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Nobleton Supply Well Groundwater Exploration Program - Site Selection Report

Palmer Project #
1704602

Prepared For
Black and Veatch

March 19, 2021

74 Berkeley Street, Toronto, ON M5A 2W7 Tel: 647-795-8153 | www.pecg.ca

March 19, 2021

Zhifei Hu, P.Eng.
Black and Veatch
50 Minthorn Blvd., Suite 501
Markham, ON
L3T 7X8

Dear Zhifei:

Re: Nobleton Supply Well Groundwater Exploration Program - Site Selection Report
Project #: 1704602

Palmer is pleased to provide Black & Veatch with the attached report describing the results of our Alternative Well Site Selection Report to support the Schedule C Class Environmental Assessment (EA) for Water and Wastewater Servicing in the Community of Nobleton, Ontario.

Thank you for the opportunity to work with our team on this interesting and challenging project. If you have any questions or require further information, please don't hesitate to contact our office. This report is subject to the Statement of Limitations provided at the end of this report.

Yours truly,
Palmer Environmental Consulting Group Inc.

Jason Cole, M.Sc., P.Geo.
Principal, Senior Hydrogeologist

Executive Summary

Palmer was retained by Black & Veatch (B&V) and the Regional Municipality of York (York Region) to complete a Groundwater Exploration Study to support the preparation of a Schedule C Class Environmental Assessment (EA) for Water and Wastewater Servicing in the Community of Nobleton, Ontario. Nobleton is currently supplied by three production wells (NOB-PW2, NOB-PW3, and NOB-PW5), which are permitted under the Ministry of the Environment, Conservation, and Parks (MECP) Permit To Take Water (PTTW) Number 2015-BK2KW2.

This Groundwater Exploration Study was completed to identify a new municipal well site to provide additional groundwater supply capacity of 35 L/s for the community of Nobleton in order to accommodate the anticipated population growth by 2041. This is completed through a series of steps as outlined in York Region's Environmental Services Department Capital Planning and Delivery Branch, Design Guidelines Section 18 – Groundwater Development and Wellhouse Design.

To meet this anticipated water demand, eight (8) potential target sites were identified within the EA study area (Well Sites A to H), and were narrowed down to the two most preferred locations based on weighted criteria related to groundwater resources (65%), engineering and logistics (25%), and policy and regulations (10%). Based on the results of the long-list alternative site selection assessment process, Well Site F and Well Site H were the highest scoring locations and were carried forward into the evaluation of the short-listed target sites where detailed hydrogeological testing was completed at each location to ultimately select a preferred well site location. Well Site F is found on the west side of Hwy 27, 400 m south of Oliver Emerson Ave. Well Site H is found at the existing well site for NOB-PW5.

Well Site F Summary

At Well Site F, a 6" diameter test well, MW9, was installed to 109 m depth, targeting the deep confined Scarborough Aquifer Formation. The depth of the well screen was selected to range from 96.0 – 109.0 mbgs and consists of a 3.01 m of #40 slot and 1.22 m of #50 slot Johnson Wire Wrap Well Screen. In accordance with the York Region Section 18 process, a short duration step-drawdown pumping test was completed under a MECP Category 3 PTTW # 1560-BNVNAB to determine aquifer transmissivity, storage and preliminary interference/boundary condition effects.

A door-to-door water well survey was carried out within a 500 m radius of Well Site F consistent with the anticipated radius of influence (ROI) for the pumping test. As the majority of the homes within the ROI are serviced by municipal water, only 3 actives wells were identified, all of which obtained potable water from the Thorncliffe Formation Aquifer.

During the step-drawdown test, MW9 was pumped at 13 L/s for 45 minutes, 18 L/s for 45 minutes, and 23 L/s for 2 hours. A total drawdown of 4.4 m was observed in MW9 at the end of the step-drawdown test. A maximum drawdown of 0.09 m was observed in the existing monitoring well network suggesting that interference effects between MW9 and the existing water supply wells is minimal. However, due to the short duration of the step-drawdown test and the large distance between MW9 and the existing monitoring well network, additional longer-duration hydraulic testing would be required to fully quantify interference effects.

Based on the results of the step-drawdown pumping test, the transmissivity of the Scarborough Aquifer at Well Site F is calculated to be 802 m^2/day with a Storativity coefficient of 3.33 x 10^{-4}. Groundwater quality at MW9 was generally good but exceeded ODWS for Mn, Fe and hardness.

To assess the potential for a large-diameter production well at Well Site F to achieve the target production rate of 35 L/s, both a forward solution analytical model and the specific capacity were used to provide an estimate. Based on a specific capacity of 5.36 L/s/m at a pumping rate of 35 L/s, the drawdown is estimated to be 8.3 m. Using a Forward Solution analysis model it was calculated that a 12" diameter production well, with similar screen design as MW9, installed at the Well Site F location and pumping at a rate of 35 L/s for 72-hours, would result in a drawdown of approximately 10.9 m and a radius of influence to 1 m drawdown of 850 m. Projecting the forward solution model out to 10 years of production would result in 13 m of drawdown. As the total available drawdown in MW9 is 69.9 m, and the predicted drawdown represents approximately 19% of the available drawdown with interference effect expected to be minimal, Well Site F is considered to have sufficient sustainable yield to support additional production capacity of 35 L/s.

Well Site H Summary

For Well Site H, the existing 6" diameter test well MW6 that was used to assess the water supply potential at NOB-PW5 by MMM (2012), was used to complete hydraulic testing to determine if Well Site H could support a second production well. MW6 is screened to a depth of 103 m and completed in the deep confined Scarborough Formation Aquifer. Due to the potential for significant well interference effects with the existing production well on site (NOB-PW5), both a short duration step-drawdown pumping test and a long-duration combined pumping test for both MW6 and NOB-PW5 was completed. A Category 3 PTTW # 3274-BK2GW2 was obtained from the MECP for this testing.

A door-to-door water well survey was carried out within an 800 m radius of Well Site H consistent with the anticipated ROI for the pumping test. A total of 2 homes were identified within the ROI as relying on potable water wells, the majority of which are completed in the Thorncliffe Aquifer. The well at 12645 Highway 7 was monitored during the hydraulic testing at Site F. No interference effects were observed at this well during the step-drawdown testing and no reports of impacts from local residents were received.

During the step test, MW6 was pumped at rates of 13 L/s, 18 L/s, and 23 L/s for 1 hour each. Following the step-drawdown test, the pumping rate at MW6 was set to 23 L/s and was pumped for 24 hours without interference from NOB-PW5 (i.e., NOB-PW5 was off). After 24 hours, NOB-PW5 was turned on to a rate of 26 L/s and both MW6 and NOB-PW5 were pumped simultaneously for an additional 48 hours to observe interference effects between the two wells.

At the end of the first 23 hours of pumping, the total drawdown at MW6 was found to be 4.32 m and drawdown within the existing monitoring well network ranged from 0.45 to 1.9 m. At the end of the 72-hour combined pumping test, the drawdown at MW6 was 8.94 m in MW6 and the drawdown at NOB-PW5 was 9.03. Water levels in the monitoring well network ranged from 3.44 to 6.59 m with a drawdown of 6.03 m observed at MW9.

Transmissivity and storativity values at Well Site H ranged from 661 to 1,246 m^2/day (1,082 m^2/day average) with storativity coefficients ranging between 2.20 x 10^{-4} to 3.79 x 10^{-3}. These values are similar to the values obtained by MMM (2012) during the initial site selection process for NOB-PW5. During the testing groundwater samples were collected and exceed ODWS for Mn, Fe, and Hardness.

During the first 23 hours of pumping at MW6 (when NOB-PW5 was off), approximately 0.8 m of interference was observed. Following the 72-hour combined pumping test, approximately 3.9 m of drawdown at MW6 was interpreted to be caused by interference effects from pumping at NOB-PW5.

Interference effects were also assessed between the combined pumping at Site H and the other municipal supply wells, NOB-PW2 and NOB-PW3. The combined drawdown pumping test resulted in approximately 4.1 m of interference between MW6/ NOB-PW5 and NOB-PW2, and 3.2 m of interference MW6/ NOB-PW5 and NOB-PW3. This magnitude of interference is not considered significant given the large available drawdown of 74.5 m and 56.7 m in wells NOB-PW2 and NOB-PW3, respectively. Should Well Site H be selected as the preferred alternative location, additional testing and assessment of interference effects between the existing production well network would be required.

To assess the potential for a large-diameter production well at Well Site H to achieve the target production rate of 35 L/s, both a forward solution analytical model and the specific capacity were used to provide an estimate. Based on a specific capacity of 6.71 L/s/m at a pumping rate of 35 L/s, the drawdown is estimated to be 6.3 m. Using a Forward Solution analysis model, it is estimated that continuously pumping a future 12” diameter well, with similar screen design as MW6, installed at the Well Site H location at a rate of 35 L/s for 72-hours, would result in a drawdown of approximately 9.6 m and a radius of influence to 1 m drawdown of 1200 m. Projecting the forward solution model out to 10 years of production would result in 15.2 m of drawdown.

As the total available drawdown in MW6 is 73.9 m, and the predicted drawdown represents approximately 20% of the available drawdown with interference effect expected to be minimal, Well Site H is considered to have sufficient sustainable yield to support additional production capacity of 35 L/s without adverse interference effects with the existing well network.

Conclusion

Based on the hydrogeological investigations completed as part of the groundwater site selection process for the community of Nobleton, Well Site H is considered to be the preferred location for a new large-diameter groundwater production well to provide 35 L/s of new water supply capacity. The short-listed alternative sites, Site H and F, have very similar aquifer properties and both are expected to be able to support production of 35 L/s. Site F has a higher potential to impact private water wells than Site H and also would require a significant change to the Source Water Protection Planning mapping for Nobleton. Site H is already a municipal well site that is owned by York Region, making the overall cost to install new well infrastructure less at Site H. While the risk of interference effects is higher with Site H, through the detailed hydraulic testing completed, the magnitude of interference effects was not found to be significant relative to the large amount of available drawdown in all the existing production wells.

Distribution List

File No.	RevNo	# Copy	PDF	Issued to	Date	Issue/Revision Description
1704602	0		Yes	Black & Veatch	November 23, 2018	Initial Draft Report
1704602	0		Yes	York Region	November 23, 2018	Initial Draft Report
1704602	1		Yes	Black & Veatch	May 31, 2019	Address comments from Black & Veatch and York Region
1704602	1		Yes	York Region	May 31, 2019	Address comments from Black & Veatch and York Region
1704602	2		Yes	Black & Veatch	July 15, 2019	Address comment from York Region and finalize
1704602	2		Yes	York Region	July 15, 2019	Address comment from York Region and finalize
1704602	3		Yes	Black & Veatch	August 19, 2019	Revise modelling results of Sunnybrook Aquitard
1704602	3		Yes	York Region	August 19, 2019	Revise modelling results of Sunnybrook Aquitard
1704602	4		Yes	Black & Veatch	August 28, 2020	Update to include hydrogeological field program and selection of the preferred site
1704602	5		Yes	Black & Veatch	February 1, 2021	Address comments from York Region and finalize

Revision Log

File No.	RevNo	Prepared By	Reviewed By	Authorized By	Issue/Revision Description
1704602	0	Corinne Hanlon	Jason Cole	Jason Cole	Initial Draft Report
1704602	1	Corinne Hanlon	Jason Cole	Jason Cole	Address comments from Black & Veatch and York Region
1704602	2	Corinne Hanlon	Jason Cole	Jason Cole	Address comment from York Region and finalize
1704602	3	Corinne Hanlon	Jason Cole	Jason Cole	Revise modelling results of Sunnybrook Aquitard
1704602	4	Adrian Lo	Jason Cole	Jason Cole	Updated to include hydrogeological field program and selection of the preferred site
1704602	5	Adrian Lo	Jason Cole	Jason Cole	Address comments from York Region and finalize

Signatures

This report was prepared and reviewed by the undersigned:

Prepared By:

Bethany Gruber, B.Sc., G.I.T.
Environmental Scientist (Hydrogeology)

Reviewed and Approved By:

PROFESSIONAL GEOSCIENTIST
R. JASON COLE
PRACTISING MEMBER
1902
ONTARIO

Jason Cole, M.Sc., P.Geo.
Principal, Senior Hydrogeologist

Table of Contents

List of Figures

List of Tables

List of Appendices

1. Introduction

1.1 Background

Palmer was retained by Black & Veatch (B&V) and the Regional Municipality of York (York Region) to complete a Groundwater Exploration Study to support the preparation of a Schedule C Class Environmental Assessment (EA) for Water and Wastewater Servicing in the Community of Nobleton, Ontario. This Groundwater Exploration Study was completed to identify a new municipal well site to provide additional groundwater supply capacity for the community of Nobleton in order to accommodate the anticipated population growth, estimated by York Region and the Township of King for the purpose of this EA, to be approximately to 10,800 persons by 2041.

The community of Nobleton (Nobleton) is centered around the intersection of King Road (Regional Road 11) and Regional Road 27 (formerly Highway 27). The study area for this project extends outside the boundaries of the developed area of Nobleton, and is generally bounded by 15th Sideroad to the north, King Vaughan Road to the south, and 8th Concession Road to the East. The west boundary follows Concession Road 10 from 15th Sideroad to King Road, then follows Concession Road 11 to the south boundary. The total study area covers approximately 18 km^2 (**Figure 1**).

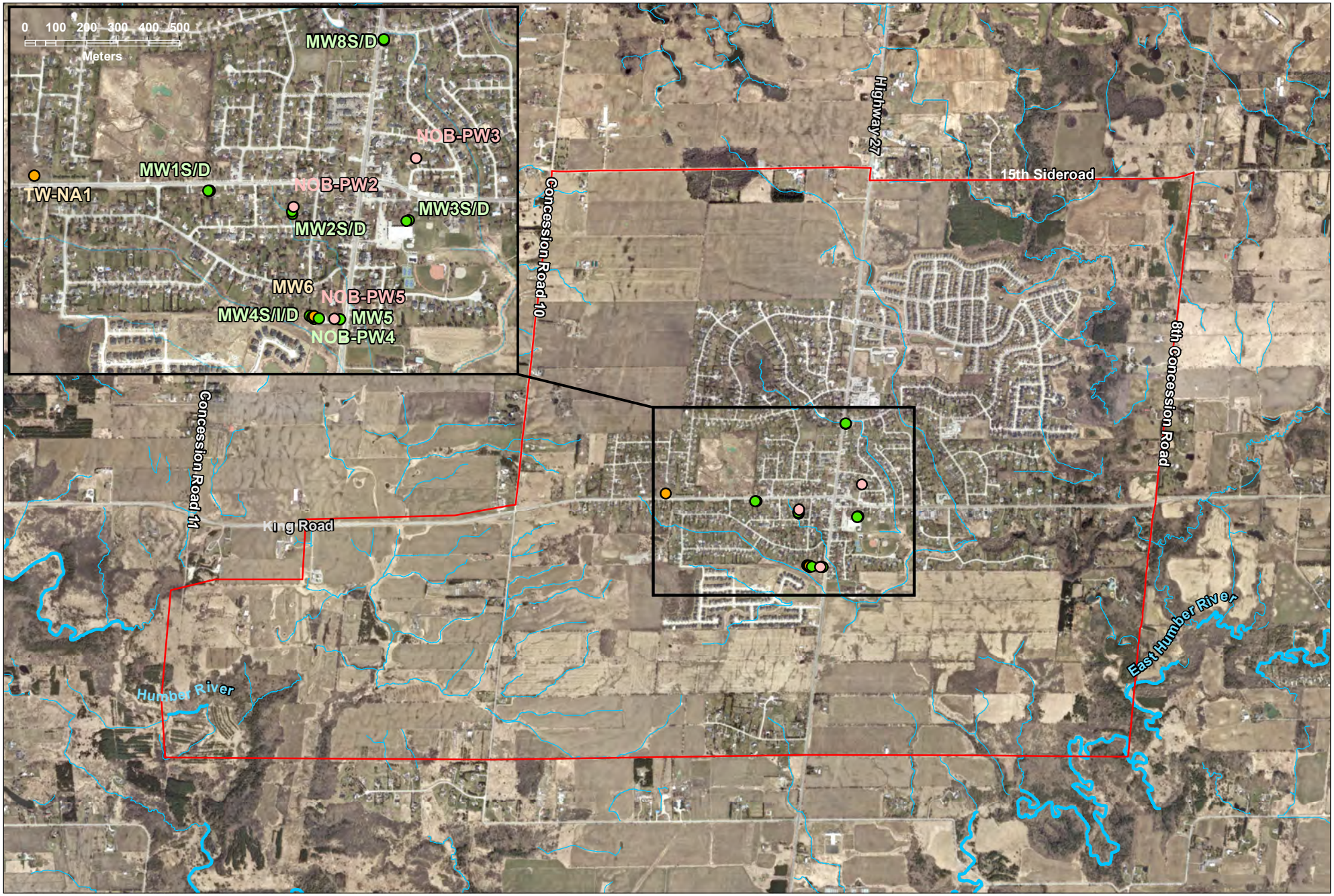
Nobleton currently operates three (3) municipal supply wells, NOB-PW2, NOB-PW3, and NOB-PW5, under the Ministry of the Environment, Conservation, and Parks (MECP) Permit To Take Water (PTTW) Number 2015-BK2KW2, which expires on December 20, 2029. The current permitted maximum daily water taking from any combination of the wells is 4,460 m^3/day (51.62 L/sec), and the system storage capacity provided by the Highway 27 and Nobleton elevated tanks is 1.8 million litres (ML) and 2.0 ML, respectively. The locations of these wells, along with the monitoring well network, is shown on **Figure 1**.

1.2 Objective

The ultimate objective of this study is to identify a preferred site for a new municipal water supply well within the study area that can meet the required additional water supply capacity for Nobleton to 2041. This is completed through a series of steps as outlined in York Region's Environmental Services Department Capital Planning and Delivery Branch, Design Guidelines Section 18 – Groundwater Development and Wellhouse Design (formerly Section 14B), dated August 13, 2019 (referred to as 'Section 18'). This report presents the findings of groundwater exploration study and alternative site selection assessment.

As part of the investigation, a thorough background assessment of the available and pertinent data, as well as baseline mapping to the project was completed to effectively identify a suitable long-list of potential well locations. A review of the following list of data sources was completed for the investigation:

- York Durham Peel Toronto (YDPT) Regional Model and database;
- Geological mapping – surficial geology, physiography and landforms, bedrock geology;
- Ministry of Environment, Conservation and Parks (MECP) Water Well Records (WWR) and Permit-to-Take-Water (PTTW) database;
- Available borehole logs;



Prepared By

Palmer

CLIENT: The Regional Municipality of York
PROJECT: Nobleton Supply Well

0 200 400 600 800
metres

N

DRAWN: S. Feist
CHECKED: C. Hanlon
PROJECT: 170462
DATE: Apr 25, 2019

Scale 1:32000
UTM Zone 17N
NAD1 983

Legend

- Study Area
- Watercourse
- Supply Wells

Monitoring Well Status

- Abandoned
- Monitoring Well

York Region

DRAFT

Study Area

FIGURE 1

Document Path: C:\Egnyte\Shared\Projects\Active\17046 - Black &V eatch\170462 - Nobleton Supply Well\2. Background Assessment\PECG data\Mapping\mxd\170462_Fig1_SiteArea.mxd

- Elevation Contour mapping;
- Source Water Protection (SWP) mapping;
- Natural Heritage Systems (NHS) mapping;
- York Region sanitary sewer and watermain location mapping;
- Oak Ridges Moraine Conservation Plan mapping and policies;
- Regional Official Plan (ROP) – land use plan, special site policy areas, natural environment plan, transportation plan; and,
- Hydrogeologic mapping and reports, including the groundwater exploration studies completed for the existing Nobleton municipal supply wells.

Results of the background assessment were evaluated against weighted screening criteria relating to groundwater resources, engineering, and the natural environment. Criteria was developed based on the *Site Selection Standards for Groundwater Exploration in York Region (MMM, 2005)*, and updated to reflect the current land use policies, updates to the understanding of the hydrogeological conditions of the study area, the evaluation of land use activities in the target areas using the 21 Prescribed Drinking Water Threats defined by the *Clean Water Act (2006),* and Official Plan Policies on wellhead protection areas.

2. Project Setting

2.1 Physiographic Setting

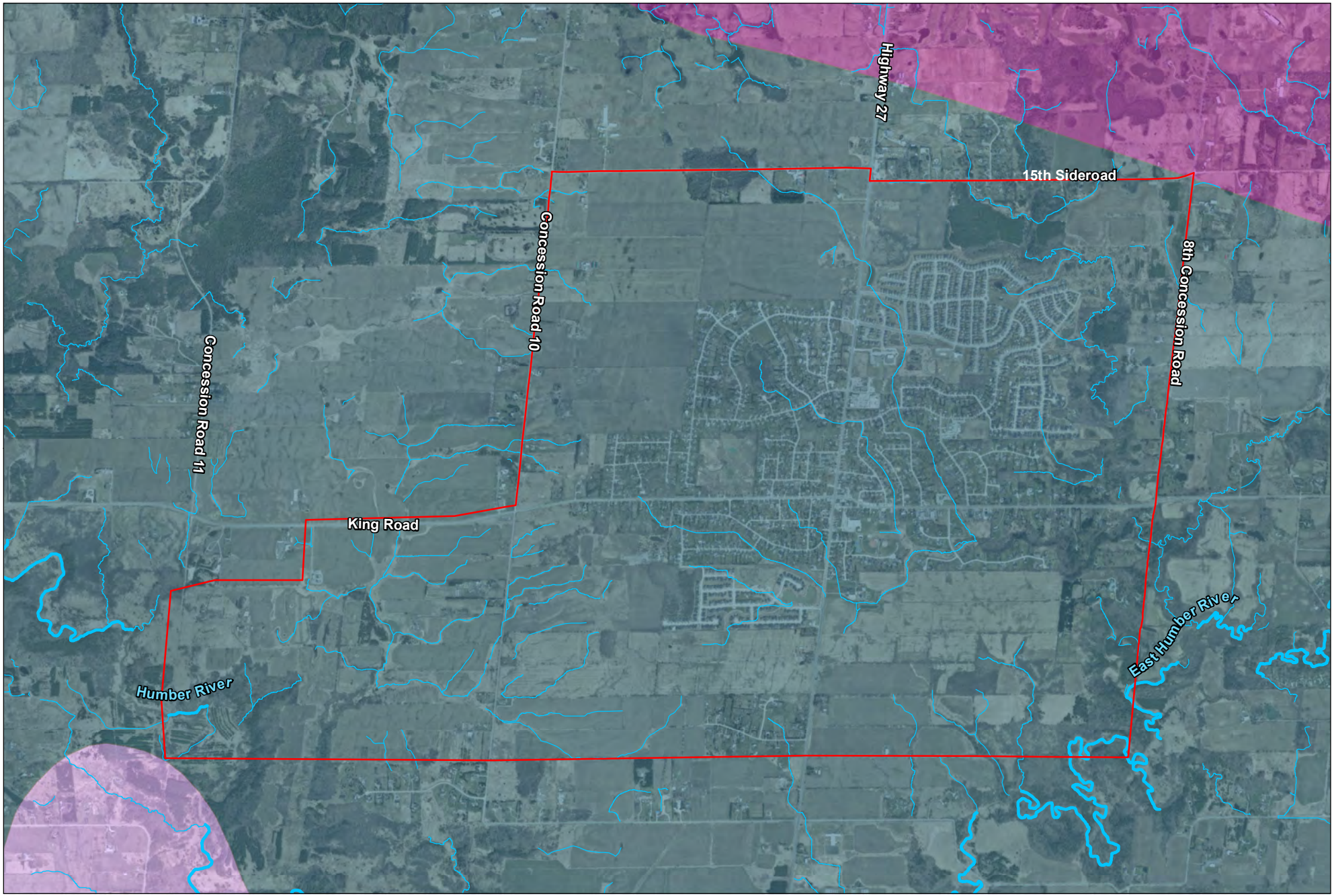
The study area is located primarily within the South Slope physiographic region as defined by Chapman and Putnam (1984). The Oak Ridges Moraine (ORM) physiographic region crosses slightly into the northern portion of study area, about 2.5 km north of King Street and Regional Road 27 (**Figure 2**).

The South Slope physiographic region begins at a sharp break in slope on the south side of the ORM and slopes downward towards Lake Ontario (Chapman and Putnam, 1984). The South Slope is characterized predominantly by clay till soils at surface, with some clay loam and loam. The topography is marked by gently rolling till plains, characterized by numerous drumlins oriented upslope. Upon deglaciation about 12,000 years ago, meltwater streams cut sharp valleys in the till locally exposing the underlying ORM sediments north of the study area.

The ORM physiographic region is considered a regionally significant geological landform due to its large capacity for groundwater recharge and discharge. It is characterized by coarse grained sand and gravel deposits. Geological landforms within this region vary between unstratified drift deposits (till moraines), and ice-contact stratified drift (kame moraines). Within the study area, the ORM is characterized by low permeability till moraines**.**

2.2 Topography and Drainage

Regional, ground surface elevation decreases southwards towards Lake Ontario. Within the study area, the topography is generally gently rolling dropping from approximately 280 meters above sea level (masl) in the north to approximately 230 masl in the south (**Figure 3**). The community of Nobleton is located on a gentle north-south trending ridge with elevations in the range of 265 to 275 masl (MMM, 2007).



Prepared By

Palmer

CLIENT: The Regional Municipality of York
PROJECT: Nobleton Supply Well

0 200 400 600 800
metres

N

DRAWN: S. Feist
CHECKED: C. Hanlon
PROJECT: 170462
DATE: Apr 25, 2019

Scale 1:32000
UTM Zone 17N
NAD1 983

Legend

- Study Area
- Watercourse

Physiographic Region

- 30 - Oak Ridges Moraine
- 32 - South Slope
- 33 - Peel Plain

York Region

DRAFT

Physiographic Regions

FIGURE 2

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Prepared By

Palmer™

CLIENT: The Regional Municipality of York
PROJECT: Nobleton Supply Well

0 200 400 600 800
metres

N

DRAWN: S. Feist
CHECKED: C. Hanlon
PROJECT: 170462
DATE: Apr 26, 2019

Scale 1:32000
UTM Zone 17N
NAD1 983

Legend

- Study Area
- Watercourse
- Watershed Boundary
- Contours (5m)

York Region

DRAFT

Topography and Drainage

FIGURE 3

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The study area is situated between two subwatersheds within the Humber River Watershed: the Main Humber River Subwatershed and the East Humber River Subwatershed (**Figure 3**). The Humber River watershed has an area of approximately 903 km^2 and is the largest watershed under the jurisdiction of the Toronto and Region Conservation Authority (TRCA) (TRCA, 2008). Headwaters of the Humber River originate within the ORM, and generally flows southwards, eventually discharging to Lake Ontario.

Within the study area, a series of small tributaries are present which flow either easterly across the south slope to discharge to the East Humber River, or westerly to discharge to the Main Humber River. The East Humber River converges with the Main Branch approximately 14 km south.

2.3 Climate

The closest operating Environment Canada weather station to the study area is the Toronto Pearson International Airport (Station ID 6158733). The monthly climate normals over the 30-year period spanning 1981 – 2010 was analysed to determine the mean annual temperature and precipitation. Based on these normals, the mean annual temperature is approximately 8.1°C, and ranges from -5.5°C in January to 21.4°C in July. The mean annual precipitation is approximately 786 mm, and ranges on average from 47.7 mm in February to 78.1 mm in August (**Table 1**).

Table 1. 1981 - 2010 Climate Normals

Month	1981 – 2010 Climate Normal Mean Temperature (°C)	1981 – 2010 Climate Normal Total Precipitation (mm)
Jan	-5.5	51.8
Feb	-4.6	47.7
Mar	0.1	49.8
Apr	7.1	68.5
May	12.1	74.3
Jun	18.6	71.5
Jul	21.4	75.7
Aug	20.6	78.1
Sep	16.2	74.5
Oct	9.5	61.1
Nov	3.7	75.1
Dec	-2.2	57.9
Average/ Total	8.09	785.8

2.4 Regional Geology

2.4.1 Bedrock Geology

The Upper Ordovician aged Georgian Bay Formation directly underlies the study area, and is described as a grey-green to dark grey shale and fossiliferous calcareous siltstone to limestone. The thickness of this formation ranges from 127 m near Nottawasaga Bay to about 183 m in the Toronto area (Armstrong and Dodge, 2007). This formation overlies the Upper Ordovician aged Blue Mountain Formation, which is located approximately 3.5 km east of the study area. The Blue Mountain Formation is described as a dark

blue-grey to brown to black shale with thin interbeds of limestone or calcareous siltstone becoming more prevalent upwards (Armstrong and Dodge, 2007). Bedrock geology is shown on **Figure 4**.

The Nobleton Community is situated within the Laurentian Valley (White, 1975), a broad bedrock depression expending over 100 km from Georgian Bay to Lake Ontario. The valley width is more than 25 km, and is greater than 100 m in depth at the base of the Niagara Escarpment. Side valleys of the Niagara Escarpment appear to be connected to the channel valley system (Hunter and Associates and Raven Beck, 1996; Holysh et al., 2003; Holysh, Davies, and Goodyear, 2004; Davies and Holysh, 2005; etc.). Estimates at the sediment volume within the valley have been conservatively approximated at 350 km^3, indicating that the valley likely plays a key hydrogeological role in regional and watershed-scale flow systems (Davies et al., 2008). The Groundwater Resources Exploration Report (MMM, 2007) for NOB-PW5 identified two local bedrock valleys within the study area that converge near King Vaughan Road and Kipling Avenue southeast of Nobleton. The base elevations of these valleys are between 100 to 110 masl along the western valley, and between 60 to 80 masl east of the study area, which compared with the high areas (between 210 to 190 masl) represents a valley depth of about 100 m.

2.4.2 Quaternary Geology

The surficial geology, as described by Ontario Geological Survey (OGS) mapping and shown on **Figure 5**, primarily consists of silty to clayey silt textured Halton Till, with the valley lands of the Humber River consisting of modern and older alluvial deposits of clay, silt, sand, and gravel. Smaller areas of coarser grained ice-contact stratified drift or glaciolacustrine deposits of sand and gravel are also present near the headwaters of the Humber River, and organic deposits of peat muck and marl associated with the Black Duck Provincially Significant Wetland Complex, and the Nobleton Provincially Significant Wetland Complex are scattered within the northern portion of the study area. The thickness of the overburden within the study area ranges from approximately 87 to 137 m (OGS, 2006).

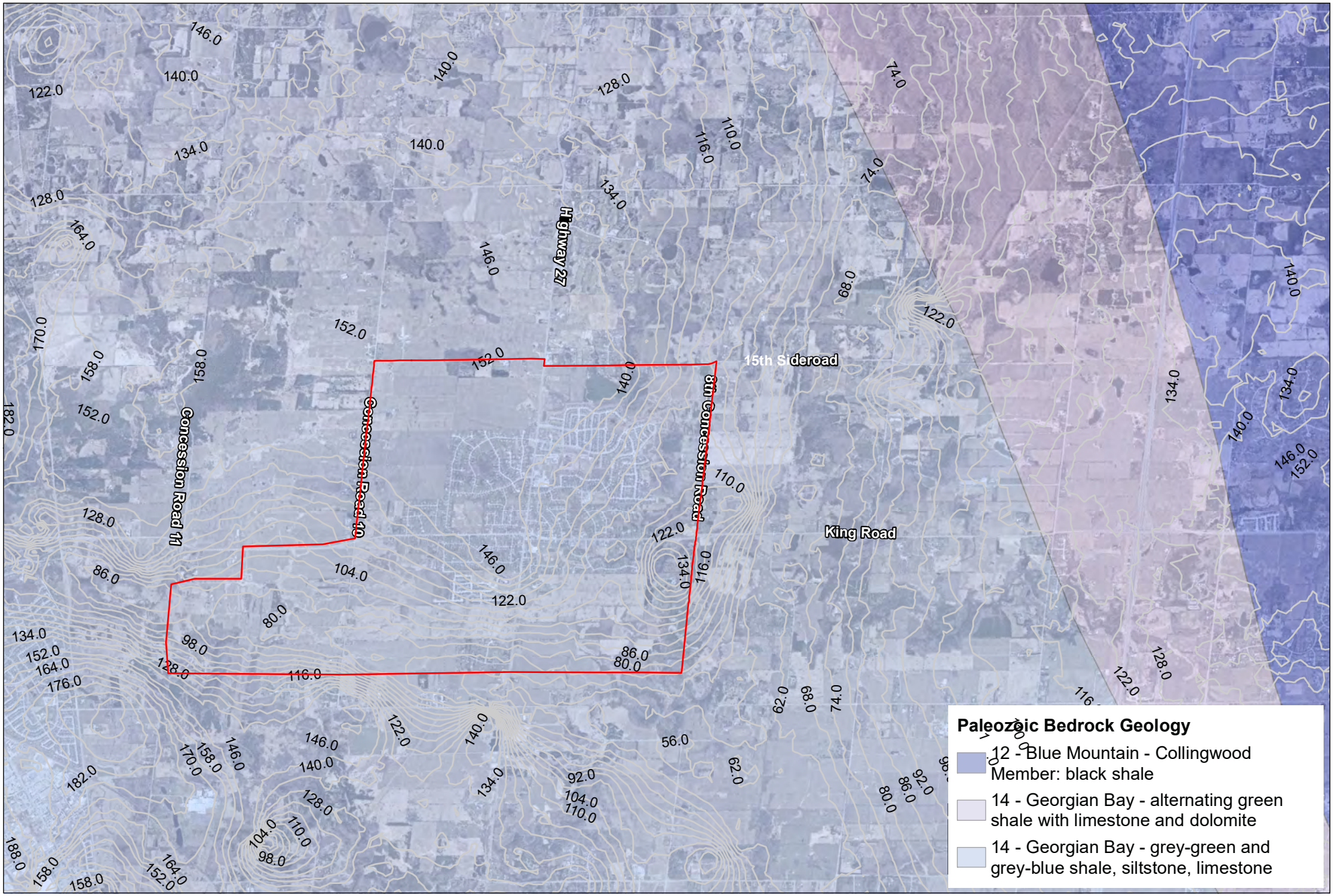
The stratigraphic units within the study area, in order of most recently deposited, are described in more detail below. These descriptions are largely based on the work by Kassenaar and Wexler (2006), and are presented in the York Region Tier 3 Water Budget and Water Quantity Assessment (Earthfx, 2013).

Modern Alluvium and Channel Deposits

Floodplains of the Humber River and other smaller floodplains were created within the post-glacial period as regional rivers incised Pleistocene sediments. Alluvial deposits consist of silt, sand, and minor sand and gravel and clay, and are typically 1 – 2 m thick. Organic deposits are found in depressions and poorly drained wetland areas.

Glaciolacustrine Deposits

Foreshore and basinal deposits of coarse grained glaciolacustrine sediments represent local ponding of water or higher water levels in major post-glacial lakes following the final glacial retreat approximately 12,500 years ago. The coarser grained sediments found near the Humber River valley along the eastern border of the study area indicate high energy depositional environments. These deposits are typically comprised of a thin veneer of sand, gravel, minor silt and clay, however locally these deposits can be several meters thick.



Prepared By

Palmer

CLIENT: The Regional Municipality of York
PROJECT: Nobleton Supply Well

0 500 1,000 1,500
metres

N

DRAWN: S. Feist
CHECKED: C. Hanlon
PROJECT: 170462
DATE: Apr 25, 2019

Scale 1:60000
UTM Zone 17N
NAD 1983

Legend

Study Area

Bedrock Depth (masl)

York Region

Imagery (2018) provided by York Region Web Mapping Services; Contains data provided by Ontario Geological Survey (OGS), 2011.

DRAFT

Bedrock Geology

FIGURE 4

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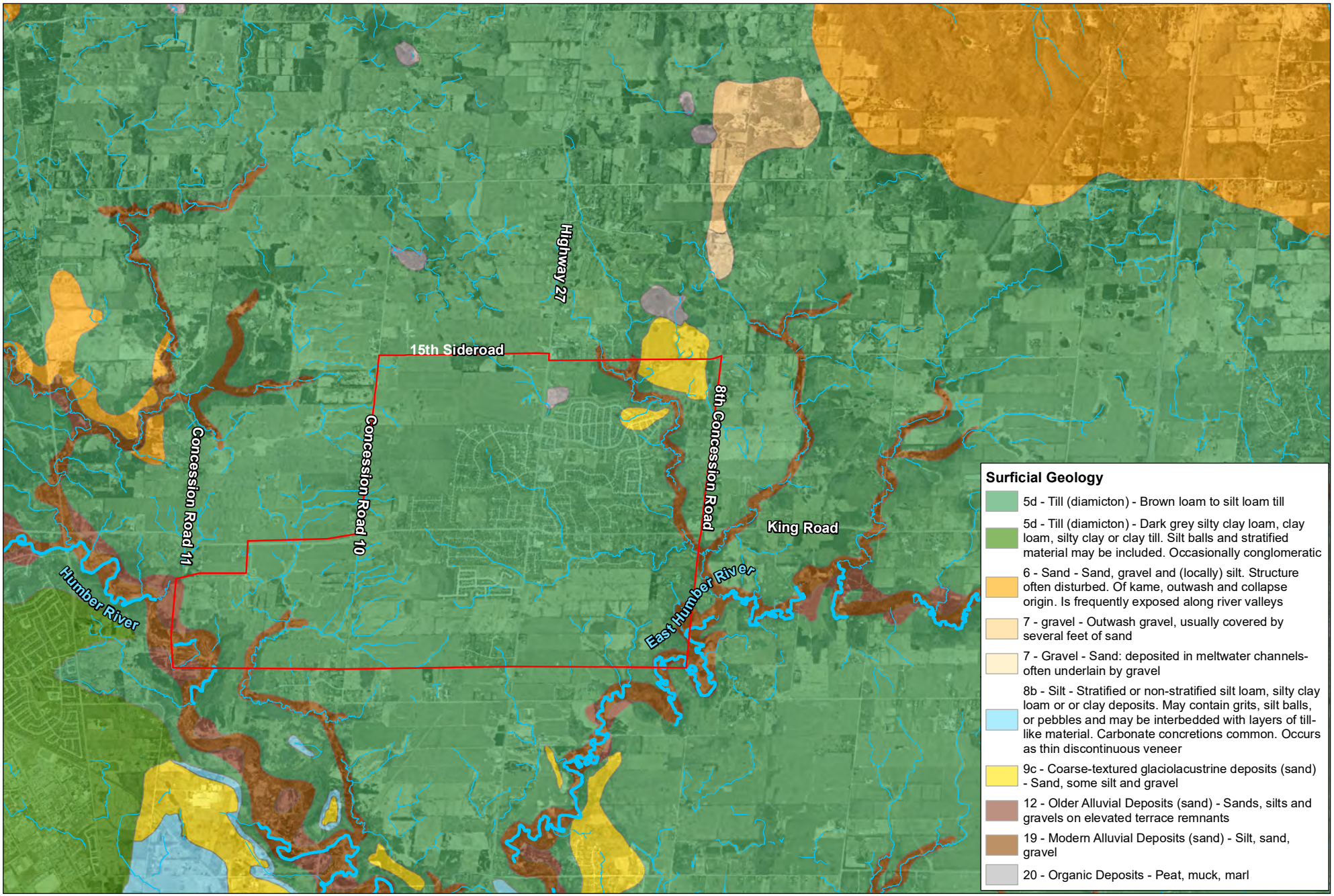

Prepared By

Palmer

CLIENT: The Regional Municipality of York
PROJECT: Nobleton Supply Well

0 500 1,000 1,500
metres

N

DRAWN: S. Feist
CHECKED: C. Hanlon
PROJECT: 170462
DATE: Apr 25, 2019

Scale 1:60000
UTM Zone 17N
NAD1 983

Legend
Study Area
Watercourse

York Region

DRAFT

Surficial Geology

FIGURE 5

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Halton Till

The Halton Till represents the latest glacial ice advance of the Lake Ontario ice lobe approximately 13,000 years ago (Eyles, 2002). It is an extensive diamicton with varying texture ranging from sandy silt till to silty clay till interbedded with silt, clay, sand and gravel (Earthfx, 2013). In areas where ice has overridden glaciolacustrine deposits the till tends to be more clay rich. Within the study area, the Halton Till has a relatively fine-grained matrix of sandy to clayey silt. The Halton Till is exposed over much of Southern Ontario to the ORM.

The thickness of the unit is typically between 10 to 20 m, however can reach 40 m in higher elevation areas northwest of Nobleton. On a local scale, granular seams within the Halton Till may provide sufficient water supply for some private wells, however regionally this unit acts as a confining aquitard, and plays a significant role in inhibiting groundwater recharge to the Oak Ridges Aquifer Complex (ORAC) (Earthfx, 2013).

Oak Ridges Moraine Aquifer Complex

The Oak Ridges Moraine Aquifer Complex (ORAC) deposits formed approximately 13,300 years ago (Eyles, 2002). The moraine was developed through rapid sedimentation in subglacial, ice-marginal, and proglacial environments formed between the Lake Ontario basin glacial ice and northern ice (Barnett et al., 1999). It is generally discontinuous and is comprised of several smaller landforms. During the brief ice-free interval following its deposition, coarse sand and gravel, minor silt and till sediments of the Oak Ridges Moraine (ORM) were dispersed by rivers flowing on the ice front. These interstadial deposits are typically less than 5 m in thickness, however can be up to 95 m beneath the crest of the moraine thinning rapidly towards its margins. They form a widespread, discontinuous layer that extends beyond the boundary of the ORM, and is typically found between the Halton and Newmarket Till units. It is believed that, locally, there is an upper and lower ORAC unit that is separated by a layer of silt and hydraulically functions as two separate units.

At surface, the ORAC terrain exhibits a hummocky, knob and basin relief with hills composed of sand and gravel. Due to the high permeability, the ORAC acts as a significant regional aquifer, and provides significant recharge to underlying aquifers (Earthfx, 2013). The ORAC contains few surface water channels, however supplies groundwater discharge to streams that drain till plains to the north and west of the study area near the Humber River valley (Earthfx, 2013). These deposits coincide with the Oak Ridges Moraine Planning Boundary.

Tunnel Channel Deposits

Late stage high energy subglacial meltwater flood events during the Late Wisconsin approximately 13,500 years ago resulted in the incision of major tunnel valleys and channels within the underlying sediment (Barnett et al., 1998; Earthfx, 2013). As the meltwater energy declined they were subsequently filled with a fining-upward sequence of alluvium deposits of boulders, cobbles, gravels, sands and silts (Sharpe et al., 1999). The channels at surface are 1 to 4 km wide and tens of meters deeps, and beneath the ORM tend to be narrower at 1 to 2 km wide and are still tens of meters deep (Pugin et al., 1999). These deposits are significant hydrogeological features as the permeable deposits can provide spatially discrete high yield aquifers up to several meters thick and can increase connectivity between regional aquifers.

One major channel system was identified to trend from Holland Landing southward towards Nobleton and Kleinburg and tends to follow a tributary of the Laurentian Valley near the Holland Marsh area (Kassenaar and Wexler, 2006; Earthfx, 2013). As mentioned above, these features act as significant hydrogeological controls, as they lead to an increase in connectivity between regional aquifers and/or act as spatially discrete local aquifers.

Newmarket Till

The Newmarket Till is typically a massive, over consolidated stony and dense silty sand diamicton deposited by the Laurentide Ice Sheet approximately 20,000 years ago (Eyles, 2002). The Newmarket Till can be subdivided into three smaller units, the Upper Newmarket Till (UNT), Inter-Newmarket Sediments (INS), and the Lower Newmarket Till (LNT). The UNT and LNT units are comprised of consolidated stony till and are considered aquitard units, whereas the INS consists of glaciolacustrine to glaciofluvial silt to gravelly sands and behaves as an aquifer. On a regional scale the Newmarket Till is considered an aquitard that effectively separates the ORAC from the underlying Thorncliffe Formation Aquifer.

It is expected that the permeable INT unit is absent within the Nobleton study area, and the less permeable UNT and LNT units are combined into one discontinuous layer. Locally, the thickness of the till can exceed 100 m, however typically is between approximately 20 – 30 m (Earthfx, 2013). This till is reported to include thin interbeds of sands and silts, boulder pavements, fractures, and joints, as well as discontinuous sand seams on the order of 1 to 2 m in thickness. Infrequently, the till may also contain rhythmites or isolated clay laminations. The level of protection provided by the low permeability Newmarket Till to wells screened in the Thorncliffe and Scarborough Formations depends on the local thickness and continuity of the Newmarket Till unit, and the presence or absence of secondary permeability structures.

Thorncliffe Formation

The Thorncliffe Formation consists of glaciofluvial deposits of sand and silty sand, and glaciolacustrine deposits of silt, sand and pebbly silt and clay that extend under most of York Region (Earthfx, 2013). This unit was deposited by glacial meltwater entering a deep ice-dammed ancestral Lake Ontario approximately 45,000 years ago (Barnett, 1992). The formation is noted for its considerable variation in the type of sediments, both locally and regionally, as it can often experience significant changes is facies over short distances (Sharpe et al., 2002). The lower part of the formation is often identified by silt-clay rhythmites (varves).

The Thorncliffe Aquifer is interpreted as the second stratigraphic aquifer in the Nobleton area. It is generally present through most of the study area and provides the water source for many domestic water wells in the area. In some areas however, it may be absent due to non-deposition or erosion by glacial ice or subglacial tunnel channel activity.

Sunnybrook Drift

The Sunnybrook Drift is a regionally extensive unit comprised of two members: the clast-poor silt to silty clay diamicton of the Sunnybrook Till, and rhythmically laminated clay of the Bloor Member. The deposition of the Sunnybrook Drift has been interpreted to have occurred approximately 45,000 years ago either by the overriding of pre-existing lake sediments through glacial ice advance, or sedimentation

within a glacially dammed lake (Eyles, 2002). This unit is considered to be a regionally extensive aquitard due to the low permeability silts and clays, and has been identified over a wide area from borehole log data. The thickness of the unit is generally less than 10 to 20 m, however tends to thicken in bedrock valley areas (Earthfx, 2013). The level of protection provided by the low permeability Sunnybrook Drift to wells screened in the Scarborough Formation Aquifer depends on the local thickness and continuity of the unit.

Scarborough Formation

The deposition of the Scarborough Formation marks the beginning of the Wisconsinan glaciation approximately 60,000 years ago. Generally, the formation consists of a gradually coarsening-upwards sequence of silt-clay rhythmites to channelized cross-bedded sands (Kelly and Martini, 1986). These deposits are generally interpreted as a lacustrine-deltaic system which outcrops in the Scarborough Bluffs (Kelly and Martini, 1986). Its deposition likely occurred by a large river flowing from Georgian Bay along the Laurentian Channel to ancestral Lake Ontario (Karrow, 1967; Eyles, 1997). The delta is considered to extend over an area of over 200 km^2 and provides water to several of York Region's deeper municipal supply wells.

2.5 Hydrogeology

2.5.1 Hydrostratigraphy

Hydrostratigraphic units can be subdivided into two distinct groups based on their capacity to permit groundwater movement, an aquifer or an aquitard. An aquifer is classically defined as a layer of soil permeable enough to permit a usable supply of water to be extracted. Conversely, an aquitard is a layer of soil that inhibits groundwater movement due to its low permeability. Descriptions of these units are primarily based on the work by Kassenaar and Wexler (2006).

Glaciolacustrine Deposits

Extensive deposits of glaciolacustrine sand, silt, and clay produce both aquifer and aquitard conditions based on the depositional environments. Surficial glaciolacustrine deposits can yield hydraulic conductivity values ranging from 10^{-4} m/sec to 10^{-8} m/sec depending on grain size distributions and the amount of weathering (Freeze and Cherry, 1979). Although these deposits are generally relatively thin, considerable water capacity is possible due to the high permeability of the coarse-grained sediments.

Halton Till Aquitard

The Halton Till Aquitard is a silty clay to clayey silt till with hydraulic conductivities ranging from about 10^{-9} m/sec to 10^{-5} m/sec (Gerber and Howard, 2000). Differences in hydraulic conductivities result from spatial differences in matrix composition, interstitial lenses of sand, and degree of weathering. On a regional scale, the Halton Till acts as a surficial aquitard as it inhibits groundwater recharge, therefore reducing the potential for contamination of the underlying aquifers (Sharpe et al., 1996). However, isolated lenses of silt and fine sand may be present on a local scale within the till which can often provide sufficient water for residential use. Within the Nobleton area only local shallow dug wells obtain water from this aquifer due to its limited extent (MMM, 2007). Within the unit, the water table is generally high due to the poorly drained nature of the soil, and groundwater flow is typically downwards towards the more permeable aquifer units.

Tunnel Channel Deposit Aquifer

This unit has been identified as a regional unconformity (Sharpe, 1999), and is marked by a series of tunnel channels and valleys that have cut into or completely through the Newmarket Till. Within the Nobleton area, two major tunnel channel deposits are found stratigraphically between the ORM and Newmarket Till. The tunnel channels are characterized by a fining-upward sequence of gravels, sands, and silts which were deposited as meltwater energy waned (Earthfx, 2013). The lower portion of coarser grained sediments therefore acts as an aquifer and has a hydraulic conductivity of approximately $1x10^{-4}$ m/sec, compared with the upper layer of finer grained deposits which effectively acts as an aquitard, and has a hydraulic conductivity of approximately $5x10^{-7}$ m/sec (Kassenaar and Wexler, 2006). These deposits are hydrogeologically significant as they have the capacity to act as spatially discrete aquifers and/or promote hydraulic connectivity between upper and lower regional aquifer units.

Newmarket Till Aquitard

The Upper and Lower units of the Newmarket Till (UNT and LNT) are considered aquitard components and are comprised of over-consolidated silty sand to sandy silt till. The hydraulic conductivity of these units is between approximately $5x10^{-9}$ m/sec and $1x10^{-8}$ m/sec (Gerber and Howard, 2000; Earthfx, 2013). The more permeable Inter-Newmarket Sediments (INS) is composed of silt to gravelly sands and can be considered an aquifer, however this unit is not present within the Nobleton study area. The hydraulic conductivity of the INS has been estimated at $8x10^{-5}$ m/sec (Gerber and Howard, 2000).

As the INS is not present within the study area, the UNT and LNT effectively combine to form one significant aquitard. This unit acts to effectively separate the upper aquifer systems associated with the ORM from the lower aquifer systems, including the Thorncliffe Formation. Groundwater flow within the dense till unit is typically in a downwards direction to more permeable aquifers (Sharpe et al., 1996).

Thorncliffe Aquifer

The Thorncliffe Aquifer forms a thick and extensive sand deposit that underlies the Newmarket Till in the Nobleton area and surrounding region. The hydraulic conductivity of the unit is typically in the range of $3x10^{-4}$ m/sec to $1x10^{-8}$ m/sec (Gerber and Howard, 2000). This aquifer is commonly used as a source for groundwater supply as the overlying Newmarket Till provides protection from surficial contamination, and typically local private wells are tapped into this aquifer. Based on Tier 3 groundwater model for the area, it is interpreted that the Thorncliffe and Scarborough aquifers are hydraulically connected in the Nobleton area due to the limited thickness and discontinuous nature of the Sunnybrook Aquitard.

