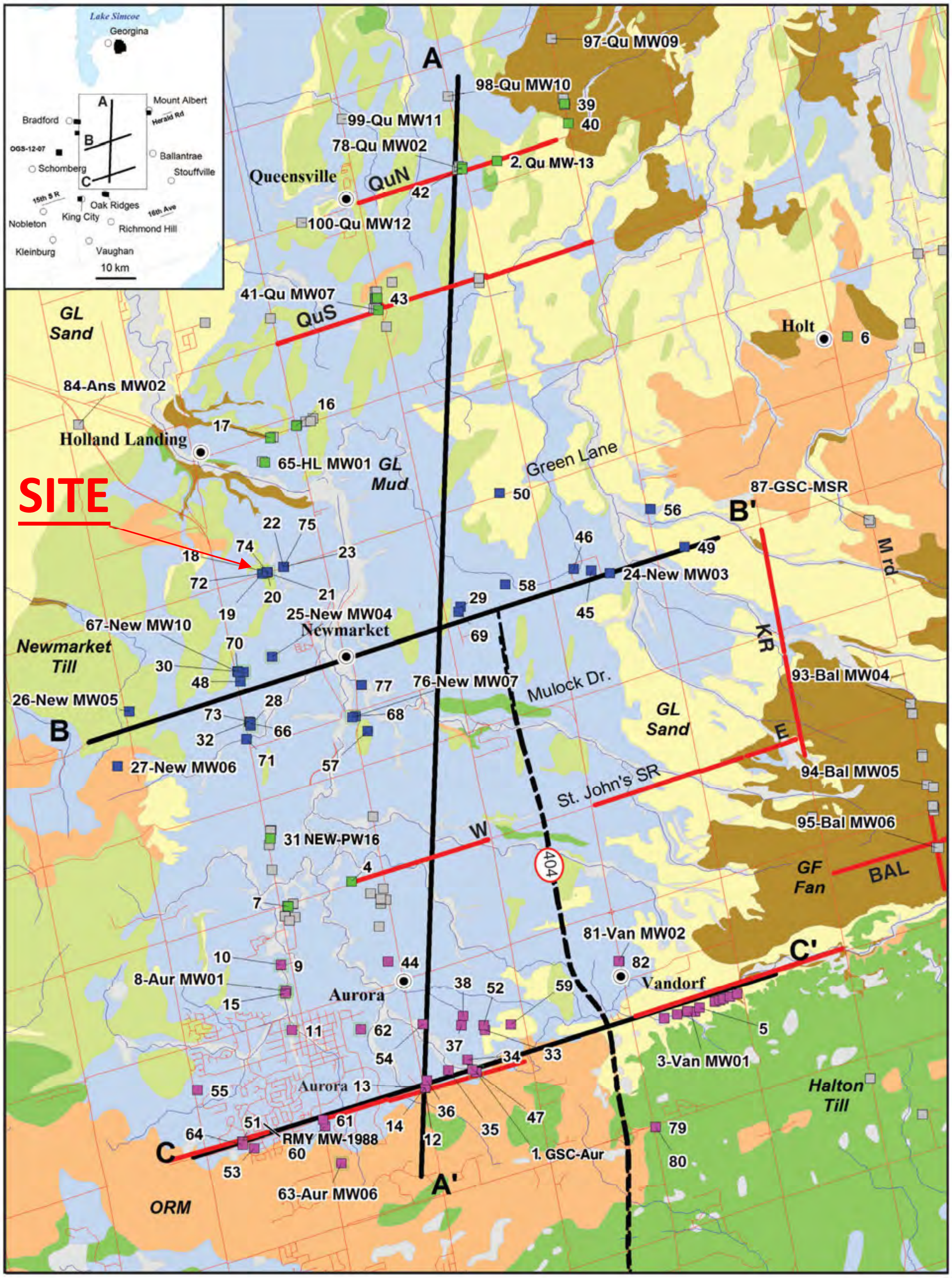


Figure 6. Geologic Transects across the Yonge Street Aquifer Area (figure adapted from Gerber et al., 2018).

Surficial geology is illustrated as shaded areas (blue – glaciolacustrine mud; yellow – glaciolacustrine sand; dark brown – glaciofluvial fan; light green – Newmarket Till; darker green – Halton Till (including Kettleby Till); orange – Oak Ridges Moraine).
Red lines represent seismic profiles; black lines mark the geologic transects. Cross-sections A-A' and B-B' are located near the Site area.

Coloured squares indicate borehole data used for the geologic cross-sections (green squares for cross-section A-A'; blue squares for cross-section B-B'; purple for cross-section C-C')

The Site is approximately 3.4 km west of A-A' and approximately 2.0 km north of B-B'

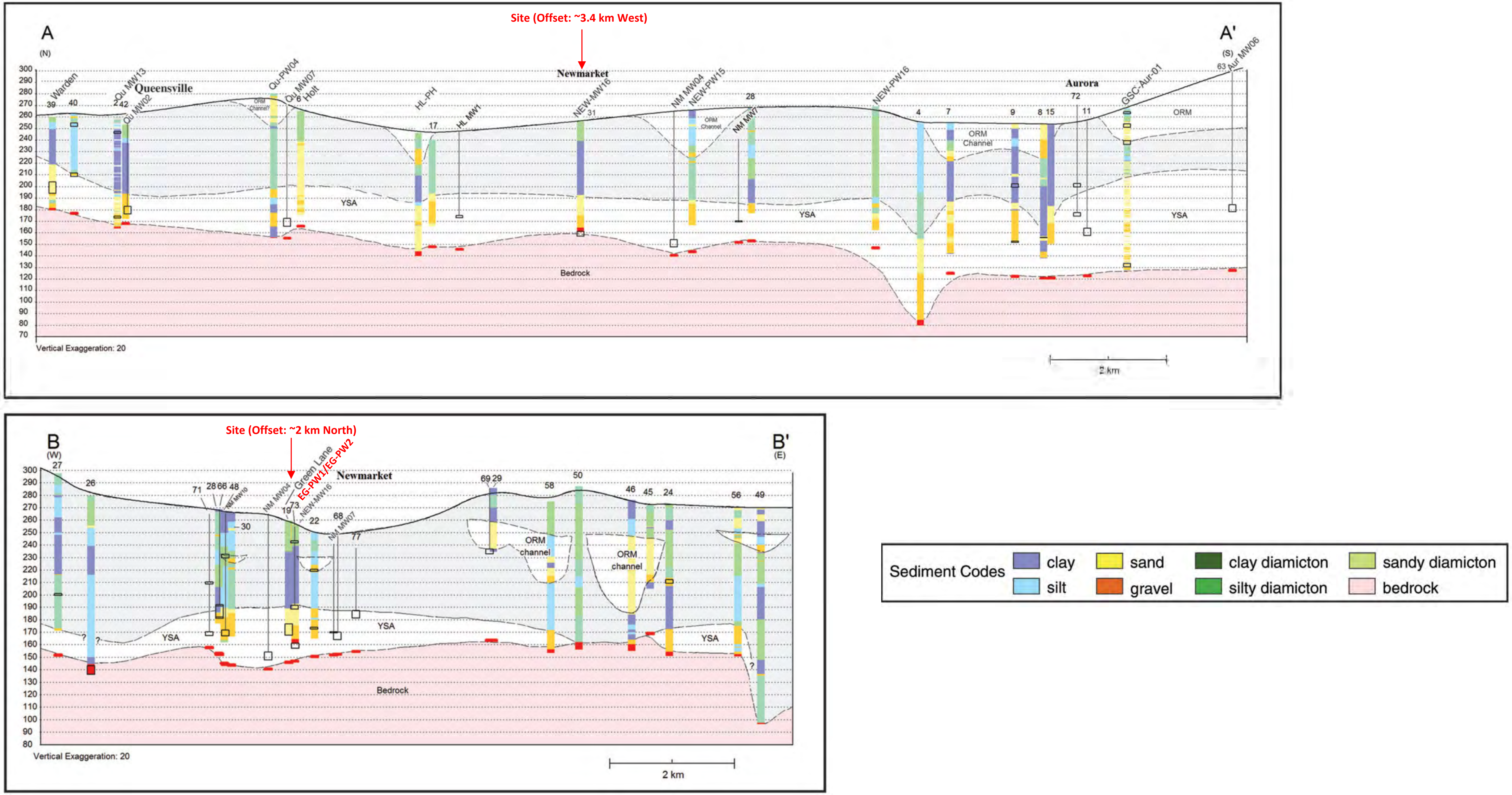


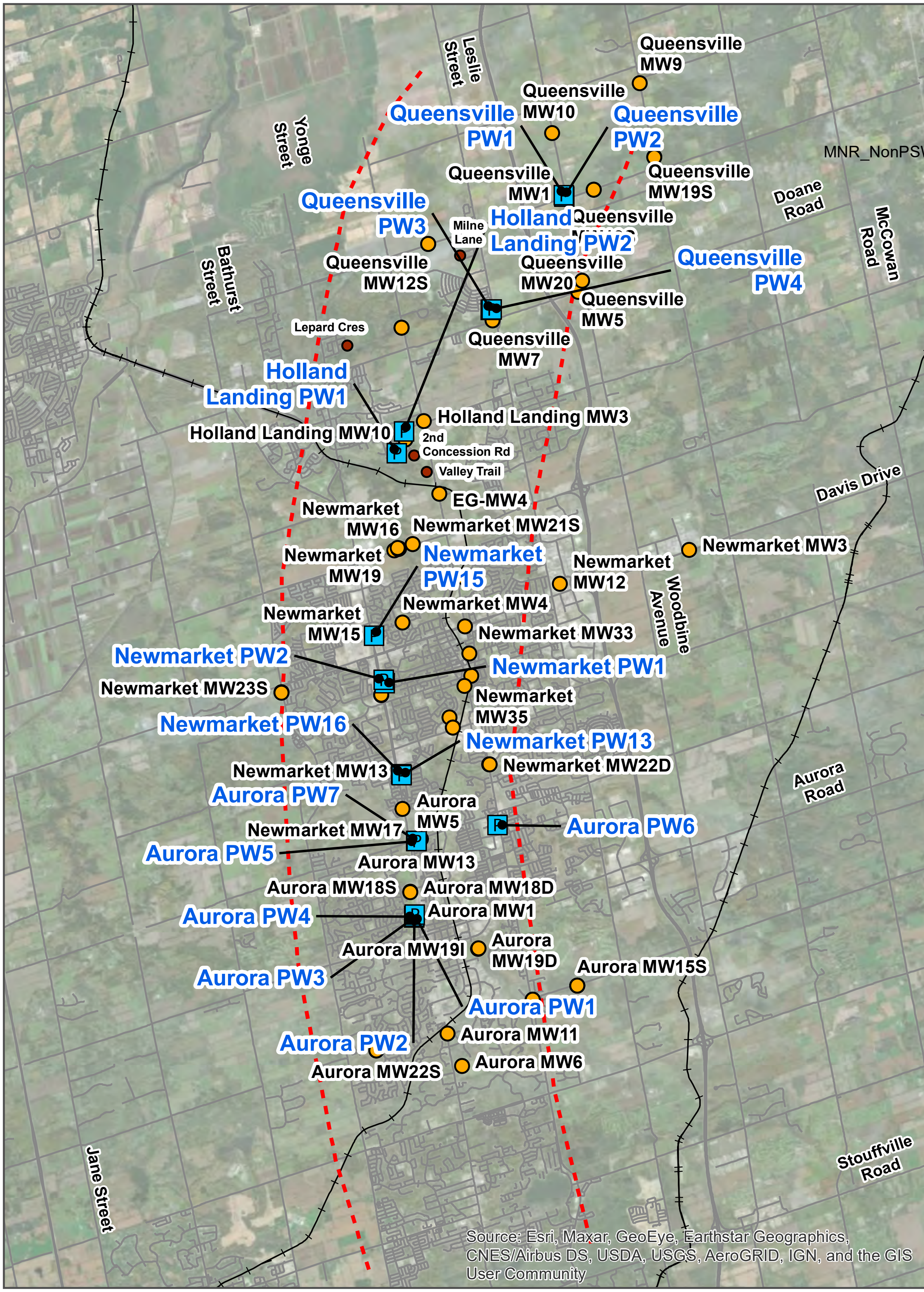
Figure 6a. North-South and West-East Geologic Cross-sections across the Yonge Street Aquifer Area (figures adapted from Gerber et al., 2018).

See Figure 6 for cross-section locations. Symbology: Small open rectangles - well screens; red - bedrock core; light grey areas - aquitard (Thorncliffe post-channel mud, Newmarket Till, and/or glaciolacustrine clay).

Borehole numbering: 19 – Newmarket MW19 ; 73 – Newmarket MW2 ; 22 – Newmarket MW21D.

The lithology encountered in EG-PW1 and EG-PW2 was consistent with the Green Lane portion of the Geber et al. 2018 B-B' Cross-section

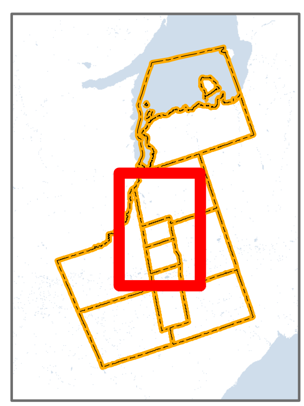
Figure 7 - Yonge Street Aquifer Groundwater Monitoring Network



Legend

- P Production Well
- Monitoring Well
- YSA Private Wells
- Yonge Street Aquifer (Approx. limits)
- Railway
- Road

Note: The Yonge Street Aquifer (YSA) limits are approximated from Gerber et al. (2018).



