Template Version: eC120200131 - C BCivil

Appendix C

Groundwater Dewatering Memo

TETRA TECH

TECHNICAL MEMO

ISSUED FOR USE

To:	Kirby McRae	**Date:**	January 24, 2020
c:	Michel Levreault	**Memo No.:**	705-1000120300-MEM-V0001-00
From:	Brent Horning	**File:**	705-1000120300
Subject:	Assessment of Groundwater Conditions near Bourkevale Park River Outfall Site Ferry Road Combined Sewer Relief		

1.0 INTRODUCTION

Initial construction shaft excavation works in the area of the Bourkevale Park River Outfall encountered very wet and soft till deposits at approximately 9 m below grade, with the resulting groundwater inflow rising to approximately 7 m below grade. Subsequent borehole drilling confirmed the presence of a wet till unit through the proposed construction area, while monitoring of the resulting groundwater levels suggested that these were below the winter water level in the Assiniboine River located approximately 80 m to the south. Concerns were therefore expressed that a hydraulic connection between the wet till unit and the river could exist which could then result in more extensive dewatering efforts for future deep excavation works in this area. It was therefore proposed to undertake a limited hydrogeological assessment of the till unit in the area in an attempt to determine potential groundwater inflow rates.

2.0 SCOPE OF WORK AND RESULTS

2.1 Drilling and Well Installation

The on-site borehole drilling and groundwater monitoring well installation activities were undertaken on January 17, 2020 by Maple Leaf Drilling Ltd. under the direction of Tetra Tech Canada Inc. (Tetra Tech). Prior to drilling, the locations of all underground utilities were identified based on the utility mapping previously undertaken as part of the overall sewer relief project, including the “soft dig” exposure of a 350 mm force main running north-south through the general area.

A total of three boreholes were drilled using 125 mm diameter solid stem augers and completed with PVC well screens and casing. These well installations included the following.

- A 100 mm Test Well was installed on the south side of Assiniboine Avenue, in the immediate area of the proposed excavation area and in the immediate vicinity of the underground forcemain and sewer lines running towards the river.
- A 50 mm monitoring well (MW1) was installed approximately 10 m to the southwest of the Test Well, to the west of the underground lines.
- A 50 mm monitoring well (MW2) was installed approximately 16 m to the north of the Test Well, on the south edge of the boulevard on the north side of Assiniboine Avenue.

These borehole/ well locations are shown on Figure 1, attached.

Tetra Tech Canada Inc.
400-161 Portage Avenue East
Winnipeg, MB R3B 0Y4
Tel 204.954.6800 Fax 204.988.0546

During drilling, the auger flights were retrieved from the boreholes at 3.0 m intervals for visual examination of the subsurface soil conditions. This inspection found the subsurface materials in the Test Well and MW2 locations to consist of a brown clay followed by dark grey clay to a depth of 6.3 m to 7.4 m below grade. In MW1, subsurface soil comprised a silt fill material, potentially associated with the near by subsurface gate chamber structure, to a depth of 5.0 m below grade, followed by dark grey clay to 8.7 m below grade with a 0.3 m thick black sand seam partway through. The dark grey clay in each of the three boreholes was followed by light grey wet silt and silt till to 8.5 m to 9.2 m below grade. Below this depth, a relatively firm silt, clay and gravel till with no significant water content was encountered. Upon reaching the wet till, free water was noted in each borehole, rising to a height of approximately 6.0 m below grade.

The groundwater wells were constructed with 1.5 m to 3.0 m long screen sections set within the wet till portion of the borehole, and solid casing to a height of approximately 0.8 m above grade. Sloughing of the boreholes partially filled the annulus adjacent to the screen sections of the wells, with clean silica sand added to a height approximately 0.5 m above the top of the screen. The borehole annulus adjacent to the solid casing was filled with granular bentonite to ground level. Each well was equipped with a J-plug type cap, and the two 50 mm diameter monitoring wells were completed with protective steel aboveground casings.

Top of well casing and ground surface elevations for each of the three well installations were subsequently surveyed relative to mean sea level.

Borehole logs describing the subsurface soil conditions encountered and well construction details are presented in Appendix A.

2.2 Hydraulic Conductivity Testing

The newly installed wells were allowed to equilibrate overnight with the surrounding subsurface water bearing formation. Measurement of the depth to groundwater were recorded on January 18 and showed water levels to be between 4.2 m and 5.3 m below grade. The resulting calculated ground water elevations showed water levels in the Test Well and MW1 to be relatively close, while MW2, showed an approximately 0.55 m higher elevation, suggesting a southerly groundwater flow direction, towards the Assiniboine River. These elevations are shown on the borehole logs and on Figure 1.

Each well was then purged using a bailer in an effort to develop the well screen sections and to assess the general rate of groundwater inflow. Each well was dewatered through the removal of just over the equivalent of one well casing volume of water, suggesting limited groundwater inflow rates.

Monitoring wells MW1 and MW2 were equipped with electronic data logging pressure transducers to record water level fluctuations in the well casing, and the groundwater levels in the wells were allowed to recover for several hours following purging. These two wells were then subjected to hydraulic conductivity testing through the use of a physical slug. A slug was lowered into the water column in each of the two monitoring wells resulting in a near instantaneous rise in the water level. The rate of the water level decrease to its original static level was then recorded by the transducers, to complete a falling head test. On the morning of January 19, 2020, the slugs were removed producing a near instantaneous lowering of the water level, with the subsequent return to static water levels again being recorded in the form of a rising head test. Later on January 19, the pressure transducer from MW2 was placed into the Test Well and the falling and rising head slug test procedure was repeated for this well.

The water level fluctuations recorded by the pressure transducers was analyzed using the AquiferTest Pro™ software. Based on the subsurface conditions observed, the Hvorslev analytical method was determined to be appropriate for calculation of the hydraulic conductivity of the water bearing silt till unit. These analyses showed a

range of hydraulic conductivity values of 3.8 x 10^{-8} m/s to 2.1 x 10^{-7} m/s, with a median value of 1.4 x 10^{-7} m/s, as summarized below. These values are consistent with representative values for a silt till formation.

