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Difference flow logging of borehole KLX10

Subarea Laxemar

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June 2007

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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 KLX10 at Oskarshamn, Sweden, in December 2005, using Posiva Flow Log. Posiva Flow Log is a multipurpose measurement instrument developed by PRG-Tec Oy for the use of Posiva Oy. The primary aim of the measurements was to determine the position and flow rate of flow yielding fractures in borehole KLX10.

The first flow logging measurements were done with a 5 m test section by moving the measurement tool in 0.5 m steps. This method was used to flow log the entire measurable part of the borehole during natural (un-pumped) as well as pumped conditions. The flow measurements were repeated at the location of detected flow anomalies using a 1 m long test section, which was moved in 0.1 m steps.

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 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. The EC of fracture-specific water was measured for a selection of fractures.

Sammanfattning

Differensflödesloggning är en snabb metod för bestämning av transmissivitet och hydraulisk tryckhöjd i borrhålssektioner och sprickor/sprickzoner i kärnborrhål. Denna rapport presenterar huvudprinciperna för metoden och resultat av mätningar utförda i borrhål KLX10 i Oskarshamn, Sverige, i december 2005 med Posiva flödesloggningsmetod. Det primära syftet med mätningarna var att bestämma läget och flödet för vattenförande sprickor i borrhål KLX10.

Flödet till eller från en 5 m lång testsektion (som förflyttades successivt med 0,5 m) mättes i borrhål KLX13A 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 längdmärkerna som frästs in i borrhålsväggen vid noggrant bestämda positioner längs borrhålet. Längmärkena detekterades med caliper-mätningar och med 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. Sprickspecifikt EC mättes även vid utvalda sprickor.

Contents

1 Introduction

This document reports the results gained by the difference flow logging, which is one of the activities performed within the site investigation at Oskarshamn, Sweden. The work was carried out in accordance with Activity Plan AP PS 400-05-082. The controlling documents for performing this activity are listed in Table 1-1. Both Activity Plan and Method Descriptions are SKB's internal controlling documents.

The difference flow logging in the core drilled borehole KLX10 at Oskarshamn was conducted between December 8–22, 2005. The borehole KLX10 is inclined c. 85 degrees from the horizontal plane and drilled to a length of c. 1,001 m. Further details on borehole construction is compiled in Table 1-2.

The location of borehole KLX10 at the drill site within the Oskarshamn area is shown in Figure 1-1.

The field work and the subsequent data interpretation were conducted by PRG-Tec Oy with Posiva Oy's equipment. 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.

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

Activity plan	Number	Version
Difference flow logging in borehole KLX10	AP PS 400-05-082	1.0
Method descriptions	**Number**	**Version**
Method description for difference flow logging	SKB MD 322.010	1.0
Instruktion för rengöring av borrhålsutrustning och viss markbaserad utrustning	SKB MD 600.004	1.0
Instruktion för längdkalibrering vid undersökningar i kärnborrhål	SKB MD 620.010	2.0
Instruktion för analys av injektions- och enhålspumptester	SKB MD 320.004	1.0

Table 1-2. Borehole construction, KLX10.

Title	Value Information about cored borehole KLX10 (2005-12-08)				
Comment:	No comment exists				
Borehole length (m):	1,001.200				
Reference level:	TOC				
Drilling Period(s):	From Date	To Date	Secup (m)	Seclow (m)	Drilling Type
	2005-05-24	2005-06-01	0.000	100.600	Percussion drilling
	2005-06-18	2005-10-15	0.000	1,001.200	Core drilling
Starting point coordinate:	Length (m)	Northing (m)	Easting (m)	Elevation	Coord System
	0.000	6366319.384	1548515.230	18.276	RT90-RHB70
Angles:	Length (m)	Bearing	Inclination (– = down)		Coord System
	0.000	250.812	–85.185		RT90-RHB70
Borehole diameter:	Secup (m)	Seclow (m)	Hole Diam (m)		
	0.000	9.200	0.343		
	9.200	12.100	0.248		
	12.100	100.500	0.197		
	100.500	100.600	0.163		
	100.500	101.130	0.086		
	101.130	1,001.200	0.076		
Core diameter:	Secup (m)	Seclow (m)	Core Diam (m)		
	100.500	101.130	0.072		
	101.130	1,001.200	0.050		
Casing diameter:	Secup (m)	Seclow (m)	Case In (m)	Case Out (m)	Comment
	0.000	12.100	0.200	0.208	
	0.120	9.200	0.280	0.311	
Cone dimensions:	Secup (m)	Seclow (m)	Cone In (m)	Cone Out (m)	
	97.480				
Grove milling:	Length(m)	Trace detectable			
	110.000	Yes			
	150.000	Yes			
	204.000	Yes			
	251.000	Yes			
	300.000	Yes			
	350.000	Yes			
	402.000	Yes			
	450.000	Yes			
	500.000	Yes			
	550.000	Yes			
	600.000	Yes			
	651.000	Yes			
	698.000	Yes			
	750.000	Yes			
	799.000	Yes			
	850.000	Yes			
	900.000	Yes			
	950.000	Yes			
	980.000	Yes			
Installed sections:	Section no	Start Date	Secup (m)	Seclow (m)	
Section status:	Packers are released				
	End of additional information				

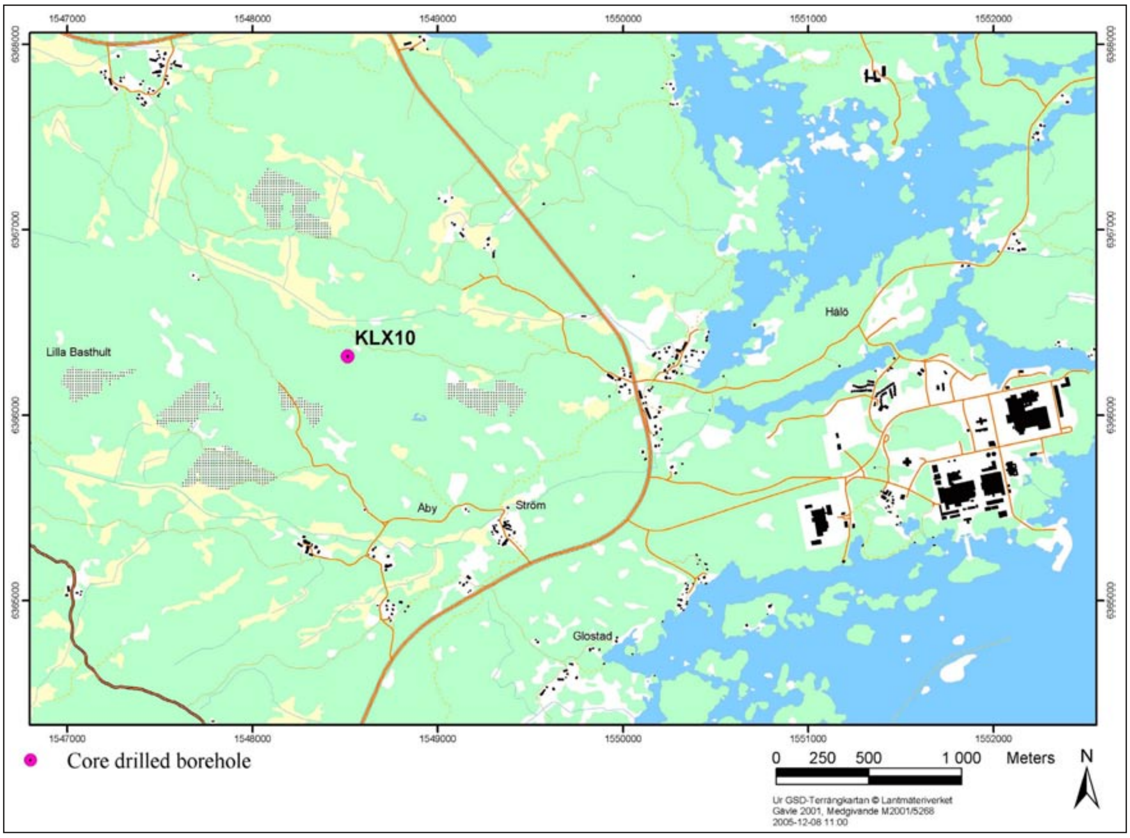

Figure 1-1. *Site map showing the location of borehole KLX10 situated in the subarea of Laxemar.*

2 Objective and scope

The main objective of the difference flow logging in KLX10 was to identify water-conductive sections/fractures, secondly the measurements are utilised for selecting suitable sections along the borehole for the subsequent water sampling. The aim is a hydrogeological characterisation, including the inspection of 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 measuring programme for borehole KLX10 also included supporting measurements, performed to gain a better understanding of the overall hydrogeochemical conditions. The data gathered in these measurements consisted of the single-point resistance of the borehole wall and the electric conductivity of the borehole water. The electric conductivity was measured for a number of selected high transmissive fractures in the borehole, too. Furthermore, the recovery of the groundwater level after pumping was registered and interpreted hydraulically.

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

Single-point resistance measurements were also combined with caliper (borehole diameter) measurements for detection of length marks milled into the borehole wall at accurately determined positions along the borehole. This procedure allowed for the length calibration of the other measurements that were conducted.

3 Principles of measurement and interpretation

3.1 Measurements

Unlike traditional types of borehole flowmeters, the Difference Flowmeter 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 discs at both ends of the downhole tool are used to isolate the flow rate in the test section from the flow rate in the rest of the borehole, see Figure 3-1. The flow inside the test section goes through its own tube and passes through the area where the flow sensors are located. The flow rate 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 entire structure is called the flow guide.

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 regards 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 thermal pulse method.

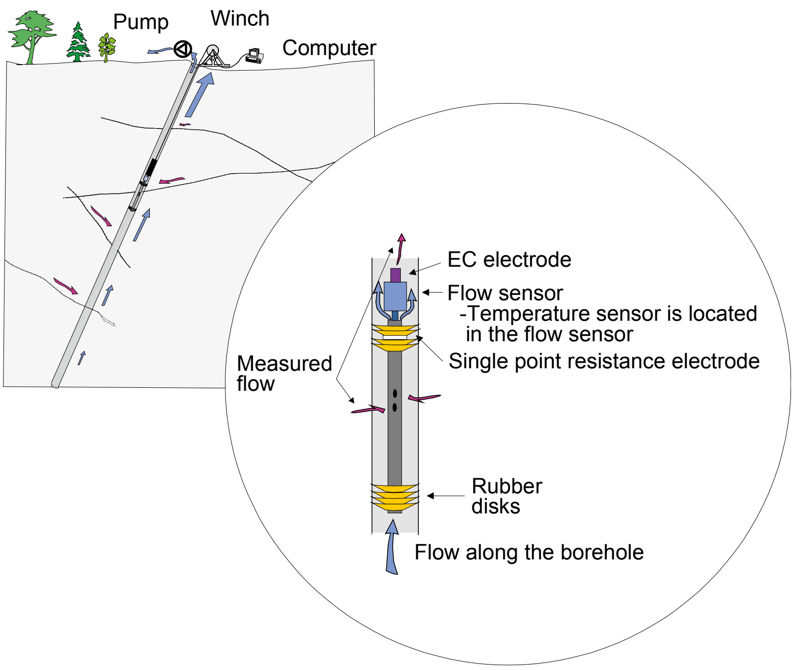

Figure 3-1. *Schematic of the downhole equipment used in the Difference Flowmeter.*

Besides incremental changes of flow the downhole tool of the Difference Flowmeter can also 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 discs, 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. 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 through a 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 KLX10.

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 and for the registration of temperature changes, 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.

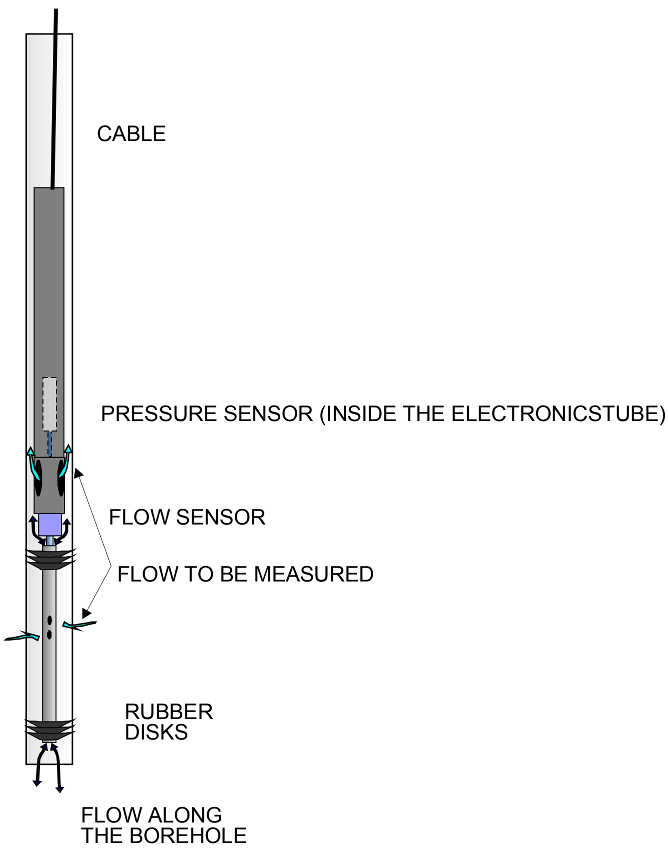

Figure 3-2. *The absolute pressure sensor is located inside the electronics tube and connected through a tube to the borehole water.*

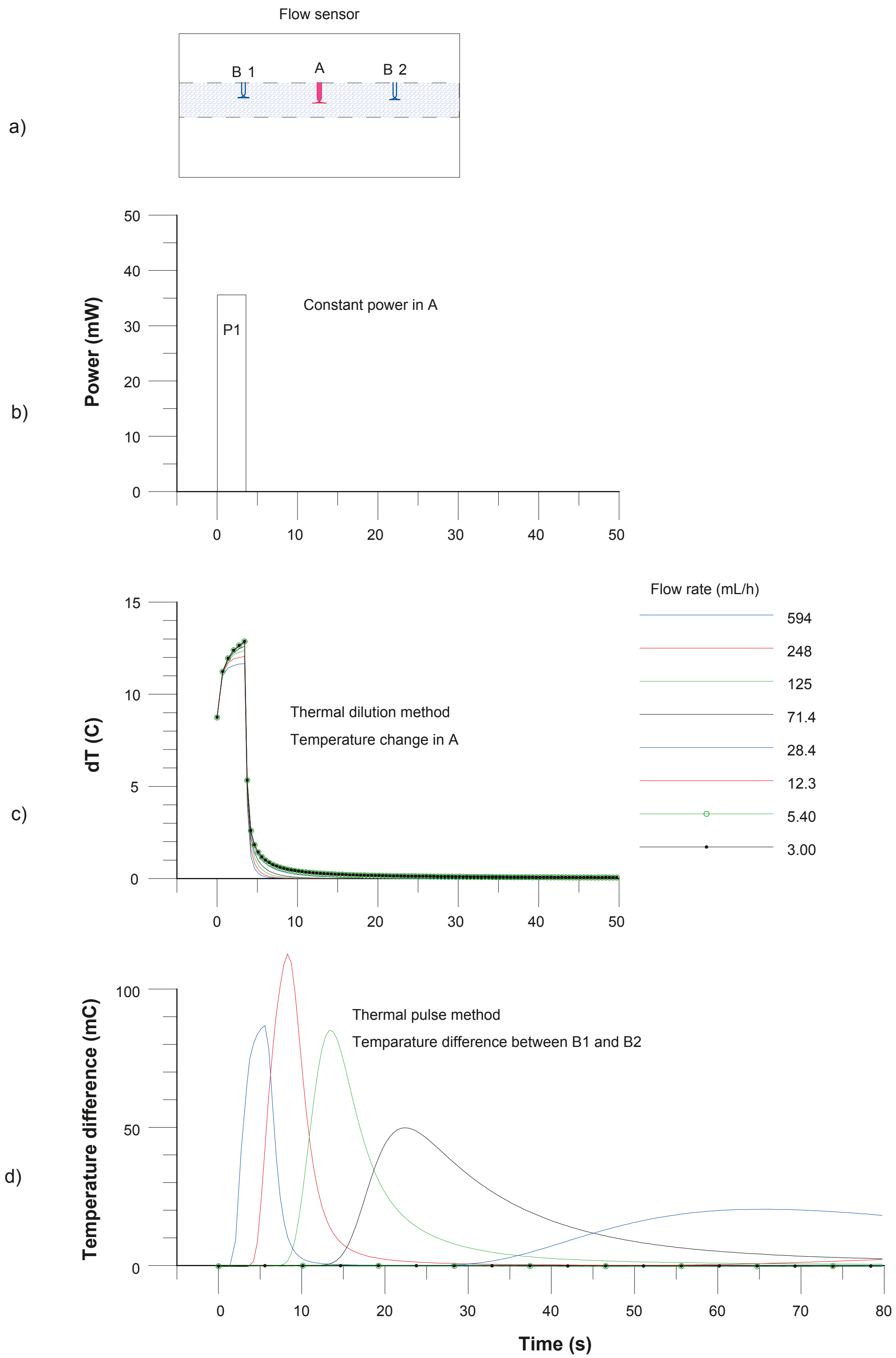

Figure 3-3. *Flow measurement, flow rate < 600 mL/h.*

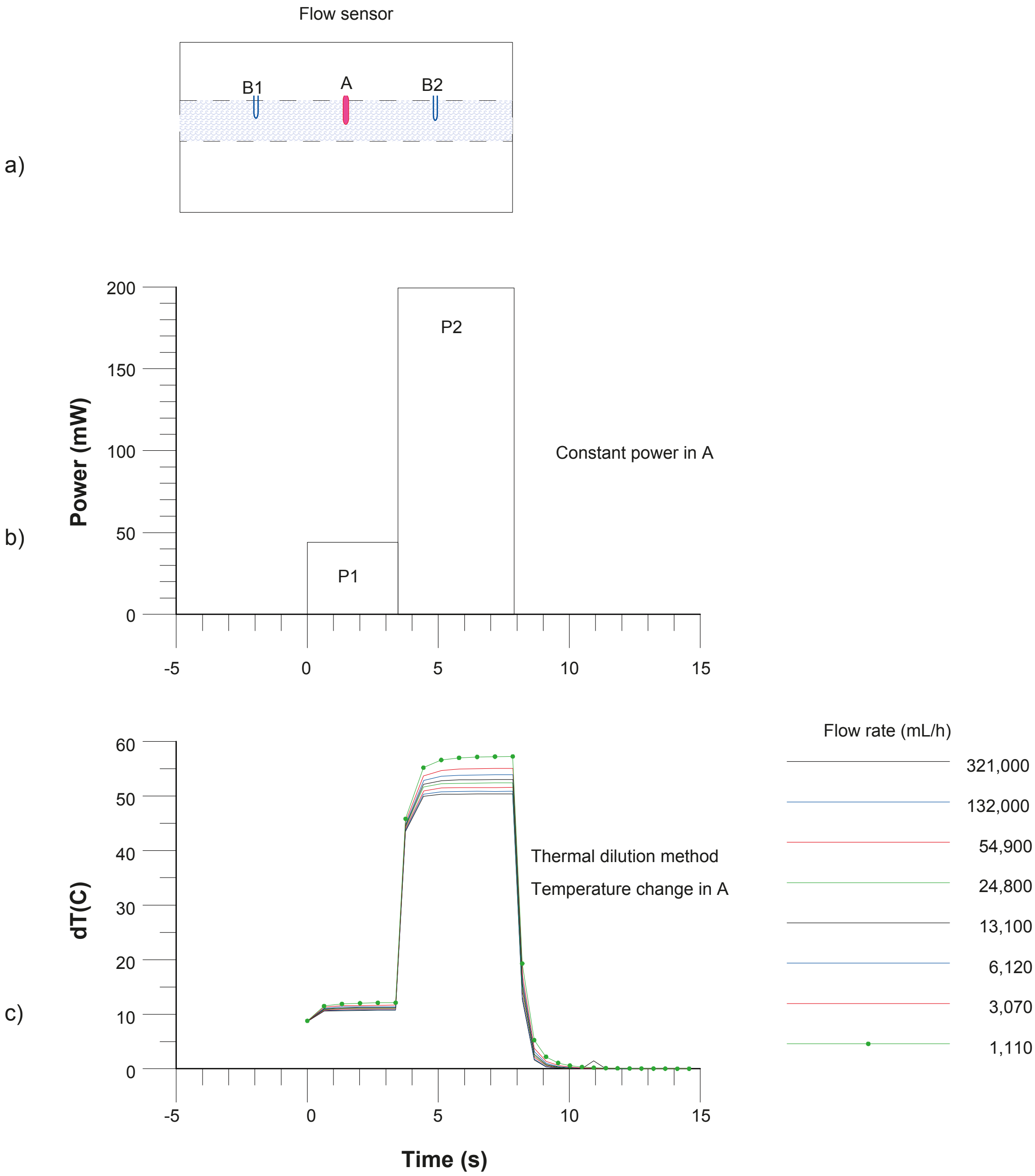

Figure 3-4. *Flow measurement, flow rate > 600 mL/h.*

Flow rate is measured during the constant power (P_1) heating (Figure 3-3b). If the flow rate exceeds 600 mL/h, the constant power heating is increased (to P_2), Figure 3-4b, 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 (Figure 3-3c) and thermal pulse response (Figure 3-3d). When applying the thermal pulse method, thermal dilution is also measured. The same heat pulse is used for the both methods.

The flow is measured when the tool is at rest. After the tool is transferred 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 applied. The waiting time after the constant power thermal pulse can also be adjusted, but is normally 10 s for thermal dilution and 300 s for thermal pulse method. The measurement range of each method is given in Table 3-1.

Table 3-1. Ranges of flow measurement.

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

The lower end limits of the thermal dilution and the thermal pulse methods in Table 3-1 are theoretical lowest measurable values. Depending on the borehole conditions these limits may not always prevail. Examples of disturbing conditions are suspended 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.

3.2 Interpretation

The interpretation is based on Thiem's or Dupuit's 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_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 head in the borehole, 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:

$Q_{s0} = T_s \cdot a \cdot (h_s - h_0)$ 3-3

$Q_{s1} = T_s \cdot a \cdot (h_s - h_1)$ 3-4

where

h_0 and h_1 are the hydraulic heads in the borehole at the test level,

Q_{s0} and Q_{s1} 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:

$h_s = (h_0–b·h_1)/(1–b)$ 3-5

$T_s = (1/a) (Q_{s0}–Q_{s1})/(h_1–h_0)$ 3-6

where

$b = Q_{s0}/Q_{s1}$

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).

$h_f = (h_0–b·h_1)/(1–b)$ 3-7

$T_f = (1/a) (Q_{f0}–Q_{f1})/(h_1–h_0)$ 3-8

where

Q_{f0} and Q_{f1} 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 considered only as indication of the 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 geometries. A discussion of potential uncertainties in the calculation of transmissivity and hydraulic head is provided in /Ludvigson et al. 2002/.

Transmissivity of the entire borehole can be evaluated in several ways using the data of the pumping phase and of the recovery phase. For the pumping phase the assumptions above (cylindrical and steady state flow) leads to Dupuit's formula (equation 3-9) /Marsily 1986/:

$$T = \frac{Q}{s2\pi}\ln\left(\frac{R}{r_0}\right) \qquad 3\text{-}9$$

where

s is drawdown and

Q is the pumping rate at the end of the pumping phase.

In the Moye's formula (equation 3-10) /Moye 1967/ it is assumed the steady state flow is cylindrical near the borehole (to distance r = L/2, where L is the section under test) and spherical further away:

$$T = \frac{Q}{s2\pi}\cdot\left[1+\ln\left(\frac{L}{2r_0}\right)\right] \qquad 3\text{-}10$$

where L is length of test section (m), in this case water filled uncased part of the borehole.

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 (which uses rubber discs to isolate the flow). 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 into a computer in digital form.

Type of instrument:	Posiva Flow Log/Difference Flowmeter.
Borehole diameters:	56 mm, 66 mm and 76 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:	See 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 1,500 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:	November 2005.
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

5.1 Execution of the field work

The commission was performed according to Activity Plan AP PS 400-05-082 (SKB internal controlling document) following the SKB Method Description 322.010, Version 1.0 (Method description for Difference flow logging). Prior to the measurements, the downhole tools and the measurement cable were disinfected. Every clock 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 KLX10, 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.

Each length mark includes two 20 mm wide tracks in the borehole wall. The distance between the marks is 100 mm. The upper track defines 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 Flowmeter system uses caliper measurements in combination with single-point resistance measurement (SPR) for this purpose (Item 8 in Table 5-1). These methods also reveal parts of the borehole widened for some reason (fracture zones, breakouts etc).

Table 5-1. Flow logging and testing in KLX10. Activity schedule.

Item	Activity	Explanation	Date
1	Mobilisation at site	Unpacking the trailer.	2005-12-08
9	EC- and temp-logging of the borehole fluid	Logging without the lower rubber discs, no pumping.	2005-12-10
11	Combined Overlapping/ Sequential flow logging	Section length L_w=5 m, Step length dL=0.5 m. No pumping.	2005-12-11–2005-12-13
10	Flow logging of the telescopic part of borehole	Section length L_w=0.5 m. Logging without the lower rubber discs, flow along the borehole closed, no pumping.	2005-12-13
12	Overlapping flow logging	Section length L_w=5 m, Step length dL=0.5 m at pumping (includes 1 day waiting after beginning of pumping).	2005-12-13–2005-12-16
13	Overlapping flow logging	Section length L_w=1 m, Step length dL=0.1 m, at pumping.	2005-12-16–2005-12-19
14	Fracture-specific EC-measurements in pre-selected fractures	Section length L_w=1 m, at pumping (in pre-selected fractures).	2005-12-19–2005-12-20
15	EC- and temp-logging of the borehole fluid	Logging without the lower rubber discs, at pumping.	2005-12-20
8	Length calibration of the downhole tool	Dummy logging (SKB Caliper and SPR). Logging without the lower rubber discs, at pumping.	2005-12-20–2005-12-21
16	Recovery transient	Measurement of water level and absolute pressure in the borehole after stopping of pumping.	2005-12-21–2005-12-31

The caliper/SPR-measurement is normally performed in boreholes before any other measurements are started. In this case, the caliper/SPR-measurement was performed after all the other measurements during pumped conditions just before ground water recovery.

The combined overlapping/sequential flow logging (Item 11) was carried out in the borehole interval 92.20–996.20 m with a 5 m section length and in 0.5 m length increments (step length). The measurements were performed during natural (un-pumped) conditions. Every tenth flow measurement (sequential mode) had a longer measurement time than normally in the overlapping mode. This was done to ensure the direction of the flow (into the borehole or out of it).

Because of unbalance in the sum of measured flows, the vertical flow along the borehole at the telescopic part was measured (Item 10).

Pumping was started on December 13. The pump intake was at level 5.8 (metres above sea level, RHB70), see Appendix 13.2. The groundwater level sensor (pressure transducer) was at 5.48 (metres above sea level, RHB70). After 22 hours waiting time, the overlapping flow logging (Item 12) was carried out in the borehole interval 96.19–996.21 m. The section length was 5 m and the step length 0.5 m.

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 13).

After that fracture specific EC of water was measured from some selected fractures (Item 14).

The EC of borehole water (Item 15) was measured while the borehole was still pumped. After the caliper- and SPR-measurements, the pump was stopped and the recovery of the groundwater level was monitored (Item 16).

The recovery of the groundwater level was monitored only with groundwater level sensor. The absolute pressure sensor located in the flow logging tool was not used. The groundwater level monitoring was done partly with our sensor and partly with SKB's sensor.

5.2 Nonconformities

All head and transmissivity calculations have been done on revised elevation data (Z-coordinates). Borehole coordinates that formed the basis for this revision of groundwater head data were retrieved from SKB Sicada 2007-03-07 EG154 (provided by SKB in file Krökdata_korrigerade_070307_KLX03-KLX29 utom KLX15, HLX13,15,26-28,32,36-38,43.xls) /Stenberg and Håkansson 2007/.

6 Results

6.1 Length calibration

6.1.1 Caliper and SPR measurement

Accurate length scale of measurements are difficult to achieve in long boreholes, i.e. the accurate position of the measurement equipment is difficult to determine. The main cause of inaccuracy is stretching of the logging cable. The stretching depends on the tension of the cable, which in turn depends, among other things, on the inclination of the borehole and the roughness (friction properties) of the borehole wall. The cable tension is higher when the borehole is measured upwards. The cables, especially new cables, may also stretch out permanently.

In KLX10 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 initially 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 except during borehole EC measurements) with the original caliper/SPR measurement.

The procedure of length correction was the following:

- Caliper/SPR measurement (Item 8) was initially length corrected in relation to the known length marks, Appendix 1.44 black curve. Corrections between the length marks were obtained for each length mark by linear interpolation.
- The SPR curve of Item 8 was then compared with the SPR curves of Items 10, 11, 12, 13 and 14 to obtain relative length errors of these measurement sequences.
- All SPR curves could then be synchronized, as can be seen in Appendices 1.2–1.43.

The results of the caliper and single-point resistance measurements from all measurements in the entire borehole are presented in Appendix 1.1. Four SPR-curves are plotted together with the SPR/caliper measurement. These measurements correspond to Items 11, 12, 13 and 14 in Table 5-1.

Caliper tool has been adjusted and specified to change its output from a high voltage value to a low voltage value between borehole diameters 77 mm–78mm.

Zoomed results of caliper and SPR are presented in Appendices 1.2–1.43. The detected length marks are listed in Table 6-1. All marks were detected at least partly by the caliper tool in the measured interval. They were also detected in the single-point resistance measurements. The SPR-anomaly is complicated due to the four rubber disks used at the upper end of the section, two on each side of the resistance electrode. A selection of length intervals where clear SPR-anomalies were found is plotted as well. If only one length mark is detected, the decision whether it is the lower or upper mark is made base on the shape of the SPR-anomaly. The SPR anomaly at the length marks has a distinctive shape, which can usually be recognized.

The aim of the plots in Appendices 1.2–1.43 is to verify the accuracy of the length correction. The curves in these plots represent length corrected results.

The magnitude of length correction along the borehole is presented in Appendix 1.44. The negative values of error represent the situation where the logging cable has been extended, i.e. the cable is longer than the nominal length marked on it.

Table 6-1. Detected length marks.

Length marks given by SKB (m)	Length marks detected by caliper	Length marks detected by SPR
110	only lower	yes
150	both	yes
204	both	yes
251	both	yes
300	both	yes
350	both	yes
402	both	yes
450	both	yes
500	both	yes
550	both	yes
600	both	yes
651	both	yes
698	both	no
750	both	yes
799	both	yes
850	both	yes
900	both	yes
950	both	yes
980	both	yes

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 following reasons:

1. Point interval in flow measurements is 0.1 m in overlapping mode. This could cause an error ± 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 them is 5 cm. This will cause rounded flow anomalies: a flow may be detected already when a fracture is situated between the upper rubber disks. These phenomena can cause an error of ± 0.05 m, when short step length (0.1 m) is used.
3. There could sometimes be a need for corrections between the length marks to be other than linear. This could cause error ± 0.1 m in the SPR/caliper measurement (Item 8).
4. SPR curves may be imperfectly synchronized. This could cause error 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.

The situation is slightly better near the length marks. In the worst case, the errors from sources 1, 2, and 4 are summed up and the total estimated error would be ± 0.2 m.

Knowing the location accurately is important when different measurements are compared, for instance if the flow logging and borehole TV. In a case like that the situation may not be as severe as the worst case above, since some of the length errors are systematic and the length error is nearly constant in fractures close to each other. However, the error caused by source 1 is random.

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 measurement was performed downwards and upwards, see Appendix 2.1, blue coloured curves.

The EC measurements were repeated during pumping (after a pumping period of about seven days), see Appendix 2.1, green coloured curves. The results show change to less saline water above the length of about 320 m.

Temperature of borehole water was measured simultaneously with the EC-measurements. The EC-values are temperature corrected to 25ºC 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.

The length calibration of the borehole electric conductivity measurements is not as accurate as of the other measurements, because single-point resistance is not registered. The length correction of the SPR/caliper measurement was applied to the borehole EC measurements, black curve in Appendix 1.44.

6.2.2 Electric conductivity 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 fractures detected in the flow measurements can be measured for electric conductivity later. These fracture specific measurements begin near the fracture, which has been chosen for inspection. The tool is first moved stepwise closer to the fracture untied the detected flow is larger than a predetermined limit. At this point the tool is stopped. The measurement is continued at the given position 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 sufficiently enough to gain accurate results. The measuring computer is programmed so that the water in the test section will be replaced approximately three times over. After a set of stationary measurements the tool is once again moved stepwise past the fracture for a short distance. The electric conductivity is also measured between the steps before and after the set of stationary measurements.

The test section in these measurements was 0.5 m and the tool was moved in 0.1 m steps. The water volume in a half metre (0.5 m) long test section is 1.6 L. Electric conductivity of fracture-specific water is presented on time scale in Appendix 14. The blue symbol represents the value when tool was moved (half metre point interval) and the red symbol is used for the set of stationary measurements.

Borehole lengths at the upper and lower ends of the section, fracture locations as well as the final EC values are listed in Table 6-2.

The electric conductivity of the entire borehole in pumped and un-pumped conditions is illustrated in Appendix 2.1 along with the fracture specific results.

Table 6-2. Fracture-specific EC.

Upper end of section (m)	Lower end of section (m)	Fractures measured (m)	EC (S/m) at 25 °C
842.73	843.23	842.9	1.49
699.91	700.41	700	0.56
538.95	539.45	539.2	1.01
353.87	354.37	354.1	0.50
119.68	120.18	119.9	0.07

6.3 Pressure measurements

Absolute pressure was registered with the other measurements in Items 10, 11, 12, 13 and 14. The pressure sensor measures the sum of hydrostatic pressure in the borehole and air pressure. Air pressure was also registered separately, Appendix 13.2. Hydraulic head along the borehole is determined in the following way. First, 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 then calculated according to the following expression /Freeze and Cherry 1979/:

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

where

h is the hydraulic head (metres above sea level) according to the RHB 70 reference system,

p_{abs} is absolute pressure (Pa),

p_b is barometric (air) pressure (Pa),

ρ_{fw} is unit density 1,000 kg/m^3,

g is standard gravity 9.80065 m/s^2 and

z is the elevation of measurement (metres above sea level) according to the RHB 70 reference system.

A tool-specific offset of 2.46 kPa is subtracted from absolute pressure raw data.

Exact z-coordinates are important in head calculation, 10 cm error in z-coordinate means 10 cm error in head. All head and transmissivity calculations have been done on revised elevation data (Z-coordinates). Borehole coordinates that formed the basis for this revision of groundwater head data were retrieved from SKB Sicada 2007-03-07 EG154 (provided by SKB in file Krökdata_korrigerade_070307_KLX03-KLX29 utom KLX15, HLX13,15,26-28,32,36-38,43.xls) /Stenberg and Håkansson 2007/.

The calculated head results are presented in a graph in Appendix 13.1.

6.4 Flow logging

6.4.1 General comments on results

The flow results are presented together with single-point resistance (right hand side) and caliper plot (in the middle), see Appendices 3.1–3.45. Single-point resistance is usually lower in value on a fracture where a 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 in between the upper rubber disks. Thus, the locations of the resistance anomalies of the leaky fractures coincide with the lower end of the flow anomalies in the data plot.

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 (dark blue curve without pumping, red curve with 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 for flow determination.

Under natural conditions or if the borehole is not pumped using a sufficient drawdown, the flow direction may be into the borehole or out from it. The direction of small flows (< 100 mL/h) cannot be detected in the normal overlapping mode (thermal dilution method). Therefore measurement time was longer (so that the thermal pulse method could be used) at every 5 m interval in both 5 m section measurements (sequential mode). The thermal pulse method was only used to detect flow direction. Longer flow direction measurement have to be done in un-pumped conditions.

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 overlap, resulting in a stepwise flow data plot. 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, see Appendices 3.1–3.45 (violet curve).

The positions (borehole length) of the detected fractures are shown on the caliper. They are interpreted on the basis of the flow curves and represent therefore flowing fractures. A long line represents the location of a leaky fracture; 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 or if they are unclear because of noise.

The colored triangles in the illustrations show the magnitudes of the measured flows. The triangles have the same color as the corresponding curves.

The tables in Appendix 10 were used to calculate conductive fracture frequency (CFF). The number of conductive fractures was counted on the same 5 meter sections as in Appendix 7 before. The number of conductive fractures was sorted in six columns depending on their flow rate. The total conductive fracture frequency is presented graphically, see Appendix 11.

The basic data for KLX10 measurements is presented in Appendix 6 and the explanations to the tables in Appendices 6–8 in Appendix 9.

6.4.2 Transmissivity and hydraulic head of borehole sections

The entire borehole between 92.20 and 993.21 m was flow logged with a 5 m section length and with 0.5 m length increments. All flow logging results presented in this report are derived from measurements with the thermal dilution method.

The results of the measurements with a 5 m section length are presented in tables, see Appendix 7. Only the results with a 5 m length increment are used. All borehole sections are shown in Appendices 3.1–3.45. Secup presented in Appendix 7 is calculated as the distance along the borehole from the reference level (top of the casing tube) to the upper end of the test section. Seclow is calculated respectively to the lower end of the test section. Secup and Seclow values for the two sequences (measurements at un-pumped and pumped conditions) are not exactly identical, due to a minor difference of the cable stretching. The difference between these two sequences was small. Secup and Seclow given in Appendix 7 are calculated as an average of these two values. The same flow rates as in Appendix 7, are also plotted in Appendices 3.1–3.45.

Pressure was measured and calculated as described in Section 6.3. Borehole head h_{0FW} and borehole head h_{1FW} in Appendix 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 in Appendix 7 (Q_0 and Q_1), 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, 25 sections were detected as flow yielding, of which 15 had a flow direction from the borehole into the bedrock (negative flow). During pumping, all 69 detected flows were directed towards the borehole.

The flow data is presented as a plot, see Appendix 4.1. 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 4.1) also the lower and upper measurement limits of flow are presented. There are theoretical and practical lower limits of flow, see Section 6.4.4.

Hydraulic head and transmissivity (T_D) of borehole sections can be calculated from flow data using the method described in Chapter 3. The 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 4.2. The measurement limits of transmissivity are also shown in Appendix 4.2 and in Appendix 7. All the measurement limit values of transmissivity are based on the actual pressure difference in the borehole (borehole head h_{0FW} and borehole head h_{1FW} in Appendix 7).

The results of measured borehole sections are deviating from the regular in two places. This can be seen for example in calculated head results, Appendix 4.2. At the length of 537.60 m the noise level of measurement without pumping is high and is possibly summed up in the measured flow value. The real flow without pumping may be even 100 mL/h lower, which would give 13.3 (metres above sea level) calculated head and $5.3 \cdot 10^{-08}$ m^2/s transmissivity for the section. At the length of 697.75 m the anomalies of the flow measurements with 5 m section lengths are clear. However, from the SPR result it can be seen that the crushed zone in the bedrock is possibly longer than 5 m, which can lead to water leak at the rubber disks. To ensure the results, longer section length should be used in this kind of crushed zones.

The sum of detected flows without pumping (Q_0) was $-3.3 \cdot 10^{-06}$ m^3/s (–12,000 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 not zero.

The wider upper part of the borehole, which was not flow logged, is partially without a casing tube and can therefore contain flowing fractures. Vertical flow along the borehole was measured at the length of c. 101.3 m. The measured flow along the borehole was c. $9.7 \cdot 10^{-07}$ m^3/s (3,500 mL/h) and flow direction was downwards, see Appendix 13.4. This flow is smaller than the flow sum measured below 100 m (–12,000 mL/h). Full balance is however difficult to obtain since small variations of water level cause large change in flow. This can be seen in the beginning of vertical flow measurement. 0.07 m change in the water level cause c. 56,000 mL/h change in the measured flow. When calculating from the entire transmissivity of the borehole ($2.1 \cdot 10^{-04}$ m^2/s), the same 0.07 m change in pressure should cause in its entirety a 54,000 mL/h flow in the borehole.

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 fracture distance is less than one meter, it may be difficult to evaluate the flow rate. There are such cases for instance in Appendix 3.1. Increase or decrease of flow anomaly at the fracture location (marked with the lines in Appendix 3) is used for determination of flow rate (filled triangles in Appendix 3).

Some fracture-specific results were classified to be "uncertain", see Appendix 8. The basis for this classification is either a minor flow rate (< 30 mL/h) or unclear fracture anomalies. Anomalies are considered unclear if the distance between them is less than one metre or their nature is unclear because of noise.

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

At the lengths of 224.75–226.75 m, 327.50–329.50 m and 336.20–337.70 m the borehole wall has been stabilized with perforated stainless steel tube, PLEX. Defining the fracture locations is problematic at these points.

Total amount of detected flowing fractures was 191, but only 4 could be defined without pumping. These 4 fractures could be used for head estimation and all 191 were used for transmissivity estimations, Appendix 8. Transmissivity and hydraulic head of fractures are plotted in Appendix 5.

Fracture-specific transmissivities were compared with transmissivities of borehole sections in Appendix 12. All fracture-specific transmissivities 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 limits of flow measurements and transmissivity

Theoretical minimum of measurable flow rate in the overlapping results (thermal dilution method only) is about 30 mL/h. The thermal pulse method can also be used when the borehole is not pumped. Its theoretical lower limit is about 6 mL/h. In this borehole the thermal pulse method was only used to detect the flow direction not the flow rate. 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 in favorable borehole conditions.

In practice, the minimum measurable flow rate may be much higher. Borehole conditions may be such that the base level of flow (noise level) is higher than assumed. The noise level can be evaluated on such intervals of the borehole where there are no 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 mud.
3) Gas bubbles in water.
4) High flow rate along the borehole.

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

Drilling mud in the borehole usually increases noise level. Typically this kind of noise is seen both in un-pumped and pumped conditions.

Pumping causes pressure drop in borehole water and in water in fractures near the borehole. This may lead to release of dissolved gas and increase the amount of gas bubbles in the water. Some fractures may produce more gas than others. Sometimes the noise level is larger just above certain fractures (when the borehole is measured upwards). The reason for this is assumed to be gas bubbles. The bubbles may cause decrease of average density of water and therefore also decrease of measured head in the borehole.

The effect of 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.

High noise level in flow masks "real" flow that is smaller than the noise. Real flows are totally invisible if they are about ten times smaller than the noise and they are registered correctly if they are about ten times larger than noise. Based on experience, real flows between 1/10 times noise level and 10 times noise level are summed up with 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 unclear whether it is applicable in each case.

The practical minimum level of measurable flow rate is evaluated and presented in Appendices 3.1–3.45 using grey dashed line (Lower limit of flow rate). The practical minimum level of measurable flow is always evaluated in pumped conditions since this measurement is the most important for transmissivity calculations. The limit is an approximation. It is evaluated to obtain a limit below which there may be fractures or structures that remain undetected.

The noise level in KLX10 was between 30–100 mL/h. In some places it fell below 30 mL/h, i.e. below the theoretical limit of the thermal dilution method. The noise line (grey dashed line) was never drawn below 30 mL/h, because the values of flow rate measured below 30 mL/h are 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 smaller drawdown. In KLX10 no measurements with smaller drawdown were needed.

The practical minimum of measurable flow rate is also presented in Appendix 7 (Q-lower limit P). 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 P and the actual head difference at each measurement location, see Appendix 7 (T_D-measl$_{LP}$). Theoretical minimum measurable transmissivity can also be evaluated using Q value of 30 mL/h (minimum theoretical flow rate with thermal dilution method) instead of Q-lower limit Practical, see Appendix 7 (T_D-measl$_{LT}$). 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 7 (T_D-measl$_U$).

All three flow limits are also plotted with measured flow rates, see Appendix 4.1. Theoretical minimum and maximum values are 30 mL/h and 300,000 mL/h, respectively.

The three transmissivity limits are also presented graphically, see Appendix 4.2.

Similar flow and transmissivity limits are not given for the fracture-specific results, Appendices 5 and 8. 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 less than one metre apart, the upper flow limit depends on the sum of flows, which must be below 300,000 mL/h.

6.4.5 Transmissivity of the entire borehole

The pumping phase for the logging and its subsequent recovery is utilized to evaluate the transmissivity of the entire borehole. This is done with the two steady state methods, described in Chapter 3.

Steady state analysis

For the Dupuit's formula (equation 3-9) R/r_0 is chosen to be 500, Q was 87 L/min and s (drawdown) was 6.85 m. Transmissivity calculated with Dupuit's formula is $2.1 \cdot 10^{-04}$ m^2/s.

In the Moye's formula (equation 3-10) length of test section L is 989.1 m (12.10–1,001.2 m) and borehole diameter $2r_0$ is 0.076 m. Transmissivity calculated with Moye's formula is $3.5 \cdot 10^{-04}$ m^2/s.

The results are given in Table 6-3 where for the steady-state analyses method of Dupuit and Moye, the flow was set to Q = 87 L/min and drawdown s = 6.85 m (Appendix 13.2). Basic test data is in Appendix 6.

6.5 Groundwater level and pumping rate

Pumping was started on December 13. The pump intake was at level 5.8 (metres above sea level, RHB70), see Appendix 13.2. The groundwater level sensor (pressure transducer) was at 5.48 (metres above sea level, RHB70). The reference level is centre point of top of casing (ToC) 18.276 (metres above sea level, RHB70).

The borehole was pumped between December 13 and 21 with a drawdown of about 6.9 meters. Pumping rate was recorded, see Appendix 13.2.

The groundwater recovery was measured after the pumping period, December 21, Appendix 13.3. The recovery was monitored only with groundwater level sensor. The absolute pressure sensor located in the flow logging tool was not used. Monitoring of groundwater recovery was continued by SKB between December 21–31, Appendix 13.3.

Table 6-3. Transmissivity of the entire borehole KLX10.

Method	Transmissivity (m^2/s)
Dupuit	$2.1 \cdot 10^{-04}$
Moye	$3.5 \cdot 10^{-04}$

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 KLX10 at Oskarshamn. 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 initially. The detected anomalies were re-measured with a 1 m section length using a 0.1 m measurement interval.

Length calibration was made using the length marks on the borehole wall. The length marks were detected by caliper and in 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 in KLX10 was 191. Transmissivity and hydraulic head were calculated for borehole sections and fractures for the depth range 92.20 m–993.21 m. The highest transmissivity ($6.9 \cdot 10^{-6}$ m^2/s) was detected in a fracture at the length of 119.9 m. High-transmissive fractures were also found at 155.8 m, 224.8 m and 322.0 m. The lowest identified flowing fracture was at the approximate length of 842.9 m.

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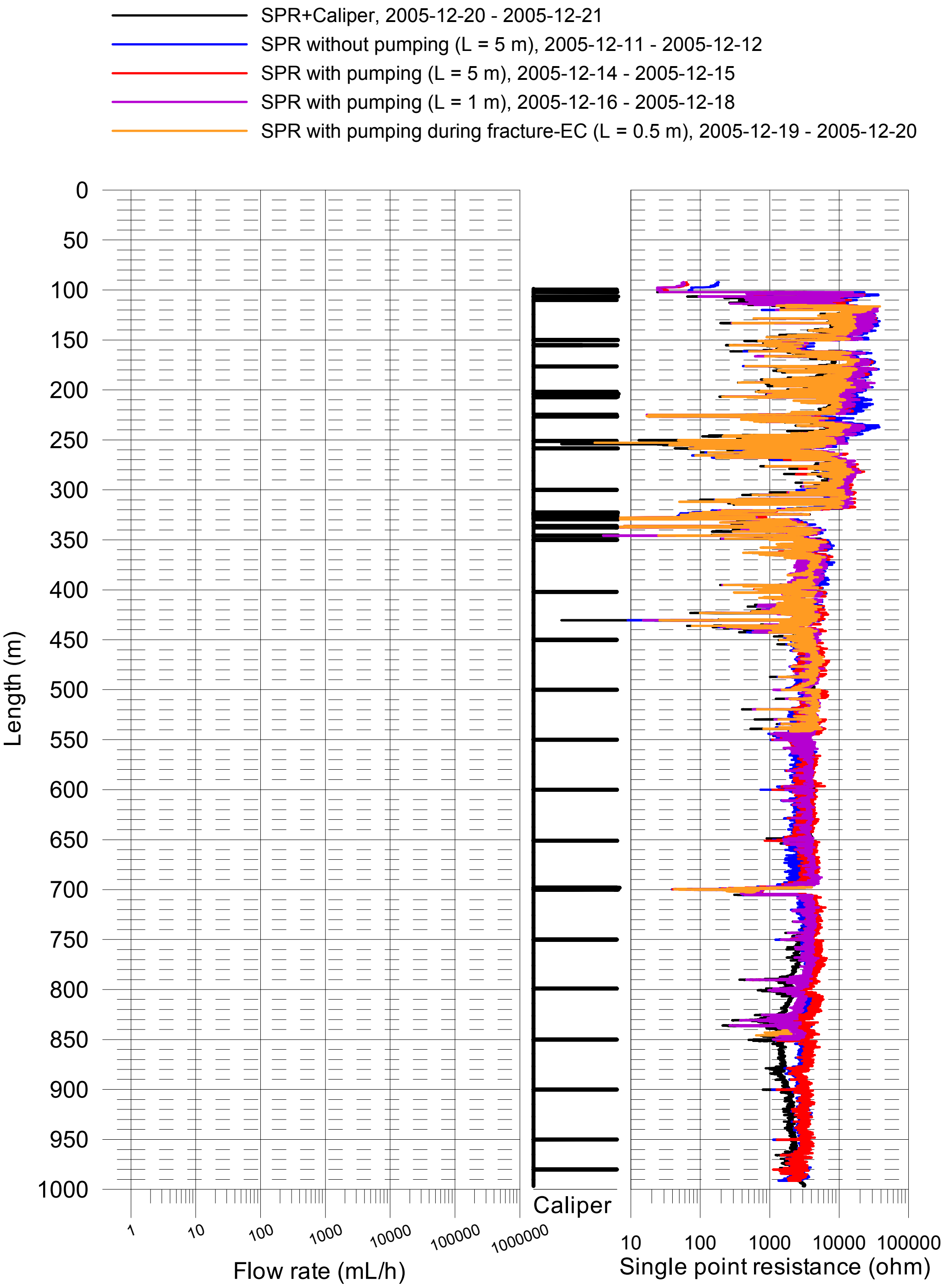
Appendices

