TECHNICAL MEMORANDUM

DATE July 19, 2018 **Project No.** 1771847

TO Andrew Finnson, P.Eng.
Caivan

FROM Brian Byerley, P.Eng. **EMAIL** bbyerley@golder.com

RESPONSE TO ENGINEERING COMMENTS ON FUCTIONAL SERVICING REPORT
HYDROGEOLOGICAL ASSESSMENT
PROPOSED RESIDENTIAL DEVELOPMENT
CONSERVANCY LANDS – PHASE 1
OTTAWA, ONTARIO

This memo provides Golder Associates Ltd. (Golder) responses to review comments by the City of Ottawa on the Function Servicing Report for Barrhaven Conservancy Phase 1 (referred to herein as “the site”) that was prepared by David Schaeffer Engineering Limited (DSEL). The specific comments addressed in this memo relate to the proposed use of sump pumps for foundation drainage.

Comment 6. *Pre-loading should be investigated.*

Preloading can be investigated further; however, based on the soil conditions encountered within Phase 1 of the development, a minimum of 2 metres of surcharge material would have to be placed above final grade during the preload period over an area of approximately 30,000 to 50,000 m^2 in order to achieve the necessary consolidation of the underlying soft clay within the western portion of the site. The preload period can be estimated to be at least 1 year; however, this cannot be confirmed without monitoring during the preload. Assuming that up to 2 metres of surcharge material would be used, in order to reduce the preload period, the amount of surcharge fill required (on top of the already planned grade raise fill) would be approximately 60,000 to 100,000 m^3. This is a large amount of fill that would need to be trucked to the site and then removed following the surcharge period. And, if settlement progresses more slowly than anticipated, construction of the development would be delayed. The use of sump pumps in Phase 1 would alleviate the need for preloading to prevent long-term settlement and would provide far less risk to the construction schedule.

Comment 7. *The Soils should be classified using the USCS system, using grain-size and Atterberg Limits.*

The results of the geotechnical investigation for this project as well as guidelines on the geotechnical aspects of developing the site were provided in the following reports:

- Report titled “Geotechnical Investigation, Proposed Residential Development, Conservancy Lands – Phase 1, Ottawa, Ontario”, dated September 2017 (report number 1771847 – Phase 1); and,
- Report titled “Geotechnical Investigation, Proposed Residential Development, Conservancy Lands, Ottawa, Ontario”, dated September 2017 (report number 1771847).

Soil descriptions according to the USCS system, based on grain-size and Atterberg Limits, are included in these reports.

Comment 8. *Monitoring well data should be provided.*

Borehole logs and monitoring well construction details are provided in the above referenced reports. Groundwater level monitoring was completed by Golder between late March 2017 and early November 2017. Manual groundwater level measurements were obtained in 15 monitoring wells (locations shown on the Attached Figure 1) at a frequency of approximately once per month. Pressure transducers/data loggers were installed in 5 of the monitoring wells to collect hourly groundwater level data. The monitoring period allowed the collection of data during the spring freshet and during numerous higher intensity rain events. The manual groundwater level measurements are attached as Table 1, and the transducer data (along with Environment Canada precipitation data) are attached as Figures 2 and 3.

Comment 9. *The hydraulic conductivity of the soil should be provided.*

Rising head tests (slug tests) were completed in all 15 monitoring wells. The analyses of the hydraulic conductivity (K) testing are attached to this memo (Attachment 1). In summary, 14 of the monitoring wells were installed within the weathered crust (grey brown silty clay to clay), at the approximate anticipated elevations of the Under Side of Footing (USF) of the residential units (maximum depth of approximately 3.0 metres below ground surface). One monitoring well (BH 17-11) was installed below the weathered crust, in the grey silty clay to clay. The results of the hydraulic conductivity testing indicated that the K of the grey clay is approximately 5.0×10^{-8} m/s and the geometric mean K of the weathered crust is approximately 3.9×10^{-6} m/s. The maximum K of the weathered crust was found to be approximately 2×10^{-5} m/s.

Comment 10. *The rate of ingress into the sumps should be calculated and provided.*

Two groundwater inflow scenarios were evaluated, based on a typical basement with dimensions of 10 m by 12 m in plan and a USF that is 1.8 m below the road centreline. The highest groundwater level was observed to be at BH17-62, located within Phase 1 (91.95 masl on March 31, 2017). The USF elevations in this area of the site are indicated to be approximately 91.15 masl. Groundwater inflow was calculated using the Dupiut-Forcheimer Equation for flow into a circular excavation based on the above values and the geometric mean K for the weathered crust (Scenario 1) and the maximum K of the weathered crust (Scenario 2). The groundwater inflow calculations are provided as Attachment 2. The steady-state groundwater inflow for Scenario 1 is estimated to be approximately 0.05 L/s and the steady-state groundwater inflow for Scenario 2 is estimated to be approximately 0.3 L/s. These rates of inflow are well within the expected capability of standard sump pumps.

Comment 12. *Page 2 of the tech memo is unclear regarding the permissible grade raises and the proposed design grades. There is a reference to "given elevations", but it not clear who gave the elevations. It is also unclear regarding the values of 0.5 – 0.7 m or the reference to 1.1 m.*

The permissible grade raise is provided in the reports referenced above and is equal to 1.8 metres for the roadways and 1.6 metres for the houses above OG. With the use of EPS lightweight fill placed within the garages and porches, the grade raise for the houses can be increased to 2.1 metres. The design grades and elevations were shown on the plans provided by DSEL. The most recent preliminary grading plan (provided by DSEL) is attached as Attachment 3. These functional grades are proposed based on a design that anticipates the use of sump pumps. An alternate design with gravity drainage would necessitate a grade increase of an additional approximately 0.5 to 0.75 metres above what is shown on the attached preliminary plans. The current grading option, based on the use of sump pumps, results in grade raises in the western portion of the site that are at or exceeding the grade raise restriction of 2.1 metres (with the use of EPS). Raising the site further would result in a greater area that exceeds the grade raise restriction in the western portion of the site (see above response to comment 6).

Comment 14. *The details for the permissible grade raises need to be provided in the geotechnical investigation. There is a reference to the analyses (in Section 5.2) but these are not included.*

As presented in Section 5.2, the results of the analyses indicate that the permissible grade raise is equal to 1.8 metres for the roadways and 1.6 metres for the houses. These limitations have been assessed based on leaving sufficient remaining capacity in the silty clay deposit such that strip footings up to 0.6 metres in width can be designed using a maximum allowable bearing pressure of 75 kilopascals, consistent with design in accordance with Part 9 of the Ontario Building Code. The analyses assume that the unit weight of the grade raise fill would be less than or equal to 18.5 kilonewtons per cubic metre (weathered brown silty clay or clear stone). It has also been assumed that the groundwater level would be lowered to about 0.5 metres above the weathered/grey silty clay interface, which is considered to be a conservative assumption.

Closure

We trust that this memo provides sufficient information for your present requirements. If you have any questions concerning this memo, please don't hesitate to contact the undersigned.

Yours truly,

Golder Associates Ltd.

W. Alex Meacoe

Alex Meacoe, P.Eng.
Geotechnical Engineer

Brian Byerley, P.Eng.
Principal, Senior Hydrogeologist

LICENSED PROFESSIONAL ENGINEER
B. T. BYERLEY
July 19/18
PROVINCE OF ONTARIO

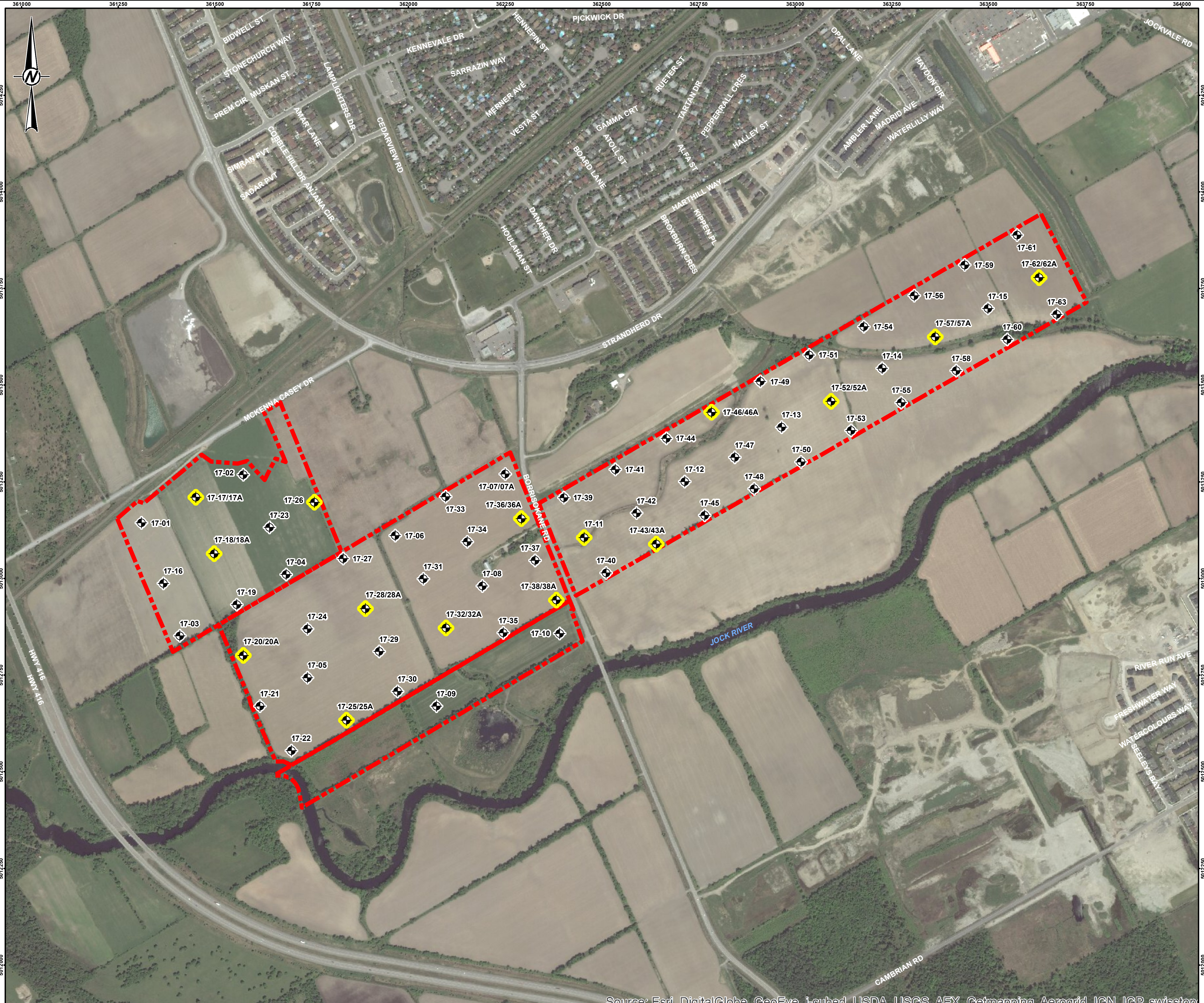
WAM/KSL/BTB/sg
\\golder.gds\gal\ottawa\active\2017\3 proj\1771847 caivan barrhaven conservancy lands ottawa\04_reporting\hydrogeo\hydrogeological assessment\1771847-001-tm-rev 1-hydrogeolgical assessment-2018 07 19.docx

