June 18, 2018

Mr. Alfred Artinger
Reid's Heritage Homes
6783 Wellington Road 34, RR #22
Cambridge, Ontario N3C 2V4

Subject: Groundwater Mounding Assessment
19-59 Lowes Road
Guelph, Ontario
Our Ref.: 160-P-0010233-0-08-305-HD-L-0002-00

Dear Sir:

Englobe Corp. (Englobe) is pleased to submit this summary of our groundwater mounding assessment for 19-59 Lowes Road in Guelph, Ontario, at the location shown on the attached Drawing 101. In addition to this groundwater mounding assessment, previous investigations of the property have been conducted by Englobe, including the following:

- Geotechnical Investigation Report – Proposed Residential Development, Lowes Road, Guelph, Ontario, May 24, 2016. Englobe Reference Number 160-P-0010233-0-01-100-GE-R-0001-00;
- Scoped Hydrogeology Study, Lowes Road, Guelph, Ontario May 30, 2017. Englobe Reference Number 160-P-0010233-0-02-300-HD-R-0001-01;
- Soil Infiltration Testing, 19-59 Lowes Road, Guelph, May 24, 2018. Englobe Reference Number 160-P-0010233-0-07-304-HD-L-0002-0A.

In addition to the reports completed by Englobe, the following reports cited below were used to assess the groundwater mounding potential at the site:

- Preliminary Stormwater Management Report. 19-59 Lowes Road, Guelph, Ontario (Revision #3). Stantec Consulting Ltd. May 28, 2018. Reference Number 1614-13228; and,
- Functional Servicing Report. Lowes Road Property (19, 29, 35, 41, 51 and 59 Lowes Road) (Revision #2), Guelph. Stantec Consulting Ltd. June 2018. Reference Number 1614-13228.

All of the abovementioned reports should be read in conjunction with this letter.

An initial groundwater mounding assessment was completed based on the infiltration rates provided in the Soil Infiltration Testing Letter (Englobe Reference Number 160-P-0010233-0-05-HD-L-0001-03, November 2017), infiltration volumes and dimensions of the proposed clean water collection system (CWC) provided by Stantec. However, in response to on comments received from a peer reviewer on behalf of the City of Guelph and the City of Guelph, an additional round of insitu infiltration testing to confirm soil infiltration capabilities and to confirm soil horizons to 1.5 m below the proposed base of the CWCs was completed. The results of this testing can be located in Englobe Report Number

160-P-0010233-0-07-304-HD-L-0002-0A. As a result of the reduced infiltration rate, the CWC system was redesigned and an analysis of the potential groundwater mounding was completed. The objective of this letter is to provide a summary of the potential groundwater mounding at the locations depicted on Drawing 101. A cumulative assessment of the mounding under each trench has also been assessed.

Groundwater Mounding Assessment

In order to assess the impact of localized infiltration of onsite stormwater at the base of the clean water collection trenches, as well as surrounding homes, a groundwater mounding calculation was completed by solving the Hantush (1967) equation for groundwater mounding beneath an infiltration basin. The calculation was solved by using an Excel spreadsheet published by Carleton (2010) in the U.S. Geological Survey Scientific Investigations Report 2010-5102 Simulation of groundwater mounding beneath hypothetic stormwater infiltration basins (Carleton, 2010).

The site consists of three CWC systems which are identified as Trenches 1, 2 and 3 and a stormwater management pond. It is understood that the CWC systems will collect clean roof water from Lots 1-7, 10, 11, 14-33. Basements have been set 1.0 m above the seasonally high groundwater level of 330.64 mASL, it is expected that there will be minimal flow from sump pumps. Therefore, the sump pumps for these corresponding lots will also be connected to the CWC. Elsewhere, sump pumps will discharge to grade. It is noted that as no basements are directly connected to the CWC systems, there is no need to locate the CWC systems above the 100-year hydraulic grade line. In addition to the CWC systems, a dry pond located near the center of the site is proposed to be lined to ensure no inadvertent infiltration will contribute to groundwater mounding. As such, no mounding calculations have been completed for this facility. Table 1, below, identifies the proposed lots that will drain to their respective CWC system.

