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Forsmark Site Investigation

Hydraulic interference test in borehole HFM01

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Abstract

An interference test was performed at Forsmark with borehole HFM01 used as pumping borehole. The test was performed in order to increase the understanding of the hydraulic conditions in the north-western part of the candidate area at Forsmark. The main purpose of the interference test was to document how different fracture zones are connected hydraulically, to quantify their hydraulic properties and to clarify whether there are any hydraulic boundaries in the area.

The interference test was performed by pumping in HFM01 and monitoring pressure responses in different observation sections in surrounding boreholes. All boreholes monitored for potential responses are part of the HMS, the Hydro Monitoring System. In total, 44 observation sections in 18 observation boreholes were included in the interference test.

The flow period lasted for approximately three weeks and the subsequent recovery was measured for about five days. The recovery period had to be shortened compared to plan due to unexpected activities in the area. The pumping flow rate in HFM01 was relatively constant at c 89 L/min during the flow period, resulting in a final drawdown in the pumping borehole of about 26 m.

Out of the 44 observation sections included in the interference test, 6 did not respond at all to pumping in HFM01 or responded very weakly. Of the remaining 38 sections, 26 showed distinct responses. Three observation sections stand out in responding most strongly. These sections, HFM13: 159–173 m, HFM21: 12–202 m and HFM02: 38–48 m, display responses that are distinct enough to be characterized as potential high-transmissive zone responses between HFM01 and the actual sections.

Three observation sections, HFM13: 159–173 m, HFM20: 101–130 m and KFM02A: 490–518 m, as well as the pumping borehole were evaluated quantitatively using methods for transient evaluation. The transmissivities of each observation section were estimated at 3.5×10^{-4} m^2/s, 2.2×10^{-4} m^2/s and 4.0×10^{-4} m^2/s, respectively. For the pumping borehole, HFM01, the transmissivity from the transient evaluation was 1.5×10^{-4} m^2/s.

The estimated transmissivities from the observation section in HFM13 and from the pumping borehole HFM01 correspond fairly well to the T-values obtained in previous tests with other methods performed in these boreholes. In the observation sections HFM20: 101–130 m and KFM02A: 490–518 m, however, the evaluated transmissivities from the interference test were higher than from previous tests in the boreholes. This fact may possibly be due to that the calculated T-values for the observation sections from the interference test are more weighted towards the hydraulic properties close to the pumping borehole HFM01.

During the entire interference test, several observation sections were influenced by so called tidal effects. This fact caused the pressure data from certain observation sections to exhibit an oscillating behaviour.

Precipitation also affected several observation sections, resulting in rising pressures. This fact made the analysis of the recovery period more difficult in these sections.

Sammanfattning

En interferenstest genomfördes i Forsmark med borrhål HFM01 som pumphål för att öka förståelsen för de hydrauliska sambanden i den nordvästra delen av kandidatområdet i Forsmark. Huvudsyftet med det utförda interferenstestet var att dokumentera hur spricksystemen hänger ihop hydrauliskt och kvantifiera deras hydrauliska egenskaper, samt att klargöra om det finns några hydrauliska gränser inom området.

Interferenstestet utfördes genom att en tryckavsänkning skapades i HFM01 och tryckresponser registrerades i olika observationssektioner i ett flertal omgivande borrhål. Alla borrhål där eventuella tryckresponser övervakades ingår i SKBs hydromoniteringssystem, HMS. 18 borrhål med sammanlagt 44 observationssektioner ingick i interfenstestet.

Pumpfasen pågick under ca tre veckor och den påföljande återhämtningen registrerades i ungefär fem dagar. Återhämtningen pågick under kortare tid än planerat på grund av oväntade aktiviteter i området. Pumpflödet från HFM01 låg relativt konstant runt 89 l/min under pumpfasen och resulterade i en slutlig avsänkning i pumpborrhålet av ca 26 m.

Av de 44 observationssektioner som ingick i interferenstestet reagerade 6 sektioner inte alls eller svagt på avsänkningen i HFM01. Av de återstående 38 sektionerna uppvisade 26 sektioner distinkta tryckresponser. Tre observationssektioner, HFM13: 159–173 m, HFM21: 12–202 m och HFM02: 38–48 m, uppvisar responser som är distinkta nog att kunna karaktäriseras som potentiella hög-transmissiva zonresponser mellan HFM01 och respektive borrhålssektion.

Tre observationssektioner, HFM13: 159–173 m, HFM20: 101–130 m och KFM02A: 490–518 m, samt pumpborrhålet utvärderades kvantitativt med metoder för transient utvärdering. Transmissiviteterna skattades till $3,5\times10^{-4}$ m^2/s, $2,2\times10^{-4}$ m^2/s respektive $4,0\times10^{-4}$ m^2/s. För pumpborrhålet, HFM01, gav den transienta utvärderingen ett värde för transmissiviteten på $1,5\times10^{-4}$ m^2/s.

De skattade transmissiviteterna för observationssektionen i HFM13 och för pumpborrhålet, HFM01, överrensstämmer relativt bra med T-värden från tidigare tester med andra metoder i de nämnda borrhålen. I de övriga två observationssektionerna, HFM20: 101–130 m och KFM02A: 490–518 m, var transmissiviteterna från den transienta utvärderingen av interferenstesten högre än de värden som erhållits vid tidigare tester i borrhålen. Detta kan möjligen bero på att T-värdena för observationssektionerna från interferenstesten styrs mer av de hydrauliska egenskaperna nära pumpborrhålet HFM01.

Under hela interferenstestet påverkades många observationssektioner av det varierande havsvattenståndet. Detta gör att tryckdata från berörda sektioner uppvisar ett oscillerande beteende.

Nederbörd påverkade också många observationssektioner med stigande tryck som följd. Detta gjorde att återhämtningsperioden blev svårare att analysera.

Contents

1 Introduction

This report documents the results from an interference test performed within the site investigation at Forsmark. It was performed in order to study how different fracture zones are connected hydraulically in the north-western part of the candidate area at Forsmark, to quantify their hydraulic properties and to clarify whether there are any major hydraulic boundaries in the area. The locations of the boreholes involved in the interference test are shown in Figure 1-1. The test was carried out in July and August of 2005 by Geosigma AB.

The open percussion drilled borehole HFM01 was used as pumping borehole for the test and 18 surrounding boreholes served as observation wells.

The interference test was conducted in accordance with activity plan AP PF 400-05-043. In Table 1-1, controlling documents for the performance of this activity are listed. Both the activity plan and method descriptions are internal controlling documents of SKB.

From pumping tests and flow logging, /1/, performed prior to the interference test, the total transmissivity of the pumping borehole, HFM01, was estimated at c 6×10^{-5} m^2/s.

Table 1-1. Controlling documents for the performance of the activity.

Activity plan	Number	Version
Hydrauliskt interferenstest med hammarborrhål HFM01 som pumphål.	AP PF 400-05-043	1.0
Method descriptions	**Number**	**Version**
Instruktion för analys av injektions- och enhålspumptester.	SKB MD 320.004	1.0
Metodbeskrivning för interferenstester.	SKB MD 330.003	1.0

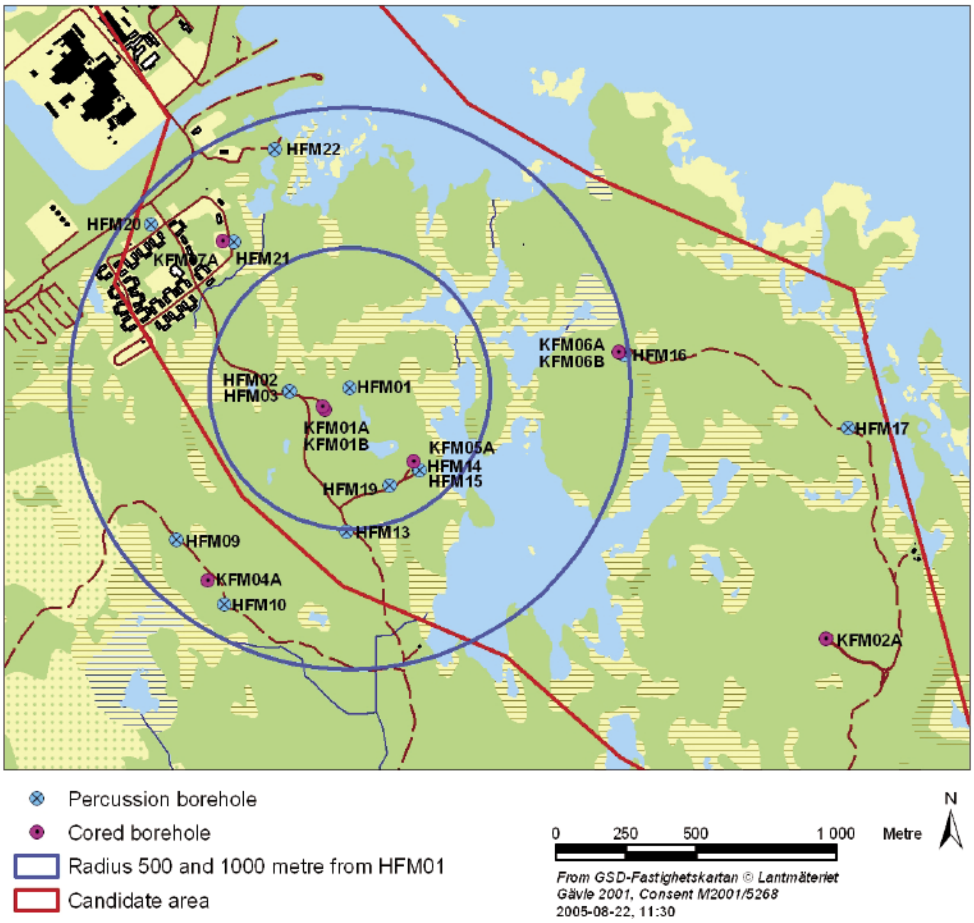


Figure 1-1. *The investigation area at Forsmark including part of the candidate area selected for more detailed investigations. The positions of the boreholes included in the test are displayed as well as the areas corresponding to radii of 500 m and 1,000 m from HFM01, respectively.*

2 Objectives

The main aim of hydraulic interference tests is to get support for interpretations of geologic structures in regard to their hydraulic and geometric properties deduced from single-hole tests. Furthermore, an interference test may provide information about the hydraulic connectivity and hydraulic boundary conditions within the tested area. Finally, interference tests make up the basis for calibration of numerical models of the area.

The interference test, with borehole HFM01 as pumping borehole, was performed in order to increase the understanding of the hydraulic conditions in the north-western part of the candidate area at Forsmark. The primary aim of the interference test was to document how different fracture zones are connected hydraulically, to quantify their hydraulic properties and to clarify whether there are any major hydraulic boundaries in the area.

The interference test was performed by pumping in the open percussion drilled borehole HFM01 and monitoring pressure responses in different observation sections in surrounding boreholes. All boreholes monitored for responses are part of the Forsmark HMS, the Hydro Monitoring System. In total, 44 observation sections in 18 observation boreholes were included in the interference test.

3 Scope

3.1 Boreholes tested

Technical data of the boreholes tested are presented in Table 3-1. Three of the boreholes that, in the Activity Plan, were intended to be included in the interference test were not supplied with pressure transducers prior to the interference test. These borehole sections are still presented in tables in this report but naturally no pressure data are available. The excluded boreholes are KFM05A, KFM06A and KFM06B. In this report boreholes are presented in order of distance from the pumping borehole, i.e. the borehole closest to HFM01 is presented first and the borehole furthest away from HFM01 is presented last. The reference point in the boreholes is always top of casing (ToC). The Swedish National coordinate system (RT90 2.5 gon V 0:–15) is used in the x-y-direction together with RHB70 in the z-direction. The coordinates of the boreholes at ground surface are shown in Table 3-2.

Table 3-1. Pertinent technical data of the tested boreholes. (From SICADA).

Borehole data Bh ID	Elevation of top of casing (ToC) (m.a.s.l.)	Borehole interval from ToC (m)	Casing/ Bh-diam. (m)	Inclination - top of bh (from horizontal plane) (º)	Dip-direc-tion-top of borehole (from local N) (º)	Remarks	Drilling finished Date (YYYY-MM-DD)
HFM01	1.731	0.000–31.930	0.204	–77.513	34.061	Borehole	2002-05-03
”		31.930–200.200	0.140			Borehole	
”		0.000–31.930	0.160			Casing ID	
KFM01A	3.125	0.000–12.000	0.440	–84.730	318.350	Borehole	2002-10-28
”		12.000–29.400	0.358			Borehole	
”		29.400–100.480	0.251			Borehole	
”		100.480–100.520	0.164			Borehole	
”		100.520–102.130	0.086			Borehole	
”		102.130–1,001.490	0.076			Borehole	
”		0.000–100.400	0.200			Casing ID	
”		0.000–29.400	0.265			Casing ID	
”		97.330–97.330	0.195			Casing ID	
”		101.990–101.990	0.080			Casing ID	
KFM01B	3.093	0.150–9.170	0.150	–79.040	267.594	Borehole	2004-01-15
”		9.170–15.560	0.101			Borehole	
”		15.560–500.520	0.076			Borehole	
”		0.000–15.530	0.078			Casing ID	
”		0.050–9.050	0.130			Casing ID	
”		8.990–9.090	0.115			Casing ID	
HFM03	3.148	0.000–13.100	0.204	–87.284	264.528	Borehole	2002-05-28
”		13.100–26.000	0.136			Borehole	
”		0.000–13.100	0.160			Casing ID	
HFM02	3.053	0.000–25.400	0.204	–87.787	6.516	Borehole	2002-05-21
”		25.400–100.000	0.137			Borehole	
”		0.000–25.400	0.160			Casing ID	

Borehole data							
Bh ID	**Elevation of top of casing (ToC) (m.a.s.l.)**	**Borehole interval from ToC (m)**	**Casing/ Bh-diam. (m)**	**Inclination - top of bh (from horizontal plane) (º)**	**Dip-direc-tion-top of borehole (from local N) (º)**	**Remarks**	**Drilling finished Date (YYYY-MM-DD)**
HFM15	3.878	0.000–6.000	0.176	–43.700	314.305	Borehole	2003-10-15
"		6.000–99.500	0.139			Borehole	
"		0.000–6.000	0.160			Casing ID	
HFM14	3.912	0.000–3.100	0.235	–59.810	331.748	Borehole	2003-10-09
"		3.100–6.000	0.189			Borehole	
"		6.000–101.300	0.138			Borehole	
"		101.300–150.500	0.136			Borehole	
"		–0.100–3.100	0.209			Casing ID	
"		0.000–6.000	0.160			Casing ID	
KFM05A [1)]	5.528	0.000–12.250	0.340	–59.804	80.897	Borehole	2004-05-05
"		12.250–100.300	0.244			Borehole	
"		100.300–100.350	0.164			Borehole	
"		100.350–110.100	0.086			Borehole	
"		110.100–1,002.710	0.077			Borehole	
"		0.000–100.020	0.200			Casing ID	
"		0.000–12.250	0.310			Casing ID	
"		0.190–12.250	0.309			Casing ID	
"		100.020–100.070	0.170			Casing ID	
HFM19	3.656	0.000–12.040	0.180	–58.103	280.915	Borehole	2003-12-18
"		12.040–185.200	0.137			Borehole	
"		0.000–12.040	0.160			Casing ID	
HFM13	5.687	0.000–4.400	0.235	–58.845	51.194	Borehole	2003-10-02
"		4.400–14.900	0.189			Borehole	
"		14.900–101.000	0.138			Borehole	
"		101.000–152.350	0.137			Borehole	
"		152.350–175.600	0.135			Borehole	
"		0.000–14.900	0.160			Casing ID	
HFM21	3.979	0.000–12.030	0.185	–58.480	88.810	Borehole	2004-06-07
"		12.030–148.000	0.139			Borehole	
"		148.000–202.000	0.137			Borehole	
"		0.000–11.940	0.160			Casing ID	
"		11.940–12.030	0.147			Casing ID	
KFM07A	3.330	0.000–9.140	0.346	–59.220	261.470	Borehole	2004-12-09
"		9.140–100.350	0.251			Borehole	
"		9.140–100.400	0.252			Borehole	
"		100.350–100.400	0.164			Borehole	
"		100.400–101.950	0.086			Borehole	
"		101.950–1,001.550	0.077			Borehole	
"		0.000–100.050	0.200			Casing ID	
"		0.000–8.940	0.311			Casing ID	
"		0.200–8.940	0.310			Casing ID	
"		100.050–100.100	0.170			Casing ID	
KFM04A	8.771	0.000–12.030	0.350	–60.080	45.240	Borehole	2003-11-19
"		12.030–107.330	0.247			Borehole	

Borehole data							
Bh ID	Elevation of top of casing (ToC) (m.a.s.l.)	Borehole interval from ToC (m)	Casing/ Bh-diam. (m)	Inclination - top of bh (from horizontal plane) (º)	Dip-direc-tion-top of borehole (from local N) (º)	Remarks	Drilling finished Date (YYYY-MM-DD)
”		107.330–107.420	0.161			Borehole	
”		107.420–108.690	0.086			Borehole	
”		108.690–1,001.420	0.077			Borehole	
”		0.000–106.910	0.200			Casing ID	
”		0.000–12.030	0.265			Casing ID	
”		0.000–106.910	0.200			Casing ID	
”		106.910–106.950	0.170			Casing ID	
HFM09	5.150	0.000–5.300	0.190	–68.899	139.359	Borehole	2003-06-30
”		5.300–17.000	0.190			Borehole	
”		17.000–50.250	0.141			Borehole	
”		0.000–17.020	0.160			Casing ID	
HFM22	1.539	0.000–12.030	0.180	–58.854	90.081	Borehole	2004-09-10
”		12.030–222.000	0.136			Borehole	
”		0.000–11.940	0.160			Casing ID	
”		11.940–12.030	0.147			Casing ID	
HFM10	4.986	0.000–4.500	0.219	–68.700	92.934	Borehole	2003-08-19
”		0.001–11.800	0.190			Borehole	
”		11.800–110.000	0.140			Borehole	
”		110.000–150.000	0.139			Borehole	
”		0.000–11.800	0.160			Casing ID	
KFM06A [1)]	4.100	0.000–2.120	0.415	–60.250	300.920	Borehole	2004-09-21
”		2.120–12.300	0.333			Borehole	
”		12.300–100.590	0.243			Borehole	
”		100.590–100.640	0.164			Borehole	
”		100.640–102.190	0.086			Borehole	
”		102.190–1,000.640	0.077			Borehole	
”		0.000–100.350	0.200			Casing ID	
”		0.190–2.120	0.392			Casing ID	
”		0.190–12.300	0.309			Casing ID	
”		100.350–100.400	0.170			Casing ID	
HFM20	2.966	0.000–12.300	0.185	–85.448	354.415	Borehole	2004-06-01
”		12.300–112.700	0.139			Borehole	
”		112.700–250.000	0.138			Borehole	
”		250.000–301.000	0.135			Borehole	
”		0.000–11.940	0.160			Casing ID	
”		11.940–12.030	0.147			Casing ID	
KFM06B [1)]	4.130	0.000–3.880	0.116	–83.520	296.960	Borehole	2003-06-08
”		3.880–4.610	0.101			Borehole	
”		4.610–6.330	0.086			Borehole	
”		6.330–100.330	0.077			Borehole	
”		0.000–4.610	0.078			Casing ID	
HFM16	3.210	0.000–12.020	0.195	–84.218	327.957	Borehole	2003-11-11
”		12.020–82.000	0.140			Borehole	
”		82.000–132.500	0.139			Borehole	
”		0.000–12.020	0.160			Casing ID	

Borehole data Bh ID	Elevation of top of casing (ToC) (m.a.s.l.)	Borehole interval from ToC (m)	Casing/ Bh-diam. (m)	Inclination - top of bh (from horizontal plane) (º)	Dip-direc-tion-top of borehole (from local N) (º)	Remarks	Drilling finished Date (YYYY-MM-DD)
HFM17	3.750	0.000–8.000	0.180	–84.186	318.576	Borehole	2003-12-08
”		8.000–120.500	0.137			Borehole	
”		120.500–210.650	0.136			Borehole	
”		0.000–8.000	0.160			Casing ID	
KFM02A	7.353	0.000–2.390	0.440	–85.385	275.764	Borehole	2003-03-12
”		2.390–11.800	0.358			Borehole	
”		11.800–100.350	0.251			Borehole	
”		100.350–100.420	0.164			Borehole	
”		100.420–102.000	0.086			Borehole	
”		102.000–1,002.440	0.077			Borehole	
”		0.000–100.140	0.200			Casing ID	
”		0.100–11.800	0.265			Casing ID	

[1)] Section not used during the interference test in HFM01.

Table 3-2. Coordinates of the tested boreholes. (From SICADA).

Borehole data Bh ID	Northing (m)	Easting (m)
HFM01	6699605.181	1631484.552
KFM01A	6699529.813	1631397.160
KFM01B	6699539.396	1631387.672
HFM03	6699592.812	1631272.626
HFM02	6699593.212	1631268.674
HFM15	6699312.444	1631733.081
HFM14	6699313.139	1631734.586
KFM05A [1)]	6699344.850	1631710.804
HFM19	6699257.585	1631626.925
HFM13	6699093.678	1631474.404
HFM21	6700125.566	1631074.054
KFM07A	6700127.080	1631031.570
KFM04A	6698921.744	1630978.964
HFM09	6699064.648	1630869.120
HFM22	6700456.184	1631217.635
HFM10	6698834.785	1631037.188
KFM06A [1)]	6699732.880	1632442.510
HFM20	6700187.496	1630776.681
KFM06B [1)]	6699732.240	1632446.410
HFM16	6699721.098	1632466.182
HFM17	6699461.952	1633261.310
KFM02A	6698712.501	1633182.863

[1)] Section not used during the interference test in HFM01.

3.2 Tests performed

The borehole sections involved in the interference test in HFM01 are listed in Table 3-3. The times referred to in Table 3-3 are the chosen start and stop times of downloaded data files used for evaluation. Alternatively, for the pumping borehole, the times referred to are the relevant times included in the original file produced by the data logger. The amount of data extracted from HMS, the Hydro Monitoring System, from the observation boreholes was chosen so as to receive an appropriate amount of data that would correspond to available data from the pumping borehole, HFM01. HMS is registering pressure continuously.

The test performance was according to the Geosigma quality plan ("Kvalitetsplan för SKB uppdrag – Hydrauliskt interferenstest med hammarborrhål HFM01 som pumphål, K535090, Kristoffer Gokall-Norman, 2005-06-07", Geosigma and SKB internal controlling document) and according to the methodology description for interference tests, SKB MD 330.003. However, no response matrix was prepared since only one interference test was performed.

Table 3-3. Borehole sections involved in the interference test in HFM01, see Figure 1-1.

Bh ID	Test section (m)	Test type[1]	Test config.	Test start date and time (YYYY-MM-DD tt:mm)	Test stop date and time (YYYY-MM-DD tt:mm)
HFM01	0–200	1B	Open borehole	2005-07-06 12:04	2005-08-09 13:52
KFM01A	0–108	2	Above packer	2005-07-06 00:00	2005-08-02 06:00
"	109–130	2	Between packers	2005-07-06 00:00	2005-08-02 06:00
"	131–204	2	Between packers	2005-07-06 00:00	2005-08-02 06:00
"	205–373	2	Between packers	2005-07-06 00:00	2005-08-02 06:00
"	374–430	2	Between packers	2005-07-06 00:00	2005-08-02 06:00
"	431–1,002	2	Below packer	2005-07-06 00:00	2005-08-02 06:00
KFM01B	0–100	2	Above packer	2005-07-06 00:00	2005-08-02 06:00
"	101–141	2	Between packers	2005-07-06 00:00	2005-08-02 06:00
"	142–500	2	Between packers	2005-07-06 00:00	2005-08-02 06:00
HFM03	0–18	2	Above packer	2005-07-06 00:00	2005-08-02 06:00
"	19–26	2	Between packers	2005-07-06 00:00	2005-08-02 06:00
HFM02	0–37	2	Above packer	2005-07-06 00:00	2005-08-02 06:00
"	38–48	2	Between packers	2005-07-06 00:00	2005-08-02 06:00
"	49–100	2	Below packer	2005-07-06 00:00	2005-08-02 06:00
HFM15	0–84	2	Above packer	2005-07-06 00:00	2005-08-02 06:00
"	85–95	2	Between packers	2005-07-06 00:00	2005-08-02 06:00
HFM14	0–150	2	Open borehole	2005-07-06 00:00	2005-08-02 06:00
KFM05A [2)]	0–1,003	2	Open borehole	2005-07-06 00:00	2005-08-02 06:00
HFM19	0–103	2	Above packer	2005-07-06 00:00	2005-08-02 06:00
"	104–167	2	Between packers	2005-07-06 00:00	2005-08-02 06:00
"	168–182	2	Between packers	2005-07-06 00:00	2005-08-02 06:00
HFM13	0–100	2	Above packer	2005-07-06 00:00	2005-08-02 06:00
"	101–158	2	Between packers	2005-07-06 00:00	2005-08-02 06:00
"	159–173	2	Between packers	2005-07-06 00:00	2005-08-02 06:00

Bh ID	Test section (m)	Test type[1]	Test config.	Test start date and time (YYYY-MM-DD tt:mm)	Test stop date and time (YYYY-MM-DD tt:mm)
HFM21	0–202	2	Open borehole	2005-07-06 00:00	2005-08-02 06:00
KFM07A	0–1,002	2	Open borehole	2005-07-06 00:00	2005-08-02 06:00
KFM04A	0–1,001	2	Open borehole	2005-07-06 00:00	2005-08-02 06:00
HFM09	0–50	2	Open borehole	2005-07-06 00:00	2005-08-02 06:00
HFM22	0–222	2	Open borehole	2005-07-06 00:00	2005-08-02 06:00
HFM10	0–99	2	Above packer	2005-07-06 00:00	2005-08-02 06:00
”	100–150	2	Below packer	2005-07-06 00:00	2005-08-02 06:00
KFM06A [2)]	0–1001	2	Open borehole	2005-07-06 00:00	2005-08-02 06:00
HFM20	0–48	2	Above packer	2005-07-06 00:00	2005-08-02 06:00
”	49–100	2	Between packers	2005-07-06 00:00	2005-08-02 06:00
”	101–130	2	Between packers	2005-07-06 00:00	2005-08-02 06:00
”	131–301	2	Below packer	2005-07-06 00:00	2005-08-02 06:00
KFM06B [2)]	0–100	2	Open borehole	2005-07-06 00:00	2005-08-02 06:00
HFM16	0–132	2	Open borehole	2005-07-06 00:00	2005-08-02 06:00
HFM17	0–211	2	Open borehole	2005-07-06 00:00	2005-08-02 06:00
KFM02A	0–132	2	Above packer	2005-07-06 00:00	2005-08-02 06:00
”	133–240	2	Between packers	2005-07-06 00:00	2005-08-02 06:00
”	241–410	2	Between packers	2005-07-06 00:00	2005-08-02 06:00
”	411–442	2	Between packers	2005-07-06 00:00	2005-08-02 06:00
”	443–489	2	Between packers	2005-07-06 00:00	2005-08-02 06:00
”	490–518	2	Between packers	2005-07-06 00:00	2005-08-02 06:00
”	519–888	2	Between packers	2005-07-06 00:00	2005-08-02 06:00
”	889–1,002	2	Below packer	2005-07-06 00:00	2005-08-02 06:00

[1)] 1B: Pumping test-submersible pump, 2: Interference test.
[2)] Section not used during the interference test in HFM01.

