Groundwater and Surface Water Baseline Conditions Report, Hydro One - Clarington Transformer Station Addendum 2

Prepared for:
Hydro One Networks Inc.
483 Bay Street
South Tower, 4th Floor
Toronto, ON M5G 2P5

Prepared by:
Stantec Consulting Ltd.
300 – 675 Cochrane Drive
Markham, ON L3R 0B8

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Sign-off Sheet

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Prepared by ______________________
(signature)

Natalie Spina, M.Sc., G.I.T.
Environmental Scientist

Prepared by ______________________
(signature)

Brant Gill, H.B.Sc., P.Geo.
Senior Hydrogeologist

Reviewed by ______________________
(signature)

Lesley Veale, M.Sc., P.Geo.
Senior Hydrogeologist

Stantec

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Abbreviations

AMSL	above mean sea level
AO	Aesthetic Objective
BTEX	benzene, toluene, ethylbenzene and xylene
BGS	below ground surface
BTOC	below top of casing
Class EA	Class Environmental Assessment
CLOCA	Central Lake Ontario Conservation Authority
DOC	Dissolved Organic Carbon
EA	Environmental Assessment
ECA	Environmental Compliance Approval
ESR	Environmental Study Report
GTA	Greater Toronto Area
Hydro One	Hydro One Networks Inc.
ID	Inner diameter
Lotowater	Lotowater Technical Services Inc.
MAC	Maximum Acceptable Concentration
Monitoring Program	Groundwater and Surface Water Monitoring Program
MOECC	Ontario Ministry of Environment and Climate Change
OD	outer diameter
ODWS	Ontario Drinking Water Standards
OG	Operational Guideline
OGS	Ontario Geological Survey
O. Reg. 903	Ontario Regulation 903
PCB	polychlorinated biphenyl
PHC	petroleum hydrocarbon
Project Area	Lands owned by Hydro One in the vicinity of the Clarington TS
PVC	polyvinyl chloride

Stantec	Stantec Consulting Ltd.
Station Site	Land Area of the Clarington Transformer Station
SVOC	semi-volatile organic compounds
TDS	Total Dissolved Solids
TS	Transformer Station
TSS	total suspended solids
USEPA	United States Environmental Protection Agency
VOC	volatile organic compounds
YPDT-CAMC	York, Peel, Durham, Toronto and the Conservation Authorities Moraine Coalition

1.0 INTRODUCTION

In 2014, Hydro One Networks Inc. (Hydro One) completed a Class Environmental Assessment for Minor Transmission Facilities (Class EA) to support the construction of the Clarington Transformer Station (TS). The Clarington TS is required to facilitate the delivery of power to the eastern portion of the Greater Toronto Area (GTA) as a result of the shutdown of the Pickering Nuclear Generating Station and to reinforce the regional reliability of power supply. The Clarington TS will be constructed on Hydro One owned property located in the Regional Municipality of Durham, in the Municipality of Clarington, bordering the east side of the City of Oshawa, northeast of Concession Road 7 and Townline Road North (Figure 1; Appendix A). The final Environmental Study Report (ESR) was submitted to the Ministry of the Environment and Climate Change (MOECC) on January 16, 2014 (Hydro One, 2014).

Stantec Consulting Ltd. (Stantec) was retained by Hydro One to prepare a groundwater monitoring plan in accordance with MOECC requirements. Following a comprehensive review and consultation period, the final monitoring program was submitted to the MOECC on June 13, 2014. Approval of the Groundwater and Surface Water Monitoring Program (Monitoring Program) was received from the MOECC on June 24, 2014. In November 2014, Stantec prepared the Pre-Station Construction Groundwater and Surface Water Baseline Conditions Report, which documented the results of the Monitoring Program for the Clarington TS (Stantec, 2014).

The Baseline Conditions report indicated that additional investigations were planned by Hydro One in support of the Clarington TS. In November / December 2014, additional water quality sampling and analysis was completed with the results presented in an addendum entitled *Pre-Station Construction Groundwater and Surface Water Baseline Conditions Report Addendum* (Stantec, 2015).

In December 2014 through April 2015, additional drilling was completed with subsequent revisions to the water balance model and groundwater seepage estimates. Groundwater quality sampling was completed at the recently installed monitoring wells in February 2015, as well as a complete round of sampling as part of the Spring 2015 semi-annual water quality monitoring program in April and May 2015. A summary of the additional on-site drilling and monitoring completed since November 2014 includes:

- Continuous core drilling and installation of three (3) additional groundwater monitoring wells at MW5;
- Continuous core drilling and installation of one (1) additional groundwater monitoring well at MW4;
- Continuous core drilling and installation of one (1) temporary groundwater monitoring well at MW8 location;

- Well development and groundwater quality sampling at MW5-14-S(2), MW5-14-D, MW5-14-I, and MW8-15 following installation;
- Continuous core drilling of one borehole at BH9 location;
- Revision of site hydrogeologic conceptual model;
- Revision of station area water balance model;
- Update of groundwater seepage estimates; and
- Completion of Spring 2015 groundwater monitoring within all Project Area monitoring wells.

1.1 REPORT OUTLINE

The following Addendum 2 Report to the Pre-Station Construction Groundwater and Surface Water Baseline Conditions Report presents the data, analyses, and results of the additional investigations completed between December 2014 and April 2015 for the Clarington TS. This report is arranged into eight (8) sections, including this introduction. Section 2 presents a summary of the continuous core drilling and monitoring well installations. Section 3 presents a summary of hydraulic response testing of the newly installed wells. A revised Site Conceptual Hydrogeologic Model is presented in Section 4, with Section 5 presenting the revised Station Area Water Balance. Section 6 presents a summary of the Permit to Take Water (PTTW) Application submitted to the MOECC in November 2014. Groundwater quality sampling results are presented in Section 7. Section 8 presents Conclusions and Recommendations, and Section 9 presents report References.

All Figures referenced throughout the report are presented in Appendix A. Appendix B includes Well Construction Details, Borehole and Monitoring Well Logs, along with borehole geophysical logging results. Grain Size Analyses Results are included in Appendix C; with Hydraulic Testing Results in Appendix D, Groundwater Quality Results in Appendix E, and Laboratory Certificates of Analyses are included in Appendix F.

2.0 CONTINUOUS CORE DRILLING & MONITORING WELL INSTALLATIONS

Throughout the Environmental Assessment (EA) process and preparations for Station construction, Hydro One has engaged and received comments from various stakeholders including the MOECC, the Municipality of Clarington (Clarington), the Central Lake Ontario Conservation Authority (CLOCA), third party reviewer SLR Consulting Ltd (SLR), and the University of Guelph G360 Applied Groundwater Research Group (G360). A result of these discussions, a resolution was made to complete additional continuous core drilling and monitoring well installations at four locations, MW5, MW4, MW8, and BH9, as shown on Figure 2. The following sub-sections present a summary of these drilling investigations.

2.1 SOUTHWEST OF STATION SITE – MW5

As a condition of the access road easement agreement between Hydro One and the Municipality of Clarington, Hydro One agreed to install a monitoring well to the depth of the Thorncliffe Aquifer, a depth of approximately 55 to 65 m below ground surface (BGS). During discussions between Hydro One, Clarington, Stantec, CLOCA, SLR, and G360 to facilitate this well installation, Hydro One agreed to advance the well to bedrock, a depth of approximately 130 m BGS. However, during drilling, it was decided to advance one shallow overburden well, MW5-14S (2); one well to the depth of the Thorncliffe Aquifer, MW5-14D; and one well to bedrock MW5-14D (2).

2.1.1 Methodology

A total of three (3) additional monitoring wells, MW5-14S(2), MW5-14D, and MW5-14D(2), were installed southwest of the Station Site at the MW5 location, within the Project Area. The monitoring well locations are presented on Figure 2.

The boreholes were advanced and monitoring wells installed by Aardvark Drilling Inc. (Aardvark) between November 24 and December 23, 2014, under the observation of Stantec personnel. In addition, G360 were present throughout during drilling activities, to log core, and collect various soil and water quality samples for subsequent research. Representatives of the MOECC, CLOCA, and SLR were also present for observations during various stages of advancing these boreholes and well installations at the MW5 and BH9 locations.

Boreholes were completed using a CME 75 track-mounted drill rig. Aardvark used 210 mm outside diameter (OD) / 108 mm inside diameter (ID) hollow stem augers with continuous coring samplers for drilling the upper overburden at all new MW5 location boreholes. Respectively, the boreholes for MW5-14-S(2), MW5-14-D, and MW5-14-D(2) were advanced to depths of 4.1 m BGS, 55.0 m BGS, and 129.5 m BGS. No water or drilling mud was used during advancement of the boreholes using auger drilling methodology. Below the depth advanced using auguring methods, a 127 mm OD / 103 mm ID Christianson wireline PQ continuous coring system was used to complete cored boreholes MW5-14D and MW5-14D(2). Drilling mud used to stabilize the borehole during PQ coring at MW5-14D and MW5-14D(2) was traced with a sodium bromide solution prepared by G360 for groundwater quality monitoring during well development. The drilling mud was mixed using water supplied by Aardvark. A nominal 168 mm (OD) black steel casing was installed to 8.7 m BGS and sealed with Portland Cement at MW5-14D(2) to support the borehole during drilling to bedrock. A 152 mm diameter tricone was used to straight drill to 50 m BGS at MW5-14D(2).

