WESA
A Better Environment For Business

August 26, 2003
Project No. CB2422-00

Township of North Stormont
2 Berwick Victoria Street
P.O. Box 99
Berwick, Ontario
K0C 1G0

Attn: Mr. Rheal Charbonneau, Clerk-Treasurer FAX: 1-613-984-2908

Re: Well Yield Re-rating Results
Community of Moose Creek Well Water Supply, Township of North Stormont

Dear Mr. Charbonneau:

The following provides the results from the well re-rating program conducted for the Village of Moose Creek communal water supply wells, Well #2 and Well #3. As you are aware, Moose Creek Well #1 was not re-rated because efforts to rehabilitate this well and return it to operation were unsuccessful.

Background Information

The three Moose Creek production wells were constructed between 1990 and 1991. Though the water supply system was commissioned in mid-1995, the most recent well-rating tests (i.e. minimum 72-hour constant discharge testing) were conducted by Jacques Whitford Environment Limited (JWEL) in 1991. The 1991 testing results (JWEL report dated April 30, 1992) are used in the existing Certificate of Approval for the water supply system and for the Permit to Take Water for the production wells. The water supply system is currently rated at a maximum daily flow of 896 m^3/day, based on the simultaneous operation of all three production wells. Various short term tests have been completed by the Ontario Clean Water Agency (OCWA) since 1996 that have indicated that the three wells are not capable of meeting the requirements of the twenty year design capacity as indicated in the Certificate of Approval. Further, Well #1 was taken off line in the spring of 2002 due to poor yield. Recent efforts to rehabilitate Well #1 and to return its yield to a practicable level have been unsuccessful.

A summary of the well construction information and the 1991 aquifer testing results for each production well is presented in Table 1 below.

Water and Earth Science Associates Ltd.
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TABLE 1: BACKGROUND WELL INFORMATION SUMMARY

	Well #1	Well #2	Well #3
Construction Details			
• Depth to bedrock	12.2 m (40')	13.1 m (43')	12.5 m (41')
• Total Depth	30.5 m (100')	31.4 m (103')	32 m (105')
• Well Screen Depth Interval	19.9 to 21.4 m 27 to 28.5 m	20.9 to 22.4 m 23.8 to 25.3 m	25 to 26.5 m 30.5 to 32 m
• Well Screen slot size	80-slot	100-slot	100-slot
1991 Aquifer Test Results			
• Static water level	1.3 m (4.3')	2.6 m (8.5')	1.4 m (4.6')
• Pumping rate	360 m^3/day(55 IGPM)	327 m^3/day(50IGPM)	360 m^3/day(55 IGPM)
• Recorded drawdown after 72 hrs	14.3 m (83.7')	18.0 m (59')	24.7 m (81')
• Recovery	95 % in 130 minutes	95 % in 120 minutes	95 % in 46 minutes
• Calculated Transmissivity			
Drawdown (early)	--	8.35 m^2/day	3.3 m^2/day
Drawdown (late)	219.6 m^2/day	25.01 m^2/day	31.6 m^2/day
Recovery (early)	199.7 m^2/day	5.56 m^2/day	3.68 m^2/day
Recovery (late)	10 m^2/day	69.0 m^2/day	50.03 m^2/day
Current Operational Status	**Off Line**	**On Line**	**On Line**
• Shut-off Probe Depth		21.9 m (71.8')	29.5 m (96.8')
• Pumping Rate		3.1 L/s (268 m^3/day)	3.1 L/s (268 m^3/day)
• Pump Depth (from ground surface)		23.6 m (77.4')	31 m (101.7')

Despite the shutdown of Well #1, the remaining site production wells have been able to meet Moose Creek's current flow demands. The 2002 flow data for the Moose Creek water supply system indicates a maximum day flow of 372 m^3/day (41.5 % of rated capacity) and an average day flow of 166 m^3/day (18.5 % of rated capacity).

The methodology and results from a well re-rating program carried out in June and July 2003 for Well#2 and Well#3 are provided herein.

WELL RE-RATING PROGRAM

The re-rating program for Well #2 and Well #3 involved conducting an initial step discharge aquifer test, followed by a 72 hour constant rate discharge test, and then a 24 hour recovery test. The initial step tests were conducted to ascertain the maximum possible pumping rates for the 72-hour tests that would not result in an unacceptable drawdown in the pumping well. Water was pumped using the existing 5 hp submersible pump that is installed in each well. The discharge rate was measured with an in-line digital read-out flow meter located at the on site pump house/reservoir building. Water was discharged to a reservoir tank situated beneath the treatment building. At high water level, the reservoir pump would then pump the water to the community water tower situated >500 metres from the site. Chlorine residuals in the pumped water were closely monitored by OCWA during the course of the testing program.

Water levels in the pumping well and in two observation wells were measured using a combination of manual data obtained with an electric sounding tape and with pressure transducer data collected through a data logger system. The well water level data collected through both methods was merged and then used for the well rating analyses. For each 72-hour constant rate test and 24-hour recovery test the two other site production wells were kept off line (Note: Well #1 is no longer pumped) and used as observation wells. Aquifer test data and calculations for Well #2 are contained in Appendix A. Aquifer test data and calculations for Well #3 are contained in Appendix B. Due to the large volume of water level data collected by data logger (i.e. collected at one minute intervals), this data has not been appended to this report, but is available on file with WESA. A site plan showing well locations is provided as Figure 1.

WELL#2 Testing Results

Step Discharge Aquifer Test

The step discharge aquifer test for Well #2 was conducted on July 7, 2003. The test was carried out in four discharge steps: 1 L/sec (86.4 m^3/day, 13.2 IGPM), 2 L/sec (172.8 m^3/day, 26.4 IGPM), 3 L/sec (259.2 m^3/day, 39.6 IGPM) and 3.45 L/sec (298 m^3/day, 45.5 IGPM). Each step was 30 minutes in length. Each step was initiated upon the completion of the previous step without allowing for aquifer recovery. The final step at 3.45 L/sec was conducted at the maximum possible discharge rate for the submersible pump and plumbing configuration. Step test data for Well #2 is provided in Appendix A. The results of the step discharge test indicated that Well #2 was capable of producing up to 3.4 L/sec for the duration of the 72-hour constant rate discharge test.

Constant Discharge Aquifer Test

The 72 hour constant rate discharge test for Well #2 was conducted between July 7, 2003 and July 10, 2003. The well was initially pumped at a constant discharge of 3.4 L/sec (293.76 m^3/day). However, at 26 hours into the test, the flow was decreased to 3.25 L/sec (280.8 m^3/day) due to concerns that a low level shut off alarm might be activated before the end of the test. The water level drawdown was monitored in the pumping well (Well #2), and the two observation wells (Well #1 and Well #3). Aquifer test data and data analysis for the Well #2 test is contained in Appendix A. Aquifer test data was analysed using Aquifer Test for Windows™, an aquifer test analysis software package developed by Waterloo Hydrogeologic of Waterloo, Ontario. Pumping (drawdown) data was analysed using the Cooper and Jacob confined aquifer method. Recovery data was analysed using the Theis and Jacob method. A summary of the static water level data, the drawdown data, and the observed aquifer recovery is presented below in Table 2. Calculated aquifer transmissivities and storativities are summarized in Table 3.

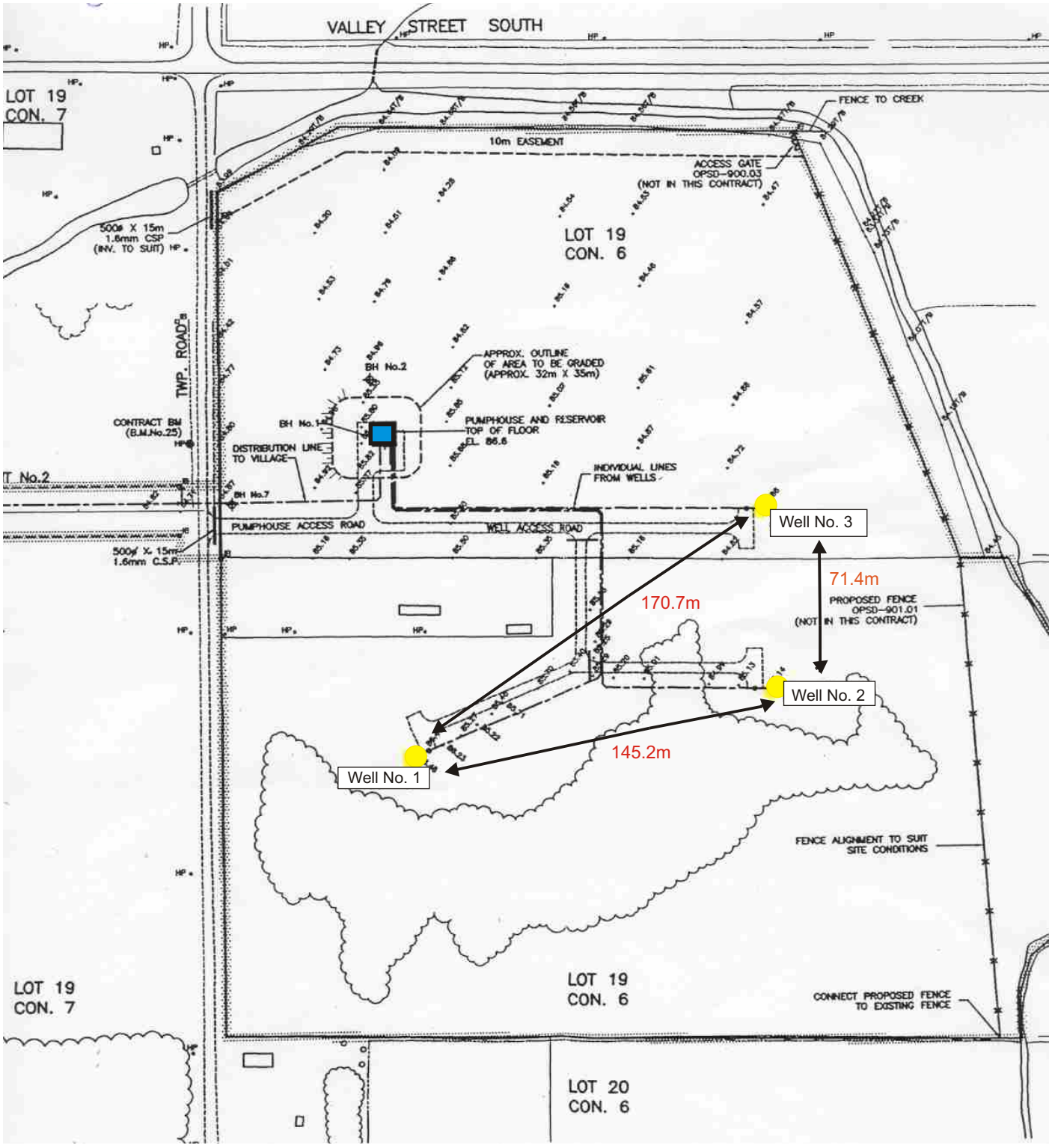

FIGURE: 1

SITE PLAN - MOOSE CREEK WELL FIELD

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TABLE 2: WELL#2 CONSTANT DISCHARGE TEST DATA SUMMARY

DISCHARGE RATE - 3.25 L/sec (42.9 IGPM, 280.8 m^3/day)

WELL NUMBER	RADIAL DIST. FROM PUMPING WELL (M)	STATIC WATER LEVEL FROM TOP OF WELL CASING (M)	'DRAWDOWN' AFTER 72 HRS PUMPING (M)	'RECOVERY' 24 HRS AFTER PUMP SHUTOFF (%)
Well#2	0	3.89	15.31	100
Well#1	145.2	4.84	0.63	100
Well#3	71.4	4.37	1.23	100

TABLE 3: WELL #2 AQUIFER ANALYSIS SUMMARY

WELL #	DATA TYPE	ANALYTICAL METHOD	CALCULATED TRANSMISSIVITY (m^2/day)	CALCULATED STORATIVITY	RADIAL DISTANCE (m)
Well #2	Drawdown - Early Data	Cooper & Jacob	5.92	---	0
	Drawdown - Late Data	Cooper & Jacob	87.7	---	
	Recovery – Early Data	Theis & Jacob	4.28	---	
	Recovery – Late Data	Theis & Jacob	89.86	---	
Well #1	Drawdown - Early Data	Cooper & Jacob	161.28	0.0001	145.2
	Drawdown - Late Data	Cooper & Jacob	249.12	0.00006	
	Recovery – Early Data	Theis & Jacob	6768	---	
	Recovery – Late Data	Theis & Jacob	134.5	---	
Well #3	Drawdown - Early Data	Cooper & Jacob	77.33	0.00007	71.4
	Drawdown - Late Data	Cooper & Jacob	256.32	0.00000006	
	Recovery – Early Data	Theis & Jacob	39.17	---	
	Recovery – Late Data	Theis & Jacob	168.48	---	

A low well efficiency for Well #2 is indicated by the data since the observed drawdown at Well #3 (located 71.4 metres from the pumping well) was only 8 % of the drawdown observed at the pumping well after 72 hours of pumping. Low well efficiency of the pumping well is also indicated by the recovery test data with 90 % of recovery in the pumping well being observed within 10 minutes of the pump shutoff. A well efficiency of less than 40% for Well #2 was reported by JWEL, in the April 30, 1992 Hydrogeological Assessment report. In general terms, well efficiency is a measurement of the performance of a well screen, and/or well design, to transmit groundwater from the aquifer to the well bore.

The range of calculated transmissivities and storativities obtained from the well testing program are close in magnitude to the original aquifer test results obtained for Well #2 by JWEL (April 12, 1992 report). The lower transmissivity values obtained for the early drawdown data and recovery data is attributable to effects from poor well efficiency and therefore, are not reflective of the true aquifer transmissivity. Based on the 'late data' aquifer test analyses, a conservative estimate of the transmissivity of the site aquifer at Well #2 is 87.7 m^2/day. An average storativity on the order of 1 x 10^{-5} is deemed representative of the aquifer at this location.

WELL#3 Results

Step Discharge Aquifer Test

The step discharge aquifer test for Well#3 was conducted on June 23, 2003. The test was carried out in four discharge steps: 1 L/sec (86.4 m^3/day, 13.2 IGPM), 2 L/sec (172.8 m^3/day, 26.4 IGPM), 3 L/sec (259.2 m^3/day, 39.6 IGPM) and 3.3 L/sec (285.1 m^3/day, 43.6 IGPM). Each step was 30 minutes in length. Each step was initiated upon the completion of the previous step without allowing for aquifer recovery. The final step at 3.3 L/sec was conducted at the maximum possible discharge rate for the plumbing configuration. The results of the step discharge test indicated that the production well was capable of producing at least 3.3 L/sec for the duration of the 72 hour test. The plumbing configuration was modified slightly following the step test, permitting a maximum possible discharge rate of 3.45 L/sec.

Constant Discharge Aquifer Test

The 72 hour constant rate discharge test was conducted between June 23, 2003 and June 26, 2003. The well was initially pumped at a discharge rate of 3.45 L/sec, but this rate decreased to 3.37 L/sec within 10 minutes of the test start up due to the well drawdown causing an increase in pumping head. The water level drawdown was monitored in the pumping well (Well #3), and the two observation wells (Well #1 and Well #2). Aquifer test data and data analysis for the Well #3 test is contained in Appendix B. Aquifer test data was analysed using Aquifer Test for Windows™. Pumping (drawdown) data was analysed using the Cooper and Jacob confined aquifer method. Recovery data was analysed using the Theis and Jacob method. A summary of the static water level data, the drawdown data, and the observed aquifer recovery is presented below in Table 4. Calculated aquifer transmissivities and storativities are summarized in Table 5.

TABLE 4: WELL #3 CONSTANT DISCHARGE TEST DATA SUMMARY

DISCHARGE RATE - 3.37 L/sec (44.5 IGPM, 291.2 m^3/day)

WELL NUMBER	RADIAL DIST. FROM PUMPING WELL (M)	STATIC WATER LEVEL FROM TOP OF WELL CASING (M)	'DRAWDOWN' AFTER 72 HRS PUMPING (M)	'RECOVERY' 24 HRS AFTER PUMP SHUTOFF (%)
Well #3	0	3.70	23.3	100
Well #1	170.7	4.17	0.84	100
Well #2	71.4	3.46	1.29	100

TABLE 5: WELL #3 AQUIFER ANALYSIS SUMMARY

WELL #	DATA TYPE	CALCULATED TRANSMISSIVITY (m^2/day)	CALCULATED STORATIVITY	RADIAL DISTANCE (m)
Well #3	Drawdown - Early Data	4.23	---	0
	Drawdown - Late Data	74.59	---	
	Recovery – Early Data	2.92	---	
	Recovery – Late Data	38.02	---	
Well #1	Drawdown - Early Data	257.76	0.000008	145.2
	Drawdown - Late Data	165.6	0.00006	
	Recovery – Early Data	135.22	---	
	Recovery – Late Data	----	---	
Well #2	Drawdown - Early Data	106.42	0.0001	71.4
	Drawdown - Late Data	178.56	0.00001	
	Recovery – Early Data	85.39	---	
	Recovery – Late Data	----	---	

As with Well #2, a low well efficiency is indicated by the data since the observed drawdown at Well #2 (located 71.4 metres from the pumping well) was only 5.5 % of the drawdown observed at the pumping well after 72 hours of pumping. Low well efficiency for Well #3 is also indicated by the recovery test data with 90 % of recovery in the pumping well being observed within 10 minutes of the pump shutoff. A well efficiency of less than 40% for Well #3 was reported by JWEL, in the April 30, 1992 Hydrogeological Assessment report.