The interpreted points of application, see explanation below, and lengths of the borehole sections involved in the interference test together with their estimated transmissivities from previous investigations /1/–/14/ are presented in Table 3-4. The distances between the pumping borehole and the observation borehole sections are shown in Table 3-5. The distances between the hydraulic points of application in the boreholes were calculated.

The estimation of the points of application in the pumping borehole and in the different observation borehole sections respectively was made in one of two ways. If it was obvious that a certain flow anomaly, identified from e.g. flow logging, contributed to the major part of the transmissivity in one section, the position of that anomaly was chosen as the point of application. Alternatively, if no evident part of the section could be chosen with regard to transmissivity, either the midpoint of the section was selected or, if several parts of the section have comparable values of transmissivity, a point of balance calculation was made to estimate the point of application.

Table 3-4. Points of application and lengths of the test sections in the interference test in HFM01 as well as their estimated transmissivities from previous investigations /1/–/14/.

Bh ID	Test section (m)	Point of application (m below TOC)	Section length (m)	Transmissivity (m^2/s)
HFM01	0–200	51	168	6.3×10^{-5}
KFM01A	0–108	105	108	–
”	109–130	118	21	1.1×10^{-7}
”	131–204	148	73	1.6×10^{-7}
”	205–373	285	168	1.9×10^{-8}
”	374–430	402	56	9.5×10^{-10}
”	431–1,002	715	569	5.5×10^{-9}
KFM01B	0–100	54	100	–
”	101–141	121	40	–
”	142–500	321	358	–
HFM03	0–18	15	18	–
”	19–26	21	7	4.2×10^{-4}
HFM02	0–37	31	37	–
”	38–48	43	10	5.9×10^{-4}
”	49–100	74	51	–
HFM15	0–84	50	84	2.2×10^{-4}
”	85–95	89	10	1.0×10^{-4}
HFM14	0–150	72	144	4.7×10^{-4}
KFM05A [1)]	0–1,003	148	903	1.2×10^{-6}
HFM19	0–103	101	103	4.0×10^{-5}
”	104–167	150	63	2.2×10^{-5}
”	168–182	176	14	2.7×10^{-4}
HFM13	0–100	50	100	–
”	101–158	106	57	2.1×10^{-5}
”	159–173	162	14	2.9×10^{-4}
HFM21	0–202	68	190	6.8×10^{-4}
KFM07A	0–1,002	122	901	1.4×10^{-3}
KFM04A	0–1,001	217	894	2.5×10^{-4}
HFM09	0–50	26	33	3.7×10^{-4}
HFM22	0–222	62	210	1.6×10^{-4}
HFM10	0–99	50	99	–
”	100–150	118	50	3.1×10^{-4}
KFM06A [1)]	0–1,001	205	900	1.4×10^{-4}
HFM20	0–48	25	48	5.7×10^{-5}
”	49–100	77	51	1.8×10^{-6}
”	101–130	118	29	1.0×10^{-5}
”	131–301	215	170	–
KFM06B [1)]	0–100	50	95	5.3×10^{-4}
HFM16	0–132	60	120	5.3×10^{-4}
HFM17	0–211	31	203	3.9×10^{-5}
KFM02A	0–132	118	132	3.0×10^{-4}
”	133–240	173	107	5.1×10^{-6}
”	241–410	282	169	1.3×10^{-5}
”	411–442	428	31	2.5×10^{-6}
”	443–489	478	46	3.9×10^{-7}
”	490–518	513	46	2.1×10^{-6}
”	519–888	558	369	6.0×10^{-9}
”	889–1,002	945	113	–

[1)] Section not used during the interference test in HFM01.

Table 3-5. Calculated distances from the pumping borehole HFM01 to the observation borehole sections involved in the interference test in HFM01.

Pumping section in HFM01 (m)	Observation sections Borehole ID	Section (m)	Distance to HFM01@51 m (m)
0–200	KFM01A	0–108	137
”	”	109–130	147
”	”	131–204	160
”	”	205–373	268
”	”	374–430	375
”	”	431–1,002	679
”	KFM01B	0–100	135
”	”	101–141	162
”	”	142–500	325
”	HFM03	0–18	222
”	”	19–26	221
”	HFM02	0–37	223
”	”	38–48	222
”	”	49–100	222
”	HFM15	0–84	352
”	”	85–95	326
”	HFM14	6–150	353
0–200	KFM05A [1)]	100–1,003	399
”	HFM19	0–103	358
”	”	104–167	355
”	”	168–182	356
”	HFM13	0–100	506
”	”	101–158	498
”	”	159–173	502
”	HFM21	12–202	635
”	KFM07A	100–1,002	726
”	KFM04A	107–1,001	769
”	HFM09	17–50	830
”	HFM22	12–222	872
”	HFM10	0–99	896
”		100–150	898
”	KFM06A [1)]	100–1,001	889
”	HFM20	0–48	917
”	”	49–100	919
”	”	101–130	922
”	”	131–301	936
”	KFM06B [1)]	5–100	959
”	HFM16	12–132	981
”	HFM17	8–211	1,776
”	KFM02A	0–132	1,911
”	”	133–240	1,910
”	”	241–410	1,910
”	”	411–442	1,920
”	”	443–489	1,925
”	”	490–518	1,930
”	”	519–888	1,936
”	”	889–1,002	2,022

[1)] Section not used during the interference test in HFM01.

3.3 Equipment check

An equipment check was performed at the Geosigma engineering workshop in Uppsala as well as at the site as a simple and fast test to establish the operating status of sensors and other equipment. In addition, calibration constants were implemented and checked.

To check the function of the pressure sensors, the pressure in air was recorded and found to be as expected. Submerged in water, the pressure coincided well with the total head of water, while lowering.

4 Description of equipment

4.1 Overview

The temporary test system used for the interference test is described in Geosigma quality plan ("Kvalitetsplan för SKB uppdrag – Hydrauliskt interferenstest med hammarborrhål HFM01 som pumphål, K535090, Kristoffer Gokall-Norman, 2005-06-07", Geosigma and SKB internal controlling document). The equipment in the pumping borehole, HFM01, consisted of the following parts:

- 4" submersible pump with submarine contact and hose to the ground surface,
- wire to anchor the pump,
- manual winch for hoisting the pump, mounted on the casing,
- 1 pressure transducer in the borehole,
- flow meter at the surface,
- data logger to sample data from the flow meter and the pressure transducer,
- flow rate control valve at the surface,
- PC to visualize the data.

Much of the equipment used for the installation in HFM01 was taken from a compound test kit normally referred to as HTHB (Swedish abbreviation for Hydraulic Test System for Percussion Boreholes), and is described in SKB MD 326.001. The HTHB unit is designed to perform pumping tests in open percussion drilled boreholes, under a single packer or between double packers in isolated sections of the boreholes down to a total depth of 200 m. A number of other tests can be performed with the HTHB system although they are not described here. The pumping tests can be performed with either constant hydraulic head or alternatively, with constant flow rate.

All the observation sections included in the interference test are part of the SKB hydro monitoring system (HMS), where pressure is recorded continuously.

The estimated lower and upper practical measurement limits for the actual equipment used for the interference test, expressed in terms of specific flow (Q/s), are Q/s-L = 3×10^{-7} m^2/s and Q/s-U = 5×10^{-3} m^2/s, respectively.

4.2 Measurement sensors

Technical data of the sensors used together with estimated data specifications of the test system for pumping tests are given in Table 4-1.

Table 4-1. Technical data of measurement sensors used as well as estimated data specifications of the test system for pumping tests (based on current laboratory and field experiences).

Technical specification Parameter		Unit	Sensor	Test system	Comments
p-absolute (HTHB)	Output signal	mA	4–20		
	Meas. range	kPa	0–1,500		
	Resolution	kPa	0.05		
	Accuracy	kPa	± 1.5 *	± 10	Depending on uncertainties of the sensor position
Flow rate (surface)	Output signal	mA	4–20		Passive
	Meas. range	L/min	1–500	1–c 165	Pumping tests
	Resolution	L/min	0.1	0.1	
	Accuracy	% o.r.**	± 0.5	± 0.5	

* Includes hysteresis, linearity and repeatability.
** Maximum error in % of actual reading (% o.r.).

Table 4-2 shows the type and position for each transducer used in the test. Positions are given in metre from reference point, i.e. top of casing (ToC).

Table 4-2. Type and position of pressure sensors (position from ToC) used in the interference test in HFM01.

Borehole information ID	Test interval (m)	Test configuration	Test type[1)]	Sensors Type	Position (m b ToC)
HFM01	0–200	Open borehole	1B	p-absolute (HTHB)	31.4
KFM01A	0–108	Above packer	2	HMS	39.3
”	109–130	Between packers	2	HMS	39.3
”	131–204	Between packers	2	HMS	39.3
”	205–373	Between packers	2	HMS	39.3
”	374–430	Between packers	2	HMS	39.3
”	431–1,002	Below packer	2	HMS	39.3
KFM01B	0–100	Above packer	2	HMS	29.3
”	101–141	Between packers	2	HMS	29.3
”	142–500	Between packers	2	HMS	29.3
HFM03	0–18	Above packer	2	HMS	29.3
”	19–26	Between packers	2	HMS	29.3
HFM02	0–37	Above packer	2	HMS	29.3
”	38–48	Between packers	2	HMS	29.3
”	49–100	Below packer	2	HMS	29.3
HFM15	0–84	Above packer	2	HMS	29.8
”	85–95	Below packer	2	HMS	29.8
HFM14	0–150	Open borehole	2	HMS	10.0
KFM05A [2)]	0–1,003	Open borehole	–	–	–
HFM19	0–103	Above packer	2	HMS	29.8
”	104–167	Between packers	2	HMS	29.8
”	168–182	Below packer	2	HMS	29.8

Borehole information				Sensors	
ID	Test interval (m)	Test configuration	Test type[1)]	Type	Position (m b ToC)
HFM13	0–100	Above packer	2	HMS	29.8
”	101–158	Between packers	2	HMS	29.8
”	159–173	Below packer	2	HMS	29.8
HFM21	0–202	Open borehole	2	HMS	15.0
KFM07A	0–1,002	Open borehole	2	HMS	10.0
KFM04A	0–1,001	Open borehole	2	HMS	10.0
HFM09	0–50	Open borehole	2	HMS	5.0
HFM22	0–222	Open borehole	2	HMS	15.0
HFM10	0–99	Above packer	2	HMS	29.3
	100–150	Below packer	2	HMS	29.3
KFM06A [2)]	0–1,001	Open borehole	–	–	–
HFM20	0–48	Above packer	2	HMS	39.3
”	49–100	Between packers	2	HMS	39.3
”	101–130	Between packers	2	HMS	39.3
”	131–301	Below packer	2	HMS	39.3
KFM06B [2)]	0–100	Open borehole	–	–	–
HFM16	0–132	Open borehole	2	HMS	11.62
HFM17	0–211	Open borehole	2	HMS	10.0
KFM02A	0–132	Above packer	2	HMS	39.3
	133–240	Between packers	2	HMS	39.3
	241–410	Between packers	2	HMS	39.3
	411–442	Between packers	2	HMS	39.3
	443–489	Between packers	2	HMS	39.3
	490–518	Between packers	2	HMS	39.3
	519–888	Between packers	2	HMS	39.3
	889–1,002	Below packer	2	HMS	39.3

[1)] 1B: Pumping test-submersible pump, 2: Interference test (observation borehole during pumping in another borehole).
[2)] Section not used during the interference test in HFM01.

5 Execution

5.1 Preparations

All sensors included in the test system in the pumping borehole are calibrated at the Geosigma engineering workshop in Librobäck, Uppsala. Calibration is performed on a yearly basis, or more often if needed. The last calibration of the pressure transducer P2, which was used in the pumping borehole, was conducted in April, 2004. The flow meter was calibrated in May, 2004. Before the tests, function checks and cleaning of equipment were performed according to the Activity Plan.

5.2 Procedure

The interference test in HFM01 was carried out as a constant flow rate test followed by a subsequent pressure recovery period. The pressure interference was recorded in totally 44 sections in 18 observation boreholes, both cored and percussion drilled boreholes, all part of the HMS (Hydro Monitoring System). The flow rate in the pumping borehole was chosen based on the results from earlier pumping tests and flow logging in HFM01, /1/. Due to other activities in the area it was not possible to perform a standard capacity test in the pumping borehole prior to the start of the test. Instead, the fine tuning of the flow rate had to be done during the initial time of the interference test. The flow rate was manually adjusted by a control valve and monitored by an electromagnetic flow meter. The data logger sampled data at a suitable frequency determined by the operator, see Table 5-1. Pumping in HFM01 was carried out using a 4" submersible pump during a period of c 22 days. The subsequent pressure recovery was measured for c 5 days.

The discharged water from the pumping borehole was led into a swampy area approximately 50 m north of HFM01.

In HFM01, the absolute pressure transducer connected to the HTHB-logger was attached to the pump hose approximately 31 m below top of casing. The transducers were connected directly to the data logger via cables. In the observation boreholes the hydro monitoring system was utilized for pressure registration.

Approximate sampling intervals for flow rate and pressure in the pumping borehole HFM01 are presented in Table 5-1. During the first hours of pumping the sampling frequency was adjusted manually and Table 5-1 reflects only the character of the changes of frequency intervals. After stop of pumping the changes of sampling frequency was automatic according to Table 5-1.

The observation boreholes are either fitted with removable miniTroll transducers equipped with an attached logger or with stationary equipment for measuring pressure in the different sections. The miniTroll transducers were logging a pressure value with the standard frequency of one reading every two hours. In addition, logging was done in case there was a pressure change of at least 0.1 m since the last logging. The stationary installations were set to automatically log once every 5 minutes and conditionally at a pressure change of 0.01 m.

Table 5-1. Approximate sampling intervals used for pressure registration in HFM01 during the interference test in HFM01.

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

[1)] The 600 s sampling interval was used during recovery instead of the 300 s interval.

5.3 Data handling

Flow and pressure data from the pumping borehole, HFM01, were downloaded from the logger (Campbell CR 5000) to a laptop running the program PC9000 and are, already in the logger, transformed to engineering units. All files are comma-separated (*.DAT) when copied to a computer. A list of the data files from the data logger is shown in Appendix 1.

5.4 Analyses and interpretation

Both qualitative and quantitative analyses have been performed for the interference test in HFM01 in accordance with the methodology descriptions for interference tests, SKB MD 330.003, and reported in Chapter 6 below. Methods for constant-flow rate tests in an equivalent porous medium were used by the analyses and interpretation of the tests.

The main objective of the interference test was to document how different fracture zones are connected hydraulically, to quantify their hydraulic properties and to clarify whether there are any major hydraulic boundaries in the area. Quantitative evaluation of three selected observation sections was also included in the commission. One section in each of the boreholes HFM13, HFM20 and KFM02A was chosen for analyses with regard to transmissivity and storativity.

Data from all available observation sections were used in the primary qualitative analyses. The qualitative analysis of the responses in interference test in HFM01A was primarily based on time versus pressure diagrams together with response diagrams. Linear diagrams of pressure versus time for all test sections are presented Appendix 2.

For the three selected observation sections the dominating flow regimes (pseudo-linear, pseudo-radial and pseudo-spherical flow, respectively) and possible outer boundary conditions were identified. In particular, pseudo-radial flow is reflected by a constant (horizontal) derivative in the diagrams, whereas no-flow- and constant head boundaries are characterized by an increase and decrease of the derivative, respectively.

Different values were applied on the filter coefficient (step length) by the calculation of the pressure derivative to investigate the effect of this coefficient on the derivative. It is desired to achieve maximum smoothing of the derivative without altering the original shape of the data.

Quantitative evaluation was only undertaken of the responses in three selected observation sections, HFM13: 159–173 m, HFM20: 101–130 m and KFM02A: 590–518 m. The sections were selected based on the results of the preliminary qualitative analyses (response analysis) and because they represent different distances from the pumping borehole HFM01 and were considered to contribute to existing knowledge of the hydraulic conditions in the Forsmark area. Furthermore, only the flow period was utilized for transient evaluation. In addition, the response in the pumping borehole HFM01 was evaluated as a single-hole pumping test according to the methods described in /15/.

The quantitative transient analysis was performed by a special version of the test analysis software AQTESOLV that enables both visual and automatic type curve matching. The transient evaluation was carried out as an iterative process of type curve matching and automatic non-linear regression. The quantitative, transient interpretation of the hydraulic parameters (transmissivity and storativity) is normally based on the identified pseudo-radial flow regime during the tests in log-log and lin-log data diagrams.

For the single-hole pumping test in HFM01 the storativity was calculated using an empirical regression relationship between storativity and transmissivity, see Equation (5-1), Rhén et al. (1997) /16/. Firstly, the transmissivity and skin factor were obtained by type curve matching on the data curve using a fixed storativity value of 10^{-6}, according to the instruction SKB MD 320.004. From the transmissivity value obtained, the storativity was then calculated according to Equation (5-1) and the type curve matching was repeated. In most cases the change of storativity did not significantly alter the calculated transmissivity by the new type curve matching. Instead, the estimated skin factor, which is strongly correlated to the storativity using the effective borehole radius concept, was altered correspondingly.

$$S = 0.0007 \times T^{0.5} \qquad (5\text{-}1)$$

S = storativity (–)

T = transmissivity (m^2/s)

5.5 Nonconformities

- Due to the fact that no capacity test could be performed in HFM01 prior to pumping start, and an incorrect set of calibration constants were implemented for the first hour of pumping, the adjustments to the intended constant flow rate took longer time than predicted.
- Three of the observation boreholes originally intended to be included in the interference test (KFM05A, KFM06A and KFM06B) were not equipped with pressure transducers and pressure data are thus not presented for these borehole sections.
- Un-scheduled pumping activities disturbed the responses during the recovery period. This fact made it necessary to shorten the recovery period.

6 Results

6.1 Nomenclature and symbols

The nomenclature and symbols used for the results of the single-hole and interference test are according to the Instruction for analysis of single-hole injection- and pumping tests (SKB MD 320.004) and the methodology description for interference tests (SKB MD 330.003), respectively (both are SKB internal controlling documents). Additional symbols used are explained in the text.

6.2 Interference test in HFM01

Visual inspection of the pressure responses in the observation sections, presented in Figures 6-3 through 6-21, indicates that significant responses were registered in c 75% of the 44 observation sections included in the interference test. There were 4 sections indicating possible, very weak responses and 7 sections were completely unaffected during the time of the interference test. The measured drawdowns (s_p) at the end of the flow period and the estimated response time lags (dt_L) in all of the observation sections are shown in Tables 6-51 and 6-50, respectively. The response time is defined as the time lag after start of pumping until a drawdown response of 0.01 m was observed in the actual observation section.

As discussed above, the pressure in several of the observation sections included in the interference test was displaying an oscillating behaviour. This is believed to be naturally caused by so called tidal fluctuations or earth tides and has, to some extent, been investigated previously in /17/.

All pressure data reported in this report have been corrected for atmospheric pressure changes by subtracting the latter pressure from the measured (absolute) pressure. This is also true for the data received from the HMS. All times presented are Swedish normal times, i.e. no adjustment for daylight saving time has been made for any reported times.

Three of the observation boreholes originally intended to be included in the interference test were not fitted with pressure transducers. These sections, KFM05A, KFM06A and KFM06B, are still included in tables in this report even though pressure data are not presented for these sections.

During the interference test, approximately 20 mm of total precipitation (c 15 mm during the flow period) was reported at stations in the vicinity of the boreholes included in the test, see Figure A2-8. In the figure the start and stop times of the interference test and flow period are marked. Most of the rain fell on four occasions of which three occasions were likely to influence the pressure in many of the observation boreholes. In particular, between July 20th and July 26th at the end of the flow period, there was a total of approximately 15 mm of rainfall. The influence of this can be clearly seen in for instance Figure 6-16. The recovery period was terminated just before the rainfall on August 2nd. Figure A2-8 shows the precipitation during the interference test as rainfall summed up to 24 hours. The station Storskäret is close to drilling site 3 in the south-eastern part of the candidate area whereas station Högmasten is located in the vicinity of the power plant. The test stop was chosen on August 2nd. After this time, intermittent pumping activities were performed which affected the recovery in some of the boreholes.

For the evaluation of the responses in the pumping borehole and observation sections, the models described in /18/ and /19/ respectively were used. Due to the variable flow rate during the first c 2 hours of pumping, the tests were analysed as variable flow rate tests by the transient evaluation.

The transient evaluation in the pumping borehole HFM01 was based on the pseudo-radial flow regime before pseudo-radial flow occurred. In the 3 selected observation sections for quantitative evaluation, the pseudo-spherical (leaky) flow regime was dominating and corresponding methods were applied by the transient evaluation. By the evaluation of the flow period, emphasis was put on the data curve before the rainfall started on July 22nd. The recovery period is strongly affected by the previous rainfall.

6.2.1 Pumping borehole HFM01: 0–200 m

General test data for the pumping test in HFM01 are presented in Table 6-1. According to Table 3-1, the borehole is cased to 31.93 m. The uncased interval of this section is thus c 32–200 m.

Table 6-1. General test data for the pumping test in HFM01: 0–200 m.

General test data			
Pumping borehole	HFM01		
Test type[1)]	Constant Rate withdrawal and recovery test.		
Test section (open borehole/packed-off section):	Open borehole		
Test No	1		
Field crew	(GEOSIGMA AB)		
Test equipment system			
General comment	Interference test		
	Nomen-clature	**Unit**	**Value**
Borehole length	L	m	200.20
Casing length	L_c	m	31.93
Test section – secup	Secup	m	31.93
Test section – seclow	Seclow	m	200.20
Test section length	L_w	m	168.27
Test section diameter[2)]	$2 \times r_w$	mm	140
Test start (start of pressure registration)		yymmdd hh:mm	050706 12:04
Packer expanded		yymmdd hh:mm:ss	
Start of flow period		yymmdd hh:mm:ss	050706 12:09:18
Stop of flow period		yymmdd hh:mm:ss	050728 10:25:33
Test stop (stop of pressure registration)		yymmdd hh:mm	050802 06:00
Total flow time	t_p	min	31,576
Total recovery time	t_F	min	6,934

Pressure data			
Relative pressure in test section before start of flow period	p_i	kPa	298.70
Relative pressure in test section before stop of flow period	p_p	kPa	41.81
Relative pressure in test section at stop of recovery period	p_F	kPa	297.90
Pressure change during flow period (p_i–p_p)	dp_p	kPa	256.89
Flow data			
Flow rate from test section just before stop of flow period.	Q_p	m^3/s	0.00148
Mean (arithmetic) flow rate during flow period.	Q_m	m^3/s	0.00148
Total volume discharged during flow period.	V_p	m^3	2,803
Manual groundwater level measurements in HFM01 (31.9–200.2 m).	GW level		

Date YYYY-MM-DD	Time tt:mm	Time (min)	(m b ToC)	(m.a.s.l.)
2005-06-28	12:24	–11,565	1.16	0.60
2005-06-28	13:32	–11,497	1.18	0.58
2005-07-06	12:26	–43	1.29	0.47
2005-07-06	12:53	–16	1.29	0.47
2005-07-12	13:32	8,663	27.54	–25.16
2005-08-09	14:08	49,019	2.06	–0.28

1) Constant Head injection and recovery or Constant Rate withdrawal and recovery.
2) Nominal diameter.

Comments on the test

The test was performed as a constant-flow rate pumping test. The flow rate was c 88 L/min and the duration of the flow period was c 22 days. A constant flow rate was reached after c 2 hours. The adjustment to reach a suitable flow rate was made complicated by the fact that no capacity test in the borehole was possible to execute prior to the test. The reason was that such a test would interfere with other activities in the area. In addition, incorrect calibration constants for pressure registration were implemented during the first hours of the test which further complicated the adjustment of flow rate. Because of this fact the water table in the borehole dropped below the pressure transducer for some time during the flow adjustment. The final drawdown in HFM01 was approximately 26 m. The pressure recovery was measured for about 5 days. Overviews of the flow rate and pressure responses in HFM01 are presented in Figures 6-1 and 6-2. The pressure responses in log-log and lin-log diagrams during the flow period are presented in Figures A2-1 and A2-2 in Appendix 2. In Figures A2-3 and A2-4, log-log and lin-log diagrams of the recovery period are shown.

Interpreted flow regimes

During the flow period, WBS is indicated during the first c 100 seconds. As mentioned above, the pressure transducer was hanging in the air for some time during the first c 1 hour of pumping. This makes interpretation of flow regimes impossible during this time. From c 10^4–10^6 s, the flow period is dominated by an approximate PRF. After this time, pseudospherical (leaky) flow occurs, probably caused by the rainfall by the end of the flow period.

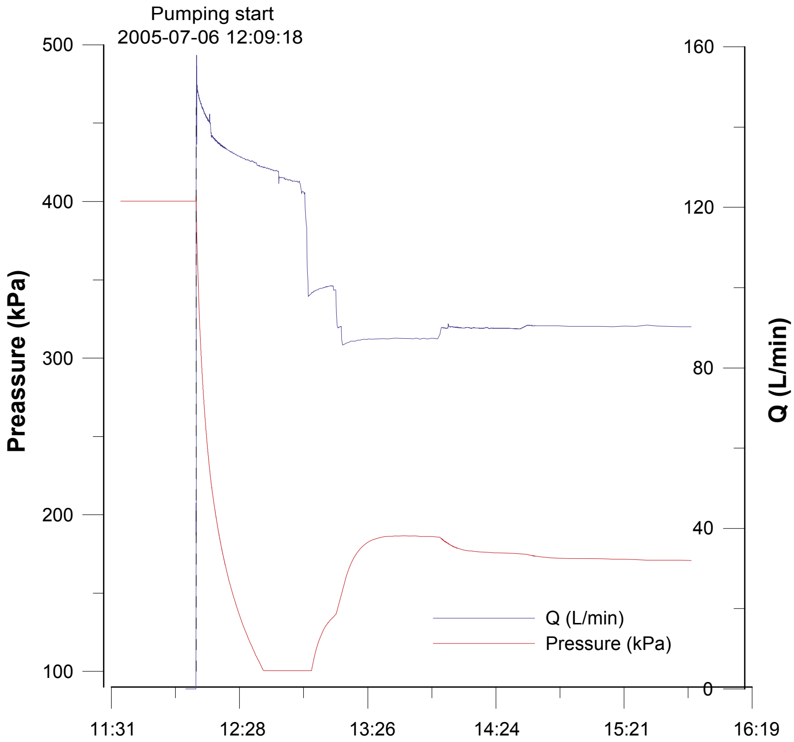


Figure 6-1. Linear plot of flow rate and pressure versus time in the pumping borehole HFM01 during the first hours of pumping.

