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Oskarshamn site investigation

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October 2006

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Keywords: Core drilling, Bedrock, Measurement while drilling, Flushing water monitoring, Water sampling, Wireline measurements, Air-lift pumping, Telescope hole.

Abstract

Borehole KLX08 is located in the Laxemar subarea. Drilling was made between January 2005 and June 2005 as a part of the site investigation for a possible repository for spent nuclear fuel in Oskarshamn municipality, Sweden.

KLX08 was core drilled to a length of 1,000.41 metres with N-size (76 mm) equipment. The uppermost section, to the length of 100.33 metres, was constructed as a telescopic section with an inner nominal diameter of 200 mm.

No water inflow was measured in the telescopic section during percussion drilling.

Seven successful pumping tests were performed in KLX08 with wireline equipment, typically with one hundred metre intervals. The resulting transmissivities (T_M) varied between $8.6 \cdot 10^{-7}$ and $3.8 \cdot 10^{-4}$ m^2/s. The most transmissive section was between 303 and 412 metres.

Continuous monitoring of drilling parameters and flushing water parameters with the drilling monitoring system was conducted throughout the core drilling phase in KLX08.

Five water samples for chemical analysis were collected during drilling of KLX08. Two of the samples had too high drill water content (i.e. tracer content) to warrant any further analysis.

An airlift pumping test in the telescopic section performed when borehole KLX08 was drilled to its full length gave a transmissivity (T_M) of $3.0 \cdot 10^{-4}$ m^2/s.

Lithologically the core consist of Ävrö granite (80%) with minor intercalations of fine-grained diorite-gabbro and fine grained granite between 100 and 400 m. From 400 to 580 the lithology is only Ävrö granite. Between 580 and 920 the core is made up of Ävrö granite with substantial intercalations of Diorite/Gabbro. Below ca 920 m the core consists of Quartz monzodiorite.

Oxidation with weak to medium intensity is not uncommon down to 420 m. Between 420 and 920 m oxidation occurs sporadically with low intensity (faint to weak). A part with medium intensity oxidation occurs around 930 m near the Ävrö granite and Quartz monzodiorite contact. Saussuritization i.e. alteration of calcic plagioclase feldspar to albite, zoisite or epidote is common in conjunction with oxidized sections, especially below 400 m.

There is a clear correlation between oxidation, both occurrence and intensity, and fracture frequency. The distribution of total fractures in the core is typically in the range of 0–10 fractures/metre with minor sections containing elevated fracture frequencies. Crushed sections notably occur at 120, 150, 220, 300, 410, 650 and 770 m drilled length.

The average fracture frequency over the entire core drilled section expressed as open fractures is 2.2 (fractures/metre).

Sammanfattning

Borrhål KLX08 ligger inom delområde Laxemar. Borrningen utfördes mellan januari 2005 och juni 2005 som ett led i platsundersökningen för ett möjligt djupförvar för använt kärnbränsle i Oskarshamns kommun.

KLX08 kärnborrades med borrstorlek N (76 mm) till 1 000,41 meters borrad längd. Den övre delen av hålet, från markytan till 100,33 meter, utfördes som en teleskopdel med ca 200 mm inre diameter.

Inget vatteninflöde kunde uppmätas i teleskopdelen vid hammarborrningen.

Sju lyckade pumptester med wireline-baserad mätutrustning utfördes över ca hundra meters intervaller. Uppmätta transmissiviteter (T_M) varierade mellan $8,6·10^{-7}$ och $3,8·10^{-4}$ m^2/s. Den mest transmissiva sektionen var mellan 303 och 412 meter.

Kontinuerliga mätningar av borrningsparametrar och spolvattenparametrar via DMS (Drilling Monitoring System) gjordes under hela kärnborrningsfasen i KLX08.

Fem vattenprover för kemisk analysering togs i samband med borrning i KLX08. Två av proverna hade ett för högt spolvatteninnehåll (dvs innehåll av spårämne) för att medge ytterligare analysering.

En mammutpumpning i teleskopdelen som gjordes när kärnborrningen utförts till full längd gav en transmissivitet (T_M) på $3,0·10^{-4}$ m^2/s.

Litologiskt domineras kärnan av Ävrögranit (80 %) med mindre inslag av finkornig diorit-gabbro och finkornig granit mellan 100 och 400 m. Från 400 till 580 m består kärnan enbart av Ävrögranit. Mellan 580 och 920 utgörs kärnan av Ävrögranit med ett betydande inslag av diorit/gabbro. Nedanför ca 920 m består kärnan av kvartsmonzodiorit.

Oxidation med svag till måttlig intensitet är inte ovanlig ner till borrad längd 420 m. Mellan 420 och 490 m förekommer oxidation sporadiskt med låg intensitet (obetydlig till svag). Ett område med medium intensitet av oxidation finns vid 930 m i anslutning till kontakten mellan Ävrögranit och kvartsmonzodiorit. Saussuritisering dvs omvandling av kalciumrik plagioklasfältspat till albit, zoisit eller epidot är vanlig i anslutning till oxiderade partier, speciellt under 400 m.

Det finns en tydlig korrelation mellan oxidation, både förekomst och intensitet, och sprick-frekvens. Fördelningen av den totala mängden sprickor i kärnan är typiskt i intervallet 0–10 sprickor/meter med mindre partier av förhöjda sprickfrekvenser. Sektioner med krossat berg förekommer bl a vid 120, 150, 220, 300, 410, 650 och 770 m borrad längd.

Den genomsnittliga sprickfrekvensen över hela borrkärnar uttryckt som öppna sprickor är 2,2 (sprickor/meter).

Contents

1 Introduction

SKB, the Swedish Nuclear Fuel and Waste Management Company, performs site investigations in order to evaluate the feasibility of locating a deep repository for spent nuclear fuel /1/. The investigations are performed in two Swedish municipalities: Östhammar and Oskarshamn. Borehole KLX08 is located in the central part of the Laxemar subarea of the investigation area in Oskarshamn.

Drilling and investigations in boreholes are fundamental activities in order to facilitate characterisation of rock and groundwater properties at depth. KLX08 was the tenth deep cored borehole within the Oskarshamn site investigation. The location of the core drilled borehole and the water source, HLX10 in the Laxemar subarea is shown in Figure 1-1.

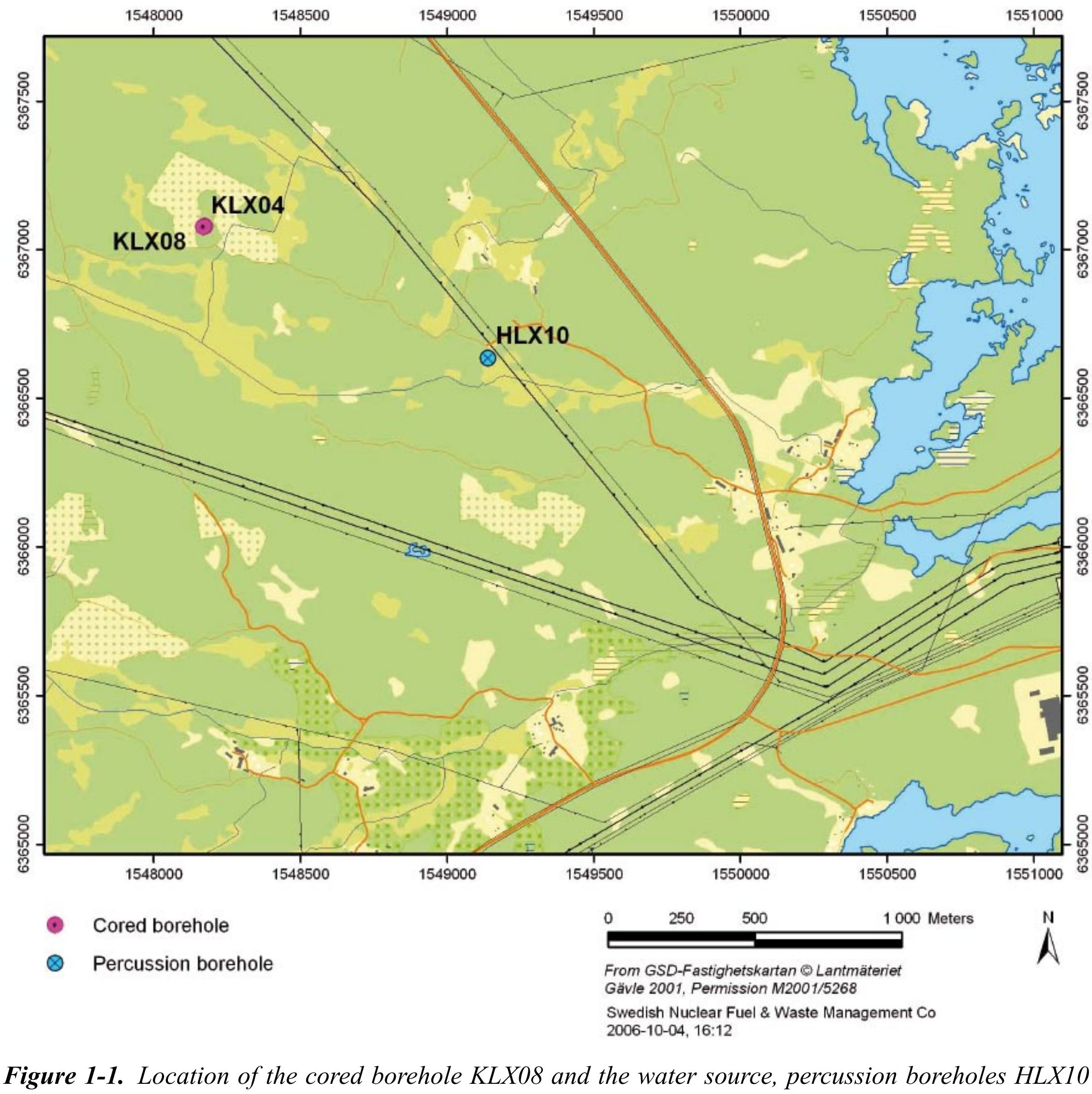


Figure 1-1. *Location of the cored borehole KLX08 and the water source, percussion boreholes HLX10 in the Laxemar subarea. The position of the cored borehole KLX04, which was drilled on the same site previously, is also shown.*

The drilling of KLX08 and all related on-site operations were performed according to a specific activity plan (AP PS 400-04-115), which in turn refers to a number of method descriptions, see Table 1-1.

The activity plans and method descriptions are SKB internal documents.

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

Activity plan	Number	Version
Kärnborrning KLX08	AP PS 400-04-115	1.0*
Method descriptions	**Number**	**Version**
Metodbeskrivning för kärnborrning	SKB MD 620.003	1.0
Metodbeskrivning för hammarborrning	SKB MD 610.003	1.0
Metodbeskrivning för genomförande av hydrauliska enhålstrester	SKB MD 321.003	1.0
Metodbeskrivning för registrering och provtagning av spolvattenparametrar samt borrkax under kärnborrning	SKB MD 640.001	1.0
Metodbeskrivning för pumptest, tryckmätning och vattenprovtagning i samband med wireline-borrning	SKB MD321.002	1.0
Mätsystembeskrivning för längdmarkering (spårfräsning)	SKB MD620.009	1.0
Instruktion för rengöring av borrhålsutrustning och viss markbaserad utrustning	SKB MD 600.004	1.0
Instruktion för användning av kemiska produkter och material vid borrning och undersökningar	SKB MD 600.006	1.0
Instruktion för borrplatsanläggning	SKB MD 600.005	1.0
Instruktion för spolvattenhantering	SKB MD 620.007	1.0
Instruktion för kvalitetssäkring av DMS data, Oskarshamn	SKB MD 640.008**	1.0
Instruktion för utsättning och inmätning av borrhål	SKB MD 600.002	1.0

* One amendment to AP PS 400-04-115 exists.

** The method description was formally approved on 2005-11-17.

2 Objective and scope

This report will describe the methods employed and the results achieved during the drilling of borehole KLX08. A number of related activities, such as wireline hydraulic tests, water sampling and monitoring of drilling parameters that were performed in conjunction with drilling will also be reported here.

The main reason for drilling the borehole was to gain geological information and facilitate further investigation at depth in the central part of the Laxemar subarea and deformation zone EW007. The decision to drill KLX08 is given in SKB id no 1033956, dated 2005-01-13.

The hole was constructed as a "telescope hole", which means that the upper, normally, 100 metre section of the hole has a wider diameter than the deeper core drilled part of the hole.

A notification in accordance with the Environmental Code was sent to the Regional Authorities 2004-10-21, SKB id no 1030716. Information of the final coordinates and details regarding the return water handling was submitted to the Regional Authorities on 2005-01-14, SKB id no 1033995.

3 Overview of the drilling method

3.1 The SKB telescope drilling method

In brief, the telescope drilling method is based on the construction of a larger diameter hole (200 mm diameter) to a length of normally 100 metres followed by a N-size (76 mm diameter) cored section to full length. The larger diameter section can either be percussion drilled or reamed with a percussion bit after core drilling of a pilot hole.

The main purpose of the upper large diameter section is to improve the removal of water from the hole by air-lift pumping in order to minimize the intrusion of foreign substances (flushing water and cuttings) to the surrounding bedrock. It also enables the use of submersible pumps for tests and to facilitate the installation of multi-packer systems for ground water pressure recordings.

After drilling 0–100 m, equipment for air lift pumping is installed in the borehole. The air-lift pumping will create a pressure drawdown and help remove water and cuttings while core drilling between 100 metres and 1,000 metres, see Figure 3-1. The effect of drawdown is dependent on the depth and capacity of major groundwater conductors.

During the core drilling phase several measurements and sampling exercises are performed through the drilling monitoring system (DMS), wireline tests for hydraulic purposes and sampling for water chemistry.

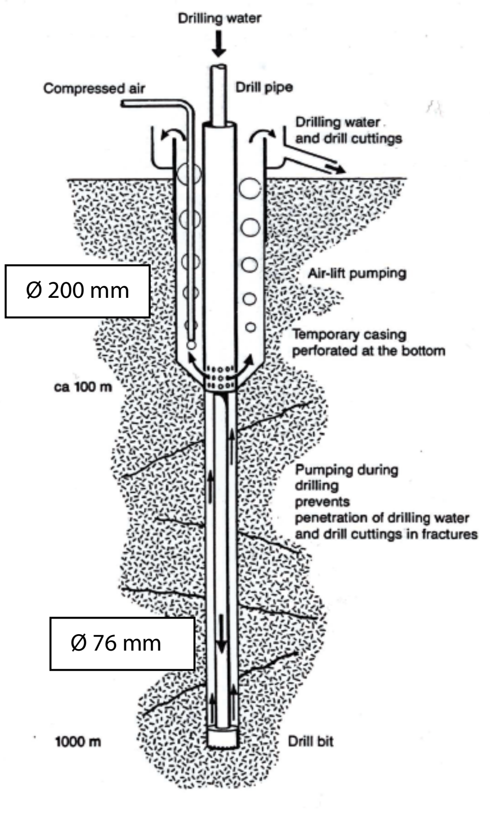


Figure 3-1. *A sketch of the telescopic drilling method with air-lift pumping for retrieval of drilling water and cuttings.*

After the core drilling is completed to full length, depth reference slots are reamed in the borehole wall and a conical guide of stainless steel is installed between the telescope part and the deeper core drilled part, see Figure 3-2.

3.1.1 The flushing water system

The handling of flushing water includes a source of water with a submersible pump, tanks and air-lift pumps for raising the water from the bottom of the telescope part to surface. The return water is led to settling containers before discharge, see Figure 3-3.

Nitrogen gas is bubbled through the drilling water to remove dissolved oxygen. This is done to avoid introduction of oxygen to the formation water and thereby disturbing the virgin chemical properties.

In order to monitor possible mixing of formation and drilling water, a tracer dye (uranine) is added to the drilling water to a fixed concentration, see Figure 3-4.

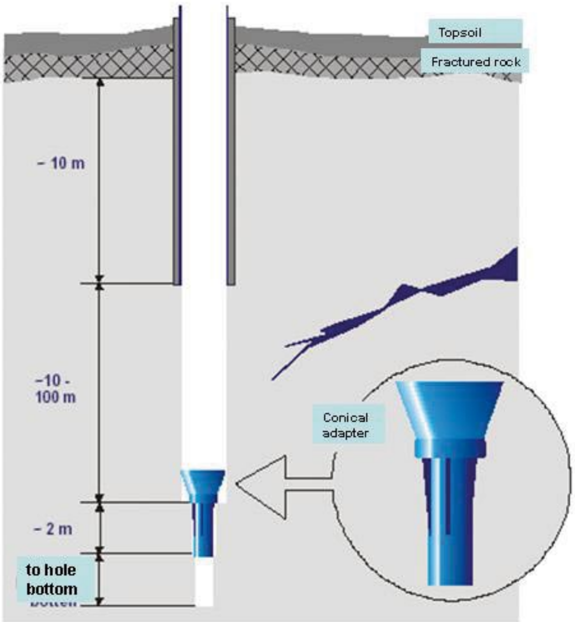


Figure 3-2. *Installation of the conical guide.*

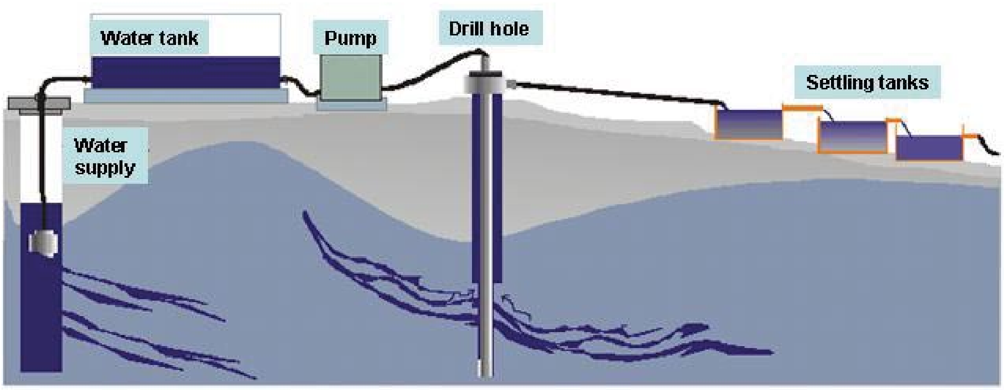


Figure 3-3. *The flushing water system from source to discharge point.*

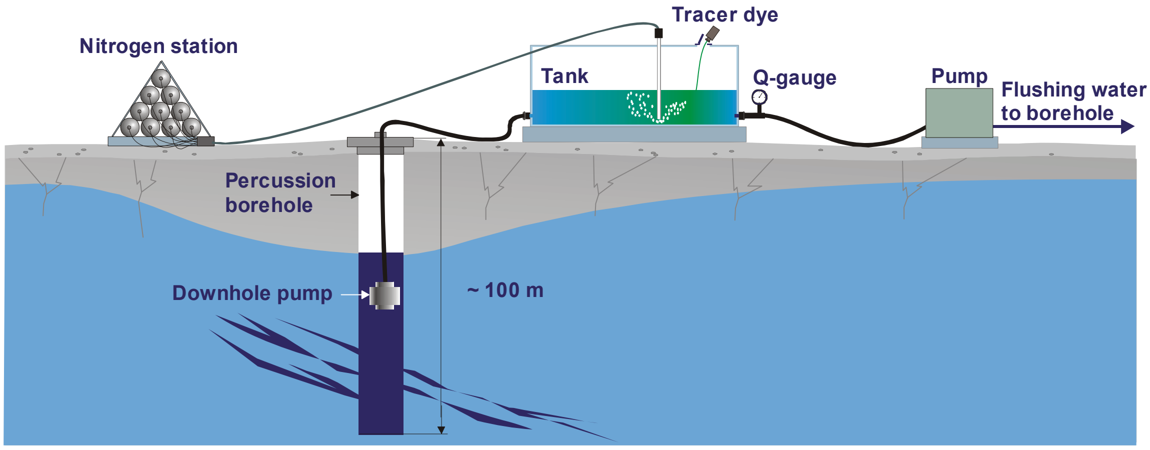


Figure 3-4. *Preparation of flushing water. Uranine is added to the water as a tracer dye. Nitrogen is bubbled through the water to remove dissolved oxygen.*

3.2 Measurements and sampling during drilling

3.2.1 Percussion drilling

Drill cuttings are collected for every metre during the percussion drilling. A preliminary geological logging of the cuttings is done on site. During the preliminary logging notes are made on the dominating lithology, size and shape of the cutting or any other noticeable geological feature. The magnetic susceptibility of the cuttings samples are measured with hand held equipment. Small cups of return water are taken systematically of the return water. The water colour and intensity are noted as indications on degree of rock oxidation and clay content. The return water flow (i.e. the amount of water driven up by compressed air) is measured when noticeable changes in flow occur. The drill penetration rate during percussion drilling is either logged automatically (most common) or manually.

3.2.2 Core drilling

The sampling and measurements during the core drilling phase of KLX08 consisted of:

- Wireline measurements.
- Air lift pumping and recovery tests.
- Water sampling at the surface.
- The drilling monitoring system.

Wireline measurements and water sampling

The measurements and the sampling are made in the borehole with a wireline based equipment. The measurements for hydrogeological purposes include pumping tests and measurements of absolute pressure and are normally performed for every 100 metres of drilled length. Sampling of water for chemical analysis is done in conjunction with the hydrogeological measurement where feasible. The wireline tests are done in accordance with SKB Method Description MB 321.002, SKB internal document.

Air lift pumping with evaluation of drawdown and/or recovery

Air lift pumping with evaluation of drawdown and/or recovery is done with 300 metres intervals, nominally at 400, 700 and 1,000 metres length. The actual levels are adapted to when changes of drill bit, or some other reason to raise the drill stem, occur. The test cycle can include both the drawdown phase and the recovery phase.

