November 13, 2017

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-0001-02

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 1. In addition to this groundwater mounding assessment, previous investigations of the property have been conducted, 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;
- Long Term Monitoring Program. On-going. Englobe Reference Number 160-P-0010233-0-05-302; and,
- Soil Infiltration Testing, 19-59 Lowes Road, Guelph, October 18, 2017. Englobe Reference Number 160-P-0010233-0-07-304-HD-L-0001-01.

These reports should be read in conjunction with this letter.

The objective of this letter report is to provide a summary of the potential groundwater mounding at the location depicted on Drawing 1.

Groundwater Mounding Assessment

In order to assess the impact of localized infiltration of on-site 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).

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Groundwater Mounding Assessment Results

In order to assess the potential impact for groundwater mounding under the proposed clean water collection trenches, as well as the potential impact to neighbouring properties as a result of infiltration of stormwater, a groundwater mounding assessment was completed.

The groundwater mounding assessment was determined by solving a simplified version of the Hantush, 1967 equation for groundwater mounding using an Excel spreadsheet published by Carleton, (2010) and described in the document “Simulation of Groundwater Mounding Beneath Hypothetical Stormwater Infiltration Basins” (U.S. Geological Survey Scientific Investigations Report 2010-5102).

The 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. It is noted that 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 conductivity of 2.78×10^{-5} m/sec obtained during in-situ infiltration testing as described in Englobe Report No. P-0010233-0-07-304-HD-L-0001-00. Further, this field saturated hydraulic conductivity 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-0001-01). 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.

The site consists of three clean water collection systems which are identified as Trenches 1, 2 and 3. Passive infiltration occurs at the center of the site; however, the majority of the stormwater will be managed and infiltrate via Trenches 1, 2 and 3. We refer you to the Functional Servicing Report published for the Site by Stantec (2017) for more information regarding these systems. The 100 Year and 2 Year Storm Event extrapolated from the Guelph Turfgrass Short Duration Rainfall Intensity-Duration-Frequency Curve (IDF Curve) were considered. The inputs for the groundwater mounding assessment are described in Table 1.

Table 1 - 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)
100 Year Storm Event (Trench 1)	0.10	0.2	2.78×10^{-5} (2.4)	22.05	1.25	1	10.4
100 Year Storm Event (Trench 2)	0.10	0.2	2.78×10^{-5} (2.4)	34.9	1	1	10.4
100 Year Storm Event (Trench 3)	0.10	0.2	2.78×10^{-5} (2.4)	27.85	0.75	1	10.4
2 Year Storm Event (Trench 1)	0.05	0.2	2.78×10^{-5} (2.4)	22.05	1.25	1	10.4
2 Year Storm Event (Trench 2)	0.05	0.2	2.78×10^{-5} (2.4)	34.9	1	1	10.4
2 Year Storm Event (Trench 3)	0.05	0.2	2.78×10^{-5} (2.4)	27.85	0.75	1	10.4

The scenario considers the 100 Year Storm Event which is approximately 101 mm of precipitation in 24 hours, based on the Guelph Turfgrass IDF Curve. An individual analysis was completed on each trench. Trench 1 has the highest groundwater mounding directly below the trench at approximately 0.06 m. Groundwater mounding below Trench 2 and Trench 3 is calculated to be approximately 0.05 m. We refer you to Figure 101, appended, for a graphical depiction of the individually calculated groundwater mounding from the center of each respective trench for the 100 Year Storm Event based on a 1 day drawdown time period.

The second scenario considers a more realistic storm event, the 2 Year Storm Event based on the Guelph Turfgrass IDF Curve. Based on these calculations, the largest anticipated groundwater mounding is expected to occur under Trench 1 with calculated groundwater mounding of 0.03 m directly under the trench. Trench 2 and Trench 3 have a calculated groundwater mounding of approximately 0.02 m beneath the respective trenches. The 2 Year Storm Event is equivalent to approximately 48 mm of precipitation in 24 hours.

