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Forsmark site investigation

Difference flow logging in borehole KFM04A

Pekka Rouhiainen, Jari Pöllänen
PRG Tec-Oy

July 2004

Svensk Kärnbränslehantering AB
Swedish Nuclear Fuel
and Waste Management Co
Box 5864
SE-102 40 Stockholm Sweden
Tel 08-459 84 00
+46 8 459 84 00
Fax 08-661 57 19
+46 8 661 57 19

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This report concerns a study which was conducted for SKB. The conclusions and viewpoints presented in the report are those of the authors and do not necessarily coincide with those of the client.

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Abstract

Difference flow logging is a swift method for determination of the transmissivity and the hydraulic head in borehole sections and fractures/fracture zones in core drilled boreholes. This report presents the main principles of the method as well as results of measurements carried out in borehole KFM04A at Forsmark, Sweden, in March 2004, using the Posiva flow log. The primary aim of the measurements was to determine the position and flow rate of flow yielding fractures in borehole KFM04A prior to groundwater sampling.

The flow rate into or out of 5 m long test sections was measured between 111.23–992.57 m borehole length during natural (un-pumped) as well as pumped conditions. The flow measurements were repeated at the location of the detected flow anomalies using a 1 m long test section, successively transferred with an overlapping of 0.1 m.

Length calibration was made based on length marks milled into the borehole wall at accurately determined positions along the borehole. The length marks were detected by caliper measurements and by single point resistance measurements using sensors connected to the flow logging tool.

A high-resolution absolute pressure sensor was used to measure the absolute total pressure along the borehole. These measurements were carried out together with the flow measurements.

Electric conductivity (EC) and temperature of borehole water was also measured. The EC-measurements were used to study the occurrence of saline water in the borehole during natural as well as pumped conditions. Finally, EC of fracture-specific water was measured for a selection offractures.

Sammanfattning

Differensflödesloggning är en snabb metod för bestämning av transmissiviteten och hydraulisk tryckhöjd i borrhålssektioner och sprickor/sprickzoner i kärnborrhål. Denna rapport presenterar huvudprinciperna för metoden och resultat av mätningar utförda i borrhål KFM04A i Forsmark, Sverige, i mars 2004 med Posiva flödesloggningsmetod. Det primära syftet med mätningarna var att bestämma läget och flödet för vattenförande sprickor i borrhål KFM04A före grundvatten-provtagning.

Flödet till eller från en 5 m lång testsektion mättes mellan 111.23–992.57 m borrhålslängd under såväl naturliga (icke-pumpade) som pumpade förhållanden. Flödesmätningarna upprepades vid lägena för de detekterade flödesanomalierna med en 1 m lång testsektion som förflyttades successivt med 0.1 m.

Längdkalibrering gjordes baserad på längdmärkena som frästs in i borrhålsväggen vid noggrant bestämda positioner längs borrhålet. Längmärkena detekterades med caliper och punktresistansmätningar med hjälp av sensorer anslutna på flödesloggningssonden.

En högupplösande absoluttryckgivare användes för att mäta det absoluta totala trycket längs borrhålet. Dessa mätningar utfördes tillsammans med flödesmätningarna.

Elektrisk konduktivitet och temperatur på borrhålsvattnet mättes också. EC-mätningarna användes för att studera förekomsten av saltvatten i borrhålet under såväl naturliga som pumpade förhållanden. Slutligen mättes EC på vattnet i ett antal utvalda sprickor.

Contents

1 Introduction

The difference flow logging in the core drilled borehole KFM04A at Forsmark was conducted between March 10–27, 2004. KFM04A is the fourth core drilled borehole in the Forsmark candidate area. The borehole is inclined c 60^{o} from the horizontal direction. The c 1000 m deep borehole is performed with telescopic drilling technique, where the interval 0–107 m is percussion drilled with the diameter c 250 mm and the remaining interval, 107–1000 m, is core drilled with the diameter 77.3 mm. The interval 0–c 107 m is cased with the inner diameter 200 mm. The location of borehole KFM04A at drilling site DS4 within the Forsmark area is shown in Figure 1-1.

The field work and the subsequent interpretation were conducted by PRG-Tec Oy. The Posiva Flow Log/Difference Flow method has previously been employed in Posiva's site characterisation programme in Finland as well as at the Äspö Hard Rock Laboratory at Simpevarp, Sweden. The commissions at the latter site included measurements in the 1700 m long cored borehole KLX02 at Laxemar together with a methodology study /Ludvigson et al, 2002/.

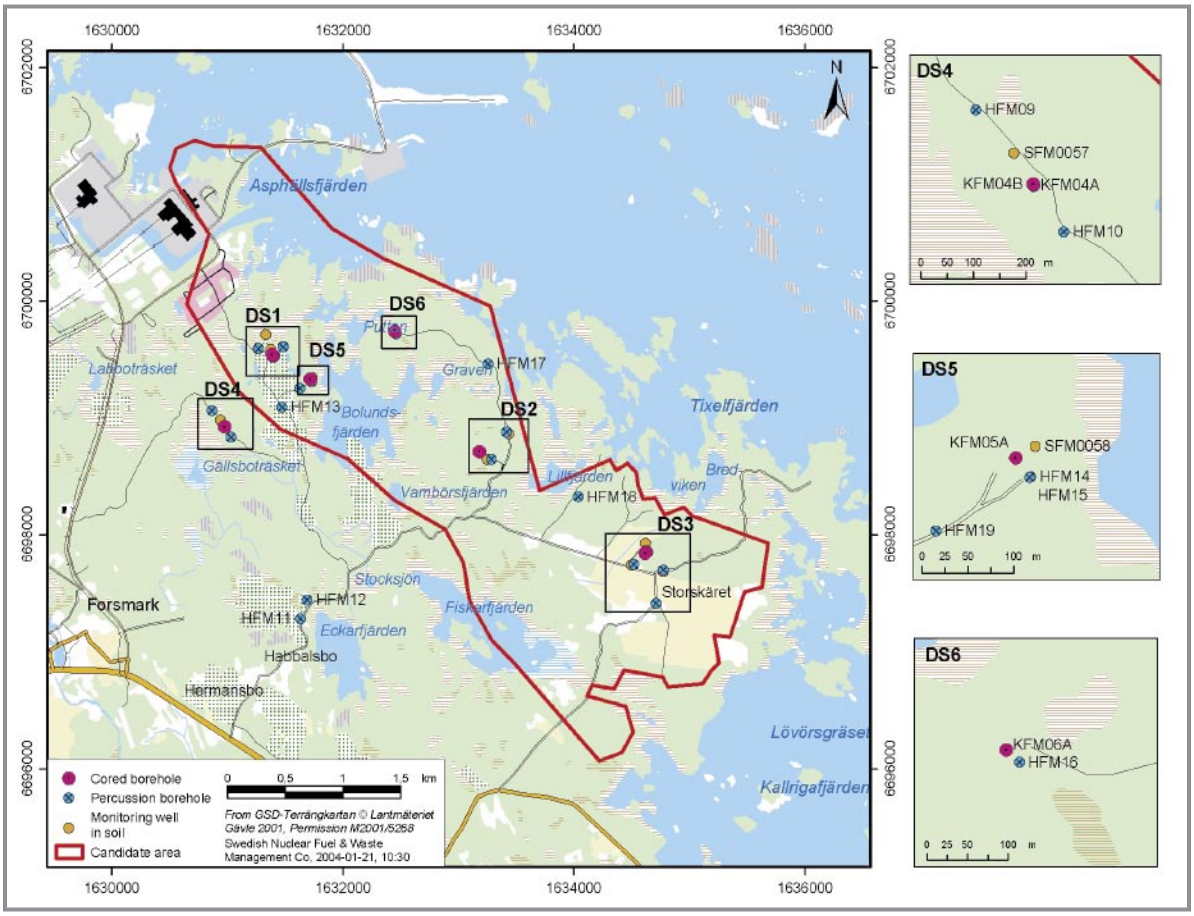

__Figure 1-1.__ Location of the drilling sites DS1-6 at Forsmark. For the drilling sites DS4-6 detailed maps of all boreholes within the sites are shown.

This document reports the results gained by the Difference flow logging in borehole KFM04A. The activity is performed within the Forsmak site investigation. The work was carried out in accordance to SKB internal controlling document AP PF 400-04-28. Data and results were delivered to the SKB site characterization database SICADA with Field note no Forsmark 275.

2 Objective and scope

The main objective of the difference flow logging in KFM04A was to identify water-conductive sections/fractures suitable for subsequent hydro-geochemical characterisation. Secondly, the measurements aimed at a hydrogeological characterisation, including the prevailing water flow balance in the borehole and the hydraulic properties (transmissivity and undisturbed hydraulic head) of the tested sections. Based on the results of these investigations, a more detailed characterisation of flow anomalies along the hole, e.g. an estimate of the conductive fracture frequency (CFF), may be obtained.

Besides the difference flow logging, the measurement programme also included supporting measurements, performed for a better understanding of the overall hydrogeochemical conditions. These measurements included electric conductivity and temperature of the borehole fluid as well as single-point resistance of the borehole wall. The electric conductivity was also measured for a number of selected high-transmissive fractures in the borehole. Furthermore, the recovery of the groundwater level after pumping was registered and interpreted hydraulically.

A high-resolution pressure sensor was used to measure the absolute pressure along the borehole. These measurements were carried out together with the flow measurements. The results are used for calculation of hydraulic head along the borehole.

Single point resistance measurements were also combined with caliper (borehole diameter) measurements for detection of depth marks milled into the borehole wall at accurately determined positions along the borehole. This procedure was applied for length calibration of all measurements.

3 Principles of measurement and interpretation

3.1 Measurements

Unlike traditional types of borehole flowmeters, the Difference flowmeter method measures the flow rate into or out of limited sections of the borehole instead of measuring the total cumulative flow rate along the borehole. The advantage of measuring the flow rate in isolated sections is a better detection of the incremental changes of flow along the borehole, which are generally very small and can easily be missed using traditional types of flowmeters.

Rubber disks at both ends of the downhole tool are used to isolate the flow in the test section from that in the rest of the borehole, see Figure 3-1. The flow along the borehole outside the isolated test section passes through the test section by means of a bypass pipe and is discharged at the upper end of the downhole tool.

The Difference flowmeter can be used in two modes, a sequential mode and an overlapping mode. In the sequential mode, the measurement increment is as long as the section length. It is used for determining the transmissivity and the hydraulic head /Öhberg and Rouhiainen, 2000/. In the overlapping mode, the measurement increment is shorter than the section length. It is mostly used to determine the location of hydraulically conductive fractures and to classify them with regard to their flow rates.

The Difference flowmeter measures the flow rate into or out of the test section by means of thermistors, which track both the dilution (cooling) of a thermal pulse and transfer of thermal pulse with moving water. In the sequential mode, both methods are used, whereas in the overlapping mode, only the thermal dilution method is used because it is faster than the thermal pulse method.

Besides incremental changes of flow, the downhole tool of the Difference flowmeter can be used to measure:

- The electric conductivity (EC) of the borehole water and fracture-specific water. The electrode for the EC measurements is placed on the top of the flow sensor, Figure 3-1.
- The single point resistance (SPR) of the borehole wall (grounding resistance), The electrode of the Single point resistance tool is located in between the uppermost rubber disks, see Figure 3-1. This method is used for high resolution depth/length determination of fractures and geological structures.
- The diameter of the borehole (caliper). The caliper tool, combined with SPR, is used for detection of the depth/length marks milled into the borehole wall, see Chapter 2. This enables an accurate depth/length calibration of the flow measurements.
- The prevailing water pressure profile in the borehole. The pressure sensor is located inside the electronics tube and connected via another tube to the borehole water, Figure 3-2.
- Temperature of the borehole water. The temperature sensor is placed in the flow sensor, Figure 3-1.

All of the above measurements were performed in KFM02A.

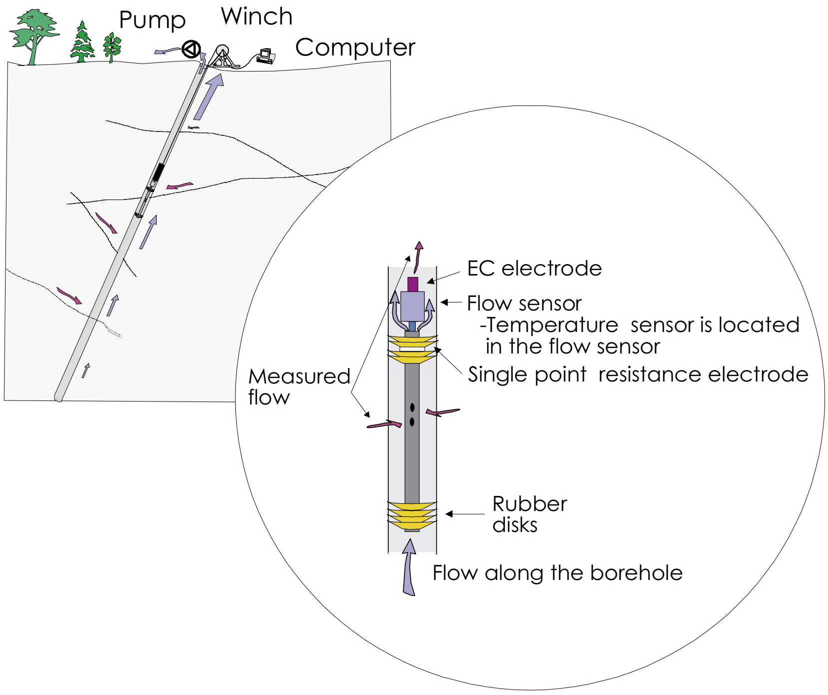

Figure 3-1. *Schematic of the downhole equipment used in the Difference flowmeter.*

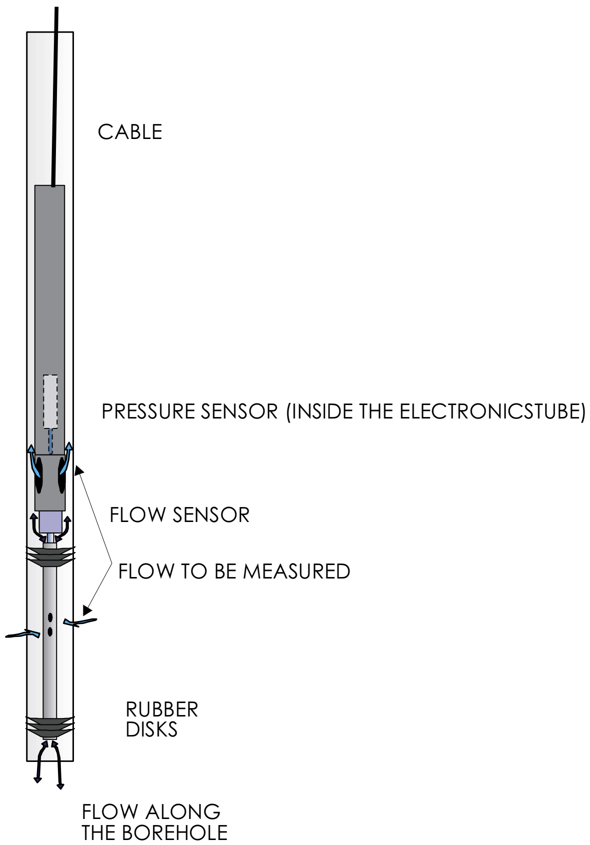

Figure 3-2. *The absolute pressure sensor is located inside the electronics tube and connected via another tube to the borehole water.*

The principles of difference flow measurements are described in Figures 3-3 and 3-4. The flow sensor consists of three thermistors, see Figure 3-3a. The central thermistor, A, is used both as a heating element for the thermal pulse method and for registration of temperature changes in the thermal dilution method, Figures 3-3b and c. The side thermistors, B1 and B2, serve to detect the moving thermal pulse, Figure 3-3d, caused by the constant power heating in A, Figure 3-3b.

Flow rate is measured during the constant power heating (Figure 3-3b). If the flow rate exceeds 600 mL/h, the constant power heating is increased, Figure 3-4a, and the thermal dilution method is applied.

If the flow rate during the constant power heating (Figure 3-3b) falls below 600 mL/h, the measurement continues with monitoring of transient thermal dilution and thermal pulse response (Figure 3-3d). When applying the thermal pulse method, also thermal dilution is always measured. The same heat pulse is used for both methods.

Flow is measured when the tool is at rest. After transfer to a new position, there is a waiting time (the duration can be adjusted according to the prevailing circumstances) before the heat pulse (Figure 3-3b) is launched. The waiting time after the constant power thermal pulse can also be adjusted, but is normally 10 s long for thermal dilution and 300 s long for thermal pulse. The measuring range of each method is given in Table 3-1.

The lower end limits of the thermal dilution and the thermal pulse methods in Table 3-1 correspond to the theoretical lowest measurable values. Depending on the borehole conditions, these limits may not always prevail. Examples of disturbing conditions are floating drilling debris in the borehole water, gas bubbles in the water and high flow rates (above about 30 L/min) along the borehole. If disturbing conditions are significant, a practical measurement limit is calculated for each set of data.

Table 3-1. Ranges of flow measurements.

Method	Range of measurement (mL/h)
Thermal dilution P1	30–6 000
Thermal dilution P2	600–300 000
Thermal pulse	6–600

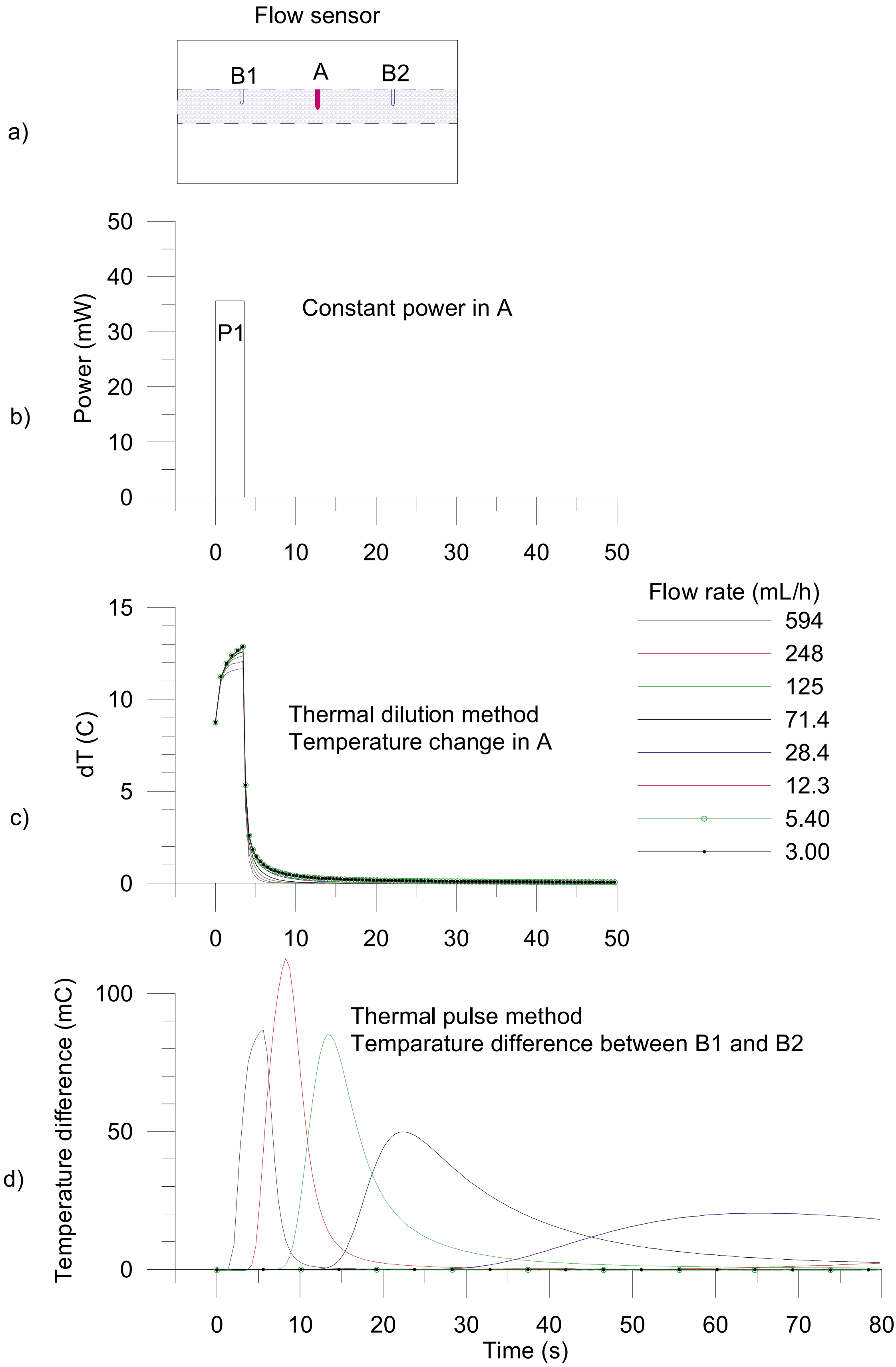

Figure 3-3. *Flow measurement, flow rate <600 mL/h.*

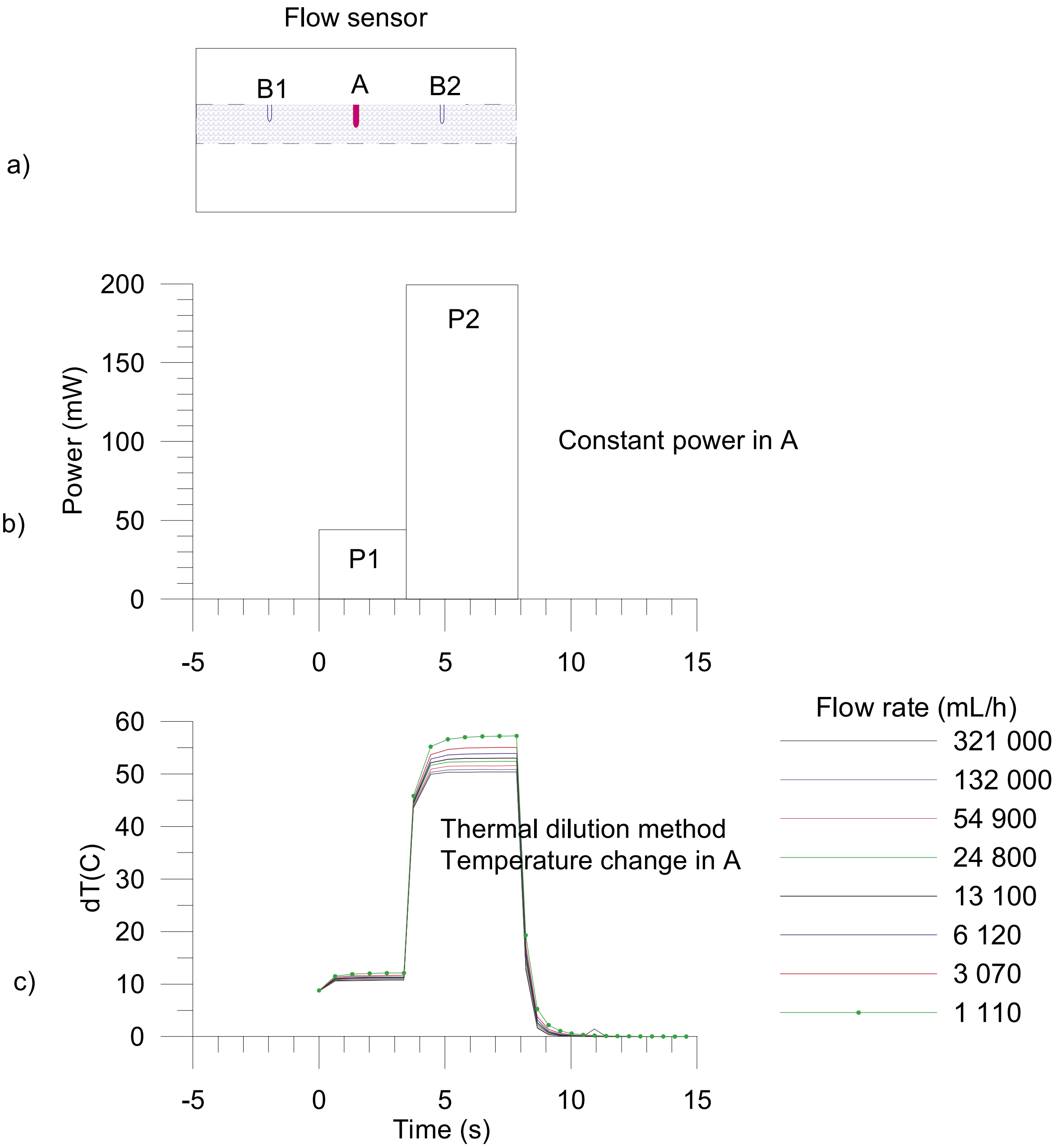

Figure 3-4. *Flow measurement, flow rate > 600 mL/h.*

3.2 Interpretation

The interpretation is based on Thiems or Dupuits formula that describes a steady state and two dimensional radial flow into the borehole /Marsily, 1986/:

$h_s - h = Q/(T \cdot a)$ 3-1

where

h is hydraulic head in the vicinity of the borehole and $h = h_s$ at the radius of influence (R),

Q is the flow rate into the borehole,

T is the transmissivity of the test section,

a is a constant depending on the assumed flow geometry. For cylindrical flow, the constant a is:

$a = 2 \cdot \pi / \ln(R/r_0)$ 3-2

where

r_0 is the radius of the well and

R is the radius of influence, i.e. the zone inside which the effect of the pumping is felt.

If flow rate measurements are carried out using two levels of hydraulic heads in the bore-hole, i.e. natural or pump-induced hydraulic heads, then the undisturbed (natural) hydraulic head and transmissivity of the tested borehole sections can be calculated. Two equations can be written directly from equation 3-1:

$Q_{s1} = T_s \cdot a \cdot (h_s - h_1)$ 3-3

$Q_{s2} = T_s \cdot a \cdot (h_s - h_2)$ 3-4

where

h_1 and h_2 are the hydraulic heads in the borehole at the test level,

Q_{s1} and Q_{s2} are the measured flow rates in the test section,

T_s is the transmissivity of the test section and

h_s is the undisturbed hydraulic head of the tested zone far from the borehole.

Since, in general, very little is known of the flow geometry, cylindrical flow without skin zones is assumed. Cylindrical flow geometry is also justified because the borehole is at a constant head and there are no strong pressure gradients along the borehole, except at its ends.

The radial distance R to the undisturbed hydraulic head h_s is not known and must be assumed. Here a value of 500 is selected for the quotient R/r_0.

The hydraulic head and the test section transmissivity can be deduced from the two measurements:

$h_s = (h_1 - b \cdot h_2)/(1 - b)$ 3-5

$T_s = (1/a)\ (Q_{s1} - Q_{s2})/(h_2 - h_1)$ 3-6

where

$b = Q_{s1}/Q_{s2}$

Transmissivity (T_f) and hydraulic head (h_f) of individual fractures can be calculated provided that the flow rates of individual fractures are known. Similar assumptions as above have to be used (a steady state cylindrical flow regime without skin zones).

$$h_f = (h_1 – b\ h_2)/(1 – b) \qquad 3\text{-}7$$

$$T_f = (1/a)\ (Q_{f1} – Q_{f2})/(h_2 – h_1) \qquad 3\text{-}8$$

where

Q_{f1} and Q_{f2} are the flow rates at a fracture and

h_f and T_f are the hydraulic head (far away from borehole) and the transmissivity of a fracture, respectively.

Since the actual flow geometry and the skin effects are unknown, transmissivity values should be taken as indicating orders of magnitude. As the calculated hydraulic heads do not depend on geometrical properties but only on the ratio of the flows measured at different heads in the borehole, they should be less sensitive to unknown fracture geometry. A discussion of potential uncertainties in the calculation of transmissivity and hydraulic head is provided in /Ludvigson et al, 2002/.

4 Equipment specifications

The Posiva Flow Log/Difference flowmeter monitors the flow of groundwater into or out from a borehole by means of a flow guide (rubber discs). The flow guide thereby defines the test section to be measured without altering the hydraulic head. Groundwater flowing into or out from the test section is guided to the flow sensor. Flow is measured using the thermal pulse and/or thermal dilution methods. Measured values are transferred in digital form to the PC computer.

Type of instrument:	Posiva Flow Log/Difference Flowmeter
Borehole diameters:	56 mm, 66 mm and 76–77 mm
Length of test section:	A variable length flow guide is used.
Method of flow measurement:	Thermal pulse and/or thermal dilution.
Range and accuracy of measurement:	Table 4-1.
Additional measurements:	Temperature, Single point resistance, Electric conductivity of water, Caliper, Water pressure.
Winch:	Mount Sopris Wna 10, 0.55 kW, 220V/50Hz. Steel wire cable 1500 m, four conductors, Gerhard-Owen cable head.
Length determination	Based on the marked cable and on the digital length counter
Logging computer:	PC, Windows 2000
Software	Based on MS Visual Basic
Total power consumption:	1.5–2.5 kW depending on the pumps
Calibrated	April 2004
Calibration of cable length	Using length marks in the borehole

Range and accuracy of sensors is presented in Table 4-1.

Table 4-1. Range and accuracy of sensors.

Sensor	Range	Accuracy
Flow	6–300 000 mL/h	+/– 10% curr.value
Temperature (middle thermistor)	0–50°C	0.1°C
Temperature difference (between outer thermistors)	–2 – +2°C	0.0001°C
Electric conductivity of water (EC)	0.02–11 S/m	+/– 5% curr.value
Single point resistance	5–500 000 Ω	+/– 10% curr.value
Groundwater level sensor	0–0.1 Mpa	+/– 1% fullscale
Absolute pressure sensor	0–20 MPa	+/– 0.01% fullscale

5 Performance

The Commission was performed according to Activity Plan AP PF 400-04-28 following the SKB Method Description 322.010, Version 1.0 (Method description for difference flow logging). The Activity Plan and the Method Description are both SKB internal controlling document. Prior to the measurements, the downhole tools and the measurement cable were disinfected. Time was synchronized to local Swedish time. The activity schedule of the borehole measurements is presented in Table 5-1. The items and activities in Table 5-1 are the same as in the Activity Plan.

Logging cables, wires, and pipe strings are exposed to stretching when lowered into a vertical or sub-vertical borehole. This will introduce a certain error in defining the position of a test tool connected to the end of e.g. a logging cable. Immediately after completion of the drilling operations in borehole KFM04A, length marks were milled into the borehole wall at certain intervals to be used for length calibration of various logging tools. By using the known positions of the length marks, logging cables etc can be calibrated in order to obtain an accurate length correction of the testing tool.

Table 5-1. Flow logging and testing in KFM04A. Activity schedule.

Item	Activity	Explanation	Date
1	Measurements of EC on selected water samples	Some selected water samples were measured in laboratory	2004-03-09
8	EC- and temp-logging of the borehole fluid	Logging without the lower rubber discs, no pumping	2004-03-10 2004-03-11
7	Length calibration of the downhole tool	Dummy logging (SKB Caliper and SPR). Logging without the lower rubber discs, no pumping	2004-03-11 2004-03-12
9	Combined sequential and overlapping flow logging	Section length Lw=5 m. Step length dL=0.5 m. Pulse measurement every 10th point, no pumping	2004-03-12 2004-03-16
10	Overlapping flow logging	Section length Lw=5 m. Step length dL=0.5 m at pumping (includes 1 day waiting after beginning of pumping)	2004-03-17 2004-03-18
11	Overlapping flow logging	Section length Lw=1 m. Step length dL=0.1 m, at pumping (only in conductive borehole intervals)	2004-03-18 2004-03-21
12	Fracture-specific EC-measurements in pre-selected fractures	Section length Lw=1 m, at pumping (in pre-selected fractures)	2004-03-21 2004-03-22
13	EC- and temp- logging of the borehole fluid	Logging without the lower rubber discs, at pumping	2004-03-22
14	Recovery transient	Measurement of water level and absolute pressure in the borehole after stop of pumping	2004-03-22 2004-03-23
11 extra	Overlapping flow logging	Section length Lw=1 m. Step length dL=0.1 m, at pumping (length interval 108–241 m was re-measured using 1 m drawdown)	2004-03-23 2004-03-24
11 extra	Overlapping flow logging	Section length Lw=1 m. Step length dL=0.1 m, at pumping (length intervals 949–957 m and 977–996 m were re-measured using 7.5 m drawdown)	2004-03-24
15	Measurements of EC on selected water samples	Some selected water samples were re-measured in laboratory	2004-03-25
13 extra	EC- and temp-logging of the borehole fluid	Re-logging without the lower rubber discs, at pumping	2004-03-26
12 extra	Fracture-specific EC-measurements in pre-selected fractures	Section length Lw=1 m, at pumping (in pre-selected fractures). Re-measurements	2004-03-26 2004-03-27

Each length mark includes two 20 mm wide tracks in the borehole wall. The distance between the marks is 100 mm. The upper track represents the reference level. An inevitable condition for a successful length calibration is that all length marks, or at least the major part of them, are detectable. The Difference flow metre system uses caliper measurements in combination with single point resistance measurement (SPR) for this purpose, and these measurements were the first to be performed in borehole KFM04A (Item 7 in Table 5-1). These methods also reveal parts of the borehole widened for other reason (fracture zones, breakouts etc).

The caliper- and SPR-measurements were preceded by measurements of electric conductivity (EC) of the borehole water (Item 8) during natural (un-pumped) conditions.

The combined sequential/overlapping flow logging (Item 9) was carried out in the borehole interval 111.23–992.57 m. The section length was 5 m, and the length increment (step length) 5 m for the thermal pulse method, respectively 0.5 m for thermal dilution method. The measurements were performed during natural (un-pumped) conditions.

Pumping was started on March 16. After 26 hours waiting time, the overlapping flow logging (Item 10) was measured in the same interval, 111.23–992.57 m, using the same section and step lengths as before.

The overlapping flow logging was then continued in the way that previously measured flow anomalies were re-measured with 1 m section length and 0.1 m step length (Item 11). After that fracture specific EC was measured on water from some selected fractures (Item 12).

Still during pumped conditions, the EC of borehole water (Item 13) was measured. After this, the pump was stopped and the recovery of the groundwater level was monitored (Item 14).

The length interval 108–241 m was re-measured using a smaller drawdown, since the flow rate exceeded the measurement limit in several fractures in this interval. The length intervals 949–957 m and 977–996 m were re-measured using a larger drawdown, to investigate possible small flow anomalies in these intervals. A section length of 1 m and a step length of 0.1 m were used here, (Item 11 extra).

The EC measurements showed decreasing EC for the different logging sequences and it was suspected that there might be a problem with the EC-electrode. The EC-sensor was tested in water samples of known salinity on March 25 (Item 15 in Table 5-1). This confirmed that the EC-electrode had changed, showing too low EC values. Mineral coating was found on the EC electrode. The EC electrode was then cleaned and re-tested again using water samples of known salinity. The original calibration was valid after cleaning. Items 12 and 13 were repeated after cleaning of the EC electrode.

6 Results

6.1 Length calibration

6.1.1 Caliper and SPR measurement

An accurate length scale of measurements is difficult to achieve in long boreholes. The main cause of inaccuracy is stretching of the logging cable. The stretching depends on the tension of the cable, the magnitude of which in turn depends, among other things, on the inclination of the borehole and on the friction against the borehole wall. The cable tension is larger when the borehole is measured upwards. The cables, especially new cables, may also stretch out permanently. In KFM04A the stretching of the cable was relatively high, since the measurements were performed from the bottom of the borehole in the upward direction.

Length marks on the borehole wall can be used to minimise the length errors. The length marks are detected with the SKB caliper tool. The length scale is firstly corrected according to the length marks. Single point resistance is recorded simultaneously with the caliper logging. All flow measurement sequences can then be length corrected by synchronising the SPR results (SPR is recorded during all measurements) with the original caliper/SPR measurement.

The procedure of length correction was the following:

- The Caliper+SPR measurements (Item 7) was initially length corrected in relation to the known length marks, Appendix 1.38, black curve. Corrections between the length marks were obtained for each length mark by linear interpolation.
- The SPR curve of Item 7 was then compared with the SPR curves of Items 9, 10, 11 and 12 to obtain relative length errors of these measurement sequences.
- All SPR curves could then be synchronized, as can be seen in Appendices 1.2–1.37.

The results of the caliper and single point resistance measurements from all measurements in the entire borehole are presented in Appendix 1.1. Seven SPR-curves are plotted together with caliper-data. These measurements correspond to Items 7, 9, 10, 11 and 12 in Table 5-1.

Zoomed results of caliper and SPR are presented in Appendices 1.2–1.37. The length marks were detected at 119 m, 150 m, 200 m, 250 m, 300 m, 350 m, 400 m, 450 m, 500 m, 550 m, 600 m (only the upper one), 650 m, 700 m, 750 m, 800 m, 850 m (only the lower one), 900 m (only the lower one) and at 950 m (only the lower one). In other words, every mark was detected at least partly. They can also be seen in the SPR results. However, the anomaly is complicated due to the four rubber disks used at the upper end of the section, two at each side of the resistance electrode. A selection of length intervals where clear SPR-anomalies were found, are plotted as well.

The aim of the plots in Appendices 1.2–1.37 is to verify the accuracy of the length correction. The curves in these plots represent length corrected results. The same length corrections were applied to the flow- and EC measurements.

The magnitude of length correction along the borehole is presented in Appendix 1.38. The error is negative, due to fact that the stretching extends the logging cable (i.e. the cable is longer than the nominal length marked on the cable).

6.1.2 Estimated error in location of detected fractures

In spite of the length correction described above, there are still length errors due to the following reasons:

1. The point interval in flow measurements is 0.1 m in overlapping mode. This could cause an error of +/– 0.05 m.
2. The length of the test section is not exact. The specified section length denotes the distance between the nearest upper and lower rubber disks. Effectively, the section length can be larger. At the upper end of the test section there are four rubber disks. The distance between these is 5 cm. This will cause rounded flow anomalies. Flow may be detected already when a fracture is situated between the upper rubber disks. These phenomena, which can only be seen with a short step length (0.1 m), could cause an error of +/– 0.05 m.
3. Corrections between the length marks can be other than linear. This could cause an error of +/– 0.1 m in the caliper/SPR measurement (Item 7).
4. SPR curves may be imperfectly synchronized. This could cause an error of +/– 0.1 m

In the worst case, the errors of points 1, 2, 3 and 4 are summed up. Then the total estimated error between the length marks would be +/– 0.3 m.

Near the length marks the situation is slightly better. In the worst case, the errors of points 1, 2 and 4 are summed up. Then the total estimated error near the length marks would be +/– 0.2 m.

Accurate location is important when different measurements are compared, for instance flow logging and borehole TV. In that case, the situation may not be as severe as the worst case above, since part of the length errors are systematic and the length error is nearly constant for fractures near each other. However, the error of point 1 is of random type.

Fractures nearly parallel with the borehole may also be problematic. Fracture location may be difficult to accurately define in such cases.

6.2 Electric conductivity and temperature

6.2.1 Electric conductivity and temperature of borehole water

The electric conductivity of the borehole water (EC) was initially measured when the borehole was at rest, i.e. at natural, un-pumped conditions. The measurements were performed in both directions, downwards and upwards, see Appendix 2.1.

The EC measurements were repeated during pumping (after a pumping period of about eight days), see Appendix 2.1, red curve 2004-03-22. This was done only downwards. These EC values are probably too low because of the mineral coating on the EC electrode. The EC-sensor was then cleaned and tested using water samples of known salinity on March 25. After cleaning and testing EC of the borehole water was re-measured, see Appendix 2.1, violet curve 2004-03-26. The re-measured curve shows higher EC values but they are still lower than the original ones without pumping.

Accumulation of mineral coating was exceptionally fast in KFM04A. Existing high electrical ground currents might cause this problem.

Temperature of borehole water was measured simultaneously with the EC-measurements. The EC-values are temperature corrected to 25°C to make them more comparable with other EC measurements /Heikkonen et al, 2002/. The temperature results in Appendix 2.2 correspond to the EC results in Appendix 2.1. Pumping changed temperature profiles above the length of 230 m; high pumping flow rate is an apparent reason to this.

6.2.2 EC of fracture-specific water

The flow direction is always from the fractures into the borehole if the borehole is pumped with a sufficiently large drawdown. This enables the determination of electric conductivity from fracture-specific water. Both electric conductivity and temperature of flowing water from the fractures were measured.

The flow measurement makes it possible to find the fractures for the EC measurement. The tool is moved so that the fracture to be tested will be located within the test section (L = 1 m). The EC measurements begin if the flow rate is larger than a predetermined limit. The tool is kept on the selected fracture. The measurement is continued at the given length allowing the fracture-specific water to enter the section. The waiting time for the EC measurement can be automatically calculated from the measured flow rate. The aim is to flush the water volume within the test section well enough. The measuring computer is programmed to change the water volume within the test section about three times. The water volume in a one metre long test section was 3.6 L. In this case waiting times were selected to be much longer than calculated times.

Electric conductivity of fracture-specific water is presented on time scale, see Appendix 8.1. The blue symbol represents the value when the tool was moved (one metre point interval) and the red symbol means that the tool was stopped on a fracture for a fracture specific EC measurement. The same fracture specific EC measurements are also presented on a zoomed time scale, see Appendix 8.2.

Borehole lengths at the upper and lower ends of the section, fracture locations as well as the final EC values are listed in Table 6-1.

Table 6-1. Fracture-specific EC.

Upper end of section (m)	Lower end of section (m)	Fractures measured (m)	EC (S/m) at 25°C
115.69	116.69	116.3	0.87
206.55	207.55	207.1	1.40
234.99	235.99	235.6	1.46
296.46	297.46	297.1	1.48
359.21	360.21	359.8	1.45

6.3 Pressure measurements

The absolute pressure was registered together with the other measurements in Items 8–14 in Table 5-1. The pressure sensor measures the sum of hydrostatic pressure in the borehole and air pressure. Air pressure was also registered, see Appendix 9. Hydraulic head along the borehole at natural and pumped conditions respectively is determined in the following way. Firstly, the monitored air pressure at the site is subtracted from the measured absolute pressure by the pressure sensor. The hydraulic head (h) at a certain elevation z is calculated according to the following expression /Nordqvist, 2001/:

$$h = (p_{abs} - p_b)/\rho_{fw}\, g + z \quad (6\text{-}1)$$

where

h is the hydraulic head (masl) according to the RHB 70 reference system,

p_{abs} is the absolute pressure (Pa),

p_b is the barometric (air) pressure (Pa),

ρ_{fw} is the unit density, 1000 kg/m^3,

g is the standard gravity, 9.80065 m/s^2 and

z is the elevation of measurement (masl) according to the RHB 70 reference system.

An offset of 2.46 kPa is subtracted from all absolute pressure results.

The calculated head distributions are presented in Appendix 4. Exact z-coordinates are important in head calculation. 10 cm error in z-coordinate means 10 cm error in head.

The length calibration of the borehole EC measurements is not as accurate as of the other measurements because SPR is not registered during the borehole EC measurements. Instead the length correction of the Caliper measurement was applied to the borehole EC measurements, black curve in Appendix 1.37.

6.4 Flow logging

6.4.1 General comments on results

The measuring program contains several flow logging sequences. They were gathered on the same diagram as the with single point resistance (right hand side) and caliper plots (in the middle), see Appendices 3.1–3.45. Single point resistance usually shows a low resistance value on a fracture where flow is detected. There are also many other resistance anomalies from other fractures and geological features. The electrode of the Single point resistance tool is located within the upper rubber disks. Thus, the locations of the resistance anomalies of the leaky fractures fit with the lower end of the flow anomalies.

The Caliper tool shows a low voltage when the borehole diameter is below 77 mm and a high voltage when the borehole diameter exceeds 77 mm.

The flow logging was firstly performed with a 5 m section length and with 0.5 m length increments, see Appendices 3.1–3.45 (red curve with pumping, dark blue curve without pumping). The method (overlapping flow logging) gives the length and the thickness of conductive zones with a length resolution of 0.5 m. To obtain quick results, only the thermal dilution method is used initially for flow determination.

Under natural conditions every tenth flow measurement was carried out using the thermal pulse method (sequential flow logging). This method is slower but has the advantage of rendering measurements of very small flow rates possible, as well as of their flow directions (into the borehole or out of it). The pulse method was used only without pumping.

The test section length determines the width of a flow anomaly of a single fracture in the plots. If the distance between flow yielding fractures is less than the section length, the anomalies will be overlapped, resulting in a stepwise flow anomaly. The overlapping flow logging was therefore repeated in the vicinity of identified flow anomalies using a 1 m long test section and 0.1 m length increments. The upper part of the borehole (above 241 m) was re-measured using smaller drawdown. The flow rate was above the measurement limit in this interval. The length intervals 949–957 m and 977–996 m were also re-measured using larger drawdown.

Detected fractures are shown on the caliper scale with their positions (borehole length). They are interpreted on the basis of the flow curves and therefore represent flowing fractures. A long line represents the location of a leaky fracture; a short line denotes that the existence of a leaky fracture is uncertain. A short line is used if the flow rate is less than 30 mL/h or if the flow anomalies are overlapping.

6.4.2 Transmissivity and hydraulic head of borehole sections

The entire borehole between 111.23 m and 992.57 m was flow logged with a 5 m section length and with 0.5 m length increments. The major part of the flow logging results presented in this report is derived from measurements with the thermal dilution method. However, every tenth flow measurement without pumping was carried out using the thermal pulse method (sequential flow logging without pumping), which enables measurements of smaller flow rates than 600 mL/h, above which limit thermal pulse results were used only for detection of the flow direction.

The results of the sequential measurements with a 5 m section length are presented in tables, see Appendices 5.1–6.2. Only the results with a 5 m length increments are useda All borehole sections are shown in Appendices 3.1–3.45. Secup1 and Secup2 presented in Appendices 5.1–5.7 are calculated as the distance along the borehole from the reference level (top of the casing tube) to the upper end of the test section. Secup1 refers to the measurements at natural, i.e. un-pumped conditions, and Secup2 to measurements during pumping. They are not identical, due to a minor difference of the cable stretching between the two sequences.

Pressure was measured and calculated as described in Chapter 6.3. Borehole Head1 and Borehole Head2 in Appendices 5.1–5.7 represent heads determined without respectively with pumping. Head in the borehole and calculated heads of borehole sections are given in RHB 70 scale.

The flow results presented in Appendices 5.1–5.7 (Flow1 and Flow2), representing flow rates derived from measurements during un-pumped respectively pumped conditions, are presented side by side to make comparison easier. Flow rates are positive if the flow direction is from the bedrock into the borehole and vice versa. With the borehole at rest, 8 sections were detected as flow yielding, of which 4 had a flow direction from the borehole into the bedrock (negative flow). During pumping, all 33 detected flows were directed towards the borehole.

The measurable flow ranges were exceeded at lengths of 111.23 m, 201.48 m, 206.49 m and 231.52 m when the borehole was pumped. Flow rates for transmissivity calculations and corresponding borehole heads at these locations (lengths) were taken from the re-measurements with a smaller drawdown (with a section length of 1 m). Similarly, the transmissivity and head of the section 952.55 (Secup) were calculated from the re-measurements at the larger drowdown.

The flow data is presented as a plot, see Appendix 6.1. The left hand side of each diagram represents flow from the borehole into the bedrock for the respective test sections, whereas the right hand side represents the opposite. If the measured flow was zero (below the measurement limit), it is not visible in the logarithmic scale of the appendices.

In the plots (Appendix 6.1) and in the tables (Appendix 5), also the lower and upper measurement limits of flow are presented. There are theoretical and practical lower limits of flow, see Chapter 6.4.4.

Hydraulic head and transmissivity (T_S) of borehole sections can be calculated from flow data using the method described in Chapter 3. Hydraulic head of sections is presented in the plots if none of the two flow values at the same length is equal to zero. Transmissivity is presented if none or just one of the flows is equal to zero, see Appendix 6.2. The measurement limits of transmissivity are also shown in Appendix 6.2 and in Appendix 5. All the measurement limit values of transmissivity are based on the actual pressure difference in the borehole (Borehole Head1 and Borehole Head 2 in Appendix 5).

The sum of detected flows without pumping (Flow1) was –99 mL/h. This sum should normally be zero if all the flows in the borehole are correctly measured, the borehole is not pumped, the water level is constant, the salinity distribution in the borehole is stabilized and the fractures are at steady state pressure. In this case the sum is very close to zero.

6.4.3 Transmissivity and hydraulic head of fractures

An attempt was made to evaluate the magnitude of fracture-specific flow rates. The results for a 1 m section length and for 0.1 m length increments were used for this purpose. The first step in this procedure is to identify the locations of individual flowing fractures and then to evaluate their flow rates.

In cases where the fracture distance is less than one metre, it may be difficult to evaluate the flow rate. There are such cases for instance in Appendix 3.4. Increase or decrease of a flow anomaly at the fracture location (marked with the lines in Appendix 3) is used for determination of flow rate.

Since sections with 1 m length were not used at un-pumped conditions, the results for a 5 m section length were used instead. The fracture locations are important when evaluating flow rate at un-pumped conditions. The fracture locations are known on the basis of the measurements for a 1 m section length. Increase or decrease of a flow anomaly at the fracture location determines the flow rate. The measurements for a 5 m section length at un-pumped conditions are used for the corresponding fracture flow rates. The flow direction is evaluated as well. The results of the evaluation are plotted in Appendix 3, blue filled triangle.

The total amount of detected flowing fractures is 71, but only 9 were seen without pumping. These 9 fractures could be used for head estimations and all 71 were used for transmissivity estimations. Transmissivity and hydraulic head of fractures are presented in Appendices 7.1–7.3.

Some fracture-specific results were rated to be "uncertain" results, see Appendix 7.1. The criterion of "uncertain" was in most cases a minor flow rate (< 30 mL/h). In some cases fracture anomalies were unclear, since the distance between them was less than one metre.

The high-transmissivity fractures at 112.4 m, 116.1 m, 202.8 m, 207.1 m, 232.7 m and 235.6 m were re-measured at a lower drawdown. The transmissivity and head of these fractures were interpreted in three ways using different data pairs, see Appendix 10. Results are quite close to each other. Only for the fracture at the length of 235.6 m some bigger differences can be seen. The pair (pumping2-pumping1) is the most unfavorable one for head calculation, because the used borehole heads deviate at most from the natural fracture head. Interpretation of fracture head is least accurate in such cases.

Fracture-specific transmissivities were compared with transmissivities of borehole sections in Appendix 11. All fracture-specific transmisivities within each 5 m interval were first summed up to make them comparable with measurements with a 5 m section length. The results are, in most cases, consistent between the two types of measurements.

6.4.4 Theoretical and practical measurements limits of flow and transmissivity

The theoretical minimum of measurable flow rate in the overlapping measurements (thermal dilution method only) is about 30 mL/h. The thermal pulse method was also used when the borehole was not pumped. Its theoretical lower limit is about 6 mL/h. The upper limit of flow measurement is 300 000 mL/h. These limits are determined on the basis of flow calibration. It is assumed that flow can be reliably detected between the upper and lower theoretical limits during favourable borehole conditions.

The minimum measurable flow rate may, however be much higher in practice. The borehole conditions may have an influence on the base level of flow (noise level). The noise level can be evaluated for intervals of the borehole without flowing fractures or other structures. The noise level may vary along the borehole.

There are several known reasons for increased noise in flow:

1) Rough borehole wall.

2) Solid particles in water such as clay or drilling debris.

3) Gas bubbles in water.

4) High flow rate along the borehole.

A rough borehole wall always causes a high noise not only in flow but also in single point resistance results. The flow curve and SPR curves are typically spiky when the borehole wall is rough.

Drilling debris usually increases the noise level. Typically this kind of noise is seen both without pumping and with pumping.

Pumping causes a pressure drop in the borehole water and in fracture water near the borehole. This may lead to release of gas from dissolved form to gas bubbles. Some fractures may produce more gas than others. Sometimes an increased noise level is obtained just above certain fractures (when the borehole is measured upwards). The reason is assumed to be gas bubbles. Bubbles may cause decrease of the average density of water and therefore also a decrease of measured head in the borehole.

The effect of a high flow rate along the borehole can often be seen above high flowing fractures. Any minor leak at the lower rubber disks is directly measured as increased noise in flow.

A high noise level in flow masks a “real” flow that is smaller than the noise. Real flows are totally invisible if they are about ten times smaller than the noise. Real flows are registered correctly if they are about ten times larger than the noise. By experience, real flows between 1/10 times noise and 10 times noise are summed up with the noise. Therefore noise level could be subtracted from the measured flow to get the real flow. This correction has not been done so far because it is not clear whether it is applicable in each case.

The noise level was not a serious problem in borehole KFM04A. The practical minimum level of flow rate is evaluated and presented in Appendices 3.1–3.45 using a grey dashed line (Lower limit of flow rate). Below this line there may be fractures or structures that remain undetected.

The noise level in KFM04A was between 10–100 ml/h. Mostly it even fell below 30 mL/h, i.e. below the theoretical limit of thermal the dilution method. However, the noise line (grey dashed line) was never drawn below 30 mL/h. In many cases there are flow anomalies smaller than 30 mL/h. These fractures are marked with a short line indicating “uncertain”.

In some boreholes the upper limit of flow measurement (300 000 mL/h) may be exceeded. Such fractures or structures hardly remain undetected (as the fractures below the lower limit). High flow fractures can be measured separately at a smaller drawdown.

The practical minimum of measurable flow rate is also presented in Appendix 5 (Q-lower limit Practical). It is taken from the plotted curve in Appendix 3 (Lower limit of flow rate). The practical minimum of measurable transmissivity can be evaluated using Q-lower limit and the actual head difference at each measurement, see Appendix 5. The theoretical minimum measurable transmissivity can also be evaluated using a Q value of 6 mL/h (minimum theoretical flow rate with the thermal pulse method) instead of Q-lower limit Practical.

The upper measurement limit of transmissivity can be evaluated using the maximum flow rate (300 000 mL/h) at the actual head difference as above, see Appendix 5 (T_s-Upper Limit).

All three flow limits are also plotted with measured flow rates, see Appendix 6.1. Theoretical minimum and maximum values are 6 mL/h and 300 000 mL/h, respectively.

The three transmissivity limits are also presented graphically, see Appendix 6.2. The upper measurement limit T is not even but shows steps upwards. At these locations, a smaller pumping rate (smaller head difference) was used, because there are high flowing fractures at these locations.

The lower measurement limit of T shows a step downward at 955 m. At this location a higher pumping rate and a larger drawdown was used to get a measurable flow rate.

Similar flow and transmissivity limits are not given for the fracture-specific results, Appendices 7.1–7.3. Approximately the same limits would be valid also for these results. The limits for fracture-specific results are more difficult to define. For instance, it may be difficult to see a small flow rate near (< 1 m) a high flowing fracture. The situation is similar for the upper flow limit. If there are several high flowing fractures nearer each other than one metre, the upper flow limit depends on the sum of flows which must fall below 300 000 mL/h.

6.5 Groundwater level and pumping rate

The level of the groundwater table in the borehole during the measurement sequences is presented in Appendix 12.1. The borehole was pumped between March 16 and 22 with a drawdown of about 3.9 metres. The borehole was pumped also between March 23 and 24 a short time with two different very small drawdowns. Finally, the borehole was pumped between March 26 and 27 during the re-measurement of EC. Pumping rate was also recorded, see Appendix 12.2.

The groundwater recovery was measured after the first pumping period,on March 22–23, Appendix 12.3. The recovery was measured with two sensors, using the water level sensor (pressure sensor for monitoring water level) and the absolute pressure sensor located at the borehole length of 976.83 m.

Data from the recovery period was utilized to calculate the total borehole transmissivity, see Appendix 13.

7 Summary

In this study, the Posiva Flow Log/Difference Flow method has been used to determine the location and flow rate of flowing fractures or structures in borehole KFM04A at Forsmark. Measurements were carried out both when the borehole was at rest and during pumping. A 5 m section length with 0.5 m length increments was used firstly. The measurements were repeated using 1 m section length with 0.1 m length increments over the flow anomalies.

Length calibration was made using the length marks on the borehole wall. The length marks were detected by caliper and single point resistance logging. The latter method was also performed simultaneously with the flow measurements, and thus all flow results could be length calibrated by synchronizing the single point resistance logs.

The distribution of saline water along the borehole was logged by electric conductivity and temperature measurements of the borehole water. In addition, electric conductivity was measured in selected flowing fractures.

The total amount of detected flowing fractures was 71. Transmissivity and hydraulic head were calculated for borehole sections and fractures. The highest transmissivity ($3.5 \cdot 10^{-5}$ m^2/s) was detected in a fracture at the borehole length of 112.4 m. High-transmissive fractures were also found at 116.1 m, 202.8 m, 207.1 m, 232.7 m and 235.6 m. Below 521.5 m no flowing fractures were identified, except a small fracture at 954.8 m at the bottom of the borehole.

The fieldwork went smoothly, at least from the contactors point of view. An important reason to this is that the site was well organized. The measurements, which were going on round the clock, including weekends, were carried out in a relatively short time.

The result tables of the difference flow logging in borehole KFM04A stored in the Sicada database are presented in Appendix 14.

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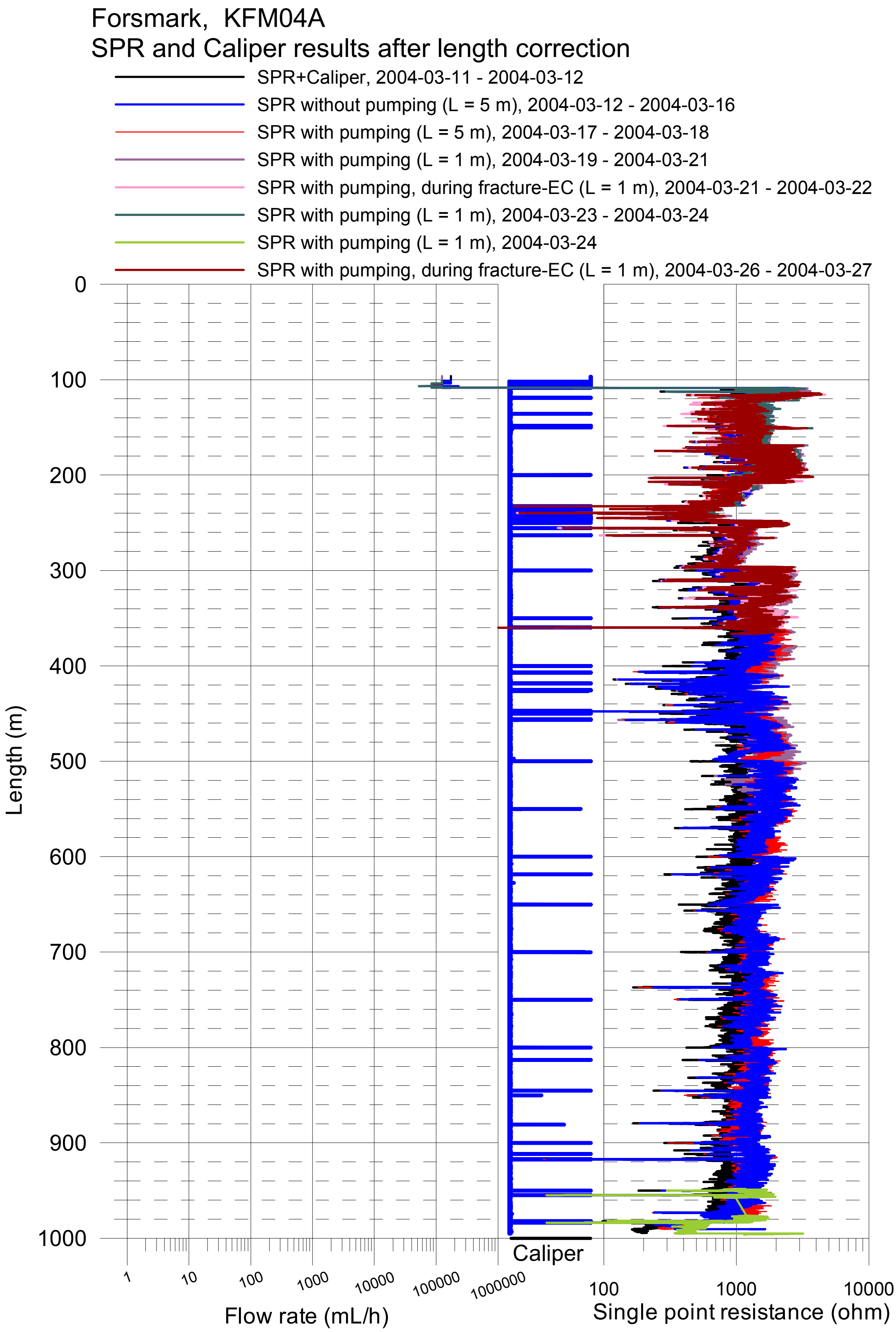
Appendices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SPR with pumping (L = 5 m), 2004-03-17 - 2004-03-18
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0
100
200
300
400
500
600
700
800
900
1000
Caliper
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
100
1000
10000
Single point resistance (ohm)

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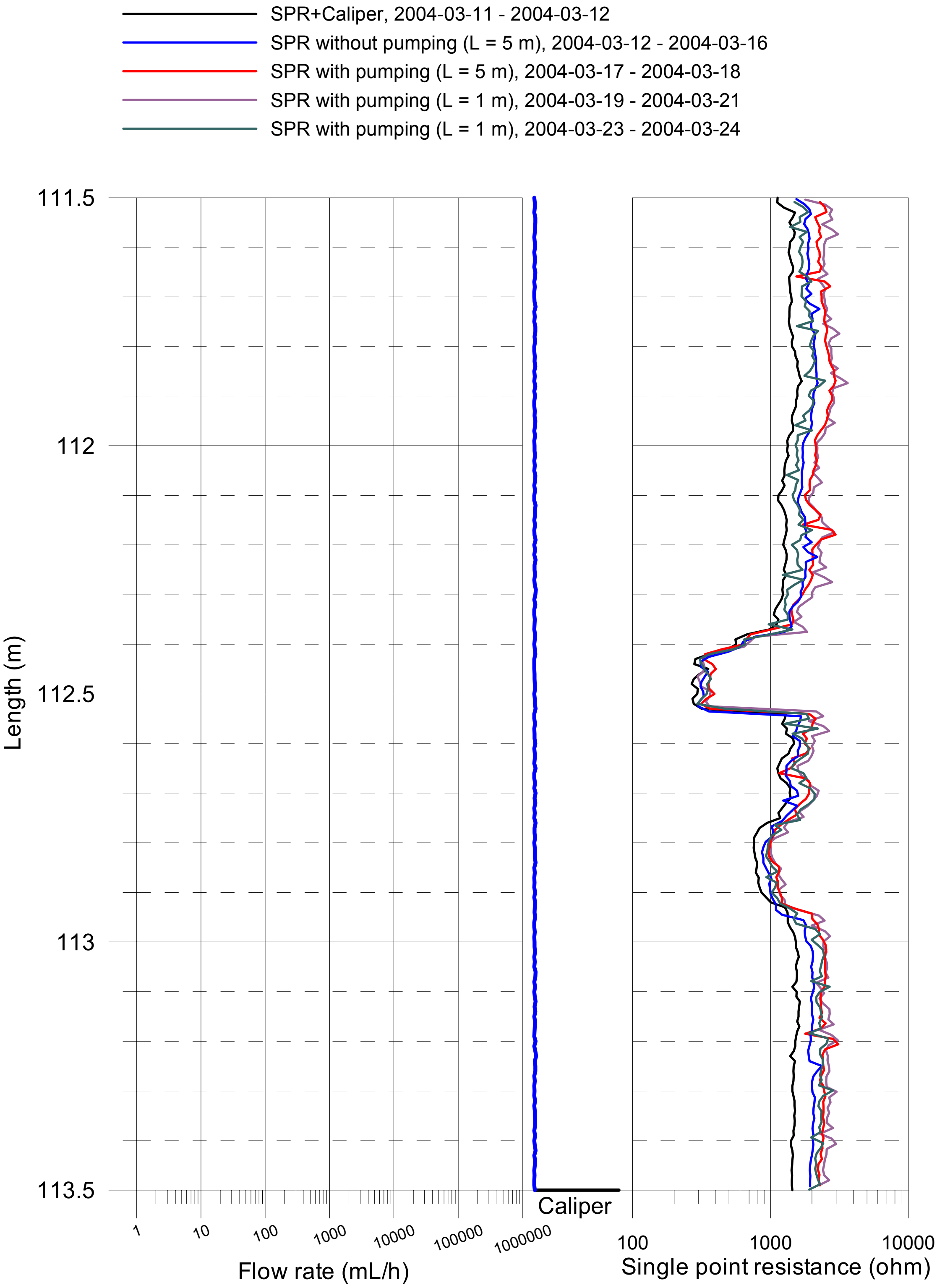
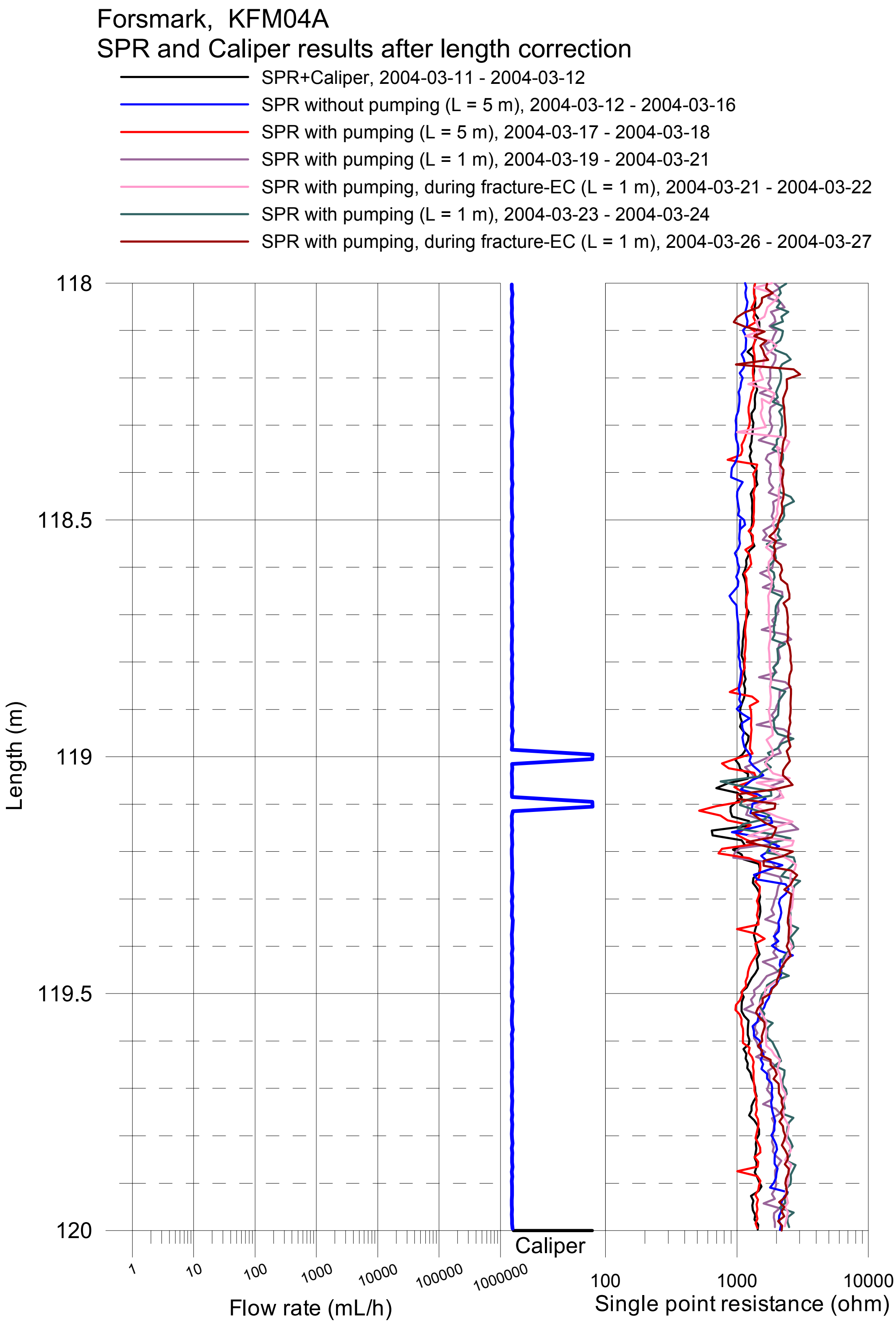
SPR and Caliper results after length correction





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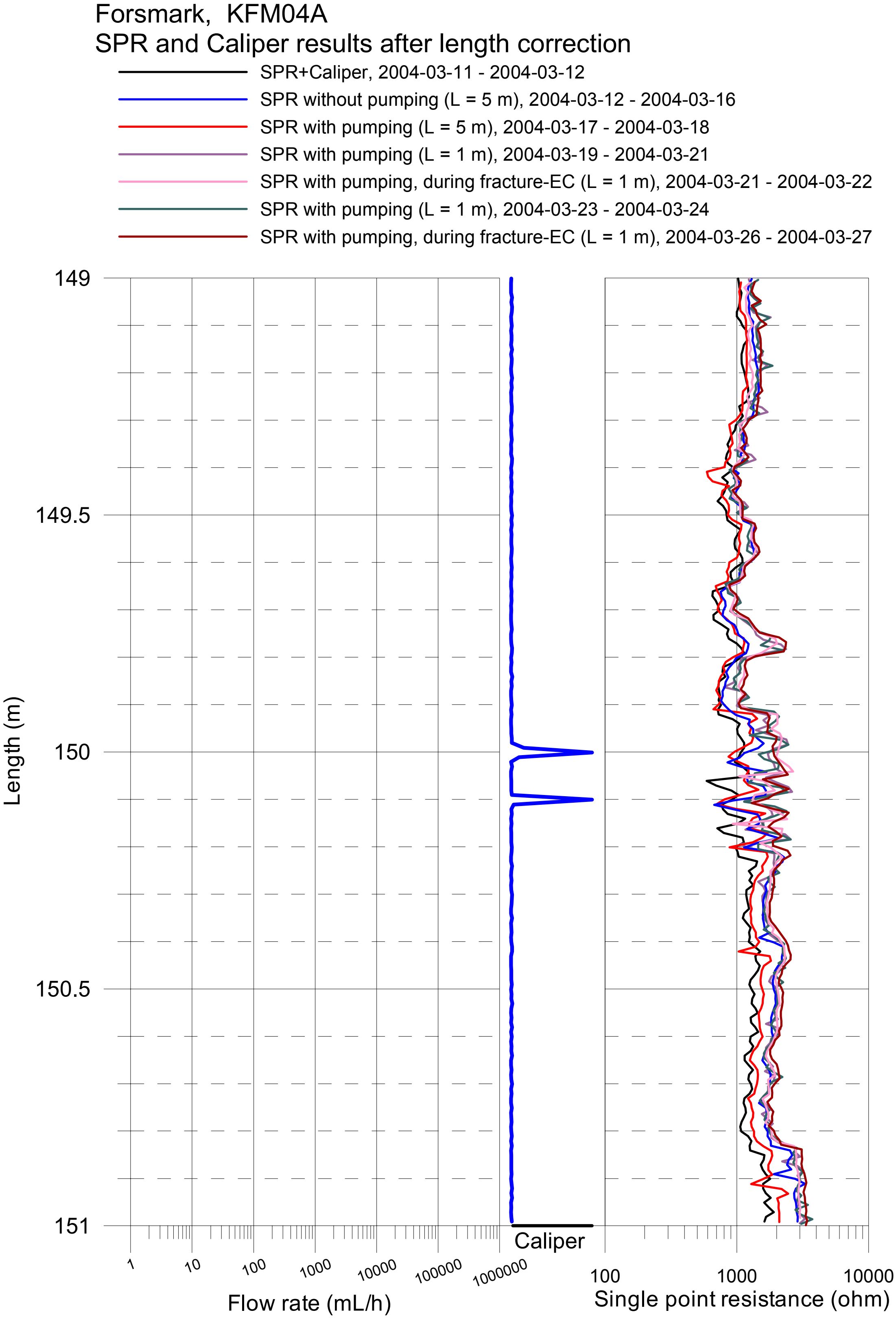
118
118.5
119
119.5
120
Length (m)
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
Caliper
100
1000
10000
Single point resistance (ohm)



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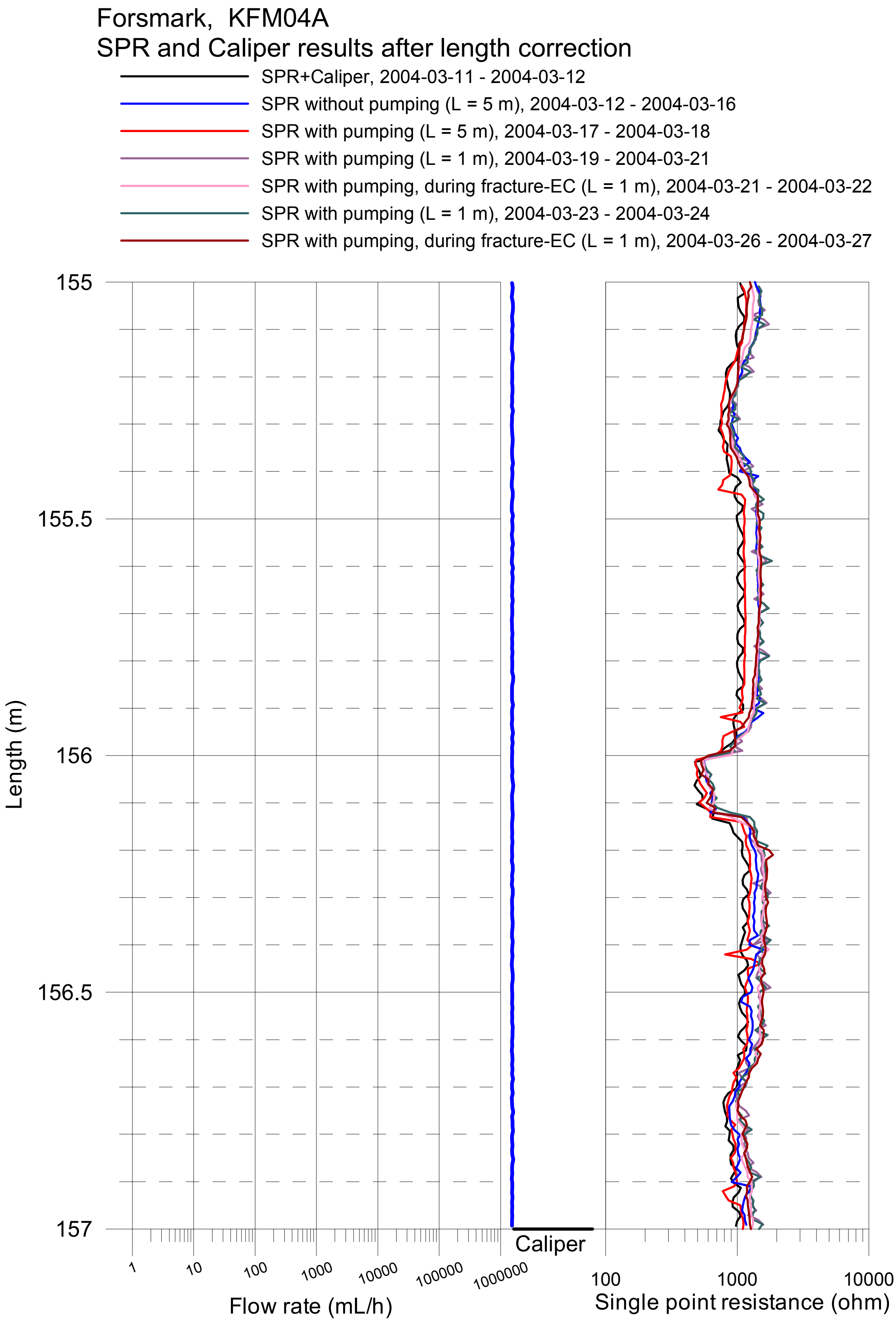
149
149.5
150
150.5
151
Length (m)
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
Caliper
100
1000
10000
Single point resistance (ohm)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Length (m)
155
155.5
156
156.5
157
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
Caliper
100
1000
10000
Single point resistance (ohm)