Sunnybrook Aquitard

The clast-poor silt and clay mud deposits of the Sunnybrook Formation forms a localized aquitard, and where present, restricts flow between the Thorncliffe Formation and the Scarborough Formation. The thickness of the unit is expected to be between 10 and 20 m, and the hydraulic conductivity has been estimated to range between $3x10^{-7}$ m/sec to $4x10^{-7}$ m/sec (Gerber and Howard, 2000).

Scarborough Aquifer

The Scarborough Aquifer is regionally extensive and is locally confined by the Sunnybrook Aquitard. The upward coarsening and the increasing thickness of layers from clay-rich rhythmites to channelized cross-bedded sands promotes the greatest groundwater transmissivity within the upper layers of the unit (Kelly and Martini, 1986). Generally, the Scarborough Aquifer is thin however relatively thick deposits between 60 and 80 m are commonly found in bedrock lows and valleys, such as the Laurentian Valley and tributaries (MMM, 2007). The hydraulic conductivity of the aquifer has been estimated to be in the range of $2x10^{-5}$ m/sec to $2x10^{-6}$ m/sec (Gerber and Howard, 2000).

The Scarborough Formation Aquifer forms the main potable water supply unit within the study area, and Nobleton's three active municipal supply wells are screened in this formation approximately at 100 mbgs.

2.5.2 Groundwater Flow

On a regional scale, the Oak Ridges Moraine acts as a both a surface water and groundwater divide, with water flowing either north towards Lake Simcoe, or south towards Lake Ontario. As Nobleton is situated south of the ORM, the groundwater flow direction within the ORAC, Thorncliffe, and Scarborough aquifer units is generally directed to the south towards Lake Ontario, as presented in Earthfx (2013). This is primarily controlled by the large topographical drop of nearly 100 m between the crest of the moraine and Lake Ontario which dominates flow direction and gradients south of the ORM.

Within the Nobleton area, shallow groundwater flow within the ORAC is strongly influenced by topography and by the local stream network, including the two main branches of the Humber River. Groundwater elevations within the ORAC range from approximately 260 masl within the topographic high areas north of the community to 215 masl near the Humber River valleys to the southeast. Near the town center, the groundwater elevation is interpreted at approximately 255 masl (MMM, 2007). The groundwater hydraulic head values measured in near-surface ORAC sediments are typically higher than the hydraulic head values measured in the lower Thorncliffe Aquifer, particularly north of Nobleton in the direction of the moraine. This indicates a downward hydraulic gradient or recharge conditions in these areas (Earthfx, 2013).

Groundwater flow in the intermediate-deep Thorncliffe Aquifer indicates a moderate influence with the potentiometric surface of the Humber River valley (Earthfx, 2013). Static water levels range from approximately 255 masl in the northern portion of the study area to approximately 210 masl south of Nobleton. Near the town center, the groundwater elevation is interpreted at approximately 249 masl (MMM, 2007).

In the deep Scarborough Aquifer, groundwater flow indicates very little evidence of flow convergence towards the Humber River system (Earthfx, 2013). Groundwater discharge from the Scarborough Aquifer does not appear to directly support base flow in local streams due to the presence of thick, low permeability units which separate the shallow and deeper groundwater systems. Static water levels range from approximately 255 masl below the ORM to the north, to approximately 215 masl south of Nobleton. Near the town center, the groundwater elevation is interpreted at approximately 237 masl (MMM, 2007).

In addition, there is potential for hydraulic connection between upper and lower aquifer units where tunnel channel deposits are present, or in areas where the Sunnybrook Drift Aquitard is absent. Two tunnel

channel deposits have been identified west of the Nobleton area (west of Concession Road 10), and one east along Concession Road 8 (Kassenaar and Wexler, 2006). The Sunnybrook Drift Aquitard is thin, and may be discontinuous within the Nobleton area, which could lead to a hydraulic connection between the Thorncliffe and Scarborough aquifers.

2.5.3 Groundwater Recharge

Hydraulic gradients are generally downward across the study area, however upward gradients are interpreted in the low-lying river valleys, such as the Humber River valleys to the east and west of Nobleton (MMM, 2007). The main area of recharge within the study area is through the coarse-grained ORM deposits. The high recharge leads to high values of hydraulic head within the ORAC which encourages groundwater recharge across the region as infiltrating groundwater reaches the deeper aquifer units. Based on modeling work by Earthfx (2013), recharge rates range from 40 – 200 mm/yr in the Nobleton area.

2.6 Source Water Protection

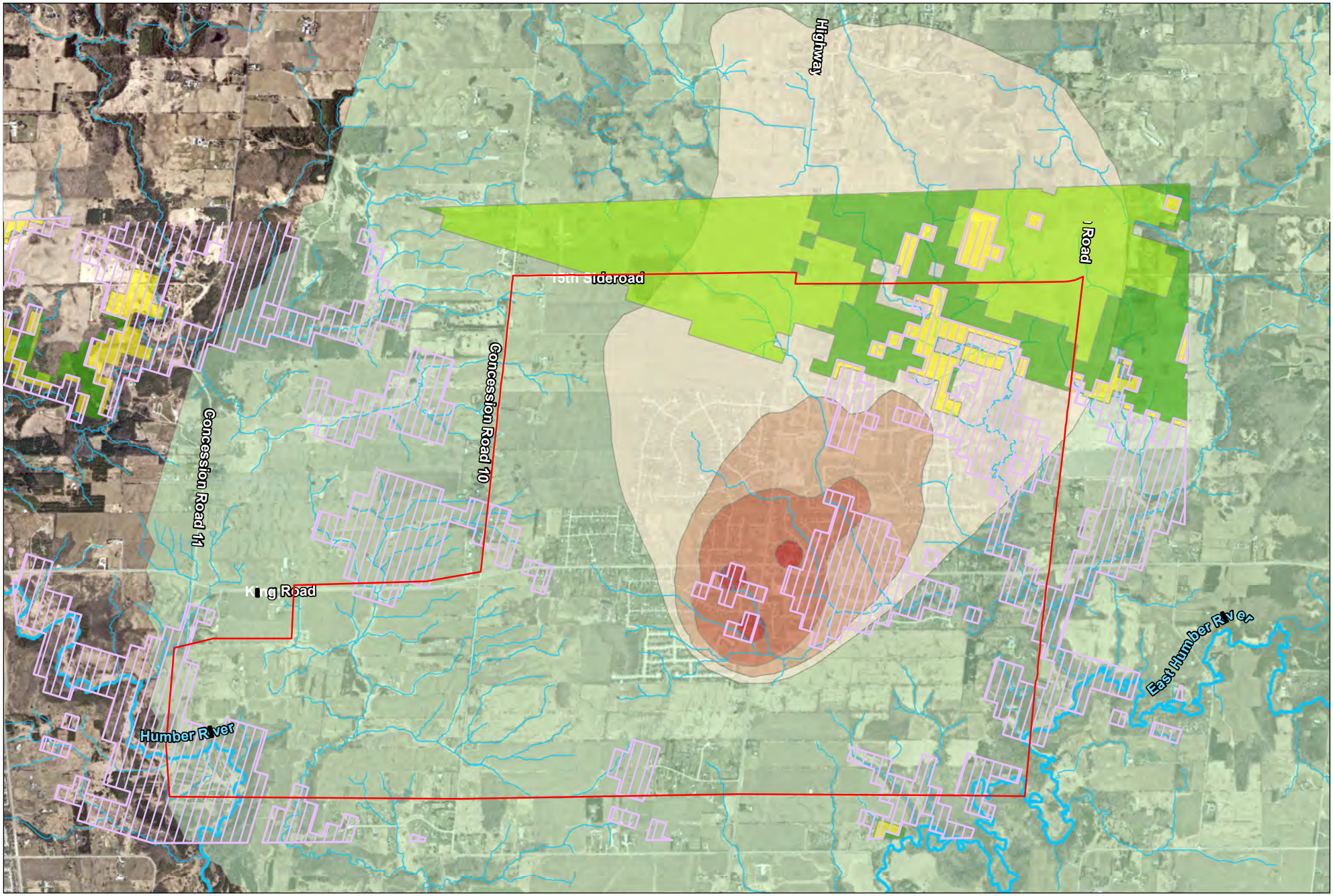
Under the *Clean Water Act, 2006* (CWA), all sources of drinking water must be assessed with respect to vulnerability. These assessments were completed in 2015 for Nobleton through the "Approved Assessment Report: Toronto and Region Source Protection Area, Water Budget and Stress Assessment".

The Technical Rules (2017) require that the Source Protection Committees (SPC) identify the types of vulnerable areas within each Source Protection Area (SPA). These vulnerable areas include: Wellhead Protection Areas (WHPAs), Highly Vulnerable Aquifers (HVAs) and Significant Groundwater Recharge areas (SGRAs). Descriptions of each area are provided in the following sections. The Source Water Protection areas that have been identified within the study area boundary based on available Source Water Protection Mapping (MECP, 2018) are shown on **Figure 6**.

2.6.1 Wellhead Protection Areas (WHPAs)

Wellhead Protection Areas (WHPAs) are delineated for drinking water systems to identify zones where the groundwater is susceptible to contamination. These zones are the basis for a community's Source Protection Plan, which provides guidelines for monitoring and regulation of land uses near the well field. Each WHPA is delineated using mathematical models to identify regions based on groundwater flow calculations and pumping rates. WHPAs assume a specified time of travel from the outer edge of the zone to the well intake. The size and shape of each WHPA depends on factors such as the pumping rate and defined aquifer properties. WHPAs are subdivided into WHPA-A, WHPA-B, WHPA-C and WHPA-D based on distance or transit time boundaries, described below.

- *WHPA-A* – an area centered on the well with an outer radius of 100 m;
- *WHPA-B* – the time of travel to the well is less than or equal to 2 years, but excluding WHPA-A;
- *WHPA-C* – the time of travel to the well is less than or equal to 5 years, but greater than 2 years;
- *WHPA-D* – the time of travel to the well is less than or equal to 25 years, but > 5 years;
- *WHPA-Q1* – where changes in groundwater use could affect the quantity of water available from the municipal supply well; and,
- *WHPA-Q2* – where changes in recharge could affect the quantity of water available from the municipal supply well.



Prepared By

Palmer

CLIENT: The Regional Municipality of York
PROJECT: Nobleton Supply Well

0 200 400 600 800
metres

N

DRAWN: S. Feist
CHECKED: C. Hanlon
PROJECT: 170462
DATE: Apr 25, 2019

Scale 1:36000
UTM Zone 17N
NAD1 983

- Study Area
- Highly Vulnerable Aquifers
- Watercourse

Wellhead Protection Areas
- WHPA-A
- WHPA-B
- WHPA-C
- WHPA-C1
- WHPA-D
- WHPA-Q1

Significant Groundwater Recharge Areas
Vulnerability Score
- 2
- 4
- 6

York Region

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Source Water Protection Mapping

FIGURE 6

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As shown in **Figure 6**, a large portion of the study area is located within WHPA- A, B, C, and D, as well as WHPA-Q1/Q2 (Recharge Management Area). Generally, WHPA-A is a 100 m radius, WHPA- B and C extends northwards but generally remains within the developed limits of Nobleton, and WHPA-D extends northwards to approximately 750 m north of the study area boundary near 15th Sideroad. **Table 2** presents a summary of the WHPA zones for each production well based on York Region's groundwater monitoring well network. The locations of the groundwater monitoring wells are presented on **Figure 1**.

Table 2. WHPAs Corresponding with York Region's Monitoring Well Network

Well ID	WHPA Zone (Corresponding Production Well(s))
MW-1S	WHPA-C (All production wells)
MW-1D	WHPA-C (All production wells)
MW-2S	WHPA-A (NOB-PW2)
MW-2D	WHPA-A (NOB-PW2)
MW-3S	WHPA-B (All production wells)
MW-3D	WHPA-B (All production wells)
MW-4S	WHPA-A (NOB-PW5)
MW-4I	WHPA-A (NOB-PW5)
MW-4D	WHPA-A (NOB-PW5)
MW-5	WHPA-A (NOB-PW5)
MW-6	WHPA-A (NOB-PW5)
MW-8S	WHPA-B (All production wells)
MW-8D	WHPA-B (All production wells)

The entire study area is located within the WHPA-Q1/Q2 and is therefore subject to the recharge management policy. The area of high permeability glaciolacustrine and glaciofluvial sands identified as Significant Groundwater Recharge Area (SGRA) classes 2 to 6.

Based on the report "Approved Assessment Report: Toronto and Region Source Protection Area, Water Budget and Stress Assessment" completed in 2015, it was concluded by York Region staff, with the concurrence of the peer reviewers, that no transport pathway adjustments were required for the three (3) Nobleton productions wells. The resultant WHPA, as part of the uncertainty assessment, shows the uncertainty in delineation of WHPA-A, WHPA-B, WHPA-C and WHPA-D and scoring of vulnerability within each are considered low for all three production wells.

2.6.2 Highly Vulnerable Aquifers

A highly vulnerable aquifer (HVA) is identified in the Ontario Clean Water Act, 2006 as highly vulnerable to contamination based on factors such as the proximity to the ground surface, the thickness and hydraulic characteristics of the overlying deposits (i.e., aquitards, aquifers), and the radial proximity to aquifers/aquitards sharing depths below ground surface.

As shown in **Figure 6**, HVAs identified within the study area generally coincide with areas of more permeable surficial deposits, such as glaciolacustrine and alluvial deposits near the Humber River valleys, and the coarse-grained ice-contact stratified drift deposits associated with the Oak Ridges Moraine, located north of the study area.

Note that the regionally significant Thorncliffe and Scarborough Aquifers are confined by low permeability glaciolacustrine silt and clay, and/or low permeability sandy silt till units in this area, indicating that while the Scarborough Aquifer is important for municipal groundwater supply, the Halton and Newmarket tills act to inhibit vertical recharge to the aquifer. The primary recharge area for this aquifer is located north of the study area, where high permeability Oak Ridges Moraine deposits are present at surface.

2.6.3 Significant Groundwater Recharge Areas

Infiltration is the term used to describe the volume of water that enters the subsurface from a surface source, whereas recharge is the term used to describe downward flowing groundwater which reaches an underlying aquifer. Infiltration aside, precipitation that reaches the ground surface is either lost to evaporation or runs off the surface directly into streams, other water bodies (i.e. lakes, ponds), or storm sewers. The remainder infiltrates into the ground, a portion of which may be transported to an underlying aquifer to act as recharge.

Recharge areas are important because they replenish aquifers. As mentioned, the ORM (where exposed at surface) exhibits the greatest rate of groundwater recharge within the vicinity of the study area due to the high permeability of these surficial deposits. Therefore, precipitation that falls within the crest of the ORM is a major source of recharge to the ORAC. Piezometer nests installed in the ORAC confirm downward groundwater flow directions and a deep-water table (e.g. Singer, 1977). Generally, within the South Slope groundwater recharge is restricted and runoff exceeds infiltration due to the low permeability of the overlying Halton and Newmarket Till units. However, minor groundwater recharge can occur in areas where the Halton Till is thin and directly overlies the ORAC.

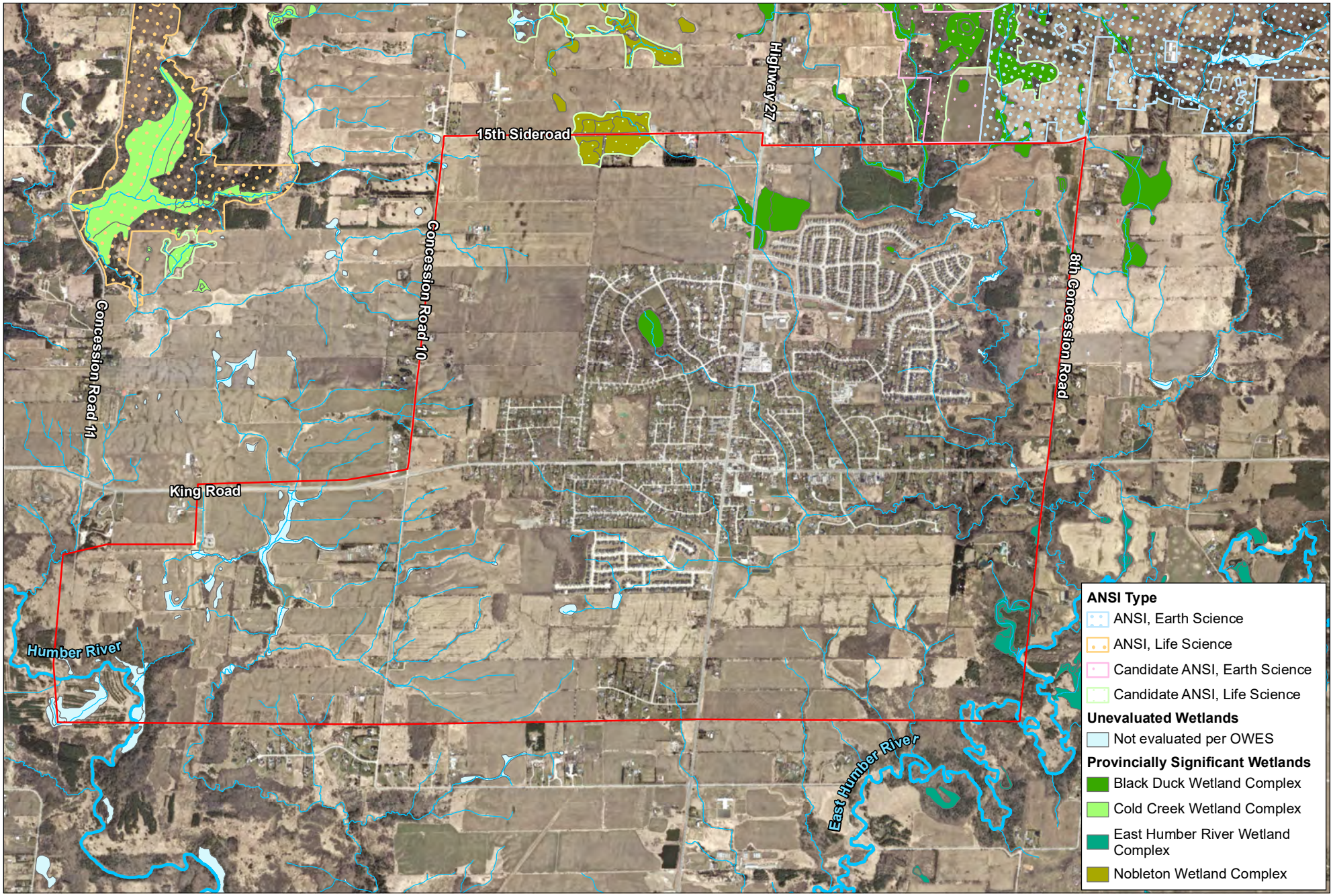
2.7 Natural Heritage Areas

2.7.1 Provincially Significant Wetlands

Wetland areas shown on **Figure 7** consist of either evaluated Provincially Significant Wetlands (PSWs) or unevaluated wetlands, as per the Ontario Wetland Evaluation System (OWES). There is a total of 95 unevaluated wetland complexes within the study area. Of the evaluated wetlands, there are five main wetland complexes: East Humber River Wetland Complex, Eaton Hall-Mary-Hackett Lakes Wetland Complex, Black Duck Wetland Complex, Nobleton Wetland Complex, and Cold Creek Wetland Complex. The East Humber River Wetland Complex is located in the southeast quadrant of the study area near the Humber River, and generally consists of regions of swamp, marsh, and open water. A small portion of the Eaton Hall-Mary-Hackett Lakes Wetland Complex is in the northeast quadrant of the study area near the headwaters of the Humber River, and consists of regions of swamp, marsh, and open water. The majority of the Black Duck Wetland Complex is situated directly north of the city center, and includes regions of swamp, bog, marsh, and open water. The Nobleton Wetland Complex is located immediately west of the Black Duck Wetland Complex and consists of swamp, marsh, and open water areas. Lastly, the Cold Creek Wetland Complex is in the west side of the study area near the Humber River valley and consists of swamp and marsh lands.

2.7.2 Areas of Natural and Scientific Interest

Areas of Natural and Scientific Interest (ANSI) are areas of land and/or water containing natural landscapes or features which have been identified as having value in life sciences and/or earth sciences related to natural heritage protection, scientific study, or education. ANSIs vary in their type and level of significance and include sites such as PSWs.



Prepared By

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

CLIENT: The Regional Municipality of York
PROJECT: Nobleton Supply Well

0 200 400 600 800
metres

N

DRAWN: S. Feist
CHECKED: C. Hanlon
PROJECT: 170462
DATE: Apr 25, 2019

Scale 1:32000
UTM Zone 17N
NAD1 983

Legend
- Study Area
- Watercourse

York Region

DRAFT

Provincially Significant Wetlands and ANSI

FIGURE 7

Document Path: C:\Egnyte\Shared\Projects\Active\17046 - Black &V eatch\170462 - Nobleton Supply Well\2. Background Assessment\PECG data\Mapping\mxd\170462_Fig7_ProvSigWetlands.mxd

Life Science and Earth Science ANSIs are both found within the study area and are associated with several PSWs including the Eaton Hall-Mary-Hackett Lakes Wetland Complex, Black Duck Wetland Complex, Nobleton Wetland Complex, and Cold Creek Wetland Complex. These areas consist of the Laskay Lakes candidate Life Science ANSI, the Linton-Kelly Lake Channels Earth Science and candidate Earth Science ANSI, the Hall-Thomspon Lake Kettles candidate Life Science ANSI, and the Cold Creek Headwaters Life Science and candidate Life Science ANSI. Each defined ANSI is within the ORM planning boundary, apart from the Cold Creek Headwaters ANSI. Each area has been characterized as non-sensitive.

3. Alternative Well Site Selection Process

3.1 Methodology

This investigative program was designed based on the *Site Selection Standards for Groundwater Exploration in York Region (MMM, 2005)* and York Region Section 18 procedures to ultimately select suitable candidate location and a preferred well site location for groundwater-based municipal supply well for the community of Nobleton. The following steps were completed as part of this evaluation:

1. Identify a long-list of six (6) potential candidate areas (eight (8) were identified for this study) based on a review of local hydrogeological and geological data;
2. Evaluate the long-listed areas against a series of weighted criteria to refine a short-list of two (2) site locations;
3. Review and deliberate findings with York Region staff;
4. Obtain property access for preliminary field investigations;
5. Complete hydrogeological field assessments at the two (2) short-list locations;
6. Evaluate the hydrogeological conditions at each location; and
7. Recommend a preferred new Municipal Well Site.

An extensive list of data was compiled by Palmer and York Region to complete steps 1-4 listed above. This data included information from the following sources or type of sources:

- The YDPT Regional Model and database;
- Published geologic mapping, including bedrock geology, surficial geology, and physiographic regional mapping data;
- Aerial Photography;
- Ontario water well records;
- Contour mapping and Digital Elevation Models (DEM);
- Source Water Protection Information, including Wellhead Protection Areas (WHPA), Significant Groundwater Recharge Areas (SRGA), Highly Vulnerable Aquifers (HVA), and Intake Protection Zones (IPZ);
- Natural Heritage Mapping, including Provincially Significant Wetlands (PSW), Areas of Scientific Interest (ANSI), watercourses;
- Planning Area designations;
- Road networks and municipalities;
- Other municipal supply well investigative investigations completed for the community of Nobleton (PW-5 and PW-3); and,

- Other applicable data provided by York Region.

The sub-regional hydrogeological model used by Palmer for this analysis was provided by York Region. This model was developed by EarthFx and provides coverage of most of the TRCA watersheds and all of York Region, including Nobleton. MODFLOW was used to represent an area extending southward from Lake Simcoe to Lake Ontario. Cells 100-m wide were used to represent stream/aquifer interaction and well drawdowns.

The vertical discretization in the model included eight layers representing the known regional stratigraphy, including recent deposits, Halton Till, ORM, Newmarket Till, Thorncliffe Formation, Sunnybrook Diamict, Scarborough Aquifer, and weathered bedrock. Palmer used the hydrogeological model to evaluate the transmissivity and thickness of the Scarborough Aquifer and the thickness of the Sunnybrook Diamict at the target locations. These data were cross-referenced with available stratigraphic and well yield data from MECP well records to provide a more complete dataset across the study area.

Steps 5 – 7, listed above, were completed based on the results of Steps 1 – 4 , and involved hydrogeological field studies and verification of the secondary source data used to provide B&V and York Region with our professional opinion of a preferred well site location.

3.1.1 Long-List Site Screening Criteria

The first stage in the selection process is the generation of a long-list of potential areas. To ensure each long-listed location is evaluated quantitatively, each potential well site was assessed using a series of weighted categories related to hydrogeologic factors such as long-term reliable well yields and optimum water quality, and non-hydrogeologic issues such as proximity to existing infrastructure, surrounding land use, property accessibility, restrictions and potential public concerns. Each potential site was assigned a total score based on its performance in each category to produce a relative ranking of the potential locations. Overall, the potential test well sites were ranked using the weighted screening criteria, Palmer's professional judgement, and consultation with Black & Veatch and York Region.

In total, six screening categories were selected across three different categories: Groundwater Resources, Engineering, and Policy and Regulation. Based on the scoring values assigned to each category, Groundwater Resources is the highest weighted with 65 of the total possible 100 points (65%), followed by Engineering and Logistics with 25 total possible points (25%), and Policy with 10 of the total possible points (10%). **Table 3** provides a summary of the screening criteria categories used in this study, as well as the maximum score possible for each category. A breakdown of each category and subcategory, including the methodology in selecting each score, is provided in the following sections.

Table 3. Weighted Criteria Scoring Breakdown

No.	Task	Description	Maximum Score
Groundwater Resources (Total Possible Score = 65)			
1	Water Quantity (Anticipated Transmissivity and Aquifer Thickness)	As water quantity is the primary factor in determining the yield of a production well, it has been assigned the highest maximum score value. The well capacity is directly related to aquifer properties such as thickness and hydraulic conductivity. Areas with greater anticipated aquifer transmissivity correlate with the best potential locations for high producing wells.	30

No.	Task	Description	Maximum Score
2	Water Quality / Protection (Aquitard thickness and aquifer depth)	Increased depth to the target aquifer and increased thickness of the confining aquitard provide protection to the aquifer from potential groundwater contamination from surface. A deep confined aquifer is therefore preferred to minimize the potential for contamination to the production well and to reduce the water quality treatment requirements before delivery.	19
3	Confidence Level in Interpreted Hydrostratigraphy	Aquifer and aquitard conditions were interpreted based on available information including existing MECP water well records and information from the YPDT Model. Areas where there are multiple well records with high positional accuracy which extend through the target aquifer are preferred (i.e., physical data, not modelled data) as this increases the level of confidence that the target aquifer will be encountered at the expected depth.	6
4	Potential for Municipal / Domestic Well Interference	The potential of well interference with either municipal or domestic wells has been evaluated by assessing the density of active wells completed within the target aquifer within 1 km of the proposed well site, as well as nearby active PTTW records. This assessment is based on the MECP water well database and the distribution of existing production wells.	10
Logistics and Engineering Feasibility (Total Score = 25)			
5	Logistics and Engineering Feasibility	Logistics and engineering feasibility accounts for physical site constraints and other potential logistical issues for drilling the production well, the ability to discharge water during well testing and operation, and ease of accessibility required for regular monitoring by York Region staff. It also accounts for the proximity to the existing water infrastructure and relative cost associated with connecting the new well to the distribution system. York Region properties were assigned a higher weighted value than private properties.	25
Applicable Policy and Regulation (Total Score = 10)			
6	Applicable Policy and Regulations	As certain policies and regulations can be restrictive to the development and construction of a new production well, consideration of the location of land use policy areas such as the ORM Planning Boundary, the Greenbelt Planning Boundary, existing SWP areas (i.e., WHPAs), and Natural Heritage Areas, relative to the proposed well site were accounted for.	10
		Total Potential Score	**100**

3.1.1.1 Groundwater Resources

Aquifer Quantity

A productive aquifer is capable of yielding economic quantities of water, such that a high rate of withdraw from the aquifer can be sustained without causing an appreciable decline in hydraulic head. The predicted water supply capacity at each location was evaluated using a combination of the computed outputs from the 2013 York Regional steady-state groundwater flow model (YPDT model), and compiled information from available MECP water well records. Generally, high aquifer transmissivity is a good indication that the area may be a suitable candidate for exploitation as transmissivity (T) is directly related to hydraulic conductivity (K) and aquifer thickness (b), where T = (K)(b).

Geological cross sections within the study area were constructed using bottom and top layer data extracted from the hydrogeological model provided by York Region combined with stratigraphic data obtained from MECP well completion reports. Driller's logs also include descriptions of the materials encountered during drilling, and in most cases, static and dynamic groundwater levels are also provided.

These cross sections are shown on **Figures 13 – 15**. The locations of the cross sections are shown on **Figures 9 – 12**.

Generally, a hydrostratigraphic unit with a transmissivity greater than 10 m^2/day has characteristics of an aquifer. However, in an ideal site location the transmissivity of the productive aquifer should be greater than 100 to 500 m^2/day. Within the study area, this information was primarily derived using the horizontal hydraulic conductivity and thickness of the Scarborough Aquifer (bottom and top elevation of layer 7) and/or Thorncliffe Aquifer (bottom and top elevation of layer 5) was generated using the hydrogeological model provided by York Region, and was refined using data provided on water well records completed within the target aquifer. The Scarborough Aquifer was considered to be a better water supply aquifer within the Nobleton area than the Thorncliffe Aquifer as it generally has a higher transmissivity, is overlain by the thick Sunnybrook Aquitard providing added protection, and there are fewer local water wells completed within the Scarborough Aquifer compared with the Thorncliffe Aquifer reducing the potential for well interference. The Thorncliffe Aquifer was therefore only considered in the scoring of potential well locations where preliminary results indicated a potentially higher transmissivity than the Scarborough Aquifer.

For the majority of MECP well records, only the specific capacity (the quantity of water a well can produce per unit of drawdown) and the well diameter data was available. In these cases, an estimate of transmissivity and hydraulic conductivity was made using Cassan's method (Cassan, 1980). This method consists of the evaluation of the σ and θ parameters according to the equations below. For each test, the values of θ were derived from the theoretical curve proposed by Cassan (1980) and were used to calculate the values of transmissivity as shown below:

$$\sigma = \frac{s}{i \cdot r_w}$$

Where,

s – drawdown value
I – hydraulic gradient
r_w – radius of the well

$$\theta = \frac{2 \cdot \pi \cdot s}{Q} \cdot T$$

Where,

Q – pumping rate
T – transmissivity

The method used to assign a score at each location with regards to aquifer transmissivity and aquifer thickness is outlined in **Table 4**.

Table 4. Scoring System for Aquifer Transmissivity vs. Thickness

Thickness (m)	Transmissivity				
	<10 m^2/day	**10 – 100 m^2/day**	**100 – 500 m^2/day**	**500 – 1000 m^2/day**	**>1000 m^2/day**
<10 m	0	5	10	20	25
10 – 20 m	0	5	10	20	25
20 – 30 m	5	10	15	25	30
30 – 40 m	5	10	15	25	30
>40 m	5	10	20	25	30

Groundwater recharge is an important factor in assessing groundwater supply potential. An ideal site location should be situated down-gradient of a known groundwater recharge area. Within the Nobleton area, the deeper aquifer systems (i.e. Thorncliffe and Scarborough aquifers) receive recharge from the

ORAC located north of the study area, as well as from leakage through the Newmarket Till and tunnel channel deposits, where the quantity of leakage is dependent on the vertical hydraulic gradient and hydraulic conductivity of the overlying aquitard units. Recharge to the aquifer is also dependent on the hydraulic properties and overall extent of the target aquifer. Groundwater recharge has therefore been considered in the weighted criteria through existing categories, including aquifer transmissivity, thickness, and aquifer protection.

Aquifer Protection

It is important to evaluate the level of aquifer protection at each location to prevent or minimize deterioration in groundwater quality from surface contamination. As the groundwater treatment processes for restoration can be technically difficult and ultimately costly, rigorous treatment over the long term is not practical. Sufficient aquifer protection from surface can minimize the magnitude and persistence of potential contaminants and can reduce overall strain on treatment systems. Known groundwater treatability issues in Nobleton include naturally elevated levels of iron, manganese, and hardness, which are common across deep aquifers across York Region, and are treated at the existing Nobleton supply wells using sodium silicate (York Region, 2016).

Contamination of the groundwater system can originate from sources such as pesticides, fertilizers, landfills, gasoline storage tanks, septic tanks, and accidental spills. The new supply well should be located at least 100 m from known sources of groundwater contamination.

In addition, the target location should be in an area where there is sufficient protection from surface. The level of aquifer protection is a function of the depth of the aquifer from ground surface and the thickness of the confining aquitard(s). Aquitards with more than 10 to 15 percent by weight of clay-sized particles have been shown to have no preferential pathways for groundwater flow and contaminant migration, such as fractures, root holes, or other discontinuities. Laterally extensive aquitards which meet this condition therefore provide the greatest degree of protection to underlying aquifers.

The thickness of the confining aquitard was determined by evaluating the thickness of the fine clay and silt sediments of the Sunnybrook Drift Aquitard or sandy silt till sediments of the Newmarket Till Aquitard. The depth to the aquifer from surface was determined by comparing the surficial elevation data layer to the target aquifer elevation data layer. Data was obtained using a combination of the outputs from the 2013 York Regional steady-state groundwater flow model, and compiled information from available MECP water well records. The criteria and weighted scoring used in assessing candidate locations based on groundwater protection are summarized in **Table 5**.

Table 5. Scoring System for Groundwater Quality and Aquifer Protection

Description	Score	
Aquitard Thickness	Predominant Lithotype	
	Silt	Clay
<10 m	0	3
10 – 20 m	2	5
20 – 30 m	4	7
30 – 40 m	4	10
> 40 m	7	15

Description	Score
Depth to Aquifer from Surface	
<30 m	0
30 – 45 m	2
45 – 60 m	3
>60 m	4

Confidence Level in Interpreted Hydrostratigraphy

Geological and hydrogeological conditions at each site have been interpreted based on a comprehensive review of available databases and the YPDT Model of the Nobleton Area, and are largely built on data sourced from MECP water well records. The degree of reliability and accuracy of the interpreted conditions is directly proportional with the density of well records near each target location. Since much of the interpreted hydrostratigraphy is derived from modelling results, areas where there is a higher density of deep drilling records (ones which extend through the target aquifer) can result in higher confidence that the target aquifer is present at the expected location and depth. The criteria used to assess the target locations is provided in **Table 6**.

Table 6. Scoring System for Confidence in Interpreted Hydrostratigraphy

Description	Score
No water well records within target aquifer within 100 m	1
<2 water well records within target aquifer within 100 m	2
2 – 5 water well records within target aquifer within 100 m	4
>5 water well records within target aquifer within 100 m	6

Well Interference

Well interference is defined as the combined drawdown effect which results from multiple wells pumping simultaneously from a single confined aquifer. This leads to a reduction in available drawdown, such that the resulting water supply is depleted and no longer adequate to support economic supply. Depending on the properties of the target aquifer, the potential for well interference increases with the number of municipal or domestic wells completed within the target aquifer in close proximity to the proposed well site. An ideal location would therefore be in an aquifer with the capacity to sustain multiple supply wells, or be a reasonable distance from other active water supply wells which are screened in the same unit.

The magnitude of potential domestic well interference for each site location was evaluated based on their proximity to other active water wells, and the screened aquifer units. The criteria used to rank each location based on the potential well interference is included in **Table 7**. Note that field verification is required to determine if the aquifer in each location has capacity to sustain multiple wells.

Table 7. Scoring System for Potential Well Interference

Description	Score
1+ municipal well within target aquifer within 500 m radius	1
> 10 domestic wells within target aquifer within 500 m radius	3
5 - 10 domestic wells within target aquifer within 500 m radius	7
< 5 domestic wells within target aquifer within 500 m radius	10

3.1.1.2 Logistics and Engineering Feasibility

The feasibility of drilling and constructing a new well at a particular site is significantly dependant on a number of logistical and engineering factors. The site should have access to electrical power, but not be directly under overhead power lines which could restrict access. The site should also have access to a storm drain, watercourse and/or roadside ditch for directing discharge volumes during well drilling, and to a sanitary or storm sewer during well operation (i.e. flushing). The site must be accessible for drilling and future maintenance and allow for sufficient space to construct treatment facilities as necessary. Site accessibility and feasibility was assessed by Palmer staff members through a site visit conducted to each potential location on November 2, 2018. The results of this visit are described in **Section 3.1.3.2**.

In addition, it is important to consider the overall potential cost of infrastructure and project duration. This is primarily driven by the proximity to the Region's or Township's existing water supply lines which controls the construction duration, costs and permitting requirements. Property ownership was also a large consideration as this can impact costs for land procurement and overall project duration.

Potential short-term environmental impacts related to the construction and hydraulic testing of a new water supply well was also considered. Local factors such as air quality, noise disturbances, and traffic restrictions were considered based on the number and proximity of residents to the proposed sites, and the location of the target site relative to the road. The criteria adopted by Palmer to assign scoring for each location are summarized in **Table 8**.

Table 8. Scoring System for Logistics and Engineering Feasibility

Description	Score
Drilling Rig Accessibility	
Direct accessibility with drilling equipment / maintenance trucks	4
Minimal work required to gain access with drilling equipment / maintenance trucks	2
Major work required to access the proposed drilling location	0
Distance from Existing Water Supply Lines	
< 500 m	9
500 m – 1,000 m	6
1,000 m – 2,000 m	3
> 2,000 m	0
Groundwater Discharge during Well Drilling	
Presence of watercourse/sanitary sewer within 300 m	1
Vacant field (privately owned)	0
Paved area and no watercourse or sanitary sewer within 300 m	
Groundwater Discharge during Well Operation	
Presence of sanitary sewer within 500 m	2
No sanitary sewer within 500 m	0
Land Availability	
Land available and owned by York Region	7
Township / Developer area available to construct well infrastructure	3
Private Land	0
Short Term Impacts	
No residential properties within 300 m radius	2
Presence of residential properties within 300 m radius	1

Description	Score
Presence of school / hospital within 300 m radius	0
Total Maximum Score	**25**

3.1.1.3 Applicable Policies and Regulations

Land use policies and regulations were considered in the weighted criteria as these may pose complications and delays in the ultimate completion of the production well. Interaction with the natural environment and the defined Natural Heritage System (NHS) takes into consideration the location of land use policy areas such as the ORM Planning Boundary, Greenbelt Planning Boundary, existing Source Water Protection (SWP) areas (i.e. WHPA), and Natural Heritage Areas (i.e. Provincially Significant Wetlands (PSW) and Areas of Natural and Scientific Interest (ANSI)), relative to the proposed well site.

The applicable policies and regulations are described below.

Oak Ridges Moraine Planning Boundary

The Oak Ridges Moraine (ORM) is a regional topographical landform characterized as a linear, high elevation ridge of hummocky topography. The ORM is north of the Greater Toronto Area (GTA) and runs roughly east to west. The ORM plays a significant hydrogeological role in controlling groundwater conditions throughout Southern Ontario.

In 2001, the Province of Ontario established the *Oak Ridges Moraine Conservation Act* and associated *Oak Ridges Moraine Conservation Plan (ORMCP)*. As the ORMCP prevails over municipal official plans, municipal planning decisions are required to conform to the ORMCP. Three land use designations within the ORM are defined under the ORMCP, which also fall within the study area boundary: Natural Core Areas, Natural Linkage Areas, and Settlement Areas.

Natural Core Areas have been established to protect lands which are critical to maintaining the integrity of the moraine. These areas include those which contain the greatest concentrations of key natural heritage features (i.e., wetlands, significant habitat, ANSI's and significant valleylands, woodlands, etc.), hydrogeologically sensitive features (i.e., streams, wetlands, kettle lakes, seepage areas and springs), and/or landform conservation areas (i.e., steep sloped areas, kames, kettles, rivers, and ridges).

Natural Linkage Areas are identified to protect critical natural and open space linkages between the Natural Core Areas and along rivers and streams.

Settlement Areas are designated to regions of existing urban development and environmental protection uses. Environmental protection uses are defined as lands which are outside of designated Natural Core Areas and contain environmental features to be protected and/or enhanced. Uses permitted in these areas are limited, and only include conservation, non-motorized trails, and legally existing uses.

Greenbelt Planning Boundary

The Greenbelt Plan (2017) was prepared and approved under the Greenbelt Act (2005) and was designed to enhance urban and rural areas and overall quality of life by promoting environmental protection strategies and promote a strong rural economy within areas designated as Protected Countryside. Under this policy, the planning, design, and construction of infrastructure for water servicing

should be carried out in accordance with the policies in Subsection 3.2.6 of the Greater Golden Horseshoe Growth Plan (2017).

Note that as all lands within the Nobleton area are within designated Protected Countryside, this component of the policy and regulation criteria does not impact the overall ranking of the well site locations. For this reason it was removed from the overall scoring.

Risk Management

Source Protection Plan policies under the *Clean Water Act (2006)* defines land use activities and restrictions for specified regions, including Wellhead Protection Areas (WHPA). Wellhead Protection Areas (WHPA) are areas delineated around existing municipal supply wells to identify zones where groundwater leading to these wells are susceptible to contamination. These zones are divided into four categories, WHPA-A to WHPA-D, based on the distance or estimated time of travel for groundwater to reach the well.

Various risk management related land use policies and restrictions are applicable to actions permitted within WHPA-A to WHPA-D, and are dependent on the assigned vulnerability scoring of each WHPA. The highest degree of policy is assigned to activities (existing and future) within WHPA-A and WHPA-B with a vulnerability score of 10. These include, but are not limited to, potential restrictions or the requirement to develop a Risk Management Plan (RMP) for the application, storage and/or handling of agricultural source material, non-agricultural source material, untreated septage, the storage of snow, the manufacturing, handing, and/or storage of organic solvents, fuels, and dense non-aqueous phase liquid (DNAPLS) and the application of road salt on private roadways, parking lots, and pedestrian walkways. The *Clean Water Act* (2006) also requires that any proposed land development application or change in activity which coincides with the designated WHPA-A, B, and/or C lands obtain a Source Water Protection Permit (Schedule 59 Notice) outlining a RMP. Therefore, candidate target well locations within the existing WHPA-A, B, or C areas are assigned a higher score, as there will be less potential for changes to the existing policies and restrictions, which will benefit existing and future business owners.

The future and proposed land uses near each target area were also considered in the weighted criteria by comparing the proposed land use for the Community of Nobleton, as defined by the Schedule A Combined Zoning By-Law for the Nobleton Urban Area (2016), with the WHPA-A area for each target location (100 m buffer), to evaluate the resulting restricted activities in each location. As the vulnerability scoring of the WHPA-B of the existing supply wells is 6, future and existing activities within WHPA-B do not trigger significant land use and activity restrictions.

Target locations which have a WHPA-A that intersects proposed industrial or commercial areas are assigned a lower ranking compared with locations which have a WHPA-A that intersects proposed residential areas, as the associated restricted activities within the WHPA-A could impact industrial activities to a greater degree than residential activities.

Natural Heritage Areas/Species at Risk Habitat

The *Provincial Policy Statement (2014)* issued under Section 3 of the *Planning Act* requires that natural features and areas are protected in the long term, such that the diversity, connectivity, ecological function and biodiversity of these features are maintained, restored, and/or improved. In addition, the

Conservation Authorities Act (1990) was implemented to promote the conservation, restoration, development, and management of natural resources and watersheds in the Province of Ontario, and prohibits certain activities within wetland features. The protection of natural features such as coldwater creeks, wetlands, critical habitats, sensitive species, and/or other biological resources was therefore considered in this assessment.

The *Endangered Species Act (2007)* was designed for protection of species and habitat which are identified as endangered or threatened. The act sets out timelines for producing strategies and plans to recover at-risk species, tools to help reduce the impact of human activity on species, and tools to encourage protection and recovery activity. Plants and animals are provided with automatic protection from harm or harassment if they are classified as being endangered, threatened, or extirpated.

The selected target locations were additionally assessed for their potential to interfere with known suitable habitat and occurrence for Species at Risk (SAR). This assessment takes into consideration the potential for the installation of water supply infrastructure to connect to existing lines to each target location to cross through potential SAR habitat. Well site locations which indicate potential crossings into SAR habitat are scored lower, as these locations can incur delays and additional costs due to construction timing windows and obtaining the necessary permitting.

The magnitude of the potential for adverse impacts related to the ORM Planning Boundary, Greenbelt Planning Boundary, Risk Management, Natural Heritage Areas (i.e., PSW and ANSI), and areas of known SAR near to the proposed well sites was evaluated using the scoring system provided in **Table 9**.

Table 9. Scoring System for Applicable Policy and Regulations

Description	Score
Oak Ridges Moraine (ORM) Planning Boundary	
Within Natural Core Area and Countryside Area	0
Inside Settlement Area and Natural Linkage Area	1
Within 300 meter buffer from Natural Core Area and Countryside Area	
Outside Settlement Area and Natural Linkage Area	2
More than 300 meters from Natural Core Area and Countryside Area	
Future and Proposed Land Use	
Industrial/commercial lands inside of future potential WHPA-A	0
Industrial/commercial lands outside of future potential WHPA-A	2
Risk Management	
Outside existing WHPA-A to C and >2 contamination risks within 100 m	1
Outside existing WHPA-A to C and 2 contamination risks within 100 m	2
Outside existing WHPA-A to C and 1 contamination risk within 100 m	3
Inside existing WHPA-A to C (subject to existing source protection plan policy)	4
Natural Heritage Areas/Species at Risk Habitat	
Within 100 meter buffer of Provincially Significant Wetland	0
Within Non-Provincially Significant Wetland	
Species at Risk Habitat Crossing	
Within 100 to 300 meter buffer from Provincially Significant Wetland	1
Within 100 meter buffer from Non-Provincially Significant Wetland	
Outside 300 meter buffer from Provincially Significant Wetland	2
Outside 100 meter buffer from Non-Provincially Significant Wetland	

Description	Score
Total Maximum Score	**10**

3.1.2 Selection of Long-Listed Areas

Based on the site selection criteria described above, a long-list of eight (8) potential areas were identified and evaluated against the selection criteria to develop a short list of the two (2) most preferred alternative site areas for a new production well. The location of the long-listed sites is presented on **Figure 8**.

The initial long-list was produced primarily on a high-level review of applicable geology and hydrogeology data. The complete list of data reviewed for this portion of the study is provided in **Section 3.1**, and includes information on borehole stratigraphy, known well yields, hydraulic conductivity, aquifer and aquitard thickness, groundwater levels, water quality, and nearby water taking data. Note that while the data provided is extensive, interpolation and extrapolation of hydrogeological data was required in areas where the density of data was sparse.

Generally, the long-listed potential areas were selected based on sites where aquifer yield was identified to be high through both the regional YPDT model and measured yield testing on nearby MECP water well records. Areas were also located outside of key policy areas, while staying within a reasonable distance from existing water supply lines.

The location of each long-listed area is provided on a series of figures spanning **Figures 9** to **21** to demonstrate how each alternative location fits within the site screening criteria. A summary of the evaluation criteria demonstrated by figure is listed below. The alternative evaluation and scoring is presented on **Table 10**.

Figure 9 – Scarborough Aquifer Thickness

Figure 10 – Scarborough Aquifer Transmissivity

Figure 11 – Sunnybrook Drift Aquitard Thickness

Figure 12 – Well Interference (MECP Water Well Records)

Figures 13 – 15 – Hydrostratigraphic Cross Sections (A-A', B-B', C-C')

Figure 16 – Proximity to Sanitary Sewer Lines

Figure 17 – Proximity to Water Supply Lines

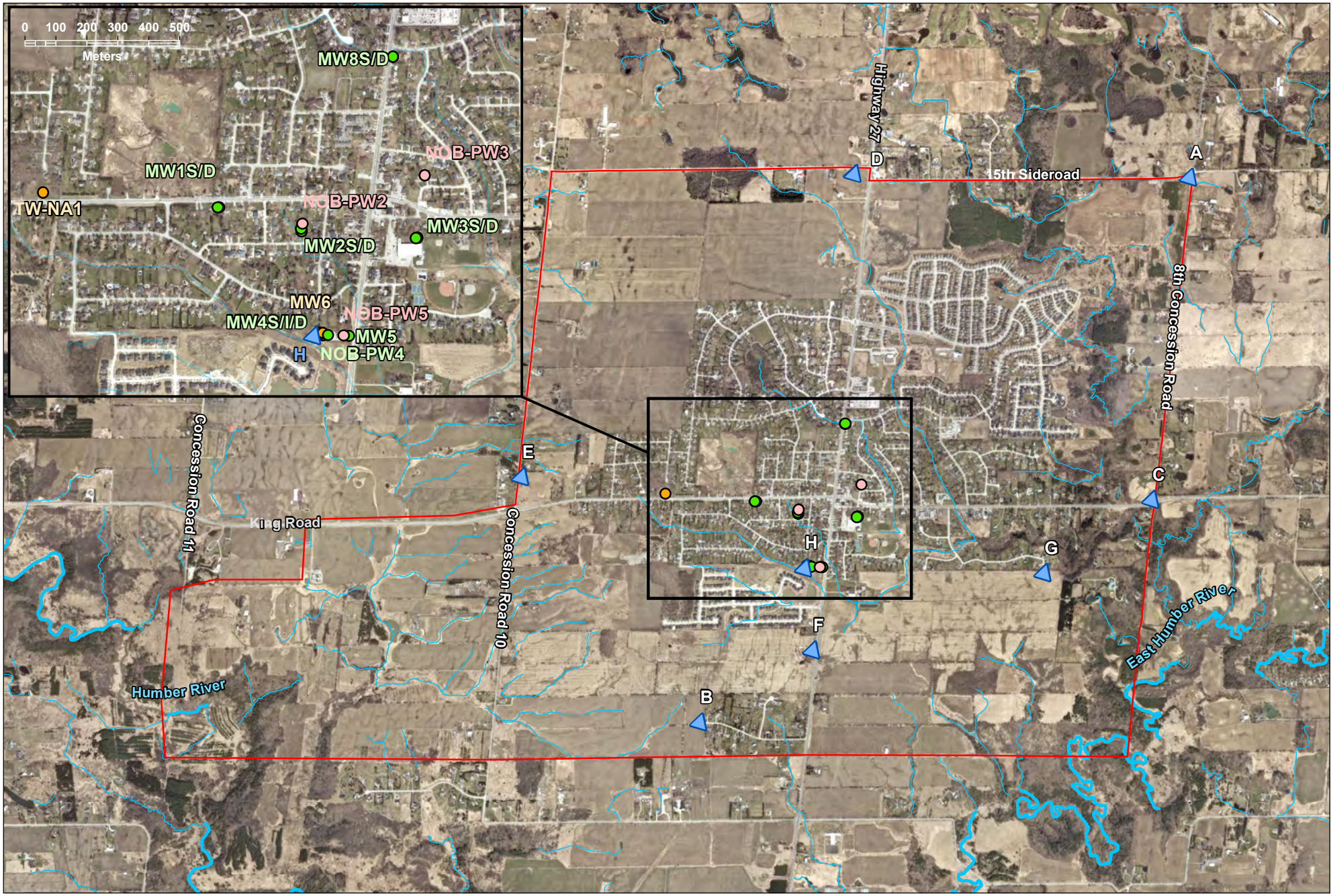
Figure 18 – Oak Ridges Moraine Planning Boundary

Figure 19 – Risk Management

Figure 20 – Natural Heritage Areas / SAR

Figure 21 – Land Use

A description of each long-listed potential well site is provided in the following section. All well sites have a 500 m search radius surrounding them, with the exception of Well Site D and Well Site H, which are limited to the York Region property line boundary of the selected parcels (as shown on **Figure 8**).