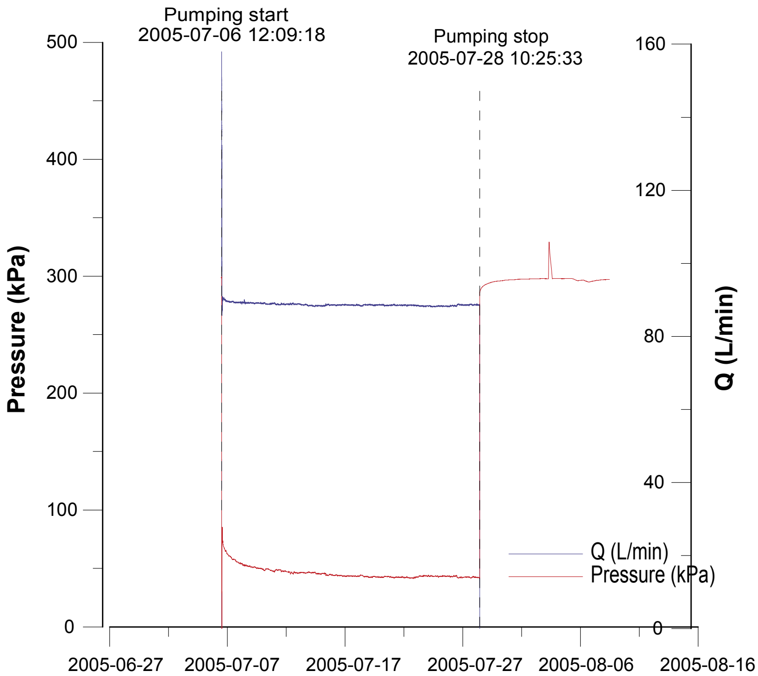


***Figure 6-2.** Linear plot of flow rate and pressure versus time in the pumping borehole HFM01 during the entire interference test in HFM01.*

During the recovery period, WBS is again indicated during the first c 100 seconds. After a transition period, an apparent PRF beginning at c 3,000 s, again transitioning to a PSF by the end of the recovery period.

Interpreted parameters

Transient, quantitative interpretation of the flow period is shown in log-log and lin-log diagrams in Figures A2-1 and A2-2 and of the recovery period in Figures A2-3 and A2-4, all in Appendix 2. The results from the transient evaluation of the single-hole pumping test in HFM01 are summarized in Table 6-54 and in the Test Summary Sheet.

6.2.2 Observation section KFM01A: 0–108 m

In Figure 6-3 an overview of the pressure responses in observation borehole KFM01A is shown. General test data from the observation section KFM01A, 0–108 m, are presented in Table 6-2. According to Table 3-1, the borehole is cased to 101.99 m. The uncased interval of this section is thus c 102–108 m.

Table 6-2. General test data from the observation section KFM01A: 0–108 m during the interference test in HFM01.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m	0.38
Hydraulic head in test section before stop of flow period.	h_p	m	–0.18
Hydraulic head in test section at stop of recovery period.	h_F	m	–0.16
Hydraulic head change during flow period (h_i–h_p).	dh_p	m	0.56

Comments on the test

A weak response to pumping is indicated in this section. It is possible that a natural decreasing trend is also affecting the response. The total drawdown during the flow period was c 0.56 m. A drawdown of 0.01 m was reached approximately 23 hours after start of pumping in HFM01. There is virtually no effect of precipitation in this section. There was a total recovery of only c 0.02 m during the recovery period lasting for approximately 5 days. The pressure in the test section is only showing a slightly oscillating behaviour, see Figure 6-3. This is believed to be natural fluctuations, mainly caused by so called tidal effects which, in part, have been studied previously in /17/.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.3 Observation section KFM01A: 109–130 m

In Figure 6-3 an overview of the pressure responses in observation borehole KFM01A is shown. General test data from the observation section KFM01A, 109–130 m, are presented in Table 6-3.

Table 6-3. General test data from the observation section KFM01A: 109–130 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	0.30
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	–1.10
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	–0.19
Hydraulic head change during flow period (h_i–h_p)	dh_p	m.a.s.l.	1.40

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 1.40 m. A drawdown of 0.01 m was reached approximately 90 minutes after the pumping started in HFM01. Around July 22, the hydraulic head in the test section started to rise slightly. This is believed to be caused by precipitation in the area, cf Figure A2-8. There was a total recovery of c 0.91 m during the recovery period that lasted for approximately 5 days.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.4 Observation section KFM01A: 131–204 m

In Figure 6-3 an overview of the pressure responses in observation borehole KFM01A is shown. General test data from the observation section KFM01A, 131–204 m, are presented in Table 6-4.

Table 6-4. General test data from the observation section KFM01A: 131–204 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	0.39
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	–0.96
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	0.14
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	1.35

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 1.35 m. A drawdown of 0.01 m was reached approximately 25 minutes after the pumping started in HFM01. Compared to section 109–130 m, the response is faster in this section but the final drawdown is not as large. Around July 22, the hydraulic head in the test section started to rise slightly. This is believed to be caused by precipitation in the area. There was a total recovery of c 1.10 m during the recovery period lasting for approximately 5 days.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.5 Observation section KFM01A: 205–373 m

In Figure 6-3 an overview of the pressure responses in observation borehole KFM01A is shown. General test data from the observation section KFM01A, 205–373 m, are presented in Table 6-5.

Table 6-5. General test data from the observation section KFM01A: 205–373 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	0.65
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	0.65
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	0.68
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	0.0

Comments on the test

No clear response to pumping is detected in this section. It is unlikely that this section is influenced by pumping in HFM01A. The pressure in the test section is showing an oscillating behaviour, see Figure 6-3. This is believed to be natural fluctuations, mainly caused by so called tidal effects which, in part, have been studied previously in /17/.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.6 Observation section KFM01A: 374–430 m

In Figure 6-3 an overview of the pressure responses in observation borehole KFM01A is shown. General test data from the observation section KFM01A, 374–430 m, are presented in Table 6-6.

Table 6-6. General test data from the observation section KFM01A: 374–430 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	1.14
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	1.19
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	1.16
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	–0.05

Comments on the test

No clear response to pumping is detected in this section. It is unlikely that this section is influenced by pumping in HFM01A. The pressure in the test section is showing an oscillating behaviour, see Figure 6-3. This is believed to be natural fluctuations, mainly caused by so called tidal effects which, in part, have been studied previously in /17/.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.7 Observation section KFM01A: 431–1,002 m

In Figure 6-3 an overview of the pressure responses in observation borehole KFM01A is shown. General test data from the observation section KFM01A, 431–1,002 m, are presented in Table 6-7.

Table 6-7. General test data from the observation section KFM01A: 431–1,002 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	0.54
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	0.05
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	0.08
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	0.49

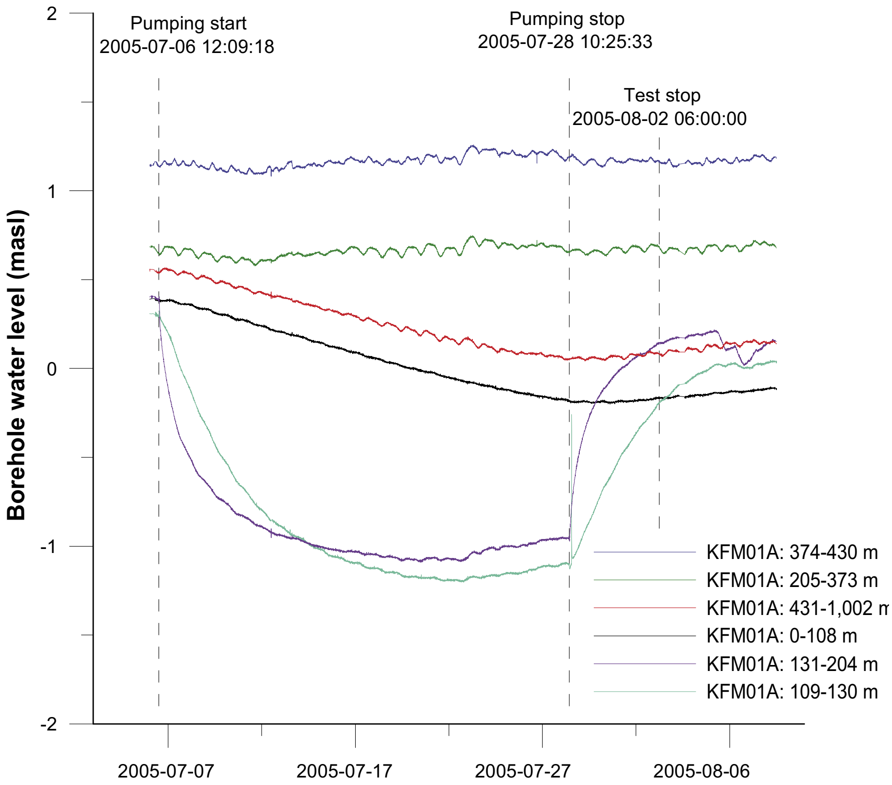


Figure 6-3. *Linear plot of pressure versus time in the observation sections in KFM01A during the interference test in HFM01.*

Comments on the test

A weak response to pumping is indicated in this section. There are, however, strong indications that this is not an actual response reflecting the pressure of this section. Instead a suspected leakage on a pressure transmitting hose above the upper packer of this section makes the pressure react directly to changes in ground water levels. The response is almost identical to that of section KFM01A: 0–108 m.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.8 Observation section KFM01B: 0–100 m

In Figure 6-4 an overview of the pressure responses in observation borehole KFM01B is shown. General test data from the observation section KFM01B, 0–100 m, are presented in Table 6-8. According to Table 3-1, the borehole is cased to 15.53 m. The uncased interval of this section is thus c 16–100 m.

Table 6-8. General test data from the observation section KFM01B: 0–100 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	0.47
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	–0.77
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	0.42
Hydraulic head change during flow period (h_i–h_p)	dh_p	m.a.s.l.	1.24

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 1.24 m. A drawdown of 0.01 m was reached approximately 9 minutes after the pumping started in HFM01. Around July 22, the hydraulic head in the test section started to rise slightly. This is believed to be caused by precipitation in the area. There was a total recovery of c 1.19 m during the recovery period that lasted for approximately 5 days.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.9 Observation section KFM01B: 101–141 m

In Figure 6-4 an overview of the pressure responses in observation borehole KFM01B is shown.

General test data from the observation section KFM01B, 101–141 m, are presented in Table 6-9.

Table 6-9. General test data from the observation section KFM01B: 101–141 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	0.37
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	–1.00
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	–0.21
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	1.37

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 1.37 m. A drawdown of 0.01 m was reached approximately 60 minutes after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise slightly. This is believed to be caused by precipitation in the area. There was a total recovery of c 0.79 m during the recovery period that lasted for approximately 5 days.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.10 Observation section KFM01B: 142–500 m

In Figure 6-4 an overview of the pressure responses in observation borehole KFM01B is shown. General test data from the observation section KFM01B, 142–500 m, are presented in Table 6-10.

Table 6-10. General test data from the observation section KFM01B: 142–500 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	0.55
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	–0.72
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	0.41
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	1.27

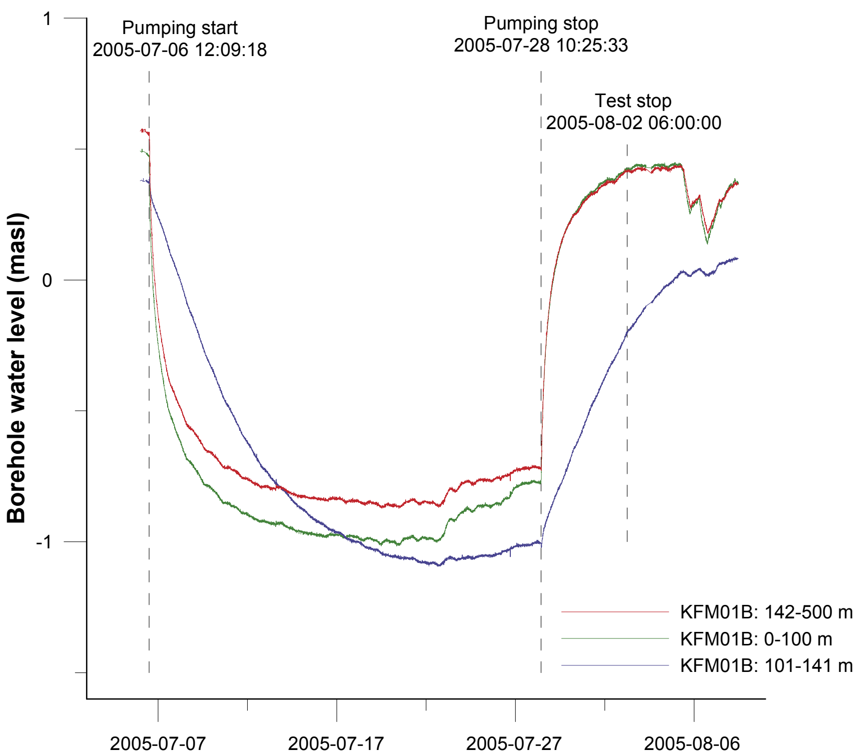


Figure 6-4. *Linear plot of pressure versus time in the observation sections in KFM01B during the interference test in HFM01.*

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 1.27 m. A drawdown of 0.01 m was reached approximately 20 minutes after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise slightly. This is believed to be caused by precipitation in the area. There was a total recovery of c 1.13 m during the recovery period that lasted for approximately 5 days.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.11 Observation section HFM03: 0–18 m

In Figure 6-5 an overview of the pressure responses in observation borehole HFM03 is shown. General test data from the observation section HFM03, 0–18 m, are presented in Table 6-11. According to Table 3-1, the borehole is cased to 13.10 m. The uncased interval of this section is thus c 13–18 m.

Table 6-11. General test data from the observation section HFM03: 0–18 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	1.11
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	–0.09
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	1.02
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	1.20

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 1.20 m. A drawdown of 0.01 m was reached approximately 32 minutes after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise slightly. This is believed to be caused by precipitation in the area. There was a total recovery of c 1.11 m during the recovery period that lasted for approximately 5 days.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.12 Observation section HFM03: 19–26 m

In Figure 6-5 an overview of the pressure responses in observation borehole HFM03 is shown. General test data from the observation section HFM03, 19–26 m, are presented in Table 6-12.

Table 6-12. General test data from the observation section HFM03: 19–26 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	1.10
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	–0.12
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	1.05
Hydraulic head change during flow period (h_i–h_p)	dh_p	m.a.s.l.	1.22

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 1.22 m. A drawdown of 0.01 m was reached approximately 10 minutes after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise slightly. This is believed to be caused by precipitation in the area. There was a total recovery of c 1.17 m during the recovery period that lasted for approximately 5 days.

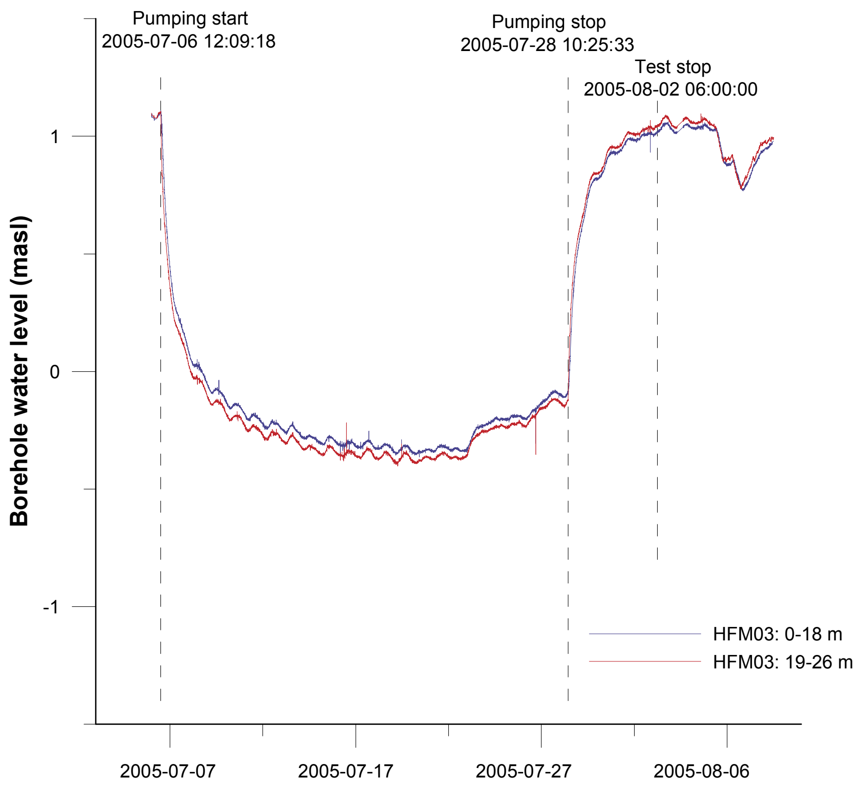


***Figure 6-5.** Linear plot of pressure versus time in the observation sections in HFM03 during the interference test in HFM01.*

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.13 Observation section HFM02: 0–37 m

In Figure 6-6 an overview of the pressure responses in observation borehole HFM02 is shown. General test data from the observation section HFM02, 0–37 m, are presented in Table 6-13. According to Table 3-1, the borehole is cased to 25.40 m. The uncased interval of this section is thus c 25–37 m.

Table 6-13. General test data from the observation section HFM02: 0–37 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	0.56
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	–0.70
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	0.43
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	1.26

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 1.26 m. A drawdown of 0.01 m was reached approximately 15 minutes after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise slightly. This is believed to be caused by precipitation in the area. There was a total recovery of c 1.13 m during the recovery period that lasted for approximately 5 days.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.14 Observation section HFM02: 38–48 m

General test data from the observation section HFM02, 38–48 m, are presented in Table 6-14. In Figure 6-6 an overview of the pressure responses in observation borehole HFM02 is shown.

Table 6-14. General test data from the observation section HFM02: 38–48 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	0.51
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	–0.77
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	0.44
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	1.28

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 1.28 m. A drawdown of 0.01 m was reached approximately 3 minutes after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise slightly. This is believed to be caused by precipitation in the area. There was a total recovery of c 1.21 m during the recovery period that lasted for approximately 5 days.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.15 Observation section HFM02: 49–100 m

General test data from the observation section HFM02, 49–100 m, are presented in Table 6-15. In Figure 6-6 an overview of the pressure responses in observation borehole HFM02 is shown.

Table 6-15. General test data from the observation section HFM02: 49–100 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	0.56
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	–0.69
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	0.50
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	1.25

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 1.25 m. A drawdown of 0.01 m was reached approximately 10 minutes after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise slightly. This is believed to be caused by precipitation in the area. There was a total recovery of c 1.19 m during the recovery period that lasted for approximately 5 days.

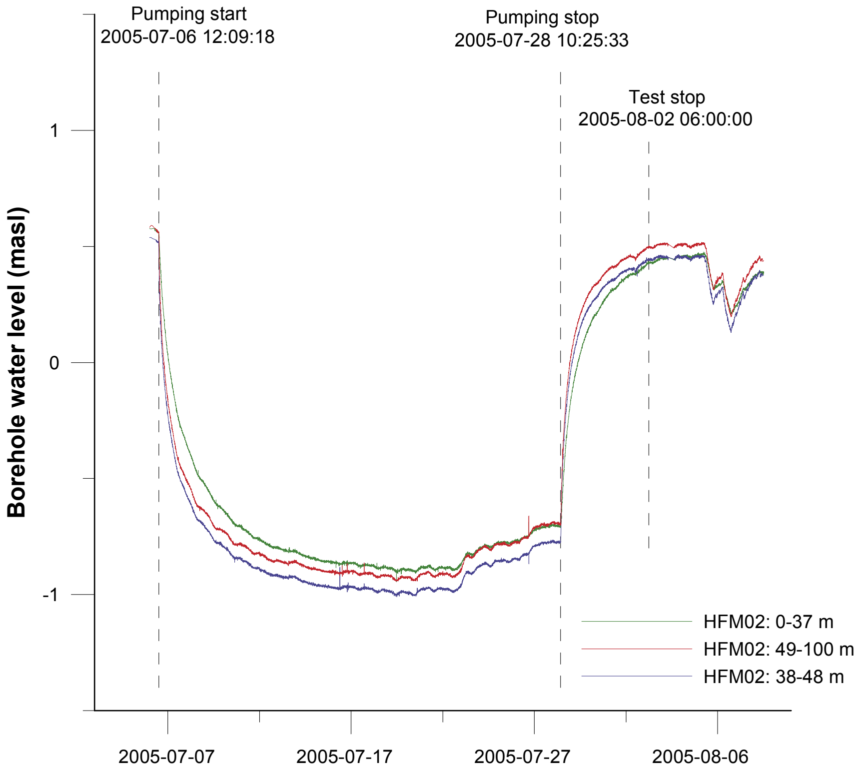


__Figure 6-6.__ Linear plot of pressure versus time in the observation sections in HFM02 during the interference test in HFM01.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.16 Observation section HFM15: 0–84 m

In Figure 6-7 an overview of the pressure responses in observation borehole HFM15 is shown. General test data from the observation section HFM15, 0–84 m, are presented in Table 6-16. According to Table 3-1, the borehole is cased to 6.00 m. The uncased interval of this section is thus c 6–84 m.

Table 6-16. General test data from the observation section HFM15: 0–84 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	1.29
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	0.81
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	1.45
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	0.48

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 0.48 m. A drawdown of 0.01 m was reached approximately 45 minutes after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area and the effect is quite strong in this section. There was a total recovery of c 0.64 m during the recovery period that lasted for approximately 5 days. At stop of recovery there is a peak in hydraulic head probably caused by rainfall.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.17 Observation section HFM15: 85–95 m

General test data from the observation section HFM15, 85–95 m, are presented in Table 6-17. In Figure 6-7 an overview of the pressure responses in observation borehole HFM15 is shown.

Table 6-17. General test data from the observation section HFM15: 85–95 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	0.84
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	0.16
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	0.81
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	0.68

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 0.68 m. A drawdown of 0.01 m was reached approximately 30 minutes after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. There was a total recovery of c 0.65 m during the recovery period that lasted for approximately 5 days.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

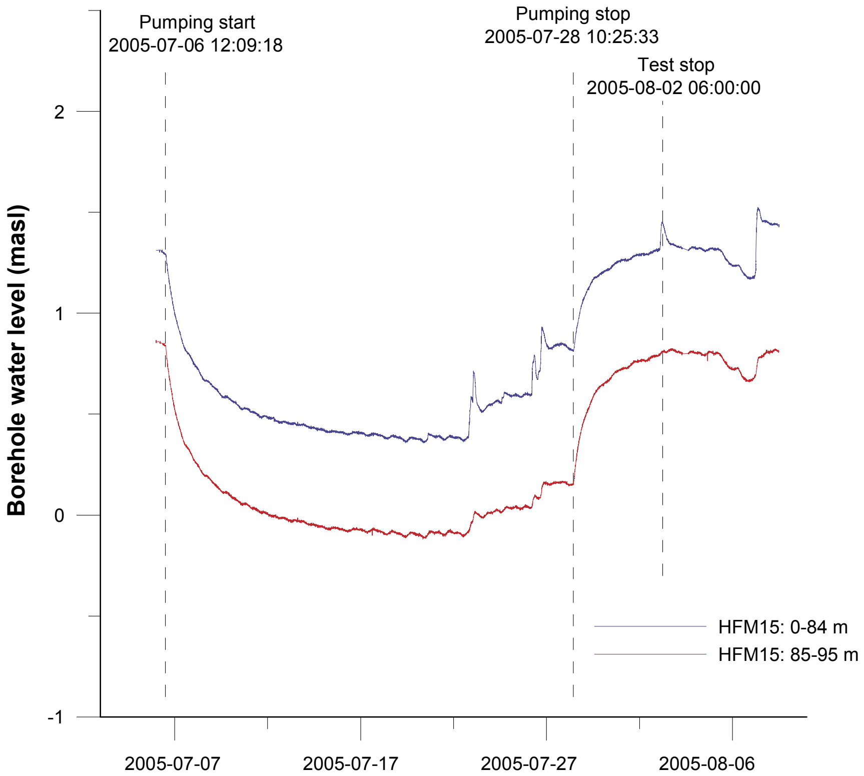


Figure 6-7. *Linear plot of pressure versus time in the observation sections in HFM15 during the interference test in HFM01.*

6.2.18 Observation section HFM14: 0–150 m

In Figure 6-8 an overview of the pressure responses in observation borehole HFM14 is shown. General test data from the observation section HFM14, 0–150 m, are presented in Table 6-18. According to Table 3-1, the borehole is cased to 6.00 m. The uncased interval of this section is thus c 6–150 m.

Table 6-18. General test data from the observation section HFM14: 0–150 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	0.73
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	0.25
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	0.89
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	0.48

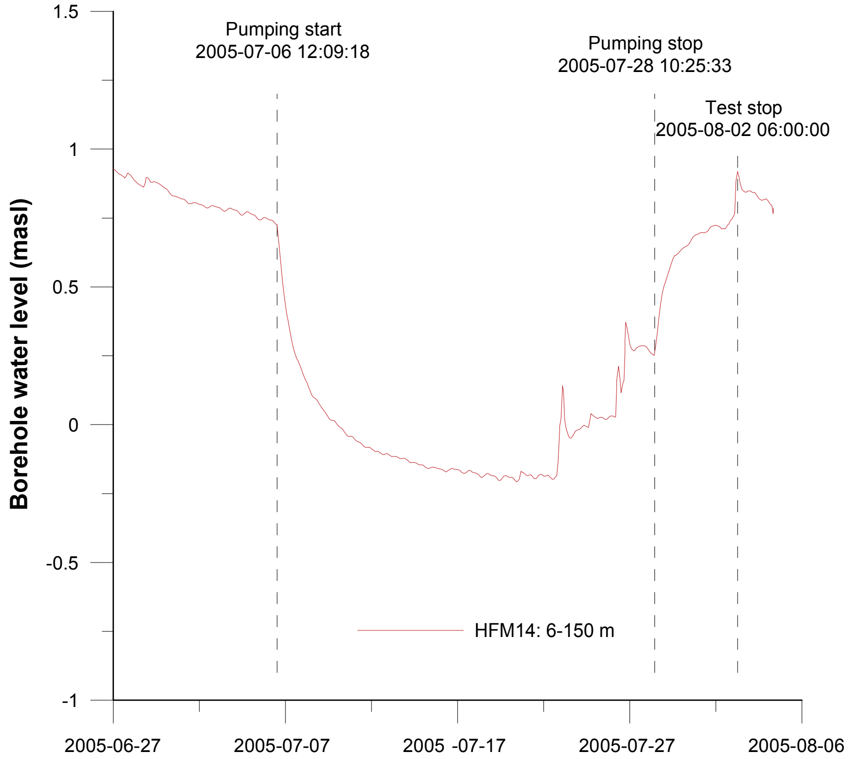


Figure 6-8. *Linear plot of pressure versus time in the observation sections in HFM14 during the interference test in HFM01.*

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 0.48 m. A drawdown of 0.01 m was reached approximately 25 minutes after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. This section is reacting rather strongly to the precipitation and there is a pressure peak registered in this section at the time of test stop, also probably caused by precipitation. The peak is resulting in an apparent recovery, stronger than the actual recovery is likely to be, see Figure 6-8. There was a total apparent recovery of c 0.64 m during the recovery period that lasted for approximately 5 days. The real recovery is believed to be closer to 0.46 m.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.19 Observation section KFM05A: 0–1,003 m

There are no test data available from the observation section KFM05A, 0–1,003 m.

Table 6-19. General test data from the observation section KFM05A: 0–1,003 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m	–
Hydraulic head in test section before stop of flow period.	h_p	m	–
Hydraulic head in test section at stop of recovery period.	h_F	m	–
Hydraulic head change during flow period (h_i–h_p).	dh_p	m	–

Comments on the test

This observation section was believed to be installed with a pressure transducer, logging the presumptive response in the interference test. However, this was not feasible and pressure data are not available for this test section.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.20 Observation section HFM19: 0–103 m

In Figure 6-9 an overview of the pressure responses in observation borehole HFM19 is shown. General test data from the observation section HFM19, 0–103 m, are presented in Table 6-20. According to Table 3-1, the borehole is cased to 12.04 m. The uncased interval of this section is thus c 12–103 m.