Table 1 – CWC System and Associated Lots

CWC Location	Lots	Total Volume (m^3/day)	Annual Infiltration Volume (m^3/year)
CWC Trench 1	10, 11, 14 - 22	1.95	710
CWC Trench 2	23 - 33	1.95	710
CWC Trench 3	1-7	1.24	452

It is understood that due to the proposed site grades, stormwater from proposed lots 8, 9, 12, 13, 34, 35 and 36 will drain offsite. We refer you to the Stormwater Management Report and the Functional Servicing Report, both published for the Site by Stantec (2018) for more information regarding these systems. The CWC systems have been sized to accept runoff from a 25 mm rainfall event. This generally accounts for approximately 80-90% of the average rainfall volume. In addition, a 125% safety factor has been used to upsize the CWC systems to account for clogging and short circuiting over time. As previously mentioned, the base of the CWC systems (and the lined dry pond) are set at an elevation at least 1 m higher than the seasonally high groundwater level of 330.64 mASL. The CWC systems are designed to have a drawdown time of less than 24 hours following a 25 mm rainfall event.

Groundwater Mounding Assessment Results

The abovementioned spreadsheet requires site specific hydraulic parameters (inputs) such as aquifer thickness, horizontal hydraulic conductivity, specific yield, basin/infrastructure size, recharge rate and duration to be entered in order to assess the potential groundwater mounding. The equation has been simplified to account for horizontal hydraulic conductivity only rather than the vertical hydraulic conductivity, which can be a fraction of the horizontal hydraulic conductivity.

For the purpose of this assessment, the field saturated hydraulic conductivities of 1.10×10^{-4} m/sec and 2.27×10^{-6} m/sec obtained during insitu infiltration testing completed on May 9, 2018 as described in Englobe Report No. P-0010233-0-07-304-HD-L-0002-0A were considered. These field saturated hydraulic conductivities aligns well with the published hydraulic conductivities for slug testing in the Scoped Hydrogeology Study (Englobe Report No. 160-P-0010233-0-02-300-HD-R-0001-02). The aquifer thickness was inferred from the MOECC Water Well Record (WWR) No. 6702457. Based on this record it is assumed that there is approximately 7 m of groundwater in the overburden “gravel and boulders” unit and that the top 3 m of the limestone bedrock would be permeable due to weathering, resulting in a saturated thickness of 10 m. A copy of WWR No. 6702457 has been appended.

This spreadsheet provides an estimate of the transient condition experienced during infiltration of stormwater (infiltration will occur over a period of time, and cease) rather than steady state (infiltration of a constant volume of water over time) (Carleton, 2010). The spreadsheet also only accounts for the impact on each individual trench and does not account for the cumulative effect that may exist when all three proposed trenches are infiltrating simultaneously. In order to address the cumulative impacts, we have added the anticipated mounding of each trench together to provide a conservatively high cumulative impact.

The inputs for the groundwater mounding assessment are described in Table 2.

Table 2 - Groundwater Mounding Inputs

Infiltration Location	Recharge Rate (m/day)	Specific Yield (unitless)	Horizontal Hydraulic Conductivity m/sec (m/day)	½ Length of the Basin (m)	½ Width of the Basin (m)	Duration of infiltration (days)	Initial Thickness of Saturation (m)
CWC Trench 1	0.2	0.2	1.01×10^{-4} (8.7)	28.5	1	1	10.4
CWC Trench 1	0.2	0.2	2.27×10^{-6} (0.20)	28.5	1	1	10.4
CWC Trench 2	0.1	0.2	1.01×10^{-4} (8.7)	34	1	1	10.4
CWC Trench 2	0.1	0.2	2.27×10^{-6} (0.20)	34	1	1	10.4
CWC Trench 3	0.1	0.2	1.01×10^{-4} (8.7)	30.5	0.75	1	10.4
CWC Trench 3	0.1	0.2	2.27×10^{-6} (0.20)	30.5	0.75	1	10.4

As previously mentioned, as the CWCs were sized to handle the 25 mm rainfall event and that negligible flow from sump pumps from the homes connected to these systems are expected as all basements are set at least 1 m above the seasonally high groundwater level of 330.64 mASL, the input for the recharge rate for all scenarios considers the 25 mm rainfall event and the volume calculated to contribute to the CWC system from each home.