Soil core samples were classified by Stantec personnel using the ASTM guideline for visual-manual description and identification of soils (ASTM D422) along with the Canadian Foundation Engineering Manual (1992). Borehole logs were prepared for each borehole and contain descriptions of soil type, texture, colour, structure, moisture content, and other observations. A total of eight (8) soil samples were collected from MW5-14D (3.8 m BGS, 4.6 m BGS, 8.4 m BGS, 13.4 m BGS, 25.0 m BGS, 38.9 m BGS, 49.6 m BGS, and 52.6 m BGS), and thirteen (13) soil samples from MW5-14D(2) (52.6 m BGS, 62.0 m BGS, 71.1 m BGS, 78.0 m BGS, 81.3 m BGS, 86.4 m BGS, 90.7 m BGS, 96.8 m BGS, 100.3 m BGS, 105.8 m BGS, 112.0 m BGS, 113.2 m BGS, and 113.7 m BGS) and were submitted for grain size analyses. At the time of producing this Addendum 2 report, additional soil grain size analyses results have not been provided by G360. Soil sampling was not completed during the first 50 m of advancement of MW5-14D(2), as this borehole/well was installed immediately adjacent to that previously logged MW5-14D.

All monitoring wells were constructed using 51 mm ID Schedule 80 polyvinyl chloride (PVC) well casing, with the exception of MW5-14S(2) which was constructed using a Schedule 40 PVC well casing. The wells were constructed with No. 10 slot (0.01 inch slot) PVC well screens 1.52 m in length. The annular space between the well and the formation was backfilled with No.1 grade silica sand surrounding the screen and extending 0.3 m to 0.7 m above the screen, with the exception of MW5-14S(2) which was backfilled with No. 2 grade silica sand. The remainder of the annular space was filled with bentonite pellets (peltonite), bentonite holeplug (chips), and/or bentonite grout to ground surface. The bentonite grout was installed using positive displacement methods. The surface seal consisted of bentonite holeplug to 0.3 m BGS to ground surface. All wells constructed as part of this investigation were completed in accordance with Ontario Regulation 903 (O. Reg. 903) with individual lockable steel protective casings.

The monitoring wells were developed by Aardvark using air-lifting techniques. Field parameters (pH, Temperature, and Specific Conductance) were measured by Stantec field personnel and water quality samples were collected by G360 (at the time of producing this Addendum 2 report, water quality samples results have not been provided by G360). All wells were developed until stability of field parameters was reached. All water and soil cuttings generated during drilling and development were discharged into settling tanks and removed off-Site.

Borehole geophysical logging of natural gamma response within monitoring well MW5-14D (steel casing installed) and natural gamma and resistivity responses in borehole MW5-14D(2) was completed by Lotowater Technical Services Inc. (Lotowater) on December 8, 2014. Borehole geophysical logging results are presented on the respective borehole logs in Appendix B.

2.1.2 Results

Boreholes for MW5-14D(2), MW5-14D, and MW5-14S(2) were advanced to total depths of 4.1 m BGS (248.5 m AMSL), 55.0 m BGS (197.5 m AMSL), and 129.5 m BGS (122.9 m AMSL), respectively. Monitoring well construction details are summarized in a table at the start of Appendix B and are also shown in the borehole logs included in Appendix B.

The boreholes at MW5 encountered a thin (0.2 m to 0.3 m) layer of topsoil, underlain by a thin layer of silty sand to sandy clayey silt to a depth of 0.8 m BGS (251.7 m AMSL). A deposit of loose, fine to medium grained sand extended as deep as 3.5 m BGS (248.9 m AMSL), where it transitioned to a dense silty sand till with some silt. This till unit extended to a depth of 5.8 m BGS (246.6 m AMSL).

Below 5.8 m BGS, a very dense silty sand till with trace to some clay, gravel, and trace cobbles was encountered. This till unit is interpreted to be Newmarket Till, and extended to a depth of 76.7 m (175.8 m AMSL). This till transitioned to interbeds of dense sand till and silty sand till between 52.3 m BGS (200.1 m AMSL) and 76.7 m BGS (175.8 m AMSL). Isolated deposits of sand and silt up to 1.7 m thick were found within this transition zone, along with laminations of sandy silt, slit, and clay.

Deposits of compact to dense, laminated sand were encountered between 76.7 m BGS (175.8 m AMSL) and 86.1 m BGS (166.3 m AMSL), transitioning to interbedded deposits of very dense, laminated silty sand and sand to a depth of 100.6 m BGS (151.9 m AMSL), and stiff to very hard clay and silt up to 107.1 m BGS (145.4 m AMSL). These deposits ranged from moist to wet and are interpreted to correspond with the Thorncliffe Aquifer. A strong sulphurous odour was noted in the soil samples from 62.0 m BGS (190.4 m AMSL) to the end of the borehole.

A very hard silty clay till unit, with trace gravel and sand was encountered below 107.1 m BGS (145.4 m AMSL), underlain by interbedded deposits of very hard clayey silt and sandy silt till with trace gravel between 109.7 m BGS (142.7 m AMSL) and 112.1 m BGS (140.4 m AMSL). These deposits are interpreted to correspond with the Sunnybrook Drift.

Interbedded deposits of wet, loose to compact sand, silty sand, and sandy silt were encountered between 112.1 m BGS (140.4 m AMSL) and 126.7 m BGS (125.8 m AMSL), underlain by interbedded sequences of silt, sand, and gravel. These deposits are interpreted to correspond with the Scarborough Aquifer and extend to 127.8 m BGS (124.7 m AMSL), where shale bedrock of the Blue Mountain Formation is encountered.

The boreholes did not intersect Oak Ridges Moraine (ORM) Sediments at the elevations interpreted by the YPDT-CAMC groundwater model (YPDT_CAMC, 2006); indicating a refinement of the core model layers may be required. Results of the upper overburden are consistent with continuous core results from MW5-14I, completed immediately adjacent to the new boreholes at MW5 (Stantec, 2014).

Soil samples were selected from intervals of interest for grain size analysis and are summarized below with grain size distribution curve results presented in Appendix C.

MW5-14D - Grain Size Distribution Analyses

Borehole	Sample	Median Depth (m)	Description*	Gravel %	Sand %	Silt %	Clay %
MW5-14D	CC4	3.8	gravelly silty SAND, little clay (Silty Sand Till)	21	46	24	9
MW5-14D	CC5	4.6	silty SAND, little gravel, some clay (Silty Sand Till)	11	52	24	13
MW5-14D	CC7	8.4	silty SAND, little gravel, some clay (Silty Sand Till)	16	38	29	17
MW5-14D	CC10	13.4	clayey silty SAND, little gravel (Silty Sand Till)	12	39	28	21
MW5-14D	CC18	25.0	silty SAND, some gravel, some clay (Silty Sand Till)	18	37	28	17
MW5-14D	CC27	38.9	SILT and SAND, some clay, little gravel (Silty Sand Till)	9	38	34	19
MW5-14D	CC34	49.6	silty SAND, some clay, trace gravel (Silty Sand Till)	1	60	23	16
MW5-14D	CC36	52.6	silty SAND, some clay (Silty Sand Till)	0	63	22	15

*Grain size distribution results based on Unified Classification System (ASTM D422) and CFEM (1992).

Soil samples from MW5-14D contain predominantly dense to very dense fine sand and silt with matrix supported coarse sand and fine to coarse gravel, consistent with that of the silty sand Newmarket Till. The grain size distribution analyses were consistent with the field descriptions noted at the time of drilling. The results of the grain size distribution analyses are included in Appendix C.

MW5-14D(2) - Grain Size Distribution Analyses

Borehole	Sample	Median Depth (m)	Description*	Gravel %	Sand %	Silt %	Clay %
MW5-14D(2)	CC3	52.6	silty SAND, some clay (Silty Sand Till)	0	63	22	15
MW5-14D(2)	CC10	62.0	silty SAND, little clay, trace gravel (Silty Sand Till)	1	60	30	9
MW5-14D(2)	CC16	71.1	silty SAND, some clay, trace gravel (Silty Sand Till)	5	50	30	15
MW5-14D(2)	CC21	78.0	SILT, some clay, little sand	0	6	81	13
MW5-14D(2)	CC24	83.1	SAND, some silt, trace clay	0	83	14	3
MW5-14D(2)	CC26	86.4	SILT, some sand, little clay	0	13	80	7
MW5-14D(2)	CC29	90.7	silty SAND, trace clay	0	72	26	2
MW5-14D(2)	CC33	96.8	SAND, some silt, trace clay	0	82	16	2
MW5-14D(2)	CC35	100.3	SILT, little clay, trace sand	0	1	93	6
MW5-14D(2)	CC39	105.8	CLAY and SILT	0	0	48	52
MW5-14D(2)	CC43	112.0	clayey SILT, some sand, trace gravel (Clayey Silt Till)	3	17	52	28
MW5-14D(2)	CC44	113.2	SAND, trace silt, trace clay	0	93	5	2
MW5-14D(2)	CC44	113.7	sandy SILT, trace clay	0	23	75	2

*Grain size distribution results based on Unified Classification System (ASTM D422) and CFEM (1992).

Soil samples from MW5-14D(2) confirm drilling encountered predominantly fine sand and silt with matrix supported coarse sand and fine to coarse gravel, with occasional thin lenses of sand, consistent with the stratigraphic sequence of till deposits of the Oak Ridges Moraine in this area. The grain size distribution analyses were consistent with the field descriptions noted at the time of drilling. The results of the grain size distribution analyses are included in Appendix C.

