APPENDIX A

PHOTOLOG

Photographic Log
Proposed Freymond Quarry, Township of Faraday, County of Hastings, ON

Photograph No. 1 – Existing Pit - License No. 624804 - looking north into pit from the Site

Photograph No. 2 – Lumber Yard owned by Freymond

Photograph No. 3 – MW1 - May-28-14

Photograph No. 4 –Pond near MW4 - May-28-14

Photograph No. 5 –Pond near MW4 - May-28-14

Photograph No. 6 – Pond near MW4 - May-28-14

Photograph No. 7 –Pond near MW3 - May-23-14

Photograph No. 8 –Pond near MW3 looking north - May-23-14

Photograph No. 9 – MW5 - looking south

Photograph No. 10 – Standing at MW6 looking south

Photograph No. 11 - Standing at MW6 looking west

Photograph No. 12 - South Stream - looking downstream

Photograph No. 13 - North Stream - upstream culvert beneath rail trail

Photograph No. 14 - North Stream - downstream culvert beneath highway

Photograph No. 15 - MW4 - flowing well

Photograph No. 16 - Manometers - MW4 - Oct-9-14

APPENDIX B

BOREHOLE LOGS

Client: Freymond Lumber Ltd.

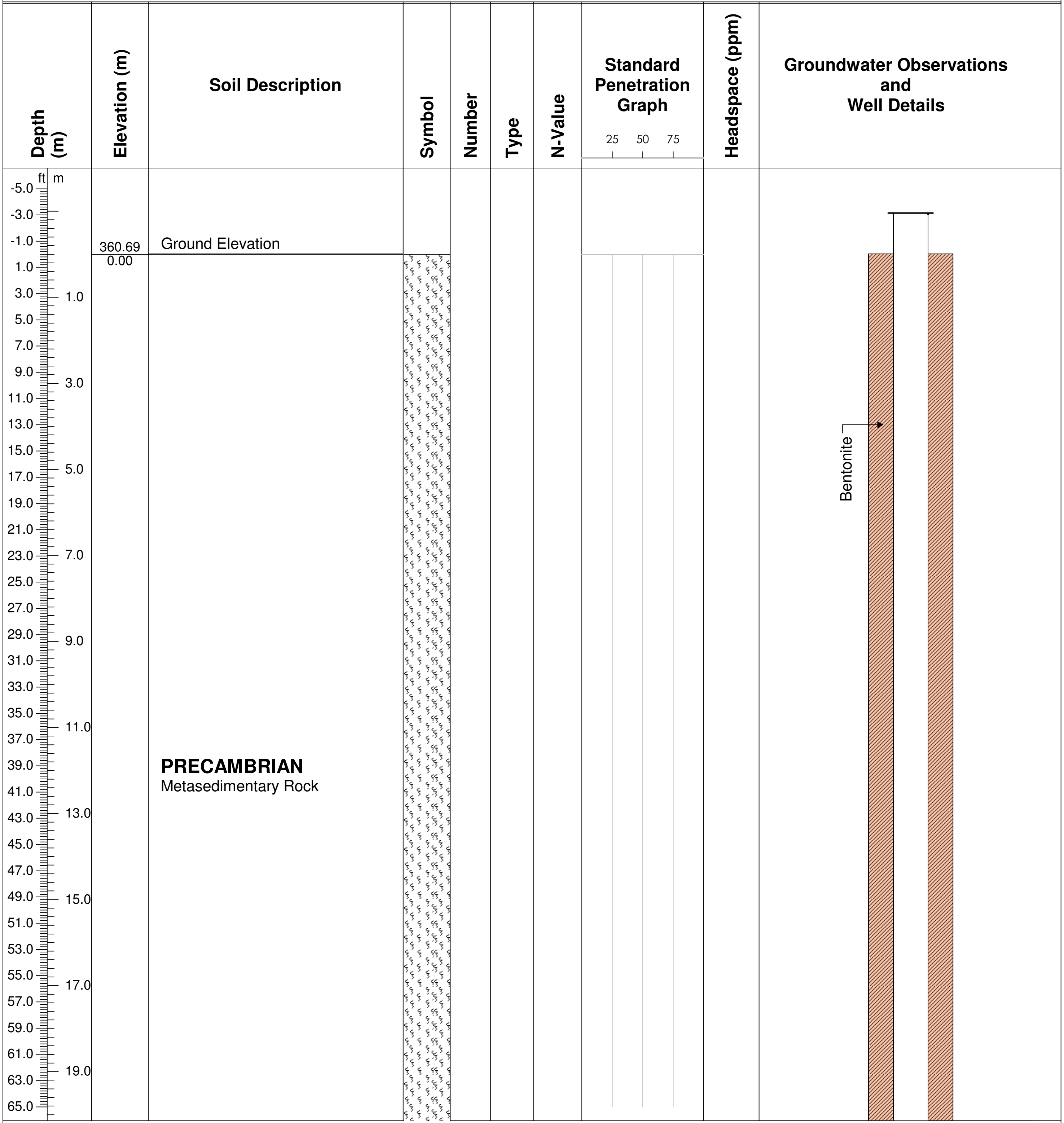
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW1d

Job Number: 33886-100

Drill Date: April 27, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Logged By: MDE

Sheet: 1 of 2

Client: Freymond Lumber Ltd.

Project: Freymond Quarry

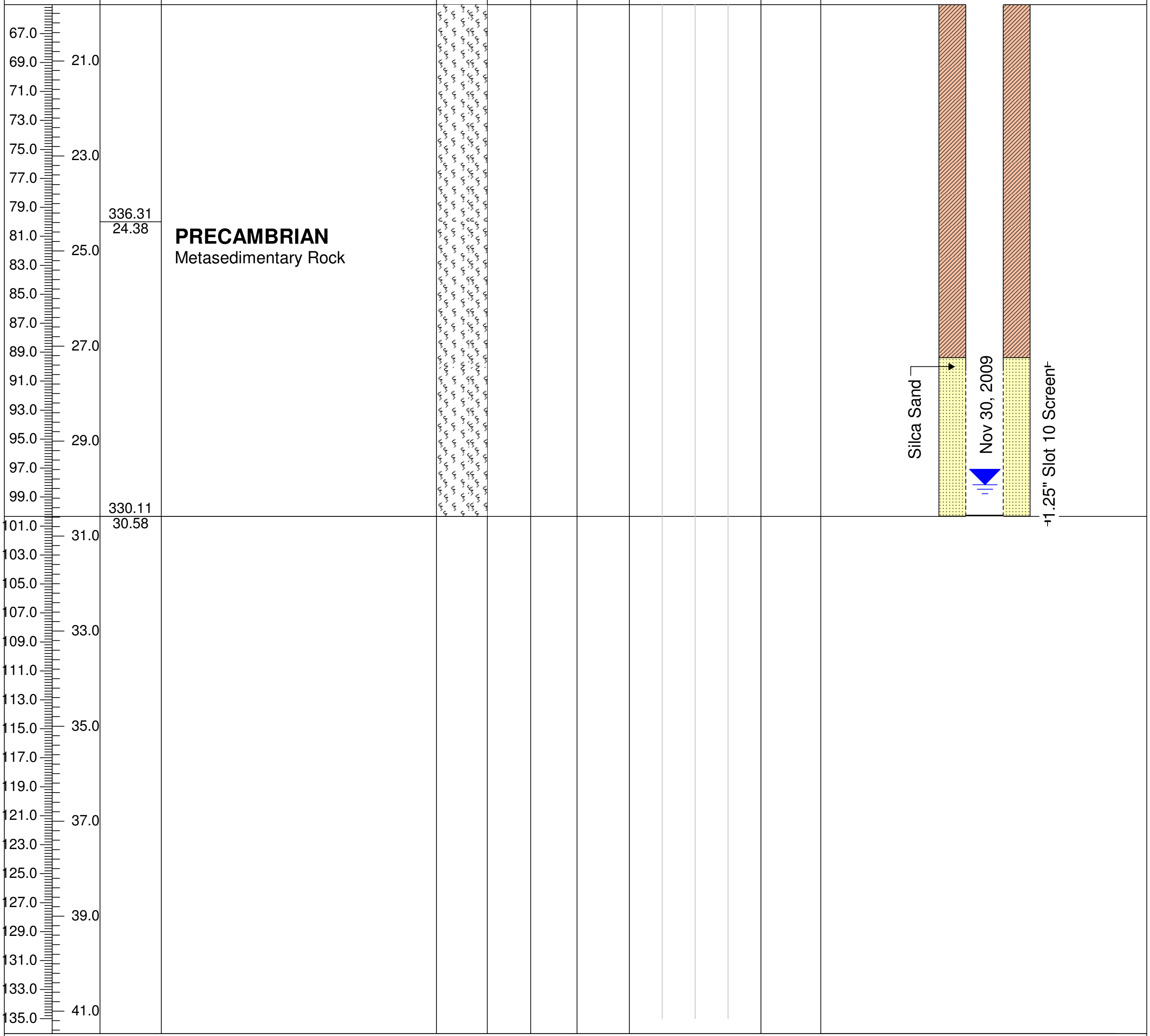
Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW1d

Job Number: 33886-100

Drill Date: April 27, 2009

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	N-Value	Standard Penetration Graph 25 50 75	Headspace (ppm)	Groundwater Observations and Well Details
	336.31 24.38	**PRECAMBRIAN** Metasedimentary Rock							
	330.11 30.58								



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 2 of 2

Client: Freymond Lumber Ltd.

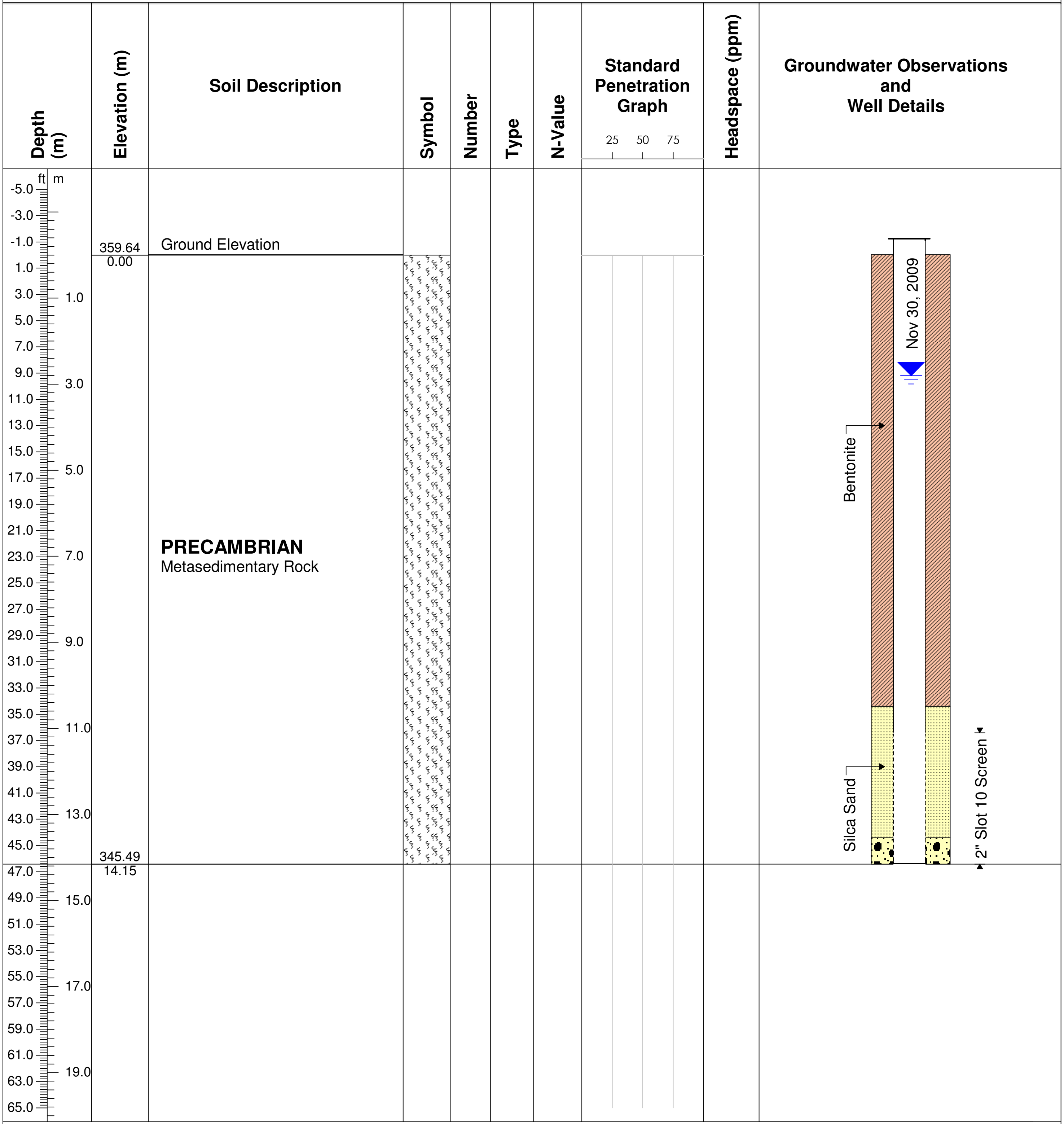
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW1s

Job Number: 33886-100

Drill Date: April 27, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Client: Freymond Lumber Ltd.

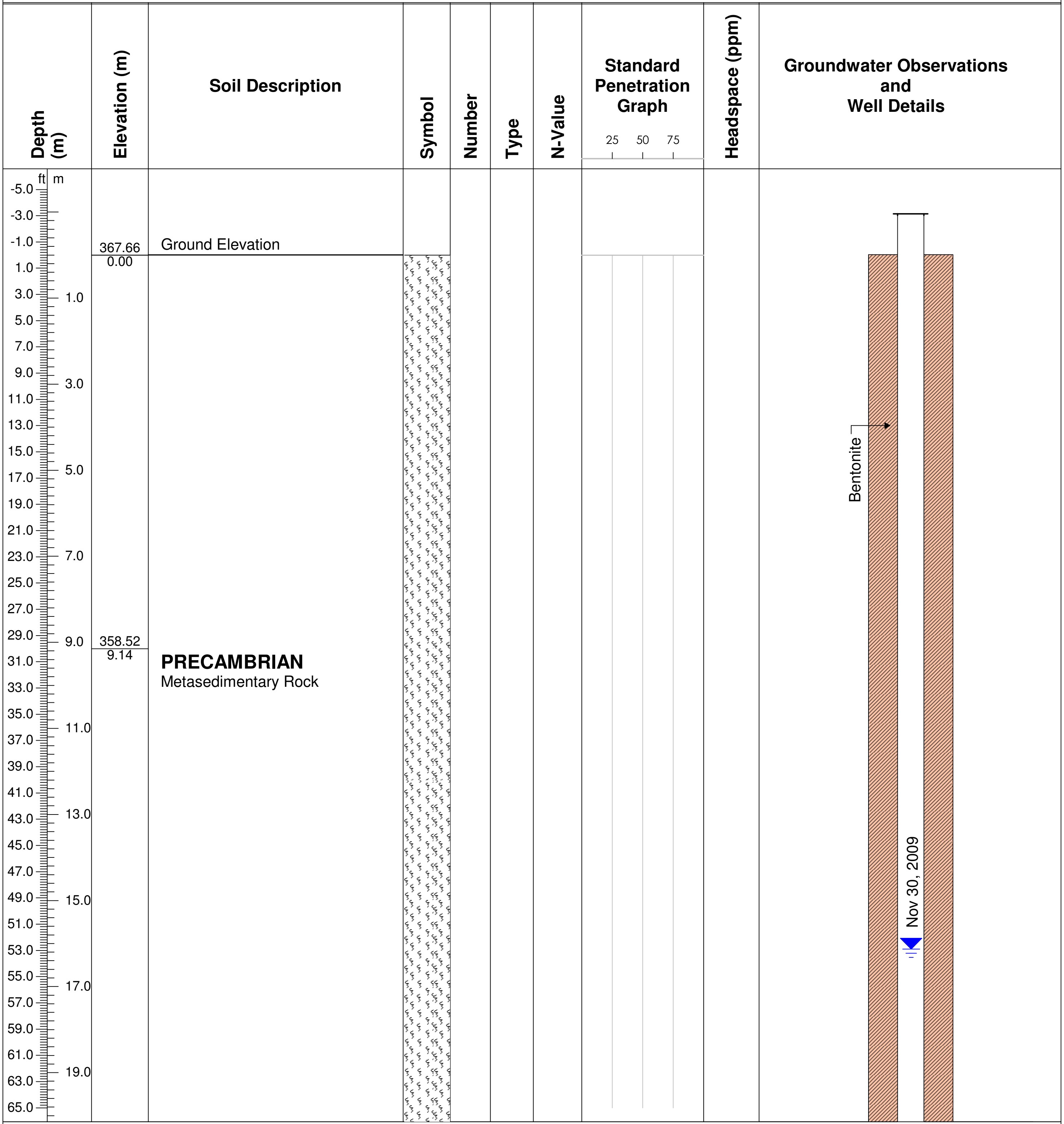
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW2d

Job Number: 33886-100

Drill Date: May 5, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 1 of 2

Client: Freymond Lumber Ltd.

Project: Freymond Quarry

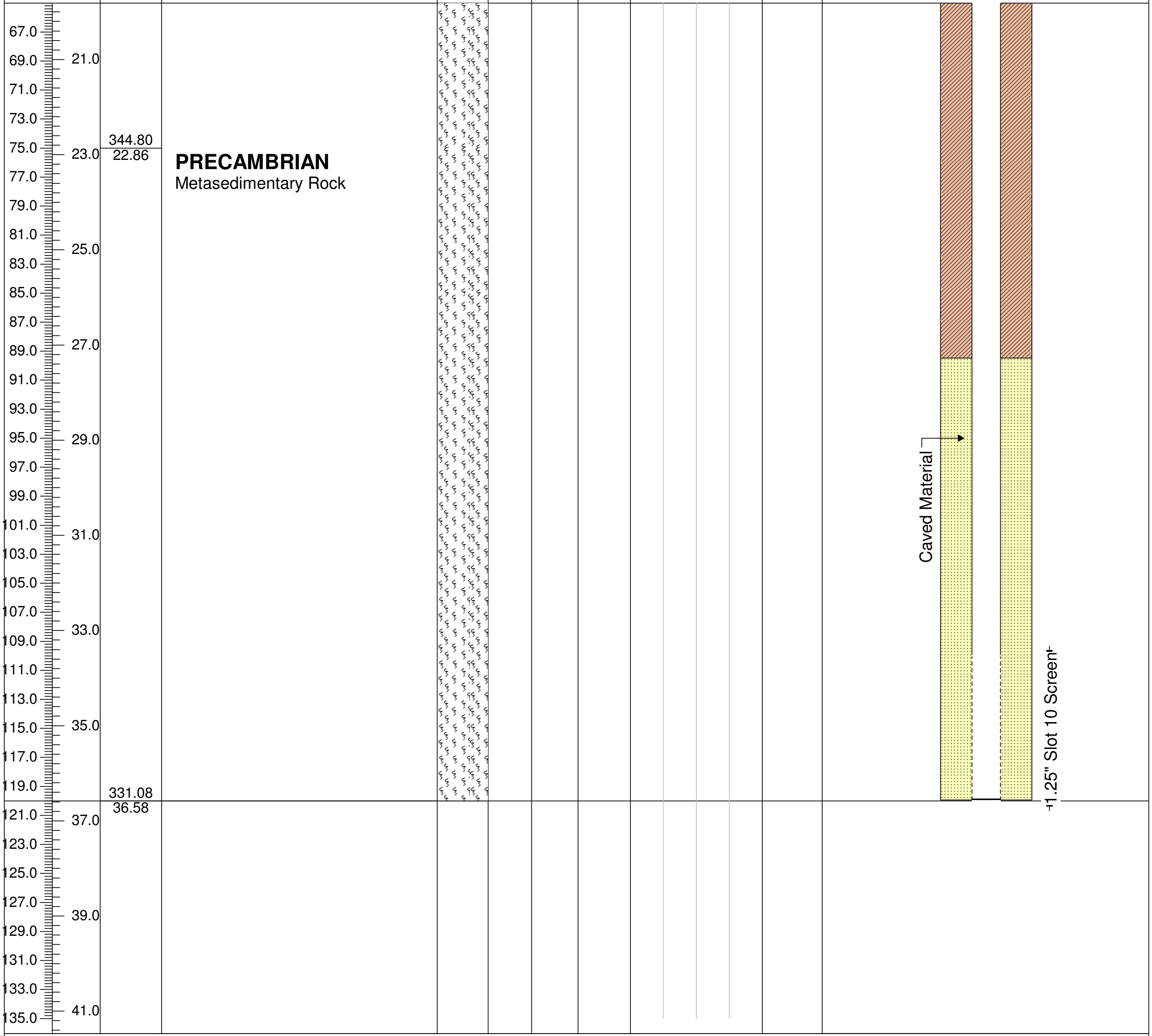
Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW2d

Job Number: 33886-100

Drill Date: May 5, 2009

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	N-Value	Standard Penetration Graph 25 50 75	Headspace (ppm)	Groundwater Observations and Well Details
	344.80 22.86	**PRECAMBRIAN** Metasedimentary Rock							
	331.08 36.58								



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 2 of 2

Client: Freymond Lumber Ltd.

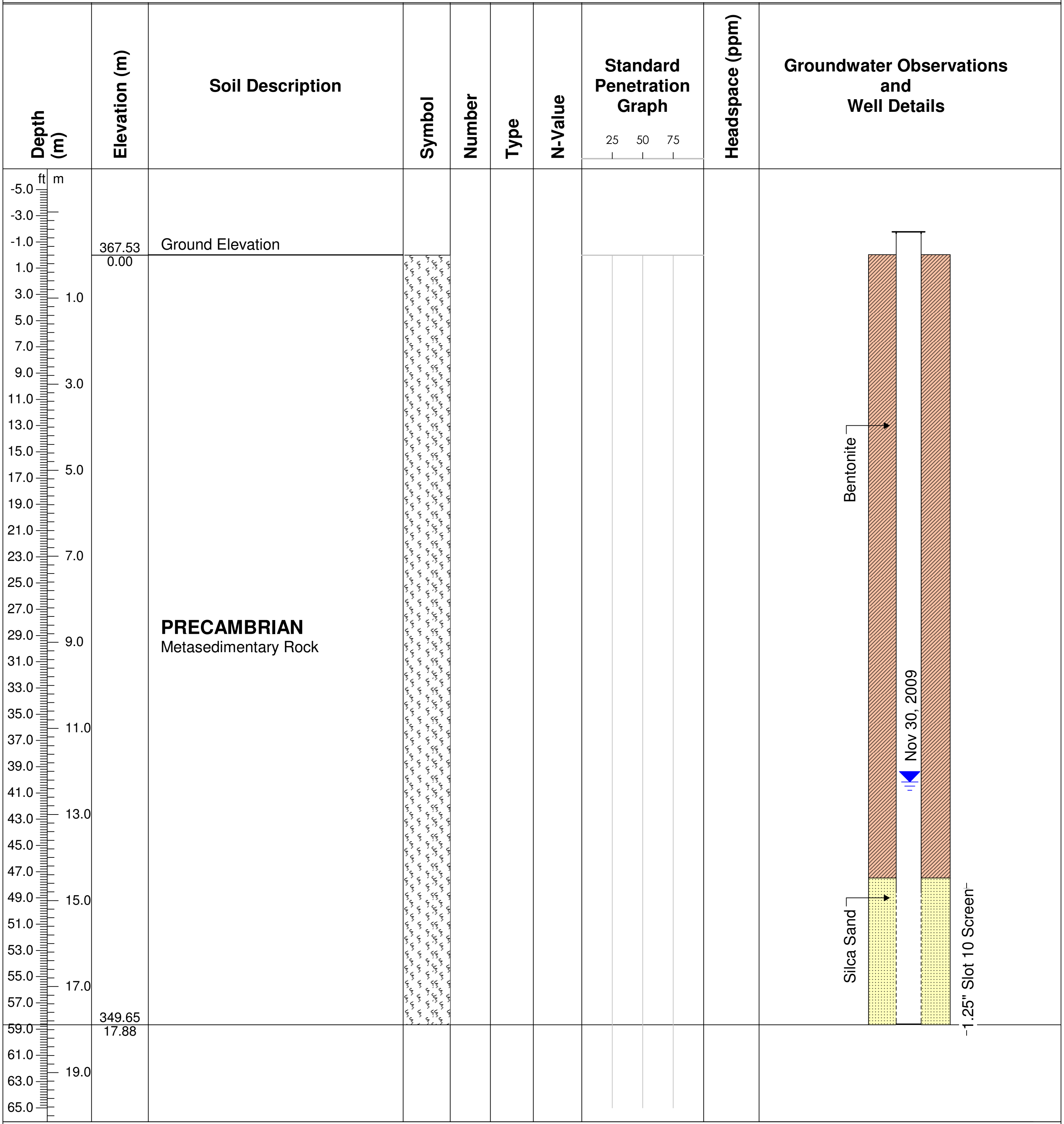
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW2s

Job Number: 33886-100

Drill Date: May 4, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 1 of 1

Client: Freymond Lumber Ltd.

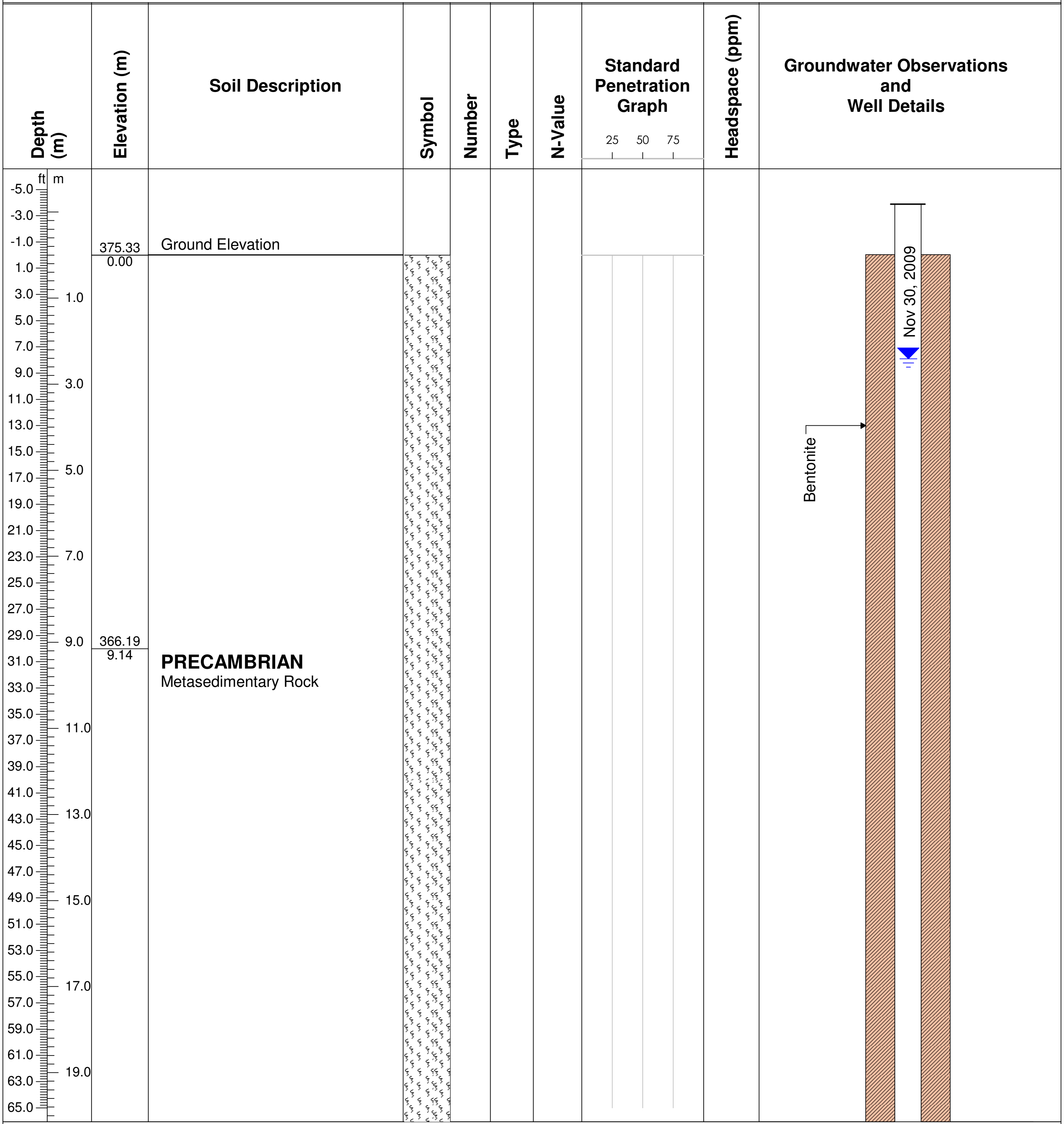
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW3d

Job Number: 33886-100

Drill Date: May 4, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 1 of 2

Client: Freymond Lumber Ltd.

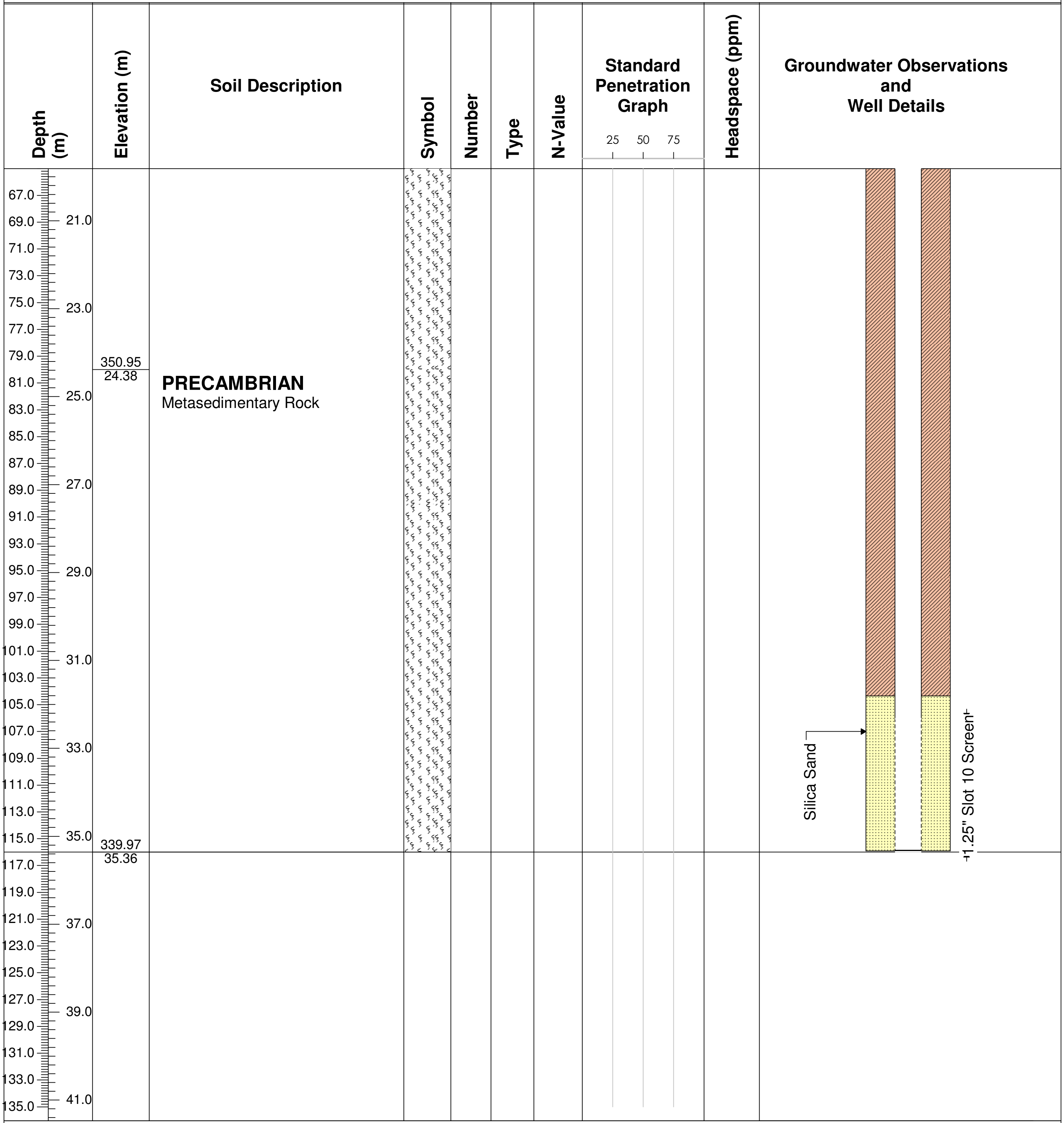
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW3d

Job Number: 33886-100

Drill Date: May 4, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 2 of 2

Client: Freymond Lumber Ltd.

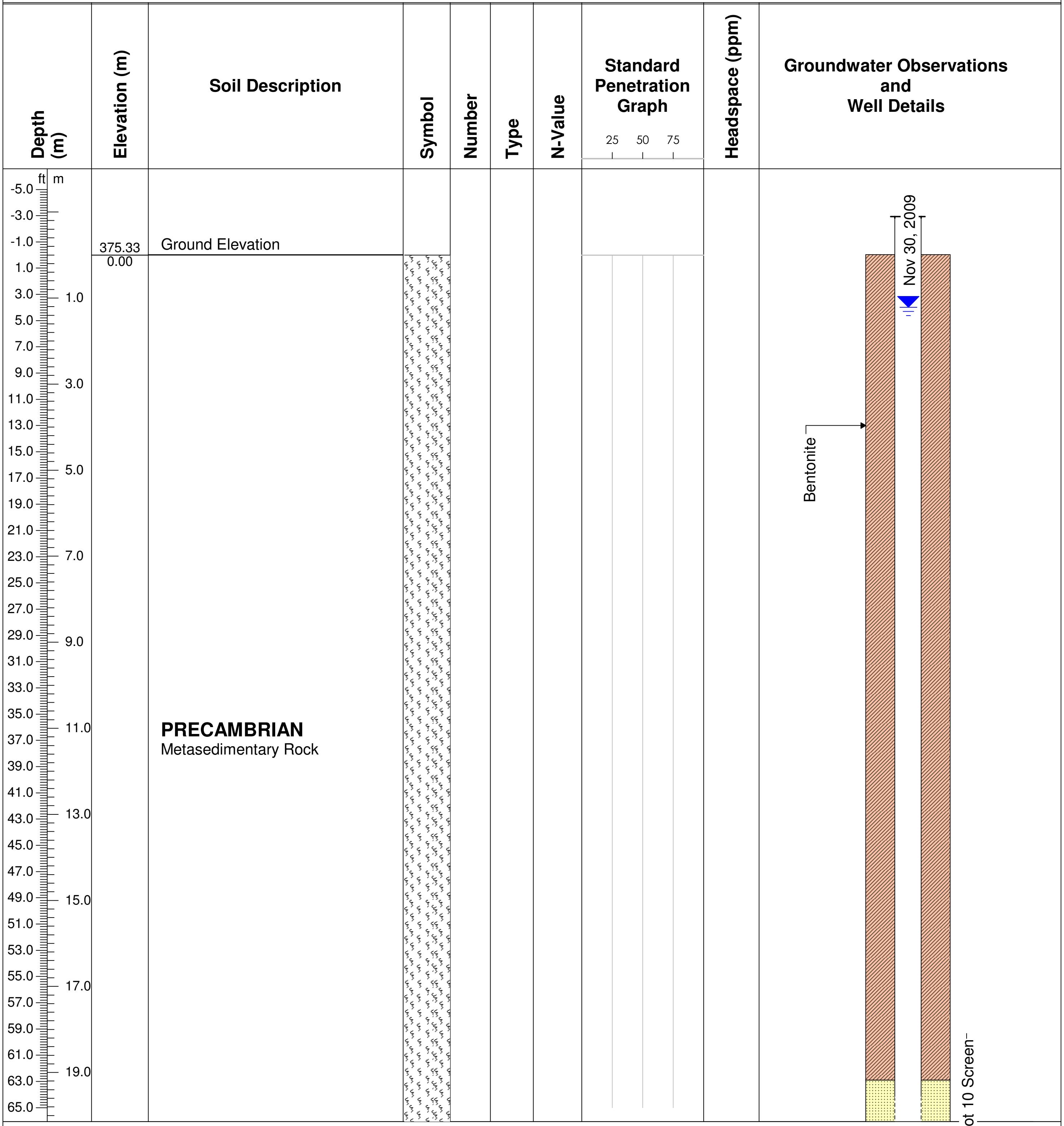
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW3s

Job Number: 33886-100

Drill Date: May 4, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 1 of 2

Client: Freymond Lumber Ltd.

Project: Freymond Quarry

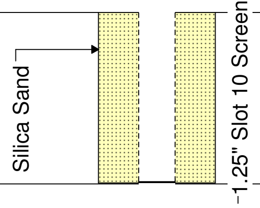
Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW3s

Job Number: 33886-100

Drill Date: May 4, 2009

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	N-Value	Standard Penetration Graph 25 50 75	Headspace (ppm)	Groundwater Observations and Well Details
67.0 69.0 21.0 71.0 73.0	352.70 22.63								
75.0 23.0 77.0 79.0 81.0 25.0 83.0 85.0 87.0 27.0 89.0 91.0 93.0 95.0 29.0 97.0 99.0 101.0 31.0 103.0 105.0 107.0 33.0 109.0 111.0 113.0 115.0 35.0 117.0 119.0 121.0 37.0 123.0 125.0 127.0 39.0 129.0 131.0 133.0 135.0 41.0									



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 2 of 2

Client: Freymond Lumber Ltd.

Project: Freymond Quarry

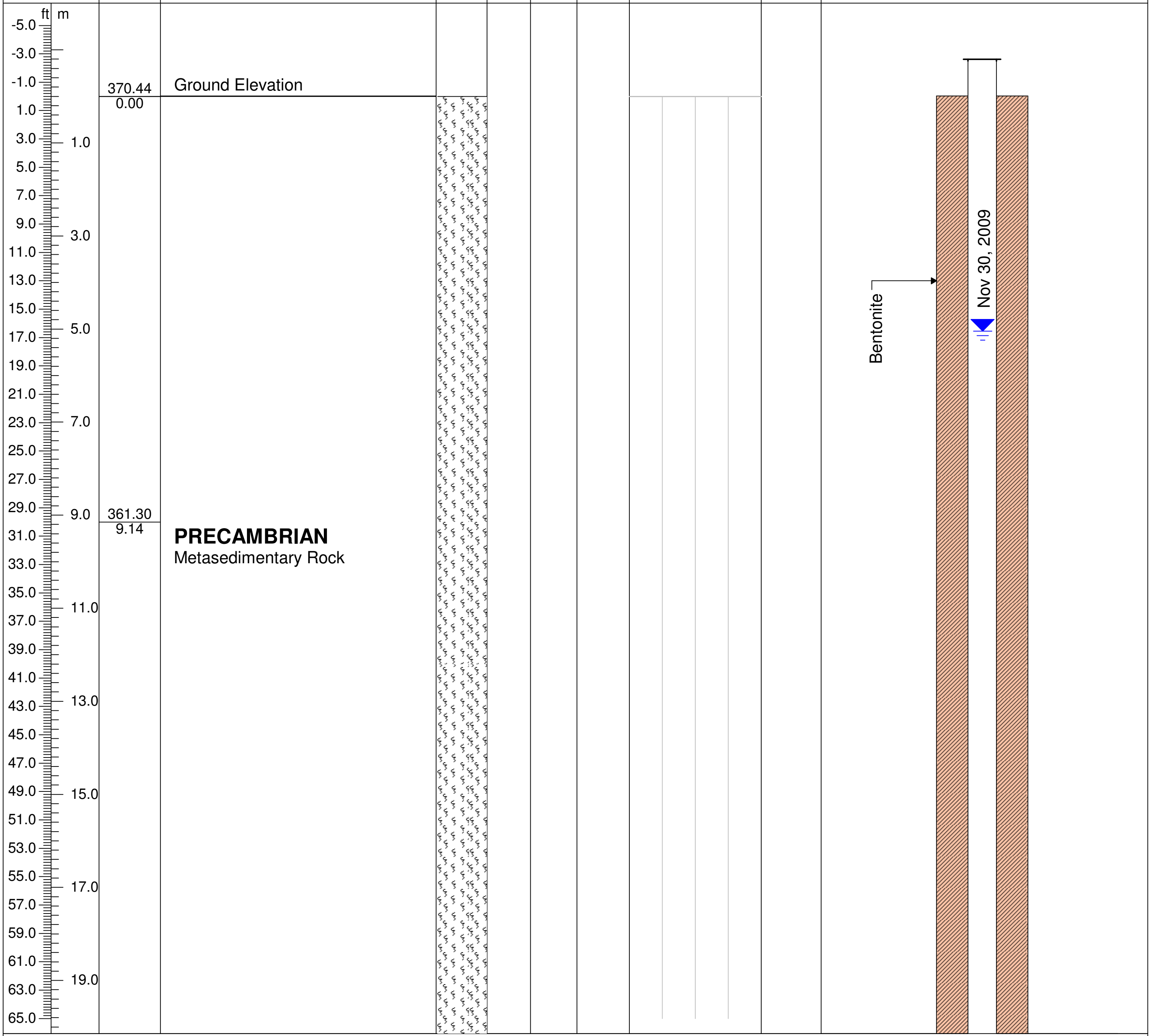
Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW4d

Job Number: 33886-100

Drill Date: May 5, 2009

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	N-Value	Standard Penetration Graph	Headspace (ppm)	Groundwater Observations and Well Details
0.00	370.44	Ground Elevation							
9.14	361.30	**PRECAMBRIAN** Metasedimentary Rock							



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 1 of 3

Client: Freymond Lumber Ltd.

Project: Freymond Quarry

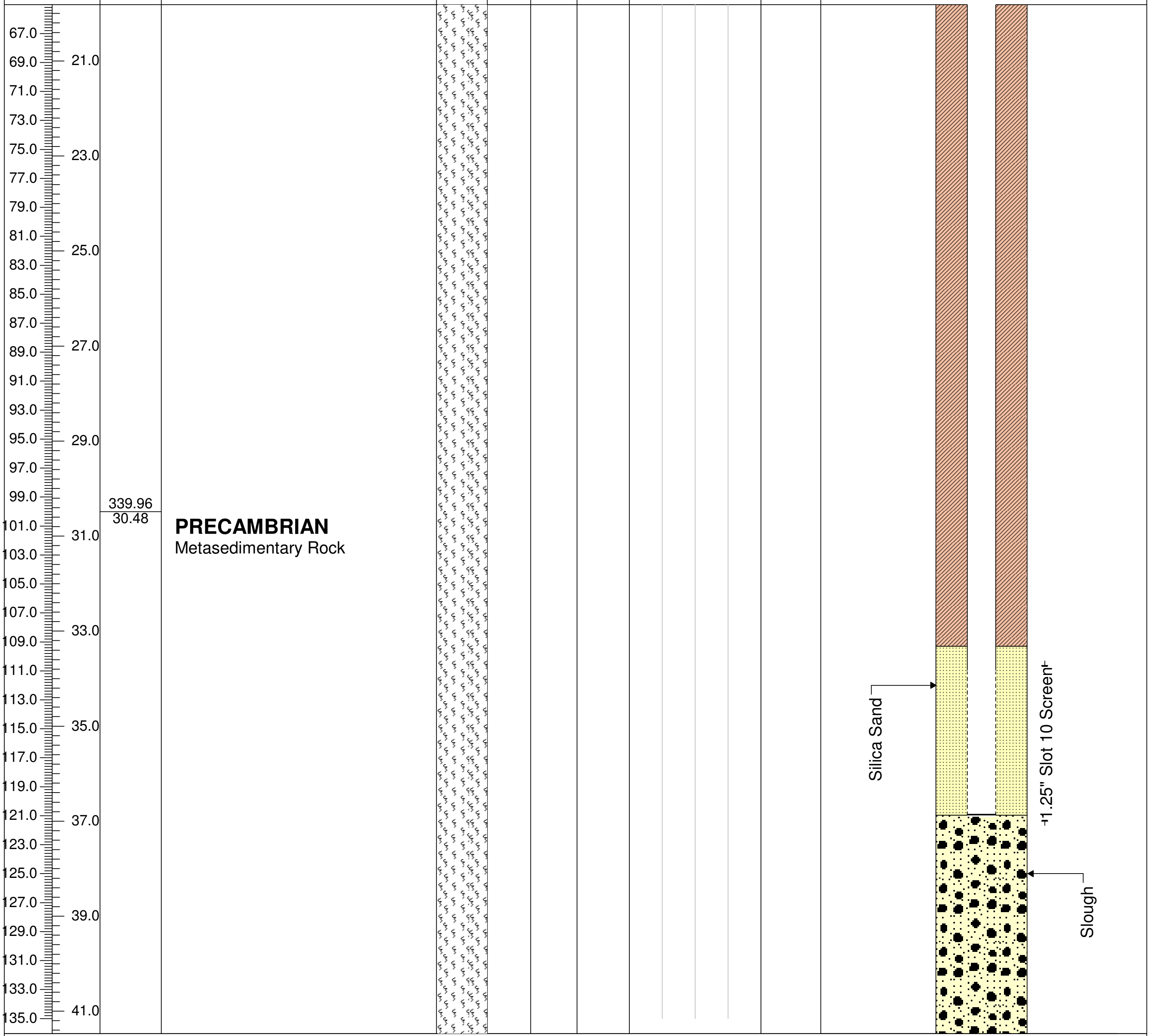
Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW4d

Job Number: 33886-100

Drill Date: May 5, 2009

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	N-Value	Standard Penetration Graph	Headspace (ppm)	Groundwater Observations and Well Details
30.48	339.96	**PRECAMBRIAN** Metasedimentary Rock							



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 2 of 3

Client: Freymond Lumber Ltd.

Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW4d

Job Number: 33886-100

Drill Date: May 5, 2009

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	N-Value	Standard Penetration Graph 25 50 75	Headspace (ppm)	Groundwater Observations and Well Details
	327.77 42.67		▨						▨

137.0
139.0
141.0
143.0
145.0
147.0
149.0
151.0
153.0
155.0
157.0
159.0
161.0
163.0
165.0
167.0
169.0
171.0
173.0
175.0
177.0
179.0
181.0
183.0
185.0
187.0
189.0
191.0
193.0
195.0
197.0
199.0
201.0
203.0
205.0

43.0
45.0
47.0
49.0
51.0
53.0
55.0
57.0
59.0
61.0

Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 3 of 3

Client: Freymond Lumber Ltd.

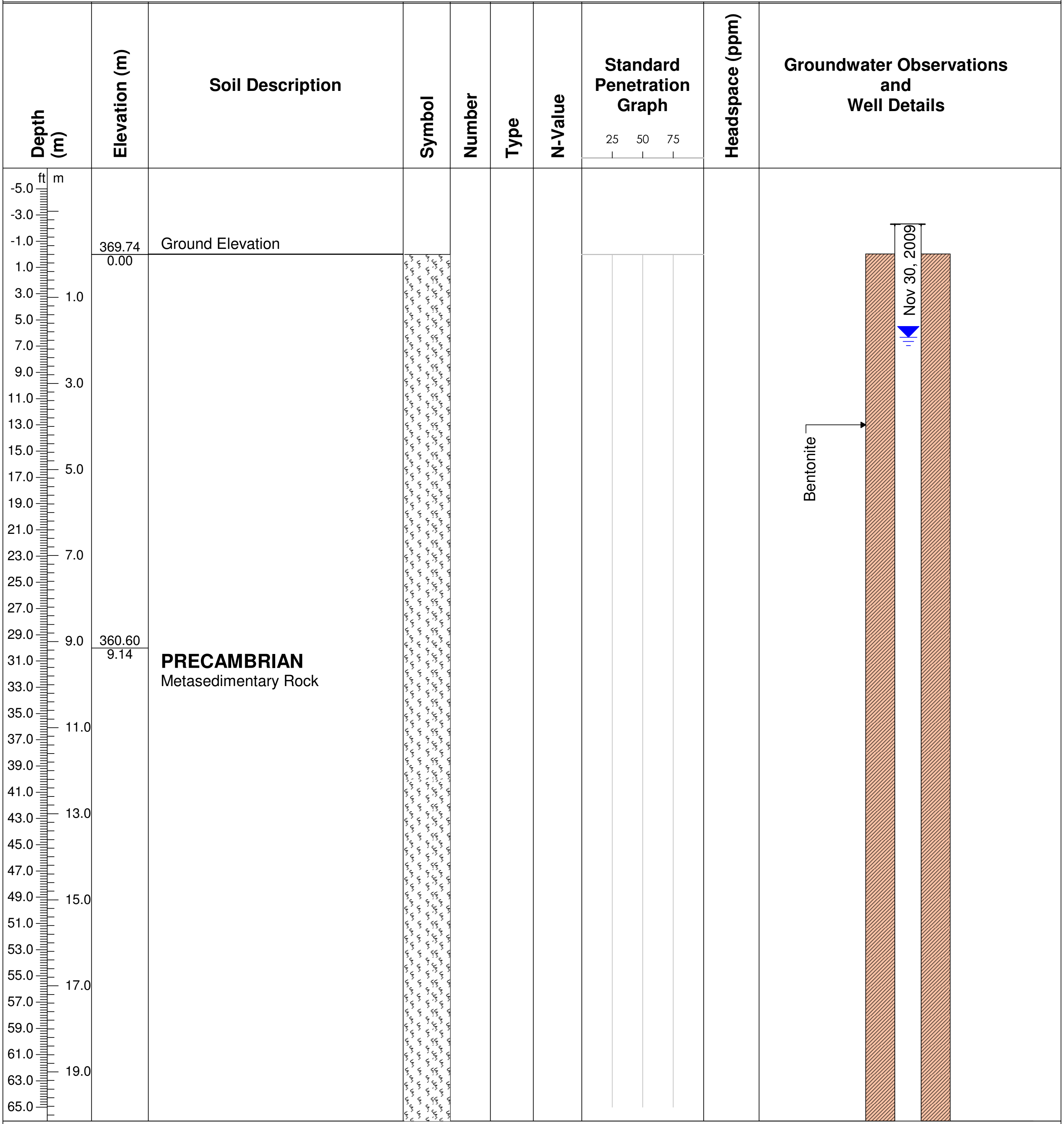
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW4s

Job Number: 33886-100

Drill Date: May 5, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 1 of 2

Client: Freymond Lumber Ltd.