Table 3 – Groundwater Mounding Results

Infiltration Location	Field Saturated Hydraulic Conductivity m/sec (m/day)	Mound Beneath Trench (m)	Mound at Closest Internal Building (m)	Mound at Property Line (m)	Furthest Anticipated Mound from Center of Trench (m)
CWC Trench 1	1.01×10^{-4} (8.7)	0.01	0.0	0.0	0.0
CWC Trench 1	2.27×10^{-6} (0.20)	0.07	0.07	0.0	27.4
CWC Trench 2	1.01×10^{-4} (8.7)	0.0	0.0	0.0	0.0
CWC Trench 2	2.27×10^{-6} (0.20)	0.02	0.02	0.0	30.5
CWC Trench 3	1.01×10^{-4} (8.7)	0.0	0.0	0.0	0.0
CWC Trench 3	2.27×10^{-6} (0.20)	0.01	0.01	0.0	30.5

Based on the results described above, the largest anticipated groundwater mounding is expected to occur under Trench 1 with calculated groundwater mounding of 0.07 m directly under the trench when considering the insitu field saturated hydraulic conductivity value of 2.27×10^{-6} m/sec. Trench 2 and Trench 3 have a calculated groundwater mounding of approximately 0.02 and 0.01 m beneath the respective trenches when considering the insitu field saturated hydraulic conductivity value of 2.27×10^{-6} m/sec. When considering an insitu field saturated hydraulic conductivity value of 1.01×10^{-4} m/sec (measured at approximately 331.6 mASL at GP-01-18, May 9, 2018) no mounding is expected beneath any CWC trench.

The closest internal building to the center of CWC Trench 1 is Lot 11 at approximately 7.5 m. Anticipated mounding at this distance from the center of CWC Trench 1 with an insitu field saturated hydraulic conductivity of 2.27×10^{-6} m/sec is 0.06 m, which is within the natural variation of the water table. No mounding is expected at this distance when an insitu field saturated hydraulic conductivity of 1.01×10^{-4} m/sec is considered.

The closest internal building to the center of CWC Trench 2 is Lot 33 (Based on Stantec Drawing SSP-1) at approximately 12.5 m. No mounding is expected at this distance when an insitu field saturated hydraulic conductivities of 1.01×10^{-4} m/sec is applied. An approximate 0.02 m increase in water levels is expected at this lot when an insitu hydraulic conductivity of 2.27×10^{-6} m/sec is applied. This increase is within the natural variation of the water table. The closest internal building to the center of CWC Trench 3

is Lots 1-7 at approximately 6.75 m. No mounding is expected at this distance when the insitu field saturated hydraulic conductivities of 1.01 x 10^{-4} m/sec is applied. An anticipated mound of approximately 0.02 m is expected at this distance when considering an insitu field saturated hydraulic conductivity of 2.27 x 10^{-6} m/sec is applied. It is noted that this increase in water level is also within the natural variation of the water table throughout the course of the year.

Lastly, when considering an insitu field saturated hydraulic conductivities of both 1.01 x 10^{-4} m/sec and 2.27 x 10^{-6} m/sec, no mounding is expected to occur at the property line from all three CWC systems. The appended Drawing 102 depicts the potential cumulative mounding of all three CWC systems infiltrating simultaneously when applying an insitu field saturated hydraulic conductivity value of 2.27 x 10^{-6} m/sec. The cumulative mound was calculated by adding the anticipated mounding at the closest internal structure for the respective CWC system together for a result of 0.10 m. It is noted that this increase in water level is contained within the site and is within the natural variation of the water table.

When considering an insitu hydraulic conductivity of 1.01 x 10^{-4} m/sec, the radius of influence of mounding is not expected to extend past the center of any of the CWC trenches. When considering an insitu hydraulic conductivity of 2.27 x 10^{-6} m/sec, the radius of influence extends 27.4 m from the center of CWC system Trench 1 and 30.5 m from the center of the CWC systems Trench 2 and 3. This results in an anticipated cumulative mound of 0.1 m. It is noted the mounding occurs within the Site and is not expected to impact neighbouring properties.

In summary, based on our results for the groundwater mounding assessment, groundwater mounding will not be an issue on the internal site structures or the neighbouring properties. However, it is recommended that any topsoil and sandy silt / silty sand materials found beneath the CWC systems (infiltration facilities) will be removed and replaced with free draining material confirmed to have an appropriate hydraulic conductivity rate. Based on this recommendation, the potential cumulative impact of all three trenches infiltrating at the property line would be no impact.

