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Oskarshamn site investigation

Hydraulic testing of percussion drilled lineament boreholes on Ävrö and Simpevarp, 2004

Sub-area Simpevarp

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November 2004

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

Abstract

Hydraulic pump tests together with flow logging and water sampling have been performed in percussion boreholes HSH04, HSH05, HAV11, HAV12, HAV13 and HAV14 at the Ävrö Island and Simpevarp Peninsula at the sub-area Simpevarp, Oskarshamn. The tests are part of the general program for site investigations and specifically for the Simpevarp sub-area. The hydraulic testing programme has the aim to characterise the rock with respect to its hydraulic properties of the fractured zones, especially to selected lineaments discovered by the percussion boreholes. Data is subsequently delivered for the site descriptive model.

This report describes the results and primary data evaluation of the hydraulic pump tests and flow logging in boreholes HSH04, HSH05, HAV11, HAV12, HAV13 and HAV14 performed between 30th June and 22nd of July 2004. In a selection of further boreholes, the piezometric heads were monitored during the pump tests, data of further monitoring boreholes were delivered by SKB for implementation in the test analysis.

The main objective of the hydraulic testing, interference testing, flow logging and water sampling was to characterize the rock around the boreholes (with special respect to connectivity of lineaments) and investigate the water quality of the boreholes. Transient evaluation during flow and recovery period provided additional information such as flow regimes, hydraulic boundaries and interferences. Constant rate pump tests were conducted in the open boreholes. The results of the test interpretation are presented as transmissivity.

Sammanfattning

Hydrauliska pumptester, flödesloggningar och vattenprovtagning har utförts i hammarborrhålen HSH04, HSH05, HAV11, HAV13 och HAV14 på Ävrön, Simpevarpshalvön. Testerna är en del av de platsundersökningar som utförs vid Oskarshamnsverket, Simpevarpsområdet. Hydraultestprogrammet har som mål att karakterisera bergmassans hydrauliska egenskaper i sprickzoner i utvalda lineament som påträffats vid borrningar. Data överförs från testerna till den platsspecifika modellen.

Föreliggande rapport beskriver resultaten och primärdata från utvärderingen av hydrauliska pumptest och flödesloggningar i hammarborrhålen HSH04, HSH05, HAV11, HAV13 och HAV14 utförda mellan den 30 juni till och med den 22 juli 2004. Observationer av grundvattenytor och grundvattentryck har även utförts i närliggande borrhål av SKB i anslutning till pumptesterna. Dessa data har ingått i analysen.

Huvudsyftet för undersökningen har varit att karakterisera responsen av grundvattentrycken mellan pumpbrunnen och observationsbrunnar i samma lineament, grundvattenkvaliteten och de hydrauliska egenskaperna i berget vid borrhålen. Transient utvärdering under flödes- och återhämtningsfasen gav ytterligare information om flödesregimer, hydrauliska gränser och interferenser. Pumptester med konstanta flöden utfördes i öppna borrhål. Resultaten presenteras som transmissiviteter (T).

Contents

1 Introduction

Hydraulic pump tests together with flow logging and water sampling have been performed in six percussion boreholes (HSH04, HSH05, HAV11, HAV12, HAV13 and HAV14). Monitoring of groundwater levels was carried out in a selection of additional monitoring boreholes (HSH06, KAV04A, HAV07, HAV08, HAV12, HAV13 and HAV14); monitoring data of further boreholes were delivered by SKB.

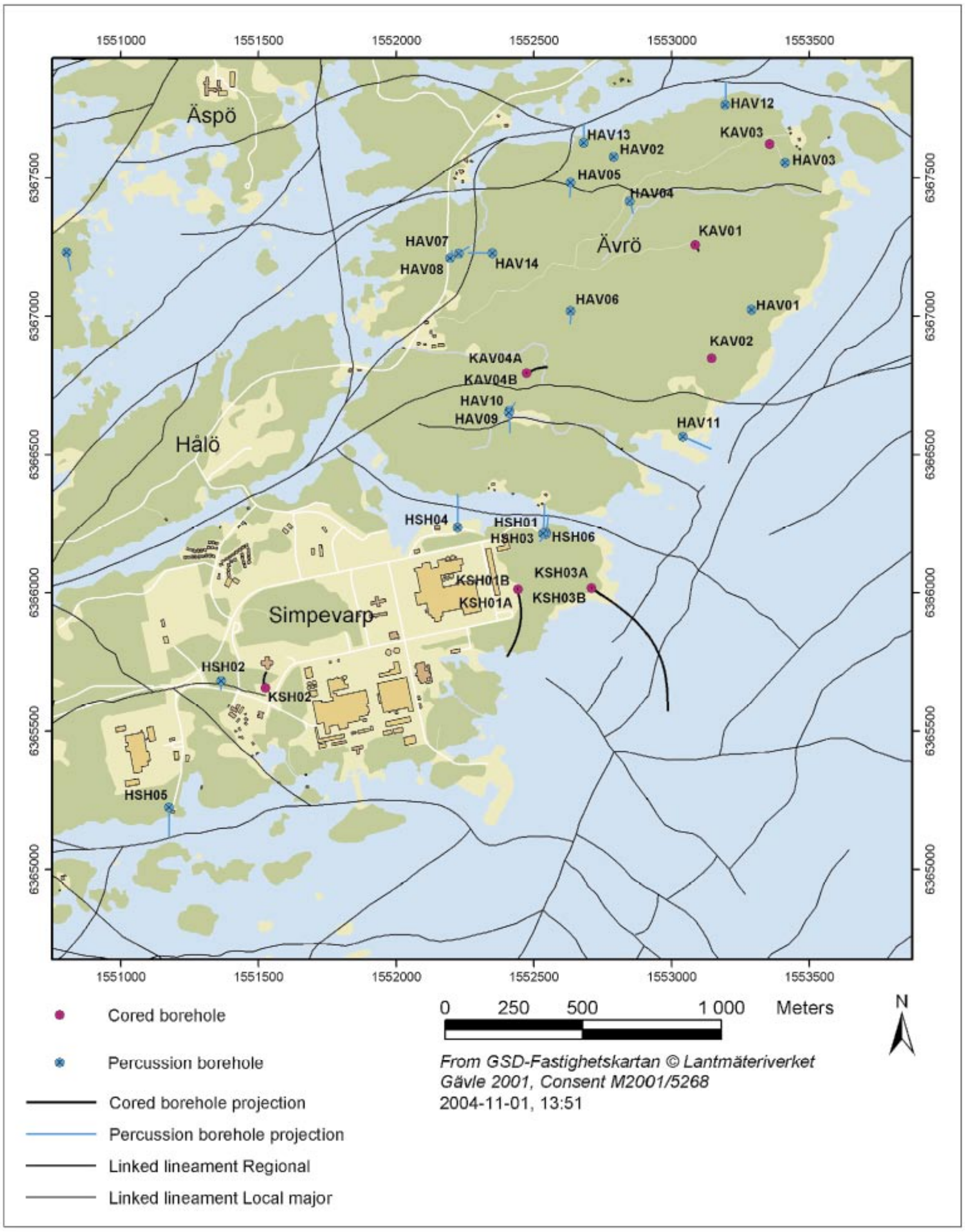

Figure 1-1. *The investigation area Simpevarp, Oskarshamn with location of boreholes.*

Measurements were carried out according during 30th of June and 23rd of July 2004 following the methodologies described in SKB MD 322.009 (flow logging), SKB MD 321.003 (pump tests) and SKB MD 330.003 (interference tests) and in the activity plan AP PS 400-03-077 (SKB internal controlling documents). Data and results were delivered to the SKB site characterization database SICADA.

The boreholes are situated on the Ävrö Island and Simpevarp Peninsula on the site of the nuclear power plant at Simpevarp and northeast of it, Figure 1-1. The percussion boreholes were mainly drilled in 2004 at approximately 200 m depth with a nominal inner diameter of 140 mm. The upper approximately 10 m are cased with large diameter telescopic casing ranging from diameter 160 mm–147 mm. The boreholes are inclined with approximately 57.8° to 60.4°.

2 Objective

The major objective of the performed testing program was the interference testing and testing of hydraulic connectivity of the lineaments connected to the percussion boreholes.

Further main objectives of the pump testing, flow logging and water sampling in the percussion boreholes was to characterize the rock around the boreholes (with special respect to the lineaments) and investigate the water quality of the boreholes. Transient evaluation during flow and recovery period in combination with further piezometric data of monitoring boreholes provided additional information such as flow regimes, hydraulic boundaries and interferences.

3 Scope of work

The scope of work consisted of preparation of the HTHB tool, which included functional checks, performing pump tests in six open boreholes (HSH04, HSH05, HAV11, HAV12, HAV13 and HAV14), monitoring the piezometric heads in further boreholes (HSH06, KAV04A, HAV07, HAV08, HAV12, HAV13 and HAV14), flow logging, water sampling, analysis and reporting.

Preparation for testing was done according to the activity plan (AP PS 400-03-077) and relevant SKB method descriptions for pump tests (SKB MD 321.003), flow logging (SKB MD 322.009) and for interference tests (SKB MD 330.003) (SKB internal controlling documents). This step mainly consists of functions checks of the equipment to be used, the HTHB tool. Function checks were documented in the daily log and/or relevant documents.

The following test programme was performed:

Table 3-1. Performed test programme.

Borehole	Priority	Method	Monitored boreholes (Golder)	Monitored boreholes (SKB)
HAV12	1	Pumptest, flow logging, water sampling	HAV13, HAV14	HAV02, HAV05, KAV01, KAV03
HAV14	2	Pumptest, flow logging, water sampling	HAV07, HAV08, HAV13, KAV04A	HAV05
HAV11	3	Pumptest, flow logging, water sampling	KAV04A	KSH03, KAV01
HSH04	4	Pumptest, flow logging, water sampling	HSH06	HSH01
HSH05	5	Pumptest, flow logging, water sampling	Single hole test	Single hole test
HAV13	6	Pumptest, water sampling	HAV07, HAV08, HAV12, HAV14	HAV02, HAV05, KAV01, KAV03

3.1 Boreholes

Technical data of the tested and monitored boreholes are shown in Tables 3-2 to 3-11. The reference point in the boreholes is the centre of top of casing (ToC), given as Elevation in the 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 diameters in the tables refer to the final diameter of the drill bit after drilling to full depth.

Table 3-2. Information about HSH01 (from SICADA 2004-09-08, 15:22:46).

Title	Value				
Borehole length (m):	200.000				
Drilling Period(s):	From Date	To Date	Secup (m)	Seclow (m)	Drilling Type
	2002-06-24	2002-07-02	0.000	200.000	Percussion drilling
Starting point coordinate:	Length (m)	Northing (m)	Easting (m)	Elevation (masl)	Coord Sys.
(centerpoint of TOC)	0.000	6366217.770	1552545.864	2.864	RT90-RHB70
Angles:	Length (m)	Bearing	Inclination (– = down)		
	0.000	4.994	–69.994		
Borehole diameter:	Secup (m)	Seclow (m)	Hole Diam (m)		
	0.000	1.500	0.270		
	1.500	12.030	0.215		
	12.030	200.000	0.140		
Casing diameter:	Secup (m)	Seclow (m)	Case In (m)	Case Out (m)	
	0.000	12.000	0.160	0.168	

Table 3-3. Information about HSH04 (from SICADA 2004-06-22, 10:44:18).

Title	Value				
Borehole length (m):	236.200				
Drilling Period(s):	From Date	To Date	Secup (m)	Seclow (m)	Drilling Type
	2004-04-05	2004-04-13	0.000	236.200	Percussion drilling
Starting point coordinate:	Length (m)	Northing (m)	Easting (m)	Elevation (masl)	Coord Sys.
(centerpoint of TOC)	0.000	6366237.275	1552223.476	2.858	RT90-RHB70
Angles:	Length (m)	Bearing	Inclination (– = down)		
	0.000	359.774	–59.000		
Borehole diameter:	Secup (m)	Seclow (m)	Hole Diam (m)		
	0.000	9.200	0.190		
	9.200	236.200	0.137		
Casing diameter:	Secup (m)	Seclow (m)	Case In (m)	Case Out (m)	
	0.000	8.600	0.160	0.168	
	8.910	9.000	0.147	0.168	

Table 3-4. Information about HSH05 (from SICADA 2004-06-22, 10:44:36).

Title	Value				
Borehole length (m):	200.200				
Drilling Period(s):	From Date	To Date	Secup (m)	Seclow (m)	Drilling Type
	2004-04-14	2004-04-19	0.000	200.200	Percussion drilling
Starting point coordinate:	Length (m)	Northing (m)	Easting (m)	Elevation (masl)	Coord Sys.
(centerpoint of TOC)	0.000	6365224.711	1551179.077	2.718	RT90-RHB70
Angles:	Length (m)	Bearing	Inclination (– = down)		
	0.000	180.869	–57.952		
Borehole diameter:	Secup (m)	Seclow (m)	Hole Diam (m)		
	0.000	6.200	0.190		
	6.200	200.200	0.139		
Casing diameter:	Secup (m)	Seclow (m)	Case In (m)	Case Out (m)	
	0.000	6.200	0.147	0.168	
	0.000	6.110	0.160	0.168	

Table 3-5. Information about HSH06 (from SICADA 2004-06-22, 10:44:46).

Title	Value				
Borehole length (m):	203.200				
Drilling Period(s):	From Date	To Date	Secup (m)	Seclow (m)	Drilling Type
	2004-04-20	2004-04-22	0.000	203.200	Percussion drilling
Starting point coordinate:	Length (m)	Northing (m)	Easting (m)	Elevation (masl)	Coord Sys.
(centerpoint of TOC)	0.000	6366214.627	1552534.621	2.346	RT90-RHB70
Angles:	Length (m)	Bearing	Inclination (– = down)		
	0.000	2.143	–57.772		
Borehole diameter:	Secup (m)	Seclow (m)	Hole Diam (m)		
	0.000	9.240	0.190		
	9.240	203.200	0.138		
Casing diameter:	Secup (m)	Seclow (m)	Case In (m)	Case Out (m)	
	0.000	9.040	0.147	0.168	
	0.000	8.950	0.160	0.168	

Table 3-6. Information about HAV02 (from SICADA 2004-09-08, 15:13:01).

Title	Value				
Borehole length (m):	163.000				
Drilling Period(s):	From Date	To Date	Secup (m)	Seclow (m)	Drilling Type
	1986-08-18	1986-08-21	0.000	163.000	Percussion drilling
Starting point coordinate:	Length (m)	Northing (m)	Easting (m)	Elevation (masl)	Coord Sys.
(centerpoint of TOC)	0.000	6367577.809	1552790.978	6.108	RT90-RHB70
Angles:	Length (m)	Bearing	Inclination (– = down)		
	0.000	137.264	–89.100		
Borehole diameter:	Secup (m)	Seclow (m)	Hole Diam (m)		
	0.000	163.000	0.110		
Casing diameter:	Secup (m)	Seclow (m)	Case In (m)	Case Out (m)	
	0.000	0.130	0.140		

Table 3-7. Information about HAV05 (from SICADA 2004-09-09, 08:20:14).

Title	Value				
Borehole length (m):	100.000				
Drilling Period(s):	From Date	To Date	Secup (m)	Seclow (m)	Drilling Type
	1987-07-26	1987-07-28	0.000	100.000	Percussion drilling
Starting point coordinate:	Length (m)	Northing (m)	Easting (m)	Elevation (masl)	Coord Sys.
(centerpoint of TOC)	0.000	6367482.658	1552634.145	6.858	RT90-RHB70
Angles:	Length (m)	Bearing	Inclination (– = down)		
	0.000	191.264	–54.500		
Borehole diameter:	Secup (m)	Seclow (m)	Hole Diam (m)		
	0.000	100.000	0.115		
Casing diameter:	Secup (m)	Seclow (m)	Case In (m)	Case Out (m)	
	0.000	1.000	0.130	0.140	

Table 3-8. Information about HAV07 (from SICADA 2004-09-08, 15:15:21).

Title	Value				
Borehole length (m):	100.000				
Drilling Period(s):	From Date	To Date	Secup (m)	Seclow (m)	Drilling Type
	1987-07-27	1987-07-28	0.000	100.000	Percussion drilling
Starting point coordinate:	Length (m)	Northing (m)	Easting (m)	Elevation (masl)	Coord Sys.
(centerpoint of TOC)	0.000	6367227.487	1552229.393	4.165	RT90-RHB70
Angles:	Length (m)	Bearing	Inclination (– = down)		
	0.000	66.264	–56.200		
Borehole diameter:	Secup (m)	Seclow (m)	Hole Diam (m)		
	0.000	100.000	0.115		
Casing diameter:	Secup (m)	Seclow (m)	Case In (m)	Case Out (m)	
	0.000	4.000	0.130	0.140	

Table 3-9. Information about HAV08 (from SICADA 2004-09-08, 15:16:10).

Title	Value				
Borehole length (m):	63.000				
Drilling Period(s):	From Date	To Date	Secup (m)	Seclow (m)	Drilling Type
	1987-09-09	1987-09-09	0.000	63.000	Percussion drilling
Starting point coordinate:	Length (m)	Northing (m)	Easting (m)	Elevation (masl)	Coord Sys.
(centerpoint of TOC)	0.000	6367210.125	1552197.507	7.078	RT90-RHB70
Angles:	Length (m)	Bearing	Inclination (– = down)		
	0.000	28.264	–61.900		
Borehole diameter:	Secup (m)	Seclow (m)	Hole Diam (m)		
	0.000	63.000	0.076		
Casing diameter:	Secup (m)	Seclow (m)	Case In (m)	Case Out (m)	

Table 3-10. Information about HAV11 (from SICADA 2004-06-22, 10:45:13).

Title	Value				
Borehole length (m):	220.500				
Drilling Period(s):	From Date	To Date	Secup (m)	Seclow (m)	Drilling Type
	2004-06-07	2004-06-14	0.000	220.500	Percussion drilling
Starting point coordinate:	Length (m)	Northing (m)	Easting (m)	Elevation (masl)	Coord Sys.
(centerpoint of TOC)	0.000	6366565.254	1553040.898	2.379	RT90-RHB70
Angles:	Length (m)	Bearing	Inclination (– = down)		
	0.000	113.471	–59.610		
Borehole diameter:	Secup (m)	Seclow (m)	Hole Diam (m)		
	0.000	6.120	0.190		
	6.120	220.500	0.140		
Casing diameter:	Secup (m)	Seclow (m)	Case In (m)	Case Out (m)	
	0.000	6.030	0.147	0.168	
	0.000	5.940	0.160	0.168	

Table 3-11. Information about HAV12 (from SICADA 2004-06-22, 10:45:19).

Title	Value				
Borehole length (m):	157.800				
Drilling Period(s):	From Date	To Date	Secup (m)	Seclow (m)	Drilling Type
	2004-05-12	2004-05-19	0.000	157.800	Percussion drilling
Starting point coordinate:	Length (m)	Northing (m)	Easting (m)	Elevation (masl)	Coord Sys.
(centerpoint of TOC)	0.000	6367765.872	1553194.416	9.404	RT90-RHB70
Angles:	Length (m)	Bearing	Inclination (– = down)		
	0.000	0.274	–58.786		
Borehole diameter:	Secup (m)	Seclow (m)	Hole Diam (m)		
	0.000	6.130	0.190		
	6.130	157.800	0.140		
Casing diameter:	Secup (m)	Seclow (m)	Case In (m)	Case Out (m)	
	0.000	5.940	0.160	0.168	
	5.940	6.030	0.147	0.168	

Table 3-12. Information about HAV13 (from SICADA 2004-06-22, 10:45:26).

Title	Value				
Borehole length (m):	142.200				
Drilling Period(s):	From Date	To Date	Secup (m)	Seclow (m)	Drilling Type
	2004-05-24	2004-05-27	0.000	142.200	Percussion drilling
Starting point coordinate:	Length (m)	Northing (m)	Easting (m)	Elevation (masl)	Coord Sys.
(centerpoint of TOC)	0.000	6367627.858	1552682.157	2.215	RT90-RHB70
Angles:	Length (m)	Bearing	Inclination (– = down)		
	0.000	0.077	–58.809		
Borehole diameter:	Secup (m)	Seclow (m)	Hole Diam (m)		
	0.000	9.120	0.190		
	9.120	142.200	0.140		
Casing diameter:	Secup (m)	Seclow (m)	Case In (m)	Case Out (m)	
	0.000	8.950	0.160	0.168	
	8.950	9.040	0.147	0.168	

Table 3-13. Information about HAV14 (from SICADA 2004-06-22, 10:45:46).

Title	Value				
Borehole length (m):	182.400				
Drilling Period(s):	From Date	To Date	Secup (m)	Seclow (m)	Drilling Type
	2004-06-01	2004-06-04	0.000	182.400	Percussion drilling
Starting point coordinate:	Length (m)	Northing (m)	Easting (m)	Elevation (masl)	Coord Sys.
(centerpoint of TOC)	0.000	6367227.977	1552350.548	7.761	RT90-RHB70
Angles:	Length (m)	Bearing	Inclination (– = down)		
	0.000	271.462	–60.418		
Borehole diameter:	Secup (m)	Seclow (m)	Hole Diam (m)		
	0.000	6.120	0.190		
	6.120	182.400	0.136		
Casing diameter:	Secup (m)	Seclow (m)	Case In (m)	Case Out (m)	
	0.000	5.940	0.160	0.168	
	5.940	6.030	0.147	0.168	

Table 3-14. Information about KAV01 (from SICADA 2004-09-08, 15:28:36).

Title	Value				
Borehole length (m):	757.310				
Drilling Period(s):	From Date	To Date	Secup (m)	Seclow (m)	Drilling Type
	2003-06-11	2004-01-10	0.000	757.310	Core drilling
Starting point coordinate:	Length (m)	Northing (m)	Easting (m)	Elevation (masl)	Coord Sys.
(centerpoint of TOC)	0.000	6367257.524	1553084.922	14.100	RT90-RHB70
Angles:	Length (m)	Bearing	Inclination (– = down)		
	0.000	237.264	–89.200		
Borehole diameter:	Secup (m)	Seclow (m)	Hole Diam (m)		
	0.000	68.740	0.200		
	0.000	502.000	0.056		
	68.740	68.840	0.165		
	68.840	70.040	0.076		
	70.040	757.310	0.056		
Casing diameter:	Secup (m)	Seclow (m)	Case In (m)	Case Out (m)	
	0.000	68.040	0.160	0.168	
	67.490	67.740	0.158		
	67.740	70.040	0.058	0.066	

Table 3-15. Information about KAV03 (from SICADA 2004-09-08, 15:33:37).

Title	Value				
Borehole length (m):	248.400				
Drilling Period(s):	From Date	To Date	Secup (m)	Seclow (m)	Drilling Type
	1986-09-23	1986-10-05	0.000	284.400	Core drilling
Starting point coordinate:	Length (m)	Northing (m)	Easting (m)	Elevation (masl)	Coord Sys.
(centerpoint of TOC)	0.000	6367624.119	1553355.586	8.738	RT90-RHB70
Angles:	Length (m)	Bearing	Inclination (– = down)		
	0.000	146.264	–89.400		
Borehole diameter:	Secup (m)	Seclow (m)	Hole Diam (m)		
	0.000	248.400	0.056		
Casing diameter:	Secup (m)	Seclow (m)	Case In (m)	Case Out (m)	
	0.000	2.800	0.057	0.064	

Table 3-16. Information about KAV04A (from SICADA 2004-06-23, 10:54:05).

Title	Value				
Borehole length (m):	1004.000				
Drilling Period(s):	From Date	To Date	Secup (m)	Seclow (m)	Drilling Type
	2003-10-06	2003-11-01	0.000	100.020	Percussion drilling
	2003-12-10	2004-05-03	99.550	1,004.000	Core drilling
Starting point coordinate:	Length (m)	Northing (m)	Easting (m)	Elevation (masl)	Coord Sys.
(centerpoint of TOC)	0.000	6366795.764	1552474.999	10.353	RT90-RHB70
Angles:	Length (m)	Bearing	Inclination (– = down)		
	0.000	77.032	–84.905		
Borehole diameter:	Secup (m)	Seclow (m)	Hole Diam (m)		
	0.000	12.670	0.349		
	12.670	100.200	0.245		
	99.550	100.950	0.086		
	100.950	1,004.000	0.076		
Core diameter:	Secup (m)	Seclow (m)	Core Diam (m)		
	99.550	100.950	0.072		
	100.950	1,004.000	0.050		
Casing diameter:	Secup (m)	Seclow (m)	Case In (m)	Case Out (m)	
	0.000	100.000	0.200	0.208	
	0.000	12.630	0.265	0.273	

Table 3-17. Information about KSH03A (from SICADA 2004-09-08, 15:27:31).

Title	Value				
Borehole length (m):	1,000.700				
Drilling Period(s):	From Date	To Date	Secup (m)	Seclow (m)	Drilling Type
	2003-08-13	2003-09-03	0.000	100.600	Percussion drilling
	2003-09-11	2003-11-07	100.600	1,000.700	Core drilling
Starting point coordinate:	Length (m)	Northing (m)	Easting (m)	Elevation (masl)	Coord Sys.
(centerpoint of TOC)	0.000	6366018.660	1552711.167	4.146	RT90-RHB70
Angles:	Length (m)	Bearing	Inclination (– = down)		
	0.000	125.025	–59.105		
Borehole diameter:	Secup (m)	Seclow (m)	Hole Diam (m)		
	0.500	11.640	0.350		
	11.640	100.500	0.247		
	100.000	101.260	0.086		
	101.260	1,000.700	0.076		
Core diameter:	Secup (m)	Seclow (m)	Core Diam (m)		
	100.000	101.260	0.072		
	101.260	1,000.700	0.050		
Casing diameter:	Secup (m)	Seclow (m)	Case In (m)	Case Out (m)	
	0.000	100.050	0.200	0.208	
	0.000	11.620	0.265	0.273	
	96.610	96.910	0.195	0.100	
	96.910	101.260	0.100	0.080	

3.2 Tests

The hydraulic tests performed in the boreholes are listed in Table 3-10. They were conducted according to the Activity Plan AP PS 400-03-077 (SKB internal document). Pump tests and flow logging tests were carried out with the HTHB (Hydro Testutrustning i Hammar-Borrhål) system. Interference tests were carried out with additional installation of pressure transducers in selected monitoring boreholes. Groundwater data of further monitoring boreholes were provided by SKB. The different test types were performed according to the corresponding methodology descriptions for single-hole pump tests (SKB MD 321.003, Metodbeskrivning för Hydrauliska Enhålspumptester), impeller flow meter logging (SKB MD 322.009, Metodbeskrivning för Flödesloggning), interference testing (SKB MD 330.003, Metodbeskrivning för Interferenstester) and water sampling (SKB MD 423.002, Metodbeskrivning för Vattenprovtagning in Hammarborhål efter Borrning) (SKB internal controlling documents). In conjunction with the flow logging, an electric conductivity- and temperature logging of the borehole water was performed.

During the capacity test and at the end of the pump test, water samples were taken and submitted to the SKB Äspö Laboratory for analysis.

Additional manual groundwater level measurements were performed in the pumped and monitoring boreholes according to Table 3-1.

Table 3-18. Tests performed.

Bh ID	Test section (m)	Test type[1]	Test no	Test start Date, time (yyyy-mm-dd hh:mm:ss)	Test stop Date, time (yyyy-mm-dd hh:mm:ss)
HAV12	11.34-157.80	1B, 6, L-EC, L-Te	1	2004-07-02 08:53:40	2004-07-03 08:44:27
HAV12	11.34-157.80	1B, 2	2	2004-07-04 08:24:35	2004-07-05 08:43:12
HAV14	6.03-182.40	1B, 2, 6, L-EC, L-Te	1	2004-07-07 08:09:24	2004-07-09 10:11:00
HAV11	6.03-220.50	1B, 2, 6, L-EC, L-Te	1	2004-07-11 08:24:24	2004-07-14 09:05:45
HSH04	9.00-236.20	1B, 2, 6, L-EC, L-Te	1	2004-07-15 08:11:19	2004-07-17 08:35:25
HSH05	6.20-200.20	1B, 6, L-EC, L-Te	1	2004-07-17 13:07:59	2004-07-19 08:43:10
HAV13	9.04-142.20	1B, 2, L-EC, L-Te	1	2004-07-20 08:02:58	2004-07-22 13:30:55

[1] 1B: Pump test submersible pump, 2: interference test, 6: flow logging-impeller, L-EC: electric conductivity logging, L-Te: temperature logging

3.3 Control of equipment

Control of equipment was mainly performed according to the HTHB tool description (Mätssystembeskrivning (MSB) för HTHB), SKB MD 326.001–015 (SKB internal controlling documents), which is composed of a general part and technical documents of the HTHB tool components.

Function checks were performed before and during the tests. Among these pressure sensors were checked at air pressure and while running in the hole calculated to the static head. Temperature and electric conductivity was checked at ground level and while running in. The impeller used in the flow logging tool was checked by the rotation of the impeller while running in the borehole. The measuring wheel (used to indicate the position of the flow logging tool in the borehole) and the sensor attached to it was checked against the previously measured and marked length of the cable.

Any malfunction was recorded, and measures were taken accordingly for proper operation. Approval was made according to SKB site manager or the “Mätssystembeskrivning”.

4 Equipment

4.1 Description of equipment

The equipment called HTHB (Swedish abbreviation for Hydraulic Test System for Percussion Boreholes) is a modular tool for testing boreholes up to ca 200 m depth (see conceptual drawing in Figure 4-1). The system components are stored inside a container suitable for transport to remote test sites and use at any weather. Briefly, the components consist of a submersible borehole pump with housing, expandable packers, pressure transducers and a pipe string and/or hose. During flow logging, sensors for measuring electric conductivity and temperature as well as an impeller for measuring the downhole flow rate are used. On the surface, the total pump rate (or injection rate) is adjusted manually by a control valve and monitored by an electromagnetic flow meter. Data are sampled by a logger with automatically sequenced intervals or at intervals set by the test operator. An external power supply of 230V is necessary to run the HTHB system.

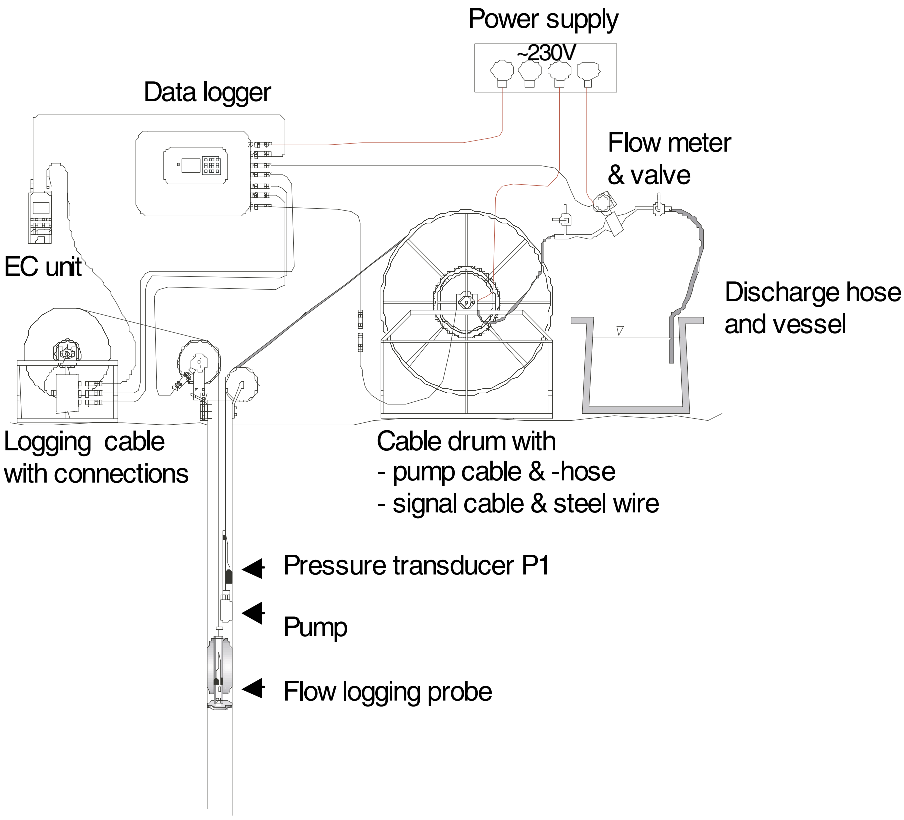

Figure 4-1. A view of the layout and equipment of HTHB for a pump test in an open borehole.

The HTHB is designed for percussion boreholes and used to perform pumping and injection tests in open boreholes or in packered sections of the borehole. It is possible to combine a pump test in an open borehole with a flow logging survey along the borehole (Figure 4-1). Tests can be performed with a constant hydraulic head or alternatively with a constant flow rate. Hydraulic tests can also be performed in packered borehole sections down to a total depth of 200 m (Figure 4-2). According to the number of pipes available, the upper packer can not be located deeper than 80 m at injection tests.

The packers are normally expanded by water with nitrogen used to pressurize the water. By deep groundwater levels (e.g. h > 25 m by a borehole diameter of 140 mm), the packers are expanded by nitrogen gas. A folding pool is used to collect the discharged water from the borehole if the salinity does not allow a direct discharge to the environment or if the water is to be used in subsequent injection tests.

The HTHB equipment is documented in photographs 1–4.

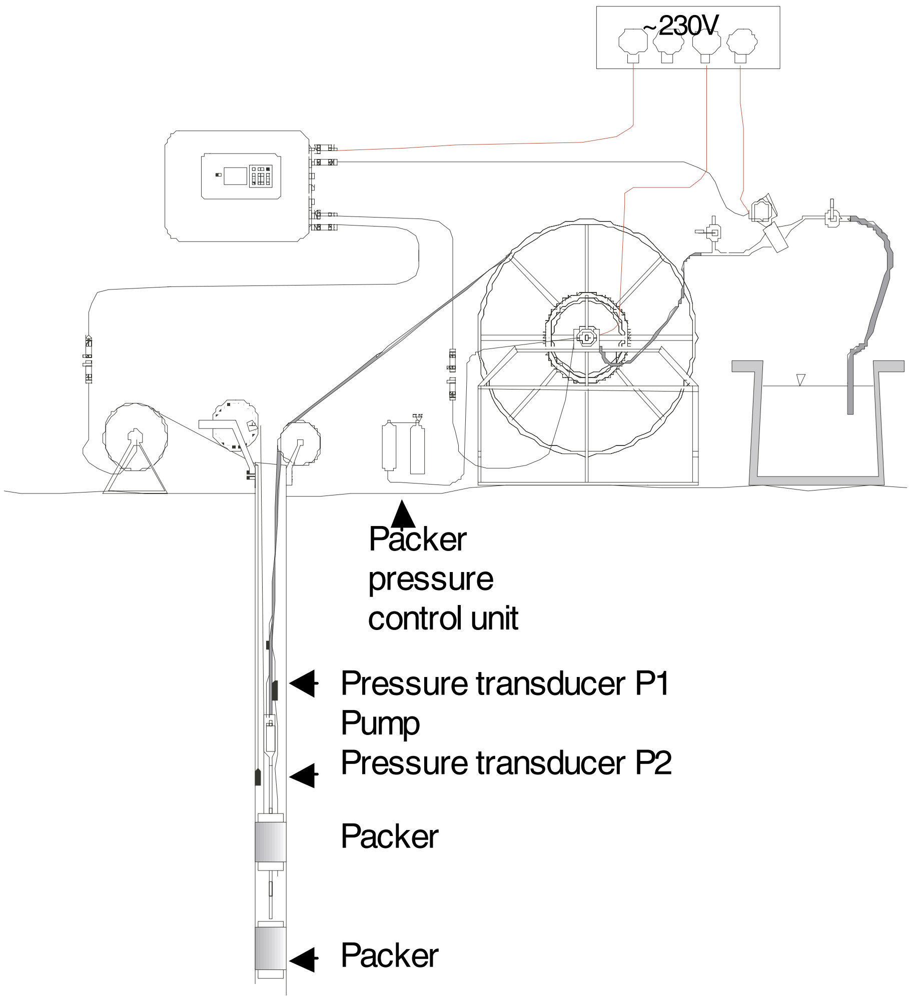

Figure 4-2. *A view of the layout and equipment of HTHB for a pump test in a packered borehole section.*

Photo 1. Container with spool for hose.

Photo 2. Equipment installed in a borehole with guiding spools on TOC.

Photo 3. Surface flow meter for measuring total flow rate.

Photo 4. Depth measuring wheel on TOC.

4.2 Sensors

Technical specifications of the sensors used together with estimated data specifications of the HTHB test equipment for pump tests and flow logging are listed in Table 4-1.

Errors in reported borehole data (e.g. borehole diameter) may significantly increase the error in measured and calculated data. Especially the flow logging impeller is very sensitive to variations in the borehole diameter. A rough borehole wall or variations in borehole diameter may lead to a bypassing water flow, indicating a too low water flow at the flow logging. In general, the flow logging impeller is calibrated for different borehole diameters. The nominal borehole diameter for all tested boreholes given by the activity plan is 140 mm, however, the information provided from the SICADA database indicating borehole diameters ranging from 136 mm to 140 mm. After positioning of the flow logger to a measurement depth, sufficient stabilisation time should be provided. The stabilisation time may be up to 30 s at flow rates close to the lower measurement limit whereas at high flow rates this stabilisation time is almost of no importance.

Table 4-1. Technical specifications of sensors.

Parameter	Sensor	Unit	Sensor range	HTHB range	Comments
Pressure	Output signal	mA	4–20		
	Meas. range	kPa	0–1,500	0–1,500	
	Resolution	kPa	0.05		
	Accuracy	kPa	± 1.5 *	± 10	Depending on uncertainties of sensor position
Temperature	Output signal	mA	4–20		
	Meas. range	°C	0–50	0–50	
	Resolution	°C	0.1		
	Accuracy	°C	± 0.6	± 0.6	
Electric Conductivity	Output signal	V	0–2		
	Meas. range	mS/m	0–50,000	0–50,000	With conductivity meter
	Resolution	% o.r. **		1	
	Accuracy	% o.r. **		± 10	
Flow (Spinner)	Output signal	Pulses/s	c 0.1–c 15		
	Meas. range	L/min		2–100	115 mm borehole diameter
				3–100	140 mm borehole diameter
				4–100	165 mm borehole diameter
	Resolution ***	L/min		0.2	140 mm borehole diameter
	Accuracy ***	% o.r. **		± 20	and 100 s sampling time
Flow (surface)	Output signal	mA	4–20		Passive
	Meas. range	L/min	1–150	5–c 80 ****	Pumping tests
	Resolution	L/min	0.1	0.1	
	Accuracy	% o.r. **	± 0.5	± 0.5	

* Includes hysteresis, linearity and repeatibility.
** Maximum error in % of actual reading (% o.r.).
*** Applicable to boreholes with a borehole diameter of 140 mm and 100 s sampling time.
**** For injection tests the minimal flow rate is 1 l/min.

Table 4-2 shows the position of sensors for each test. Positions for the following equipments are given: Pump (bottom), pressure (P1), temperature (Te) and electric conductivity (EC). The sensors for temperature and electric conductivity are placed in the flow logging unit and therefore of variable depth during a test. Positions are given in meter from the reference point (TOC). Equipment affecting the wellbore storage coefficient (WBS) is given with diameter of the submerged tool. All pump tests were performed in open boreholes, therefore, all positions are "in section". The volume of the submerged pump (ca 4 dm^3) is in most cases of minor importance.

Table 4-2. Sensor positions and wellbore storage (WBS) controlling factors.

Borehole information			Sensors		Equipment affecting WBS coefficient		
ID	Test section (m)	Test no	Type	Position (m fr ToC)	Position	Function	Outer diameter (mm)
HAV12	11.34–157.80	1	Pump (bottom) P1 Flow logging Equipment	27.00 23.72 variable (30–156)	in section	Pump string (hose) signal cable signal cable	37 8 13.5
HAV12	11.34–157.80	2	Pump (bottom) P1 Flow logging Equipment	27.00 23.72 30	in section	Pump string (hose) signal cable signal cable	37 8 13.5
HAV14	12.85–182.40	1	Pump (bottom) P1 Flow logging Equipment	27.00 23.72 variable (32–180)	in section	Pump string (hose) signal cable signal cable	37 8 13.5
HAV11	6.03–220.50	1	Pump (bottom) P1 Flow logging Equipment	20.00 16.72 variable (26–122)	in section	Pump string (hose) signal cable signal cable	37 8 13.5
HSH04	9.00–236.20	1	Pump (bottom) P1 Flow logging Equipment	20.00 16.72 variable (25–202)	in section	Pump string (hose) signal cable signal cable	37 8 13.5
HSH05	6.20–200.20	1	Pump (bottom) P1 Flow logging Equipment	30.00 26.72 variable (36–198)	in section	Pump string (hose) signal cable signal cable	37 8 13.5
HAV13	9.04–142.20	1	Pump (bottom) P1 Flow logging Equipment	18.00 14.72 22	in section	Pump string (hose) signal cable signal cable	37 8 13.5

4.3 Data acquisition system

The data acquisition system in the HTHB unit contains a data logger (Campbell CR 5000) which transforms the raw data automatically to engineering units and a laptop with the software PC 9000 to download the data for further processing. A second laptop is connected to the HTHB laptop, containing the evaluation software, Interpret 2000.

The data acquisition system can be set to sequenced logging intervals or can be manually set to fix logging intervals depending on the change of pressure versus time. The pump tests were started and stopped by switching the pump on or off manually.

Additional data loggers (Geometrik) were installed in selected monitoring wells. Previously to the pump test, an approximately 24 h period was logged with a 2 min logging interval for general background data. For the period of the pump test and recovery phase, the loggers in the monitoring wells were set to an interval of 1 min.

5 Execution

5.1 Preparations

All sensors of the HTHB system are calibrated at GEOSIGMAs engineering workshop in Librobäck, Uppsala. Calibration is performed on a yearly basis, or more often if needed. The last calibration before the described pump test campaign was done in June 2004. Protocols of the performed calibration were submitted with the HTHB system description, a calibration protocol form including the actual calibration constants was submitted with the delivery of raw data after finishing the test campaign.

Following preparation work and functional checks were conducted prior to starting test activities:

- Placing the container beside the borehole.
- Cleaning of all in-hole equipment with alcohol.
- Synchronize clocks on all computers.
- Run in the borehole with a dummy to check if the hole is free.
- Lowering the flow logger to the bottom of the borehole respectively the lower logging depth.
- Check pressure gauges against atmospheric pressure and then on test depth against column of water, a malfunction of P1 was detected after finishing the pump test in HAV12, it was replaced by P2.
- Check functionality of sensors for temperature and electric conductivity.
- Check functionality of measuring wheel against measured cable length.
- Measure and assemble test tool.
- Lower the pump according to the previous measured groundwater level considering the expected drawdown.

5.2 Execution of tests/measurements

5.2.1 Test principle

Pump tests

The pump tests were conducted as constant flow rate tests (CRw phase) followed by a pressure recovery period (CRr phase). The intention was to obtain approximately steady-state conditions at the end of the pump phase. To set up an appropriate flow rate for the pump test with a target value of 10 m drawdown, a capacity test was performed with duration of approximately 10 min.

Flow logging

The flow logging was performed during pumping with flow measurements at constant intervals of 2 m, starting from the bottom of the borehole and upward. In cases of an increase of the flow rate of > 1 l/min from one interval to the next, additional flow logging was performed in 0.5 m intervals downwards to the previous measurement. To allow a stabilization of the flow in the borehole, flow logging started earliest 2 hours after start of pumping. Every flow logging was performed with a logging duration of 100 s. The uppermost flow logging was made with a minimum distance of 4 m to the bottom of the pump to avoid errors caused by turbulences from the pump. In general, duration of flow logging is between 3–7 hours in a percussion borehole but this duration depends on the length and character of the borehole.

Observation wells

For evaluation as interference tests, selected boreholes were used to monitor the groundwater levels previous to and during running pump tests. Approximately 24 hours before starting the pump tests, data loggers were installed in the selected observation boreholes and started with a logging interval of 2 min to collect background data. Before starting the pump test, these loggers were set to intervals of 1 min for the pump and recovery phase of the pump test.

Groundwater level data from further observation boreholes were provided by SKB from long time monitoring programs. These data were included in the interference test analysis.

5.2.2 Test procedure

Before starting a pump test, function checks, cleaning and preparation of equipment together with time synchronisation of clocks, data loggers and laptops were performed according to the activity plan and method descriptions. All tests were carried out when the drill work at the borehole locations were finished.

Pump tests

A short (10 min) flow capacity test was carried out prior to each pump test to choose an appropriate flow rate for the test. The evaluation of the capacity test was performed according to Appendix 5 of the method description for single borehole tests (SKB MD 321.003) (SKB internal controlling documents). The extracted water was discharged on the hard rock, running down slope to the sea from the pumped borehole.

The general schedule for the performed pump tests consisted of a 10 hours pump phase in combination with flow logging (except pump test in HAV13) and monitoring of further observation wells (except pump test in HSH05). At the pump tests in HSH04 and HSH05, the pump rate was adjusted during the pump phase to maintain a constant flow rate. The flow phase was followed by a recovery phase of approximately 13 to 15 hours. For the sampling frequency during the pump phase, the automatically sequence option of the data logger was used (Table 5-1). For the recovery phase, the sampling frequency was set manually as shown in Table 5-2.

Table 5-1. Sampling frequency for pump phase (sequence option).

Time interval (s) from start of pumping	Sampling frequency (s)
1–300	1
301–600	10
601–3,600	60
> 3,600	600

Table 5-2. Sampling frequency for recovery phase (manual).

Time interval (s) from start of pumping	Sampling frequency (s)
1–300	1
301–600	5
601–900	10
> 900	60

Flow logging

As preparation for flow logging, the flow log impeller was lowered to the bottom of the holes respectively to the lowest flow log depth according to the observations during the borehole check with the dummy.

The flow logging was performed during the pump phase and started approximately 2 hours after start of pumping. Starting from the bottom, the flow logger was lifted in steps of 2 m and halted for measurements with a time period of 100 s. When a flow anomaly with a difference of > 1 l/min comparing to the previous measurement was detected, the flow logger was then lowered in 0.5 m steps until the previous flow rate was retrieved for a more detailed depth identification of the anomaly. The flow logging then continued in further 2 m intervals along the hole.

5.3 Data handling

The data handling followed several stages. The data acquisition software included in the logger (Campbell CR 5000) transformed the data already to engineering units. These files are comma-separated (*.dat files) and contain the time, pressure, flow rate, temperature and electric conductivity data.