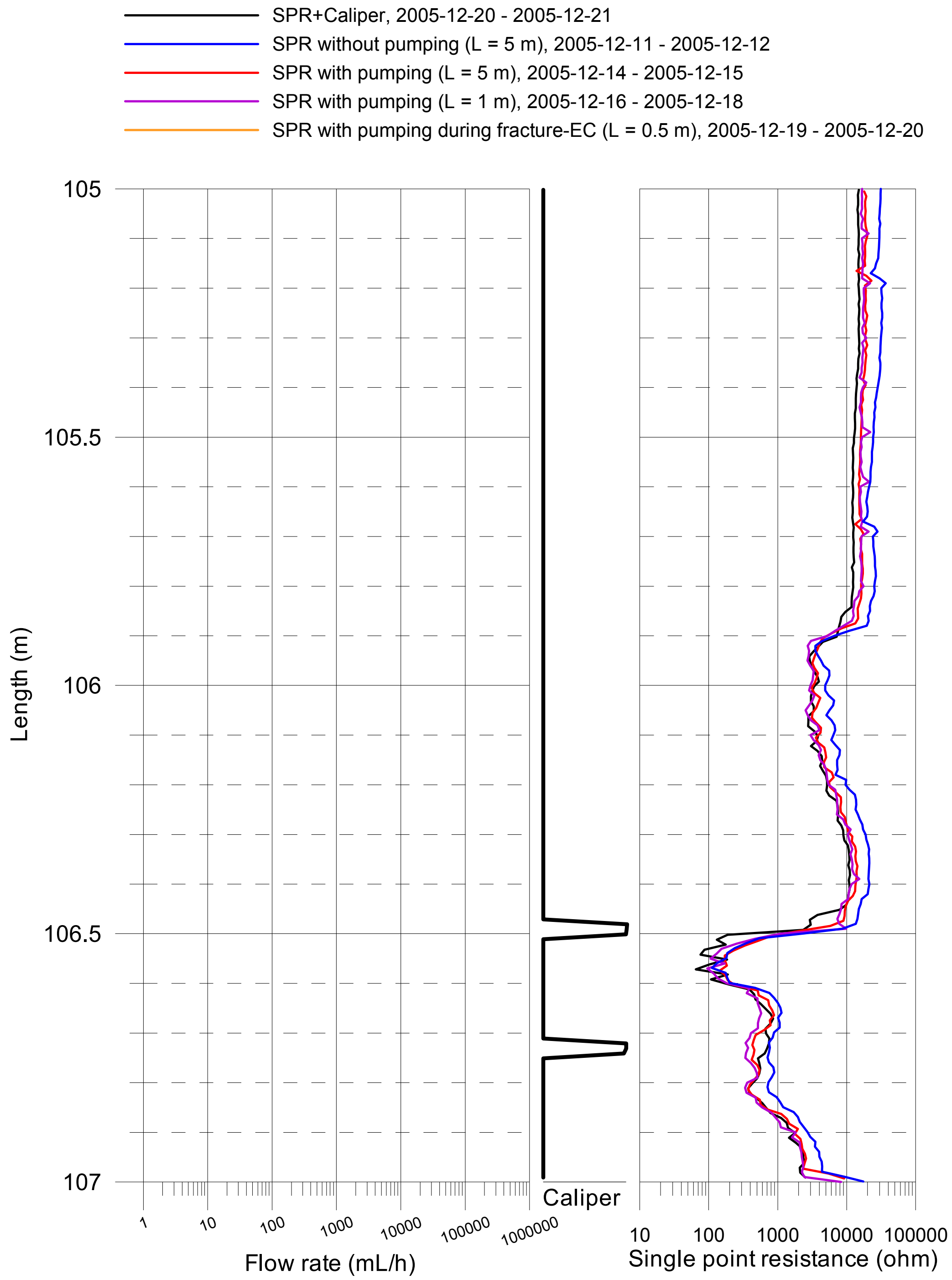
Appendix 1.1

Laxemar, borehole KLX10
SPR and Caliper results after length correction



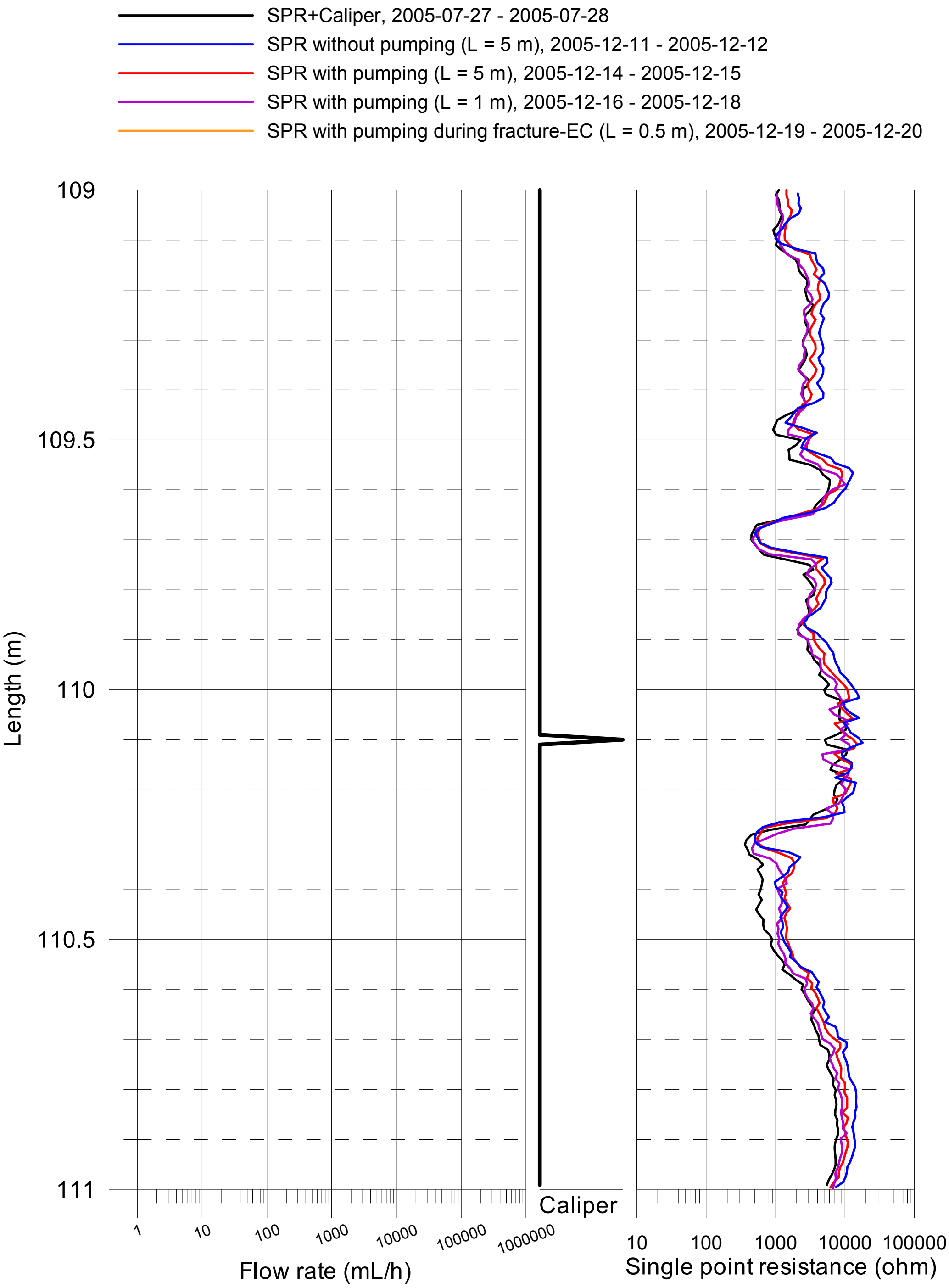
Appendix 1.2

Laxemar, borehole KLX10
SPR and Caliper results after length correction

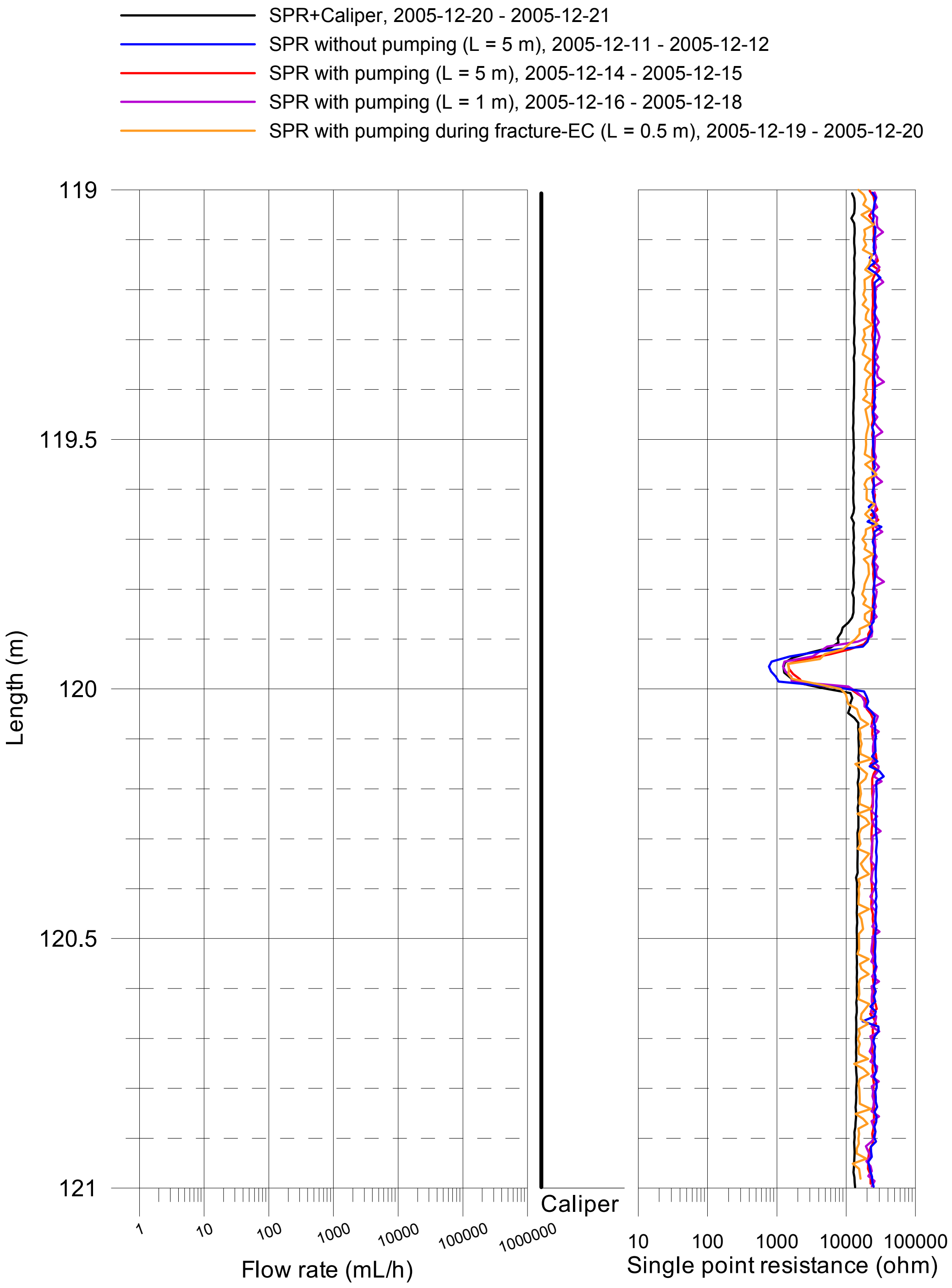


Appendix 1.3

Laxemar, borehole KLX10
SPR and Caliper results after length correction

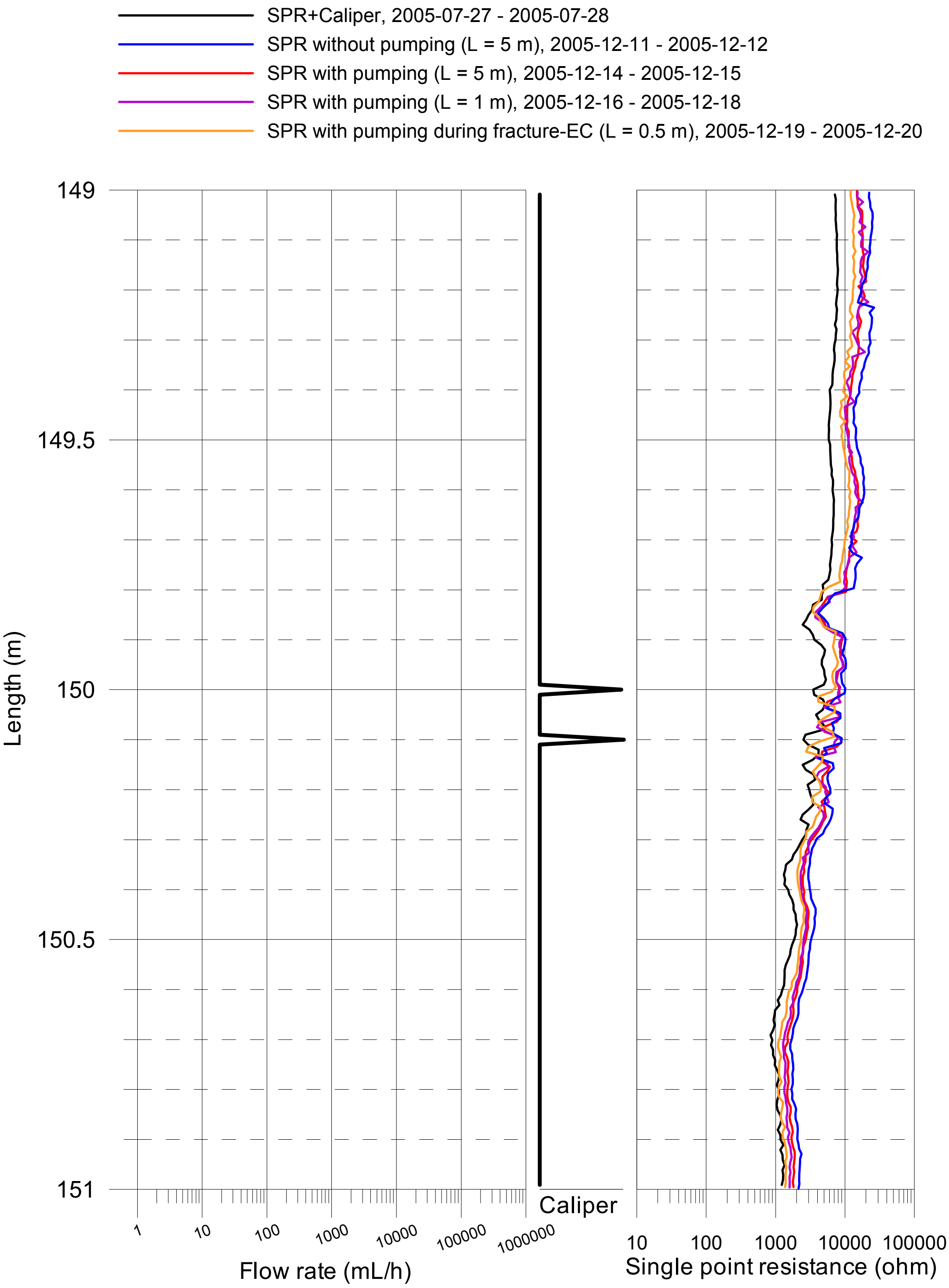


Laxemar, borehole KLX10
SPR and Caliper results after length correction



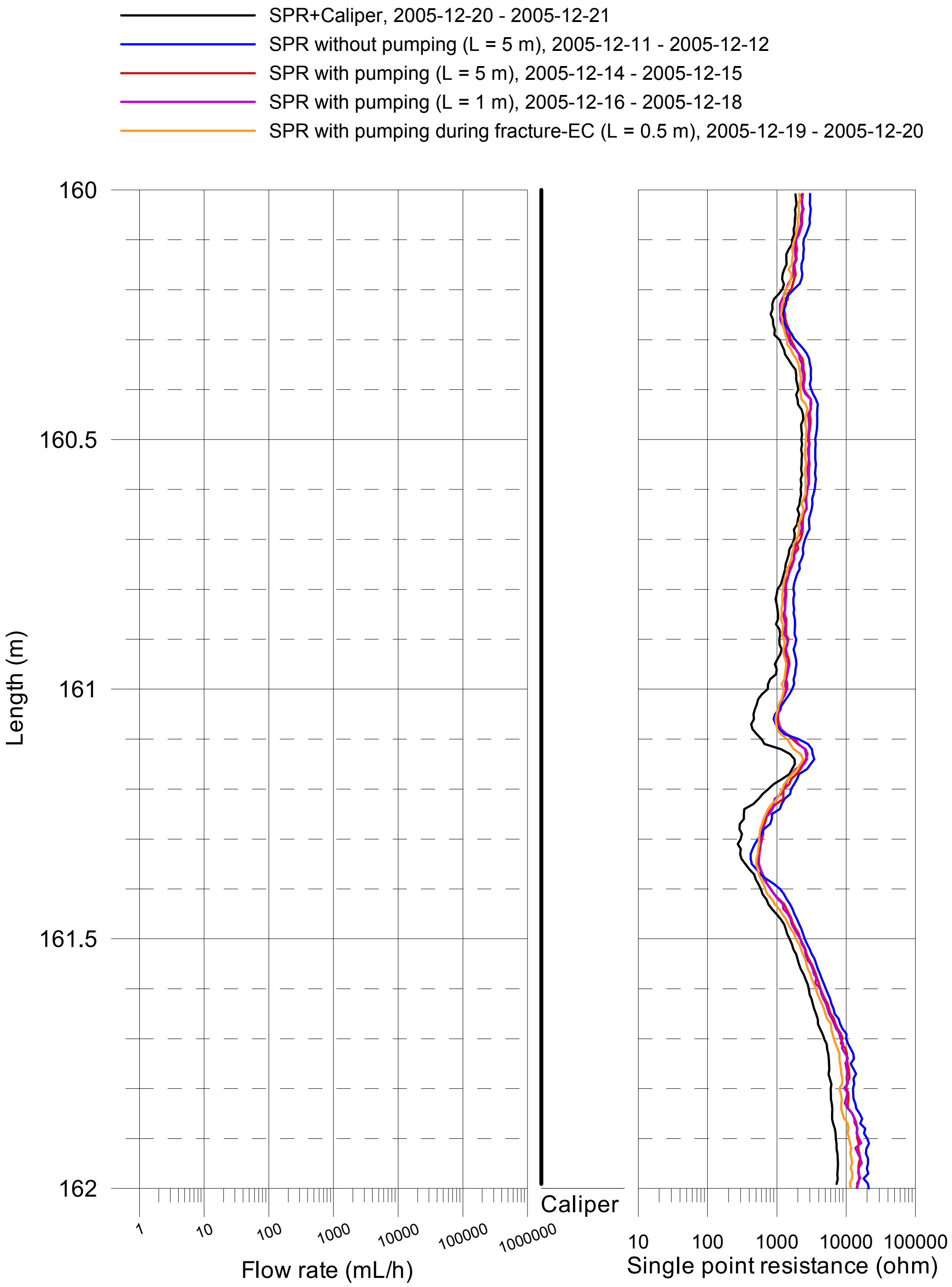
Appendix 1.5

Laxemar, borehole KLX10
SPR and Caliper results after length correction

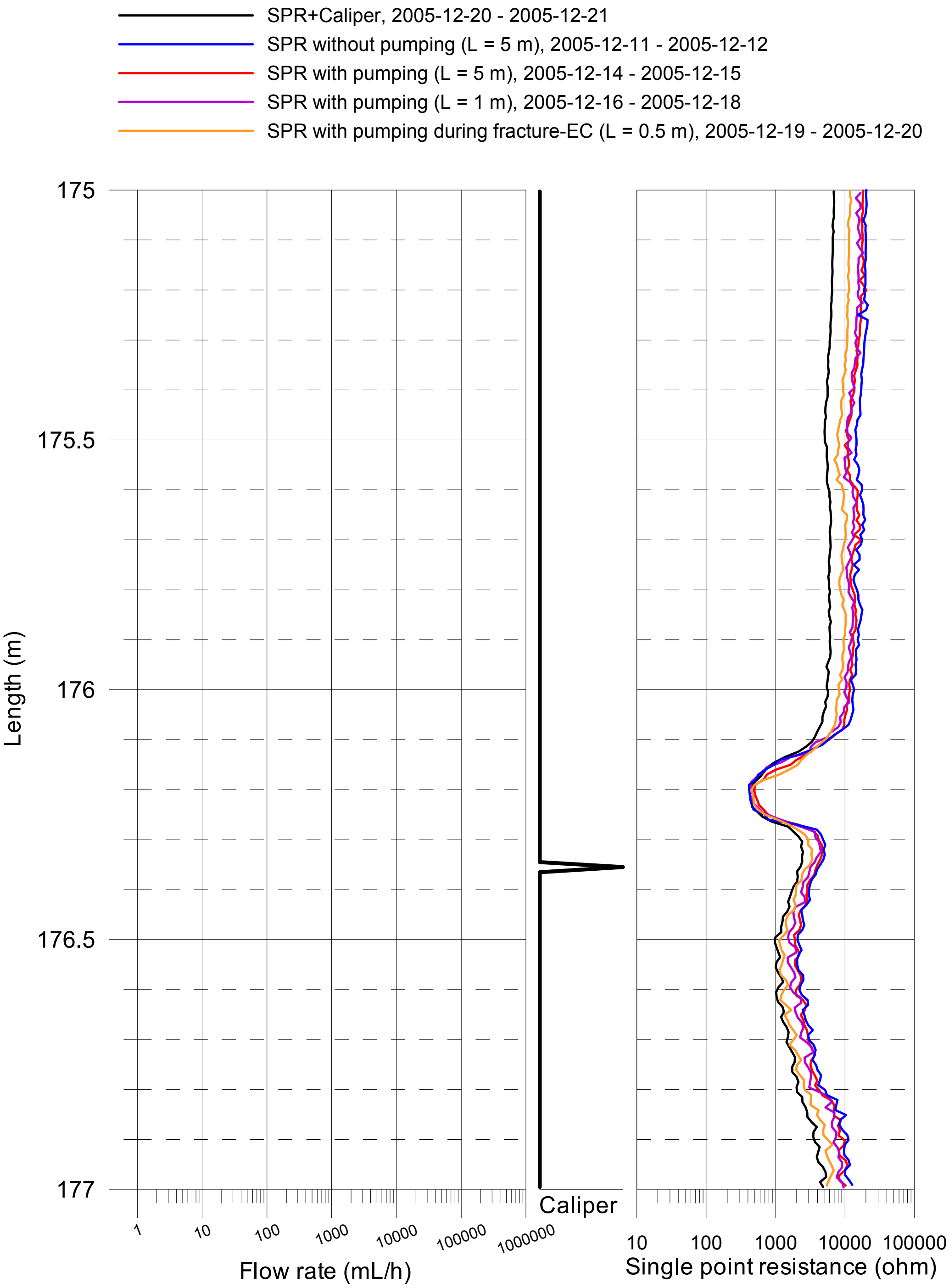


Appendix 1.6

Laxemar, borehole KLX10
SPR and Caliper results after length correction

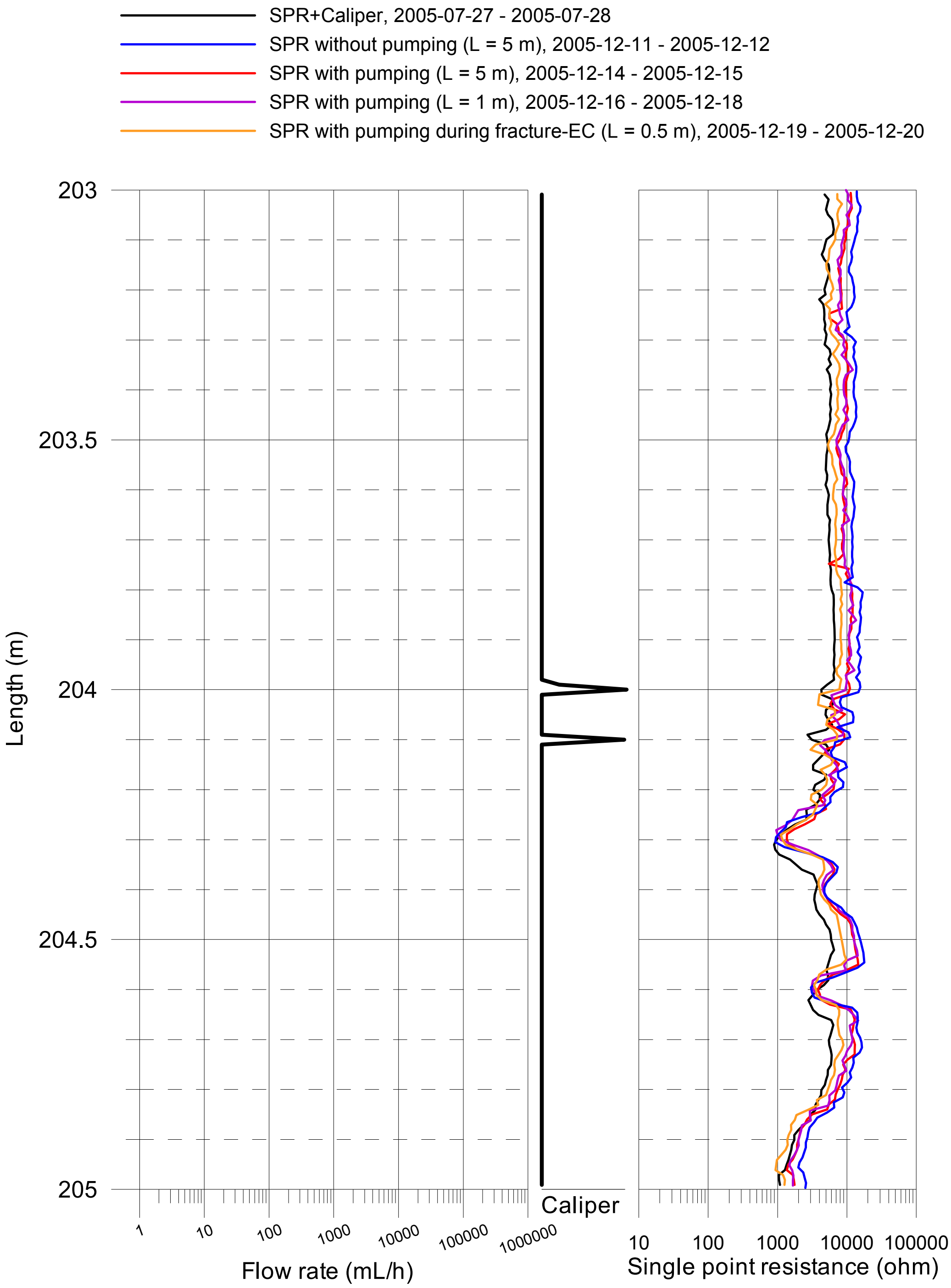


Laxemar, borehole KLX10
SPR and Caliper results after length correction



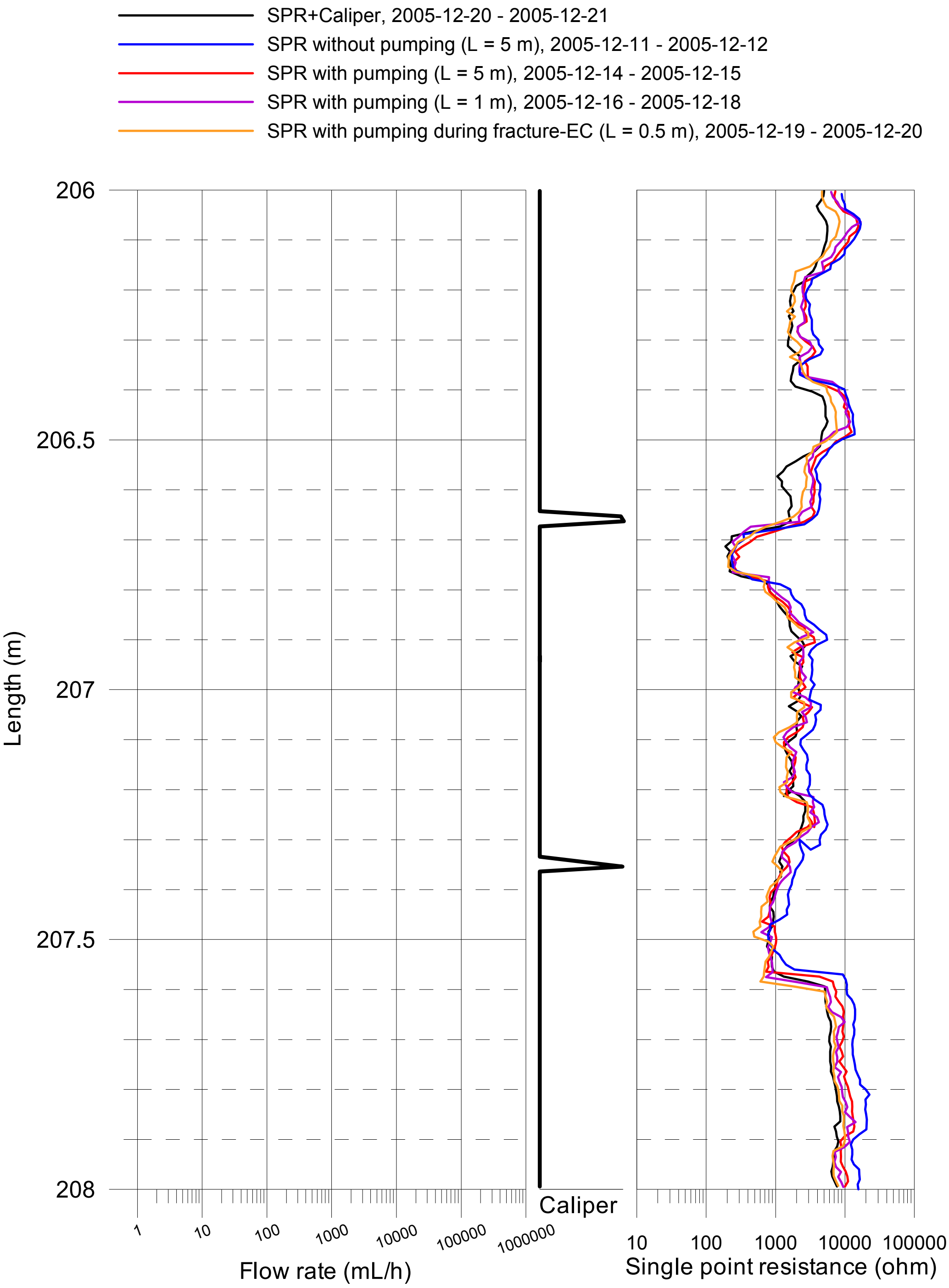
Appendix 1.8

Laxemar, borehole KLX10
SPR and Caliper results after length correction



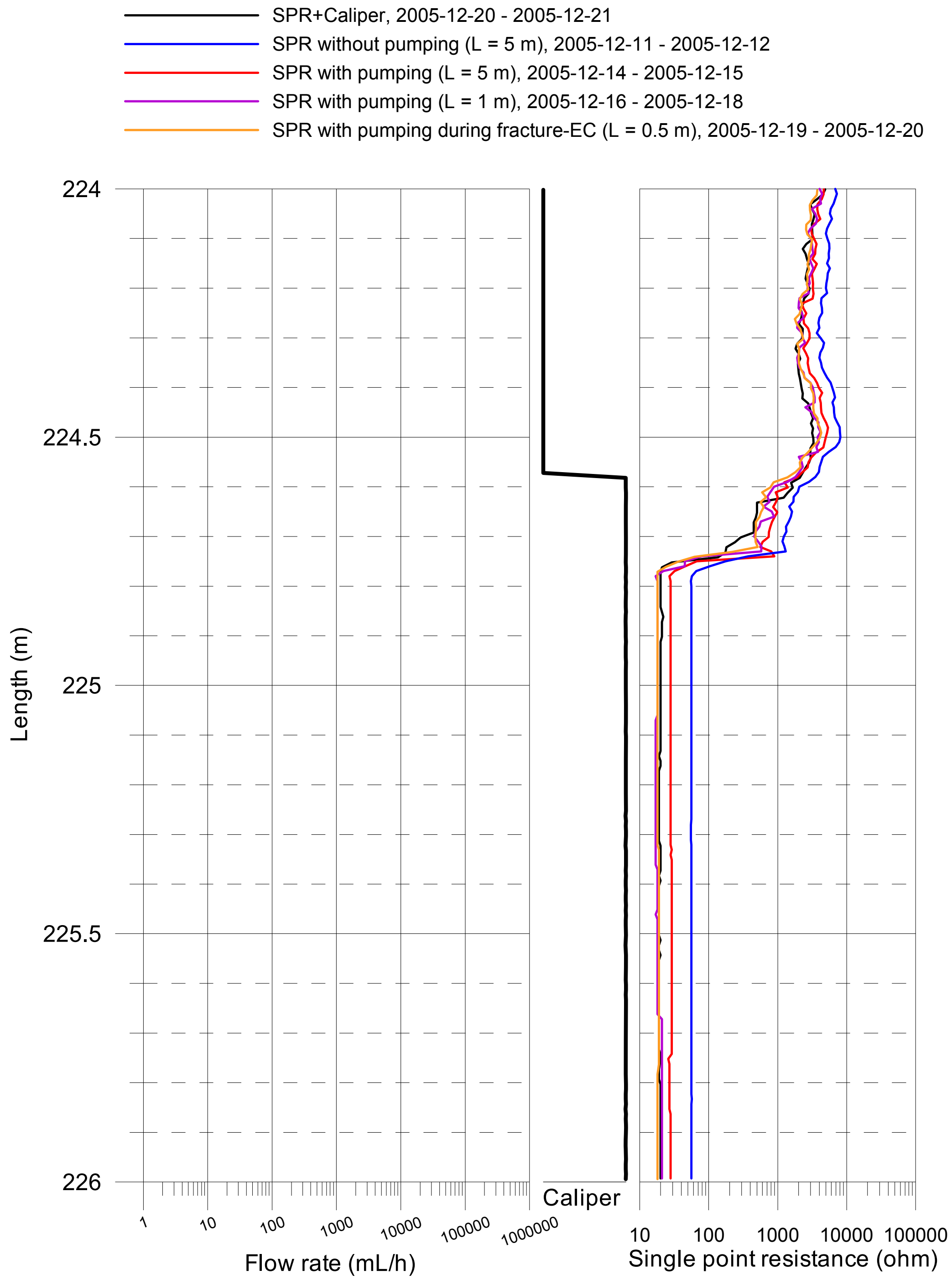
Appendix 1.9

Laxemar, borehole KLX10
SPR and Caliper results after length correction



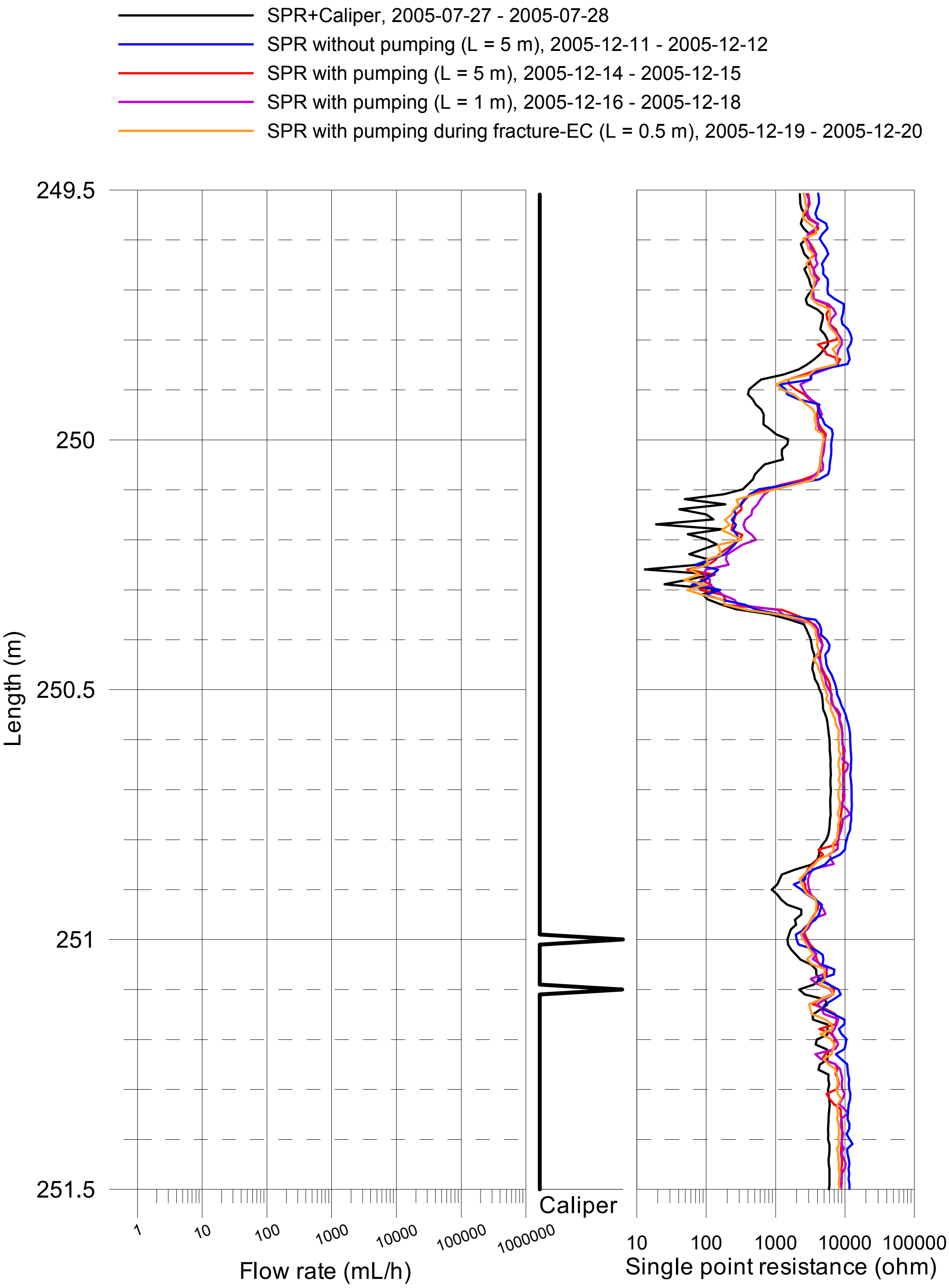
Appendix 1.10

Laxemar, borehole KLX10
SPR and Caliper results after length correction



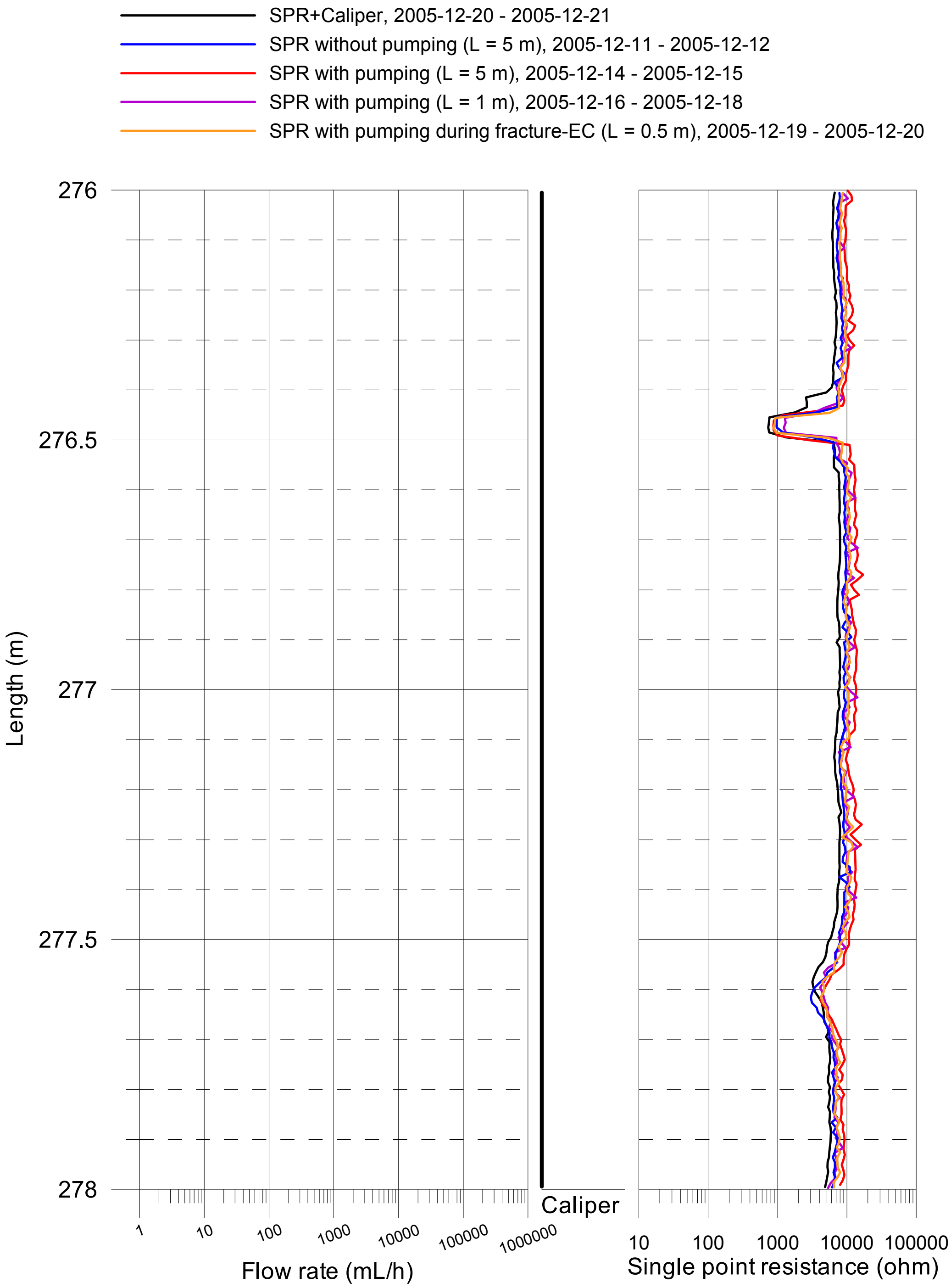
Appendix 1.11

Laxemar, borehole KLX10
SPR and Caliper results after length correction



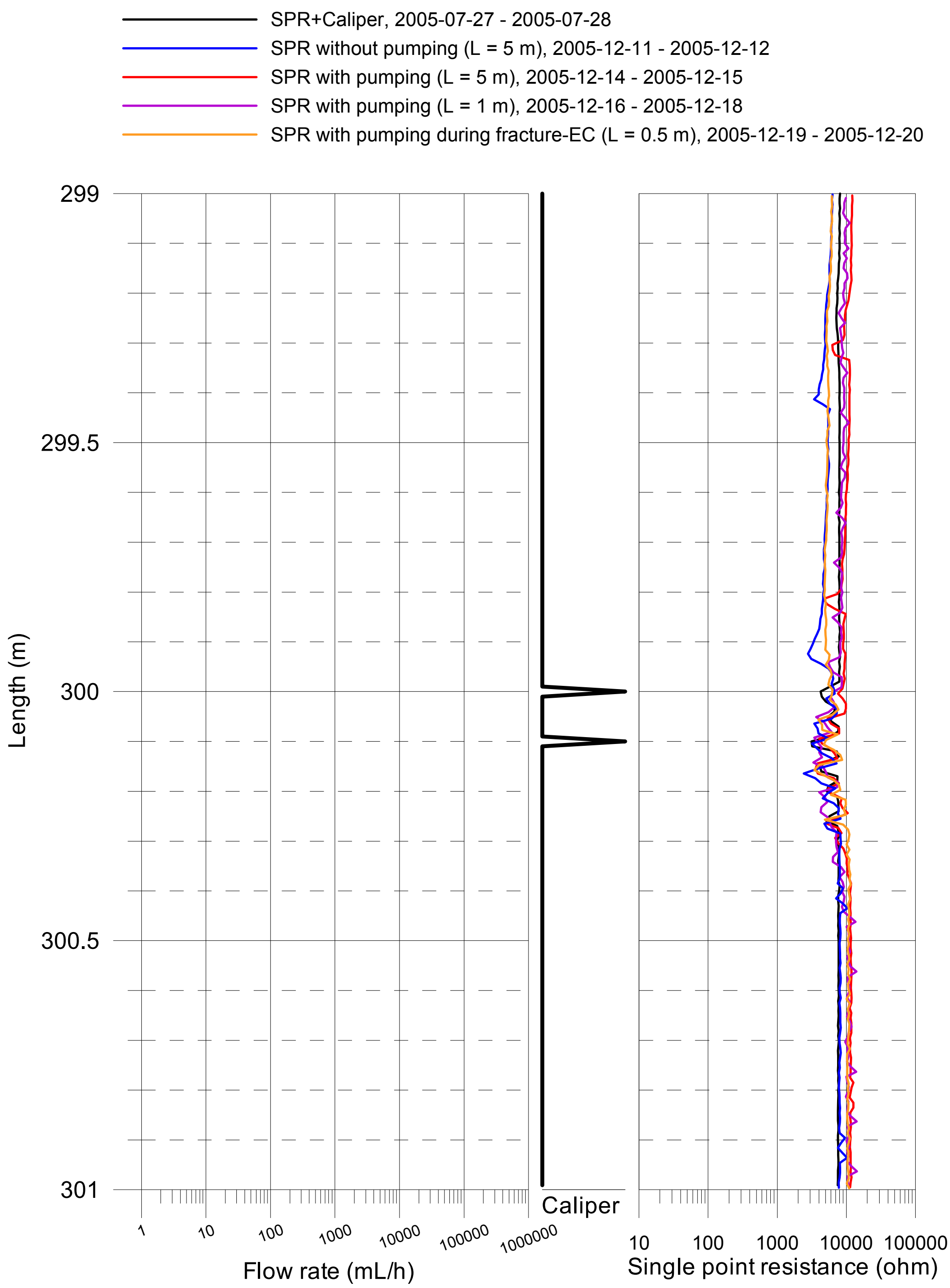
Appendix 1.12

Laxemar, borehole KLX10
SPR and Caliper results after length correction



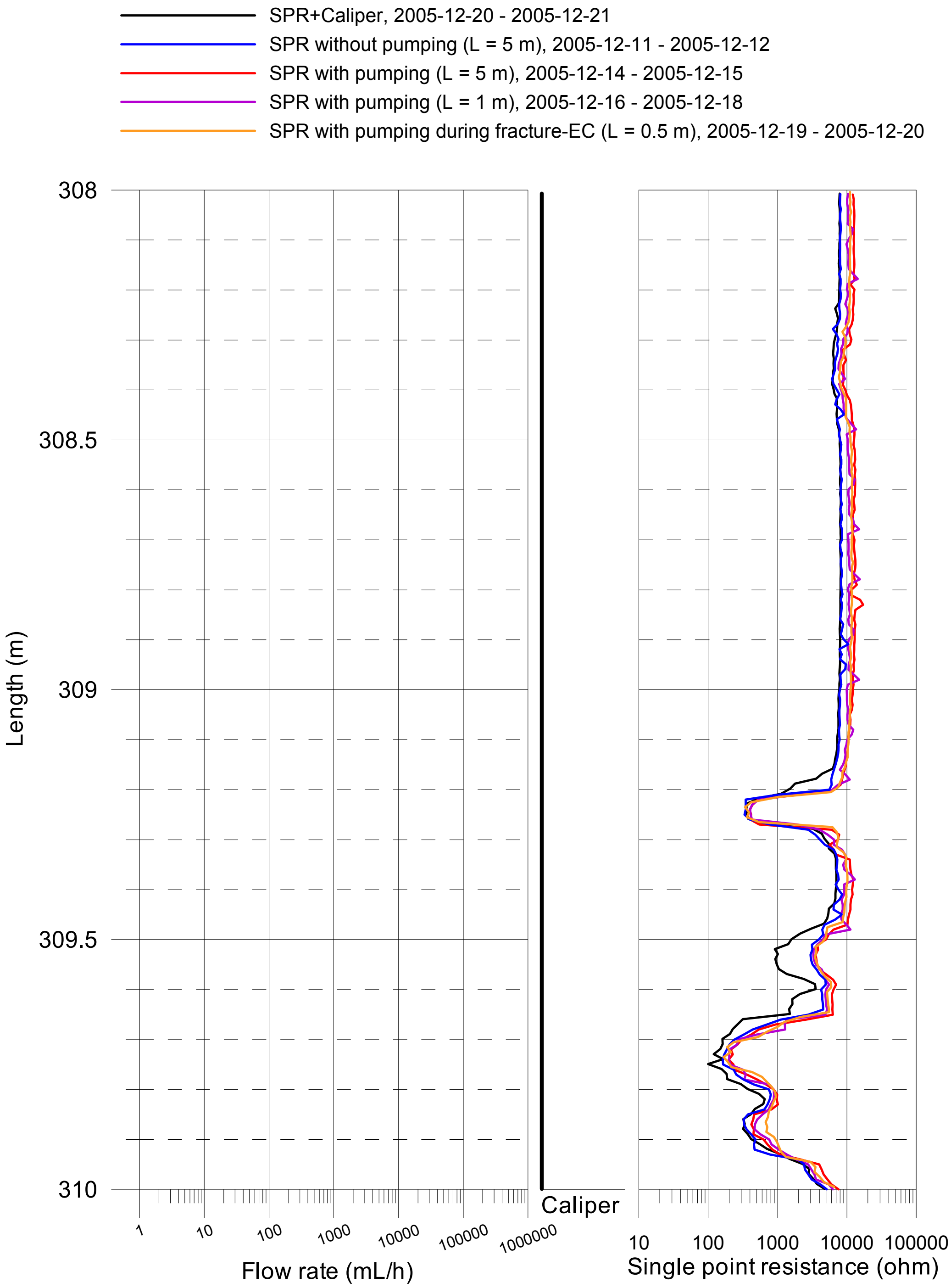
Appendix 1.13

Laxemar, borehole KLX10
SPR and Caliper results after length correction



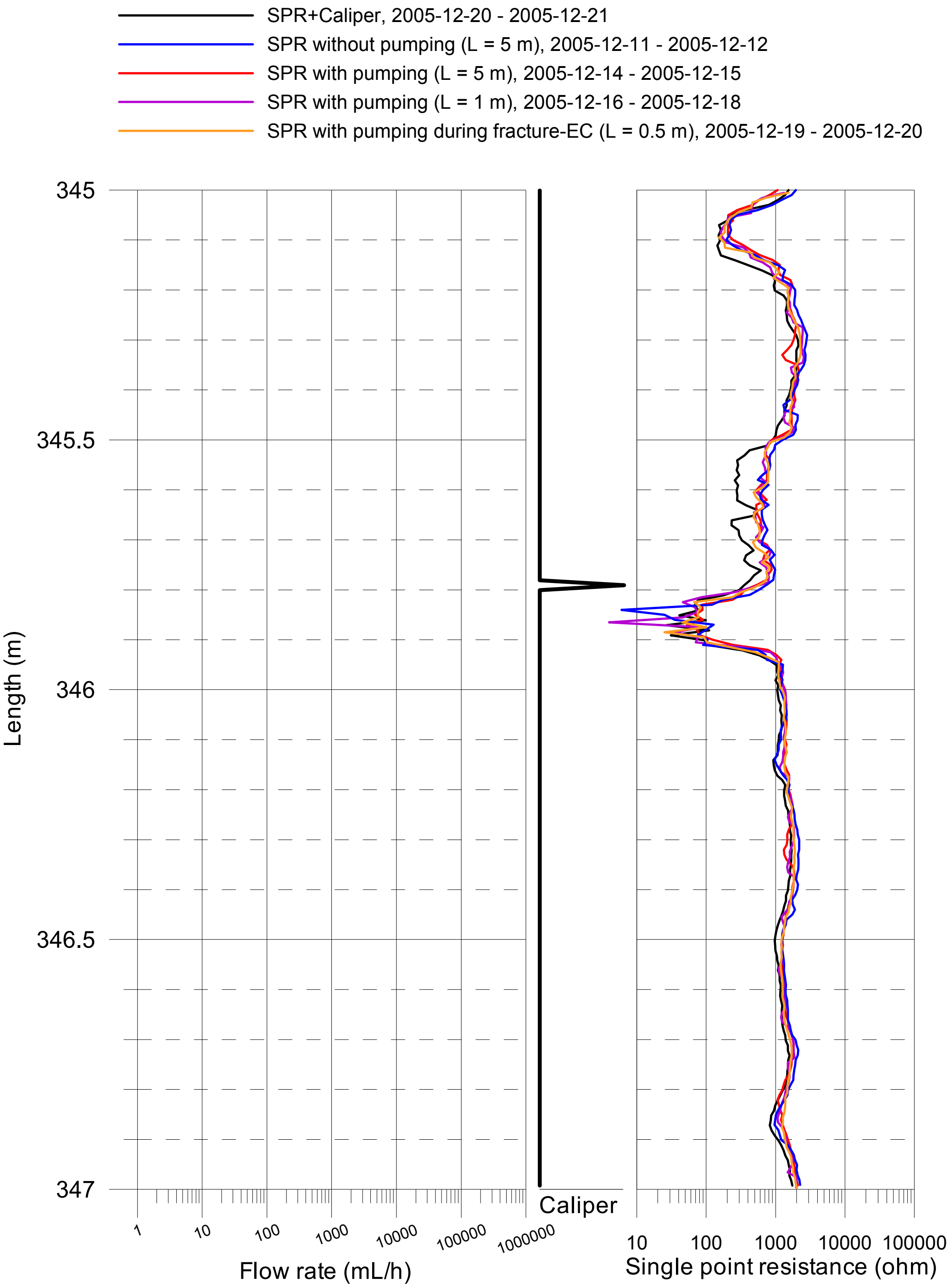
Appendix 1.14

Laxemar, borehole KLX10
SPR and Caliper results after length correction



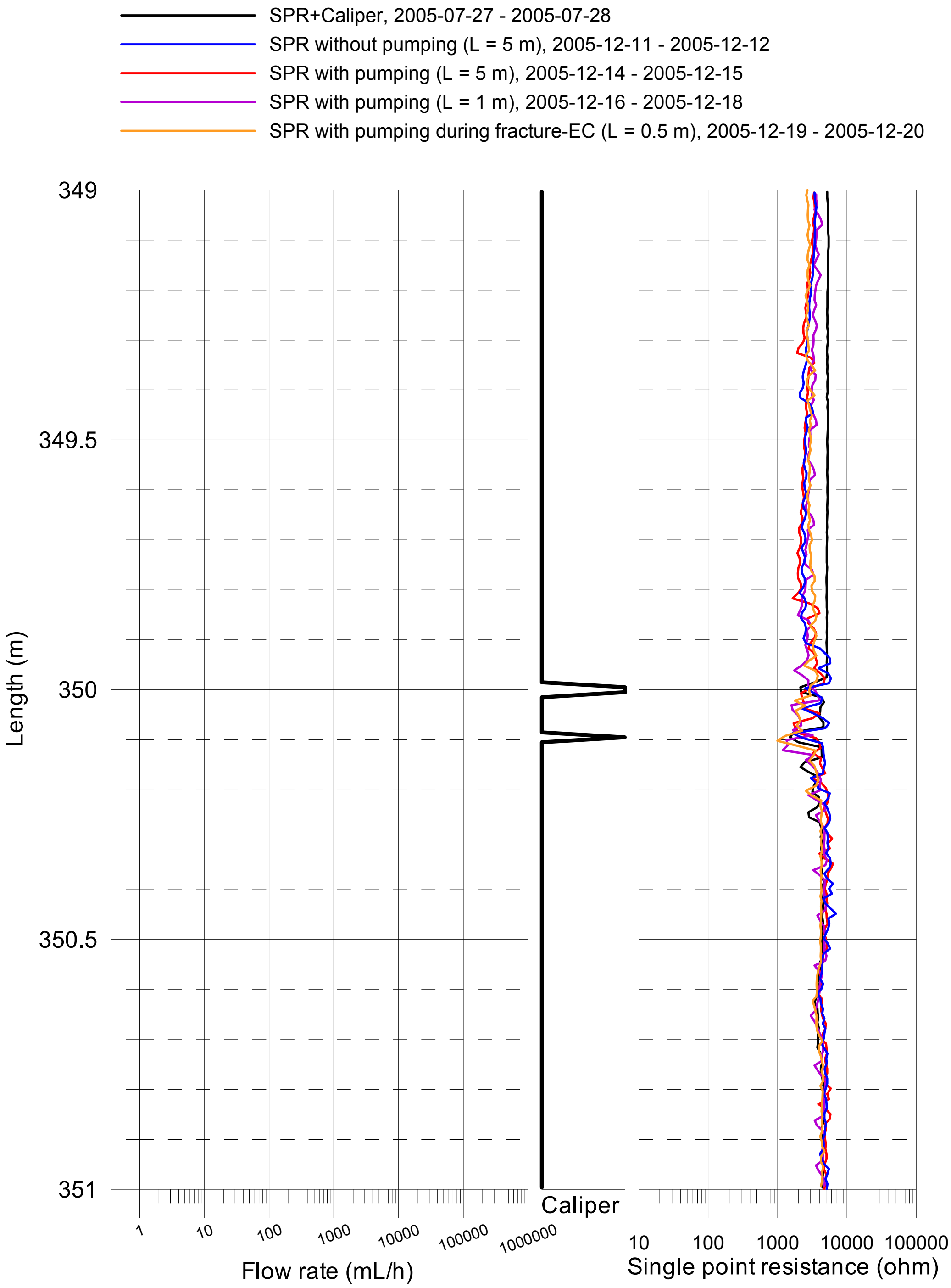
Appendix 1.15

Laxemar, borehole KLX10
SPR and Caliper results after length correction



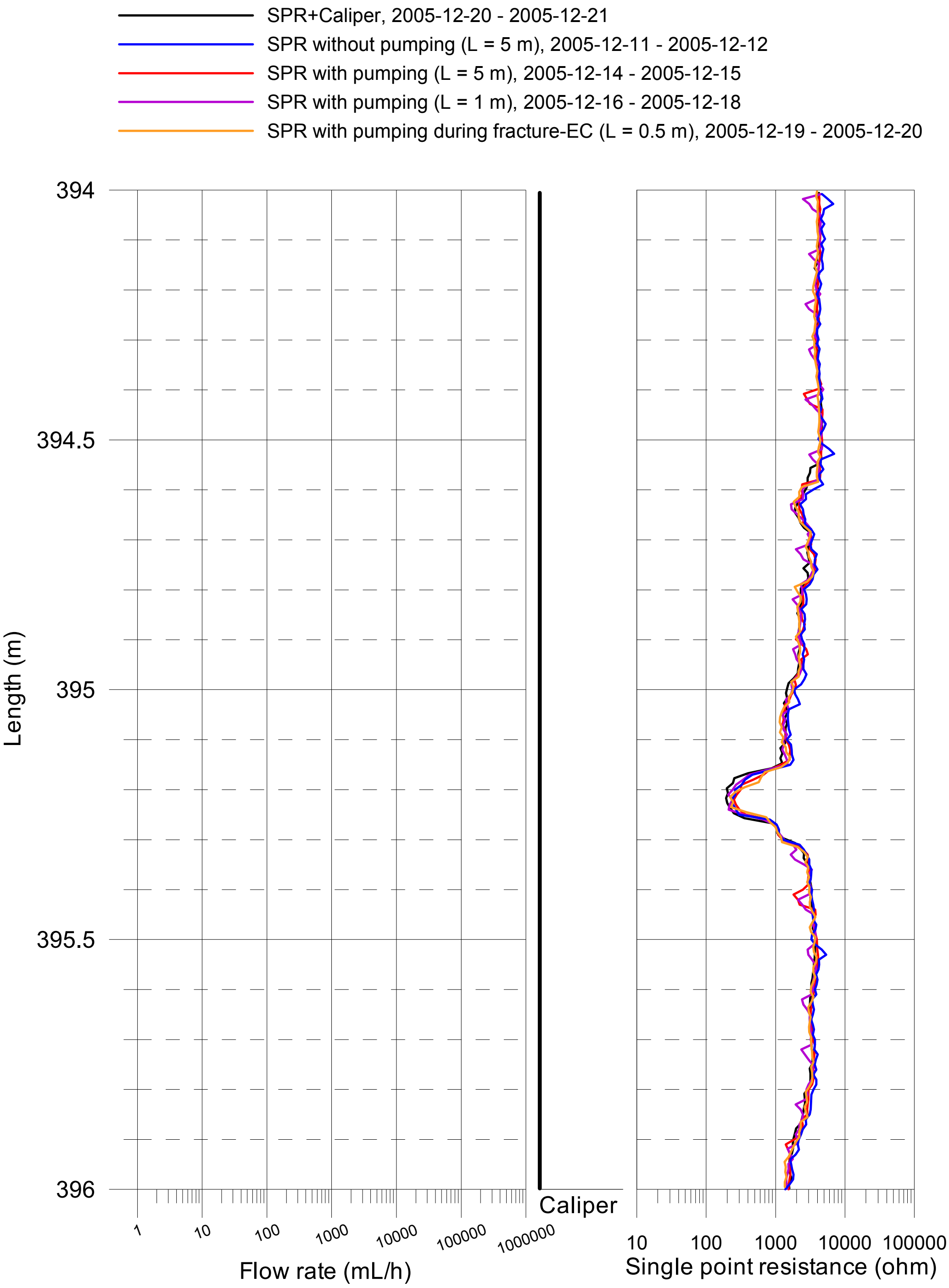
Appendix 1.16

Laxemar, borehole KLX10
SPR and Caliper results after length correction



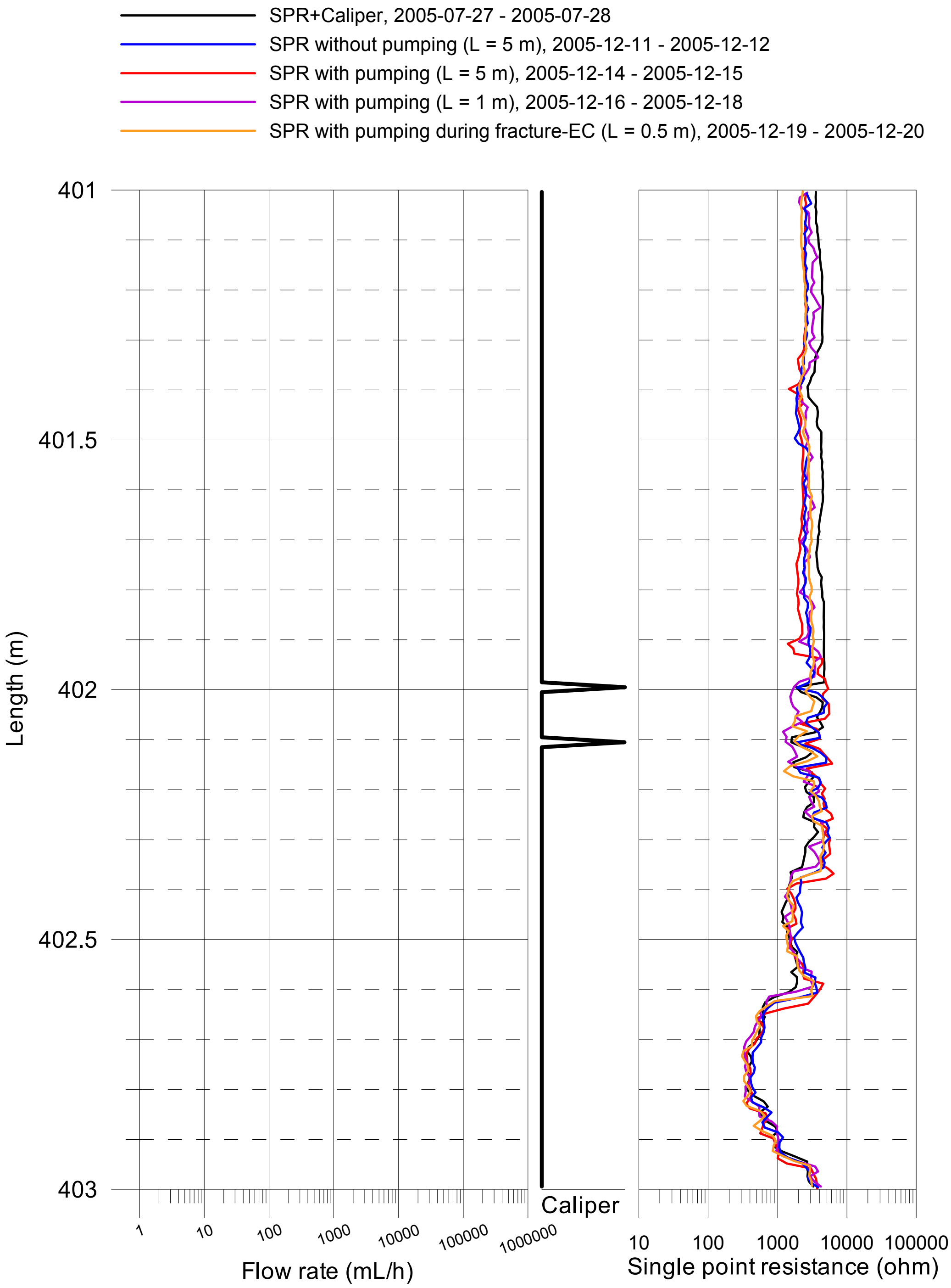
Appendix 1.17

Laxemar, borehole KLX10
SPR and Caliper results after length correction

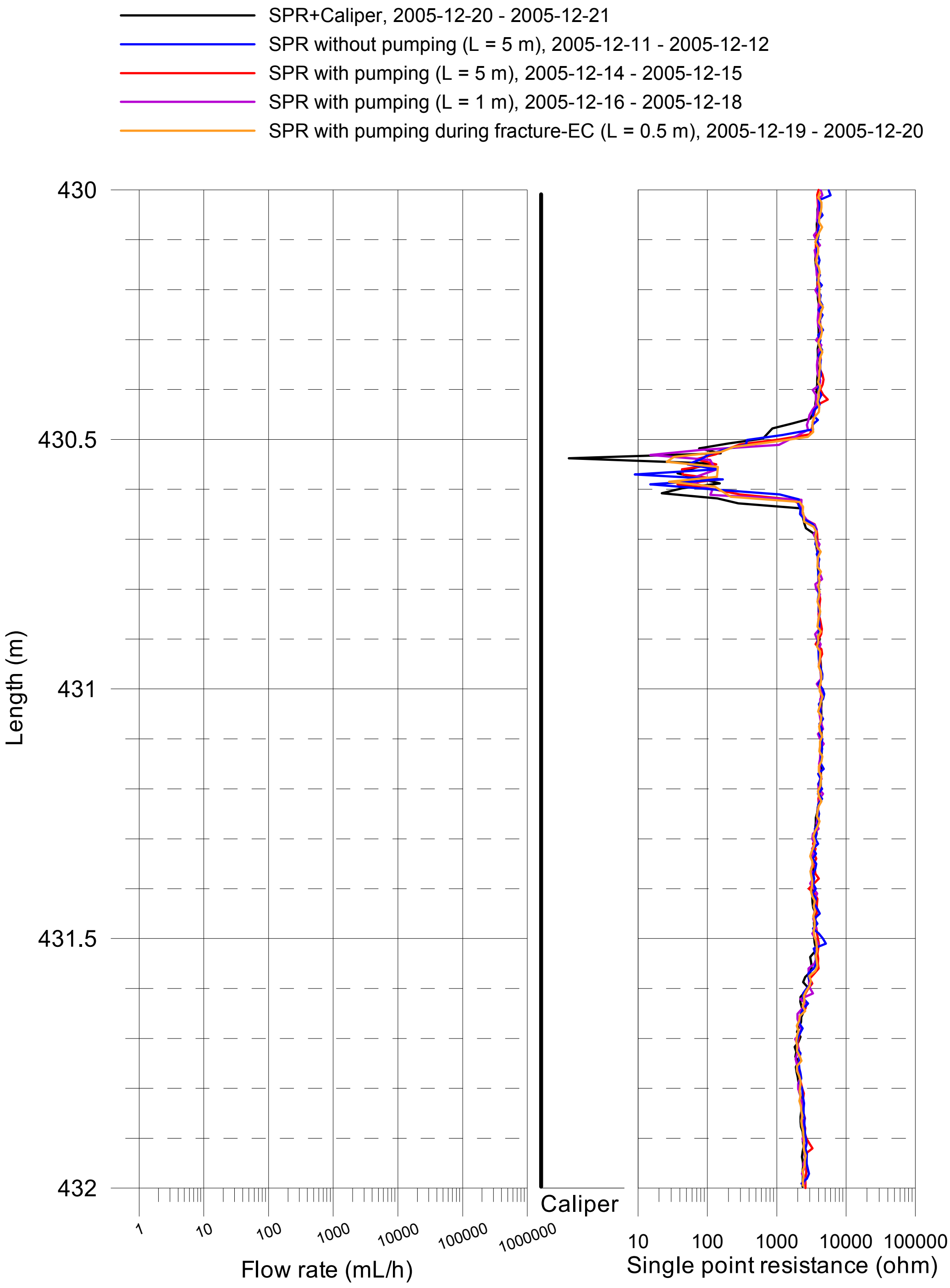


Appendix 1.18

Laxemar, borehole KLX10
SPR and Caliper results after length correction

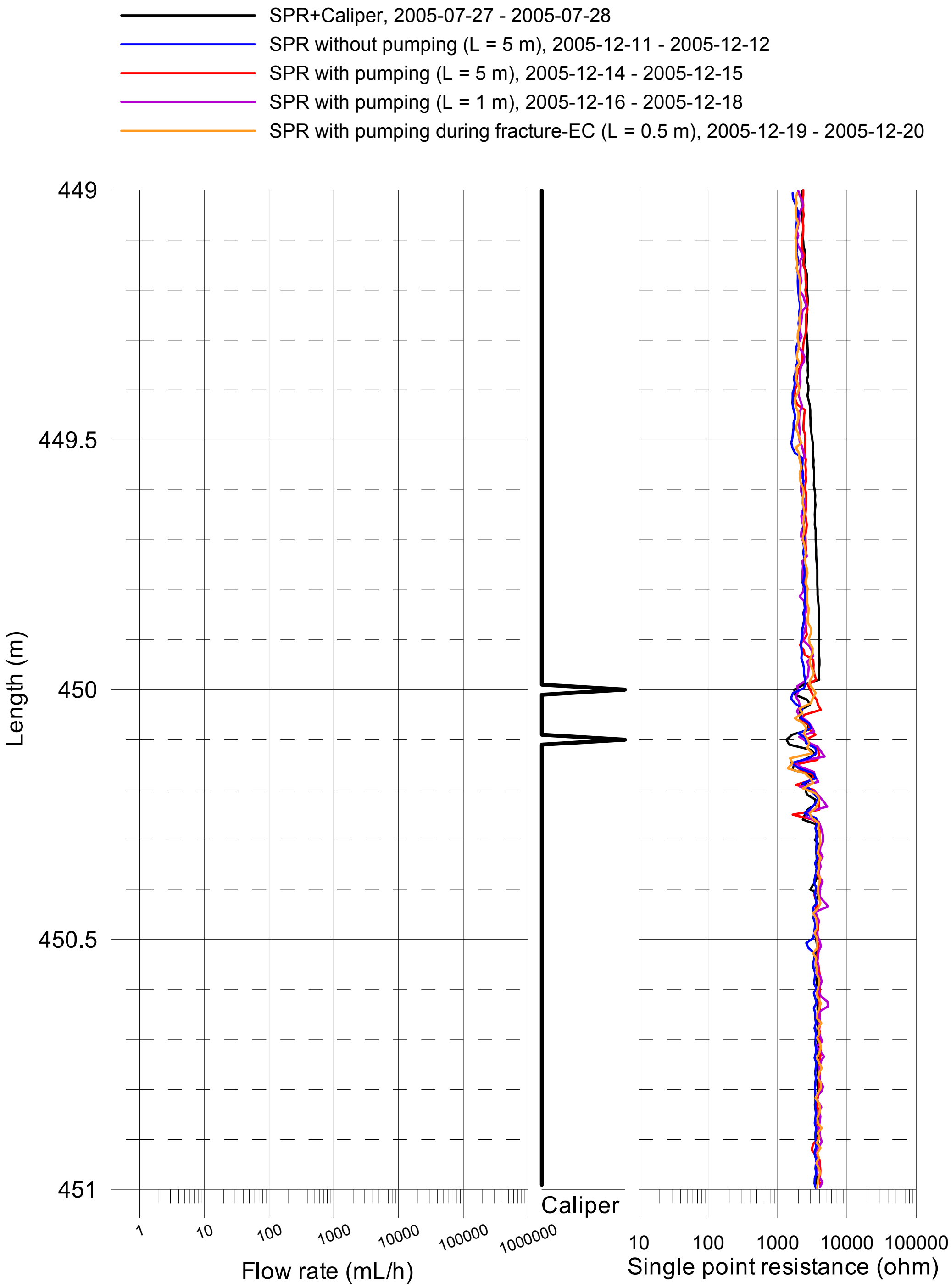


Laxemar, borehole KLX10