0 2.5 5 Kilometers

York Region

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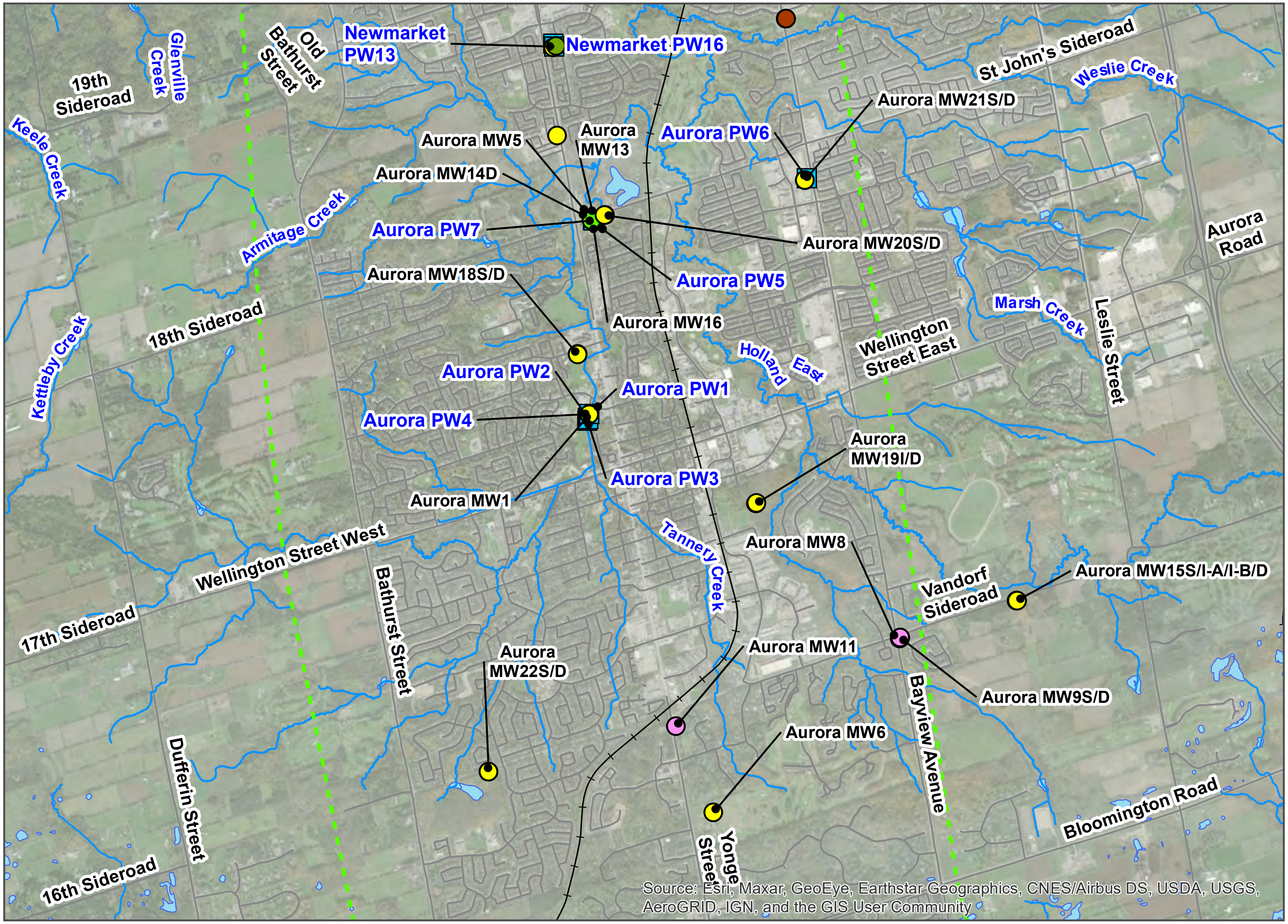
Figure 7a - Groundwater Monitoring Network (Aurora)



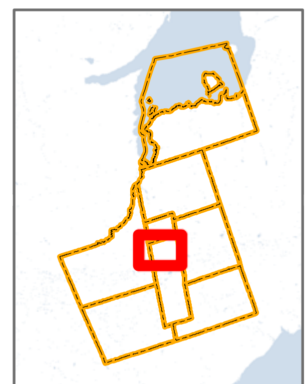
Legend

- Road
- Railway
- Watercourse
- Waterbody
- Yonge Street Aquifer (Approx. limits)
- P Production Well

Monitoring Well

Interpreted Screened Unit

- Recent Deposits
- ORAC
- ORM Channel Silt / Newmarket Till
- ORM Channel Sand
- Upper Newmarket Till
- INS
- Lower Newmarket Till/YSA
- YSA
- Thorncliffe Formation
- Scarborough Formation



Meters
0 500 1,000

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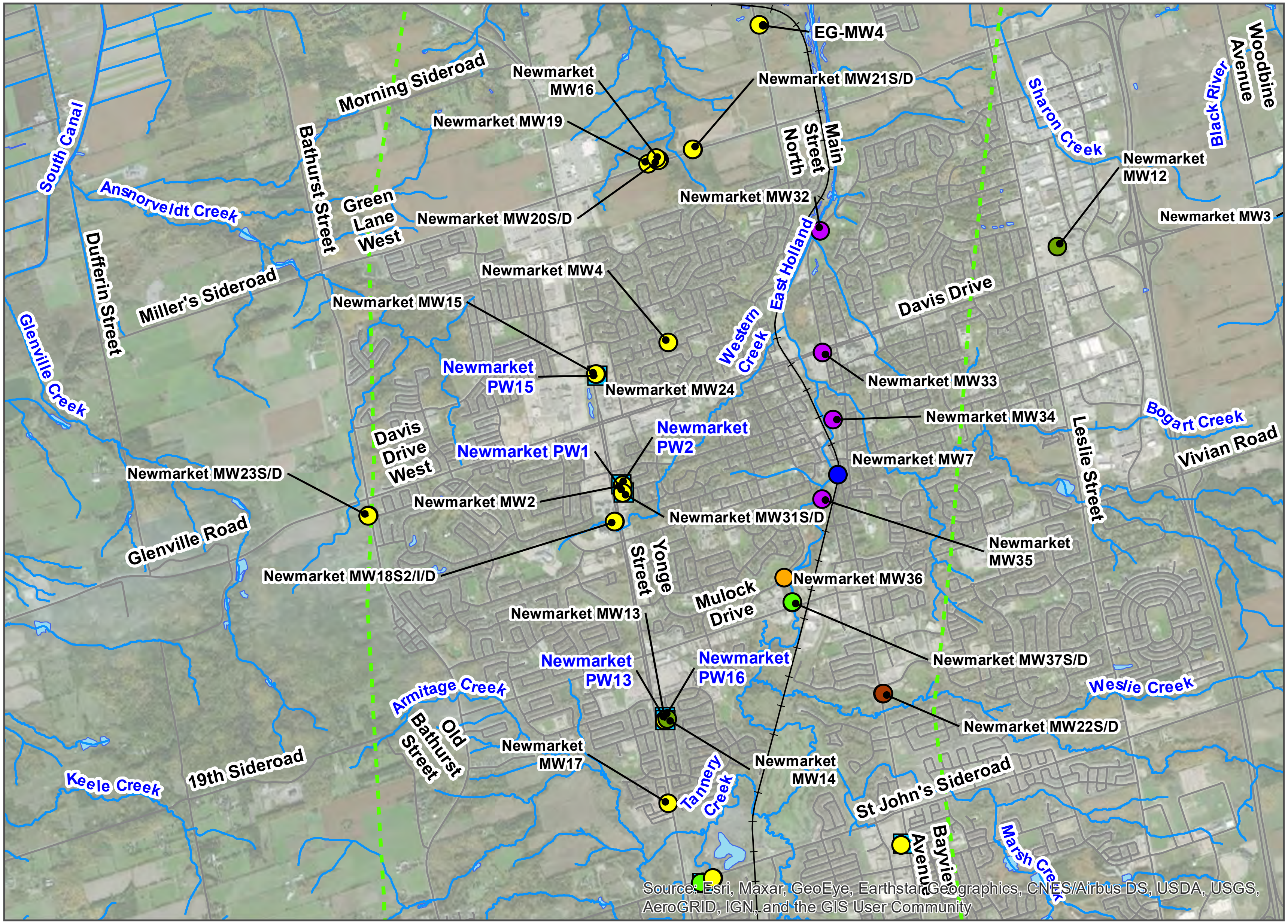
Note The YSA limits are approximated from Gerber et al. (2018).

Figure 7b - Groundwater Monitoring Network (Newmarket)



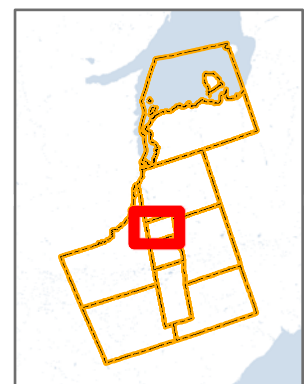
Legend

- Production Well
- Road
- Railway
- Watercourse
- Waterbody
- Yonge Street Aquifer (Approx. limits)

Monitoring Well

Interpreted Screened Unit

- Recent Deposits
- ORAC
- ORM Channel Silt / Newmarket Till
- ORM Channel Sand
- Upper Newmarket Till
- INS
- Lower Newmarket Till/YSA
- YSA
- Thorncliffe Formation
- Scarborough Formation



Meters
0 500 1,000

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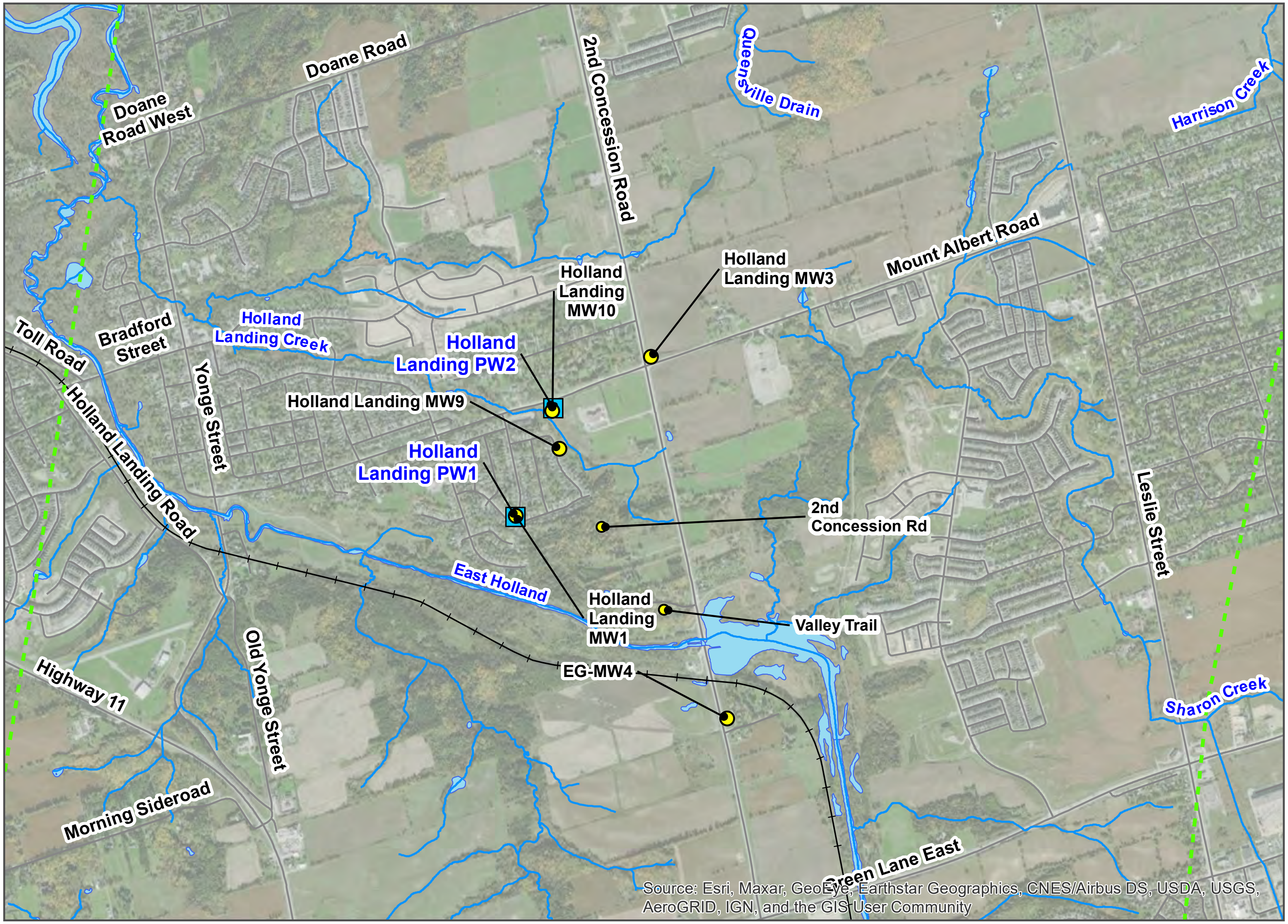
Note The YSA limits are approximated from Gerber et al. (2018).