The *.dat files of the pump test were synthesized in Excel to a *.xls file for plotting purposes of the Karthesian plot. Finally, the processed test data to be delivered to SKB were exported from Excel in *.csv format. These files were also used for the subsequent test analysis with Interpret 2000.

The *.dat files of the flow logging were synthesized with an Excel macro for evaluation.

All raw data files were renamed and handed over to SKB (Appendix 1).

5.4 Analyses and interpretation

5.4.1 Analysis software

The tests were analysed using a type curve matching method. The analysis was performed using Interpret 2000. Interpret 2000 is an interactive analysis environment allowing the user to interpret constant pressure and constant rate in a source as well as in observation boreholes. The program allows the calculation of type-curves for homogeneous, dual porosity and composite flow models in variable flow geometries from linear to spherical.

5.4.2 Analysis approach

Constant rate and pressure recovery tests are analysed using the method described by /Gringarten, 1986/ and /Bourdet et al. 1989/ by using type curve derivatives calculated for different flow models.

5.4.3 Analysis methodology

Each of the relevant test phases is subsequently analyzed using the following steps:

- Identification of the flow model by evaluation of the derivative on the log-log diagnostic plot. Initial estimates of the model parameters are obtained by conventional straight-line analysis.
- Superposition type curve matching in log-log coordinates. A non-linear regression algorithm is used to provide optimized model parameters in the latter stages.
- Non-linear regression in semi-log coordinates (superposition HORNER plot; /Horner, 1951/. In this stage of the analysis, the static formation pressure is selected for regression.

The test analysis methodology is best explained in /Horne, 1990/.

5.4.4 Steady state analysis

In addition to the type curve analysis, an interpretation based on the assumption of stationary conditions was performed as described by /Moye, 1967/.

5.4.5 Flow models used for analysis

The flow models used in analysis were derived from the shape of the pressure derivative calculated with respect to log time and plotted in log-log coordinates.

In several cases the pressure derivative suggests a change of transmissivity with the distance from the borehole. In such cases a composite flow model was used in the analysis.

In other cases, the use of a homogeneous flow model led to very large skin factors (e.g. 20). In these cases, in addition to the homogeneous flow model analysis an analysis using a composite flow model was conducted. In these cases the skin was represented explicitly as inner composite zone.

The flow dimension displayed by the test can be diagnosed from the slope of the pressure derivative. A slope of 0.5 indicates linear flow, a slope of 0 (horizontal derivative) indicates radial flow and a slope of –0.5 indicates spherical flow. The flow dimension diagnosis was commented for each of the tests. However, in all cases it was possible to achieve to acceptable analysis results (good match quality) by using radial flow geometry (flow dimension of 2).

5.4.6 Calculation of the static formation pressure and equivalent freshwater head

The static pressure measured at transducer depth, was derived from the pressure recovery (CRr) following the constant rate pump phase by using straight line or type curve extrapolation in the Horner plot. No corrections of measured data (e.g. for atmospheric pressure variations, tidal and other background effects) have been made by the analysis of data but a general air pressure correction has been performed.

The equivalent freshwater head (expressed in meters above sea level) was calculated from the static formation pressure, corrected for the vertical depth considering the inclination of the borehole, by assuming a water density of 1,000 kg/m^3 (freshwater). The equivalent freshwater head is the static water level an individual open borehole would show if full of freshwater.

The freshwater head in meters above sea level is calculated as following:

$$h_{iwf} = \frac{(p^* - p_{atm})}{\rho \cdot g}$$

which is the P* value expressed in a water column of freshwater.

With consideration of the elevation of the reference point (RP) and the gauge depth (Gd), the freshwater head is

$$head = RP_{elev} - Gd + \frac{(p^* - p_{atm})}{\rho \cdot g}$$

5.4.7 Derivation of the recommended transmissivity and the confidence range

In most of the cases more than one analysis was conducted on a specific test. Typically both test phases were analysed (CRw and CRr). The parameter sets (i.e. transmissivities) derived from the individual analyses of a specific test usually differ. In the case when the differences are small (which is typically the case) the recommended transmissivity value is chosen from the test phase that shows the best data and derivative quality, which is most of the cases at the CRr phase. In cases when a composite flow model was deemed to be most representative for the hydraulic behaviour of the specific test section, than the outer zone transmissivity was selected as recommended value, because it is regarded as most representative for the large scale undisturbed formation properties.

The confidence range of the transmissivity was derived using expert judgement. Factors considered were the range of transmissivities derived from the individual analyses of the test as well as additional sources of uncertainty such as noise in the flow rate measurement, numeric effects in the calculation of the derivative or possible errors in the measurement of the wellbore storage coefficient. No statistical calculations were performed to derive the confidence range of transmissivity.

5.4.8 Flow logging

The parameters derived from flow logging (flow rate, temperature and electric conductivity of the borehole fluid) are plotted versus borehole length. Flow anomalies where the flow rate changes more than 1 l/min were identified along the borehole. The range of the inflow at the flow anomaly is determined by the relevant change in flow rate at the anomaly interval. In most cases, flow anomalies are accompanied by corresponding changes in temperature and/or electric conductivity.

Flow logging was performed in the borehole interval from 1 m above the bottom of the borehole to 4 m below the submersible pump. The upper part of the borehole (from 4 m below the submersible pump to the groundwater level) could not be flow-logged, although high inflow zones may be observed (e.g. in HSH04). Such superficial inflows were identified by comparing the cumulative flow at the top of the flow-logged interval (ΣQ_i) with the discharged flow rate (Q_p) from the hole according to the surface flow meter. One or more inflow zones are most likely to exist above the flow-logged interval if the latter flow rate is significantly higher than the cumulative flow rate.

The transmissivity (T) of the entire borehole is calculated from the analysis of the pump test during flow logging. The cumulative transmissivity at the top of the flow-logged interval (ΣT_i) is then calculated according to the SKB document "Methodology for flow logging" (SKB MD 322.009, Metodbeskrivning för flödesloggning) (SKB internal controlling documents) with the assumption of a zero natural flow in the borehole.

$$\Sigma T_i = T \cdot \Sigma Q_i / Q_p \qquad (5\text{-}1)$$

Flow anomalies above the flow-logged interval will lead to $\Sigma Q_i < Q_p$. In this case, the order of magnitude of the sum of these anomalies is estimated from equation (5-1).

The transmissivity of an individual flow anomaly in the flow logged interval (T_i) is calculated from the measured inflow rate (Q_i) of the anomaly and the calculated transmissivity of the entire borehole (T) according to the SKB document "Methodology for flow logging" (SKB MD 322.009, Metodbeskrivning för flödesloggning) (SKB internal controlling documents):

$$T_i = T \cdot Q_i / Q_p \qquad (5\text{-}2)$$

The lower limit of transmissivity (Tl-measl) in the flow logging interval is estimated similar to equation (5-1):

$$T_{Fmeasl\text{-}L} = T \cdot Q_{Fmeasl\text{-}L} / Q_p \qquad (5\text{-}3)$$

In a borehole with a diameter of 140 mm, the lower measuring limit for the flow rate is: $Q_{Fmeasl\text{-}L}$ = 3 l/min (see Table 4-1) whereas Q_p is the actual flow rate during flow logging measured with the surface flow meter.

The flow logging test data are summarized in Appendix 5.

6 Results

In the following, results of all 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, 7-2 and 7-3 of the Synthesis chapter and in the test summary sheets (Appendix 3).

6.1 Nomenclature and symbols

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), "Instruction for analysis of interference tests" (SKB MD 330.003, Metodbeskrivning för Interferenstester) and "Methodology description for flow logging" (SKB MD 322.009, Metodbeskrivning för flödesloggning), respectively (SKB internal controlling documents). If additional symbols are used, they are explained in the report text.

6.2 Water sampling

At the beginning of the capacity tests and at the end of the pump phase of the pump tests, water samples were taken and submitted to the SKB Äspö laboratory for subsequent analysis. Bottles prepared with acid for sample stabilization during storage and transport as well as filters, were received from SKB prior to sampling. The water samples were stored in a fridge until delivery to SKB. All samples taken and submitted for analysis are listed in Table 6-1.

Table 6-1. Data of water samples taken during pump tests.

Borehole ID	Date	Time	Section (m)	Pumped volume (m^3)	Sample ID	Remarks
HAV12	2004-06-30	18:35	11.34–157.80	0.33	7558	capacity test
	2004-07-02	21:24	11.34–157.80	36.9	7556	pump test
HAV14	2004-07-07	13:06	6.03–182.40	0.26	7553	capacity test
	2004-07-08	19:35	6.03–182.40	41.3	7559	pump test
HAV11	2004-07-12	13:38	6.03–220.50	0.43	7552	capacity test
	2004-07-13	18:17	6.03–220.50	41.9	7551	pump test
HSH04	2004-07-15	10:30	9.00–236.20	0.60	7554	capacity test
	2004-07-16	17:25	9.00–236.20	19.4	7555	pump test
HSH05	2004-07-17	13:39	6.20–200.20	0.32	7550	capacity test
	2004-07-18	17:18	6.20–200.20	2.3	7556	pump test
HAV13	2004-07-20	11:10	9.04–142.20	1.1	7549	capacity test
	2004-07-21	17:44	9.04–142.20	37.5	7557	pump test

6.3 Pump tests

In the following, the analysis results of the single borehole pump tests are represented. No corrections of measured data (e.g. for atmospheric pressure changes, tidal and other background effects) have been made by the analysis of data but a general air pressure correction has been performed. General test data and test summary sheets are presented in Appendix 3.

6.3.1 Borehole HAV12, first test

Comments to test

The test was composed of a constant rate pump test phase with a mean flow rate of 64 l/min, followed by a pressure recovery phase. The flow rate control during the CRw phase was good. The pumped flow rate decreased from 67.8 l/min at start of the CRw phase to 63.7 l/min at the end. The recovery phase (CRr) shows no problems and is 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 CRw and CRr phases show a valley of the derivative at middle times and a hump at the late time of the phase. For the analysis of the CRw and CRr phase a radial composite flow model was chosen. The interpretation of the derivative curves assumes a change in transmissivity and storativity depending on the distance to the borehole. The analysis is presented in Appendix 2-1.

Selected representative parameters

The recommended transmissivity of 2.8E–4 m^2/s was derived from the analysis of the CRr phase (inner zone), which shows a good data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 1.0E–4 m^2/s to 3.0E–4 m^2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CRr phase using straight line extrapolation in the Horner plot to a value of 217 kPa.

The analysis of the CRw and CRr phases shows good consistency. No further analysis is recommended.

6.3.2 Borehole HAV12, second test

Comments to test

The pump test in the borehole HAV12 was repeated while a malfunction of the data loggers in the observation boreholes during the first test was detected. The test was composed of a constant rate pump test phase with a mean flow rate of 64 l/min, followed by a pressure recovery phase. The flow rate control during the CRw phase was good. The pumped flow rate decreased from 67.7 l/min at start of the CRw phase to 63.5 l/min at the end. The recovery phase (CRr) shows no problems and is 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 CRw and CRr phases show a valley of the derivative at middle times and a hump at the late time of the phase. For the analysis of the CRw and CRr phase a radial composite flow model was chosen. The interpretation of the derivative curves assumes a change in transmissivity and storativity depending on the distance to the borehole. The analysis is presented in Appendix 2-1.

Selected representative parameters

The recommended transmissivity of 8.0E–4 m^2/s was derived from the analysis of the CRr phase (inner zone), which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 1.0E–4 m^2/s to 1.0E–3 m^2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CRr phase using straight line extrapolation in the Horner plot to a value of 221 kPa.

The analysis of the CRw and CRr phases shows good consistency. No further analysis is recommended.

6.3.3 Borehole HAV14

Comments to test

The pump test in the borehole HAV14 was composed of a constant rate pump test phase with a mean flow rate of 64.4 l/min, followed by a pressure recovery phase. The flow rate control during the CRw phase was good. The pumped flow rate decreased from 66.9 l/min at start of the CRw phase to 63.4 l/min at the end. The recovery phase (CRr) shows no problems and is 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 CRw shows a slightly dropping derivative. The CRr phase shows a slightly increasing derivative in the middle part of the phase and a sharp valley at the end of the phase. This last part of the CRr derivative is most likely influenced by some background effects – the data curves of observation wells HAV07 and HAV08 show a background effect at the same time range. Therefore this late part of the CRr derivative was not considered in the evaluation. For the analysis of the CRw and CRr phase a radial composite flow model was chosen. The interpretation of the derivative curves assumes a slight change in transmissivity and storativity depending on the distance to the borehole. The analysis is presented in Appendix 2-2.

Selected representative parameters

The recommended transmissivity of 1.6E–4 m^2/s was derived from the analysis of the CRr phase (inner zone), which shows a good data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 1.0E–4 m^2/s to 3.0E–4 m^2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CRr phase using straight line extrapolation in the Horner plot to a value of 208 kPa.

The analysis of the CRw and CRr phases shows good consistency. No further analysis is recommended.

6.3.4 Borehole HAV11

Comments to test

The pump test in the borehole HAV11 was composed of a constant rate pump test phase with a mean flow rate of 71.4 l/min, followed by a pressure recovery phase. The flow rate control during the CRw phase was good. The pumped flow rate decreased from 72.0 l/min at start of the CRw phase to 71.2 l/min at the end. The recovery phase (CRr) shows no problems and is 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 CRw and CRr phases show an increasing derivative to the end of the test phases. For the analysis of the CRw and CRr phase a radial composite flow model was chosen. The interpretation of the derivative curves assumes a change in transmissivity and slight change in storativity depending on the distance to the borehole. The analysis is presented in Appendix 2-3.

Selected representative parameters

The recommended transmissivity of 7.2E–4 m^2/s was derived from the analysis of the CRw phase (inner zone), which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 8.0E–5 m^2/s to 1.0E–3 m^2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CRr phase using straight line extrapolation in the Horner plot to a value of 248 kPa.

The analysis of the CRw and CRr phases shows good consistency. No further analysis is recommended.

6.3.5 Borehole HSH04

Comments to test

The pump test in the borehole HSH04 was composed of a pump test phase with a mean flow rate of 34.9 l/min, followed by a pressure recovery phase. The flow rate has to be readjusted 38 min after start of pumping. An uncontrolled change in the pump rate happened during flow logging when the flow logger got slightly stuck in the borehole and subsequent rescue operations. Control during the CRw phase was poor. The pumped flow rate started with 43.6 l/min, was readjusted 38 min after start of pumping to 34.5 l/min and changed uncontrolled to 33.7 l/min approximately 5 h and 20 min after start of pumping. At the end of the pump phase, the rate was at 33.6 l/min. The recovery phase (CRr) shows no problems and is 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 CRw phase was not analysed according to changes in the flow rate. The CRr phase shows a flat derivative at the late test phase. For the analysis of the CRr phase a radial homogenous infinite acting flow model was chosen. The analysis is presented in Appendix 2-4.

Selected representative parameters

The recommended transmissivity of 9.6E–4 m^2/s was derived from the analysis of the CRr phase, which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 6.0E–4 m^2/s to 2.0E–3 m^2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CRr phase using straight line extrapolation in the Horner plot to a value of 242 kPa. The calculated skin of 83 is very high. This skin may be related to e.g. turbulent flow in fractures entering the borehole.

The analysis of the CRr phase shows good quality. No further analysis is recommended.

6.3.6 Borehole HSH05

Comments to test

The pump test in the borehole HSH05 was composed of a pump test phase with a mean flow rate of 4.2 l/min, followed by a pressure recovery phase. The flow rate was slightly readjusted to keep the rate stabile for the whole pump phase. Control during the CRw phase was good. The pumped flow rate started with 4.2 l/min, was readjusted 1 min after start of pumping to 4.2 l/min and again readjusted after 4 h and 9 min after start of pumping to 4.1 l/min. At the end of the pump phase, the rate was at 4.1 l/min. The recovery phase (CRr) shows no problems and is 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. The CRw phase shows a flat derivative at the late test phase with a decreasing derivative at the very late end. In case of the present test the CRw phase was analysed using a radial homogenous infinite acting flow model. For the analysis of the CRr phase a radial composite flow model was chosen. The analysis is presented in Appendix 2-5.

Selected representative parameters

The recommended transmissivity of 5.2E–6 m^2/s was derived from the analysis of the CRr phase (inner zone), which shows a good data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 4.0E–6 m^2/s to 6.0E–4 m^2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CRr phase using straight line extrapolation in the Horner plot to a value of 324 kPa.

The analysis of the CRw and CRr phases shows inconsistencies in the derivative evaluation. The data curves of the pump and recovery phases are of very different shape and together with the derivative decrease at the very late end of the pump phase there is an indication of some change of transmissivity during pumping. Probably some fractures were washed out from drill mud by pumping and/or the transmissivity increases by around two decades at a larger distance from the borehole. Therefore, the inner zone transmissivity of the recovery phase was chosen as recommended transmissivity representing the formation in the near vicinity of the borehole. No further analysis is recommended.

6.3.7 Borehole HAV13

Comments to test

The pump test in the borehole HAV13 was composed of a constant rate pump test phase with a mean flow rate of 70.1 l/min, followed by a pressure recovery phase. The flow rate control during the CRw phase was good. The pumped flow rate decreased from 70.3 l/min at start of the CRw phase to 69.1 l/min at the end. The recovery phase (CRr) shows no problems and is 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 CRw and CRr phases show a flat derivative at middle times and a hump at the late time of the phases. For the analysis of the CRw and CRr phase a radial composite flow model was chosen. The interpretation of the derivative curves assumes a change in transmissivity and storativity depending on the distance to the borehole. The analysis is presented in Appendix 2-6.

Selected representative parameters

The recommended transmissivity of 2.2E–4 m^2/s was derived from the analysis of the CRw phase (inner zone), which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 1.0E–4 m^2/s to 3.0E–4 m^2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CRr phase using straight line extrapolation in the Horner plot to a value of 198 kPa.

The analysis of the CRw and CRr phases shows good consistency. No further analysis is recommended.

6.4 Flow logging

Flow logging diagrams including the measured flow rates along the borehole during flow logging in combination with the electric conductivity (EC) and the temperature (Te) of the borehole fluid is shown in Appendix 4. General test data for the flow logging in the boreholes HAV12, HAV14, HAV11, HSH04, HSH05 and HAV13 are presented in Appendix 5. All flow logging was performed during the pump tests in the open boreholes.

The nomenclature used for the flow logging test evaluation is according to the SKB document "Method description for flow logging" (SKB MD 322.009, Metodbeskrivning för flödesloggning) (SKB internal controlling documents). The measured inflow (Q_i) at the detected flow anomalies together with the percentages of the total flow rate at the surface are presented in subsequent tables at logging results. The cumulative transmissivity (ΣT_i) at the top of the flow-logged borehole section was calculated according to equation (5-1) and the individual transmissivity of single flow anomalies (T_i) according to equation (5-2). The specific flow (Q_i/s_{FL}) of single anomalies was used for an interpretation of the transmissivity of these anomalies.

6.4.1 Borehole HAV12

Comments to test

The flow logging in HAV12 was performed from 156 m below TOC upward. There was no flow logging from 156 m to the bottom of the hole at 157.8 m to avoid lowering the flow logger in drill mud at the bottom of the hole. The first flow anomaly was detected at 151 m. The step length between flow measurements in the borehole was maximally 2 m. When anomalies were detected, the length between measurements was reduced to 0.5 m. The flow logging was performed between 156 m and 30 m below TOC.

Logging results

The transmissivity of the entire borehole was derived from the transient calculation of the pump test during flow logging to T = 2.82 E–4 m^2/s.

Table 6-2. Analyses results; flow logging HAV12.

HAV12		ΣQ_i = 1.14E-3 (m^3/s)	Q_p = 1.07E-3 (m^3/s)	ΣT_i = 2.82E-4 (m^2/s)	s_{FL} = 7.88 m	Remarks
Anomaly depth (m from TOC)	**Anomaly length (m)**	**Q_i (m^3/s)**	**Q_i/Q_p (%)**	**T_i (m^2/s)**	**Q_i/s_{FL} (m^2/s)**	
152-151	1	4.78E-4	44.8	1.19E-4	6.07E-5	
146-142.5	3.5	3.57E-4	33.4	8.85E-5	4.53E-5	
136-134.5	1.5	1.35E-4	12.7	3.35E-5	1.71E-5	
36-32.5	3.5	1.67E-4	15.6	4.13E-5	2.12E-5	
Total		**1.14E-3**	**106.5**	**2.82E-4**	**1.44E-4**	
Difference		$Qp-\Sigma Q_i$ = -7E-5	6.5	$T- \Sigma T_i$ = 0		Inconsistency in flow rates Q_p and ΣQ_i

ΣQ_i = cumulative flow at the top of the logged section, Q_p = pumped flow rate at surface flowmeter, s_{FL} = drawdown during pump test.

The total flow of the logged interval from 156 m to 30 m below TOC (ΣQ_i) is slightly above the measured flow rate of the total flow at the surface (Q_p). This indicates that there is no additional inflow to the borehole between the groundwater level at 11.34 m below TOC and the top of the logged section. The major inflow to the borehole was measured near the bottom of the hole in three separate sections between 152 m and 134.5 m depth, covering approximately 90% of the total flow. One further inflow was measured in shallow depths of 36 m to 32.5 m below TOC.

Appendix 4-1 shows the logging diagrams. A decrease in electric conductivity and temperature is related to every of the detected inflow zones. A further decrease in electric conductivity and temperature was observed at the section from 44 m to 42 m below TOC, but no flow anomaly was measured at this depth. Appendix 4-1 shows the calculated cumulative transmissivity (ΣT_i) along the borehole length. Since the detected flow anomalies running over a specific interval of the borehole, the change in transmissivity is represented by a sloping line across this interval. The calculated lower limit of transmissivity and the total borehole transmissivity (T) are also shown in this appendix.

6.4.2 Borehole HAV14

Comments to test

The flow logging in HAV14 was performed from 180 m below TOC upward. There was no flow logging from 180 m to the bottom of the hole at 182.4 m to avoid lowering the flow logger in drill mud at the bottom of the hole. The first flow anomaly was detected at 167 m. The step length between flow measurements in the borehole was maximally 2 m. When anomalies were detected, the length between measurements was reduced to 0.5 m. The flow logging was performed between 180 m and 32 m below TOC.

Logging results

The transmissivity of the entire borehole was derived from the transient calculation of the pump test during flow logging to T = 1.58 E–4 m^2/s.

Table 6-3 Analyses results; flow logging HAV14.

HAV12		**ΣQ_i = 1.00E-3 (m^3/s)**	**Q_p = 1.07E-3 (m^3/s)**	**ΣT_i = 1.48E-4 (m^2/s)**	**s_{FL} = 6.47 m**	**Remarks**
Anomaly depth (m from TOC)	**Anomaly length (m)**	**Q_i (m^3/s)**	**Q_i/Q_p (%)**	**T_i (m^2/s)**	**Q_i/s_{FL} (m^2/s)**	
167-165	2	6.13E-4	57.2	9.03E-5	9.47E-5	
45-42	3	3.92E-4	36.5	5.77E-5	6.043E-5	
Total		**1.00E-3**	**93.7**	**1.58E-4**	**1.5544E-4**	
Difference		Qp-ΣQ_i = 7.0E-5	6.3	T- ΣT_i = 1.0E-5		Further inflow at 32-12.85 m ?

ΣQ_i = cumulative flow at the top of the logged section, Q_p = pumped flow rate at surface flowmeter, s_{FL} = drawdown during pump test.

The total flow of the logged interval from 180 m to 32 m below TOC (ΣQ_i) is slightly below the measured flow rate of the total flow at the surface (Q_p). This indicates one or several additional inflows to the borehole between the groundwater level at 12.85 m below TOC and the top of the logged section. The major inflow to the borehole was measured near the bottom of the hole between 167 m and 165 m depth, covering approximately 57% of the total flow. One further inflow was measured in shallow depths of 45 m to 42 m below TOC, covering further approximately 36% of the total inflow.

Appendix 4-2 shows the logging diagrams. The electric conductivity (29.7–32.6 mS/m) is in general low compared with the other tested boreholes. At the inflow at 167–165 m depth, a slight increase in electric conductivity was observed followed by a general increasing trend along the borehole upwards. At the upper inflow (45–42 m), a sharp drop of electric conductivity from 32.5 mS/m to 31.4 mS/m was observed, an indication of some sweetwater inflow to the borehole at this shallow depth. Further up the electric conductivity increases slightly. The temperature decreases slightly from bottom to top of the borehole with additional decreasing trends at the two inflow zones. Appendix 4-2 shows the calculated cumulative transmissivity (ΣT_i) along the borehole length. Since the detected flow anomalies running over a specific interval of the borehole, the change in transmissivity is represented by a sloping line across this interval. The calculated lower limit of transmissivity and the total borehole transmissivity (T) are also shown in this appendix.

6.4.3 Borehole HAV11

Comments to test

The flow logging in HAV11 was performed from 122 m below TOC upward. There was no flow logging from 122 m to the bottom of the hole at 220.5 m because of problems checking the borehole with a dummy previous to the flow logging at those depths. A major inflow was detected when starting flow logging at 122 m. The step length between flow measurements in the borehole was maximally 2 m. When anomalies were detected, the length between measurements was reduced to 0.5 m. The flow logging was performed between 122 m and 26 m below TOC.

Logging results

The transmissivity of the entire borehole was derived from the transient calculation of the pump test during flow logging to T = 7.20 E–4 m^2/s.

Table 6-4. Analyses results; flow logging HAV11.

HAV12		**ΣQ_i = 1.19E-3 (m^3/s)**	**Q_p = 1.19E-3 (m^3/s)**	**ΣT_i = 7.21E-4 (m^2/s)**	**s_{FL} = 4.10 m**	**Remarks**
Anomaly depth (m from TOC)	**Anomaly length (m)**	**Q_i (m^3/s)**	**Q_i/Q_p (%)**	**T_i (m^2/s)**	**Q_i/s_{FL} (m^2/s)**	
220.5-122	98.5	1.10E-3	92.3	6.65E-4	2.68E-4	
61.5-57.5	4	9.17E-5	7.7	5.55E-5	2.24E-5	
Total		**1.19E-3**	**100**	**7.20E-4**	**2.90E-4**	
Difference		Qp-ΣQ_i = 0.0	0.0	T- ΣT_i = -1E-6		

ΣQ_i = cumulative flow at the top of the logged section, Q_p = pumped flow rate at surface flowmeter, s_{FL} = drawdown during pump test.

The total flow of the logged interval from 122 m to 26 below TOC (ΣQ_i) matches the measured flow rate of the total flow at the surface (Q_p). This indicates no further additional inflows to the borehole between the bottom of casing at 6.03 m below TOC and the top of the logged section. The major inflow to the borehole was measured between the bottom of the hole and the deepest flow logging at 122 m, covering approximately 92% of the total flow. One further inflow was measured in depths of 61.5 m to 57.5 m below TOC, covering further approximately 8% of the total inflow.

Appendix 4-3 shows the logging diagrams. The electric conductivity shows water with high salinity and an increasing trend from the bottom of the borehole upwards. At the inflow at 61.5–57.5 m depth, a sharp drop in electric conductivity was observed followed by a stabilisation along the borehole upwards. A further slight drop in electric conductivity was observed at a depth between 44–42 m from TOC. The temperature decreases slightly from bottom to top of the borehole with an additional drop at the inflow zones at 61.5–57.5 m depth. Appendix 4-3 shows the calculated cumulative transmissivity (ΣT_i) along the borehole length. Since the detected flow anomalies running over a specific interval of the borehole, the change in transmissivity is represented by a sloping line across this interval. The calculated lower limit of transmissivity and the total borehole transmissivity (T) are also shown in this appendix.

6.4.4 Borehole HSH04

Comments to test

The flow logging in HSH04 was performed from 202 m below TOC upward. There was no flow logging from 202 m to the bottom of the hole at 236.2 m because of problems checking the borehole with a dummy previous to the flow logging at those depths and the length of the measuring cable. A minor inflow was detected at 29–28 m. The step length between flow measurements in the borehole was maximally 2 m. When anomalies were detected, the length between measurements was reduced to 0.5 m. The flow logging was performed between 202 m and 25 m below TOC.

Logging results

The transmissivity of the entire borehole was derived from the transient calculation of the pump test during flow logging to T = 9.60 E–4 m^2/s.

Table 6-5. Analyses results; flow logging HSH04.

HAV12		**ΣQ_i = 4.35E-5 (m^3/s)**	**Q_p = 5.82E-4 (m^3/s)**	**ΣT_i = 7.20E-5 (m^2/s)**	**s_{FL} = 8.41 m**	**Remarks**
Anomaly depth (m from TOC)	**Anomaly length (m)**	**Q_i (m^3/s)**	**Q_i/Q_p (%)**	**T_i (m^2/s)**	**Q_i/s_{FL} (m^2/s)**	
29-28	1	4.35E-5	7.5	7.20E-5	5.17E-6	
Total		**4.35E-5**	**7.5**	**7.20E-5**	**5.17E-6**	
Difference		$Q_p - \Sigma Q_i$ = 5.39E-4	92.5	$T - \Sigma T_i$ = 8.9E-4		

ΣQ_i = cumulative flow at the top of the logged section, Q_p = pumped flow rate at surface flowmeter, s_{FL} = drawdown during pump test.

The total flow of the logged interval from 202 m to 25 below TOC (ΣQ_i) was much below of the measured flow rate of the total flow at the surface (Q_p). This indicates further additional inflows to the borehole between the bottom of casing at 9.00 m below TOC and the top of the logged section. The minor inflow to the borehole at 29–28 m covers only approximately 7.5% of the total flow.

Appendix 4-4 shows the logging diagrams. The electric conductivity shows water with high salinity and a decreasing trend from the bottom of the borehole upwards to 132 m depth. Above of a depth of 132 m there is a slightly increasing electric conductivity. A sharp drop of electric conductivity was observed from 54–50 m, with an increase upwards of this depth to the top of the logged interval, including a sharp up rise from 40–38 m depth. The temperature decreases slightly from bottom of the borehole upwards to 134 m depth. Above of a depth of 134 m there is a slightly increasing of the temperature until the top of the logged interval up to 12.5°C. This remarkable up rise of temperature near the surface may be influenced by the neighboured cooling water outlet of the three power plants. Appendix 4-4 shows the calculated cumulative transmissivity (ΣT_i) along the borehole length. Since the detected flow anomalies running over a specific interval of the borehole, the change in transmissivity is represented by a sloping line across this interval. The calculated lower limit of transmissivity and the total borehole transmissivity (T) are also shown in this appendix.

6.4.5 Borehole HSH05

Comments to test

The flow logging in HSH05 was performed from 198 m below TOC upward. There was no flow logging from 198 m to the bottom of the hole at 200.2 m to avoid lowering the flow logger in drill mud at the bottom of the hole. A minor inflow was detected at 64–62 m which was actually below of the measurement limit but nevertheless indicated some inflow to the borehole. The step length between flow measurements in the borehole was maximally 2 m. When anomalies were detected, the length between measurements was reduced to 0.5 m. The flow logging was performed between 198 m and 36 m below TOC.

Logging results

The transmissivity of the entire borehole was derived from the transient calculation of the pump test during flow logging to T = 5.22 E–6 m^2/s.

Table 6-6. Analyses results; flow logging HSH04.

HAV12		**ΣQ_i = 1.67E-5 (m^3/s)**	**Q_p = 5.26E-5 (m^3/s)**	**ΣT_i = 1.25E-6 (m^2/s)**	**s_{FL} = 13.37 m**	**Remarks**
Anomaly depth (m from TOC)	**Anomaly length (m)**	**Q_i (m^3/s)**	**Q_i/Q_p (%)**	**T_i (m^2/s)**	**Q_i/s_{FL} (m^2/s)**	
64-62	1	1.67E-5	31.7	1.25E-6	1.25E-6	
Total		**1.67E-5**	**31.7**	**5.22E-6**	**1.25E-6**	
Difference		$Qp-\Sigma Q_i$ = 5.26E-5	68.3	T- ΣT_i = 3.97E-6		Further inflow at 36-9 m ?

ΣQ_i = cumulative flow at the top of the logged section, Q_p = pumped flow rate at surface flowmeter, s_{FL} = drawdown during pump test.

The total flow of the logged interval from 198 m to 6.2 m below TOC (ΣQ_i) was much below of the measured flow rate of the total flow at the surface (Q_p) by a low flow rate at all. This indicates further additional inflows to the borehole between the bottom of casing at 6.20 m below TOC and the top of the logged section. The inflow to the borehole at 64–62 m covers only approximately 31.7% of the total flow.

Appendix 4-5 shows the logging diagrams. The electric conductivity shows water with high salinity and a decreasing trend from the bottom of the borehole upwards. At the depth interval from 140–110 m, two major drops with following increase of the electric conductivity were observed. From 110 m to 64 m a slightly decrease of the electric conductivity was detected, followed by a moderate decrease from 64 m upwards. The temperature decreases slightly from bottom of the borehole upwards to the top of the logged interval with a moderate decrease from 140 m to 130 m and a stabilization from 62 m upwards. Appendix 4-5 shows the calculated cumulative transmissivity (ΣT_i) along the borehole length. Since the detected flow anomalies running over a specific interval of the borehole, the change in transmissivity is represented by a sloping line across this interval. The calculated lower limit of transmissivity and the total borehole transmissivity (T) are also shown in this appendix.

6.4.6 Borehole HAV13

Comments to test

The flow logging in HAV13 was not performed due to major problems by running in with the dummy prior to flow logging. The flow log was placed instead below the pump at a depth of 22 m below TOC, where one flow logging measurement was performed. At this depth, the measured flow matched the total flow measured with the surface flow meter.

Logging results

The transmissivity of the entire borehole was derived from the transient calculation of the pump test during flow logging to T = 2.16 E–4 m^2/s.

Table 6-7. Analyses results; flow logging HAV13.

HAV12		**ΣQ_i = 1.20E-3 (m^3/s)**	**Q_p = 1.17E-3 (m^3/s)**	**ΣT_i = 1.88E-4 (m^2/s)**	**s_{FL} = 4.81 m**	**Remarks**
Anomaly depth (m from TOC)	**Anomaly length (m)**	**Q_i (m^3/s)**	**Q_i/Q_p (%)**	**T_i (m^2/s)**	**Q_i/s_{FL} (m^2/s)**	
142.2-22	120.2	1.20E-3	102.6	2.16E-4	2.49E-4	
Total		**1.20E-3**	**102.6**	**2.16E-4**	**2.49E-4**	
Difference		$Qp-\Sigma Q_i$ = 5.26E-5	68.3	T- ΣT_i = 0		

ΣQ_i = cumulative flow at the top of the logged section, Q_p = pumped flow rate at surface flowmeter, s_{FL} = drawdown during pump test.

The total flow of the interval below of the pump from 142.2 m to 22 m below TOC (ΣQ_i) was matching the measured flow rate of the total flow at the surface (Q_p). This indicates no further additional inflows to the borehole between the bottom of casing at 9.04 m below TOC and the top of the logged section. The inflow to the borehole at 142.2–22 m covers approximately 102.6% of the total flow; the slightly higher value of the flow rate from the flow log against the total flow of the surface flow meter may be related to fluctuations of the flow rate during the pump test.

Appendix 4-6 shows the logging diagrams. The electric conductivity shows water with high salinity. The temperature was in the typical range of the comparable temperatures measured during the pump tests. Appendix 4-6 shows the calculated cumulative transmissivity (ΣT_i) along the borehole length. Since the detected flow anomalies running over a specific interval of the borehole, the change in transmissivity is represented by a sloping line across this interval. The calculated lower limit of transmissivity and the total borehole transmissivity (T) are also shown in this appendix.

6.5 Interference tests

During the performed pump tests, a selected number of observation boreholes were monitored by installation of pressure transducers. Monitoring data from further observation boreholes were obtained from SKB (see Table 3-1) and recalculated to Swedish summer time. The following table shows, where a clear response of the water level during the performed pump tests could be observed.

Table 6-8. Distances and observed interference during pump tests.

Pumped Borehole	Point of application (m btoc)	Monitored boreholes	Packer position (secup-seclow)	Point of application (m btoc)	Radial distance (m)	Observed response (max kPa)
HAV12	157	HAV02,	no packer	midhole	488	–
		HAV05,	no packer	midhole	692	–
		HAV13,	16–142.2	121	535	–
		HAV14,	17.2–182.4	182	1,120	0.7
		KAV01,	no packer	midhole	651	–
		KAV03	no packer	midhole	372	–
HAV14	167	HAV05,	no packer	midhole	440	–
		HAV07,	no packer	midhole	102	6.2
		HAV08,	no packer	midhole	135	3.2
		HAV13,	16–142.2	121	620	–
		KAV04A	18–1,004	secmid	492	–
HAV11	220	KAV01,	no packer	midhole	751	–
		KAV04A,	20–1,004	secmid	734	–
		KSH03A	no packer	midhole	785	–
HSH04	125	HSH01,	no packer	midhole	329	–
		HSH06	18–203.2	midhole	316	–
HSH05	–	Single hole test	–	–	–	–
HAV13	121	HAV02,	no packer	midhole	163	8.8
		HAV05,	no packer	midhole	253	–
		HAV07,	no packer	midhole	630	–
		HAV08,	no packer	midhole	677	–
		HAV12,	18–157.8	158	535	0.9
		HAV14,	18–182.4	182	629	–
		KAV01,	no packer	midhole	654	–
		KAV03	no packer	midhole	745	–

No further response could be observed in any other of the observation boreholes. Some of the observation boreholes showed background effects with regular time intervals. Further background effects like general trends and/or changes in water level which could not be matched with the performed pump tests were observed as well.

Table 6-9. Response matrix for the interference tests.

Pumped Boreholes	Section (m)	HAV02	HAV05	HAV07	HAV08	HAV12	HAV13	HAV14	KAV01	KAV03	KAV04A	HSH01	HSH06	KSH03A
		Observed boreholes												
HAV12	11.34-157.80	x	x			-	x	x	x	x				
HAV14	6.03-182.40		x	M	B		x	-			x			
HAV11	6.03-220.50								x		x			x
HSH04	9.00-236.20											x	x	
HSH05	6.20-200.20													
HAV13	9.04-142.20	B	x	x	x	x	-	x	x	x				

Index 1 = dtL/rs²
Normalised responsetime with distance

$dtL/rs^2 < 0.01\ s/m^2$	E = Excellent
$0.01 <= dtL/rs^2 < 0.1\ s/m^2$	G = Good
$0.1 <= dtL/rs^2 < 0.3\ s/m^2$	M = Medium
$dtL/rs^2 >= 0.3\ s/m^2$	B = Bad

dtL = time after pumpstart/-stop when dp > 1 kPa in observation borehole
rs = radial distance between pumped and observed borehole

x = observed but no response at all
blank = not observed

Index 2 = dpp/Qp
Normalised drawdown with pumpcapacity

$dpp/Qp > 1\ E05\ s/m^2$	Excellent
$3\ E04 < dpp/Qp <= 1\ E05\ s/m^2$	High
$1\ E04 < dpp/Qp <= 3\ E04\ s/m^2$	Medium
$dpp/Qp <= 1\ E04\ s/m^2$	Low
$dpp/Qp < 0.1\ s/m^2$	No response

dpp = drawdown at pumpstop in observation borehole
Qp = flow rate at end of pump phase

The Index 1 (for recovery data) and Index 2 (drawdown data) were calculated according to (SKB MD 330.003) (Metodbeskrivning för Interferenstester, Appendix 4) where applicable responses were observed (SKB internal controlling documents). The response matrix gives an overview of the monitored observation boreholes and a classification of the observed responses.

Where a response at observation wells was observed, these data were evaluated. The distance between the pumped and observed boreholes was calculated as the distance between the positions of dominating flow anomalies identified during drilling and flow logging respectively to the midpoint of the uncased borehole where no distinctive flow anomalies were detected. Radial distance data were provided by SKB and included in Table 6-8 above.

The boreholes where responses were observed are all related to a fractured zone running in a general northeast-southwest direction at the northern edge of the Ävrö Island. Selected representative parameters for the observation boreholes are presented in Test Summary Sheets in Appendix 3.

Selected diagrams of the evaluated observation wells are presented in Appendix 2-1 to Appendix 2-6. For all five evaluated observation wells, the drawdown and recovery periods were evaluated. In general a very good consistency of both of the periods was observed by evaluation.

According to the Indices 1 and 2, shown in the response matrix (Table 6-9), there is a medium to bad normalised response time and a low, respectively no response evaluated for the five monitored boreholes where a response was observed at all. At all other monitored boreholes, no response related to the pump tests was observed. Even where a hydraulic connection between pumped and monitored boreholes was observed, this connectivity is of poor quality.

In the following, observed and analysed responses in the monitoring boreholes are discussed more in detail. The monitoring data where no response was observed are documented in Appendix 2 related to the relevant pumped boreholes.

6.5.1 Borehole HAV12 pumped, HAV14 observed

Comments to test

The test was composed of a constant rate pump test phase in HAV12 with a mean flow rate of 64 l/min, followed by a pressure recovery phase. In HAV14, a maximum drawdown response of 0.7 kPa was observed which is rated by Index 2 as "no response" because of a response < 1 kPa. Index 1 was not calculated because of the low response.

Flow regime and calculated parameters

The flow dimension is interpreted from the slope of the semi-log derivative plotted in log-log coordinates. For the analysis of the CRw and CRr phase a homogeneous radial flow model was chosen. The analysis is presented in Appendix 2-1 and Appendix 3-1.

Selected representative parameters

The recommended transmissivity of 8.75E–4 m^2/s was derived from the analysis of the CRr phase (inner zone), which shows a good data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 6.0E–4 m^2/s to 3.0E–3 m^2/s. The flow dimension displayed during the test is 2. According to the low response in combination with background effects, no static pressure could be derived from straight line extrapolation in the Horner plot.

The analysis of the CRw and CRr phases shows good consistency. No further analysis is recommended.

6.5.2 Borehole HAV14 pumped, HAV08 observed

Comments to test

The test was composed of a constant rate pump test phase in HAV14 with a mean flow rate of 64 l/min, followed by a pressure recovery phase. In HAV08, a maximum drawdown response of 3.2 kPa was observed which is rated by Index 1 with a "bad response time" and with Index 2 as "low response".

Flow regime and calculated parameters

The flow dimension is interpreted from the slope of the semi-log derivative plotted in log-log coordinates. For the analysis of the CRw phase a composite and for the CRr phase a homogeneous radial flow model was chosen. The analysis is presented in Appendix 2-2 and Appendix 3-2.

Selected representative parameters

The recommended transmissivity of 2.32E–4 m^2/s was derived from the analysis of the CRr phase (inner zone), which shows a good data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 5.0E–5 m^2/s to 3.0E–3 m^2/s. The flow dimension displayed during the test is 2. According to the low response in combination with background effects, no static pressure was derived from straight line extrapolation in the Horner plot.

The analysis of the CRw and CRr phases shows good consistency. No further analysis is recommended.

6.5.3 Borehole HAV14 pumped, HAV07 observed

Comments to test

The test was composed of a constant rate pump test phase in HAV14 with a mean flow rate of 64 l/min, followed by a pressure recovery phase. In HAV07, a maximum drawdown response of 6.2 kPa was observed which is rated by Index 1 with a "medium response time" and with Index 2 as "low response".

Flow regime and calculated parameters

The flow dimension is interpreted from the slope of the semi-log derivative plotted in log-log coordinates. For the analysis of the CRw and CRr phase a radial composite flow model was chosen. The analysis is presented in Appendix 2-2 and Appendix 3-2.

Selected representative parameters

The recommended transmissivity of 2.2E–4 m^2/s was derived from the analysis of the CRr phase (inner zone), which shows a good data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 1.0E–4 m^2/s to 1.0E–3 m^2/s. The flow dimension displayed during the test is 2. According to the low response in combination with background effects, no static pressure was derived from straight line extrapolation in the Horner plot.

The analysis of the CRw and CRr phases shows good consistency. No further analysis is recommended.

6.5.4 Borehole HAV13 pumped, HAV12 observed

Comments to test

The test was composed of a constant rate pump test phase in HAV13 with a mean flow rate of 70 l/min, followed by a pressure recovery phase. In HAV12, a maximum drawdown response of 0.9 kPa was observed which is rated by Index 2 as “no response” because of a response < 1 kPa. Index 1 was not calculated because of the low response.

Flow regime and calculated parameters

The flow dimension is interpreted from the slope of the semi-log derivative plotted in log-log coordinates. For the analysis of the CRw and CRr phase a homogeneous radial flow model was chosen. The analysis is presented in Appendix 2-6 and Appendix 3-6.

Selected representative parameters

The recommended transmissivity of 7.59E–4 m^2/s was derived from the analysis of the CRr phase, which shows a good data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 5.0E–4 m^2/s to 5.0E–3 m^2/s. The flow dimension displayed during the test is 2. According to the low response in combination with background effects, no static pressure was derived from straight line extrapolation in the Horner plot.

The analysis of the CRw and CRr phases shows good consistency. No further analysis is recommended.

6.5.5 Borehole HAV13 pumped, HAV02 observed

Comments to test

The test was composed of a constant rate pump test phase in HAV13 with a mean flow rate of 70 l/min, followed by a pressure recovery phase. In HAV02, a maximum drawdown response of 8.8 kPa was observed which is rated by Index 1 with a “bad response time” and with Index 2 as “low response”.

Flow regime and calculated parameters

The flow dimension is interpreted from the slope of the semi-log derivative plotted in log-log coordinates. For the analysis of the CRw and CRr phase a homogeneous radial flow model was chosen. The analysis is presented in Appendix 2-6 and Appendix 3-6.

Selected representative parameters

The recommended transmissivity of 5.37E–5 m^2/s was derived from the analysis of the CRw phase, which shows a good data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 4.0E–5 m^2/s to 1.0E–4 m^2/s. The flow dimension displayed during the test is 2. According to the low response in combination with background effects, no static pressure was derived from straight line extrapolation in the Horner plot.

The analysis of the CRw and CRr phases shows good consistency. No further analysis is recommended.

7 Synthesis

The synthesis chapter summarizes the basic test parameters and analysis results. In addition, the correlation between steady state and transient transmissivities as well as between the matched and the theoretical wellbore storage (WBS) coefficient are presented and discussed.