Project: Freymond Quarry

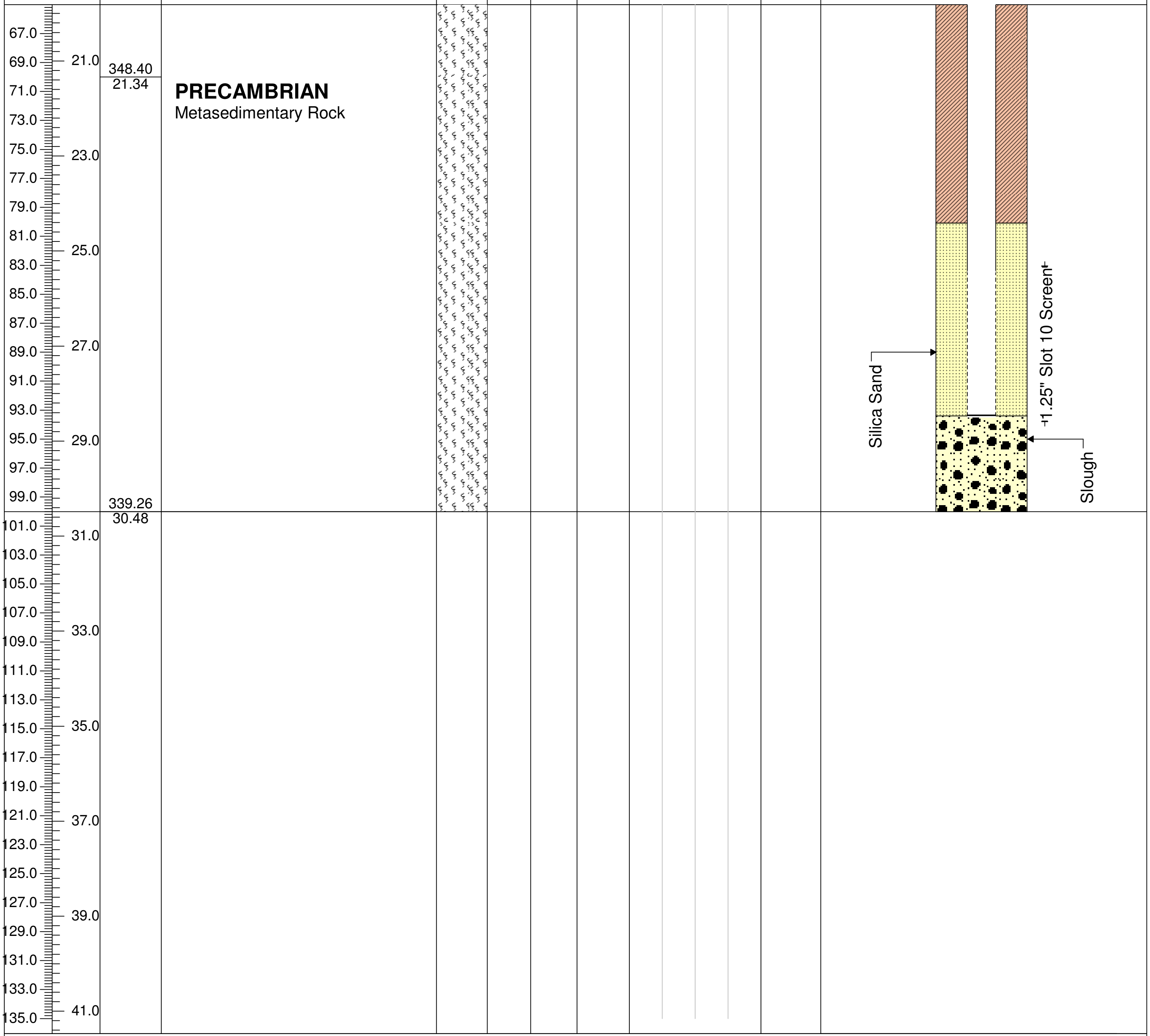
Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW4s

Job Number: 33886-100

Drill Date: May 5, 2009

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	N-Value	Standard Penetration Graph 25 50 75	Headspace (ppm)	Groundwater Observations and Well Details
21.34	348.40	**PRECAMBRIAN** Metasedimentary Rock							
30.48	339.26								



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 2 of 2

Client: Freymond Lumber Ltd.

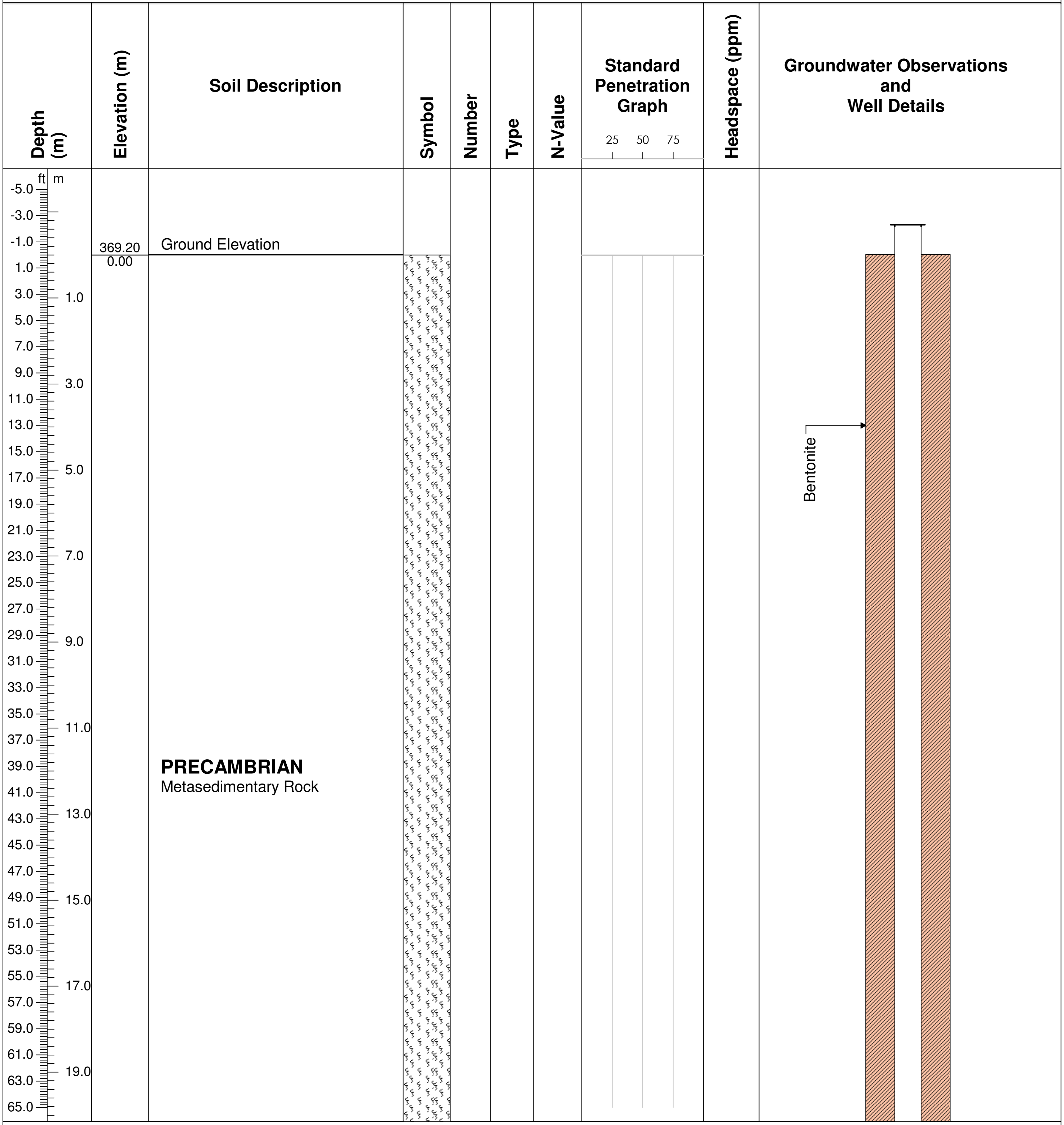
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW5d

Job Number: 33886-100

Drill Date: May 5, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 1 of 2

Client: Freymond Lumber Ltd.

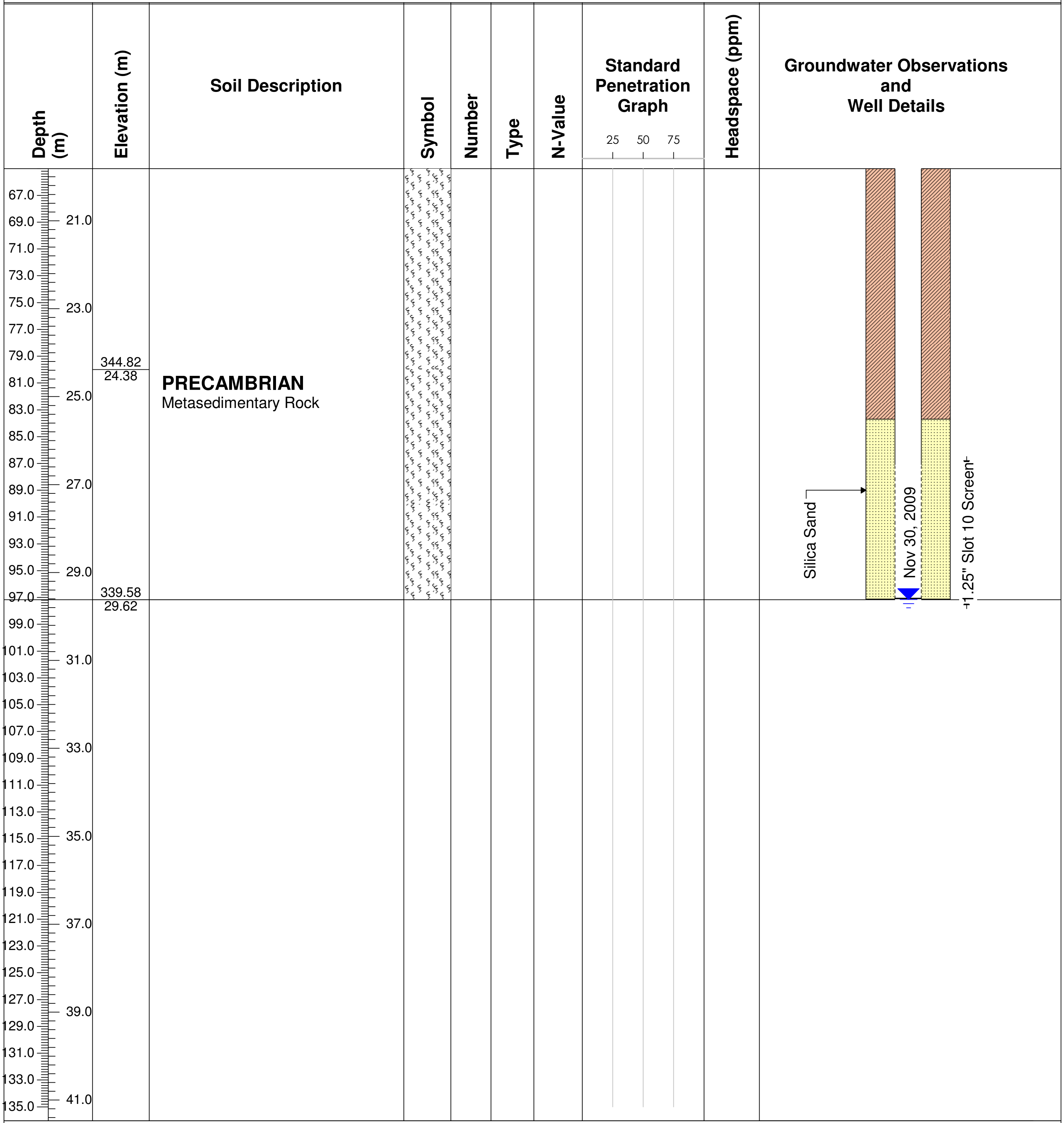
Borehole Number: MW5d

Project: Freymond Quarry

Job Number: 33886-100

Location: Lot 51 & 52, Township of Faraday, Hastings County

Drill Date: May 5, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Logged By: MDE

Sheet: 2 of 2

Client: Freymond Lumber Ltd.

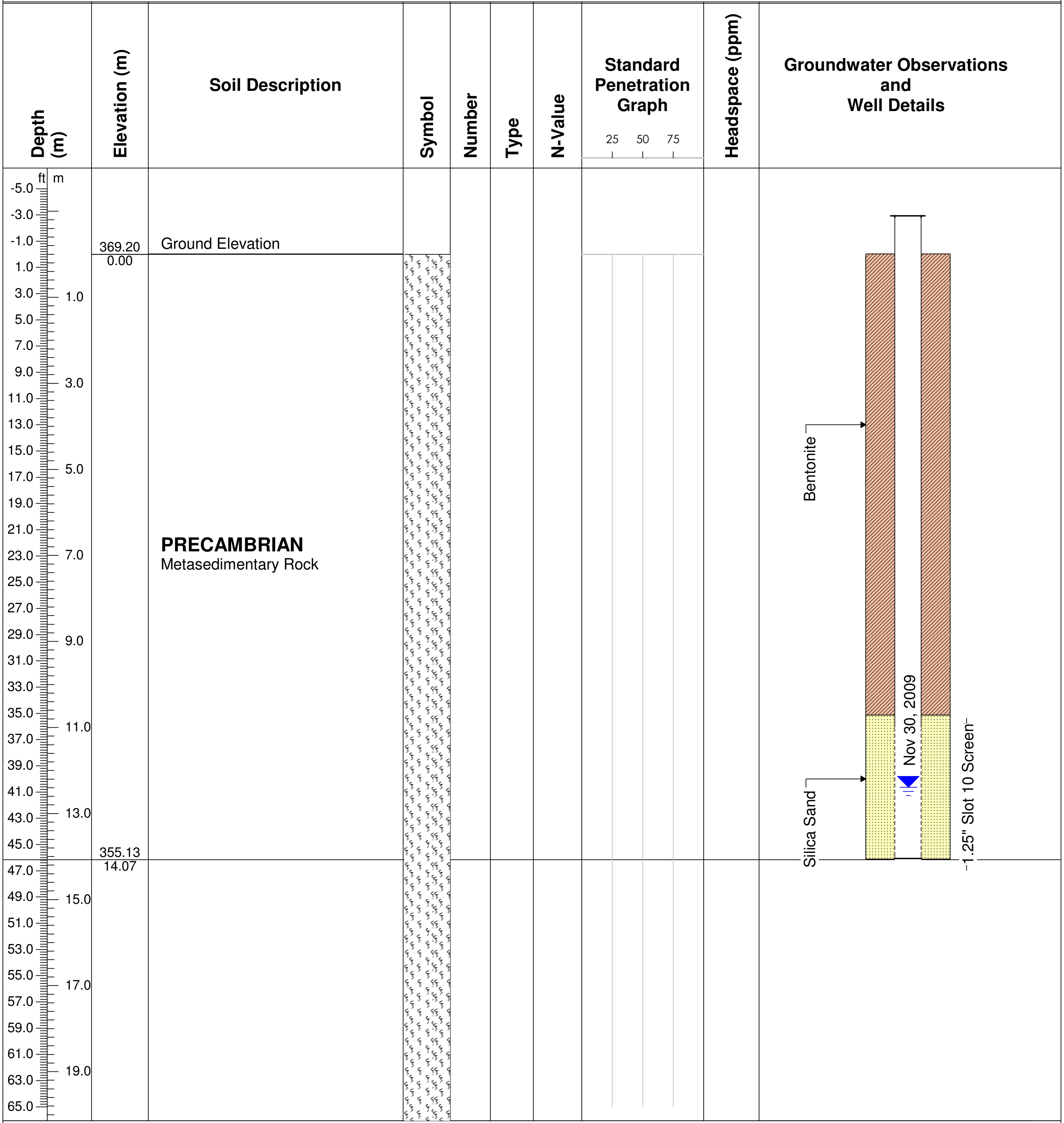
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW5s

Job Number: 33886-100

Drill Date: May 6, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 1 of 1

Client: Freymond Lumber Ltd.

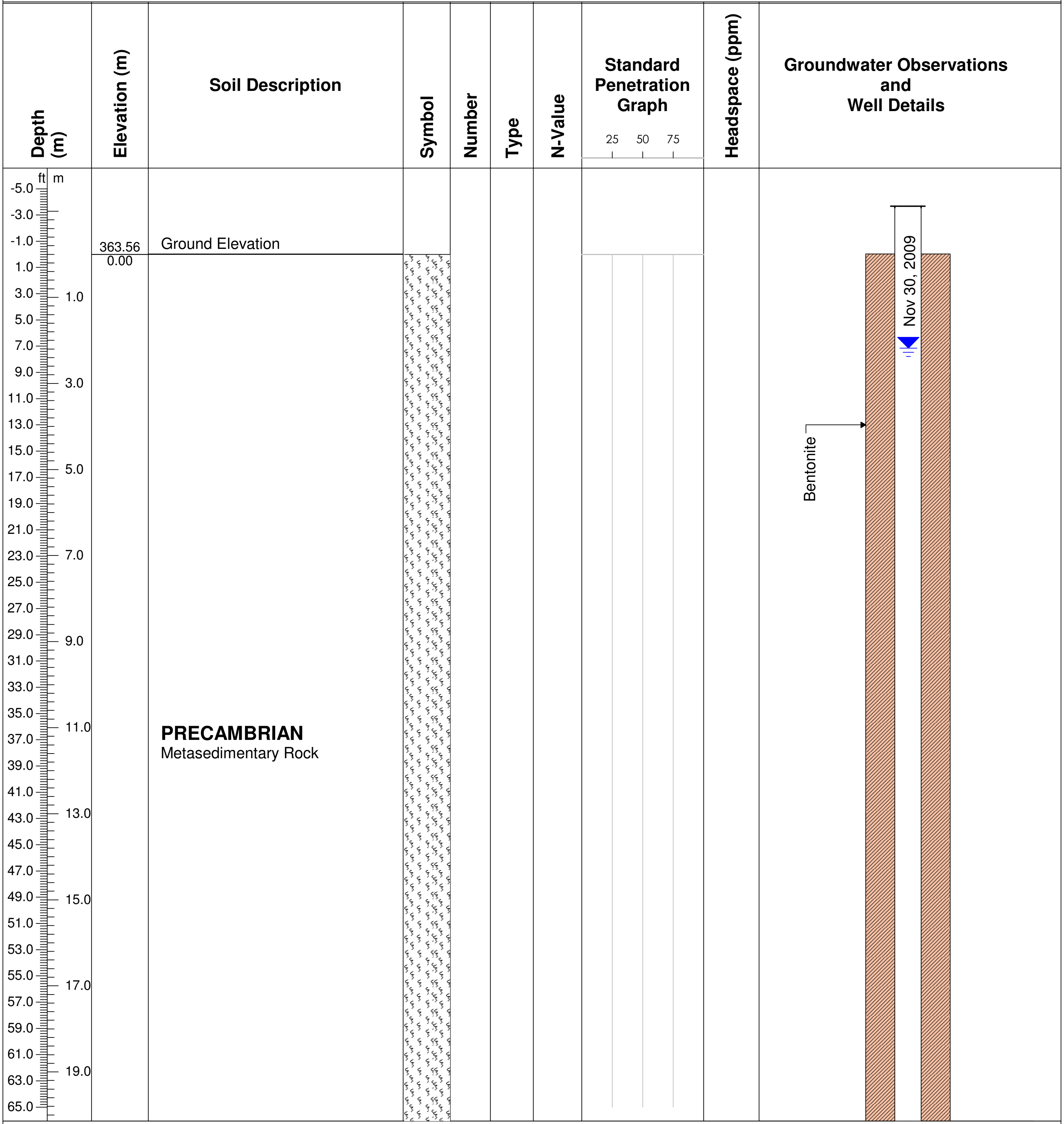
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW6s

Job Number: 33886-100

Drill Date: May 6, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 1 of 2

Client: Freymond Lumber Ltd.

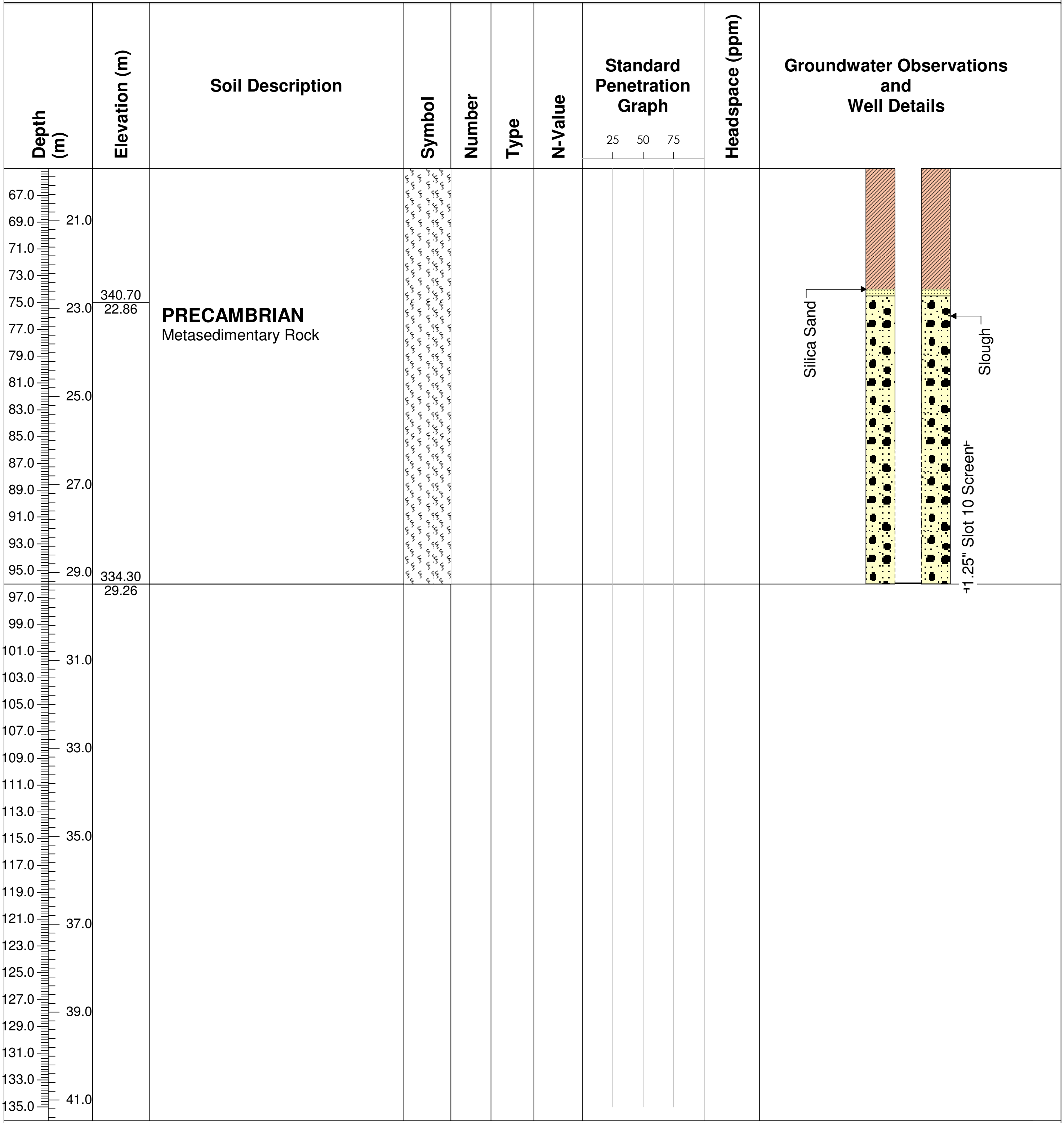
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW6s

Job Number: 33886-100

Drill Date: May 6, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 2 of 2

Client: Freymond Lumber Ltd.

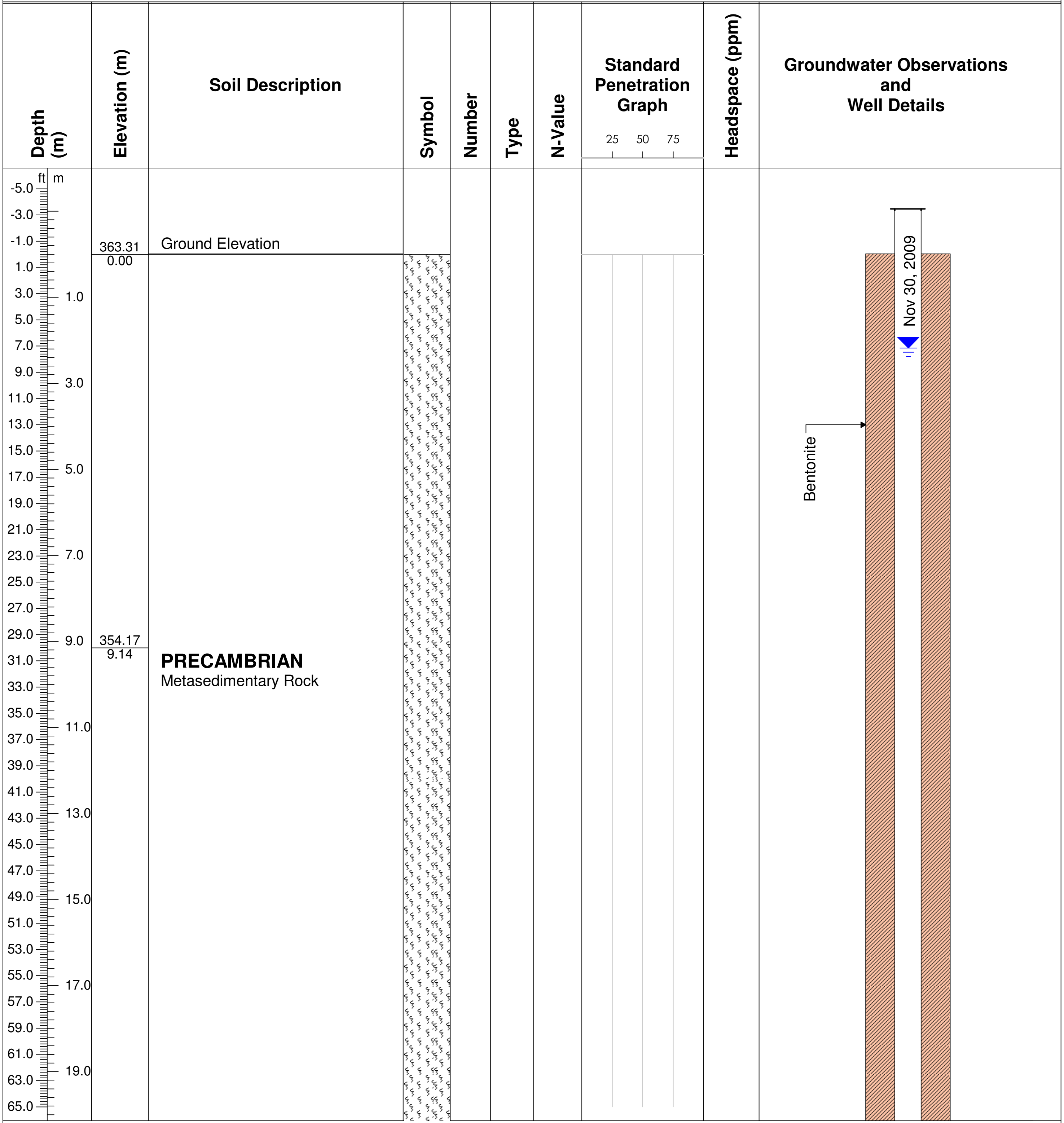
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW6d

Job Number: 33886-100

Drill Date: May 6, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 1 of 3

Client: Freymond Lumber Ltd.

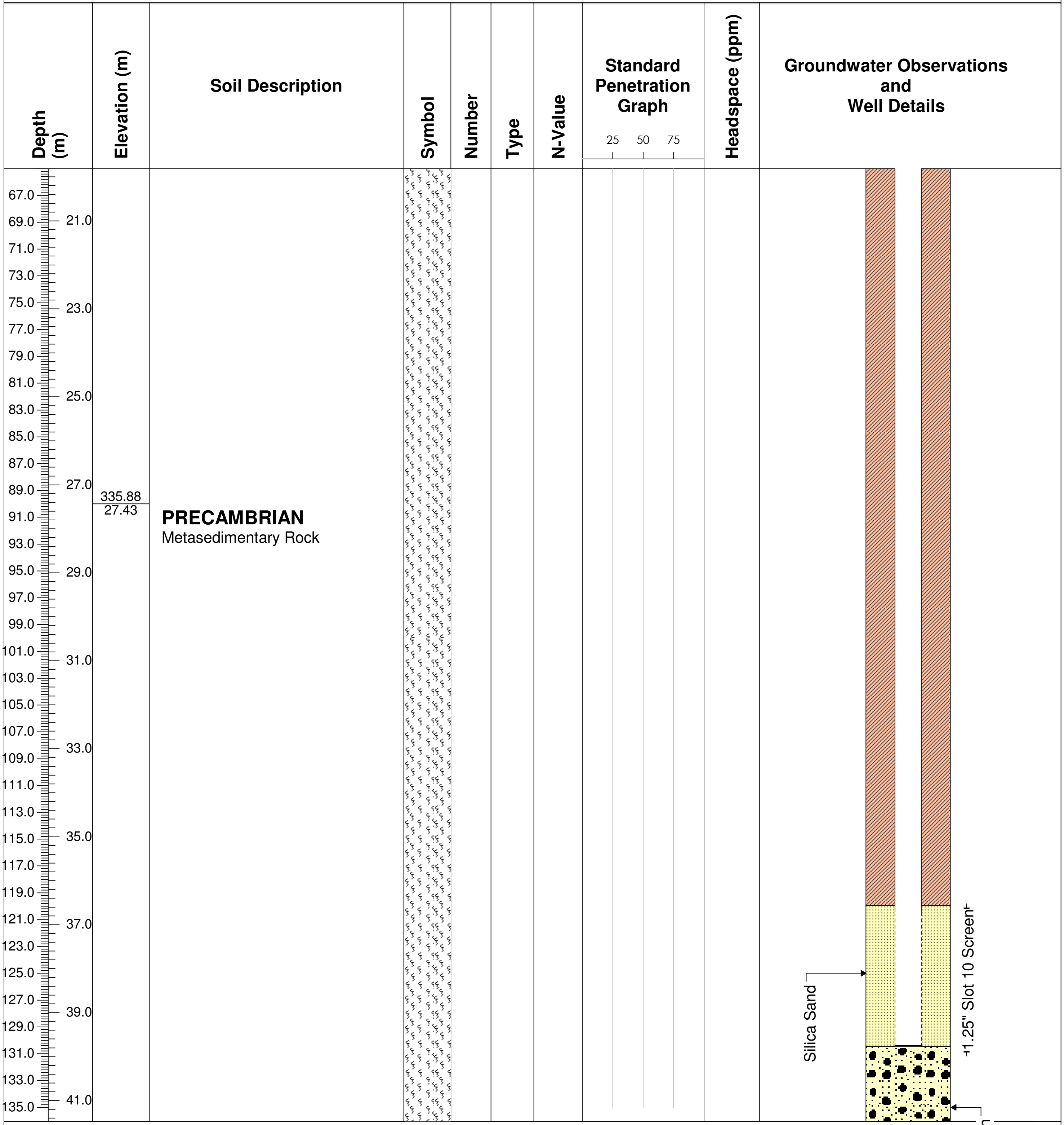
Borehole Number: MW6d

Project: Freymond Quarry

Job Number: 33886-100

Location: Lot 51 & 52, Township of Faraday, Hastings County

Drill Date: May 6, 2009



PRECAMBRIAN
Metasedimentary Rock

Reviewed By: WSC

Method: Air Percussion

Notes:

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Logged By: MDE

Sheet: 2 of 3

Client: Freymond Lumber Ltd.

Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW6d

Job Number: 33886-100

Drill Date: May 6, 2009

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	N-Value	Standard Penetration Graph 25 50 75	Headspace (ppm)	Groundwater Observations and Well Details
	320.64 42.67								Slough

137.0
139.0
141.0 — 43.0
143.0
145.0
147.0 — 45.0
149.0
151.0
153.0 — 47.0
155.0
157.0
159.0
161.0 — 49.0
163.0
165.0
167.0 — 51.0
169.0
171.0
173.0 — 53.0
175.0
177.0
179.0
181.0 — 55.0
183.0
185.0
187.0 — 57.0
189.0
191.0
193.0 — 59.0
195.0
197.0
199.0 — 61.0
201.0
203.0
205.0

Reviewed By: WSC

Method: Air Percussion

Notes:

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Logged By: MDE

Sheet: 3 of 3

Client: Freymond Lumber

Borehole Number: MW7

Project: Freymond Quarry

Job Number: 33886-100

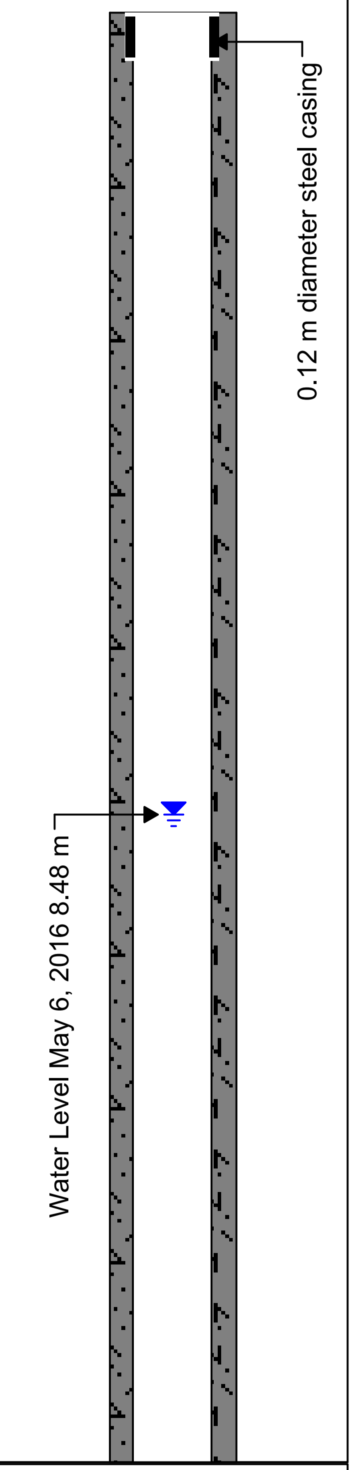
Location: Bancroft Ontario

Drill Date: May 6, 2016

Depth (m)	Elevation (masl)	Geological Description
		GNEISS dark grey, metasedimentary bedrock, feldspar, quartz and mica rich
2.00		
	380.21	*Near vertical weathered fracture 8-10'*
4.00		
	377.56	medium-dark grey
	377.18	
	376.88	*minor iron staining starting at 117'11"* *Weathered zone 18'11" - 20'5"*
6.00		
	376.01	mottled grey, pyrite mineralization
8.00		
	374.47	*Wavy near vertical laminations with pyrite minerlization*
	372.97	grey, thin vertical laminations
10.00		
	371.47	
	371.06	grey, mottled, laminated *Weaker zone at 38-39' weathered*
12.00		
	369.92	grey, mottled *Weathered zone 42'5" - 43'3" and 46'2" - 46'6"*
14.00		
	368.37	grey, vertical laminations

Strength	Weathering	Run #	% Recovery	% RQD	No. of Sets	Types (s)	Orientation	Spacing	Roughness	Aperture	Filling	Staining	Fractures
VH	S	1	100	100	4	SJ	F	C	SP	N	N	-	
VH	S	2	100	100	6	B S	F D,V	C	SP RP	N M	T O	-	
VH	S	3	100	100	4	B S	F V	C	SP	N	T O	-	
VH	M	4	100	93	7	B S	F V	C	RP SP	N W	T O	-	
VH	U	5	100	100	3	B	F	C	SU	M	T	-	
VH	U	6	100	95	4	B S	F D	C	SU	N	T	-	
VH	U	7	100	95	6	B	F	C	SU	M	T	-	
VH	UM	8	100	96	6	B S	F	C	SU	M W	T O	Yes	
H	UM	9	100	77	7	B SJ	F	C	SU RU	M W	T O	Yes	
VH	U	10	100	96	3	SJ	F	C	SU	N	T	-	

Groundwater Observations and Well Details



Reviewed By: PAG

Logged By: PAG

Method: NQ Wet Rotary

Notes:

Sheet: 1 of 3

Client: Freymond Lumber

Borehole Number: MW7

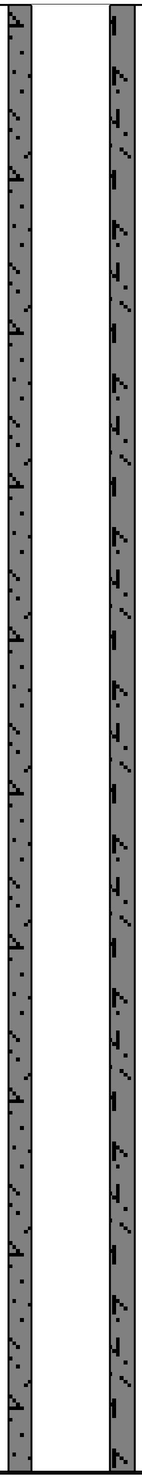
Project: Freymond Quarry

Job Number: 33886-100

Location: Bancroft Ontario

Drill Date: May 6, 2016

Depth (m)	Elevation (masl)	Geological Description	Strength	Weathering	Run #	% Recovery	% RQD	No. of Sets	Types (s)	Orientation	Spacing	Roughness	Aperture	Filling	Staining	Fractures	Groundwater Observations and Well Details
													M				
	366.79																
16.00		light - med grey, green															
		Inclined fracture, weaker zone 52'8"	H	UM	11	100	100	5	SJ	F D	C	SU	M W	T O	Yes		
	365.58																
		Pyrite minerilization at 56'															
		grey, inclined laminations															
18.00																	
	364.36		VH	UM	12	100	96	6	SJ	F D	C	SU	N M	T O	Yes		
		Iron staining in break at 60'															
	363.75																
		dark grey, laminated															
			H	UM	13	100	96	3	SJ	F D	C	SU	M W	T O	Yes		
20.00	362.53																
		Weak weathered break at 66'															
		dark grey, pyrite in laminations															
			VH	U	14	100	100	5	J	F	C	SU	N	T	-		
	360.80																
22.00		dark grey, mottled															
			VH	U	15	100	94	6	J	F	C	SU	N	T	-		
	359.23																
		dark grey															
24.00		Vertical fracture, pyrite infilling 77', 77'11"	VH	U	16	100	87.5	6	J	F V	C	SU	N M	T	-		
	357.68																
		dark grey to black															
		Wavy laminations with pyrite minerization	VH	U	17	100	97	3	J	F	C	SU	N	T	-		
26.00																	
	356.24																
		dark grey to black															
	355.57																
		Iron staining at 88'10"	H	UM	18	100	100	4	JS	F	C	SU	N M	T O	Yes		
28.00	354.63																
		dark grey/black, mottled, laminated															
	353.97																
		Pyrite mineralization at 94'1"	VH	U	19	100	97	4	J	F	C	SU	N	T	-		
	353.11																
		dark grey to black															
30.00																	
			VH	U	20	100	97	4	J	F	C	SU	N	T	-		



Reviewed By: PAG

Logged By: PAG

Method: NQ Wet Rotary

Notes:

Sheet: 2 of 3

Client: Freymond Lumber

Borehole Number: MW7

Project: Freymond Quarry

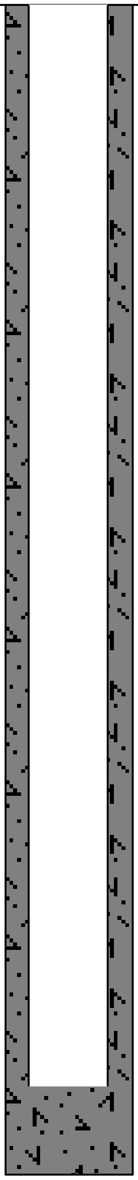
Job Number: 33886-100

Location: Bancroft Ontario

Drill Date: May 6, 2016

Depth (m)	Elevation (masl)	Geological Description	Strength	Weathering	Run #	% Recovery	% RQD	No. of Sets	Types (s)	Orientation	Spacing	Roughness	Aperture	Filling	Staining	Fractures
32.00	351.61	dark grey, laminated	VH	U	21	100	98	5	J	F	C	SU	N M	T	-	
	350.36	*heavily pyrite mineralized 105'11"*														
	350.06	dark grey, laminated, mottled	VH	UM	22	100	100	3	J	F	C	SU	N M	T	-	
34.00	348.53	grey, mottled	H	US	23	100	90	7	JS	F D	C	SU	N M	T O	-	
36.00	346.70	*minor iron staining at 117'11"*	H	US	24	100	97	6	B J	F	C	SU	M	T O	Yes	
38.00	345.15	*pyrite mineralization in vertical fracture 123-124'*	VH	US	25	100	92	6	B J	F V	C	SU	N M	T	-	
	343.96	grey, mottled, laminations	VH	U	26	100	100	1	B	F	C	SU	N	T	-	
40.00	342.11	Hole Terminated														
42.00																
44.00																

Groundwater Observations and Well Details



Reviewed By: PAG

Logged By: PAG

Method: NQ Wet Rotary

Notes:

Sheet: 3 of 3

APPENDIX C

AQUIFER TEST DATA SHEETS

MTE Consultants Inc.
520 Bingemans Centre Dr.
Kitchener, ON N2B 3X9

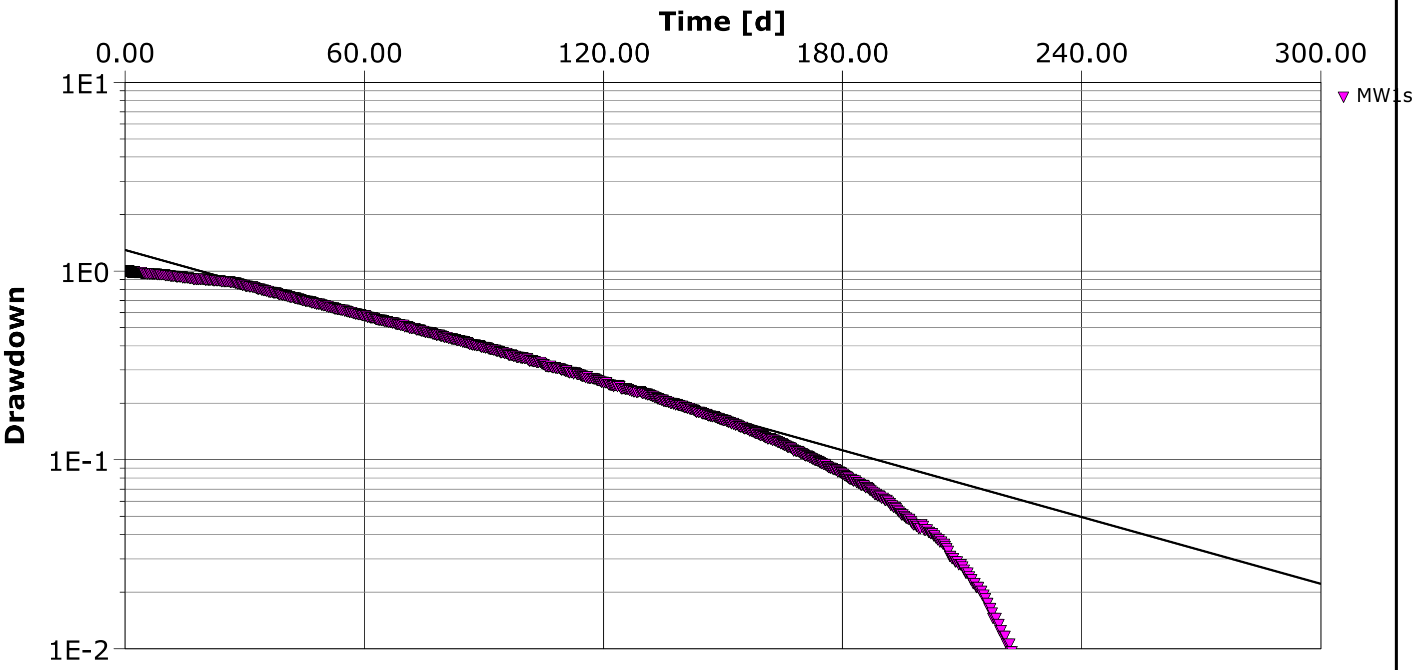
Slug Test Analysis Report

Project: Freymond Quarry

Number: 33886-100

Client: Freymond Quarry

Location: Lot 51&52, Con.WHR, Twn.Faraday	Slug Test: MW1s Rcrvy	Test Well: MW1s
Test Conducted by:		Test Date: 6/3/2009
Analysis Performed by: MDE	Hvorslev	Analysis Date: 6/3/2009
Aquifer Thickness: 1.10 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]
MW1s	6.97×10^{-11}

MTE Consultants Inc.
520 Bingemans Centre Dr.
Kitchener, ON N2B 3X9

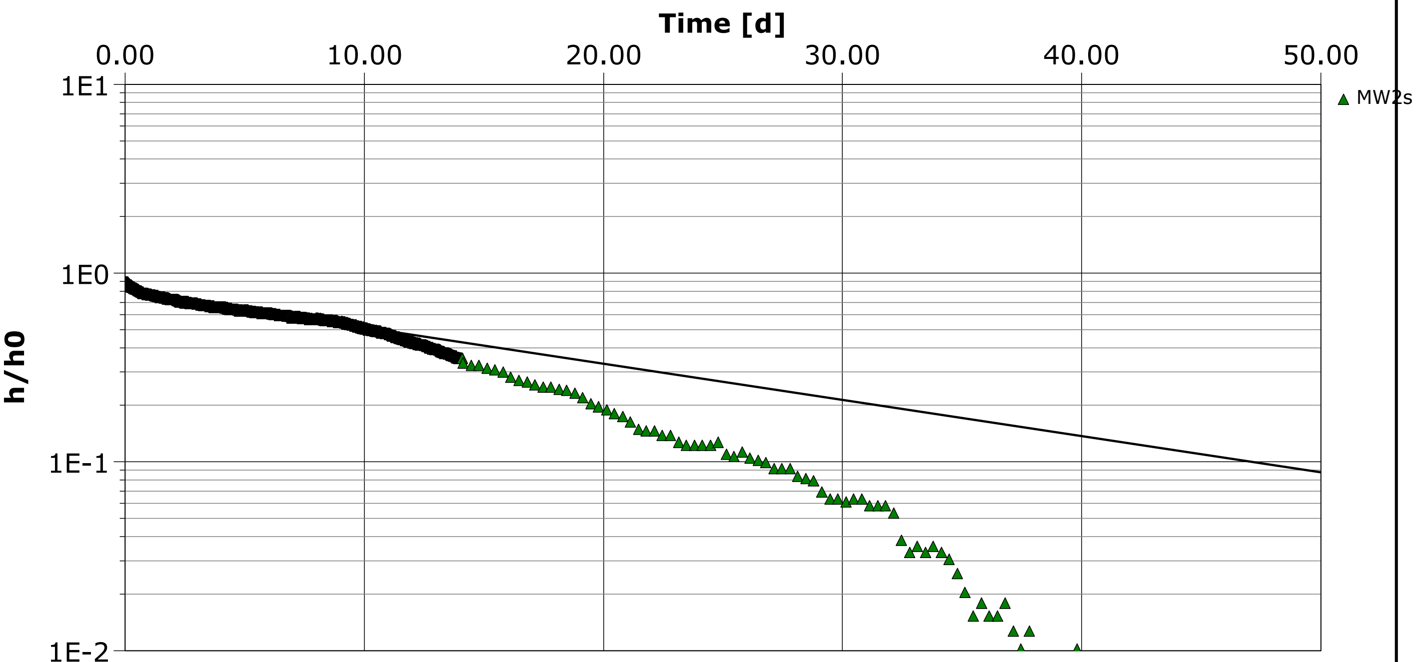
Slug Test Analysis Report

Project: Freymond Quarry

Number: 33886-100

Client: Freymond Quarry

Location: Lot 51&52, Con.WHR, Twn.Faraday	Slug Test: MW2s Rcvry	Test Well: MW2s
Test Conducted by: ME/BC		Test Date: 6/3/2009
Analysis Performed by: MDE	Hvorslev	Analysis Date: 6/3/2009
Aquifer Thickness: 3.18 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]
MW2s	2.41×10^{-10}