The range of calculated transmissivities and storativities obtained from the well testing program are close in magnitude to the original aquifer test results obtained for Well #3 by JWEL (April 12, 1992). The lower transmissivity values obtained for the early drawdown data and recovery data is attributable to effects from poor well efficiency and therefore, are not reflective of the true aquifer transmissivity. Based on the 'late data' aquifer test analyses, a conservative estimate of the transmissivity of the site aquifer at Well #3 is 74.59 m^2/day. An average calculated storativity on the order of 1 x 10^{-5} is deemed representative of the aquifer at this location.

Sustainable Well Yield

Sustainable well yields for Well #2 and Well #3 were determined for a one year, ten year and twenty year continuous pumping period in consideration of the mutual well interference effects from the simultaneous pumping of both wells and in consideration of well loss due to poor well efficiency. The sustainable well yield calculations are provided in Appendix C.

Theoretical well interference calculations for the pumping of Well #2 and Well #3 are provided in Appendix C using the *Theis Nonequilibrium Equation*. Theoretical aquifer drawdown after 20 years of continuous pumping is provided for various pumping rates and at various distances from each pumping well. At a 20 year continuous flow rate of 2.7 L/sec for each pumping well, the predicted drawdown interference at the adjacent pumping well (71.4 metres away) is 4.2 metres at Well #2 and 3.6 metres at Well #3. Based on these numbers, a mutual well interference of 4.0 metres was used as a conservative value in the sustainable well yield calculations. Since the operation of the production wells is never likely to be continuous, the actual well interference induced by the well field is expected to be far less than the theoretical well interference values.

The estimation of sustainable 'aquifer yield' is normally based on available drawdown in the pumping well (i.e. the depth interval between the static water level and the top of pump) and the assumption that the pumping well efficiency is at or near 100%. Due to the poor well efficiency of the Moose Creek Wells, a well loss equivalent to 50% of the available drawdown has been incorporated into the sustainable 'well yield' calculations for both production wells. For Well #2 this represents a well loss of 10 metres of available drawdown. For Well #3 this represents a well loss of 11 metres of available drawdown.

The results of the sustainable well yield assessment are summarized below in Table 6.

TABLE 6: SUSTAINABLE WELL YIELD SUMMARY

WELL NUMBER	SAFE PERRENIAL YIELD	10 YEAR SUSTAINABLE YIELD	20 YEAR SUSTAINABLE YIELD
Well #2	255.2 m^3/day	234.3 m^3/day	228.7 m^3/day
Well #3	254.8 m^3/day	233.9 m^3/day	228.2 m^3/day

The well re-rating results in Table 6 indicate 20 year sustainable yields of 228.7 m^3/day for Well #2 and 228.2 m^3/day for Well #3. Consequently, the existing 20 year sustainable capacity for the Moose Creek water supply system is 456.9 m^3/day, approximately 51% of the current Certificate of Approval design rating of 896 m^3/day. Though the 20 year sustainable yield equates to a continuous flow rate of 2.7 L/sec for each production well, current pumping rates of up to 3.45 L/sec for each production well do not pose an immediate concern since current demand (2002 average day flow of 166 m^3/day) is only 36 % of the 20 year sustainable yield.

If you have any questions regarding the results of the Moose Creek well re-rating program, please do not hesitate to contact the undersigned.

Sincerely,

Robert J. Hillier, B.Sc. P.Geo.
Senior Hydrogeologist

Encl.

cc: James C. Johnston, Kostuch Engineering/Genivar Consulting Group. Fax: 944-7216

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APPENDIX A

WELL #2 PUMPING TEST DATA AND ANALYSES

Cooper-Jacob I : Time-Drawdown

The Cooper & Jacob Method (Confined Aquifer)

The Cooper & Jacob (1946) method is a simplification of the Theis method which approximates the infinite series describing W(u) by the first two terms in the series as follows:

$$W(u) = -0.5772 - \ln(u) \ .$$

This solution that is valid for greater time and smaller separation distance from the pumping well (smaller u values, i.e. $u < 0.01$). The resulting equation is:

$$s = \left(\frac{2.3Q}{4\pi T} \right) \log_{10} \left(\frac{2.25Tt}{S r^2} \right)$$

where s is drawdown, Q is the well discharge rate, t is time, r is the radial distance, and S and T are the storativity and transmissivity respectively.

The above equation plots as a straight line on semi-logarithmic paper if the limiting condition is met. Thus, straight-line plots of drawdown versus time can be produced after sufficient time has elapsed. In pumping tests with multiple observation wells, the closer wells will meet the conditions before the more distant ones. Time is plotted along the logarithmic x-axis and drawdown is plotted along the linear y-axis.

For the Time-Drawdown method, transmissivity and storativity are calculated as follows:

$$T = \frac{2.3Q}{4\pi \Delta s}$$

$$S = \frac{2.25Tt_0}{r^2}$$

where, *delta s* is the change in drawdown over one logarithmic cycle, and *to* is the time value where the straight line fit of the data intersects the time axis.

The Cooper-Jacob solution assumes the following:

- the aquifer is confined and has an "apparent" infinite extent

- the aquifer is homogeneous, isotropic, of uniform thickness over the area influenced by pumping
- the piezometric surface was horizontal prior to pumping
- the well is pumped at a constant rate
- the well is fully penetrating
- water removed from storage is discharged instantaneously with decline in head
- the well diameter is small so that well storage is negligible
- the values of u are small (rule of thumb $u < 0.01$)

The data requirements for the Cooper-Jacob solution are:

- drawdown vs. time data at an observation well
- distance from the pumping well to the observation well
- pumping well rate.

Cooper Jacob Analysis Parameters

Theis and Jacob Recovery Test

Theis & Jacob Recovery Test (Confined Aquifer)

The recovery / rebound of the water level in a pumping well can also be used to estimate aquifer transmissivity. Analysis of the recovery can be used to confirm data values obtained using the pumping test data, or it may be the only data available in the case where only a pumping well is available. In cases where observation well data are not available and it is necessary to estimate aquifer properties with only a pumping well, water level data during the pumping test cannot be used because they are subject to *well losses* which cause the drawdown in the well to be significantly greater than the drawdown in the aquifer just outside the well. This can be overcome by measuring the **recovery** of the water level in the well after the pump has been shut down.

According to Theis (1935), the residual drawdown after pumping has ceased is:

$$s' = \frac{Q}{4\pi T} W(u) - W(u')$$

where, $$u = \frac{r^2 S}{4Tt}, \qquad u' = \frac{r^2 S'}{4Tt'}$$

and, Q is the constant discharge, T is the transmissivity, r is the distance to the observation well, s' is the residual drawdown, S and S' are the storativity values during pumping and recovery respectively, and t and t' are the elapsed times from the start and ending of pumping respectively.

Using the approximation for the W(u) shown in the Cooper-Jacob method, this equation becomes,

$$s' = \frac{Q}{4\pi T}\left(\ln \frac{4Tt}{r^2 S} - \ln \frac{4Tt'}{r^2 S'}\right)$$

When S and S' are constant and equal and T is constant, this equation can be reduced to,

$$s' = \frac{2.3\,Q}{4\pi T} \log\left(\frac{t}{t'}\right)$$

When S and S' are constant but unequal and T is constant, the straight line throught the data

$(t/t')_o$

intercepts the time axis where s'=0, and where t/t' = $(t/t')_o$. As a result the equation becomes,

$$0 = \frac{2.3Q}{4\pi T}\left[\log\left(\frac{t}{t'}\right)_o - \log\frac{S}{S'}\right]$$

Since the $2.3Q/4\pi T \neq 0$, then $\log (t/t')_o - \log (S/S') = 0$, and hence $(t/t')_o = S/S'$, determining the relative ratio of S.

To analyze this data, s' is plotted on the logarithmic y-axis and time is plotted on the linear x-axis as the ratio of t/t' (total time since pumping began divided by the time since the pumping ceased).

The Theis & Jacob Recovery Test Method assumes the following:

- the aquifer is confined and has an "apparent" infinite extent
- the aquifer is homogeneous, isotropic, of uniform thickness over the area influenced by pumping
- the piezometric surface was horizontal prior to pumping
- the well is pumped at a constant rate
- the well is fully penetrating
- water removed from storage is discharged instantaneously with decline in head
- the well diameter is small so that well storage is negligible
- the values of u are small (rule of thumb $u < 0.01$)
- the length of pumping and recovery measured is $> 25r^2/T$.

The data requirements for the Theis&Jacob recovery solution are:

- recovery vs. time data at a pumping well
- a pumping rate and a time when the pumping was ceased.

Recovery Test Analysis Parameters

STEP TEST DATA	JOB# B2422	WELL#: 2

Type of aquifer test:	step test	Well type:	Pumping
How Q Measured:	digital flow meter	Data type:	Step test
Dist. From pumping well (m):	0	Depth pump(m):	24.6 m
Meas. point for w. l.'s:	T.O.C.	Pump on: July 7/2003	9:01:00 AM
Elev. of Meas. Point (mASL):	86.51	Pump off:	11:01:00 AM
Static Water Level (m):	18.10	Pumping rate:	1, 2, 3, 3.45 L/sec

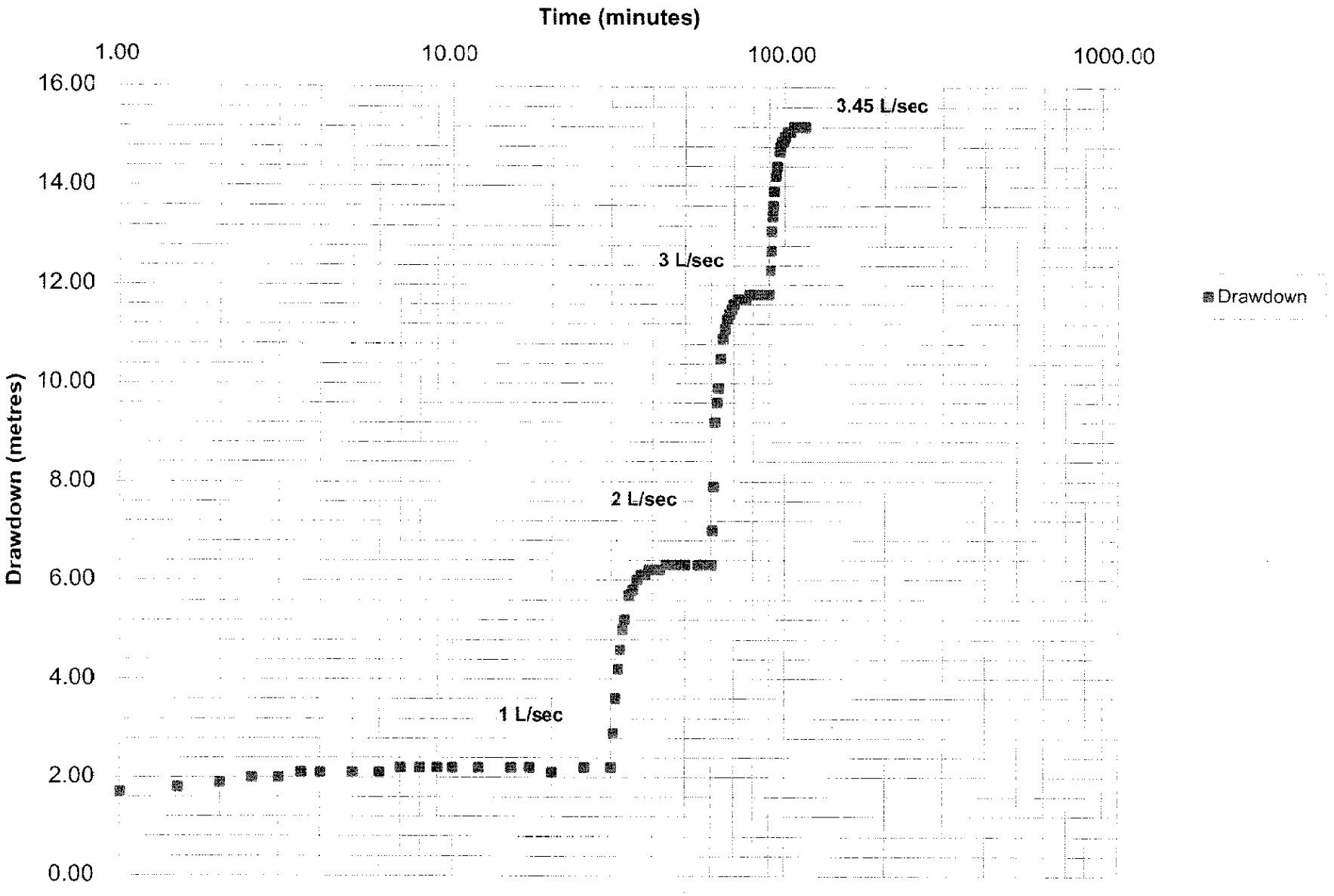
Time (min.)	Water Level (m)	Drawdown (m)	Pumping Rate (L/sec)	Comments
0.50	16.50	1.60	1	
1.00	16.40	1.70		
1.50	16.30	1.80		
2.00	16.20	1.90		
2.50	16.10	2.00		
3.00	16.10	2.00		
3.50	16.00	2.10		
4.00	16.00	2.10		
5.00	16.00	2.10		
6.00	16.00	2.10		
7.00	15.90	2.20		
8.00	15.90	2.20		
9.00	15.90	2.20		
10.00	15.90	2.20		
12.00	15.90	2.20		
15.00	15.90	2.20		
17.00	15.90	2.20		
20.00	16.00	2.10		
25.00	15.90	2.20		
30.00	15.90	2.20		
30.50	15.20	2.90	2	
31.00	14.50	3.60		
31.50	13.90	4.20		
32.00	13.50	4.60		
32.50	13.10	5.00		
33.00	12.90	5.20		
34.00	12.40	5.70		
35.00	12.30	5.80		
36.00	12.10	6.00		
37.00	12.00	6.10		
38.00	12.00	6.10		
39.00	11.90	6.20		
40.00	11.90	6.20		
42.00	11.90	6.20		
44.00	11.80	6.30		
47.00	11.80	6.30		
50.00	11.80	6.30		
55.00	11.80	6.30		
59.00	11.80	6.30		
60.00	11.80	6.30		

STEP TEST DATA **JOB# B2422** **WELL#: 2**

Type of aquifer test:	step test	Well type:	Pumping
How Q Measured:	digital flow meter	Data type:	Step test
Dist. From pumping well (m):	0	Depth pump(m):	24.6 m
Meas. point for w. l.'s:	T.O.C.	Pump on: July 7/2003	9:01:00 AM
Elev. of Meas. Point (mASL):	86.51	Pump off:	11:01:00 AM
Static Water Level (m):	18.10	Pumping rate:	1, 2, 3, 3.45 L/sec

Time (min.)	Water Level (m)	Drawdown (m)	Pumping Rate (L/sec)	Comments
60.50	11.10	7.00	3	
61.00	10.20	7.90		
61.50	8.90	9.20		
62.50	8.50	9.60		
63.00	8.20	9.90		
64.00	7.60	10.50		
65.00	7.20	10.90		
66.00	7.00	11.10		
67.00	6.80	11.30		
68.00	6.70	11.40		
69.00	6.60	11.50		
70.00	6.50	11.60		
72.00	6.40	11.70		
74.00	6.40	11.70		
76.00	6.40	11.70		
78.00	6.30	11.80		
80.00	6.30	11.80		
85.00	6.30	11.80		
90.00	6.30	11.80		
90.50	5.80	12.30	3.45	
91.00	5.40	12.70		
91.50	5.00	13.10		
92.00	4.70	13.40		
92.50	4.50	13.60		
93.00	4.20	13.90		
94.00	3.90	14.20		
95.00	3.70	14.40		
96.50	3.40	14.70		
97.00	3.30	14.80		
98.00	3.20	14.90		
99.00	3.20	14.90		
100.00	3.10	15.00		
102.00	3.00	15.10		
104.00	3.00	15.10		
106.50	2.90	15.20		
108.00	2.90	15.20		
110.00	2.90	15.20		
115.00	2.90	15.20		
120.00	2.80	15.30		

