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Oskarshamn site investigation

Pumping tests and water sampling in borehole KLX04, 2004

Sub-area Laxemar

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January 2005

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Keywords: Site/project, Hydrogeology, Hydraulic tests, Pump tests, Flow logging, Hydraulic parameters, Transmissivity, Water sampling.

Abstract

Upon completion of the injection tests, pump tests have been performed during water sampling in borehole KLX04 at the Laxemar Area, Oskarshamn. The pump tests are part of the general program for site investigations and specifically for the Laxemar sub-area. The main objective was to take water samples in certain depths for chemical analyses. The data of the pumping tests were analysed to characterize the rock with respect to its hydraulic properties. Data is subsequently delivered for the site descriptive model.

This report describes the results and primary data evaluation of the hydraulic pump tests in borehole KLX04 between 9^{th} and 30^{th} of September 2004.

Sammanfattning

Efter avslutade injektionstester utfördes vattenprovtagning och pumptester i borrhål KLX04, Laxemarområdet, Oskarshamn. Huvudsyftet med pumpningen var primärt provtagning av grundvatten på olika djup för kemiska analyser. I samband med provtagningen har dock pumptester utförts vilka är en del av undersökningsprogrammet för platsundersökningarna vid Laxemarområdet. Pumptest data har analyserats för karakterisering av berget med avseende på dess hydrauliska egenskaper. Data levereras till den platsspecifika modellen.

Denna rapport redovisar resultaten och utvärderingen av primärdata från pumptesterna i borrhål KLX04 utförda mellan den 9:e och 30:e september 2004.

Contents

1 Introduction

Water sampling and hydraulic pump tests have been performed in KLX04 in three different sections. The length of the water sampling sections was 5 m and the selection of those sections is based on preliminary results from the Difference flow logging lengths and was made by SKB. The duration of pumping depended on the time for reaching acceptable uranine concentrations. Uranine is a conservative tracer used to tag the flush water utilised during drilling.

Measurements were carried out in borehole KLX04 during 09th September to 29th September 2004 according to the methodology described in SKB MD 323.001e respectively in the activity plan AP PS 400-04-75 (SKB internal controlling documents). Data and results were delivered to the SKB site characterization database SICADA.

Borehole KLX04 is situated in the Laxemar area approximately 1 km west of the nuclear power plant of Simpevarp, Figure 1-1. The borehole was drilled from February 2004 to June 2004 at 993.49 m depth with an inner diameter of 76 mm and an inclination of –84.68°. The upper 12.24 m is cased with large diameter telescopic casing ranging from diameter (outer diameter) 208 mm–324 mm.

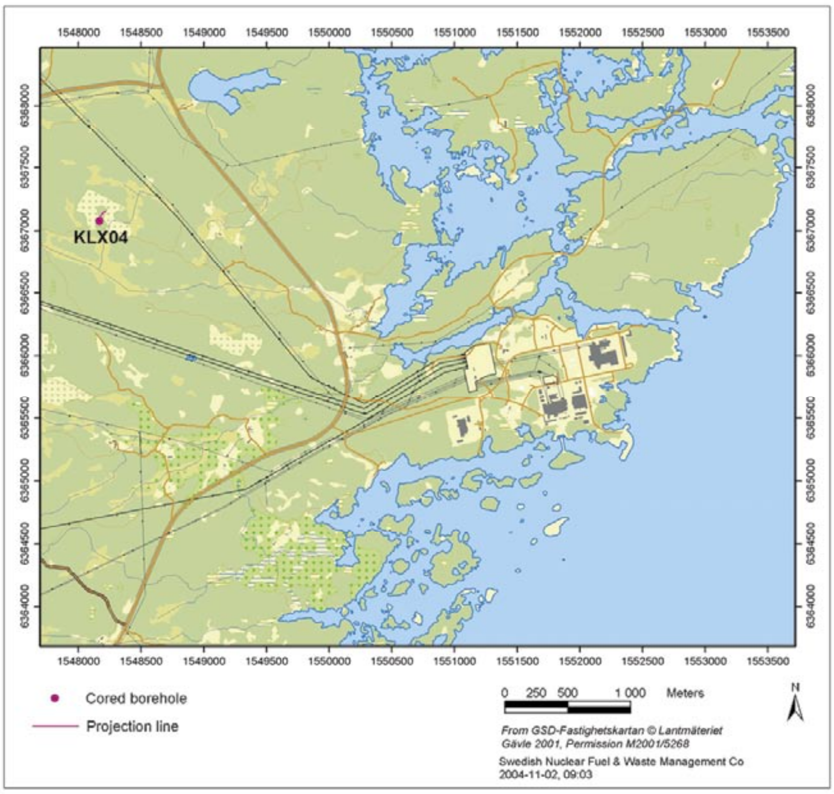

Figure 1-1. *The investigation area Laxemar, Oskarshamn with location of KLX04.*

2 Objective

The main objective of the pumping tests was the sampling of water in certain depths for chemical analyses. Additionally, the pumping was conducted and analysed as constant pressure pumping tests followed by a pressure recovery. The water sampling sections had a length of 5 m and are selected based on the preliminary results of the Difference flow logging. The samples taken from the upper section (104–109 m) should be analysed according to SKB chemistry class 4. The other two samples (from 510.56–515.56 m and 971.21–976.21 m depth) should be analysed according to SKB chemistry class 5.

3 Scope of work

The scope of work consisted of preparation of the PSS2 tool, which included cleaning of the down-hole tools (pump and pump basket), performing pump tests at 5 m test sections, measuring the uranine concentration in the field, water sampling, analysis and reporting.

Preparation for testing was done according to the activity plan (AP PS 400-04-75) and relevant SKB method descriptions (SKB internal controlling documents).

The following test programme was performed:

Table 3-1. Performed test programme.

Borehole	Test no	Section (m b ToC)	Date (start–end)
KLX04	1	971.26–976.26	09.09.2004–17.09.2004
KLX04	1	510.56–515.56	17.09.2004–29.09.2004
KLX04	1	104.00–109.00	29.09.2004–30.09.2004

3.1 Borehole

The borehole is telescope drilled with specifications on its construction according to Table 3-2. The reference point in the boreholes is the centre of top of casing (ToC), given as Elevation in table below. The Swedish National coordinate system (RT90) is used in the x-y direction and RHB70 in the z-direction. Northing and Easting refer to the top of the boreholes at the ground surface. The borehole diameter in Table 3-2 refers to the final diameter of the drill bit after drilling to full depth.

Table 3-2. Information about KLX04 (from SICADA 2004-08-11 09:43:36).

Title	Value				
Borehole length (m):	993.490				
Drilling Period(s):	From Date	To Date	Secup (m)	Seclow (m)	Drilling Type
	2004-02-11	2004-02-18	0.000	100.400	Percussion drilling
	2004-03-13	2004-06-28	0.000	993.490	Core drilling
Starting point coordinate:	Length (m)	Northing (m)	Easting (m)	Elevation (masl)	Coord Sys.
(centerpoint of TOC)	0.000	6367077.188	1548171.937	24.089	RT90-RHB70
Angles:	Length (m)	Bearing	Inclination (– = down)		
	0.000	0.109	–84.683		
Borehole diameter:	Secup (m)	Seclow (m)	Hole Diam (m)		
	0.000	12.000	0.347		
	12.000	12.240	0.254		
	12.240	100.300	0.196		
	100.350	101.470	0.086		
	101.470	993.490	0.076		
Core diameter:	Secup (m)	Seclow (m)	Core Diam (m)		
	100.350	101.470	0.050		
	101.470	993.490	0.050		
Casing diameter:	Secup (m)	Seclow (m)	Case In (m)	Case Out (m)	
	0.000	12.240	0.200	0.208	
	0.000	11.900	0.310	0.324	
Grove milling:	Length (m)	Trace detectable			
	110.000	YES			
	150.000	YES			
	200.000	YES			
	250.000	YES			
	300.000	YES			
	349.000	YES			
	400.000	YES			
	450.000	YES			
	500.000	YES			
	550.000	YES			
	600.000	YES			
	650.000	YES			
	700.000	YES			
	750.000	YES			
	800.000	YES			
	849.000	YES			
	899.000	YES			
	950.000	YES			

During this testing campaign, the markers at 800.0 m and 849.0 m could not be detected with the positioner.

3.2 Tests and water sampling

Pumping tests and water sampling were conducted according to the Activity Plan AP PS 400-04-75 (SKB internal controlling documents). The intention was to conduct constant pressure tests with a drawdown of about 350 kPa. As mentioned above, the main objective of these pumping tests was to reach an acceptable uranine concentration as fast as possible to take water samples from the borehole. Acceptable in this case means a target of an uranine concentration of less than 5% of the concentration used for previous injection tests (concentration in injection tank). In sections 971.21–976.21 m bToC and 510.56–515.56 m bToC it was not possible to keep the pressure conditions stable. However, parts of both tests were still adequate for quantitative analysis.

The uranine ratio of the water inside the injection tank was taken as reference value for the uranine concentration. This value of 170.7 µg/L was taken as 100%. After start of pumping, one water sampling was performed each day. After the uranine ratio reached 10%, two water samples were taken. These water samples were delivered to the Äspo chemistry laboratory. Simultaneous, the uranine content was measured in the field a few times a day. The pumping was performed until the ratio was at about 5%. The decision, when to abort pumping and take the final water chemistry sample, was made by SKB.

3.3 Control of equipment

Control of equipment was mainly performed according to the Quality plan. The basis for equipment handling is described in the "Mätssystembeskrivning" SKB MD 345.101–123 which is composed of two parts 1) management description, 2) drawings and technical documents of the modified PSS2 tool (SKB internal controlling documents).

Function checks were performed before and during the tests. Among these pressure sensors were checked while running in the hole calculated to the static head.

Any malfunction was recorded.

The pressure sensor for the section below (P_b) started produce wrong values at the end of the pumping phase in the first section from 971.21–976.21 m. After discussion with SKB it was decided not to interrupt the pumping in order to change this transducer for the performed subsequent pumping tests.

4 Equipment

4.1 Description of equipment

The equipment called PSS2 (Pipe String System 2) is a highly integrated tool for testing boreholes at great depth (see conceptual drawing in the next figure). The system is built inside a container suitable for testing at any weather. Briefly, the components consists of a hydraulic rig, down-hole equipment including packers, pressure gauges, shut-in tool and level indicator, racks for pump, gauge carriers, breakpins, etc shelfs and drawers for tools and spare parts.

There are three spools for a multi-signal cable, a test valve hose and a packer inflation hose. There is a water tank for injection purposes, pressure vessels for injection of packers, to open test valve and for low flow injection. The PSS2 has been upgraded with a computerized flow regulation system. The office part of the container consists of a computer, regulation valves for the nitrogen system, a 24 V back-up system in case of power shut-offs and a flow regulation board.

PSS2 is documented in photographs 1–6.

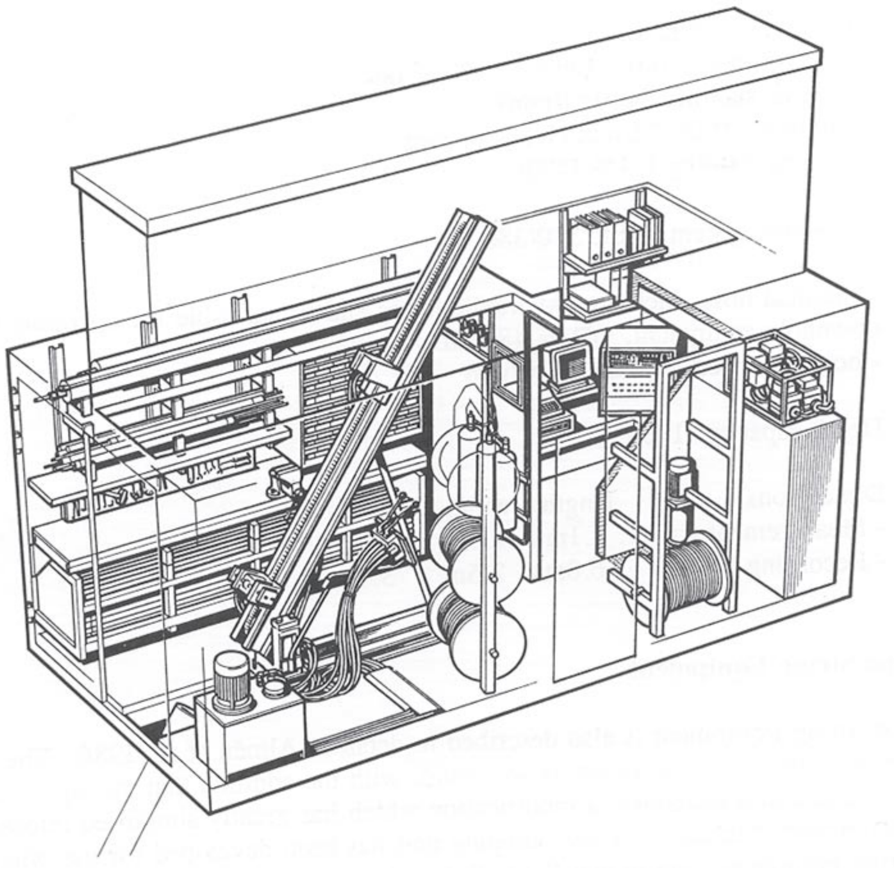

Figure 4-1. *A view of the layout and equipment of PSS2.*

Photo 1. *Hydraulic rig.*

Photo 2. *Rack for pump, down-hole equipment, workbench and drawers for tools.*

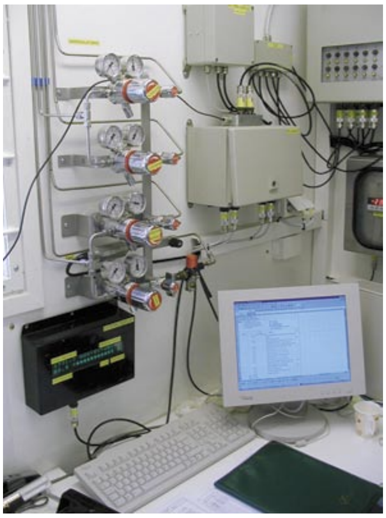

Photo 3. *Computer room, displays and gas regulators.*

Photo 4. *Pressure vessels for test valve, packers and injection.*

Photo 5. *Top of test string with shunt valve and nylon line down to the pump basket.*

Photo 6. *Control board of the pump with remote control.*

The down-hole equipment consists from bottom to top of the following equipment:

- Level indicator – SS 630 mm pipe with OD 73 mm with 3 plastic wheels connected to a Hallswitch.
- Gauge carrier – SS 1.5 m carrying bottom section pressure transducer and connections from positioner.
- Lower packer – SS and PUR 1.5 m with OD 72 mm, stiff ends, tightening length 1.0 m, maximum pressure 6.5 MPa, working pressure 1.6 MPa.
- Gauge carrier with breakpin – SS 1.75 m carrying test section pressure transducer, temperature sensor and connections for sensors below. Breakpin with maximum load of 47.3 (± 1.0) kN. The gauge carrier is covered by split pipes and connected to a stone catcher on the top.
- Pop joint – SS 1.0 or 0.5 m with OD 33 mm and ID 21 mm, double O-ring fittings, trapezoid thread, friction loss of 3 kPa/m at 50 L/min.
- Pipe string – SS 3.0 m with OD 33 mm and ID 21 mm, double O-ring fittings, trapezoid thread, friction loss of 3 kPa/m at 50 L/min.
- Contact carrier – SS 1.0 m carrying connections for sensors below.
- Upper packer – SS and PUR 1.5 m with OD 72 mm, fixed ends, seal length 1.0 m, maximum pressure 6.5 MPa, working pressure 1.6 MPa.
- Breakpin – SS 250 mm with OD 33.7 mm. Maximum load of 47.3 (± 1.0) kN.
- Gauge carrier – SS 1.5 m carrying top section pressure transducer, connections from sensors below. Flow pipe is double bent at both ends to give room for sensor equipment. The pipe gauge carrier is covered by split pipes.
- Shut-in tool (test valve) – SS 1.0 m with a OD of 48 mm, Teflon coated valve piston, friction loss of 11 kPa at 10 L/min (260 kPa–50 L/min). Working pressures 2.8–4.0 MPa. Breakpipe with maximum load of 47.3 (± 1.0) kN. The shut-in tool is covered by split pipes and connected to a stone catcher on the top.