Table 6-20. General test data from the observation section HFM19: 0–103 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	2.68
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	1.95
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	2.61
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	0.73

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 0.73 m. A drawdown of 0.01 m was reached approximately 35 minutes after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. There was a total recovery of c 0.66 m during the recovery period that lasted for approximately 5 days.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.21 Observation section HFM19: 104–167 m

In Figure 6-9 an overview of the pressure responses in observation borehole HFM19 is shown. General test data from the observation section HFM19, 104–167 m, are presented in Table 6-21.

Table 6-21. General test data from the observation section HFM19: 104–167 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	2.88
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	2.12
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	2.83
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	0.76

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 0.76 m. A drawdown of 0.01 m was reached approximately 15 minutes after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. There was a total recovery of c 0.71 m during the recovery period that lasted for approximately 5 days.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.22 Observation section HFM19: 168–182 m

In Figure 6-9 an overview of the pressure responses in observation borehole HFM19 is shown. General test data from the observation section HFM19, 168–182 m, are presented in Table 6-22.

Table 6-22. General test data from the observation section HFM19: 168–182 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	2.01
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	1.23
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	1.96
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	0.78

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 0.78 m. A drawdown of 0.01 m was reached approximately 20 minutes after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. There was a total recovery of c 0.73 m during the recovery period that lasted for approximately 5 days.

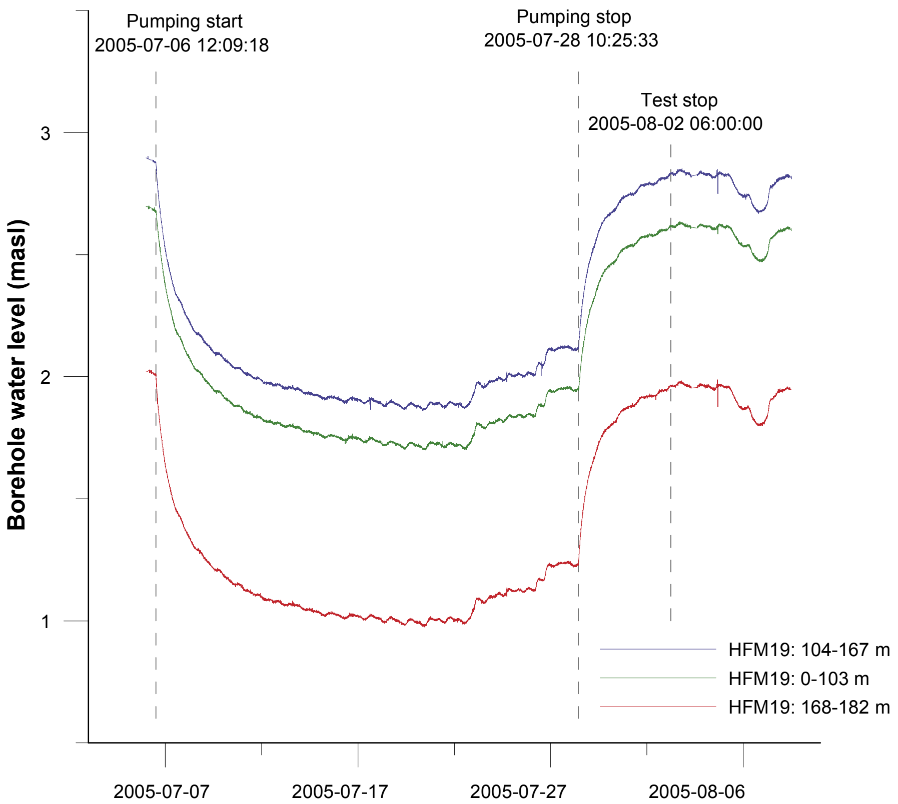


Figure 6-9. *Linear plot of pressure versus time in the observation sections in HFM19 during the interference test in HFM01.*

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.23 Observation section HFM13: 0–100 m

In Figure 6-10 an overview of the pressure responses in observation borehole HFM13 is shown. General test data from the observation section HFM13, 0–100 m, are presented in Table 6-23. According to Table 3-1, the borehole is cased to 14.90 m. The uncased interval of this section is thus c 15–100 m.

Table 6-23. General test data from the observation section HFM13: 0–100 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	2.71
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	2.22
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	2.42
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	0.49

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 0.49 m. A drawdown of 0.01 m was reached approximately 12 hours after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. There was a total recovery of c 0.20 m during the recovery period that lasted for approximately 5 days.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.24 Observation section HFM13: 101–158 m

In Figure 6-10 an overview of the pressure responses in observation borehole HFM13 is shown. General test data from the observation section HFM13, 101–158 m, are presented in Table 6-24.

Table 6-24. General test data from the observation section HFM13: 101–158 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	1.32
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	0.51
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	1.18
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	0.81

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 0.81 m. A drawdown of 0.01 m was reached approximately 5 hours after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. There was a total recovery of c 0.67 m during the recovery period that lasted for approximately 5 days.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.25 Observation section HFM13: 159–173 m

In Figure 6-10 an overview of the pressure responses in observation borehole HFM13 is shown. General test data from the observation section HFM13, 159–173 m, are presented in Table 6-25.

Table 6-25. General test data from the observation section HFM13: 159–173 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	0.57
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	–0.20
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	0.50
Hydraulic head change during flow period (h_i–h_p)	dh_p	m.a.s.l.	0.77

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 0.77 m. A drawdown of 0.01 m was reached approximately 10 minutes after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. There was a total recovery of c 0.70 m during the recovery period that lasted for approximately 5 days.

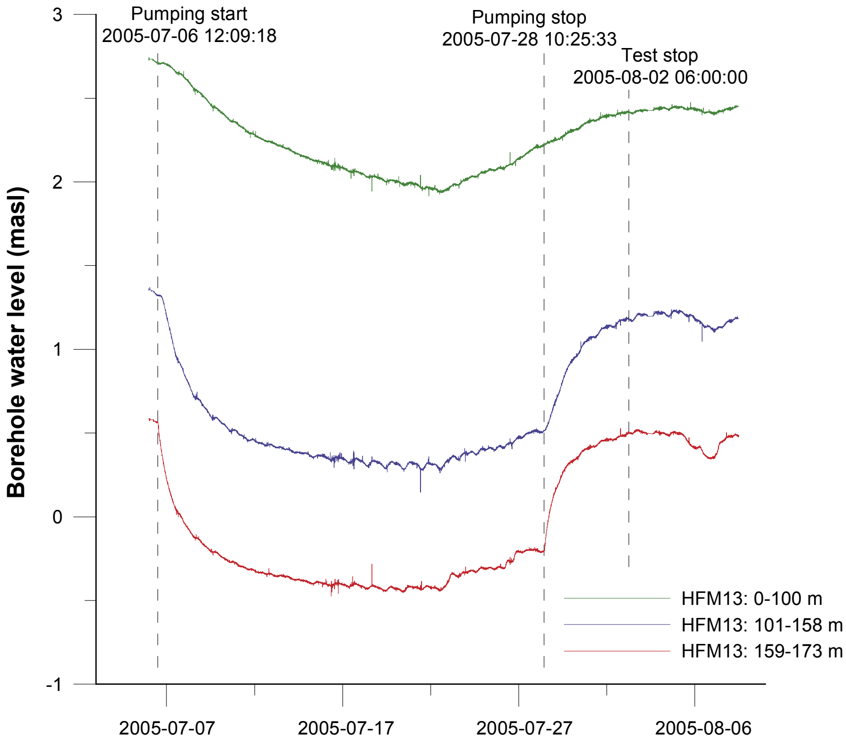


Figure 6-10. *Linear plot of pressure versus time in the observation sections in HFM13 during the interference test in HFM01.*

Interpreted flow regimes

During the flow period an approximate PRF lasting between c 5×10^4 and 2×10^5 s may be identified. The PRF is then transitioning into a PSF. Near the end of the flow period the effect of precipitation becomes apparent and interpretation of flow regimes is not possible.

Interpreted parameters

Transient evaluation of the flow period was chosen as most representative and only results from this period are presented in this report. The transient evaluation was performed using the Hantush-Jacob model for confined leaky aquifers. Transient, quantitative interpretation of the flow period is shown in a log-log diagram in Figure A2-5, Appendix 2. The results from the transient evaluation are summarized in Table 6-55.

6.2.26 Observation section HFM21: 0–202 m

In Figure 6-11 an overview of the pressure responses in observation borehole HFM21 is shown. General test data from the observation section HFM21, 0–202 m, are presented in Table 6-26. According to Table 3-1, the borehole is cased to 12.03 m. The uncased interval of this section is thus c 12–202 m.

Table 6-26. General test data from the observation section HFM21: 0–202 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	0.46
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	–0.28
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	0.37
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	0.74

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 0.74 m. A drawdown of 0.01 m was reached approximately 17 minutes after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. There was a total recovery of c 0.65 m during the recovery period that lasted for approximately 5 days. There is an indication in Figure 6-11 of a certain event a short time before stop of recovery. This may be the effect of pumping activities in the vicinity of the borehole.

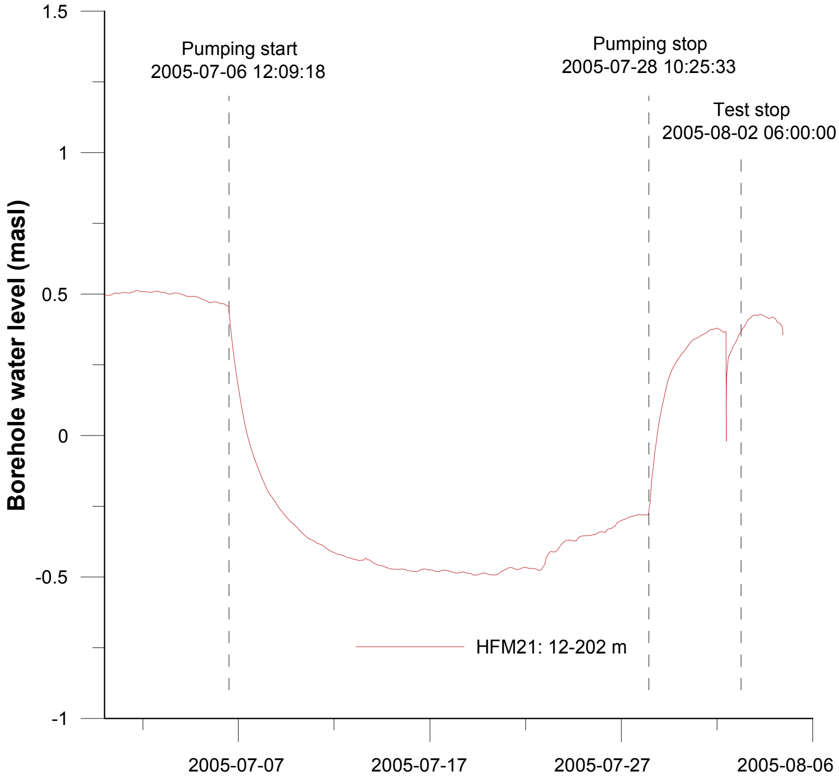


Figure 6-11. Linear plot of pressure versus time in the observation sections in HFM21 during the interference test in HFM01.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.27 Observation section KFM07A: 0–270 m

In Figure 6-12 an overview of the pressure responses in observation borehole KFM07A is shown. General test data from the observation section KFM07A, 0–270 m, are presented in Table 6-27. It should be noted that the pressure values given in Table 6-27 are only valid for relative comparison. The transducers had been installed only a short time prior to the interference test and calibration to render absolute values, in metres above sea level, had not yet been performed. According to Table 3-1, the borehole is cased to 100.10 m. The uncased interval of this section is thus c 100–270 m.

Table 6-27. General test data from the observation section KFM07A: 0–270 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m	1,004.47
Hydraulic head in test section before stop of flow period.	h_p	m	1,003.74
Hydraulic head in test section at stop of recovery period.	h_F	m	1,004.45
Hydraulic head change during flow period (h_i–h_p).	dh_p	m	0.73

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 0.73 m. A drawdown of 0.01 m was reached approximately 120 minutes after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. There was a total recovery of c 0.71 m during the recovery period that lasted for approximately 5 days.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.28 Observation section KFM07A: 271–1,002 m

In Figure 6-12 an overview of the pressure responses in observation borehole KFM07A is shown. General test data from the observation section KFM07A, 271–1,002 m, are presented in Table 6-28. It should be noted that the pressure values given in Table 6-28 are only valid for relative comparison. The transducers had been installed only a short time prior to the interference test and calibration to render absolute values, in metres above sea level, had not yet been performed.

Table 6-28. General test data from the observation section KFM07A: 271–1,002 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m	1,004.50
Hydraulic head in test section before stop of flow period.	h_p	m	1,004.57
Hydraulic head in test section at stop of recovery period.	h_F	m	1,004.62
Hydraulic head change during flow period (h_i–h_p).	dh_p	m	–0.07

Comments on the test

No clear response to pumping is detected in this section. It is unlikely that this section is influenced by pumping in HFM01A. The pressure in the test section is showing an oscillating behaviour, see Figure 6-12. This is believed to be natural fluctuations, mainly caused by so called tidal effects which, in part, have been studied previously in /17/.

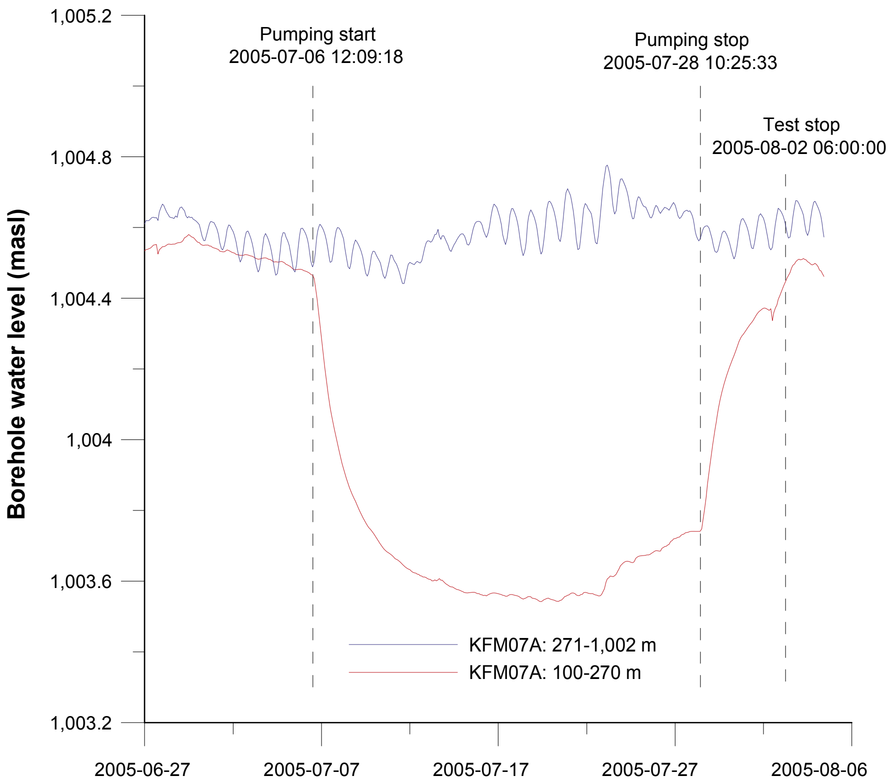


Figure 6-12. *Linear plot of pressure versus time in the observation sections in KFM07A during the interference test in HFM01.*

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.29 Observation section KFM04A: 0–1,001 m

In Figure 6-13 an overview of the pressure responses in observation borehole KFM04A is shown. General test data from the observation section KFM04A, 0–1,001 m, are presented in Table 6-29. According to Table 3-1, the borehole is cased to 106.95 m. The uncased interval of this section is thus c 107–1,001 m.

Table 6-29. General test data from the observation section KFM04A: 0–1,001 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	2.17
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	1.97
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	2.03
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	0.20

Comments on the test

It is uncertain if this section is responding to pumping in HFM01. Prior to the start of pumping in HFM01 there was a clear decreasing trend in the recorded hydraulic head in this observation borehole. It seems however, that the slope of the pressure curve is changing slightly at the time of pumping start, cf Figure 6-13. The response is likely to be much weaker than is indicated by the figures in Table 6-29 above. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. The pressure continues to rise with an approximately constant rate until the end of the recovery period and it is therefore difficult to distinguish between effects from precipitation and rising pressure due to stop of pumping in HFM01.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

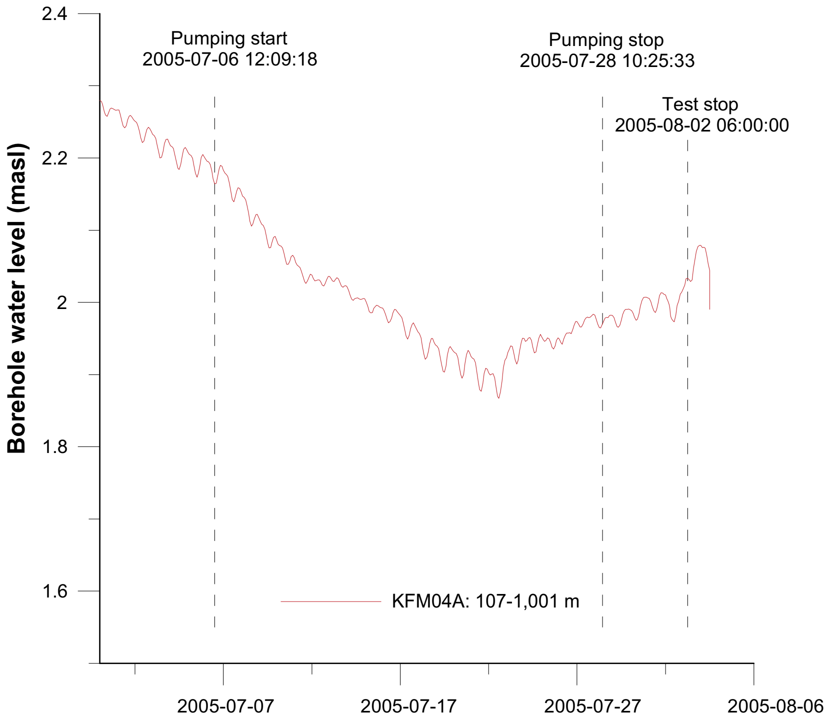


Figure 6-13. *Linear plot of pressure versus time in the observation section in KFM04A during the interference test in HFM01.*

6.2.30 Observation section HFM09: 0–50 m

In Figure 6-14 an overview of the pressure responses in observation borehole HFM09 is shown. General test data from the observation section HFM09, 0–50 m, are presented in Table 6-30. According to Table 3-1, the borehole is cased to 17.02 m. The uncased interval of this section is thus c 17–50 m.

Table 6-30. General test data from the observation section HFM09: 0–50 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	2.76
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	2.55
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	2.61
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	0.21

Comments on the test

This section may respond weakly to pumping in HFM01. Prior to the start of pumping in HFM01 there is a clear falling trend in the recorded hydraulic head in this observation borehole. It seems however, that the slope of the pressure curve is changing slightly at the time of pumping start, cf Figure 6-14. The response is likely to be much weaker than is indicated by the figures in Table 6-30 above. If no consideration is taken to the falling trend, the total drawdown during the flow period was measured to c 0.21 m and a drawdown of 0.01 m was reached approximately 120 minutes after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. The pressure continues to rise with an approximately constant rate until the end of the recovery period and it is therefore difficult to distinguish between effects from precipitation and rising pressure due to the interruption of pumping in HFM01.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

Figure 6-14. *Linear plot of pressure versus time in the observation sections in HFM09 during the interference test in HFM01.*

6.2.31 Observation section HFM22: 0–222 m

In Figure 6-15 an overview of the pressure responses in observation borehole HFM22 is shown. General test data from the observation section HFM22, 0–222 m, are presented in Table 6-31. According to Table 3-1, the borehole is cased to 12.03 m. The uncased interval of this section is thus c 12–222 m.

Table 6-31. General test data from the observation section HFM22: 0–222 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m.a.s.l.	0.17
Hydraulic head in test section before stop of flow period	h_p	m.a.s.l.	–0.45
Hydraulic head in test section at stop of recovery period	h_F	m.a.s.l.	0.18
Hydraulic head change during flow period (h_i–h_p)	dh_p	m.a.s.l.	0.62

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 0.62 m. A drawdown of 0.01 m was reached approximately 120 minutes after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. There was a total recovery of c 0.63 m during the recovery period that lasted for approximately 5 days. There is an indication in Figure 6-15 of an event a short time before stop of recovery. This may be the effect of pumping activities in the vicinity of the borehole.

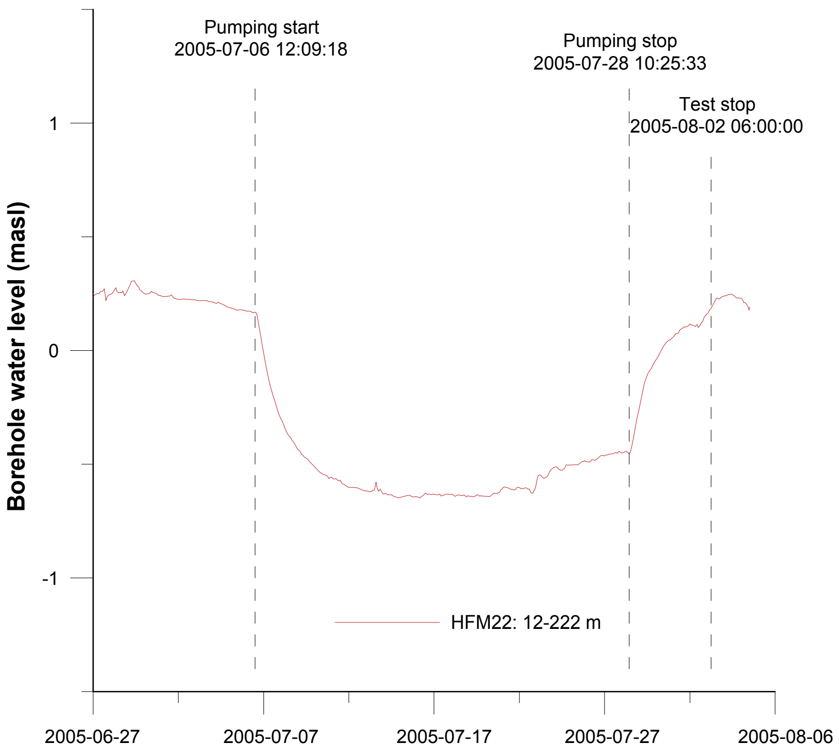


Figure 6-15. *Linear plot of pressure versus time in the observation sections in HFM22 during the interference test in HFM01.*

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.32 Observation section HFM10: 0–99 m

In Figure 6-16 an overview of the pressure responses in observation borehole HFM10 is shown. General test data from the observation section HFM10, 0–99 m, are presented in Table 6-32. According to Table 3-1, the borehole is cased to 11.80 m. The uncased interval of this section is thus c 12–99 m.

Table 6-32. General test data from the observation section HFM10: 0–99 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	2.11
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	1.78
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	1.78
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	0.33

Comments on the test

This section is likely to be unaffected by pumping in HFM01. Prior to the start of pumping in HFM01 there is a clear falling trend in the recorded hydraulic head in this observation section and there is none or a very weak change in the trend following the start of the flow period. The apparent response indicated by the data in Table 6-32 above must be interpreted as fictitious. Around July 22, hydraulic head in the test section started to rise, see Figure 6-16. This is believed to be caused by precipitation in the area.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.33 Observation section HFM10: 100–150 m

In Figure 6-16 an overview of the pressure responses in observation borehole HFM10 is shown. General test data from the observation section HFM10, 100–150 m, are presented in Table 6-33.

Table 6-33. General test data from the observation section HFM10: 100–150 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	2.86
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	2.67
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	2.70
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	0.19

Comments on the test

This section is likely to be unaffected by pumping in HFM01. Prior to the start of pumping in HFM01 there is a clear falling trend in the recorded hydraulic head in this observation section and there is none or a very weak change in the trend following the start of the flow period. The apparent response indicated by the data in Table 6-33 above must be interpreted as fictitious. Around July 22, hydraulic head in the test section started to rise, see Figure 6-16. This is believed to be caused by precipitation in the area.

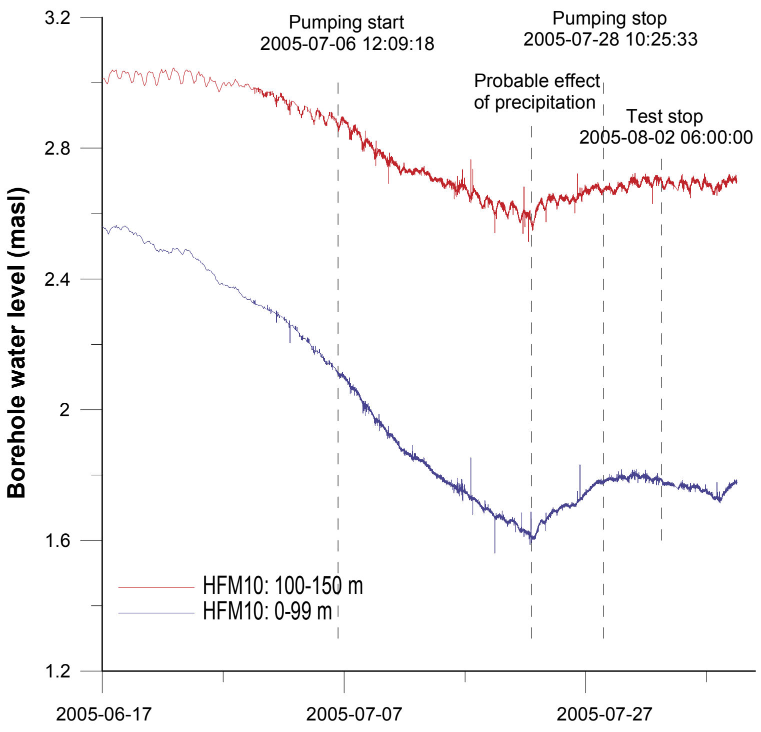


__Figure 6-16.__ Linear plot of pressure versus time in the observation sections in HFM10 during the interference test in HFM01.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.34 Observation section KFM06A: 0–1,001 m

There are no test data available from the observation section KFM06A, 0–1,001 m.

Table 6-34. General test data from the observation section KFM06A: 0–1,001 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m	–
Hydraulic head in test section before stop of flow period.	h_p	m	–
Hydraulic head in test section at stop of recovery period.	h_F	m	–
Hydraulic head change during flow period (h_i–h_p).	dh_p	m	–

Comments on the test

This observation section was believed to be installed with a pressure transducer, logging the presumptive response in the interference test. However, this was not feasible and pressure data are not available for this test section.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.35 Observation section HFM20: 0–48 m

In Figure 6-17 an overview of the pressure responses in observation borehole HFM20 is shown. General test data from the observation section HFM20, 0–48 m, are presented in Table 6-35. According to Table 3-1, the borehole is cased to 12.03 m. The uncased interval of this section is thus c 12–48 m.

Table 6-35. General test data from the observation section HFM20: 0–48 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	–0.05
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	–0.49
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	–0.25
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	0.44

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 0.44 m. A drawdown of 0.01 m was reached approximately 200 minutes after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. There was a total recovery of c 0.24 m during the recovery period that lasted for approximately 5 days.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.36 Observation section HFM20: 49–100 m

In Figure 6-17 an overview of the pressure responses in observation borehole HFM20 is shown. General test data from the observation section HFM20, 49–100 m, are presented in Table 6-36.