Step Test Well#2
July 7, 2003



WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Time-Drawdown-method after COOPER & JACOB Confined aquifer	Date: 17.07.2003	Page 2
		Project: B2422	
		Evaluated by: T. Praamsma	

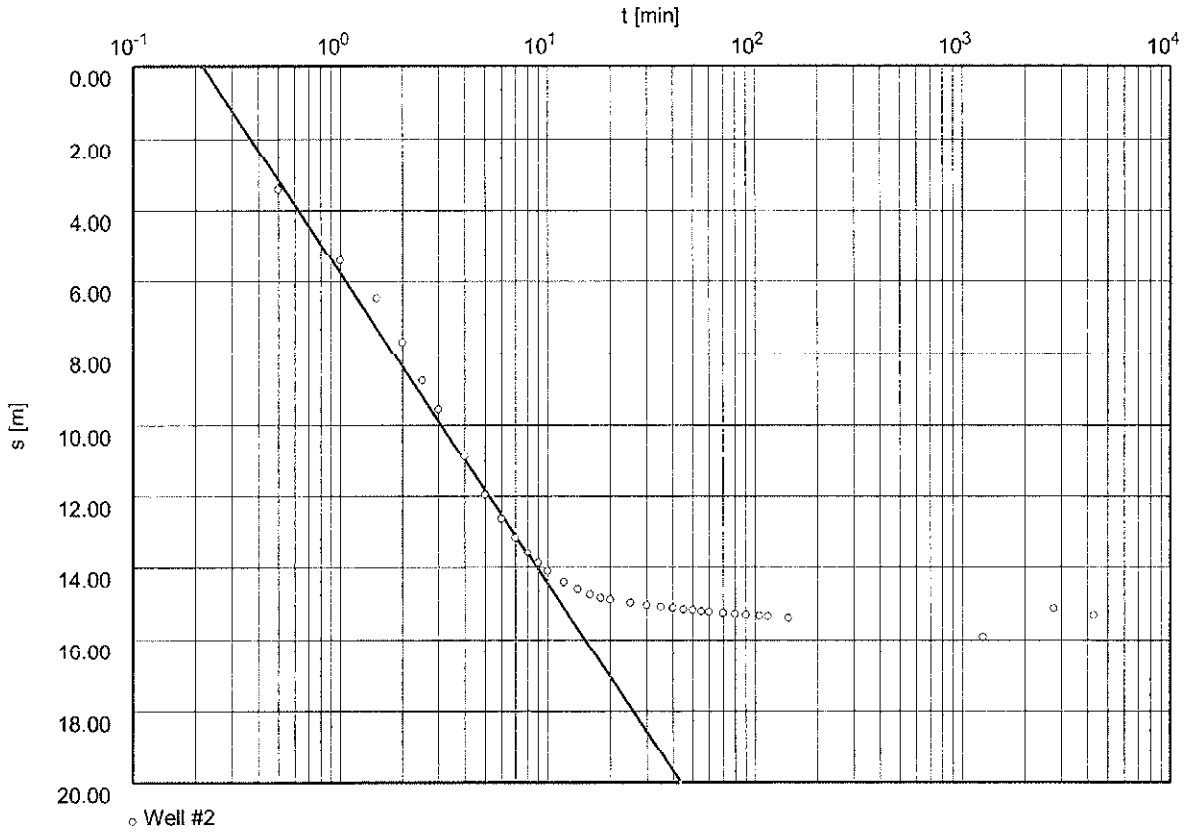
Pumping Test No. 2	Test conducted on: 07.07.2003
Well #2	Well #2
Discharge 3.25 l/s	Distance from the pumping well 0.100 m

Static water level: 3.890 m below datum

	Pumping test duration [min]	Water level [m]	Drawdown [m]	
2	0.50	7.300	3.410	
3	1.00	9.300	5.410	
4	1.50	10.350	6.460	
5	2.00	11.550	7.660	
6	2.50	12.650	8.760	
7	3.00	13.450	9.560	
8	4.00	14.770	10.880	
9	5.00	15.840	11.950	
10	6.00	16.500	12.610	
11	7.00	17.020	13.130	
12	8.00	17.450	13.560	
13	9.00	17.750	13.860	
14	10.00	17.980	14.090	
15	12.00	18.290	14.400	
16	14.00	18.480	14.590	
17	16.00	18.630	14.740	
18	18.00	18.720	14.830	
19	20.00	18.770	14.880	
20	25.00	18.860	14.970	
21	30.00	18.920	15.030	
22	35.00	18.970	15.080	
23	40.00	19.000	15.110	
24	45.00	19.040	15.150	
25	50.00	19.060	15.170	
26	55.00	19.090	15.200	
27	60.00	19.110	15.220	
28	70.00	19.140	15.250	
29	80.00	19.170	15.280	
30	90.00	19.190	15.300	
31	105.00	19.210	15.320	
32	115.00	19.230	15.340	
33	145.00	19.280	15.390	
34	578.00	19.558	15.668	
35	1058.00	19.703	15.813	
36	1256.00	19.800	15.910	
37	1537.00	19.799	15.909	
38	1709.00	19.589	15.699	
39	1719.00	18.876	14.986	
40	2189.00	18.943	15.053	
41	2668.00	19.000	15.110	
42	2756.00	19.020	15.130	
43	3148.00	19.024	15.134	
44	3628.00	19.095	15.205	
45	4107.00	19.154	15.264	
46	4278.00	19.200	15.310	

WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Time-Drawdown-method after COOPER & JACOB Confined aquifer	Date: 17.07.2003	Page 1
		Project: B2422	
		Evaluated by: T. Praamsma	

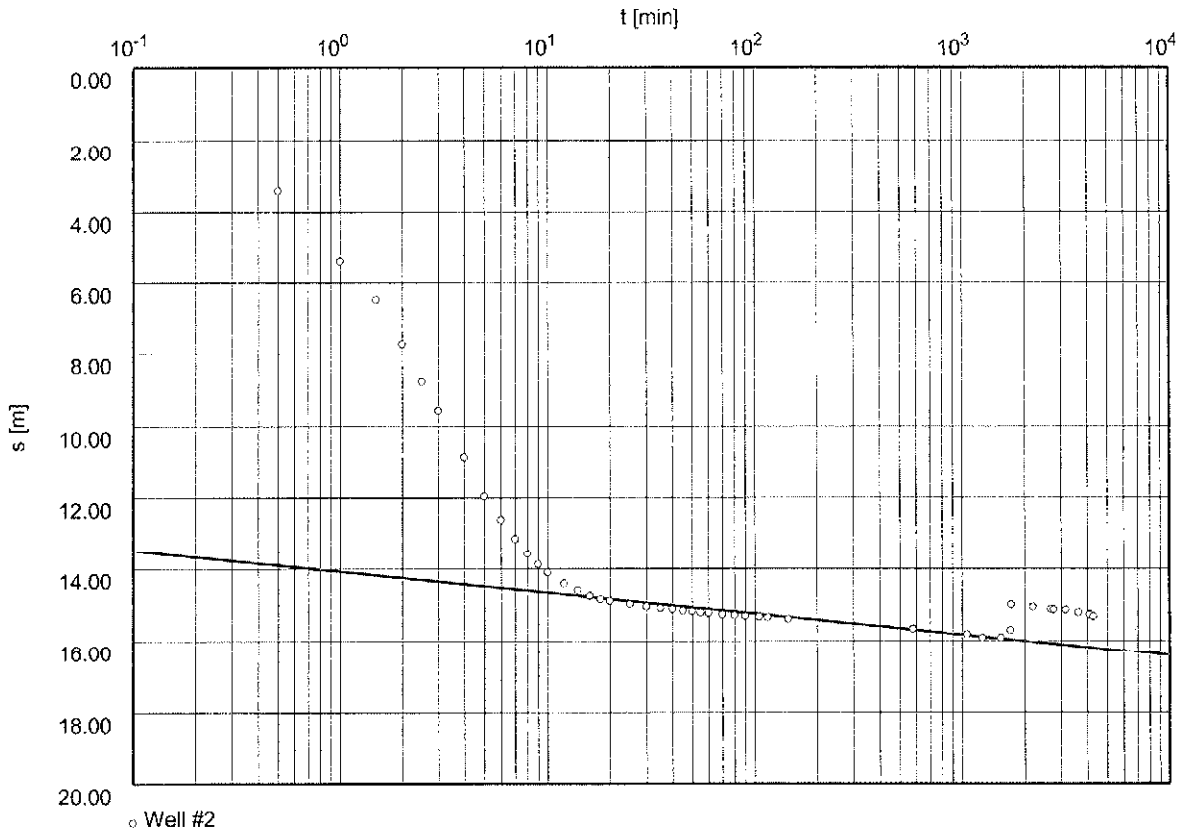
Pumping Test No. 2	Test conducted on: 07.07.2003
Well #2	
Discharge 3.25 l/s	



Transmissivity [m²/min]: 4.11×10^{-3}

WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Time-Drawdown-method after COOPER & JACOB Confined aquifer	Date: 17.07.2003	Page 1
		Project: B2422	
		Evaluated by: T. Praamsma	

Pumping Test No. 2	Test conducted on: 07.07.2003
Well #2	
Discharge 3.25 l/s	



Transmissivity [m^2/min]: 6.09×10^{-2}

Storativity: 1.38×10^{-23}

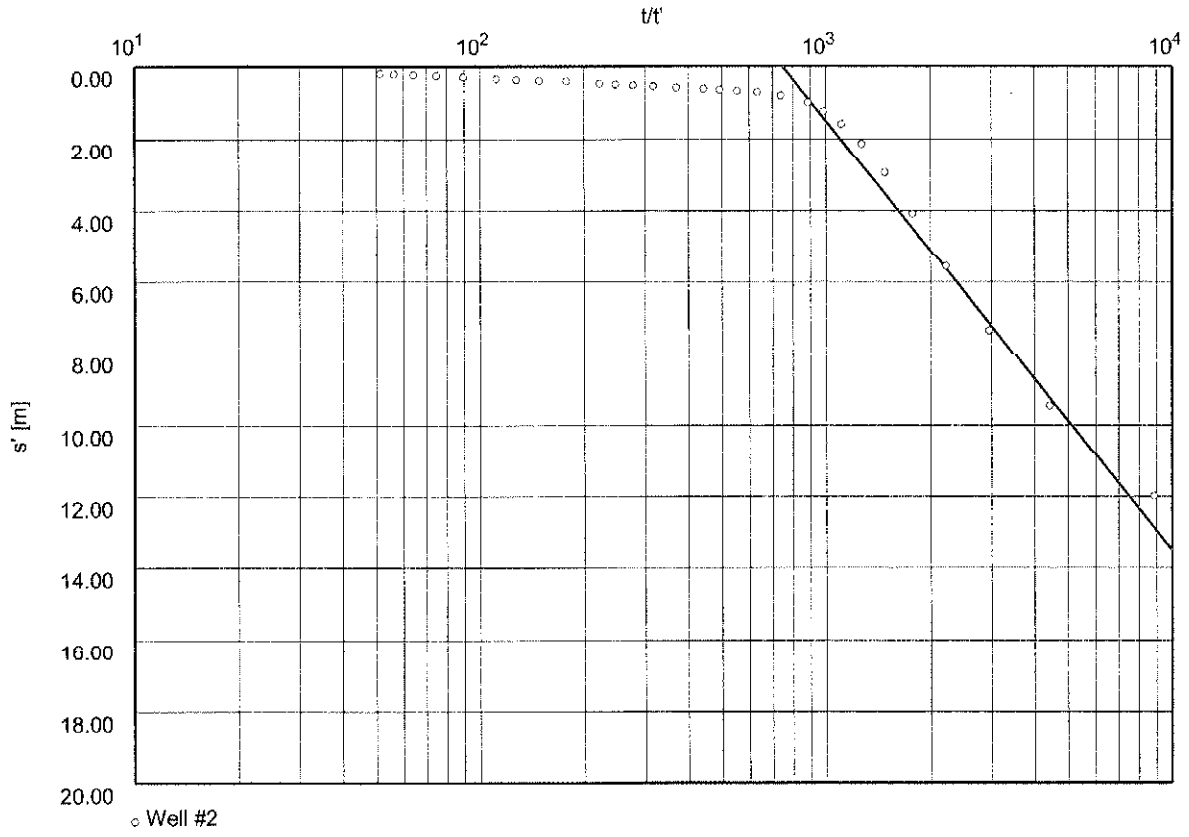
WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Recovery method after THEIS & JACOB Confined aquifer	Date: 17.07.2003	Page 2
		Project: B2422	
		Evaluated by: T. Praamsma	

Pumping Test No. 2	Test conducted on: 10.07.2003
Well #2	Well #2
Discharge 3.25 l/s	
Static water level: 3.890 m below datum	Pumping test duration: 4440.00 min

	Time from end of pumping [min]	Water level [m]	Residual drawdown [m]
2	0.50	15.870	11.980
3	1.00	13.350	9.460
4	1.50	11.220	7.330
5	2.00	9.460	5.570
6	2.50	7.970	4.080
7	3.00	6.840	2.950
8	3.50	6.020	2.130
9	4.00	5.470	1.580
10	4.50	5.115	1.225
11	5.00	4.880	0.990
12	6.00	4.690	0.800
13	7.00	4.600	0.710
14	8.00	4.560	0.670
15	9.00	4.530	0.640
16	10.00	4.505	0.615
17	12.00	4.470	0.580
18	14.00	4.430	0.540
19	16.00	4.405	0.515
20	18.00	4.380	0.490
21	20.00	4.360	0.470
22	25.00	4.290	0.400
23	30.00	4.275	0.385
24	35.00	4.250	0.360
25	40.00	4.230	0.340
26	50.00	4.180	0.290
27	60.00	4.145	0.255
28	70.00	4.115	0.225
29	80.00	4.100	0.210
30	88.00	4.080	0.190

WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Recovery method after THEIS & JACOB Confined aquifer	Date: 17.07.2003	Page 1
		Project: B2422	
		Evaluated by: T. Praamsma	

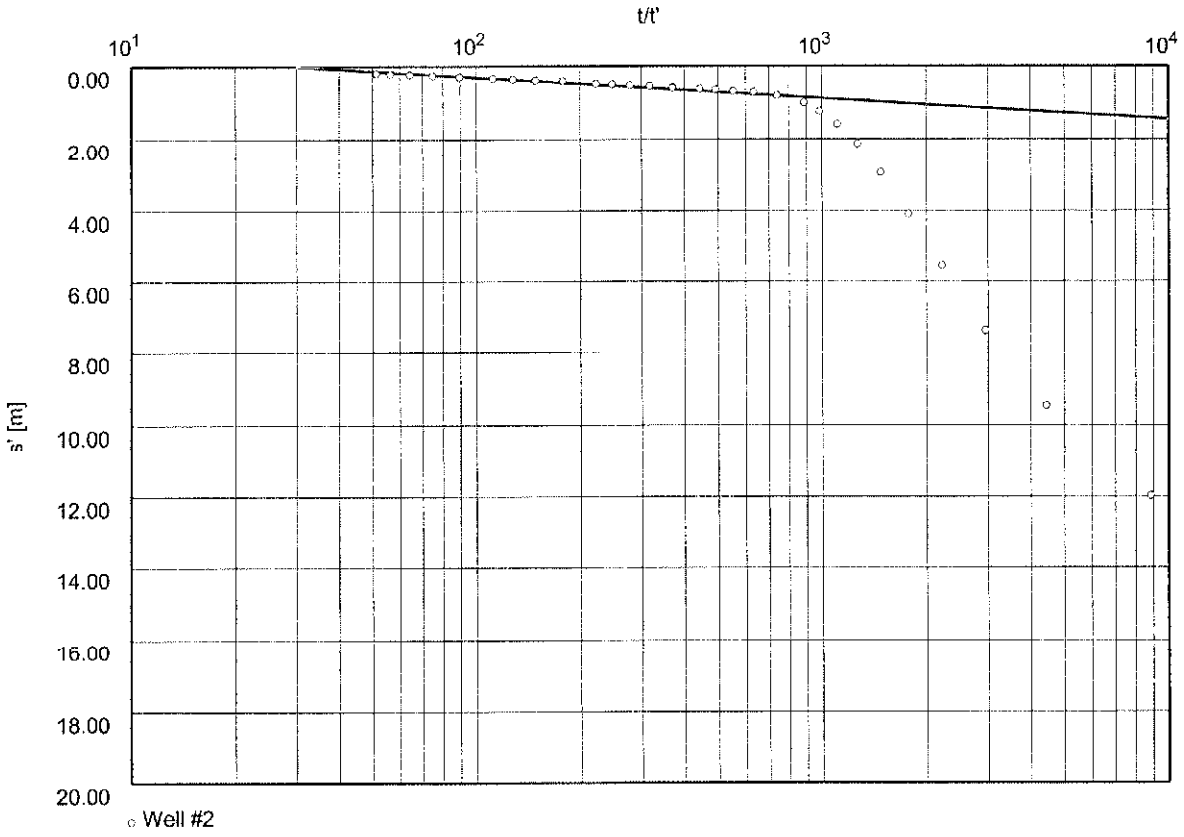
Pumping Test No. 2	Test conducted on: 10.07.2003
Well #2	
Discharge 3.25 l/s	
	Pumping test duration: 4440.00 min