- The test cycle is started with air-lift pumping in the telescopic section.
- Drilling or other related activities such as rinsing of drill cuttings can occur prior to lifting the stem. This means that an inflow of water through the drill stem can occur during the initial stages of the test cycle.
- After the stem has been removed the air lift pumping continues between 30 minutes and one hour to achieve stable conditions.
- The air lift pumping is stopped.
- The recovery of the water table in the telescopic section is monitored.

Water sampling at the surface

Water samples of flushing and return water, i.e. the water entering and returning from the borehole at the surface, are taken at 10 to 20 metres intervals of drilled length for analysis of drilling water content (uranine tracer content) and electrical conductivity.

Drilling monitoring system (DMS)

Drilling is monitored on-line by continuous registration of drill rig parameters (logged every centimetre of bit penetration) and flushing water parameters (logged every 10 seconds). The data is compiled into a database called Drilling Monitoring System (DMS).

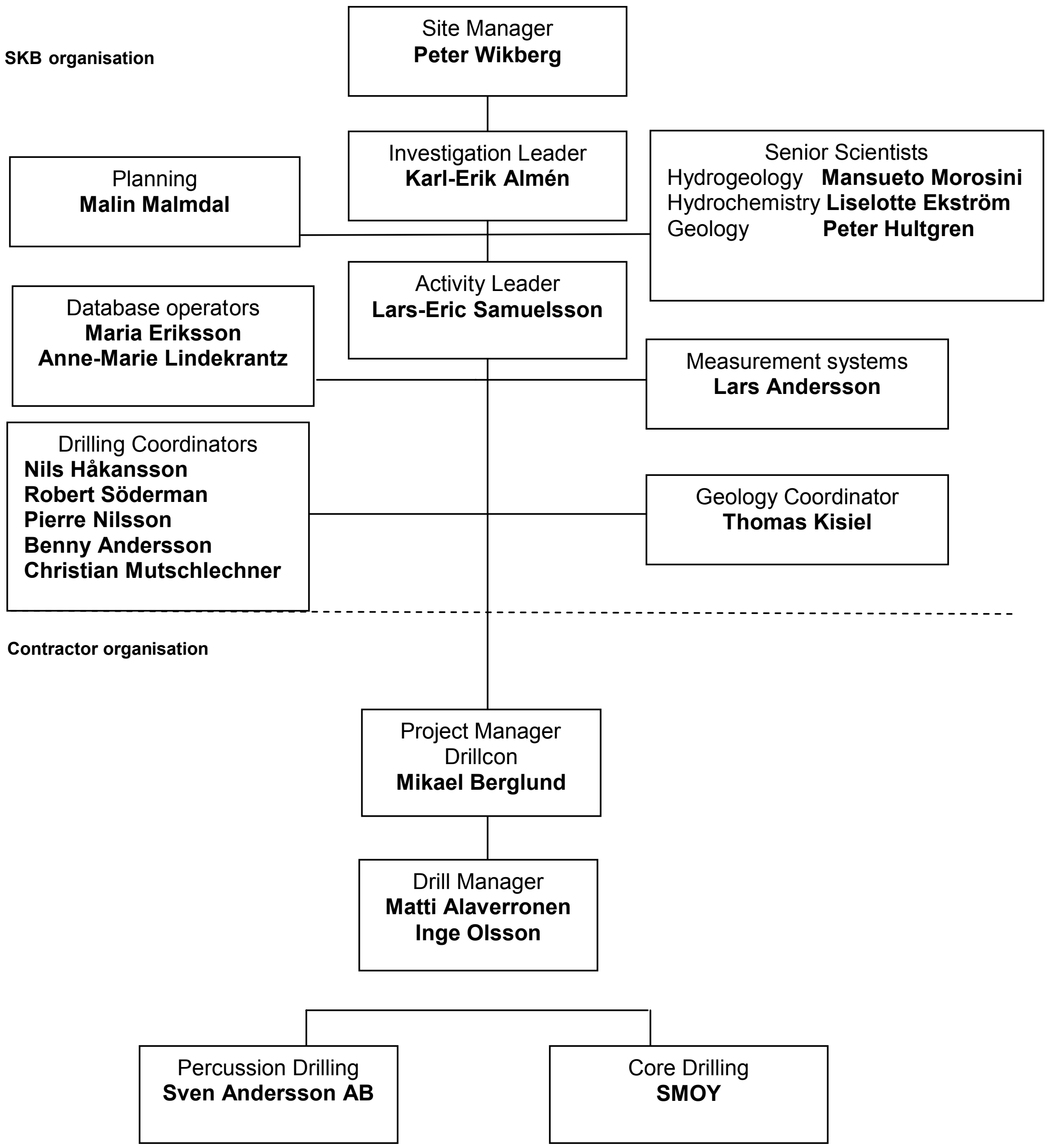
4 Contractors and equipment

4.1 Contractors

The main contractor for drilling was Drillcon Core AB, with subcontractor for core-drilling Suomen Malmi OY (SMOY) and subcontractor for percussion drilling Sven Andersson AB.

An overview of the organisation for the drilling activity is given in Table 4-1.

Table 4-1. Drill activity organisation.



4.2 Percussion drilling equipment

The equipment used in KLX08 was a Comacchio MC1500 percussion drill rig with an Atlas Copco XRVS 455 Md air compressor. Overburden drilling was made with NO-X 280 mm equipment. The down-the-hole hammer was a Secoroc 165 mm for the pilot borehole and the drill rods were Driqoneq 114 mm. Reamings were done with Secoroc DTH-hammers for 200 or 250 mm diameter. The casings utilized were 208·4 mm (SS 2343, stainless) and 324·7 mm (non stainless). The casing dimensions are presented here as outer diameter·thickness.

4.3 Core drilling equipment

Core drilling in KLX08 was made with a B 20 P Atlas Copco fully hydraulic machine fitted with a modern and environmentally adapted diesel engine. The drilling was done with N-size, i.e. giving a borehole of 76 mm diameter. The core barrel was of the type Corac N3/50, a triple tube wireline equipment which gives a core diameter of 50.2 mm. The rods were of type NT.

4.3.1 Equipment for directional drilling

No directional drilling was done in KLX08.

4.3.2 Measurements with wireline probe

The wireline probe has been developed by SKB. With this equipment water sampling, pump tests and measurements of absolute pressure in a borehole section can be made without having to lift the drill stem.

Measurements are made as specified in method description SKB MD 321.002, SKB internal document.

The principal components are:

- An inflatable packer.
- Pressure gauges for the test section and for the packer.
- A water sampler.
- A submersible pump (placed in the upper part of the drill stem).
- A flow meter (placed at the ground surface).

The probe is lowered through the drill stem into position at the drill bit. The test section is between the lower end of the packer and the bottom of the borehole, see Figure 4-1.

Before the pumping tests are made, measurements for absolute pressure and a leakage test of the drill string are done.

Hydraulic tests performed during drilling are generally affected to some degree by disturbances caused by the drilling operations. Transients from changes in pressure, temperature and salinity might affect the hydraulic response curves.

Pumping tests

The wireline probe is emplaced at the bottom of the drill stem. A submersible pump (Grundfoss MP1 or equivalent) is lowered into the upper part of the drill stem at a length of about 40 m. The test section is hydraulically connected to the drill stem by opening a valve at a predetermined pressure. This creates a passage between the test section and the water column in the drill stem. The packer remains expanded during the entire test. Water is pumped from the drill

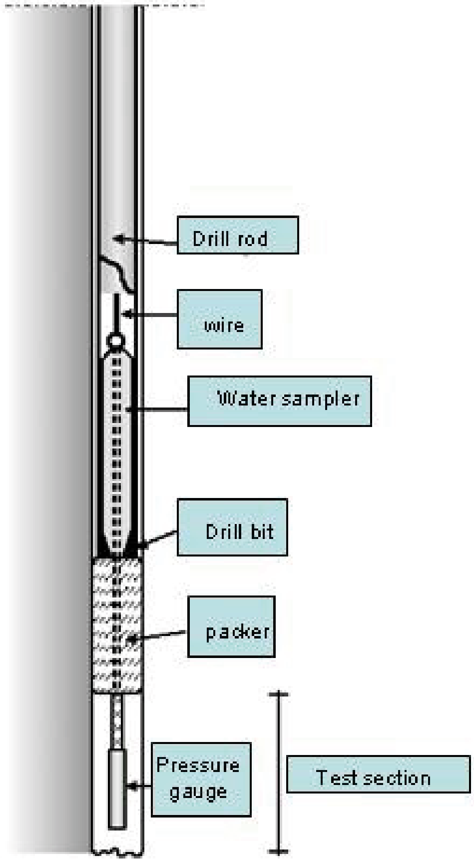


Figure 4-1. *The wireline probe and its emplacement in the hole.*

stem and the pressure in the test section and packer are recorded in a data logger. The pumped surface flow rate is recorded in a data logger on the ground surface. The pressure gauge (or pressure transducer) is situated 1.10 m below the lower end of the packer. The test consists of a pressure drawdown phase and a recovery phase. Typically the pumping time is three hours with a recovery phase of the same duration. However, the duration is sometimes adapted to the hydraulic situation of the tested section. The tests are normally carried out in sections of about 100 m length.

Water sampling

The equipment for water sampling is the same as for the pumping tests. The water volume in the section is removed at least three times by pumping water out of the drill stem. The water in the test section is then replaced by formation water and a sample is collected. The wireline probe, with the sampling unit containing a maximum volume of 5 litres, is subsequently brought to the surface.

Pumping tests and water sampling are normally performed as an integrated activity. The aim is to characterize the hydrochemistry as well as the hydrology in the bedrock when the conditions are least affected by hydraulic short circuiting in the borehole.

Absolute pressure measurement

The wireline probe is placed in position at the drill bit. The packer is inflated and the pressure build-up in the test section is recorded for a period of at least eight hours, typically this is done overnight. The measuring range for the pressure gauge is 0–20 MPa. The absolute pressure measurement is conducted if the flowrate during the pumping test exceeds 1 litre per minute.

4.3.3 Drilling monitoring system

During the core drilling phase continual monitoring was made of several measurement-while-drilling (MWD) parameters and flushing water parameters. The data is compiled into the DMS database. The procedure for data handling and quality assurance is given in method description SKB MD 640.008 (SKB internal document).

The drill rig (MWD) parameters include:

- Rotational pressure (bar).
- Bit force (kN).
- Flush water flow in (l/min).
- Water pressure at bit (kPa).
- Rotation (rpm).
- Penetration rate (cm/min).

The flushing water parameters include:

- Water level in the telescope part of the borehole (kPa).
- Oxygen level of flushing water (mg/l).
- Flow of flushing (ingoing) and return (outgoing) water (l/min).
- Electrical conductivity of flushing and return water (mS/m).
- Barometric pressure (kPa).

Data from on-line monitoring of flushing water parameters were stored on two different logging units (CR10 and CR23). A separate logging unit was used for the measurement-while-drilling (MWD) dataset. The data from the loggers was downloaded either continuously (CR10 and CR23) or by diskette or CD-ROM to the DMS database.

Figure 4-2. *The CR23 logging unit for parameters "air-pressure" and "electrical conductivity".*

4.3.4 Equipment for deviation measurements

Deviation measurements are performed to keep track on the borehole direction and dip in order to make decisions on whether directional drilling is needed or not.

Deviation measurements was made with the Reflex MAXIBOR™ (non-magnetic) optical equipment when the hole was drilled to full length. The final run with the Maxibor is stored in the Sicada database and used for orientation of borehole features.

Check-up or in-fill deviation measurements were made at 100 metre intervals with the magnetometer/accelerometer method Reflex EZ-AQ/EMS, also called "Easy-shot" with single or multishot capabilities.

4.3.5 Equipment for reaming reference slots

In order to establish accurate and similar depth references for the various measurements that will be performed in the borehole, reference slots are reamed in the borehole wall.

The equipment has been developed by SKB and consists of a reaming tool that can be fitted to conventional drilling rods for 56 and 76 mm drilling equipment. The reaming tool is operated hydraulically from the surface, so that the cutters expand when the water pressure is increased.

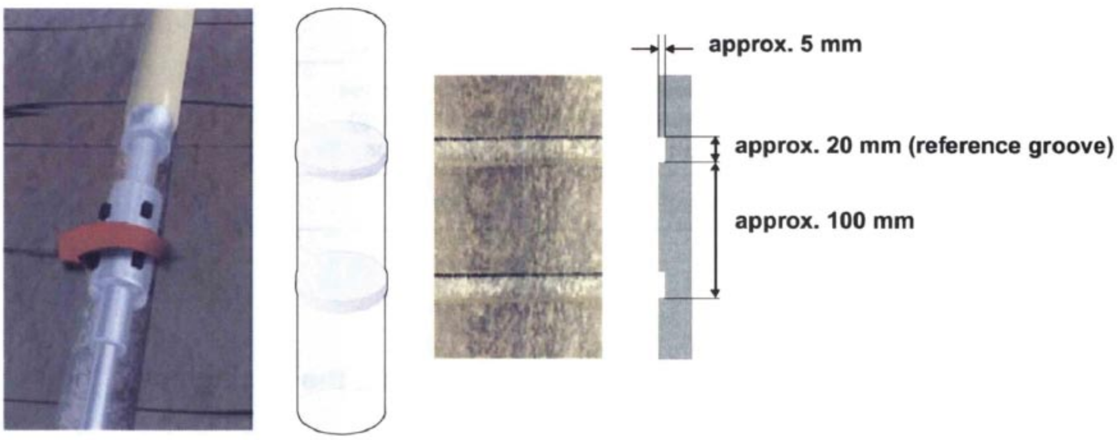


Figure 4-3. The equipment for reaming of reference slots. To the left, the reaming tool with openings for the cutters is shown. The resulting reference slots are illustrated in the three pictures to the right.

5 Execution and results

5.1 Summary of KLX08 drilling

A technical summary of the drilling of KLX08 is given in Table 5-1. A graphical presentation of the borehole after completion is given in Figure 5-1. A summary of drilling progress and borehole measurements is given in Table 5-2 and chronological summary is presented in Table 5-3. Further descriptions of the two main drilling steps, the percussion drilled telescopic section 0–100.33 metres and the core drilled section 100.33–1,000.41 metres are given in Sections 5.2 and 5.3 respectively. Results from hydrogeological and hydrogeochemical measurements during core drilling are presented in Section 5.4. Drilling progress over time is further reported in Section 5.5 "Drilling monitoring results".

After the drilling phase was finished the borehole measurements of for instance geophysical and hydrogeological properties were started. The measurements were done as separate activities and will not be reported here. However, a hydrogeological tool, the PFL probe, got stuck in the borehole and a salvaging operation had to be done in August and September of 2005. Further mention of these events will be given in Section 5.6.

Table 5-1. KLX08 Technical summary.

General	Technical
Name of hole: KLX08	Percussion drill rig Comacchio MC1500
Location: Laxemar, Oskarshamn Municipality, Sweden	Percussion hole length 100.2 m (diam 196.8 mm) 100.33 m (diam 165.4 mm)
Contractor for drilling: Drillcon AB	Core drill rig B 20 P Atlas Copco
Subcontractor percussion drilling: Sven Andersson AB	Core drill dimension N-size (76 mm)
Subcontractor core drilling: Suomen Malmi OY (SMOY)	Cored interval 100.33–1,000.41 m
Drill start date January 12, 2005	Average core length retrieved in one run 2.55 m
Completion date June 13, 2005	Number of runs 353
	Diamond bits used 23
	Average bit life 39 metres
	Position KLX08 (RT90 RH70) at top of casing:
	N 6367079.10 E 1548176.71 Z 24.31 (m.a.s.l.)
	Azimuth (0–360)/Dip (0–90)
	199.2/–60.3
	Position KLX08 (RT90 RH70) at 996 m length:
	N 6366630.87 E 1547925.88 Z –827.81 (m.a.s.l.)
	Azimuth (0–360)/Dip (0–90)
	213.0/–56.2

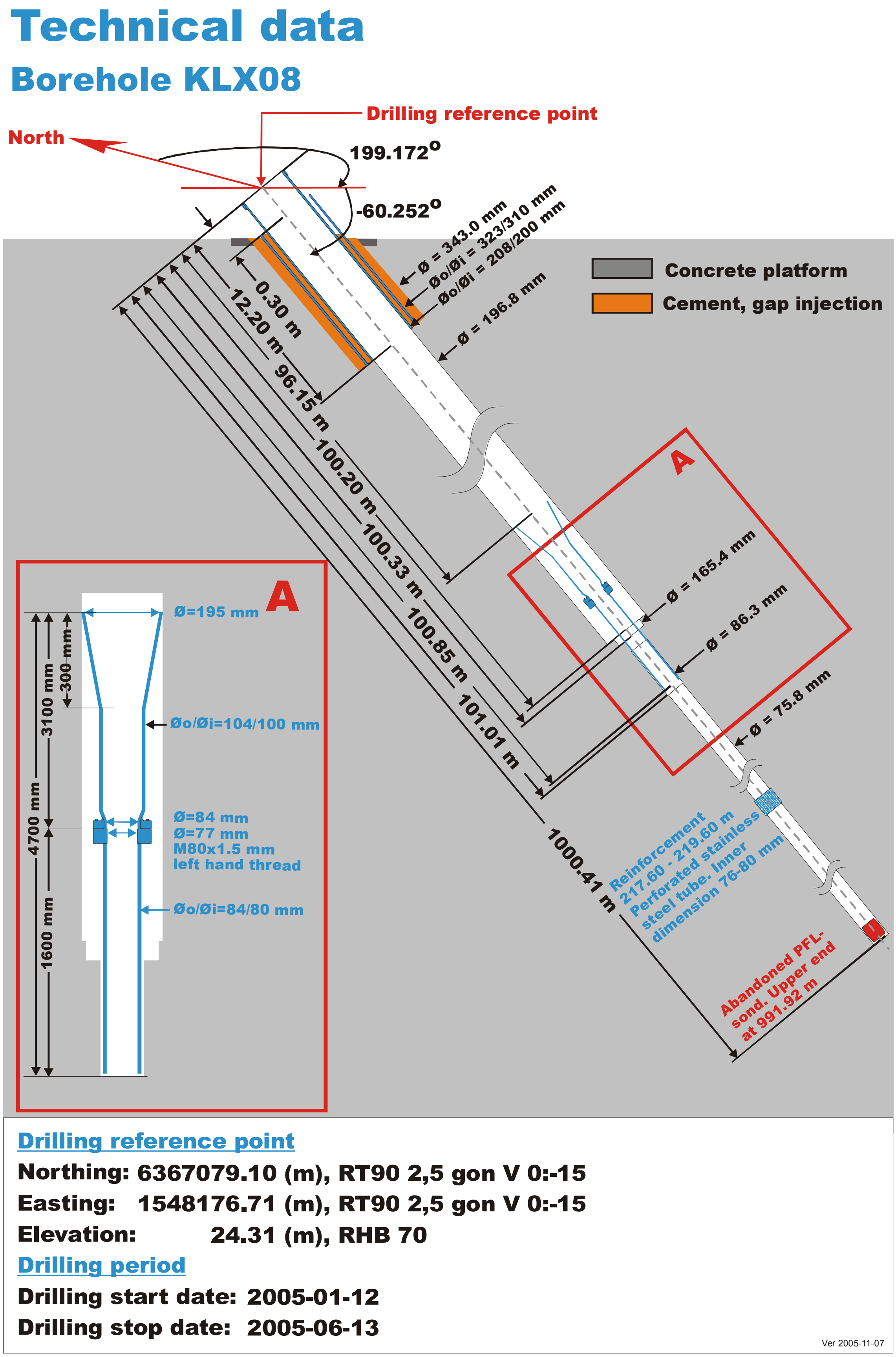


Figure 5-1. *Technical data from KLX08.*

Table 5-2. Summary of core drilling progress and borehole measurements in KLX08.

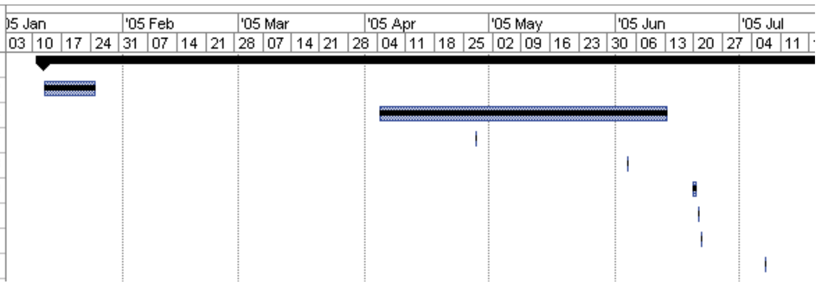
0 m

Drilled length, pumping tests and water sampling	Measurements of absolute pressure	Airlift pumping with evaluation of drawdown and/or recovery	Deviation measurement	Miscellaneous
			050119 EZ-shot 95 m. Dip –60° Bearing 198° (magnetic reading – not corrected for declination).	
050207 Open hole pumping test in the telescopic section 12–100 m.				
050411 Pumping test 189–200 m. 12.1 L/min at 17 m drawdown. Water sample with 0.4% DWC. 050412 Pumping test 0–200 m. 26 L/min at 6 m drawdown. Water sample (test made in open hoe lie no WL probe). 050419. Pumping test 197–303 m. 13.5 L/min with 13 m drawdown. Water sample.	050412 Measurement of absolute pressure 189–200 m. 050413 Measurement of absolute pressure 105–209 m. 050420 Measurement of absolute pressure 206–303 m.	050427 Airlift pumping 12–350 m. No drillstem in borehole.	050413 Multishot 0–198 m. Dip –60° Bearing 209°. 050413 Multishot 0–198 m. Dip –60° Bearing 209°. 050420 Multishot 303 m. Dip –60° Bearing 214°. 050427 Multishot 345 m. Dip –59° Bearing 211°.	050411 A water bearing fracture was indicated at 199 m.
050503 Pumping test 303–412 m. 12.4 L/min with 10 m drawdown. Water sample. 050510 Pumping test 410–518 m. 7 L/min with 14 m drawdown. Water sample. 050517 Pumping test 516–613 m. 0 L/min with 17 m drawdown. No water sample, no pressure measurement. 050527 Pumping test 612–713 m. 4.3 L/min with 17 m drawdown. Water sample.	050504 Measurement of absolute pressure 302–424 m. 050511 Measurement of absolute pressure 410–529 m. 050529 Measurement of absolute pressure 612–724 m.		050503 Multishot 410 m. Dip –59° Bearing 213°. 050513 Multishot 530 m. Dip –59° Bearing 212°. 050518 Multishot 610 m. Dip –59° Bearing 211°.	050528 Deviation measurement failed. The tool got stuck at 223 m.
050602 Pumping test 709–797 m. 0 L/min with 10 m drawdown. No water sample and no pressure measurement. 050608 Pumping test 800–900 m. Three failed attempts due to technical reasons (poor thread in drill stem). 050613 Pumping test 794–1,000 m. 0.6 L/min with 22 m draw-down. No water sample and no pressure measurement.		050603 Airlift pumping 12–797 m. No drillstem in borehole. 050621 Airlift pumping 12.2–1,000.41 m. No drillstem in borehole.	050603 Multishot 790 m. Dip –58° Bearing 212°. 050621 Maxibor 0– 996 m. Dip –56.19°. Azimuth 213.02°.	050615 Water flushing towards zones with unstable rock. 211–220 m, 278–280 m, 290–302 m. 050616 Nitrogen flushing with drill stem at 195 m. 050617–050618 Nitrogen flushing 0–1,000 m. 050618 Dummy probe lowered to 1,000 m without problems.