Figure 7c - Groundwater Monitoring Network (Holland Landing)



Legend

Monitoring Well

Interpreted Screened Unit

- Recent Deposits
- ORAC
- ORM Channel Silt / Newmarket Till
- ORM Channel Sand
- Upper Newmarket Till
- INS
- Lower Newmarket Till/YSA
- YSA
- Thorncliffe Formation
- Scarborough Formation
- YSA Private Wells
- Production Well
- Yonge Street Aquifer (Approx. limits)
- Railway
- Watercourse
- Waterbody
- Road

Meters
0 250 500

York Region

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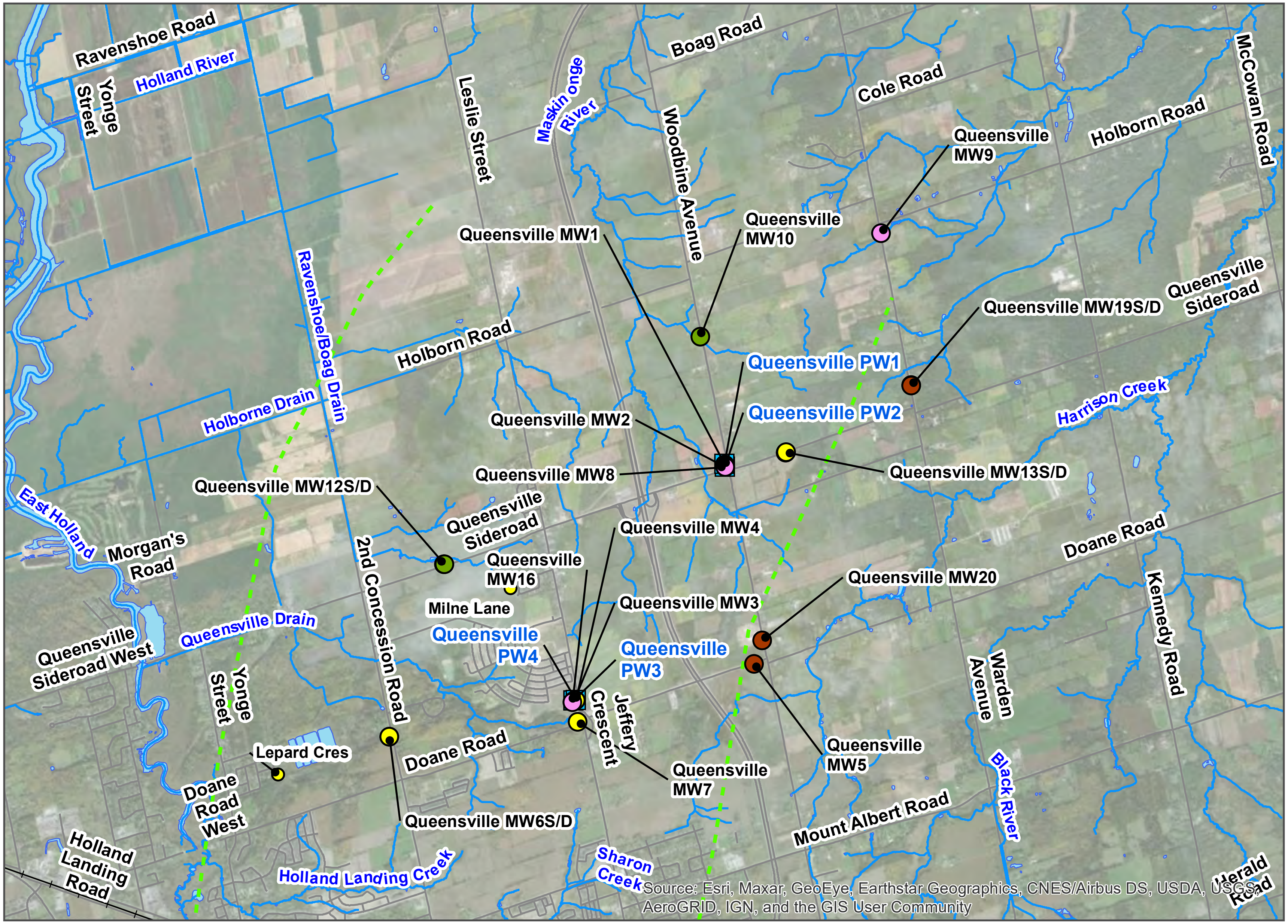
Note The YSA limits are approximated from Gerber et al. (2018).

Figure 7d - Groundwater Monitoring Network (Queensville)

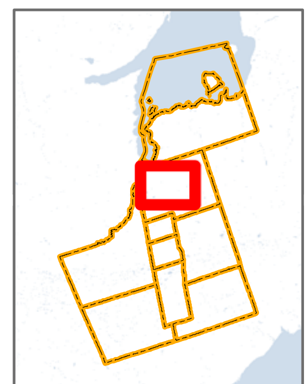


Legend

Monitoring Well

Interpreted Screened Unit

- Recent Deposits
- ORAC
- ORM Channel Silt / Newmarket Till
- ORM Channel Sand
- Upper Newmarket Till
- INS
- Lower Newmarket Till/YSA
- YSA
- Thorncliffe Formation
- Scarborough Formation
- YSA Private Wells
- Production Well
- Yonge Street Aquifer (Approx. limits)
- Railway
- Watercourse
- Waterbody
- Road



Meters
0 500 1,000

York Region

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Imagery:
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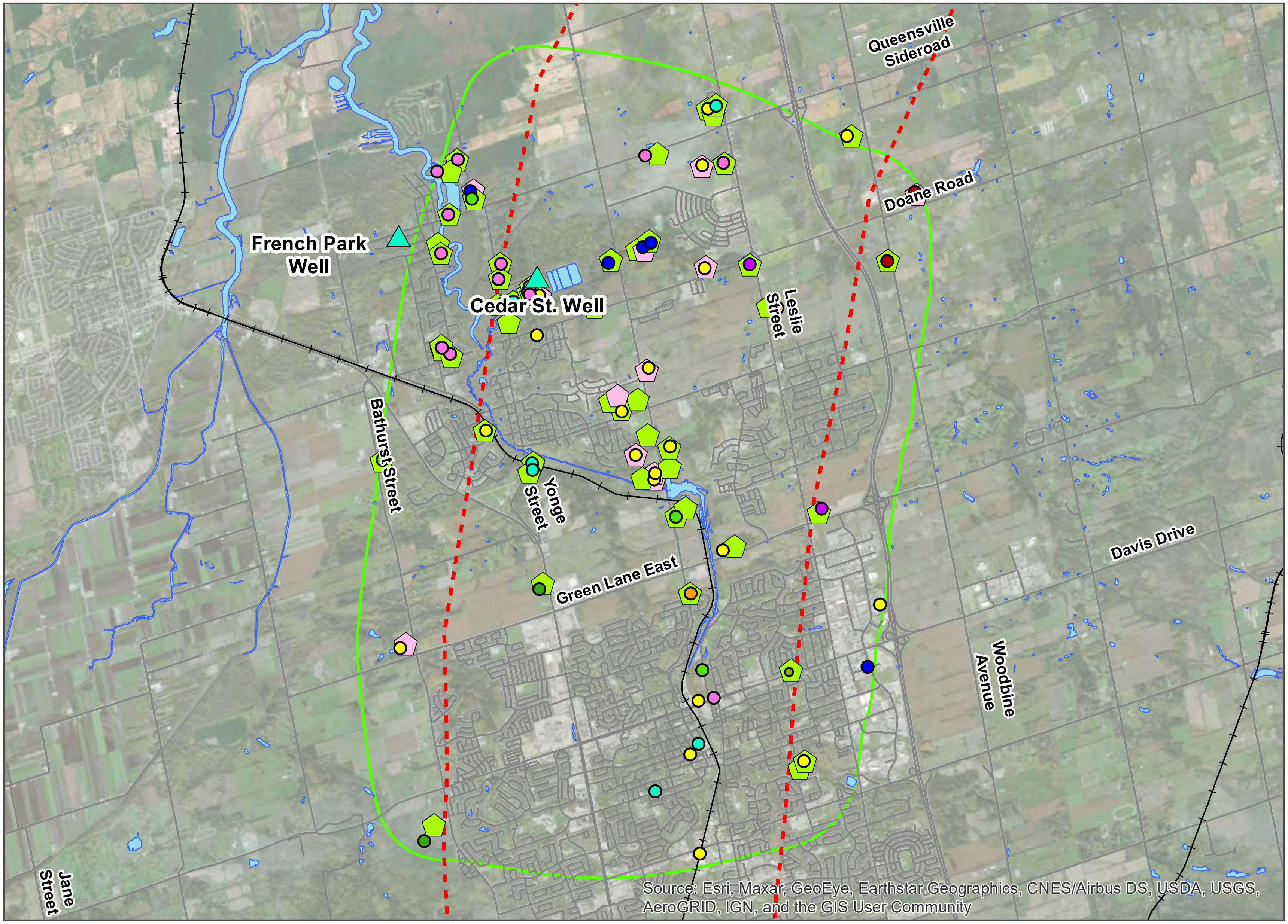
Note The YSA limits are approximated from Gerber et al. (2018).

Figure 8 - Private Well Survey Results



Legend

Interpred Screened Unit

- ORAC
- ORAC Channel
- ORM Channel
- ORAC Channel or Upper Newmarket Till
- Upper Newmarket Till
- Inter Newmarket Sediment
- Lower Newmarket Till
- YSA
- Thorncliffe Formation or YSA
- Scarborough Formation
- Bedrock

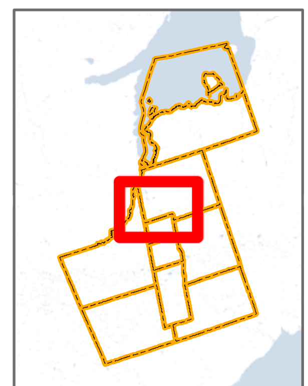
Site Visit

- No
- Yes

- Yonge Street Aquifer (Approx. limits)
- Waterbody
- Road
- Extent of Private Well Survey (York, 2021)

Notes: The Yonge Street Aquifer (YSA) limits are approximated from Gerber et al. (2018).

The ZOI is defined as the radius of influence around the pumping wells where the estimated drawdown is expected to be approximately 1 m.



Kilometers
0 1 2

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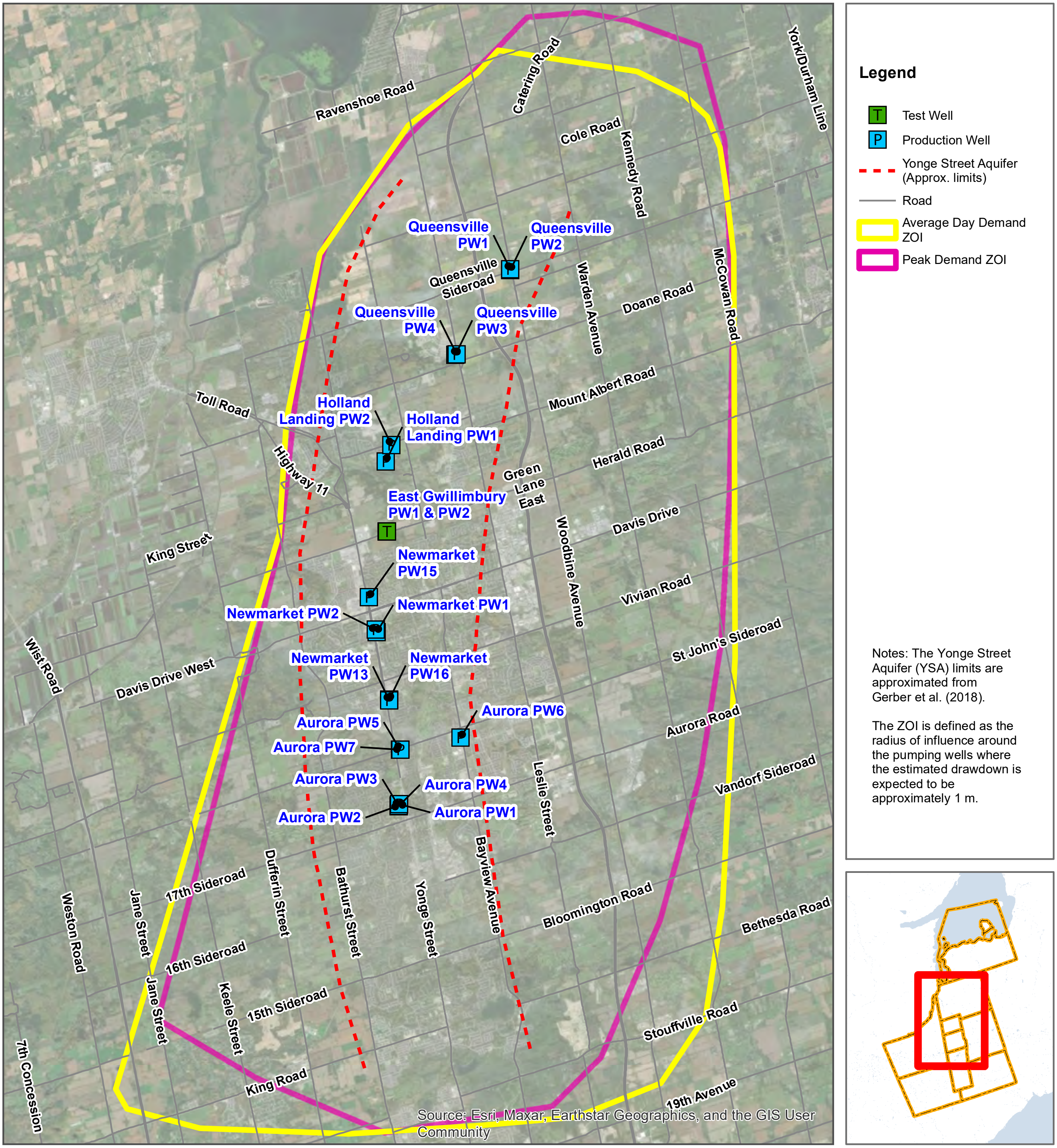
Figure 9 – Predicted Zone of Influence for the Peak Demand and Average Day Demand Scenarios



Kilometers
0 1 2

Green Lane Well Site Groundwater Resource Evaluation

180 Green Lane East,
East Gwillimbury, ON

York Region

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October 2022

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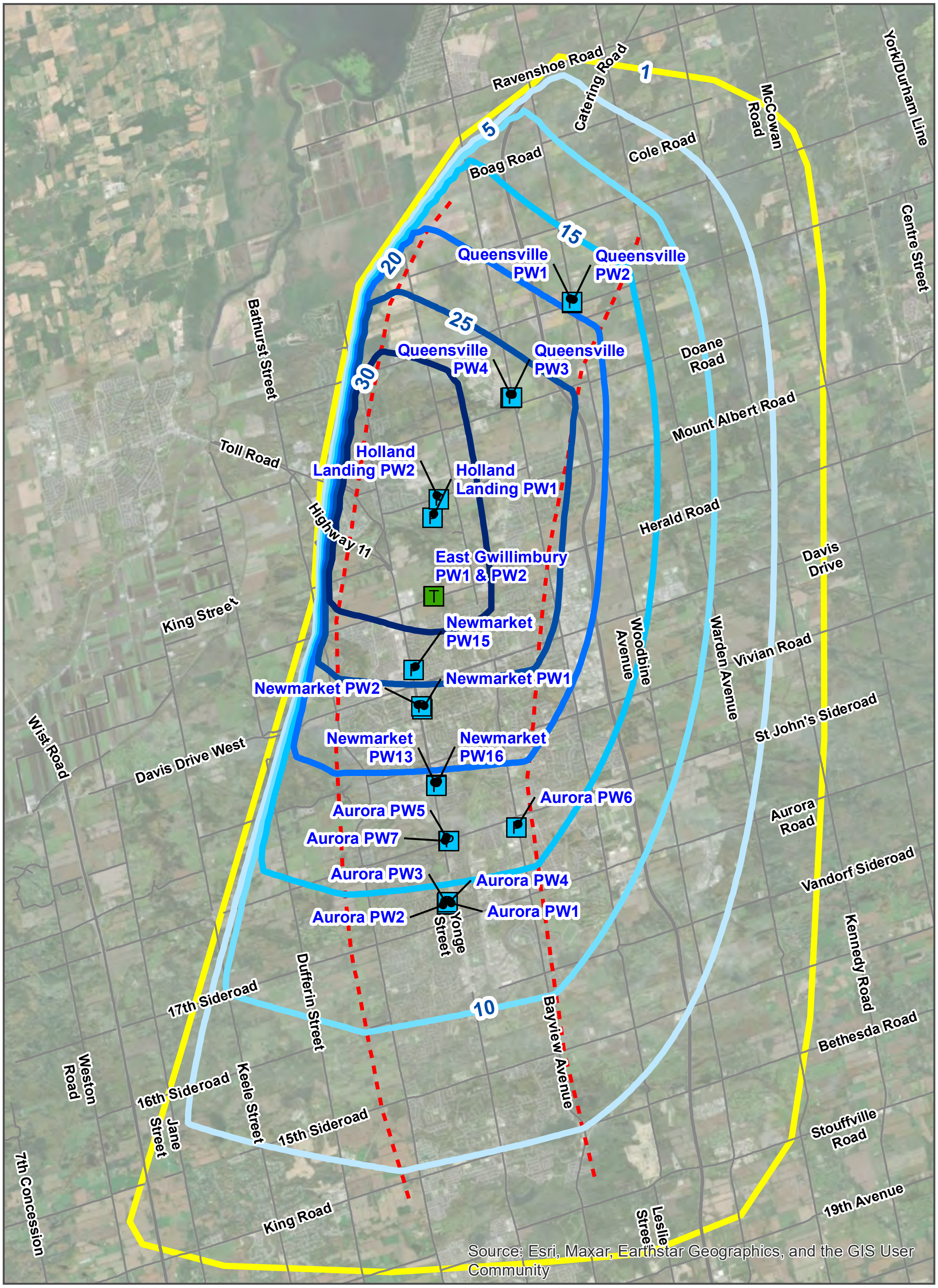
Figure 9a – Predicted Zone of Influence for the Average Day Demand Scenario with Simulated Drawdown Contours