Transmissivity [m²/min]: 2.97×10^{-3}

WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Recovery method after THEIS & JACOB Confined aquifer	Date: 17.07.2003	Page 1
		Project: B2422	
		Evaluated by: T. Praamsma	

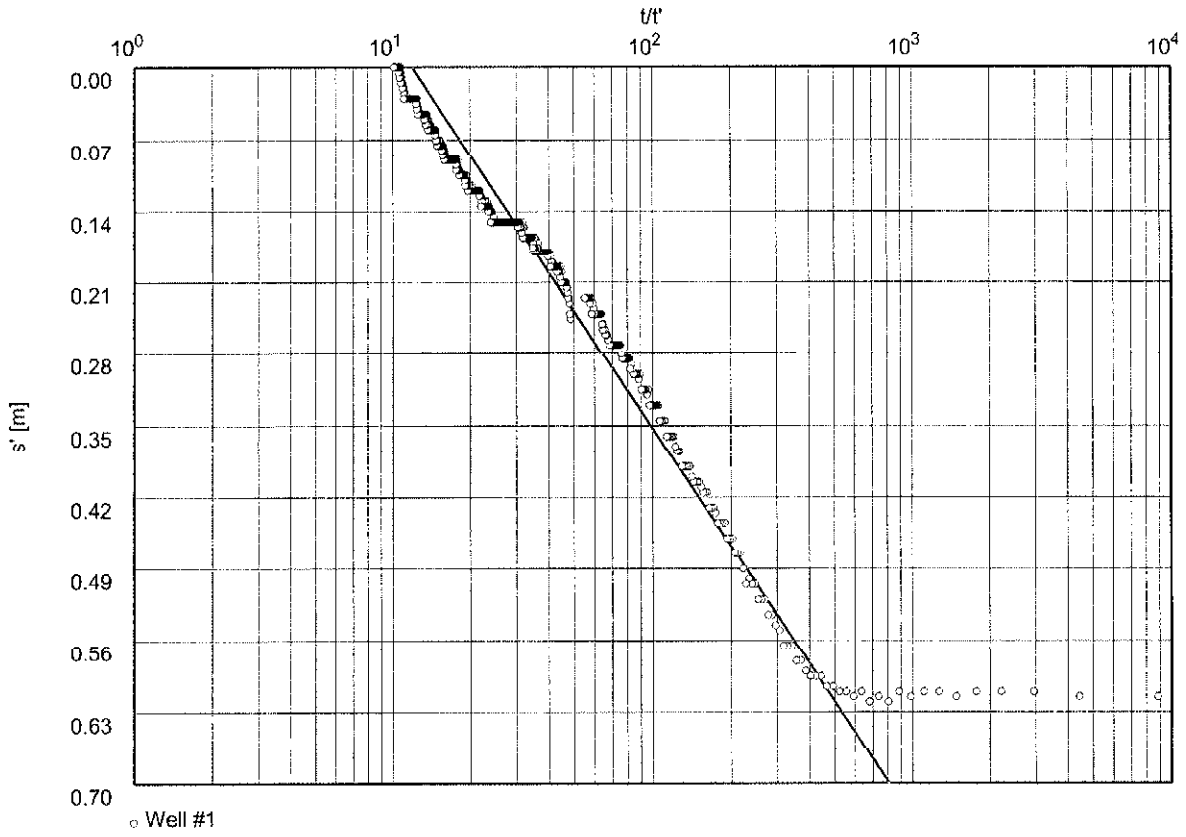
Pumping Test No. 2	Test conducted on: 10.07.2003
Well #2	
Discharge 3.25 l/s	
	Pumping test duration: 4440.00 min



Transmissivity [m²/min]: 6.24×10^{-2}

WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Recovery method after THEIS & JACOB Confined aquifer	Date: 18.07.2003	Page 1
		Project: B2422	
		Evaluated by: T. Praamsma	

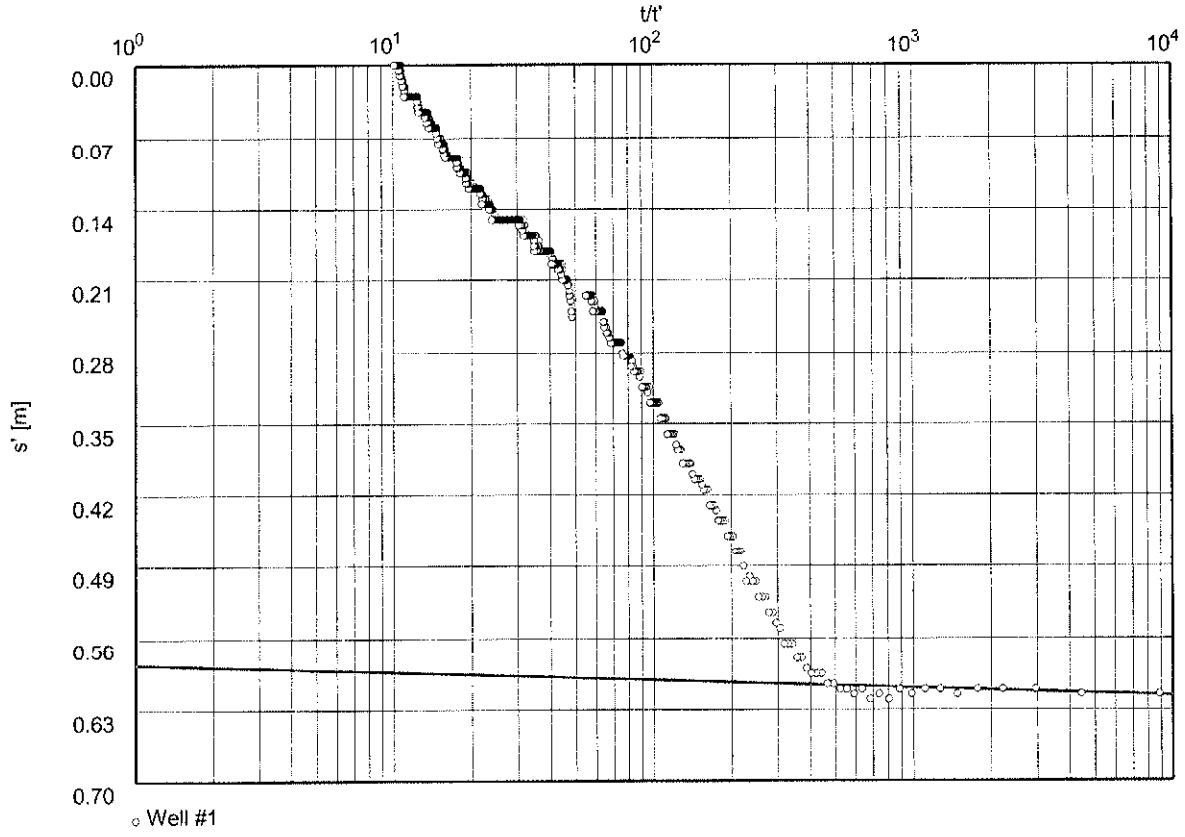
Pumping Test No. 2	Test conducted on: 10.07.2003
Well #2	
Discharge 3.25 l/s	
	Pumping test duration: 4440.00 min



Transmissivity [m²/min]: 9.34×10^{-2}

WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Recovery method after THEIS & JACOB Confined aquifer	Date: 18.07.2003	Page 1
		Project: B2422	
		Evaluated by: T. Praamsma	

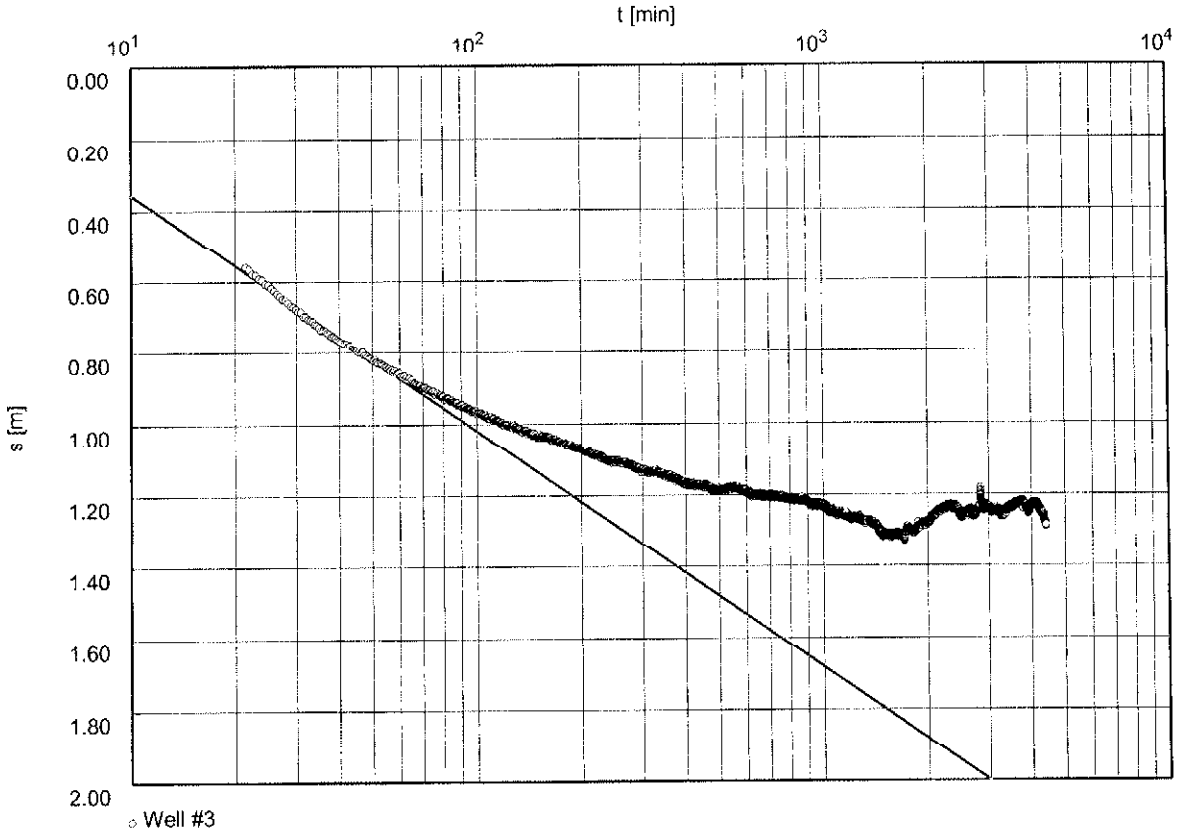
Pumping Test No. 2	Test conducted on: 10.07.2003
Well #2	
Discharge 3.25 l/s	
	Pumping test duration: 4440.00 min



Transmissivity [m²/min]: 4.70×10^{0}

WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Time-Drawdown-method after COOPER & JACOB Confined aquifer	Date: 21.07.2003	Page 1
		Project: B2422	
		Evaluated by: T. Praamsma	

Pumping Test No. 2	Test conducted on: 07.07.2003
Well #2	
Discharge 3.25 l/s	

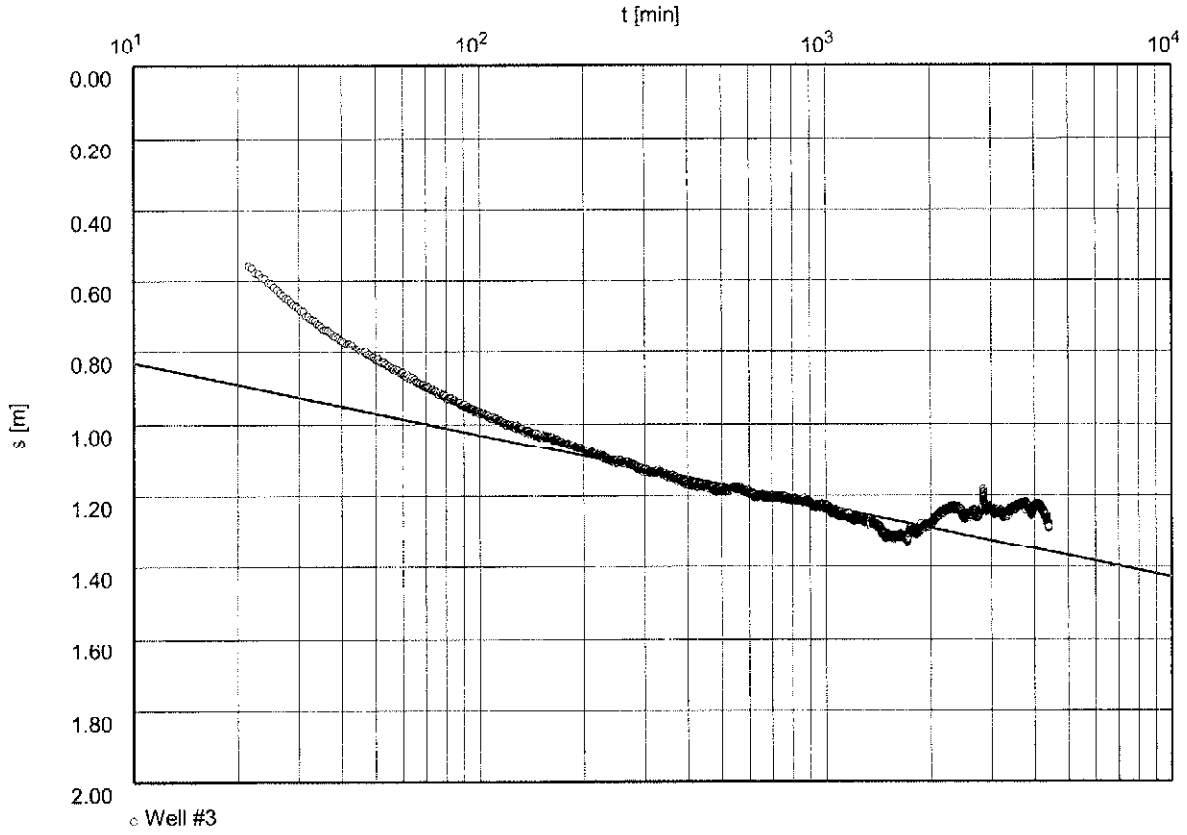


Transmissivity [m²/min]: 5.37×10^{-2}

Storativity: 6.96×10^{-5}

WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Time-Drawdown-method after COOPER & JACOB Confined aquifer	Date: 21.07.2003	Page 1
		Project: B2422	
		Evaluated by: T. Praamsma	