Prepared By

Palmer

CLIENT: The Regional Municipality of York
PROJECT: Nobleton Supply Well

0 200 400 600 800
metres

N

DRAWN: S. Feist
CHECKED: C. Hanlon
PROJECT: 170462
DATE: May 22, 2019

Scale 1:32000
UTM Zone 17N
NAD1 983

Legend

- Study Area
- Watercourse
- PECG Target Locations
- Supply Wells

Monitoring Well Status

- Abandoned
- Monitoring Well

York Region

DRAFT

Target Well Area Locations

FIGURE 8

Document Path: C:\Egnyte\Shared\Projects\Active\17046 - Black &V eatch\170462 - Nobleton Supply Well\2. Background Assessment\PECG data\Mapping\mxd\170462_Fig8_Target Well Area Locations.mxd

3.1.2.1 Well Site A

The center point of Well Site A is located near the northeast corner of the study area along 15th Sideroad, approximately 720 m east of Concession Road 8. Based on the results of the regional model and MECP well records, it is anticipated that the thickness of the Scarborough Aquifer is approximately 36 m, and the transmissivity is greater than 1,000 m^2/day. This was supported through several records of artesian conditions and high yield supply wells identified in this area. The depth of the Scarborough Aquifer is approximately 109 m from surface, and the overlying Sunnybrook Drift is expected to be approximately 13 m thick, providing adequate protection from potential surface contamination.

This location is outside of the existing WHPAs for NOB-PW2, NOB-PW3, and NOB-PW5, and is approximately 2 km east of the Nobleton Water Tower at 15th Sideroad and Highway 27. Within a 500 m radius, 2 domestic supply wells are present screened within the Scarborough Aquifer and 3 within the Thorncliffe Aquifer. This location is approximately 275 m northeast of the Black Duck Provincially Significant Wetland Complex and is within a designated Settlement Area of the ORM Planning Boundary. The land use in this area is designated as rural based on the 2003 Regional Official Plan and is presently privately owned.

3.1.2.2 Well Site B

The center point of Well Site B is located south of Nobleton, at the western end of Diana Drive. Here, the results of the YPDT model and MECP well records indicate that the thickness of the Scarborough Aquifer is 71 m, and the transmissivity is greater than 2,500 m^2/day, suggesting excellent potential for water supply from the aquifer. The depth of the Scarborough Aquifer is approximately 92 m from surface, and the overlying Sunnybrook Drift is expected to be approximately 21 m thick and extensive, indicating this area is well protected from potential contamination from surface.

This location is south of the existing WHPA for NOB-PW2, NOB-PW3, and NOB-PW5, and is outside of the ORM boundary. This area is currently reliant on private groundwater wells for potable water supply and is approximately 1,500 m from the York Region owned watermain pipelines at NOB-PW5. Within a 500 m radius, there are approximately 4 domestic supply wells screened within the Scarborough Aquifer and 7 within the Thorncliffe Aquifer, indicating there is some potential for well interference. The land use of this area has been designated as agricultural based on the 2003 Regional Official Plan and it is privately owned.

3.1.2.3 Well Site C

The center point of Well Site C is located approximately 2 km east of Nobleton's city center, at the intersection of King Road and Concession Road 8. Based on the YPDT model and MECP well records, the thickness of the Scarborough Aquifer is estimated to be 24 m and the transmissivity between approximately 100 – 500 m^2/day, indicating adequate water supply from the aquifer. The depth to the Scarborough Aquifer is approximately 97 m from surface, and the overlying Sunnybrook Drift is expected to be approximately 11 m thick.

This location is outside of the WHPA for NOB-PW2, NOB-PW3, and NOB-PW5, and outside of the ORM boundary. It is expected that the domestic supply wells are active in this area, and within a 500 m radius of the well site there are 3 that are screened within the Scarborough Aquifer and 5 that are screened in

shallower units (Thorncliffe Aquifer, Newmarket Till, or ORAC). This location is about 150 m from the East Humber River, and 300 m north of the East Humber River Wetland Complex. The land use has been designated as rural based on the 2003 Regional Official Plan, and the land is currently privately owned.

3.1.2.4 Well Site D

Well Site D is located within the York Region owned land parcel located at the intersection of Highway 27 and 15th Sideroad by the existing Nobleton Water Tower. This area was selected as it is already owned and operated by York Region, and also allows for direct access to York Region water supply lines. Based on the regional model, the thickness of the Scarborough Aquifer is approximately 6 m, and the transmissivity is between 50 – 75 m^2/day, indicating the groundwater yield may not be sufficient.

The potential for screening the Thorncliffe Aquifer was also considered in this area, as based on the regional model the transmissivity of the Thorncliffe is 122 m^2/day in this location, indicating good potential for water supply. However, screening a well within the Thorncliffe Aquifer may be associated with increased risk of contamination from surface due to the variability in geology of the overlying Newmarket Till aquitard, increased risk of well interference due to the higher number of active private wells screened within the unit, and increased risk that the aquifer yield may not be sustainable for long-term municipal pumping. The depth to the Thorncliffe Aquifer in this location is approximately 29 m from surface.

This area is within a designated Settlement Area of the Oak Ridges Moraine Planning Boundary, and is approximately 300 m from the Black Duck Provincially Significant Wetland Complex. In addition, it falls within the WHPA-D for the existing supply wells, and there is the potential for well interference as there are 2 wells screened within the Scarborough Aquifer and 16 screened in shallower units (Thorncliffe Aquifer, Newmarket Till, or ORAC) within a 500 m radius. It is likely that these wells are actively used for water supply as this area is just outside of the existing servicing area for water supply.

3.1.2.5 Well Site E

The center point of Well Site E is located west of Nobleton near the intersection of Concession Road 10 and King Road. Based on the results of the regional model and MECP well records, the thickness of the Scarborough Aquifer is expected to be approximately 36 m, and the transmissivity greater than 1,000 m^2/day, indicating good potential for sufficient water supply capacity. In addition, the depth of the Scarborough Aquifer is approximately 92 m below surface, and the overlying Sunnybrook Drift is expected to be approximately 43 m thick and extensive, providing adequate protection from potential surface contamination.

This location is also outside of the existing WHPA for NOB-PW2, NOB-PW3, and NOB-PW5, and within a 500 m radius there are approximately 4 domestic supply wells screened within the Scarborough Aquifer and 2 within the ORAC. This location is not near designated wetland complexes or ANSI, and is not within the ORM Planning Boundary. The land use in the area is designated as agricultural based on the 2003 Regional Official Plan and is currently privately owned.

3.1.2.6 Well Site F

The center point of Well Site F is located along Highway 27, approximately 950 m south of King Road. This area was selected due to the higher thickness of the Scarborough Aquifer shown in the regional

model and MECP well records (43 m), and high transmissivity (500 – 1,000 m^2/day). The depth of the Scarborough Aquifer is approximately 91 m from surface, and the overlying Sunnybrook Drift thickness is approximately 13 m and is extensive, such that should provide adequate protection from potential surface contamination.

This location is outside of the existing WHPA, while still being relatively close to the well field and water supply lines. Within a 500 m radius, there is approximately 1 well screened within the Scarborough Aquifer, and 9 wells screened in upper units (Thorncliffe, Newmarket, or ORAC). Despite this, the potential for well interference is low as this area of Nobleton is already serviced with municipal water, such that the nearby domestic wells are not active. The land use in the area is designated as agricultural based on the 2003 Regional Official Plan and it is currently owned by a land developer.

3.1.2.7 Well Site G

The center point of Well Site G is located within agricultural land near the east end of Woodhill Avenue. The YPDT model and MECP well records indicate that the thickness of the Scarborough Aquifer is approximately 42 m and the transmissivity is between 500 and 1,000 m^2/day, suggesting sufficient aquifer yield for water supply. The depth to the Scarborough Aquifer is approximately 96 m from surface, and the overlying Sunnybrook Drift is expected to be approximately 27 m thick, providing adequate protection from potential surface contamination. Note that aquitard may not be extensive in this area as the model also indicates a drastic decrease in thickness of the aquitard to the east.

This location is outside of the existing WHPA and ORM boundaries. The potential for well interference is also low as this area is serviced with municipal water supply. Within a 500 m radius, there are about 3 domestic supply wells screened within the Scarborough Aquifer and 16 screened within the shallower units (Thorncliffe, Newmarket, or ORAC). This location approximately 550 m northeast of the East Humber River Wetland Complex, and approximately 300 m west of the East Humber River. Land use in this area is designated future development in the 2016 Schedule A Combined Zoning By-law for the Nobleton Urban Area and is currently owned by a land developer.

3.1.2.8 Well Site H

Well Site H is located within the York Region owned parcel of land which contains NOB-PW5. Twinning of the existing water supply well at NOB-PW5 was considered a potential alternative as preliminary aquifer analysis by Palmer suggested that this area could potentially support additional water supply capacity but was limited by the well screen design of NOB-PW5 (information on the maximum well screen capacity was provided by York Region in an October 23, 2018 memorandum). In addition, there is a high level of confidence in the positional accuracy (i.e. depth and thickness) of the target aquifer and aquitard in this location as there are multiple wells installed within close proximity. These wells were installed and tested as part of the comprehensive groundwater and geology investigation completed for NOB-PW5 (MMM, 2007, 2012). Based on the reported results, the thickness of the Scarborough Aquifer is approximately 12.2 m thick, and the transmissivity is approximately 790 m^2/day. The depth to the Scarborough Aquifer is approximately 88 m from surface, and the overlying Sunnybrook drift is expected to be approximately 40 m thick, providing adequate protection from potential surface contamination. Note that aquitard may not be extensive in this area as the model also indicates a drastic decrease in thickness of the aquitard to the northeast.

This location is within the WHPA-A/B of the existing NOB-PW5 supply well, such that there is a potential of municipal well interference, however this provides the benefit of being adjacent to the existing well field infrastructure and supply lines. This also provides protection to the groundwater quality from future contamination threats as source protection policies are already in place within the existing WHPA-A to C. Within a 500 m radius, there are no domestic supply wells screened within the Scarborough Aquifer and 19 are screened within the shallower units (Thorncliffe, Newmarket, or ORAC). The land use in this area is designated as institutional in the 2016 Schedule A Combined Zoning By-law for the Nobleton Urban Area.

3.1.3 Short-Listed Areas

The summary of the overall scoring results for each location is provided in **Table 10**, and details of the results for each category and subcategory are described in the following sections.

3.1.3.1 Groundwater Resources

Groundwater Resources represents 65% of the overall scoring as it is considered the most significant category in selecting an appropriate location for a municipal supply well. The eight proposed target locations (A – H) were each assessed based on the predicted aquifer parameters (30%), level of water quality protection (19%), degree of confidence in the interpolated hydrostratigraphy (6%), and potential for well interference (10%). These parameters were determined using a combination of the York Region YPDT model, and MECP well record data to reinforce the modeled results. Preference was given to well sites which demonstrated strong results through both the regional model and the MECP well records.

Parameters of the Scarborough Aquifer as identified in the YPDT model, including aquifer thickness and transmissivity, are shown on **Figures 9 and 10**. Generally the aquifer thickness and transmissivity tends to increase towards the Laurentian Channel bedrock valleys located east and south of Nobleton (**Figure 4**). Well Sites A, B, F, and G were selected near to these valleys while remaining within the limits of the EA study area boundary in order to gain as much benefit from the high predicted aquifer yield as possible. Targeted areas were selected in locations where both the model and reported yields in the nearby MECP well records suggested good aquifer capacity, as this provided confidence and support to the model. Well Site C was selected even though the model indicated a thinner Scarborough Aquifer, as the MECP well records showed good well yields. Well Site E was selected as the regional model indicated a thick Scarborough Aquifer and Sunnybrook Drift, and MECP well records indicated reasonably high well yields. Well Site D was selected as it is located on York Region owned property, and indicated potential for high transmissivity within the Thorncliffe Aquifer. Well Site H was selected as it is within York Region owned property, and the hydrogeological investigations into the Scarborough Aquifer by MMM (2007, 2012) indicate the aquifer may have the potential to support multiple production wells at this location.

The depth of the Scarborough Aquifer and thickness of the overlying Sunnybrook Drift Aquitard was also considered in the assessment as it provides protection to the targeted Scarborough Aquifer from surface contamination. The thickness of the Sunnybrook Drift as identified on the York Region regional model database is shown on **Figure 11**. In an ideal location, the aquifer layer will be at an adequate depth, and the aquitard layer will be adequately thick, impermeable, and extensive. Preference was given to areas where these parameters were consistent between the modelled results and the MECP well records.

Three hydrogeological cross sections through the proposed target locations A – H were prepared based on stratigraphic descriptions in MECP well records. The locations of the MECP wells are provided on **Figure 12**, and the cross sections are provided on **Figures 13 – 15**. Results from the cross sections were used to estimate the thickness of the aquifer and aquitard units, and the modelled results were used to estimate the transmissivity of the aquifer in order to best represent the hydrogeological conditions at each location. Aquitard unit thickness was focused on the combined Newmarket Till and Sunnybrook Drift to provide a complete characterization of aquifer confinement. Locations where deep MECP well records are present within 100 m were assigned a higher score as the presence of these records adds confidence in the interpolated hydrogeological conditions.

A 500 m buffer was assigned to each target location to gauge the potential for well interference. Active domestic supply wells screened in the target aquifer (Scarborough or Thorncliffe) were identified, and each area was assigned a weighted score based on the number of wells within the buffer. Target areas which contain a municipal supply well were assigned the lowest score to reduce the possibility of interference effects and groundwater level drawdown resulting from over-pumping the target aquifer. **Figure 12** shows the locations of MECP well records relative to a 500 m radius of each target site location.

Scoring of the well sites accounted for discrepancies in the aquifer and aquitard thicknesses between the model and the well records, and results from the previous test wells drilled for the NOB-PW5 well investigation study. This was done by scoring the aquifer and aquitard thicknesses by using the smaller of the value provided in either the MECP well records or the regional model. For example, though the model indicated that the aquifer thickness at Well Site A is 36 m and the aquitard thickness is 37 m, the MECP well records suggest the thickness of the aquifer is approximately 51 m and the aquitard is approximately 13 m (**Figure 12 and 13**). Therefore, the aquifer thickness used for scoring was 36 m, and the aquitard thickness was 13 m. A reduced score was given to Well Site E due to its proximity to TW-NA1, which did not encounter the Scarborough Aquifer during drilling (MMM, 2007), and raises the potential for discrepancies between the model and the subsurface conditions at this location (**Figure 15**).

The results of the Groundwater Resources scoring suggest that Well Site F is best suited for groundwater supply, as it scored the highest with a score of 55 of the total possible 65. The transmissivity was estimated using the model to be between 500 and 1,000 m^2/day, and based on nearby well records and the results of the model, the aquifer thickness is approximately 43 m. The overlying Newmarket Till and Scarborough aquitards are predominately low permeability clay material and approximately 40 m thick. In addition, the potential for well interference is relatively low, as there are no existing municipal supply wells within 500 m. Of the 18 private water wells within 500 m, only three (3) are interpreted to be screened within the Scarborough Aquifer, and 15 screened in more shallow aquifers.

Well Site G had the second highest score for water resources with a score of 52 of the total possible 65. The transmissivity was estimated using the model at between 500 and 1,000 m^2/day, and based on nearby well records and the results of the model, the aquifer thickness is approximately 42 m. The overlying aquitard is predominately low permeability clay material and is approximately 46 m thick. In addition, the potential for well interference is relatively low, as there are no existing municipal supply wells within 500 m. There are 5 domestic supply wells present within 500 m screened within the Scarborough Aquifer, and 14 screened in more shallow aquifers. It likely that these wells are not currently active as this location is within the existing water servicing lines, further limited the potential for interference.

Table 10. Summary of Weighted Scoring Criteria for Target Locations A - H

1) Groundwater Resources

Aquifer Quantity						**Target Area**								
Transmissivity / Thickness	<10 m^2/day	10 - 100 m^2/day	100 - 500 m^2/day	500 - 1000 m^2/day	> 1000 m^2/day	**A**	**B**	**C**	**D-Scarborough**	**D-Thorncliffe**	**E**	**F**	**G**	**H**
<10 m	0	5	10	20	25				5					
10 - 20 m	0	5	10	20	25									20[3]
20 - 30 m	5	10	15	25	30			15[1]						
30 - 40 m	5	10	15	25	30	30[1]					15[2]			
> 40 m	5	10	20	25	30		30			20		25	25	

Aquifer Protection			**Target Areas**								
Aquitard Thickness	**Predominant lithotype: Silt**	**Predominant lithotype: Clay**	**A**	**B**	**C**	**D-Scarborough**	**D-Thorncliffe**	**E**	**F**	**G**	**H**
<10 meters	0	3									
10 - 20 meters	2	5	5[1]		5						
20 - 30 meters	4	7		7[1]		7[1]	4				
30 - 40 meters	4	10									
> 40 meters	7	15						15	15	15	15[3]

Depth to Aquifer from Surface	**Score**	**A**	**B**	**C**	**D-Scarborough**	**D-Thorncliffe**	**E**	**F**	**G**	**H**
<30 meters	0					0				
30 – 45 meters	2									
45 – 60 meters	3									
>60 meters	4	4	4	4	4		4	4	4	4[3]

Well Interference		**Target Areas**								
Description	**Score**	**A**	**B**	**C**	**D-Scarborough**	**D-Thorncliffe**	**E**	**F**	**G**	**H**
≥ 1 municipal well within target aquifer 500 m radius	1									1
> 10 domestic wells within target aquifer within 500 m radius	3					3				
5 - 10 domestic wells within target aquifer within 500 m radius	7	7	7		7				7	
< 5 domestic wells within 500 m radius	10			10			10	10		

Degree of Confidence in Interpolated Hydrostratigraphy		**Target Areas**								
Description	**Score**	**A**	**B**	**C**	**D-Scarborough**	**D-Thorncliffe**	**E**	**F**	**G**	**H**
No MECP WWR within target aquifer within 100 m	1	1	1	1	1		1	1	1	
<2 MECP WWR within target aquifer within 100 m	2									
2 – 5 MECP WWR within target aquifer within 100 m	4					4				
>5 MECP WWR within target aquifer within 100 m	6									6
Overall Score for Groundwater Resources (Maximum = 65)		**47**	**49**	**35**	**24**	**31**	**45**	**55**	**52**	**46**

2) Logistics and Engineering Feasibility

Rig Accessibility		**Target Areas**								
Description	**Score**	**A**	**B**	**C**	**D-Scarborough**	**D-Thorncliffe**	**E**	**F**	**G**	**H**
Direct accessibility for drilling equipment / maintenance trucks	4		4		4	4		4		4
Minimal work required to gain access	2	2		2			2		2	
Major work required to gain access	0									

Distance from water city's water supply lines		**Target Areas**								
Description	**Score**	**A**	**B**	**C**	**D-Scarborough**	**D-Thorncliffe**	**E**	**F**	**G**	**H**
≤ 500 meters	9				9	9		9		9
500 - 1000 meters	6						6		6	
1000 - 2000 meters	3		3	3						
≥ 2000 meters	0	0								

Groundwater Discharge during Well Drilling		**Target Areas**								
Description	**Score**	**A**	**B**	**C**	**D-Scarborough**	**D-Thorncliffe**	**E**	**F**	**G**	**H**
Presence of watercourse/sanitary sewer within 300 m	1	1	1	1	1	1	1	1	1	1
Vacant field (privately owned) / Paved area and no watercourse or sanitary sewer within 300 m	0									

Groundwater Discharge during Well Operation		**Target Areas**								
Description	**Score**	**A**	**B**	**C**	**D-Scarborough**	**D-Thorncliffe**	**E**	**F**	**G**	**H**
Presence of sanitary sewer within 500 m	2						2	2		2
No sanitary sewer within 500 m	0	0	0	0	0	0			0	

Land availability		**Target Areas**								
Description	**Score**	**A**	**B**	**C**	**D-Scarborough**	**D-Thorncliffe**	**E**	**F**	**G**	**H**
Land available and owned by York Region	7				7	7				7
Land owned by Township / Developer	3	3	3					3	3	
Private Land	0			0			0			

Short Term Impacts		**Target Areas**								
Description	**Score**	**A**	**B**	**C**	**D-Scarborough**	**D-Thorncliffe**	**E**	**F**	**G**	**H**
No residential properties within 300 meter radius	2									

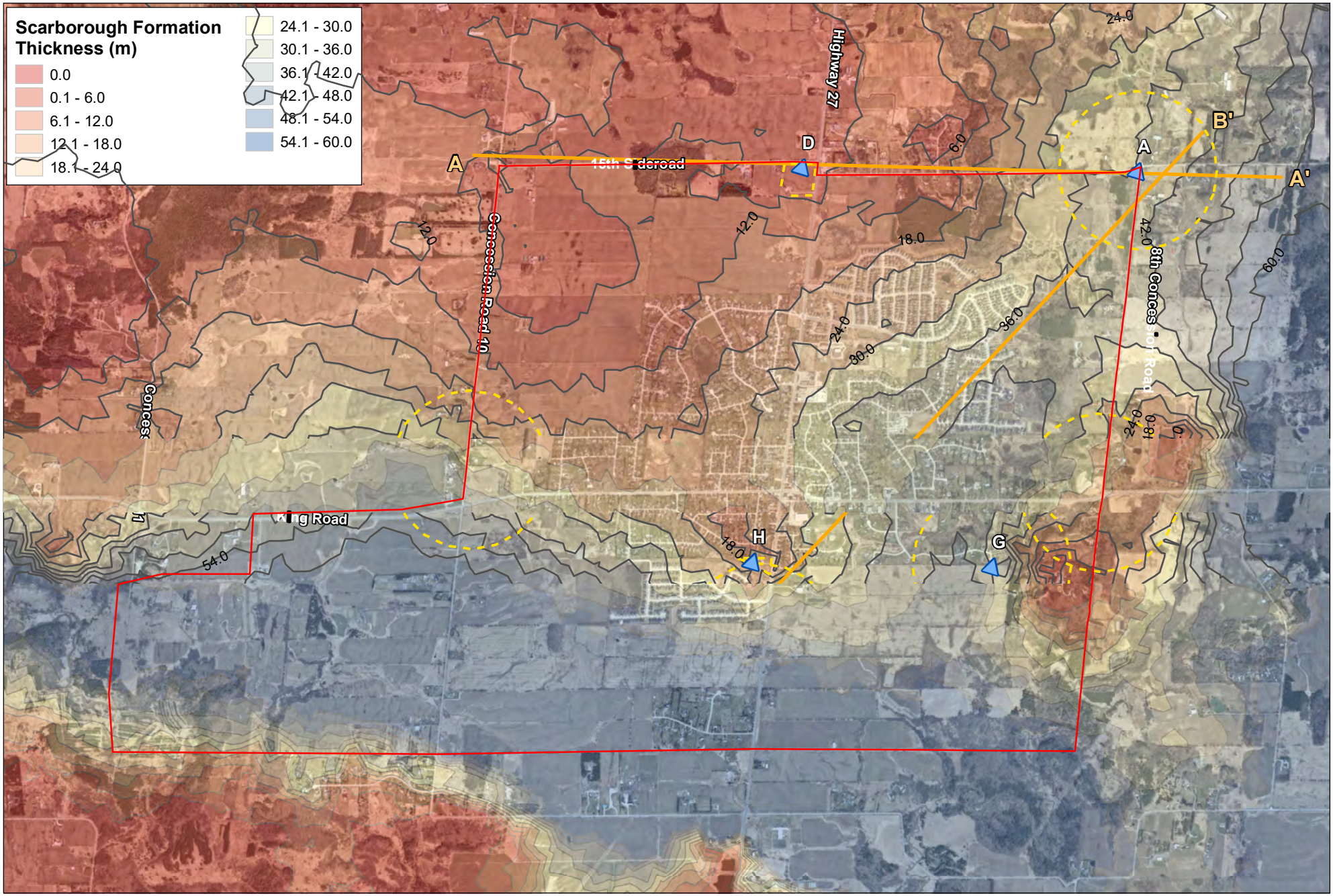
Presence of residential properties within 300 meter radius	1	1	1	1	1	1	1	1	1	1	1
Presence of school / hospital within 300 meter radius	0										
Overall Score for Engineering and Logistics (Maximum = 25)		**7**	**12**	**7**	**22**	**22**	**12**	**20**	**13**	**24**

3) Applicable Policies and Regulations

Oak Ridges Moraine (ORM)		**Target Areas**								
Description	**Score**	**A**	**B**	**C**	**D-Scarborough**	**D-Thorncliffe**	**E**	**F**	**G**	**H**
Within Natural Core Area and Countryside Area	0									
Inside Settlement Area and Natural Linkage Area	1	1			1	1				
Within 300 meter buffer from Natural Core Area and Countryside Area										
Outside Settlement Area and Natural Linkage Area	2		2	2			2	2	2	2
More than 300 meters from Natural Core Area and Countryside Area										
Risk Management		**Target Areas**								
Description	**Score**	**A**	**B**	**C**	**D-Scarborough**	**D-Thorncliffe**	**E**	**F**	**G**	**H**
Outside existing WHPA A to C and > 2 contamination risks within 100 m	1		1	1			1	1		
Outside existing WHPA A to C and 2 contamination risks within 100 m	2	2			2	2				
Outside existing WHPA A to C and ≤ 1 contamination risk within 100 m	3								3	
Inside existing WHPA A-C (subject to existing source protection plan policy)	4									4
Heritage Areas/Species at Risk Habitat		**Target Areas**								
Description	**Score**	**A**	**B**	**C**	**D-Scarborough**	**D-Thorncliffe**	**E**	**F**	**G**	**H**
Within 100 meter buffer of Provincially Significant Wetland	0	0	0	0				0	0	
Within Non-Provincially Significant Wetland										
Species at Risk Habitat Crossing										
Within 100 to 300 meter buffer from Provincially Significant Wetland	1				1	1				
Within 100 meter buffer from Non-Provincially Significant Wetland										
Outside 300 meter buffer from Provincially Significant Wetland	2						2			2
Outside 100 meter buffer from Non-Provincially Significant Wetland										
Existing and Proposed Land Use		**Target Areas**								
Description	**Score**	**A**	**B**	**C**	**D-Scarborough**	**D-Thorncliffe**	**E**	**F**	**G**	**H**
Industrial/commercial lands inside of future potential WHPA-A	0									
Industrial/commercial lands outside of future potential WHPA-A	2	2	2	2	2	2	2	2	2	2
Overall Score for Applicable Policies and Regulations (Maximum = 10)		**5**	**5**	**5**	**6**	**6**	**7**	**5**	**7**	**10**

Final Score (Maximum = 100)	**59**	**66**	**47**	**52**	**59**	**64**	**80**	**72**	**80**

[1] *Scoring affected by assigning the smaller reported thickness of the York Region regional model and the MECP well records*
[2] *Penalty of -15 assigned to account for poor drilling results at nearby TW-NA1*
[3] *Scoring based on drilling and testing results at NOB-PW5 well site (MMM, 2007, 2012)*



Prepared By

Palmer

CLIENT: The Regional Municipality of York
PROJECT: Nobleton Supply Well

0 200 400 600 800
metres

N

DRAWN: S. Feist
CHECKED: C. Hanlon
PROJECT: 170462
DATE: May 22, 2019

Scale 1:32000
UTM Zone 17N
NAD 1983

Legend

- Study Area
- PECG Target Locations
- Well Investigation Area
- Cross Sections

York Region

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Scarborough Aquifer Thickness (YPDT Model)

FIGURE 9

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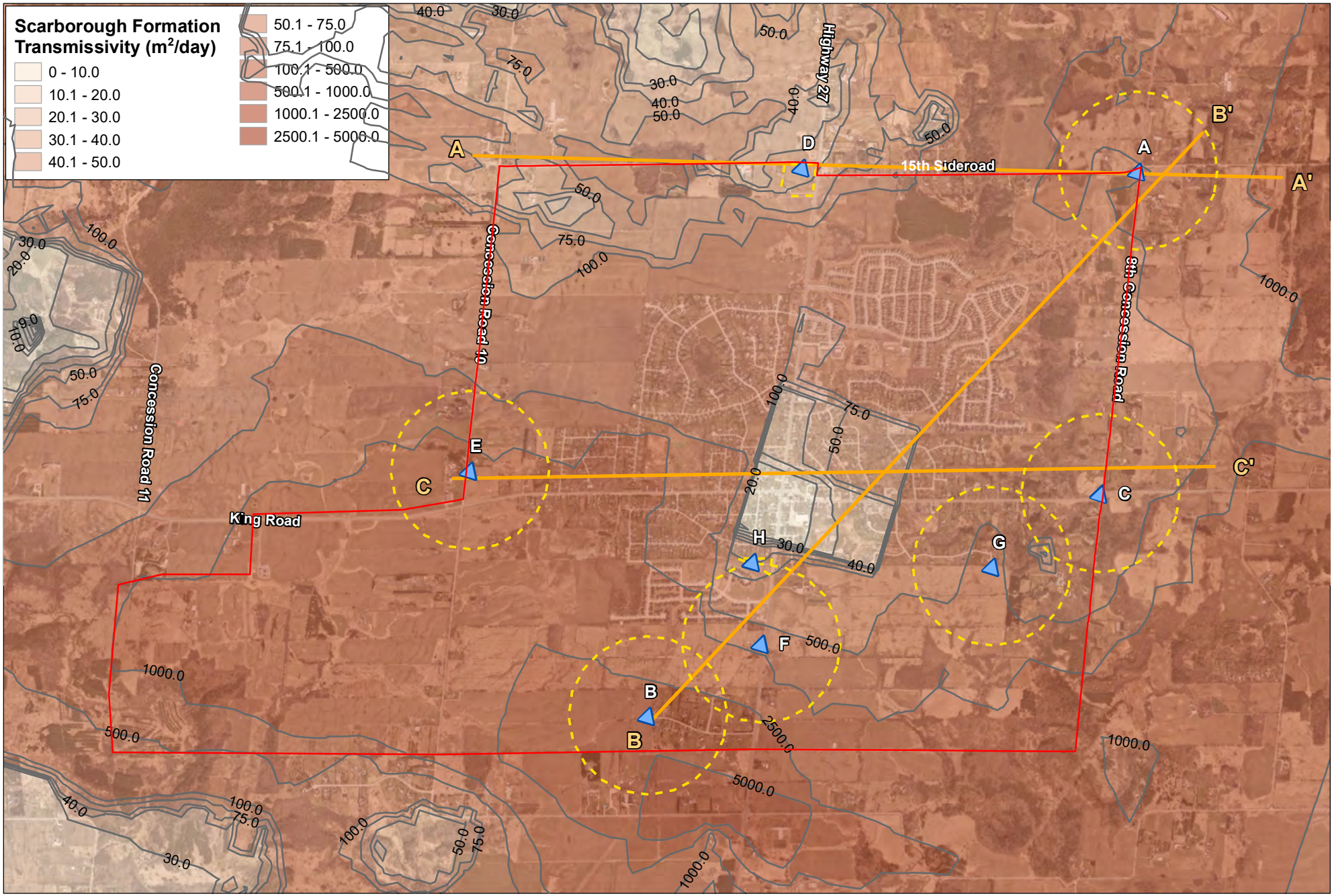

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PROJECT: Nobleton Supply Well

0 200 400 600 800
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N

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- Well Investigation Area
- Cross Sections

York Region

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Scarborough Aquifer Transmissivity (YPDT Model)

FIGURE 10

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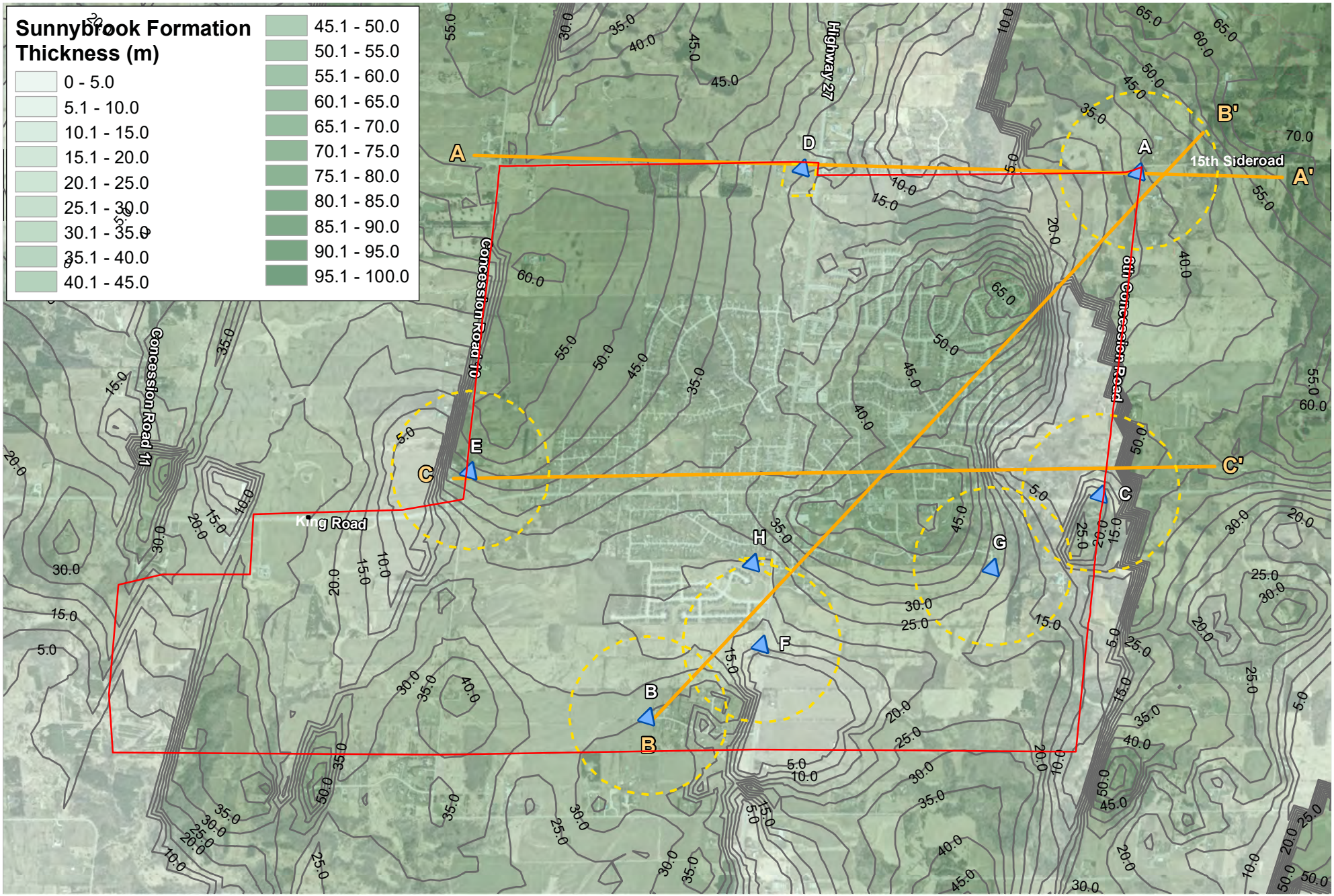

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PROJECT: Nobleton Supply Well

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PROJECT: 170462
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Scale 1:32000
UTM Zone 17N
NAD 1983

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- PECG Target Locations
- Well Investigation Area
- Cross Sections

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Sunnybrook Drift Aquitard Thickness (YPDT Model)

FIGURE 11

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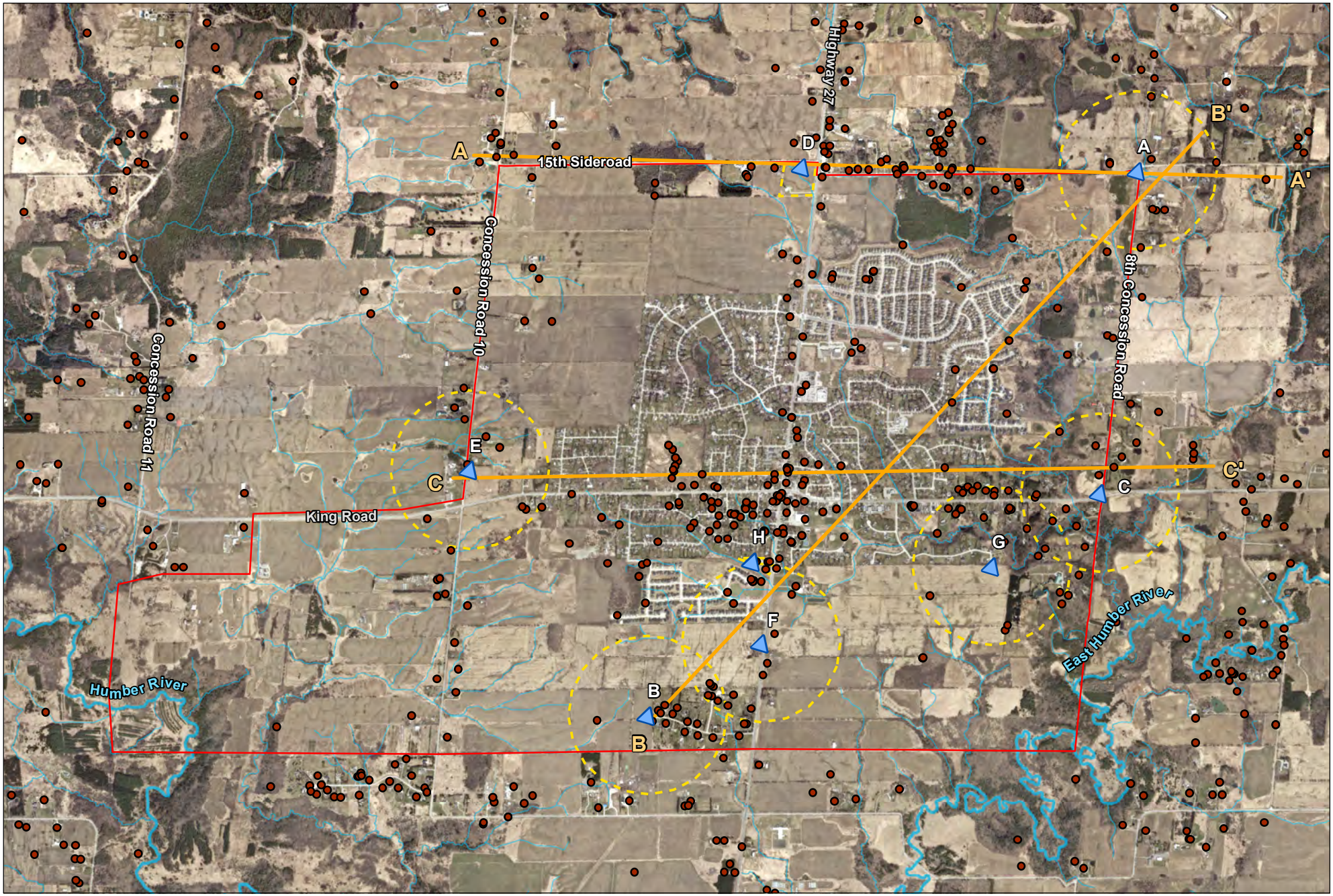

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PROJECT: Nobleton Supply Well

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metres

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CHECKED: C. Hanlon
PROJECT: 170462
DATE: May 22, 2019

Scale 1:32000
UTM Zone 17N
NAD1 983

Legend

- Study Area
- PECG Target Locations
- MECP Well
- Cross Sections
- Well Investigation Area
- Watercourse

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Ministry of Environment, Conservation and Parks (MECP) Well Records

FIGURE 12

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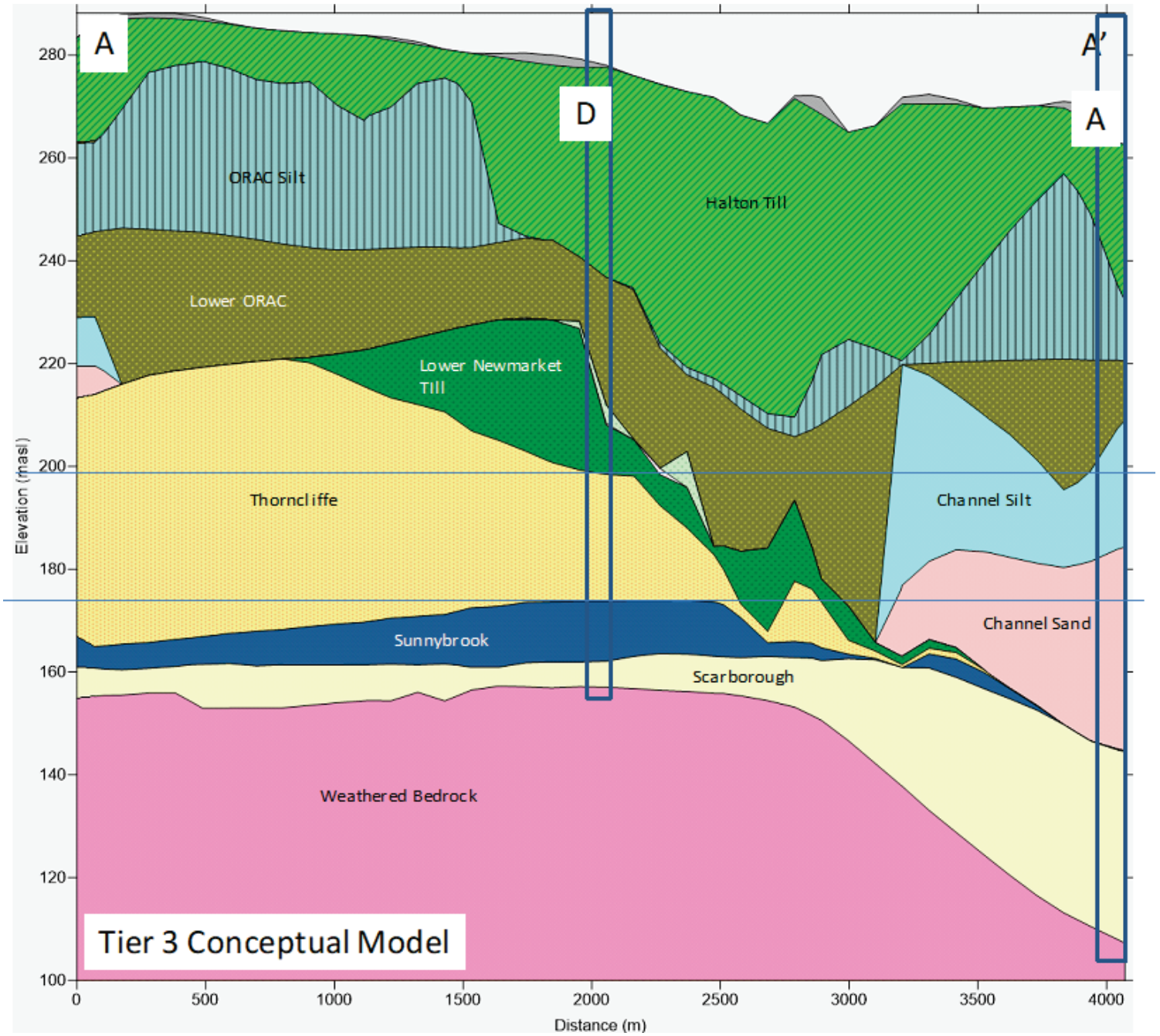

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DATE: Sep 27, 2019
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PROJECT:
Nobleton Supply Well

TITLE:
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Tier 3 Conceptual Model

Figure 13

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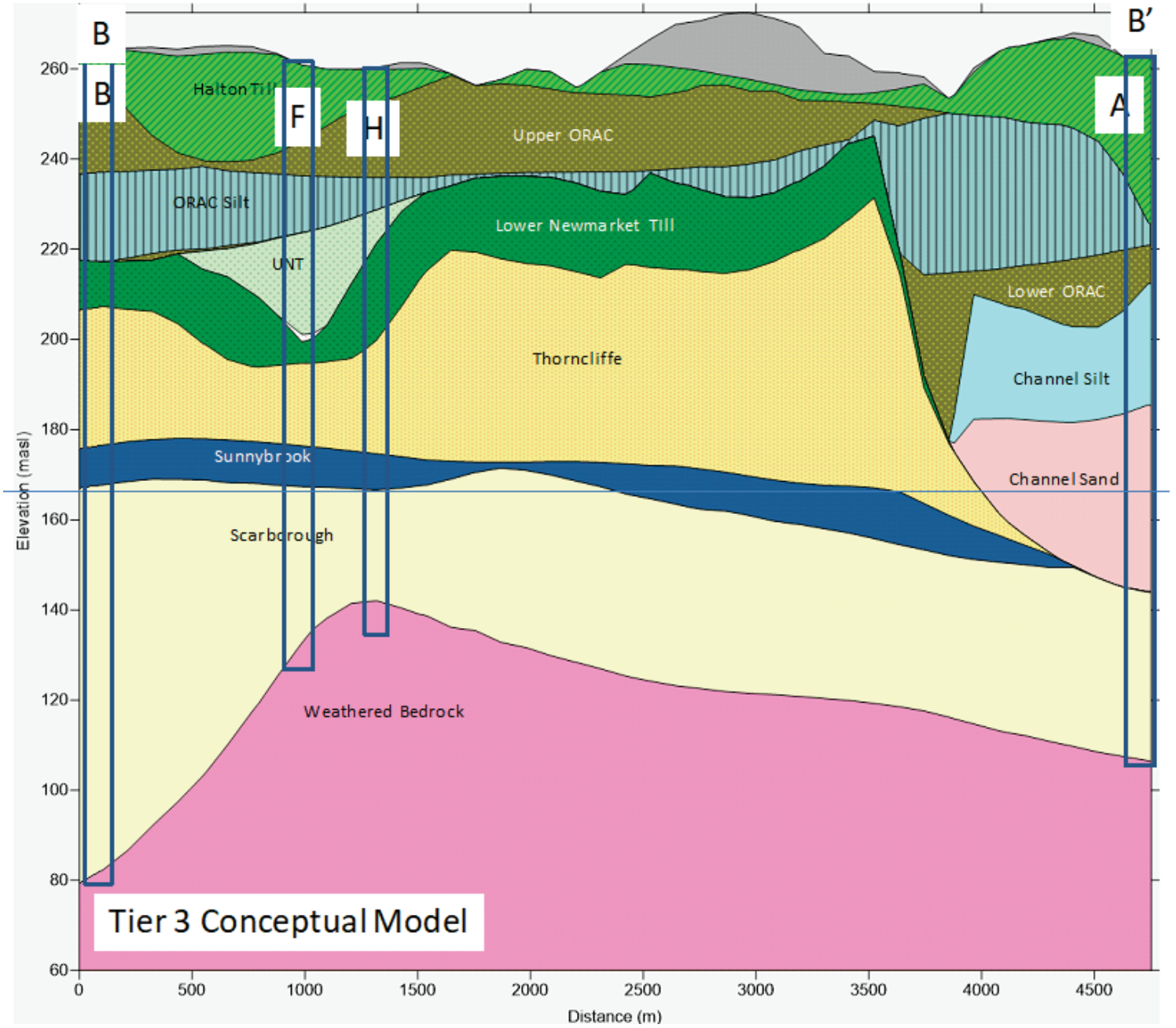

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PROJECT:
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Tier 3 Conceptual Model

Figure 14

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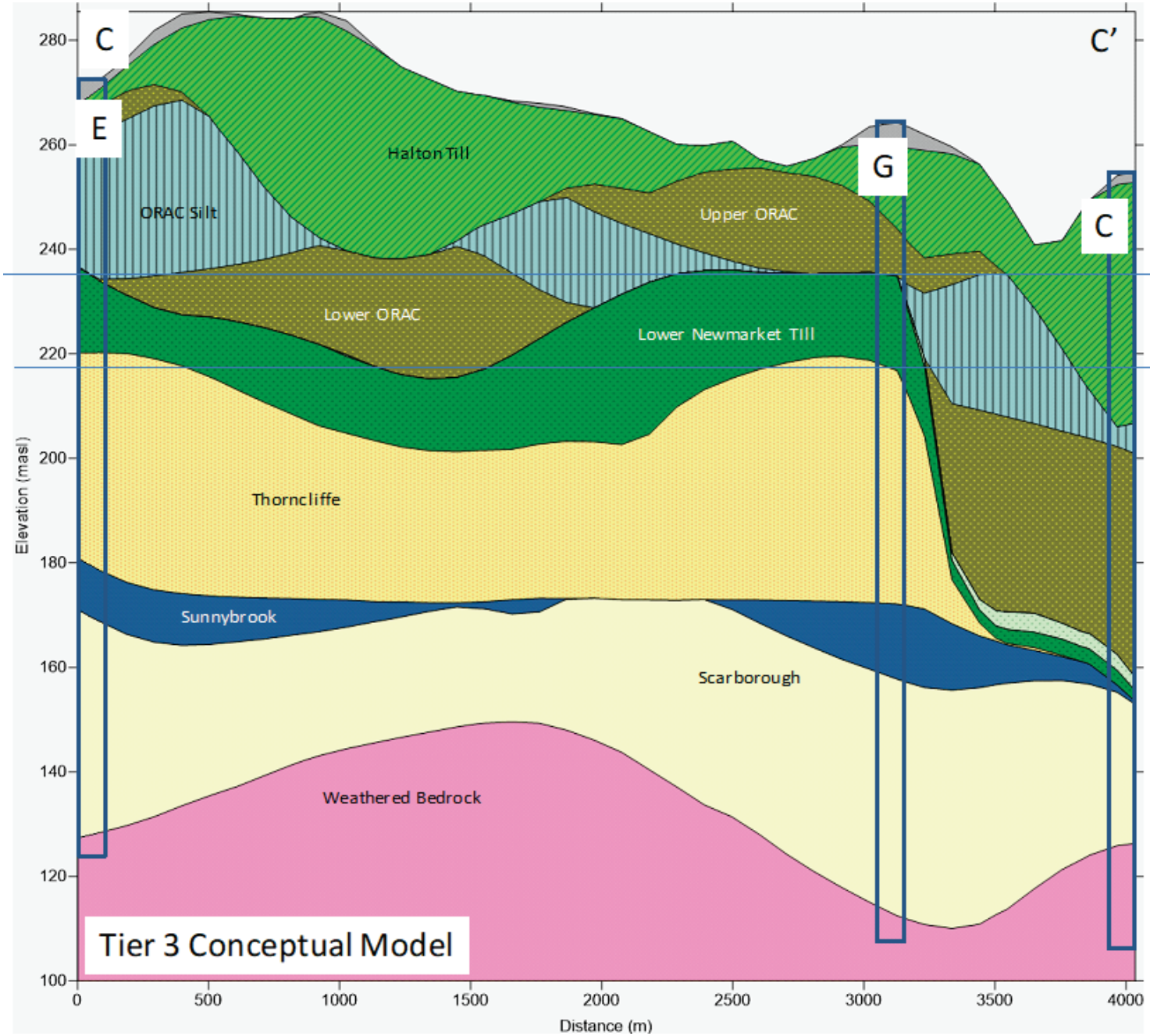

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7, 2019
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PROJECT:
Nobleton Supply Well

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Tier 3 Conceptual Model

Figure 15

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The highest degree of confidence in encountering suitable aquifer/ aquitard conditions was assigned to Well Site H, as it is within the existing NOB-PW5 supply well site and consists of shallow, intermediate, and deeply screened monitoring wells. Based on the results of the site-specific drilling and hydraulic testing investigation for NOB-PW5, the transmissivity of the aquifer is approximately 790 m^2/day, the aquifer thickness is approximately 12 m, and the aquitard thickness is approximately 40 m.