MTE Consultants Inc.
520 Bingemans Centre Dr.
Kitchener, ON N2B 3X9

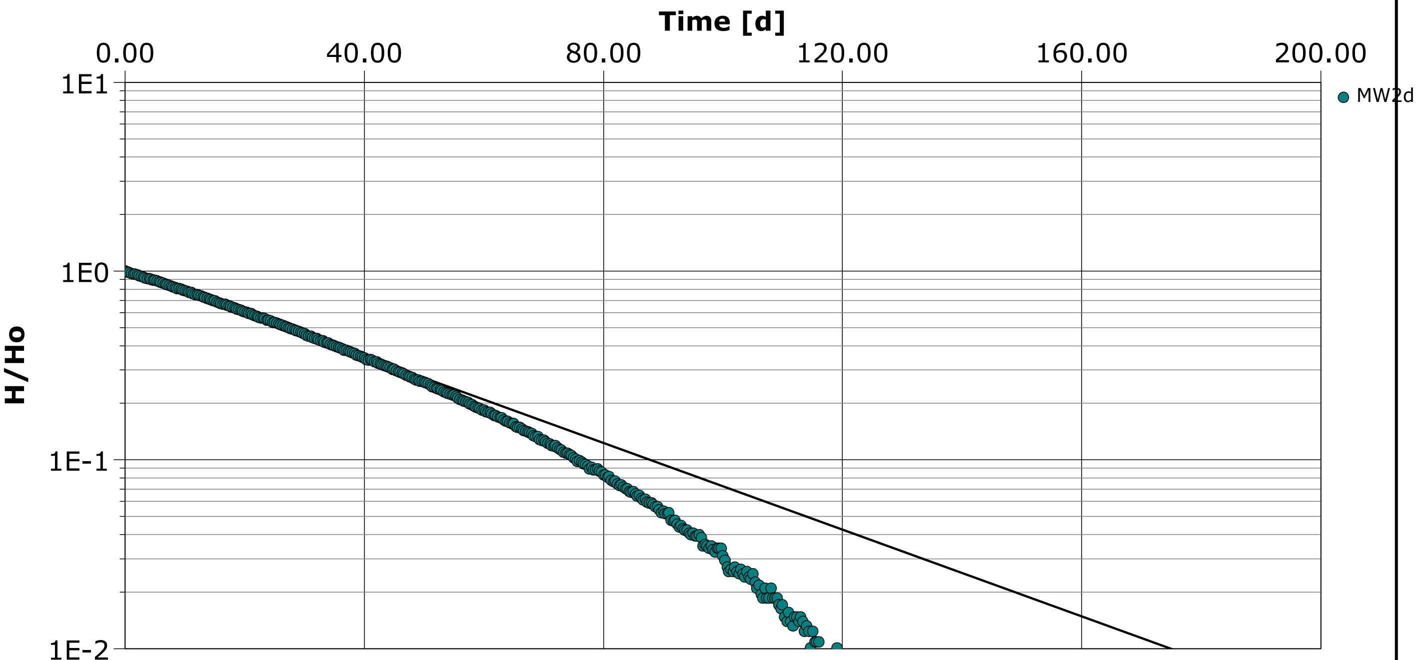
Slug Test Analysis Report

Project: Freymond Quarry

Number: 33886-100

Client: Freymond Quarry

Location: Lot 51&52, Con.WHR, Twn.Faraday	Slug Test: MW2d Rcrvy	Test Well: MW2d
Test Conducted by: MDE		Test Date: 2/2/2010
Analysis Performed by: MDE	Hvorslev	Analysis Date: 5/26/2010
Aquifer Thickness: 19.28 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]
MW2d	6.36×10^{-11}

MTE Consultants Inc.
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Kitchener, ON N2B 3X9

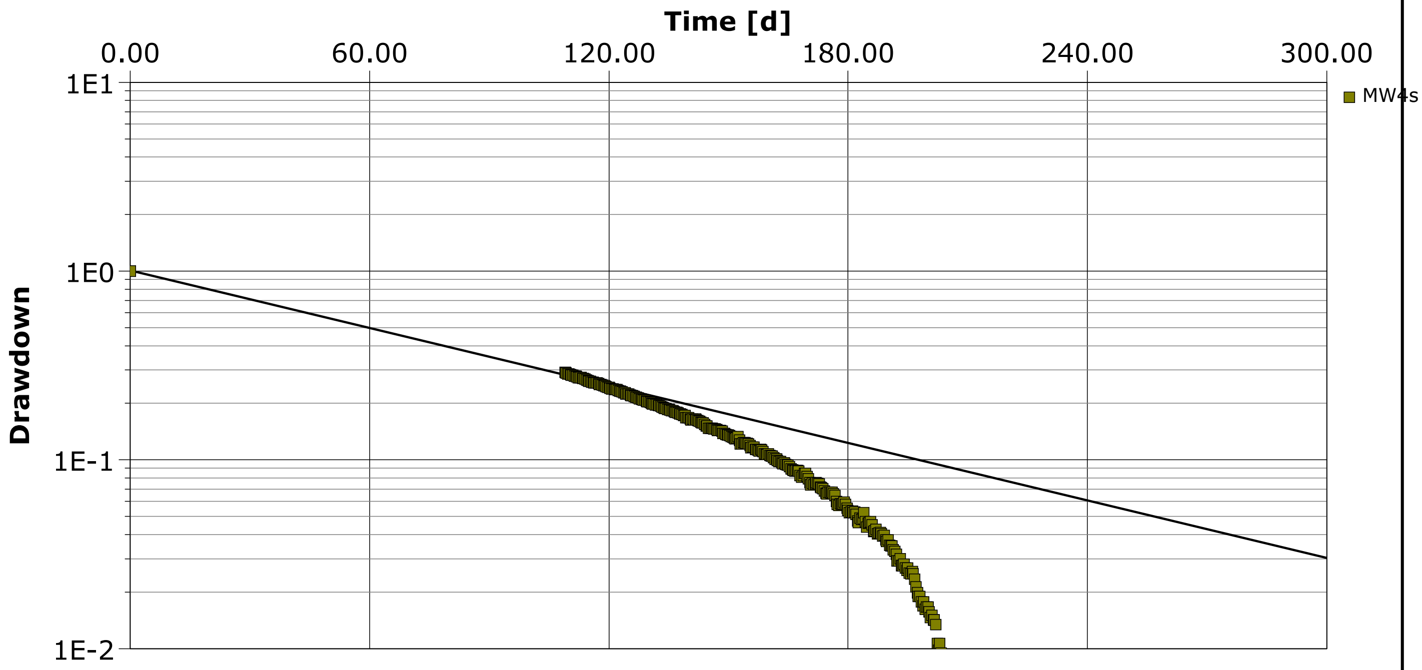
Slug Test Analysis Report

Project: Freymond Quarry

Number: 33886-100

Client: Freymond Quarry

Location: Lot 51&52, Con.WHR, Twn.Faraday	Slug Test: MW4s Rcrvy	Test Well: MW4s
Test Conducted by:		Test Date: 2/2/2010
Analysis Performed by: MDE	Hvorslev	Analysis Date: 2/2/2010
Aquifer Thickness: 25.39 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]
MW4s	5.61×10^{-11}

MTE Consultants Inc.
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Kitchener, ON N2B 3X9

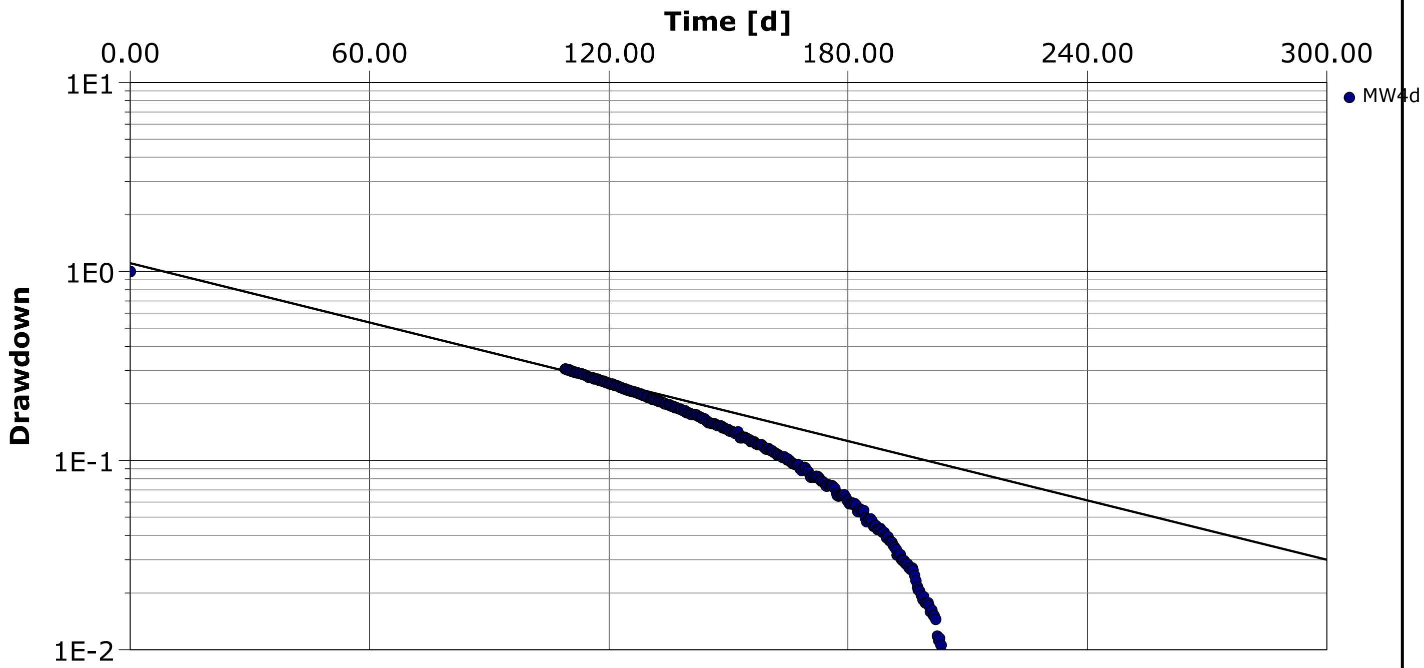
Slug Test Analysis Report

Project: Freymond Quarry

Number: 33886-100

Client: Freymond Quarry

Location: Lot 51&52, Con.WHR, Twn.Faraday	Slug Test: MW4d Rcrvy	Test Well: MW4d
Test Conducted by:		Test Date: 2/2/2010
Analysis Performed by: MDE	Hvorslev	Analysis Date: 2/2/2010
Aquifer Thickness: 30.38 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW4d	6.34×10^{-11}	

MTE Consultants Inc.
520 Bingemans Centre Dr.
Kitchener, ON N2B 3X9

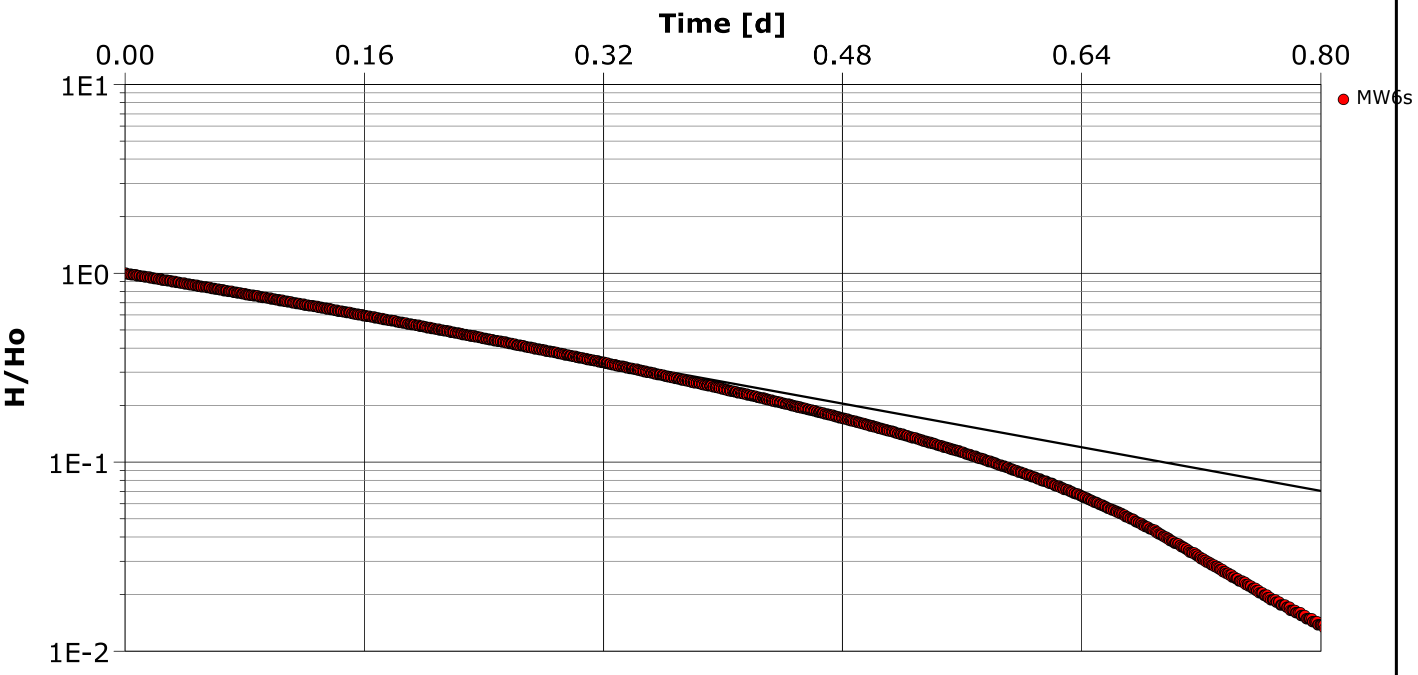
Slug Test Analysis Report

Project: Freymond Quarry

Number: 33886-100

Client: Freymond Quarry

Location: Lot 51&52, Con.WHR, Twn.Faraday	Slug Test: MW6s Rcvry	Test Well: MW6s
Test Conducted by: ME/BC		Test Date: 6/3/2009
Analysis Performed by: MDE	Hvorslev	Analysis Date: 6/3/2009
Aquifer Thickness: 26.25 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW6s	1.07×10^{-8}	

MTE Consultants Inc.
520 Bingemans Centre Drive
Kitchener, Ontario
N2B 3X9

Slug Test Analysis Report

Project: Freymond Quarry

Number: 33886-100

Client: Freymond Quarry

Location: Lot 51&52, Con.WHR

Slug Test: MW7 Rising - Large Slug

Test Well: MW7

Test Conducted by: SDB

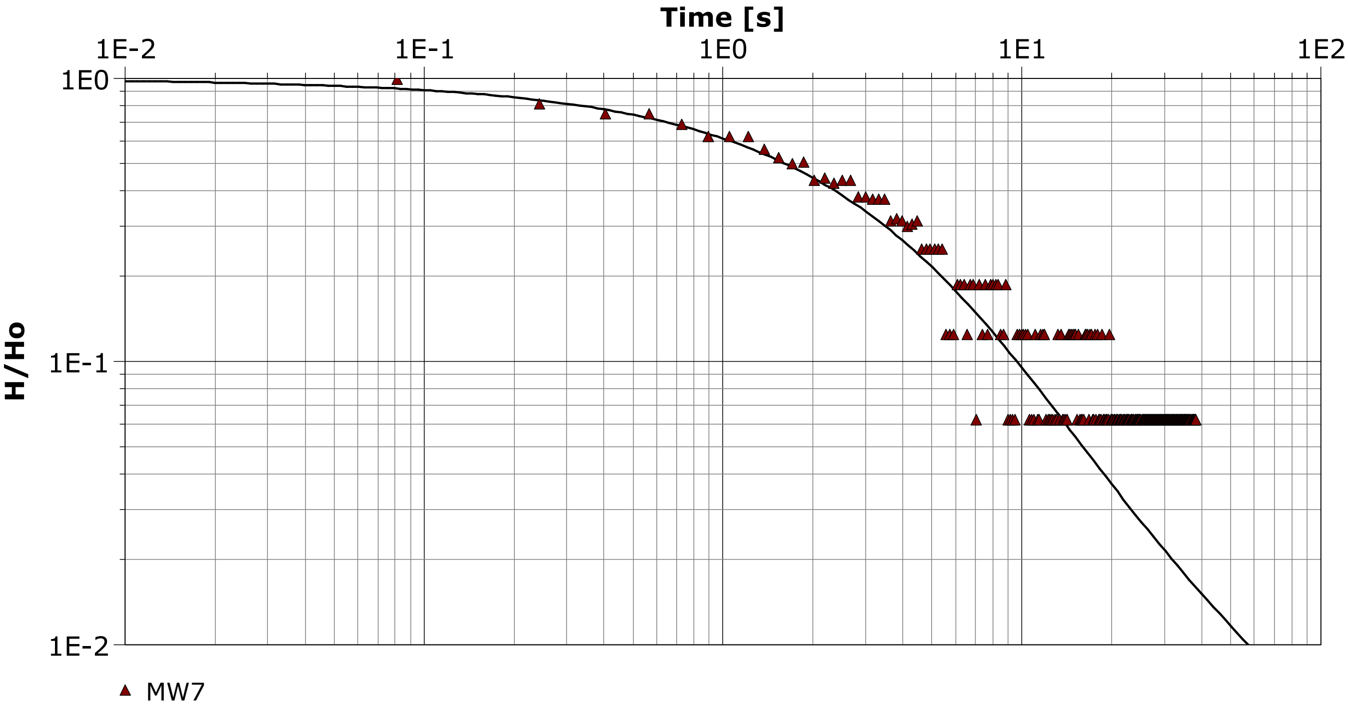
Test Date: 9/22/2016

Analysis Performed by: SDB

MW 7 Rising

Analysis Date: 9/29/2016

Aquifer Thickness: 30.22 m



Calculation using Cooper-Bredehoeft-Papadopulos

Observation Well	Transmissivity [m²/s]	Hydraulic Conductivity [m/s]	Well-bore storage coefficient	
MW7	1.01×10^{-4}	3.35×10^{-6}	1.29×10^{-2}	

MTE Consultants Inc.
520 Bingemans Centre Drive
Kitchener, Ontario
N2B 3X9

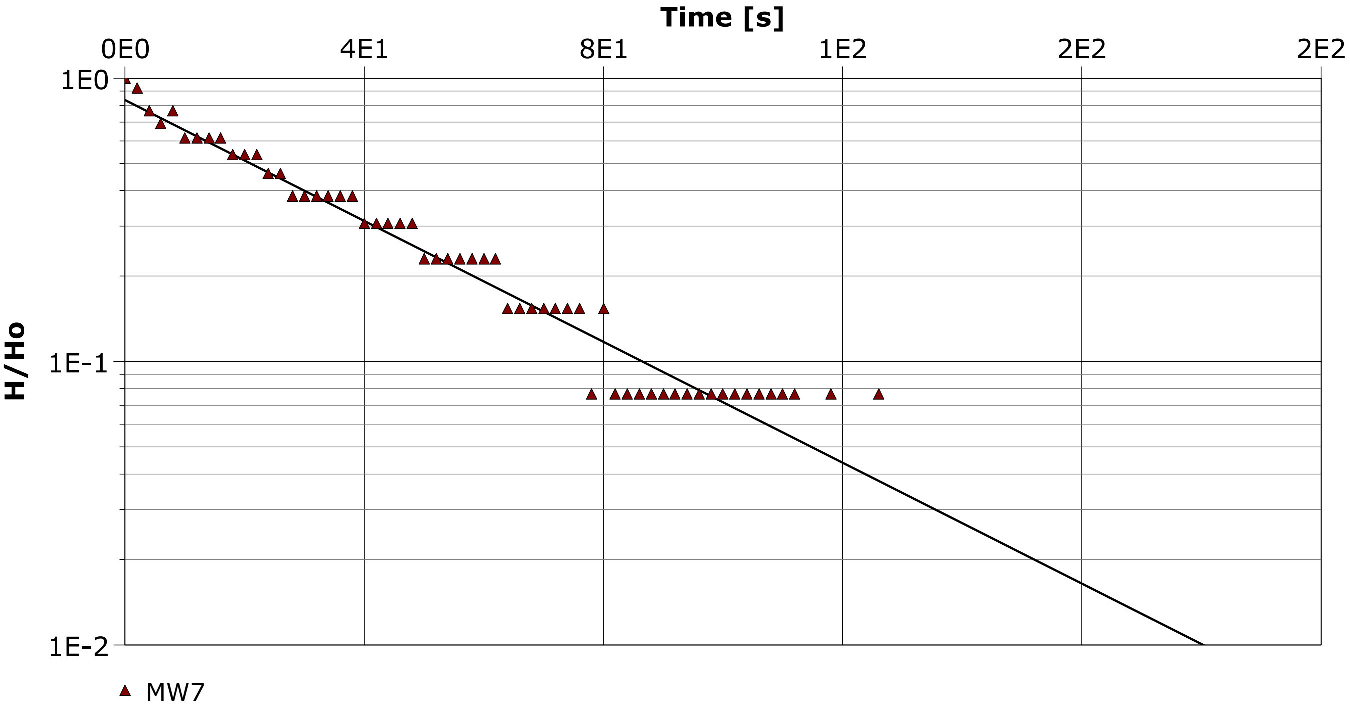
Slug Test Analysis Report

Project: Freymond Quarry

Number: 33886-100

Client: Freymond Quarry

Location: Lot 51&52, Con.WHR	Slug Test: MW7 Falling - Large Slug	Test Well: MW7
Test Conducted by:		Test Date: 9/29/2016
Analysis Performed by: SDB	MW7 Falling	Analysis Date: 9/29/2016
Aquifer Thickness: 30.22 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW7	6.54 × 10^{-6}	

APPENDIX D

PRIVATE WELL INVENTORIES

Drawing on experience...Building on strength.

Water Well Inventory – Page 1

33886-100

Resident Name PW1

911 Number ________ Road ________

Address ________

Phone Number ________ email ________

Property Owner: ☒ Yes ☐ No If No, Property Owner's Name ________

Previous Property Owners ________

Number of Wells on property 1 ☐ Don't Know

Type of Well: ☒ Drilled ☐ Dug ☐ Sand Point ☐ Other ________ ☐ Don't Know

Diameter of Well: ☐ 2 inches ☐ 4 inches ☒ 6 inches ☐ 8 inches ☐ 3 feet ☐ Don't Know

Depth of Well 300 ft ☐ Don't Know

Depth to Water 37 ft ☐ Don't Know

Pump Depth 200 ☐ Don't Know

Pump Type Submersible ☐ Don't Know

Water Source: ☒ Bedrock ☐ Sand/Gravel/Overburden ☐ Don't Know

Name of Well Driller Earl V. Marquardt & Son Inc. ☐ Don't Know

Date Installed Nov. 25, 2005 ☐ Don't Know

I have the MOE Water Well Record ☒ Yes ☐ No ☐ Don't Know

MOE Water Well Record Number A032653 ☐ Don't Know

Type of Water Use: ☒ Domestic ☐ Farm ☐ Irrigation ☐ Industrial ☐ Other ________

Water Treatment: ☐ Softener ☐ Sand Filter ☐ Carbon Filter ☒ Fiber Filter ☐ Aluminum Oxide

☐ UV ☐ Reverse Osmosis ☐ Distillation ☐ Ion Exchange ☐ Ozonation

Other Water Treatment ________ ☐ Don't Know

Water Well Inventory – Page 2

33886-100

Condition of Well Casing ☒Good ☐Buried ☐Corroded ☐Seized ☐Broken ☐Don't Know

Other

Any problems with water quantity in the past? ☐Yes ☒No

Any problems with water quality in the past? ☐ Yes☒No

If yes, what type ? ☐Sulphur smell ☐Iron taste ☐Brown water ☐Bacteria

Other

Location of Septic Bed West end of house

Potential Sources of Contamination: ☐barn ☐manure pile ☐gas tanks ☐heating oil tank

Other

Is the well easily accessible? ☒Yes ☐No

If Yes, may we measure the water level in this well? ☒ Yes ☐ No

Describe Well Location East end of house

Sketch a diagram to show the location of well(s), house, buildings, road(s), and septic bed:

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www.wellaware.ca

Water Well Inventory – Page 1

33886-100

Resident Name PW2

911 Number ____________ Road ____________

Address ____________

Phone Number ____________ email ____________

Property Owner: ☒ Yes ☐ No If No, Property Owner's Name ____________

Previous Property Owners ____________

Number of Wells on property 2 ☐ Don't Know

Type of Well: ☒ Drilled ☐ Dug ☐ Sand Point ☐ Other and dug ☐ Don't Know

Diameter of Well: ☐ 2 inches ☐ 4 inches ☐ 6 inches ☒ 8 inches ☐ 3 feet ☐ Don't Know

Depth of Well 220 ft ☐ Don't Know

Depth to Water 200 ft ☐ Don't Know

Pump Depth 150 ☐ Don't Know

Pump Type submersible ☐ Don't Know

Water Source: ☒ Bedrock ☐ Sand/Gravel/Overburden ☐ Don't Know

Name of Well Driller Terry Marquardt ☐ Don't Know

Date Installed 1997 ☐ Don't Know

I have the MOE Water Well Record ☐ Yes ☒ No ☐ Don't Know

MOE Water Well Record Number ____________ ☐ Don't Know

Type of Water Use: ☒ Domestic ☐ Farm ☐ Irrigation ☐ Industrial ☐ Other ____________

Water Treatment: ☐ Softener ☐ Sand Filter ☐ Carbon Filter ☐ Fiber Filter ☐ Aluminum Oxide

☐ UV ☐ Reverse Osmosis ☐ Distillation ☐ Ion Exchange ☐ Ozonation

Other Water Treatment ____________ ☐ Don't Know

Water Well Inventory – Page 2

33886-100

Condition of Well Casing ☒Good ☐Buried ☐Corroded ☐Seized ☐Broken ☐Don't Know

Other ______________________________

Any problems with water quantity in the past? ☐Yes ☒No

Any problems with water quality in the past? ☐ Yes ☒No

If yes, what type ? ☐Sulphur smell ☐Iron taste ☐Brown water ☐Bacteria

Other ______________________________

Location of Septic Bed north side of house

Potential Sources of Contamination: ☐barn ☐manure pile ☐gas tanks ☐heating oil tank

Other ______________________________

Is the well easily accessible? ☒Yes ☐No

If Yes, may we measure the water level in this well? ☒Yes ☐No

Describe Well Location south side of house

Sketch a diagram to show the location of well(s), house, buildings, road(s), and septic bed:

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Water Well Inventory – Page 1

33886-100

Resident Name PW3

911 Number ____________ Road ____________

Address ____________

Phone Number ____________ email ____________

Property Owner: ☒ Yes ☐ No If No, Property Owner's Name ____________

Previous Property Owners ____________

Number of Wells on property 3 ☐ Don't Know

Type of Well: ☒ Drilled ☐ Dug ☐ Sand Point ☐ Other and dug ☐ Don't Know

Diameter of Well: ☐ 2 inches ☐ 4 inches ☒ 6 inches ☐ 8 inches ☐ 3 feet ☐ Don't Know

Depth of Well 182 ft ☐ Don't Know

Depth to Water ____________ ☐ Don't Know

Pump Depth ____________ ☒ Don't Know

Pump Type ____________ ☒ Don't Know

Water Source: ☒ Bedrock ☐ Sand/Gravel/Overburden ☐ Don't Know

Name of Well Driller Marquardt Well Drilling ☐ Don't Know

Date Installed 1991 ☐ Don't Know

I have the MOE Water Well Record ☐ Yes ☐ No ☒ Don't Know

MOE Water Well Record Number ____________ ☒ Don't Know

Type of Water Use: ☒ Domestic ☐ Farm ☐ Irrigation ☐ Industrial ☐ Other ____________

Water Treatment: ☐ Softener ☐ Sand Filter ☐ Carbon Filter ☐ Fiber Filter ☐ Aluminum Oxide

☐ UV ☐ Reverse Osmosis ☐ Distillation ☐ Ion Exchange ☐ Ozonation

Other Water Treatment ____________ ☒ Don't Know

Water Well Inventory – Page 2

33886-100

Condition of Well Casing ☒Good ☐Buried ☐Corroded ☐Seized ☐Broken ☐Don't Know

Other __________

Any problems with water quantity in the past? ☒Yes ☐No

Any problems with water quality in the past? ☒ Yes ☐No

If yes, what type ? ☐Sulphur smell ☐Iron taste ☐Brown water ☒Bacteria

Other from road (oil)

Location of Septic Bed side of house at front on East side

Potential Sources of Contamination: ☐barn ☐manure pile ☐gas tanks ☐heating oil tank

Other __________

Is the well easily accessible? ☒Yes ☐No

If Yes, may we measure the water level in this well? ☒ Yes ☐ No

Describe Well Location well is at the back west side of house

Sketch a diagram to show the location of well(s), house, buildings, road(s), and septic bed:

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Water Well Inventory – Page 1

33886-100

Resident Name PW4

911 Number Road

Address

Phone Number email

Property Owner: ☒ Yes ☐ No If No, Property Owner's Name

Previous Property Owners

Number of Wells on property 1 ☐ Don't Know

Type of Well: ☐ Drilled ☐ Dug ☒ Sand Point ☐ Other dug wellpit ☐ Don't Know

Diameter of Well: ☐ 2 inches ☐ 4 inches ☐ 6 inches ☐ 8 inches ☒ 3 feet ☐ Don't Know

Depth of Well 15 ft ☐ Don't Know

Depth to Water 6 ft ☐ Don't Know

Pump Depth 15 ☐ Don't Know

Pump Type ☐ Don't Know

Water Source: ☐ Bedrock ☒ Sand/Gravel/Overburden ☐ Don't Know

Name of Well Driller Charly Hannah (deceased) ☐ Don't Know

Date Installed ~May 1975 ☐ Don't Know

I have the MOE Water Well Record ☐ Yes ☒ No ☐ Don't Know

MOE Water Well Record Number ☐ Don't Know

Type of Water Use: ☒ Domestic ☐ Farm ☐ Irrigation ☐ Industrial ☒ Other no drinking

Water Treatment: ☐ Softener ☐ Sand Filter ☐ Carbon Filter ☐ Fiber Filter ☐ Aluminum Oxide

☐ UV ☐ Reverse Osmosis ☐ Distillation ☐ Ion Exchange ☐ Ozonation

Other Water Treatment treated yearly with chlorine ☐ Don't Know

Water Well Inventory – Page 2

33886-100

Condition of Well Casing ☐Good ☒Buried ☐Corroded ☐Seized ☐Broken ☐Don't Know

Other 1/4 above ground tile

Any problems with water quantity in the past? ☐Yes ☒No

Any problems with water quality in the past? ☐ Yes ☒No

If yes, what type ? ☐ Sulphur smell ☐ Iron taste ☐ Brown water ☒ Bacteria

Other vegitation Tree roots?

Location of Septic Bed 10 feet behind house on the right side

Potential Sources of Contamination: ☐ barn ☐ manure pile ☐ gas tanks ☐ heating oil tank

Other put in legally (Hawley)

Is the well easily accessible? ☒ Yes ☐ No

If Yes, may we measure the water level in this well? ☒ Yes ☐ No

Describe Well Location left hand of cottage in line of pump about 30 feet from house.

Sketch a diagram to show the location of well(s), house, buildings, road(s), and septic bed:

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Water Well Inventory – Page 1

33886-100

Resident Name PW5

911 Number ______ Road ______

Address ______

______

Phone Number ______ email ______

Property Owner: ☒ Yes ☐ No If No, Property Owner's Name ______

Previous Property Owners ______

Number of Wells on property 1 ☐ Don't Know

Type of Well: ☒ Drilled ☐ Dug ☐ Sand Point ☐ Other ______ ☐ Don't Know

Diameter of Well: ☐ 2 inches ☐ 4 inches ☒ 6 inches ☐ 8 inches ☐ 3 feet ☐ Don't Know

Depth of Well ______ ☒ Don't Know

Depth to Water ______ ☒ Don't Know

Pump Depth ______ ☒ Don't Know

Pump Type ______ ☒ Don't Know

Water Source: ☐ Bedrock ☒ Sand/Gravel/Overburden ☐ Don't Know

Name of Well Driller Terry Marquardt ☐ Don't Know

Date Installed 2001? ☐ Don't Know

I have the MOE Water Well Record ☐ Yes ☒ No ☐ Don't Know

MOE Water Well Record Number ______ ☒ Don't Know

Type of Water Use: ☒ Domestic ☐ Farm ☐ Irrigation ☐ Industrial ☐ Other ______

Water Treatment: ☐ Softener ☒ Sand Filter ☐ Carbon Filter ☐ Fiber Filter ☐ Aluminum Oxide ☐ UV ☐ Reverse Osmosis ☐ Distillation ☐ Ion Exchange ☐ Ozonation

Other Water Treatment ______ ☐ Don't Know

Water Well Inventory – Page 2

33886-100

Condition of Well Casing ☒Good ☐Buried ☐Corroded ☐Seized ☐Broken ☐Don't Know

Other ____________________

Any problems with water quantity in the past? ☐Yes ☒No

Any problems with water quality in the past? ☐ Yes ☒No

If yes, what type ? ☐Sulphur smell ☐Iron taste ☐Brown water ☐Bacteria

Other ____________________

Location of Septic Bed ____________________

Potential Sources of Contamination: ☐barn ☐manure pile ☐gas tanks ☐heating oil tank

Other ____________________

Is the well easily accessible? ☒Yes ☐No

If Yes, may we measure the water level in this well? ☒Yes ☐ No

Describe Well Location Lower driveway next to lawn

Sketch a diagram to show the location of well(s), house, buildings, road(s), and septic bed:

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Water Well Inventory – Page 1

33886-100

Resident Name PW6

911 Number ______ Road ______

Address ______

Phone Number ______ email ______

Property Owner: ☒ Yes ☐ No If No, Property Owner's Name ______

Previous Property Owners ______

Number of Wells on property 1 ☐ Don't Know

Type of Well: ☒ Drilled ☐ Dug ☐ Sand Point ☐ Other ______ ☐ Don't Know

Diameter of Well: ☐ 2 inches ☐ 4 inches ☐ 6 inches ☒ 8 inches ☐ 3 feet ☐ Don't Know

Depth of Well ______ ☒ Don't Know

Depth to Water ______ ☒ Don't Know

Pump Depth ______ ☒ Don't Know

Pump Type ______ ☒ Don't Know

Water Source: ☐ Bedrock ☒ Sand/Gravel/Overburden ☐ Don't Know

Name of Well Driller ______ ☒ Don't Know

Date Installed ______ ☒ Don't Know

I have the MOE Water Well Record ☐ Yes ☒ No ☐ Don't Know

MOE Water Well Record Number ______ ☐ Don't Know

Type of Water Use: ☒ Domestic ☐ Farm ☐ Irrigation ☐ Industrial ☐ Other ______

Water Treatment: ☐ Softener ☐ Sand Filter ☐ Carbon Filter ☐ Fiber Filter ☐ Aluminum Oxide

☐ UV ☐ Reverse Osmosis ☐ Distillation ☐ Ion Exchange ☐ Ozonation

Other Water Treatment Sand Filter ☐ Don't Know

Water Well Inventory – Page 2

33886-100

Condition of Well Casing ☒Good ☐Buried ☐Corroded ☐Seized ☐Broken ☐Don't Know

Other ______________________________

Any problems with water quantity in the past? ☐Yes ☒No

Any problems with water quality in the past? ☐ Yes☒No

If yes, what type ? ☐Sulphur smell ☐ Iron taste ☐Brown water ☐Bacteria

Other ______________________________

Location of Septic Bed ______________________________

Potential Sources of Contamination: ☐barn ☐manure pile ☐gas tanks ☐heating oil tank

Other ______________________________

Is the well easily accessible? ☒Yes ☐No

If Yes, may we measure the water level in this well? ☒ Yes ☐ No

Describe Well Location Behind house, next to pool house

Sketch a diagram to show the location of well(s), house, buildings, road(s), and septic bed:

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Project #: 33886-100

WATER WELL INVENTORY

Resident Name: PW7

911 Number: ______ **Road:** Gaebel Rd.

Address: 119 Gaebel Rd. Bancroft, ON

Phone Number: ______ **Email:** ______

Property Owner: ■ Yes ☐ No **If No, Property Owner's Name**: ______

Previous Property Owners: ______

Number of Wells on Property: ______ ☐ Don't Know

Type of Well: ■ Drilled ☐ Dug ☐ Sand Point ☐ Other ______ ☐ Don't Know

Diameter of Well: ☐ 2 in. ☐ 4 in. ■ 6 in. ☐ 8 in. ☐ 3 ft. ☐ Don't Know

Depth of Well: 145' ☐ Don't Know

Depth of Water: 17.92m ☐ Don't Know

Pump Depth: 120' ☐ Don't Know

Pump Type: Submer ☐ Don't Know

Water Source: ■ Bedrock ☐ Sand/Gravel/Overburden ☐ Don't Know

Name of Well Driller: Earl V. Manquardt & Son Inc. ☐ Don't Know

Date Installed: January 6, 1989 ☐ Don't Know

I have the MOE Water Well Record: ■ Yes ☐ No ☐ Don't Know

MOE Water Well Record Number: ______ ☐ Don't Know

Type of Water Use: ■ Domestic ☐ Farm ☐ Irrigation ☐ Industrial ☐ Other ______

Water Treatment: ☐ Softener ☐ Sand Filter ☐ Carbon Filter ☐ Fiber Filter. ☐ Aluminum Oxide
☐ UV ☐ Reverse Osmosis ☐ distillation ☐ Ion Exchange. ☐ Ozonation

Other Water Treatment: Particulate Filter ☐ Don't Know

☑ ☐

Well is located 4m south of house and 38m east of Gaebel Rd.

Well is drilled but buried a few inches beneath ground. Owner doesn't mind digging down to it.

Ha[illegible] be[illegible] s[illegible]yed[illegible]t can can also easily pinpoint the well.

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WATER WELL INVENTORY

Condition of Well Casing: ☐ Good ☐ Buried ☐ Corroded ☐ Seized ☐ Broken ☐ Don't Know
Other: ____________________

Any problems with water quantity in the past? ☐ Yes ☐ No

Any problem with water quality in the past? ☐ Yes ☐ No

If yes, what type? ☐ Sulphur smell ☐ Iron Taste ☐ Brown Water ☐ Bacteria
Other: ____________________

Location of Septic Bed: ____________________

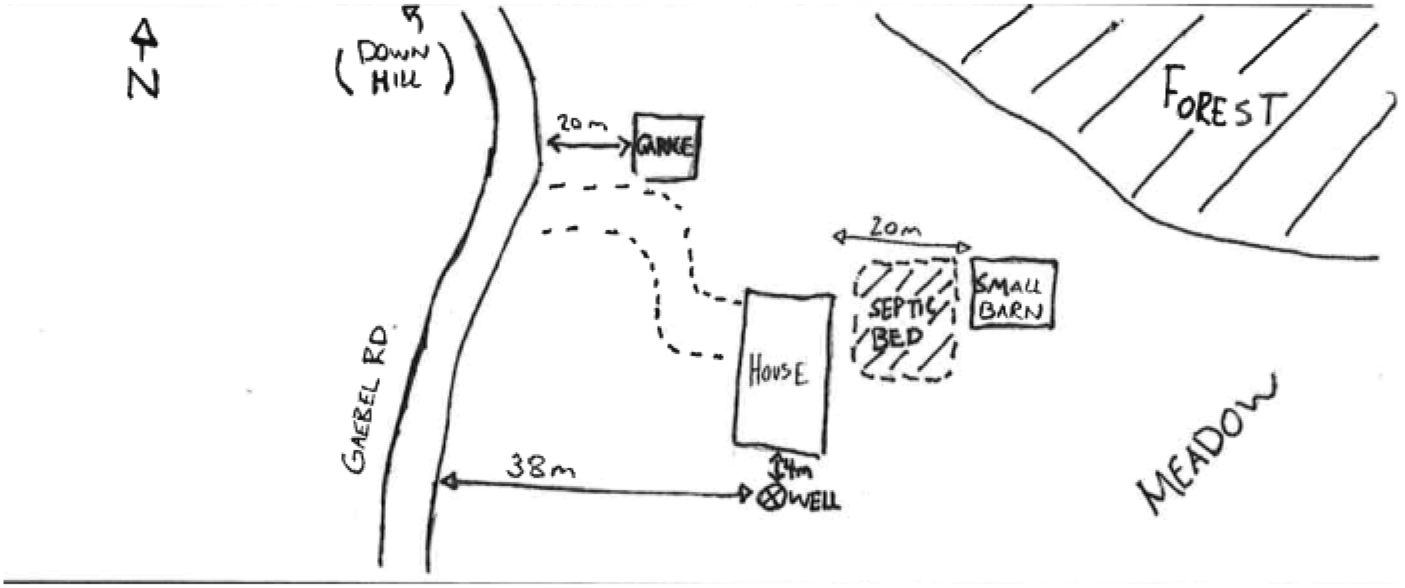
Potential Sources of Contamination: ☐ Barn ☐ Manure Pile ☐ Gas Tanks ☐ Heating Oil Tank
Other: ____________________

Is the well easily accessible? ☐ Yes ☐ No

If Yes, may we measure water levels in this well? ☐ Yes ☐ No

If necessary, could we sample your well for water quality testing? Yes No

Describe Well Location ____________________



Water Well Inventory – Page 1

Resident Name PW8

911 Number 431 Road Gaebel Road

Address Bancroft, ON K0L 1C0

Phone Number email

Property Owner: ☒ Yes ☐ No If No, Property Owner's Name

Previous Property Owners

Number of Wells on property 1 ☐ Don't Know

Type of Well: ☐ Drilled ☒ Dug ☐ Sand Point ☐ Other ☐ Don't Know

Diameter of Well: ☐ 2 inches ☐ 4 inches ☐ 6 inches ☐ 8 inches ☒ 3 feet ☐ Don't Know

Depth of Well 2.56 ☐ Don't Know

Depth to Water 1.15 ☐ Don't Know

Pump Depth ☒ Don't Know

Pump Type Submersible ☐ Don't Know

Water Source: ☐ Bedrock ☒ Sand/Gravel/Overburden ☐ Don't Know

Name of Well Driller ☒ Don't Know

Date Installed ☒ Don't Know

I have the MOE Water Well Record ☐ Yes ☒ No ☐ Don't Know

MOE Water Well Record Number ☒ Don't Know

Type of Water Use: ☒ Domestic ☒ Farm ☐ Irrigation ☐ Industrial ☐ Other

Water Treatment: ☐ Softener ☐ Sand Filter ☐ Carbon Filter ☐ Fiber Filter ☐ Aluminum Oxide ☐ UV ☐ Reverse Osmosis ☐ Distillation ☐ Ion Exchange ☐ Ozonation

Other Water Treatment no treatment ☐ Don't Know

Water Well Inventory – Page 2

33886-100

Condition of Well Casing ☐ Good ☐ Buried ☐ Corroded ☐ Seized ☒ Broken ☐ Don't Know

Other missing 3' lid

Any problems with water quantity in the past? ☐ Yes ☒ No

Any problems with water quality in the past? ☐ Yes ☒ No

If yes, what type ? ☐ Sulphur smell ☐ Iron taste ☐ Brown water ☐ Bacteria

Other

Location of Septic Bed between house and greenhouse

Potential Sources of Contamination: ☐ barn ☐ manure pile ☐ gas tanks ☐ heating oil tank

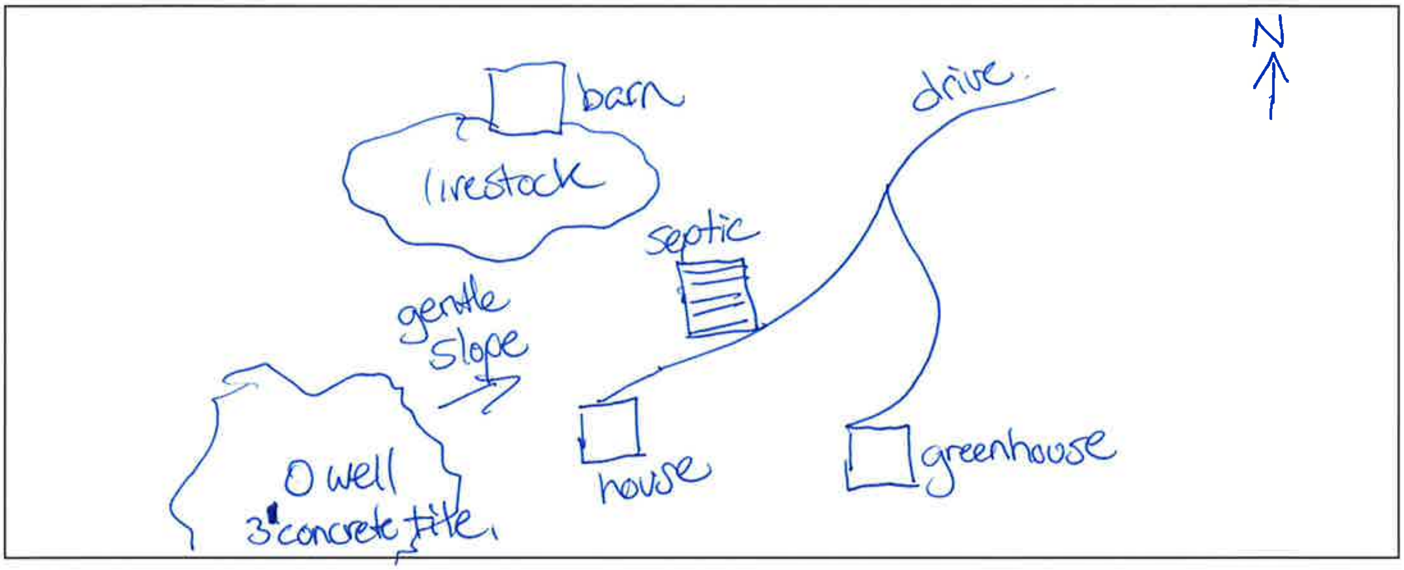
Other well exposed to animals and organics

Is the well easily accessible? ☒ Yes ☐ No

If Yes, may we measure the water level in this well? ☒ Yes ☐ No

Describe Well Location wooded area behind house

Sketch a diagram to show the location of well(s), house, buildings, road(s), and septic bed:



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Water Well Inventory – Page 1

33886-100

Resident Name PW9

911 Number 72 Road Gaebel Road

Address RR1, Bancroft, ON K0L 1C0

Phone Number email

Property Owner: ☒ Yes ☐ No If No, Property Owner's Name

Previous Property Owners

Number of Wells on property 1 ☐ Don't Know

Type of Well: ☒ Drilled ☐ Dug ☐ Sand Point ☐ Other ☐ Don't Know

Diameter of Well: ☐ 2 inches ☐ 4 inches ☐ 6 inches ☒ 8 inches ☐ 3 feet ☐ Don't Know

Depth of Well 320 ft ☒ Don't Know

Depth to Water 80 ft ☒ Don't Know

Pump Depth 300 ☒ Don't Know

Pump Type submersible ☒ Don't Know

Water Source: ☒ Bedrock ☐ Sand/Gravel/Overburden ☐ Don't Know

Name of Well Driller Joe Legge ☒ Don't Know

Date Installed July 2009 ☒ Don't Know

I have the MOE Water Well Record ☒ Yes ☐ No ☐ Don't Know

MOE Water Well Record Number ☐ Don't Know

Type of Water Use: ☒ Domestic ☐ Farm ☐ Irrigation ☐ Industrial ☐ Other

Water Treatment: ☐ Softener ☒ Sand Filter ☐ Carbon Filter ☐ Fiber Filter ☐ Aluminum Oxide

☐ UV ☐ Reverse Osmosis ☐ Distillation ☐ Ion Exchange ☐ Ozonation

Other Water Treatment Sand Filter ☐ Don't Know

Water Well Inventory – Page 2

33886-100

Condition of Well Casing ☒Good ☐Buried ☐Corroded ☐Seized ☐Broken ☐Don't Know

Other ______

Any problems with water quantity in the past? ☐Yes ☒No

Any problems with water quality in the past? ☐ Yes ☒No

If yes, what type ? ☐ Sulphur smell ☐ Iron taste ☐Brown water ☐ Bacteria

Other ______

Location of Septic Bed 100 ft from well

Potential Sources of Contamination: ☐barn ☐manure pile ☐gas tanks ☐heating oil tank

Other ______

Is the well easily accessible? ☒Yes ☐No

If Yes, may we measure the water level in this well? ☒Yes ☐ No

Describe Well Location Behind house, on hill near deck

Sketch a diagram to show the location of well(s), house, buildings, road(s), and septic bed:

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Water Well Inventory – Page 1

Resident Name PW10

911 Number # 27 Road Battelle Rd

Address P.O.B. 155
BANCROFT ONT

Phone Number ____ email ____

Property Owner: ☒ Yes ☐ No If No, Property Owner's Name ____

Previous Property Owners ____

Number of Wells on property 1 ☐ Don't Know

Type of Well: ☒ Drilled ☐ Dug ☐ Sand Point ☐ Other ____ ☐ Don't Know

Diameter of Well: ☐ 2 inches ☐ 4 inches ☒ 6 inches ☐ 8 inches ☐ 3 feet ☐ Don't Know

Depth of Well 80 ft. 78ft ☐ Don't Know

Depth to Water static level 16ft ☐ Don't Know

Pump Depth 75feet ☐ Don't Know

Pump Type Submersable ☐ Don't Know

Water Source: ☒ Bedrock ☐ Sand/Gravel/Overburden ☐ Don't Know

Name of Well Driller Marquette ☐ Don't Know

Date Installed ____ ☐ Don't Know

I have the MOE Water Well Record ☐ Yes ☐ No ☐ Don't Know

MOE Water Well Record Number 1975 ☐ Don't Know

Type of Water Use: ☐ Domestic ☒ Farm ☐ Irrigation ☐ Industrial ☐ Other ____

Water Treatment: ☐ Softener ☐ Sand Filter ☐ Carbon Filter ☐ Fiber Filter ☐ Aluminum Oxide
☐ UV ☐ Reverse Osmosis ☐ Distillation ☐ Ion Exchange ☐ Ozonation

Other Water Treatment NO WATER TREATMENT ☐ Don't Know

Water Well Inventory – Page 2

33886-100

Condition of Well Casing ☒Good ☐Buried ☐Corroded ☐Seized ☐Broken ☐Don't Know

Other ____________________

Any problems with water quantity in the past? ☐Yes ☒No

Any problems with water quality in the past? ☐Yes ☒No

If yes, what type ? ☐Sulphur smell ☐Iron taste ☐Brown water ☐Bacteria

Other ____________________

Location of Septic Bed TOWN SEWERS

Potential Sources of Contamination: ☐barn ☐manure pile ☐gas tanks ☐heating oil tank

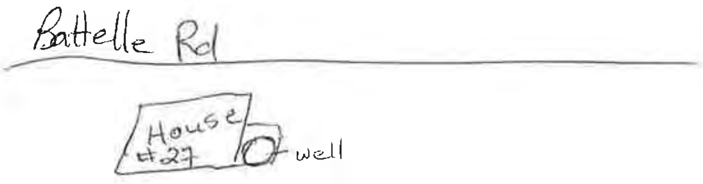
Other ____________________

Is the well easily accessible? ☒Yes ☐No

If Yes, may we measure the water level in this well? ☐Yes ☐No

Describe Well Location back of house on East side of house

Sketch a diagram to show the location of well(s), house, buildings, road(s), and septic bed:



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Project #: 33886-100

WATER WELL INVENTORY

Resident Name: PW11

911 Number: ______ **Road:** Gaebel Rd.

Address: 288 Gaebel Rd. Bancroft, ON

Phone Number: ______ **Email:** ______

Property Owner: ☒ Yes ☐ No **If No, Property Owner's Name**: ______

Previous Property Owners: ______

Number of Wells on Property: 1 ☐ Don't Know

Type of Well: ☐ Drilled ☒ Dug ☐ Sand Point ☐ Other ______ ☐ Don't Know

Diameter of Well: ☐ 2 in. ☐ 4 in. ☐ 6 in. ☐ 8 in. ☒ 3 ft. ☐ Don't Know

Depth of Well: 2.45m ☐ Don't Know

Depth of Water: 0.51m ☐ Don't Know

Pump Depth: ______ ☐ Don't Know

Pump Type: ______ ☐ Don't Know

Water Source: ☐ Bedrock ☒ Sand/Gravel/Overburden ☐ Don't Know

Name of Well Driller: Pat Monroe ☐ Don't Know

Date Installed: Over 50 years ago ☐ Don't Know

I have the MOE Water Well Record: ☐ Yes ☒ No ☐ Don't Know

MOE Water Well Record Number: ______ ☐ Don't Know

Type of Water Use: ☒ Domestic ☐ Farm ☐ Irrigation ☐ Industrial ☐ Other ______

Water Treatment: ☐ Softener ☐ Sand Filter ☐ Carbon Filter ☐ Fiber Filter. ☐ Aluminum Oxide
☐ UV ☐ Reverse Osmosis ☐ distillation ☐ Ion Exchange. ☐ Ozonation

Other Water Treatment: ______ ☐ Don't Know

☑ ☐

Dug well is located 1m off of North side of house, and about 8m off of the road.