1,000 m

Table 5-3. Chronological summary of main drilling events.

Aktivitet	Start
First activity starts	**Wed 05-01-12**
Percussion drilling	Wed 05-01-12
Core drilling	Mon 05-04-04
Recovery test	Wed 05-04-27
Recovery test	Fri 05-06-03
Length calibration marks	Sun 05-06-19
Maxibor measurement	Tue 05-06-21
Recovery test	Tue 05-06-21
Maxibor measurement	Thu 05-07-07



5.2 Drilling, measurements and results in the telescopic section 0–100.33 m

Drilling, reaming and grouting (gap injection) were made from January 12 to 24, 2005.

5.2.1 Preparations

A cement pad for emplacement of drill rig, fuel container and compressor was built.

Cleaning of all DTH (down-the-hole) equipment was done with a high-capacity steam cleaner.

5.2.2 Drilling and casing installation

The construction of the upper telescope section (0–100.33 metres) of KLX08 was made in steps as described below:

Drilling was done by Sven Andersson AB and consisted of the following items:

- Drilling was made to 12.20 metres length with NO-X 280 mm equipment. This gave a hole diameter of 343 mm and left a casing (323.7 mm diameter) to a length of 12.20 m.
- Inner supportive casing for guidance for the drill string was mounted.
- A pilot percussion hole was drilled to a depth of 100.33 metres. The diameter at full length was 165.4 mm.
- Deviation measurement was made with EZ-shot at 95 metres. No significant deviation from planned values was noted. The dip was –60° and the bearing 198° (magnetic reading i.e. not corrected for declination).
- Stainless casing of 208.4 mm was installed from 0 to 12.20 m.
- Gap injection (casing grouting) with low alkali cement based concrete (464 kg/520 litres) was made for both sets of casing as described in Figure 5-2.
- After the concrete had hardened, the hole was reamed from 12.20 to 100.20 m. The diameter at full length was 196.8 mm. The borehole was rinsed and flushed to remove concrete and water.

Between 53 and 57 metres, “poor” rock conditions were noted during percussion drilling. This is also reflected in reduced penetration times as can be seen in Figure 5-3. The reduced penetration times at 54 and 57 m do, however, also correspond to changes in lithology.

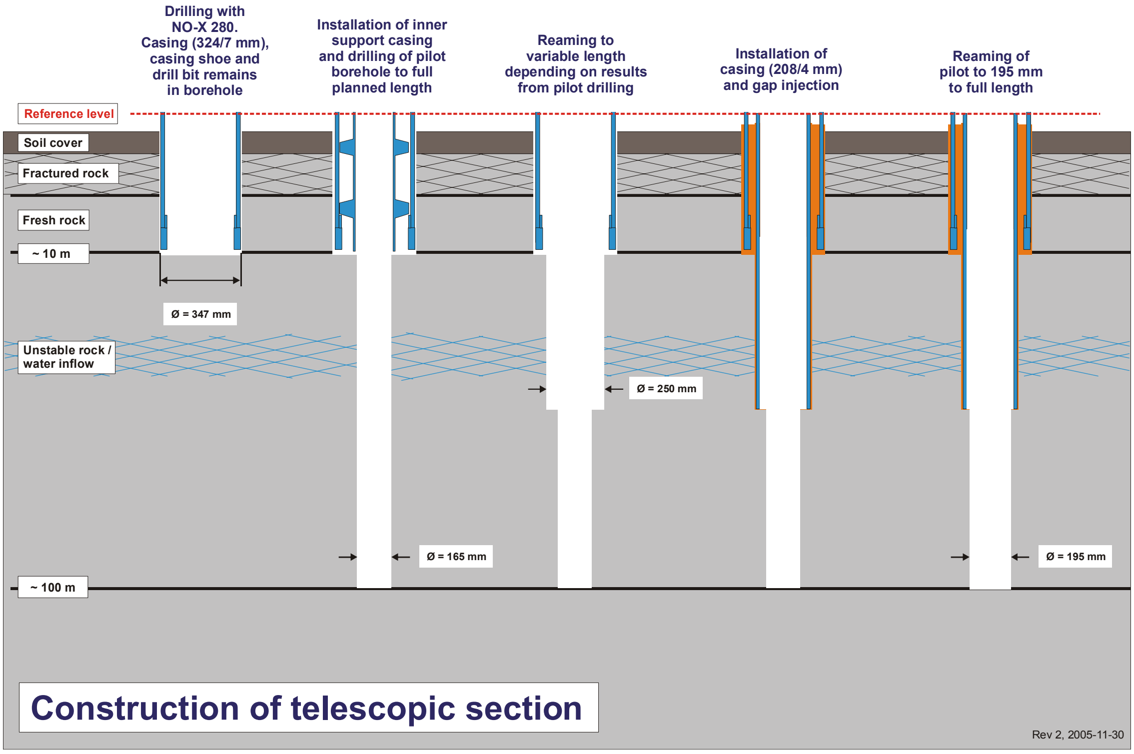


Figure 5-2. *Construction of the telescopic section. The gap filling cement is introduced between the casing and the rock wall. The drill bit acts as a barrier so that cement does not enter the pilot hole.*

5.2.3 Measurements and sampling in the telescopic section

Sampling and measurements done during drilling of the telescopic section included:

- The percussion drilling progress was monitored by the geology coordinator (or contracted geologist). Drill cuttings samples were collected every metre and a preliminary geological logging including measurement of magnetic susceptibility was made.
- Penetration rate (expressed as seconds per 20 cm) was recorded manually and observation of changes in water flow was noted.

The preliminary geological results with penetration rate and magnetic susceptibility as measured on the cuttings are presented in Figure 5-3. No water inflow was measured.

The depth to bedrock was 2.8 m. The observed soil sequence is given in Table 5-4.

Table 5-4. Soil sequence in KLX08.

From (m)	To (m)	Observation
0.19	0.50	Fill material, gravel
0.50	1.80	Sand and wood (tree stumps)
1.80	2.80	Boulders, gravel, sand and wood. Predominantly Ävrö granite composition

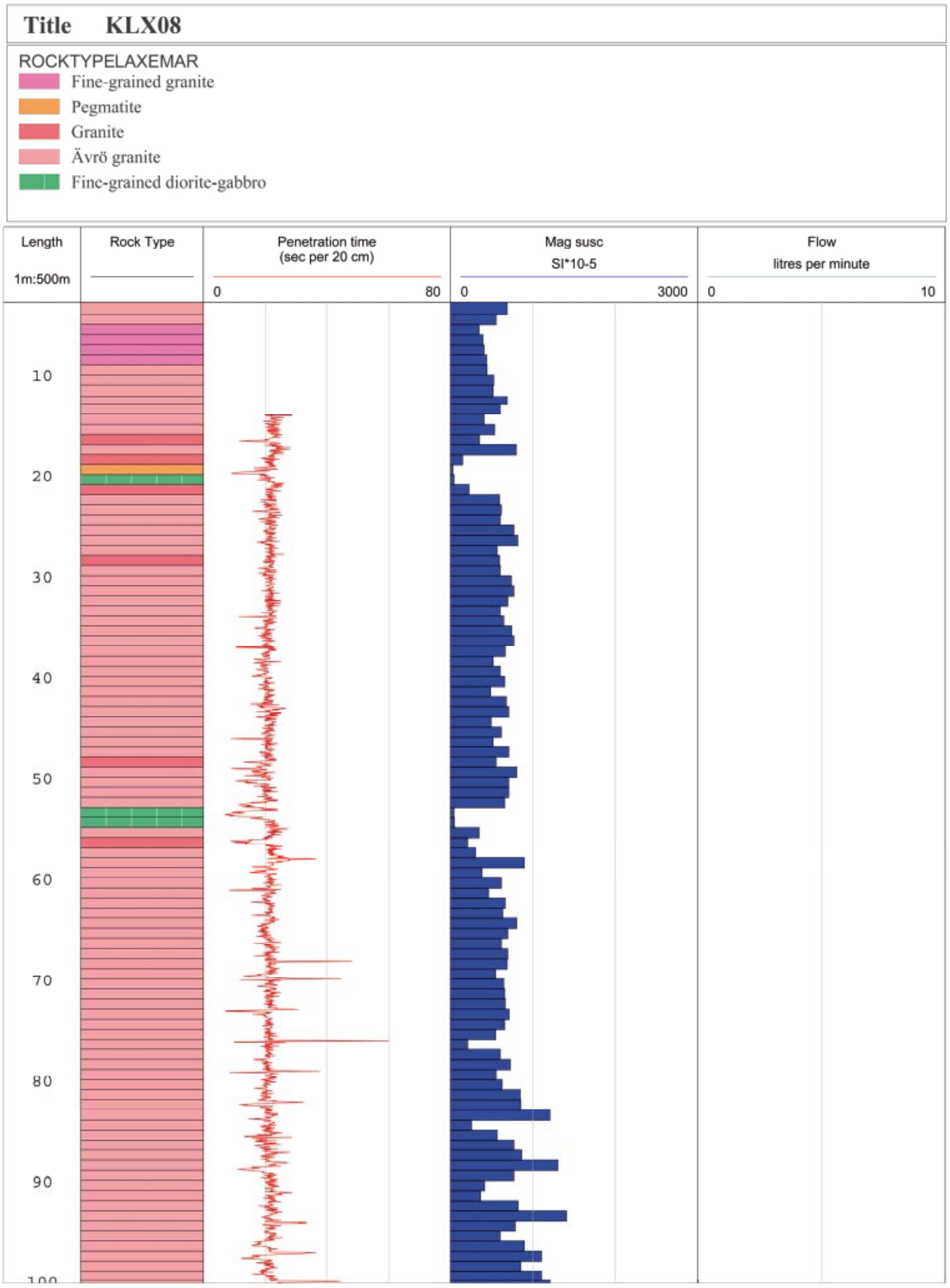


Figure 5-3. *Preliminary geological results based on logging of drill cuttings and penetration rate from percussion drilling of KLX08.*

Hydrogeology

No water inflow could be measured from the telescopic section in KLX08.

Hydrochemistry

No water samples were collected from the telescopic section in KLX08.

5.3 Core drilling KLX08 100.33–1,000.41 m

Core drilling in KLX08 was conducted between April 4, 2005 and June 13, 2005.

The main work in KLX08 after drilling the telescopic section consisted of the following steps:

- Preparations for core drilling.
- Flushing and return water handling.
- Core drilling including directional drilling and deviation measurements.
- Borehole completion.

Measurements and results from wireline tests and drill monitoring are given in Sections 5.4 and 5.5.

5.3.1 Preparations

The preparations for core drilling started on March 20, 2005 and consisted of installation of air-lift pumping equipment and supportive casing for alignment of the core drill rods, see Figure 5-4.

The installation of supportive casing was done in steps:

- An outer casing with a diameter of 98/89 mm, fitted with fins to align with the diameter of the percussion drilled borehole was installed.
- Equipment for air-lift pumping was installed and a discharge header was fitted to collect the return water.
- Drilling was made between 100.33 and 101.01 m with T-86 equipment. An inner supportive casing with diameter 84/77 mm was installed to 101.01 m.

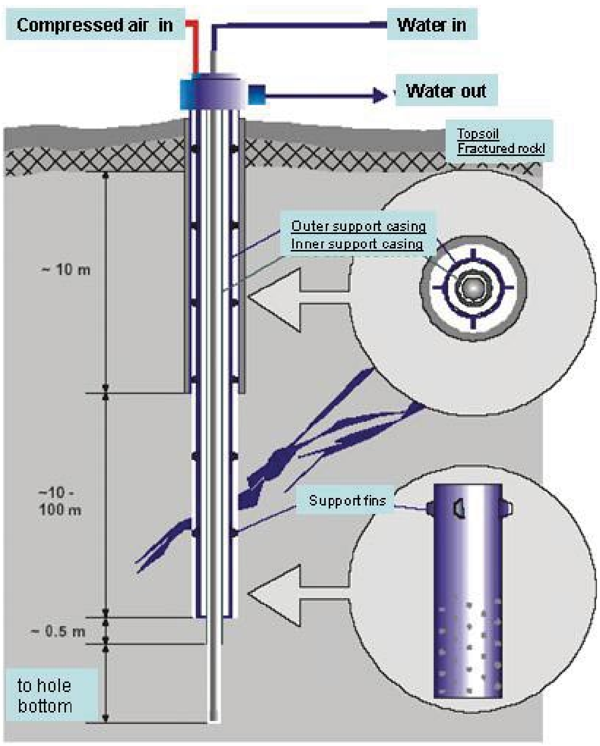


Figure 5-4. In the telescopic part of the drill hole a temporary installation is made with casing tubes for support and alignment and equipment for air-lift pumping. In the uppermost part the return water discharge header is mounted. The water discharge is led to the settling containers.

The supportive casings have a perforated section between 99.20 and 99.60 metres length so that water from the borehole can be lead to the air-lift pumping system outside the supportive casings. A pressure meter for monitoring of the water level was emplaced at a length of 89 metres.

5.3.2 Flushing and return water handling

The flushing water source was percussion borehole HLX10, see Figure 1-1.

Treatment of the flushing water before introduction into the boreholes consisted of removal of oxygen by nitrogen flushing and addition of the fluorescent tracer uranine. The water is also treated with ultraviolet light in order to reduce the microbial content. The flushing and return water handling and the emplacement of related monitoring equipment in KLX08 is shown in Figure 5-5.

The targeted content for uranine in the flushing water is 0.20 mg/L and the actual average uranine content was 0.183 mg/L, see also Figure 5-9 and Section 5.4.2.

The return water from drilling was led to a series of sedimentation containers in order to collect sludge before infiltration to the ground, see also Section 5.8.

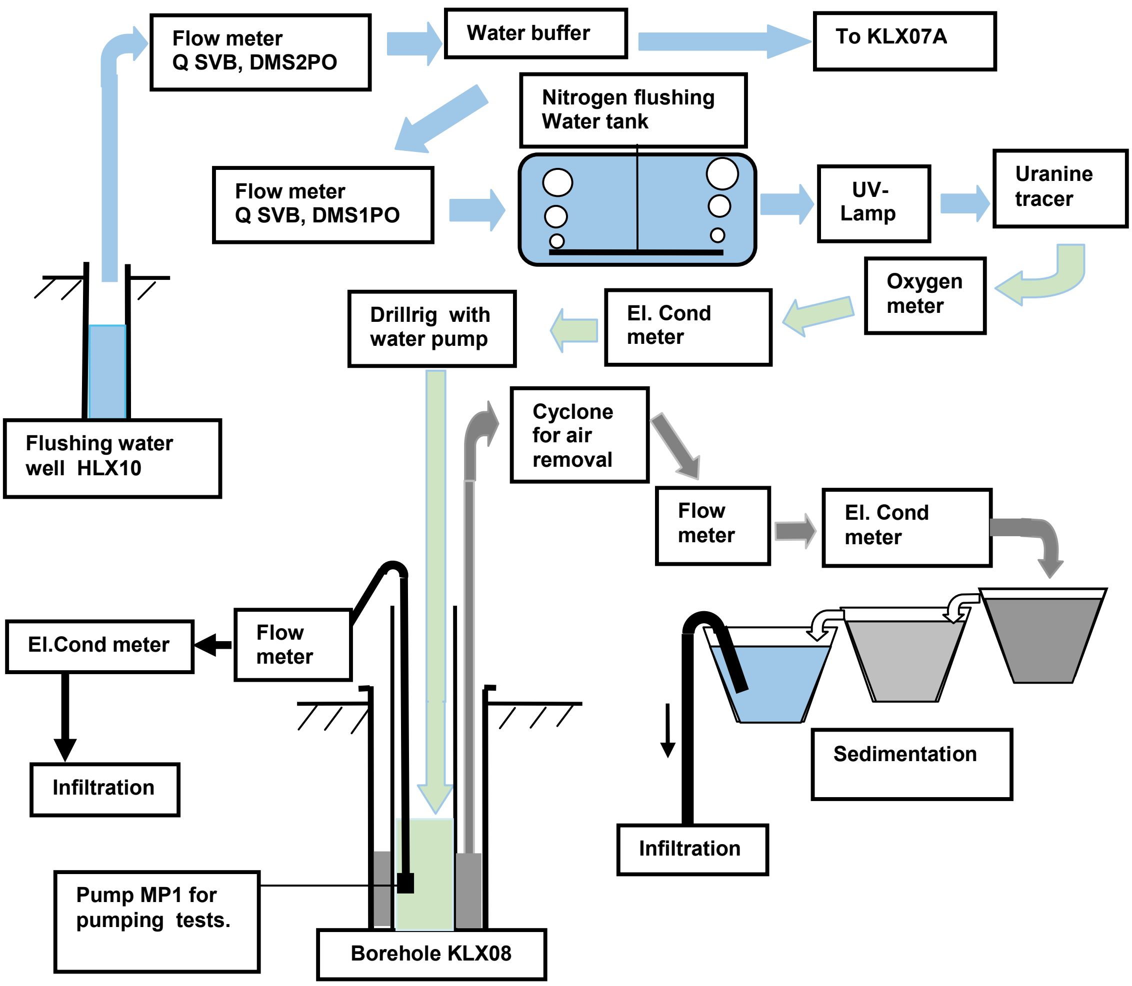


Figure 5-5. The flushing and return water handling and the emplacement of related monitoring equipment in KLX08.

5.3.3 Drilling and deviation measurements KLX08

Core drilling with N-size (76 mm) triple-tube, wireline equipment was conducted from 100.98 m to the final length of 1,000.41 m in KLX08.

The core diameters and intervals for different drilling dimensions or method of directional drilling are given in Table 5-5.

Eight deviation measurements with the Easy-shot equipment, were made for following the core drilling progress in KLX08. The resulting dips and azimuths showed a reasonable consistency over the length of the borehole. Horizontal and vertical plots of the results of the final run with the Maxibor method covering the entire length of borehole KLX08 are given in Appendix 4. The results from the final Maxibor measurements are stored in the Sicada database and are shown in Table 5-6.

Core losses were noted in the Boremap mapping (see Section 5.7) at the intervals given in Table 5-7.

A total of twenty four drill bits were used for KLX08, see Figure 5-6. The unusually large amount of drill bits used is due to the use of second-hand bits.

Table 5-5. Core diameters, borehole diameters and drilling dimensions during core drilling.

Core diameter (mm)	Borehole diameter (mm)	Interval (m)	Drilling dimension or directional drilling method
72.0	86	100.33–101.01	T-86
50.2	76	101.01–1,000.41	N

Table 5-6. Results from the deviation measurement stored in Sicada for KLX08.

Date	Method	Drilled length (m)	Dip	Azimuth
2005-06-21	Maxibor	996	–56.19°	213.02°

Table 5-7. Core losses noted in KLX08.

From (m)	To (m)	Length (m)	Comment
158.15	158.25	0.10	Missing core piece
161.95	162.13	0.18	Missing core piece
217.52	219.53	2.01	Mechanical
526.13	526.23	0.10	Missing core piece
529.12	529.17	0.06	Missing core piece
613.25	613.32	0.07	Missing core piece
654.63	654.68	0.05	Missing core piece
655.39	655.42	0.03	Missing core piece
658.70	658.72	0.02	Missing core piece
737.05	737.11	0.06	Missing core piece

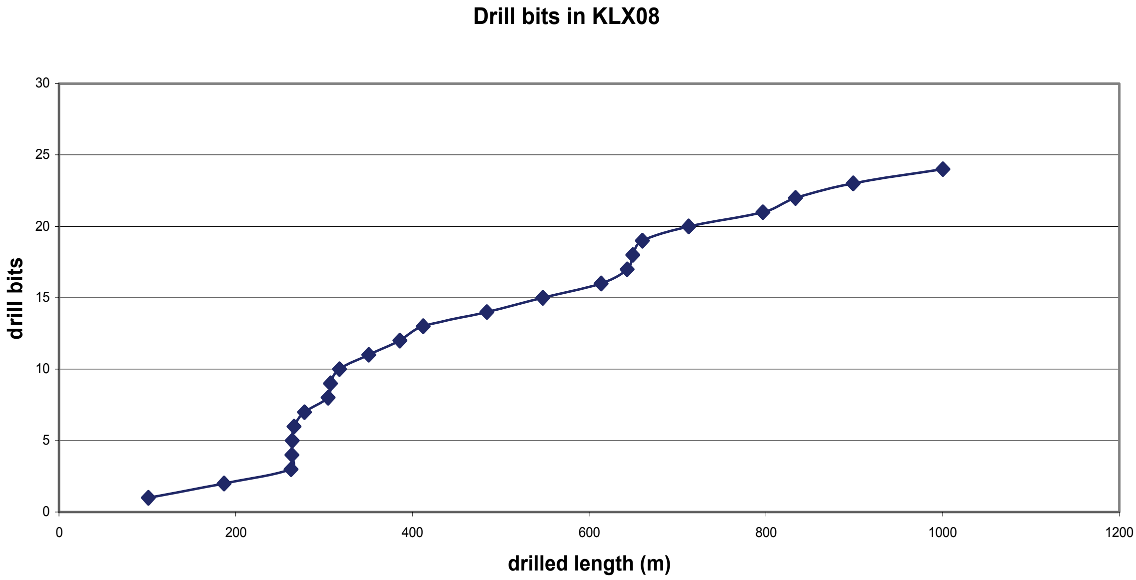


Figure 5-6. *Changes of drill bits during core drilling in KLX08.*

Further results from drill monitoring i.e. drill penetration rate and various measurements will be presented in Section 5.5 "Drilling monitoring results" and in Appendix 1. The drilling progress over time is shown in Section 5.5, see Figure 5-16.