3.1.3.2 Engineering and Logistics Feasibility

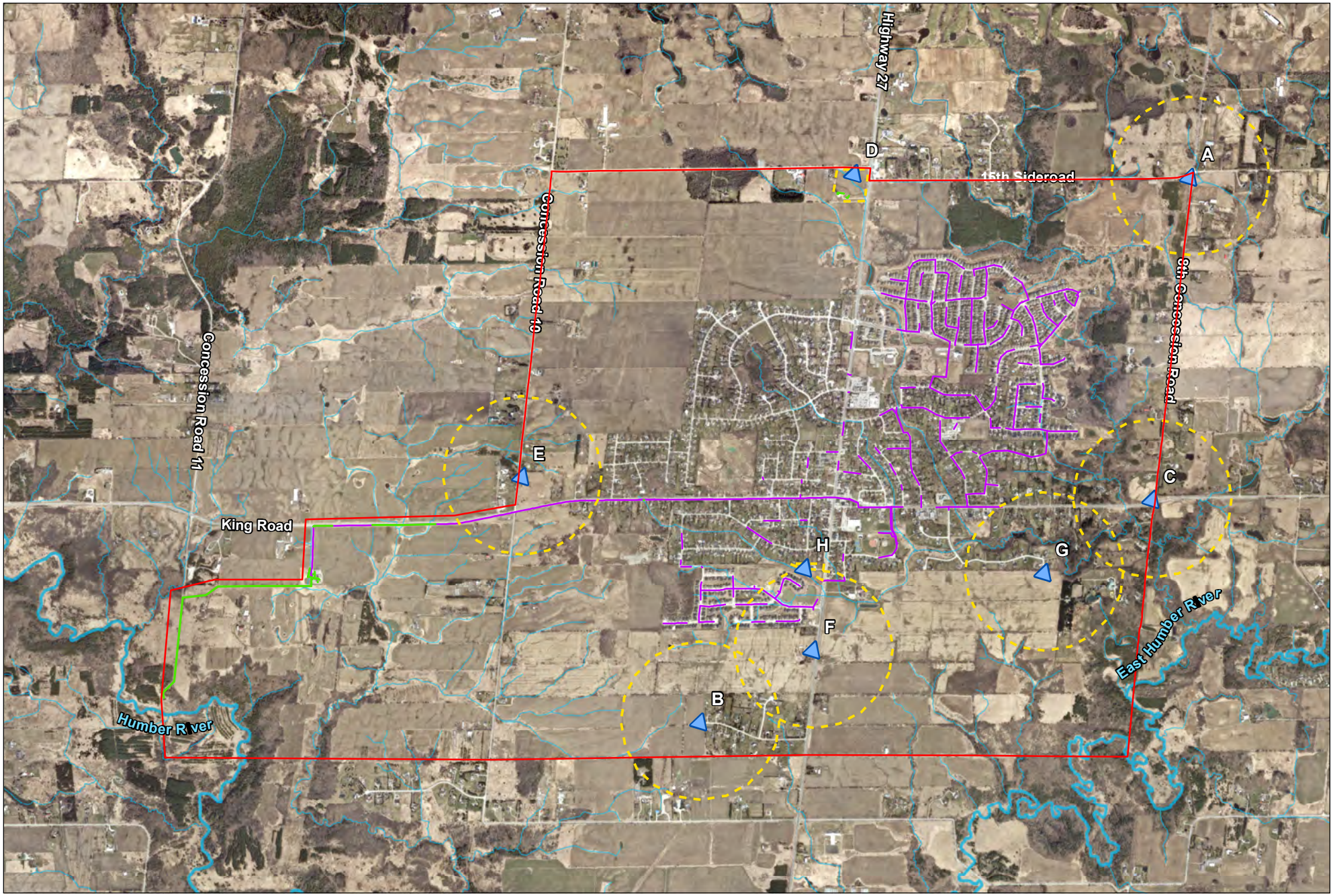
Engineering and Logistics represents 25% of the overall scoring. The eight proposed target locations (A – H) were each assessed based on the distance from the existing water supply lines (9%), property ownership (7%), site accessibility (4%), groundwater discharge management (3%), and potential short-term impacts (2%). These parameters were determined through a combination of the York Region regional model database results, site visits, and consultation with York Region.

Site visits to each target location were conducted on November 2, 2018 to assess the accessibility of the sites and identify potential groundwater discharge locations. The accessibility of each site considered the space requirements for drilling and construction of the well, accommodating long-term maintenance equipment, and ease of access for extended monitoring. Conditions such as slope, fencing, treed areas, overhead wires, wetlands, and road access were considered. Generally, all sites indicated reasonably good access with either minimal or no work required. Examples of work required include fencing and tree branch removal or applying mats in areas of uneven terrain or rig mats in areas prone to mud.

Potential locations for directing groundwater discharge were also investigated for receptors for discharge during drilling and operation of the well, and included road side ditching, sanitary sewers, and nearby watercourses. The size of each potential receptor was noted, as receptors should be sized to accommodate an additional 5 – 60 L/sec to the existing flows, and have remaining capacity for potential precipitation events. Based on both the site visit observations and a desktop review of the areas, all sites have good access to either road side ditching equipped with culverts, or a watercourse within 300 m for directing discharge during drilling and testing. Based on the anticipated volume requirements, it is expected that these receptors are appropriately sized for successful discharge during drilling and testing phases. The location of the sanitary sewer pipelines within Nobleton are shown on **Figure 16** as these can potentially be used for directing discharge during the operation of the well.

The distance to the existing water supply lines is shown on **Figure 17**. As this can significantly influence project costs and delays this category was assigned an overall weight of 9%. Based on the results of the scoring, Well Site D, F and H are the preferred locations as they are nearest to the existing lines. Area D is located directly within municipally owned land near the Nobleton Water Tower, and Area H is within the municipally owned NOB-PW5 well site, so they are both easily accessible by the region and the water supply lines are property of York Region. Area F requires minimal watermain pipe construction to connect it to the existing lines as it is located a short distance south of the watermain connecting to Oliver Emerson Ave and NOB-PW5, which are owned by York Region.

Existing land ownership was reviewed as additional logistics may be required by York Region to gain permission to construct the supply well. Based on review of land ownership in the Nobleton Area, Well Sites D and H are the most feasible as they are located within land already owned by York Region. Sites A, B, F, and G are within land owned by developers, and Sites C and E are within private land.



Prepared By

Palmer

CLIENT: The Regional Municipality of York
PROJECT: Nobleton Supply Well

0 200 400 600 800
metres

N

DRAWN: S. Feist
CHECKED: C. Hanlon
PROJECT: 170462
DATE: May 22, 2019

Scale 1:32000
UTM Zone 17N
NAD1 983

Legend

- Study Area
- PECG Target Locations
- Well Investigation Area
- Watercourse

Sanitary Sewer Ownership

- Township of King
- York Region

York Region

DRAFT

Sanitary Sewer Lines

FIGURE 16

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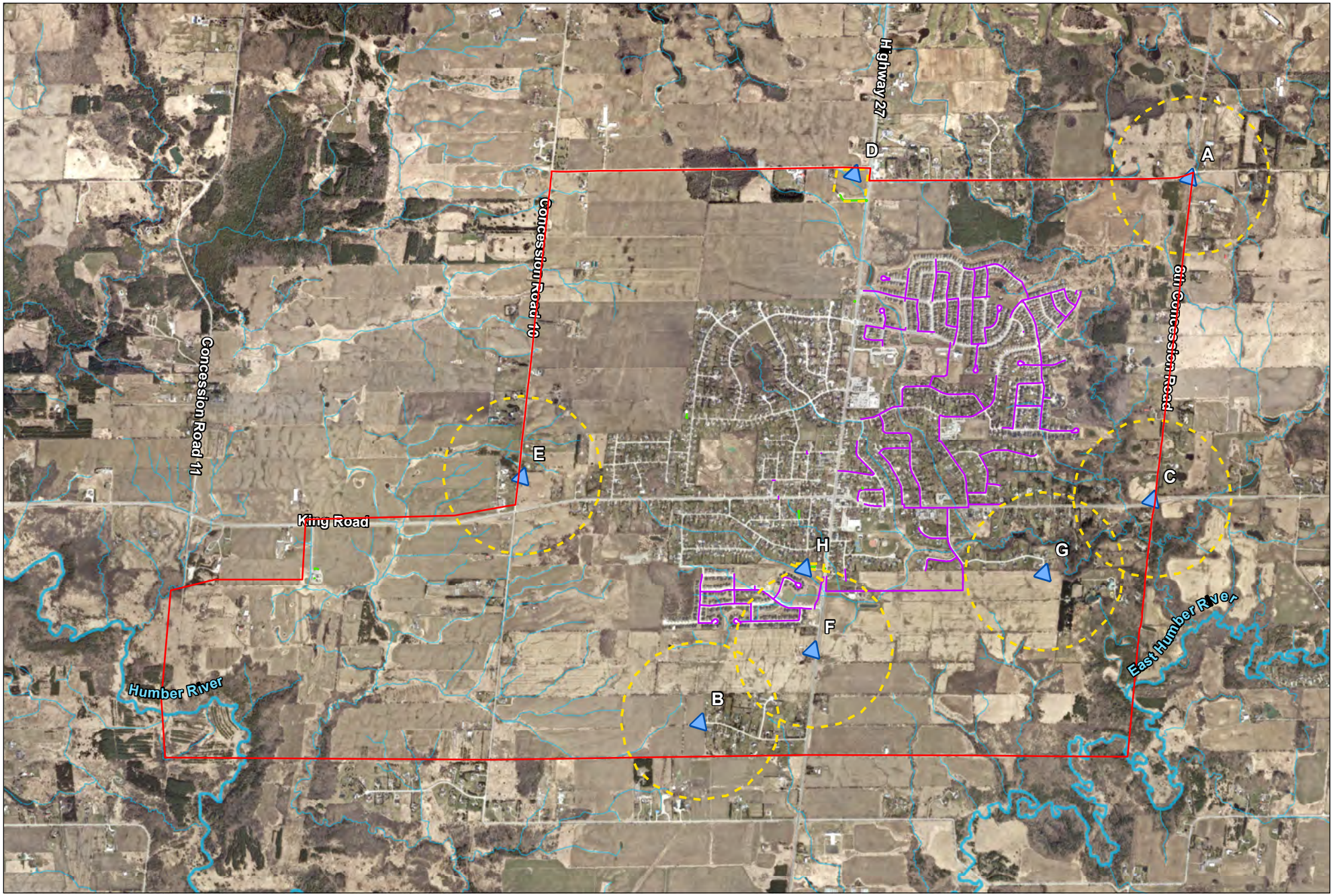

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PROJECT: Nobleton Supply Well

0 200 400 600 800
metres

N

DRAWN: S. Feist
CHECKED: C. Hanlon
PROJECT: 170462
DATE: May 22, 2019

Scale 1:32000
UTM Zone 17N
NAD1 983

Legend

- Study Area
- PECG Target Locations
- Well Investigation Area
- Watercourse

Watermain Ownership

- Township of King
- York Region

York Region

DRAFT

Water Supply Lines

FIGURE 17

Document Path: C:\Egnyte\Shared\Projects\Active\17046 - Black &V eatch\170462 - Nobleton Supply Well\2. Background Assessment\PECG data\Mapping\mxd\170462_Fig17_WaterSupplyLines.mxd

Short-term impacts such as air quality, noise, and traffic were considered using the location of each site relative to roadways, residential areas, and public areas such as schools and/or hospitals. It is expected that traffic will not be impacted as a result of drilling or testing investigations as all sites are proposed in locations off of the roadway and do not require lane closures. The noise and air quality impacts are also expected to be minimal, as each site falls outside of school and hospital zones and are within a residential area of relatively low density.

The overall results for Engineering and Logistics Feasibility demonstrate that Well Site H is the preferred location in this category, as it scored 24 points of the total possible 25. Well Site H is located on a 1.0 ha parcel owned by York Region for the operation of NOB-PW5. A small watercourse is present adjacent to the property which can act as a receptor for directing discharge during well drilling and testing, and the site has access to existing sewers for discharge during well operation. In addition, based on the previous investigations at NOB-PW5 and the results of the weighted criteria, encountering sustainable groundwater supply at Well Site H is probable.

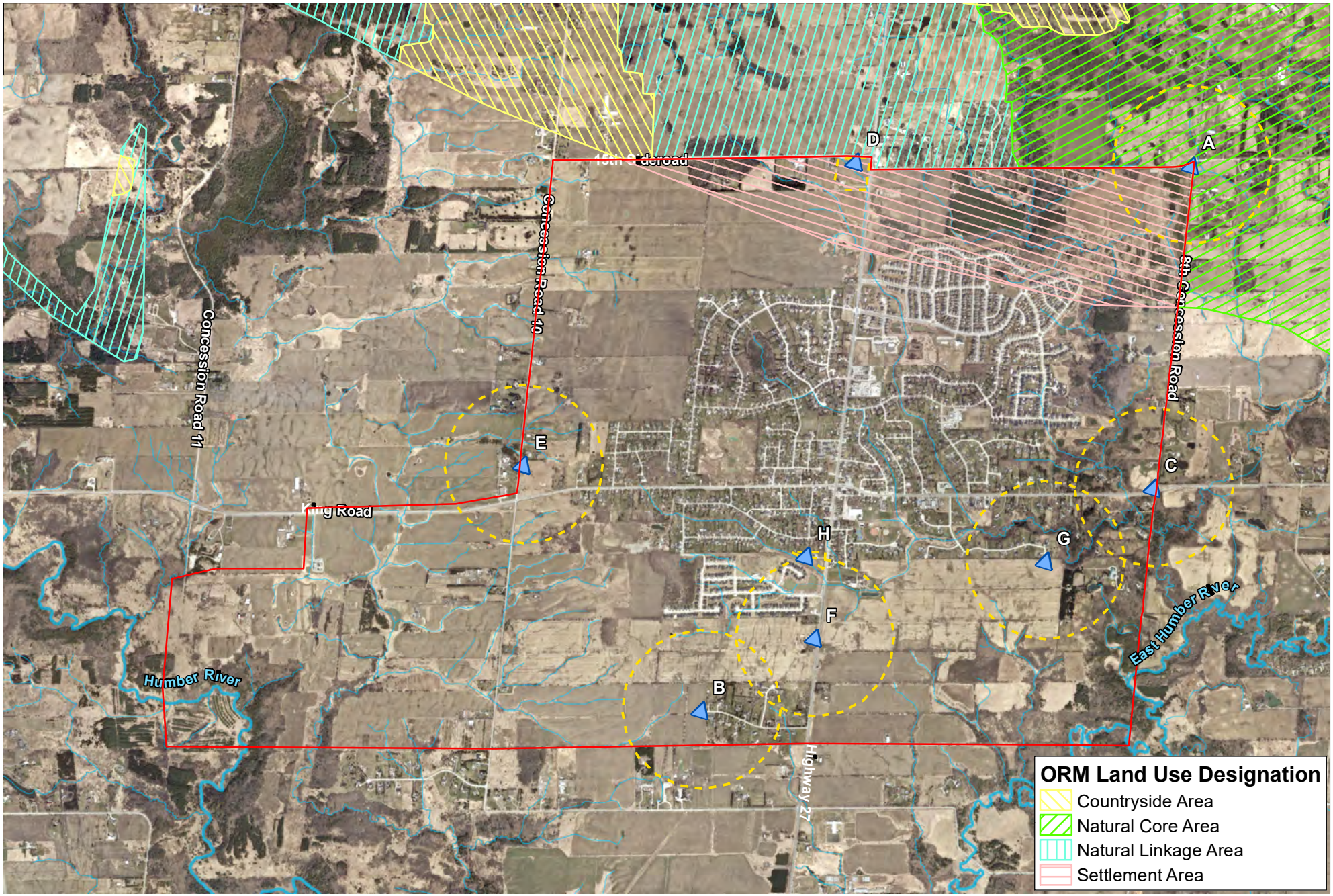
Well Site D also scored well for Engineering and Logistics, and scored 22 points of the 25. This location highly ranked as it is located on York Region owned land, a watercourse is present running through the property, and is directly accessible to existing water supply lines. It is also expected that short term impacts in this area are minimal as the site is within a low-density residential area. Discharge during well operation would require construction, as existing sanitary sewer lines are >500 m from the target location.

3.1.3.3 Applicable Policy and Regulation

Applicable Policy and Regulation comprises the final 10% of the overall scoring. The eight proposed target locations (A – H) were each assessed based on their location relative to the WHPAs of the existing supply wells (4%), Oak Ridges Moraine Planning Boundary (2%), natural heritage areas and potential species at risk habitat crossing (2%), and the future and existing land use within the approximate WHPA-A and WHPA-B of the proposed well locations (2%).

The relation of the land use designations of the Oak Ridges Moraine Planning Boundary to the proposed target locations are shown on **Figure 18**. This was completed as work that is proposed within either Natural Core or Natural Linkage Areas within the ORM Planning Boundary may not be permitted under the *Oak Ridges Moraine Conservation Act, 2001*. Based on the comparison, Well Site s A and D both fall within the Settlement Area of the ORM, such that changes to the land area are allowed, and Well Site s B, C, E, F, G, and H are each outside of the ORM and are greater than 300 m from the boundary of the Natural Core Area and Countryside Area, such that these policies do not apply.

The scoring representing risk management was weighted the highest in this category to address increased concerns of potential for contamination. As businesses within existing WHPA-A/B/C are already subject to source protection plan policies and have obtained a Source Water Protection Permit (Schedule 59 Notice). Therefore, candidate target well locations within the existing WHPA-A, B, or C areas are assigned a higher score, as existing potential contamination sources will have RMPs already in place. Based on the results of the assessment, all proposed target locations aside from Well Site H are outside of the defined WHPA-A/B/C of the existing supply wells. Locations outside of the WHPA were compared against known potential sources of contamination, such as gas stations, dry cleaners, auto shops, agricultural land, and septic tanks, shown on **Figure 19**.



Prepared By

Palmer

CLIENT: The Regional Municipality of York
PROJECT: Nobleton Supply Well

0 200 400 600 800
metres

N

DRAWN: S. Feist
CHECKED: C. Hanlon
PROJECT: 170462
DATE: May 22, 2019

Scale 1:32000
UTM Zone 17N
NAD1 983

Legend

- Study Area
- PECG Target Locations
- Well Investigation Area
- Watercourse

York Region

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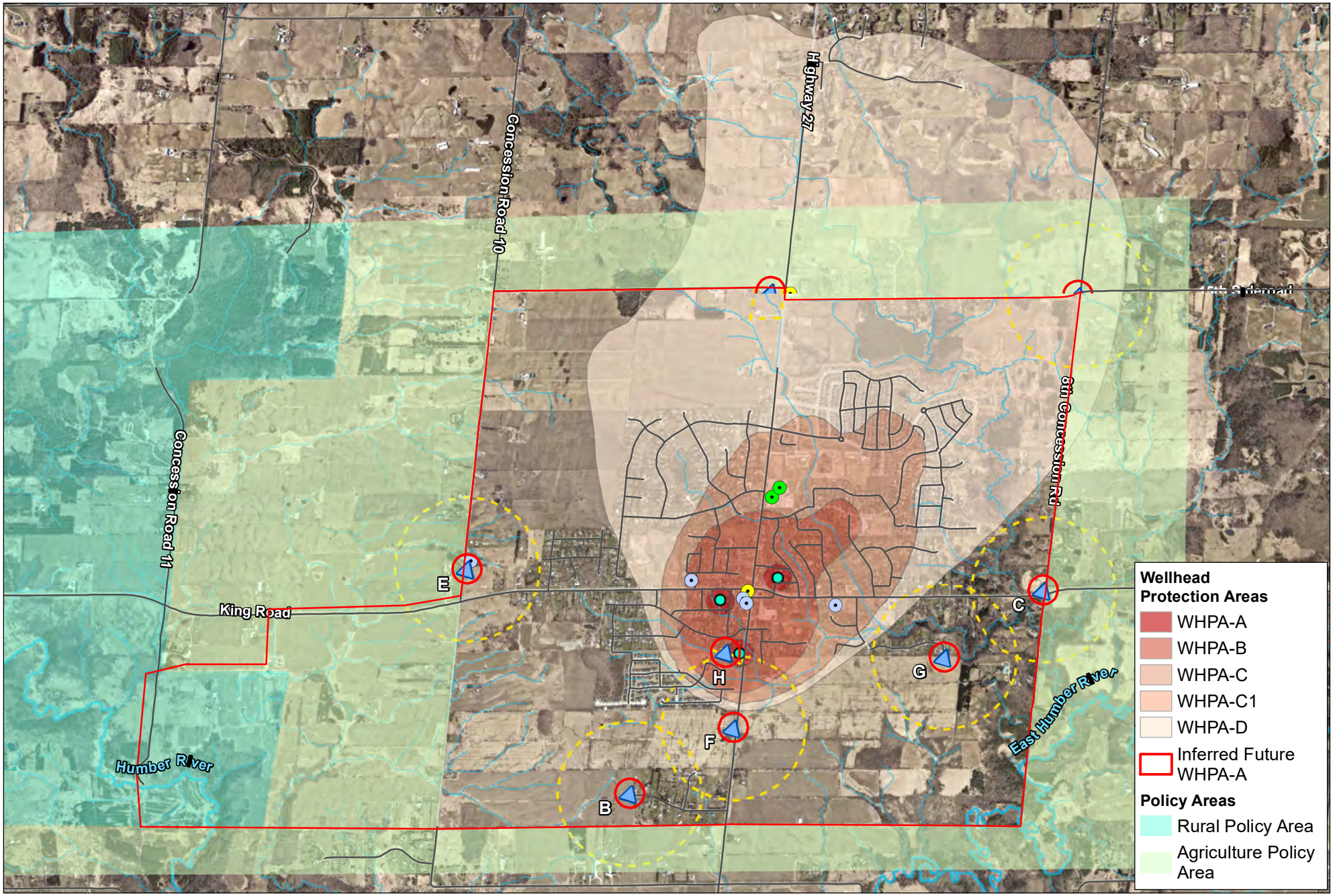
Oak Ridges Moraine Planning Boundary

FIGURE 18

Document Path: C:\Egnyte\Shared\Projects\Active\17046 - Black &V eatch\170462 - Nobleton Supply Well\2. Background Assessment\PECG data\Mapping\mxd\170462_Fig18_ORMboundaries.mxd



Prepared By

Palmer

CLIENT: The Regional Municipality of York
PROJECT: Nobleton Supply Well

0 200 400 600 800
metres

N

DRAWN: S. Feist
CHECKED: C. Hanlon
PROJECT: 170462
DATE: May 22, 2019

Scale 1:35000
UTM Zone 17N
NAD1 983

- Study Area
- PECG Target Locations
- Road
- Watercourse
- Well Investigation Area
- Existing Nobleton Production Wells

Potential Point Contamination

- Auto shop
- Dry Cleaner
- Gas Station

York Region

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Risk Management

FIGURE 19

Document Path: C:\Egnyte\Shared\Projects\Active\17046 - Black &V eatch\170462 - Nobleton Supply Well\2. Background Assessment\PECG data\Mapping\mxd\170462_Fig19_existingWells_WHPA.mxd

The selected target locations were additionally assessed based on their potential to interfere with natural features and areas, and/or known suitable habitat and occurrence for species at risk (SAR), in accordance with the *Provincial Policy Statement (2014)* of the *Planning Act*, the *Conservation Authorities Act (1990)*, and the *Endangered Species Act (2007)*. Based on this assessment, all target areas are more than 300 m outside of the evaluated PSWs and non-PSWs except Well Site A, which is approximately 95 m from the Black Duck Provincially Significant Wetland Complex, and Well Site D which is approximately 280 m from the Black Duck Provincially Significant Wetland Complex (**Figure 20**).

Based on previous correspondence with the Ministry of Natural Resources (MNRF) Aurora District regarding the King Township, Natural Heritage Information Center (NHIC) online data query for the proposed sites (MNRF, 2018), Fisheries and Oceans Canada critical habitat and distribution map for aquatic species (DFO, 2018), and professional knowledge of SAR habitat, no SAR habitat is present or is likely to be present within any of the selected locations. However, there is potential that the required construction of linear infrastructure from Well Sites B, C, F, and G may require a crossing of aquatic SAR habitat within a tributary to the East Humber River (**Figure 20**). This tributary has habitat for Redside Dace (*Clinostomus elongatus*) habitat, an endangered minnow species. If selected, the watercourse crossings associated with these sites may require a permit or approval under the *Endangered Species Act, 2007*.

Land uses within the predicted WHPA-A for each target location was screened to identify areas of existing or proposed industrial or commercial land uses, as these areas would be subject to various restrictions and limitations. A 100 m buffer was added to each target location to identify WHPA-A, and the land use was determined based on the 2016 Schedule A Combined Zoning By-law for the Nobleton Urban Area (**Figure 21**).

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Palmer

CLIENT: The Regional Municipality of York
PROJECT: Nobleton Supply Well

0 200 400 600 800
metres

N

DRAWN: S. Feist
CHECKED: C. Hanlon
PROJECT: 170462
DATE: May 22, 2019

Scale 1:32000
UTM Zone 17N
NAD 1983

- Study Area
- PECG Target Locations
- Well Investigation Area
- Aquatic SAR Habitat (Endangered)
- Watercourse
- Humber Watershed NHS

Wetland Significance

- Evaluated-Provincial
- Not evaluated per OWES

York Region

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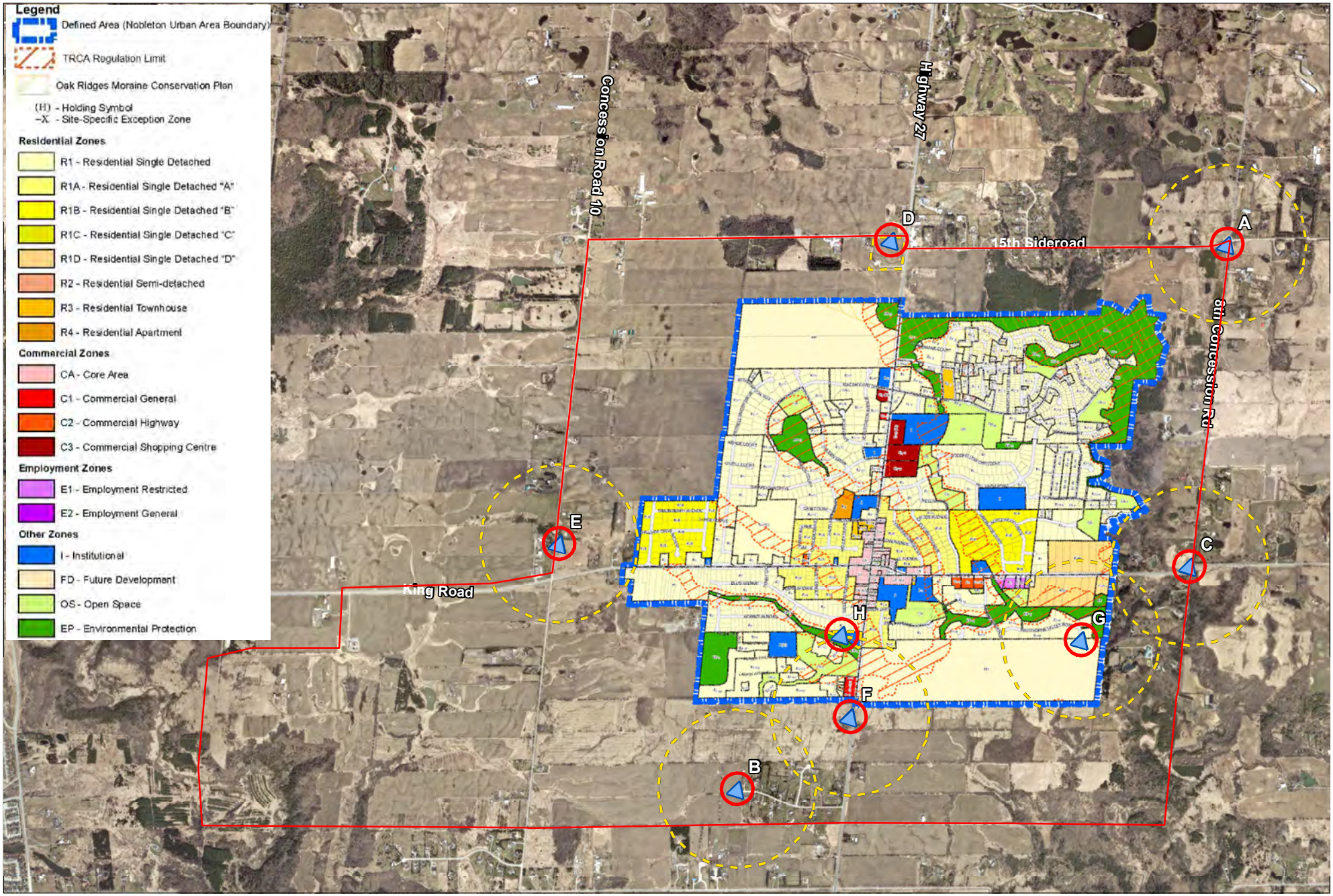
Natural Heritage System and Aquatic Species at Risk (SAR)

FIGURE 20

Document Path: C:\Egnyte\Shared\Projects\Active\17046 - Black & Veatch\170462 - Nobleton Supply Well\2. Background Assessment\PECG data\Mapping\mxd\170462_Fig20_Heritage-SAR.mxd



Prepared By

Palmer

CLIENT: The Regional Municipality of York
PROJECT: Nobleton Supply Well

0 200 400 600 800
metres

N

DRAWN: S. Feist
CHECKED: C. Hanlon
PROJECT: 170462
DATE: May 22, 2019

Scale 1:32000
UTM Zone 17N
NAD 1983

Legend

Study Area
PECG Target Locations
Well Investigation Area

Inferred Wellhead Protection Areas

WHPA-A

York Region

Imagery (2018) provided by York Region Web Mapping Services; Nobleton Community Land Use Plan Data: Township of King/York Region, October 2003

DRAFT

Land Use Within Nobleton Community Plan

FIGURE 21

Document Path: C:\Egnyte\Shared\Projects\Active\17046 - Black & Veatch\170462 - Nobleton Supply Well\2. Background Assessment\PECG data\Mapping\mxd\170462_Fig21_LandUse_WHPA.mxd

4. Justification on Next Steps

Based on the results of the long-list alternative site selection assessment process, of the eight (8) identified long-listed potential areas, there was a tie between Well Site F and Well Site H, which both scored 80 points (**Table 10**). Overall, Well Site F was the highest ranking site for groundwater resource potential, and scored well for site logistics and policy/ regulations. Well Site H scored well for groundwater resource potential, and was the highest ranking site for site logistics and policy/ regulations. The two preferred locations are shown on **Figure 8**.

Well Site F and Well Site H will be carried forward into the Evaluation of the Short-Listed Target Sites where detailed hydrogeological testing will be completed at each location to select a preferred well site location. A summary of the two preferred well sites is provided below.

Well Site F is located along Highway 27, approximately 950 m south of the intersection with King Road. It is anticipated that the Scarborough Aquifer is approximately 43 m thick in this location, according to York Region's Tier 3 Conceptual Model, and the transmissivity is between 500 and 1,000 m^2/day, indicating high water supply potential from the aquifer. The overlying Sunnybrook Drift is expected to be approximately 40 m thick and extensive, indicating this area is well protected from potential contamination from surface. The unit thicknesses derived from the YPDT model and MECP water well records were generally in agreement and were within +/- 5 m of each other for the aquifer, and +/- 10 m for the aquitard. The potential for well interference is relatively low, as there are no existing municipal supply wells within 500 m. Of the 21 private water wells within 500 m, only three (3) are interpreted to be screened within the Scarborough Aquifer, and 15 screened in more shallow aquifers. This location also scored well for Engineering and Logistics, as it is currently owned by a private land developer, is within 500 m of the existing water supply lines, avoid industrial/ commercial land use within a 300 m radius, has appropriately sized storm ditching for directing groundwater discharge, and has direct site accessibility for field work and future construction. This location is outside of the existing WHPAs and is outside of the ORM boundary. However, selection of this area would potentially require a SAR habitat crossing along Highway 27 during construction of the watermain north to join to the existing water servicing. Additional source protection plan policy and risk management may have to be implemented as the future WHPA-A and WHPA-B of this area may intersect agricultural land, salt runoff from Highway 27, private septic sources, as well as affect future land use planning along the Highway 27 corridor. However, this could also be seen as a benefit as it would allow for the area around Well Site F to be suitably planned to meet Source Water Protection Policies and avoid future land use conflicts or unexpected restrictions.

Well Site H is located within the York Region owned parcel of land containing the well and infrastructure for the existing municipal supply well NOB-PW5. Based on preliminary analysis of aquifer yields, the Scarborough Aquifer at this location is likely able to support a second production well, as the yield at NOB-PW5 was found to be limited by the well screen design, not by aquifer properties (York Region, 2018). Based on the drilling and hydraulic testing results at this location for the installation of NOB-PW5 and NOB-PW4, the Scarborough Aquifer is approximately 12 m thick, and the transmissivity is approximately 790 m^2/day, indicating high water supply potential from the aquifer. According to York Region's Tier 3 model, the overlying Sunnybrook Drift Aquitard is approximately 10 m thick at the Site H location, however based on logs from the test wells and production wells installed for NOB-PW5, the

Sunnybrook Aquitard could be up to 50 m in thickness at this location, indicating this area is well protected from potential contamination from surface. As this area was previously investigated for the installation of NOB-PW5 and NOB-PW4, the level of confidence in the interpreted subsurface conditions is high, such that there is greater potential in encountering sufficient aquifer conditions at this location. This location also scored well for Engineering and Logistics, as the land parcel is currently owned and operated by York Region, therefore minimizing additional work for obtaining land access and ownership. It also has space available to construct the necessary infrastructure for water treatment and distribution, and has immediate access to appropriately sized receptors for directing groundwater discharge. The location is within the WHPA-A/B of NOB-PW5, which provides protection against potential future groundwater threats as this area is already subject to source protection plan policies and risk management. However, the close proximity and same target aquifer will require increased hydraulic testing to fully investigate the interference effects of combined drawdown between NOB-PW5 and a new production well, as well as the other two existing production wells (NOB-PW2 and NOB-PW3) to ensure sufficient groundwater supply capacity can be obtained before a preferred location is ultimately selected.

5. Evaluation of Target Sites

Based on our understanding of the future water demands in Nobleton, a sustainable pumping rate of at least 35 L/s is required from the Preferred Well Site. From the eight (8) potential target areas identified within the EA study area (Well Sites A to H), Well Sites F and H were determined to be the two (2) short-listed preferred locations based on weighted criteria related to the potential for encountered high yielding groundwater resources, engineering and logistical feasibility, protection of natural features and existing water users, and applicable policies and regulations. Additional hydraulic testing was completed at these well sites to further investigate their potential for installing a municipal water supply well.

The Evaluation of Target Sites was completed generally following York Region Section 18 requirements, which involve the following steps:

1. Completion of a Water Well Survey and Notice of Well Testing with 500 m or the Expected Radius of Influence;
2. Installation of a small diameter (6”) test well and initial yield testing;
3. Submission of a Permit to Take Water (PTTW) for Step-Drawdown Testing/ Pumping Tests;
4. Completion of Short-Duration Step-Drawdown Testing & Combined Pumping Tests with NOB-PW5 at Well Site H and Short Duration Step-Drawdown Testing at Well Site F;
5. Data Analysis and Comparative Evaluation; and
6. Recommendation for a Preferred Well Site Location.

In **Section 5**, the investigation of Well Sites F and H are discussed in further detail.

5.1 Modification of Hydrogeological Field Program from Section 18

Modifications were made to the York Region Section 18 process to account for different hydrogeological priorities for evaluating Well Sites H and F. The Section 18 process is best suited to find, test and evaluate *new well site locations* or *greenfield well sites*, where the hydrogeological conditions and aquifer

properties are not well understood. However, for areas in close proximity to active well fields where the hydrogeological conditions are already known but the risk of interference is high, additional testing beyond what is outlined in Section 18 may be required to address more complex hydrogeological issues.

Well Site H is located at an *existing* municipal well site, and therefore the type and level of testing as outlined in Section 18 was changed to best evaluate the potential effects from adding a second well to an existing well site (NOB-PW5) (i.e. twinning the well site). Rather then install a new small diameter test well and focus on step-drawdown testing to evaluate Well Site H, site investigations focused on detailed hydraulic testing of an existing 6" diameter test well to characterize well interference and combined drawdown effects to quantify a sustainable yield for both NOB-PW5 and a new production well. The existing small diameter test well, MW6, was used to complete a step-drawdown test, comprised of multiple steps, a 24-hour pumping test and a combined pumping test MW6 and NOB-PW5 over an additional 48-hours to quantify interference effects.

As Well Site F is a greenfield well site that has a low potential for significant interference with the existing Nobleton Production Well network, this investigation followed the Section 18 steps. A small diameter test well, MW9, was drilled to bedrock within the Well Site F area and screened within the Scarborough Formation Aquifer. A step-drawdown test was completed assess the properties of the aquifer in this location.

The results of the hydrogeological field assessments and comparative analysis at Well Sites F and H are described in detail below.

5.2 Existing Monitoring Well Network

Five monitoring wells/ well nests (MW1S/D, MW3S/D, MW4S/I/D, MW5, and MW6) and three pumping wells (NOB-PW2, NOB-PW3, and NOB-PW5) were available for Palmer to monitor during our hydrogeological field program at both Well Sites F and H. The location of the existing monitoring wells and pumping well is shown on **Figure 8**. Details on the pumping well and monitoring well network can be found in **Table 11**. The monitoring wells are monitored using data loggers, either Solinst M30 or M100 data loggers, and the pumping wells were monitored using a SCADA probe. A barologger was used to compensate water level monitoring data for atmospheric pressure fluctuations.

Table 11. Monitoring Well Network

Monitoring Well	Logger Interval for Pumping Test	Well Diameter (m)	Screened Interval (mbgs)	Screened Aquifer	Thorncliffe/ Scarborough Aquifer Depth (mbgs)	Thorncliffe/ Scarborough Aquifer Thickness (m)
MW1S	30 min	0.128	33.53 – 36.58	Lower ORAC	-	-
MW1D	30 min	0.128	103.6 – 106.7	Thorncliffe/ Scarborough	96.3 – 110.0	13.7
MW3S	30 min	0.128	27.7 – 30.8	Lower ORAC	-	-
MW3D	30 min	0.128	86.41 – 89.45	Thorncliffe/ Scarborough	85.7 – 89.5	3.8

Monitoring Well	Logger Interval for Pumping Test	Well Diameter (m)	Screened Interval (mbgs)	Screened Aquifer	Thorncliffe/ Scarborough Aquifer Depth (mbgs)	Thorncliffe/ Scarborough Aquifer Thickness (m)
MW4S	30 sec	0.152	18.6 – 21.0	Upper ORAC	-	-
MW4I	30 sec	0.152	37.8 – 40.8	Lower ORAC	-	-
MW4D	30 sec	0.152	99.1 – 102.1	Thorncliffe/ Scarborough	91.4 - 102.1	10.7
MW5	30 sec	0.152	98.4 – 101.5	Thorncliffe/ Scarborough	93.0 - 102.4	9.4
MW6	30 sec	0.152	96.6 – 103.0	Thorncliffe/ Scarborough	91.4 - 106.7	15.3
MW9*	30 sec	0.152	103.8 – 108	Thorncliffe/ Scarborough	96.0 – 109.0	13.0
NOB-PW5	1 minute	0.305	96.77 – 101.19	Thorncliffe/ Scarborough	93.9 - 106.5	12.6
NOB-PW3	1 minute	0.321	83.2 – 89.9	Thorncliffe/ Scarborough	83.2 – 93.0	9.8
NOB-PW2	1 minute	0.324	104.5 – 109.4	Thorncliffe/ Scarborough	103.6 – 111.9	8.3

*installed as part of the investigation at Well Site F

5.3 Water Well Survey

Local water well surveys were carried out by Palmer staff in a 500 m radius of Well Site F on April 2, 2020 and within an 800 m radius of Well Site H on February 3, 2020 based on the anticipated radius of influence (ROI) that was calculated in the PTTW for each location. The purpose of the well surveys was to identify nearby wells to the test sites, to obtain information from local residents about their groundwater supplies and usage, and to offer each well owner well monitoring during the hydrogeological field testing program.

A large portion of the study areas have access to municipal water supply, as evident from the presence of fire hydrants, storm sewers, and water valves. A Notice of the Well Inventory was delivered to each individual property that was determined to be on well water and each were provided with a water well survey form to gather information about their water supply. If the property owner was not home at the time of the survey, a well survey notice was dropped off at the door or mailbox informing them of the visit and providing contact information to assist in completing the survey.

Based on the results of the water well survey, it was determined there are approximately 21 active domestic wells within 500 m of Well Site F. It is expected that approximately three (3) wells are screened within the Scarborough Aquifer, and the remaining wells are screened in upper units (Thorncliffe, Newmarket, or Upper and Lower ORAC).

Based on the results of the water well survey, it was determined there are approximately two (2) active domestic wells within 800 m Well Site H. It is expected that none of the domestic supply wells are screened within the Scarborough Aquifer and the wells are screened within the shallower units (Thorncliffe, Newmarket, or ORAC).

Overall, there was a low level of response to the water well survey from residents within the study areas, as only one (1) resident agreed to have their well monitored during the step and pumping test at Site H.

5.4 Hydrogeological Field Assessment

5.4.1 Well Site F

5.4.1.1 Test Well Drilling

At Well Site F, a small diameter test well, MW9, was drilled on the west side of Hwy 27, approximately 400 m south of Oliver Emerson Ave, between December 3 to December 19, 2019 by Boadway Well Drilling (**Figure 8**). The borehole log for MW9 was interpreted by carefully assessing the drill cuttings, and is provided in **Appendix A**. The 6-inch (0.152 m) diameter test well was installed in accordance with Ontario Regulation 903. The elevation and location of MW9 was collected using a SOKKIA GCX3 GNSS Receiver. The depth of the well screen was selected to range from 96.0 – 109.0 mbgs and consists of a 3.01 m of #40 slot and 1.22 m of #50 slot Johnson Wire Wrap Well Screen. The screen dimensions were determined through experience and characterizing the aquifer material on site, with the intention of maximizing groundwater yield. This test well was installed to provide a well to conduct a short duration step-drawdown test at Well Site F.

The York Region's Tier 3 Conceptual Model predicted the Sunnybrook Aquitard to be 10 m thick, within the vicinity of Well Site F, however, from the drilling, it was interpreted to be approximately 17 m, which is thicker than the model, but still within the expected range in the Nobleton area. Based on the model, the Scarborough Aquifer was estimated to be 43 m thick, however, the drilling results confirmed a thickness of approximately 13 m.

To ensure that MW9 was in a sand free state and had low turbidity, the well was developed for approximately 8 hours on December 19, 2019 by the drilling contractors. Groundwater was discharged into the roadside ditching. The discharge water was found to have turbidity of 6 Nephelometric Turbidity Units (NTU) upon completion of development. Sand content was checked in accordance with AWWA procedures (AWWA Standard A100-97) using the Rossum Sand Sampler. Initially, sand was found at 84.5 ppm and was reduced to 7.9 ppm at the end of the development.

5.4.1.2 Step-Drawdown Testing

A step-drawdown test was carried out by Palmer and Ontario Water Well Services (OWWS) personnel at MW9 beginning at 9:50 AM on June 23, 2020 consisting of three (3) steps at rates of 13 L/s, 18 L/s, and 23 L/s. The pumping rates were increased incrementally without permitting the well to recover between steps. The step test was completed in accordance with a MECP Category 3 PTTW # 1560-BNVNAB, which was received April 23, 2020. MW9 and the existing wells in the York Region monitoring well network were monitored using data loggers (either Solinst M30 or M100 data loggers) and the existing

pumping wells (NOB-PW2,3, & 5) were monitored using a SCADA probe. Manual water level measurements were also obtained from the monitoring wells using a water level tape during the test.

Groundwater discharge during the step test was discharged into roadside ditching along Hwy 27, that flows southwards. To prevent erosion to the ditch water was discharged through a diffusor onto a splash mat to slow down the velocity and then diverted overland through vegetated areas to minimize disturbance.

A detailed displacement-time graph for the step test at Well Site F is shown in **Figure 22**. The duration of the first two steps were shortened to 45 minutes each (from the planned 1-hour each) as the drawdown achieved during each step was lower than anticipated at approximately 1.4 and 1.0 m, respectively. It should be noted that the drawdown in the first step is relatively high due to over pumping during the start up process to adjust to the first pumping rate. The third step was extended to 2-hours at a rate of 23 L/s to achieve the maximum flow rate under allowed under the PTTW and the limitation of pumping a 6" diameter well. The intention of the last step was to maximize the radius of influence of the step test. Over a 2-hour pumping duration at 23 L/s, a drawdown of approximately 2 m was observed at MW9 and the shape of the drawdown curve was flat showing a drawdown rate of 0.002 m/min during the final 30 min of testing. Details regarding the step test at MW9 and the surrounding monitoring network wells can be found in **Table 12**. Although it is evident that pumping at MW9 affects the well within the monitoring network, drawdown was minimal and ranged from 0.04 to 0.09 m in MW4D, MW5, MW6, and NOB-PW5. In the first step for these wells and the second step in NOB-PW5, water levels are still rising since the supply wells have recently stopped pumping and are in a recovery phase. Prior to their off cycles, NOB-PW2 was pumping at a rate of approximately 18 L/s, NOB-PW3 was pumping at a rate of approximately 24 L/s, and NOB-PW5 was pumping at a rate of approximately 26 L/s. Since the monitoring wells were relatively far from MW9 (greater than 661 m), the drawdown effects are low. A drawdown of 0.09 m was determined to reach up to 661 m from MW9, which was also the maximum ROI observed.

Table 12. Step Test at MW9 Details

Monitoring Well	Static Water Level (mbtoc)	Distance from MW6 (m)	Total Drawdown (m)		
			End of First Step - 45 min (13 L/s)	End of Second Step – 45 min (18 L/s)	End of Step Test – 120 min (23 L/s)
MW4D	28.9	669	-0.01	0.01	0.08
MW5	28.4	661	-0.01	0.02	0.09
MW6	29.1	666	-0.01	0.01	0.08
MW9 (Pumping Well)	33.9	-	1.4	2.4	4.4
NOB-PW5	28.0	658	-0.06	-0.05	0.04

Figure 23 shows the data for monitoring wells (MW4S/I/D, MW5, and MW6), including shallow monitoring wells, and the recovery of MW9 after the step test. It is evident that pumping from the Scarborough

Aquifer did not influence the shallower wells that are screened in the Upper and Lower ORACs since no drawdown was observed in MW4S and MW4I. It is important to note that the immediate recovery is not representative of the aquifer and is due to the pump releasing the water back into the well after it has been stopped. While it is recognized that the pumping duration was short, no boundary condition effects, or significant interference effects were observed during pumping of MW9 at Well Site F.

Figure 24 shows the Specific Capacity plot at MW9 by comparing the discharge rate to the drawdown and indicates the well has a specific capacity of approximately 5.36 L/s/m at a pumping rate of 23 L/s. It is evident that the well is inefficient and there is well loss, resulting in increasing drawdown with increasing discharge. This is taken into account in the trendline. Based on the specific capacity, the drawdown is estimated to be 8.3 m if the pumping rate is to be increased to 35 L/s,.

Transmissivity and Storativity values were calculated using the displacement-time data and were analysed using the Theis (1935) method for confined aquifers, as modelled by Aqtesolv™ software. The analysis results are presented in **Appendix B**, and the calculated transmissivity and storativity values are summarized in **Table 13**. Due to the distance and insufficient drawdown response of MW4D, MW5, MW6, and NOB-PW5 from the pumping well, the transmissivity values from these wells were determined to not be representative of actual transmissivity and only the pumping well data at MW9 was used. This analysis indicates that the transmissivity of the Scarborough Aquifer at Well Site F is 802 m^2/day. The storativity coefficient based on preliminary data, is found to be 3.33 x 10^{-4}. This is considered representative of the conditions at Site F based on previous MMM values and match the results from Site H. The report by MMM in 2012 calculated a transmissivity value of 790 m^2/day in NOB-PW5 and the report by MMM in 2007 calculated a storativity value of 1x10^{-4} in NOB-PW4 (**Appendix A**), which is located within the same wellhouse as NOB-PW5.

It is evident that the water level is rising prior to conducting the test, indicating that nearby municipal supply wells have stopped pumping and the water level is recovering across the site. The transmissivity is found to be higher in the analysis of the observation wells partly due to the water level recovering after an on-cycle from the nearby municipal wells, thus, artificially increasing the transmissivity. Well interference effects are evident during the step test, however, these minor changes in water levels will not greatly affect the analysis of the step test.