The closest proposed internal buildings (Proposed Lots 1 to 7) are approximately 5 m from the center of the Proposed Infiltration Trench 3. A proposed ground surface elevation of 333.0 mASL (based on lowest proposed ground surface elevation located at proposed Lot 6), the lowest proposed underside of footing elevation of 331.64 mASL across the site (based on the Preliminary Grading Plan, May 2017), and a groundwater elevation of 330.22 mASL corresponding to the highest measured groundwater level from Monitoring Well BH-04-16 at the time of this letter being written was used to determine the groundwater mounding impacts on the proposed internal buildings. Assuming the 100 Year Storm Event was to occur, it is anticipated that mounding would be approximately 0.05 m higher than the groundwater elevation of 330.22 mASL.

Therefore it is anticipated that the groundwater elevation would be 330.27 mASL based on the assumptions described above. This would correspond to groundwater elevations being approximately 1.37 m below the proposed underside of footing elevation of 331.64 mASL. Assuming the 2 Year Storm Event was to occur, it is anticipated that mounding would be approximately 0.02 m higher than the groundwater elevation of 330.22 mASL, resulting in a groundwater elevation of 330.24 mASL. Groundwater would be approximately 1.40 m below the underside of footing elevation. The 5 m cumulative recharge surplus mounding for Trench 3 for both the 100 and 2 Year Storm Events are depicted on the appended Drawing 2.

The closest building is approximately 41 m from the center of the proposed Infiltration Trench 1, located at 69 Lowes Road West. This structure is assumed to have a basement, with an assumed finished floor elevation of 329.6 mASL, based on a typical basement depth of 2.4 m below ground surface and an assumed ground surface elevation of 332.0 mASL obtained from the topographic contours from the topographic sketch of the Site provided by Stantec, dated April 2016, and available topographic data from GRCA contour mapping (1 m intervals). It is assumed the groundwater elevation under this building is approximately 330.3 mASL based on a recorded high groundwater elevation of 330.31 mASL recorded between May 6 and May 7, 2017 from the datalogger installed in Monitoring Well BH-01-16. An interpretation of these assumptions indicates groundwater beneath 69 Lowes Road West is approximately 0.7 m above the assumed finished floor elevation under pre development conditions. Considering both the 100 and 2 Year Storm Events, it is not anticipated there would be any impacts on this neighbouring property, as depicted on the appended Figures 101 and 102.

In summary, based on the groundwater mounding elevation of 330.27 mASL under the 100 Year Storm Event and the lowest proposed underside of footing elevation for the proposed development of 331.64 mASL, a separation of 1.42 m is achieved, satisfying Item 15 of the City of Guelph's Subdivision Plans and Profiles. It is noted that the Geotechnical Investigation Report (160-P-0010233-0-01-100-GE-R-0001-00, May 24, 2016) was released prior to the Hydrogeology Study, Soil Infiltration Testing, Groundwater Mounding Assessment and proposed SWM facility elevations. The concern of groundwater interfacing with the SWM facility from the Geotechnical Report was proven to not be an issue in the subsequent abovementioned reports. Based on the conclusions described in both the Soil Infiltration Letter (Englobe Report No. 160-P-0010233-0-07-304-HD-L-0001-01) and this report, we believe from a hydrogeological standpoint the proposed development will not appreciably impact neighbouring properties.