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WATER WELL INVENTORY

Condition of Well Casing: ☐ Good ☐ Buried ☐ Corroded ☐ Seized ☐ Broken ☐ Don't Know
Other: ____________________

Any problems with water quantity in the past? ☐ Yes ☐ No

Any problem with water quality in the past? ☐ Yes ☐ No

If yes, what type? ☐ Sulphur smell ☐ Iron Taste ☐ Brown Water ☐ Bacteria
Other: ____________________

Location of Septic Bed: ____________________

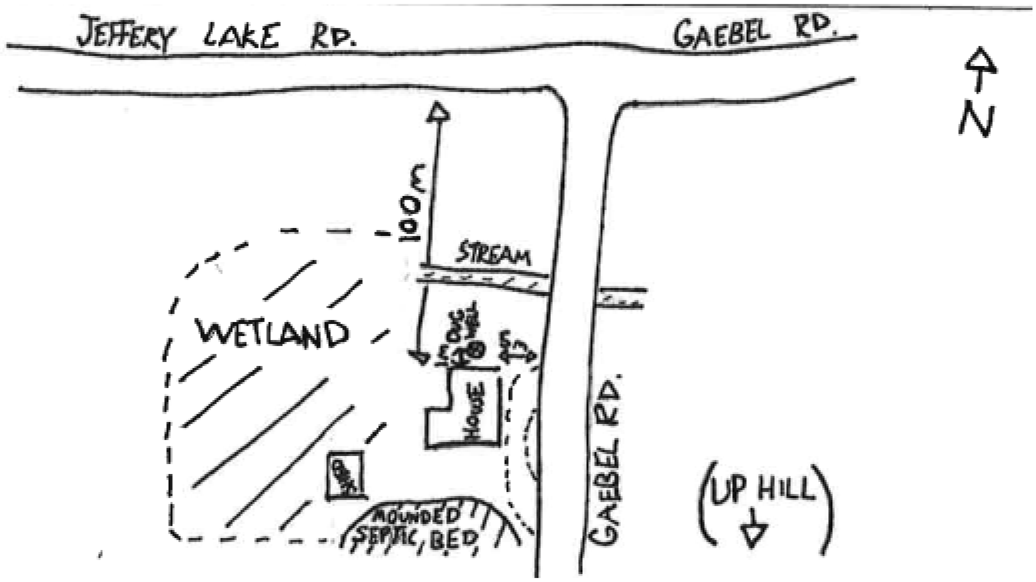
Potential Sources of Contamination: ☐ Barn ☐ Manure Pile ☐ Gas Tanks ☐ Heating Oil Tank
Other: ____________________

Is the well easily accessible? ☐ Yes ☐ No

If Yes, may we measure water levels in this well? ☐ Yes ☐ No

If necessary, could we sample your well for water quality testing? Yes No

Describe Well Location ____________________



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Project #: 33886-100

WATER WELL INVENTORY

Resident Name: PW12

911 Number: **Road:** Gaebel Rd.

Address: 114 Gaebel Rd. Bancroft, ON

Phone Number: **Email:**

Property Owner: ☐ Yes ☐ No **If No, Property Owner's Name:**

Previous Property Owners:

Number of Wells on Property: 1 ☐ Don't Know

Type of Well: ■ Drilled ☐ Dug ☐ Sand Point ☐ Other ☐ Don't Know

Diameter of Well: ☐ 2 in. ☐ 4 in. ■ 6 in. ☐ 8 in. ☐ 3 ft. ☐ Don't Know

Depth of Well: 130' ☐ Don't Know

Depth of Water: 7.52 ☐ Don't Know

Pump Depth: ☐ Don't Know

Pump Type: Jet Pump ☐ Don't Know

Water Source: ■ Bedrock ☐ Sand/Gravel/Overburden ☐ Don't Know

Name of Well Driller: Wayne B. Marquardt & Sons Ltd. ☐ Don't Know

Date Installed: 2006 ☐ Don't Know

I have the MOE Water Well Record: ☐ Yes ☐ No ☐ Don't Know

MOE Water Well Record Number: A042386 ☐ Don't Know

Type of Water Use: ■ Domestic ☐ Farm ☐ Irrigation ☐ Industrial ☐ Other

Water Treatment: ☐ Softener ☐ Sand Filter ☐ Carbon Filter ☐ Fiber Filter. ☐ Aluminum Oxide
☐ UV ☐ Reverse Osmosis ☐ distillation ☐ Ion Exchange. ☐ Ozonation

Other Water Treatment: ☐ Don't Know

WATER WELL INVENTORY

Condition of Well Casing: ☐ Good ☐ Buried ☐ Corroded ☐ Seized ☐ Broken ☐ Don't Know
Other: __________

Any problems with water quantity in the past? ☐ Yes ☑ No

Any problem with water quality in the past? ☐ Yes ☑ No

If yes, what type? ☐ Sulphur smell ☐ Iron Taste ☐ Brown Water ☐ Bacteria
Other: __________

Location of Septic Bed: In front of house.

Potential Sources of Contamination: ☐ Barn ☐ Manure Pile ☐ Gas Tanks ☐ Heating Oil Tank
Other: __________

Is the well easily accessible? ☐ Yes ☐ No

If Yes, may we measure water levels in this well? ☐ Yes ☐ No

If necessary, could we sample your well for water quality testing? ☑ Yes ☐ No

Describe Well Location Well is located 10m off North side of house.
Well is drilled and stands 2' tall, very visible. If facing house from road, the brightly painted shed is about 10m directly behind well.

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Project #: 33886-100

WATER WELL INVENTORY

Resident Name: PW12

911 Number: ____________ **Road:** Gaebel Rd.

Address: 114 Gaebel Rd. Bancroft, ON

Phone Number: ____________ **Email:** ____________

Property Owner: ☐ Yes ☐ No **If No, Property Owner's Name**: ____________

Previous Property Owners: ____________

Number of Wells on Property: 1 ☐ Don't Know

Type of Well: ☒ Drilled ☐ Dug ☐ Sand Point ☐ Other ________ ☐ Don't Know

Diameter of Well: ☐ 2 in. ☐ 4 in. ☒ 6 in. ☐ 8 in. ☐ 3 ft. ☐ Don't Know

Depth of Well: 130' ☐ Don't Know

Depth of Water: 7.52 ☐ Don't Know

Pump Depth: ____________ ☐ Don't Know

Pump Type: Jet Pump ☐ Don't Know

Water Source: ☒ Bedrock ☐ Sand/Gravel/Overburden ☐ Don't Know

Name of Well Driller: Wayne B. Marquardt & Sons Ltd. ☐ Don't Know

Date Installed: 2006 ☐ Don't Know

I have the MOE Water Well Record: ☐ Yes ☐ No ☐ Don't Know

MOE Water Well Record Number: A042386 ☐ Don't Know

Type of Water Use: ☒ Domestic ☐ Farm ☐ Irrigation ☐ Industrial ☐ Other ________

Water Treatment: ☐ Softener ☐ Sand Filter ☐ Carbon Filter ☐ Fiber Filter. ☐ Aluminum Oxide
☐ UV ☐ Reverse Osmosis ☐ distillation ☐ Ion Exchange. ☐ Ozonation

Other Water Treatment: ____________ ☐ Don't Know

WATER WELL INVENTORY

Condition of Well Casing: ☐ Good ☐ Buried ☐ Corroded ☐ Seized ☐ Broken ☐ Don't Know
Other:

Any problems with water quantity in the past? ☐ Yes ☑ No

Any problem with water quality in the past? ☐ Yes ☑ No

If yes, what type? ☐ Sulphur smell ☐ Iron Taste ☐ Brown Water ☐ Bacteria
Other:

Location of Septic Bed: In front of house.

Potential Sources of Contamination: ☐ Barn ☐ Manure Pile ☐ Gas Tanks ☐ Heating Oil Tank
Other:

Is the well easily accessible? ☐ Yes ☐ No

If Yes, may we measure water levels in this well? ☐ Yes ☐ No

If necessary, could we sample your well for water quality testing? ☑ Yes ☐ No

Describe Well Location Well is located 10m off North side of house.
Well is drilled and stands 2' tall, very visible. If facing house from road, the brightly painted shed is about 10m directly behind well.

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Project #: 33886-100

WATER WELL INVENTORY

Resident Name: PW12

911 Number: ____________ **Road:** Gaebel Rd.

Address: 114 Gaebel Rd. Bancroft, ON

Phone Number: ____________ **Email:** ____________

Property Owner: ☐ Yes ☐ No **If No, Property Owner's Name**: ____________

Previous Property Owners: ____________

Number of Wells on Property: 1 ☐ Don't Know

Type of Well: ☒ Drilled ☐ Dug ☐ Sand Point ☐ Other ______ ☐ Don't Know

Diameter of Well: ☐ 2 in. ☐ 4 in. ☒ 6 in. ☐ 8 in. ☐ 3 ft. ☐ Don't Know

Depth of Well: 130' ☐ Don't Know

Depth of Water: 7.52 ☐ Don't Know

Pump Depth: ______ ☐ Don't Know

Pump Type: Jet Pump ☐ Don't Know

Water Source: ☒ Bedrock ☐ Sand/Gravel/Overburden ☐ Don't Know

Name of Well Driller: Wayne B. Marquardt & Sons Ltd. ☐ Don't Know

Date Installed: 2006 ☐ Don't Know

I have the MOE Water Well Record: ☐ Yes ☐ No ☐ Don't Know

MOE Water Well Record Number: A042386 ☐ Don't Know

Type of Water Use: ☒ Domestic ☐ Farm ☐ Irrigation ☐ Industrial ☐ Other ______

Water Treatment: ☐ Softener ☐ Sand Filter ☐ Carbon Filter ☐ Fiber Filter. ☐ Aluminum Oxide
☐ UV ☐ Reverse Osmosis ☐ distillation ☐ Ion Exchange. ☐ Ozonation

Other Water Treatment: ____________ ☐ Don't Know

WATER WELL INVENTORY

Condition of Well Casing: ☐ Good ☐ Buried ☐ Corroded ☐ Seized ☐ Broken ☐ Don't Know
Other: ______

Any problems with water quantity in the past? ☐ Yes ☑ No

Any problem with water quality in the past? ☐ Yes ☑ No

If yes, what type? ☐ Sulphur smell ☐ Iron Taste ☐ Brown Water ☐ Bacteria
Other: ______

Location of Septic Bed: In front of house.

Potential Sources of Contamination: ☐ Barn ☐ Manure Pile ☐ Gas Tanks ☐ Heating Oil Tank
Other: ______

Is the well easily accessible? ☐ Yes ☐ No

If Yes, may we measure water levels in this well? ☐ Yes ☐ No

If necessary, could we sample your well for water quality testing? ☑ Yes ☐ No

Describe Well Location Well is located 10m off North side of house.
Well is drilled and stands 2' tall, very visible. If facing house from road, the brightly painted shed is about 10m directly behind well.

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Project #: 33886-100

WATER WELL INVENTORY

Resident Name: PW12

911 Number: ________ **Road:** Gaebel Rd.

Address: 114 Gaebel Rd. Bancroft, ON

Phone Number: ________ **Email:** ________

Property Owner: ☐ Yes ☐ No **If No, Property Owner's Name:** ________

Previous Property Owners: ________

Number of Wells on Property: 1 ☐ Don't Know

Type of Well: ☒ Drilled ☐ Dug ☐ Sand Point ☐ Other ________ ☐ Don't Know

Diameter of Well: ☐ 2 in. ☐ 4 in. ☒ 6 in. ☐ 8 in. ☐ 3 ft. ☐ Don't Know

Depth of Well: 130' ☐ Don't Know

Depth of Water: 7.52 ☐ Don't Know

Pump Depth: ________ ☐ Don't Know

Pump Type: Jet Pump ☐ Don't Know

Water Source: ☒ Bedrock ☐ Sand/Gravel/Overburden ☐ Don't Know

Name of Well Driller: Wayne B. Marquardt & Sons Ltd. ☐ Don't Know

Date Installed: 2006 ☐ Don't Know

I have the MOE Water Well Record: ☐ Yes ☐ No ☐ Don't Know

MOE Water Well Record Number: A042386 ☐ Don't Know

Type of Water Use: ☒ Domestic ☐ Farm ☐ Irrigation ☐ Industrial ☐ Other ________

Water Treatment: ☐ Softener ☐ Sand Filter ☐ Carbon Filter ☐ Fiber Filter. ☐ Aluminum Oxide
☐ UV ☐ Reverse Osmosis ☐ distillation ☐ Ion Exchange. ☐ Ozonation

Other Water Treatment: ________ ☐ Don't Know

WATER WELL INVENTORY

Condition of Well Casing: ☐ Good ☐ Buried ☐ Corroded ☐ Seized ☐ Broken ☐ Don't Know
Other: ______

Any problems with water quantity in the past? ☐ Yes ☑ No

Any problem with water quality in the past? ☐ Yes ☑ No

If yes, what type? ☐ Sulphur smell ☐ Iron Taste ☐ Brown Water ☐ Bacteria
Other: ______

Location of Septic Bed: In front of house.

Potential Sources of Contamination: ☐ Barn ☐ Manure Pile ☐ Gas Tanks ☐ Heating Oil Tank
Other: ______

Is the well easily accessible? ☐ Yes ☐ No

If Yes, may we measure water levels in this well? ☐ Yes ☐ No

If necessary, could we sample your well for water quality testing? ☑ Yes ☐ No

Describe Well Location Well is located 10m off North side of house.
Well is drilled and stands 2' tall, very visible. If facing house from road, the brightly painted shed is about 10m directly behind well.

MTE

APPENDIX E

TECHNICAL MEMORANDUM – STORMWATER MANAGEMENT FACILITY

MTE

EXTERNAL MEMORANDUM

TO:	Freymond Lumber Ltd.	**MTE FILE NO.:**	C33886-100
	c/o EcoVue Consulting Services Inc.	**DATE:**	December 1, 2016
	311 George St. N, Suite 200	**FROM:**	Kurtis Romanchuk, E.I.T.
	Peterborough, ON, K9J 3H3		
cc:	Jay Flanagan, MTE	**PROJECT NAME:**	Freymond Quarry

Re: Stormwater Management Strategy

1.0 INTRODUCTION

The purpose of this memorandum is to develop a conceptual strategy to address the potential impacts associated with discharging water from the proposed Freymond Quarry, located on part of Lots 51 & 52, Concession W.H.R., Township of Faraday, Concessions of Hastings, or 2287 Bay Lake Road, Bancroft, Ontario (hereafter referred to as the “Site”).

The quarry lands are proposed to drain by gravity to a stormwater management pond located in the southeast corner of the Site, which is proposed to provide the required water quality and quantity control before outlet to an unnamed stream south of the Site (hereafter referred to as the “South Stream”), which flows east to the York River approximately 500m downstream.

2.0 STORMWATER MANAGEMENT CRITERIA

The proposed stormwater management works shall be designed in accordance with the Ministry of Natural Resources (MNR) and the Ministry of the Environment (MOE) *Stormwater Management Planning and Design Manual* (MOE, 2003). As the stormwater management facility is proposed to outlet to a stream system, water quality and erosion controls must be incorporated. Additionally, the stream crosses several access routes for the area, including Highway 62 going into the Town of Bancroft, so the stormwater management plan must include water quantity control to mitigate the flood hazard. The criteria for development of this stormwater management plan are therefore as follows:

- Provide an *Enhanced* (MOE, 2003) level of quality control,
- Provide 24 hour detention of the 25mm 4-hour Chicago storm event for erosion control,
- Provide pre- to post-excavation peak flow matching for the 2 through 100-year return period storm events.

3.0 WATER QUALITY

The Ministry of Natural Resources has specified that stormwater management facilities which outlet to the South Stream must provide an *Enhanced* level of quality control as described in Table 3.2 of the MOE *Stormwater Management Planning and Design Manual* (MOE, 2003).

The Site is proposed to be excavated in 4 phases, from the initial excavated condition to the final rehabilitated condition, and the layout of the excavation, overburden stockpiling, existing/remediated vegetation, and stormwater management facility on Site was provided in sketches to MTE from MHBC. The sketched areas were then quantified by MTE for design purposes, and both the initial and quantified sketches, as well as a table summarizing the hydrologic properties of each area, are attached to this memo. It was assumed that both the excavation and the overburden stockpiling areas would be completely impervious for this design, as there is very little overburden on Site to stockpile, and therefore the potential exists for these areas to be exposed bedrock. Phase 3 has the largest amount of open excavation and therefore the highest impervious value, and will therefore be considered the 'design phase' for the purpose of this stormwater management plan.

During the most intense phase of excavation (Phase 3), the Site has an imperviousness of approximately 55.5% over its 33.27ha area, which in a wet pond facility requires a permanent pool of 5,032m^3 and an extended detention storage volume of 1,331m^3, the latter of which is to be retained for a minimum of 24 hours (MOE, 2003). The proposed stormwater management facility has a permanent pool of 6,150m^3, sufficient for the subject site. General facility details, including quality control, are shown in **Table 1** below.

4.0 EROSION CONTROL

Erosion control will be provided as per the MOE manual by ensuring that the volume of a 25mm 4-hour Chicago design storm event will be retained in the stormwater management facility for a minimum of 24 hours (MOE, 2003).

Design storm event modeling for the Site was performed using MIDUSS (version 2.25 revision 473) software, and is attached to this memo. Rainfall Intensity-Duration-Frequency (IDF) data was obtained from the Ontario Ministry of Transportation (MTO) IDF curve lookup application for the Bancroft area, and then used (in conjunction with the MIDUSS IDF curve fit tool) to create Chicago design storm parameters for the 2 through 100-year return period events. Chicago design storm parameters for the 25mm event were based on the 2-year return period with a lowered "A" coefficient to obtain the desired 25mm total rainfall depth, and are attached to this memo. The total volume of the 25mm event during the design extraction phase is 4,392m^3.

5.0 WATER QUANTITY

In order to mitigate downstream flooding considerations, post-excavation peak flows into the South Stream will be controlled to pre-excavation levels for the 2 through 100-year return period events. As described previously, Chicago design storm parameters were derived using the MTO IDF curve lookup application for the Bancroft area, and are attached to this memo. The pre-excavation catchment area draining to the South Stream (catchment 104 as detailed on **Figure 14: Drainage Assessment – Existing Conditions** within the body of this report) is attached in a table to this memo along with catchment parameters for each of the excavation phases. The pre- and post-excavation MIDUSS modeling is also attached to this memo, and the results are summarized in **Table 2** below.

Though the Site is proposed to be remediated after the extraction is complete, there will always be an increased drainage area directed to the South Stream (catchment 504 as detailed on **Figure 18: Drainage Assessment – Phase 4** within the body of this report) so the stormwater management pond is proposed to remain in the remediated condition to continue to provide peak flow attenuation and erosion control to the South Stream. Additional flow due to groundwater seepage from the excavation was assumed to be negligible.

TABLE 1: Stormwater Management Facility Design Characteristics

General	Facility Characteristics
Stormwater Management Facility Type	Wet Pond
Required MOE Water Quality Protection	Level 1 (Enhanced)
Total Contributing Area	33.27 ha
Imperviousness	55.53%
Bottom Elevation (of main facility)	328.50m
Storage	
Unit Area Storage Volume Requirements as per SWMMP (MOE 2003)	191.24 m^3/ha
Required Total Volume	6,363m^3
Permanent Pool	
Required Permanent Pool Volume	5,032m^3
Provided Permanent Pool Volume	6,150m^3
Permanent Pool Elevation	331.00m
Extended Detention	
Minimum Required Volume	25mm Event
Approximate Drawdown Time (for MOE Table 3.2 requirement)	66.4 hr.
Extended Detention Elevation (for 25mm event)	331.89m
Peak Release Rate for Extended Detention (for 25mm event)	0.018m^3/s
Settling	
Required Settling Length	91m
Provided Settling Length	95m
Outlet Controls	
Precast Concrete Box Manhole Outlet Structure	
Orifice 1 Diameter (Extended Detention)	95mm
Orifice 1 Invert Elevation (Extended Detention)	331.00m
Weir 1 Crest (Quantity Control)	1.25m
Weir 1 Side Slopes (Quantity Control)	Vertical
Weir 1 Elevation (Quantity Control)	331.90m

TABLE 2: MIDUSS Modeling Summary

Storm Event	Pre-Excavation Peak Flow (m^3/s)	Pre-Excavation Runoff Volume (m^3)	Post-Excavation Pond Inflow (m^3/s)	Post-Excavation Runoff Volume (m^3)	Post-Excavation Pond Outflow (m^3/s)	Required Storage Volume (m^3)	Peak Ponding Elevation (m)
25mm	0.098	1333	2.709	4392	0.018	4047	331.89
2 Year	0.169	1765	3.414	5220	0.078	4633	332.00
5 Year	0.421	3260	4.829	7758	0.329	5704	332.20
10 Year	0.653	4385	5.738	9494	0.506	6295	332.30
25 Year	0.982	5972	6.759	11787	0.792	7124	332.45
50 Year	1.314	7124	7.603	13370	1.015	7723	332.55
100 Year	1.639	8438	8.477	15110	1.273	8372	332.66

6.0 STORMWATER MANAGEMENT FACILITY DESIGN

6.1 Facility Outlet

As described in **Sections 3.0 & 4.0** above, both the 1,331m^3 MOE water quality volume and the 4,392m^3 25mm storm event volume must be retained for a minimum of 24 hours, so it is the smaller MOE quality volume which limits the maximum size of the extended detention orifice. An orifice drawdown design sheet is attached to this memo, which shows that based on the pond geometry a 95mm diameter orifice may be used to provide minimum 24-hour extended detention for the aforementioned volumes. The extended detention outlet control is therefore proposed to be a 95mm diameter orifice with its invert at the permanent pool elevation, set to 331.00m to ensure adequate fall exists to the South Stream at elevation 330.00m. The peak extended detention ponding elevation occurs for the larger 25mm event volume and is 331.89m as per **Table 1**.

In order to provide quantity control for larger storm durations as described in **Section 5.0**, a 1.25m horizontal weir is proposed at elevation 331.90m, above the extended detention storage levels. The peak ponding elevations and storage volumes for each design storm are shown in **Table 2**.

The weir, along with the aforementioned orifice, are proposed to be located within the side of a precast concrete box manhole as indicated on MTE **Figure 19: Stormwater Management Facility**. The orifice is proposed to be protected from debris by half of a CSP riser pipe such that water must flow beneath the bottom of and back up through the CSP to reach the orifice, as detailed on the drawing. The 1.25m quantity control weir is to be located above the CSP riser pipe at elevation 331.90m, and shall be protected by a grate as detailed on the drawing. The top of the precast box manhole outlet structure is to be open, covered by galvanized ditch inlet grating, and at elevation 332.70m, to provide an emergency overflow outlet above the maximum modeled ponding elevations.

The box manhole will outlet directly to a 900mm diameter concrete pipe at a minimum 0.5% slope, sufficient to convey the peak facility outflow of 1.273m^3/s to the South Stream. The pipe will continue until its spring line emerges from the embankment to the South Stream, at which point the pipe will be terminated and a rip-rap lined outlet channel shall be graded into the embankment to carry flows the remainder of the distance to the South Stream. The end of the pipe is to be covered with 150-200mm diameter rip-rap to provide flow dissipation along with the outlet channel, refer to MTE drawing **Figure 19: Stormwater Management Facility** for details.

6.2 Settling Length

Since the majority of annual rainfall occurs in storms less than or equal to the 25mm storm event, the majority of water borne sediment is also transported to the stormwater management facilities in these less intense events[1]. Therefore, the facility has been designed using berms to elevation 331.90m to provide a long settling length for the 25mm event to target these smaller flows, while allowing the upper portions of the facility to provide unimpeded storage and a greater area of flow for the more intense storm events.

The facility design is based on classic particle settling and flow dispersion equations as presented in the MOE *Stormwater Management Practices Planning and Design Manual* (MOE, 1994). The design flow for

---

[1] From MOE-1994, Figure C.1: 62% less than 5mm, 78% < 10mm, 90% < 15mm and 97% < 25mm

the settling length was taken to be the peak outflow from the facility during the 25mm event, and the settling velocity was assumed to be 0.00001300m/s in order to ensure settling of particles >20µm (MOE, 1994). Additionally, flow dispersion and scour velocity checks were made, including the permanent pool area, to ensure that sufficient length is provided to mitigate all concerns. The required settling length was calculated to be 91m, and approximately 95m of settling length is provided in the pond. Settling calculations are attached to this memo.

6.3 Additional Features

The following additional features have been incorporated into the stormwater management facility design:

- The permanent pool has been excavated to 2.5m where possible to provide additional settling volume and reduce cleanout frequency,
- The maximum active storage retention depth has been limited to 2.0m, with 0.30m of freeboard,
- For safety, side slopes have been limited to 5:1 for 3m to either side of the permanent pool, and to 3:1 elsewhere,
- An access & maintenance road of 4m width has been incorporated into the design to ensure sufficient access to the outlet structures and pond bottom for ease of inspection and maintenance. The access road will have a maximum longitudinal slope of 10:1 and a minimum inside radius of curvature of 10m,
- As this pond will be constructed below the groundwater level, an impermeable (geotextile or clay) pond liner may be required.

7.0 MONITORING PROGRAM

Effluent from the SWM facility shall be sampled monthly under non-freezing conditions after significant rainfall events (>8mm), provided that there are sufficient volumes of water to be sampled, for a period of two years after operations commence, as specified below:

- Samples are to be analyzed for the following parameters:
  a) Total Suspended Solids (TSS).
  b) Total Ammonia.
  c) Total Petroleum Hydrocarbons (fractions F1 through F4).
- During sampling, the pH and temperature of the water sample will be collected and recorded in-situ. The concentration of un-ionized ammonia shall be calculated using the total ammonia concentration, pH, and temperature using the methodology stipulated in "Ontario's Provincial Water Quality objectives" dated July 1994, as amended, for ammonia (un-ionized).
- The quarry operator shall measure, record, and calculate the volume of flow discharging over the control structure on each day of sampling.
- After two years of operations, the effluent monitoring program shall be reviewed on an annual basis and revised if necessary.

8.0 CONCLUSIONS & RECOMMENDATIONS

Based on the foregoing analyses, it is concluded that:

- The described stormwater management facility will provide adequate quality and flood control measures for stormwater runoff from the Site,
- The described stormwater management facility will provide best management practices for erosion control based on MOE guidelines.

These conclusions lead to the following recommendations:

- That a fluvial geomorphological assessment of the South Stream should be performed in order to establish specific erosion control criteria.
- That the facility design be reviewed in conjunction with the updated *Environmental Impact Statement* when it becomes available, specifically with respect to any mitigation measures for the South Stream.
- That the stormwater management facility be constructed as described in this memo, including the specified outlet, settling length, and impermeable pond liner.
- That the extraction operator may not at any point exceed the total disturbed area and/or area of exposed bedrock face assumed for the design phase of the stormwater management facility, as described in **Section 3.0**.
- That the facility effluent be monitored as described in **Section 7.0** to verify facility performance.
- That the facility remain in the rehabilitated condition to continue to provide peak flow attenuation and erosion control for the South Stream.

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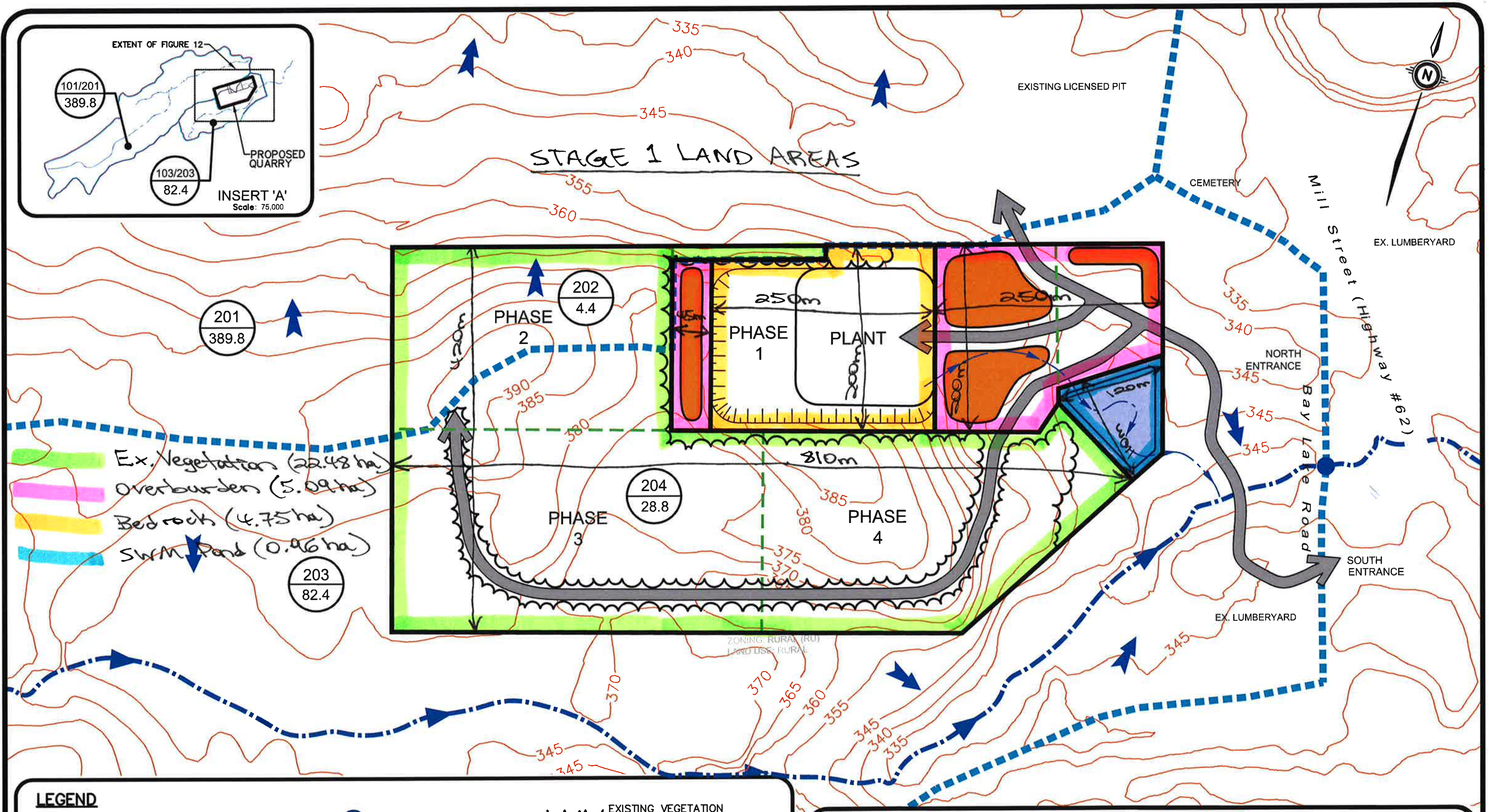
CAD: P:\P\33886\WORKING\33886-100-EV13-KUF

Project: 33886-100

EV13.1

July 21, 2016 – 4:09 p.m. – Plotted By: emacintyre



LEGEND

— — — PROPOSED FREYMOND QUARRY (THE "SITE")

■ ■ ■ EXTRACTION CATCHMENT AREA

- - - PHASE BOUNDARY

203 / 82.4 — CATCHMENT ID# (PRE=100'S, POST=200's) — CATCHMENT AREA (ha)

● A. ASSESSMENT NODE

—385— EXISTING SURFACE CONTOURS (5m)

➤➤ DIRECTION OF OVERLAND FLOW

–·–➤– EXISTING CREEK

︶︶︶ EXISTING VEGETATION OR NEW VEGETATION

🟧 AREA BEING REHABILITATED OR NEW VEGETATION

☐ PLANT

🟦 STORMWATER MANAGEMENT POND

┴┴┴┴ EXPOSED ROCK FACE

DRAINAGE ASSESSMENT: PHASE 1

MTE
Engineers | Scientists | Surveyors

Project Name	Freymond Proposed Quarry

Site	Client
Bancroft, Ontario	Freymond Lumber Limited

Scale (11x17)	MTE Project No.	Date	Figure No.
1:4000	33886-100	February 2016	15

Project: 33886-100 CAD: P:\P\33886\WORKING\33886-100-EV14-KUF

EV14.1

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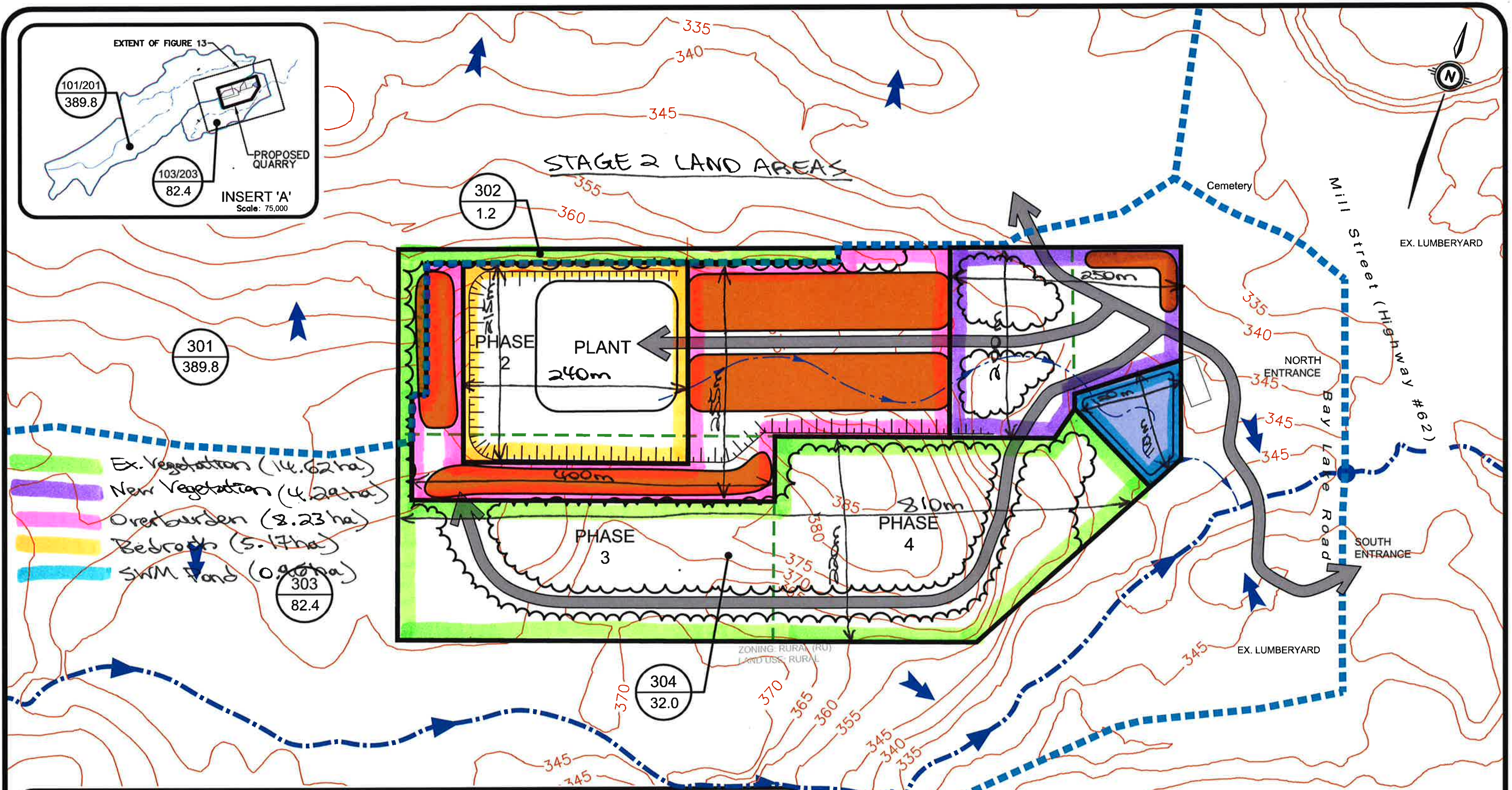


LEGEND

— — —	PROPOSED FREYMOND QUARRY (THE "SITE")
▪▪▪▪▪	EXTRACTION CATCHMENT AREA
	PHASE BOUNDARY
303 / 82.5	CATCHMENT ID# (PRE=100'S, POST=200's) CATCHMENT AREA (ha)
● A.	ASSESSMENT NODE
385	EXISTING SURFACE CONTOURS (5m)
➤	DIRECTION OF OVERLAND FLOW
	EXISTING CREEK
	EXISTING VEGETATION OR NEW VEGETATION
🟧	AREA BEING REHABILITATED OR NEW VEGETATION
☐	PLANT
🟦	STORMWATER MANAGEMENT POND
	EXPOSED ROCK FACE

DRAINAGE ASSESSMENT: PHASE 2

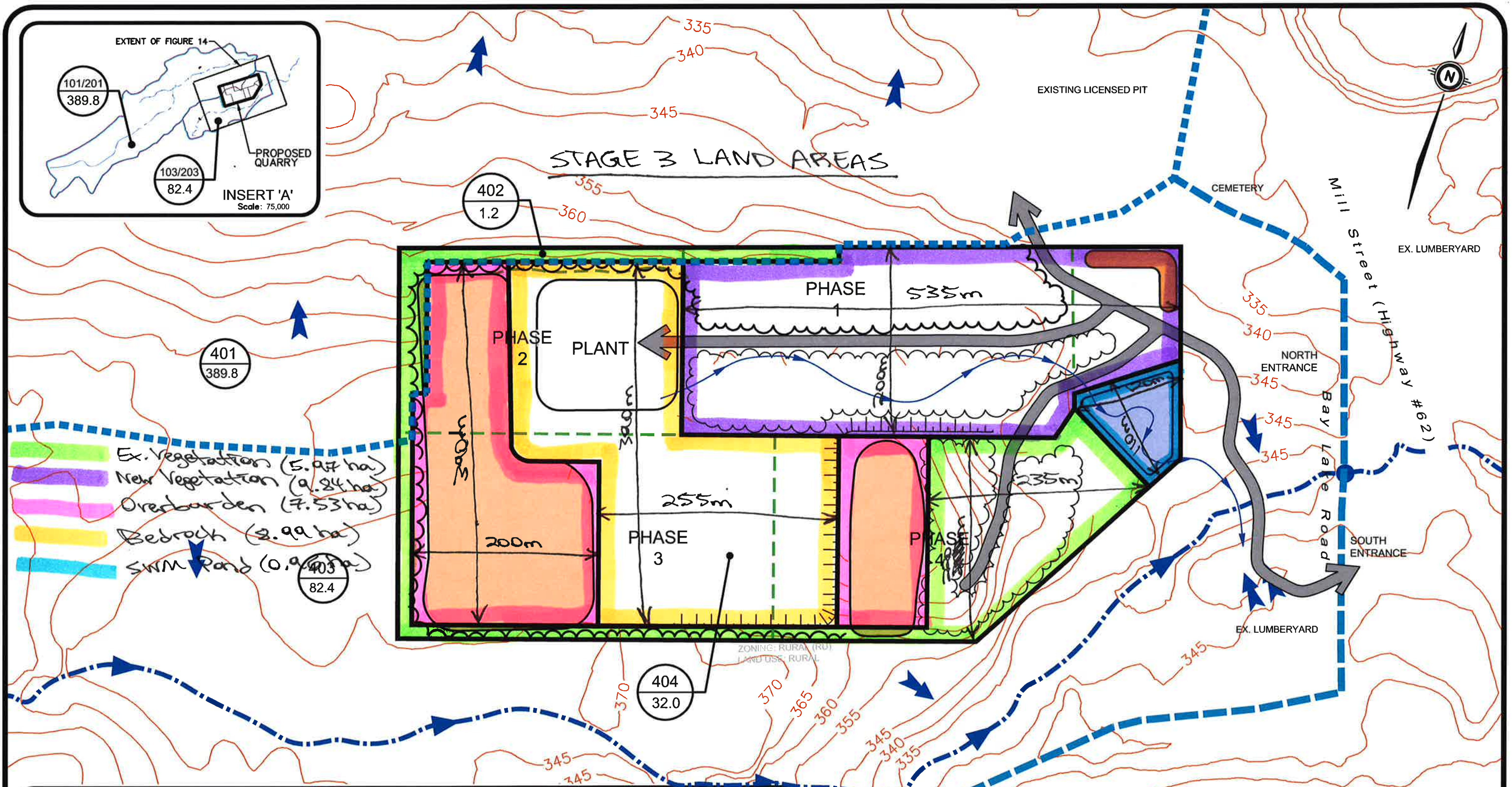
MTE
Engineers | Scientists | Surveyors

Project Name	Freymond Proposed Quarry
Site	Bancroft, Ontario
Client	Freymond Lumber Limited
Scale (11x17)	1:4000
MTE Project No.	33886-100
Date	February 2016
Figure No.	16

Project: 33886-100 CAD: P:\P\33886\WORKING\33886-100-EV15-KUF

EV15.1

July 21, 2016 – 5:14 p.m. – Plotted By: emacintyre



STAGE 3 LAND AREAS

🟩 Ex. Vegetation (5.97 ha)
🟪 New Vegetation (9.84 ha)
🟥 Overburden (7.53 ha)
🟨 Bedrock (8.99 ha)
🟦 SWM Pond (0.9[illegible]ha)

LEGEND

— — — PROPOSED FREYMOND QUARRY (THE "SITE")
■ ■ ■ ■ EXTRACTION CATCHMENT AREA
- - - - PHASE BOUNDARY
401 / 389.8 CATCHMENT ID# (PRE=100'S, POST=200's) / CATCHMENT AREA (ha)
● A. ASSESSMENT NODE
385 EXISTING SURFACE CONTOURS (5m)
➤➤ DIRECTION OF OVERLAND FLOW
-·-➤-·- EXISTING CREEK
⌒⌒⌒ EXISTING VEGETATION OR NEW VEGETATION
🟧 AREA BEING REHABILITATED OR NEW VEGETATION
☐ PLANT
🟦 STORMWATER MANAGEMENT POND
⊥⊥⊥⊥ EXPOSED ROCK FACE

DRAINAGE ASSESSMENT: PHASE 3

MTE
Engineers | Scientists | Surveyors

Project Name	Freymond Proposed Quarry
Site	Bancroft, Ontario
Client	Freymond Lumber Limited
Scale (11x17)	1:4000
MTE Project No.	33886-100
Date	February 2016
Figure No.	17

Project: 33886-100 CAD: P:\P\33886\WORKING\33886-100-EV16-KUF

EV16.1

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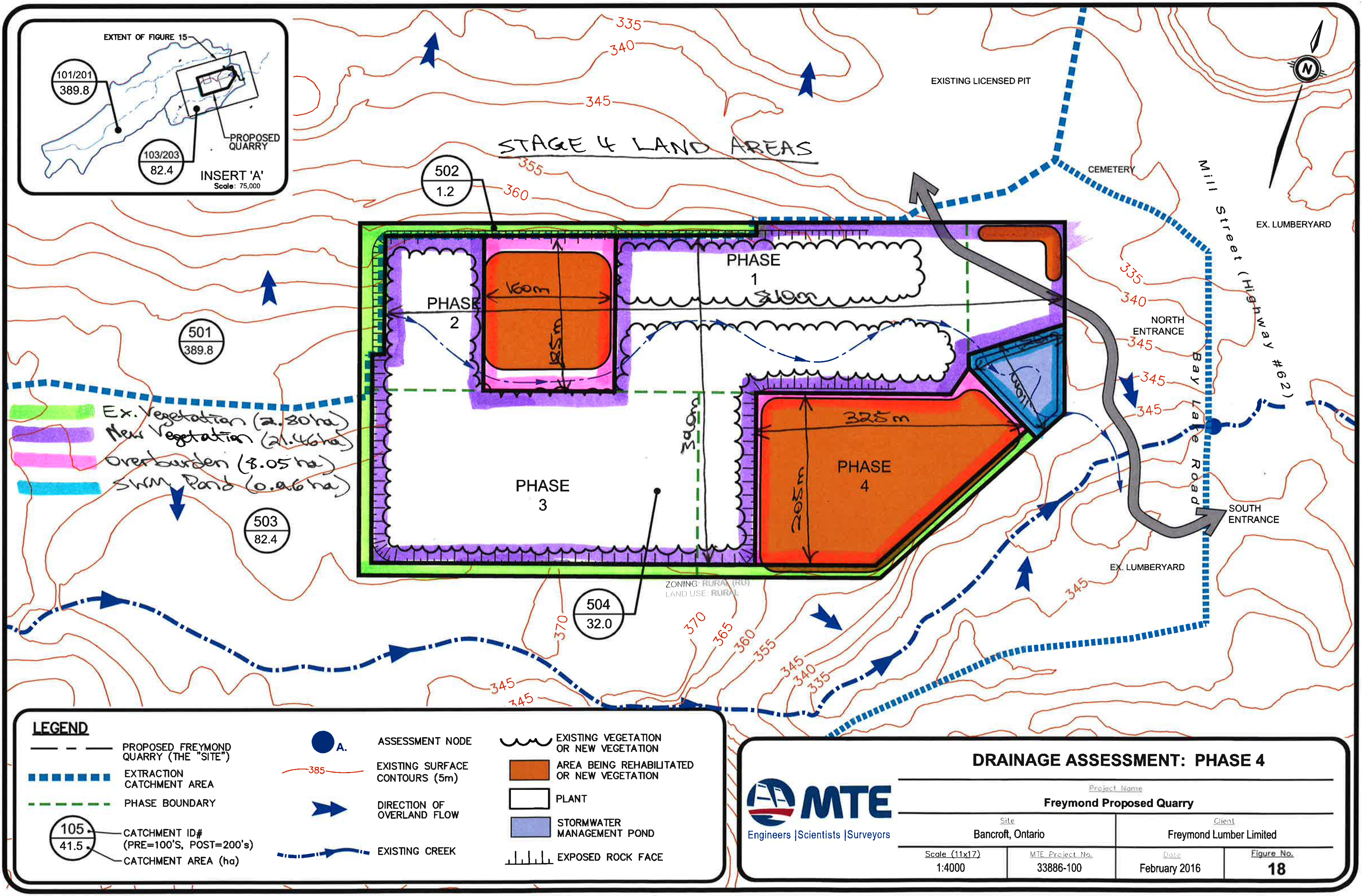


DRAINAGE ASSESSMENT: PHASE 4

MTE
Engineers | Scientists | Surveyors

Project Name	
Freymond Proposed Quarry	

Site	Client
Bancroft, Ontario	Freymond Lumber Limited

Scale (11x17)	MTE Project No.	Date	Figure No.
1:4000	33886-100	February 2016	18

FREYMOND QUARRY

PRELIMINARY STORMWATER MANAGEMENT DESIGN

Bancroft, Ontario

Project Number:	33886-100
Date:	July 25, 2016
Designer:	KMR
File:	Q:\33886\Micro Drainage Analysis\SWM\33886-100 SWM Design Kurtis.xlsx