SPR and Caliper results after length correction



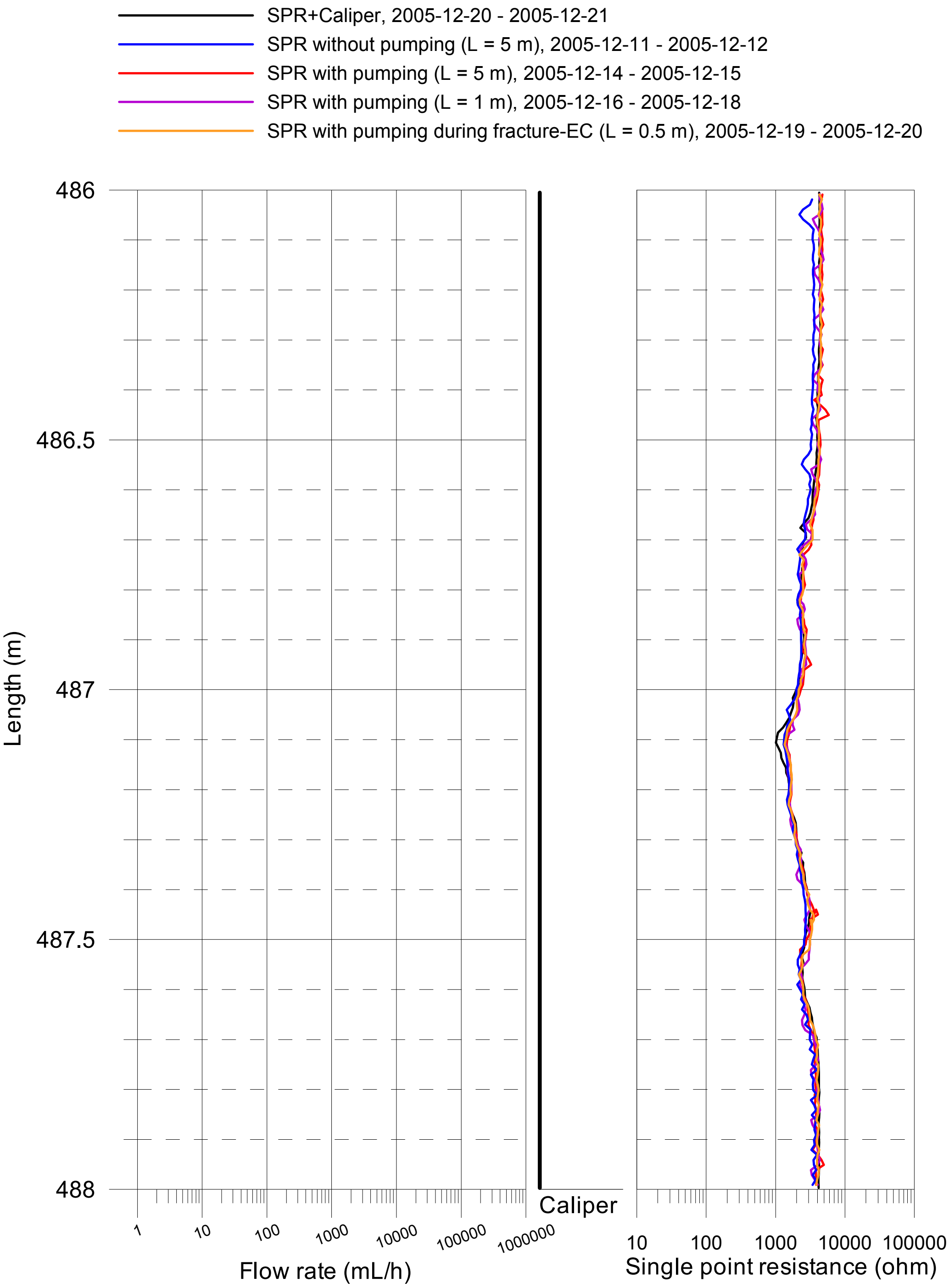
Appendix 1.20

Laxemar, borehole KLX10
SPR and Caliper results after length correction



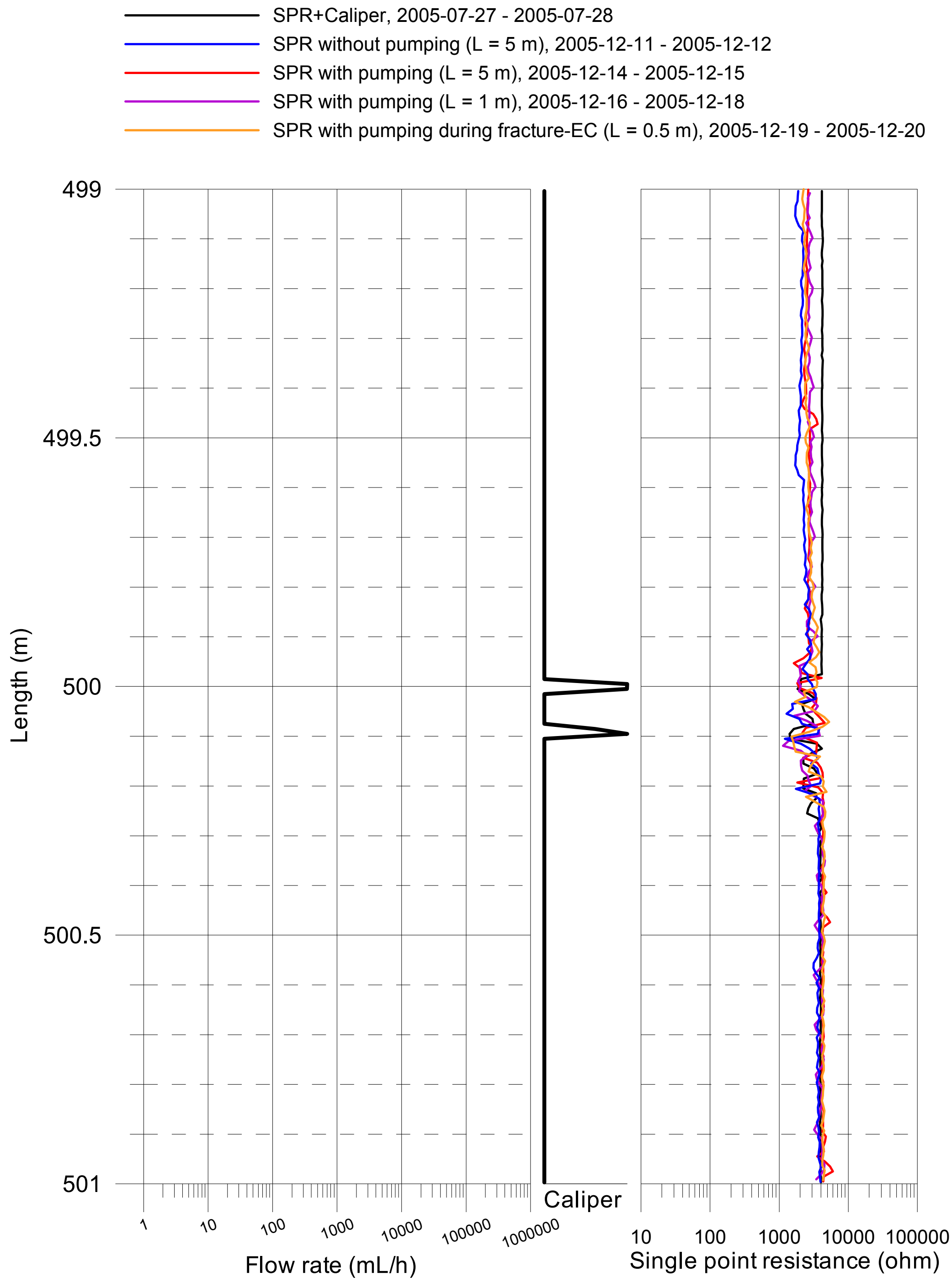
Appendix 1.21

Laxemar, borehole KLX10
SPR and Caliper results after length correction



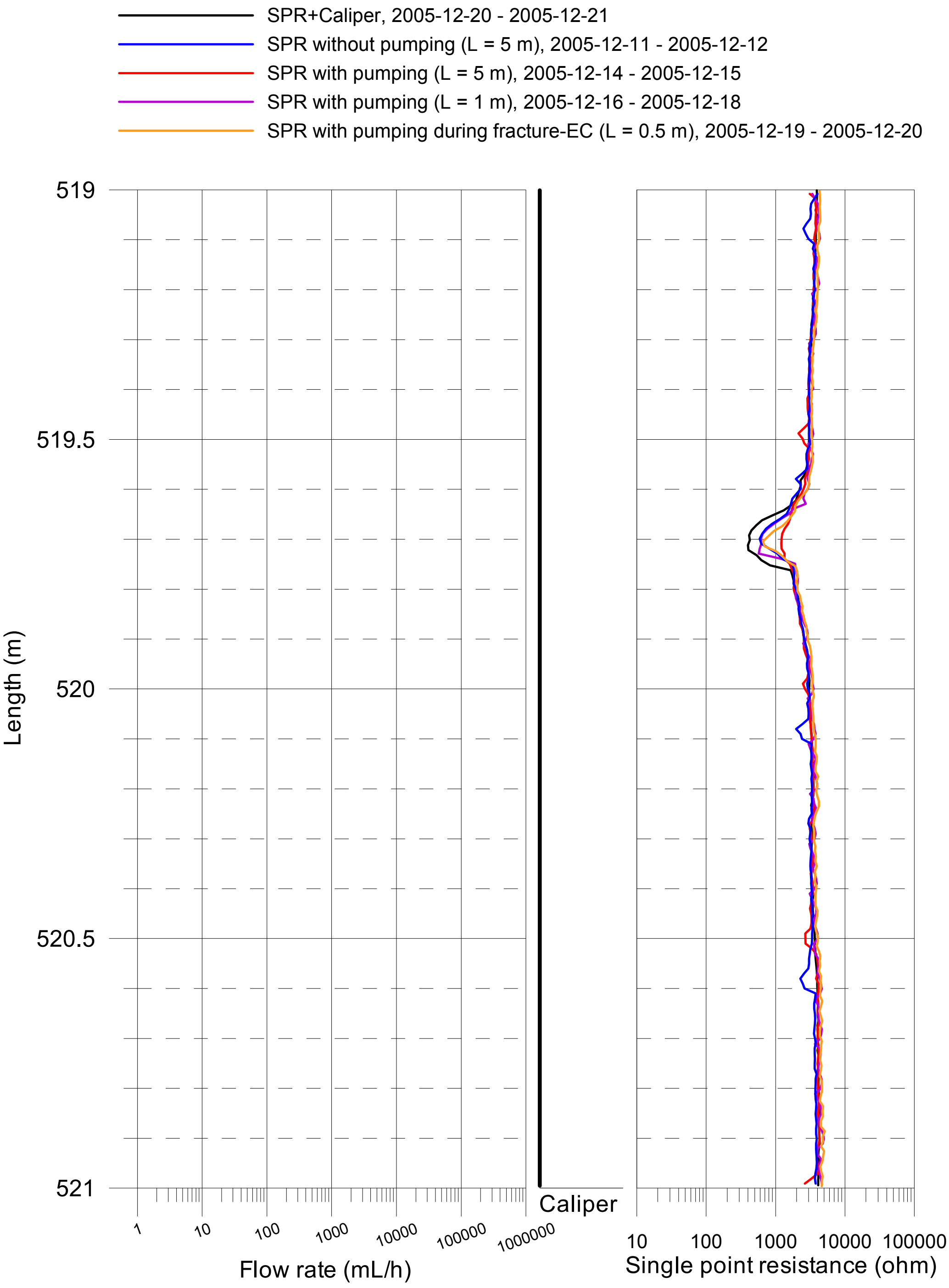
Appendix 1.22

Laxemar, borehole KLX10
SPR and Caliper results after length correction



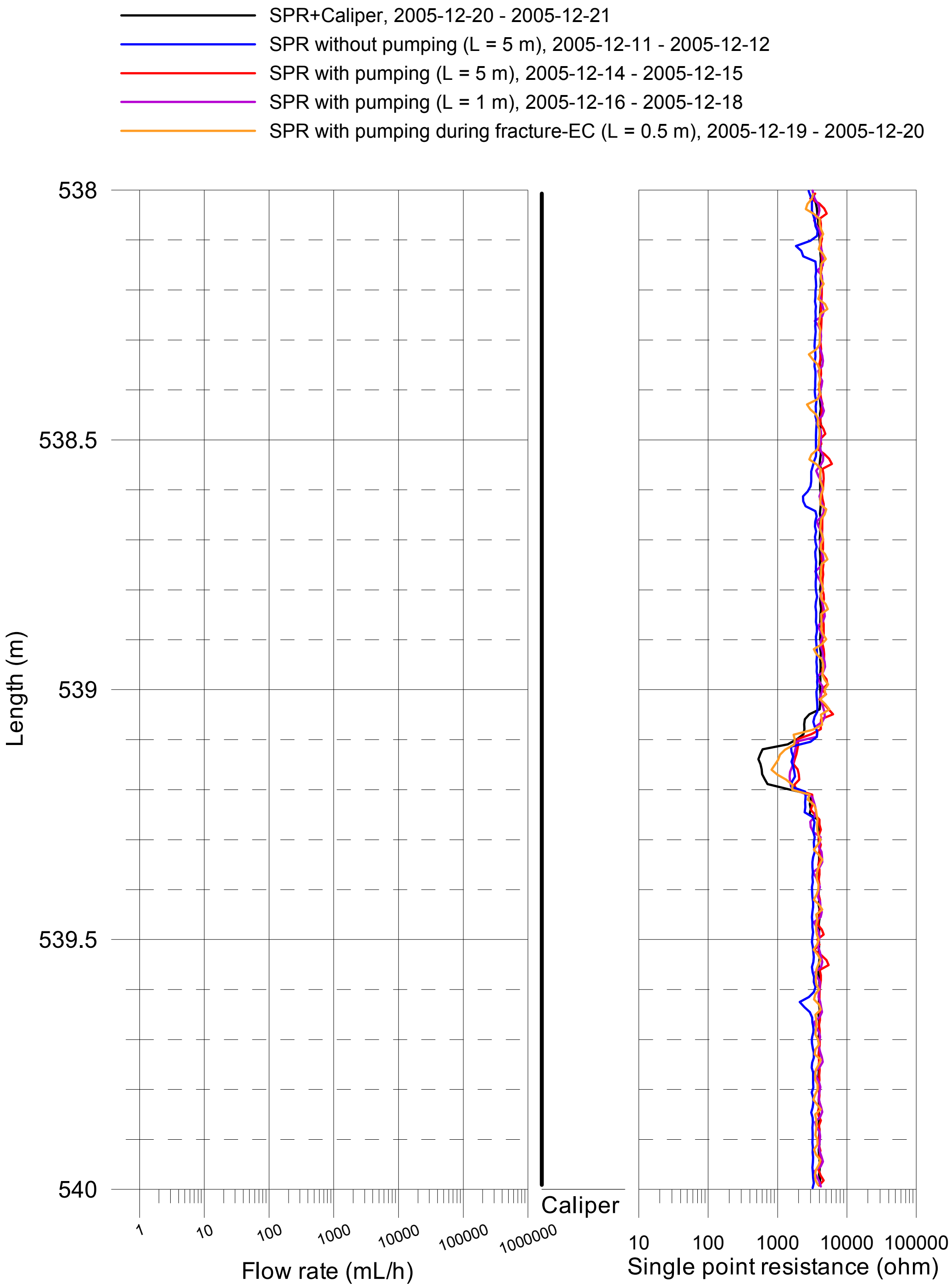
Appendix 1.23

Laxemar, borehole KLX10
SPR and Caliper results after length correction



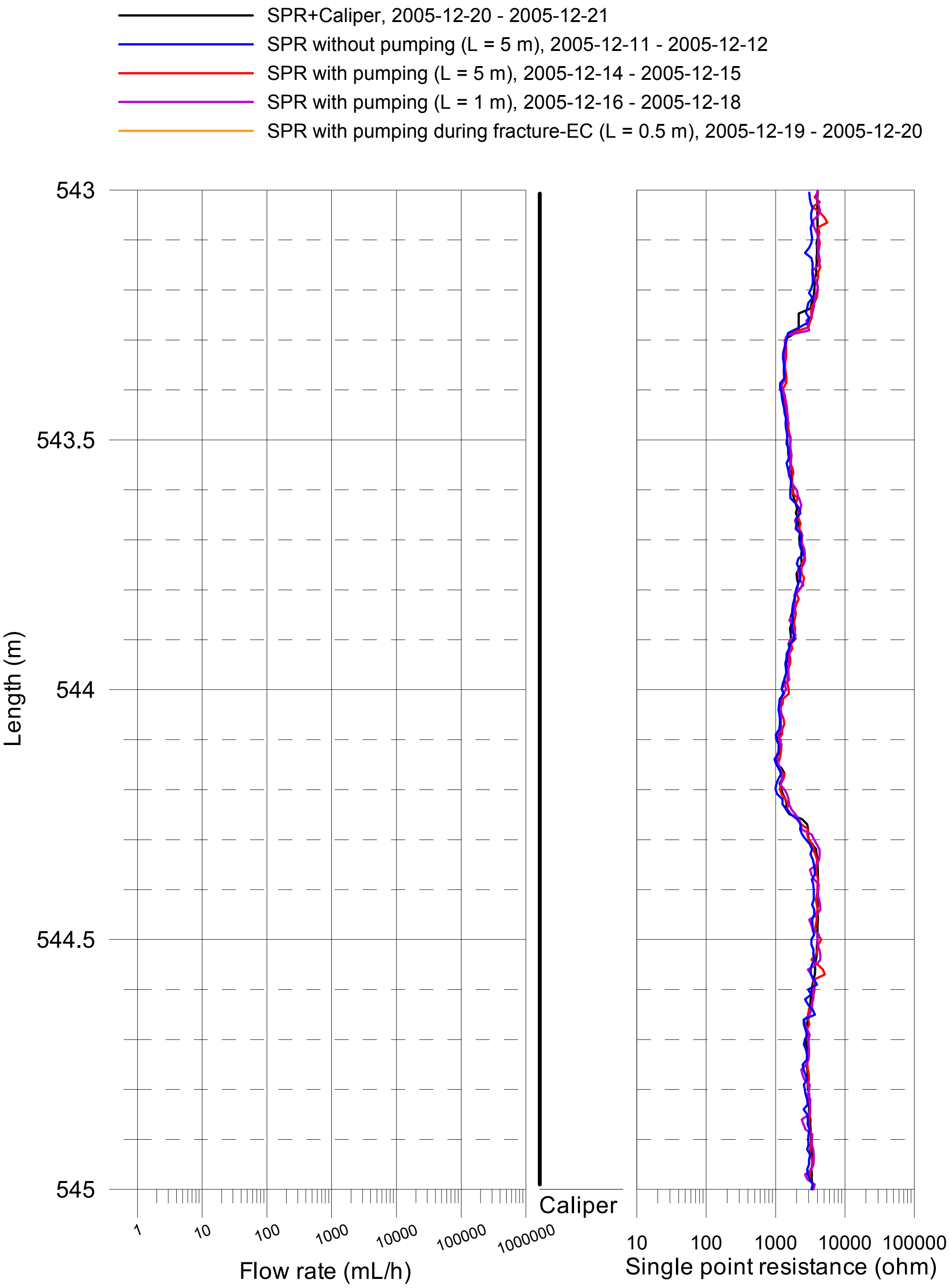
Appendix 1.24

Laxemar, borehole KLX10
SPR and Caliper results after length correction



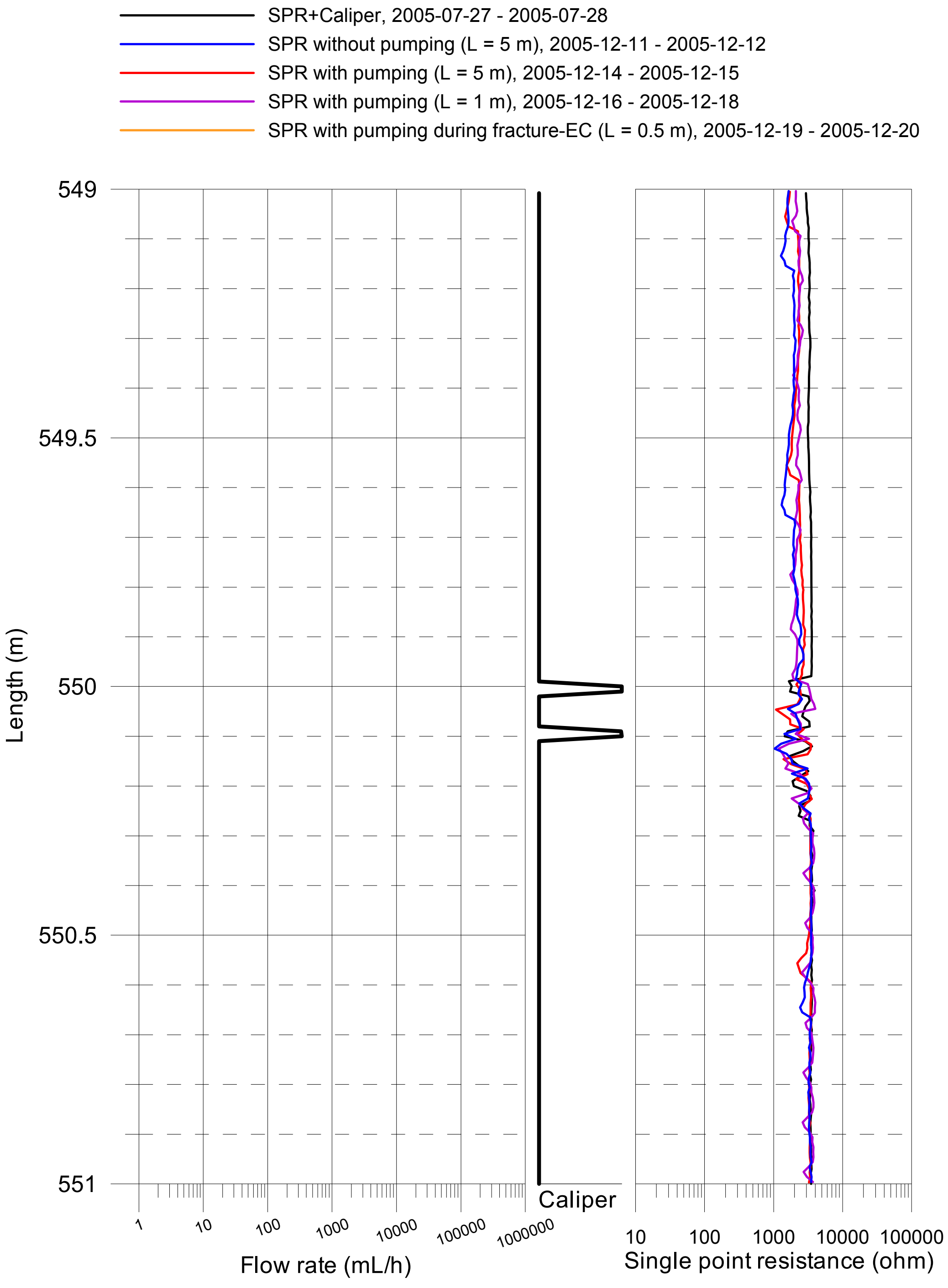
Appendix 1.25

Laxemar, borehole KLX10
SPR and Caliper results after length correction



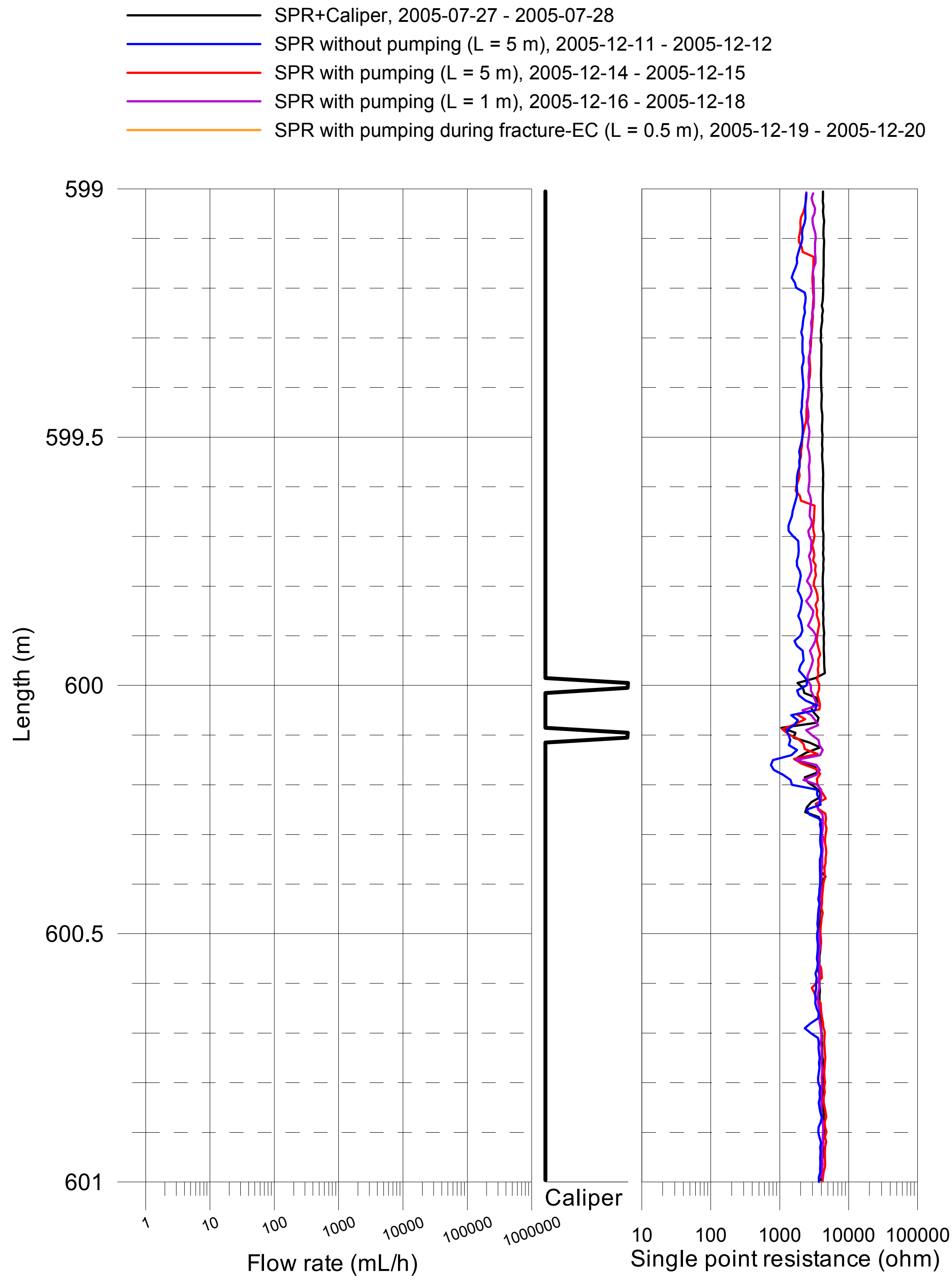
Appendix 1.26

Laxemar, borehole KLX10
SPR and Caliper results after length correction



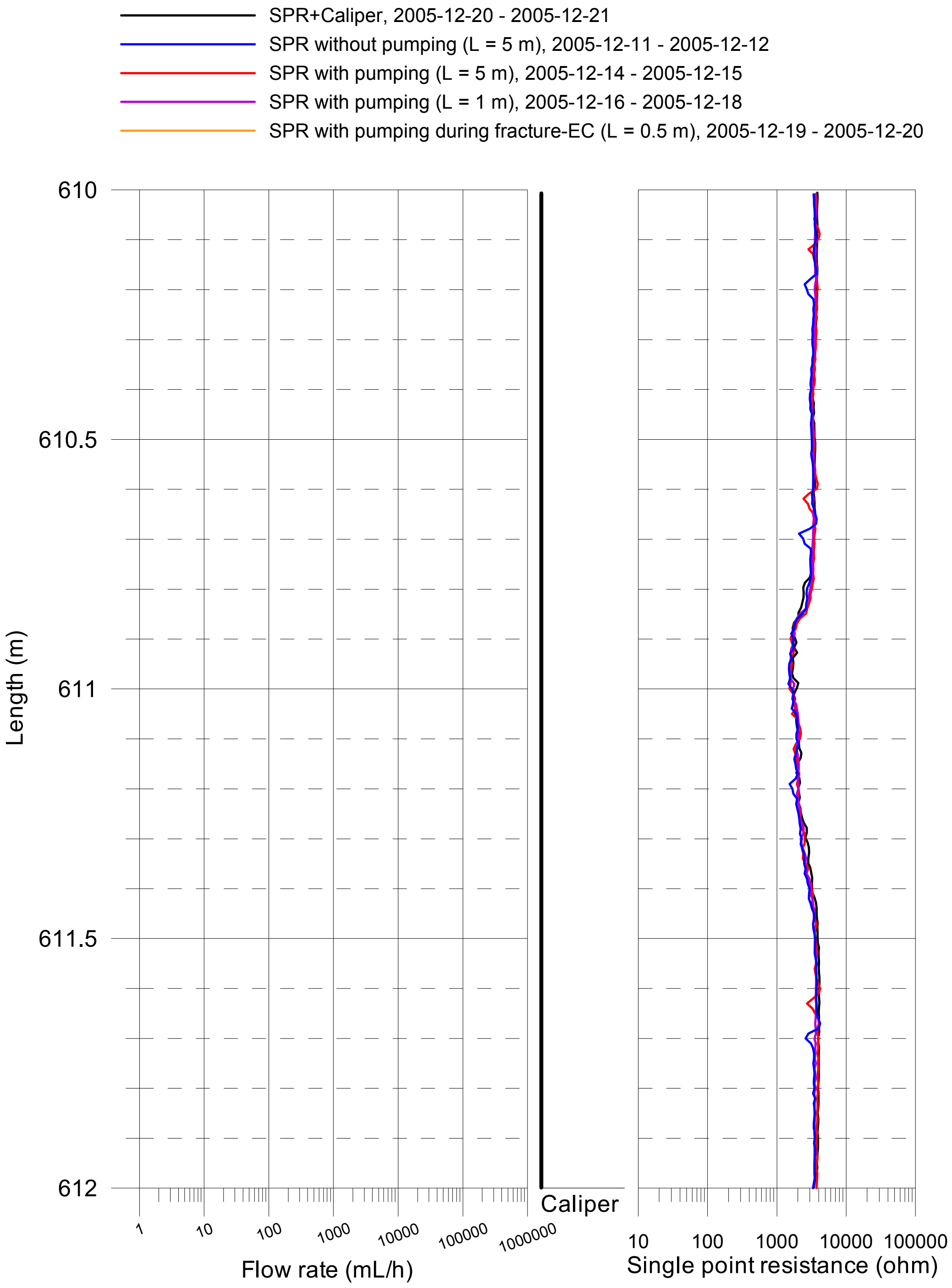
Appendix 1.27

Laxemar, borehole KLX10
SPR and Caliper results after length correction



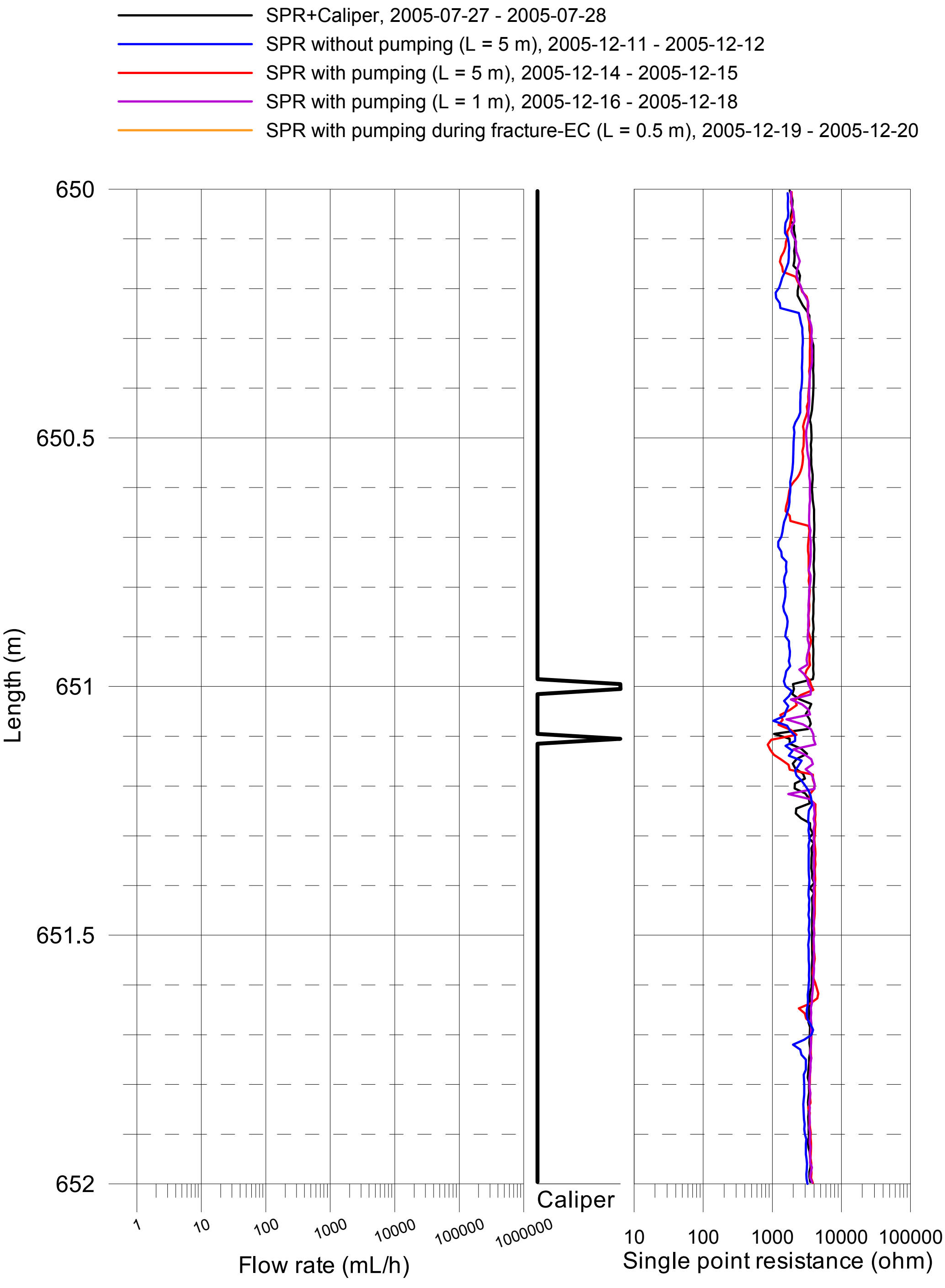
Appendix 1.28

Laxemar, borehole KLX10
SPR and Caliper results after length correction

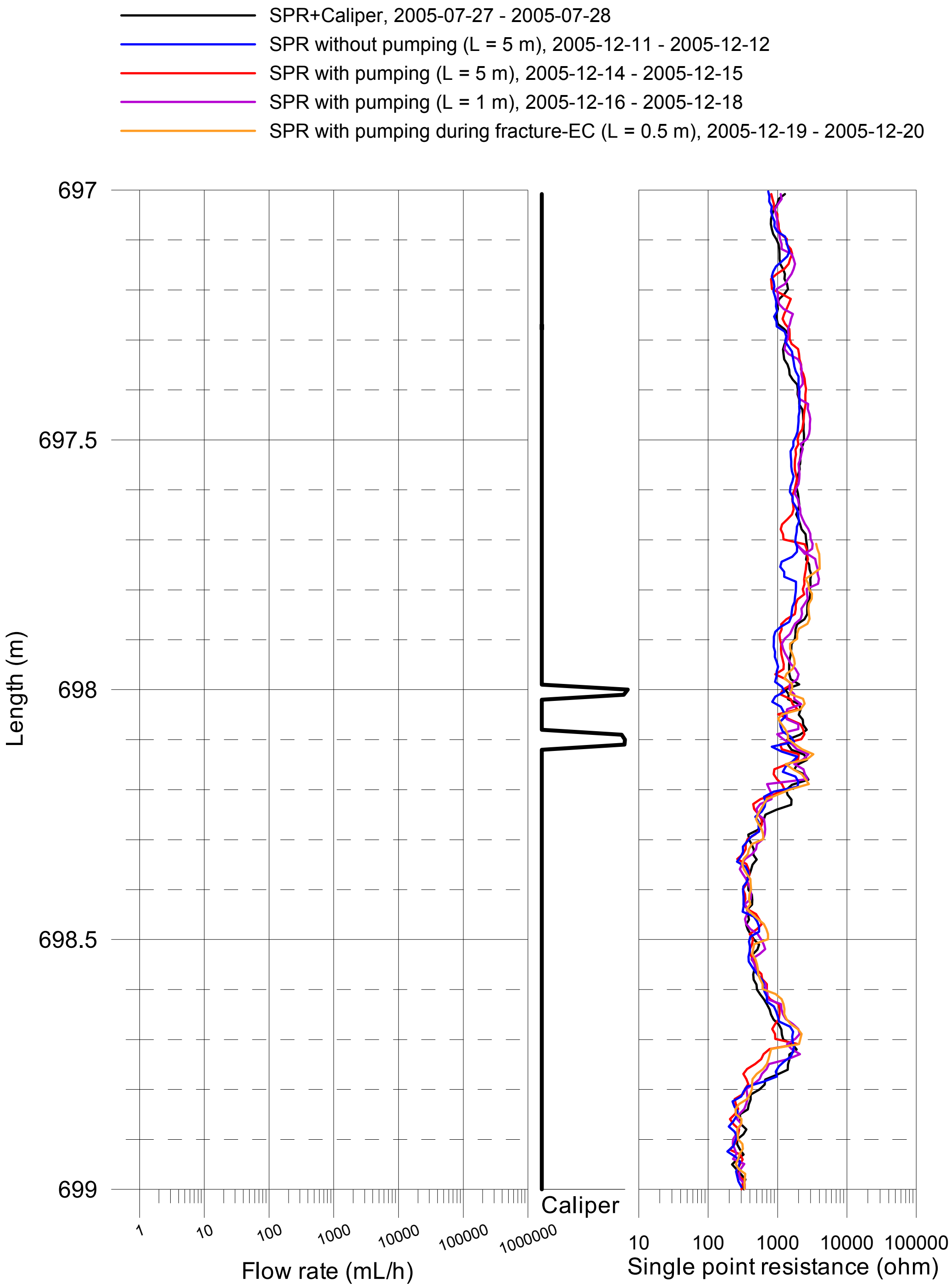


Appendix 1.29

Laxemar, borehole KLX10
SPR and Caliper results after length correction

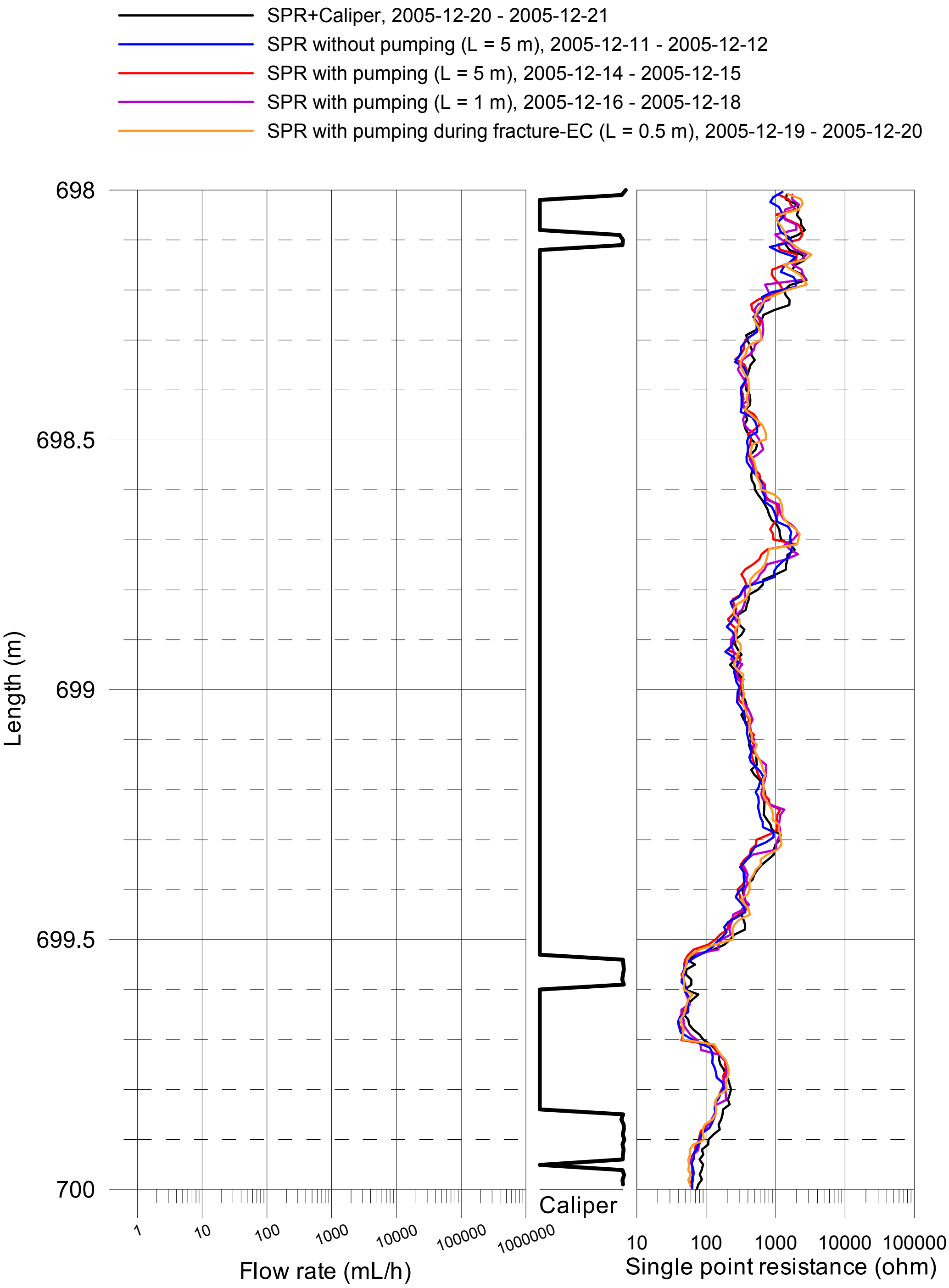


Laxemar, borehole KLX10
SPR and Caliper results after length correction

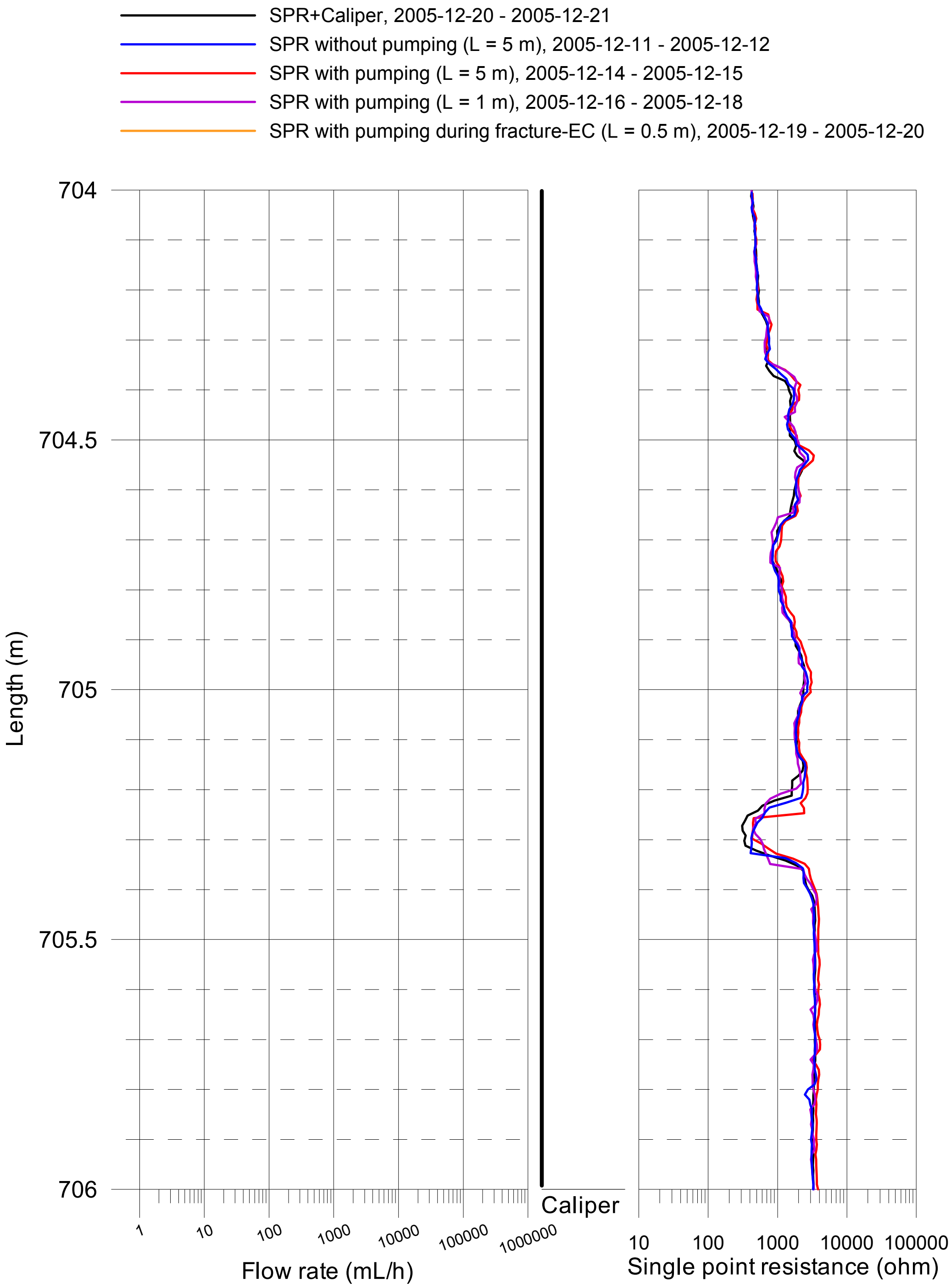


Appendix 1.31

Laxemar, borehole KLX10
SPR and Caliper results after length correction

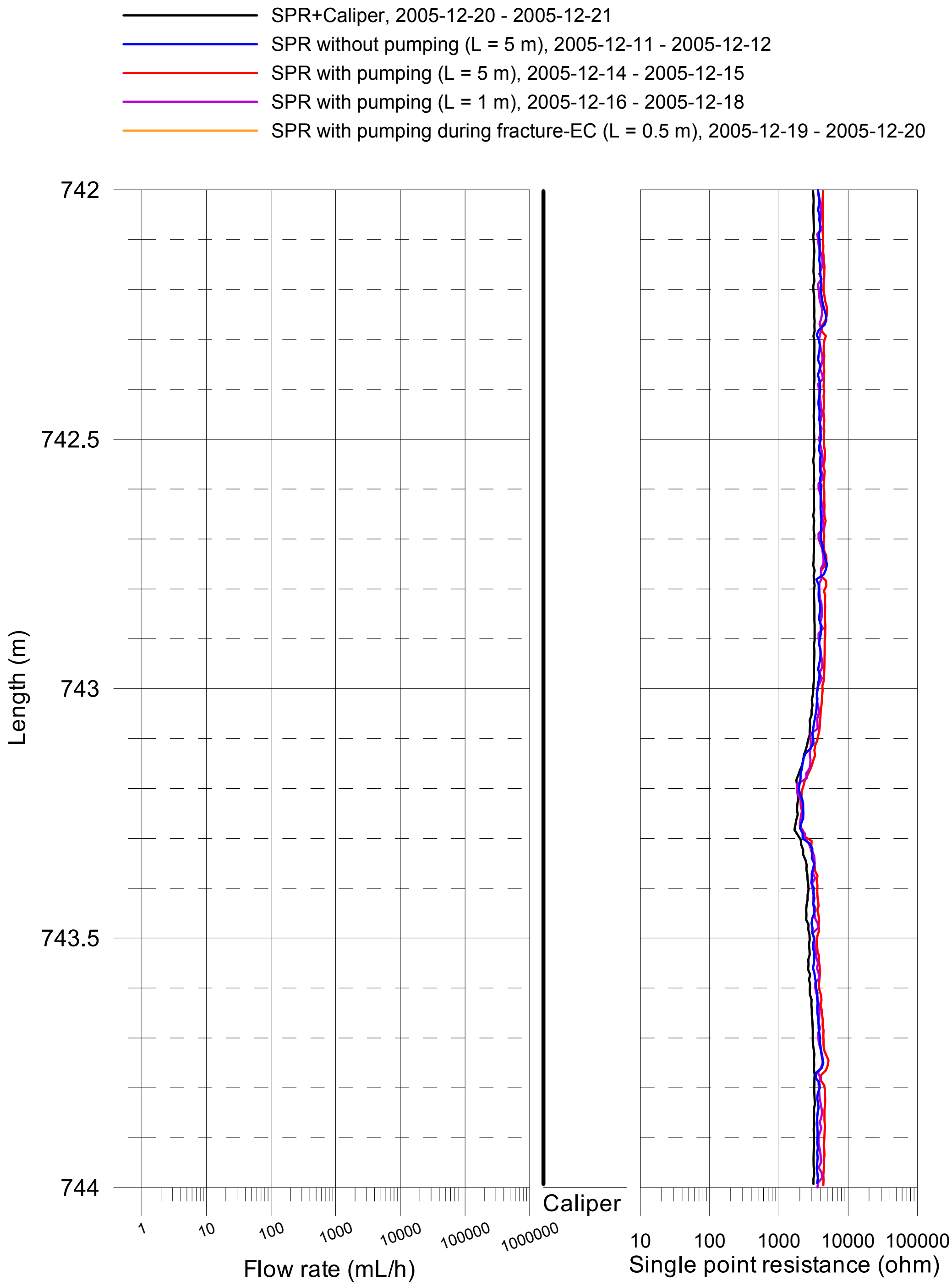


Laxemar, borehole KLX10
SPR and Caliper results after length correction



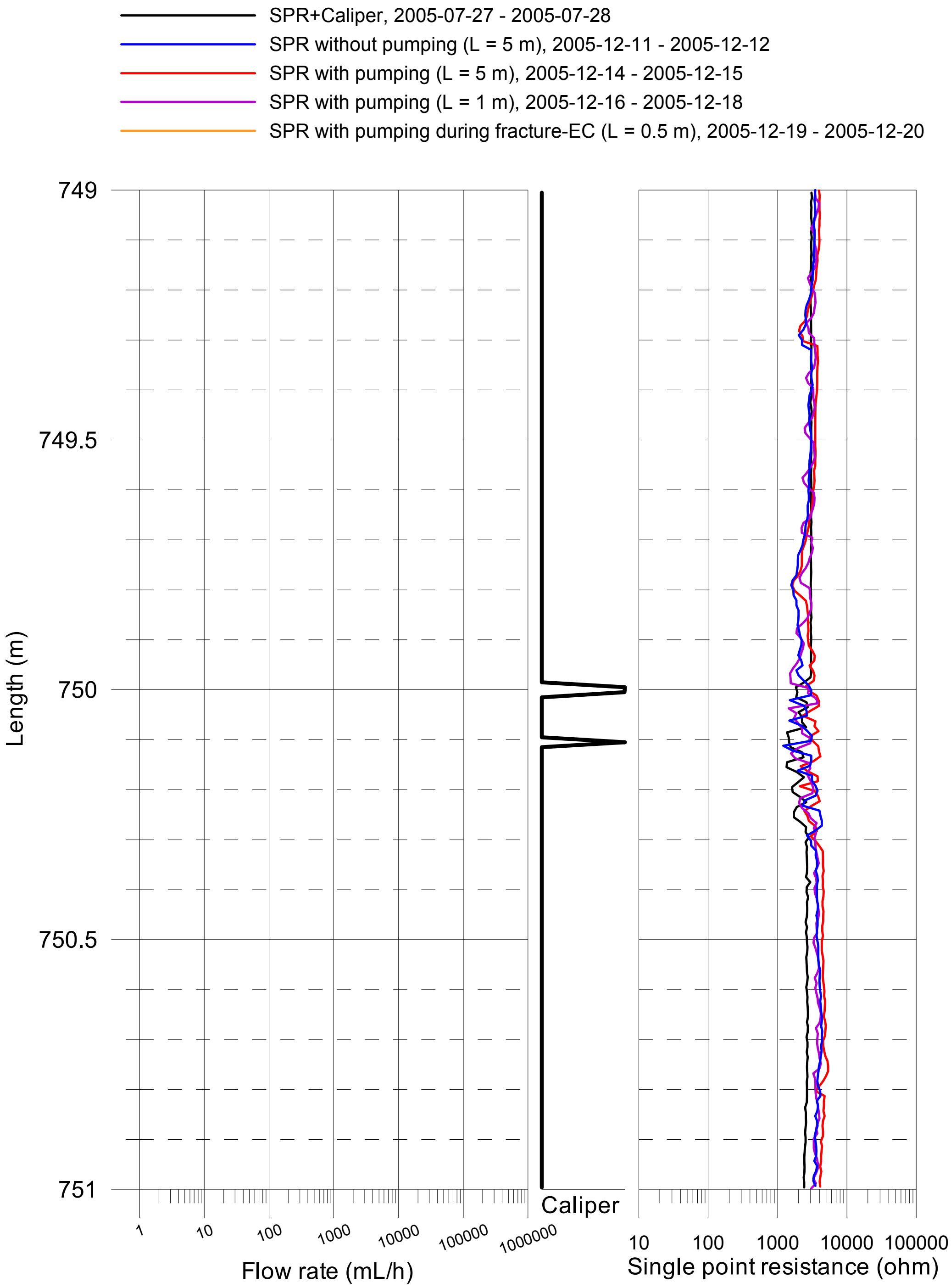
Appendix 1.33

Laxemar, borehole KLX10
SPR and Caliper results after length correction



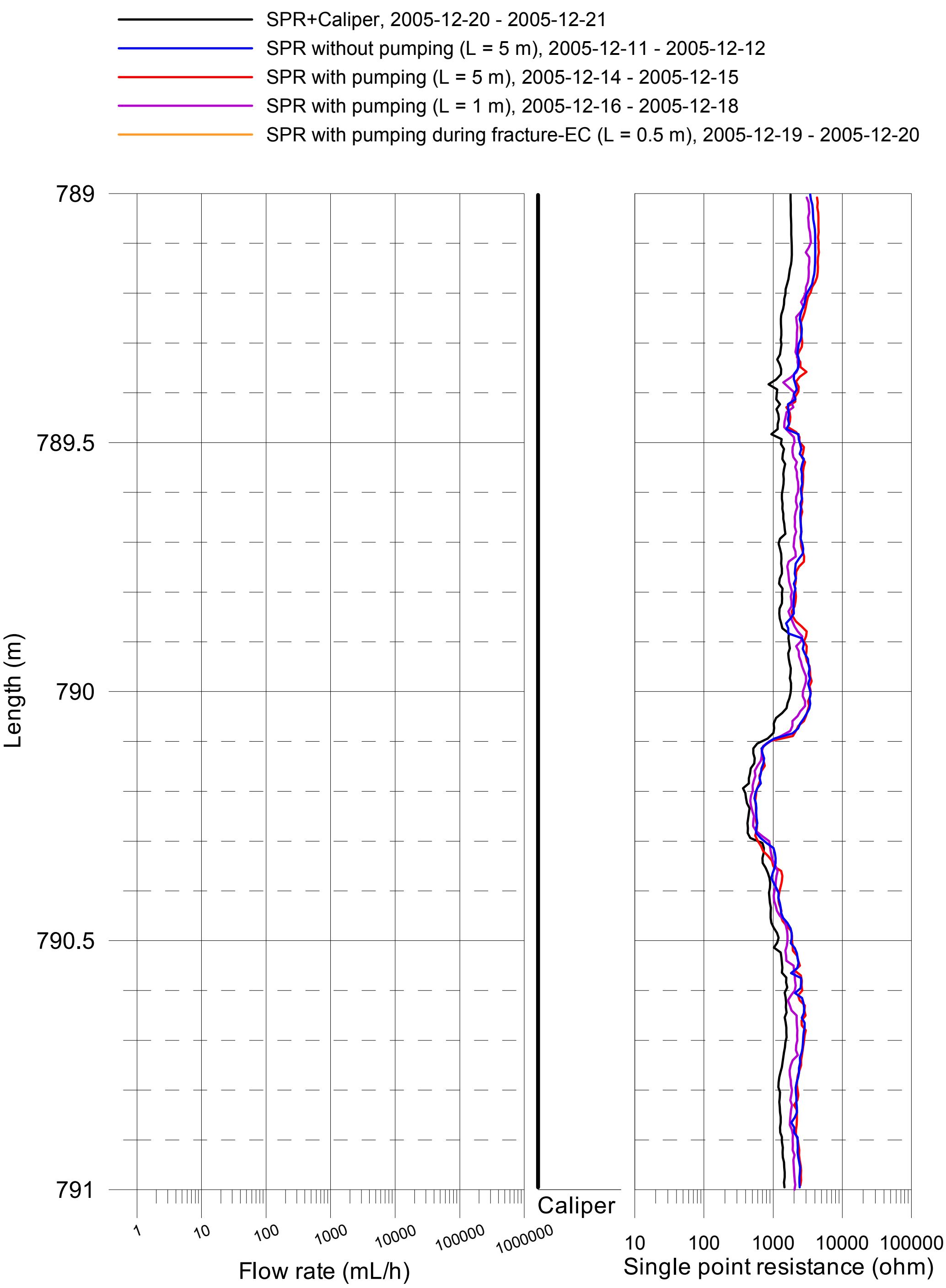
Appendix 1.34

Laxemar, borehole KLX10
SPR and Caliper results after length correction



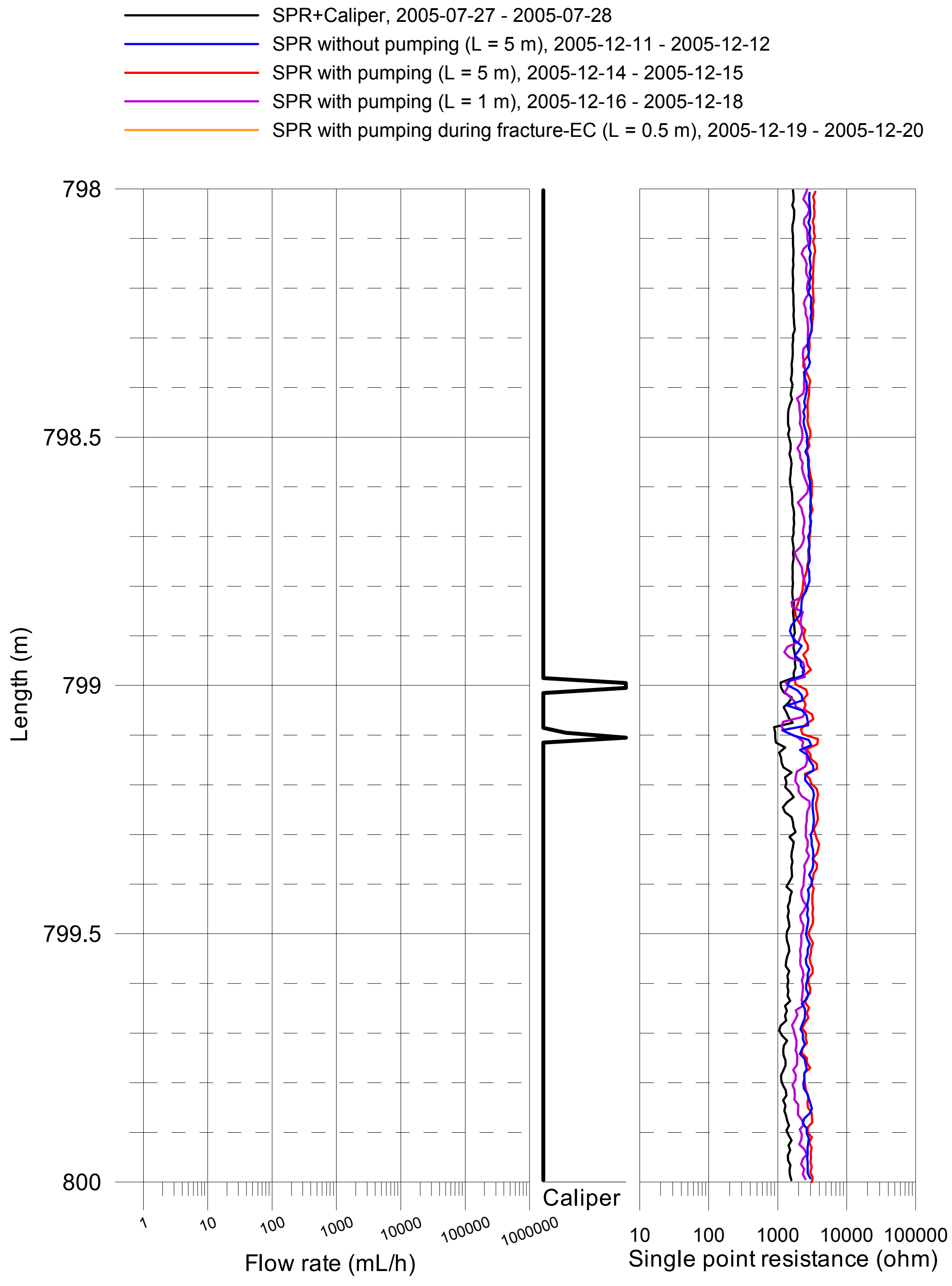
Appendix 1.35

Laxemar, borehole KLX10
SPR and Caliper results after length correction



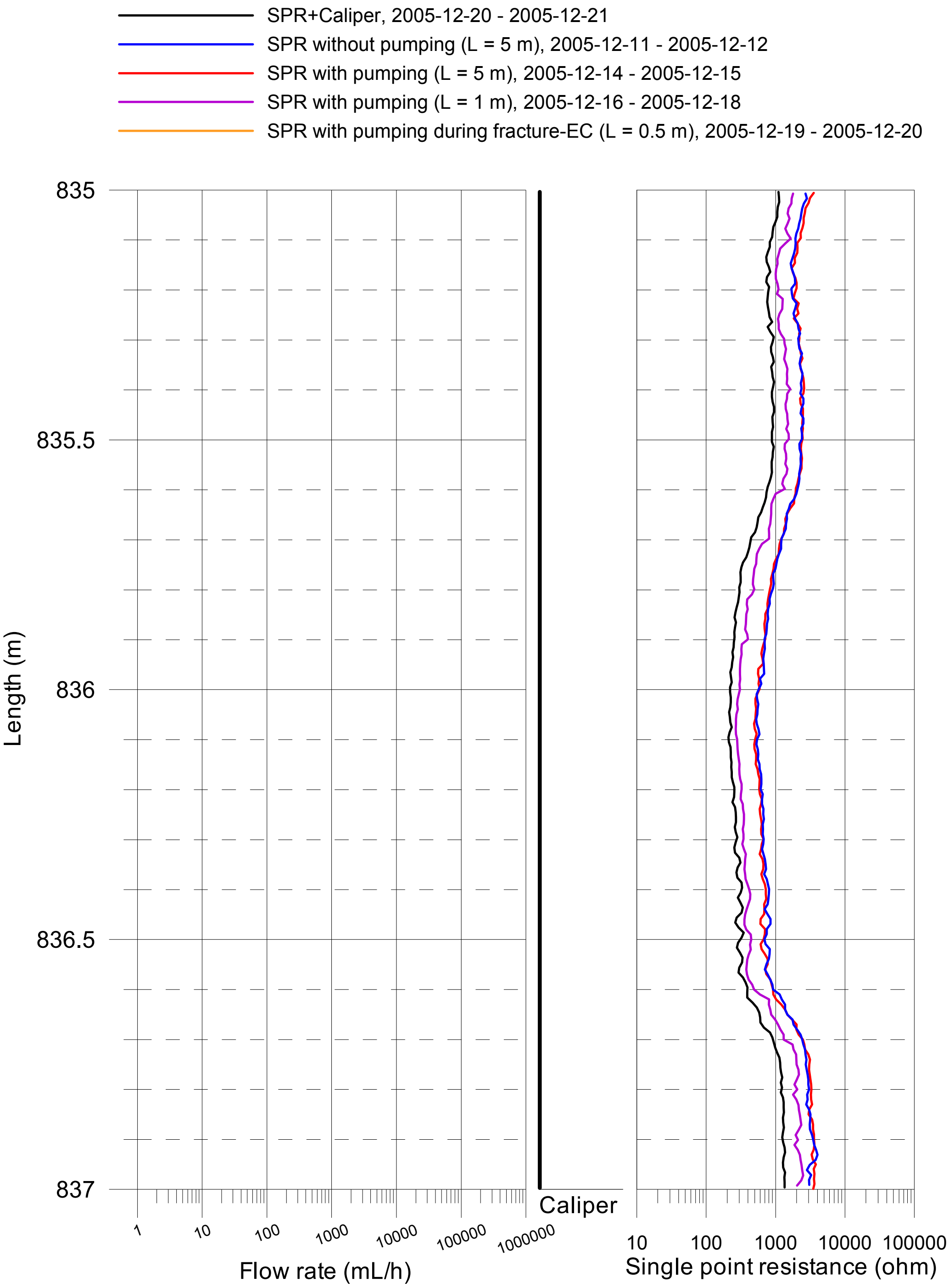
Appendix 1.36

Laxemar, borehole KLX10
SPR and Caliper results after length correction

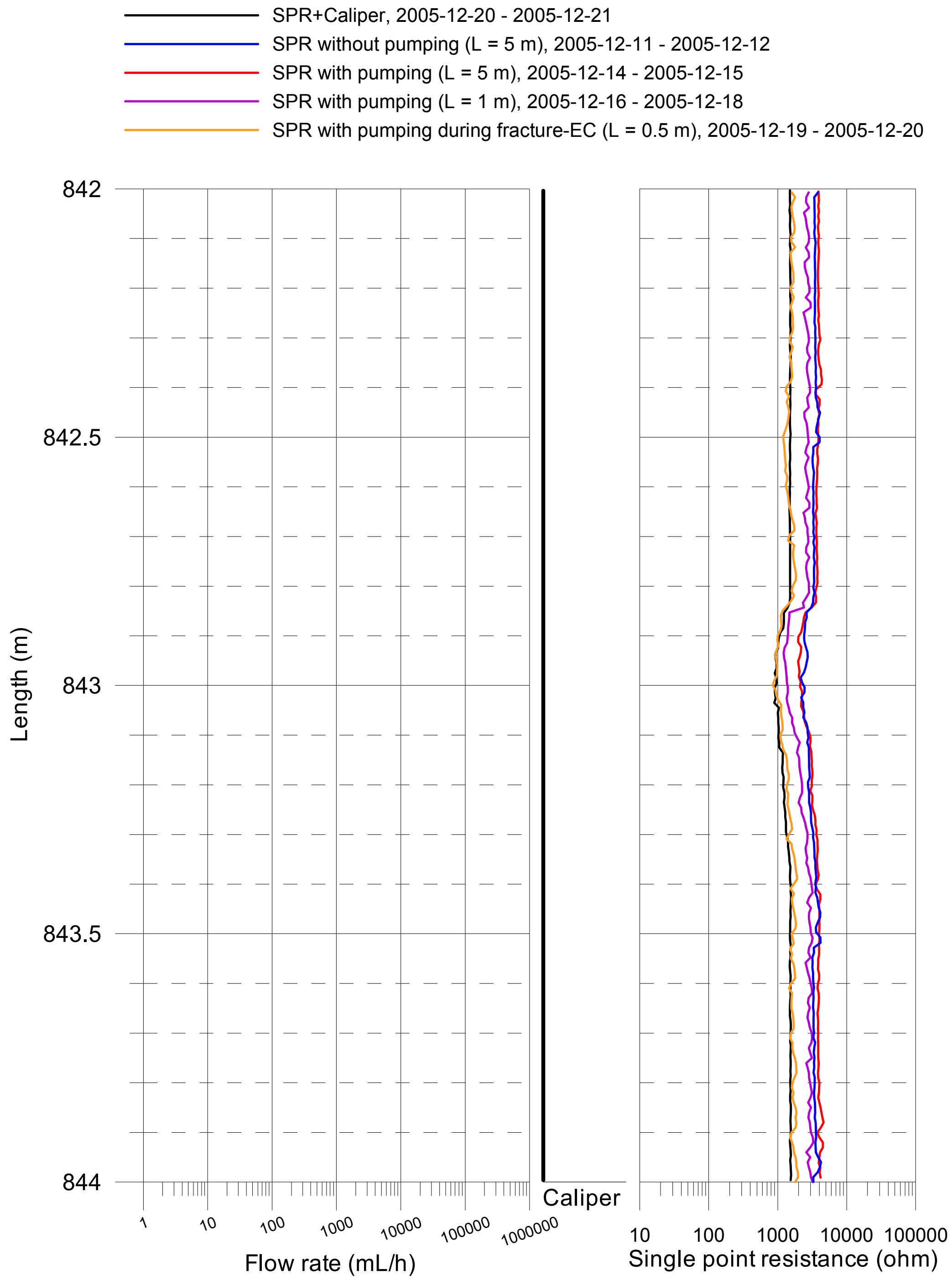


Appendix 1.37

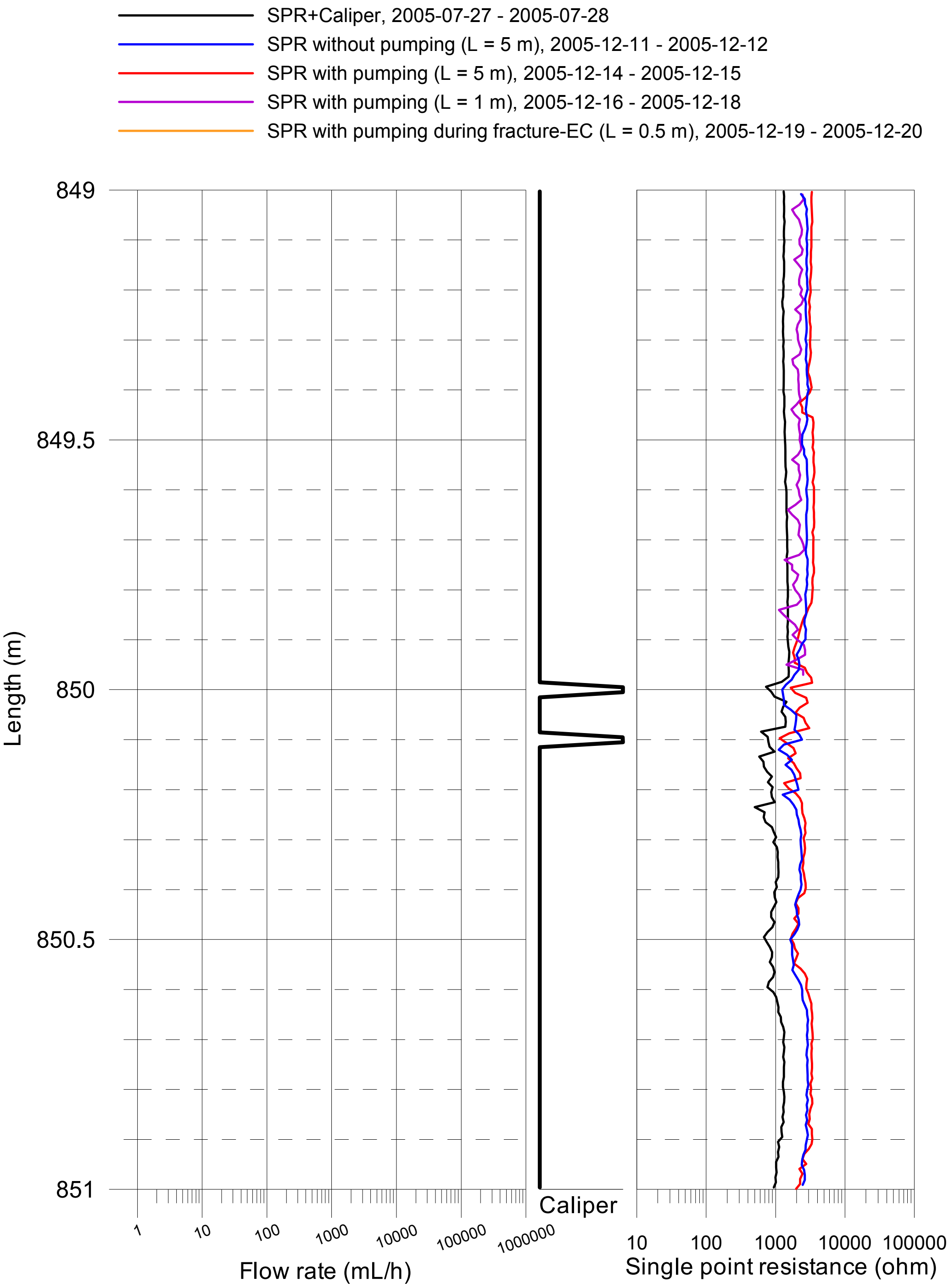
Laxemar, borehole KLX10
SPR and Caliper results after length correction