5.3.4 Borehole completion and borehole wall assessment

Reaming of depth reference slots was done at intervals as shown in Table 5-8. The depth reference slots are used for depth calibration of down-hole equipment for subsequent investigations in the hole.

The presence of the depth reference slots have been confirmed by caliper log measurements.

The air lift pumping equipment and the inner supportive casing in the telescopic section was removed.

A steel conical guide was installed in KLX08 between 96.15 m and 99.25 m together with a 84/80 mm casing between 99.25 and 100.85 m. The conical guide tapers from an inner diameter of 195 mm to 77 mm.

The length of the holes was rinsed by flushing with nitrogen gas at three instances each spanning over two days, see Table 5-9.

Table 5-8. Depth reference slots (m) in KLX08.

111.00	600.00
150.00	650.00
200.00	700.00
250.00	750.00
300.00	800.00
349.00	850.00
400.00	900.00
450.00	950.00
500.00	980.00
550.00	

Table 5-9. Dates for nitrogen gas flushing in KLX08.

Date	Time*	Interval (m)	Water lifted (m^3)
050617	15.20–18.00	0–1,000.41	10.5
050618	6.00–9.00	0–1,000.40	6
050704	13.00–18.00	0–995	No data
050705	6.00–16.00	0–995	No data
050923	13.00–18.00	0–990	No data
050924	8.00–12.00	0–990	8

* Local time i.e. daylight savings time.

The drill crew noted a drop in water pressure while drilling on April 11, 2005 at about 199 m. On May 28 the EZ-shot tool for deviation measurement stopped at 223 m by what was judged as "a problem in the hole".

The sections deemed to be "problematic" (211–220 m, 278–280 m, 290–302 m) were water flushed with high pressure. The length of the borehole was also flushed with nitrogen gas.

A dummy probe was run through the length of the hole on June 18, 2005 to ensure that the hole was straight and unobstructed. The indicator (caliper log) for detecting the reference slots was run through the length of the borehole without any problems on June 22.

A BIPS-logging (borehole image processing system i.e. a down-hole digital camera) of the interval 0–240 m was done and SKB decided not to perform any stabilising measures in the borehole.

The boreholes were secured by mounting of lockable steel caps fastened to the concrete pad. All equipment was removed, the site cleaned and inspected by representatives from SKB and the contractor to ensure that the site had been satisfactorily restored.

After the core drilling phase was finished other down-hole investigations were initialised. However a hydrogeological tool got stuck in the borehole in August and a drill rig had to be mobilised to the site again, see Section 5.6.

5.4 Hydrogeological and hydrochemical measurements and results KLX08 100.30–1,000.41 m.

Wireline measurements:

- Nine pumping tests were conducted at various intervals, seven were successful, see Section 5.4.1.
- Six measurements for absolute pressure, see Section 5.4.1.
- Six water samples were successfully collected from the nine pumping tests, see Section 5.4.2.
- 25 samples for pore water chemistry analysis (pore matrix samples) were collected from the drillcore.

Analytical results from sampling of flushing and return water at the surface are given in Section 5.4.2.

Three air-lift pumping tests with evaluation of drawdown and/or recovery phase were made, for results see Section 5.4.3.

5.4.1 Hydrogeological results from wireline measurements

Results from the wireline tests in KLX08 are presented in Table 5-10 and Figure 5-7.

The pumping tests were evaluated with steady-state assumption in accordance with Moye (1967) /2/. The flow rate at the end of the drawdown phase was used for calculating the transmissivity (T_M), and the specific capacity (Q/s), where Q is the flow rate in L/min, and s is the drawdown in kPa.

A total of nine pumping tests were performed, and seven achieved sufficiently stable conditions for calculating pseudo steady-state transmissivity. The plots from the pumping tests are given in Appendix 5.

Table 5-10. Pumping tests with wireline probe in KLX08.

Tested section [m]	Q/s [m²/s]	T_M [m²/s]	Comments
188.90–199.94	$2.8 \cdot 10^{-4}$	$2.7 \cdot 10^{-4}$	Test functionally ok, good data.
100.30–199.94	$6.1 \cdot 10^{-5}$	$8.0 \cdot 10^{-5}$	Test without WL-sonde, h_i and h_p from pressure in drill stem. Slightly variable flow, but test functionally ok.
197.50–303.86	$3.2 \cdot 10^{-4}$	$4.1 \cdot 10^{-4}$	Slightly variable flow, pressure in casing = 0 kPa during the test.
302.80–412.15	$2.9 \cdot 10^{-4}$	$3.8 \cdot 10^{-4}$	Test functionally ok. Pressure in casing in transient recovery phase unaffected of pumping test.
410.59–518 .00	$1.2 \cdot 10^{-5}$	$1.5 \cdot 10^{-5}$	Test functionally ok, good data. Pressure in casing in transient recovery phase, unaffected of pumping test.
516.73–613.37	$3.6 \cdot 10^{-6}$	–	Extremely short pumping period, due to no flow. Only an approximate specific capacity calculated.
612.00–713.00	$3.8 \cdot 10^{-6}$	$4.9 \cdot 10^{-6}$	Test functionally ok, good data. Pressure in casing in transient recovery phase unaffected of pumping phase.
709.50–796.95	$1.6 \cdot 10^{-6}$	–	Extremely short pumping period, due to no flow. Only an approximate specific capacity calculated.
794.50–1,000.41	$6.1 \cdot 10^{-7}$	$8.6 \cdot 10^{-7}$	Increasing flow after approximately 2 hours pumping.

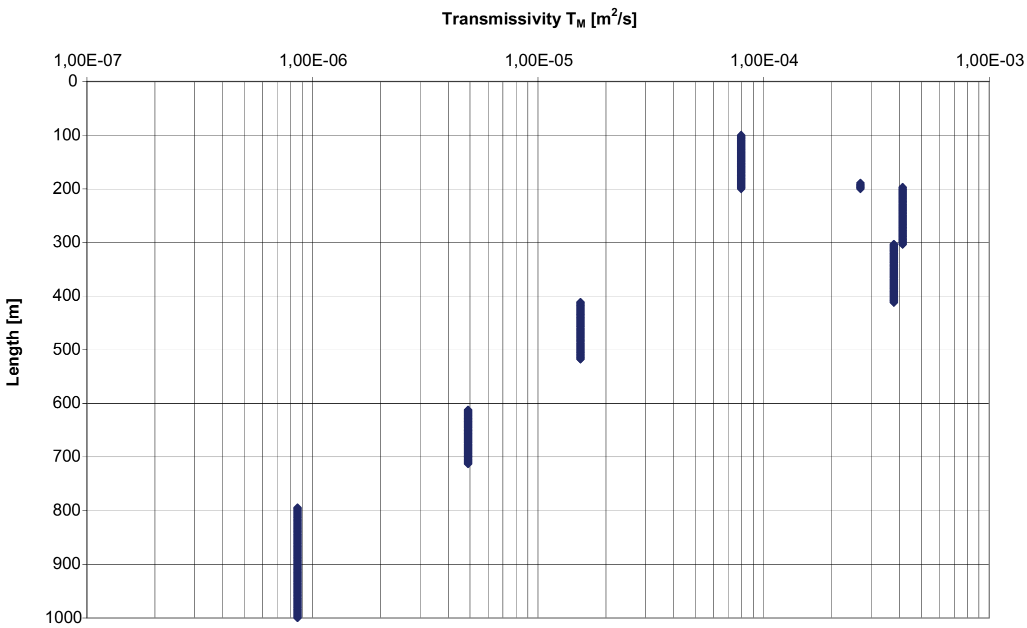


Figure 5-7. *Transmissivity from wireline pumping tests in KLX08 versus borehole length.*

The start and stop times for the interval used for evaluation of the pumping tests are given in Table 5-11.

Measurements of the absolute pressure were conducted in six sections, as specified in Table 5-12 and Figure 5-8.

After packer inflation the pressure stabilization phase often displays different types of transient effects, both of increasing and decreasing pressure. The reason for these transients is not known, though they might be attributable to previous disturbances in the borehole caused by the drilling operations, such as pressure, salinity, and temperature.

Table 5-11. Evaluated test periods.

Tested section (m)	Start (YYYY-MM-DD HH:MM)	Stop (YYYY-MM-DD HH:MM)
188.90–199.94	2005-04-11 12:08	2005-04-12 02:27
100.30–199.94	2005-04-12 17:22	2005-04-13 02:10
197.50–303.86	2005-04-19 18:45	2005-04-20 02:30
302.80–412.15	2005-05-03 17:45	2005-05-04 03:07
410.59–518.00	2005-05-10 17:15	2005-05-11 02:32
516.73–613.37	2005-05-17 17:40	2005-05-17 17:55
612.00–713.00	2005-05-27 16:30	2005-05-28 02:32
709.50–796.95	2005-06-02 17:33	2005-06-02 17:48
794.50–1,000.41	2005-06-14 19:37	2005-06-14 21:51

Table 5-12. Absolute pressure measurements in KLX08.

Tested section [m]	Last pressure reading during build-up [kPa]	Duration of pressure build-up [hours]	Borehole length to pressure gauge [m]
188.90–199.94	1,610	6.1	190.00
104.95–208.96	868	12.4	106.05
206.50–303.86	1,764	47.6	207.60
302.80–424.40	2,574	13.4	303.90
410.59–529.18	3,491	12.2	411.69
612.00–724.22	5,190	13.7	613.10

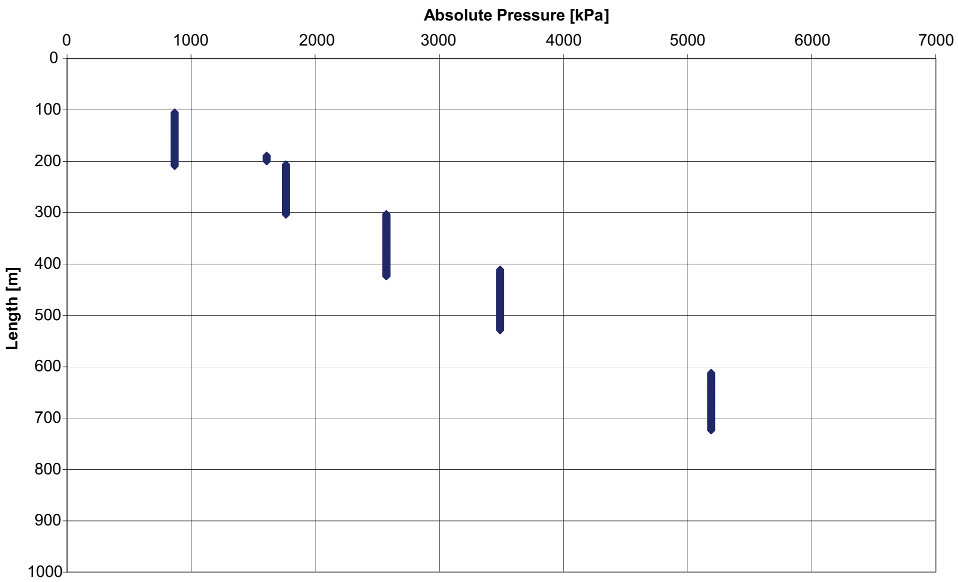


***Figure 5-8.** Absolute pressure measurements from wireline tests in KLX08 versus borehole length.*

5.4.2 Hydrochemistry

In total, six water samples were collected in connection with core drilling in KLX08. The times and lengths for the samples are given in Table 5-13.

Sampling and analysis were performed according to the SKB classes specified in Table 5-13. All samples were collected at the drill site as soon as possible after the sampling occasion and prepared and conserved at the Äspö laboratory.

All six samples were intended for analysis according to SKB chemistry class 3, however, samples 10289 and 10315 were only analysed for drill water percentage. The drilling water content is a measure of the amount of uranine tracer in the return water. A low percentage of drilling water implies that the amount of pristine formation water is high in the sample i.e. low amount of the uranine-spiked flushing water.

Sample 10232 was not analysed for isotopes despite the low drill water percentage, instead sample 10230 was prioritised for isotope analysis because it has a shorter section interval. However, bottles intended for analysis of the isotopes deuterium, tritium and ^{18}O for sample 10232 are stored in freezer and refrigerator at the Äspö laboratory.

Archive samples have been collected for all class 3 samples in Table 5-13.

Selected analytical results from KLX08 are given in Table 5-14. A complete record of analytical results is given in Appendix 2. A further account on analytical methods, chemistry class 3 and analytical quality is given in Appendix 3.

The percussion drilled borehole HLX10 was used as a water source during the drilling of KLX08. Samples of total organic content, TOC, has been collected from HLX10 at earlier occasions and results from these samples are reported in previous reports /4 and 7/.

Table 5-13. Sample dates and length during core drilling in KLX08.

SKB sample number	Borehole	Date	Test section, length (m)	SKB chemistry class
10230	KLX08	2005-04-12	188.90–199.94	3* and all option isotopes
10232	KLX08	2005-04-13	0.00–199.94**	3 (not analysed for isotopes)
10244	KLX08	2005-04-20	197.50–303.86	3 and all option isotopes
10281	KLX08	2005-05-04	302.80–412.15	3 and all option isotopes
10289	KLX08	2005-05-11	410.59–518.00	1 (only analysed for drill water percentage)
10315	KLX08	2005-05-28	612.00–713.00	1 (only analysed for drill water percentage)

* The analysed parameters included in "SKB chemistry class 3" are shown in Appendix 3.

** Sampling was made with a MP1 pump i.e. not with the wireline probe. The position of the drill bit was at 92 metres.

Table 5-14. Analytical results from water chemistry sampling.

Borehole	Sample no	Sample date	From (m)	To (m)	Drill water %	pH	Electrical conductivity mS/m	Cl^- mg/l
KLX08	10230	2005-04-12	188.90	199.94	0.38	8.27	52.2	9.9
KLX08	10232	2005-04-13	0.00	199.94	1.37	8.15	48.7	9.6
KLX08	10244	2005-04-20	197.50	303.86	30.80	8.35	54.1	17.0
KLX08	10281	2005-05-04	302.80	412.15	25.40	8.56	74.2	82.5
KLX08	10289	2005-05-11	410.59	518.00	45.60	–	–	–
KLX08	10315	2005-05-28	612.00	713.00	60.20	–	–	–

Sampling for determination of microorganism content

Three samples were taken in order to determine the microorganism content within the flushing water system. They were all sampled on April 21, 2005 after cleaning the system. The samples were taken from three different locations within the flushing water system. The results are reported separately /9/.

Sampling for pore water analysis

Sampling of the drill core for pore water chemistry analysis (pore matrix sampling) was done in borehole KLX08. A total of 25 samples were collected in the borehole, see Table 5-15.

The analytical results are not available at the time of writing and will be presented in a separate report /8/.

Water sampling and analysis of uranine tracer content and electrical conductivity

From KLX08, a total of 125 samples for laboratory testing of uranine content and electrical conductivity in flushing and returning water were taken along the borehole. In addition 23 samples were analysed for uranine content on the drill site with a hand held fluorometer.

The results are shown graphically in Figure 5-9. A complete account of samples and results are given in Appendix 7. The uranine results obtained from analysis on the drill site shown with bold italics in Appendix 7.

Table 5-15. Summary of sampling for pore water chemistry.

Sample date	Sample no	Borehole	Secup (m)	Seclow (m)
2005-04-08	9700	KLX08	150.00	150.43
2005-04-11	9701	KLX08	199.30	199.60
2005-04-13	9702	KLX08	200.07	200.45
2005-04-13	9703	KLX08	200.45	200.80
2005-04-13	9704	KLX08	201.21	201.47
2005-04-13	9705	KLX08	201.47	201.76
2005-04-13	9706	KLX08	202.30	202.65
2005-04-13	9707	KLX08	203.07	203.25
2005-04-13	9708	KLX08	203.65	204.00
2005-04-15	9709	KLX08	250.07	250.32
2005-04-19	9710	KLX08	302.17	302.50
2005-04-27	9711	KLX08	346.92	347.27
2005-05-02	9712	KLX08	395.49	395.80
2005-05-06	9713	KLX08	451.52	451.72
2005-05-09	9714	KLX08	499.66	499.90
2005-05-13	9715	KLX08	550.10	550.35
2005-05-16	9716	KLX08	601.54	601.81
2005-05-23	9717	KLX08	659.90	660.15
2005-05-27	9718	KLX08	701.86	702.23
2005-05-31	9719	KLX08	750.64	750.95
2005-06-04	9720	KLX08	802.06	802.37
2005-06-07	9721	KLX08	857.82	858.14
2005-06-10	9722	KLX08	903.10	903.45
2005-06-11	9723	KLX08	945.69	946.00
2005-06-12	9724	KLX08	983.00	983.35

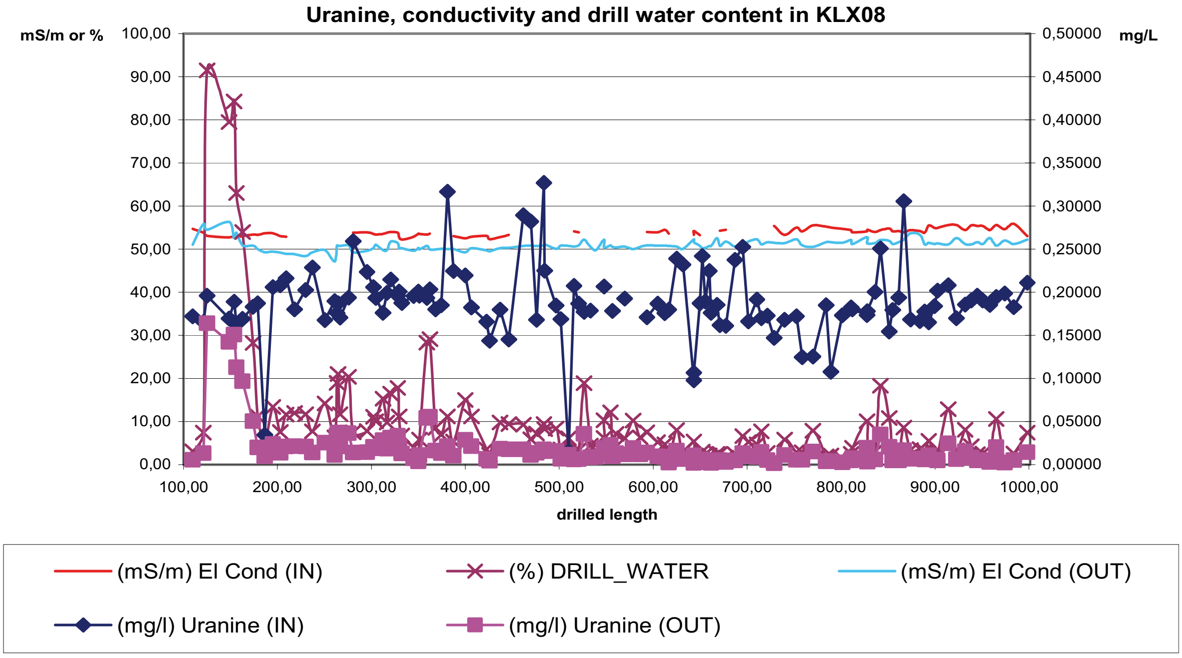


Figure 5-9*. The uranine concentration, electrical conductivity of flushing water (IN) and returning water (OUT) and drill water percentage in KLX08 during drilling. Notably, the electrical conductivity of the return water is lower than the ingoing flushing water.*

The calculated average uranine content for the whole borehole, 0,183 mg/l, is based only on the results from the Äspö laboratory. This value has also been used for further calculations of the drill water content in the samples collected after drilling. However, for the samples collected during drilling (i.e the samples in this report), the drill water content for each sample is based on the average uranine content in the flushing water samples up to the time of sampling.

5.4.3 Results from air lift pumping with evaluation of drawdown and/or recovery

Two airlift pumping tests were conducted during drilling, and one additional test was conducted after the borehole was drilled to full depth. The execution of the tests can vary in detail as drilling or other related activities such as cleaning and flushing of drill cuttings can occur prior to lifting the stem.

The steady state transmissivity, T_M, was calculated according to Moye (1967) /2/, as well as the specific capacity, Q/s. The results are shown in Table 5-16, and stored in the SICADA database as “recovery tests” (code HY050). The tested section is here defined as the section between the lower end of the grouted casing and the borehole bottom. The calculated specific capacity (Q/s) and transmissivity (T_M) was derived from the drawdown phase. No transient evaluation of the recovery phase was made.

Table 5-16. Results from airlift pumping in KLX08.