LAND USE CHARACTERISTICS

	SCS Curve Number			%
	AMC II	AMC III	Imp.	Imp.
Existing Vegetation	81	91	98	0
New Vegetation	81	91	98	15
Rehabilitation/Overburden	81	91	98	100
Excavation/Plant	N/A	N/A	98	100
Stormwater Management	81	91	98	50

LAND USE BY STAGE

	Land Use																						
	Existing Vegetation				New Vegetation				Rehabilitation/Overburden				Excavation/Plant				Stormwater Management				TOTAL (area weighted)		
	Area (ha)	Length (m)	Width (m)	Slope (%)	Area (ha)	Length (m)	Width (m)	Slope (%)	Area (ha)	Length (m)	Width (m)	Slope (%)	Area (ha)	Length (m)	Width (m)	Slope (%)	Area (ha)	Length (m)	Width (m)	Slope (%)	Area (ha)	Imp. (%)	Slope (%)
Pre-Excavation	28.88	810	420	7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28.88	0.00	7.5
Stage 1	22.47	810	420	7.5	0	0	0	0	5.09	250	200	2	4.75	250	200	1	0.96	120	110	33	33.27	31.02	6.5
Stage 2	14.62	810	220	7.5	4.29	250	200	2	8.23	400	255	2	5.17	240	215	1	0.96	120	110	33	33.27	43.65	5.2
Stage 3 (Design Stage)	5.95	235	220	7.5	9.84	535	200	2	7.53	390	200	2	8.99	390	255	1	0.96	120	110	33	33.27	55.53	3.6
Stage 4	2.8	810	15	7.5	21.46	810	390	2	8.05	185	160	2	0	0	0	0	0.96	120	110	33	33.27	35.31	3.4

FREYMOND QUARRY
PRELIMINARY STORMWATER MANAGEMENT DESIGN
Bancroft, Ontario

Project Number: 33886-100
Date: July 25, 2016
Designer: KMR
File: Q:\33886\Micro Drainage Analysis\SWM\33886-100 SWM Design Kurtis.xlsx

Step 1: Choose Level of Water Quality Control

Enhanced 80% long-term S.S. removal

Step 2: Choose Type of Facility

Wet Pond

Step 3: Define Catchment area and Imperviousness

Catchment Area (ha)	Imperviousness (%)
33.27	55.53

Interpolated Storage Volume Requirement (m^3/ha)

191.24

Permanent Pool Required (m^3)

5031.92

Extended Detention Volume Required (m^3)

1330.80

Table 3.2 Water Quality Storage Requirements based on Receiving Waters (from MOE Stormwater Management Planning and Design Manual, March 2003)

Protection Level	**SWMP Type**	**Storage Volume (m^3/ha) for Impervious Level**			
		35	**55**	**70**	**85**
Enhanced 80% long-term S.S. removal	*Wetlands*	80	105	120	140
	Hybrid Wet Pond/Wetland	110	150	175	195
	Wet Pond	140	190	225	250
Normal 70% long-term S.S. Removal	*Wetlands*	60	70	80	90
	Hybrid Wet Pond/Wetland	75	90	105	120
	Wet Pond	90	110	130	150
Basic 60% long-term S.S. Removal	*Wetlands*	60	60	60	60
	Hybrid Wet Pond/Wetland	60	70	75	80
	Wet Pond	60	75	85	95
	Dry Pond (Continuous Flow)	90	150	200	240

FREYMOND QUARRY
STORMWATER MANAGEMENT
Bancroft, Ontario

Project Number:	33886-100
Date:	October 14, 2016
Designer:	KMR
File:	Q:\33886\Micro Drainage Analysis\SWM\33886-100 SWM Design Kurtis.xlsx

QUANTITY CONTROL MODELING SUMMARY (Permanent Pool = 331.00m)

Storm Event	Pre-Excavation Peak Flow (m^3/s)	Pre-Excavation Runoff Volume (m^3)	Post-Excavation Pond Inflow (m^3/s)	Post-Excavation Runoff Volume (m^3)	Post-Excavation Pond Outflow (m^3/s)	Required Storage Volume (m^3)	Peak Ponding Elevation (m)
25mm	0.098	1333	2.709	4392	0.018	4047	331.89
2 Year	0.169	1765	3.414	5220	0.078	4633	332.00
5 Year	0.421	3260	4.829	7758	0.329	5704	332.20
10 Year	0.653	4385	5.738	9494	0.506	6295	332.30
25 Year	0.982	5972	6.759	11787	0.792	7124	332.45
50 Year	1.314	7124	7.603	13370	1.015	7723	332.55
100 Year	1.639	8438	8.477	15110	1.273	8372	332.66

IDF PARAMETERS - MTO Curve Lookup Application; Bancroft

Frequency	a	b	c	t_{TOTAL} (min.)
25mm	282.1	0.116	0.6954	240
2 Year	348.96	0.116	0.6954	180
5 Year	464.78	0.019	0.6928	180
10 Year	548.91	0.091	0.6948	180
25 Year	641.06	0.011	0.6923	180
50 Year	721.06	0.031	0.6946	180
100 Year	797.52	0.036	0.6954	180

$Intensity = a / (t + b)^{c}$

FREYMOND QUARRY
STORMWATER MANAGEMENT
Bancroft, Ontario

Project Number: 33886-100
Date: October 14, 2016
Designer: KMR
File: Q:\33886\Micro Drainage Analysis\SWM\33886-100 SWM Design Kurtis.xlsx

STAGE-STORAGE RELATIONSHIP - WET POND

Stage	Active Depth	Main Pond			Total Pond Volume	Active Storage Volume	Total Outflow*	Volume Summary	Ponding Elevation	Comments	Stage
		Area	Volume	Cumulative Volume							
m	m	m^2	m^3	m^3	m^3	m^3	m^3/s	m^3	m		m
328.50		1326	0	0	0		*from				328.50
328.60		1413	137	137	137		MIDUSS				328.60
328.70		1500	146	283	283						328.70
328.80		1587	154	437	437		95mm				328.80
328.90		1674	163	600	600		orifice				328.90
329.00		1762	172	772	772		@ 331.00m				329.00
329.10		1849	181	952	952		+				329.10
329.20		1936	189	1142	1142		1.25m				329.20
329.30		2023	198	1340	1340		weir				329.30
329.40		2110	207	1546	1546		@ 331.90m				329.40
329.50		2197	215	1762	1762						329.50
329.60		2285	224	1986	1986						329.60
329.70		2372	233	2218	2218						329.70
329.80		2459	242	2460	2460						329.80
329.90		2546	250	2710	2710						329.90
330.00		2633	259	2969	2969						330.00
330.10		2720	268	3237	3237						330.10
330.20		2807	276	3513	3513						330.20
330.30		2895	285	3798	3798						330.30
330.40		2982	294	4092	4092						330.40
330.50		3131	306	4398	4398						330.50
330.60		3280	321	4718	4718						330.60
330.70		3429	335	5054	5054						330.70
330.80		3578	350	5404	5404						330.80
330.90		3727	365	5770	5770						330.90
331.00		3876	380	6150	6150			6150		Permanent Pool	331.00
331.00	0.00	3876	0	6150	6150	0	0.000				331.00
331.10	0.10	4039	396	6545	6545	396	0.004				331.10
331.20	0.20	4201	412	6957	6957	808	0.007				331.20
331.30	0.30	4363	428	7386	7386	1236	0.010				331.30
331.40	0.40	4525	444	7830	7830	1680	0.011	1331	331.33	MOE Extended Detention	331.40
331.50	0.50	4687	461	8291	8291	2141	0.013				331.50
331.60	0.60	4849	477	8767	8767	2618	0.014				331.60
331.70	0.70	4959	490	9258	9258	3108	0.016				331.70
331.80	0.80	5068	501	9759	9759	3609	0.017				331.80
331.90	0.90	5177	512	10271	10271	4122	0.018	4047	331.89	25mm Event	331.90
332.00	1.00	5307	524	10796	10796	4646	0.080	4633	332.00	1:2 Year Event	332.00
332.10	1.10	5437	537	11333	11333	5183	0.192				332.10
332.20	1.20	5567	550	11883	11883	5733	0.336	5704	332.20	1:5 Year Event	332.20
332.30	1.30	5697	563	12446	12446	6297	0.507	6295	332.30	1:10 Year Event	332.30
332.40	1.40	5827	576	13022	13022	6873	0.701				332.40
332.50	1.50	5957	589	13612	13612	7462	0.915	7124	332.45	1:25 Year Event	332.50
332.60	1.60	6087	602	14214	14214	8064	1.148	7723	332.55	1:50 Year Event	332.60
332.70	1.70	6217	615	14829	14829	8679	1.398	8372	332.66	1:100 Year Event	332.70
332.80	1.80	6347	628	15457	15457	9308	1.664				332.80
332.90	1.90	6477	641	16099	16099	9949	1.945				332.90
333.00	2.00	6607	654	16753	16753	10603	2.240				333.00
333.10	2.10	6737	667	17420	17420	11270					333.10
333.20	2.20	6867	680	18100	18100	11950					333.20
333.30	2.30	6997	693	18793	18793	12644				Freeboard	333.30

FREYMOND QUARRY
STORMWATER MANAGEMENT
Bancroft, Ontario

Project Number: 33886-100
Date: October 14, 2016
Designer: KMR
File: Q:\33886\Micro Drainage Analysis\SWM\33886-100 SWM Design Kurtis.xlsx

SETTLING CALCULATIONS
MOE SWM Planning and Design Manual, 2003

Design Flows

Peak flow into facility during the 1:100-year return period event	3.671	m^3/s
Peak flow into facility during the 25 mm - 4 hour design storm event	2.709	m^3/s
Peak flow from facility outlet for the 25 mm - 4 hour design storm event	0.018	m^3/s

Facility Characteristics

b = 5.0 *m* bottom width
y = 3.4 *m* 25mm storm storage depth
z = 3 :1 side slope
w = 15.2 *m* average width
R = 1.95 *m* hydraulic radius
A = 51.7 m^2 cross-sectional area

1. Length Calculation Based on Settling Velocity

L = facility flow length *(m)*
r = length-to-width ratio
Q_p = peak flow rate through facility *(m^3/s)*
v_s = settling velocity *(m/s)*

$$L = \sqrt{\frac{rQ_p}{v_s}}$$

Equation 4.5: Forebay Settling Length

a) Required Settling Length (assuming Q_p = pond discharge & v_s = 0.00002540 m/s)

Q_p = 0.018 m^3/s peak flow rate through facility
v_s = 0.00002540 *m/s* settling velocity
r = 3.07 length-to-width ratio
L = 46.6 *m* required settling length
L = *46.6* *m* *trial length*

b) Required Settling Length (assuming Q_p = pond discharge & v_s = 0.00001300 m/s)

Q_p = 0.018 m^3/s peak flow rate through facility
v_s = 0.00001300 *m/s* settling velocity
r = 5.99 length-to-width ratio
L = 91.0 *m* required settling length
L = *91* *m* *trial length*

Table 1: Average settling velocities

	Mass Removed	Particle Size Range	Average Settling Velocity
	%	*µm*	*m/s*
	80 - 100	x ≤ 20	0.00000254
Enhanced:	70 - 80	20 < x ≤ 40	0.00001300
Normal:	60 - 70	40 < x ≤ 60	0.00002540
Basic:	40 - 60	60 < x ≤ 130	0.00012700
Medium Sand:	20 - 40	130 < x ≤ 400	0.00059267
Gross Grit:	0 - 20	400 < x ≤ 4000	0.00550333

2. Length Calculation Based on Flow Dispersion Length

Q = 3.67 m^3/s peak inlet flow rate
d = 3.4 *m* depth of permanent pool in facility
V_f = 0.50 *m/s* desired velocity in facility (typical value ≤ 0.50 *m/s*)
L = 17.3 m required length of dispersion

$$L_D = \frac{8Q}{dV_f}$$

Equation 4.6: Dispersion Length

3. Required Facility Length

L = 91.0 *m* design length
r = 5.99 design length-to-width ratio (typical minimum of 2.0)

4. Scour Velocity

v_s = 0.15 *m/s* scour velocity (typical value = 0.15 *m/s*)
v = 0.071 *m/s* actual velocity

OK The actual velocity through the facility is less than the scour velocity.

5. Estimated Cleanout Frequency

Facility

Spare permanent pool volume beyond requirement	1118	m^3
Estimated TSS removal efficiency	80%	
Impervious level	56%	
Estimated annual sediment loading	1.9	m^3/ha
Contributing area	33.27	*ha*
Annual sediment volume	51	m^3/yr
Frequency for 100% spare volume reduction	**22.1**	***years***

Table 2: Annual sediment loading

Impervious Level	Annual Loading
%	m^3/ha
35%	0.6
55%	1.9
70%	2.8
85%	3.8

FREYMOND QUARRY
STORMWATER MANAGEMENT
Bancroft, Ontario

Project Number:	33886-100
Date:	October 14, 2016
Design By:	KMR
File:	Q:\33886\Micro Drainage Analysis\SWM\33886-100 SWM Design Kurtis.xlsx

FALLING HEAD DRAWDOWN CALCULATION
MOEE SWM Planning and Design Manual, 2003

$$t = \frac{0.66C_2h^{1.5} + 2C_3h^{0.5}}{2.75A_O}$$ Equation 4.11

where

$t =$	238890	*s*	
	66.4	*hr*	drawdown time
$A_p =$	4411.48	m^2	surface area of the pond
$C =$	0.63		discharge coefficient
$d =$	95	*mm*	diameter of the orifice
$A_O =$	0.00709	m^2	cross-sectional area of the orifice
$g =$	9.81	m/s^2	gravitational acceleration constant
$h_1 =$	331.330	*m*	starting water elevation above the orifice
$h_2 =$	331.000	*m*	ending water elevation above the orifice
$h =$	0.33	*m*	maximum water elevation above the orifice
$C_2 =$	1621.17		slope coefficient from the area-depth linear regression
$C_3 =$	3876.5		intercept from the area-depth linear regression

	ELEVATION *m*	STAGE *m*	AREA m^2	COMMENTS
1	331.000	0	3876.5	
2	331.100	0.1	4038.6	
3	331.200	0.2	4200.7	
4	331.300	0.3	4362.8	
5	331.400	0.4	4525.0	
6	331.500	0.5	4687.1	

DRAWDOWN TIME: 238890 *s*
66.4 *hr*

Regression Output:

$m_1 =$	1621.17	slope coefficient from the area-depth linear regression
$b =$	3876.50	intercept from the area-depth linear regression
$se_1 =$	0.00	standard error for coefficient m_1
$se_b =$	0.00	standard error for constant b
$R^2 =$	1.0000	coefficient of determination
$se_y =$	0.00	standard error of the *y* estimate
$F =$	3.31E+27	F statistic
$df =$	4	degrees of freedom
$ss_{reg} =$	459932	regression sum of squares
$ss_{resid} =$	0	residual sum of squares

APPENDIX F

TECHNICAL MEMORANDUM – MACRO DRAINAGE ANALYSIS

TECHNICAL MEMORANDUM

TO:		**MTE FILE NO.:**	33886-200
COMPANY:	Freymond Lumber Ltd.	**DATE:**	December 1, 2016
		FROM:	PAG/TFC
		PROJECT NAME:	Freymond Quarry

RE: PROPOSED FREYMOND QUARRY – MACRO DRAINAGE ANALYSIS

The purpose of this Drainage Analysis is to investigate runoff and infiltration rates prior to and throughout the extraction process (Phase 1- Phase 4) at the proposed Freymond Quarry. The proposed Freymond Quarry is located on Lot 51 and 52, Concession WHR in the Township of Faraday, County of Hastings (hereby referred to as the “Site”) see Figure 1 of MTE’s Level 1 and Level 2 Hydrogeological Investigation.

OBM mapping identifies two unnamed streams north and south of the Site, hereby referred to as North and South Stream. The catchment area for the North Stream was delineated from its confluence with the York River near Mill St., while the catchment area for the South Stream was delineated from the point where it crosses Bay Lake Rd. (see Figure 14 of MTE’s Level 1 and Level 2 Hydrogeological Investigation). Figure 14 also indicates surface water drainage flow patterns.

HYDROLOGIC CYCLE

The natural cyclic process by which water moves from the atmosphere, on to and through the ground into streams/rivers before reaching the oceans and returning to the atmosphere is called the hydrologic cycle. The hydrologic cycle has no beginning or end and the amount of water moving through the hydrologic cycle is in constant change.

The hydrologic cycle may be assessed through an analysis of the water budget that attempts to balance water inputs with water outputs. Water budget components are affected by a number of features including:

- Physiography;
- Topography;
- Geology;
- Groundwater;
- Surface Water;
- Evaporation; and
- Precipitation.

Water interacting and/or moving through each of these features determines water balance changes.

WATER BALANCE

A water balance calculation is the numerical approximation of water circulating through the hydrologic cycle. The water budget balances water inputs (precipitation, surface water flow, and groundwater movement) and water outputs (evaporation and transpiration [collectively evapotranspiration], surface water flow, and groundwater movement).

$$\text{Water}_{\text{In}} = \text{Water}_{\text{Out}} \quad \textit{(Eq. 1.1)}$$

The water budget equation is valid for any land use, subwatershed, or watershed. Eq. 1.1 can be expanded into:

$$P + R_{IN} + G_{IN} = ET + R_{OUT} + G_{OUT} + I \qquad \textit{(Eq. 1.2)}$$

Where:

P = Precipitation
R_{IN} = Runoff In (Surface Water)
G_{IN} = Groundwater In
R_{OUT} = Runoff Out (Surface Water)
ET = Evapotranspiration
G_{OUT} = Groundwater Out
I = Infiltration

This water balance model was used to assess potential volumetric changes of water discharging to the North and South Streams. Water balance calculations have been included in the *Freymond Quarry – Macro Drainage Analysis* spreadsheet (Attachment 1).

PRE-EXTRACTION CONDITIONS

Pre-extraction catchment areas for the North and South Streams are divided into four sub-catchments (see Figure 14 of MTE's Level 1 and Level 2 Hydrogeological Investigation):

- Sub-Catchment 101 – includes the entire catchment area for the North Stream excluding the portion found on the Site (389.8 ha).
- Sub-Catchment 102 – includes the portion of the Site draining to the North Stream (8.0 ha).
- Sub-Catchment 103 – includes the entire catchment area for the South Stream, excluding the portion found on the Site (82.4 ha).
- Sub-Catchment 104 – includes the portion of the Site draining to the South Stream (26.7 ha).

Flows from catchment areas 101 and 102 are assessed at assessment node 'A' located at the confluence with the York River near Mill Street. Flows from catchment areas 103 and 104 are assessed at assessment node 'B' located where the South stream crosses Bay Lake Road. See Figure 14 of MTE's Level 1 and Level 2 Hydrogeological Investigation for the locations of assessment node A & B.

Hydrologic cycle component values for evapotranspiration, surface runoff and infiltration were derived using physical attributes such as land-use, soil type, and topography. Soil type was determined from Quaternary geology maps (Barnett, 1985); land use from aerial photography; and topography from Ontario Base Map contours. The water balance example in Table 3.1 of the MOE *Stormwater Management Planning and Design Manual* (SMPDM) (March 2003) provided the basis for the hydrologic cycle component values used. The table was revised with factors and rates specific to latitude ~45°N.

Average annual precipitation values were obtained from the Haliburton Ministry of the Environment and Climate Change (MOECC) station Climate Normals (1971-2000). The average annual precipitation at this station totals 1073.5 mm/yr. A water balance analysis indicating how precipitation (P) is distributed into evapotranspiration (ET), surface runoff (R), and infiltration (I) within each catchment area was completed for pre-extraction conditions in order to establish current annual runoff and infiltration rates (mm/yr).

The average annual evapotranspiration rate has an estimated range of 544-546 mm/year using climate normal temperature data and the Thornthwaite and Mather (1957) approach. Infiltration factors were assigned based on topographic conditions (i.e. land slope), land cover (i.e. forest vs. meadow), and soil conditions assumed below:

- Approximately 95% of water from precipitation that is not lost to evapotranspiration enters surface water features as runoff.
- Recharge into the Precambrian bedrock groundwater surface is expected to be primarily controlled by the secondary porosity (i.e. fractures). The secondary porosity of crystalline bedrock is on the order of 2-5% (Fetter, 2001; Freeze and Cherry, 1979) and would generally occur close to ground surface where weathering processes have had an opportunity to increase the porosity.
- Based on the above, MTE assumes 5% of water from precipitation that is not lost to evapotranspiration would be available to recharge the Precambrian bedrock groundwater system.

Using these assumptions, the calculated annual volume of pre-extraction surface runoff from the North Catchment (101 + 102) totals 1,972,892 m^3/yr, while the annual volume from the South Catchment (103 + 104) totals 547,616 m^3/yr.

POST – EXTRACTION CONDITIONS

The post-extraction sub-catchment Phase naming convention is summarized as follows:

Phase	Naming Convention
1	200
2	300
3	400
4	500

All sub-catchments are named after their pre-extraction equivalents.

The Drainage Analysis for the Site is presented in Attachment 1 and the results are summarized below:

North Catchment

Runoff	Pre-Extraction	Phase 1	Phase 2	Phase 3	Phase 4
Total Pre-Development (m^3/year)	1,972,892	1,972,892	1,972,892	1,972,892	1,972,892
Total Post-Development (m^3/year)	-	1,954,626	1,938,568	1,938,568	1,938,568
% Net Loss of Surface Runoff	-	0.9%	1.7%	1.7%	1.7%

South Catchment

Runoff	Pre-Extraction	Phase 1	Phase 2	Phase 3	Phase 4
Total Pre-Development (m^3/year)	547,616	547,616	547,616	547,616	547,616
Total Post-Development (m^3/year)	-	580,774	600,370	614,485	590,211
% Net Gain of Surface Runoff	-	6.1%	9.6%	12.2%	7.8%

Following Phase 1 (see Figure 15 of MTE's Level 1 and Level 2 Hydrogeological Investigation) annual runoff is predicted to decrease in the North Stream by 0.9% and increase in the South Stream by 6.1%.

Following the completion of Phase 2 (see Figure 16 of MTE's Level 1 and Level 2 Hydrogeological Investigation) an additional 6.84 ha will drain towards the South Stream, which previously drained to the North Stream. As such, annual runoff is predicted to decrease by an additional 0.8% for a total of 1.7% in the North Stream, while runoff in the South Stream is predicted to increase by an additional 3.5% for a total of 9.6% when compared to pre-extraction conditions. The North Stream annual surface runoff does not change for the remainder of quarrying activities.

Completion of Phase 3 (see Figure 17 of MTE's Level 1 and Level 2 Hydrogeological Investigation) results in a net gain of 12.2% in annual runoff to the South Stream. This gain in annual runoff is attributed to changes in land-use/soil type to *Exposed Quarry Floor* (Attachment 1). Following the completion of Phase 4 (Figure 18 of MTE's Level 1 and Level 2 Hydrogeological Investigation), progressive rehabilitation begins to minimize exposed bedrock. As such, runoff decreases by ~4% compared to Phase 3 resulting in an overall increase of 7.8% when compared to pre-extraction conditions.

SUMMARY

Following the completion of Phase 2 the catchment area for the North Stream will decrease by 6.84 ha (1.7%) with a decrease in annual volume of approximately 1 l/s. Following the completion of Phase 4 the catchment area for the South Stream will increase by 6.84 ha (6.3%) with an increase in annual volume of approximately 1.4 l/s due to the increased runoff area directed south from the Site. These changes are not expected to have a negative impact on the hydrologic regimes of either stream.

REFERENCES

1. Environment Canada. (2015, September 22). *Canadian Climate Normals 1971-2000 Station Data*. Retrieved November 30, 2015, from Climate: http://climate.weather.gc.ca/climate_normals/results_e.html?stnID=4486&lang=e&StationName=owen+sound&SearchType=Contains&stnNameSubmit=go&dCode=1&dispBack=1

2. Barnett, P. J., 1985: *Quaternary Geology of the Bancroft Area;* Ontario Geological Survey, Map 2500, Quaternary Geology Series, scale 1: 50 000, Geology 1978, 1979.

3. Fetter, C.W., 2001: *Applied Hydrogeology 4th ed.,* Prentice Hall, Upper Saddle River, New Jersey, 07458.

4. Freeze, A. and J. Cherry, 1979: *Groundwater*, Englewood Cliffs, New Jersey, Prentice-Hall, Inc.

5. Ministry of the Environment. (2003). *Stormwater Management Planning and Design Manual.* Ministry of the Environment.

6. Ontario Ministry of Natural Resources. (1984). *Water Quantity Resources of Ontario.* Ministry of Natural Resources.

ATTACHMENT

Attachment 1: Macro Drainage Analysis

Freymond Quarry

Town of Bancroft, Hastings County

Project: 33886-100
Date: December 1, 2016
By: TFC

Hydrologic Cycle Component Values

Land-use/Soil Type	Hydrologic Components (mm/year)		
	Evapotranspiration	Runoff	Infiltration
Mature Forests Fine Sandy Loam (Type B)	544	503	26
Mature Forests Silt Loam (Type C)	546	501	26
Mature Forests Precambrian Bedrock (Type D)	545	502	26
Lakes / Ponds / Small Reservoirs	700	374	0
Exposed Quarry Floor	209	821	43
Overburden - Urban Lawn / Glaciofluvial outwash, gravelly sand (Type B)	521	524	28
Rahabilitated Land- Shrub / Glaciofluvial outwash, gravelly sand (Type B)	535	511	27
Overburden - Urban Lawn / Precambrian Bedrock Type D	521	524	28
Rahabilitated Land- Shrub / Precambrian Bedrock (Type D)	539	507	27

North Catchment Area:

Land Use / Soil Type	Pre-Extraction (101 & 102)			Phase 1 (201 & 202)			Phase 2 (301 & 302)			Phase 3 (401 & 402)			Phase 4 (501 & 502)		
	Area Draining to North Creek (ha)	Runoff (mm/yr)	Volume to Stream (m^3/year)	Area Draining to North Creek (ha)	Runoff (mm/yr)	Volume to Stream (m^3/year)	Area Draining to North Creek (ha)	Runoff (mm/yr)	Volume to Stream (m^3/year)	Area Draining to North Creek (ha)	Runoff (mm/yr)	Volume to Stream (m^3/year)	Area Draining to North Creek (ha)	Runoff (mm/yr)	Volume to Stream (m^3/year)
Mature Forest / Silty to sandy, stony (Type C)	9.00	501	45,078	9.00	501	45,078	9.00	501	45,078	9.00	501	45,078	9.00	501	45,078
Mature Forest / Glaciofluvial outwash, gravelly sand (Type B)	73.50	503	369,521	73.50	503	369,521	73.50	503	369,521	73.50	503	369,521	73.50	503	369,521
Mature Forest / Precambrian Bedrock (Type D)	292.70	502	1,468,787	289.06	502	1,450,522	285.86	502	1,434,464	285.86	502	1,434,464	285.86	502	1,434,464
Mature Forest / Bog & Swamp Deposits (Type C)	4.00	501	20,035	4.00	501	20,035	4.00	501	20,035	4.00	501	20,035	4.00	501	20,035
Lake	18.60	374	69,471	18.60	374	69,471	18.60	374	69,471	18.60	374	69,471	18.60	374	69,471
Total	*397.80*		**1,972,892**	*394.16*		**1,954,626**	*390.96*		**1,938,568**	*390.96*		**1,938,568**	*390.96*		**1,938,568**
	Total Pre-Development (m^3)		**1,972,892**	**Total Post-Development (m^3)**		**1,954,626**			**1,938,568**			**1,938,568**			**1,938,568**
				Net Loss of Surface Runoff (m^3)		**18,266**			**34,324**			**34,324**			**34,324**
				% Net Loss of Surface Runoff		**0.9%**			**1.7%**			**1.7%**			**1.7%**

South Catchment Area:

Land Use / Soil Type	Pre-Extraction (103 & 104)			Phase 1 (203 & 204)			Phase 2 (303 & 304)			Phase 3 (403 & 404)			Phase 4 (503 & 504)		
	Area Draining to North Creek (ha)	Runoff (mm/yr)	Volume to Stream (m^3/year)	Area Draining to North Creek (ha)	Runoff (mm/yr)	Volume to Stream (m^3/year)	Area Draining to North	Runoff (mm/yr)	Volume to Stream (m^3/year)	Area Draining to North	Runoff (mm/yr)	Volume to Stream (m^3/year)	Area Draining to North	Runoff (mm/yr)	Volume to Stream (m^3/year)
Mature Forest / Glaciofluvial outwash, gravelly sand (Type B)	15.40	503	77,423	14.83	503	74,558	14.83	503	74,558	14.83	503	74,558	12.90	503	64,855
Mature Forest / Precambrian Bedrock (Type D)	93.70	502	470,193	87.11	502	437,124	82.46	502	413,790	73.79	502	370,283	72.57	502	364,161
Overburden - Urban Lawn / Glaciofluvial outwash, gravelly sand (Type B)	0.00	521	0	0.00	521	0	0.00	521	0	0.00	521	0	1.93	521	10,055
Rehabilitated Land- Shrub / Glaciofluvial outwash, gravelly sand (Type B)	0.00	535	0	0.00	535	0	0.00	535	0	0.00	535	0	0.00	535	0
Overburden - Urban Lawn / Precambrian Bedrock Type D	0.00	521	0	5.09	521	26,519	8.23	521	42,878	7.53	521	39,231	6.12	521	31,885
Rehabilitated Land- Shrub / Precambrian Bedrock (Type D)	0.00	539	0	0.00	539	0	4.29	539	23,123	9.84	539	53,038	21.46	539	115,669
Mature Forest / Bog & Swamp Deposits (Type C)	0.00	501	0	0.00	501	0	0.00	501	0	0.00	501	0	0.00	501	0
Exposed Quarry Floor	0.00	821	0	4.75	821	38,988	5.17	821	42,435	8.99	821	73,790	0.00	821	0
Quarry Pond	0.00	374	0	0.96	374	3,586	0.96	374	3,586	0.96	374	3,586	0.96	374	3,586
Total	*109.10*		**547,616**	*112.74*		**580,774**	*115.94*		**600,370**	*115.94*		**614,485**	*115.94*		**590,211**
	Total Pre-Development (m^3)		**547,616**	**Total Post-Development (m^3)**		**580,774**			**600,370**			**614,485**			**590,211**
				Net Loss of Surface Runoff (m^3)		**33,158**			**52,754**			**66,869**			**42,595**
				% Net Loss of Surface Runoff		**6.1%**			**9.6%**			**12.2%**			**7.8%**

Assumptions:

1) Precambrian bedrock is assumed to act like Soil Type D (Clay) to provide high runoff
2) Bog cover is considered "mature forest"
3) Bog is Type C soil (some infiltration)
4) No major depression storage
6) Overburden cover is considered "urban lawn"
7) Rehabilitated land is considered "shrub"
8) Lake evaporation obtained from Government of Canada "Mean Lake Evaporation" map:
(http://open.canada.ca/data/en/dataset/67de4f04-855d-5d23-bb4a-2a270d1488d0)
9) Surplus water to stream is Precipitation minus Evapotranspiration (assuming infiltration becomes stream interflow)

APPENDIX G

TECHNICAL MEMORANDUM – GROUNDWATER DRAWDOWN ZONE OF INFLUENCE

TECHNICAL MEMORANDUM

TO:		**MTE FILE NO.:**	33886-100
COMPANY:	Freymond Lumber Ltd	**DATE:**	December 1, 2016
		FROM:	PAG/TFC
		PROJECT NAME:	Freymond Quarry

RE: GROUNDWATER DRAWDOWN & ZONE OF INFLUENCE

The technical memo is intended to provide additional information regarding potential impacts of operating a Class A, Category 2, below-ground water table quarry at Lot 51 and 52, Concession WHR in the Township of Faraday, County of Hastings (hereby referred to as the "Site") see Figure 1 of MTE's Level 1 and Level 2 Hydrogeological Investigation.

CONCEPTUAL MODEL

Since the geology of the Site is composed of crystalline Precambrian rocks these rocks become the host of infiltrated groundwater. As such, an analytical zone-of-influence calculation will describe the potential impacts to groundwater resources from quarry operations. The conceptual model developed by MTE to describe how groundwater will enter the quarry at the conclusion of quarrying is outlined below:

- At the conclusion of quarrying activities, the final shape of the proposed quarry can be approximated by a wedge oriented in a west-east direction;
- When operations commence, the bedrock excavation is modeled to perform as a circular well with an effective area equivalent to the Site and that groundwater entering the well will occur through a gravity driven seepage process;
- Since the final shape of the quarry can be approximated as a wedge, flow into the quarry is approximately half that calculated for a circular well that theoretically receives water uniformly around its circumference from radial flow with a constant or fixed amount (highest) of drawdown;
- The proposed final floor elevation at the outlet will be at approximately 333 mAMSL;
- Groundwater monitoring shows the maximum (or highest) groundwater elevation is located at ~376 mAMSL;
- The entire quarry face will be dewatered via gravity, resulting in a maximum drawdown of approximately 43 m at the westward/leading or up-gradient edge within the Site;
- Since quarry dewatering is a passive gravity driven process and that no wells will be used to dewater the quarry, groundwater within the proposed quarry, and ultimately beyond it cannot theoretically be drawn down below the quarry floor; and

- Following quarry operations, the rehabilitated quarry will continue to exert an influence on the Precambrian bedrock until such time that the groundwater elevation at the quarry face equals the elevation of the quarry floor and the groundwater system enters into equilibrium.

ANALYTICAL MODEL SELECTION

For the purposes of this analytical model, and consistent with the industry's approach to the application of analytical solutions of this type MTE assumes that the bedrock groundwater system at the Site acts as an ideal confined aquifer with the following characteristics (Fetter, 2001):

- The aquifer is bounded on the bottom by a confining layer;
- All geological formations are horizontal and have an infinite extent;
- The potentiometric surface of the aquifer is horizontal prior to the start of dewatering;
- All changes in the positions of the potentiometric surface are due to the effect of dewatering;
- The aquifer is homogeneous and isotropic;
- All flow is radial to the quarry;
- Groundwater flow is horizontal;
- Darcy's Law is valid;
- Groundwater has a constant density and viscosity;
- The quarry (well) is 'screened' over the entire thickness of the aquifer; and
- The quarry (well) has an infinitesimal diameter and is 100% efficient.

Under these conditions, transient drawdown effects in the confined aquifer are described using the Theis (1935) nonequilibrium equation:

$$h_o\text{-}h = \frac{Q}{4\,\pi T}\,W(u) \qquad \textit{Eq. 1.1}$$

Where: $h^o\text{-}h$ = drawdown at a distance "r" from the quarry (well) (m)

Q = constant dewatering (drainage) rate (m^3/day)

T = aquifer transmissivity (m^2/day)

$W(u)$ = well function

The well function is an infinite series term that approximates an exponential integral where the argument u is given by:

$$u = \frac{r^2S}{4Tt} \qquad \textit{Eq. 1.2}$$

Where : r = radial distance from the quarry (m)
S = the aquifer storativity (dimensionless)
T = aquifer transmissivity (m^2/day)
t = time since dewatering (drainage) began (days)

In addition to the assumptions presented above, the Theis (1935) equation has the following assumptions (Fetter, 2004):

- The aquifer is confined top and bottom;
- There is no source of recharge to the aquifer (ie. infiltrating precipitation is not accounted for);
- The aquifer is compressible and water is released instantaneously from the aquifer as the head is lowered; and
- The quarry drains at a constant rate.

Values used for the input parameters for *Eq. 1.1* and *Eq. 1.2* are described below:

ANALYTICAL MODEL INPUT PARAMETERS

Eq.1.1 Parameters

Hydraulic Conductivity (K)

Hydraulic conductivity testing for on-Site monitoring wells resulted in a calculated geometric mean of 6.8×10^{-5} m/day (7.9×10^{-10}m/sec).

Aquifer Thickness (b)

For the purposes of this analytical model, the entire Precambrian bedrock sequence to be quarried is assumed to be saturated and will act as an ideal confined aquifer with an average thickness of 43 m.

Drainage/Pumping Rate (Q)

From Darcy's Law, water flowing through any circular section of an aquifer towards a well is a product of the area of the circular system multiplied by the horizontal hydraulic conductivity multiplied by the horizontal hydraulic gradient (expressed as the change in head over the radial distance from the well) (Fetter, 2004). Flow through the circular system can be expressed as:

$$Q = (2\pi rb) \quad * \quad K \quad * \quad (d_h/d_r) \qquad \textit{Eq. 1.3.}$$

Where:
Q = drainage/pumping rate (m^3/day)
r = radial distance from the circular section to the well (m)
b = aquifer thickness (m)
K = hydraulic conductivity (m/day)
(d_h/d_r) = hydraulic gradient (m/m)

During quarry extraction through natural drainage, a zone-of-influence on the groundwater system is exerted around the quarry. Under the conceptual model, the maximum drawdown (dh) observed in the Precambrian bedrock at the quarry face could be approximately 43 m.

At any one time during quarry dewatering, the zone-of-influence has a theoretical maximum size at which point the effects of quarry dewatering are no longer theoretically measureable. The radial distance from the quarry to the point where the zone-of-influence can no longer be theoretically measured is used as "dr" to calculate the horizontal hydraulic gradient within the zone-of-influence.

Additionally, the point at which the theoretical maximum zone-of-influence occurs (dr) also represents the point (r) within the ideal confined system where the system is supplying groundwater at the maximum flow rate required to sustain drawdown at the quarry edge.

Since r appears as a numerator and d_r as a denominator in *Eq. 1.3* and the maximum theoretical drawdown at the quarry edge is known (43 m), thus *Eq. 1.3* can be re-written as:

$$Q = (2\pi b) \quad * \quad K \quad * \quad d_h \qquad \textit{Eq. 1.4.}$$

Eq. 1.4 assumes that the well is receiving water from a uniform thickness around its entire circumference. Under the conceptual model presented above, the Site is assumed to act as a circular well with the same effective area as the Site but due to final shape of the quarry being wedge shaped, the quarry will only receive half the flow. Therefore *Eq. 1.4* can be re-written as:

$$Q = \frac{(2\pi b) \quad * \quad K \quad * \quad d_h}{2} \qquad \textit{Eq. 1.5.}$$

Using a hydraulic conductivity of 6.8x10^{-5} m/day; an aquifer thickness of 43 m; and a drawdown value of 43 m, a pumping rate (or in this case the gravity driven drainage rate) was calculated to be approximately 0.41 m^3/day.

$$Q = \frac{(2\pi 43) * \quad 6.82 \times 10^{-5} * \quad 43}{2}$$

$$Q = \quad 0.41 \quad m^3/day$$

Transmissivity (T)

Transmissivity (T) is a product of the aquifer thickness (b) and the hydraulic conductivity (K) (T=Kb). Transmissivity for the Precambrian bedrock at the Site was calculated to be 2.9 x 10^{-3} m^2/day. This T value is also used in Eq.1.2.

Radial Distance from the Pumping Well (r) (Eq. 1.2)

In Eq. 1.2, the radial distance from the pumping well (r) is used to assess pumping related drawdown at varying distances from the centre of the quarry (well). In order to select meaningful assessment points, MTE assumes that as each phase is completed, the area of the Site extracted acts as a large diameter well with an effective area equal to the area of the extracted area. The effective radius is given as:

$$r_s = \sqrt{A/\pi}$$

where;

r_s = Effective Radius

A = Area Extracted

The effective radius for each of the phases is outlined in the table below.

Phase	Total Area Extracted (ha)	Effective Radius (m)
1	8.1	161
1 + 2	13.2	205
1 + 2 + 3	21.2	260
1 + 2 + 3 + 4	27.8	296

As such, the extracted area and the associated effective radius where drawdown can be predicted to occur increases with each phase of extraction.

For example after the completion of Phase 1 the extracted area of the Site occupies an area of approximately 8.1 ha (81,000 m^2); therefore; the effective radius of the quarry dewatering is given as:

$$
\begin{aligned}
r_s &= \sqrt{A/\pi} \\
&= \sqrt{81{,}000/3.14} \\
&\approx 161 \text{ m}
\end{aligned}
$$

Any drawdown calculated at a distance r within 161 m of the centre of the quarry (well) is not meaningful as it would effectively be inside the “well”. In order to assess potential drawdown on the Precambrian groundwater system from quarry dewatering activities, drawdown after the completion of each phase was assessed at 1, 100 and 500 metres from the quarry [well] edge.

Storativity (S)

In a confined aquifer condition, storativity (S) values range from 0.005 to 0.00005 (Freeze and Cherry, 1979). In order to assess the zone-of-influence on the Precambrian groundwater system, a storativity of 0.0005 was selected for inclusion in Eq. 1.2 considering a variety of literature sources (Driscoll, 1986; Fetter, 2001; Freeze and Cherry, 1979).

Since an assumption of the Theis equation is that no recharge of the aquifer occurs during pumping, the zone-of-influence will continue to expand indefinitely so long as pumping continues. In order to assess the effects that prolonged dewatering without recharge would have on the Precambrian groundwater flow system, drawdown was assessed after the completion of Phases 1 through 3, as well as 20 years after the final phase (4).

PREDICTION ANALYSIS

Predicted drawdown at assessment distances (r) for each phase are presented in Attachment A and the cumulative drawdown after each phase and 20 years following Phase 4 is summarized below.

Phase	Distance from Quarry (m)		
	1	100	500
	Drawdown (m)		
Post Phase 1	12.01	4.92	0.05
Post Phase 2	20.13	8.18	0.08
Post Phase 3	26.75	11.12	0.14
Post Phase 4 - 20 Years	34.86	15.41	0.35

Drawdown was calculated using the United States Geological Survey (USGS) Theis Excel spreadsheet for predicting drawdown response from a single pumping well in a Theis aquifer, detailed calculations are presented in Attachment B. The time needed to complete each phase is based on a 300,000 tonnes/year extraction rate.

Just as the effective radius of the quarry increases with each phase, so too does the cumulative drawdown. Cumulative drawdown at the end of each phase was calculated by summing the drawdown of the previous phase(s) (see Attachment A) to that of the current phase. Therefore the drawdown for Phase 3 was calculated by summing the drawdown calculated in Phase 3 with the drawdown calculated in Phases 1 and 2.

Drawdown following Phase 1, 2, 3, and 20 years after the completion of Phase 4 is estimated to be limited to within 500 m and have a maximum drawdown one meter away from the quarry of 12 m (Phase 1), 20 m (Phase 2), 27 m (Phase 3), 35 m (20 years after Phase 4). Figures 20 through 22 of MTE's Level 1 and Level 2 Hydrogeological Investigation present the zone of influence following the extraction of Phases 1 through 3.

The predicted drawdown twenty years following the completion of Phase 4 is estimated to be 34.9, 15.4 and 0.4 m at respective distances of one, 100 and 500 m away from the quarry edge. Figure 23 of MTE's Level 1 and Level 2 Hydrogeological Investigation illustrates the zone of influence twenty years after the completion of Phase 4 at distances of 100 m (red) and 500 m (green). The 500 m zone of influence is smaller east and north of the proposed quarry compared to the west and south as the topography in this location (Figure 3 of MTE's Level 1 and Level 2 Hydrogeological Investigation) falls below the proposed quarry floor elevation (~337 masl).

MTE considers measurable drawdown to be one meter. At a radial distance of 500 m from the quarry face the drawdown was calculated to be 0.4 m, which will be indiscernible from seasonal water table fluctuations (Hydrograph 1).