Table 13. Transmissivity and Storativity for Well Site F (MW9)

Well	Transmissivity (m^2/day)	Storativity Coefficient (-)
MW9	802	3.33 x 10^{-4}

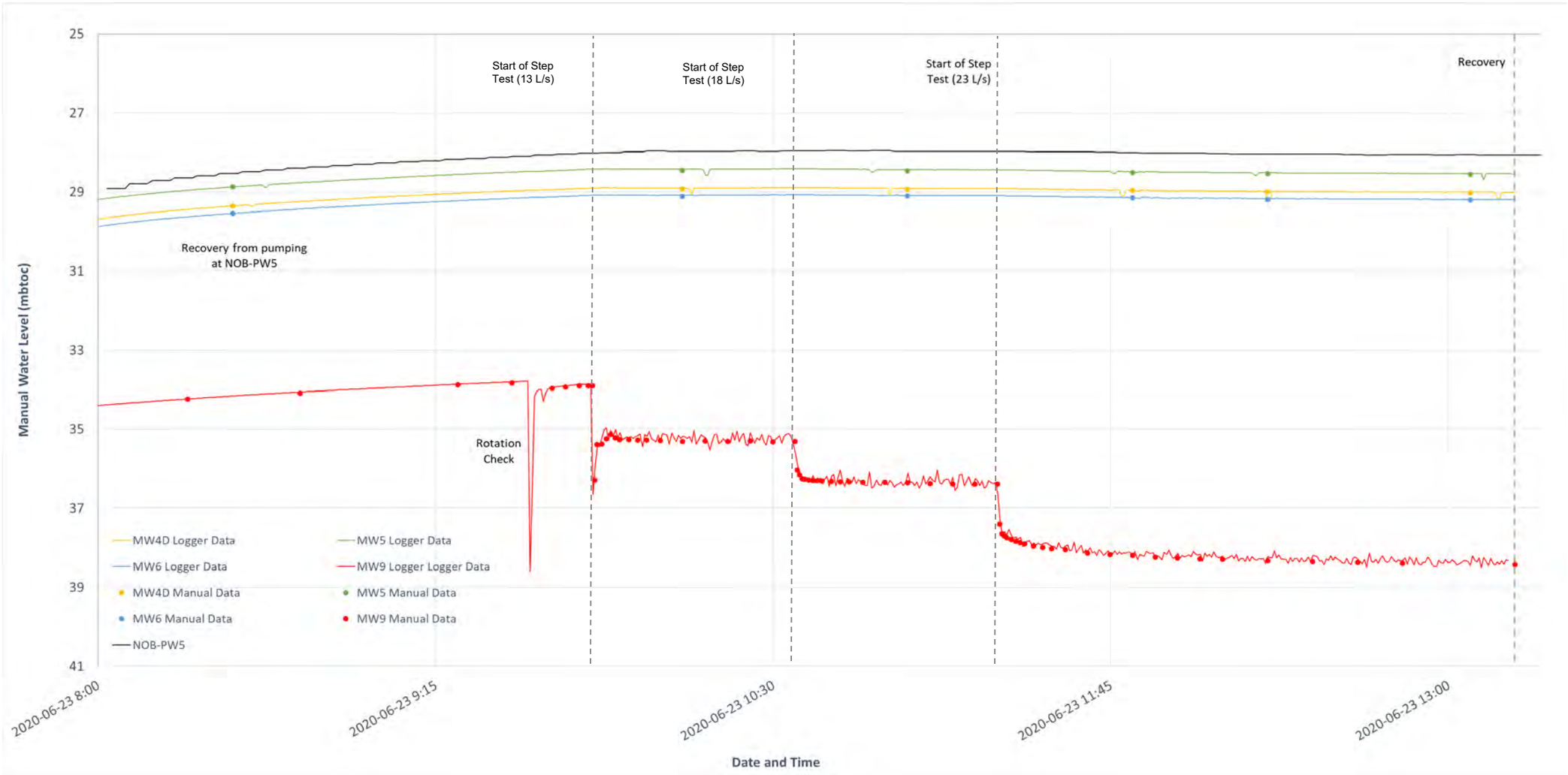


Figure 22. Step Test at MW9

Figure 23. Step Test at MW9 w/ Recovery and Monitoring Network

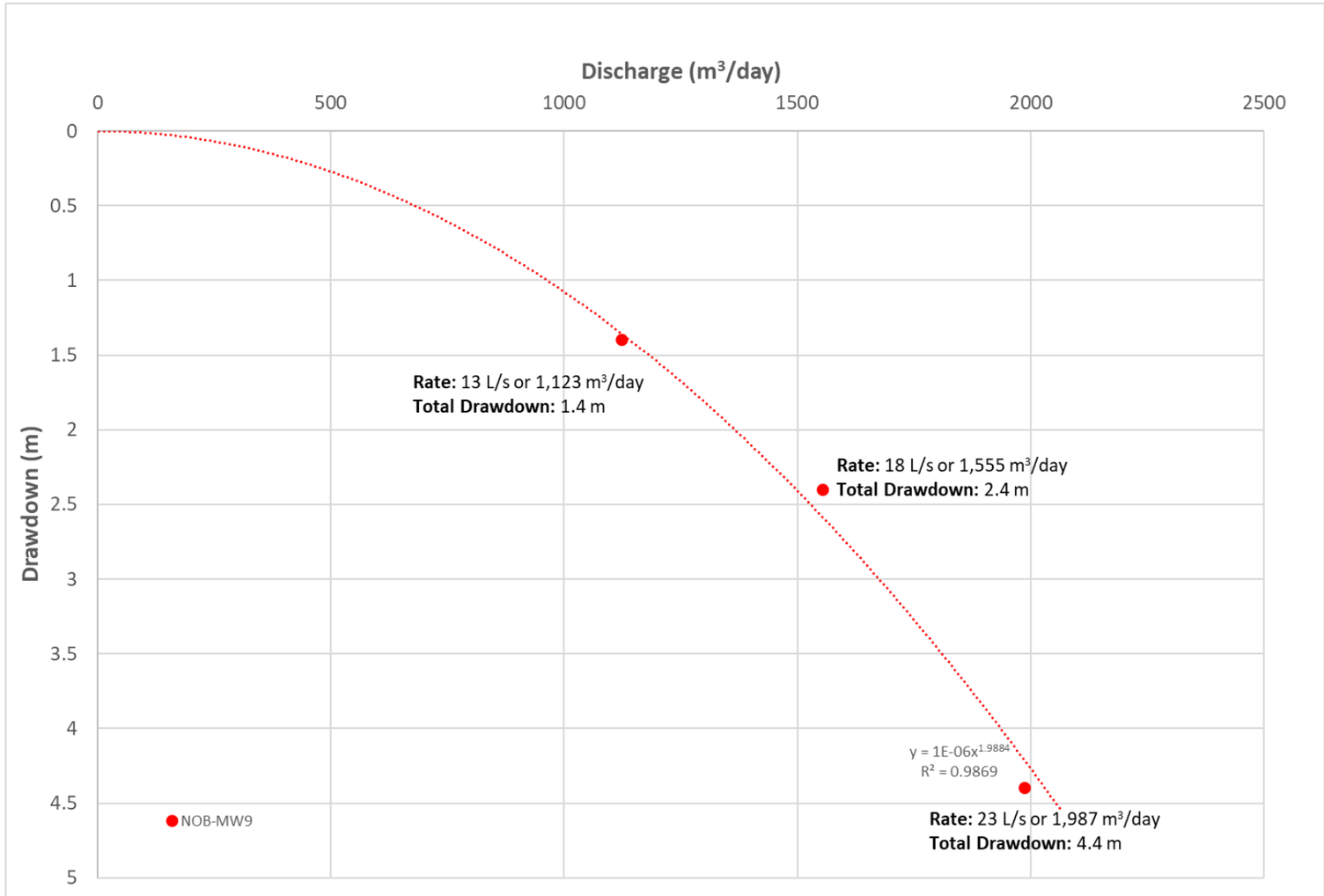


Figure 24. Specific Capacity Plot at MW9

5.4.1.3 Groundwater Quality

Four (4) groundwater chemistry samples were collected from MW9 on June 23, 2020 at the beginning of the step test and again prior to each rate change. The samples were analyzed against general ODWS parameters for a suite of water quality parameters including general water chemistry, VOCs, major and minor ions, nutrients, metals, bacteriological parameters, and general water quality indicators. The final sample was analyzed for all parameters listed in Tables 1, 2, and 4 of the ODWS. A summary table of the groundwater analysis results is presented on **Table 14**, and the Certificate of Analysis is provided in **Appendix C**.

Generally, water quality for MW9 remained consistent over the period of the step test. Results indicate that turbidity started high, however, after the first sample, it consistently met the criteria of 5 NTU throughout the step test. Colour consistently exceeded the 5 TCU objective and ranged from 11.4 to 20.2 CU. The groundwater is generally hard with hardness ranging between 219 and 234 mg/L, above the ODWS aesthetic criteria of 80-100 mg/L. Chloride (6.0 to 6.86 mg/L) and sodium (10.0 to 14.6 mg/L) were generally consistent and met their ODWS criterion of 250 and 20 mg/L, respectively. Bacterial tests were non-detectible in all samples collected.

Nitrate and nitrites were below detection limits throughout the test pumping program. Presence of nitrate is typically associated with the contamination from the agricultural activities found in the field west of the monitoring well. Absence of nitrates in the raw water is an indication of aquifer being well protected from surface sources of contamination. The absence of sulphate, also measured at non-detectible levels, supports this statement as sulphate, which is common in shallow aquifers, is reduced by anaerobic bacteria in deep aquifers when there is little oxygen in the system.

Iron was detected to range from 0.59 to 0.88 mg/L and was consistently greater than the ODWS standard of 0.3 mg/L. Manganese was also consistently above the 0.05 mg/L ODWS, however, is below the 0.1 mg/L MAC criteria in all samples, ranging between 0.050 and 0.097 mg/L.

Methylene Chloride, herbicides, pesticides, PCBs, Dioxins, and Furans were all under Table 1 – 4 ODWS criteria after 2-hours of pumping.

Table 14. Groundwater Quality Results at MW9

Parameter	Detection Limit	ODWS		Units	Sample Concentration			
		Operational Guideline	Schedule 1, 2, and 4 Standards		Pretest	13 L/s	18 L/s	23 L/s
Physical Tests								
Colour, Apparent	2.0	5	-	CU	11.4	17.2	20.2	2
Conductivity	3.0	-	-	umhos/cm	469	469	461	-
pH	0.10	6.5 -> 8.5	-	pH units	8.05	8.09	8.05	8.01
Redox Potential	-1000	-	-	mV	261	278	284	-
Total Dissolved Solids	20	500	-	mg/L	251	254	258	-

Parameter	Detection Limit	ODWS		Units	Sample Concentration			
		Operational Guideline	Schedule 1, 2, and 4 Standards		Pretest	13 L/s	18 L/s	23 L/s
Turbidity	0.10	5	-	NTU	6.16	3.06	4.94	1.5
Anions and Nutrients (Water)								
Alkalinity, Bicarbonate (as CaCO3)	2.0	-	-	mg/L	256	252	251	250
Alkalinity, Carbonate (as CaCO3)	2.0	-	-	mg/L	<2.0	<2.0	<2.0	-
Alkalinity, Hydroxide (as CaCO3)	2.0	-	-	mg/L	<2.0	<2.0	<2.0	-
Alkalinity, Total (as CaCO3)	2.0	30 -> 500	-	mg/L	256	252	251	250
Ammonia, Total (as N)	0.010	-	-	mg/L	0.593	0.569	0.583	0.620
Bromide (Br)	0.10	-	-	mg/L	<0.10	<0.10	<0.10	-
Chloride (Cl)	0.50	250	-	mg/L	6.69	6.75	6.86	7.8
Computed Conductivity	-	-	-	uS/cm	429	412	414	-
Conductivity % Difference	-	-	-	%	-9	-13	-11	-
Fluoride (F)	0.020	-	1.5	mg/L	0.142	0.143	0.145	0.180
Total Kjeldahl Nitrogen (TKN)	0.10	-	-	mg/L	-	-	-	0.71
Microcystin	0.0001	-	-	mg/L	-	-	-	0.0001
Dissolved Organic Carbon	0.40	-	-	mg/L	-	-	-	1.0
Hardness (as CaCO3)	-	80 -> 100	-	mg/L	234	219	222	220
Ion Balance	-	-	-	%	121	115	118	-
Langelier Index	-	-	-	-	1	1	1	-
Nitrate (as N)	0.020	-	10	mg/L	<0.020	<0.020	<0.020	<0.10
Nitrite (as N)	0.010	-	1	mg/L	<0.010	<0.010	<0.010	<0.010
Nitrate + Nitrite (N)	0.10	-	-	mg/L	-	-	-	<0.10
Saturation pH	-	-	-	pH	7.27	7.32	7.31	-
Orthophosphate-Dissolved (as P)	0.0030	-	-	mg/L	0.0190	0.0269	0.0240	-
TDS (Calculated)	-	-	-	mg/L	257	247	248	270
Sulfate (SO4)	0.30	500	-	mg/L	1.36	1.14	0.76	<1.0
Sulphide (as S)	0.018	0.05	-	-	<0.018	<0.018	<0.018	-
Sulphide (as H2S)	0.019	0.05	-	-	<0.019	<0.019	<0.019	-
Sulphide	0.02	-	-	mg/L	-	-	-	<0.02
Anion Sum	-	-	-	me/L	4.47	4.4	4.38	-
Cation Sum	-	-	-	me/L	5.4	5.07	5.15	-
Cation - Anion Balance	2.0	-	-	%	9	7	8	-
Total Organic Nitrogen	0.1	-	-	mg/L	-	-	-	<0.10

Parameter	Detection Limit	ODWS		Units	Sample Concentration			
		Operational Guideline	Schedule 1, 2, and 4 Standards		Pretest	13 L/s	18 L/s	23 L/s
WAD Cyanide (Free)	0.0010	-	-	mg/L	-	-	-	<0.0010
Inorganic Parameters (Water)								
Silica	0.21	-	-	mg/L	22.5	22.3	23.3	-
Bacteriological Tests (Water)								
E. Coli	-	-	0	CFU/100mL	0	<2	<2	0
Heterotrophic Plate Count	-	-	-	CFU/100ml	-	-	-	5
Fecal Coliforms	0	-	0	CFU/100mL	0	<2	<2	-
Total Coliform Background	1000	-	-	CFU/100mL	750	204	56	15
Total Coliforms	1000	-	0	CFU/100mL	<2	<2	<2	0
Metals (Water)								
Sodium Adsorption Ratio	0.10	-	-	SAR	0.41	0.42	0.42	-
Total Metals (Water)								
Aluminum (Al)-Total	0.010	0.1	-	mg/L	0.190	0.030	0.086	<0.049
Antimony (Sb)-Total	0.00010	-	0.006	mg/L	<0.00010	<0.00010	<0.00010	<0.0005
Arsenic (As)-Total	0.00010	-	0.01	mg/L	0.00128	0.00097	0.00089	<0.001
Barium (Ba)-Total	0.00020	-	1	mg/L	0.253	0.245	0.233	0.220
Beryllium (Be)-Total	0.00010	-	-	mg/L	<0.00010	<0.00010	<0.00010	-
Bismuth (Bi)-Total	0.000050	-	-	mg/L	<0.000050	<0.000050	<0.000050	-
Boron (B)-Total	0.010	-	5	mg/L	0.046	0.040	0.041	0.040
Cadmium (Cd)-Total	0.000010	-	0.005	mg/L	<0.000010	<0.000010	<0.000010	<0.000090
Calcium (Ca)-Total	0.50	-	-	mg/L	54.9	48.9	50.3	50.0
Cesium (Cs)-Total	0.000010	-	-	mg/L	0.000028	<0.000010	0.000013	-
Chromium (Cr)-Total	0.00050	-	0.05	mg/L	0.00196	0.00094	0.00076	<0.005
Cobalt (Co)-Total	0.00010	-	-	mg/L	0.00018	<0.00010	0.00010	-
Copper (Cu)-Total	0.0010	1	-	mg/L	0.0013	<0.0010	<0.0010	<0.0090
Iron (Fe)-Total	0.050	0.3	-	mg/L	0.882	0.588	0.684	0.510
Lead (Pb)-Total	0.00010	-	0.01	mg/L	0.00031	<0.00010	0.00014	<0.00050
Magnesium (Mg)-Total	0.050	-	-	mg/L	23.6	23.5	23.5	24.0
Manganese (Mn)-Total	0.00050	0.05	-	mg/L	0.0969	0.0724	0.0751	0.058
Molybdenum (Mo)-Total	0.000050	-	-	mg/L	0.00118	0.00119	0.00101	-
Nickel (Ni)-Total	0.00050	-	-	mg/L	0.00117	0.00090	<0.00050	-
Phosphorus (P)-Total	0.050	-	-	mg/L	0.077	0.065	0.065	-
Potassium (K)-Total	0.050	-	-	mg/L	1.53	1.42	1.41	1.30
Rubidium (Rb)-Total	0.00020	-	-	mg/L	0.00102	0.00065	0.00069	-
Selenium (Se)-Total	0.000050	-	0.05	mg/L	<0.000050	<0.000050	<0.000050	<0.002
Silicon (Si)-Total	0.10	-	-	mg/L	10.5	10.4	10.9	-
Silver (Ag)-Total	0.000050	-	-	mg/L	<0.000050	<0.000050	<0.000050	-
Sodium (Na)-Total	0.50	200	20	mg/L	14.6	14.3	14.4	14.0

Parameter	Detection Limit	ODWS		Units	Sample Concentration			
		Operational Guideline	Schedule 1, 2, and 4 Standards		Pretest	13 L/s	18 L/s	23 L/s
Strontium (Sr)-Total	0.0010	-	-	mg/L	0.480	0.453	0.443	-
Sulfur (S)-Total	0.50	-	-	mg/L	0.55	0.55	<0.50	-
Tellurium (Te)-Total	0.00020	-	-	mg/L	<0.00020	<0.00020	<0.00020	-
Thallium (Tl)-Total	0.000010	-	-	mg/L	<0.000010	<0.000010	<0.000010	-
Thorium (Th)-Total	0.00010	-	-	mg/L	<0.00010	<0.00010	<0.00010	-
Tin (Sn)-Total	0.00010	-	-	mg/L	<0.00010	<0.00010	<0.00010	-
Titanium (Ti)-Total	0.0030	-	-	mg/L	0.00998	0.00126	0.00427	-
Tungsten (W)-Total	0.00010	-	-	mg/L	<0.00010	<0.00010	<0.00010	-
Uranium (U)-Total	0.000010	-	0.02	mg/L	0.000460	0.000237	0.000173	<0.00010
Vanadium (V)-Total	0.00050	-	-	mg/L	0.00057	<0.00050	<0.00050	-
Zinc (Zn)-Total	0.0030	5	-	mg/L	<0.0030	<0.0030	<0.0030	<0.005
Zirconium (Zr)-Total	0.00030	-	-	mg/L	<0.00030	<0.00030	<0.00030	-
Mercury (Hg)	0.00010	-	-	mg/L	-	-	-	<0.00010
Volatile Organic Compounds (Water)								
Methane, Dissolved	5.0	2000	-	ug/L	443	628	542	110
1,1-Dichloroethylene	0.10	-	-	ug/L	-	-	-	<0.10
1,2-Dichlorobenzene	0.20	-	-	ug/L	-	-	-	<0.20
1,2-Dichlloroethane	0.20	-	-	ug/L	-	-	-	<0.20
1,4-Dichlorobenzene	0.20	-	-	ug/L	-	-	-	<0.20
Benzene	0.10	-	-	ug/L	-	-	-	<0.10
Bromodichloromethane	0.10	-	-	ug/L	-	-	-	<0.10
Bromoform	0.20	-	-	ug/L	-	-	-	<0.20
Carbon Tetrachloride	0.10	-	-	ug/L	-	-	-	<0.10
Chlorobenzene	0.10	-	-	ug/L	-	-	-	<0.10
Chloroform	0.10	-	-	ug/L	-	-	-	0.14
Dibromochloromethane	0.20	-	-	ug/L	-	-	-	<0.20
Methylene Chloride (Dichloromethane)	0.50	-	-	ug/L	-	-	-	<0.50
Ethylbenzene	0.10	-	-	ug/L	-	-	-	<0.10
Tetrachloroethylene	0.10	-	-	ug/L	-	-	-	<0.10
Toluene	0.20	-	-	ug/L	-	-	-	<0.20
Trichloroethylene	0.10	-	-	ug/L	-	-	-	<0.10
Vinyl Chloride	0.20	-	-	ug/L	-	-	-	<0.20
o-Xylene	0.10	-	-	ug/L	-	-	-	<0.10
p+m-Xylene	0.10	-	-	ug/L	-	-	-	<0.10
Total Xylenes	0.10	-	-	ug/L	-	-	-	<0.10
Total Trihalomethanes	0.20	-	-	ug/L	-	-	-	<0.20
Pesticides and Herbicides								

Parameter	Detection Limit	ODWS		Units	Sample Concentration			
		Operational Guideline	Schedule 1, 2, and 4 Standards		Pretest	13 L/s	18 L/s	23 L/s
Glyphosate	10	-	-	ug/L	-	-	-	<10
Diquat	7.0	-	-	ug/L	-	-	-	<7.0
Diuron	10	-	-	ug/L	-	-	-	<10
Guthion (Azinphos-methyl)	2.0	-	-	ug/L	-	-	-	<2.0
Paraquat	1.0	-	-	ug/L	-	-	-	<1.0
Temephos	10	-	-	ug/L	-	-	-	<10
Lindane	0.0060	-	-	ug/L	-	-	-	<0.0060
Heptachlor	0.0060	-	-	ug/L	-	-	-	<0.0060
Aldrin	0.0060	-	-	ug/L	-	-	-	<0.0060
Heptachlor epoxide	0.0060	-	-	ug/L	-	-	-	<0.0060
Oxychlordane	0.0060	-	-	ug/L	-	-	-	<0.0060
g-Chlordane	0.0060	-	-	ug/L	-	-	-	<0.0060
a-Chlordane	0.0060	-	-	ug/L	-	-	-	<0.0060
Dieldrin	0.0060	-	-	ug/L	-	-	-	<0.0060
o,p-DDE	0.0060	-	-	ug/L	-	-	-	<0.0060
p,p-DDE	0.0060	-	-	ug/L	-	-	-	<0.0060
o,p-DDD	0.0060	-	-	ug/L	-	-	-	<0.0060
p,p-DDD	0.0060	-	-	ug/L	-	-	-	<0.0060
o,p-DDT	0.0060	-	-	ug/L	-	-	-	<0.0060
p,p-DDT	0.0060	-	-	ug/L	-	-	-	<0.0060
Methoxychlor	0.024	-	-	ug/L	-	-	-	<0.024
Aroclor 1016	0.050	-	-	ug/L	-	-	-	<0.050
Aroclor 1221	0.050	-	-	ug/L	-	-	-	<0.050
Aroclor 1232	0.050	-	-	ug/L	-	-	-	<0.050
Aroclor 1242	0.050	-	-	ug/L	-	-	-	<0.050
Aroclor 1248	0.050	-	-	ug/L	-	-	-	<0.050
Aroclor 1254	0.050	-	-	ug/L	-	-	-	<0.050
Aroclor 1260	0.050	-	-	ug/L	-	-	-	<0.050
Dioxins and Furans								
2,3,7,8-Tetra CDD *	1.16	-	-	pg/L	-	-	-	<1.16
1,2,3,7,8-Penta CDD *	1.92	-	-	pg/L	-	-	-	<1.92
1,2,3,4,7,8-Hexa CDD *	1.25	-	-	pg/L	-	-	-	<1.25
1,2,3,6,7,8-Hexa CDD *	1.06	-	-	pg/L	-	-	-	<1.06
1,2,3,7,8,9-Hexa CDD *	1.07	-	-	pg/L	-	-	-	<1.07
1,2,3,4,6,7,8-Hepta CDD *	1.48	-	-	pg/L	-	-	-	<1.48
Octa CDD *	1.88	-	-	pg/L	-	-	-	<1.88
Total Tetra CDD *	1.16	-	-	pg/L	-	-	-	<1.16
Total Penta CDD *	1.92	-	-	pg/L	-	-	-	<1.92

Parameter	Detection Limit	ODWS		Units	Sample Concentration			
		Operational Guideline	Schedule 1, 2, and 4 Standards		Pretest	13 L/s	18 L/s	23 L/s
Total Hexa CDD *	1.12	-	-	pg/L	-	-	-	<1.12
Total Hepta CDD *	1.48	-	-	pg/L	-	-	-	<1.48
2,3,7,8-Tetra CDF **	1.05	-	-	pg/L	-	-	-	<1.05
1,2,3,7,8-Penta CDF **	1.59	-	-	pg/L	-	-	-	<1.59
2,3,4,7,8-Penta CDF **	1.56	-	-	pg/L	-	-	-	<1.56
1,2,3,4,7,8-Hexa CDF **	1.18	-	-	pg/L	-	-	-	<1.18
1,2,3,6,7,8-Hexa CDF **	1.06	-	-	pg/L	-	-	-	<1.06
2,3,4,6,7,8-Hexa CDF **	1.18	-	-	pg/L	-	-	-	<1.18
1,2,3,7,8,9-Hexa CDF **	1.31	-	-	pg/L	-	-	-	<1.31
1,2,3,4,6,7,8-Hepta CDF **	0.934	-	-	pg/L	-	-	-	<0.934
1,2,3,4,7,8,9-Hepta CDF **	1.19	-	-	pg/L	-	-	-	<1.19
Octa CDF **	1.88	-	-	pg/L	-	-	-	<1.88
Total Tetra CDF **	1.05	-	-	pg/L	-	-	-	<1.05
Total Penta CDF **	1.57	-	-	pg/L	-	-	-	<1.57
Total Hexa CDF **	1.17	-	-	pg/L	-	-	-	<1.17
Total Hepta CDF **	1.05	-	-	pg/L	-	-	-	<1.05
Semivolatile Organics								
2,3,4,6-Tetrachlorophenol	0.50	-	-	ug/L	-	-	-	<0.50
2,4,5-T	1.0	-	-	ug/L	-	-	-	<1.0
2,4,6-Trichlorophenol	0.50	-	-	ug/L	-	-	-	<0.50
2,4-D	1.0	-	-	ug/L	-	-	-	<1.0
2,4-Dichlorophenol	0.25	-	-	ug/L	-	-	-	<0.25
Alachlor	0.50	-	-	ug/L	-	-	-	<0.50
Aldicarb	5.0	-	-	ug/L	-	-	-	<5.0
Atrazine	0.50	-	-	ug/L	-	-	-	<0.50
Des-ethyl atrazine	0.50	-	-	ug/L	-	-	-	<0.50
Atrazine + Desethyl-atrazine	1.0	-	-	ug/L	-	-	-	<1.0
Bendiocarb	2.0	-	-	ug/L	-	-	-	<2.0
Bromoxynil	0.50	-	-	ug/L	-	-	-	<0.50
Carbaryl	5.0	-	-	ug/L	-	-	-	<5.0
Carbofuran	5.0	-	-	ug/L	-	-	-	<5.0
Chlorpyrifos (Dursban)	1.0	-	-	ug/L	-	-	-	<1.0
Cyanazine (Bladex)	1.0	-	-	ug/L	-	-	-	<1.0
Diazinon	1.0	-	-	ug/L	-	-	-	<1.0
Dicamba	1.0	-	-	ug/L	-	-	-	<1.0

Parameter	Detection Limit	ODWS		Units	Sample Concentration			
		Operational Guideline	Schedule 1, 2, and 4 Standards		Pretest	13 L/s	18 L/s	23 L/s
Diclofop-methyl	0.90	-	-	ug/L	-	-	-	<0.90
Dimethoate	2.5	-	-	ug/L	-	-	-	<2.5
Dinoseb	1.0	-	-	ug/L	-	-	-	<1.0
Malathion	5.0	-	-	ug/L	-	-	-	<5.0
Metolachlor	0.50	-	-	ug/L	-	-	-	<0.50
Metribuzin (Sencor)	5.0	-	-	ug/L	-	-	-	<5.0
Ethyl Parathion	1.0	-	-	ug/L	-	-	-	<1.0
Pentachlorophenol	0.50	-	-	ug/L	-	-	-	<0.50
Phorate	0.50	-	-	ug/L	-	-	-	<0.50
Picloram	5.0	-	-	ug/L	-	-	-	<5.0
Prometryne	0.25	-	-	ug/L	-	-	-	<0.25
Simazine	1.0	-	-	ug/L	-	-	-	<1.0
Terbufos	0.50	-	-	ug/L	-	-	-	<0.50
Triallate	1.0	-	-	ug/L	-	-	-	<1.0
Trifluralin	1.0	-	-	ug/L	-	-	-	<1.0
Benzo(a)pyrene	0.0050	-	-	ug/L	-	-	-	<0.0050
Methyl parathion	1.0	-	-	ug/L	-	-	-	<1.0
Calculated Parameters								
Aldrin + Dieldrin	0.006	-	-	ug/L	-	-	-	<0.006
Chlordane (Total)	0.006	-	-	ug/L	-	-	-	<0.006
DDT+ Metabolites	0.006	-	-	ug/L	-	-	-	<0.006
Heptachlor + Heptachlor epoxide	0.006	-	-	ug/L	-	-	-	<0.006
Total PCB	0.05	-	-	ug/L	-	-	-	<0.05
Miscellaneous Parameters								
NTA	0.050	-	-	mg/L	-	-	-	<0.05
Fixed Gases								
Methane	0.005	-	-	L/m^3	-	-	-	1.6
NDMA/D/F/MIB/GEO								
N-Nitrosodimethylamine	0.0009	-	-	ug/L	-	-	-	<0.0009
Radionuclides								
Tritium	15	-	-	Bq/L	-	-	-	<15
Gross Alpha	0.10	-	-	Bq/L	-	-	-	0.13
Gross Beta	0.10	-	-	Bq/L	-	-	-	<0.10

Sample exceeds ODWS standards

5.4.1.4 Interference with Municipal Wells

There was no pumping activity at the nearby municipal wells (NOB-PW2, NOB-PW3, and NOB-PW5) during the step test, however the wells were observed to be recovering from water level drawdown from pumping NOB-PW5 prior to completing the step test at Well Site F (**Figure 25**). However, minor impacts are expected to the analysis as the water level remains relatively stable prior to the testing. During the recovery portion after the step test, NOB-PW2 and NOB-PW3 were observed to be pumping at a rate of approximately 18 L/s and 24 L/s, respectively.

Over the short duration of the test, interference between MW9 and the existing monitoring wells and productions wells ranged from 0.03 to 0.09 m. A better measure of the interference effects between MW9 and the well network was observed during the combined pumping test completed at Well Site H, where up to 6.03 m of interference was measured at MW9 from the combined pumping at NOB-PW5 and MW6. This indicates that there is interference that will need to be assessed through a long term pumping test if Site F is selected as the preferred site.

5.4.1.5 Interference with Private Wells

While no private wells were monitored during the step testing at Well Site F, no water level response was observed in the shallower wells found in the Upper and Lower ORAC (MW4s, MW4I).

The nearest private well to MW9 that is screened in the Scarborough Aquifer is approximately 230 m to the southwest (on Hilda Road). Based on a distance drawdown assessment and forward solution analysis (discussed further in Section 5.4.1.6), it is expected that drawdown at this well was less than 0.5 m during the step-drawdown test. As this well is approximately 94 m deep, a 0.5 m drawdown from pumping would not adversely affect the water supply potential for this private well. This observation along with the small drawdown from pumping (4.4 m) strongly suggests that nearby private wells will not be adversely impacted by future pumping at Well Site F.

Since drawdown predictions were completed using a short duration step test and the total effect of pumping was likely not realized, future hydraulic testing and monitoring will be required to confirm this conclusion, which will be completed should Well Site F be the preferred site.

5.4.1.6 Evaluation of Site F

To assess the potential for Well Site F to support a future municipal supply well with a sustainable pumping rate of at least 35 L/s, a step-drawdown test was completed to proceed with York Region Section 18. Based on the results of Palmer's field testing and analysis, the transmissivity of the Scarborough aquifer at Site F was found to be 802 m^2/day with a storativity coefficient of 3.33 x $10^{-4,}$ based on preliminary data. A drawdown of 0.09 m was determined to reach up to 661 m from MW9, which was also the maximum ROI observed, however, it should be noted that a short term test will not allow for a full assessment of the ZOI. The additional drawdown in MW9 after pumping the third step of 23 L/s for 2-hours was 2 m, and the shape of the drawdown curve was flattening showing a drawdown rate of 0.002 m/min during the final 30 min of testing.

To determine if the MW9 can support a higher pumping rate, both a forward solution analytical model and the specific capacity were used to provide an estimate. The specific capacity was calculated to 5.36 L/s/m

with an R^2 value of 0.987, which is considered to be high and suitable to estimate future drawdown by using the equation of the trendline. Assuming no increased drawdown from interference or well losses, based on the specific capacity of MW9, if the pumping rate is to be increased to 35 L/s, the drawdown is estimated to be 8.3 m. As the total available drawdown in MW9 during the step test, measured by the distance between the static water level and the top of the screen, was 69.9 m, and the predicted drawdown represents approximately 12% of the available drawdown. **Figure 26** shows the available water column in MW9.

A Forward Solution analysis model of the step test was conducted using Aqtesolv™ software based the average/ geomean measured transmissivity and storativity coefficient and analyzed using the Theis (1935)/ Hantush (1961) method for confined aquifers. As part of QA/QC on the modelling process, the Forward Solution Model was first used to model the measured step test results. As observed in **Figure 27** below, the forward solution model predicted a drawdown of 6.4 m for the step test, whereas the measured drawdown was 4.4 m. The theoretical value is greater than the measured drawdown and this is due to the pumping of NOB-PW5 prior to testing. The recovery of the wells may be recharging MW9, artificially lowering the drawdown value. Using these values for the forward solution will provide conservative results. It is estimated that continuously pumping a future 12” diameter well, with similar screen design as MW9, installed at the Well Site F location at a rate of 35 L/s for 72 hours, 1 year, and 10 years, would results in a drawdown of approximately 10.9 m, 12.2 m, and 13 m, respectively (**Figure 28**). The predicted drawdown after 10 years of continuous pumping represents approximately 19% of the available drawdown. The radius of influence to 1 m drawdown of 850 m (**Figure 29**). The analyses for the forward solution can be found in **Appendix B**.

No residential wells were monitored during the step test process. However, since it has been determined that they are installed within the Upper and Lower ORAC, or Newmarket Till, MW4S and MW4I is be used as a representation of these wells. As evident in **Figure 23**, water levels in both wells did not change during the step test and it can be concluded that pumping in the Scarborough Aquifer will not adversely affect nearby residential wells as the drawdown at the nearest well completed in the Scarborough Aquifer is predicted to be less than 1 m.

Based on the results of the step-drawdown testing, data analysis and Forward Solution modelling, the Well Site F location has a very high potential to support a future Municipal Production Well with a pumping rate of at least 35 L/s without adversely affecting the existing supply wells, other groundwater users or the natural environment.

During the step test, only NOB-PW2 and NOB-PW5 are affected by pumping at MW9 as water levels in this well were observed to drop by up to 0.03 m. As comparison, drawdown in MW4D, MW5, MW6, and NOB-PW5 was ranged from 0.04 to 0.09 m. An estimate of the interference effects can also be interpreted from the pumping test conducted at Well Site H. After the step test was conducted at MW6, MW9 had a drawdown of 0.49 m. After 23 hours of pumping at MW6 and 72 hours of combined pumping at MW6 and NOB-PW5, the total drawdown is determined to be 1.55 m and 6.03 m. This indicates that there is potential interference that will need to be assessed through a long-term pumping test if Site F is selected as the preferred site. Since the available water column is large (approx. 75 m), interference from nearby municipal supply wells is not considered significant.

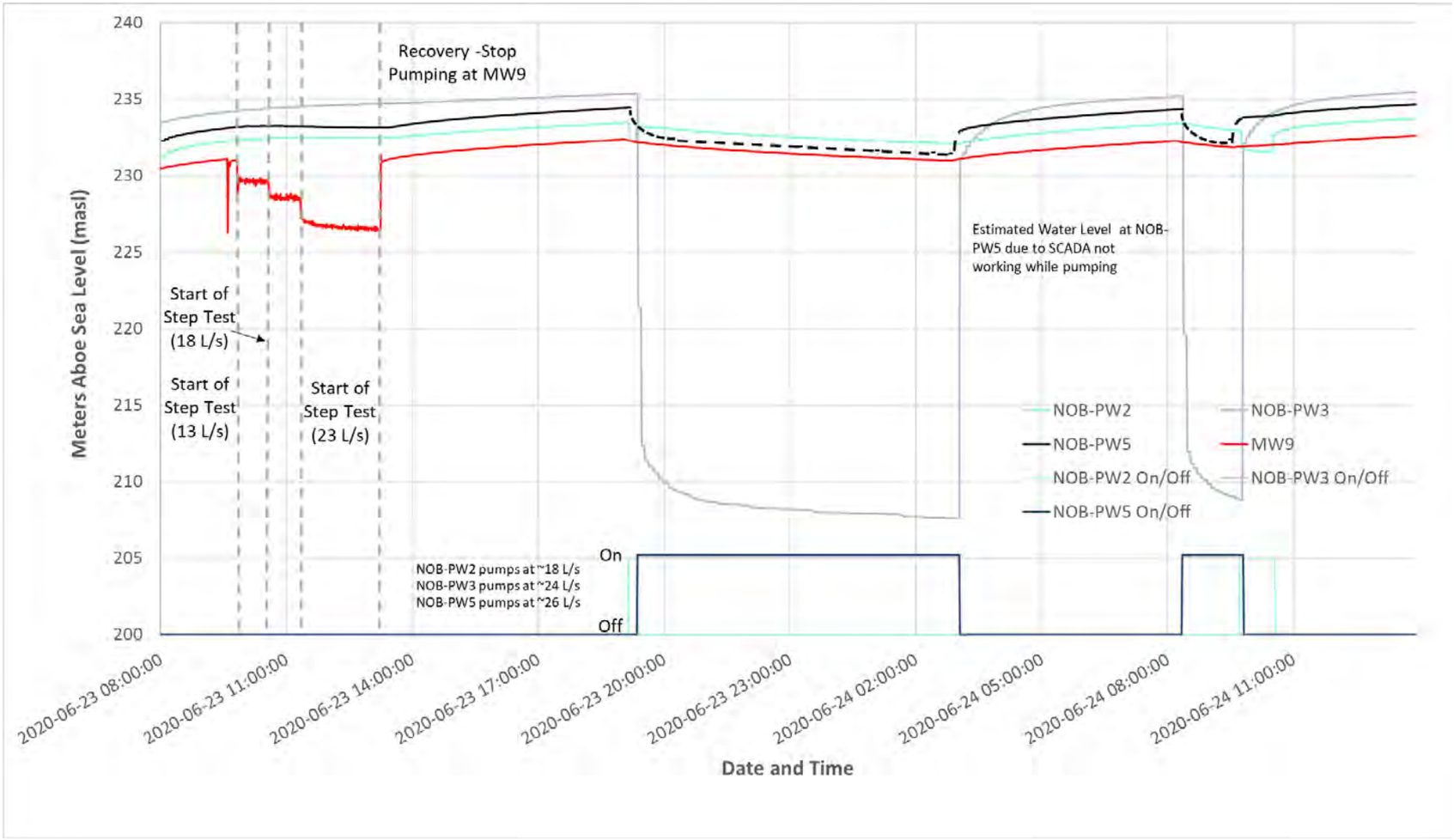


Figure 25. Nobleton Municipal Supply Wells at Site F

Figure 26. Available Drawdown in MW9

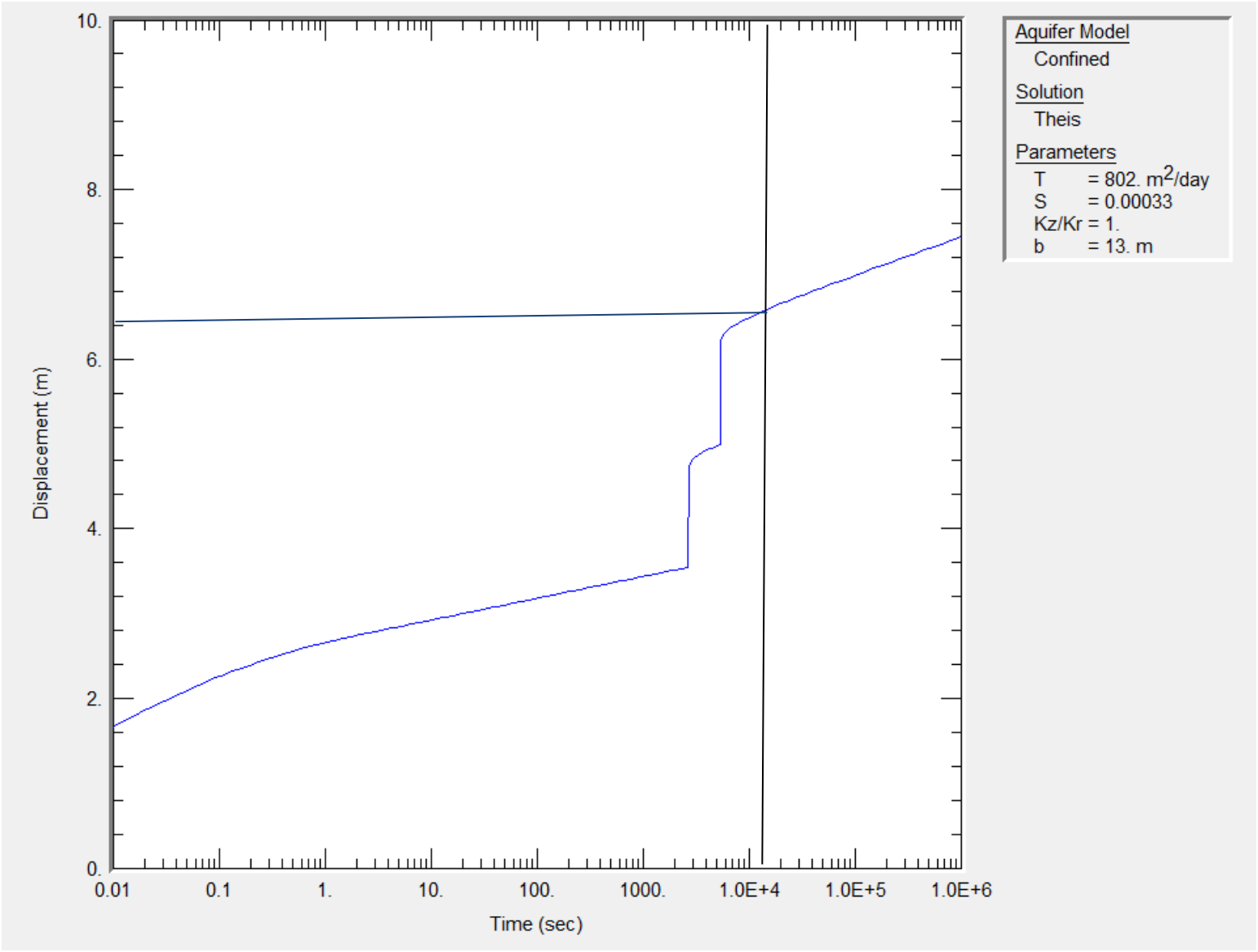


Figure 27. Well Site F – Forward Solution for Displacement

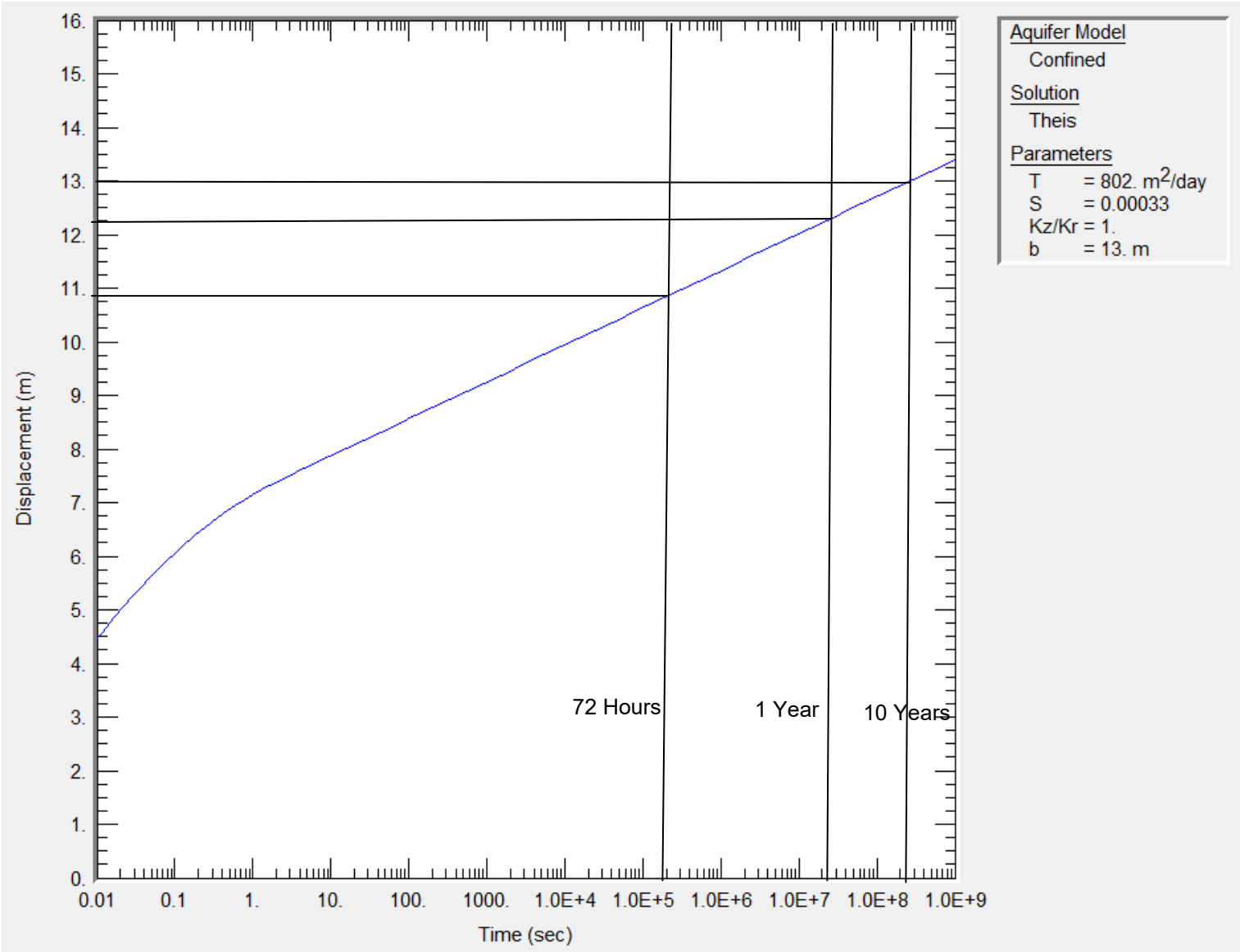


Figure 28. Well Site F – Forward Solution for 35 L/s

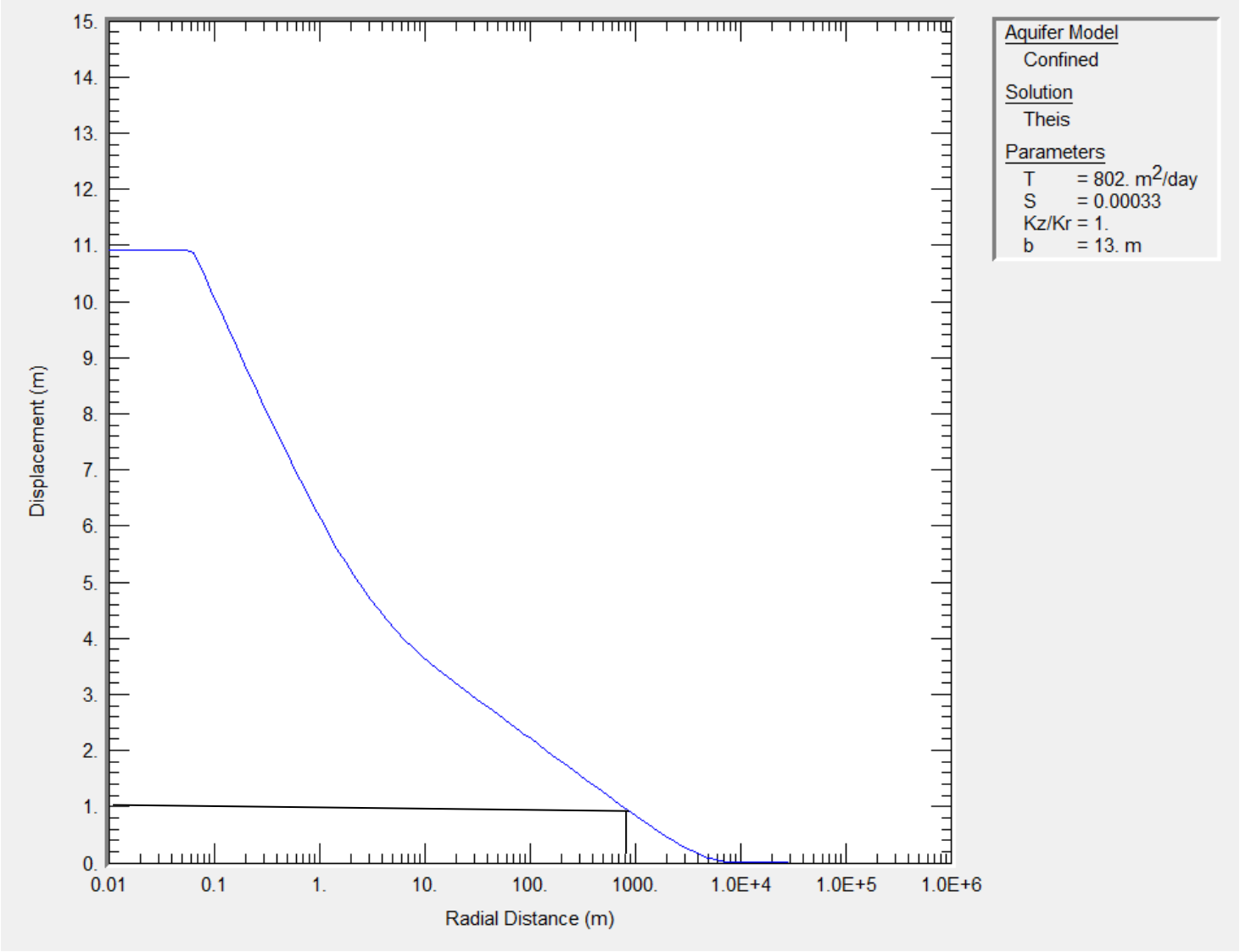


Figure 29. Well Site F – ROI for a Drawdown of 1 m

5.4.2 Well Site H

5.4.2.1 Test Well Development

As Well Site H is an existing well site with previously completed well testing, the existing small diameter test well MW6 was used to complete the hydrogeological field investigation program for Well Site H. This test well was drilled by MMM in 2012 and its BH logs can be found in **Appendix A**. MW6, similar to MW9, is a 6-inch (0.152 m) test well screened within the Scarborough Aquifer. The depth of the well screen ranges from 96.6 – 103.0 mbgs. From the BH logs, the Sunnybrook Aquitard was interpreted to be approximately 48.7 m thick. This is much thicker than York Region's Tier 3 Conceptual Model, which predicted a 10 m thickness. The Scarborough Aquifer was interpreted to be approximately 15.3 m thick.

To ensure that MW6 was in a sand free state and had low turbidity, the well was developed for approximately 6 hours on March 13, 2020 and allowed to recovery for two days to allow the water level to return to static. Groundwater discharge was initially found with a turbidity of 5.72 NTU and eventually reached a low of 0.24 NTU. Sand content was checked in accordance with AWWA procedures (AWWA Standard A100-97) using the Rossum Sand Sampler. Before development, sand was found at 23.78 ppm and was reduced to 2.47 ppm after development. A summary of turbidity and sand progress during well development can be found in **Table 15**.

Table 15. Turbidity and Sand Content During Well Development

Time	Elapsed Time (min)	Turbidity (NTU)	Sand Measurement (ml)	Sand Content (ml/min)	Sand Content (ppm)
9:11:00 AM	11	5.72	-	-	-
9:15:00 AM	15	-	0.225	0.045	23.78
9:25:00 AM	25	-	0.125	0.025	13.21
9:40:00 AM	40	0.87	-	-	-
9:50:00 AM	50	-	0.125	0.025	13.21
10:05:00 AM	65	-	0.125	0.013	6.60
10:25:00 AM	85	2.26	0.15	0.015	7.93
10:40:00 AM	100	-	0.19	0.019	10.04
11:10:00 AM	130	-	0.175	0.018	9.25
11:40:00 AM	160	-	0.14	0.014	7.40
1:05:00 PM	245	0.78	0.27	0.009	4.76
2:00:00 PM	300	-	0.3	0.010	5.28
2:35:00 PM	335	0.24	0.14	0.005	2.47

5.4.2.2 Step-Drawdown Testing

For Well Site H, the existing monitoring well MW6 was used to complete the step test and the combined 72-hour pumping test with NOB-PW5. A Category 2 PTTW was obtained on December 20, 2019 (PTTW # 3274-BK2GW2) to complete the hydraulic testing at Well Site H. This test was conducted in

coordination with York Region as it was planned to have NOB-PW5 turned off (i.e. not pumping) for the step test and the first 24 hours of the 72-hour pumping test. All monitoring wells within the well site, MW4S/I/D, MW5, and NOB-PW5, were monitored during the entire test.