7.1 Summary of results

Table 7-1. General test data from constant rate 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)	EC_w (mS/m)	Test phases measured Analysed test phases marked bold
HAV12	11.34	157.80	20040702 08:54	20040703 08:44	1.06E-03	1.07E-03	36180	39180	–	215.9	137.1	214.1	8.34	820.8	**CRw CRr**
HAV12 repeat	11.34	157.80	20040704 08:24	20040705 08:43	1.06E-03	1.07E-03	36060	51540	–	218.4	137.3	215.9	8.36	817.7	**CRw CRr**
HAV14	6.03	182.40	20040707 08:09	20040709 10:11	1.06E-03	1.07E-03	39000	45300	–	208.9	144.2	203.6	8.42	32.0	**CRw CRr**
HAV11	6.03	220.50	20040711 08:24	20040714 09:06	1.19E-03	1.19E-03	38220	48840	–	246.7	205.5	242.7	8.79	1143	**CRw CRr**
HSH04	9.00	236.20	20040715 08:11	20040717 08:35	5.60E-04	5.82E-04	36240	51600	–	240.2	156.1	242.1	12.49	878.0	**#NV CRr**
HSH05	6.20	200.20	20040717 13:08	20040719 08:43	6.95E-05	6.93E-05	36600	51900	–	325.5	191.8	322.4	8.52	737.3	**CRw CRr**
HAV13	9.04	142.20	20040720 08:03	20040722 13:31	1.15E-03	1.17E-03	36060	67500	–	197.2	149.1	194.9	8.66	833.7	**CRw CRr**

#NV Not analysed.
CRw Constant rate pump (withdrawal) phase.
CRr Recovery phase following the constant rate pump phase.

Table 7-2. Results from analysis of constant rate 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 m^2/s	T_M m^2/s	Perturb. Phase	Recovery Phase	T_{f1} m^2/s	T_{f2} m^2/s	T_{s1} m^2/s	T_{s2} m^2/s	T_T m^2/s	T_{TMIN} m^2/s	T_{TMAX} m^2/s	C m^3/Pa	ξ –	dt_1 min	dt_2 min	p* kPa	h_{wif} masl
HAV12	11.34	157.80	1.35E-04	1.71E-04	WBS22	WBS22	2.1E-04	2.6E-04	2.8E-04	1.8E-04	2.8E-04	1.0E-04	3.0E-04	1.98E-06	1.6	9	600	217	–0.24
HAV12 repeat	11.34	157.80	1.31E-04	1.66E-04	WBS22	WBS22	3.0E-04	1.7E-04	8.0E-04	1.1E-04	8.0E-04	1.0E-04	1.0E-03	1.99E-06	16.1	12	600	221	+0.17
HAV14	6.03	182.40	1.63E-04	2.10E-04	WBS22	WBS22	1.6E-04	2.1E-04	1.6E-04	1.4E-04	1.6E-04	1.0E-04	3.0E-04	1.59E-06	–2.79	12	240	208	–1.23
HAV11	6.03	220.50	2.89E-04	3.85E-04	WBS22	WBS22	7.2E-04	9.2E-05	9.5E-04	1.2E-04	7.2E-04	8.0E-05	1.0E-03	2.75E-06	1.02	6	600	248	+0.21
HSH04	9.00	236.20	6.65E-05	8.89E-05	#NV	WBS2	#NV	#NV	9.6E-04	#NV	9.6E-04	8.0E-04	1.0E-03	1.65E-06	83.3	36	480	242	+0.19
HSH05	6.20	200.20	5.20E-06	6.81E-06	WBS2	WBS22	4.2E-06	#NV	5.2E-06	5.2E-04	5.2E-06	4.0E-06	6.0E-04	2.28E-06	0	420	600	324	+0.12
HAV13	9.04	142.20	2.39E-04	2.99E-04	WBS22	WBS22	2.2E-04	1.8E-04	2.3E-04	2.2E-04	2.2E-04	1.0E-04	3.0E-04	1.58E-06	–4.39	2.4	300	198	–0.63

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.

The recommended transmissivity TT typically refers to the T1 value (inner zone transmissivity).

2 The parameter p* denoted the static formation pressure (measured at transducer depth) and was derived from the HORNER plot of the CRr phase using straight line or type-curve extrapolation.

3 The flow regime description refers to the recommended model used in the transient analysis. WBS denotes wellbore storage and skin and is followed by a set of numbers describing the flow dimension used in the analysis (1 = linear flow, 2 = radial flow, 3 = spherical flow). If only one number is used (e.g. WBS2 or 2) a homogeneous flow model (1 composite zone) was used in the analysis, if two numbers are given (WBS22 or 22) a 2 zones composite model was used.

#NV Not analysed.

Table 7-3. Results from analysis of interference tests.

Observation borehole			Pumped borehole		Transient analysis														
					Flow regime		Formation parameters											Static conditions	
Borehole ID	up m btoc	low m btoc	Borehole ID	Distance m	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	S –	ξ –	dt_1 min	dt_2 min	p* kPa	h_{wif} masl
HAV14	6.03	182.40	HAV12	1120	WBS2	WBS2	1.7E-03	#NV	8.8E-04	#NV	8.8E-04	6.0E-04	3.0E-03	1.3E-05	1.02	–	–	–	–
HAV08	0.00	63.00	HAV14	135	WBS22	WBS2	7.0E-05	1.4E-03	2.3E-04	#NV	2.3E-04	5.0E-05	3.0E-03	5.8E-04	–0.88	–	–	–	–
HAV07	4.00	100.00	HAV14	102	WBS22	WBS22	2.2E-04	5.4E-04	3.3E-04	7.8E-04	2.2E-04	1.0E-04	1.0E-03	2.0E-04	–0.35	–	–	–	–
HAV12	11.34	157.80	HAV13	535	WBS2	WBS2	7.6E-04	#NV	2.8E-03	#NV	7.6E-04	5.0E-04	5.0E-03	1.2E-04	–0.10	–	–	–	–
HSH02	0.13	163.00	HAV13	163	WBS2	WBS2	7.8E-05	#NV	5.4E-05	#NV	5.4E-05	4.0E-05	1.0E-04	1.3E-04	–0.13	–	–	–	–

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.

The recommended transmissivity T_T typically refers to the T2 value (far field transmissivity).

2 The parameter p* denoted the static formation pressure (measured at transducer depth) and was derived from the HORNER plot of the CRr phase using straight line or type-curve extrapolation.

3 The flow regime description refers to the recommended model used in the transient analysis. WBS denotes wellbore storage and skin and is followed by a set of numbers describing the flow dimension used in the analysis (1 = linear flow, 2 = radial flow, 3 = spherical flow). If only one number is used (e.g. WBS2 or 2) a homogeneous flow model (1 composite zone) was used in the analysis, if two numbers are given (WBS22 or 22) a 2 zones composite model was used.

#NV Not analysed.

7.2 Correlation analysis

A correlation analysis was used with the aim of examining the consistency of results and deriving general conclusion regarding the testing and analysis methods used.

7.2.1 Comparison of steady state and transient analysis results

The steady state derived transmissivities (T_M and Q/s) were compared in a cross-plot with the recommended transmissivity values derived from the transient analysis (see following figure).

The correlation analysis shows that most of the steady state derived transmissivities differ by less than one order of magnitude from the transmissivities derived from the transient analysis. In the borehole of HSH04, where the difference is approximately one order of magnitude, the steady state calculation is considered as probably influenced by some turbulent flow (very high skin of 83) whereas the transient analysis shows that the transmissivities are much higher in larger distance to the borehole.

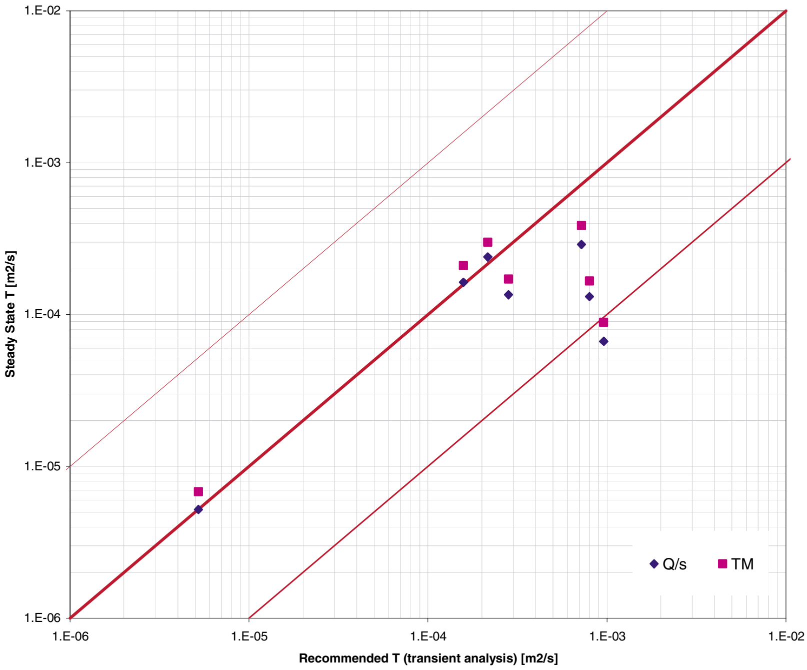

Figure 7-1. *Correlation analysis of transmissivities at pumped boreholes derived by steady state and transient methods.*

7.2.2 Comparison between the matched and theoretical wellbore storage coefficient

The wellbore storage coefficient describes the capacity of the test interval to store fluid as result to a unit pressure change in the interval. For a closed system (i.e. closed downhole valve) the theoretical value of the wellbore storage coefficient is given by the product between the interval volume and the test zone compressibility. The interval volume is calculated from the borehole radius and interval length. There are uncertainties concerning the interval volume calculation. Cavities or high transmissivity fractures intersecting the interval may enlarge the effective volume of the interval. The test zone compressibility is given by the sum of compressibilities of the individual components present in the interval (water, packer elements, other test tool components, and the borehole wall). A minimum value for the test zone compressibility is given by the water compressibility which is approx 5E–10 1/Pa. For the calculation of the theoretical wellbore storage coefficient a test zone compressibility of 7E–10 1/Pa was used. The matched wellbore storage coefficient is derived from the transient type curve analysis by matching the unit slope early times derivative plotted in log-log coordinates.

The following figure presents a cross-plot of the matched and theoretical wellbore storage coefficients.

It can be seen that the matched wellbore storage coefficients are less of one order of magnitude larger than the theoretical values and therefore showing a good consistency of the results.

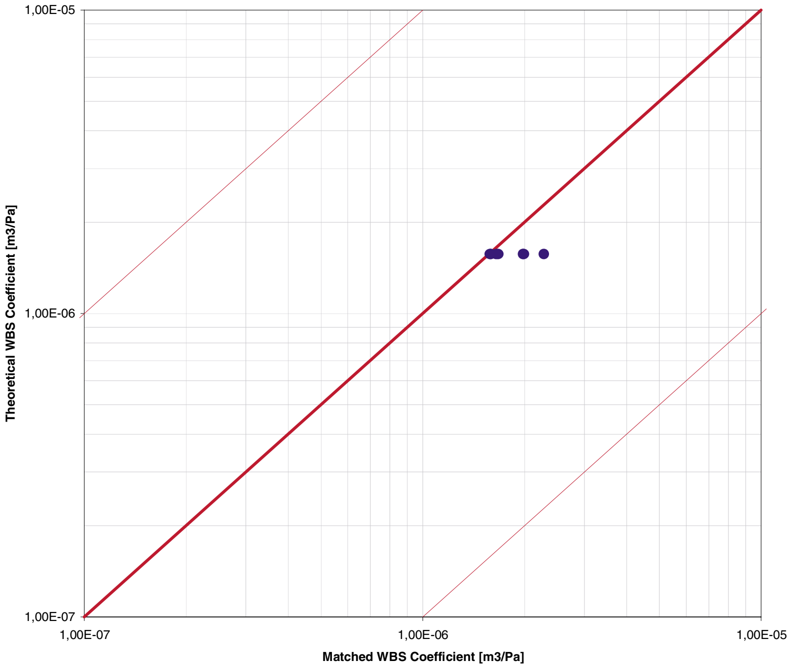

Figure 7-2. *Correlation analysis of theoretical and matched wellbore storage coefficients of pumped boreholes.*

8 Conclusions

8.1 Transmissivity

Figure 7-1 presents a correlation analysis of transmissivities derived from steady state calculations and from the transient analysis. The method used for deriving the recommended transmissivity and its confidence range is described in Section 5.4.7.

Whenever possible, the transmissivities derived are representative for the "undisturbed formation" further away from the borehole. The borehole vicinity was typically described using a skin effect.

In one case (pump test in HSH05) the steady state analysis shows a much smaller transmissivity than the recommended transmissivity. However, the transient analysis derived a consistent transmissivity in the near vicinity of the borehole but a much larger transmissivity for the "undisturbed formation" at larger distance.

In one case (HSH04), the pump phase was not analysable due to changes in the flow volume. In this case, only the recovery period of the test was analysed.

The transmissivities derived from the transient analysis of the responses in observation boreholes are in consistency with the range of the recommended transmissivities from the pumped boreholes. The tested formation is typically characterized by transmissivities in the range from 1E–4 m^2/s to 1E–3 m^2/s. In the near vicinity of the boreholes and between a pumped and monitored borehole with small distance the derived transmissivities may show different ranges of transmissivities.

8.2 Flow regimes encountered

The flow models used in analysis were derived from the shape of the pressure derivative calculated with respect to log time and plotted in log-log coordinates.

In several cases the pressure derivative suggests a change of transmissivity with the distance from the borehole. In such cases a composite flow model was used in the analysis.

The flow dimension displayed by the test can be diagnosed from the slope of the pressure derivative. A slope of 0.5 indicates linear flow, a slope of 0 (horizontal derivative) indicates radial flow and a slope of –0.5 indicates spherical flow. The flow dimension diagnosis was commented for each of the tests. However, in all cases it was possible to achieve to acceptable analysis results (good match quality) by using radial flow geometry (flow dimension of 2).

8.3 Interference tests and hydraulic connectivity

During five of the six performed pump tests, an overall amount of 13 different boreholes were used for monitoring responses along specific lineaments. Only in five of the monitored boreholes, responses could be observed related to the pump tests.

The boreholes where responses were observed are all related to a lineament running in a general northeast-southwest direction at the northern edge of the Ävrö Island. The pumped boreholes HAV12, HAV13 and HAV14 are all connected to this lineament as well as the boreholes where a response could be observed (i.e. HAV02, HAV07, HAV08, HAV12 and HAV14).

The evaluation of the interference test data shows in general a poor hydraulic connectivity and a medium to bad normalised response time.

No further response at all other monitored boreholes (even when linked to other lineaments) could be observed.

9 References

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APPENDIX 1

File Description Table

HYDROTESTING WITH HTHB					DRILLHOLE IDENTIFICATION NO.: HAV12		
TEST- AND FILEPROTOCOL					Testorder dated : 2004-06-29		
Teststart		Interval boundaries (m)		Name of Datafile			
Date	Time	Upper	Lower	Test type	Data file	Parameters	Comments
02.07.2004	08:54	11.34	157.8	1B, 6, L-EC, L-Te	HAV12_11.34-157.80_040702_1_CRwr_r.xls	P, Q, EC, Te	
02.07.2004	08:54	11.34	157.8	1B, 6, L-EC, L-Te	HAV12_030_040624_Ref_Da00.DAT	C, R	
02.07.2004	08:54	11.34	157.8	1B, 6, L-EC, L-Te	HAV12_030_040629_FlowLo00_original.DAT	P, Q, EC, Te	
02.07.2004	08:54	11.34	157.8	1B, 6, L-EC, L-Te	HAV12_030_040702_FlowLo00_edited.DAT	P, Q, EC, Te	
02.07.2004	08:54	11.34	157.8	1B, 6, L-EC, L-Te	HAV12_030_040629_Spinne00.DAT	(P, Q) EC, Te, Sp	P, Q only at Spinner data
02.07.2004	08:54	11.34	157.8	1B, 6, L-EC, L-Te	HAV12_030_040629_Spinner_evaluated.xls	(P, Q) EC, Te, Sp	P, Q only at Spinner data
02.07.2004	08:54	11.34	157.8	1B, 6, L-EC, L-Te	HAV13_040702_obs.TXT	P	
02.07.2004	08:54	11.34	157.8	1B, 6, L-EC, L-Te	HAV14_040702_obs.TXT	P	
04.07.2004	08:24	11.34	157.8	1B	HAV12_11.34-157.80_040704_2_CRwr_r.xls	P, Q, EC, Te	test repeated
04.07.2004	08:24	11.34	157.8	1B	HAV12_030_040629_FlowLo00_original.DAT	P, Q, EC, Te	test repeated
04.07.2004	08:24	11.34	157.8	1B	HAV12_030_040704_FlowLo00_edited.DAT	P, Q, EC, Te	test repeated
04.07.2004	08:24	11.34	157.8	1B	HAV13_040704_obs.TXT	P	test repeated
04.07.2004	08:24	11.34	157.8	1B	HAV14_040704_obs.TXT	P	test repeated

HYDROTESTING WITH HTHB					DRILLHOLE IDENTIFICATION NO.: HAV14		
TEST- AND FILEPROTOCOL					Testorder dated : 2004-06-29		
Teststart		Interval boundaries (m)		Name of Datafile			
Date	Time	Upper	Lower	Test type	Data file	Parameters	Comments
07.07.2004	08:09	6.03	182.4	1B, 6, L-EC, L-Te	HAV14_6.03-182.40_040707_1_CRwr_r.xls	P, Q, EC, Te	
07.07.2004	08:09	6.03	182.4	1B, 6, L-EC, L-Te	HAV14_032_040624_Ref_Da00.DAT	C, R	
07.07.2004	08:09	6.03	182.4	1B, 6, L-EC, L-Te	HAV14_032_040708_FlowLo00.DAT	P, Q, EC, Te	
07.07.2004	08:09	6.03	182.4	1B, 6, L-EC, L-Te	HAV14_032_040708_Spinne00.DAT	(P, Q) EC, Te, Sp	P, Q only at Spinner data
07.07.2004	08:09	6.03	182.4	1B, 6, L-EC, L-Te	HAV14_032_040708_Spinner_evaluated.xls	(P, Q) EC, Te, Sp	P, Q only at Spinner data
07.07.2004	08:09	6.03	182.4	1B, 6, L-EC, L-Te	HAV07_040707_obs_1.TXT	P	
07.07.2004	08:09	6.03	182.4	1B, 6, L-EC, L-Te	HAV07_040707_obs_2.TXT	P	
07.07.2004	08:09	6.03	182.4	1B, 6, L-EC, L-Te	HAV07_040707_obs_edited.TXT	P	
07.07.2004	08:09	6.03	182.4	1B, 6, L-EC, L-Te	HAV08_040707_obs_1.TXT	P	
07.07.2004	08:09	6.03	182.4	1B, 6, L-EC, L-Te	HAV08_040708_obs_2.TXT	P	
07.07.2004	08:09	6.03	182.4	1B, 6, L-EC, L-Te	HAV08_040707_obs_edited.TXT	P	
07.07.2004	08:09	6.03	182.4	1B, 6, L-EC, L-Te	HAV13_040707_obs_1.TXT	P	
07.07.2004	08:09	6.03	182.4	1B, 6, L-EC, L-Te	HAV13_040708_obs_2.TXT	P	
07.07.2004	08:09	6.03	182.4	1B, 6, L-EC, L-Te	HAV13_040707_obs_edited.TXT	P	
07.07.2004	08:09	6.03	182.4	1B, 6, L-EC, L-Te	KAV04A_040707_obs_1.TXT	P	
07.07.2004	08:09	6.03	182.4	1B, 6, L-EC, L-Te	KAV04A_040708_obs_2.TXT	P	
07.07.2004	08:09	6.03	182.4	1B, 6, L-EC, L-Te	KAV04A_040707_obs_edited.TXT	P	

HYDROTESTING WITH HTHB					DRILLHOLE IDENTIFICATION NO.: HAV11			
TEST- AND FILEPROTOCOL					Testorder dated : 2004-06-29			
Teststart		Interval boundaries (m)		Name of Datafile				
Date	Time	Upper	Lower	Test type	Data file	Parameters	Comments	
11.07.2004	08:24	6.03	220.5	1B, 6, L-EC, L-Te	HAV11_6.03-220.50_040711_1_CRwr_r.xls	P, Q, EC, Te		
11.07.2004	08:24	6.03	220.5	1B, 6, L-EC, L-Te	HAV11_026_040624_Ref_Da00_original.DAT	C, R		
11.07.2004	08:24	6.03	220.5	1B, 6, L-EC, L-Te	HAV11_026_040711_Ref_Da00_edited.DAT	C, R		
11.07.2004	08:24	6.03	220.5	1B, 6, L-EC, L-Te	HAV11_026_040707_FlowLo00_original.DAT	P, Q, EC, Te		
11.07.2004	08:24	6.03	220.5	1B, 6, L-EC, L-Te	HAV11_026_040711_FlowLo00_edited.DAT	P, Q, EC, Te		
11.07.2004	08:24	6.03	220.5	1B, 6, L-EC, L-Te	HAV11_026_040708_Spinne00_original.DAT	(P, Q) EC, Te, Sp	P, Q only at Spinner data	
11.07.2004	08:24	6.03	220.5	1B, 6, L-EC, L-Te	HAV11_026_040711_Spinne00_edited.DAT	(P, Q) EC, Te, Sp	P, Q only at Spinner data	
11.07.2004	08:24	6.03	220.5	1B, 6, L-EC, L-Te	HAV11_026_040711_Spinner_evaluated.xls	(P, Q) EC, Te, Sp	P, Q only at Spinner data	
11.07.2004	08:24	6.03	220.5	1B, 6, L-EC, L-Te	KAV04A_040711_obs_1.TXT	P		
11.07.2004	08:24	6.03	220.5	1B, 6, L-EC, L-Te	KAV04A_040713_obs_2.TXT	P		
11.07.2004	08:24	6.03	220.5	1B, 6, L-EC, L-Te	KAV04A_040711_obs_ edited.TXT	P		

HYDROTESTING WITH HTHB					DRILLHOLE IDENTIFICATION NO.: HSH04			
TEST- AND FILEPROTOCOL					**Testorder dated : 2004-06-29**			
Teststart		Interval boundaries (m)		Name of Datafile				
Date	Time	Upper	Lower	Test type	Data file	Parameters	Comments	
15.07.2004	08:11	9	236.2	1B, 6, L-EC, L-Te	HSH04_9.00-236.20_040715_1_CRwr_r.xls	P, Q, EC, Te		
15.07.2004	08:11	9	236.2	1B, 6, L-EC, L-Te	HSH04_025_040624_Ref_Da00_original.DAT	C, R		
15.07.2004	08:11	9	236.2	1B, 6, L-EC, L-Te	HSH04_025_040717_Ref_Da00_edited.DAT	C, R		
15.07.2004	08:11	9	236.2	1B, 6, L-EC, L-Te	HSH04_025_040715_FlowLo00.DAT	P, Q, EC, Te		
15.07.2004	08:11	9	236.2	1B, 6, L-EC, L-Te	HSH04_025_040716_Spinne00.DAT	(P, Q) EC, Te, Sp	P, Q only at Spinner data	
15.07.2004	08:11	9	236.2	1B, 6, L-EC, L-Te	HSH04_025_040716_Spinner_evaluated.xls	(P, Q) EC, Te, Sp	P, Q only at Spinner data	
15.07.2004	08:11	9	236.2	1B, 6, L-EC, L-Te	HSH06_040715_obs_1.TXT	P		
15.07.2004	08:11	9	236.2	1B, 6, L-EC, L-Te	HSH06_040716_obs_2.TXT	P		
15.07.2004	08:11	9	236.2	1B, 6, L-EC, L-Te	HSH06_040715_obs_edited.TXT	P		

HYDROTESTING WITH HTHB — **DRILLHOLE IDENTIFICATION NO.: HSH05**

TEST- AND FILEPROTOCOL — **Testorder dated : 2004-06-29**

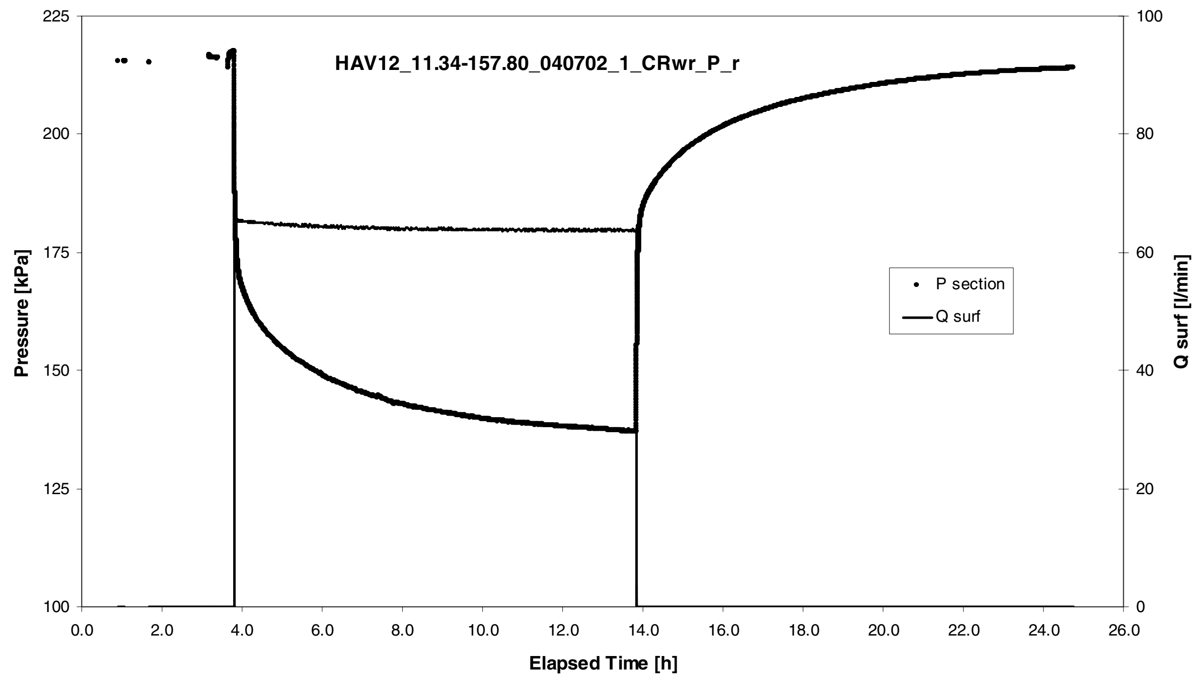
Teststart		Interval boundaries (m)		Name of Datafile			
Date	Time	Upper	Lower	Test type	Data file	Parameters	Comments
17.07.2004	13:08	6.2	200.2	1B, 6, L-EC, L-Te	HSH05_6.20-200.20_040717_1_CRwr_r.xls	P, Q, EC, Te	
17.07.2004	13:08	6.2	200.2	1B, 6, L-EC, L-Te	HSH05_036_040624_Ref_Da00_original.DAT	C, R	
17.07.2004	13:08	6.2	200.2	1B, 6, L-EC, L-Te	HSH05_036_040717_Ref_Da00_edited.DAT	C, R	
17.07.2004	13:08	6.2	200.2	1B, 6, L-EC, L-Te	HSH05_036_040717_FlowLo00.DAT	P, Q, EC, Te	
17.07.2004	13:08	6.2	200.2	1B, 6, L-EC, L-Te	HSH05_036_040718_Spinne00.DAT	(P, Q) EC, Te, Sp	P, Q only at Spinner data
17.07.2004	13:08	6.2	200.2	1B, 6, L-EC, L-Te	HSH05_036_040718_Spinner_evaluated.xls	(P, Q) EC, Te, Sp	P, Q only at Spinner data

HYDROTESTING WITH HTHB					DRILLHOLE IDENTIFICATION NO.: HAV13			
TEST- AND FILEPROTOCOL					Testorder dated : 2004-06-29			
Teststart		Interval boundaries (m)		Name of Datafile				
Date	Time	Upper	Lower	Test type	Data file	Parameters	Comments	
20.07.2004	08:03	9.04	142.2	1B, 6, L-EC, L-Te	HAV13_9.04-142.20_040720_1_CRwr_r.xls	P, Q, EC, Te		
20.07.2004	08:03	9.04	142.2	1B, 6, L-EC, L-Te	HAV13_022_040624_Ref_Da00_original.DAT	C, R		
20.07.2004	08:03	9.04	142.2	1B, 6, L-EC, L-Te	HAV13_022_040720_Ref_Da00_edited.DAT	C, R		
20.07.2004	08:03	9.04	142.2	1B, 6, L-EC, L-Te	HAV13_022_040721_FlowLo00.DAT	P, Q, EC, Te		
20.07.2004	08:03	9.04	142.2	1B, 6, L-EC, L-Te	HAV13_022_040721_Spinne00.DAT	(P, Q) EC, Te, Sp	P, Q only at Spinner data	
20.07.2004	08:03	9.04	142.2	1B, 6, L-EC, L-Te	HAV13_022_040721_Spinner_evaluated.xls	(P, Q) EC, Te, Sp	P, Q only at Spinner data	
20.07.2004	08:03	9.04	142.2	1B, 6, L-EC, L-Te	HAV07_040720_obs_1.TXT	P		
20.07.2004	08:03	9.04	142.2	1B, 6, L-EC, L-Te	HAV07_040721_obs_2.TXT	P		
20.07.2004	08:03	9.04	142.2	1B, 6, L-EC, L-Te	HAV07_040720_obs_edited.TXT	P		
20.07.2004	08:03	9.04	142.2	1B, 6, L-EC, L-Te	HAV08_040720_obs_1.TXT	P		
20.07.2004	08:03	9.04	142.2	1B, 6, L-EC, L-Te	HAV08_040721_obs_2.TXT	P		
20.07.2004	08:03	9.04	142.2	1B, 6, L-EC, L-Te	HAV08_040720_obs_edited.TXT	P		
20.07.2004	08:03	9.04	142.2	1B, 6, L-EC, L-Te	HAV12_040720_obs_1.TXT	P		
20.07.2004	08:03	9.04	142.2	1B, 6, L-EC, L-Te	HAV12_040721_obs_2.TXT	P		
20.07.2004	08:03	9.04	142.2	1B, 6, L-EC, L-Te	HAV12_040720_obs_edited.TXT	P		
20.07.2004	08:03	9.04	142.2	1B, 6, L-EC, L-Te	HAV14_040720_obs_1.TXT	P		
20.07.2004	08:03	9.04	142.2	1B, 6, L-EC, L-Te	HAV14_040721_obs_2.TXT	P		
20.07.2004	08:03	9.04	142.2	1B, 6, L-EC, L-Te	HAV14_040720_obs_edited.TXT	P		

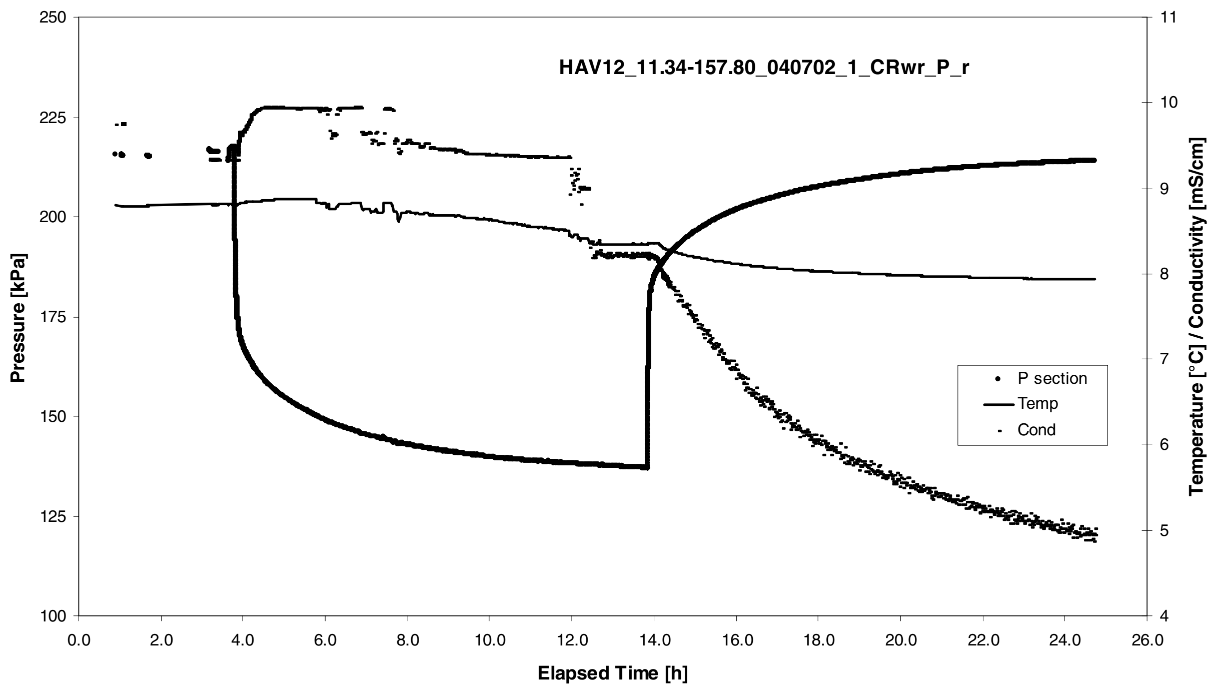
APPENDIX 2-1

HAV12

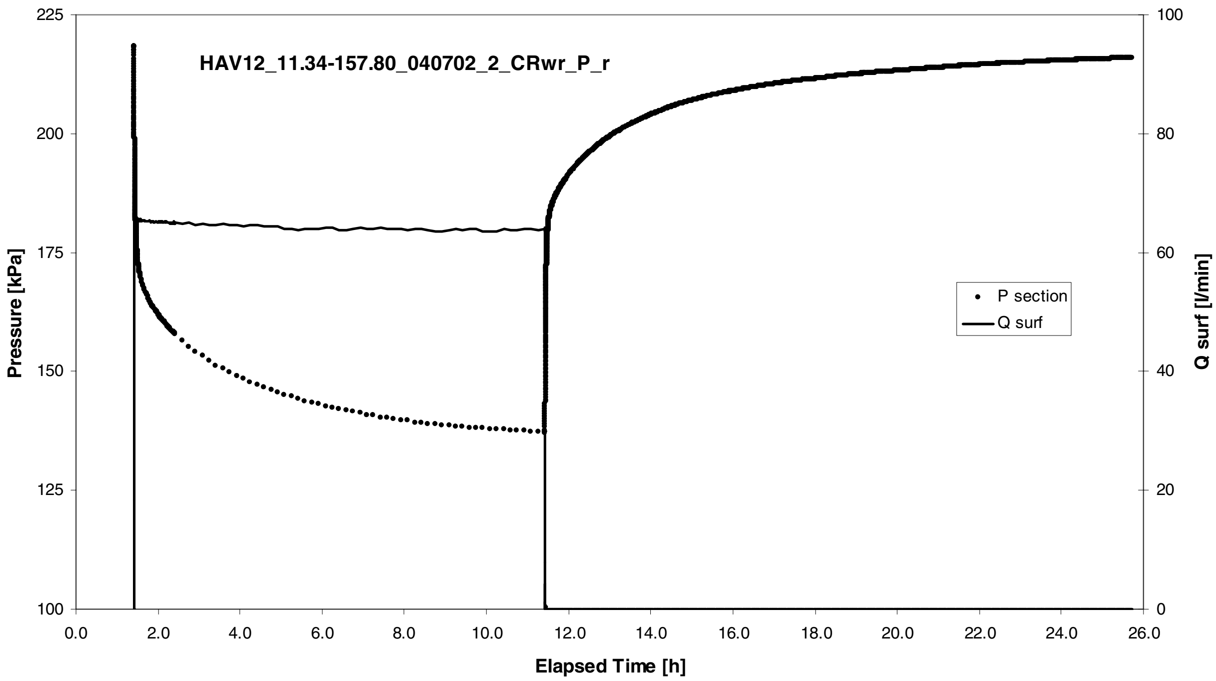
Pump Test Analysis diagrams



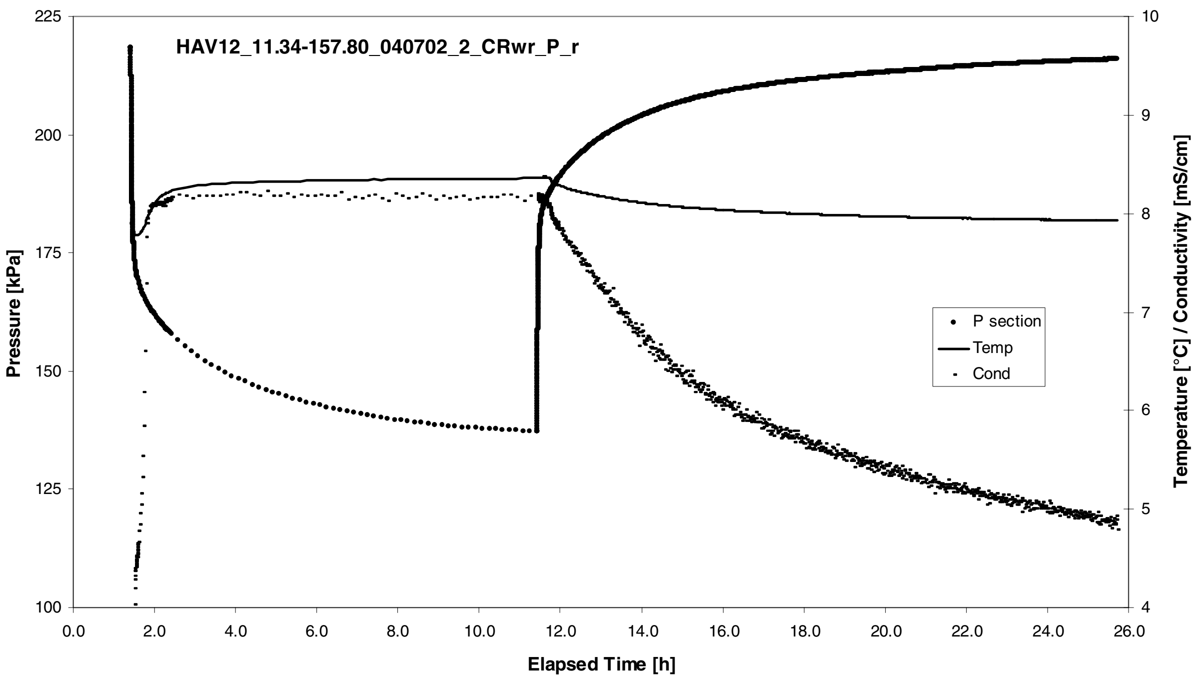
Pressure and flow rate vs. time; cartesian plot (1st test)



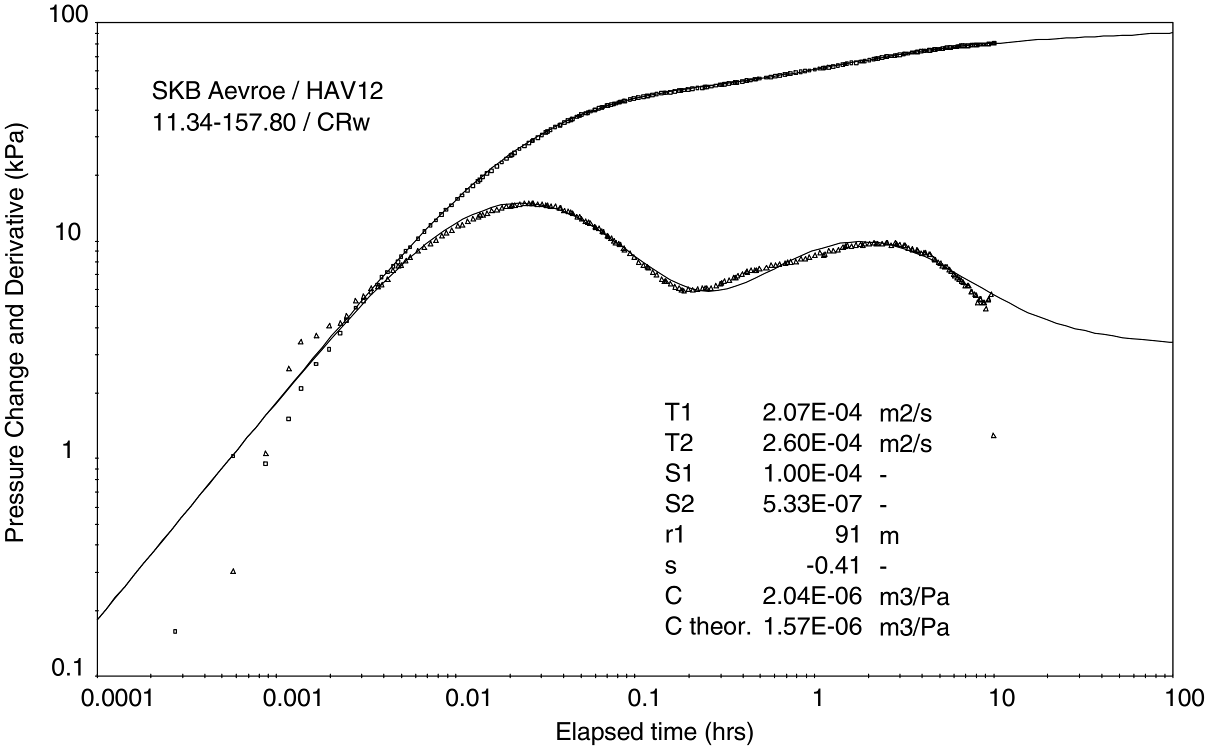
Pressure, temperature and conductivity vs. time; cartesian plot (1st test)



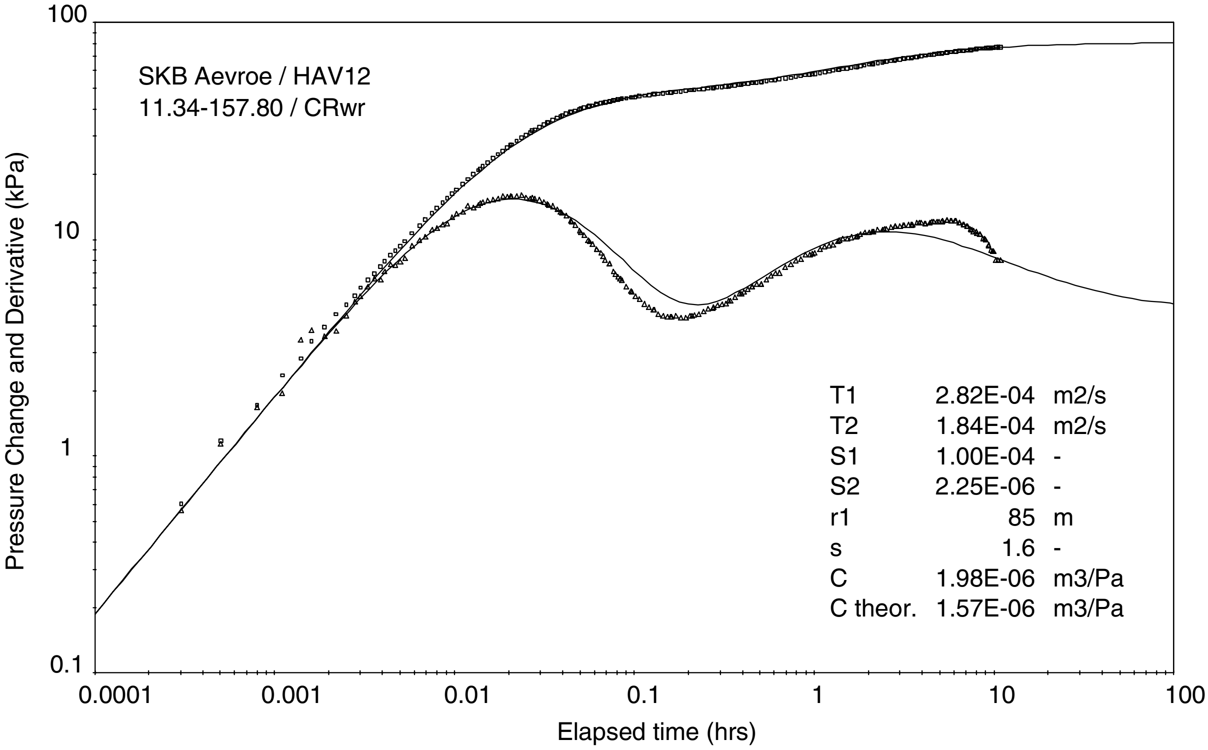
Pressure and flow rate vs. time; cartesian plot (2^{nd} test)



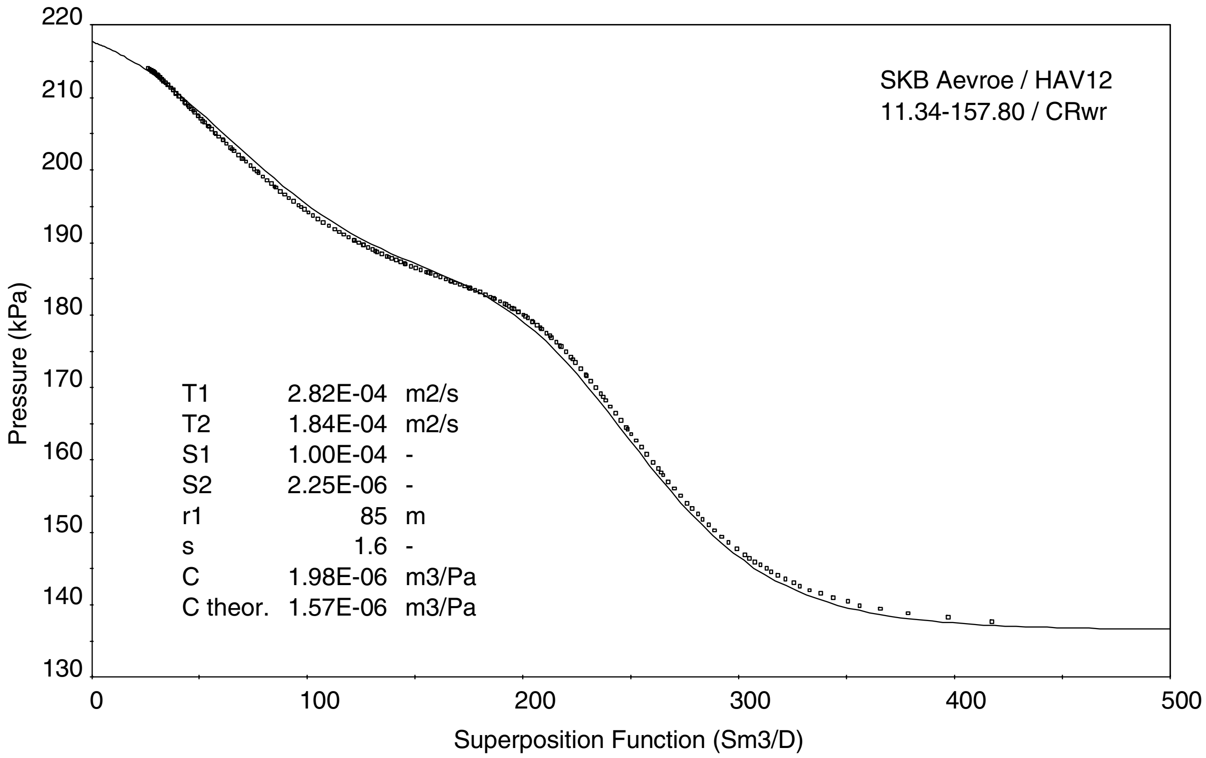
Pressure, temperature and conductivity vs. time; cartesian plot (2^{nd} test)