Table 6-36. General test data from the observation section HFM20: 49–100 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	–0.61
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	–1.21
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	–0.71
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	0.60

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 0.60 m. A drawdown of 0.01 m was reached approximately 150 minutes after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. There was a total recovery of c 0.50 m during the recovery period that lasted for approximately 5 days.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.37 Observation section HFM20: 101–130 m

In Figure 6-17 an overview of the pressure responses in observation borehole HFM20 is shown. General test data from the observation section HFM20, 101–130 m, are presented in Table 6-37.

Table 6-37. General test data from the observation section HFM20: 101–130 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	–0.60
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	–1.26
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	–0.63
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	0.66

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 0.66 m. A drawdown of 0.01 m was reached approximately 140 minutes after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. There was a total recovery of c 0.63 m during the recovery period that lasted for approximately 5 days.

Interpreted flow regimes

The pressure response during the flow period is shown in a log-log diagram in Figure A2-6, Appendix 2. A short PRF lasting between c $1–2\times10^5$ s may be identified which then is transitioning into a PSF. Near the end of the flow period the effect of precipitation becomes apparent and interpretation of flow regimes is not possible.

Interpreted parameters

Transient evaluation of the flow period was chosen as most representative and only results from that period are presented in this report. The transient evaluation was performed using the Hantush-Jacob model for confined leaky aquifers. The transient, quantitative interpretation of the flow period is shown in a log-log diagram in Figure A2-6, Appendix 2. The results from the transient evaluation are summarized in Table 6-55.

6.2.38 Observation section HFM20: 131–301 m

In Figure 6-17 an overview of the pressure responses in observation borehole HFM20 is shown. General test data from the observation section HFM20, 131–301 m, are presented in Table 6-38.

Table 6-38. General test data from the observation section HFM20: 131–301 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	–0.41
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	–1.11
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	–0.45
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	0.70

Comments on the test

A clear response to pumping was recorded in this section. The total drawdown during the flow period was c 0.70 m. A drawdown of 0.01 m was reached approximately 120 minutes after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. There was a total recovery of c 0.66 m during the recovery period that lasted for approximately 5 days.

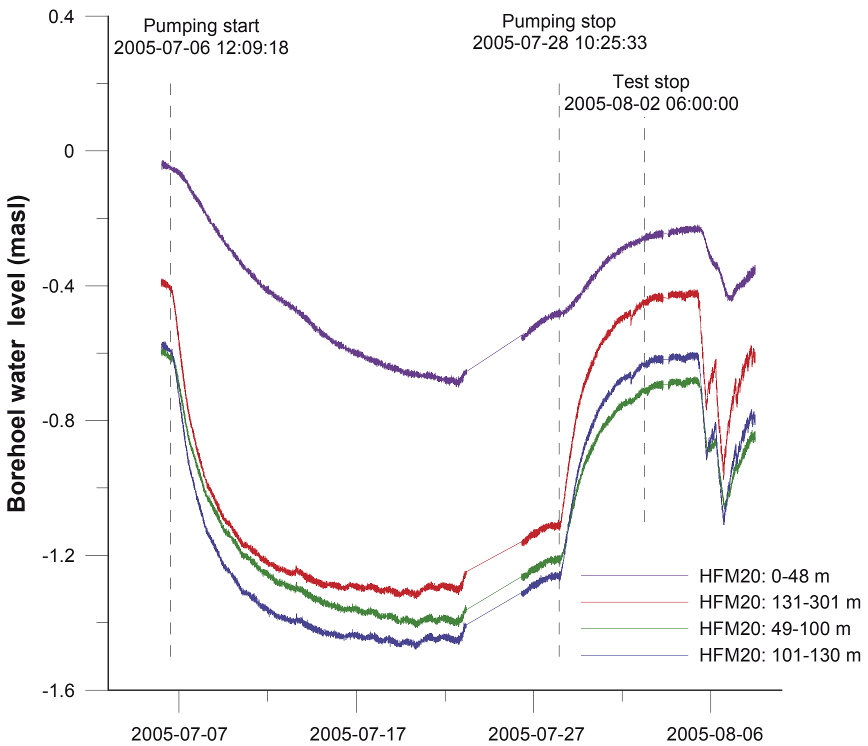


Figure 6-17. Linear plot of pressure versus time in the observation sections in HFM20 during the interference test in HFM01.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.39 Observation section KFM06B: 0–100 m

There are no test data available from the observation section KFM06B, 0–100 m.

Table 6-39. General test data from the observation section KFM06B: 0–100 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m	–
Hydraulic head in test section before stop of flow period.	h_p	m	–
Hydraulic head in test section at stop of recovery period.	h_F	m	–
Hydraulic head change during flow period (h_i–h_p).	dh_p	m	–

Comments on the test

This observation section was believed to be installed with a pressure transducer, logging the presumptive response in the interference test. However, this was not feasible and pressure data are not available for this test section. Pressure data from borehole HFM16 (presented below) should be fairly representative for the responses in KFM06B.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.40 Observation section HFM16: 0–132 m

In Figure 6-18 an overview of the pressure responses in observation borehole HFM16 is shown. General test data from the observation section HFM16, 0–132 m, are presented in Table 6-40. According to Table 3-1, the borehole is cased to 12.02 m. The uncased interval of this section is thus c 12–132 m.

Table 6-40. General test data from the observation section HFM16: 0–132 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	0.61
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	0.52
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	0.69
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	0.09

Comments on the test

A clear but weak response to pumping was recorded in this section. The total drawdown during the flow period was c 0.09 m. A drawdown of 0.01 m was reached approximately 14 hours after the pumping started in HFM01. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. The pressure in the test section continued to rise with an approximately constant rate until the end of the recovery period and it is not possible to determine if any of the recovery is actually caused by the interruption of pumping in HFM01. It is very likely that the recovery indicated by the data in Table 6-40 is overestimated.

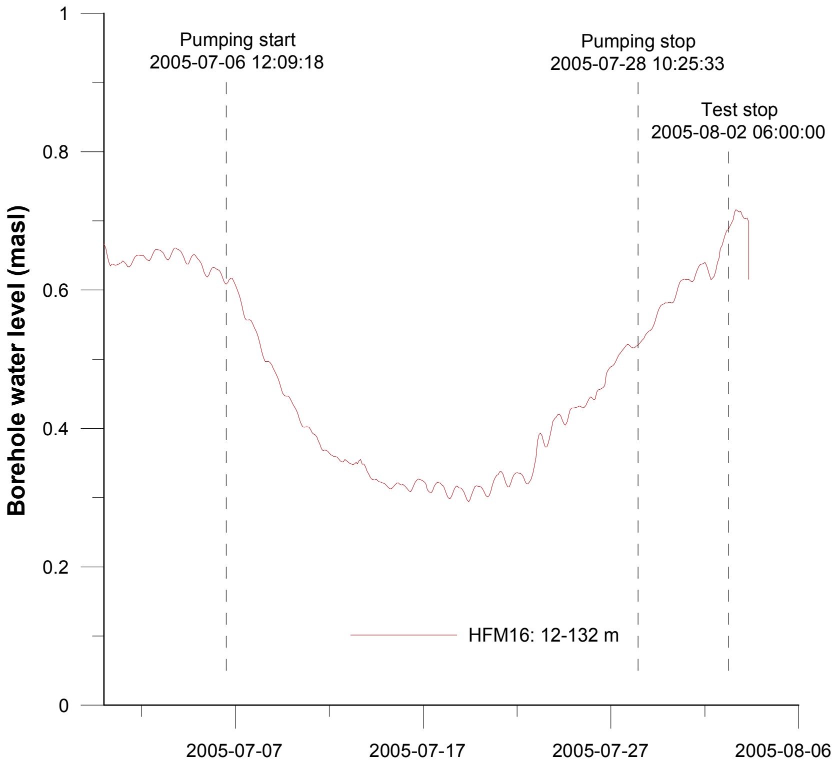


Figure 6-18. Linear plot of pressure versus time in the observation sections in HFM16 during the interference test in HFM01.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.41 Observation section HFM17: 0–211 m

In Figure 6-19 an overview of the pressure responses in observation borehole HFM17 is shown. General test data from the observation section HFM17, 0–211 m, are presented in Table 6-41. According to Table 3-1, the borehole is cased to 8.00 m. The uncased interval of this section is thus c 8–211 m.

Table 6-41. General test data from the observation section HFM17: 0–211 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m.a.s.l.	0.53
Hydraulic head in test section before stop of flow period.	h_p	m.a.s.l.	0.67
Hydraulic head in test section at stop of recovery period.	h_F	m.a.s.l.	0.71
Hydraulic head change during flow period (h_i–h_p).	dh_p	m.a.s.l.	–0.14

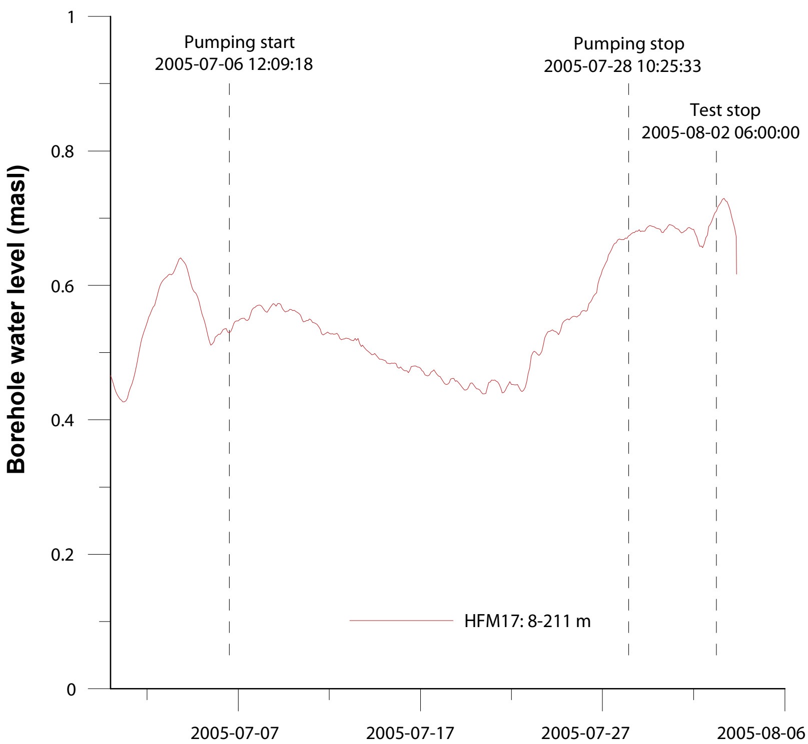


Figure 6-19. *Linear plot of pressure versus time in the observation sections in HFM17 during the interference test in HFM01.*

Comments on the test

A possible, very weak response to pumping in HFM01 is indicated in this section. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. The effect is large compared to the possible effect of pumping in HFM01 and erases any possible traces of a recovery. This, together with the fact that the hydraulic head in the section increases in the beginning of the flow period makes the interpretation difficult.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.42 Observation section KFM02A: 0–132 m

In Figure 6-21 an overview of the pressure responses in observation borehole KFM02A is shown. General test data from the observation section KFM02A, 0–132 m, are presented in Table 6-42. It should be noted that the pressure values given in Table 6-42 are only valid for relative comparison. The transducers had been installed only a short time prior to the interference test and calibration to render absolute values, in metres above sea level, had not yet been performed. According to Table 3-1, the borehole is cased to 100.14 m. The uncased interval of this section is thus c 100–132 m.

Table 6-42. General test data from the observation section KFM02A: 0–132 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period	h_i	m	1,031.38
Hydraulic head in test section before stop of flow period	h_p	m	1,031.84
Hydraulic head in test section at stop of recovery period	h_F	m	1,031.86
Hydraulic head change during flow period (h_i–h_p)	dh_p	m	–0.46

Comments on the test

This section is probably unaffected by pumping in HFM01. Around July 22, the hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. The effect is large compared to the possible effect of pumping in HFM01 and erases any possible traces of a recovery. This, together with the fact that the hydraulic head in the section increases in the beginning of the flow period makes an interpretation difficult.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.43 Observation section KFM02A: 133–240 m

In Figure 6-21 an overview of the pressure responses in observation borehole KFM02A is shown. General test data from the observation section KFM02A, 133–240 m, are presented in Table 6-43.

Table 6-43. General test data from the observation section KFM02A: 133–240 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m	1,031.39
Hydraulic head in test section before stop of flow period.	h_p	m	1,031.64
Hydraulic head in test section at stop of recovery period.	h_F	m	1,031.67
Hydraulic head change during flow period (h_i–h_p).	dh_p	m	–0.25

Comments on the test

This section is probably unaffected by pumping in HFM01. Around July 22, the hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. The effect is large compared to the possible effect of pumping in HFM01 and erases any possible traces of a recovery. This, together with the fact that the hydraulic head in the section increases in the beginning of the flow period makes an interpretation difficult.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.44 Observation section KFM02A: 241–410 m

In Figure 6-20 an overview of the pressure responses in observation borehole KFM02A is shown. General test data from the observation section KFM02A, 241–410 m, are presented in Table 6-44.

Table 6-44. General test data from the observation section KFM02A: 241–410 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m	1,031.47
Hydraulic head in test section before stop of flow period.	h_p	m	1,031.45
Hydraulic head in test section at stop of recovery period.	h_F	m	1,031.57
Hydraulic head change during flow period (h_i–h_p).	dh_p	m	0.02

Comments on the test

A possible weak response to pumping was recorded in this section. The total drawdown during the flow period was c 0.02 m. A drawdown of 0.01 m was reached approximately 2 days after the pumping started in HFM01. The periodic fluctuations in pressure caused by so called tidal effects (to some extent discussed in /17/) are very evident in this borehole. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. The pressure in the test section continued to rise with an approximately constant rate until the end of the recovery period and it is not possible to determine if any of the recovery is actually caused by the interruption of pumping in HFM01. It is very likely that the recovery indicated by the data in Table 6-44 is much overestimated.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.45 Observation section KFM02A: 411–442 m

In Figure 6-20 an overview of the pressure responses in observation borehole KFM02A is shown. General test data from the observation section KFM02A, 411–442 m, are presented in Table 6-45.

Table 6-45. General test data from the observation section KFM02A: 411–442 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m	1,031.10
Hydraulic head in test section before stop of flow period.	h_p	m	1,031.05
Hydraulic head in test section at stop of recovery period.	h_F	m	1,031.18
Hydraulic head change during flow period (h_i–h_p).	dh_p	m	0.05

Comments on the test

A weak response to pumping was recorded in this section. The total drawdown during the flow period was c 0.05 m. A drawdown of 0.01 m was reached approximately 20 hours after the pumping started in HFM01. The periodic fluctuations in pressure caused by so called tidal effects (to some extent discussed previously in /17/) are very evident in this borehole. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. The pressure in the test section continued to rise in an approximate constant rate until the end of the recovery period and it is not possible to determine if any of the recovery is actually caused by the interruption of pumping in HFM01. It is very likely that the recovery indicated by the data in Table 6-45 is much overestimated.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.46 Observation section KFM02A: 443–489 m

In Figure 6-20 an overview of the pressure responses in observation borehole KFM02A is shown. General test data from the observation section KFM02A, 443–489 m, are presented in Table 6-46. It should be noted that the pressure values given in Table 6-46 are only valid for relative comparison. The transducers had been installed only a short time prior to the interference test and calibration to render absolute values, in metres above sea level, had not yet been performed.

Table 6-46. General test data from the observation section KFM02A: 443–489 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m	1,031.13
Hydraulic head in test section before stop of flow period.	h_p	m	1,031.06
Hydraulic head in test section at stop of recovery period.	h_F	m	1,031.20
Hydraulic head change during flow period (h_i–h_p).	dh_p	m	0.07

Comments on the test

A weak response to pumping was recorded in this section. The total drawdown during the flow period was c 0.07 m. A drawdown of 0.01 m was reached approximately 20 hours after the pumping started in HFM01. The periodic fluctuations in pressure caused by so called tidal effects (to some extent discussed previously in /17/) are very evident in this borehole. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. The pressure in the test section continued to rise with an approximately constant rate until the end of the recovery period and it is not possible to determine if any of the recovery is actually caused by the interruption of pumping in HFM01. It is very likely that the recovery indicated by the data in Table 6-46 is much overestimated.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.47 Observation section KFM02A: 490–518 m

In Figure 6-20 an overview of the pressure responses in observation borehole KFM02A is shown. General test data from the observation section KFM02A, 490–518 m, are presented in Table 6-47. It should be noted that the pressure values given in Table 6-47 are only valid for relative comparison. The transducers had been installed only a short time prior to the interference test and calibration to render absolute values, in metres above sea level, had not yet been performed.

Table 6-47. General test data from the observation section KFM02A: 490–518 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m	1,031.07
Hydraulic head in test section before stop of flow period.	h_p	m	1,031.00
Hydraulic head in test section at stop of recovery period.	h_F	m	1,031.13
Hydraulic head change during flow period (h_i–h_p).	dh_p	m	0.07

Comments on the test

A weak response to pumping was recorded in this section. The total drawdown during the flow period was c 0.07 m. A drawdown of 0.01 m was reached approximately 20 hours after the pumping started in HFM01. The periodic fluctuations in pressure caused by so called tidal effects (to some extent discussed previously in /17/) are very evident in this borehole. Around July 22, hydraulic head in the test section started to rise. This is believed to be caused by precipitation in the area. The pressure in the test section continued to rise with an approximately constant rate until the end of the recovery period and it is not possible to determine if any of the recovery is actually caused by the interruption of pumping in HFM01. It is very likely that the recovery indicated by the data in Table 6-47 is much overestimated.

Interpreted flow regimes

The pressure response during the flow period is shown in a log-log diagram in Figure A2-7, Appendix 2. The periodic fluctuations discussed above make interpretation of flow regimes difficult. There is no clear PRF but only a PSF during the flow period. Near the end of the flow period the effect of precipitation becomes apparent and interpretation of flow regimes is not possible here.

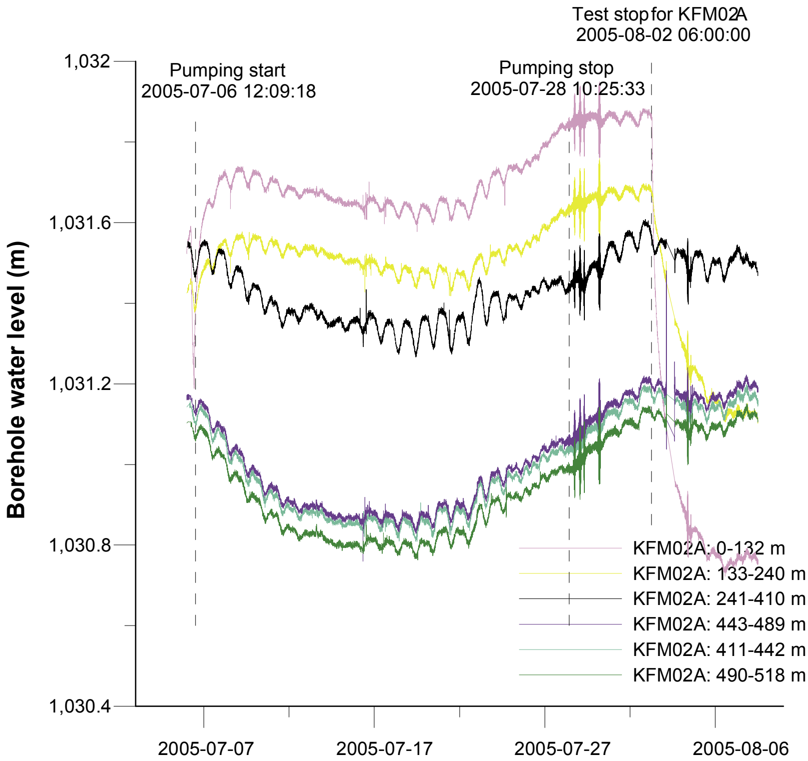


Figure 6-20. *Linear plot of pressure versus time in the observation sections in KFM02A during the interference test in HFM01. Only sections with possible pressure responses are shown.*

Interpreted parameters

Transient evaluation of the flow period was chosen as most representative and only results from that period are presented in this report. The transient evaluation was performed using the Hantush-Jacob model for confined leaky aquifers. Transient, quantitative interpretation of the flow period is shown in a log-log diagram in Figure A2-7, Appendix 2. The results from the transient evaluation are summarized in Table 6-55.

6.2.48 Observation section KFM02A: 519–888 m

In Figure 6-21 an overview of the pressure responses in observation borehole KFM02A is shown. General test data from the observation section KFM02A, 519–888 m, are presented in Table 6-48. It should be noted that the pressure values given in Table 6-48 are only valid for relative comparison. The transducers had been installed only a short time prior to the interference test and calibration to render absolute values, in metres above sea level, had not yet been performed.

Table 6-48. General test data from the observation section KFM02A: 519–888 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m	1,031.24
Hydraulic head in test section before stop of flow period.	h_p	m	1,031.32
Hydraulic head in test section at stop of recovery period.	h_F	m	1,031.33
Hydraulic head change during flow period (h_i–h_p).	dh_p	m	–0.08

Comments on the test

No clear response to pumping is detected in this section. It is unlikely that this section is influenced by pumping in HFM01A. The pressure in the test section is showing an oscillating behaviour; see Figure 6-21. This is believed to be natural fluctuations, mainly caused by so called tidal effects which, in part, have been studied previously in /17/.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

6.2.49 Observation section KFM02A: 889–1,002 m

In Figure 6-21 an overview of the pressure responses in observation borehole KFM02A is shown. General test data from the observation section KFM02A, 889–1,002 m, are presented in Table 6-49. It should be noted that the pressure values given in Table 6-49 are only valid for relative comparison. The transducers had been installed only a short time prior to the interference test and calibration to render absolute values, in metres above sea level, had not yet been performed.

Table 6-49. General test data from the observation section KFM02A: 889–1,002 m during the interference test in HFM01A.

Pressure data	Nomenclature	Unit	Value
Hydraulic head in test section before start of flow period.	h_i	m	1,031.02
Hydraulic head in test section before stop of flow period.	h_p	m	1,031.49
Hydraulic head in test section at stop of recovery period.	h_F	m	1,031.51
Hydraulic head change during flow period (h_i–h_p).	dh_p	m	–0.47

Comments on the test

No clear response to pumping is detected in this section. The hydraulic head is increasing throughout the test period and it is unlikely that this section is influenced by pumping in HFM01A. The pressure in the test section is showing an oscillating behaviour; see Figure 6-21. This is believed to be natural fluctuations, mainly caused by so called tidal effects which, in part, have been studied previously in /17/.

Interpreted flow regimes

No interpretation of flow regimes has been made for this section.

Interpreted parameters

No transient parameter interpretation has been made for this section.

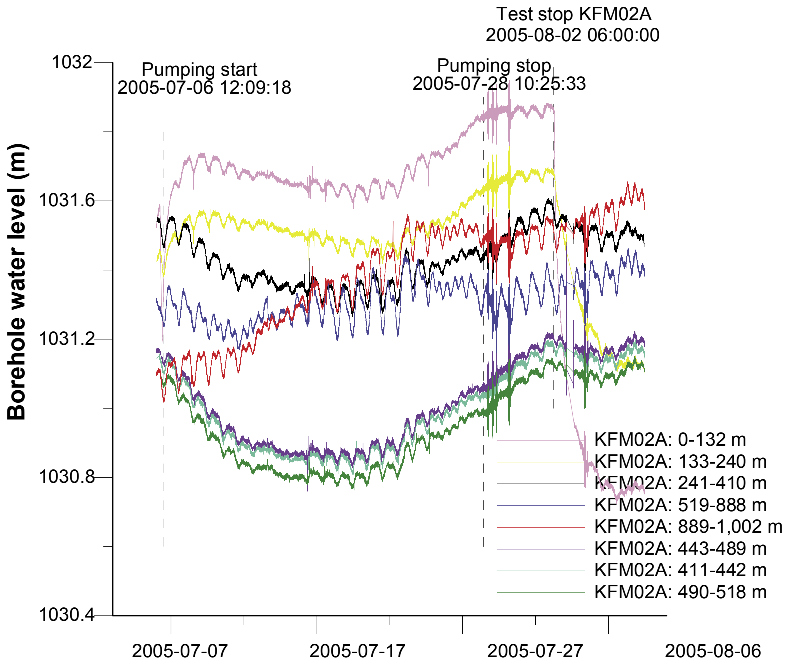


Figure 6-21. *Linear plot of pressure versus time in the observation sections in KFM02A during the interference test in HFM01.*

6.3 Response analysis

A response analysis according to the methodology description for interference tests was made. However, because there was only one test made, no response matrix was prepared. The response time lags (dt_L) in the observation sections during pumping in HFM01 are shown in Table 6-50. The lag times were derived from the drawdown curves in the observation borehole sections at an actual drawdown of 0.01 m. Because of the oscillating behaviour of the measured pressure in some of the observation sections, see for instance Figure 6-3, it was difficult to determine the exact time to reach a 0.01 m drawdown. It was possible, however, to make an approximate estimate from the drawdown curves.

An increase of pressure, most likely the effect of precipitation in the area, was observed in several of the observations sections, starting around July 22. Due to this fact the parameter s_p, i.e. the drawdown in the actual observation section at stop of pumping, was not representative for the interferences from pumping in HFM01. To achieve a more relevant approximation of the drawdown caused by pumping in HFM01, the values for s_p were taken at July 22, 12:00 PM. This time is indicated in Figure 6-16, showing the pressure response in observation borehole HFM10 where the rising pressure due to precipitation can be clearly observed.

Only observation sections in which an assumed pressure response was recorded are included in the response analysis. In Tables 6-50 and 6-51 only sections comprised in the response analysis are presented.

The normalized response time with respect to the distance to the pumping borehole was calculated. This time is inversely related to the hydraulic diffusivity (T/S) of the formation. In addition, the normalized drawdown with respect to the flow rate was calculated and is presented in Table 6-51.

In Figure 6-22 a response diagram, showing the presumptive responding observation sections, is presented. In this figure the observation sections are represented by different symbols. In the response diagram, observation sections represented by data points lying to the left generally indicate a better connectivity, a higher hydraulic diffusivity, in regard to the pumping borehole section than sections represented by data points further to the right in the diagram.

$dt_L[s = 0.01\ m]/r_s^2$ = normalized response time with respect to the distance r_s (s/m²).

$dt_L[s = 0.01\ m]$ = time after start of pumping (s) at a drawdown s = 0.01 m in the observation section.

r_s = 3D-distance between the hydraulic point of application (hydr p a) in the pumping borehole and observation borehole (m).

s_p/Q_p = normalized drawdown with respect to the pumping flow rate (s/m²).

s_p = drawdown at stop of pumping in the actual observation borehole/section (m).

Q_p = pumping flow rate by the end of the flow period (m³/s).

The (normalized) response time lag for many of the observation sections included in the interference test, where a response was detected, must be considered as rough estimates. The main reason for this is, as mentioned above, the difficulty to make an estimate of this parameter due to the oscillating pressure.

When grouping observation sections by the strength of response, illustrated by the tentative separating line in the response diagram in Figure 6-22, the observation sections with the most distinct responses can be identified. Figure 6-22 indicates that the largest drawdown was found in section HFM02: 38–48 m and the weakest response in section HFM17: 8–211 m. The most delayed response occurred in section KFM01A: 0–108 m. However, both the latter responses are considered as uncertain.

A tentative division line may be drawn in Figure 6-22. Observation sections located above this line correspond to sections with clear and distinct responses, whereas sections located below the line represent more uncertain responses. Some of these sections are likely to represent sections with apparent responses due to the prevailing natural decreasing pressure trend at the beginning of the flow period. On the other hand, at least some of the observation sections located above the division line are likely to represent more or less direct responses along fracture zones between borehole HFM01 and the actual sections.