Pumping Test No. 2	Test conducted on: 07.07.2003
Well #2	
Discharge 3.25 l/s	

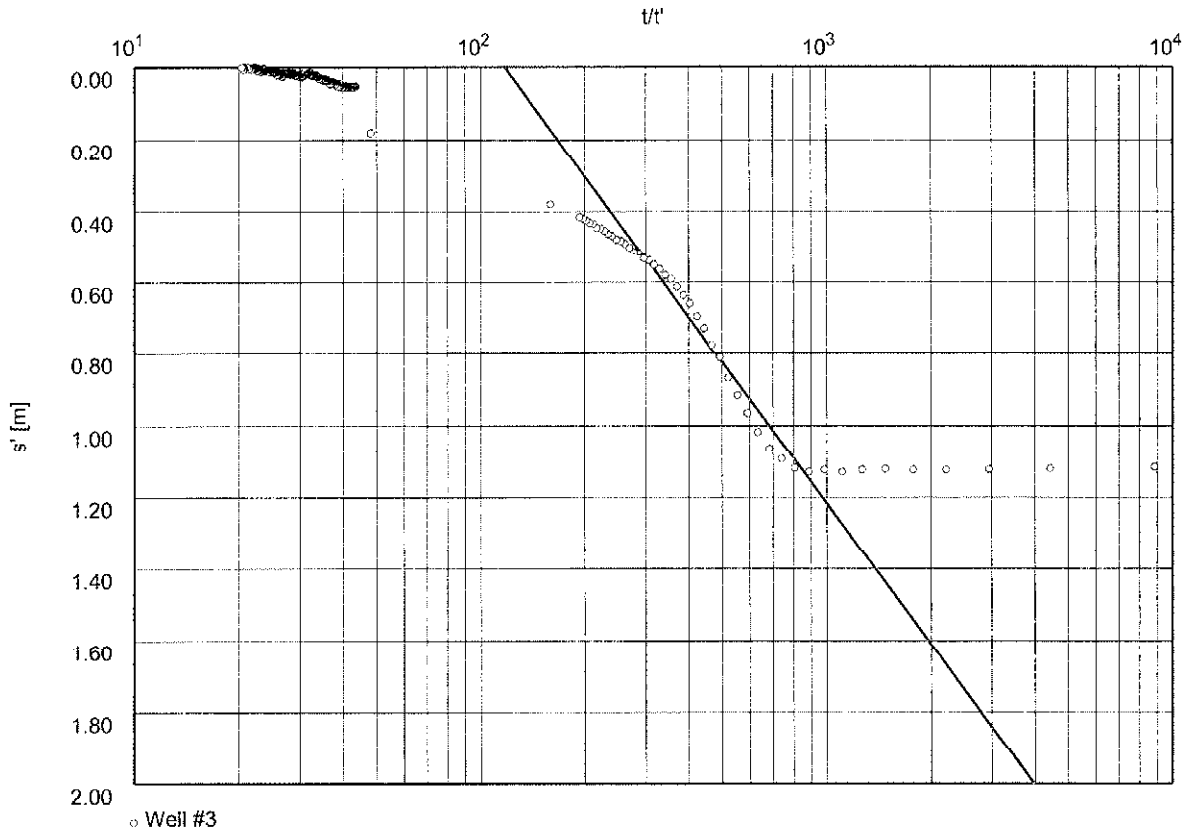


Transmissivity [m²/min]: 1.78×10^{-1}

Storativity: 5.59×10^{-6}

WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Recovery method after THEIS & JACOB Confined aquifer	Date: 21.07.2003	Page 1
		Project: B2422	
		Evaluated by: T. Praamsma	

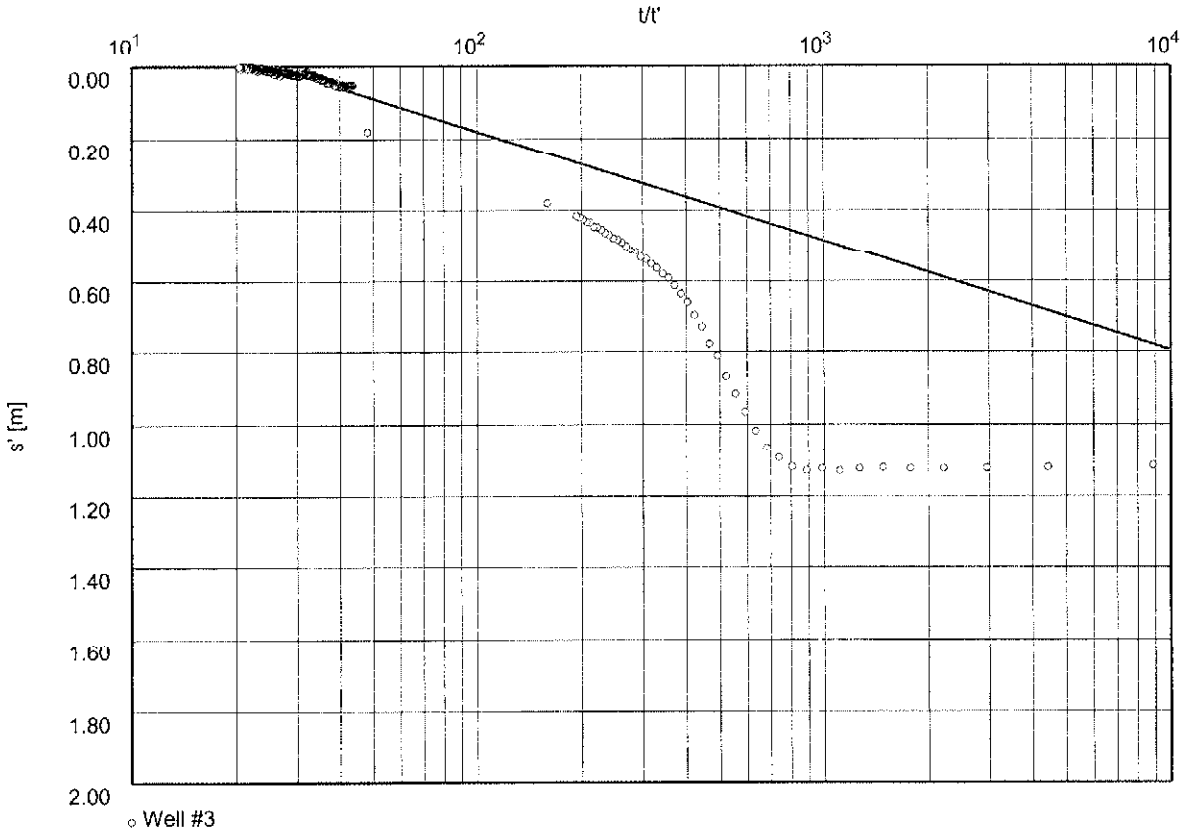
Pumping Test No. 2	Test conducted on: 10.07.2003
Well #2	
Discharge 3.25 l/s	
	Pumping test duration: 4440.00 min



Transmissivity [m²/min]: 2.72×10^{-2}

WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Recovery method after THEIS & JACOB Confined aquifer	Date: 21.07.2003	Page 1
		Project: B2422	
		Evaluated by: T. Praamsma	

Pumping Test No. 2	Test conducted on: 10.07.2003
Well #2	
Discharge 3.25 l/s	
	Pumping test duration: 4440.00 min



Transmissivity [m²/min]: 1.17×10^{-1}

WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Time-Drawdown-method after COOPER & JACOB Confined aquifer	Date: 21.08.2003	Page 2
		Project: B2422	
		Evaluated by: T. Praamsma	

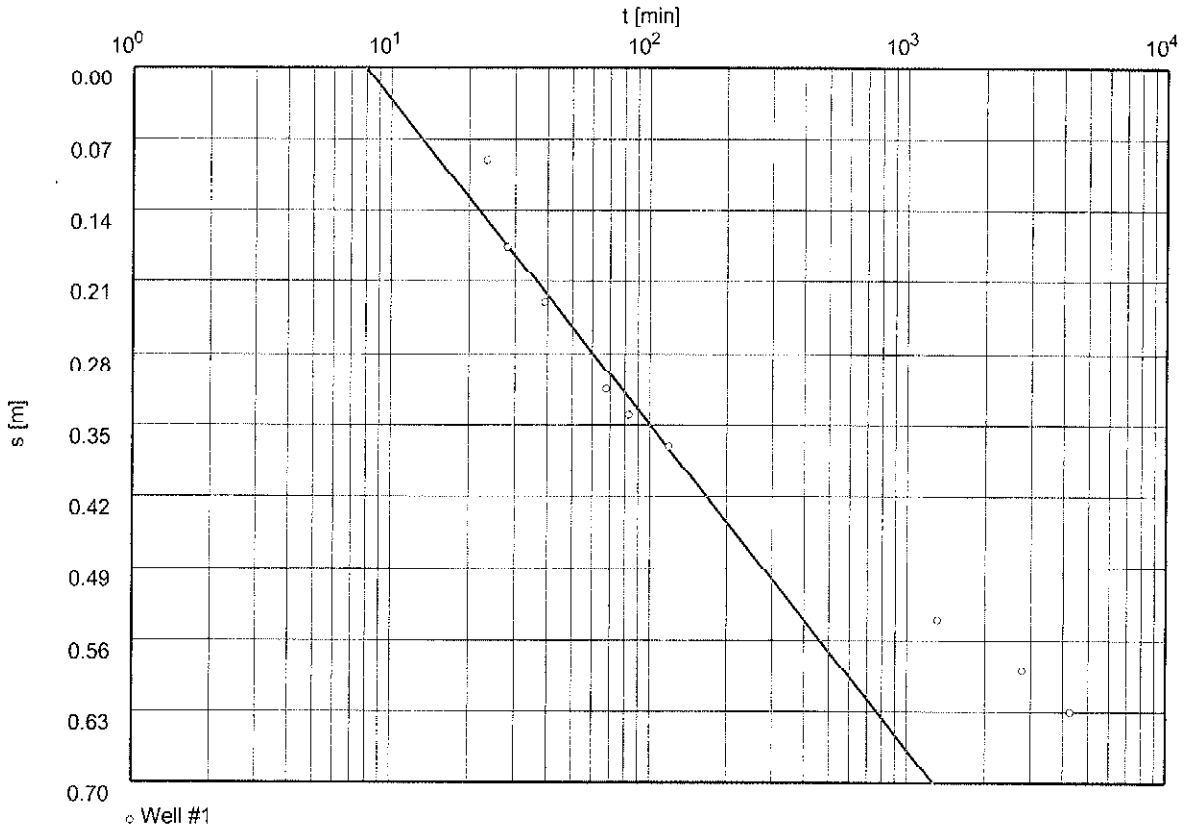
Pumping Test No. 2	Test conducted on: 07.07.2003
Well#2	Well #1
Discharge 3.25 l/s	Distance from the pumping well 145.200 m

Static water level: 4.840 m below datum

	Pumping test duration [min]	Water level [m]	Drawdown [m]
2	8.00	4.835	-0.005
3	23.50	4.930	0.090
4	28.15	5.015	0.175
5	39.15	5.070	0.230
6	68.00	5.155	0.315
7	83.00	5.180	0.340
8	119.00	5.210	0.370
9	1316.00	5.380	0.540
10	2792.00	5.430	0.590
11	4278.00	5.470	0.630

WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Time-Drawdown-method after COOPER & JACOB Confined aquifer	Date: 21.08.2003 | Page 1 Project: B2422 Evaluated by: T. Praamsma

Pumping Test No. 2	Test conducted on: 07.07.2003
Well#2	
Discharge 3.25 l/s	

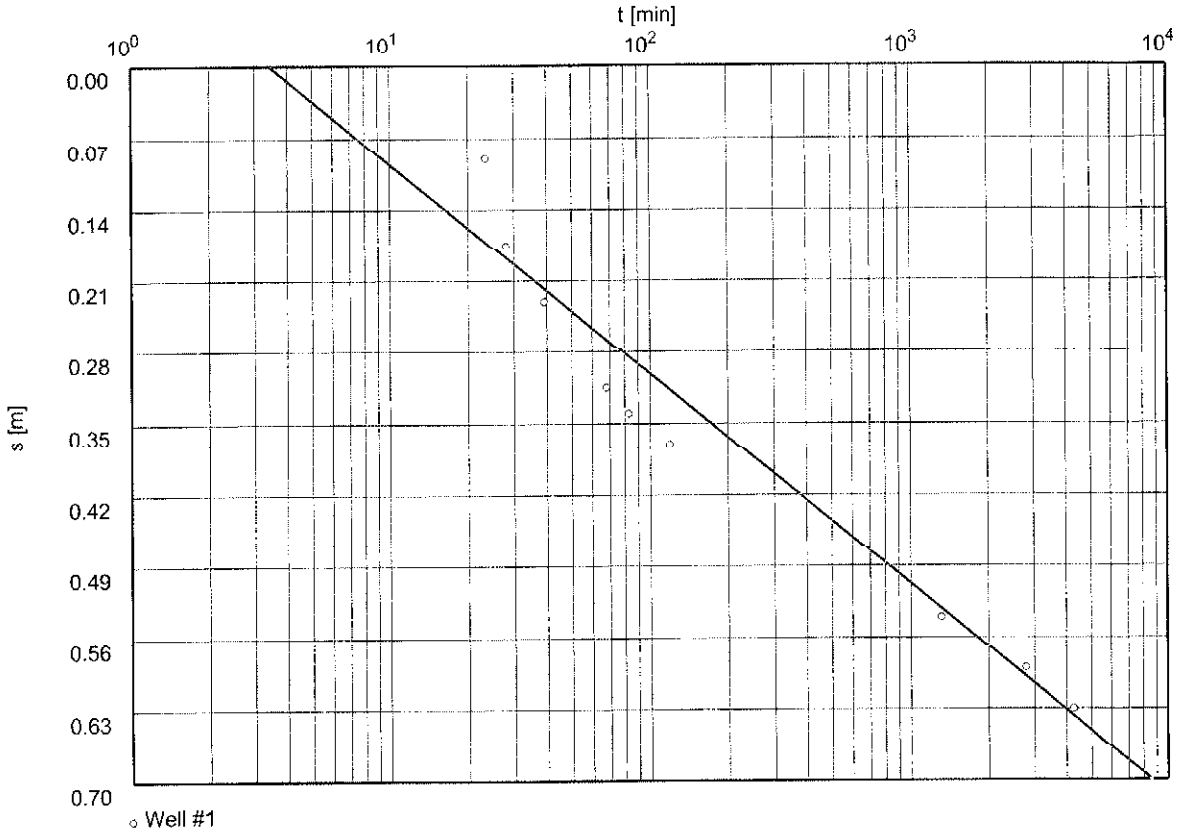


Transmissivity [m²/min]: 1.12×10^{-1}

Storativity: 9.53×10^{-5}

WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Time-Drawdown-method after COOPER & JACOB Confined aquifer	Date: 21.08.2003	Page 1
		Project: B2422	
		Evaluated by: T. Praamsma	

Pumping Test No. 2	Test conducted on: 07.07.2003
Well#2	
Discharge 3.25 l/s	



Transmissivity [m²/min]: 1.73×10^{-1}

Storativity: 6.37×10^{-5}

APPENDIX B

WELL #3 PUMPING TEST DATA AND ANALYSES

STEP TEST DATA	JOB# B2422	WELL#: Well #3

Type of aquifer test:	Step Test	Well type:	Pumping
How Q Measured:	digital flow meter	Data type:	Pumping
Dist. From pumping well (m):	0	Depth pump(m):	32 m
Meas. point for w. l.'s:	T.O.C.	Pump on: June 23/2003	9:45:00 AM
Elev. of Meas. Point (mASL):	86.96	Pump off: June 23, 2003	11:45:00 AM
Static Water Level (m):	3.94	Pumping rate:	1, 2, 3, 3.4 L/sec