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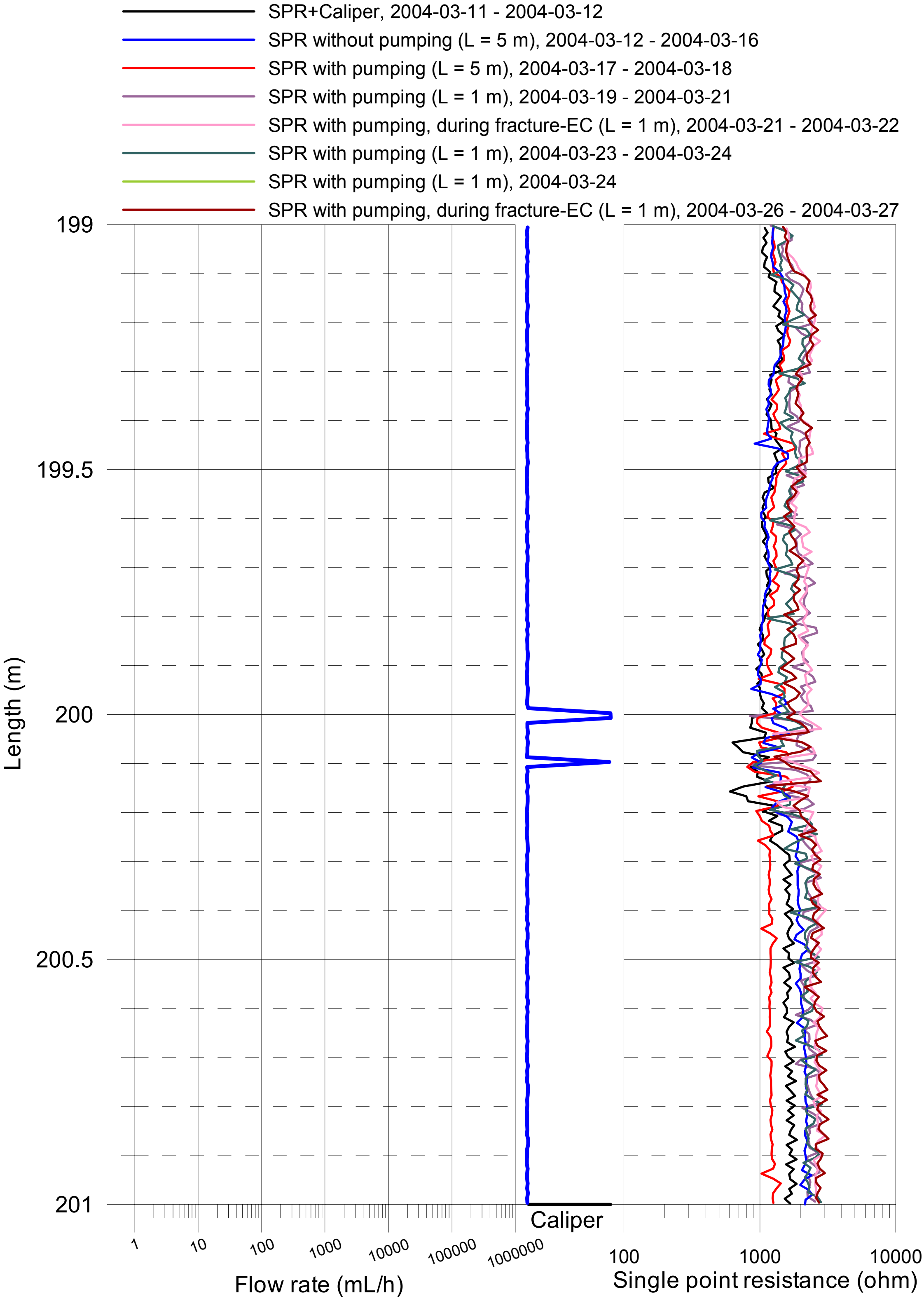
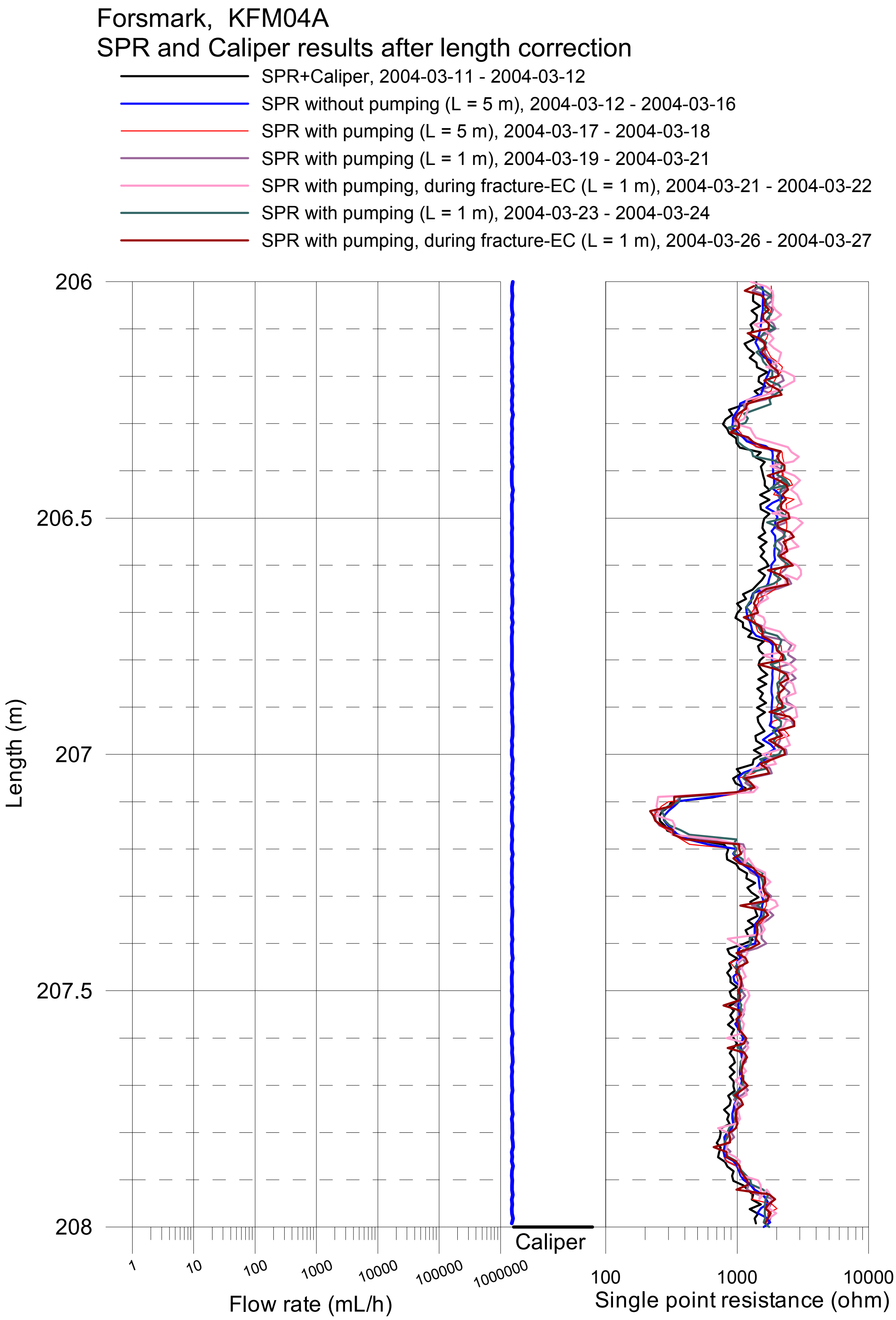
SPR and Caliper results after length correction

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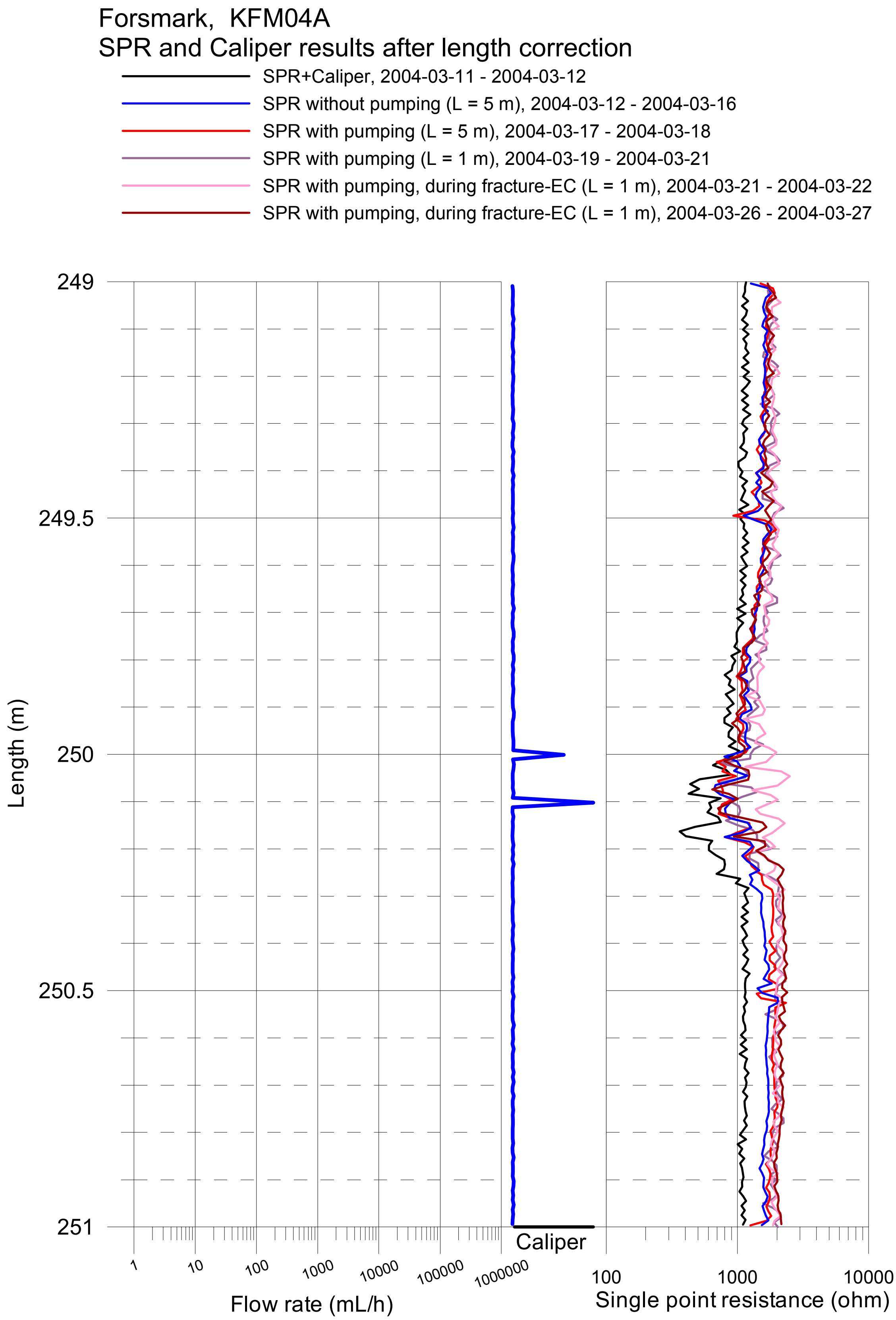
SPR with pumping (L = 1 m), 2004-03-23 - 2004-03-24
SPR with pumping, during fracture-EC (L = 1 m), 2004-03-26 - 2004-03-27
Length (m)
206
206.5
207
207.5
208
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
Caliper
100
1000
10000
Single point resistance (ohm)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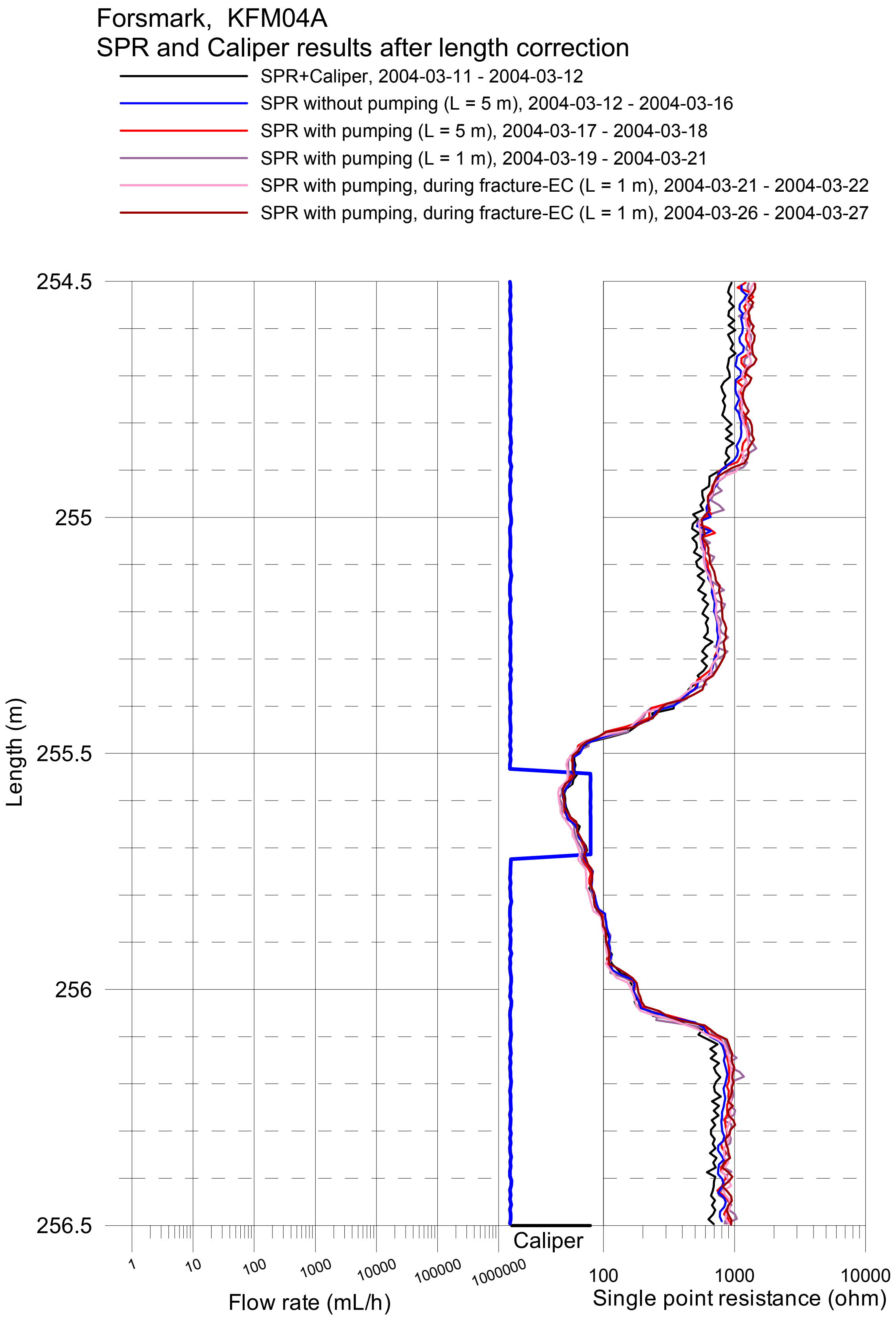
SPR with pumping, during fracture-EC (L = 1 m), 2004-03-21 - 2004-03-22
SPR with pumping, during fracture-EC (L = 1 m), 2004-03-26 - 2004-03-27
Length (m)
249
249.5
250
250.5
251
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
Caliper
100
1000
10000
Single point resistance (ohm)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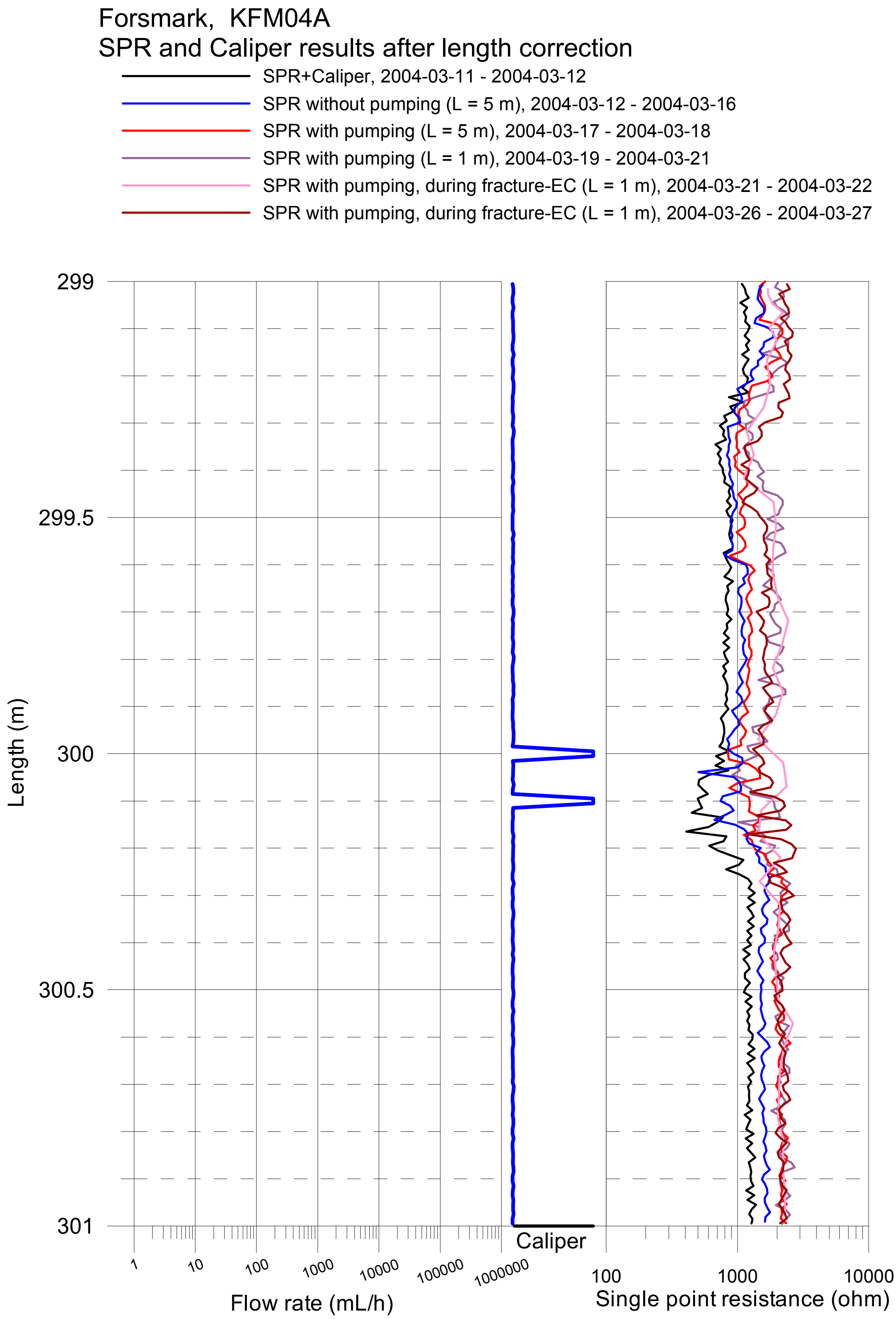
Length (m)
254.5
255
255.5
256
256.5
Caliper
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
100
1000
10000
Single point resistance (ohm)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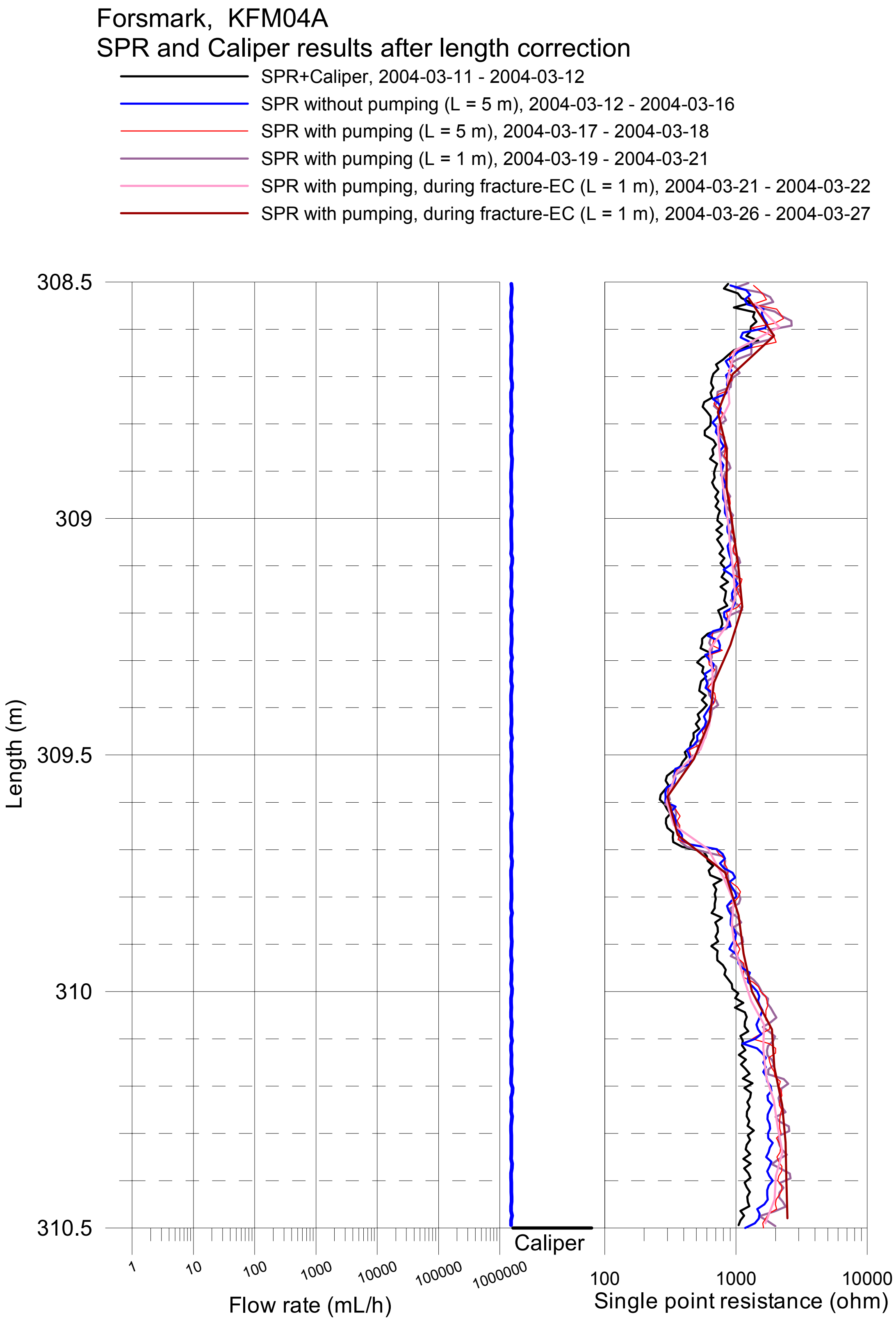
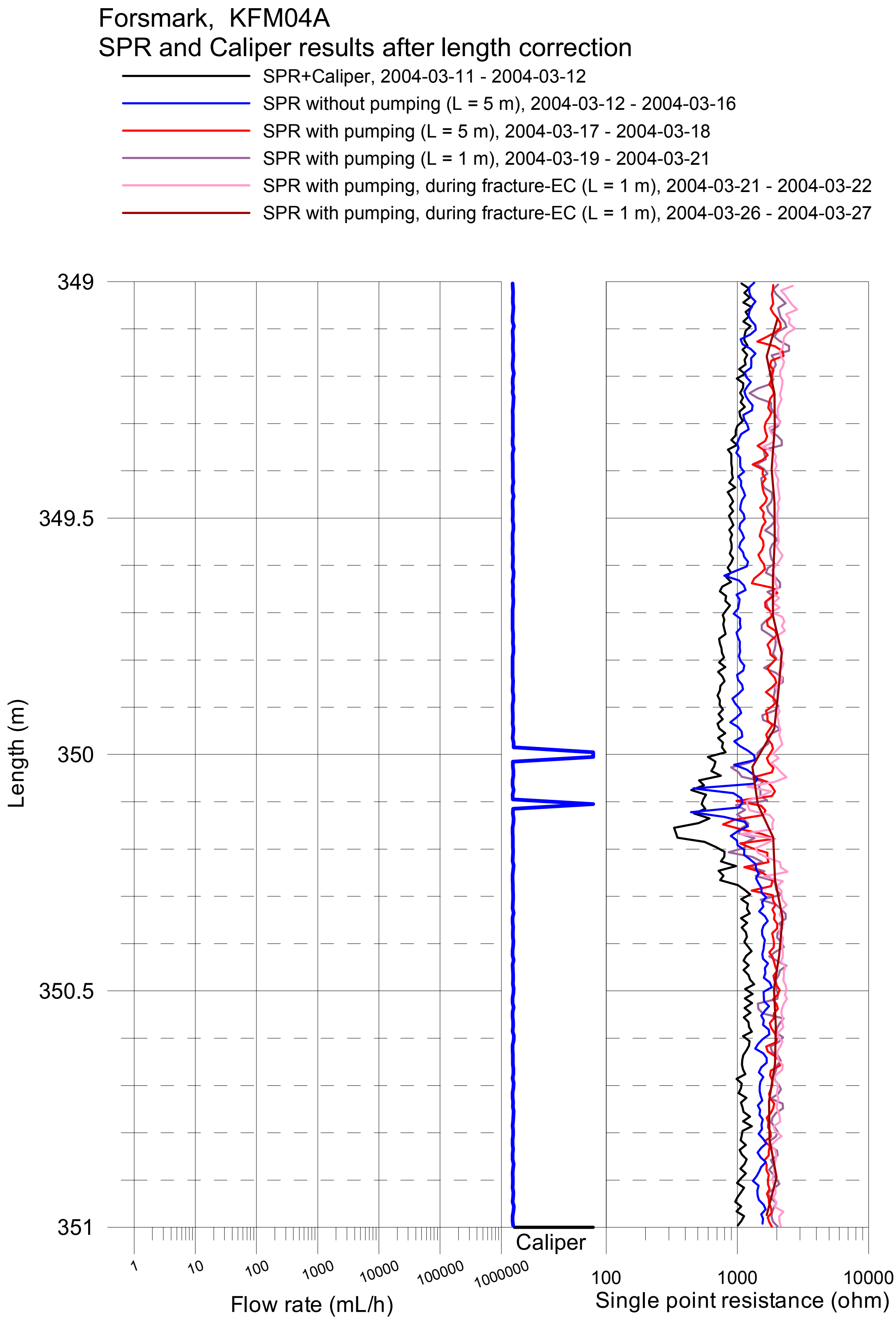
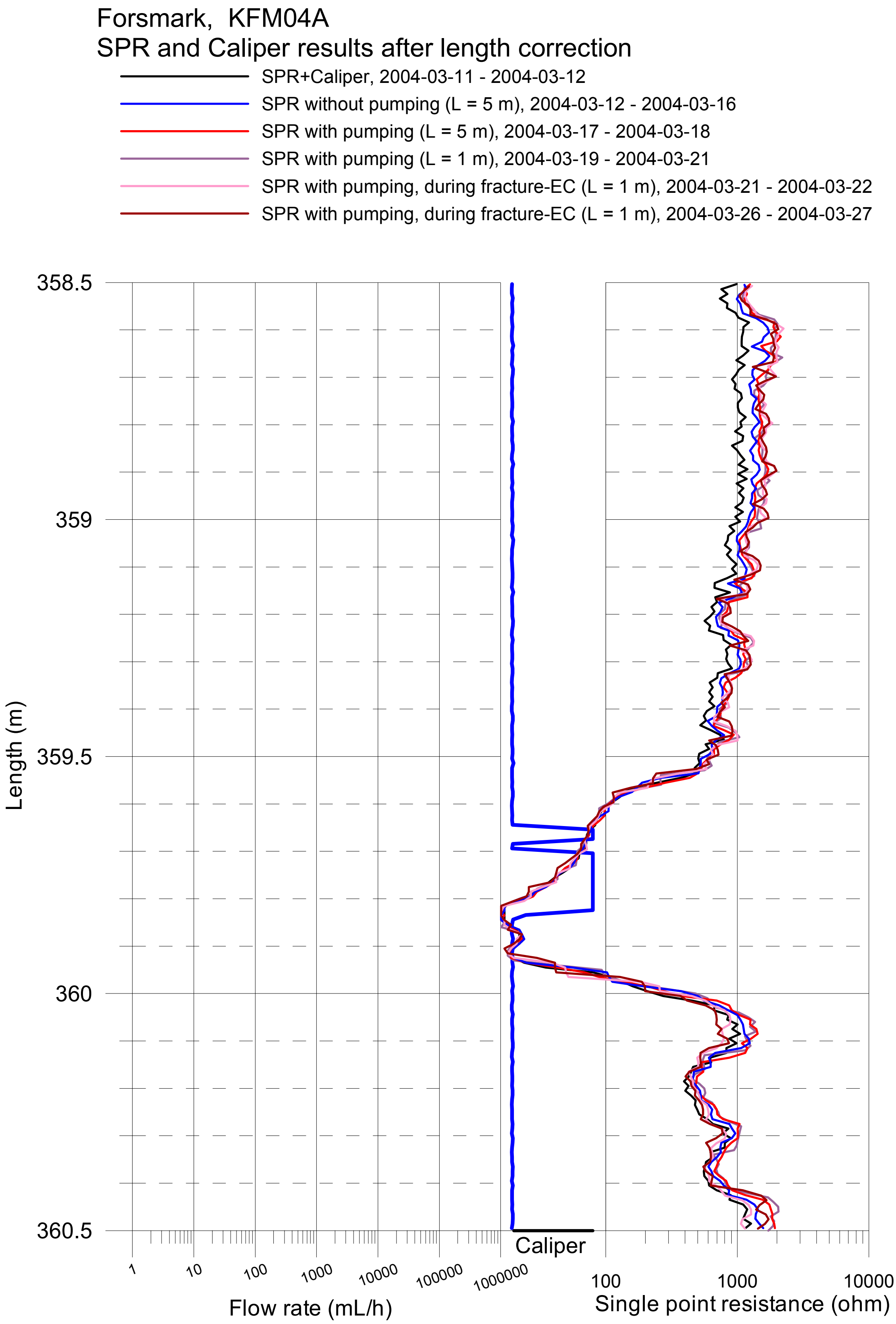
SPR with pumping, during fracture-EC (L = 1 m), 2004-03-21 - 2004-03-22
SPR with pumping, during fracture-EC (L = 1 m), 2004-03-26 - 2004-03-27
299
299.5
300
300.5
301
Length (m)
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
Caliper
100
1000
10000
Single point resistance (ohm)

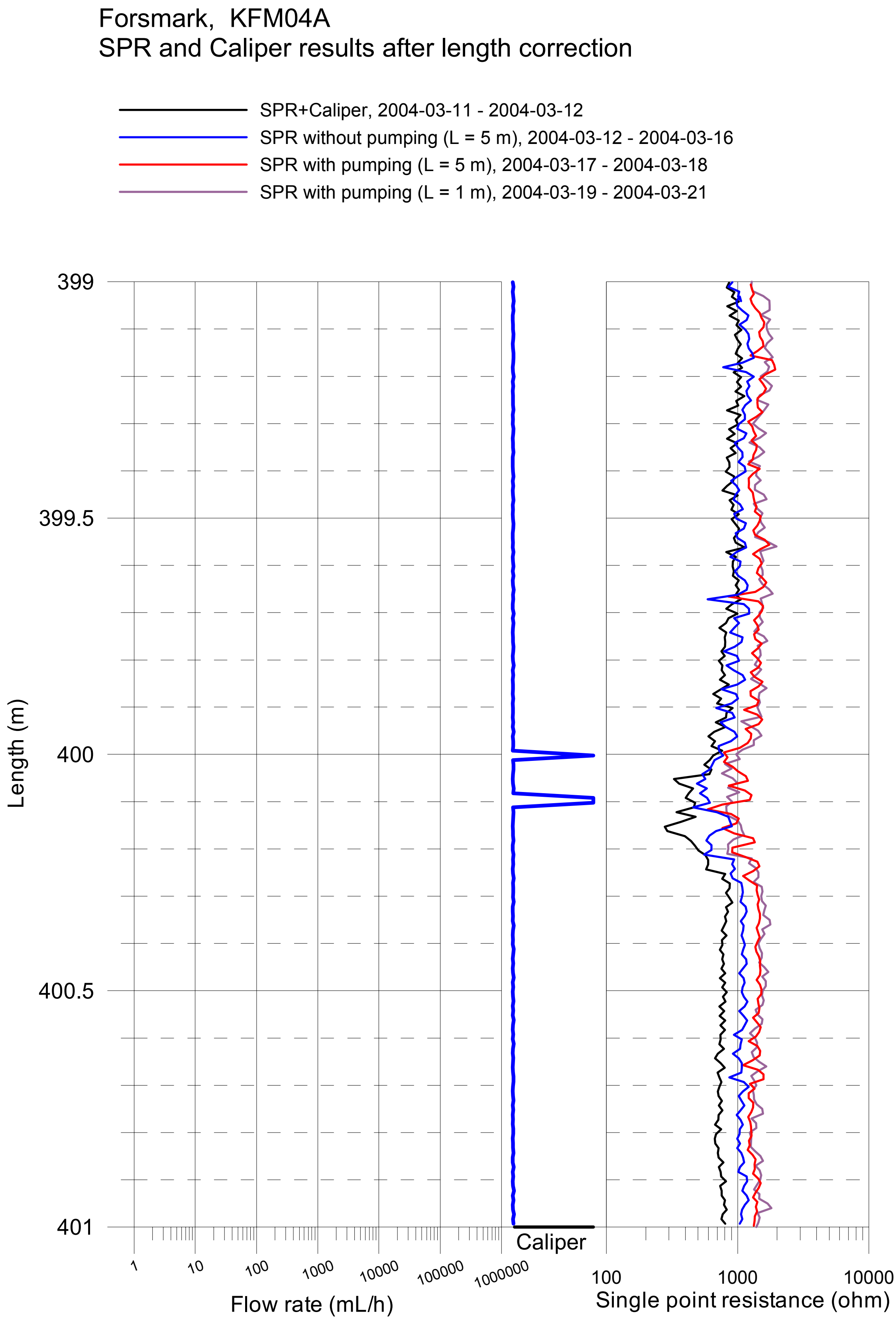

Forsmark, KFM04A
SPR and Caliper results after length correction
SPR+Caliper, 2004-03-11 - 2004-03-12
SPR without pumping (L = 5 m), 2004-03-12 - 2004-03-16
SPR with pumping (L = 5 m), 2004-03-17 - 2004-03-18
SPR with pumping (L = 1 m), 2004-03-19 - 2004-03-21
SPR with pumping, during fracture-EC (L = 1 m), 2004-03-21 - 2004-03-22
SPR with pumping, during fracture-EC (L = 1 m), 2004-03-26 - 2004-03-27
Length (m)
308.5
309
309.5
310
310.5
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
Caliper
100
1000
10000
Single point resistance (ohm)

Appendix 1.12

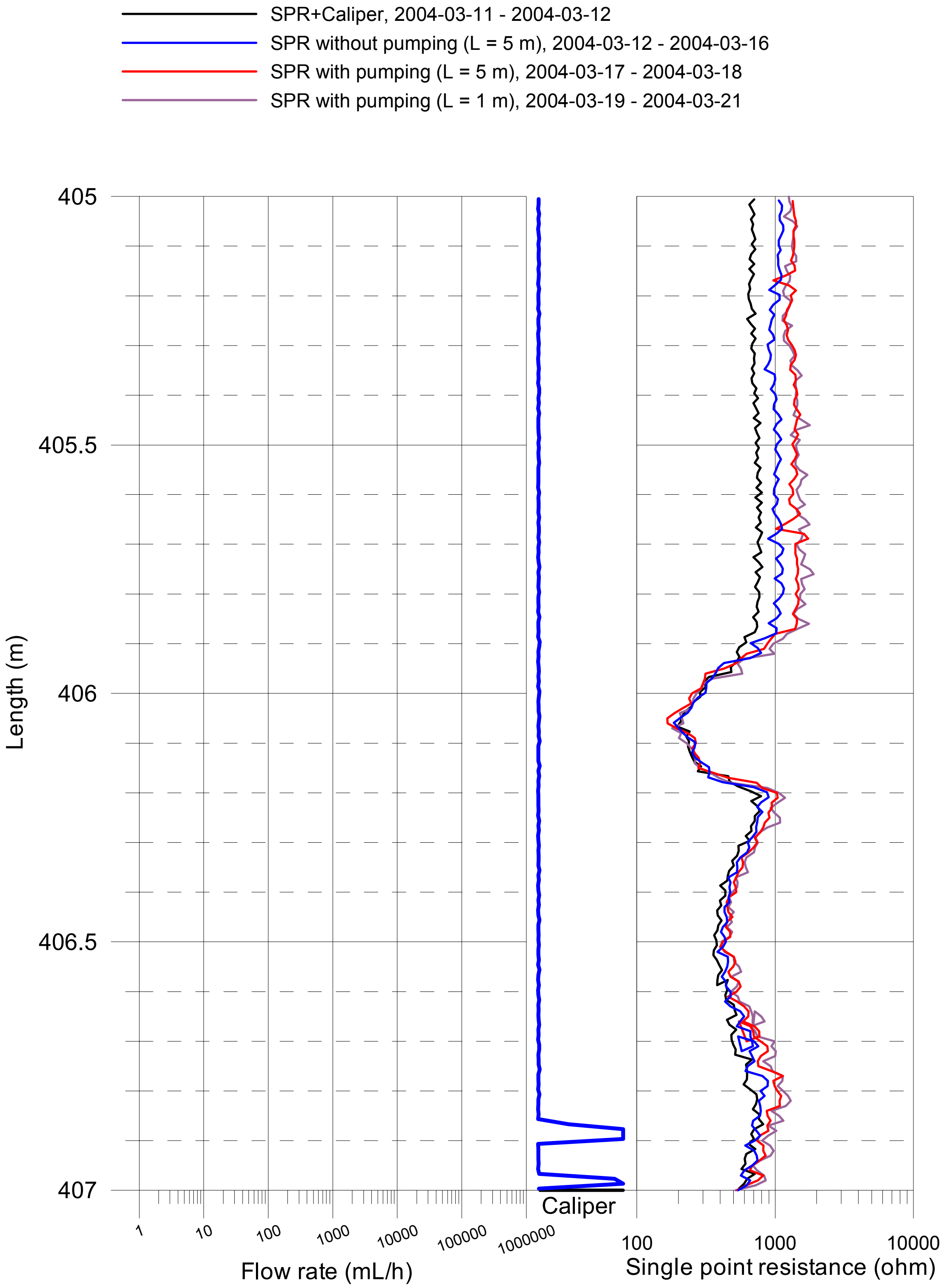



Forsmark, KFM04A
SPR and Caliper results after length correction
SPR+Caliper, 2004-03-11 - 2004-03-12
SPR without pumping (L = 5 m), 2004-03-12 - 2004-03-16
SPR with pumping (L = 5 m), 2004-03-17 - 2004-03-18
SPR with pumping (L = 1 m), 2004-03-19 - 2004-03-21
SPR with pumping, during fracture-EC (L = 1 m), 2004-03-21 - 2004-03-22
SPR with pumping, during fracture-EC (L = 1 m), 2004-03-26 - 2004-03-27
358.5
359
359.5
360
360.5
Length (m)
Caliper
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
100
1000
10000
Single point resistance (ohm)

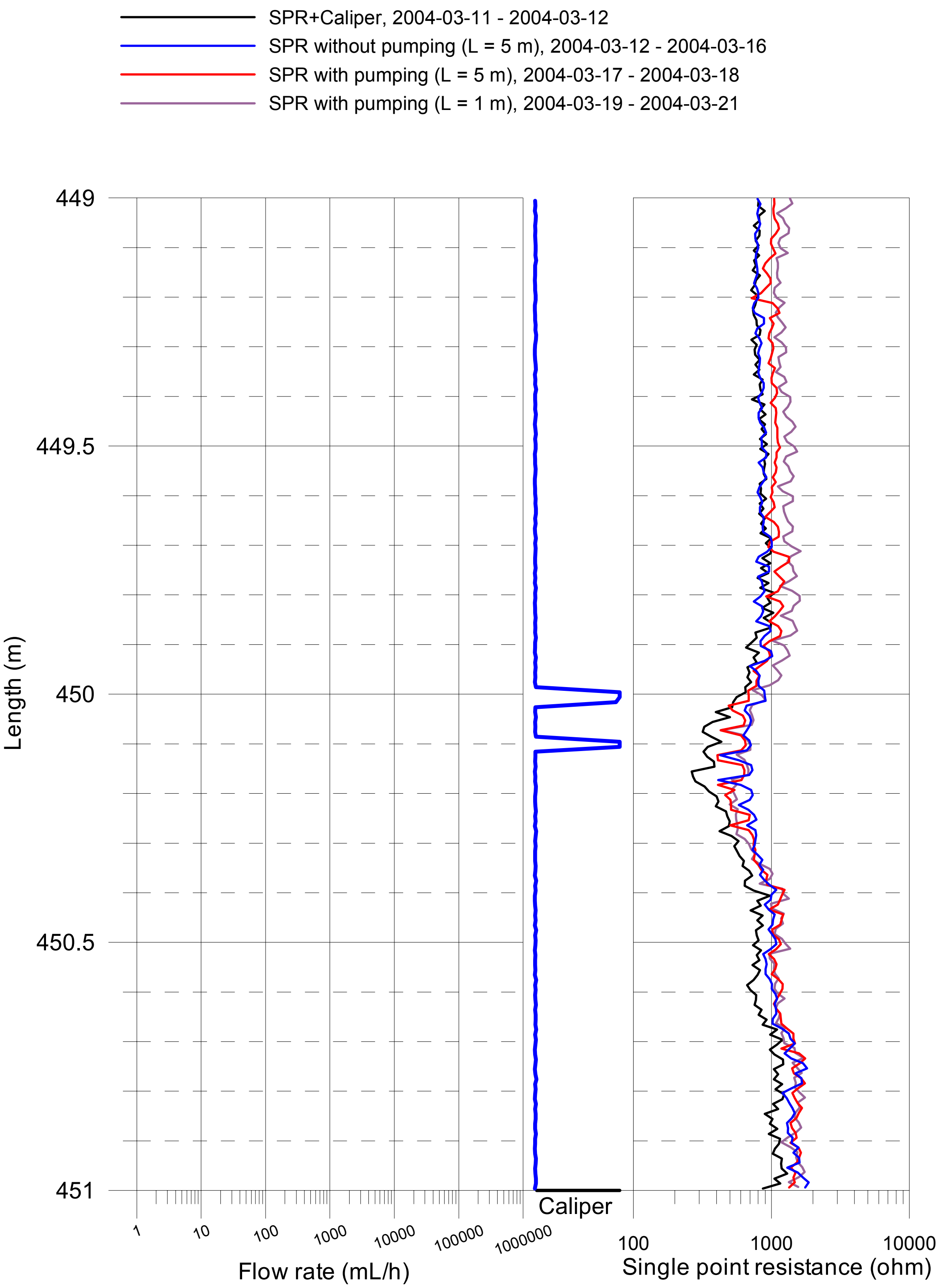
Appendix 1.14



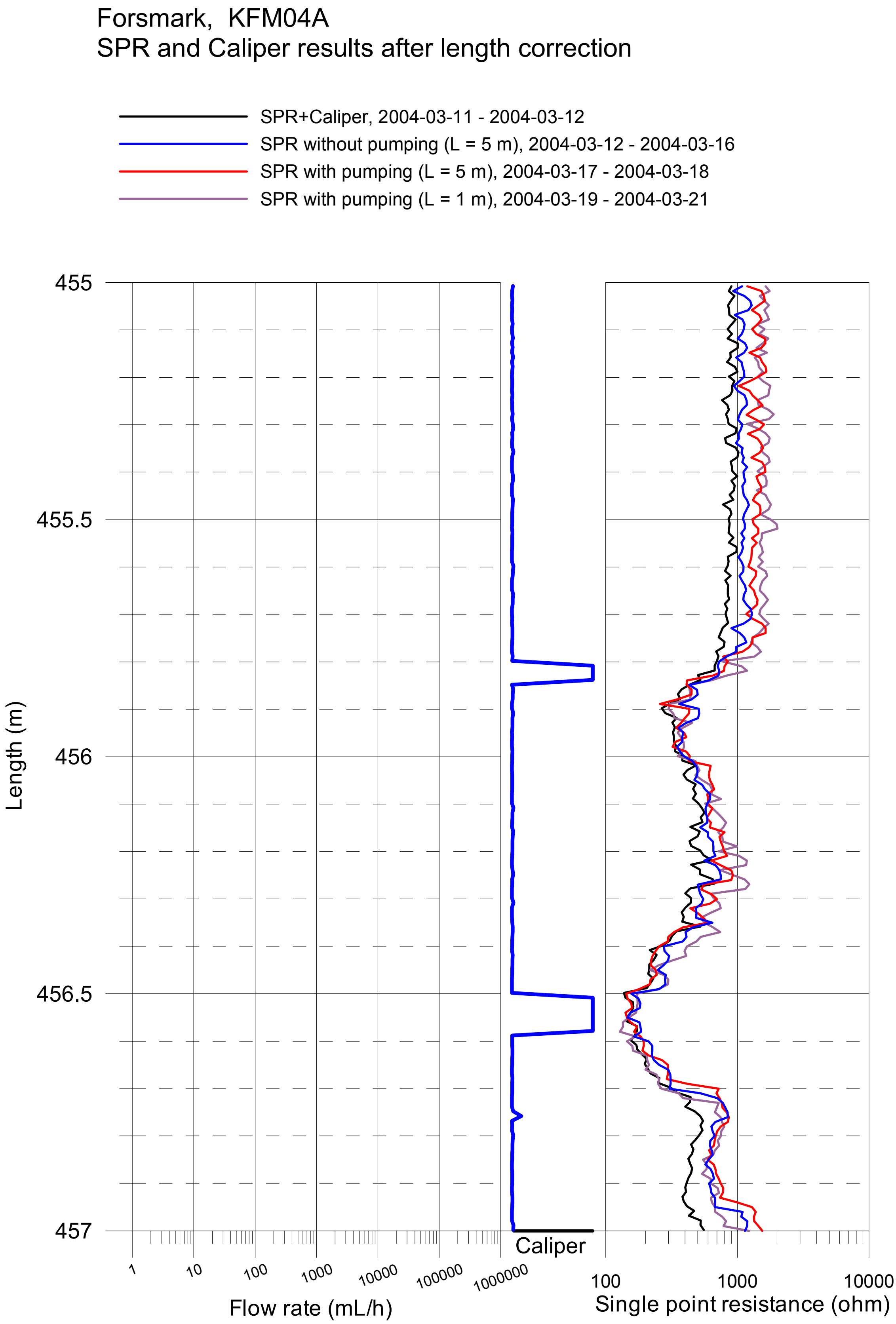
Forsmark, KFM04A
SPR and Caliper results after length correction



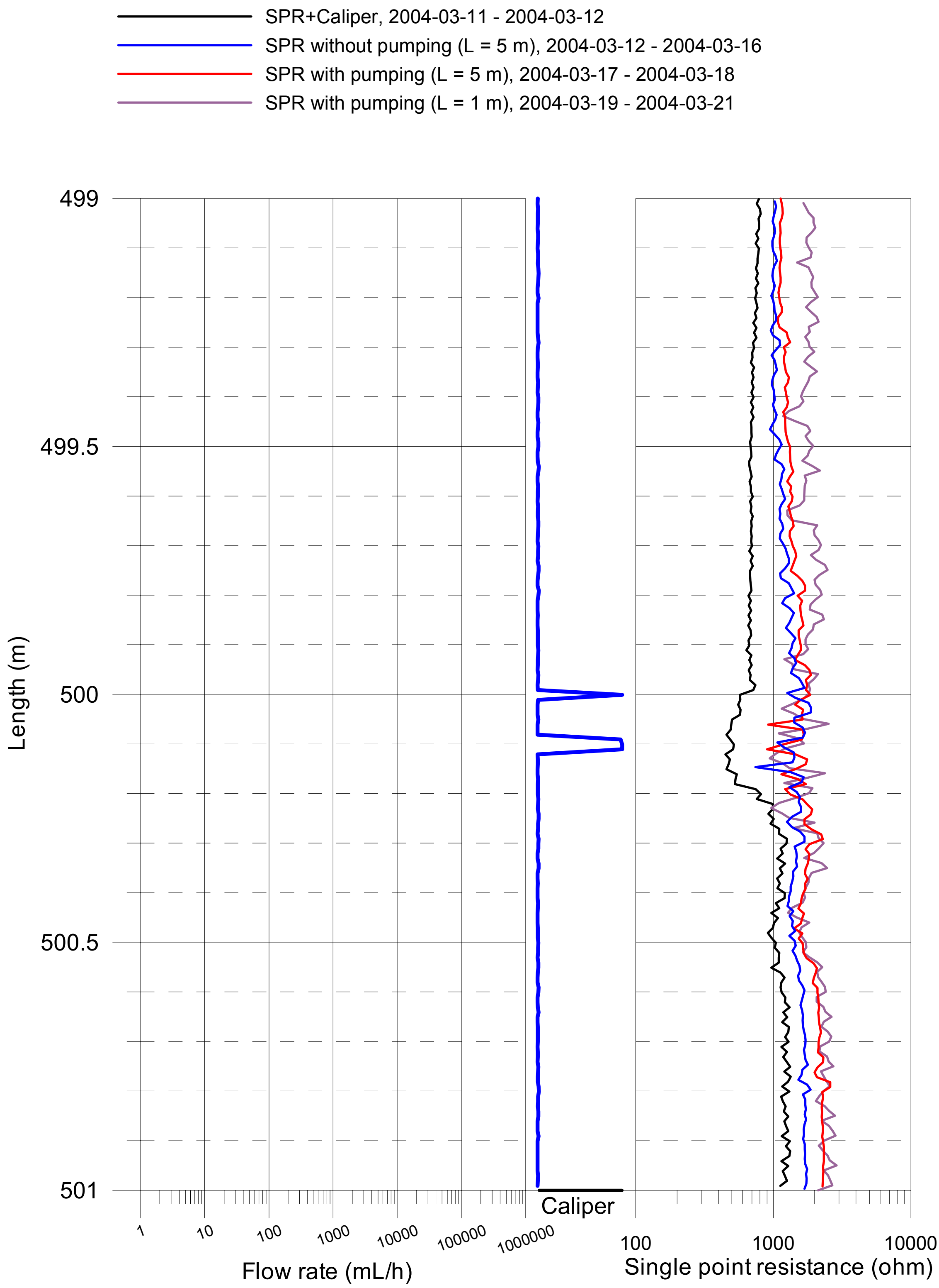
Forsmark, KFM04A
SPR and Caliper results after length correction



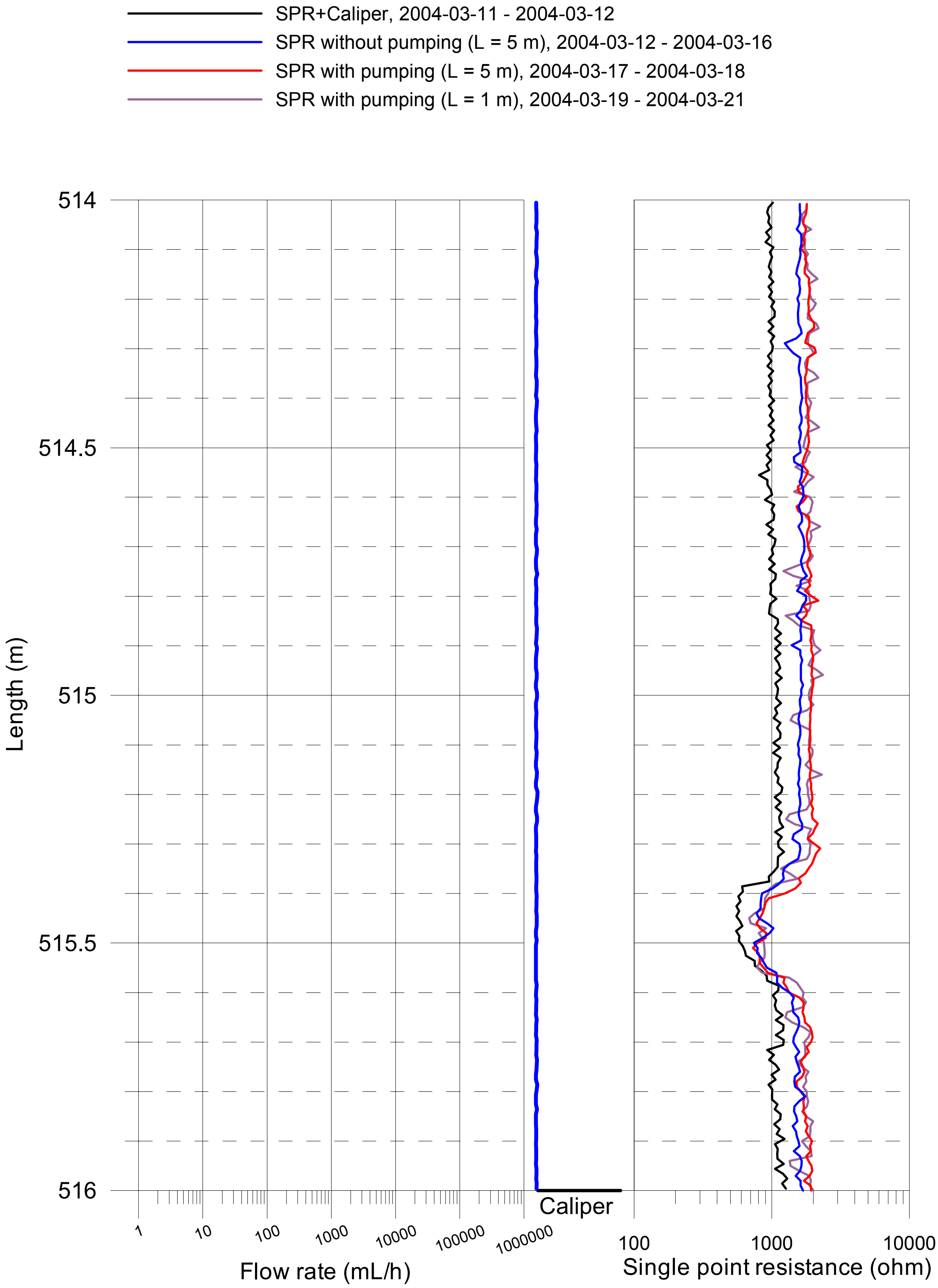
Appendix 1.17



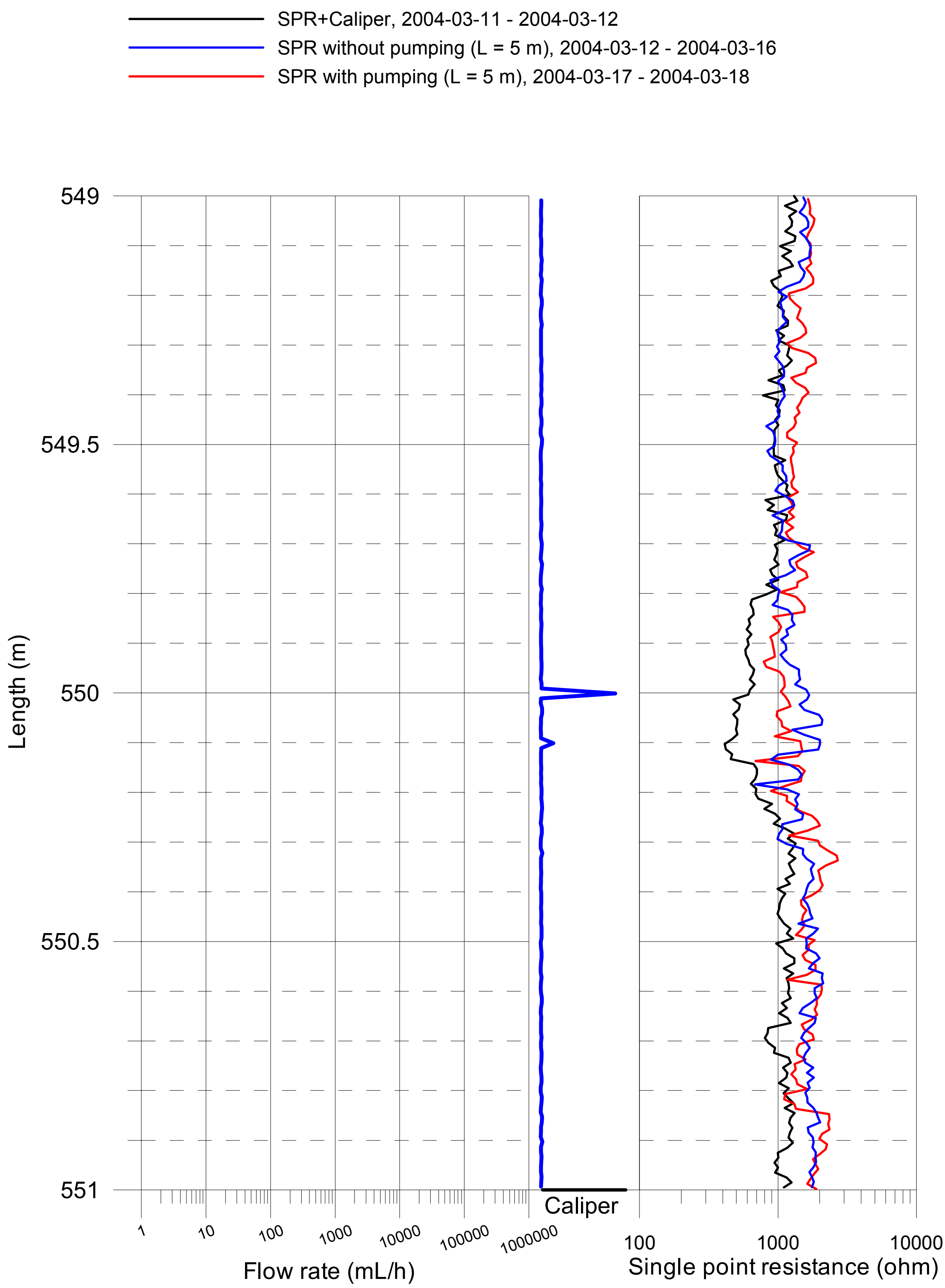
Forsmark, KFM04A
SPR and Caliper results after length correction



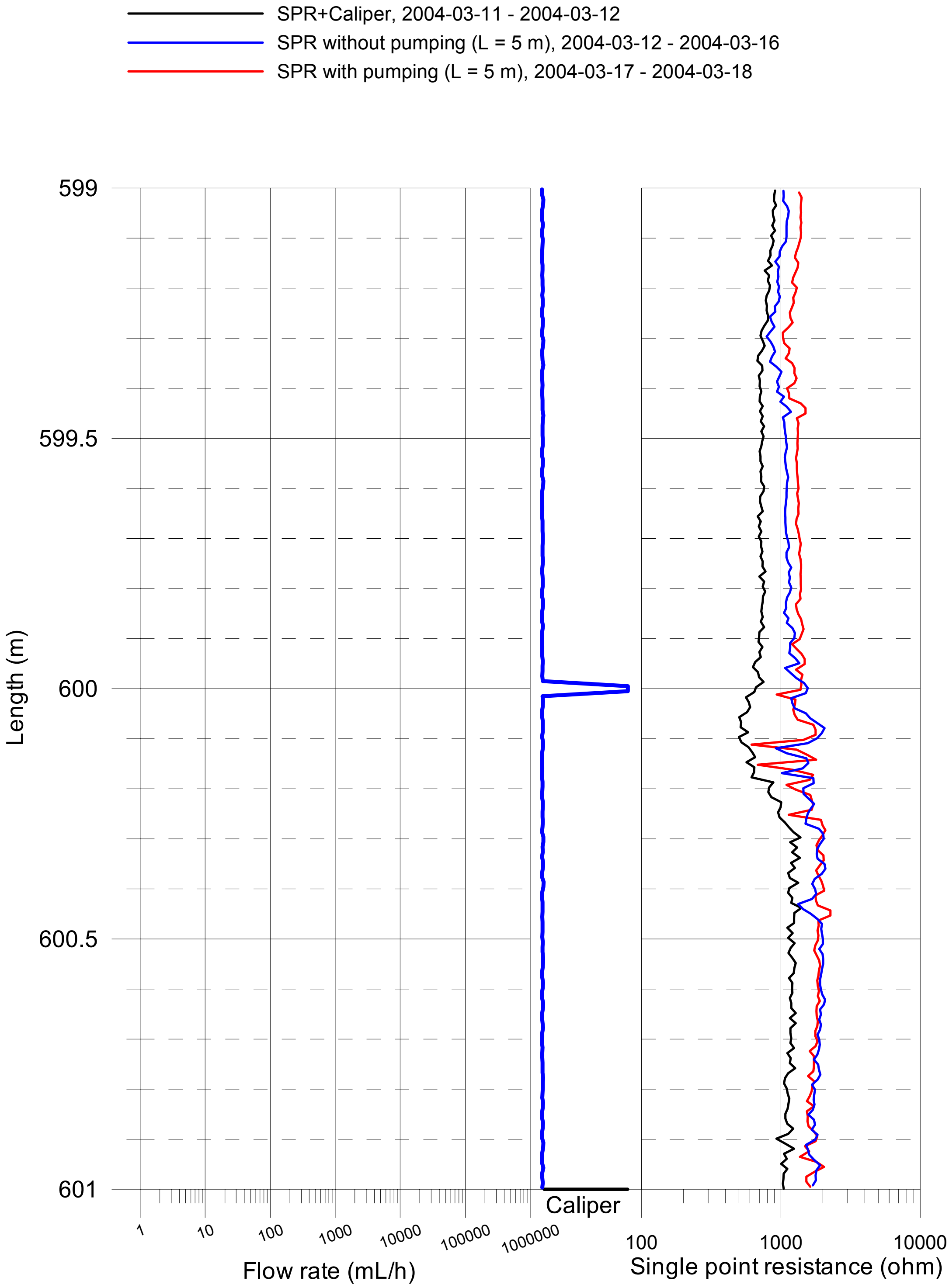
Forsmark, KFM04A
SPR and Caliper results after length correction



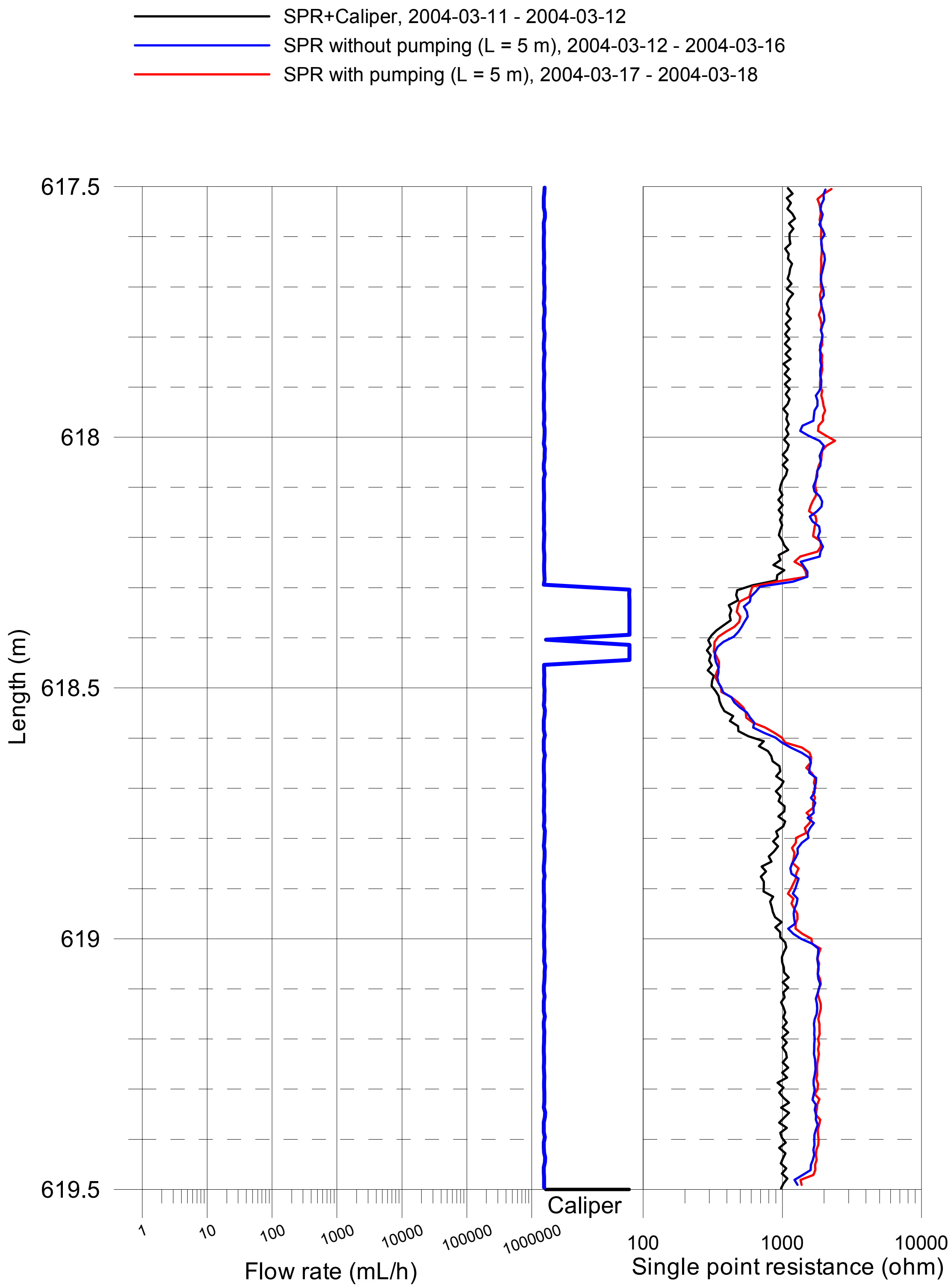
Forsmark, KFM04A
SPR and Caliper results after length correction



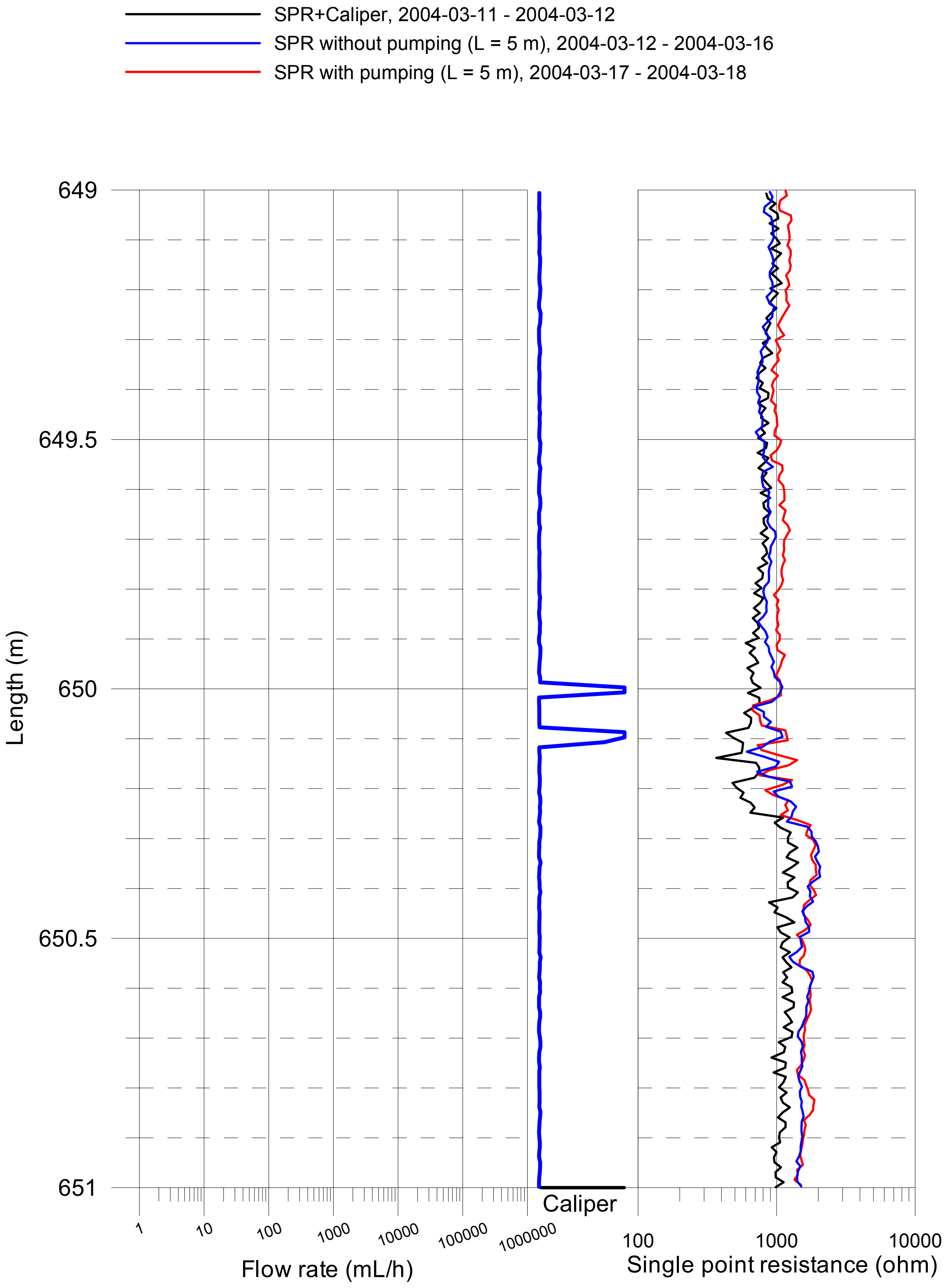
Forsmark, KFM04A
SPR and Caliper results after length correction



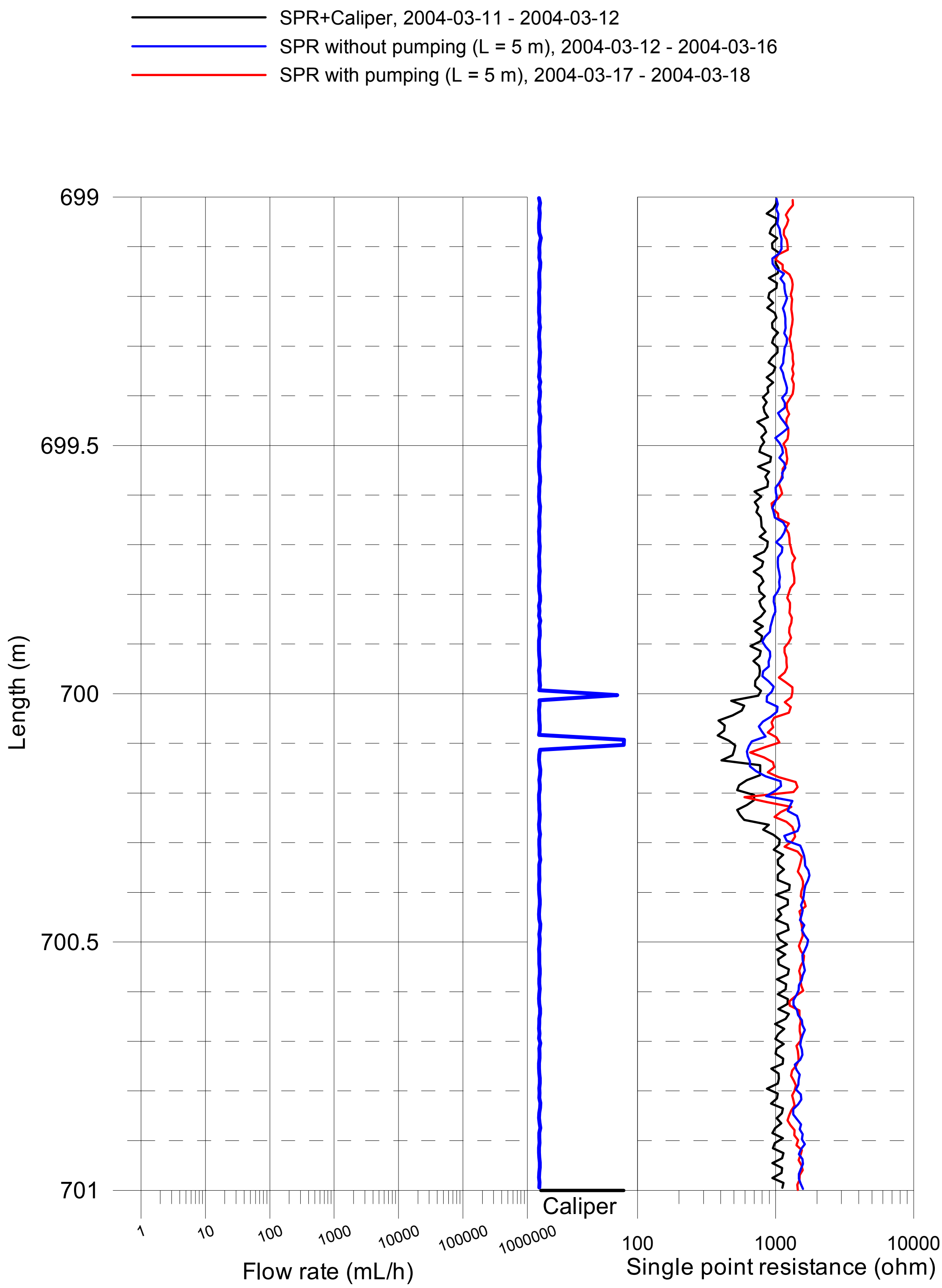
Forsmark, KFM04A
SPR and Caliper results after length correction