2.2 SOUTH SIDE OF PROJECT AREA – MW4

Located south of the Station Site and near the southern Project Area boundary at an elevation of 238.7 m AMSL, the intermediate depth borehole at MW4-13 was advanced to a depth of 15.2 m BGS (MW4-13I), with a shallow borehole advanced beside it to a depth of 4.6 m BGS (MW4-

13S). Throughout baseline water level monitoring in 2014, hydraulic testing was not able to be completed MW4-13I due to the limited water available within the well. For this reason, a deeper well was installed at MW4 (MW4-15D) in order to confirm the deep water level and downward vertical groundwater gradient observed at the MW4 location, and to attempt hydraulic testing of the new well.

2.2.1 Methodology

Monitoring Well MW4-15D was installed near the southern boundary of the Project Area, as shown on Figure 2. The monitoring well was installed by Aardvark between January 9 and January 14 2015, under the observation of Stantec personnel. The borehole was completed using a CME 75 track-mounted drill rig. Aardvark used 210 mm OD / 108 mm ID hollow stem augers with continuous soring samplers for drilling the upper overburden. A 127 mm OD / 103 mm ID Christianson wireline PQ continuous coring system was used to complete the lower overburden, below 2.6 m BGS. Drilling mud was used during PQ coring to stabilize the borehole. The drilling mud was mixed using water supplied by Aardvark. No water or drilling mud was used during completion of the auger drilling. All water and soil cuttings generated during drilling were discharged into settling tanks and removed off-site.

Soil core samples were classified by Stantec personnel using the ASTM guideline for visual-manual description and identification of soils, along with the Canadian Foundation Engineering Manual (1992). Borehole logs were prepared for each borehole and contain descriptions of soil type, texture, colour, structure, moisture content, and other observations.

The monitoring well was constructed using 51 mm ID Schedule 40 PVC well casing, constructed with a No. 10 slot (0.01 inch slot) PVC well screen 3.05 m in length. The annular space between the well and the formation was backfilled with No.1 grade silica sand surrounding the screen and extending 0.6 m above the screen. The remainder of the annular space was filled with bentonite holeplug (chips) to ground surface. The monitoring well was constructed with an individual lockable steel protective casing, in accordance with O. Reg. 903.

The monitoring well was developed using 16 mm diameter HDPE tubing connected to a Waterra® foot valve. Well development was completed by Stantec and Hydro One environmental technicians. The well was purged dry and due to the slow recovery no additional development was completed.

2.2.2 Results

The borehole at MW4-15D was advanced to a total depth of 25.2 m BGS (213.6 m AMSL). Monitoring well construction details are summarized in a table at the start of Appendix B and are also shown in the borehole log included in Appendix B.

Borehole drilling encountered a thin (0.3 m) layer of silty sand topsoil with organics, underlain by deposits of loose sand with some silt and sandy silt with trace clay to a depth of 2.6 m BGS (236.1 m AMSL). Below these deposits, a thin deposit (0.5 m) of very dense sandy silt to silty sand till with trace gravel was found, underlain by a very dense silty sand till, interpreted to be Newmarket Till, to the bottom of the borehole at 25.2 m BGS.

2.3 SOUTHEAST SIDE OF STATION SITE – MW8

Stantec discussions with SLR led to recommendations to advance a continuous cored borehole and install a temporary monitoring well at the planned location for the eastern transformer. A previous geotechnical report by exp Global Inc. (exp) had advanced a borehole (BH7D) at this location, and had reported encountering a 1.5 m thick layer of sand and gravel at a depth of 5.6 m BGS. It was noted by both Stantec and SLR that this geotechnical borehole soil interval description was based on a split spoon recovery of 127mm (approximately only 20% recovery), and may not be representative of the geologic formation as a whole. In order to confirm the shallow stratigraphy at this location, in January 2015, a continuously cored borehole was advanced at the location of the eastern transformer, with a temporary monitoring well installed (MW8-15) which would be decommissioned prior to Station grading.

2.3.1 Methodology

Monitoring well MW8-15 was installed by Aardvark between January 14 and January 16 2015, under the observation of Stantec personnel. The borehole was completed using a CME 75 track-mounted drill rig. Aardvark used 210 mm OD / 108 mm ID hollow stem augers with continuous soring samplers for drilling the upper overburden. A 127 mm OD / 103 mm ID Christianson wireline PQ continuous coring system was used to complete the lower overburden, below 2.8 m BGS. Drilling mud was used during PQ coring to stabilize the borehole. The drilling mud was mixed using water supplied by Aardvark. No water or drilling mud was used during completion of the auger drilling. All water and soil cuttings generated during drilling were discharged into settling tanks and removed off-site.

Soil core samples were classified by Stantec personnel using the ASTM guideline for visual-manual description and identification of soils, along with the Canadian Foundation Engineering Manual (1992). Borehole logs were prepared for each borehole and contain descriptions of soil type, texture, colour, structure, moisture content, and other observations.

A total of three (3) soil samples from MW8-15 (4.0 m BGS, 8.6 m BGS, and 16.4 m BGS), were submitted for grain size analysis. Grain size distribution results are included in Appendix C.

The temporary monitoring well was constructed using 51 mm ID Schedule 40 PVC well casing, constructed with a No. 10 slot (0.01 inch slot) PVC well screen 1.52 m in length. The annular space between the well and the formation was backfilled with No.1 grade silica sand surrounding the screen and extending 0.6 m above the screen. The remainder of the annular space was filled with bentonite holeplug (chips) to ground surface. MW8-15 was constructed with an individual lockable steel protective casing, in accordance with O. Reg. 903.

The monitoring well was developed using 16 mm diameter HDPE tubing connected to a Waterra® foot valve. Well development was completed by Stantec and Hydro One environmental technicians. A total of ten (10) well volumes were purged from the monitoring well, where stability of field parameters was reached.

Due to the location of this monitoring well within the footprint of the Station Site, the temporary monitoring well was decommissioned as planned to allow for future Station construction. MW8-15 was decommissioned on April 30, 2015 by Aardvark in accordance with the requirements under O. Reg. 903.

2.3.2 Results

The borehole at MW8-15 was advanced to a total depth of 16.7 m BGS (237.5 m AMSL). Monitoring well construction details are summarized in a table at the start of Appendix B and are also shown in the borehole log included in Appendix B.

Borehole drilling encountered a thin (0.36 m) deposit of sandy silt topsoil, underlain by a thin (0.15 m) deposit of loose fine grained sand with little fine grained gravel. Alternating deposits of silty sand till to sandy silt till, interpreted to be Newmarket Till, was encountered below 0.51 m BGS (253.92 m AMSL) to the end of the borehole. Between 13.1 m BGS and 14.5 m BGS, the driller lost drilling fluid, resulting in only the coarser grained gravel being recovered. Based on the volume of gravel within the core recovered over this interval, it is assumed the material may have been a fine to medium silty sand with approximately 20% gravel.

Soil samples were selected from intervals of interest for grain size analysis and are summarized below.

MW8-15 - Grain Size Distribution Analyses

Borehole	Sample	Median Depth (m)	Description*	Gravel %	Sand %	Silt and Clay** %
MW8-15	CC4	4.02	silty SAND, little clay, little gravel (Silty Sand Till)	6	52	44
MW8-15	CC7	8.64	silty SAND, some gravel, little clay, (Silty Sand Till)	15	47	38
MW8-15	CC12	16.39	SILT and SAND, little gravel, little clay (Silty and Sand Till)	12	45	43

*Grain size distribution results based on Unified Classification System (ASTM D422) and CFEM (1992).
** Hydrometer testing not completed on samples submitted to Golder Laboratory. Silt and Clay fractions are combined.

All soil samples from MW8-15 contain predominantly fine sand and silt with matrix supported coarse sand and fine to coarse gravel, consistent with soil descriptions of the Newmarket Till. The grain size distribution analyses were consistent with the field descriptions noted at the time of drilling. The results of the grain size distribution analyses are included in Appendix C.

As discussed above, the exp well log for BH7D indicated potential coarser material (logged as silty sand and gravel) at 5.6 m BGS (248.8 m AMSL) to 7.1 m BGS (247.3 m AMSL). Based on continuous core results at MW8-15, the above-noted interval in the exp borehole log was confirmed to contain deposits of silty sand till, with no sand and gravel encountered.

As noted above, the soil description for the interval between 13.3 m and 14.2 m BGS was not able to be confirmed, as a result of a wash out fine grained sediments by drilling fluids.

2.4 CENTRE OF STATION SITE – BH9

On March 6, 2015, the MOECC issued a request to Hydro One to advance a borehole at the location of the oil/water separators (OWS) to a depth of 10 m BGS in order to conclude whether a sand and gravel layer was present beneath the Station Area that may have an impact on station construction, groundwater seepage estimates, and the technical review of the PTTW application submitted to allow dewatering during construction. In March 2015, BH9-15 was advanced to a depth of 10.1 m BGS.

2.4.1 Methodology

Borehole BH9-15 was completed within the centre of the Station Site, as shown on Figure 2. The borehole was advanced by Aardvark on March 25, 2015 and March 26, 2015, under the observation of Stantec personnel. Members of the MOECC, CLOCA, and SLR were present during drilling activities.

The borehole was completed using a CME 75 track-mounted drill rig. Aardvark used 279 mm OD / 159 mm ID hollow stem augers with continuous soring samplers for drilling through the overburden. No drilling water or drilling mud was used during completion of the borehole. All water and soil cuttings generated during drilling were discharged into settling tanks and removed off-site.