The 3"-pump is placed in a pump basket and connected to the test string at about 50 to 60 m below ToC. The pumping frequency of the pump is set with a remote control on surface. The flow can be regulated with a shunt-valve on top of the test string, a nylon line connects the valve with the pump basket, so that the water can circulate and the pump cannot run out of water (photo 5).

The tool scheme is presented in Figure 4-2.

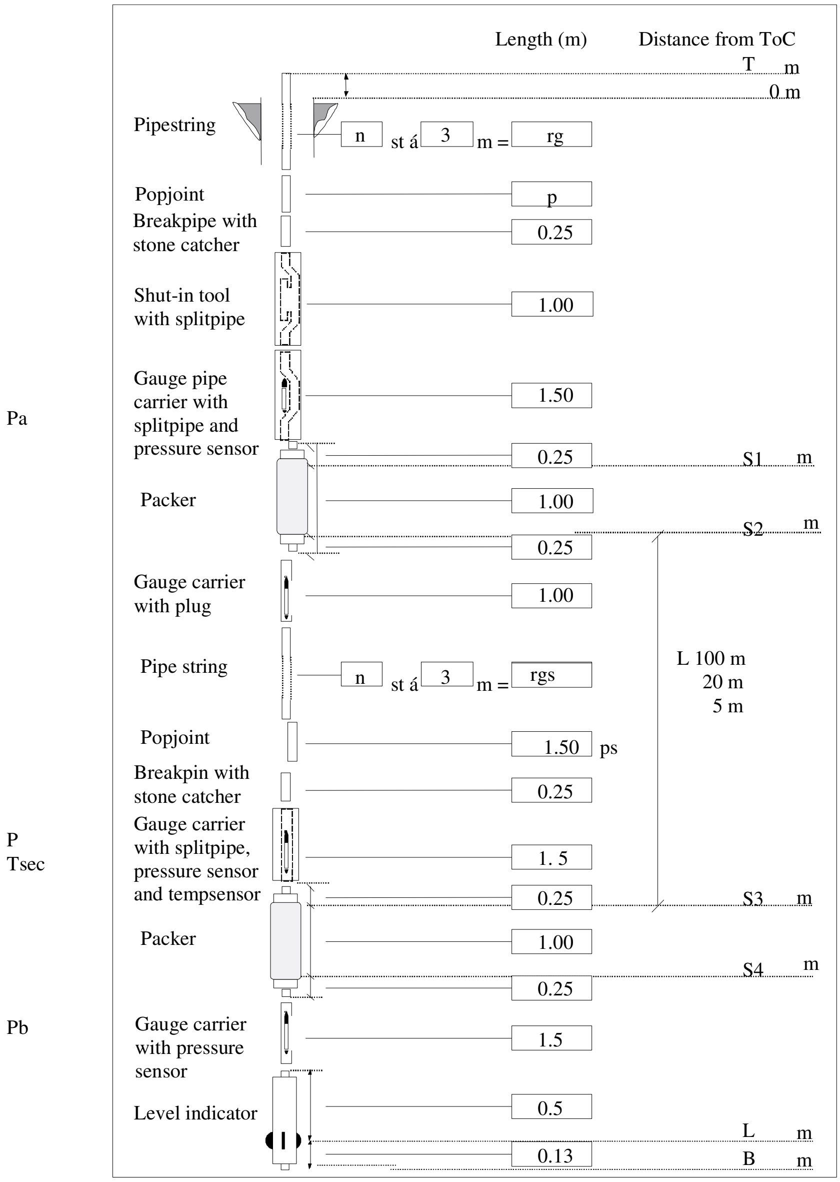

Figure 4-2. *Schematic drawing of the down-hole equipment in the PSS2 system.*

4.2 Sensors

Table 4-1. Technical specifications of sensors.

Keyword	Sensor	Name	Value/range	Unit	Comments
$p_{sec,a,b}$	Pressure	Druck PTX 162-1464abs	9–30 4–20 0–13.5 Resolution Accuracy	VDC mA MPa % of FS	
$T_{sec,surf,air}$	Temperature	BGI	18–24 4–20 0–32 0.1	VDC mA °C °C	
Q_{big}	Flow	Micro motion Elite sensor	0–100 ± 0.1	kg/min %	Massflow
Q_{small}	Flow	Micro motion Elite sensor	0–1.8 ± 0.1	kg/min %	Massflow
p_{air}	Pressure	Druck PTX 630	9–30 4–20 0–120 ± 0.1	VDC mA KPa % of FS	
p_{pack}	Pressure	Druck PTX 630	9–30 4–20 0–4 ± 0.1	VDC mA MPa % of FS	
$p_{in,out}$	Pressure	Druck PTX 1400	9–28 4–20 0–2.5	VDC mA MPa	

4.3 Data acquisition system

The data acquisition system in the PSS2 container contains a stationary PC with the software Orchestrator, pump- and injection tests parameters such as pressure, temperature and flow are monitored and sensor data collected. A second laptop PC is connected to the stationary PC through a network containing evaluation software, Flowdim.

The data acquisition system is able to start and stop the test automatically or it can be disengaged for manual operation of magnetic and regulation valves within the injection/ pumping system. The flow regulation board is used for differential pressure and valve settings prior testing and for monitoring valves during actual test. An outline of the data acquisition system is shown in Figure 4-3.

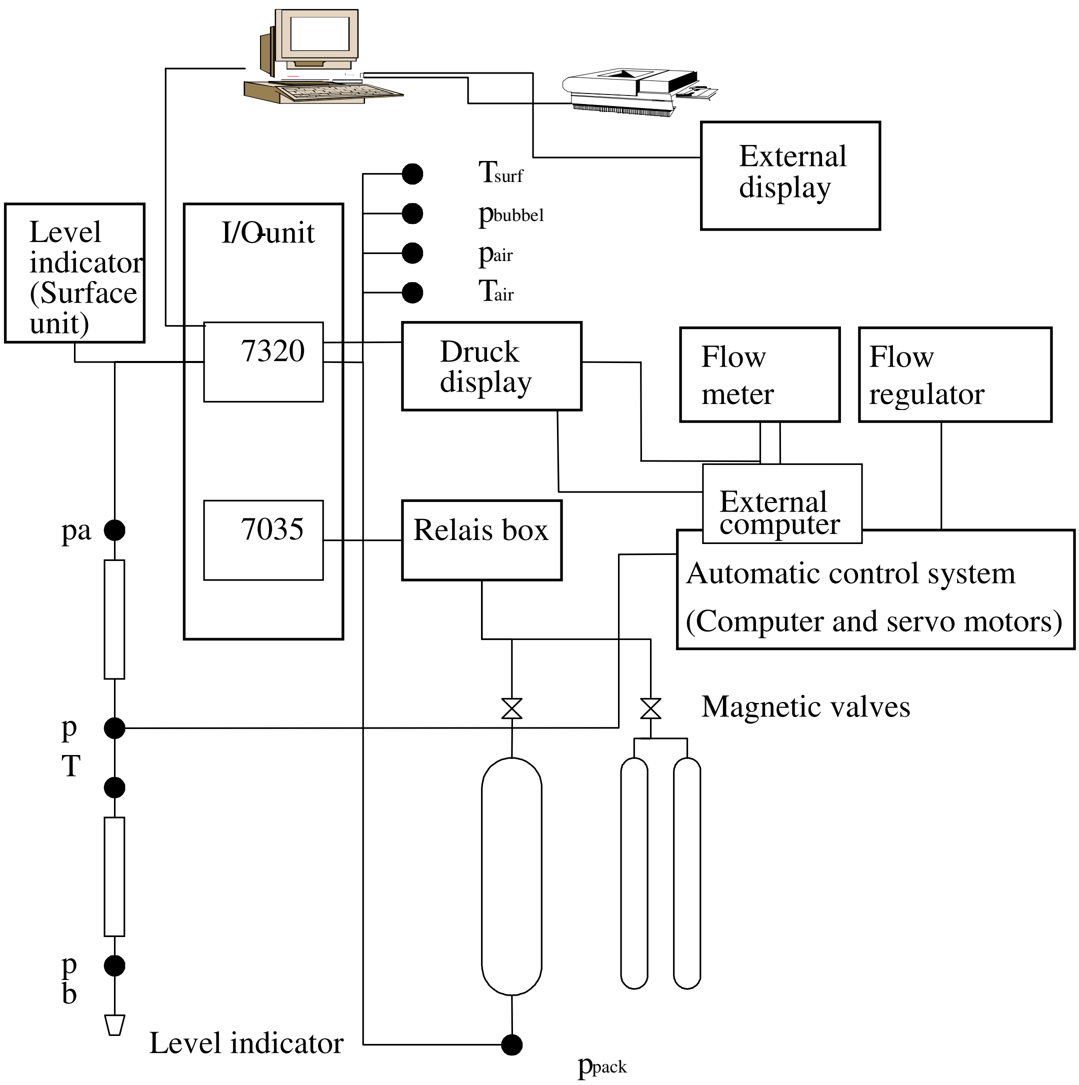

Figure 4-3. *Schematic drawing of the data acquisition system and the flow regulation control system in PSS2.*

5 Execution

5.1 Preparations

Due to the injection tests conducted in the borehole before the water sampling, the container was already prepared for pumping. The pump had to be installed and connected with the test string. The test string was connected with a hose to the regulation system, so that the flow could be regulated to get a constant pressure difference. After passing the regulation valves, the water was collected in the 3 m^3 tank outside the container.

5.2 Execution of tests/measurements

5.2.1 Test principle

The intention was to conduct the tests as constant pressure withdrawal (CHw phase) followed by a shut-in pressure recovery (CHwr phase). The main purpose of this pumping was to take water samples, so the focus of the tests was to get an acceptable uranine ratio as fast as possible, even if this was not compatible with the aim of having constant pressure.

5.2.2 Test procedure

A test cycle includes the following phases: 1) Transfer of down-hole equipment to the next section and connect the pump to the test string. 2) Packer inflation. 3) Pressure stabilisation. 4) Constant head withdrawal. 5) Pressure recovery. 6) Packer deflation. The intention of the pump tests in KLX04 was to apply a constant drawdown of 200 to 350 kPa (20–35 m water column) to the static formation pressure in the test section. The test execution for the test in section 510.56–515.56 m bToC was as described above. For both other sections it was not possible to hold constant pressure over the whole pumping time and pump with a maximum rate at the same time. As mentioned above, the priority was to take water samples from the borehole and reach an uranine concentration of 5% compared to the starting value as quick as possible.

In all three tests after closing the test valve (pressure stabilisation phase), the formation pressure was reached after a few minutes. The duration for each test depended on the uranine concentration. The duration of the pumping phase was between 16.5 (104–109 m) and more than 277 hours (510.56–515.56 m). The recovery phase lasted 18 minutes for the 510–515 m section and about 18 hours for the first section from 971–976 m.

5.3 Data handling

The data handling followed several stages. The data acquisition software (Orchestrator) produced an ASCII raw data file (*.ht2) which contains the data in voltage and milliampere format plus calibration coefficients. The *.ht2 files were processed to *.dat files using the SKB program called IPPlot. These files contain the time, pressure, flow rate and temperature data. The *.dat files were synthesised in Excel to a *.xls file for plotting purposes. Finally, the test data to be delivered to SKB were exported from Excel in *.csv format. These files were also used for the subsequent test analysis.

5.4 Analyses and interpretation

Information about the theoretical background of the analyses and the methods used for interpretation of the test data are described in the report "Hydraulic injection tests in borehole KLX04, 2004" (report in preparation, P-04-292).

6 Results

In the following, results of the tests are presented and analysed. The results are given as general comments to test performance, the identified flow regimes and calculated parameters and finally the parameters which are considered as most representative are chosen and justification is given. All results are also summarised in Tables 7-1 and 7-2 of the Synthesis chapter and in the test summary sheets (Appendix 3). Chapter 6.2 is a summary of the evaluation of uranine concentrations and of transmissivity and wellbore storage calculations.

6.1 5 m single hole pumping tests

The nomenclature and symbols used during evaluation and for presentation of the results of the pump tests and flow logging are according to the SKB documents "Instruction for analysis of single-hole injection and pump tests" (SKB MD 320.004, Instruktion för analysis av injections- och enhålspumptester) (SKB internal controlling documents). If additional symbols are used, they are explained in the report text.

6.1.1 104.00–109.00 m

Comments to test

The test was conducted as a constant pressure pump phase (CHw) followed by a pressure recovery phase (CHwr). The flow rate during the pumping phase was at about 4.3 L/min at a drawdown of ca 355 kPa. A slight connection to the upper section was observed. After 16.5 hours of pumping the final water chemistry sample was taken. The CHwr phase shows fast recovery. Both phases are adequate for quantitative analysis.

Flow regime and calculated parameters

The flow dimension is interpreted from the slope of the semi-log derivative plotted in log-log coordinates. In case of the present test, the CHw and the CHwr phase show a flat derivative at late times, indicating a flow dimension of 2. For the analysis of both phases a radial composite flow model was chosen. The analysis is presented in Appendix 2-1.

Selected representative parameters

The recommended transmissivity of 4.2E–6 m^2/s was derived from the analysis of the CHwr phase (inner zone), which shows the best data and derivative quality. The confidence range for the transmissivity is estimated to be 1.0E–6 to 2.0E–5 m^2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CHwr phase using straight line extrapolation in the Horner plot to a value of 1,052.0 kPa.

The analysis of the CHw and CHwr phases shows good consistency. No further analysis is recommended.

6.1.2 510.56–515.56 m

Comments to test

The test was conducted as a constant pressure pump phase (CHw) followed by a pressure recovery phase (CHwr). The flow rate during the pumping phase was at about 1.6 L/min at a drawdown of ca 220 kPa for the first 90 hours. After 90 hours, the flow rate was increased to lower the uranine concentration faster. The increased flow rate of 2.0 L/min (manually measured) led to a drawdown of 360 kPa. The pump seemed to suck air and due to that the flow measurements became very noisy and are not amenable for quantitative analysis anymore. Only the first part of the CHw phase was analysed. After 277 hours in total, the final water chemistry sample was taken. The CHwr phase shows a fast recovery, but it is still amenable for quantitative analysis.

Flow regime and calculated parameters

The flow dimension is interpreted from the slope of the semi-log derivative plotted in log-log coordinates. In case of the present test, the CHw phase shows a flat derivative at late times, indicating a flow dimension of 2. The CHwr phase shows a downward trend at late times, which is indicative for a transition to a zone of higher transmissivity in some distance from the borehole. For the analysis of the CHw phase a homogeneous radial flow model was chosen. The CHwr phase was analysed using a radial two shell composite flow model. The analysis is presented in Appendix 2-2.

Selected representative parameters

The recommended transmissivity of 2.6E–6 m^2/s was derived from the analysis of the first part of the CHw phase, which shows good data and derivative quality. The confidence range for the transmissivity is estimated to be 8.0E–7 to 5.0E–6 m^2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CHwr phase using straight line extrapolation in the Horner plot to a value of 5,007.7 kPa.

The analysis of the CHw and CHwr phases shows good consistency. No further analysis is recommended.

The results of this test show good consistency to the results of the injection test made in the same section.