Groundwater discharge during the pumping test was discharged to a cobble swale located on the NOB-PW5 property. To further prevent erosion to the creek, water was discharged through a diffusor onto a splash mat to slow down the velocity and then diverted overland through vegetated areas to minimize disturbance before ultimately flowing into a tributary of the East Humber River. As this tributary is considered to be redside dace SAR habitat, staff from MECP and TRCA were consulted and approved the discharge plan. In addition, the tributary was constantly monitored at a downstream reference point to ensure no flooding or erosion occurred from the extra discharge from the pumping tests.

A step test was carried out at MW6 beginning at 9:30 AM on March 16, 2020, consisting of three (3) 1-hour steps at rates of 13 L/s, 18 L/s, and 23 L/s. The monitoring wells were monitored using data loggers (Either Solinst M30 or M100 data loggers) and the pumping wells were monitored using a SCADA probe. Manual water level measurements were also obtained from the monitoring wells using water level tape. The pumping rates were increased incrementally without permitting the well to recover between steps. The final step was completed at approximately 12:30 PM, which was carried forward into the pumping 72-hour pumping test. The step test results confirmed that a rate of 23 L/s could be easily maintained over a 72-hour period. The additional drawdown in MW6 after pumping the third step of 23 L/s for 1-hour was 0.73 m and the shape of the drawdown curve was starting to flatten showing a drawdown rate of 0.003 m/min during the final 30 min of testing.

Table 16 shows the static water level at each monitoring well that was closely monitored during the step test and combined pumping test at MW6. Static water levels across the monitoring well network that was screen within the same aquifer unit ranged from 21.3 to 26.8 mbtoc. The total drawdown at MW6 was 3.45 m and drawdown in the monitoring well network (MW1D, MW3D, MW4D, MW5, MW9, and NOB-PW5) ranged from 0.02 to 0.90 m by the end of the step testing.

Table 16. Step Test and Combined Pumping Test at MW6 Details

Monitoring Well	Static Water Level (mbtoc)	Distance from MW6 (m)	Total Drawdown (m)				
			End of First Step (1 hour) (13 L/s)	End of Second Step (1 hour) (18 L/s)	End of Step Third Test (1 hour) (23 L/s)	End of Pumping Test w/o NOB-PW5 pumping (23 hours) (23 L/s)	End of Pumping Test w/ NOB-PW5 pumping (72 hours) (23 L/s)
MW1S	17.6	526	0.00	-0.01	-0.01	-0.12	0.01
MW1D	35.0*	526	0.08	0.17	0.24	1.56	4.01
MW3S	9.4	407	0.04	0.05	0.05	0.11	0.09
MW3D	24	407	0.00	0.00	0.02	0.45	3.44
MW4S	6.3	8	-0.04	-0.05	-0.06	-0.07	-0.09
MW4I	7.84	7	-0.01	0.00	0.00	0.08	0.01
MW4D	22.3	13	0.31	0.60	0.90	1.90	6.58
MW5	21.7	83	0.25	0.47	0.71	1.72	6.59
MW6 (Pumping Well)	22.7	-	1.46	2.72	3.45	4.32	8.94
MW9	26.8	692	0.13	0.29	0.49	1.55	6.03
NOB-PW5	21.3	65	0.29	0.49	0.70	1.50	9.03

*Assumed water depth due to tape not reaching static water level

A detailed time-drawdown graph of the step test is presented on **Figure 30**. Prior to the test, water levels are rising and this is due to PW2 and PW3 finishing an on cycle, allowing the aquifer to recharge, as seen in **Figure 34**. This may potentially underestimate the potential drawdown. The Specific Capacity plot (**Figure 31**) at MW6 is shown by comparing the discharge rate to the drawdown and indicates the well has a specific capacity of about 6.71 L/s/m. Additionally, the R^2 value is 0.971, indicating that the trend line fits the data well and the drawdown can be predicted with relative accuracy if discharge is increased. Based on specific capacity, if the pumping rate is to be increased to 35 L/s, the drawdown is estimated to be 6.3 m. The low variance also shows that the well efficiency is high and that the screen design is suitable for the geological conditions, which will be important if Well Site H is chosen to install the municipal supply well.

5.4.2.3 Combined Pumping Test with NOB-PW5

To expand upon the step testing results and to provide a detailed hydrogeological assessment of potential well interference effects with the existing supply wells, to proceed with the detailed hydrogeological phase of Section 18, a constant rate pumping test was carried out at Well Site H over a 72 hour period beginning at 11:30 AM on March 16, 2020 and ending at 11:30 PM March 19, 2020. The following summarizes the pumping test completed at Well Site H:

- Well Development at MW6;

- 3-hour step-drawdown test at MW6, transitioning into a 24-hour pumping test at MW6 at a rate of 23 L/s with NOB-PW5 off (i.e. not pumping);
- After 24-hours of pumping MW6 at 23 L/s, NOB-PW5 is also turned on at a rate of 26 L/s for 48-hour combined drawdown pumping test; and
- After 72-hours total, both wells are turned off and allowed to recover to at least 95% of static.

During the test, all monitoring wells in the Nobleton well network were monitored by data loggers and/or manual measurements. A private well, located at 12645 Highway 27, approximately 720 m south of the test well, was also monitored by manual measurements. A graph of all logger data within the study area can be found on **Figure 32**. It should be noted that due to the SCADA not working in NOB-PW5 while it was pumping, the estimated water level based on manual measurements is provided in the graph.

Following the step-drawdown test, the pumping rate at MW6 was set to 23 L/s and was pumped for 24 hours without interference from NOB-PW5. After 24 hours, NOB-PW5 was turned to a rate of 26 L/s and both MW6 and NOB-PW5 were pumped simultaneously for an additional 48 hours to observe interference effects from NOB-PW5 on MW6, and vice-versa.

At the end of the first 24-hours of the pumping test, the drawdown at MW6 was found to be 4.32 m and the monitoring wells ranged from 0.45 to 1.9 m. At the end of the 72-hour combined pumping test where both MW6 and NOB-PW5 were pumping at 23 L/s and 26 L/s, respectively, the drawdown was determined to be 8.94 m in MW6 and 9.03 in NOB-PW5. Water levels in the monitoring well network ranged from 3.44 to 6.59 m following the combined 72-hour pumping test.

Transmissivity and Storativity values were calculated using the displacement-time data and were analysed using the Theis (1935) method for confined aquifers, as modelled by Aqtesolv™ software. The analysis results are presented in **Appendix B**, and the calculated transmissivity and storativity values are summarized in **Table 17.** These analyses indicate that the transmissivity of the Scarborough Aquifer at Well Site H ranges from 520 to 1,246 m^2/day with storativity coefficients ranging between 2.20 x 10^{-4} to 3.79 x 10^{-3}. The report by MMM in 2012 calculated a transmissivity value of 790 m^2/day in NOB-PW5 and the report by MMM in 2007 calculated a storativity value of 1x10^{-4} in NOB-PW4 (**Appendix A**), which is located within the same wellhouse as NOB-PW5. The ROI was determined reach up to 1,226 m from MW6. The curve matching data from the pumping (**Appendix B**) indicates the presence of a no flow boundary condition within the ROI MW6. This boundary condition is interpreted to be located to the west of the Well Site H location as the MMM (2012) groundwater exploration study identified the absence of the Scarborough Formation Aquifer in a well located approximately 1 km west of Hwy 27 along King Road. While not assessed in detail as part of this study, a no flow boundary condition at this distance fits the observed drawdown data from MW6 well.

A distance-drawdown graph, **Figure 33**, was also created to determine the transmissivity values based on how far the monitoring wells were compared to MW6 and how much drawdown was found in each well after 24 hours of pumping. Using this method, the well efficiency was determined to be approximately 95% and the change in head per magnitude of distance was found to be 0.7 m.

Table 17. Transmissivity and Storativity for Well Site H (MW6)

Monitoring Well	Transmissivity (m^2/day)	Storativity Coefficient (-)
MW1D	1,181	6.29×10^{-4}
MW3D	1,246	3.79×10^{-3}
MW4D	1,241	8.71×10^{-4}
MW5	1,113	2.47×10^{-4}
MW6	825	-
MW9	661	3.77×10^{-4}
NOB-PW5	1,176	2.20×10^{-4}
Distance Drawdown Analysis	1,214	-
Average/ Geomean	1,082	5.91×10^{-4}

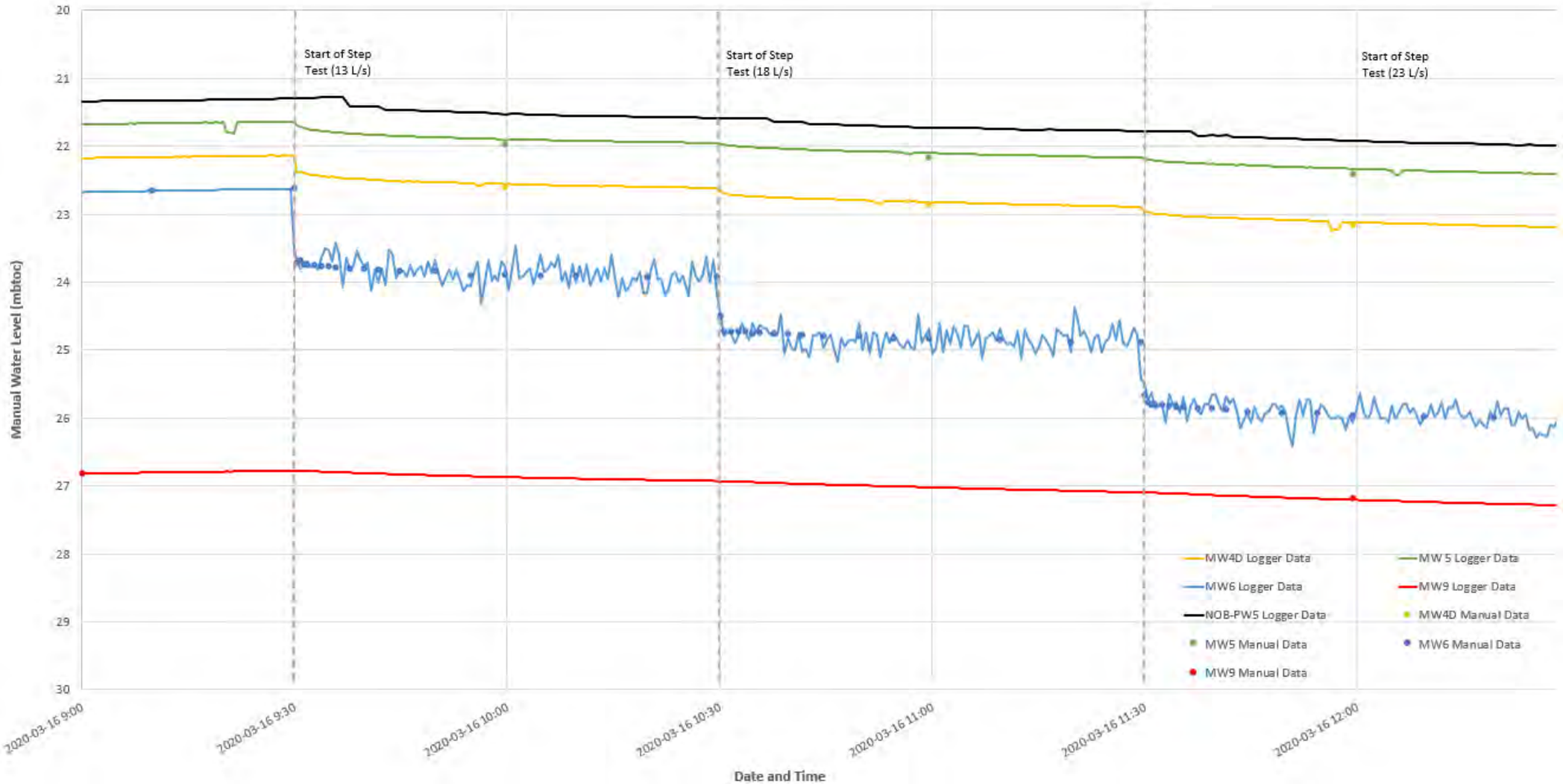


Figure 30. Step Test at MW6

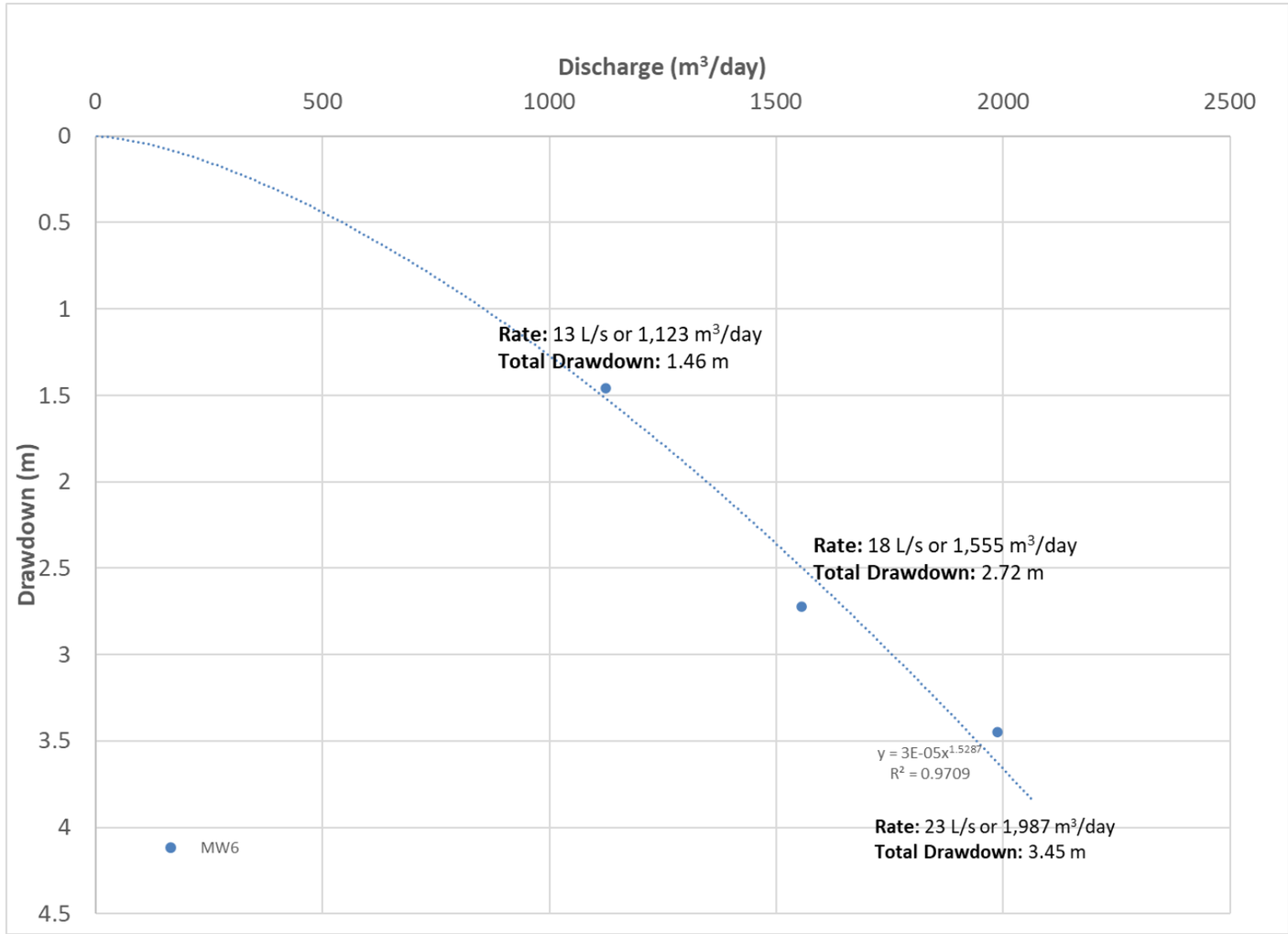


Figure 31. Specific Capacity Plot at MW6

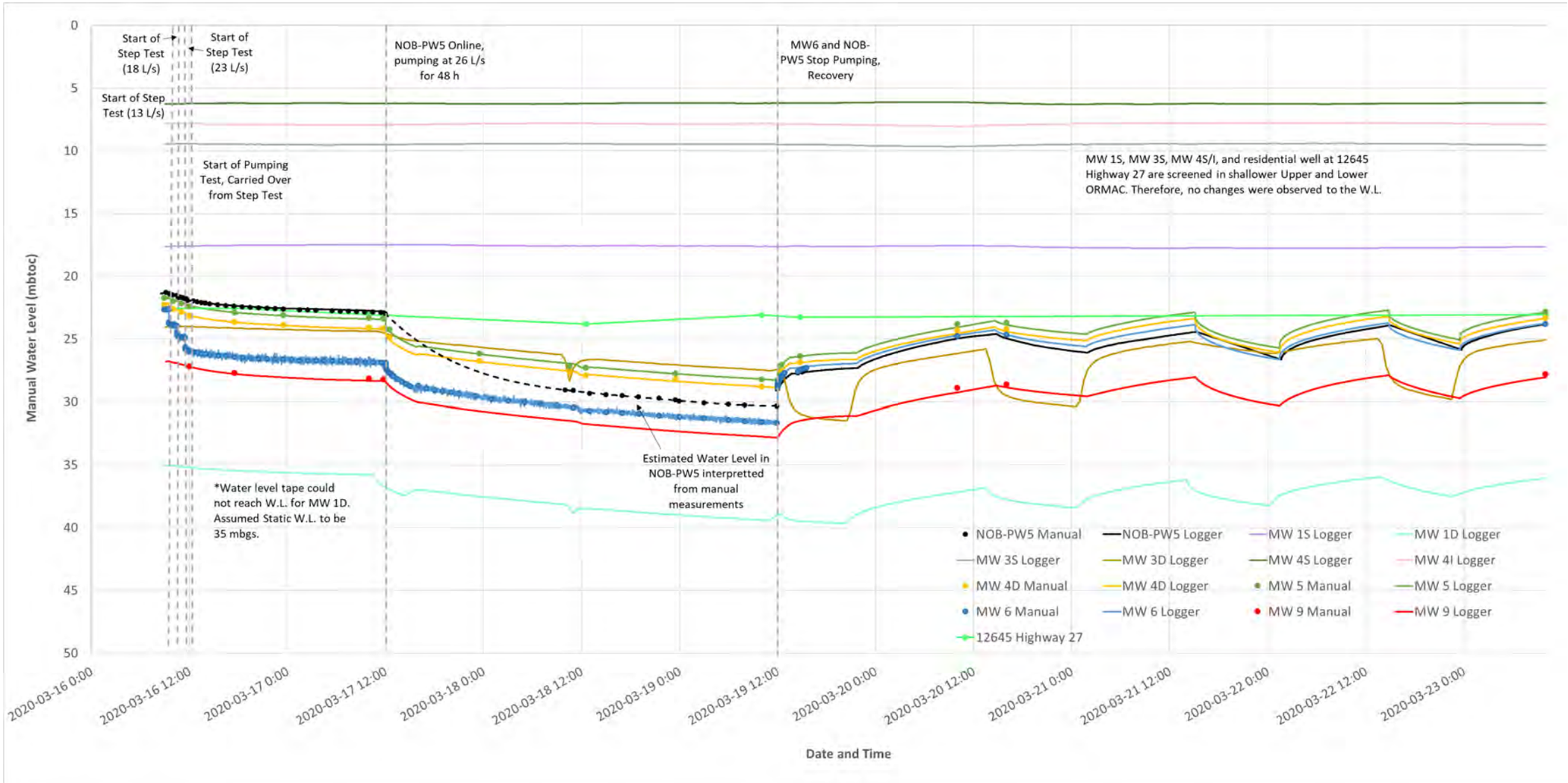


Figure 32. Step Test and Pumping Test at MW6 w/ Recovery and Monitoring Network

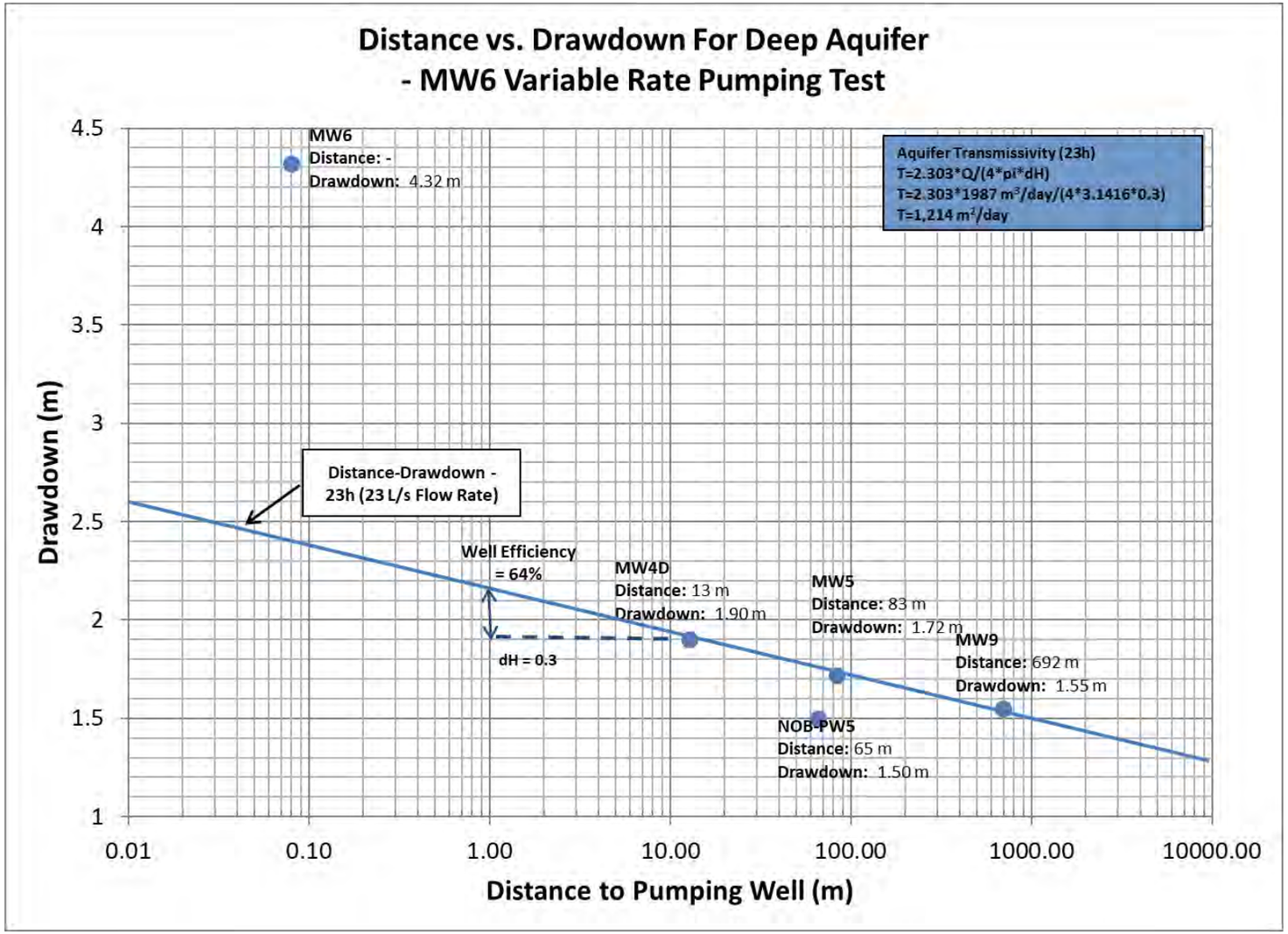


Figure 33. Distance vs Drawdown at MW6

5.4.2.4 Groundwater Quality

Groundwater samples were obtained from the pumping well at the beginning of the step test and prior to each rate change. It was also collected at the time intervals of 6, 12, 24, 36, 48, 60 and 72 hours for the pumping test. All water samples were tested against ODWS standards for general water chemistry, VOCs, major and minor ions, nutrients, metals, bacteriological parameters, and general water quality indicators. The final sample was further analyzed for parameters listed in Tables 1, 2, and 4 of the ODWS. A summary table of the groundwater analysis results is presented on **Table 16**, and the Certificate of Analysis is provided in **Appendix C**.

Generally, water quality for MW6 remained consistent over the period of the step test and 72-hour rate pumping test. The groundwater is generally hard with hardness ranging between 225 and 251 mg/L, above the ODWQS aesthetic criteria of 80-100 mg/L. Results indicate that turbidity consistently met the criteria of 5 NTU throughout the long term rate test except during the 24 hour of the pumping test, where it was found to be 5.6 NTU. This was timed with the start of pumping from NOB-PW5 and may be due to part of the casing entering the sample. Colour consistently exceeded the 5 TCU objective and ranged from 13.4 to 26.3 CU, which may be due to the high iron content in the groundwater. Conductivity was consistent throughout the test ranging between 453 to 462 umho/cm. The pH was measured between 7.95 to 8.08, compared to the ODWS range of 6.5 to 8.5.

Nitrate and nitrites were below detection limits throughout the test pumping program. Presence of nitrate is typically associated with the contamination from the agricultural activities and/or septic systems. Absence of nitrates in the raw water is an indication of aquifer being well protected from surface sources of contamination. The absence of sulphate, also measured at non-detectible levels, supports this statement as sulphate, which is common in shallow aquifers, is reduced by anaerobic bacteria in deep aquifers when there is little oxygen in the system.

Chloride (4.85 to 5.5 mg/L) and sodium (10.6 to 11.5 mg/L) were generally consistent and met their ODWS criterion of 250 and 20 mg/L, respectively.

Iron was detected to range from 0.73 to 0.87 mg/L and was consistently greater than the ODWS standard of 0.3 mg/L. Manganese was also consistently above the 0.05 mg/L ODWS, however, is below the 0.1 mg/L MAC criteria in all samples, ranging between 0.055 and 0.063 mg/L.

Total Coliforms were detected in the first two samples, however, bacterial tests were under the ODWS standards for the rest of the test.

Methylene Chloride, herbicides, pesticides, PCBs, Dioxins, and Furans were non-detectible in the 72-hour sample.

Table 18. Groundwater Quality Results at MW6

Parameter	Detection Limit	ODWS		Units	Sample Concentration										
		Operational Guideline	Schedule 1 and 2 Standards		Step Test				Pumping Test						
					Pretest	13 L/s	18 L/s	23 L/s	6H	12H	24H	36H	48H	60H	72 H
Physical Tests															
Colour, Apparent	2.0	5	-	CU	14.9	13.4	14.8	13.7	14.7	14.6	22.6	21.1	26.3	24.0	<2.0
Conductivity	3.0	-	-	umhos/cm	457	453	457	460	455	458	455	459	462	461	-
pH	0.10	6.5 -> 8.5	-	pH units	8.08	8.02	8.03	8.04	8.08	8.06	7.95	7.96	7.97	7.99	8.03
Redox Potential	-1000	-	-	mV	291	288	286	280	284	277	278	280	275	284	-
Total Dissolved Solids	20	500	-	mg/L	237	251	244	246	246	261	258	257	274	274	-
Turbidity	0.10	5	-	NTU	4.41	3.42	3.80	3.49	4.87	4.01	5.60	4.66	4.69	4.23	3.7
Anions and Nutrients (Water)															
Alkalinity, Bicarbonate (as CaCO3)	2.0	-	-	mg/L	251	251	254	247	254	254	255	248	250	252	-
Alkalinity, Carbonate (as CaCO3)	2.0	-	-	mg/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	-
Alkalinity, Hydroxide (as CaCO3)	2.0	-	-	mg/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	-
Alkalinity, Total (as CaCO3)	2.0	30 -> 500	-	mg/L	251	251	254	247	254	254	255	248	250	252	240
Ammonia, Total (as N)	0.010	-	-	mg/L	0.334	0.304	0.312	0.306	0.308	0.310	0.306	0.306	0.305	0.304	0.45
Bromide (Br)	0.10	-	-	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	-
Chloride (Cl)	0.50	250	-	mg/L	4.99	4.85	4.85	4.89	4.98	5.05	5.26	5.36	5.45	5.50	6.0
Computed Conductivity	-	-	-	uS/cm	423	404	418	423	427	431	411	409	407	412	-
Conductivity % Difference	-	-	-	%	-8	-11	-9	-8	-6	-6	-10	-11	-13	-11	-
Fluoride (F)	0.020	-	1.5	mg/L	0.130	0.133	0.138	0.138	0.134	0.137	0.132	0.131	0.129	0.130	0.180
Hardness (as CaCO3)	-	80 -> 100	-	mg/L	244	225	239	247	247	251	229	231	228	231	230
Ion Balance	-	-	-	%	126	117	122	130	126	127	116	121	118	119	-
Langelier Index	-	-	-	-	1	1	1	1	1	1	1	1	1	1	-
Nitrate (as N)	0.020	-	10	mg/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.10
Nitrite (as N)	0.010	-	1	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.10
Nitrate + Nitrite (N)	0.10	-	-	mg/L	-	-	-	-	-	-	-	-	-	-	<0.10

Parameter	Detection Limit	ODWS		Units	Sample Concentration										
		Operational Guideline	Schedule 1 and 2 Standards		Step Test				Pumping Test						
					Pretest	13 L/s	18 L/s	23 L/s	6H	12H	24H	36H	48H	60H	72 H
Total Organic Nitrogen	0.01	-	-	mg/L	-	-	-	-	-	-	-	-	-	-	<0.10
Saturation pH	-	-	-	pH	7.26	7.3	7.27	7.27	7.25	7.24	7.27	7.28	7.28	7.27	-
Orthophosphate-Dissolved (as P)	0.0030	-	-	mg/L	0.0142	0.0143	0.0116	0.0119	0.0105	0.0086	0.0121	0.0108	0.0080	0.0089	-
TDS (Calculated)	-	-	-	mg/L	250	243	250	249	253	255	248	244	244	247	270
Sulfate (SO4)	0.30	500	-	mg/L	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<1.0
Sulphide (as S)	0.018	0.05	-		<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	0.019	<0.018	<0.018	<0.018	-
Sulphide (as H2S)	0.019	0.05	-		<0.019	<0.019	<0.019	<0.019	<0.019	<0.019	0.02	<0.019	<0.019	<0.019	-
Sulphide	0.02	-	-	mg/L	-	-	-	-	-	-	-	-	-	-	<0.02
Anion Sum	-	-	-	me/L	4.31	4.3	4.35	4.24	4.36	4.37	4.38	4.26	4.29	4.34	-
Cation Sum	-	-	-	me/L	5.44	5.02	5.3	5.49	5.48	5.57	5.09	5.15	5.06	5.15	-
Cation - Anion Balance	2.0	-	-	%	12	8	10	13	11	12	8	9	8	9	-
Inorganic Parameters (Water)															
Silica	0.21	-	-	mg/L	28.7	28.5	27.9	29.1	28.6	30	27	28.2	26.7	27	-
Total Kjeldahl Nitrogen (TKN)	0.10	-	-	mg/L	-	-	-	-	-	-	-	-	-	-	0.40
Microcystin	0.10	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	0.10
Dissolved Organic Carbon	0.40	-	-	mg/L	-	-	-	-	-	-	-	-	-	-	0.94
WAD Cyanide (Free)	0.0010	-	-	mg/L	-	-	-	-	-	-	-	-	-	-	<0.0010
Bacteriological Tests (Water)															
E. Coli	-	-	0	CFU/100mL	0	0	0	0	0	0	0	0	0	0	0
Fecal Coliforms	0	-	0	CFU/100mL	0	0	0	0	0	0	0	0	0	0	0
Total Coliform Background	1000	-	-	CFU/100mL	34	9	1	0	0	0	0	0	0	0	1
Total Coliforms	1000	-	0	CFU/100mL	11	2	0	0	0	0	0	0	0	0	0
Metals (Water)															
Sodium Adsorption Ratio	0.10	-	-	SAR	0.32	0.31	0.31	0.31	0.31	0.32	0.31	0.31	0.31	0.31	-
Total Metals (Water)															
Aluminum (Al)-Total	0.010	0.1	-	mg/L	0.022	<0.010	0.017	<0.010	<0.010	0.024	<0.010	<0.010	<0.010	<0.010	<0.005
Antimony (Sb)-Total	0.00010	-	0.006	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.0005

Parameter	Detection Limit	ODWS		Units	Sample Concentration										
		Operational Guideline	Schedule 1 and 2 Standards		Step Test				Pumping Test						
					Pretest	13 L/s	18 L/s	23 L/s	6H	12H	24H	36H	48H	60H	72 H
Arsenic (As)-Total	0.00010	-	0.01	mg/L	0.00032	0.00026	0.00033	0.00031	0.00029	0.00030	0.00023	0.00023	0.00020	0.00022	<0.0010
Barium (Ba)-Total	0.00020	-	1	mg/L	0.240	0.221	0.224	0.226	0.228	0.236	0.221	0.224	0.222	0.225	0.220
Beryllium (Be)-Total	0.00010	-	-	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	-
Bismuth (Bi)-Total	0.000050	-	-	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000082	<0.000050	<0.000050	<0.000050	-
Boron (B)-Total	0.010	-	5	mg/L	0.031	0.028	0.029	0.031	0.031	0.031	0.029	0.029	0.029	0.029	0.023
Cadmium (Cd)-Total	0.000010	-	0.005	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Calcium (Ca)-Total	0.50	-	-	mg/L	57.3	52.5	55.9	57.7	58.0	59.8	54.8	55.0	54.4	55.5	55.0
Cesium (Cs)-Total	0.000010	-	-	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	-
Chromium (Cr)-Total	0.00050	-	0.05	mg/L	0.00203	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.005
Cobalt (Co)-Total	0.00010	-	-	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	-
Copper (Cu)-Total	0.0010	1	-	mg/L	0.0022	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Iron (Fe)-Total	0.050	0.3	-	mg/L	0.9	0.8	0.8	0.8	0.8	0.9	0.7	0.8	0.7	0.7	0.68
Lead (Pb)-Total	0.00010	-	0.01	mg/L	0.00011	<0.00010	<0.00010	<0.00010	0.00106	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00050
Magnesium (Mg)-Total	0.050	-	-	mg/L	24.6	22.8	24.0	25.0	24.7	24.6	22.4	22.9	22.3	22.5	22.0
Manganese (Mn)-Total	0.00050	0.05	-	mg/L	0.0620	0.0563	0.0589	0.0590	0.0589	0.0632	0.0559	0.0563	0.0545	0.0556	0.050
Molybdenum (Mo)-Total	0.000050	-	-	mg/L	0.000681	0.000618	0.000628	0.000691	0.000669	0.000646	0.000663	0.000654	0.000648	0.000641	-
Nickel (Ni)-Total	0.00050	-	-	mg/L	0.00082	0.00266	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	-
Phosphorus (P)-Total	0.050	-	-	mg/L	0.08800	0.07300	0.06600	0.06600	0.06800	0.08000	0.05900	0.07400	0.07200	0.06100	-
Potassium (K)-Total	0.050	-	-	mg/L	1.33	1.25	1.30	1.32	1.32	1.35	1.26	1.30	1.23	1.28	1.10
Rubidium (Rb)-Total	0.00020	-	-	mg/L	0.00052	0.00049	0.00047	0.00051	0.00050	0.00054	0.00046	0.00043	0.00044	0.00045	-
Selenium (Se)-Total	0.000050	-	0.05	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.002
Silicon (Si)-Total	0.10	-	-	mg/L	13.4	13.3	13.0	13.6	13.4	14.0	12.6	13.2	12.5	12.6	-
Silver (Ag)-Total	0.000050	-	-	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	-
Sodium (Na)-Total	0.50	200	20	mg/L	11.5	10.7	11.0	11.4	11.3	11.5	10.7	10.9	10.6	10.8	10.0
Strontium (Sr)-Total	0.0010	-	-	mg/L	0.383	0.350	0.374	0.387	0.390	0.393	0.366	0.362	0.363	0.363	-
Sulfur (S)-Total	0.50	-	-	mg/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	-
Tellurium (Te)-Total	0.00020	-	-	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	-

Parameter	Detection Limit	ODWS		Units	Sample Concentration										
		Operational Guideline	Schedule 1 and 2 Standards		Step Test				Pumping Test						
					Pretest	13 L/s	18 L/s	23 L/s	6H	12H	24H	36H	48H	60H	72 H
Thallium (Tl)-Total	0.000010	-	-	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	-
Thorium (Th)-Total	0.00010	-	-	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	-
Tin (Sn)-Total	0.00010	-	-	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	0.00013	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	-
Titanium (Ti)-Total	0.0030	-	-	mg/L	0.00077	0.00031	0.00076	<0.00030	<0.00030	0.00116	<0.00030	<0.00030	<0.00030	<0.00030	-
Tungsten (W)-Total	0.00010	-	-	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	-
Uranium (U)-Total	0.000010	-	0.02	mg/L	0.000036	0.000031	0.000033	0.000032	0.000034	0.000037	0.000030	0.000029	0.000027	0.000026	<0.00010
Vanadium (V)-Total	0.00050	-	-	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	-
Zinc (Zn)-Total	0.0030	5	-	mg/L	<0.0030	<0.0030	<0.0030	<0.0030	0.0153	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0050
Zirconium (Zr)-Total	0.00030	-	-	mg/L	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	-
Mercury (Hg)	0.0001	-	-	mg/L	-	-	-	-	-	-	-	-	-	-	<0.0001
Volatile Organic Compounds (Water)															
Ethane, Dissolved	5.0	-	-	ug/L	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	-
Ethene, Dissolved	5.0	-	-	ug/L	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	-
Methane, Dissolved	5.0	2000	-	ug/L	224	297	525	358	381	464	494	486	654	434	370
1,1-Dichloroethylene	0.10	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.10
1,2-Dichlorobenzene	0.20	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.20
1,2-Dichloroethane	0.20	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.20
1,4-Dichlorobenzene	0.20	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.20
Benzene	0.10	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.10
Bromodichloromethane	0.10	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.10
Bromoform	0.20	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.20
Carbon Tetrachloride	0.10	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.10
Chlorobenzene	0.10	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.10
Chloroform	0.10	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.10
Dibromochloromethane	0.20	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.20
Methylene Chloride(Dichloromethane)	0.50	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.50
Ethylbenzene	0.10	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.10

Parameter	Detection Limit	ODWS		Units	Sample Concentration										
		Operational Guideline	Schedule 1 and 2 Standards		Step Test				Pumping Test						
					Pretest	13 L/s	18 L/s	23 L/s	6H	12H	24H	36H	48H	60H	72 H
Tetrachloroethylene	0.10	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.10
Toluene	0.20	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.20
Trichloroethylene	0.10	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.10
Vinyl Chloride	0.20	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.20
o-Xylene	0.10	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.10
p+m-Xylene	0.10	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.10
Total Xylenes	0.10	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.10
Total Trihalomethanes	0.20	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.20
1,1-Dichloroethylene	0.10	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.10
1,2-Dichlorobenzene	0.20	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.20
1,2-Dichloroethane	0.20	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.20
1,4-Dichlorobenzene	0.20	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.20
Semivolatile Organics															
2,3,4,6-Tetrachlorophenol	0.50	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	0.50
2,4,5-T	1.0	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	1.0
2,4,6-Trichlorophenol	0.50	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	0.50
2,4-D	1.0	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	1.0
2,4-Dichlorophenol	0.25	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	0.25
Alachlor	0.50	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	0.50
Aldicarb	5.0	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	5.0
Atrazine	0.50	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	0.50
Des-ethyl atrazine	0.50	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	0.50
Atrazine + Desethyl-atrazine	1.0	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	1.0
Bendiocarb	2.0	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	2.0
Bromoxynil	0.50	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	0.50
Carbaryl	5.0	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	5.0
Carbofuran	5.0	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	5.0

Parameter	Detection Limit	ODWS		Units	Sample Concentration										
		Operational Guideline	Schedule 1 and 2 Standards		Step Test				Pumping Test						
					Pretest	13 L/s	18 L/s	23 L/s	6H	12H	24H	36H	48H	60H	72 H
Chlorpyrifos (Dursban)	1.0	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	1.0
Cyanazine (Bladex)	1.0	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	1.0
Diazinon	1.0	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	1.0
Dicamba	1.0	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	1.0
Diclofop-methyl	0.90	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	0.90
Dimethoate	2.5	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	2.5
Dinoseb	1.0	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	1.0
Malathion	5.0	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	5.0
Metolachlor	0.50	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	0.50
Metribuzin (Sencor)	5.0	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	5.0
Ethyl Parathion	1.0	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	1.0
Pentachlorophenol	0.50	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	0.50
Phorate	0.50	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	0.50
Picloram	5.0	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	5.0
Prometryne	0.25	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	0.25
Simazine	1.0	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	1.0
Terbufos	0.50	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	0.50
Triallate	1.0	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	1.0
Trifluralin	1.0	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	1.0
Benzo(a)pyrene	0.0050	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	0.0050
Methyl parathion	1.0	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	1.0
Pesticides and Herbicides															
Glyphosate	10	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<10
Diquat	7.0	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<7.0
Diuron	10	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<10
Guthion (Azinphos-methyl)	2.0	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<2.0
Paraquat	1.0	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<1.0

Parameter	Detection Limit	ODWS		Units	Sample Concentration										
		Operational Guideline	Schedule 1 and 2 Standards		Step Test				Pumping Test						
					Pretest	13 L/s	18 L/s	23 L/s	6H	12H	24H	36H	48H	60H	72 H
Temephos	10	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<10
Lindane	0.0060	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.0060
Heptachlor	0.0060	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.0060
Aldrin	0.0060	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.0060
Heptachlor epoxide	0.0060	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.0060
Oxychlordane	0.0060	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.0060
g-Chlordane	0.0060	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.0060
a-Chlordane	0.0060	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.0060
Dieldrin	0.0060	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.0060
o,p-DDE	0.0060	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.0060
p,p-DDE	0.0060	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.0060
o,p-DDD	0.0060	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.0060
p,p-DDD	0.0060	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.0060
o,p-DDT	0.0060	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.0060
p,p-DDT	0.0060	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.0060
Methoxychlor	0.024	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.024
Aroclor 1016	0.050	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.050
Aroclor 1221	0.050	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.050
Aroclor 1232	0.050	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.050
Aroclor 1242	0.050	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.050
Aroclor 1248	0.050	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.050
Aroclor 1254	0.050	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.050
Aroclor 1260	0.050	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.050
Dioxins and Furans															
2,3,7,8-Tetra CDD *	1.24	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.24
1,2,3,7,8-Penta CDD *	1.25	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.25
1,2,3,4,7,8-Hexa CDD *	1.31	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.31

Parameter	Detection Limit	ODWS		Units	Sample Concentration										
		Operational Guideline	Schedule 1 and 2 Standards		Step Test				Pumping Test						
					Pretest	13 L/s	18 L/s	23 L/s	6H	12H	24H	36H	48H	60H	72 H
1,2,3,6,7,8-Hexa CDD *	1.25	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.25
1,2,3,7,8,9-Hexa CDD *	1.15	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.15
1,2,3,4,6,7,8-Hepta CDD *	1.22	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.22
Octa CDD *	1.21	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.21
Total Tetra CDD *	1.24	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.24
Total Penta CDD *	1.25	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.25
Total Hexa CDD *	1.46	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.46 (2)
Total Hepta CDD *	1.22	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.22
2,3,7,8-Tetra CDF **	1.22	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.22
1,2,3,7,8-Penta CDF **	1.14	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.14
2,3,4,7,8-Penta CDF **	1.17	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.17
1,2,3,4,7,8-Hexa CDF **	1.21	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.21
1,2,3,6,7,8-Hexa CDF **	1.17	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.17
2,3,4,6,7,8-Hexa CDF **	1.17	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.17
1,2,3,7,8,9-Hexa CDF **	1.34	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.34
1,2,3,4,6,7,8-Hepta CDF **	1.19	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.19 (2)
1,2,3,4,7,8,9-Hepta CDF **	1.24	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.24
Octa CDF **	1.12	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.12
Total Tetra CDF **	1.22	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.22
Total Penta CDF **	1.16	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.16
Total Hexa CDF **	1.22	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.22
Total Hepta CDF **	1.28	-	-	pg/L	-	-	-	-	-	-	-	-	-	-	<1.28 (2)
Miscellaneous Parameters															
NTA	0.05	-	-	mg/L	-	-	-	-	-	-	-	-	-	-	<0.050
Fixed Gases															
Methane	0.005	-	-	L/m^3	-	-	-	-	-	-	-	-	-	-	0.56
Calculated Parameters															

Parameter	Detection Limit	ODWS		Units	Sample Concentration										
		Operational Guideline	Schedule 1 and 2 Standards		Step Test				Pumping Test						
					Pretest	13 L/s	18 L/s	23 L/s	6H	12H	24H	36H	48H	60H	72 H
Aldrin + Dieldrin	0.006	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.006
Chlordane (Total)	0.006	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.006
DDT+ Metabolites	0.006	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.006
Heptachlor + Heptachlor epoxide	0.006	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.006
Total PCB	0.05	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.05
NDMA/D/F/MIB/GEO															
N-Nitrosodimethylamine	0.0009	-	-	ug/L	-	-	-	-	-	-	-	-	-	-	<0.0009
Surrogate Recovery (%)															
C13-1234678 HeptaCDD *	-	-	-	%	-	-	-	-	-	-	-	-	-	-	86
C13-1234678 HeptaCDF **	-	-	-	%	-	-	-	-	-	-	-	-	-	-	72
C13-123678 HexaCDD *	-	-	-	%	-	-	-	-	-	-	-	-	-	-	84
C13-123678 HexaCDF **	-	-	-	%	-	-	-	-	-	-	-	-	-	-	76
C13-12378 PentaCDD *	-	-	-	%	-	-	-	-	-	-	-	-	-	-	71
C13-12378 PentaCDF **	-	-	-	%	-	-	-	-	-	-	-	-	-	-	59
C13-2378 TetraCDD *	-	-	-	%	-	-	-	-	-	-	-	-	-	-	76
C13-2378 TetraCDF **	-	-	-	%	-	-	-	-	-	-	-	-	-	-	63
C13-OCDD *	-	-	-	%	-	-	-	-	-	-	-	-	-	-	100
D6-N-Nitrosodimethylamine	-	-	-	%	-	-	-	-	-	-	-	-	-	-	33
2,4,5,6-Tetrachloro-m-xylene	-	-	-	%	-	-	-	-	-	-	-	-	-	-	78
Decachlorobiphenyl	-	-	-	%	-	-	-	-	-	-	-	-	-	-	115
2,4,6-Tribromophenol	-	-	-	%	-	-	-	-	-	-	-	-	-	-	77
2,4-Dichlorophenyl Acetic Acid	-	-	-	%	-	-	-	-	-	-	-	-	-	-	81
2-Fluorobiphenyl	-	-	-	%	-	-	-	-	-	-	-	-	-	-	60
D14-Terphenyl (FS)	-	-	-	%	-	-	-	-	-	-	-	-	-	-	85
D5-Nitrobenzene	-	-	-	%	-	-	-	-	-	-	-	-	-	-	61
4-Bromofluorobenzene	-	-	-	%	-	-	-	-	-	-	-	-	-	-	98
D4-1,2-Dichloroethane	-	-	-	%	-	-	-	-	-	-	-	-	-	-	99

Parameter	Detection Limit	ODWS		Units	Sample Concentration										
		Operational Guideline	Schedule 1 and 2 Standards		Step Test				Pumping Test						
					Pretest	13 L/s	18 L/s	23 L/s	6H	12H	24H	36H	48H	60H	72 H
D8-Toluene	-	-	-	%	-	-	-	-	-	-	-	-	-	-	99
Radionuclide															
Gross Alpha	0.10	-	-	Bq/L	-	-	-	-	-	-	-	-	-	-	<0.10
Gross Beta	0.10	-	-	Bq/L	-	-	-	-	-	-	-	-	-	-	<0.10
Tritium	15	-	-	Bq/L	-	-	-	-	-	-	-	-	-	-	<15
Fixed Gases															
Calculated Methane	0.003	-	-	mg/L	-	-	-	-	-	-	-	-	-	-	0.37

5.4.2.5 Interference with Municipal Wells

Given the high potential for interference between a new well at Well Site H and the existing municipal supply wells, a detailed assessment of the observed interference effects during the pumping test at MW6 and the combined pumping test at MW6 and NOB-PW5 is provided. Other than NOB-PW5, NOB-PW2 and NOB-PW3 were observed, which pumped at a rate of approximately 18 L/s and 24 L/s, respectively. During the testing, NOB-PW2 was pumping from 11:49 AM to 3:49 PM on March 17, 2020 and on again from 11:32 AM to 12:07 PM on March 18, 2020 during the testing. NOB-PW3 started pumping from 10:55 AM to 11:28 PM on March 18, 2020.

During the first 23 hours of pumping at MW6 at 23 L/s, when NOB-PW5 was off, 0.8 m of interference was observed between MW6 and NOB-PW5 (**Figure 34**). Interference between MW6 and NOB-PW2 and NOB-PW3, was 0.8 m and 0.2 m, respectively. Well interference results are summarized in **Table 19**. Additional drawdown from pumping at NOB-PW2 was observed at approximately 23-hours into the pumping test. Therefore, drawdown values presented in **Table 19** are from 23-hours of pumping.

During the last 48 hours of the 72-hour pumping test, NOB-PW5 was pumped at a rate of 26 L/s, in addition to the 23 L/s pumping at MW6. Based on the combined pumping hydrograph on **Figure 34** and comparing to the drawdown levels to 23 hours of pumping, approximately 3.7 m of drawdown at MW6 can be attributed to interference from pumping at NOB-PW5. After 48-hours of combined pumping at MW6 and NOB-PW5, the water level at NOB-PW2 had declined by approximately 4.1 m. However, NOB-PW2 was observed to be pumping simultaneously, thus increasing the magnitude of interference and providing a conservative result. After 48-hours of combined pumping at MW6 and NOB-PW5, the water level at NOB-PW3 had declined by approximately 3.2 m, although the well was switched on briefly midway through the test increasing the magnitude of the measured water level drawdown.

Based on the results of this detailed assessment, while there is notable interference between each of the existing supply wells and MW6, the magnitude of the interference is reasonable given the large amount of available drawdowns of 74.5 m and 56.7 m in wells NOB-PW2 and NOB-PW3, respectively. However, we understand that York Region is considering increasing the pumping rate at NOB-PW2 from the permitted rate of 28.6 L/s to around 32 – 34 L/s. Increased interference between increased pumping at NOB-PW2 with NOB-PW5 and a new production well at Well Site H is not likely to adversely affect the production of these wells, however, it may limit the available drawdown in NOB-PW3. The operating water level of NOB-PW3 is at approximately 33.4 m (MMM, 2007), and the pump is set at 48.8 m. Additional drawdown from Well Site H of 3 m or more, plus increased drawdown from NOB-PW2 has the potential to draw the water level down to the pumping setting of NOB-PW3. Should Well Site H be selected as the preferred site, additional well testing will be required to confirm the magnitude of combined drawdown at NOB-PW3, taking into consideration not only Well Site H, but also the potential for increased pumping at NOB-PW2.