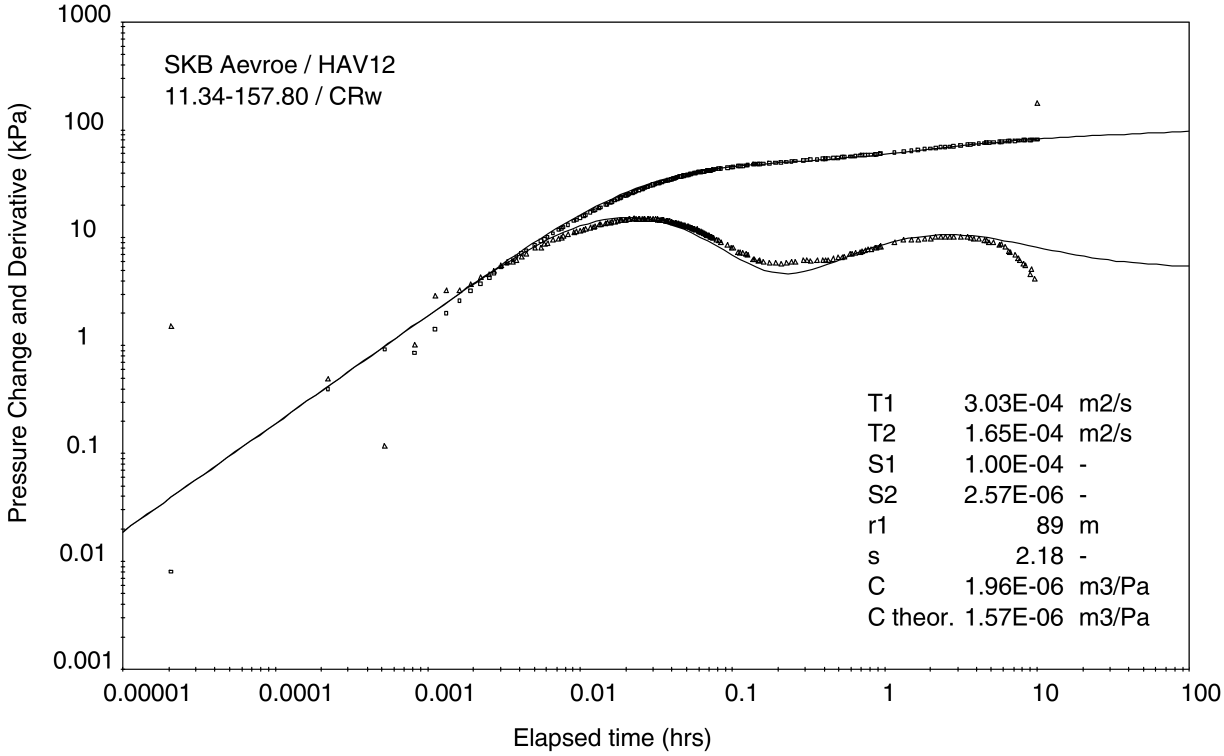
CRw phase; log-log match (1st test)



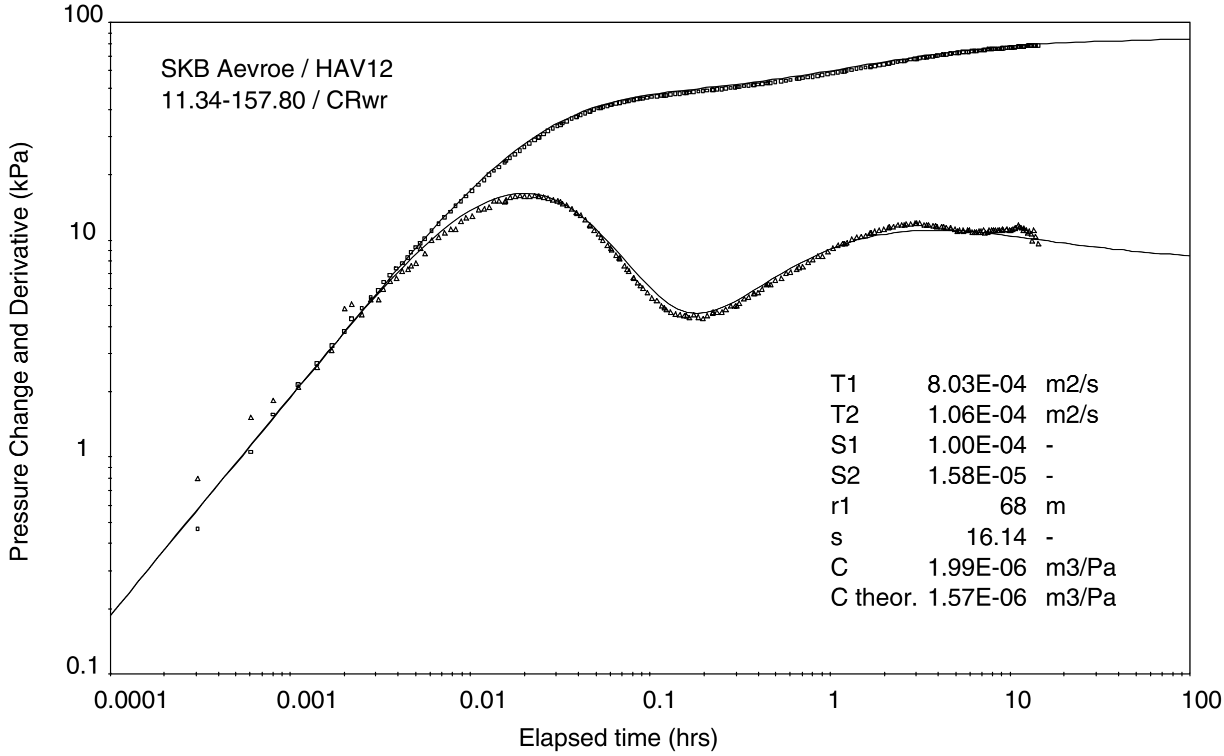
CRwr phase; log-log match (1st test)



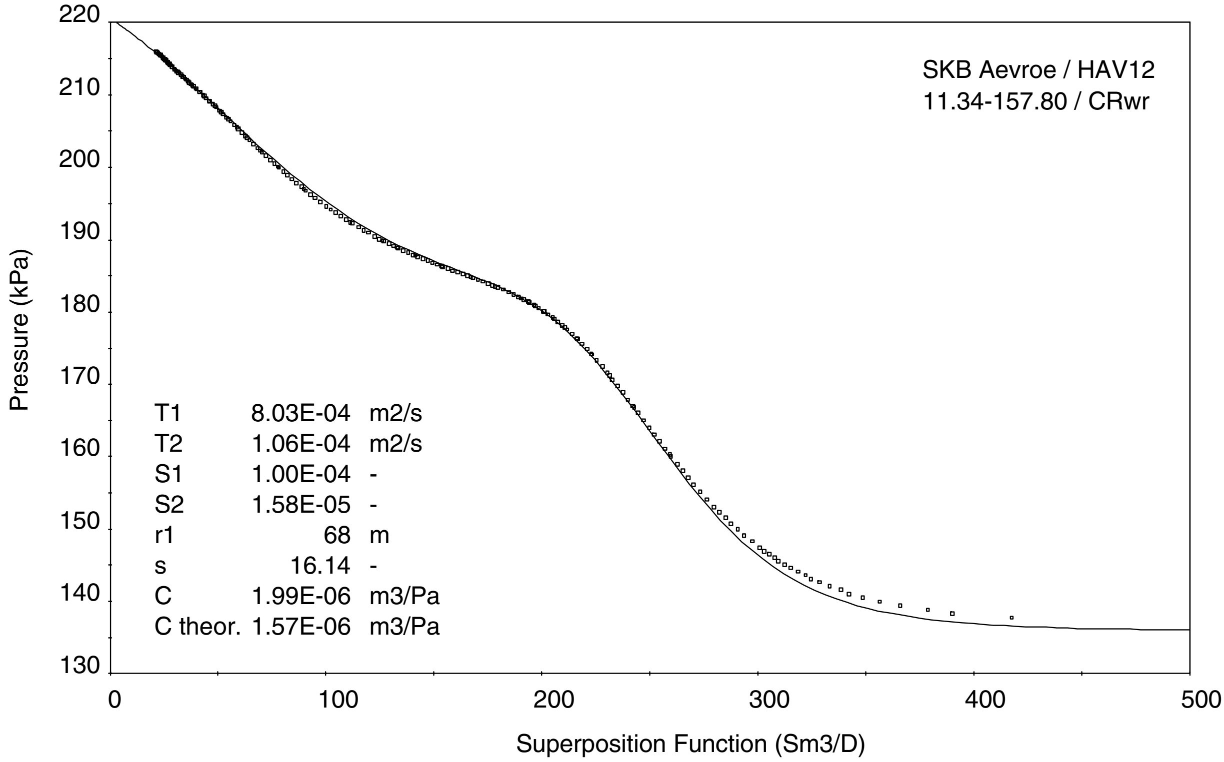
CRwr phase; HORNER match (1st test)



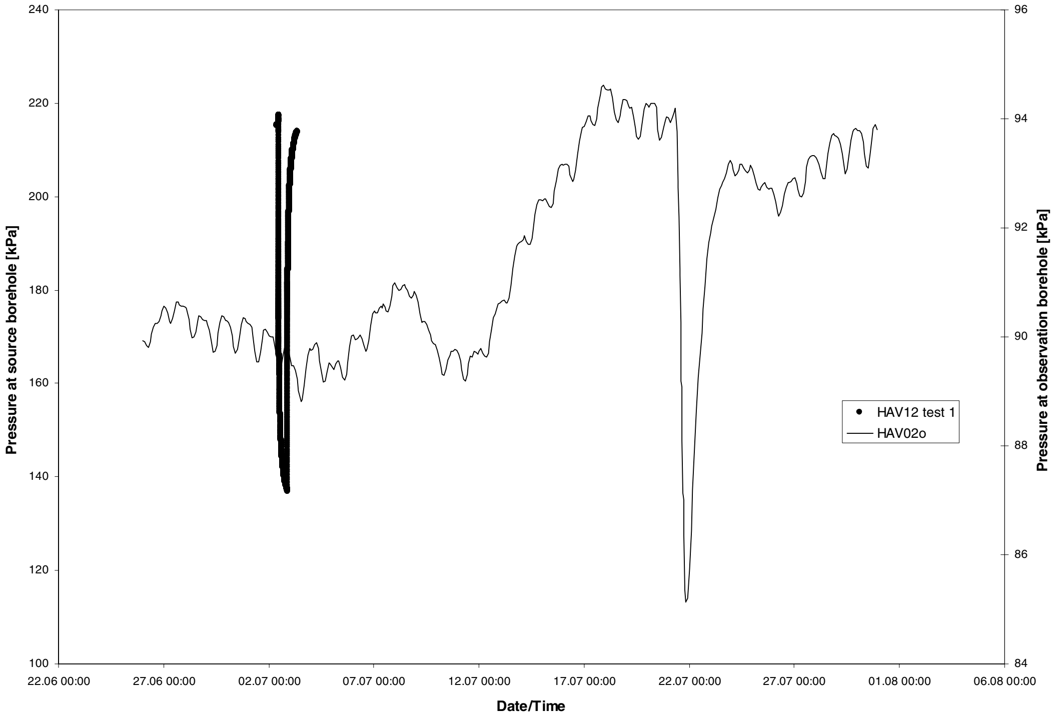
CRw phase; log-log match (2nd test)



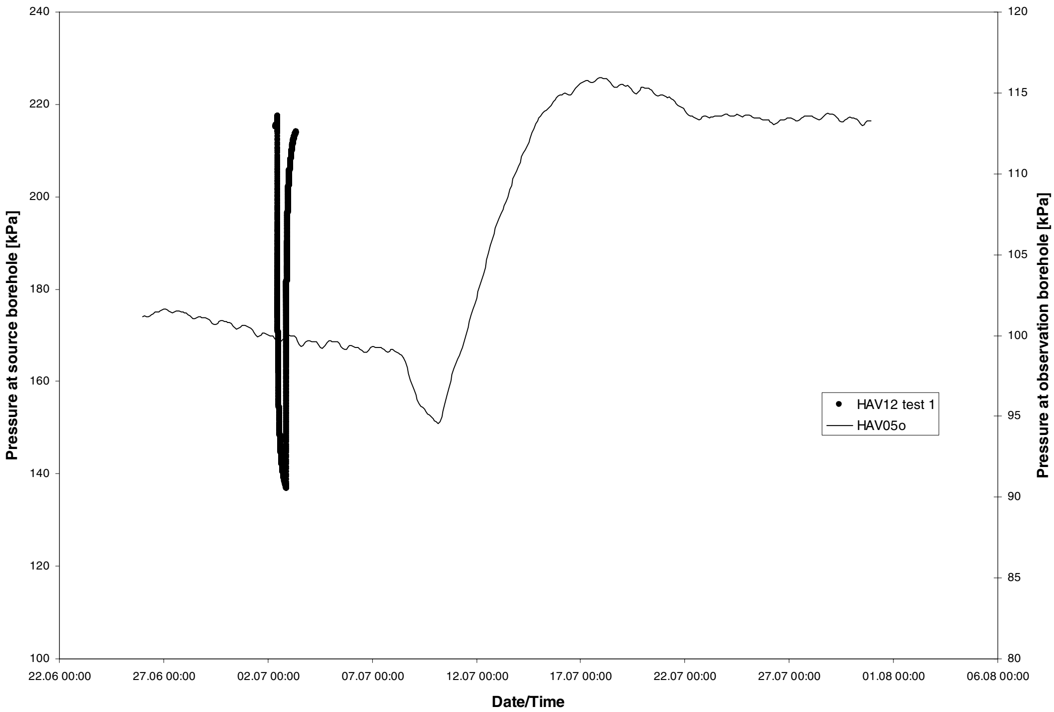
CRwr phase; log-log match (2nd test)



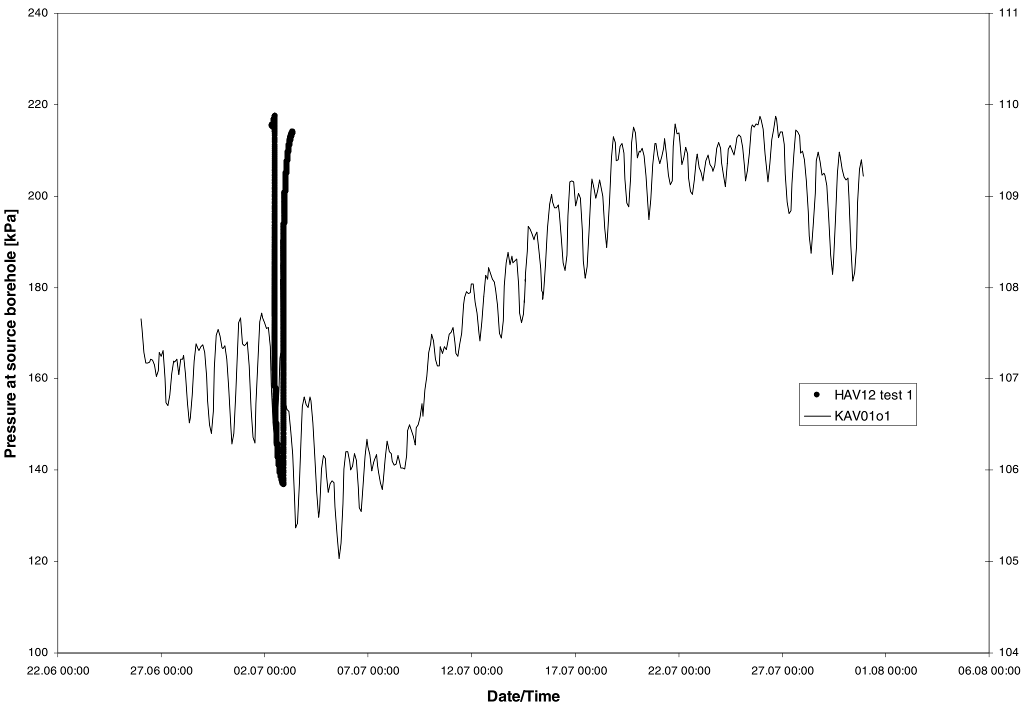
CRwr phase; HORNER match (2nd test)



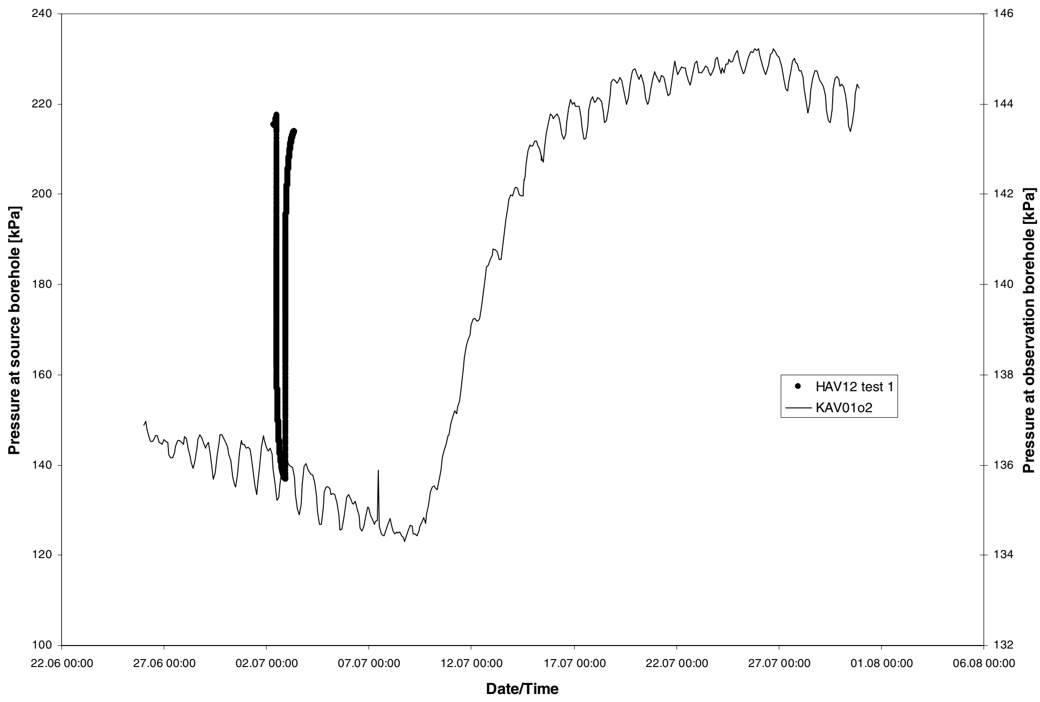
Pressure vs. time; HAV12 pumped and HAV02 observed



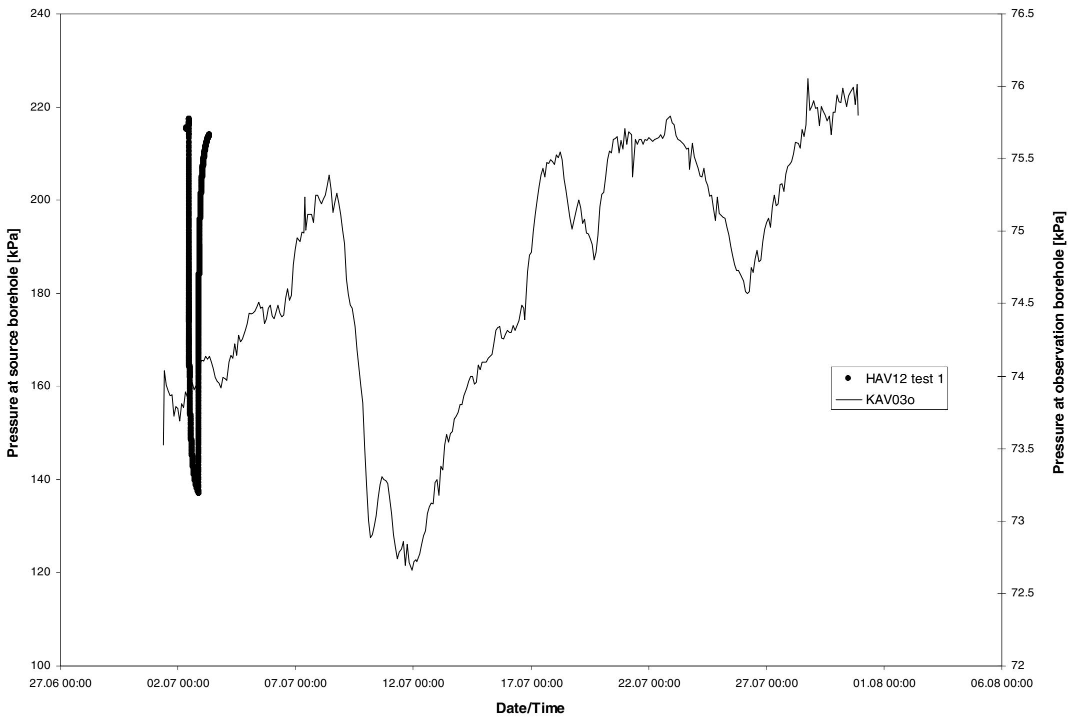
Pressure vs. time; HAV12 pumped and HAV05 observed



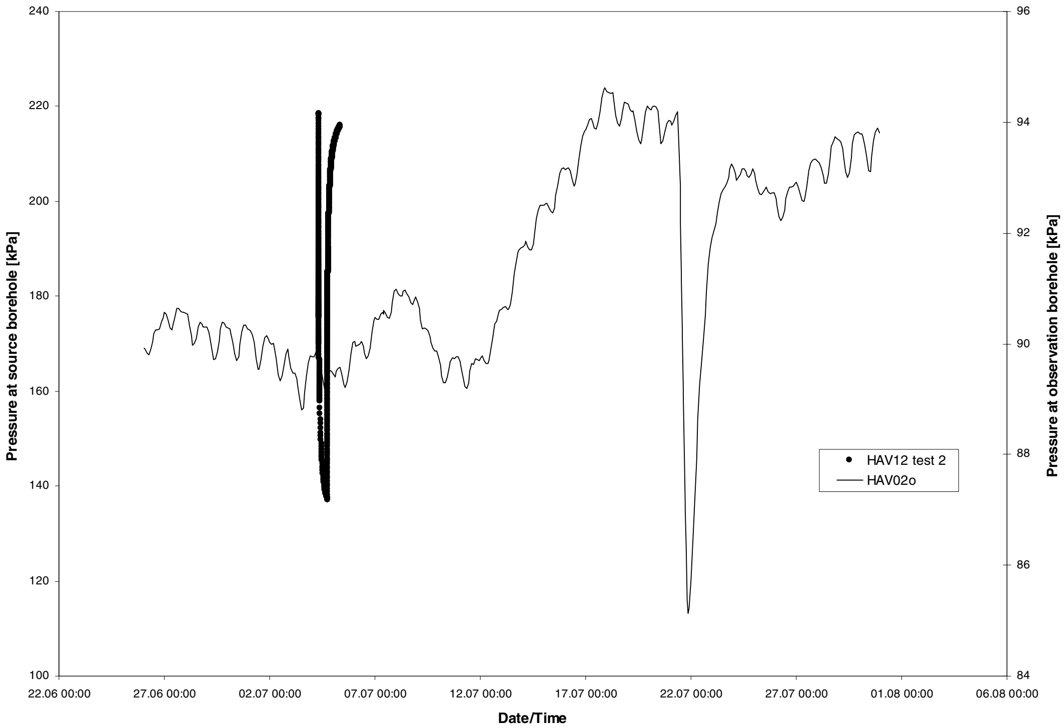
Pressure vs. time; HAV12 pumped and KAV01o1 observed



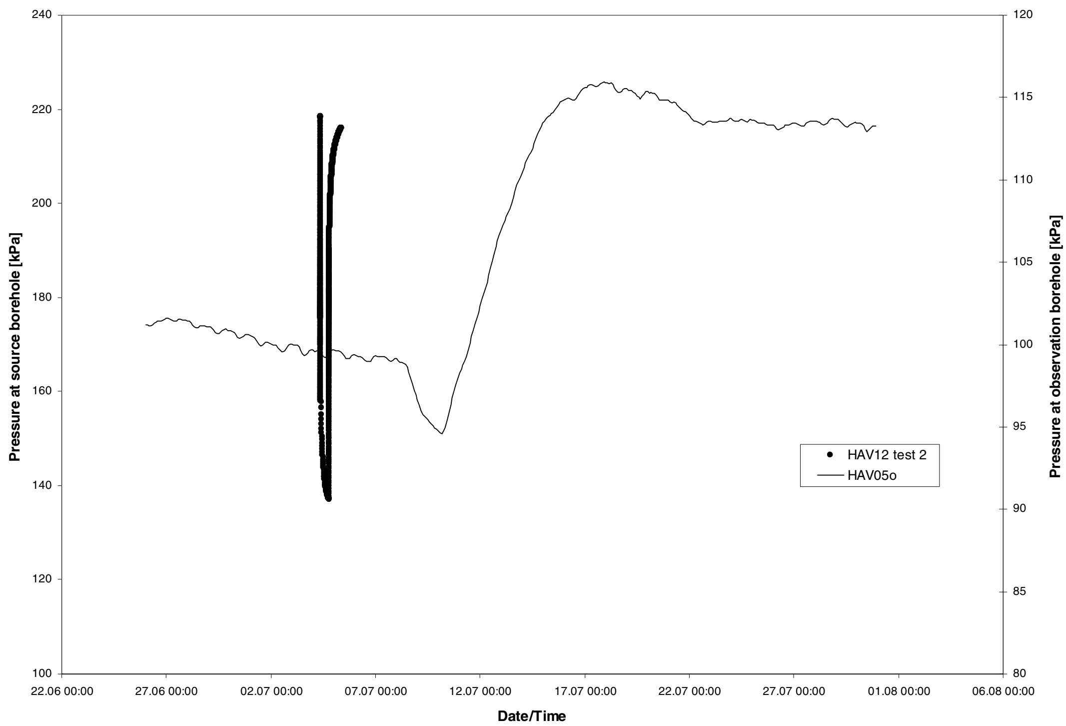
Pressure vs. time; HAV12 pumped and KAV01o2 observed



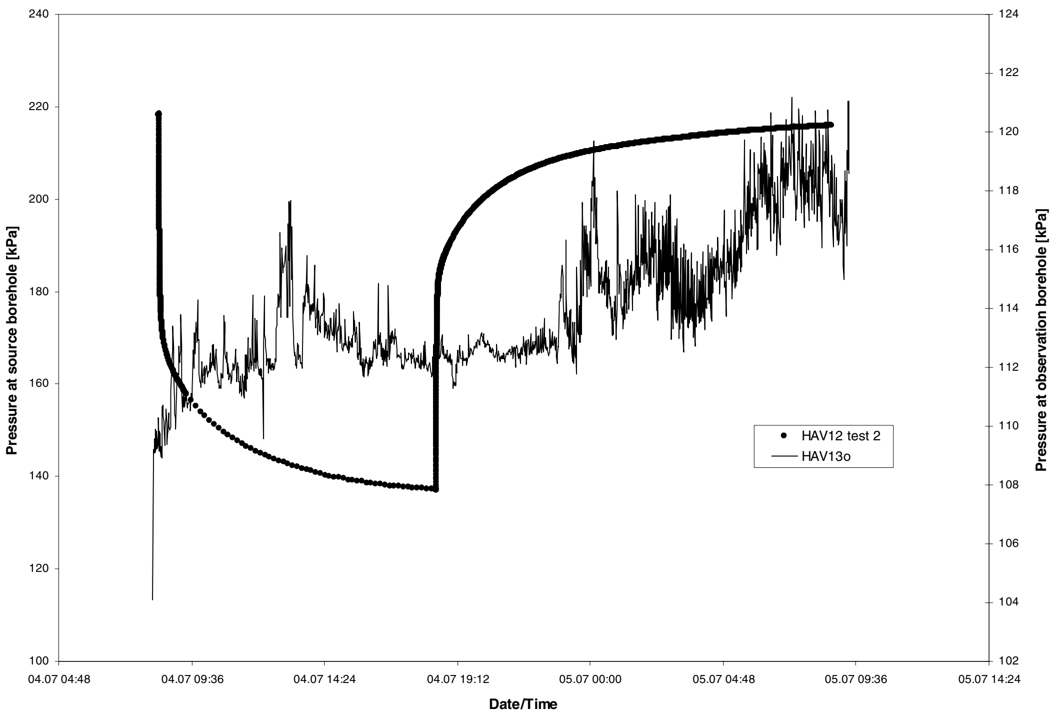
Pressure vs. time; HAV12 pumped and KAV03 observed



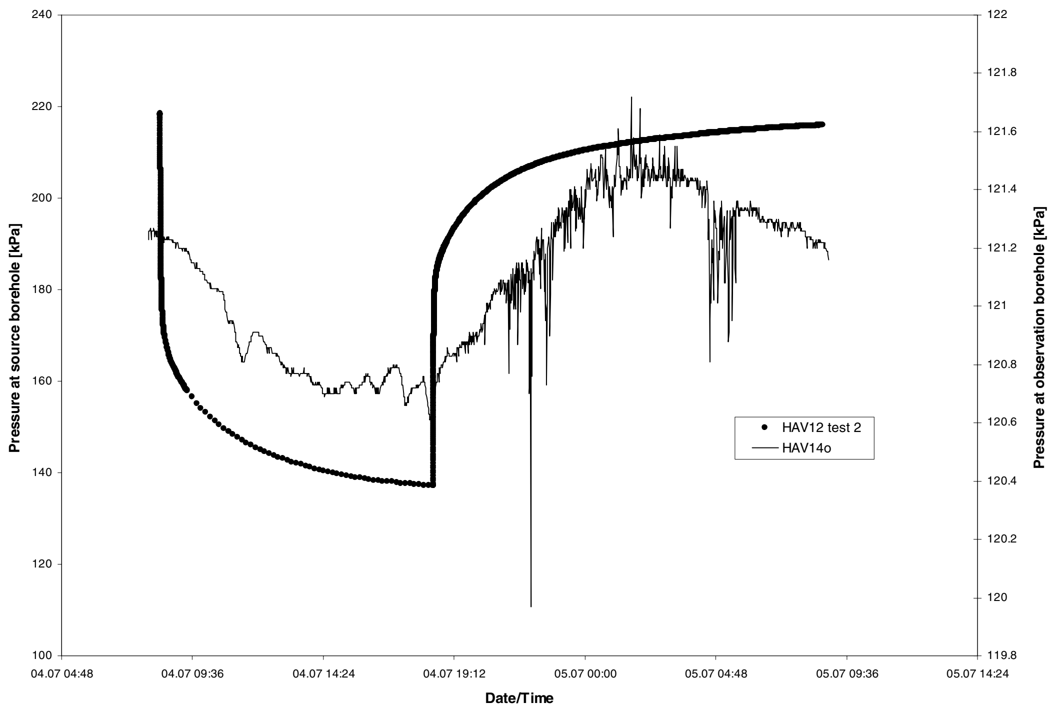
Pressure vs. time; HAV12 pumped and HAV02 observed



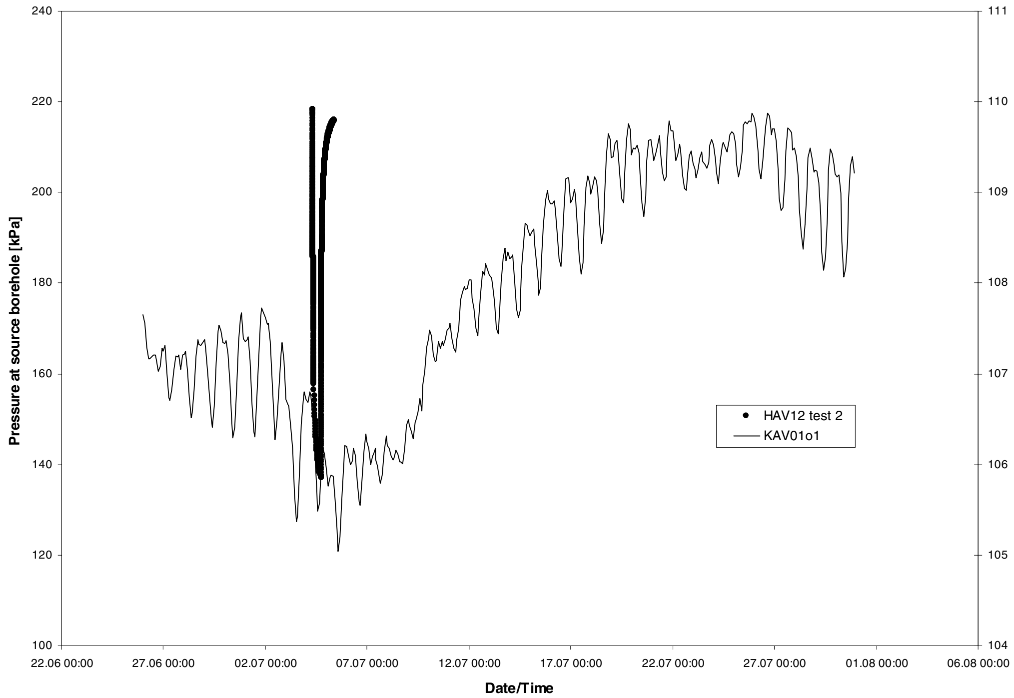
Pressure vs. time; HAV12 pumped and HAV05 observed



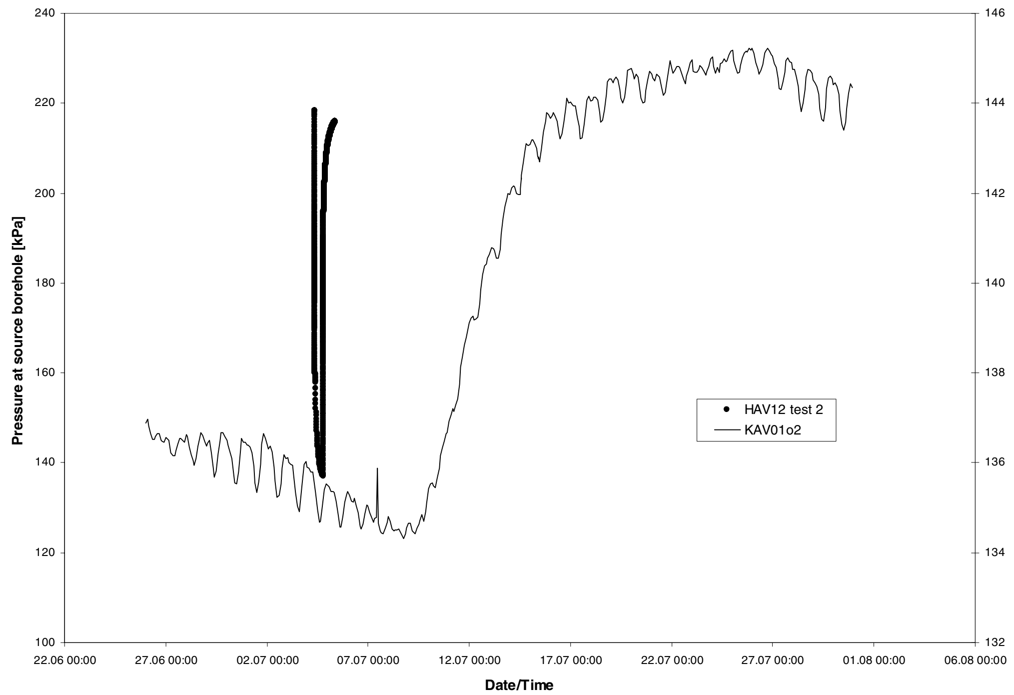
Pressure vs. time; HAV12 pumped and HAV13 observed



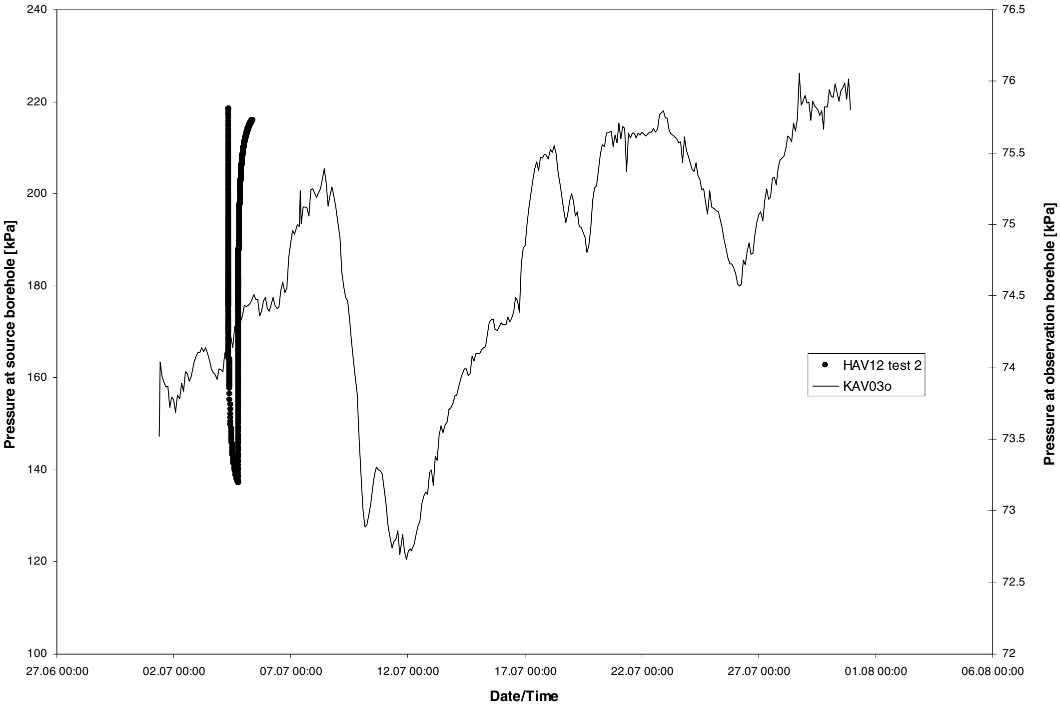
Pressure vs. time; HAV12 pumped and HAV14 observed



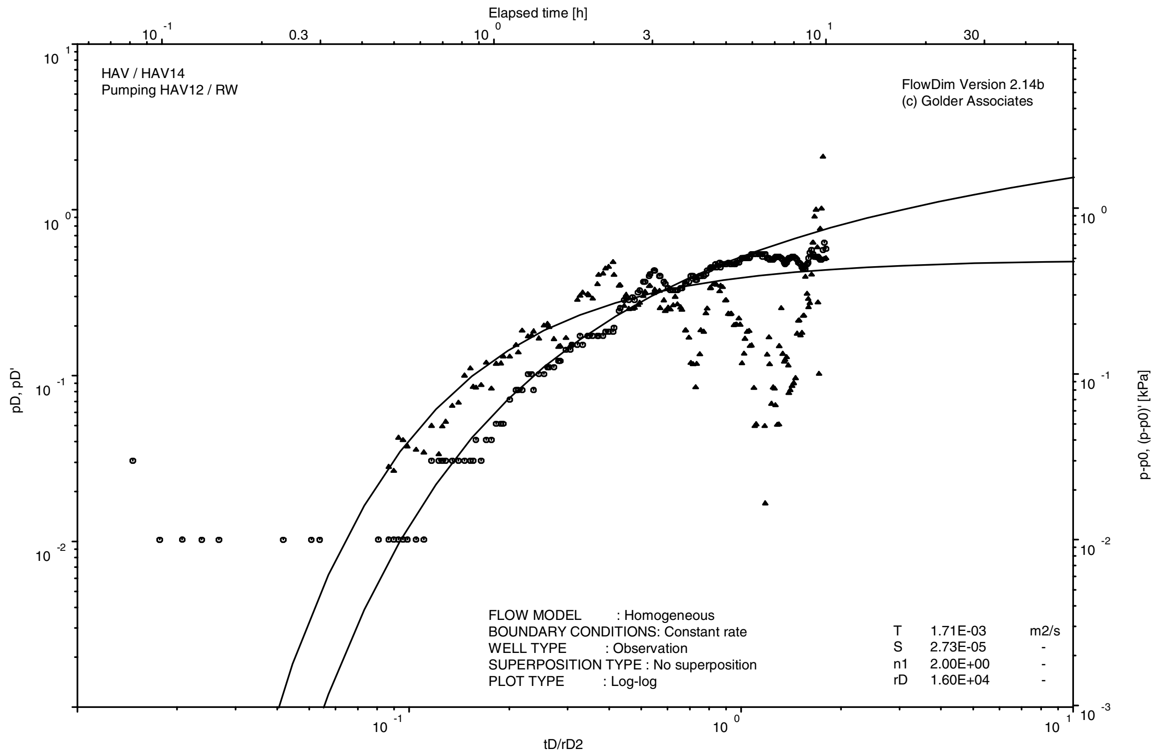
Pressure vs. time; HAV12 pumped and KAV01o1 observed



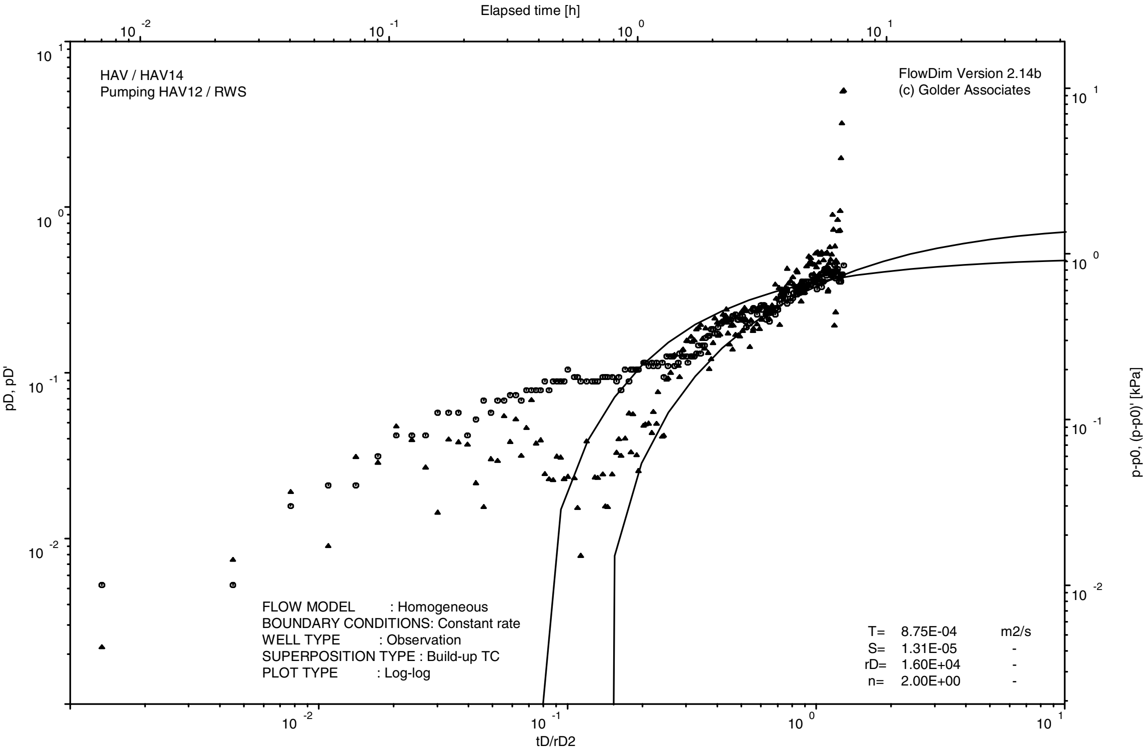
Pressure vs. time; HAV12 pumped and KAV01o2 observed



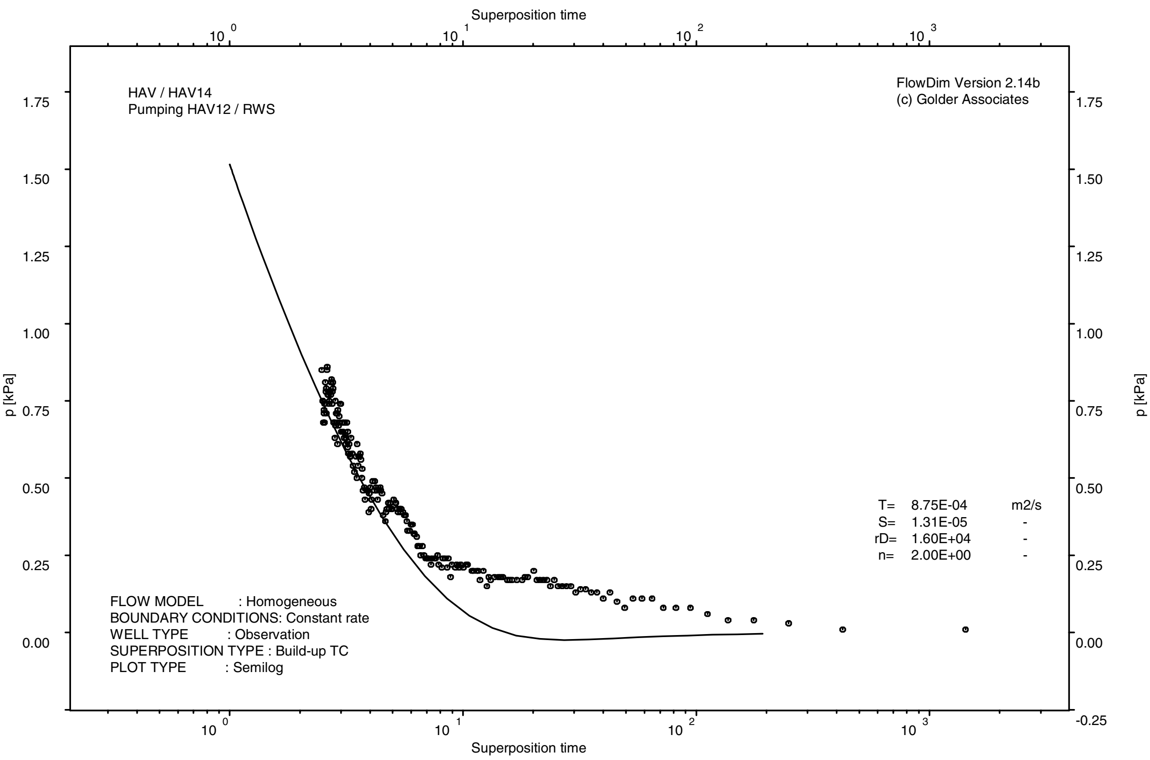
Pressure vs. time; HAV12 pumped and KAV03 observed