6.1.3 971.21–976.21 m

Comments to test

The test was conducted as a constant pressure pump phase (CHw) followed by a pressure recovery phase (CHwr). The flow rate decreased from 0.18 L/min at the beginning to 0.14 L/min at the end of the CHw phase. The drawdown during the pumping phase was not constant and decreased from 320 kPa at the beginning to 280 kPa at the end. Due to the low flow rate the flow measurements are noisy, but still amenable for quantitative analysis. No hydraulic connection to the adjacent zones was observed. After 161 hours of pumping the final water chemistry sample was taken. The CHwr phase shows fast recovery. However, it is still adequate for quantitative analysis.

Flow regime and calculated parameters

The flow dimension is interpreted from the slope of the semi-log derivative plotted in log-log coordinates. In case of the present test, the CHw phase shows a flat derivative at late times, indicating a flow dimension of 2. The downward trend at middle times is caused by the time needed to get stable pressure and flow conditions. The CHwr phase is flat at late times, indicating a flow dimension of 2. For the analysis of the CHw phase a radial composite flow model was chosen. The CHwr phase was analysed using a homogeneous infinite acting radial flow model with wellbore storage and skin. The analysis is presented in Appendix 2-3.

Selected representative parameters

The recommended transmissivity of 4.0E–7 m^2/s was derived from the analysis of the CHwr phase, which shows the best data and derivative quality. The confidence range for the transmissivity is estimated to be 2.0E–7 to 1.0E–6 m^2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CHwr phase using straight line extrapolation in the Horner plot to a value of 9,517.9 kPa.

The analysis of the CHw and CHwr phases shows good consistency. No further analysis is recommended.

6.1.4 Transmissivity and wellbore storage

The recommended transmissivities range from 1E–5 to 4E–7 m^2/s. The results for section 510.56–515.56 m bToC (T=2.6E–6 m^2/s) correspond well to the results of the injection test in the same section (T=2.3E–6 m^2/s).

Similar to the injection tests, the matched wellbore storage for these pumping tests is about 2 orders of magnitude higher than the theoretical, which is given by the product of the interval volume and the test zone compressibility. A test zone compressibility of 7E–10 1/Pa was assumed. The discrepancy can be explained by increased compressibility of the packer system. In order to better understand this phenomenon, a series of tool compressibility tests should be conducted in order to measure the tool compressibility and to assess to what extent the system behaves elastically.

6.2 Watersampling

6.2.1 Uranine concentration

The uranine concentration versus pumping time for test 510.56–515.56 and 971.21–976.21 m bToC is shown in Figures 6-1 and 6-2.

The curves in Figures 6-1 and 6-2 show two very different shapes. The flow rate in Figure 6-1 was about ten times higher than it was in the test represented in Figure 6-2, but it took much longer to get a low uranine concentration. During the first three days the uranine concentration increased slowly, before it starts after about 80 hours to decrease. Another remarkableness in Figure 6-1 is, that it looks like the uranine concentration did not decreased at all during the night (flat horizontal parts), but only during daytime. In Figure 6-2 the uranine concentration decreased for the first 24 hours to increase for the following 24 hours. The expected exponential course is only in the second part of this figure displayed.

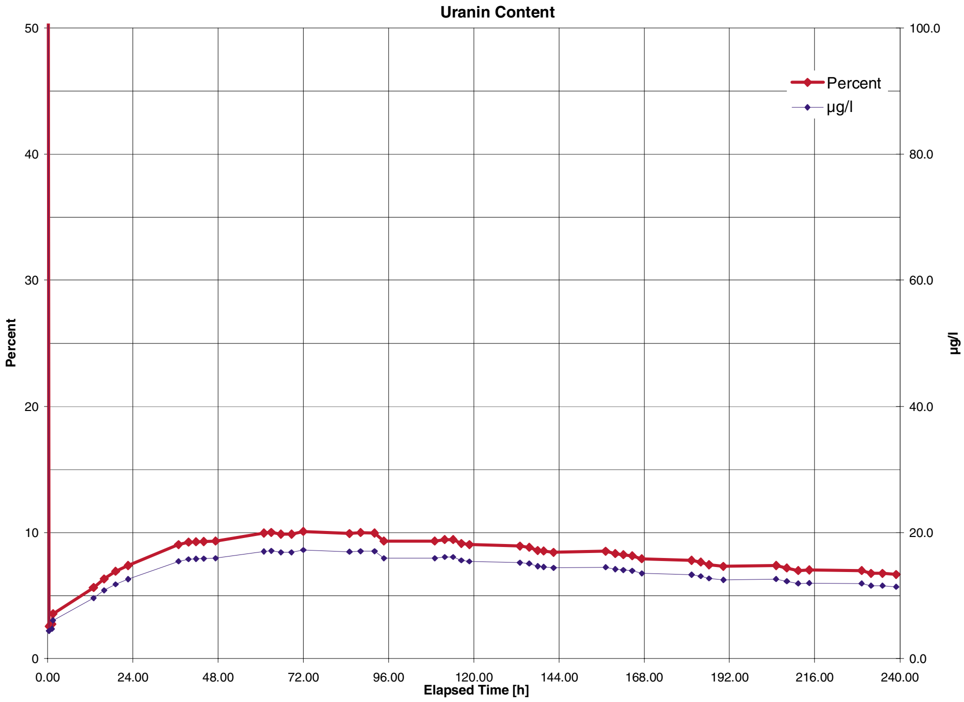

Figure 6-1. Uranine concentration during pumping in section 510.56–515.56.

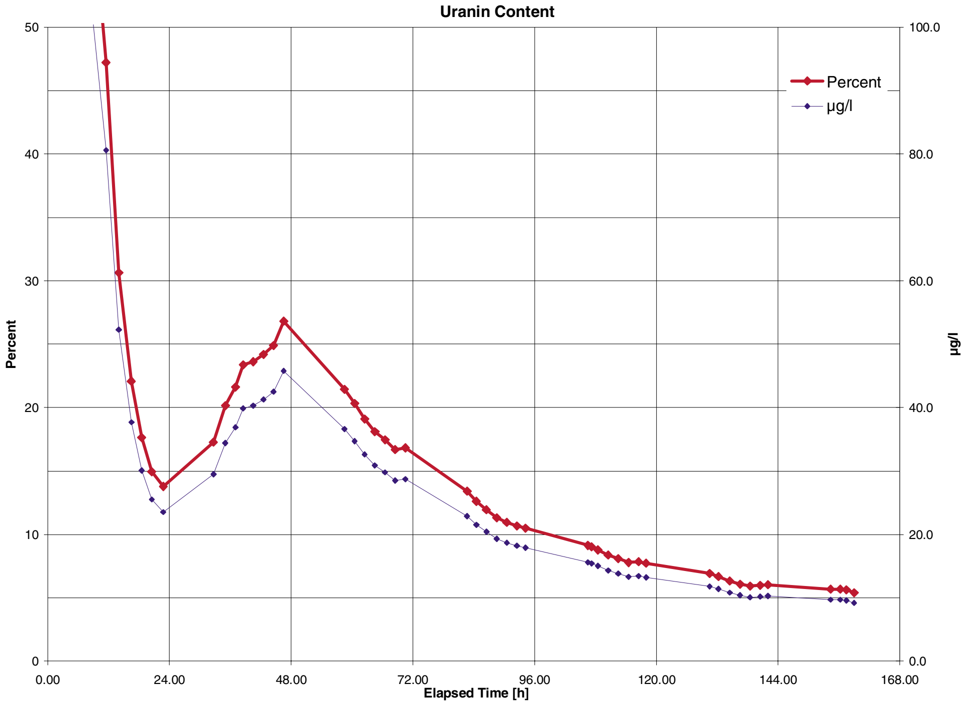

Figure 6-2. Uranine concentration during pumping in section 971.21–976.21.

There is no graph for the last test from 104 to 109 m bToc, because it took only about 16 hours pumping over night to get an acceptable uranine concentration.

Concerning these observations, there are many factors affecting this process and it is very difficult to predict the time needed to get a certain uranine concentration.

6.2.2 Water samples

First results of water chemistry analyses were delivered from SKB (via email from November 23, 2004). The results are summarized below in Table 6-1.

It is clearly visible from the analyses results that the chloride content and the electric conductivity are increasing parallel with greater sampling depth. In the opposite, the content of hydrogen carbonate is decreasing with greater sampling depth, whereas the pH value keeps on a stable level.

Table 6-1. Water chemistry, analyses results.

Sampling date	Secup (m)	Seclow (m)	Sample no	SKB analysis level	HCO_3 (mg/l)	Cl (mg/l)	pH	El cond (mS/m)	Drill water (%)
2004-09-30 10:10	104.00	109.00	7856	4	324	23.5	7.73	59.6	0.09
2004-09-29 08:30	510.56	515.56	7776	5	51.4	1,480	7.83	478	4.41
2004-09-16 11:00	971.21	976.21	7752	5	8.48	7,910	7.61	2,120	3.98

7 Synthesis

The synthesis chapter summarizes the basic test parameters and analysis results in Tables 7-1 and 7-2.

7.1 Summary of results

Table 7-1. General test data from constant head pump tests.

Borehole ID	Borehole secup (m)	Borehole seclow (m)	Date and time for test, start YYYYMMDD hh:mm	Date and time for test, stop YYYYMMDD hh:mm	Q_p (m**3/s)	Q_m (m**3/s)	tp (s)	t_F (s)	p_0 (kPa)	p_i (kPa)	p_p (kPa)	p_F (kPa)	Te_w (°C)	Test phases measured Analysed test phases marked bold
KLX04	104.00	109.00	20040929 16:57	20040930 13:47	7.10E-05	7.25E-05	59400	12420	1049	1052	699	1050	8.7	**CHw CHwr**
KLX04	510.56	515.56	20040917 17:51	20040929 09:07	3.17E-05	3.17E-05	1004940	1080	5025	5020	4652	5005	14.9	**CHw CHwr**
KLX04	971.21	976.21	20040909 20:29	20040917 08:08	2.40E-06	2.48E-06	579480	64020	9528	9535	9254	9515	22.4	**CHw CHwr**

CHw: Constant head pump (withdrawal) phase.
CHwr: Recovery phase following the constant head pump phase.

Table 7-2. Results from analysis of constant head pump tests.

Interval position			Stationary flow parameters		Transient analysis													
					Flow regime		Formation parameters										Static conditions	
Borehole ID	up m btoc	low m btoc	Q/s m²/s	T_M m²/s	Perturb. Phase	Recovery Phase	T_{f1} m²/s	T_{f2} m²/s	T_{s1} m²/s	T_{s2} m²/s	T_T m²/s	T_{TMIN} m²/s	T_{TMAX} m²/s	C m³/Pa	ξ –	dt_1 min	dt_2 min	p* kPa	h_{wif} masl
KLX04	104.00	109.00	1.97E-06	1.63E-06	22	WBS22	1.6E-06	1.0E-05	4.2E-06	1.1E-05	4.2E-06	1.0E-06	2.0E-05	1.54E-10	6.6	2	145	1052	13.85
KLX04	510.56	515.56	8.44E-07	6.97E-07	2	WBS22	2.6E-06	–	1.8E-06	6.7E-06	2.6E-06	8.0E-07	5.0E-06	4.57E-10	6.5	99	4039	5007.7	12.45
KLX04	971.21	976.21	1.63E-04	2.10E-04	22	WBS2	5.0E-08	3.1E-07	4.0E-07	–	4.0E-07	2.0E-07	1.0E-06	6.21E-10	19.8	18	265	9517.9	14.35

Notes

1 T1 and T2 refer to the transmissivity(s) derived from the analysis while using the recommended flow model. In case a homogeneous flow model was recommended only one T value is reported, in case a two zones composite model was recommended both T1 and T2 are given.

2 The parameter p* denoted the static formation
extrapolation.

3 The flow regime description refers to the recommended mode
dimension used in the analysis (1 = linear flow, 2 = radial flo
analysis, if two numbers are given (WBS22 or 22) a 2 zones composite model was used

8 References

Bourdet D, Ayoub J A, Pirard Y M, 1989. Use of pressure derivative in well-test interpretation. Coc. Of Petroleum Engineers, SPE Formation Evaluation, pp 293–302.

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Horne R N, 1990. Modern well test analysis. Petroway, Inc, Palo Alto, Calif.

Horner D R, 1951. Pressure build-up in wells. Third World Pet. Congress, E J Brill, Leiden II, pp 503–521.

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Moye D G, 1967. Diamond drilling for foundation exploration Civil Eng. Trans, Inst. Eng. Australia, Apr 1967, pp 95–100.

APPENDIX 1

File Description Table

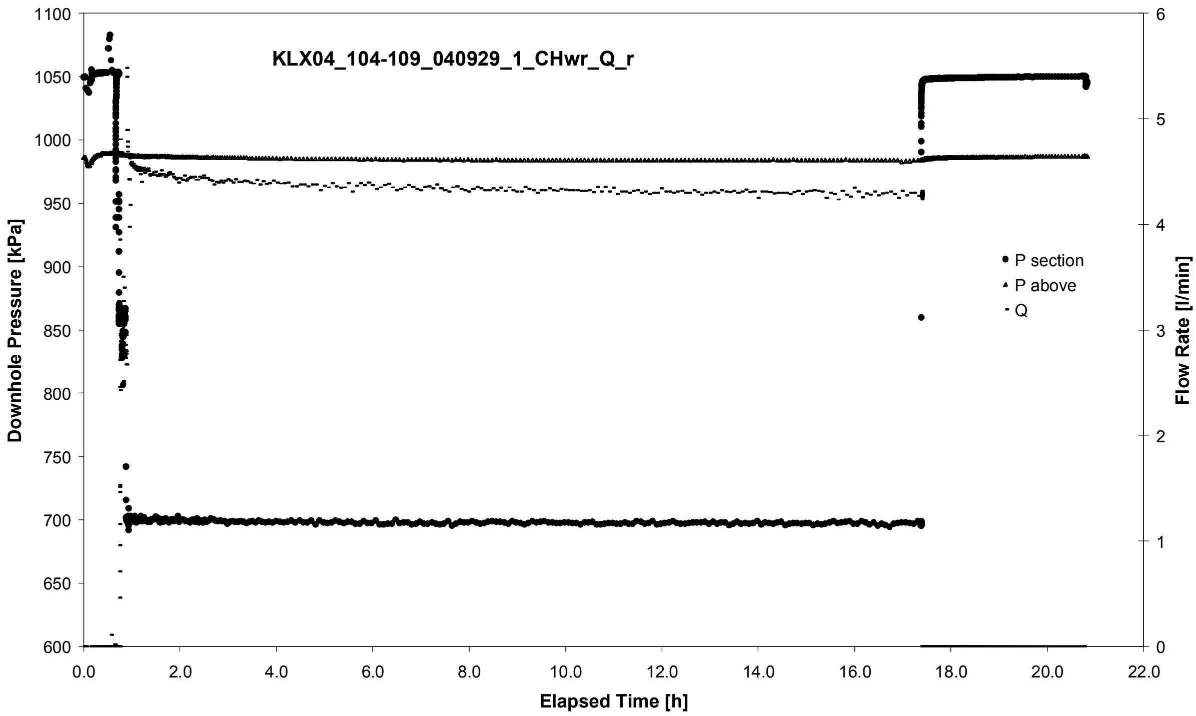
HYDROTESTING WITH PSS	DRILLHOLE IDENTIFICATION NO.: KLX04
TEST- AND FILEPROTOCOL	Testorder dated : 2004-08-18