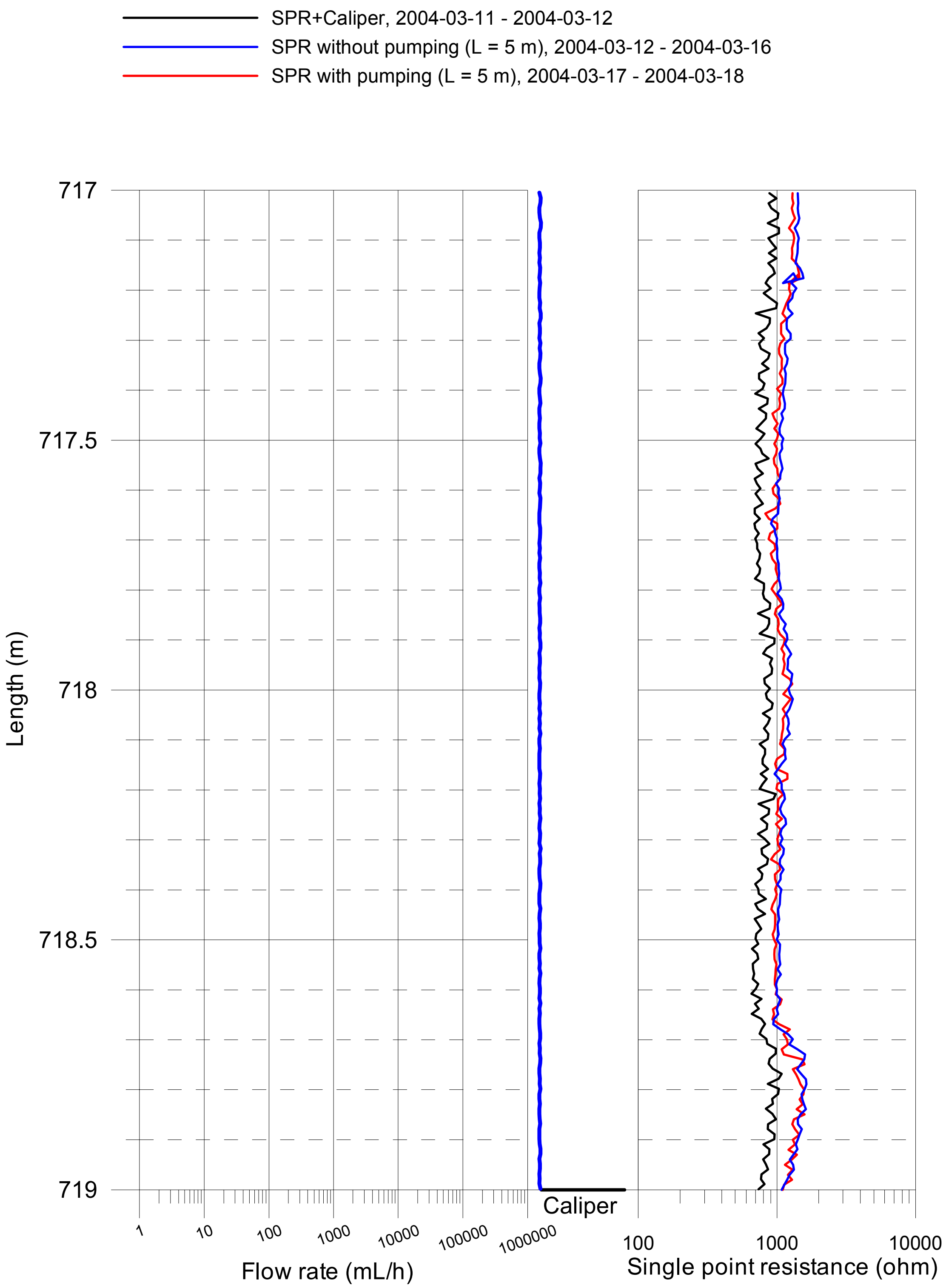
Forsmark, KFM04A
SPR and Caliper results after length correction



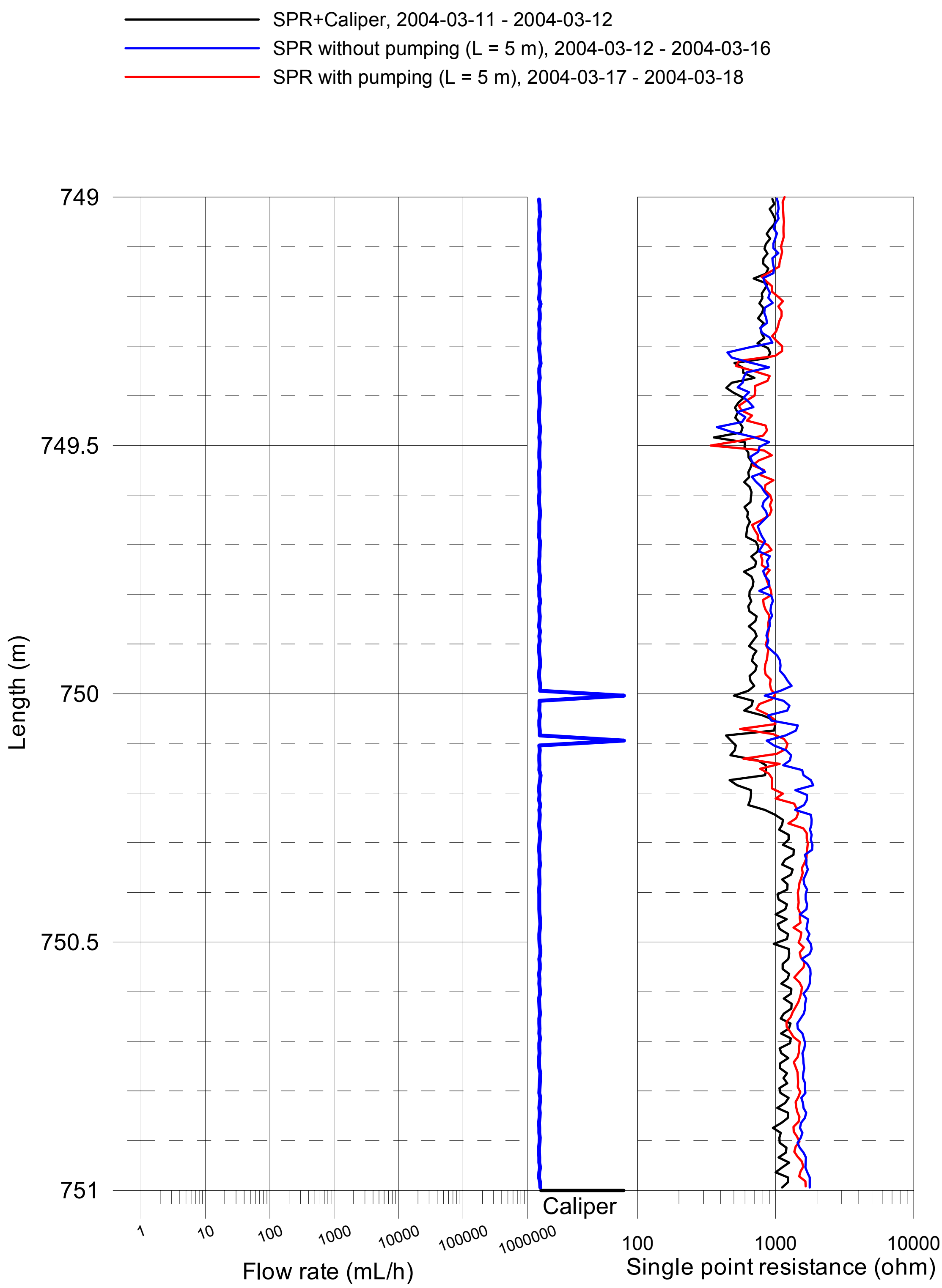
Forsmark, KFM04A
SPR and Caliper results after length correction



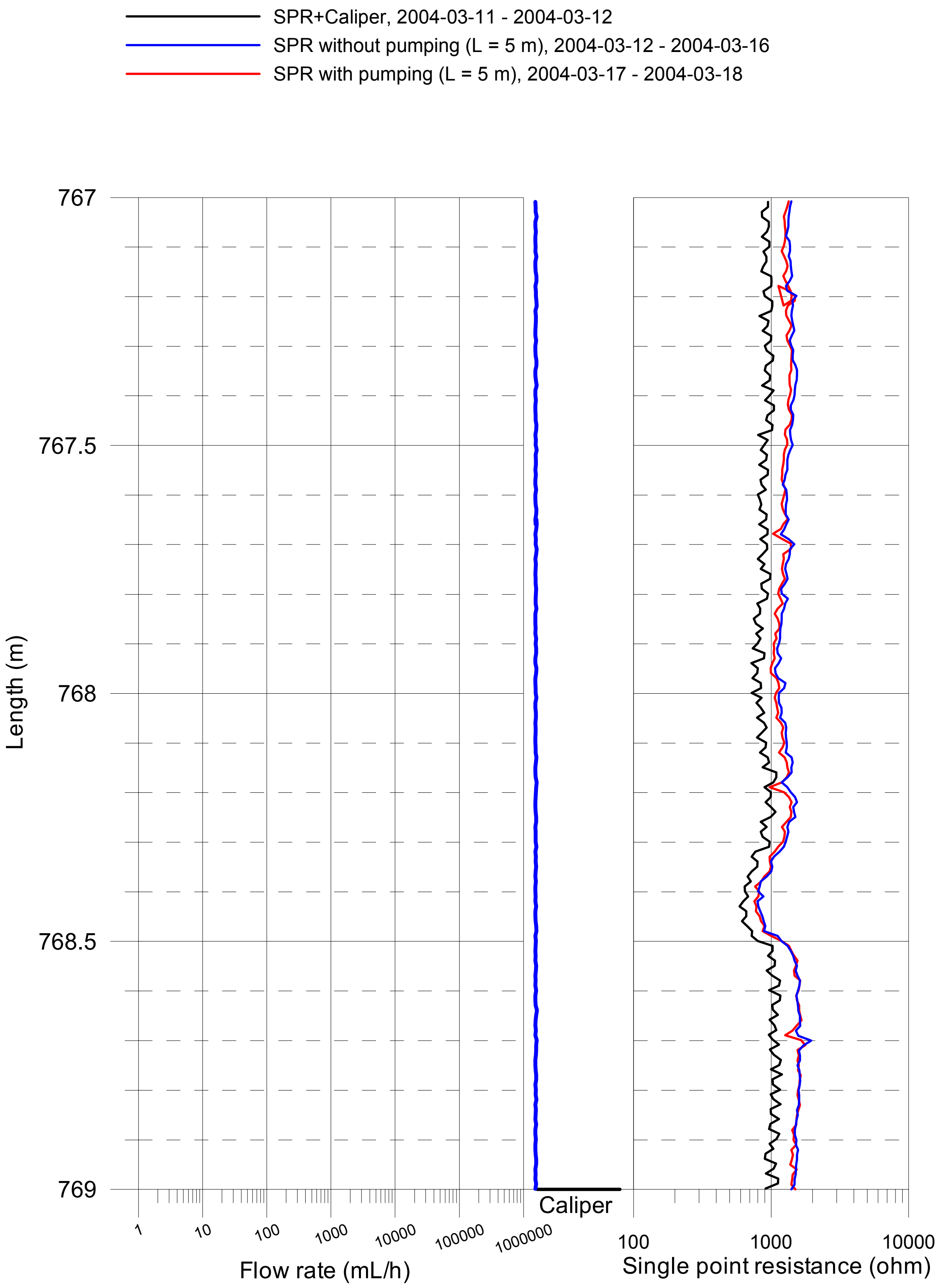
Forsmark, KFM04A
SPR and Caliper results after length correction



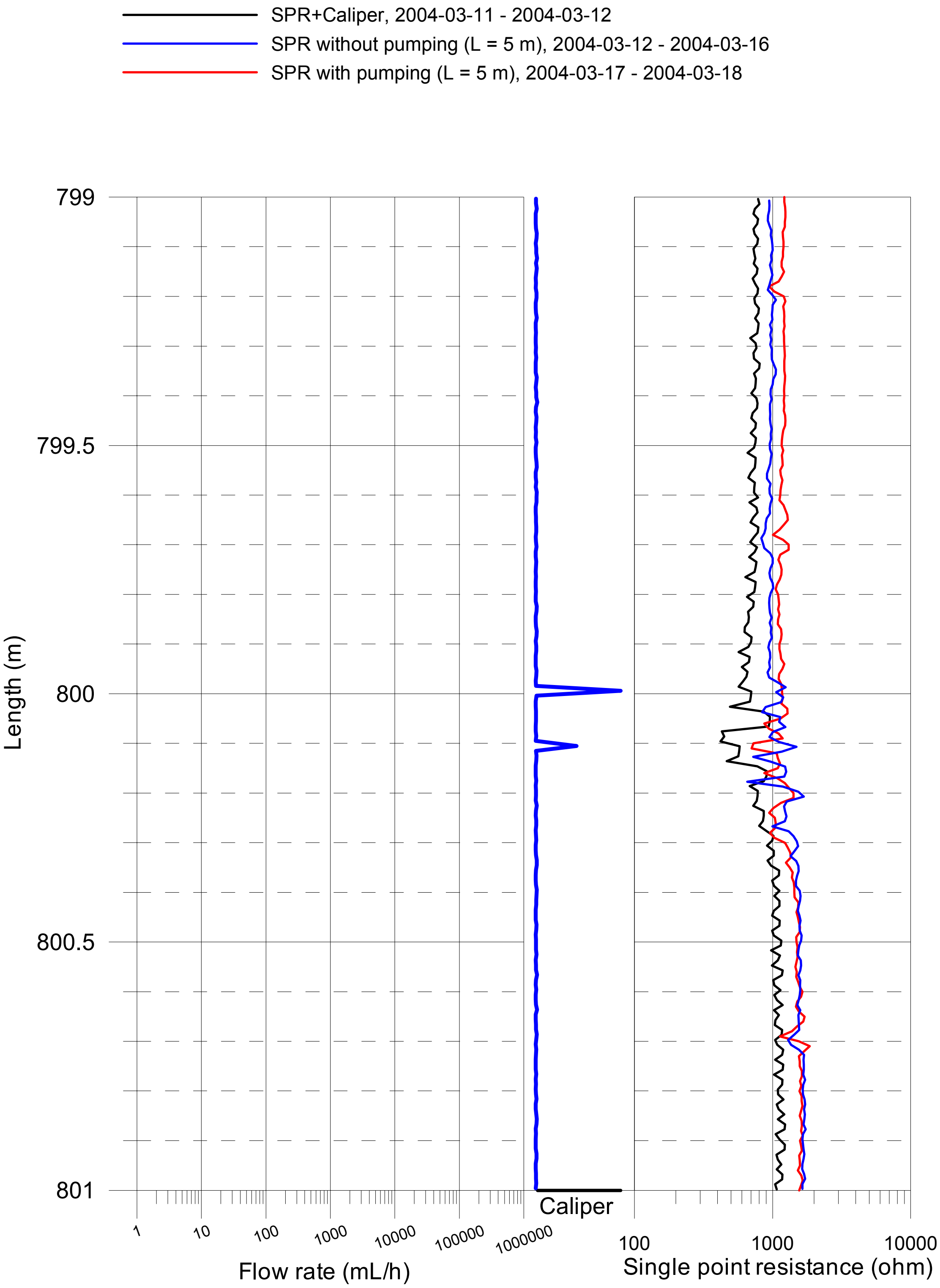
Forsmark, KFM04A
SPR and Caliper results after length correction



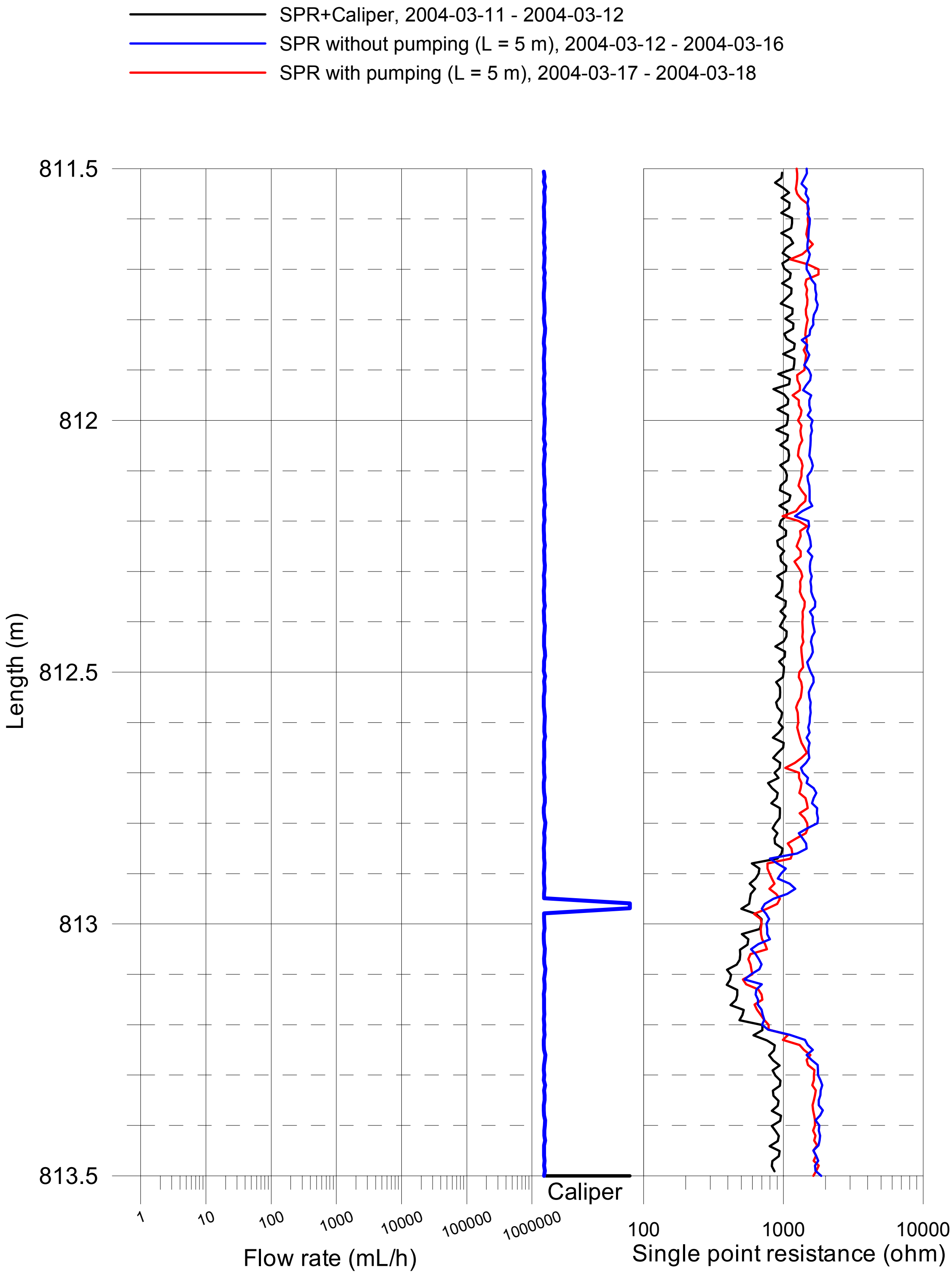
Forsmark, KFM04A
SPR and Caliper results after length correction



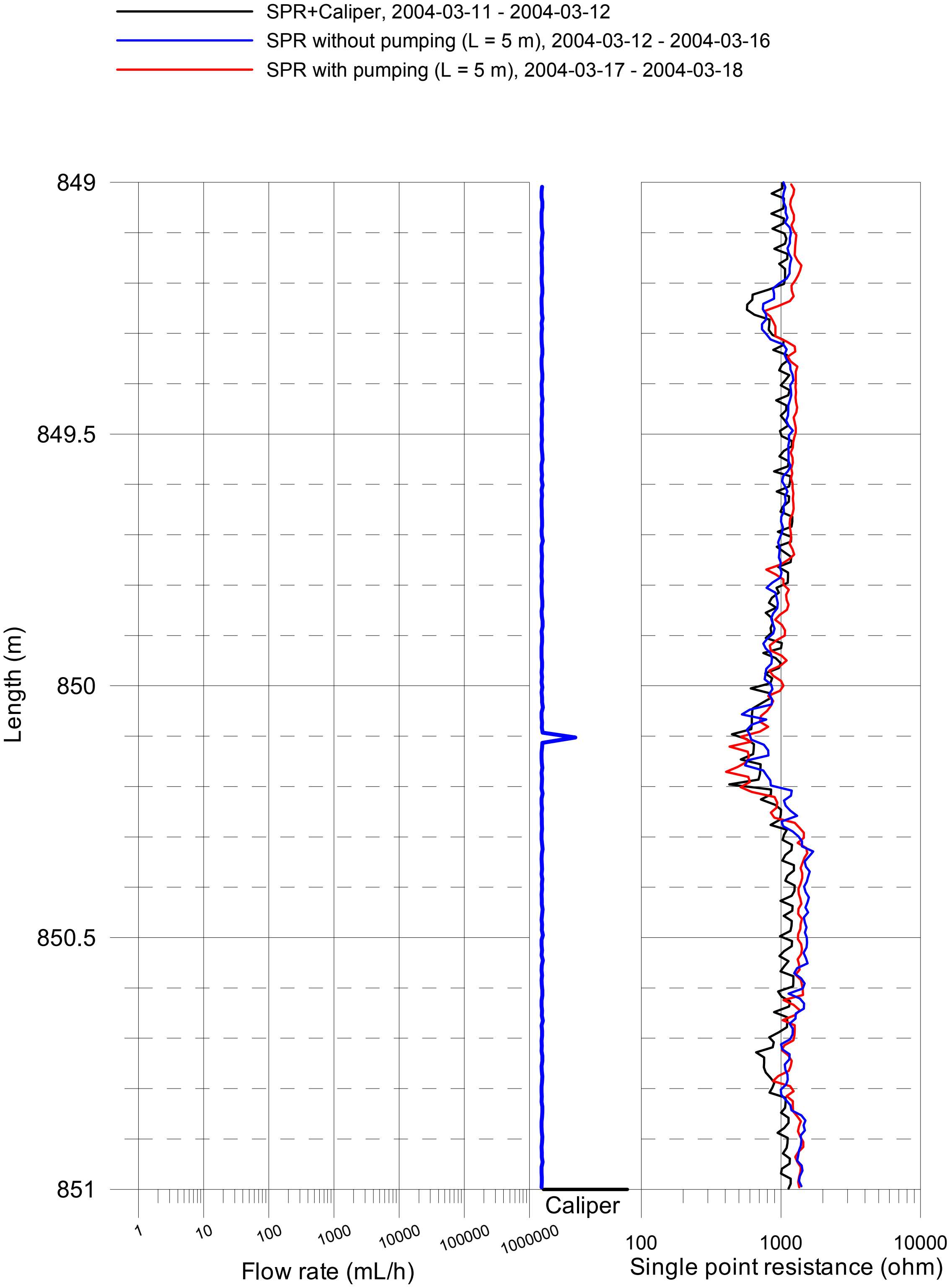
Forsmark, KFM04A
SPR and Caliper results after length correction



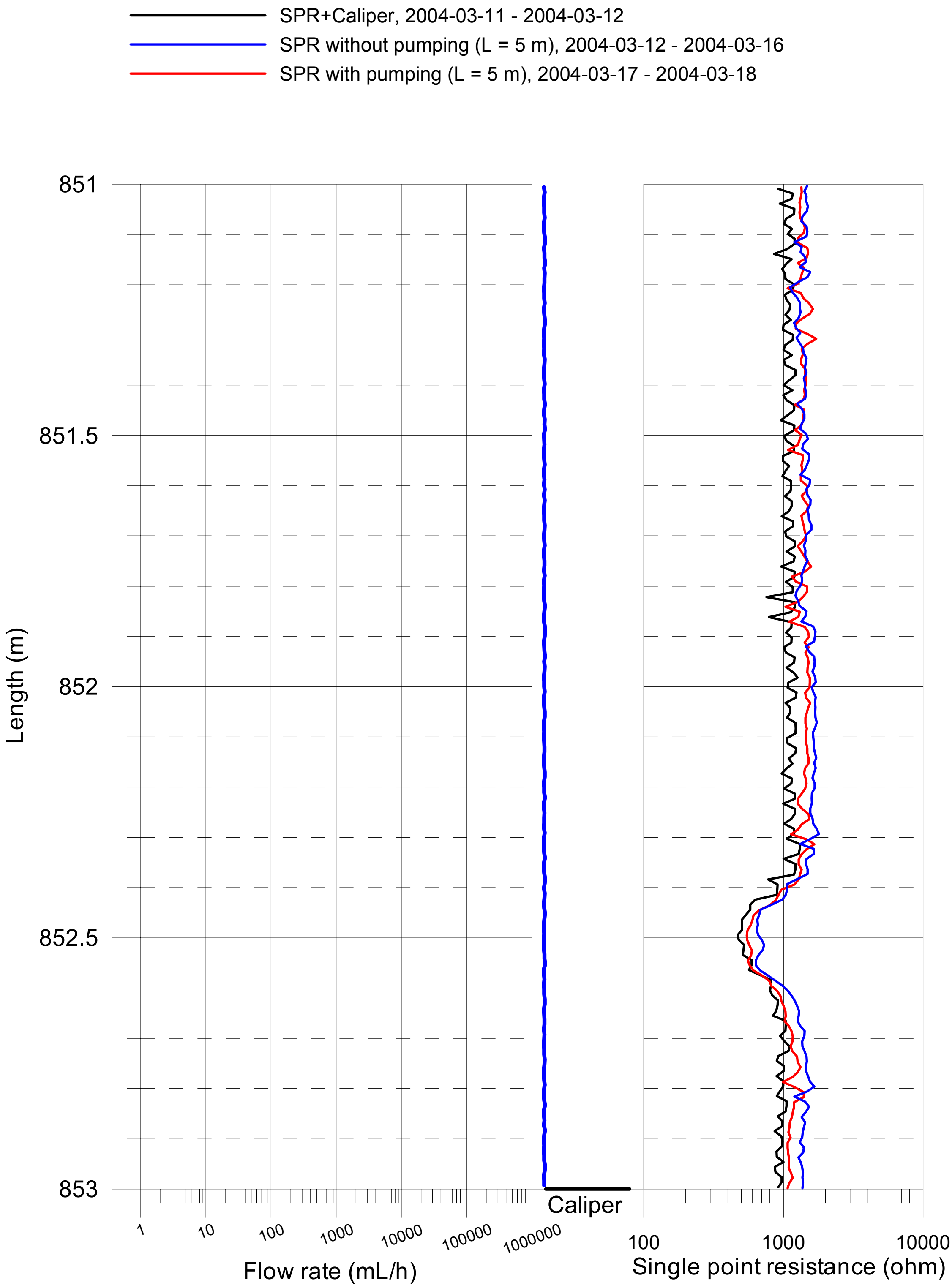
Forsmark, KFM04A
SPR and Caliper results after length correction



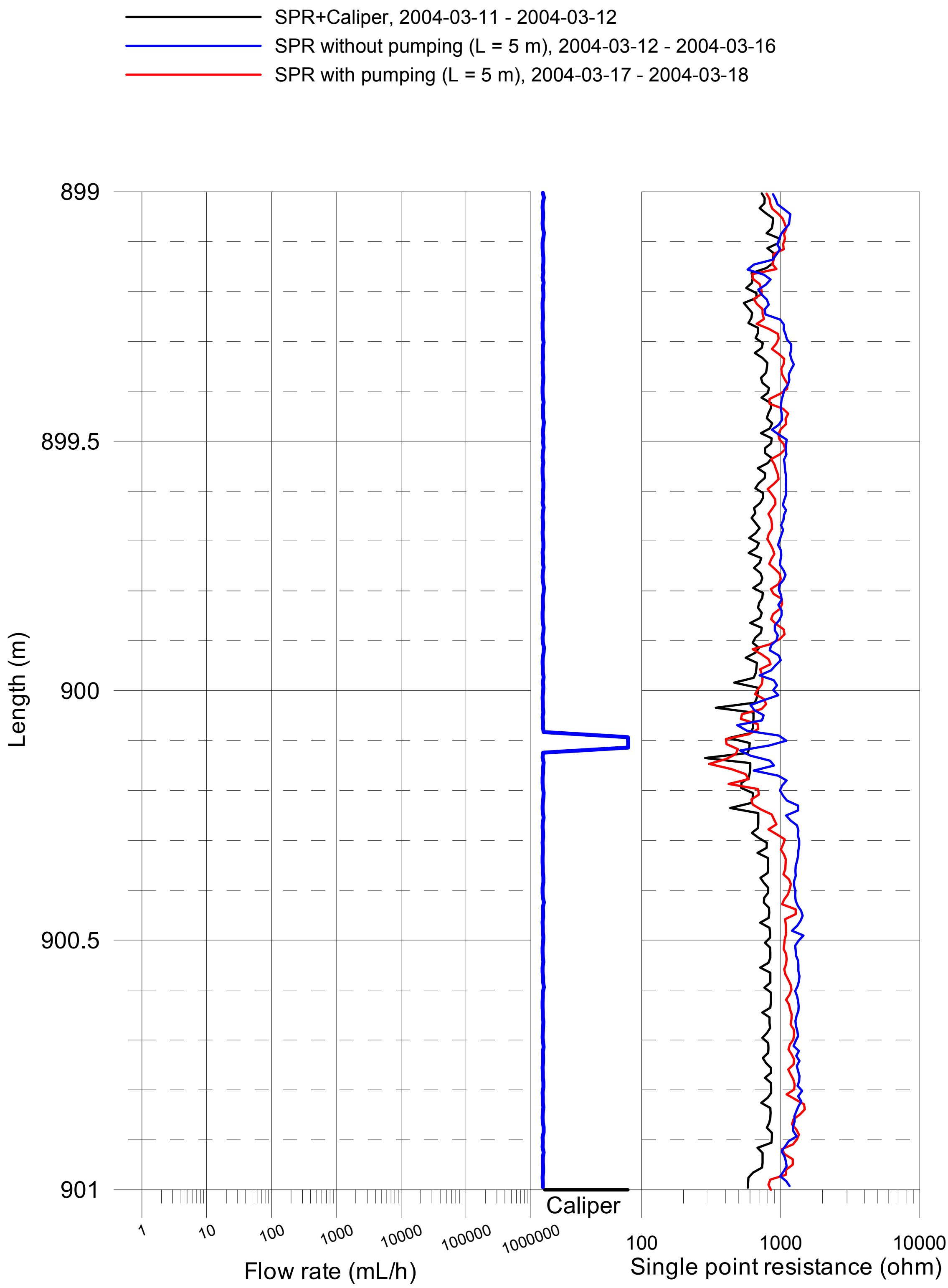
Forsmark, KFM04A
SPR and Caliper results after length correction



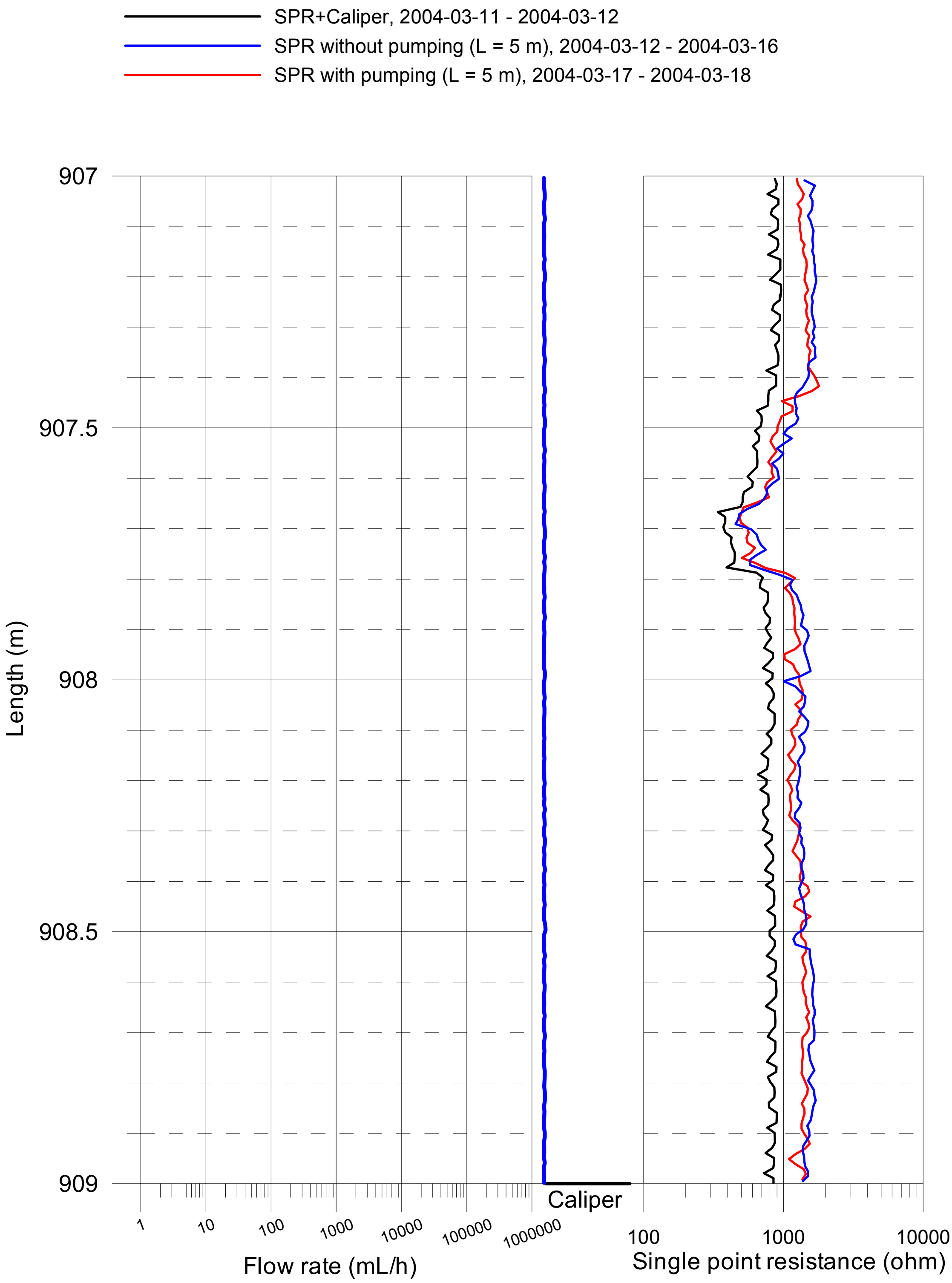
Forsmark, KFM04A
SPR and Caliper results after length correction



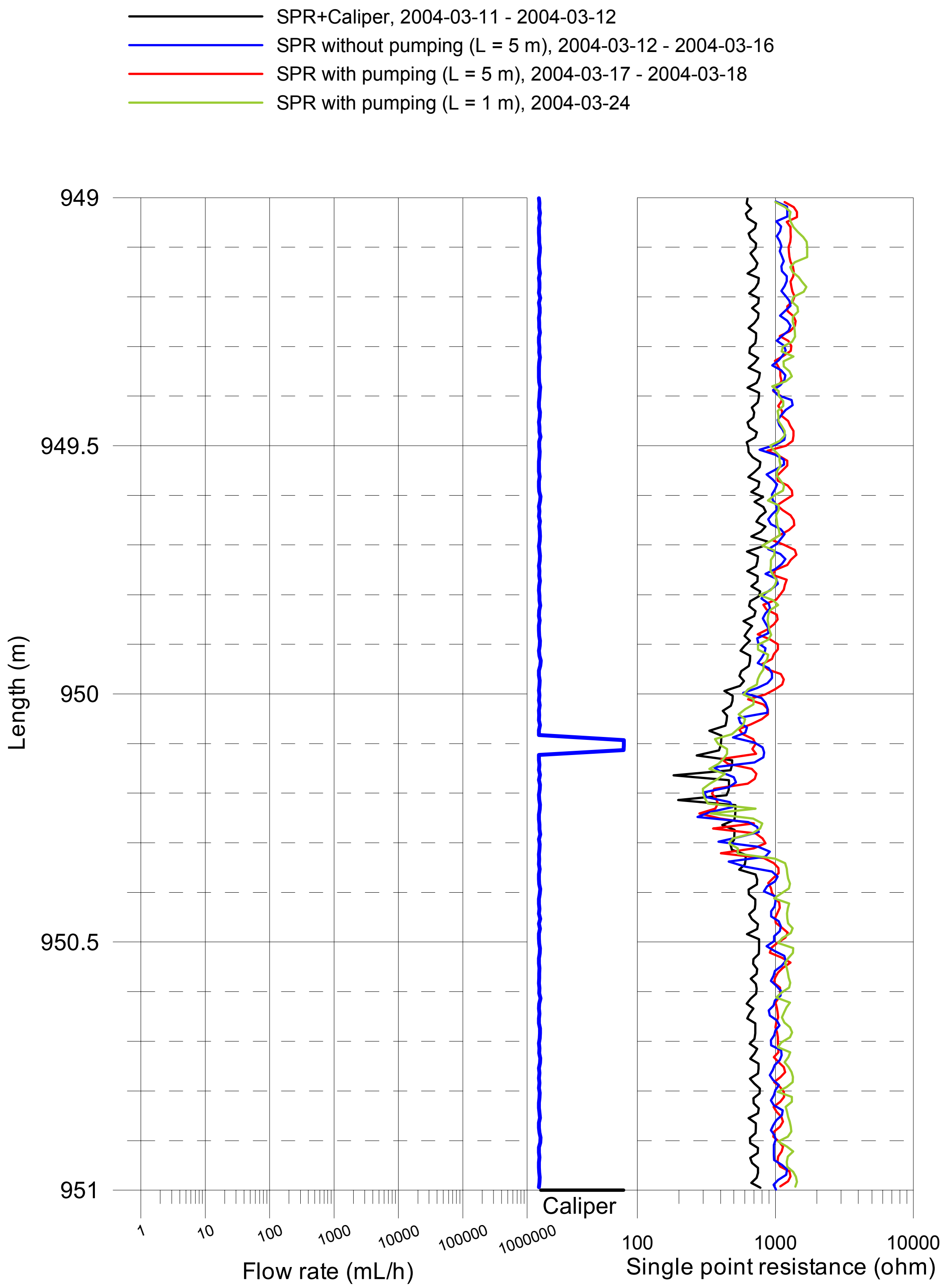
Forsmark, KFM04A
SPR and Caliper results after length correction

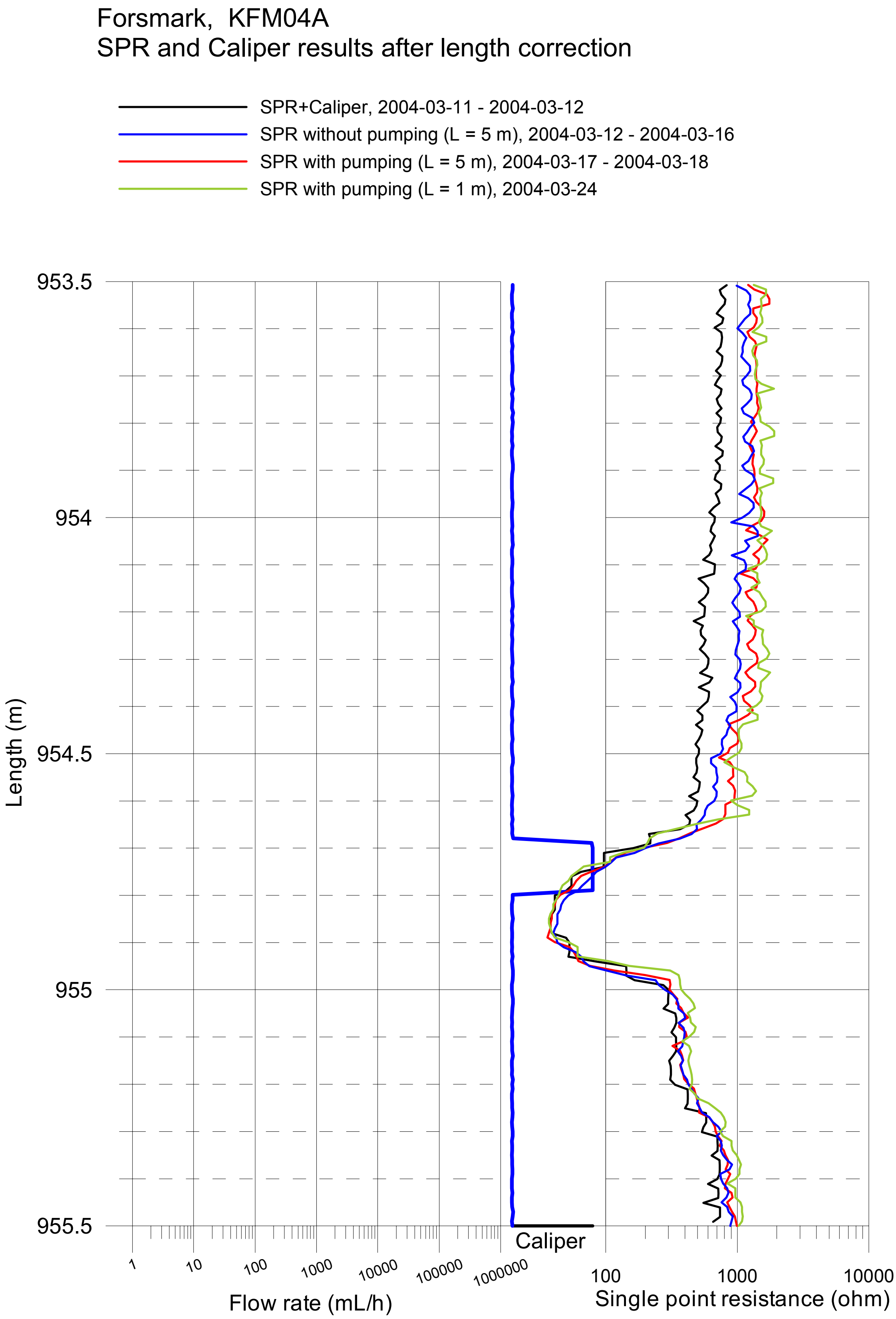


Forsmark, KFM04A
SPR and Caliper results after length correction

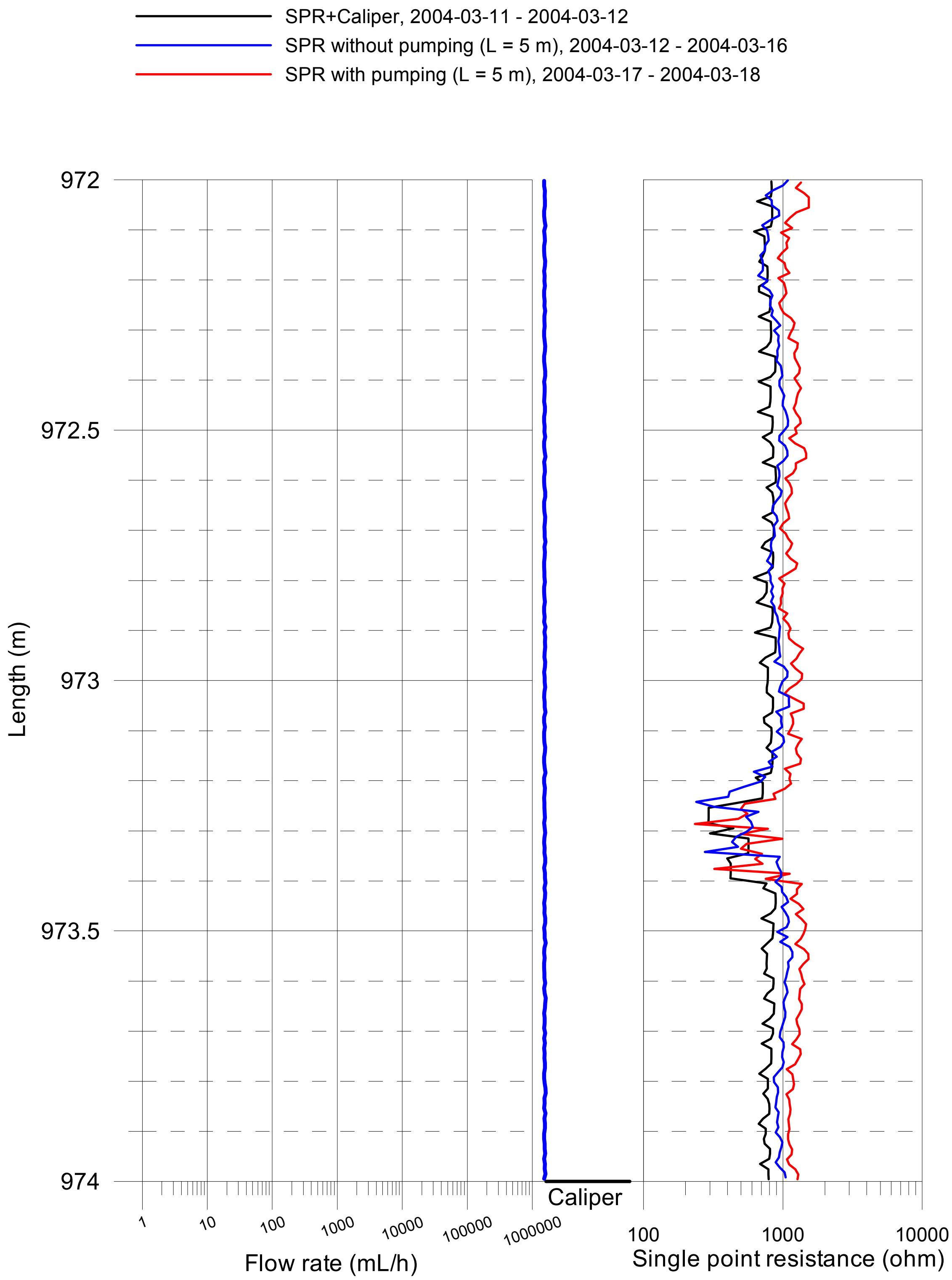


Forsmark, KFM04A
SPR and Caliper results after length correction

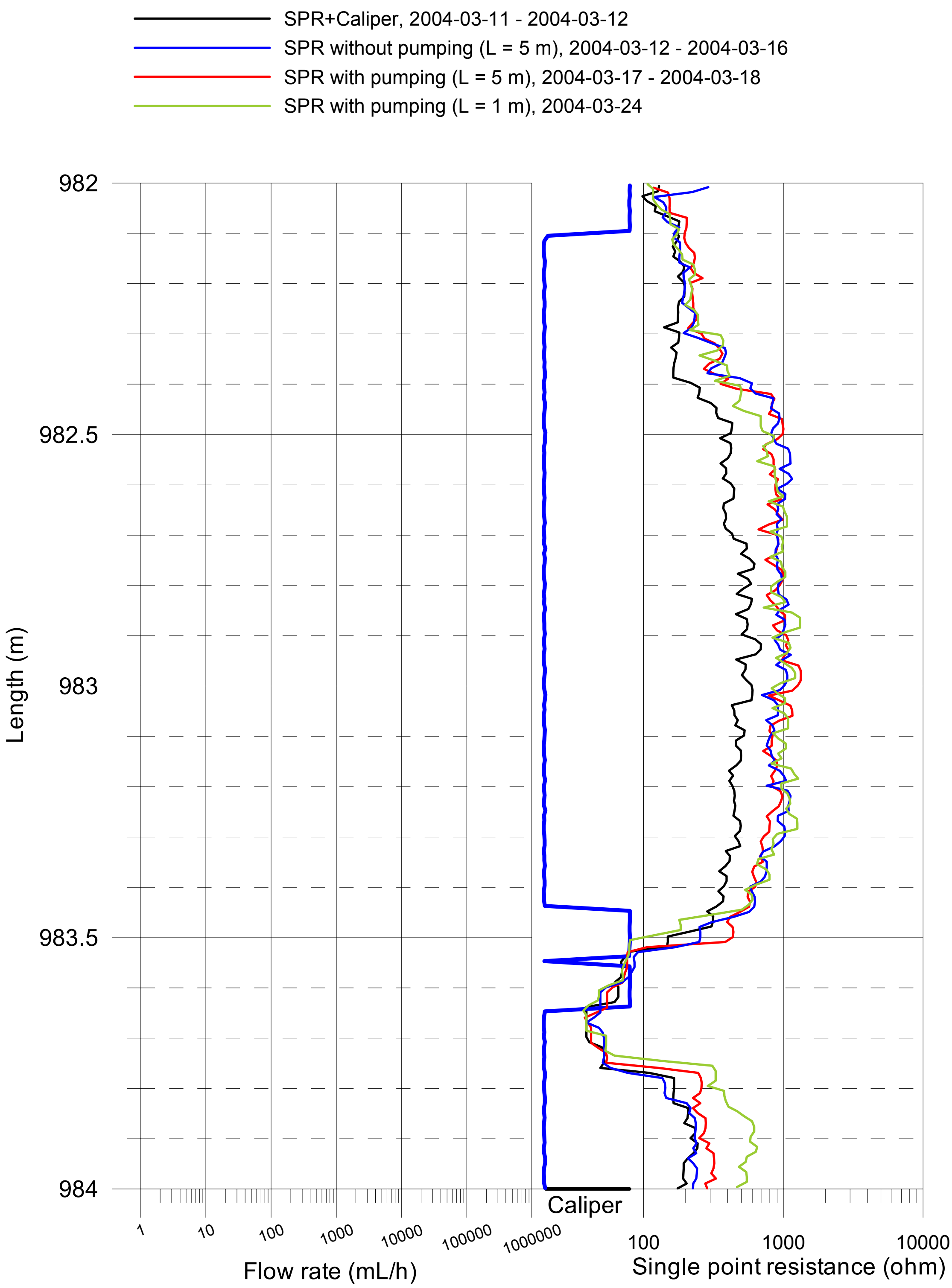


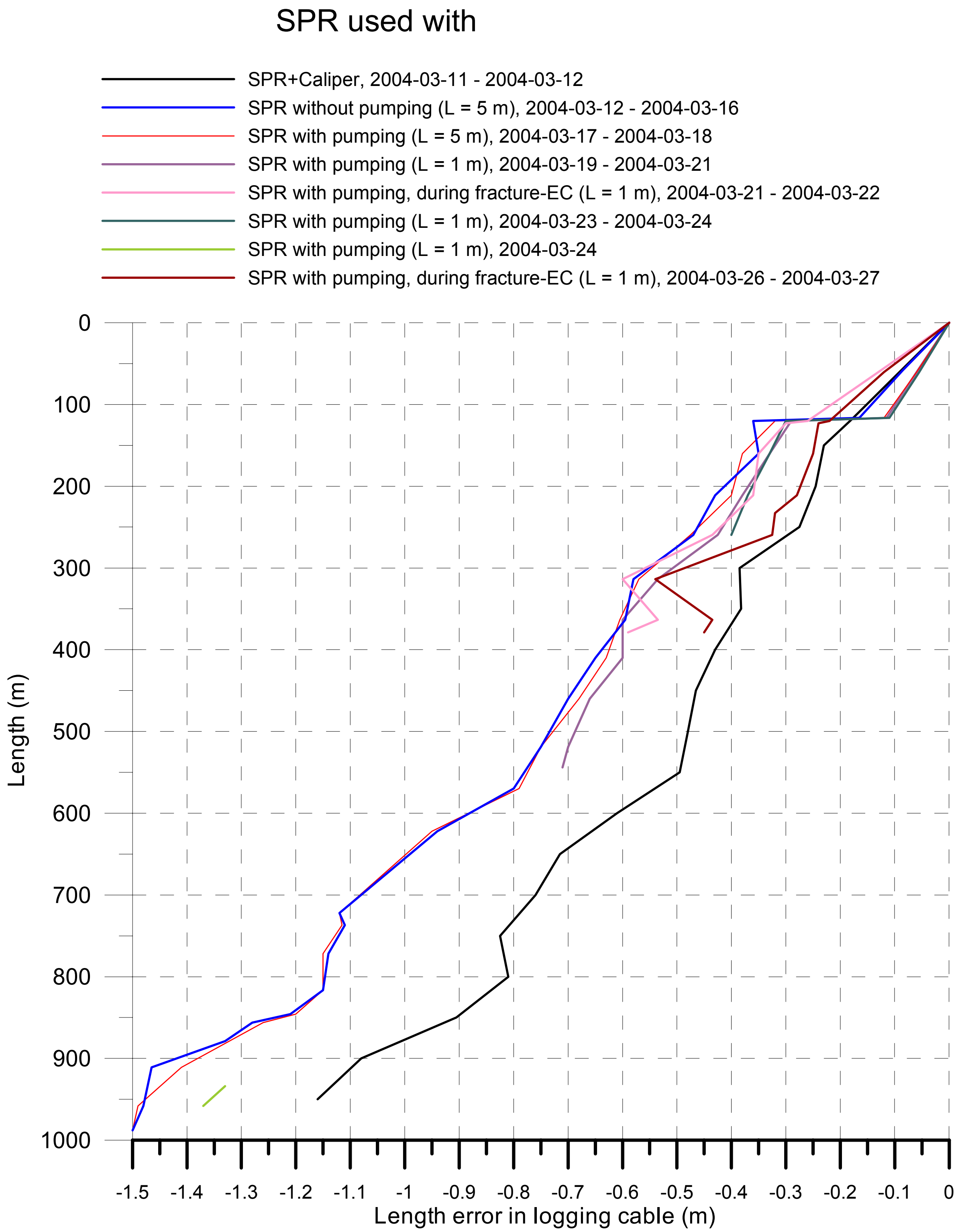

Forsmark, KFM04A
SPR and Caliper results after length correction
SPR+Caliper, 2004-03-11 - 2004-03-12
SPR without pumping (L = 5 m), 2004-03-12 - 2004-03-16
SPR with pumping (L = 5 m), 2004-03-17 - 2004-03-18
SPR with pumping (L = 1 m), 2004-03-24
953.5
954
954.5
955
955.5
Length (m)
Caliper
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
100
1000
10000
Single point resistance (ohm)

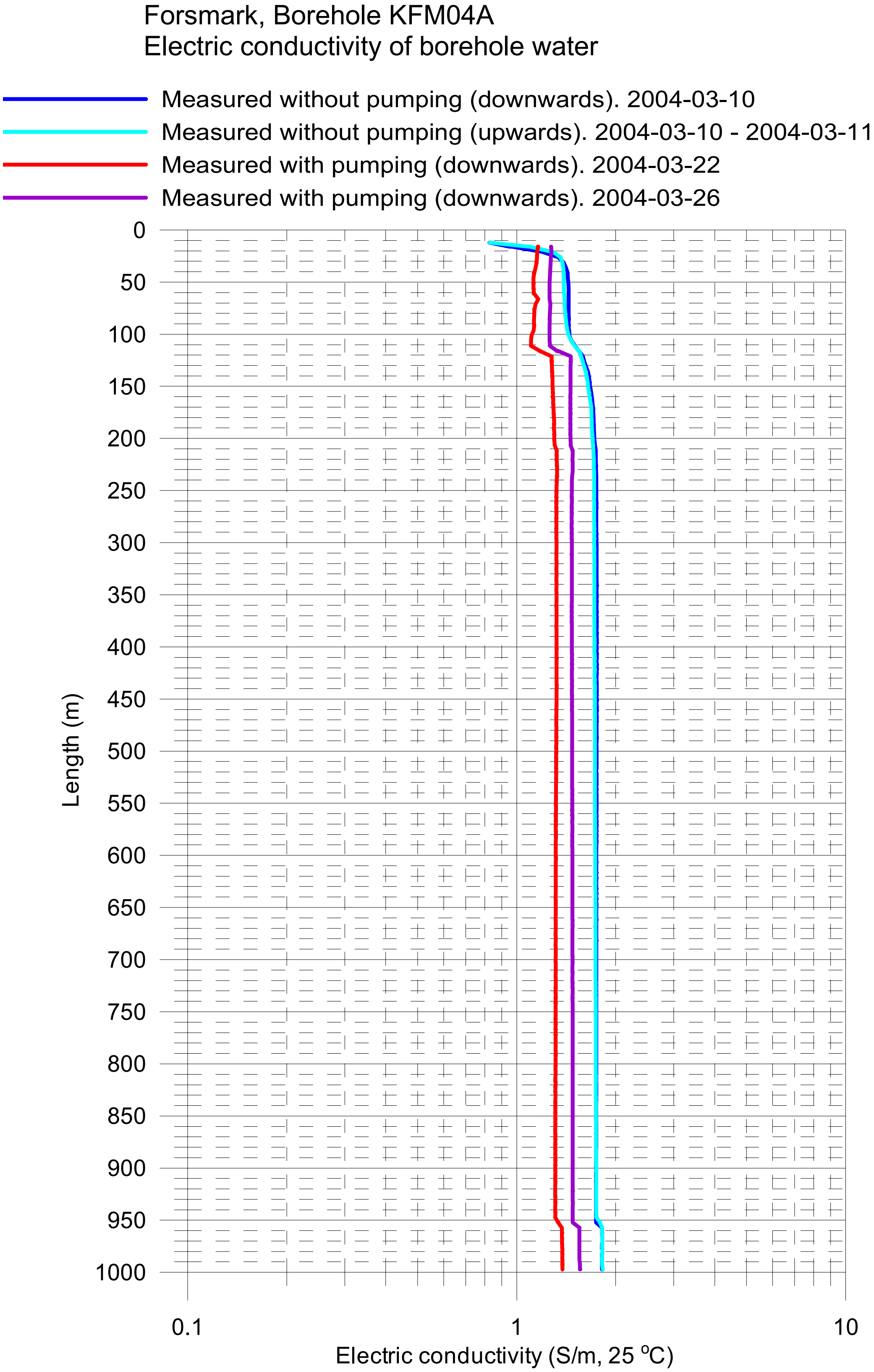
Forsmark, KFM04A
SPR and Caliper results after length correction



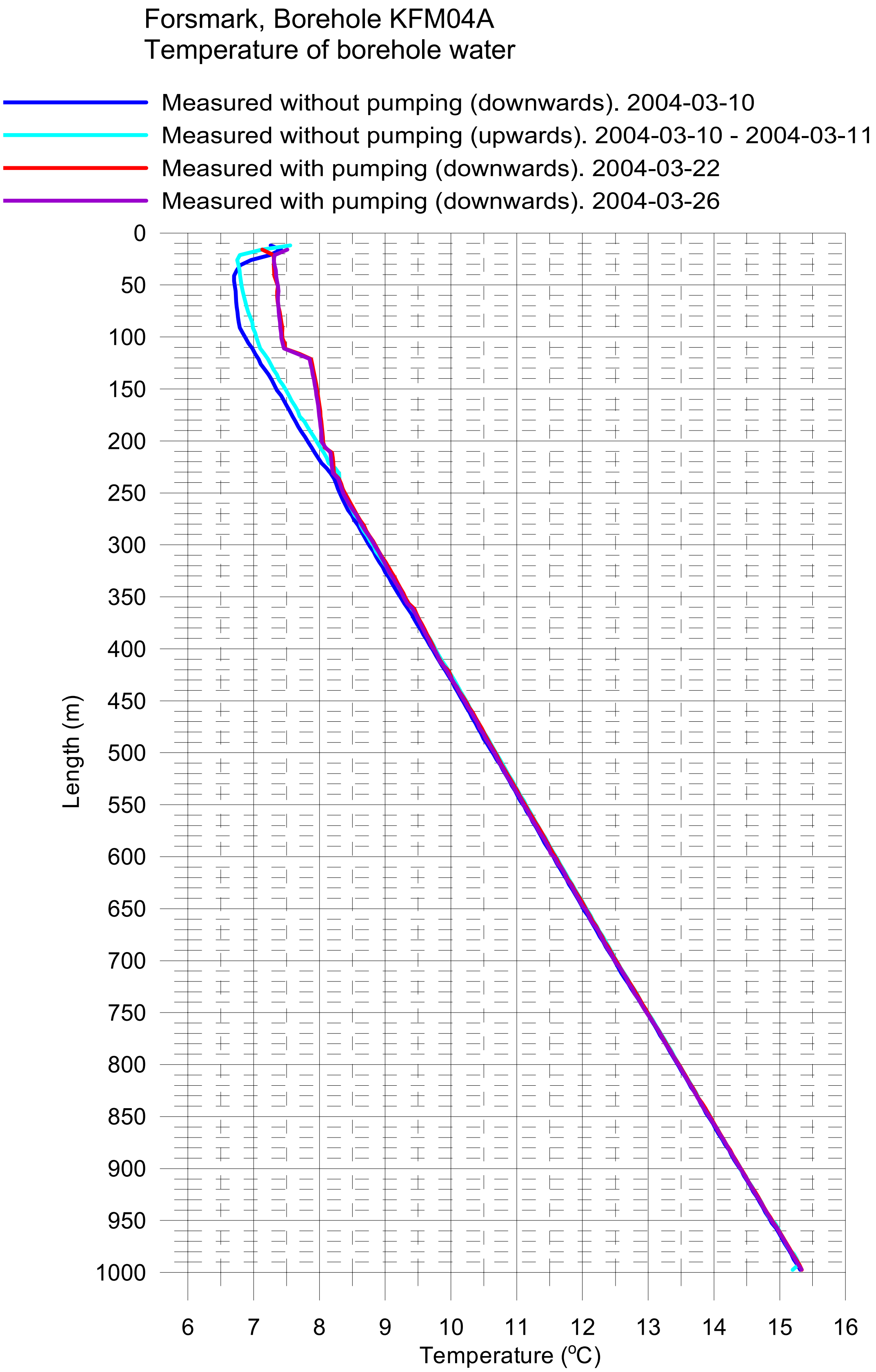
Forsmark, KFM04A
SPR and Caliper results after length correction



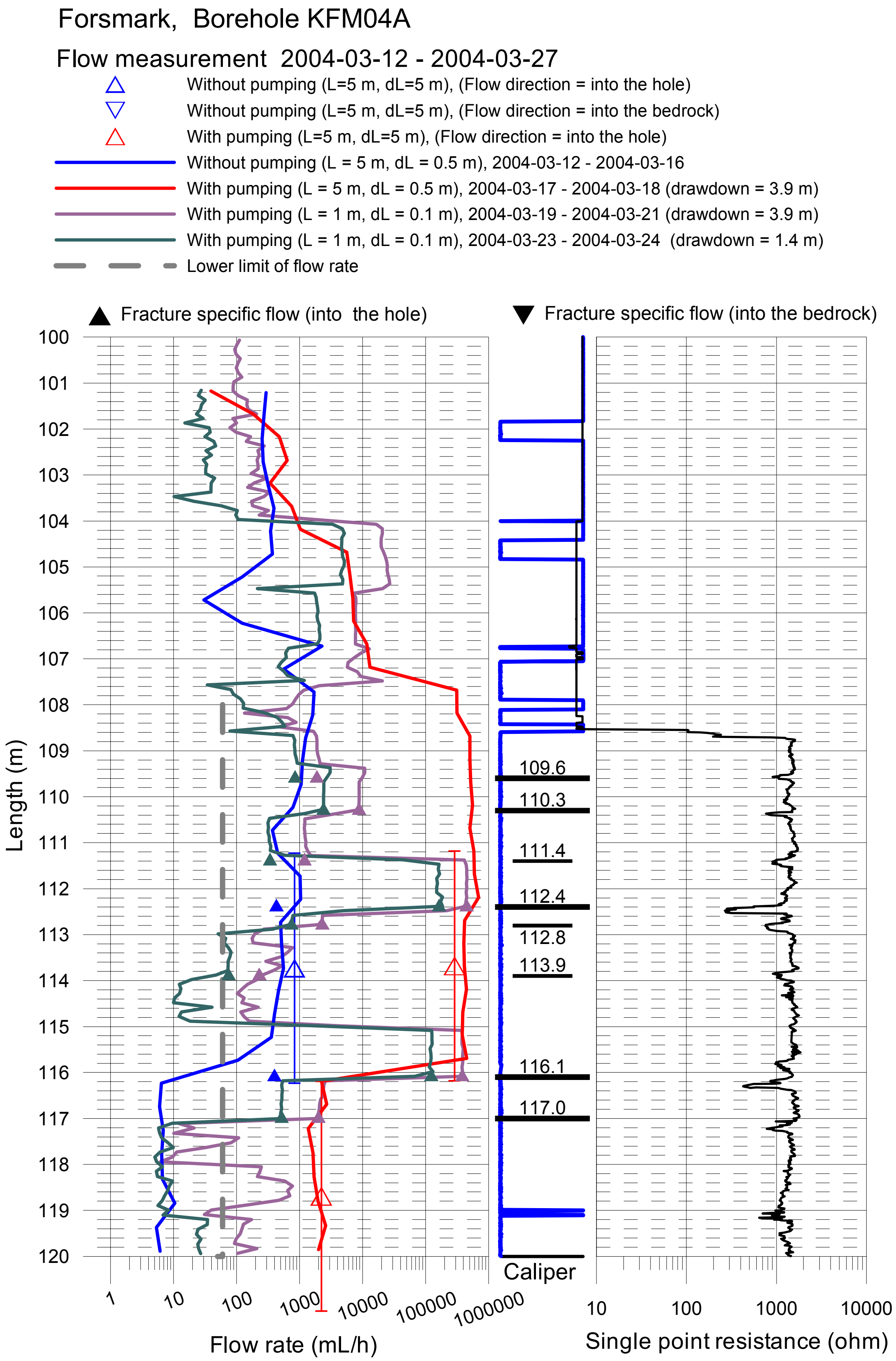

SPR used with
SPR+Caliper, 2004-03-11 - 2004-03-12
SPR without pumping (L = 5 m), 2004-03-12 - 2004-03-16
SPR with pumping (L = 5 m), 2004-03-17 - 2004-03-18
SPR with pumping (L = 1 m), 2004-03-19 - 2004-03-21
SPR with pumping, during fracture-EC (L = 1 m), 2004-03-21 - 2004-03-22
SPR with pumping (L = 1 m), 2004-03-23 - 2004-03-24
SPR with pumping (L = 1 m), 2004-03-24
SPR with pumping, during fracture-EC (L = 1 m), 2004-03-26 - 2004-03-27
Length (m)
0
100
200
300
400
500
600
700
800
900
1000
-1.5
-1.4
-1.3
-1.2
-1.1
-1
-0.9
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0
Length error in logging cable (m)


Forsmark, Borehole KFM04A
Electric conductivity of borehole water
Measured without pumping (downwards). 2004-03-10
Measured without pumping (upwards). 2004-03-10 - 2004-03-11
Measured with pumping (downwards). 2004-03-22
Measured with pumping (downwards). 2004-03-26
Length (m)
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
0.1
1
10
Electric conductivity (S/m, 25 °C)

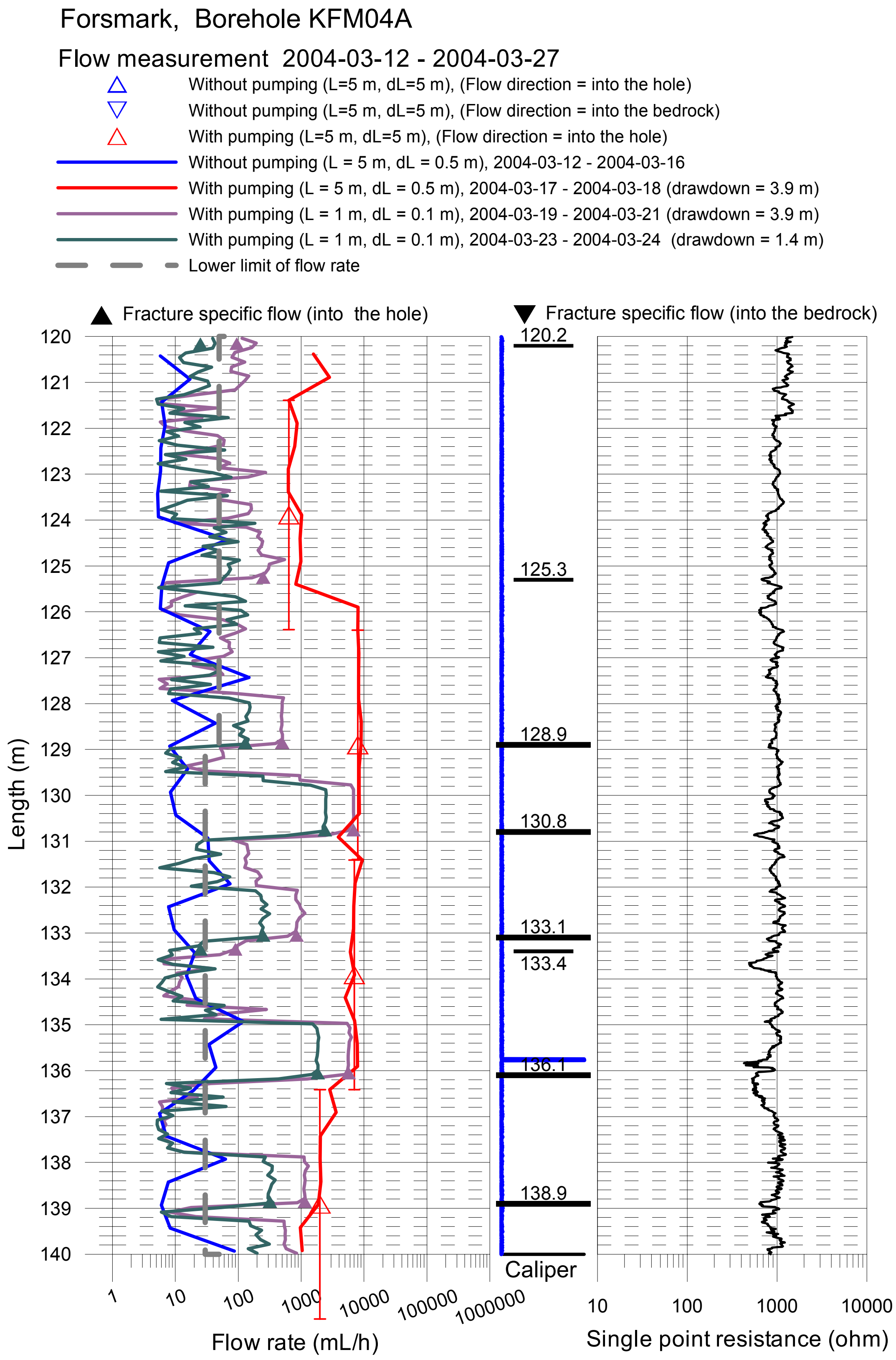
Appendix 2.2

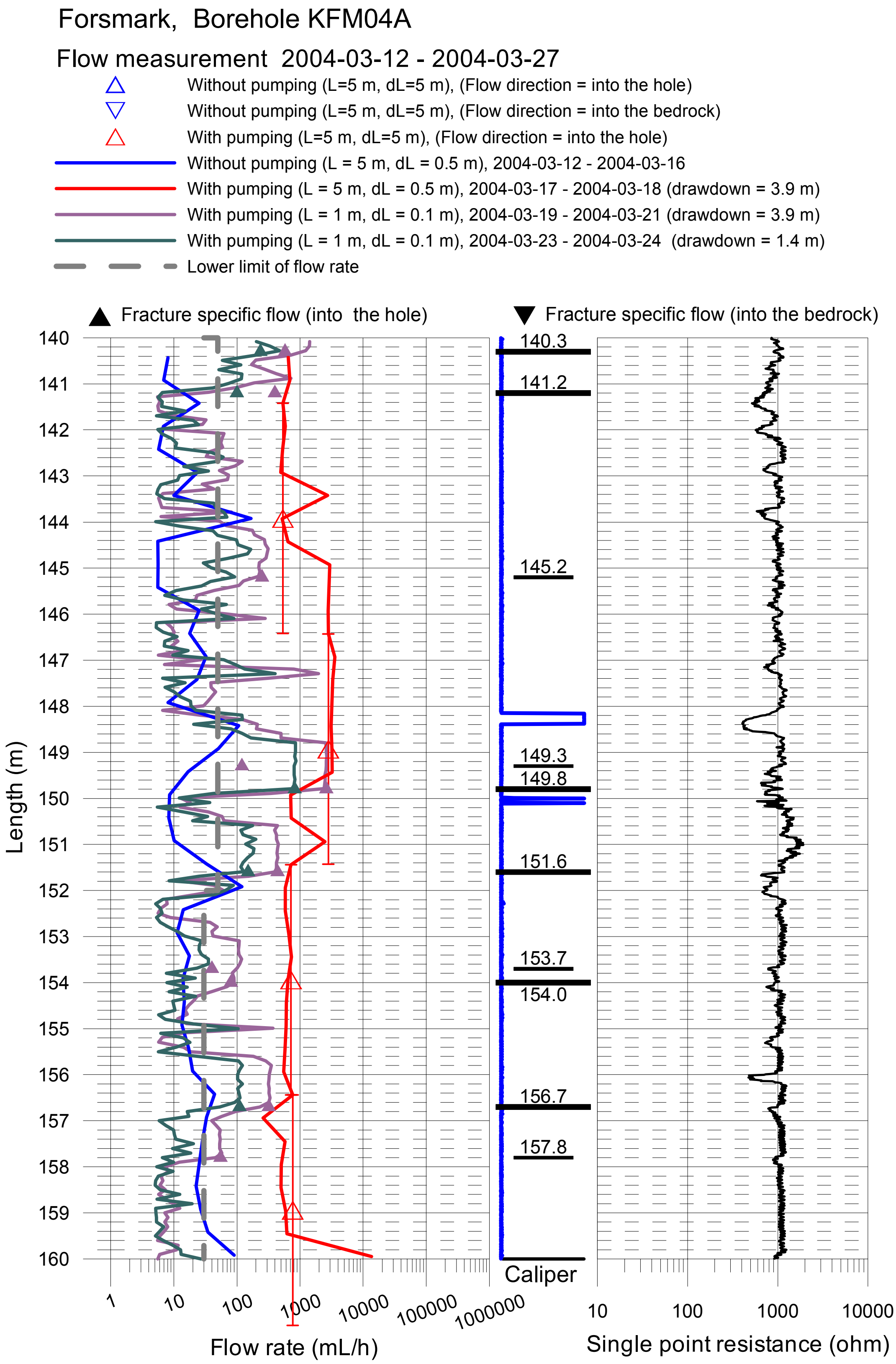


Forsmark, Borehole KFM04A
Temperature of borehole water
Measured without pumping (downwards). 2004-03-10
Measured without pumping (upwards). 2004-03-10 - 2004-03-11
Measured with pumping (downwards). 2004-03-22
Measured with pumping (downwards). 2004-03-26
Length (m)
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
6
7
8
9
10
11
12
13
14
15
16
Temperature (°C)