Attachments: Table 1 - Groundwater Level Measurements
Figure 1 - Site Plan
Figure 2 - Groundwater Depth Data
Figure 3 - Groundwater Elevation Data
Attachment 1 - Hydraulic Conductivity Analyses
Attachment 2 - Groundwater Inflow Calculations
Attachment 3 - DSEL Preliminary Grading Plan

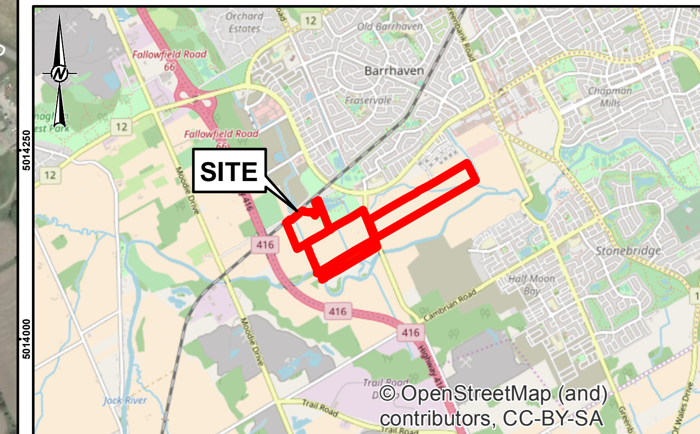
TABLE 1
Groundwater Level Measurements
Barrhaven Conservancy Lands

Well ID	Top of Pipe Elevation (masl)	Ground Elevation (masl)	Stick-Up (m)	31-Mar-17			13-Apr-17			02-May-17			09-Jun-17			10-Aug-17			23-Aug-17			29-Sep-17			01-Nov-17		
				mbtoc	mbgs	masl	mbtoc	mbgs	masl	mbtoc	mbgs	masl	mbtoc	mbgs	masl	mbtoc	mbgs	masl	mbtoc	mbgs	masl	mbtoc	mbgs	masl	mbtoc	mbgs	masl
17-11	92.364	91.194	1.17	nm			1.52	0.35	90.85	1.46	0.29	90.90	1.68	0.51	90.68	1.59	0.42	90.78	nm			1.89	0.72	90.48	1.64	0.47	90.73
17-17	92.836	91.818	1.02	1.63	0.61	91.21	1.68	0.66	91.16	1.31	0.29	91.53	1.76	0.74	91.08	2.04	1.02	90.80	nm			2.20	1.19	90.63	1.62	0.60	91.21
17-18	92.422	91.400	1.02	1.47	0.45	90.95	1.60	0.58	90.82	1.20	0.18	91.22	1.92	0.90	90.50	2.10	1.08	90.32	nm			2.46	1.44	89.96	1.52	0.50	90.90
17-20	92.171	91.032	1.14	1.80	0.66	90.37	1.52	0.38	90.65	1.48	0.34	90.69	2.01	0.87	90.16	nm			2.13	0.99	90.04	2.31	1.17	89.86	1.28	0.14	90.89
17-25	92.088	91.089	1.00	1.01	0.01	91.08	1.06	0.06	91.03	1.06	0.06	91.03	1.84	0.84	90.25	nm			2.06	1.06	90.03	2.45	1.45	89.64	1.02	0.02	91.07
17-26	92.481	91.537	0.94	1.21	0.26	91.28	1.34	0.39	91.15	1.20	0.26	91.28	1.69	0.75	90.79	1.86	0.92	90.62	nm			2.02	1.07	90.47	1.29	0.34	91.20
17-28	92.136	91.100	1.04	1.36	0.32	90.78	1.35	0.31	90.79	1.26	0.23	90.87	2.10	1.07	90.03	nm			2.03	0.99	90.11	2.26	1.22	89.88	1.20	0.16	90.94
17-32	92.178	91.054	1.12	1.55	0.42	90.63	1.30	0.18	90.88	1.33	0.21	90.85	2.17	1.05	90.01	nm			2.14	1.02	90.04	2.37	1.25	89.81	1.28	0.16	90.90
17-36	92.467	91.350	1.12	1.74	0.62	90.73	1.70	0.58	90.77	1.32	0.20	91.15	2.01	0.89	90.46	nm			2.18	1.07	90.28	2.41	1.29	90.06	1.61	0.49	90.86
17-38	92.290	91.235	1.06	1.66	0.60	90.63	1.51	0.45	90.79	1.24	0.18	91.05	2.02	0.97	90.27	nm			2.21	1.15	90.09	2.43	1.37	89.86	1.47	0.41	90.82
17-43	92.760	91.524	1.24	1.16	-0.08	91.60	1.28	0.04	91.48	1.25	0.02	91.51	1.70	0.46	91.07	2.13	0.90	90.63	nm			2.21	0.97	90.55	1.73	0.49	91.03
17-46	92.692	91.629	1.06	1.34	0.27	91.36	1.25	0.19	91.44	1.08	0.02	91.61	2.04	0.98	90.65	2.32	1.26	90.37	nm			2.46	1.39	90.24	1.23	0.16	91.47
17-52	92.551	91.428	1.12	1.09	-0.03	91.46	1.17	0.05	91.38	1.16	0.04	91.39	1.53	0.40	91.02	1.93	0.80	90.62	nm			2.00	0.88	90.55	1.15	0.03	91.40
17-57	92.466	91.423	1.04	1.26	0.22	91.21	1.38	0.33	91.09	1.14	0.10	91.33	1.59	0.54	90.88	1.97	0.92	90.50	nm			2.08	1.03	90.39	1.31	0.27	91.15
17-62	93.002	91.929	1.07	1.05	-0.02	91.95	1.11	0.03	91.90	1.08	0.01	91.92	1.51	0.44	91.49	1.93	0.85	91.08	nm			2.30	1.23	90.70	1.13	0.05	91.88

Notes:
nm - not measured
mbtoc - metres below top of casing
mbgs - metres below ground surface
masl - metres above sea level



KEY MAP



SCALE 1:100,000

LEGEND

- APPROXIMATE BOREHOLE LOCATION
- APPROXIMATE BOREHOLE LOCATION WITH MONITORING WELL
- APPROXIMATE SITE BOUNDARY

NOTE(S)

1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1771847.

REFERENCE(S)

1. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2014
2. SOURCE: ESRI, DIGITALGLOBE, GEOEYE, I-CUBED, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY
3. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: MTM ZONE 9, VERTICAL DATUM: CGVD28