Teststart		Interval boundaries		Name of Datafiles		Testtype	Copied to	Plotted	Sign.
Date	Time	Upper	Lower	(*.HT2-file)	(*.CSV-file)		disk/CD	(date)	
2004-09-09	20:29	971.21	976.21	___KLX04_0971.21_200409092029.ht2	KLX04_971.21-976.21_040909_1_CHwr_Q_r.csv	CHwr	2004-10-04	2004-10-01	
2004-09-17	17:51	510.56	515.56	___KLX04_0510.56_200409171751.ht2	KLX04_510.56-515.56_040917_1_CHwr_Q_r.csv	CHwr	2004-10-04	2004-10-01	
2004-09-29	16:57	104.00	109.00	___KLX04_0104.00_200409291657.ht2	KLX04_104-109_040929_1_CHwr_Q_r.csv	CHwr	2004-10-04	2004-10-01	

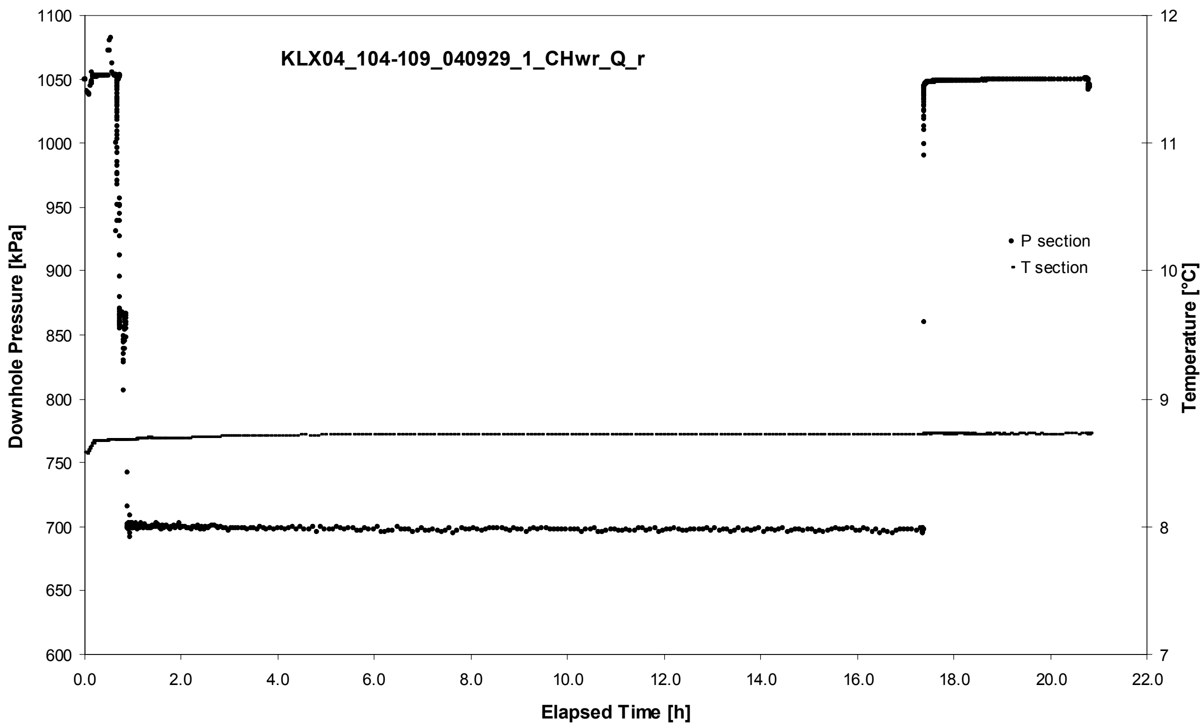
APPENDIX 2-1

Test 104 – 109 m

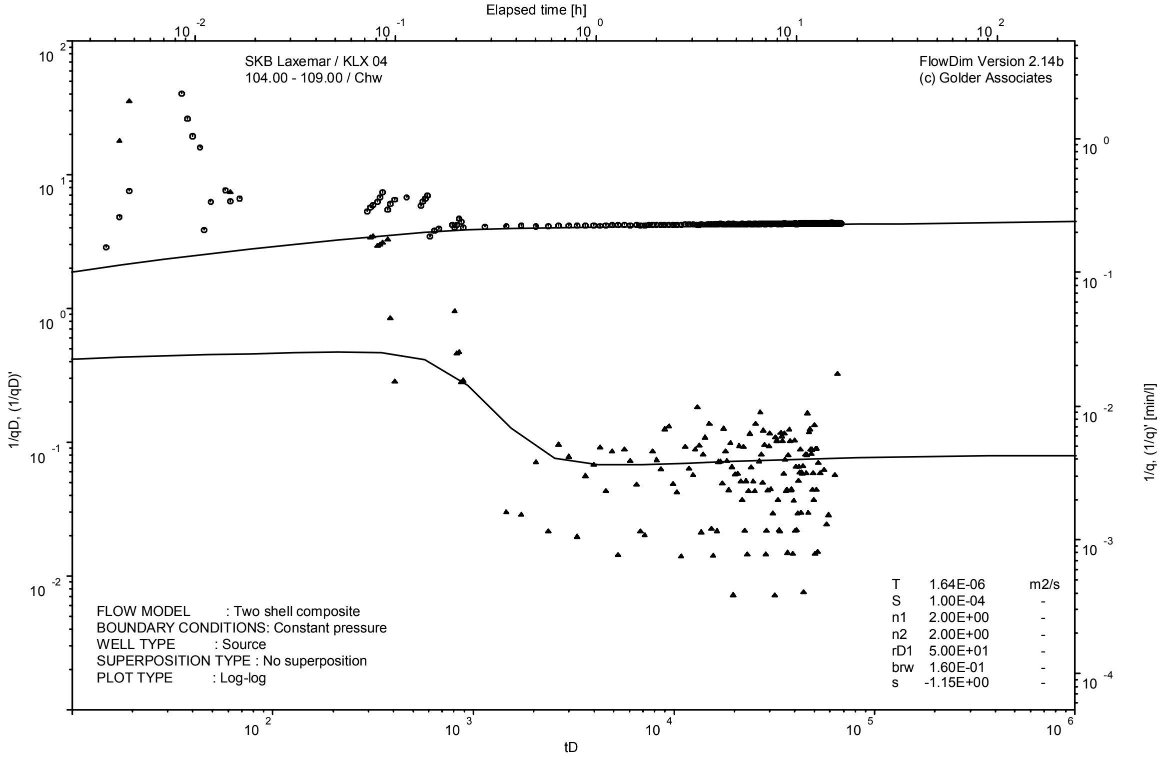
Analysis diagrams



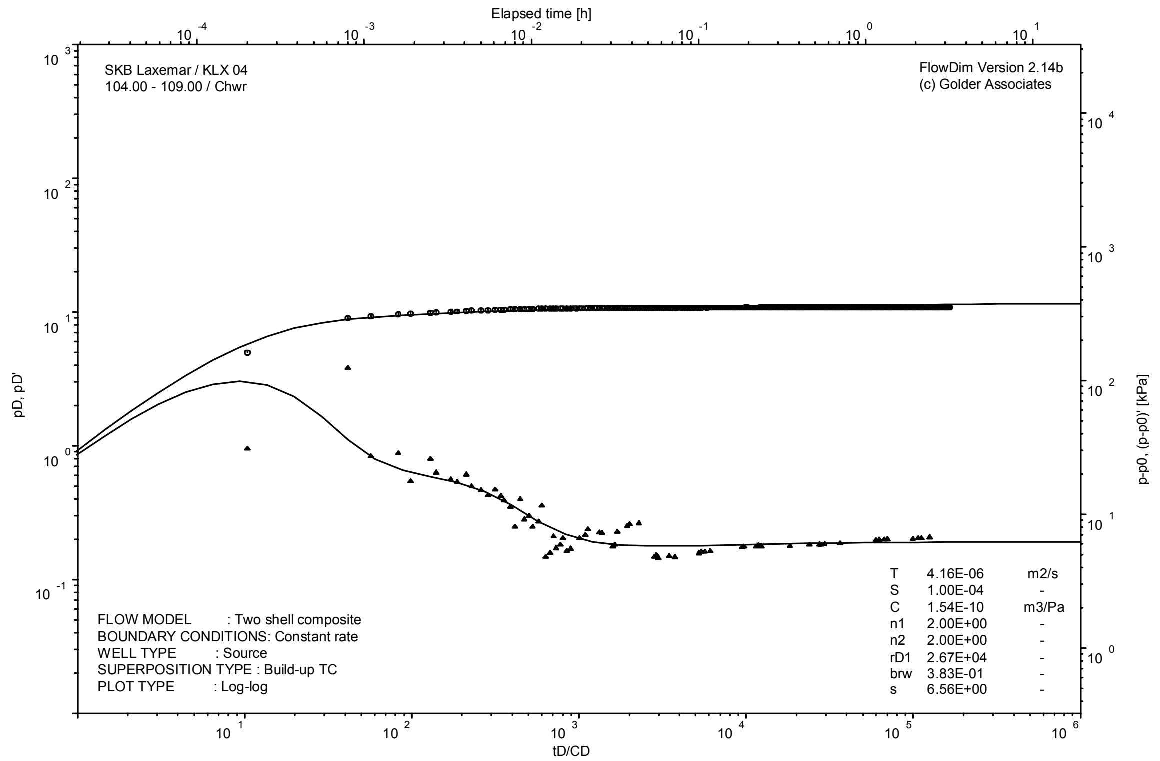
Pressure and flow rate vs. time; cartesian plot



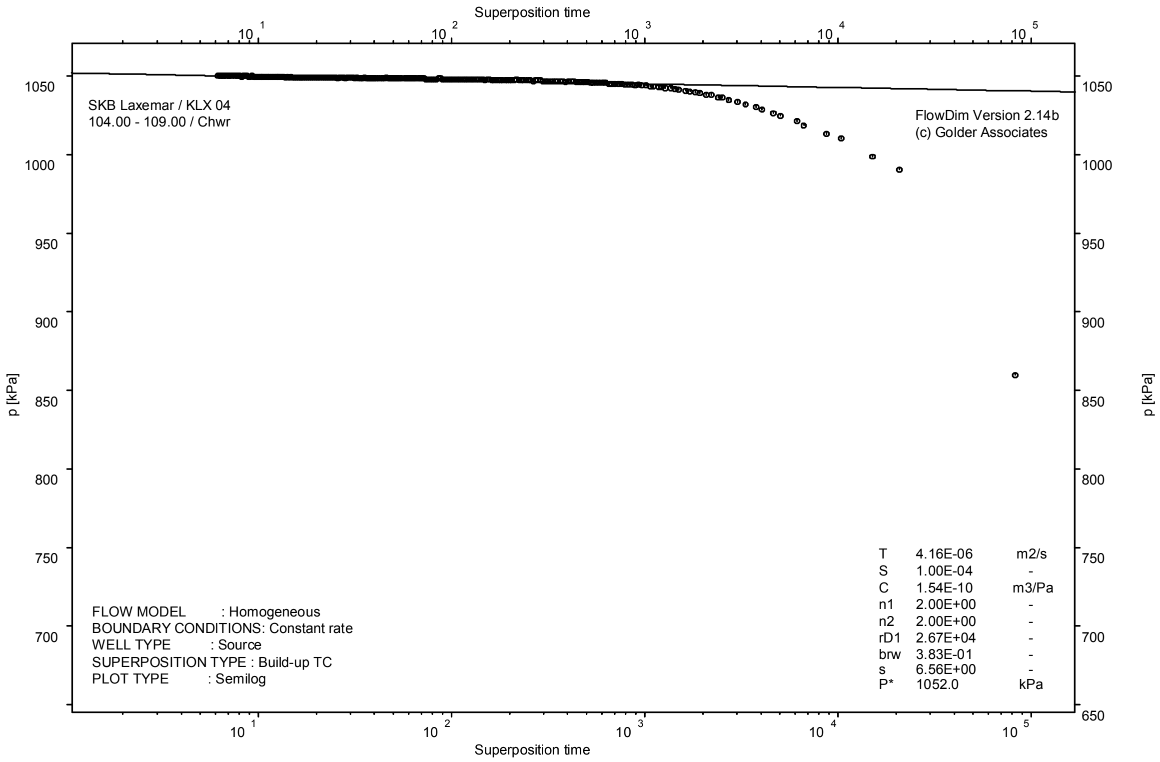
Interval pressure and temperature vs. time; cartesian plot