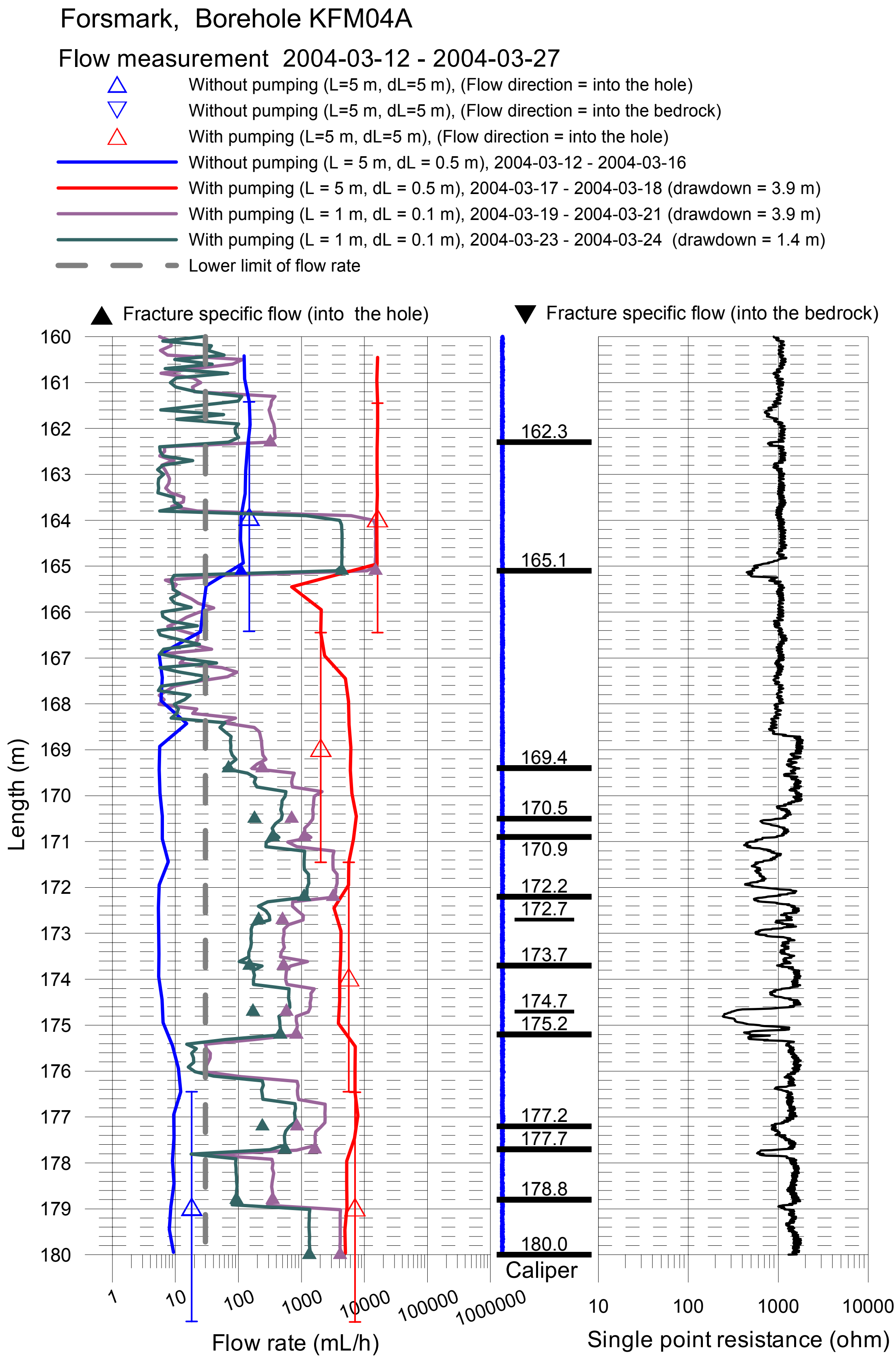


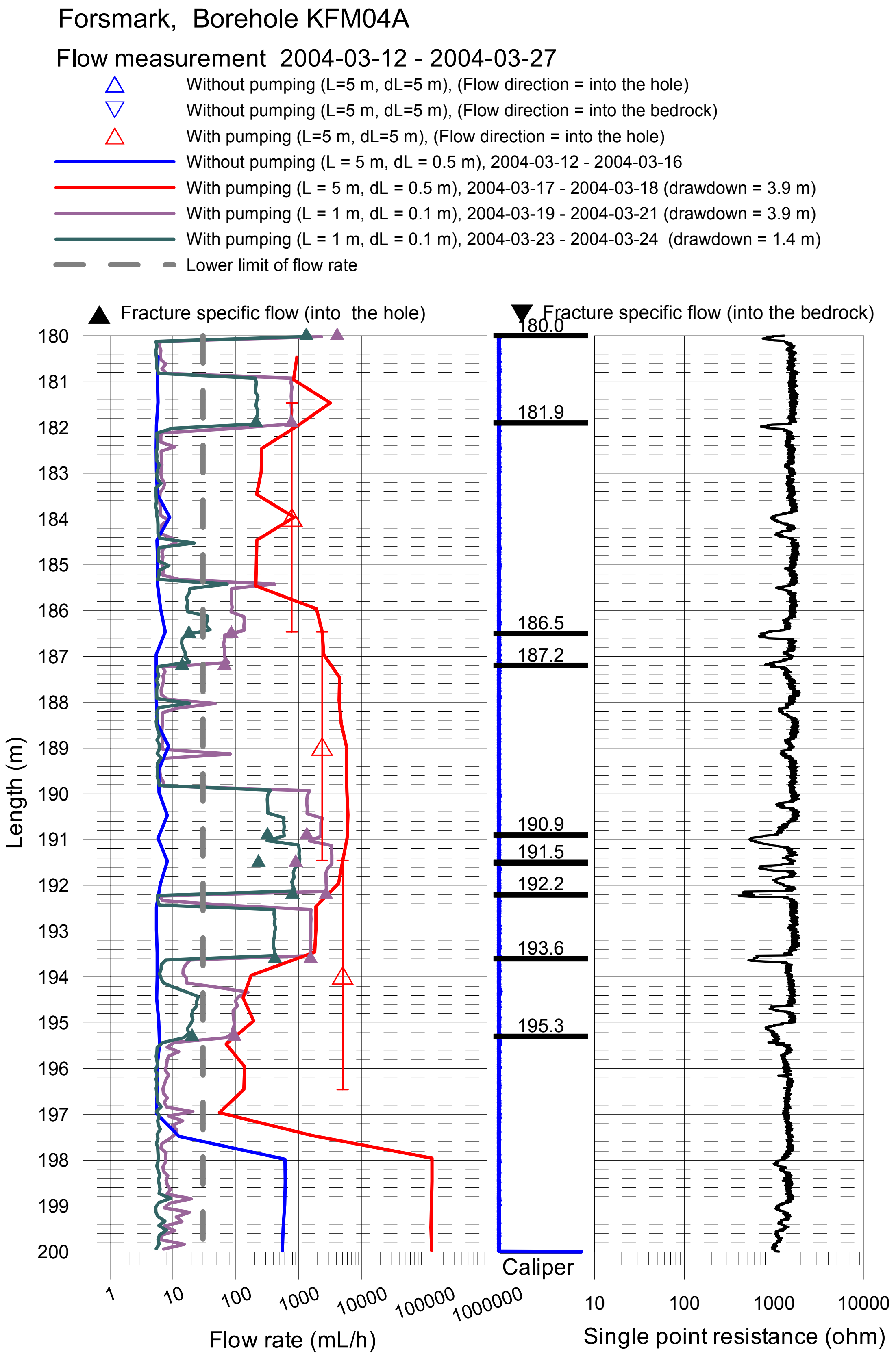
Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-19 - 2004-03-21 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-23 - 2004-03-24 (drawdown = 1.4 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
109.6
110.3
111.4
112.4
112.8
113.9
116.1
117.0
Caliper
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
10
100
1000
10000
Single point resistance (ohm)


Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-19 - 2004-03-21 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-23 - 2004-03-24 (drawdown = 1.4 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
120.2
125.3
128.9
130.8
133.1
133.4
136.1
138.9
Caliper
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
10
100
1000
10000
Single point resistance (ohm)


Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-19 - 2004-03-21 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-23 - 2004-03-24 (drawdown = 1.4 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
140.3
141.2
145.2
149.3
149.8
151.6
153.7
154.0
156.7
157.8
Caliper
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
10
100
1000
10000
Single point resistance (ohm)

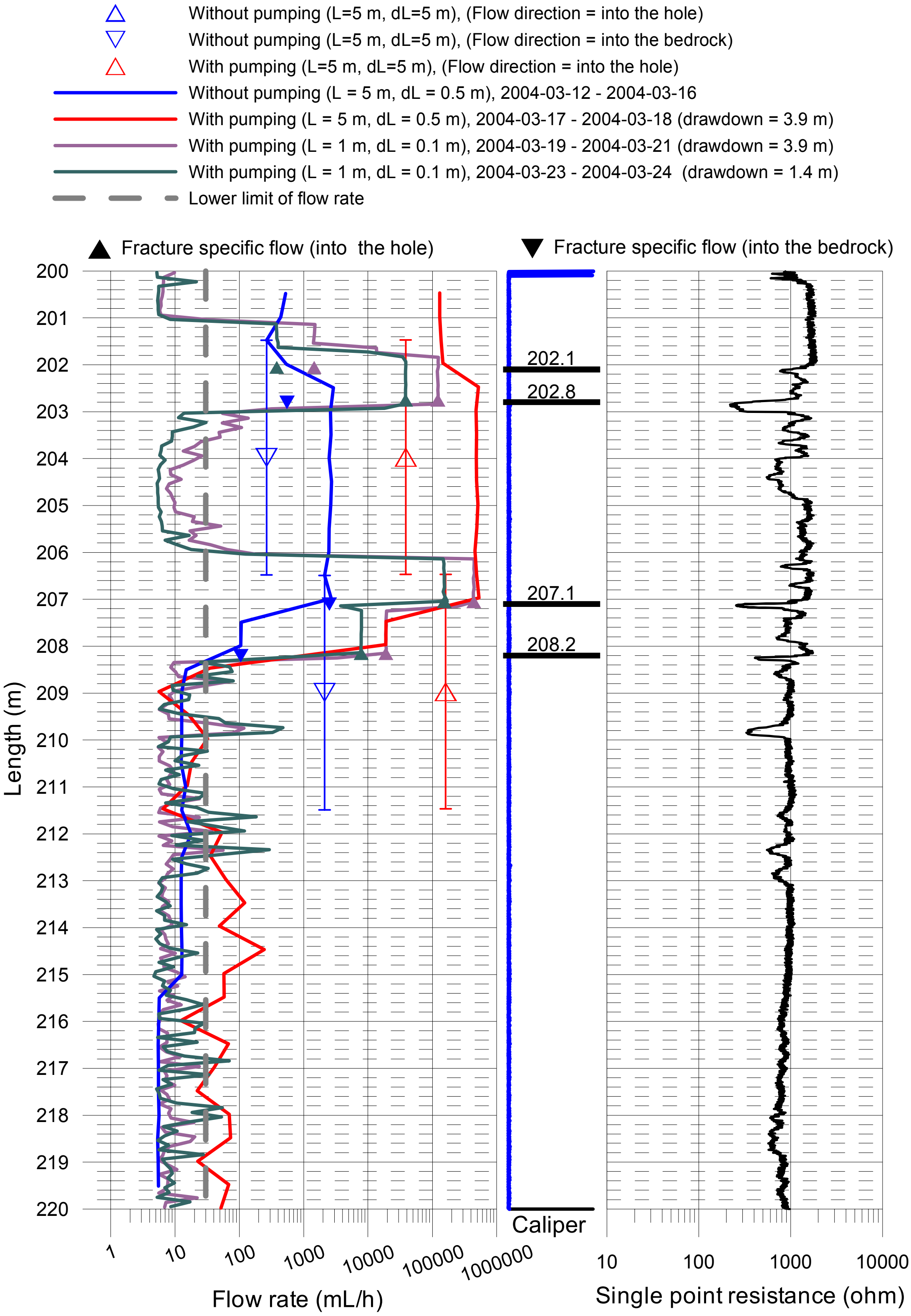
Appendix 3.4

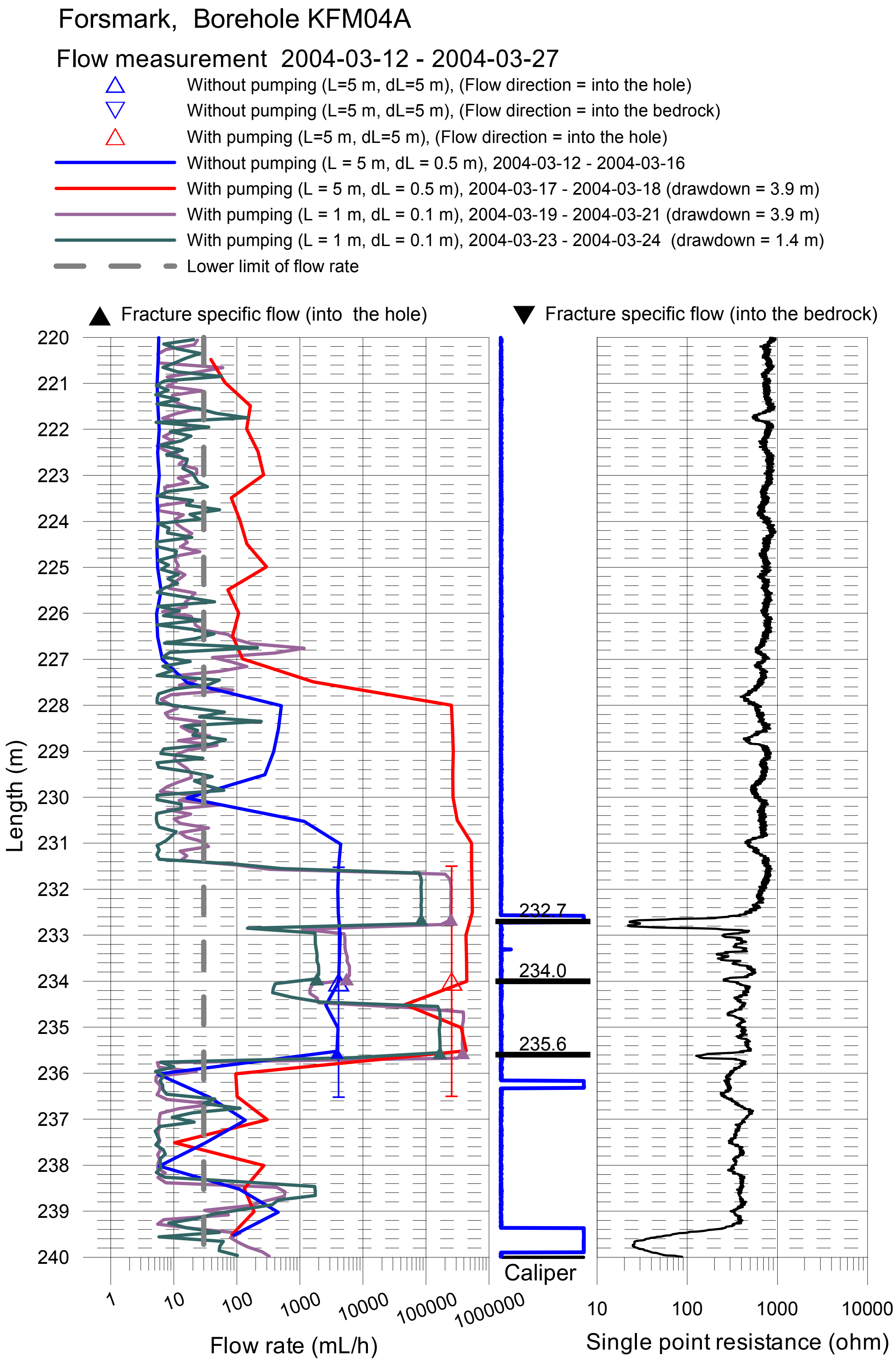

Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-19 - 2004-03-21 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-23 - 2004-03-24 (drawdown = 1.4 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
Flow rate (mL/h)
Caliper
Single point resistance (ohm)
162.3
165.1
169.4
170.5
170.9
172.2
172.7
173.7
174.7
175.2
177.2
177.7
178.8
180.0


Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-19 - 2004-03-21 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-23 - 2004-03-24 (drawdown = 1.4 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
180.0
181.9
186.5
187.2
190.9
191.5
192.2
193.6
195.3
Caliper
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
10
100
1000
10000
Single point resistance (ohm)

Forsmark, Borehole KFM04A

Flow measurement 2004-03-12 - 2004-03-27

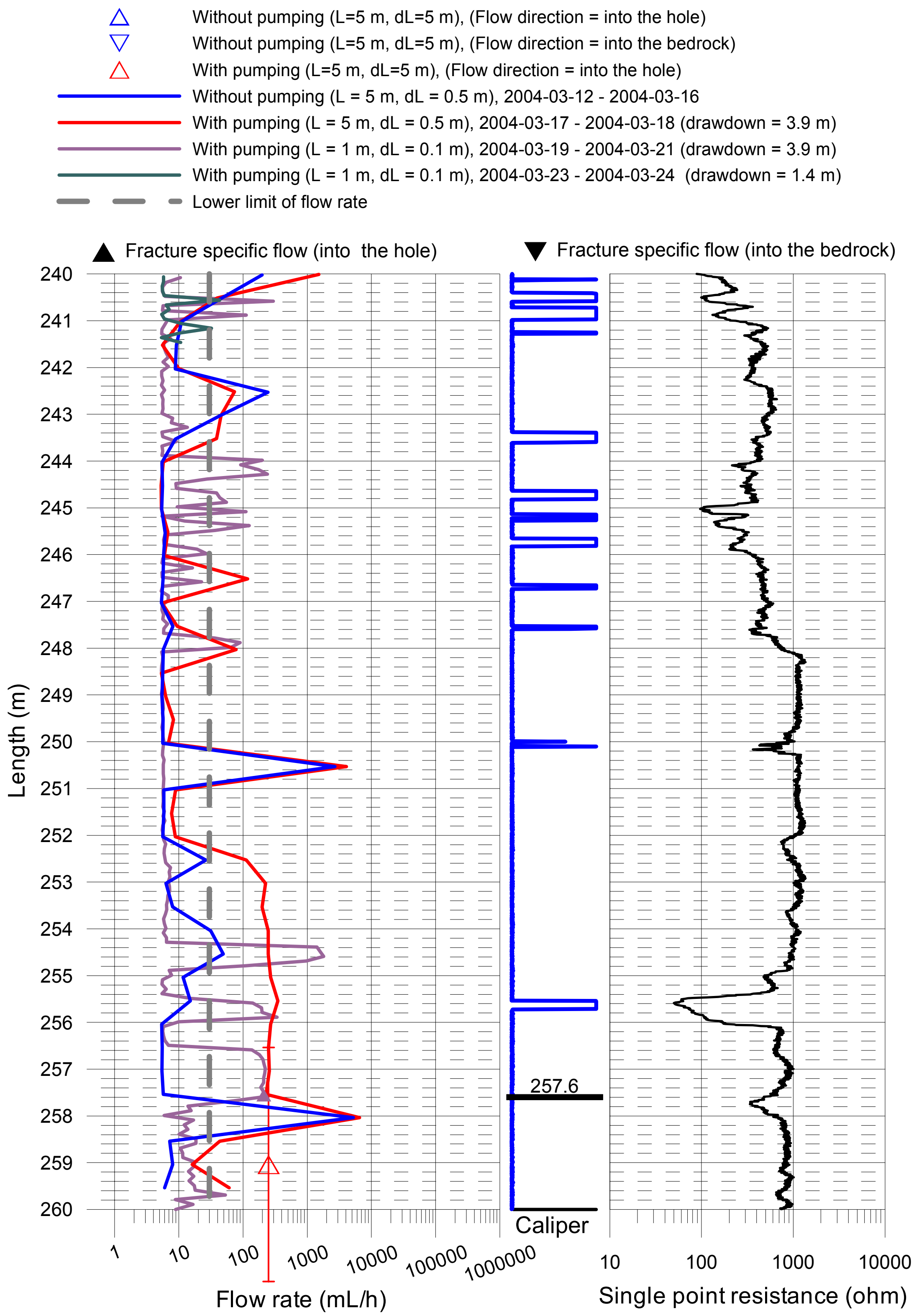


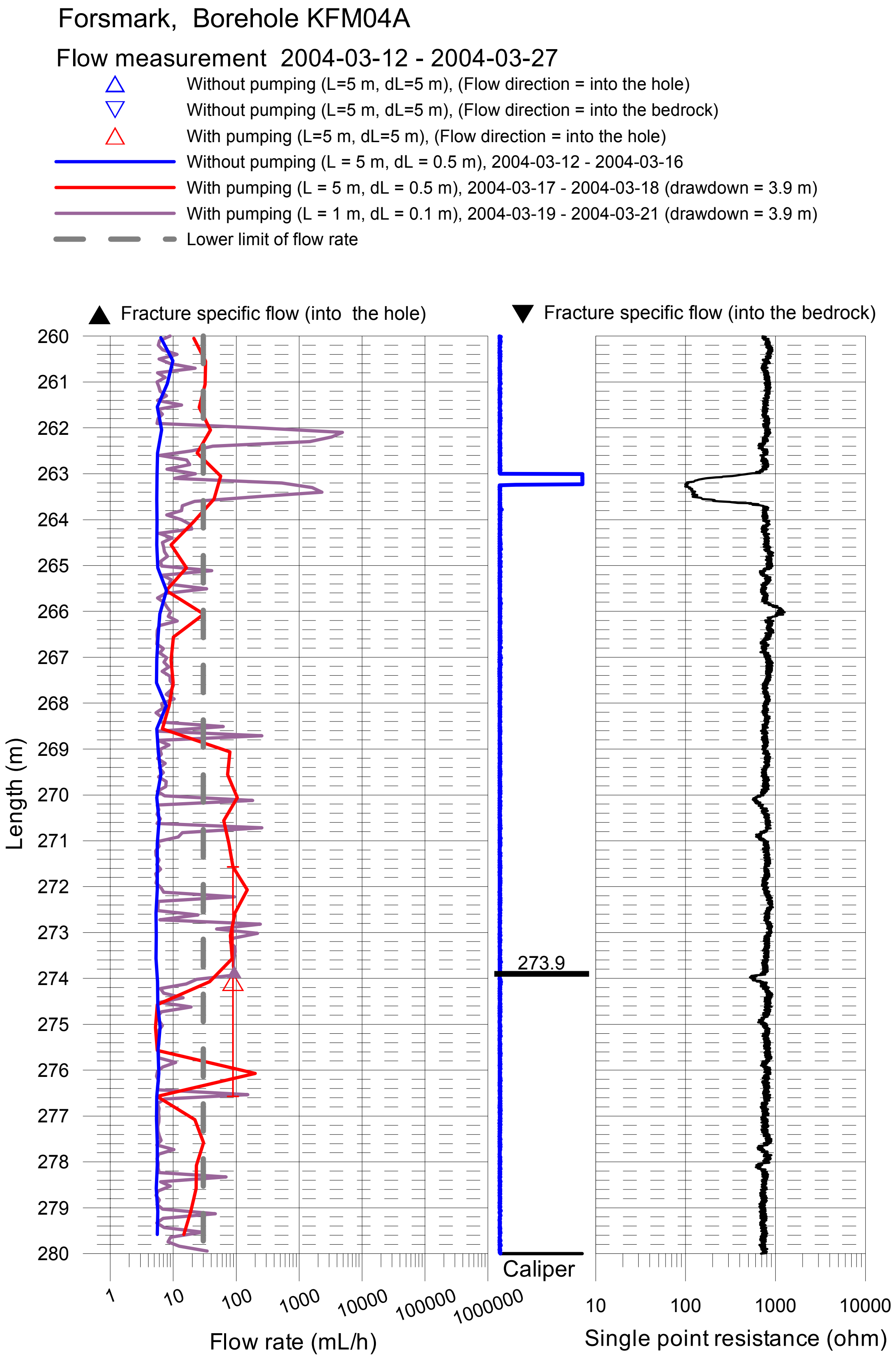


Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-19 - 2004-03-21 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-23 - 2004-03-24 (drawdown = 1.4 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
232.7
234.0
235.6
Caliper
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
10
100
1000
10000
Single point resistance (ohm)

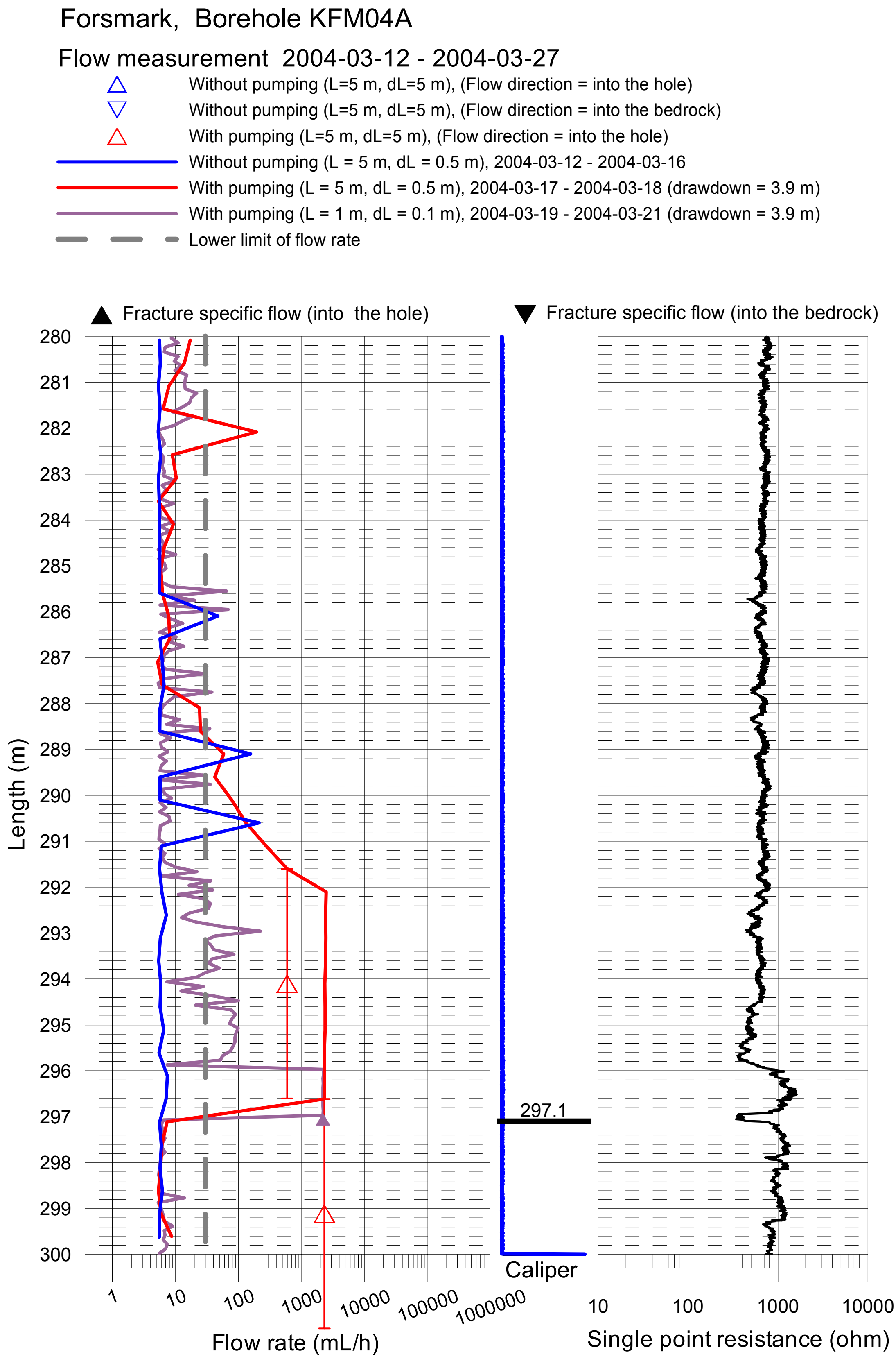
Forsmark, Borehole KFM04A

Flow measurement 2004-03-12 - 2004-03-27

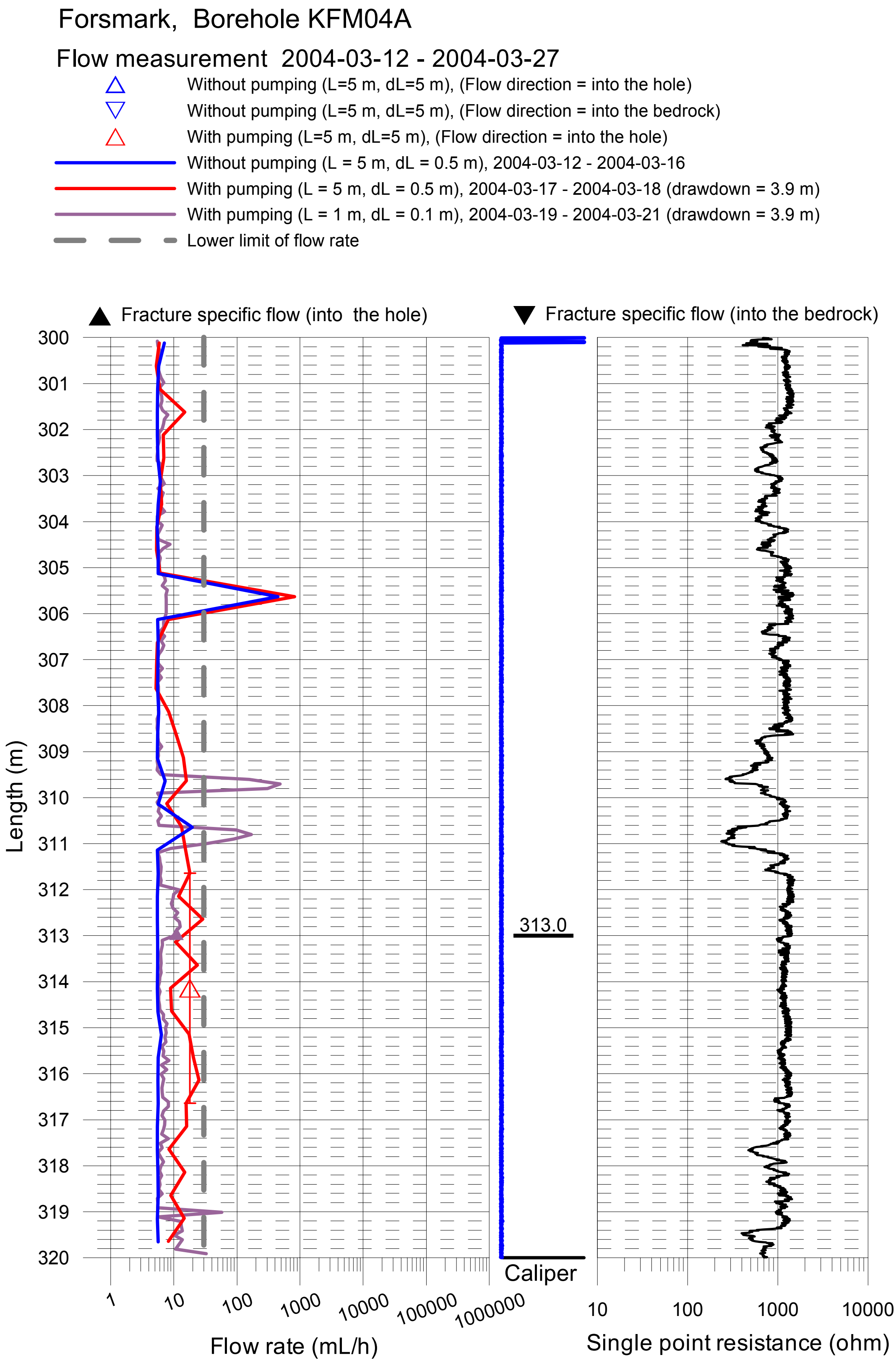




Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-19 - 2004-03-21 (drawdown = 3.9 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
273.9
Caliper
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
10
100
1000
10000
Single point resistance (ohm)



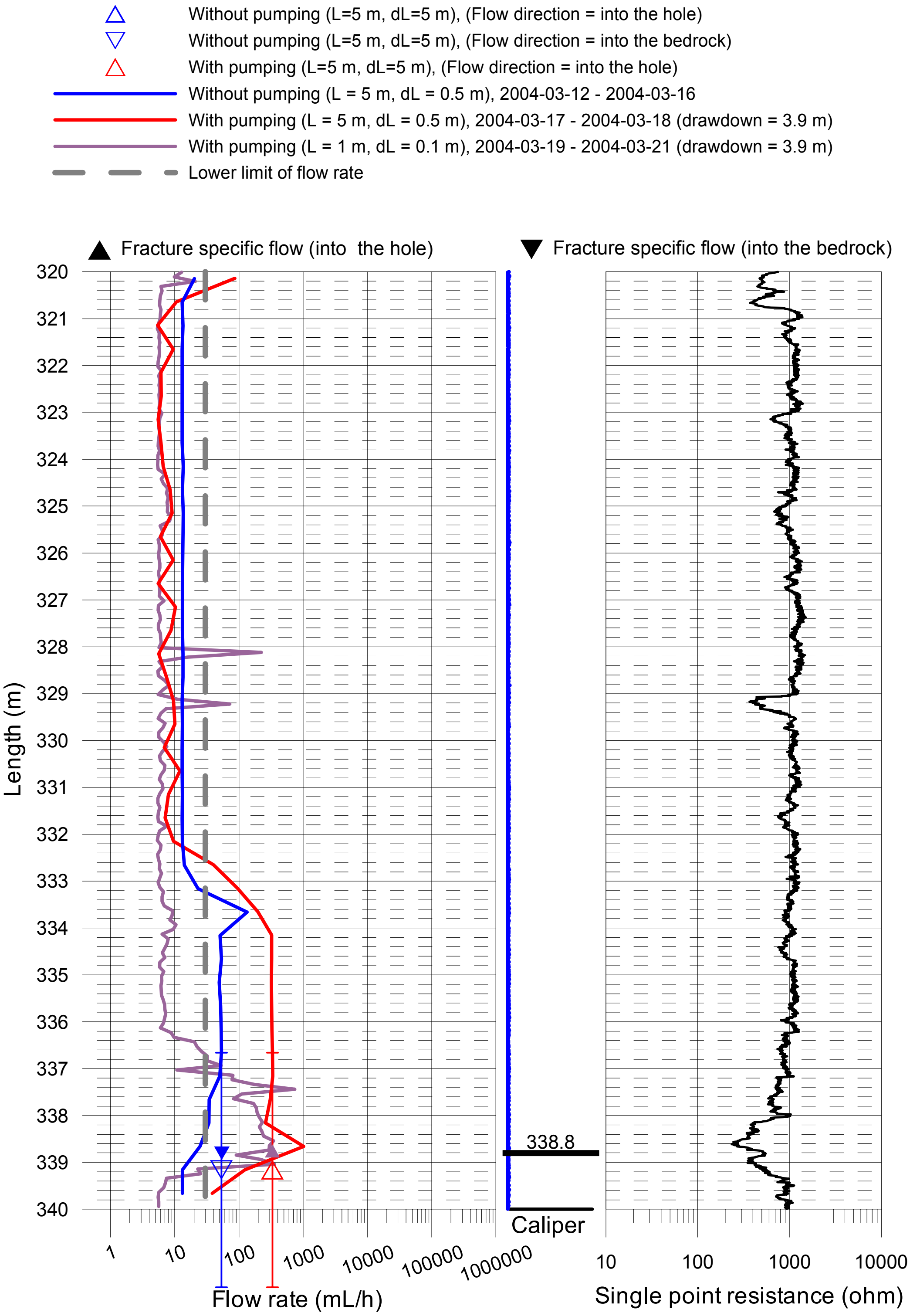
Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-19 - 2004-03-21 (drawdown = 3.9 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
297.1
Caliper
10
100
1000
10000
Single point resistance (ohm)

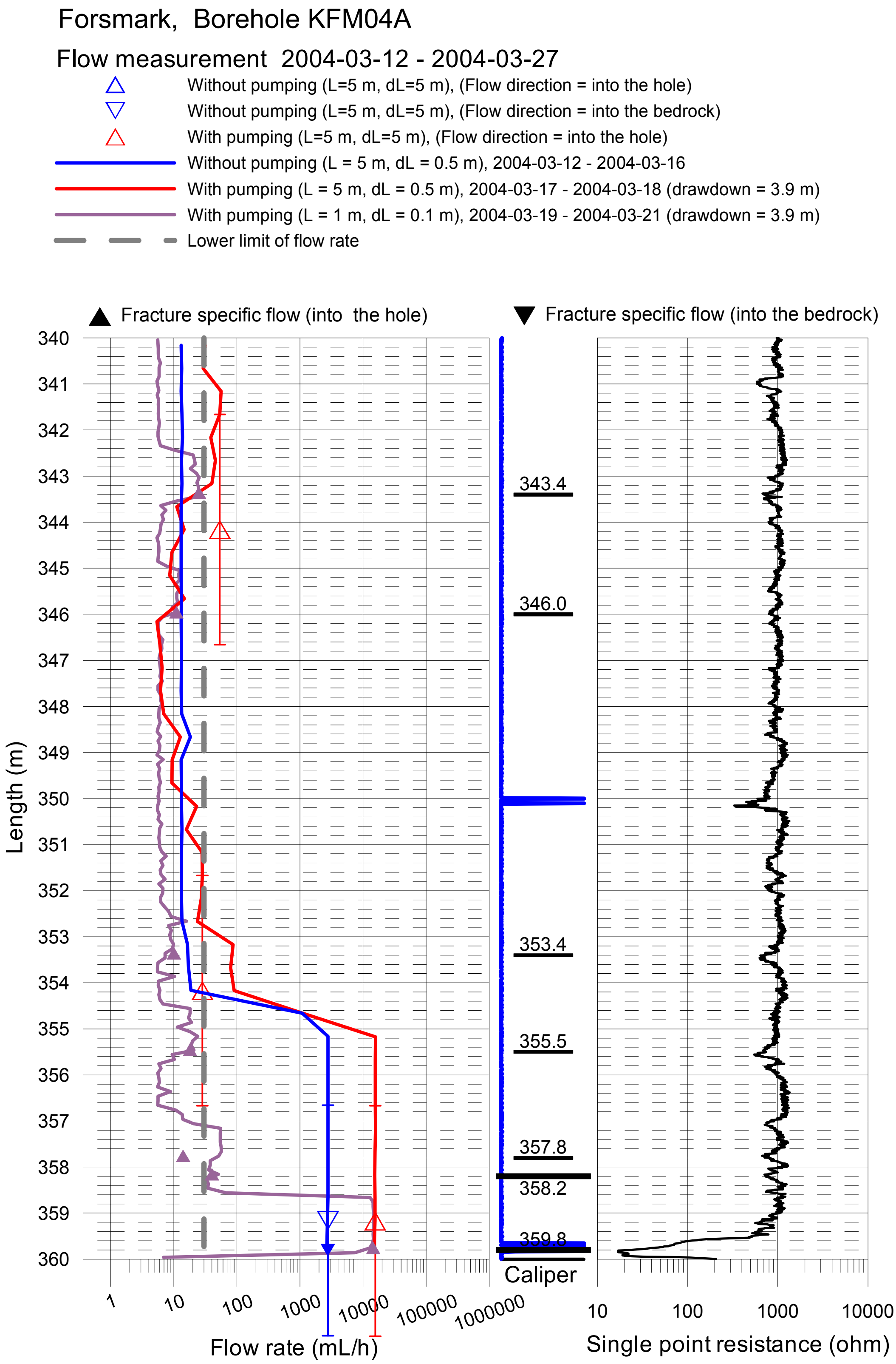


Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-19 - 2004-03-21 (drawdown = 3.9 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
313.0
Caliper
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
10
100
1000
10000
Single point resistance (ohm)

Forsmark, Borehole KFM04A

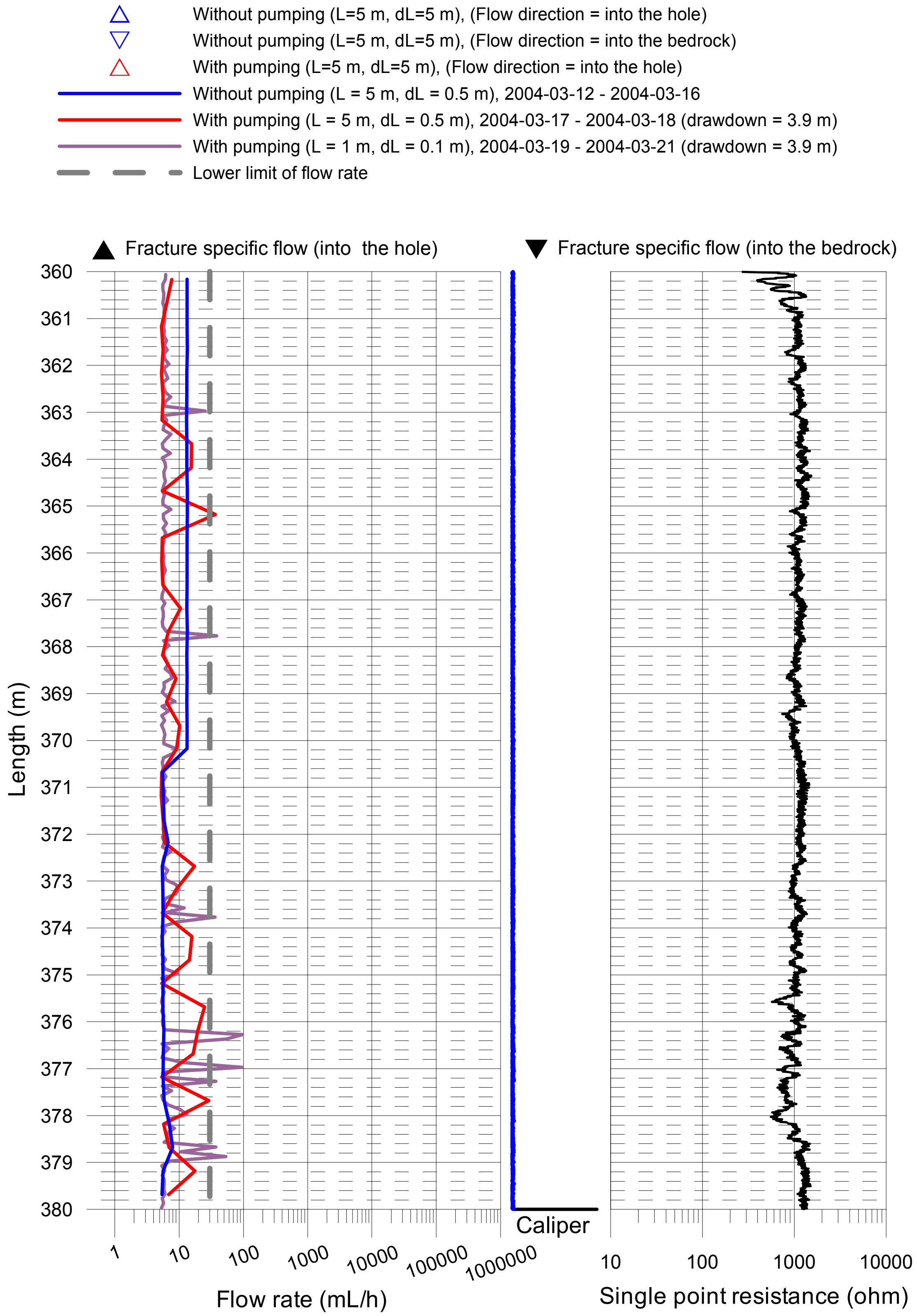
Flow measurement 2004-03-12 - 2004-03-27

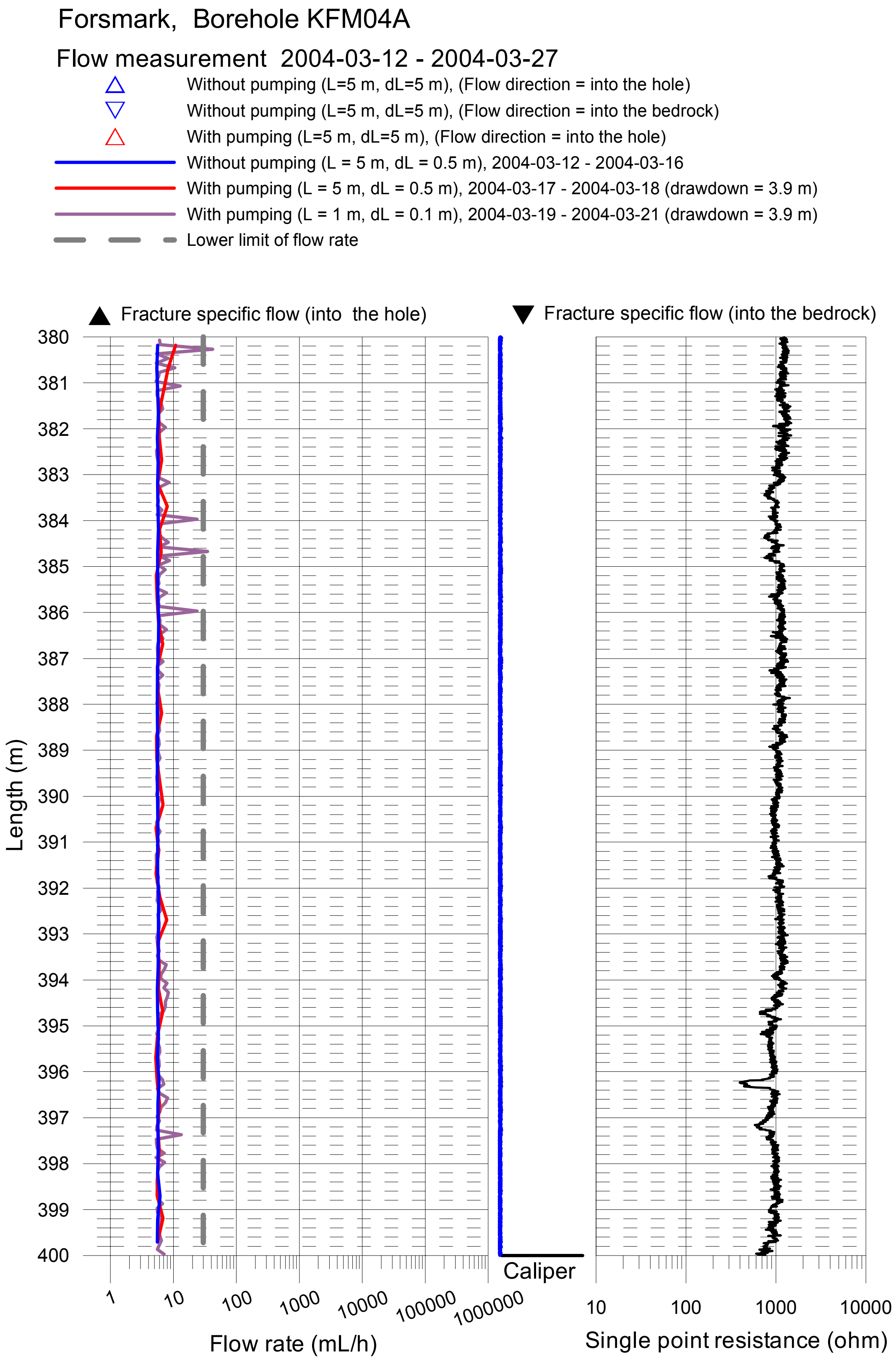



Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-19 - 2004-03-21 (drawdown = 3.9 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
343.4
346.0
353.4
355.5
357.8
358.2
359.8
Caliper
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
10
100
1000
10000
Single point resistance (ohm)

Forsmark, Borehole KFM04A

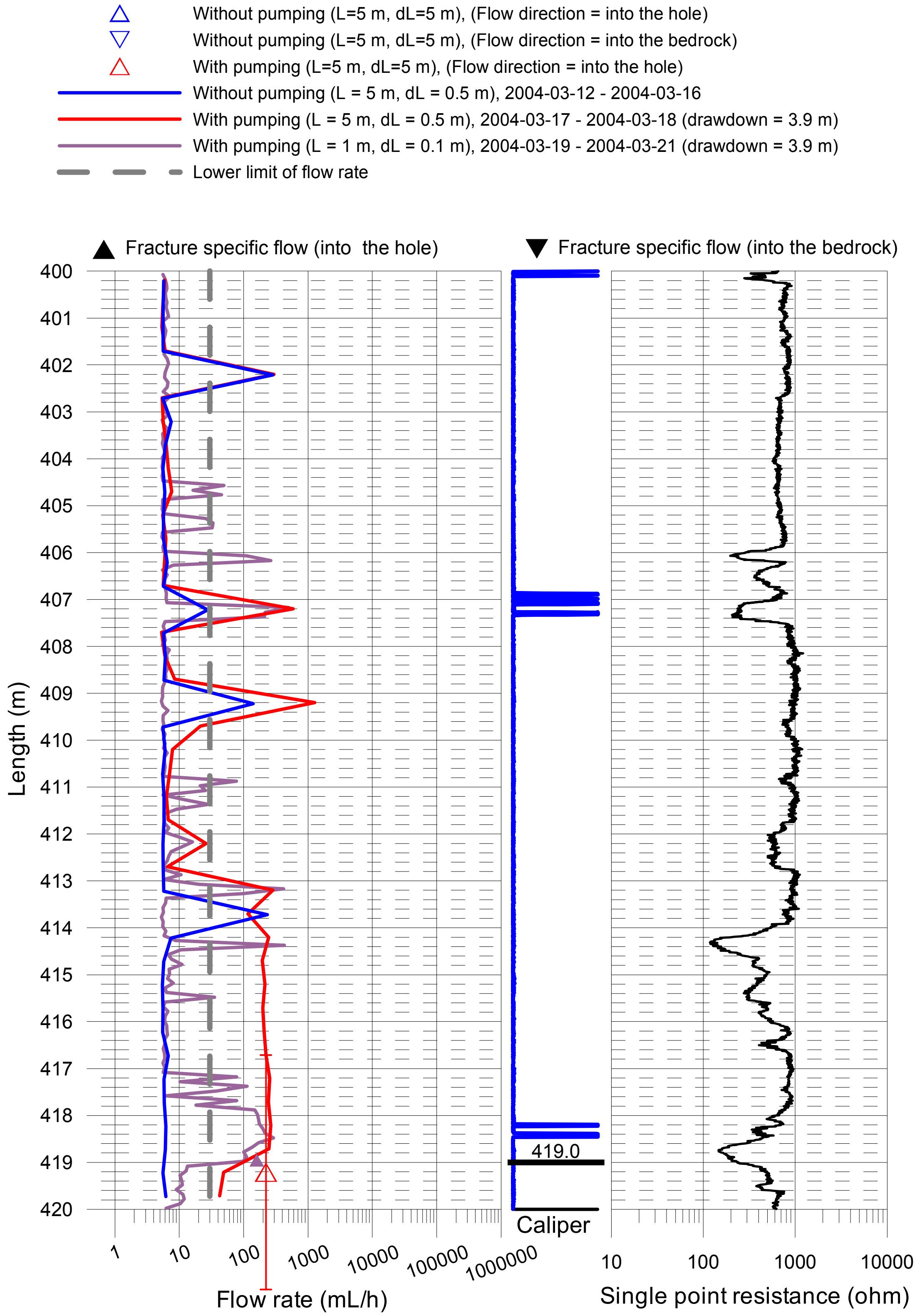
Flow measurement 2004-03-12 - 2004-03-27

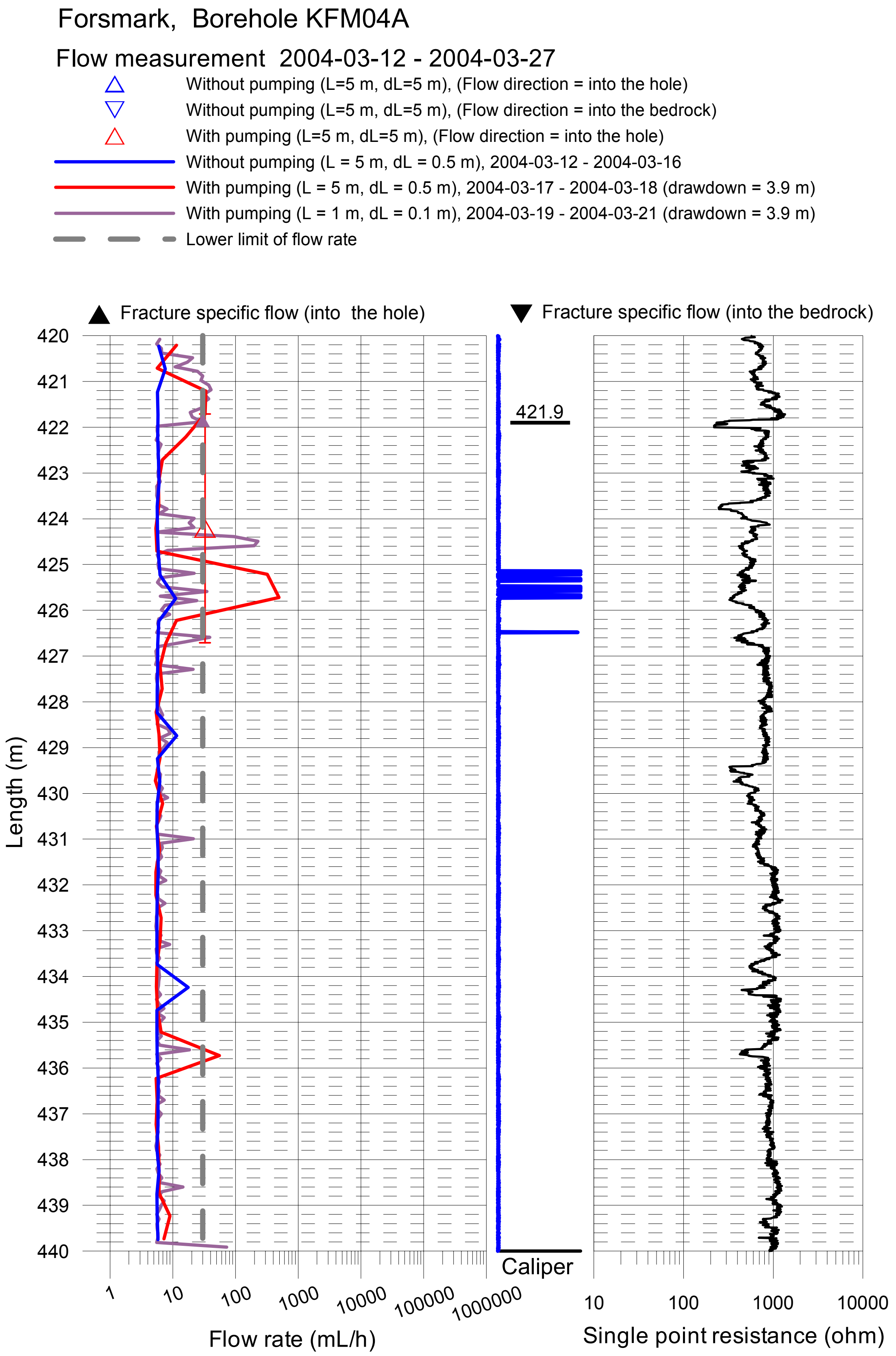



Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-19 - 2004-03-21 (drawdown = 3.9 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
Caliper
10
100
1000
10000
Single point resistance (ohm)

Forsmark, Borehole KFM04A

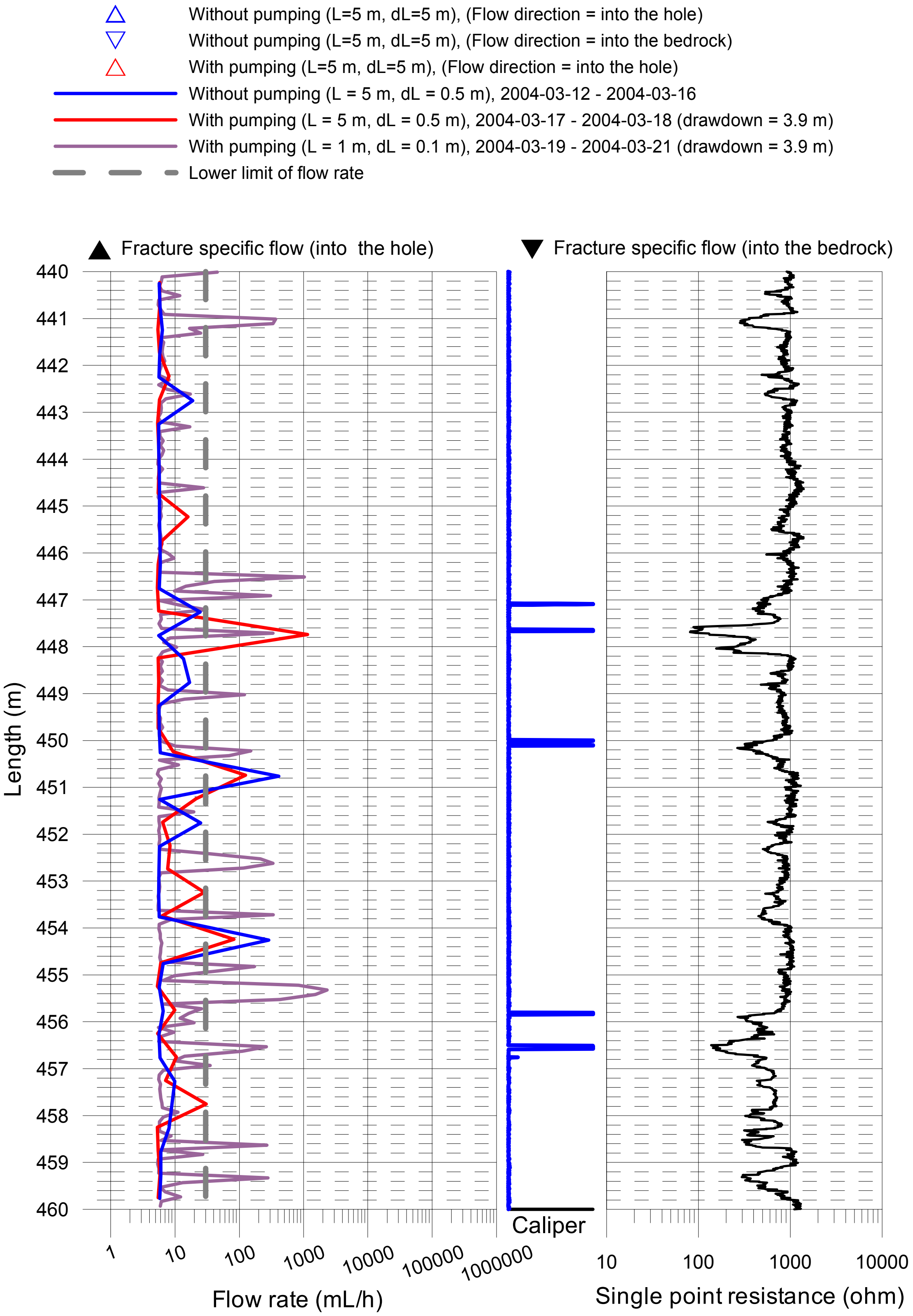
Flow measurement 2004-03-12 - 2004-03-27

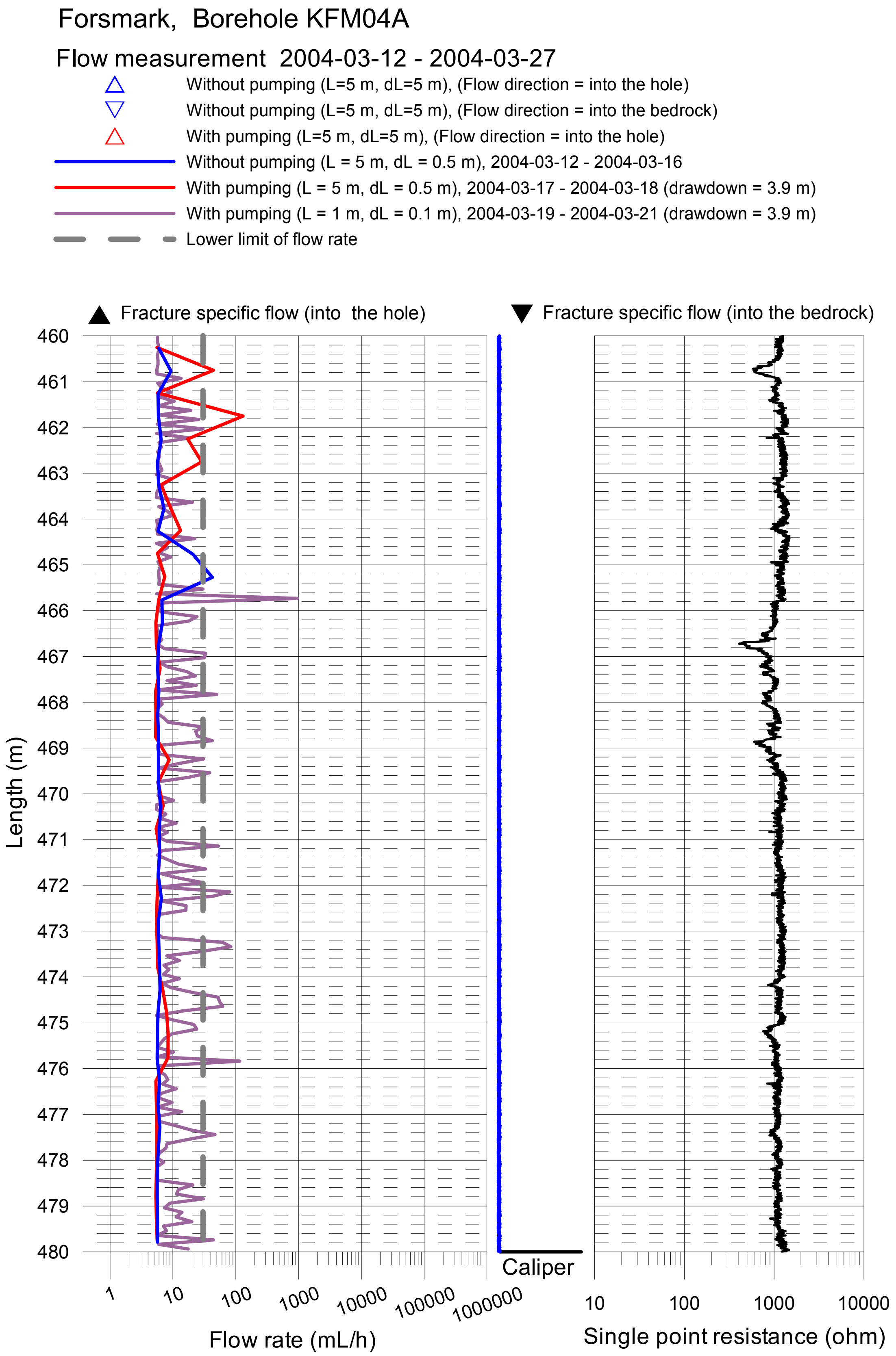



Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-19 - 2004-03-21 (drawdown = 3.9 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
421.9
Caliper
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
10
100
1000
10000
Single point resistance (ohm)

Forsmark, Borehole KFM04A

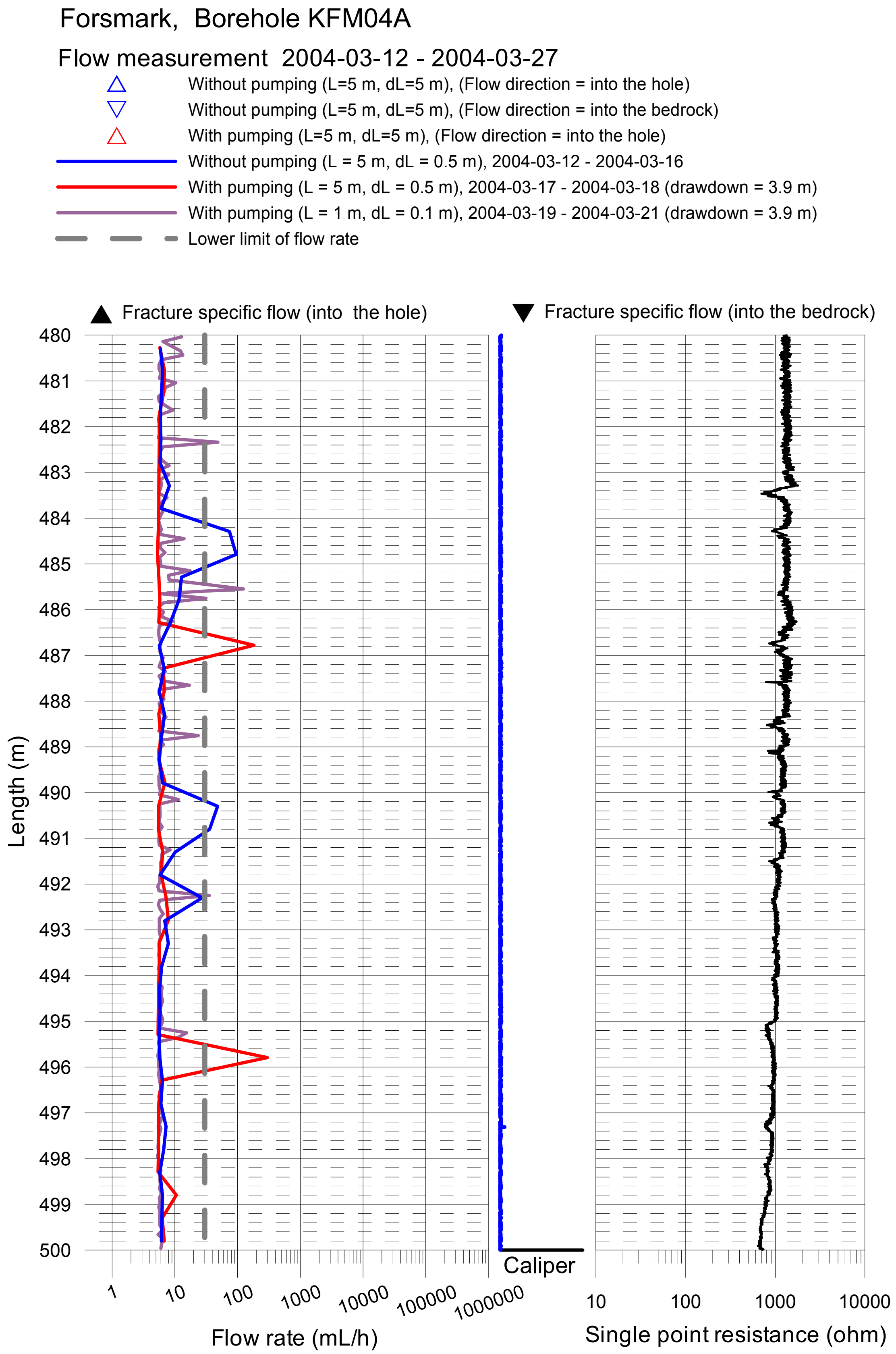
Flow measurement 2004-03-12 - 2004-03-27

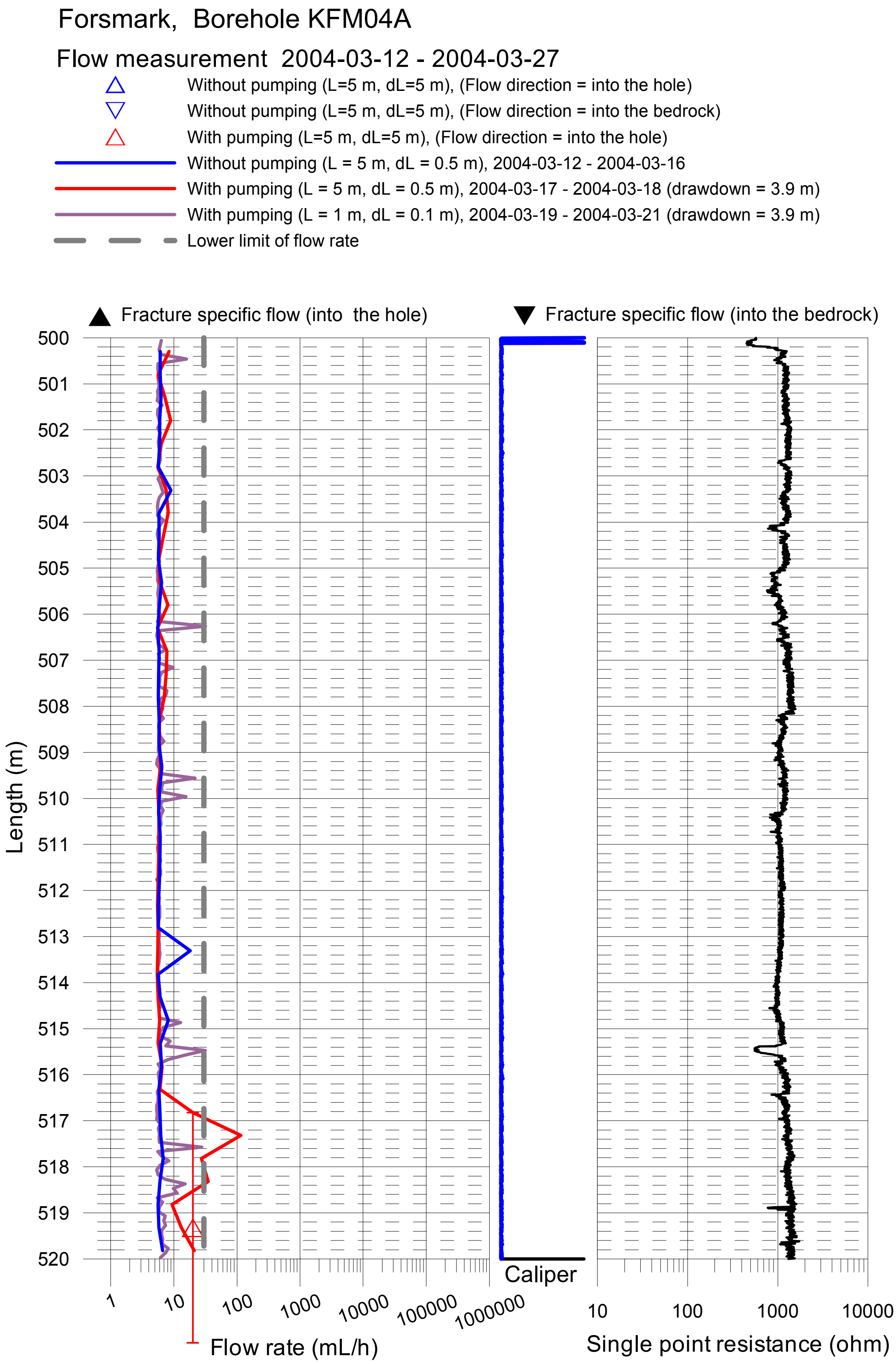




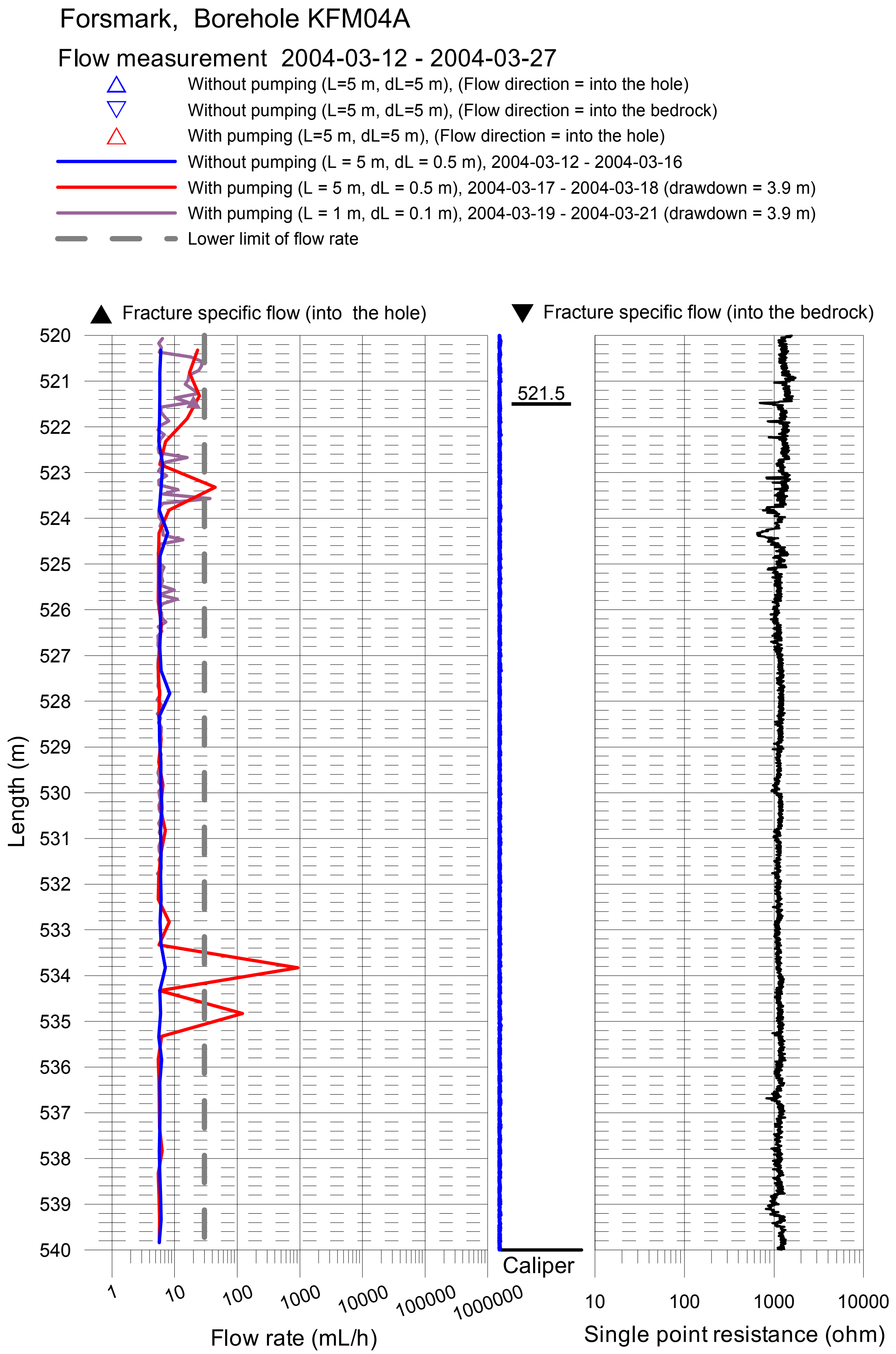
Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-19 - 2004-03-21 (drawdown = 3.9 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
Caliper
10
100
1000
10000
Single point resistance (ohm)