REFERENCES

1. Driscoll, F.G., 1986: *Groundwater and Wells* (second Edition), Johnson Division, St. Paul, Minnesota.

2. Fetter, C.W., 2001: *Applied Hydrogeology 4th ed.,* Prentice Hall, Upper Saddle River, New Jersey, 07458.

3. Freeze, A. and J. Cherry, 1979: *Groundwater*, Englewood Cliffs, New Jersey, Prentice-Hall, Inc.

4. USGS. Retrieved November 30, 2015, from United States Geological Survey: http://nevada.usgs.gov/tech/excelforhydrology/Listing_and_Description.htm

ATTACHMENT A

DRAWDOWN CALCULATIONS

Attachment A: Theis Calculations

Post-Phase 1

Input Parmeter	Value	Units
Hyraulic Conductivity (K)	7.89E-10	m/s
Storativity (S)	**5.00E-04**	
Aquifer Thickness (b)	43	m
Pumping Rate (Q)	4.69E-06	m^3/sec
	4.05E-01	m^3/day
Transmissivity (T)	2.93E-03	m^2/day
Excavated Area	8.16	ha
Efffective Radius (r_e)	161	m

Values of u (r,t)				
t (days)	r(m)--->	**162**	**261**	**661**
4745		2.36E-01	6.13E-01	3.93E+00

Values of Well Function W[u(r,t)]				
t (years)	r(m)--->	**162**	**261**	**661**
13		1.09E+00	4.47E-01	4.77E-03

Values for drawdown s(r,t) (m)				
t (years)	r(m)--->	**162**	**261**	**661**
13		12.01	4.92	0.05

Attachment A: Theis Calculations

Post-Phase 2

Input Parmeter	Value	Units
Hyraulic Conductivity (K)	7.89E-10	m/s
Storativity (S)	**5.00E-04**	
Aquifer Thickness (b)	43	m
Pumping Rate (Q)	4.69E-06	m^3/sec
	4.05E-01	m^3/day
Transmissivity (T)	2.93E-03	m^2/day
Excavated Area	1.33E+01	ha
Efffective Radius (r_e)	205	m

Values of u (r,t)				
t (days)	r(m)--->	**206**	**305**	**705**
7300		2.49E-01	5.45E-01	2.91E+00

Values of Well Function W[u(r,t)]				
t (years)	r(m)--->	**206**	**305**	**705**
13		7.38E-01	2.96E-01	2.92E-03

Values for drawdown s(r,t) (m)				
t (years)	r(m)--->	**206**	**305**	**705**
13		8.12	3.26	0.03

Attachment A: Theis Calculations

Post-Phase 3

Input Parmeter	Value	Units
Hyraulic Conductivity (K)	7.89E-10	m/s
Storativity (S)	**5.00E-04**	
Aquifer Thickness (b)	43	m
Pumping Rate (Q)	4.69E-06	m^3/sec
	4.05E-01	m^3/day
Transmissivity (T)	2.93E-03	m^2/day
Excavated Area	2.13E+01	ha
Efffective Radius (r_e)	260	m

Values of u (r,t)				
t (days)	r(m)--->	**261**	**360**	**760**
6205		4.69E-01	8.92E-01	3.97E+00

Values of Well Function W[u(r,t)]				
t (years)	r(m)--->	**261**	**360**	**760**
17		6.02E-01	2.68E-01	4.61E-03

Values for drawdown s(r,t) (m)				
t (years)	r(m)--->	**261**	**360**	**760**
17		6.62	2.94	0.05

Attachment A: Theis Calculations

20 Years Post-Phase 4

Input Parmeter	Value	Units
Hyraulic Conductivity (K)	7.89E-10	m/s
Storativity (S)	**5.00E-04**	
Aquifer Thickness (b)	43	m
Pumping Rate (Q)	4.69E-06	m^3/sec
	4.05E-01	m^3/day
Transmissivity (T)	2.93E-03	m^2/day
Excavated Area	2.75E+01	ha
Efffective Radius (r_e)	296	m

Values of u (r,t)				
t (days)	r(m)--->	**297**	**396**	**796**
9855		3.81E-01	6.78E-01	2.74E+00

Values of Well Function W[u(r,t)]				
t (years)	r(m)--->	**297**	**396**	**796**
27		7.37E-01	3.89E-01	1.93E-02

Values for drawdown s(r,t) (m)				
t (years)	r(m)--->	**297**	**396**	**796**
27		8.11	4.29	0.21

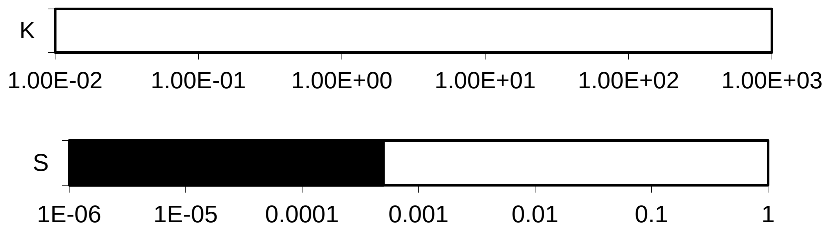
ATTACHMENT B

ZONE OF INFLUENCE CALCULATIONS

Drawdown Prediction for Confined Aquifers, Theis(1935)

Input Data for prediction of drawdown

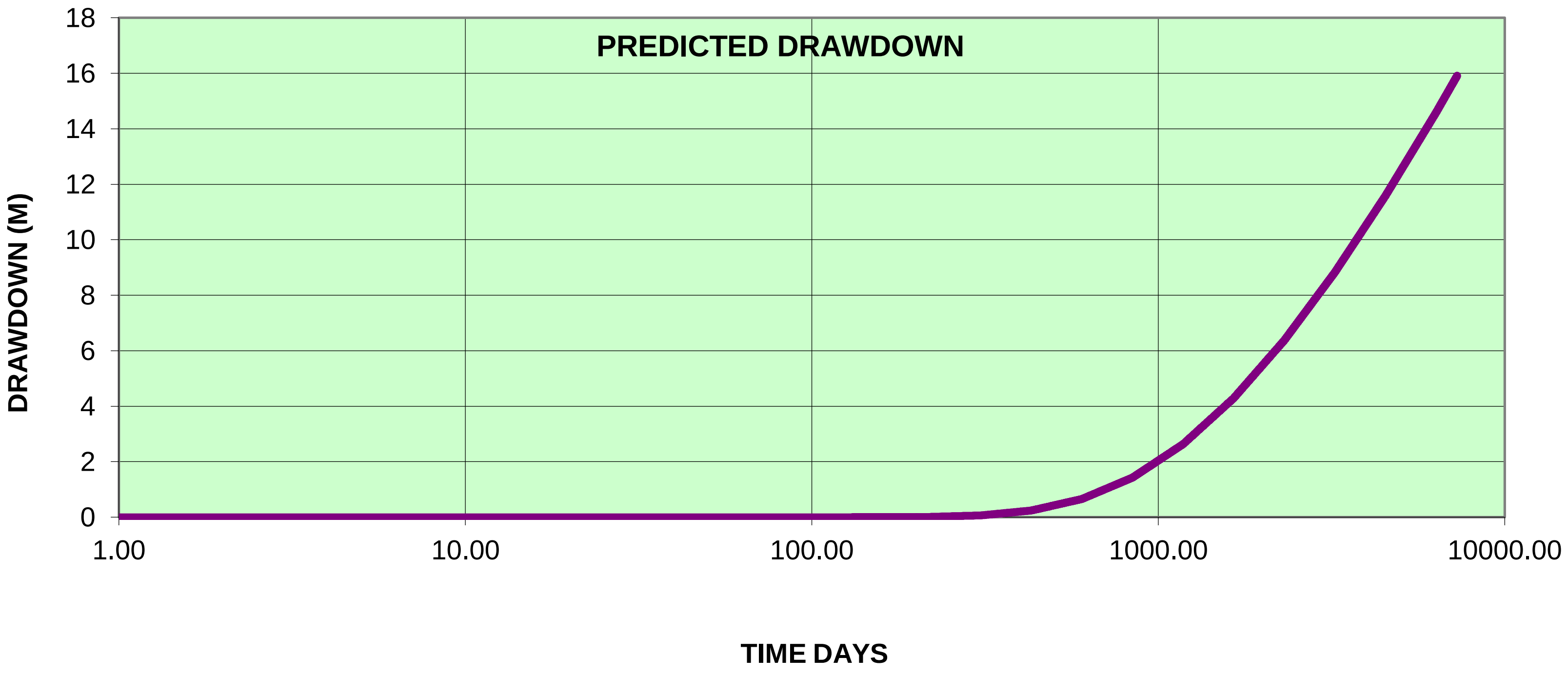
Phase	1
Hydraulic conductivity, K, m/day	6.82E-05
Aquifer Thickness, b, m	43
Storage Coefficient, S	0.0005
Pumping Rate, m^3/day	0.405182
Distance from well, m	162

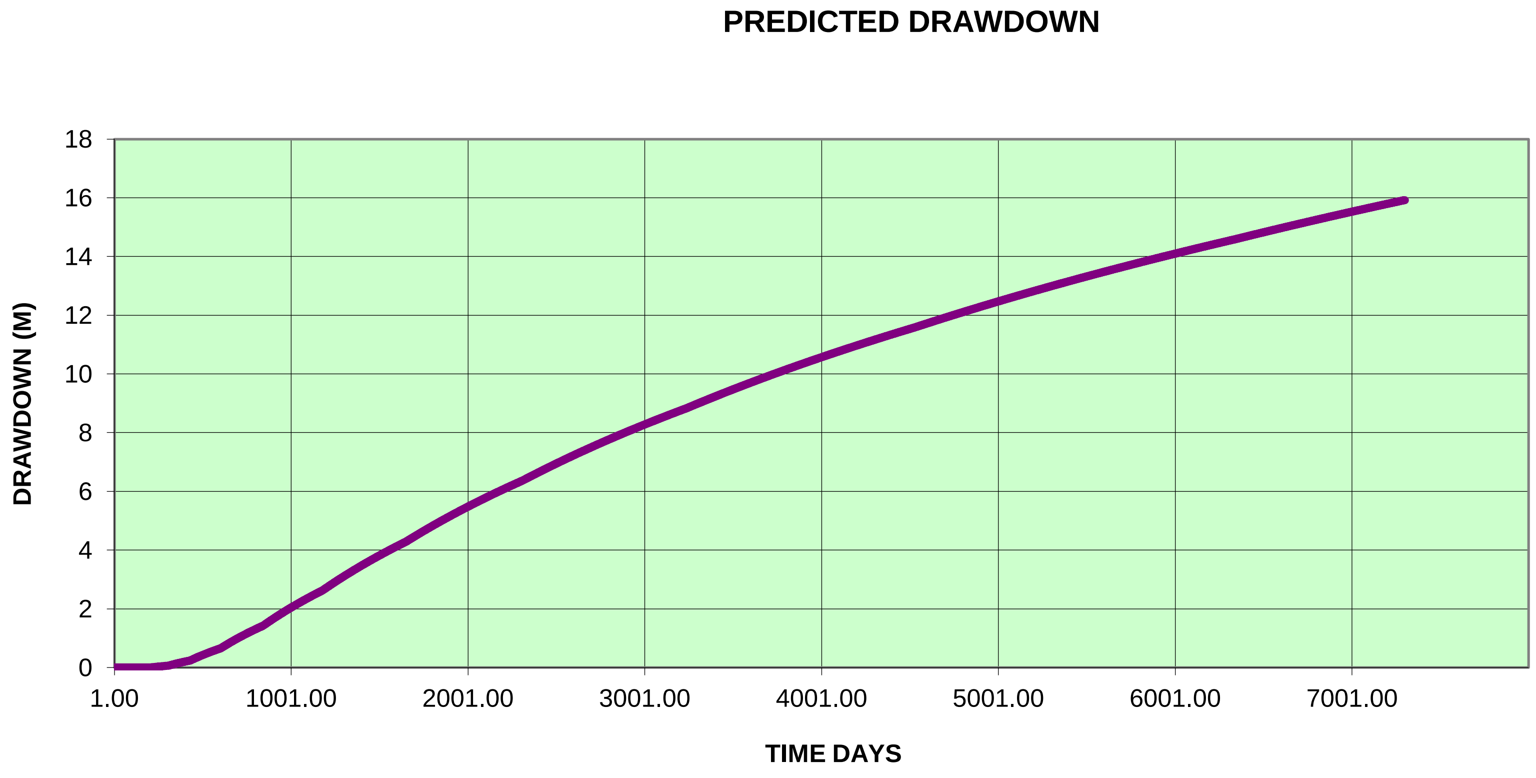


Equation used in prediction

$$s = \frac{Q(W(u))}{4\pi T} \qquad u = \frac{r^2 S}{4Tt}$$

s is drawdown, W(u) is the well function

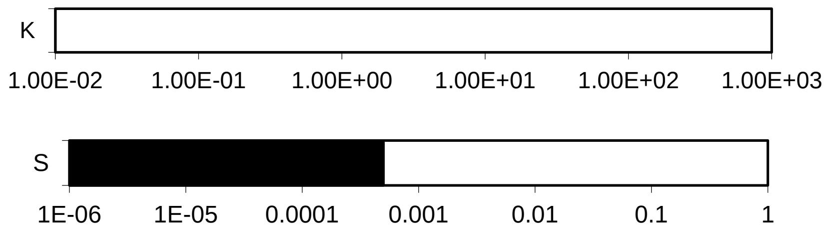




Drawdown Prediction for Confined Aquifers, Theis(1935)

Input Data for prediction of drawdown

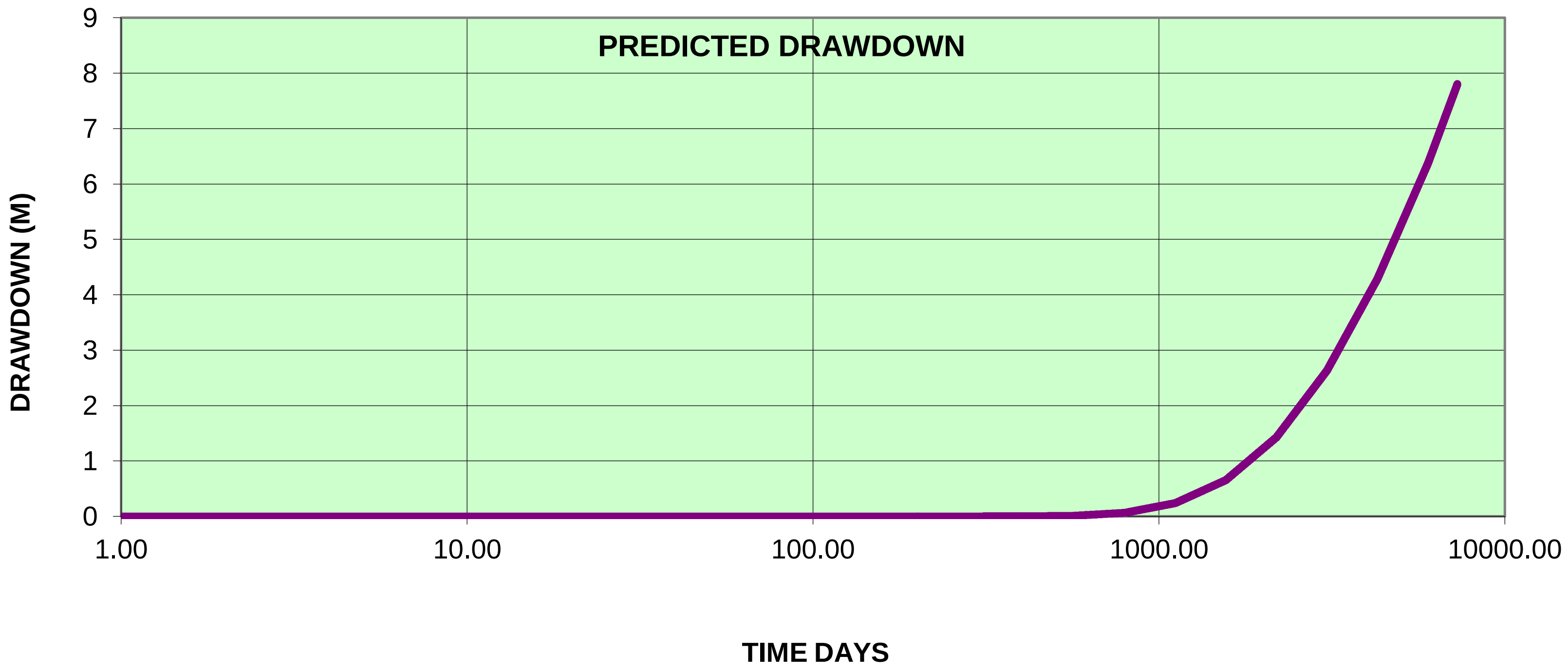
Phase	1
Hydraulic conductivity, K, m/day	6.82E-05
Aquifer Thickness, b, m	43
Storage Coefficient, S	0.0005
Pumping Rate, m^3/day	0.405182
Distance from well, m	261



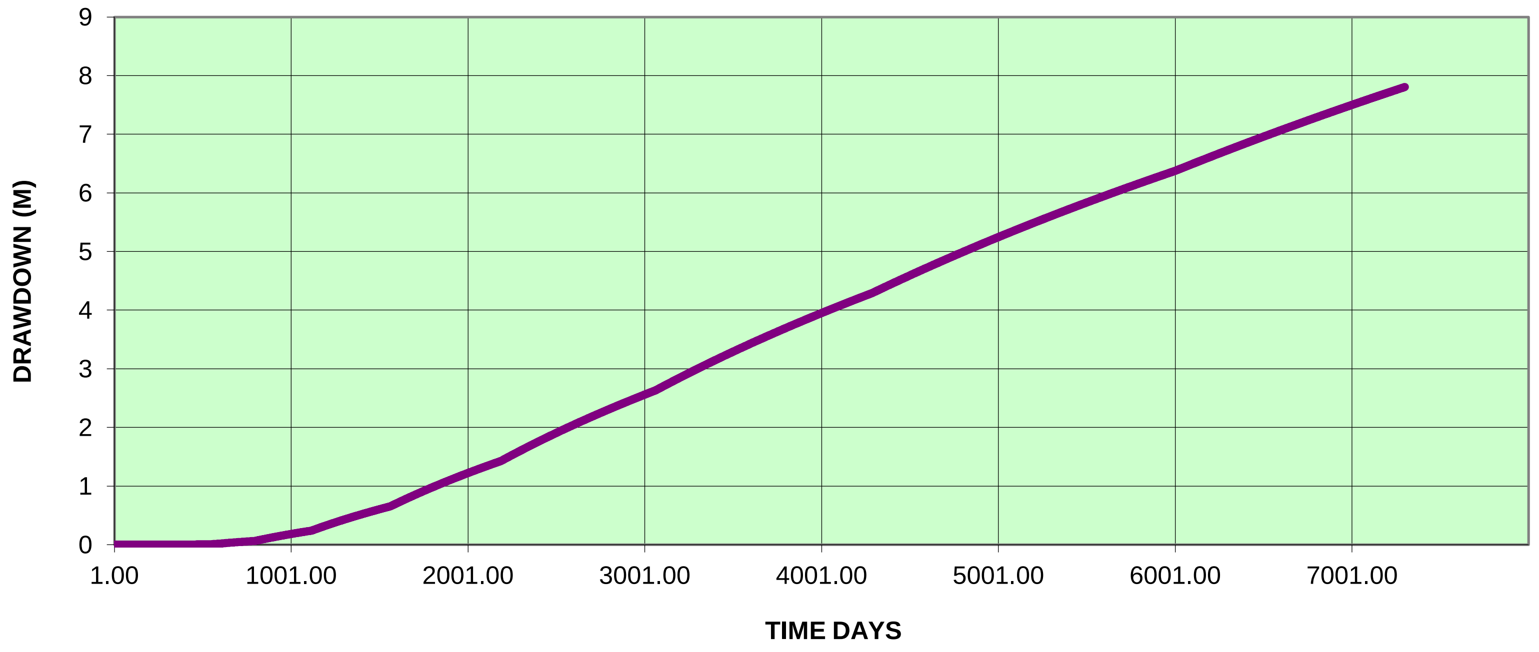
Equation used in prediction

$$s = \frac{Q(W(u))}{4\pi T} \qquad u = \frac{r^2 S}{4Tt}$$

s is drawdown, W(u) is the well function



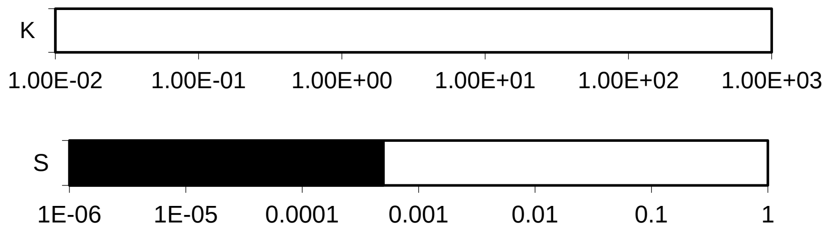
PREDICTED DRAWDOWN



Drawdown Prediction for Confined Aquifers, Theis(1935)

Input Data for prediction of drawdown

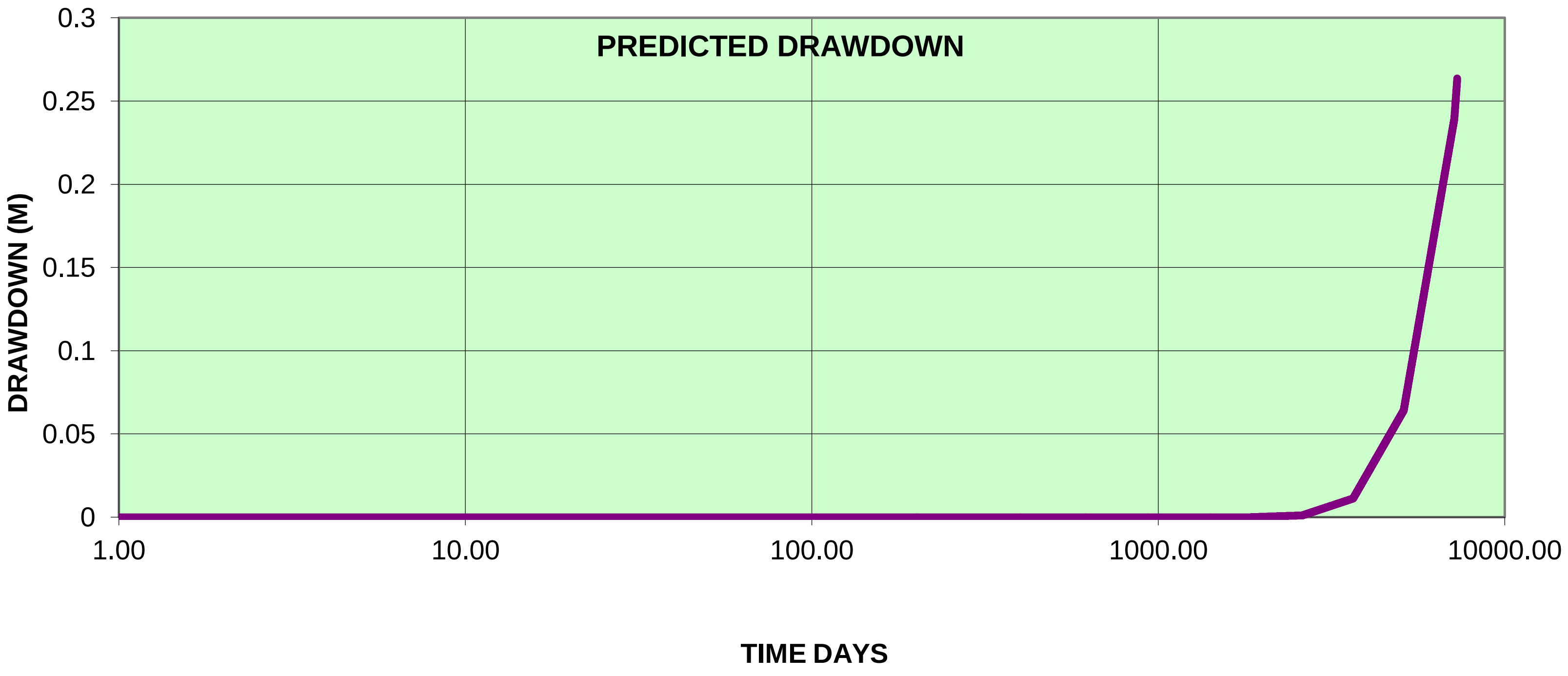
Phase	1
Hydraulic conductivity, K, m/day	6.82E-05
Aquifer Thickness, b, m	43
Storage Coefficient, S	0.0005
Pumping Rate, m^3/day	0.405182
Distance from well, m	661

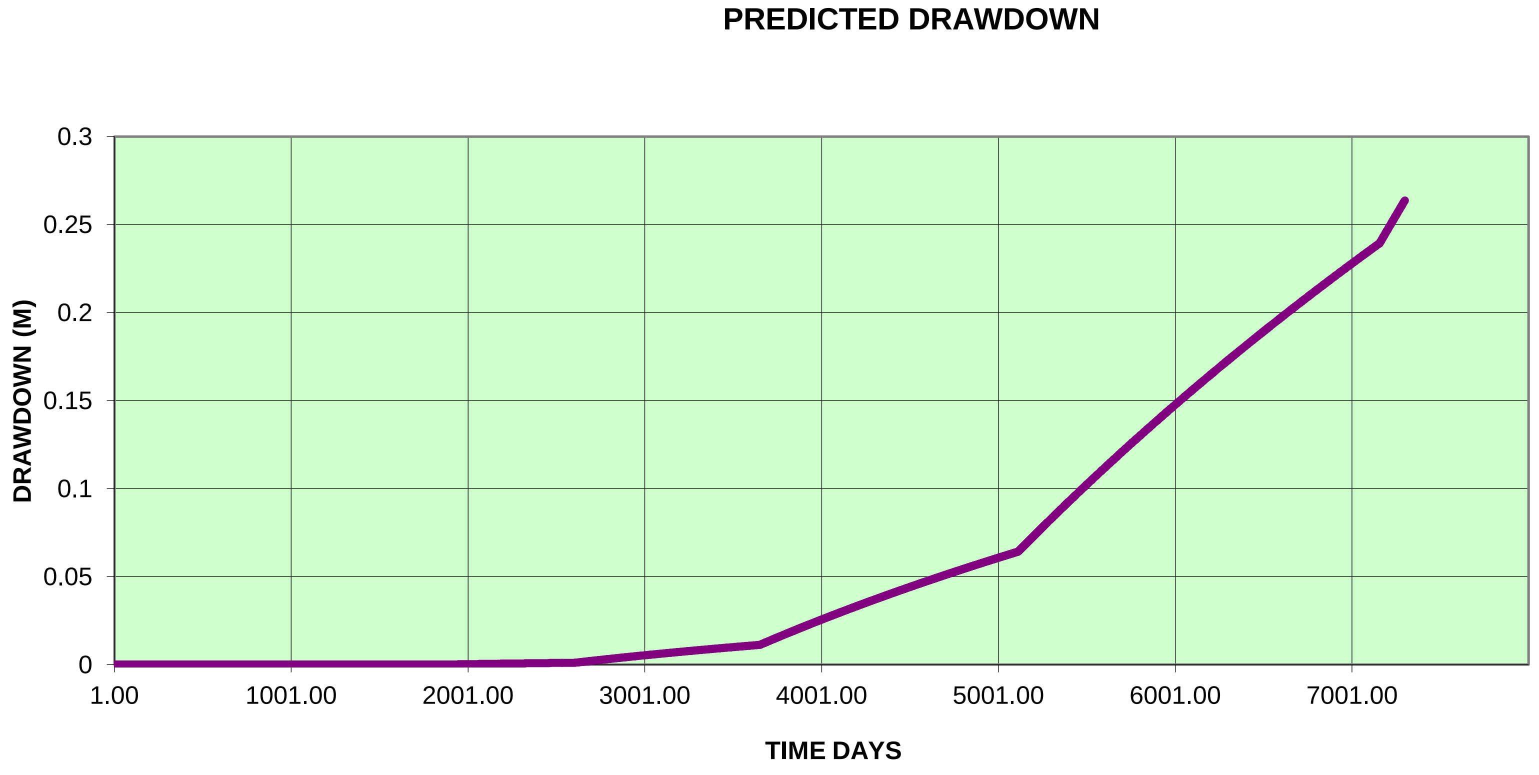


Equation used in prediction

$$s = \frac{Q(W(u))}{4\pi T} \qquad u = \frac{r^2 S}{4Tt}$$

s is drawdown, W(u) is the well function

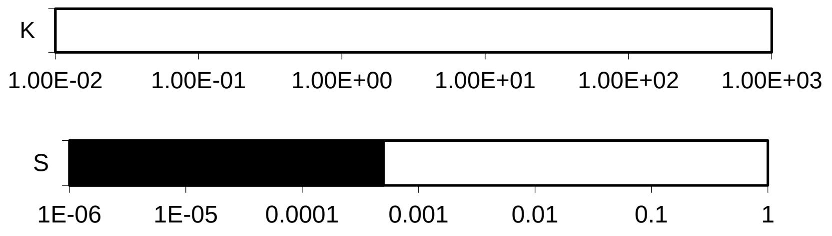




Drawdown Prediction for Confined Aquifers, Theis(1935)

Input Data for prediction of drawdown

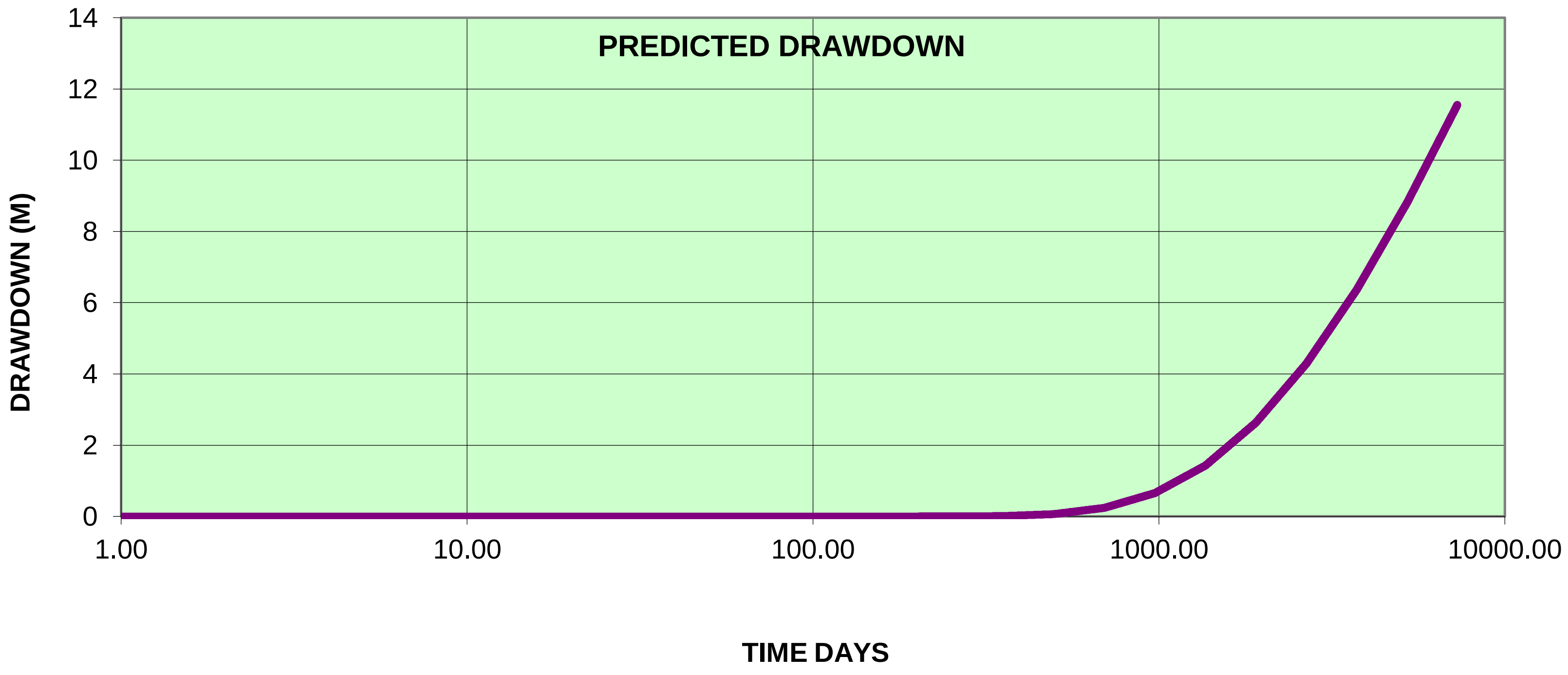
Phase	2
Hydraulic conductivity, K, m/day	6.82E-05
Aquifer Thickness, b, m	43
Storage Coefficient, S	0.0005
Pumping Rate, m^3/day	0.405182
Distance from well, m	206

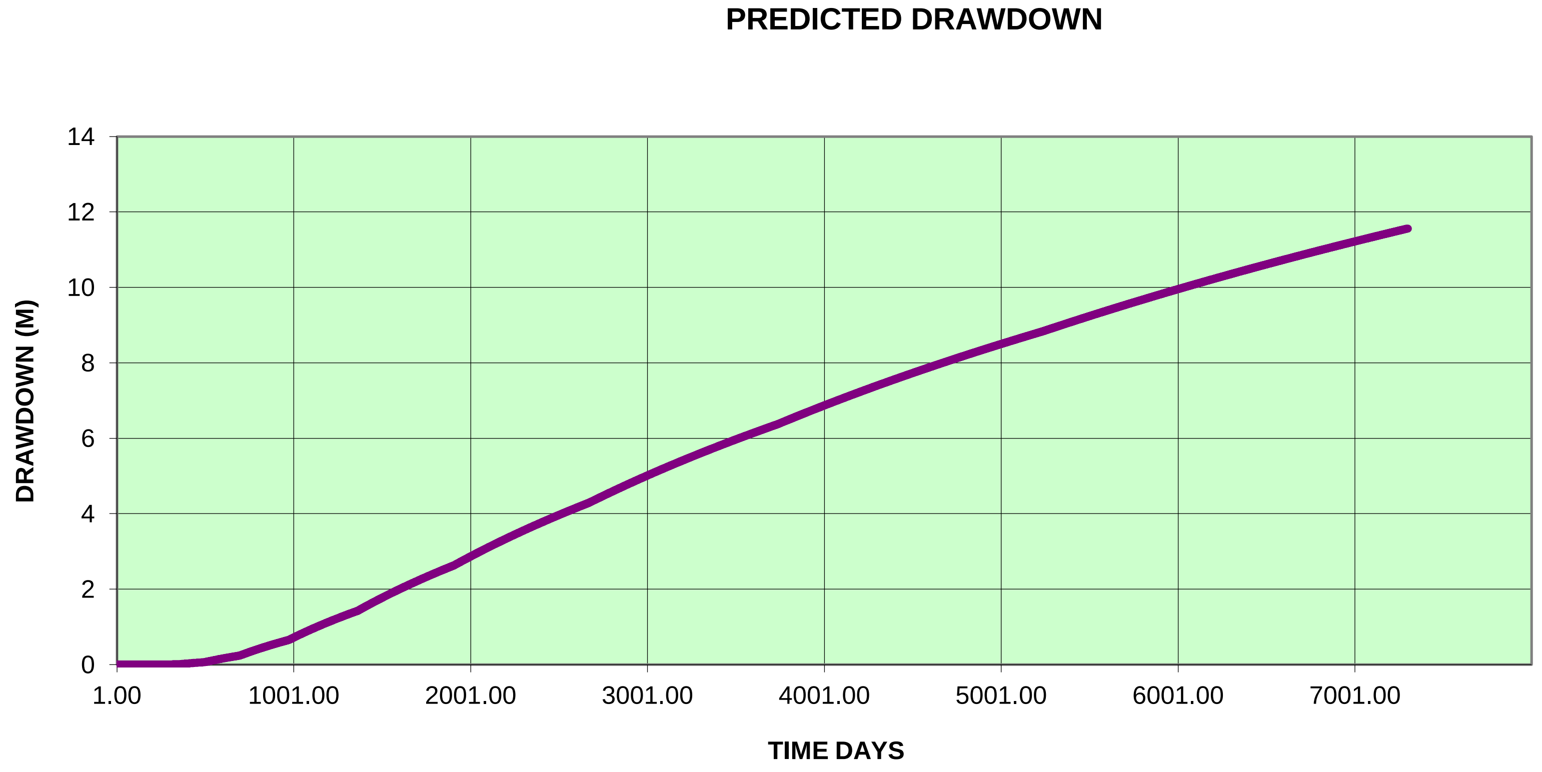


Equation used in prediction

$$s = \frac{Q(W(u))}{4\pi T} \qquad u = \frac{r^2 S}{4Tt}$$

s is drawdown, W(u) is the well function

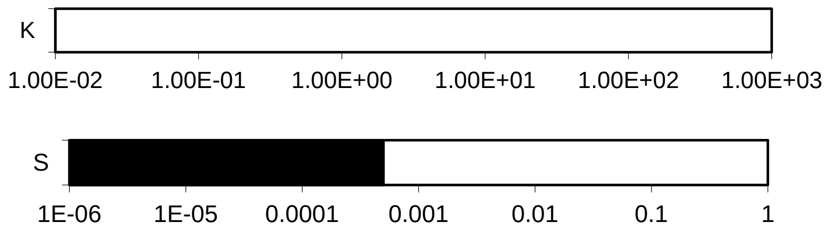




Drawdown Prediction for Confined Aquifers, Theis(1935)

Input Data for prediction of drawdown

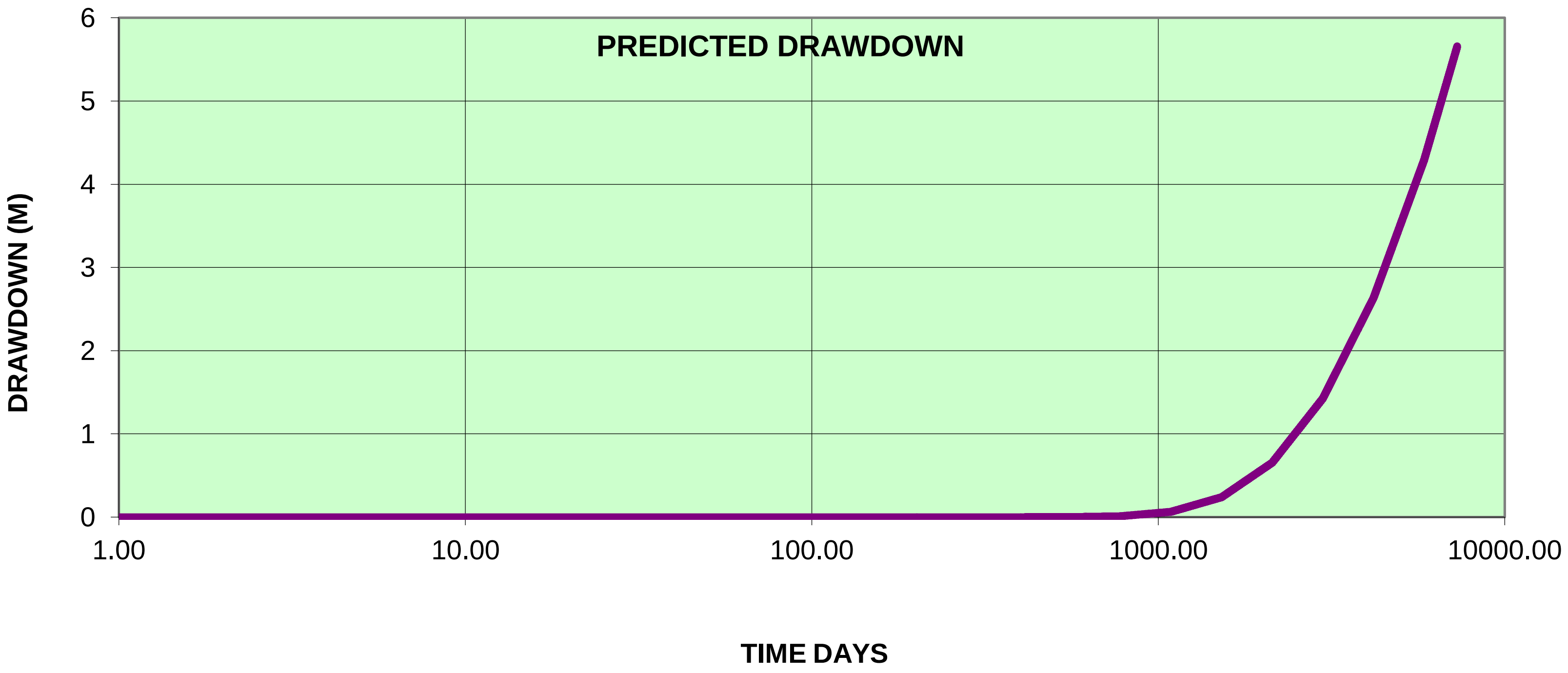
Phase	2
Hydraulic conductivity, K, m/day	6.82E-05
Aquifer Thickness, b, m	43
Storage Coefficient, S	0.0005
Pumping Rate, m^3/day	0.405182
Distance from well, m	305

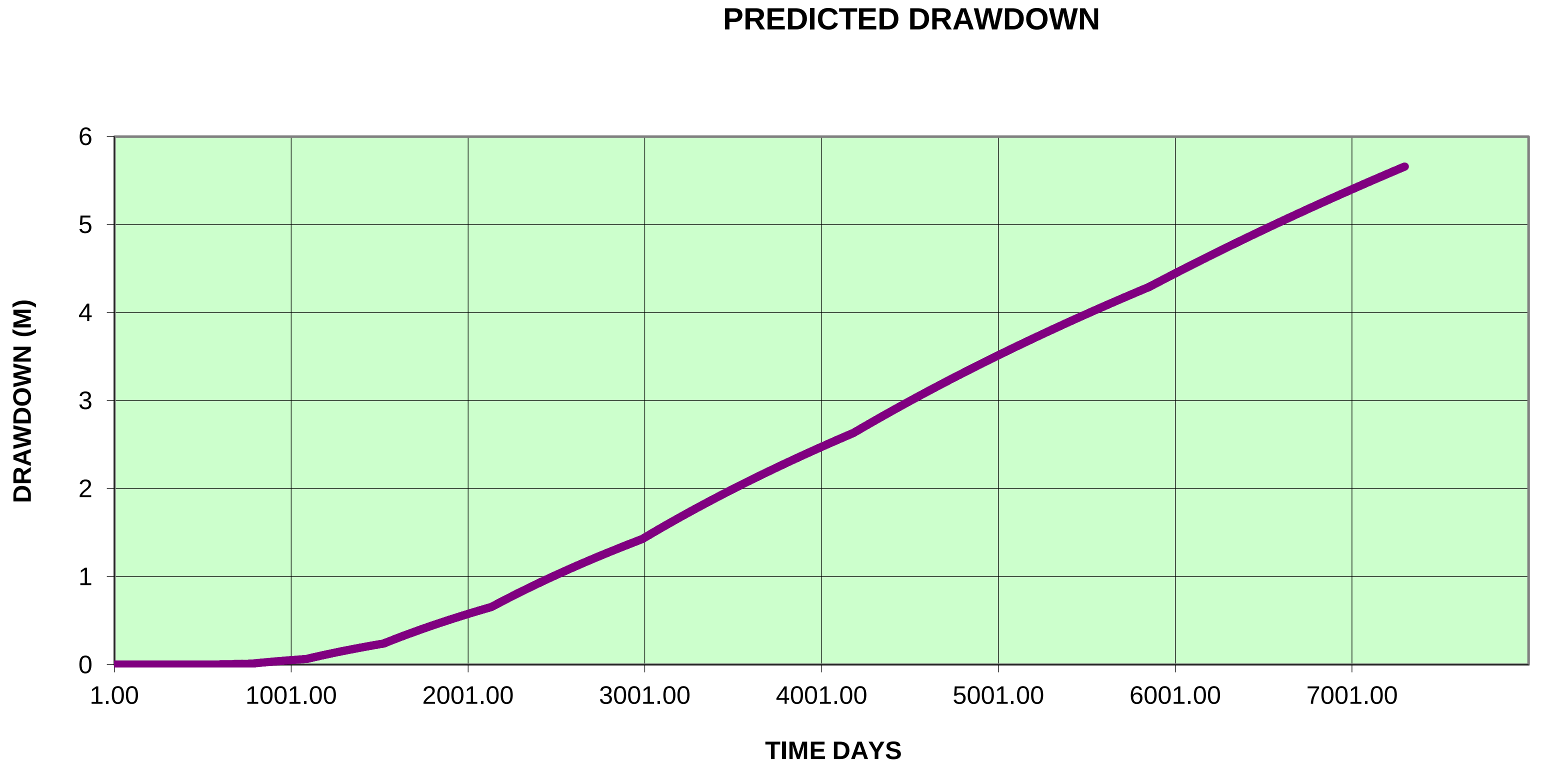


Equation used in prediction

$$s = \frac{Q(W(u))}{4\pi T} \qquad u = \frac{r^2 S}{4Tt}$$

s is drawdown, W(u) is the well function

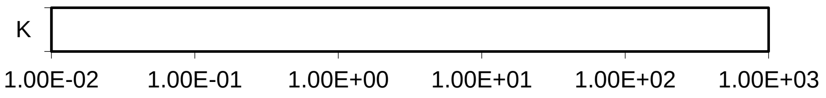




Drawdown Prediction for Confined Aquifers, Theis(1935)

Input Data for prediction of drawdown

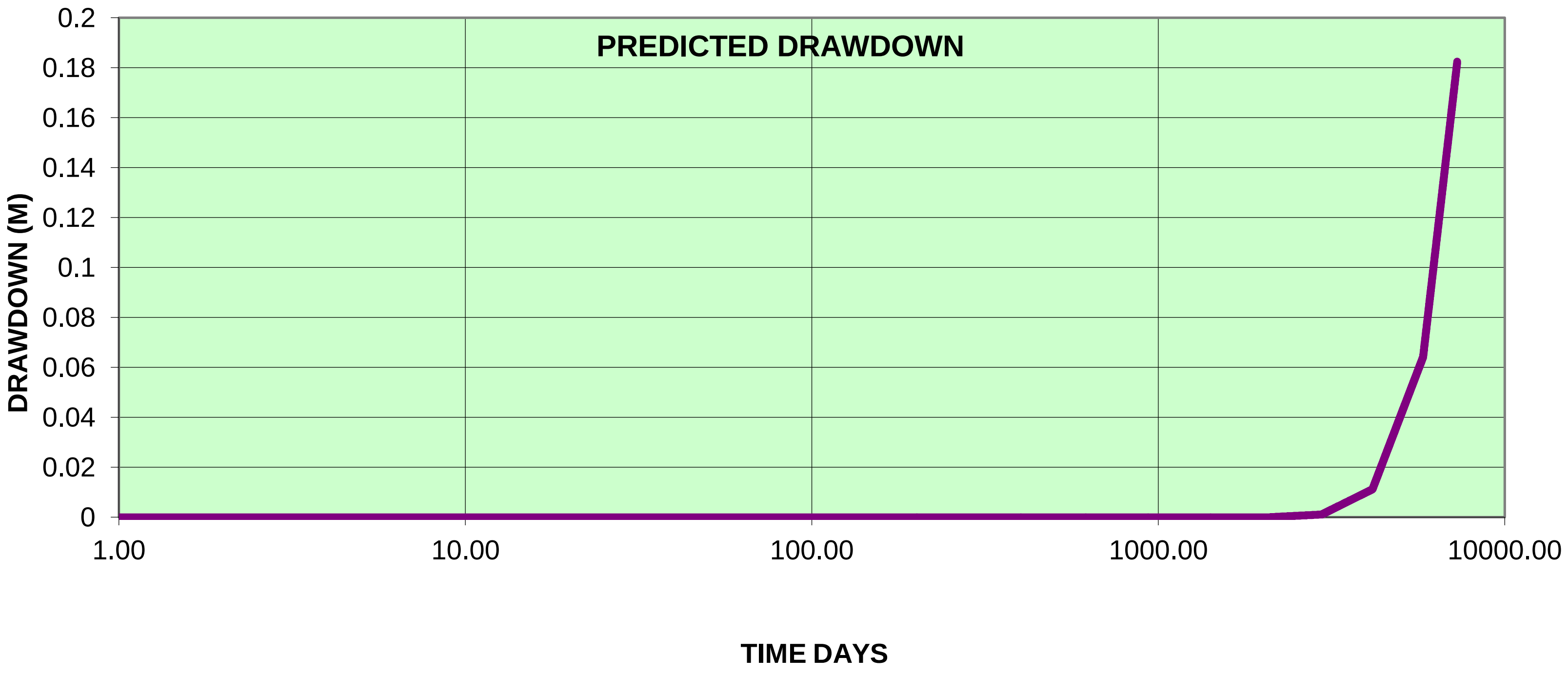
Phase	2
Hydraulic conductivity, K, m/day	6.82E-05
Aquifer Thickness, b, m	43
Storage Coefficient, S	0.0005
Pumping Rate, m^3/day	0.405182
Distance from well, m	705

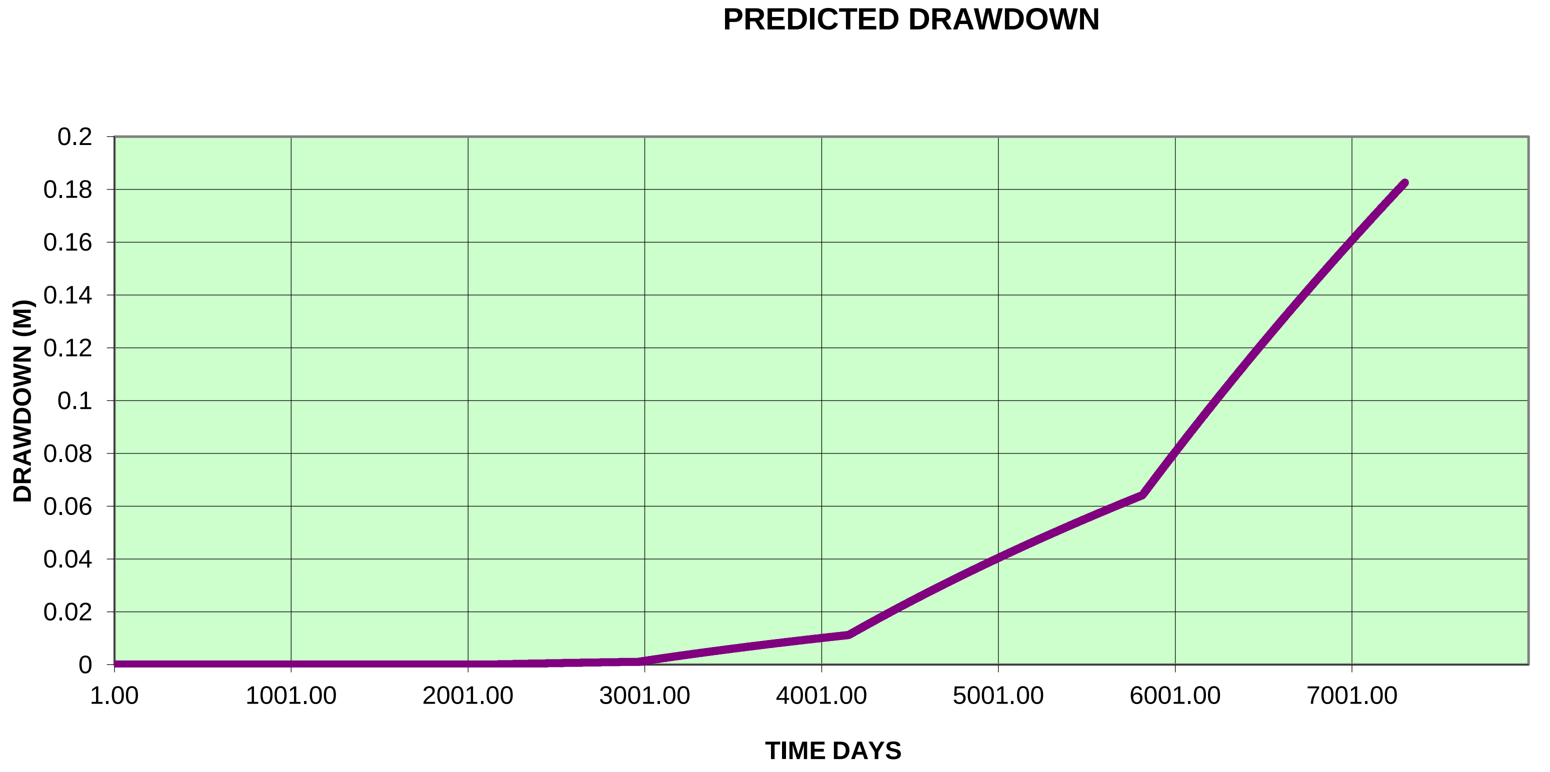


Equation used in prediction

$$s = \frac{Q(W(u))}{4\pi T} \qquad u = \frac{r^2 S}{4Tt}$$

s is drawdown, W(u) is the well function

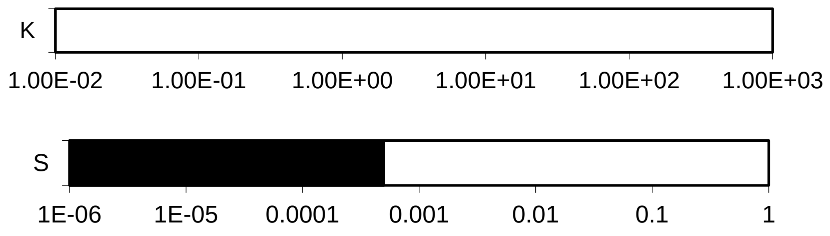




Drawdown Prediction for Confined Aquifers, Theis(1935)

Input Data for prediction of drawdown

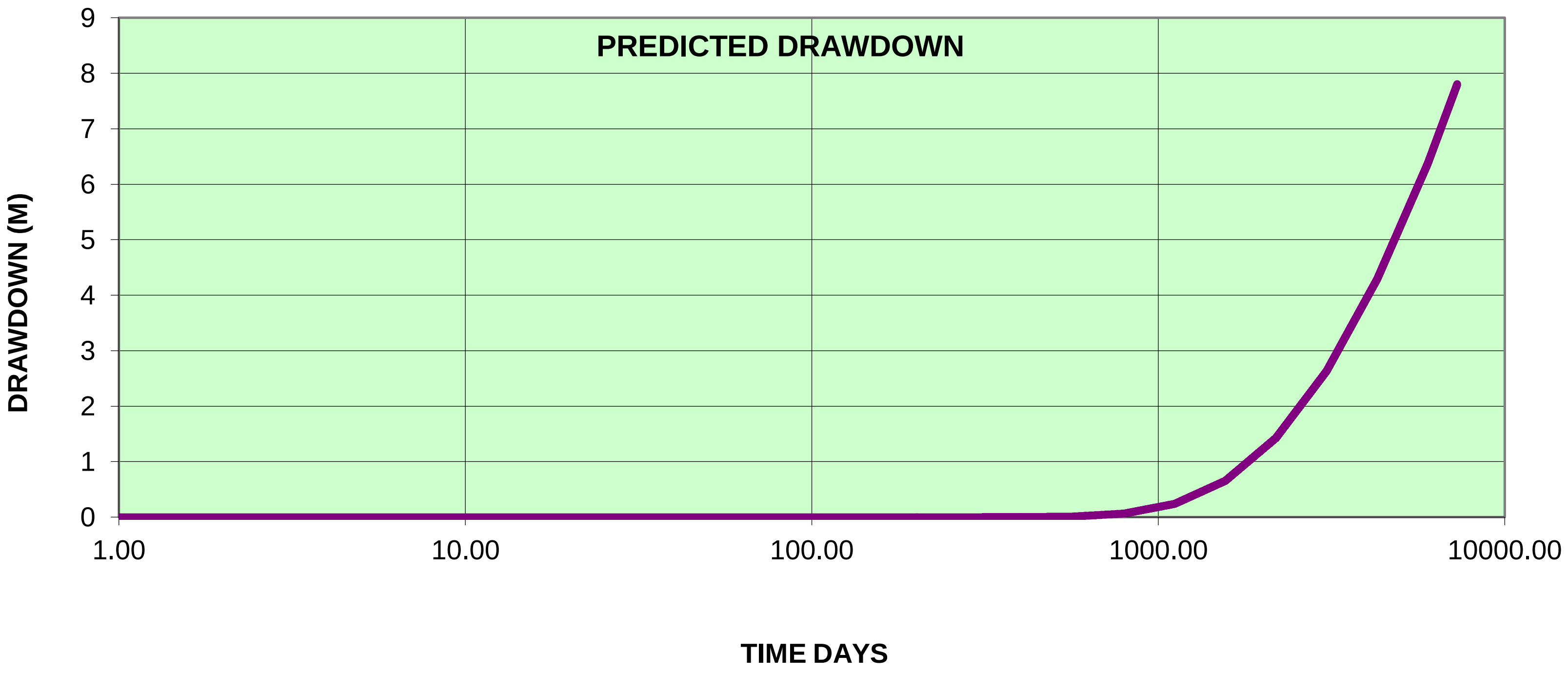
Phase	3
Hydraulic conductivity, K, m/day	6.82E-05
Aquifer Thickness, b, m	43
Storage Coefficient, S	0.0005
Pumping Rate, m^3/day	0.405182
Distance from well, m	261