AquiferTest Pro Slug Test Analysis		
Well ID	**Falling Head**	**Rising Head**
MW1	2.10E-07	1.30E-07
MW2	6.00E-08	1.50E-07
Test well	3.80E-08	1.50E-07
Median =		1.40E-07
Average =		1.23E-07

Copies of the hydraulic conductivity plots produced by these slug tests are provided in Appendix B.

2.3 Groundwater Inflow Calculation

It is anticipated that the required excavation in this area will be approximately 5 m long by 5 m wide and extend to a depth of approximately 9.5 m below grade. Groundwater infiltration into the excavation is therefore anticipated along the side walls of the excavation through the wet till unit generally encountered between 7 and 9 m below grade. Minimal infiltration is anticipated through the stiff till base of the excavation.

An estimate of the total groundwater inflow volume for this proposed excavation was then calculated based on the median hydraulic conductivity calculated for the wet till unit, and established analytical solutions for steady-state groundwater inflows to rectangular excavations as compiled by S.S. Papadopulos & Associates Inc. The resulting total groundwater flow in to the proposed excavation is therefore estimated to be in the order of 0.01 L/s (1180 L/day or 0.2 Imperial gallons per minute (Igpm)).

In the above calculation, the area of influence of the resulting groundwater drawdown cone is calculated using an established method (Sichardt and Kryieleis). The resulting value of 5.6 m is considered valid since no noticeable impact to groundwater levels were noted in monitoring well MW1 located 10 m from the Test Well during either the initial purging or the slug test activities. As a test of the potential range of groundwater inflow rates due to natural subsurface heterogeneity, the radius of influence of the groundwater drawdown cone was reduced to 1.0 m from the edge of the excavation to be indicative of faster recharge (e.g., potential hydraulic connection to the river). The resulting groundwater inflow in this situation is estimated at 0.05 L/s (4060 L/ day or 0.6 Igpm).

The input and output for these calculations are presented in Appendix C.

3.0 DISCUSSION/ CONCLUSIONS

Based on the subsurface stratigraphy encountered during the December 2019 and January 2020 borehole drilling events and subsequent hydraulic conductivity testing, a water bearing silt and silt till unit is generally present throughout the area at depths of approximately 7 m to 9 m below grade. Although this unit has a significant water content, the fine grained nature of the silt limits its ability to transmit this water. A 5 m x 5m open excavation in to this unit is therefore expected to produce in the order of 1000 L/day to 4000 L/day which could be managed through the use of a typical sump pump arrangement in the base of the excavation.

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5.0 CLOSURE

We trust this technical memo meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech Canada Inc.

705-1000120300-V0001-00
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BH/ac

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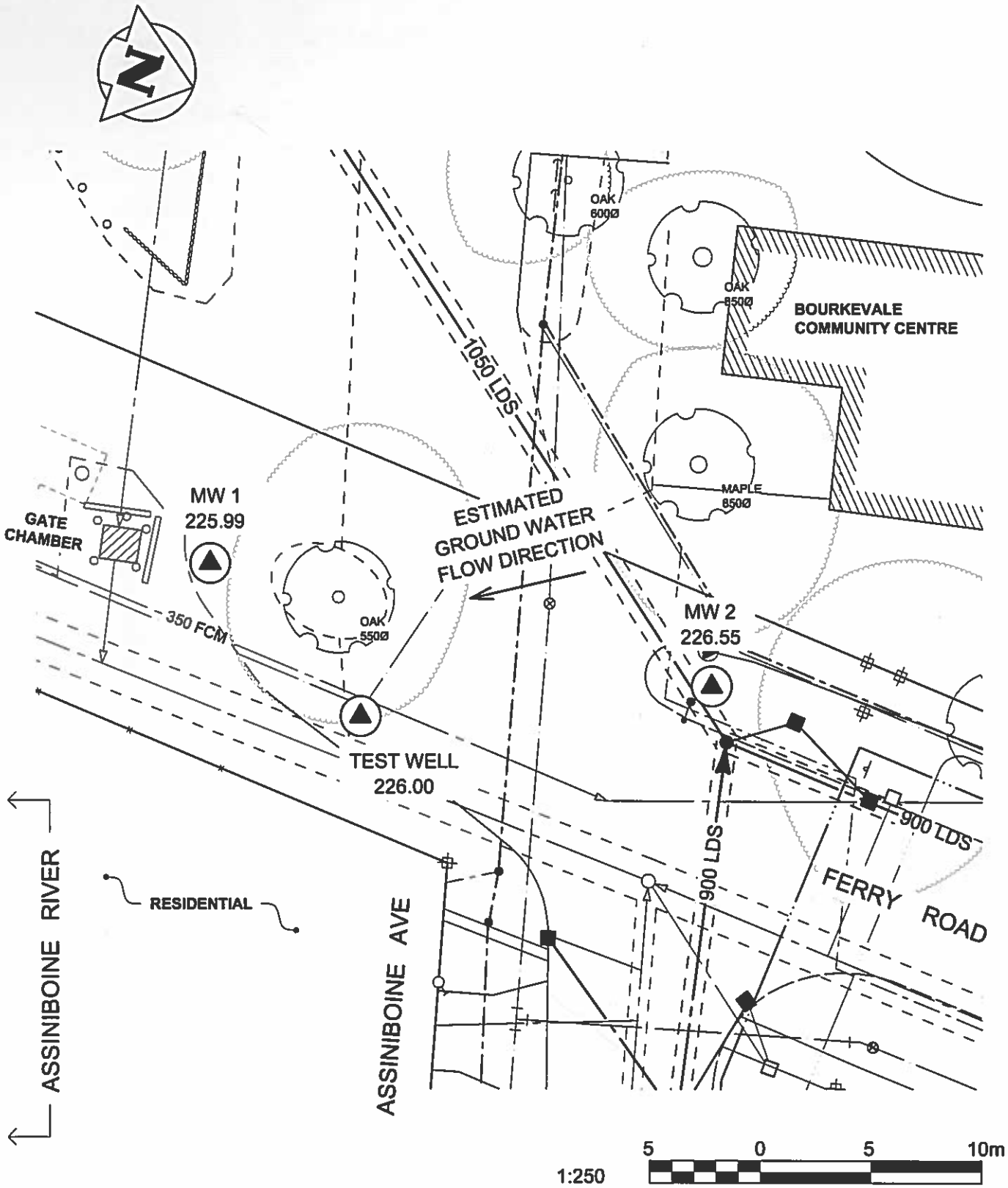
FIGURES



