DRILLHOLE FLOWMETER FOR HYDRAULIC TESTING

The Posiva Flow Log, Difference flow method (PFL DIFF) uses a flowmeter that incorporates a flow guide and can be used for relatively quick determinations of hydraulic conductivity and hydraulic head in fractures/fractured zones in cored drillholes.

Unlike conventional drillhole flowmeters which measure the total cumulative flow rate along a drillhole, the PFL DIFF probe measures the flow rate into or out of defined drillhole sections. The advantage that follows from measuring the flow rate in isolated sections is improved detection of incremental changes of flow along the drillhole. As these are generally very small, they can easily be missed when using conventional flowmeters.

The equipment employed in the PFL DIFF method (a trailer-mounted winch and cable, a downhole probe and a computer) can be used in drillholes of depths up to 1500 m that have a diameter of 56 mm or greater.

Flow rates into or out of the test section are monitored using thermistors, which track both the dilution (cooling) of a thermal pulse and its transfer by the moving water. The thermal dilution method is used in measuring flow rates because it is faster than the thermal pulse method, and the latter is used only to determine flow direction within a given time frame. Both methods are used simultaneously at each measurement location.

The distance between the upper and lower rubber disk can vary. Commonly used distances are 0.5 m and 2 m (see the result below). Logging speed with the 0.5 m distance and 0.1 m measuring point interval is about 10 m/hour.

In addition to incremental changes in flow, the PFL DIFF probe can also be used to measure:

- The electrical conductivity (EC) of both drillhole water and fracture-specific water. The electrode used in EC measurements is located at the top of the flow sensor, see Figure 1.
- The single point resistance (SPR) of the drillhole wall (grounding resistance). The electrode used for SPR measurements is located between the uppermost rubber sealing disks, see Figure 1, and is used for the high-resolution depth determination of fractures and geological structures.
- The prevailing water pressure profile in the drillhole. Located inside the watertight electronics assembly, the pressure sensor transducer is connected to the drillhole water through a tube, see Figure 2.
- The temperature of the water in the drillhole. The temperature sensor is part of the flow sensor.

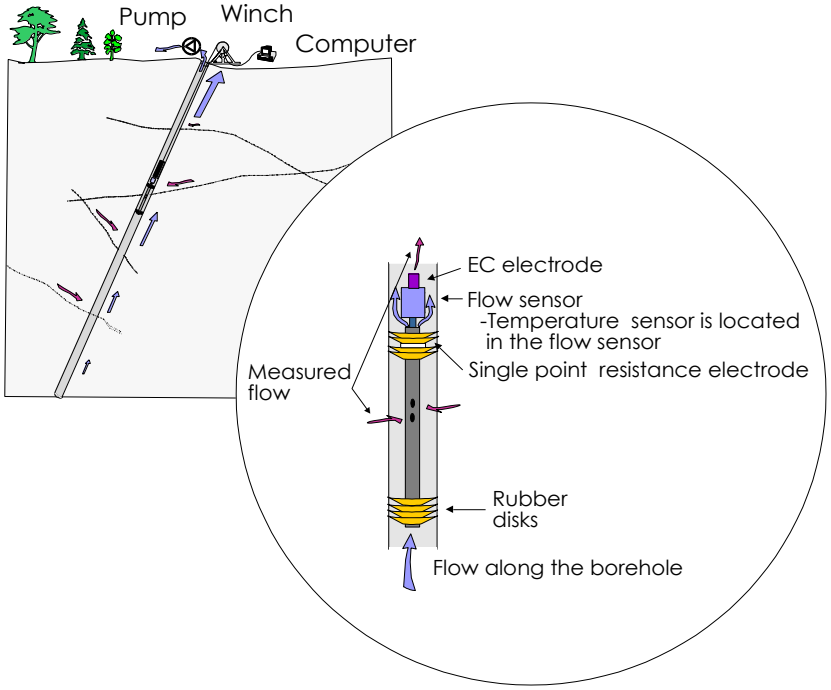


Figure 1. *Schematic of the probe used in the PFL DIFF.*

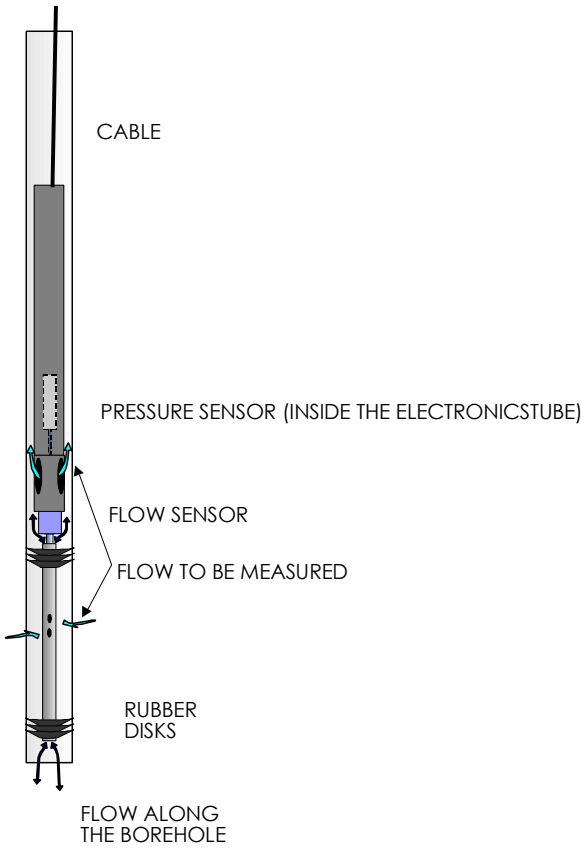


Figure 2. *The absolute pressure sensor is located inside the electronics assembly and connected to the drillhole water through a tube.*

EQUIPMENT SPECIFICATIONS

In the PFL DIFF method, the flow of groundwater into or out of a drillhole section is monitored using a flow guide which employs rubber sealing disks to isolate any such flow from the flow of water along the drillhole. This flow guide defines the test section being measured without altering the hydraulic head. Groundwater flowing into or out of the test section is guided to the flow sensor, and flow is measured using the thermal pulse and thermal dilution methods. Measured values are transferred to a computer in digital form. The main parts and features of the equipment are listed in Table 1.