Laxemar, borehole KLX10
SPR and Caliper results after length correction

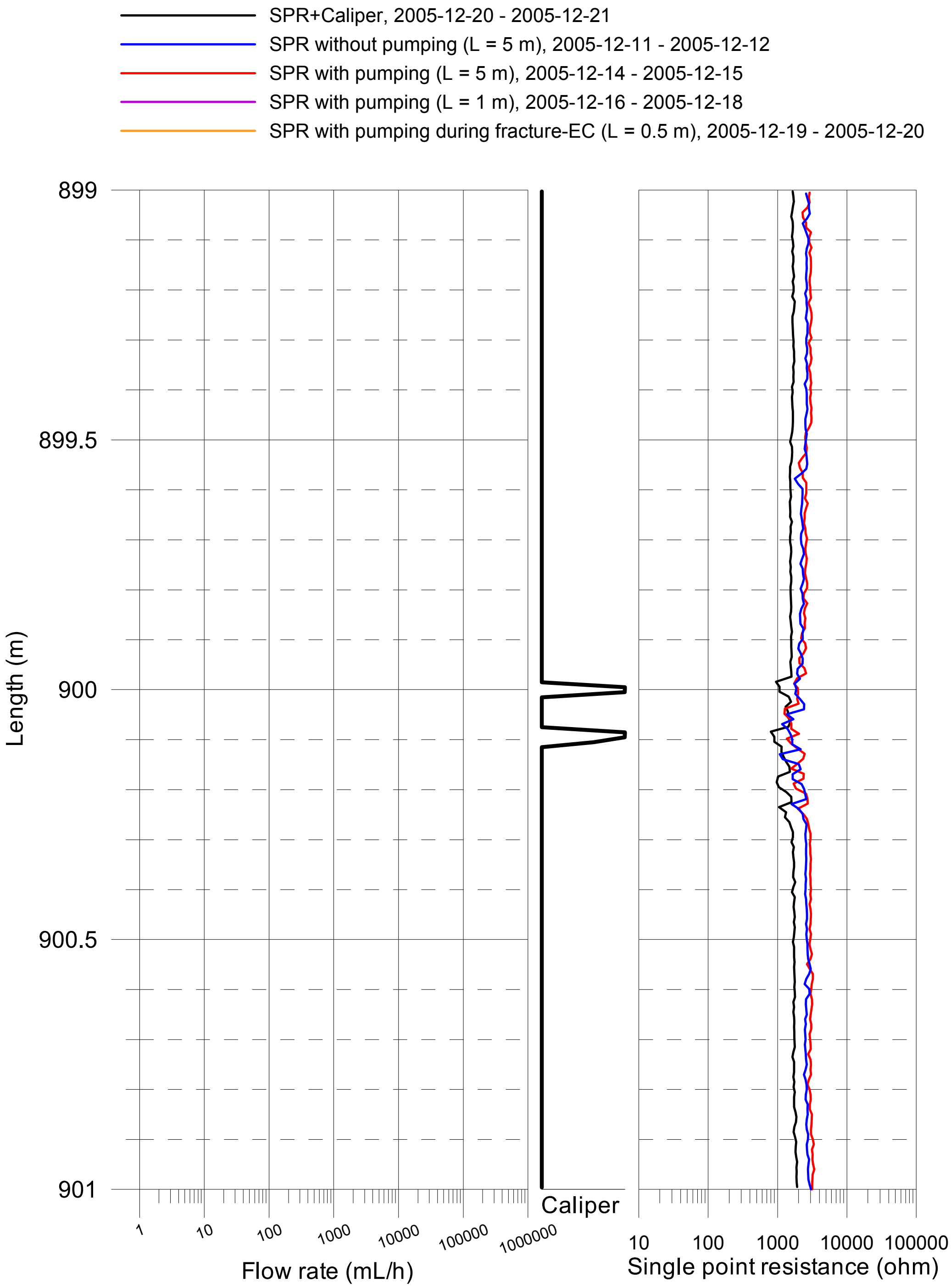


Laxemar, borehole KLX10
SPR and Caliper results after length correction



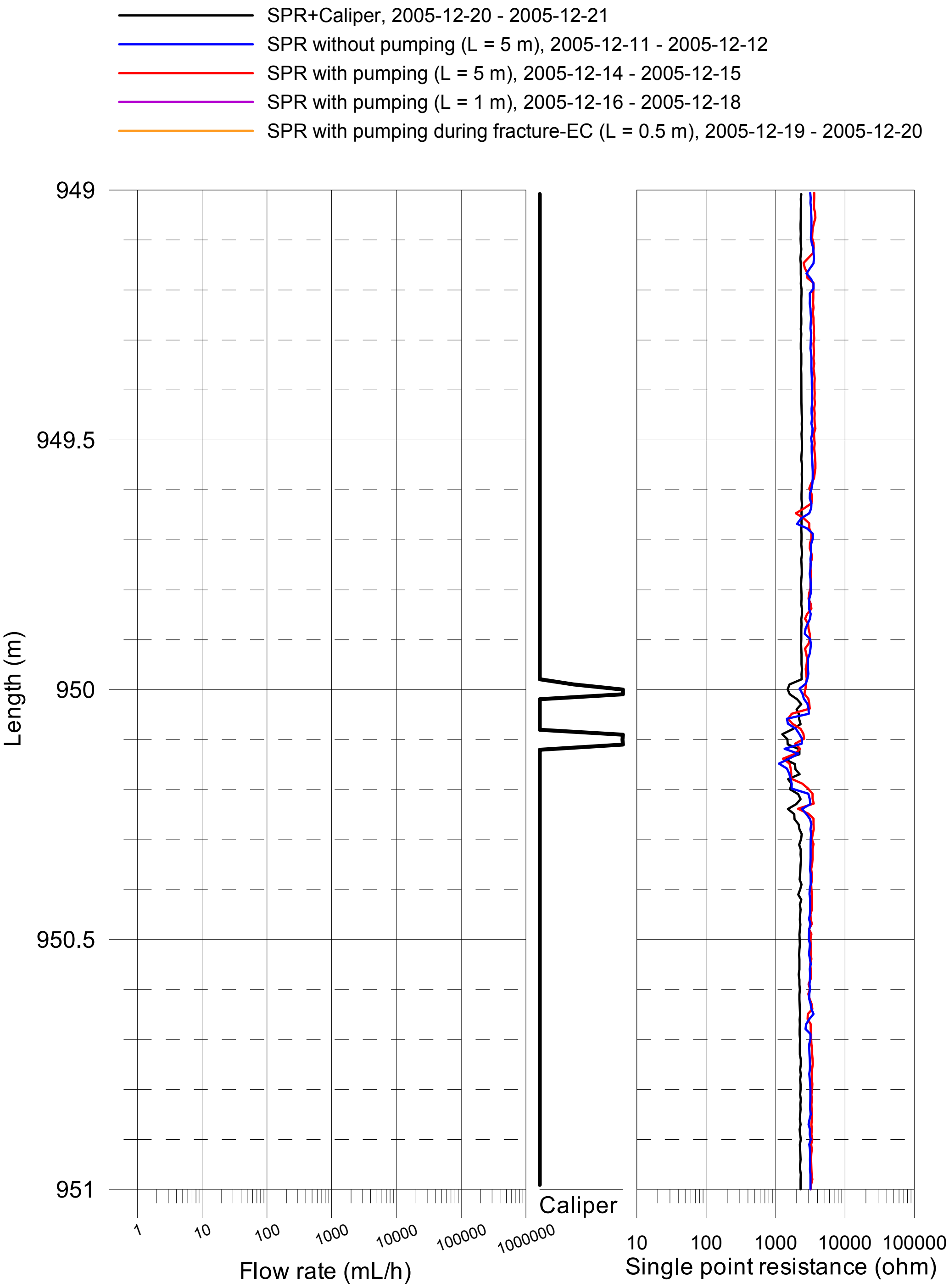
Appendix 1.40

Laxemar, borehole KLX10
SPR and Caliper results after length correction



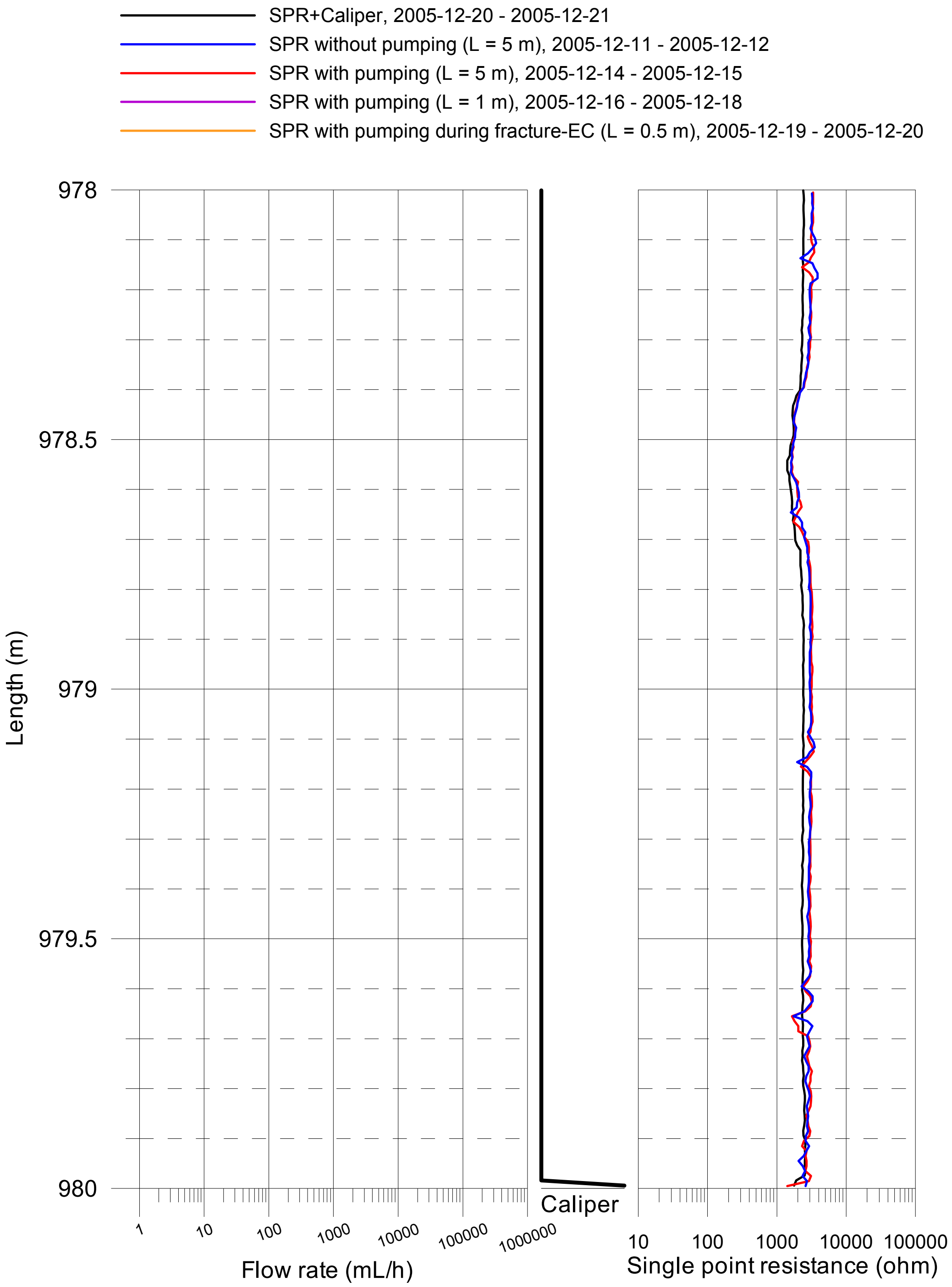
Appendix 1.41

Laxemar, borehole KLX10
SPR and Caliper results after length correction



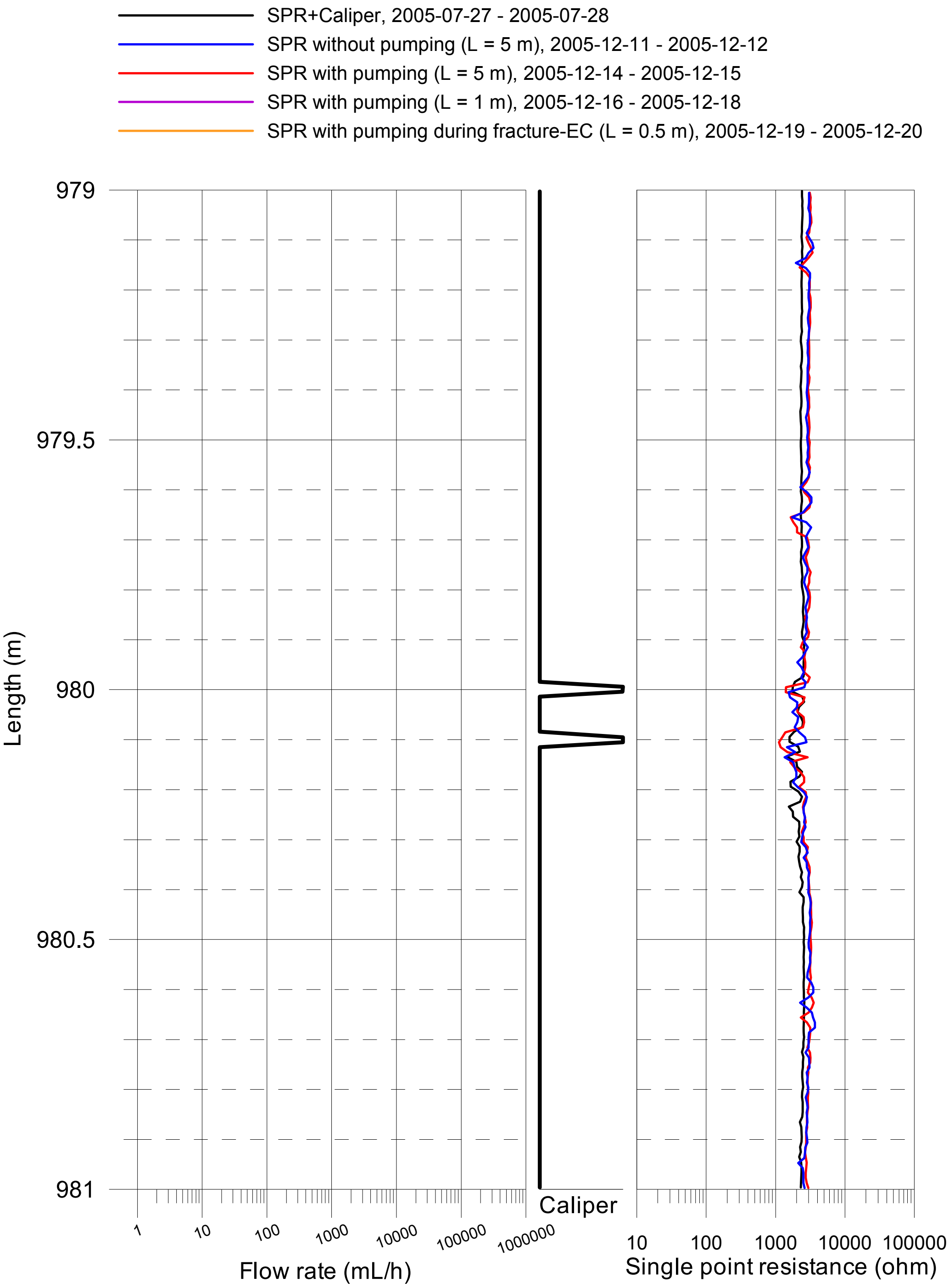
Appendix 1.42

Laxemar, borehole KLX10
SPR and Caliper results after length correction



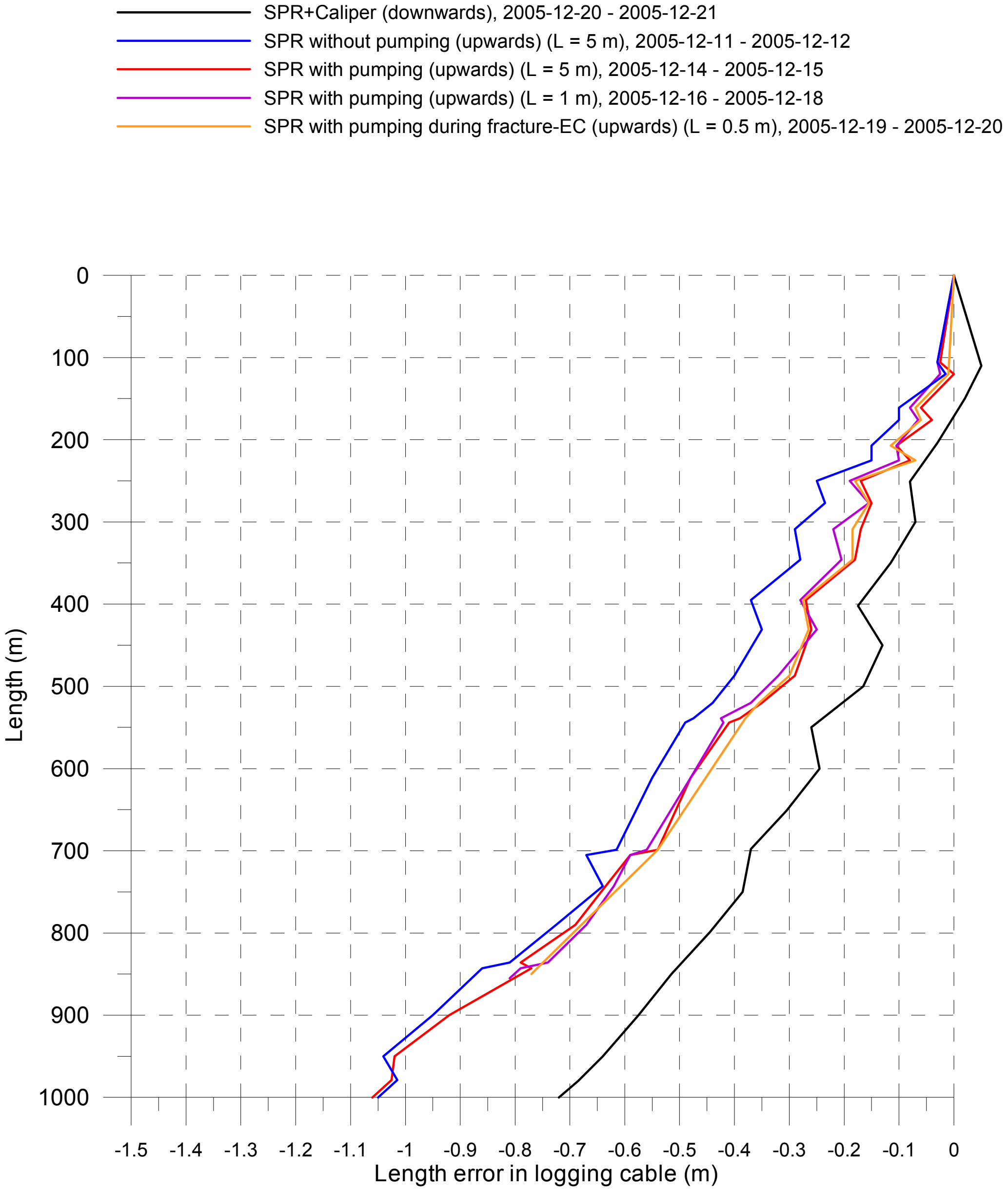
Appendix 1.43

Laxemar, borehole KLX10
SPR and Caliper results after length correction



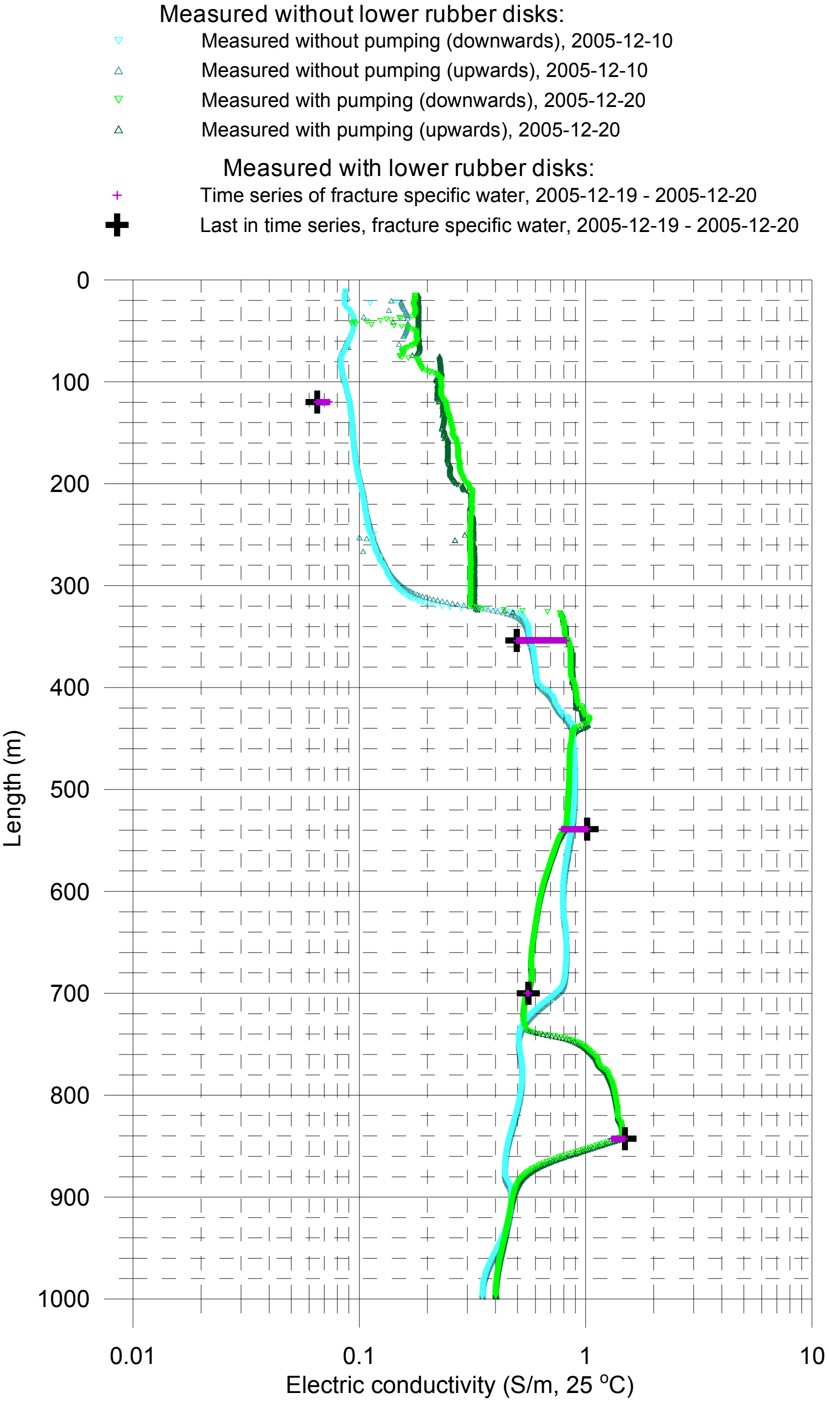
Appendix 1.44

Laxemar, borehole KLX10
Length correction



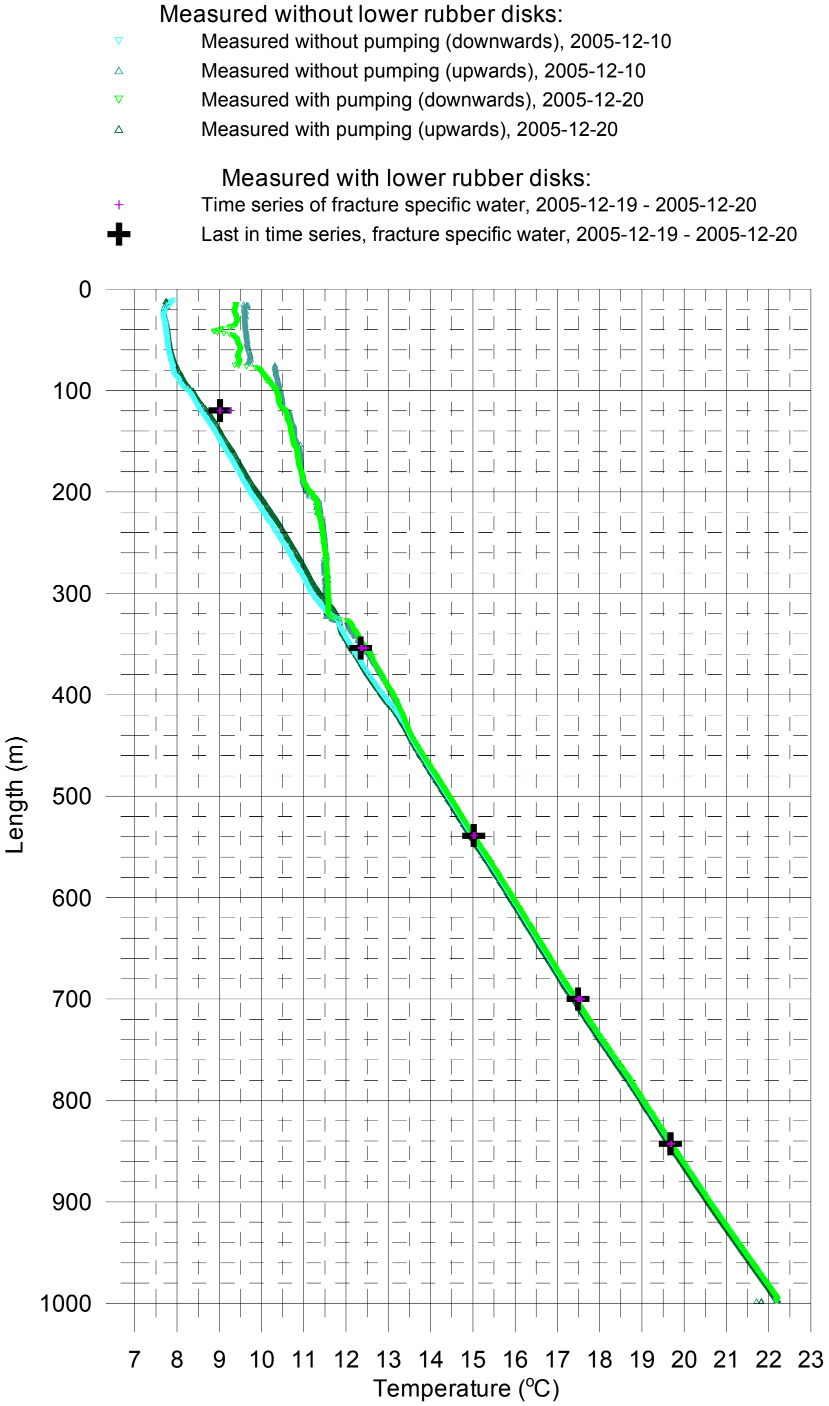
Appendix 2.1

Laxemar, borehole KLX10
Electric conductivity of borehole water



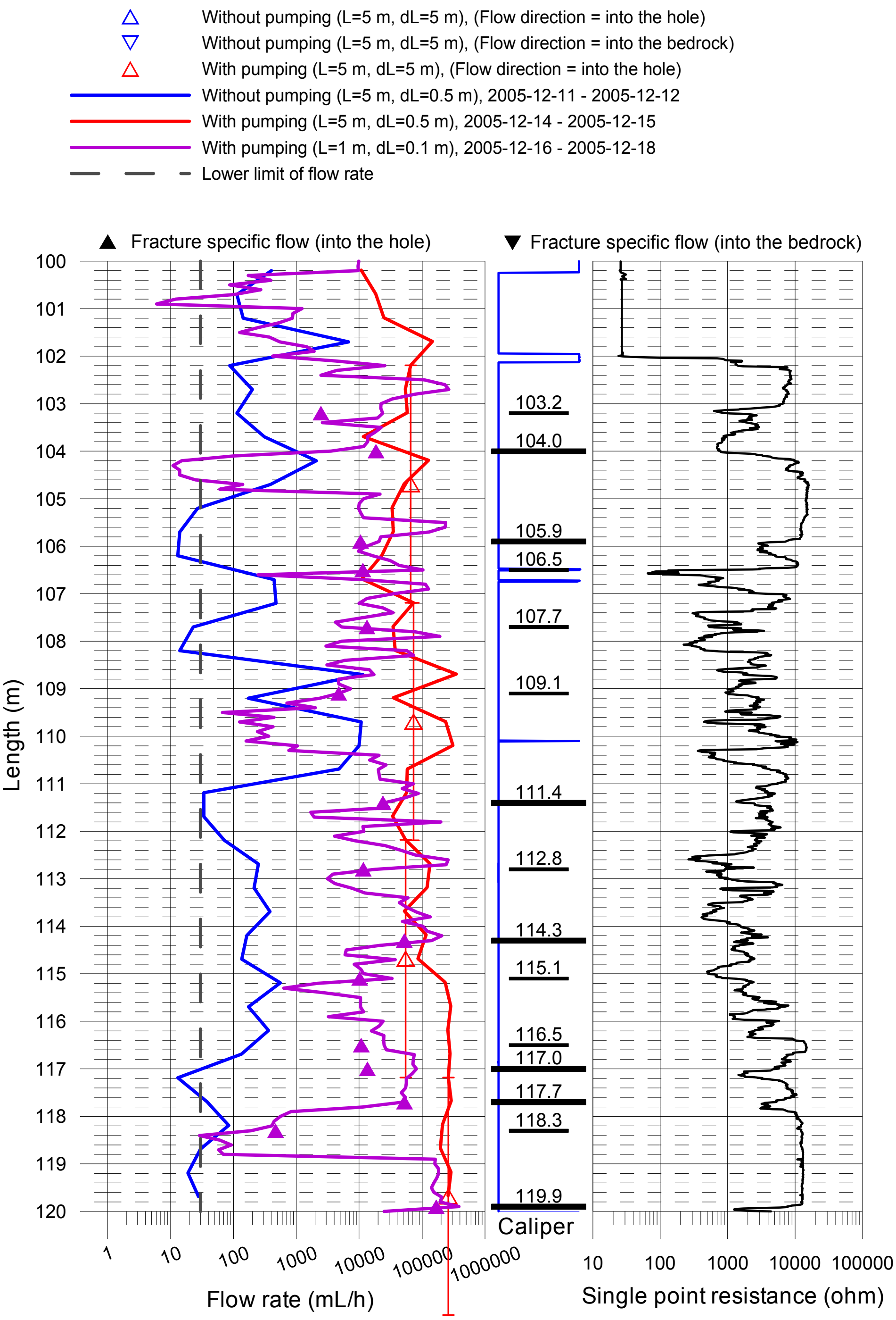
Appendix 2.2

Laxemar, borehole KLX10
Temperature of borehole water

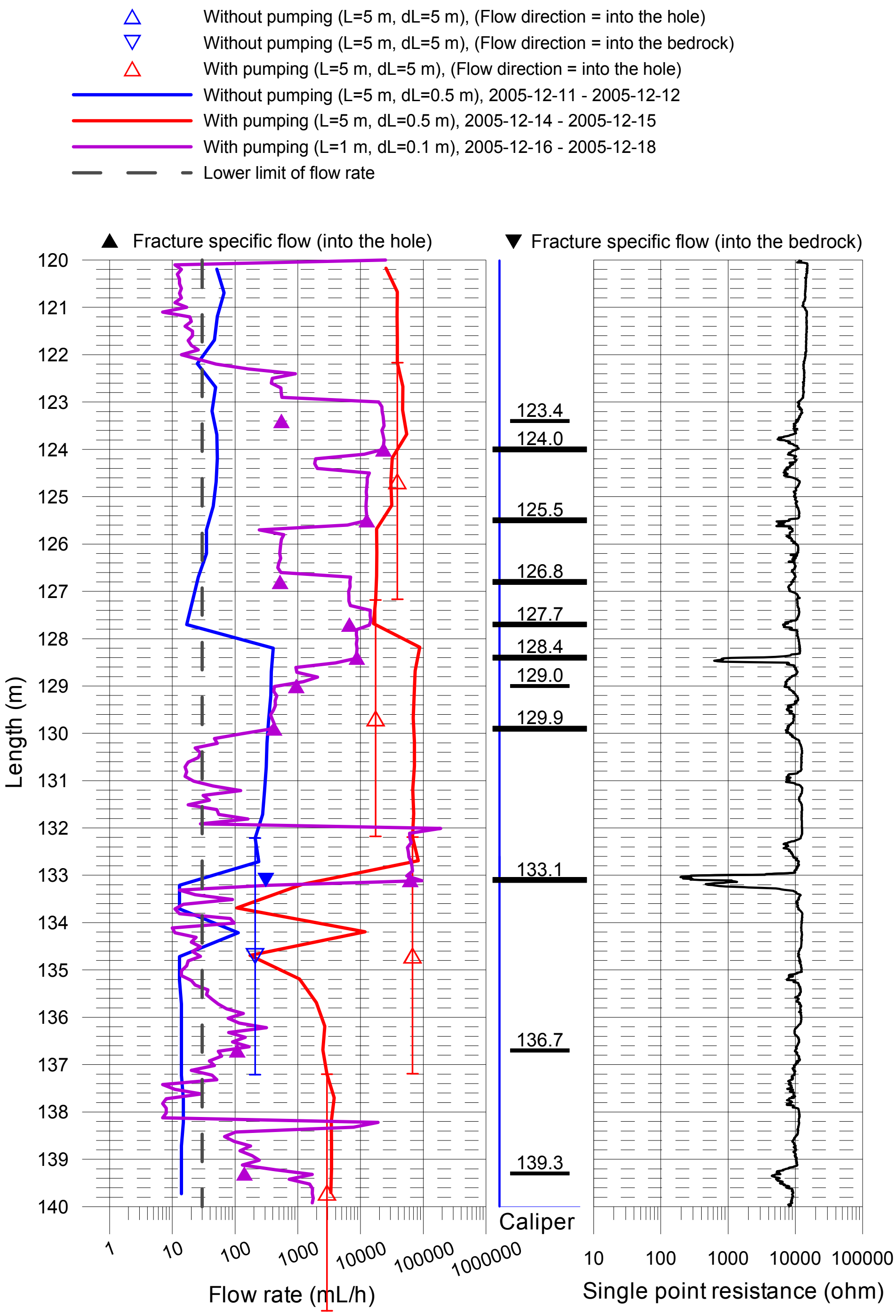


Appendix 3.1

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance

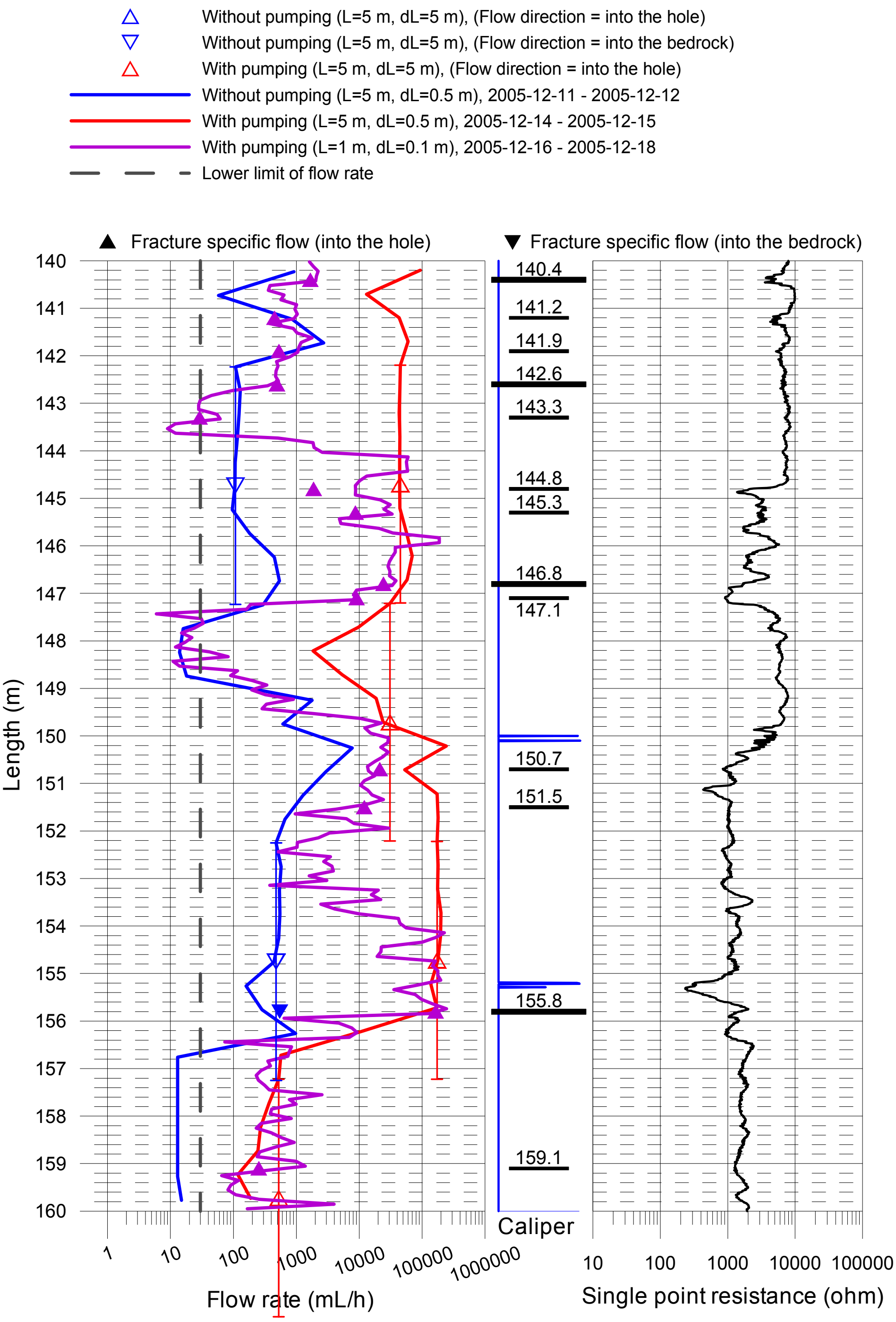


Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



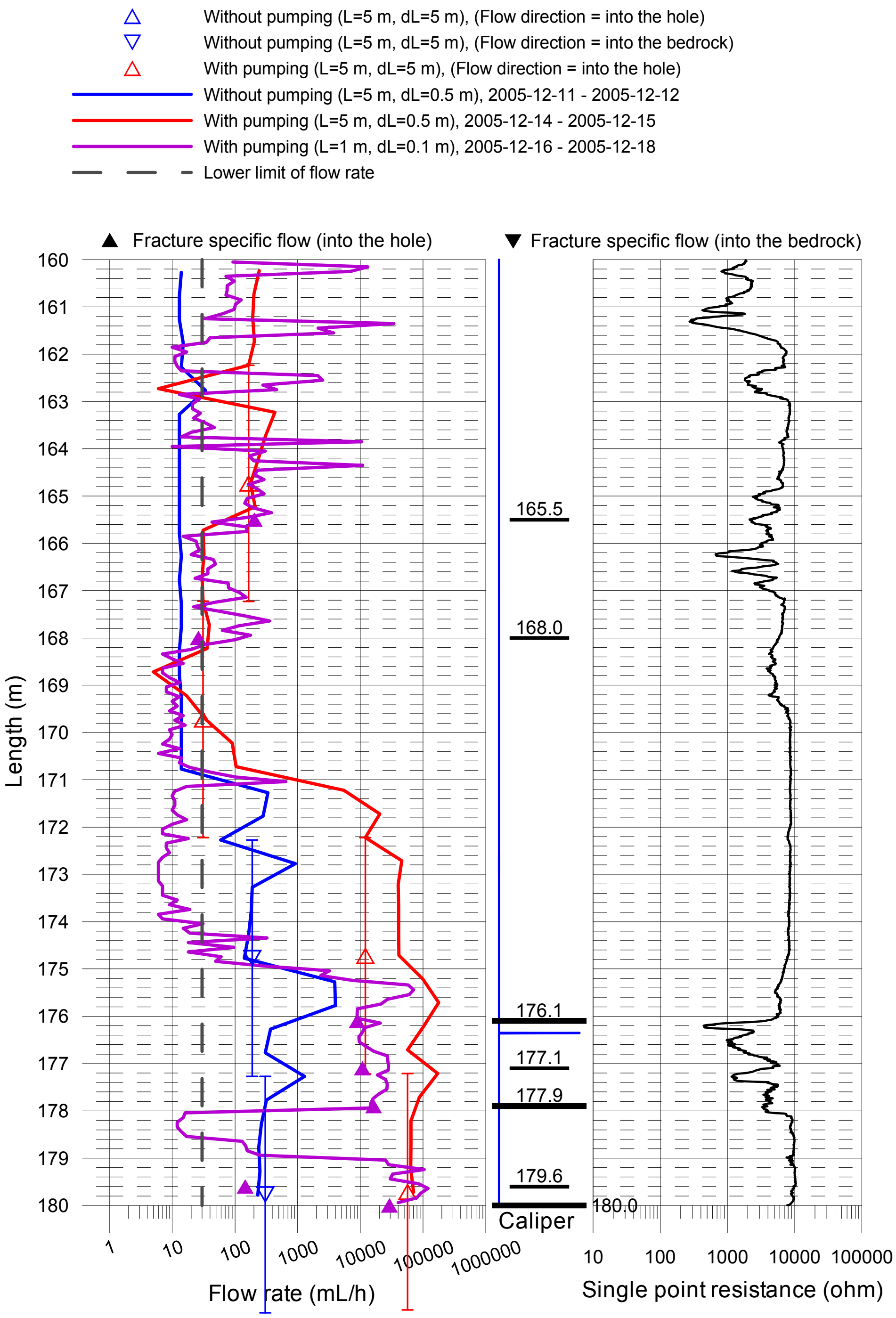
Appendix 3.3

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



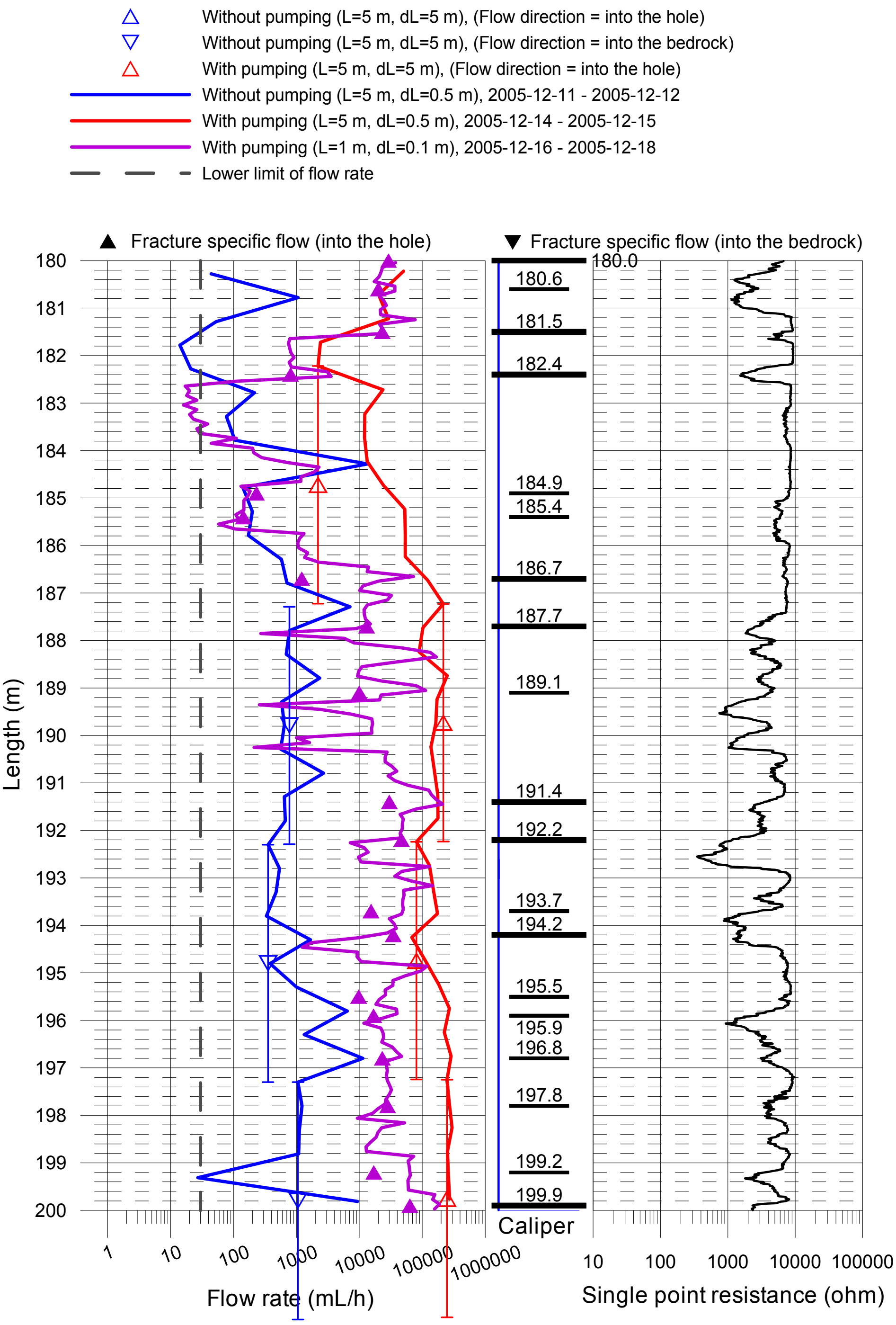
Appendix 3.4

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



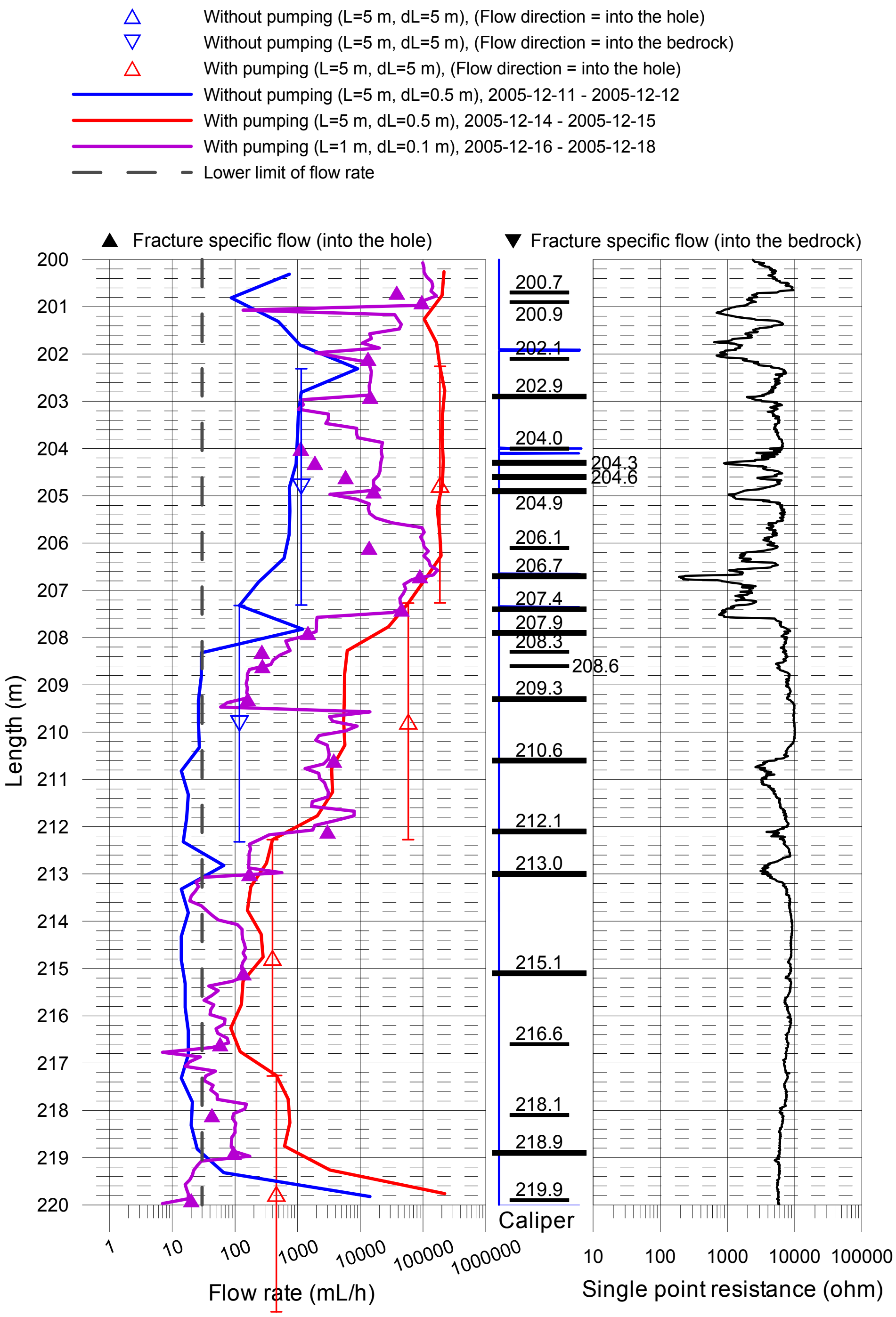
Appendix 3.5

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



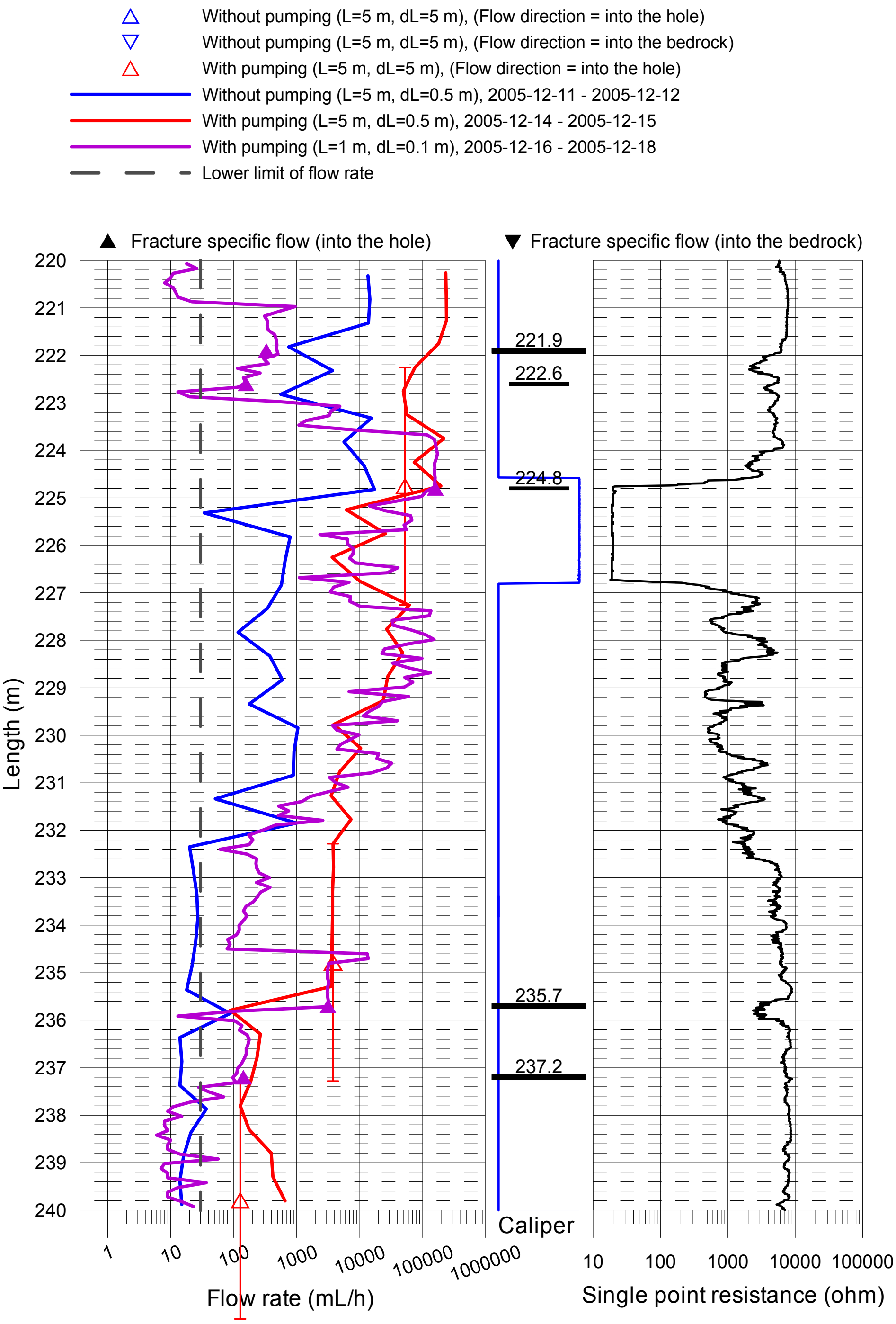
Appendix 3.6

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



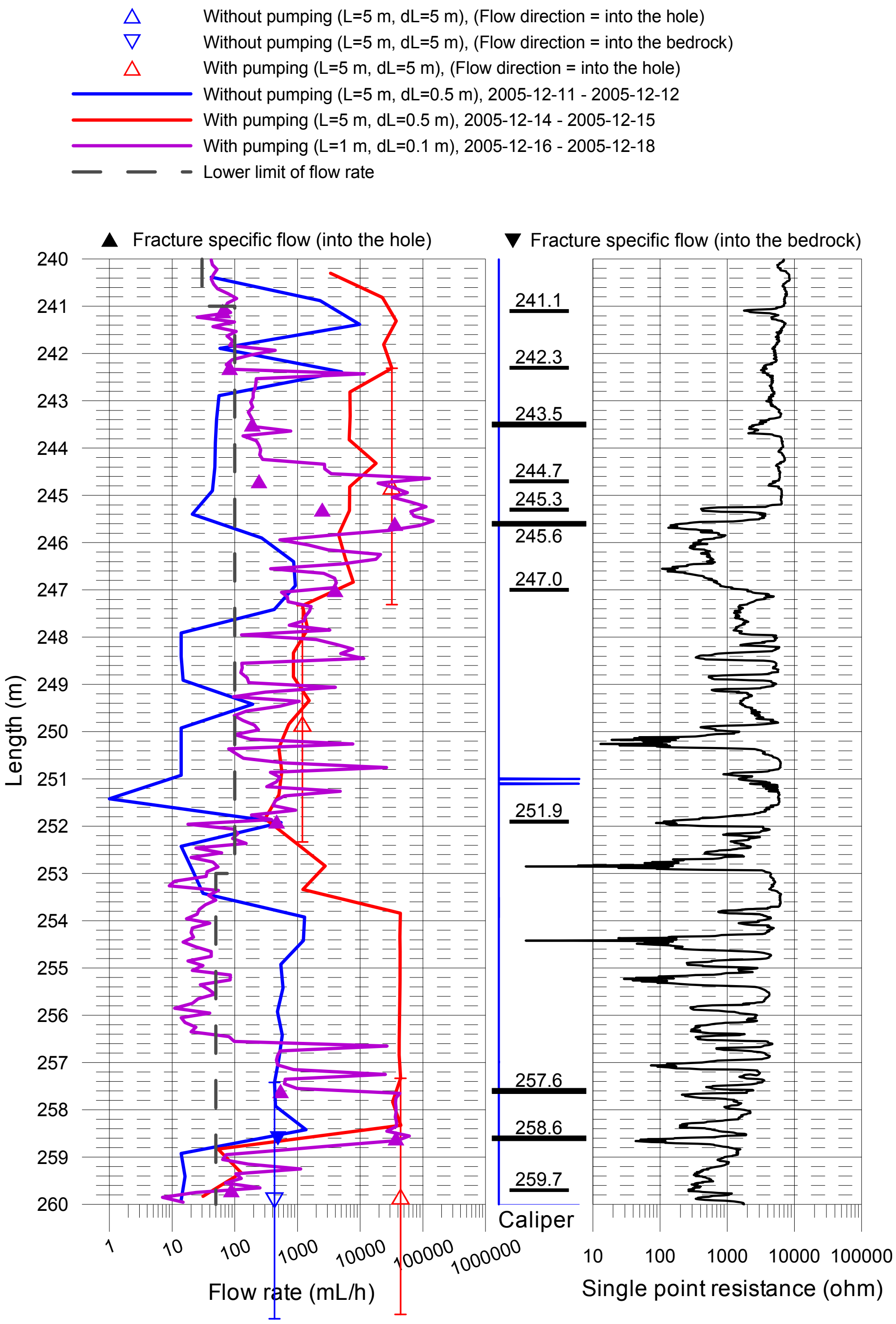
Appendix 3.7

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



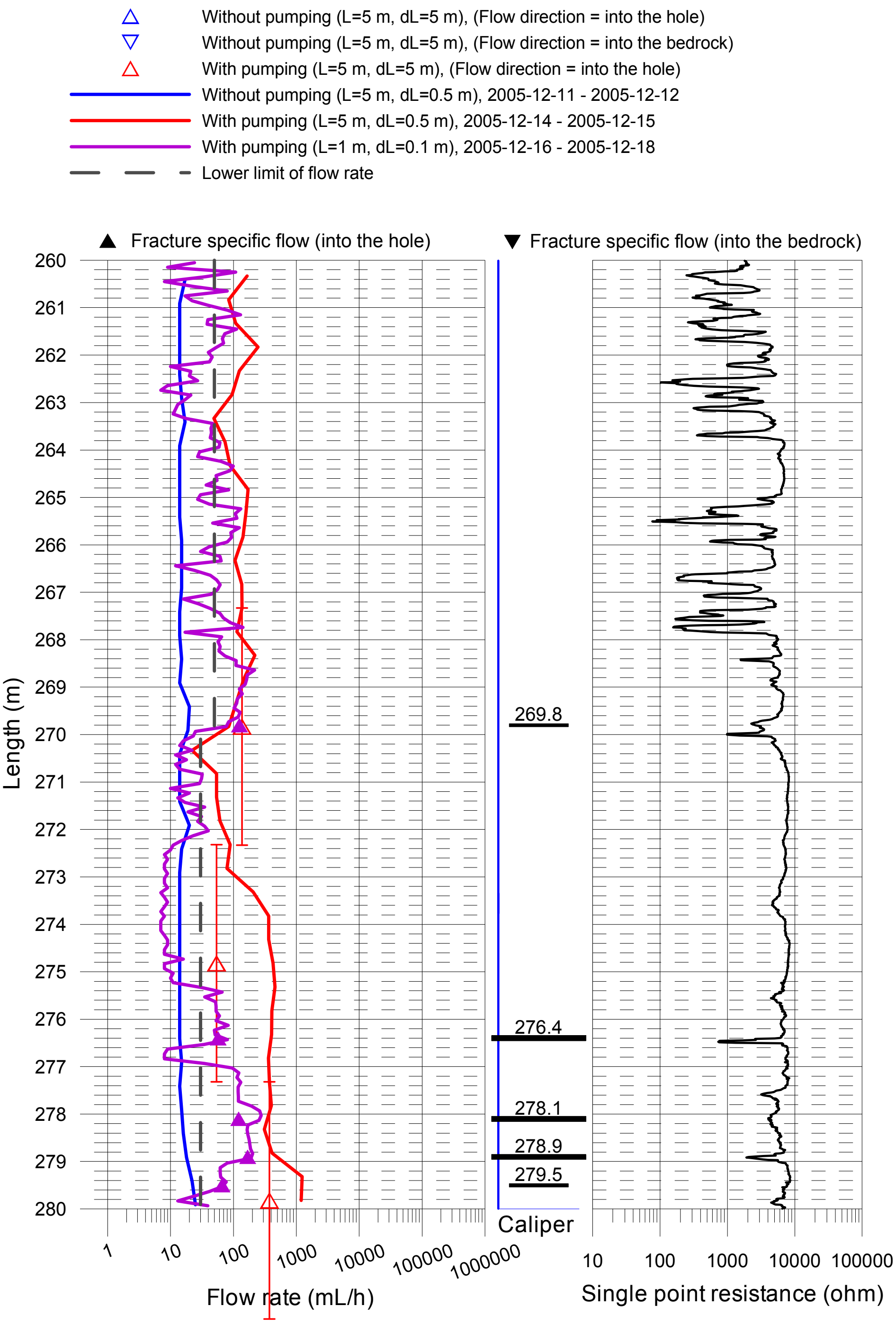
Appendix 3.8

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



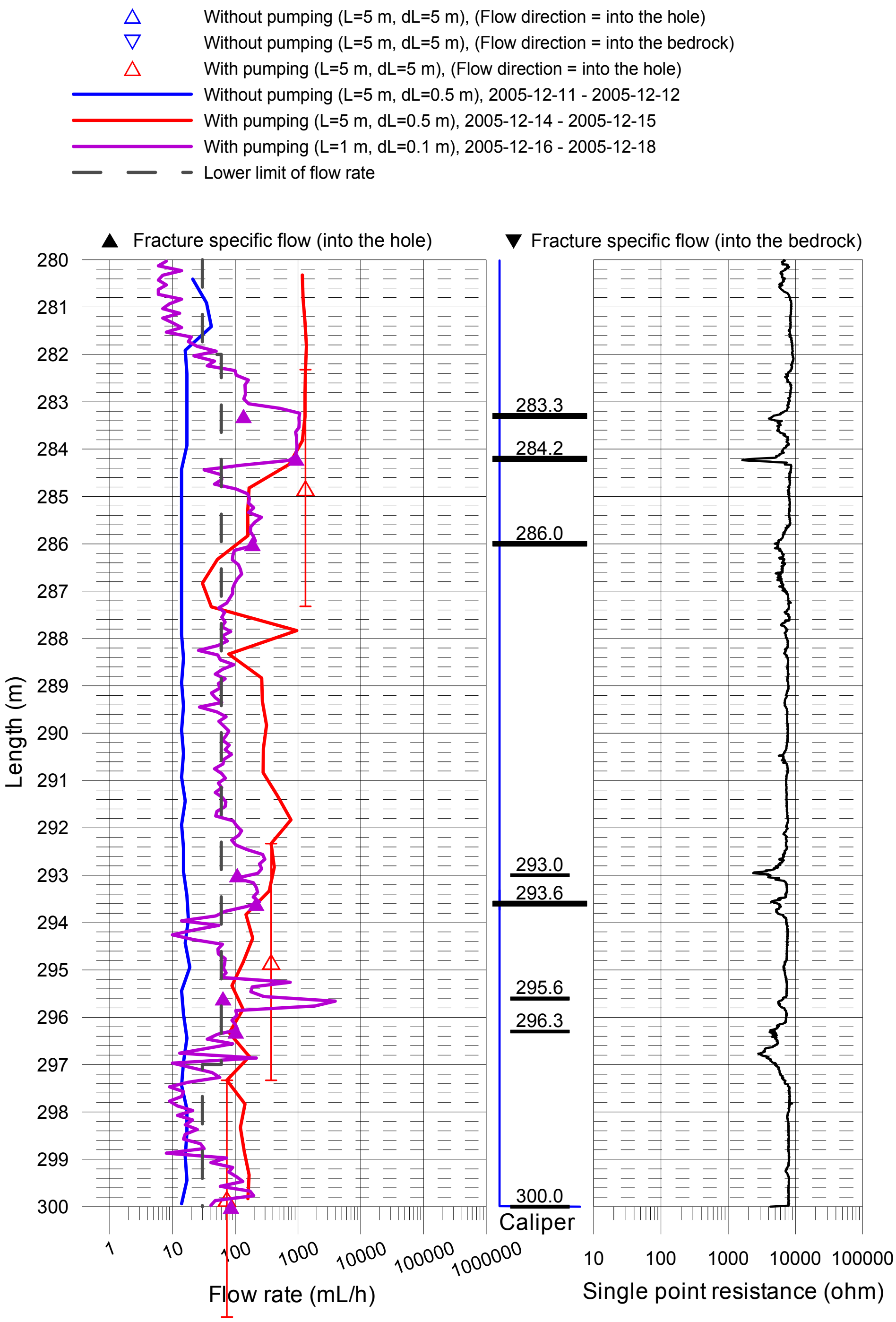
Appendix 3.9

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



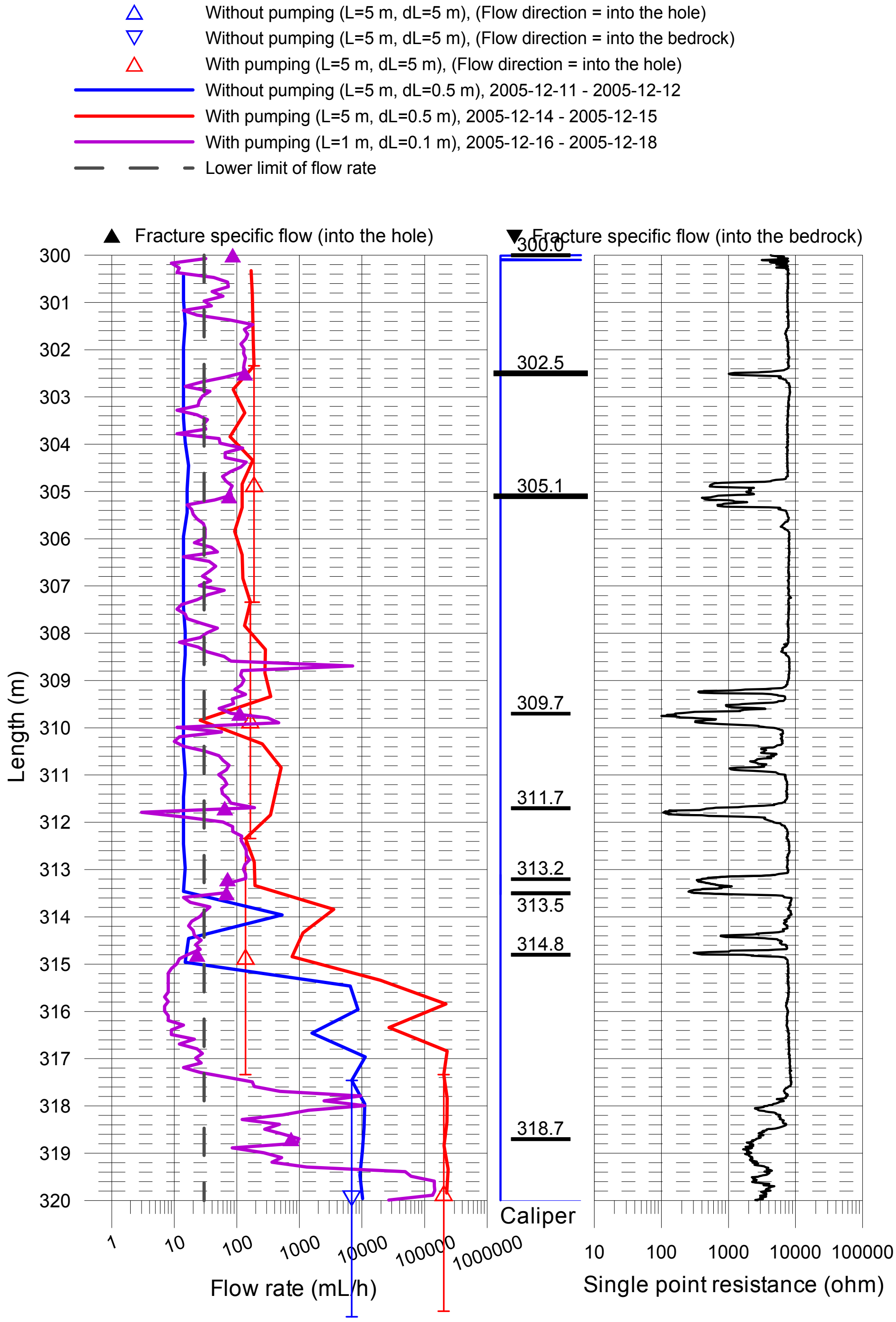
Appendix 3.10

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



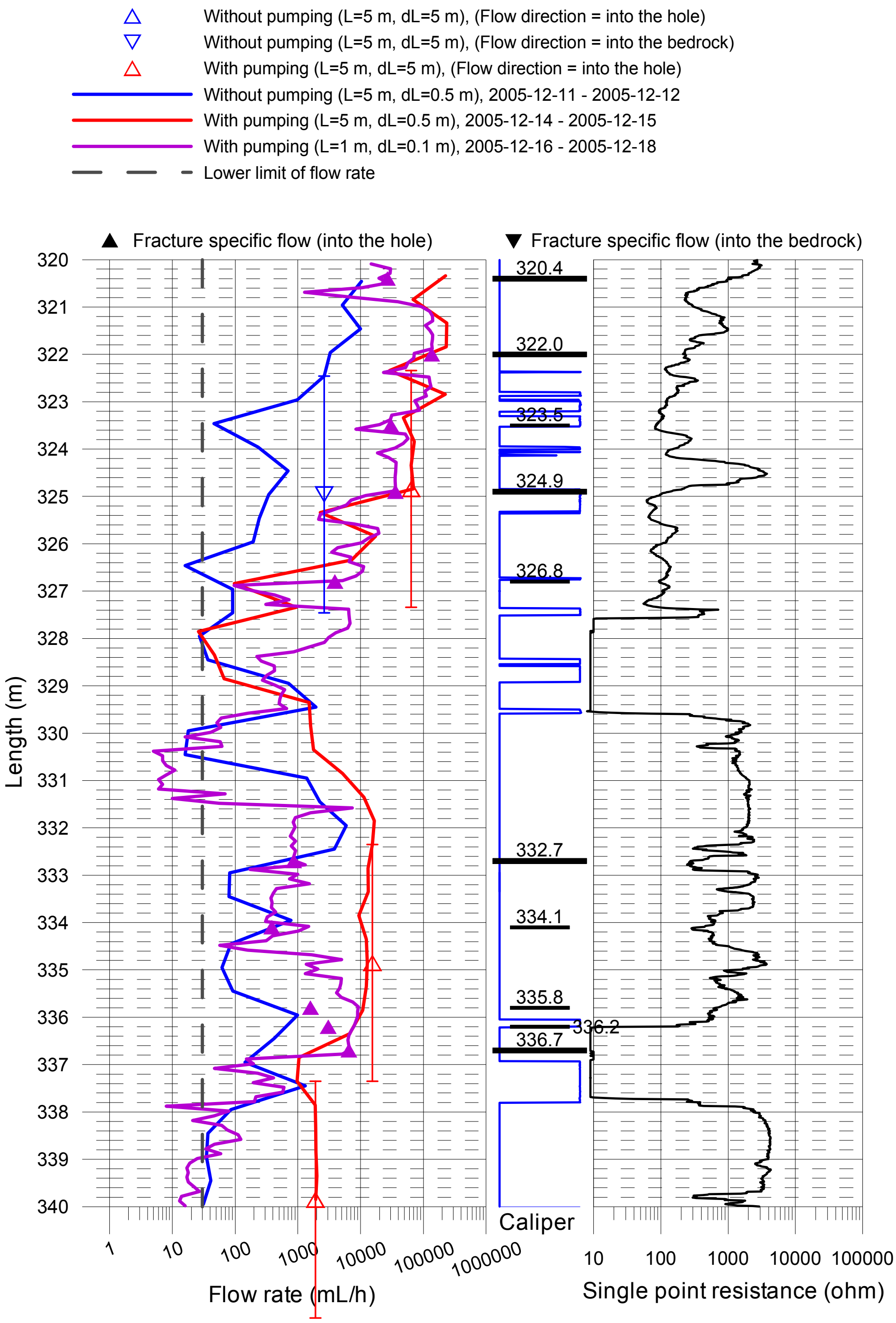
Appendix 3.11

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



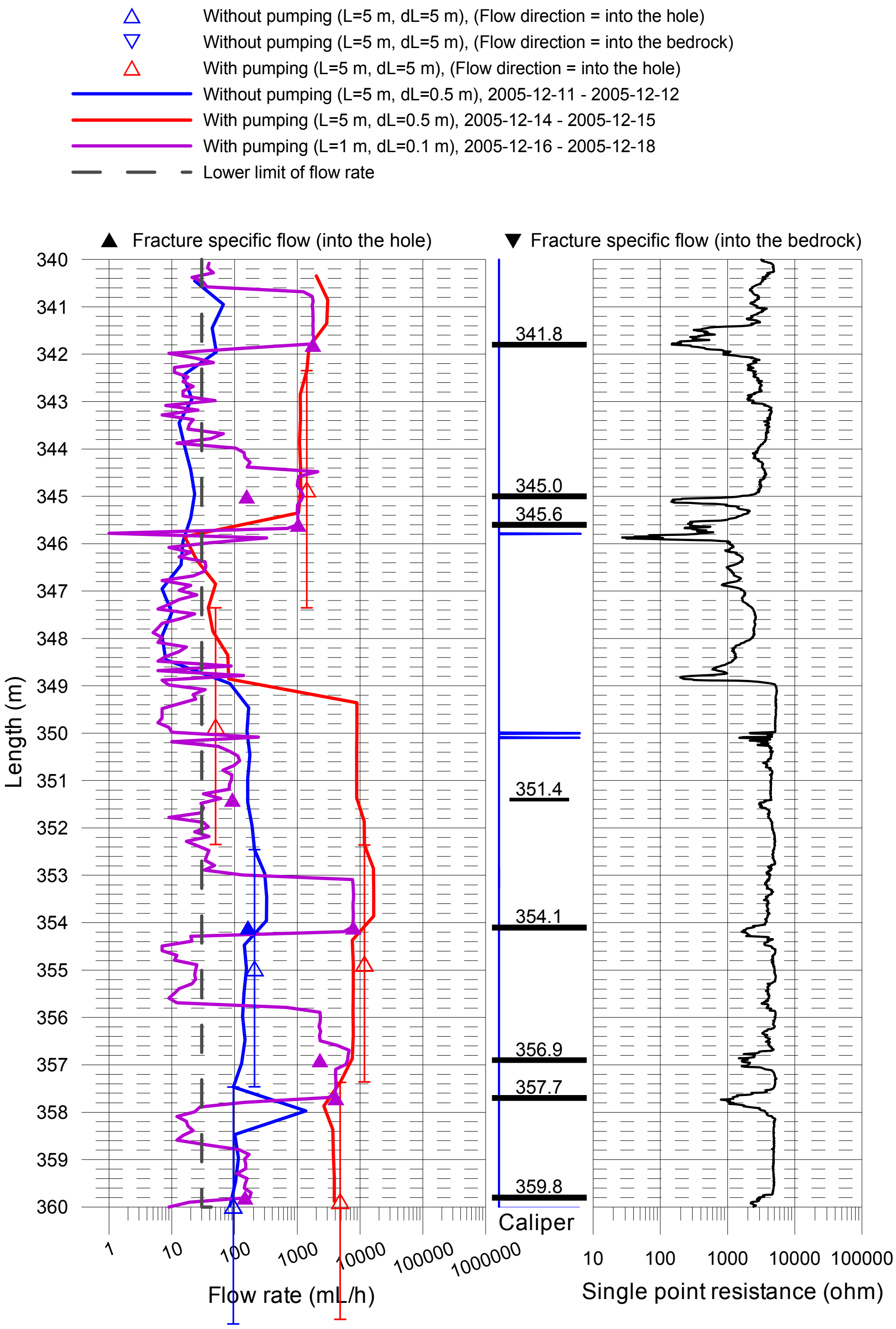
Appendix 3.12

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



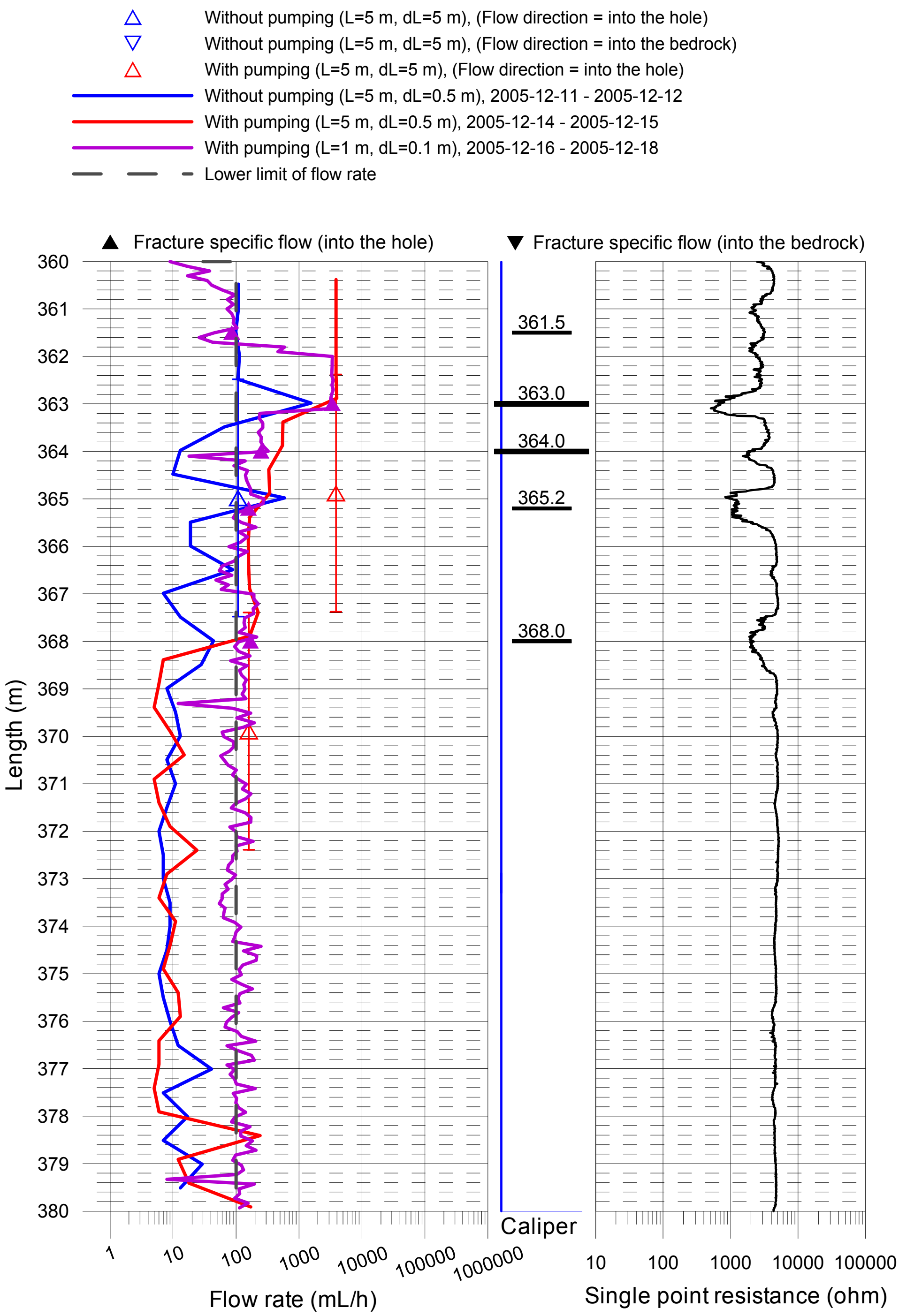
Appendix 3.13

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



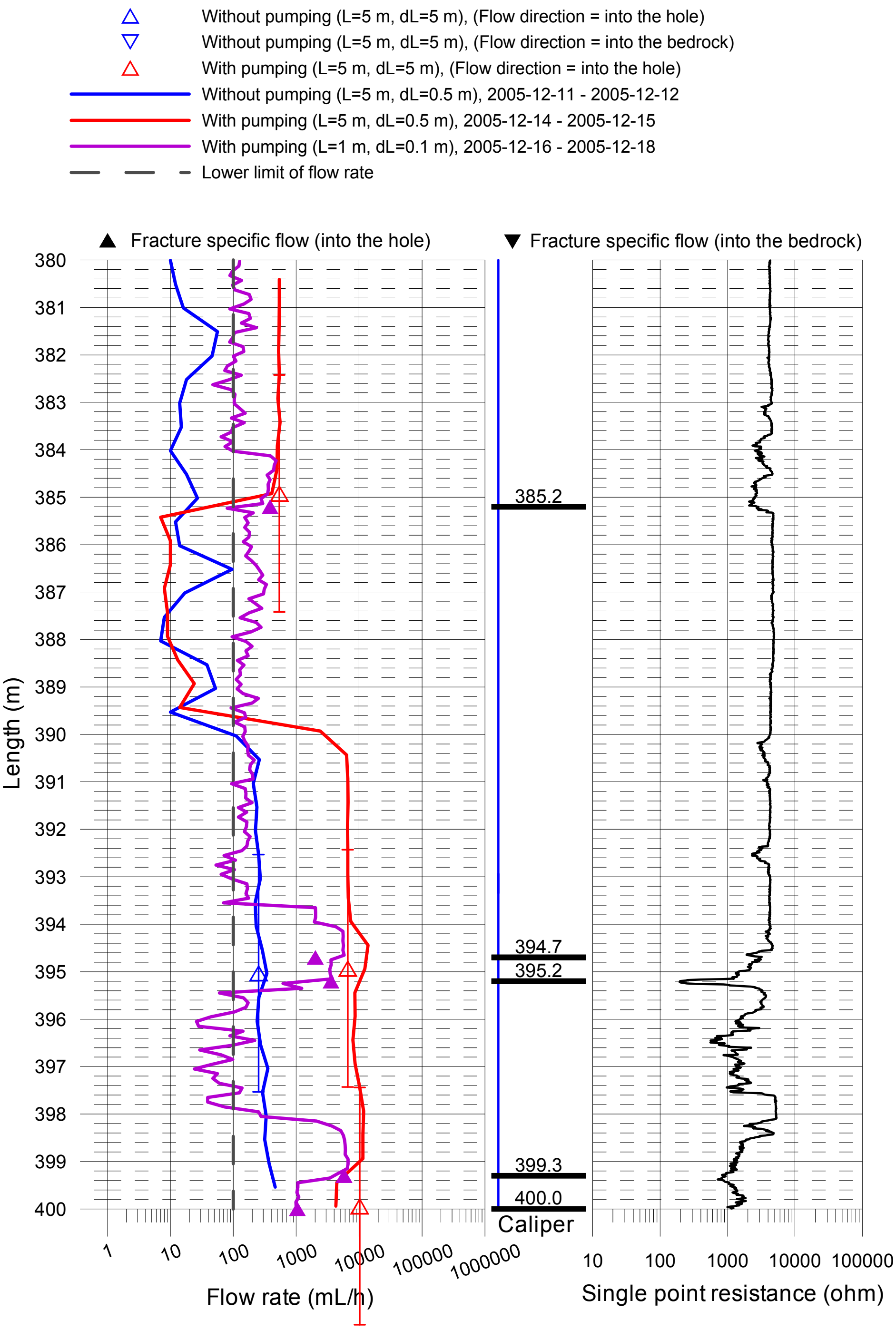
Appendix 3.14

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



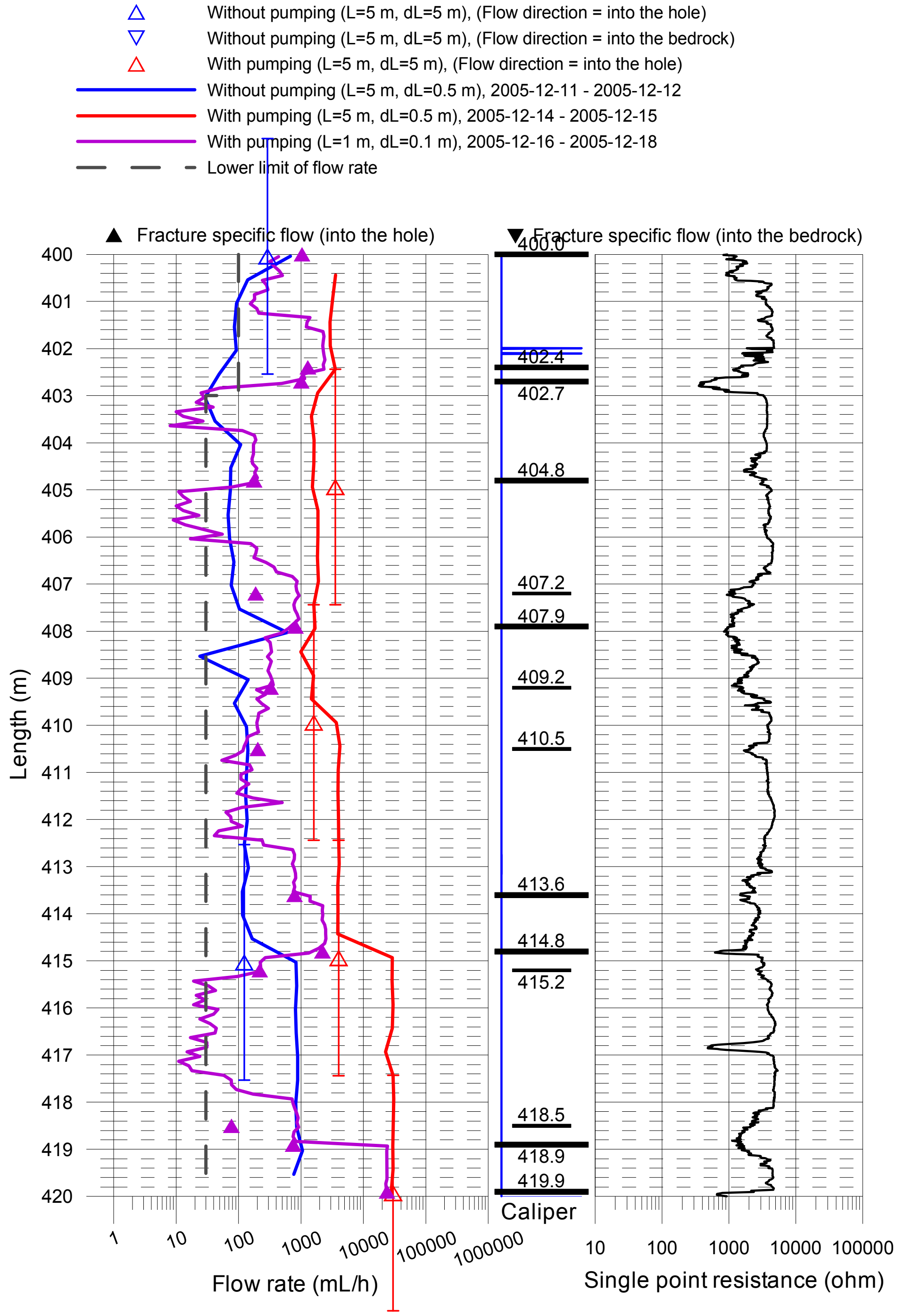
Appendix 3.15

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



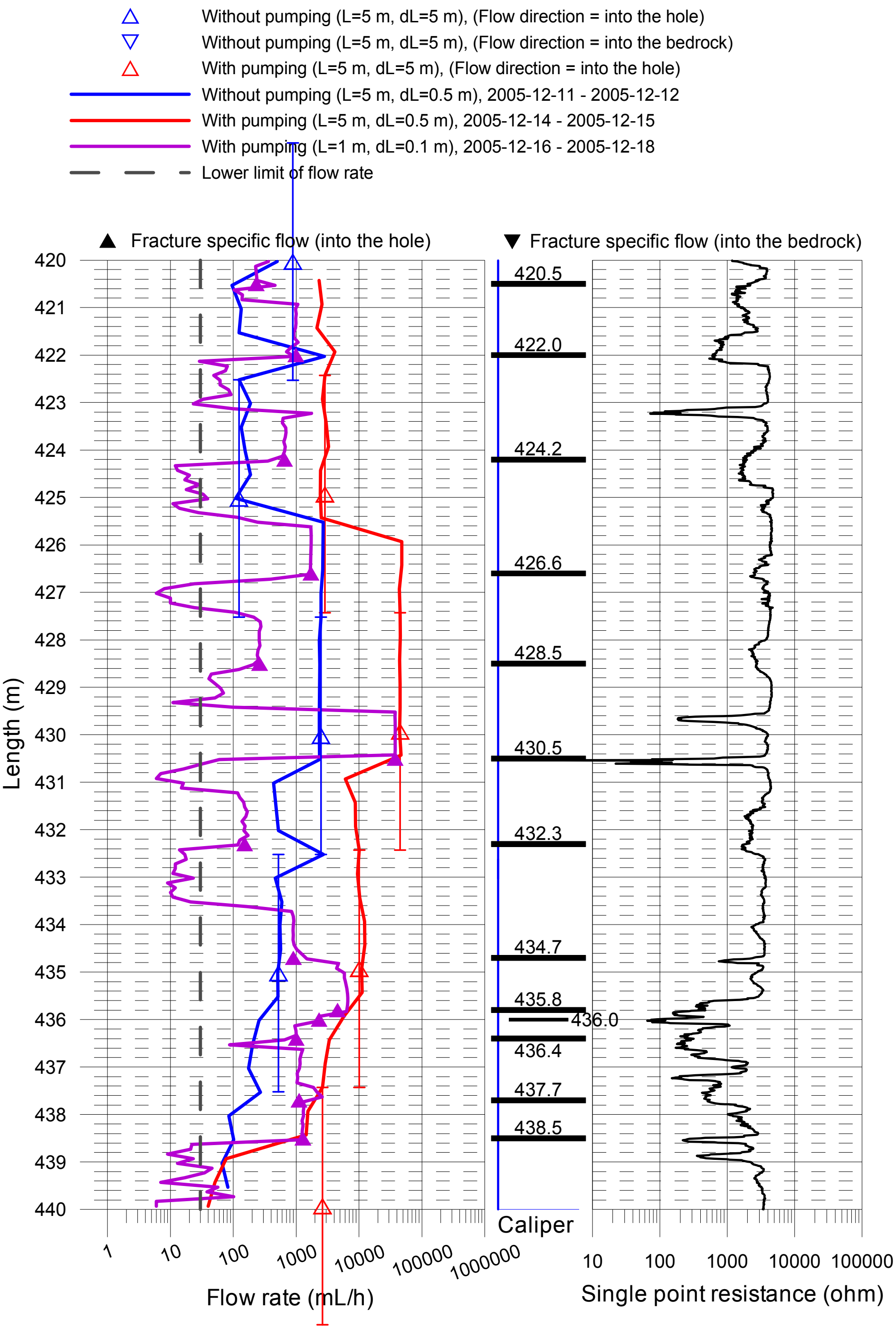
Appendix 3.16

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



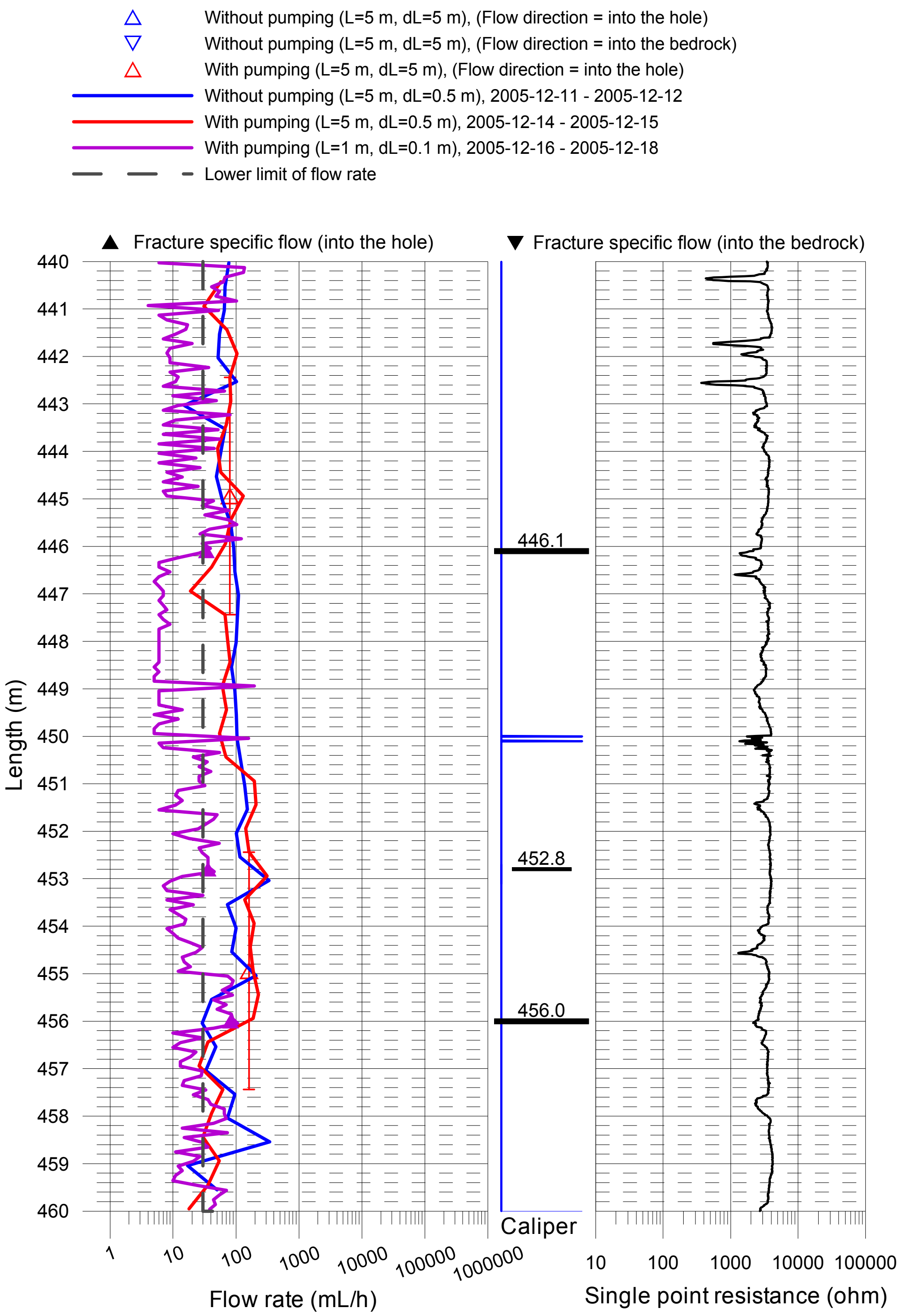
Appendix 3.17

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance

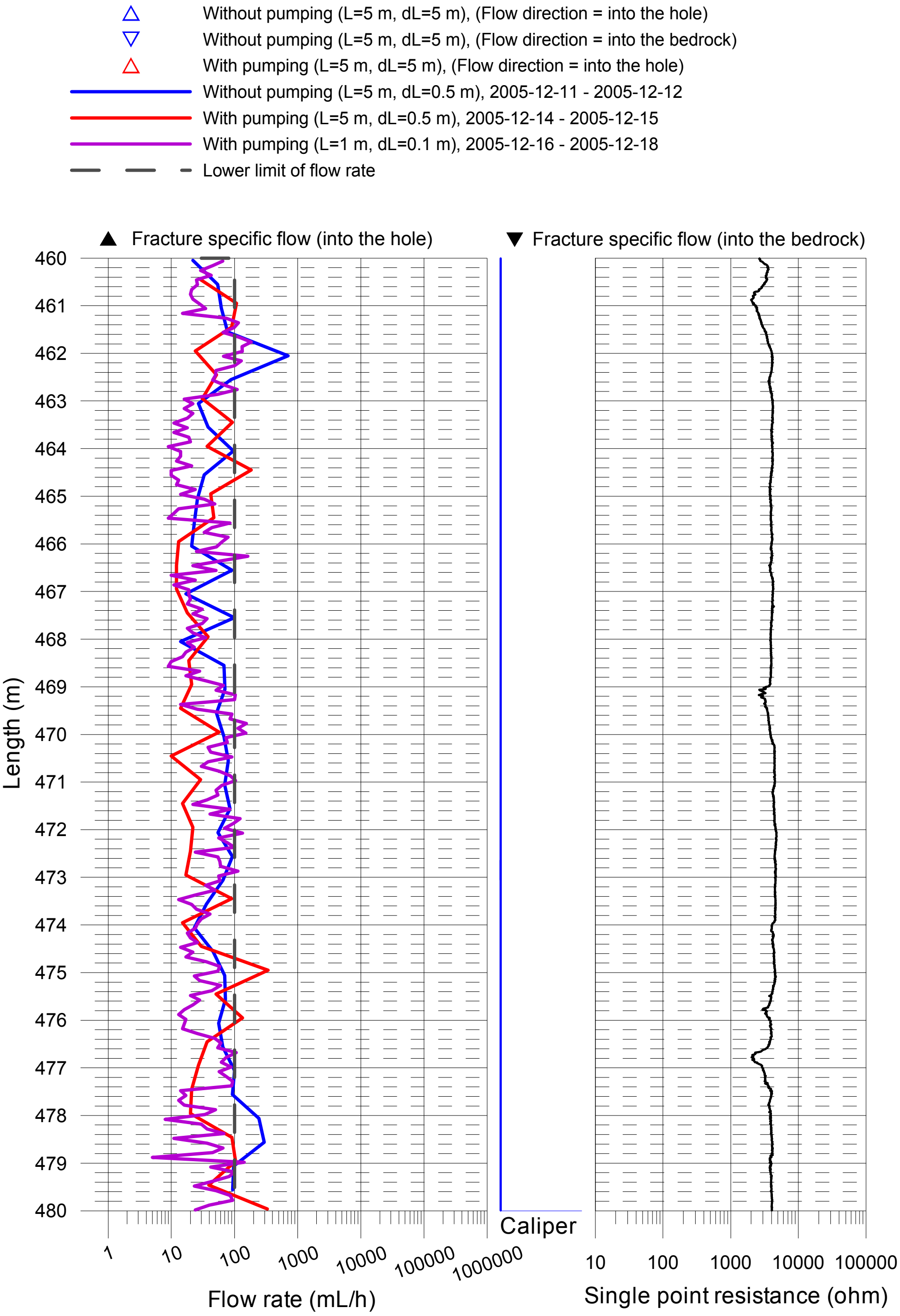


Appendix 3.18

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance

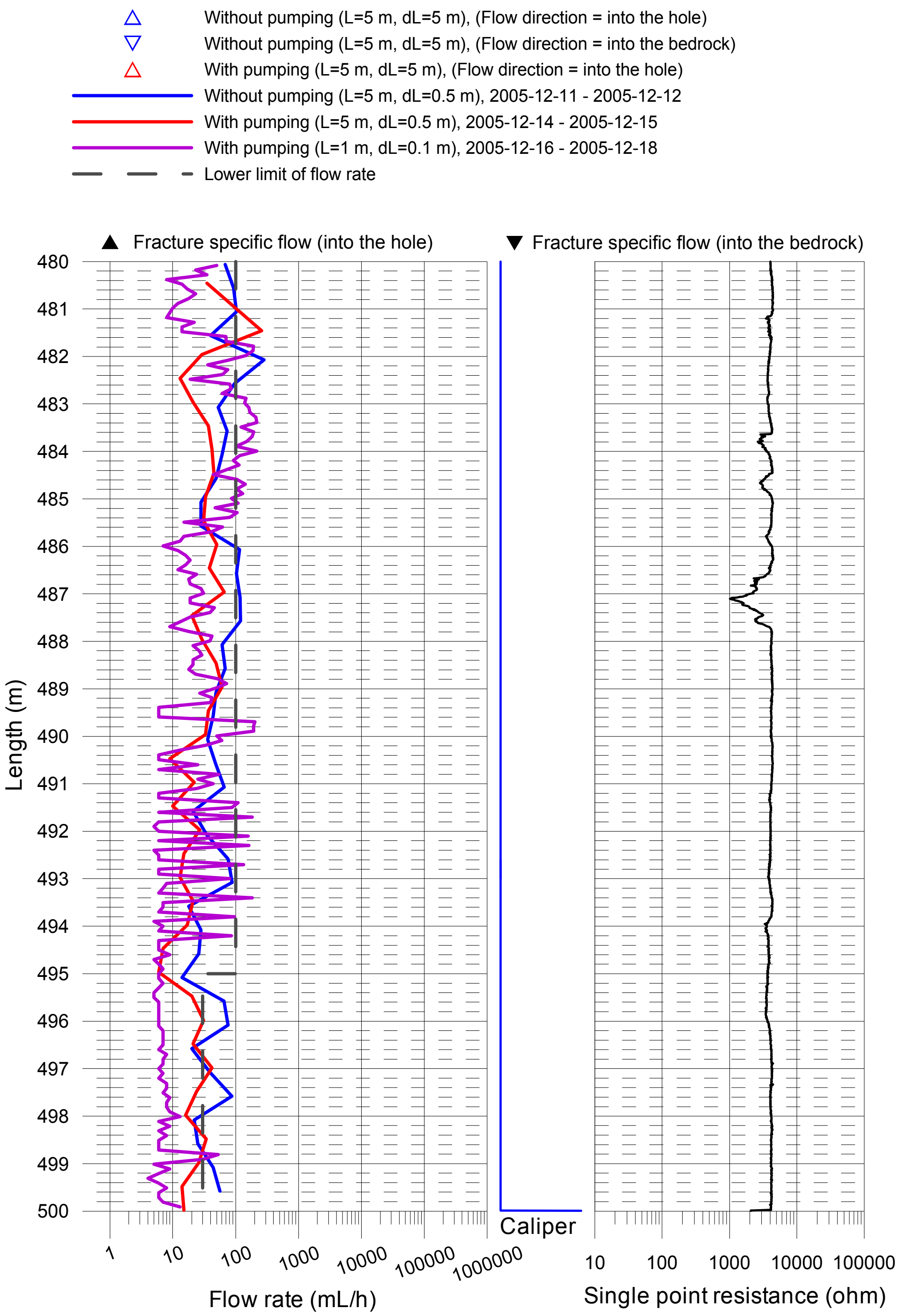


Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



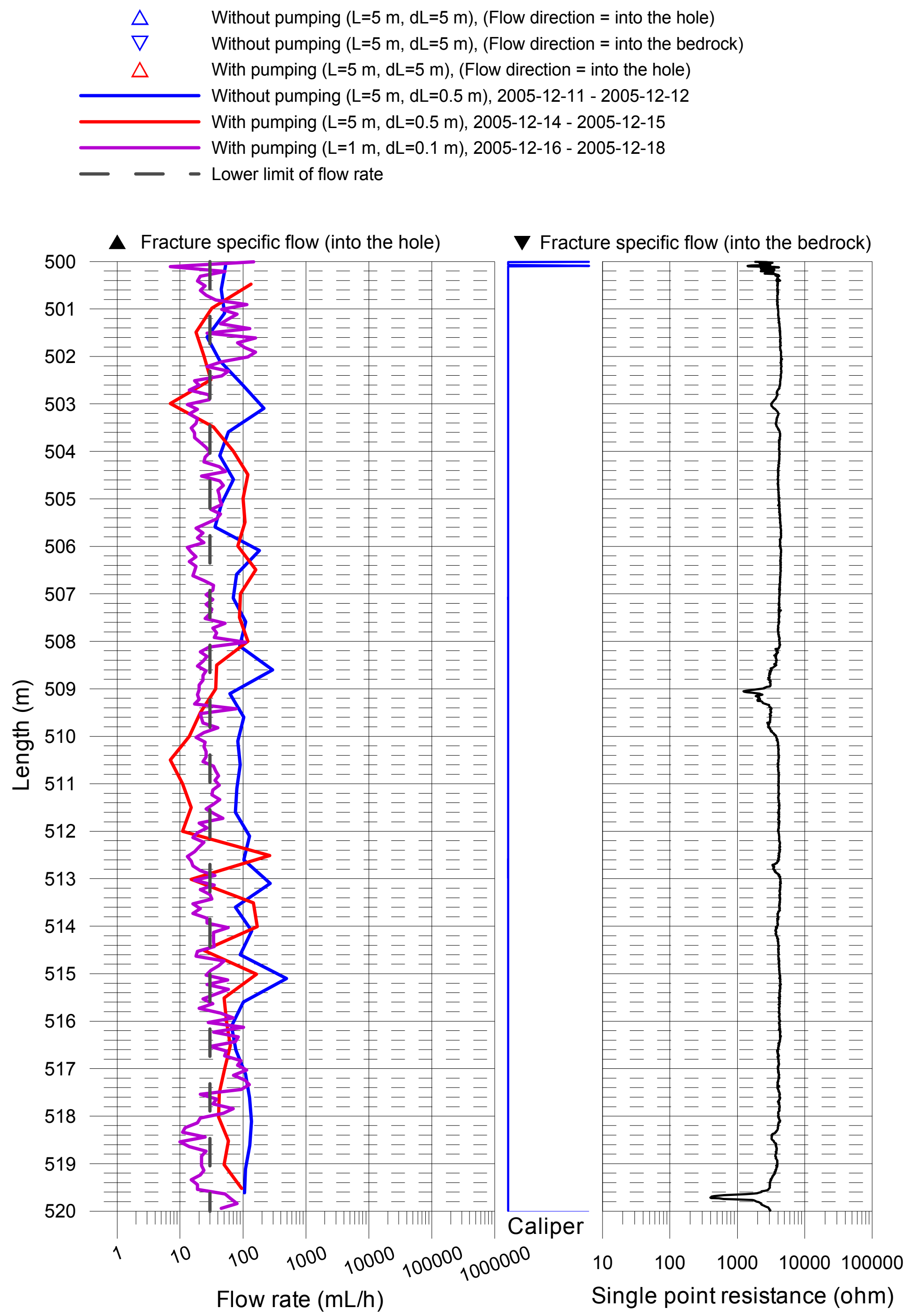
Appendix 3.20

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



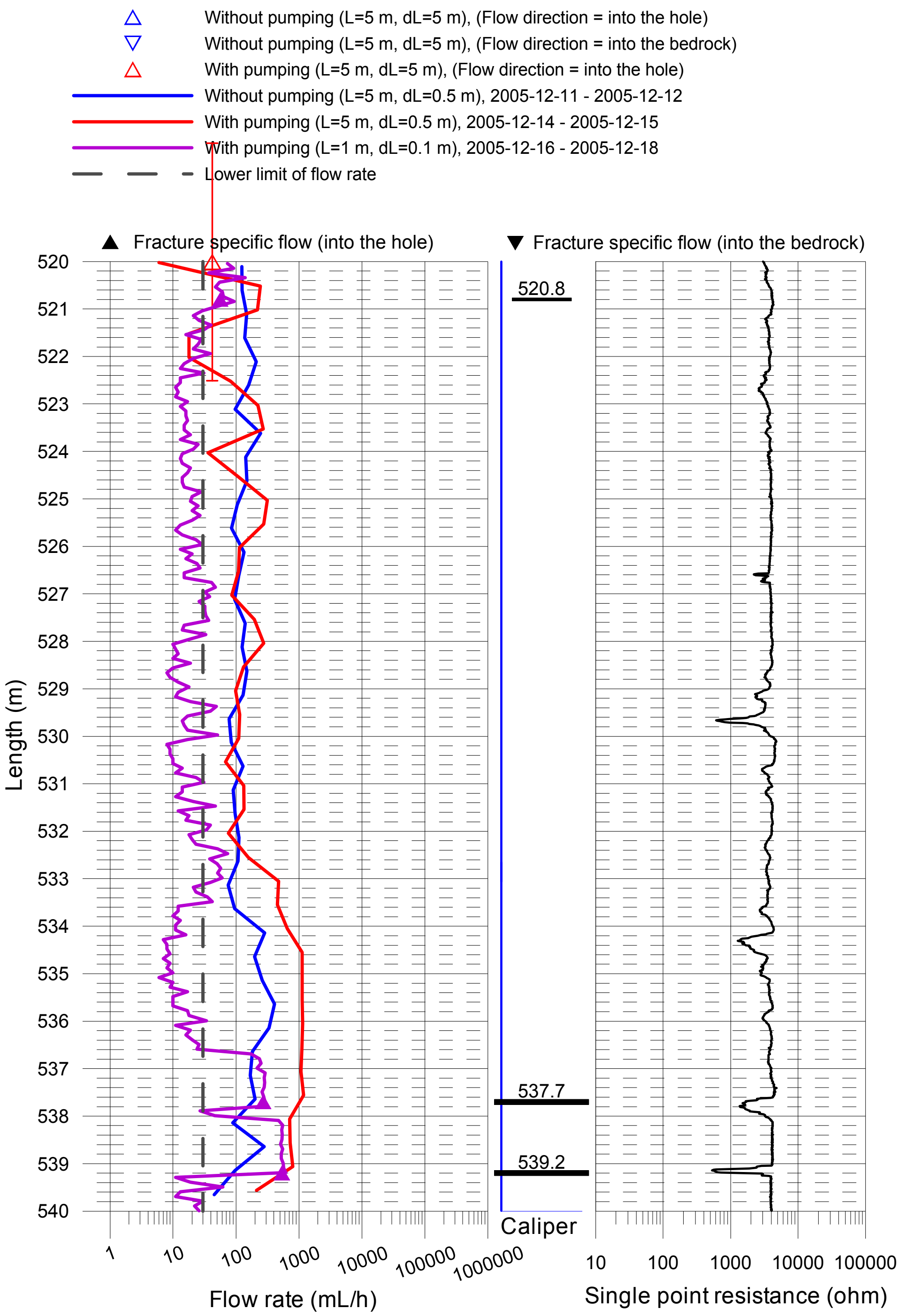
Appendix 3.21

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



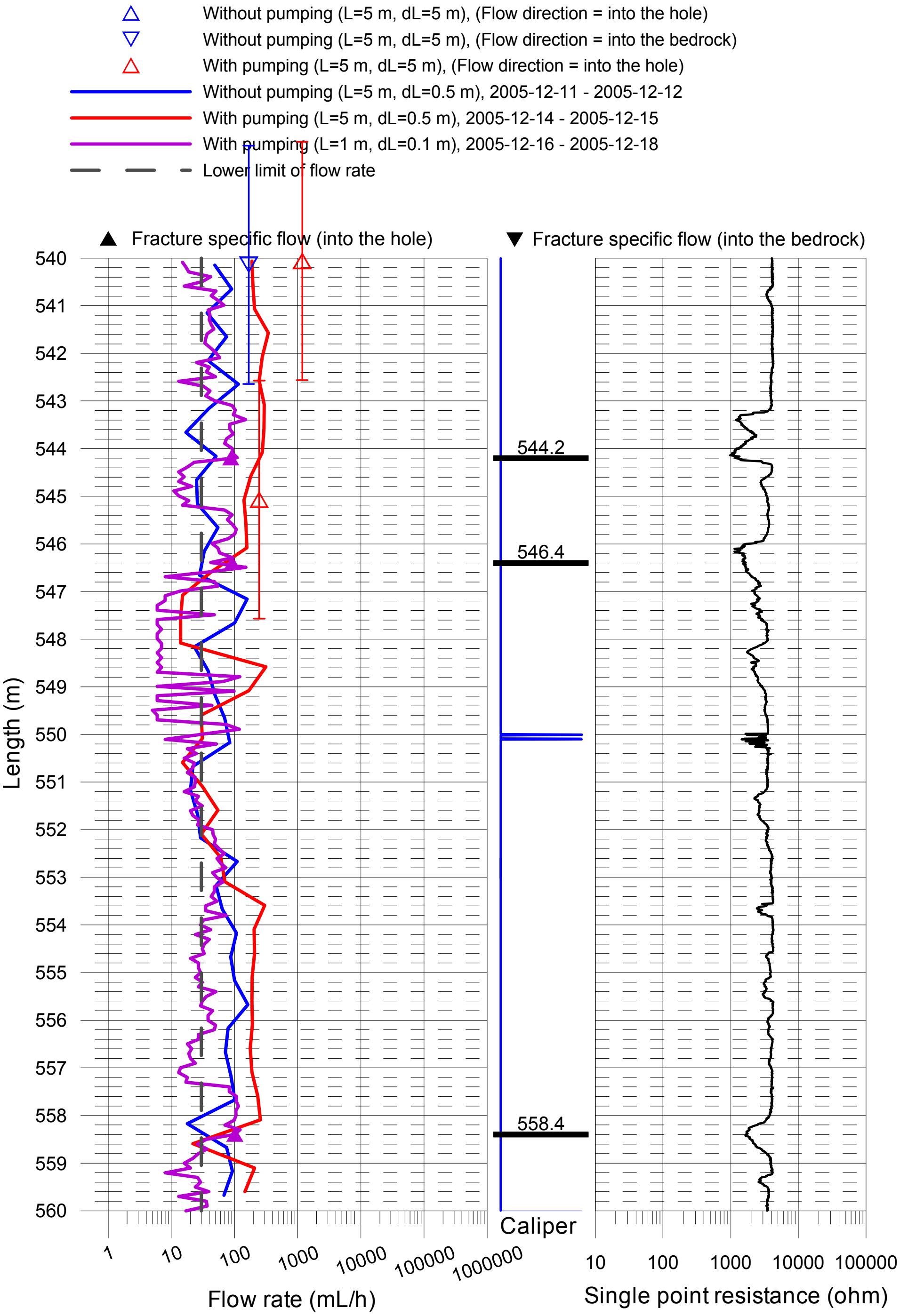
Appendix 3.22

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance

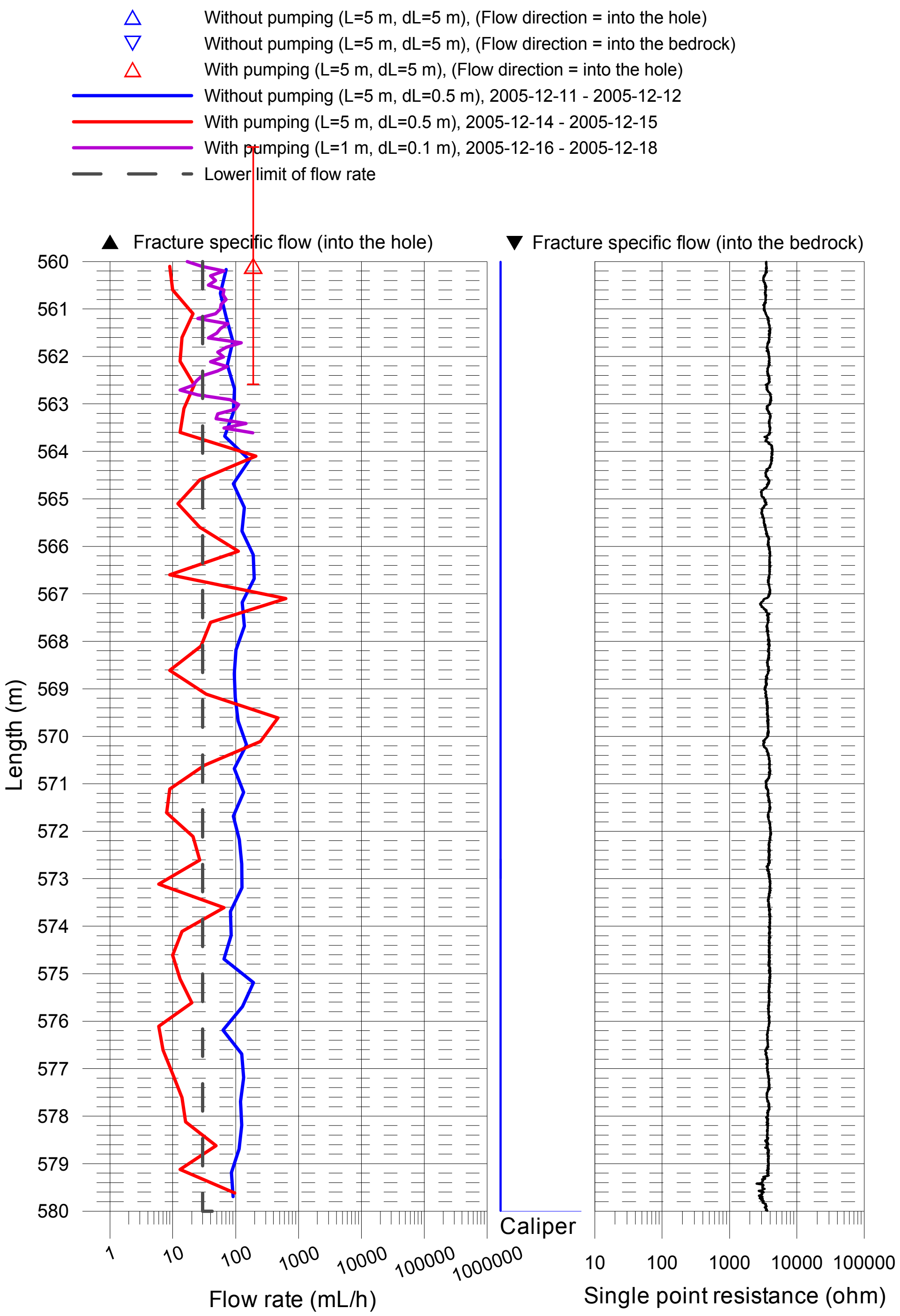


Appendix 3.23

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance

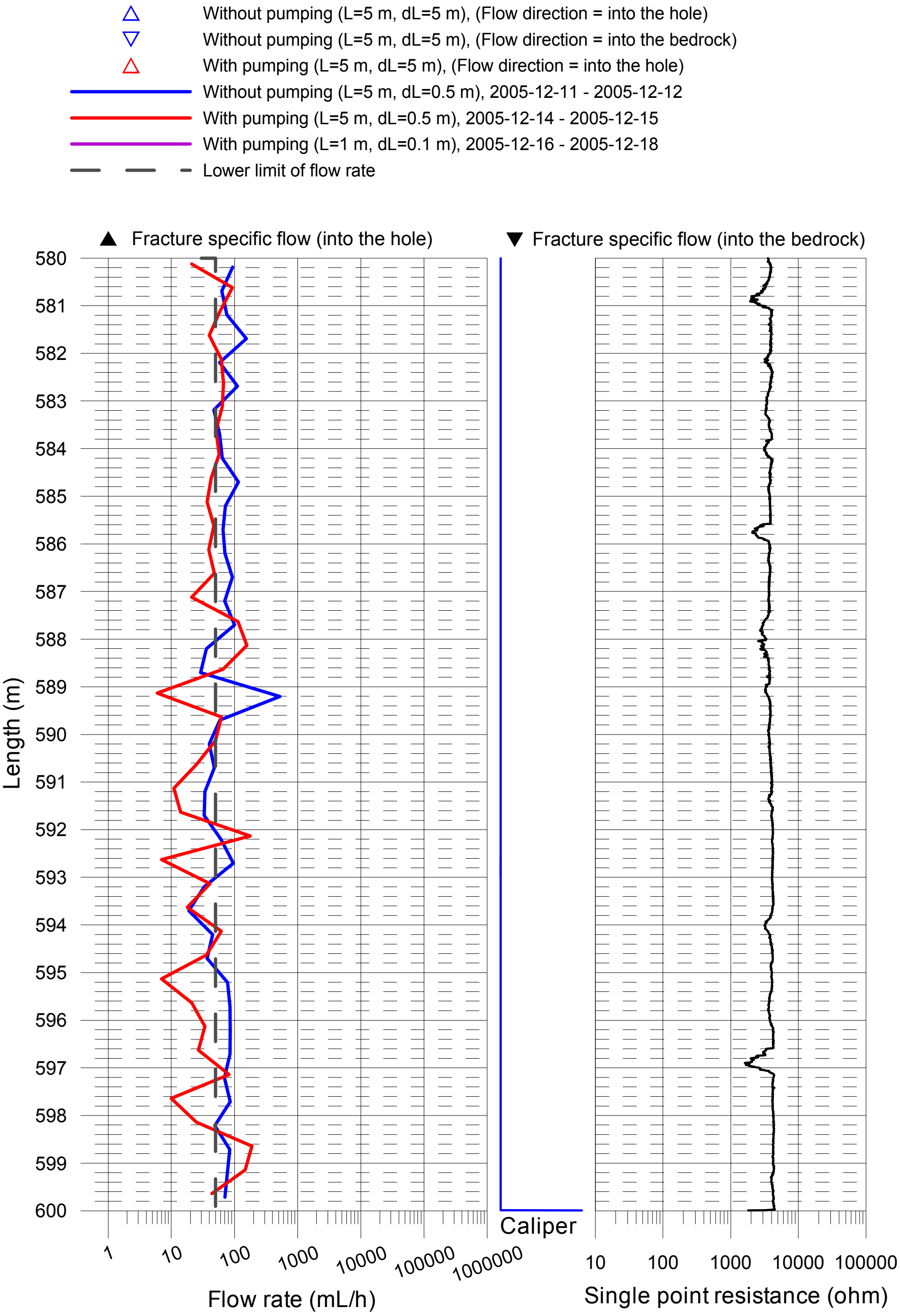


Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



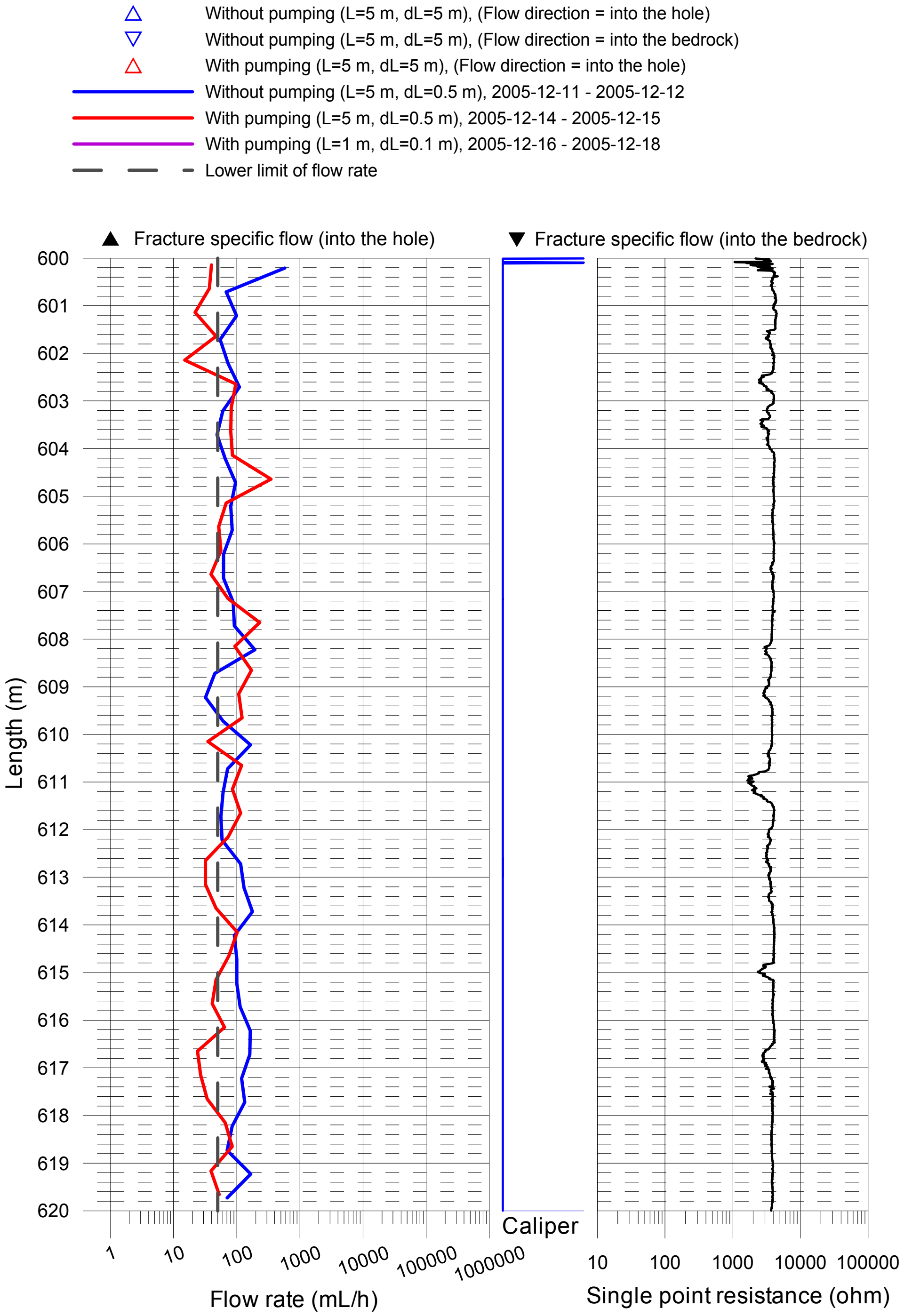
Appendix 3.25

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance

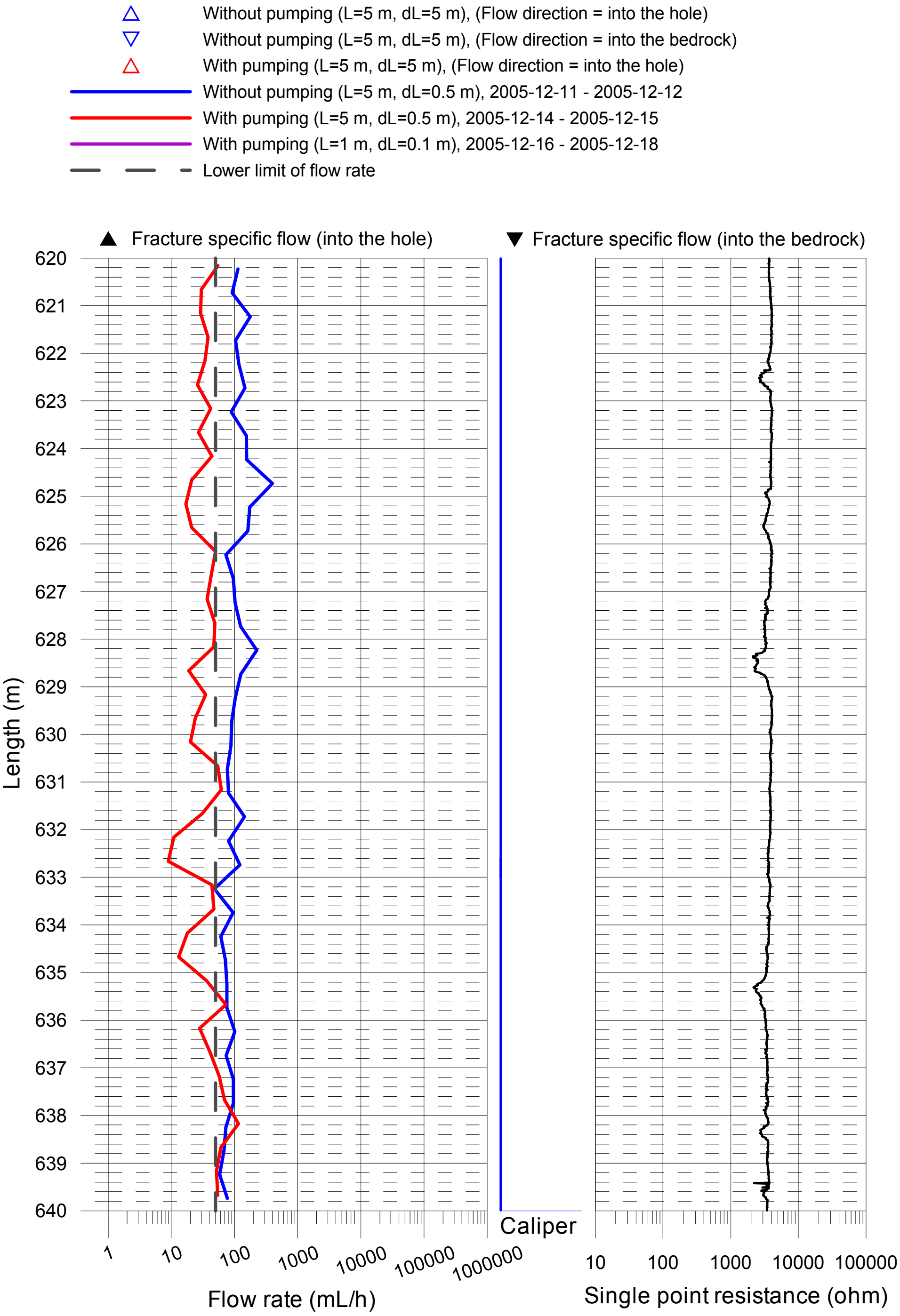


Appendix 3.26

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance

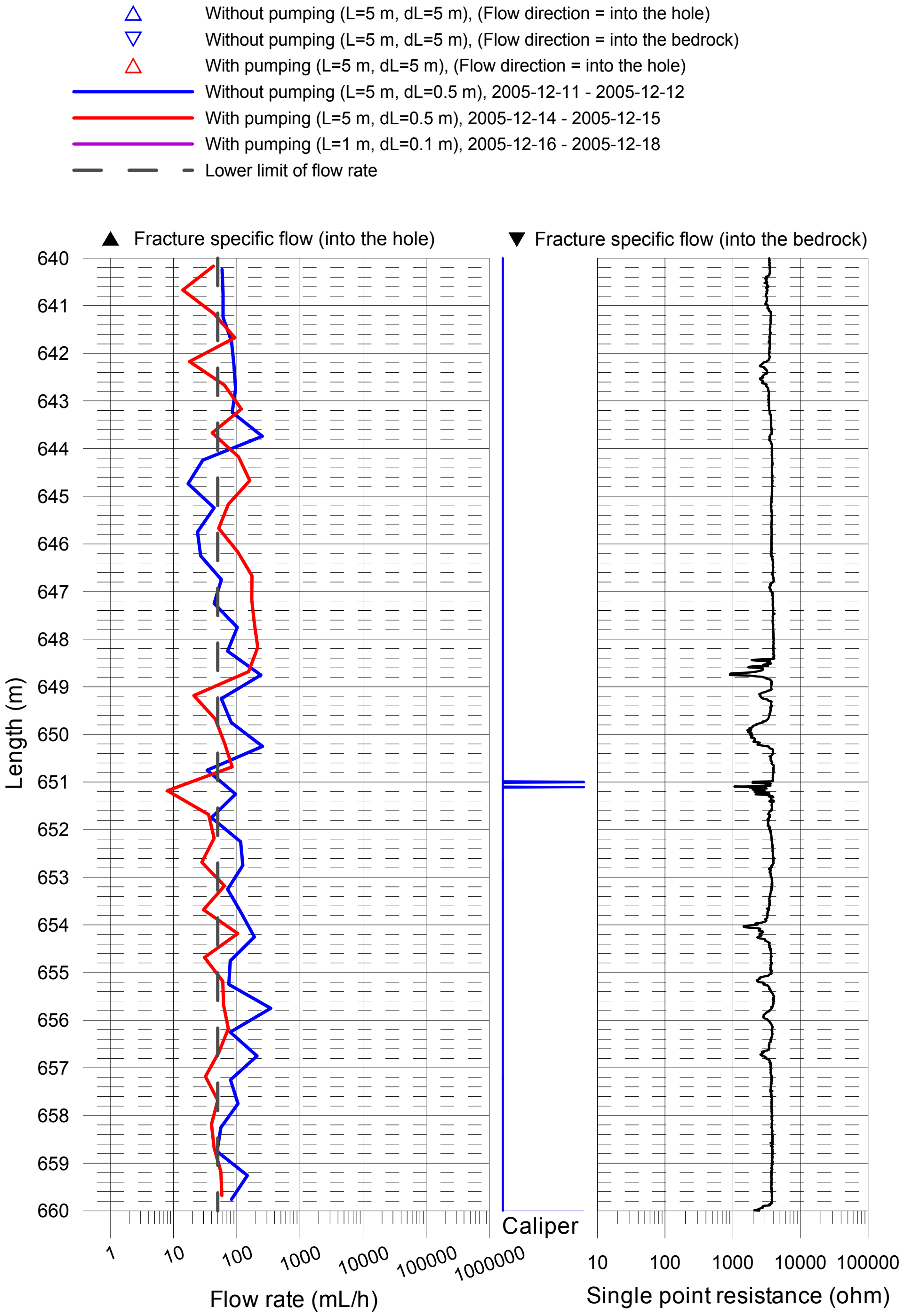


Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



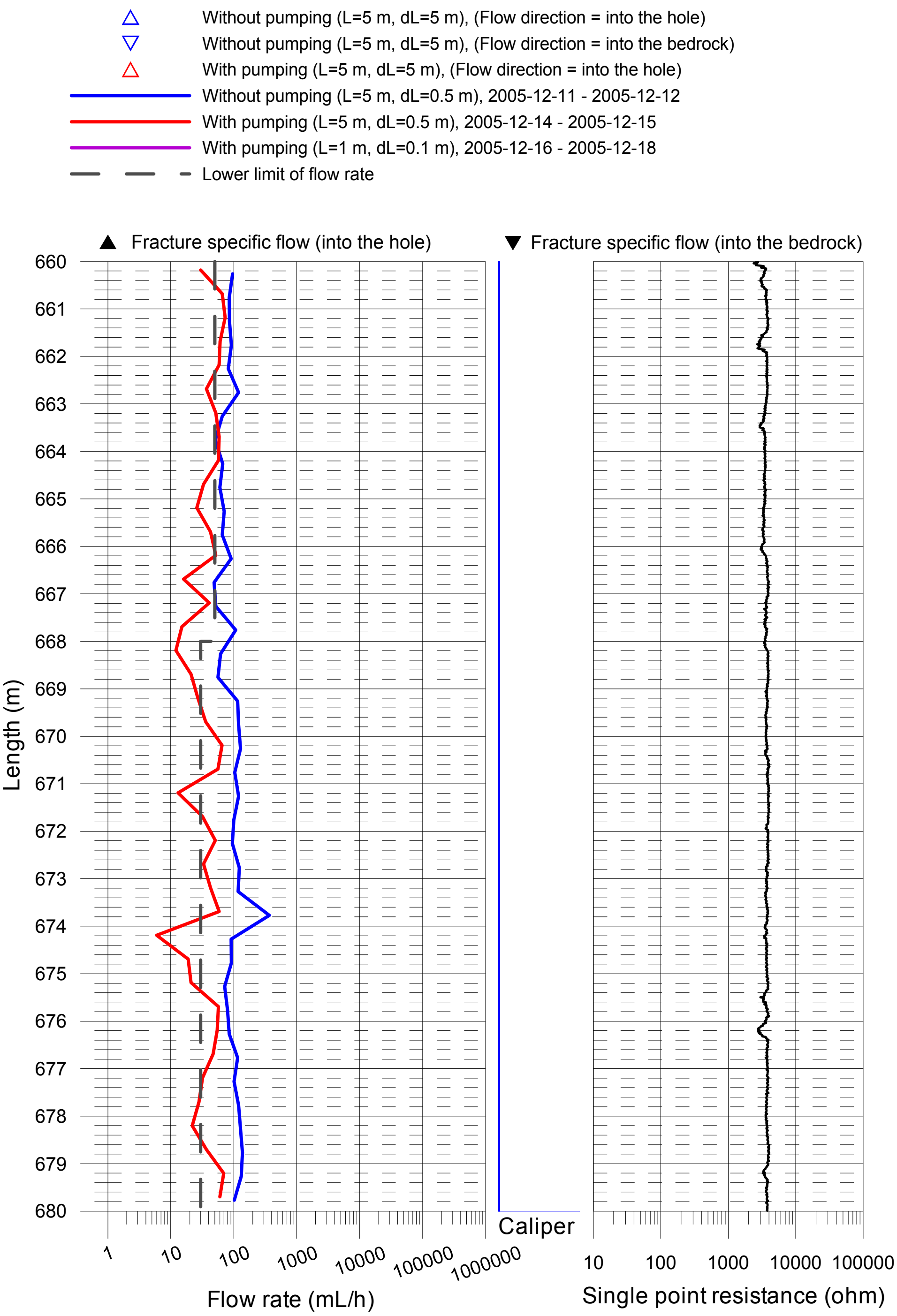
Appendix 3.28

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



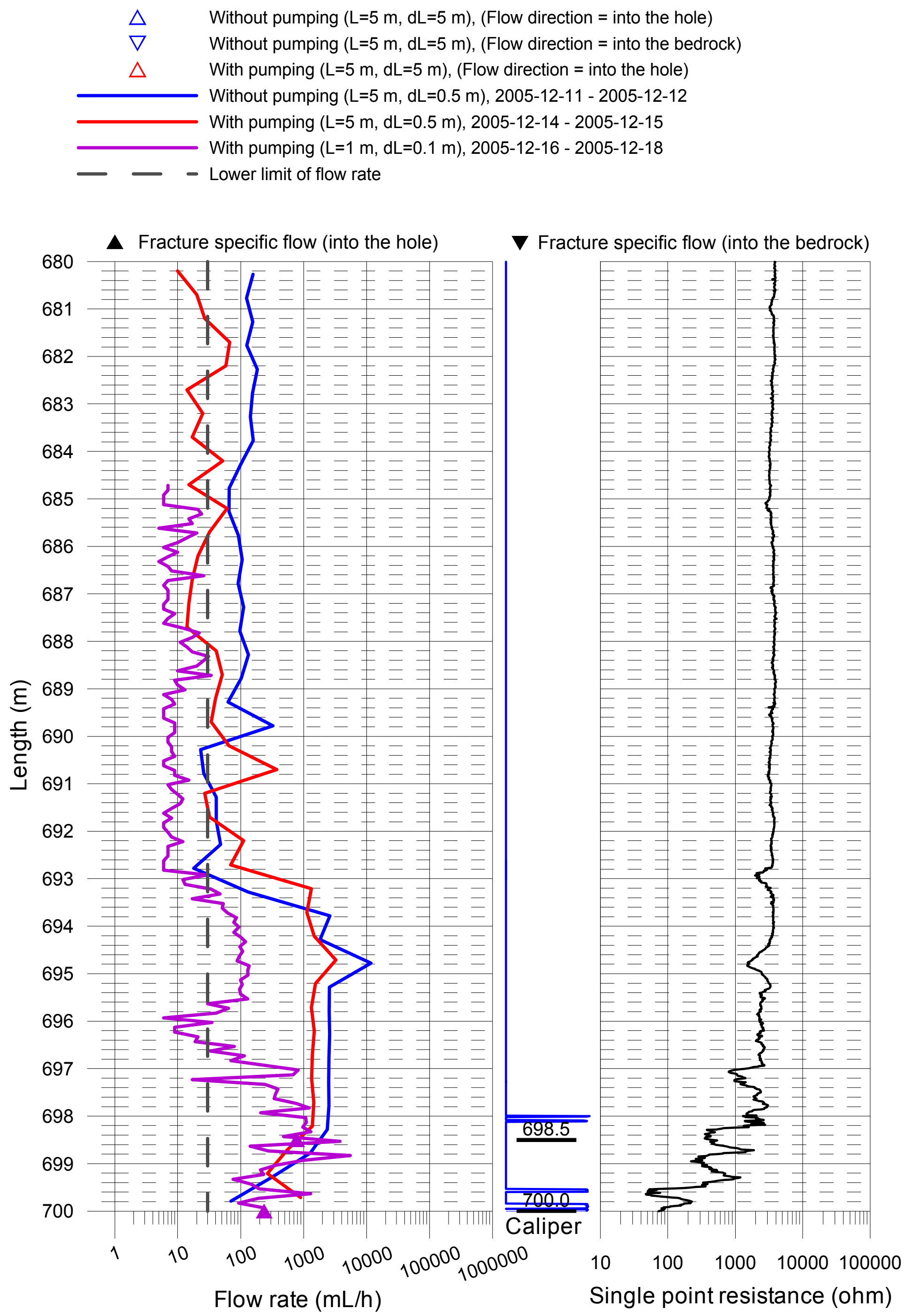
Appendix 3.29

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



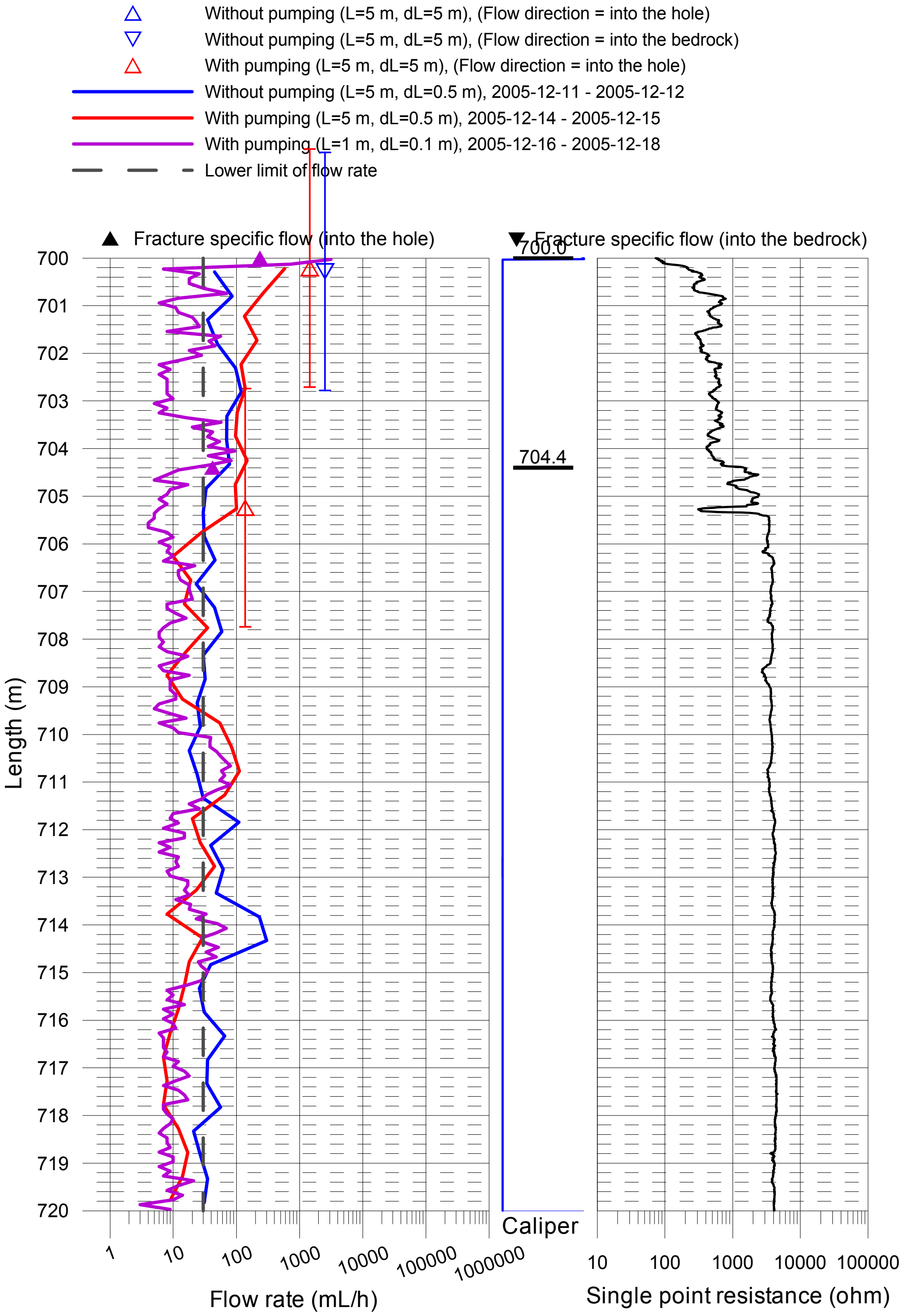
Appendix 3.30

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



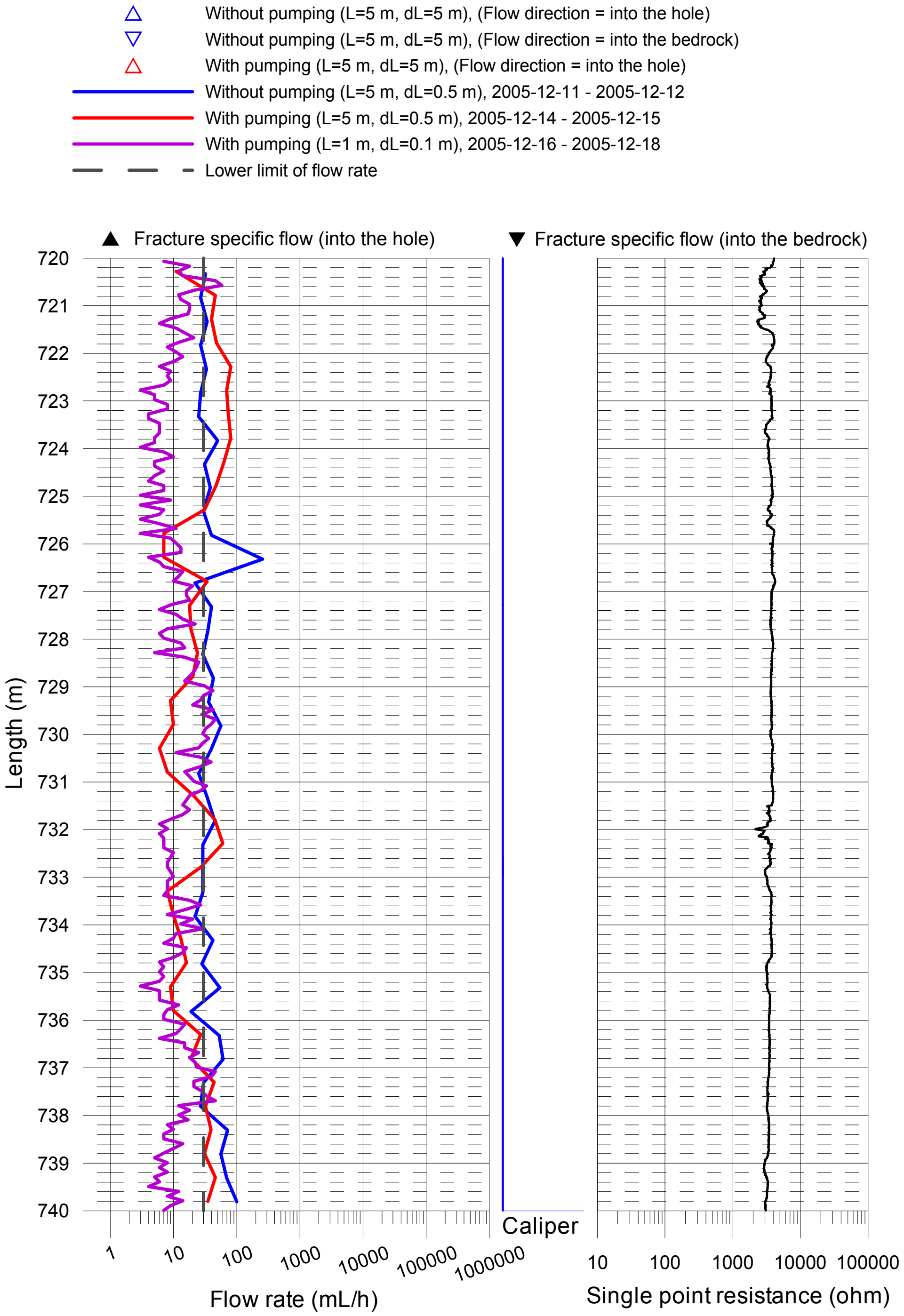
Appendix 3.31

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



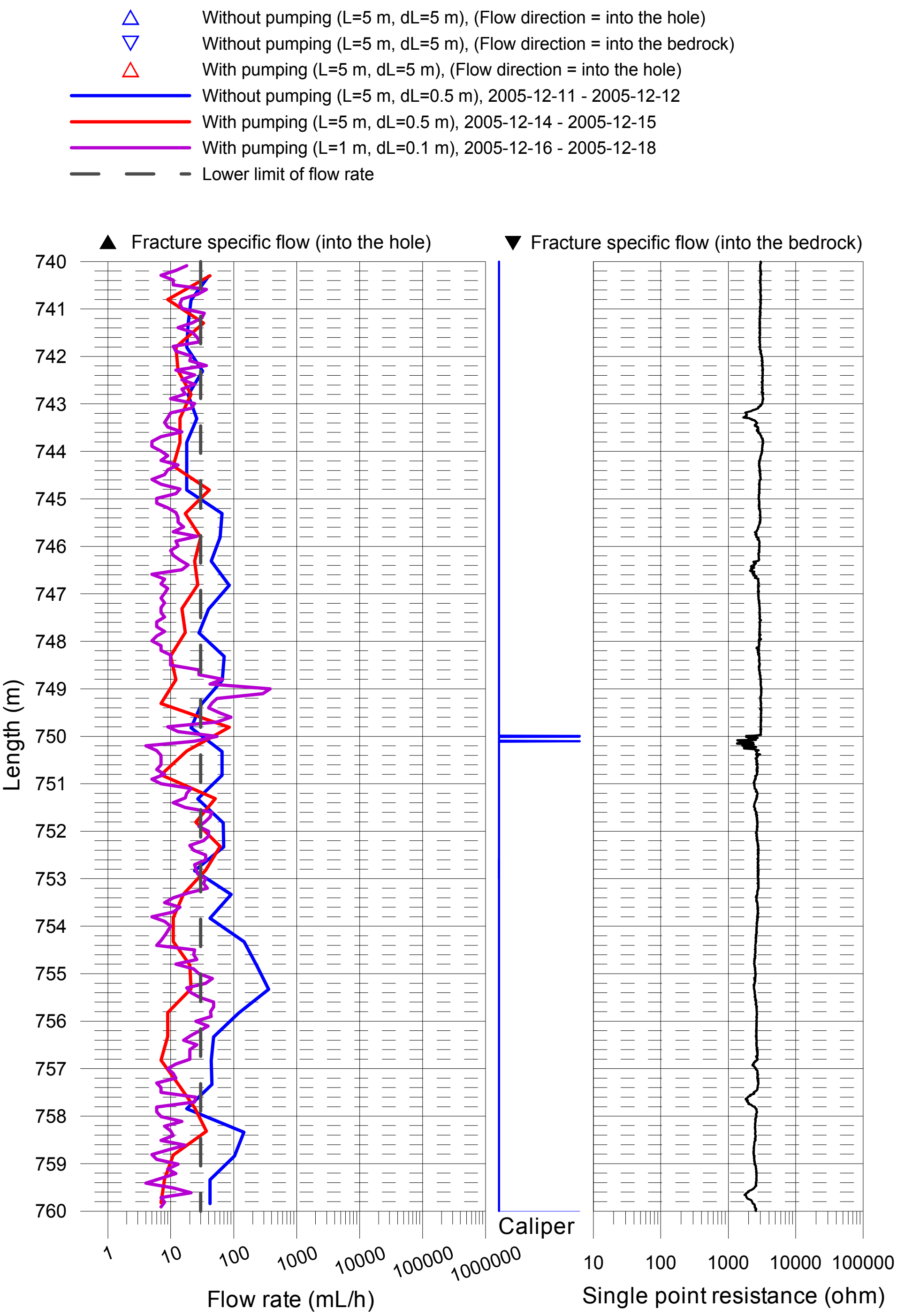
Appendix 3.32

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



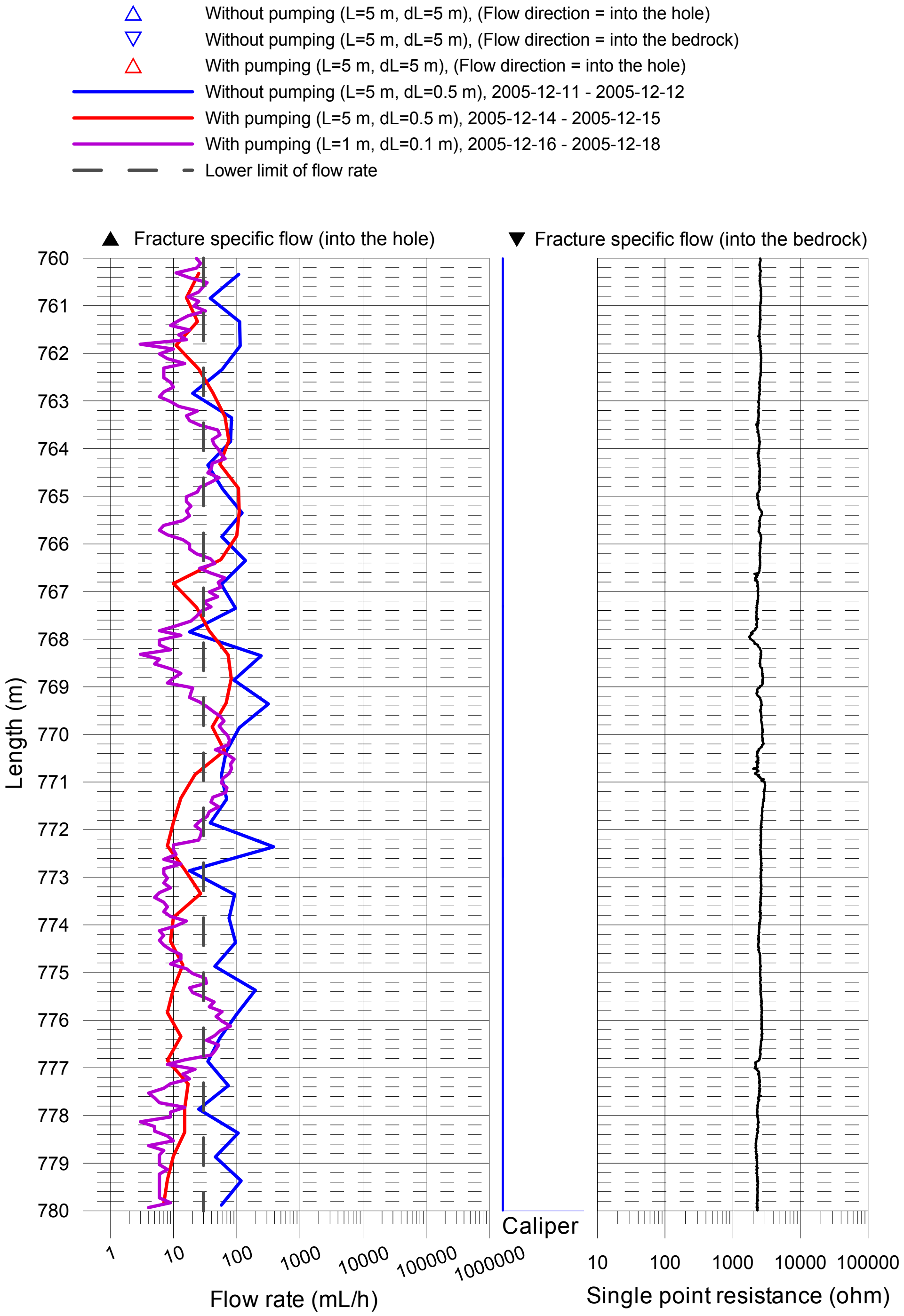
Appendix 3.33

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



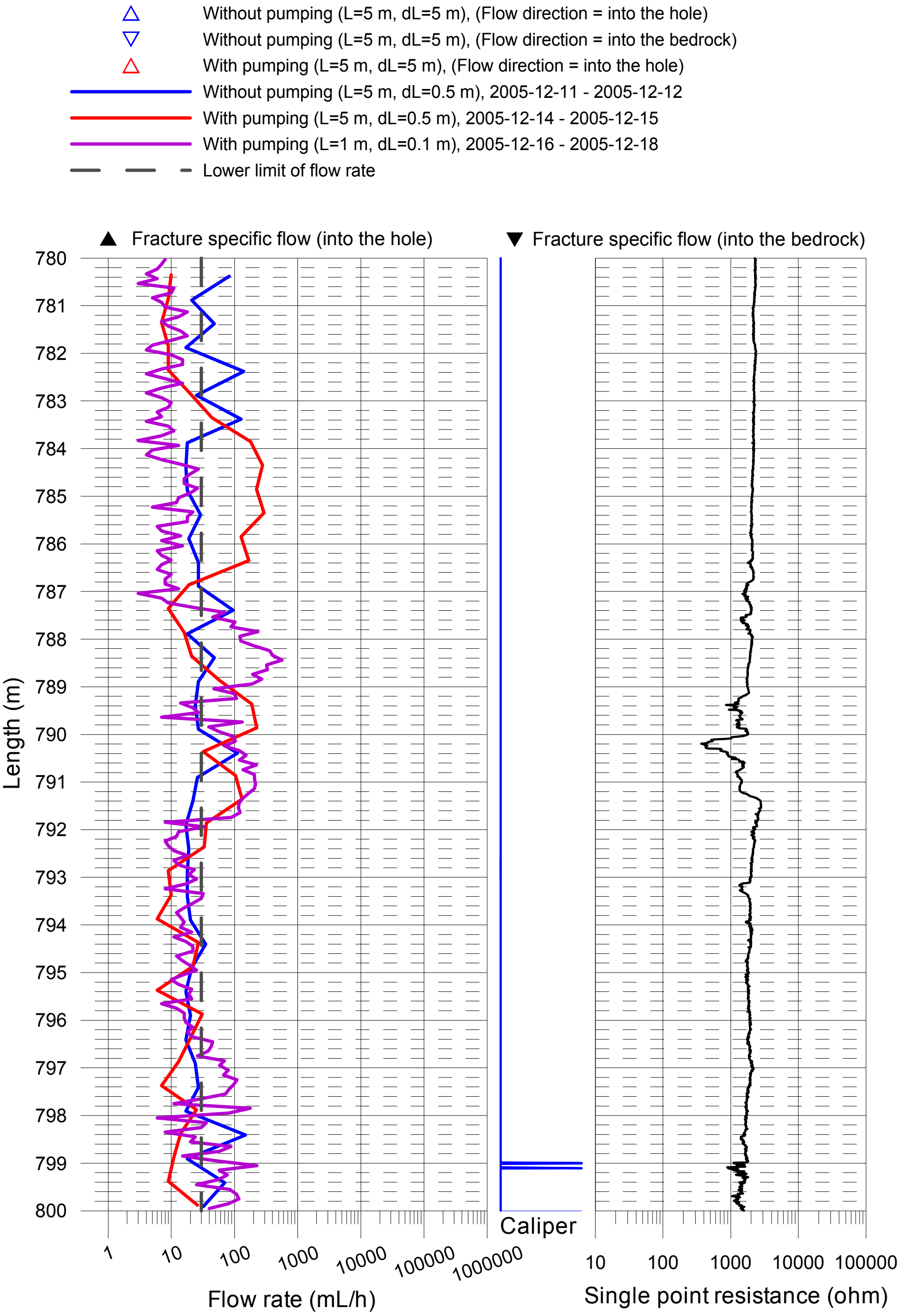
Appendix 3.34

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



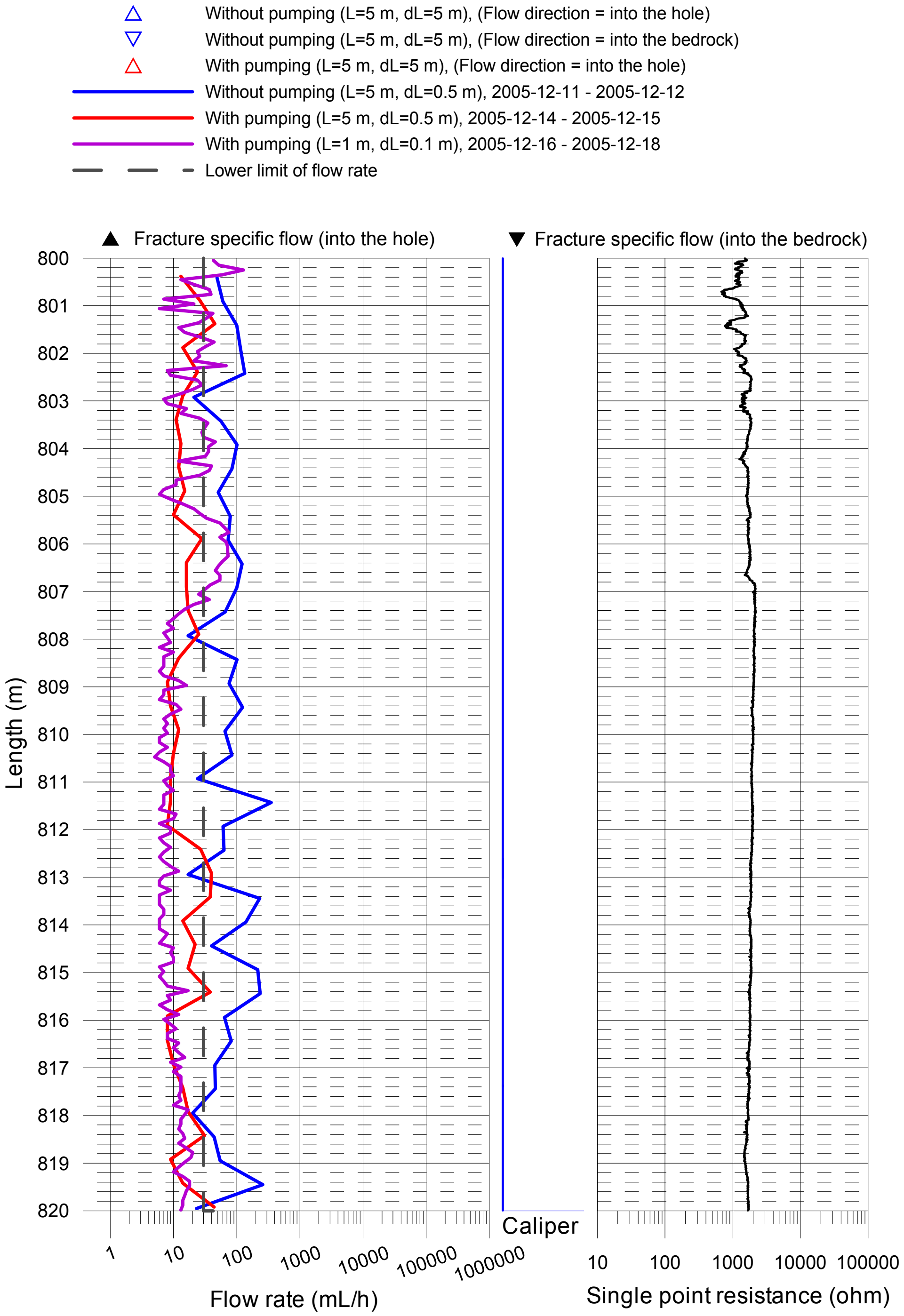
Appendix 3.35

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



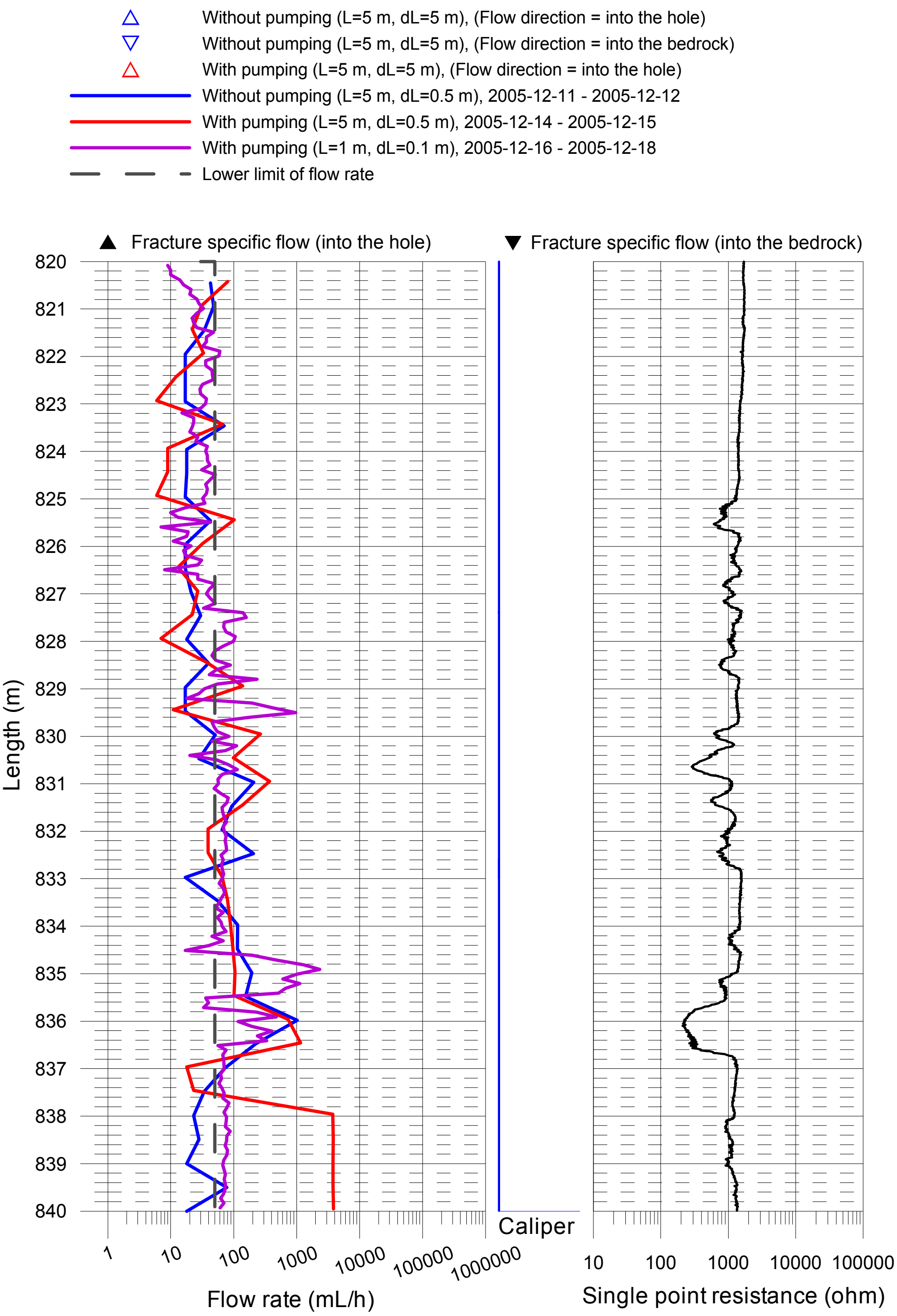
Appendix 3.36

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



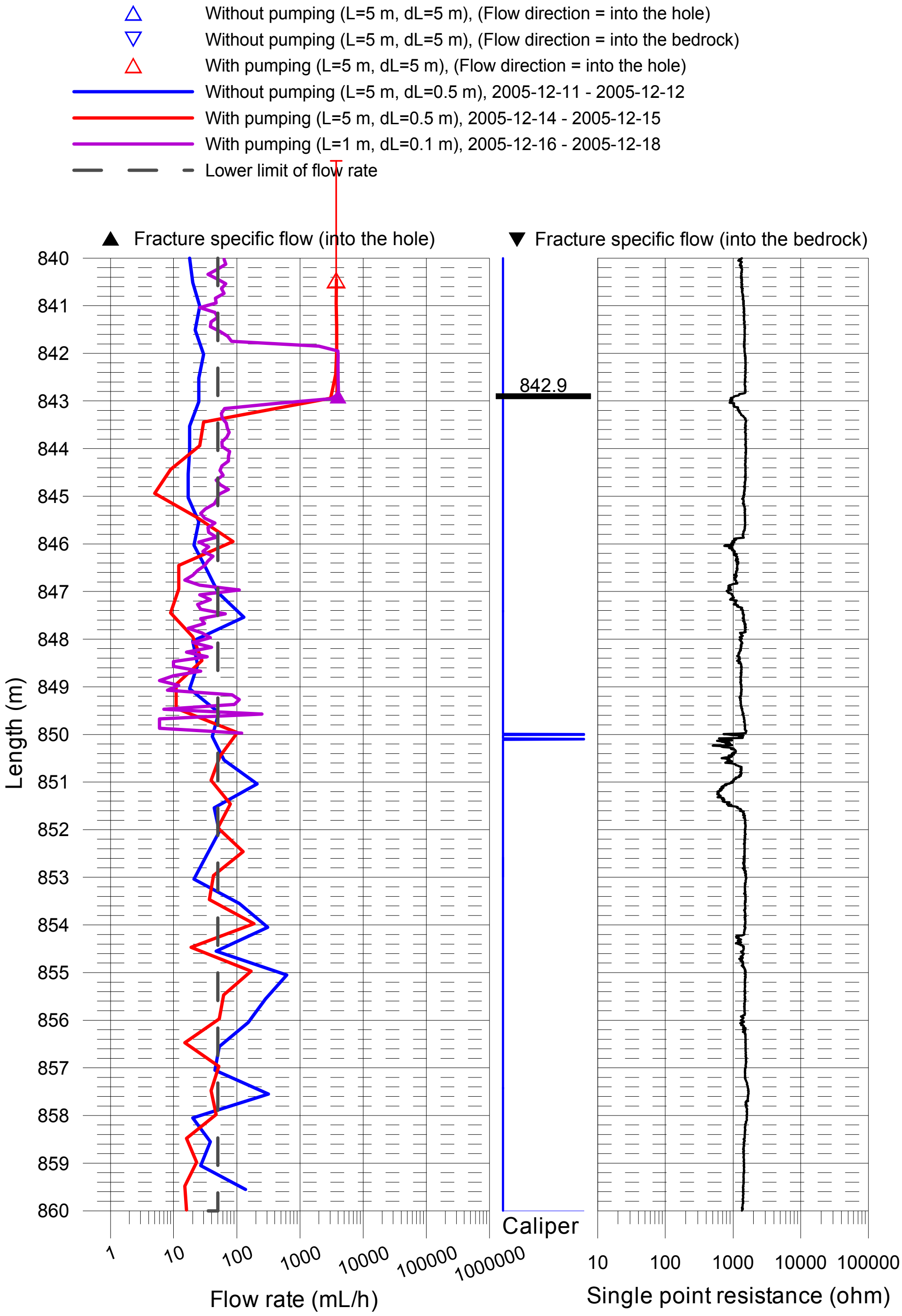
Appendix 3.37

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



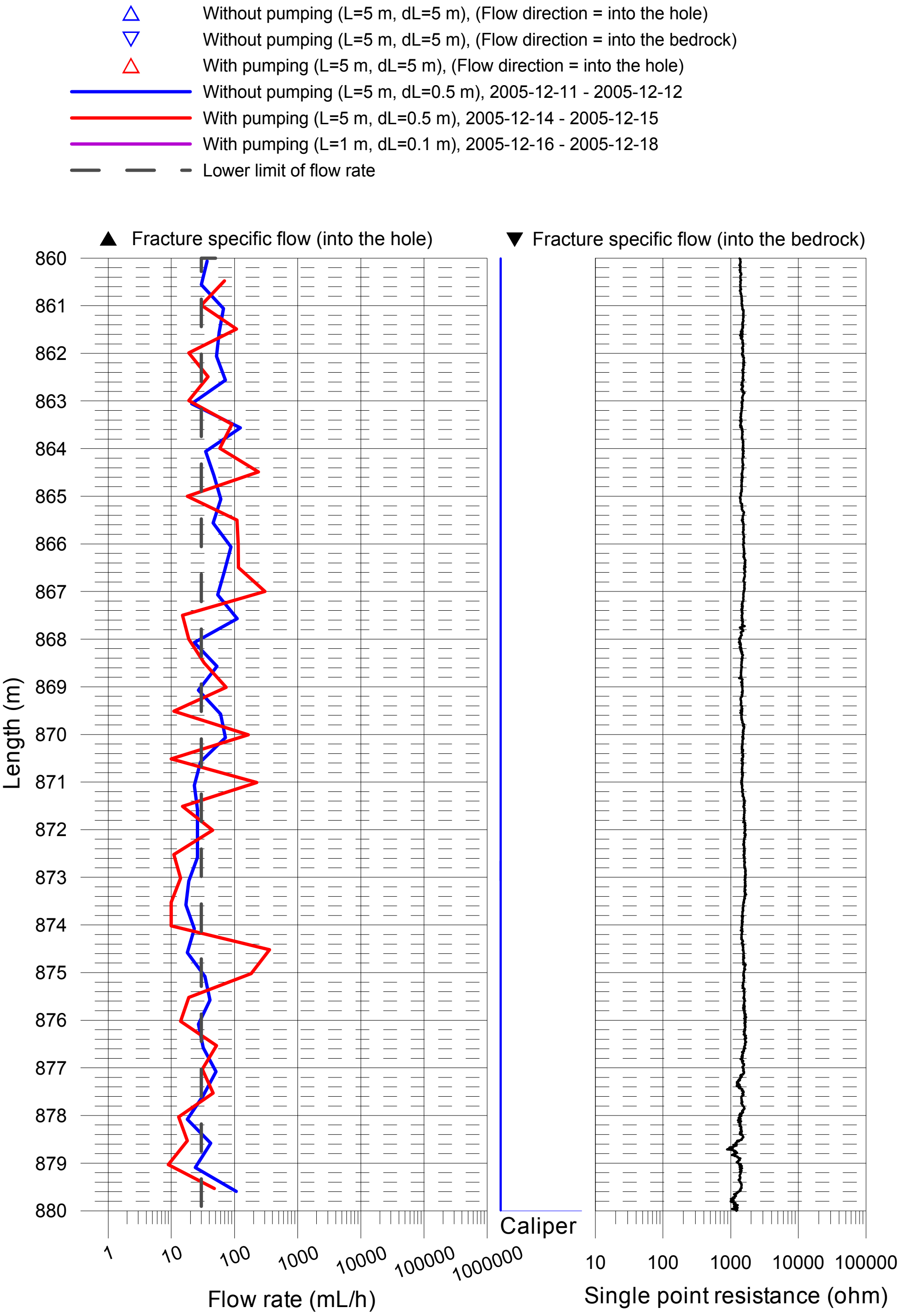
Appendix 3.38

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



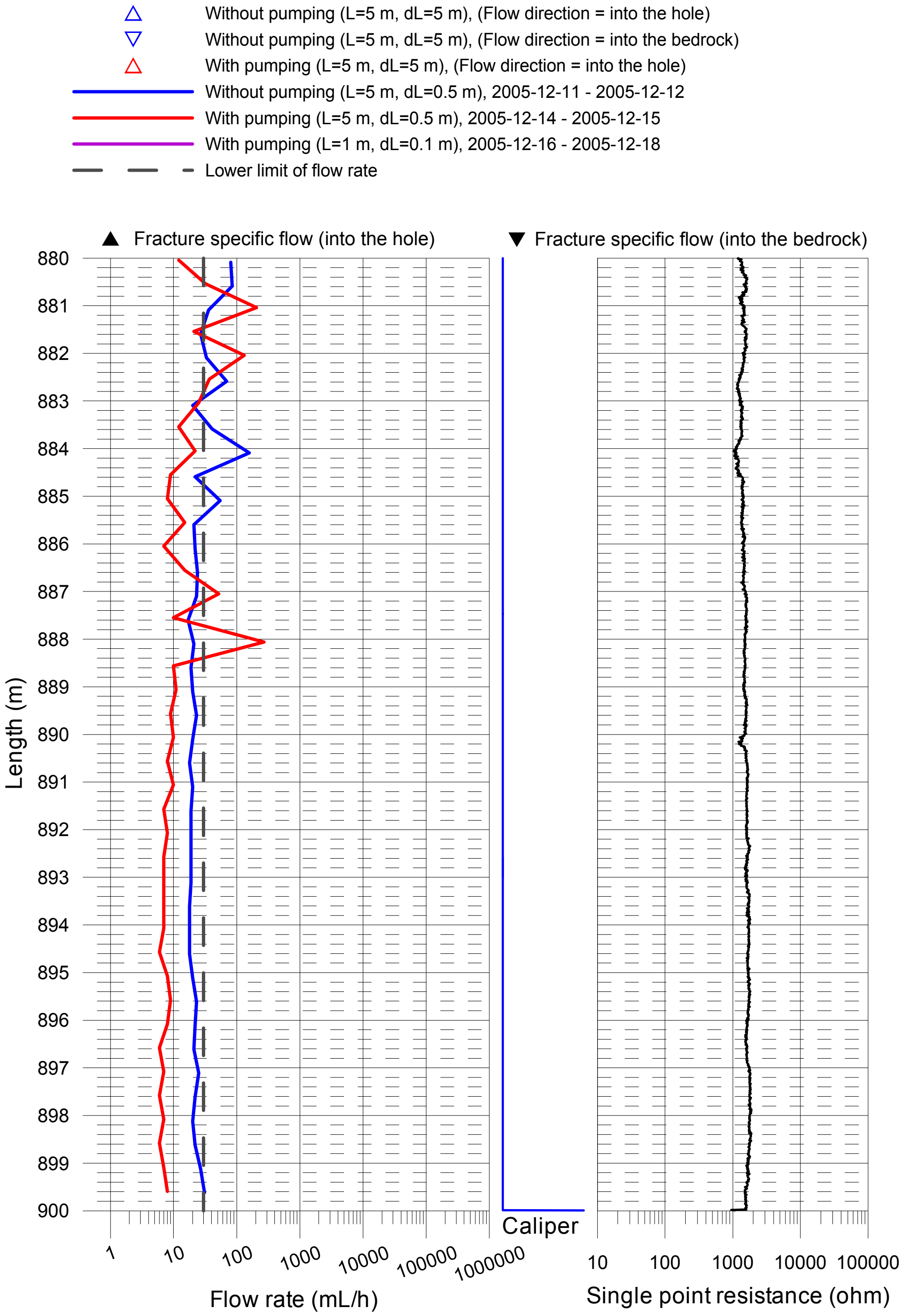
Appendix 3.39

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



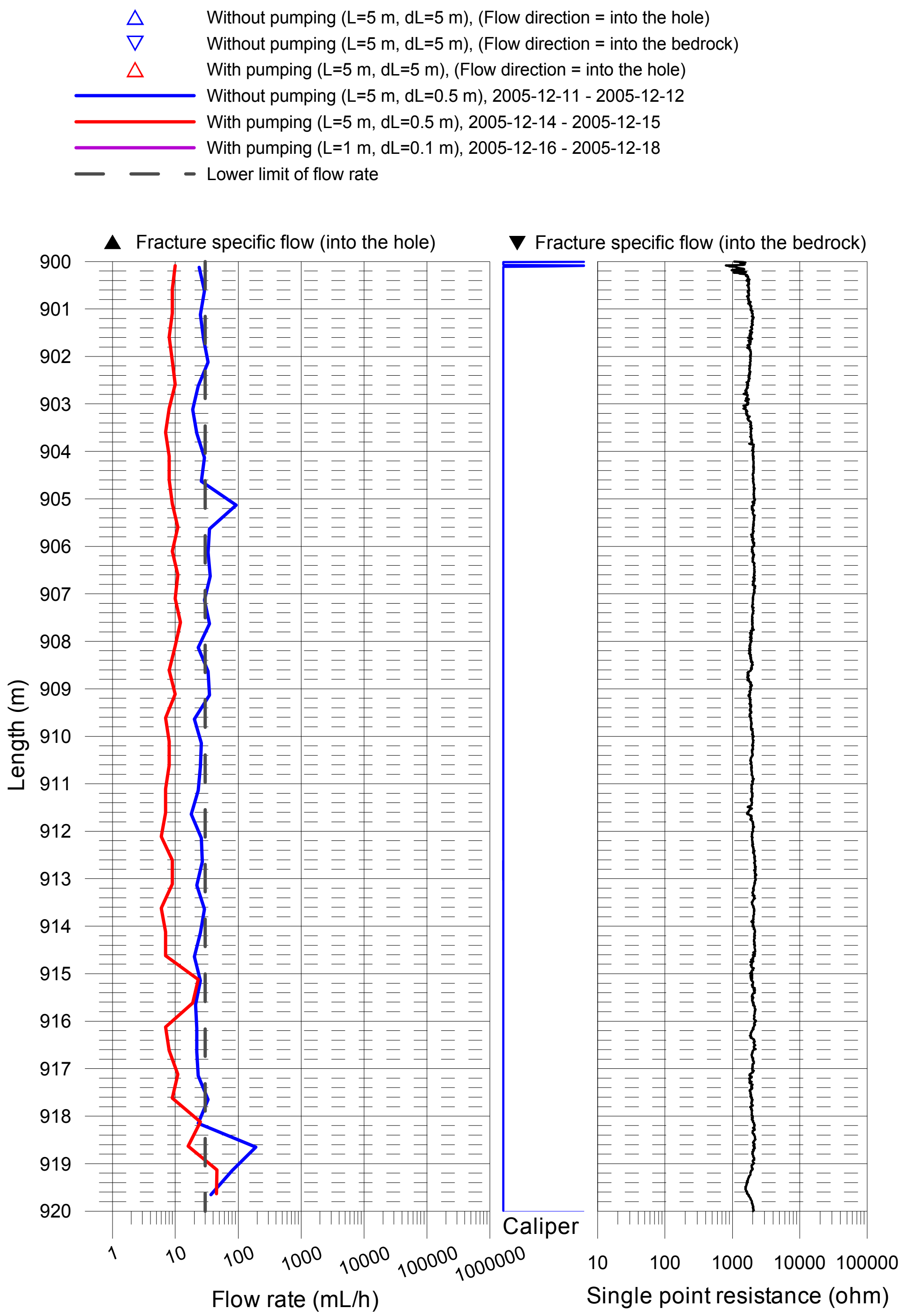
Appendix 3.40

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance

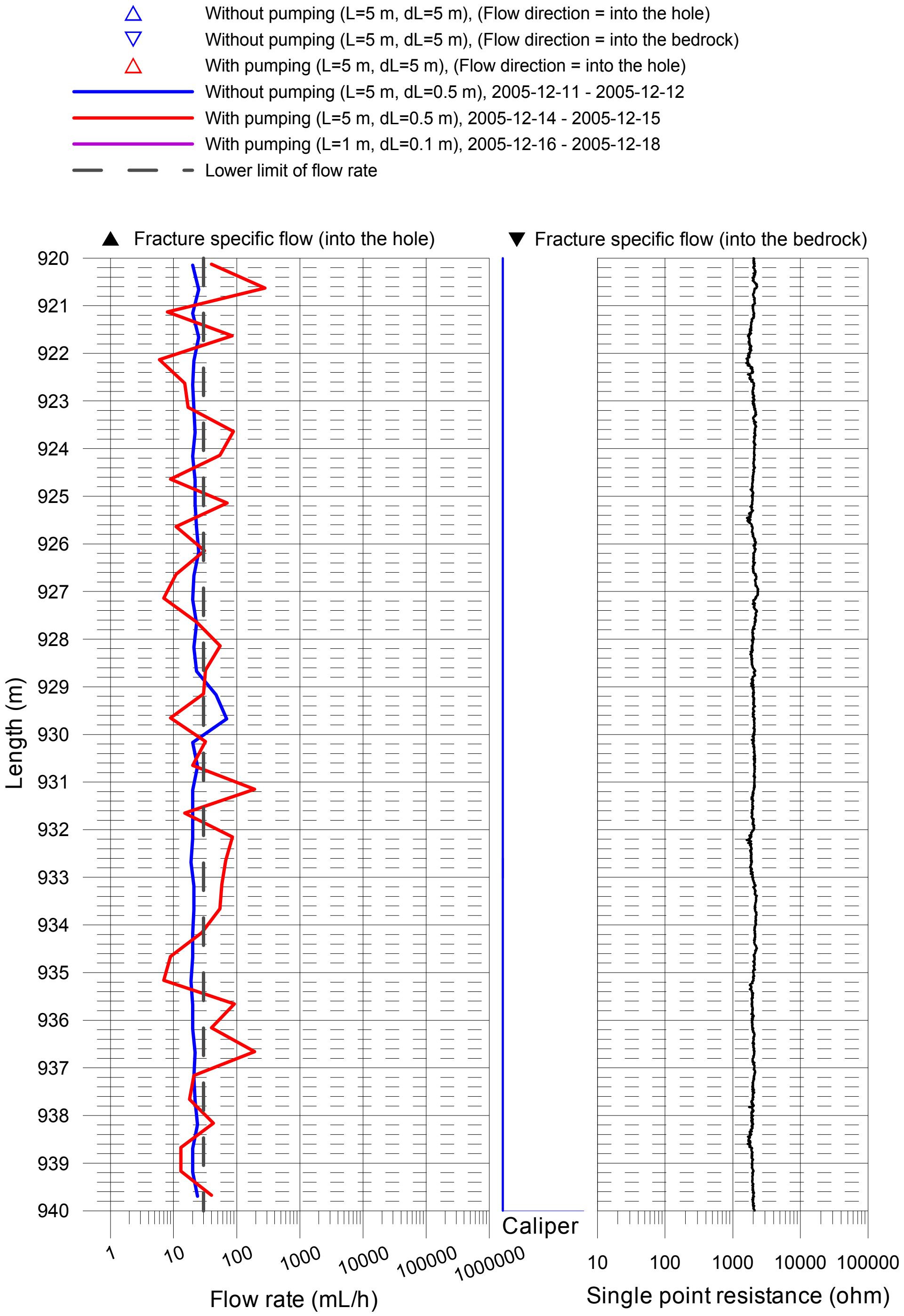


Appendix 3.41

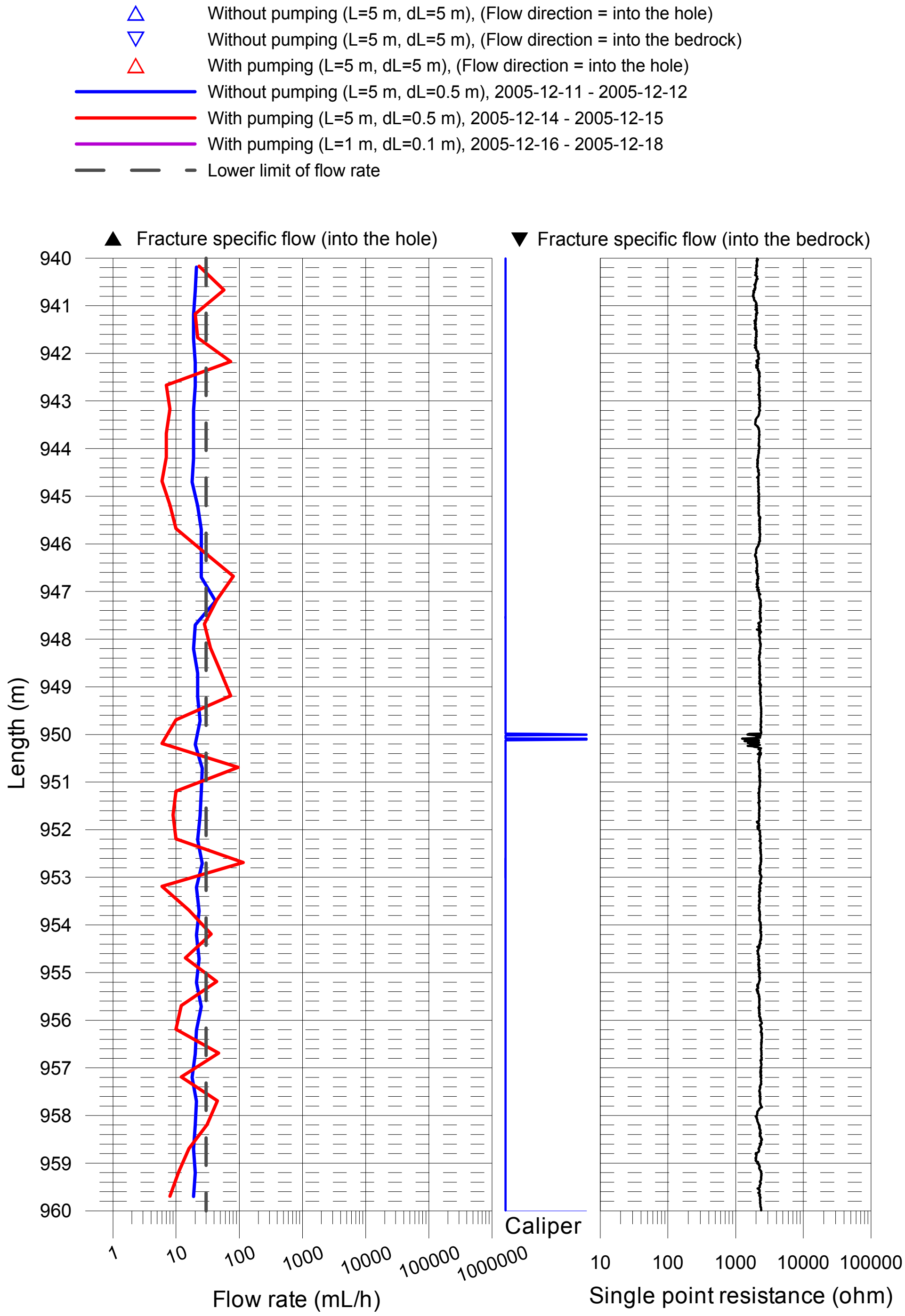
Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



Laxemar, borehole KLX10
Flow rate, caliper and single point resistance

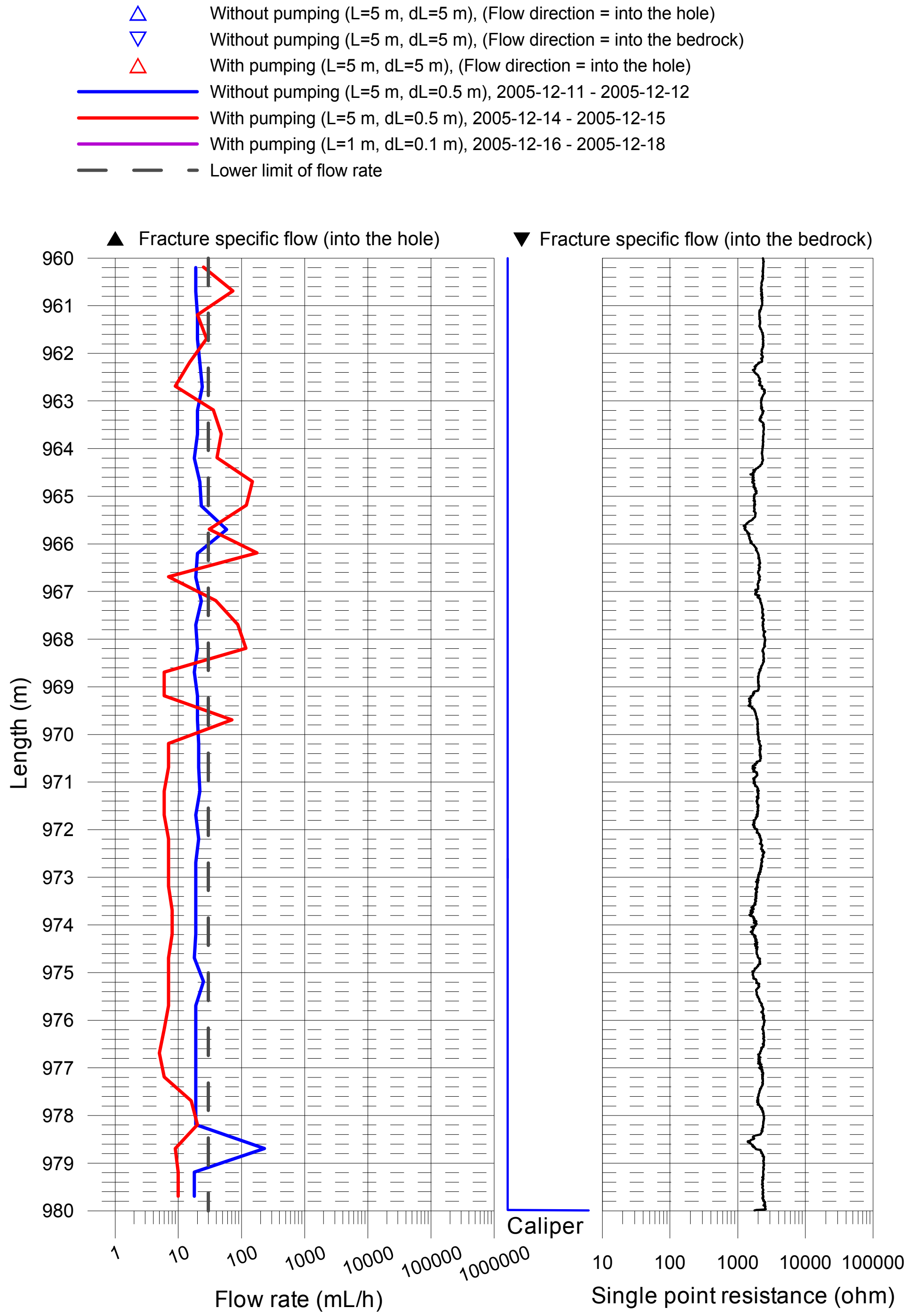


Laxemar, borehole KLX10
Flow rate, caliper and single point resistance



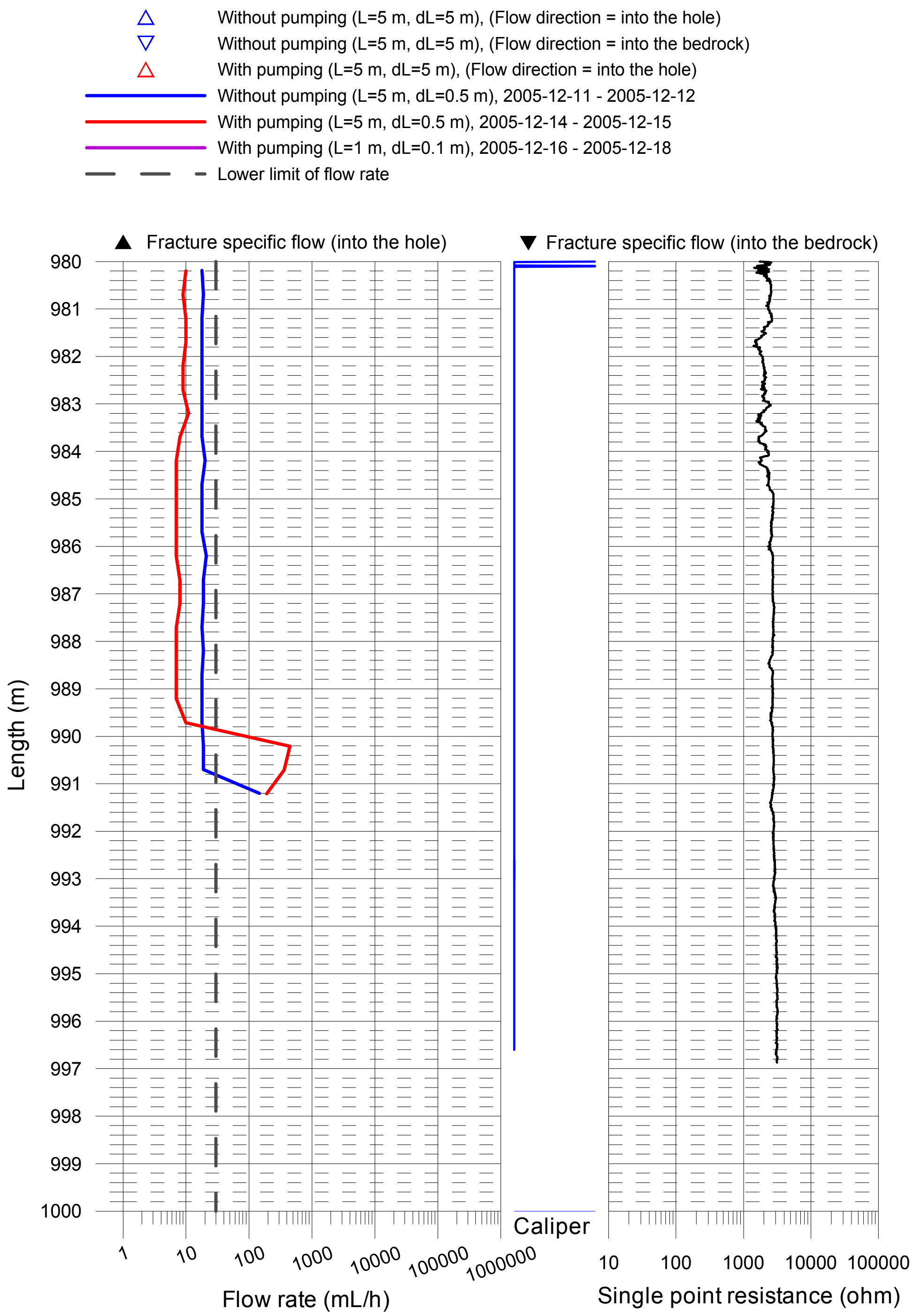
Appendix 3.44

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance

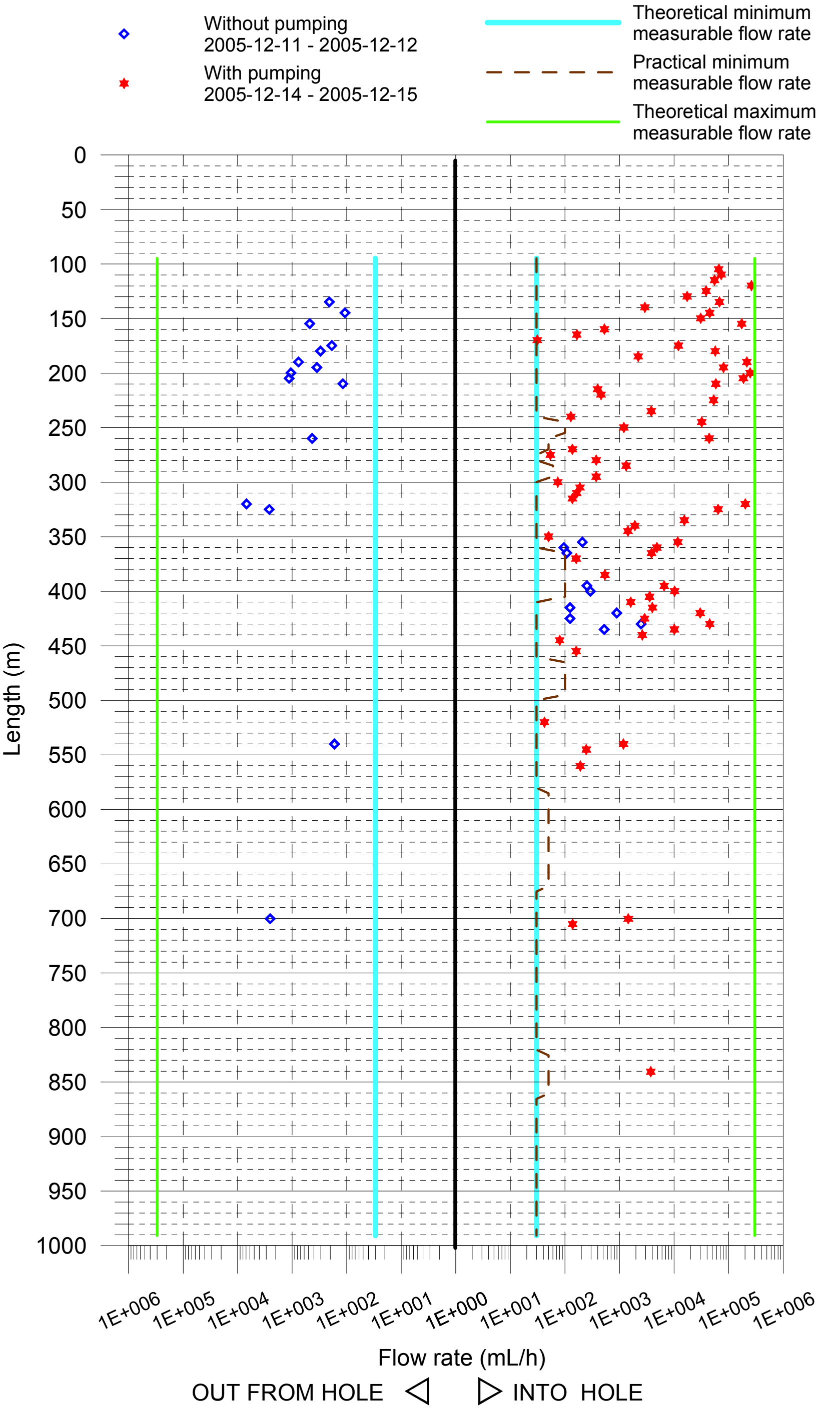


Appendix 3.45

Laxemar, borehole KLX10
Flow rate, caliper and single point resistance

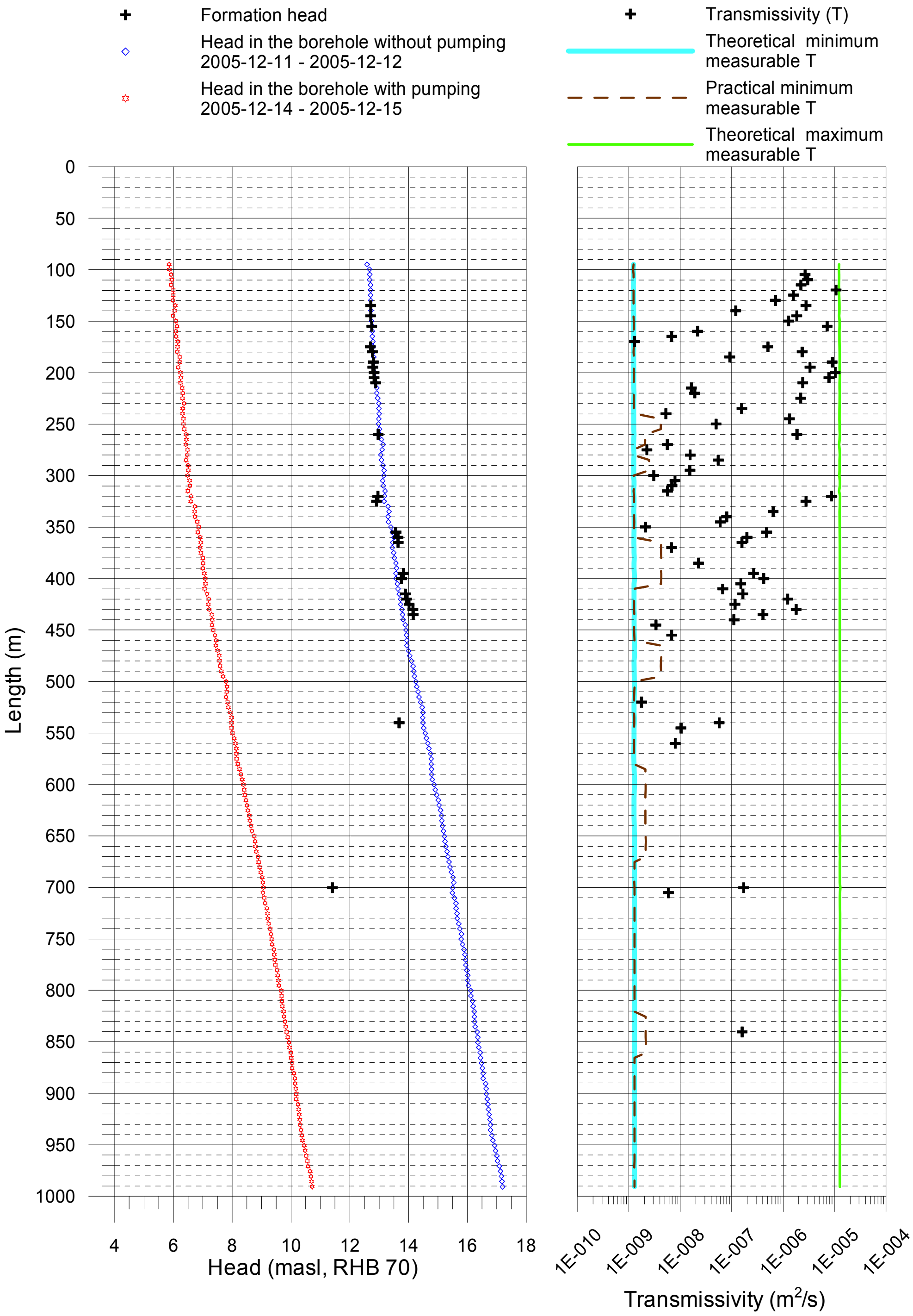


Laxemar, borehole KLX10
Flow rates of 5 m sections