Soil core samples were classified by Stantec personnel using the ASTM guideline for visual-manual description and identification of soils along with the Canadian Foundation Engineering Manual (1992). Borehole logs were prepared for each borehole and contain descriptions of soil type, texture, colour, structure, moisture content, and other observations.

A total of three (3) soil samples from BH9-15 (3.3 m BGS, 6.6 m BGS, and 9.9 m BGS), were submitted for grain size analysis. The grain size results are included in Appendix C.

Due to the location of this borehole within the footprint of the Station Site, a monitoring well was not installed. The borehole was abandoned by Aardvark immediately following drilling activities. The annular space filled with bentonite holeplug (chips) to ground surface, in accordance with O. Reg. 903.

2.4.2 Results

The borehole at BH9-15 was advanced to a total depth of 10.1 m BGS (243.5 m AMSL). Stratigraphy details of this location are presented in a borehole log in Appendix B.

Borehole drilling encountered a unit of topsoil and sandy clayey silt to a depth of 0.5 m BGS (253.1 m AMSL). These deposits were underlain by a compact sand till with some silt, gravel, and cobbles. The till transitioned to a dense sand to silty sand till at 2.5 m BGS (251.1 m AMSL), interpreted to be the Newmarket Till. During drilling, a large cobble became blocked at the tip of the continuous core sampler, resulting in no soil recovery from 2.0 to 2.5 m BGS (251.6 to 251.1 m AMSL). Very dense, silty sand with some clay and trace gravel and cobbles, was encountered at 4.0 m BGS (249.69 m AMSL) to the end of the borehole.

Soil samples were selected from intervals of interest for grain size analysis and are summarized below.

BH9-15 - Grain Size Distribution Analyses

Borehole	Sample	Median Depth (m)	Description*	Gravel %	Sand %	Silt %	Clay %
BH9-15	CC4	3.34	silty SAND, some gravel, some clay (Silty Sand Till)	15	34	33	18
BH9-15	CC8	6.64	gravelly silty SAND, little clay (Silty Sand Till)	24	35	26	15
BH9-15	CC11	9.94	silty SAND, some clay, little gravel (Silty Sand Till)	9	35	33	20

*Grain size distribution results based on Unified Classification System (ASTM D422) and CFEM (1992)

All soil samples from BH9-15 contain predominantly fine sand and silt with matrix supported minor constituents of coarse sand and fine to coarse gravel, consistent with soil descriptions of the Newmarket Till. The grain size distribution analyses were consistent with the field descriptions noted at the time of drilling. The results of the grain size distribution analyses are included in Appendix C.

The observations at BH9-15 from continuous coring drilling indicated a predominantly very dense silty sand till, and did not encounter coarser deposits of sand and gravel through to its termination depth of 10.1 m BGS. Following completion of drilling BH9-15, representatives from the MOECC and CLOCA agreed that no sand and gravel deposits were encountered and concluded that no further drilling or hydraulic testing were needed at this location for them to complete their technical assessments and review of the PTTW application.

3.0 HYDRAULIC RESPONSE TESTING

In order to estimate the horizontal hydraulic conductivity of the soil in the vicinity of the monitoring wells, Stantec performed hydraulic response testing within the new shallow and deep monitoring wells installed on Site including MW5-14S(2), MW5-14D, MW4-15D, and MW8-15. Laboratory vertical permeability testing was completed by Golder Associates Ltd. (Golder) geotechnical laboratory.

3.1.1 Methodology

The hydraulic response testing consisted of a rising head slug test completed by rapidly removing a known volume of water from the well using a bailer, followed by recording the time taken for the water level to return to static conditions. Hydraulic conductivity testing was not completed at MW5-14D(2) as this well is to be tested and monitored by the G360 group, with hydraulic response testing of this well outside the scope of this project. Due to the slow recovery at MW4-15D only one (1) test was completed at these locations.

The results were analyzed using the Bouwer and Rice (1976) solution provided in the software package AQTESOLV™ to determine the hydraulic conductivity of the overburden material within the immediate vicinity of the well screen. Results of hydraulic response testing are summarized in a table at the start of Appendix B, with the AQTESOLV solutions presented in Appendix D.

Two (2) continuous core soil samples from drilling MW8-15 we also submitted to Golder's geotechnical soils laboratory for vertical permeability (hydraulic conductivity) testing. The tested sections of soil core were intervals 4.0 to 4.3 m BGS and 8.3 to 8.9 m BGS.

3.1.2 Results

Results of the hydraulic conductivity analyses discussed below are summarized in a table at the start of Appendix B, and presented in Appendix D. The water level within MW4-15 recovered very slowly, similar to that in the adjacent monitoring well MW4-13I. In order to estimate hydraulic conductivity, the water level in the well was recorded during recovery. The static water level was estimated to be 18.5 m BGS. Based on the available data, a hydraulic conductivity of 2.8×10^{-10} m/s was estimated.

At the shallow monitoring well MW5-14S(2), the monitoring well screen and sand pack is partially installed or connected to the shallow sand and the underlying sand to silty sand till unit. As a result, testing indicated a hydraulic conductivity of 3×10^{-7} m/s, slightly higher than that observed elsewhere within the Project Area for the silty sand till (Newmarket Till).

Horizontal hydraulic testing at the deeper monitoring well MW5-14D resulted in a hydraulic conductivity of 3.3 x 10-7 m/s for the interval of 52.4 to 54.0 m BGS interpreted to be screened within the Thorncliffe Aquifer Formation.

At MW8-15, horizontal hydraulic testing resulted in a hydraulic conductivity of 7.4 x 10-6 m/s for the screened interval installed within silty sand to sandy silt (13.7 to 15.2 m BGS). Vertical permeability testing by Golder of the shallow cored soil sample from 4.0 to 4.3 m BGS (sandy silt to silty sand) indicated a vertical hydraulic conductivity of 3.6 x 10^{-9} m/s. Testing of the cored sample from 8.3 to 8.9 m BGS (silty sand) indicated vertical hydraulic conductivity of 1.8 x 10^{-8} m/s. Both of these results are consistent with a dense silty sand till, and representative of the Newmarket Till. Notably, the vertical hydraulic conductivity results are from sample intervals above the screened interval, indicating the dense sandy silt till soil will limit downward groundwater movement.

4.0 REFINED SITE CONCEPTUAL HYDROGEOLOGIC MODEL

The Site Conceptual Hydrogeologic Model presented in the Clarington TS Baseline Conditions Report was confirmed by recent drilling investigations at MW5-14D(2), MW5-14D, MW5-14S(2), MW4-15D, MW8-15 and BH9-15. In December 2014, drilling and monitoring investigations included advancing continuous cored boreholes to depths of 55.0 m (MW5-14D) and 121.9 m (bedrock well MW5-14D(2)) with monitoring wells installed in each. In January 2015, a continuously cored borehole was advanced at the location of the eastern transformer, with a temporary monitoring well installed (MW8-15). In March 2015, BH9-15 was advanced at the location of the planned OWS to a depth of 10.1 m BGS. The completion of these borehole and groundwater monitoring investigations allowed for a refinement of the Site Conceptual Hydrogeologic Model presented in the Baseline Conditions Report.

Based on the results of the recent drilling investigations at BH9-15, it is interpreted that dense silty sand Newmarket Till is present at this location from immediately below the farmed upper 0.5 m below ground surface to the termination depth of the boreholes, and is consistent with other recent continuously cored holes within the Project Area.

Notably, in areas where the Newmarket Till is found at surface, younger hydrostratigraphic units such as the Mackinaw and Halton Till deposited on top of the Newmarket Till cannot be present, as these deposits are only found deposited on top of the Newmarket Till. These recent drilling results, in combination with Ontario Geological Survey surficial geology mapping (OGS, 2003) for the area indicates that the Newmarket Till is at or very near surface across the Clarington TS Project Area; thereby eliminating the possibility for extensive Halton Till or Mackinaw Interstadial sand and gravel deposits.

The revised Conceptual Hydrogeologic Model has been derived from the findings of the extensive borehole program that has been completed with the Project Area to date. The key hydrogeologic layers overlying the Thorncliffe Aquifer are as follows:

- Surficial Sand – comprised of more permeable surficial deposits, including organics, surficial sand, and highly weathered till. For the purpose of calculations, an average thickness of 0.7 m from borehole data across the eastern side of the Station area is assumed;
- Weathered / Compact Newmarket Till – comprised of till units that have undergone some degree of weathering or depressurization as evidenced by less dense/compact material noted either through geotechnical testing (blow counts) or through soil descriptions in the borehole logs. For calculation purposes, an average thickness of 1.8 m (to a depth of 2.5 m) from borehole data across the eastern side of the Station Area is assumed; and
- Newmarket Till – comprised of dense to very dense silty sand, sandy silt, and sand till. This unit extends to depths of 55 m to 65 m below ground surface and is known to contain

thin isolated lenses with more sand or gravel content that may be present well below the Station Area grading excavation elevation.

Isopach maps of the Surficial Sand thickness and of the combined sand and weathered till thickness are presented on Figures 3 and 4, respectively. A west-east cross-section through the middle of the Station Area is presented on Figure 5.

5.0 STATION AREA WATER BALANCE

Based on 2014-2015 drilling and testing, and discussions with the MOECC, CLOCA, and SLR from October 2014 to April 2015, a further refinement of the Station's water balance is provided below. This water balance was used to evaluate the conceptual model for the Station Area, and supports the overall interpretation of groundwater flow conditions presented in the Baseline Conditions Report.