CHW phase; log-log match



CHWR phase; log-log match

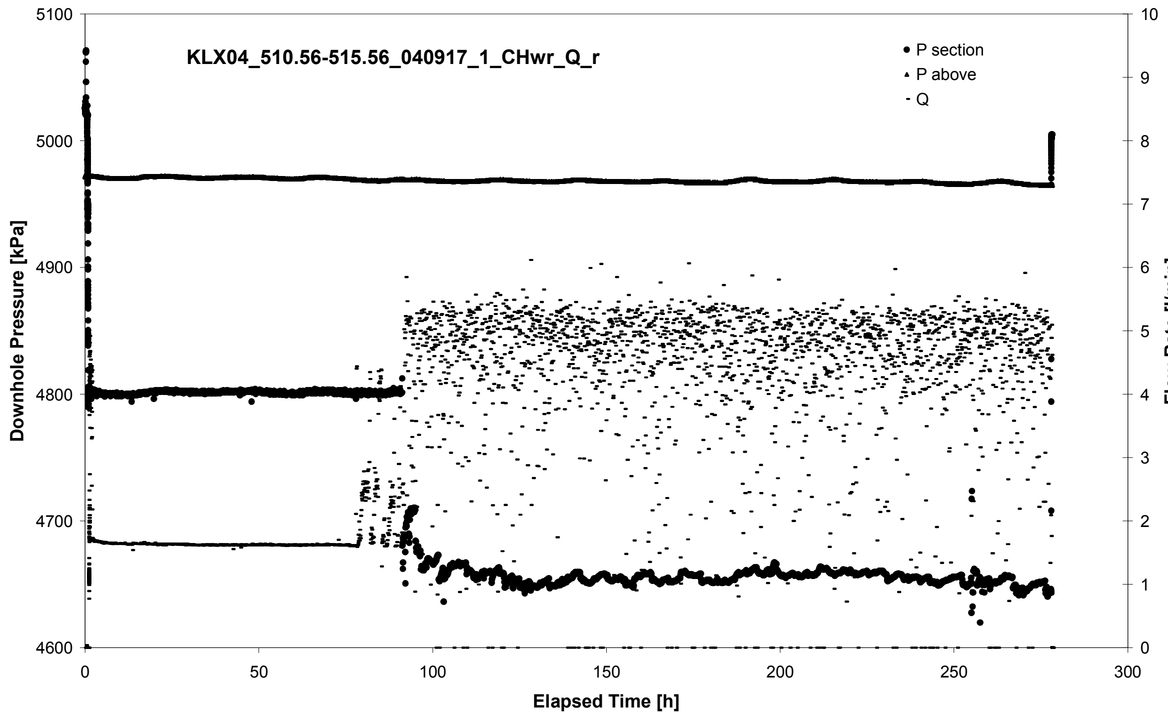


CHWR phase; HORNER match

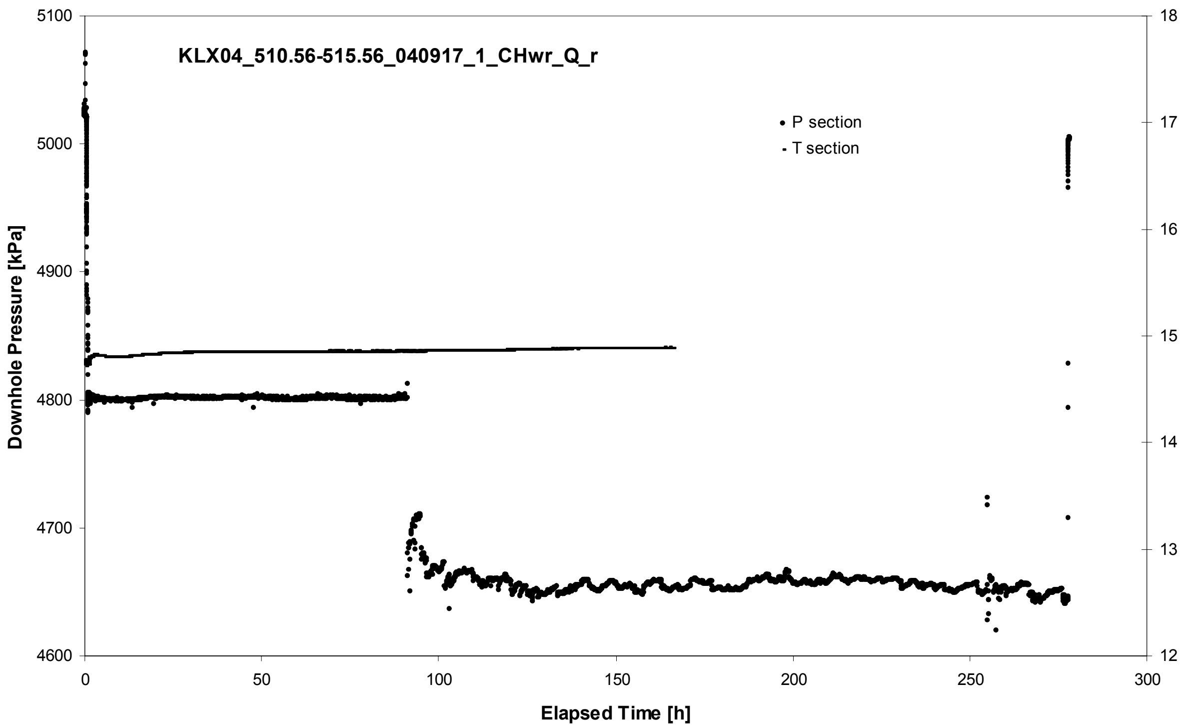
APPENDIX 2-2

Test 510.56 – 515.56 m

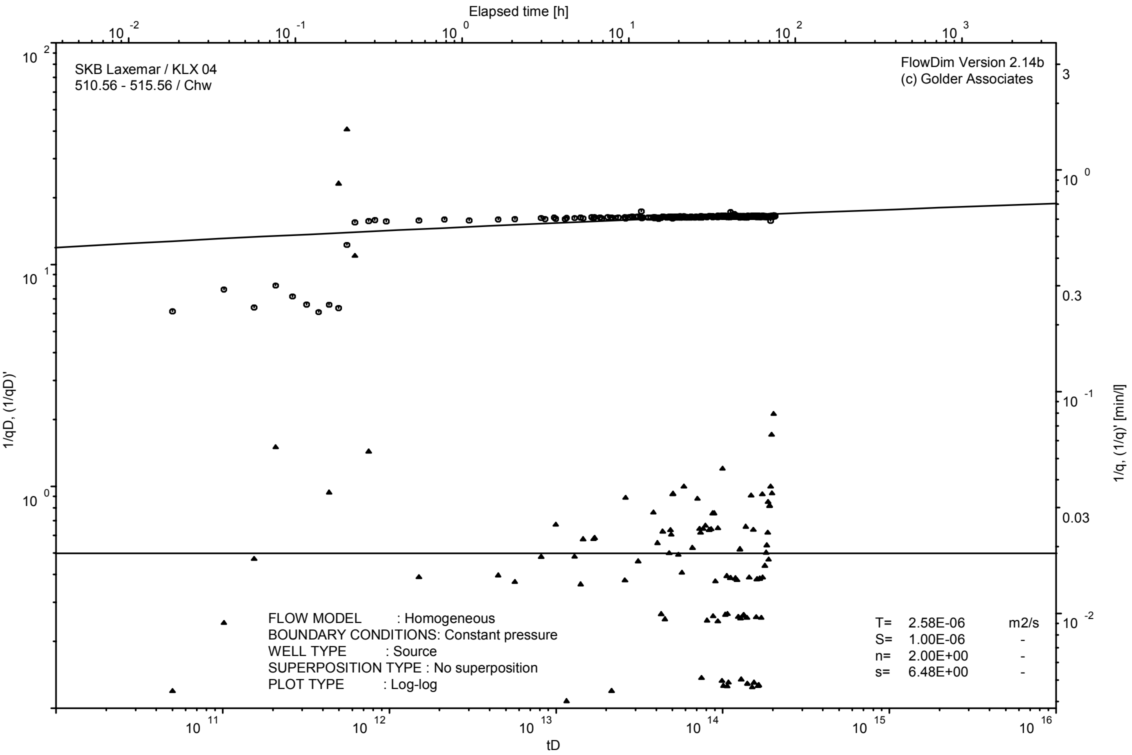
Analysis diagrams



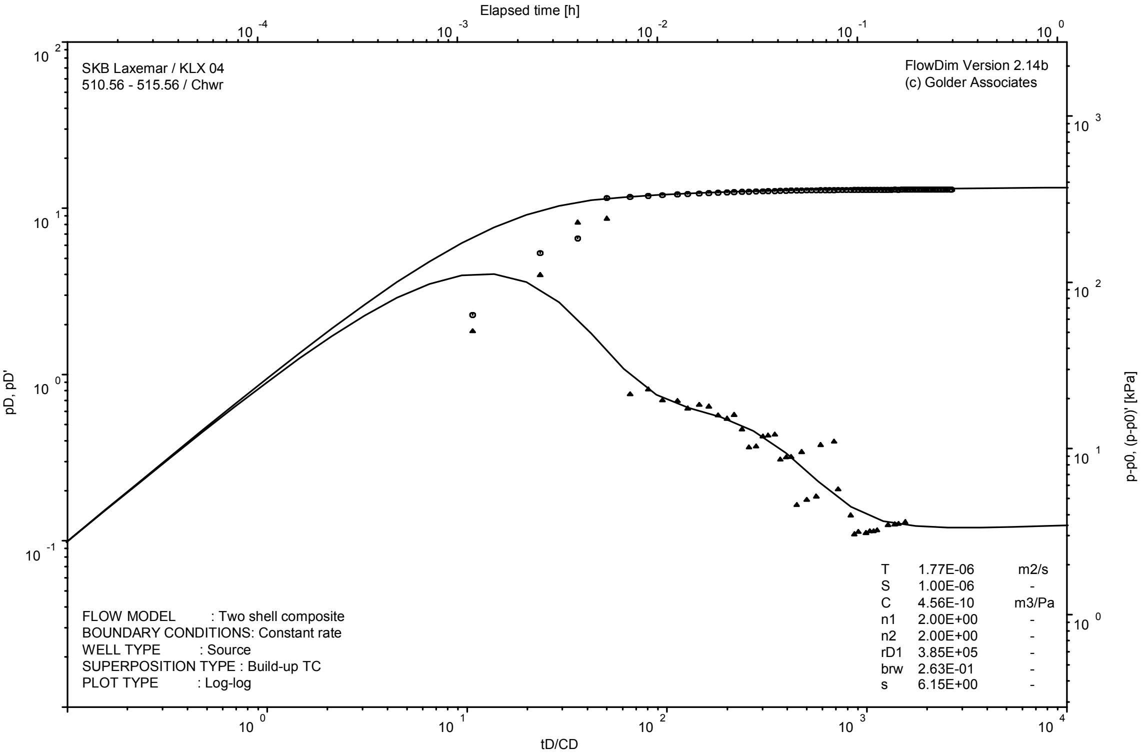
Pressure and flow rate vs. time; cartesian plot



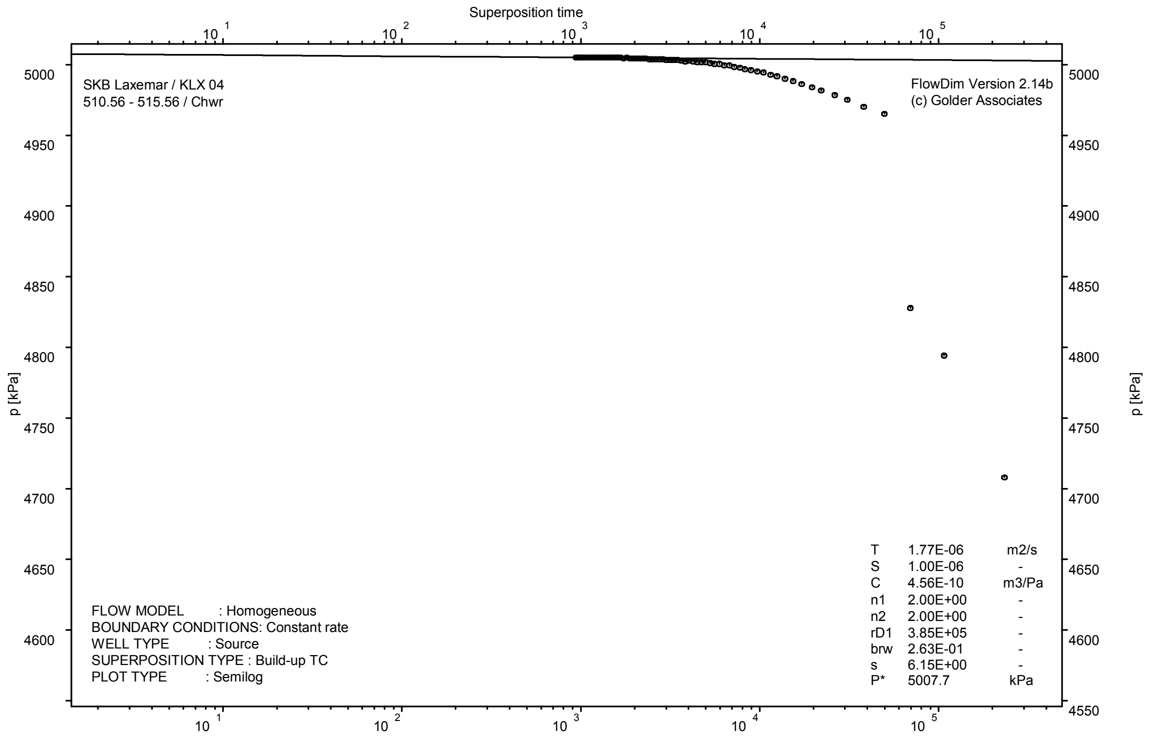
Interval pressure and temperature vs. time; cartesian plot