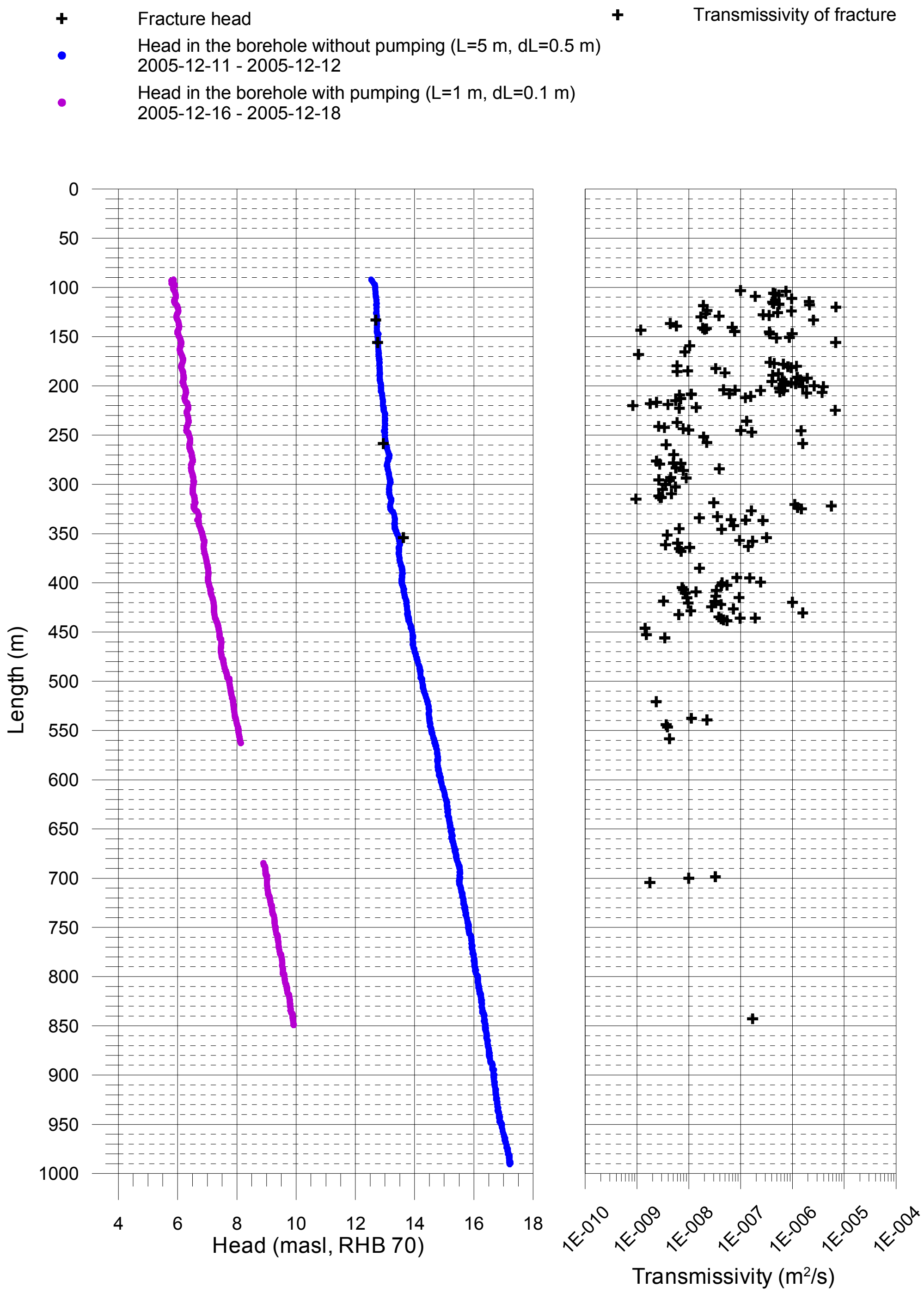
Appendix 4.2

Laxemar, borehole KLX10
Transmissivity and head of 5 m sections



Appendix 5

Laxemar, borehole KLX10
Transmissivity and head of detected fractures



Appendix 6

PFL – DIFFERENCE FLOW LOGGING – Basic test data

Borehole ID	Logged interval Secup (m)	Seclow (m)	Test type (1–6)	Date of test, start YYYYMMDD	Time of test, start hh:mm	Date of flowl., start YYYYMMDD	Time of flowl., start hh:mm	Date of test, stop YYYYMMDD	Time of test, stop hh:mm	L_w (m)	dL (m)	Q_{p1} (m^3/s)	Q_{p2} (m^3/s)
KLX10	92.20	993.21	5A	20051213	15:12	20051214	13:38	20051221	12:25	5	5	1.45E–3	

PFL – DIFFERENCE FLOW LOGGING – Basic test data

t_{p1} (s)	t_{p2} (s)	t_{F1} (s)	t_{F2} (s)	h_0 (m.a.s.l.)	h_1 (m.a.s.l.)	h_2 (m.a.s.l.)	s_1 (m)	s_2 (m)	T Entire hole (m^2/s)	Reference (–)	Comments (–)
681,180		846,600		12.69	5.84		–6.85		2.09E–4		

DIFFERENCE FLOW LOGGING – Sequential flow logging

Borehole ID	Secup L (m)	Seclow L (m)	L_w (m)	Q_0 (m^3/s)	h_{0FW} (m.a.s.l.)	Q_1 (m^3/s)	h_{1FW} (m.a.s.l.)	T_D (m^2/s)	h_i (m.a.s.l.)	Q-lower limit P (mL/h)	T_D-measl$_{LT}$ (m^2/s)	T_D-measl$_{LP}$ (m^2/s)	T_D-measl$_U$ (m^2/s)	Comments
KLX10	92.20	97.20	5	–	12.59	–	5.85	–	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	97.20	102.20	5	–	12.67	–	5.86	–	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	102.20	107.20	5	–	12.68	1.83E–05	5.92	2.7E–06	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	107.20	112.20	5	–	12.68	2.03E–05	5.95	3.0E–06	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	112.19	117.19	5	–	12.71	1.53E–05	5.92	2.2E–06	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	117.19	122.19	5	–	12.71	7.25E–05	6.00	1.1E–05	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	122.18	127.18	5	–	12.71	1.08E–05	6.00	1.6E–06	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	127.19	132.19	5	–	12.71	4.81E–06	5.99	7.1E–07	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	132.20	137.20	5	–5.78E–08	12.73	1.87E–05	6.06	2.8E–06	12.7	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	137.21	142.21	5	–	12.72	8.08E–07	6.04	1.2E–07	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	142.22	147.22	5	–3.00E–08	12.73	1.25E–05	5.99	1.8E–06	12.7	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	147.23	152.23	5	–	12.74	8.56E–06	6.08	1.3E–06	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	152.24	157.24	5	–1.33E–07	12.77	4.81E–05	6.12	7.2E–06	12.8	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	157.24	162.24	5	–	12.77	1.46E–07	6.08	2.2E–08	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	162.25	167.25	5	–	12.77	4.58E–08	6.09	6.8E–09	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	167.25	172.25	5	–	12.79	8.61E–09	6.15	1.3E–09	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	172.25	177.25	5	–5.22E–08	12.80	3.33E–06	6.14	5.0E–07	12.7	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	177.24	182.24	5	–8.44E–08	12.81	1.57E–05	6.13	2.3E–06	12.8	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	182.25	187.25	5	–	12.82	6.11E–07	6.21	9.1E–08	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	187.26	192.26	5	–2.14E–07	12.82	6.00E–05	6.21	9.0E–06	12.8	30	1.2E–09	1.2E–09	1.3E–05	
KLX10	192.27	197.27	5	–9.83E–08	12.82	2.24E–05	6.16	3.3E–06	12.8	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	197.28	202.28	5	–2.94E–07	12.86	6.86E–05	6.24	1.0E–05	12.8	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	202.29	207.29	5	–3.17E–07	12.87	5.17E–05	6.25	7.8E–06	12.8	30	1.2E–09	1.2E–09	1.3E–05	
KLX10	207.30	212.30	5	–3.28E–08	12.89	1.61E–05	6.24	2.4E–06	12.9	30	1.2E–09	1.2E–09	1.2E–05	

Borehole ID	Secup L (m)	Seclow L (m)	L_w (m)	Q_0 (m^3/s)	h_{0FW} (m.a.s.l.)	Q_1 (m^3/s)	h_{1FW} (m.a.s.l.)	T_D (m^2/s)	h_i (m.a.s.l.)	Q-lower limit P (mL/h)	T_D-measl$_{LT}$ (m^2/s)	T_D-measl$_{LP}$ (m^2/s)	T_D-measl$_U$ (m^2/s)	Comments
KLX10	212.30	217.30	5	–	12.92	1.10E–07	6.30	1.6E–08	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	217.29	222.29	5	–	12.92	1.27E–07	6.32	1.9E–08	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	222.29	227.29	5	–	12.95	1.47E–05	6.31	2.2E–06	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	227.30	232.30	5	–	12.99	–	6.36	–	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	232.32	237.32	5	–	12.99	1.06E–06	6.32	1.6E–07	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	237.33	242.33	5	–	13.00	3.56E–08	6.31	5.3E–09	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	242.35	247.35	5	–	12.99	8.89E–06	6.34	1.3E–06	–	100	1.2E–09	4.1E–09	1.2E–05	
KLX10	247.37	252.37	5	–	12.98	3.33E–07	6.34	5.0E–08	–	100	1.2E–09	4.1E–09	1.2E–05	
KLX10	252.38	257.38	5	–	13.01	–	6.37	–	–	100	1.2E–09	4.1E–09	1.2E–05	
KLX10	257.38	262.38	5	–1.19E–07	13.03	1.22E–05	6.43	1.9E–06	13.0	50	1.2E–09	2.1E–09	1.3E–05	
KLX10	262.37	267.37	5	–	13.08	–	6.44	–	–	50	1.2E–09	2.1E–09	1.2E–05	
KLX10	267.37	272.37	5	–	13.14	3.81E–08	6.42	5.6E–09	–	50	1.2E–09	2.0E–09	1.2E–05	
KLX10	272.37	277.37	5	–	13.10	1.50E–08	6.48	2.2E–09	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	277.37	282.37	5	–	13.06	1.04E–07	6.47	1.6E–08	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	282.37	287.37	5	–	13.08	3.67E–07	6.43	5.5E–08	–	60	1.2E–09	2.5E–09	1.2E–05	
KLX10	287.38	292.38	5	–	13.13	–	6.50	–	–	60	1.2E–09	2.5E–09	1.2E–05	
KLX10	292.38	297.38	5	–	13.17	1.04E–07	6.51	1.5E–08	–	60	1.2E–09	2.5E–09	1.2E–05	
KLX10	297.39	302.39	5	–	13.16	2.06E–08	6.48	3.0E–09	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	302.40	307.40	5	–	13.12	5.22E–08	6.55	7.9E–09	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	307.40	312.40	5	–	13.14	4.56E–08	6.56	6.8E–09	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	312.40	317.40	5	–	13.20	3.81E–08	6.49	5.6E–09	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	317.40	322.40	5	–1.91E–06	13.18	5.61E–05	6.60	8.7E–06	13.0	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	322.40	327.40	5	–7.31E–07	13.17	1.78E–05	6.59	2.8E–06	12.9	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	327.40	332.40	5	–	13.30	–	6.73	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	332.40	337.40	5	–	13.34	4.28E–06	6.72	6.4E–07	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	337.40	342.40	5	–	13.30	5.28E–07	6.73	7.9E–08	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	342.40	347.40	5	–	13.31	3.94E–07	6.81	6.0E–08	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	347.40	352.40	5	–	13.40	1.39E–08	6.86	2.1E–09	–	30	1.3E–09	1.3E–09	1.3E–05	