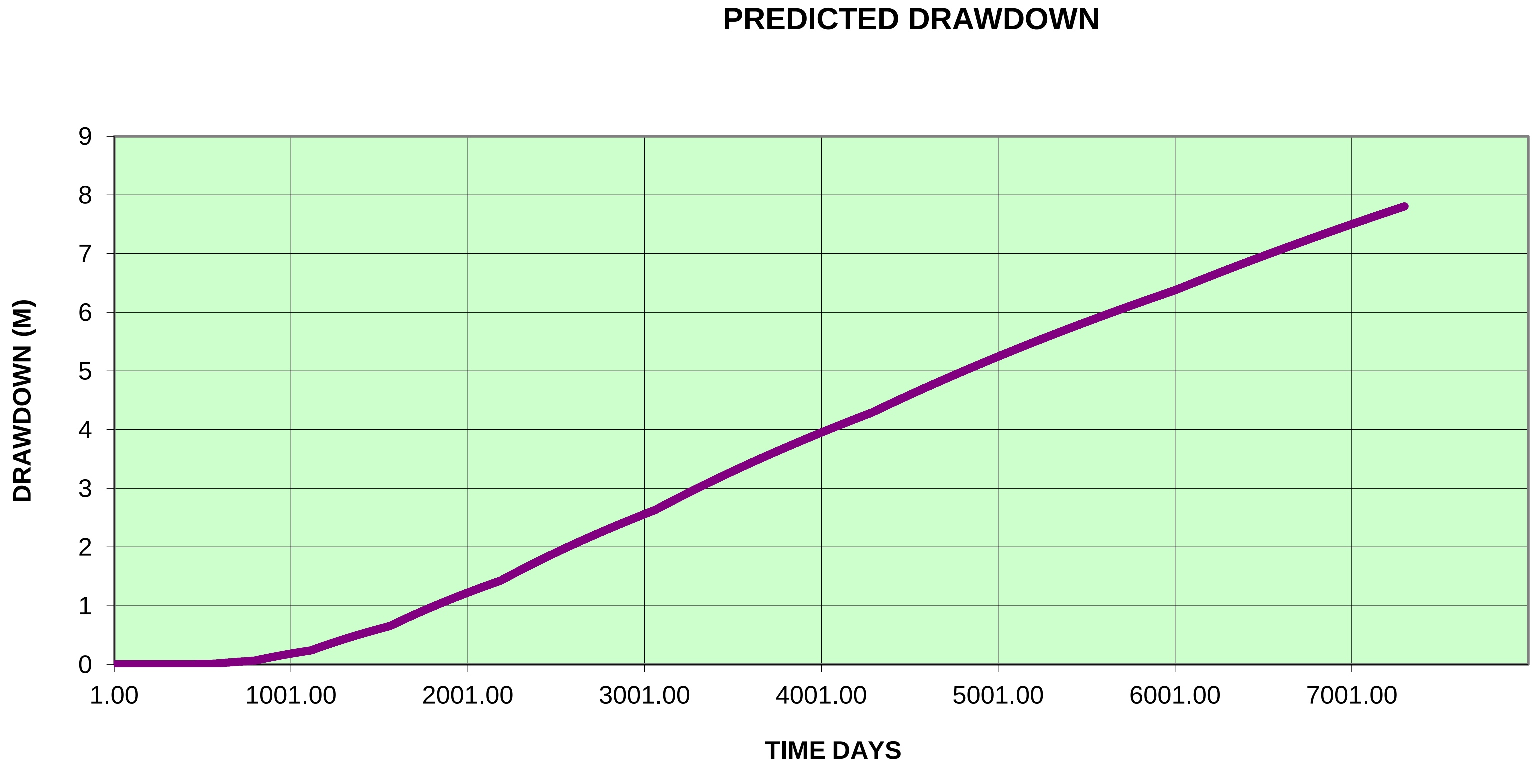


Equation used in prediction

$$s = \frac{Q(W(u))}{4\pi T} \qquad u = \frac{r^2 S}{4Tt}$$

s is drawdown, W(u) is the well function

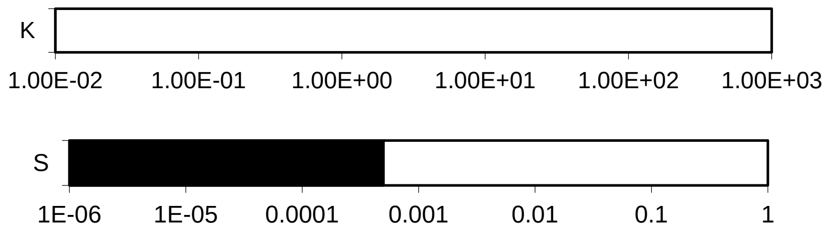




Drawdown Prediction for Confined Aquifers, Theis(1935)

Input Data for prediction of drawdown

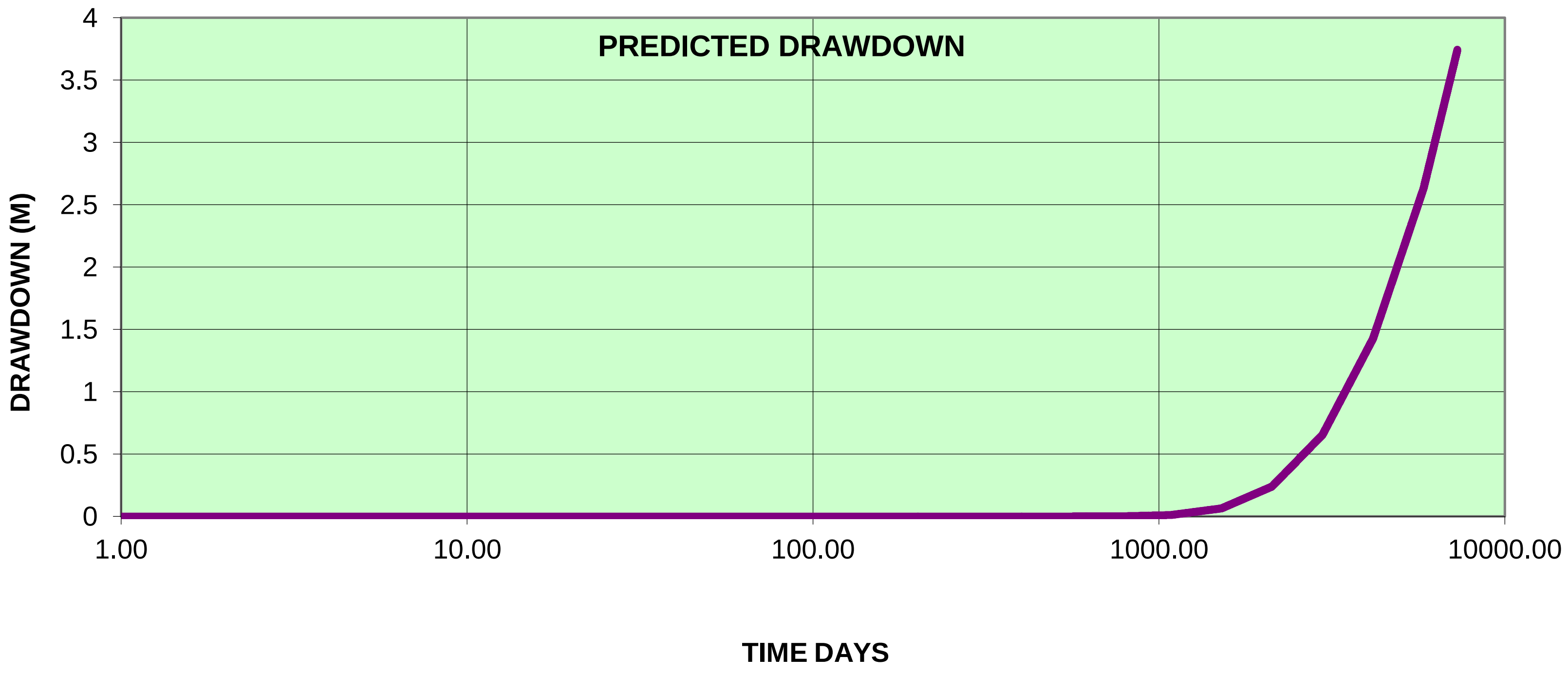
Phase	3
Hydraulic conductivity, K, m/day	6.82E-05
Aquifer Thickness, b, m	43
Storage Coefficient, S	0.0005
Pumping Rate, m^3/day	0.405182
Distance from well, m	360

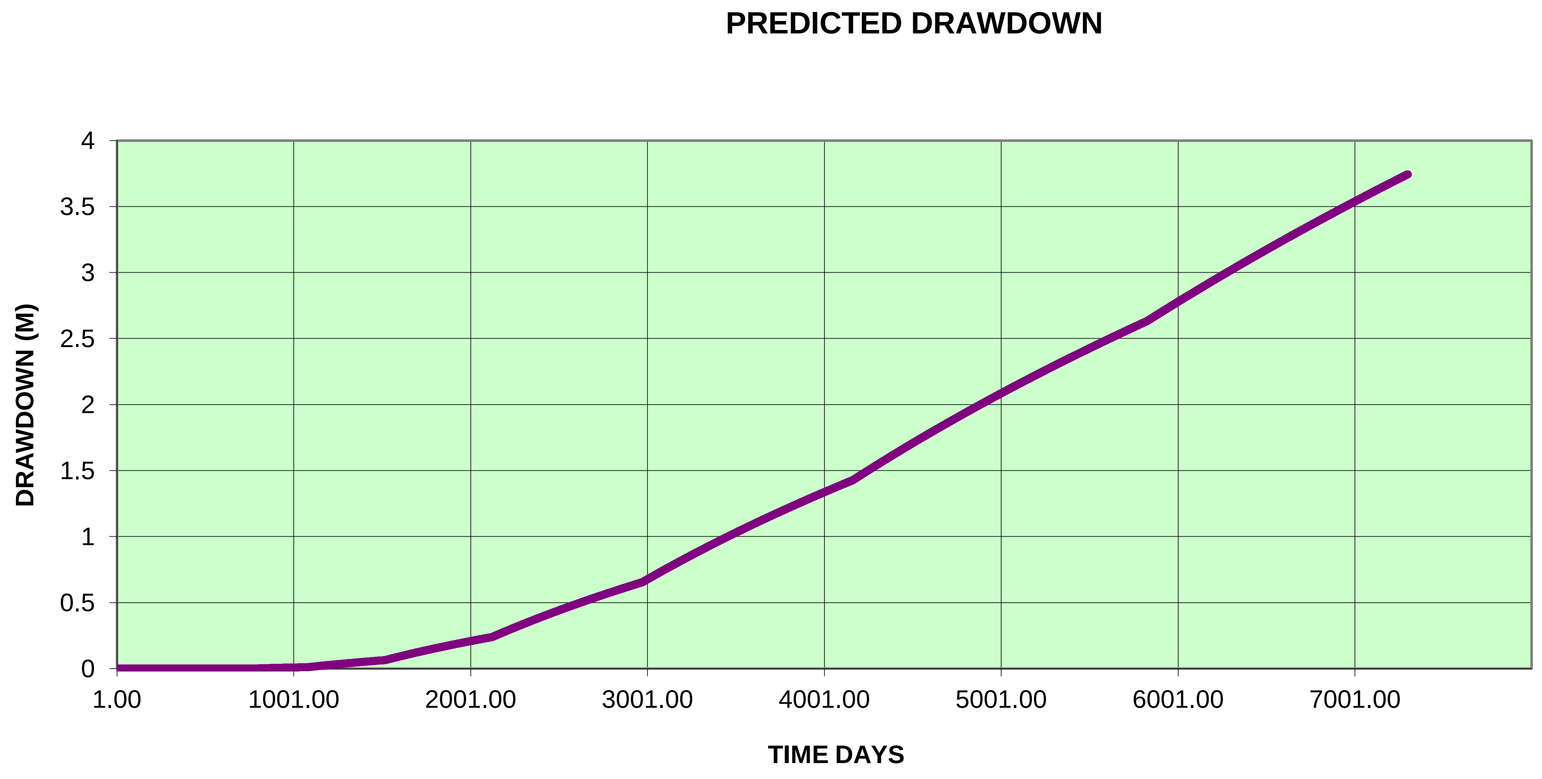


Equation used in prediction

$$s = \frac{Q(W(u))}{4\pi T} \qquad u = \frac{r^2 S}{4Tt}$$

s is drawdown, W(u) is the well function

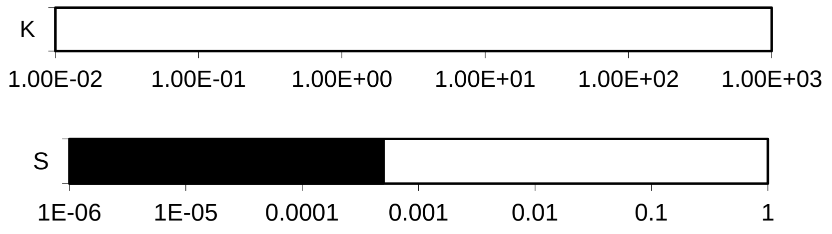




Drawdown Prediction for Confined Aquifers, Theis(1935)

Input Data for prediction of drawdown

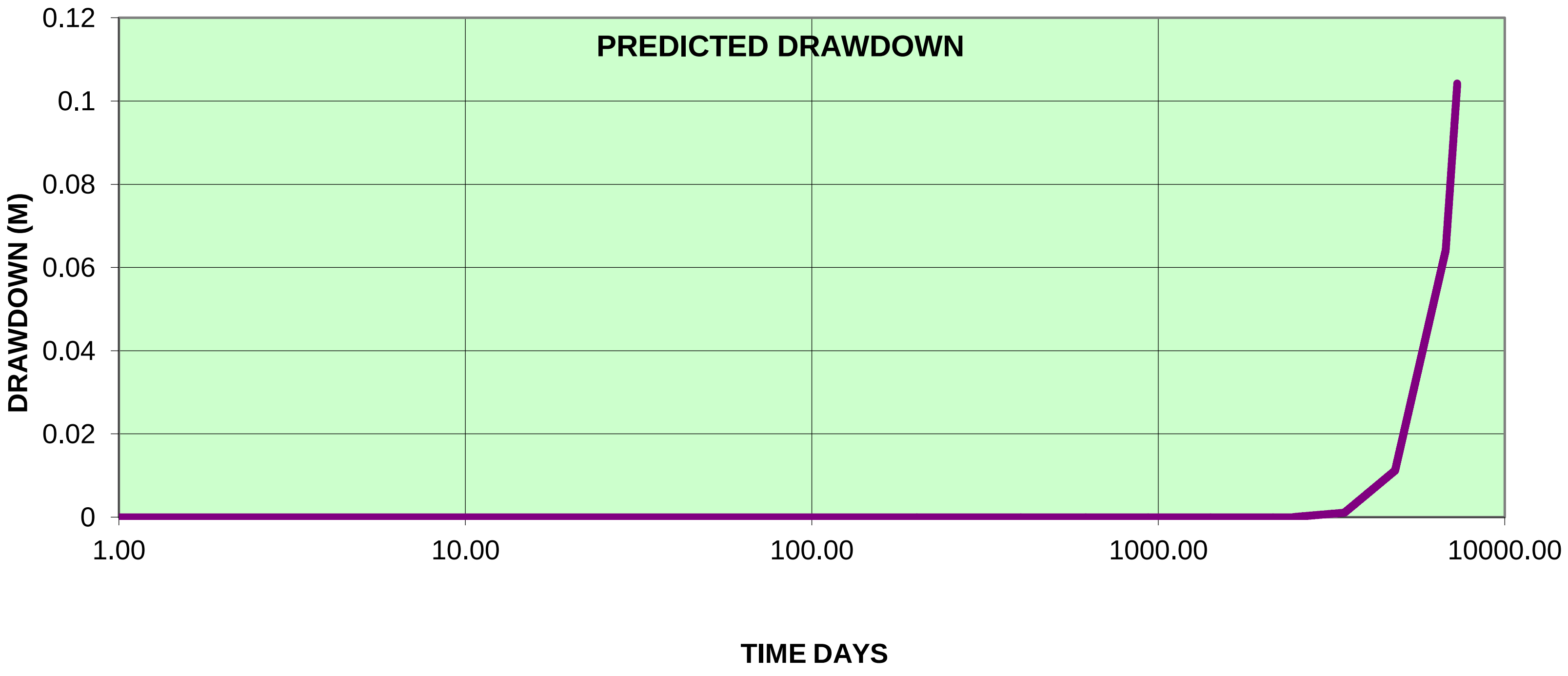
Phase	3
Hydraulic conductivity, K, m/day	6.82E-05
Aquifer Thickness, b, m	43
Storage Coefficient, S	0.0005
Pumping Rate, m^3/day	0.405182
Distance from well, m	760



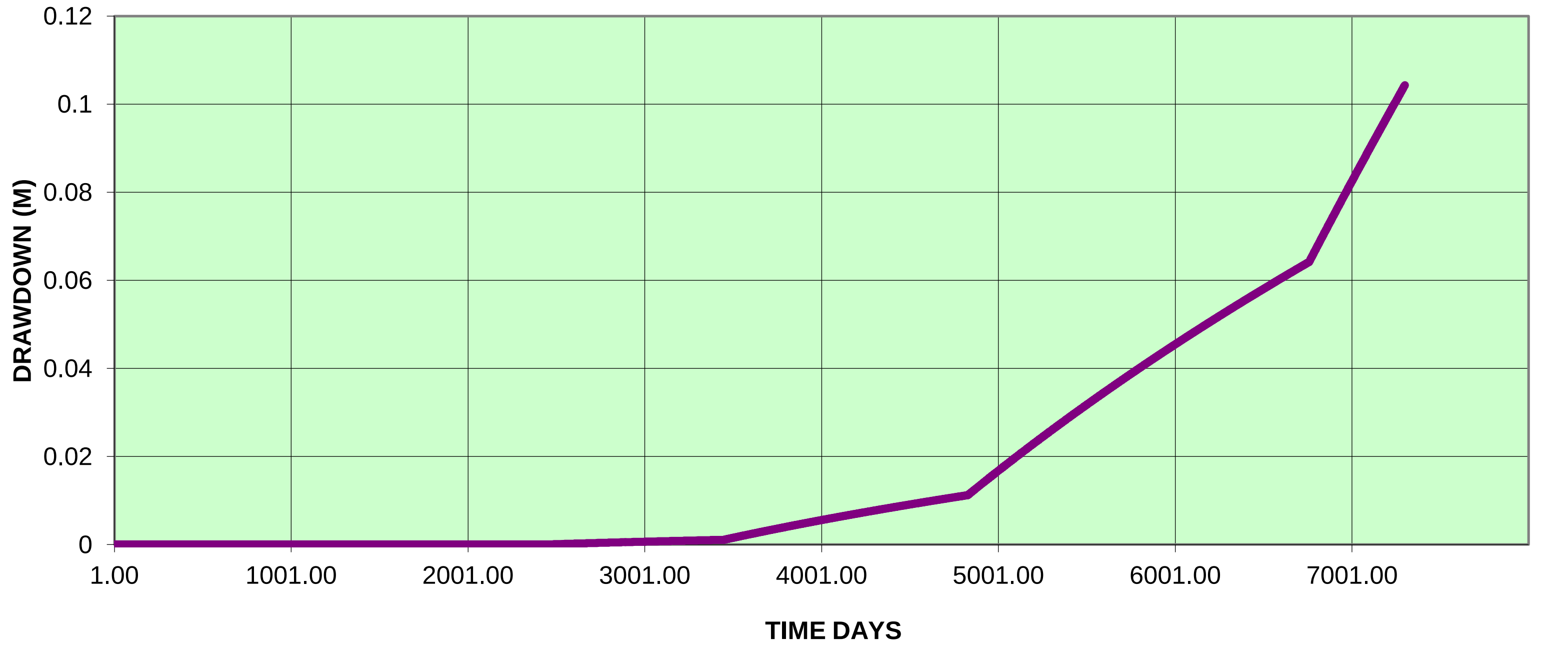
Equation used in prediction

$$s = \frac{Q(W(u))}{4\pi T} \qquad u = \frac{r^2 S}{4Tt}$$

s is drawdown, W(u) is the well function



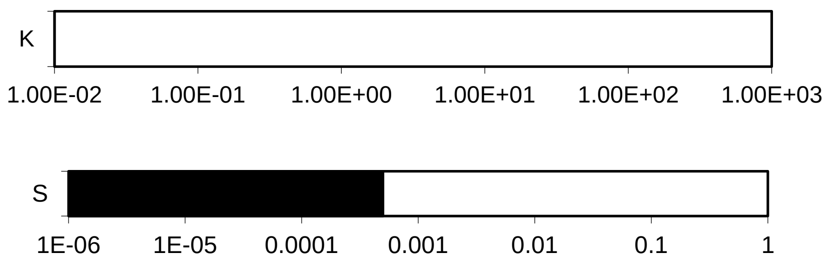
PREDICTED DRAWDOWN



Drawdown Prediction for Confined Aquifers, Theis(1935)

Input Data for prediction of drawdown

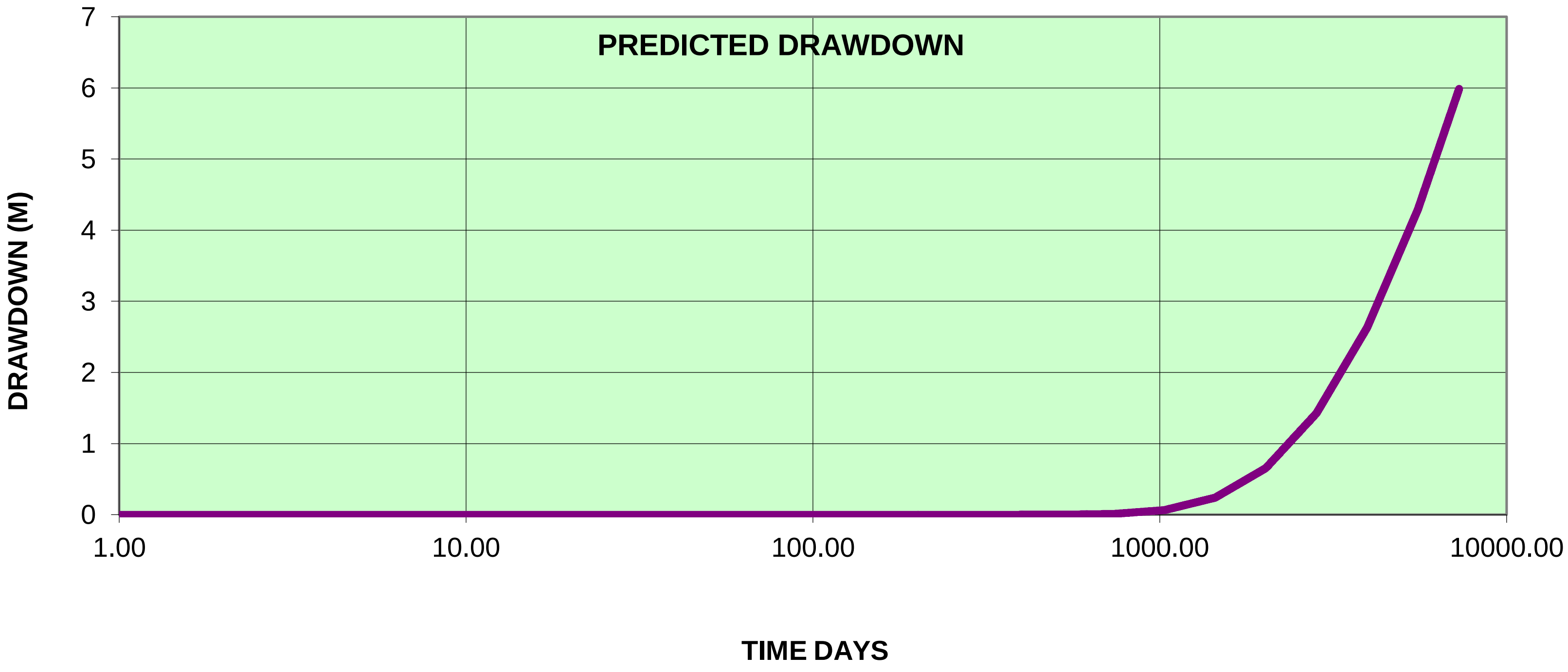
Phase	20 years following extraction
Hydraulic conductivity, K, m/day	6.82E-05
Aquifer Thickness, b, m	43
Storage Coefficient, S	0.0005
Pumping Rate, m^3/day	0.405
Distance from well, m	297

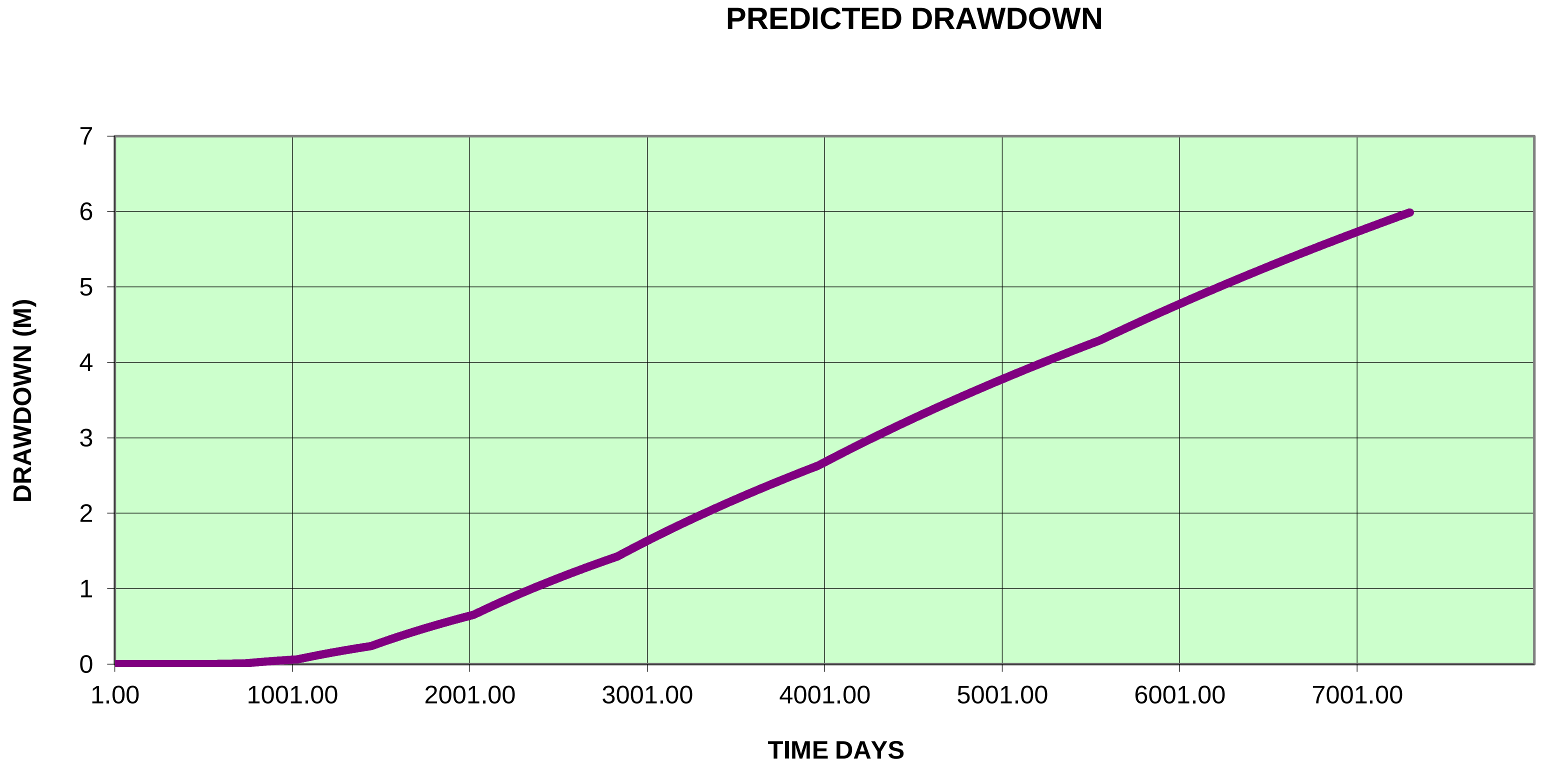


Equation used in prediction

$$s = \frac{Q(W(u))}{4\pi T} \qquad u = \frac{r^2 S}{4Tt}$$

s is drawdown, W(u) is the well function

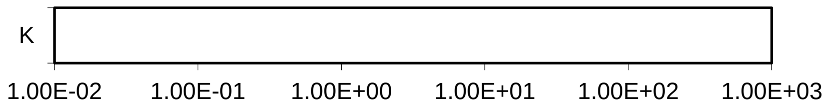




Drawdown Prediction for Confined Aquifers, Theis(1935)

Input Data for prediction of drawdown

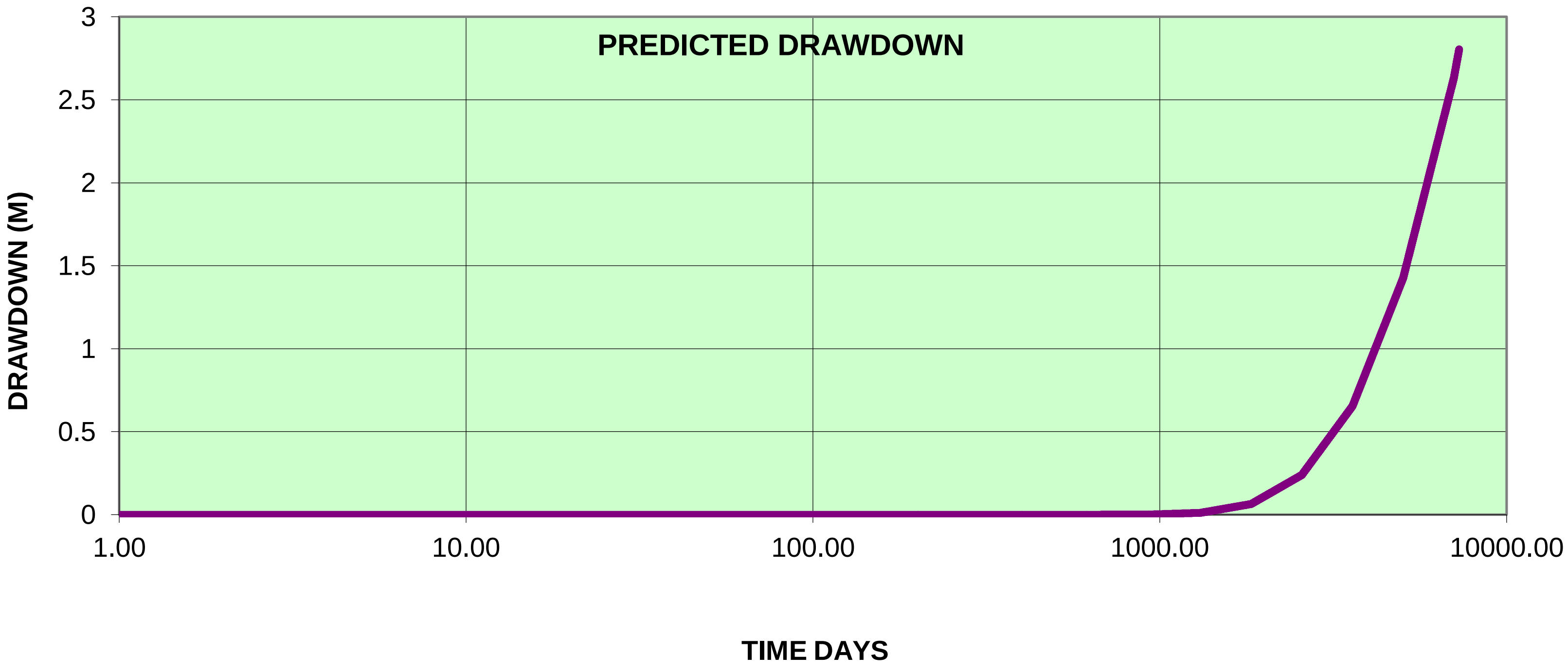
Phase	20 years following extraction
Hydraulic conductivity, K, m/day	6.82E-05
Aquifer Thickness, b, m	43
Storage Coefficient, S	0.0005
Pumping Rate, m^3/day	0.405
Distance from well, m	396

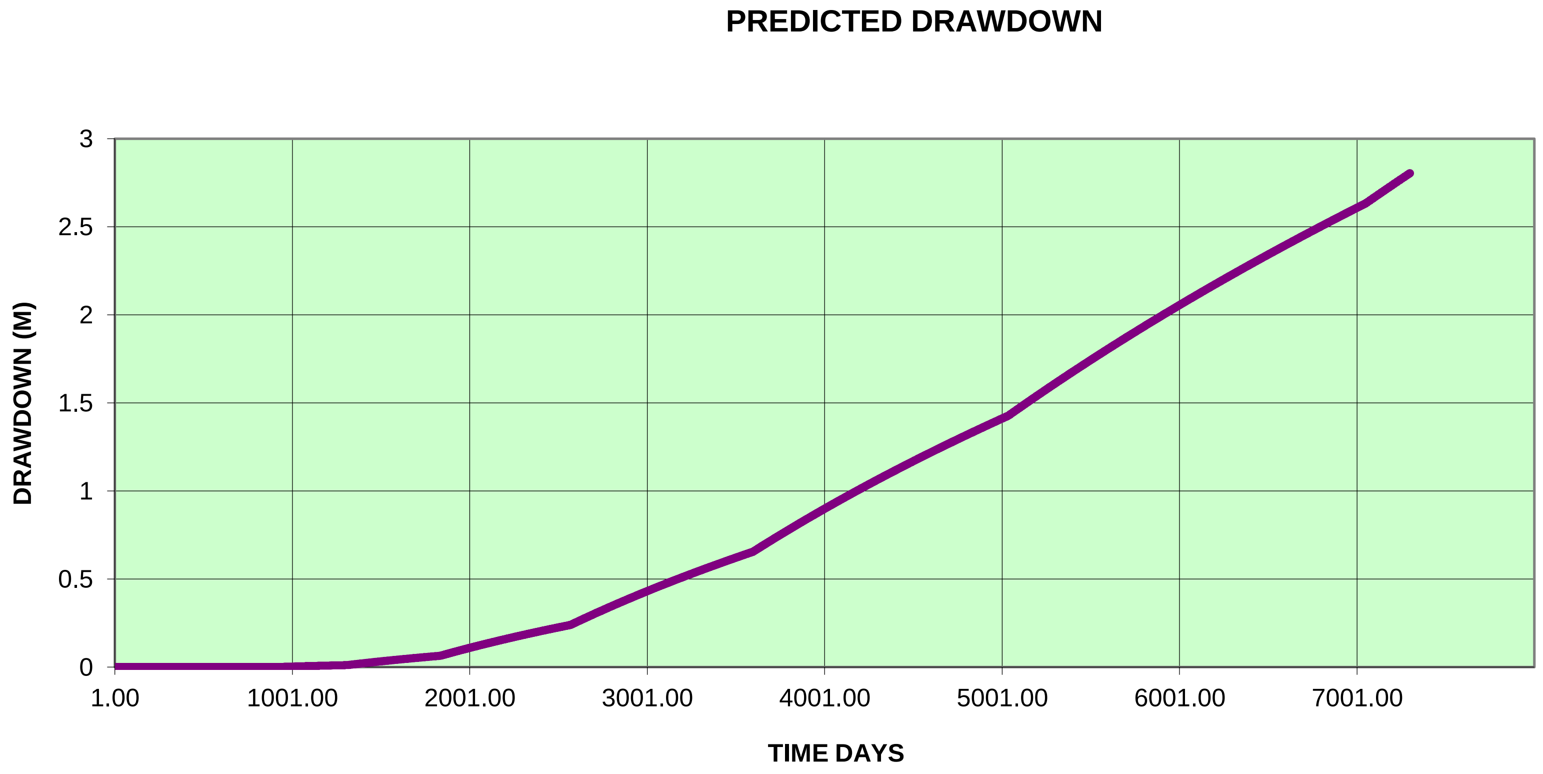


Equation used in prediction

$$s = \frac{Q(W(u))}{4\pi T} \qquad u = \frac{r^2 S}{4Tt}$$

s is drawdown, W(u) is the well function

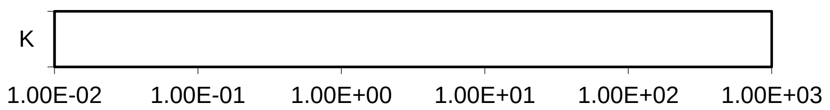




Drawdown Prediction for Confined Aquifers, Theis(1935)

Input Data for prediction of drawdown

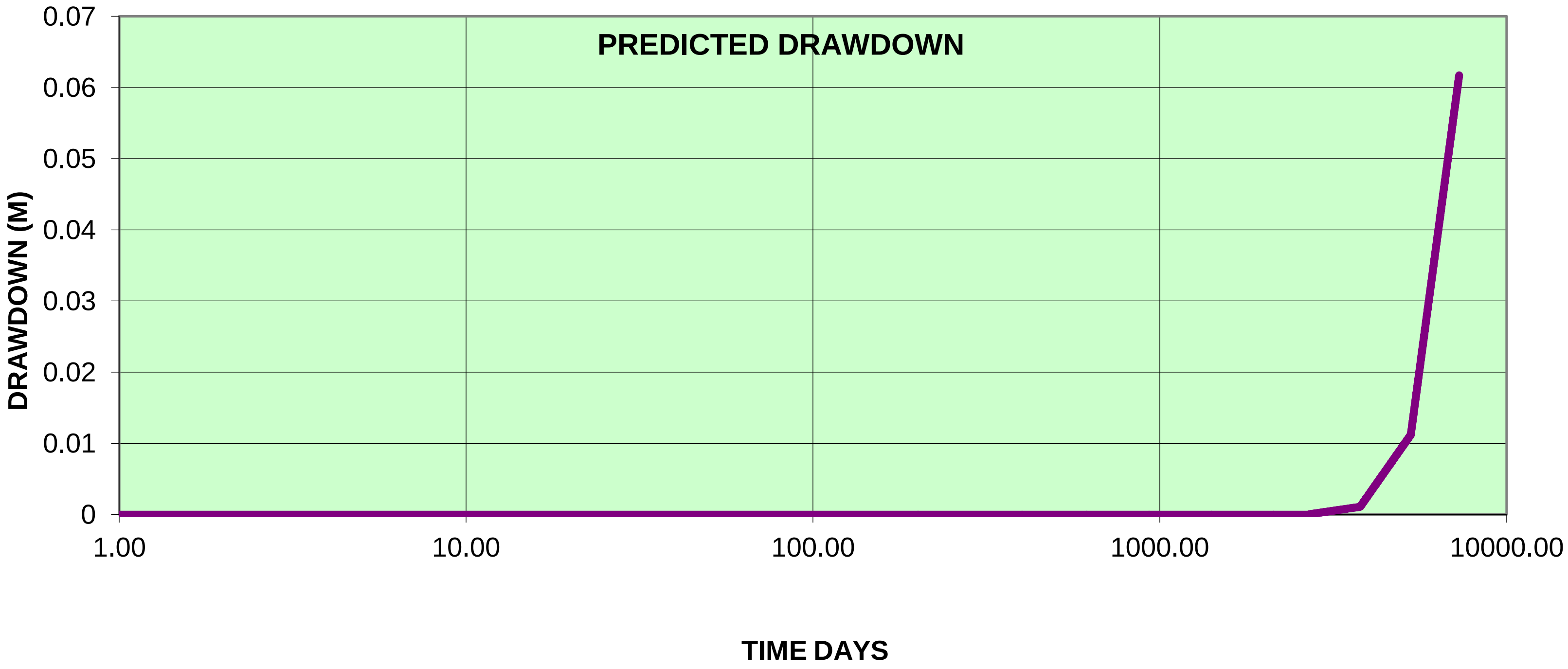
Phase	20 years following extraction
Hydraulic conductivity, K, m/day	6.82E-05
Aquifer Thickness, b, m	43
Storage Coefficient, S	0.0005
Pumping Rate, m^3/day	0.405
Distance from well, m	796

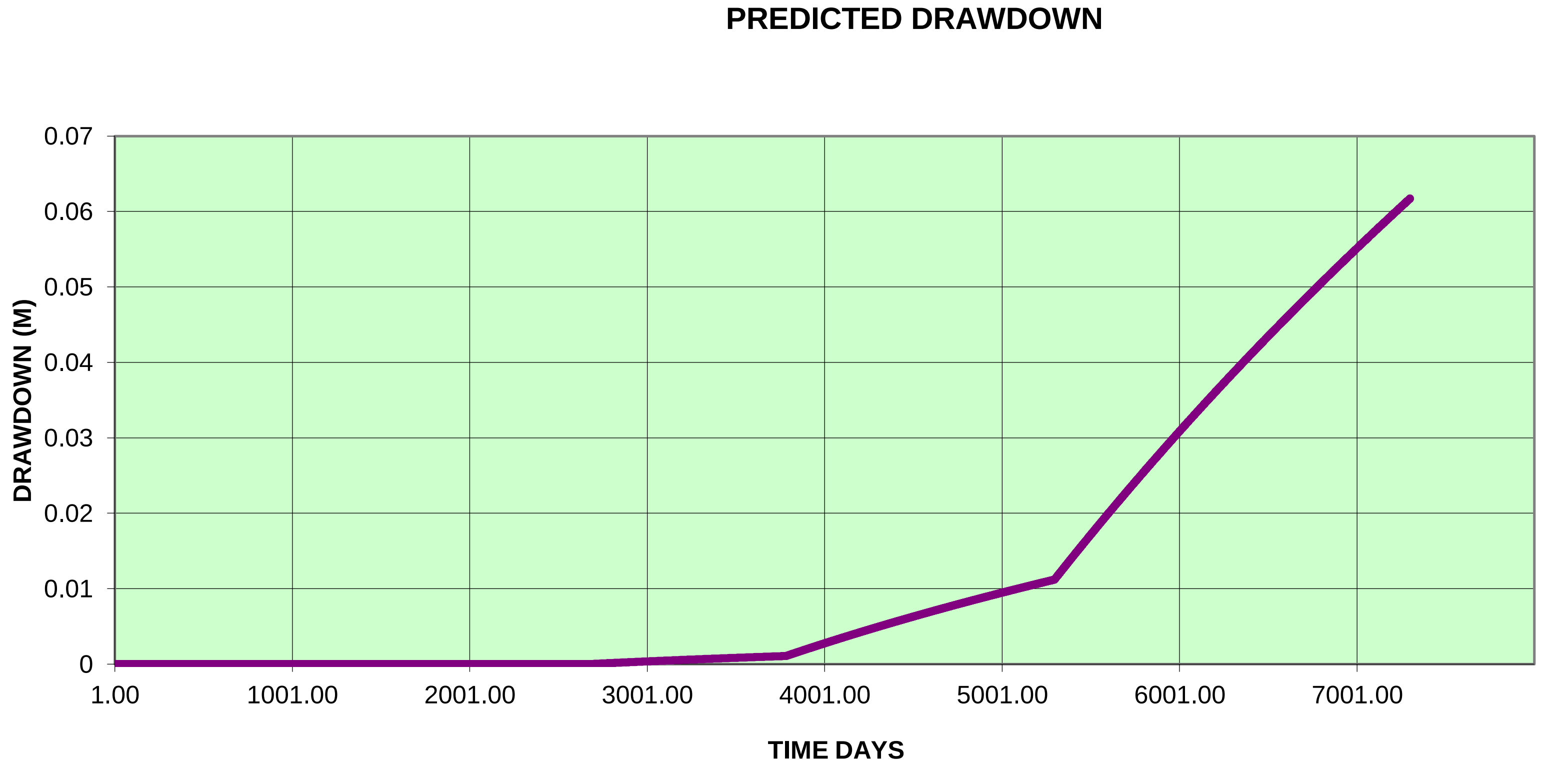


Equation used in prediction

$$s = \frac{Q(W(u))}{4\pi T} \qquad u = \frac{r^2 S}{4Tt}$$

s is drawdown, W(u) is the well function





APPENDIX H

CURRICULUM VITAS

Peter A. Gray, P.Geo., QP$_{ESA}$

Title: Vice President, Environmental
Role: Senior Hydrogeologist

Contact Peter

Professional Experience

Mr. Gray is a Vice President and Senior Hydrogeologist for MTE. He has over 28 years of experience on various types of projects ranging from international to domestic assignments, including groundwater, surface water, soil and contaminant investigations, to the exploration / development and protection of municipal groundwater and surface water supplies. He has been responsible for the design, construction, supervision and testing of municipal wells and assessing the impacts of various contaminants on groundwater and surface water resources. He is experienced with scoping, managing and reporting on large-scale groundwater developments, site assessment and contamination investigations. Mr. Gray has also completed risk communication training to assist in the transfer of sensitive and detailed technical knowledge to audiences including clients, peers, legal counsel and the general public including lay persons.

Mr. Gray is experienced in the start-up and operation of private businesses, including Frontline Environmental in 1995; and Wavefront Environmental, a University of Waterloo spinoff company in 2000. In 2007, Frontline merged with MTE. As a member of MTE's senior leadership team, Mr. Gray has extensive experience related to strategic planning, development and implementation of environmental services and operations.

Mr. Gray is one of the founding directors and is the volunteer president of the Children's Water Education Council (CWEC). This is a registered, non-profit charitable organization that in 1994 initiated the first Children's Groundwater Festival, since which more than 600,000 children have become educated about a wide variety of water-based issues and concepts. This year water festivals will be held in 27 communities across Ontario, educating more than 60,000 children annually.

Mr. Gray has worked across Canada and the United States, and has also assessed groundwater and surface water resources in Malawi, Bangladesh and Southeast Asia. He was the co-team leader in 2005 for a Canadian-led team conducting Community Based Environmental Assessments for the Southeast Asia Tsunami Response Team on behalf of World Vision Canada and the Canadian International Development Agency (CIDA) in the countries of Indonesia, Sri Lanka, Thailand and India.

Relevant Projects

Aggregate Resources

Ferma Aggregates | Carden Quarry | Hydrogeological Investigation | Kirkfield, ON | 2011 - 2012

This project involved an exploration well installation (cored holes) for the purpose of aggregate quality testing. The results of the cored holes were used in a geological evaluation for the purpose of assessing bedrock quality and quantity at the quarry. This project also included groundwater level and quality monitoring to comply with the aggregate license and the Environmental Compliance Approval needed to discharge water back into the natural environment. Annual compliance reports are submitted to the Ministry of Natural Resources and MOE to demonstrate the impact of the quarry on surface and groundwater resources.

Education

Bachelor of Science (Honours Co-op Earth Sciences) | University of Waterloo | 1987

Professional Designations

Professional Geoscientist (P.Geo.) | Association of Professional Geoscientists of Ontario (APGO)

Qualified Person for Environmental Site Assessment (QP$_{ESA}$) | O. Reg. 153/04 | Ministry of the Environment

Professional Development

Advanced Wilderness First Aid | Stonehearth Open Learning Opportunities (SOLO) | 2013

Training for Property Entry per Section 88 of Clean Water Act | Ministry of the Environment | 2008

Assessment Report Technical Training-Drinking Water Source Protection | Ministry of the Environment | 2008

Peter A. Gray, P.Geo., QP$_{\text{ESA}}$

Title: Vice President, Environmental
Role: Senior Hydrogeologist

Contact Peter

Memberships

National Ground Water Association: Association of Groundwater Scientists and Engineers | Since 1993

International Association of Hydrogeologists (IAH) | Since 1995

Canadian Council of Professional Geoscientists (CCPG) | Since 2002

American Association of Petroleum Geologists (AAPG), Division of Environmental Geosciences | Since 2011

Community Involvement

Current President | Children's Water Education Council | Since 2001

Dean's Council | Environmental Studies Faculty | University of Waterloo | 2002 – 2010

Board of Directors | Earth Sciences Museum | University of Waterloo | Since 2006

Water Forum Committee | Grand River Conservation Authority | 2000 – 2010

Advisory Council, Past Co-Chair Environmental Studies Faculty | University of Waterloo | 2000 – 2010

Fowler Construction Company | Fleming Quarry | Surface & Groundwater Studies | Washago, ON | 2010 - Present

This project required the completion of a Hydrogeological Investigation to support an application for a quarry below the water table. This project included drilling and installation of eight onsite bedrock water wells and two wetland monitoring stations. Mr. Gray was responsible for overseeing the technical reports that were required for the assessment of potential impacts to surface water and groundwater resources from quarrying activities as required to obtain a Permit to Take Water and a Certificate of Approval for quarry dewatering.