CRw phase; log-log match; HAV14 observed by HAV12 pumped (2nd test)



CRwr phase; log-log match; HAV14 observed by HAV12 recovered (2nd test)

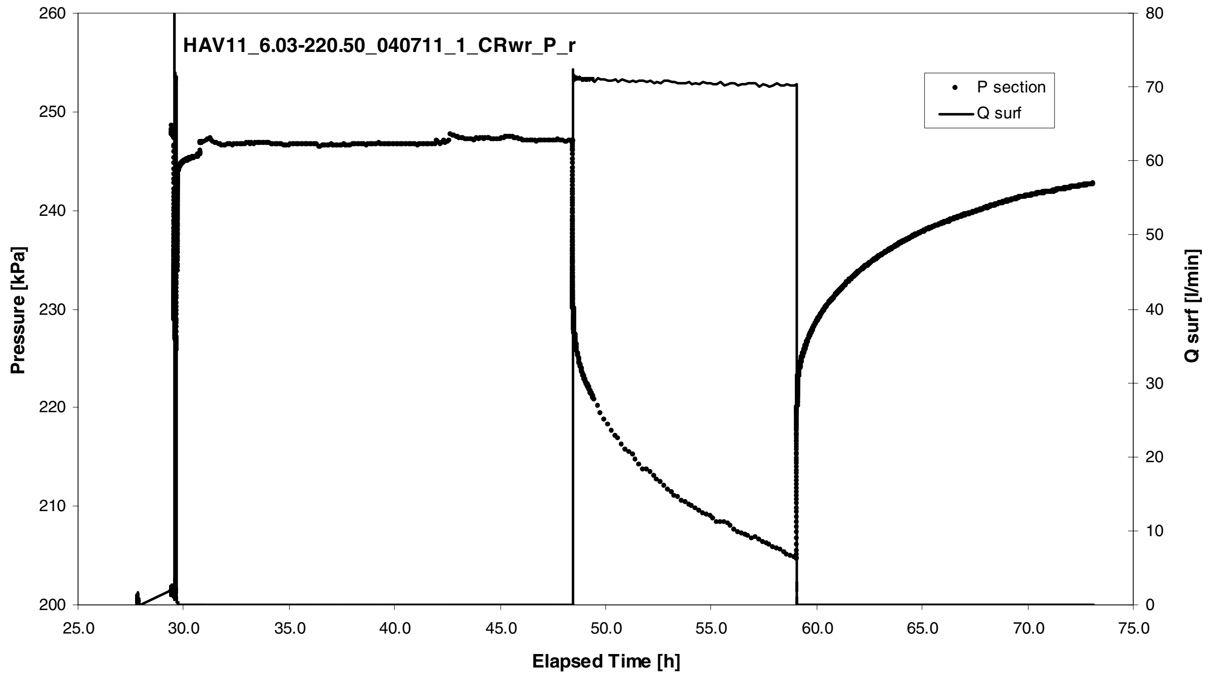


CRwr phase; HORNER match; HAV14 observed by HAV12 recovered (2nd test)

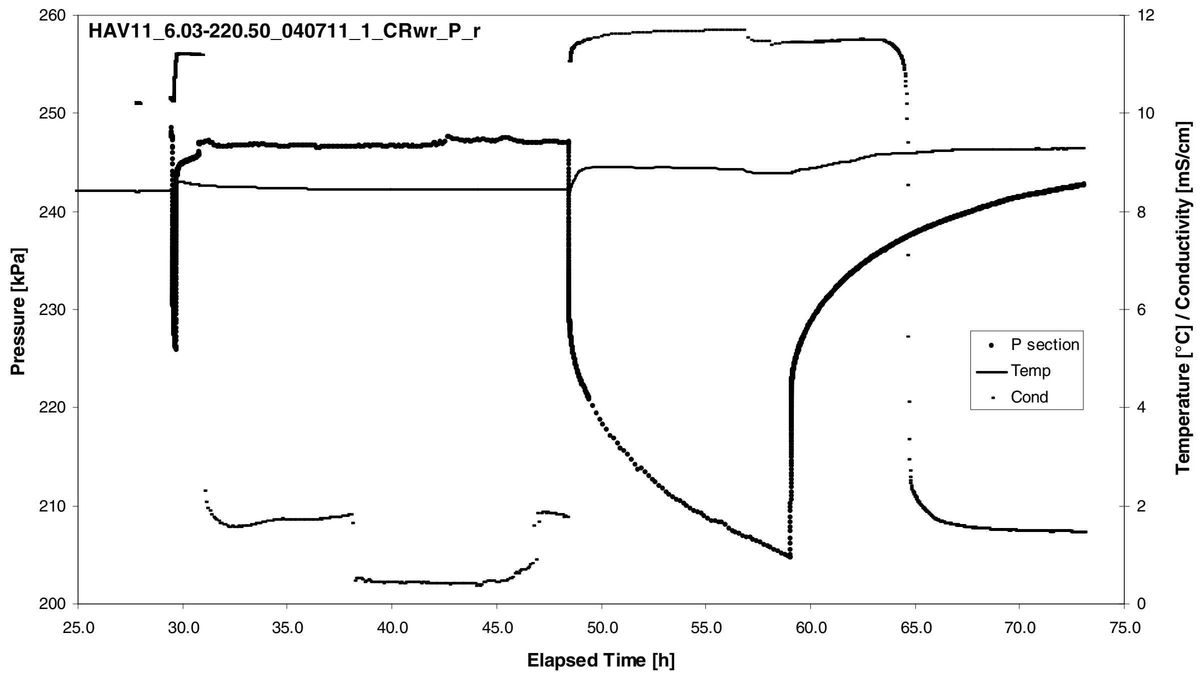
APPENDIX 2-3

HAV11

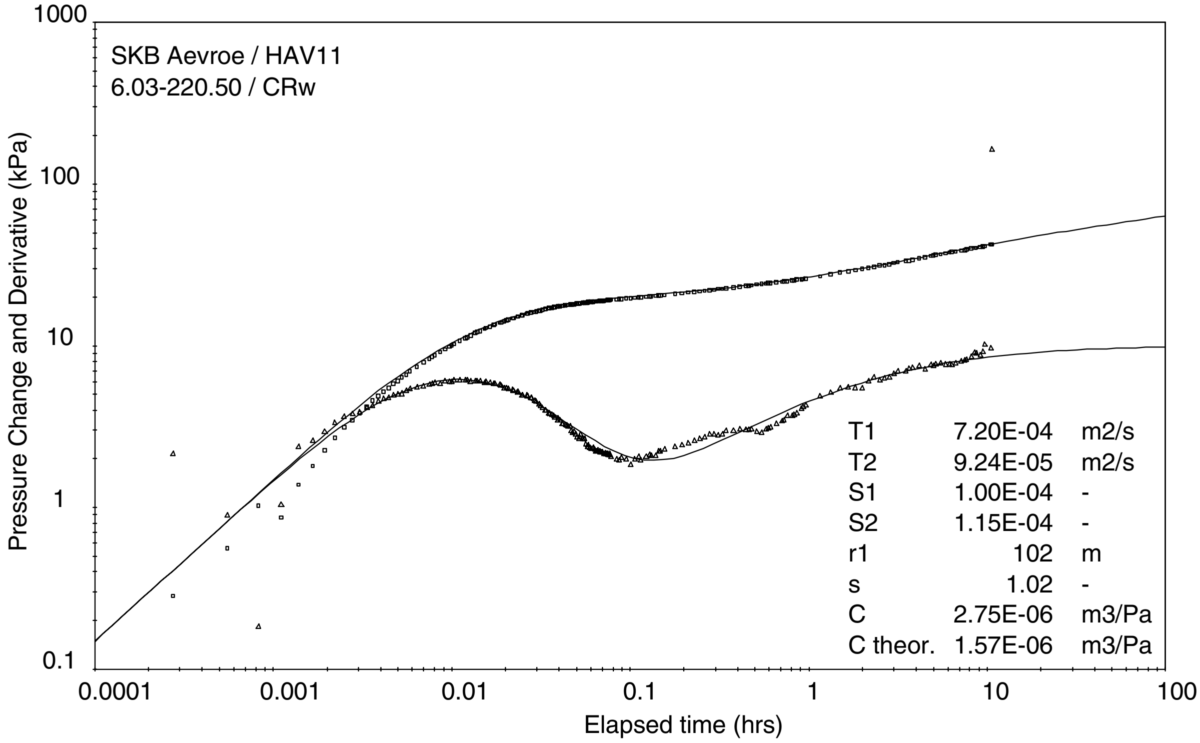
Pump Test Analysis diagrams



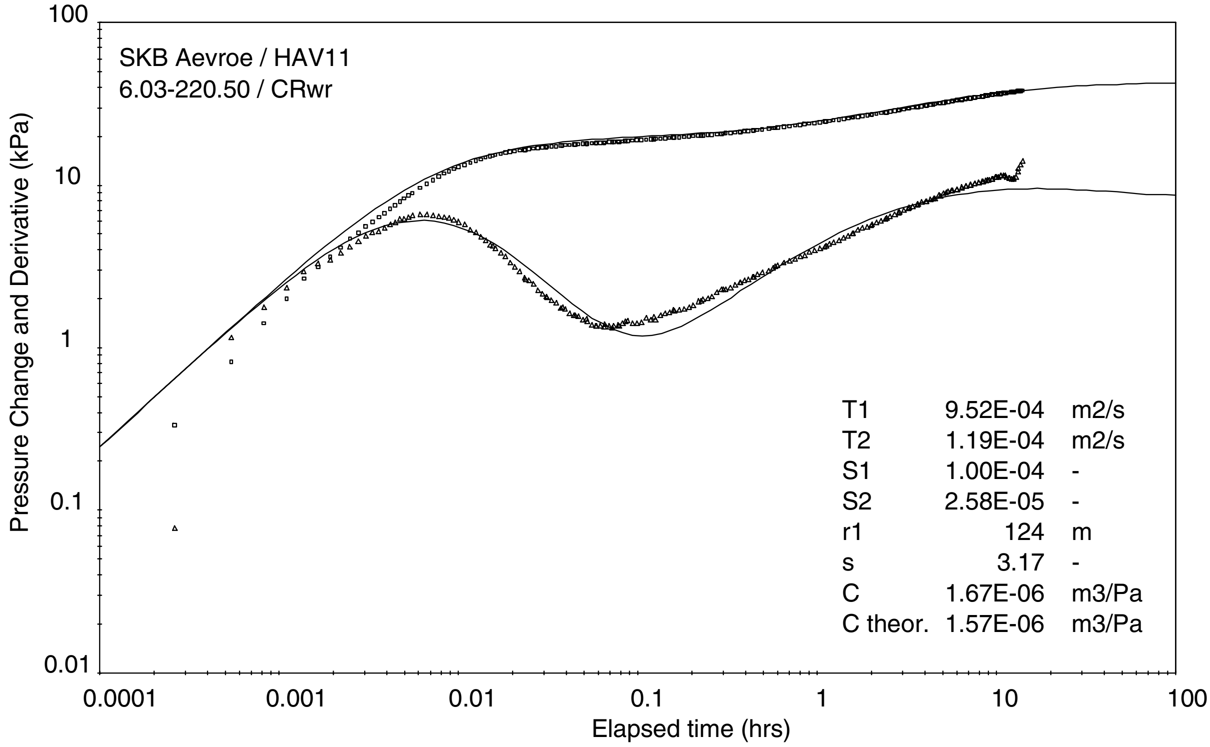
Pressure and flow rate vs. time; cartesian plot



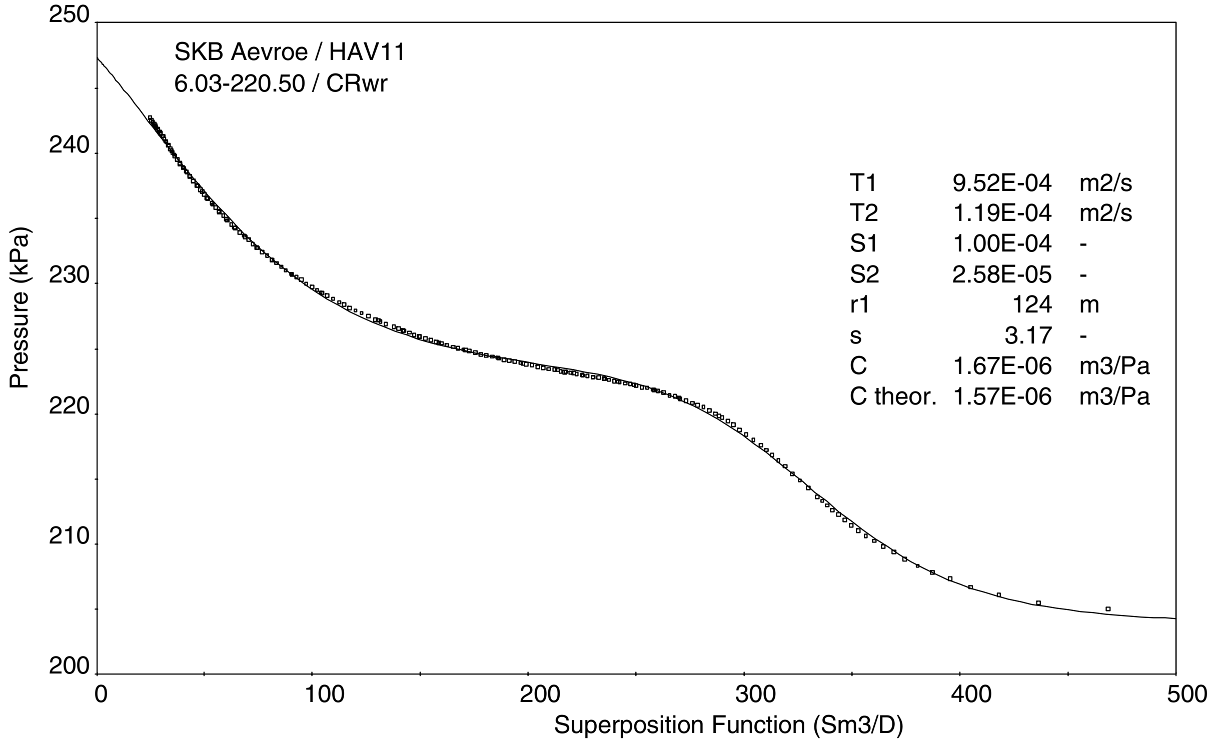
Pressure, temperature and conductivity vs. time; cartesian plot



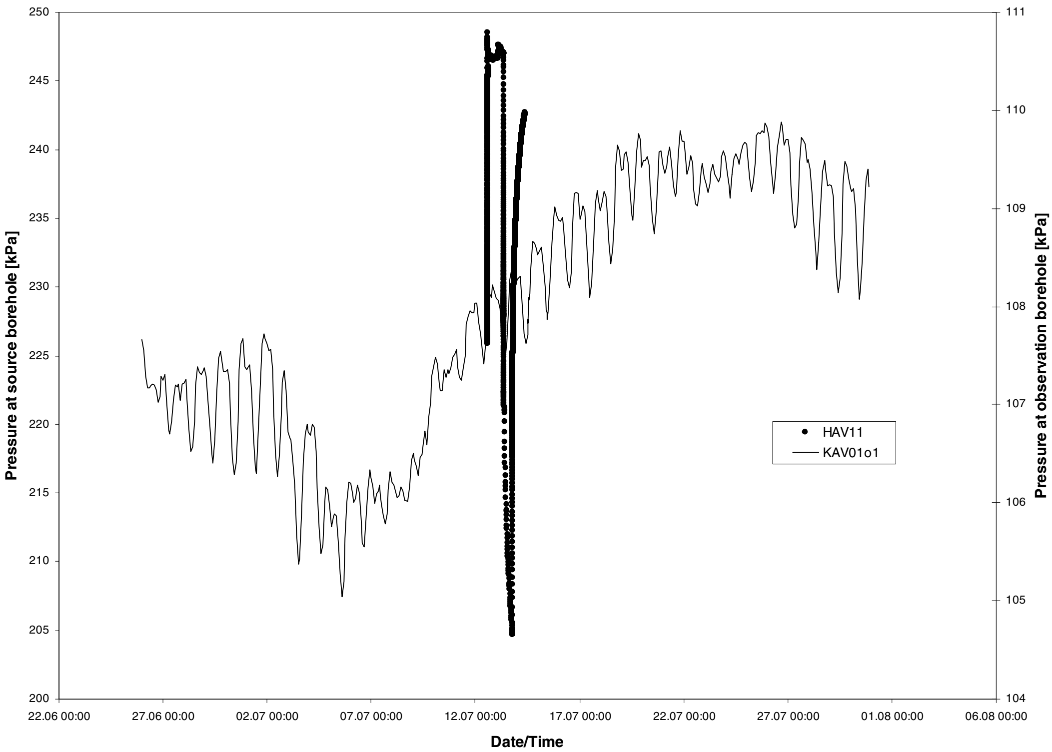
CRw phase; log-log match



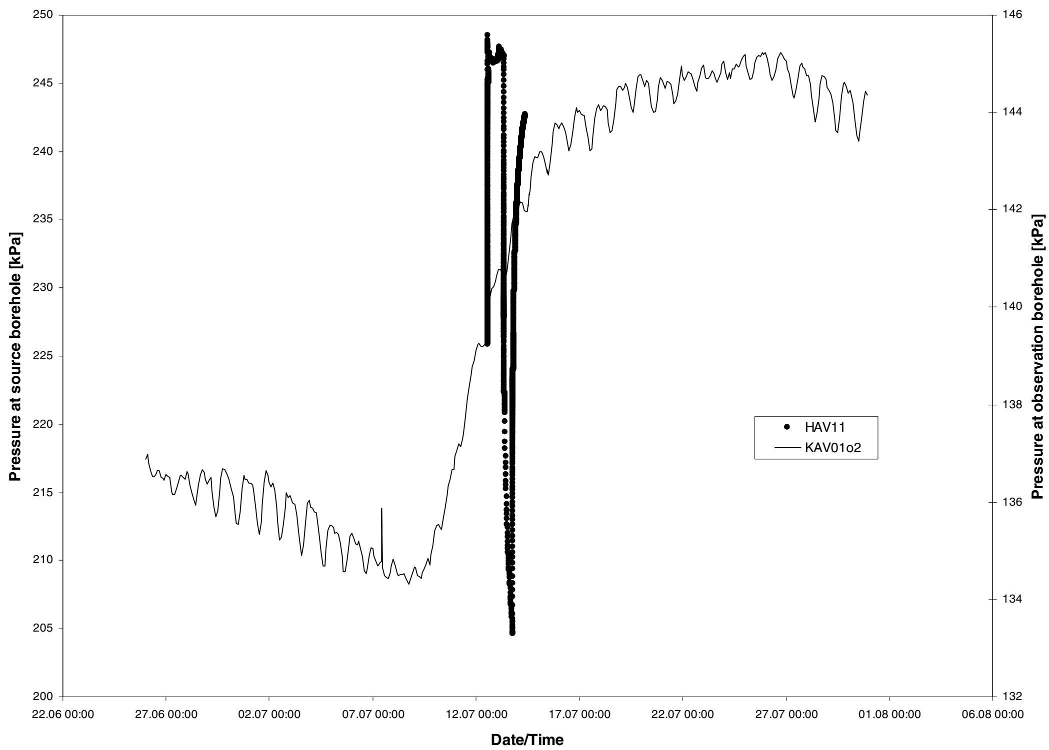
CRwr phase; log-log match



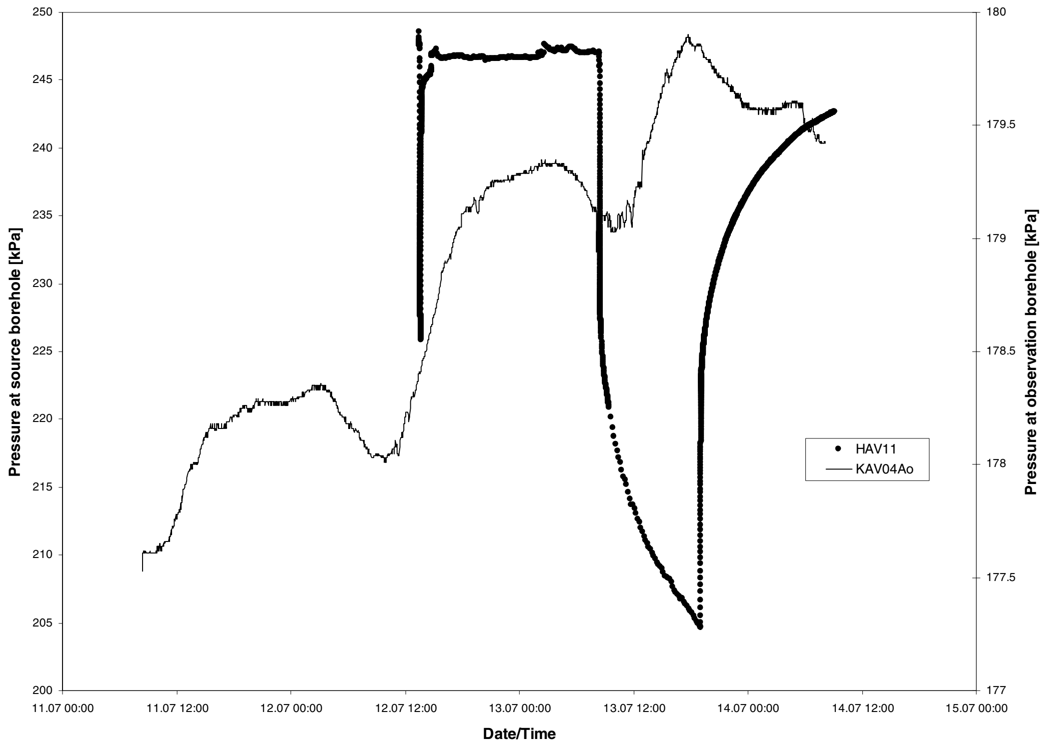
CRwr phase; HORNER match



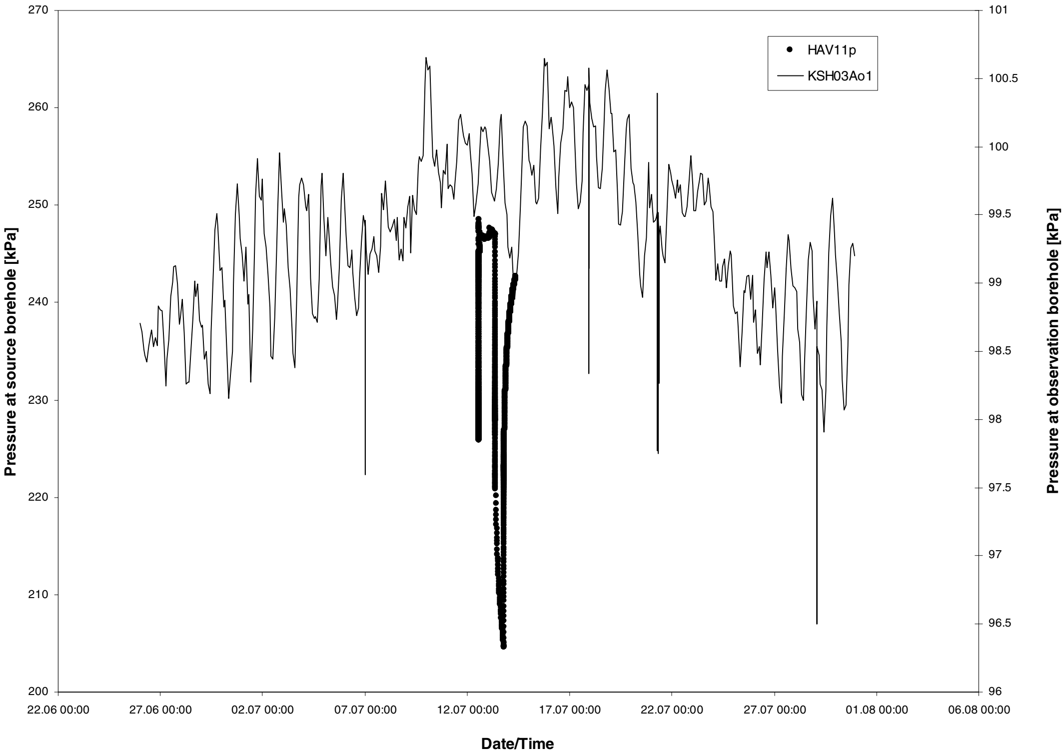
Pressure vs. time; HAV11 pumped and KAV01o1 observed



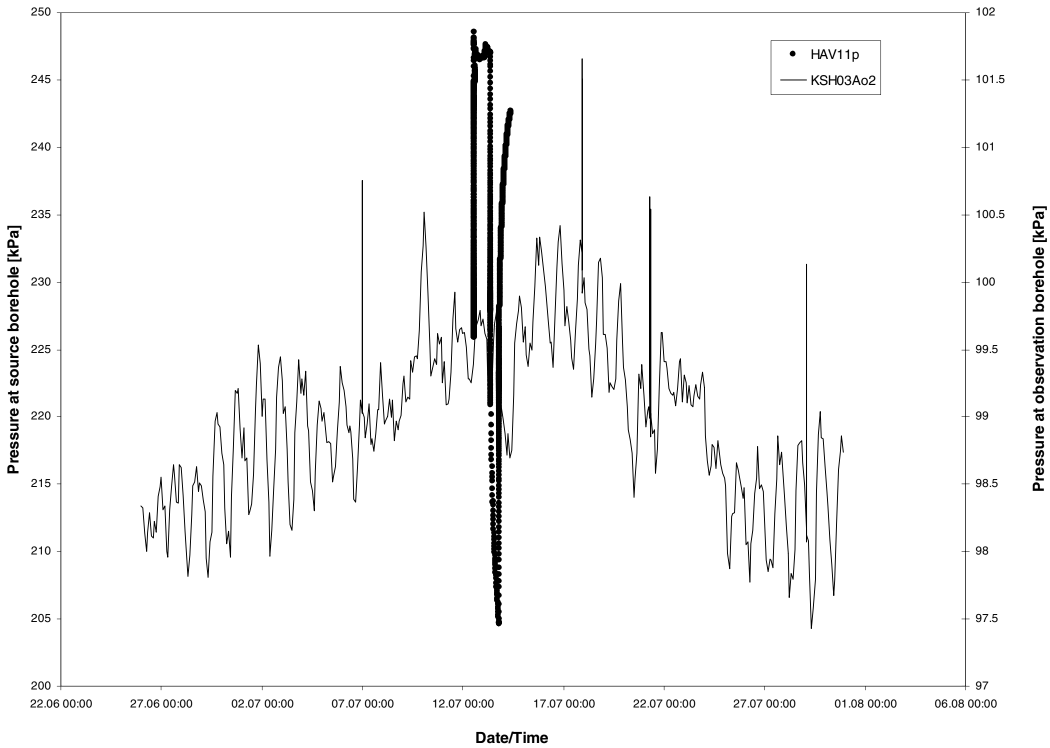
Pressure vs. time; HAV11 pumped and KAV01o2 observed



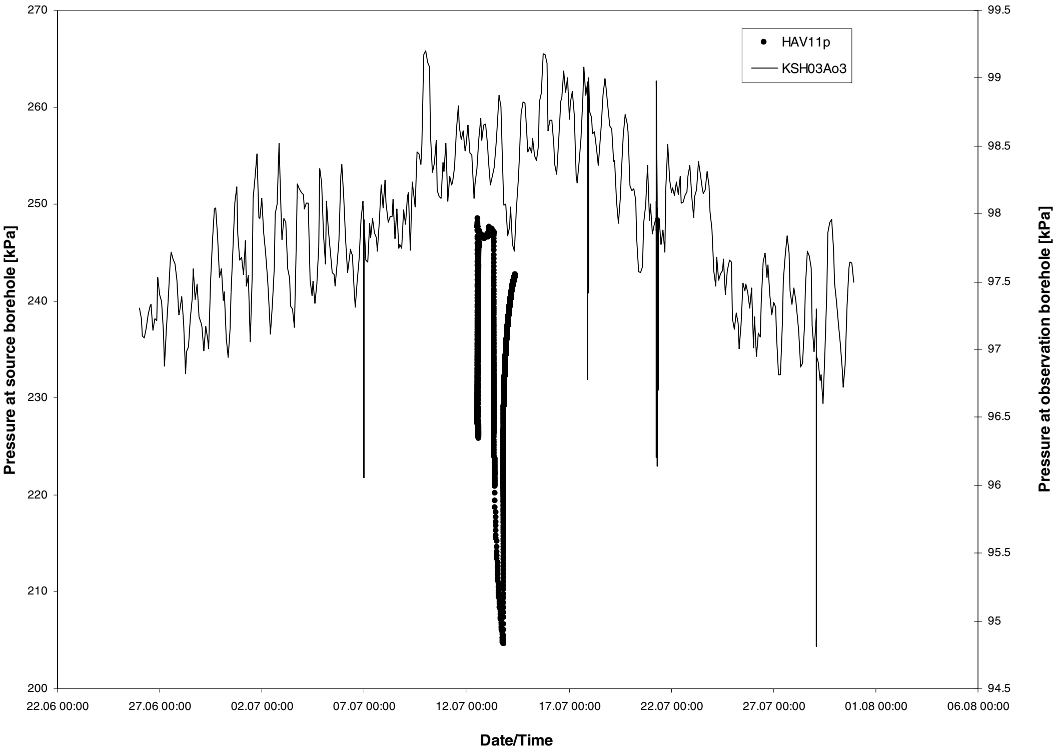
Pressure vs. time; HAV11 pumped and KAV04A observed



Pressure vs. time; HAV11 pumped and KSH03Ao1 observed



Pressure vs. time; HAV11 pumped and KSH03Ao2 observed



Pressure vs. time; HAV11 pumped and KSH03o3 observed

APPENDIX 3-1

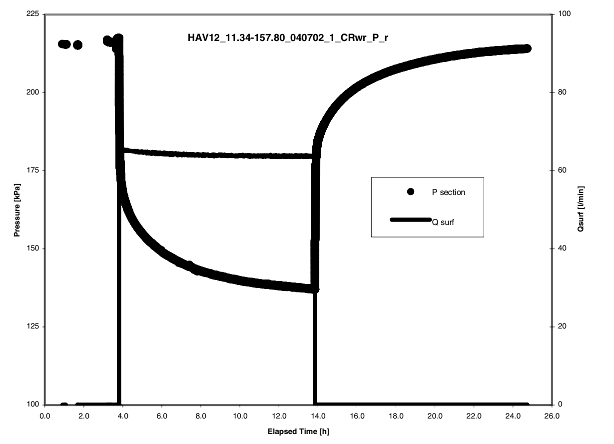
HAV12
HAV14o

Pump Test Summary Sheets

Test Summary Sheet

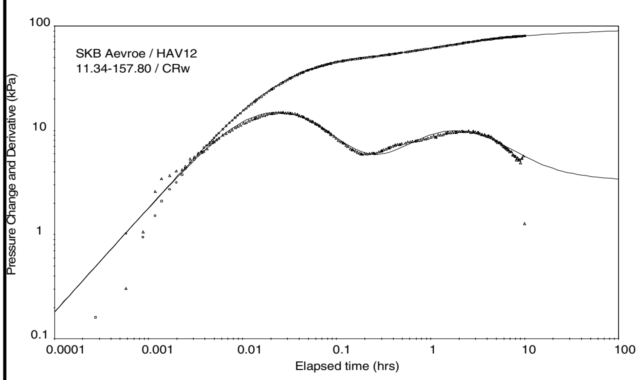
Project:	Oskarshamn site investigation	Test type:[1]	CRwr
Area:	Ävrö	Test no:	1
Borehole ID:	HAV12	Test start:	040702 08:33
Test section from - to (m):	11.34 - 157.80 m	Responsible for test execution:	Reinder van der Wall
Section diameter, $2 \cdot r_w$ (m):	0.14	Responsible for test evaluation:	C. Enachescu

Linear plot Q and p

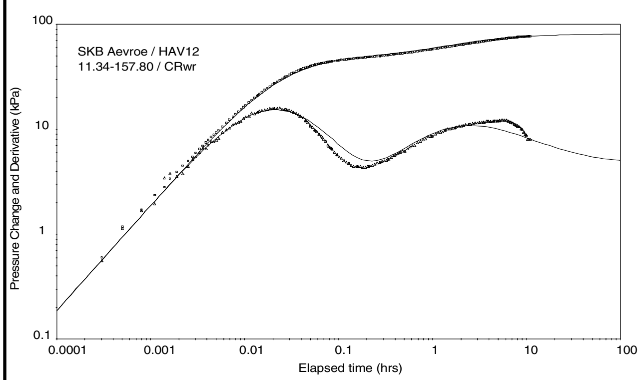


Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa) =	0		
p_i (kPa) =	215.9		
p_p(kPa) =	137.1	p_F (kPa) =	214.1
Q_p (m^3/s)=	1.06E-03		
tp (s) =	36180	t_F (s) =	39180
S^* (-)=	1.00E-04	S^* (-)=	1.00E-04
EC_w (mS/m)=	820.8		
$Temp_w$(gr C)=	8.34		
Derivative fact.=	0.08	Derivative fact.=	0.04
Results		**Results**	
Q/s (m^2/s)=	1.3E-04		
T_M (m^2/s)=	1.7E-04		
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	9.00	dt_1 (min) =	9.00
dt_2 (min) =	600.00	dt_2 (min) =	600.00
T (m^2/s) =	2.60E-04	T (m^2/s) =	1.84E-04
S (-) =	5.33E-07	S (-) =	2.25E-06
K_s (m/s) =	1.78E-06	K_s (m/s) =	1.26E-06
S_s (1/m) =	3.64E-09	S_s (1/m) =	1.54E-08
C (m^3/Pa) =	2.04E-06	C (m^3/Pa) =	1.98E-06
C_D (-) =	1.24E+02	C_D (-) =	2.86E+01
ξ (-) =	-0.41	ξ (-) =	1.6
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) =	9	C (m^3/Pa) =	1.98E-06
dt_2 (min) =	600	C_D (-) =	2.86E+01
T_T (m^2/s) =	2.82E-04	ξ (-) =	1.6
S (-) =	2.25E-06		
K_s (m/s) =	1.93E-06		
S_s (1/m) =	1.54E-08		

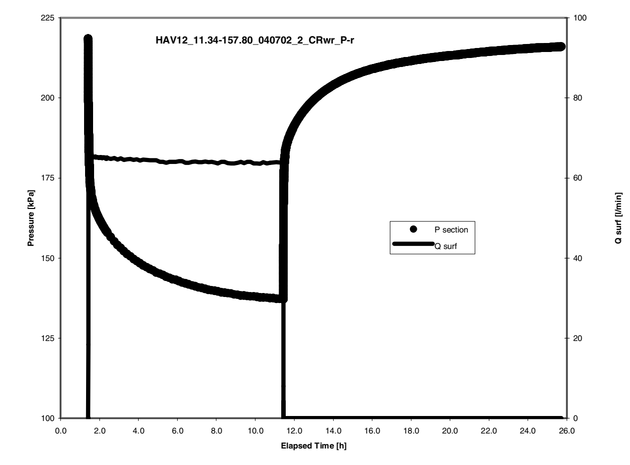
Comments:

The recommended transmissivity of 2.82E-4 m2/s was derived from the analysis of the CRr phase (inner zone), which shows a good data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 1.0E-4 to 3.0E-4 m2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CRr phase using straight line extrapolation in the Horner plot to a value of 217 kPa.

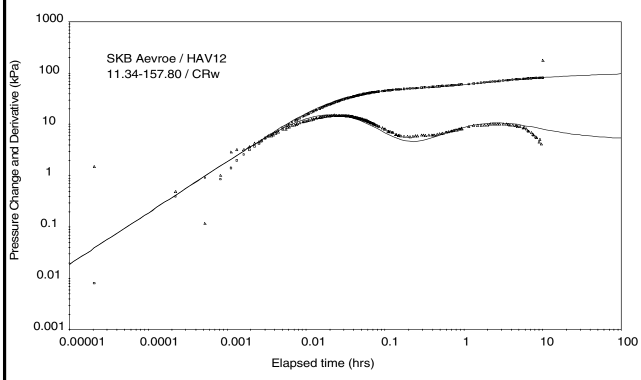
Test Summary Sheet

Project:	Oskarshamn site investigation	Test type:[1]	CRwr
Area:	Ävrö	Test no:	2
Borehole ID:	HAV12	Test start:	040704 08:08
Test section from - to (m):	11.34 - 157.80 m	Responsible for test execution:	Reinder van der Wall
Section diameter, $2 \cdot r_w$ (m):	0.14	Responsible for test evaluation:	C. Enachescu

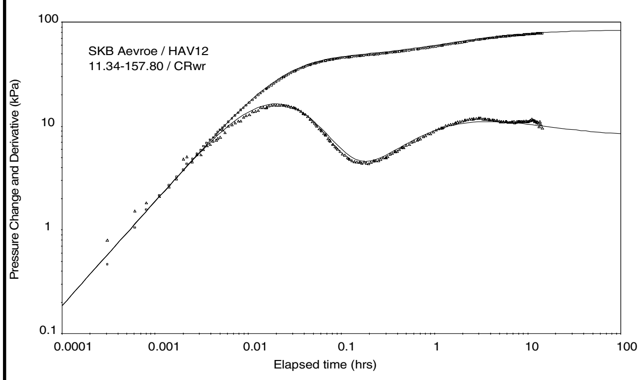
Linear plot Q and p



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa) =	0		
p_i (kPa) =	218.4		
p_p(kPa) =	137.3	p_F (kPa) =	215.9
Q_p (m^3/s)=	1.06E-03		
tp (s) =	36060	t_F (s) =	51540
S^* (-)=	1.00E-04	S^* (-)=	1.00E-04
EC_w (mS/m)=	817.7		
$Temp_w$(gr C)=	8.36		
Derivative fact.=	0.05	Derivative fact.=	0.04
Results		**Results**	
Q/s (m^2/s)=	1.3E-04		
T_M (m^2/s)=	1.7E-04		
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	12.00	dt_1 (min) =	12.00
dt_2 (min) =	600.00	dt_2 (min) =	600.00
T (m^2/s) =	1.65E-04	T (m^2/s) =	1.06E-04
S (-) =	2.57E-06	S (-) =	1.58E-05
K_s (m/s) =	1.13E-06	K_s (m/s) =	7.24E-07
S_s (1/m) =	1.75E-08	S_s (1/m) =	1.08E-07
C (m^3/Pa) =	1.96E-06	C (m^3/Pa) =	1.99E-06
C_D (-) =	2.48E+01	C_D (-) =	4.09E+00
ξ (-) =	2.18	ξ (-) =	16.14
T_{GRF}(m^2/s) =		T_{GRF}(m^2/s) =	
S_{GRF}(-) =		S_{GRF}(-) =	
D_{GRF} (-) =		D_{GRF} (-) =	

Selected representative parameters.

dt_1 (min) =	12	C (m^3/Pa) =	1.99E-06
dt_2 (min) =	600	C_D (-) =	4.09E+00
T_T (m^2/s) =	8.03E-04	ξ (-) =	16.14
S (-) =	1.58E-05		
K_s (m/s) =	5.48E-06		
S_s (1/m) =	1.08E-07		

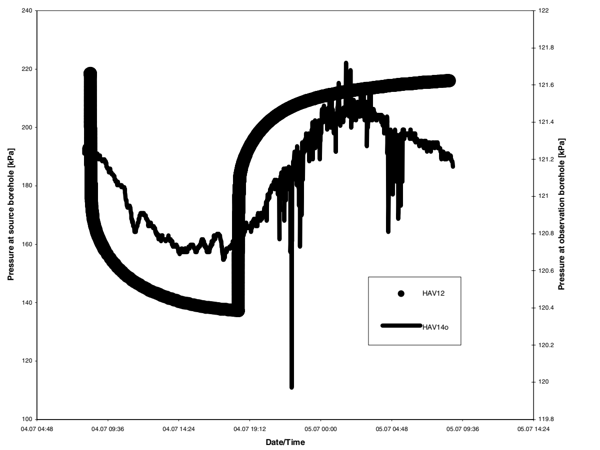
Comments:

The recommended transmissivity of 8.03E-4 m2/s was derived from the analysis of the CRr phase, which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 1.0E-4to 1.0E-3 m2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CRr phase using straight line extrapolation in the Horner plot to a value of 221 kPa.

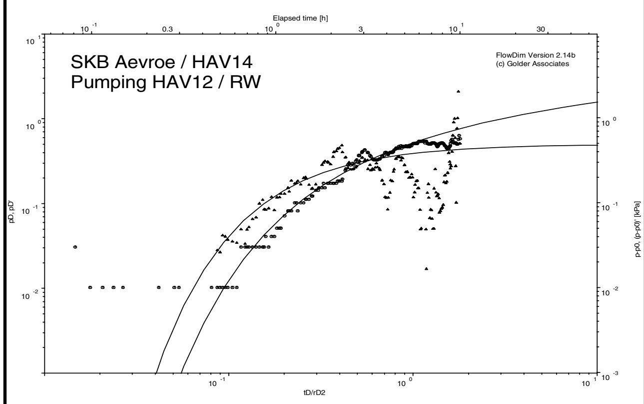
Test Summary Sheet

Project:	Oskarshamn site investigation	Test type:[1]	CRwr
Area:	Ävrö	Test no:	2
Borehole ID:	HAV14o	Test start:	040704 08:08
Test section from - to (m):	6.03 - 182.40 m	Responsible for test execution:	Reinder van der Wall
Section diameter, $2 \cdot r_w$ (m):	0.14	Responsible for test evaluation:	C. Enachescu

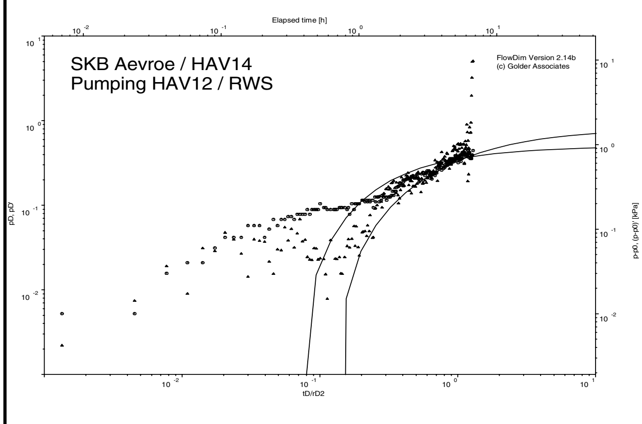
Linear plot Q and p



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa) =	0		
p_i (kPa) =	121.27		
p_p(kPa) =	120.61	p_F (kPa) =	121.48
Q_p (m^3/s)=	1.06E-03		
tp (s) =	36060	t_F (s) =	51540
S^* (-)=	1.00E-04	S^* (-)=	1.00E-04
EC_w (mS/m)=			
$Temp_w$(gr C)=			
Derivative fact.=	0.14	Derivative fact.=	0.12
Results		**Results**	
Q/s (m^2/s)=			
T_M (m^2/s)=			
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	30.00	dt_1 (min) =	60.00
dt_2 (min) =	300.00	dt_2 (min) =	480.00
T (m^2/s) =	1.71E-03	T (m^2/s) =	8.75E-04
S (-) =	2.73E-05	S (-) =	1.31E-05
K_s (m/s) =	9.70E-06	K_s (m/s) =	4.96E-06
S_s (1/m) =	1.55E-07	S_s (1/m) =	7.43E-08
C (m^3/Pa) =	2.00E-06	C (m^3/Pa) =	2.00E-06
C_D (-) =	2.38E+00	C_D (-) =	4.96E+00
ξ (-) =	0.65	ξ (-) =	1.02
T_{GRF}(m^2/s) =		T_{GRF}(m^2/s) =	
S_{GRF}(-) =		S_{GRF}(-) =	
D_{GRF} (-) =		D_{GRF} (-) =	

Selected representative parameters.

dt_1 (min) =	60	C (m^3/Pa) =	2.00E-06
dt_2 (min) =	480	C_D (-) =	4.96E+00
T_T (m^2/s) =	8.75E-04	ξ (-) =	1.02
S (-) =	1.31E-05		
K_s (m/s) =	4.96E-06		
S_s (1/m) =	7.43E-08		

Comments:

The recommended transmissivity of 8.75E-4 m2/s was derived from the analysis of the CRr phase, which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 6.0E-4to 3.0E-3 m2/s. The flow dimension displayed during the test is 2.