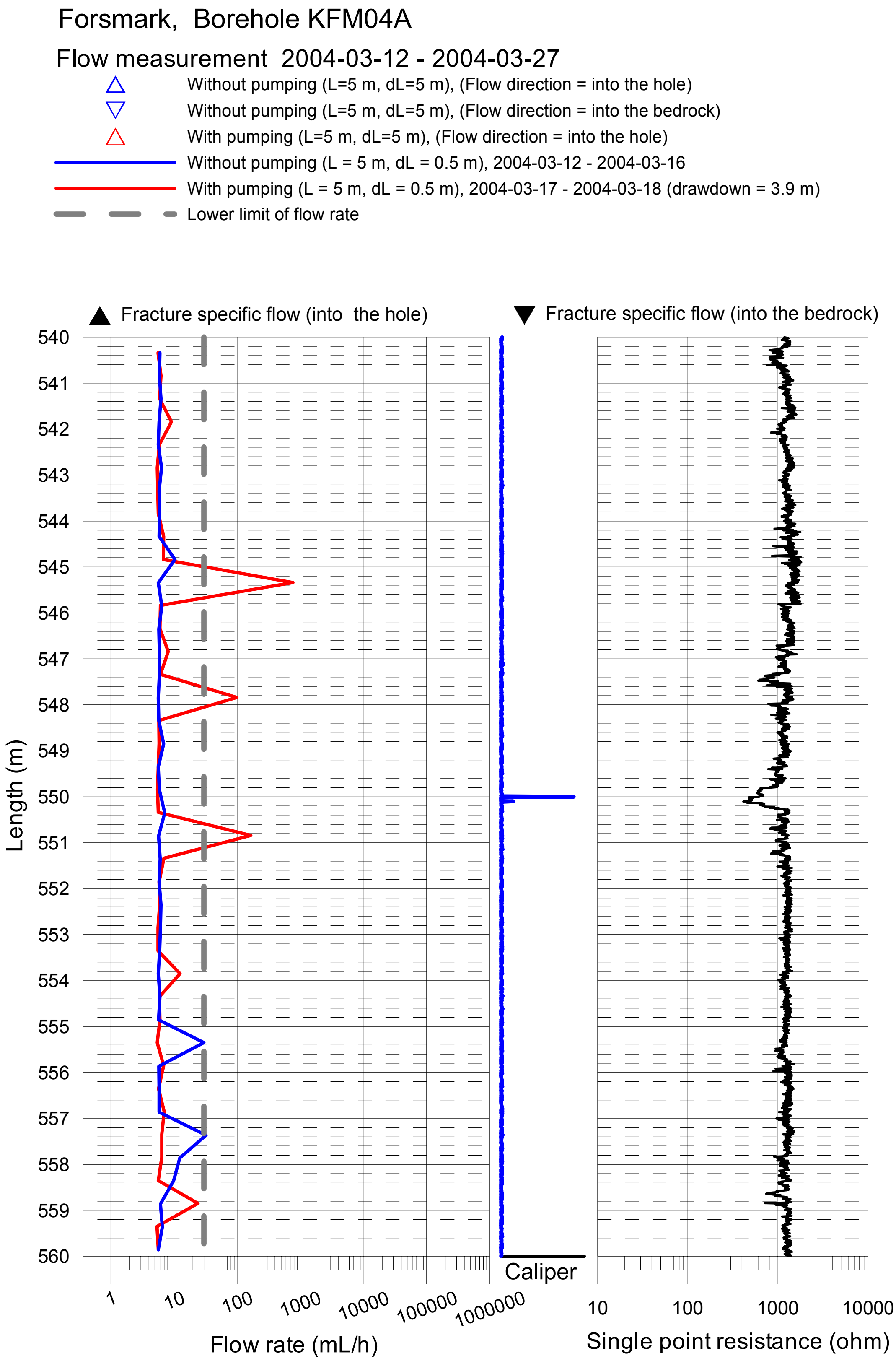
Appendix 3.20

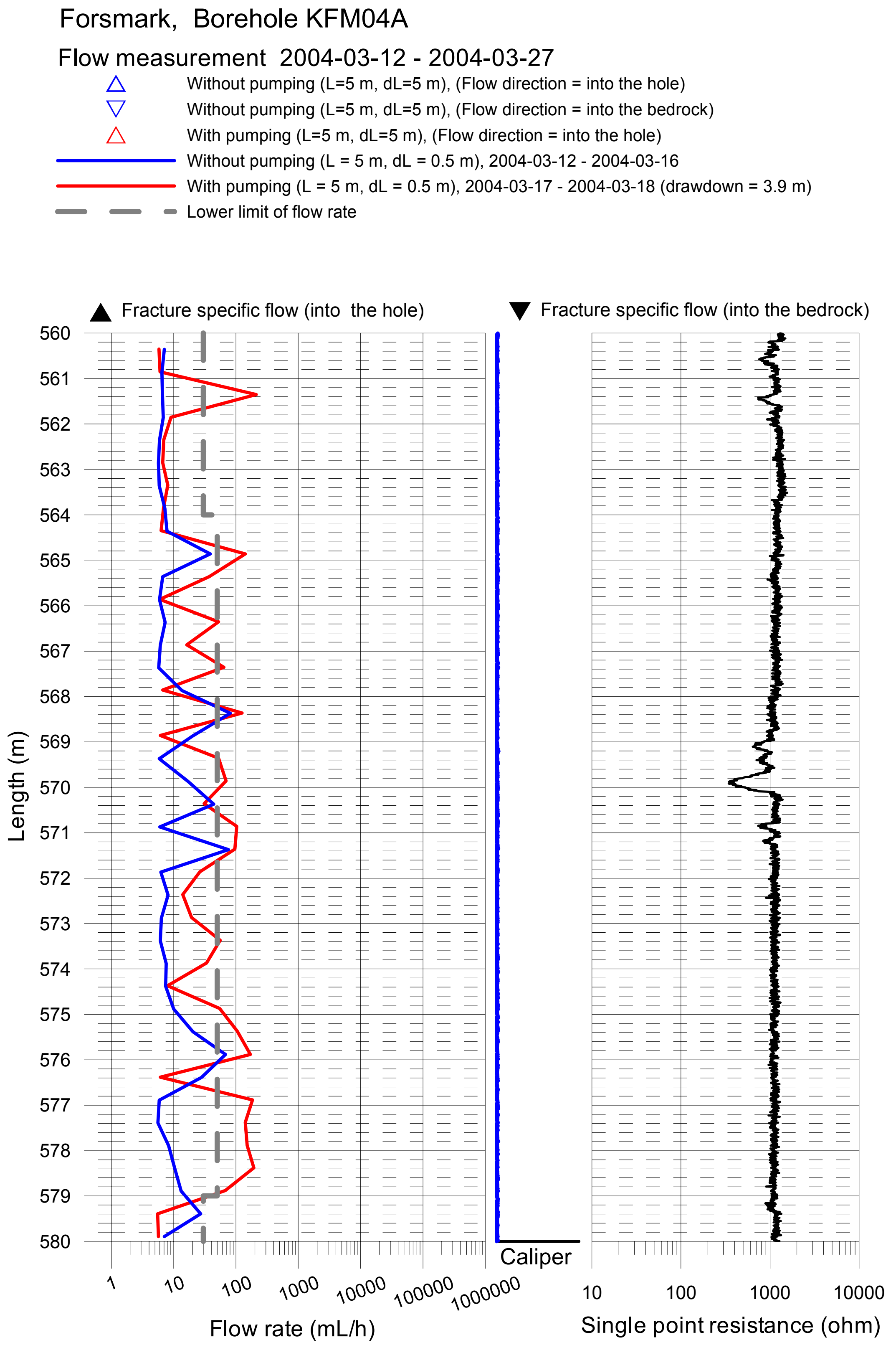


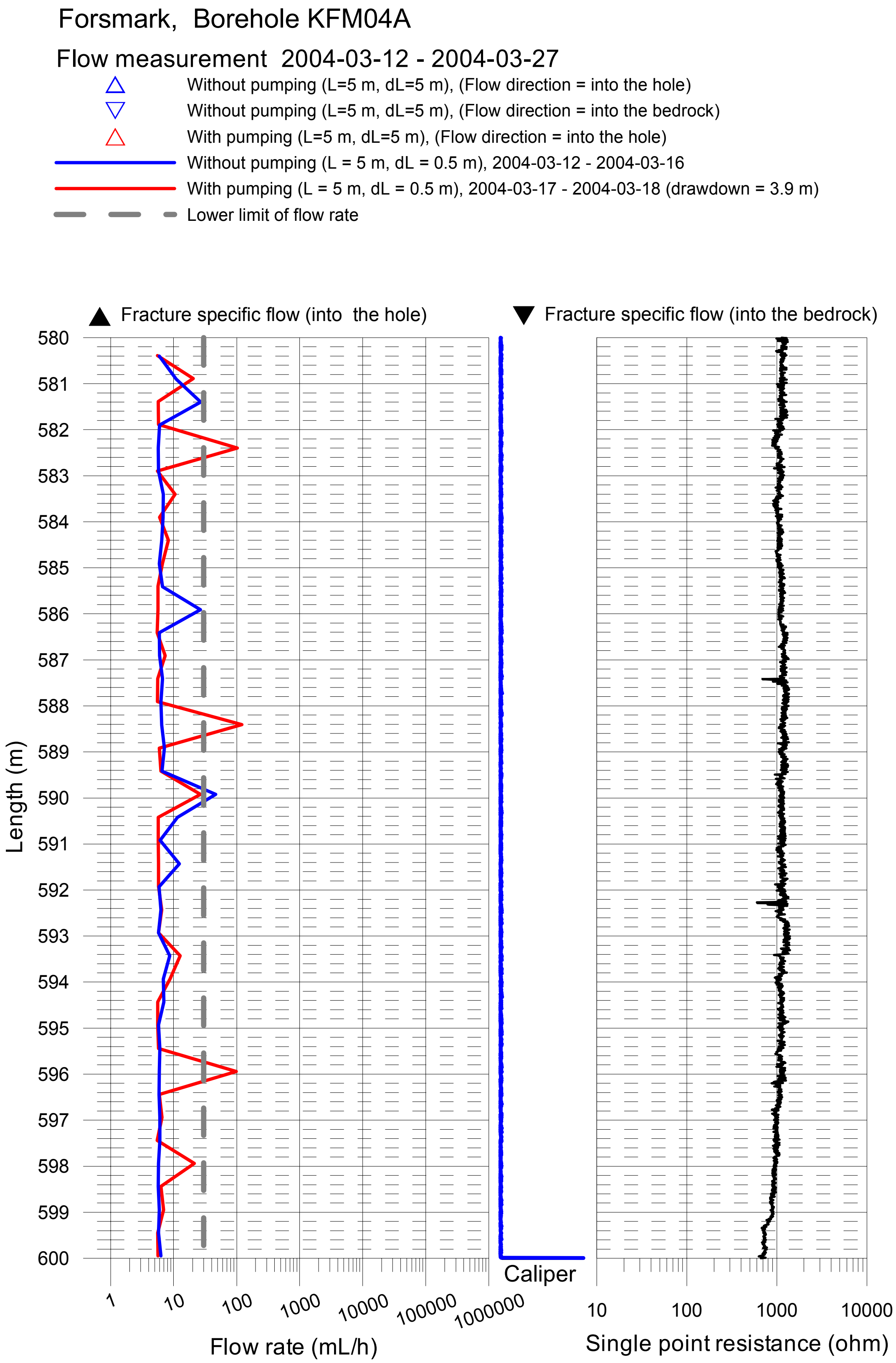


Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-19 - 2004-03-21 (drawdown = 3.9 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
Caliper
10
100
1000
10000
Single point resistance (ohm)


Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-19 - 2004-03-21 (drawdown = 3.9 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
521.5
Caliper
Length (m)
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
10
100
1000
10000
Single point resistance (ohm)

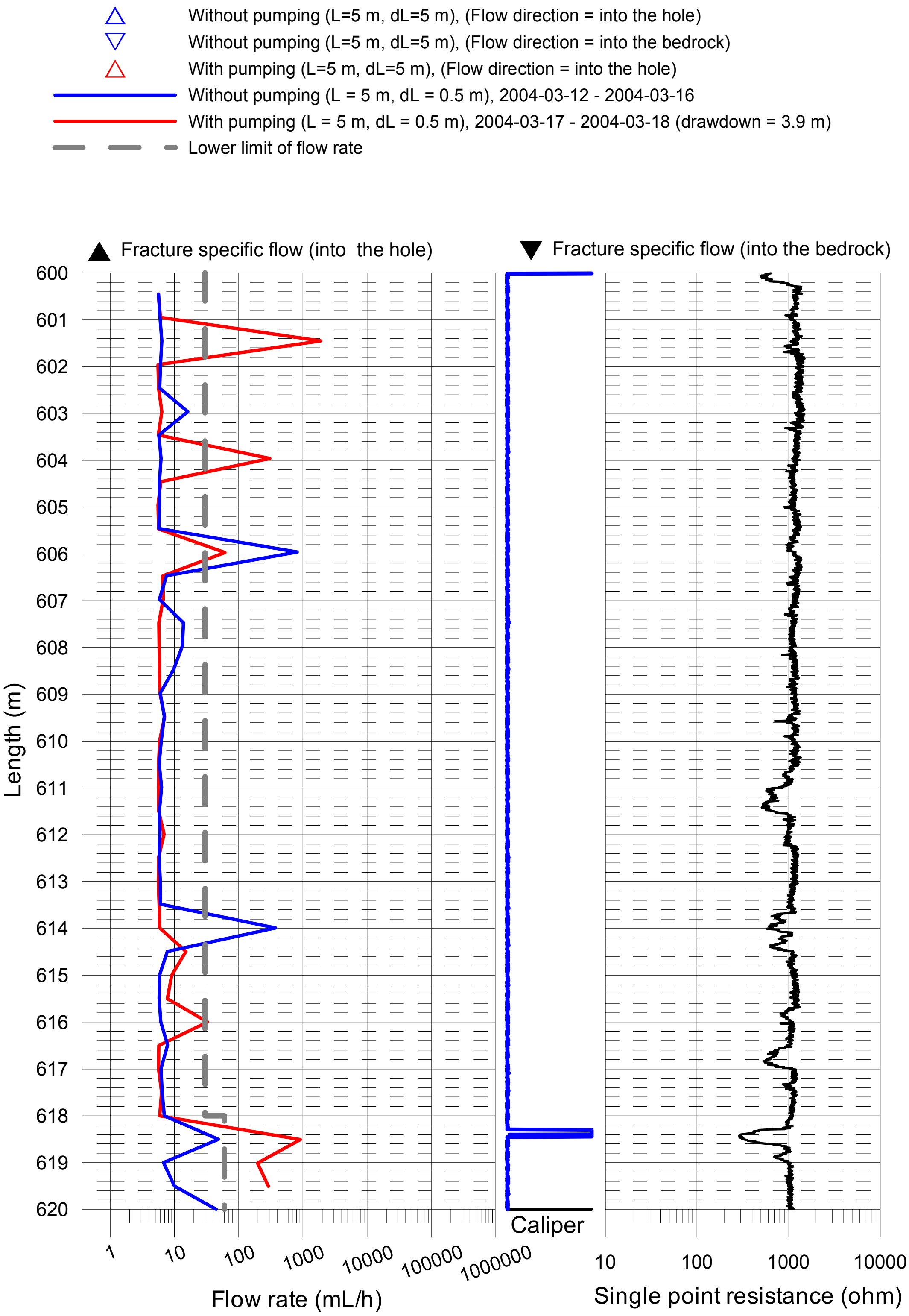

Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
Caliper
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
10
100
1000
10000
Single point resistance (ohm)

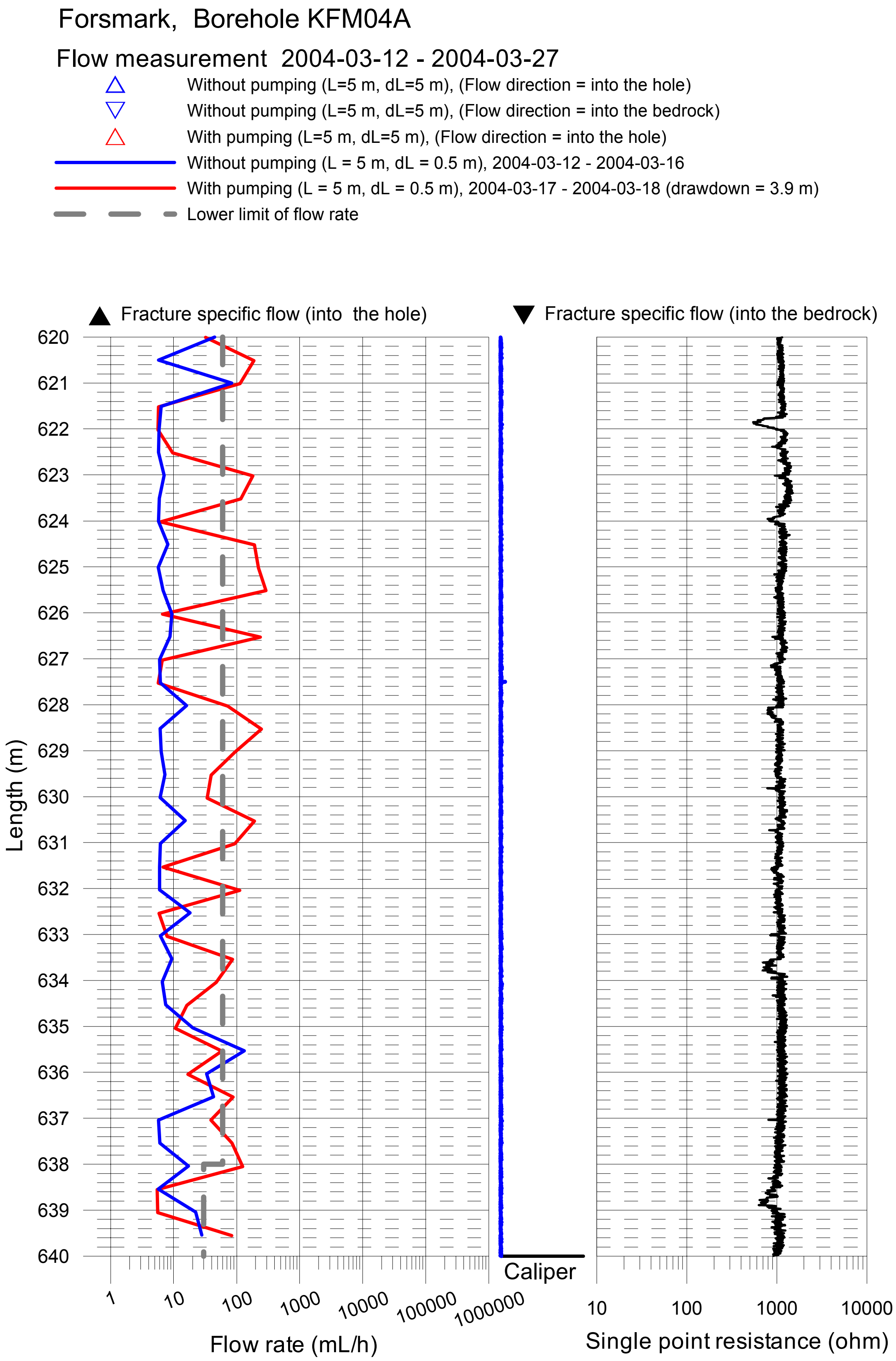

Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
Caliper
10
100
1000
10000
Single point resistance (ohm)


Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
Caliper
10
100
1000
10000
Single point resistance (ohm)

Forsmark, Borehole KFM04A

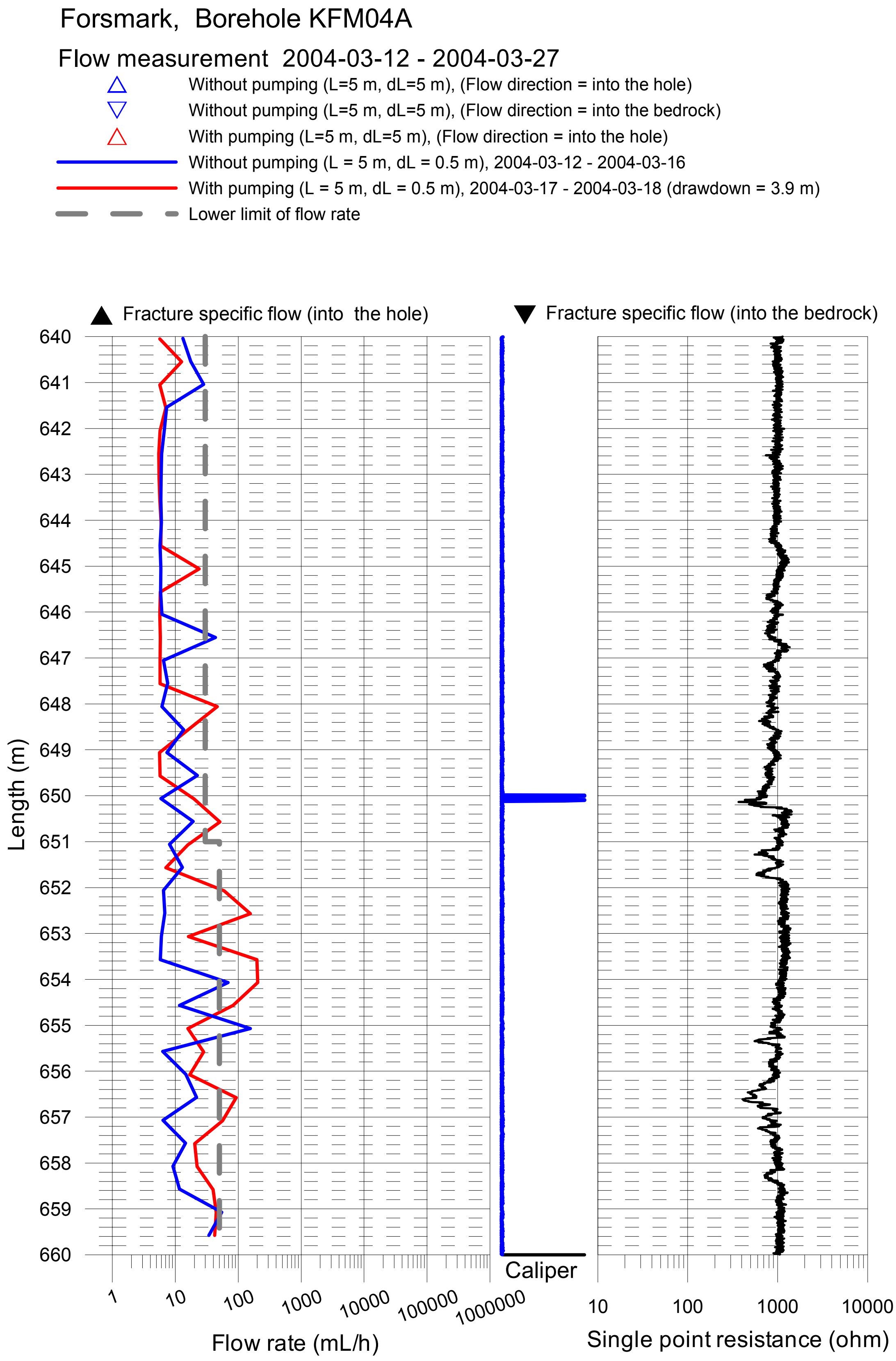
Flow measurement 2004-03-12 - 2004-03-27





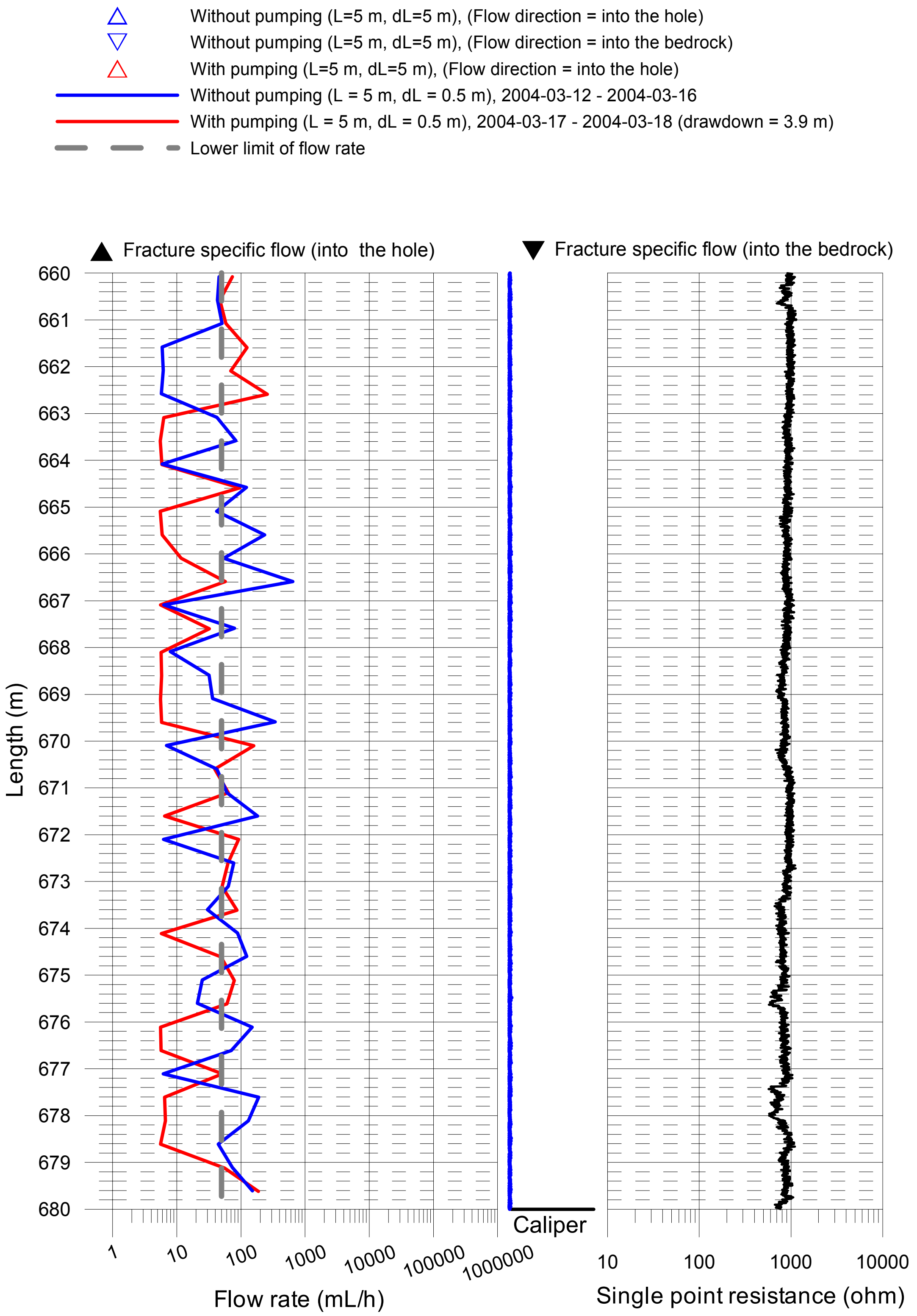
Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
Caliper
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
10
100
1000
10000
Single point resistance (ohm)

Appendix 3.28

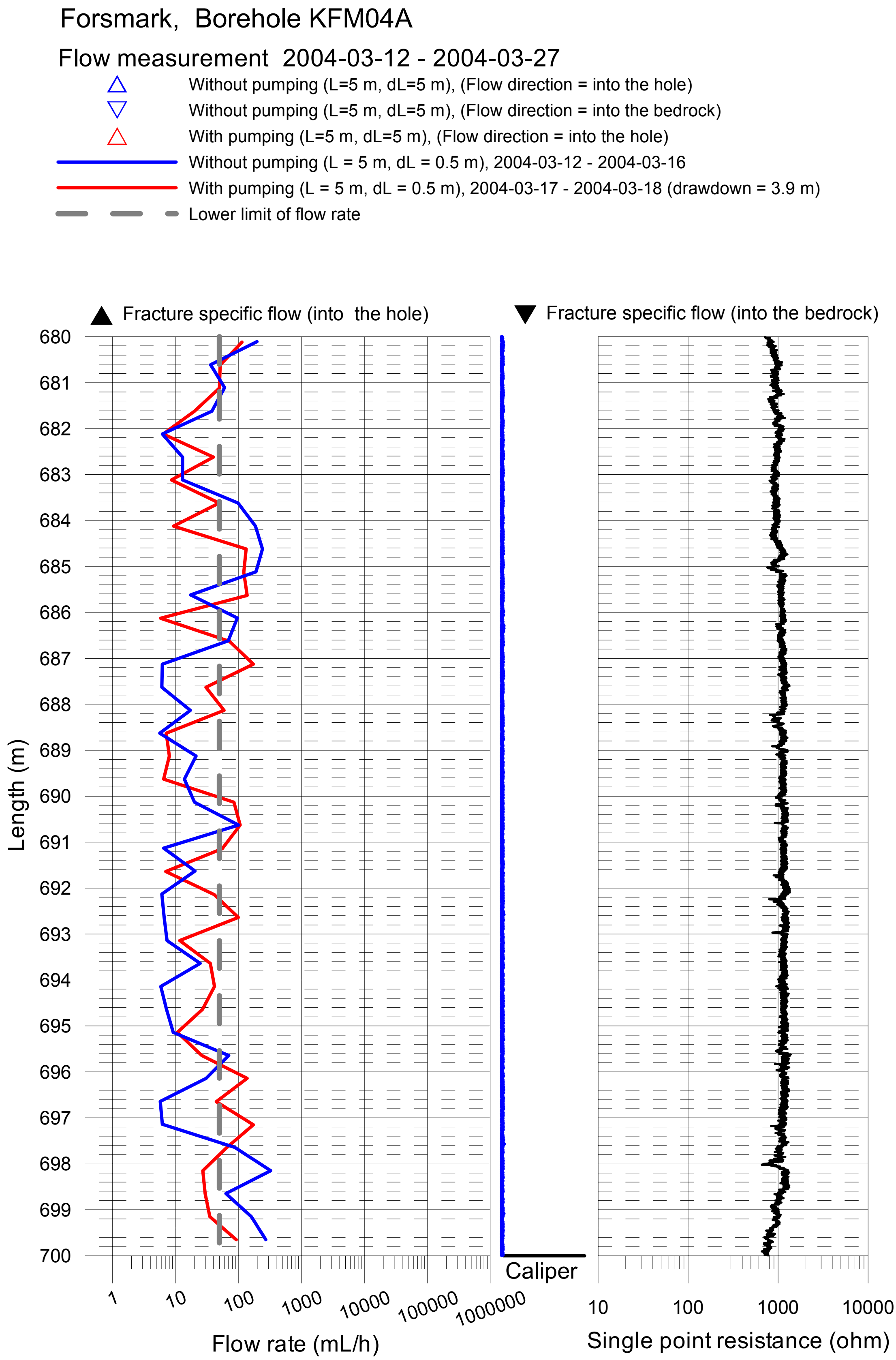


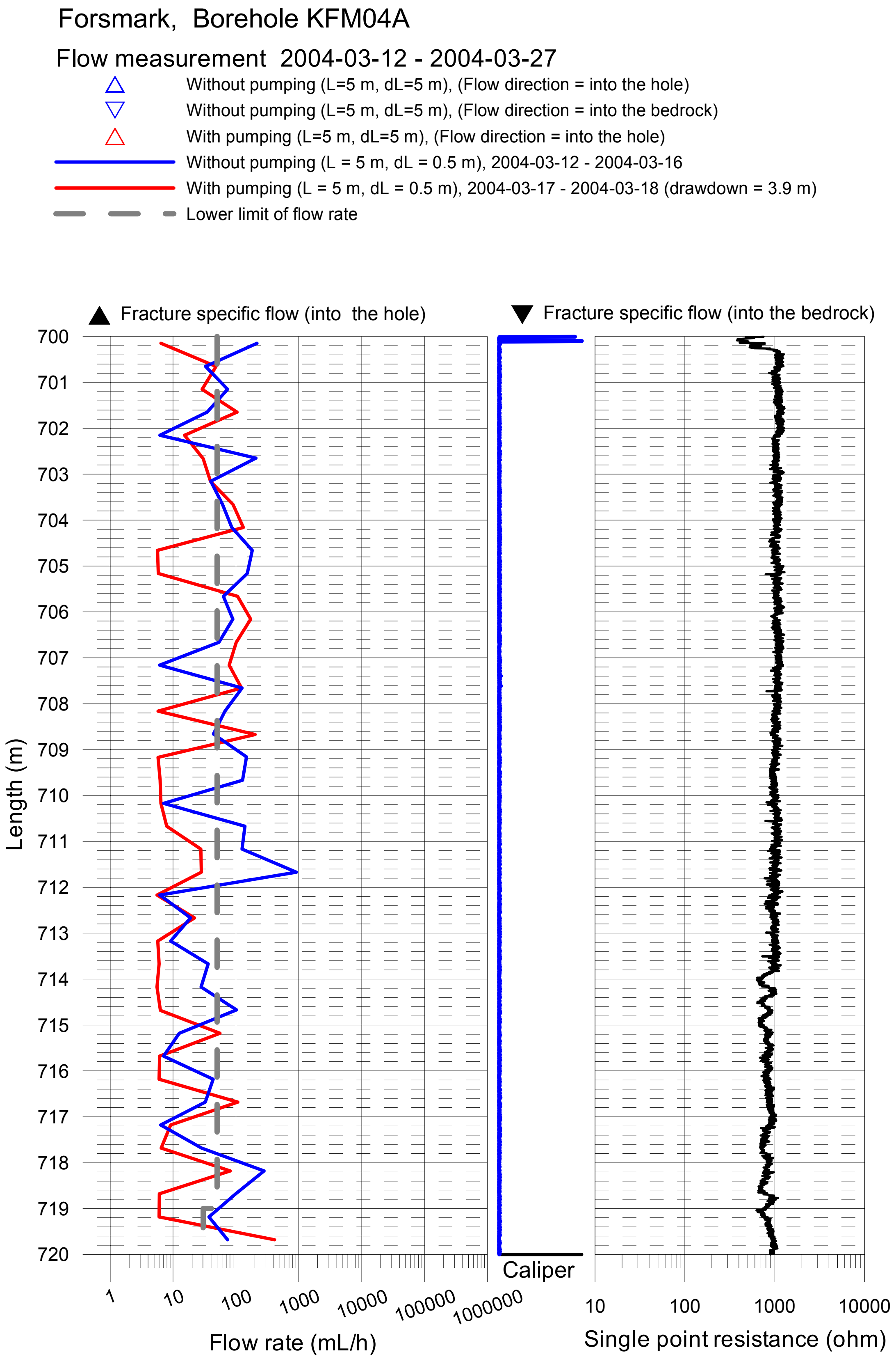
Forsmark, Borehole KFM04A

Flow measurement 2004-03-12 - 2004-03-27



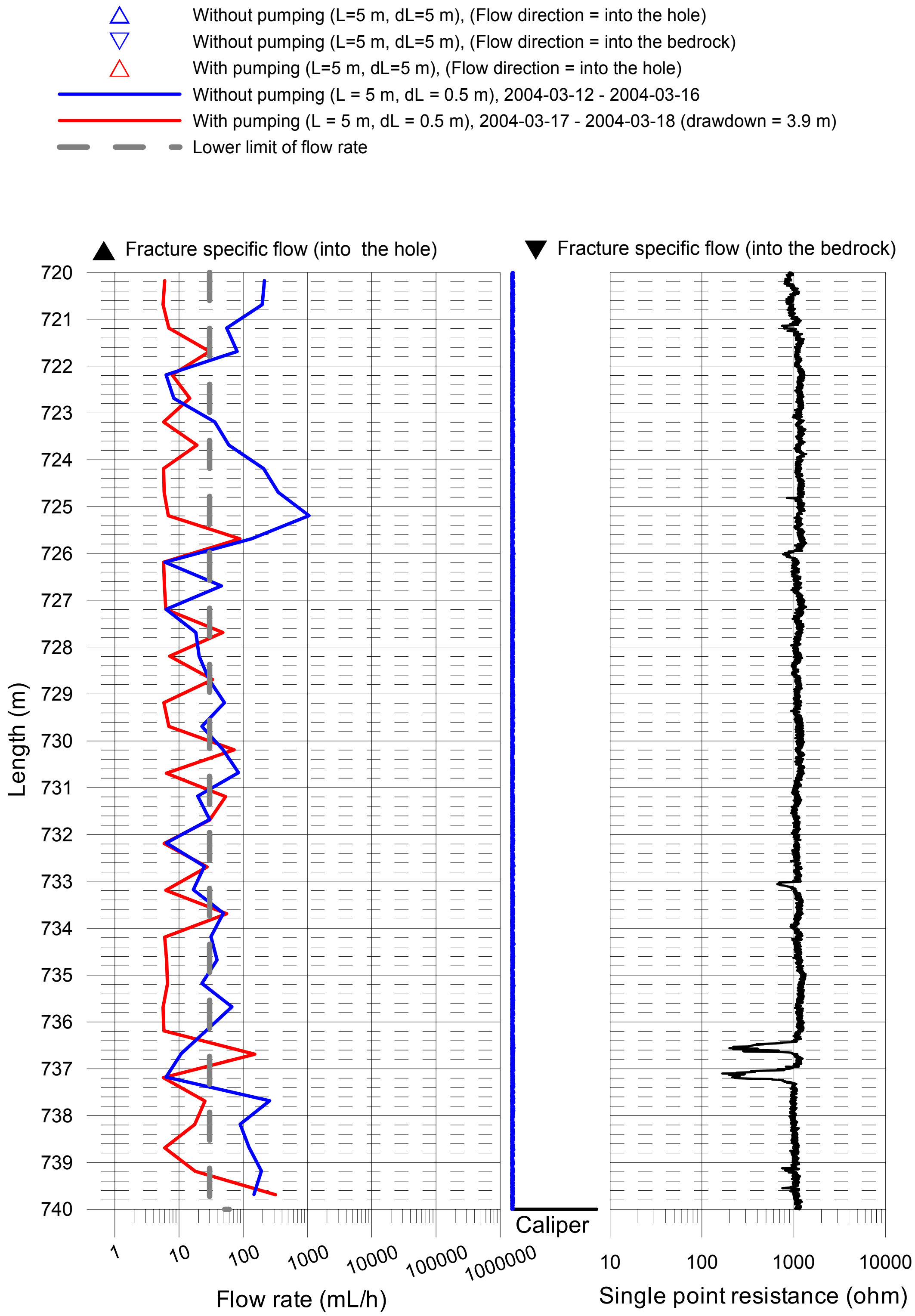
Appendix 3.30

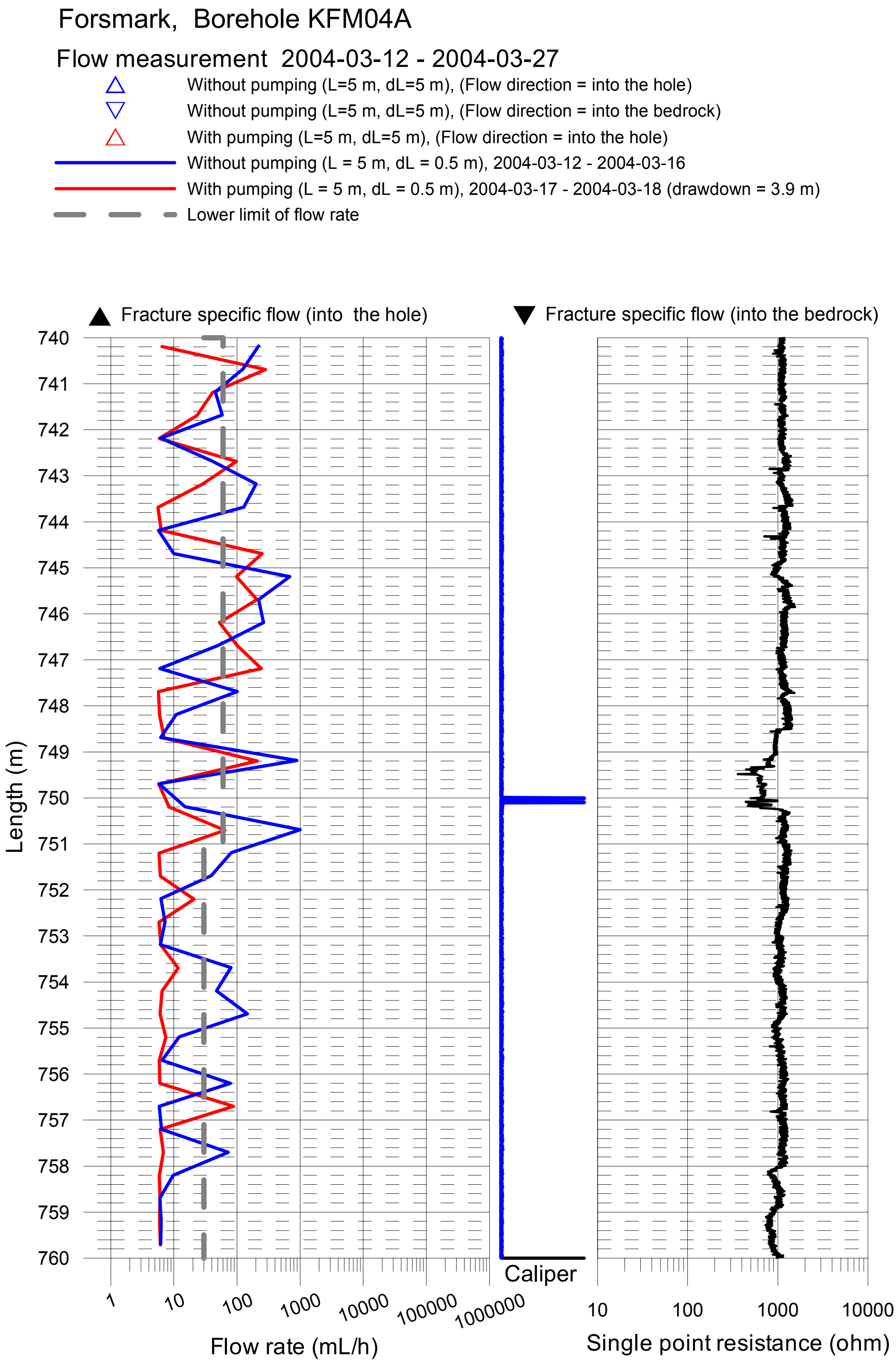


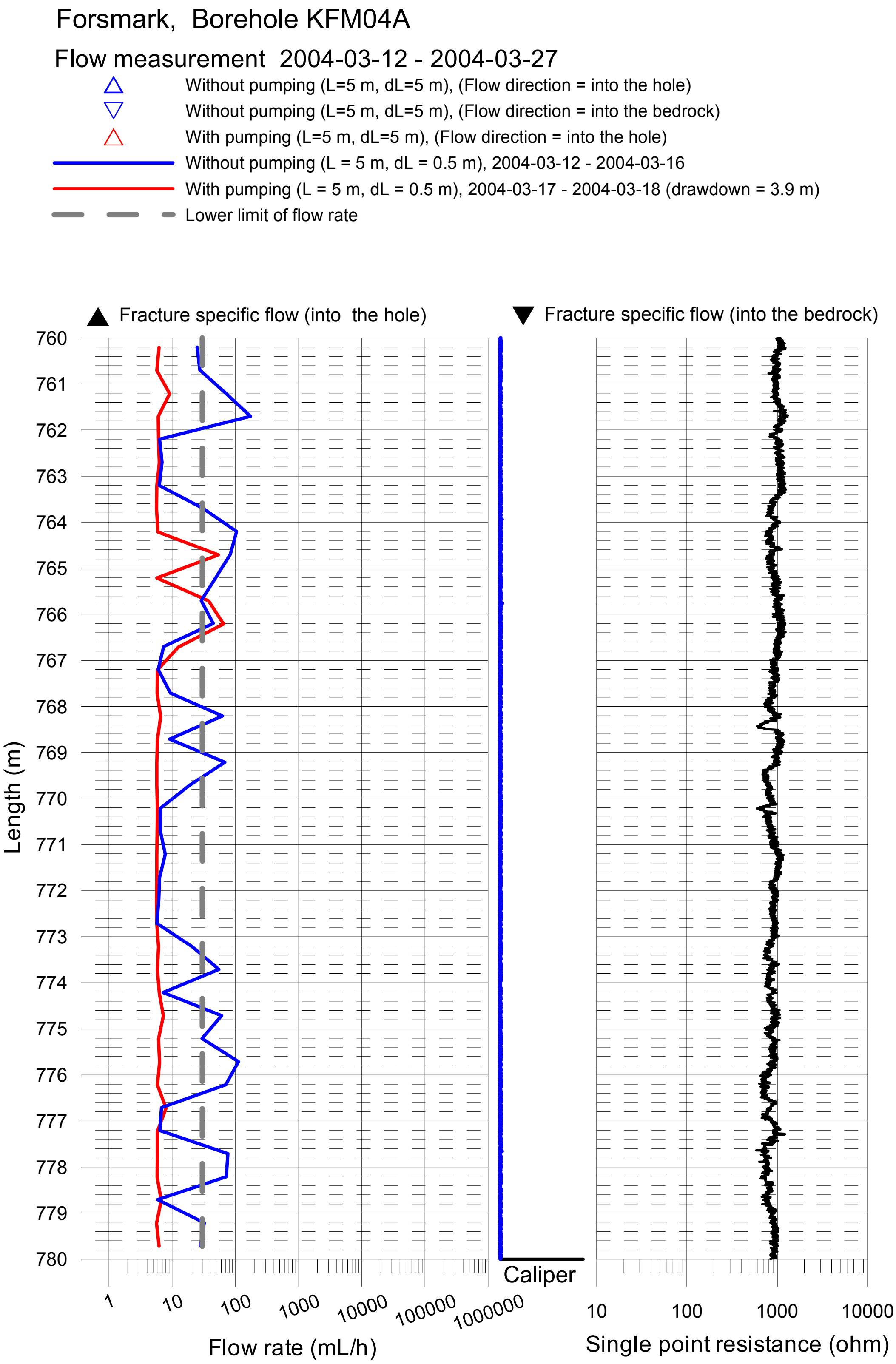

Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
Caliper
10
100
1000
10000
Single point resistance (ohm)

Forsmark, Borehole KFM04A

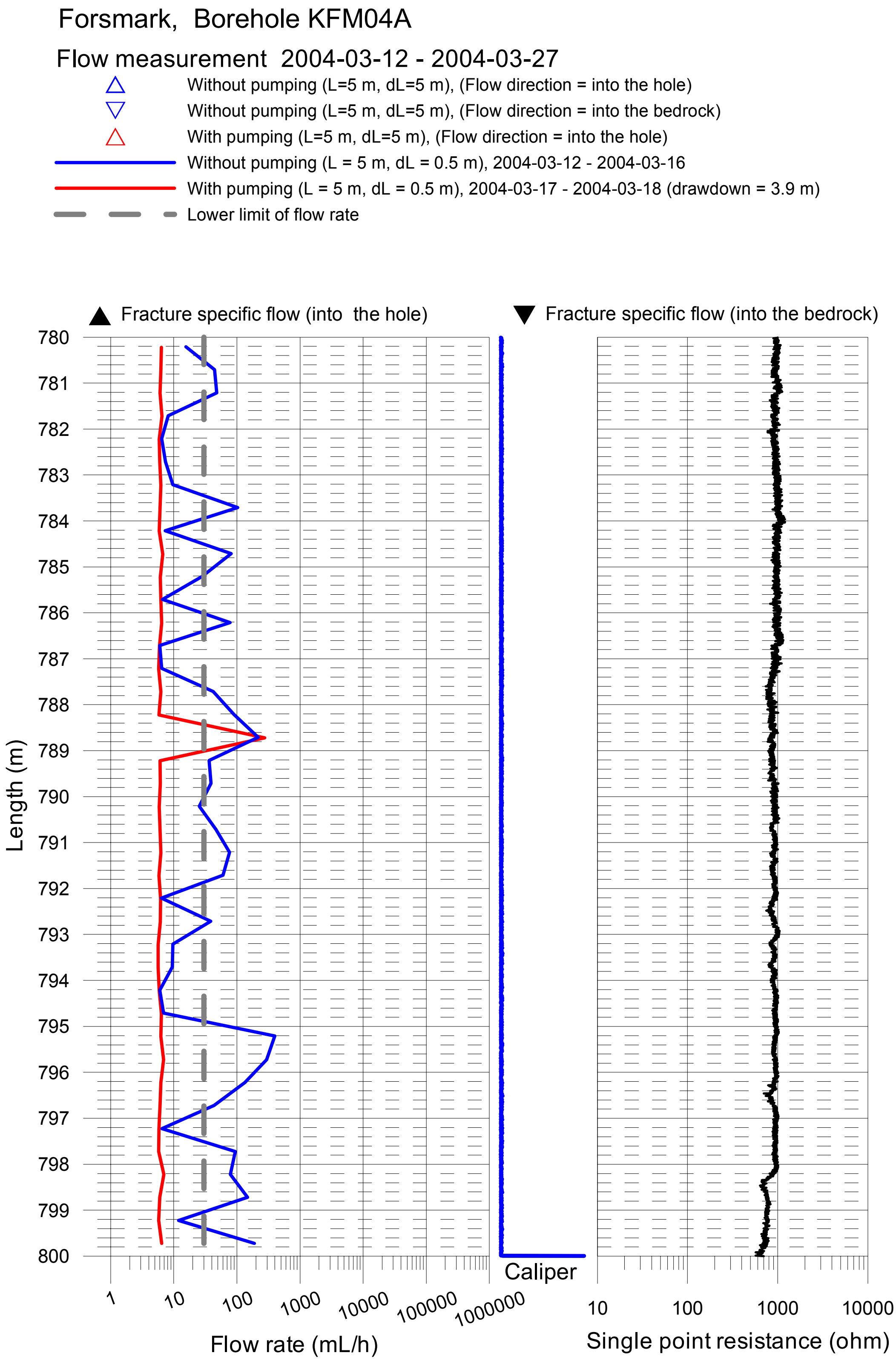
Flow measurement 2004-03-12 - 2004-03-27

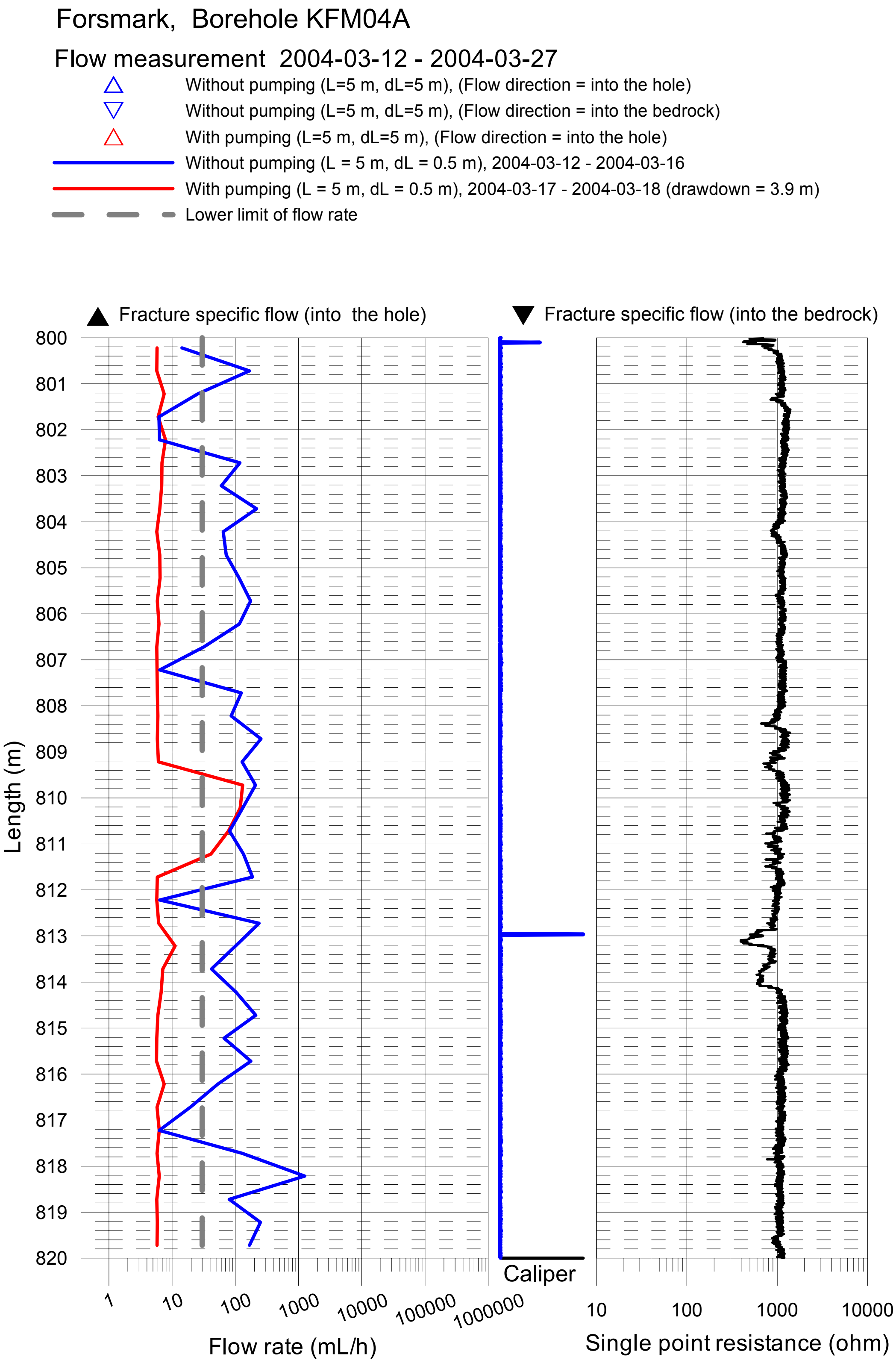


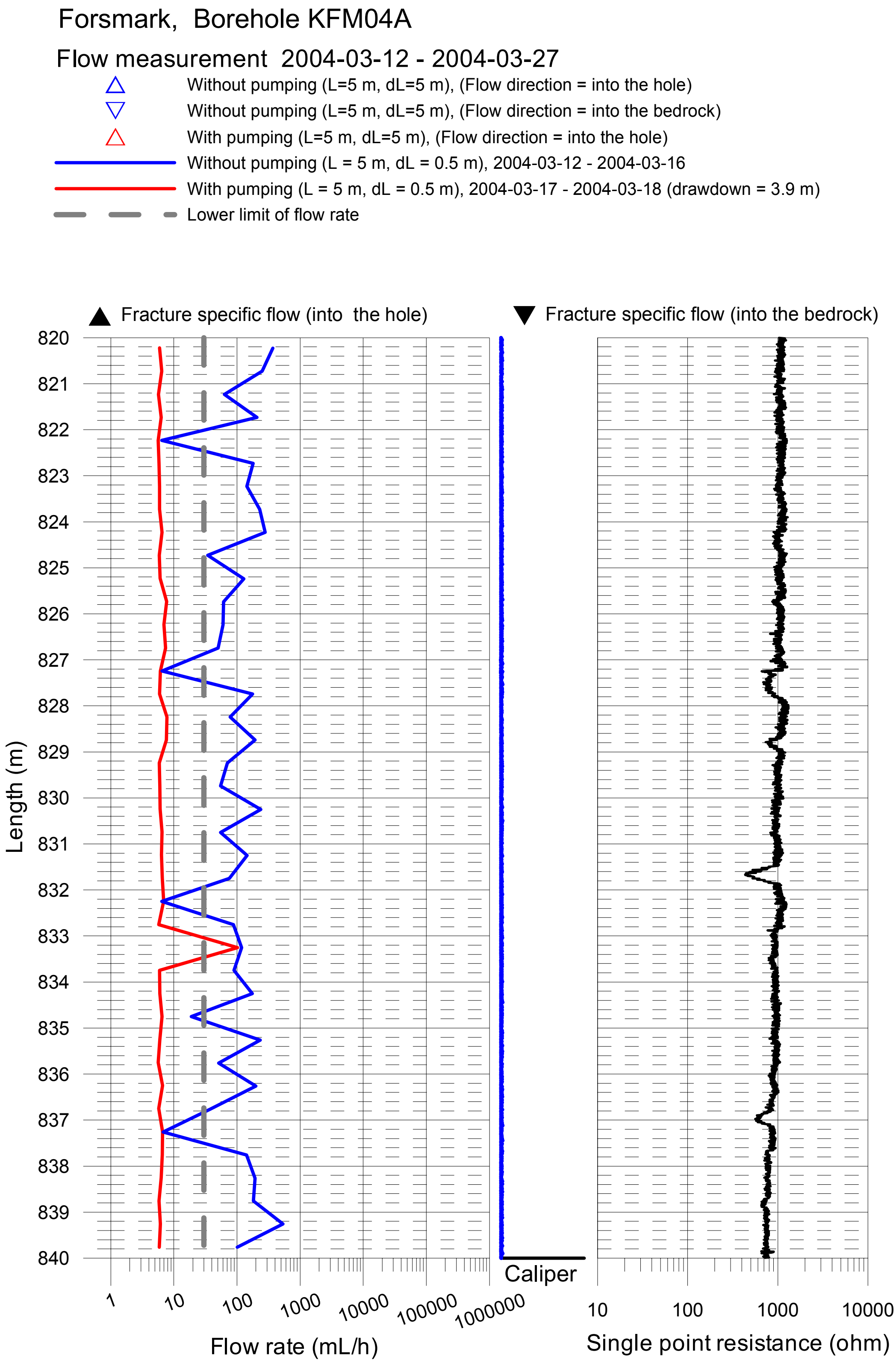

Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
Caliper
10
100
1000
10000
Single point resistance (ohm)



Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
Caliper
10
100
1000
10000
Single point resistance (ohm)

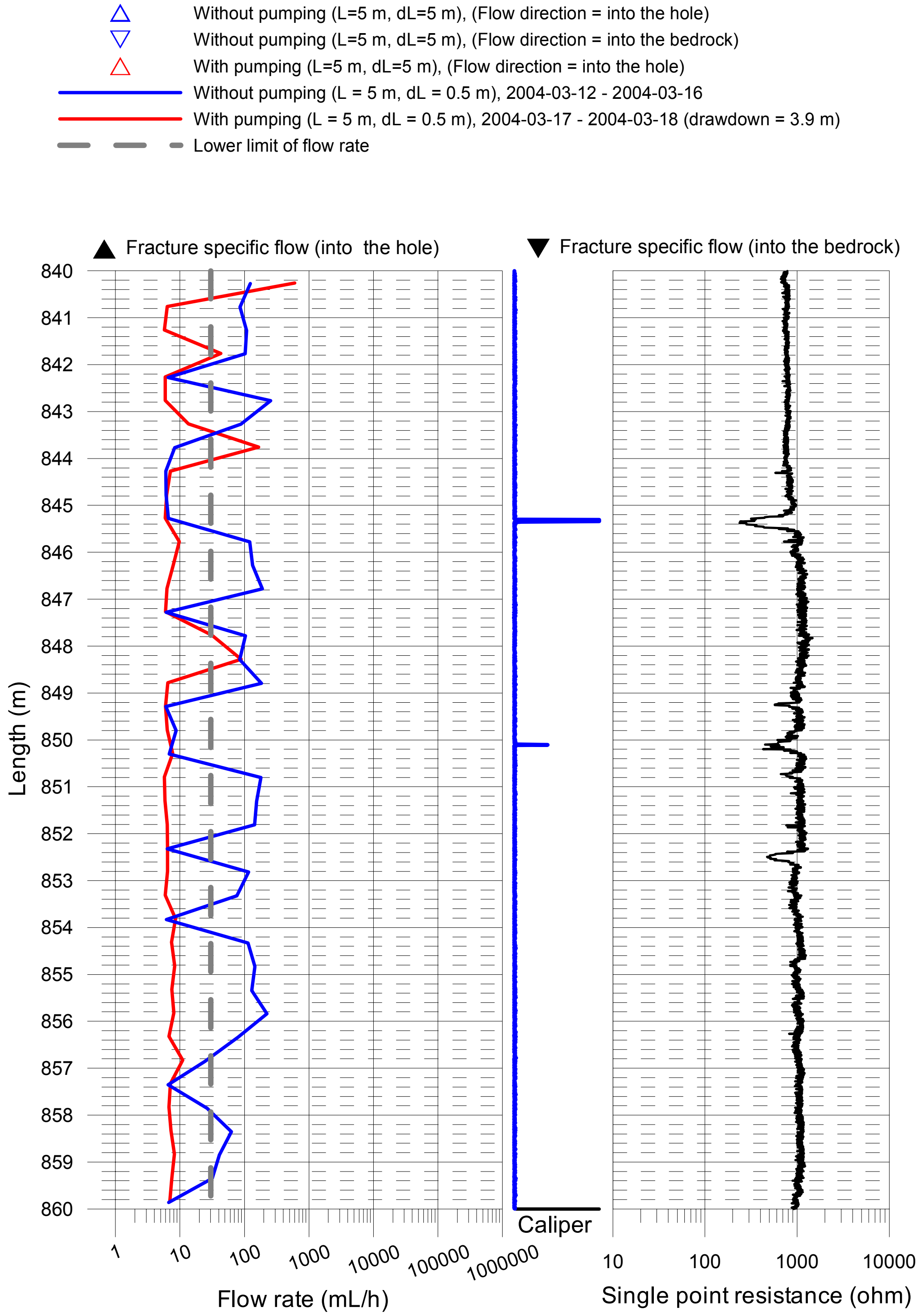

Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
Caliper
10
100
1000
10000
Single point resistance (ohm)

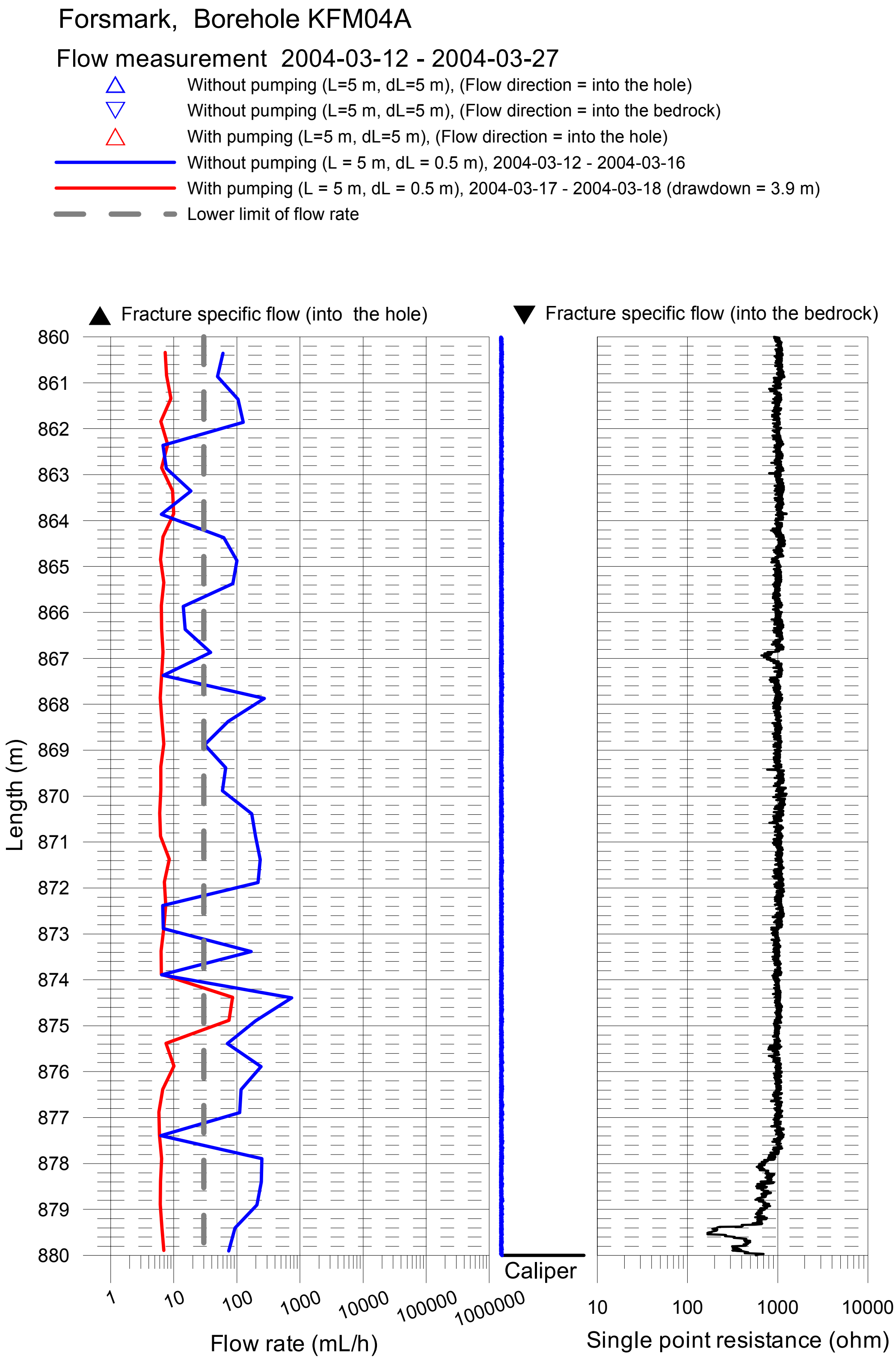

Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
Caliper
10
100
1000
10000
Single point resistance (ohm)


Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
Caliper
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
10
100
1000
10000
Single point resistance (ohm)

Forsmark, Borehole KFM04A

Flow measurement 2004-03-12 - 2004-03-27

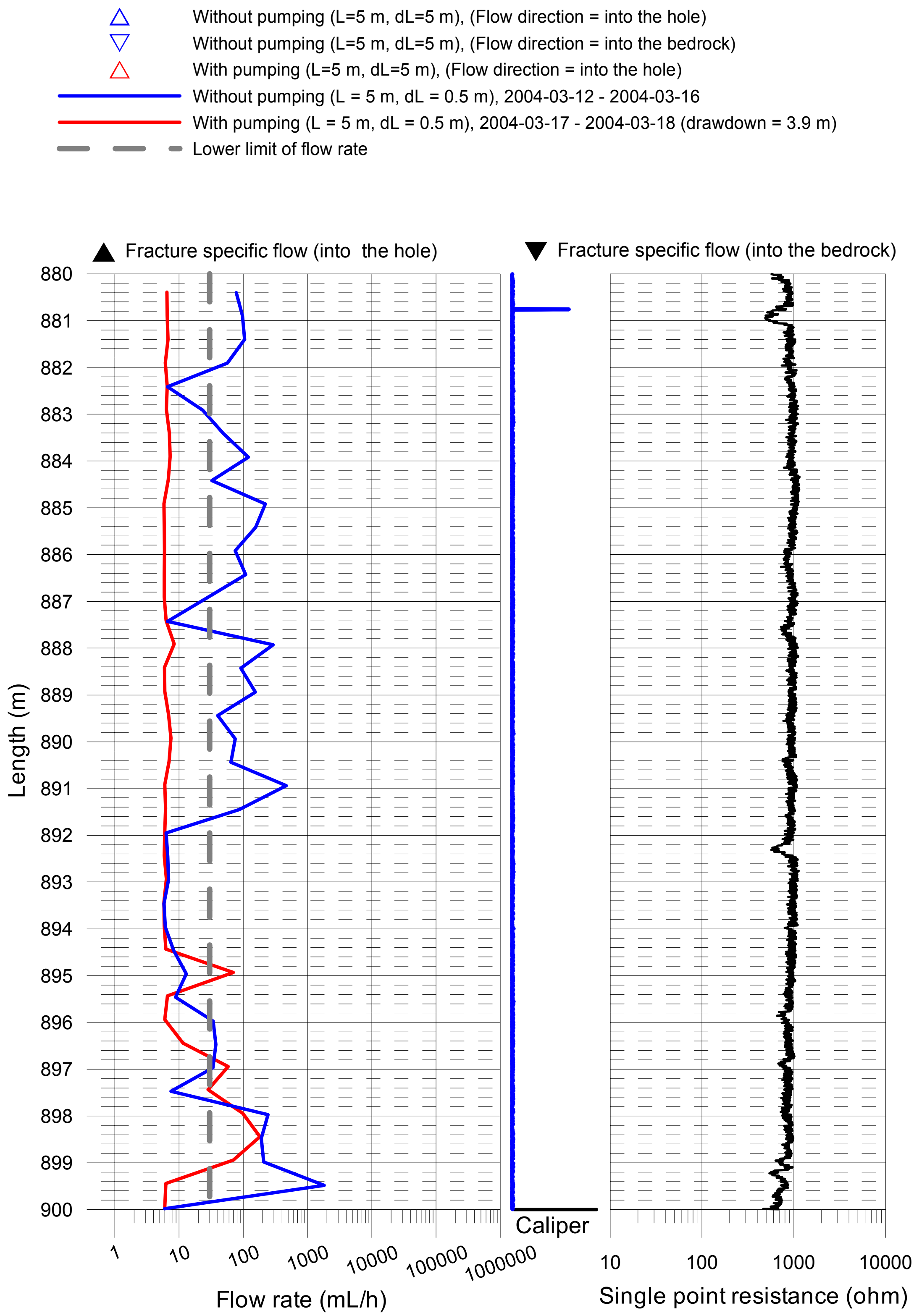


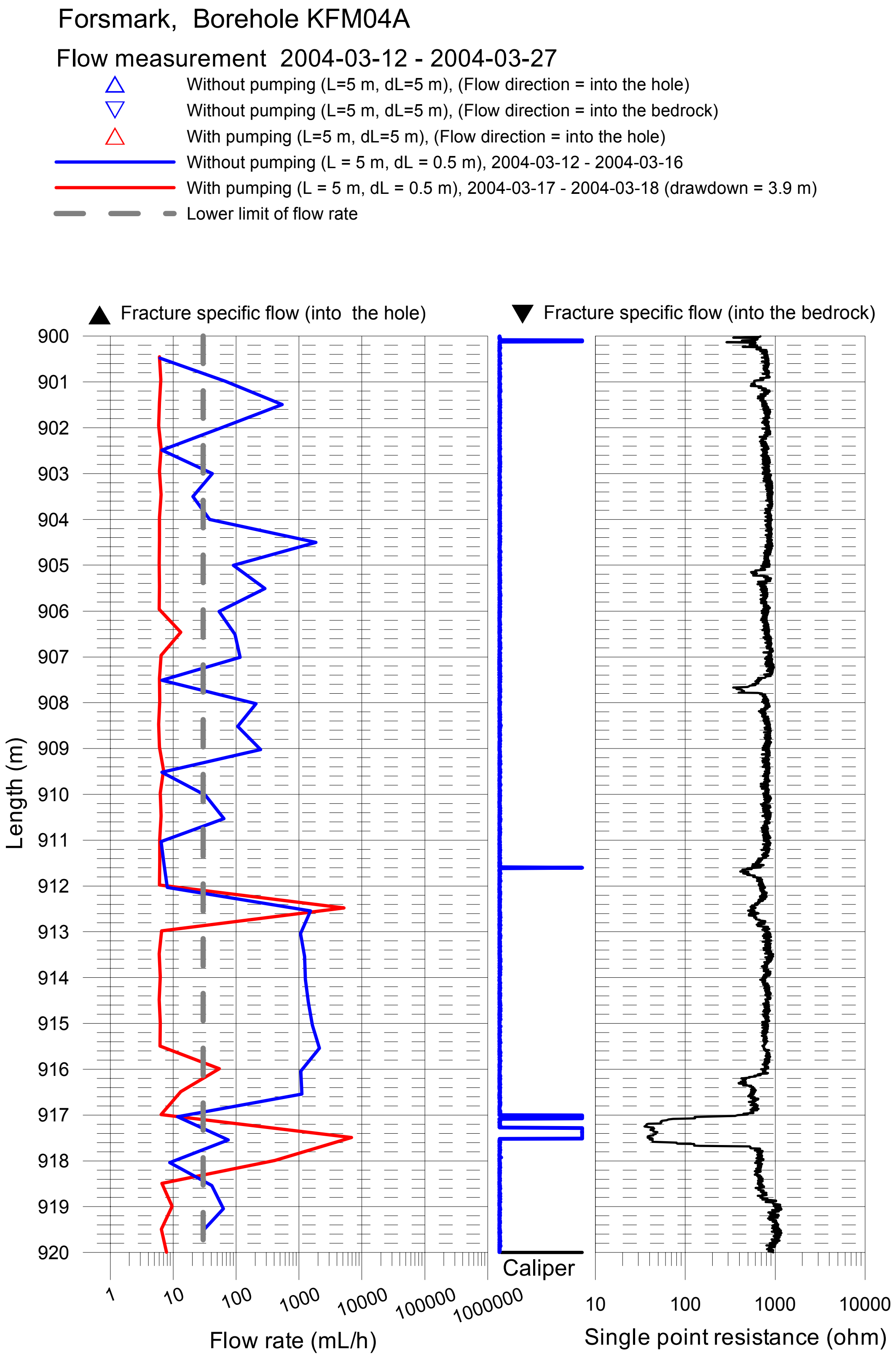


Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
Caliper
10
100
1000
10000
Single point resistance (ohm)

Forsmark, Borehole KFM04A

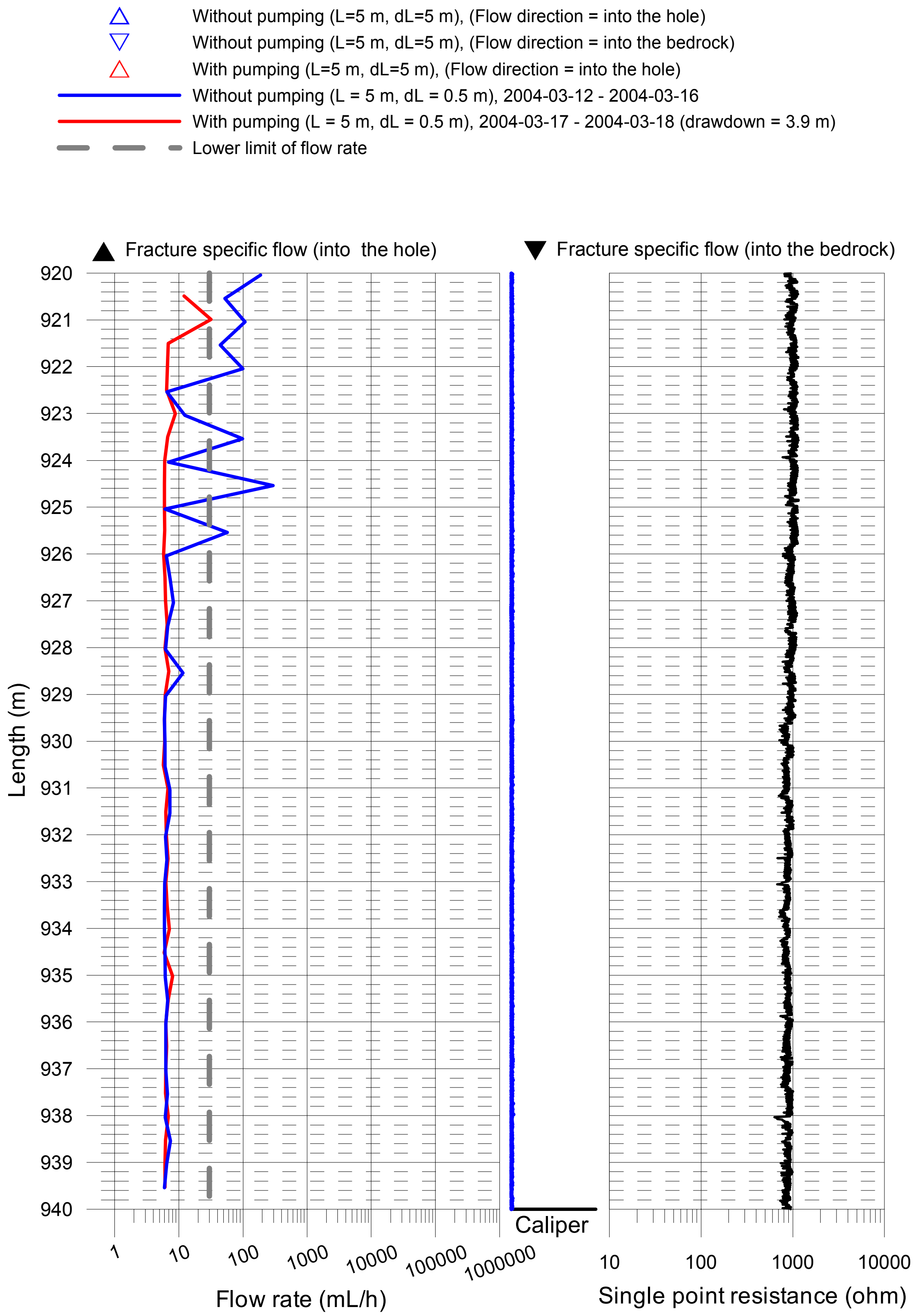
Flow measurement 2004-03-12 - 2004-03-27