We trust that this report is suitable for your present requirements, and we thank you for this opportunity to have been of service. If you have any questions or require further hydrogeological consultation, please do not hesitate to contact our office.

Yours very truly,

Elysha Brears

Elysha Brears, G.I.T., M.E.S.
Groundwater Technologist

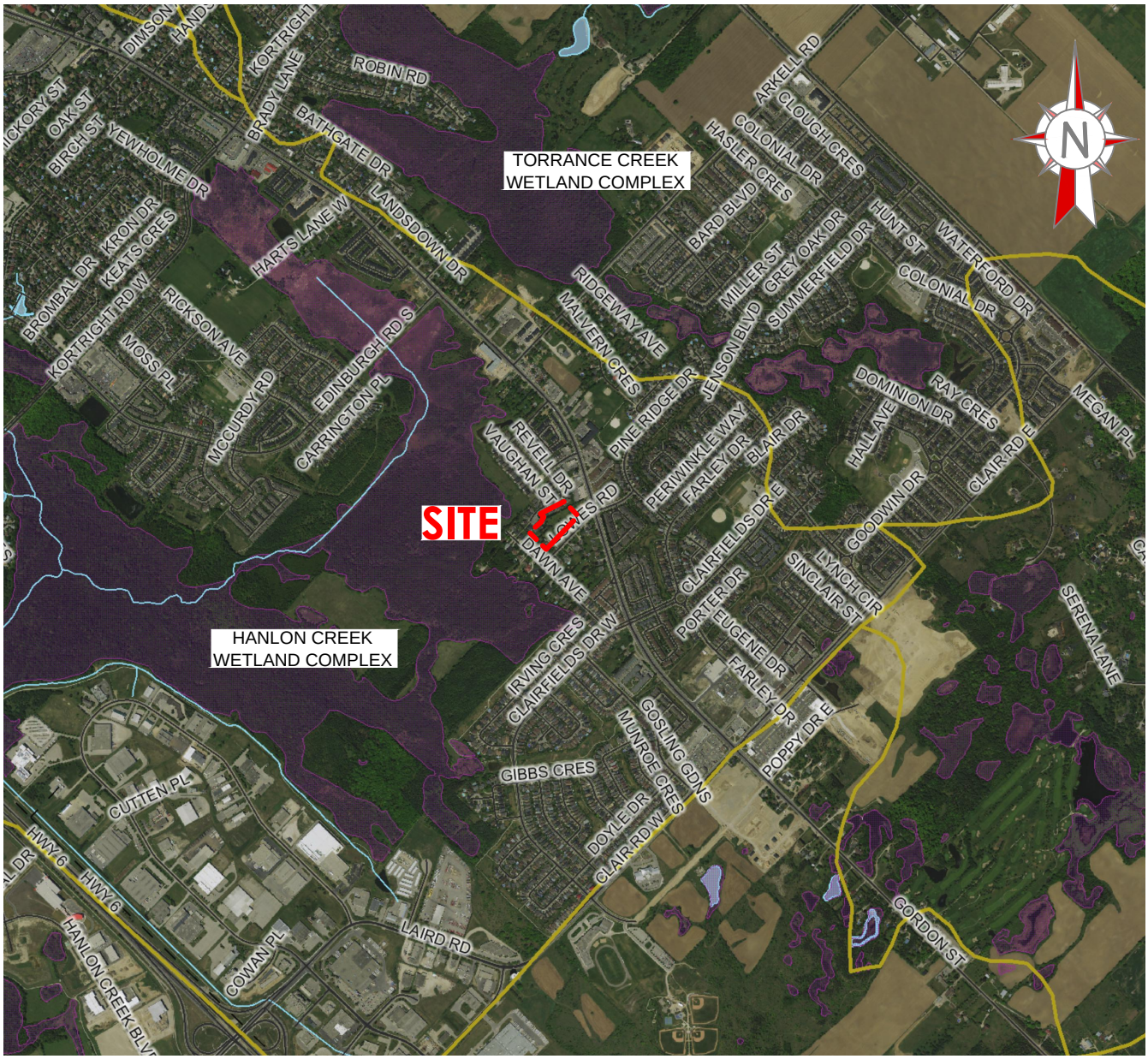
Audrey Beaudoin

Audrey Beaudoin, P.Eng.
Hydrogeologist

LICENSED PROFESSIONAL ENGINEER
2018-06-18
A. BEAUDOIN
100514423
PROVINCE OF ONTARIO

jw/pc

Encl. Drawing 101 – Location Plan
Encl. Drawing 102 – Groundwater Mounding Cumulative Impact
Encl. Ministry of Environment and Climate Change Water Well Record No. 6702457