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,

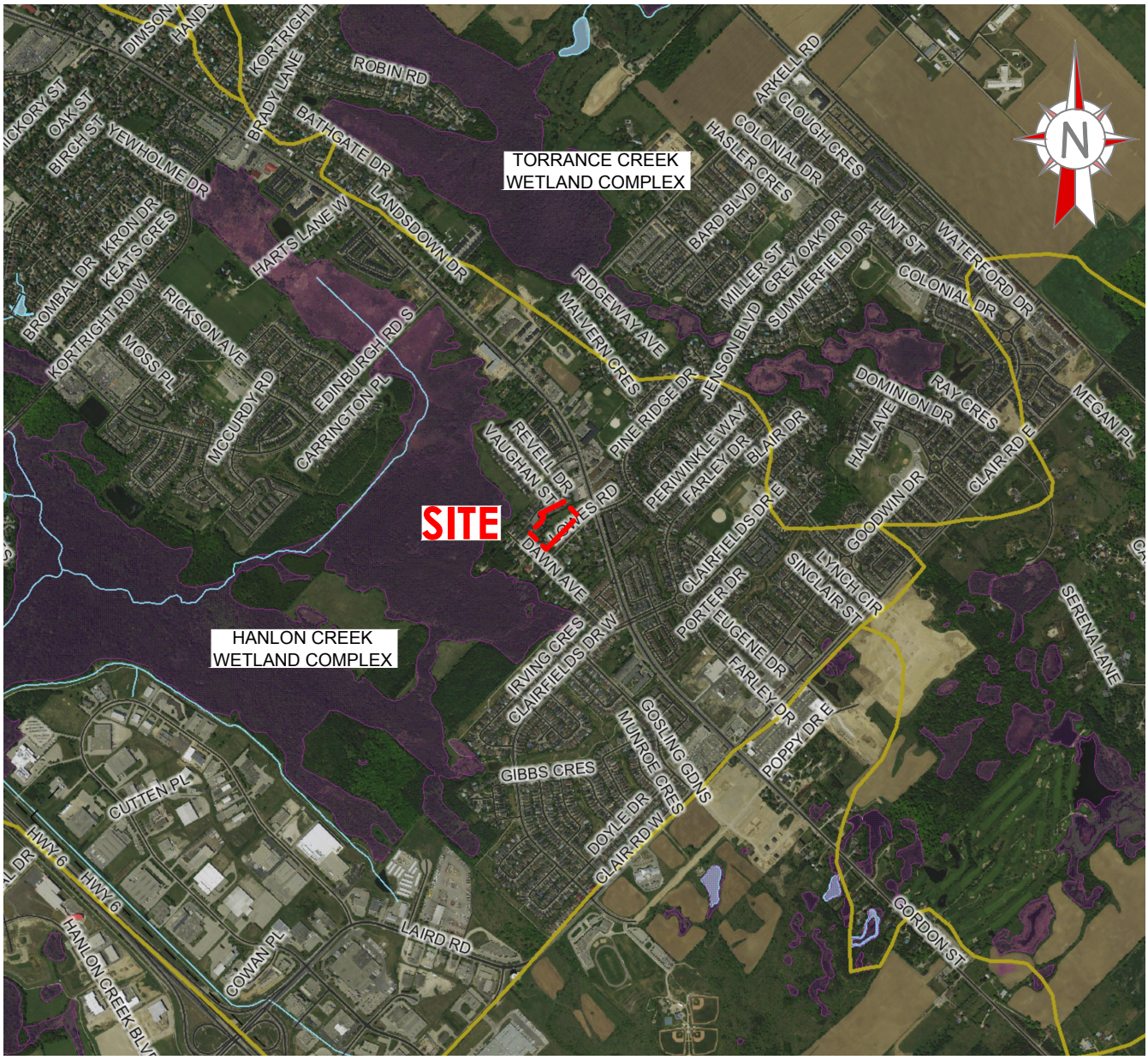
Elysha Brears, G.I.T., M.E.S.
Groundwater Technologist

Kelvin Antoniuk, P.Geo., B.Sc.
Senior Geoscientist

jw

Encl. Drawing 1 – Location Plan
Encl. Drawing 2 – Groundwater Mounding Impacts on Internal Buildings
Encl. Ministry of Environment and Climate Change Water Well Record No. 6702457
Encl. Figure 101 – Groundwater Mounding – 100 Year Storm Event 1 Day Drawdown
Encl. Figure 102 – Groundwater Mounding – 2 Year Storm Event 1 Day Drawdown