The water balance presented in the baseline monitoring report was refined to include the following three (3) hydrogeological units within the shallow overburden:

- 0.0 to 0.7 m BGS – Surficial Sand layer;
    - Either found as sand, organics, or highly weathered till near surface within the Project Area;
    - Based on average thickness of surficial sand and/or organic soils and/or highly weathered till from borehole data across the east side of the Station Area;
- 0.7 to 2.5 m BGS – Weathered Newmarket Till
    - Depth determined by borehole log soil description and transition to increased density of till soil samples encountered during drilling;
    - Based on average thickness from borehole data across the east side of Station Area (MW1-13, MW6-14, and MW7-14);
- 2.5 m to 55 to 65 m BGS – Dense to very dense Newmarket Till (as encountered in MW5-14D); and
- 55 to 65 m BGS represents the depth of the upper boundary of the Thorncliffe Aquifer (as encountered in MW5-14D).

The refined Water Balance model data assumptions are provided below for clarity. The data assumptions are consistent with the original baseline conditions report, unless indicated as revised:

- Station Area surficial area: 108,800 m^2;
- Total water available for groundwater recharge (Q_{TAR}) within Station Area: 12,504 m^3/yr;
    - from Water Balance presented in Section 6.2.5 and summarized in Appendix B, Table 6 of the Baseline Conditions Report;
    - Further water balance detailed calculation tables are presented in Appendix H of the Baseline Conditions Report;
- Groundwater infiltration to Thorncliffe Aquifer: 18 mm/yr;
    - Presented in Section 6.2.4 of the Baseline Conditions Report;

  - Based on hydraulic conductivity results from MW5-14I (1.3×10^{-9} m/s) and vertical hydraulic gradient (0.6 m/m) obtained from observed water levels in monitoring wells MW5-14S and MW5-14I;
  - dH/dL = 17.5 m / 31 m = 0.56 m/m;
  - As noted in Section 6.2.4 of the Baseline Conditions Report, this is a conservative estimate, as it is approximately 50% of the estimated Thorncliffe Aquifer Recharge estimated by Gerber and Howard (2002);
- The shallow horizontal gradient has been divided into three (3) shallow zones that flow from the east side of the Station Area toward the northwest (wetland), west, and southwest boundaries of the Station Area, labelled as Discharge Boundaries 1, 2, and 3, respectively on Figure 6.
  - The horizontal gradient for each zone is as follows:
    - Zone 1 (northwest): dH/dL = 10m / 249m = 0.040 m/m;
    - Zone 2 (west): dH/dL = 10m / 408m = 0.025 m/m;
    - Zone 3 (southwest): dH/dL = 10m / 237m = 0.042 m/m;
- Horizontal hydraulic conductivity of surficial sand/organic layer : K = 1.6×10^{-5} m/s;
  - Obtained from K-test of MW5-14S; and
- Horizontal hydraulic conductivity of upper weathered Newmarket Till: K = 1.0×10^{-6} m/s;
  - Estimated based on using a more conductive value (due to weathering) than determined from geometric mean of K-test results from shallow wells MW1-13S, MW6-14, and MW7-14 (3.1×10^{-7} m/s), and a less conductive value than the surficial sand unit (1.6×10^{-5} m/s).

5.1 WATER BALANCE CALCULATIONS

The following section details the horizontal seepage through the Station Area as presented in the baseline conditions report and provides additional details of calculations and assumptions for clarity.

The rate of recharge of the Thorncliffe Aquifer within the area beneath the Project Area was presented in Section 6.2.4 of the Baseline Conditions Report. The vertical hydraulic gradient and hydraulic conductivity was determined based on the water levels recorded within monitoring wells MW5-14S (shallow depth) and MW5-14I (intermediate depth), and hydraulic testing of MW5-14I.

The downward recharge of the Thorncliffe Aquifer using the following equation, where **Q** is the vertical downward groundwater flow rate, **K** is the hydraulic conductivity of the geologic material, and **i** is the groundwater gradient:

$$Q = K \times i$$

$$Q = 1.3 \times 10^{-9} \text{ m/s} \times 0.56 \text{ m/m}$$

$$Q = 7.8 \times 10^{-10} \text{ m/s, or}$$

$$Q = 17.3 \text{ mm/yr}$$

This value was rounded up to 18 mm/yr., and represents approximately 50% of the estimates provided by Gerber and Howard (2002). While actual recharge may vary, using the calculated 18 mm/yr requires more water to be accounted for in the Water Balance within the upper soil units, than may be required to balance the model.

As presented in the Baseline Conditions Report, of the total available recharge (TAR), only 115 mm/yr is available for groundwater recharge:

$$Q_{TAR} = \text{Rate of infiltration / Area, or}$$

$$\text{Rate of GW Infiltration} = Q_{TAR} \text{ / Station Area}$$

$$\text{Rate of GW Infiltration} = 12{,}504 \text{ m}^3\text{/yr / } 108{,}800 \text{ m}^2$$

$$\text{Rate of GW Infiltration} = 115 \text{ mm/yr}$$

Of the 12,504 m^3/yr TAR volume available for annual groundwater recharge, or 115 mm/yr within the Station Area, only 18 mm/yr infiltrates down through the Newmarket Till and ultimately recharges the underlying deep Thorncliffe Aquifer. Based on vertical hydraulic gradients and the hydraulic conductivity of the Newmarket Till, it is estimated that it could take in excess of 700 years for recharge to reach the Thorncliffe Aquifer. Therefore the vertical groundwater flow downward to the Thorncliffe Aquifer (Q_{TA}) would be:

$$Q_{TA} = \text{Rate of infiltration x Area}$$

$$Q_{TA} = 18 \text{ mm/yr} \times 108{,}800 \text{ m}^2$$

$$Q_{TA} = 1{,}958 \text{ m}^3\text{/yr}$$

Subtracting the amount that infiltrates through the Newmarket Till to the Thorncliffe Aquifer from the total available for recharge yields the volume of water that flows horizontally (Q_{HOR}) through the Station Area within the upper surficial sand and weathered till units (upper 2.5 m) toward the Harmony Creek tributaries on the north, west, and south sides of the Station Area:

$$Q_{HOR} = Q_{TAR} - Q_{TA}$$

$$Q_{HOR} = 12{,}504 \text{ m}^3\text{/yr} - 1{,}958 \text{ m}^3\text{/yr}$$

$$Q_{HOR} = 10{,}546 \text{ m}^3\text{/yr, or}$$

$$Q_{HOR} = 0.33 \text{ L/s}$$

Therefore, for the amount of recharge and discharge to balance, a total horizontal seepage through the Station Area of at least 0.33 L/s is required, which is consistent with seasonal observations of intermittent streamflow within the adjacent Harmony Creek tributary.

For verification, the calculation of horizontal seepage detailed above is applied to the revised Site Conceptual Hydrogeologic Model in the following discussion.

The shallow groundwater flow direction through the upper few meters of the Station area is expected to follow the same general flow direction as observed in the shallow monitoring wells installed within the Project Area (Figure 2); that is, following surficial topography. The shallow groundwater flow is predominantly from east to west, with some flow to the south west, and a minimal amount to the northwest toward the northern wetland and the headwaters of Harmony Creek tributary.

We have assumed that the amount of flow to the northwest from the Station Area is minimal. Therefore, the majority of the horizontal shallow groundwater flow through the upper 2.5 m of ground surface is assumed to migrate to the west and southwest of the Station Area. The length of the area through which water leaves the Station Area is shown on Figure 6 as a segmented line generally perpendicular to the shallow groundwater flow direction. The cross-section flow path is approximately 220 m long on the west side of the Station Area (1), and 375 m on the south side (2), for a total discharge length of 595 m (Figure 6).

The average flow rate through a 0.7m thick surficial sand/organic/highly weathered till unit (Q_{SAND}) can be determined using Darcy's law equation as shown below for Zone 1:

$$Q_{SAND} = K\ i\ A$$

$$Q_{SAND} = 1.6 \times 10^{-5}\ m/s \times 0.040\ m/m \times (156\ m \times 0.7\ m)$$

$$Q_{SAND} = 2{,}205\ m^3/yr,\ or$$

$$Q_{SAND} = 0.07\ L/s$$

The same calculations were completed for each of the shallow zones, with the results presented in Table 1 below:

Table 1 – Horizontal Groundwater Flow through Surficial Sand Layer

Surficial Sand Flow Zone	K	I	A	Q_{SAND}	Q_{SAND}
(Direction)	**(m/s)**	**(m/m)**	**(m^2)**	**(m^3/yr)**	**(L/s)**
Zone 1 (NW)	1.6×10^{-5}	0.040	109.2	2,205	0.07
Zone 2 (W)	1.6×10^{-5}	0.025	280.7	3,543	0.11
Zone 3 (SW)	1.6×10^{-5}	0.042	179.2	3,800	0.12
			Total	**9,548 m^3/yr**	**0.30 L/s**