APPENDIX 3-2

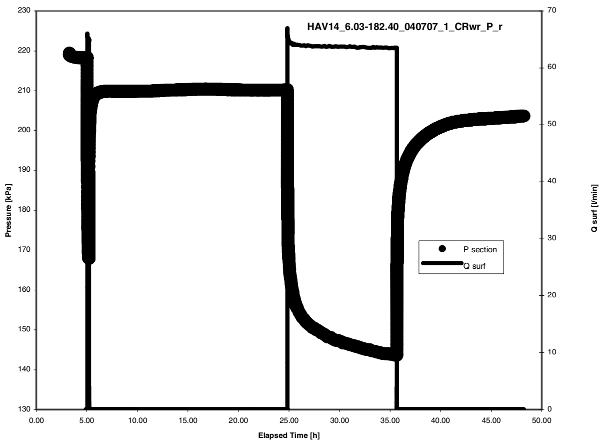
HAV14
HAV07o
HAV08o

Pump Test Summary Sheets

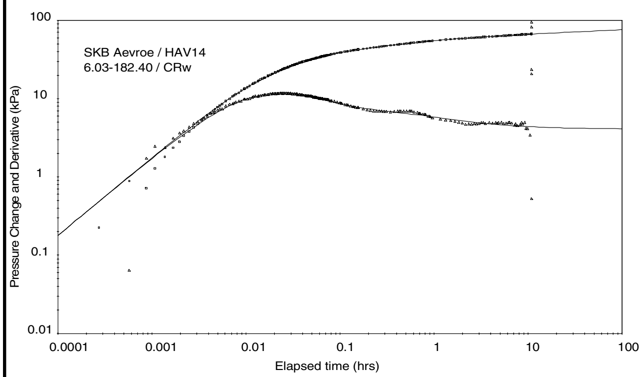
Test Summary Sheet

Project:	Oskarshamn site investigation	Test type:[1]	CRwr
Area:	Ävrö	Test no:	1
Borehole ID:	HAV14	Test start:	040707 08:09
Test section from - to (m):	6.03 - 182.40 m	Responsible for test execution:	Reinder van der Wall
Section diameter, $2 \cdot r_w$ (m):	0.14	Responsible for test evaluation:	C. Enachescu

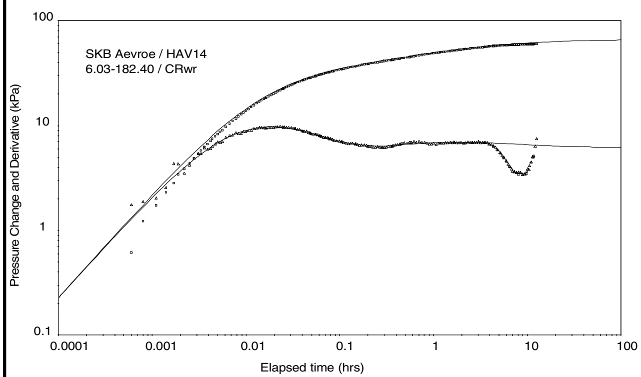
Linear plot Q and p



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa) =	0		
p_i (kPa) =	208.9		
p_p(kPa) =	144.2	p_F (kPa) =	203.6
Q_p (m^3/s)=	1.06E-03		
tp (s) =	39000	t_F (s) =	45300
S^* (-)=	1.00E-04	S^* (-)=	1.00E-04
EC_w (mS/m)=	32.0		
$Temp_w$(gr C)=	8.42		
Derivative fact.=	0.08	Derivative fact.=	0.05
Results		**Results**	
Q/s (m^2/s)=	1.6E-04		
T_M (m^2/s)=	2.1E-04		
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	12.00	dt_1 (min) =	12.00
dt_2 (min) =	600.00	dt_2 (min) =	240.00
T (m^2/s) =	2.05E-04	T (m^2/s) =	1.39E-04
S (-) =	4.12E-05	S (-) =	6.04E-05
K_s (m/s) =	1.21E-06	K_s (m/s) =	8.21E-07
S_s (1/m) =	2.43E-07	S_s (1/m) =	3.57E-07
C (m^3/Pa) =	2.03E-06	C (m^3/Pa) =	1.59E-06
C_D (-) =	1.60E+00	C_D (-) =	8.55E-01
ξ (-) =	-2.37	ξ (-) =	-2.79
T_{GRF}(m^2/s) =		T_{GRF}(m^2/s) =	
S_{GRF}(-) =		S_{GRF}(-) =	
D_{GRF} (-) =		D_{GRF} (-) =	

Selected representative parameters.			
dt_1 (min) =	12	C (m^3/Pa) =	1.59E-06
dt_2 (min) =	240	C_D (-) =	8.55E-01
T_T (m^2/s) =	1.58E-04	ξ (-) =	-2.79
S (-) =	6.04E-05		
K_s (m/s) =	9.33E-07		
S_s (1/m) =	3.57E-07		

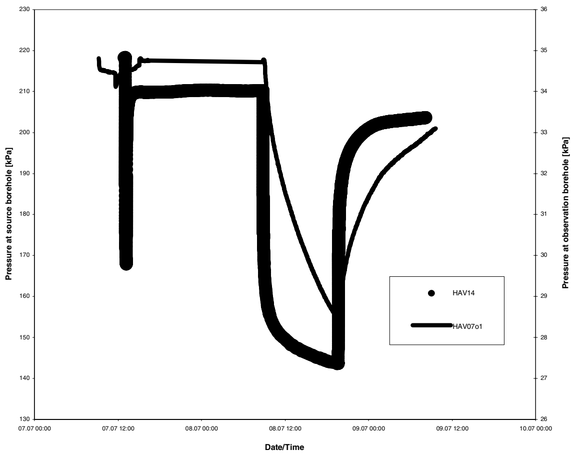
Comments:

The recommended transmissivity of 1.58E-4 m2/s was derived from the analysis of the CRr phase (inner zone), which shows a good data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 1.0E-4 to 3.0E-4 m2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CRr phase using straight line extrapolation in the Horner plot to a value of 208 kPa.

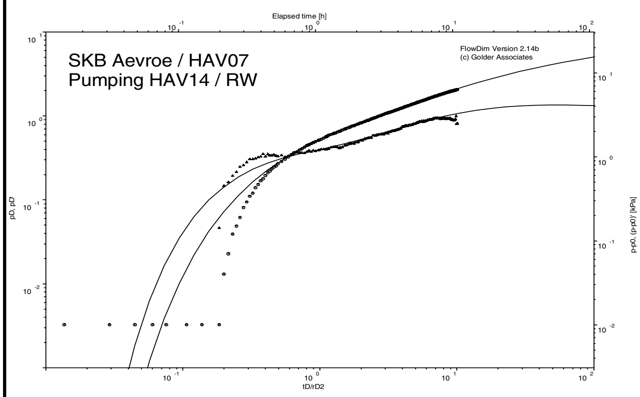
Test Summary Sheet

Project:	Oskarshamn site investigation	Test type:[1]	CRwr
Area:	Ävrö	Test no:	1
Borehole ID:	HAV07o	Test start:	040707 08:09
Test section from - to (m):	4.00 - 100.00 m	Responsible for test execution:	Reinder van der Wall
Section diameter, $2 \cdot r_w$ (m):	0.14	Responsible for test evaluation:	C. Enachescu

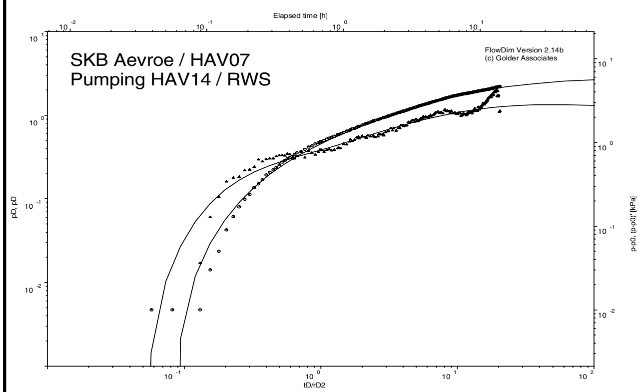
Linear plot Q and p



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa) =	0		
p_i (kPa) =	34.77		
p_p(kPa) =	28.52	p_F (kPa) =	33.1
Q_p (m^3/s)=	1.06E-03		
tp (s) =	39000	t_F (s) =	45300
S^* (-)=	1.00E-04	S^* (-)=	1.00E-04
EC_w (mS/m)=			
$Temp_w$(gr C)=			
Derivative fact.=	0.05	Derivative fact.=	0.07
Results		**Results**	
Q/s (m^2/s)=			
T_M (m^2/s)=			
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	48.00	dt_1 (min) =	42.00
dt_2 (min) =	540.00	dt_2 (min) =	600.00
T (m^2/s) =	5.40E-04	T (m^2/s) =	7.84E-04
S (-) =	2.01E-04	S (-) =	1.85E-04
K_s (m/s) =	5.63E-06	K_s (m/s) =	8.17E-06
S_s (1/m) =	2.09E-06	S_s (1/m) =	1.93E-06
C (m^3/Pa) =	2.00E-06	C (m^3/Pa) =	2.00E-06
C_D (-) =	3.23E-01	C_D (-) =	3.51E-01
ξ (-) =	-0.35	ξ (-) =	-0.31
T_{GRF}(m^2/s) =		T_{GRF}(m^2/s) =	
S_{GRF}(-) =		S_{GRF}(-) =	
D_{GRF} (-) =		D_{GRF} (-) =	

Selected representative parameters.

dt_1 (min) =	48	C (m^3/Pa) =	2.00E-06
dt_2 (min) =	540	C_D (-) =	3.23E-01
T_T (m^2/s) =	2.20E-04	ξ (-) =	-0.35
S (-) =	2.01E-04		
K_s (m/s) =	2.29E-06		
S_s (1/m) =	2.09E-06		

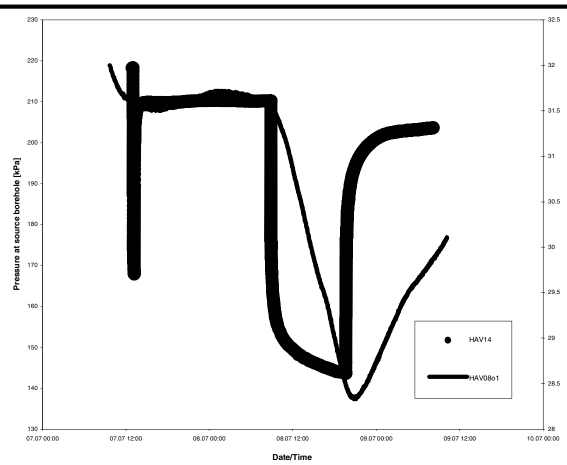
Comments:

The recommended transmissivity of 5.4E-4 m2/s was derived from the analysis of the CRw phase (inner zone), which shows a good data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 1.0E-4 to 1.0E-3 m2/s. The flow dimension displayed during the test is 2.

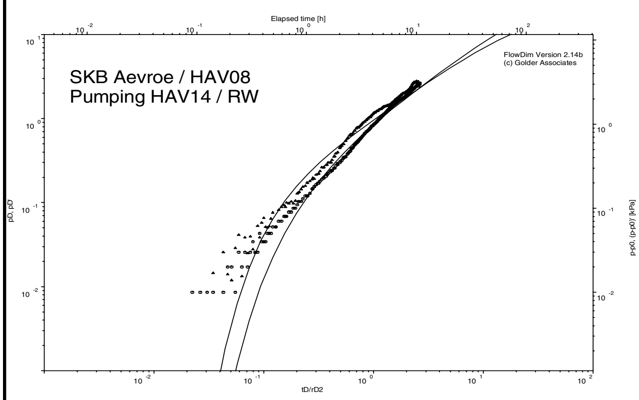
Test Summary Sheet

Project:	Oskarshamn site investigation	Test type:[1]	CRwr
Area:	Ävrö	Test no:	1
Borehole ID:	HAV08o	Test start:	040707 08:09
Test section from - to (m):	0.00 - 63.00 m	Responsible for test execution:	Reinder van der Wall
Section diameter, $2 \cdot r_w$ (m):	0.14	Responsible for test evaluation:	C. Enachescu

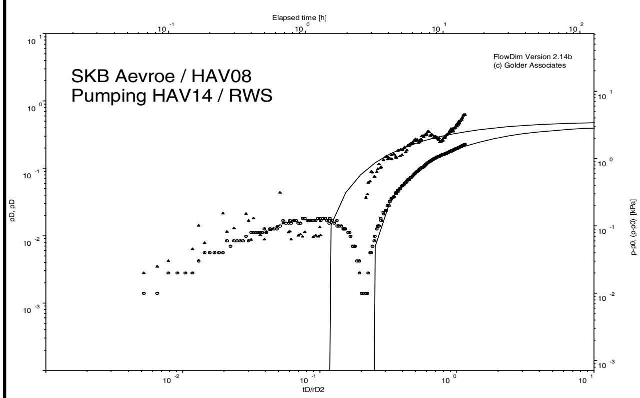
Linear plot Q and p



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa) =	0		
p_i (kPa) =	31.57		
p_p(kPa) =	28.35	p_F (kPa) =	30.1
Q_p (m^3/s)=	1.06E-03		
tp (s) =	39000	t_F (s) =	45300
S^* (-)=	1.00E-04	S^* (-)=	1.00E-04
EC_w (mS/m)=			
$Temp_w$(gr C)=			
Derivative fact.=	0.02	Derivative fact.=	0.05
Results		**Results**	
Q/s (m^2/s)=			
T_M (m^2/s)=			
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	60.00	dt_1 (min) =	180.00
dt_2 (min) =	600.00	dt_2 (min) =	720.00
T (m^2/s) =	1.42E-03	T (m^2/s) =	2.32E-04
S (-) =	1.15E-03	S (-) =	5.79E-04
K_s (m/s) =	2.25E-05	K_s (m/s) =	3.68E-06
S_s (1/m) =	1.83E-05	S_s (1/m) =	9.19E-06
C (m^3/Pa) =	2.00E-06	C (m^3/Pa) =	2.00E-06
C_D (-) =	5.65E-02	C_D (-) =	1.12E-01
ξ (-) =	0.85	ξ (-) =	-0.88
T_{GRF}(m^2/s) =		T_{GRF}(m^2/s) =	
S_{GRF}(-) =		S_{GRF}(-) =	
D_{GRF} (-) =		D_{GRF} (-) =	

Selected representative parameters.			
dt_1 (min) =	180	C (m^3/Pa) =	2.00E-06
dt_2 (min) =	720	C_D (-) =	1.12E-01
T_T (m^2/s) =	2.32E-04	ξ (-) =	-0.88
S (-) =	5.79E-04		
K_s (m/s) =	3.68E-06		
S_s (1/m) =	9.19E-06		

Comments:

The recommended transmissivity of 2.3E-4 m2/s was derived from the analysis of the CRr phase, which shows a good data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 5.0E-5 to 3.0E-3 m2/s. The flow dimension displayed during the test is 2.

APPENDIX 3-3

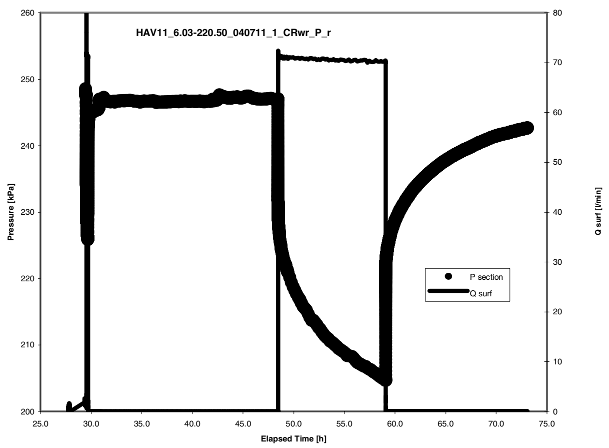
HAV11

Pump Test Summary Sheets

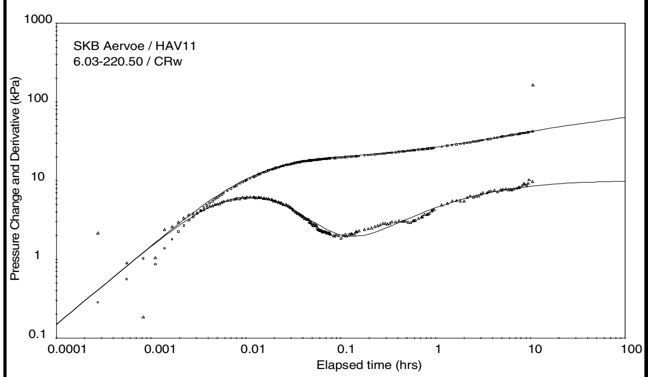
Test Summary Sheet

Project:	Oskarshamn site investigation	Test type:[1]	CRwr
Area:	Ävrö	Test no:	1
Borehole ID:	HAV11	Test start:	040711 08:24
Test section from - to (m):	6.03 - 220.50 m	Responsible for test execution:	Reinder van der Wall
Section diameter, $2 \cdot r_w$ (m):	0.14	Responsible for test evaluation:	C. Enachescu

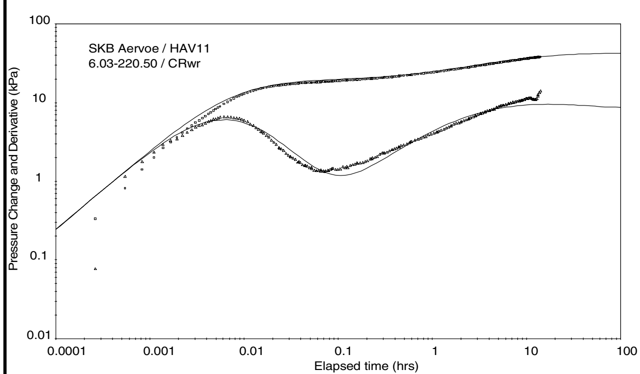
Linear plot Q and p



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		**Recovery period**	
Indata		**Indata**	
p_0 (kPa) =	0		
p_i (kPa) =	246.7		
p_p(kPa) =	205.5	p_F (kPa) =	242.7
Q_p (m^3/s)=	1.19E-03		
tp (s) =	38220	t_F (s) =	48840
S^* (-)=	1.00E-04	S^* (-)=	1.00E-04
EC_w (mS/m)=	1143		
$Temp_w$(gr C)=	8.79		
Derivative fact.=	0.075	Derivative fact.=	0.082
Results		**Results**	
Q/s (m^2/s)=	2.9E-04		
T_M (m^2/s)=	3.8E-04		
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	6.00	dt_1 (min) =	3.60
dt_2 (min) =	600.00	dt_2 (min) =	600.00
T (m^2/s) =	9.24E-05	T (m^2/s) =	1.19E-04
S (-) =	1.15E-04	S (-) =	2.58E-05
K_s (m/s) =	4.31E-07	K_s (m/s) =	5.55E-07
S_s (1/m) =	5.36E-07	S_s (1/m) =	1.20E-07
C (m^3/Pa) =	2.75E-06	C (m^3/Pa) =	1.67E-06
C_D (-) =	7.77E-01	C_D (-) =	2.10E+00
ξ (-) =	1.02	ξ (-) =	3.17
T_{GRF}(m^2/s) =		T_{GRF}(m^2/s) =	
S_{GRF}(-) =		S_{GRF}(-) =	
D_{GRF} (-) =		D_{GRF} (-) =	

Selected representative parameters.

dt_1 (min) =	6	C (m^3/Pa) =	2.75E-06
dt_2 (min) =	600	C_D (-) =	7.77E-01
T_T (m^2/s) =	7.20E-04	ξ (-) =	1.02
S (-) =	1.15E-04		
K_s (m/s) =	3.36E-06		
S_s (1/m) =	5.36E-07		

Comments:

The recommended transmissivity of 7.2E-4 m2/s was derived from the analysis of the CRw phase, which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 8.0E-5 to 1.0E-3 m2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CRr phase using straight line extrapolation in the Horner plot to a value of 248 kPa.

APPENDIX 3-4

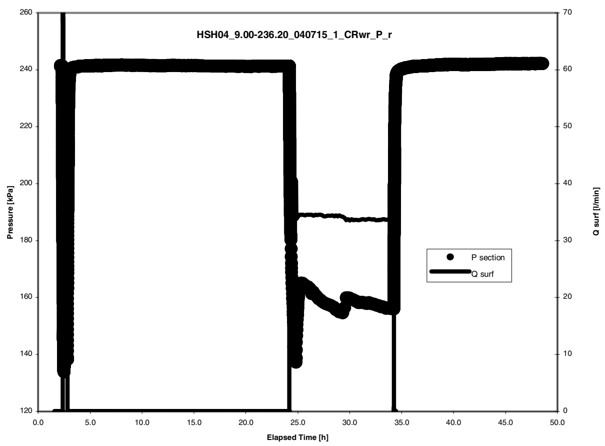
HSH04

Pump Test Summary Sheets

Test Summary Sheet

Project:	Oskarshamn site investigation	Test type:[1]	CRwr
Area:	Simpevarp	Test no:	1
Borehole ID:	HSH04	Test start:	040715 08:11
Test section from - to (m):	9.00 - 236.20 m	Responsible for test execution:	Reinder van der Wall
Section diameter, $2 \cdot r_w$ (m):	0.14	Responsible for test evaluation:	C. Enachescu

Linear plot Q and p

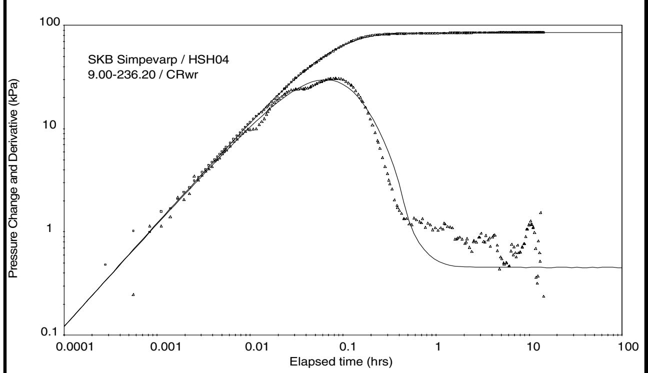


Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa) =	0		
p_i (kPa) =	240.2		
p_p(kPa) =	156.1	p_F (kPa) =	242.1
Q_p (m^3/s)=	5.60E-04		
tp (s) =	36240	t_F (s) =	51600
S^* (-)=	1.00E-04	S^* (-)=	1.00E-04
EC_w (mS/m)=	878		
$Temp_w$(gr C)=	12.49		
Derivative fact.=	NA	Derivative fact.=	0.05
Results		**Results**	
Q/s (m^2/s)=	6.7E-05		
T_M (m^2/s)=	8.9E-05		
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	NA	dt_1 (min) =	36.00
dt_2 (min) =	NA	dt_2 (min) =	480.00
T (m^2/s) =	NA	T (m^2/s) =	9.60E-04
S (-) =	NA	S (-) =	1.00E-04
K_s (m/s) =	NA	K_s (m/s) =	4.23E-06
S_s (1/m) =	NA	S_s (1/m) =	4.40E-07
C (m^3/Pa) =	NA	C (m^3/Pa) =	1.65E-06
C_D (-) =	NA	C_D (-) =	5.36E-01
ξ (-) =	NA	ξ (-) =	83.25
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

Not Analysed

Log-Log plot incl. derivatives- recovery period



Selected representative parameters.			
dt_1 (min) =	36	C (m^3/Pa) =	1.65E-06
dt_2 (min) =	480	C_D (-) =	5.36E-01
T_T (m^2/s) =	9.60E-04	ξ (-) =	83.25
S (-) =	1.00E-04		
K_s (m/s) =	4.23E-06		
S_s (1/m) =	4.40E-07		

Comments:

The recommended transmissivity of 9.6E-4 m2/s was derived from the analysis of the CRwr phase, which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 6.0E-4 to 2.0E-3 m2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CRr phase using straight line extrapolation in the Horner plot to a value of 242 kPa.

APPENDIX 3-5

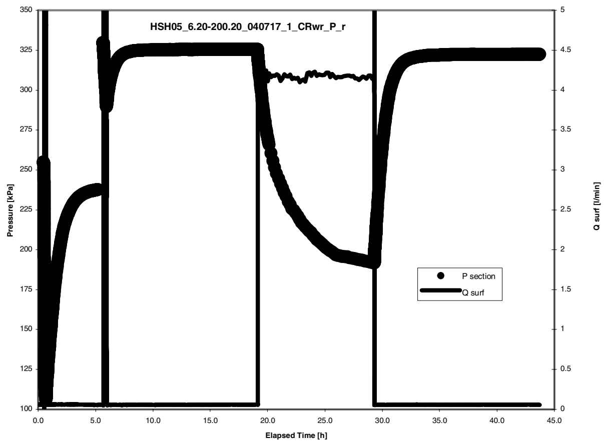
HSH05

Pump Test Summary Sheets

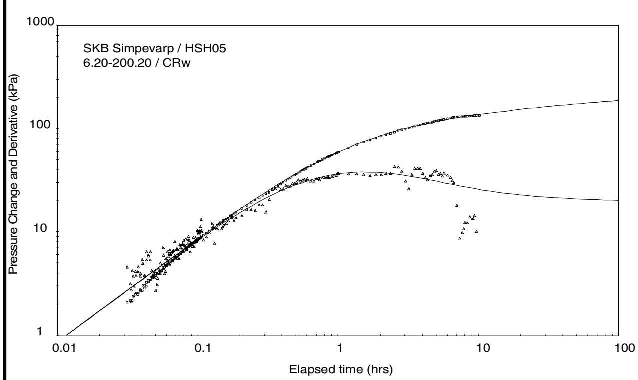
Test Summary Sheet

Project:	Oskarshamn site investigation	Test type:[1]	CRwr
Area:	Simpevarp	Test no:	1
Borehole ID:	HSH05	Test start:	040717 13:07
Test section from - to (m):	6.20 - 200.20 m	Responsible for test execution:	Reinder van der Wall
Section diameter, $2 \cdot r_w$ (m):	0.14	Responsible for test evaluation:	C. Enachescu

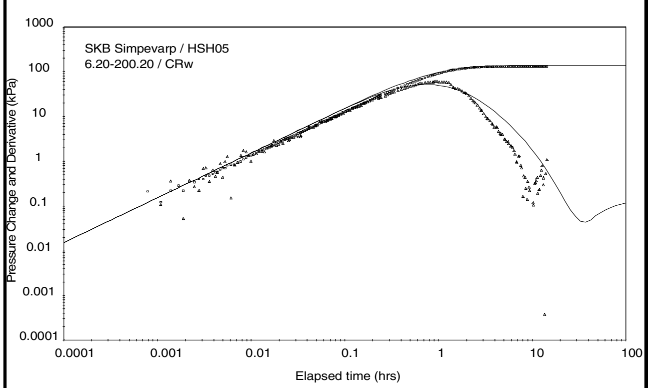
Linear plot Q and p



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa) =	0		
p_i (kPa) =	325.5		
p_p(kPa) =	191.8	p_F (kPa) =	322.4
Q_p (m^3/s)=	6.95E-05		
tp (s) =	36600	t_F (s) =	51900
S^* (-)=	1.00E-04	S^* (-)=	1.00E-04
EC_w (mS/m)=	737.3		
$Temp_w$(gr C)=	8.52		
Derivative fact.=	0.03	Derivative fact.=	0.02
Results		**Results**	
Q/s (m^2/s)=	5.2E-06		
T_M (m^2/s)=	6.8E-06		
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	90.00	dt_1 (min) =	420.00
dt_2 (min) =	360.00	dt_2 (min) =	600.00
T (m^2/s) =	4.23E-06	T (m^2/s) =	5.22E-04
S (-) =	1.00E-04	S (-) =	1.00E-04
K_s (m/s) =	2.18E-08	K_s (m/s) =	2.69E-06
S_s (1/m) =	5.15E-07	S_s (1/m) =	5.15E-07
C (m^3/Pa) =	4.14E-06	C (m^3/Pa) =	2.28E-06
C_D (-) =	1.34E+00	C_D (-) =	7.41E-01
ξ (-) =	-2.93	ξ (-) =	0
T_{GRF}(m^2/s) =		T_{GRF}(m^2/s) =	
S_{GRF}(-) =		S_{GRF}(-) =	
D_{GRF} (-) =		D_{GRF} (-) =	

Selected representative parameters.			
dt_1 (min) =	420	C (m^3/Pa) =	2.28E-06
dt_2 (min) =	600	C_D (-) =	7.41E-01
T_T (m^2/s) =	5.22E-06	ξ (-) =	0
S (-) =	1.00E-04		
K_s (m/s) =	2.69E-08		
S_s (1/m) =	5.15E-07		

Comments:

The recommended transmissivity of 5.22E-6 m2/s was derived from the analysis of the CRr phase (inner zone), which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 4.0E-6 to 6.0E-4 m2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CRr phase using straight line extrapolation in the Horner plot to a value of 324 kPa.

APPENDIX 3-6

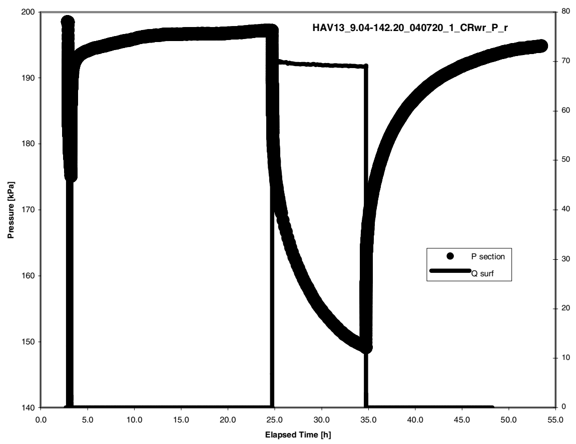
HAV13
HAV02o
HAV12o

Pump Test Summary Sheets

Test Summary Sheet

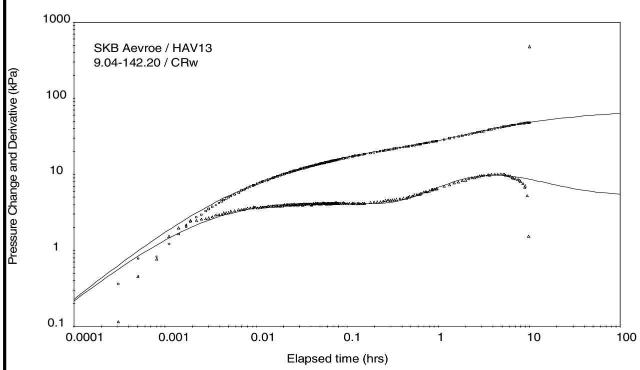
Project:	Oskarshamn site investigation	Test type:[1]	CRwr
Area:	Ävrö	Test no:	1
Borehole ID:	HAV13	Test start:	040720 08:02
Test section from - to (m):	9.04 - 142.20 m	Responsible for test execution:	Reinder van der Wall
Section diameter, $2 \cdot r_w$ (m):	0.14	Responsible for test evaluation:	C. Enachescu

Linear plot Q and p

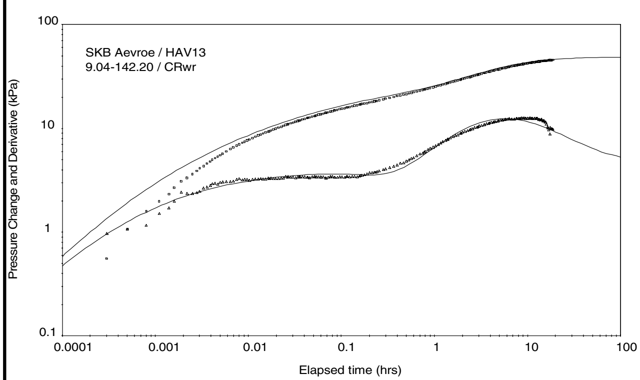


Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa) =	0		
p_i (kPa) =	197.2		
p_p(kPa) =	149.1	p_F (kPa) =	194.9
Q_p (m^3/s)=	1.15E-03		
tp (s) =	36060	t_F (s) =	67500
S^* (-)=	1.00E-04	S^* (-)=	1.00E-04
EC_w (mS/m)=	833.7		
$Temp_w$(gr C)=	8.66		
Derivative fact.=	0.09	Derivative fact.=	0.09
Results		**Results**	
Q/s (m^2/s)=	-2.3E-04		
T_M (m^2/s)=	-2.9E-04		
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	2.40	dt_1 (min) =	2.40
dt_2 (min) =	300.00	dt_2 (min) =	600.00
T (m^2/s) =	1.83E-04	T (m^2/s) =	2.15E-04
S (-) =	4.81E-06	S (-) =	9.64E-07
K_s (m/s) =	1.37E-06	K_s (m/s) =	1.61E-06
S_s (1/m) =	3.61E-08	S_s (1/m) =	7.24E-09
C (m^3/Pa) =	1.58E-06	C (m^3/Pa) =	4.71E-07
C_D (-) =	1.07E+01	C_D (-) =	1.59E+01
ξ (-) =	-4.39	ξ (-) =	-4.34
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) =	2.4	C (m^3/Pa) =	1.58E-06
dt_2 (min) =	300	C_D (-) =	1.07E+01
T_T (m^2/s) =	2.16E-04	ξ (-) =	-4.39
S (-) =	4.81E-06		
K_s (m/s) =	1.62E-06		
S_s (1/m) =	3.61E-08		

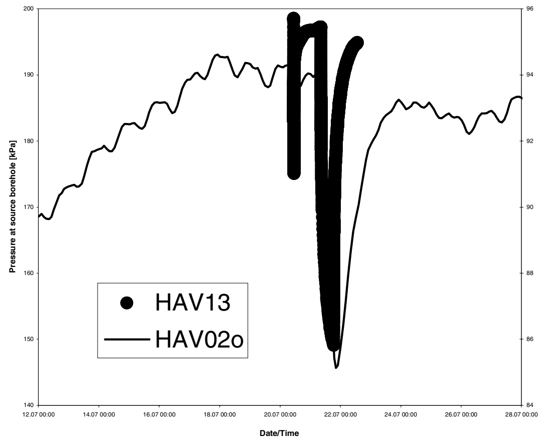
Comments:

The recommended transmissivity of 2.16E-4 m2/s was derived from the analysis of the CRw phase (inner zone), which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 1.0E-4 to 3.0E-4 m2/s. The flow dimension displayed during the test is 2. The static pressure measured at transducer depth, was derived from the CRr phase using straight line extrapolation in the Horner plot to a value of 198 kPa.

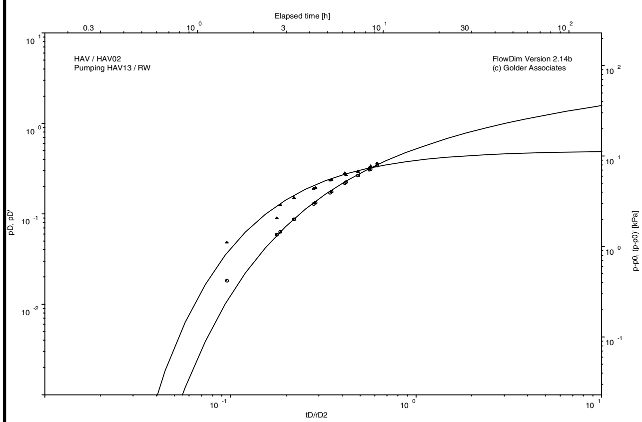
Test Summary Sheet

Project:	Oskarshamn site investigation	Test type:[1]	CRwr
Area:	Ävrö	Test no:	1
Borehole ID:	HAV02o	Test start:	040720 08:02
Test section from - to (m):	0.13 - 163.00 m	Responsible for test execution:	Reinder van der Wall
Section diameter, $2 \cdot r_w$ (m):	0.14	Responsible for test evaluation:	C. Enachescu

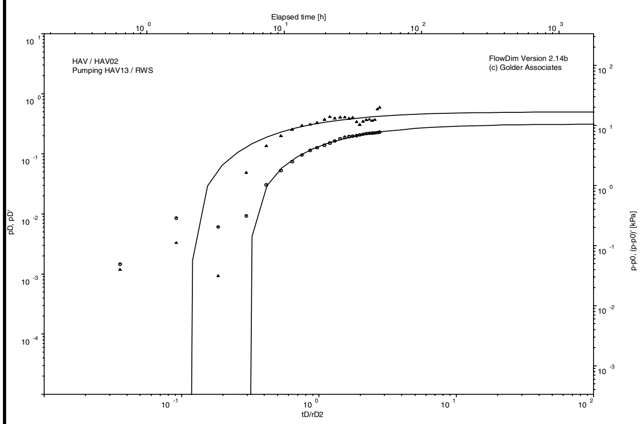
Linear plot Q and p



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa) =	0		
p_i (kPa) =	94.02		
p_p(kPa) =	85.21	p_F (kPa) =	93.25
Q_p (m^3/s)=	1.15E-03		
tp (s) =	36060	t_F (s) =	67500
S^* (-)=	1.00E-04	S^* (-)=	1.00E-04
EC_w (mS/m)=			
$Temp_w$(gr C)=			
Derivative fact.=	0.11	Derivative fact.=	0.02
Results		**Results**	
Q/s (m^2/s)=	-1.3E-03		
T_M (m^2/s)=	-1.6E-03		
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	150.00	dt_1 (min) =	480.00
dt_2 (min) =	540.00	dt_2 (min) =	1800.00
T (m^2/s) =	7.85E-05	T (m^2/s) =	5.37E-05
S (-) =	1.60E-04	S (-) =	1.30E-04
K_s (m/s) =	4.82E-07	K_s (m/s) =	3.30E-07
S_s (1/m) =	9.82E-07	S_s (1/m) =	7.98E-07
C (m^3/Pa) =	2.00E-06	C (m^3/Pa) =	2.00E-06
C_D (-) =	4.06E-01	C_D (-) =	5.00E-01
ξ (-) =	-0.24	ξ (-) =	-0.13
T_{GRF}(m^2/s) =		T_{GRF}(m^2/s) =	
S_{GRF}(-) =		S_{GRF}(-) =	
D_{GRF} (-) =		D_{GRF} (-) =	

Selected representative parameters.

dt_1 (min) =	480	C (m^3/Pa) =	2.00E-06
dt_2 (min) =	1800	C_D (-) =	5.00E-01
T_T (m^2/s) =	5.37E-05	ξ (-) =	-0.13
S (-) =	1.30E-04		
K_s (m/s) =	3.30E-07		
S_s (1/m) =	7.98E-07		

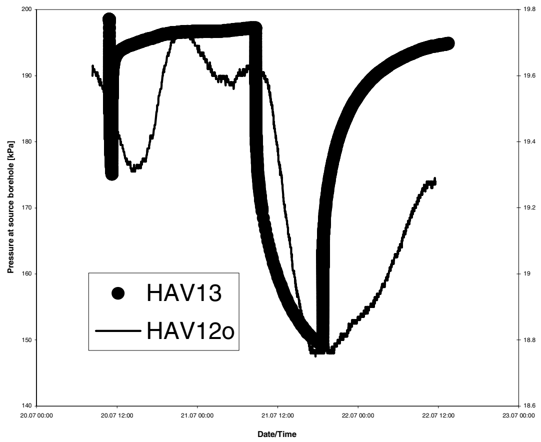
Comments:

The recommended transmissivity of 5.37E-4 m2/s was derived from the analysis of the CRwr phase, which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 4.0E-5 to 1.0E-4 m2/s. The flow dimension displayed during the test is 2.

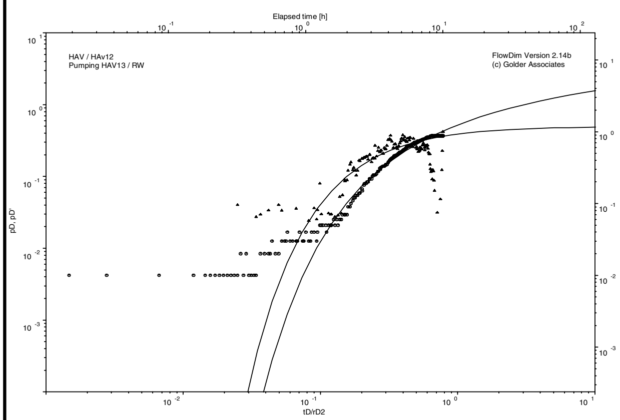
Test Summary Sheet

Project:	Oskarshamn site investigation	Test type:[1]	CRwr
Area:	Ävrö	Test no:	1
Borehole ID:	HAV12o	Test start:	040720 08:02
Test section from - to (m):	11.34 - 157.80 m	Responsible for test execution:	Reinder van der Wall
Section diameter, $2 \cdot r_w$ (m):	0.14	Responsible for test evaluation:	C. Enachescu

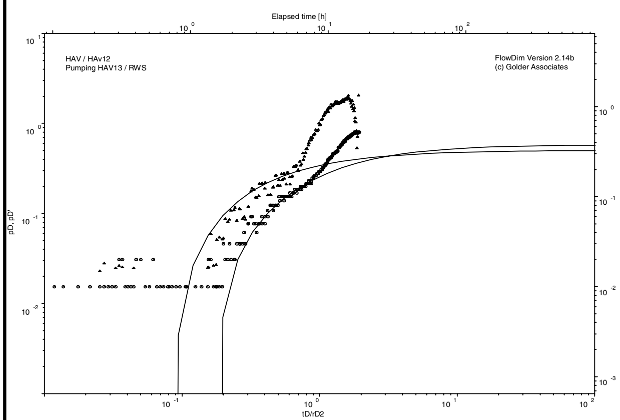
Linear plot Q and p



Log-Log plot incl. derivates- flow period



Log-Log plot incl. derivatives- recovery period



Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa) =	0		
p_i (kPa) =	19.64		
p_p(kPa) =	18.77	p_F (kPa) =	19.28
Q_p (m^3/s)=	1.15E-03		
tp (s) =	36060	t_F (s) =	67500
S^* (-)=	1.00E-04	S^* (-)=	1.00E-04
EC_w (mS/m)=			
$Temp_w$(gr C)=			
Derivative fact.=	0.12	Derivative fact.=	0.02
Results		**Results**	
Q/s (m^2/s)=			
T_M (m^2/s)=			
Flow regime:	transient	Flow regime:	transient
dt_1 (min) =	120.00	dt_1 (min) =	120.00
dt_2 (min) =	480.00	dt_2 (min) =	420.00
T (m^2/s) =	7.59E-04	T (m^2/s) =	2.78E-03
S (-) =	1.22E-04	S (-) =	3.03E-04
K_s (m/s) =	5.18E-06	K_s (m/s) =	1.90E-05
S_s (1/m) =	8.33E-07	S_s (1/m) =	2.07E-06
C (m^3/Pa) =	2.00E-06	C (m^3/Pa) =	2.00E-06
C_D (-) =	5.32E-01	C_D (-) =	2.14E-01
ξ (-) =	-0.1	ξ (-) =	-0.55
T_{GRF}(m^2/s) =		T_{GRF}(m^2/s) =	
S_{GRF}(-) =		S_{GRF}(-) =	
D_{GRF} (-) =		D_{GRF} (-) =	
Selected representative parameters.			
dt_1 (min) =	120	C (m^3/Pa) =	2.00E-06
dt_2 (min) =	480	C_D (-) =	5.32E-01
T_T (m^2/s) =	7.59E-04	ξ (-) =	-0.1
S (-) =	1.22E-04		
K_s (m/s) =	5.18E-06		
S_s (1/m) =	8.33E-07		

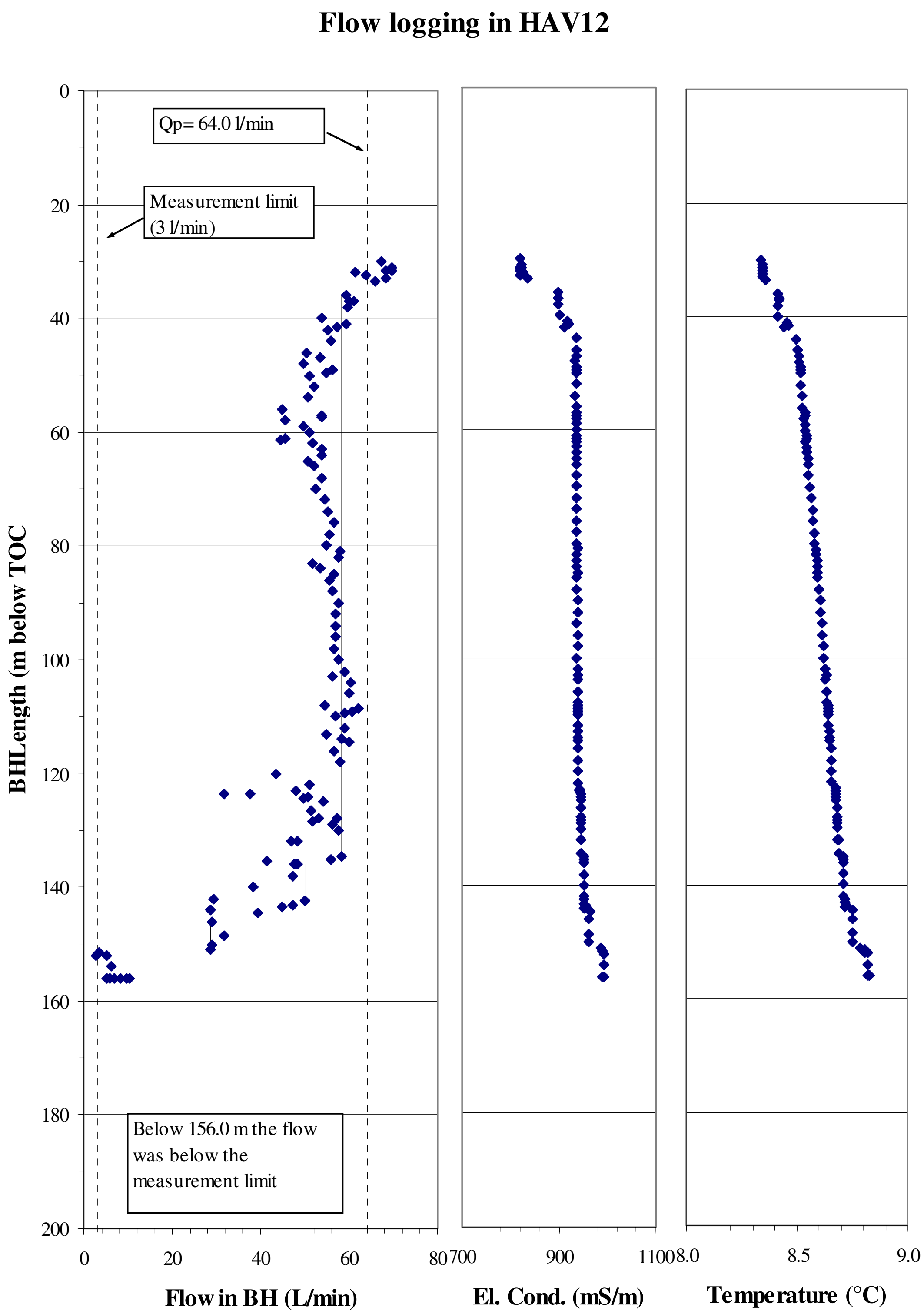
Comments:

The recommended transmissivity of 7.59E-4 m2/s was derived from the analysis of the CRw phase, which shows the best data and derivative quality. The confidence range for the borehole transmissivity is estimated to be 5.0E-4 to 5.0E-3 m2/s. The flow dimension displayed during the test is 2.