Tested section [m]	Flow rate [L/min]	Drawdown [m]	Q/s [m²/s]	T_M [m²/s]	Comments
12.2–349.94	31.9	12.0	$4.4 \cdot 10^{-05}$	$6.6 \cdot 10^{-05}$	Uncertain h_p due to variable water level, caused by highly variable flow.
					Q derives from accumulated volumes of water in and out. Q = ΣV/dt
12.2–796.95	55.0	1.6	$5.7 \cdot 10^{-04}$	$9.3 \cdot 10^{-04}$	Q derives from accumulated volumes of water in and out. Q = ΣV/dt
12.2–1,000.41	54.4	5.1	$1.8 \cdot 10^{-04}$	$3.0 \cdot 10^{-04}$	Q derives from accumulated volumes of water in and out. Q = ΣV/dt

The plots from the drawdown tests are given in Figures 5-10, 5-11, and 5-12. It should be emphasized that each plot represents a full day which could also include drilling. Typically, the air-lift pumping in the telescopic section starts in the morning and continues throughout most part of the day. Drilling is indicated by water being pumped into the borehole (flow in). Towards the end of the day drilling is stopped and the drill stem is removed from the borehole. The "flow in" is reduced to zero when drilling stops. Air-lift pumping in the telescopic section however continues for a period of 30 minutes to two hours. This period of undisturbed air-lift pumping without the drill stem in the borehole constitutes the drawdown period on which the test evaluation is based.

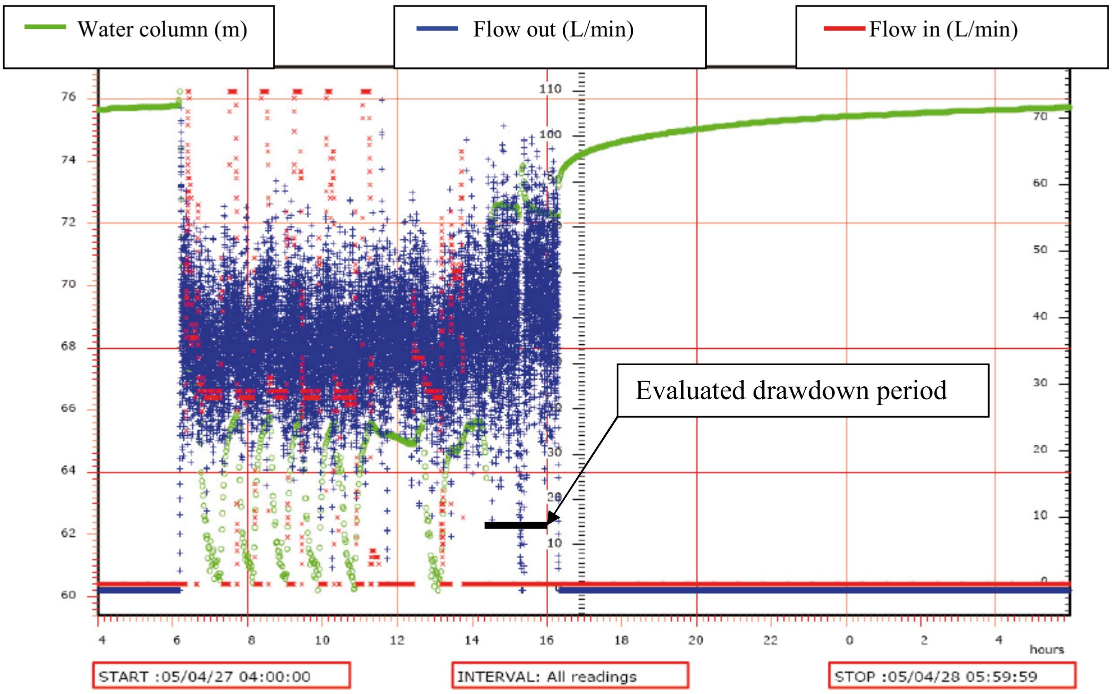


Figure 5-10. *Air-lift pumping in KLX08 12.20–349.94 m. The green line represents the height of the water column in the borehole, the flow out (i.e. pumped flow from air-lift pumping in the telescopic section) is shown as the blue dotted line. Inflow of water (red line) is related to drilling. The drawdown period on which the test results are derived is given with a black bar.*

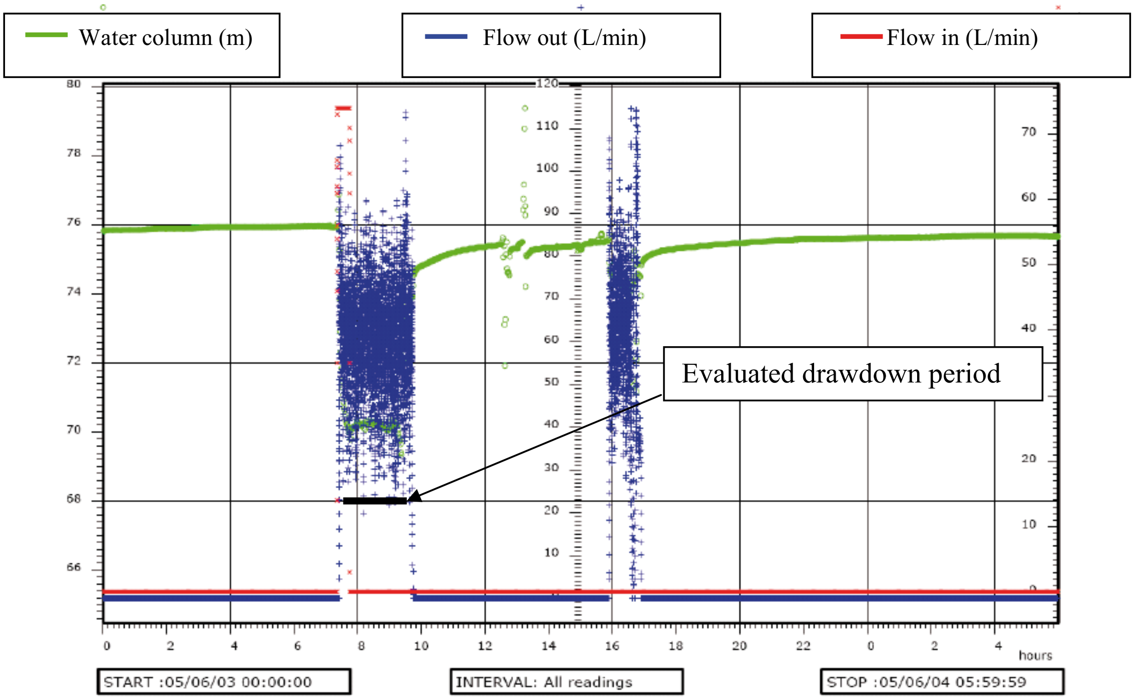


Figure 5-11. *Air-lift pumping in KLX08 12.20–796.95 m. The green line represents the height of the water column in the borehole, the flow out (i.e. pumped flow from air-lift pumping in the telescopic section) is shown as the blue dotted line. Inflow of water (red line) is related to drilling. The drawdown period on which the test results are derived is given with a black bar.*

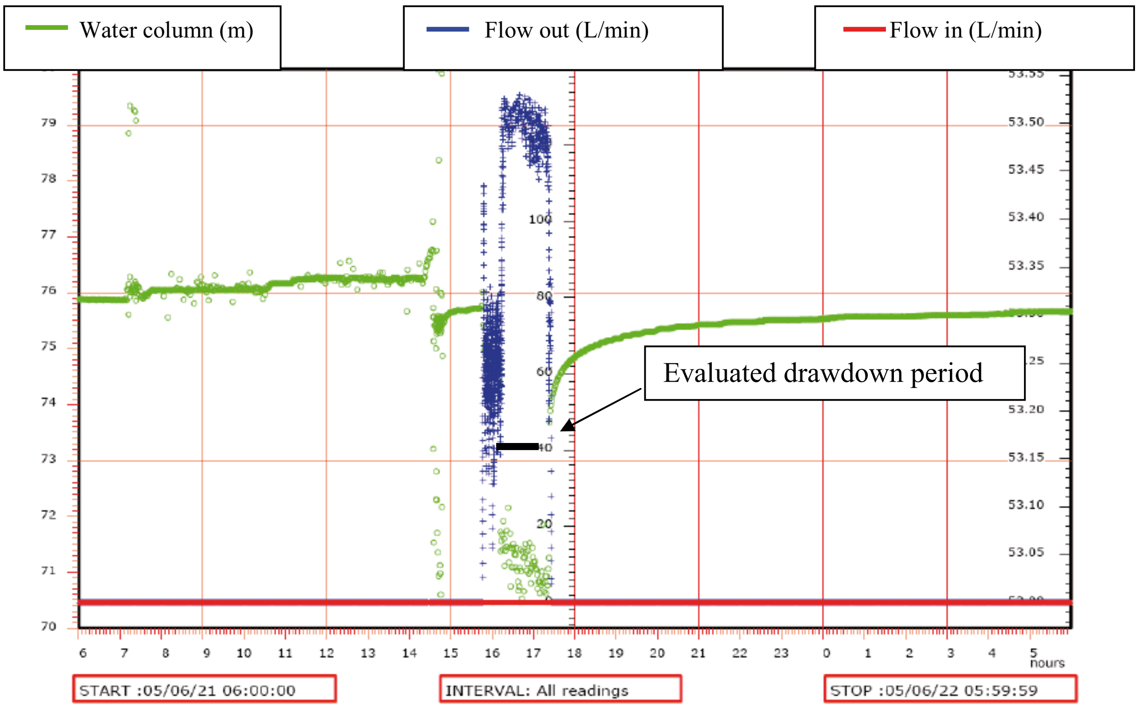


Figure 5-12. *Air-lift pumping in KLX08 12.20–1,000.41 m. The green line represents the height of the water column in the borehole, the flow out (i.e. pumped flow from air-lift pumping in the telescopic section) is shown as the blue dotted line. Inflow of water (red line) is related to drilling. The drawdown period on which the test results are derived is given with a black bar.*

5.4.4 Hydraulic responses in near-by boreholes.

Hydraulic responses from activities in a borehole are mainly created by the drawdown from air-lift pumping and from flushing the borehole with nitrogen gas.

Hydraulic responses in near-by boreholes from air-lift pumping in KLX08

A correlation between air-lift pumping in KLX08 and hydraulic responses in selected near-by boreholes (HLX14, 25 and 30) is probable, see Figure 5-13.

Hydraulic responses in near-by boreholes from nitrogen gas flushing in KLX08

Nitrogen gas flushing covering the entire length of the borehole was done in three events each covering two days, also see Table 5-9.

Near-by located boreholes were checked for possible hydraulic responses from nitrogen gas flushing in KLX08, see Table 5-17. The results show consistent hydraulic responses during the three different nitrogen gas flushing events. The locations of mentioned boreholes are given in Figure 5-14. Graphical examples of hydraulic draw-down from nitrogen gas flushing are given in Figure 5-15.

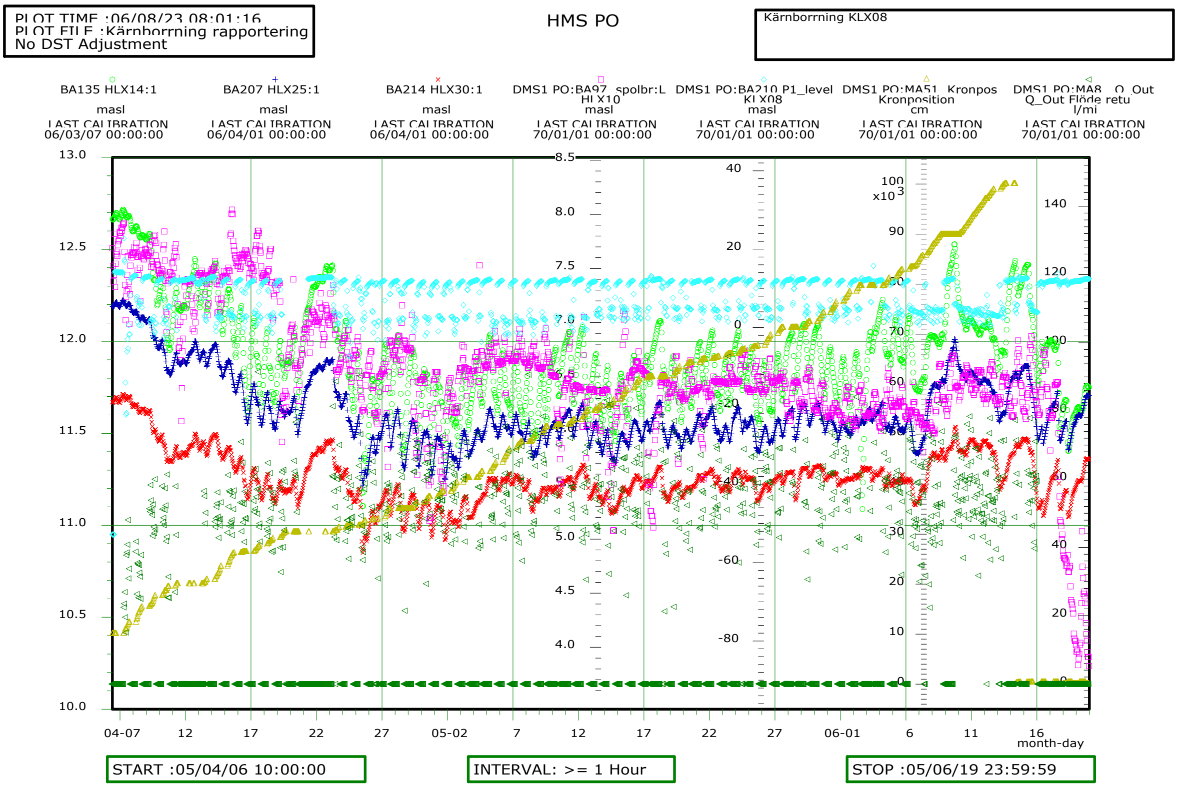


Figure 5-13. *Monitoring of water levels in near-by boreholes. The drilling progress over time in KLX08 is given by the light brown line increasing from left to right. The light blue line shows the water level in the telescopic section in KLX08 i.e. the air-lift pumping cycles. The purple curve shows the water level fluctuations in the water source HLX10. The water tables in percussion boreholes HLX14 (light green), HLX25 (dark blue) and HLX30 (red) show a strong correlation of the larger scale trends (weekly to monthly) with the water level in HLX10. No drilling was performed and hence no air-lift pumping in the telescopic section of KLX08 between April 19 and 23 due to technical problems. A distinct recovery curve during this period can be seen in the water levels in HLX14, 25 and 30 also indicating a correlation between air-lift pumping in KLX08 and hydraulic response in HLX14, 25 and 30. The shorted cycles (daily) as can be seen as jagged lines in HLX14, 25 and 30 are likely to be linked to the air-lift pumping in KLX08.*

Table 5-17. Hydraulic responses from nitrogen gas flushing in KLX08.

Borehole (section*)	KLX08	Drawdown 050617–18 (m)	Drawdown 050704–05 (m)	Drawdown 050923–24 (m)
HLX13	Yes	0.4	0.35	0.2
HLX14	Yes	0.5	0.5	0.35
HLX20	No			
HLX21	No			
HLX22	No			
HLX23	No			
HLX24	No			
HLX25	Yes	0.2	0.3	0.2
HLX30	Yes	0.2	0.3	0.2
HLX31	Yes	0.2	0.35	0.15
HLX33	No			
HLX35	No			
HLX36	No	(Not drilled)	(Not drilled)	
KLX04 (1*)	No			
KLX04 (2)	No			
KLX04 (3)	No			
KLX04 (4)	No			
KLX04 (5)	Yes	1	1	0.8
KLX04 (6)	No			
KLX04 (7)	Yes	2.5	1.9	1.7
KLX04 (8)	Yes	0.8	0.7	0.45

* Installation for long term monitoring in cored boreholes are made in a series of sections divided by packers along the length of the borehole. In KLX04 section 1 is the lowest (i.e. deepest in the hole) and section 8 the uppermost.

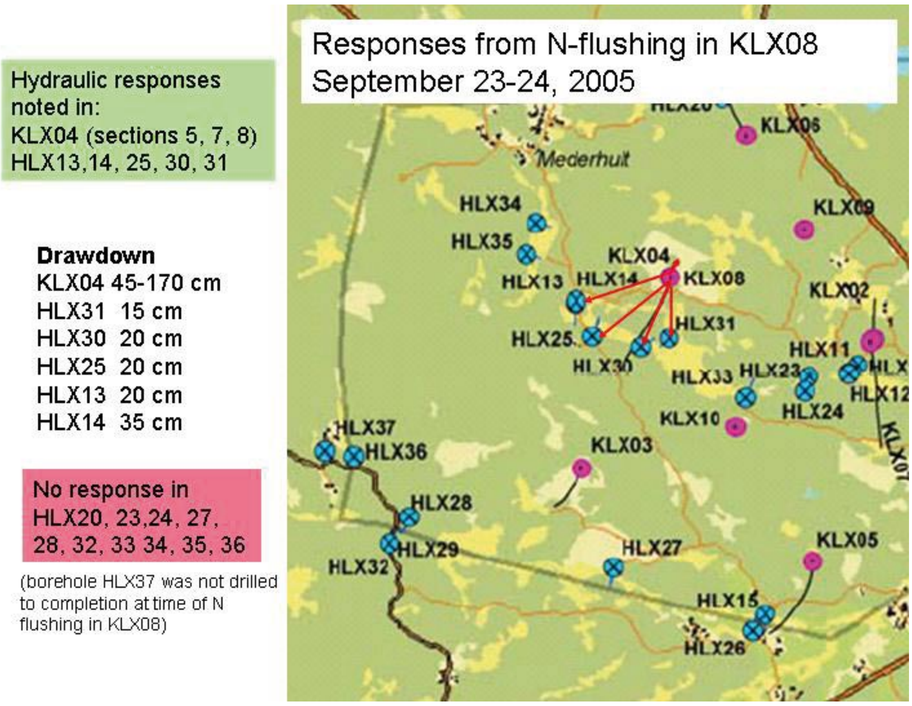


Figure 5-14. Flushing with nitrogen in borehole KLX08 gave a drawdown in boreholes KLX04, HLX13, 14, 25, 30 and 31 as indicated by red arrows.

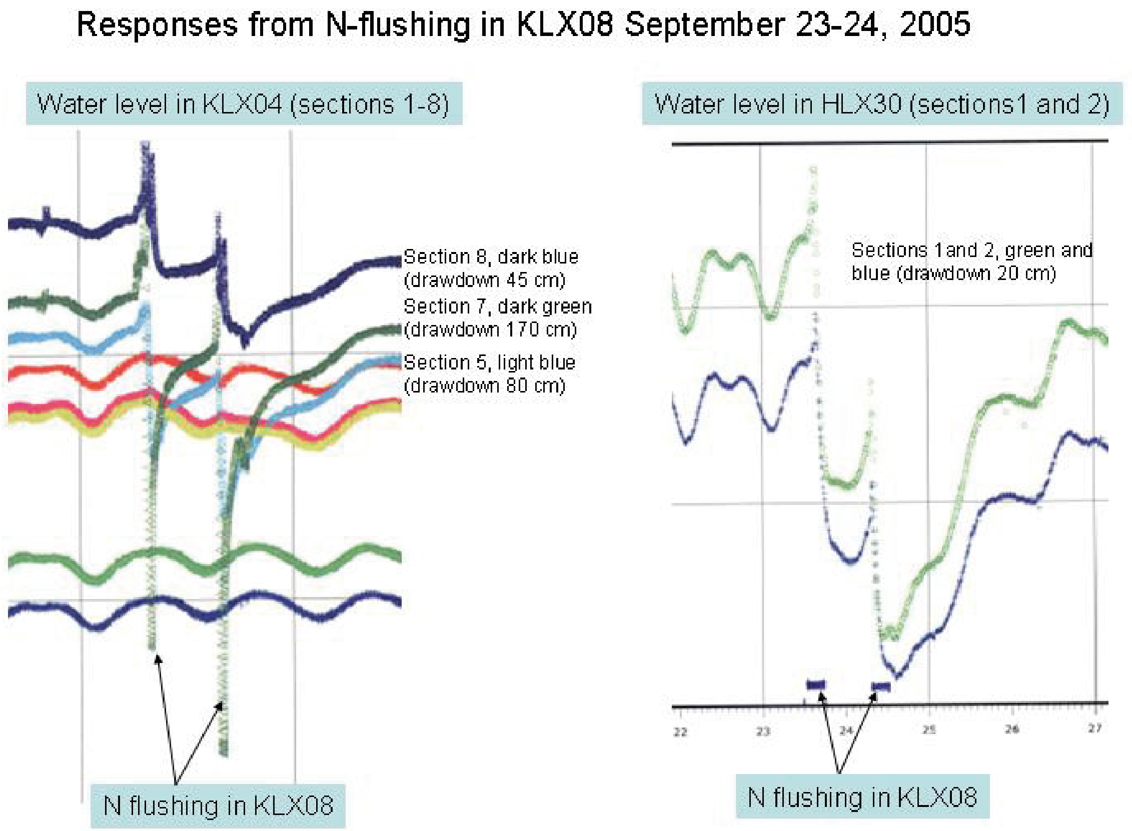


Figure 5-15. *Drawdown curves in KLX04 (left) and HLX30 (right) of hydraulic response from nitrogen gas flushing in KLX08.*

5.5 Drilling monitoring results

This section presents the results from drill monitoring i.e. continuous data series of water parameters or technical drilling parameters. The two main drilling steps, the telescope section 0–100.33 metres and the core drilling section 100.33–1,000.41 metres are described in Sections 5.2 and 5.3 respectively.

5.5.1 Drill monitoring system – DMS

The DMS database contains substantial amounts of drilling monitoring data. A selection of results primarily from the monitoring of the flushing water parameters are presented in Figures 5-16 through 5-18 below.

Selected parameters from the drill rig (MWD parameters) are presented in Appendix 1. The MWD parameters require some explanation:

- Drillability ratio – this parameter is defined as penetration rate divided by feed force.
- Flushing water ratio – this is defined as flushing water flow divided by flushing water pressure.
- Water pressure (of the water entering the drill stem).
- Flushing water flow (flow of ingoing water).
- Penetration rate (rate of drill bit penetration as measured on the surface on the drill stem)
- Hydraulic indication – this parameter is defined as penetration rate divided by flushing water flow.