Borehole ID	Secup L (m)	Seclow L (m)	L_w (m)	Q_0 (m^3/s)	h_{0FW} (m.a.s.l.)	Q_1 (m^3/s)	h_{1FW} (m.a.s.l.)	T_D (m^2/s)	h_i (m.a.s.l.)	Q-lower limit P (mL/h)	T_D-measl$_{LT}$ (m^2/s)	T_D-measl$_{LP}$ (m^2/s)	T_D-measl$_U$ (m^2/s)	Comments
KLX10	352.41	357.41	5	5.78E–08	13.45	3.25E–06	6.83	4.8E–07	13.6	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	357.42	362.42	5	2.64E–08	13.51	1.34E–06	6.91	2.0E–07	13.6	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	362.43	367.43	5	3.00E–08	13.46	1.07E–06	6.93	1.6E–07	13.7	100	1.3E–09	4.2E–09	1.3E–05	
KLX10	367.44	372.44	5	–	13.45	4.44E–08	6.91	6.7E–09	–	100	1.3E–09	4.2E–09	1.3E–05	
KLX10	372.45	377.45	5	–	13.49	–	6.93	–	–	100	1.3E–09	4.2E–09	1.3E–05	
KLX10	377.46	382.46	5	–	13.52	–	7.00	–	–	100	1.3E–09	4.2E–09	1.3E–05	
KLX10	382.47	387.47	5	–	13.57	1.50E–07	7.01	2.3E–08	–	100	1.3E–09	4.2E–09	1.3E–05	
KLX10	387.48	392.48	5	–	13.59	–	7.00	–	–	100	1.3E–09	4.2E–09	1.3E–05	
KLX10	392.48	397.48	5	7.00E–08	13.57	1.83E–06	7.05	2.7E–07	13.8	100	1.3E–09	4.2E–09	1.3E–05	
KLX10	397.49	402.49	5	8.11E–08	13.57	2.83E–06	7.08	4.2E–07	13.8	100	1.3E–09	4.2E–09	1.3E–05	
KLX10	402.49	407.49	5	–	13.62	9.86E–07	7.09	1.5E–07	–	100	1.3E–09	4.2E–09	1.3E–05	
KLX10	407.49	412.49	5	–	13.64	4.44E–07	7.06	6.7E–08	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	412.49	417.49	5	3.42E–08	13.68	1.11E–06	7.14	1.6E–07	13.9	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	417.48	422.48	5	2.46E–07	13.73	8.33E–06	7.20	1.2E–06	13.9	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	422.48	427.48	5	3.42E–08	13.73	7.97E–07	7.19	1.2E–07	14.0	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	427.48	432.48	5	6.89E–07	13.77	1.25E–05	7.22	1.8E–06	14.2	30	1.3E–09	1.3E–09	1.2E–05	
KLX10	432.48	437.48	5	1.46E–07	13.80	2.81E–06	7.30	4.0E–07	14.2	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	437.48	442.48	5	–	13.82	7.28E–07	7.32	1.1E–07	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	442.49	447.49	5	–	13.89	2.22E–08	7.31	3.3E–09	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	447.49	452.49	5	–	13.91	–	7.35	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	452.49	457.49	5	–	13.93	4.47E–08	7.41	6.8E–09	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	457.49	462.49	5	–	13.94	–	7.45	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	462.50	467.50	5	–	13.94	–	7.44	–	–	100	1.3E–09	4.2E–09	1.3E–05	
KLX10	467.50	472.50	5	–	14.00	–	7.50	–	–	100	1.3E–09	4.2E–09	1.3E–05	
KLX10	472.51	477.51	5	–	14.04	–	7.56	–	–	100	1.3E–09	4.2E–09	1.3E–05	
KLX10	477.51	482.51	5	–	14.10	–	7.57	–	–	100	1.3E–09	4.2E–09	1.3E–05	
KLX10	482.52	487.52	5	–	14.16	–	7.59	–	–	100	1.3E–09	4.2E–09	1.3E–05	
KLX10	487.52	492.52	5	–	14.18	–	7.63	–	–	100	1.3E–09	4.2E–09	1.3E–05	

Borehole ID	Secup L (m)	Seclow L (m)	L_w (m)	Q_0 (m^3/s)	h_{0FW} (m.a.s.l.)	Q_1 (m^3/s)	h_{1FW} (m.a.s.l.)	T_D (m^2/s)	h_i (m.a.s.l.)	Q-lower limit P (mL/h)	T_D-measl_{LT} (m^2/s)	T_D-measl_{LP} (m^2/s)	T_D-measl_U (m^2/s)	Comments
KLX10	492.53	497.53	5	–	14.20	–	7.69	–	–	100	1.3E–09	4.2E–09	1.3E–05	
KLX10	497.53	502.53	5	–	14.25	–	7.79	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	502.54	507.54	5	–	14.28	–	7.82	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	507.55	512.55	5	–	14.32	–	7.81	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	512.56	517.56	5	–	14.36	–	7.79	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	517.56	522.56	5	–	14.41	1.17E–08	7.84	1.8E–09	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	522.57	527.57	5	–	14.47	–	7.87	–	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	527.58	532.58	5	–	14.49	–	7.94	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	532.59	537.59	5	–	14.48	–	7.98	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	537.60	542.60	5	–4.67E–08	14.49	3.28E–07	7.98	5.7E–08	13.7	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	542.61	547.61	5	–	14.52	6.83E–08	7.98	1.0E–08	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	547.62	552.62	5	–	14.57	–	8.01	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	552.63	557.63	5	–	14.61	–	8.07	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	557.63	562.63	5	–	14.66	5.28E–08	8.11	8.0E–09	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	562.64	567.64	5	–	14.69	–	8.14	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	567.64	572.64	5	–	14.75	–	8.14	–	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	572.65	577.65	5	–	14.77	–	8.15	–	–	30	1.2E–09	1.2E–09	1.2E–05	
KLX10	577.65	582.65	5	–	14.77	–	8.19	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	582.66	587.66	5	–	14.78	–	8.25	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	587.67	592.67	5	–	14.78	–	8.30	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	592.67	597.67	5	–	14.81	–	8.34	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	597.68	602.68	5	–	14.87	–	8.38	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	602.68	607.68	5	–	14.91	–	8.41	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	607.69	612.69	5	–	14.96	–	8.43	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	612.69	617.69	5	–	15.01	–	8.47	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	617.69	622.69	5	–	15.04	–	8.50	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	622.69	627.69	5	–	15.09	–	8.53	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	627.69	632.69	5	–	15.12	–	8.58	–	–	50	1.3E–09	2.1E–09	1.3E–05	

Borehole ID	Secup L (m)	Seclow L (m)	L_w (m)	Q_0 (m^3/s)	h_{0FW} (m.a.s.l.)	Q_1 (m^3/s)	h_{1FW} (m.a.s.l.)	T_D (m^2/s)	h_i (m.a.s.l.)	Q-lower limit P (mL/h)	T_D-measl$_{LT}$ (m^2/s)	T_D-measl$_{LP}$ (m^2/s)	T_D-measl$_U$ (m^2/s)	Comments