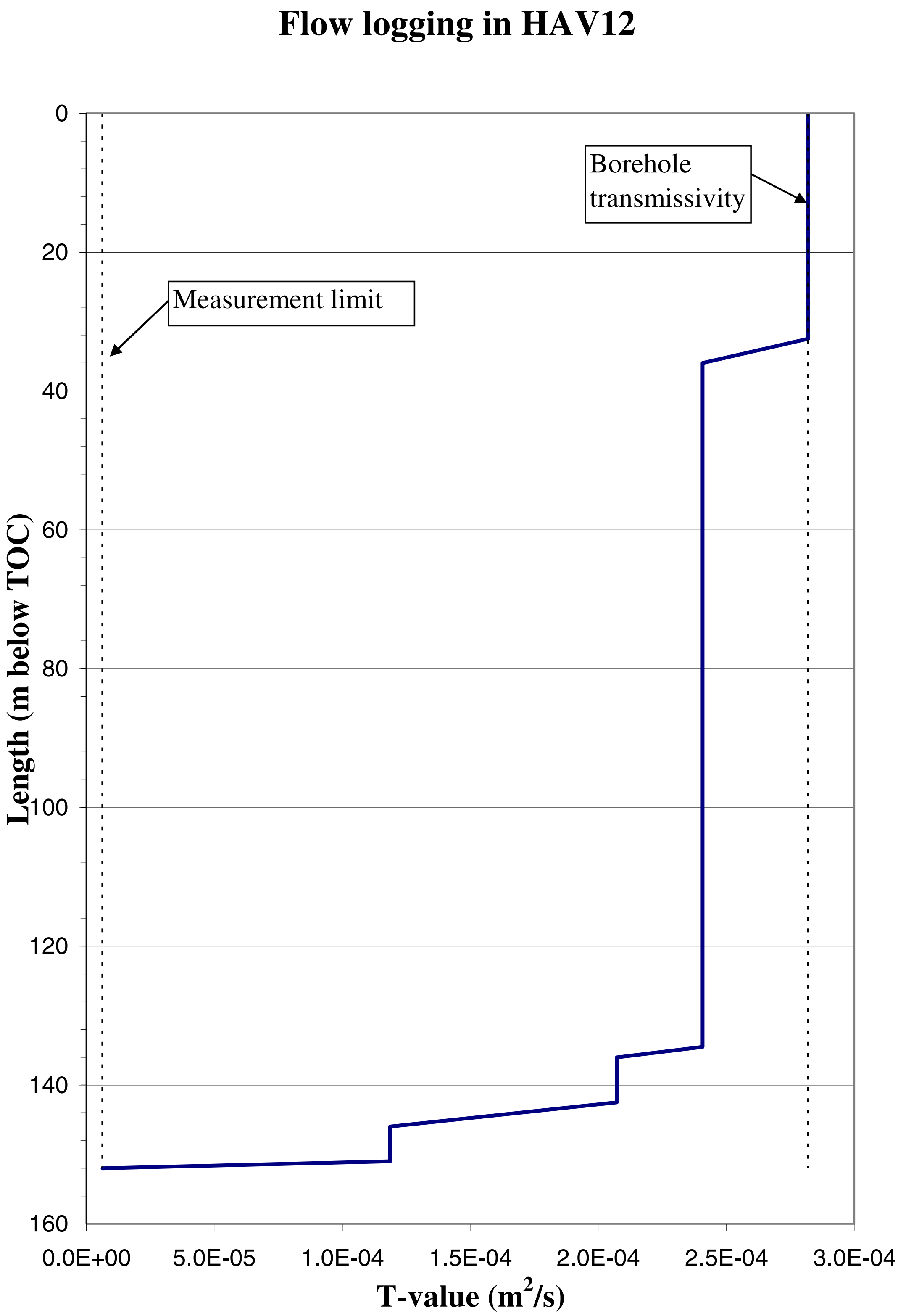
APPENDIX 4-1

HAV12

Flow Logging Analysis diagrams



HAV12: Distribution of flow (Q_i), electric conductivity (EC) and temperature (Te) along the borehole

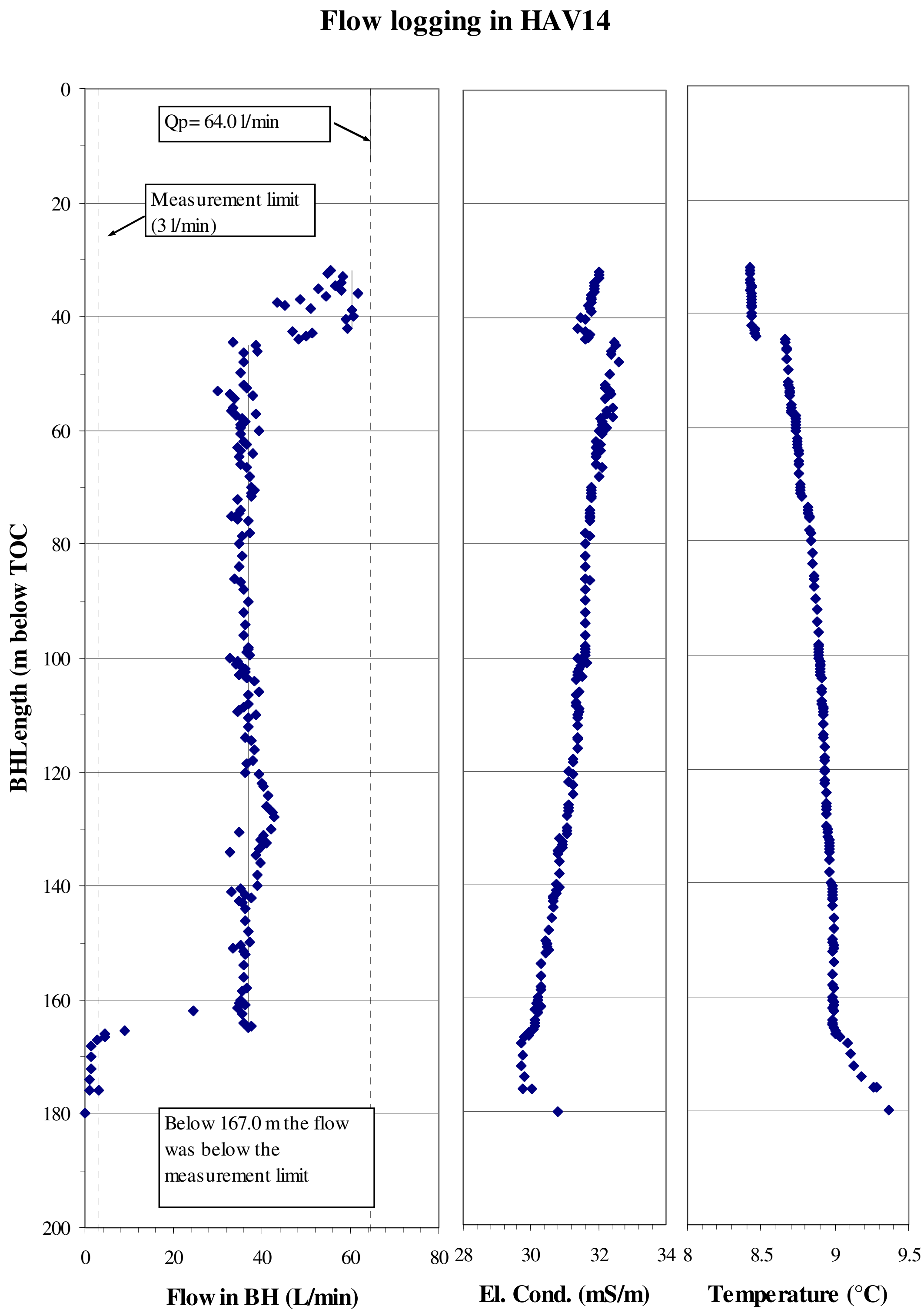


HAV12: Calculated cumulative transmissivity (T_i) along the borehole

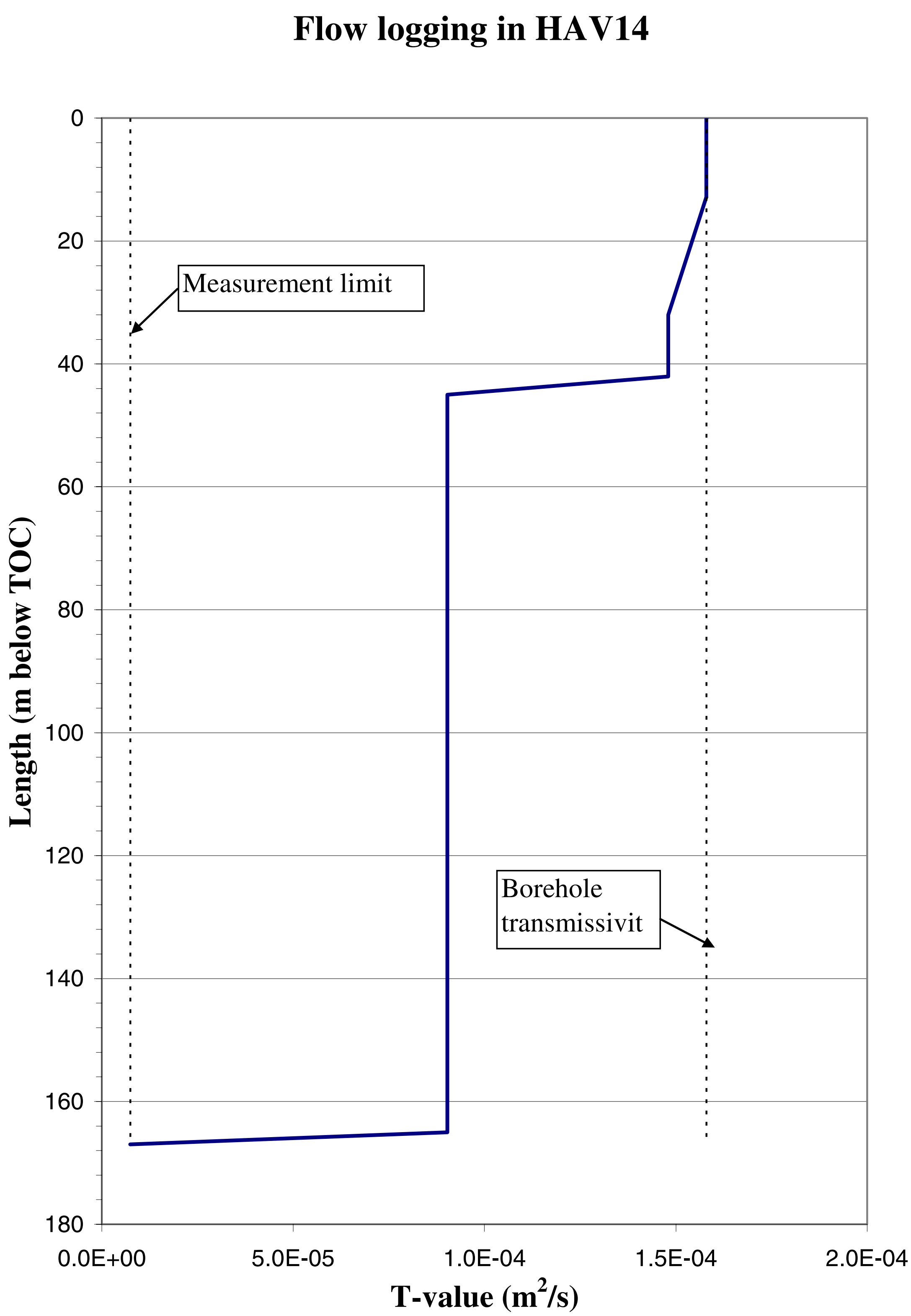
APPENDIX 4-2

HAV14

Flow Logging Analysis diagrams



HAV14: Distribution of flow (Q_i), electric conductivity (EC) and temperature (Te) along the borehole

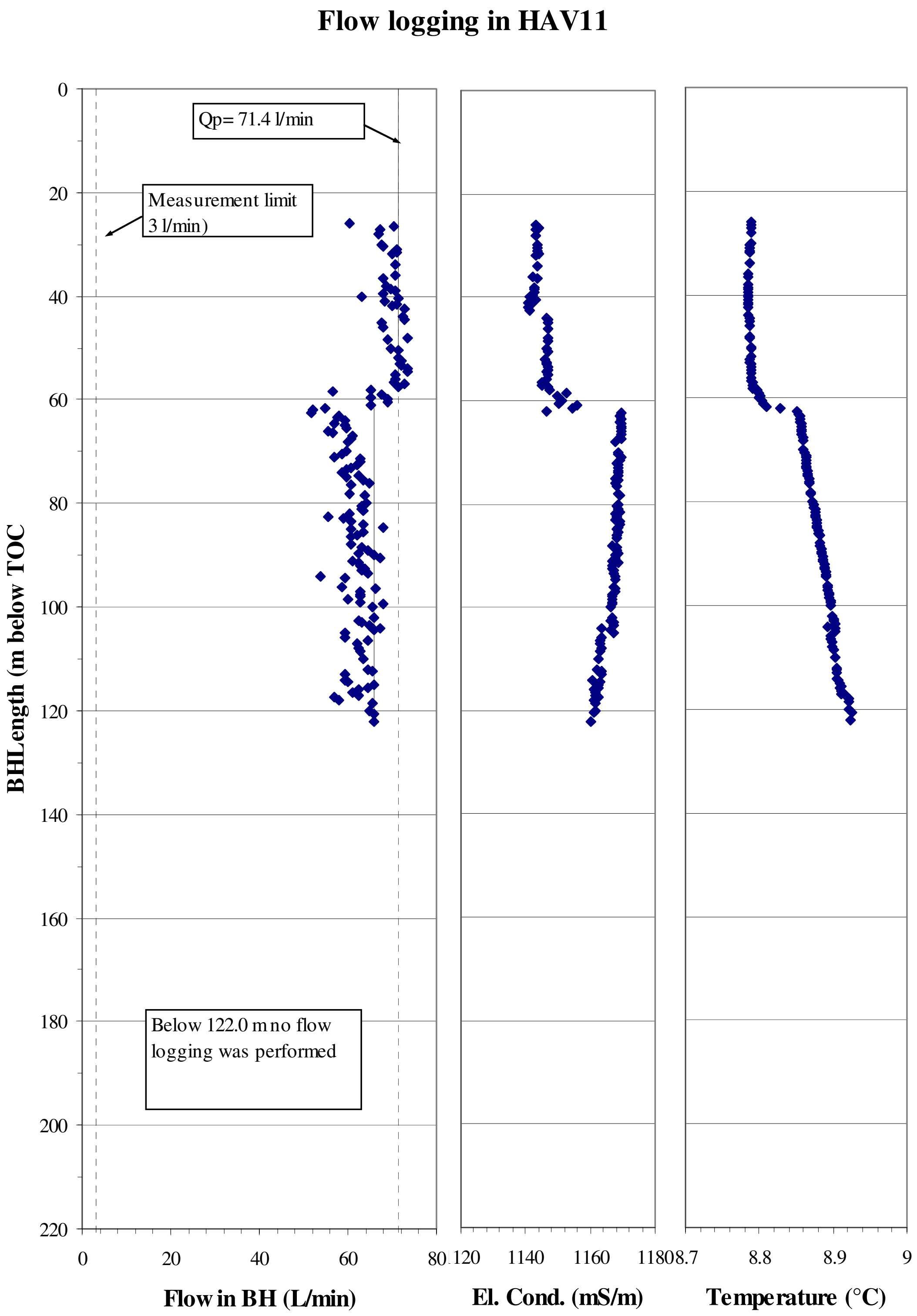


HAV14: Calculated cumulative transmissivity (T_i) along the borehole

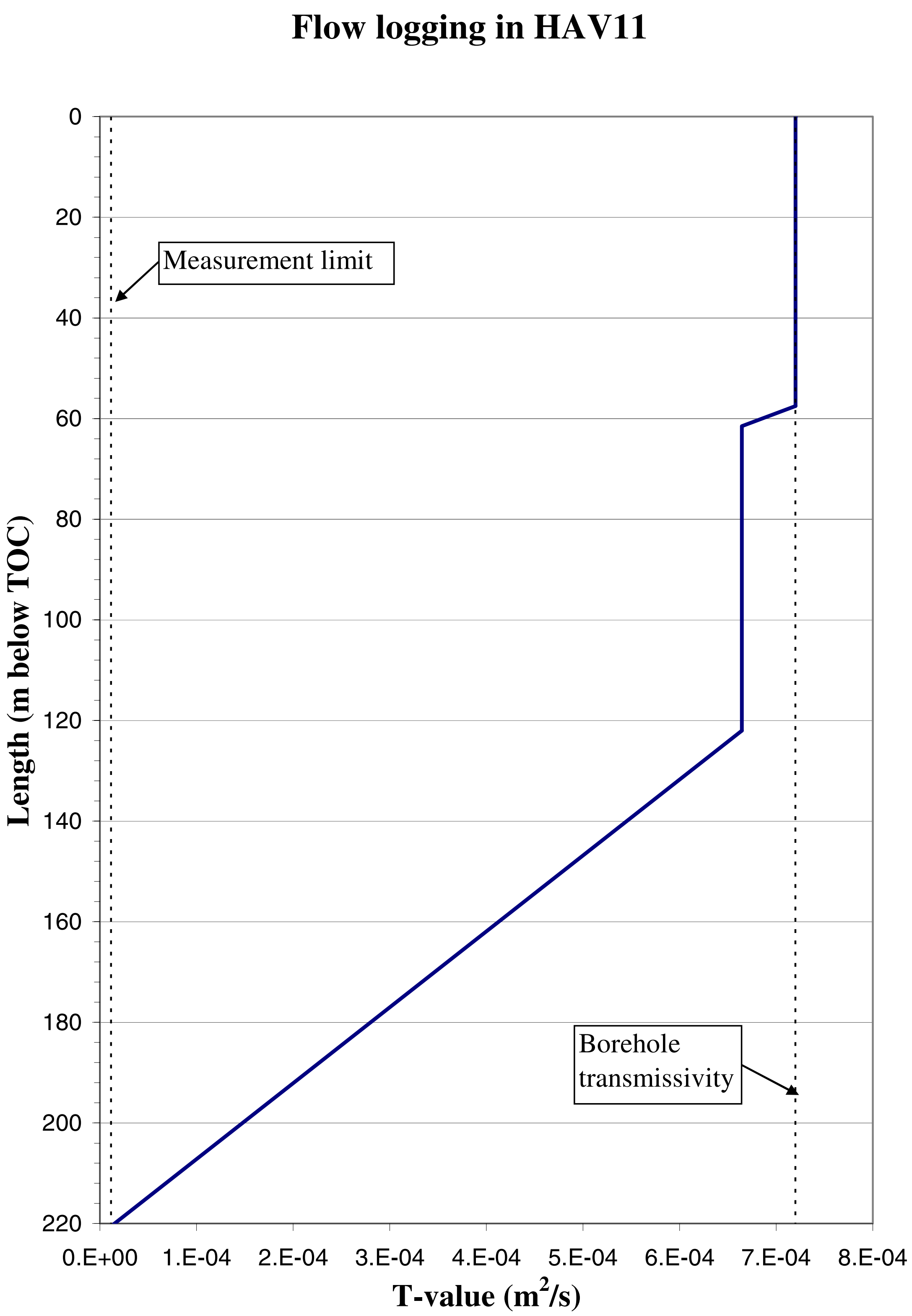
APPENDIX 4-3

HAV11

Flow Logging Analysis diagrams



HAV11: Distribution of flow (Q_i), electric conductivity (EC) and temperature (Te) along the borehole

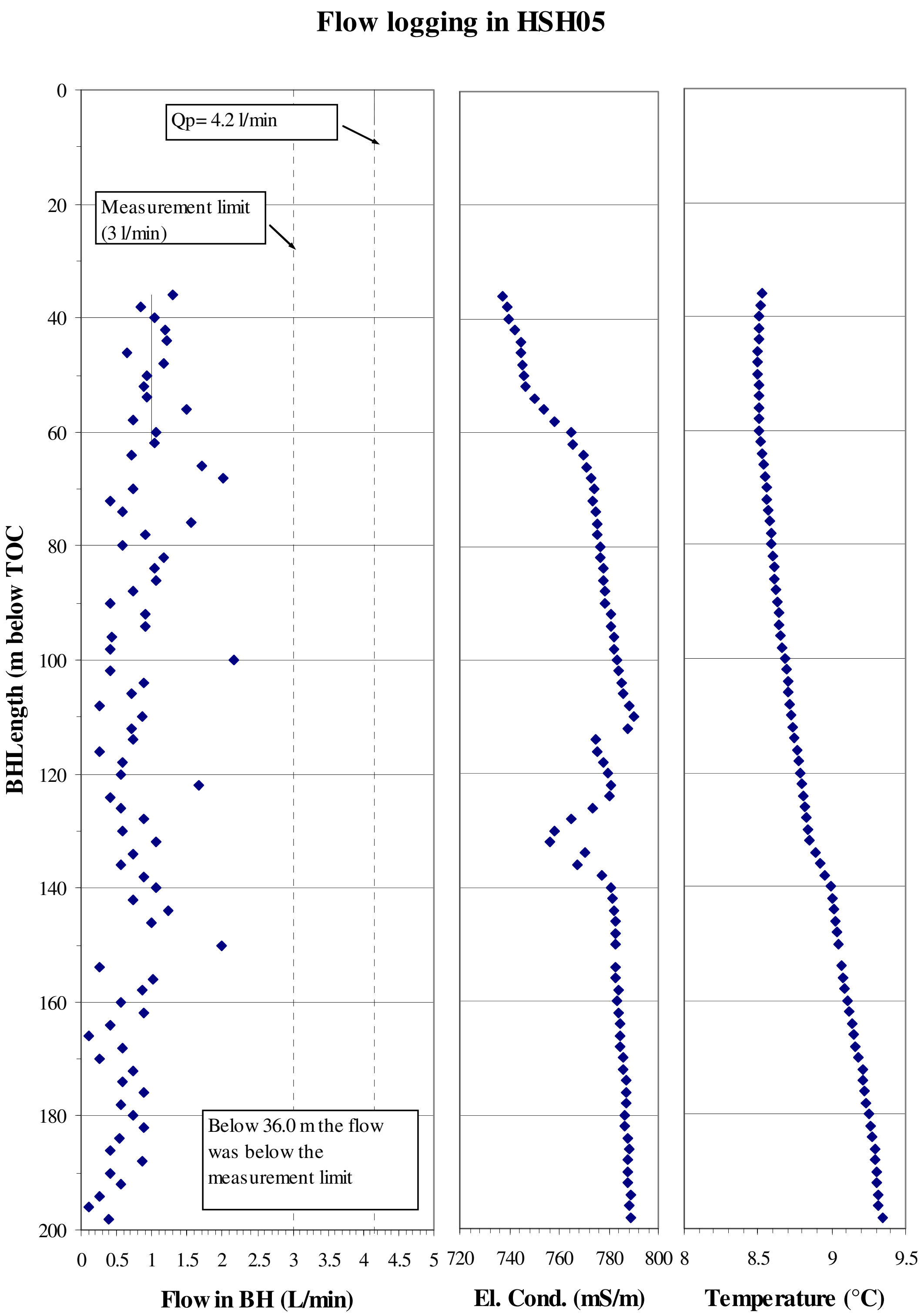


HAV11: Calculated cumulative transmissivity (T_i) along the borehole

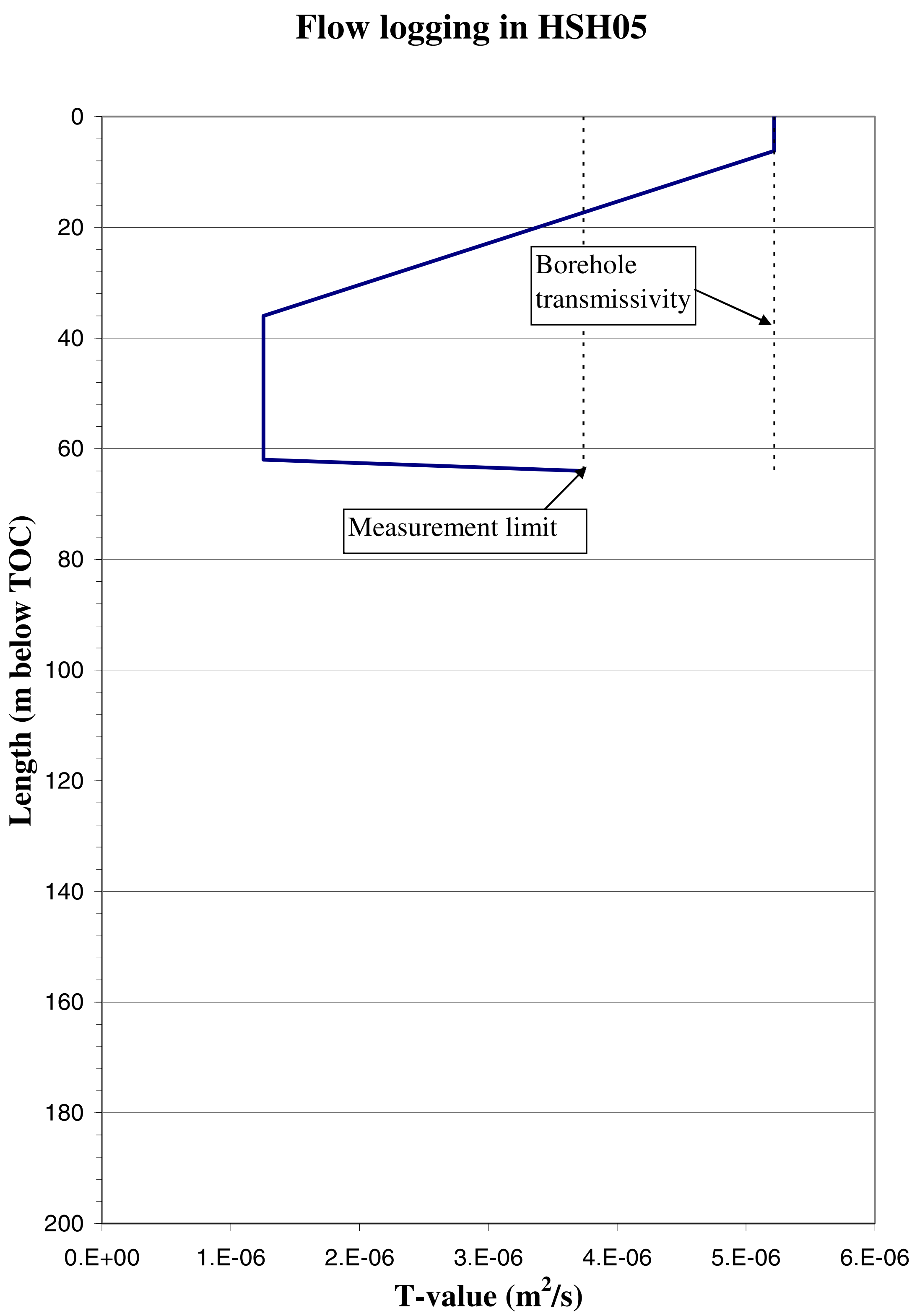
APPENDIX 4-5

HSH05

Flow Logging Analysis diagrams



HSH05: Distribution of flow (Q_i), electric conductivity (EC) and temperature (Te) along the borehole

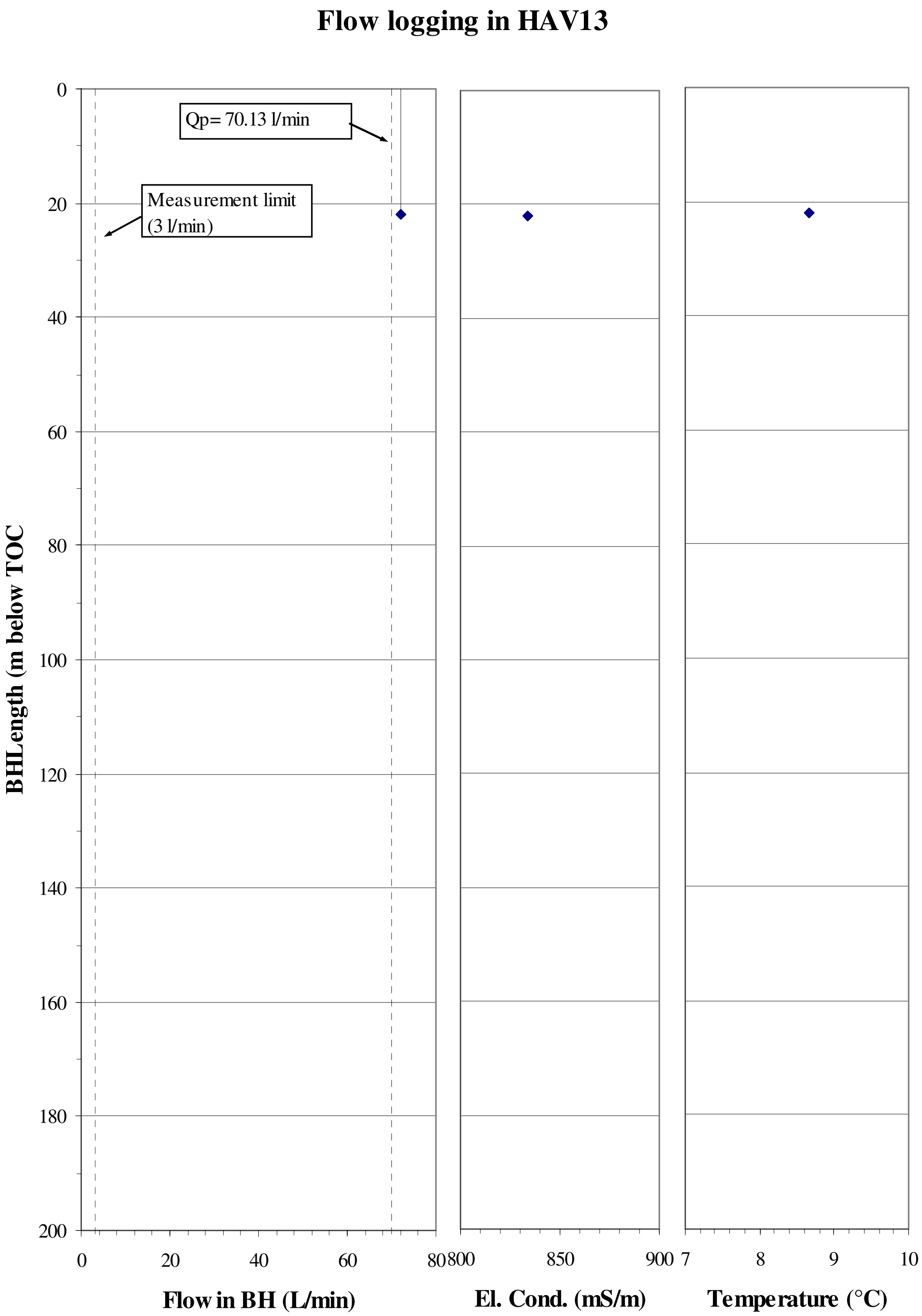


HSH05: Calculated cumulative transmissivity (T_i) along the borehole

APPENDIX 4-6

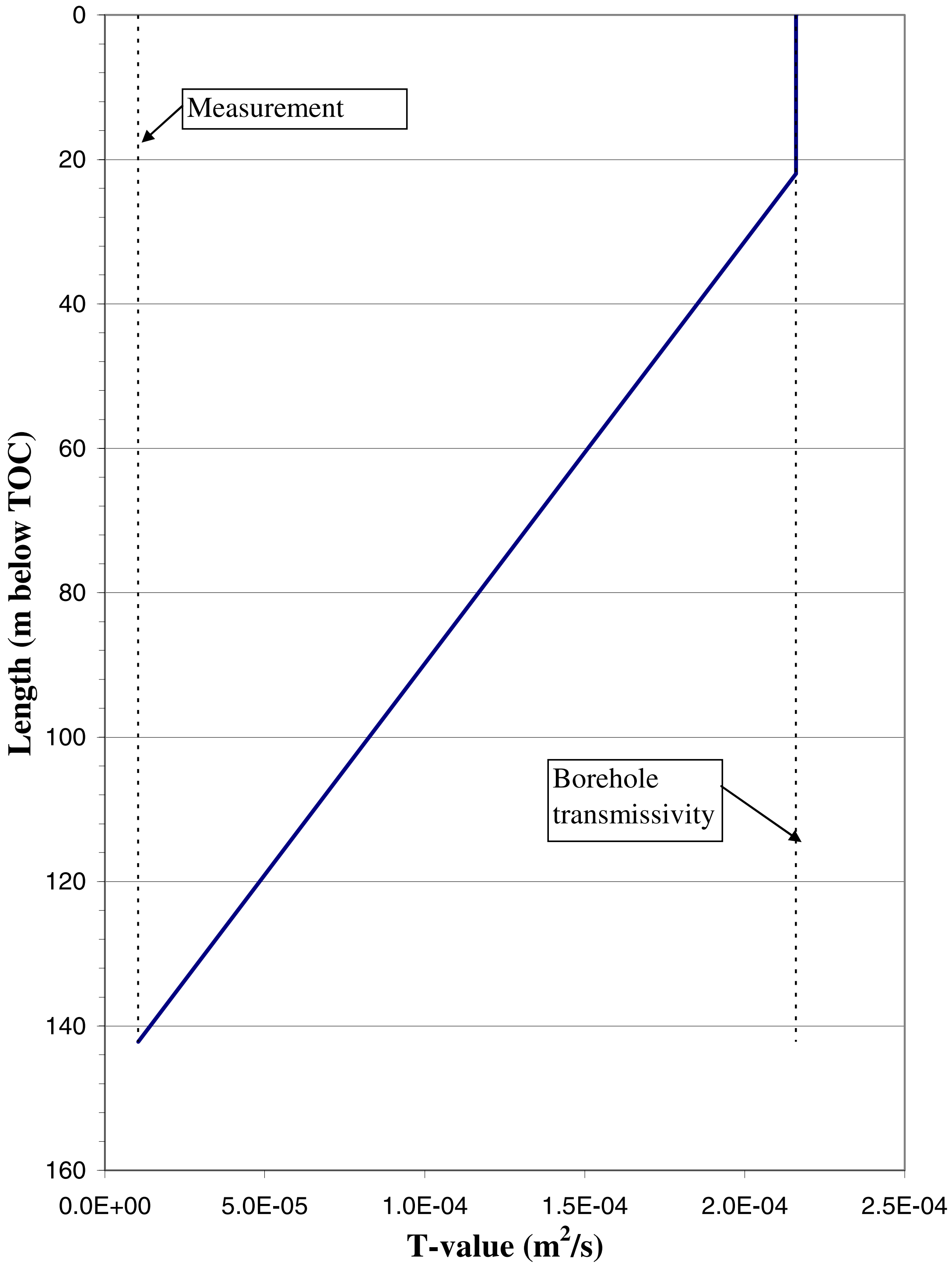
HAV13

Flow Logging Analysis diagrams



HAV13: Distribution of flow (Q_i), electric conductivity (EC) and temperature (Te) along the borehole

Flow logging in HAV13



HAV13: Calculated cumulative transmissivity (T_i) along the borehole

APPENDIX 5

Flow Logging Test Data

FLOWLOGG-IMPELLER TESTS

Borehole	Borehole (m)	Borehole (m)	L_0 (m)	L (m)	Test type (1-6)	Date for YYYYMMDD	Date for YYYYMMDD	Te_{wn} (^{o} C)	ECwn (mS/m)	TDS_{wn} (mg/ L)	ΣQ_n (m^3/s)	Q_I (m^3/s)	tp (min)	t_F (min)
HAV12	30	156			5	20040702	20040702					1.1595E-03	603	653
HAV14	32	180			5	20040708	20040708					1.0263E-03	650	755
HAV11	26	122			5	20040713	20040713					1.1740E-03	637	814
HSH04	25	202			5	20040716	20040716					4.3500E-05	604	860
HSH05	36	198			5	20040718	20040718					1.6670E-05	610	865
HAV13	22	22			5	20040721	20040721					1.1980E-03	601	1125

Borehole	Borehole (m)	Borehole (m)	h_i (m asl)	h_1 (m asl)	Te_w (^{o}C)	EC_w (mS/m)	TDS_w (mg/ L)	ΣQ_0 (m^3/s)	ΣQ (m^3/s)	T (m^2/ s)	ΣT_I (m^2/ s)	T_I-measlim (m^2/ s)	Reference	Comments (-)
HAV12	30	156	-0.59	-8.47	8.34	820.8		1.1595E-03	1.1230E-03	1.84E-04	1.840E-04	6.25E-06		
HAV14	32	180	-3.41	-9.88	8.42	32.0		1.0263E-03	1.1230E-03	1.40E-04	1.311E-04	7.46E-06		
HAV11	26	122	0.25	-3.87	8.79	1143.0		1.1740E-03	1.1900E-03	9.20E-05	9.200E-05	1.18E-05		
HSH04	25	202	0.28	-8.13	12.49	878.0		4.3500E-05	5.8170E-04	9.60E-04	7.180E-05	5.87E-06		
HSH05	36	198	-0.11	-13.48	8.52	737.3		1.6670E-05	6.9330E-05	5.22E-04	1.255E-04	3.74E-06		
HAV13	22	22	-0.62	-5.43	8.66	833.7		1.1980E-03	1.1688E-03	1.83E-04	1.830E-04	1.04E-05		

APPENDIX 6

Nomenclature

Character	SICADA designation	Explanation	Dimension	Unit
Variables, constants				
A_w		Horizontal area of water surface in open borehole, not including area of signal cables, etc.	$[L^2]$	m^2
b		Aquifer thickness (Thickness of 2D formation)	[L]	m
B		Width of channel	[L]	m
L		Corrected borehole length	[L]	m
L_0		Uncorrected borehole length	[L]	m
L_p		Point of application for a measuring section based on its centre point or centre of gravity for distribution of transmissivity in the measuring section.	[L]	m
L_w		Test section length.	[L]	m
dL		Step length, Positive Flow Log - overlapping flow logging. (step length, PFL)	[L]	m
r		Radius	[L]	m
r_w		Borehole, well or soil pipe radius in test section.	[L]	m
r_{we}		Effective borehole, well or soil pipe radius in test section. (Consideration taken to skin factor)	[L]	m
r_s		Distance from test section to observation section, the shortest distance.	[L]	m
r_t		Distance from test section to observation section, the **interpreted** shortest distance via conductive structures.	[L]	m
r_D		Dimensionless radius, $r_D=r/r_w$	-	-
z		Level above reference point	[L]	m
z_r		Level for reference point on borehole	[L]	m
z_{wu}		Level for test section (section that is being flowed), upper limitation	[L]	m
z_{wl}		Level for test section (section that is being flowed), lower limitation	[L]	m
z_{ws}		Level for sensor that measures response in test section (section that is flowed)	[L]	m
z_{ou}		Level for observation section, upper limitation	[L]	m
z_{ol}		Level for observation section, lower limitation	[L]	m
z_{os}		Level for sensor that measures response in observation section	[L]	m
E		Evaporation: hydrological budget:	$[L^3/(T L^2)]$ $[L^3/T]$	mm/y, mm/d, m^3/s
ET		Evapotranspiration hydrological budget:	$[L^3/(T L^2)]$ $[L^3/T]$	mm/y, mm/d, m^3/s
P		Precipitation hydrological budget:	$[L^3/(T L^2)]$ $[L^3/T]$	mm/y, mm/d, m^3/s
R		Groundwater recharge hydrological budget:	$[L^3/(T L^2)]$ $[L^3/T]$	mm/y, mm/d, m^3/s
D		Groundwater discharge hydrological budget:	$[L^3/(T L^2)]$ $[L^3/T]$	mm/y, mm/d, m^3/s
Q_R		Run-off rate	$[L^3/T]$	m^3/s
Q_p		Pumping rate	$[L^3/T]$	m^3/s
Q_I		Infiltration rate	$[L^3/T]$	m^3/s
Q		Volumetric flow. Corrected flow in flow logging ($Q_1 - Q_0$) (Flow rate)	$[L^3/T]$	m^3/s
Q_0		Flow in test section during undisturbed conditions (flow logging).	$[L^3/T]$	m^3/s

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
Q_1		Flow in test section during pumping with pump flow Q_{p1}, (flow logging).	$[L^3/T]$	m^3/s
Q_2		Flow in test section during pumping with pump flow Q_{p1}, (flow logging).	$[L^3/T]$	m^3/s
ΣQ	SumQ	Cumulative volumetric flow along borehole	$[L^3/T]$	m^3/s
ΣQ_0	SumQ0	Cumulative volumetric flow along borehole, undisturbed conditions (ie, not pumped)	$[L^3/T]$	m^3/s
ΣQ_1	SumQ1	Cumulative volumetric flow along borehole, with pump flow Q_{p1}	$[L^3/T]$	m^3/s
ΣQ_2	SumQ2	Cumulative volumetric flow along borehole, with pump flow Q_{p2}	$[L^3/T]$	m^3/s
ΣQ_{C1}	SumQC1	Corrected cumulative volumetric flow along borehole, ΣQ_1-ΣQ_0	$[L^3/T]$	m^3/s
ΣQ_{C2}	SumQC2	Corrected cumulative volumetric flow along borehole, ΣQ_2-ΣQ_0	$[L^3/T]$	m^3/s
q		Volumetric flow per flow passage area (Specific discharge (Darcy velocity, Darcy flux, Filtration velocity)).	$([L^3/T*L^2]$	m/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
v		Velocity	$([L^3/T*L^2]$	m/s
v_a		Mean transport velocity (Average linear velocity (Average linear groundwater velocity, Mean microscopic velocity));. $v_a=q/n_e$	$([L^3/T*L^2]$	m/s
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
h_p		Pressure head; Level above reference level for height of measuring point of stationary column of water giving corresponding static pressure at measuring point	[L]	m
h_v		Velocity head; height corresponding to the lifting for which the kinetic energy is capable (usually neglected in hydrogeology)	[L]	m
s		Drawdown; Drawdown from undisturbed level (same as dh_p, positive)	[L]	m
s_p		Drawdown in measuring section before flow stop.	[L]	m
			[L]	
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		^oC

		logging). Temperature		
Te_{w0}		Temperature in the test section during undisturbed conditions (taken from temperature logging). Temperature		^oC
Te_o		Temperature in the observation section (taken from temperature logging). Temperature		^oC
EC_w		Electrical conductivity of water in test section.		mS/m
EC_{w0}		Electrical conductivity of water in test section during undisturbed conditions.		mS/m
EC_o		Electrical conductivity of water in observation section		mS/m
TDS_w		Total salinity of water in the test section.	$[M/L^3]$	mg/L
TDS_{w0}		Total salinity of water in the test section during undisturbed conditions.	$[M/L^3]$	mg/L
TDS_o		Total salinity of water in the observation section.	$[M/L^3]$	mg/L
g		Constant of gravitation (9.81 $m*s^{-2}$) (Acceleration due to gravity)	$[L/T^2]$	m/s^2
π	pi	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)		
ME		Mean error in residuals. $ME = \frac{1}{n}\sum_{i=1}^{n} r_i$		
NME		Normalized ME. NME=ME/(x_{MAX}-x_{MIN}), x: measured variable considered.		
MAE		Mean absolute error. $MAE = \frac{1}{n}\sum_{i=1}^{n} \lvert r_i \rvert$		
NMAE		Normalized MAE. NMAE=MAE/(x_{MAX}-x_{MIN}), x: measured variable considered.		
RMS		Root mean squared error. $RMS = \left(\frac{1}{n}\sum_{i=1}^{n} r_i^2\right)^{0.5}$		
NRMS		Normalized RMR. NRMR=RMR/(x_{MAX}-x_{MIN}), x: measured variable considered.		
SDR		Standard deviation of residual. $SDR = \left(\frac{1}{n-1}\sum_{i=1}^{n} (r_i - ME)^2\right)^{0.5}$		
SEMR		Standard error of mean residual. $SEMR = \left(\frac{1}{n(n-1)}\sum_{i=1}^{n} (r_i - ME)^2\right)^{0.5}$		
Parameters				
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

dt_L		Response time to obtain 0.1 m (or 1 kPa) drawdown in observation section counted from start of recovery phase.	[T]	s
TB		Flow capacity in a one-dimensional structure of width B and transmissivity T. Transient evaluation of one-dimensional structure	$[L^3/T]$	m^3/s
T		Transmissivity	$[L^2/T]$	m^2/s
T_M		Transmissivity according to Moye (1967)	$[L^2/T]$	m^2/s
T_Q		Evaluation based on Q/s and regression curve between Q/s and T, as example see Rhén et al (1997) p. 190.	$[L^2/T]$	m^2/s
T_S		Transmissivity evaluated from slug test	$[L^2/T]$	m^2/s
T_D		Transmissivity evaluated from PFL-Difference Flow Meter	$[L^2/T]$	m^2/s
T_I		Transmissivity evaluated from Impeller flow log	$[L^2/T]$	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
T_{Tot}		Judged most representative transmissivity for particular test section and (in certain cases) evaluation time with respect to available data (made by SKB at a later stage).	$[L^2/T]$	m^2/s
K		Hydraulic conductivity	[L/T]	m/s
K_s		Hydraulic conductivity based on spherical flow model	[L/T]	m/s
K_m		Hydraulic conductivity matrix, intact rock	[L/T]	m/s
k		Intrinsic permeability	$[L^2]$	m^2
kb		Permeability-thickness product: kb=k·b	$[L^3]$	m^3
SB		Storage capacity in a one-dimensional structure of width B and storage coefficient S. Transient evaluation of one-dimensional structure	[L]	m
SB*		Assumed storage capacity in a one-dimensional structure of width B and storage coefficient S. Transient evaluation of one-dimensional structure	[L]	m
S		Storage coefficient, (Storativity)	[-]	-
S*		Assumed storage coefficient	[-]	-
S_y		Theoretical specific yield of water (Specific yield; unconfined storage. Defined as total porosity (n) minus retention capacity (S_r)	[-]	-
S_{ya}		Specific yield of water (Apparent specific yield); unconfined storage, field measuring. Corresponds to volume of water achieved on draining saturated soil or rock in free draining of a volumetric unit. S_{ya}= S_y (often called S_y in literature)	[-]	-
S_r		Specific retention capacity, (specific retention of water, field capacity) (Specific retention); unconfined storage. Corresponds to water volume that the soil or rock has left after free draining of saturated soil or rock.	[-]	-
S_f		Fracture storage coefficient	[-]	-
S_m		Matrix storage coefficient	[-]	-
S_{NLR}		Storage coefficient, evaluation based on non-linear regression	[-]	-
S_{Tot}		Judged most representative storage coefficient for particular test section and (in certain cases) evaluation	[-]	-

		time with respect to available data (made by SKB at a later stage).		
S_s		Specific storage coefficient; confined storage.	[1/L]	1/m
S_s*		Assumed specific storage coefficient; confined storage.	[1/L]	1/m
c_f		Hydraulic resistance: The hydraulic resistance is an aquitard with a flow vertical to a two-dimensional formation. The inverse of c is also called Leakage coefficient. c_f=b´/K´ where b´ is thickness of the aquitard and K´ its hydraulic conductivity across the aquitard.	[T]	s
L_f		Leakage factor: $L_f = (K \cdot b \cdot c_f)^{0.5}$ where K represents characteristics of the aquifer.	[L]	m
ξ	Skin	Skin factor	[-]	-
ξ*	Skin	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	Stor-ratio	$\omega = S_f / (S_f + S_m)$, storage ratio (Storativity ratio); the ratio of storage coefficient between that of the fracture and total storage.	[-]	-
λ	Interflow-coeff	$\lambda = \alpha \cdot (K_m / K_f) \cdot r_w^2$ 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
nc_t		Porosity-compressibility factor: $nc_t = n \cdot c_t$	$[(LT^2)/M]$	1/Pa
nc_tb		Porosity-compressibility-thickness product: $nc_tb = n \cdot c_t \cdot b$	$[(L^2T^2)/M]$	m/Pa
n		Total porosity	-	-
n_e		Kinematic porosity, (Effective porosity)	-	-
e		Transport aperture. $e = n_e \cdot b$	[L]	m
ρ	Density	Density	$[M/L^3]$	kg/(m^3)
ρ_w	Density-w	Fluid density in measurement section during pumping/injection	$[M/L^3]$	kg/(m^3)
ρ_o	Density-o	Fluid density in observation section	$[M/L^3]$	kg/(m^3)
ρ_{sp}	Density-sp	Fluid density in standpipes from measurement section	$[M/L^3]$	kg/(m^3)
μ	my	Dynamic viscosity	[M/LT]	Pa s
μ_w	my	Dynamic viscosity (Fluid density in measurement section during pumping/injection)	[M/LT]	Pa s
FC_T		Fluid coefficient for intrinsic permeability, transference of k to K; $K = FC_T \cdot k$; $FC_T = \rho_w \cdot g / \mu_w$	[1/LT]	1/(ms)
FC_S		Fluid coefficient for porosity-compressibility, transference	$[M/T^2L^2]$	Pa/m

		of c_t to S_s ; S_s=FC_S·n·c_t ; FC_S=ρ_w ·g		
Index on K, T and S				
S		S: semi-log		
L		L: log-log		
f		Pump phase or injection phase, designation following S or L (withdrawal)		
s		Recovery phase, designation following S or L (recovery)		
NLR		NLR: Non-linear regression. Performed on the entire test sequence, perturbation and recovery		
M		Moye		
GRF		Generalised Radial Flow according to Barker (1988)		
m		Matrix		
f		Fracture		
measl		Measurement limit. Estimated measurement limit on parameter being measured (T or K)		
T		Judged best evaluation based on transient evaluation.		
Tot		Judged most representative parameter for particular test section and (in certain cases) evaluation time with respect to available data (made by SKB at a later stage).		
b		Bloch property in a numerical groundwater flow model		
e		Effective property (constant) within a domain in a numerical groundwater flow model.		
Index on p and Q				
0		Initial condition, undisturbed condition in open holes		
i		Natural, "undisturbed" condition of formation parameter		
f		Pump phase or injection phase (withdrawal, flowing phase)		
s		Recovery, shut-in phase		
p		Pressure or flow in measuring section at end of perturbation period		
F		Pressure in measuring section at end of recovery period.		
m		Arithmetical mean value		
c		Estimated value. The index is placed last if index for “where” and “what” are used. Simulated value		
m		Measured value. The index is placed last if index for “where” and “what” are used. Measured value		
Some miscellaneous indexes on p and h				
w		Test section (final difference pressure during flow phase in test section can be expressed dp_{wp}; First index shows “where” and second index shows “what”)		
o		Observation section (final difference pressure during flow phase in observation section can be expressed dp_{op}; First index shows “where” and second index shows “what”)		
f		Fresh-water head. Water is normally pumped up from section to measuring hoses where pressure and level are observed. Density of the water is therefore approximately the same as that of the measuring section. Measured groundwater level is therefore normally represented by what is defined as point-water head. If pressure at the measuring level is recalculated to a level for a column of water with density of fresh water above the measuring point it is referred to as fresh-water head and h is indicated last by an f. Observation section (final level during flow phase in observation section can be expressed h_{opf}; the first index shows “where” and the second index shows “what” and the last one “recalculation”)		