- TEST WELL/ MONITORING WELL

FCM	FORCEMAIN
LDS	LAND DRAINAGE SEWER
900	PIPE DIAMETER (mm)
226.000	GROUNDWATER ELEVATION (m) ASL

TETRA TECH
Complex World
Clear Solutions

DRAWING DESCRIPTION

TEST WELL AND MONITORING WELL LOCATIONS FOR FERRY ROAD CSR WORKS CONTRACT 7A

DESIGNED BY:	DRAWN BY: NL	DRAWING NO.	REV.
REVIEWED BY:	SCALE: 1:250	FIGURE 1	A

X:\A-CIC\CITY OF WINNIPEG - WATER & WASTE DEPARTMENT - 0012\1000\203.03 - FERRY ROAD\CONTRACT 7\CADSKETCH\SWELLS AT BOURKEVALE PARK.DWG 20.01.23 11:22 AM

APPENDIX A

BOREHOLE LOGS

TETRA TECH

RECORD OF BOREHOLE

Test Well

Sheet 1 of 1

705-1000120300

CLIENT: City of Winnipeg | DATE DRILLED: January 17, 2020 | DATUM: Geodetic

PROJECT TITLE: Ferry Road CSO Renewal | PROJECT SITE: South End of Ferry Road, Winnipeg | NORTHING: 5526194.397

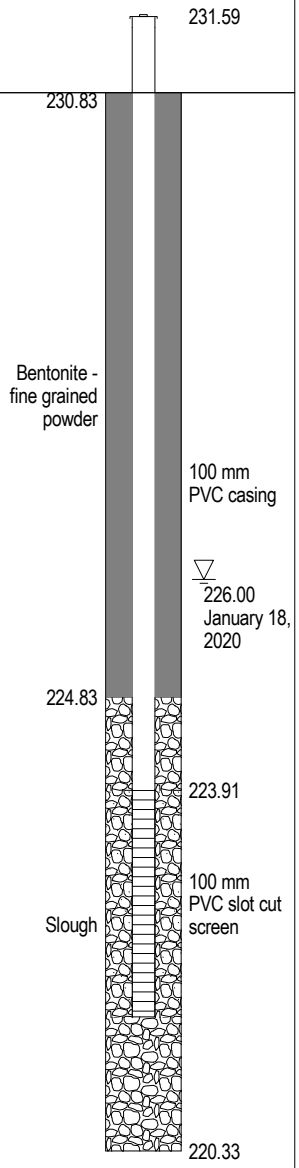
BOREHOLE LOCATION: Northeast corner of CSO Outfall Structure Property. | EASTING: 627944.981

BORING METHOD: Maple Leaf Drilling Ltd., Acker Renegade Track Rig, Auger - Solid Stem

DEPTH SCALE (m / ft)

ELEV DEPTH (m)	DESCRIPTION	SYMBOLS	SAMPLE NAME	SAMPLE TYPE	LAB TESTING (Primary)	LAB TESTING (Secondary)	GUIDELINE COMPARISON
230.83	Ground Surface						
230.33	**Gravel** Surface fill, fine grained, brown, frozen.						
0.50	**Clay** Some silt, brown, soft, non plastic, moist. - Frost penetration to 1.1 m below grade.						
225.83							
5.00	**Clay** Some silt, dark grey, soft, damp.						
224.53							
6.30	**Silt** Some clay, dark grey, soft, wet.						
223.53							
7.30	**Till** Silt, trace gravel, light grey, very soft, wet.						
221.63							
9.20	**Till** Silt, trace gravel, light grey, semi-stiff, damp.						
220.33							
10.50	***End of Borehole at 10.50m***						

MONITORING WELL
Test Well



SCALE 1: 75.0 | LOGGED BY: BH | CHECKED BY:

TETRA TECH

RECORD OF BOREHOLE

MW1

705-1000120300

CLIENT: City of Winnipeg | DATE DRILLED: January 17, 2020 | DATUM: Geodetic

PROJECT TITLE: Ferry Road CSO Renewal | PROJECT SITE: South End of Ferry Road, Winnipeg | NORTHING: 5526185.633

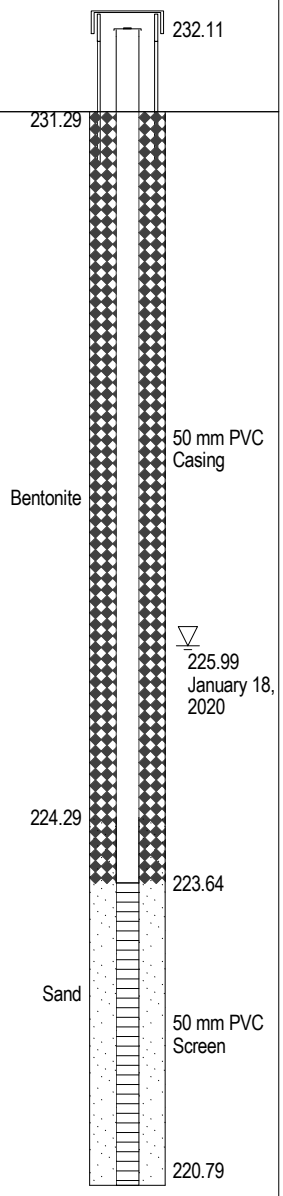
BOREHOLE LOCATION: Northeast corner of CSO Outfall Structure Property - 10 m southwest of Test Well. | EASTING: 627940.898

BORING METHOD: Maple Leaf Drilling Ltd., Acker Renegade Track Rig, Auger - Solid Stem