0 100 200 400

1:10,000 METRES

CLIENT
CAIVAN

PROJECT
HYDROGEOLOGICAL ASSESSMENT
PROPOSED RESIDENTIAL DEVELOPMENT
CONSERVANCY LANDS
OTTAWA, ONTARIO

TITLE
SITE PLAN

CONSULTANT

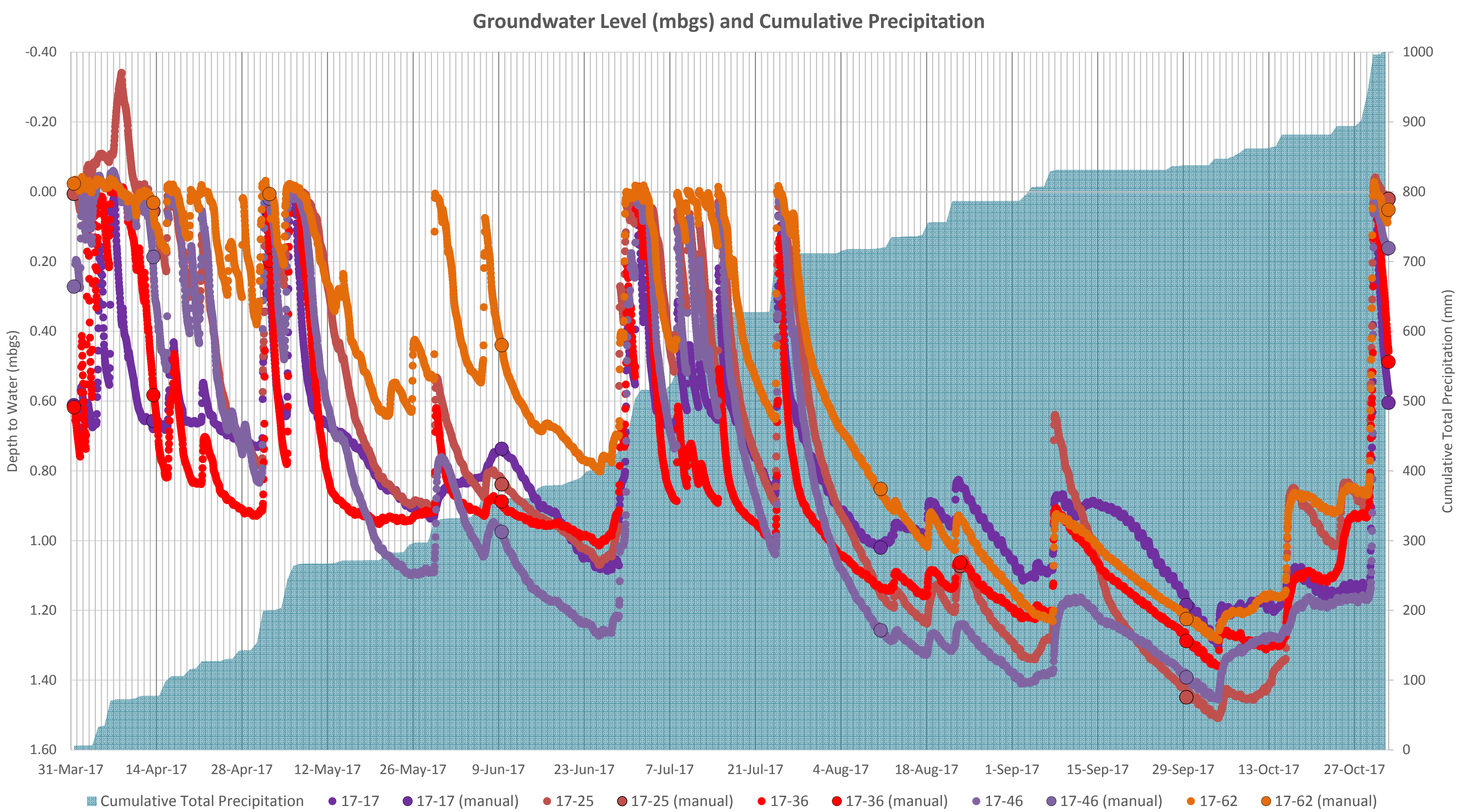
GOLDER

YYYY-MM-DD	2018-07-06
DESIGNED	----
PREPARED	JEM
REVIEWED	SD
APPROVED	TMS

PROJECT NO.	CONTROL	REV.	FIGURE
1771847	0008	0	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

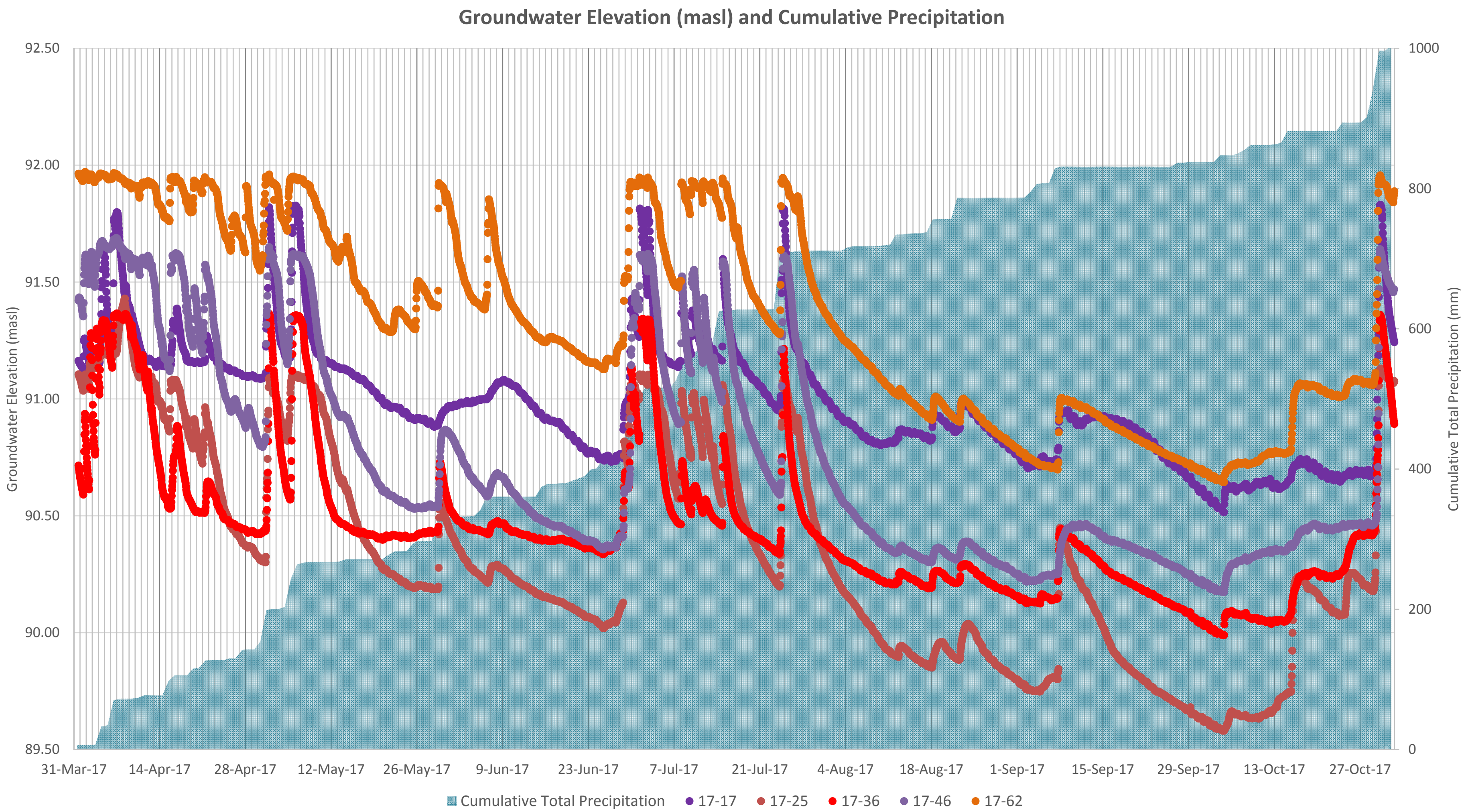
25mm



CLIENT	PROJECT
CAIVAN	Hydrogeological Assessment Proposed Residential Development Conservancy Lands

CONSULTANT		TITLE
GOLDER	YYYY-MM-DD: 2017-07-06 PREPARED: CT DESIGN: CT REVIEW: BTB APPROVED: BTB	Groundwater Depth Data

PROJECT No.		Rev.	
1771847	0001	0	2



CLIENT CAIVAN	PROJECT Hydrogeological Assessment Proposed Residential Development Conservancy Lands
CONSULTANT GOLDER YYYY-MM-DD 2017-07-06 PREPARED CT DESIGN CT REVIEW BTB APPROVED BTB	TITLE Groundwater Elevation Data PROJECT No. 1771847 0001 Rev. 0 3

ATTACHMENT 1

Hydraulic Conductivity Analyses

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST 17-11

INTERVAL (metres below ground surface)

Top of Interval = **3.65**
Bottom of Interval = **5.17**

$$K = \frac{r_c^2}{2L_e} ln\left[\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right]\left[\frac{ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

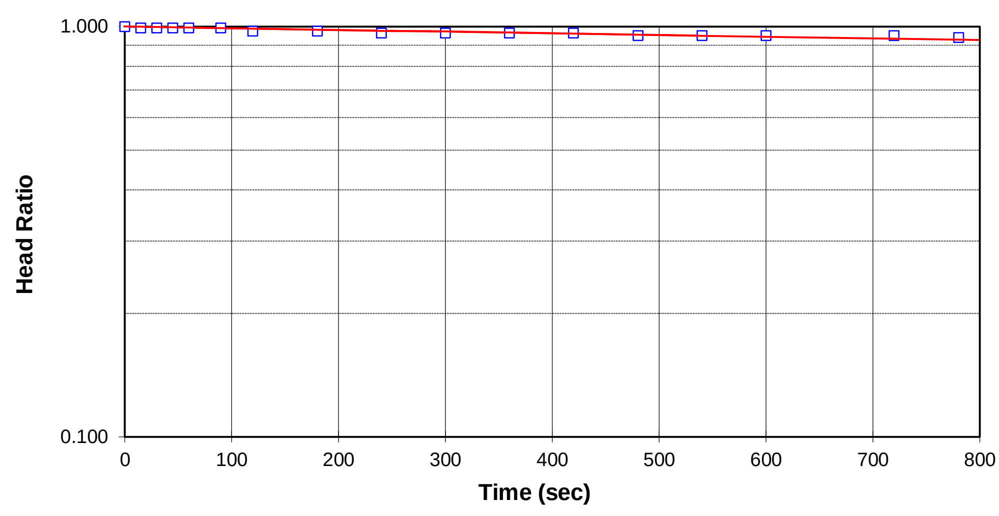
where:
- r_c = casing radius (metres)
- R_e = filter pack radius (metres)
- L_e = length of screened interval (metres)
- t = time (seconds)
- h_t = head at time t (metres)

INPUT PARAMETERS

r_c =	2.5E-02
R_e =	1.0E-01
L_e =	1.5
t_1 =	0
t_2 =	540
h_1/h_0 =	1.00
h_2/h_0 =	0.95

RESULTS

K=	5E-08	m/sec
K=	5E-06	cm/sec



Project Name: Caivan/Barrhaven
Project No.: 1771847
Test Date: 09/06/2017

Analysis By: CWT
Checked By: DH
Analysis Date: 13/06/2017

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST 17-17

INTERVAL (metres below ground surface)