Harold Sutherland Construction | Keppel Quarry | Hydrogeological Investigation | Keppel, ON | 2006 - Present

These Level 1 and Level 2 Hydrogeological Investigations supported an application for a quarry expansion and assessed the risk to groundwater and surface water resources as a result of the expansion. First Nations consultation began during the Stage 1 investigation, and continued through the Stage 2 investigation up to and including the Ontario Municipal Board and Environmental Review Tribunal hearings. From this investigation, an Adaptive Management Plan was developed allowing for strategic decision making with respect to quarry operations so that potential impacts to the natural environment can be fully assessed and mitigated prior to any adverse impact. Before the Adaptive Management Plan was developed the Hydrogeological Investigation was peer reviewed by several professional hydrogeologists including those at the Ministry of Natural Resources, MOE, and the Niagara Escarpment Commission.

Severn Aggregates | Cumberland Quarry | Hydrogeological Investigation | Township of Severn, ON | 2007 - Present

MTE conducted a regional-scale groundwater assessment (Level 1 and Level 2 Hydrogeological Investigation) in support of an application for a quarry below the water table. This project includes a drainage basin analysis for the purpose of identifying groundwater and surface water interactions. The drainage basin analysis involves the assessment of baseflow condition of onsite creeks, as well as the completion of water budget calculations. Groundwater levels and quality monitoring as well as hydrological monitoring (stream flow) is being done on the site to track long-term fluctuation over time. This information is being inputted into a database used for the development of a numerical groundwater model using FEFLOW 6.0. The purpose of the numerical model will be to assess the potential impacts of the quarry on surface water and groundwater resources and their uses as the quarry develops.

Environmental Site Assessment & Technical Review

Various Projects | Phase I / One & II / Two Environmental Site Assessment (ESA) | Various Locations | 1995 - Present

Since 1995 Mr. Gray has served in the capacity of Senior Hydrogeologist for Frontline / MTE. He has undertaken, internally reviewed and peer reviewed hundreds of Phase I / One and II / Two ESAs, along with Remedial Action Plans, Environmental Compliance Audits and Environmental Site Restoration Plans. Mr. Gray has served as QP$_{\text{ESA}}$ for a number of Ontario Ministry of the Environment (MOE) orders issued to clients, and has served as QP$_{\text{ESA}}$ as a Vendor Of Record with the current MOE Consulting Services for Expert Multi-Disciplinary Scientific Reviews of Brownfield Sites.

Peter A. Gray, P.Geo., QP_{ESA}

Title: Vice President, Environmental
Role: Senior Hydrogeologist

Contact Peter

Awards

Nominee | Volunteer of the Year | Cambridge Chamber of Commerce | 2015

June Callwood Outstanding Achievement Award for Volunteerism in Ontario | Ontario Ministry of Citizenship, Immigration and International Trade | 2015

20-Year Service Ontario Volunteer Award | For Waterloo Wellington Children's Groundwater Festival Chair | Ontario Ministry of Citizenship, Immigration and International Trade, Ontario Volunteer Service Awards | 2015

Volunteer Impact Award, Shining Stars: Planning Action Award | Volunteer Action Centre of Kitchener-Waterloo and Area | 2013

Heritage Community Recognition Award for Lifetime Achievement | Ontario Heritage Trust | 2012

American Association of Petroleum Geologists (AAPG): Division of Environmental Geosciences Public Outreach Award | Houston, TX | 2011

15-Year Service Ontario Volunteer Award | For Waterloo Wellington Children's Groundwater Festival Chair | Ontario Ministry of Citizenship and Immigration, Ontario Volunteer Awards | 2011

Faculty of Science, Alumni Award of Honour | University of Waterloo 50th Anniversary Awards | 2007

Canadian General-Tower | Phase II Environmental Site Assessment & Remediation Plan | Cambridge, ON | 1994 - Present

Mr. Gray is responsible for the review and reporting on data collection, data analysis, environmental characterization, statistical and computer modelling, and report preparation, presentations at public meetings and coordination of regulatory approvals. Additional services includes drilling supervision, packer testing, design and monitoring well installation in dolostone bedrock formations and overburden environments, geologic core logging, review / analysis of packer test results, geophysical log / borehole video log response to assist in interpretation of bedrock geologic / hydrogeologic environment. Further, design, construction and testing of groundwater control / free-product contamination recovery wells and municipal production wells, design, coordination and supervision of pumping tests, supervision of staff / sub-contractor adherence to health and safety protocols.

City of Kitchener | Bramm Street Works Yard | Phase II Environmental Site Assessment & Remediation Plan | Kitchener, ON | 2005 - Present

Mr. Gray was the Senior Hydrogeologist for a comprehensive Phase II ESA for the City of Kitchener. The project involved investigating past land uses of the property as a landfill. The workplan included the installation of 11 boreholes and 15 monitoring wells to investigate potential areas of concern and to develop a remedial action plan. Contaminates of concern included PAHs, petroleum hydrocarbons, VOCs, lead, arsenic, sodium adsorption ratio, electrical conductivity, and antimony in cinders, ash, native soil and groundwater. The remediation plan identified volumes of impacted soil and the recommendation of a scoped Site-Specific Risk Assessment and partial intrusive remediation of the site in designated areas of environmental impacts.

Brownfield Redevelopment | Systems Engineering Approaches | Waterloo, ON | 2006 - 2011

Mr. Gray has served as an advisor to the University of Waterloo, Engineering Faculty, Department of Systems Design Engineering for a NSERC Strategic-funded project called Systems Engineering Approaches for Brownfield Redevelopment. Mr. Gray contributed to and reviewed the work being undertaken at the University, as evidenced by his participation as an author on several papers or presentations documenting the outcomes of this leading edge research on brownfield redevelopment.

City of Kitchener | Joseph & Gaukel Streets | Coal Tar Remediation | Kitchener, ON | 2005 – Present

Mr. Gray was the Senior Hydrogeologist during the $29-million coal tar remediation as part of a municipal road reconstruction project. The site is the location of a historic coal gasification plant and resulted in extensive coal tar impacts to soil and groundwater. He was responsible for the completion of Phase I and II Environmental Site Assessments, remediation and Risk Assessment.

Former CP Rail Site | Brownfield Redevelopment | Environmental Investigations | Port McNicoll, ON | 2000 – Present

Mr. Gray was the Senior Hydrogeologist for the project that included Phase I, Phase II and Phase III Environmental Site Assessments, and a Record of Site Condition (RSC).

Peter A. Gray, P.Geo., QP_{ESA}

Title: Vice President, Environmental
Role: Senior Hydrogeologist

Contact Peter

Awards

25th Anniversary Provincial Award | For "Just Add Water", Children's Water Education Council (CWEC) President | Ontario Trillium Foundation | 2007

10-Year Service Ontario Volunteer Award | For Waterloo Wellington Children's Groundwater Festival Chair | Ontario Ministry of Citizenship and Immigration, Ontario Volunteer Awards | 2006

2005 Environmental Education Award | For "Just Add Water", a combined Ontario Water Works Association (OWWA) / Children's Water Education Council (CWEC) program sponsored by The Ontario Trillium Foundation, CWEC President | AWWA /OWWA | 2005

Community Recognition Program -Environmental Sector | For Outstanding Contribution to the Community as Chair of the Waterloo Wellington Children's Groundwater Festival | Ontario Heritage Foundation | 2005

Michael R. Follett Community Leader Award Nominee | Greater Kitchener Waterloo Chamber of Commerce Business Excellence Awards | 2005

Grand River Watershed Conservation Award | Waterloo Wellington Children's Groundwater Festival, Chair | Grand River Conservation Authority | 2004

First Nations Consultation

Mr. Gray has extensive experience working with First Nations through the Duty to Consult – Constitution Act, 1982, as it relates to work performed on various gravel pit and bedrock quarry sites that Mr. Gray has been involved as a QP across Ontario. Mr. Gray has attended and provided expert witness testimony at the Ontario Environment Review Tribunal on matters concerning First Nations consultation, and has worked for individual bands on a project by project basis, including the Chippewa's of the Thames, Ojibwe Nation near London, ON, the Dokis Nation, near Lake Nipissing, ON, and the Cree Nation near Mistissini, QC.

Water Resources - Groundwater / Surface Water / Landfills

Region of Waterloo | Hydrogeological Assessment | Battler Road Snow Storage Facility | Kitchener, ON | 2014 - Present

Mr. Gray is currently acting as the Project Hydrogeologist for the selection of a new snow storage facility in the City of Kitchener. During the site selection process the hydrogeological conditions were assessed, including assessing the site in the local and regional hydrogeological framework, along with considering proposed risks to groundwater and surface water quality as a result of chloride impacts from melting snow.

Region of Waterloo | Groundwater Resource Evaluation | Maple Grove Road & Fountain Street | Cambridge, ON | 2010 - 2015

Mr. Gray served as Project Hydrogeologist for an evaluation of groundwater resources for the Region. The evaluation was a Class C Environmental Assessment for a Water Supply System. The objective of this project was to determine the maximum sustained pumping rate at the newly constructed 305-mm water well and existing production well sites designed by MTE. A number of monitoring wells were installed throughout the study area to determine the most suitable location for a new test production well. To aid in the prediction of the long-term effects of pumping MTE used the predictive FEFLOW model. The model also provided an understanding of the existing geological setting and hydrogeological properties of the study area. MTE completed a long-term pumping test (40 days) at a rate of 80 L/sec from two production wells to assess the potential for groundwater interference with existing groundwater users. Water levels from 40 private domestic water supplies and surface water features were monitored using electronic pressure transducers along with the collection and assessment of surface water flow data from a nearby creek and precipitation data. Groundwater quality and quantity were assessed using water samples obtained during the pumping test to monitor the impacts on local surface water courses.

Region of Waterloo | Hydrogeological Monitoring | Middleton Street Water Treatment Plant | Cambridge, ON | 2010

Mr. Gray served as the Project Manager and Project Hydrogeologist for the Region during the construction phase of the Middleton Street Water Treatment Plant. Hydrogeological monitoring was undertaken as a condition of the Region's Permit To Take Water on the neighbouring Canadian General-Tower property, which included monitoring water levels, water quality and vibration using on site monitoring wells.

Peter A. Gray, P.Geo., QP$_{ESA}$

Title: Vice President, Environmental
Role: Senior Hydrogeologist

Contact Peter

Awards

The Outstanding Achievement Award for Voluntarism in Ontario | Waterloo Wellington Children's Groundwater Festival, Chair | Ministry of Culture and Tourism | 2002

Environmental Education Award | Waterloo Wellington Children's Groundwater Festival, Chair | Regional Municipality of Waterloo | 1999

Environmental Sustainability Award in Education | For Waterloo Wellington Children's Groundwater Festival, Chair | Waterloo Region Chamber of Commerce | 1999

Award for Education | For Children's Groundwater Institute, Director | Financial Post | 1996

Region of Waterloo | Groundwater Assessment | St. Agatha, ON | 2007 - 2009
From 2007 to 2009 Mr. Gray served as Project Manager and Project Hydrogeologist for a groundwater exploration program to assess the potential to develop a new municipal groundwater supply to service, and potentially replace the existing nitrate impacted municipal wells in the Hamlet of St. Agatha. The project included the drilling and construction of monitoring wells, executing private property access agreements, and drilling, construction, design and hydraulic testing of one test production well.

Municipality of North Huron | Hydrogeological Study | Wingham & Blyth, ON | 2004 - 2006
MTE was retained to conduct a hydrogeologic study for the determiniation of Groundwater Under the Direct Influence of Surface Water (GUDI). This project included coordination of field activities, selection of water quality testing methods, isotopic analysis, bacteriological analysis, review of pumping test results and determination of the influence of surface water on groundwater resources. Specific project tasks included hydrogeologic setting assessment, conducting a door-to-door survey to identify water quality concerns and to establish monitoring points for use during pumping tests, installation of piezometers, well inspections, pumping tests, and water quality sampling, data compilation and interpretation, groundwater modelling, and hydrogeologic reporting for the determination of the need for filtration for the municipal wells.

Municipality of South Huron | Groundwater Management Study | Exeter, ON | 2003 - 2006
The Town of Exeter initially retained MTE to conduct a Groundwater Management Study under the Ontario Government's "Provincial Water Protection Fund" program. The study focused on Exeter's existing groundwater supplies and covered an area of approximately 140 square kilometres in southern Huron County. Since the initial study, MTE has assisted the project team in completing a GUDI assessment of the water supplies and has undertaken the hydrogeological component of a Class EA Study for Long-Term Water Supply.

Region of Waterloo | River Wells Assessment | Kitchener, ON | 1997 - 1999
Mr. Gray served as Project Manager and Project Hydrogeologist, in association with EarthFx, to assess the hydrogeology of the River Wells, a series of nine wells located along the Grand River east of Kitchener (including the Forwell, Pompeii and Woolner well fields). The assignment included the construction and calibration of a 3D groundwater flow model, with both forward and backward in time particle tracking to understand the flow regime in which the wells were constructed. The project also included a study of potential adverse impacts to the wells from gravel extraction activities and future land use plans.

Region of Waterloo | Well Oversight & Testing | Peaking Wells K90 – K93 | Kitchener-Waterloo, ON | 1990 - 1992
Mr. Gray served as Project Hydrogeologist for a groundwater development project that included the test drilling, design, construction oversight, hydraulic testing and permitting for municipal wells K90, K91, K92 and K93. The intention of the wells was to assist in meeting peak water supply demands for the Region.

Region of Waterloo | Hydrogeological Consulting | Guidelines for Privately Serviced Developments | Kitchener-Waterloo, ON | Early 1990's
In the early 90's, Mr. Gray served on a team of consultants that drafted the terms of reference for hydrogeological studies to be undertaken for proposed rural developments on private services. The investigations, which have been updated over time, included assessing water supply demands from a quality and quantity perspective, as well as waste water requirements, including sewage disposal systems.

Region of Waterloo | Well Interference Complaints | Kitchener-Waterloo, ON | Late 1980's - Early 1990's
Mr. Gray investigated well interference complaints on behalf of the Region through the Well Interference Complaint Committee. These complaints had been registered by rural landowners across the Region, alleging that their private water supply had been affected by the pumping of a nearby municipal well. The investigations included meeting with the landowners, collection and review of background data, well inspection, summary report preparation and presentation of findings and recommendations to the Committee.

City of Cornwall | Landfill Assessments | Cornwall, ON | 2007 - 2012
Mr. Gray was the Senior Hydrogeologist for various Landfill Assessments for both open and closed landfills in Cornwall, ON.

Ministry of the Environment | Vendor of Record | Hydrogeology | 2007 - Present
MTE was selected as a Vendor of Record for the Ministry of Environment. Mr. Gray was the Senior Hydrogeologist for any assignments the required input and expertise related to hydrogeology.

Other Experience

- Responsible for management, design and implementation of municipal and private groundwater supply investigations, and well interference complaint investigations across Ontario.
- Assisted in developing guidelines for hydrogeological studies for privately serviced developments, including water and septic in the Region of Waterloo.
- Conducted Hydrogeological Investigations and assessments related to water supply and sewage impact analyses for trailer parks, campgrounds, private developments and municipalities
- Conducted screening level environmental assessments in accordance with the Canadian Environmental Assessment Act.

Litigation Support and Expert Testimony
Mr. Gray has assisted in the collection, assessment and reporting of site data which has supported litigation for numerous projects relating to water supply and water resources / interference issues, environmental site assessments and impacts, land redevelopment and MOE Control Orders. He also has experience as an expert witness for cross-examination in support of OMB hearings and civil trial cases.

International Experience

Community Based Environmental Assessments on Rehabilitation Projects | Southeast Asia | 2005

Mr. Gray was the Co-Team Leader for Community-Based Environmental Assessment Reports for Indonesia, Thailand, Sri-Lanka – CIDA and non-CIDA, and India – CIDA and non-CIDA funded projects, on behalf of World Vision Canada / CIDA SE Asia Tsunami Response Team, following the December 26, 2004 Southeast Asia Tsunami.

Canadian International Development Agency | Save the Buriganga Program | 2000 - 2002

Mr. Gray was the Project Director for the "Save the Buriganga Program;" a river clean-up project sponsored by the Canadian International Development Agency (CIDA), in association with the Ministry of Environment and Forest; and Department of Environment, Government of the People's Republic of Bangladesh.

Vinyl Manufacturing Facility | Contaminant Hydrogeological Assessment | Toledo, OH | 1996 - 1997

Mr Gray was the Project Manager for a stormwater and surface water assessment at a vinyl manufacturing facility.

Groundwater Supply Development | Zomba, Malawi | 1995

Mr. Gray was the Senior Hydrogeologist for the development of a groundwater supply for the Naming'azi Farm Training Centre, an elementary school and a youth hostel and local villages located near the City of Zomba, Malawi in Southeast Africa. This work was completed through the Presbyterian World Service and Development (PWS&D) in association with the Church of Central Africa Presbyterian (CCAP).

Publications & Presentations

Gray, P.A. (2015). "Navigating Permits to Take Water (PTTWs)", Presented at the Ontario Stone, Sand and Gravel Association, Environmental Workshop. November 25, 2015. Mississauga, ON.

Gray, P.A. and J. Flanagan (2015). " A fine balance. Progressive rehabilitation helps make water balance naturally through vegetated areas", Avenues Magazine. Volume 5, Issue 2. November, 2015.

Gray, P.A. and M. Bradley (2015). "Leadership in action: The Children's Groundwater Festival successfully promotes environmental leadership by educating our youth", Avenues Magazine. Volume 5, Issue 1. February, 2015.

Gray, P.A. (2014). "Navigating Permits to Take Water (PTTWs)", Presented at the Ontario Stone, Sand and Gravel Association, Environmental Workshop. November 4, 2014. Mississauga, ON.

Gray, P.A. (2014). "Working with Water from Africa to Asia to Waterloo Region", Presented for the Haysville Sunshine Retirees Club. June 19, 2014. Haysville, ON

Gray, P.A. (2014). "Water Education Beyond the Classroom – 20 Years Later", Environmental Science and Engineering Magazine. January-February Issue, 2014.

Gray, P.A. (2013). "Working with Water From Africa to Asia", SAWA – Stratford Area World Aid Water Project- Dukam, Ethiopia. November 7, 2013. Stratford, ON.

Gray, P.A. (2011). "Just Add Water" – Soupfest: World Water Day, Children's Water Education Council. March 22, 2011. Kitchener, ON.

Gray, P.A. (2010). "Just Add Water" – Soupfest: World Water Day, Children's Water Education Council. March 22, 2010. Kitchener, ON.

Gray, P.A. (2009). Community Based Environmental Assessments Where Hazards / Catastrophes / Society Come Together. Case Study: SE Asia Tsunami Response – Indonesia, Sri Lanka, Thailand, India; May-July 2005. Presented at the International Association of Hydrogeologists / Hydrogeology Division of Canada Geotechnical Society. March 2, 2009. Kitchener, ON.

Reid, S. and **P.A. Gray** (2008). Water Education: Beyond the Classroom. Presented at the Ontario Society for Environmental Education (OSEE) Summer Conference. May 8, 2008. Oshawa, ON.

Gray, P.A. (2008). Uncertainty and Conflict in a Disaster Zone: Case Study: SE Asia Tsunami Response, Environmental Policy and Planning Course. February 7, 2008. McMaster University, Hamilton, ON.

Lizhong, W., L. Fang, K. Hipel and **P.A. Gray** (2008). Subsurface Contaminant Remediation and Cost/Benefit Sharing to Redevelop a Naphtha Contaminated Brownfield. Proceedings of Water Down Under 2008, incorporating the 31st Hydrology and Water Resources Symposium and the 4th International Conference on Water Resources and Environment Research. April 14 to 17, 2008. Adelaide, Australia. pp. 2423-2433.

Reid, S. and **P.A. Gray** (2007). Beyond the Classroom: An Overview of the Water Education in Ontario, Day 1, Environmental Education and Communications. A.D. Latornell Conservation Symposium: Your Watersheds, Our Great Lakes. November 14, 2007. Alliston, ON.

Yousefi, S., K. Hipel, K.T. Hegazy, J.A. Witmer and **P.A. Gray** (2007). Negotiation Characteristics in Brownfield Redevelopment Projects. Presented at 2007 IEEE International Conference on Systems, Man and Cybernetics. October 2007. Montreal, QC.

Yousefi, S., K. Hipel, K.T. Hegazy, J.A. Witmer and **P.A. Gray** (2007). Cooperative Brownfield Redevelopment for an Educational Institution. Presented at Brownfields Redevelopment Negotiation and Strategy Workshop, Wilfrid Laurier University. June 23, 2007. Waterloo, ON.

Yousefi, S., K. Hipel, K.T. Hegazy, J.A. Witmer and **P.A. Gray** (2007). Cooperative Brownfield Redevelopment for an Educational Institution. Presented at 4th International Conference in Group Decision and Negotiation (GDN). March, 2007. Montreal, QC.

Gray, P.A. (2006). Water Festivals to Field Programs. Presented at 7th Annual Water Forum, Grand River Conservation Authority. September, 2006.

Gray, P.A. (2006): The World's Thirst for Water, presented at International Projects and Issues Conference, Rotary International, Cameron Heights Collegiate Institute. May 25, 2006. Kitchener, ON.

Gray, P.A. (2006). The World's Thirst For Water. Presented at World Vision 30-Hour Famine. April 29, 2006. Cambridge, ON.

Gray, P.A. and J. Johnson (2006). Rotary International Minds Conference... a think tank for youth. Great Lakes: Climate Change – Are Water Levels in the Great Lakes Rising or Falling, University of Waterloo, Waterloo, Ontario, April 13, 2006.

Gray, P.A. (2006). The Dec 26/04 Tsunami meets the Water Table, Banda Aceh, Sumatra Island, Indonesia, What on Earth, A Canadian Newsletter for the Earth Sciences, Volume 4, Number 1, University of Waterloo, March 2006.

Gray P.A. and S. Reid (2005). Water Education, Beyond the Classroom. Presented at the Ontario Water Works Association Annual Conference. May 8, 2005.

Gray, P.A. (2005) Rotary International Minds Conference... A think tank for youth. Great Lakes: Planning for Competing Interests, University of Waterloo. April 10, 2005. Waterloo, ON.

Gray, P.A., E. Hodgins and B. Veale (2004). Planning for Water Conservation and Use in Waterloo Region, Chapter 17, Towards a Grand Sense of Place. Writings on the changing environments, land-uses, landscapes, lifestyles and planning of a Canadian Heritage River. pp. 225-240, 2004.

Gray, P.A. (2004). Rotary International Minds Conference... A Think Tank for Youth. A Civic Youth Conference on Water, Wilfrid Laurier University. April 16, 2004. Waterloo, ON.

Gray P.A., T.A. Bonin and M.F. Ahmed (2004) Dhaka's Waterways: Save the Buriganga River Program. Presented to 39th Central Canadian Symposium on Water Quality Research, Drinking Water Session. February 9, 10, 2004. Burlington, ON.

Gray, P.A. and D. Schultz (2003). Water Management Building Blocks, Breakthroughs and Opportunities. Environmental Science and Engineering Magazine. November 2003.

Gray, P.A. (2003). 3rd Annual Grand River Watershed Water Forum, Building Blocks, Breakthroughs & Opportunities, Afternoon Session Moderator, September 12, 2003. Cambridge, ON.

Gray, P.A. and T. Bonin (2003). Dhaka's Waterways, Save the Buriganga Program. Presented to St. Lawrence River Institute of Environmental Science: Large River Ecosystems - Under Stress Conference. May 13-15, 2003. Cornwall, ON.

Fedy, R.**, P. Gray,** R. Barnes and J. Witmer (2003). Ralgreen Restoration Project, A Brownfield Cleanup Project in a Residential Neighbourhood. Presented to 38th Central Canadian Symposium on Water Quality Research. February 10-11, 2003. Burlington, ON.

Gray, P.A. and S. Reid (2002). Children's Water Education Council, Water Festivals and Grade 8 Programming. Presented at and published in proceedings of 2002 Groundwater Foundation Fall Conference, "Groundwater: the Forgotten Element of Watershed Protection". November 2002. Eugene, OR.

Gray, P.A. and S. Reid (2002). A Practical Approach to Educating Children About Water. Presented on behalf of the Children's Water Education Council at the Managing Shared Waters International Conference. June 2002. Hamilton, ON.

Gray, P.A., B. Davidson, A. MacDonald (2001). Pressure Pulse Technology (PPT): A Revolutionary Fluid Flow Technology for Porous Media. Presented at 2001 An Earth Odyssey, 54th Canadian Geotechnical Conference, 2nd Joint IAH and CGS Groundwater Conference. September 16-19, 2001. Calgary, AB.

Bajc, A.F., White, T.N. and **Gray, P.A.** (2001). Quaternary geology of the Northwest Bay area. Ontario Geological Survey, Map 2572, scale 1:50,000.

Gray, P. A. (2001). Source Zone Removal Using Pressure Pulse Technology. Presented at the 2001 Groundwater Foundation Fall Conference and Groundwater Guardian Designation Conference on Today's Technology Protecting Tomorrow's Groundwater. November 14-16, 2001. Pittsburgh, PA.

Gray, P.A., E. Hodgins and B. Veale (2001). Water, water everywhere? Understanding and protecting our nation's most valuable resource. *Environments* 29(1): 39-66. Theme Issue: Urban Environmental Planning, Management and Decision Making.

Gray, P.A. and A. MacDonald (2000). Dramatic LNAPL Recovery using Pressure Pulse Technology (PPT) at a Manufacturing Facility in Ontario. Environmental Science and Engineering Magazine, November-December, 2000.

Gray, P.A. (2000). Measuring Water Quality Management Performance Conference, Session 2 Chair, Water Performance Issues. Presented by Federated Press. October 30-31, 2000. Toronto, ON.

Gray, P.A. (2000). Water Quality Issues and Challenges. Presented to and paper at the Federated Press, Measuring Water Quality Management Performance Conference. October 30-31, 2001, Toronto, ON.

Gray, P.A. (2000). The Importance and Sensitivity of Our Water Resources; presented at the Western Ontario Water Works Conference, Windsor, Ontario, October 4, 2000.

Gray, P.A. (2000). Water, Water Everywhere? Workshop Series. Presentation and paper on Urban Living and Environmental Change, The Urban Environmental Project – Workshop Series, Session II. Presented by the Heritage Resource Center, Interdisciplinary Research Fund, Dean of Environmental Studies and the School of Planning at the University of Waterloo in conjunction with the Rotary Club of Kitchener; January 20, 2000.

Gray, P.A. and T.A. Bonin (1999). 3-D Visualization of Groundwater Flow from an Industrial Property Towards Canada's Newest Heritage River. Presented at 22nd Biennial Ground Water Conference "Interconnected Water Supply in California". September 20-21, 1999.

Gray, P.A. (1997) The Role of Quaternary Geology in Computer Modeling of Groundwater Flow. Presented at the Quaternary Discussion Group, University of Waterloo. November, 1997.

Gray, P.A. (1995) Groundwater Resources – An Overview. Presented at the Spring (May 1995) and Fall (October 1995) Workshops, Groundwater Development and Well Design, Operation and Maintenance, Western Ontario Waterworks Conference and Ontario Waterworks Association, a section of AWWA, Toronto (May 1995), Stratford (October 1995), ON.

Gray, P.A. (1994). Wellhead Protection – An Overview. Presented at the CanWell '94 Convention, Technical Session C: Aquifer Protection. April 1994. Vancouver, B.C.

Gray, P.A. (1994) Groundwater Education in Ontario – Consultants and Contractors Make It Happen. Presented at CanWell '94 Convention, Technical Session C: Management Issues. April 1994. Vancouver, B.C.

Gray, P.A. (1993). Groundwater Education in Ontario – Consultants and Contractors Make It Happen. Presented at the Second American Ground Water Trust National Workshop on Ground Water Education, NGWA Convention. November 1993. Kansas City, MO.

Gray, P.A. (1991). Proper Protection and Placement of Domestic Wells. Parent-Child Guide Book.

Bajc, A.F. and **P.A. Gray** (1987) Quaternary Geology of the Rainy River Area, District of Rainy River. Ontario Geological Survey, Map P. 3065; Geological Series – Preliminary Map; Scale 1:50,000. Geology 1986.

Jay Flanagan, B.E.S., B.Ed.

Senior Project Manager

Contact Jay

Professional Experience

Mr. Flanagan's project management expertise includes planning, budget preparation and tracking, coordination of staff and sub-contractors, and communication with residents and reviewing agencies. Mr. Flanagan has completed Level 1 and Level 2 Hydrogeological Investigations for aggregate resource applications, Permit to Take Water (PTTW) applications, Certificate of Approval (C of A) applications, Environmental Compliance Approval (ECA) and reporting for compliance with PTTW, C of A, ECA and extraction licenses.

Mr. Flanagan has detailed knowledge of site characterization and hydrogeological modelling, as well as field experience in sampling techniques including groundwater, surface water, soil and sediment sampling. He also has a broad understanding of aggregate quarrying and effluent, as well as water management. His fieldwork experience incorporates hollow stem and solid stem augering, geoprobe, continuous core sampling, air-rotary drilling, monitoring well installation, and soil sampling. He also has detailed knowledge of provincial guidelines and regulations in particular the Aggregate Resources Act, Ontario Water Resources Act and Environmental Protection Act.

Relevant Projects

Aggregate Resources

Aecon Construction and Materials | Oliver Pit | Hydrogeological Investigation | Oliver, ON

This Hydrogeological Investigation was completed to support an application for a Permit To Take Water (PTTW) for a proposed wash plant. The annual groundwater monitoring and compliance reporting was completed as per the PTTW and extraction license. Mr. Flanagan was responsible for the implementation of a monitoring program that included annual reporting on water levels and water quality for a gravel pit in the Township of North Dumfries. The annual reporting considered the effects of the gravel pit on groundwater and surface water resources by reviewing data from seven monitoring wells, two surface water staff gauges in a provincially significant wetland, and two private wells.

Aecon Construction and Materials | Marmora Mine | Preliminary Dewatering Impact Assessment | Marmora, ON

This assessment was completed to investigate the feasibility of dewatering an open pit mine so that it can be used for a pumped storage hydro power project to be operated by Northland Power Inc. The mine has been filling with water (i.e. precipitation, runoff, and groundwater) since 1978 when extraction ceased. The mine is currently a lake and approximately 90 percent of the water would need to be discharged into a nearby Provincially Significant Wetland (PSW). As part of this investigation, the quality and quantity of the water in the mine was determined, baseline habitats studies were completed, and the risk of flooding as well as the ability of the PSW to assimilate the water assessed. The information collected was used to make recommendations for managing the water so that a final dewatering strategy could be developed. Mr. Flanagan was responsible for coordinating and completing the field work, report writing, and making a formal presentation to the stakeholders regarding the preliminary findings of the study. The surface water and ecological components of this study are ongoing.

Education

Environmental Engineering Applications Post Graduate Diploma | Conestoga College | 2003

Bachelor of Education | University of Western Ontario | 2001

Bachelor of Environmental Studies | University of Waterloo | 1997

Certificate | Environmental Assessment | University of Waterloo | 1997

Professional Designations

Certified Well Technician (O. Reg. 903) | Ministry of Environment (MOE) | 2007

Professional Development

40-Hour Contaminated Site Health and Safety Training Course | 2000

Project Management Bootcamp | PSMJ Resources, Inc. | 2010

Hazardous Waste Operations and Emergency Response (HAZWOPER) | Ontario Health and Safety Association (OHSA) Standard (29CFR 1910.120 Certified) | 2012

Professional Development

Standard First Aid & CPR / AED Certification | 2012

WHMIS Certification | MTE Consultants | Updated Annually

Aecon Construction and Materials | Mountain Lake Quarry | Surface Water Study | Mississagua Landing, ON
MTE was retained to complete a surface water assessment in support of a Permit to Take Water (PTTW) for a wash plant. The assessment was requested to determine the potential impact on the natural environment related to taking water from a nearby body of water known as Mountain Lake. The water was needed for aggregate washing purposes. The scope of work for the surface water study included mapping the drainage area for Mountain Lake in combination with designing a field program to collect background data on the flows from Mountain Lake. The drainage area mapping was used to complete water balance calculations to estimate the average annual inputs into Mountain Lake, while the field program involved establishing continuous flow monitoring stations at a culvert which drains from Mountain Lake. MTE completed discrete flow monitoring at the culvert and will create a rating table for which continuous flow data can be generated. The flow data will help assess any future impacts of the proposed water taking from Mountain Lake. The surface water study is ongoing.

Bot Construction Group | Sebright Quarry | Surface and Groundwater Studies | Sebright, ON
This project included groundwater monitoring of 28 onsite bedrock wells and 16 offsite private water supply wells. Mr. Flanagan was responsible for ensuring completion of technical reports to assess the potential impacts to surface water and groundwater resources from quarrying activities as required to obtain a Permit to Take Water and a Certificate of Approval for quarry dewatering.

Durham Stone and Paving | Feversham Pit | Groundwater Study | Feversham, ON
This project required the completion of a Hydrogeological Investigation to support an application for a pit that is above the water table as well as a Hydrogeological Investigation to support an application for a Permit to Take Water for a wash plant. This project included installation of eight onsite water wells. Mr. Flanagan was responsible for ensuring completion of technical reports to assess the potential impacts to groundwater resources from pit activities as required to obtain a Permit To Take Water and an aggregate license under the Aggregate Resources Act.

Ferma Aggregates | Carden Quarry | Hydrogeological Investigation | Kirkfield, ON
This project involved an exploration well installation (cored holes) for the purpose of aggregate quality testing. The results of the cored holes were used in a geological evaluation for the purpose of assessing bedrock quality and quantity at the quarry. This project also included groundwater level and quality monitoring to comply with the aggregate license and the Environmental Compliance Approval needed to discharge water back into the natural environment. Annual compliance reports are submitted to the Ministry of Natural Resources and Ministry of the Environment to demonstrate the impact of the quarry on surface and groundwater resources.

Fowler Construction Company | Fleming Quarry | Surface & Groundwater Studies | Washago, ON
This project required the completion of a Hydrogeological Investigation to support an application for a quarry below the water table. This project included drilling and installation of eight onsite bedrock water wells and two wetland monitoring stations. Mr. Flanagan was responsible for ensuring completion of technical reports to assess the potential impacts to surface water and groundwater resources from quarrying activities as required to obtain a Permit To Take Water and a Certificate of Approval for quarry dewatering.

Fowler Construction Company | Rosewarne Quarry | Permit To Take Water (PTTW) & Annual Groundwater Monitoring | Bracebridge, ON
This project involves a reapplication for a PTTW, annual reporting on groundwater and surface water monitoring for the PTTW, and monitoring compliance with a Certificate of Approval.

G.W. Clarke Drainage Contractors | Bokor Pit | Groundwater Impact Assessment | Cedar Springs, ON
This Level 1 and Level 2 Hydrogeological Investigation was to support a new below-water-table gravel pit application. This project included ongoing groundwater water monitoring of six onsite groundwater monitoring wells for the purpose of monitoring impacts to groundwater resources. Annual compliance reports are submitted to the Ministry of Natural Resources that report on the changes to the groundwater flow regime as the pit expands.

Greenwood Construction | East and West Pits | Surface and Groundwater Studies | Orangeville, ON
This project required the completion of a Hydrogeological Investigation to support an application for a Class A Gravel Pit that is above the water table. This project was a preliminary Hydrogeological Investigation for the purpose of determining the final extraction elevation to the established groundwater table. It included drilling and installation of water wells for the purpose of mapping groundwater levels across the site. Mr. Flanagan was responsible for ensuring completion of technical reports to assess the potential impacts to surface water and groundwater resources from quarrying activities as required to obtain an aggregate license under the Aggregate Resources Act.

Greenwood Construction | Greenwood Ready-Mix Plant | Hydrogeology Study | Elora, ON
This project required the completion of a Hydrogeological Investigation to support a development permit needed for the construction of a ready-mix plant. The elevation of the established groundwater table was determined as wells as the groundwater connection of the site to a nearby wetland. The information was used to help design a stormwater retention pond to manage overland runoff. This project included drilling and installation of monitoring wells for the purpose of mapping groundwater levels across the site as well as piezometers in the nearby wetland to establish the groundwater connection. Mr. Flanagan was responsible for ensuring the completion of technical reports to assess the potential impacts to surface water and groundwater resources from the development of the ready-mix plant.

Greenway Environmental Management | Inland Pit | Hydrogeological Investigation | Arkona, ON
This Level 1 and Level 2 Hydrogeological Investigation was to support a gravel pit expansion. The annual groundwater monitoring and compliance reporting was per Permit to Take Water.

Harold Sutherland Construction | Keppel Quarry | Hydrogeological Investigation | Keppel, ON
This Level 1 and Level 2 Hydrogeological Investigation was in support of an application for a quarry expansion. This investigation was done to assess the risk to groundwater and surface water resources as a result of a quarry expansion. From this investigation, management plans were development called an Adaptive Management Plan that will allow for strategic decision making with respect to quarry operations so that potential impacts to the natural environment can be fully assessed and mitigated prior to any adverse impact. Before the Adaptive Management Plan was developed the results of the Hydrogeological Investigation was peer reviewed by several professional hydrogeologists including those at the Ministry of Natural Resources, Ministry of the Environment, and the Niagara Escarpment Commission.

Sarjent Company | Waverley Pits | Groundwater Impact Assessment | Waverley, ON
This Level 1 and Level 2 Hydrogeological Investigation was to support a new below-water-table gravel pit application. This project included ongoing groundwater water monitoring of nine onsite groundwater monitoring wells and seven offsite private water supply wells.

Severn Aggregates Ltd. | Cumberland Quarry | Hydrogeological Investigation | Township of Severn, ON
MTE conducted a regional-scale groundwater assessment (Level 1 and Level 2 hydrogeological investigation) in support of an application for a quarry below the water table. This project includes a drainage basin analysis for the purpose of identifying groundwater and surface water interactions. The drainage basin analysis involves the assessment of baseflow condition of onsite creeks, as well as the completion of water budget calculations. Groundwater levels and quality monitoring as well as hydrological monitoring (stream flow) is being done on the site to track long-term fluctuation over time. This information is being inputted into a database used for the development of a numerical groundwater model using FEFLOW 6.0. The purpose of the numerical model will be to assess the potential impacts of the quarry on surface water and groundwater resources and their uses as the quarry develops.

Jim Brown & Sons Trucking | Brown Pit | Surface and Groundwater Studies | Orangeville, ON
This project involved the completion of Hydrogeological and Hydrologic Assessments in support of an application for a gravel pit below the water table. This project includes drainage basin analysis for the purpose of identifying groundwater and surface water interactions as well as water budget calculations to determine the impact of the proposed pit on a nearby wetland. Groundwater test wells were installed on the site so that groundwater levels could be tracked over time.

Limehouse Clay Products | Limehouse Quarry | Level 1 & Level 2 Hydrogeological Investigation | Georgetown, ON
This project has involved groundwater and surface water analysis and groundwater levels since 2004. Recent work involved application for quarry deepening. Work assessing risk to upgradient wells and designing a monitoring and mitigation plan to handle any potential environmental risk was included in the application.

St. Marys Cement | Tikal Pit | Groundwater Monitoring | Puslinch, ON
This project involved a groundwater and surface water monitoring plan for a below-water-table gravel pit. Mr. Flanagan was responsible for the implementation of comprehensive groundwater monitoring plan to assess potential impacts on groundwater and surface water resources from a below-water-table gravel pit. His duties involved coordinating with field staff to collect weekly groundwater and surface water level measurements and annual groundwater and surface water samples; review and comparison of the weekly monitoring data to threshold limits established as part of the contingency plan for the gravel pit; and, annual reporting to the Township, Conservation Authority, and Ministry of Natural Resources.

St. Marys Cement | Woods-Gray Pit | Groundwater Monitoring | Orangeville, ON
This Hydrogeological Investigation was completed to support an application for a Permit to Take Water (PTTW) for a proposed wash plant. The annual groundwater monitoring and compliance reporting was completed as per the PTTW. Mr. Flanagan was responsible for the implementation of a groundwater monitoring program that included bi-annual reporting on water levels for a gravel pit in the Township of East Garafraxa. The annual reporting considered the effects of the gravel pit on groundwater and surface water resources by reviewing data from 10 monitoring wells, and two surface water staff gauges in nearby private groundwater sourced ponds.

McCann Redi-Mix | Bell Pit | Groundwater and Surface Water Impact Assessment | St. Marys, ON
This Level 1 and Level 2 Hydrogeological Investigation was to support an expansion to an existing below-water-table gravel pit application. This project included ongoing groundwater water monitoring of three onsite groundwater monitoring wells for the purpose of monitoring impacts to groundwater and surface water resources (Flat Creek). Annual compliance reports are submitted to the Ministry of Natural Resources reporting on the changes to the groundwater flow regime as the pit expands.

Residential Applications

Carson Reid Homes | Elora Meadows | Hydrogeological Investigation | Elora, ON
This project involved an impact assessment of a groundwater collection system on groundwater and surface water resources. The system was designed to protect the basements of residential dwellings from flood risks associated with high water table conditions. It also included annual monitoring and compliance reporting as per the Permit to Take Water related to dewatering activities for the installation of a culvert crossing.

Reid's Heritage Homes | Aberfoyle Meadows | Hydrogeological Investigation | Guelph, ON
This site required a comprehensive groundwater resource evaluation, with an assessment of sustainable supply. A communal supply well was drilled into bedrock (Amabel Formation) to provide water for 59 residential units. A backup well was drilled nearby. For the long-term pumping test, 24 data loggers were installed in every creek, pond, observation well and accessible private well in the area. Pumping was conducted at 1,180 L per minute to stress the aquifer to calculate the hydraulic parameters. Nestlès' bottled-water facility is located less than 500 m to the west, so mutual interference was readily observed. With interpretation of the data, and predictions of the regional water supply, a Permit to Take Water was obtained from the Ministry of the Environment to adequately supply the development. An ongoing comprehensive monitoring program assures that all of the conditions are satisfied.

Robertson Rural | Industrial & Commercial Development | Hydrogeological Investigation | Guelph, ON
This project involved an impact assessment of a development on the bedrock aquifer and Clythe Creek. This local-scale groundwater assessment included a contaminant attenuation capacity for septic systems proposed for an industrial and commercial development. Mr. Flanagan was the Project Manager responsible for overseeing the completion of several well tests on private wells surrounding the site to assess the sustainability of the aquifer as a water supply. Mr. Flanagan also collected and assessed water quality results obtained from various private wells to ensure the aquifer had adequate water quality. His tasks included the supervision of nitrate loading calculations for the septic systems, the completion of hydrogeological monitoring and analysis (groundwater levels, stream flow measurements, and precipitation volumes), and the preparation of a hydrogeological report that summarized and interpreted the findings and included geological cross-sections and groundwater flow maps.

Property Severance | Hydrogeological Study and Environmental Impact Study | Maryhill, ON
The hydrogeological component of this study included a local-scale groundwater assessment that involved nitrate loading calculations for the septic systems proposed for property, groundwater flow mapping and preparation of geological cross-sections to identify underlying aquifers. Mr. Flanagan was the Project Manager responsible for overseeing the installation of monitoring wells for the purpose of mapping the established water table and the collection of groundwater quality samples. The environmental impact component of this study involved investigating the significance and ecological sensitivity of a environmental core feature, designated by the Region of Waterloo, adjacent to the site. For this component, Mr. Flanagan was responsible for overseeing the field work and meetings with the Grand River Conservation Authority. This study is ongoing.

Groundwater Contamination

Commercial Site | Phase II Environmental Site Assessment | Kitchener, ON
This Phase II ESA investigated extent and potential sources of groundwater contamination.

Provincial Conifer | Westroc Gypsum Mine | Phase II Environmental Site Assessment
This Phase I ESA and Limited Phase II ESA investigated potential areas of concern and extent of possible groundwater contamination.

Residential Site | Phase II Environmental Site Assessment | Toronto, ON
This limited Phase II ESA investigated the extent of groundwater contamination.

Industrial Site | Phase II Environmental Site Assessment | Lynden, ON
This Phase II ESA investigated the extent of groundwater contamination related to a fertilizer spill and made recommendations for remediation.

Commercial Rental Resort | Phase I Environmental Site Assessment | Roseneath, ON
This Phase I ESA met the requirements of CSA Z768-01 and was completed with consideration toward the methodology of O. Reg. 153/04 (as amended). The purpose of a Phase I ESA is to identify actual or potential contamination on the property, based on the evaluation of information collected through records review, site visits and interviews.

Fraser Cummings, M.Sc.

Environmental Scientist

Contact Fraser

Professional Experience

Mr. Cummings has over one year of field experience in sampling techniques including groundwater, surface water, soil and sediment sampling as well as knowledge of site characterization and hydrogeological modelling. Fraser is also familiar with provincial guidelines and regulations, in particular the Ontario Water Resources Act and Environmental Protection Act.

Education

Masters of Science | Earth Science | University of Waterloo | 2014

Honours Bachelor of Science | Earth Science, Environmental Specialization | University of Waterloo | 2012

Professional Designations

Geoscientist-in-Training (G.I.T.) | Association of Professional Geoscientists of Ontario (APGO)

Professional Development

WHMIS Certification | MTE Consultants | Updated Annually

Relevant Projects

Chicopee Ski and Summer Resort | Snow Making Investigation | KItchener, ON

This project involved an investigation to examine Chicopee's water supply and evaluate their options for expanding snow production. Fraser was involved with the drilling of a hole to assess soil conditions, collection of soil samples and equipping the hole with a permanent monitoring well to preform hydraulic testing. Long-term pumping tests are currently being conducted to evaluate aquifer conditions.

Carson Reid Homes | Elora Meadows | Hydrogeological Investigation | Elora, ON

This project involved an impact assessment of a groundwater collection system on groundwater and surface water resources. The system was designed to protect the basements of residential dwellings from flood risks associated with high water table conditions. It also included annual monitoring and compliance reporting as per the Permit to Take Water related to dewatering activities for the installation of a culvert crossing. As the Environmental Scientist on the project, Fraser conducts monitoring activities on an ongoing basis.

Aecon Construction and Materials | Oliver Pit | Hydrogeological Investigation | Oliver, ON

This Hydrogeological Investigation was completed to support an application for a Permit To Take Water (PTTW) for a proposed wash plant. The annual groundwater monitoring and compliance reporting was completed as per the PTTW and extraction license. MTE implemented a monitoring program that included annual reporting on water levels and water quality for a gravel pit in the Township of North Dumfries. Mr. Cummings collected data for the annual report which considered the effects of the gravel pit on groundwater and surface water resources. He assisted with fieldwork which involved seven monitoring wells, two surface water staff gauges in a provincially significant wetland, and two private wells.

Aecon Construction and Materials | Marmora Mine | Preliminary Dewatering Impact Assessment | Marmora, ON

This assessment was completed to investigate the feasibility of dewatering an open pit mine so that it can be used for a pumped storage hydro power project to be operated by Northland Power Inc. The mine has been filling with water (i.e. precipitation, runoff, and groundwater) since 1978 when extraction ceased. The mine is currently a lake and approximately 90 percent of the water would need to be discharged into a nearby Provincially Significant Wetland (PSW). As part of this investigation, the quality and quantity of the water in the mine was determined, baseline habitats studies were completed, and the risk of flooding as well as the ability of the PSW to assimilate the water assessed. The information collected was used to make recommendations for managing the water so that a final dewatering strategy could be developed.

Kurtis Romanchuk, B.Sc., EIT

Designer

Contact Kurtis

Professional Experience

Mr. Romanchuk has over three years of experience in civil engineering with specific knowledge in the fields of planning and design for municipal and development engineering. His technical background and industry-leading knowledge of hydraulic and hydrologic modeling software allow him to provide timely and efficient turnaround of designs optimized to suit varied civil engineering requirements

Education

Bachelor of Science | Civil Engineering | Queen's University | 2014

Professional Designations

Engineer in Training (EIT) | Professional Engineers of Ontario | 2014

Professional Development

HEC-RAS Workshop | Canadian Water Resources Association | November 2015

WHMIS Training | MTE Consultants | Updated Annually

Relevant Projects

City of Cambridge | Cambridge West Residential | Preliminary Engineering | Cambridge, ON

To provide the necessary environmental and servicing studies to develop approximately 103 ha (255 acres) of land for residential development, the City of Cambridge and area landowners undertook a Cambridge West Master Environmental Servicing Plan and Community Plan. A comprehensive Surface Water Monitoring Program was developed by MTE Consultants to assess conditions within the watercourses and wetland features within the study area. Additional services provided include an existing conditions surface water resources analysis, conceptual stormwater management plan, and water and sanitary servicing analysis. Kurtis is currently involved in the preliminary design of this 65-ha subdivision. His role is to model the proposed subwatershed hydrology using GAWSER and MIDUSS software to provide optimized designs for stormwater management and surface water resource requirements.

Northgate Subdivision | Land Development | Waterloo, ON

Kurtis is currently assisting with the Preliminary Stormwater Management Report in support of draft plan approval of the proposed 58.8-ha Northgate Subdivision in Waterloo.

Elora Mill | Site Redevelopment | Elora, ON

MTE is currently providing civil and structural engineering services for the extensive redevelopment of the Elora Mill site. The project will encompass both sides of the Grand River with plans that include condominiums, a conference centre and banquet hall, a wedding chapel, inn and commercial space. Kurtis is currently involved with hydraulic modeling of the Grand River in HEC-RAS to ensure design viability.

Waterloo Inn | Land Redevelopment | Waterloo, ON

Kurtis performed a two-zone floodplain encroachment analysis in HEC-RAS for the redevelopment of this 19-ha property along King and Weber street in Waterloo.

Freymond Quarry | Stormwater Management Study | Bancroft, ON

Kurtis assisted with a pre-extraction / post-rehabilitation water balance analysis on a 500-ha subwatershed using MIDUSS software. He also designed the stormwater management systems for the proposed quarry.