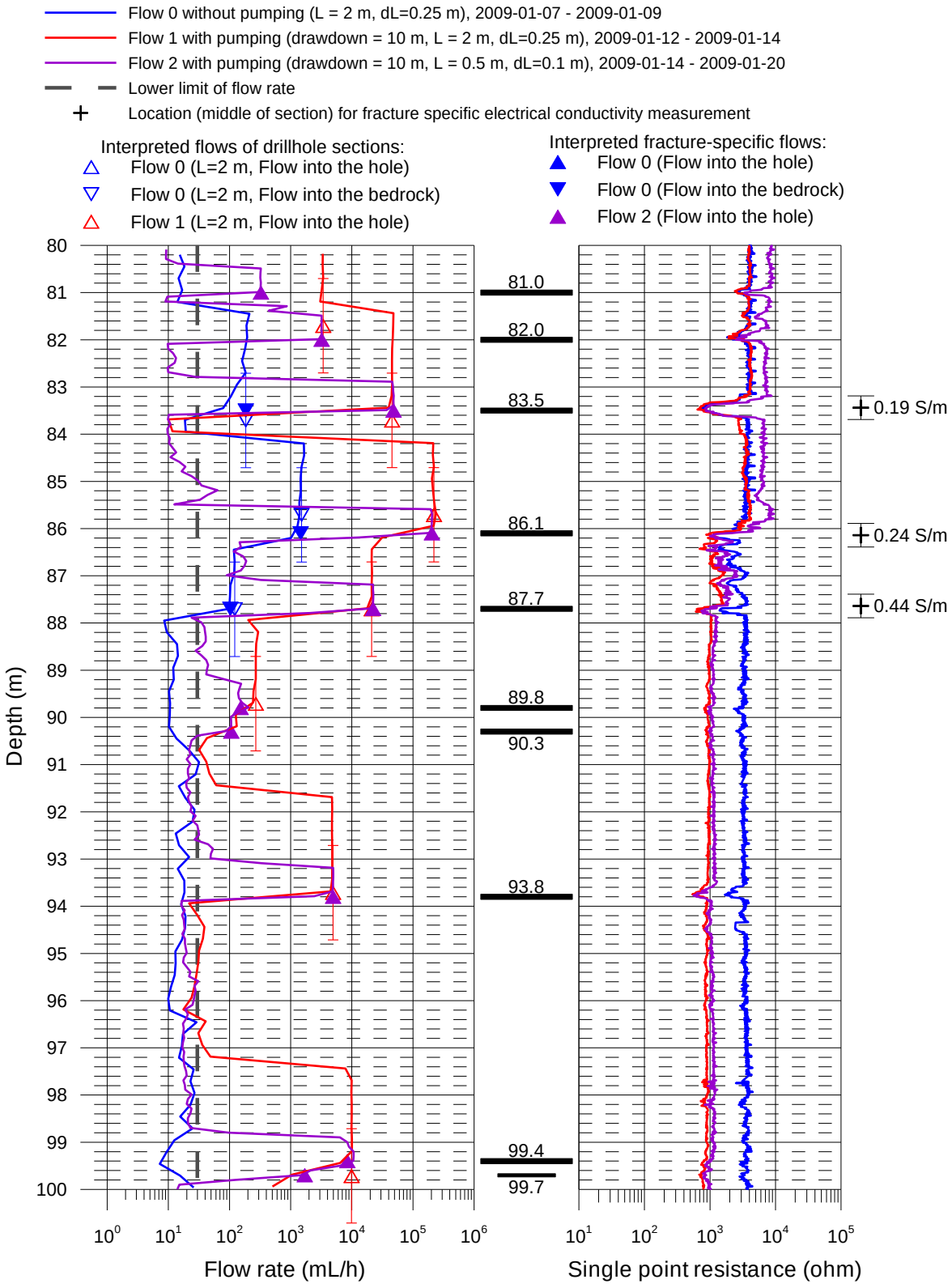
Table 1. *Equipment and features.*

Part/Feature	**Description**
Flowmeter	PFL DIFF probe
Measurable drillhole diameters	56 mm, 66 mm and 76 mm (or larger)
Length of test section	The flow guide length can be varied
Method of flow measurement	Thermal pulse (direction) and thermal dilution (rate).
Additional measurements	Temperature, Single-point resistance, Electrical conductivity of water, Water pressure
Winch	Mount Sopris Wna 10, 0.55 kW, Steel wire cable 1500 m, four conductors, Gerhard -Owen cable head.
Depth determination	Based on a digital distance counter.
Logging computer	PC (Windows XP)
Software	Based on MS Visual Basic
Total power consumption	1.5 - 2.5 kW depending on the type of pump employed

Table 2. *Range and accuracy of sensors.*

Sensor	Range	Accuracy
Flow	30 – 300 000 mL/h	± 10% curr.value
Temperature (central thermistor)	0 – 50 °C	0.1 °C
Temperature difference (between outer thermistors)	-2 – (+2) °C	0.0001 °C
Electrical 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% full-scale
Air pressure sensor	800 – 1060 hPa	± 5 hPa
Absolute pressure sensor	0 – 20 MPa	± 0.01% full-scale

Olkiluoto, drillhole OL-KR49
Flow rate and single point resistance



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