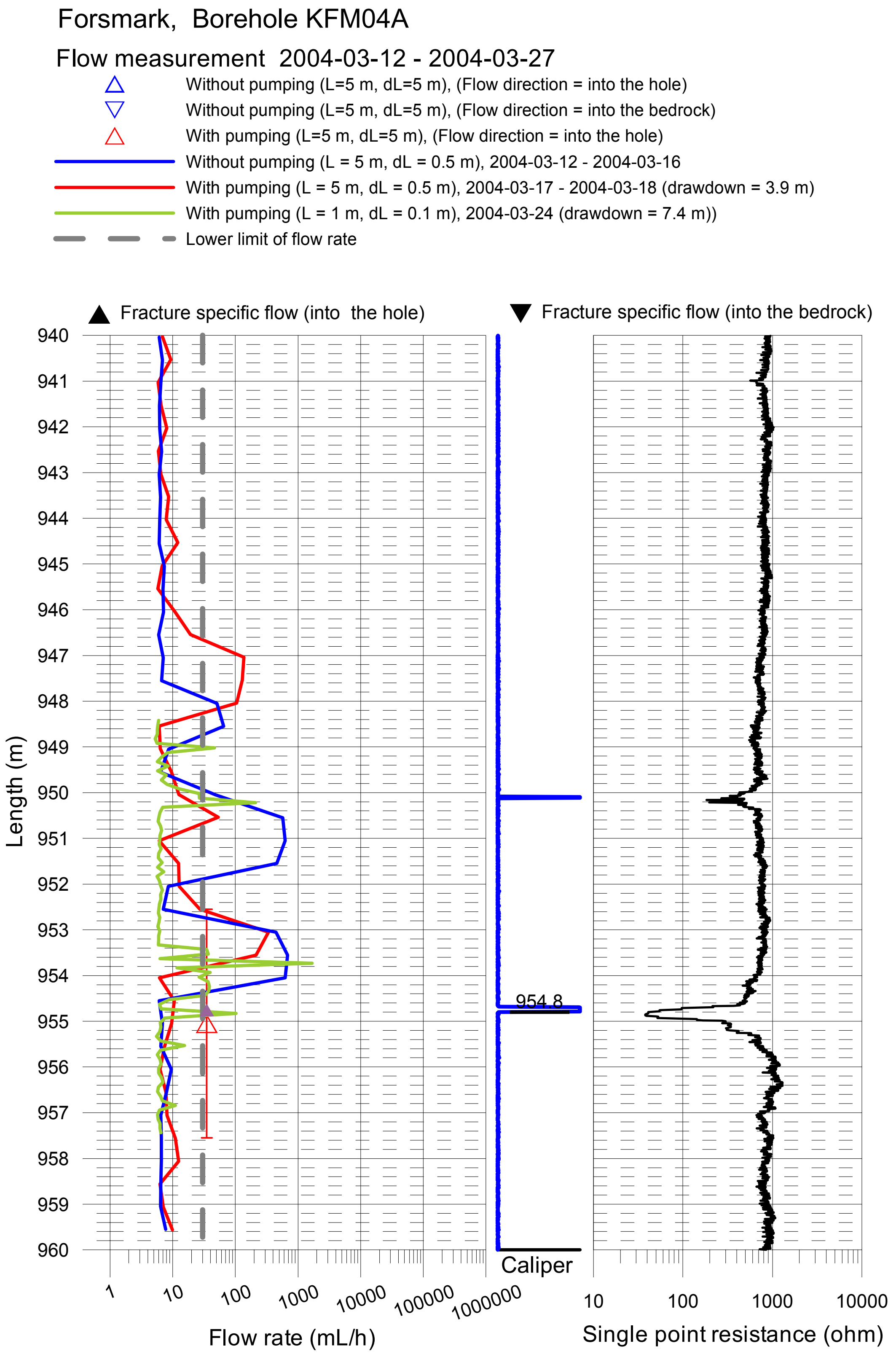


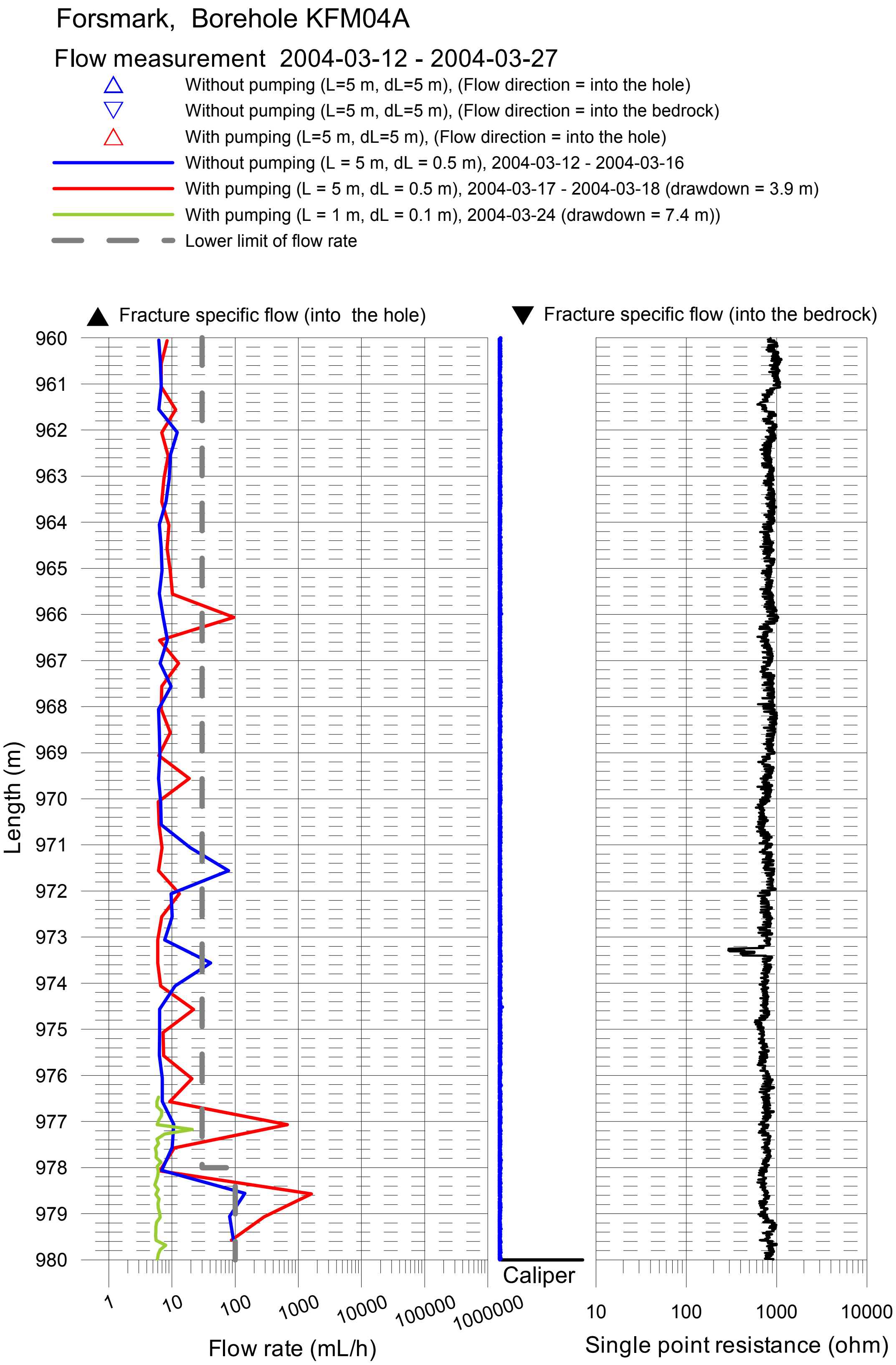

Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
Caliper
10
100
1000
10000
Single point resistance (ohm)

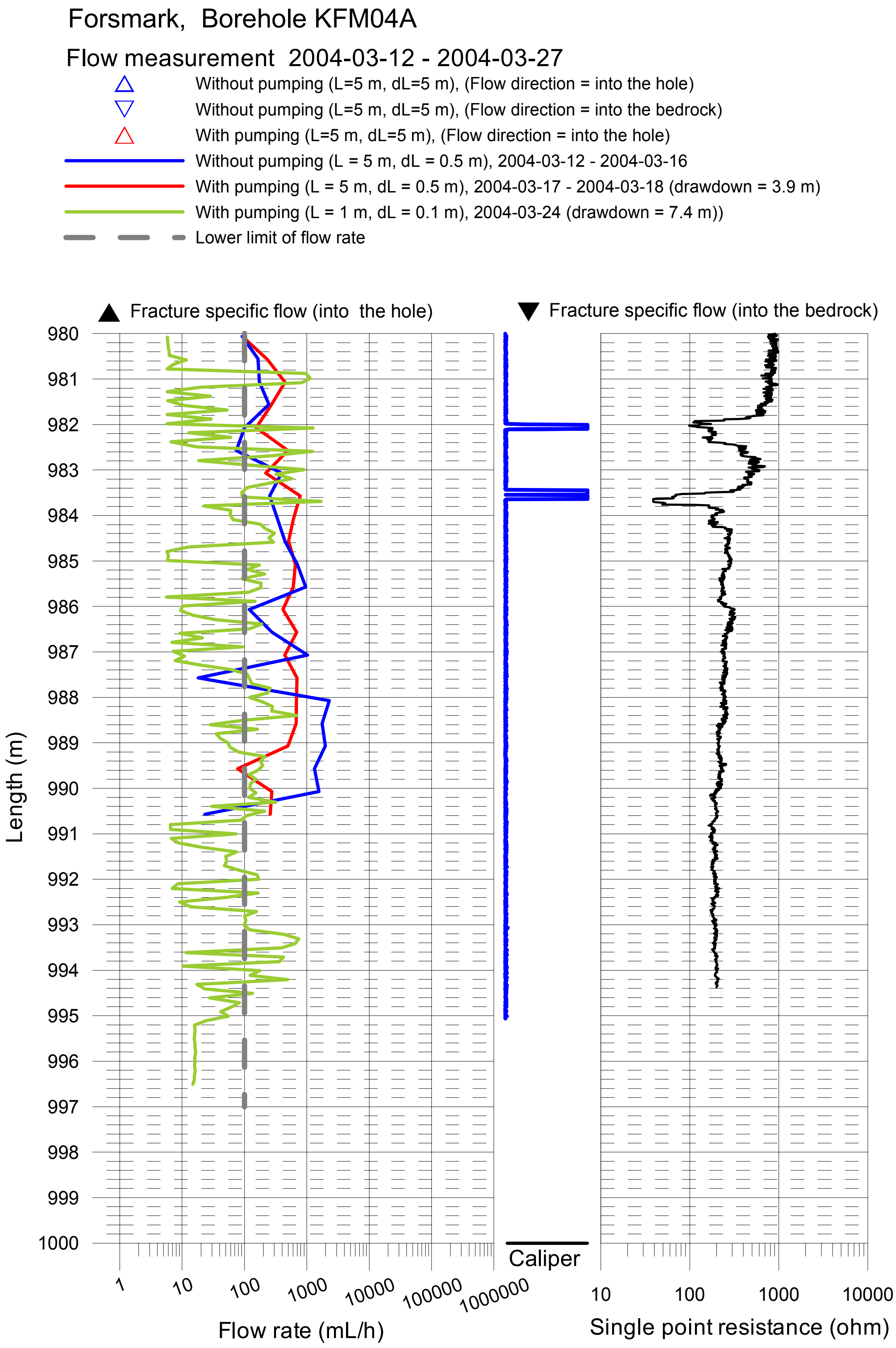
Forsmark, Borehole KFM04A

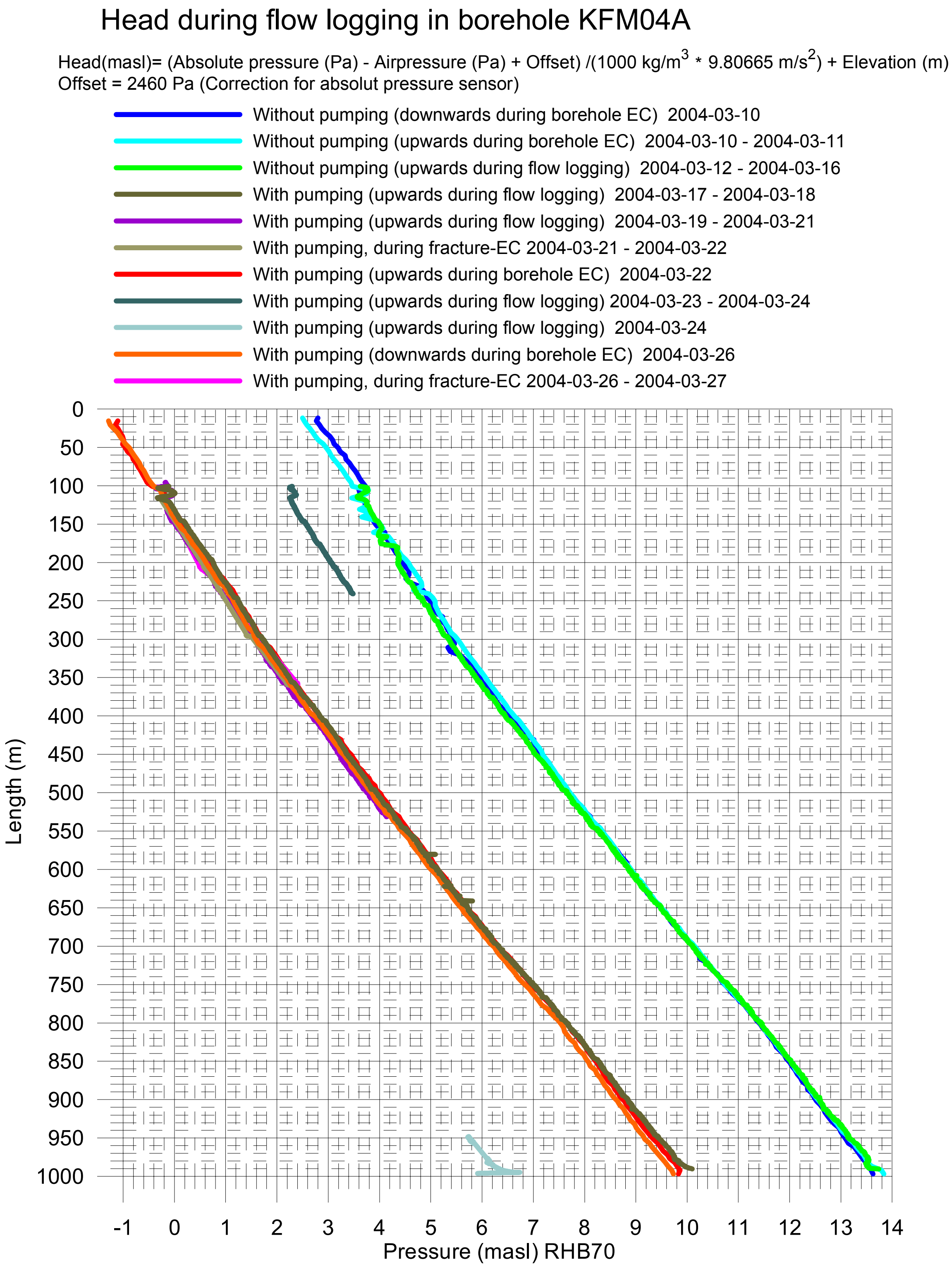
Flow measurement 2004-03-12 - 2004-03-27




Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-24 (drawdown = 7.4 m))
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
954.8
Caliper
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
10
100
1000
10000
Single point resistance (ohm)


Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-24 (drawdown = 7.4 m))
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
Caliper
10
100
1000
10000
Single point resistance (ohm)


Forsmark, Borehole KFM04A
Flow measurement 2004-03-12 - 2004-03-27
Without pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L=5 m, dL=5 m), (Flow direction = into the bedrock)
With pumping (L=5 m, dL=5 m), (Flow direction = into the hole)
Without pumping (L = 5 m, dL = 0.5 m), 2004-03-12 - 2004-03-16
With pumping (L = 5 m, dL = 0.5 m), 2004-03-17 - 2004-03-18 (drawdown = 3.9 m)
With pumping (L = 1 m, dL = 0.1 m), 2004-03-24 (drawdown = 7.4 m))
Lower limit of flow rate
Fracture specific flow (into the hole)
Fracture specific flow (into the bedrock)
Length (m)
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000
1
10
100
1000
10000
100000
1000000
Flow rate (mL/h)
Caliper
10
100
1000
10000
Single point resistance (ohm)


Head during flow logging in borehole KFM04A
Head(masl)= (Absolute pressure (Pa) - Airpressure (Pa) + Offset) /(1000 kg/m3 * 9.80665 m/s2) + Elevation (m)
Offset = 2460 Pa (Correction for absolut pressure sensor)
Without pumping (downwards during borehole EC) 2004-03-10
Without pumping (upwards during borehole EC) 2004-03-10 - 2004-03-11
Without pumping (upwards during flow logging) 2004-03-12 - 2004-03-16
With pumping (upwards during flow logging) 2004-03-17 - 2004-03-18
With pumping (upwards during flow logging) 2004-03-19 - 2004-03-21
With pumping, during fracture-EC 2004-03-21 - 2004-03-22
With pumping (upwards during borehole EC) 2004-03-22
With pumping (upwards during flow logging) 2004-03-23 - 2004-03-24
With pumping (upwards during flow logging) 2004-03-24
With pumping (downwards during borehole EC) 2004-03-26
With pumping, during fracture-EC 2004-03-26 - 2004-03-27
Length (m)
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
-1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Pressure (masl) RHB70

Appendix 5.1

Secup1 (m)	Borehole Head1 (masl)	Flow1 (mL/h)	Secup2 (m)	Borehole Head2 (masl)	Flow2 (mL/h)	Section Head (masl)	T_S (m^2/s)	Q-lower limit Practical (mL/h)	T_S-Lower Limit Theoretical (m^2/s)	T_S-Lower Limit Practical (m^2/s)	T_S-Upper Limit (m^2/s)
987.57	13.54	0	987.57	10.10	0	-	-	100	4.79E-10	7.99E-09	2.40E-05
982.57	13.51	0	982.57	9.93	0	-	-	100	4.60E-10	7.67E-09	2.30E-05
977.56	13.55	0	977.57	9.83	0	-	-	30	4.43E-10	2.22E-09	2.22E-05
972.56	13.53	0	972.56	9.74	0	-	-	30	4.35E-10	2.18E-09	2.18E-05
967.56	13.47	0	967.56	9.72	0	-	-	30	4.40E-10	2.20E-09	2.20E-05
962.55	13.39	0	962.56	9.65	0	-	-	30	4.41E-10	2.20E-09	2.20E-05
957.55	13.35	0	957.56	9.58	0	-	-	30	4.37E-10	2.19E-09	2.19E-05
952.55	13.26	0	952.55	5.80	35	-	1.29E-09 **	30	2.21E-10	1.11E-09	2.19E-05
947.55	13.16	0	947.54	9.45	0	-	-	30	4.44E-10	2.22E-09	2.22E-05
942.54	13.13	0	942.53	9.38	0	-	-	30	4.39E-10	2.20E-09	2.20E-05
937.54	13.08	0	937.52	9.31	0	-	-	30	4.37E-10	2.19E-09	2.19E-05
932.54	13.03	0	932.51	9.26	0	-	-	30	4.37E-10	2.19E-09	2.19E-05
927.54	12.96	0	927.51	9.21	0	-	-	30	4.39E-10	2.19E-09	2.19E-05
922.54	12.86	0	922.50	9.14	0	-	-	30	4.43E-10	2.22E-09	2.22E-05
917.54	12.79	0	917.49	9.07	0	-	-	30	4.44E-10	2.22E-09	2.22E-05
912.54	12.75	0	912.48	9.02	0	-	-	30	4.41E-10	2.21E-09	2.21E-05
907.51	12.66	0	907.47	8.94	0	-	-	30	4.43E-10	2.22E-09	2.22E-05
902.49	12.63	0	902.45	8.90	0	-	-	30	4.43E-10	2.21E-09	2.21E-05
897.47	12.60	0	897.44	8.85	0	-	-	30	4.39E-10	2.20E-09	2.20E-05
892.45	12.52	0	892.43	8.78	0	-	-	30	4.41E-10	2.20E-09	2.20E-05
887.43	12.47	0	887.41	8.72	0	-	-	30	4.40E-10	2.20E-09	2.20E-05
882.41	12.41	0	882.40	8.65	0	-	-	30	4.39E-10	2.19E-09	2.19E-05
877.39	12.35	0	877.38	8.61	0	-	-	30	4.41E-10	2.21E-09	2.21E-05
872.38	12.30	0	872.37	8.55	0	-	-	30	4.40E-10	2.20E-09	2.20E-05
867.37	12.24	0	867.36	8.50	0	-	-	30	4.40E-10	2.20E-09	2.20E-05
862.36	12.19	0	862.34	8.43	0	-	-	30	4.38E-10	2.19E-09	2.19E-05

Appendix 5.2

Secup1 (m)	Borehole Head1 (masl)	Flow1 (mL/h)	Secup2 (m)	Borehole Head2 (masl)	Flow2 (mL/h)	Section Head (masl)	T_S (m^2/s)	Q-lower limit Practical (mL/h)	T_S-Lower Limit Theoretical (m^2/s)	T_S-Lower Limit Practical (m^2/s)	T_S-Upper Limit (m^2/s)
857.35	12.14	0	857.33	8.36	0	-	-	30	4.35E-10	2.18E-09	2.18E-05
852.32	12.07	0	852.30	8.32	0	-	-	30	4.40E-10	2.20E-09	2.20E-05
847.28	12.03	0	847.27	8.27	0	-	-	30	4.38E-10	2.19E-09	2.19E-05
842.27	11.96	0	842.26	8.16	0	-	-	30	4.34E-10	2.17E-09	2.17E-05
837.26	11.90	0	837.25	8.13	0	-	-	30	4.37E-10	2.18E-09	2.18E-05
832.25	11.85	0	832.24	8.07	0	-	-	30	4.35E-10	2.18E-09	2.18E-05
827.24	11.79	0	827.24	8.00	0	-	-	30	4.35E-10	2.18E-09	2.18E-05
822.23	11.71	0	822.23	7.96	0	-	-	30	4.40E-10	2.20E-09	2.20E-05
817.22	11.67	0	817.22	7.91	0	-	-	30	4.39E-10	2.19E-09	2.19E-05
812.22	11.60	0	812.22	7.82	0	-	-	30	4.36E-10	2.18E-09	2.18E-05
807.22	11.55	0	807.22	7.77	0	-	-	30	4.36E-10	2.18E-09	2.18E-05
802.22	11.48	0	802.22	7.70	0	-	-	30	4.36E-10	2.18E-09	2.18E-05
797.22	11.45	0	797.22	7.64	0	-	-	30	4.34E-10	2.17E-09	2.17E-05
792.21	11.34	0	792.22	7.57	0	-	-	30	4.38E-10	2.19E-09	2.19E-05
787.21	11.28	0	787.22	7.50	0	-	-	30	4.36E-10	2.18E-09	2.18E-05
782.21	11.23	0	782.22	7.45	0	-	-	30	4.36E-10	2.18E-09	2.18E-05
777.21	11.17	0	777.22	7.41	0	-	-	30	4.38E-10	2.19E-09	2.19E-05
772.21	11.09	0	772.22	7.35	0	-	-	30	4.41E-10	2.20E-09	2.20E-05
767.20	11.05	0	767.21	7.27	0	-	-	30	4.36E-10	2.18E-09	2.18E-05
762.20	10.98	0	762.21	7.18	0	-	-	30	4.34E-10	2.17E-09	2.17E-05
757.20	10.92	0	757.20	7.14	0	-	-	30	4.36E-10	2.18E-09	2.18E-05
752.19	10.86	0	752.20	7.05	0	-	-	60	4.33E-10	4.33E-09	2.16E-05
747.19	10.80	0	747.19	6.99	0	-	-	60	4.33E-10	4.33E-09	2.17E-05
742.18	10.69	0	742.19	6.92	0	-	-	30	4.38E-10	2.19E-09	2.19E-05
737.18	10.62	0	737.19	6.87	0	-	-	30	4.39E-10	2.19E-09	2.19E-05
732.18	10.55	0	732.19	6.80	0	-	-	30	4.39E-10	2.20E-09	2.20E-05

Appendix 5.3

Secup1 (m)	Borehole Head1 (masl)	Flow1 (mL/h)	Secup2 (m)	Borehole Head2 (masl)		Flow2 (mL/h)		Section Head (masl)	T_S (m^2/s)	Q-lower limit Practical (mL/h)	T_S-Lower Limit Theoretical (m^2/s)	T_S-Lower Limit Practical (m^2/s)	T_S-Upper Limit (m^2/s)
727.19	10.48	0	727.19	6.70	0	-	-	30	4.37E-10		2.18E-09		2.18E-05
722.19	10.41	0	722.19	6.67	0	-	-	30	4.40E-10		2.20E-09		2.20E-05
717.18	10.35	0	717.18	6.59	0	-	-	50	4.39E-10		3.65E-09		2.19E-05
712.17	10.28	0	712.17	6.49	0	-	-	50	4.35E-10		3.62E-09		2.17E-05
707.16	10.23	0	707.16	6.45	0	-	-	50	4.36E-10		3.63E-09		2.18E-05
702.15	10.16	0	702.15	6.40	0	-	-	50	4.39E-10		3.66E-09		2.20E-05
697.14	10.11	0	697.15	6.33	0	-	-	50	4.36E-10		3.64E-09		2.18E-05
692.13	10.03	0	692.14	6.23	0	-	-	50	4.34E-10		3.62E-09		2.17E-05
687.13	9.95	0	687.13	6.18	0	-	-	50	4.36E-10		3.64E-09		2.18E-05
682.12	9.89	0	682.12	6.11	0	-	-	50	4.37E-10		3.64E-09		2.18E-05
677.11	9.83	0	677.11	6.05	0	-	-	50	4.36E-10		3.63E-09		2.18E-05
672.10	9.81	0	672.10	5.98	0	-	-	50	4.31E-10		3.59E-09		2.15E-05
667.09	9.75	0	667.09	5.93	0	-	-	50	4.31E-10		3.59E-09		2.16E-05
662.08	9.68	0	662.09	5.90	0	-	-	50	4.36E-10		3.64E-09		2.18E-05
657.07	9.60	0	657.08	5.82	0	-	-	50	4.35E-10		3.63E-09		2.18E-05
652.06	9.52	0	652.07	5.76	0	-	-	30	4.37E-10		2.19E-09		2.19E-05
647.05	9.48	0	647.06	5.71	0	-	-	30	4.37E-10		2.19E-09		2.19E-05
642.04	9.41	0	642.05	5.61	0	-	-	30	4.34E-10		2.17E-09		2.17E-05
637.04	9.33	0	637.04	5.58	0	-	-	60	4.39E-10		4.39E-09		2.20E-05
632.03	9.27	0	632.04	5.57	0	-	-	60	4.46E-10		4.46E-09		2.23E-05
627.02	9.23	0	627.03	5.45	0	-	-	60	4.36E-10		4.36E-09		2.18E-05
622.01	9.14	0	622.02	5.39	0	-	-	60	4.39E-10		4.39E-09		2.20E-05
616.99	9.08	0	617.00	5.34	0	-	-	30	4.41E-10		2.20E-09		2.20E-05
611.98	9.04	0	611.99	5.28	0	-	-	30	4.39E-10		2.19E-09		2.19E-05

Appendix 5.4

Secup1 (m)	Borehole Head1 (masl)	Flow1 (mL/h)	Secup2 (m)	Borehole Head2 (masl)	Flow2 (mL/h)	Section Head (masl)	T_S (m^2/s)	Q-lower limit Practical (mL/h)	T_S-Lower Limit Theoretical (m^2/s)	T_S-Lower Limit Practical (m^2/s)	T_S-Upper Limit (m^2/s)
606.97	8.99	0	606.97	5.24	0	-	-	30	4.39E-10	2.20E-09	2.20E-05
601.95	8.92	0	601.96	5.19	0	-	-	30	4.41E-10	2.21E-09	2.21E-05
596.94	8.87	0	596.94	5.12	0	-	-	30	4.40E-10	2.20E-09	2.20E-05
591.93	8.79	0	591.92	5.01	0	-	-	30	4.37E-10	2.19E-09	2.19E-05
586.91	8.75	0	586.91	4.97	0	-	-	30	4.35E-10	2.18E-09	2.18E-05
581.90	8.69	0	581.89	4.95	0	-	-	30	4.41E-10	2.20E-09	2.20E-05
576.89	8.63	0	576.88	4.89	0	-	-	50	4.41E-10	3.67E-09	2.20E-05
571.87	8.55	0	571.86	4.80	0	-	-	50	4.40E-10	3.67E-09	2.20E-05
566.87	8.51	0	566.86	4.76	0	-	-	50	4.40E-10	3.67E-09	2.20E-05
561.86	8.46	0	561.85	4.72	0	-	-	30	4.41E-10	2.21E-09	2.21E-05
556.86	8.40	0	556.85	4.68	0	-	-	30	4.43E-10	2.22E-09	2.22E-05
551.85	8.31	0	551.85	4.61	0	-	-	30	4.45E-10	2.22E-09	2.22E-05
546.85	8.28	0	546.84	4.53	0	-	-	30	4.39E-10	2.20E-09	2.20E-05
541.84	8.15	0	541.84	4.42	0	-	-	30	4.41E-10	2.21E-09	2.21E-05
536.84	8.12	0	536.83	4.39	0	-	-	30	4.41E-10	2.21E-09	2.21E-05
531.83	8.07	0	531.83	4.31	0	-	-	30	4.39E-10	2.20E-09	2.20E-05
526.83	8.03	0	526.83	4.28	0	-	-	30	4.40E-10	2.20E-09	2.20E-05
521.82	7.94	0	521.82	4.24	0	-	-	30	4.45E-10	2.22E-09	2.22E-05
516.82	7.85	0	516.82	4.18	20	-	1.50E-09	30	4.49E-10	2.25E-09	2.25E-05
511.81	7.80	0	511.81	4.09	0	-	-	30	4.44E-10	2.22E-09	2.22E-05
506.81	7.75	0	506.80	4.04	0	-	-	30	4.44E-10	2.22E-09	2.22E-05
501.80	7.71	0	501.80	3.98	0	-	-	30	4.42E-10	2.21E-09	2.21E-05
496.80	7.64	0	496.79	3.92	0	-	-	30	4.43E-10	2.22E-09	2.22E-05
491.80	7.55	0	491.79	3.83	0	-	-	30	4.44E-10	2.22E-09	2.22E-05
486.79	7.49	0	486.78	3.78	0	-	-	30	4.43E-10	2.22E-09	2.22E-05
481.79	7.45	0	481.77	3.75	0	-	-	30	4.45E-10	2.22E-09	2.22E-05
476.78	7.39	0	476.77	3.70	0	-	-	30	4.47E-10	2.23E-09	2.23E-05
471.78	7.35	0	471.76	3.65	0	-	-	30	4.45E-10	2.23E-09	2.23E-05

Appendix 5.5

Secup1 (m)	Borehole Head1 (masl)	Flow1 (mL/h)	Secup2 (m)	Borehole Head2 (masl)	Flow2 (mL/h)	Section Head (masl)	T_S (m^2/s)	Q-lower limit Practical (mL/h)	T_S-Lower Limit Theoretical (m^2/s)	T_S-Lower Limit Practical (m^2/s)	T_S-Upper Limit (m^2/s)
466.78	7.30	0	466.76	3.60	0	-	-	30	4.45E-10	2.23E-09	2.23E-05
461.77	7.24	0	461.75	3.54	0	-	-	30	4.46E-10	2.23E-09	2.23E-05
456.77	7.18	0	456.75	3.47	0	-	-	30	4.45E-10	2.22E-09	2.22E-05
451.76	7.11	0	451.74	3.42	0	-	-	30	4.47E-10	2.23E-09	2.23E-05
446.76	7.03	0	446.74	3.36	0	-	-	30	4.49E-10	2.25E-09	2.25E-05
441.75	6.99	0	441.73	3.31	0	-	-	30	4.48E-10	2.24E-09	2.24E-05
436.75	6.94	0	436.73	3.28	0	-	-	30	4.51E-10	2.25E-09	2.25E-05
431.74	6.89	0	431.72	3.23	0	-	-	30	4.50E-10	2.25E-09	2.25E-05
426.74	6.84	0	426.72	3.18	0	-	-	30	4.50E-10	2.25E-09	2.25E-05
421.73	6.77	0	421.71	3.14	32.58	-	2.47E-09	30	4.54E-10	2.27E-09	2.27E-05
416.73	6.70	0	416.71	3.08	222	-	1.68E-08	30	4.54E-10	2.27E-09	2.27E-05
411.72	6.65	0	411.70	3.02	0	-	-	30	4.55E-10	2.28E-09	2.28E-05
406.72	6.59	0	406.70	2.97	0	-	-	30	4.56E-10	2.28E-09	2.28E-05
401.71	6.50	0	401.70	2.89	0	-	-	30	4.57E-10	2.29E-09	2.29E-05
396.70	6.44	0	396.69	2.83	0	-	-	30	4.57E-10	2.29E-09	2.29E-05
391.70	6.38	0	391.69	2.79	0	-	-	30	4.59E-10	2.29E-09	2.29E-05
386.69	6.33	0	386.69	2.73	0	-	-	30	4.57E-10	2.29E-09	2.29E-05
381.69	6.28	0	381.68	2.65	0	-	-	30	4.54E-10	2.27E-09	2.27E-05
376.68	6.24	0	376.68	2.60	0	-	-	30	4.53E-10	2.26E-09	2.26E-05
371.67	6.15	0	371.68	2.51	0	-	-	30	4.53E-10	2.26E-09	2.26E-05
366.67	6.11	0	366.68	2.46	0	-	-	30	4.52E-10	2.26E-09	2.26E-05
361.66	6.04	0	361.67	2.42	0	-	-	30	4.55E-10	2.27E-09	2.27E-05
356.66	5.99	-2773.15	356.67	2.36	15517	5.44	1.39E-06	30	4.54E-10	2.27E-09	2.27E-05
351.66	5.91	0	351.67	2.27	28.39	-	2.14E-09	30	4.52E-10	2.26E-09	2.26E-05
346.66	5.87	0	346.66	2.23	0	-	-	30	4.53E-10	2.26E-09	2.26E-05
341.66	5.81	0	341.66	2.18	53.64	-	4.07E-09	30	4.55E-10	2.27E-09	2.27E-05

Appendix 5.6

Secup1 (m)	Borehole Head1 (masl)	Flow1 (mL/h)	Secup2 (m)	Borehole Head2 (masl)	Flow2 (mL/h)	Section Head (masl)	T_S (m^2/s)	Q-lower limit Practical (mL/h)	T_S-Lower Limit Theoretical (m^2/s)	T_S-Lower Limit Practical (m^2/s)	T_S-Upper Limit (m^2/s)
336.66	5.77	-53.21	336.66	2.13	331	5.27	2.90E-08	30	4.53E-10	2.26E-09	2.26E-05
331.66	5.69	0	331.65	2.08	0	-	-	30	4.56E-10	2.28E-09	2.28E-05
326.65	5.64	0	326.65	2.02	0	-	-	30	4.56E-10	2.28E-09	2.28E-05
321.65	5.60	0	321.65	1.96	0	-	-	30	4.54E-10	2.27E-09	2.27E-05
316.65	5.54	0	316.64	1.92	0	-	-	30	4.56E-10	2.28E-09	2.28E-05
311.65	5.49	0	311.64	1.87	17.95	-	1.36E-09	30	4.55E-10	2.27E-09	2.27E-05
306.63	5.44	0	306.63	1.82	0	-	-	30	4.55E-10	2.28E-09	2.28E-05
301.62	5.39	0	301.62	1.77	0	-	-	30	4.55E-10	2.27E-09	2.27E-05
296.61	5.34	0	296.61	1.72	2322.08	-	1.77E-07	30	4.56E-10	2.28E-09	2.28E-05
291.60	5.24	0	291.60	1.63	592	-	4.50E-08	30	4.56E-10	2.28E-09	2.28E-05
286.59	5.22	0	286.59	1.59	0	-	-	30	4.55E-10	2.27E-09	2.27E-05
281.58	5.18	0	281.58	1.56	0	-	-	30	4.56E-10	2.28E-09	2.28E-05
276.57	5.14	0	276.57	1.51	0	-	-	30	4.54E-10	2.27E-09	2.27E-05
271.56	5.07	0	271.57	1.45	88.64	-	6.70E-09	30	4.55E-10	2.27E-09	2.27E-05
266.55	5.03	0	266.56	1.41	0	-	-	30	4.55E-10	2.28E-09	2.28E-05
261.54	4.99	0	261.55	1.36	0	-	-	30	4.55E-10	2.27E-09	2.27E-05
256.54	4.95	0	256.54	1.32	250	-	1.89E-08	30	4.54E-10	2.27E-09	2.27E-05
251.53	4.89	0	251.53	1.28	0	-	-	30	4.56E-10	2.28E-09	2.28E-05
246.53	4.85	0	246.52	1.24	0	-	-	30	4.57E-10	2.28E-09	2.28E-05
241.52	4.77	0	241.52	1.15	0	-	-	30	4.56E-10	2.28E-09	2.28E-05
236.52	4.71	0	236.51	1.10	0	-	-	30	4.57E-10	2.28E-09	2.28E-05
231.52	4.67	4110	231.50	3.42	254500	4.69	5.50E-05 *	30	4.57E-10	2.28E-09	6.60E-05
226.51	4.64	0	226.49	1.03	0	-	-	30	4.57E-10	2.28E-09	2.28E-05
221.51	4.55	0	221.49	0.96	0	-	-	30	4.59E-10	2.30E-09	2.30E-05
216.50	4.52	0	216.48	0.91	0	-	-	30	4.57E-10	2.28E-09	2.28E-05
211.50	4.47	0	211.47	0.86	0	-	-	30	4.57E-10	2.29E-09	2.29E-05

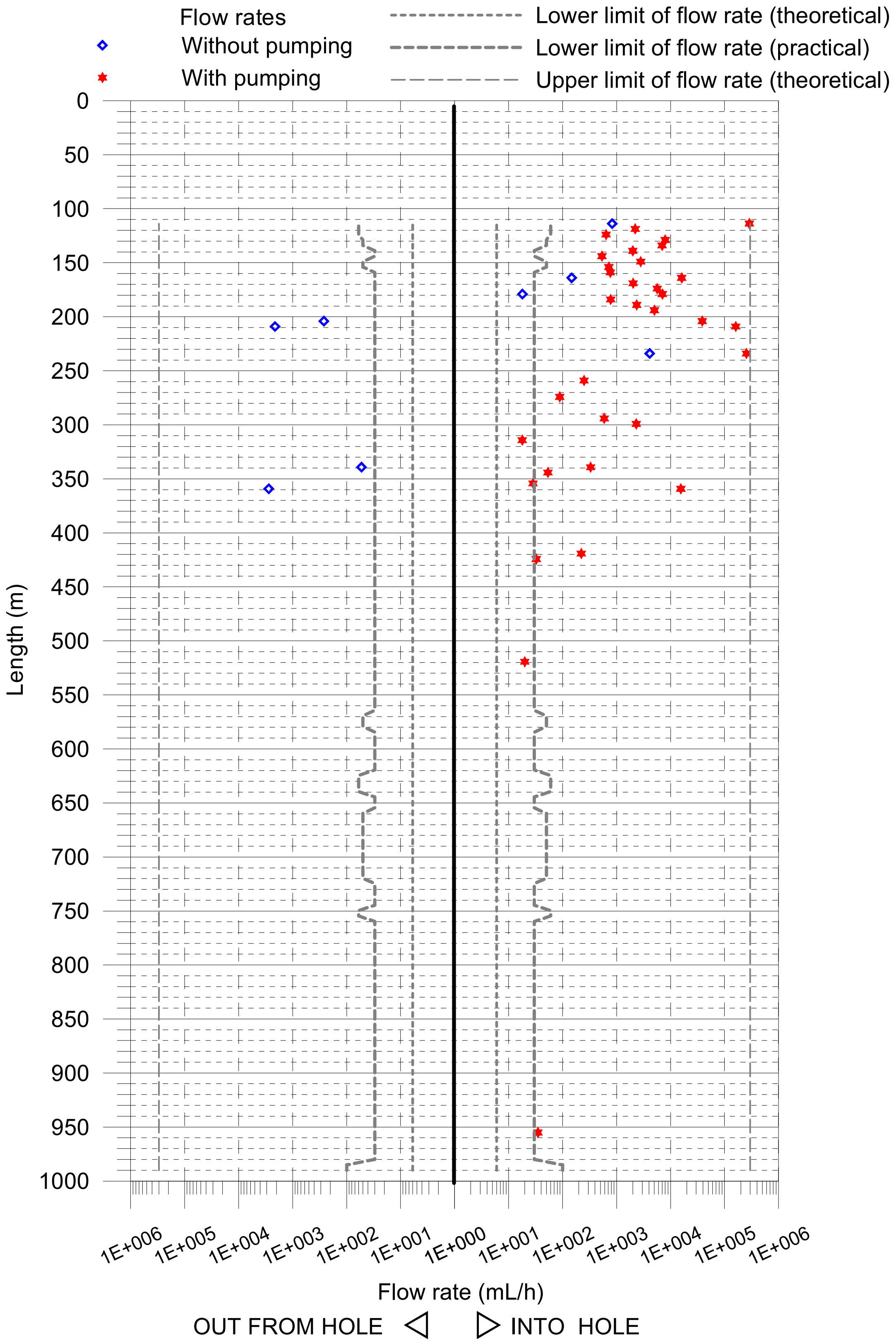
Appendix 5.7

Secup1 (m)	Borehole Head1 (masl)	Flow1 (mL/h)	Secup2 (m)		Borehole Head2 (masl)	Flow2 (mL/h)	Section Head (masl)	T_S (m^2/s)	Q-lower limit Practical (mL/h)	T_S-Lower Limit Theoretical (m^2/s)	T_S-Lower Limit Practical (m^2/s)	T_S-Upper Limit (m^2/s)
206.49	4.41	-2114.2	206.47	3.15	161450	4.4	3.54E-05 *	30	4.57E-10	2.29E-09	6.50E-05
201.48	4.38	-264	201.47	3.09	38680	4.37	8.30E-06 *	30	4.56E-10	2.28E-09	6.39E-05
196.48	4.37	0	196.46	0.75	0	-	-	30	4.56E-10	2.28E-09	2.28E-05
191.47	4.37	0	191.46	0.68	5025	-	3.75E-07	30	4.47E-10	2.23E-09	2.23E-05
186.46	4.36	0	186.46	0.63	2367.09	-	1.75E-07	30	4.42E-10	2.21E-09	2.21E-05
181.45	4.34	0	181.46	0.57	780	-	5.70E-08	30	4.37E-10	2.19E-09	2.19E-05
176.45	4.32	18.1	176.46	0.52	7080	4.32	5.10E-07	30	4.34E-10	2.17E-09	2.17E-05
171.44	4.02	0	171.45	0.47	5657	-	4.37E-07	30	4.64E-10	2.32E-09	2.32E-05
166.43	4.06	0	166.45	0.42	2027.78	-	1.53E-07	30	4.53E-10	2.27E-09	2.27E-05
161.42	3.99	147.75	161.45	0.36	16155	4.02	1.21E-06	30	4.54E-10	2.27E-09	2.27E-05
156.42	4.01	0	156.44	0.30	765	-	5.65E-08	30	4.44E-10	2.22E-09	2.22E-05
151.42	4.04	0	151.44	0.26	719	-	5.25E-08	50	4.37E-10	3.64E-09	2.19E-05
146.42	4.00	0	146.43	0.20	2807	-	2.03E-07	50	4.34E-10	3.62E-09	2.17E-05
141.42	3.92	0	141.42	0.11	537	-	3.87E-08	30	4.33E-10	2.16E-09	2.16E-05
136.43	3.88	0	136.41	0.06	2000	-	1.44E-07	30	4.32E-10	2.16E-09	2.16E-05
131.43	3.83	0	131.41	0.02	7000	-	5.05E-07	50	4.32E-10	3.60E-09	2.16E-05
126.43	3.80	0	126.40	-0.02	7967	-	5.75E-07	50	4.32E-10	3.60E-09	2.16E-05
121.43	3.75	0	121.39	-0.07	640	-	4.61E-08	60	4.32E-10	4.32E-09	2.16E-05
116.23	3.73	0	116.19	-0.18	2217.06	-	1.56E-07	60	4.22E-10	4.22E-09	2.11E-05
111.23	3.57	830	111.18	2.30	288590	3.57	6.25E-05 *	60	4.22E-10	4.22E-09	6.50E-05

* Drawdown = 1.4 m result was used for calculations

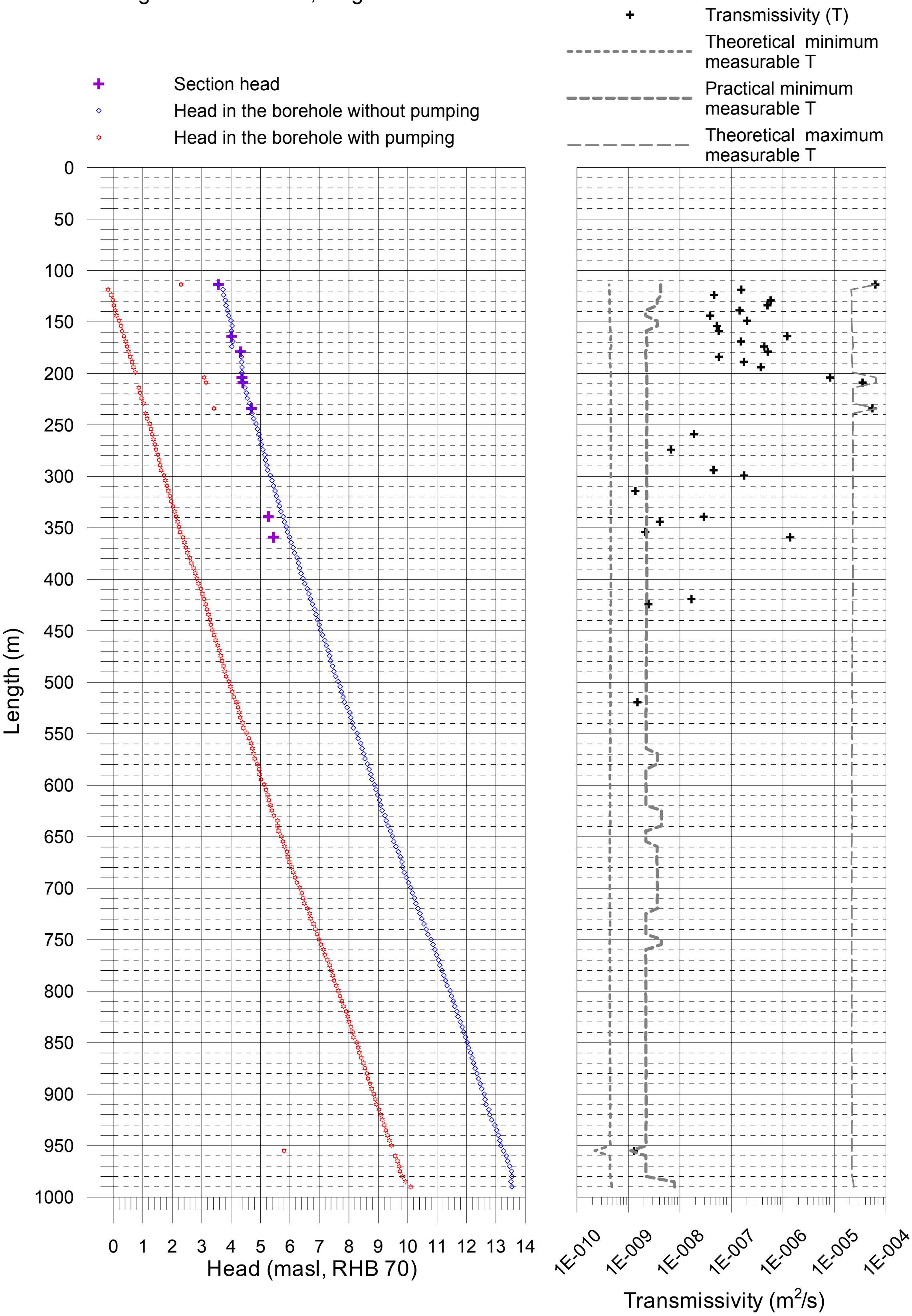
** Drawdown = 7.4 m result was used for calculations

Forsmark, Borehole KFM04A
Difference flow measurement 2004-03-12 - 2004-03-27
Length of section 5 m, depth increment 5 m



Appendix 6.2

Forsmark, Borehole KFM04A
Difference flow measurement 2004-03-12 - 2004-03-27
Length of section 5 m, length increment 5 m



Appendix 7.1

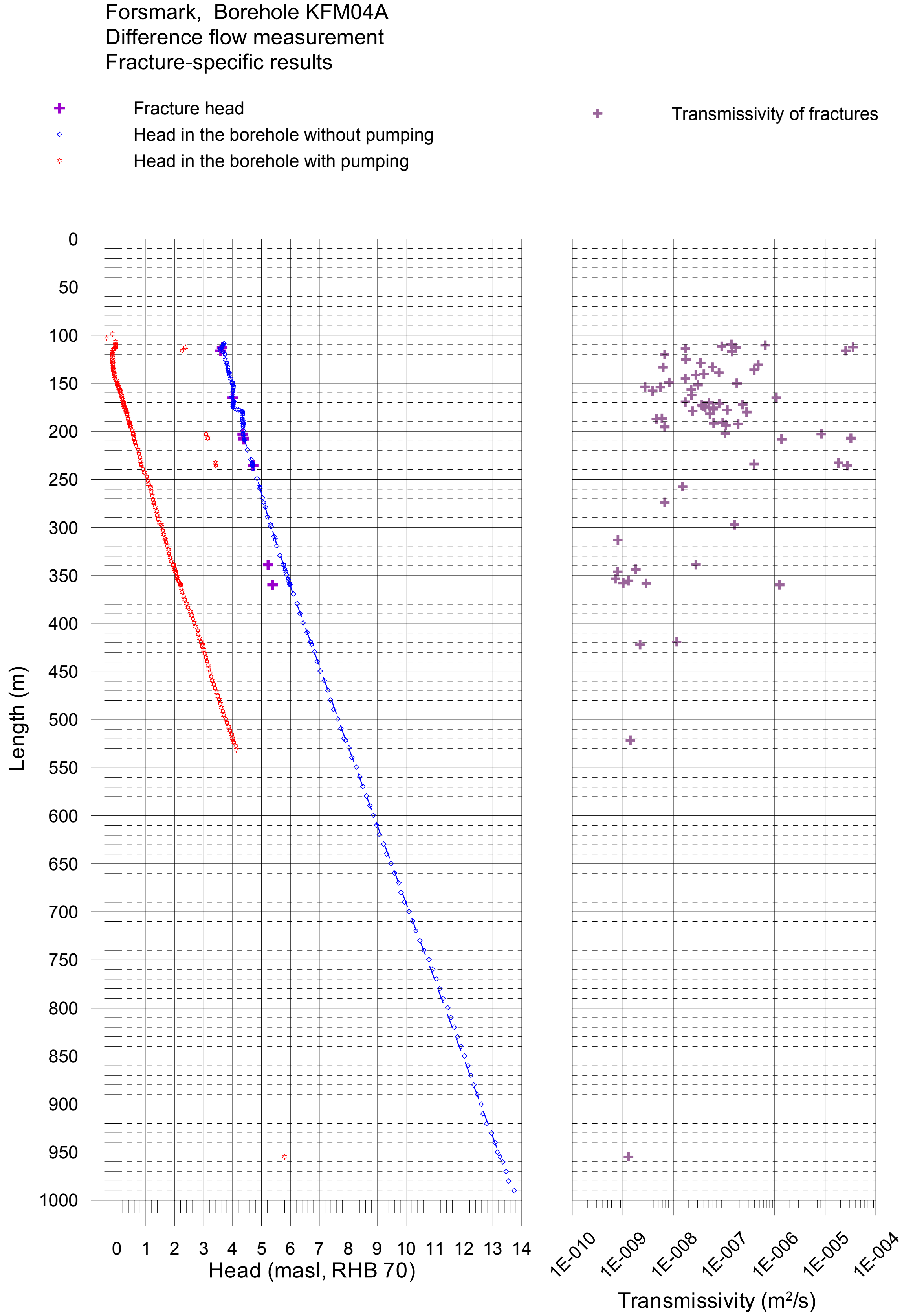
Length to fracture (m)	Borehole head1 (masl)	Flow1 (mL/h)	Borehole head2 (masl)	Flow2 (mL/h)	T_f (m^2/s)	Fracture head (masl)
109.6	3.68	0	-0.046	1890	1.39E-07	-
110.3	3.666	0	-0.042	8800	6.52E-07	-
111.4	3.64	0	-0.033	1200	8.98E-08 ***	-
112.4	3.64	430	2.37	164000	3.54E-05 *	3.64
112.8	3.643	0	-0.044	2300	1.71E-07 ***	-
113.9	3.569	0	-0.091	230	1.73E-08 ***	-
116.1	3.585	400	2.264	123500	2.56E-05	3.59
117	3.666	0	-0.147	2000	1.44E-07 *	-
120.2	3.748	0	-0.157	95	6.68E-09 ***	-
125.3	3.753	0	-0.161	250	1.75E-08 ***	-
128.9	3.798	0	-0.152	500	3.48E-08	-
130.8	3.801	0	-0.144	6800	4.74E-07	-
133.1	3.828	0	-0.141	850	5.88E-08	-
133.4	3.832	0	-0.134	90	6.23E-09 ***	-
136.1	3.84	0	-0.13	5700	3.95E-07	-
138.9	3.876	0	-0.105	1150	7.94E-08	-
140.3	3.888	0	-0.092	580	4.00E-08	-
141.2	3.892	0	-0.086	400	2.76E-08	-
145.2	3.93	0	-0.055	250	1.72E-08 ***	-
149.3	3.999	0	0.012	120	8.27E-09 ***	-
149.8	4.003	0	0.016	2600	1.79E-07	-
151.6	4.016	0	0.028	440	3.03E-08	-
153.7	4.036	0	0.05	40	2.76E-09 ***	-
154	4.035	0	0.053	80	5.52E-09	-
156.7	4.023	0	0.101	320	2.24E-08	-
157.8	4.019	0	0.113	55	3.87E-09 ***	-
162.3	3.996	0	0.16	320	2.29E-08	-
165.1	3.977	110	0.171	15000	1.07E-06	4.01
169.4	4.043	0	0.211	240	1.72E-08	-
170.5	4.032	0	0.227	700	5.05E-08	-
170.9	4.006	0	0.23	1100	8.00E-08	-
172.2	4.027	0	0.244	3200	2.32E-07	-
172.7	4.013	0	0.241	500	3.64E-08 ***	-
173.7	4.017	0	0.256	520	3.80E-08	-
174.7	4.021	0	0.269	580	4.25E-08 ***	-
175.2	4.029	0	0.272	830	6.07E-08	-
177.2	4.142	0	0.31	850	6.09E-08	-
177.7	4.211	0	0.312	1640	1.16E-07	-
178.8	4.328	0	0.323	350	2.40E-08	-
180	4.358	0	0.339	4100	2.80E-07	-
181.9	4.359	0	0.354	770	5.28E-08	-
186.5	4.339	0	0.392	85	5.92E-09	-
187.2	4.351	0	0.402	66	4.59E-09	-

Appendix 7.2

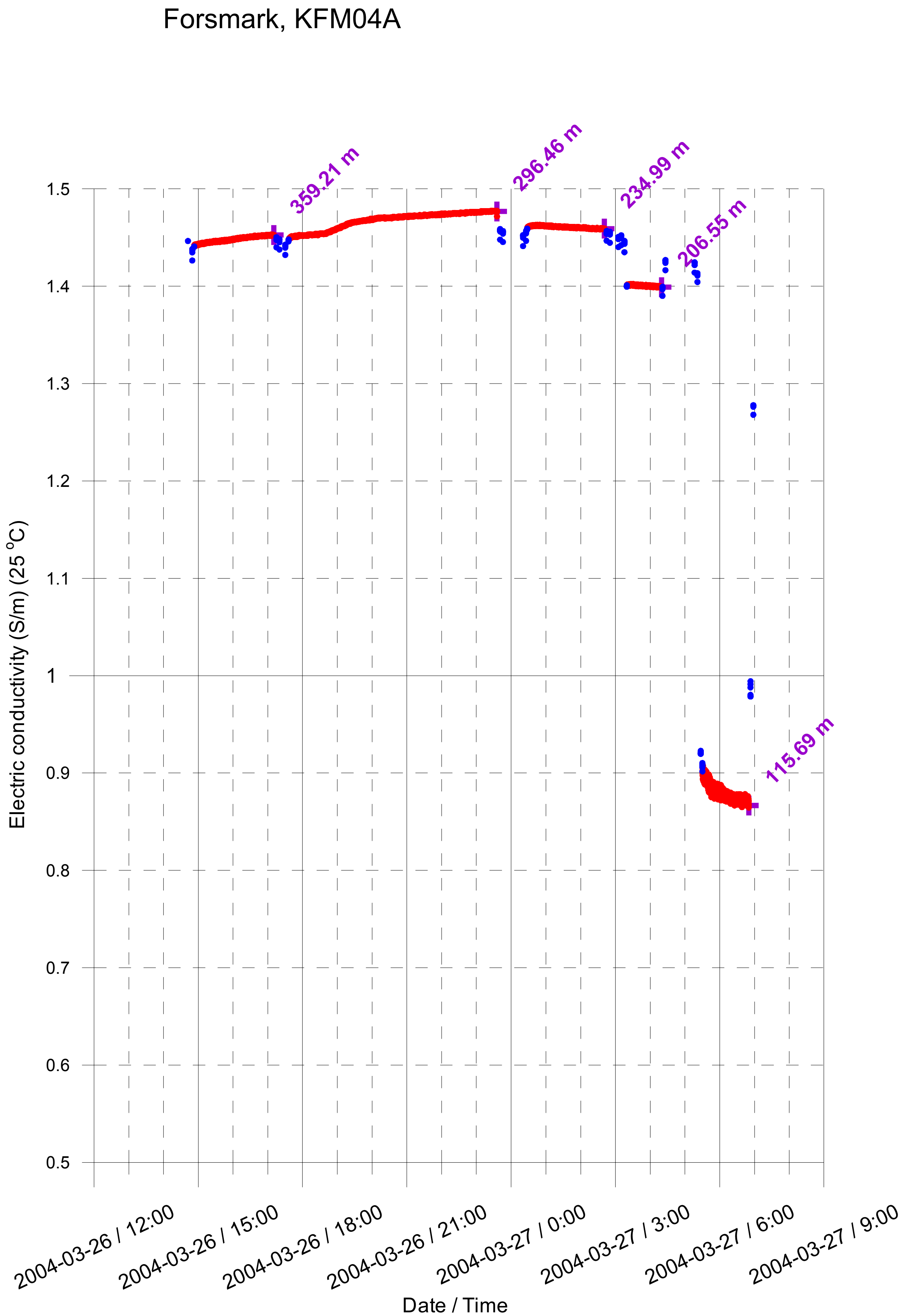
Length to fracture (m)	Borehole head1 (masl)	Flow1 (mL/h)	Borehole head2 (masl)	Flow2 (mL/h)	T_f (m^2/s)	Fracture head (masl)
190.9	4.359	0	0.436	1350	9.45E-08	-
191.5	4.38	0	0.436	900	6.27E-08	-
192.2	4.383	0	0.448	2720	1.90E-07	-
193.6	4.367	0	0.456	1550	1.09E-07	-
195.3	4.361	0	0.473	95	6.71E-09	-
202.1	4.36	0	0.56	1450	1.05E-07	-
202.8	4.372	-550	3.089	38300	8.32E-06 *	4.35
207.1	4.4	-2500	3.148	153600	3.21E-05 *	4.38
208.2	4.41	-105	0.598	19000	1.38E-06	4.39
232.7	4.672	0	3.411	84000	1.83E-05 *	-
234	4.7	0	0.842	5500	3.92E-07	-
235.6	4.682	3900	3.423	165000	2.73E-05 *	4.71
257.6	4.942	0	1.156	210	1.52E-08	-
273.9	5.074	0	1.278	93	6.73E-09	-
297.1	5.317	0	1.537	2210	1.61E-07	-
313	5.481	0	1.687	11	7.96E-10 ***	-
338.8	5.766	-54	1.949	330	2.76E-08	5.23
343.4	5.821	0	2.009	25	1.80E-09 ***	-
346	5.838	0	2.033	11	7.94E-10 ***	-
353.4	5.924	0	2.087	10	7.16E-10 ***	-
355.5	5.938	0	2.11	18	1.29E-09 ***	-
357.8	5.969	0	2.194	14	1.02E-09 ***	-
358.2	5.973	0	2.18	40	2.90E-09	-
359.8	5.984	-2750	2.215	14500	1.26E-06	5.38
419	6.706	0	2.915	160	1.16E-08	-
421.9	6.739	0	2.952	30	2.18E-09 ***	-
521.5	7.916	0	4.012	20	1.41E-09 ***	-
954.8	13.257	0	5.802	35	1.29E-09 **/***	-

* Drawdown = 1.4 m result was used for calculations
** Drawdown = 7.4 m result was used for
*** Uncertain

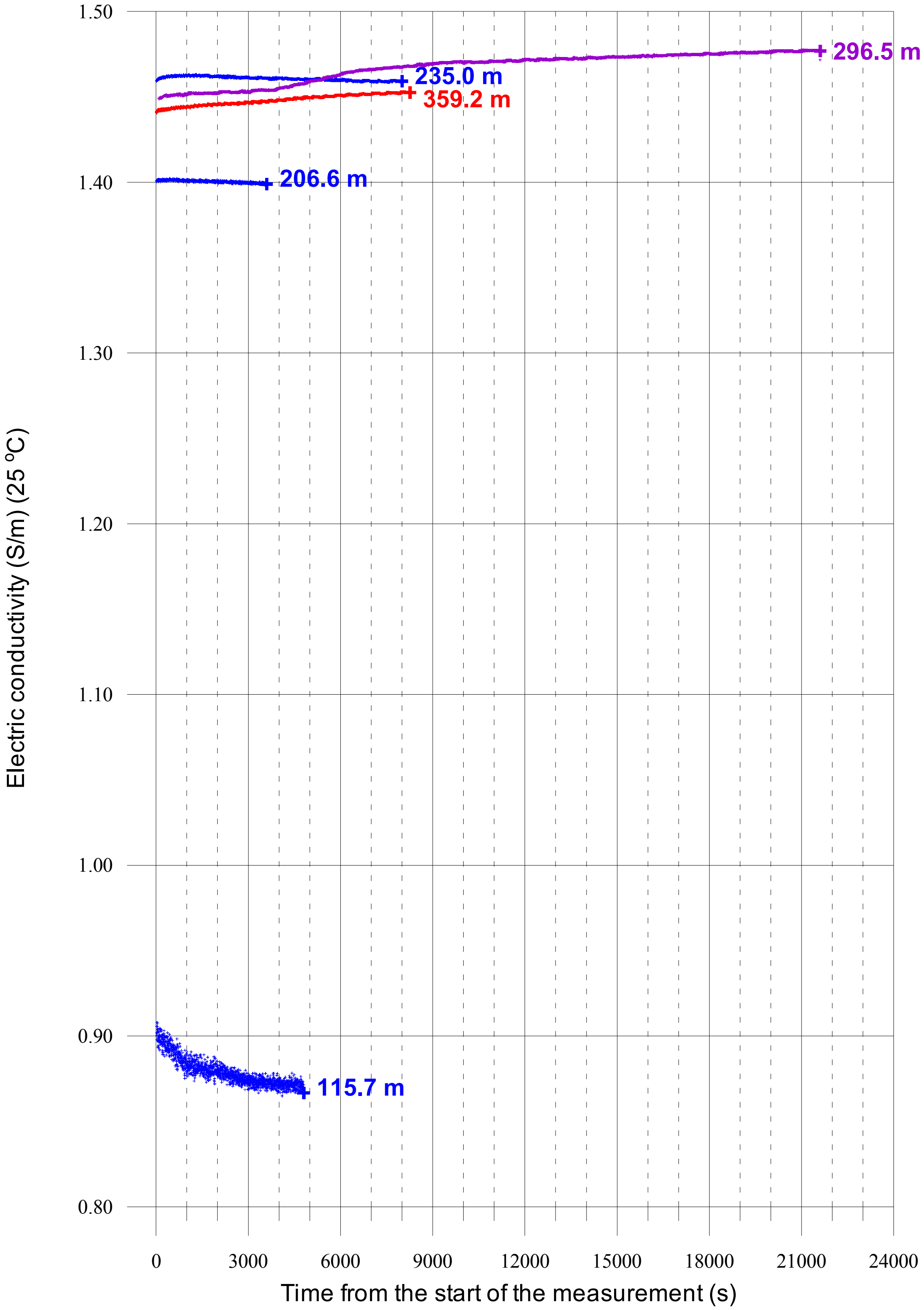
Appendix 7.3

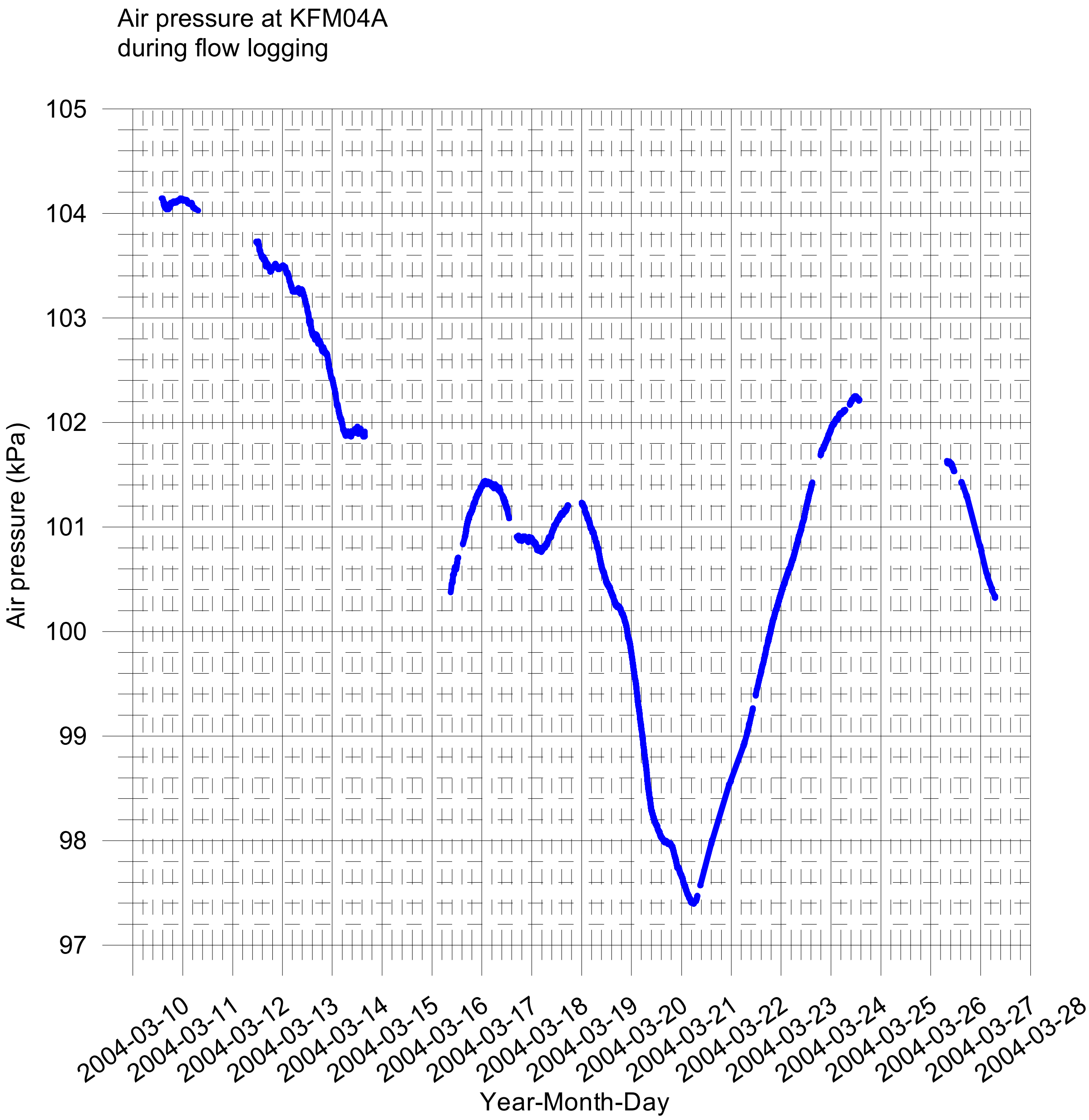


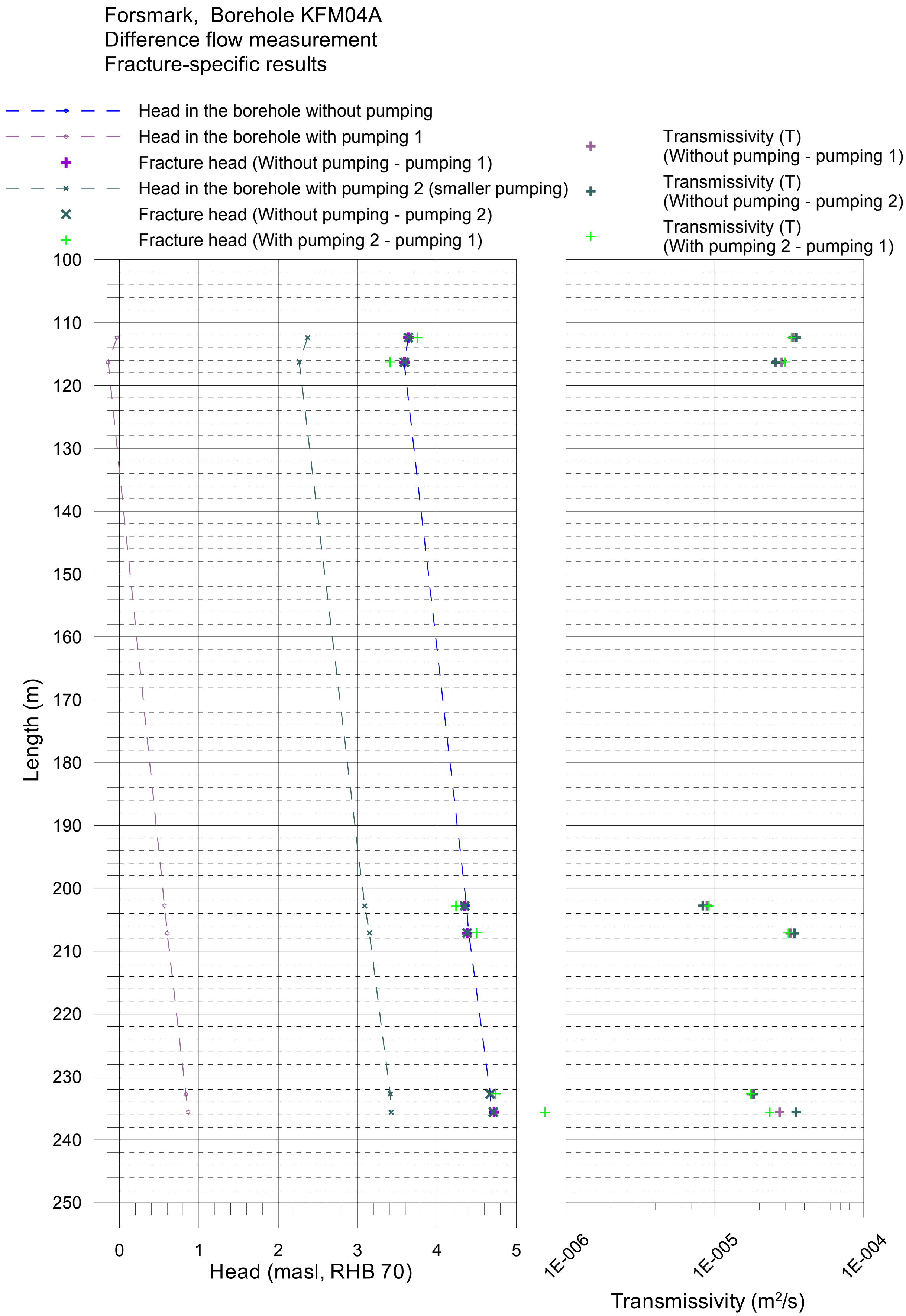
Forsmark, Borehole KFM04A
Difference flow measurement
Fracture-specific results
Fracture head
Head in the borehole without pumping
Head in the borehole with pumping
Transmissivity of fractures
Length (m)
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Head (masl, RHB 70)
1E-010 1E-009 1E-008 1E-007 1E-006 1E-005 1E-004
Transmissivity (m²/s)