LEGEND :

GRCA WETLANDS

GRCA SUBWATERSHED BOUNDARY

NOTES :

1-REFERENCES : GRAND RIVER CONSERVATION AUTHORITY, 2010 Aerial Photograph (2016).

2-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.

0 250 500 750 1000 m

SCALE 1:25000

Project

Groundwater Mounding Assessment

19-59 Lowes Road, Guelph, Ontario

Title

LOCATION PLAN

Englobe Corp.
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

Prepared	E.Ciochon	Discipline	HYDROGEOLOGY	Project manager	E.Brears
Drawn	E.Ciochon	Scale	1 : 25000	Sequence no.	01 of 02
Checked	E.Brears	Date	2018-06-18		

M. dept.	Project	Disc.	Dwg no.	Rev.
160	P-0010233-0-08-305	HD	101	00

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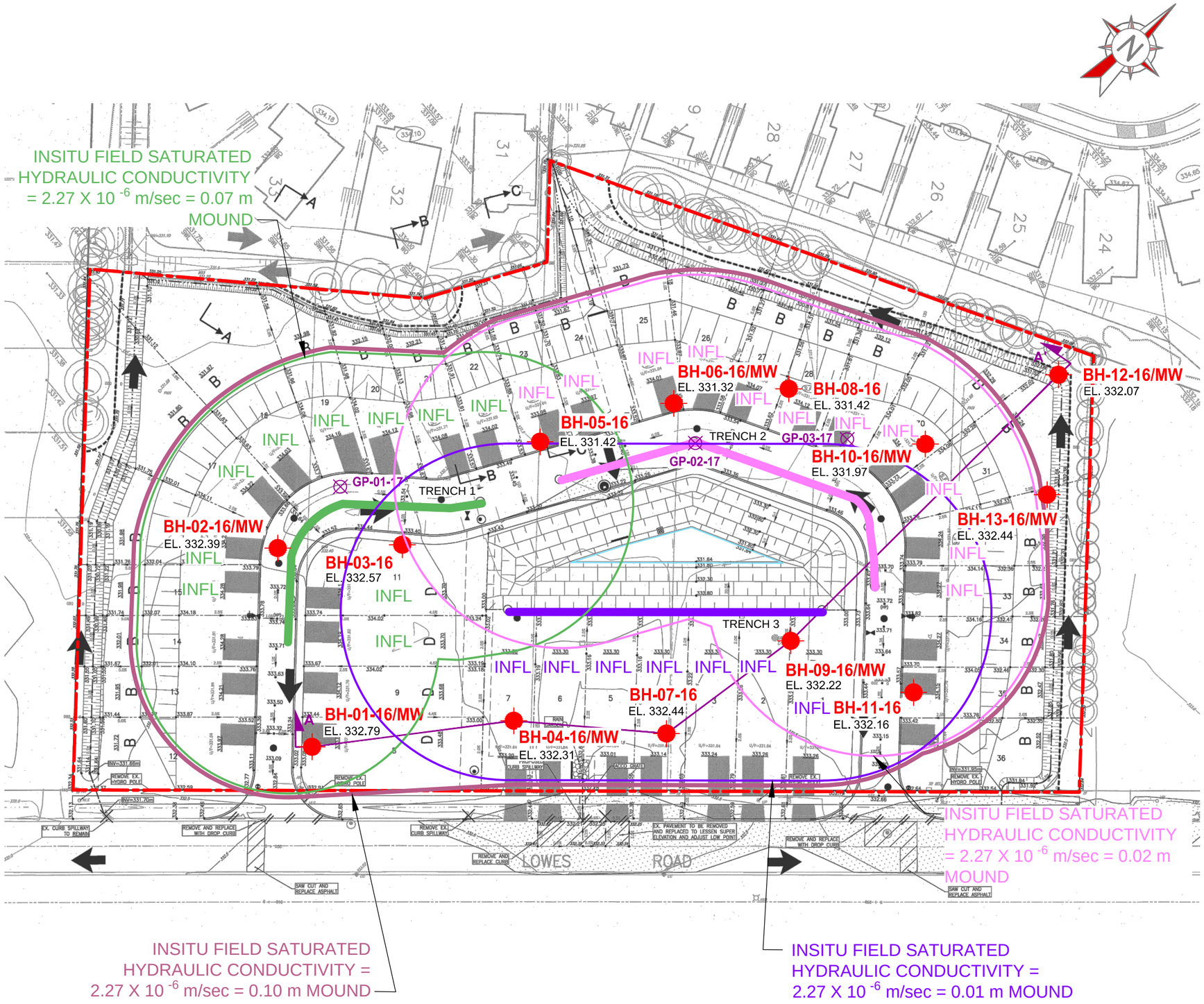