Top of Interval = 1.40
Bottom of Interval = 2.92

$$K = \frac{r_c^2}{2L_e} ln\left[\frac{L_e}{2R_e} + \sqrt{1+\left(\frac{L_e}{2R_e}\right)^2}\right]\left[\frac{ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

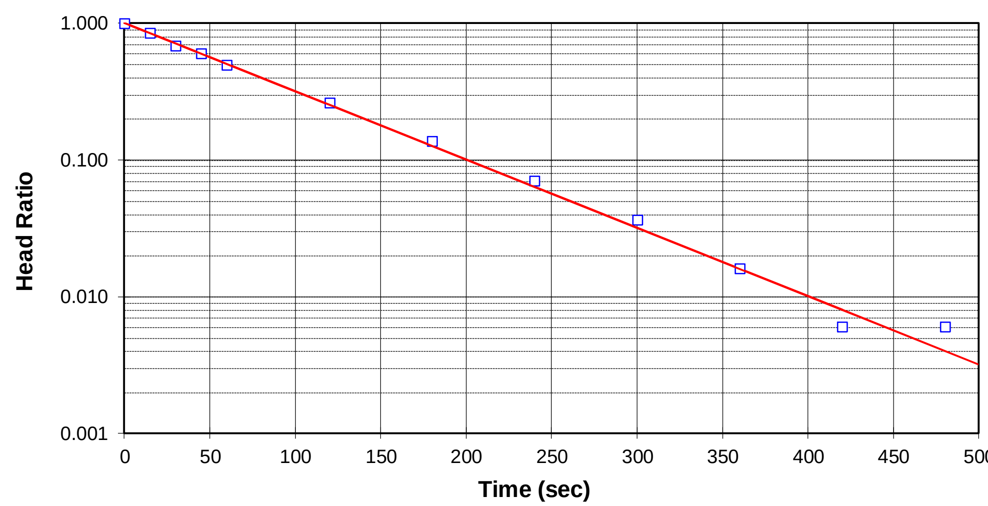
where:
- r_c = casing radius (metres)
- R_e = filter pack radius (metres)
- L_e = length of screened interval (metres)
- t = time (seconds)
- h_t = head at time t (metres)

INPUT PARAMETERS

r_c =	2.5E-02
R_e =	1.0E-01
L_e =	1.5
t_1 =	0
t_2 =	420
h_1/h_0 =	1.00
h_2/h_0 =	0.01

RESULTS

K=	7E-06	m/sec
K=	7E-04	cm/sec



Project Name: Caivan/Barrhaven
Project No.: 1771847
Test Date: 13/04/2017

Analysis By: CWT
Checked By: DH
Analysis Date: 18/04/2017

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST 17-18

INTERVAL (metres below ground surface)

Top of Interval = 1.40
Bottom of Interval = 2.92

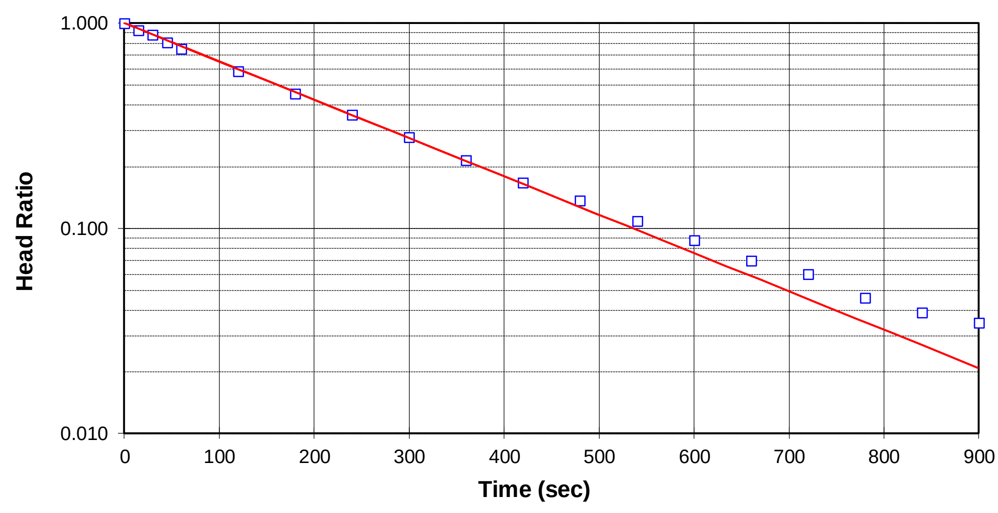
$$K = \frac{r_c^2}{2L_e} ln\left[\frac{L_e}{2R_e} + \sqrt{1+\left(\frac{L_e}{2R_e}\right)^2}\right]\left[\frac{ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

where:
- r_c = casing radius (metres)
- R_e = filter pack radius (metres)
- L_e = length of screened interval (metres)
- t = time (seconds)
- h_t = head at time t (metres)

INPUT PARAMETERS	
r_c =	2.5E-02
R_e =	1.0E-01
L_e =	1.5
t_1 =	0
t_2 =	540
h_1/h_0 =	1.00
h_2/h_0 =	0.10

RESULTS

K=	2E-06	m/sec
K=	2E-04	cm/sec



Project Name: Caivan/Barrhaven
Project No.: 1771847
Test Date: 13/04/2017

Analysis By: CWT
Checked By: 0
Analysis Date: 18/04/2017

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST 17-20

INTERVAL (metres below ground surface)

Top of Interval = 1.40
Bottom of Interval = 2.92

$$K = \frac{r_c^{\ 2}}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right]\left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{\left(t_2 - t_1\right)}\right]$$ where K = (m/sec)

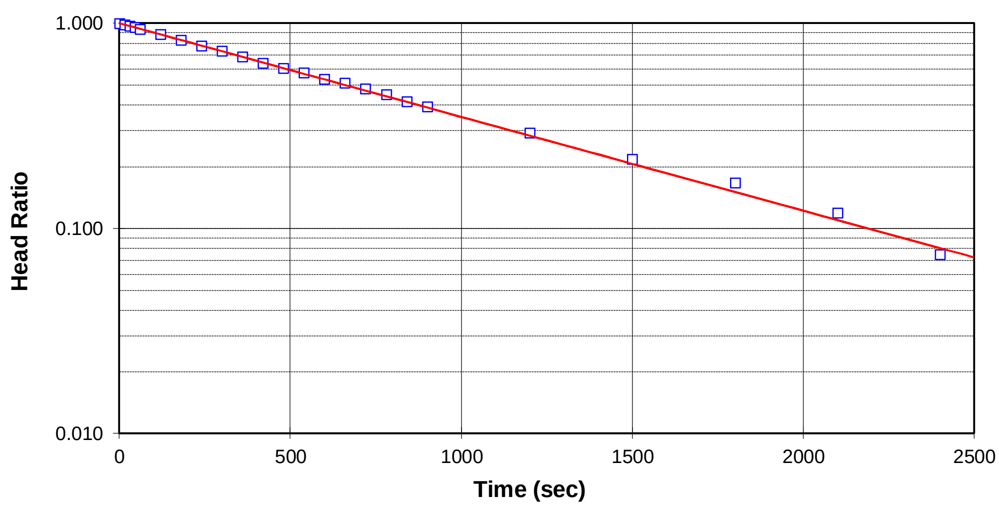
where:
- r_c = casing radius (metres)
- R_e = filter pack radius (metres)
- L_e = length of screened interval (metres)
- t = time (seconds)
- h_t = head at time t (metres)

INPUT PARAMETERS

r_c =	2.5E-02
R_e =	1.0E-01
L_e =	1.5
t_1 =	0
t_2 =	2400
h_1/h_0 =	1.00
h_2/h_0 =	0.08

RESULTS

K=	6E-07	m/sec
K=	6E-05	cm/sec



Project Name: Caivan/Barrhaven
Project No.: 1771847
Test Date: 13/04/2017

Analysis By: CWT
Checked By: DH
Analysis Date: 18/04/2017

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST 17-25

INTERVAL (metres below ground surface)

Top of Interval =	**1.40**
Bottom of Interval =	**2.92**

$$K = \frac{r_c^2}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right] \left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

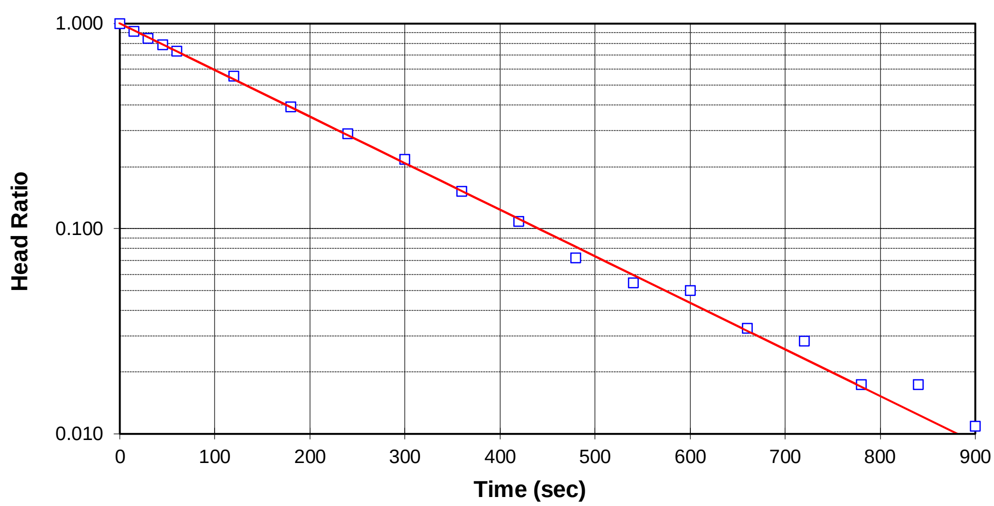
where:
r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS

r_c =	2.5E-02
R_e =	1.0E-01
L_e =	1.5
t_1 =	0
t_2 =	780
h_1/h_0 =	1.00
h_2/h_0 =	0.02