Forsmark, KFM04A
Electric conductivity (S/m) (25 °C)
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
359.21 m
296.46 m
234.99 m
206.55 m
115.69 m
2004-03-26 / 12:00
2004-03-26 / 15:00
2004-03-26 / 18:00
2004-03-26 / 21:00
2004-03-27 / 0:00
2004-03-27 / 3:00
2004-03-27 / 6:00
2004-03-27 / 9:00
Date / Time

Time series of fracture-specific EC
Forsmark, borehole KFM04A, 2004-03-26 - 2004-03-27



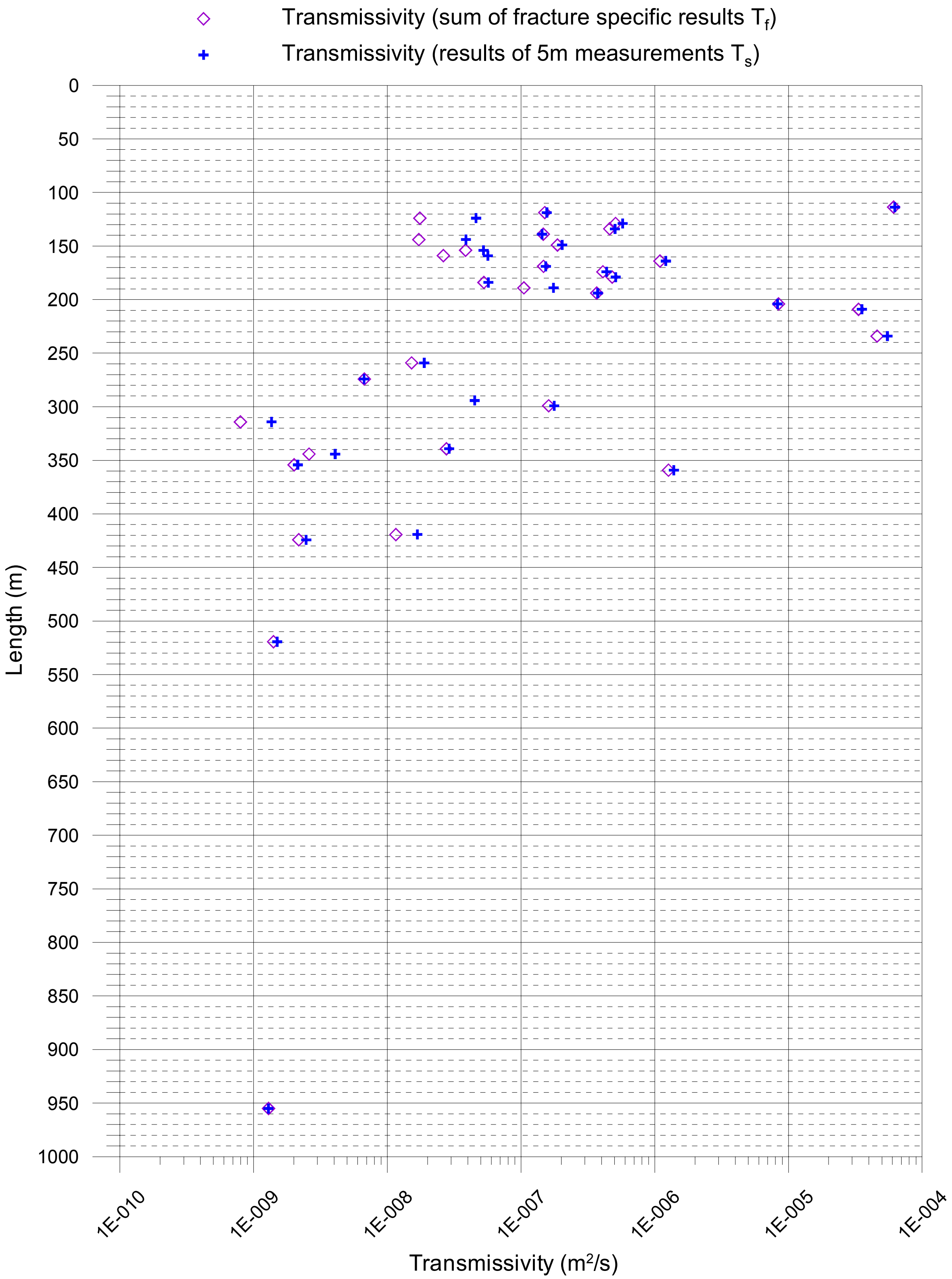

Air pressure at KFM04A
during flow logging
105
104
103
102
101
100
99
98
97
Air pressure (kPa)
2004-03-10
2004-03-11
2004-03-12
2004-03-13
2004-03-14
2004-03-15
2004-03-16
2004-03-17
2004-03-18
2004-03-19
2004-03-20
2004-03-21
2004-03-22
2004-03-23
2004-03-24
2004-03-25
2004-03-26
2004-03-27
2004-03-28
Year-Month-Day

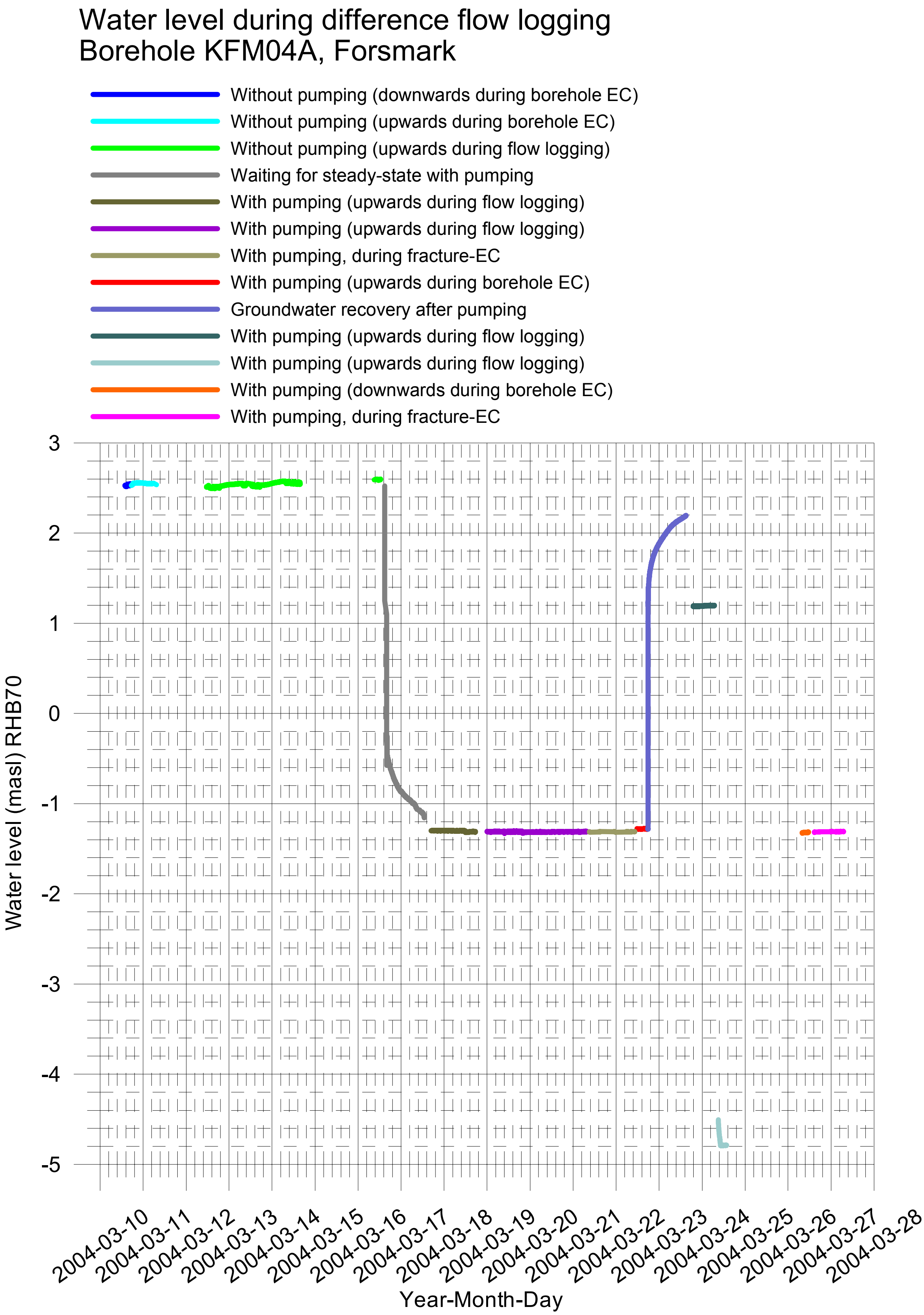


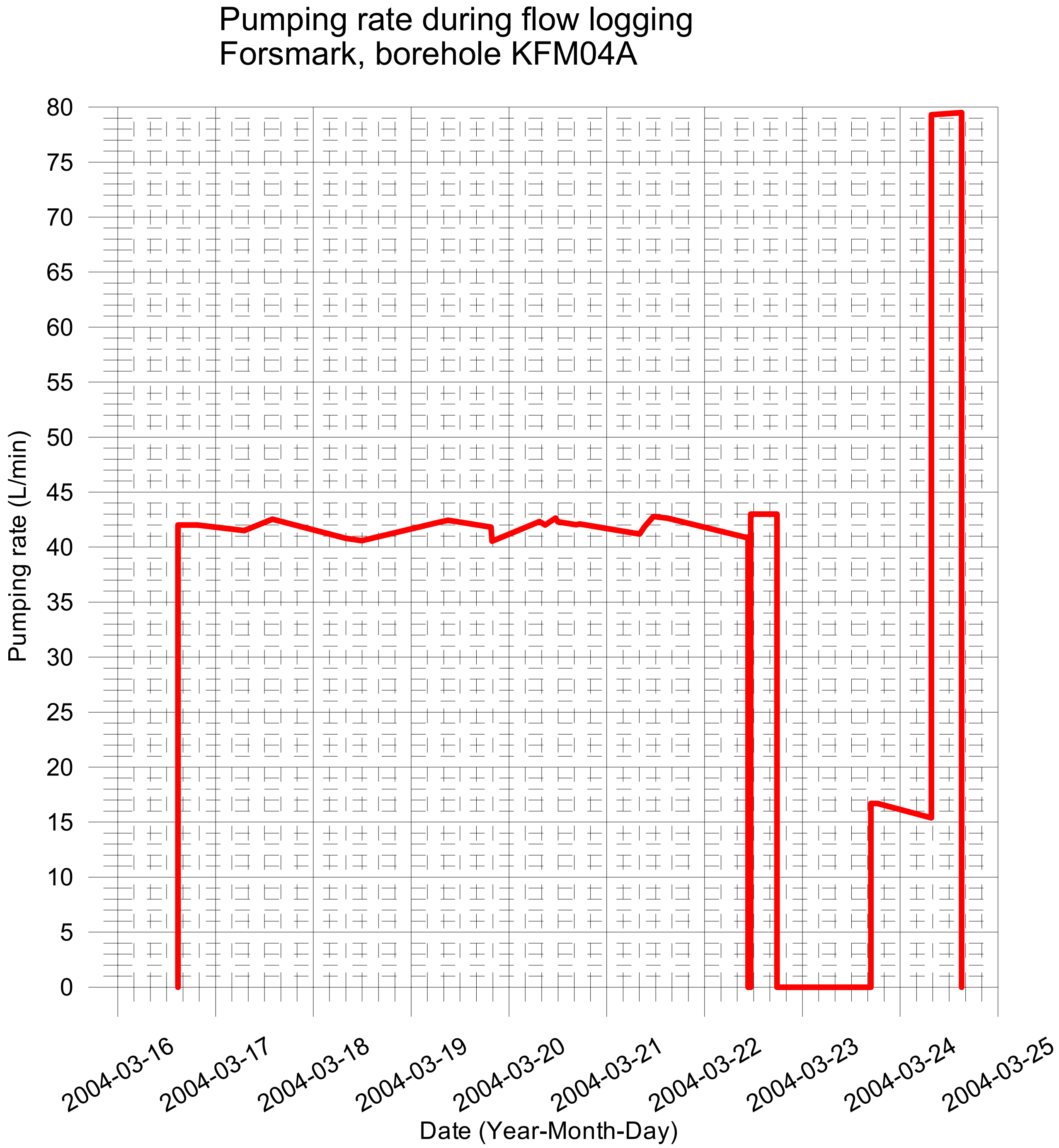
Forsmark, Borehole KFM04A
Difference flow measurement
Fracture-specific results
Head in the borehole without pumping
Head in the borehole with pumping 1
Fracture head (Without pumping - pumping 1)
Head in the borehole with pumping 2 (smaller pumping)
Fracture head (Without pumping - pumping 2)
Fracture head (With pumping 2 - pumping 1)
Transmissivity (T) (Without pumping - pumping 1)
Transmissivity (T) (Without pumping - pumping 2)
Transmissivity (T) (With pumping 2 - pumping 1)
Length (m)
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
0
1
2
3
4
5
Head (masl, RHB 70)
1E-006
1E-005
1E-004
Transmissivity (m²/s)

Appendix 11

Forsmark, Borehole KFM04A
Comparison of transmissivity of borehole sections (5m) and fracture transmissivities

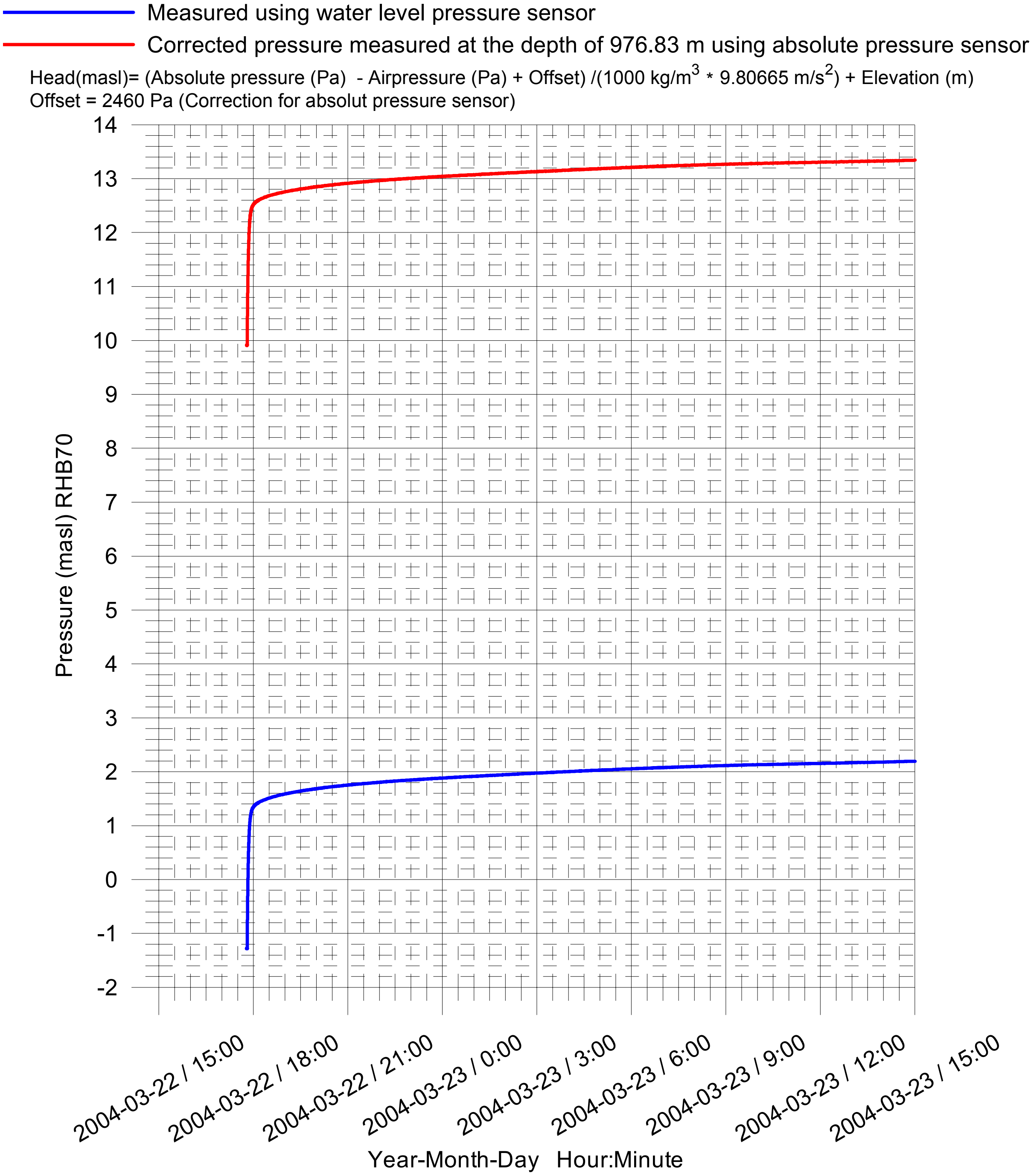



Water level during difference flow logging
Borehole KFM04A, Forsmark
Without pumping (downwards during borehole EC)
Without pumping (upwards during borehole EC)
Without pumping (upwards during flow logging)
Waiting for steady-state with pumping
With pumping (upwards during flow logging)
With pumping (upwards during flow logging)
With pumping, during fracture-EC
With pumping (upwards during borehole EC)
Groundwater recovery after pumping
With pumping (upwards during flow logging)
With pumping (upwards during flow logging)
With pumping (downwards during borehole EC)
With pumping, during fracture-EC
Water level (masl) RHB70
3
2
1
0
-1
-2
-3
-4
-5
2004-03-10
2004-03-11
2004-03-12
2004-03-13
2004-03-14
2004-03-15
2004-03-16
2004-03-17
2004-03-18
2004-03-19
2004-03-20
2004-03-21
2004-03-22
2004-03-23
2004-03-24
2004-03-25
2004-03-26
2004-03-27
2004-03-28
Year-Month-Day


Pumping rate during flow logging
Forsmark, borehole KFM04A
Pumping rate (L/min)
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
2004-03-16
2004-03-17
2004-03-18
2004-03-19
2004-03-20
2004-03-21
2004-03-22
2004-03-23
2004-03-24
2004-03-25
Date (Year-Month-Day)

Appendix 12.3

Groundwater recovery after pumping



Appendix 13

Evaluation of pumping test during difference flow logging in borehole KFM04A

Jan-Erik Ludvigson

Geosigma AB

June 2004

Key words: Forsmark, hydrogeology, pumping test, hydraulic parameters, hydraulic transmissivity, hydraulic conductivity, AP PF 400-04-28

Abstract

The pressure history during the c. 6 days long open-hole pumping test in borehole KFM04A during difference flow logging of the borehole was used to calculate the total transmissivity of the uncased cored borehole interval (c. 109-1000 m). In addition, possible effects of outer hydraulic boundaries during the pumping test were studied.

After stop of pumping, the recovery of the water level in the borehole was recorded during c. 1 day. In addition, the pressure recovery was measured at the bottom of the hole by a high-resolution pressure sensor. The pressure recovery in the borehole was evaluated by transient methods. In addition, an approximate evaluation was made on the pressure drawdown during the first part of the flow period. The flow rate was measured manually during the flow period.

The total transmissivity of the cored borehole interval was calculated from both the first part of the flow period and from the recovery period. The total transmissivity of the borehole KFM04A was calculated to c. $2.5 \cdot 10^{-4}$ m^2/s. According to the difference flow logging, the main inflow to the borehole occurs from the borehole intervals at c. 110-120 m, 200-210 m and 230-240 m.

No significant effects of outer hydraulic boundaries, e.g. no-flow boundaries, could be observed, neither from the responses during the relatively long flow period, nor during the recovery period. This fact may indicate that the assumed fracture zones intersecting the borehole have a large lateral extent.

Sammanfattning

Tryckresponserna under den c:a 6 dygn långa pumptesten i öppet hål under differensflödesloggningen i borrhål KFM04A användes för att beräkna den totala trans-missiviteten av det ofodrade kärnborrhålsintervallet (c:a 109-1000 m). Dessutom studerades förekomsten av eventuella hydrauliska gränser under pumptesten.

Efter stopp av pumpningen registrerades återhämtningen av vattennivån i borrhålet under c:a 1 dygn. Dessutom mättes tryckåterhämtningen även i botten av hålet med en tryckgivare med hög upplösning. Tryckåterhämtningen utvärderades med transienta metoder. En approximativ utvärdering gjordes även av tryckavsänkningen under den första delen av flödesperioden då pumpflödet var nästan konstant. Pumpflödet mättes manuellt under flödesperioderna.

Den totala transmissiviteten av kärnborrhålet beräknades dels från den första delen av flödesperioden och dels från återhämtningsperioden. Den totala transmissiviteten för kärnborrhål KFM04A beräknades till c:a $2.5 \cdot 10^{-4}$ m^2/s. Enligt differensflödesloggningen kommer det huvudsakliga inflödet till borrhålet från borrhålsintervallen c:a 110-120 m, 200-210 m och 230-240 m.

Inga tydliga effekter av yttre hydrauliska gränser, t.ex. negativa gränser, kunde observeras, varken under den relativt långa totala flödesperioden eller under återhämtningsperioden. Detta kan tyda på att de förmodade sprickzonerna som skär borrhålet har stor lateral utbredning.

Contents

1 Introduction

The pumping activity in conjunction with the difference flow logging campaign in borehole KFM04A was evaluated as a singe-hole pumping test. The water level in the open pumping borehole was registered by a superficial pressure sensor as well as a high-resolution absolute pressure sensor during both the flow- and recovery period of the pumping test. The pumping flow rate from the borehole during the first phase of the main flow period was c. 42 L/min, causing a maximal drawdown of the water level of c. 3.9 m. The pressure recovery after the flow period was registered by the high-resolution absolute pressure sensor located at the bottom of the borehole. In addition, the water level in the borehole was registered by the superficial sensor.

Manual readings of the pumping flow rate were made by a mechanical flow meter during the flow period. The difference flow logging showed that the main inflow to the borehole occurs in the upper part at c. 112.4 m, 116.1 m, 207.1 m, 232.7 m and 235.6 m.

2 Objective

The main purposes of the analysis of the pumping test during difference flow logging in borehole KFM04A were to estimate the total transmissivity of the cored borehole interval (c. 109-1000 m) and to deduce information on possible hydraulic outer hydraulic boundaries during the test.

Furthermore, the results of the pumping test should be compared with the results of the difference flow logging and other hydraulic tests performed in the borehole.

3 Scope

3.1 Borehole

Selected main technical data for borehole KFM04A are shown in Table 3-1. The borehole, which is c. 1000 m long, is inclined c. 60 degrees from the horizontal and performed with a telescopic drilling technique. The borehole is cased to c. 107 m with an inner diameter of 0.200 m. Below this casing there is a c. 2 m long casing with a smaller diameter (0.080 m). More detailed borehole data are available from SICADA. The reference point in the borehole is the top of casing (ToC). The reference coordinate system for the X-Y-coordinates is RT90 and RHB70 for the elevation data. The starting point coordinates (at ToC) of the borehole are:

Northing (m): 6698921.744 RT90 2,5 gon W 0:-15

Easting (m):   1630978.964 RT90 2,5 gon W 0:-15

Table 3-1.Selected main technical data of the cored borehole KFM04A. (From SICADA).

Borehole KFM04A							
ID	Elevation of top of casing (ToC) (m.a.s.l.)	Borehole interval from ToC (m)	Casing ID/ Bh-diam. (m)	Inclination- top of bh (from horizontal plane) (º)	Dip-direction- top of borehole (from local N) (º)	Remarks	Drilling finished Date (YYYY-MM-DD)
KFM04A " "	8.771	0.0-106.91 106.91-108.69* 108.69-1001.42**	0.200 0.080 0.077	-60.081	45.244	Casing ID " Open hole	2003-11-19

* this interval is cased with a smaller diameter
** uncased cored borehole interval

3.2 Tests performed

During difference flow logging in borehole KFM04A, pumping of the open borehole was performed during c. 6 days followed by a recovery period of c. 23 h. The registration of the water level and flow rate together with the pressure recovery in borehole KFM04A was mainly performed according to the Activity Plan AP PF 400-04-28 and the methodology description for difference flow logging (SKB MD 322.010, Version 1.0), both SKB internal controlling document. Pertinent data of the pumping test during difference flow logging in KFM04A are shown in Table 3-2.

Table 3-2. Pertinent data of the pumping test during difference flow logging in borehole KFM04A.

Pumping Bh ID	Pumped section (open hole) (m)	Test type[1]	Test no	Test start date and time (YYYY-MM-DD tt:mm)	Test stop date and time (YYYY-MM-DD tt:mm)
KFM04A	108.69-1001.42	1B	1	2004-03-16 14:47	2004-03-23 16:48

1) 1B: Pumping test with submersible pump with subsequent recovery

3.3 Equipment check

An equipment check was performed 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.

4 Equipment

4.1 Description of equipment

The pumping test was carried out with the standard equipment in the Posiva difference flow logging system including the following parts:

- submersible pump and hose to the ground surface
- winch and steel wire
- flow rate control valve at the surface
- vessel in the borehole to maintain a constant water level
- superficial pressure transducer (gauge pressure)
- data logger
- logging computer

In addition, a high-resolution pressure sensor, implemented in the flow logging system, was used to measure the pressure recovery at the bottom of the borehole, see Table 4.2. Finally, a pressure sensor for registration of the barometric pressure was used.

4.2 Sensors

Technical specifications of the sensor for barometric pressure together with the superficial- and high resolution pressure transducers (P1 and P_{abs}) used for registration of the water level and bottom-hole pressure, respectively are listed in Table 4-1, cf. Chapter 4 in the main report.

Table 4-1. Technical specification of the pressure sensors used for registration of the barometric pressure, water level and bottom-hole pressure in borehole KFM04A. FS=Full Scale.

Technical specification of pressure sensors*				
Sensor	**Parameter**	**Unit**	**Value/range**	**Comments**
Barometric pressure	Output signal Meas. Range Resolution Accuracy	VDC kPa kPa kPa	0 – 5 80-106 0.01 ±0.03	 at +20 °C
Superficial pressure P1 (groundwater level)	Output signal Meas. Range Resolution Accuracy	mA kPa kPa kPa	4 – 20 0 – 100 0.1 ±1% of FS	
Absolute Pressure P_{abs}	Output signal Meas. Range Resolution Accuracy	digital kPa kPa kPa	 0 – 20000 0.0001 % of FS ±0.01% of FS	

* according to the manufacturers

Table 4-2 illustrates the position of the pressure sensors and other borehole equipment during the pumping test. The position of the pressure sensors (P1 and P_{abs}) together with the (lower) level of the submersible pump (Pump) is shown. Positions are given in borehole length from top of casing (ToC). Equipment affecting wellbore storage is given in terms of diameter of the submerged parts. The volume of the submerged pump (~a few dm^3) is in most cases of minor importance regarding wellbore storage.

Table 4-2. Position along the borehole (from ToC) of sensors and borehole equipment affecting wellbore storage in the pumping borehole KFM04A.

Borehole information			**Sensors**		**Equipment affecting wellbore storage (WBS)**		
ID	**Test section (m)**	**Test no**	**Type**	**Position (m b. ToC)**	**Position[1)]**	**Function**	**Outer diameter (mm)**
KFM04A	108.69-1001.42	1	Pump vessel (lower level) P (P1) P_{abs}	12.00 12.00 976.83	In open borehole	Pump hose Signal cable Pump cable wire	18 6 11.5 3

[1)] Position of equipment that can affect wellbore storage.

5 Execution

5.1 Performance of the test

5.1.1 Test principle

During the first part of the main flow period, before the difference flow logging started, the pumping flow rate from the borehole was rather constant but still varying. The water level in the borehole was then kept constant (at different drawdown) during the various flow logging sequences. The main flow period was followed by a pressure recovery period.

5.1.2 Test procedure

The pumping flow rate varied between c. 41.5-42.5 L/min with an average value of c. 42 L/min during the first c. 24 h of the main flow period, cf. Appendix 12:2 in the main report. The difference flow logging started after c. 1 day of pumping at a constant drawdown of c. 3.8 m. The duration of the main flow period in KFM04A was c. 6 days, followed by a recovery period of c. 1 d.

The pumped flow was discharged at the ground surface sloping downhill from the pumping borehole. The flow rate was measured manually c. 5-6 times/day by a mechanical flow meter.

The changes of the water level were registered by the superficial pressure sensor during both the flow- and recovery period. During the latter period, the pressure recovery was also measured at the bottom of the borehole at c. 976 m borehole length by the absolute pressure sensor. The latter sensor was also used during the first phase of the flow period. The sampling frequency of the registration of the water level in the borehole by the superficial sensor was c. 30-60 s during the main flow period. During the recovery period the sampling frequency was according to Table 5-1, both for the superficial- and the absolute pressure sensor.

Table 5-1. Sampling frequency for pressure registration during the recovery period of the pumping test in borehole KFM04A.

Time interval (min) from stop of pumping	Sampling frequency (s)
0.0-22.5	2
22.5-840	30
840-1380	60

5.2 Data handling

A list of the raw data files of pressure versus time from the recovery phase is shown in Appendix 13:1. From these files, drawdown – and recovery files were prepared and plotted in selected diagrams in accordance with the Method Instruction SKB MD 320.004, Version 1.0 (Instruktion för analys av injektions- och enhålspumptester), an SKB internal controlling document. By the calculation of the pressure drawdown and -recovery from the absolute pressure sensor, the barometric pressure was firstly subtracted from the measured pressure data. However, no such corrections were made on the measured (gauge) pressure data from the superficial transducer.

By the calculation of the pressure derivatives during the flow- and recovery periods, different values were applied on the filter coefficient (step length) to study its effect on the derivative. It is desired to achieve maximum smoothing of the derivative without altering the original shape of the data curve.

5.3 Analyses and interpretation

The evaluation of the pumping test was mainly made from the pressure recovery period using data from the high-resolution absolute pressure sensor at the bottom of the hole. For comparison, corresponding data from the superficial sensor were also used. Further-more, an approximate analysis was made on the first part (c. 24 h) of the flow period, using data from both the superficial- and the absolute pressure sensor. Due to the change to a submersible pump with higher flow capacity, the first phase of the flow period was distorted and data are partly lacking.

Firstly, a qualitative evaluation was performed to identify the actual flow regimes during the flow- and recovery period (e.g. wellbore storage, pseudo-radial flow etc.) and possible outer hydraulic boundary conditions. The qualitative analysis was made from the pressure responses together with the corresponding pressure derivatives versus time, preferably in the log-log diagrams. The pressure recovery was plotted versus real time after stop of pumping since both the pressure and flow rate were rather stable at the end of the flow period and the recovery period was rather short compared to the flow period.

The quantitative, transient interpretation of hydraulic parameters from the pumping borehole (e.g. transmissivity and skin factor) was based on the identified pseudo-radial flow regimes according to methods described in /1/ and in the Instruction mentioned above for constant flow rate tests in an equivalent porous medium using the code AQTESOLV. A brief description of the latter code and its application is provided in related pumping test reports, e.g. /3/. In addition, the wellbore storage coefficient was estimated from the initial phase of the recovery period. Finally, a steady-state analysis (Moye's formula) was also made from the flow period.

6 Results

6.1 Nomenclature and symbols

The nomenclature and symbols used for the results of the pumping test are according to SKB MD 320.004. Additional symbols used are explained in the text. The nomenclature used in the diagrams from the code Aqtesolv is shown in Appendix 13:2.

6.2 Single-hole pumping test

General test data from the pumping test during flow logging in borehole KFM04A are presented in Table 6-1. As expained in Section 5.2, the atmospheric pressure was subtracted from the measured data from the absolute pressure sensor by the analysis of the test data, whereas no corrections were made on the water level data from the superficial (gauge) sensor in the borehole. The atmospheric pressure during the pumping test and the approximate start and stop of pumping is shown in Figure 6-1.

Since no data from observation boreholes were available, a value on the storativity must be assumed by the calculation of the skin factor. In this case the value $S^*=5\cdot10^{-5}$, obtained from interference tests between HFM01 and HFM02, /2/, was used. A summary of the results of the single-hole pumping test in KFM04A is presented in Table 6-2 and 6-3. Test diagrams are shown in Appendix 13:2.

Table 6-1. General test data from the pumping test in borehole KFM04A.

General test data			
Testtype[1]	Constant flow rate and recovery test		
Test section (open borehole/packed-off section):	open borehole		
Test No	1		
Field crew	J. Pöllänen and P. Heikkinen, PRG Tec-Oy		
Test equipment system	Posiva difference flow logging system		
General comment	Single-hole test		
	Nomen-clature	**Unit**	**Value**
Borehole length	L	m	1001.42
Total casing length	L_c	m	108.61*
Test section- secup	Secup	m	108.61
Test section- seclow	Seclow	m	1001.42
Test section length	L_w	m	892.81
Test section diameter	$2\cdot r_w$	mm	77.3
Test start (start of pressure registration)		yymmdd hh:mm	2004-03-16 14:47
Packer expanded		yymmdd hh:mm:ss	-
Start of flow period		yymmdd hh:mm:ss	2004-03-16 14:47
Stop of flow period		yymmdd hh:mm:ss	2004-03-22 17:48
Test stop (stop of pressure registration)		yymmdd hh:mm	2004-03-23 16:48
Total flow time	t_p	min	8821
Total recovery time	t_F	min	1380

*the interval 106.91-108.61m is cased with a smaller casing diameter (ID 80 mm)

Groundwater level data

Groundwater level data in pumping borehole KFM04A	Nomen-clature	Unit	Value (m.a.s.l)
Level in borehole before start of flow period	h_i	m	2.59
Level in borehole before stop of flow period	h_p	m	-1.28
Level in borehole at stop of recovery period	h_F	m	2.19
Maximum drawdown in borehole during flow period	s_p	m	3.87

Flow data

Flow data in pumping borehole KFM04A	Nomen-clature	Unit	Value
Flow rate from test section just before stop of flow period	Q_p	m^3/s	$7.17 \cdot 10^{-4}$
Mean (arithmetic) flow rate during flow period	Q_m	m^3/s	-
Total volume discharged during flow period	V_p	m^3	-

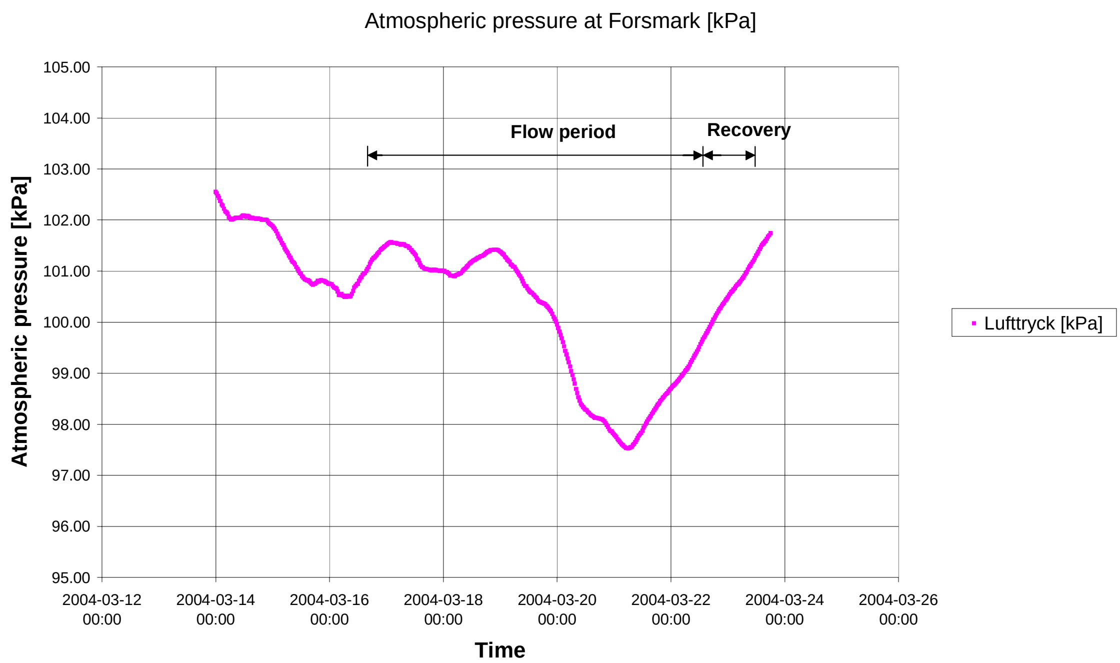


Figure 6-1. *Atmospheric pressure at Forsmark during the pumping test in conjunction with difference flow logging in borehole KFM04A.*

Interpreted flow regimes

Selected test diagrams according to the Instruction for analysis of single-hole injection- and pumping tests together with simulated responses are presented in Appendix 13:2. Figure 13:2-5 shows the pressure recovery versus time after stop of pumping using data from the absolute pressure sensor at the bottom of the borehole. The figure shows that wellbore storage effects (WBS) were seen during the first c. 100 s in the (open) pumping borehole during the recovery period. After a transition period, two well-defined periods with pseudo-radial flow occurred during intermediate and late times, respectively as indicated by the pressure derivative. This fact may represent scale effects, i.e. transition from a near-region scale to a larger-scale of the investigated bedrock by the end of the test.

No effects of hydraulic outer boundaries were seen during the recovery period. Although not shown, a very similar pressure response was obtained using water level data from the superficial pressure sensor during the recovery period.

The analysis of drawdown data (from the absolute pressure sensor) during the first phase (c. 24 h) of the flow period supports the late pseudo-radial flow period after c. 15000 s (c. 4 h), c f Figure 13:2-2 in Appendix 13:2. As mentioned above, the first part of the flow period was disturbed by the exchange of submersible pump in the borehole. No evidences of outer hydraulic boundaries were seen during the flow period. The drawdown data from the absolute- and superficial pressure sensors were again very similar during this period.

Interpreted parameters

The transient analyses of the flow- and recovery periods according to the methods described in section 5-3, based on the identified periods with pseudo-radial flow, are shown in the figures in Appendix 13:2. The results are presented in Table 6-3.

6.3 Summary of test data

Test data from the single-hole pumping test in conjunction with difference flow logging in borehole KFM04A are summarized in Table 6-2. The calculated hydraulic parameters together with the estimated measurement limits are presented in Table 6-3 and in the Test Summary Sheet below. The calculated hydraulic parameters represent the open borehole interval 108.61-1001.42 m. The main inflow zones to this borehole section are located in the intervals at c. 110-120 m, 200-210 m and 230-240 m as identified from the difference flow logging.

The parameter files of the results from the pumping test for storage in the SICADA data base are presented in Appendix 13:3 below.

Table 6-2. Summary of test data of the single-hole pumping test during the difference flow logging in the open borehole KFM04A.

Interval (m)	Test type[1)]	h_i (m a s l)	h_p (m a s l)	h_F (m a s l)	Q_p (m^3/s)	V_p (m^3)	Q_m (m^3/s)
108.61-1001.42	1B	2.59	-1.28	2.19	$7.17 \cdot 10^{-4}$	-	-

[1)] 1B: Pumping test-submersible pump followed by a recovery test

Table 6-3. Summary of calculated hydraulic parameters from the pumping test in conjunction with difference flow logging in borehole KFM04A.

Test period	Time of evaluation	Q/s (m^2/s)	T_M (m^2/s)	T_T (m^2/s)	S* (-)	ζ (-)	C (m^3/Pa)
Flow period	late	$1.85 \cdot 10^{-4}$	$3.05 \cdot 10^{-4}$	$2.13 \cdot 10^{-4}$	$5 \cdot 10^{-5}$	-3.10	
recovery	early-intermediate			$5.12 \cdot 10^{-4}$	$5 \cdot 10^{-5}$	3.72	$3.45 \cdot 10^{-6}$
recovery	late			$2.56 \cdot 10^{-4}$	$5 \cdot 10^{-5}$	-2.43	

Q/s= specific flow
T_M= steady-state transmissivity from Moye´s formula
T_T = calculated transmissivity from transient evaluation of the test
S^*= assumed value on the storativity
ζ = skin factor
C = wellbore storage coefficient

6.4 Conclusions

The total long-term transmissivity of the interval 108.61-1001.42 m in borehole KFM04A was calculated to c. $2.5 \cdot 10^{-4}$ m^2/s from the pumping test during difference flow logging. As identified from the latter logging, the dominant inflow into the cored interval of borehole KFM04A occurred within the intervals at c. 110-120 m, 200-210 m and 230-240.

The pumping test showed no significant effects of outer hydraulic boundaries, e.g. no-flow boundaries, during the rather long (c. 6 days) flow period. This fact may indicate that the assumed fracture zones at these intervals are extensive in the lateral direction.

The calculated transmissivity from the pumping test may be compared with the results of the difference flow logging in this borehole interval. The cumulative transmissivity in this interval from the flow logging in 5 m sections ($\sum T_D$) and detailed flow logging in 1 m sections ($\sum T_{Df}$) are shown in Table 6-4 together with the estimated total transmissivity T_T from the pumping test. Table 6-4 indicates that the results from the pumping test and difference flow logging are consistent.

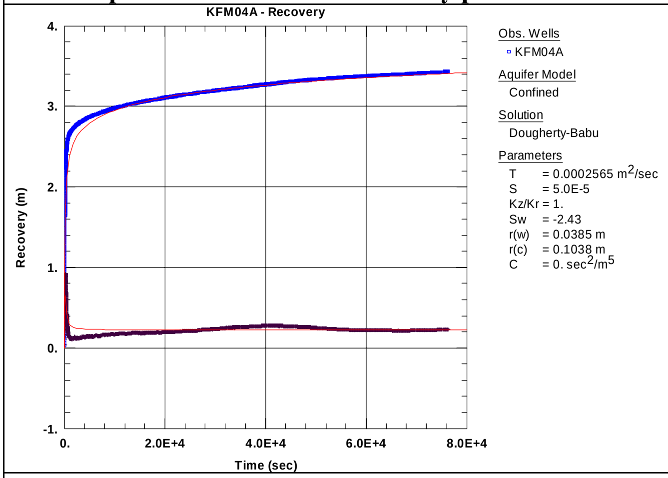
Table 6-4. Comparison of total transmissivity of the open part of borehole KFM04A together with cumulative transmissivity from the difference flow logging.

Borehole ID	Test method	Measured interval (m)	T_T (m^2/s)	$\sum T_D$ (m^2/s)	$\sum T_{Df}$ (m^2/s)
KFM04A	Pumping test	108.61-1001.42	$2.56 \cdot 10^{-4}$		
	Difference flow logging	108.61-992.57		$1.67 \cdot 10^{-4}$	$1.55 \cdot 10^{-4}$

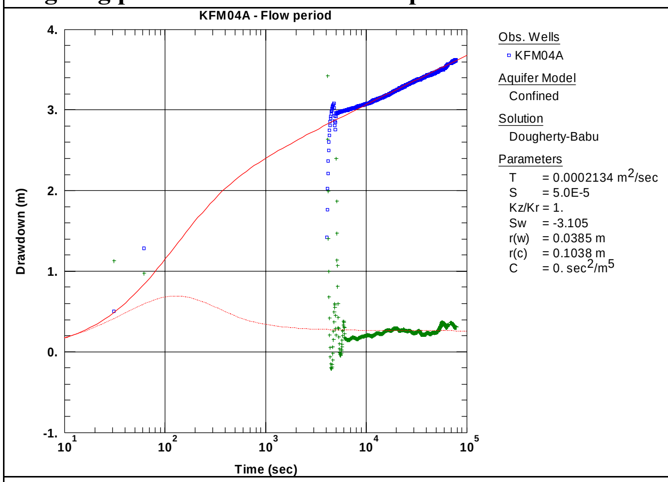
Test Summary Sheet – Pumping borehole KFM04A

Project:	PLU	Test type:	1B
Area:	Forsmark	Test no:	1
Borehole ID:	KFM04A	Test start:	2004-03-16 14:47
Test section (m):	108.61-1001.42	Responsible for test performance:	P. Rouhiainen, PRG-Tec Oy
Section diameter, $2 \cdot r_w$ (m):	0.077	Responsible for test evaluation:	GEOSIGMA AB J-E Ludvigson

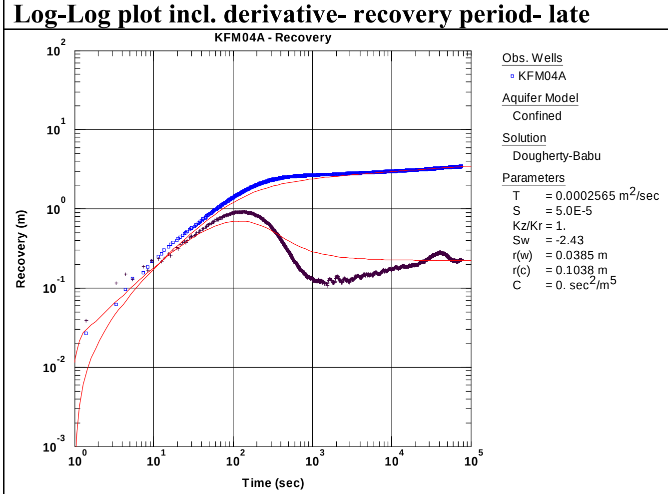
Lin-Lin plot incl. derivative – recovery period-late



Log-Log plot incl. derivative- flow period-late



Log-Log plot incl. derivative- recovery period- late



Flow period		**Recovery period**	
Indata		**Indata**	
h_0 (m.a.s.l.)	2.59		
h_i (m.a.s.l.)	2.59		
h_p (m.a.s.l.)	-1.28	h_F (m.a.s.l.)	-0.28
Q_p (m^3/s)	$7.17 \cdot 10^{-4}$		
tp (s)	529 260	t_F (s)	82800
S^*	$5 \cdot 10^{-5}$	S^*	$5 \cdot 10^{-5}$
EC_w (mS/m)	-		
Te_w(gr C)	-		
Derivative fact.	0.1	Derivative fact.	0.1
Results		**Results**	
Q/s (m^2/s)	$1.85 \cdot 10^{-4}$		
T_M (m^2/s)	$3.05 \cdot 10^{-4}$		
Flow regime:	PRF-late	Flow regime:	PRF-late
t_1 (s)	15000	t_1 (min)	20000
t_2 (s)	60000	t_2 (min)	82800
T_w (m^2/s)	$2.13 \cdot 10^{-4}$	T_w (m^2/s)	$2.56 \cdot 10^{-4}$
S_w (-)	-	S_w (-)	-
K_{sw} (m/s)	-	K_{sw} (m/s)	-
S_{sw} (1/m)	-	S_{sw} (1/m)	-
C (m^3/Pa)	-	C (m^3/Pa)	$3.45 \cdot 10^{-6}$
C_D (-)	-	C_D (-)	-
ξ (-)	-3.10	ξ (-)	-2.43
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-late	C (m^3/Pa)	$3.45 \cdot 10^{-6}$
t_1 (min)	20000	C_D (-)	-
t_2 (min)	82800	ξ (-)	-2.43
T_T (m^2/s)	$2.56 \cdot 10^{-4}$		
S (-)	-		
K_s (m/s)	-		
S_s (1/m)	-		

Comments: After initial wellbore storage- and skin effects, pseudo-radial flow occurred during intermediate and late times during the recovery period. During the first phase (before constant head) of the flow period only the late pseudo-radial flow period occurred. The early phase of the flow period was disturbed by the change of borehole pump.

7 References

1 **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. Technical Report 86-27, Svensk Kärnbränslehantering AB.

2 **Ludvigson J-E, Jönsson S, 2003.** Forsmark Site Investigation - Hydraulic interference tests. Boreholes HFM01, HFM02 and HFM03. Report P-03-35, Svensk Kärnbränslehantering AB.

3 **Ludvigson J-E, Jönsson S, Hjerne C, 2004.** Forsmark Site Investigation – Pumping tests and flow logging. Boreholes KFM06A (0-100 m) and HFM16. Report P-04-65, Svensk Kärnbränslehantering AB.

8 Appendices

Appendix 13:1: Test data files

Appendix 13:2: Test data diagrams

Appendix 13:3: Parameter file to SICADA

APPENDIX 13:1 – TEST DATA FILES

Bh ID	Test section (m)	Test type[1]	Test start Date, time YYYY-MM-DD tt:mm	Test stop Date, time YYYY-MM-DD tt:mm	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	Selected Parameters measured	Comments
KFM04A	108.61-1001.42[2]	1B	2004-03-16 13:30	2004-03-23 16:48	2004-03-16 14:47	2004-03-24 15:03	FOF04APU08A005T105.CSV	Q	Entire flow period (Item 10-12 in AP)
KFM04A	108.61-1001.42[2]	1B	2004-03-16 13:30	2004-03-23 16:48	2004-03-16 14:47:03	2004-03-17 13:04:35	FOF04AGL13E050D105.CSV	P1, P_{abs}	Flow period Item 10 in AP
KFM04A	108.61-1001.42[2]	1B	2004-03-16 13:30	2004-03-23 16:48	2004-03-17 16:47:46	2004-03-18 17:30:04	FOF04AGW12E050D105.CSV	P1, P_{abs}	Cont. Item 10 in AP
KFM04A	108.61-1001.42[2]	1B	2004-03-16 13:30	2004-03-23 16:48	2004-03-19 00:00:41	2004-03-21 07:44:46	FOF04AGW12E010D105.CSV	P1, P_{abs}	Flow period Item 11 in AP
KFM04A	108.61-1001.42[2]	1B	2004-03-16 13:30	2004-03-23 16:48	2004-03-21 09:05:49	2004-03-22 10:22:05	FOF04AGW12G010D105.CSV	P1, P_{abs}	Fracture-EC Item 12 in AP
KFM04A	108.61-1001.42[2]	1B	2004-03-16 13:30	2004-03-23 16:48	2004-03-22 11:45:05	2004-03-22 17:39:29	FOF04APR12D005D105.CSV	P1, P_{abs}	Borehole-EC Item 13
KFM04A	108.61-1001.42[2]	1B	2004-03-16 13:30	2004-03-23 16:48	2004-03-22 17:46:44	2004-03-23 15:00:21	FOF04AGL12R005D105.CSV	P1, P_{abs}	Recovery period Item 14

1: 1B: Pumping test-submersible pump
2: Uncased cored borehole interval)

APPENDIX 13:2 TEST DATA DIAGRAMS

Nomenclature used in diagrams from 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)

S_w=skin factor

r(w)=borehole radius (m)

r(c)= effective casing radius (m)

C= well loss constant (set to 0)

Diagrams

Flow period (lin-lin, log-log and lin-log)

Recovery period (lin-lin, log-log and lin-log)

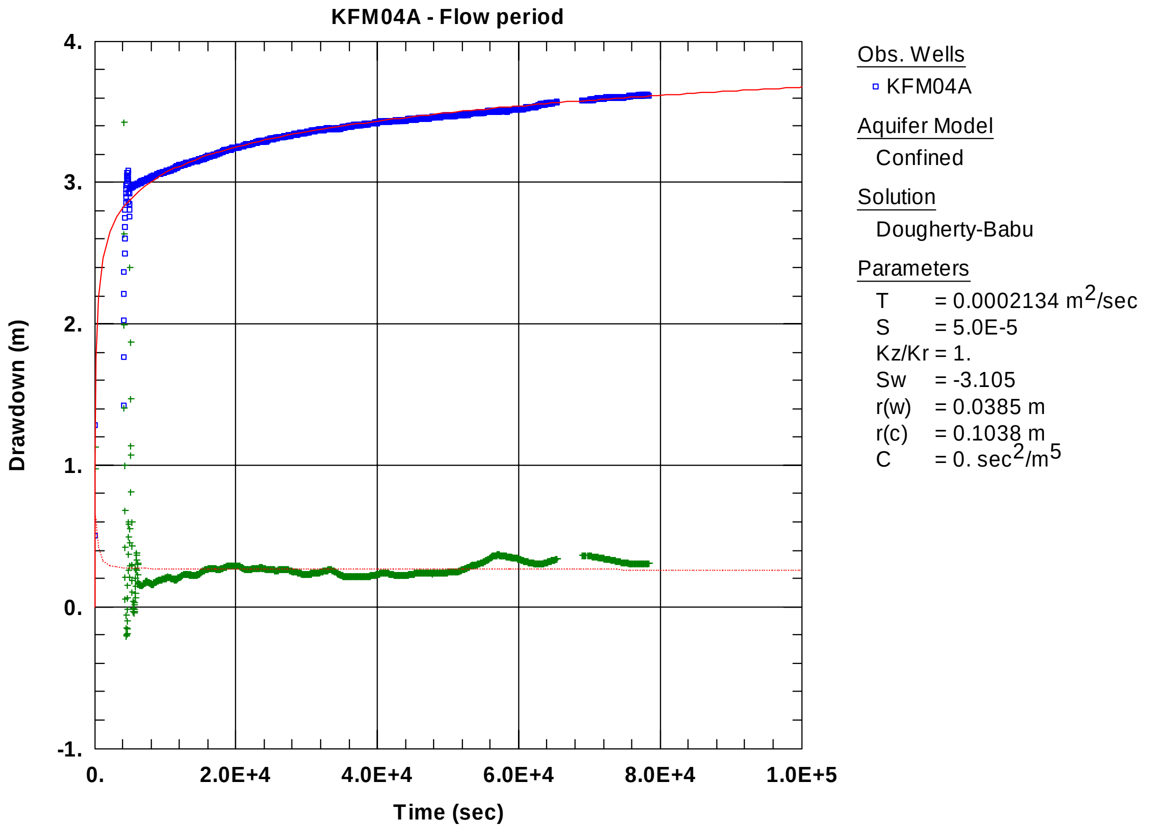


Figure 13:2-1*. Linear plot of measured (blue) and simulated (red) pressure drawdown and –derivative (green) versus time during the first phase of the pumping test in conjunction with difference flow logging in borehole KFM04A.*

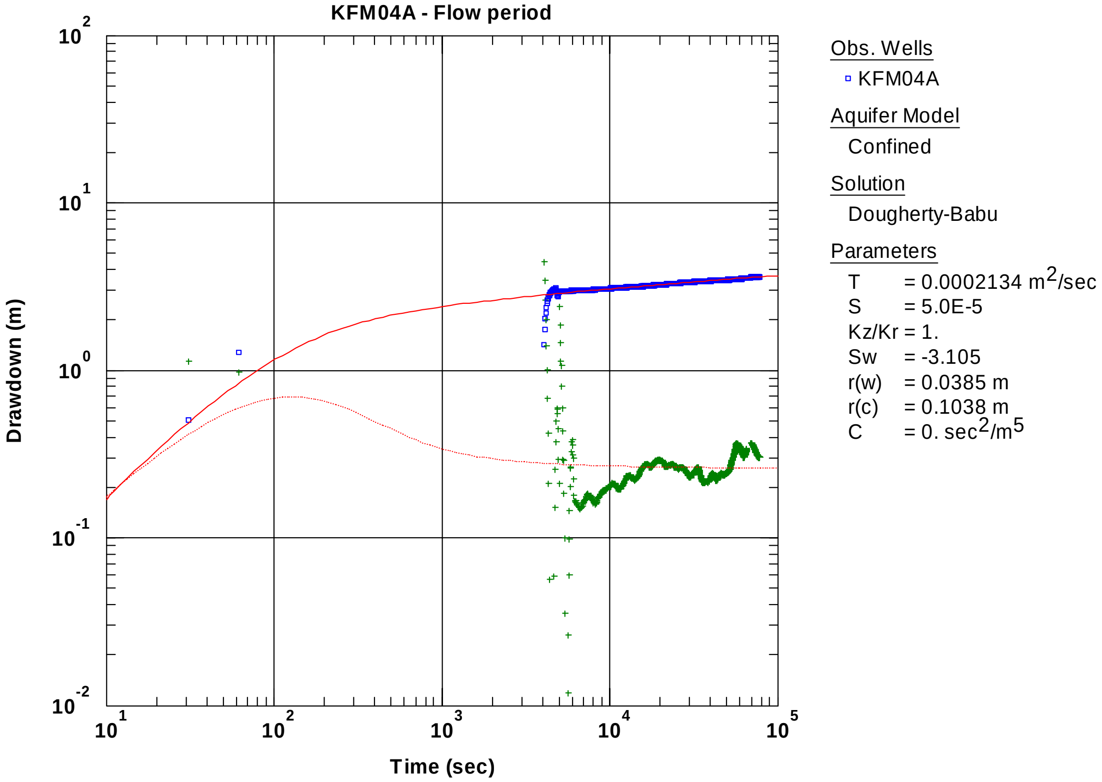


Figure 13:2-2. *Log-log plot of measured (blue) and simulated (red) pressure drawdown and – derivative (green) versus time during the first phase of the flow period of the pumping test in borehole KFM04A.*

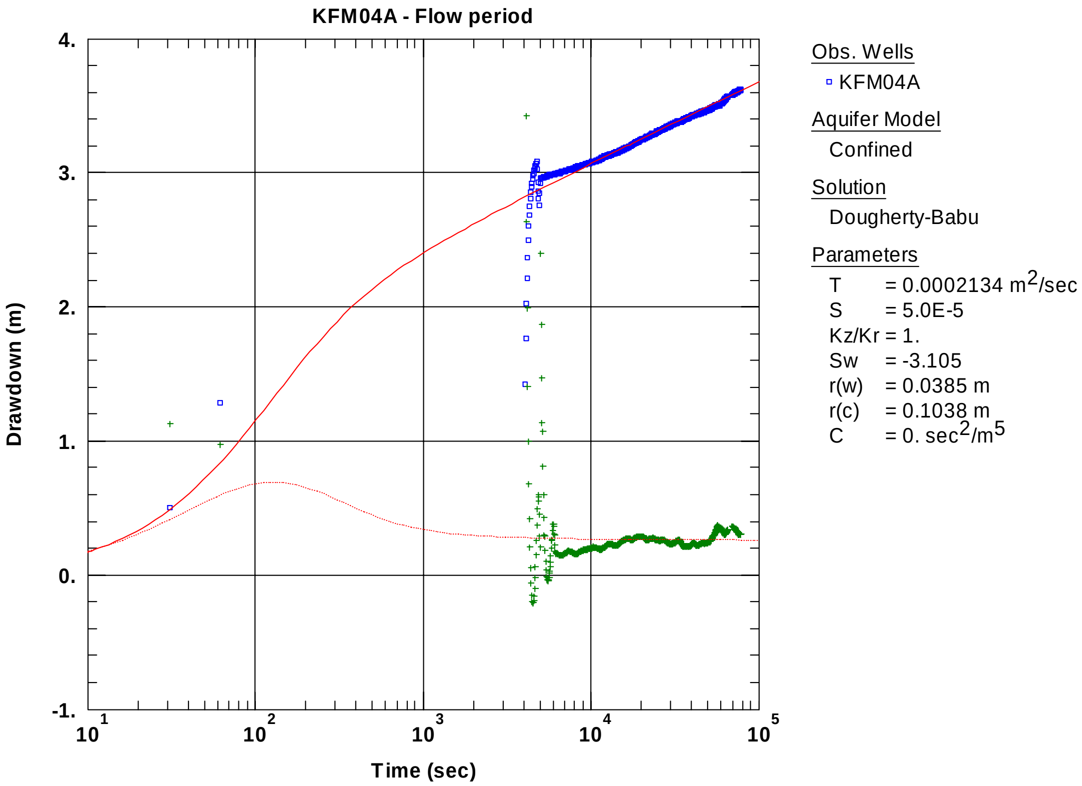


Figure 13:2-3. *Lin-log plot of measured (blue) and simulated (red) pressure drawdown and – derivative (green) versus time during the first phase of the flow period of the pumping test in borehole KFM04A.*

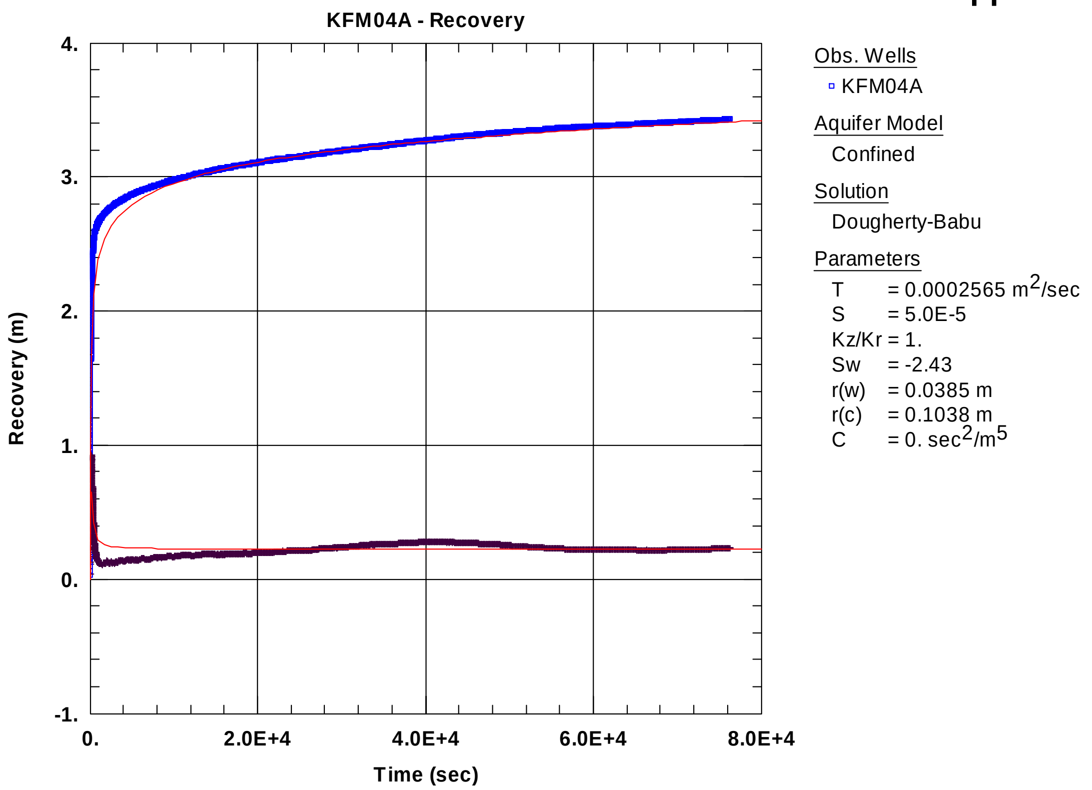


Figure 13:2-4. *Linear plot of measured (blue) and simulated (red) pressure recovery and –derivative (green) versus time during the pumping test in borehole KFM04A. The simulation is based on the late-time pressure behavior.*

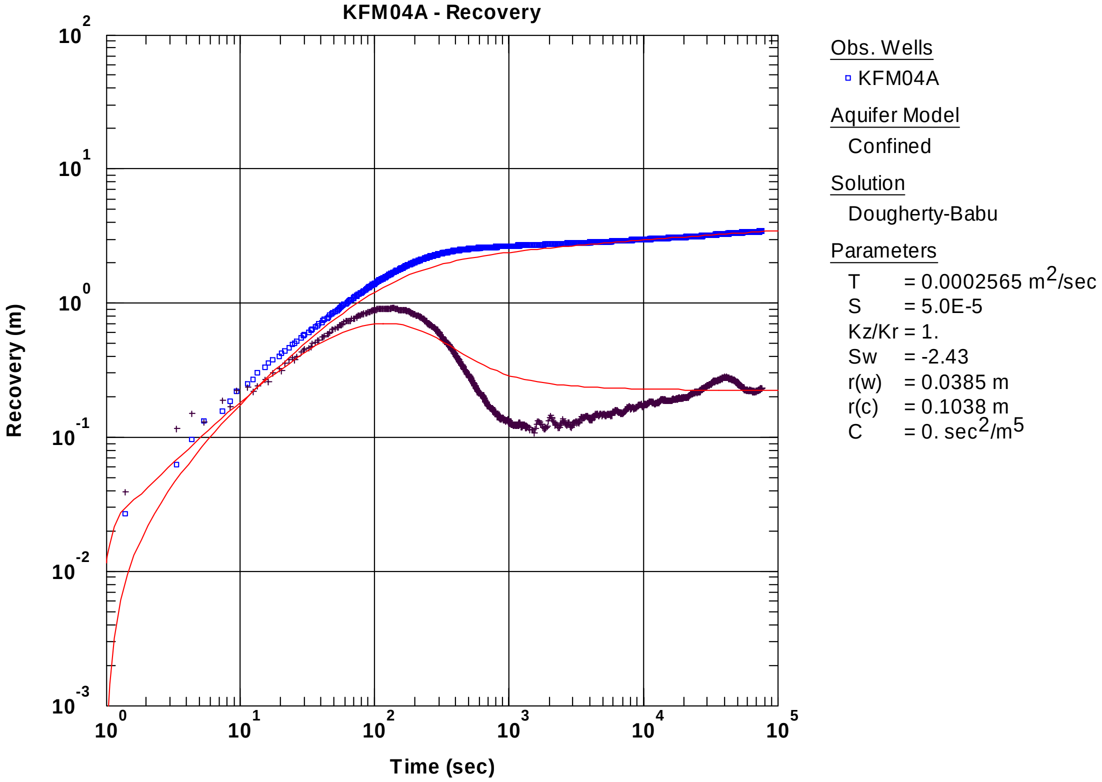


Figure 13:2-5. *Log-log plot of measured (blue) and simulated (red) pressure recovery and –derivative (green) versus time during the pumping test in borehole KFM04A. The simulation is based on the late-time pressure behavior.*

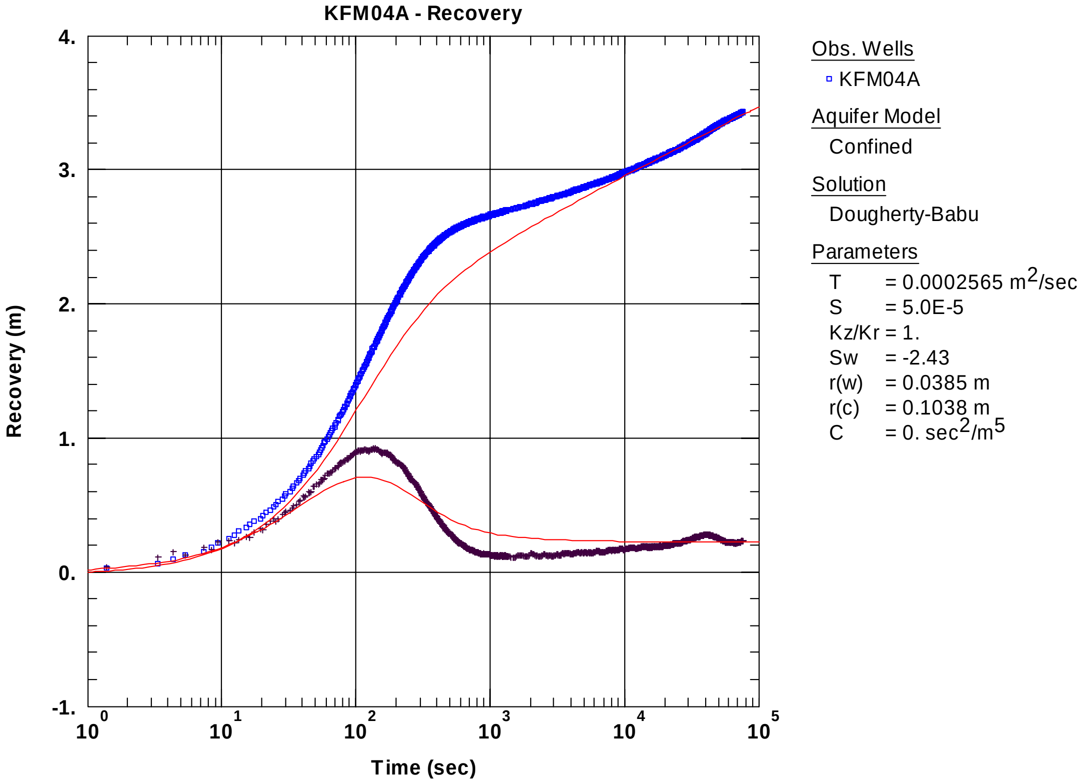


Figure 13:2-6. *Lin-log plot of measured (blue) and simulated (red) pressure recovery and –derivative (green) versus time during the pumping test in borehole KFM04A. The simulation is based on the late-time pressure behavior.*

APPENDIX 13:3 PARAMETER FILE TO SICADA

Result Tables for Single-hole pumping- and injection tests

Appendix 13

Parameter file of results from single-hole pumping test in borehole KFM04A during difference flow logging.

SINGLEHOLE TESTS, Pumping and injection, s_hole_test_d; General information

Borehole	Borehole secup (m)	Borehole seclow (m)	Test type (1-7)	Formation type (-)	Date and time for test, start YYYYMMDD hh:mm	Date and time for test, stop YYYYMMDD hh:mm	Date and time of flow/ injection, start YYYYMMDD hh:mm:ss	Date and time of flow/ injection, stop YYYYMMDD hh:mm:ss	Q_p (m**3/s)	Value type-Q_p (-1,0,1)	Q-measl-L (m**3)/s	Q-measl-U (m**3)/s
KFM04A	108.61	1001.42	1B	1	2004-03-16 14:47	2004-03-23 16:48	2004-03-16 14:47	2004-03-22 16:48	7.17E-04	0		

cont.

V_p (m**3)	Q_m (m**3/s)	tp (s)	t_F (s)	h_i (m a sl)	h_p (m a sl)	h_F (m a sl)	p_i (kPa)	p_p (kPa)	p_F (kPa)	Te_w (^{o} C)	EC_w (mS/m)	TDS_w (mg/ L)	TDS_{wm} (mg/ L)	Reference	Comments (-)
		529260	82800	2.59	-1.28	2.19									

SINGLEHOLE TESTS, Pumping and injection, s_hole_test_ed1; Basic evaluation

Borehole	Borehole secup (m)	Borehole seclow (m)	Date and time for test, start YYYYMMDD hh:mm	Q/s (m^2/ s)	Value type-Q/s (-1, 0, 1)	T_Q (m^2/ s)	T_M (m^2/ s)	b (m)	B (m)	TB (1D) (m^3/ s)	TB-measl-L (1D) (m^3/ s)	TB-measl-U (1D) (m^3/ s)	SB (1D) (m)	SB* (1D) (m)	L_f (1D) (m)	T_T (2D) (m^2/ s)	Value type-T_T (-1, 0, 1)
KFM04A	108.61	1001.42	2004-03-16 14:47	1.85E-04	0		3.05E-04	892.81								2.56E-04	0

cont.

Q/s-measl-L (m^2/ s)	Q/s-measl-U (m^2/ s)	S (2D) (-)	S* (2D) (-)	K´/b´ (2D) (1/s)	K_S (3D) (m/s)	K_S-measl-L (3D) (m/s)	K_S-measl-U (3D) (m/s)	S_S (3D) (1/m)	S_S* (3D) (1/m)	L_p (m)	C (m**3/Pa)	C_D (-)	ξ (2D) (-)	ω (-)	λ (-)	t_1 (s)	t_2 (s)	Comments (-)
2.00E-08	2.00E-03		5.00E-05								3.45E-06		-2.43			20000	81600	

Header	Unit	Explanation
Borehole		ID for borehole
Borehole secup	m	Length coordinate along the borehole for the upper limit of the test section
Borehole seclow	m	Length coordinate along the borehole for the lower limit of the test section
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, 5A: Difference flow logging-PFL-DIFF-sequential, 5B: Difference flow logging-PFL-DIFF-overlapping, 6:Flow logging_Impeller,7:Grain size analysis
Date for test start		Date for the start of the pumping or injection test (YYYYMMDD hh:mm)
Start flow / injection		Date and time for the start of the pumping or injection period (YYMMDD hh:mm:ss)
Start flow / injection		Date and time for the end of the pumping or injection period (YYMMDD hh:mm:ss)
Q_m	m^3/s	Arithmetic mean flow rate of the pumping/injection period.
Q_p	m^3/s	Flow rate at the end of the pumping/injection period.
Value type	-	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	m^3/s	Estimated lower measurement limit for flow rate
Q-measl_U	m^3/s	Estimated upper measurement limit for flow rate
V_p	m^3	Total volume pumped (positive) or injected (negative) water during the flow period.
t_p	s	Time for the flowing phase of the test
t_F	s	Time for the recovery phase of the test
h_i	m	Initial formation hydraulic head. Measured as water level in open stand pipes from borehole section with reference level in the local coordinates system with z=0 m.
h_p	m	Final hydraulic head at the end of the pumping/injection period. Measured as water level in open stand pipes from borehole section with reference level in the local coordinates system with z=0 m.
h_F	m	Final hydraulic head at the end of the recovery period. Measured as water level in open stand pipes from borehole section with reference level in the local coordinates system with z=0 m.
p_i	kPa	Initial formation pressure.
p_p	kPa	Final pressure at the end of the pumping/injection period.
p_F	kPa	Final pressure at the end of the recovery period.
Te_w	gr C	Fluid temperature in the test section representative for the evaluated parameters
EC_w	mS/m	Electrical conductivity of the fluid in the test section representative for the evaluated parameters
TDS_w	mg/L	Total salinity of the fluid in formation at test section based on EC.
TDS_{wn}	mg/L	Total salinity of the fluid in formation at test section based on water sampling and chemical analysis.
Sec.type,	(-)	Test section (pumping or injection) is labeled 1 and all observation sections are labeled 2
Q/s	m2/s	Specific capacity, based on Qp and s=abs(pi-pp). Only given for test section (label 1) in interference test.
T_Q	m2/s	Steady-state transmissivity based on specific capacity and a function for T=f(Q/s). The function used should be referred in "Comments"
T_M	m2/s	Steady-state transmissivity based on Moye (1967)
b	m	Interpreted formation thickness representative for evaluated T ot TB.
B	m	Interpreted witdth of a formation with evaluated TB
TB	m3/s	1D model for evaluation of formation properties. T=transmissivity, B=width of formation
TB-measl-L	m2/s	Estimated measurement limit for evaluated TB. If estimated TB equals TB-measlim in the table actual TB is considered to be equal or less than TB-measlim
TB-measl-L	m2/s	Estimated measurement limit for evaluated TB. If estimated TB equals TB-measlim in the table actual TB is considered to be equal or greater than TB-measlim
SB	m	1D model for evaluation of formation properties. S= Storativity, B=width of formation
SB*	m	1D model for evaluation of formation properties. Assumed SB. S= Storativity, B=width of formation
L_f	m	1D model for evaluation of Leakage factor
T_T	m2/s	2D model for transient evaluation of formation properties. T=transmissivity

T-measl-L	m2/s	Estimated measurement limit for evaluated T (TT, TQ, TM). If estimated T equals T-measlim in the table actual T is considered to be equal or less than T-measlim
T-measl-U	m2/s	Estimated measurement limit for evaluated T (TT, TQ, TM). If estimated T equals T-measlim in the table actual T is considered to be equal or grater than T-measlim
S	(-)	2D model for evaluation of formation properties. S= Storativity
S*	(-)	2D model for evaluation of formation properties. Assumed S. S= Storativity
K´/b´	(1/s)	2D model for evaluation of leakage coefficient. K´= hydraulic conductivity in direction of leaking flow for the aquitard, b´= Saturated thickness of aquitard (leaking formation)
K_S	m/s	3D model for evaluation of formation properties. K=Hydraulic conductivity
K_S-measl-L	m/s	Estimated measurement limit for evaluated KS. If estimated KS equals KS-measlim in the table actual KS is considered to be equal or less than KS-measlim
K_S-measl-U	m/s	Estimated measurement limit for evaluated KS. If estimated KS equals KS-measlim in the table actual KS is considered to be equal or greater than KS-measlim
S_S	1/m	3D model for evaluation of formation properties. Ss=Specific Storage
S_S*	1/m	3D model for evaluation of formation properties. Assumed Ss. Ss=Specific Storage
L_p	m	Hydraulic point of appication, based on hydraulic conductivity distribution (if available) or the midpoint of the borehole test section
C	(m3/Pa)	Wellbore storage coefficient
C_D	(-)	Dimensionless wellbore storage coefficient
ξ	(-)	Skin factor
ω	(-)	Storativity ratio
λ	(-)	Interporosity flow coefficient
t_1	s	Estimated start time after pump/injection start OR recovery start, for the period used for the evaluated parameter
t_2	s	Estimated stop time after pump/injection start OR recovery start, for the period used for the evaluated parameter
References		SKB report No for reports describing data and evaluation
Index w		Active borehole or borehole section

Appendix 14

PFL-Difference flow logging- Basic data

Borehole	Logged interval from	to	Test type	Q-measl-L-theore-tical	Q-measl-L-practical	Q-measl-U	Q-measl-U	Item in AP	Formation type	Date and time of test, start	Date and time of flowl., start	Date and time of flowl., stop	Lw	dL
ID	L (m)	L (m)	(1-7)	(m^3/s)	(mL/h)	(mL/h)	(m^3/s)		(-)	YYYYMMDD hh:mm	YYYYMMDD hh:mm	YYYYMMDD hh:mm	(m)	(m)
KFM04A	111,00	993	5A	1,67E-09	30-100	300000	8,33E-05	9	1	2004-03-12 11:23	2004-03-12 11:23	2004-03-16 12:34	5	5
KFM04A	111,00	993	5B	8,33E-09	30-100	300000	8,33E-05	9	1	2004-03-12 11:23	2004-03-12 11:23	2004-03-16 12:34	5	0,5
KFM04A	111,00	993	5B	8,33E-09	30-100	300000	8,33E-05	10	1	2004-03-16 13:30	2004-03-17 16:47	2004-03-18 17:30	5	0,5
KFM04A	111,00	535	5B	8,33E-09	30-60	300000	8,33E-05	11	1	2004-03-18 00:00	2004-03-18 00:00	2004-03-21 07:45	1	0,1
KFM04A	111,00	245	5B	8,33E-09	30-60	300000	8,33E-05	11extra	1	2004-03-23 16:48	2004-03-23 18:58	2004-03-24 06:51	1	0,1
KFM04A	952,00	993	5B	8,33E-09	30-100	300000	8,33E-05	11extra	1	2004-03-24 09:02	2004-03-24 09:02	2004-03-24 13:27	1	0,1

Cont.