DEPTH SCALE (m / ft)

ELEV DEPTH (m)	DESCRIPTION	SYMBOLS	SAMPLE NAME	SAMPLE TYPE	LAB TESTING (Primary)	LAB TESTING (Secondary)	GUIDELINE COMPARISON
231.29	Ground Surface						
	Silt With sand, brown, loose, dry. Possibly fill from adjacent combined sewer gate chamber install? - Frost penetration to 1.0 m below grade. - Stiff at 3.0 m. - Soft at 4.0 m.						
226.29 (5.00)	**Clay** Dark gray, stiff, moist to wet.						
224.59 (6.70)	**Sand** Black, fine grained, damp.						
224.29 (7.00)	**Clay** Some brown silt inclusions, grey, soft, damp.						
222.59 (8.70)	**Till** Silt, light grey, soft, wet.						
222.09 (9.20)	**Till** Silt, trace gravel, grey and brown, stiff, damp						
220.64 (10.65)	***End of Borehole at 10.65m***						

MONITORING WELL MW1



SCALE 1: 75.0 | LOGGED BY: BH | CHECKED BY:

TETRA TECH

RECORD OF BOREHOLE

MW2

Sheet 1 of 1

705-1000120300

CLIENT: City of Winnipeg | DATE DRILLED: January 17, 2020 | DATUM: Geodetic

PROJECT TITLE: Ferry Road CSO Renewal | PROJECT SITE: South End of Ferry Road, Winnipeg | NORTHING: 5526208.825

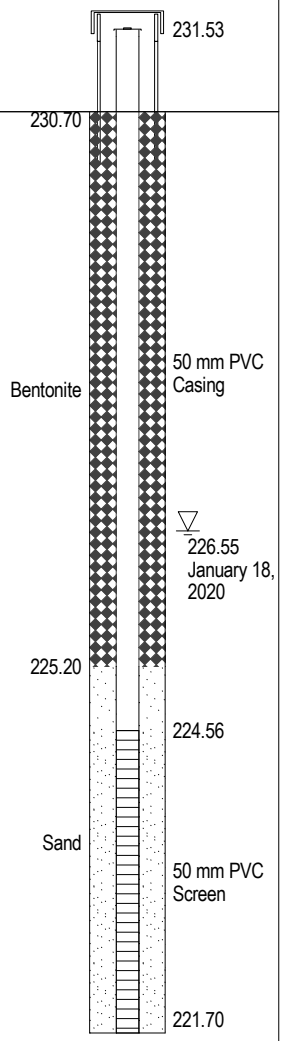
BOREHOLE LOCATION: South end of boulevard east of Bourkevale Community Centre. | EASTING: 627938.16

BORING METHOD: Maple Leaf Drilling Ltd., Acker Renegade Track Rig, Auger - Solid Stem

DEPTH SCALE (m / ft)

ELEV DEPTH (m)	DESCRIPTION	SYMBOLS	SAMPLE NAME	SAMPLE TYPE	LAB TESTING (Primary)	LAB TESTING (Secondary)	GUIDELINE COMPARISON
230.70	Ground Surface						
230.40 / 0.30	**Gravel** Surface fill, brown, fine grained, frozen.						
	Clay Brown, stiff, moist. - Frost penetration to 0.9 m below grade. - Grey silt seam at 4.0 m below grade.						
225.70 / 5.00	**Clay** Some silt, dark grey, soft, highly plastic, damp. - Becomes wet at 6.2 m below grade.						
223.30 / 7.40	**Till** Silt, trace gravel, soft, wet.						
222.20 / 8.50	**Till** Silt, trace gravel, semi-stiff, damp.						
221.56 / 9.14	***End of Borehole at 9.14m***						

MONITORING WELL MW2



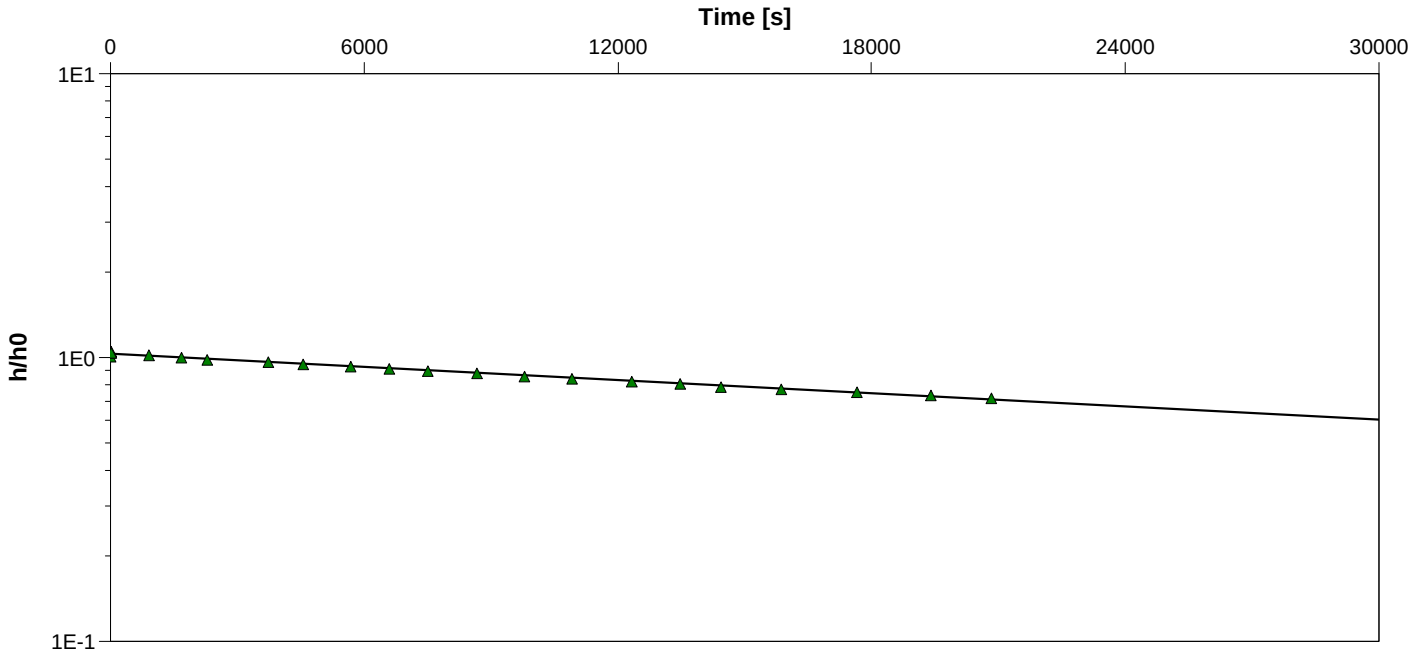
SCALE 1: 75.0 | LOGGED BY: BH | CHECKED BY:

APPENDIX B

HYDRAULIC CONDUCTIVITY GRAPHS

TETRA TECH	**Slug Test Analysis Report**
	Project: Ferry Road Groundwater
	Number: 705-1000120300
	Client: City of Winnipeg

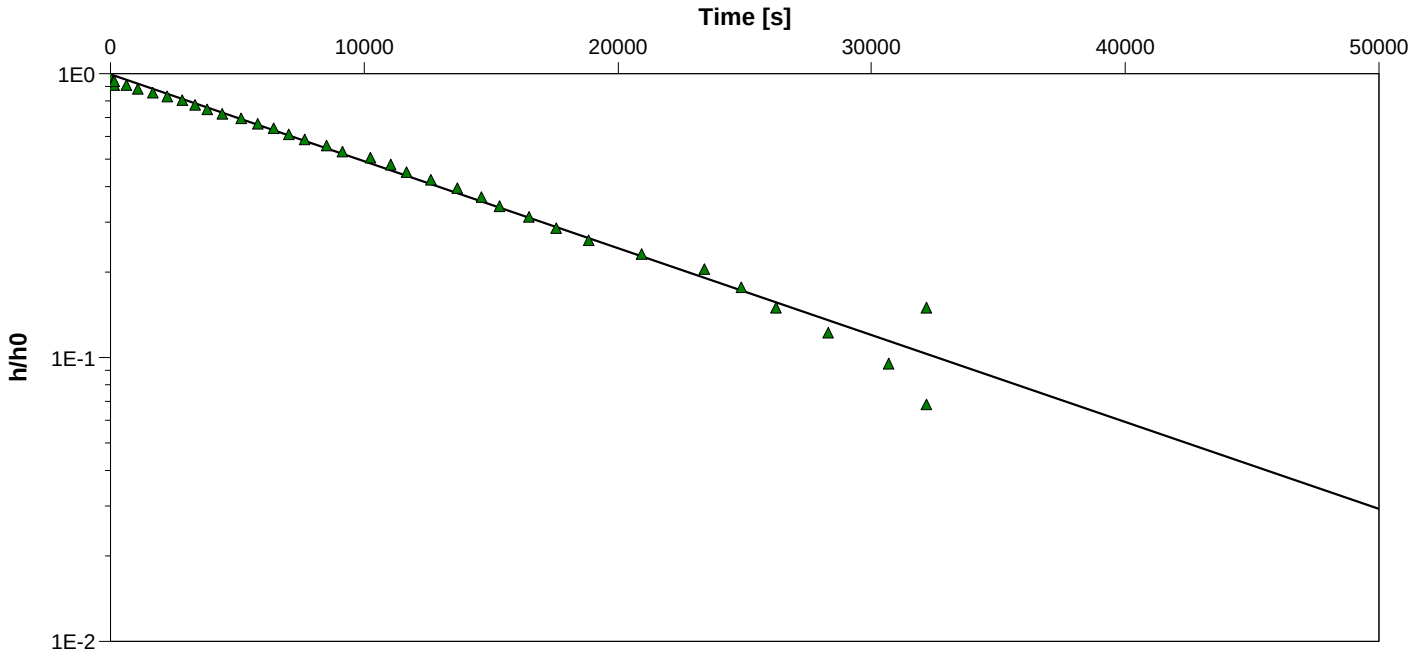
Location: Ferry Road - Winnipeg	Slug Test: Test Well Rising Head	Test Well: Test Well
Test Conducted by:		Test Date: 1/19/2020
Analysis Performed by:	Rising Head	Analysis Date: 1/21/2020
Aquifer Thickness:		



Calculation using Hvorslev		
Observation Well	Hydraulic Conductivity [m/s]	
Test Well	3.80×10^{-8}	

TETRA TECH	**Slug Test Analysis Report**
	Project: Ferry Road Groundwater
	Number: 705-1000120300
	Client: City of Winnipeg