The same calculation estimate is then completed for the underlying 1.8 m thick layer of Weathered Upper Till using a lower hydraulic conductivity of 1.0 x 10^{-6} m/s, as shown in the calculation for Zone 1, and for each of the three Zones in Table 2 below:

$$Q_{WUT} = K\ i\ A$$

$$Q_{WUT} = 1.0 \times 10^{-6} \text{ m/s} \times 0.040 \text{ m/m} \times (156 \text{ m} \times 1.8 \text{ m})$$

$$Q_{WUT} = 354 \text{ m}^3\text{/yr, or}$$

$$Q_{WUT} = 0.01 \text{ L/s}$$

Table 2 – Horizontal Groundwater Flow through Weathered Upper Till Layer

Weathered Till Flow Zone	K	I	A	Q_{WUT}	Q_{WUT}
	(m/s)	(m/m)	(m^2)	(m^3/yr)	(L/s)
Zone 1 (NW)	1.0 X 10^{-6}	0.040	280.8	354	0.01
Zone 2 (W)	1.0 X 10^{-6}	0.025	721.8	569	0.02
Zone 3 (SW)	1.0 X 10^{-6}	0.042	460.8	611	0.02
			Total	**1,535 m^3/yr**	**0.05 L/S**

Using the results of the above groundwater recharge / flow calculations, the water balance for the Station Area is summarized below:

Total Available Recharge	=	12,504 m^3/yr
Lateral Flow Through Surficial Sand	=	- 9,548 m^3/yr
Lateral Flow Through Weathered Upper Till	=	- 1,535 m^3/yr
Infiltration Through Newmarket Till	=	- 1,958 m^3/yr
Total Flow Discharge Surplus	=	(537) m^3/yr

The Water Balance shown above indicates the shallow groundwater system is capable of discharging all of the Total Available Groundwater Recharge, plus an additional 537 m^3/yr (0.02 L/s), which is negligible relative to the total recharge of 12,504 m^3/yr. Following revising the Station Area Water Balance, it is now known that a shallow tile drainage system has been in place beneath the farmed field on the eastern side of the Station Area. This tile drain system directs shallow groundwater away from the proposed grading area to the east of the Station, and toward the wetland north of the Station Area. This would reduce the amount of shallow groundwater flow following a recharge event, and direct it more quickly to the wetland area north of the Station Area and toward the tributary to Harmony Creek.

This Water Balance calculation should be used as a qualitative tool only; however, it demonstrates that a theoretical significant flow system, such as a deeper sand and gravel layer, is not required in the Site Conceptual Hydrogeologic Model to balance the volume of groundwater recharge / discharge within the Station Area.

Based on the above water balance for the Clarington TS Station Area, all available recharge water can be reasonably accounted for with the above assumptions and the refined Site Conceptual Hydrogeologic Model, which is based on data collected from the Project Area.

6.0 PTTW APPLICATION

The construction of the Clarington TS requires grading of the Station Area. Pre-station construction monitoring confirmed that the grading will extend below the elevation of the shallow groundwater level at the eastern extent of the Station Area, and groundwater seepage is expected during construction activities. Initial conservative estimates indicated that seepage rates may approach 50,000 L/day, and as a result, a Permit to take Water (PTTW) would be required in order to manage groundwater seepage and precipitation/runoff during construction.

Based on the expected groundwater seepage during Station Site construction activities, Stantec on behalf of Hydro One prepared a Category 3 PTTW Application to allow management of water during construction. The PTTW Application, which was submitted to the MOECC on November 17, 2014, presented the following information:

- Description of the geologic and hydrogeologic setting;
- Outlined the proposed Station Site construction activity and water management strategy, as available;
- Estimated average and maximum day pumping rates for groundwater seepage, including impacts from precipitation and runoff; and
- Assessed potential adverse effects on nearby private wells and the natural environment due to the proposed pumping.

While it is proposed that water will be managed within the Station Area on an as-required basis, a MOECC PTTW application requires that a maximum pumping rate per minute, maximum pumping rate per day, and typical (average) pumping rate per day be determined. A summary of the rationale/methodology used to calculate these estimated pumping rates are presented below.

6.1 GROUNDWATER SEEPAGE

The predicted groundwater seepage from the cut slope was estimated based on the modified Darcy equation and solutions from Edelman (1947), as detailed by ILRI (1994). The calculations also assume an instantaneous drop in water level following excavation. It is expected that grading will commence at the eastern extent of the Station Site, slowly decreasing ground surface elevation until the final grade is reached. The assumption of an instantaneous decrease in water will result in higher initial seepage rates that are not expected within the Station Site. The equations and detailed calculations were included with the PTTW Application for technical review.

The following assumptions were made when estimating potential groundwater seepage rates and drawdown extent:

- The cut slope extends a total length of approximately 400 m as shown on Figure 2.

- The final grade of the Station Site will be approximately 253 to 254 m AMSL with the final grade of the perimeter ditch ranging from 252 m AMSL to 253.5 m AMSL. The proposed grading for the Station Site requires a maximum excavation to 252.0 m AMSL for installation of the drainage system (Section 2.2.1). Dewatering calculations were completed assuming the cut slope extends to an elevation of 252 m AMSL. It was further assumed that it would take two (2) weeks to grade the cut slope to this elevation;
- The excavation will primarily extend through the surficial sand and into the silty sand to sandy silt till interpreted as a weathered Newmarket Till. The hydraulic conductivity of this material as measured at MW1-13S, MW6-14 and MW7-14 ranged from $9x10^{-8}$ m/s to $8x10^{-7}$ m/s, with a geometric mean of $3x10^{-7}$ m/s;
- Groundwater levels were assumed to be at ground surface at the eastern extent of the Station Site. Contour mapping indicates that the ground surface elevation at the top of the slope is 261 m AMSL; and,
- Groundwater seepage rates will be primarily controlled by the upper overburden material. For calculation purposes, the silty sand till (geologic material being dewatered) was given an assumed thickness of 18 m, and represents the total thickness of the dewatering plus the estimated thickness of the upper portion of the Upper Aquitard beneath the area of grading.

6.2 PTTW DEWATERING RATES

With the additional drilling and hydraulic testing that was completed within the Project Area since the original submission of Hydro One's PTTW Application, there was an opportunity to update the PTTW calculations presented in the application based on the refined Site Conceptual Hydrogeologic Model and Water Balance presented above.

Stantec recognizes that our approach in estimating groundwater seepage rates presented in the PTTW Application is likely to have conservatively over-estimated the extent of shallow groundwater drawdown. The purpose of the conservative seepage estimate is to allow for an assessment of 'worst-case' scenarios and their potential adverse effects in order to determine whether mitigation is required for construction to be completed, and to provide a pumping rate that is sufficient to address unexpected conditions during the construction period, such as rainfall and surface runoff that may require management.

Despite that over-estimation of groundwater drawdown, we had concluded that no adverse effects to the natural environment or to neighbouring private wells are anticipated from grading the Station Area.

Through the PTTW review process with the MOECC, technical comments were received suggesting that by not including recharge in the predicted groundwater seepage model, that the amount of groundwater seepage from the graded slope would be under-estimated.

In order to demonstrate that the conservative seepage estimates included in the PTTW Application remain valid, the previous groundwater seepage estimates were refined using the same conceptual hydrogeologic model used above for the Station Area Water Balance, and potential groundwater recharge was included in the total estimate seepage rate.

6.2.1 Seepage Estimate Methodology

In order to compare the seepage estimate presented in the PTTW Application with those derived from the above refined conceptual hydrogeologic model, the same seepage estimate calculations to the refined model were employed.

The predicted groundwater seepage from the cut slope was estimated based on the modified Darcy equation and solutions from Edelman (1947), as detailed by ILRI (1994). The equations assume an unconfined aquifer of infinite extent (though not present at the site), horizontal flow, no recharge, and drawdown significantly less than aquifer thickness. In this application, where the vertical hydraulic conductivity is approximately two (2) orders of magnitude (100 times) less than the horizontal hydraulic conductivity, it is reasonable to assume significantly more water will be conveyed horizontally through the shallow groundwater system than vertically downward.

In the groundwater seepage calculations, potential seepage from the upper 9.0 m BGS was considered; recognizing this is a conservative estimate, as the greatest depth of the cut on the eastern slope face will be only 7.7 m BGS. Groundwater levels have been recorded at or very near ground surface within the monitoring wells on the eastern side of the property. As a result, calculations conservatively assume that the upper Surficial Sand Unit is completely saturated. Groundwater seepage contributed from each of the refined hydrogeologic model layers within the upper 9.0 m of ground surface was estimated with the layer results added together, resulting in a combined total groundwater seepage volume presented in Table 3 below, and a combined predicted groundwater drawdown from the edge of the cut slope (Figures 6 and 7).

It should be noted that the groundwater seepage estimates presented in Table 3 assume an instantaneous cut to the total depth of the graded slope with the entire excavation removed at once. It is anticipated that the Station Area will be graded in gradual lifts; thereby reducing the actual initial seepage rates.