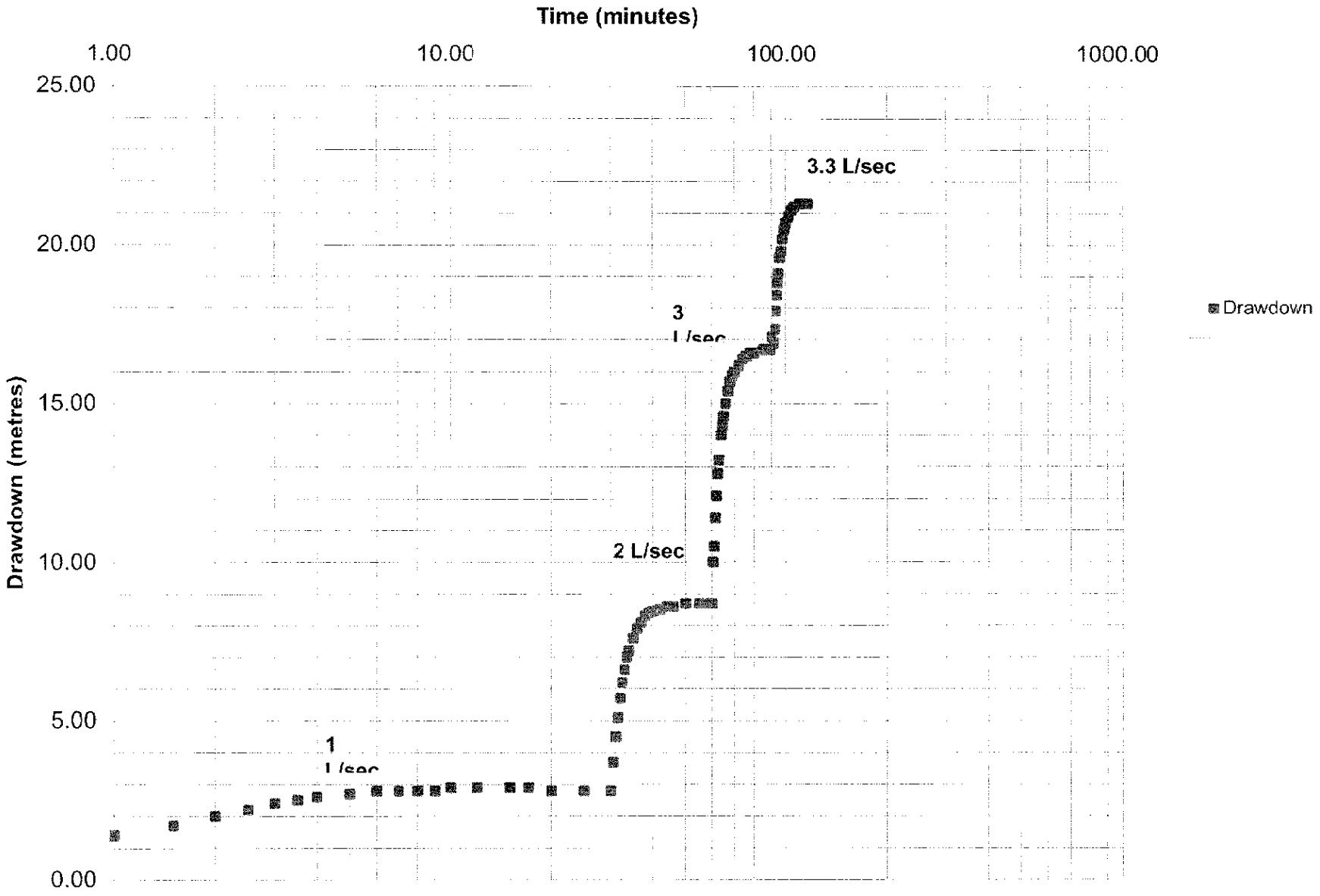
Time (min.)	Water Level (m)	Drawdown (m)	Pumping Rate (L/sec)	Comments
0.25	4.44	0.50	1	
0.50	4.84	0.90		
1.00	5.34	1.40		
1.50	5.64	1.70		
2.00	5.94	2.00		
2.50	6.14	2.20		
3.00	6.34	2.40		
3.50	6.44	2.50		
4.00	6.54	2.60		
5.00	6.64	2.70		
6.00	6.74	2.80		
7.00	6.74	2.80		
8.00	6.74	2.80		
9.00	6.74	2.80		
10.00	6.84	2.90		
12.00	6.84	2.90	0.98	
15.00	6.84	2.90	0.98	
17.00	6.84	2.90		
20.00	6.74	2.80		
25.00	6.74	2.80	0.965	
30.00	6.74	2.80	2	
30.50	7.64	3.70		
31.00	8.44	4.50		
31.50	9.04	5.10		
32.00	9.64	5.70		
32.50	10.14	6.20		
33.00	10.54	6.60		
33.50	10.94	7.00		
34.00	11.14	7.20	1.975	
35.00	11.54	7.60		
36.00	11.84	7.90		
37.00	12.04	8.10		
38.00	12.24	8.30		
39.00	12.34	8.40		
40.00	12.39	8.45		
42.00	12.44	8.50		
44.00	12.54	8.60		
46.00	12.54	8.60		
50.00	12.64	8.70	1.95	
55.00	12.64	8.70		
59.00	12.64	8.70	1.948	

STEP TEST DATA **JOB# B2422** **WELL #: Well #3**

Type of aquifer test:	Step Test	Well type:	Pumping
How Q Measured:	digital flow meter	Data type:	Pumping
Dist. From pumping well (m):	0	Depth pump(m):	32 m
Meas. point for w. l.'s:	T.O.C.	Pump on: June 23/2003	9:45:00 AM
Elev. of Meas. Point (mASL):	86.96	Pump off: June 23, 2003	11:45:00 AM
Static Water Level (m):	3.94	Pumping rate:	1, 2, 3, 3.4 L/sec

Time (min.)	Water Level (m)	Drawdown (m)	Pumping Rate (L/sec)	Comments
60.00	12.64	8.70	3	
60.50	13.94	10.00		
61.00	14.44	10.50		
61.50	15.34	11.40		
62.00	16.04	12.10		
62.50	16.74	12.80		
63.00	17.14	13.20		
64.00	17.94	14.00	2.93	
64.50	18.24	14.30		
65.00	18.54	14.60		
66.00	18.94	15.00		
67.00	19.34	15.40		
68.00	19.64	15.70		
69.00	19.84	15.90		
70.00	19.94	16.00		
72.00	20.14	16.20	2.87	
74.00	20.34	16.40		
76.00	20.44	16.50		
78.00	20.54	16.60		
80.00	20.54	16.60		
85.00	20.64	16.70		
89.00	20.64	16.70	2.81	
90.00	20.64	16.70	3.42	Gate Valve wide
90.50	21.04	17.10		open
92.00	20.84	16.90		
93.00	21.26	17.32		
93.50	21.84	17.90		
94.00	22.34	18.40		
94.50	22.74	18.80	3.39	
95.00	23.04	19.10		
96.00	23.54	19.60	3.36	
97.00	23.74	19.80	3.35	
98.00	24.14	20.20		
99.00	24.44	20.50		
100.00	24.64	20.70		
102.00	24.84	20.90	3.32	
104.00	25.04	21.10		
106.00	25.14	21.20		
110.00	25.24	21.30		
116.00	25.24	21.30	3.3	

Step Test Well #3
June 23, 2003



WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Time-Drawdown-method after COOPER & JACOB Confined aquifer	Date: 23.07.2003	Page 2
		Project: B2422	
		Evaluated by: T. Praamsma	

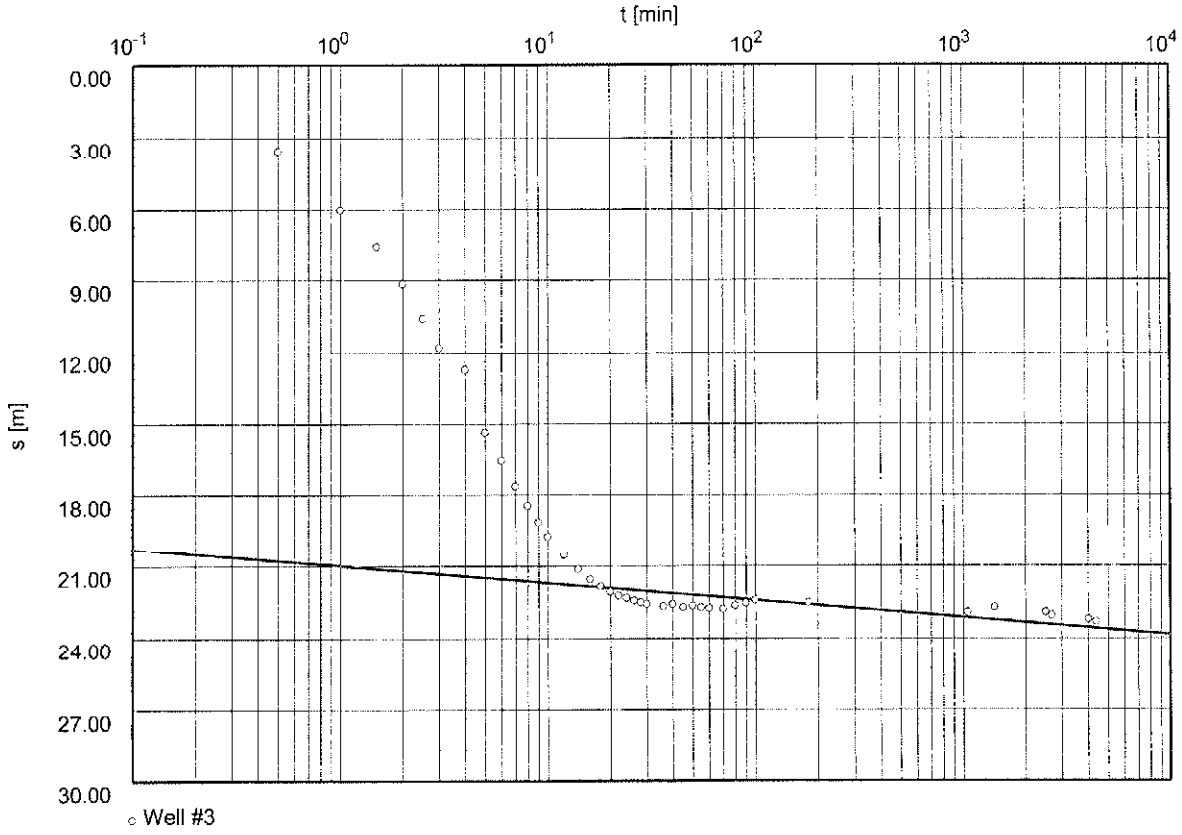
Pumping Test No. 1	Test conducted on: 23.06.2003
Well #3	Well #3
Discharge 3.37 l/s	Distance from the pumping well 0.100 m

Static water level: 3.700 m below datum

	Pumping test duration [min]	Water level [m]	Drawdown [m]
1	0.50	7.230	3.530
2	1.00	9.710	6.010
3	1.50	11.210	7.510
4	2.00	12.840	9.140
5	2.50	14.270	10.570
6	3.00	15.450	11.750
7	4.00	16.470	12.770
8	5.00	19.040	15.340
9	6.00	20.270	16.570
10	7.00	21.340	17.640
11	8.00	22.130	18.430
12	9.00	22.830	19.130
13	10.00	23.410	19.710
14	12.00	24.220	20.520
15	14.00	24.830	21.130
16	16.00	25.240	21.540
17	18.00	25.530	21.830
18	20.00	25.760	22.060
19	22.00	25.915	22.215
20	24.00	26.015	22.315
21	26.00	26.130	22.430
22	28.00	26.200	22.500
23	30.00	26.260	22.560
24	36.00	26.360	22.660
25	40.00	26.260	22.560
26	45.00	26.400	22.700
27	50.00	26.345	22.645
28	55.00	26.400	22.700
29	60.00	26.440	22.740
30	70.00	26.475	22.775
31	80.00	26.330	22.630
32	90.00	26.220	22.520
33	100.00	26.100	22.400
34	180.00	26.200	22.500
35	1050.00	26.600	22.900
36	1415.00	26.400	22.700
37	2505.00	26.600	22.900
38	2685.00	26.730	23.030
39	4035.00	26.900	23.200
40	4390.00	27.000	23.300

WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Time-Drawdown-method after COOPER & JACOB Confined aquifer	Date: 23.07.2003	Page 1
		Project: B2422	
		Evaluated by: T. Praamsma	

Pumping Test No. 1	Test conducted on: 23.06.2003
Well #3	
Discharge 3.37 l/s	

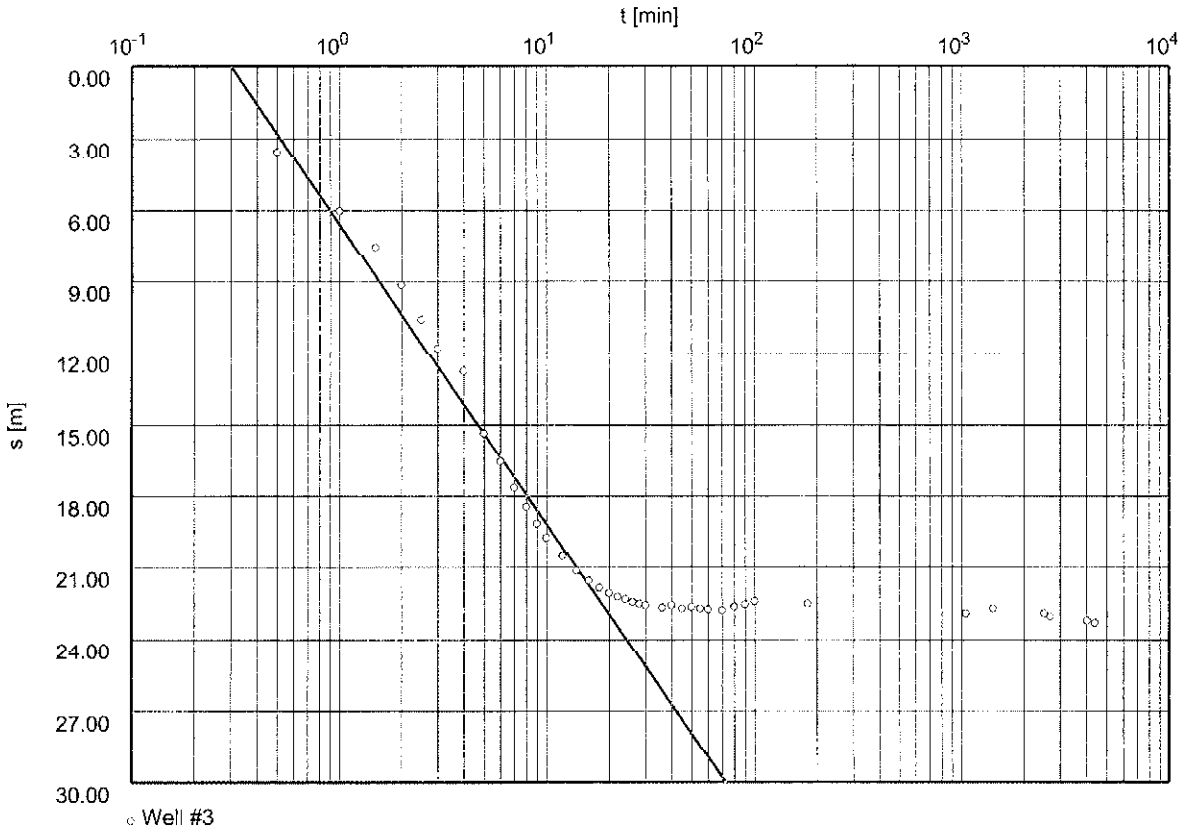


Transmissivity [m²/min]: 5.18×10^{-2}

Storativity: 5.03×10^{-20}

WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Time-Drawdown-method after COOPER & JACOB Confined aquifer	Date: 23.07.2003	Page 1
		Project: B2422	
		Evaluated by: T. Praamsma	

Pumping Test No. 1	Test conducted on: 23.06.2003
Well #3	
Discharge 3.37 l/s	



Transmissivity [m²/min]: 2.94×10^{-3}

Storativity: 1.99×10^{-1}

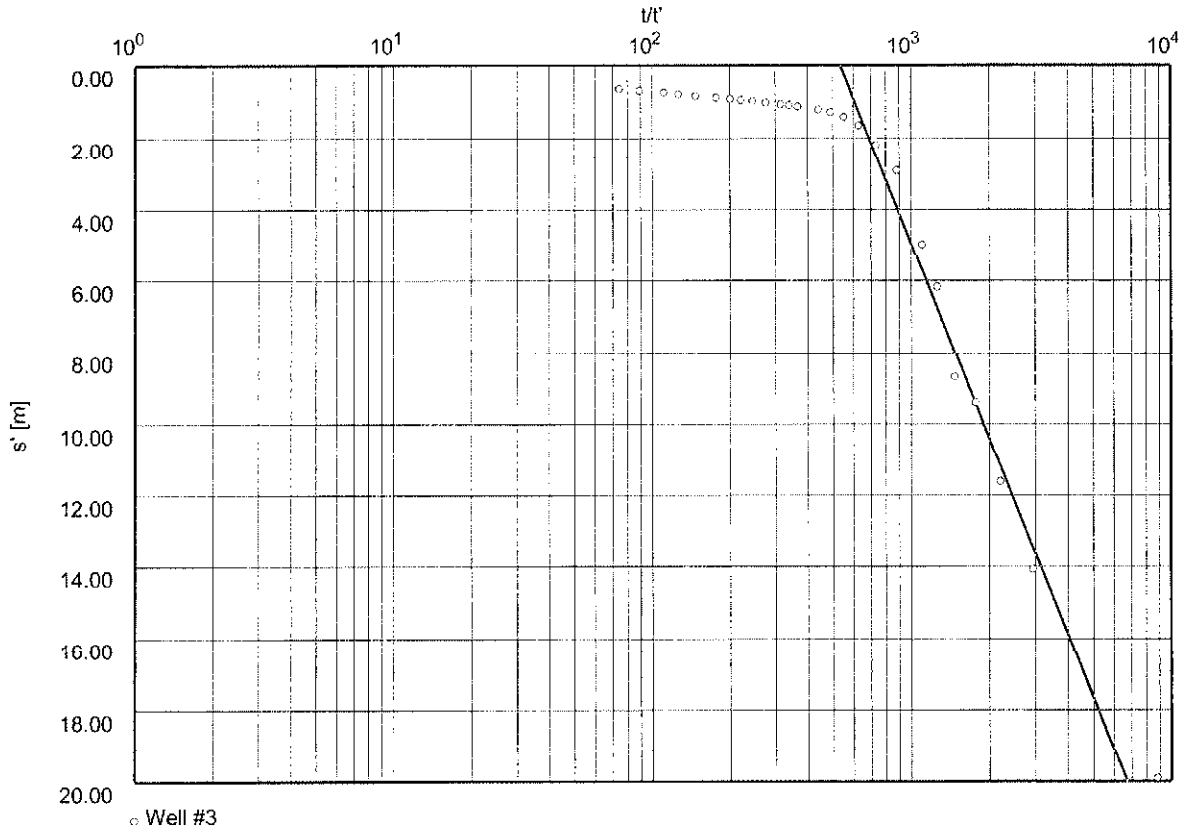
WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Recovery method after THEIS & JACOB Confined aquifer	Date: 23.07.2003	Page 2
		Project: B2422	
		Evaluated by: T. Praamsma	