1ec: Reid's Heritage Homes, Attention: Mr. Jim Dodd
1ec: Stantec Consulting Ltd., Attention: Mr. Peter Fitzgerald
1ec: Planning Consultants, Attention: Ms. Astrid Clos



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 03
Checked	E.Brears	Date	2017-11-10		

M. dept.	Project	Disc.	Dwg no.	Rev.
160	P-0010233-0-08-305	HD	001	02

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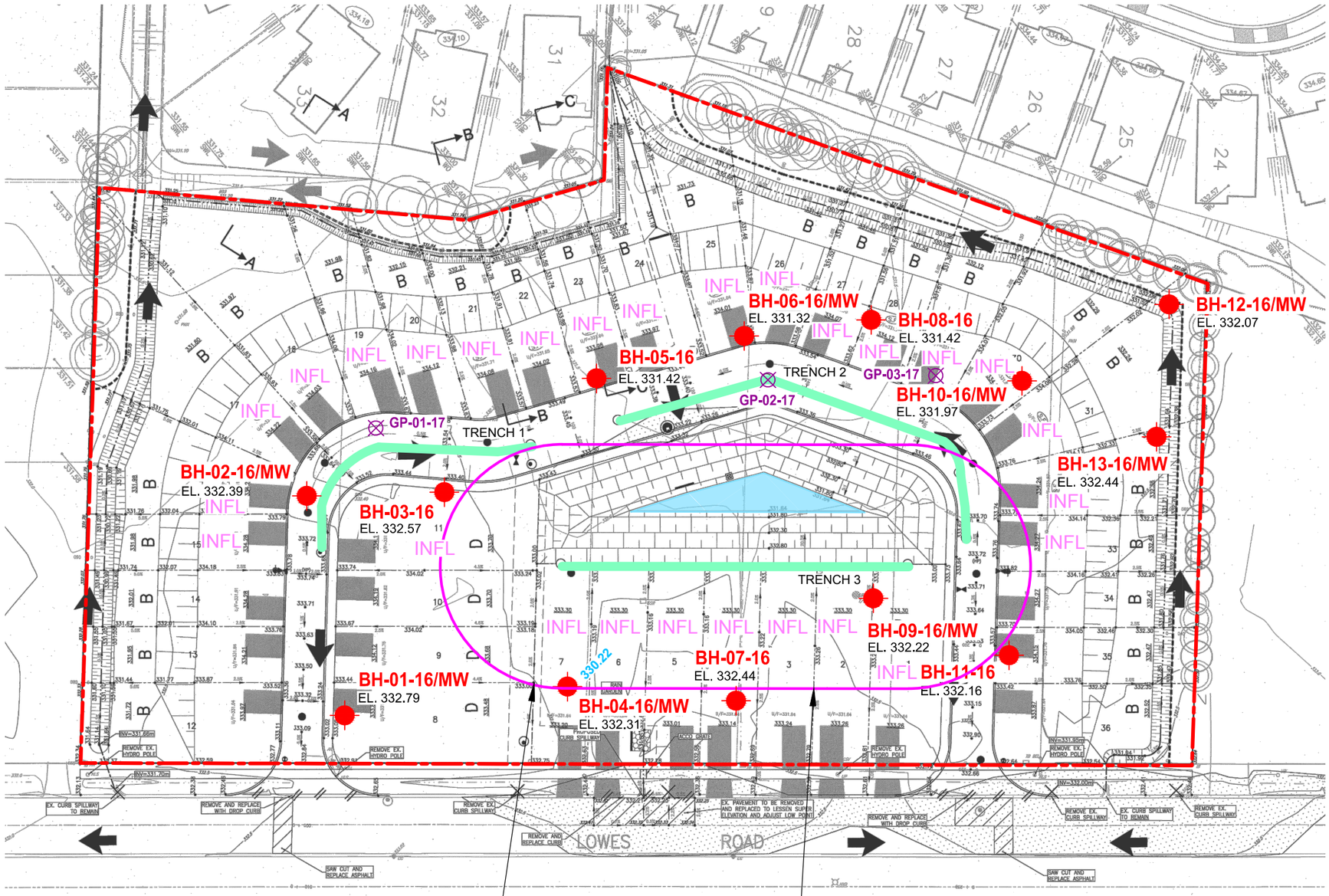