Legend

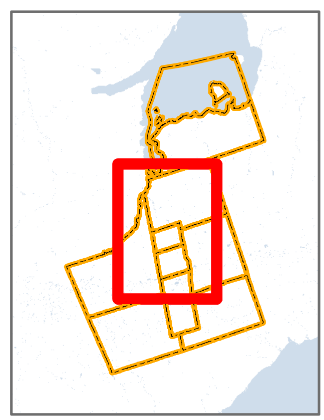
- T Test Well
- P Production Well

Simulated Average Day Demand Drawdown Contours (m)

- 5
- 10
- 15
- 20
- 25
- 30
- Yonge Street Aquifer (Approx. limits)
- Road
- Average Day Demand ZOI

Notes: The Yonge Street Aquifer (YSA) limits are approximated from Gerber et al. (2018).

The ZOI is defined as the radius of influence around the pumping wells where the estimated drawdown is expected to be approximately 1 m.



Kilometers 0 1 2

York Region

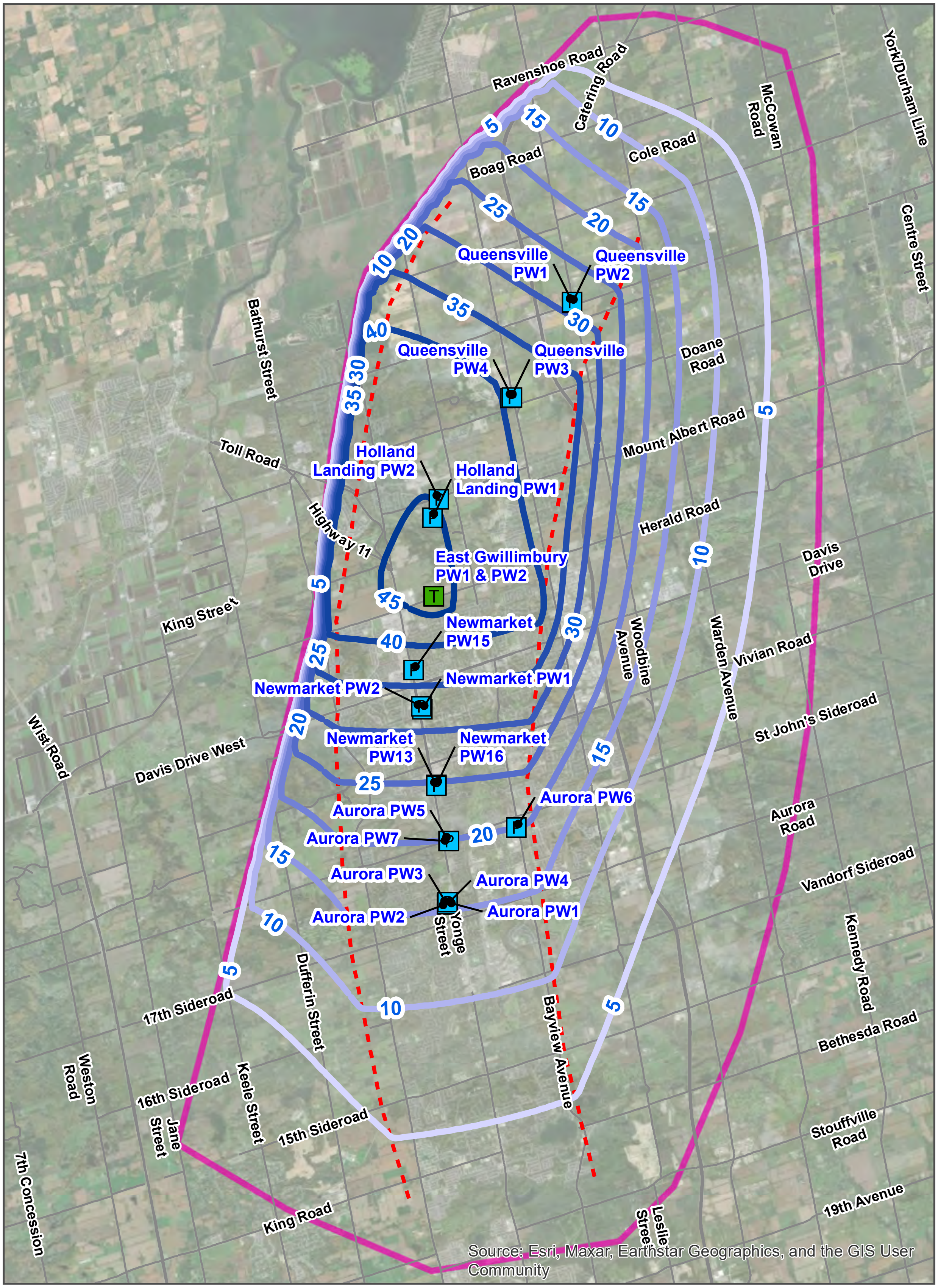
Green Lane Well Site Groundwater Resource Evaluation

180 Green Lane East,
East Gwillimbury, ON

Produced by:
The Regional Municipality of York
Water Resources, Environmental Services
October 2022

Gerber, R.E., Sharpe, D.R., Russel, H.A.J., Holysh, S., and E. Khazaei. 2018. Conceptual Hydrogeological Model of the Yonge Street Aquifer, South-Central Ontario: A Glaciofluvial Channel-Fan Setting. Canadian Journal of Earth Science. 55(7): 730-767. http://www.nrcresearchpress.com/doi/pdf/10.1139/cjes-2017-0172.

Figure 9b – Predicted Zone of Influence for the Peak Demand Scenario with Simulated Drawdown Contours



Legend

- T Test Well
- P Production Well

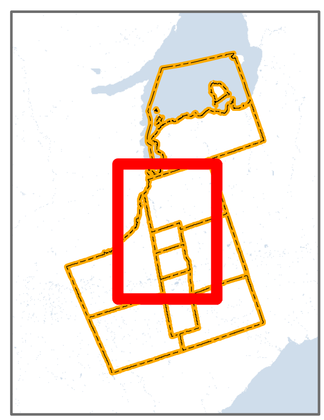
Simulated Peak Demand Drawdown Contours (m)

- 5
- 10
- 15
- 20
- 25
- 30
- 35
- 40
- 45

- Yonge Street Aquifer (Approx. limits)
- Road
- Peak Demand ZOI

Notes: The Yonge Street Aquifer (YSA) limits are approximated from Gerber et al. (2018).

The ZOI is defined as the radius of influence around the pumping wells where the estimated drawdown is expected to be approximately 1 m.



Kilometers
0 1 2

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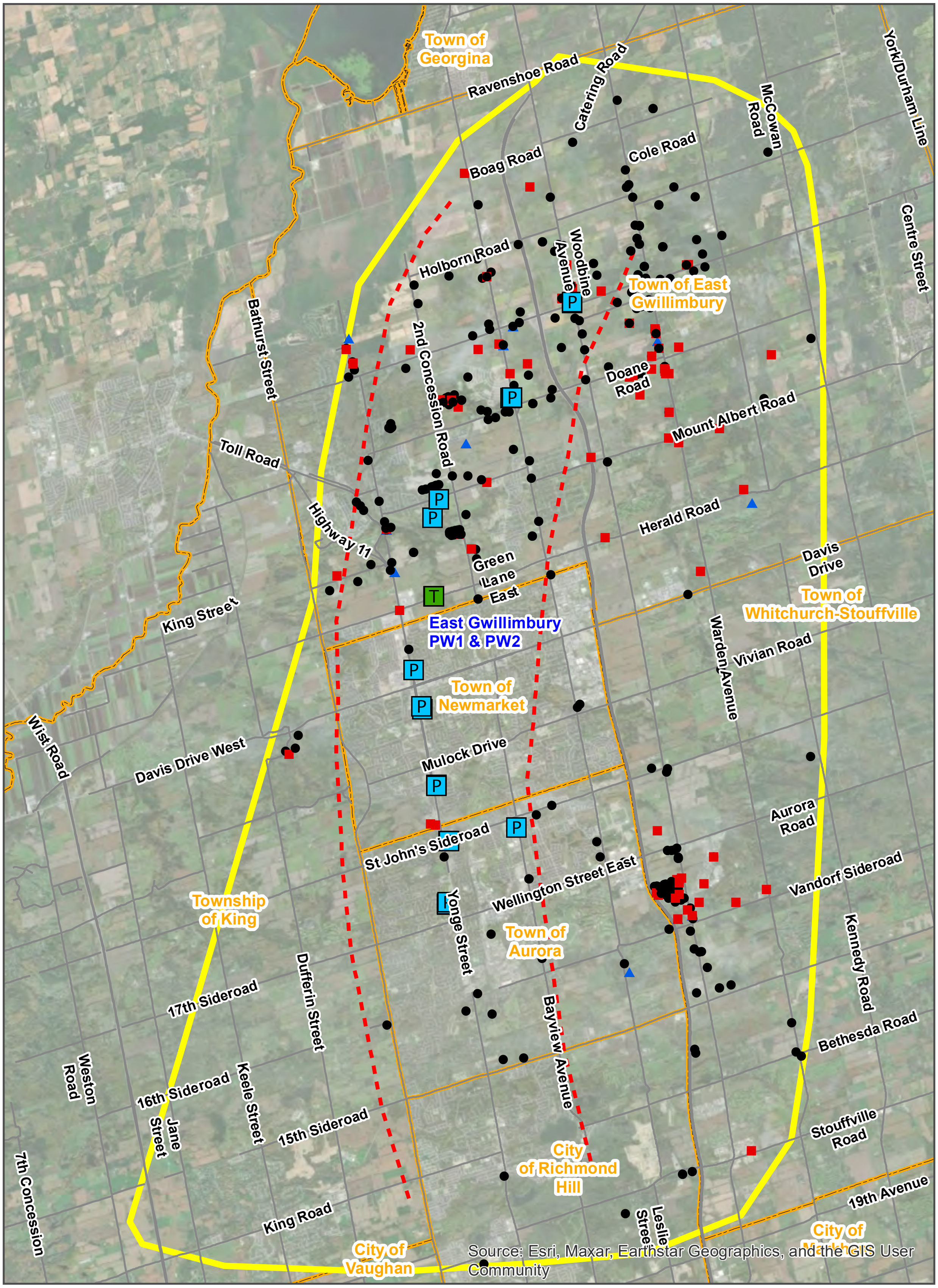
Figure 10 - Well Interference Complaints (1990 to 2020) within the Average Day Demand ZOI



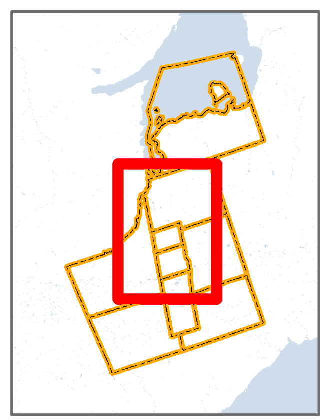
Legend

- T Test Well
- P Production Well
- Well Interference Complaint Year
  - 1999
  - 2005
  - 1990-1998, 2000-2004, 2006-2020
- Yonge Street Aquifer (Approx. limits)
- Road
- Average Day Demand ZOI
- Municipal Boundary

Notes: The Yonge Street Aquifer (YSA) limits are approximated from Gerber et al. (2018).

Well complaints pertain to "Out of Water" issues.

The ZOI is defined as the radius of influence around the pumping wells where the estimated drawdown is expected to be approximately 1 m.