CHW phase; log-log match



CHWR phase; log-log match

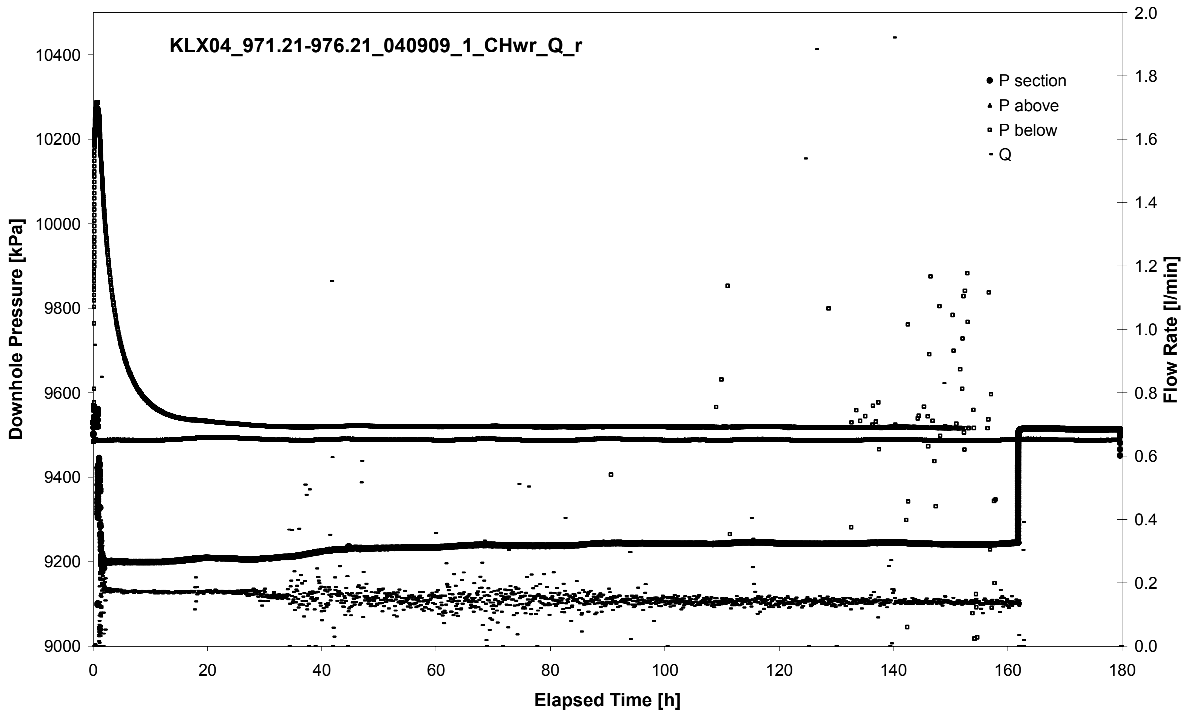


CHWR phase; HORNER match

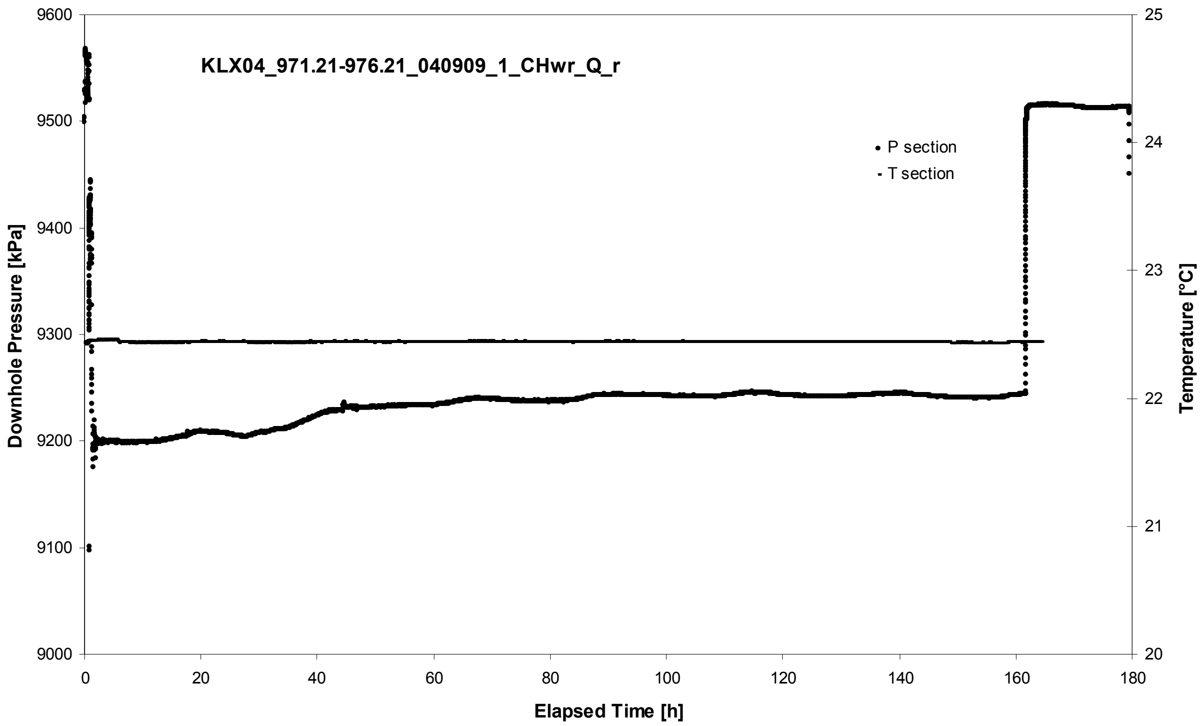
APPENDIX 2-3

Test 971.21 – 976.21 m

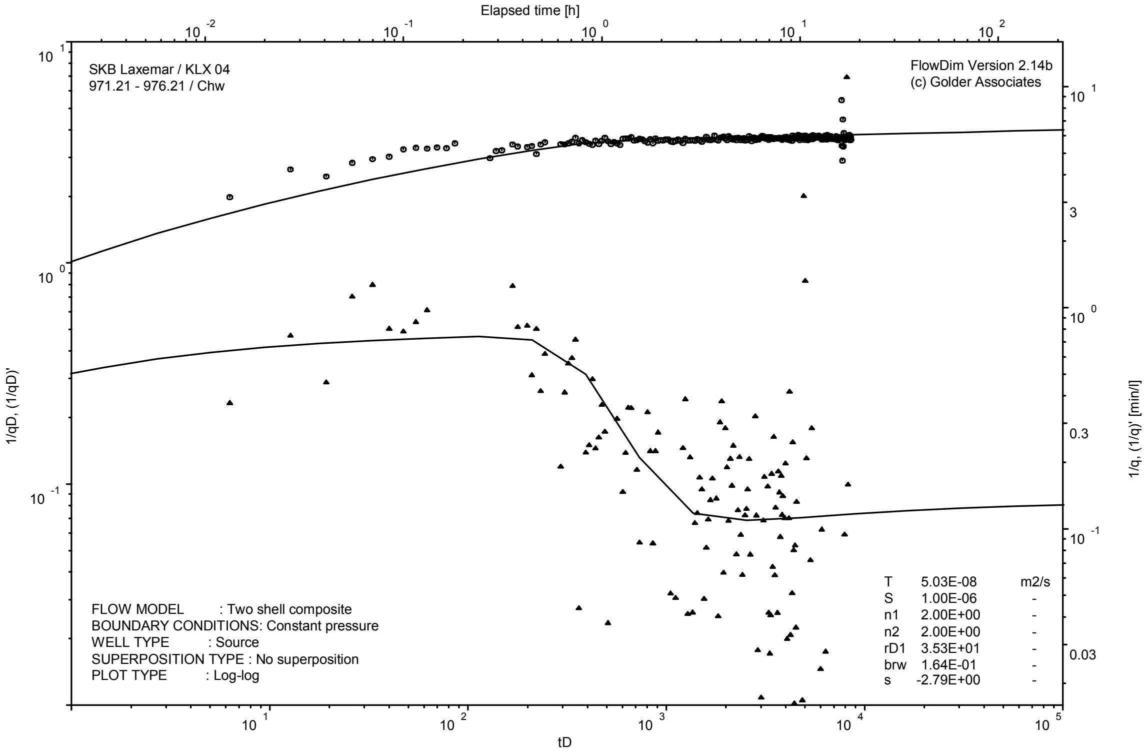
Analysis diagrams



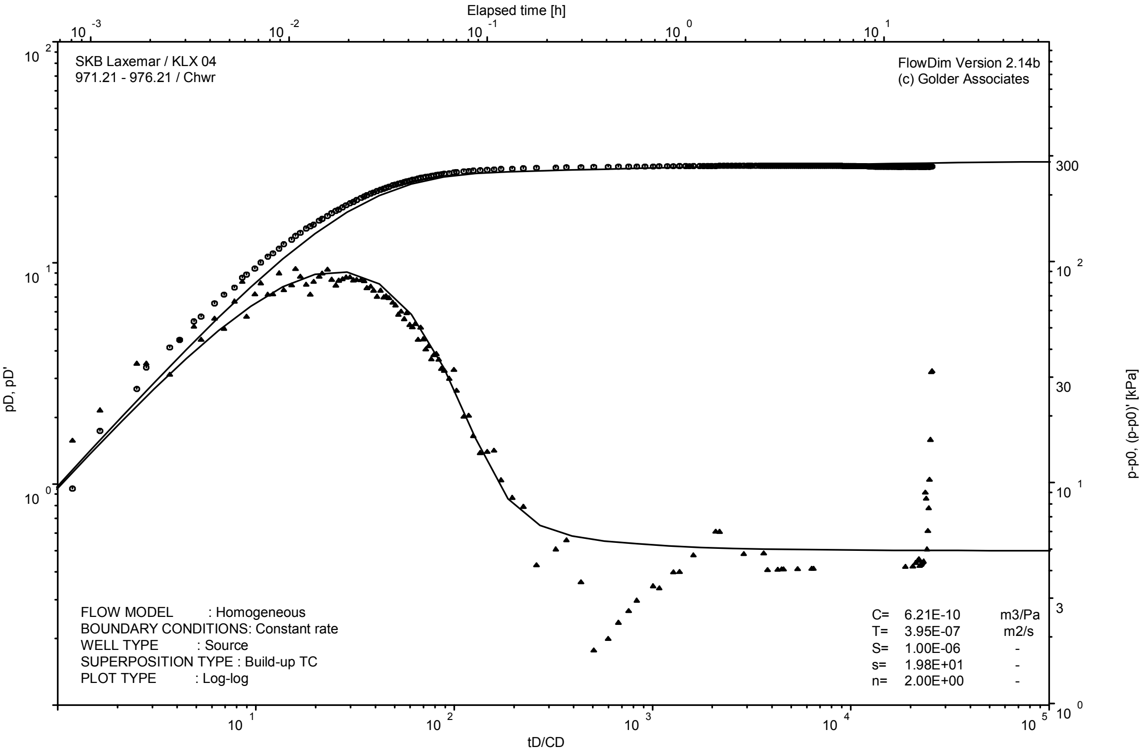
Pressure and flow rate vs. time; cartesian plot



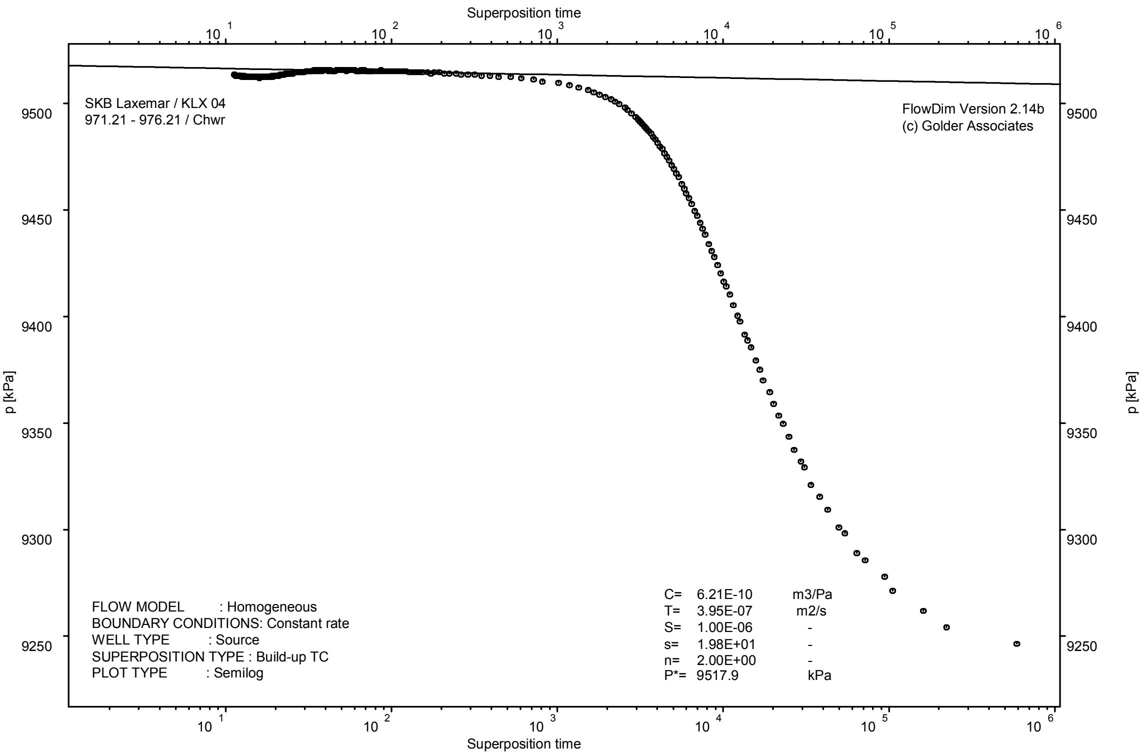
Interval pressure and temperature vs. time; cartesian plot



CHW phase; log-log match



CHWR phase; log-log match



CHWR phase; HORNER match

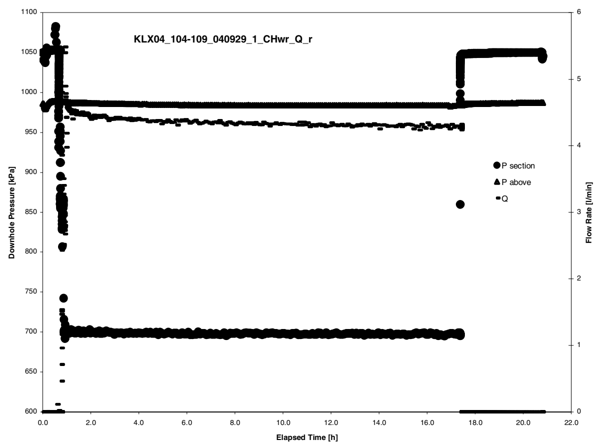
APPENDIX 3

Test Summary Sheets

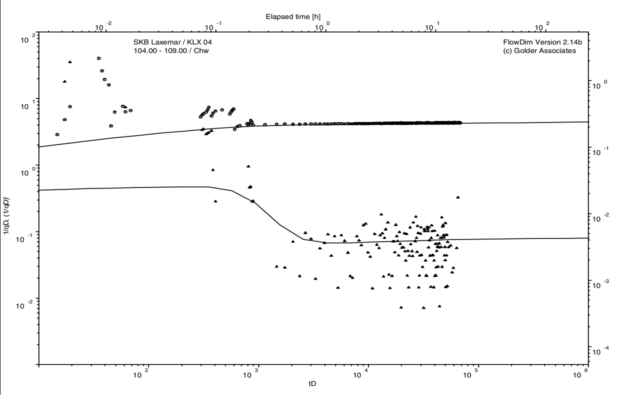
Test Summary Sheet

Project:	Oskarshamn site investigation	Test type:[1]	Chwr
Area:	Laxemar	Test no:	1
Borehole ID:	KLX04	Test start:	040929 16:57
Test section from - to (m):	104.00 -109.00	Responsible for test execution:	Jörg Böhner
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	Cristian Enachescu

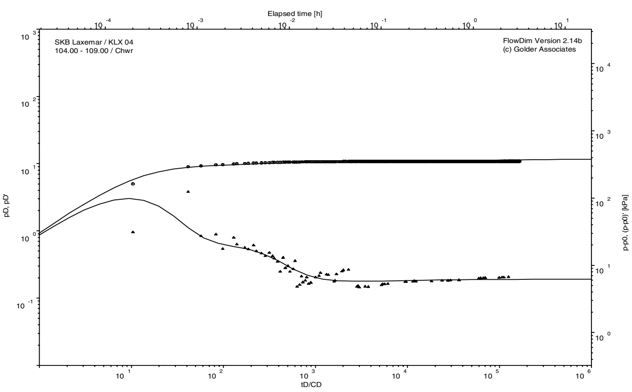
Linear plot Q and p



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa) =	1049		
p_i (kPa) =	1052		
p_p(kPa) =	699	p_F (kPa) =	1050
Q_p (m^3/s)=	7.10E-05		
tp (s) =	59400	t_F (s) =	12420
S el S^* (-)=	1.00E-06	S el S^* (-)=	1.00E-06
EC_w (mS/m)=			
$Temp_w$(gr C)=	8.7		
Derivative fact.=	0.11	Derivative fact.=	0.01
Results		**Results**	
Q/s (m^2/s)=	2.0E-06		
T_M (m^2/s)=	1.6E-06		
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	43.93	dt_1 (min) =	1.90
dt_2 (min) =	769.80	dt_2 (min) =	145.15
T (m^2/s) =	1.0E-05	T (m^2/s) =	4.2E-06
S (-) =	1.0E-04	S (-) =	1.0E-04
K_s (m/s) =	2.1E-06	K_s (m/s) =	2.2E-06
S_s (1/m) =	2.0E-05	S_s (1/m) =	2.0E-05
C (m^3/Pa) =	NA	C (m^3/Pa) =	1.5E-10
C_D (-) =	NA	C_D (-) =	1.7E-04
ξ (-) =	-1.2	ξ (-) =	6.6
T_{GRF}(m^2/s) =		T_{GRF}(m^2/s) =	
S_{GRF}(-) =		S_{GRF}(-) =	
D_{GRF} (-) =		D_{GRF} (-) =	

Selected representative parameters.

dt_1 (min) =	1.90	C (m^3/Pa) =	1.5E-10
dt_2 (min) =	145.15	C_D (-) =	1.7E-04
T_T (m^2/s) =	4.2E-06	ξ (-) =	6.6
S (-) =	1.0E-04		
K_s (m/s) =	2.2E-06		
S_s (1/m) =	2.0E-05		

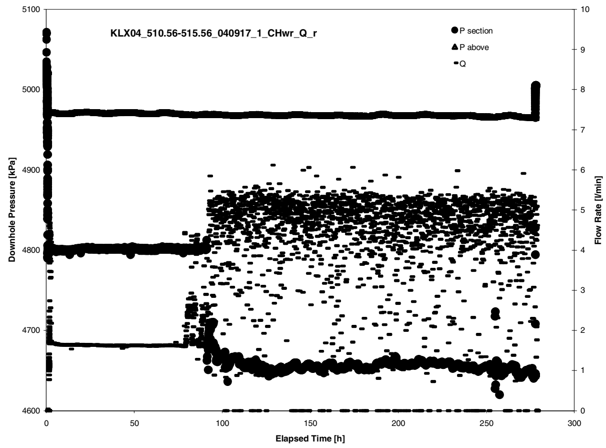
Comments:

The recommended transmissivity of 4.2E-6 m2/s was derived from the analysis of the CHwr phase, which shows the best data and derivative quality. The confidence range for the transmissivity is estimated to be 1.0E-6 to 2.0E-5 m2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CHwr phase using straight line extrapolation in the Horner plot to a value of 1052.0 kPa.