Table 3 – Estimated Groundwater Seepage from Graded Slope

Time	Surficial Sand Seepage	Weathered Till Seepage	Newmarket Till Seepage	Total Groundwater Seepage		
(days)	m^3/day	m^3/day	m^3/day	m^3/day	L/day	L/sec
7	25.3	33.2	126.7	185.1	185,120	2.1
14	17.9	23.5	89.6	130.9	130,900	1.5
30	12.2	16.0	61.2	89.4	89,420	1.0
100	6.7	8.8	33.5	49.0	48,980	0.6
200	4.7	6.2	23.7	34.6	34,630	0.4
300	3.9	5.1	19.4	28.3	28,280	0.3
365	3.5	4.6	17.5	25.6	25,630	0.3
10 Years	1.1	1.5	5.6	8.1	8,110	0.1

Groundwater recharge would contribute a nominal amount of shallow groundwater seepage at the cut slope. The amount of seepage associated with annual shallow groundwater recharge (Q_{GWR}) is estimated by multiplying the annual recharge rate of (115 mm/yr. - 18 mm/yr. = 97 mm/yr.) by the area within the sub-watershed that is upgradient of the eastern cut slope, as shown below:

$$Q_{SGW} = \text{Rate of Shallow GW Infiltration x Catchment Area Upgradient}$$

$$Q_{GWR} = 97 \text{ mm/yr x } 73{,}257 \text{ m}^2$$

$$Q_{SGWR} = 7{,}106 \text{ m}^3\text{/yr, or}$$

$$\mathbf{Q_{SGWR} = 19.45 \text{ m}^3\text{/day}}\text{, or}$$

$$Q_{SGWR} = 0.2 \text{ L/s}$$

Adding the contribution of shallow groundwater recharge to the groundwater seepage volume yields the following Total Groundwater Seepage as shown in Table 4, below:

Table 4 – Total Estimated Groundwater Seepage from Graded Slope

Time	Groundwater Seepage	GW Recharge	Total Groundwater Seepage Including Recharge		
(days)	m³/day	m³/day	m³/day	L/day	L/sec
7	185.1	19.5	204.6	204,570	2.4
14	130.9	19.5	150.4	150,350	1.7
30	89.4	19.5	108.9	108,870	1.3
100	49.0	19.5	68.5	68,430	0.8
200	34.6	19.5	54.1	54,080	0.6
300	28.3	19.5	47.8	47,730	0.6
365	25.6	19.5	45.1	45,080	0.5
10 Years	8.1	19.5	27.6	27,550	0.3

The calculated groundwater seepage calculations presented in the PTTW Application found the estimated groundwater seepage after 14 days to be 200,400 L/day, with seepage after 100 days reduced to 77,200 L/day. The calculated seepage rates based on the refined model presented above result in estimated groundwater seepage rates after 14 days to be reduced to 150,350 L/day, with seepage after 100 days reduced to 68,430 L/day. With the refined model, after 300 days, the total seepage is estimated to be below 50,000 L/day. As a result of the above refinements and, no changes to the original PTTW Application were requested.

6.2.2 Vertical Groundwater Seepage

The Cut / Fill Finished Grade for the Station is at an elevation of 253.53 m AMSL with a toe drain to be constructed along the eastern toe of the graded slope excavated to an elevation of 252.45. The elevations of the Cut / Fill Finished Grade and the Toe Drain are above the water level elevation recorded upon completion in MW8-15. Therefore, no long term additional vertical seepage is anticipated to contribute to the total groundwater seepage rates presented above.

The MOECC had requested clarification as to whether groundwater seepage into the 4.0 m deep excavations required to complete installation of the OWS would impact the above seepage calculations. Drilling investigations within the Project Area have confirmed that there is no continuous sand and gravel layer across the site that will be intersected by grading within the Station Area. However, we do recognize that a (0.9 m thick) lens within the silty sand till with approximately 20% gravel was encountered at a depth of 13.1 m BGS at MW8-15. The water level recorded in MW8-15 was found to be 2.0 m BGS, or approximately 4.0 m above the planned excavation for the OWS.

Using the vertical hydraulic conductivity measured in MW8-15of 3.6 x 10^{-9} m/s for the shallow soil from 4.0 m BGS, a vertical seepage estimate using Darcy's law equation yields a negligible additional temporary contribution to groundwater seepage of only 0.02 m^3/day, or 0.0002 L/sec during installation of the OWS. Using a more conservative hydraulic conductivity that is an order of magnitude higher (3.6 x 10^{-8} m/s), calculated seepage into the OWS excavation would remain negligible at 0.17 m^3/day. Installation of the OWS is expected to require less than one week to complete. Following installation of the OWS, backfilling around the OWS will be completed, and no further groundwater seepage is anticipated.

It is noted that Stantec presented the findings of the above revised groundwater seepage estimates, both horizontal and vertical estimates, to the MOECC and peer reviewer SLR in May, 2015 prior to the MOECC completing their technical review and approving Hydro One's PTTW application.

6.3 STORM WATER MANAGEMENT

During Station Site grading and construction of the drainage system, any precipitation or storm water runoff within the cut/grading area must be managed to maintain a safe work area and to prevent erosion and sediment transport within the Station Site and/or surrounding environment. Any precipitation that collects within the drainage ditch / toe drain will be managed along with groundwater seepage as discussed below.

The extent of storm water management will be dependent on construction conditions, precipitation and temperature. As the work may extend over a 6 to 7 month period, it was reasonable to assume that a significant rainfall event may occur during this time period, and the runoff may need to be managed by the Contractor. The ground surface may also freeze during winter months and not allow for infiltration.

To evaluate pumping requirements due to precipitation events, the potential impact due to a significant rainfall event was evaluated. A 25 mm precipitation event was selected for the calculations, as this value is used by the MOECC for erosion and water quality design (MOECC, 2003). The cut slope will extend 22 m in width and approximately 400 m in length as shown on Figure 2. The estimated volume of water generated due to direct precipitation along the cut slope is 220,000 L for a 25 mm rain event.

In order to control runoff from the hill to the east collecting in the construction area, a temporary berm/trench has been constructed on the east side of the grading area to divert runoff during precipitation events around the Station Area.

6.4 POTENTIAL ADVERSE EFFECTS

An important component of Hydro One's PTTW Application was assessing the potential for adverse effects on the natural environment and local water resource users. Given the total estimated groundwater seepage using the refined hydrogeologic model and temporary additional seepage during installation of the OWS, no adverse effects to the natural environment or local water well users are anticipated.

There is no proposed net taking of water during station construction activities, as all water is to be returned to the natural environment within the Harmony Creek tributary sub-watershed, using the water management measures described in Hydro One's PTTW Application.

The closest shallow private well is located 440 m east of the top of the cut slope at the eastern extent of the Station Site. As shown in Figures 7 and 8, the extent of drawdown after 1 year is 110 m from the cut face, and 350 m after 10 years. As a result, no adverse effects are anticipated on local well users. In the unlikely event that well interference is identified, Hydro One is committed to its Well Interference Response Plan, which requires assessment of well interference claims, and allows for determination of appropriate mitigation to ensure local well users can continue to rely on the local groundwater resources.

6.5 MONITORING AND CONTINGENCY PLAN

Hydro One's PTTW Application has been reviewed and approved by the MOECC (Permit No. 3113-9UZL7Y, May 26, 2015). The PTTW is subject to specific Terms and Conditions which include the following monitoring requirements:

- Record the daily volume and rate of water taking;
- Implement Hydro One's monitoring and mitigation program as described in the Category 3 PTTW Hydrogeologic Assessment Report, the Pre-Station Construction Groundwater and Surface Water Baseline Conditions Report, and Stantec's Groundwater and Surface Water Monitoring Program letter to Hydro One (June 13, 2014); and
- Implement the Monitoring and Contingency Plan identified in Hydro One's letter to the MOECC (May 15, 2015).

Transducers are already installed in these monitoring wells, recording water level data hourly. During Station Area grading, the data from these transducers will be downloaded monthly for the first six (6) months, and compared to the predicted groundwater drawdown, as presented above. Hydro One has committed to reviewing the water level monitoring data results with the MOECC, whereupon it will be determined whether any mitigation is required.

Hydro One has submitted a Monitoring and Contingency Plan (Hydro One letter - May, 2015) to the MOECC which includes a commitment to monitor groundwater levels within the monitoring wells located on Hydro One property on the east side of the graded cut slope (Mw1-13, MW6-14, and MW7-14).

7.0 GROUNDWATER QUALITY MONITORING

Stantec was retained by Hydro One to prepare a groundwater monitoring plan in accordance with MOECC requirements. Following a comprehensive review and consultation period, the final monitoring program was submitted to the MOECC on June 13, 2014. Approval of the Groundwater and Surface Water Monitoring Program (Monitoring Program) was received from the MOECC on June 24, 2014. In November 2014, Stantec prepared the Pre-Station Construction Groundwater and Surface Water Baseline Conditions Report (Baseline Conditions Report), which documented the results of the Monitoring Program for the Clarington TS (Stantec, 2014).

The Baseline Conditions Report indicated that additional investigations were planned by Hydro One in support of the Clarington TS. In November / December 2014, additional water quality sampling and analysis was completed, with the results presented in a report entitled Pre-Station Construction Groundwater and Surface Water Baseline Conditions Report Addendum (Addendum).

The Addendum report provided the following recommendations regarding groundwater sampling protocol:

- Future groundwater sampling should be completed using low flow sampling methods to minimize entrained sediment within the samples;
- Benzo(a)pyrene within on-site monitoring wells should continue to be analyzed for both unfiltered and lab filtered water quality samples in accordance with O.Reg.153;
- Water quality sampling of MW5-14S(2), MW5-14I, MW5-14D should be completed once the wells are fully developed to document groundwater quality. Sampling of the bedrock well at MW5-14D(2) may be completed as part of a separate research project, with appropriate agreements with Hydro One; and
- A replacement monitoring well was installed adjacent to MW4-13D in 2015 at a slightly deeper depth. Future monitoring should be completed at this location to facilitate representative groundwater sample collection.