Table 19. Magnitude of Interference with Municipal Wells

Drawdown after 23-hours of Pumping at MW6				**Additional Drawdown after 48-hours of Pumping at MW6 and NOB-PW5**			
MW6	NOB-PW2	NOB-PW3	NOB-PW5	MW6	NOB-PW2	NOB-PW3	NOB-PW5
0.9	0.8	0.2	0.8	4.6	4.1	3.2	7.5

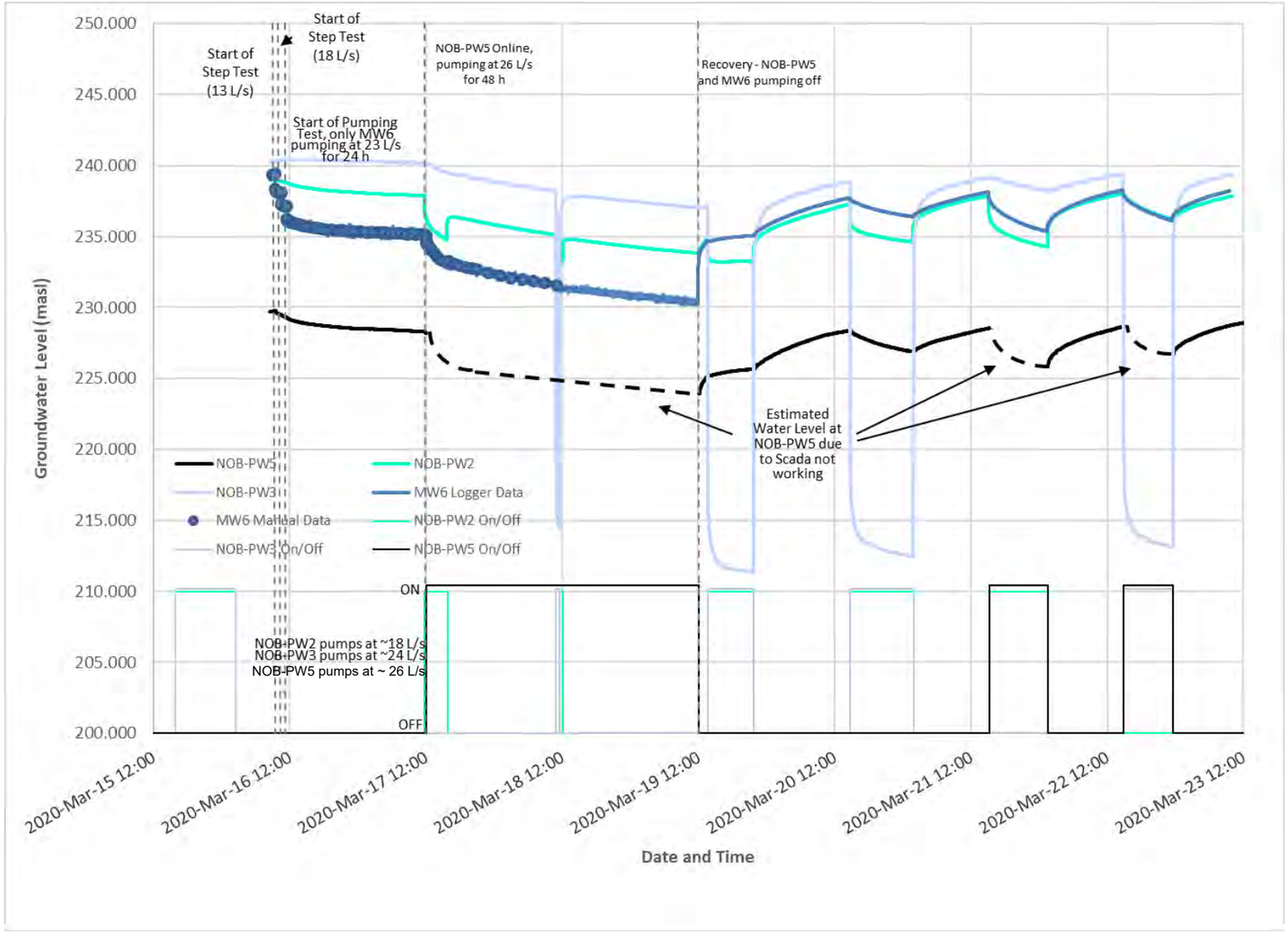


Figure 34. Municipal Supply Wells for Well Site H

5.4.2.6 Interference with Private Wells

One off-site private domestic well, 12645 Highway 27, agreed to monitoring during testing at Well Site H. It is located approximately 579 m south of the site from MW6. According to MECP water well records, this well is screened from 76.8 to 78.3 mbgs, placing it within the Upper or Lower ORAC. Monitoring began on March 16, 2020 by taking manual readings of the well throughout the day. Measurements were taken between 9 AM and 6 PM to minimize disturbance to the resident. The manual data from this well indicated minor fluctuations in the water level, which is likely due to water usage by the resident. Since is screened in a different aquifer unit as MW6, it shows that there is no connection between the two units.

It is evident that shallower wells found in the Upper and Lower ORAC are not affected by the pumping test as no significant drawdown can be seen. The residential well at 12645 Highway 27 also did not see any significant drawdown, and movement in the water level was likely due to residents pumping the well (**Figure 32**). No adverse interference effects with private wells is anticipated with increased pumping at the Well Site H location.

5.4.2.7 Evaluation of Site H

To assess the potential for Well Site H to support a future municipal supply well with a sustainable pumping rate of at least 35 L/s and taking into consideration the high potential for well interference, a step-drawdown test was completed using existing MW6, followed by a 24-hour constant rate test and a 72-hour combined pumping test with NOB-PW5. This was completed to proceed with York Region Section 18 and was determined to be necessary to fully assess the potential for adverse well interference effects from adding a new production well in close proximity to the existing well field.

Based on the results of Palmer's field testing and analysis, the transmissivity of the Scarborough Formation Aquifer at Site H ranged from 520 to 1,246 m^2/day with storativity coefficients ranging between 2.20×10^{-4} to 3.79×10^{-3}. The ROI was determined to reach up to 1,228 m from MW6. The drawdown in MW6 after pumping the third step of 23 L/s for 1-hour was 0.73 m and the shape of the drawdown curve was flattening showing a drawdown rate of 0.003 m/min during the final 30 min of testing. A no-flow boundary condition effect was first observed leading to increased drawdown relative to the predicted Theis Solution. Following 23-hours of pumping the total drawdown was measured to be 4.32 m. After an additional 48-hours of combined pumping with NOB-PW5, the total drawdown in MW6 was measured to 8.94 m. The boundary condition effect can be observed in the pumping test data and based on some preliminary assessments added boundary conditions to Aqtesolv™ is anticipated to be located approximately 350 m west of Well Site H.

To determine if Well Site H can support a higher pumping rate, both a forward solution and the specific capacity from MW6 can be used to provide an estimate. The specific capacity was calculated to 6.71 L/s/m with an R^2 value of 0.971. Since this value is high, the drawdown can be estimated by using the equation of the line of best fit. Assuming no increased drawdown from interference or well losses, based on the specific capacity of MW6, if the pumping rate is to be increased to 35 L/s, the drawdown is estimated to be 6.3 m. The total available drawdown in MW6 during the step test was 84.0 m (**Figure 35**) and indicates there is sufficient water column to support a municipal supply well. This value is representative of the drawdown in MW6 if NOB-PW5 was not pumping simultaneously.

A Forward Solution analysis model of the 72-hour combined drawdown pumping conducted using Aqtesolv™ software based the average/ geomean measured transmissivity, storativity coefficient, and ROI, and analyzed using the Theis (1935)/ Hantush (1961) method for confined aquifers. As part of QA/QC on the modelling process, the Forward Solution Model was first used to model the measured pumping test results. As observed in **Figure 36** below, the forward solution model predicted a drawdown of 7.5 m for MW6 and 8.2 for NOB-PW5, whereas the actual drawdown was 8.94 m for MW6 and 9.0 m for NOB-PW5. Since the theoretical and measured drawdown were relatively close in value, they can be used to provide an estimated drawdown at a higher pumping rate of 35 L/s. Note that this will underestimate the estimated drawdown value.

As shown on **Figure 37**, It is estimated that continuously pumping a future 12" diameter well, with similar screen design as MW6, installed at the Well Site H location at a rate of 35 L/s for 72 hours, 1 year, and 10 years, would results in a drawdown of approximately 9.6 m, 13.4 m, and 15.2 m in MW6 and 9.4 m, 13.0 m, and 15 m in NOB-PW5 respectively. The radius of influence to 1 m drawdown of 1200 m (**Figure 38**). The analyses for the forward solution can be found in **Appendix B**. This value represents approximately 20% of the 73.9 m of available drawdown, after 10 years of continuous pumping, which was determined by calculating the distance between the static water level and top of the screen. This is based on a combined pumping rate of 35 L/s for a new Production Well and 26 L/s for the existing NOB-PW5 well. Considering this drawdown is from pumping two municipal supply wells in close proximity, the drawing is considered reasonable and sustainable.

Based on the results of the step-drawdown testing, combined 72-hour pumping test, data analysis and Forward Solution modelling, the Well Site H location has the potential to support a second Municipal Production Well on the existing NOB-PW5 site with a pumping rate of at least 35 L/s. While there were notable interference effects between each of the existing supply wells and MW6, the magnitude of the interference is reasonable given the large amount of available drawdown. However, we understand that York Region is considering increasing the pumping rate at NOB-PW2 from the permitted rate of 28.6 L/s to around 32 – 34 L/s. Our analysis indicates that the increased interference between increased pumping at NOB-PW2 with NOB-PW5 and a new production well at Well Site H is not likely to adversely affect the production of these wells, but it may limit the available drawdown in NOB-PW3. The operating water level of NOB-PW3 is at approximately 33.4 m and the pump is set at approximately 48.8 m. Additional drawdown from Well Site H of 3 m or more, plus increased drawdown from NOB-PW2 has the potential to draw the water level down to the pumping level of NOB-PW3. The pump at NOB-PW3 should be lowered to be closer to the screen as a precautionary measure.

The combined pumping test at Well Site H confirmed that the Scarborough Aquifer is hydraulically separated from the shallower Upper and Lower ORAC, as no water level response was measured. Therefore, no adverse interference effects to shallower aquifers or private wells in the vicinity of Well Site H are anticipated with the development of additional water supply at this location.

Should Well Site H be selected as the preferred site, additional well testing will be required to confirm the magnitude of combined drawdown at NOB-PW3, taking into consideration not only Well Site H, but also the potential for increased pumping at NOB-PW2.

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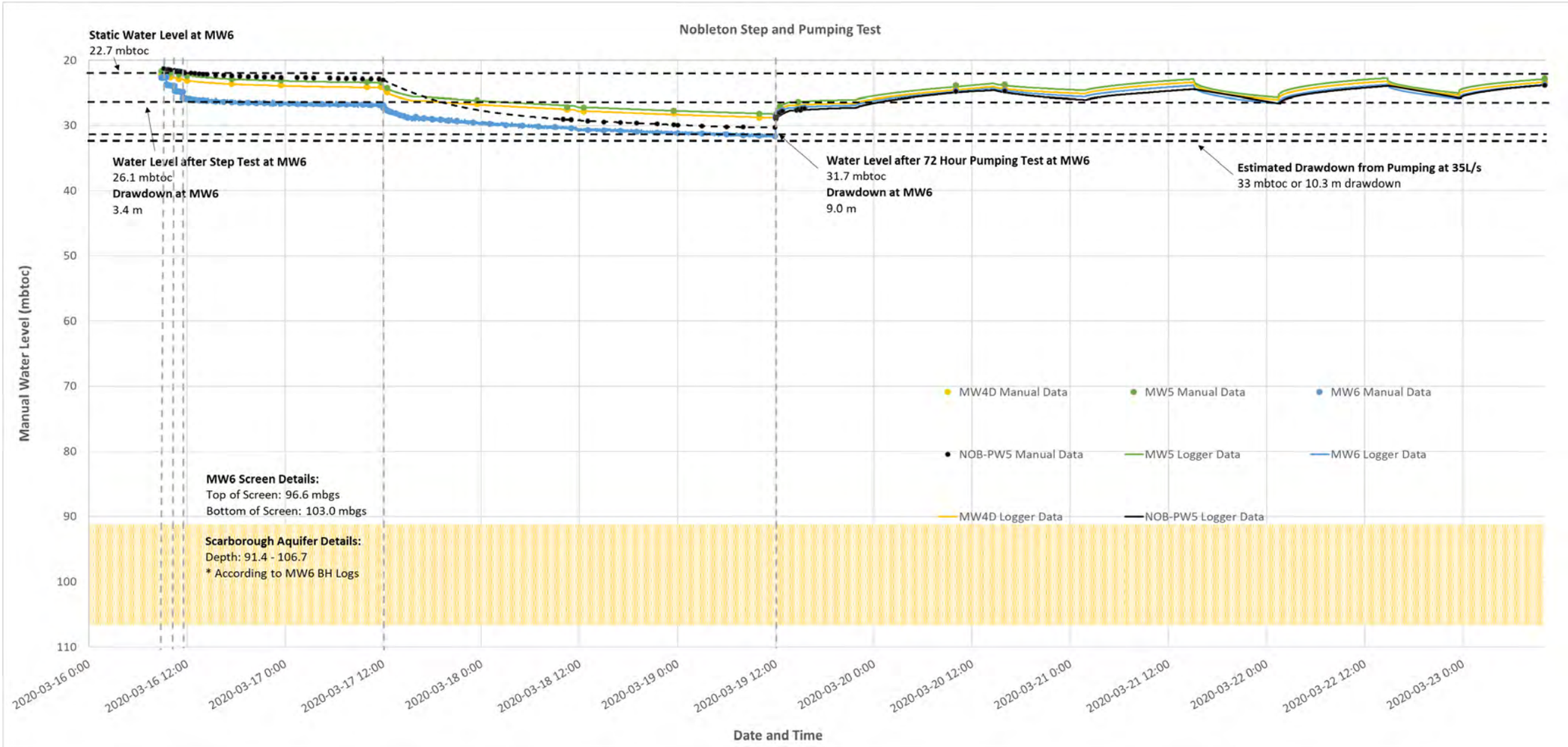

Figure 35. Available Water Column at Well Site H

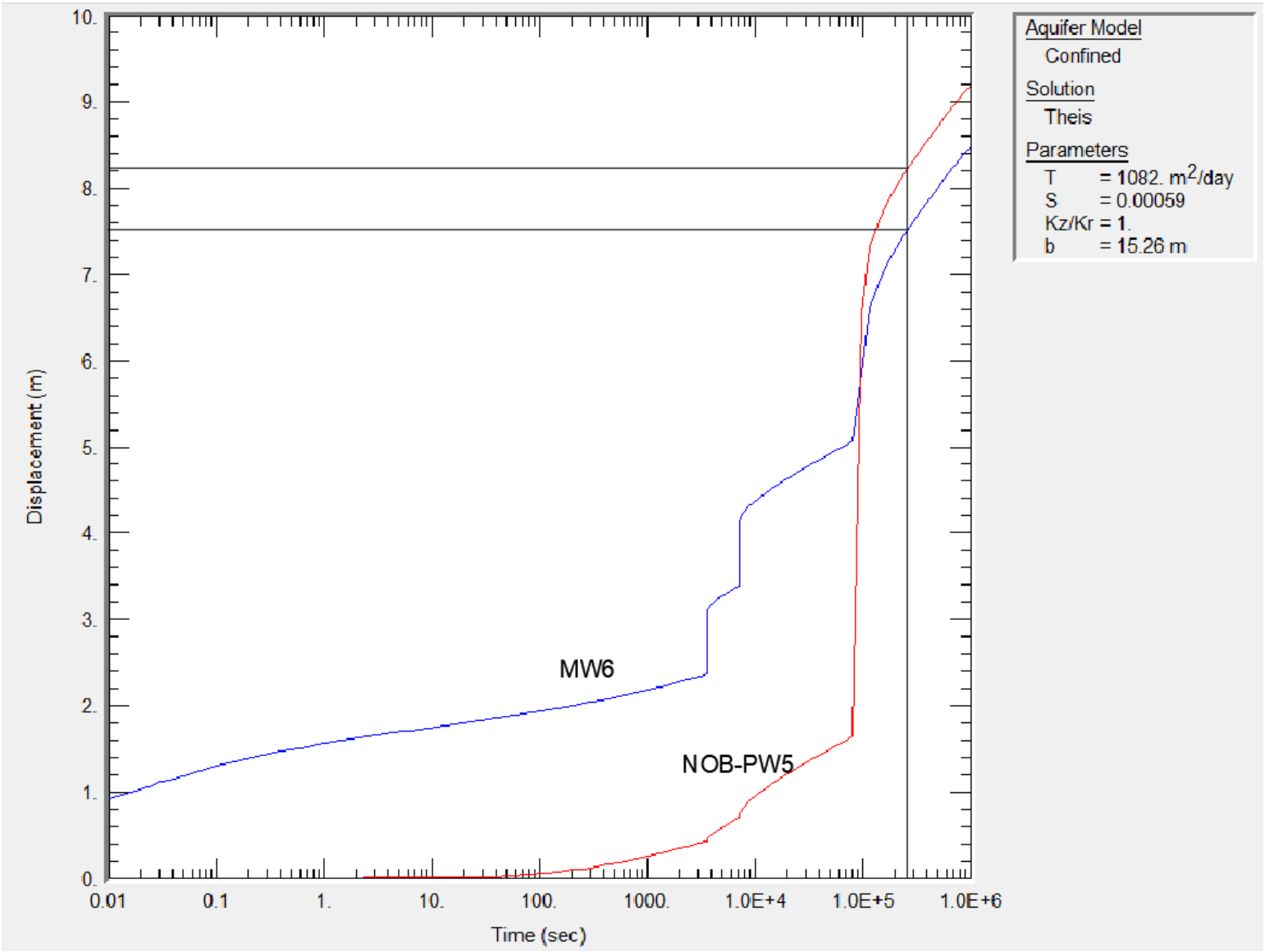

Figure 36. Well Site H – Forward Solution for Displacement

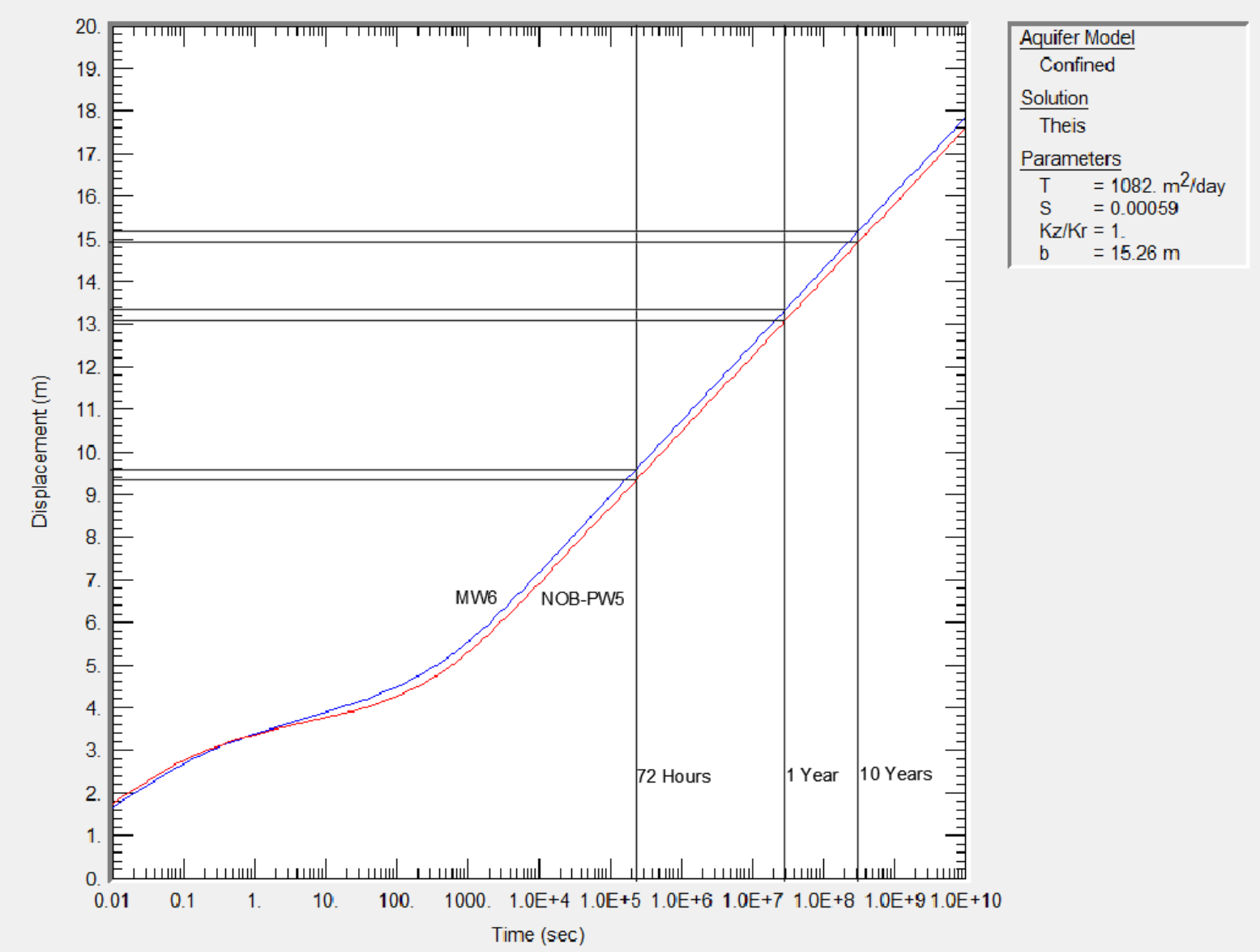

Figure 37. Well Site H – Forward Solution for 35 L/s

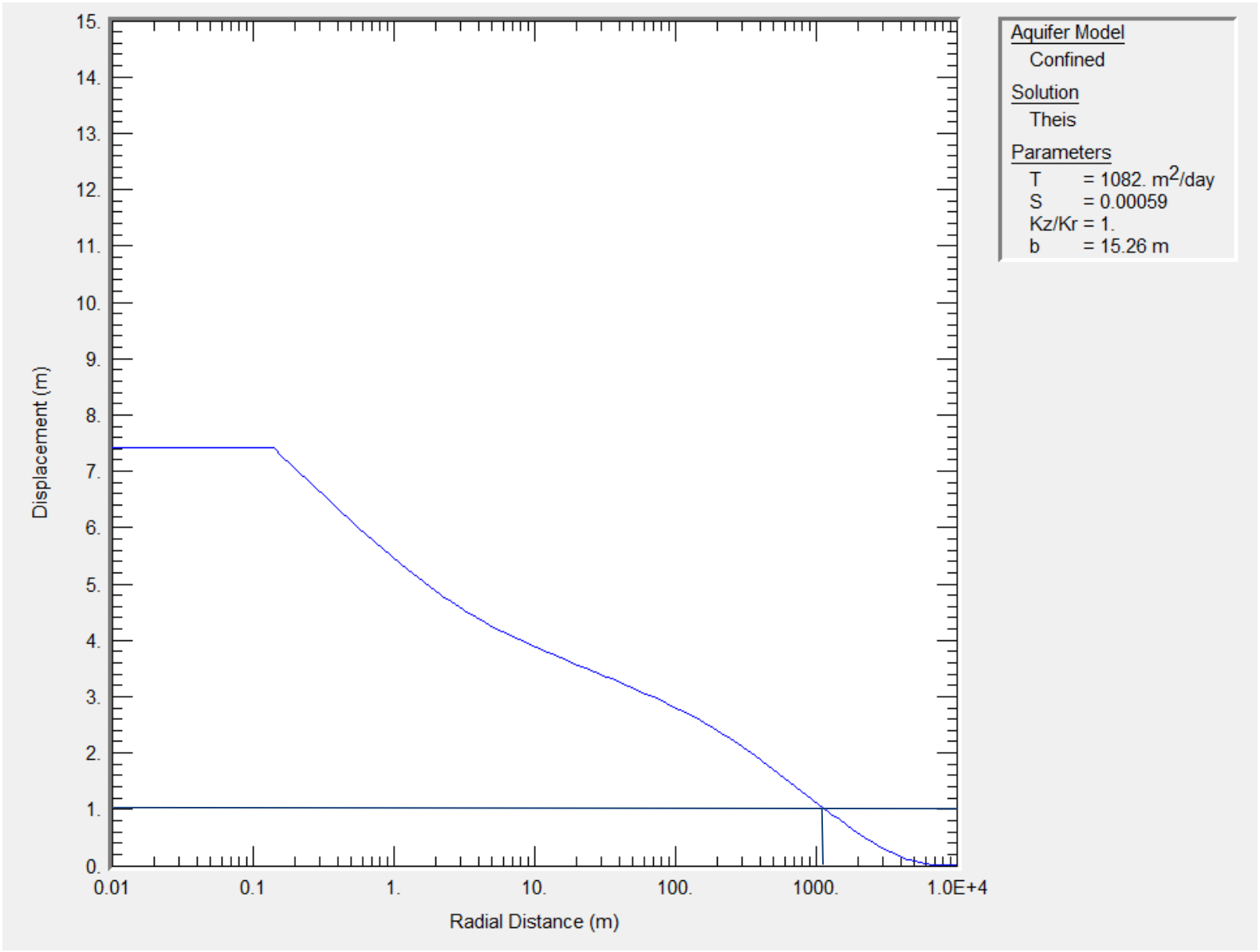

Figure 38. Well Site H – ROI for a Drawdown of 1 m

6. Selection of the Preferred Well Site

The Alternative Well Site Selection Process (Section 3) ranked Well Site F and Well Site H the same based on Groundwater Recourse Potential, Engineering/ Logistics and Policy Criteria. Well Site F had the highest scoring for Groundwater Resource potential and a good scoring for Engineering/ Logistics and Policy Criteria, while Well Site H had a good score for Groundwater Resource Potential and the highest score for Engineering/ Logistics and Policy Criteria.

Well Site F and H were carried forward to complete detailed hydraulic testing to ultimately select a preferred site for a future Municipal Production Well. Based on the results of this detailed test (Section 5) it was confirmed that *both* Well Site F and Well Site H can support a new Municipal Production Well capable of producing 35 L/s of groundwater. This is a positive result as it confirms that a groundwater-based solution to support growth in the Community of Nobleton to 2041 can be achieved.

Table 20 presents comparison of Well Sites F and H based on hydrogeological criteria as determined through the hydraulic testing program completed by Palmer. Based on the results of the detailed hydraulic testing and a hydrogeological focused comparative analysis, Site H is selected as the preferred well site from a hydrogeological perspective. Both sites have high aquifer transmissivity and can meet the 35 L/s yield target. Site F has less interference effects with the existing supply wells. However, it may interfere with private wells, requires an updated Source Water Protection Permit, and requires more capital to establish a completely new well site. Site H provides a slightly greater transmissivity and does not interfere with private wells, has a larger available drawdown, is being constructed near an existing well house, and has existing Source Water Protection policies in place. However, it will interfere with the existing NOB-PW5.

Based on comparing the hydrogeological properties of two good candidate Production Well sites at Well Sites F and H, **Well Site H is considered to be the preferred site**. In terms of hydrogeological properties, both sites are relatively similar, however, Site H provides more ideal conditions in terms of Source Water Protection zoning which will help in expediting the construction process. Additional comparative analysis between Well Site F and H will be completed through the EA Process looking at detailed engineering, feasibility, cost and natural environmental factors.

Table 20. Hydrogeological Comparison Between Well Sites F and H

Aquifer Property	Well Site F	Well Site H	Comments
Transmissivity of Test Well (T)	802 m^2/day	1,082 m^2/day	The transmissivity at Well Site H is 26% higher than at Well Site F
Aquifer Thickness	13 m	15 m	Aquifer thickness is similar between the well sites
Available Drawdown	69.9	73.9	Available drawdown slightly greater in Well Site H

Aquifer Property	Well Site F	Well Site H	Comments
Chemistry	Exceeded ODWS for Mn, Fe, and Hardness	Exceeded ODWS for Mn, Fe, and Hardness	Chemistry is similar between the well sites
Interference Effects	Negligible interference with existing NOB-PW2, NOB-PW3 and NOB-PW5 observed. However, this must be assessed through a long-term pumping test if Site F is selected as the preferred site. Less than 1 m of interference with three (3) private wells screened in the Scarborough Aquifer.	Moderate interference effects with NOB-PW2, NOB-PW3 and NOB-PW5. No interference with private wells	Interference effects with private wells at Well Site F are less significant than the interference effects of Well Site H with the existing Nobleton production well network
Groundwater Under Direct Influence of surface water (GUDI)	Unlikely to be GUDI based on water quality results, depth of aquifer, confining units, etc	Unlikely to be GUDI based on water quality results, depth of aquifer, confining units, etc	Both Well Site are unlikely to be GUDI
Source Water Protection	By adding a new well at Well Site F, a new WHPA will need to be defined for the south part of town. This will restrict some future land uses within the WHPA-A & B for this area. The King Official Plan provides further restrictions on the activities in a WHPA-A.	By adding another municipal well to Well Site H, the WHPAs and the Vulnerable areas under Source Water Protection for Nobleton will not significantly increase.	A new well at Well Site H is preferred for Source Water Protection Policies as they will be little changed and land-use policies are already in place
Estimated Production Rate	35 L/s Confirmed through step test	35 L/s Confirmed through step test and combined pumping tests with NOB-PW5	Both sites can support the estimated production rate of 35 L/s

6.1 Preliminary Production Well Design Considerations

As Well Site H is already an existing production well site for NOB-PW5 and formerly for NOB-PW4 (now decommissioned) a lot of knowledge already exists for this site to successfully install a production well. The following guidance is provided on the design considerations for a new 12” diameter production well installed at the Well Site H location:

- A screen length of approximately 4-5 m is expected based on the Scarborough Aquifer Formation thickness at Site H;

- A well screen slot size ranging from a #10 slot to a #100 slot is expected;
- It may be beneficial to consider a hi-flow well screen to maximize entrance velocity and minimize well loss. This should be assessed further at the next design stage;
- The well casing wall thickness is expected to be 8 US gauge or potentially 3/16 inch stainless steel. This should be assessed further at the next design stage; and
- The location of the 12” diameter production well should maximize the distance between the new well and NOB-PW5 and be located outside of the floodplain/ meander belt for the adjacent tributary. The expected location is along the western fence line of the existing NOB-PW5 site.

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8. Statement of Limitations

The extent of this study was limited to the specific scope of work for which we were retained and that is described in this report. Palmer has assumed that the information provided by the client or any secondary sources of information are factual and accurate. Palmer accepts no responsibility for any deficiency, misstatement or inaccuracy contained in this report as a result of omissions, misinterpretations or negligent acts from relied upon data. Judgment has been used by Palmer in the interpretation of the information provided but subsurface physical and chemical characteristics may differ from regional scale geology mapping and vary between or beyond monitoring well/borehole locations given the inherent variability in geological and hydrogeological conditions.

In addition, Palmer is not a guarantor of the geological or groundwater conditions at the subject site, but warrants only that its work was undertaken and its report prepared in a manner consistent with the level of skill and diligence normally exercised by competent geoscience professionals practicing in the Province of Ontario. Our findings, conclusions and recommendations should be evaluated in light of the limited scope of our work.

Appendix A

Borehole Logs

(MMM, 2007; MMM, 2012; and Palmer, 2020)

Appendix B

Borehole Logs, Well Logs and Well Construction Details

Project No: 14-05124-01-HG2
Project: Nobleton Class EA
Client: York Region
Location: 6173 King Rd. W.

Northing: 4861718.4
Easting: 607735.4
MOE Well ID: A033946
Logged By: Mike Holmes

Log of Borehole: MW-F1D

MW1D

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Elev/ Depth	Well Data	Number	Type	Recovery	Comments
		Ground Surface	268.97					
0		***DAYLIGHTED*** Some clay and silt, trace cobbles.	0.00					Stick Up: 1.06 mags Well Diameter: 0.15 m Bentonite: 0 m to 6.1 m Annulus grouted from: 6.1 m to ~103 m
3		***SANDY SILT TILL*** Grey, trace clay, gravel and cobble.	266.23 2.74					Material observed to be hard between 0.0 m and 2.7 m (1,000 psi)
6					SA-1	WC		
7								Steel casing (0.188 m thick, 0.16 m diameter) between 0.0 m and 103.6 m
10			258.61					
		Less cobbles	10.36					
15			253.43					
16		***SANDY SILT*** Grey/light brown, with coarse sand and gravel, trace clay (Till-like appearance).	15.54					Easier push for drill (400 psi) below 15.5 m
17					SA-2	WC		
18		Increased sand content below 18.6 m						
19					SA-3	WC		
20								

Drilled By: Boadway Well Drilling
Drill Method: Mud Rotary
Drill Date: May 17 - June 2, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic
Sheet: 1 of 6

Project No: 14-05124-01-HG2
Project: Nobleton Class EA
Client: York Region
Location: 6173 King Rd. W.

Northing: 4861718.4
Easting: 607735.4
MOE Well ID: A033946
Logged By: Mike Holmes

Log of Borehole: MW-F1D

MW1D

SUBSURFACE PROFILE

Depth (mbgs)	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
21	***SANDY SILT with COARSE SAND and GRAVEL (continued)***						
22							
23	Increased cobbles @ 21.3 m	245.20					
24	***COARSE SAND and FINE GRAVEL*** Grey.	23.77		SA-4	WC		
25		243.67					
26	***SANDY SILT some clay trace gravel*** Grey.	25.30 242.76					Very difficult drilling between 25.30 m and 26.21 m.
27	***COARSE SAND and FINE GRAVEL*** Grey, trace silt.	26.21		SA-5	WC		
28							
29		239.71					SWL on October 31, 2006: 27.75 mbTOC
30	***COARSE SAND and FINE GRAVEL*** Grey.	29.26					
31							
32							
33		235.14					
34	***COARSE GRAVEL some coarse sand*** Grey, gravel up to 25 mm diameter.	33.83					Material between 33.83 m and 42.97 m is ~ 50% gravel. Loss of drill mud observed
35							
36				SA-6	WC		
37							
38		230.57					
39	***COARSE SAND and FINE GRAVEL*** Grey, with 0.3 m thick clay/silt lenses reported.	38.40					
40							

Drilled By: Boadway Well Drilling
Drill Method: Mud Rotary
Drill Date: May 17 - June 2, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic

Project No: 14-05124-01-HG2
Project: Nobleton Class EA
Client: York Region
Location: 6173 King Rd. W.

Northing: 4861718.4
Easting: 607735.4
MOE Well ID: A033946
Logged By: Mike Holmes

Log of Borehole: MW-F1D
MW1D

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
41					SA-7	WC		
42								
43			226.00					
		FINE to MED. GRAVEL and COARSE SAND trace clay	42.97					
44		Occasional clay/silt seams but less than above.						
45					SA-8	WC		
46								
47								
48								
49								
50					SA-9	WC		
51								
			217.12					
52		Gravel coarsened, up to 25 mm diameter, rounded and angular	51.85					
53								
54		Sand coarsened with increased depth below 51.8 m						
55								
56								
57								
			211.36					
58		***CLAYEY SILT TILL with FINE to MED. GRAVEL***	57.61		SA-10	WC		
		Very Hard.	210.45					
59			58.52					
60								

Drilled By: Boadway Well Drilling
Drill Method: Mud Rotary
Drill Date: May 17 - June 2, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic

Project No: 14-05124-01-HG2
Project: Nobleton Class EA
Client: York Region
Location: 6173 King Rd. W.

Northing: 4861718.4
Easting: 607735.4
MOE Well ID: A033946
Logged By: Mike Holmes

Log of Borehole: MW-F1D
MW1D

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
61								Very dense, slow drilling with significant chattering between 57.61 m and 70.41 m. 1000 PSI on drill bit
62								
63								
64								
65		Stratified layers of till with fine sand and silt below 65.8 m						
66								
67								
68		Coarse gravel layer @ 67.4 m			SA-11	WC		
69								
70			198.56					
71		***CLAYEY SILT trace to some fine sand*** Grey, soft.	70.41					Soft drilling, no chattering or return of gravel below 70.4 m
72								
73								
74								
75								
76								
77								
78								
79								
80								

Drilled By: Boadway Well Drilling
Drill Method: Mud Rotary
Drill Date: May 17 - June 2, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic
Sheet: 4 of 6

Project No: 14-05124-01-HG2
Project: Nobleton Class EA
Client: York Region
Location: 6173 King Rd. W.

Northing: 4861718.4
Easting: 607735.4
MOE Well ID: A033946
Logged By: Mike Holmes

Log of Borehole: MW-F1D
MW1D

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
81		***CLAYEY SILT (continued)***						
82								
83								
84								
85								
86								
87								
88								
89								Recovering clumpy clay mixed with drill mud between 88.7 m and 96.3 m
90								
91								
92								
93								
94								
95								
96			172.65		SS-1	SS	100%	
		FINE to MED. SAND and GRAVEL to COBBLE Grey, trace silt, wet.	96.32		SS-2	SS	80%	
97			172.01					
		SILTY SAND and GRAVEL Grey.	96.96					Borehole continuously sampled between 96.0 m and 98.8 m
98					SS-3	SS	10%	
			170.21					
99		***MED. SAND*** Grey, trace gravel.	98.76					
100								

Drilled By: Boadway Well Drilling
Drill Method: Mud Rotary
Drill Date: May 17 - June 2, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic

Project No: 14-05124-01-HG2
Project: Nobleton Class EA
Client: York Region
Location: 6173 King Rd. W.

Northing: 4861718.4
Easting: 607735.4
MOE Well ID: A033946
Logged By: Mike Holmes

Log of Borehole: MW-F1D
MW1D

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
101								
102			166.56					
103		***MED. to COARSE SAND and GRAVEL*** Grey.	102.41					Very little recovery between 102.4 m and 107.0 m, large amounts of water produced
104								
105					SA-12	WC		Significant chattering on drill bit and mud loss throughout formation
106			162.29					
107		Gravel coarsens up to 40 mm diameter	106.68					
108								Screen: #25 slot, steel Screen Depth: 103.6 m to 106.7 m, 0.14 m diameter
109								
110			158.94					
		CLAYEY SILT	110.03					
		End of Borehole						
111								
112								
113								
114								
115								
116								
117								
118								
119								
120								

Drilled By: Boadway Well Drilling
Drill Method: Mud Rotary
Drill Date: May 17 - June 2, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic
Sheet: 6 of 6

Project No: 14-05124-01-HG2
Project: Nobleton Class EA
Client: York Region
Location: 6173 King Rd. W.

Northing: 4861716.9
Easting: 607730.6
MOE Well ID: A033946
Logged By: Mike Holmes

Log of Borehole: MW-F1S
MW1S

Depth (mbgs)	Symbol	Description	Elev/ Depth	Well Data	Number	Type	Recovery	Comments
		Ground Surface	269.03					
0		***TOPSOIL over CLAY*** Brown.	0.00					Stick Up: 0.59 mag Well Diameter: 0.0635 m Well Material: Sch. 40 PVC Outer Casing: 0.16 m dia. Depth of Outer Casing: 0.0 m to 25.91 m Bentonite: 0.0 m to 32.92 m Well diameter of 0.20 m from 0.0 m to 6.09 m
3		***SILT and CLAY*** Grey.	265.99 3.04					
17								SWL @ October 31, 2006: 17.17 mbTOC

Drilled By: Boadway Drilling Ltd.
Drill Method: Mud Rotary
Drill Date: June 30, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.16 m
Datum: Geodetic

Project No: 14-05124-01-HG2
Project: Nobleton Class EA
Client: York Region
Location: 6173 King Rd. W.

Northing: 4861716.9
Easting: 607730.6
MOE Well ID: A033946
Logged By: Mike Holmes

Log of Borehole: MW-F1S

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
21		***SILT and CLAY (continued)***						
22								
23								
24								
25								
26								
27			241.59					
28		***FINE to MED. SAND*** Brown.	27.44					
29								
30								
31								
32								
33								Screen Depth: 33.53 m to 36.58 m
34								Slot: #10 Schedule 40 PVC
35								Sand Pack: 32.92 m to 36.58 m
36			232.45					
37		End of Borehole	36.58					
38								
39								
40								

Drilled By: Boadway Drilling Ltd.
Drill Method: Mud Rotary
Drill Date: June 30, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.16 m
Datum: Geodetic
Sheet: 2 of 2

Project No: 14-05124-01-HG2
Project: Nobleton Class EA
Client: York Region
Location: Nobleton Arena (North Side)

Northing: 4861813.6
Easting: 608378.6
MOE Well ID: A033947
Logged By: Mike Holmes

Log of Borehole: MW-F3D
MW3D

SUBSURFACE PROFILE

Depth (mbgs)	Description	Elev/ Depth	Well Data	Number	Type	Recovery	Comments
	Ground Surface	262.14					
0	***TOPSOIL***	0.00					Stick Up: 0.78 mags Well Diameter: 0.064 m Concrete: 0.0 m to 0.6 m Holeplug: 0.6 m to 8.5 m Grout: 8.5 m to 60.35 m
1	***MED. SAND*** Brown.						
2		260.01					
	SANDY SILT some fine to med. gravel and clay Brown, very dense.	2.13					
3							
4							
5							
	Sand layer @ 5.8 m						
6		255.74					Drilling difficult (greater than 1500 psi)
	SILTY SAND some gravel Brown, some fragmented gravel (fine to med., rounded), trace clay.	6.40		SS1	WC		
7							
8							
9							
10							
11							Drilling easily at 500 psi
12							
13							
14							
		247.24					
15	Increase cobble content	14.90					
16							
17							
		244.14					
18	0.3 m dia. granite boulder @ 18.0 m Increased clay content below 18.0 m	18.00					
19							
20							

Drilled By: Boadway Well Drilling
Drill Method: Mud Rotary
Drill Date: June 27 - 29, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.127 m
Datum: Geodetic

Project No: 14-05124-01-HG2
Project: Nobleton Class EA
Client: York Region
Location: Nobleton Arena (North Side)

Northing: 4861813.6
Easting: 608378.6
MOE Well ID: A033947
Logged By: Mike Holmes

Log of Borehole: MW-F3D
MW3D

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
			241.44					SWL on October 31, 2006: 20.43 mbTOC
21		***CLAYEY SILT TILL some sand and gravel*** Grey, trace cobble.	20.70					
22								
23								
24								
25			236.54					
26		***SILTY SAND and GRAVEL*** Grey.	25.60					
27								
28		Stratified with clay layers reported between 25.6 m and 29.9 m						
29								
			232.27					
30		***CLAYEY SILT TILL trace fine to med. sand*** Grey.	29.87					
31								
32		30% fine to med., rounded gravel content between 29.9 m and 36.6 m			SS2	WC		
33								
			228.31					
34		Becoming less hard below 33.8 m	33.83					
35								
36								
			225.56					
37		***FINE to MED. GRAVEL and CLAY*** Grey, gravel is rounded, possible water bearing seam.	36.58					Predominantly gravel and formation took on mud between 36.58 m and 38.40 m
38								
			223.74					
39		***CLAYEY SILT trace to some fine sand and fine gravel*** Grey, soft, rounded, possibly till.	38.40					
40								

Drilled By: Boadway Well Drilling
Drill Method: Mud Rotary
Drill Date: June 27 - 29, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.127 m
Datum: Geodetic

Project No: 14-05124-01-HG2
Project: Nobleton Class EA
Client: York Region
Location: Nobleton Arena (North Side)

Northing: 4861813.6
Easting: 608378.6
MOE Well ID: A033947
Logged By: Mike Holmes

Log of Borehole: MW-F3D

MW3D

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
41								
42								
43		Frequent thin gravel seams between 38.4 m and 43.0 m						
44								
45								
46								
47			214.59					
48		***CLAYEY SILT to CLAY-SILT trace fine sand and gravel*** Grey.	47.55					No chattering of drill from 47.6 m
49								
50								Clay in formation thickens drill mud naturally, less bentonite used in mix between 47.6 m and 61.3 m
51								
52								
53								
54								
55								
56								
57								
58								
59								
60								

Drilled By: Boadway Well Drilling
Drill Method: Mud Rotary
Drill Date: June 27 - 29, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.127 m
Datum: Geodetic

Project No: 14-05124-01-HG2
Project: Nobleton Class EA
Client: York Region
Location: Nobleton Arena (North Side)

Northing: 4861813.6
Easting: 608378.6
MOE Well ID: A033947
Logged By: Mike Holmes

Log of Borehole: MW-F3D

MW3D

SUBSURFACE PROFILE								
Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
61			200.88					
		CLAY-SILT trace sand and gravel	61.26					
62		Grey.						
63								
64								
65								
66								
67								
68								
69								
70								
71								
72								
73								
74								
75								
76								
77								
78								
79								
80								

Drilled By: Boadway Well Drilling
Drill Method: Mud Rotary
Drill Date: June 27 - 29, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.127 m
Datum: Geodetic
Sheet: 4 of 6

Project No: 14-05124-01-HG2
Project: Nobleton Class EA
Client: York Region
Location: Nobleton Arena (North Side)

Northing: 4861813.6
Easting: 608378.6
MOE Well ID: A033947
Logged By: Mike Holmes

Log of Borehole: MW-F3D

MW3D

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
81		***CLAY-SILT (continued)***						
82								Screen Depth: 86.41 m to 89.45 m Sand Pack: 60.35 m 102.41 m Well Slot: #10, Sch. 40 PVC
83								
84								
85			176.49					
86		***SAND AND GRAVEL trace clay and silt*** Grey.	85.65					
87					SS3	WC		Drill chattering significantly through this formation and pronounced mud loss between 85.7 m and 89.5 m (2,000 psi)
88		Mixture of gravel, cobble and boulders observed between 85.7 m and 89.5 m						
89			172.68					
90		***CLAYEY SILT TILL trace to some fine sand and gravel*** Grey , hard.	89.46		SS4	WC		
91			170.70					
92		***SILTY CLAY*** Grey, soft.	91.44					Drilling advanced easily between 91.4 m to 93.3 m
93								
94		Clay chips between 91.4 m and 98.6 m exhibit laminations						
95								500 psi to 98.6 m
96								
97								
98			163.54					Drilling became very hard, required over 45 minutes to advance 5 m below 98.6 m (2,000 psi below 98.6 m)
99		***CLAYEY SILT TILL trace to some fine sand and gravel*** Grey.	98.60					
100								

Drilled By: Boadway Well Drilling
Drill Method: Mud Rotary
Drill Date: June 27 - 29, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.127 m
Datum: Geodetic
Sheet: 5 of 6

Project No: 14-05124-01-HG2
Project: Nobleton Class EA
Client: York Region
Location: Nobleton Arena (North Side)

Northing: 4861813.6
Easting: 608378.6
MOE Well ID: A033947
Logged By: Mike Holmes

Log of Borehole: MW-F3D

MW3D

SUBSURFACE PROFILE								
Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
101		***CLAYEY SILT TILL (continued)***						
102			159.74					
		End of Borehole	102.40					
103								
104								
105								
106								
107								
108								
109								
110								
111								
112								
113								
114								
115								
116								
117								
118								
119								
120								

Drilled By: Boadway Well Drilling
Drill Method: Mud Rotary
Drill Date: June 27 - 29, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.127 m
Datum: Geodetic
Sheet: 6 of 6

Project No: 14-05124-01-HG2
Project: Nobleton Class EA
Client: York Region
Location: Nobleton Arena

Northing: 4861810.1
Easting: 608373.2
MOE Well ID: A033947
Logged By: Mike Holmes

Log of Borehole: MW-F3S

MW3S

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Elev/ Depth	Well Data	Number	Type	Recovery	Comments
		Ground Surface	262.31					
0		***TOPSOIL***	0.00					Stick Up: 0.65 mag Well Diameter: 0.064 m Bentonite: 0.0 m to 21.3 m
1		***SANDY SILT*** Brown.						
			260.48					
2		***SILT TILL with cobbles*** Brown.	1.83					
3								
4								
5								
6								
			255.91					
		FINE GRAVEL and SAND	6.40					
7								
8								SWL @ October 31, 2006: 8.0 mbTOC
9								
10								
11								
			251.03					
		CLAYEY SILT TILL some cobbles Brown.	11.28					
12								Observed layering of fine gravel between 11.3 m and 14.3 m
13		Increased grey colour in content below 13.1 m						
14								
			247.98					
		SILTY SAND and GRAVEL Grey.	14.33					
15								
			246.77					
		FINE to MED. SAND and GRAVEL Brown, trace grey clay.	15.54					
16								Hard unit, drill chattered significantly between 15.5 m and 17.7 m
17								
			244.63					
		CLAYEY SILT TILL some cobbles Grey, trace to some silty fine sand.	17.68					
18								
19								
			243.11					
		SAND Grey.	19.20					
20								

Drilled By: Boadway Well Drilling
Drill Method: Mud Rotary
Drill Date: July 5, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic

Project No: 14-05124-01-HG2
Project: Nobleton Class EA
Client: York Region
Location: Nobleton Arena

Northing: 4861810.1
Easting: 608373.2
MOE Well ID: A033947
Logged By: Mike Holmes

Log of Borehole: MW-F3S

MW3S

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
21			241.28					
		CLAYEY SILT TILL some coarse gravel Grey.	21.03					
22								
23								
24								
25								
26			236.10					
		FINE GRAVEL and SAND Grey, with streaks of clay.	26.21					
27								Screen Depth: 27.7 m to 30.8 m Sand Pack: 21.3 m to 43.0 m Slot: #10 Sch. 40 PVC
28								
29								
30			232.13					
		CLAYEY SILT Grey, trace to some silt, sand, and gravel (fine).	30.18					Drilling quietly below 30.2 m
31								
32								Observed finely laminated clay between 30.2 m and 38.4 m
33								
34								
35								
36								
37								
38			223.91					
		CLAYEY SILT TILL some med. sand trace find gravel Grey.	38.40					Hard unit, very slow advance at 2000 psi below 38.4 m
39								
40								

Drilled By: Boadway Well Drilling
Drill Method: Mud Rotary
Drill Date: July 5, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic

Project No: 14-05124-01-HG2
Project: Nobleton Class EA
Client: York Region
Location: Nobleton Arena

Northing: 4861810.1
Easting: 608373.2
MOE Well ID: A033947
Logged By: Mike Holmes

Log of Borehole: MW-F3S

MW3S

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
41								
42								
43			219.33					
		End of Borehole	42.98					
44								
45								
46								
47								
48								
49								
50								
51								
52								
53								
54								
55								
56								
57								
58								
59								
60								

Drilled By: Boadway Well Drilling
Drill Method: Mud Rotary
Drill Date: July 5, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic
Sheet: 3 of 3

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861425.7
Easting: 608163.3
MOE Well ID: A035564
Logged By: Gerrits Well Drilling Inc.

Log of Borehole: MW-NB1D

MW4D

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Elev/ Depth	Well Data	Number	Type	Recovery	Comments
		Ground Surface	260.54					
0		***TOPSOIL*** Black.	0.00 / 259.64		SS1	WC		Stick Up: 0.959 mag Well Diameter: 0.076 m Outer Casing: 0.15 m dia. Depth of Outer Casing: 1.07 mag to 0.762 mbg Cement: 0.0 m to 0.6 m Sand: 0.6 m to 1.2 m Bentonite: 1.2 m to 96.2 m
1		***CLAYEY SILT*** Brown.	0.90 / 258.84					
2		***SILTY SAND*** Brown.	1.70		SS2	WC		
3					SS3	WC		
4								
5			254.74		SS4	WC		
6		***SILT some gravel and clay*** Brown.	5.80		SS5	WC		
7								
8					SS6	WC		
9			251.14					
10		***CLAYEY SILT*** Grey, wet.	9.40		SS7	WC		
11					SS8	WC		
12								
13					SS9	WC		
14			245.94		SS10	WC		
15		***SILT some sand*** Grey, wet.	14.60					
16					SS11	WC		
17			243.14					
18		***SAND some gravel*** Brown, wet.	17.40		SS12	WC		
19					SS13	WC		SWL @ October 31, 2006: 19.77 mbTOC
20			240.44 / 20.10					

Drilled By: Gerrits Well Drilling Inc.
Drill Method: Air & Mud Rotary
Drill Date: August 15 - 22, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic
Sheet: 1 of 6

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861425.7
Easting: 608163.3
MOE Well ID: A035564
Logged By: Gerrits Well Drilling Inc.