Kilometers 0 1 2

York Region

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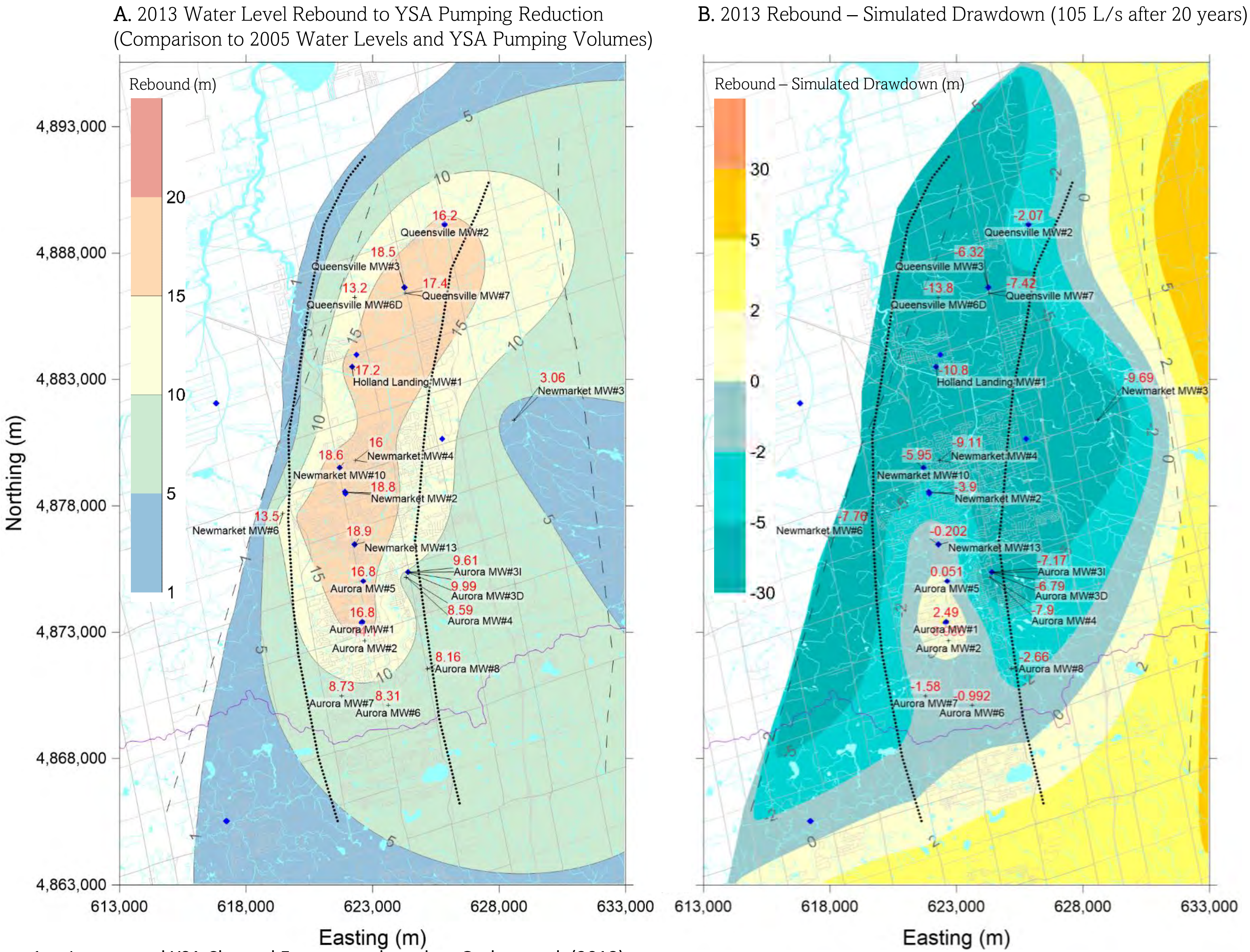

1. Interpreted YSA Channel Extents are based on Gerber et al. (2018).
2. Interpreted Extents of Groundwater Response to YSA Pumping Reduction are based on Gerber et al. (2018).
3. Refer to **Table 4-2** for annual daily average water levels from 2005 and 2013.
4. Simulated drawdown is based on the simulated hydraulic heads from the Average Day Demand Scenario (**Section 4.1.2**).

Figure 11 Impact Assessment Area of Focus Refinement

Legend

- York Region Water Supply Well
- York Region Monitoring Well
- Road
- Watercourse
- Waterbody
- Watershed Divide
- Interpreted YSA Channel Extents
- Interpreted Extents of Groundwater Response to YSA Pumping Reduction

York Region

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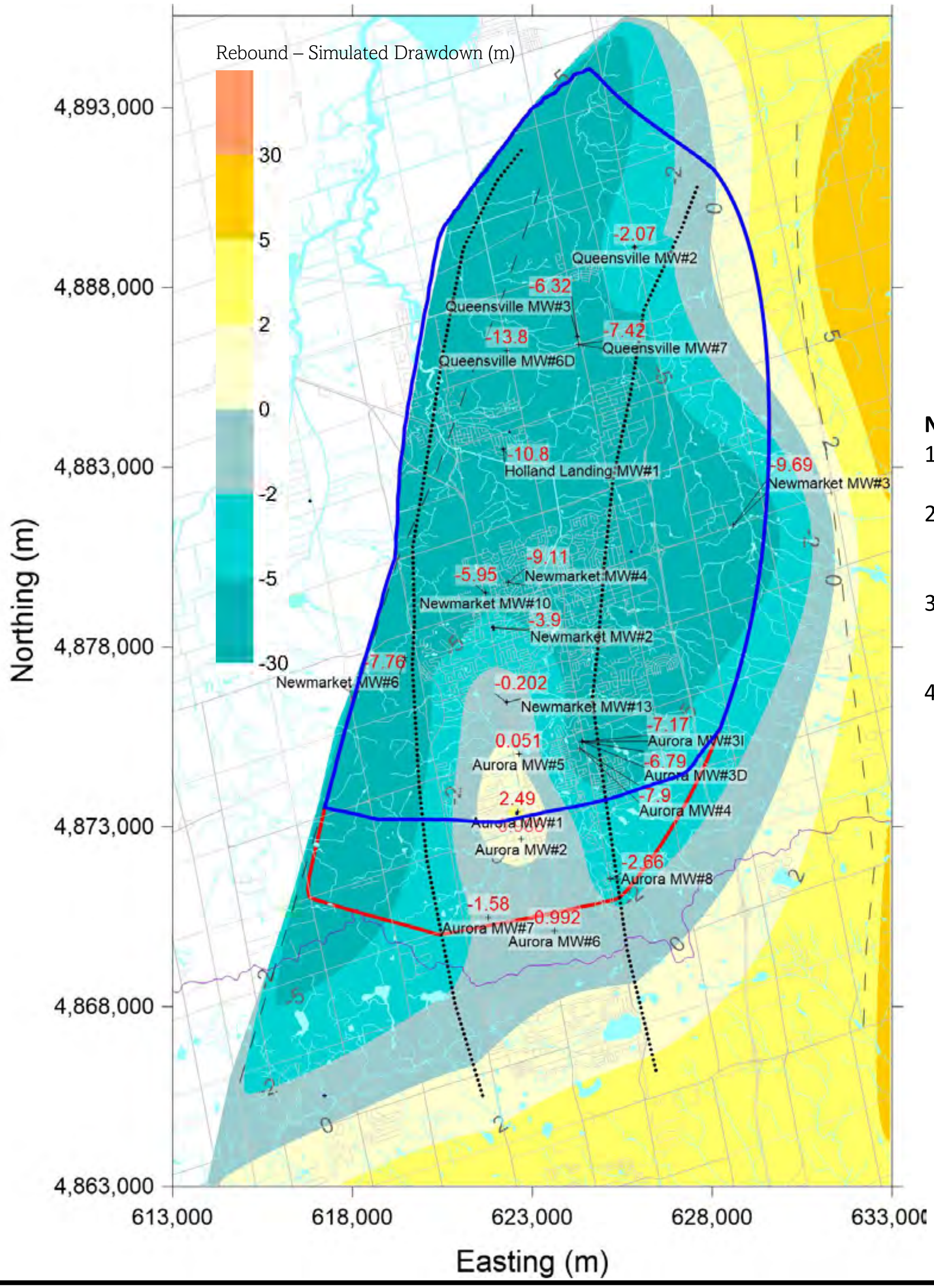
Imagery:
See York.ca for disclaimer information.

N



Note:

1. Interpreted YSA Channel Extents are based on Gerber et al. (2018).
2. Interpreted Extents of Groundwater Response to YSA Pumping Reduction are based on Gerber et al. (2018).
3. Refer to **Table 4-2** for annual daily average water levels from 2005 and 2013 (used to determine the 'rebound').
4. Simulated drawdown is based on the simulated hydraulic heads from the Average Day Demand Scenario (**Section 4.1.2**).

Figure 12 Impact Assessment Area of Focus

Legend

- York Region Water Supply Well
- York Region Monitoring Well
- Road
- Watercourse
- Waterbody
- Watershed Divide
- Interpreted YSA Channel Extents
- Interpreted Extents of Groundwater Response to YSA Pumping Reduction
- Impact Assessment Area of Focus
- Average Day Demand 10 m Simulated Drawdown

York Region

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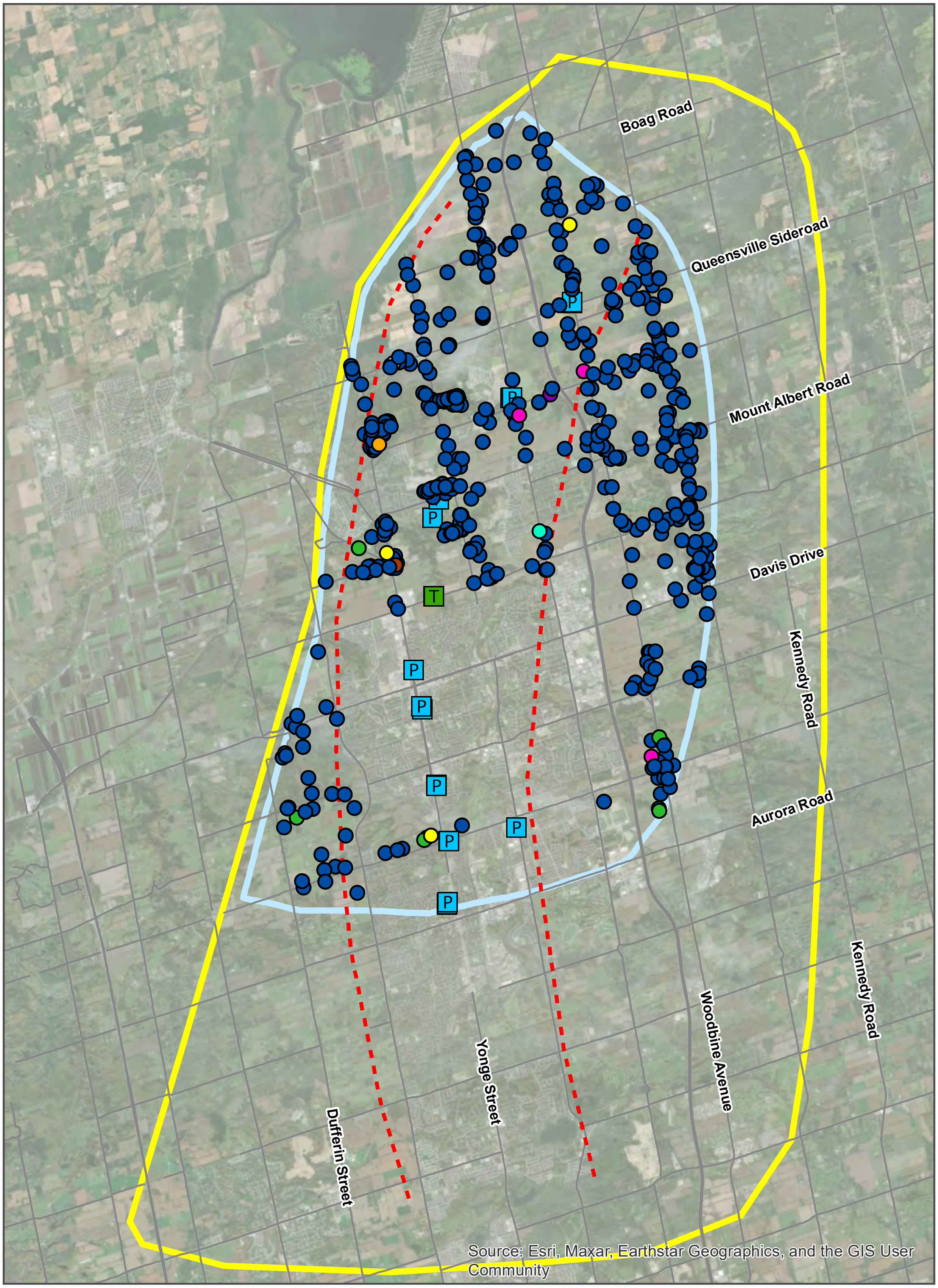
Imagery:
See York.ca for disclaimer information.

N

Figure 13a - Active Private Water Supply Well Users Within the Impact Assessment Area of Focus



Legend

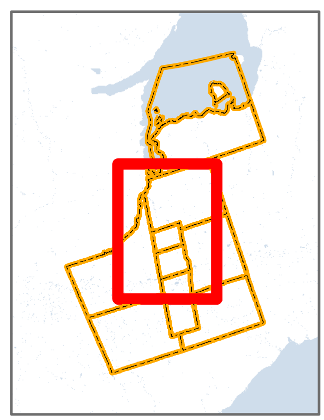
Active Private Water Supply Users

- Water Supply - Campgrounds or Trailer Park
- Water Supply - Communal
- Water Supply - Domestic
- Water Supply - Hotel
- Water Supply - Nursery
- Water Supply - Other (Commercial)
- Water Supply - Other (Industrial)
- Water Supply - Other (Water Supply)
- Water Supply - School
- Unknown
- T Test Well
- P Production Well
- Yonge Street Aquifer (Approx. limits)
- Road
- Average Day Demand ZOI
- Impact Assessment Area of Focus

Notes: The Yonge Street Aquifer (YSA) limits are approximated from Gerber et al. (2018).

Well records were sourced from the ORMGP (2002).