Pumping Test No. 1	Test conducted on: 23.06.2003
Well #3	Well #3
Discharge 3.37 l/s	Distance from the pumping well 0.100 m
Static water level: 3.700 m below datum	Pumping test duration: 4411.00 min

	Time from end of pumping [min]	Water level [m]	Residual drawdown [m]
1	0.50	23.590	19.890
2	1.50	17.770	14.070
3	2.00	15.310	11.610
4	2.50	13.100	9.400
5	3.00	12.390	8.690
6	3.50	9.870	6.170
7	4.00	8.660	4.960
8	5.00	6.610	2.910
9	6.00	5.890	2.190
10	7.00	5.350	1.650
11	8.00	5.110	1.410
12	9.00	4.990	1.290
13	10.00	4.910	1.210
14	12.00	4.830	1.130
15	13.00	4.790	1.090
16	14.00	4.760	1.060
17	16.00	4.720	1.020
18	18.00	4.680	0.980
19	20.00	4.650	0.950
20	22.00	4.620	0.920
21	25.00	4.580	0.880
22	30.00	4.530	0.830
23	35.00	4.480	0.780
24	40.00	4.440	0.740
25	50.00	4.390	0.690
26	60.00	4.340	0.640
27	1424.00	3.640	-0.060

WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Recovery method after THEIS & JACOB Confined aquifer	Date: 23.07.2003	Page 1
		Project: B2422	
		Evaluated by: T. Praamsma	

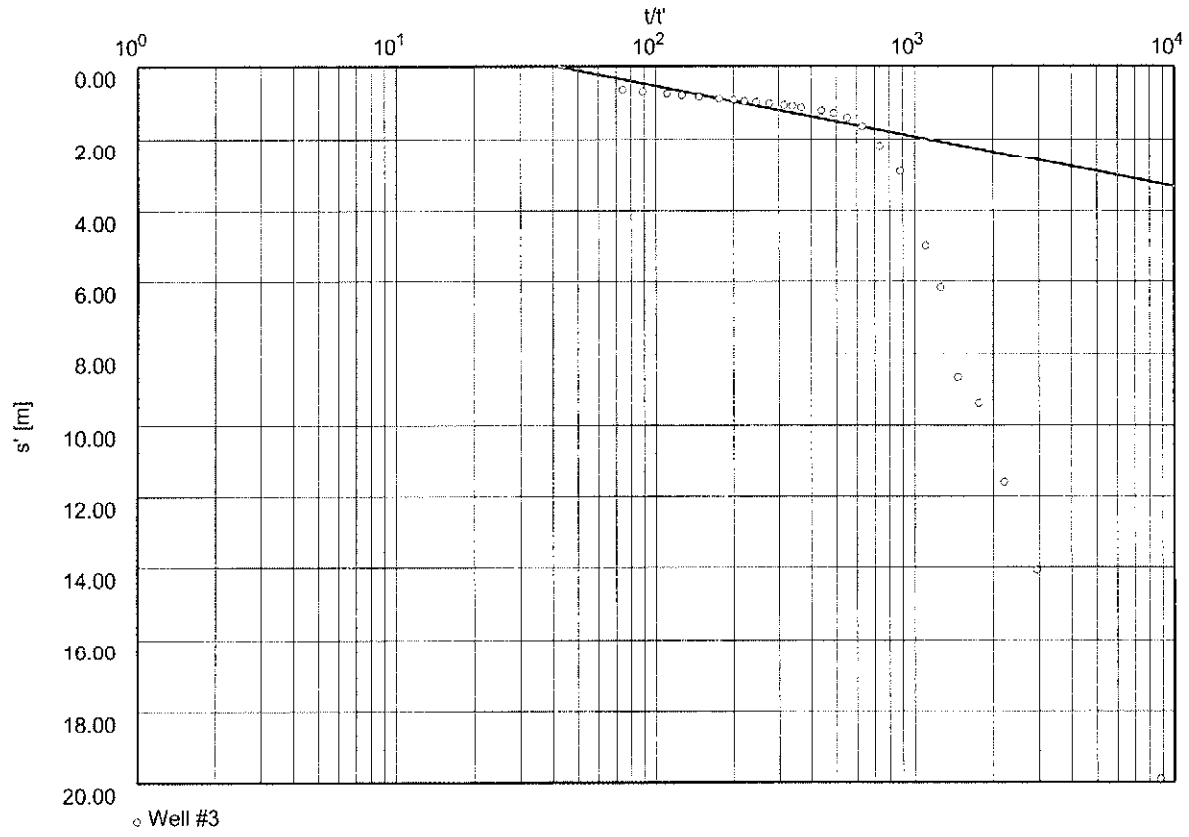
Pumping Test No. 1	Test conducted on: 23.06.2003
Well #3	
Discharge 3.37 l/s	
	Pumping test duration: 4411.00 min



Transmissivity [m²/min]: 2.03×10^{-3}

WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Recovery method after THEIS & JACOB Confined aquifer	Date: 23.07.2003	Page 1
		Project: B2422	
		Evaluated by: T. Praamsma	

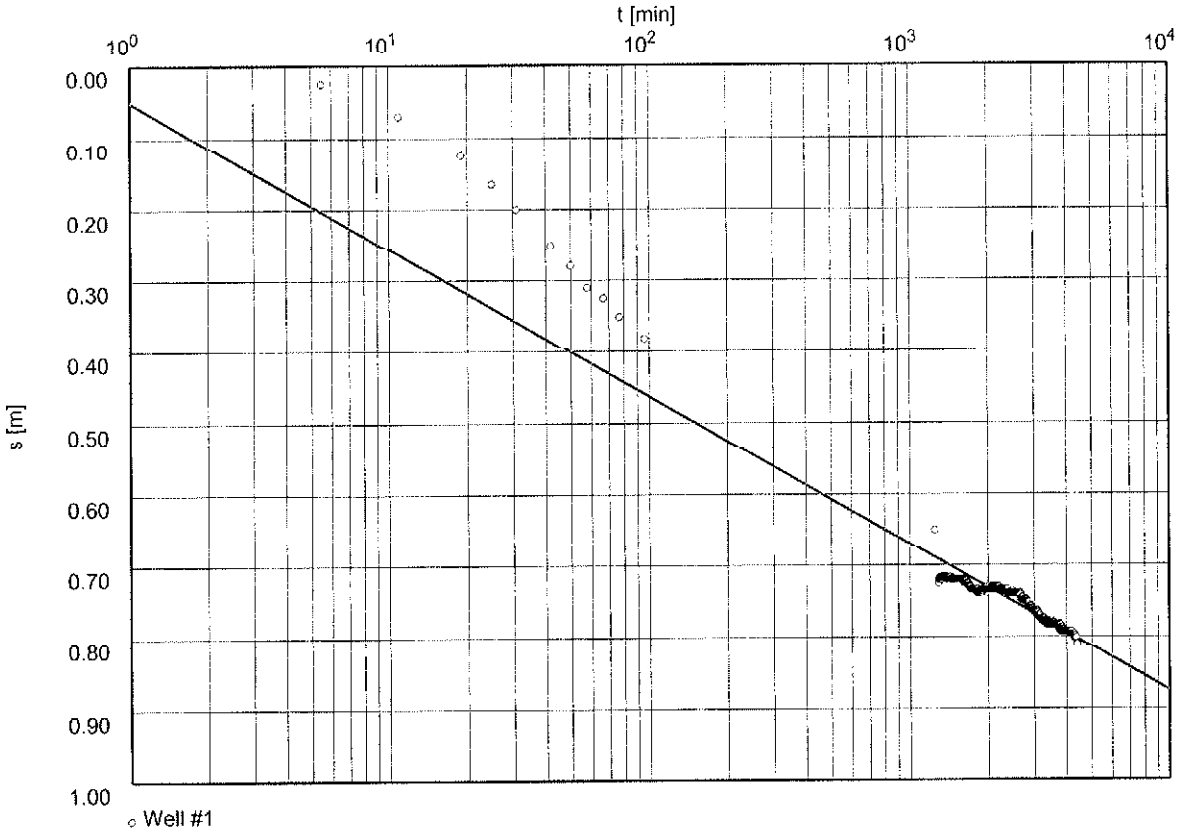
Pumping Test No. 1	Test conducted on: 23.06.2003
Well #3	
Discharge 3.37 l/s	
	Pumping test duration: 4411.00 min



Transmissivity [m²/min]: 2.64×10^{-2}

WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Time-Drawdown-method after COOPER & JACOB Confined aquifer	Date: 23.07.2003	Page 1
		Project: B2422	
		Evaluated by: T. Praamsma	

Pumping Test No. 1	Test conducted on: 23.06.2003
Well #3	
Discharge 3.37 l/s	

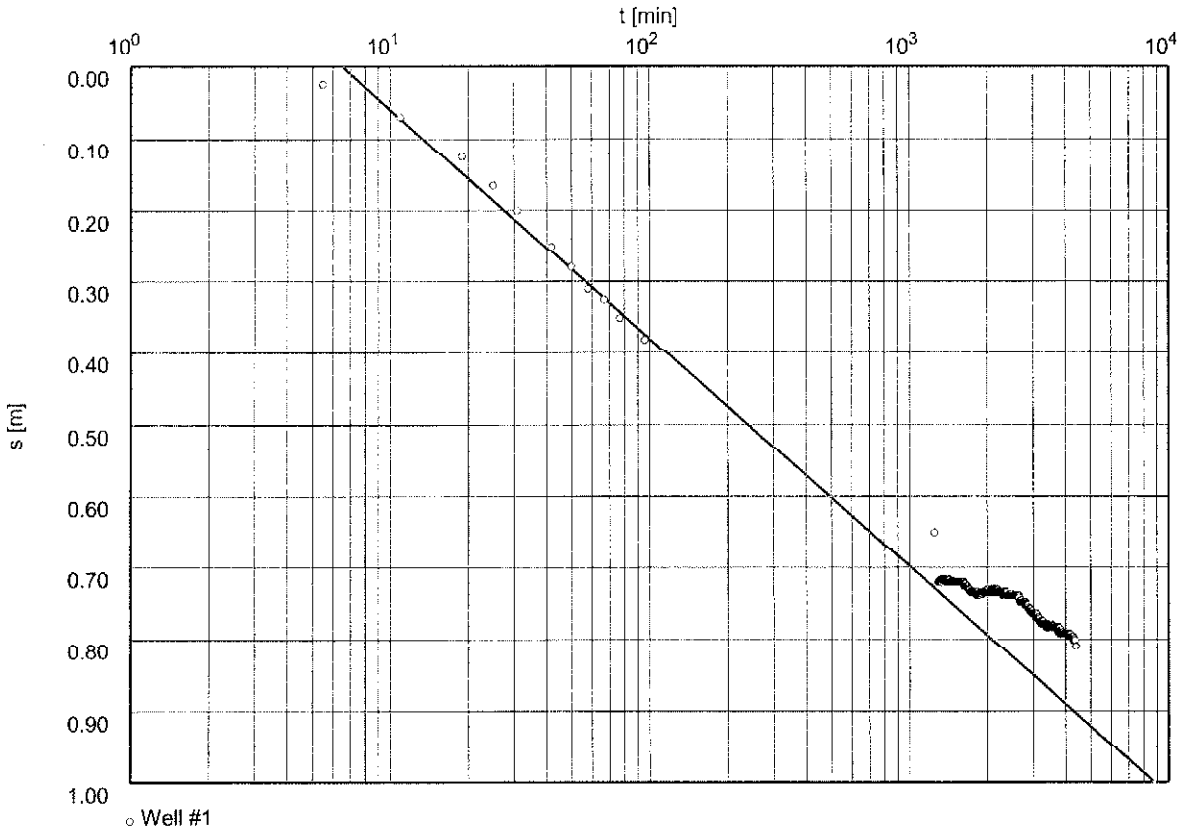


Transmissivity [m²/min]: 1.79×10^{-1}

Storativity: 7.94×10^{-6}

WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Time-Drawdown-method after COOPER & JACOB Confined aquifer	Date: 23.07.2003	Page 1
		Project: B2422	
		Evaluated by: T. Praamsma	

Pumping Test No. 1	Test conducted on: 23.06.2003
Well #3	
Discharge 3.37 l/s	

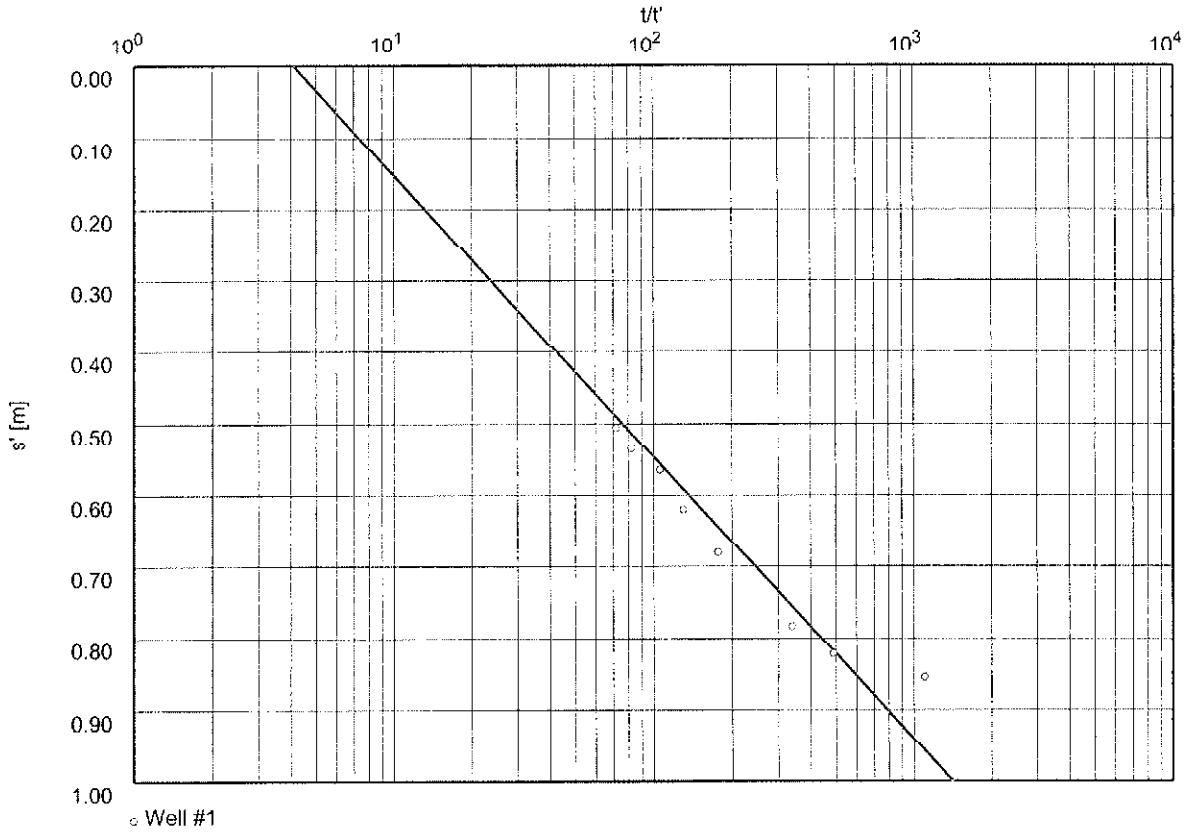


Transmissivity [m²/min]: 1.15×10^{-1}

Storativity: 5.84×10^{-5}

WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Recovery method after THEIS & JACOB Confined aquifer	Date: 23.07.2003	Page 1
		Project: B2422	
		Evaluated by: T. Praamsma	