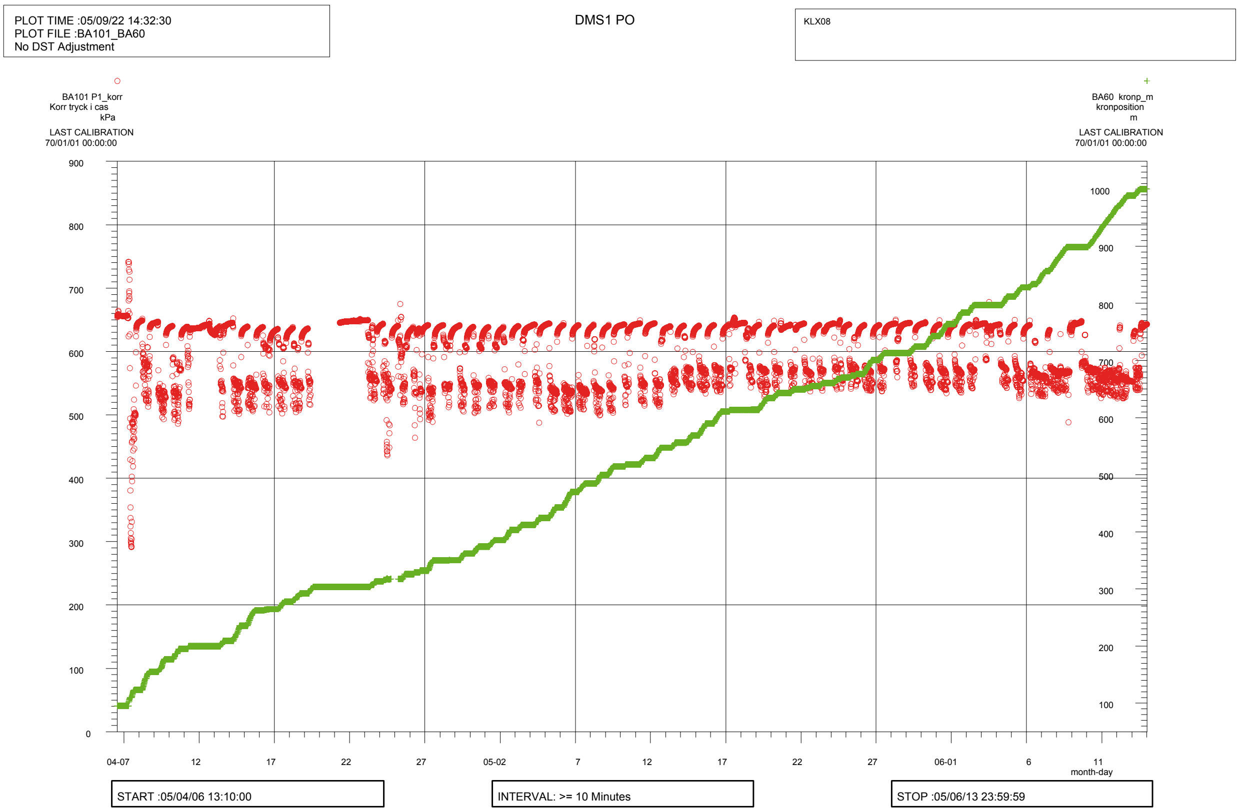


Figure 5-16. *Drill bit position (green) and water level from air-lift pumping (red). The water level is expressed as the pressure in kPa of the water column overlying the pressure gauge i.e. the ambient air-pressure has been subtracted. The pressure gauge is emplaced at 89 metres borehole length. The drill bit position is given in metres.*

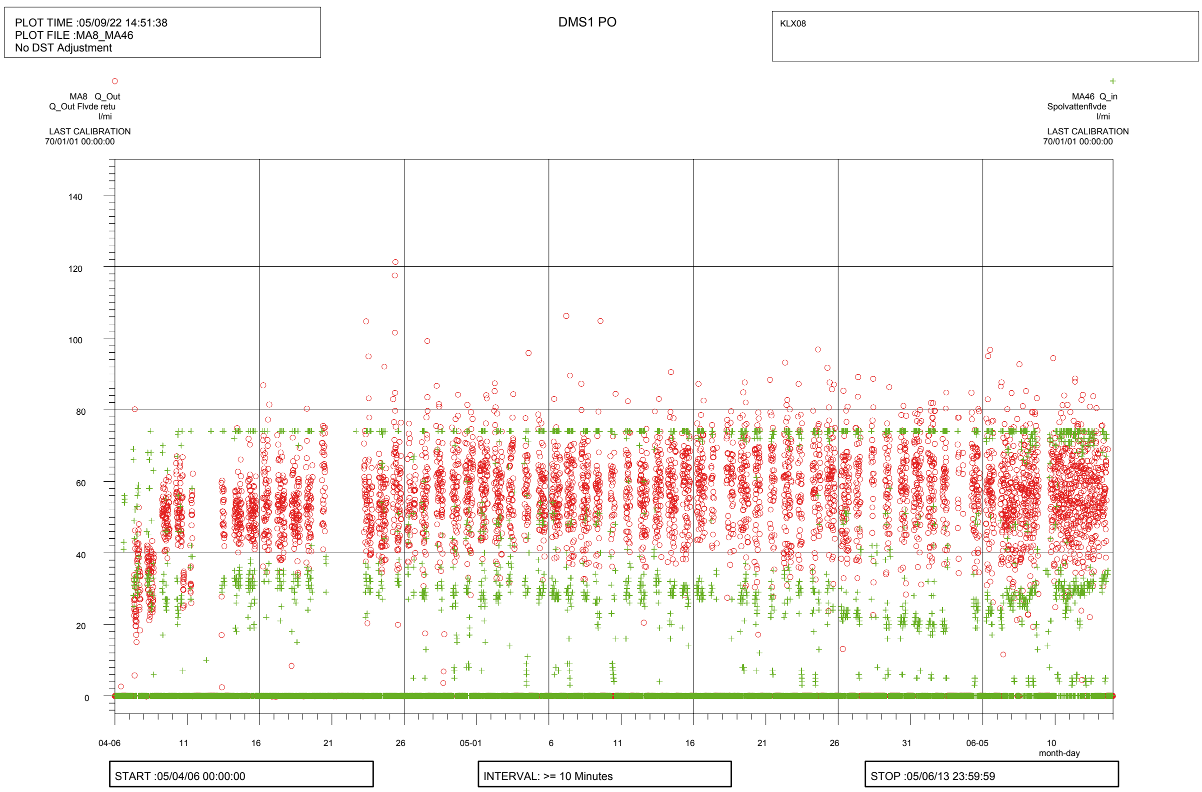


Figure 5-17. *Flushing water flow (green) and return water flow (red) in litres per minute.*

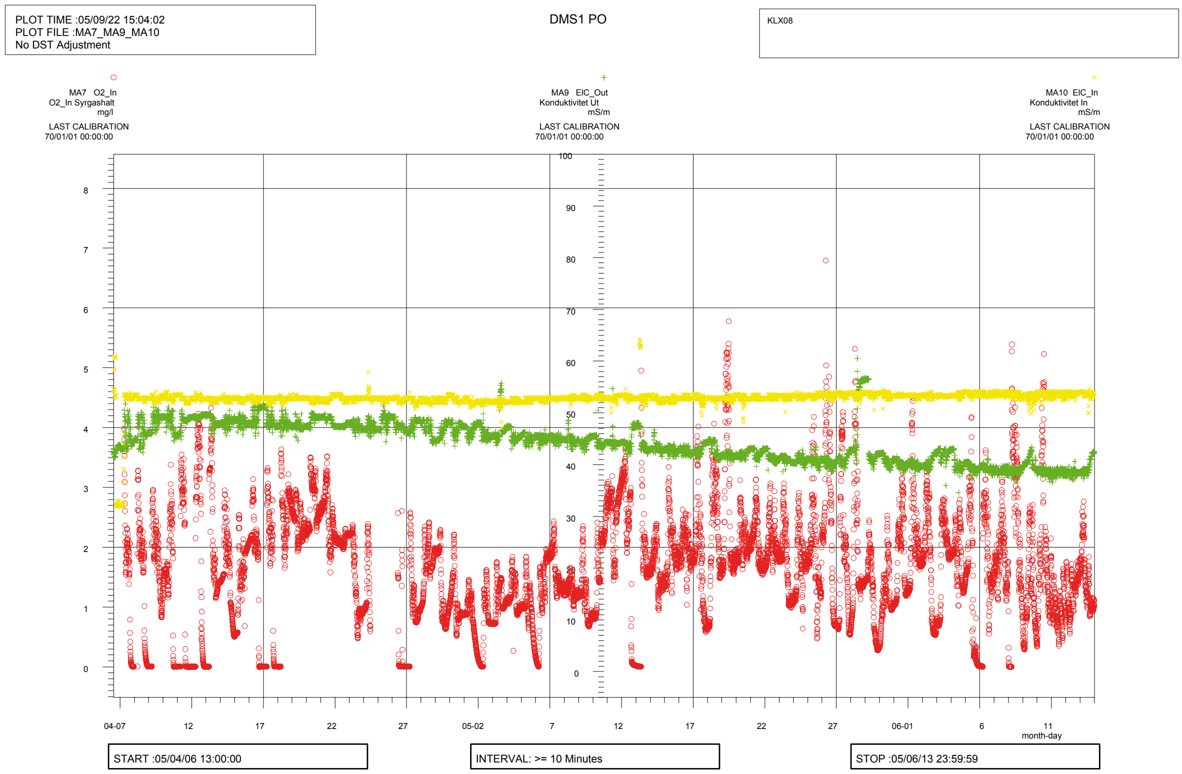


Figure 5-18 *Conductivity of flushing water (yellow) and return water (green). The oxygen content in mg/l of the flushing water (red) is also shown. The oxygen content of the flushing water is normally well below 4 mg/l with occasional peaks between 4 and 7 mg/l.*

In order to maintain reasonable size data files, a reduction in the number of points incorporated in the pictures has been done in Figures 5-14 through 5-16. Since DMS data are related to time (i.e. not strictly to borehole length) periods were drilling is not performed are also registered.

Figure 5-16 depicts the drill bit position (green) over time and the water level (red) in the telescope part of the drill hole. The water level, given as pressure of the overlying water column reflects the air-lift pumping activity in the hole.

Figure 5-17 shows the flushing water flow (green) entering the hole and the return water flow (red). The flushing water flows (green) show two distinct levels of pumped flow:

- A flow of 20–40 litres/minute corresponding to pumped flow during drilling.
- A flow of ca 70 litres/minute corresponding to the flow while pumping down the core-barrel.

Figure 5-18 shows the conductivity of the ingoing flushing water, conductivity of the return water and the oxygen content of the flushing water. The oxygen content of the flushing water is low, typically well below 4 mg/L with occasional peaks between 4 and 7 mg/l. The peaks are attributed to growth of algae and dirt in the oxygen meter. The erroneous data were noted immediately and the measuring equipment was cleaned.

5.5.2 Measurements of flushing water and drill cuttings

A calculation of accumulated amounts of water flowing in and out of the borehole based on water flow measurements from the DMS system (continuous readings) is given in Figure 5-19.

The amount of flushing water consumed during drilling was 1,000 m^3, giving an average consumption of ca 1.1 m^3 per metre drilled. The amount of effluent return water from drilling in KLX08 was 2,600 m^3, giving an average of ca 2.9 m^3 per metre drilled.

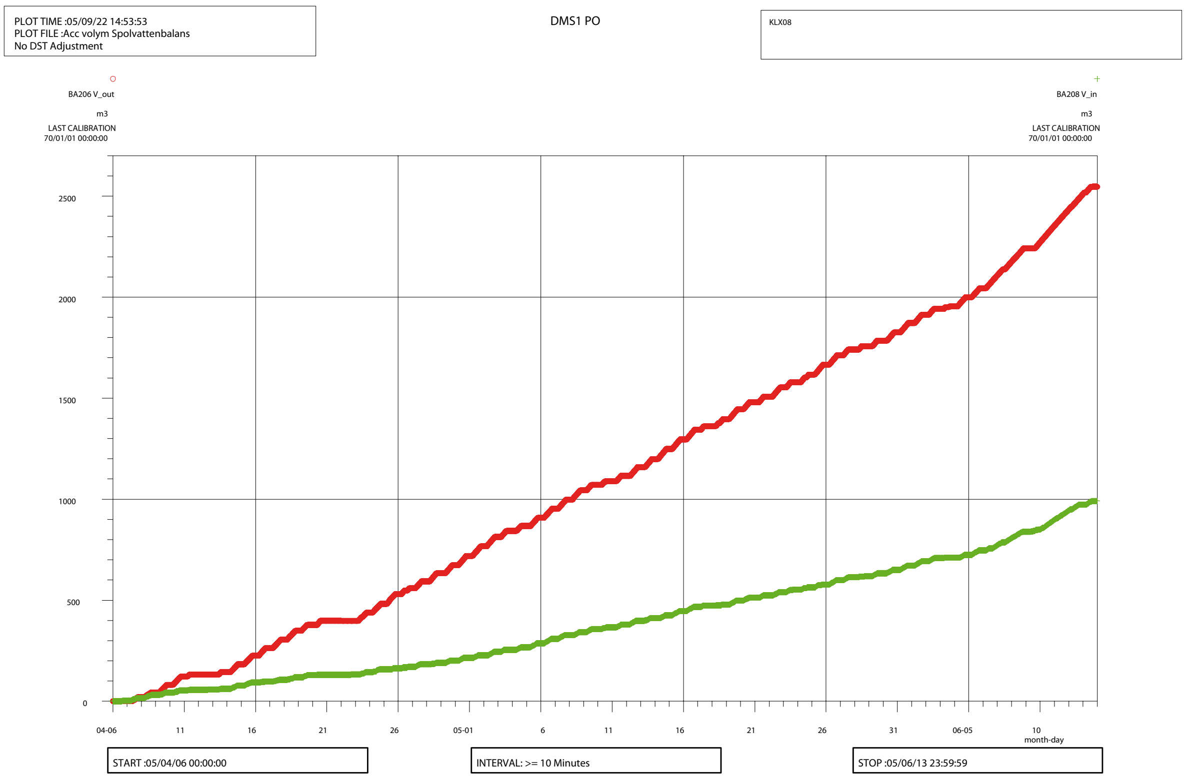


Figure 5-19. *Flushing water balance from KLX08 as recorded by the DMS system. The accumulated volume of the ingoing flushing water is shown in green and the outgoing return water is shown in red.*

Drill cutting balance

The weight of cuttings in the settling containers amounted to 820 kg. The content of suspended material in the return water was not analysed in borehole KLX08, however previous sampling has shown the content to be 400 mg/L /5/. The amount of material in suspension carried with the return water would amount to 1,040 kg. The theoretical amount that should be produced from drilling with 76 mm triple tubing over a length of 900 metres is 6,000 kg assuming a density of 2.65 kg/dm^3. This means that about 31% of the material liberated by drilling is removed from the formation.

The recovered drill cuttings were collected in steel containers. After completion of drilling, the containers were removed from the site and emptied at an approved site.

Uranine tracer balance

The amount of introduced and recovered uranine is presented in Table 5-18. The results show that 27% of the introduced uranine was retrieved during drilling of KLX08.

Table 5-18. Balance calculation of uranine tracer in KLX08.

Average uranine content IN (mg/L)	0.183*
Flushing water volume IN (m^3)	1,000
Amount uranine introduced (g)	183
Average uranine content OUT (mg/L)	0.019
Return water volume OUT (m^3)	2,600
Amount uranine recovered (g)	49

* Uranine content based on results from Äspö laboratory.

5.6 Salvage and stabilising operations during August and September 2005

After the core drilling activity was completed other measurement for geophysical and hydrogeological purposes were made in borehole KLX08. A hydrogeological probe (PFL tool) got stuck at 300 m in the borehole on July 28 and a salvage operation had to be mounted in order to clear the hole for subsequent borehole investigations.

An Onram 1000 drill rig was mobilized to the site on August 9-12.

Salvage operations started on August 13 with a 53 mm diameter aluminium drillstring. Parts of the PFL tool was recovered but the lowermost 7 metres of the tool remained at 140 m. During attempts to recover the lower section of the PFL tool, the drill rods (141 m length) were dropped in the borehole while shifting the hold on the rods.

Over the period August 14–24 new equipment was mobilised to the site and attempts to retrieve the drill rods and the PFL tool were made. On August 24 all the lost drill rods together with ca 80 cm of the PFL tool were salvaged successfully.

A final unsuccessful attempt to recover the remaining parts of the PFL tool was made on August 25. During this attempt the depth to the upper end of the PFL tool was measured to 991.92 m. A decision was then taken to abandon the PFL tool in the borehole and to stabilise the borehole wall.

The mounting of a stabilising steel tube with the PLEX-method requires Corac N3/50 or Hagby WL76 drill rods. Equipment for the PLEX-mounting was mobilised between August 29 and 31. A perforated reinforcement plate was emplaced on September 1 between 217.6 and 219.6 m in order to stabilise the rock wall. The PLEX method is schematically described in Figure 5-20 and consists of:

- Lowering of the PLEX tool to the section to be stabilised.
- Extruding the reaming cutters with water pressure and gently reaming the problematic section.
- Expanding the rubber packer with water pressure and thereby forcing the perforated roll of steel plate into contact with the borehole wall
- When the water pressure is removed the PLEX tool can be retracted and the borehole wall is stabilised but retains a permeability for water flow (and hence it is possible to do hydrogeological tests).

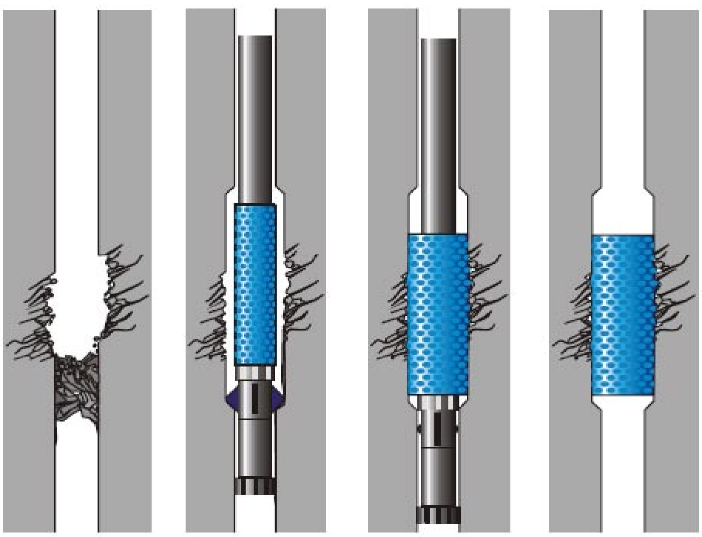


Figure 5-20. Schematic description of the PLEX method.

The borehole was subsequently logged with BIPS, steeel brushed and flushed with nitrogen gas to ensure removal of loose rock fragments. The BIPS logging was however not done as part of the core drilling activity.

A borehole wall risk assessment was compiled on September 28 (SKB id 1044617, internal document) as a support for contractors performing down-hole measurements in KLX08.

5.7 Geology

A preliminary geological mapping of the core is done as drilling progresses as part of the drilling activity. This mapping phase includes a first pass mapping of major geological features as well as RQD-logging and photodocumentation of the core.

A more detailed mapping with the Boremap method is made after measurements have been made in the borehole that can provide orientation of geological features. Boremap mapping and the related measurements are not part of the drilling activity but the results from the Boremap logging is nevertheless included in this report as it represents a more complete geological record than the preliminary geological mapping.

The geological results based on the Boremap logging are shown in Appendix 1. It should be emphasized that the geological description given in this report is a brief summary only. A more complete account is given in /3/.

Lithologically the core consist of Ävrö granite (80%) with minor intercalations of fine-grained diorite-gabbro and fine grained granite between 100 and 400 m. From 400 to 580 the lithology is only Ävrö granite. Between 580 and 920 the core is made up of Ävrö granite with substantial intercalations of diorite/gabbro. Below ca 920 m the core consists of Quartz monzodiorite.

Oxidation with weak to medium intensity is not uncommon down to 420 m. Between 420 and 920 m oxidation occurs sporadically with low intensity (faint to weak). A part with medium intensity oxidation occurs around 930 m near the Ävrö granite and Quartz monzodiorite contact. Saussuritization i.e. alteration of calcic plagioclase feldspar to albite, zoisite or epidote is common in conjunction with oxidized sections, especially below 400 m.

There is a clear correlation between oxidation, both occurrence and intensity, and fracture frequency. The distribution of total fractures in the core is typically in the range of 0–10 fractures/metre with minor sections containing elevated fracture frequencies. Crushed sections notably occurs at 120, 150, 220, 300, 410, 650 and 770 m drilled length.

The average fracture frequency over the entire core drilled section expressed as open fractures is 2.2 (fractures/metre). The fracture frequency given in Appendix 1 shows the total fracture frequency (i.e. open fractures, sealed fractures and fractures in crushed sections)

5.8 Data handling

Data collected by the drilling contractor and the SKB drill coordinators were reported in daily logs and other protocols and delivered to the Activity Leader. The information was entered to SICADA (SKB database) by database operators.

5.9 Environmental control

The SKB routine for environmental control (SDP-301, SKB internal document) was followed throughout the activity. A checklist was filled in and signed by the Activity Leader and filed in the SKB archive.

All waste generated during the establishment, drilling and completion phases have been removed and disposed of properly. Water effluent from drilling was allowed to infiltrate to the ground in accordance with an agreement with the environmental authorities. The location of the water emission area is shown in Figure 5-21. Precautionary guideline values for effluent return water emission to the ground were prescribed by the Regional Authorities for the following parameters:

- Salinity, 2,000 mg/l (monitored as electrical conductivity, with the limit 300 mS/m).
- Uranine content, 0.3 mg/l.
- Suspended material, 600 mg/l.