Q_{p1} (L/min)	Qp2 (L/min)	Qp3 (L/min)	Qp4 (L/min)	tp1 (s)	tp2 (s)	tp3 (s)	tp4 (s)	tF (s)	h0 (m a s l)	h1 (m a s l)	h2 (m a s l)	h3 (m a s l)	h4 (m a s l)	hF (m a s l)	s1 (m)	s2 (m)	s3 (m)	s4 (m)	Reference (-)	Comments (-)
									2,60										R-04-	No pumping
									2,60										R-04-	No pumping
40,6										-1,30					3,90				R-04-	
41,2				447480						-1,30					3,90				R-04-	
	16,7				53520						1,20					1,40			R-04-	
		79,5				20820						-4,80					7,40		R-04-	

PFL-Difference flow logging- Sequential flow logging

Bore-hole	Date and time of test, start	Logged interval from (m)	Logged interval to (m)	Secup (m)	Seclow (m)	b (m)	Test type	q0 (m³/s)	Value type Q0	q1 (m³/s)	Value type-Q1	Q-measl-L-practical (m³/s)	h0f (masl)	h1f (masl)	h2f (masl)	TD (m²/s)	Value type TD	TD-measl-L-practical (m²/s)	TD-measl-U (m²/s)	hi (masl)	Value type hi	Tew (°C)	Comments
KFM04A	2004-03-12 11:23	992,57	111,23	987,57	992,57	5	5A	0,0E+0	-1			2,78E-08	13,54				-1	8,0E-9	2,4E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	982,57	987,57	5	5A	0,0E+0	-1			2,78E-08	13,51				-1	7,7E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	977,56	982,56	5	5A	0,0E+0	-1			8,33E-09	13,55				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	972,56	977,56	5	5A	0,0E+0	-1			8,33E-09	13,53				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	967,56	972,56	5	5A	0,0E+0	-1			8,33E-09	13,47				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	962,55	967,55	5	5A	0,0E+0	-1			8,33E-09	13,39				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	957,55	962,55	5	5A	0,0E+0	-1			8,33E-09	13,35				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	952,55	957,55	5	5A	0,0E+0	-1			8,33E-09	13,26			1,29E-9	0	1,1E-9	1,1E-5		-1		Remeasured at a higher drawdown
KFM04A	2004-03-12 11:23	992,57	111,23	947,55	952,55	5	5A	0,0E+0	-1			8,33E-09	13,16				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	942,54	947,54	5	5A	0,0E+0	-1			8,33E-09	13,13				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	937,54	942,54	5	5A	0,0E+0	-1			8,33E-09	13,08				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	932,54	937,54	5	5A	0,0E+0	-1			8,33E-09	13,03				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	927,54	932,54	5	5A	0,0E+0	-1			8,33E-09	12,96				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	922,54	927,54	5	5A	0,0E+0	-1			8,33E-09	12,86				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	917,54	922,54	5	5A	0,0E+0	-1			8,33E-09	12,79				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	912,54	917,54	5	5A	0,0E+0	-1			8,33E-09	12,75				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	907,51	912,51	5	5A	0,0E+0	-1			8,33E-09	12,66				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	902,49	907,49	5	5A	0,0E+0	-1			8,33E-09	12,63				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	897,47	902,47	5	5A	0,0E+0	-1			8,33E-09	12,60				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	892,45	897,45	5	5A	0,0E+0	-1			8,33E-09	12,52				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	887,43	892,43	5	5A	0,0E+0	-1			8,33E-09	12,47				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	882,41	887,41	5	5A	0,0E+0	-1			8,33E-09	12,41				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	877,39	882,39	5	5A	0,0E+0	-1			8,33E-09	12,35				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	872,38	877,38	5	5A	0,0E+0	-1			8,33E-09	12,30				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	867,37	872,37	5	5A	0,0E+0	-1			8,33E-09	12,24				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	862,36	867,36	5	5A	0,0E+0	-1			8,33E-09	12,19				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	857,35	862,35	5	5A	0,0E+0	-1			8,33E-09	12,14				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	852,32	857,32	5	5A	0,0E+0	-1			8,33E-09	12,07				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	847,28	852,28	5	5A	0,0E+0	-1			8,33E-09	12,03				-1	2,2E-9	2,2E-5		-1		

Appendix 14

Bore-hole	Date and time of test, start	Logged interval from (m)	Logged interval to (m)	Secup (m)	Seclow (m)	b (m)	Test type	q0 (m³/s)	Value type Q0	q1 (m³/s)	Value type-Q1	Q-measl-L-practical (m³/s)	h0f (masl)	h1f (masl)	h2f (masl)	TD (m²/s)	Value type TD	TD-measl-L-practical (m²/s)	TD-measl-U (m²/s)	hi (masl)	Value type hi	Tew (°C)	Comments
KFM04A	2004-03-12 11:23	992,57	111,23	842,27	847,27	5	5A	0,0E+0	-1			8,33E-09	11,96				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	837,26	842,26	5	5A	0,0E+0	-1			8,33E-09	11,90				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	832,25	837,25	5	5A	0,0E+0	-1			8,33E-09	11,85				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	827,24	832,24	5	5A	0,0E+0	-1			8,33E-09	11,79				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	822,23	827,23	5	5A	0,0E+0	-1			8,33E-09	11,71				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	817,22	822,22	5	5A	0,0E+0	-1			8,33E-09	11,67				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	812,22	817,22	5	5A	0,0E+0	-1			8,33E-09	11,60				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	807,22	812,22	5	5A	0,0E+0	-1			8,33E-09	11,55				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	802,22	807,22	5	5A	0,0E+0	-1			8,33E-09	11,48				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	797,22	802,22	5	5A	0,0E+0	-1			8,33E-09	11,45				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	792,21	797,21	5	5A	0,0E+0	-1			8,33E-09	11,34				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	787,21	792,21	5	5A	0,0E+0	-1			8,33E-09	11,28				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	782,21	787,21	5	5A	0,0E+0	-1			8,33E-09	11,23				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	777,21	782,21	5	5A	0,0E+0	-1			8,33E-09	11,17				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	772,21	777,21	5	5A	0,0E+0	-1			8,33E-09	11,09				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	767,2	772,2	5	5A	0,0E+0	-1			8,33E-09	11,05				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	762,2	767,2	5	5A	0,0E+0	-1			8,33E-09	10,98				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	757,2	762,2	5	5A	0,0E+0	-1			8,33E-09	10,92				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	752,19	757,19	5	5A	0,0E+0	-1			1,67E-08	10,86				-1	4,3E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	747,19	752,19	5	5A	0,0E+0	-1			1,67E-08	10,80				-1	4,3E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	742,18	747,18	5	5A	0,0E+0	-1			8,33E-09	10,69				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	737,18	742,18	5	5A	0,0E+0	-1			8,33E-09	10,62				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	732,18	737,18	5	5A	0,0E+0	-1			8,33E-09	10,55				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	727,19	732,19	5	5A	0,0E+0	-1			8,33E-09	10,48				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	722,19	727,19	5	5A	0,0E+0	-1			8,33E-09	10,41				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	717,18	722,18	5	5A	0,0E+0	-1			1,39E-08	10,35				-1	3,7E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	712,17	717,17	5	5A	0,0E+0	-1			1,39E-08	10,28				-1	3,6E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	707,16	712,16	5	5A	0,0E+0	-1			1,39E-08	10,23				-1	3,6E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	702,15	707,15	5	5A	0,0E+0	-1			1,39E-08	10,16				-1	3,7E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	697,14	702,14	5	5A	0,0E+0	-1			1,39E-08	10,11				-1	3,6E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	692,13	697,13	5	5A	0,0E+0	-1			1,39E-08	10,03				-1	3,6E-9	2,2E-5		-1		

Bore-hole	Date and time of test, start	Logged interval from (m)	Logged interval to (m)	Secup (m)	Seclow (m)	b (m)	Test type	q0 (m³/s)	Value type Q0	q1 (m³/s)	Value type-Q1	Q-measl-L-practical (m³/s)	h0f (masl)	h1f (masl)	h2f (masl)	TD (m²/s)	Value type TD	TD-measl-L-practical (m²/s)	TD-measl-U (m²/s)	hi (masl)	Value type hi	Tew (°C)	Comments
KFM04A	2004-03-12 11:23	992,57	111,23	687,13	692,13	5	5A	0,0E+0	-1			1,39E-08	9,95				-1	3,6E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	682,12	687,12	5	5A	0,0E+0	-1			1,39E-08	9,89				-1	3,6E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	677,11	682,11	5	5A	0,0E+0	-1			1,39E-08	9,83				-1	3,6E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	672,1	677,1	5	5A	0,0E+0	-1			1,39E-08	9,81				-1	3,6E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	667,09	672,09	5	5A	0,0E+0	-1			1,39E-08	9,75				-1	3,6E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	662,08	667,08	5	5A	0,0E+0	-1			1,39E-08	9,68				-1	3,6E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	657,07	662,07	5	5A	0,0E+0	-1			1,39E-08	9,60				-1	3,6E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	652,06	657,06	5	5A	0,0E+0	-1			8,33E-09	9,52				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	647,05	652,05	5	5A	0,0E+0	-1			8,33E-09	9,48				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	642,04	647,04	5	5A	0,0E+0	-1			8,33E-09	9,41				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	637,04	642,04	5	5A	0,0E+0	-1			1,67E-08	9,33				-1	4,4E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	632,03	637,03	5	5A	0,0E+0	-1			1,67E-08	9,27				-1	4,5E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	627,02	632,02	5	5A	0,0E+0	-1			1,67E-08	9,23				-1	4,4E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	622,01	627,01	5	5A	0,0E+0	-1			1,67E-08	9,14				-1	4,4E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	616,99	621,99	5	5A	0,0E+0	-1			8,33E-09	9,08				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	611,98	616,98	5	5A	0,0E+0	-1			8,33E-09	9,04				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	606,97	611,97	5	5A	0,0E+0	-1			8,33E-09	8,99				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	601,95	606,95	5	5A	0,0E+0	-1			8,33E-09	8,92				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	596,94	601,94	5	5A	0,0E+0	-1			8,33E-09	8,87				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	591,93	596,93	5	5A	0,0E+0	-1			8,33E-09	8,79				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	586,91	591,91	5	5A	0,0E+0	-1			8,33E-09	8,75				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	581,9	586,9	5	5A	0,0E+0	-1			8,33E-09	8,69				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	576,89	581,89	5	5A	0,0E+0	-1			1,39E-08	8,63				-1	3,7E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	571,87	576,87	5	5A	0,0E+0	-1			1,39E-08	8,55				-1	3,7E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	566,87	571,87	5	5A	0,0E+0	-1			1,39E-08	8,51				-1	3,7E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	561,86	566,86	5	5A	0,0E+0	-1			8,33E-09	8,46				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	556,86	561,86	5	5A	0,0E+0	-1			8,33E-09	8,40				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	551,85	556,85	5	5A	0,0E+0	-1			8,33E-09	8,31				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	546,85	551,85	5	5A	0,0E+0	-1			8,33E-09	8,28				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	541,84	546,84	5	5A	0,0E+0	-1			8,33E-09	8,15				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	536,84	541,84	5	5A	0,0E+0	-1			8,33E-09	8,12				-1	2,2E-9	2,2E-5		-1		

Appendix 14

Bore-hole	Date and time of test, start	Logged interval from (m)	Logged interval to (m)	Secup (m)	Seclow (m)	b (m)	Test type	q0 (m³/s)	Value type Q0	q1 (m³/s)	Value type-Q1	Q-measl-L-practical (m³/s)	h0f (masl)	h1f (masl)	h2f (masl)	TD (m²/s)	Value type TD	TD-measl-L-practical (m²/s)	TD-measl-U (m²/s)	hi (masl)	Value type hi	Tew (°C)	Comments
KFM04A	2004-03-12 11:23	992,57	111,23	531,83	536,83	5	5A	0,0E+0	-1			8,33E-09	8,07				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	526,83	531,83	5	5A	0,0E+0	-1			8,33E-09	8,03				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	521,82	526,82	5	5A	0,0E+0	-1			8,33E-09	7,94				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	516,82	521,82	5	5A	0,0E+0	-1			8,33E-09	7,85			1,50E-9	0	2,3E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	511,81	516,81	5	5A	0,0E+0	-1			8,33E-09	7,80				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	506,81	511,81	5	5A	0,0E+0	-1			8,33E-09	7,75				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	501,8	506,8	5	5A	0,0E+0	-1			8,33E-09	7,71				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	496,8	501,8	5	5A	0,0E+0	-1			8,33E-09	7,64				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	491,8	496,8	5	5A	0,0E+0	-1			8,33E-09	7,55				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	486,79	491,79	5	5A	0,0E+0	-1			8,33E-09	7,49				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	481,79	486,79	5	5A	0,0E+0	-1			8,33E-09	7,45				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	476,78	481,78	5	5A	0,0E+0	-1			8,33E-09	7,39				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	471,78	476,78	5	5A	0,0E+0	-1			8,33E-09	7,35				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	466,78	471,78	5	5A	0,0E+0	-1			8,33E-09	7,30				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	461,77	466,77	5	5A	0,0E+0	-1			8,33E-09	7,24				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	456,77	461,77	5	5A	0,0E+0	-1			8,33E-09	7,18				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	451,76	456,76	5	5A	0,0E+0	-1			8,33E-09	7,11				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	446,76	451,76	5	5A	0,0E+0	-1			8,33E-09	7,03				-1	2,3E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	441,75	446,75	5	5A	0,0E+0	-1			8,33E-09	6,99				-1	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	436,75	441,75	5	5A	0,0E+0	-1			8,33E-09	6,94				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	431,74	436,74	5	5A	0,0E+0	-1			8,33E-09	6,89				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	426,74	431,74	5	5A	0,0E+0	-1			8,33E-09	6,84				-1	2,3E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	421,73	426,73	5	5A	0,0E+0	-1			8,33E-09	6,77			2,47E-9	0	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	416,73	421,73	5	5A	0,0E+0	-1			8,33E-09	6,70			1,68E-8	0	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	411,72	416,72	5	5A	0,0E+0	-1			8,33E-09	6,65				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	406,72	411,72	5	5A	0,0E+0	-1			8,33E-09	6,59				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	401,71	406,71	5	5A	0,0E+0	-1			8,33E-09	6,50				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	396,7	401,7	5	5A	0,0E+0	-1			8,33E-09	6,44				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	391,7	396,7	5	5A	0,0E+0	-1			8,33E-09	6,38				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	386,69	391,69	5	5A	0,0E+0	-1			8,33E-09	6,33				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	381,69	386,69	5	5A	0,0E+0	-1			8,33E-09	6,28				-1	2,3E-9	2,3E-5		-1		

Bore-hole	Date and time of test, start	Logged interval from (m)	Logged interval to (m)	Secup (m)	Seclow (m)	b (m)	Test type	q0 (m³/s)	Value type Q0	q1 (m³/s)	Value type-Q1	Q-measl-L-practical (m³/s)	h0f (masl)	h1f (masl)	h2f (masl)	TD (m²/s)	Value type TD	TD-measl-L-practical (m²/s)	TD-measl-U (m²/s)	hi (masl)	Value type hi	Tew (°C)	Comments
KFM04A	2004-03-12 11:23	992,57	111,23	376,68	381,68	5	5A	0,0E+0	-1			8,33E-09	6,24				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	371,67	376,67	5	5A	0,0E+0	-1			8,33E-09	6,15				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	366,67	371,67	5	5A	0,0E+0	-1			8,33E-09	6,11				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	361,66	366,66	5	5A	0,0E+0	-1			8,33E-09	6,04				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	356,66	361,66	5	5A	-7,7E-7	0			8,33E-09	5,99			1,39E-6	0	2,3E-9	2,3E-5	5,44	0		
KFM04A	2004-03-12 11:23	992,57	111,23	351,66	356,66	5	5A	0,0E+0	-1			8,33E-09	5,91			2,14E-9	0	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	346,66	351,66	5	5A	0,0E+0	-1			8,33E-09	5,87				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	341,66	346,66	5	5A	0,0E+0	-1			8,33E-09	5,81			4,07E-9	0	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	336,66	341,66	5	5A	-1,5E-8	0			8,33E-09	5,77			2,90E-8	0	2,3E-9	2,3E-5	5,27	0		
KFM04A	2004-03-12 11:23	992,57	111,23	331,66	336,66	5	5A	0,0E+0	-1			8,33E-09	5,69				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	326,65	331,65	5	5A	0,0E+0	-1			8,33E-09	5,64				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	321,65	326,65	5	5A	0,0E+0	-1			8,33E-09	5,60				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	316,65	321,65	5	5A	0,0E+0	-1			8,33E-09	5,54				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	311,65	316,65	5	5A	0,0E+0	-1			8,33E-09	5,49			1,36E-9	0	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	306,63	311,63	5	5A	0,0E+0	-1			8,33E-09	5,44				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	301,62	306,62	5	5A	0,0E+0	-1			8,33E-09	5,39				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	296,61	301,61	5	5A	0,0E+0	-1			8,33E-09	5,34			1,77E-7	0	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	291,6	296,6	5	5A	0,0E+0	-1			8,33E-09	5,24			4,50E-8	0	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	286,59	291,59	5	5A	0,0E+0	-1			8,33E-09	5,22				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	281,58	286,58	5	5A	0,0E+0	-1			8,33E-09	5,18				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	276,57	281,57	5	5A	0,0E+0	-1			8,33E-09	5,14				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	271,56	276,56	5	5A	0,0E+0	-1			8,33E-09	5,07			6,70E-9	0	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	266,55	271,55	5	5A	0,0E+0	-1			8,33E-09	5,03				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	261,54	266,54	5	5A	0,0E+0	-1			8,33E-09	4,99				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	256,54	261,54	5	5A	0,0E+0	-1			8,33E-09	4,95			1,89E-8	0	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	251,53	256,53	5	5A	0,0E+0	-1			8,33E-09	4,89				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	246,53	251,53	5	5A	0,0E+0	-1			8,33E-09	4,85				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	241,52	246,52	5	5A	0,0E+0	-1			8,33E-09	4,77				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	236,52	241,52	5	5A	0,0E+0	-1			8,33E-09	4,71				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	231,52	236,52	5	5A	1,1E-6	0			8,33E-09	4,67			5,45E-5	0	2,3E-9	6,6E-5	4,69	0		Remeasured at a lower drawdown

Appendix 14

Bore-hole	Date and time of test, start	Logged interval from (m)	Logged interval to (m)	Secup (m)	Seclow (m)	b (m)	Test type	q0 (m³/s)	Value type Q0	q1 (m³/s)	Value type-Q1	Q-measl-L-practical (m³/s)	h0f (masl)	h1f (masl)	h2f (masl)	TD (m²/s)	Value type TD	TD-measl-L-practical (m²/s)	TD-measl-U (m²/s)	hi (masl)	Value type hi	Tew (°C)	Comments
KFM04A	2004-03-12 11:23	992,57	111,23	226,51	231,51	5	5A	0,0E+0	-1			8,33E-09	4,64				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	221,51	226,51	5	5A	0,0E+0	-1			8,33E-09	4,55				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	216,5	221,5	5	5A	0,0E+0	-1			8,33E-09	4,52				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	211,5	216,5	5	5A	0,0E+0	-1			8,33E-09	4,47				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	206,49	211,49	5	5A	-5,9E-7	0			8,33E-09	4,41			3,54E-5	0	2,3E-9	6,5E-5	4,4	0		Remeasured at a lower drawdown
KFM04A	2004-03-12 11:23	992,57	111,23	201,48	206,48	5	5A	-7,3E-8	0			8,33E-09	4,38			8,30E-6	0	2,3E-9	6,4E-5	4,37	0		Remeasured at a lower drawdown
KFM04A	2004-03-12 11:23	992,57	111,23	196,48	201,48	5	5A	0,0E+0	-1			8,33E-09	4,37				-1	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	191,47	196,47	5	5A	0,0E+0	-1			8,33E-09	4,37			3,75E-7	0	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	186,46	191,46	5	5A	0,0E+0	-1			8,33E-09	4,36			1,75E-7	0	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	181,45	186,45	5	5A	0,0E+0	-1			8,33E-09	4,34			2,33E-7	0	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	176,45	181,45	5	5A	5,0E-9	0			8,33E-09	4,32			5,10E-7	0	2,2E-9	2,2E-5	4,32	0		
KFM04A	2004-03-12 11:23	992,57	111,23	171,44	176,44	5	5A	0,0E+0	-1			8,33E-09	4,02			4,37E-7	0	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	166,43	171,43	5	5A	0,0E+0	-1			8,33E-09	4,06			1,53E-7	0	2,3E-9	2,3E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	161,42	166,42	5	5A	4,1E-8	0			8,33E-09	3,99			1,21E-6	0	2,3E-9	2,3E-5	4,02	0		
KFM04A	2004-03-12 11:23	992,57	111,23	156,42	161,42	5	5A	0,0E+0	-1			8,33E-09	4,01			5,65E-8	0	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	151,42	156,42	5	5A	0,0E+0	-1			1,39E-08	4,04			5,25E-8	0	3,6E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	146,42	151,42	5	5A	0,0E+0	-1			1,39E-08	4,00			2,03E-7	0	3,6E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	141,42	146,42	5	5A	0,0E+0	-1			8,33E-09	3,92			3,87E-8	0	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	136,43	141,43	5	5A	0,0E+0	-1			8,33E-09	3,88			2,06E-7	0	2,2E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	131,43	136,43	5	5A	0,0E+0	-1			1,39E-08	3,83			6,75E-7	0	3,6E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	126,43	131,43	5	5A	0,0E+0	-1			1,39E-08	3,80			5,75E-7	0	3,6E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	121,43	126,43	5	5A	0,0E+0	-1			1,67E-08	3,75			4,61E-8	0	4,3E-9	2,2E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	116,23	121,23	5	5A	0,0E+0	-1			1,67E-08	3,73			1,56E-7	0	4,2E-9	2,1E-5		-1		
KFM04A	2004-03-12 11:23	992,57	111,23	111,23	116,23	5	5A	2,3E-7	0			1,67E-08	3,57			6,25E-5	0	4,2E-9	6,5E-5	3,57	0		Remeasured at a lower drawdown
KFM04A	2004-03-17 16:47	992,57	111,18	987,57	992,57	5	5A			0,0E+0	-1	2,78E-08		10,10									
KFM04A	2004-03-17 16:47	992,57	111,18	982,57	987,57	5	5A			0,0E+0	-1	2,78E-08		9,93									

Bore-hole	Date and time of test, start	Logged interval from (m)	Logged interval to (m)	Secup (m)	Seclow (m)	b (m)	Test type	q0 (m³/s)	Value type Q0	q1 (m³/s)	Value type-Q1	Q-measl-L-practical (m³/s)	h0f (masl)	h1f (masl)	h2f (masl)	TD (m²/s)	Value type TD	TD-measl-L-practical (m²/s)	TD-measl-U (m²/s)	hi (masl)	Value type hi	Tew (°C)	Comments
KFM04A	2004-03-17 16:47	992,57	111,18	977,57	982,57	5	5A			0,0E+0	-1	8,33E-09		9,83									
KFM04A	2004-03-17 16:47	992,57	111,18	972,56	977,56	5	5A			0,0E+0	-1	8,33E-09		9,74									
KFM04A	2004-03-17 16:47	992,57	111,18	967,56	972,56	5	5A			0,0E+0	-1	8,33E-09		9,72									
KFM04A	2004-03-17 16:47	992,57	111,18	962,56	967,56	5	5A			0,0E+0	-1	8,33E-09		9,65									
KFM04A	2004-03-17 16:47	992,57	111,18	957,56	962,56	5	5A			0,0E+0	-1	8,33E-09		9,58									
KFM04A	2004-03-24 09:02	992,57	111,18	952,55	957,55	5	5A			9,7E-9	0	8,33E-09		5,80									Remeasured at a higher drawdown
KFM04A	2004-03-17 16:47	992,57	111,18	947,54	952,54	5	5A			0,0E+0	-1	8,33E-09		9,45									
KFM04A	2004-03-17 16:47	992,57	111,18	942,53	947,53	5	5A			0,0E+0	-1	8,33E-09		9,38									
KFM04A	2004-03-17 16:47	992,57	111,18	937,52	942,52	5	5A			0,0E+0	-1	8,33E-09		9,31									
KFM04A	2004-03-17 16:47	992,57	111,18	932,51	937,51	5	5A			0,0E+0	-1	8,33E-09		9,26									
KFM04A	2004-03-17 16:47	992,57	111,18	927,51	932,51	5	5A			0,0E+0	-1	8,33E-09		9,21									
KFM04A	2004-03-17 16:47	992,57	111,18	922,5	927,5	5	5A			0,0E+0	-1	8,33E-09		9,14									
KFM04A	2004-03-17 16:47	992,57	111,18	917,49	922,49	5	5A			0,0E+0	-1	8,33E-09		9,07									
KFM04A	2004-03-17 16:47	992,57	111,18	912,48	917,48	5	5A			0,0E+0	-1	8,33E-09		9,02									
KFM04A	2004-03-17 16:47	992,57	111,18	907,47	912,47	5	5A			0,0E+0	-1	8,33E-09		8,94									
KFM04A	2004-03-17 16:47	992,57	111,18	902,45	907,45	5	5A			0,0E+0	-1	8,33E-09		8,90									
KFM04A	2004-03-17 16:47	992,57	111,18	897,44	902,44	5	5A			0,0E+0	-1	8,33E-09		8,85									
KFM04A	2004-03-17 16:47	992,57	111,18	892,43	897,43	5	5A			0,0E+0	-1	8,33E-09		8,78									
KFM04A	2004-03-17 16:47	992,57	111,18	887,41	892,41	5	5A			0,0E+0	-1	8,33E-09		8,72									
KFM04A	2004-03-17 16:47	992,57	111,18	882,4	887,4	5	5A			0,0E+0	-1	8,33E-09		8,65									
KFM04A	2004-03-17 16:47	992,57	111,18	877,38	882,38	5	5A			0,0E+0	-1	8,33E-09		8,61									
KFM04A	2004-03-17 16:47	992,57	111,18	872,37	877,37	5	5A			0,0E+0	-1	8,33E-09		8,55									
KFM04A	2004-03-17 16:47	992,57	111,18	867,36	872,36	5	5A			0,0E+0	-1	8,33E-09		8,50									
KFM04A	2004-03-17 16:47	992,57	111,18	862,34	867,34	5	5A			0,0E+0	-1	8,33E-09		8,43									
KFM04A	2004-03-17 16:47	992,57	111,18	857,33	862,33	5	5A			0,0E+0	-1	8,33E-09		8,36									
KFM04A	2004-03-17 16:47	992,57	111,18	852,3	857,3	5	5A			0,0E+0	-1	8,33E-09		8,32									
KFM04A	2004-03-17 16:47	992,57	111,18	847,27	852,27	5	5A			0,0E+0	-1	8,33E-09		8,27									
KFM04A	2004-03-17 16:47	992,57	111,18	842,26	847,26	5	5A			0,0E+0	-1	8,33E-09		8,16									
KFM04A	2004-03-17 16:47	992,57	111,18	837,25	842,25	5	5A			0,0E+0	-1	8,33E-09		8,13									

Appendix 14

Bore-hole	Date and time of test, start	Logged interval from (m)	Logged interval to (m)	Secup (m)	Seclow (m)	b (m)	Test type	q0 (m^3/s)	Value type Q0	q1 (m^3/s)	Value type-Q1	Q-measl-L-practical (m^3/s)	h0f (masl)	h1f (masl)	h2f (masl)	TD (m^2/s)	Value type TD	TD-measl-L-practical (m^2/s)	TD-measl-U (m^2/s)	hi (masl)	Value type hi	Tew (°C)	Comments
KFM04A	2004-03-17 16:47	992,57	111,18	832,24	837,24	5	5A			0,0E+0	-1	8,33E-09		8,07									
KFM04A	2004-03-17 16:47	992,57	111,18	827,24	832,24	5	5A			0,0E+0	-1	8,33E-09		8,00									
KFM04A	2004-03-17 16:47	992,57	111,18	822,23	827,23	5	5A			0,0E+0	-1	8,33E-09		7,96									
KFM04A	2004-03-17 16:47	992,57	111,18	817,22	822,22	5	5A			0,0E+0	-1	8,33E-09		7,91									
KFM04A	2004-03-17 16:47	992,57	111,18	812,22	817,22	5	5A			0,0E+0	-1	8,33E-09		7,82									
KFM04A	2004-03-17 16:47	992,57	111,18	807,22	812,22	5	5A			0,0E+0	-1	8,33E-09		7,77									
KFM04A	2004-03-17 16:47	992,57	111,18	802,22	807,22	5	5A			0,0E+0	-1	8,33E-09		7,70									
KFM04A	2004-03-17 16:47	992,57	111,18	797,22	802,22	5	5A			0,0E+0	-1	8,33E-09		7,64									
KFM04A	2004-03-17 16:47	992,57	111,18	792,22	797,22	5	5A			0,0E+0	-1	8,33E-09		7,57									
KFM04A	2004-03-17 16:47	992,57	111,18	787,22	792,22	5	5A			0,0E+0	-1	8,33E-09		7,50									
KFM04A	2004-03-17 16:47	992,57	111,18	782,22	787,22	5	5A			0,0E+0	-1	8,33E-09		7,45									
KFM04A	2004-03-17 16:47	992,57	111,18	777,22	782,22	5	5A			0,0E+0	-1	8,33E-09		7,41									
KFM04A	2004-03-17 16:47	992,57	111,18	772,22	777,22	5	5A			0,0E+0	-1	8,33E-09		7,35									
KFM04A	2004-03-17 16:47	992,57	111,18	767,21	772,21	5	5A			0,0E+0	-1	8,33E-09		7,27									
KFM04A	2004-03-17 16:47	992,57	111,18	762,21	767,21	5	5A			0,0E+0	-1	8,33E-09		7,18									
KFM04A	2004-03-17 16:47	992,57	111,18	757,2	762,2	5	5A			0,0E+0	-1	8,33E-09		7,14									
KFM04A	2004-03-17 16:47	992,57	111,18	752,2	757,2	5	5A			0,0E+0	-1	1,67E-08		7,05									
KFM04A	2004-03-17 16:47	992,57	111,18	747,19	752,19	5	5A			0,0E+0	-1	1,67E-08		6,99									
KFM04A	2004-03-17 16:47	992,57	111,18	742,19	747,19	5	5A			0,0E+0	-1	8,33E-09		6,92									
KFM04A	2004-03-17 16:47	992,57	111,18	737,19	742,19	5	5A			0,0E+0	-1	8,33E-09		6,87									
KFM04A	2004-03-17 16:47	992,57	111,18	732,19	737,19	5	5A			0,0E+0	-1	8,33E-09		6,80									
KFM04A	2004-03-17 16:47	992,57	111,18	727,19	732,19	5	5A			0,0E+0	-1	8,33E-09		6,70									
KFM04A	2004-03-17 16:47	992,57	111,18	722,19	727,19	5	5A			0,0E+0	-1	8,33E-09		6,67									
KFM04A	2004-03-17 16:47	992,57	111,18	717,18	722,18	5	5A			0,0E+0	-1	1,39E-08		6,59									
KFM04A	2004-03-17 16:47	992,57	111,18	712,17	717,17	5	5A			0,0E+0	-1	1,39E-08		6,49									
KFM04A	2004-03-17 16:47	992,57	111,18	707,16	712,16	5	5A			0,0E+0	-1	1,39E-08		6,45									
KFM04A	2004-03-17 16:47	992,57	111,18	702,15	707,15	5	5A			0,0E+0	-1	1,39E-08		6,40									
KFM04A	2004-03-17 16:47	992,57	111,18	697,15	702,15	5	5A			0,0E+0	-1	1,39E-08		6,33									
KFM04A	2004-03-17 16:47	992,57	111,18	692,14	697,14	5	5A			0,0E+0	-1	1,39E-08		6,23									
KFM04A	2004-03-17 16:47	992,57	111,18	687,13	692,13	5	5A			0,0E+0	-1	1,39E-08		6,18									
KFM04A	2004-03-17 16:47	992,57	111,18	682,12	687,12	5	5A			0,0E+0	-1	1,39E-08		6,11									

Bore-hole	Date and time of test, start	Logged interval from (m)	Logged interval to (m)	Secup (m)	Seclow (m)	b (m)	Test type	q0 (m³/s)	Value type Q0	q1 (m³/s)	Value type-Q1	Q-measl-L-practical (m³/s)	h0f (masl)	h1f (masl)	h2f (masl)	TD (m²/s)	Value type TD	TD-measl-L-practical (m²/s)	TD-measl-U (m²/s)	hi (masl)	Value type hi	Tew (°C)	Comments
KFM04A	2004-03-17 16:47	992,57	111,18	677,11	682,11	5	5A			0,0E+0	-1	1,39E-08		6,05									
KFM04A	2004-03-17 16:47	992,57	111,18	672,1	677,1	5	5A			0,0E+0	-1	1,39E-08		5,98									
KFM04A	2004-03-17 16:47	992,57	111,18	667,09	672,09	5	5A			0,0E+0	-1	1,39E-08		5,93									
KFM04A	2004-03-17 16:47	992,57	111,18	662,09	667,09	5	5A			0,0E+0	-1	1,39E-08		5,90									
KFM04A	2004-03-17 16:47	992,57	111,18	657,08	662,08	5	5A			0,0E+0	-1	1,39E-08		5,82									
KFM04A	2004-03-17 16:47	992,57	111,18	652,07	657,07	5	5A			0,0E+0	-1	8,33E-09		5,76									
KFM04A	2004-03-17 16:47	992,57	111,18	647,06	652,06	5	5A			0,0E+0	-1	8,33E-09		5,71									
KFM04A	2004-03-17 16:47	992,57	111,18	642,05	647,05	5	5A			0,0E+0	-1	8,33E-09		5,61									
KFM04A	2004-03-17 16:47	992,57	111,18	637,04	642,04	5	5A			0,0E+0	-1	1,67E-08		5,58									
KFM04A	2004-03-17 16:47	992,57	111,18	632,04	637,04	5	5A			0,0E+0	-1	1,67E-08		5,57									
KFM04A	2004-03-17 16:47	992,57	111,18	627,03	632,03	5	5A			0,0E+0	-1	1,67E-08		5,45									
KFM04A	2004-03-17 16:47	992,57	111,18	622,02	627,02	5	5A			0,0E+0	-1	1,67E-08		5,39									
KFM04A	2004-03-17 16:47	992,57	111,18	617	622	5	5A			0,0E+0	-1	8,33E-09		5,34									
KFM04A	2004-03-17 16:47	992,57	111,18	611,99	616,99	5	5A			0,0E+0	-1	8,33E-09		5,28									
KFM04A	2004-03-17 16:47	992,57	111,18	606,97	611,97	5	5A			0,0E+0	-1	8,33E-09		5,24									
KFM04A	2004-03-17 16:47	992,57	111,18	601,96	606,96	5	5A			0,0E+0	-1	8,33E-09		5,19									
KFM04A	2004-03-17 16:47	992,57	111,18	596,94	601,94	5	5A			0,0E+0	-1	8,33E-09		5,12									
KFM04A	2004-03-17 16:47	992,57	111,18	591,92	596,92	5	5A			0,0E+0	-1	8,33E-09		5,01									
KFM04A	2004-03-17 16:47	992,57	111,18	586,91	591,91	5	5A			0,0E+0	-1	8,33E-09		4,97									
KFM04A	2004-03-17 16:47	992,57	111,18	581,89	586,89	5	5A			0,0E+0	-1	8,33E-09		4,95									
KFM04A	2004-03-17 16:47	992,57	111,18	576,88	581,88	5	5A			0,0E+0	-1	1,39E-08		4,89									
KFM04A	2004-03-17 16:47	992,57	111,18	571,86	576,86	5	5A			0,0E+0	-1	1,39E-08		4,80									
KFM04A	2004-03-17 16:47	992,57	111,18	566,86	571,86	5	5A			0,0E+0	-1	1,39E-08		4,76									
KFM04A	2004-03-17 16:47	992,57	111,18	561,85	566,85	5	5A			0,0E+0	-1	8,33E-09		4,72									
KFM04A	2004-03-17 16:47	992,57	111,18	556,85	561,85	5	5A			0,0E+0	-1	8,33E-09		4,68									
KFM04A	2004-03-17 16:47	992,57	111,18	551,85	556,85	5	5A			0,0E+0	-1	8,33E-09		4,61									
KFM04A	2004-03-17 16:47	992,57	111,18	546,84	551,84	5	5A			0,0E+0	-1	8,33E-09		4,53									
KFM04A	2004-03-17 16:47	992,57	111,18	541,84	546,84	5	5A			0,0E+0	-1	8,33E-09		4,42									
KFM04A	2004-03-17 16:47	992,57	111,18	536,83	541,83	5	5A			0,0E+0	-1	8,33E-09		4,39									
KFM04A	2004-03-17 16:47	992,57	111,18	531,83	536,83	5	5A			0,0E+0	-1	8,33E-09		4,31									
KFM04A	2004-03-17 16:47	992,57	111,18	526,83	531,83	5	5A			0,0E+0	-1	8,33E-09		4,28									

Appendix 14

Bore-hole	Date and time of test, start	Logged interval from (m)	Logged interval to (m)	Secup (m)	Seclow (m)	b (m)	Test type	q0 (m³/s)	Value type Q0	q1 (m³/s)	Value type-Q1	Q-measl-L-practical (m³/s)	h0f (masl)	h1f (masl)	h2f (masl)	TD (m²/s)	Value type TD	TD-measl-L-practical (m²/s)	TD-measl-U (m²/s)	hi (masl)	Value type hi	Tew (°C)	Comments
KFM04A	2004-03-17 16:47	992,57	111,18	521,82	526,82	5	5A			0,0E+0	-1	8,33E-09		4,24									
KFM04A	2004-03-17 16:47	992,57	111,18	516,82	521,82	5	5A			5,6E-9	0	8,33E-09		4,18									
KFM04A	2004-03-17 16:47	992,57	111,18	511,81	516,81	5	5A			0,0E+0	-1	8,33E-09		4,09									
KFM04A	2004-03-17 16:47	992,57	111,18	506,8	511,8	5	5A			0,0E+0	-1	8,33E-09		4,04									
KFM04A	2004-03-17 16:47	992,57	111,18	501,8	506,8	5	5A			0,0E+0	-1	8,33E-09		3,98									
KFM04A	2004-03-17 16:47	992,57	111,18	496,79	501,79	5	5A			0,0E+0	-1	8,33E-09		3,92									
KFM04A	2004-03-17 16:47	992,57	111,18	491,79	496,79	5	5A			0,0E+0	-1	8,33E-09		3,83									
KFM04A	2004-03-17 16:47	992,57	111,18	486,78	491,78	5	5A			0,0E+0	-1	8,33E-09		3,78									
KFM04A	2004-03-17 16:47	992,57	111,18	481,77	486,77	5	5A			0,0E+0	-1	8,33E-09		3,75									
KFM04A	2004-03-17 16:47	992,57	111,18	476,77	481,77	5	5A			0,0E+0	-1	8,33E-09		3,70									
KFM04A	2004-03-17 16:47	992,57	111,18	471,76	476,76	5	5A			0,0E+0	-1	8,33E-09		3,65									
KFM04A	2004-03-17 16:47	992,57	111,18	466,76	471,76	5	5A			0,0E+0	-1	8,33E-09		3,60									
KFM04A	2004-03-17 16:47	992,57	111,18	461,75	466,75	5	5A			0,0E+0	-1	8,33E-09		3,54									
KFM04A	2004-03-17 16:47	992,57	111,18	456,75	461,75	5	5A			0,0E+0	-1	8,33E-09		3,47									
KFM04A	2004-03-17 16:47	992,57	111,18	451,74	456,74	5	5A			0,0E+0	-1	8,33E-09		3,42									
KFM04A	2004-03-17 16:47	992,57	111,18	446,74	451,74	5	5A			0,0E+0	-1	8,33E-09		3,36									
KFM04A	2004-03-17 16:47	992,57	111,18	441,73	446,73	5	5A			0,0E+0	-1	8,33E-09		3,31									
KFM04A	2004-03-17 16:47	992,57	111,18	436,73	441,73	5	5A			0,0E+0	-1	8,33E-09		3,28									
KFM04A	2004-03-17 16:47	992,57	111,18	431,72	436,72	5	5A			0,0E+0	-1	8,33E-09		3,23									
KFM04A	2004-03-17 16:47	992,57	111,18	426,72	431,72	5	5A			0,0E+0	-1	8,33E-09		3,18									
KFM04A	2004-03-17 16:47	992,57	111,18	421,71	426,71	5	5A			9,1E-9	0	8,33E-09		3,14									
KFM04A	2004-03-17 16:47	992,57	111,18	416,71	421,71	5	5A			6,2E-8	0	8,33E-09		3,08									
KFM04A	2004-03-17 16:47	992,57	111,18	411,7	416,7	5	5A			0,0E+0	-1	8,33E-09		3,02									
KFM04A	2004-03-17 16:47	992,57	111,18	406,7	411,7	5	5A			0,0E+0	-1	8,33E-09		2,97									
KFM04A	2004-03-17 16:47	992,57	111,18	401,7	406,7	5	5A			0,0E+0	-1	8,33E-09		2,89									
KFM04A	2004-03-17 16:47	992,57	111,18	396,69	401,69	5	5A			0,0E+0	-1	8,33E-09		2,83									
KFM04A	2004-03-17 16:47	992,57	111,18	391,69	396,69	5	5A			0,0E+0	-1	8,33E-09		2,79									
KFM04A	2004-03-17 16:47	992,57	111,18	386,69	391,69	5	5A			0,0E+0	-1	8,33E-09		2,73									
KFM04A	2004-03-17 16:47	992,57	111,18	381,68	386,68	5	5A			0,0E+0	-1	8,33E-09		2,65									
KFM04A	2004-03-17 16:47	992,57	111,18	376,68	381,68	5	5A			0,0E+0	-1	8,33E-09		2,60									
KFM04A	2004-03-17 16:47	992,57	111,18	371,68	376,68	5	5A			0,0E+0	-1	8,33E-09		2,51									

Bore-hole	Date and time of test, start	Logged interval from (m)	Logged interval to (m)	Secup (m)	Seclow (m)	b (m)	Test type	q0 (m³/s)	Value type Q0	q1 (m³/s)	Value type-Q1	Q-measl-L-practical (m³/s)	h0f (masl)	h1f (masl)	h2f (masl)	TD (m²/s)	Value type TD	TD-measl-L-practical (m²/s)	TD-measl-U (m²/s)	hi (masl)	Value type hi	Tew (°C)	Comments
KFM04A	2004-03-17 16:47	992,57	111,18	366,68	371,68	5	5A			0,0E+0	-1	8,33E-09		2,46									
KFM04A	2004-03-17 16:47	992,57	111,18	361,67	366,67	5	5A			0,0E+0	-1	8,33E-09		2,42									
KFM04A	2004-03-17 16:47	992,57	111,18	356,67	361,67	5	5A			4,3E-6	0	8,33E-09		2,36									
KFM04A	2004-03-17 16:47	992,57	111,18	351,67	356,67	5	5A			7,9E-9	0	8,33E-09		2,27									
KFM04A	2004-03-17 16:47	992,57	111,18	346,66	351,66	5	5A			0,0E+0	-1	8,33E-09		2,23									
KFM04A	2004-03-17 16:47	992,57	111,18	341,66	346,66	5	5A			1,5E-8	0	8,33E-09		2,18									
KFM04A	2004-03-17 16:47	992,57	111,18	336,66	341,66	5	5A			9,2E-8	0	8,33E-09		2,13									
KFM04A	2004-03-17 16:47	992,57	111,18	331,65	336,65	5	5A			0,0E+0	-1	8,33E-09		2,08									
KFM04A	2004-03-17 16:47	992,57	111,18	326,65	331,65	5	5A			0,0E+0	-1	8,33E-09		2,02									
KFM04A	2004-03-17 16:47	992,57	111,18	321,65	326,65	5	5A			0,0E+0	-1	8,33E-09		1,96									
KFM04A	2004-03-17 16:47	992,57	111,18	316,64	321,64	5	5A			0,0E+0	-1	8,33E-09		1,92									
KFM04A	2004-03-17 16:47	992,57	111,18	311,64	316,64	5	5A			5,0E-9	0	8,33E-09		1,87									
KFM04A	2004-03-17 16:47	992,57	111,18	306,63	311,63	5	5A			0,0E+0	-1	8,33E-09		1,82									
KFM04A	2004-03-17 16:47	992,57	111,18	301,62	306,62	5	5A			0,0E+0	-1	8,33E-09		1,77									
KFM04A	2004-03-17 16:47	992,57	111,18	296,61	301,61	5	5A			6,5E-7	0	8,33E-09		1,72									
KFM04A	2004-03-17 16:47	992,57	111,18	291,6	296,6	5	5A			1,6E-7	0	8,33E-09		1,63									
KFM04A	2004-03-17 16:47	992,57	111,18	286,59	291,59	5	5A			0,0E+0	-1	8,33E-09		1,59									
KFM04A	2004-03-17 16:47	992,57	111,18	281,58	286,58	5	5A			0,0E+0	-1	8,33E-09		1,56									
KFM04A	2004-03-17 16:47	992,57	111,18	276,57	281,57	5	5A			0,0E+0	-1	8,33E-09		1,51									
KFM04A	2004-03-17 16:47	992,57	111,18	271,57	276,57	5	5A			2,5E-8	0	8,33E-09		1,45									
KFM04A	2004-03-17 16:47	992,57	111,18	266,56	271,56	5	5A			0,0E+0	-1	8,33E-09		1,41									
KFM04A	2004-03-17 16:47	992,57	111,18	261,55	266,55	5	5A			0,0E+0	-1	8,33E-09		1,36									
KFM04A	2004-03-17 16:47	992,57	111,18	256,54	261,54	5	5A			6,9E-8	0	8,33E-09		1,32									
KFM04A	2004-03-17 16:47	992,57	111,18	251,53	256,53	5	5A			0,0E+0	-1	8,33E-09		1,28									
KFM04A	2004-03-17 16:47	992,57	111,18	246,52	251,52	5	5A			0,0E+0	-1	8,33E-09		1,24									
KFM04A	2004-03-17 16:47	992,57	111,18	241,52	246,52	5	5A			0,0E+0	-1	8,33E-09		1,15									
KFM04A	2004-03-17 16:47	992,57	111,18	236,51	241,51	5	5A			0,0E+0	-1	8,33E-09		1,10									
KFM04A	2004-03-23 16:48	992,57	111,18	231,5	236,5	5	5A			7,0E-5	0	8,33E-09		3,42									Remeasured at a lower drawdown
KFM04A	2004-03-17 16:47	992,57	111,18	226,49	231,49	5	5A			0,0E+0	-1	8,33E-09		1,03									

Appendix 14

Bore-hole	Date and time of test, start	Logged interval from (m)	Logged interval to (m)	Secup (m)	Seclow (m)	b (m)	Test type	q0 (m³/s)	Value type Q0	q1 (m³/s)	Value type-Q1	Q-measl-L-practical (m³/s)	h0f (masl)	h1f (masl)	h2f (masl)	TD (m²/s)	Value type TD	TD-measl-L-practical (m²/s)	TD-measl-U (m²/s)	hi (masl)	Value type hi	Tew (°C)	Comments
KFM04A	2004-03-17 16:47	992,57	111,18	221,49	226,49	5	5A			0,0E+0	-1	8,33E-09		0,96									
KFM04A	2004-03-17 16:47	992,57	111,18	216,48	221,48	5	5A			0,0E+0	-1	8,33E-09		0,91									
KFM04A	2004-03-17 16:47	992,57	111,18	211,47	216,47	5	5A			0,0E+0	-1	8,33E-09		0,86									
KFM04A	2004-03-23 16:48	992,57	111,18	206,47	211,47	5	5A			4,5E-5	0	8,33E-09		3,15									Remeasured at a lower drawdown
KFM04A	2004-03-23 16:48	992,57	111,18	201,47	206,47	5	5A			1,1E-5	0	8,33E-09		3,09									Remeasured at a lower drawdown
KFM04A	2004-03-17 16:47	992,57	111,18	196,46	201,46	5	5A			0,0E+0	-1	8,33E-09		0,75									
KFM04A	2004-03-17 16:47	992,57	111,18	191,46	196,46	5	5A			1,4E-6	0	8,33E-09		0,68									
KFM04A	2004-03-17 16:47	992,57	111,18	186,46	191,46	5	5A			6,6E-7	0	8,33E-09		0,63									
KFM04A	2004-03-17 16:47	992,57	111,18	181,46	186,46	5	5A			8,9E-7	0	8,33E-09		0,57									
KFM04A	2004-03-17 16:47	992,57	111,18	176,46	181,46	5	5A			2,0E-6	0	8,33E-09		0,52									
KFM04A	2004-03-17 16:47	992,57	111,18	171,45	176,45	5	5A			1,6E-6	0	8,33E-09		0,47									
KFM04A	2004-03-17 16:47	992,57	111,18	166,45	171,45	5	5A			5,6E-7	0	8,33E-09		0,42									
KFM04A	2004-03-17 16:47	992,57	111,18	161,45	166,45	5	5A			4,5E-6	0	8,33E-09		0,36									
KFM04A	2004-03-17 16:47	992,57	111,18	156,44	161,44	5	5A			2,1E-7	0	8,33E-09		0,30									
KFM04A	2004-03-17 16:47	992,57	111,18	151,44	156,44	5	5A			2,0E-7	0	1,39E-08		0,26									
KFM04A	2004-03-17 16:47	992,57	111,18	146,43	151,43	5	5A			7,8E-7	0	1,39E-08		0,20									
KFM04A	2004-03-17 16:47	992,57	111,18	141,42	146,42	5	5A			1,5E-7	0	8,33E-09		0,11									
KFM04A	2004-03-17 16:47	992,57	111,18	136,41	141,41	5	5A			7,9E-7	0	8,33E-09		0,06									
KFM04A	2004-03-17 16:47	992,57	111,18	131,41	136,41	5	5A			2,6E-6	0	1,39E-08		0,02									
KFM04A	2004-03-17 16:47	992,57	111,18	126,4	131,4	5	5A			2,2E-6	0	1,39E-08		-0,02									
KFM04A	2004-03-17 16:47	992,57	111,18	121,39	126,39	5	5A			1,8E-7	0	1,67E-08		-0,07									
KFM04A	2004-03-17 16:47	992,57	111,18	116,19	121,19	5	5A			6,2E-7	0	1,67E-08		-0,18									
KFM04A	2004-03-23 16:48	992,57	111,18	111,18	116,18	5	5A			8,0E-5	0	1,67E-08		2,30									Remeasured at a lower drawdown

PFL-Difference flow logging- Overlapping logging

Borehole	Date and time of test, start	Logged interval from	Logged interval to	b	dL	Test type	Li	Upper limit	Lower limit	q0	Value type-Q0	q1	Value type-Q1	Q-measl-L-practical	h0f	h1f	bi	TD	Value type-TD	TD-measl-L-practical	TD-measl-U	hi	Value type-hi	Tef	ECf	ecf	tf	Comments
ID	yyyymmdd	(m)	(m)	(m)	(m)	(1-6)	(m)	L (m)	L (m)	(m³/s)		(m³/s)		m³/s	(masl)	(masl)	(m)	(m²/s)	(m²/s)	(m²/s)	(m²/s)	(m)		ºC	(S/m)	(mS/m)	(s)	(-)
KFM04A	20040318	535	100	1	0,1	5B	110	109,55	109,7	0	-1	5,3E-7	0	1,7E-8	3,68	-0,05	0,1	1,39E-7	0	4,42E-9	2,21E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	110	110,25	110,4	0	-1	2,4E-6	0	1,7E-8	3,67	-0,04	0,1	6,52E-7	0	4,45E-9	2,22E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	111	111,35	111,5	0	-1	3,3E-7	0	1,7E-8	3,64	-0,03	0,1	8,98E-8	0	4,49E-9	2,24E-5	-	-1					Uncertain
KFM04A	20040318	535	100	1	0,1	5B	112	112,35	112,5	1,19E-7	0	4,6E-5	0	1,7E-8	3,64	2,37	0,1	3,54E-5	0	4,49E-9	6,49E-5	3,64	0					Measured at s=1.4 m
KFM04A	20040318	535	100	1	0,1	5B	113	112,75	112,9	0	-1	6,4E-7	0	1,7E-8	3,64	-0,04	0,1	1,71E-7	0	4,47E-9	2,24E-5	-	-1					Uncertain
KFM04A	20040318	535	100	1	0,1	5B	114	113,85	114	0	-1	6,4E-8	0	1,7E-8	3,57	-0,09	0,1	1,73E-8	0	4,50E-9	2,25E-5	-	-1					Uncertain
KFM04A	20040318	535	100	1	0,1	5B	116	116,25	116,4	1,11E-7	0	3,4E-5	0	1,7E-8	3,59	2,26	0,1	2,56E-5	0	4,32E-9	6,24E-5	3,59	0	7,15	0,867	866,6	4801	Measured at s=1.4 m
KFM04A	20040318	535	100	1	0,1	5B	117	117,15	117,3	0	-1	5,6E-7	0	1,7E-8	3,67	-0,15	0,1	1,44E-7	0	4,32E-9	2,16E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	120	120,15	120,3	0	-1	2,6E-8	0	1,7E-8	3,75	-0,16	0,1	6,68E-9	0	4,22E-9	2,11E-5	-	-1					Uncertain
KFM04A	20040318	535	100	1	0,1	5B	125	125,25	125,4	0	-1	6,9E-8	0	1,7E-8	3,75	-0,16	0,1	1,75E-8	0	4,21E-9	2,11E-5	-	-1					Uncertain
KFM04A	20040318	535	100	1	0,1	5B	129	128,85	129	0	-1	1,4E-7	0	1,4E-8	3,80	-0,15	0,1	3,48E-8	0	3,48E-9	2,09E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	131	130,75	130,9	0	-1	1,9E-6	0	1,4E-8	3,80	-0,14	0,1	4,74E-7	0	3,48E-9	2,09E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	133	133,05	133,2	0	-1	2,4E-7	0	1,4E-8	3,83	-0,14	0,1	5,88E-8	0	3,46E-9	2,08E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	133	133,35	133,5	0	-1	2,5E-8	0	1,4E-8	3,83	-0,13	0,1	6,23E-9	0	3,46E-9	2,08E-5	-	-1					Uncertain
KFM04A	20040318	535	100	1	0,1	5B	136	136,05	136,2	0	-1	1,6E-7	0	1,4E-8	3,84	-0,13	0,1	3,88E-8	0	3,46E-9	2,08E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	139	138,85	139	0	-1	3,2E-7	0	8,3E-9	3,88	-0,11	0,1	7,94E-8	0	2,07E-9	2,07E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	140	140,25	140,4	0	-1	1,6E-7	0	8,3E-9	3,89	-0,09	0,1	4,00E-8	0	2,07E-9	2,07E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	141	141,15	141,3	0	-1	4,7E-8	0	8,3E-9	3,89	-0,09	0,1	1,17E-8	0	2,07E-9	2,07E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	145	145,15	145,3	0	-1	6,9E-8	0	8,3E-9	3,93	-0,06	0,1	1,72E-8	0	2,07E-9	2,07E-5	-	-1					Uncertain
KFM04A	20040318	535	100	1	0,1	5B	149	149,25	149,4	0	-1	3,3E-8	0	1,4E-8	4,00	0,01	0,1	8,27E-9	0	3,45E-9	2,07E-5	-	-1					Uncertain
KFM04A	20040318	535	100	1	0,1	5B	150	149,75	149,9	0	-1	7,2E-7	0	1,4E-8	4,00	0,02	0,1	1,79E-7	0	3,45E-9	2,07E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	152	151,55	151,7	0	-1	1,2E-7	0	1,4E-8	4,02	0,03	0,1	3,03E-8	0	3,44E-9	2,07E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	154	153,65	153,8	0	-1	1,1E-8	0	1,4E-8	4,04	0,05	0,1	2,76E-9	0	3,45E-9	2,07E-5	-	-1					Uncertain
KFM04A	20040318	535	100	1	0,1	5B	154	153,95	154,1	0	-1	2,2E-8	0	1,4E-8	4,04	0,05	0,1	5,52E-9	0	3,45E-9	2,07E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	157	156,65	156,8	0	-1	8,9E-8	0	8,3E-9	4,02	0,10	0,1	2,24E-8	0	2,10E-9	2,10E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	158	157,75	157,9	0	-1	1,5E-8	0	8,3E-9	4,02	0,11	0,1	3,87E-9	0	2,11E-9	2,11E-5	-	-1					Uncertain
KFM04A	20040318	535	100	1	0,1	5B	162	162,25	162,4	0	-1	8,9E-8	0	8,3E-9	4,00	0,16	0,1	2,29E-8	0	2,15E-9	2,15E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	165	165,05	165,2	3,06E-8	0	4,2E-6	0	8,3E-9	3,98	0,17	0,1	1,07E-6	0	2,17E-9	2,17E-5	4,01	0					
KFM04A	20040318	535	100	1	0,1	5B	169	169,35	169,5	0	-1	6,7E-8	0	8,3E-9	4,04	0,21	0,1	1,72E-8	0	2,15E-9	2,15E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	171	170,45	170,6	0	-1	1,9E-7	0	8,3E-9	4,03	0,23	0,1	5,05E-8	0	2,17E-9	2,17E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	171	170,85	171	0	-1	3,1E-7	0	8,3E-9	4,01	0,23	0,1	8,00E-8	0	2,18E-9	2,18E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	172	172,15	172,3	0	-1	8,9E-7	0	8,3E-9	4,03	0,24	0,1	2,32E-7	0	2,18E-9	2,18E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	173	172,65	172,8	0	-1	1,4E-7	0	8,3E-9	4,01	0,24	0,1	3,64E-8	0	2,19E-9	2,19E-5	-	-1					Uncertain
KFM04A	20040318	535	100	1	0,1	5B	174	173,65	173,8	0	-1	1,4E-7	0	8,3E-9	4,02	0,26	0,1	3,80E-8	0	2,19E-9	2,19E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	175	174,65	174,8	0	-1	1,6E-7	0	8,3E-9	4,02	0,27	0,1	4,25E-8	0	2,20E-9	2,20E-5	-	-1					Uncertain
KFM04A	20040318	535	100	1	0,1	5B	175	175,15	175,3	0	-1	2,3E-7	0	8,3E-9	4,03	0,27	0,1	6,07E-8	0	2,19E-9	2,19E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	177	177,15	177,3	0	-1	2,4E-7	0	8,3E-9	4,14	0,31	0,1	6,09E-8	0	2,15E-9	2,15E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	178	177,65	177,8	0	-1	4,6E-7	0	8,3E-9	4,21	0,31	0,1	1,16E-7	0	2,11E-9	2,11E-5	-	-1					

Appendix 14

Borehole	Date and time of test, start	Logged interval from	Logged interval to	b	dL	Test type	Li	Upper limit	Lower limit	q0	Value type-Q0	q1	Value type-Q1	Q-measl-L-prac-tical	h0f	h1f	bi	TD	Value type-TD	TD-measl-L-practical	TD-measl-U	hi	Value type-hi	Tef	ECf	ecf	tf	Comments
KFM04A	20040318	535	100	1	0,1	5B	179	178,75	178,9	0	-1	9,7E-8	0	8,3E-9	4,33	0,32	0,1	2,40E-8	0	2,06E-9	2,06E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	180	179,95	180,1	0	-1	1,1E-6	0	8,3E-9	4,36	0,34	0,1	2,80E-7	0	2,05E-9	2,05E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	182	181,85	182	0	-1	2,1E-7	0	8,3E-9	4,36	0,35	0,1	5,28E-8	0	2,06E-9	2,06E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	187	186,45	186,6	0	-1	2,4E-8	0	8,3E-9	4,34	0,39	0,1	5,92E-9	0	2,09E-9	2,09E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	187	187,15	187,3	0	-1	1,8E-8	0	8,3E-9	4,35	0,40	0,1	4,59E-9	0	2,09E-9	2,09E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	191	190,85	191	0	-1	3,8E-7	0	8,3E-9	4,36	0,44	0,1	9,45E-8	0	2,10E-9	2,10E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	192	191,45	191,6	0	-1	1,8E-7	0	8,3E-9	4,38	0,44	0,1	4,39E-8	0	2,09E-9	2,09E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	192	192,15	192,3	0	-1	7,6E-7	0	8,3E-9	4,38	0,45	0,1	1,90E-7	0	2,09E-9	2,09E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	194	193,55	193,7	0	-1	4,3E-7	0	8,3E-9	4,37	0,46	0,1	1,09E-7	0	2,11E-9	2,11E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	195	195,25	195,4	0	-1	2,6E-8	0	8,3E-9	4,36	0,47	0,1	6,71E-9	0	2,12E-9	2,12E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	202	202,05	202,2	0	-1	4,0E-7	0	8,3E-9	4,36	0,56	0,1	1,05E-7	0	2,17E-9	2,17E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	203	202,75	202,9	-1,53E-7	0	1,1E-5	0	8,3E-9	4,37	3,09	0,1	8,32E-6	0	2,17E-9	6,42E-5	4,35	0					Measured at s=1.4 m
KFM04A	20040318	535	100	1	0,1	5B	207	207,05	207,2	-6,94E-7	0	4,3E-5	0	8,3E-9	4,40	3,15	0,1	3,21E-5	0	2,17E-9	6,58E-5	4,38	0	7,95	1,399	1399	3599	Measured at s=1.4 m
KFM04A	20040318	535	100	1	0,1	5B	208	208,15	208,3	-2,92E-8	0	5,3E-6	0	8,3E-9	4,41	0,60	0,1	1,38E-6	0	2,16E-9	2,16E-5	4,39	0					
KFM04A	20040318	535	100	1	0,1	5B	233	232,65	232,8	0	-1	2,3E-5	0	8,3E-9	4,67	3,41	0,1	1,83E-5	0	2,15E-9	6,54E-5	-	-1					Measured at s=1.4 m
KFM04A	20040318	535	100	1	0,1	5B	234	233,95	234,1	0	-1	1,5E-6	0	8,3E-9	4,70	0,84	0,1	3,92E-7	0	2,14E-9	2,14E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	236	235,55	235,7	1,08E-6	0	4,6E-5	0	8,3E-9	4,68	3,42	0,1	2,73E-5	0	2,15E-9	6,55E-5	4,71	0	8,23	1,459	1459	7999	Measured at s=1.4 m
KFM04A	20040318	535	100	1	0,1	5B	258	257,55	257,7	0	-1	5,8E-8	0	8,3E-9	4,94	1,16	0,1	1,52E-8	0	2,18E-9	2,18E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	274	273,85	274	0	-1	2,6E-8	0	8,3E-9	5,07	1,28	0,1	6,73E-9	0	2,17E-9	2,17E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	297	297,05	297,2	0	-1	6,1E-7	0	8,3E-9	5,32	1,54	0,1	1,61E-7	0	2,18E-9	2,18E-5	-	-1	8,80	1,477	1477	21606	
KFM04A	20040318	535	100	1	0,1	5B	313	312,95	313,1	0	-1	3,1E-9	0	8,3E-9	5,48	1,69	0,1	7,97E-10	0	2,17E-9	2,17E-5	-	-1					Uncertain
KFM04A	20040318	535	100	1	0,1	5B	339	338,75	338,9	-1,50E-8	0	9,2E-8	0	8,3E-9	5,77	1,95	0,1	2,76E-8	0	2,16E-9	2,16E-5	5,23	0					
KFM04A	20040318	535	100	1	0,1	5B	343	343,35	343,5	0	-1	6,9E-9	0	8,3E-9	5,82	2,01	0,1	1,80E-9	0	2,16E-9	2,16E-5	-	-1					Uncertain
KFM04A	20040318	535	100	1	0,1	5B	346	345,95	346,1	0	-1	3,1E-9	0	8,3E-9	5,84	2,03	0,1	7,94E-10	0	2,17E-9	2,17E-5	-	-1					Uncertain
KFM04A	20040318	535	100	1	0,1	5B	353	353,35	353,5	0	-1	2,8E-9	0	8,3E-9	5,92	2,09	0,1	7,16E-10	0	2,15E-9	2,15E-5	-	-1					Uncertain
KFM04A	20040318	535	100	1	0,1	5B	356	355,45	355,6	0	-1	5,0E-9	0	8,3E-9	5,94	2,11	0,1	1,29E-9	0	2,15E-9	2,15E-5	-	-1					Uncertain
KFM04A	20040318	535	100	1	0,1	5B	358	357,75	357,9	0	-1	3,9E-9	0	8,3E-9	5,97	2,19	0,1	1,02E-9	0	2,18E-9	2,18E-5	-	-1					Uncertain
KFM04A	20040318	535	100	1	0,1	5B	358	358,15	358,3	0	-1	1,1E-8	0	8,3E-9	5,97	2,18	0,1	2,90E-9	0	2,17E-9	2,17E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	360	359,75	359,9	-7,64E-7	0	4,0E-6	0	8,3E-9	5,98	2,22	0,1	1,26E-6	0	2,19E-9	2,19E-5	5,38	0	9,35	1,453	1453	8257	
KFM04A	20040318	535	100	1	0,1	5B	419	418,95	419,1	0	-1	4,4E-8	0	8,3E-9	6,71	2,92	0,1	1,16E-8	0	2,17E-9	2,17E-5	-	-1					
KFM04A	20040318	535	100	1	0,1	5B	422	421,85	422	0	-1	8,3E-9	0	8,3E-9	6,74	2,95	0,1	2,18E-9	0	2,18E-9	2,18E-5	-	-1					Uncertain
KFM04A	20040318	535	100	1	0,1	5B	522	521,45	521,6	0	-1	5,6E-9	0	8,3E-9	7,92	4,01	0,1	1,41E-9	0	2,11E-9	2,11E-5	-	-1					Uncertain
KFM04A	20040318	535	100	1	0,1	5B	955	954,75	954,9	0	-1	9,7E-9	0	8,3E-9	13,26	5,80	0,1	1,29E-9	0	1,11E-9	1,11E-5	-	-1					Uncertain measured at s=7.4 m

SICADA - description PLU PFL-Difference Flowlogging

Header	Unit	Description
Borehole		borehole identification code
Secup	m	Length coordinate along the borehole for the upper limit of the logged section (Based on corrected length L)
Seclow	m	Length coordinate along the borehole for the lower limit of the logged section. (Based on corrected length L)
Test type		1A: Pumping test - wireline eq., 1B:Pumping test-submersible pump, 1C: Pumpingtest-airlift pumping, 2: Interference test, 3: Injection test, 4: Slug test, 5A: Difference flow logging-PFL-DIFF-Sequential, 5B: Difference flow logging-PFL-DIFF-Overlapping, 6: Flow logging-Impeller
Formation type		1: Rock, 2: Soil (superficial deposits)
Date and time of test, start		Date for the start of the test (YYYY-MM-DD hh:mm)
Date and time of test, stop		Date for the stop of the test (YYYY-MM-DD hh:mm)
Date and time of flow logging, start		Date and time of flow logging start (YYYY-MM-DD hh:mm:ss)
Date and time of flow logging, stop		Date and time of flow logging stop (YYYY-MM-DD hh:mm:ss)
Lw	m	Section length used in the difference flow logging
dL	m	Step length (increment) used in the difference flow logging
Q-measl-L-theoretical	mL/h	Theoretical lower measurement limit for borehole flow rate in flow logging probe
Q-measl-L-practical	mL/h	Estimated practical lower measurement limit for borehole flow rate in flow logging probe
Q-measl-U	mL/h	Upper measurement limit for borehole flow rate in flowlogging probe
Qp1	m3/s	Flow rate at surface by the end of the first pumping period of the flow logging
Qp2	m3/s	Flow rate at surface by the end of the second pumping period of the flow logging
tp1	s	Duration of the first pumping period
tp2	s	Duration of the second pumping period
tF1	s	Duration of the first recovery period
tF2	s	Duration of the second recovery period
h0	m.a.s.l.	Initial hydraulic head. Measured as water level in open borehole with reference level in the local coordinates system with z=0 m.
h1	m.a.s.l.	Stabilized hydraulic head during first pumping period. Measured as water level in open borehole with reference level in the local coordinates system with z=0 m.
h2	m.a.s.l.	Stabilized hydraulic head during second pumping period.Measured as water level in open borehole with reference level in the local coordinates system with z=0 m.
hF	m.a.s.l.	Stabilized hydraulic head at the end of the recovery period.Measured as water level in open borehole with reference level in the local coordinates system with z=0 m.
s1	m	Drawdown of the water level in the borehole during first pumping period. Difference between the actual hydraulic head and the initial head (s1= h1-h0)
s2	m	Drawdown of the water level in the borehole during second pumping period. Difference between the actual hydraulic head and the initial head (s2=h2-h0)
Upper limit	m	Length along the borehole of the upper limit of the test section or flow anomaly (based on corrected length L)
Lower limit	m	Length along the borehole of the lower limit of the test section or flow anomaly (based on corrected length L)
b	m	Represenative thickness estimated as section length Lw used in the difference flow logging.

Appendix 14

Header	Unit	Description
Q0	mL/h	Measured flow rate through the test section or flow anomaly under natural conditions (no pumping) with h=h0 in the open borehole
Value type-Q0		Code for Q0-value; -1 means Q0< lower measurement limit, 0 means measured value within the meausurement limits, 1 means Q0>upper measurement limit.
Q1	mL/h	Measured flow rate through the test section or flow anomaly during the first pumping period
Value type-Q1		Code for Q1-value; -1 means Q1< lower measurement limit, 0 means measured value within the meausurement limits, 1 means Q1 Q1>upper measurement limit.
Q2	m**3/s	Measured flow rate through the test section or flow anomaly during the second pumping period
Value type-Q2		Code for Q2-value; -1 means Q2< lower measurement limit, 0 means measured value within the meausurement limits, 1 means Q2>upper measurement limit.
h0f	m.a.s.l.	Measured initial hydraulic head distribution along the borehole before pumping
h1f	m.a.s.l.	Measured hydraulic head distribution along the borehole during the first flow period.
h2f	m.a.s.l.	Measured hydraulic head distribution along the borehole during the second flow period.
TD	m**2/s	Transmissivity of section or flow anomaly based on 2D model for evaluation of formation properties of the test section based on PFL-DIFF.
Value type-TD		Code for TD -value; -1 means TD < lower measurement limit, 0 means evaluated value within the meausurement limits, 1 means TD >upper measurement limit.
TD-measl-L-practical	m**2/s	Estimated practical measurement limit for evaluated TD. If the estimated TD equals TD-measlim, the actual TD is considered to be equal or less than TD-measlim.
TD-measl-U	m**2/s	Upper measurement limit for evaluated TD. If the estimated TD equals TD-measlim, the actual TD is considered to be equal or grater than TD-measlim.
hi	m	Calculated natural freshwater head for test section or flow anomaly (undisturbed conditions)
Value type-hi		Code for hi-value; -1 means hi< lower measurement limit, 0 means measured value within the meausurement limits, 1 means hi>upper measurement limit.
Tew	centigrade	Measured borehole fluid temperature in the test section during difference flow logging
ECw	mS/m, S/m	Measured electric conductivity of the borehole fluid in the test section during difference flow logging
TDSw	mg/L	Total salinity of the fluid in the test section representative for the evaluated parameters based on EC.
bi	m	Estimated thickness of flow anomaly or, alternatively the step length used in the overlapping logging
Li	m	Length along the borehole to inferred flow anomaly during overlapping flow logging
Tef	ºC	Measured fracture-specific fluid temperature in flow anomaly during difference flow logging
ECf	mS/m	Measured fracture-specific electric conductivity (EC) of the fluid in flow anomaly during difference flow logging
TDSf	mg/L	Total salinity of the fluid in the test section representative for the evaluated parameters based on EC.
tf	s	Duration of fracture-specific EC-measurement in flow anomaly
references		SKB report No for reports describing data and evaluation
comments		Short comment to the evaluated parameters