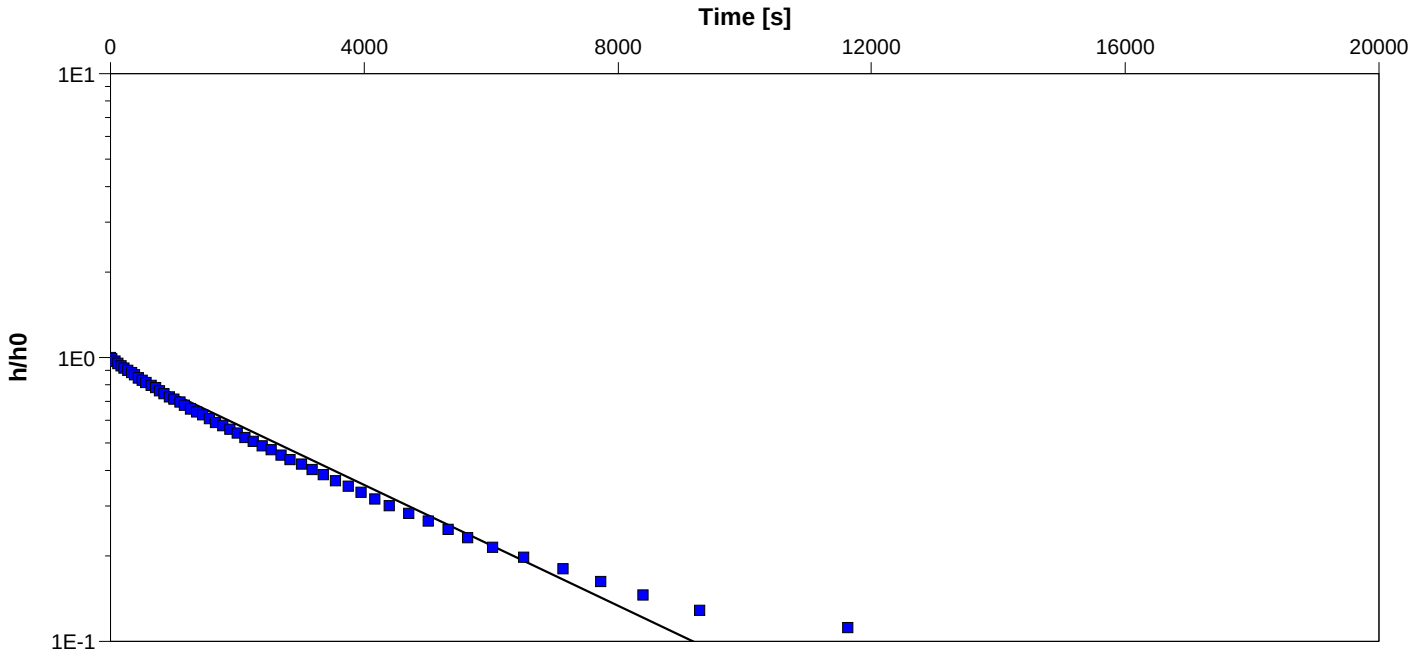
Location: Ferry Road - Winnipeg	Slug Test: Test Well Falling Head	Test Well: Test Well
Test Conducted by:		Test Date: 1/19/2020
Analysis Performed by:	Falling Head	Analysis Date: 1/21/2020
Aquifer Thickness:		



Calculation using Hvorslev		
Observation Well	Hydraulic Conductivity [m/s]	
Test Well	1.50×10^{-7}	

TETRA TECH	**Slug Test Analysis Report**
	Project: Ferry Road Groundwater
	Number: 705-1000120300
	Client: City of Winnipeg

Location: Ferry Road - Winnipeg	Slug Test: MW1Falling Head	Test Well: MW1
Test Conducted by: B. Honring		Test Date: 1/18/2020
Analysis Performed by:	Falling Head	Analysis Date: 1/21/2020
Aquifer Thickness: 2.00 m		

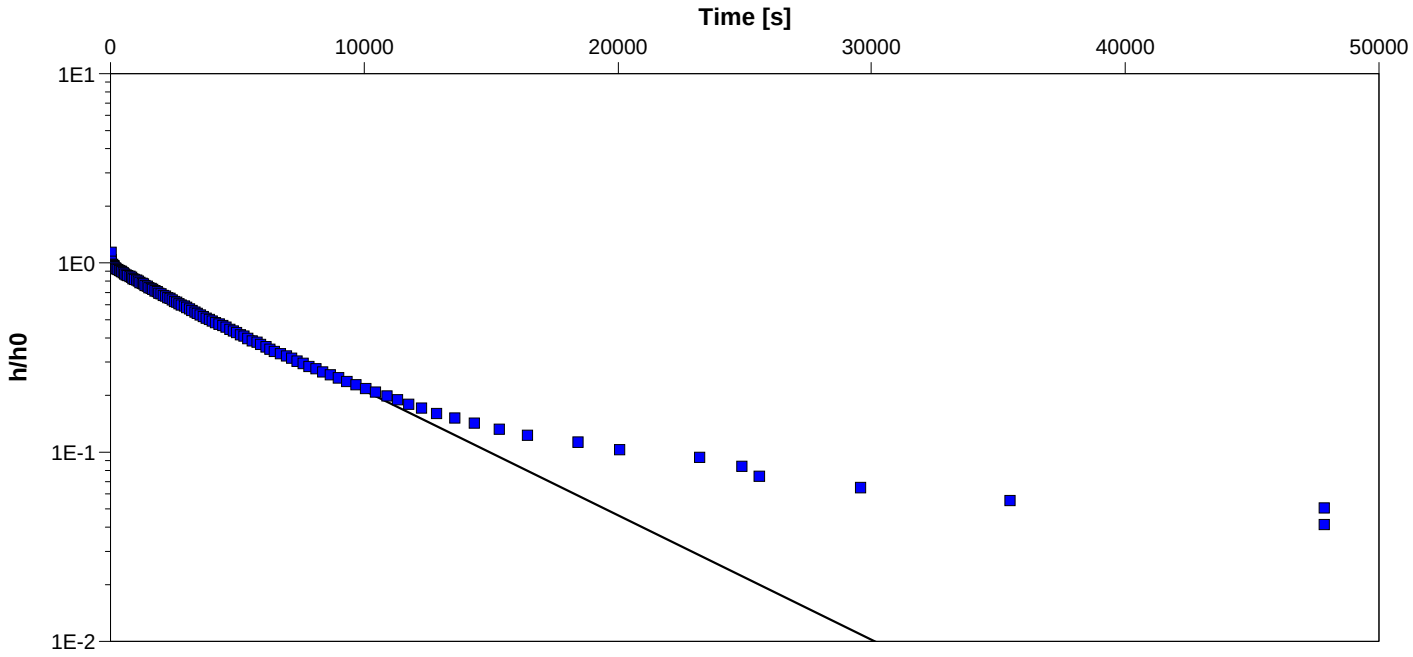


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW1	2.10×10^{-7}	

TETRA TECH	**Slug Test Analysis Report**
	Project: Ferry Road Groundwater
	Number: 705-1000120300
	Client: City of Winnipeg

Location: Ferry Road - Winnipeg	Slug Test: MW1 Rising Head	Test Well: MW1
Test Conducted by:		Test Date: 1/18/2020
Analysis Performed by:	Rising Head	Analysis Date: 1/21/2020
Aquifer Thickness:		