Well record filtering process is described in Section 4.2.1 and summarized in Table 4-3



Kilometers 0 1 2

York Region

Green Lane Well Site Groundwater Resource Evaluation

180 Green Lane East, East Gwillimbury, ON

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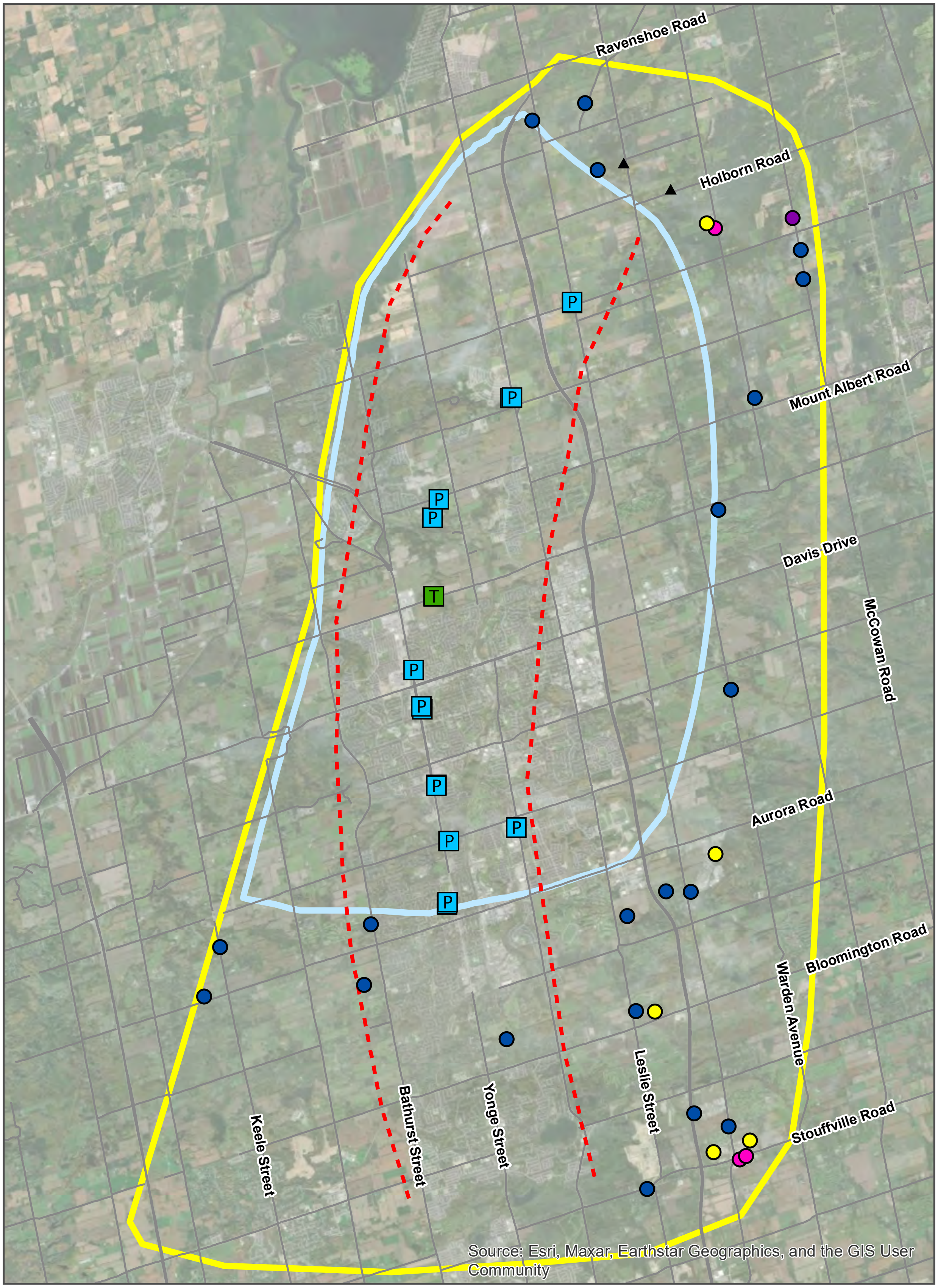
Figure 13b - Recently Drilled Active Private Water Supply Well Users Outside the Impact Assessment Area of Focus



Legend

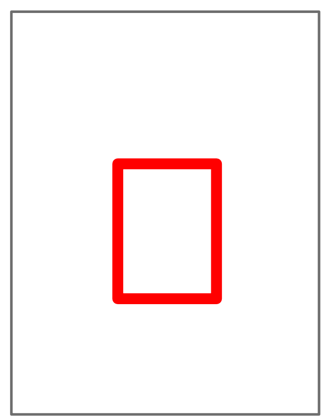
Active Private Water Supply Users

- Water Supply - Domestic
- Water Supply - Golf Course - Irrigation, Club House, etc
- Water Supply - Other (Commercial)
- Water Supply - Other (Industrial)
- Water Supply - Other (Water Supply)
- Unknown
- T Test Well
- P Production Well
- Yonge Street Aquifer (Approx. limits)
- Road
- Average Day Demand ZOI
- Impact Assessment Area of Focus

Notes: The Yonge Street Aquifer (YSA) limits are approximated from Gerber et al. (2018).

Well records were sourced from the ORMGP (2002).

Well record filtering process is described in Section 4.2.1 and summarized in Table 4-4



Kilometers
0 1 2

York Region

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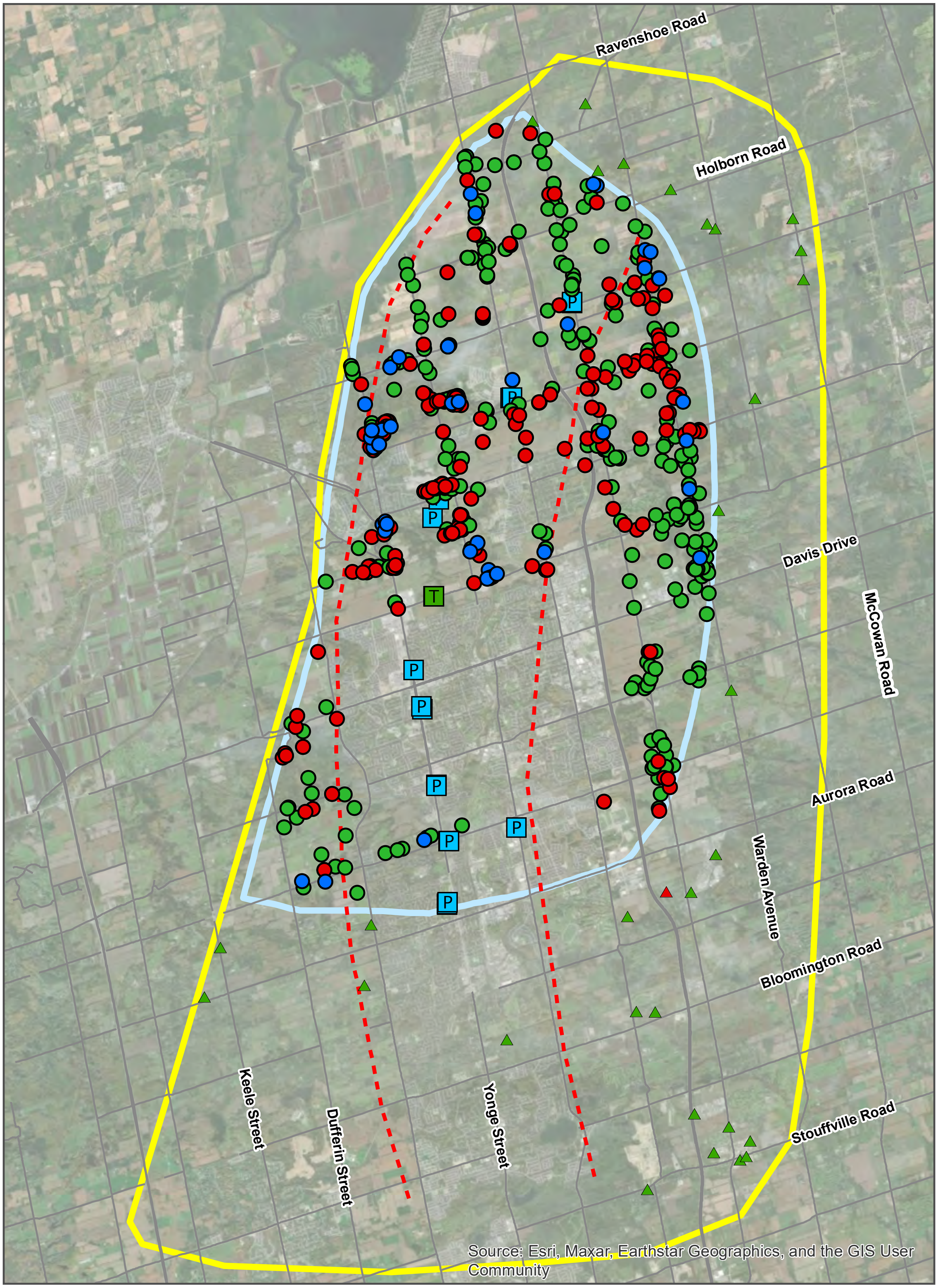
Figure 14a - Potentially Impacted Active Water Supply Users



Legend

Potential Impact for Active Water Supply Users in the Impact Assessment Area of Focus

- Yes
- No
- Unassigned

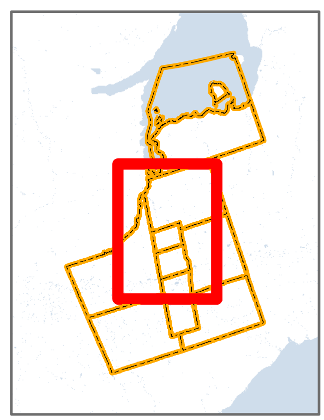
Potential Impact for Recently Drilled Active Water Supply Users Outside the Impact Assessment Area of Focus

- Yes
- No
- T Test Well
- P Production Well
- Yonge Street Aquifer (Approx. limits)
- Road
- Average Day Demand ZOI
- Impact Assessment Area of Focus

Notes: The Yonge Street Aquifer (YSA) limits are approximated from Gerber et al. (2018).

Well records were sourced from the ORMGP (2002).

Impact Assessment methodology are proided in Section 4.2.1.1 and results summarized in Table 4-5



Kilometers
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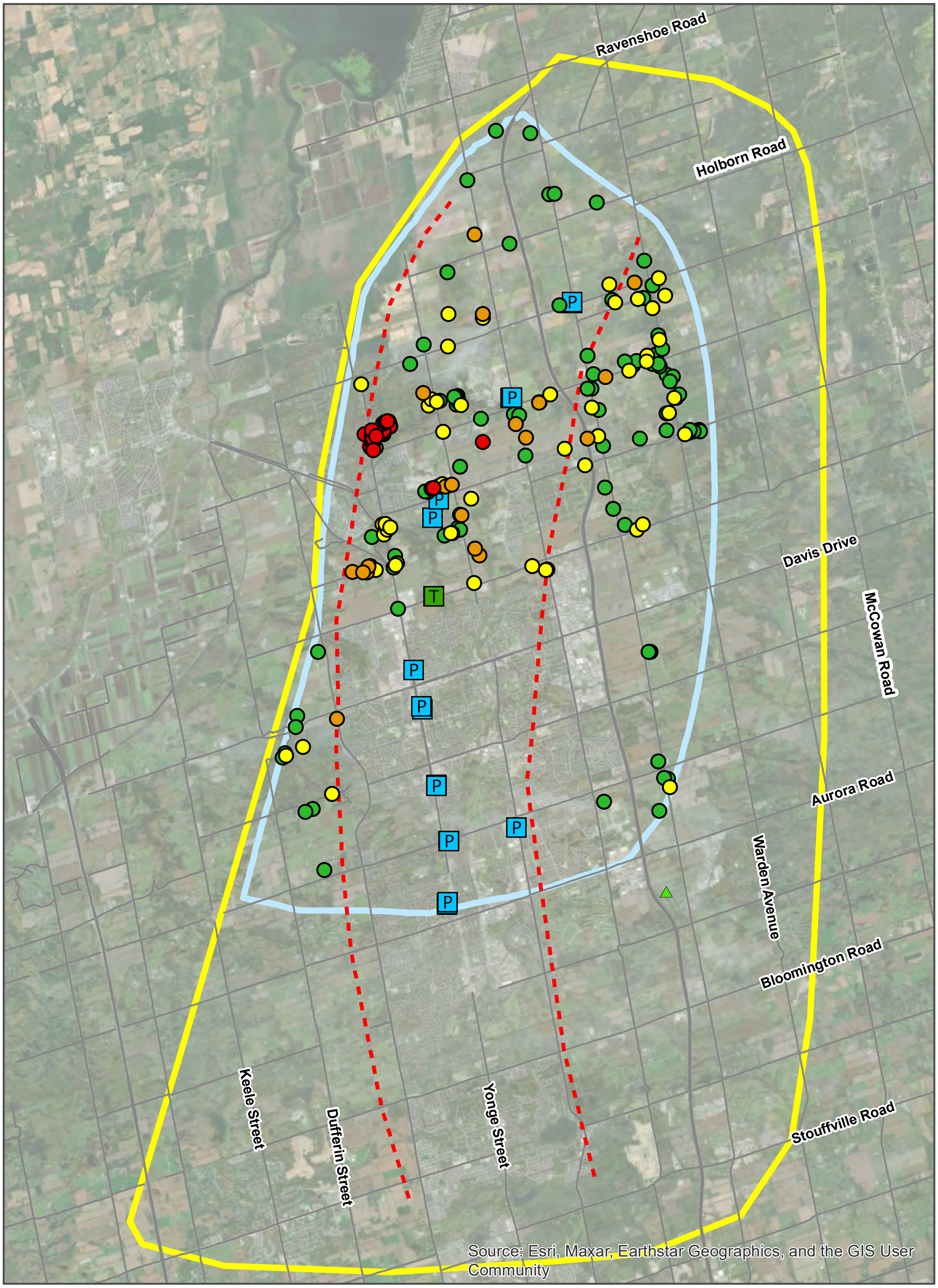
Figure 14b - Potentially Impacted Locations Binned by Drawdown Deficit



Legend

Drawdown Deficit for Active Water Supply Users in the Impact Assessment Area of Focus

- Less than 0 to 5 m
- Less than 5 to 10 m
- Less than 10 to 20 m
- Less than 20 m

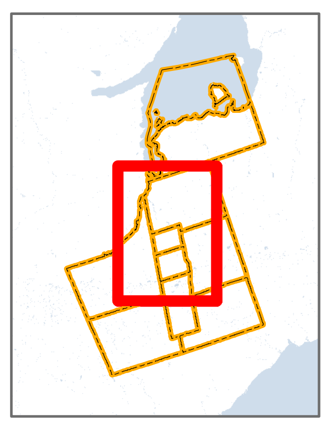
Drawdown Deficit for Active Water Supply Users Outside the Impact Assessment Area of Focus

- Less than 0 to 5 m
- T Test Well
- P Production Well
- Yonge Street Aquifer (Approx. limits)
- Road
- Average Day Demand ZOI
- Impact Assessment Area of Focus

Notes: The Yonge Street Aquifer (YSA) limits are approximated from Gerber et al. (2018).