KLX10	632.70	637.70	5	–	15.13	–	8.60	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	637.71	642.71	5	–	15.15	–	8.64	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	642.71	647.71	5	–	15.19	–	8.67	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	647.71	652.71	5	–	15.22	–	8.75	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	652.72	657.72	5	–	15.24	–	8.78	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	657.72	662.72	5	–	15.27	–	8.79	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	662.72	667.72	5	–	15.31	–	8.82	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	667.73	672.73	5	–	15.34	–	8.88	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	672.73	677.73	5	–	15.38	–	8.90	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	677.74	682.74	5	–	15.41	–	8.93	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	682.74	687.74	5	–	15.46	–	8.97	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	687.74	692.74	5	–	15.51	–	9.02	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	692.75	697.75	5	–	15.54	–	9.04	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	697.75	702.75	5	–7.03E–07	15.50	4.03E–07	9.06	1.7E–07	11.4	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	702.78	707.78	5	–	15.49	3.83E–08	9.04	5.9E–09	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	707.80	712.80	5	–	15.57	–	9.09	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	712.80	717.80	5	–	15.61	–	9.12	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	717.80	722.80	5	–	15.62	–	9.18	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	722.81	727.81	5	–	15.65	–	9.20	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	727.81	732.81	5	–	15.66	–	9.21	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	732.81	737.81	5	–	15.71	–	9.24	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	737.81	742.81	5	–	15.75	–	9.29	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	742.81	747.81	5	–	15.80	–	9.32	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	747.82	752.82	5	–	15.79	–	9.34	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	752.83	757.83	5	–	15.84	–	9.36	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	757.83	762.83	5	–	15.89	–	9.42	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	762.84	767.84	5	–	15.92	–	9.43	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	767.84	772.84	5	–	15.94	–	9.45	–	–	30	1.3E–09	1.3E–09	1.3E–05	

Borehole ID	Secup L (m)	Seclow L (m)	L_w (m)	Q_0 (m^3/s)	h_{0FW} (m.a.s.l.)	Q_1 (m^3/s)	h_{1FW} (m.a.s.l.)	T_D (m^2/s)	h_i (m.a.s.l.)	Q-lower limit P (mL/h)	T_D-measl$_{LT}$ (m^2/s)	T_D-measl$_{LP}$ (m^2/s)	T_D-measl$_U$ (m^2/s)	Comments
KLX10	772.85	777.85	5	–	15.95	–	9.47	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	777.86	782.86	5	–	15.99	–	9.53	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	782.87	787.87	5	–	16.02	–	9.55	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	787.88	792.88	5	–	16.02	–	9.57	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	792.88	797.88	5	–	16.04	–	9.59	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	797.90	802.90	5	–	16.12	–	9.67	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	802.91	807.91	5	–	16.12	–	9.68	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	807.92	812.92	5	–	16.18	–	9.69	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	812.93	817.93	5	–	16.20	–	9.71	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	817.94	822.94	5	–	16.24	–	9.75	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	822.94	827.94	5	–	16.24	–	9.76	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	827.95	832.95	5	–	16.25	–	9.80	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	832.96	837.96	5	–	16.27	–	9.82	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	837.98	842.98	5	–	16.33	1.04E–06	9.85	1.6E–07	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	842.98	847.98	5	–	16.36	–	9.89	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	848.00	853.00	5	–	16.36	–	9.93	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	853.00	858.00	5	–	16.39	–	9.95	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	858.02	863.02	5	–	16.44	–	10.00	–	–	50	1.3E–09	2.1E–09	1.3E–05	
KLX10	863.03	868.03	5	–	16.45	–	10.01	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	868.04	873.04	5	–	16.48	–	10.04	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	873.05	878.05	5	–	16.51	–	10.04	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	878.06	883.06	5	–	16.54	–	10.10	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	883.07	888.07	5	–	16.54	–	10.13	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	888.08	893.08	5	–	16.62	–	10.14	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	893.09	898.09	5	–	16.64	–	10.16	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	898.10	903.10	5	–	16.65	–	10.18	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	903.11	908.11	5	–	16.68	–	10.18	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	908.12	913.12	5	–	16.70	–	10.24	–	–	30	1.3E–09	1.3E–09	1.3E–05	

Borehole ID	Secup L (m)	Seclow L (m)	L_w (m)	Q_0 (m^3/s)	h_{0FW} (m.a.s.l.)	Q_1 (m^3/s)	h_{1FW} (m.a.s.l.)	T_D (m^2/s)	h_i (m.a.s.l.)	Q-lower limit P (mL/h)	T_D-measl$_{LT}$ (m^2/s)	T_D-measl$_{LP}$ (m^2/s)	T_D-measl$_U$ (m^2/s)	Comments
KLX10	913.13	918.13	5	–	16.72	–	10.26	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	918.14	923.14	5	–	16.75	–	10.28	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	923.15	928.15	5	–	16.77	–	10.30	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	928.16	933.16	5	–	16.79	–	10.31	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	933.17	938.17	5	–	16.79	–	10.34	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	938.18	943.18	5	–	16.84	–	10.37	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	943.19	948.19	5	–	16.87	–	10.39	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	948.19	953.19	5	–	16.93	–	10.45	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	953.20	958.20	5	–	16.96	–	10.48	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	958.20	963.20	5	–	17.01	–	10.52	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	963.20	968.20	5	–	17.03	–	10.56	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	968.20	973.20	5	–	17.09	–	10.58	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	973.19	978.19	5	–	17.13	–	10.65	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	978.19	983.19	5	–	17.16	–	10.68	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	983.20	988.20	5	–	17.18	–	10.70	–	–	30	1.3E–09	1.3E–09	1.3E–05	
KLX10	988.21	993.21	5	–	17.20	–	10.72	–	–	30	1.3E–09	1.3E–09	1.3E–05	