Figure 6-23 displays the same parameters as in the response diagram, but in a different type of diagram. In this diagram a third index is also displayed, i.e. the ratio between the two indices in the response diagram. Clearly, sections with higher ratios correspond to sections which are hydraulically well connected to the pumping borehole. In the diagram, all observation sections that responded to pumping in HFM01, but one, are included. In Figure 6-23 observation section KFM01A: 0–108 m is not included. This section demonstrates the weakest and most uncertain response and is excluded to clarify the diagram. All other sections are ranked so that sections showing the weakest responses are located to the left in the diagram and observation sections with stronger responses are located to the right. In the figure the three observation sections mentioned above again stand out as those with the strongest responses.

Three observation sections stand out as responding most strongly. These sections, HFM13: 159–173, HFM21: 12–202 and HFM02: 38–48, display responses that are distinct enough to be characterized as potential zone responses between HFM01 and the actual sections.

Table 6-50. Calculated response lag times and normalized response time lags for the observation sections included in the interference test.

Pumping borehole	Observation borehole	Section (m)	dt_L[s = 0.01 m] (s)	r_s (m)	dt_L[s = 0.01 m]/r_s^2 (s/m²)
HFM01	KFM01A	0–108	69,000	137	3.676
”	”	109–130	5,390	147	2.494×10^{-1}
”	”	131–204	1,500	160	5.859×10^{-2}
”	”	205–373	–	268	–
”	”	374–430	–	375	–
”	”	431–1,002	81,300	679	1.763×10^{-1}
HFM01	KFM01B	0–100	540	135	2.963×10^{-2}
”	”	101–141	3,600	162	1.372×10^{-1}
”	”	142–500	1,200	325	1.136×10^{-2}
HFM01	HFM03	0–18	1,900	222	3.855×10^{-2}
”	”	19–26	630	221	1.290×10^{-2}
HFM01	HFM02	0–37	900	223	1.810×10^{-2}
”	”	38–48	180	222	3.652×10^{-3}
”	”	49–100	600	222	1.217×10^{-2}
HFM01	HFM15	0–84	2,700	352	2.179×10^{-2}
”	”	85–95	1,800	326	1.694×10^{-2}
HFM01	HFM14	6–150	1,486	353	1.193×10^{-2}
HFM01	KFM05A 1)	100–1,003	–	399	–
HFM01	HFM19	0–103	2,100	358	1.639×10^{-2}
”	”	104–167	900	355	7.141×10^{-3}
”	”	168–182	1,200	356	9.469×10^{-3}
HFM01	HFM13	0–100	44,101	506	1.722×10^{-1}
”	”	101–158	16,500	498	6.653×10^{-2}
”	”	159–173	600	502	2.381×10^{-3}
HFM01	HFM21	12–202	1,048	635	2.599×10^{-3}
HFM01	KFM07A	100–1,002	7,200	726	1.366×10^{-2}
HFM01	KFM04A	107–1,001	79,200	769	1.339×10^{-1}
HFM01	HFM09	17–50	72,000	830	1.045×10^{-1}
HFM01	HFM22	12–222	7,200	872	9.469×10^{-3}
HFM01	HFM10	0–99	33,000	896	4.111×10^{-2}
”	”	100–150	77,100	898	9.561×10^{-2}
HFM01	KFM06A 1)	100–1,001	–	889	–
HFM01	HFM20	0–48	12,000	917	1.427×10^{-2}
”	”	49–100	8,810	919	1.043×10^{-2}
”	”	101–130	8,530	922	1.003×10^{-2}
”	”	131–301	7,200	936	8.218×10^{-3}
HFM01	KFM06B 1)	5–100	–	959	–
HFM01	HFM16	12–132	50,400	981	5.237×10^{-2}
HFM01	HFM17	8–211	525,600	1,776	1.666×10^{-1}
HFM01	KFM02A	0–132	–	1,911	–
”	”	133–240	–	1,910	–
”	”	241–410	167,970	1,910	4.604×10^{-2}
”	”	411–442	71,400	1,920	1.937×10^{-2}
”	”	443–489	70,500	1,925	1.903×10^{-2}
”	”	490–518	70,200	1,930	1.885×10^{-2}
”	”	519–888	–	1,936	–
”	”	889–1,002	–	2,022	–

1) Section not used during the interference test in HFM01.

Table 6-51. Drawdown and normalized drawdown for the observation sections included in the interference test.

Pumping borehole	Flow rate Q_p (m^3/s)	Observation borehole	Section (m)	s_p (m)	s_p/Q_p (s/m^2)
HFM01	1.48×10^{-3}	KFM01A	0–108	0.44	298.3
”	1.48×10^{-3}	”	109–130	1.49	1,005.5
”	1.48×10	”	131–204	1.46	989.4
”	1.48×10	”	205–373	–	–
”	1.48×10	”	374–430	–	–
”	1.48×10	”	431–1,002	0.40	270.1
HFM01	1.48×10	KFM01B	0–100	1.47	990.3
”	1.48×10	”	101–141	1.45	982.0
”	1.48×10	”	142–500	1.41	953.0
HFM01	1.48×10	HFM03	0–18	1.43	964.2
”	1.48×10	”	19–26	1.47	991.8
HFM01	1.48×10	HFM02	0–37	1.45	977.3
”	1.48×10	”	38–48	1.50	1,013.0
”	1.48×10	”	49–100	1.48	1,001.6
HFM01	1.48×10	HFM15	0–84	0.92	622.7
”	1.48×10	”	85–95	0.94	634.7
HFM01	1.48×10	HFM14	6–150	0.92	623.8
HFM01	1.48×10	KFM05A [1)]	100–1,003	–	–
HFM01	1.48×10	HFM19	0–103	0.97	653.2
”	1.48×10	”	104–167	1.01	679.7
”	1.48×10	”	168–182	1.02	690.0
HFM01	1.48×10	HFM13	0–100	0.76	514.1
”	1.48×10	”	101–158	1.04	699.4
”	1.48×10	”	159–173	1.00	675.4
HFM01	1.48×10	HFM21	12–202	0.93	627.8
HFM01	1.48×10	KFM07A	100–1,002	0.90	610.8
HFM01	1.48×10	KFM04A	107–1,001	0.29	198.7
HFM01	1.48×10	HFM09	17–50	0.30	205.1
HFM01	1.48×10	HFM22	12–222	0.78	525.9
HFM01	1.48×10	HFM10	0–99	0.50	335.7
”	1.48×10	”	100–150	0.30	203.1
HFM01	1.48×10	KFM06A [1)]	100–1,001	–	–
HFM01	1.48×10	HFM20	0–48	0.64	432.4
”	1.48×10	”	49–100	0.78	528.6
”	1.48×10	”	101–130	0.85	577.2
”	1.48×10	”	131–301	0.89	603.9
HFM01	1.48×10	KFM06B [1)]	5–100	–	–
HFM01	1.48×10	HFM16	12–132	0.29	194.9
HFM01	1.48×10	HFM17	8–211	0.09	58.3
HFM01	1.48×10	KFM02A	0–132	–	–
”	1.48×10	”	133–240	–	–
”	1.48×10	”	241–410	0.16	110.1
”	1.48×10	”	411–442	0.25	170.3
”	1.48×10	”	443–489	0.25	169.6
”	1.48×10	”	490–518	0.26	173.6
”	1.48×10	”	519–888	–	–
”	1.48×10	”	889–1,002	–	–

[1)] Section not used during the interference test in HFM01.

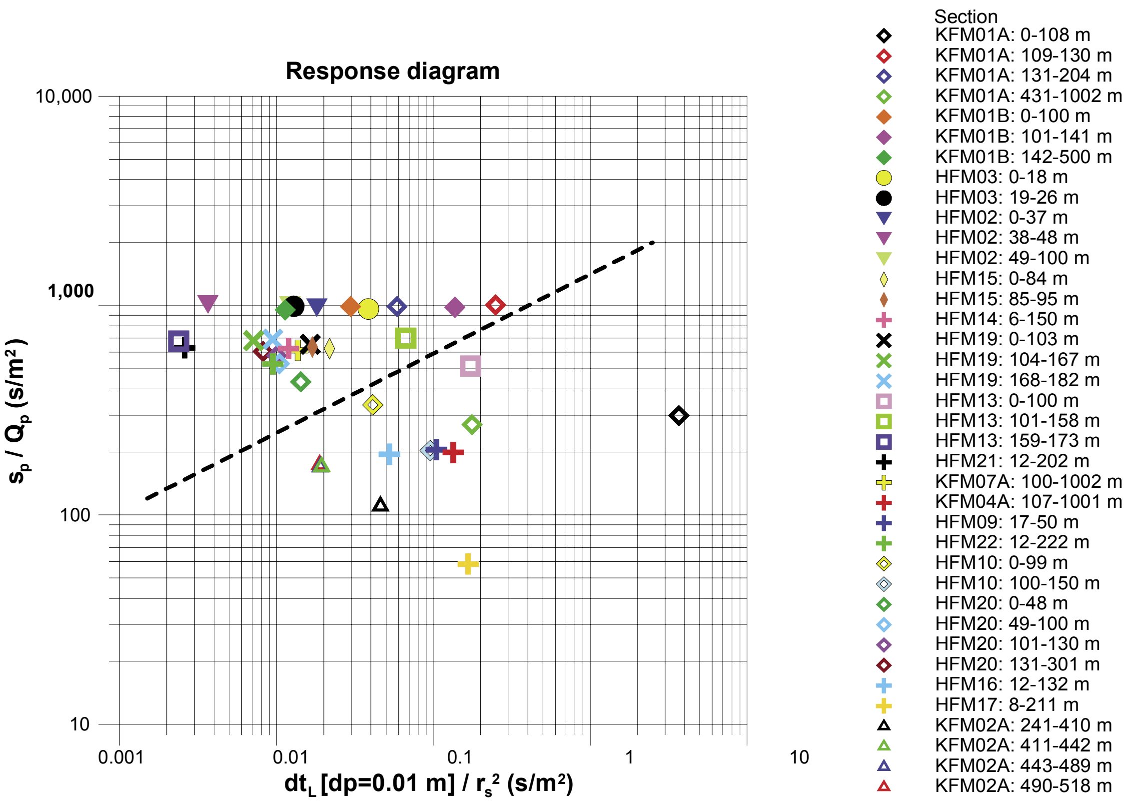


Figure 6-22. Response diagram showing the responses in the presumed responding observation sections during the interference test in HFM01.

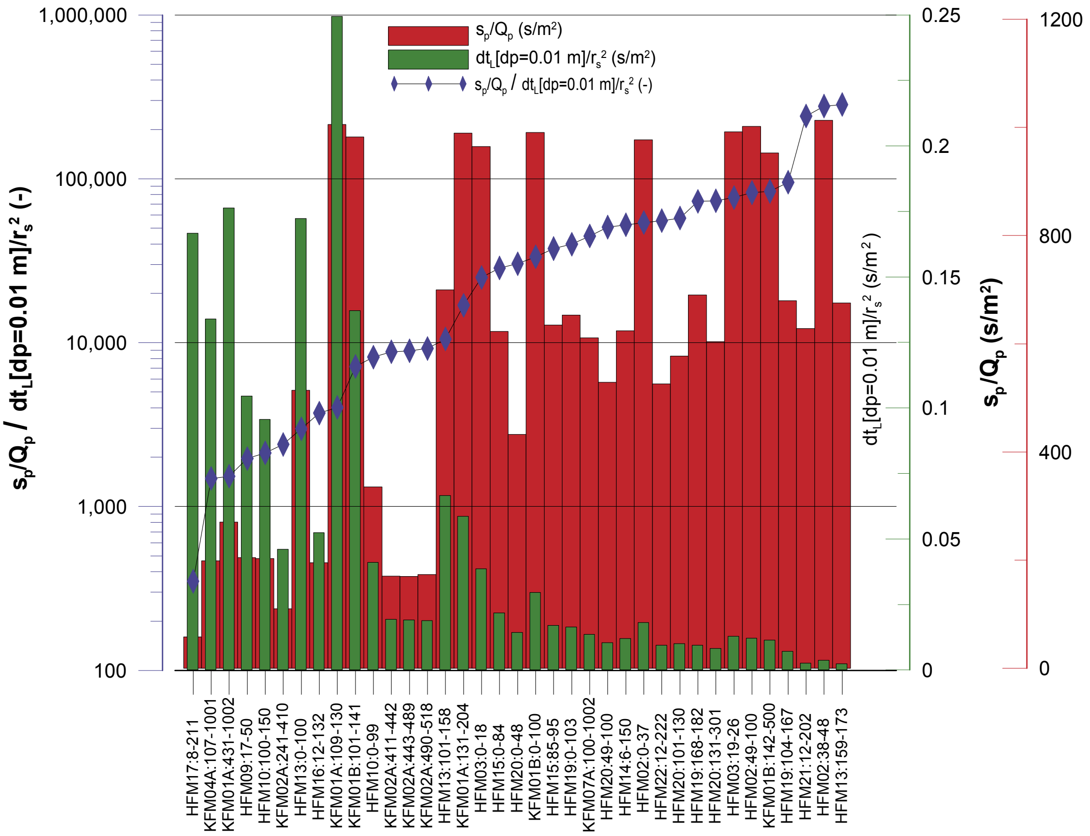


Figure 6-23. Diagram showing normalized drawdown, normalized response time and the ratio between the two parameters. The observation sections are sorted by the magnitude of the ratio.

6.4 Summary of the results of the interference test

A compilation of measured test data from the interference test in HFM01 is shown in Tables 6-52 and 6-53. In Tables 6-54 and 6-55 calculated hydraulic parameters for the pumping borehole and three observation sections selected for quantitative evaluation are presented.

Out of the 44 observation sections included in the interference test, 6 did not respond at all to pumping in HFM01 or responded very weakly. Of the remaining 38 sections, 26 showed distinct responses. Three observation sections stand out as responding most strongly. These sections, HFM13: 159–173, HFM21: 12–202 and HFM02: 38–48, display responses that are distinct enough to be characterized as potential zone responses between HFM01 and the actual sections.

The estimated T-value for HFM01 in Table 6-54 from the transient evaluation is in reasonable agreement with that ($T = 6.3\times10^{-5}$ m²/s) from the previous pumping test and flow logging in this borehole, /1/. The estimated transmissivity from observation section 490–518 m in KFM02A is significantly higher than the T-value obtained from the injection tests /14/ performed earlier in KFM02A, cf Table 3-4. This fact may possibly be due to that the calculated T-values from interference tests are more weighted towards the hydraulic properties close to the pumping borehole HFM01 because of the long distance between the boreholes. Alternatively, the estimated transmissivity in this section may be overestimated from the interference test due to rather poor hydraulic connection to the pumping borehole, cf Figures 6-22 and 6-23. The calculated T-values for HFM01 and KFM02A: 490–518 m are fairly similar, cf Table 6-54 and 6-55.

Also observation section HFM20: 101–130 exhibits an evaluated transmissivity from the interference test that is larger than from previous tests, /6/. Although the difference is not as big as for the test section in KFM02A the reasons to the discrepancy may be the same. The evaluated transmissivity value in observation section HFM13: 159–173, corresponds well to that from previous flow logging and pumping tests in this borehole, /3/. This section has a very good hydraulic connection with the pumping borehole.

Table 6-52. Summary of test data from the pumping borehole during the interference test performed in HFM01 in the Forsmark area.

Pumping borehole ID	Section (m)	Test type[1)]	h_i (m)	h_p (m)	h_F (m)	Q_p (m³/s)	Q_m (m³/s)	V_p (m³)
HFM01	32–200	1B	30.44	4.26	30.36	0.00148	0.00148	2,803

[1)] 1B: Pumping test-submersible pump, 2: Interference test (observation borehole during pumping in another borehole).

Table 6-53. Summary of test data from the observation sections involved in the interference test performed in HFM01 in the Forsmark area.

Pumping borehole ID	Borehole ID	Section (m)	Test type[1)]	h_i (m)	h_p (m)	h_F (m)
HFM01	KFM01A	0–108	2	0.38	–0.18	–0.16
”	”	109–130	2	0.30	–1.10	–0.19
”	”	131–204	2	0.39	–0.96	0.14
”	”	205–373	2	0.65	0.65	0.68
”	”	374–430	2	1.14	1.19	1.16
”	”	431–1,002	2	0.54	0.05	0.08
HFM01	KFM01B	0–100	2	0.47	–0.77	0.42
”	”	101–141	2	0.37	–1.00	–0.21
”	”	142–500	2	0.55	–0.72	0.41
HFM01	HFM03	0–18	2	1.11	–0.09	1.02
”	”	19–26	2	1.10	–0.12	1.05
HFM01	HFM02	0–37	2	0.56	–0.70	0.43
”	”	38–48	2	0.51	–0.77	0.44
”	”	49–100	2	0.56	–0.69	0.50
HFM01	HFM15	0–84	2	1.29	0.81	1.45
”	”	85–95	2	0.84	0.16	0.81
HFM01	HFM14	6–150	2	0.73	0.25	0.89
HFM01	KFM05A [2)]	100–1,003	2	–	–	–
HFM01	HFM19	0–103	2	2.68	1.95	2.61
”	”	104–167	2	2.88	2.12	2.83
”	”	168–182	2	2.01	1.23	1.96
HFM01	HFM13	0–100	2	2.71	2.22	2.42
”	”	101–158	2	1.32	0.51	1.18
”	”	159–173	2	0.57	–0.20	0.50
HFM01	HFM21	12–202	2	0.46	–0.28	0.37
HFM01	KFM07A	100–1,002	2	1,004.47	1,003.74	1,004.45
HFM01	KFM04A	107–1,001	2	2.17	1.97	2.03
HFM01	HFM09	17–50	2	2.76	2.55	2.61
HFM01	HFM22	12–222	2	0.17	–0.45	0.18
HFM01	HFM10	0–99	2	2.11	1.78	1.78
”	”	100–150	2	2.86	2.67	2.70
HFM01	KFM06A [2)]	100–1,001	2	–	–	–
HFM01	HFM20	0–48	2	–0.05	–0.49	–0.25
”	”	49–100	2	–0.61	–1.21	–0.71
”	”	101–130	2	–0.60	–1.26	–0.63
”	”	131–301	2	–0.41	–1.11	–0.45
HFM01	KFM06B [2)]	5–100	2	–	–	–
HFM01	HFM16	12–132	2	0.61	0.52	0.69
HFM01	HFM17	8–211	2	0.53	0.67	0.71
HFM01	KFM02A	0–132	2	1,031.38	1,031.84	1,031.86
”	”	133–240	2	1,031.39	1,031.64	1,031.67
”	”	241–410	2	1,031.47	1,031.45	1,031.57
”	”	411–442	2	1,031.10	1,031.05	1,031.18
”	”	443–489	2	1,031.13	1,031.06	1,031.20
”	”	490–518	2	1,031.07	1,031.00	1,031.13
”	”	519–888	2	1,031.24	1,031.32	1,031.33
”	”	889–1,002	2	1,031.02	1,031.49	1,031.51

[1)] 1B: Pumping test-submersible pump, 2: Interference test (observation borehole during pumping in another borehole).
[2)] Section not used during the interference test in HFM01

Table 6-54. Summary of calculated hydraulic parameters from the single-hole test in HFM01 in the Forsmark area.

Pumping borehole ID	Section (m)	Test type	Q/s (m^2/s)	T_M (m^2/s)	T_T (m^2/s)	ζ (–)	C (m^3/Pa)	S* (–)
HFM01	32–200	1B	5.65×10^{-5}	7.28×10^{-5}	1.46×10^{-4}	5.82	3.48×10^{-6}	5.015×10^{-5}

Table 6-55. Summary of calculated hydraulic parameters from the interference test between HFM01 and the observation boreholes HFM13, HFM20 and KFM02A respectively in the Forsmark area.

Pumping borehole ID	Observation borehole ID	Section (m)	Test type	T_o (m^2/s)	S_o (–)
HFM01	HFM13	159–173	2	3.55×10^{-4}	6.075×10^{-5}
”	HFM20	101–130	2	2.17×10^{-4}	3.84×10^{-5}
”	KFM02A	490–518	2	4.00×10^{-4}	5.31×10^{-5}

Q/s = specific flow for the pumping/injection borehole.

T_M = steady state transmissivity from Moye´s equation.

T_T = transmissivity from transient evaluation of single-hole test.

T_o = transmissivity from transient evaluation of interference test.

S_o = storativity from transient evaluation of interference test.

S* = assumed storativity by the estimation of the skin factor in single hole tests.

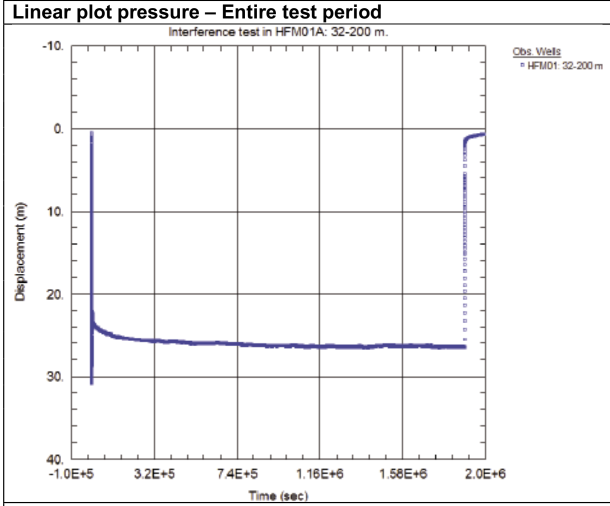
C = wellbore storage coefficient.

ζ = skin factor.

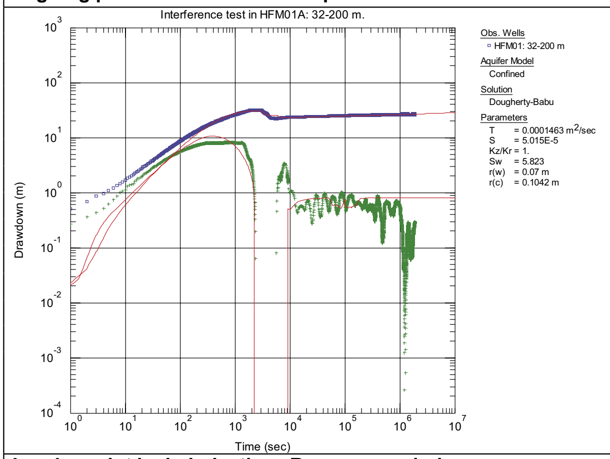
Test Summary Sheet - Pumping section HFM01: 32-200 m

Project:	PLU	Test type:	1B
Area:	Forsmark	Test no:	1
Borehole ID:	HFM01	Test start:	2005-07-06 12:04
Test section (m):	32-200	Responsible for test performance:	GEOSIGMA AB K Gokall-Norman
Section diameter, 2×rw (m):	0.140 (nominal)	Responsible for test evaluation:	GEOSIGMA AB J-E Ludvigson

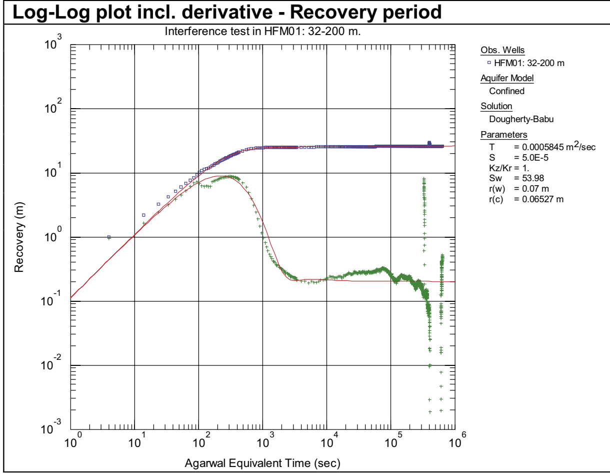
Linear plot pressure – Entire test period



Log-Log plot incl. derivate - Flow period



Log-Log plot incl. derivative - Recovery period



Flow period		Recovery period	
Indata		**Indata**	
p_0 (kPa)			
p_i (kPa)	298.70		
p_p(kPa)	41.81	p_F (kPa)	297.90
Q_p (m^3/s)	1.48×10^{-3}		
tp (s)	1,894,560	t_F (s)	416,040
S*	5.015×10^{-5}	S*	5.0×10^{-5}
EC_w (mS/m)			
Te_w(gr C)			
Derivative fact.	0.3	Derivative fact.	0.2
Results		**Results**	
Q/s (m^2/s)	5.65×10^{-5}		
T_{Moye}(m^2/s)	7.28×10^{-5}		
Flow regime:		Flow regime:	
t_1 (s)	20,000	dt_{e1} (s)	500
t_2 (s)	1,000,000	dt_{e2} (s)	200,000
T_w (m^2/s)	1.46×10^{-4}	T_w (m^2/s)	5.84×10^{-4}
S_w (-)		S_w (-)	
K_{sw} (m/s)		K_{sw} (m/s)	
S_{sw} (1/m)		S_{sw} (1/m)	
C (m^3/Pa)	3.48×10^{-6}	C (m^3/Pa)	1.36×10^{-6}
C_D (-)		C_D (-)	
ξ (-)	5.82	ξ (-)	54
T_{GRF}(m^2/s)		T_{GRF}(m^2/s)	
S_{GRF}(-)		S_{GRF}(-)	
D_{GRF} (-)		D_{GRF} (-)	

Interpreted formation and well parameters.

Flow regime:	PRF	C (m^3/Pa)	
t_1 (s)	20,000	C_D (-)	
t_2 (s)	1,000,000	ξ (-)	5.82
T_T (m^2/s)	1.46×10^{-4}		
S (-)			
K_s (m/s)			
S_s (1/m)			

Comments: All pressure data are relative pressures.

7 References

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/13/ **Rouhiainen P, Pöllänen J, 2004.** Forsmark site investigation. Difference flow logging in borehole KFM02A. SKB P-04-188, Svensk Kärnbränslehantering AB.

/14/ **Källgården J, Ludvigson J-E, Jönsson J, 2004.** Forsmark site investigation. Single-hole injection tests in borehole KFM02A. SKB P-04-100, Svensk Kärnbränslehantering AB.

/15/ **Almén K-E, Andersson J-E, Carlsson L, Hansson K, Larsson N-Å, 1986.** Hydraulic testing in crystalline rock. A comparative study of single-hole test methods. SKB TR 86-27, Svensk Kärnbränslehantering AB.

/16/ **Rhen I (ed), Gustafson G, Stanfors R, Wikberg P, 1997.** Äspö HRL – Geoscientific evaluation 1997/5. Models based on site characterization 1986–1995. SKB TR 97-06, Svensk Kärnbränslehantering AB.

/17/ **Ludvigson J-E, Jönsson S, Levén J, 2004.** Forsmark site investigation. Hydraulic evaluation of pumping activities prior to hydro-geochemical sampling in borehole KFM03A – Comparison with results from difference flow logging. SKB P-04-96, Svensk Kärnbränslehantering AB.

/18/ **Dougherty D E, Babu D K, 1984.** Flow to a partially penetrating well in a double-porosity reservoir. Water Resour. Res, 20 (8), 1116–1122.

/19/ **Hantush M S, 1955.** Nonsteady radial flow in an infinite leaky aquifer. Am. Geophys. Union Trans, v. 36, no 1, pp 95–100.