Log of Borehole: MW-NB1D

MW4D

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
21		***MED. SAND some gravel*** Grey, wet.			SS14	WC		Water bearing between 17.4 m and 24.4 m
22					SS15	WC		
23					SS16	WC		
24			236.14					
25		***CLAYEY SILT*** Grey, wet.	24.40		SS17	WC		
26					SS18	WC		
27					SS19	WC		
28					SS20	WC		
29								
30			230.04					
31		***CLAYEY SILT to SILTY CLAY*** Grey, wet.	30.50		SS21	WC		
32					SS22	WC		
33								
34					SS23	WC		
35								
36					SS24	WC		
37			223.64					
		SILTY SAND and GRAVEL Grey.	36.90		SS25	WC		Water bearing between 36.9 m and 37.8 m
38			222.74					
		CLAYEY SILT to SILTY CLAY Grey, soft.	37.80		SS26	WC		
39								
40								

Drilled By: Gerrits Well Drilling Inc.
Drill Method: Air & Mud Rotary
Drill Date: August 15 - 22, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic
Sheet: 2 of 6

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861425.7
Easting: 608163.3
MOE Well ID: A035564
Logged By: Gerrits Well Drilling Inc.

Log of Borehole: MW-NB1D
MW4D

SUBSURFACE PROFILE								
Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
41		***CLAYEY SILT to SILTY CLAY (continued)***			SS27	WC		
42					SS28	WC		
43					SS29	WC		
44		***CLAY-SILT*** Grey.	216.64 43.90		SS30	WC		
45					SS31	WC		
46					SS32	WC		
47					SS33	WC		
48					SS34	WC		
49					SS35	WC		
50					SS36	WC		
51					SS37	WC		
52					SS38	WC		
53					SS39	WC		
54								
55		***SILT some clay*** Grey.	205.94 54.60					
56								
57								
58								
59								
60								

Drilled By: Gerrits Well Drilling Inc.
Drill Method: Air & Mud Rotary
Drill Date: August 15 - 22, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861425.7
Easting: 608163.3
MOE Well ID: A035564
Logged By: Gerrits Well Drilling Inc.

Log of Borehole: MW-NB1D
MW4D

SUBSURFACE PROFILE								
Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
61		***SILT some clay (continued)***			SS40	WC		
62					SS41	WC		
63		***CLAYEY SILT to SILTY CLAY*** Grey.	197.74 62.80		SS42	WC		
64					SS43	WC		
65					SS44	WC		
66					SS45	WC		
67					SS46	WC		
68					SS47	WC		
69					SS48	WC		
70					SS49	WC		
71					SS50	WC		
72					SS51	WC		
73					SS52	WC		
74					SS53	WC		
75								
76								
77								
78								
79								
80								

Drilled By: Gerrits Well Drilling Inc.
Drill Method: Air & Mud Rotary
Drill Date: August 15 - 22, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic
Sheet: 4 of 6

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861425.7
Easting: 608163.3
MOE Well ID: A035564
Logged By: Gerrits Well Drilling Inc.

Log of Borehole: MW-NB1D

MW4D

SUBSURFACE PROFILE

Depth (mbgs)	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
81	***CLAYEY SILT to SILTY CLAY (continued)***			SS53			
82				SS54	WC		
83				SS55	WC		
84				SS56	WC		
85				SS57	WC		
86				SS58	WC		
87				SS59	WC		
88				SS60	WC		
89		171.24		SS61	WC		Water bearing between 91.4 m and 102.1 m
90	***SILT*** Grey.	89.30		SS62	WC		
91		169.14		SS63	WC		
92	***FINE SAND trace to some silt*** Grey.	91.40		SS64	WC		Screen Depth: 99.1 m to 102.1 m Sand Pack: #1 silica 96.2 m to 102.1 m Slot: #10 Sch. 40 PVC
93				SS65	WC		
94				SS66	WC		
95		165.14					
96	***MED. to COARSE SAND and GRAVEL*** Grey.	95.40					
97							
98							
99							
100							

Drilled By: Gerrits Well Drilling Inc.
Drill Method: Air & Mud Rotary
Drill Date: August 15 - 22, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic
Sheet: 5 of 6

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861425.7
Easting: 608163.3
MOE Well ID: A035564
Logged By: Gerrits Well Drilling Inc.

Log of Borehole: MW-NB1D

MW4D

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
101		***MED. to COARSE SAND and GRAVEL (continued)***			SS67	WC		
102			158.43					
		End of Borehole	102.11					
103								
104								
105								
106								
107								
108								
109								
110								
111								
112								
113								
114								
115								
116								
117								
118								
119								
120								

Drilled By: Gerrits Well Drilling Inc.
Drill Method: Air & Mud Rotary
Drill Date: August 15 - 22, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic
Sheet: 6 of 6

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861420.2
Easting: 608178.8
MOE Well ID: A035562
Logged By: Sudhakar Kurli

Log of Borehole: MW-NB1I

MW4I

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Elev/ Depth	Well Data	Number	Type	Recovery	Comments
		Ground Surface	260.42					
0		***TOPSOIL***	0.00		SS1	WC		Stick Up: 0.77 mag Well Diameter: 0.076 m Bentonite: 0.0 m to 36.5 m
1			258.92					
2		***CLAYEY SILT*** Brown.	1.50		SS2	WC		
3					SS3	WC		
4								
5					SS4	WC		
6								
7					SS5	WC		
8					SS6	WC		SWL @ October 31, 2006: 7.82 mbTOC
9			251.28					
10		***SAND and SILT*** Brown.	9.14		SS7	WC		
11					SS8	WC		
12								
13					SS9	WC		
14					SS10	WC		
15			245.18					
16		***COARSE SAND and GRAVEL***	15.24		SS11	WC		
17					SS12	WC		
18								
19					SS13	WC		
20								

Drilled By: Gerrits Well Drilling Inc.
Drill Method: Air & Mud Rotary
Drill Date: August 28 - 30, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861420.2
Easting: 608178.8
MOE Well ID: A035562
Logged By: Sudhakar Kurli

Log of Borehole: MW-NB1I
MW4I

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
21					SS14	WC		
22					SS15	WC		
23					SS16	WC		
24					SS17	WC		
25					SS18	WC		
26					SS19	WC		
27					SS20	WC		
28					SS21	WC		
29			231.42		SS22	WC		
30		***SAND and SILT*** Grey.	29.00		SS23	WC		
31					SS24	WC		
32					SS25	WC		Screen Depth: 37.8 m to 40.8 m Sand Pack: 36.5 m 41.14 m Slot: #10 Sch. 40 PVC
33			226.89		SS26	WC		
34		***GRAVEL some sand and silt***	33.53					
35								
36								
37		Becomes only gravel and sand below 37.5 m						
38			222.32					
39		***GRAVEL some sand*** Brown.	38.10					
40								

Drilled By: Gerrits Well Drilling Inc.
Drill Method: Air & Mud Rotary
Drill Date: August 28 - 30, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861420.2
Easting: 608178.8
MOE Well ID: A035562
Logged By: Sudhakar Kurli

Log of Borehole: MW-NB1I
MW4I

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
41			219.62		SS27	WC		
		CLAYEY SILT to SILTY CLAY Grey.	40.80					
		End of Borehole						
42								
43								
44								
45								
46								
47								
48								
49								
50								
51								
52								
53								
54								
55								
56								
57								
58								
59								
60								

Drilled By: Gerrits Well Drilling Inc.
Drill Method: Air & Mud Rotary
Drill Date: August 28 - 30, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic
Sheet: 3 of 3

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861423.2
Easting: 608171.4
MOE Well ID: A035562
Logged By: Mike Holmes

Log of Borehole: MW-NB1S
MW4S

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Elev/ Depth	Well Data	Number	Type	Recovery	Comments
		Ground Surface	260.54					
0		***TOPSOIL*** Brown, some organics, moist.	0.00 259.63					Stick Up: 0.82 mag Well Diameter: 0.15 m Grout: 0.0 m to 6.2 m
1		***SILTY CLAY to CLAYEY SILT*** Medium brown, stiff to hard, trace fine sand, moist.	0.91 259.02					
2		***SILTY FINE SAND*** Medium to light brown, some fine gravel, trace clay, loose, dry.	1.52					
3								
4								Returns of dry sediment produces dust
5								
6		Becoming moist @ 4.3 m						SWL @ October 31, 2006: 5.93 mbTOC
7								
8								
9								
10								
11								
12								
13								
14								
15		***FINE to COARSE SAND*** Grey, trace to some fine to med. gravel, compact, moist.	245.61 14.93					
16								
17								Screen: #8 slot - 18.6 m to 19.8 m #10 slot - 19.8 m - 21.0 m
18			242.25 18.29					
19		***MED. SAND and GRAVEL*** Grey, wet.			SS1	WC		
20								

Drilled By: G. Hart & Sons
Drill Method: Air & Mud Rotary
Drill Date: July 20 - 24, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861423.2
Easting: 608171.4
MOE Well ID: A035562
Logged By: Mike Holmes

Log of Borehole: MW-NB1S
MW4S

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
21		Clay content increased between 21.0 m to 21.9 m	238.64					
22		***MED. SAND some fine to coarse gravel*** Grey, loose, wet.	21.90					
23								
24			236.15					
		End of Borehole	24.38					
25								
26								
27								
28								
29								
30								
31								
32								
33								
34								
35								
36								
37								
38								
39								
40								

Drilled By: G. Hart & Sons
Drill Method: Air & Mud Rotary
Drill Date: July 20 - 24, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic
Sheet: 2 of 2

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861442.7
Easting: 608259.5
MOE Well ID: A035562
Logged By: Joseph Ng

Log of Borehole: MW-NB2D
MW5

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Elev/ Depth	Well Data	Number	Type	Recovery	Comments
		Ground Surface	260.33					
0		***TOPSOIL***	0.00 259.73					Stick Up: 0.46 mag Well Diameter: 0.076 m Outer Casing: 0.25 m dia. Depth of Outer Casing: 6.0 m Holeplug/grout: 0.0 m to 94.8 m
1		***SILTY CLAY to CLAY some silt*** Brown.	0.60		SA-1	WC		
2					SA-2	WC		
3					SA-3	WC		
4								
5		Becomes grey below 4.6 m			SA-4	WC		
6			254.23					
7		***SILTY SAND*** Grey.	6.10		SA-5	WC		
8		Observed clay lenses between 6.10 m and 9.14 m			SA-6	WC		
9								
10					SA-7	WC		
11		Observed some clay below 9.14 m			SA-8	WC		
12			248.21					
13		***SILT trace clay***	12.12		SA-9	WC		
14		Observed trace clay between 12.19 m and 18.29 m			SA-10	WC		
15								
16					SA-11	WC		
17								
18			242.04		SA-12	WC		
19		Grades to silty sand between 18.29 m and 21.34 m	18.29		SA-13	WC		SWL @ October 31, 2006: 19.08 mbTOC
20								

Drilled By: G. Hart & Sons
Drill Method: Air & Mud Rotary
Drill Date: Aug. 29 to Sept. 5, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861442.7
Easting: 608259.5
MOE Well ID: A035562
Logged By: Joseph Ng

Log of Borehole: MW-NB2D
MW5

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
21			239.03		SA-14	WC		
22		***COARSE SAND some gravel***	21.30		SA-15	WC		
23					SA-16	WC		
24			235.93					
25		***SILTY SAND some clay and gravel***	24.40		SA-17	WC		
26					SA-18	WC		
27					SA-19	WC		
28					SA-20	WC		
29					SA-21	WC		
30					SA-22	WC		
31					SA-23	WC		
32					SA-24	WC		
33					SA-25	WC		
34					SA-26	WC		
35								
36								
37								
38			222.23					
39		***COARSE SAND and SILT***	38.10					
40								

Drilled By: G. Hart & Sons
Drill Method: Air & Mud Rotary
Drill Date: Aug. 29 to Sept. 5, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861442.7
Easting: 608259.5
MOE Well ID: A035562
Logged By: Joseph Ng

Log of Borehole: MW-NB2D
MW5

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
41			219.23		SA-27	WC		
		CLAYEY SILT	41.10					
42					SA-28	WC		
43					SA-29	WC		
44								
45					SA-30	WC		Material dense between 41.2 m and 67.1 m
46								
47					SA-31	WC		
48					SA-32	WC		
49								
50					SA-33	WC		
51					SA-34	WC		
52								
53					SA-35	WC		
54					SA-36	WC		
55								
56					SA-37	WC		
57					SA-38	WC		
58								
59					SA-39	WC		
60								

Drilled By: G. Hart & Sons
Drill Method: Air & Mud Rotary
Drill Date: Aug. 29 to Sept. 5, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861442.7
Easting: 608259.5
MOE Well ID: A035562
Logged By: Joseph Ng

Log of Borehole: MW-NB2D
MW5

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
61		***CLAYEY SILT (continued)***			SA-40	WC		
62					SA-41	WC		
63					SA-42	WC		
64					SA-43	WC		
65					SA-44	WC		
66								
67			193.23					
		CLAY	67.10		SA-45	WC		
68								
69					SA-46	WC		
70								
71					SA-47	WC		
72					SA-48	WC		
73		Siltier between 73.15 m and 79.25 m						
74					SA-49	WC		
75					SA-50	WC		
76								
77					SA-51	WC		
78					SA-52	WC		
79			181.13					
		CLAYEY SILT	79.20		SA-53	WC		
80								

Drilled By: G. Hart & Sons
Drill Method: Air & Mud Rotary
Drill Date: Aug. 29 to Sept. 5, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic
Sheet: 4 of 6

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861442.7
Easting: 608259.5
MOE Well ID: A035562
Logged By: Joseph Ng

Log of Borehole: MW-NB2D
MW5

SUBSURFACE PROFILE

Depth (mbgs)	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
81				SA-53			
82				SA-54	WC		Observed no change in lithology between 67.1 m and 92.6 m
83				SA-55	WC		
84				SA-56	WC		
85		174.99					
86	***SILTY CLAY to CLAYEY SILT***	85.34		SA-57	WC		
87				SA-58	WC		
88							
89				SA-59	WC		
90				SA-60	WC		
91	Silt and sand content increased below 91.4 m						
92				SA-61	WC		
93		167.33					
94	***COARSE SAND and GRAVEL***	93.00		SA-62	WC		
95				SA-63	WC		Hole Plug: 94.8 m to 96.7 m #10 Slot Screen (Sch. 40 PVC) 98.4 m to 101.5 m Sand Pack: 96.7 m to 101.5 m
96		164.33					
97	***GRAVEL and COBBLES*** Gravel is rounded.	96.00		SA-64	WC		
98				SA-65	WC		
99		161.23					
100	***SAND and GRAVEL***	99.10		SA-66	WC		

Drilled By: G. Hart & Sons
Drill Method: Air & Mud Rotary
Drill Date: Aug. 29 to Sept. 5, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic
Sheet: 5 of 6

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861442.7
Easting: 608259.5
MOE Well ID: A035562
Logged By: Joseph Ng

Log of Borehole: MW-NB2D
MW5

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
101		***SAND and GRAVEL (continued)***	158.53		SA-67	WC		Cave: 101.5 m to 102.4 m
102		***COARSE SAND***	101.80 157.93					
		End of Borehole	102.40					
103								
104								
105								
106								
107								
108								
109								
110								
111								
112								
113								
114								
115								
116								
117								
118								
119								
120								

Drilled By: G. Hart & Sons
Drill Method: Air & Mud Rotary
Drill Date: Aug. 29 to Sept. 5, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic
Sheet: 6 of 6

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861428.1
Easting: 608175.9
MOE Well ID: A035563
Logged By: Mike Holmes

Log of Borehole: TW-NB1
MW6

SUBSURFACE PROFILE

Depth (mbgs)	Description	Elev/ Depth	Well Data	Number	Type	Recovery	Comments
	Ground Surface	260.79					
0	***TOPSOIL*** Brown, some organics, moist.	0.00					Outer Casing 0.25 m dia. Stick Up: 0.89 mag Outer Working Casing to 9.1 m depth (removed)
1	***SILTY CLAY to CLAYEY SILT some fine sand*** Brown, moist.	259.69 1.10		SA-1	WC		
2	Clay chips show fine laminations	258.99 1.80		SA-2	WC		Well Diameter: 0.159 m, steel, 0.007 m thick
3	***SILTY FINE SAND*** Medium to light brown, trace coarse sand and gravel to 3.0 m depth, loose, dry.						
4							
5							Returns of dry sediment produce dust between 1.8 m and 4.6 m
6				SA-3	WC		
7	Moist @ 4.6 m						
8	Some clay and gravel (fine) below 6.0 m						
9							
10	Grey colour below 10.0 m and silt content increased						
11				SA-4	WC		
12							
13							
14	***FINE to MED. SAND some silt*** Grey, some silt, trace to some fine to med. gravel, wet.	246.79 14.00		SA-5	WC		
15							
16							
17				SA-6	WC		
18							
19				SA-7	WC		SWL @ October 31, 2006: 18.98 mbTOC
20							

Drilled By: G. Hart & Sons
Drill Method: Air & Mud Rotary
Drill Date: July 24 to Aug. 14, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861428.1
Easting: 608175.9
MOE Well ID: A035563
Logged By: Mike Holmes

Log of Borehole: TW-NB1
MW6

SUBSURFACE PROFILE

Depth (mbgs)	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
21	Clay and gravel content increasing from 24.0 m			SA-8	WC		
22							Approximately 20% gravel between 21.9 m and 25.0 m
23				SA-9	WC		
24				SA-10	WC		
25	***CLAYEY SILT*** Grey, some gravel (fine to med.) and sand (fine), moist.	235.79 25.00		SA-11	WC		
26							
27							
28				SA-12	WC		
29							
30				SA-13	WC		
31							
32	Decreased to no gravel content below 32 m	228.79 32.00		SA-14	WC		
33							
34							
35							
36	***FINE to COARSE SAND and GRAVEL*** Grey to black, gravel is rounded to angular, trace silt, loose, wet.	224.79 36.00		SA-15	WC		
37							
38				SA-16	WC		Water bearing formation
39							
40							

Drilled By: G. Hart & Sons
Drill Method: Air & Mud Rotary
Drill Date: July 24 to Aug. 14, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic
Sheet: 2 of 6

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861428.1
Easting: 608175.9
MOE Well ID: A035563
Logged By: Mike Holmes

Log of Borehole: TW-NB1
MW6

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
41					SA-17	WC		
42			218.09					
43		***SILTY CLAY to CLAYEY SILT*** Grey, trace grey to black fine sand, moist.	42.70		SA-18	WC		Returns are primarily grey mud from drill water mixing with sediment between 42.7 m and 80.2 m
44								
45								
46					SA-19	WC		Material is stiff between 42.7 m and 89.6 m
47								
48								
49					SA-20	WC		
50								
51								
52					SA-21	WC		
53								
54								
55					SA-22	WC		
56								
57								
58					SA-23	WC		Returns are primarily hard clay chips in sample SA-23
59								
60								

Drilled By: G. Hart & Sons
Drill Method: Air & Mud Rotary
Drill Date: July 24 to Aug. 14, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic
Sheet: 3 of 6

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861428.1
Easting: 608175.9
MOE Well ID: A035563
Logged By: Mike Holmes

Log of Borehole: TW-NB1 MW6

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
61		***SILTY CLAY to CLAYEY SILT (continued)*** Grey, trace grey to black fine sand, moist.						
62					SA-24	WC		
63								
64					SA-25	WC		
65								
66					SA-26	WC		
67								
68								
69					SA-27	WC		
70								
71								
72		Silt content reduced to trace; clay chips show fine < 1.0 mm laminations on fresh surfaces @ 72.0 m						
73					SA-28	WC		
74								
75								
76					SA-29	WC		
77								
78		Clayey silt layers 0.15 m to 0.3 m thick from 78.0 m to 79.2 m						
79								
80								

Drilled By: G. Hart & Sons
Drill Method: Air & Mud Rotary
Drill Date: July 24 to Aug. 14, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic
Sheet: 4 of 6

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861428.1
Easting: 608175.9
MOE Well ID: A035563
Logged By: Mike Holmes

Log of Borehole: TW-NB1
MW6

SUBSURFACE PROFILE

Depth (mbgs)	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
81	***SILTY CLAY to CLAYEY SILT (continued)*** Grey, trace grey to black fine sand, moist.			SA-30	WC		
82							
83				SA-31	WC		
84							
85							
86				SA-32	WC		
87							
88				SA-33	WC		
89	Increased silt content between 89.6 m to 91.4 m						
90				SA-34	WC		
91		169.35					
92	***SILTY FINE SAND*** Grey, loose, wet.	91.44		SA-35	WC		Casing advanced by 0.5 m to 1.0 m by its own weight @ 92.0 m
93							
94							
95		165.09					Estimated to produce water @ 100 igpm with air lift
96	***FINE SAND*** Grey to black, wet.	95.70		SA-36	WC		
97	Sand is coarsening downward	163.23		SA-37	WC		
98	***FINE to COARSE SAND, GRAVEL and COBBLES*** Grey to black.	97.56		SA-38	WC		Gravel between 97.5 m and 103.6 m is typically sub-angular or fractured, 10 mm to 40 mm diameter, and displays a broad range of lithologies
99							
100				SA-39			

Drilled By: G. Hart & Sons
Drill Method: Air & Mud Rotary
Drill Date: July 24 to Aug. 14, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic
Sheet: 5 of 6

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861428.1
Easting: 608175.9
MOE Well ID: A035563
Logged By: Mike Holmes

Log of Borehole: TW-NB1
MW6

Depth (mbgs)	Description	Depth/ Elev	Number	Type	Recovery	Comments
101			SA-39	WC		Stainless steel wire bound screen from 96.6 m to 103.0 m 5 sections with 0.14 m spacers between screens: - #40 slot (1.22 m) - #50 slot (1.22 m) - #50 slot (1.22 m) - #35 slot (1.22 m) - #20 slot (0.91 m)
102	Sand content decreases to 102.0 m		SA-40	WC		
103		157.19	SA-41	WC		
104	***FINE to COARSE SAND some silt*** Grey/black, trace to some gravel to 104.2 m, wet.	103.60	SA-42	WC		Bentonite: 103.0 m to 108.2 m
105						
106	No gravel content below 104.5 m	154.09	SA-43	WC		
107	***SHALE BEDROCK*** Grey, soft.	106.70	SA-44	WC		
108		152.59				
	End of Borehole	108.20				
109						
110						
111						
112						
113						
114						
115						
116						
117						
118						
119						
120						

Drilled By: G. Hart & Sons
Drill Method: Air & Mud Rotary
Drill Date: July 24 to Aug. 14, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.15 m
Datum: Geodetic
Sheet: 6 of 6

LOG OF BOREHOLE NOB-MW9

PROJECT: Groundwater Exploration Study, Nobleton, ON

CLIENT: York Region

PROJECT LOCATION: Nobleton, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan (UTM 17T)

Method: Tricone Drilling

Diameter: 150

Date: Dec-03-2019 to Dec-18-2019

REF. NO.: 170462

ENCL NO.: 1

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	SAMPLES TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
Ground Surface											
0.0	**Halton Till:** brown to grey clayey silt till, trace sand, trace gravel		1	AS							
			2	AS							
			3	AS							
			4	AS							
10.0	**Upper and Lower Oak Ridges Moraine Aquifer Complex (ORMAC):** grey fine sand and silt, trace silt, moist to wet		5	AS							
			6	AS							

Continued Next Page

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES: + 3, × 3: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

PROJECT: Groundwater Exploration Study, Nobleton, ON

CLIENT: York Region

PROJECT LOCATION: Nobleton, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan (UTM 17T)

Method: Tricone Drilling

Diameter: 150

Date: Dec-03-2019 to Dec-18-2019

REF. NO.: 170462

ENCL NO.: 1

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	SAMPLES TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued										
	Upper and Lower Oak Ridges Moraine Aquifer Complex (ORMAC): grey fine sand and silt, trace silt, moist to wet Continued)		7	AS							
21.5	**Newmarket Till:** grey clayey silt till, some sand, some gravel		8	AS							
33.0	**Newmarket Till:** grey silty sand till, some gravel, occ. cobbles		9	AS							

Continued Next Page

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES $+^{3}$, $\times^{3}$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

PROJECT: Groundwater Exploration Study, Nobleton, ON

CLIENT: York Region

PROJECT LOCATION: Nobleton, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan (UTM 17T)

Method: Tricone Drilling

Diameter: 150

Date: Dec-03-2019 to Dec-18-2019

REF. NO.: 170462

ENCL NO.: 1

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" BLOWS/0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued										
41	**Newmarket Till:** grey silty sand till, some gravel, occ. cobbles(Continued)		10	AS							
42			11	AS							
43			12	AS							
43.0	**Newmarket Till:** grey clayey silt till, some sand, some gravel		13	AS							
44											
45											
46											
47											
48											
49											
50											
51											
52							Riser				
53			14	AS							
53.0	**Thorncliffe Formation (Aquifer):** grey medium to coarse grained sand, some gravel, wet										
54											
55			15	AS							
56											
57											
57.0	**Thorncliffe Formation (Aquifer):** grey clayey silt till, some sand, trace gravel		16	AS							
58											
59											
60											

Continued Next Page

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES

$+^3$, $\times^3$: Numbers refer to Sensitivity

○ ε_f=3% Strain at Failure

PROJECT: Groundwater Exploration Study, Nobleton, ON

CLIENT: York Region

PROJECT LOCATION: Nobleton, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan (UTM 17T)

Method: Tricone Drilling

Diameter: 150

Date: Dec-03-2019 to Dec-18-2019

REF. NO.: 170462

ENCL NO.: 1

(m) ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRATA PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued											
61	**Thorncliffe Formation (Aquifer):** grey clayey silt till, some sand, trace gravel(Continued)		17	AS								
61.0	**Thorncliffe Formation (Aquifer):** grey well sorted sand, some gravel, wet		18	AS								
64			19	AS								
72.0	**Thorncliffe Formation (Aquifer):** grey clayey silt till, some sand, trace gravel		20	AS								
79			21	AS								
79.0	**Sunnybrook Formation:** grey silty clay											

Continued Next Page

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES: + 3, × 3: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

PROJECT: Groundwater Exploration Study, Nobleton, ON

CLIENT: York Region

PROJECT LOCATION: Nobleton, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan (UTM 17T)

Method: Tricone Drilling

Diameter: 150

Date: Dec-03-2019 to Dec-18-2019

REF. NO.: 170462

ENCL NO.: 1

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued											
	Sunnybrook Formation: grey silty clay(Continued)		22	AS								
96.0	**Scarborough Formation (Aquifer): grey sandy silt, wet**		23	AS								
			24	AS								

Continued Next Page

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES

+ 3, × 3: Numbers refer to Sensitivity

○ ε=3% Strain at Failure

LOG OF BOREHOLE NOB-MW9

PROJECT: Groundwater Exploration Study, Nobleton, ON
CLIENT: York Region
PROJECT LOCATION: Nobleton, ON
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan (UTM 17T)

Method: Tricone Drilling
Diameter: 150
Date: Dec-03-2019 to Dec-18-2019

REF. NO.: 170462
ENCL NO.: 1

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued							
100.0	**Scarborough Formation (Aquifer):** grey well sorted medium to coarse sand and gravel, some silt, wet		25	AS				
			26	AS				
			27	AS				
			28	AS				
			29	AS			Screen	
108.0	**Scarborough Formation (Aquifer):** grey well sorted coarse sand and gravel, occ. cobbles, wet		30	AS				
			31	AS				
109.0	**Georgian Bay Formation:** limestone/shale bedrock		32	AS			Bottom	
110.5	**END OF MONITORING WELL** Screen interval was placed between 103.8 and 108 mbgs - 0.31 m of riser/packer - 3.01 m of #40 slot Johnson Wire Wrap Well Screen - 1.22 m of #50 slot Johnson Wire Wrap Well Screen							

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH (kPa)
○ UNCONFINED + FIELD VANE & Sensitivity
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30

POCKET PEN. (C_u) (kPa)

NATURAL UNIT WT (kN/m³)

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
+ 3, × 3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

MMM GROUP

Project No: 14-05124-001-HG1
Project: Hydrogeological Investigation
Client: Regional Municipality of York
Location: Nobleton, Ontario

Northing: 4864319
Easting: 608241
MOE ID#: A125896
Logged By: NC

Log of Borehole PW5 (NOB-PW5)

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Elev/ Depth	Well Data	Number	Type	Recovery	Comments
		Ground Surface	260.50					
0		***TOPSOIL*** Black	0.00 260.05 0.45					**Well Construction** - Stick up: 0.92 mags - Well Diameter: 0.30 m - Outer Casing Diameter: 0.45 m - Inner well casing extends to 96.62 mbgs - Outer well casing extends to 41.15 mbgs - Annulus space between outer well casing and working casing filled with: - cement from 0 to 4.27 mbgs - Annulus space between inner and outer well casings filled with: - cement grout from 0 to 25.91 mbgs - bentonite grout from 25.91 to 41.15 mbgs - Annulus space filled with bentonite mud from 41.15 to 70.10 mbgs - Screened depth: 96.62 to 101.19 mbgs
1		***SILTY SAND*** Brown						
			258.67					
2		***CLAY*** Brown, some sand and gravel	1.83					
3								
4								
			255.93					
5		***SAND AND GRAVEL*** Brown, waterbearing	4.57					
6								
			254.10					
7		***SILT*** Grey, some clay	6.40					
8								
9								
10								
11								
12		From 12.50 to 17.37 mbgs: Some fine sand, trace clay						
13								
14								
15								
16								
17			243.13					
		SAND Brownish grey, waterbearing	17.37					
18								
			241.91					
19		***SAND AND GRAVEL*** Grey, waterbearing	18.59					
			240.38					
20			20.12					

Drilled By: G Hart & Sons Well Drilling Ltd.
Drill Method: Dual Air and Mud Rotary
Drill Date: May 23, 2012

MMM Group Limited
100 Commerce Valley Drive West
Thornhill, Ontario L3T 0A1
Borehole Log is for Environmental Purposes Only

Hole Size: 0.45 m
Datum: NAD 83

MMM GROUP

Project No: 14-05124-001-HG1
Project: Hydrogeological Investigation
Client: Regional Municipality of York
Location: Nobleton, Ontario

Northing: 4864319
Easting: 608241
MOE ID#: A125896
Logged By: NC

Log of Borehole PW5 (NOB-PW5)

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Elev/ Depth	Well Data	Number	Type	Recovery	Comments
21		***SILTY SAND AND GRAVEL*** Grey, waterbearing	238.86 21.64					Water level on June 11, 2012 was 20.49 mbgs.
22		***SAND AND GRAVEL*** Grey, waterbearing						
23								
24			235.81 24.69					
25		***SANDY CLAY*** Grey						
26								
27								
28			231.54 28.96					
29		***SILTY SAND AND GRAVEL*** Grey, some clay, wet	230.63 29.87					
30		***CLAY*** Grey						
31								
32								
33								
34								
35			225.14 35.36					
36		***SILTY SAND AND GRAVEL*** Grey, waterbearing						
37								
38			222.40 38.10					
39		***GRAVEL*** Grey, some sand, waterbearing	221.18 39.32					
40		***SILT WITH CLAY*** Grey, layered						

Drilled By: G Hart & Sons Well Drilling Ltd.
Drill Method: Dual Air and Mud Rotary
Drill Date: May 23, 2012

MMM Group Limited
100 Commerce Valley Drive West
Thornhill, Ontario L3T 0A1
Borehole Log is for Environmental Purposes Only

Hole Size: 0.45 m
Datum: NAD 83

MMM GROUP

Project No: 14-05124-001-HG1
Project: Hydrogeological Investigation
Client: Regional Municipality of York
Location: Nobleton, Ontario

Northing: 4864319
Easting: 608241
MOE ID#: A125896
Logged By: NC

Log of Borehole PW5 (NOB-PW5)

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Elev/ Depth	Well Data	Number	Type	Recovery	Comments
41								
42								
43								
44								
45								
46								
47								
48								
49								
50								
51			209.60 50.90					
		CLAYEY SILT Grey						
52								
53								
54								
55								
56			204.72 55.78					
		SILT WITH CLAY TO CLAYEY SILTY Grey						
57								
58								
59								
60								

Drilled By: G Hart & Sons Well Drilling Ltd.
Drill Method: Dual Air and Mud Rotary
Drill Date: May 23, 2012

MMM Group Limited
100 Commerce Valley Drive West
Thornhill, Ontario L3T 0A1
Borehole Log is for Environmental Purposes Only

Hole Size: 0.45 m
Datum: NAD 83
Sheet: 3 of 6

MMM GROUP

Project No: 14-05124-001-HG1
Project: Hydrogeological Investigation
Client: Regional Municipality of York
Location: Nobleton, Ontario

Northing: 4864319
Easting: 608241
MOE ID#: A125896
Logged By: NC

Log of Borehole PW5 (NOB-PW5)

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Elev/ Depth	Well Data	Number	Type	Recovery	Comments
61								
62								
			197.71					
63		***CLAYEY SILT TO SILT AND CLAY*** Grey	62.79					
64								
65								
66								
67								
68								
69								
70								- End of 0.45 m outer well casing
71								
72								
73								
74								
75								
76								
77								
78								
79								
80								

Drilled By: G Hart & Sons Well Drilling Ltd.
Drill Method: Dual Air and Mud Rotary
Drill Date: May 23, 2012

MMM Group Limited
100 Commerce Valley Drive West
Thornhill, Ontario L3T 0A1
Borehole Log is for Environmental Purposes Only

Hole Size: 0.45 m
Datum: NAD 83

MMM GROUP

Project No: 14-05124-001-HG1
Project: Hydrogeological Investigation
Client: Regional Municipality of York
Location: Nobleton, Ontario

Northing: 4864319
Easting: 608241
MOE ID#: A125896
Logged By: NC

Log of Borehole PW5 (NOB-PW5)

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Elev/ Depth	Well Data	Number	Type	Recovery	Comments
81								
82								
83								
84								
85								
86								
87			173.63 86.87					
		SILT WITH CLAY Grey						
88			171.80 88.70					
89		***SILT WITH CLAY TO SANDY SILT*** Grey, wet						
90								
91								
92								
93								
94			166.62 93.88					
		SILTY SAND TO FINE SAND Grey, waterbearing	165.71					
95		***FINE TO MEDIUM SAND WITH GRAVEL*** Grey,waterbearing	94.79					
96								
			163.88					
97		***SAND AND GRAVEL*** Grey, waterbearing	96.62					- Natural sand pack from 96.62 to 98.15 mbgs - Packer: 96.62 to 96.77 mbgs - #0 slot from 96.77 to 98.15 mbgs - #50 slot from 98.15 to 98.76 mbgs - #50 expanding to #100 slot from 98.76 to 99.36 mbgs - #100 slot from 99.36 to 101.19 mbgs - Hole was backfilled with caved in material from 101.19 to 107.29 mbgs
98								
99								
100								

Drilled By: G Hart & Sons Well Drilling Ltd.
Drill Method: Dual Air and Mud Rotary
Drill Date: May 23, 2012

MMM Group Limited
100 Commerce Valley Drive West
Thornhill, Ontario L3T 0A1
Borehole Log is for Environmental Purposes Only

Hole Size: 0.45 m
Datum: NAD 83
Sheet: 5 of 6

MMM GROUP

Project No: 14-05124-001-HG1
Project: Hydrogeological Investigation
Client: Regional Municipality of York
Location: Nobleton, Ontario

Northing: 4864319
Easting: 608241
MOE ID#: A125896
Logged By: NC

Log of Borehole PW5 (NOB-PW5)

SUBSURFACE PROFILE

Depth (mbgs)	Symbol	Description	Elev/ Depth	Well Data	Number	Type	Recovery	Comments
101			159.31					
		CLAYEY SILT WITH SILTY SAND AND GRAVEL	101.19					
		Grey						
102		101.2 to 102.4 mbgs: Clayey Silt, some sand						
		102.4 to 104.2 mbgs: Clayey Silt, Sand & Gravel, wet						
103								
104		104.2 to 106.1 mbgs: Silty Sand, waterbearing						
105								
106		106.1 to 106.5 mbgs: Silty Sand, some gravel, waterbearing	153.97					
		SHALE	106.53					
107		Greenish grey	153.21					
		End of Borehole	107.29					
108								
109								
110								
111								
112								
113								
114								
115								
116								
117								
118								
119								
120								

Drilled By: G Hart & Sons Well Drilling Ltd.
Drill Method: Dual Air and Mud Rotary
Drill Date: May 23, 2012

MMM Group Limited
100 Commerce Valley Drive West
Thornhill, Ontario L3T 0A1
Borehole Log is for Environmental Purposes Only

Hole Size: 0.45 m
Datum: NAD 83
Sheet: 6 of 6

J.B

UTM | 1 | 7 | Z | 6 0 8 3 0 0 | E
| 5 | R | 4 8 6 1 7 7 5 | N
Elev. | 4 | R | 0 8 5 0 (KP)
Basin | 2 4 |

Con VIII Lot 6

30413

The Ontario Water Resources Commission Act

WATER WELL RECORD

County or District: YORK
Township, Village, Town or ~~City~~: King Township
Con.: 8 Lot: 6 Date completed: 18 (day) 5 (month) 68 (year)

Owner (print in block letters): Public Utilities Commission of Nobleton
Address: Mrs. H. Hill Nobleton P/O

Casing and Screen Record

Inside diameter of casing: 12 5/8
Total length of casing: 283
Type of screen: Jonson stainlessteel
Length of screen: 22' 10'-10" nipple on top
Depth to top of screen: 273
Diameter of finished hole: 12 5/8

Pumping Test

Static level: 54' 4"
Test-pumping rate: 350 I.P.G. G.P.M.
Pumping level: 91' 4"
Duration of test pumping: 72 Hours
Water clear or cloudy at end of test: Clear
Recommended pumping rate: 300 G.P.M.
with pump setting of 160 feet below ground surface

Well Log

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
Brown Clay	0	4	173	Fresh
" " and sand	4	34		
" " gravel "	34	43		
gravel sand bolders mud	43	85		
sillt	85	204		
Blue Clay	204	273		
Fine sand	273	280		
middium sand	280	292	280	"
gravel middium sand	292	305		
Hart pan	305	308		

For what purpose(s) is the water to be used? Domestic P.U.C.

Is well on upland, in valley, or on hillside? upland

Drilling or Boring Firm: Van den Boom Welldrilling

Address: Nobleton Box 245

Licence Number: 2405

Name of Driller or Borer: R. van den Boom

Address: Same

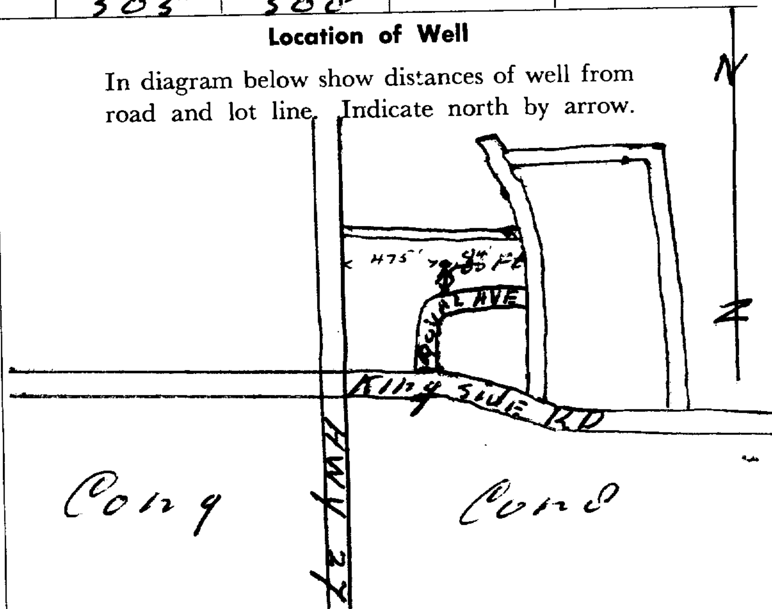
Date: 18-5-68

(Signature of Licensed Drilling or Boring Contractor)

Police Village of Nobleton

Location of Well

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



Form 7 15M-60-4138

S.C.

CSS.S8

OWRC COPY

UTM 17 Z 608054 E
5 R 4861471 N
Elev. 15 R 0816 5
Basin 42A 5

30M13

GROUND WATER BR...
69 No 10[illegible] 2458
ONTARIO WATER RESOURCES C... ION

The Ontario Water Resources Commission Act, 1957

WATER WELL RECORD

County or District YORK Township, Village, Town or City King Nobleton

Con. 9 Lot 5 Date completed 19 (day) Feb. (month) 1961 (year)

Owner Police Village of Nobleton (print in block letters) Address Nobleton, Ontario

Casing and Screen Record

Inside diameter of casing 12 3/4" ø

Total length of casing 347 from grade

Type of screen Johnson #125 slot 35

Length of screen 19'8" with 3'6" of 10" pipe on top

Depth to top of screen 342'10"

Diameter of finished hole 12 3/4"

Pumping Test

Static level Approx. 59'

Test-pumping rate 300 G.P.M.

Pumping level 89' 6"

Duration of test pumping 24 hr.

Water clear or cloudy at end of test clear

Recommended pumping rate 300 G.P.M.

with pumping level of Approx. 82'

Well Log

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	No. of feet water rises	Kind of water (fresh, salty, sulphur)
Brown Clay	0	15	39		
Blue Clay	15	39	327	268	fresh
Sand & Gravel	39	45			
Clay, Sand & Gravel	45	140			
Blue Clay	140	327			
Sand, Gravel & Clay					
Packed very tight	327	340			
Clean sand & Gravel	340	361			
Gravel, Clay & Boulders	361	362			
Sand & Fine Gravel	362	366			
Sand and few small stones	366	367			

For what purpose(s) is the water to be used?

MUNICIPAL

Is well on upland, in valley, or on hillside?

UPLAND

Drilling Firm C. H. Rutledge

Address

Licence Number

Name of Driller same

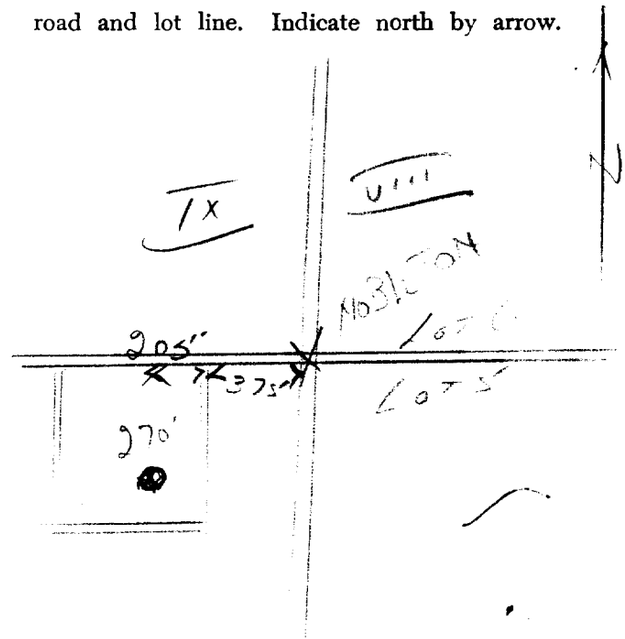
Address

Date MARCH

(Signature of Licensed Drilling Contractor)

Location of Well

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



Form 5

CSS.S8

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861428.7
Easting: 608189.0
MOE Well ID: A032051
Logged By: Joseph Ng

Log of Borehole: NB4-PW

SUBSURFACE PROFILE

Depth (mbgs)	Description	Elev/ Depth	Number	Type	Recovery	Comments
	Ground Surface	260.64				
0	***TOPSOIL***	0.00				Stick Up: 0.71 mags
1	***CLAYEY SILT*** Brown, moist, clayey becoming gravelly by 3.0 m depth.		SA-1	WC		Well Diameter: 0.30 m Temporary Outer Casing: 0.46 m Depth of Outer Casing: 47.2 m
2			SA-2	WC		
3		257.59				Hole Dia.: 0.48 m from 0.0 m to 47.2 m
	GRAVEL Brown, angular.	3.05	SA-3	WC		
4		256.07				Hole Dia.: 0.33 m from 47.2 m to 103.6 m
	SILT trace to some clay and gravel Brown, wet.	4.57	SA-4	WC		Annular seal from surface to 47.2 m
5						
6			SA-5	WC		
7	Some angular gravel, trace clay between 7.6 m and 9.1 m					
8			SA-6	WC		
9						
10			SA-7	WC		
11						
			SA-8	WC		
12	Trace angular gravel, increased clay content between 12.2 m and 13.7 m					
13			SA-9	WC		
		246.93				
14	***FINE to MED. SAND*** Brown/multicolor, wet.	13.71	SA-10	WC		
15						
16			SA-11	WC		
17						
			SA-12	WC		
18						
19			SA-13	WC		
20						

Drilled By: Gerrits Well Drilling Inc.
Drill Method: Air and Mud Rotary
Drill Date: Aug. 30 to Oct. 4, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.33 m
Datum: Geodetic
Sheet: 1 of 6

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861428.7
Easting: 608189.0
MOE Well ID: A032051
Logged By: Joseph Ng

Log of Borehole: NB4-PW

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
21			239.30		SA-14	WC		SWL @ 20.08 m on October 31, 2006
22		***SAND and GRAVEL*** Multicolor (exotic), angular, cobbles noted.	21.34		SA-15	WC		
23					SA-16	WC		
24			236.26					
25		***FINE SAND*** Brown, wet.	24.38		SA-17	WC		
26		Trace angular cobble between 24.4 m and 25.1 m			SA-18	WC		
27			233.21					
28		***SILT some clay, sand and gravel*** Brown, moist.	27.43		SA-19	WC		
29					SA-20	WC		
30			230.14					
31		***SILT some fine sand*** Grey.	30.50		SA-21	WC		
32					SA-22	WC		
33			227.14					
34		***CLAYEY SILT*** Grey.	33.50		SA-23	WC		
35					SA-24	WC		
36			224.06					
37		***COARSE SAND and GRAVEL some cobbles*** Grey/multicolour, angular and rounded.	36.58		SA-25	WC		
38					SA-26	WC		
39			221.02					
40			39.62					

Drilled By: Gerrits Well Drilling Inc.
Drill Method: Air and Mud Rotary
Drill Date: Aug. 30 to Oct. 4, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.33 m
Datum: Geodetic

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861428.7
Easting: 608189.0
MOE Well ID: A032051
Logged By: Joseph Ng

Log of Borehole: NB4-PW

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
41		***SILT*** Grey, moist.	219.49		SA-27	WC		
42		***CLAYEY SILT*** Grey, moist. Some gravel between 41.1 m and 42.7 m	41.15		SA-28	WC		
43					SA-29	WC		
44					SA-30	WC		
45					SA-31	WC		
46					SA-32	WC		0.48m borehole annular seal from surface to 47.2 m
47					SA-33	WC		
48					SA-34	WC		
49					SA-35	WC		
50			207.30		SA-36	WC		
51		***SILT*** Grey, moist.	53.34		SA-37	WC		
52					SA-38	WC		
53					SA-39	WC		
54								
55								
56								
57								
58								
59								
60								

Drilled By: Gerrits Well Drilling Inc.
Drill Method: Air and Mud Rotary
Drill Date: Aug. 30 to Oct. 4, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.33 m
Datum: Geodetic

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861428.7
Easting: 608189.0
MOE Well ID: A032051
Logged By: Joseph Ng

Log of Borehole: NB4-PW

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
61		***SILT (continued)***			SA-40	WC		
62					SA-41	WC		
63					SA-42	WC		
64		Becomes wet @ 64.0 m			SA-43	WC		
65			195.11					
66		***CLAYEY SILT***	65.53		SA-44	WC		
67		Grey, moist.			SA-45	WC		
68					SA-46	WC		
69					SA-47	WC		
70					SA-48	WC		
71					SA-49	WC		
72					SA-50	WC		
73					SA-51	WC		
74					SA-52	WC		
75					SA-53	WC		
76								
77								
78								
79								
80								

Drilled By: Gerrits Well Drilling Inc.
Drill Method: Air and Mud Rotary
Drill Date: Aug. 30 to Oct. 4, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.33 m
Datum: Geodetic

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861428.7
Easting: 608189.0
MOE Well ID: A032051
Logged By: Joseph Ng

Log of Borehole: NB4-PW

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
					SA-53			
81		***CLAYEY SILT (continued)***			SA-54	WC		
82								
83					SA-55	WC		
84								
85					SA-56	WC		
86								
87					SA-57	WC		
88								
89			171.44		SA-58	WC		
		SILT some sand and clay	89.20					
90		Brown.			SA-59	WC		
91								
92					SA-60	WC		
93								
94			166.14		SA-61	WC		Screened depth: 95.4 m to 100.6 m Natural Sand Pack: 95.4 m to 103.6 m
		SAND some gravel	94.50		SA-62	WC		Note: Top of stainless steel screen set within casing due to installation difficulties
95		Brown.						Casing to 95.4 mbgs
			164.63		SA-63	WC		Packer: 93.57 mbgs to 93.72 mbgs
96		***GRAVEL some sand and silt***	96.01					#0 Slot: 93.72 to 94.79 mbgs
97		Brown.			SA-64	WC		#10 Slot: 94.79 expanding to #60 Slot at 95.40 mbgs
98					SA-65	WC		#90 Slot: 95.40 to 97.53 mbgs #45 Slot: 97.53 to 100.58 mbgs
99								
100					SA-66	WC		

Drilled By: Gerrits Well Drilling Inc.
Drill Method: Air and Mud Rotary
Drill Date: Aug. 30 to Oct. 4, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.33 m
Datum: Geodetic
Sheet: 5 of 6

Project No: 14-05124-01-HG1
Project: Nobleton Class EA
Client: York Region
Location: Site N-B1

Northing: 4861428.7
Easting: 608189.0
MOE Well ID: A032051
Logged By: Joseph Ng

Log of Borehole: NB4-PW

Depth (mbgs)	Symbol	Description	Depth/ Elev	Well Data	Number	Type	Recovery	Comments
			160.14					
101		***SAND*** Brown.	100.50		SA-67	WC		
102		***CLAYEY SILT*** Grey.	158.54 102.10					
103			157.04					
104		End of Borehole	103.60					
105								
106								
107								
108								
109								
110								
111								
112								
113								
114								
115								
116								
117								
118								
119								
120								

Drilled By: Gerrits Well Drilling Inc.
Drill Method: Air and Mud Rotary
Drill Date: Aug. 30 to Oct. 4, 2006

MARSHALL MACKLIN MONAGHAN
80 Commerce Valley Drive East
Thornhill, Ontario L3T 7N4
Borehole Log is for Environmental Purposes Only

Hole Size: 0.33 m
Datum: Geodetic
Sheet: 6 of 6