RESULTS

K=	3E-06	m/sec
K=	3E-04	cm/sec



Project Name: Caivan/Barrhaven
Project No.: 1771847
Test Date: 13/04/2017

Analysis By: CWT
Checked By: 0
Analysis Date: 18/04/2017

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST 17-26

INTERVAL (metres below ground surface)

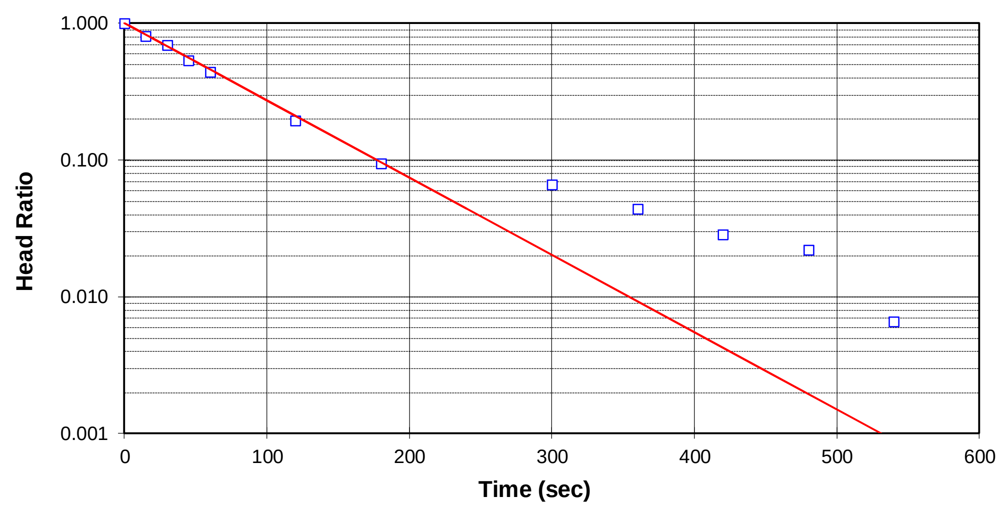
Top of Interval = 1.40
Bottom of Interval = 2.90

$$K = \frac{r_c^2}{2L_e} ln\left[\frac{L_e}{2R_e} + \sqrt{1+\left(\frac{L_e}{2R_e}\right)^2}\right]\left[\frac{ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

where:
r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS	
r_c =	2.5E-02
R_e =	1.0E-01
L_e =	1.5
t_1 =	0
t_2 =	240
h_1/h_0 =	1.00
h_2/h_0 =	0.04

RESULTS		
K=	8E-06	m/sec
K=	8E-04	cm/sec



Project Name: Caivan/Barrhaven
Project No.: 1771847
Test Date: 13/04/2017

Analysis By: CWT
Checked By: DH
Analysis Date: 18/04/2017

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST 17-28

INTERVAL (metres below ground surface)

Top of Interval =	**1.40**
Bottom of Interval =	**2.92**

$$K = \frac{r_c^{\,2}}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1+\left(\frac{L_e}{2R_e}\right)^2}\right]\left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

where:

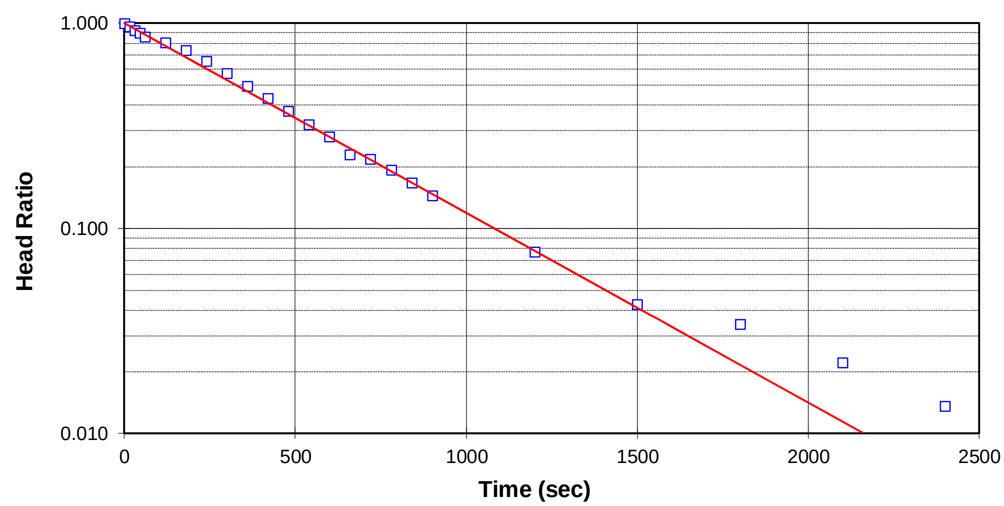
r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS

r_c =	2.5E-02
R_e =	1.0E-01
L_e =	1.5
t_1 =	0
t_2 =	1500
h_1/h_0 =	1.00
h_2/h_0 =	0.04

RESULTS

K=	1E-06	m/sec
K=	1E-04	cm/sec



Project Name: Caivan/Barrhaven
Project No.: 1771847
Test Date: 13/04/2017

Analysis By: CWT
Checked By: DH
Analysis Date: 18/04/2017

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST 17-32

INTERVAL (metres below ground surface)

Top of Interval =	**1.40**
Bottom of Interval =	**2.92**

$$K = \frac{r_c^2}{2L_e} ln\left[\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right]\left[\frac{ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

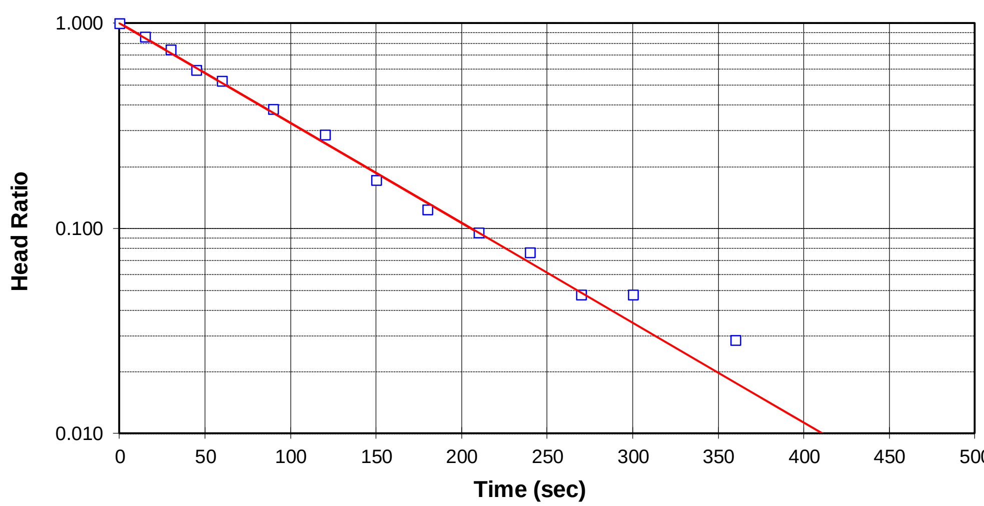
where:
- r_c = casing radius (metres)
- R_e = filter pack radius (metres)
- L_e = length of screened interval (metres)
- t = time (seconds)
- h_t = head at time t (metres)

INPUT PARAMETERS

r_c =	**2.5E-02**
R_e =	**1.0E-01**
L_e =	**1.5**
t_1 =	**0**
t_2 =	**210**
h_1/h_0 =	**1.00**
h_2/h_0 =	**0.10**

RESULTS

K=	**6E-06**	**m/sec**
K=	**6E-04**	**cm/sec**



Project Name: Caivan/Barrhaven
Project No.: 1771847
Test Date: 09/06/2017

Analysis By: CWT
Checked By: DH
Analysis Date: 13/06/2017

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST 17-36

INTERVAL (metres below ground surface)

Top of Interval =	**1.35**
Bottom of Interval =	**2.87**

$$K = \frac{r_c^2}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1+\left(\frac{L_e}{2R_e}\right)^2}\right]\left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

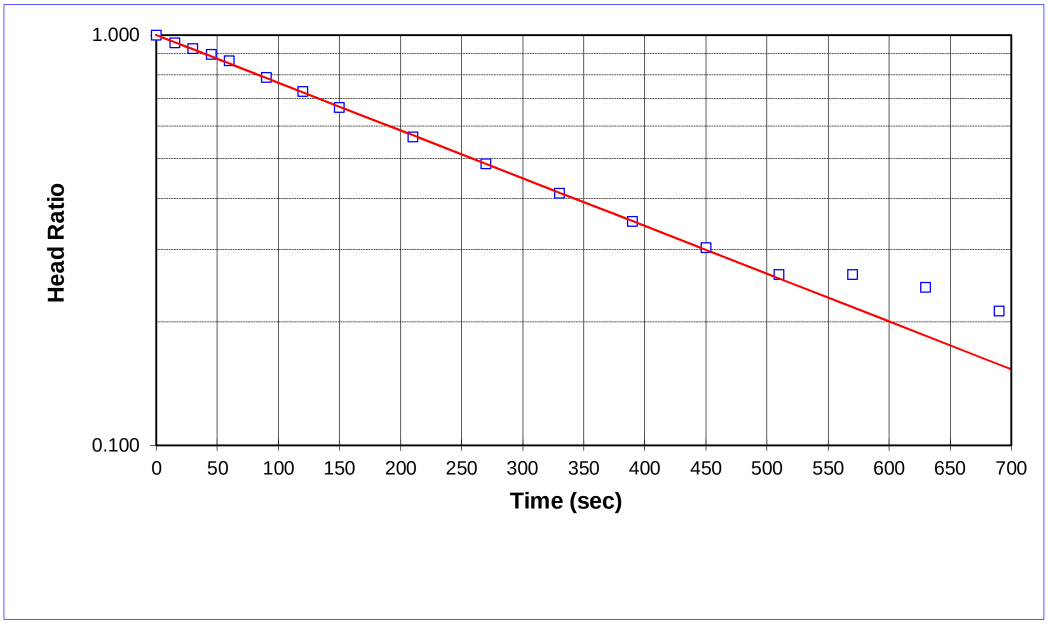
where:
- r_c = casing radius (metres)
- R_e = filter pack radius (metres)
- L_e = length of screened interval (metres)
- t = time (seconds)
- h_t = head at time t (metres)