Appendix 8

PFL – DIFFERENCE FLOW LOGGING – Inferred flow anomalies from overlapping flow logging

Borehole ID	Length to flow anom. L (m)	L_w (m)	dL (m)	Q_0 (m³/s)	h_{0FW} (m.a.s.l.)	Q_1 (m³/s)	h_{1FW} (m.a.s.l.)	T_D (m²/s)	h_i (m.a.s.l.)	Comments
KLX10	103.2	1	0.1	–	12.67	6.83E–07	5.88	1.0E–07	–	*
KLX10	104.0	1	0.1	–	12.67	5.14E–06	5.90	7.5E–07	–	
KLX10	105.9	1	0.1	–	12.68	2.92E–06	5.93	4.3E–07	–	
KLX10	106.5	1	0.1	–	12.67	3.17E–06	5.92	4.6E–07	–	*
KLX10	107.7	1	0.1	–	12.69	3.69E–06	5.93	5.4E–07	–	*
KLX10	109.1	1	0.1	–	12.70	1.31E–06	5.94	1.9E–07	–	*
KLX10	111.4	1	0.1	–	12.70	6.64E–06	5.92	9.7E–07	–	
KLX10	112.8	1	0.1	–	12.72	3.22E–06	5.89	4.7E–07	–	*
KLX10	114.3	1	0.1	–	12.71	1.45E–05	5.89	2.1E–06	–	
KLX10	115.1	1	0.1	–	12.71	2.83E–06	5.90	4.1E–07	–	*
KLX10	116.5	1	0.1	–	12.72	3.00E–06	5.91	4.4E–07	–	*
KLX10	117.0	1	0.1	–	12.71	3.75E–06	5.95	5.5E–07	–	
KLX10	117.7	1	0.1	–	12.69	1.46E–05	5.96	2.1E–06	–	
KLX10	118.3	1	0.1	–	12.71	1.31E–07	5.97	1.9E–08	–	*
KLX10	119.9	1	0.1	–	12.71	4.67E–05	6.00	6.9E–06	–	
KLX10	123.4	1	0.1	–	12.71	1.52E–07	6.03	2.3E–08	–	*
KLX10	124.0	1	0.1	–	12.71	6.44E–06	6.03	9.5E–07	–	
KLX10	125.5	1	0.1	–	12.70	3.50E–06	6.01	5.2E–07	–	
KLX10	126.8	1	0.1	–	12.72	1.45E–07	5.98	2.1E–08	–	
KLX10	127.7	1	0.1	–	12.71	1.85E–06	5.96	2.7E–07	–	
KLX10	128.4	1	0.1	–	12.72	2.42E–06	5.97	3.5E–07	–	
KLX10	129.0	1	0.1	–	12.73	2.63E–07	5.97	3.9E–08	–	*
KLX10	129.9	1	0.1	–	12.71	1.16E–07	5.96	1.7E–08	–	
KLX10	133.1	1	0.1	–8.58E–08	12.72	1.72E–05	6.00	2.5E–06	12.7	
KLX10	136.7	1	0.1	–	12.73	3.00E–08	6.03	4.4E–09	–	*
KLX10	139.3	1	0.1	–	12.73	3.92E–08	6.05	5.8E–09	–	*
KLX10	140.4	1	0.1	–	12.72	4.64E–07	6.05	6.9E–08	–	
KLX10	141.2	1	0.1	–	12.71	1.25E–07	6.04	1.9E–08	–	*
KLX10	141.9	1	0.1	–	12.72	1.47E–07	6.04	2.2E–08	–	*
KLX10	142.6	1	0.1	–	12.73	1.37E–07	6.03	2.0E–08	–	
KLX10	143.3	1	0.1	–	12.72	8.06E–09	6.02	1.2E–09	–	*
KLX10	144.8	1	0.1	–	12.74	5.22E–07	6.00	7.7E–08	–	*
KLX10	145.3	1	0.1	–	12.71	2.43E–06	6.00	3.6E–07	–	*
KLX10	146.8	1	0.1	–	12.77	6.72E–06	6.03	9.9E–07	–	
KLX10	147.1	1	0.1	–	12.78	2.52E–06	6.02	3.7E–07	–	*
KLX10	150.7	1	0.1	–	12.76	5.89E–06	6.07	8.7E–07	–	*
KLX10	151.5	1	0.1	–	12.76	3.33E–06	6.07	4.9E–07	–	*
KLX10	155.8	1	0.1	–1.51E–07	12.77	4.56E–05	6.13	6.8E–06	12.8	
KLX10	159.1	1	0.1	–	12.77	7.03E–08	6.11	1.0E–08	–	*
KLX10	165.5	1	0.1	–	12.78	5.67E–08	6.09	8.4E–09	–	*
KLX10	168.0	1	0.1	–	12.78	7.22E–09	6.12	1.1E–09	–	*
KLX10	176.1	1	0.1	–	12.82	2.48E–06	6.16	3.7E–07	–	
KLX10	177.1	1	0.1	–	12.81	3.00E–06	6.15	4.5E–07	–	*
KLX10	177.9	1	0.1	–	12.81	4.50E–06	6.14	6.7E–07	–	

Borehole ID	Length to flow anom. L (m)	L_w (m)	dL (m)	Q_0 (m^3/s)	h_{0FW} (m.a.s.l.)	Q_1 (m^3/s)	h_{1FW} (m.a.s.l.)	T_D (m^2/s)	h_i (m.a.s.l.)	Comments
KLX10	179.6	1	0.1	–	12.82	4.03E–08	6.13	6.0E–09	–	*
KLX10	180.0	1	0.1	–	12.82	8.06E–06	6.12	1.2E–06	–	
KLX10	180.6	1	0.1	–	12.82	5.56E–06	6.12	8.2E–07	–	*
KLX10	181.5	1	0.1	–	12.81	6.39E–06	6.13	9.5E–07	–	
KLX10	182.4	1	0.1	–	12.82	2.24E–07	6.13	3.3E–08	–	
KLX10	184.9	1	0.1	–	12.83	6.42E–08	6.18	9.5E–09	–	*
KLX10	185.4	1	0.1	–	12.82	4.00E–08	6.17	6.0E–09	–	*
KLX10	186.7	1	0.1	–	12.81	3.36E–07	6.19	5.0E–08	–	
KLX10	187.7	1	0.1	–	12.83	3.61E–06	6.18	5.4E–07	–	
KLX10	189.1	1	0.1	–	12.81	2.78E–06	6.19	4.2E–07	–	*
KLX10	191.4	1	0.1	–	12.83	8.31E–06	6.21	1.2E–06	–	
KLX10	192.2	1	0.1	–	12.83	1.30E–05	6.20	1.9E–06	–	
KLX10	193.7	1	0.1	–	12.83	4.25E–06	6.20	6.3E–07	–	*
KLX10	194.2	1	0.1	–	12.82	9.61E–06	6.19	1.4E–06	–	
KLX10	195.5	1	0.1	–	12.83	2.71E–06	6.16	4.0E–07	–	*
KLX10	195.9	1	0.1	–	12.84	4.67E–06	6.17	6.9E–07	–	*
KLX10	196.8	1	0.1	–	12.85	6.42E–06	6.19	9.5E–07	–	*
KLX10	197.8	1	0.1	–	12.86	7.78E–06	6.19	1.2E–06	–	*
KLX10	199.2	1	0.1	–	12.86	4.72E–06	6.20	7.0E–07	–	*
KLX10	199.9	1	0.1	–	12.87	1.76E–05	6.21	2.6E–06	–	
KLX10	200.7	1	0.1	–	12.86	1.06E–05	6.24	1.6E–06	–	*
KLX10	200.9	1	0.1	–	12.86	2.64E–05	6.24	3.9E–06	–	*
KLX10	202.1	1	0.1	–	12.86	3.69E–06	6.26	5.5E–07	–	*
KLX10	202.9	1	0.1	–	12.87	3.97E–06	6.26	5.9E–07	–	
KLX10	204.0	1	0.1	–	12.86	3.11E–07	6.28	4.7E–08	–	*
KLX10	204.3	1	0.1	–	12.88	5.22E–07	6.27	7.8E–08	–	
KLX10	204.6	1	0.1	–	12.88	1.61E–06	6.28	2.4E–07	–	
KLX10	204.9	1	0.1	–	12.87	4.50E–06	6.27	6.7E–07	–	
KLX10	206.1	1	0.1	–	12.86	3.83E–06	6.28	5.8E–07	–	*
KLX10	206.7	1	0.1	–	12.88	2.48E–05	6.29	3.7E–06	–	
KLX10	207.4	1	0.1	–	12.90	1.26E–05	6.28	1.9E–06	–	
KLX10	207.9	1	0.1	–	12.90	4.06E–07	6.27	6.1E–08	–	
KLX10	208.3	1	0.1	–	12.90	7.44E–08	6.27	1.1E–08	–	*
KLX10	208.6	1	0.1	–	12.90	7.58E–08	6.27	1.1E–08	–	*
KLX10	209.3	1	0.1	–	12.89	4.44E–08	6.26	6.6E–09	–	
KLX10	210.6	1	0.1	–	12.90	1.05E–06	6.25	1.6E–07	–	
KLX10	212.1	1	0.1	–	12.91	8.31E–07	6.24	1.2E–07	–	
KLX10	213.0	1	0.1	–	12.92	4.72E–08	6.23	7.0E–09	–	
KLX10	215.1	1	0.1	–	12.93	3.78E–08	6.25	5.6E–09	–	
KLX10	216.6	1	0.1	–	12.92	1.61E–08	6.28	2.4E–09	–	*
KLX10	218.1	1	0.1	–	12.92	1.19E–08	6.34	1.8E–09	–	*
KLX10	218.9	1	0.1	–	12.92	2.64E–08	6.34	4.0E–09	–	
KLX10	219.9	1	0.1	–	12.92	5.56E–09	6.35	8.4E–10	–	*
KLX10	221.9	1	0.1	–	12.96	9.25E–08	6.36	1.4E–08	–	
KLX10	222.6	1	0.1	–	12.95	4.39E–08	6.36	6.6E–09	–	*
KLX10	224.8	1	0.1	–	12.96	4.47E–05	6.33	6.7E–06	–	*
KLX10	235.7	1	0.1	–	13.00	8.78E–07	6.37	1.3E–07	–	
KLX10	237.2	1	0.1	–	13.00	4.00E–08	6.35	6.0E–09	–	

Borehole ID	Length to flow anom. L (m)	L_w (m)	dL (m)	Q_0 (m^3/s)	h_{0FW} (m.a.s.l.)	Q_1 (m^3/s)	h_{1FW} (m.a.s.l.)	T_D (m^2/s)	h_i (m.a.s.l.)	Comments
KLX10	241.1	1	0.1	–	12.99	1.78E–08	6.31	2.6E–09	–	*
KLX10	242.3	1	0.1	–	12.99	2.31E–08	6.30	3.4E–09	–	*
KLX10	243.5	1	0.1	–	13.00	5.28E–08	6.29	7.8E–09	–	
KLX10	244.7	1	0.1	–	12.99	6.78E–08	6.29	1.0E–08	–	*
KLX10	245.3	1	0.1	–	12.97	6.86E–07	6.28	1.0E–07	–	*
KLX10	245.6	1	0.1	–	12.96	9.94E–06	6.29	1.5E–06	–	
KLX10	247.0	1	0.1	–	13.00	1.10E–06	6.35	1.6E–07	–	*
KLX10	251.9	1	0.1	–	12.99	1.29E–07	6.41	1.9E–08	–	*
KLX10	257.6	1	0.1	–	13.02	1.49E–07	6.41	2.2E–08	–	
KLX10	258.6	1	0.1	–1.35E–07	13.02	1.04E–05	6.42	1.6E–06	12.9	
KLX10	259.7	1	0.1	–	13.03	2.44E–08	6.40	3.7E–09	–	*
KLX10	269.8	1	0.1	–	13.14	3.47E–08	6.47	5.2E–09	–	*
KLX10	276.4	1	0.1	–	13.09	1.58E–08	6.51	2.4E–09	–	
KLX10	278.1	1	0.1	–	13.08	3.36E–08	6.48	5.0E–09	–	
KLX10	278.9	1	0.1	–	13.07	4.69E–08	6.47	7.0E–09	–	
KLX10	279.5	1	0.1	–	13.06	1.83E–08	6.47	2.8E–09	–	*
KLX10	283.3	1	0.1	–	13.08	3.78E–08	6.44	5.6E–09	–	
KLX10	284.2	1	0.1	–	13.09	2.61E–07	6.45	3.9E–08	–	
KLX10	286.0	1	0.1	–	13.10	5.25E–08	6.46	7.8E–09	–	
KLX10	293.0	1	0.1	–	13.15	3.00E–08	6.54	4.5E–09	–	*
KLX10	293.6	1	0.1	–	13.16	6.00E–08	6.53	9.0E–09	–	
KLX10	295.6	1	0.1	–	13.19	1.78E–08	6.53	2.6E–09	–	*
KLX10	296.3	1	0.1	–	13.16	2.83E–08	6.53	4.2E–09	–	*
KLX10	300.0	1	0.1	–	13.16	2.39E–08	6.53	3.6E–09	–	*
KLX10	302.5	1	0.1	–	13.14	3.69E–08	6.52	5.5E–09	–	
KLX10	305.1	1	0.1	–	13.12	2.08E–08	6.51	3.1E–09	–	
KLX10	309.7	1	0.1	–	13.15	3.08E–08	6.53	4.6E–09	–	*
KLX10	311.7	1	0.1	–	13.17	1.78E–08	6.56	2.7E–09	–	*
KLX10	313.2	1	0.1	–	13.17	1.97E–08	6.57	3.0E–09	–	*
KLX10	313.5	1	0.1	–	13.19	1.89E–08	6.57	2.8E–09	–	*
KLX10	314.8	1	0.1	–	13.21	6.39E–09	6.57	9.5E–10	–	*
KLX10	318.7	1	0.1	–	13.19	2.03E–07	6.59	3.0E–08	–	*
KLX10	320.4	1	0.1	–	13.17	7.39E–06	6.57	1.1E–06	–	
KLX10	322.0	1	0.1	–	13.18	3.78E–05	6.54	5.6E–06	–	
KLX10	323.5	1	0.1	–	13.17	8.44E–06	6.54	1.3E–06	–	*
KLX10	324.9	1	0.1	–	13.17	9.97E–06	6.56	1.5E–06	–	
KLX10	326.8	1	0.1	–	13.22	1.08E–06	6.60	1.6E–07	–	*
KLX10	332.7	1	0.1	–	13.32	2.38E–07	6.72	3.6E–08	–	
KLX10	334.1	1	0.1	–	13.32	1.07E–07	6.69	1.6E–08	–	*
KLX10	335.8	1	0.1	–	13.34	4.42E–07	6.67	6.6E–08	–	*
KLX10	336.2	1	0.1	–	13.33	8.47E–07	6.65	1.3E–07	–	*
KLX10	336.7	1	0.1	–	13.32	1.81E–06	6.67	2.7E–07	–	
KLX10	341.8	1	0.1	–	13.32	4.92E–07	6.73	7.4E–08	–	
KLX10	345.0	1	0.1	–	13.32	4.33E–08	6.77	6.5E–09	–	
KLX10	345.6	1	0.1	–	13.35	2.86E–07	6.78	4.3E–08	–	
KLX10	351.4	1	0.1	–	13.43	2.56E–08	6.84	3.8E–09	–	*
KLX10	354.1	1	0.1	4.56E–08	13.48	2.16E–06	6.86	3.2E–07	13.6	
KLX10	356.9	1	0.1	–	13.49	6.39E–07	6.89	9.6E–08	–	
KLX10	357.7	1	0.1	–	13.48	1.14E–06	6.91	1.7E–07	–	
KLX10	359.8	1	0.1	–	13.52	4.08E–08	6.89	6.1E–09	–	
KLX10	361.5	1	0.1	–	13.51	2.39E–08	6.88	3.6E–09	–	*

Borehole ID	Length to flow anom. L (m)	L_w (m)	dL (m)	Q_0 (m^3/s)	h_{0FW} (m.a.s.l.)	Q_1 (m^3/s)	h_{1FW} (m.a.s.l.)	T_D (m^2/s)	h_i (m.a.s.l.)	Comments
KLX10	363.0	1	0.1	–	13.49	9.39E–07	6.87	1.4E–07	–	
KLX10	364.0	1	0.1	–	13.48	6.94E–08	6.88	1.0E–08	–	
KLX10	365.2	1	0.1	–	13.48	4.39E–08	6.88	6.6E–09	–	*
KLX10	368.0	1	0.1	–	13.48	4.72E–08	6.90	7.1E–09	–	*
KLX10	385.2	1	0.1	–	13.57	1.07E–07	7.03	1.6E–08	–	
KLX10	394.7	1	0.1	–	13.58	5.58E–07	7.02	8.4E–08	–	
KLX10	395.2	1	0.1	–	13.57	9.92E–07	7.03	1.5E–07	–	
KLX10	399.3	1	0.1	–	13.55	1.60E–06	7.04	2.4E–07	–	
KLX10	400.0	1	0.1	–	13.57	2.89E–07	7.05	4.4E–08	–	
KLX10	402.4	1	0.1	–	13.59	3.58E–07	7.07	5.4E–08	–	
KLX10	402.7	1	0.1	–	13.60	2.81E–07	7.06	4.2E–08	–	
KLX10	404.8	1	0.1	–	13.61	4.94E–08	7.08	7.5E–09	–	
KLX10	407.2	1	0.1	–	13.62	5.22E–08	7.10	7.9E–09	–	*
KLX10	407.9	1	0.1	–	13.63	2.26E–07	7.10	3.4E–08	–	
KLX10	409.2	1	0.1	–	13.62	9.06E–08	7.11	1.4E–08	–	*
KLX10	410.5	1	0.1	–	13.65	5.64E–08	7.12	8.5E–09	–	*
KLX10	413.6	1	0.1	–	13.67	2.18E–07	7.15	3.3E–08	–	
KLX10	414.8	1	0.1	–	13.67	6.14E–07	7.18	9.4E–08	–	
KLX10	415.2	1	0.1	–	13.69	6.08E–08	7.17	9.2E–09	–	*
KLX10	418.5	1	0.1	–	13.72	2.14E–08	7.20	3.3E–09	–	*
KLX10	418.9	1	0.1	–	13.73	2.09E–07	7.21	3.2E–08	–	
KLX10	419.9	1	0.1	–	13.73	6.61E–06	7.21	1.0E–06	–	
KLX10	420.5	1	0.1	–	13.73	6.44E–08	7.22	9.8E–09	–	
KLX10	422.0	1	0.1	–	13.72	2.74E–07	7.22	4.2E–08	–	
KLX10	424.2	1	0.1	–	13.75	1.81E–07	7.22	2.8E–08	–	
KLX10	426.6	1	0.1	–	13.75	4.78E–07	7.23	7.3E–08	–	
KLX10	428.5	1	0.1	–	13.75	7.28E–08	7.23	1.1E–08	–	
KLX10	430.5	1	0.1	–	13.75	1.04E–05	7.24	1.6E–06	–	
KLX10	432.3	1	0.1	–	13.76	4.22E–08	7.24	6.4E–09	–	
KLX10	434.7	1	0.1	–	13.79	2.51E–07	7.26	3.8E–08	–	
KLX10	435.8	1	0.1	–	13.78	1.26E–06	7.26	1.9E–07	–	
KLX10	436.0	1	0.1	–	13.77	6.44E–07	7.25	9.8E–08	–	*
KLX10	436.4	1	0.1	–	13.78	2.77E–07	7.27	4.2E–08	–	
KLX10	437.7	1	0.1	–	13.81	3.08E–07	7.30	4.7E–08	–	
KLX10	438.5	1	0.1	–	13.78	3.56E–07	7.31	5.4E–08	–	
KLX10	446.1	1	0.1	–	13.87	9.44E–09	7.38	1.4E–09	–	
KLX10	452.8	1	0.1	–	13.92	1.00E–08	7.42	1.5E–09	–	*
KLX10	456.0	1	0.1	–	13.95	2.28E–08	7.43	3.5E–09	–	
KLX10	520.8	1	0.1	–	14.44	1.56E–08	7.88	2.4E–09	–	*
KLX10	537.7	1	0.1	–	14.51	7.50E–08	7.96	1.1E–08	–	
KLX10	539.2	1	0.1	–	14.50	1.49E–07	7.97	2.3E–08	–	
KLX10	544.2	1	0.1	–	14.53	2.42E–08	8.00	3.7E–09	–	
KLX10	546.4	1	0.1	–	14.54	2.56E–08	8.03	3.9E–09	–	
KLX10	558.4	1	0.1	–	14.66	2.81E–08	8.10	4.2E–09	–	
KLX10	698.5	1	0.1	–	15.52	2.15E–07	9.00	3.3E–08	–	*
KLX10	700.0	1	0.1	–	15.51	6.56E–08	9.02	1.0E–08	–	*
KLX10	704.4	1	0.1	–	15.49	1.17E–08	9.01	1.8E–09	–	*
KLX10	842.9	1	0.1	–	16.34	1.12E–06	9.89	1.7E–07	–	

* Uncertain = The flow rate is less than 30 mL/h or the flow anomalies are overlapping or they are unclear because of noise.

Appendix 9

EXPLANATIONS

Header	Unit	Explanations
Borehole		ID for borehole.
Secup	m	Length along the borehole for the upper limit of the test section (based on corrected length L).
Seclow	m	Length along the borehole for the lower limit of the test section (based on corrected length L).
L	m	Corrected length along borehole based on SKB procedures for length correction.
Length to flow anom.	m	Length along the borehole to inferred flow anomaly during overlapping flow logging.
Test type (1–6)	(–)	1A: Pumping test – wire-line eq., 1B: Pumping test-submersible pump, 1C: Pumping test-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.
Date of test, start	YY-MM-DD	Date for start of pumping.
Time of test, start	hh:mm	Time for start of pumping.
Date of flowl., start	YY-MM-DD	Date for start of the flow logging.
Time of flowl., start	hh:mm	Time for start of the flow logging.
Date of test, stop	YY-MM-DD	Date for stop of the test.
Time of test, stop	hh:mm	Time for stop of the test.
L_w	m	Section length used in the difference flow logging.
dL	m	Step length (increment) used in the difference flow logging.
Q_{p1}	m^3/s	Flow rate at surface by the end of the first pumping period of the flow logging.
Q_{p2}	m^3/s	Flow rate at surface by the end of the second pumping period of the flow logging.
t_{p1}	s	Duration of the first pumping period.
t_{p2}	s	Duration of the second pumping period.
t_{F1}	s	Duration of the first recovery period.
t_{F2}	s	Duration of the second recovery period.
h_0	m.a.s.l.	Initial hydraulic head before pumping. Elevation of water level in open borehole in the local co-ordinates system with z=0 m.
h_1	m.a.s.l.	Stabilized hydraulic head during the first pumping period. Elevation of water level in open borehole in the local co-ordinates system with z=0 m.
h_2	m.a.s.l.	Stabilized hydraulic head during the second pumping period. Elevation of water level in open borehole in the local co-ordinates system with z=0 m.
s_1	m	Drawdown of the water level in the borehole during first pumping period. Difference between the actual hydraulic head and the initial head ($s_1=h_1–h_0$).
s_2	m	Drawdown of the water level in the borehole during second pumping period. Difference between the actual hydraulic head and the initial head ($s_2=h_2–h_0$).
T	m^2/s	Transmissivity of the entire borehole.
Q_0	m^3/s	Measured flow rate through the test section or flow anomaly under natural conditions (no pumping) with $h=h_0$ in the open borehole.
Q_1	m^3/s	Measured flow rate through the test section or flow anomaly during the first pumping period.
Q_2	m^3/s	Measured flow rate through the test section or flow anomaly during the second pumping period.
h_{0FW}	m.a.s.l.	Corrected initial hydraulic head difference along the hole due to e.g. varying salinity conditions of the borehole fluid before pumping.
h_{1FW}	m.a.s.l.	Corrected hydraulic head difference along the hole due to e.g. varying salinity conditions of the borehole fluid during the first pumping period.
h_{2FW}	m.a.s.l.	Corrected hydraulic head difference along the hole due to e.g. varying salinity conditions of the borehole fluid during the second pumping period.
EC_w	S/m	Measured electric conductivity of the borehole fluid in the test section during difference flow logging.
Te_w	°C	Measured borehole fluid temperature in the test section during difference flow logging.
EC_f	S/m	Measured fracture-specific electric conductivity of the fluid in flow anomaly during difference flow logging.
Te_f	°C	Measured fracture-specific fluid temperature in flow anomaly during difference flow logging.
T_D	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.
T-measl$_{LT}$	m^2/s	Estimated theoretical lower measurement limit for evaluated T_D. If the estimated T_D equals T_D-measlim, the actual T_D is considered to be equal or less than T_D-measlim.
T-measl$_{LP}$	m^2/s	Estimated practical lower measurement limit for evaluated T_D. If the estimated T_D equals T_D-measlim, the actual T_D is considered to be equal or less than T_D-measlim.
T-measl$_U$	m^2/s	Estimated upper measurement limit for evaluated T_D. If the estimated T_D equals T_D-measlim, the actual T_D is considered to be equal or less than T_D-measlim.
h_i	m.a.s.l.	Calculated relative, natural freshwater head for test section or flow anomaly (undisturbed conditions).

Appendix 10

Calculation of conductive fracture frequency

Borehole ID	SecUp (m)	SecLow (m)	Number of fractures, Total	Number of fractures 10–100 (ml/h)	Number of fractures 100–1,000 (ml/h)	Number of fractures 1,000–10,000 (ml/h)	Number of fractures 10,000–100,000 (ml/h)	Number of fractures 100,000–1,000,000 (ml/h)
KLX10	92.20	97.20	0	0	0	0	0	0
KLX10	97.20	102.20	0	0	0	0	0	0
KLX10	102.20	107.20	4	0	0	1	3	0
KLX10	107.20	112.20	3	0	0	1	2	0
KLX10	112.19	117.19	5	0	0	0	5	0
KLX10	117.19	122.19	3	0	1	0	1	1
KLX10	122.18	127.18	4	0	2	0	2	0
KLX10	127.19	132.19	4	0	2	2	0	0
KLX10	132.20	137.20	2	0	1	0	1	0
KLX10	137.21	142.21	4	0	3	1	0	0
KLX10	142.22	147.22	6	1	1	3	1	0
KLX10	147.23	152.23	2	0	0	0	2	0
KLX10	152.24	157.24	1	0	0	0	0	1
KLX10	157.24	162.24	1	0	1	0	0	0
KLX10	162.25	167.25	1	0	1	0	0	0
KLX10	167.25	172.25	1	1	0	0	0	0
KLX10	172.25	177.25	2	0	0	1	1	0
KLX10	177.24	182.24	5	0	1	0	4	0
KLX10	182.25	187.25	4	0	3	1	0	0
KLX10	187.26	192.26	4	0	0	1	3	0
KLX10	192.27	197.27	5	0	0	1	4	0
KLX10	197.28	202.28	6	0	0	0	6	0
KLX10	202.29	207.29	7	0	0	3	4	0
KLX10	207.30	212.30	7	0	3	3	1	0
KLX10	212.30	217.30	3	1	2	0	0	0
KLX10	217.29	222.29	4	3	1	0	0	0
KLX10	222.29	227.29	2	0	1	0	0	1
KLX10	227.30	232.30	0	0	0	0	0	0
KLX10	232.32	237.32	2	0	1	1	0	0
KLX10	237.33	242.33	2	2	0	0	0	0
KLX10	242.35	247.35	5	0	2	2	1	0
KLX10	247.37	252.37	1	0	1	0	0	0
KLX10	252.38	257.38	0	0	0	0	0	0
KLX10	257.38	262.38	3	1	1	0	1	0
KLX10	262.37	267.37	0	0	0	0	0	0
KLX10	267.37	272.37	1	0	1	0	0	0
KLX10	272.37	277.37	1	1	0	0	0	0
KLX10	277.37	282.37	3	1	2	0	0	0
KLX10	282.37	287.37	3	0	3	0	0	0
KLX10	287.38	292.38	0	0	0	0	0	0
KLX10	292.38	297.38	4	1	3	0	0	0
KLX10	297.39	302.39	1	1	0	0	0	0

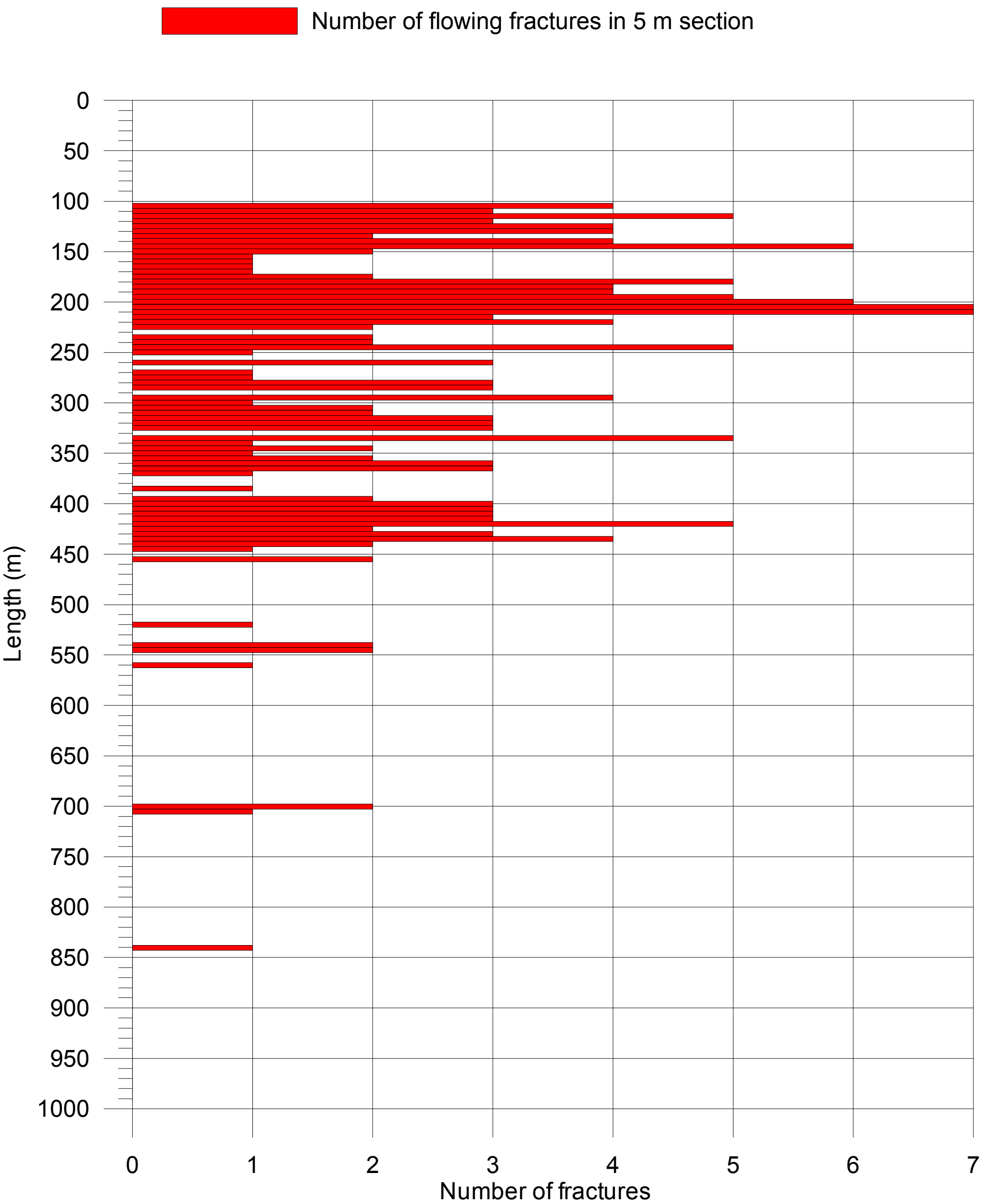
Borehole ID	SecUp (m)	SecLow (m)	Number of fractures, Total	Number of fractures 10–100 (ml/h)	Number of fractures 100–1,000 (ml/h)	Number of fractures 1,000–10,000 (ml/h)	Number of fractures 10,000–100,000 (ml/h)	Number of fractures 100,000–1,000,000 (ml/h)
KLX10	302.40	307.40	2	1	1	0	0	0
KLX10	307.40	312.40	2	1	1	0	0	0
KLX10	312.40	317.40	3	3	0	0	0	0
KLX10	317.40	322.40	3	0	1	0	1	1
KLX10	322.40	327.40	3	0	0	1	2	0
KLX10	327.40	332.40	0	0	0	0	0	0
KLX10	332.40	337.40	5	0	2	3	0	0
KLX10	337.40	342.40	1	0	0	1	0	0
KLX10	342.40	347.40	2	0	1	1	0	0
KLX10	347.40	352.40	1	1	0	0	0	0
KLX10	352.41	357.41	2	0	0	2	0	0
KLX10	357.42	362.42	3	1	1	1	0	0
KLX10	362.43	367.43	3	0	2	1	0	0
KLX10	367.44	372.44	1	0	1	0	0	0
KLX10	372.45	377.45	0	0	0	0	0	0
KLX10	377.46	382.46	0	0	0	0	0	0
KLX10	382.47	387.47	1	0	1	0	0	0
KLX10	387.48	392.48	0	0	0	0	0	0
KLX10	392.48	397.48	2	0	0	2	0	0
KLX10	397.49	402.49	3	0	0	3	0	0
KLX10	402.49	407.49	3	0	2	1	0	0
KLX10	407.49	412.49	3	0	3	0	0	0
KLX10	412.49	417.49	3	0	2	1	0	0
KLX10	417.48	422.48	5	1	3	0	1	0
KLX10	422.48	427.48	2	0	1	1	0	0
KLX10	427.48	432.48	3	0	2	0	1	0
KLX10	432.48	437.48	4	0	2	2	0	0
KLX10	437.48	442.48	2	0	0	2	0	0
KLX10	442.49	447.49	1	1	0	0	0	0
KLX10	447.49	452.49	0	0	0	0	0	0
KLX10	452.49	457.49	2	2	0	0	0	0
KLX10	457.49	462.49	0	0	0	0	0	0
KLX10	462.50	467.50	0	0	0	0	0	0
KLX10	467.50	472.50	0	0	0	0	0	0
KLX10	472.51	477.51	0	0	0	0	0	0
KLX10	477.51	482.51	0	0	0	0	0	0
KLX10	482.52	487.52	0	0	0	0	0	0
KLX10	487.52	492.52	0	0	0	0	0	0
KLX10	492.53	497.53	0	0	0	0	0	0
KLX10	497.53	502.53	0	0	0	0	0	0
KLX10	502.54	507.54	0	0	0	0	0	0
KLX10	507.55	512.55	0	0	0	0	0	0
KLX10	512.56	517.56	0	0	0	0	0	0
KLX10	517.56	522.56	1	1	0	0	0	0
KLX10	522.57	527.57	0	0	0	0	0	0
KLX10	527.58	532.58	0	0	0	0	0	0

Borehole ID	SecUp (m)	SecLow (m)	Number of fractures, Total	Number of fractures 10–100 (ml/h)	Number of fractures 100–1,000 (ml/h)	Number of fractures 1,000–10,000 (ml/h)	Number of fractures 10,000–100,000 (ml/h)	Number of fractures 100,000–1,000,000 (ml/h)
KLX10	532.59	537.59	0	0	0	0	0	0
KLX10	537.60	542.60	2	0	2	0	0	0
KLX10	542.61	547.61	2	2	0	0	0	0
KLX10	547.62	552.62	0	0	0	0	0	0
KLX10	552.63	557.63	0	0	0	0	0	0
KLX10	557.63	562.63	1	0	1	0	0	0
KLX10	562.64	567.64	0	0	0	0	0	0
KLX10	567.64	572.64	0	0	0	0	0	0
KLX10	572.65	577.65	0	0	0	0	0	0
KLX10	577.65	582.65	0	0	0	0	0	0
KLX10	582.66	587.66	0	0	0	0	0	0
KLX10	587.67	592.67	0	0	0	0	0	0
KLX10	592.67	597.67	0	0	0	0	0	0
KLX10	597.68	602.68	0	0	0	0	0	0
KLX10	602.68	607.68	0	0	0	0	0	0
KLX10	607.69	612.69	0	0	0	0	0	0
KLX10	612.69	617.69	0	0	0	0	0	0
KLX10	617.69	622.69	0	0	0	0	0	0
KLX10	622.69	627.69	0	0	0	0	0	0
KLX10	627.69	632.69	0	0	0	0	0	0
KLX10	632.70	637.70	0	0	0	0	0	0
KLX10	637.71	642.71	0	0	0	0	0	0
KLX10	642.71	647.71	0	0	0	0	0	0
KLX10	647.71	652.71	0	0	0	0	0	0
KLX10	652.72	657.72	0	0	0	0	0	0
KLX10	657.72	662.72	0	0	0	0	0	0
KLX10	662.72	667.72	0	0	0	0	0	0
KLX10	667.73	672.73	0	0	0	0	0	0
KLX10	672.73	677.73	0	0	0	0	0	0
KLX10	677.74	682.74	0	0	0	0	0	0
KLX10	682.74	687.74	0	0	0	0	0	0
KLX10	687.74	692.74	0	0	0	0	0	0
KLX10	692.75	697.75	0	0	0	0	0	0
KLX10	697.75	702.75	2	0	2	0	0	0
KLX10	702.78	707.78	1	1	0	0	0	0
KLX10	707.80	712.80	0	0	0	0	0	0
KLX10	712.80	717.80	0	0	0	0	0	0
KLX10	717.80	722.80	0	0	0	0	0	0
KLX10	722.81	727.81	0	0	0	0	0	0
KLX10	727.81	732.81	0	0	0	0	0	0
KLX10	732.81	737.81	0	0	0	0	0	0
KLX10	737.81	742.81	0	0	0	0	0	0
KLX10	742.81	747.81	0	0	0	0	0	0
KLX10	747.82	752.82	0	0	0	0	0	0
KLX10	752.83	757.83	0	0	0	0	0	0
KLX10	757.83	762.83	0	0	0	0	0	0

Borehole ID	SecUp (m)	SecLow (m)	Number of fractures, Total	Number of fractures 10–100 (ml/h)	Number of fractures 100–1,000 (ml/h)	Number of fractures 1,000–10,000 (ml/h)	Number of fractures 10,000–100,000 (ml/h)	Number of fractures 100,000–1,000,000 (ml/h)
KLX10	762.84	767.84	0	0	0	0	0	0
KLX10	767.84	772.84	0	0	0	0	0	0
KLX10	772.85	777.85	0	0	0	0	0	0
KLX10	777.86	782.86	0	0	0	0	0	0
KLX10	782.87	787.87	0	0	0	0	0	0
KLX10	787.88	792.88	0	0	0	0	0	0
KLX10	792.88	797.88	0	0	0	0	0	0
KLX10	797.90	802.90	0	0	0	0	0	0
KLX10	802.91	807.91	0	0	0	0	0	0
KLX10	807.92	812.92	0	0	0	0	0	0
KLX10	812.93	817.93	0	0	0	0	0	0
KLX10	817.94	822.94	0	0	0	0	0	0
KLX10	822.94	827.94	0	0	0	0	0	0
KLX10	827.95	832.95	0	0	0	0	0	0
KLX10	832.96	837.96	0	0	0	0	0	0
KLX10	837.98	842.98	1	0	0	1	0	0
KLX10	842.98	847.98	0	0	0	0	0	0
KLX10	848.00	853.00	0	0	0	0	0	0
KLX10	853.00	858.00	0	0	0	0	0	0
KLX10	858.02	863.02	0	0	0	0	0	0
KLX10	863.03	868.03	0	0	0	0	0	0
KLX10	868.04	873.04	0	0	0	0	0	0
KLX10	873.05	878.05	0	0	0	0	0	0
KLX10	878.06	883.06	0	0	0	0	0	0
KLX10	883.07	888.07	0	0	0	0	0	0
KLX10	888.08	893.08	0	0	0	0	0	0
KLX10	893.09	898.09	0	0	0	0	0	0
KLX10	898.10	903.10	0	0	0	0	0	0
KLX10	903.11	908.11	0	0	0	0	0	0
KLX10	908.12	913.12	0	0	0	0	0	0
KLX10	913.13	918.13	0	0	0	0	0	0
KLX10	918.14	923.14	0	0	0	0	0	0
KLX10	923.15	928.15	0	0	0	0	0	0
KLX10	928.16	933.16	0	0	0	0	0	0
KLX10	933.17	938.17	0	0	0	0	0	0
KLX10	938.18	943.18	0	0	0	0	0	0
KLX10	943.19	948.19	0	0	0	0	0	0
KLX10	948.19	953.19	0	0	0	0	0	0
KLX10	953.20	958.20	0	0	0	0	0	0
KLX10	958.20	963.20	0	0	0	0	0	0
KLX10	963.20	968.20	0	0	0	0	0	0
KLX10	968.20	973.20	0	0	0	0	0	0
KLX10	973.19	978.19	0	0	0	0	0	0
KLX10	978.19	983.19	0	0	0	0	0	0
KLX10	983.20	988.20	0	0	0	0	0	0
KLX10	988.21	993.21	0	0	0	0	0	0

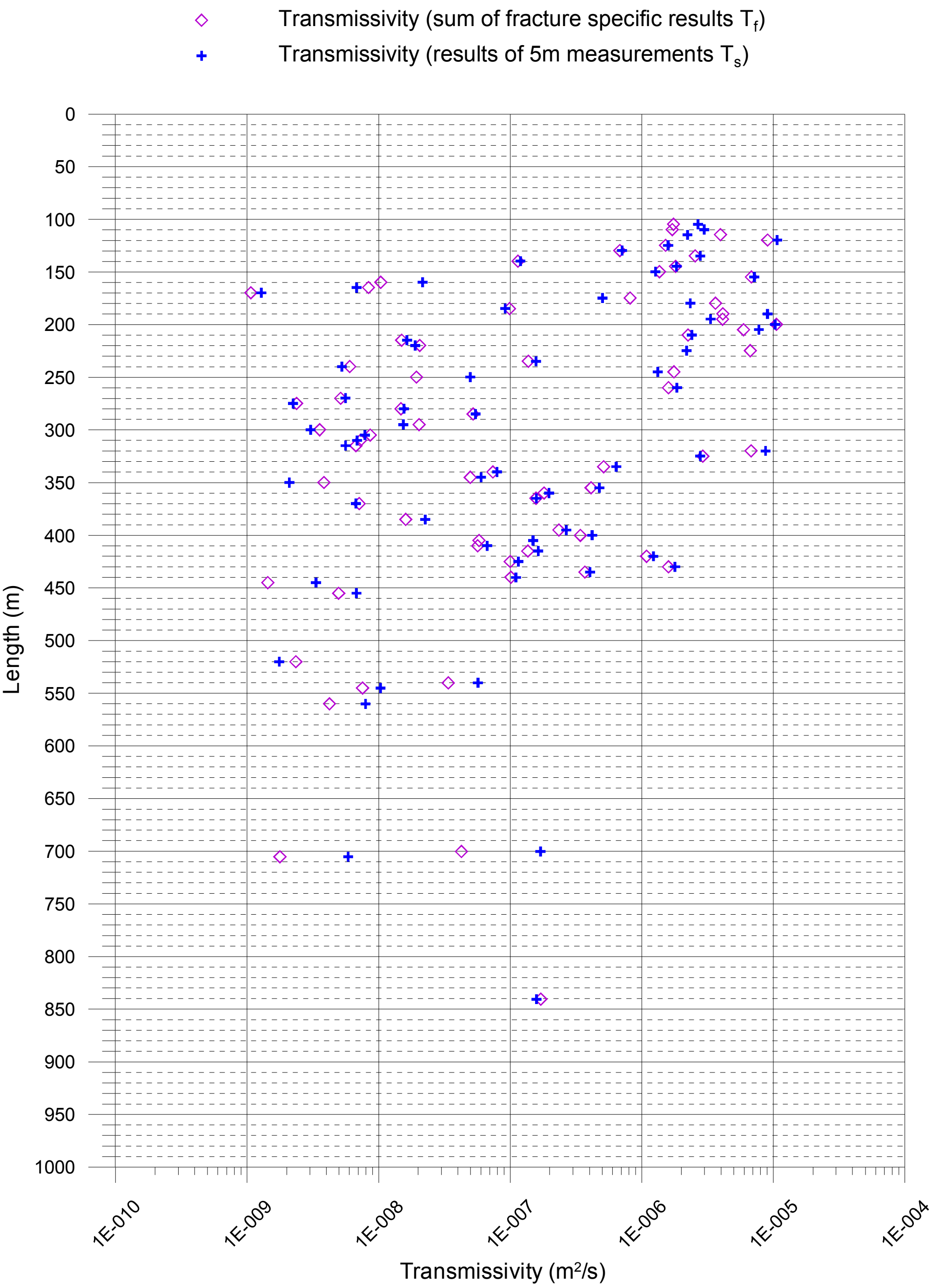
Appendix 11

Laxemar, borehole KLX10
Calculation of conductive fracture frequency



Appendix 12

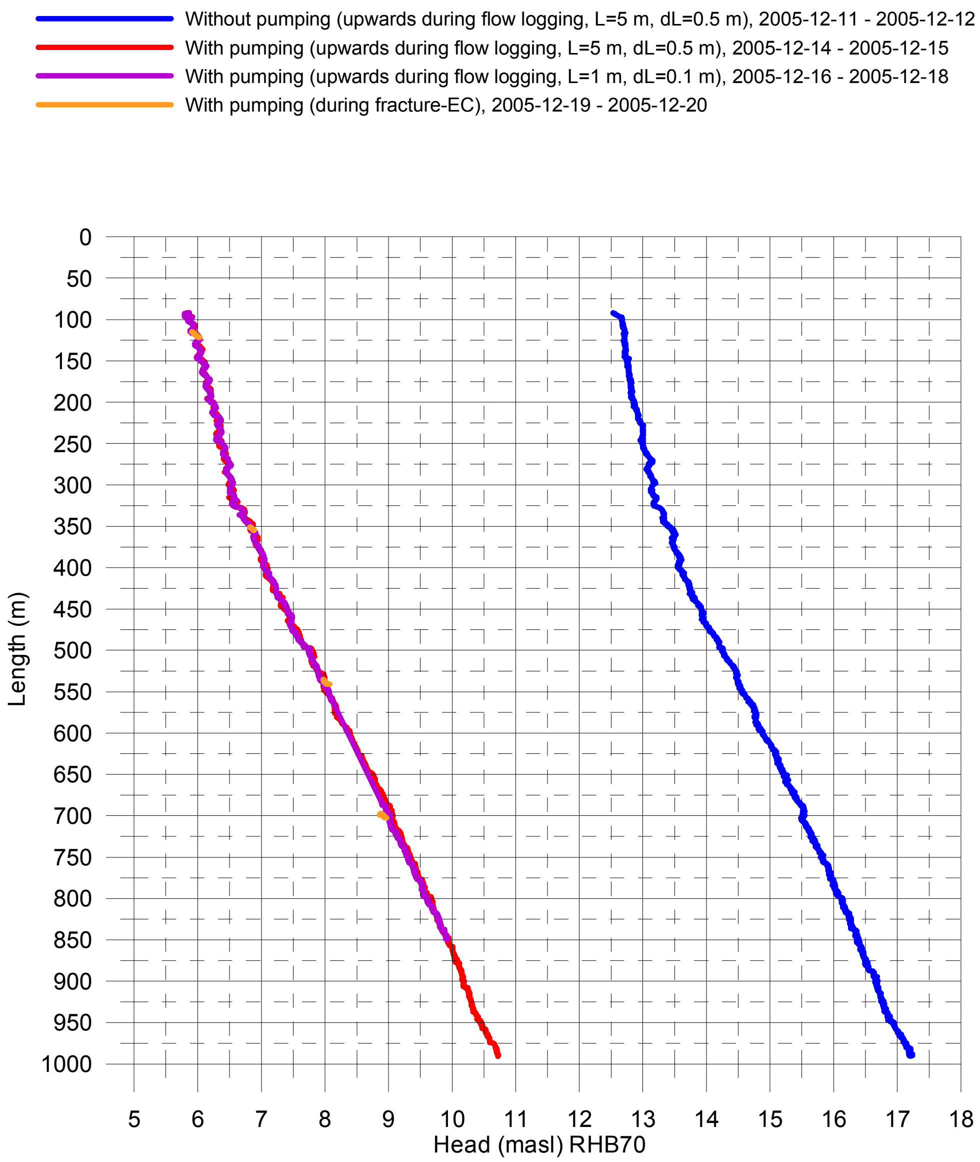
Laxemar, borehole KLX10
Comparison between section transmissivity and fracture transmissivity



Appendix 13.1

Laxemar, borehole KLX10
Head in the borehole during flow logging

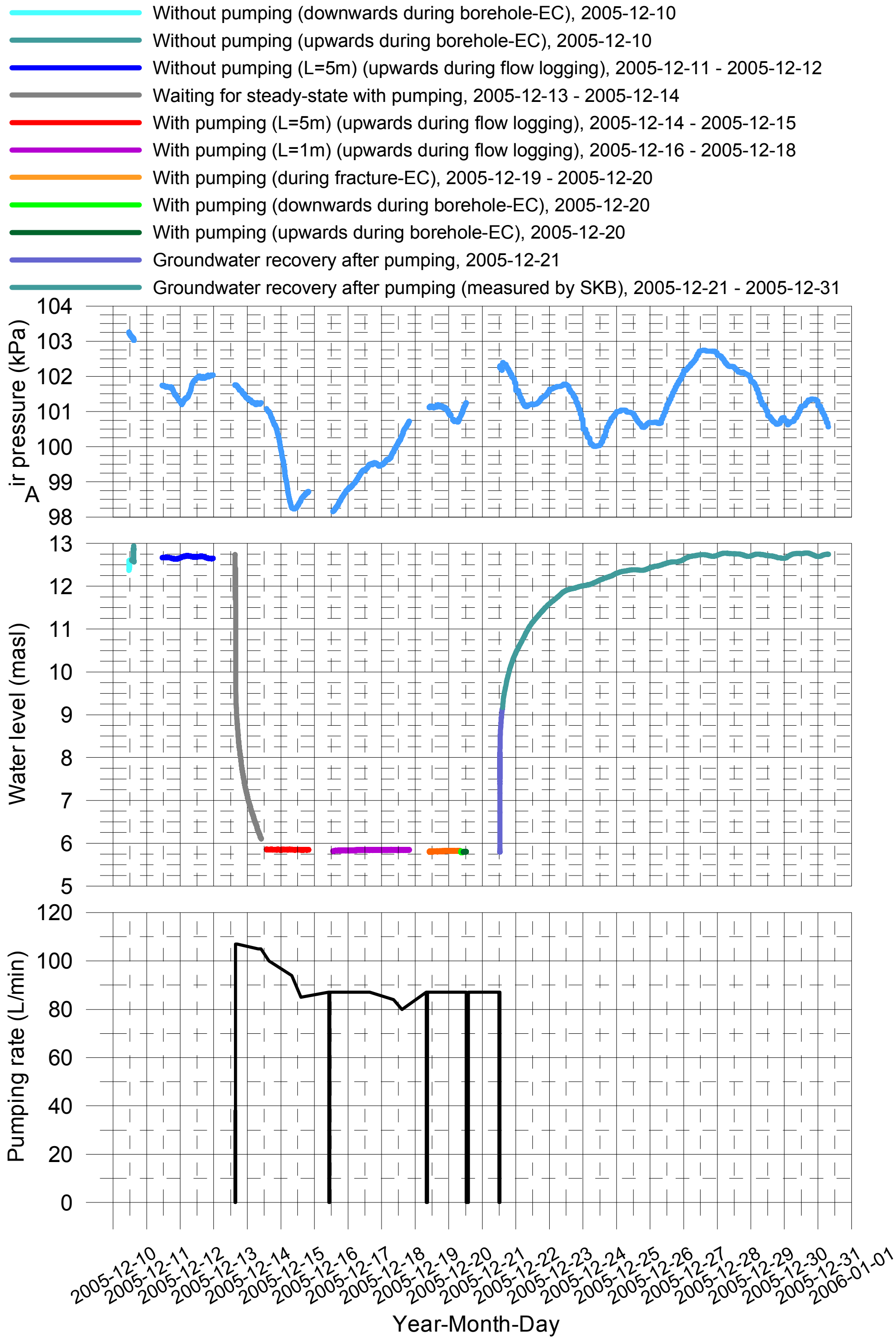
Head(masl)= (Absolute pressure (Pa) - Airpressure (Pa) + Offset) /(1000 kg/m^3 * 9.80665 m/s^2) + Elevation (m)
Offset = 2460 Pa (Correction for absolut pressure sensor)



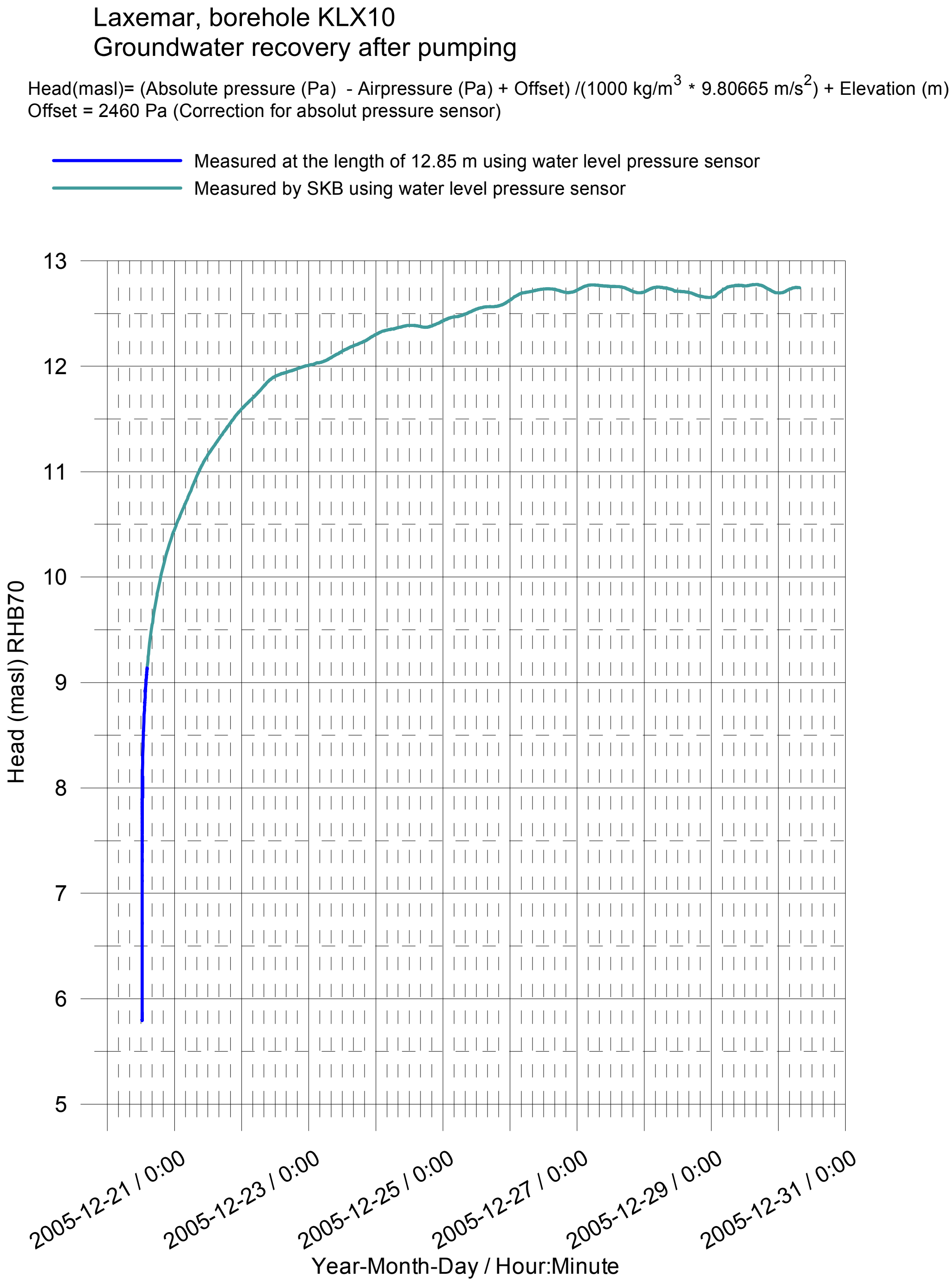
Appendix 13.2

Laxemar, borehole KLX10

Air pressure, water level in the borehole and pumping rate during flow logging

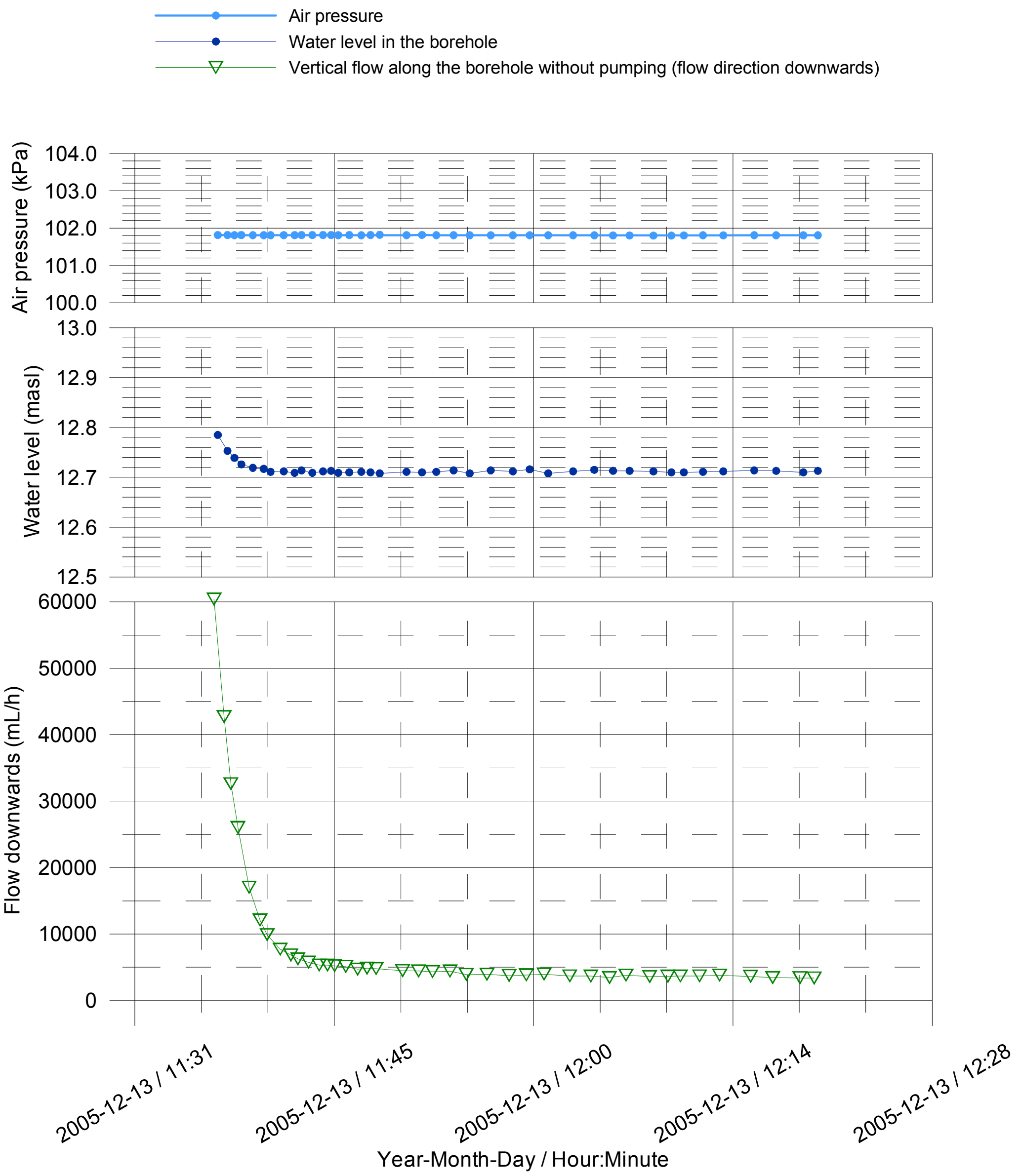


Appendix 13.3



Appendix 13.4

Laxemar, borehole KLX10
Vertical flow along the borehole at the length of 101.3 m



Appendix 14

Laxemar, borehole KLX10
Fracture-specific EC results by date