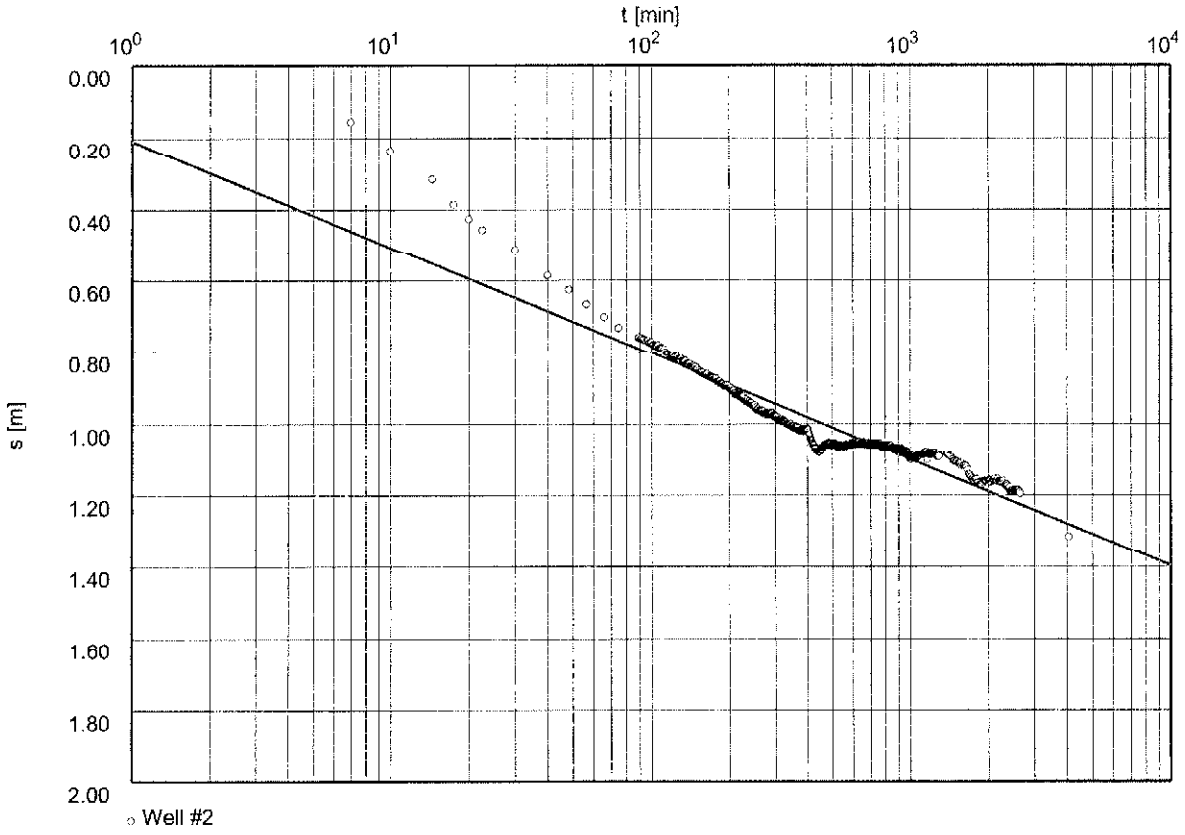
Pumping Test No. 1	Test conducted on: 23.06.2003
Well #3	
Discharge 3.37 l/s	
	Pumping test duration: 4411.00 min



Transmissivity [m²/min]: 9.39×10^{-2}

WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Time-Drawdown-method after COOPER & JACOB Confined aquifer	Date: 24.07.2003	Page 1
		Project: B2422	
		Evaluated by: T. Praamsma	

Pumping Test No. 1	Test conducted on: 23.06.2003
Well #3	
Discharge 3.37 l/s	

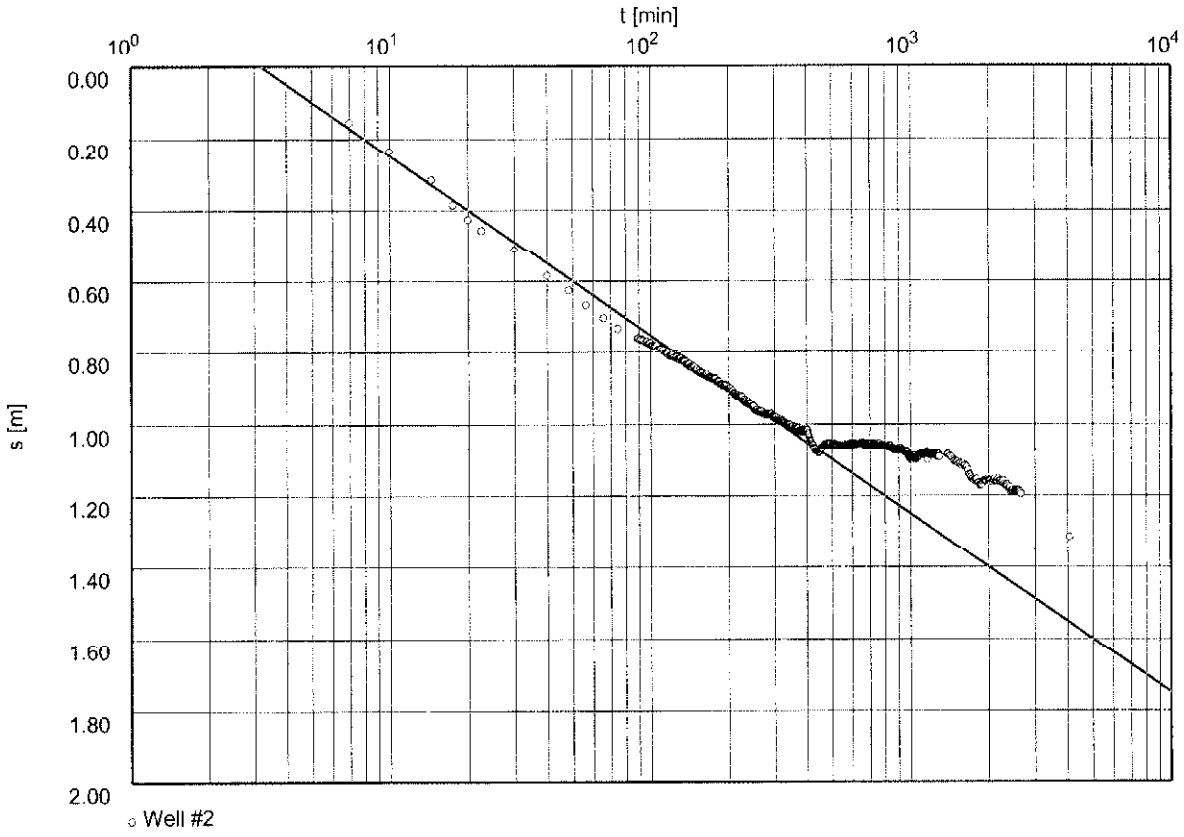


Transmissivity [m²/min]: 1.24×10^{-1}

Storativity: 1.10×10^{-5}

WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Time-Drawdown-method after COOPER & JACOB Confined aquifer	Date: 24.07.2003	Page 1
		Project: B2422	
		Evaluated by: T. Praamsma	

Pumping Test No. 1	Test conducted on: 23.06.2003
Well #3	
Discharge 3.37 l/s	

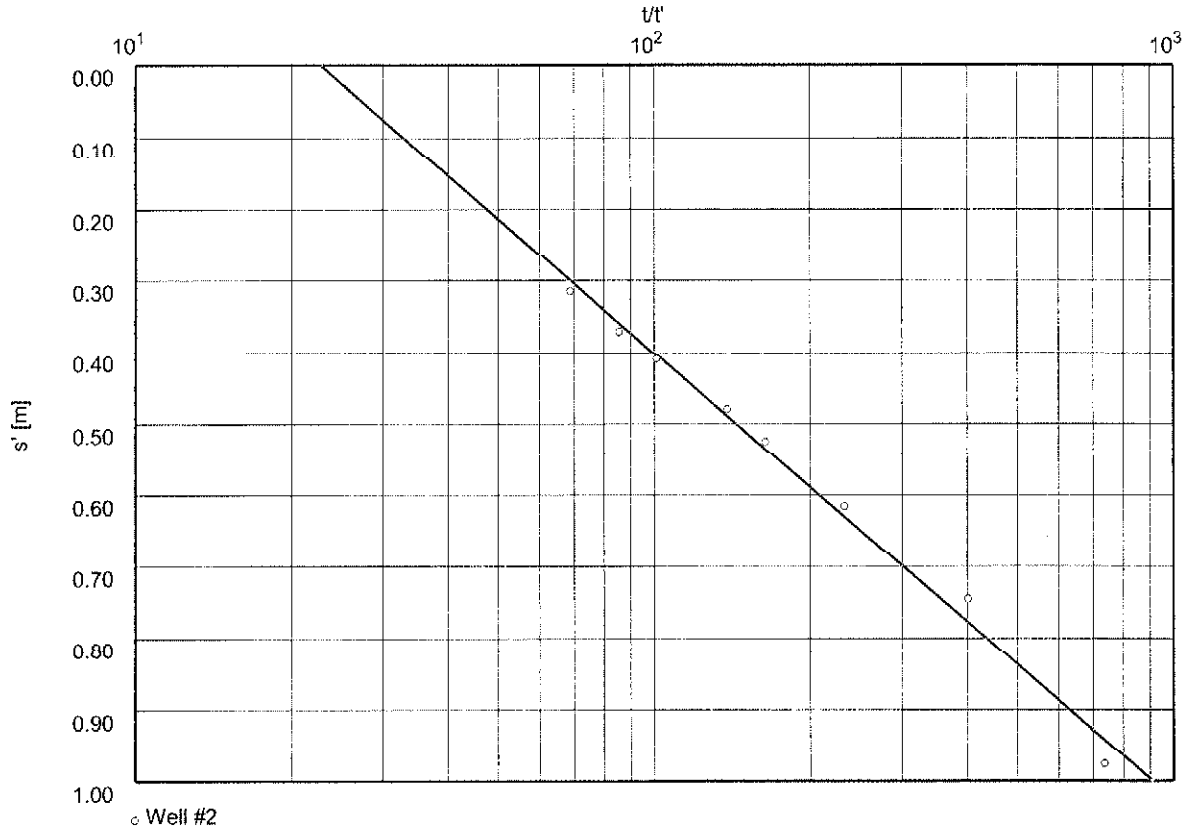


Transmissivity [m²/min]: 7.39×10^{-2}

Storativity: 1.04×10^{-4}

WESA 3108 Carp Road Carp, Ontario 613-839-3053	Pumping test analysis Recovery method after THEIS & JACOB Confined aquifer	Date: 24.07.2003	Page 1
		Project: B2422	
		Evaluated by: T. Praamsma	

Pumping Test No. 1	Test conducted on: 23.06.2003
Well #3	
Discharge 3.37 l/s	
	Pumping test duration: 4411.00 min



Transmissivity [m²/min]: 5.93×10^{-2}

APPENDIX C

SUSTAINABLE WELL YIELD CALCULATIONS

WELL #2 THEORETICAL WELL YIELD CALCULATIONS

Using Theis Nonequilibrium Equation:

$$u = \frac{r^2 S}{4Tt}, \quad Q(max) = \frac{4\P Ts}{W(u)}$$

S = **0.00001**
s = **6** **metres (max. available drawdown, simultaneous pumping of Well #**
= **20 m (avail. Drawdown) - 10 m (Well Loss) - 4 m (Well #3 interference)**
r = **0.2** **metres (16" diameter borehole)**

for T = **87.7** **m²/day**
(representative value)

(1) 10 Year Sustainable Yield:

t = 3650 days

therefore, u = 3.12E-13
W(u) = 28.22
Q(max) = 234.3 m^3/day
= 36.8 IGPM
= 2.8 l/sec

(2) 20 Year Sustainable Yield:

for t = 7300 days

therefore, u = 1.56E-13
W(u) = 28.91
Q(max) = 228.7 m^3/day
= 36.0 IGPM
= 2.7 l/sec

(3) Safe Perennial Yield:

for t = 365 days

therefore, u = 3.12E-12
W(u) = 25.91
Q(max) = 255.2 m^3/day
= 40.1 IGPM
= 3.0 l/sec

WELL #2 THEORETICAL INTERFERENCE CALCULATIONS

Using Theis Nonequilibrium Equation:

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

S = 0.00001

for T = 87.7 m^2/day

20-year Theoretical Drawdowns

(1) Q = 216 m^3/day = 2.5 L/sec

t = 7300 days

Radius (m)	u	W(u)	Theoretical s
0.2 Well#2	1.56E-13	28.91	5.7
71.4 Well#3	1.99E-08	17.15	3.4
145.2 Well#1	8.23E-08	15.74	3.1
500	9.76E-07	13.26	2.6
1000	3.90E-06	11.88	2.3

(2) Q = 233.28 m^3/day = 2.7 L/sec

t = 7300 days

Radius (m)	u	W(u)	s (m)
0.2 Well#2	1.56E-13	28.91	6.1
71.4 Well#3	1.99E-08	17.15	3.6
145.2 Well#1	8.23E-08	15.74	3.3
500	9.76E-07	13.26	2.8
1000	3.90E-06	11.88	2.5

(3) Q = 250.56 m^3/day = 2.9 L/sec

t = 7300 days

Radius (m)	u	W(u)	s (m)
0.2 Well#2	1.56E-13	28.91	6.6
71.4 Well#3	1.99E-08	17.15	3.9
145.2 Well#1	8.23E-08	15.74	3.6
500	9.76E-07	13.26	3.0
1000	3.90E-06	11.88	2.7

(4) Q = 267.84 m^3/day = 3.1 L/sec

t = 7300 days

Radius (m)	u	W(u)	s (m)
0.2 Well#2	1.56E-13	28.91	7.0
71.4 Well#3	1.99E-08	17.15	4.2
145.2 Well#1	8.23E-08	15.74	3.8
500	9.76E-07	13.26	3.2
1000	3.90E-06	11.88	2.9

WELL #3 THEORETICAL WELL YIELD CALCULATIONS

Using Theis Nonequilibrium Equation:

$$u = \frac{r^2 S}{4Tt}, \quad Q(max) = \frac{4\P Ts}{W(u)}$$

S = **0.00001**
s = **7** **metres (max. avail.drawdown, simultaneous pumping of Well #2)**
= **22 m (avail. Drawdown) - 11 m (Well Loss) - 4 m (Well #2 interference)**
r = **0.2** **metres (16" diameter borehole)**

for T = **74.59** **m²/day**
(representative value)

(1) 10 Year Sustainable Yield:

t =	3650	days
therefore, u =	3.67E-13	
W(u) =	28.06	
Q(max) =	233.9	m^3/day
=	36.8	IGPM
=	2.8	l/sec

(2) 20 Year Sustainable Yield:

for t =	7300	days
therefore, u =	1.84E-13	
W(u) =	28.75	
Q(max) =	228.2	m^3/day
=	35.9	IGPM
=	2.7	l/sec

(3) Safe Perrenial Yield:

for t =	365	days
therefore, u =	3.67E-12	
W(u) =	25.75	
Q(max) =	254.8	m^3/day
=	40.1	IGPM
=	3.0	l/sec

WELL #2 THEORETICAL INTERFERENCE CALCULATIONS

Using Theis Nonequilibrium Equation:

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

S = 0.00001

for T = 74.59 m^2/day

20-year Theoretical Drawdowns

(1) Q = 216 m^3/day = 2.5 L/sec

t = 7300 days

Radius (m)	u	W(u)	Theoretical s
0.2 Well#3	1.84E-13	28.75	6.6
71.4 Well#2	2.34E-08	16.99	3.9
145.2 Well#1	9.68E-08	15.57	3.6
500	1.15E-06	13.10	3.0
1000	4.59E-06	11.71	2.7

(2) Q = 233.28 m^3/day = 2.7 L/sec

t = 7300 days

Radius (m)	u	W(u)	s (m)
0.2 Well#3	1.84E-13	28.75	7.2
71.4 Well#2	2.34E-08	16.99	4.2
145.2 Well#1	9.68E-08	15.57	3.9
500	1.15E-06	13.10	3.3
1000	4.59E-06	11.71	2.9

(3) Q = 241.9 m^3/day = 2.8 L/sec

t = 7300 days

Radius (m)	u	W(u)	s (m)
0.2 Well#3	1.84E-13	28.75	7.4
71.4 Well#2	2.34E-08	16.99	4.4
145.2 Well#1	9.68E-08	15.57	4.0
500	1.15E-06	13.10	3.4
1000	4.59E-06	11.71	3.0

(4) Q = 267.84 m^3/day = 3.1 L/sec

t = 7300 days

Radius (m)	u	W(u)	s (m)
0.2 Well#3	1.84E-13	28.75	8.2
71.4 Well#2	2.34E-08	16.99	4.9
145.2 Well#1	9.68E-08	15.57	4.5
500	1.15E-06	13.10	3.7
1000	4.59E-06	11.71	3.3