APPENDIX 7

SICADA Data Tables

APPENDIX 7-1

Capacity Test

(Simplified version v1.2)

SICADA/Data Import Template

SKB & Ergodata AB 2004

File Identity	
Created By	Reinder van der Wall
Created	2004.09.09 16:38

Activity Type	9 Capacity test
Project	AP PS 400-03-077

Activity Information						Additional Activity Data									
						C30	C40	I160	I250	P20	P200	P220	R110	R240	R90
Idcode	**Start Date**	**Stop Date**	**Secup (m)**	**Seclow (m)**	**Section No**	**Company evaluating data**	**Company performing field work**	**Instrument**	**Test equipment**	**Field crew manager**	**Field crew**	**Person evaluating data**	**Field Notes ID**	**calibration type**	**Quality plan**
HAV12	2004.06.30 18:30	2004.06.30 18:40	11.34	157.80		Golder	Golder		HTHB	Reinder van der Wall	Reinder van der Wall, Nils Rahm	Cristian Enachescu			
HAV14	2004.07.07 13:00	2004.07.07 13:13	12.85	182.40		Golder	Golder		HTHB	Reinder van der Wall	Reinder van der Wall, Tomas Cronquist	Cristian Enachescu			
HAV11	2004.07.12 13:32	2004.07.12 13:42	6.03	220.50		Golder	Golder		HTHB	Reinder van der Wall	Reinder van der Wall, Karsten Ebeling	Cristian Enachescu			
HSH04	2004.07.15 10:20	2004.07.15 10:50	9.00	236.20		Golder	Golder		HTHB	Reinder van der Wall	Reinder van der Wall, Karsten Ebeling	Cristian Enachescu			
HSH05	2004.07.17 13:31	2004.07.17 13:41	6.20	200.20		Golder	Golder		HTHB	Reinder van der Wall	Reinder van der Wall, Karsten Ebeling	Cristian Enachescu			
HAV13	2004.07.20 10:55	2004.07.20 11:15	9.04	142.20		Golder	Golder		HTHB	Reinder van der Wall	Reinder van der Wall, Karsten Ebeling	Cristian Enachescu			

APPENDIX 7-2

Flow Logging-Impeller

(Simplified version v1.2)

SICADA/Data Import Template

SKB & Ergodata AB 2004

File Identity	500
Created By	Reinder van der Wall
Created	2004.09.21 11:07

Activity Type	PLU Flow logging-Impeller	**Project**	AP PS 400-03-077

Activity Information						Additional Activity Data								
						C10	I250	P20	P200	P220	R110	R240	R25	R90
Idcode	**Start Date**	**Stop Date**	**Secup (m)**	**Seclow (m)**	**Section No**	**Company**	**Test equipment**	**Field crew manager**	**Field crew**	**Person evaluating data**	**Field Notes ID**	**calibration type**	**Report**	**Quality plan**
HAV12	2004.07.02 13:50	2004.07.02 20:52	30.00	156.00		Golder	HTHB	Reinder van der Wall	Reinder van der Wall, Tomas Cronquist	Reinder van der Wall				
HAV14	2004.07.08 11:00	2004.07.08 19:36	32.00	180.00		Golder	HTHB	Reinder van der Wall	Reinder van der Wall, Tomas Cronquist	Reinder van der Wall				
HAV11	2004.07.13 10:30	2004.07.13 19:03	26.00	122.00		Golder	HTHB	Reinder van der Wall	Reinder van der Wall, Karsten Ebeling	Reinder van der Wall				
HSH04	2004.07.16 10:15	2004.07.16 15:50	25.00	202.00		Golder	HTHB	Reinder van der Wall	Reinder van der Wall, Karsten Ebeling	Reinder van der Wall				
HSH05	2004.07.18 10:30	2004.07.18 15:18	36.00	198.00		Golder	HTHB	Reinder van der Wall	Reinder van der Wall, Karsten Ebeling	Reinder van der Wall				
HAV13	2004.07.21 11:42	2004.07.21 11:42	22.00	22.00		Golder	HTHB	Reinder van der Wall	Reinder van der Wall, Karsten Ebeling	Reinder van der Wall				

Table	plu_impell_main_res
	Flowlogging with impeller, evaluated data of the entire hole

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
l_corr	FLOAT	m	Corrected length to point of measured value
cum_flow_q	FLOAT	m**3/s	Q: Cumulative flow rate:Q1-Qo, see table description
cum_flow_qo	FLOAT	m**3/s	Qo: Undisturbed cumulative flow rate, see table description
cum_flow_q1	FLOAT	m**3/s	Q1: Pumpeded cumulative flow rate, see table description
cum_flow_qt	FLOAT	m**3/s	Q_T:Cumulative flow rate:Q at the top of meas.interval,see .
cum_flow_q1t	FLOAT	m**3/s	Q_1T:Cumulative flow:Q1at the top of measured interval,see .
qt_corr	FLOAT	m**3/s	QTcorr:Cumulative flow QT based on corrected bh.diameter.
transmissivity_	FLOAT	m**2/s	T: Transmissivity of the entire hole, see table description
value_type_t	CHAR		0:true value,-1:T<lower meas.limit,1:T>upper meas.limit
bc_t	CHAR		Best choice code: 1 means T is best transm. choice, else 0
cum_transmiss	FLOAT	m**2	T_F: Cumulative transmissivity, see table description
value_type_tf	CHAR		0:true value,-1:TF<lower meas.limit,1:TF>upper meas.limit
bc_tf	CHAR		Best choice code: 1 means TF is best transm. choice, else 0
transmissivity_	FLOAT	m**2	T_FT: Cumulative transmissivity, see table description
value_type_tft	CHAR		0:true value,-1:TFT<lower meas.limit,1:TFT>upper meas.limit
l_meas_limit_t	FLOAT	m**2/s	Lower measurement limit of T_F,see table description
u_meas_limit_	FLOAT	m**2/s	Upper measurement limit of T_F, see table description
bc_tft	CHAR		Best choice code: 1 means TFT is best transm. choice,else 0
fluid_temp_tew	FLOAT	oC	Undisturbed fluid temperature of test section,see
fluid_elcond_e	FLOAT	mS/m	Undisturbed fluid el.conductivity of testsection,see descr.
total_salinity_t	FLOAT	mg/l	Undisturbed total salinity of test section, see table descr.
fluid_temp_tew	FLOAT	oC	Fluid temperature of test section,see table descr.
fluid_elcond_e	FLOAT	mS/m	Fluid el.conductivity of test section,see table descr.
total_salinity_t	FLOAT	mg/l	Total salinity of test section, see table descr.
reference	CHAR		SKB number for reports describing data and results
comments	CHAR		Short comment to evaluated data (optional)
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	l_corr	cum_flow_q
HAV12	2004.07.02 13:50	2004.07.02 20:52	30.00	156.00			1.1595E-03
HAV14	2004.07.08 11:00	2004.07.08 19:36	32.00	180.00			1.0263E-03
HAV11	2004.07.13 10:30	2004.07.13 19:03	26.00	122.00			1.1740E-03
HSH04	2004.07.16 10:15	2004.07.16 15:50	25.00	202.00			4.3500E-05
HSH05	2004.07.18 10:30	2004.07.18 15:18	36.00	198.00			1.6670E-05
HAV13	2004.07.21 11:42	2004.07.21 11:42	22.00	22.00			1.1980E-03

idcode	cum_flow_qo	cum_flow_q1	cum_flow_qt	cum_flow_q1t	qt_corr	transmissivity_hole_t	value_type_t	bc_t
HAV12			1.1230E-03			1.84E-04	0	0
HAV14			1.1230E-03			1.40E-04	0	0
HAV11			1.1900E-03			9.20E-05	0	0
HSH04			5.8170E-04			9.60E-04	0	0
HSH05			6.9330E-05			5.22E-04	0	0
HAV13			1.1688E-03			1.83E-04	0	0

idcode	cum_transmissivity_tf	value_type_tf	bc_tf	transmissivity_tft	value_type_tft	l_meas_limit_tf	u_meas_limit_tf	bc_tft
HAV12	1.84000E-04	0	0			6.25E-06		
HAV14	1.31100E-04	0	0			7.46E-06		
HAV11	9.20000E-05	0	0			1.18E-05		
HSH04	7.18000E-05	0	0			5.87E-06		
HSH05	1.25500E-04	0	0			3.74E-06		
HAV13	1.83000E-04	0	0			1.04E-05		

idcode	fluid_temp_tewo	fluid_elcond_ecwo	total_salinity_tdswo	fluid_temp_tew	fluid_elcond_ecw	total_salinity_tdsw	reference	comments
HAV12	8.83	993.0		8.34	820.8			
HAV14	9.37	30.8		8.42	32.0			
HAV11	8.92	1161.0		8.79	1143.0			
HSH04	9.63	824.8		12.49	878.0			
HSH05	9.34	789.0		8.52	737.3			
HAV13				8.66	833.7			

Table	plu_impeller_anomaly
	Evaluated data of interpreted anomalies

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
upper_limit	FLOAT	m	Corrected upper limit of anomaly, see table description
lower_limit	FLOAT	m	Corrected lower limit of anomaly in borehole,see descr.
fluid_temp_tew	FLOAT	oC	Section fluid temperature, see table description.
fluid_elcond_ecw	FLOAT	mS/m	section fluid electric conductivity,see table description
fluid_salinity_tdsw	FLOAT	mg/l	Total salinity of section fluid, see table description
deltaqi	FLOAT	m**3/s	deltaQi : Flow rate of interpreted flow anomaly i
deltaqi_corr	FLOAT	m**3/s	deltaQicorr=deltaQ1 based on corrected borehole diam.
spec_cap_deltaqi_sf	FLOAT	m**2/s	deltaQi/S_FL: Specific capacity of interpreted flow anomaly
value_type_qi_sfl	CHAR		0:true value,-1:<lower meas.limit,1:>upper meas.limit.
bi	FLOAT	m	Interpreted formation thickness representative for Ti, see..
transmissivity_ti	FLOAT	m**2/s	Ti:Evaluated transmissivity of flow anomaly,see table descr.
value_type_ti	CHAR		0:true value,-1:Ti<lower meas.limit,1:Ti>upper meas.limit.
bc_ti	CHAR		Best choice code.1 means Ti is best choice oT, else 0
l_meas_limit_ti	FLOAT	m**2/s	Lower measurement limit of Ti, see table description
u_meas_limit_ti	FLOAT	m**2/s	Upper measurement limit of Ti, see table description
comments	CHAR		Short comment on 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	upper_limit	lower_limit	fluid_temp_tew	fluid_elcond_ecw	fluid_salinity_tdsw
HAV12	2004.07.02 13:50	2004.07.02 20:52	30.00	156.00		151.00	152.00	8.82	992.8	
HAV12	2004.07.02 13:50	2004.07.02 20:52	30.00	156.00		142.50	146.00	8.75	962.3	
HAV12	2004.07.02 13:50	2004.07.02 20:52	30.00	156.00		134.50	136.00	8.71	951.8	
HAV12	2004.07.02 13:50	2004.07.02 20:52	30.00	156.00		32.50	36.00	8.41	898.0	
HAV14	2004.07.08 11:00	2004.07.08 19:36	32.00	180.00		165.00	167.00	9.04	29.8	
HAV14	2004.07.08 11:00	2004.07.08 19:36	32.00	180.00		42.00	45.00	8.66	32.5	
HAV11	2004.07.13 10:30	2004.07.13 19:03	26.00	122.00		122.00	220.50	8.92	1160.0	
HAV11	2004.07.13 10:30	2004.07.13 19:03	26.00	122.00		57.50	61.50	8.81	1154.0	
HSH04	2004.07.16 10:15	2004.07.16 15:50	25.00	202.00		28.00	29.00	12.18	863.0	
HSH05	2004.07.18 10:30	2004.07.18 15:18	36.00	198.00		62.00	64.00	8.53	769.6	
HAV13	2004.07.21 11:42	2004.07.21 11:42	22.00	22.00		22.00	142.20	8.66	833.7	

idcode	deltaqi	deltaqi_corr	spec_cap_deltaqi_sfl	value_type_qi_sfl	bi	transmissivity_ti	value_type_ti	bc_ti	l_meas_limit_ti	u_meas_limit_ti	comments
HAV12	4.7830E-04				1.00	7.74E-05	0	0	6.25E-06		
HAV12	3.5670E-04				3.50	5.77E-05	0	0	6.25E-06		
HAV12	1.3500E-04				1.50	2.19E-05	0	0	6.25E-06		
HAV12	1.6670E-04				3.50	2.70E-05	0	0	6.25E-06		
HAV14	6.1330E-04				2.00	8.00E-05	0	0	7.46E-06		
HAV14	3.9170E-04				3.00	5.11E-05	0	0	7.46E-06		
HAV11	1.0980E-03				98.50	8.49E-05	0	0	1.18E-05		
HAV11	9.1670E-05				4.00	7.09E-06	0	0	1.18E-05		
HSH04	4.3500E-05				1.00	7.18E-05	0	0	5.87E-06		
HSH05	1.6670E-05				2.00	1.25E-04	0	0	3.74E-06		
HAV13	1.1980E-03				120.20	1.83E-04	0	0	1.04E-05		

Table	plu_impeller_basic_d
	Flow logging using impeller, basic data

Column	Datatype	Unit	Column Description
site	CHAR		Investigation site name
start_date	DATE		Date (yymmdd hh:mm:ss)
stop_date	DATE		Date (yymmdd hh:mm:ss)
start_flowlogging	DATE	yyyymmdd	Date and time of flowlogging start (YYYY-MM-DD hh:mm:ss)
stop_flowlogging	DATE	yyyymmdd	Date and time of flowlogging stop (YYYY-MM-DD hh:mm:ss)
l_corrected	FLOAT	m	Corrected length during logging, see table description
test_type	CHAR		Type of test, one of 7; see table description
formation_type	CHAR		1: Rock, 2: Soil (supeficial deposits)
q_measl_l	FLOAT	m**3/s	Estimated lower measurement limit of borehole flow in probe
q_measl_u	FLOAT	m**3/s	Estimated upper measurement limit of borehole flow in probe
surface_flow_qp	FLOAT	m**3/s	Flow rate at surface during flow logging
dur_flow_phase_tp	FLOAT	s	Time for the flowing phase of the test
dur_flowlog_tfl	FLOAT	s	Time for flowlogging survey
drawdown_sfl	FLOAT	m	Average drawdown open borehole during flowlogging
initial_head_ho	FLOAT	m.a.s.l.	Initial hydraulic head (open borehole),see table description
head_first_pump_hp	FLOAT	m.a.s.l.	Stabilised head during 1st pump period,see table description
reference	CHAR		SKB report number for reports describing data & evaluation
comments	VARCHAR		Short comment to the evaluated parameters (optional))

idcode	start_date	stop_date	secup	seclow	section_no	start_flowlogging	stop_flowlogging	l_corrected	test_type	formation_type
HAV12	2004.07.02 13:50	2004.07.02 20:52	30.00	156.00		2004.07.02 13:50	2004.07.02 20:52		6	1
HAV14	2004.07.08 11:00	2004.07.08 19:36	32.00	180.00		2004.07.08 11:00	2004.07.08 19:36		6	1
HAV11	2004.07.13 10:30	2004.07.13 19:03	26.00	122.00		2004.07.13 10:30	2004.07.13 19:03		6	1
HSH04	2004.07.16 10:15	2004.07.16 15:50	25.00	202.00		2004.07.16 10:15	2004.07.16 15:50		6	1
HSH05	2004.07.18 10:30	2004.07.18 15:18	36.00	198.00		2004.07.18 10:30	2004.07.18 15:18		6	1
HAV13	2004.07.21 11:42	2004.07.21 11:42	22.00	22.00		2004.07.21 11:42	2004.07.21 11:42		6	1

idcode	q_measl_l	q_measl_u	surface_flow_qp	dur_flow_phase_tp	dur_flowlog_tfl	drawdown_sfl	initial_head_ho	head_first_pump_hp	reference	comments
HAV12	5.0000E-05	1.6670E-03	1.0600E-03	36180.00	25320.00	7.88	-0.59	-8.47		
HAV14	5.0000E-05	1.6670E-03	1.0600E-03	39000.00	30960.00	6.47	-3.41	-9.88		
HAV11	5.0000E-05	1.6670E-03	1.1900E-03	38220.00	30780.00	4.12	0.25	-3.87		
HSH04	5.0000E-05	1.6670E-03	5.6000E-04	36240.00	20100.00	8.41	0.28	-8.13		
HSH05	5.0000E-05	1.6670E-03	6.9500E-05	36600.00	17280.00	13.37	-0.11	-13.48		
HAV13	5.0000E-05	1.6670E-03	1.1500E-03	36060.00	100.00	4.81	-0.62	-5.43		

APPENDIX 7-3

Interference Test - CRwr

(Simplified version v1.2)

SICADA/Data Import Template

SKB & Ergodata AB 2004

File Identity	
Created By	Reinder van der Wall
Created	2004.09.10 13:54

Activity Type	10 PLU Interference test - CRwr
Project	AP PS 400-03-077

Activity Information						**Additional Activity Data**							
						C10	ID80	P20	P200	P220	R110	R25	R90
Idcode	**Start Date**	**Stop Date**	**Secup (m)**	**Seclow (m)**	**Section No**	**Company**	**Observation borehole**	**Field crew manager**	**Field crew**	**Person evaluating data**	**Field Notes ID**	**Report**	**Quality plan**
HAV12	040702 08:54	040703 08:44	11.34	157.80		Golder	HAV13, HAV14, HAV02, HAV03, HAV05, HAV07, HAV08, KAV01	Reinder van der Wall	Reinder van der Wall, Nils Rahm	Cristian Enachescu			
HAV12 rep	040704 08:24	040705 08:43	11.34	157.80		Golder	HAV13, HAV14, HAV02, HAV03, HAV05, HAV07, HAV08, KAV02	Reinder van der Wall	Reinder van der Wall, Tomas Cronquist	Cristian Enachescu			
HAV14	040707 08:09	040709 10:11	12.85	182.40		Golder	HAV13, KAV04A, HAV05, HAV07, HAV08	Reinder van der Wall	Reinder van der Wall, Karsten Ebeling	Cristian Enachescu			
HAV11	040711 08:24	040714 09:06	6.03	220.50		Golder	KAV04A, KSH03, KAV01	Reinder van der Wall	Reinder van der Wall, Karsten Ebeling	Cristian Enachescu			
HSH04	040715 08:11	040717 08:35	9.00	236.20		Golder	HSH06, HSH01	Reinder van der Wall	Reinder van der Wall, Karsten Ebeling	Cristian Enachescu			
HSH05	040717 13:08	040719 08:43	6.20	200.20		Golder		Reinder van der Wall	Reinder van der Wall, Karsten Ebeling	Cristian Enachescu			
HAV13	040720 08:03	040722 13:31	9.04	142.20		Golder	HAV12, HAV14, HAV02, HAV03, HAV05, HAV07, HAV08, KAV01	Reinder van der Wall	Reinder van der Wall, Karsten Ebeling	Cristian Enachescu			

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 oeriod
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_l	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	Fimal 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
HAV12	040702 08:54	040703 08:44	11.34	157.80		1B	1
HAV12 rep	040704 08:24	040705 08:43	11.34	157.80		1B	1
HAV14	040707 08:09	040709 10:11	6.03	182.40		1B	1
HAV11	040711 08:24	040714 09:06	6.03	220.50		1B	1
HSH04	040715 08:11	040717 08:35	9.00	236.20		1B	1
HSH05	040717 13:08	040719 08:43	6.20	200.20		1B	1
HAV13	040720 08:03	040722 13:31	9.04	142.20		1B	1

idcode	start_flow_period	stop_flow_period	mean_flow_rate_qm	flow_rate_end_qp	value_type_qp	q_measl_l	q_measl_u
HAV12	2004.07.02 11:48:00	2004.07.02 21:51:00	1.0700E-03	1.0600E-03	0	5.0000E-05	1.6700E-03
HAV12 rep	2004.07.04 08:25:00	2004.07.04 18:26:00	1.0700E-03	1.0600E-03	0	5.0000E-05	1.6700E-03
HAV14	2004.07.08 08:50:00	2004.07.08 19:40:00	1.0700E-03	1.0600E-03	0	5.0000E-05	1.6700E-03
HAV11	2004.07.13 08:27:00	2004.07.13 19:04:00	1.1900E-03	1.1900E-03	0	5.0000E-05	1.6700E-03
HSH04	2004.07.16 08:12:00	2004.07.16 18:15:00	5.8200E-04	5.6000E-04	0	5.0000E-05	1.6700E-03
HSH05	2004.07.18 08:08:00	2004.07.18 18:18:00	6.9300E-05	6.9500E-05	0	5.0000E-05	1.6700E-03
HAV13	2004.07.21 08:44:00	2004.07.21 18:45:00	1.1700E-03	1.1500E-03	0	5.0000E-05	1.6700E-03

idcode	tot_volume_vp	dur_flow_phase_tp	dur_rec_phase_tf	initial_head_hi	head_at_flow_end_hp	final_head_hf	initial_press_pi	press_at_flow_end_pp
HAV12	3.6900E+01	36180.00	39180.00	-0.59	-8.47	-0.47	215.90	137.10
HAV12 rep	3.8464E+01	36060.00	51540.00	-0.34	-8.45	-0.59	218.40	137.30
HAV14	4.1730E+01	39000.00	45300.00	-3.41	-9.88	-3.94	208.90	144.20
HAV11	4.5482E+01	38220.00	48840.00	0.25	-3.87	-0.15	246.70	205.50
HSH04	2.1092E+01	36240.00	51600.00	0.28	-8.13	0.47	240.20	156.10
HSH05	2.5364E+00	36600.00	51900.00	-0.11	-13.48	-0.42	325.50	191.80
HAV13	4.2190E+01	36060.00	67500.00	-0.62	-5.43	-0.85	197.20	149.10

idcode	final_press_pf	fluid_temp_tew	fluid_elcond_ecw	fluid_salinity_tdsw	fluid_salinity_tdswm	reference	comments	lp
HAV12	214.10	8.34	820.8					
HAV12 rep	215.90	8.36	817.7					
HAV14	203.60	8.42	32.0					
HAV11	242.70	8.79	1143.0					
HSH04	242.10	12.49	878.0					
HSH05	322.40	8.52	737.3					
HAV13	194.90	8.66	833.7					

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	transmissivity_moye
HAV12	040702 08:54	040703 08:44	11.34	157.80		1B	1	152.00		1.35E-04	0				1.71E-04
HAV12 rep	040704 08:24	040705 08:43	11.34	157.80		1B	1	152.00		1.31E-04	0				1.66E-04
HAV14	040707 08:09	040709 10:11	6.03	182.40		1B	1	167.00		1.63E-04	0				2.10E-04
HAV11	040711 08:24	040714 09:06	6.03	220.50		1B	1	220.00		2.89E-04	0				3.85E-04
HSH04	040715 08:11	040717 08:35	9.00	236.20		1B	1	125.00		6.65E-05	0				8.89E-05
HSH05	040717 13:08	040719 08:43	6.20	200.20		1B	1			5.20E-06	0				6.81E-06
HAV13	040720 08:03	040722 13:31	9.04	142.20		1B	1	121.00		2.39E-04	0				2.99E-04

idcode	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	transmissivity_tt	value_type_tt	bc_tt	l_measl_q_s
HAV12	0	0										1.80E-04	0	1	1.00E-04
HAV12 rep	0	0										1.06E-04	0	1	1.00E-04
HAV14	0	0										1.39E-04	0	1	1.00E-04
HAV11	0	0										9.20E-05	0	1	8.00E-05
HSH04	0	0										9.60E-04	0	1	8.00E-04
HSH05	0	0										5.22E-04	0	1	4.00E-06
HAV13	0	0										1.83E-04	0	1	1.00E-04

idcode	u_measl_q_s	storativity_s	assumed_s	leakage_koeff	hydr_cond_ks	value_type_ks	l_meas_limit_ks	u_meas_limit_ks	spec_storage_ss	assumed_ss	c	cd	skin	stor_ratio	interflow_coeff
HAV12	3.00E-04	2.25E-06	1.00E-04								1.98E-06	2.86E+01	1.60E+00		
HAV12 rep	1.00E-03	1.58E-05	1.00E-04								1.99E-06	4.09E+00	1.61E+01		
HAV14	3.00E-04	6.04E-05	1.00E-04								1.59E-06	8.55E-01	-2.79E+00		
HAV11	1.00E-03	1.15E-04	1.00E-04								2.75E-06	7.77E-01	1.02E+00		
HSH04	1.00E-03	1.00E-04	1.00E-04								1.65E-06	5.36E-01	8.33E+01		
HSH05	6.00E-04	1.00E-04	1.00E-04								2.28E-06	7.41E-01	0.00E+00		
HAV13	3.00E-04	4.81E-06	1.00E-04								1.58E-06	1.07E+01	-4.39E+00		

idcode	dt1	dt2	transmissivity_t_ilr	storativity_s_ilr	value_type_t_ilr	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
HAV12	540.00	36000.00															
HAV12 rep	720.00	36000.00															
HAV14	720.00	14400.00															
HAV11	360.00	36000.00															
HSH04	2160.00	28800.00															
HSH05	25200.00	36000.00															
HAV13	144.00	18000.00															

APPENDIX 7-4

Interference Test – Observed Holes

(Simplified version v1.2)

SICADA/Data Import Template

SKB & Ergodata AB 2004

File Identity	
Created By	Reinder van der Wall
Created	2004.09.10 13:55

Activity Type	PLU Interference test-obs.holes
Project	AP PS 400-03-077

Activity Information						**Additional Activity Data**									
						C30	C40	I160	P20	P200	P220	R110	R25	R85	R90
Idcode	**Start Date**	**Stop Date**	**Secup (m)**	**Seclow (m)**	**Section No**	**Company evaluating data**	**Company performing field work**	**Instrument**	**Field crew manager**	**Field crew**	**Person evaluating data**	**Field Notes ID**	**Report**	**Pumped/injected borehole**	**Quality plan**
HAV14	2004.07.04 07:59	2004.07.05 08:57	6.03	182.40		Golder	Golder		Reinder van der Wall	Reinder van der Wall, Karsten Ebeling	Cristian Enachescu				
HAV08	2004.07.07 09:40	2004.07.09 10:11	0.00	63.00		Golder	Golder		Reinder van der Wall	Reinder van der Wall, Karsten Ebeling	Cristian Enachescu				
HAV07	2004.07.07 09:13	2004.07.09 09:39	4.00	100.00		Golder	Golder		Reinder van der Wall	Reinder van der Wall, Karsten Ebeling	Cristian Enachescu				
HAV12	2004.07.20 08:19	2004.07.22 11:34	11.34	157.80		Golder	Golder		Reinder van der Wall	Reinder van der Wall, Karsten Ebeling	Cristian Enachescu				
HAV02	2004.06.26 00:23	2004.07.30 22:23	0.13	163.00		Golder	Golder		Reinder van der Wall	Reinder van der Wall, Karsten Ebeling	Cristian Enachescu				

Table	plu_inf_test_obs_d PLU interference test, Observation section data

Column	Datatype	Unit	Column Description
site	CHAR		Investigation site name
activity_type	CHAR		
start_date	DATE		
stop_date	DATE		
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, one of 7, see table description
formation_type	CHAR		1: Rock, 2: Soil (superficial deposits)
start_flow_period	DATE	yyyymmdd	Date and time start of pumping/injection(YYMMDDhhmmss)
stop_flow_period	DATE	yyyymmdd	Date and time stop of pumping/injection(YYMMDDhhmmss)
test_borehole	CHAR		Idcode of pumped/injected borehole
test_secup	FLOAT	m	Upper limit of pumped/injected section
test_seclow	FLOAT	m	Lower limit of pumped/injected section
lp	FLOAT	m	Hydraulic point of application, see table description
radial_distance_rs	FLOAT	m	Radial distance:test sec.-obs.sec., see table description
shortest_distance_rt	FLOAT	m	Shortest distance: test sec.-obs.sec., see table description
time_lag_press_dtl	FLOAT	s	Time lag, pressure response obs. hole. See table description
initial_head_hi	FLOAT	m	Initial formation hydraulic 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 descr.
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 descript.
final_press_pf	FLOAT	kPa	Final pressure at the end of recovery phase, see table desc.
fluid_temp_teo	FLOAT	oC	Fluid temperature in formation at observation section
fluid_elcond_eco	FLOAT	mS/m	Fluid electrical conductivity of formation at obs-section
fluid_salinity_tdso	FLOAT	mg/l	Total salinity of section fluid,based on EC see table descr
fluid_salinity_tdsom	FLOAT	mg/l	Tot salinity of section fluid based on sampling,see descr
reference	CHAR		SKB report No for reports describing data and evaluation
comment	CHAR		Short comment to evaluated 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)

idcode	start_date	stop_date	secup	seclow	section_no	test_type	formation_type	start_flow_period	stop_flow_period
HAV14	2004.07.04 07:59	2004.07.05 08:57	6.03	182.40			1		
HAV08	2004.07.07 09:40	2004.07.09 10:11	0.00	63.00			1		
HAV07	2004.07.07 09:13	2004.07.09 09:39	4.00	100.00			1		
HAV12	2004.07.20 08:19	2004.07.22 11:34	11.34	157.80			1		
HAV02	2004.06.26 00:23	2004.07.30 22:23	0.13	163.00			1		

idcode	test_borehole	test_secup	test_seclow	lp	radial_distance_rs	shortest_distance_rt	time_lag_press_dtl	initial_head_hi	head_at_flow_end_hp
HAV14	HAV12	11.34	157.80	152.00	1120.00		564.00		
HAV08	HAV14	6.03	182.40	167.00	135.00		4196.00		
HAV07	HAV14	6.03	182.40	167.00	102.00		321.00		
HAV12	HAV13	9.04	142.20	121.00	535.00		5770.00		
HAV02	HAV13	9.04	142.20	121.00	163.00				

idcode	final_head_hf	initial_press_pi	press_at_flow_end_pp	final_press_pf	fluid_temp_teo	fluid_elcond_eco	fluid_salinity_tdso	fluid_salinity_tdsom	reference	comment
HAV14		121.27	120.61	121.48						
HAV08		31.57	28.35	30.10						
HAV07		34.77	28.52	33.10						
HAV12		19.64	18.77	19.28						
HAV02		94.02	85.21	93.25						

Table	plu_inf_test_obs_ed
	PLU interference test,Observation section 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_borehole	CHAR		Idcode of pumped/injected borehole
test_secup	FLOAT	m	Upper limit of pumped/injected section
test_seclow	FLOAT	m	Lower limit of pumped/injected section
formation_width_b	FLOAT	m	b:interpreted formation thickness repr. for evaluated T/B
width_of_channel_b	FLOAT	m	B:Interpreted width of formation with evaluated TB
tbo	FLOAT	m**3/s	TBo,T=transmissivity,B= width of formation, see table descr.
l_meas_limit_tb	FLOAT	m**3/s	Estimated lower limit for evaluated TB, see table descript.
u_meas_limit_tb	FLOAT	m**3/s	Estimated upper limit for evaluated TB,see table descript.
sbo	FLOAT	m	SBo;S=storativity,B=width of formation,see table description
leakage_factor_lfo	FLOAT	m	Lfo: 1D model for evaluation of leakage factor
transmissivity_tto	FLOAT	m**2/s	TTo=transmissivity, 2D model, see table description
value_type_tto	CHAR		0:true value (TTo),-1:<lower meas.limit,1:>upper meaus.limit
l_meas_limit_t	FLOAT	m**2/s	Estimated lower limit for evaluated TTO,see table descript.
u_meas_limit_t	FLOAT	m**2/s	Estimated upper limit of evaluated TTo,see table description
storativity_so	FLOAT		S:2D model for evaluation of storativity, see table descr.
leakage_coeff_o	FLOAT	1/s	K´/b´ :2D model evaluation of leakage coefficient,see descr.
hydr_kond_kso	FLOAT	m**2/s	3Dmodel evaluation of hydraulic conductivity,see table desc.
l_meas_limit_ks	FLOAT	m**2/s	Estimated lowermeas. limit of Ks,see table description
u_meas_limit_ks	FLOAT	m**2/s	Estimated upper meas. limit of Ks,see table description
spec_storage_sso	FLOAT	1/m	3Dmodel for evaluation of specific storage,se table descr.
dt1	FLOAT	s	Estimated start time of evaluation, see table description
dt2	FLOAT	s	Estimated stop time of evaluation, see table description
comments	CHAR		short comment to the evaluated parameters(0ptional)
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_borehole	test_secup	test_seclow	formation_width_b	width_of_channel_b	tbo	l_meas_limit_tb	u_meas_limit_tb	sbo
HAV14	2004.07.04 07:59	2004.07.05 08:57	6.03	182.40		HAV12	11.34	157.80		176.37				
HAV08	2004.07.07 09:40	2004.07.09 10:11	0.00	63.00		HAV14	6.03	182.40		63.00				
HAV07	2004.07.07 09:13	2004.07.09 09:39	4.00	100.00		HAV14	6.03	182.40		96.00				
HAV12	2004.07.20 08:19	2004.07.22 11:34	11.34	157.80		HAV13	9.04	142.20		146.46				
HAV02	2004.06.26 00:23	2004.07.30 22:23	0.13	163.00		HAV13	9.04	142.20		162.87				

idcode	leakage_factor_lfo	transmissivity_tto	value_type_tto	l_meas_limit_t	u_meas_limit_t	storativity_so	leakage_coeff_o	hydr_kond_kso	l_meas_limit_ks	u_meas_limit_ks	spec_storage_sso	dt1	dt2	comments
HAV14		8.75E-04	0			1.31E-05								
HAV08		2.32E-04	0			5.79E-04								
HAV07		5.40E-04	0			2.01E-04								
HAV12		7.59E-04	0			1.22E-04								
HAV02		5.37E-05	0			1.30E-04								

APPENDIX 7-5

Pumping Test - Submersible Pump

(Simplified version v1.2)

SICADA/Data Import Template

SKB & Ergodata AB 2004

File Identity	
Created By	Reinder van der Wall
Created	2004.09.09 13:51

Activity Type	10 Pumping test-submersible pump	**Project**	AP PS 400-03-077

Activity Information						**Additional Activity Data**							
						C10	I250	P20	P200	P220	R110	R25	R90
Idcode	**Start Date**	**Stop Date**	**Secup (m)**	**Seclow (m)**	**Section No**	**Company**	**Test equipment**	**Field crew manager**	**Field crew**	**Person evaluating data**	**Field Notes ID**	**Report**	**Quality plan**
HAV12	040702 08:54	040703 08:44	11.34	157.80		Golder	HTHB	Reinder van der Wall	Reinder van der Wall, Nils Rahm	Cristian Enachescu			
HAV12 rep	040704 08:24	040705 08:43	11.34	157.80		Golder	HTHB	Reinder van der Wall	Reinder van der Wall, Tomas Cronquist	Cristian Enachescu			
HAV14	040707 08:09	040709 10:11	12.85	182.40		Golder	HTHB	Reinder van der Wall	Reinder van der Wall, Karsten Ebeling	Cristian Enachescu			
HAV11	040711 08:24	040714 09:06	6.03	220.50		Golder	HTHB	Reinder van der Wall	Reinder van der Wall, Karsten Ebeling	Cristian Enachescu			
HSH04	040715 08:11	040717 08:35	9.00	236.20		Golder	HTHB	Reinder van der Wall	Reinder van der Wall, Karsten Ebeling	Cristian Enachescu			
HSH05	040717 13:08	040719 08:43	6.20	200.20		Golder	HTHB	Reinder van der Wall	Reinder van der Wall, Karsten Ebeling	Cristian Enachescu			
HAV13	040720 08:03	040722 13:31	9.04	142.20		Golder	HTHB	Reinder van der Wall	Reinder van der Wall, Karsten Ebeling	Cristian Enachescu			

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 oeriod
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_	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	Fimal 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
HAV12	040702 08:54	040703 08:44	11.34	157.80		1B	1
HAV12 rep	040704 08:24	040705 08:43	11.34	157.80		1B	1
HAV14	040707 08:09	040709 10:11	6.03	182.40		1B	1
HAV11	040711 08:24	040714 09:06	6.03	220.50		1B	1
HSH04	040715 08:11	040717 08:35	9.00	236.20		1B	1
HSH05	040717 13:08	040719 08:43	6.20	200.20		1B	1
HAV13	040720 08:03	040722 13:31	9.04	142.20		1B	1

idcode	start_flow_period	stop_flow_period	mean_flow_rate_qm	flow_rate_end_qp	value_type_qp	q_measl__l	q_measl__u
HAV12	2004.07.02 11:48:00	2004.07.02 21:51:00	1.0700E-03	1.0600E-03	0	5.0000E-05	1.6700E-03
HAV12 rep	2004.07.04 08:25:00	2004.07.04 18:26:00	1.0700E-03	1.0600E-03	0	5.0000E-05	1.6700E-03
HAV14	2004.07.08 08:50:00	2004.07.08 19:40:00	1.0700E-03	1.0600E-03	0	5.0000E-05	1.6700E-03
HAV11	2004.07.13 08:27:00	2004.07.13 19:04:00	1.1900E-03	1.1900E-03	0	5.0000E-05	1.6700E-03
HSH04	2004.07.16 08:12:00	2004.07.16 18:15:00	5.8200E-04	5.6000E-04	0	5.0000E-05	1.6700E-03
HSH05	2004.07.18 08:08:00	2004.07.18 18:18:00	6.9300E-05	6.9500E-05	0	5.0000E-05	1.6700E-03
HAV13	2004.07.21 08:44:00	2004.07.21 18:45:00	1.1700E-03	1.1500E-03	0	5.0000E-05	1.6700E-03

idcode	tot_volume_vp	dur_flow_phase_tp	dur_rec_phase_tf	initial_head_hi	head_at_flow_end_hp	final_head_hf	initial_press_pi
HAV12	3.6900E+01	36180.00	39180.00	-0.59	-8.47	-0.47	215.90
HAV12 rep	3.8464E+01	36060.00	51540.00	-0.34	-8.45	-0.59	218.40
HAV14	4.1730E+01	39000.00	45300.00	-3.41	-9.88	-3.94	208.90
HAV11	4.5482E+01	38220.00	48840.00	0.25	-3.87	-0.15	246.70
HSH04	2.1092E+01	36240.00	51600.00	0.28	-8.13	0.47	240.20
HSH05	2.5364E+00	36600.00	51900.00	-0.11	-13.48	-0.42	325.50
HAV13	4.2190E+01	36060.00	67500.00	-0.62	-5.43	-0.85	197.20

idcode	press_at_flow_end_pp	final_press_pf	fluid_temp_tew	fluid_elcond_ecw	fluid_salinity_tdsw	fluid_salinity_tdswm	reference	comments	lp
HAV12	137.10	214.10	8.34	820.8					
HAV12 rep	137.30	215.90	8.36	817.7					
HAV14	144.20	203.60	8.42	32.0					
HAV11	205.50	242.70	8.79	1143.0					
HSH04	156.10	242.10	12.49	878.0					
HSH05	191.80	322.40	8.52	737.3					
HAV13	149.10	194.90	8.66	833.7					

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	transmissivity_moye
HAV12	040702 08:54	040703 08:44	11.34	157.80		1B	1	152.00		1.35E-04	0				1.71E-04
HAV12 rep	040704 08:24	040705 08:43	11.34	157.80		1B	1	152.00		1.31E-04	0				1.66E-04
HAV14	040707 08:09	040709 10:11	6.03	182.40		1B	1	167.00		1.63E-04	0				2.10E-04
HAV11	040711 08:24	040714 09:06	6.03	220.50		1B	1	220.00		2.89E-04	0				3.85E-04
HSH04	040715 08:11	040717 08:35	9.00	236.20		1B	1	125.00		6.65E-05	0				8.89E-05
HSH05	040717 13:08	040719 08:43	6.20	200.20		1B	1			5.20E-06	0				6.81E-06
HAV13	040720 08:03	040722 13:31	9.04	142.20		1B	1	121.00		2.39E-04	0				2.99E-04

idcode	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	transmissivity_tt	value_type_tt	bc_tt	l_measl_q_s
HAV12	0	0										1.80E-04	0	1	1.00E-04
HAV12 rep	0	0										1.06E-04	0	1	1.00E-04
HAV14	0	0										1.39E-04	0	1	1.00E-04
HAV11	0	0										9.20E-05	0	1	8.00E-05
HSH04	0	0										9.60E-04	0	1	8.00E-04
HSH05	0	0										5.22E-04	0	1	4.00E-06
HAV13	0	0										1.83E-04	0	1	1.00E-04

idcode	u_measl_q_s	storativity_s	assumed_s	leakage_koeff	hydr_cond_ks	value_type_ks	l_meas_limit_ks	u_meas_limit_ks	spec_storage_ss	assumed_ss	c	cd	skin	stor_ratio	interflow_coeff
HAV12	3.00E-04	2.25E-06	1.00E-04								1.98E-06	2.86E+01	1.60E+00		
HAV12 rep	1.00E-03	1.58E-05	1.00E-04								1.99E-06	4.09E+00	1.61E+01		
HAV14	3.00E-04	6.04E-05	1.00E-04								1.59E-06	8.55E-01	-2.79E+00		
HAV11	1.00E-03	1.15E-04	1.00E-04								2.75E-06	7.77E-01	1.02E+00		
HSH04	1.00E-03	1.00E-04	1.00E-04								1.65E-06	5.36E-01	8.33E+01		
HSH05	6.00E-04	1.00E-04	1.00E-04								2.28E-06	7.41E-01	0.00E+00		
HAV13	3.00E-04	4.81E-06	1.00E-04								1.58E-06	1.07E+01	-4.39E+00		

idcode	dt1	dt2	transmissivity_t_ilr	storativity_s_ilr	value_type_t_ilr	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
HAV12	540.00	36000.00															
HAV12 rep	720.00	36000.00															
HAV14	720.00	14400.00															
HAV11	360.00	36000.00															
HSH04	2160.00	28800.00															
HSH05	25200.00	36000.00															
HAV13	144.00	18000.00															