7.1 GROUNDWATER QUALITY SAMPLING

Groundwater quality sampling was completed following installation and development of new monitoring wells MW5-14-S(2), MW5-14-I, MW5-14-D, and MW8-15 on February 3 and 4, 2015. The complete round of Spring 2015 semi-annual groundwater monitoring was completed in April 2015. The Spring 2015 groundwater monitoring event represents the last round of water quality sampling prior to the start of Station grading and construction. The following discusses sampling methodology and presents the water quality data from the Spring 2015 monitoring event. A complete analysis of water quality results and trends will be presented in the 2015 Annual Monitoring Report, to be released following the Fall 2015 monitoring event.

7.1.1 Spring 2015 Water Quality Sampling

Stantec and Hydro One environmental technicians completed groundwater quality sampling within the shallow, intermediate, and deep monitoring wells as part of on-site Spring 2015 semi-annual monitoring on April 7 to 10, 2015, April 13 and 14, 2015, and May 14, 2015. Groundwater quality results are summarized in Appendix E with laboratory certificates for Spring 2015 sampling included in Appendix F.

Groundwater sampling was completed with the use of low flow purging and sampling procedures for all Spring 2015 groundwater sampling; a procedure which minimizes the drawdown of water in a well, and the mixing or disturbance of the standing water within the well, by removing water from a discrete depth within the well screen.

A Geopump™ bladder pump with HDPE tubing was used to pump the water from the middle of the well screen at a constant rate. New tubing was used at each well to eliminate the potential for cross contamination. The low flow procedure was based on the United States Environmental Protection Agency (USEPA) low flow/minimal drawdown well purging protocol (USEPA, 2010). The purging protocol consists of pumping water from the midpoint of the well screen at a steady rate of 100 mL to 500 mL/min. Based on the protocol, water levels were measured frequently to monitor drawdown. Flow rate was decreased as needed for low yielding wells to reduce drawdown. During purging, field parameters were measured at five minute intervals with sampling completed once parameters had stabilized. Sampling was modified at the following locations:

- Due to the minimal well volume and low recovery, sampling at MW3-13S, MW3-13D and MW4-15D was completed with minimal to no purging.
- At Monitoring Well MW5-14I, the purge rate was reduced as low as possible; however, water levels continued to decline prior to sampling.
- At Monitoring Well MW5-14S(2), field parameters were recorded every 5 minutes. Due to declining yield, sampling was completed prior to stabilization of field parameters.

Groundwater samples were collected directly from the HDPE tubing into the appropriate pre-labeled laboratory-supplied sample containers. Where appropriate, the laboratory placed preservative into the sample containers prior to shipping them to the site. Each sample for metals analysis was field filtered and preserved. All groundwater samples collected were packed into sample coolers, which were refrigerated using ice packs, and delivered to the accredited laboratory Maxxam Analytics Inc. (Maxxam) for laboratory analyses. Groundwater samples were submitted for total suspended solids (TSS), turbidity, benzene, toluene, ethylbenzene and xylene (BTEX) parameters, petroleum hydrocarbons (PHC) F1 to F4, polychlorinated biphenyls (PCBs), filtered and unfiltered semi-volatile organic compounds (SVOCs), volatile organic compounds (VOCs) and field filtered metals. Chain of custody forms were completed and included with the sample submissions.

Under Ontario Regulation 153/04 (O.Reg. 153), the standard sampling and analysis of SVOCs is on an unfiltered sample. SVOCs tend to be hydrophobic and will adsorb to both the sample bottle and any particulate material in the sample. As such, the default method of analysis is "whole sample" analysis in which the entire contents of the sample are extracted. MOE (2011b) acknowledges that the inclusion of particulate material will tend to produce a high bias result.

MOE (2011b) indicates that if particulate material is noted during sample collection, a separate sample can be collected for lab filtered benzo(a)pyrene analysis in accordance with O.Reg. 153. Samples for lab filtered analysis of benzo(a)pyrene were collected in Spring 2015 groundwater monitoring samples in accordance with O.Reg. 153. The samples were also analyzed for lab filtered phthalates, polycyclic aromatic hydrocarbons and remaining semi-volatile organic compounds.

Maxxam followed internal QA/QC protocols, which included internal replicates, process blanks, process recovery, and matrix spike analyses. Maxxam reported that the results for their internal QA/QC were within acceptable limits, and these results were considered acceptable for use in the report. The results of the lab replicates are not presented in the summary table in Appendix E, but are included in the detailed laboratory certificates of analyses in Appendix F.

7.2 GROUNDWATER QUALITY RESULTS

Groundwater quality results from Spring 2015 monitoring of groundwater wells within the Project Area met the Ontario Drinking Water Standards (ODWS) maximum acceptable concentration (MAC) for all health related parameters (ODWS-MAC) with the exception of nitrate, which was detected at MW1-13S (20.4 mg/L), MW5-14S (12.6 mg/L), and MW5-15-4 S(2) (13.9 mg/L) above the ODWS-MAC of 10 mg/L. The elevated nitrate concentrations at these locations are attributed to agricultural fertilizer that has historically been used within the Project Area. The following parameters were detected above the ODWS Aesthetic Objective (AO) or ODWS Operational Guideline (OG) during Spring 2015 monitoring:

- Dissolved Organic Carbon (DOC) (5 mg/L AO) within MW4-15-D (6.3 mg/L), and MW5-14-D (13 mg/L);
- Hardness (80 to 100 mg/L OG) within all monitoring wells;
- Iron (300 μg/L AO) within MW8-15 (530 μg/L);
- Manganese (50 μg/L AO) within MW6-14 (120 μg/L);
- Sodium (200 mg/L AO and 20 mg/L MOH) within MW2-13-D (27 mg/L), MW3-13-D (190 mg/L), MW4-15-D (88 mg/L), MW5-14-D (51 mg/L), and MW5-14-I (58 mg/L);
- Sulphate (500 mg/L AO) within MW3-13-D (760 mg/L);
- Total Dissolved Solids (TDS) (500 mg/L AO) within MW3-13-D (1,490 mg/L), and MW4-13-S (526 mg/L); and,
- Turbidity (5 NTU AO) within all monitoring wells, except MW3-13S (3.4 ntu) and MW8-15 (2.2 ntu).

Of note, water quality results from the Spring 2015 monitoring event indicate that there were no detections of BTEX and PHC F1 to F4, PCBs, SVOCs (including phthalates and polycyclic aromatic hydrocarbons (benzo(a)pyrene)), or VOCs above the laboratory detection limit in any of the Project Area monitoring wells.

8.0 CONCLUSIONS

Based on the results presented in this Groundwater and Surface Water Baseline Conditions Report Addendum 2, the following conclusions are provided:

- Additional drilling and groundwater monitoring investigations were completed between December 2014 and April 2015 at four locations; MW4, MW5, MW8, and BH9;
- The findings of these investigations were used to further refine the pre-Station construction Site conditions presented in the Baseline Conditions Report (Stantec, 2014), including the Site Conceptual Hydrogeologic Model, Station Area Water Balance, and PTTW Application calculations;
- Continuous core drilling and installation of monitoring wells MW5-14D (Thorncliffe Well) and MW5-14D (2) (Bedrock Well) was completed as required to satisfy a condition of the access agreement between Hydro One and the Municipality of Clarington;
- Continuous core drilling and installation of a temporary monitoring well at MW8-15 confirmed that silty Sand and Gravel was not present as noted in the geotechnical borehole log (exp BH7D). This well was decommissioned as planned in accordance with the requirements under O. Reg. 903;
- Continuous core drilling at BH9-15 at the planned location of the OWS (centre of Station Area) confirmed that a sand and gravel unit (Mackinaw) was not present within the upper 10.1 m BGS at this location, thereby concluding that there is no significant continuous shallow sand and gravel unit blanketing the Site;
- The Site Conceptual Hydrogeologic Model was refined to include:
    - Surficial Sand – comprised of surficial sand and more permeable surficial deposits, including organics, surficial sand, and highly weathered till;
    - Weathered / Compact Newmarket Till – comprised of till units that have undergone some degree of weathering or depressurization as evidenced by less dense/compact material;
    - Newmarket Till – comprised of dense to very dense silty sand, sandy silt, and sand till. This unit extends to depths of 55 m to 65 m below ground;
- The Water Balance for the Site was revised to take into account the refined Site Conceptual Hydrogeologic Model and groundwater recharge. All available recharge water can be reasonably accounted for with the assumptions presented herein and the refined hydrogeologic conceptual model, which is based on data collected from the Site;

- Calculations used to estimate potential groundwater seepage were updated to allow for the refined Site Conceptual Hydrogeologic Model and refined Station Area Water Balance; resulting in groundwater seepage estimates that were less than those presented in the PTTW Application;

- Groundwater quality results from Spring 2015 monitoring of groundwater wells within the Project Area met the ODWS for all health related parameters (ODWS-MAC) with the exception of nitrate, which was detected in three (3) shallow monitoring wells, and are attributed to agricultural fertilizer that have historically been used at the Site;

- Spring 2015 groundwater monitoring results from wells within the Project Area indicate ODWS AO and/or OG were exceeded in selected monitoring wells for the following parameters: DOC, hardness, iron, manganese, sodium, sulphate, TDS, and turbidity; and

- Spring 2015 groundwater monitoring results from wells within the Project Area indicate the following compounds were not detected above their respective laboratory detection limits: BTEX and PHC F1 to F4, PCBs, SVOCs (including phthalates and polycyclic aromatic hydrocarbons (benzo(a)pyrene)), or VOCs.

9.0 REFERENCES

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