Well records were sourced from the ORMGP (2002).

Drawdown Deficit is summarized in Table 4-6.



Kilometers
0 1 2

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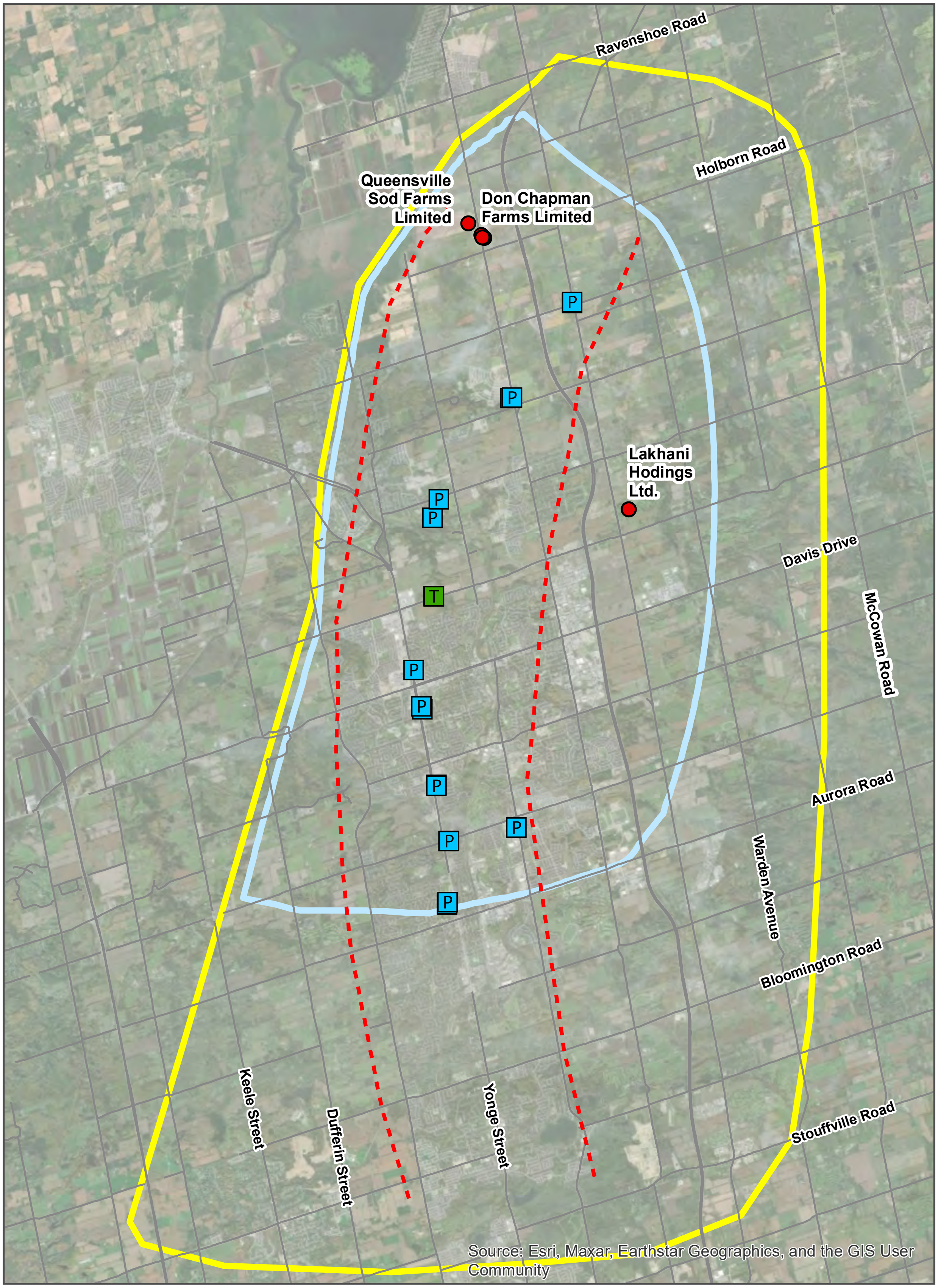
Figure 15a - Active Non-Municipal PTTW Groundwater User Locations Within the Impact Assessment Area of Focus



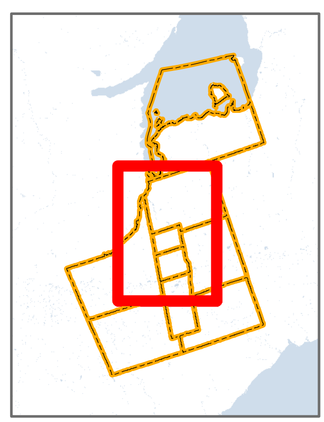
Legend

- Non-Municipal PTTW Users in the Impact Assessment Area of Focus
- T Test Well
- P Production Well
- Yonge Street Aquifer (Approx. limits)
- Road
- Average Day Demand ZOI
- Impact Assessment Area of Focus

Notes: The Yonge Street Aquifer (YSA) limits are approximated from Gerber et al. (2018).

PTTW users were sourced from the MECP (2022).

The Non-Municipal PTTW user filtering process is described in Section 4.2.2 and summarized in Table 4-7



Kilometers
0 1 2

Green Lane Well Site Groundwater Resource Evaluation

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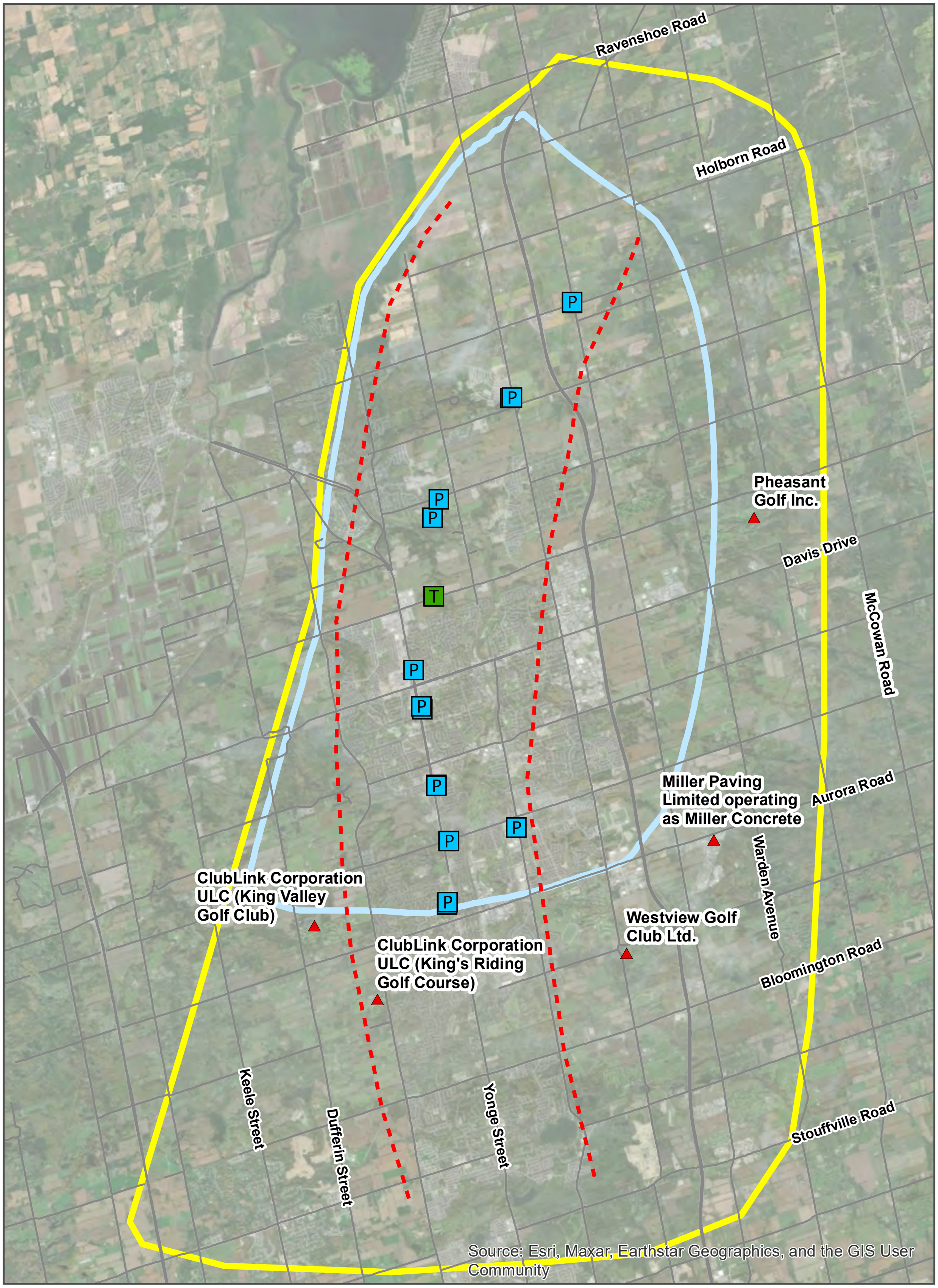
Figure 15b - Recently Drilled Active Non-Municipal PTTW Groundwater User Locations Outside the Impact Assessment Area of Focus



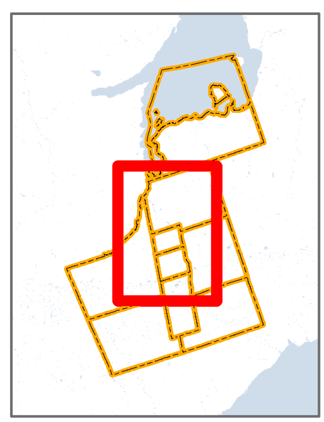
Legend

- Non-Municipal PTTW Users Outside the Impact Assessment Area of Focus
- T Test Well
- P Production Well
- Yonge Street Aquifer (Approx. limits)
- Road
- Average Day Demand ZOI
- Impact Assessment Area of Focus

Notes: The Yonge Street Aquifer (YSA) limits are approximated from Gerber et al. (2018).

PTTW users were sourced from the MECP (2022).

The Non-Municipal PTTW user filtering process is described in Section 4.2.2 and summarized in Table 4-8.



Kilometers
0 1 2

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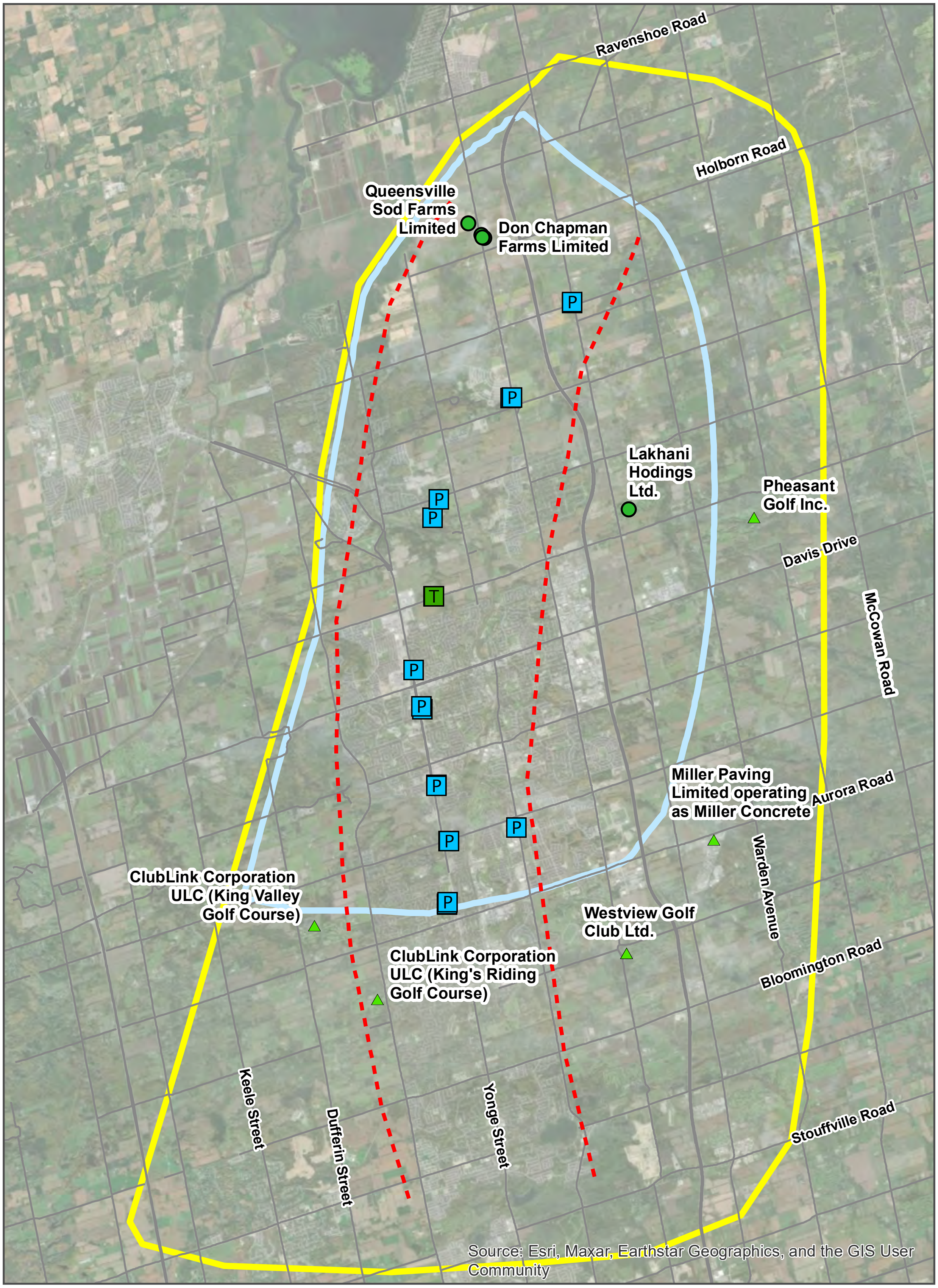
Figure 16 - Potentially Impacted Active Non-Municipal PTTW Groundwater Users



Legend

Potential Impact for Active PTTW Groundwater Users in the Impact Assessment Area of Focus

- No

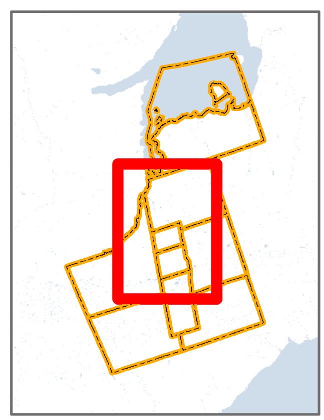
Potential Impact for Recently Drilled Active Non-Municipal PTTW Groundwater Users Outside the Impact Assessment Area of Focus

- No
- Test Well
- Production Well
- Yonge Street Aquifer (Approx. limits)
- Road
- Average Day Demand ZOI
- Impact Assessment Area of Focus

Notes: The Yonge Street Aquifer (YSA) limits are approximated from Gerber et al. (2018).