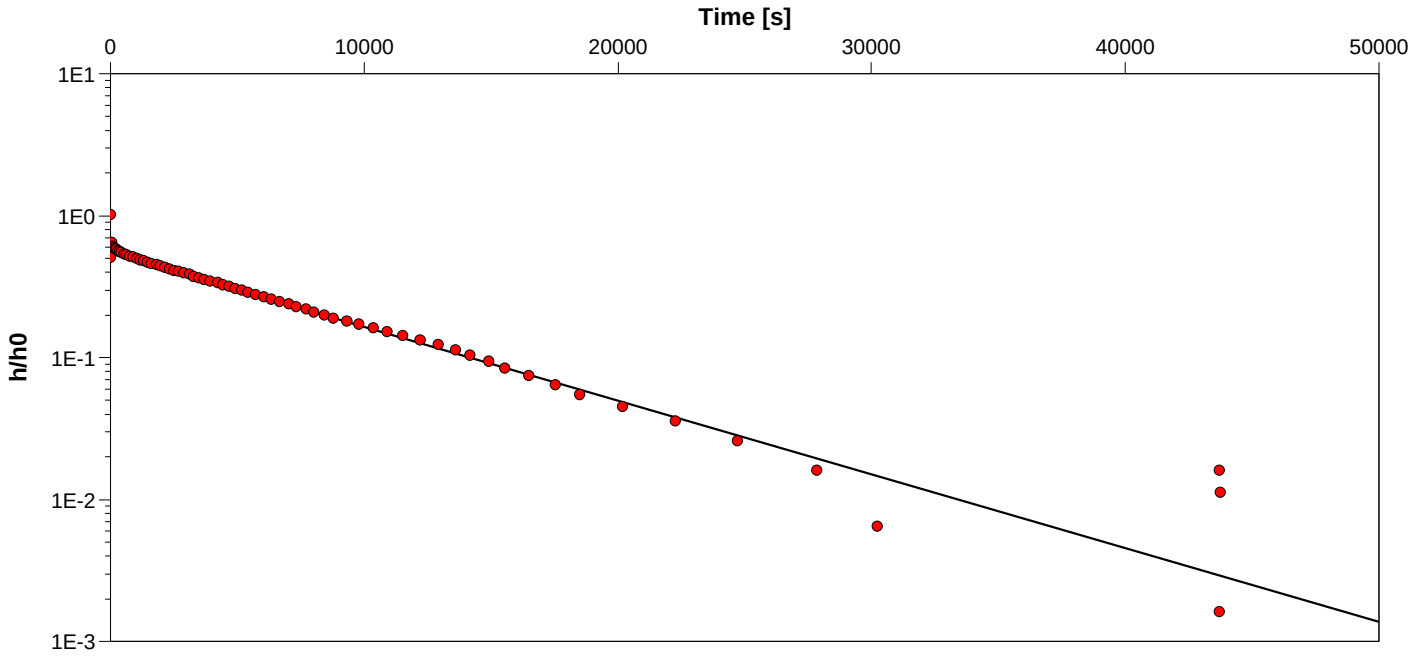


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW1	1.30×10^{-7}	

TETRA TECH	**Slug Test Analysis Report**
	Project: Ferry Road Groundwater
	Number: 705-1000120300
	Client: City of Winnipeg

Location: Ferry Road - Winnipeg	Slug Test: Mw2 Falling Head	Test Well: MW2
Test Conducted by:		Test Date: 1/21/2020
Analysis Performed by:	Falling Head	Analysis Date: 1/21/2020
Aquifer Thickness:		

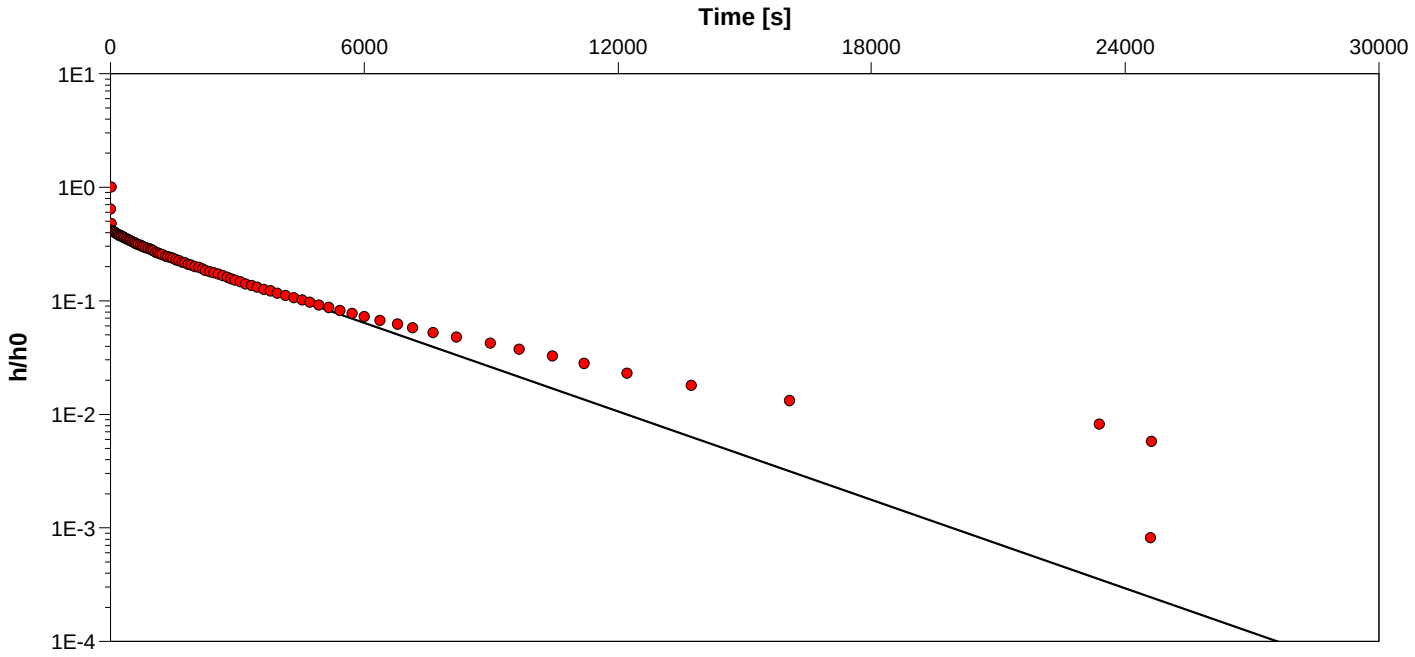


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW2	6.00×10^{-8}	

TETRA TECH	**Slug Test Analysis Report**
	Project: Ferry Road Groundwater
	Number: 705-1000120300
	Client: City of Winnipeg