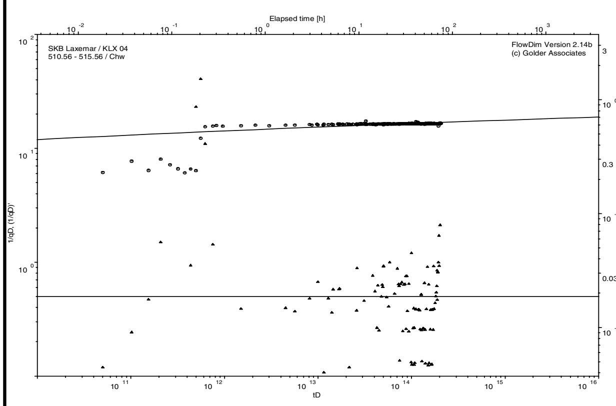
Test Summary Sheet

Project:	Oskarshamn site investigation	Test type:[1]	Chwr
Area:	Laxemar	Test no:	1
Borehole ID:	KLX04	Test start:	040917 17:51
Test section from - to (m):	510.56-515.56 m	Responsible for test execution:	Jörg Böhner
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	Cristian Enachescu

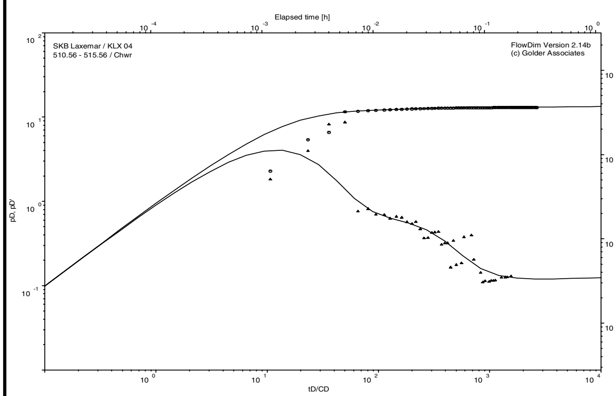
Linear plot Q and p



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa) =	5025		
p_i (kPa) =	5020		
p_p(kPa) =	4652	p_F (kPa) =	5005
Q_p (m^3/s)=	3.17E-05		
tp (s) =	1004940	t_F (s) =	1080
S el S^* (-)=	1.00E-06	S el S^* (-)=	1.00E-06
EC_w (mS/m)=			
$Temp_w$(gr C)=	14.9		
Derivative fact.=	0.06	Derivative fact.=	0.02
Results		**Results**	
Q/s (m^2/s)=	8.4E-07		
T_M (m^2/s)=	7.0E-07		
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	98.81	dt_1 (min) =	*
dt_2 (min) =	4038.84	dt_2 (min) =	*
T (m^2/s) =	2.6E-06	T (m^2/s) =	6.7E-06
S (-) =	1.0E-06	S (-) =	1.0E-06
K_s (m/s) =	5.2E-07	K_s (m/s) =	1.3E-06
S_s (1/m) =	2.0E-07	S_s (1/m) =	2.0E-07
C (m^3/Pa) =	NA	C (m^3/Pa) =	4.6E-10
C_D (-) =	NA	C_D (-) =	5.0E-02
ξ (-) =	6.5	ξ (-) =	6.2
T_{GRF}(m^2/s) =		T_{GRF}(m^2/s) =	
S_{GRF}(-) =		S_{GRF}(-) =	
D_{GRF} (-) =		D_{GRF} (-) =	

Selected representative parameters.

dt_1 (min) =	98.81	C (m^3/Pa) =	4.6E-10
dt_2 (min) =	4038.84	C_D (-) =	5.0E-02
T_T (m^2/s) =	2.6E-06	ξ (-) =	6.5
S (-) =	1.0E-06		
K_s (m/s) =	5.2E-07		
S_s (1/m) =	2.0E-07		

Comments:

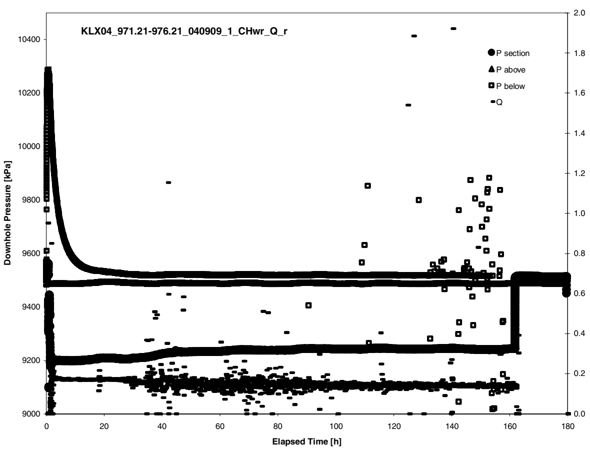
*: IARF not measured

The recommended transmissivity of 2.6E-6 m2/s was derived from the analysis of the first part of the CHw phase, which shows the best data and derivative quality. The confidence range for the transmissivity is estimated to be 8.0E-7 to 5.0E-6 m2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CHwr phase using straight line extrapolation in the Horner plot to a value of 5007.7 kPa.

Test Summary Sheet

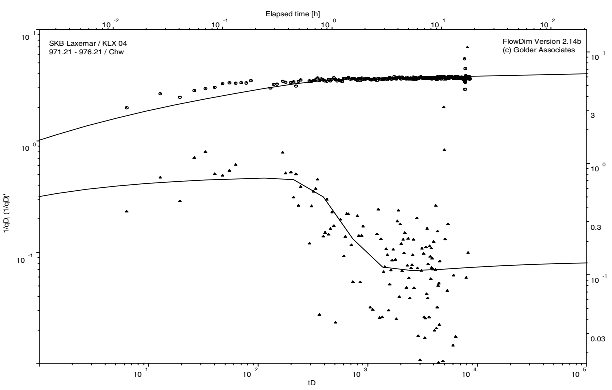
Project:	Oskarshamn site investigation	Test type:[1]	Chwr
Area:	Laxemar	Test no:	1
Borehole ID:	KLX04	Test start:	040909 20:29
Test section from - to (m):	971.21-976.21 m	Responsible for test execution:	Stephan Rohs
Section diameter, $2 \cdot r_w$ (m):	0.076	Responsible for test evaluation:	Cristian Enachescu

Linear plot Q and p

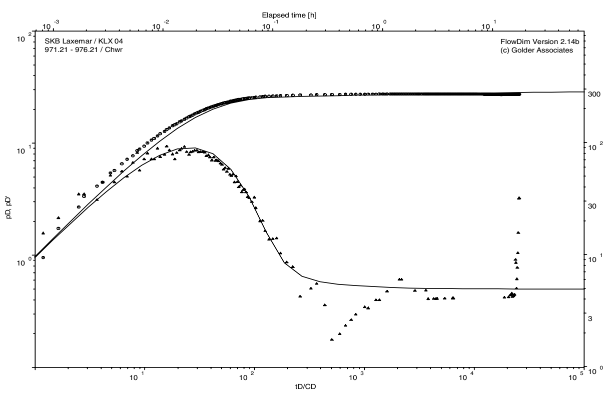


Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa) =	9528		
p_i (kPa) =	9535		
p_p(kPa) =	9254	p_F (kPa) =	9515
Q_p (m^3/s)=	2.40E-06		
tp (s) =	579480	t_F (s) =	64020
S el S^* (-)=	1.00E-06	S el S^* (-)=	1.00E-06
EC_w (mS/m)=			
$Temp_w$(gr C)=	22.4		
Derivative fact.=	0.19	Derivative fact.=	0.02
Results		**Results**	
Q/s (m^2/s)=	8.4E-08		
T_M (m^2/s)=	6.9E-08		
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	176.93	dt_1 (min) =	17.83
dt_2 (min) =	771.84	dt_2 (min) =	264.85
T (m^2/s) =	3.1E-07	T (m^2/s) =	4.0E-07
S (-) =	1.0E-06	S (-) =	1.0E-06
K_s (m/s) =	6.1E-08	K_s (m/s) =	7.9E-08
S_s (1/m) =	2.0E-07	S_s (1/m) =	2.0E-07
C (m^3/Pa) =	NA	C (m^3/Pa) =	6.2E-10
C_D (-) =	NA	C_D (-) =	6.8E-02
ξ (-) =	-2.8	ξ (-) =	19.8
T_{GRF}(m^2/s) =		T_{GRF}(m^2/s) =	
S_{GRF}(-) =		S_{GRF}(-) =	
D_{GRF} (-) =		D_{GRF} (-) =	

Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Selected representative parameters.

dt_1 (min) =	17.83	C (m^3/Pa) =	6.2E-10
dt_2 (min) =	264.85	C_D (-) =	6.8E-02
T_T (m^2/s) =	4.0E-07	ξ (-) =	19.8
S (-) =	1.0E-06		
K_s (m/s) =	7.9E-08		
S_s (1/m) =	2.0E-07		

Comments:

The recommended transmissivity of 4.0E-7 m2/s was derived from the analysis of the CHwr phase, which shows the best data and derivative quality. The confidence range for the transmissivity is estimated to be 2.0E-7 to 1.0E-6 m2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CHwr phase using straight line extrapolation in the Horner plot to a value of 9517.9 kPa.

APPENDIX 4

Nomenclature

The following symbols are extracted from the more comprehensive list of symbols provided by SKB. Only the symbols that were used or deemed to be used in the future in the context of test analysis are presented.

Character	Explanation	Dimension	Unit
b	Aquifer thickness (Thickness of 2D formation)	[L]	m
L_w	Test section length.	[L]	m
r_w	Borehole, well or soil pipe radius in test section.	[L]	m
r_D	Dimensionless radius, $r_D=r/r_w$	-	-
Q_p	Flow in test section immediately before stop of flow. Stabilised pump flow in flow logging.	$[L^3/T]$	m^3/s
Q_m	Arithmetical mean flow during perturbation phase.	$[L^3/T]$	m^3/s
V	Volume	$[L^3]$	m^3
V_w	Water volume in test section.	$[L^3]$	m^3
V_p	Total water volume injected/pumped during perturbation phase.	$[L^3]$	m^3
t	Time	[T]	hour,min,s
t_0	Duration of rest phase before perturbation phase.	[T]	s
t_p	Duration of perturbation phase. (from flow start as far as p_p).	[T]	s
t_F	Duration of recovery phase (from p_p to p_F).	[T]	s
t_1, t_2 etc	Times for various phases during a hydro test.	[T]	hour,min,s
dt	Running time from start of flow phase and recovery phase respectively.	[T]	s
dt_e	$dt_e = (dt \cdot tp) / (dt + tp)$ Agarwal equivalent time with dt as running time for recovery phase.	[T]	s
t_D	$t_D = T \cdot t / (S \cdot r_w^2)$. Dimensionless time	-	-
p	Static pressure; including non-dynamic pressure which depends on water velocity. Dynamic pressure is normally ignored in estimating the potential in groundwater flow relations.	$[M/(LT)^2]$	kPa
p_a	Atmospheric pressure	$[M/(LT)^2]$	kPa
p_t	Absolute pressure; $p_t=p_a+p_g$	$[M/(LT)^2]$	kPa
p_g	Gauge pressure; Difference between absolute pressure and atmospheric pressure.	$[M/(LT)^2]$	kPa
p_0	Initial pressure before test begins, prior to packer expansion.	$[M/(LT)^2]$	kPa
p_i	Pressure in measuring section before start of flow.	$[M/(LT)^2]$	kPa
p_f	Pressure during perturbation phase.	$[M/(LT)^2]$	kPa
p_s	Pressure during recovery.	$[M/(LT)^2]$	kPa
p_p	Pressure in measuring section before flow stop.	$[M/(LT)^2]$	kPa
p_F	Pressure in measuring section at end of recovery.	$[M/(LT)^2]$	kPa
p_D	$p_D=2\pi \cdot T \cdot p/(Q \cdot \rho_w g)$, Dimensionless pressure	-	-
dp	Pressure difference, drawdown of pressure surface between two points of time.	$[M/(LT)^2]$	kPa
dp_f	$dp_f = p_i - p_f$ or $= p_f - p_i$, drawdown/pressure increase of pressure surface between two points of time during perturbation phase. dp_f usually expressed positive.	$[M/(LT)^2]$	kPa
dp_s	$dp_s = p_s - p_p$ or $= p_p - p_s$, pressure increase/drawdown of pressure surface between two points of time during recovery phase. dp_s usually expressed positive.	$[M/(LT)^2]$	kPa
dp_p	$dp_p = p_i - p_p$ or $= p_p - p_i$, **maximal** pressure increase/drawdown of pressure surface between two points of time during perturbation phase. dp_p expressed positive.	$[M/(LT)^2]$	kPa
dp_F	$dp_F = p_p - p_F$ or $= p_F - p_p$, **maximal** pressure increase/drawdown of pressure surface between two points of time during recovery phase. dp_F expressed positive.	$[M/(LT)^2]$	kPa

H	Total head; (potential relative a reference level) (indication of h for phase as for p). $H=h_e+h_p+h_v$	[L]	m
h	Groundwater pressure level (hydraulic head (piezometric head; possible to use for level observations in boreholes, static head)); (indication of h for phase as for p). $h=h_e+h_p$	[L]	m
h_e	Height of measuring point (Elevation head); Level above reference level for measuring point.	[L]	m
s_p	Drawdown in measuring section before flow stop.	[L]	m
h_0	Initial above reference level before test begins, prior to packer expansion.	[L]	m
h_i	Level above reference level in measuring section before start of flow.	[L]	m
h_f	Level above reference level during perturbation phase.	[L]	m
h_s	Level above reference level during recovery phase.	[L]	m
h_p	Level above reference level in measuring section before flow stop.	[L]	m
h_F	Level above reference level in measuring section at end of recovery.	[L]	m
dh	Level difference, drawdown of water level between two points of time.	[L]	m
dh_f	$dh_f = h_i - h_f$ or $= h_f - h_i$, drawdown/pressure increase of pressure surface between two points of time during perturbation phase. dh_f usually expressed positive.	[L]	m
dh_s	$dh_s = h_s - h_p$ or $= h_p - h_s$, pressure increase/drawdown of pressure surface between two points of time during recovery phase. dh_s usually expressed positive.	[L]	m
dh_p	$dh_p = h_i - h_p$ or $= h_p - h_i$, maximal pressure increase/drawdown of pressure surface between two points of time during perturbation phase. dh_p expressed positive.	[L]	m
dh_F	$dh_F = h_p - h_F$ or $= h_F - h_p$, maximal pressure increase/drawdown of pressure surface between two points of time during perturbation phase. dh_F expressed positive.	[L]	m
Te_w	Temperature in the test section (taken from temperature logging). Temperature		^oC
Te_{w0}	Temperature in the test section during undisturbed conditions (taken from temperature logging). Temperature		^oC
g	Constant of gravitation (9.81 $m*s^{-2}$) (Acceleration due to gravity)	$[L/T^2]$	m/s^2
π	Constant (approx 3.1416).	[-]	
r	Residual. $r= p_c-p_m$, $r= h_c-h_m$, etc. Difference between measured data (p_m, h_m, etc) and estimated data (p_c, h_c, etc)		
Q/s	Specific capacity $s=dp_p$ or $s=s_p=h_0-h_p$ (open borehole)	$[L^2/T]$	m^2/s
D	Interpreted flow dimension according to Barker, 1988.	[-]	-
dt_1	Time of starting for semi-log or log-log evaluated characteristic counted from start of flow phase and recovery phase respectively.	[T]	s
dt_2	End of time for semi-log or log-log evaluated characteristic counted from start of flow phase and recovery phase respectively.	[T]	s
T	Transmissivity	$[L^2/T]$	m^2/s
T_M	Transmissivity according to Moye (1967)	$[L^2/T]$	m^2/s
T_S	Transmissivity evaluated from slug test	$[L^2/T]$	m^2/s
T_{Sf}, T_{Lf}	Transient evaluation based on semi-log or log-log diagram for perturbation phase in injection or pumping.	$[L^2/T]$	m^2/s
T_{Ss}, T_{Ls}	Transient evaluation based on semi-log or log-log diagram for recovery phase in injection or pumping.	$[L^2/T]$	m^2/s