LEGEND :

- SITE OUTLINE
- BOREHOLE LOCATION
- EL. 331.32 — GROUND SURFACE ELEVATION (m)
- A A' — CROSS SECTION (Refer to Drawing 3)
- DRY POND (LINED)
- INFL — INFILTRATION LOT
- MW — MONITORING WELL
- CWC TRENCH 1
- CWC TRENCH 2
- CWC TRENCH 3
- CUMULATIVE MOUND FOR ALL 3 CWC TRENCHES

0 10 20 30 m
SCALE 1:750

NOTES :
1-REFERENCES: STANTEC, Preliminary Grading Plan Site Plan Number, Drawing No.GP-1, August 2016..

2-Borehole coordinates and elevations based on Sokkia network data.

3-Drawing scale may be distorted due to file conversion and/or copying. Measurements taken from the drawing must be verified in the field.

Project

Groundwater Mounding Assessment

19-59 Lowes Road, Guelph, Ontario

Title

GROUNDWATER MOUNDING CUMULATIVE IMPACT

Englobe Corp.
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
Fax : 519.741.5422

Prepared	E.Ciochon	Discipline	HYDROGEOLOGY
Drawn	E.Ciochon	Scale	1:750
Checked	E.Brears	Date	2018-06-18
Project manager	E.Brears	Sequence no.	02 of 02

M. dept.	Project	Disc.	Dwg no.	Rev.
160	P-0010233-0-08-305	HD	102	00

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UTM | | Z | | | | | | | E
| 9 | R | | | | | | | N
Elev. | 9 | R | 1085 |
Basin | 23 | | | | |

ONTARIO

The Water-well Drillers Act, 1954
Department of Mines

67 № 2457

Water-Well Record

County or Territorial District ..... Township, ~~Village, Town or City~~ Rushbrook

[redacted] Village, Town or City) .....

[redacted] ddress Guelph

(day) (month) (year)

Pipe and Casing Record

Casing diameter(s) 4"
Length(s) 40'
Type of screen
Length of screen

Pumping Test

Static level 16'
Pumping rate 10 gal per min
Pumping level 20'
Duration of test 1 hour

Well Log / Water Record

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, or sulphur)
gravel & boulders	0	40			
limestone rock	40	117	116	100	fresh

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

Is water clear or cloudy? clear

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

Drilling firm G. H. Lloyd

Address Phil Fergus

Name of Driller

Address

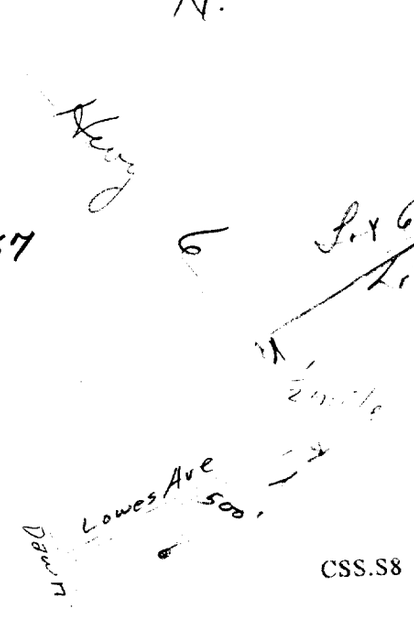
Licence Number

I certify that the foregoing statements of fact are true.

Date ..... Signature of Licensee

Location of Well

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



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Form 5