LEGEND :

- SITE OUTLINE
- BOREHOLE LOCATION
- EL. 331.32 — GROUND SURFACE ELEVATION (m)
- INFILTRATION GALLERY
- CLEAN WATER COLLECTION SYSTEM
- INFL — INFILTRATION
- 330.22 — GROUNDWATER ELEVATION (mASL) (May 11, 2017)
- MW — MONITORING WELL
- 20 m MOUNDING RADIUS
- ABC — 100 YEAR STORM EVENT
- ABC — 2 YEAR STORM IVENT

0 10 20 30 m
SCALE 1:750

NOTES :

1-REFERENCE: 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 IMPACT ON INTERNAL BUILDINGS

Englobe Corp.
353, Bridge Street East
Kitchener (Ontario) N2K 2Y5
Telephone : 519.741.1313
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Prepared	E.Ciochon	Discipline	HYDROGEOLOGY
Drawn	E.Ciochon	Scale	1:750
Checked	E.Brears	Date	2017-11-10
Project manager	E.Brears	Sequence no.	02 of 02

M. dept.	Project	Disc.	Dwg no.	Rev.
160	P-0010233-0-08-305	HD	002	02

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UTM | | Z | | | | | | | E
| 9 | R | | | | | | | N
Elev. | 9 | R | 1 | 0 | 8 | 5 |
Basin | 23 | | | | |

ONTARIO

The Water-well Drillers Act, 1954
Department of Mines

No. 2457

Water-Well Record

County or Territorial District ..... Township, ~~Village, Town or City~~ .....
[redacted] Village, Town or City) .....
[redacted] ddress .....

(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

Overburden and Bedrock Record	From ft.	To ft.
gravel & boulders	0	40
limestone rock	40	117

Water Record

Depth(s) at which water(s) found	No. of feet water rises	Kind of water (fresh, salty, or sulphur)
116	100	fresh

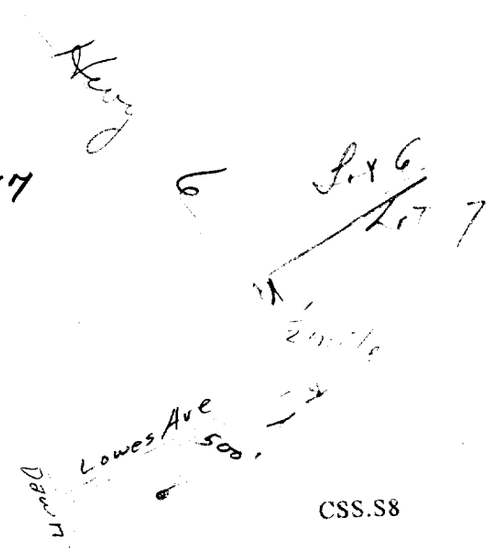
For what purpose(s) is the water to be used? House
Is water clear or cloudy? clear
Is well on upland, in valley, or on hillside? upland
Drilling firm ..... D. H. Lloyd
Address ..... RR 5 Fergus
Name of Driller .....
Address .....
Licence Number .....