Appendix 1

List of data files

Files are named: Interferenstest_Pumphål_"BhID"_"YYYYMMDD"_"hhmm"_"File Type". Interferenstest_Pumphål is just an internal marker. "BhID" is the name of the borehole, after that the datafile start time is given. Pumpin and Ref_Da are parts of the original file names produced by the HTHB data logger. Ref_Da contains constants of calibration and background data. Pumpin contains data from pumping tests (no combined flow logging).

Bh ID	**Test section (m)**	**Test type**[1]	**Test no**	**Test start Date, time YYYY-MM-DD tt:mm:ss**	**Test stop Date, time YYYY-MM-DD tt:mm:ss**	**Datafile, start Date, time YYYY-MM-DD tt:mm:ss**	**Datafile, stop Date, time YYYY-MM-DD tt:mm:ss**	**Data files of raw and primary data**	**Con-tent (parameters)**[2]	**Comments**
HFM01	32–200	1B		20050706 12:04:35	20050802 06:00:00	20050706 11:35:23	20050809 13:52:44	Interferenstest_Pump-hål_HFM01_20050706_1135_Pumpin11.DAT	P, Q	Pressure and flow registration in HFM01 for interference.
HFM01	32–200	1B	20050706 12:04:35	20050802 06:00:00	20050706 11:35:23	20050809 13:52:44	Interferenstest_Pump-hål_HFM01_20050706_1135_Ref_Da07.DAT	C, R		

[1] 1B: Pumping test-submersible pump, 2: Interference test (observation borehole during pumping in another borehole).
[2] P = Pressure, Q = Flow, Te = Temperature, EC = El. conductivity. SPR = Single Point Resistance, C = Calibration file, R = Reference file, Sp = Spinner rotations.

Appendix 2

Test diagrams

Nomenclature for AQTESOLV:

T = transmissivity (m^2/s)

S = storativity (–)

K_Z/K_r = ratio of hydraulic conductivities in the vertical and radial direction (set to 1)

Sw = skin factor

r(w) = borehole radius (m)

r(c) = effective casing radius (m)

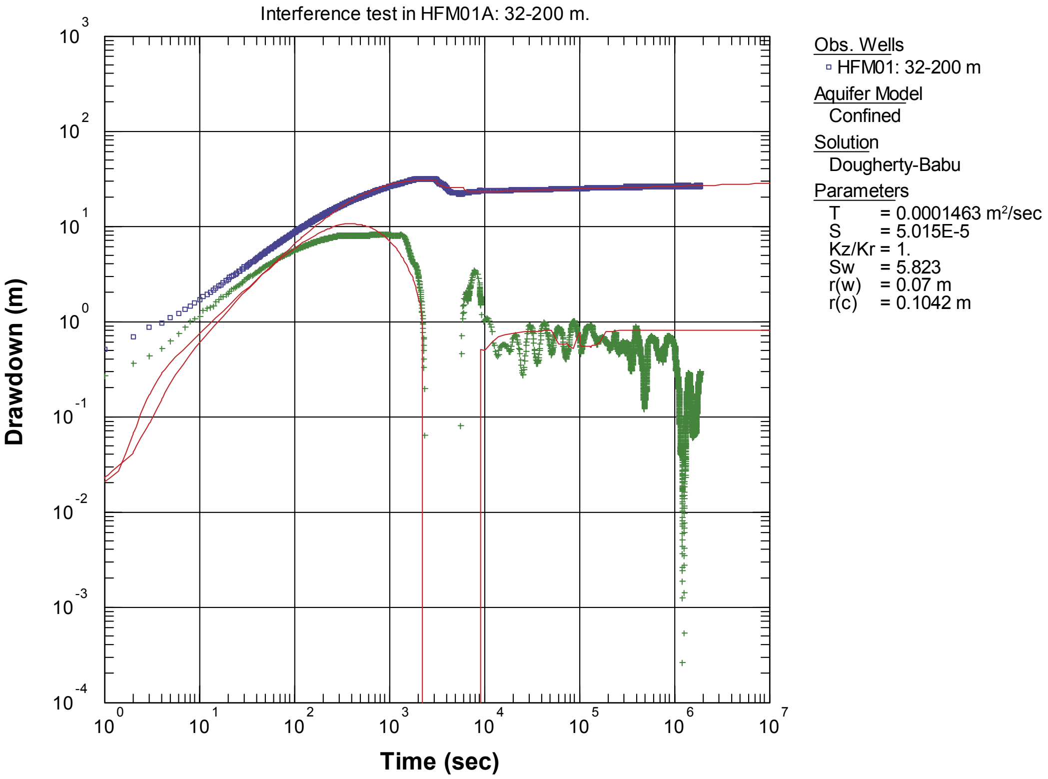

Figure A2-1. *Log-log plot of drawdown (▫) and drawdown derivative, ds/d(ln t) (+), versus time in HFM01 during the interference test in HFM01.*

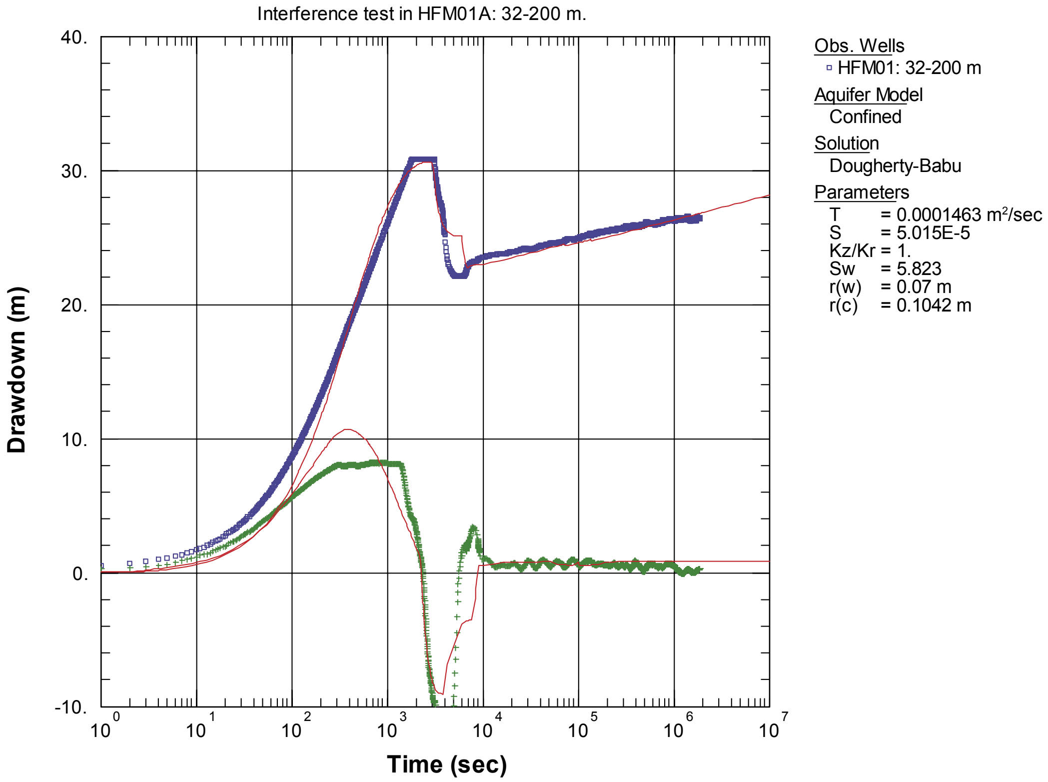

Figure A2-2. *Lin-log plot of drawdown (▫) and drawdown derivative, ds/d(ln t) (+), versus time in HFM01 during the interference test in HFM01.*

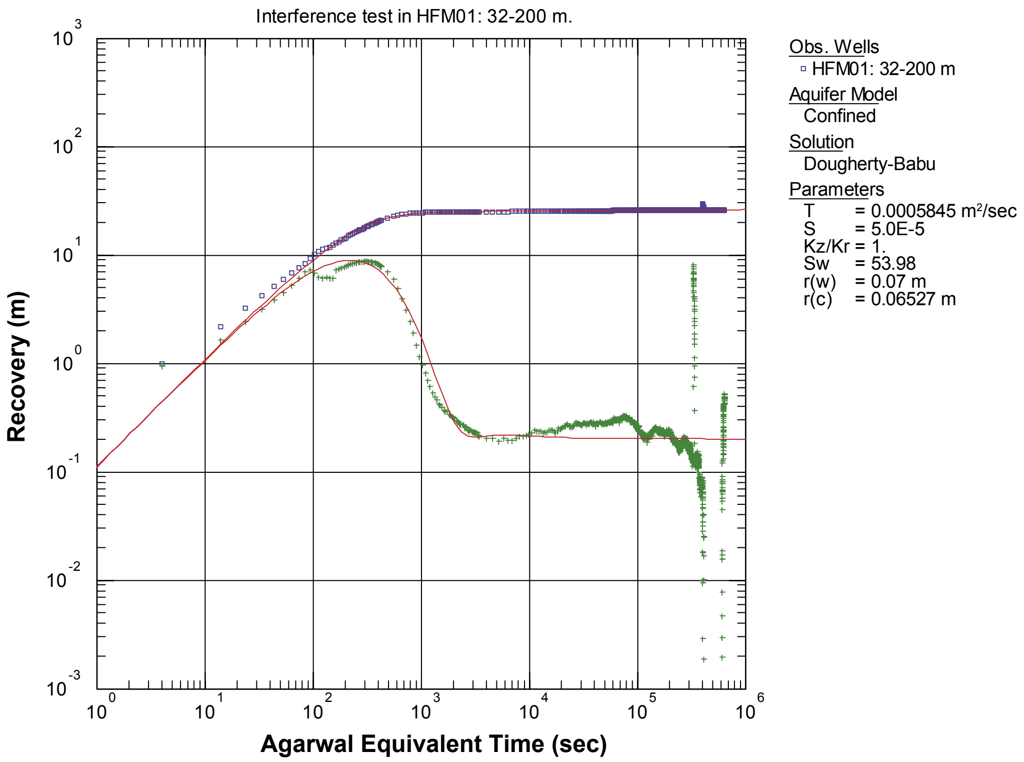

Figure A2-3. *Log-log plot of pressure recovery (▫) and derivative, dsp/d(ln dte) (+), versus equivalent time in HFM01 during the interference test.*

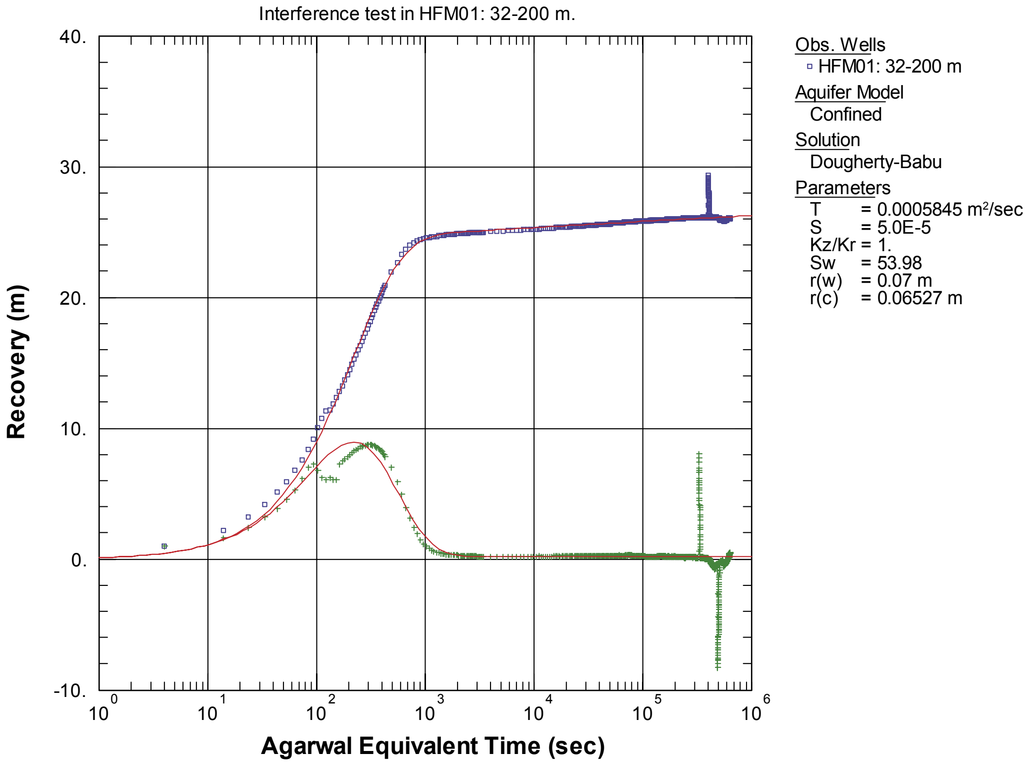

Figure A2-4. *Lin-log plot of pressure recovery (▫) and derivative, dsp/d(ln dte) (+), versus equivalent time in HFM01 during the interference test in HFM01.*

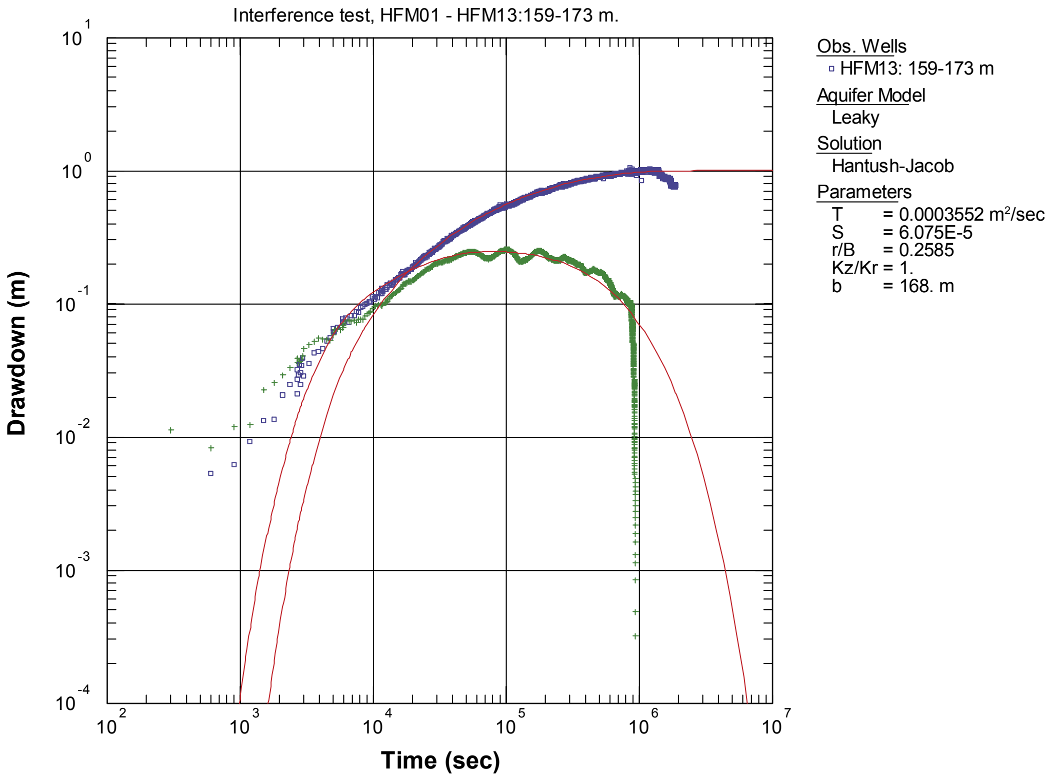

Figure A2-5. *Log-log plot of drawdown (▫) and drawdown derivative, ds/d(ln t) (+), versus time in observation section HFM13: 159–173 m during the interference test in HFM01.*

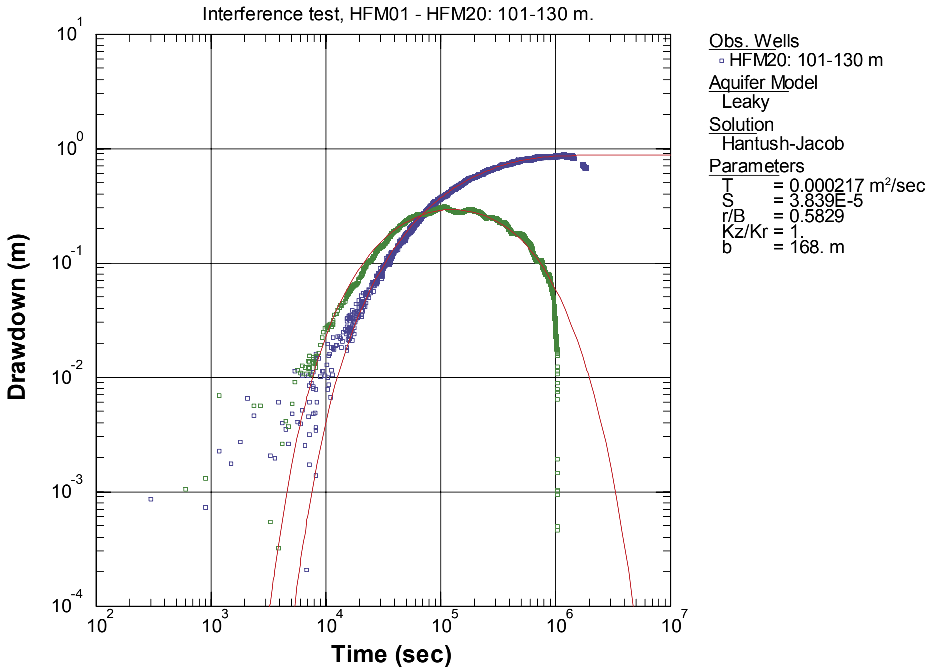

__Figure A2-6.__ Log-log plot of drawdown (▫) and drawdown derivative, ds/d(ln t) (+), versus time in observation section HFM20: 101–130 m during the interference test in HFM01.

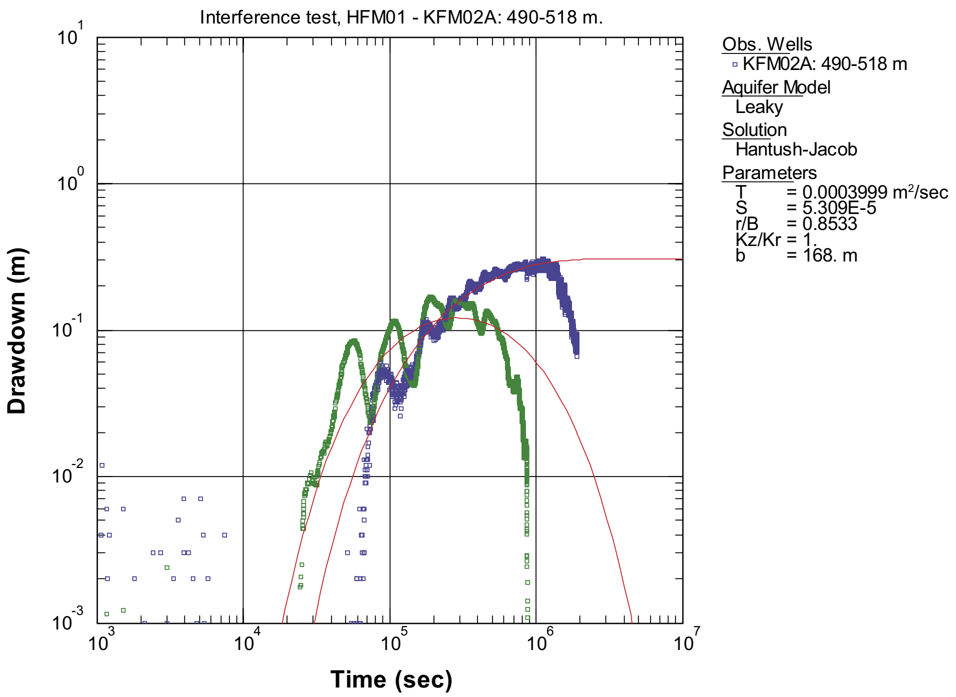

__Figure A2-7.__ Log-log plot of drawdown (▫) and drawdown derivative, ds/d(ln t) (+), versus time in observation section KFM02A: 490–518 m during the interference test in HFM01.

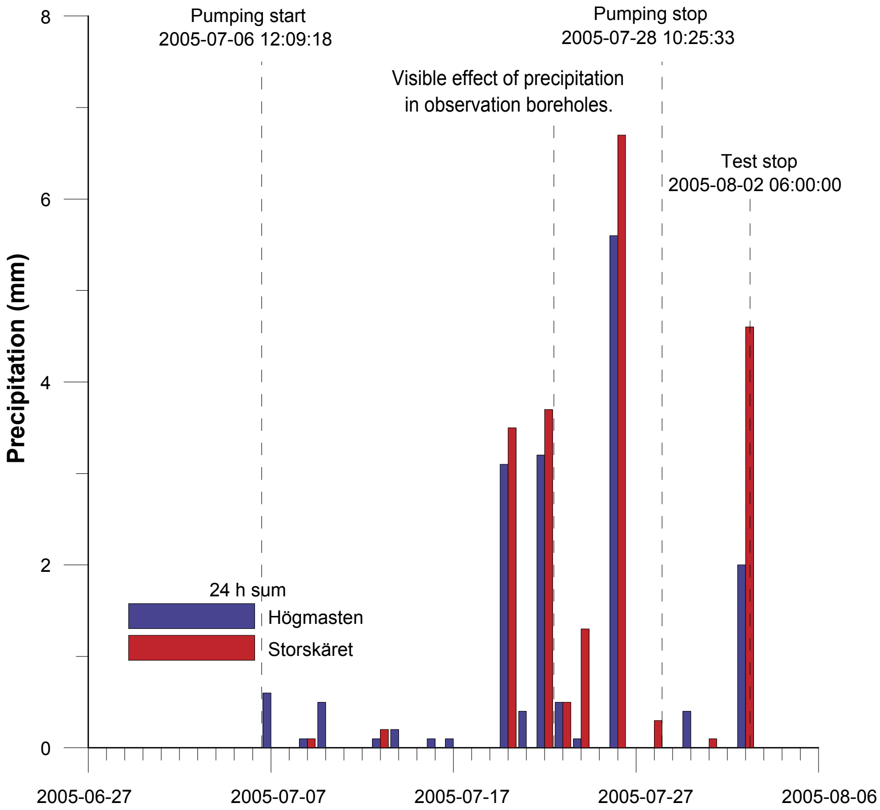

Figure A2-8. *24 hours summed precipitation in the Forsmark area during the interference test in HFM01.*

Result tables to SICADA

Result tables to SICADA from the single hole test in HFM01

plu_s_hole_test_d

idcode	start_date	stop_date	secup	seclow	section_no	test_type	formation_type	start_flow_period	stop_flow_period
HFM01	2005-07-06 12:04	2005-08-02 06:00	0.00	200.20		1B	1	2005-07-06 12:09:18	2005-07-28 10:25:33

cont.

flow_rate_end_qp	value_type_qp	mean_flow_rate_qm	q_measl__l	q_measl__u	tot_volume_vp	dur_flow_phase_tp	dur_rec_phase_tf	initial_head_hi
1.4800E–03	0	1.4800E–03			2.8030E+03	1,894,560.00	416,040.00	

cont.

head_at_flow_end_hp	final_head_hf	initial_press_pi	press_at_flow_end_pp	final_press_pf	fluid_temp_tew	fluid_elcond_ecw	fluid_salinity_tdsw
		298.70	41.81	297.90			

cont.

fluid_salinity_tdswm	reference	comments	lp
		Pressure values are relative air pressure.	

SICADA – description of plu_s_hole_test_d

PLU Injection and Pumping tests. General information.

SICADA Header	Header	Unit	Explanation
Idcode	Borehole		ID for borehole.
Secup	Borehole secup	(m)	Length coordinate along the borehole for the upper limit of the test section.
Seclow	Borehole seclow	(m)	Length coordinate along the borehole for the lower limit of the test section.
Test_type	Test type (1–7)	(–)	1A: Pumping test – wireline eq, 1B:Pumping test-submersible pump, 1C: Pumpingtest-airlift pumping, 2: Interference test, 3: Injection test, 4: Slug test, 4B: Pulse test 5A: Difference flow logging-PFL-DIFF-sequential, 5B: Difference flow logging-PFL-DIFF-overlapping, 6:Flow logging_Impeller,7:Grain size analysis.
start_date	Date for test start	YYYY- MM-DD hh::mm	Date for the start of the pumping or injection test (YYYY-MM-DD hh:mm).
start_flow_period	Start flow/ injection	YYYY- MM-DD hh::mm:ss	Date and time for the start of the pumping or injection period (YYYY-MM-DD hh:mm:ss).
stop_flow_period	Start flow/ injection	YYYY- MM-DD hh::mm:ss	Date and time for the end of the pumping or injection period (YYYY-M-M DD hh:mm:ss).
mean_flow_rate_qm	Q_m	(m^3/s)	Arithmetic mean flow rate during flow (pumping/injection) period.
flow_rate_end_qp	Q_p	(m^3/s)	Flow rate at the end of the flow (pumping/injection) period.
value_type_qp			Code for Q_p-value; –1 means Q_p < lower measurement limit, 0 means measured value, 1 means Q_p > upper measurement value of flowrate.
q_measl_l	Qmeasl_L	(m^3/s)	Estimated lower measurement limit for flow rate .
q_measl_u	Qmeasl_U	(m^3/s)	Estimated upper measurement limit for flow rate .
total_volume_vp	V_p	(m^3)	Total volume pumped or injected water during the flow period.
dur_flow_phase_tp	t_p	(s)	Duration of the flow period.
dur_rec_phase_tf	t_F	(s)	Duration of the recovery period.
initial_head_hi	h_i	(m)	Hydraulic head in test section at start of the flow period.
head_at_flow_end_hp	h_p	(m)	Hydraulic head in test section at stop of the flow period.

SICADA Header	Header	Unit	Explanation
final_head_hf	h_F	(m)	Hydraulic head in test section at stop of the recovery period.
initial_press_pi	p_i	(kPa)	Ground water pressure in test section at start of the flow period.
press_at_flow_end_pp	p_p	(kPa)	Ground water pressure in test section at stop of the flow period.
final_press_pf	p_F	(kPa)	Ground water pressure in test section at stop of the recovery period.
fluid_temp_tew	Te_w	(C^o)	Measured borehole fluid temperature in the test section (representative for evaluated parameters, in general the last temperature value).
fluid_elcond_ecw	EC_w	(mS/m)	Measured electric conductivity of the borehole fluid in the test section (representative for evaluated parameters, in general the last EC value).
fluid_salinity_tdsw	TDS_w	(mg/L)	Calculated total dissolved solids of the borehole fluid in the test section, based on EC-measurement.
fluid_salinity_tdswn	TDS_{wn}	(mg/L)	Measured total dissolved solids of the borehole fluid in the test section, based on water sampling and chemical analysis.
reference	references		SKB report No for reports describing data and evaluation.
comments	comments		Short comment to data.

plu_s_hole_test_ed1

idcode	start_date	stop_date	secup	seclow	section_no	test_type	formation_type	lp	seclen_class	spec_capacity_q_s
HFM01	2005-07-06 12:04	2005-08-02 06:00	0	200.2		1B	1	51		5.65E–05

cont.

value_type_q_s	transmissivity_tq	value_type_tq	bc_tq	transmissivity_moye	bc_tm	value_type_tm	hydr_cond_moye	formation_width_b
0				7.28E–05	0	0	4.33E–07	168.27

cont.