INPUT PARAMETERS

r_c =	**2.5E-02**
R_e =	**1.0E-01**
L_e =	**1.5**
t_1 =	**0**
t_2 =	**510**
h_1/h_0 =	**1.00**
h_2/h_0 =	**0.26**

RESULTS

K=	**2E-06**	**m/sec**
K=	**2E-04**	**cm/sec**



Project Name:	Caivan/Barrhaven	Analysis By:	CWT
Project No.:	1771847	Checked By:	DH
Test Date:	09/06/2017	Analysis Date:	13/06/2017

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST 17-38

INTERVAL (metres below ground surface)

Top of Interval = 1.40
Bottom of Interval = 2.92

$$K = \frac{r_c^2}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right] \left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

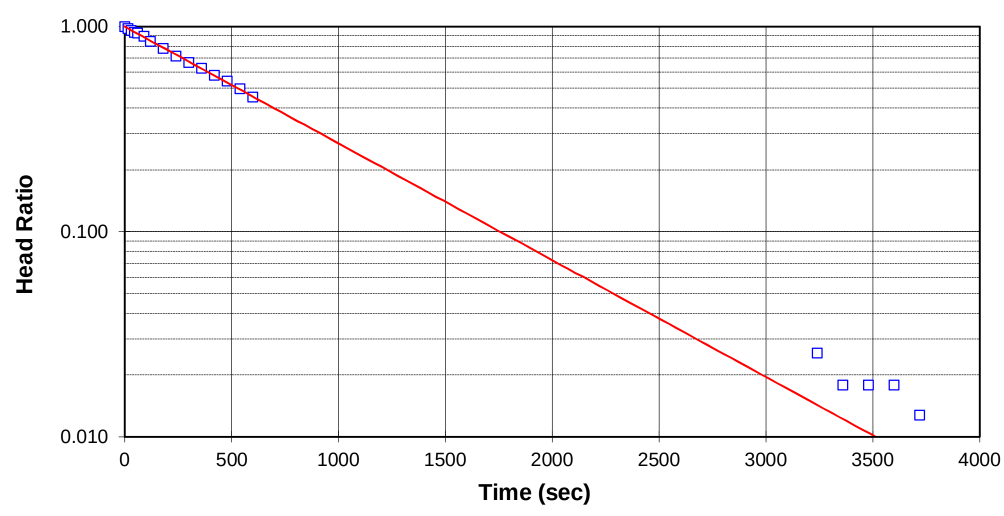
where:
r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS

r_c =	2.5E-02
R_e =	1.0E-01
L_e =	1.5
t_1 =	0
t_2 =	1500
h_1/h_0 =	1.00
h_2/h_0 =	0.14

RESULTS

K=	8E-07	m/sec
K=	8E-05	cm/sec



Project Name: Caivan/Barrhaven
Project No.: 1771847
Test Date: 09/06/2017

Analysis By: CWT
Checked By: DH
Analysis Date: 13/06/2017

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST 17-43

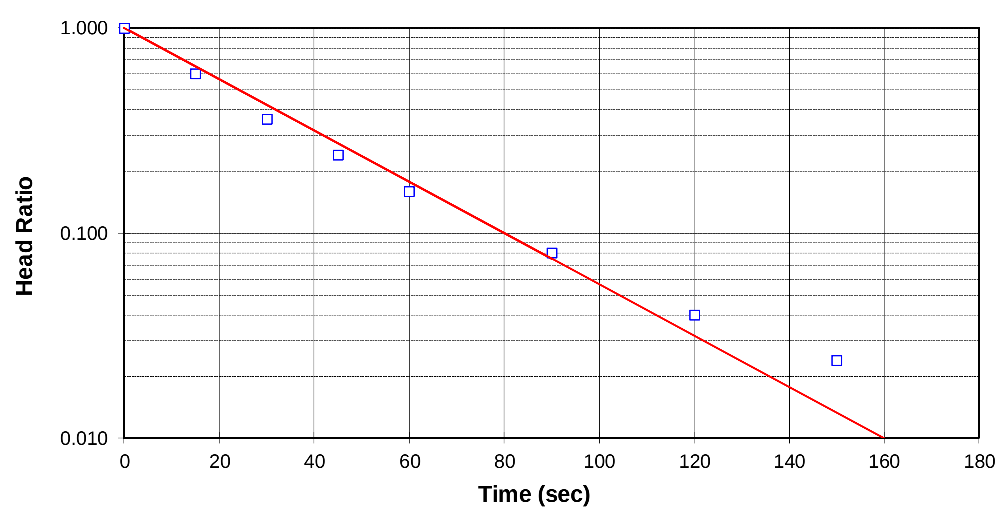
INTERVAL (metres below ground surface)

Top of Interval = 1.40
Bottom of Interval = 2.92

$$K = \frac{r_c^{\,2}}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1+\left(\frac{L_e}{2R_e}\right)^2}\right] \left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{\left(t_2 - t_1\right)}\right]$$ where K = (m/sec)

where: r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS		RESULTS		
r_c =	2.5E-02			
R_e =	1.0E-01			
L_e =	1.5	K=	2E-05	m/sec
t_1 =	0	K=	2E-03	cm/sec
t_2 =	90			
h_1/h_0 =	1.00			
h_2/h_0 =	0.08			



Project Name: Caivan/Barrhaven
Project No.: 1771847
Test Date: 09/06/2017

Analysis By: CWT
Checked By: DH
Analysis Date: 13/06/2017

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST 17-46

INTERVAL (metres below ground surface)

Top of Interval =	**1.40**
Bottom of Interval =	**2.92**

$$K = \frac{r_c^{\,2}}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1+\left(\frac{L_e}{2R_e}\right)^2}\right]\left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

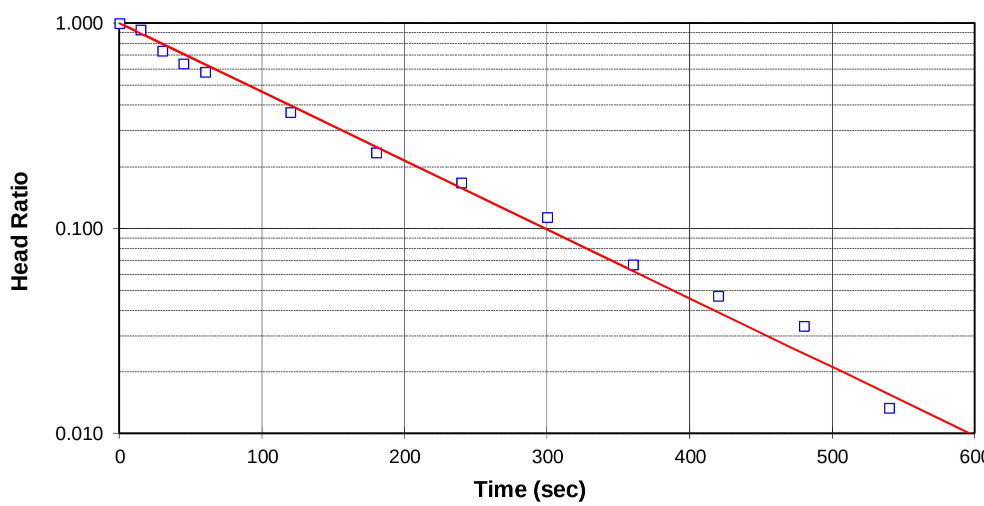
where:
- r_c = casing radius (metres)
- R_e = filter pack radius (metres)
- L_e = length of screened interval (metres)
- t = time (seconds)
- h_t = head at time t (metres)

INPUT PARAMETERS

r_c =	**2.5E-02**
R_e =	**1.0E-01**
L_e =	**1.5**
t_1 =	**0**
t_2 =	**360**
h_1/h_0 =	**1.00**
h_2/h_0 =	**0.06**

RESULTS

K=	**4E-06**	**m/sec**
K=	**4E-04**	**cm/sec**



Project Name: Caivan/Barrhaven
Project No.: 1771847
Test Date: 09/06/2017

Analysis By: CWT
Checked By: DH
Analysis Date: 13/06/2017

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST 17-52

INTERVAL (metres below ground surface)

Top of Interval =	**1.40**
Bottom of Interval =	**2.92**

$$K = \frac{r_c^{\ 2}}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1+\left(\frac{L_e}{2R_e}\right)^2}\right]\left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