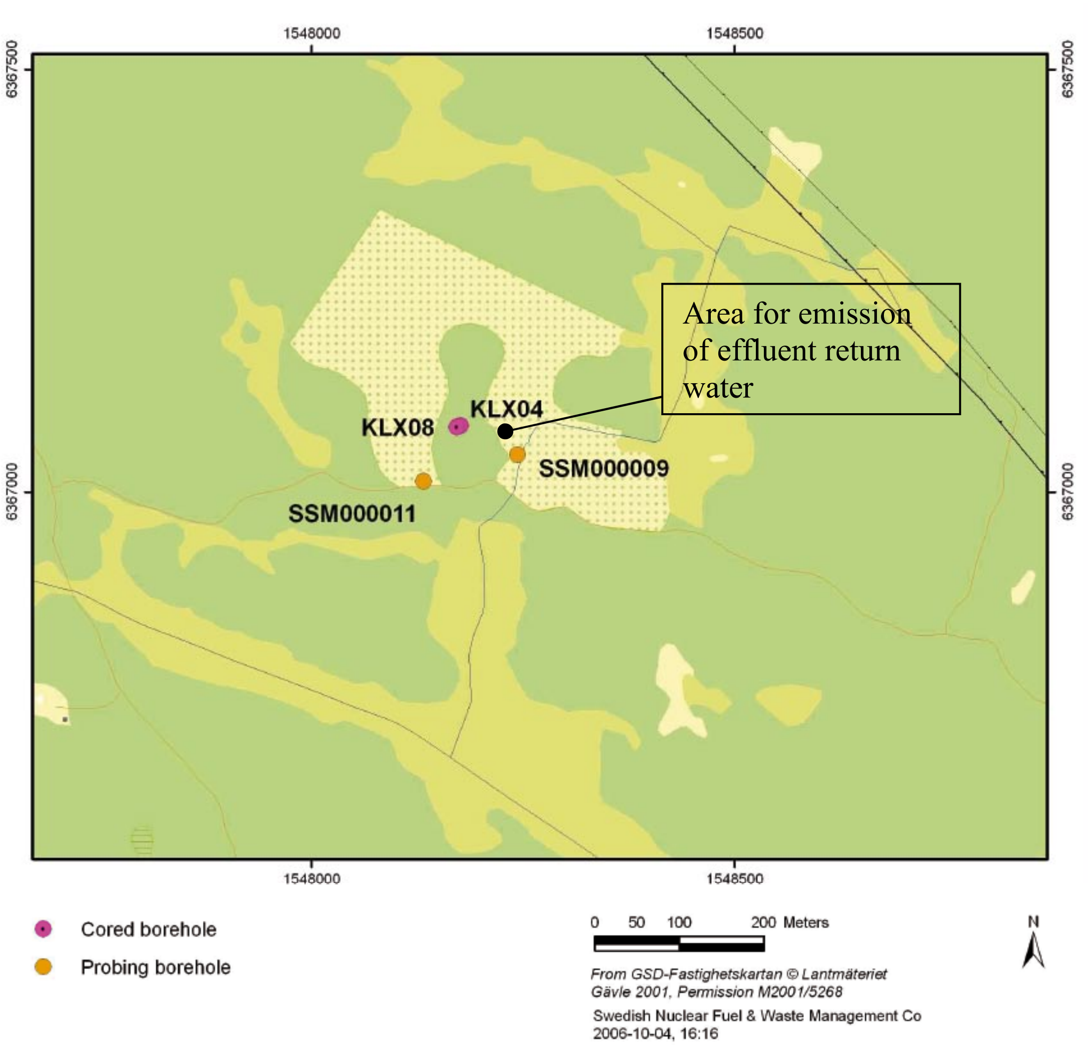


Figure 5-21. *Location of environmental monitoring wells SSM000011 and SSM000009 in relation to the core drill site for KLX08.*

Monitoring of effluent water

The effluent water, i.e. discharge to the ground, from the core drilling of KLX08 never exceeded the guideline value of 300 mS/m. Typical conductivity values were in the range of 30–80 mS/m, see Figures 5-9 and 5-18.

The uranine content was well below 0.25 mg/l, see Figure 5-9.

The concentration of suspended material was not analysed in the boreholes, however previous sampling has shown that the concentration was well below 600 mg/L /5/.

To sum up the monitored parameters in the emitted water complied with the prescribed guideline values.

Drilling of environmental monitoring wells

KLX08 was drilled from an established drillsite, KLX04. Installations for environmental monitoring were therefore already installed. The technical data for the environmental wells is given in /6/. The location of the environmental monitoring wells SSM000011 and SSM000009 is shown in Figure 5-21.

Reference sampling

Reference sample of surface soil and ground water in environmental monitoring wells SSM00009 and SSM00011 were taken in conjunction with establishing the drill site for drilling of cored borehole KLX04 /6/.

Monitoring of soil ground water levels

A pressure logger (transducer) for measuring the ground water table was installed in SSM000011 during the drilling.

5.9.1 Consumption of oil and chemicals

No significant amounts of oils or lubricants were consumed during the drilling.

The concrete consumption was 520 litres in total. The concrete was based on white silica, low alkali cement.

5.10 Nonconformities

The tightness of the concrete gap injection of the casing in the upper part of the telescopic section was not tested due to a slight modification of drilling procedure. Previous drillings and related testing show that the gap injections fulfil the requirements stated in the method description (SKB MD 620.003 v1.0, internal document) for core drilling.

Data on the initial drill bit diameter (and hence upper borehole diameter) is not available for the percussion drilling of the pilot hole (165 mm) and the reaming (ca 197 mm).

References

/1/ **SKB, 2001**. Platsundersökningar, Undersökningsmetoder och generellt genomförande-program. SKB R-01-10, Svensk Kärnbränslehantering AB.

/2/ **Moye, D G, 1967.** Diamond drilling for foundation exploration, Civil Eng. Trans. Inst. Eng, Australia.

/3/ **Dahlin, Ehrenborg, 2005.** Boremap mapping of core drilled borehole KLX08. SKB P-06-42, Svensk Kärnbränslehantering AB.

/4/ **Ask, Morosini, Samuelsson, Ekström, 2004.** Drilling of cored borehole KSH02. SKB P-04-151, Svensk Kärnbränslehantering AB.

/5/ **Ask, Morosini, Samuelsson, Ekström, Håkanson, 2004.** Core drilling of KSH03. SKB P-04-233, Svensk Kärnbränslehantering AB.

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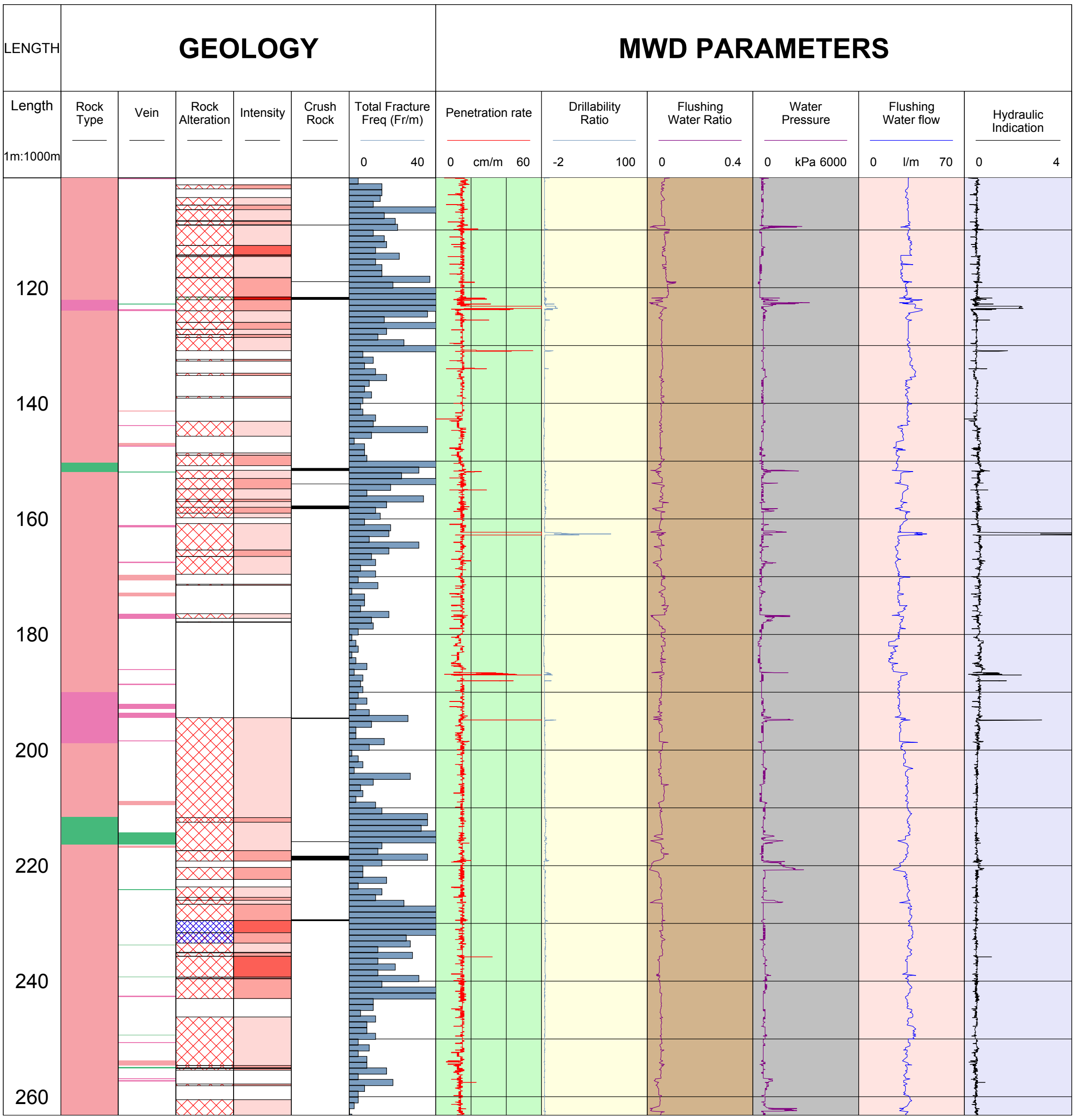
/8/ **Waber, Smellie, 2006.** (In press.) Borehole KLX08, Characterisation of pore water. SKB P-06-163, Svensk Kärnbränslehantering AB.

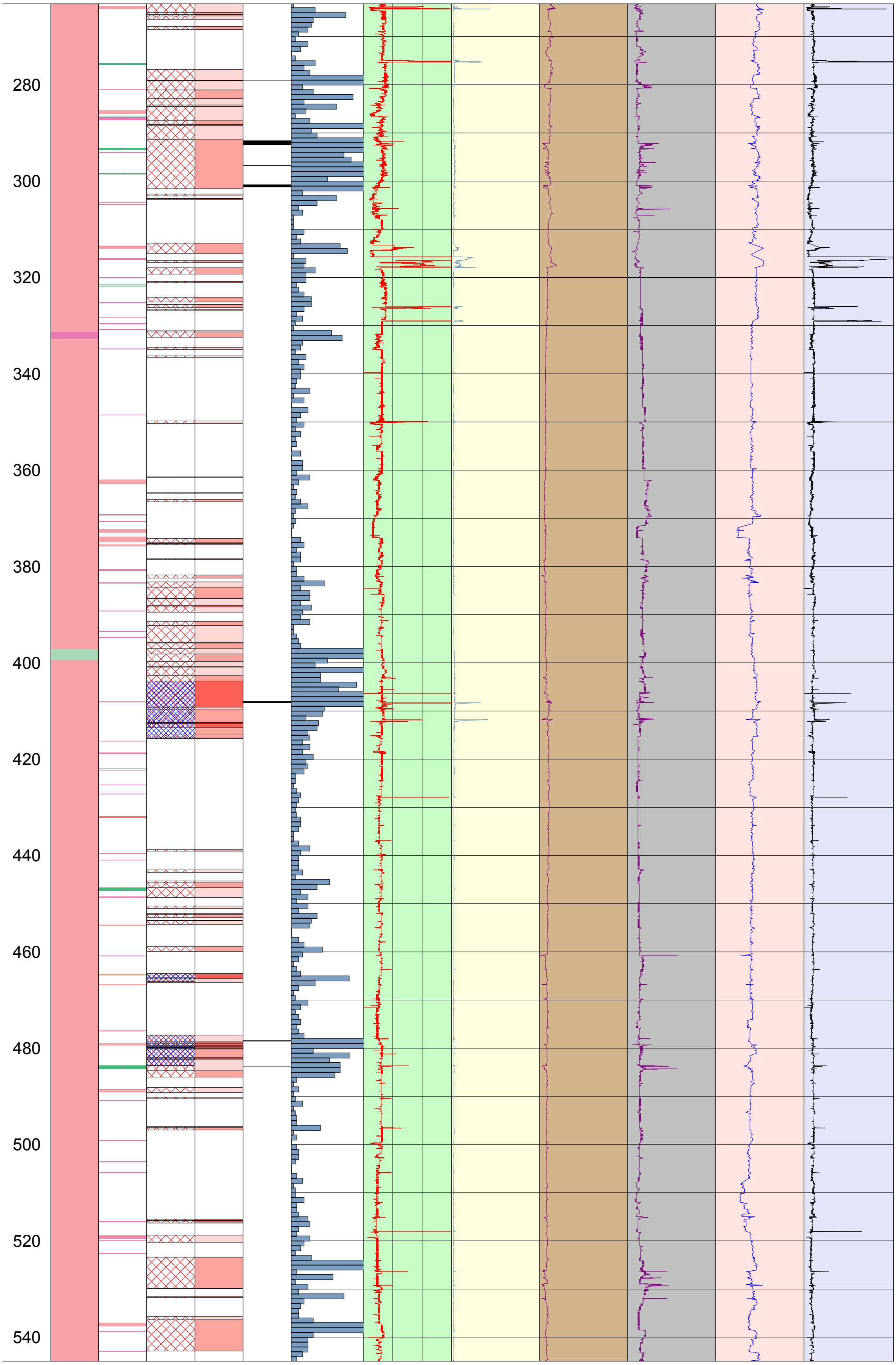
/9/ **Pedersen, 2005.** Control of microorganisms content in flushing water used for drilling of KLX08. SKB P-05-147, Svensk Kärnbränslehantering AB.

Geology and MWD parameters KLX08

Title	GEOLOGY & MWD PARAMETERS KLX08		Appendix 1
Site	LAXEMAR	Coordinate System	RT90-RHB70
Borehole	KLX08	Northing [m]	6367079.10
Diameter [mm]	76	Easting [m]	1548176.71
Length [m]	1000.410	Elevation [m.a.s.l.]	24.31
Bearing [°]	199.17	Drilling Start Date	2005-01-12 14:00:00
Inclination [°]	-60.24	Drilling Stop Date	2005-06-13 14:00:00
Date of mapping	2005-10-11 09:01:00	Plot Date	2007-01-16 22:15:47

ROCKTYPE LAXEMAR	ROCK ALTERATION	INTENSITY
Fine-grained granite	Oxidized	Faint
Ävrö granite	Chloritisized	Weak
Quartz monzodiorite	Epidotisized	Medium
Diorite / Gabbro	Silicification	Strong
Fine-grained dioritoid	Argillization	
Fine-grained diorite-gabbro	Albitization	
	Saussuritization	

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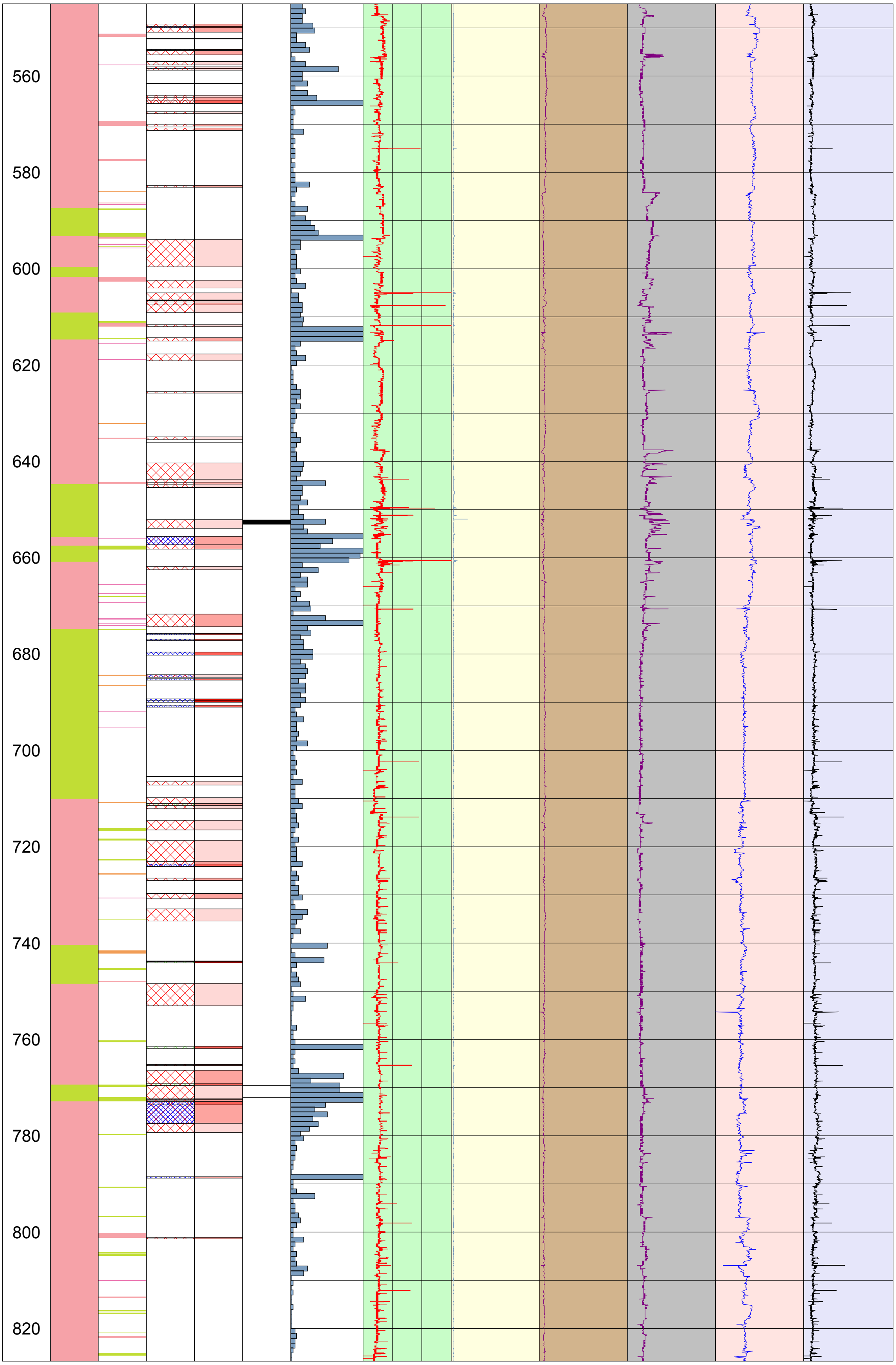
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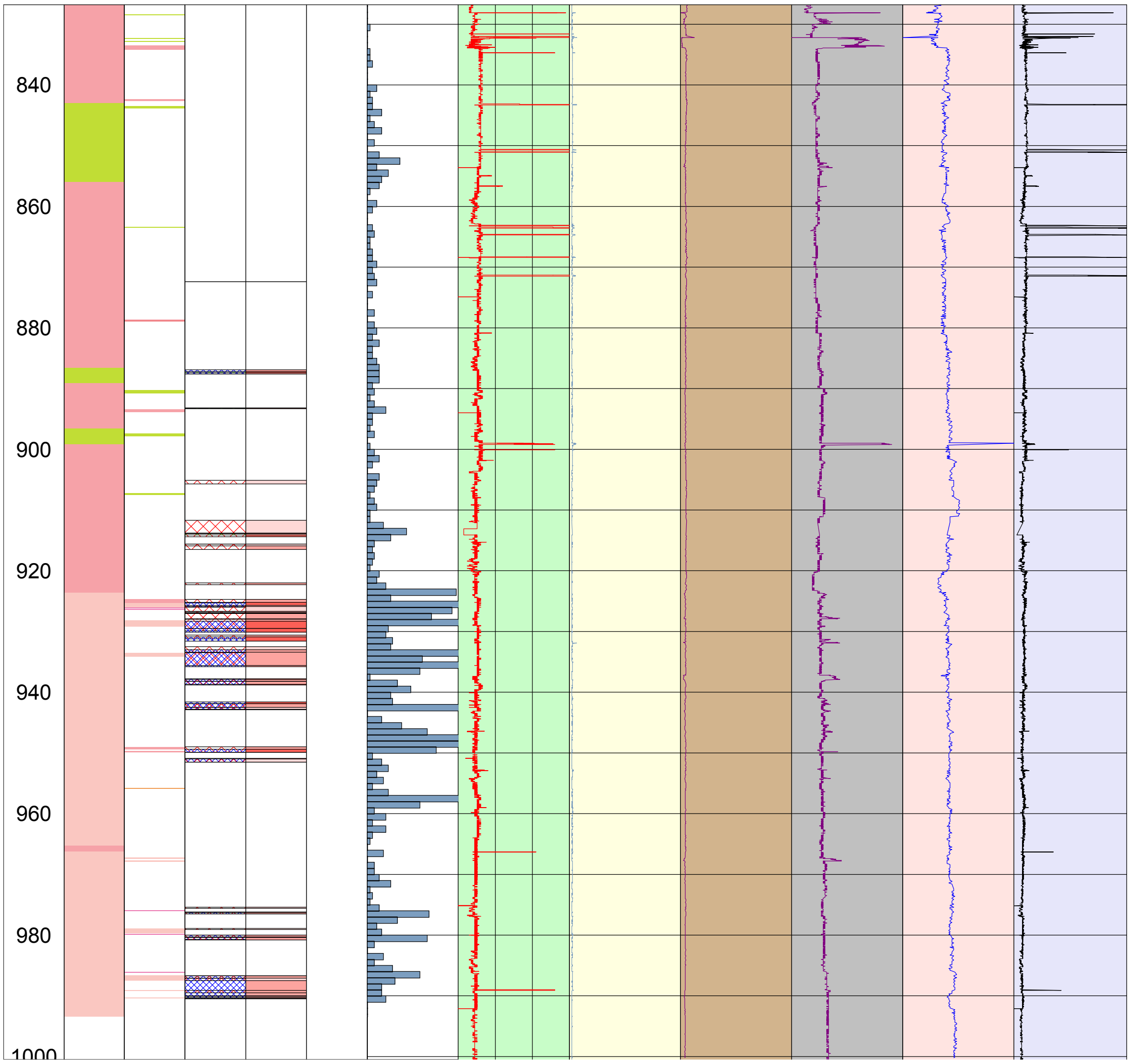
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Appendix 2

Chemical results

Borehole	KLX08	KLX08	KLX08	KLX08	KLX08	KLX08
Date of measurement	2005-04-12	2005-04-13	2005-04-20	2005-05-04	2005-05-11	2005-05-28
Upper section limit (m)	188.90	0.00	197.50	302.80	410.59	612.00
Lower section limit (m)	199.94	199.94	303.86	412.15	518.00	713.00
Sample_no	10230	10232	10244	10281	10289	10315
Groundwater Chemistry Class	3	3	3	3	1	1
pH	8.27	8.15	8.35	8.56		
Conductivity mS/m	52.2	48.7	54.1	74.2		
Drill water %	0.38	1.37	30.80	25.40	45.60	60.20
Charge balance %	–2.61	–1.07	0.19	–1.97		
Na mg/l	97.7	87.8	93.1	130.0		
K mg/l	2.90	3.29	5.78	3.27		
Ca mg/l	18.0	22.5	19.3	19.1		
Mg mg/l	3.5	4.6	5.0	4.0		
HCO3 mg/l Alkalinity	317	297	272	237		
Cl mg/l	9.9	9.6	17.0	82.5		
SO4 mg/l	9.16	12.40	23.20	42.80		
SO4_S mg/l Total Sulphur	3.36	4.36	7.76	14.20		
Br mg/l	–0.200	–0.200	–0.200	0.325		
F mg/l	2.58	2.34	2.78	4.16		
Si mg/l	6.89	7.14	12.10	11.90		
Fe mg/l Total Iron	2.740	1.780	6.940	9.600		
Mn mg/l	0.1160	0.0992	0.2000	0.2510		
Li mg/l	0.017	0.016	0.019	0.028		
Sr mg/l	0.289	0.325	0.281	0.283		
PMC % Modern Carbon	67.01		61.17	50.74		
C-13 dev PDB	–17.00		–17.71	–16.98		
AGE_BP Groundwater age	3161		3894	5396		
AGE_BP_CORR	35		30	30		
D dev SMOW	–76.1		–75.6	–82.0		
Tr TU	1.0		2.9	2.3		
O-18 dev SMOW	–10.7		–10.7	–11.5		
B-10 B-10/B-11	0.2377		0.2400	0.2381		
S-34 dev SMOW	46.2		23.9	30.8		
Cl-37 dev SMOC	0.25		0.07	0.19		
Sr-87 Sr-87/Sr86	0.715452		0.716243	0.715903		

Appendix 3

Chemistry – analytical method

SKB Chemistry class 3.