Location: Ferry Road - Winnipeg	Slug Test: MW2 Rising Head	Test Well: MW2
Test Conducted by:		Test Date: 1/21/2020
Analysis Performed by:	Rising Head	Analysis Date: 1/21/2020
Aquifer Thickness:		



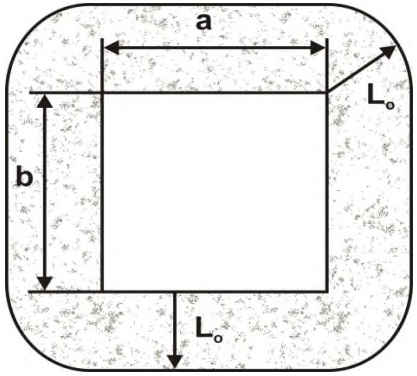
Calculation using Hvorslev

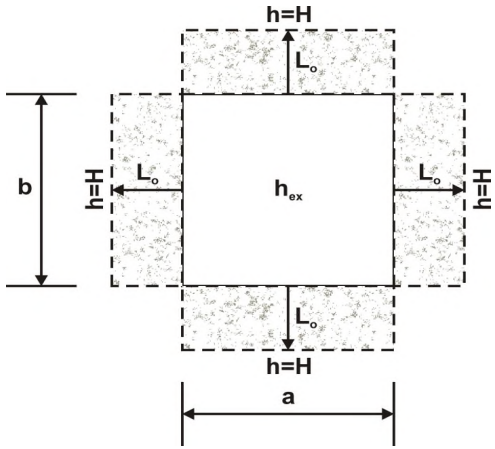
Observation Well	Hydraulic Conductivity [m/s]	
MW2	1.50×10^{-7}	

APPENDIX C

GROUNDWATER INFLOW CALCULATION

Calculation No. 1
Flow into an approximately rectangular excavation with a nearby constant head boundary
Calculated Area of Influence





Units are labels only; the user must specify consistent units

Parameter	Units	Value	User-specified units
Hydraulic conductivity, K	L/T	1.40E-07	m/s
Elevation of base of aquifer, z_{bot}	L	221.6	m
Thickness of aquifer where confined, D	L	2.9	m
Distance from outside of long excavation to constant-head boundary, L_0 (Sichardt and Kryieleis Method)	L	5.6	m
Rectangular excavation length, a (a≈b)	L	5.0	m
Rectangular excavation width, b	L	5.0	m
Head at the constant-head boundary, H	L	226.0	m
Head in the excavation, h_d	L	221.0	m

Result

Calculated inflow, Q	L^3/T	1.361E-05	m^3/s
		0.01	L/s
		1176	L/day
		0.18	Igpm

Reference:
Steady groundwater inflows into open excavations: Rectangular excavations
Christopher J. Neville and Xiaomin Wang
S.S. Papadopulos & Associates, Inc.
Last update: 2017/04/28

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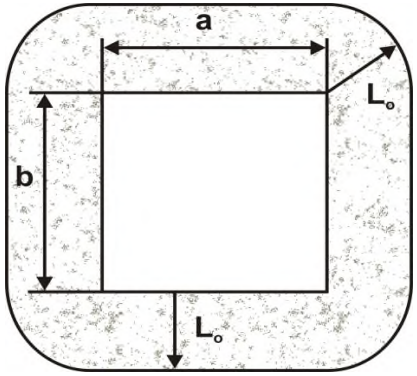
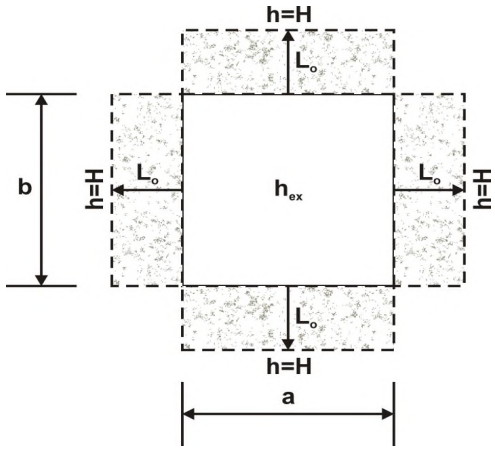
Calculation No. 2

Flow into an approximately rectangular excavation with a nearby constant head boundary

Conservative Estimate of Area of Influence





Units are labels only; the user must specify consistent units

Parameter	Units	Value	User-specified units
Hydraulic conductivity, K	L/T	1.40E-07	m/s
Elevation of base of aquifer, z_{bot}	L	221.6	m
Thickness of aquifer where confined, D	L	2.9	m
Distance from outside of long excavation to constant-head boundary, L_0 (Conservative Estimate)	L	1.0	m
Rectangular excavation length, a (a≈b)	L	5.0	m
Rectangular excavation width, b	L	5.0	m
Head at the constant-head boundary, H	L	226.0	m
Head in the excavation, h_d	L	221.0	m

Result

Calculated inflow, Q	L^3/T	4.698E-05	m^3/s
		0.05	L/s
		4059	L/day
		0.62	Igpm

Reference:

Steady groundwater inflows into open excavations: Rectangular excavations

Christopher J. Neville and Xiaomin Wang

S.S. Papadopulos & Associates, Inc.

Last update: 2017/04/28

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