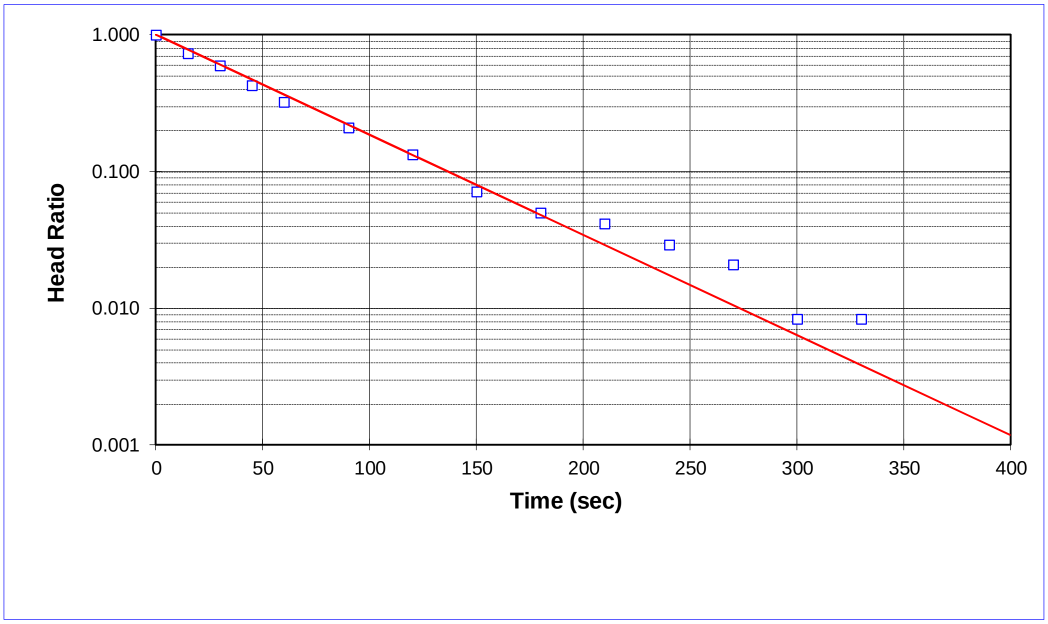
where:
r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS

r_c =	2.5E-02
R_e =	1.0E-01
L_e =	1.5
t_1 =	0
t_2 =	180
h_1/h_0 =	1.00
h_2/h_0 =	0.05

RESULTS

K=	1E-05	m/sec
K=	1E-03	cm/sec



Project Name: Caivan/Barrhaven
Project No.: 1771847
Test Date: 09/06/2017

Analysis By: CWT
Checked By: DH
Analysis Date: 13/06/2017

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST 17-57

INTERVAL (metres below ground surface)

Top of Interval = **1.40**
Bottom of Interval = **2.92**

$$K = \frac{r_c^2}{2L_e} \ln\left[\frac{L_e}{2R_e} + \sqrt{1 + \left(\frac{L_e}{2R_e}\right)^2}\right]\left[\frac{\ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

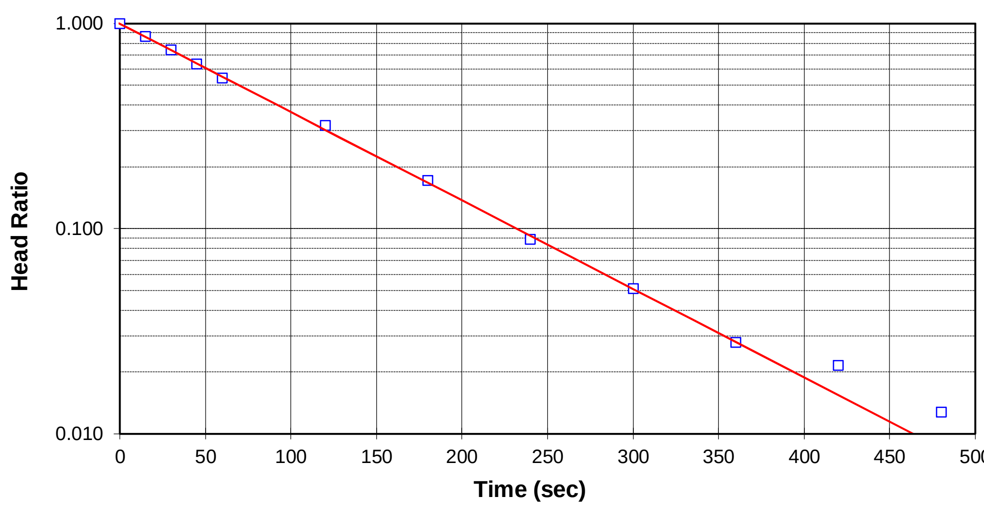
where:
r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS

r_c =	2.5E-02
R_e =	1.0E-01
L_e =	1.5
t_1 =	0
t_2 =	360
h_1/h_0 =	1.00
h_2/h_0 =	0.03

RESULTS

K=	6E-06	m/sec
K=	6E-04	cm/sec



Project Name: Caivan/Barrhaven
Project No.: 1771847
Test Date: 02/05/2017

Analysis By: CWT
Checked By: DH
Analysis Date: 25/05/2017

Golder Associates Ltd.

HVORSLEV SLUG TEST ANALYSIS
RISING HEAD TEST 17-62

INTERVAL (metres below ground surface)

Top of Interval = **1.40**
Bottom of Interval = **2.90**

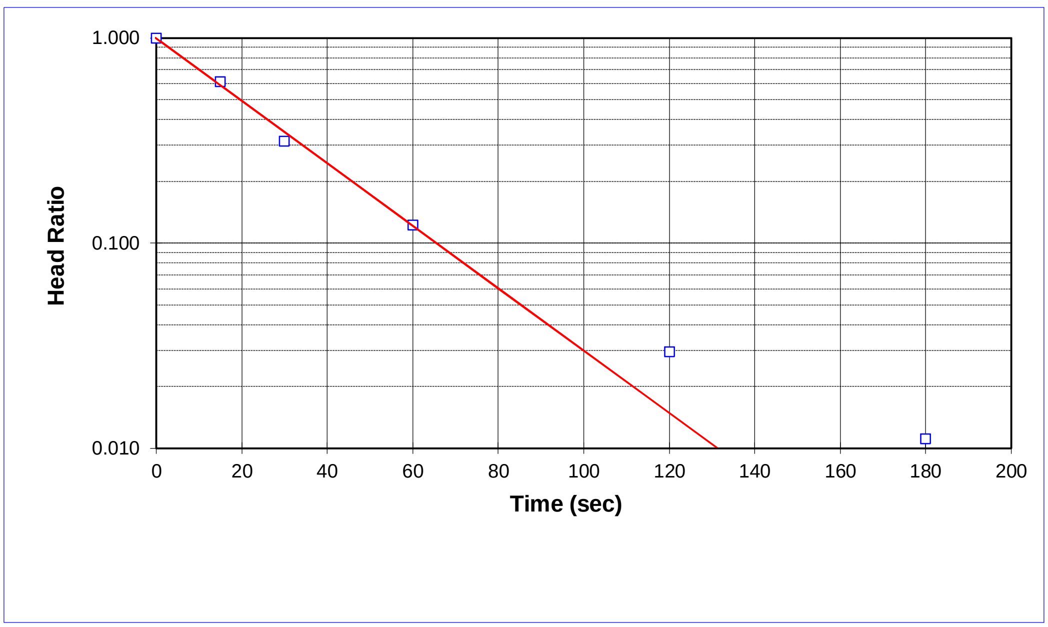
$$K = \frac{r_c^2}{2L_e} ln\left[\frac{L_e}{2R_e} + \sqrt{1+\left(\frac{L_e}{2R_e}\right)^2}\right]\left[\frac{ln\left(\frac{h_1}{h_2}\right)}{(t_2 - t_1)}\right]$$ where K = (m/sec)

where:
r_c = casing radius (metres)
R_e = filter pack radius (metres)
L_e = length of screened interval (metres)
t = time (seconds)
h_t = head at time t (metres)

INPUT PARAMETERS	
r_c =	2.5E-02
R_e =	1.0E-01
L_e =	1.5
t_1 =	0
t_2 =	60
h_1/h_0 =	1.00
h_2/h_0 =	0.12

RESULTS

K=	2E-05	m/sec
K=	2E-03	cm/sec



Project Name: Caivan/Barrhaven
Project No.: 1771847
Test Date: 02/05/2017

Analysis By: CWT
Checked By: DH
Analysis Date: 25/05/2017

Golder Associates Ltd.

ATTACHMENT 2

Groundwater Inflow Calculations

Scenario 1
Inflow to Basement Excavation
Dupuit-Forchheimer Equation:

$$Q = \left(\frac{\pi K (H^2 - h^2)}{\ln\left(\frac{R}{r}\right)} \right)$$

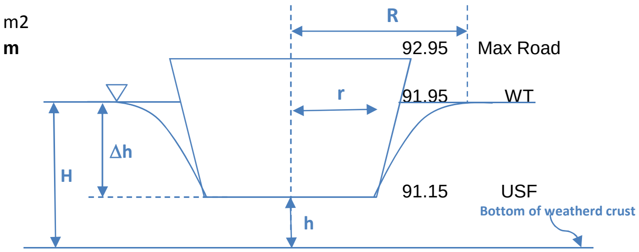
K (m/sec)	3.9E-06	
H (m)	3.1	**r - radius of pit**
h (m)	2.3	**R - radius of influence**
r (m)	**6.2**	

R (m)	ROI from edge	Q (L/s)
8.2	2.0	0.187
9.2	3.0	0.132
11.2	5.0	0.088
16.2	10.0	0.054
21.2	15.0	0.042
26.2	20.0	0.036
36.2	30.0	0.030
46.2	40.0	0.026