PTTW users were sourced from the MECP (2022).

Impact assessment methodology is described in Section 4.2.2.1 and results are summarized in Table 4-9.



Kilometers
0 1 2

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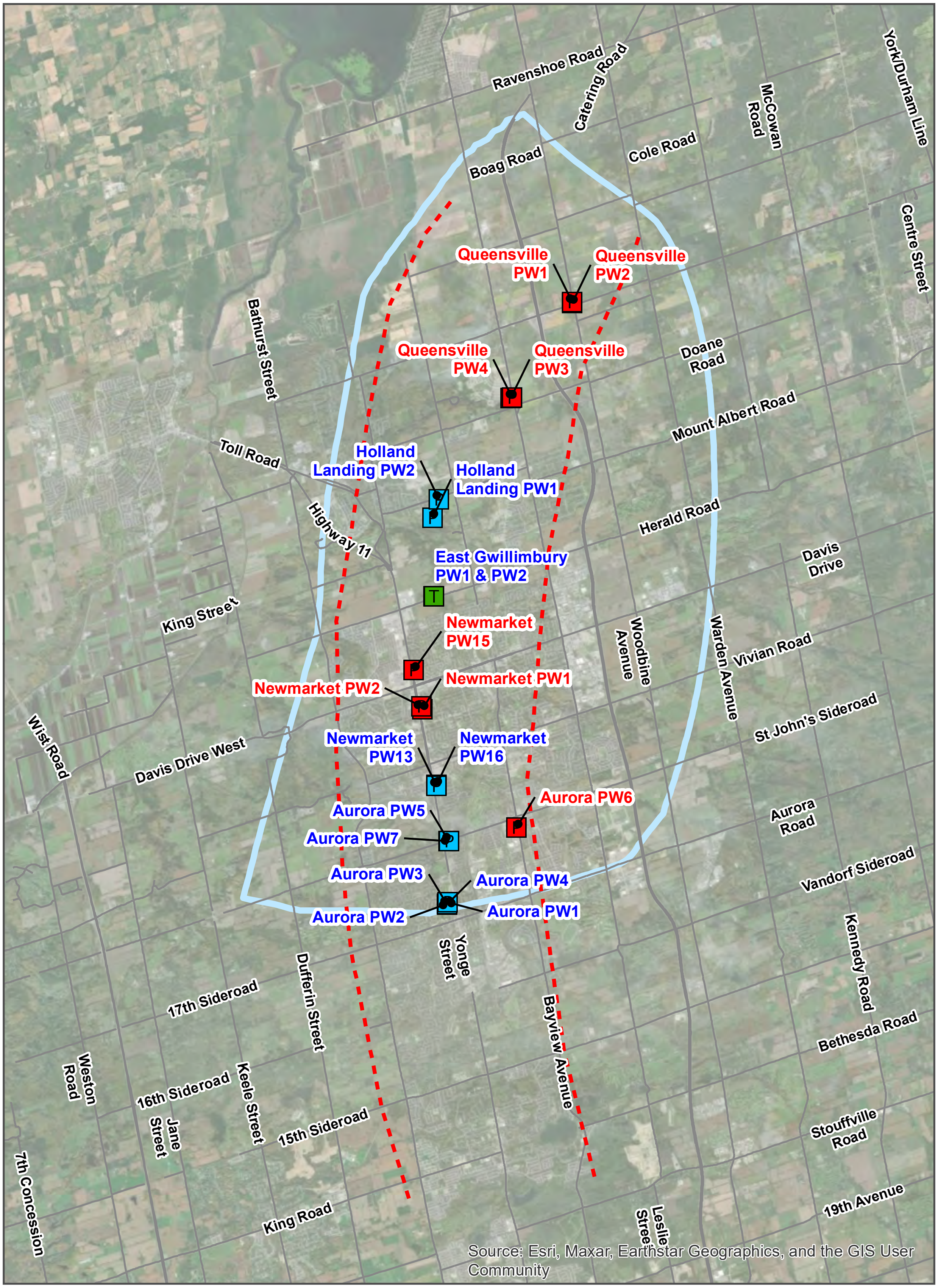
Figure 17 - Potential Impact to Municipal PTTW Groundwater Users



Legend

- T Test Well
- P Production Wells
- P Potentially Impacted Production Wells based on the Safe Available Drawdown
- Yonge Street Aquifer (Approx. limits)
- Road
- Impact Assessment Area of Focus

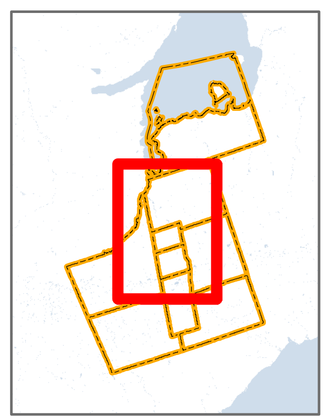
Notes: The Yonge Street Aquifer (YSA) limits are approximated from Gerber et al. (2018).

Impact assessment methodology is described in Section 4.2.3.1 and results are summarized in Table 4-10.

Production Wells symbolized with a red square may be negatively impacted due to prolonged Site operations, based on the Safe Available Drawdown.

Newmarket PW1, as well as Queensville PW3 and PW4 may not be negatively impacted should their pump settings be lowered.

Aurora PW6 and Newmarket PW15 are likely to be decommissioned after the commissioning of EG-PW1 and EG-PW2.



Kilometers
0 1 2

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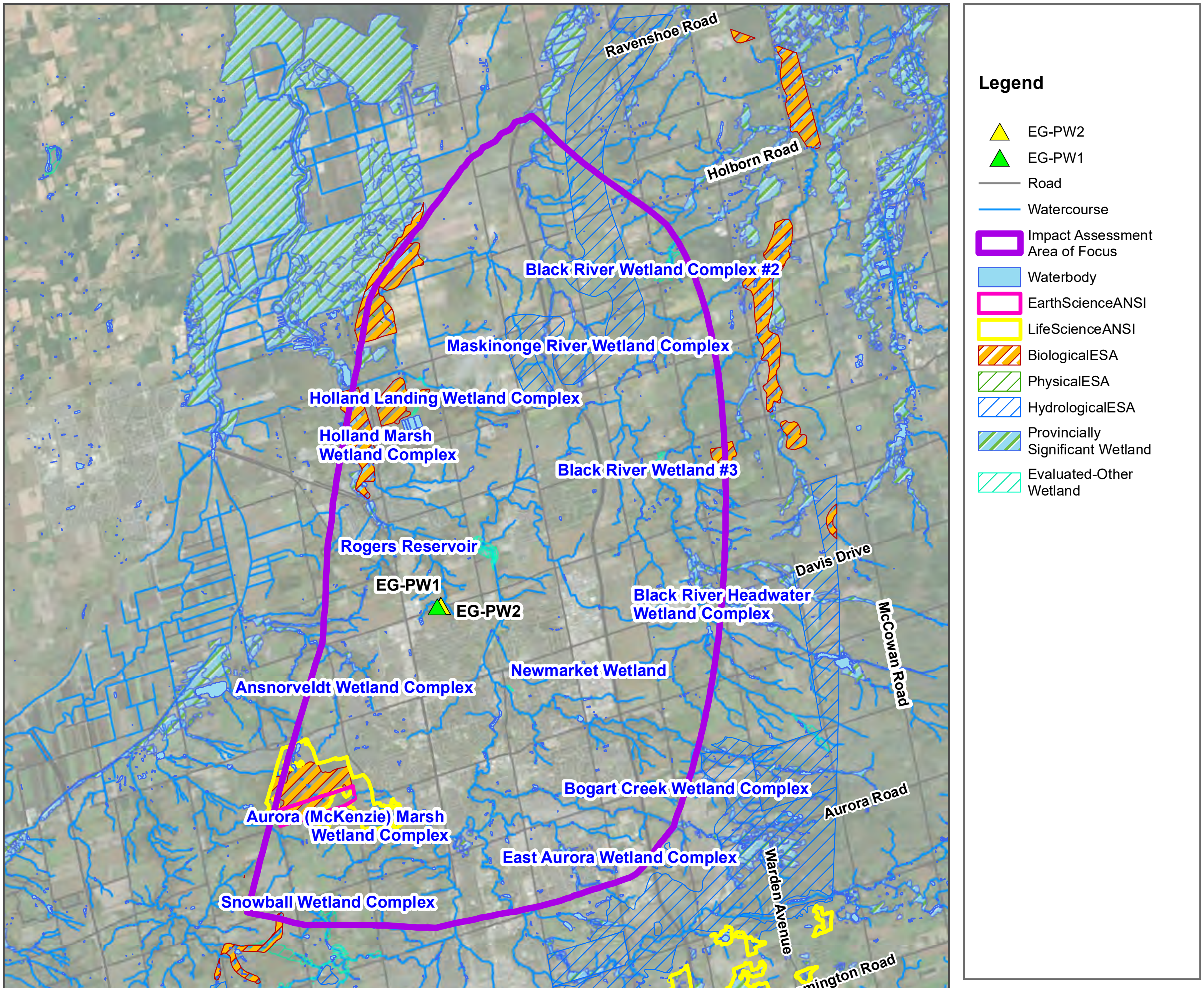
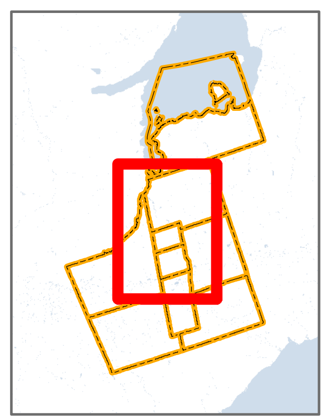
Figure 18 – Surface Water and Other Natural Features within the Impact Assessment Area of Focus





0 1 2 Kilometers

York Region

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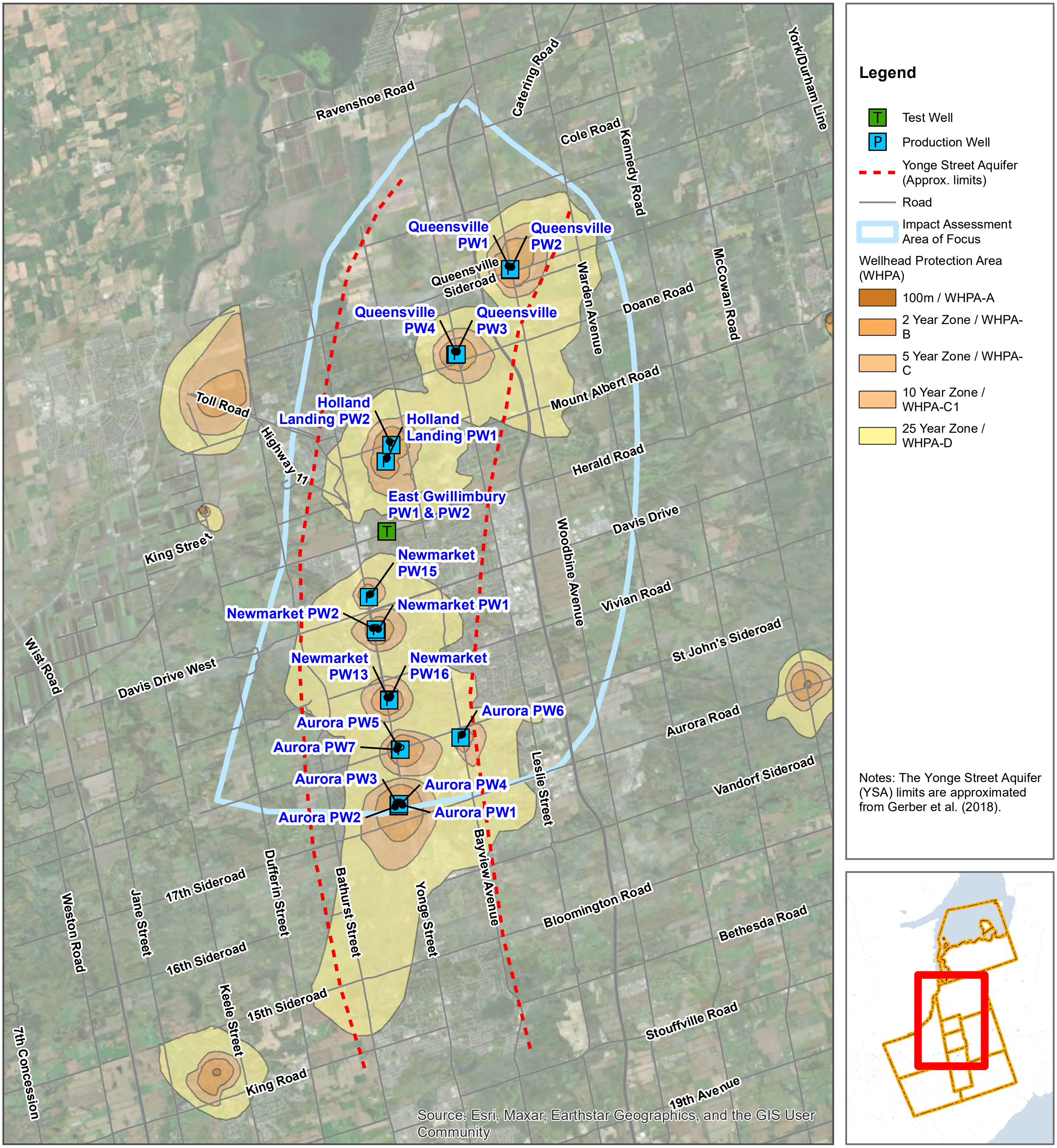
Figure 19 - Well Head Protection Areas for YSA Production Wells within the Impact Assessment Area of Focus



Kilometers
0 1 2

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