T_T	Transient evaluation (log-log or lin-log). Judged best evaluation of T_{Sf}, T_{Lf}, T_{Ss}, T_{Ls}	$[L^2/T]$	m^2/s
T_{NLR}	Evaluation based on non-linear regression.	$[L^2/T]$	m^2/s
S	Storage coefficient, (Storativity)	[-]	-
S*	Assumed storage coefficient	[-]	-
S_f	Fracture storage coefficient	[-]	-
S_m	Matrix storage coefficient	[-]	-
S_{NLR}	Storage coefficient, evaluation based on non-linear regression	[-]	-
S_s	Specific storage coefficient; confined storage.	[1/L]	1/m
S_s*	Assumed specific storage coefficient; confined storage.	[1/L]	1/m
ξ	Skin factor	[-]	-
ξ*	Assumed skin factor	[-]	-
C	Wellbore storage coefficient	$[(LT^2)\cdot M^2]$	m^3/Pa
C_D	$C_D = C\cdot\rho_w g/(2\pi\cdot S\cdot r_w^2)$, Dimensionless wellbore storage coefficient	[-]	-
ω	$\omega = S_f/(S_f + S_m)$, storage ratio (Storativity ratio); the ratio of storage coefficient between that of the fracture and total storage.	[-]	-
λ	$\lambda = \alpha\cdot(K_m / K_f)\cdot r_w^2$ interporosity flow coefficient.	[-]	-
T_{GRF}	Transmissivity interpreted using the GRF method	$[L^2/T]$	m^2/s
S_{GRF}	Storage coefficient interpreted using the GRF method	[1/L]	1/m
D_{GRF}	Flow dimension interpreted using the GRF method	[-]	-
c_w	Water compressibility; corresponding to β in hydrogeological literature.	$[(LT^2)/M]$	1/Pa
c_r	Pore-volume compressibility, (rock compressibility); Corresponding to α/n in hydrogeological literature.	$[(LT^2)/M]$	1/Pa
c_t	$c_t = c_r + c_w$, total compressibility; compressibility per volumetric unit of rock obtained through multiplying by the total porosity, n. (Presence of gas or other fluids can be included in c_t if the degree of saturation (volume of respective fluid divided by n) of the pore system of respective fluid is also included)	$[(LT^2)/M]$	1/Pa
n	Total porosity	-	-
ρ	Density	$[M/L^3]$	$kg/(m^3)$
ρ_w	Fluid density in measurement section during pumping/injection	$[M/L^3]$	$kg/(m^3)$
μ	Dynamic viscosity	[M/LT]	Pa s
μ_w	Dynamic viscosity (Fluid density in measurement section during pumping/injection)	[M/LT]	Pa s

APPENDIX 5

SICADA data tables

(Simplified version v1.2)

SICADA/Data Import Template

SKB & Ergodata AB 2004

File Identity	
Created By	Stephan Rohs
Created	2004.11.03 13:06

Activity Type	KLX04 KLX04 - Pumping and Watersampling

Project	AP PS 400-04-75

Activity Information						Additional Activity Data						
						C10	P20	P200	P220	R110	R25	R90
Idcode	Start Date	Stop Date	Secup (m)	Seclow (m)	Section No	Company	Field crew manager	Field crew	Person evaluating data	Field Notes ID	Report	Quality plan
KLX04	2004.09.09 20:00	2004.09.30 13:47	104.00	976.21		Golder	Jörg Böhner, Stephan Rohs	Nils Rahm, Jörg Böhner, Stephan Rohs, Tomas Cronquist	Cristian Enachescu, Jörg Böhner, Stephan Rohs			

Table	plu_s_hole_test_d
	PLU Injection and pumping, General information

Column	Datatype	Unit	Column Description
site	CHAR		Investigation site name
activity_type	CHAR		Activity type code
start_date	DATE		Date (yymmdd hh:mm:ss)
stop_date	DATE		Date (yymmdd hh:mm:ss)
project	CHAR		project code
idcode	CHAR		Object or borehole identification code
secup	FLOAT	m	Upper section limit (m)
seclow	FLOAT	m	Lower section limit (m)
section_no	INTEGER	number	Section number
test_type	CHAR		Test type code (1-7), see table description
formation_type	CHAR		1: Rock, 2: Soil (superficial deposits)
start_flow_period	DATE	yyyymmdd	Date & time of pumping/injection start (YYYY-MM-DD hh:mm:ss)
stop_flow_period	DATE	yyyymmdd	Date & time of pumping/injection stop (YYYY-MM-DD hh:mm:ss)
mean_flow_rate_qm	FLOAT	m**3/s	Arithmetic mean flow rate of the pumping/injection
flow_rate_end_qp	FLOAT	m**3/s	Flow rate at the end of the flowing period
value_type_qp	CHAR		0:true value,-1<lower meas.limit1:>upper meas.limit
q_measl__l	FLOAT	m**3/s	Estimated lower measurement limit of flow rate
q_measl__u	FLOAT	m**3/s	Estimated upper measurement limit of flow rate
tot_volume_vp	FLOAT	m**3	Total volume of pumped(positive) or injected(negative) water
dur_flow_phase_tp	FLOAT	s	Time for the flowing phase of the test
dur_rec_phase_tf	FLOAT	s	Time for the recovery phase of the test
initial_head_hi	FLOAT	m	Initial formation head, see table description
head_at_flow_end_h	FLOAT	m	Hydraulic head at end of flow phase, see table description
final_head_hf	FLOAT	m	Hydraulic head at end of recovery phase,see table descript.
initial_press_pi	FLOAT	kPa	Initial formation pressure. Actual formation pressure
press_at_flow_end_	FLOAT	kPa	Pressure at the end of flow phase, see table description.
final_press_pf	FLOAT	kPa	Final pressure at the end of the recovery, see table descr.
fluid_temp_tew	FLOAT	oC	Section fluid temperature, see table description
fluid_elcond_ecw	FLOAT	mS/m	Section fluid el. conduvtivity,see table description
fluid_salinity_tdsw	FLOAT	mg/l	Total salinity of section fluid based on EC,see table descr.
fluid_salinity_tdswm	FLOAT	mg/l	Tot. section fluid salinity based on water sampling,see...
reference	CHAR		SKB report No for reports describing data and evaluation
comments	VARCHAR		Short comment to data
error_flag	CHAR		If error_flag = "*" then an error occured and an error
in_use	CHAR		If in_use = "*" then the activity has been selected as
sign	CHAR		Signature for QA data accknowledge (QA - OK)
lp	FLOAT	m	Hydraulic point of application

idcode	start_date	stop_date	secup	seclow	section_no	test_type	formation_type	start_flow_period	stop_flow_period	mean_flow_rate_qm	flow_rate_end_qp	value_type_qp	q_measl__l	q_measl__u	tot_volume_vp	dur_flow_phase_tp
KLX04	2004.09.29 16:57:00	2004.09.30 13:47:00	104.00	109.00		1	1	2004.09.29 17:50:00	2004.09.30 10:20:00	7.25E-05	7.10E-05	0	1.6667E-08	8.3333E-04	4.31E+00	59400
KLX04	2004.09.17 17:51:00	2004.09.29 09:18:00	510.66	515.66		1	1	2004.09.17 19:02:00	2004.09.29 09:00:00	5.84E-05	8.48E-05	0	1.6667E-08	8.3333E-04	3.18E+01	1004940
KLX04	2004.09.09 20:29:00	2004.09.17 08:08:00	971.21	976.21		1	1	2004.09.09 21:21:00	2004.09.16 14:19:00	2.48E-06	2.40E-06	0	1.6667E-08	8.3333E-04	1.44E+00	579480

idcode	secup	seclow	dur_rec_phase_tf	initial_head_hi	head_at_flow_end_hp	final_head_hf	initial_press_pi	press_at_flow_end_pp	final_press_pf	fluid_temp_tew	fluid_elcond_ecw	fluid_salinity_tdsw	fluid_salinity_tdswm	reference	comments	lp
KLX04	104.00	109.00	12420			13.85	1052	699	1050	8.7						106.50
KLX04	510.66	515.66	1080			12.45	5020	4652	5005	14.7						513.06
KLX04	971.21	976.21	64020			14.35	9535	9254	9515	22.4						973.71

Table	plu_s_hole_test_ed1 PLU Single hole tests, pumping/injection. Basic evaluation		
Column	**Datatype**	**Unit**	**Column Description**
site	CHAR		Investigation site name
activity_type	CHAR		Activity type code
start_date	DATE		Date (yymmdd hh:mm:ss)
stop_date	DATE		Date (yymmdd hh:mm:ss)
project	CHAR		project code
idcode	CHAR		Object or borehole identification code
secup	FLOAT	m	Upper section limit (m)
seclow	FLOAT	m	Lower section limit (m)
section_no	INTEGER	number	Section number
test_type	CHAR		Test type code (1-7), see table description!
formation_type	CHAR		Formation type code. 1: Rock, 2: Soil (superficial deposits)
lp	FLOAT	m	Hydraulic point of application
seclen_class	FLOAT	m	Planned ordinary test interval during test campaign.
spec_capacity_q_s	FLOAT	m**2/s	Specific capacity (Q/s) of test section, see table descript.
value_type_q_s	CHAR		0:true value,-1:Q/s<lower meas.limit,1:Q/s>upper meas.limit
transmissivity_tq	FLOAT	m**2/s	Tranmissivity based on Q/s, see table description
value_type_tq	CHAR		0:true value,-1:TQ<lower meas.limit,1:TQ>upper meas.limit.
bc_tq	CHAR		Best choice code. 1 means TQ is best choice of T, else 0
transmissivity_moye	FLOAT	m**2/s	Transmissivity,TM, based on Moye (1967)
bc_tm	CHAR		Best choice code. 1 means Tmoye is best choice of T, else 0
value_type_tm	CHAR		0:true value,-1:TM<lower meas.limit,1:TM>upper meas.limit.
hydr_cond_moye	FLOAT	m**2/s	K_M: Hydraulic conductivity based on Moye (1967)
formation_width_b	FLOAT	m	b:Interpreted formation thickness repr. for evaluated T/TB
width_of_channel_b	FLOAT	m	B:Interpreted width of formation with evaluated TB
tb	FLOAT	m**3/s	TB:T=transmissivity,B=width of formation,see description
l_measl_tb	FLOAT	m**3/s	Estimated lower meas. limit for evaluated TB,see description
u_measl_tb	FLOAT	m**3/s	Estimated upper meas. limit of evaluated TB,see description
sb	FLOAT	m	SB:S=storativity,B=width of formation,1Dmodel,see descript.
assumed_sb	FLOAT	m	SB* : Assumed SB,S=storativity,B=width of formation,see...
leakage_factor_lf	FLOAT	m	Lf:1D model for evaluation of Leakage factor
transmissivity_tt	FLOAT	m**2/s	T=transmissivity, 2D model, see table description
value_type_tt	CHAR		0:true value,-1:TT<lower meas.limit,1:TT>upper meas.limit,
bc_tt	CHAR		Best choice code. 1 means TT is best choice of T, else 0
l_measl_q_s	FLOAT	m**2/s	Estimated lower meas. limit for evaluated T,see table descr.
u_measl_q_s	FLOAT	m**2/s	Estimated upper meas. limit for evaluated T,see description
storativity_s	FLOAT		2D model for evaluation of S=storativity,see table descript.
assumed_s	FLOAT		Assumed Storativity,2D model evaluation,see table descr.
leakage_koeff	FLOAT	1/s	K'/b':2Dmodel evaluation of leakage coefficient,see desc.
hydr_cond_ks	FLOAT	m**2/s	Ks:3D model evaluation of hydraulic conductivity,see desc.
value_type_ks	CHAR		0:true value,-1:Ks<lower meas.limit,1:Ks>upper meas.limit,
l_meas_limit_ks	FLOAT	m**2/s	Estimated lower meas.limit for evaluated Ks, see table desc.
u_meas_limit_ks	FLOAT	m**2/s	Estimated upper meas.limit for evaluated Ks,see table descr.
spec_storage_ss	FLOAT	1/m	Ss:Specific storage,3Dmodel evaluation,see table descr.
assumed_ss	FLOAT	1/m	Assumed Spec.storage,3D model evaluation,see table des.
c	FLOAT	m**3/pa	C: Wellbore storage coefficient
cd	FLOAT		CD: Dimensionless wellbore storage constant
skin	FLOAT		Skin factor
stor_ratio	FLOAT		Storativity ratio
interflow_coeff	FLOAT		Interporosity flow coefficient
dt1	FLOAT	s	Estimated start time of evaluation, see table description
dt2	FLOAT	s	Estimated stop time of evaluation. see table description
transmissivity_t_ilr	FLOAT	m**2/s	T_ILR Transmissivity based on None Linear Regression...
storativity_s_ilr	FLOAT		S_ILR=storativity based on None Linear Regression,see..
value_type_t_ilr	CHAR		0:true value,-1:T_ILR<lower meas.limit,1:>upper meas.limit
bc_t_ilr	CHAR		Best choice code. 1 means T_ILR is best choice of T, else 0
c_ilr	FLOAT	m**3/pa	Wellbore storage coefficient, based on ILR, see descr.
cd_ilr	FLOAT		Dimensionless wellbore storage constant, see table descrip.
skin_ilr	FLOAT		Skin factor based on Non Linear Regression,see desc.
stor_ratio_ilr	FLOAT		Storativity ratio based on Non Linear Regression, see descr.
interflow_coeff_ilr	FLOAT		Interporosity flow coefficient based on Non Linear Regr....
transmissivity_t_grf	FLOAT	m**2/s	T_GRF:Transmissivity based on Gen.Rad. Flow,see...
value_type_t_grf	CHAR		0:true value,-1:T_GRF<lower meas.limit,1:>upper meas.limit
bc_t_grf	CHAR		Best choice code. 1 means T_GRF is best choice of T, else 0
storativity_s_grf	FLOAT		S_GRF:Storativity basd on Gen. Rad.Flow, see table descri.
flow_dim_grf	FLOAT		Flow dimesion based on Gen. Rad.Flow. interpretation model
comment	VARCHAR	no_unit	Short comment to the evaluated parameters
error_flag	CHAR		If error_flag = "*" then an error occured and an error
in_use	CHAR		If in_use = "*" then the activity has been selected as
sign	CHAR		Signature for QA data accknowledge (QA - OK)

idcode	start_date	stop_date	secup	seclow	section_no	test_type	formation_type	lp	seclen_class	spec_capacity_q_s	value_type_q_s	transmissivity_tq	value_type_tq	bc_tq
KLX04	2004.08.20 10:27	2004.08.20 12:44	104.00	109.00		1	1	106.50	5	1.97E-06	0			
KLX04	2004.08.20 16:11	2004.08.20 17:40	510.66	515.66		1	1	513.06	5	8.44E-07	0			
KLX04	2004.08.21 08:14	2004.08.21 10:33	971.21	976.21		1	1	973.71	5	8.38E-08	0			

idcode	secup	seclow	transmissivity_moye	bc_tm	value_type_tm	hydr_cond_moye	formation_width_b	width_of_channel_b	tb	l_measl_tb	u_measl_tb	sb	assumed_sb	leakage_factor_lf
KLX04	104.00	109.00	1.63E-06	0	0	3.26E-07								
KLX04	510.66	515.66	6.97E-07	0	0	1.39E-07								
KLX04	971.21	976.21	6.92E-08	0	0	1.38E-08								

idcode	secup	seclow	transmissivity_tt	value_type_tt	bc_tt	l_measl_q_s	u_measl_q_s	storativity_s	assumed_s	leakage_koeff	hydr_cond_ks	value_type_ks	l_meas_limit_ks	u_meas_limit_ks
KLX04	104.00	109.00	4.20E-06	0	1	1.00E-06	2.00E-05	1.00E-04	1.00E-04		8.40E-07			
KLX04	510.66	515.66	2.58E-06	0	1	8.00E-07	5.00E-06	1.00E-06	1.00E-06		5.16E-07			
KLX04	971.21	976.21	3.95E-07	0	1	2.00E-07	1.00E-06	1.00E-06	1.00E-06		7.90E-08			

idcode	secup	seclow	spec_storage_ss	assumed_ss	c	cd	skin	stor_ratio	interflow_coeff	dt1	dt2	transmissivity_t_ilr	storativity_s_ilr	value_type_t_ilr
KLX04	104.00	109.00			1.54E-10	1.70E-04	6.60E+00							
KLX04	510.66	515.66			8.43E-10	5.00E-02	6.48E+00							
KLX04	971.21	976.21			6.21E-10	6.80E-02	1.98E+01							

idcode	secup	seclow	bc_t_ilr	c_ilr	cd_ilr	skin_ilr	stor_ratio_ilr	interflow_coeff_ilr	transmissivity_t_grf	value_type_t_grf	bc_t_grf	storativity_s_grf	flow_dim_grf	comment
KLX04	104.00	109.00												
KLX04	510.66	515.66												
KLX04	971.21	976.21												