Equivalent radius of excavation

AB=pi r^2

width A=	10	m
length B=	12	m
area=	120	m2
r=	6.2	**m**



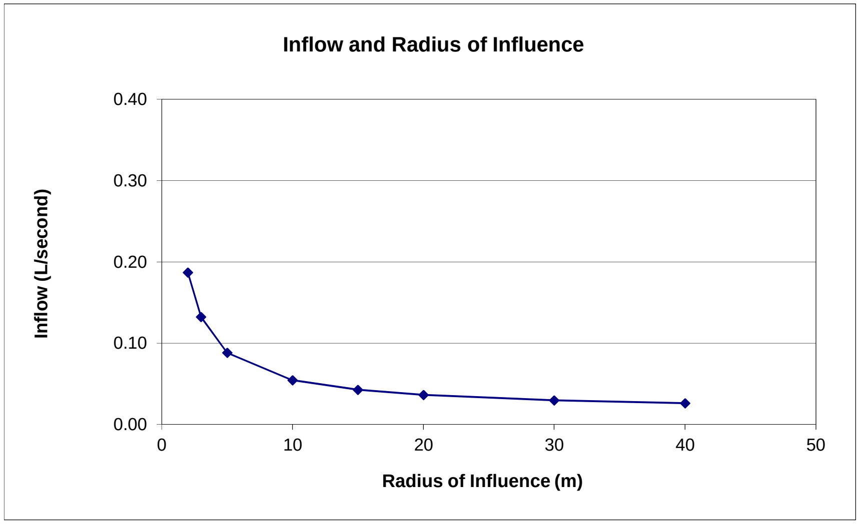
CROSS SECTON

h=	2.27	m
H=	3.07	m
wt =	1.00	mbgs

Sichart and Kyrieleis Equation:

$$R = 3000 \Delta h \sqrt{K}$$

Radius of Influence (m) 5



Notes
L - litres
m - metres
ROI = Radius of Influence (m)

Scenario 2
Inflow to Basement Excavation
Dupuit-Forchheimer Equation:

$$Q = \left(\frac{\pi K (H^2 - h^2)}{\ln\left(\frac{R}{r}\right)} \right)$$

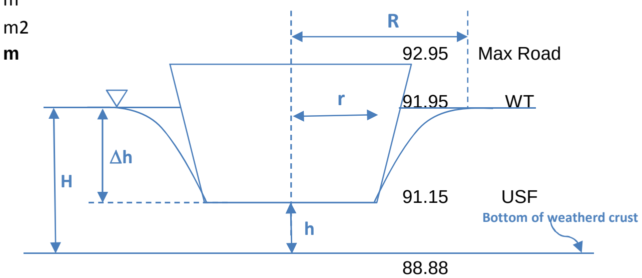
K (m/sec)	2.0E-05		
H (m)	3.1	**r - radius of pit**	
h (m)	2.3	**R - radius of influence**	
r (m)	**6.2**		

R (m)	ROI from edge	Q (L/s)
8.2	2.0	0.957
9.2	3.0	0.678
11.2	5.0	0.453
16.2	10.0	0.279
21.2	15.0	0.218
26.2	20.0	0.186
36.2	30.0	0.152
46.2	40.0	0.133

Equivalent radius of excavation

AB=pi r^2

width A=	10	m
length B=	12	m
area=	120	m2
r=	6.2	**m**



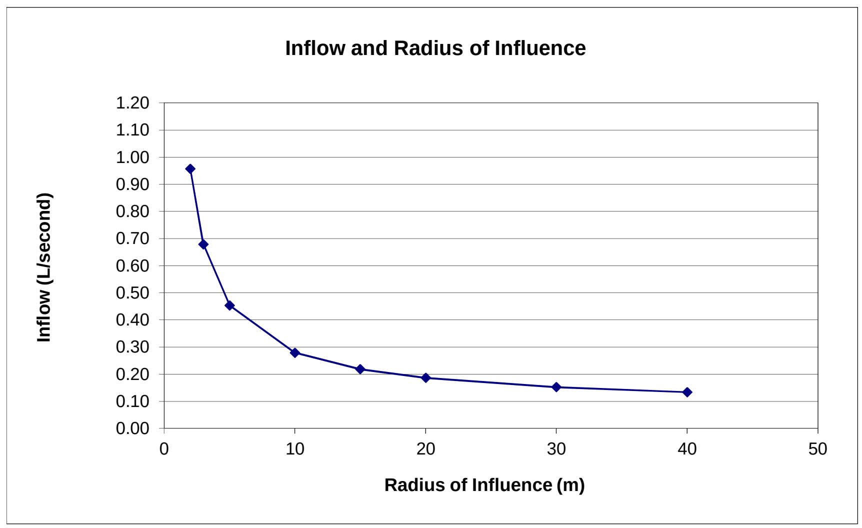
CROSS SECTON

h=	2.27	m
H=	3.07	m
wt =	1.00	mbgs

Sichart and Kyrieleis Equation:

$$R = 3000 \Delta h \sqrt{K}$$

Radius of Influence (m) 11

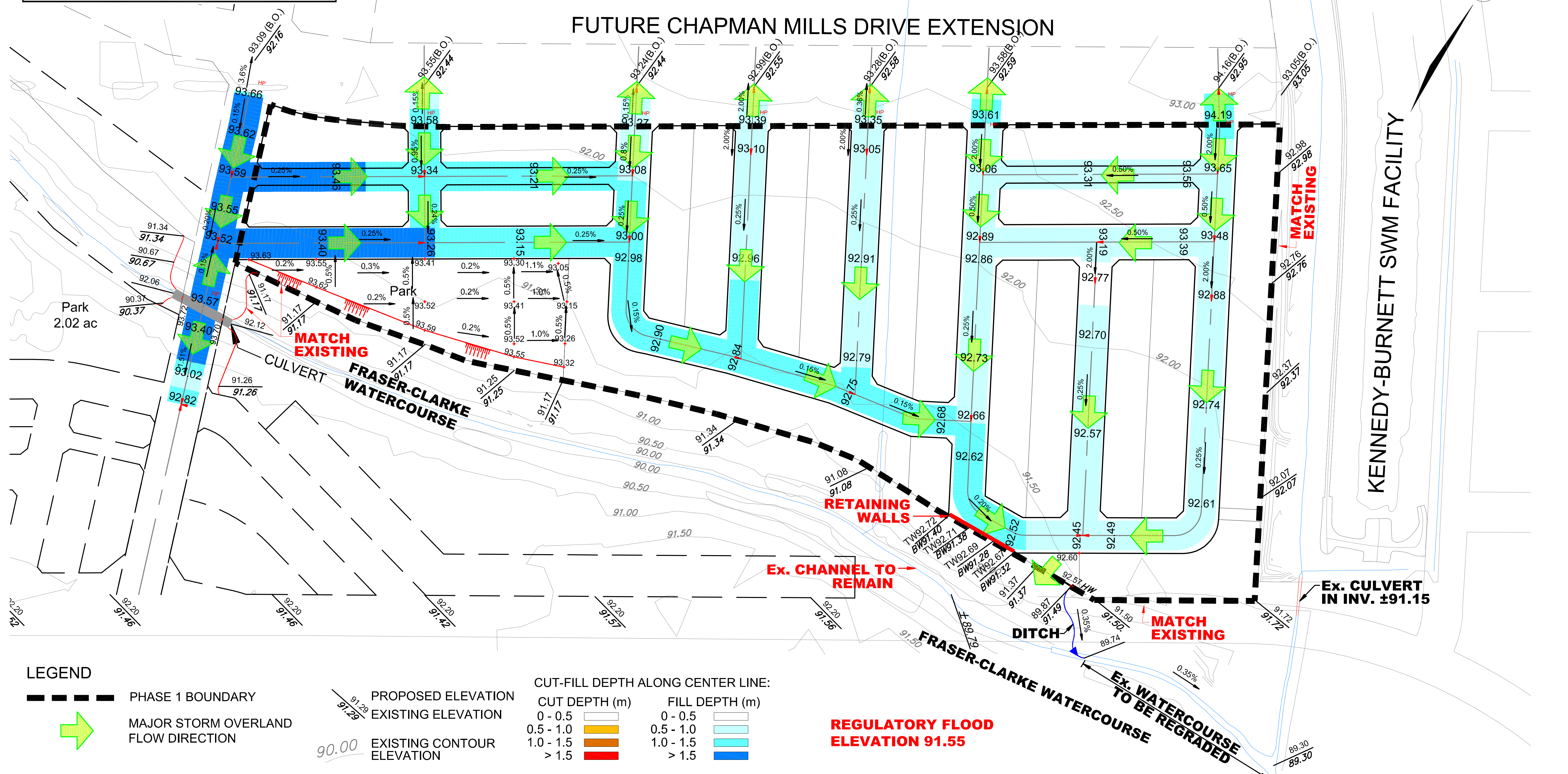


Notes
L - litres
m - metres
ROI = Radius of Influence (m)

ATTACHMENT 3

DSEL Preliminary Grading Plan

ASSUMPTIONS:
- STORM CONNECTIONS WITH SUMP PUMPS
- SAW TOOTH ROAD DESIGN @ MINIMUM 0.15%
- ELEVATIONS SHOWN REPRESENT THE LOWEST ROAD GRADES
- OGS



LEGEND

PHASE 1 BOUNDARY

MAJOR STORM OVERLAND FLOW DIRECTION

91.29 PROPOSED ELEVATION
91.29 EXISTING ELEVATION

90.00 EXISTING CONTOUR ELEVATION

CUT-FILL DEPTH ALONG CENTER LINE:

CUT DEPTH (m)	FILL DEPTH (m)
0 - 0.5	0 - 0.5
0.5 - 1.0	0.5 - 1.0
1.0 - 1.5	1.0 - 1.5
> 1.5	> 1.5

DSEL
david schaeffer engineering ltd
120 Iber Road, Unit 103
Stittsville, ON K2S 1E9
TEL: (613) 836-0856
FAX: (613) 836-7183
www.DSEL.ca

BARRHAVEN CONSERVANCY PHASE 1
PRELIMINARY GRADING PLAN
CITY OF OTTAWA

PROJECT No.:	16-891
SCALE:	1:2000
DATE:	JULY 2018
FIGURE:	7