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
168.27								1.46E–04	0	1

cont.

u_measl_q_s	storativity_s	assumed_s	s_bc	ri	ri_index	leakage_coeff	hydr_cond_ksf	value_type_ksf	l_measl_ksf	u_measl_ksf
5.00E–03		5.02E–05								

cont.

spec_storage_ssf	assumed_ssf	c	cd	skin	dt1	dt2	t1	t2	dte1	dte2	p–horner	transmissivity_t_nlr	storativity_s_nlr
		3.48E–06		5.82			20,000	1,000,000	500	200,000			

cont.

value_type_t_nlr	bc_t_nir	c_nir	cd_nir	skin_nir	transmissivity_t_grf	value_type_t_grf	bc_t_grf	storativity_s_grf	flow_dim_grf	comment

SICADA – description of plu_s_hole_test_ed1

PLU Single hole tests, pumping and injection. Basic evaluation

SICADA Header	Header	Unit	Explanation
idcode	Borehole		ID for borehole.
secup	Borehole secup	m	Length coordinate along the borehole for the upper limit of the test section.
seclow	Borehole seclow	(m)	Length coordinate along the borehole for the lower limit of the test section.
test_type	Test type (1–7)	(–)	1A: Pumpingtest-wireline eq, 1B: Pumpingtest-submersible pump, 1C: Pumpingtest-airlift pumping, 2: Interference test, 3: Injection test, 4: Slug test, 4B: Pulse Test, 5A: Flowlogging-PFL-DIFF_sequential, 5B: Flowlogging-PFL-DIFF_overlapping, 6: Flowlogging-Impeller, 7: Grain size analysis.
formation_type	Formation type	(–)	1: Rock, 2: Soil (Superficial deposits).
seclen_class		(m)	Planned ordinary test interval during a test campaign when a great part of a borehole is tested. The test interval length might differ due to border conditions (e.g borehole end) but is still considered to be included in the same section length class.
start_date		YYYY-MM-DD hh:mm	Date for the start of the test (YYYY-MM-DD hh:mm).
lp	L_p	(m)	Hydraulic point of application for a test section, based on the geometric midpoint of test section or the main point of transmissivity distribution in test section.
spec_capacity_q_s	Q/s	m^2/s	Specific capacity, generally estimated from Q_p, s_p or dh_p.
value_type_q_s			Code for Q/s; –1 means Q/s < lower measurement limit, 0 means measured value,–1 means Q/s > upper measurement limit.
transmissivity_tq	T_Q	m^2/s	Transmissivity, based on Q/s and a function T = f(Q/s), see e.g. Rhén et al. (1997) s. 190. The function used should be refered to in “Comments”.
transmissivity_moye	T_M	m^2/s	Transmissivity (T_M) based on /Moye, 1967/.
value_type_tm			Code for T_M ; –1 means T_M < lower measurement limit, 0 means measured value,–1 means T_M > upper measurement limit.
formation_width_b	b	m	Representative aquifer thickness for inferred transmissivity, generally estimated as test section length L_w.
width_of_channel_b	B	m	Inferred width of formation for evaluated TB.
tb	TB	m^3/s	Flow capacity in 1D formation of width B and transmissivity T based on transient evaluation. Considered best estimate from transient evaluation of flow period or recovery period.
l_measl_tb	TB-measl-L	m^3/s	Estimated lower measurement limit for evaluated TB.
u_measl_tb	TB-measl-L	m^3/s	Estimated upper measurement limit for evaluated TB.

SICADA Header	Header	Unit	Explanation
sb	SB	m	Storage capacity of 1D formation of width B and storativity S based on transient evaluation. Considered best estimate from transient evaluation of flow period or recovery period.
assumed_sb	SB*	m	Assumed storage capacity of 1D formation of width B and storativity S based on transient evaluation.
ri_index	ri-index		ri-index = 0: Pressure response indicates that the size of the hydraulic feature is greater than radius of influence based on time for last pressure response measured (tp = t2). Size of hydraulic feature greater than radius of influence based on t2. ri-index = 1: Pressure response indicates that the hydraulic feature assigned the representative transmissivity is connected to hydraulic feature with less transmissivity or barrier boundary. Size of hydraulic feature estimated as radius of influence based on t2. (Size of feature somewhat under estimated using t2- but error considered as small.) ri-index = –1: Pressure response indicates that the hydraulic feature assigned the representative transmissivity is connected to hydraulic feature with greater transmissivity or a constant head boundary. Size of hydraulic feature estimated as radius of influence based on t2. (Size of feature somewhat under estimated using t2- but error considered as small.)
bc_s	S-BC		Calculated by using S if S = value or S = f(T) if S* = value.
leakage_factor_lf	L_f	m	Leakage factor. $L_f = (K \cdot b \cdot c_f)^{0.5}$ where K represents the aquifer conditions. c_f = b´/K´ based on 1D linear flow model. Considered best estimate from transient evaluation of flow period or recovery period.
transmissivity_tt	T_T	m^2/s	Transmissivity (T) of formation, based on 2D radial flow model. Considered best estimate from transient evaluation of flow period or recovery period.
value_type_tt			Code for T_T; –1 means T_T < lower measurement limit, 0 means measured value,–1 means T_T > upper measurement limit.
l_measl_q_s	Q/s-measl-L	m^2/s	Estimated measurement limit for evaluated T (T_T, T_Q, T_M). If estimated T equals Q/s-measl in the table actual T is considered to be equal or less than Q/s-measl.
u_measl_q_s	Q/s-measl-U	m^2/s	Estimated measurement limit for evaluated T (T_T, T_Q, T_M). If estimated T equals Q/s-measl in the table actual T is considered to be equal or grater than Q/s-measl.
storativity_s	S	(–)	Storativity (Storage coefficient) of formation based on 2D radial flow model. Considered best estimate from transient evaluation of flow period or recovery period.
assumed_s	S*		Assumed storativity of formation based on 2D radial flow model.
leakage_koeff	K´/b´	(1/s)	Leakage coefficient evaluated from 2D radial flow model. K´ = hydraulic conductivity across the aquitard, b´ = water saturated thickness of aquitard (leaky formation). Considered best estimate from transient evaluation of flow period or recovery period.
hydr_kond_ksf	K_{sf}	m/s	Hydraulic conductivity of formation, based on 3D spherical flow model. Considered best estimate from transient evaluation of flow period or recovery period.
value_type_ksf			Code for K_{Sf}; –1 means K_{Sf} < lower measurement limit, 0 means measured value,–1 means K_{Sf} > upper measurement limit.
l_measl_ksf	K_S-measl-L	m/s	Estimated lower measurement limit for evaluated K_{sf}.
u_measl_ksf	K_S-measl-U	m/s	Estimated upper measurement limit for evaluated K_{sf}.

SICADA Header	Header	Unit	Explanation
spec_storage_ss	S_{sf}	1/m	Specific storage of formation based on 3D spherical flow model. Considered best estimate from transient evaluation of flow period or recovery period.
assumed_ss	S_{sf}*	1/m	Assumed specific storage of formation based on 3D spherical flow model.
c	C	(m^3/Pa)	Wellbore storage coefficient. Considered best estimate from transient evaluation of flow period or recovery period.
cd	C_D	(–)	Dimensionless wellbore storage coefficient, $C_D = C \times \rho_w g / (2\pi \cdot S \cdot r_w^2)$.
skin	ξ		Skin factor. Considered best estimate from transient evaluation of flow period or recovery period.
dt1	dt_1	s	Estimated start time after pump/injection start or recovery start, for the period used for the evaluated parameter.
dt1	dt_2	s	Estimated stop time after pump/injection start or recovery start, for the period used for the evaluated parameter.
dte1	dt_{e1}		Start time for evaluated parameter from start of recovery period.
dte2	dt_{e2}		Stop time for evaluated parameter from start of recovery period.
t1	t_1		Start time for evaluated parameter from start of flow period.
t2	t_2		Stop time for evaluated parameter from start of flow period.
p_horner	p*		Horner extrapolated pressure (used as an estimation of natural pressure of the test section).
transmissivity_t_nlr	T_{ILR}	m^2/s	Transmissivity, based on Non Linear Regression of the entire test sequence.
storativity_s_nlr	S_{ILR}	(–)	Storativity, based on Non Linear Regression of the entire test sequence.
c_nlr	C_{ILR}	(m^3/Pa)	Wellbore storage coefficient, based on Non Linear Regression of entire test sequence.
cd_nlr	$C_{D,ILR}$		Dimensionless wellbore storage coefficient, based on Non Linear Regression of entire test sequence.
skin_nlr	ξ_{NLR}		Skin factor, based on Non Linear Regression of entire test sequence.
transmissivity_t_grf	T_{GRF}	m^2/s	Transmissivity, based on the Generalized Radial Flow model /Baker, 1988/. Considered best estimate from transient evaluation of flow period or recovery period.
storativity_s_grf	S_{GRF}	(–)	Storativity, based on Generalised Radial Flow model. Considered best estimate from transient evaluation of flow period or recovery period.
flow_dim_grf	D_{GRF}	(–)	Inferred flow dimension, based on the Generalized Radial Flow model /Barker, 1988/. Considered best estimate from transient evaluation of flow period or recovery period.
comment	comment		Comments on the test.

Result table to SICADA from the interference test in HFM01

plu_inf_test_obs_d

idcode	start_date	stop_date	secup	seclow	sec-tion_no	test_type	forma-tion_type	start_flow_period	stop_flow_period	test_borehole	test_secup	test_seclow	lp	radial_distance_rs
KFM01A	2005-07-06 12:04	2005-08-02 06:00	0.00	108.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	105.00	137.00
KFM01A	2005-07-06 12:04	2005-08-02 06:00	109.00	130.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	118.00	147.00
KFM01A	2005-07-06 12:04	2005-08-02 06:00	131.00	204.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	148.00	160.00
KFM01A	2005-07-06 12:04	2005-08-02 06:00	205.00	373.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	285.00	268.00
KFM01A	2005-07-06 12:04	2005-08-02 06:00	374.00	430.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	402.00	375.00
KFM01A	2005-07-06 12:04	2005-08-02 06:00	431.00	1000.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	715.00	679.00
KFM01B	2005-07-06 12:04	2005-08-02 06:00	0.00	100.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	54.00	135.00
KFM01B	2005-07-06 12:04	2005-08-02 06:00	101.00	141.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	121.00	162.00
KFM01B	2005-07-06 12:04	2005-08-02 06:00	142.00	500.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	321.00	325.00
HFM03	2005-07-06 12:04	2005-08-02 06:00	0.00	18.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	15.00	222.00
HFM03	2005-07-06 12:04	2005-08-02 06:00	19.00	26.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	21.00	221.00
HFM02	2005-07-06 12:04	2005-08-02 06:00	0.00	37.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	31.00	223.00
HFM02	2005-07-06 12:04	2005-08-02 06:00	38.00	48.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	43.00	222.00
HFM02	2005-07-06 12:04	2005-08-02 06:00	49.00	100.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	74.00	222.00
HFM15	2005-07-06 12:04	2005-08-02 06:00	0.00	84.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	50.00	352.00
HFM15	2005-07-06 12:04	2005-08-02 06:00	85.00	95.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	89.00	326.00
HFM14	2005-07-06 12:04	2005-08-02 06:00	6.00	150.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	72.00	353.00
HFM19	2005-07-06 12:04	2005-08-02 06:00	0.00	103.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	101.00	358.00
HFM19	2005-07-06 12:04	2005-08-02 06:00	104.00	167.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	150.00	355.00
HFM19	2005-07-06 12:04	2005-08-02 06:00	168.00	182.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	176.00	356.00
HFM13	2005-07-06 12:04	2005-08-02 06:00	0.00	100.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	50.00	506.00
HFM13	2005-07-06 12:04	2005-08-02 06:00	101.00	158.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	106.00	498.00
HFM13	2005-07-06 12:04	2005-08-02 06:00	159.00	173.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	162.00	502.00

idcode	start_date	stop_date	secup	seclow	sec-tion_no	test_type	forma-tion_type	start_flow_period	stop_flow_period	test_borehole	test_secup	test_seclow	lp	radial_distance_rs
HFM21	2005-07-06 12:04	2005-08-02 06:00	12.00	202.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	68.00	635.00
KFM07A	2005-07-06 12:04	2005-08-02 06:00	0.00	1,001.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	122.00	726.00
KFM04A	2005-07-06 12:04	2005-08-02 06:00	0.00	1,001.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	217.00	769.00
HFM09	2005-07-06 12:04	2005-08-02 06:00	0.00	50.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	26.00	830.00
HFM22	2005-07-06 12:04	2005-08-02 06:00	0.00	222.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	62.00	872.00
HFM10	2005-07-06 12:04	2005-08-02 06:00	0.00	99.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	50.00	896.00
HFM10	2005-07-06 12:04	2005-08-02 06:00	100.00	150.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	118.00	898.00
HFM20	2005-07-06 12:04	2005-08-02 06:00	0.00	48.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	25.00	917.00
HFM20	2005-07-06 12:04	2005-08-02 06:00	49.00	100.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	77.00	919.00
HFM20	2005-07-06 12:04	2005-08-02 06:00	101.00	130.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	118.00	922.00
HFM20	2005-07-06 12:04	2005-08-02 06:00	131.00	301.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	215.00	936.00
HFM16	2005-07-06 12:04	2005-08-02 06:00	0.00	132.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	60.00	981.00
HFM17	2005-07-06 12:04	2005-08-02 06:00	0.00	211.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	31.00	1,776.00
KFM02A	2005-07-06 12:04	2005-08-02 06:00	0.00	132.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	118.00	1,911.00
KFM02A	2005-07-06 12:04	2005-08-02 06:00	133.00	240.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	173.00	1,910.00
KFM02A	2005-07-06 12:04	2005-08-02 06:00	241.00	410.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	282.00	1,910.00
KFM02A	2005-07-06 12:04	2005-08-02 06:00	411.00	442.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	428.00	1,920.00
KFM02A	2005-07-06 12:04	2005-08-02 06:00	443.00	489.00		2	1	2005-07-06 12:09:18	2005-07-28 10:25:33	HFM01	0.00	200.20	478.00	1,925.00

cont.

lp	radial_distance_rs	shortest_ distance_rt	time_lag_press_dtl	initial_head_hi	head_at_flow_end_hp	final_head_hf	initial_press_pi	press_at_flow_end_pp	final_press_pf
105.00	137.00		69,000.00	0.38	–0.18	–0.16			
118.00	147.00		5,390.00	0.30	–1.10	–0.19			
148.00	160.00		1,500.00	0.39	–0.96	0.14			
285.00	268.00		–	0.65	0.65	0.68			
402.00	375.00		–	1.14	1.19	1.16			
715.00	679.00		81,300.00	0.54	0.05	0.08			
54.00	135.00		540.00	0.47	–0.77	0.42			
121.00	162.00		3,600.00	0.37	–1.00	–0.21			
321.00	325.00		1,200.00	0.55	–0.72	0.41			
15.00	222.00		1,900.00	1.11	–0.09	1.02			
21.00	221.00		630.00	1.10	–0.12	1.05			
31.00	223.00		900.00	0.56	–0.70	0.43			
43.00	222.00		180.00	0.51	–0.77	0.44			
74.00	222.00		600.00	0.56	–0.69	0.50			
50.00	352.00		2,700.00	1.29	0.81	1.45			
89.00	326.00		1,800.00	0.84	0.16	0.81			
72.00	353.00		1,486.00	0.73	0.25	0.89			
101.00	358.00		2,100.00	2.68	1.95	2.61			
150.00	355.00		900.00	2.88	2.12	2.83			
176.00	356.00		1,200.00	2.01	1.23	1.96			
50.00	506.00		44,101.00	2.71	2.22	2.42			
106.00	498.00		16,500.00	1.32	0.51	1.18			
162.00	502.00		600.00	0.57	–0.20	0.50			
68.00	635.00		10,48.00	0.46	–0.28	0.37			

lp	radial_distance_rs	shortest_ distance_rt	time_lag_press_dtl	initial_head_hi	head_at_flow_end_hp	final_head_hf	initial_press_pi	press_at_flow_end_pp	final_press_pf
122.00	726.00		7,200.00	1,004.47	1,003.74	1,004.45			
217.00	769.00		79,200.00	2.17	1.97	2.03			
26.00	830.00		72,000.00	2.76	2.55	2.61			
62.00	872.00		72,00.00	0.17	–0.45	0.18			
50.00	896.00		33,000.00	2.11	1.78	1.78			
118.00	898.00		77,100.00	2.86	2.67	2.70			
25.00	917.00		12,000.00	–0.05	–0.49	–0.25			
77.00	919.00		8,810.00	–0.61	–1.21	–0.71			
118.00	922.00		8,530.00	–0.60	–1.26	–0.63			
215.00	936.00		7,200.00	–0.41	–1.11	–0.45			
60.00	981.00		50,400.00	0.61	0.52	0.69			
31.00	1,776.00		525,600.00	0.53	0.67	0.71			
118.00	1,911.00		–	1,031.38	1,031.84	1,031.86			
173.00	1,910.00		–	1,031.39	10,31.64	1,031.67			
282.00	1,910.00		167,970.00	1,031.47	1,031.45	1,031.57			
428.00	1,920.00		71,400.00	1,031.10	1,031.05	1,031.18			
478.00	1,925.00		70,500.00	1,031.13	1,031.06	1,031.20			
513.00	1,930.00		70,200.00	1,031.07	1,031.00	1,031.13			
558.00	1,936.00		–	1,031.24	1,031.32	1,031.33			
945.00	2,022.00		–	1,031.02	1,031.49	1,031.51			

cont.

fluid_temp_teo	fluid_elcond_eco	fluid_salinity_tdso	fluid_salinity_tdsom	reference	comment
					dtl is for 0.01 m change
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fluid_temp_teo	fluid_elcond_eco	fluid_salinity_tdso	fluid_salinity_tdsom	reference	comment
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SICADA – description of plu_inf_test_obs_d

PLU interference tests, Observation section data.

SICADA Header	Header	Unit	Explanation
idcode	ID Obs Borehole		ID for observation borehole.
secup	Borehole secup	(m)	Length coordinate along the borehole for the upper limit of observation section.
seclow	Borehole seclow	(m)	Length coordinate along the borehole for the lower limit of observation section.
start_date	Date for test start	YYYY-M M-DD hh:mm	Date for the start of the pumping/injection test (YYYY-MM-DD hh:mm).
stop_date	Date for test stop	YYYY-M M-DD hh:mm	Date for the stop of the pumping/injection test (YYYY-MM-DD hh:mm).
test_type	Test type (1–7)	(–)	1A:Pumping test-wireline eq,1B: Pumping test-submersible pump, 1C: Pumping test-airlift pumping. 2: Interference test.3: Injection test. 4: Slug test., 4B: Pulse test. 5A: Flowlogging-PFL-DIFF_sequential. 5B Flowlogging-PFL-DIFF_overlapping. 6: Flowlogging Impeller. 7: Grain size analysis.
test_borehole	ID. pumped Borehole	(–)	ID for pumped or injected borehole.
test_secup	Test secup	(m)	Length coordinate along the borehole for the upper limit of pumped or injected section.
test_seclow	Test seclow	(m)	Length coordinate along the borehole for the lower limit of pumped or injected section.
start_flow_period	Start flow	YYYY-MM-DD hh:mm:ss	Time for the start of the pumping/injection period (YYYY-MM-DD hh:mm:ss).
stop_flow_period	Stop flow	YYYY-MM-DD hh:mm:ss	Time for the stop of the pumping/injection period (YYYY-MM-DD hh:mm:ss).
lp	Lp	(m)	Hydraulic point of application for a test section, based on the geometric midpoint of test section or the main point of transmissivity distribution in test section.
radial_distance_rs	rs	(m)	Geometrical distance from point of application in test section to point of application in observation section.
shortest_distance_rt	rt	(m)	Representative hydraulic distance from point of application in test section to point of application in observation section via inferred major conductive features. The actual structural model version shall be reported.
time_lag_press_dtl	dtL	(s)	Time lag for pressure response to reach observation section after start/stop of pumping or injection, based on the first significant response in the observation section.
initial_head_hi	hi	(m)	Hydraulic head in observation section at start of flow period.

SICADA Header	Header	Unit	Explanation
head_at_flow_end_hp	hp	(m)	Hydraulic head in observation section at stop of flow period.
final_head_hf	hF	(m)	Hydraulic head in observation section at stop of recovery period.
initial_press_pi	pi	(kPa)	Groundwater pressure in observation section at start of flow period.
press_at_flow_end_pp	pp	(kPa)	Groundwater pressure in observation section at stop of flow period.
final_press_pf	pF	(kPa)	Groundwater pressure in observation section at stop of recovery period.
fluid_temp_teo	Teo	(Co)	Measured borehole fluid temperature in the observation section (representative for evaluated parameters).
fluid_elcond_eco	ECo	(mS/m)	Measured electric conductivity of the borehole fluid in the observation section (representative for evaluated parameters).
fluid_salinity_tdso	TDSo	(mg/L)	Calculated total dissolved solids of the borehole fluid in the observation section, based on EC-measurement.
fluid_salinity_tdso	TDSom	(mg/L)	Measured total dissolved solids of the borehole fluid in the observation section, based on water sampling and chemical analysis.
reference	References		SKB report No for reports describing data and evaluation.
comment	Comments		Short comment to the evaluated parameters (Optional).

Index o			Observation borehole or observation section (o short for observation).

plu_inf_test_obs_ed

idcode	start_date	stop_date	secup	seclow	section_no	test_borehole	test_secup	test_seclow	formation_width_b
HFM13	2005-07-06 12:04	2005-08-02 06:00	159.00	173.00		HFM01	0.00	200.20	14.00
HFM20	2005-07-06 12:04	2005-08-02 06:00	101.00	130.00		HFM01	0.00	200.20	29.00
KFM02A	2005-07-06 12:04	2005-08-02 06:00	490.00	518.00		HFM01	0.00	200.20	28.00

cont.

lp	width_of_channel_b	tbo	l_measl_tbo	u_measl_tbo	sbo	leakage_factor_lof	transmissivity_to	value_type_to	l_measl_to
162.00							3.55E–04	0	
118.00							2.17E–04	0	
513.00							4.00E–04	0	

cont.

u_measl_to	storativity_so	leakage_coeff_o	hydr_cond_kosf	l_measl_kosf	u_measl_kosf	spec_storage_sosf	dt1	dt2	t1	t2
	6.08E–05								50,000	200,000
	3.84E–05								100,000	200,000
	5.31E–05									

cont.

dte1	dte2	transmissivity_to_nlr	value_type_to_nlr	storativity_so_nlr	transmissivity_to_grf	value_type_to_grf

cont.

storativity_so_grf	flow_dim_grf_o	comments

SICADA – description of plu_inf_test_obs_ed

PLU interference test, evaluated data of observation sections.

SICADA Header	Header	Unit	Explanation
idcode	ID Obs. Borehole		ID for obsevation borehole.
secup	Borehole secup	m	Length coordinate along the borehole for the upper limit of the observation section.
seclow	Borehole seclow	(m)	Length coordinate along the borehole for the lower limit of the observation section.
start_date	Date for test start	YYYY-MM-DD hh:mm	Date for the start of the interference test (YYYY-MM-DD hh:mm).
stop_date	Date for test stop	YYYY-MM-DD hh:mm	Date for the stop of the interference test (YYYY-MM-DD hh:mm)
test_borehole	ID- Pumped borehole	(–)	ID for pumped or injected borehole.
test_secup		(m)	Length coordinate along the borehole for the upper limit of pumped or injected section.
test_seclow		(m)	Length coordinate along the borehole for the lower limit of pumped or injected section.
formation_width_b	b	m	b:Representative aquifer thickness for inferred transmissivity, generally estimated as observation section length L_o.
width_of_channel_b	B	m	B:Inferred width of formation for evaluated TB.
lp	L_p		Hydraulic point of application for a test section, based on the geometric midpoint of test section or the main point of transmissivity distribution in test section.
tbo	TB_o	m^3/s	Flow capacity in 1D formation of width B and transmissivity T based on transient evaluation in observation section. Considered best estimate from transient evaluation of flow period or recovery period.
l_meas_limit_tbo	TB-measl-L	m^3/s	Estimated lower measurement limit for evaluated TB in observation section.
u_meas_limit_tbo	TB-measl-U	m^3/s	Estimated upper measurement limit for evaluated TB in observation section.
sbo	SB_o	m	SB_o: Storage capacity of 1D formation of width B and storativity S based on transient evaluation in observation section. Considered best estimate from transient evaluation of flow period or recovery period.
leakage_factor_lof	L_{of}	m	Leakage coefficient in observation section evaluated from 2D radial flow model. K´ = hydraulic conductivity across the aquitard, b´ = water saturated thickness of aquitard (leaky formation). Considered best estimate from transient evaluation of flow period or recovery period.
transmissivity_to	T_o	m^2/s	Transmissivity of formation in observation section, based on 2D radial flow model. Considered best estimate from transient evaluation of flow period or recovery period.
l_measl_to	$T_{o\text{-measl-L}}$	m^2/s	Estimated lower measurement limit for evaluated T_o in observation section.
u_measl_to	$T_{o\text{-measl-U}}$	m^2/s	Estimated upper measurement limit for evaluated T_o in observation section.

SICADA Header	Header	Unit	Explanation
storativity_so	S_o	(–)	Storativity (Storage coefficient) of formation in observation section based on 2D radial flow model. Considered best estimate from transient evaluation of flow period or recovery period.
leakage_coeff_o	$(K'/b')_o$	(l/s)	Leakage coefficient in observation section evaluated from 2D radial flow model. K´ = hydraulic conductivity across the aquitard, b´ = water saturated thickness of aquitard (leaky formation). Considered best estimate from transient evaluation of flow period or recovery period.
hydr_kond_kosf	K_{osf}	m/s	Hydraulic conductivity of formation in observation section, based on 3D spherical flow model. Considered best estimate from transient evaluation of flow period or recovery period.
l_measl_kosf	$K_{osf\text{-}measl\text{-}L}$	m/s	Estimated lower measurement limit for evaluated K_{osf} in observation section.
u_measl_kosf	$K_{osf\text{-}measl\text{-}U}$	m/s	Estimated upper measurement limit for evaluated K_{osf} in observation section.
spec_storage_sosf	S_{osf}	1/m	Specific Storage of formation in observation section, based on 3D spherical flow. Considered best estimate from transient evaluation of flow period or recovery period.
dt1	dt_1	s	Estimated start time after pump/injection start or recovery start, for the period used for the evaluated parameter.
dt2	dt_2	s	Estimated stop time after pump/injection start or recovery start, for the period used for the evaluated parameter.
t1	t_1	s	Start time for evaluated parameter from start of flow period.
t2	t_2	s	Stop time for evaluated parameter from start of flow period.
dte1	dt_{e1}	s	Start time for evaluated parameter from start of recovery period.
dte2	dt_{e2}	s	Stop time for evaluated parameter from start of recovery period.
transmissivity_to_nlr	T_{oNLR}	m^2/s	Transmissivity in observation section, based on Non Linear Regression of the entire test sequence.
storativity_so_nlr	S_{oNLR}	(–)	Storativity in observation section, based on Non Linear Regression of the entire test sequence.
transmissivity_to_grf	T_{oGRF}	m^2/s	Transmissivity in observation section, based on the Generalised Radial Flow model /Baker, 1988/. Considered best estimate from transient evaluation of flow period or recovery period.
storativity_so_grf	S_{oGRF}	(–)	Storativity in observation section, based on Generalised Radial Flow model. Considered best estimate from transient evaluation of flow period or recovery period.
flow_dim_grf_o	D_{oGRF}	(–)	Inferred flow dimension in observation section, based on the Generalised Radial Flow model /Barker, 1988/. Considered best estimate from transient evaluation of flow period or recovery period.
Comments	Comments		Short comment to the evaluated parameters (Optional).