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

FIGURE 101

GROUNDWATER MOUNDING - 100 YEAR STORM EVENT 1 DAY DRAWDOWN

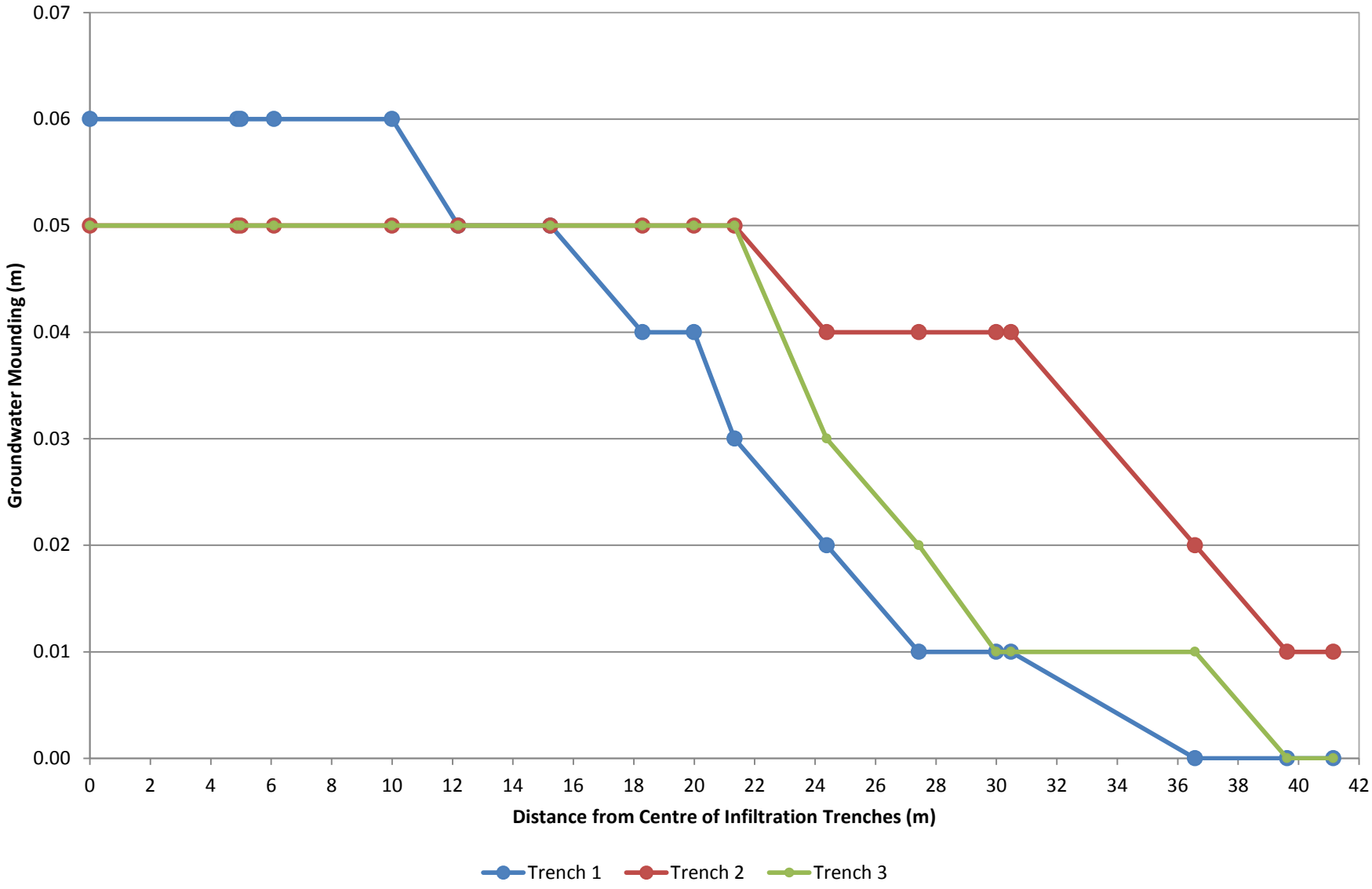

FIGURE 102

GROUNDWATER MOUNDING - 2 YEAR STORM EVENT 1 DAY DRAWDOWN