Analysis	Sample bottle	Preparation	SKB label	Laboratory
pH, conduktivity, alkalinity	250 ml		green	Äspö/field
Anions (F^-, Br^-, Cl^-, SO_4^{2-})	250 ml		green	Äspö/field
Uranine	100 ml brown glass		green	Äspö/field
Main components (except Fe, Mn)	Analytica's 100 ml acid washed	1 ml HNO_3 suprapur, filtering membrane filter	red	Analytica
Archive samples	2 ea 250 ml	Filtering Pallfilter	green	
Option				
Deuterium, O-18	100 ml square		green	IFE
Tritium	500 ml dried	Flooded at least once	green	Waterloo
Sr-87	100 ml square		green	IFE
Cl-37	500 ml		green	Waterloo
B-10	*Same as for main components*	Filtering membrane filter	red	Analytica
C-13, PMC	2 st 100 ml brown glass		green	Waterloo
S-34	1,000 ml		green	IFE

Quality of the analyses

The charge balance errors (see Appendix 2) give an indication of the quality and uncertainty of the analyses of the major components. The relative charge balance errors are calculated for the selected set of data from the borehole KLX08. The errors do not exceed ± 5% in any of the samples.

The charge balance error is not calculated for the samples 10289 and 10315 collected in KLX08.

The following routines for quality control and data management are generally applied for hydrogeochemical analysis data, independent of sampling method or sampling object.

- Several components are determined by more than one method and/or laboratory. Control analyses by an independent laboratory are normally performed as a standard procedure on every five or ten collected samples. Control analyses of Br^- were performed at Analytica on samples 10244 and 10281. The results are stored in SICADA´s raw data tables.
- All analytical results were stored in the SICADA database. The chemistry part of the database contains two types of tables, raw data tables and primary data tables (final data tables).
- Data on basic water analyses are inserted into raw data tables for further evaluation. The evaluation results in a final reduced data set for each sample. These data sets are compiled in a primary data table named "water composition". The evaluation is based on:
  – Comparison of the results from different laboratories and/or methods. The analyses are repeated if a large disparity is noted (generally more than 10%).
  – Calculation of charge balance errors. Relative errors within ± 5% are considered acceptable. For surface waters errors of ± 10%.
- $$\text{Rel. Error (\%)} = 100 \cdot \frac{(\sum \text{cations(equivalents)} - \sum \text{anions(equivalents)})}{(\sum \text{cations(equivalents)} + \sum \text{anions(equivalents)})}$$
- General expert judgement of plausibility based on earlier results and experiences.

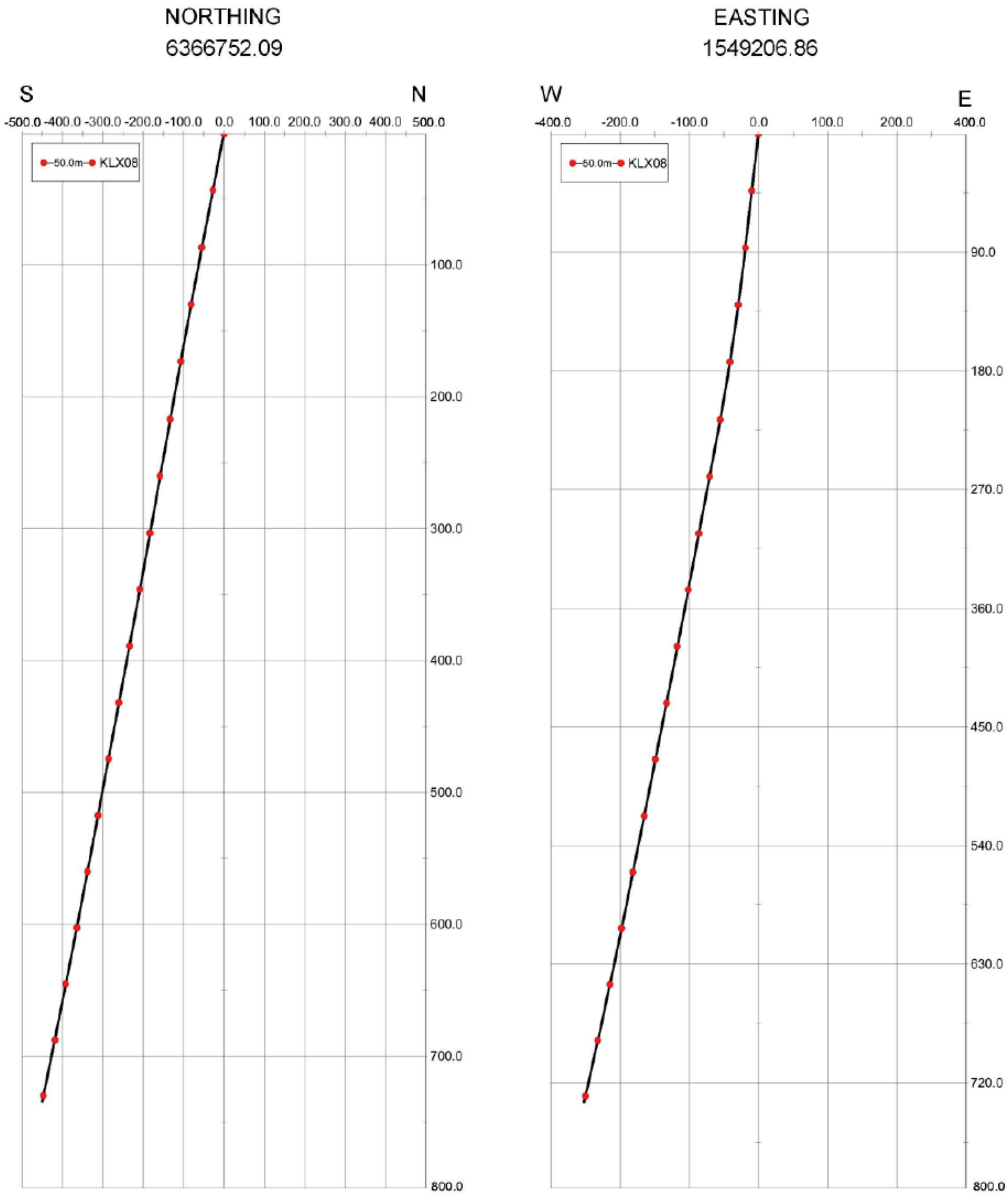
All results from "biochemical" components and special analyses of trace metals and isotopes are inserted directly into primary data tables. In those cases where the analyses are repeated or performed by more than one laboratory, a "best choice" notation will indicate those results which are considered most reliable.

Appendix 4

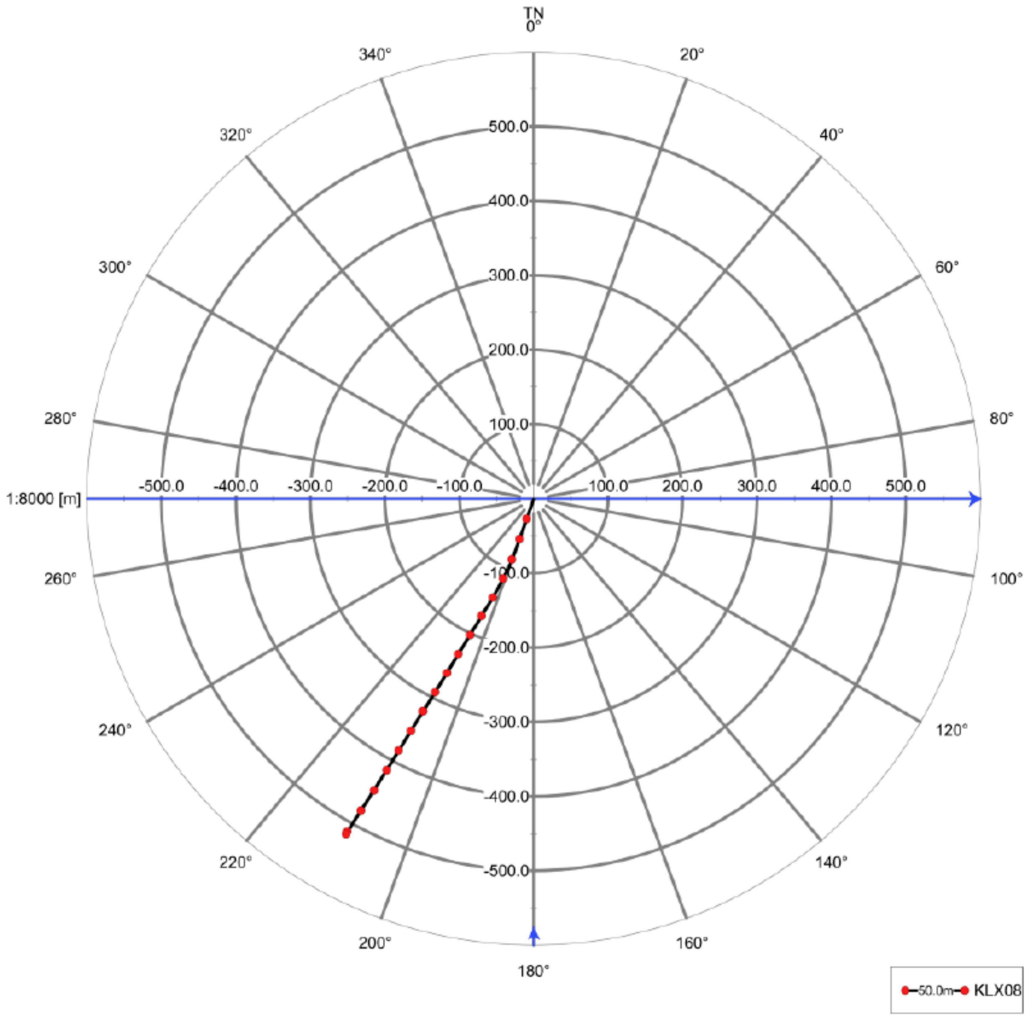
Deviation measurements

Vertical section / Orthogonal projection — Appendix 4

Borehole	**KLX08**
Site	**Laxemar**
Coordinate system	**RT90-RHB70**
Length	**1000.410**
Bearing	**199.17**
Inclination	**-60.24**
● Interval	



Deviation measurement		Appendix: 4
	Site	LAXEMAR
	Borehole	KLX08
	View from above	



Appendix 5

Wireline pumping tests

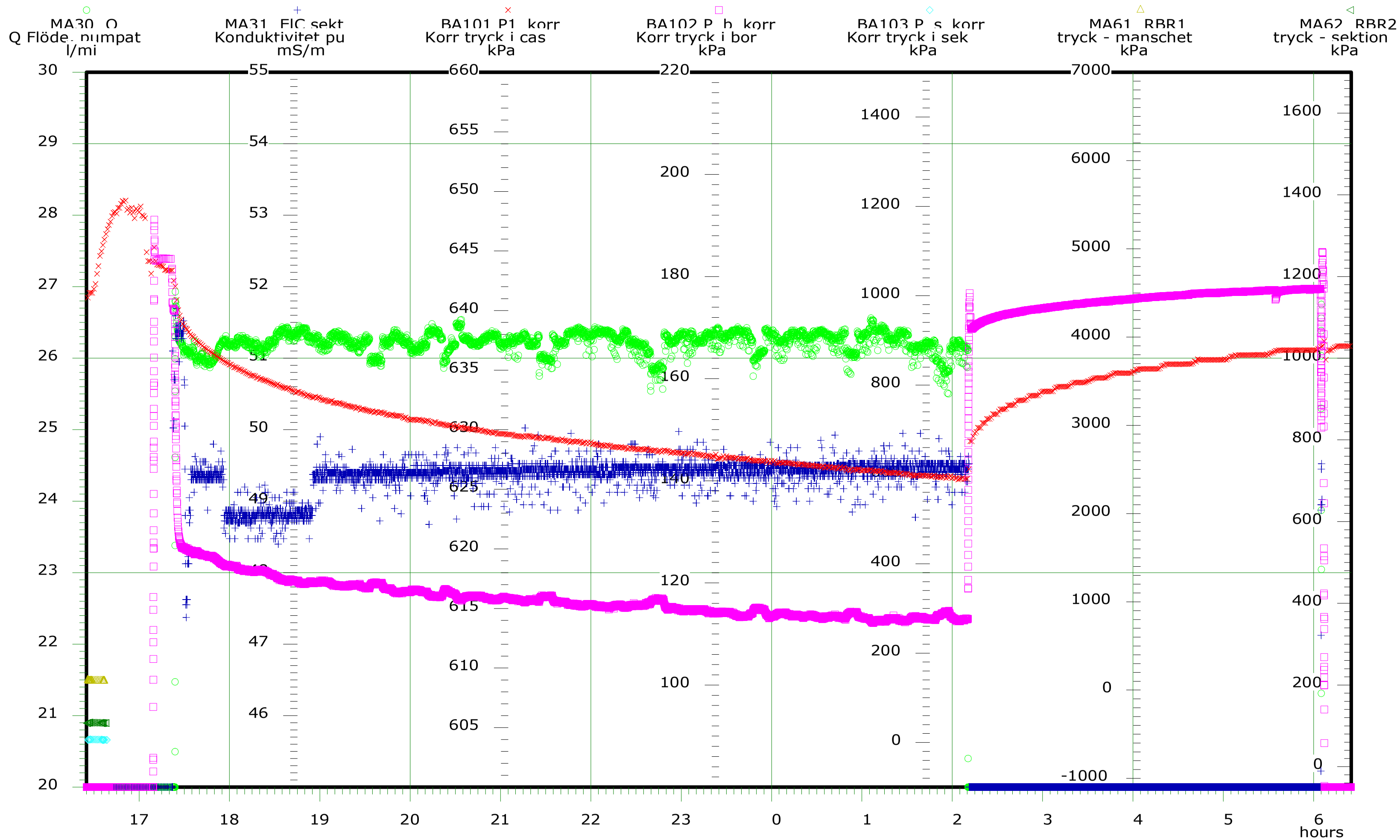
Description of the parameters in the enclosed plots.

Channel	Parameter	Unit	Description
MA30	Water flow	Litre/minute	Flow of water pumped up from the borehole during the test.
MA31	Electrical conductivity	mS/m	Electrical conductivity in the pumped out water
BA101	Pressure	kPa	Pressure of the water column in the telescopic section subtracted with the ambient air pressure.
BA102	Pressure	kPa	Pressure of the water column in the test section ie at depth in the borehole, subtracted with the ambient air pressure.
BA103	Pressure - section	kPa	Pressure of the water column in the test section ie at depth in the borehole, subtracted with the ambient air pressure.
MA61	Pressure – packer	kPa	Inflation pressure in packer
MA62	Pressure – section	kPa	Pressure of the water column in the test section i.e. at depth in the borehole. Not corrected for ambient air pressure

PLOT TIME :06/10/12 13:50:38
PLOT FILE :P_Pumptest
Adjusted for DST

DMS1 PO

Pumping test wireline probe
KLX08 , 100.30 - 199.94 m



START :05/04/12 16:25:00

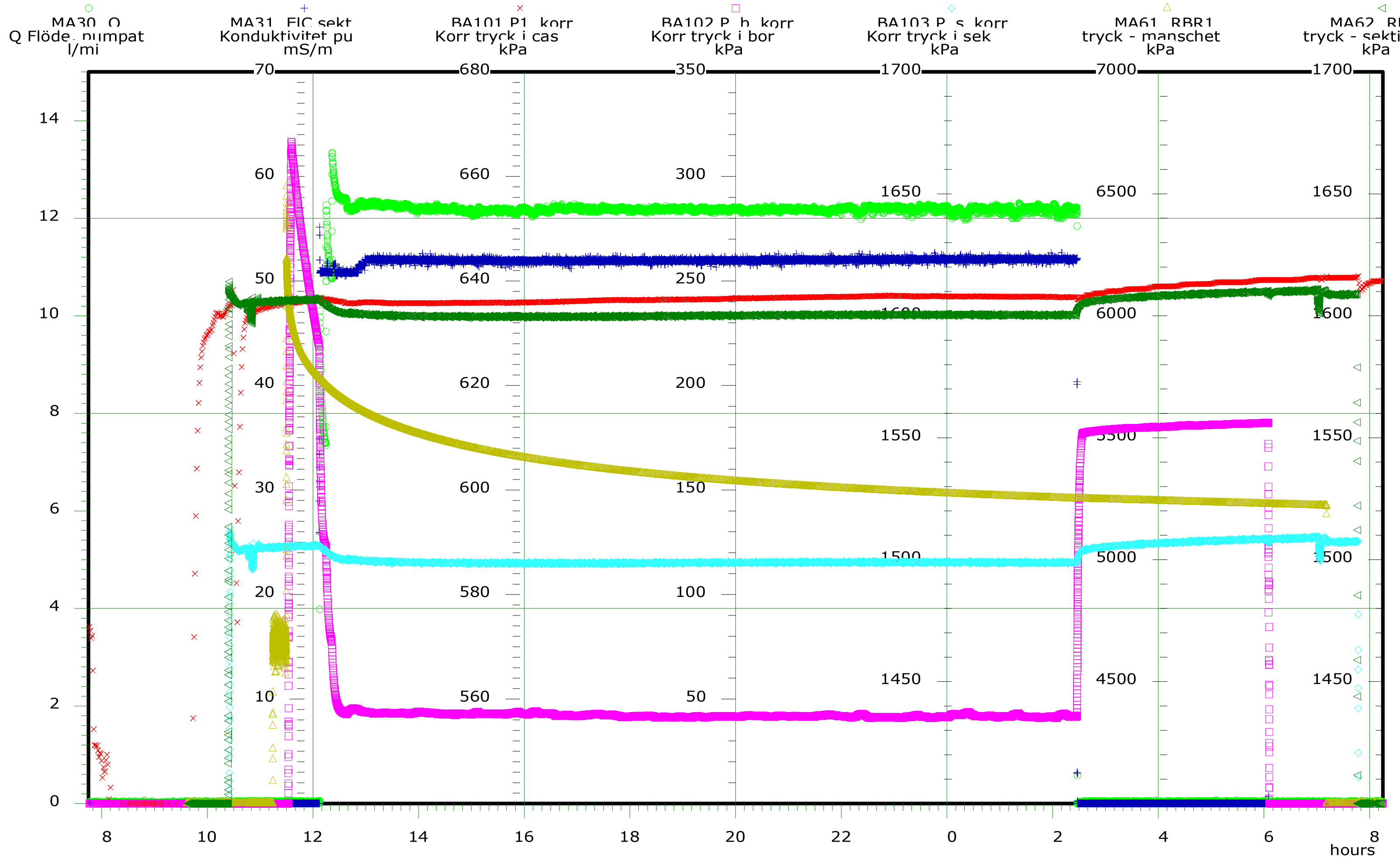
INTERVAL: All readings

STOP :05/04/13 06:24:59

PLOT TIME :05/04/14 10:33:28
PLOT FILE :P_Pumptest
Adjusted for DST

DMS1 PO

Pumping test
KLX08 188.90-199.94m
Wireline sond



START :05/04/11 07:45:00

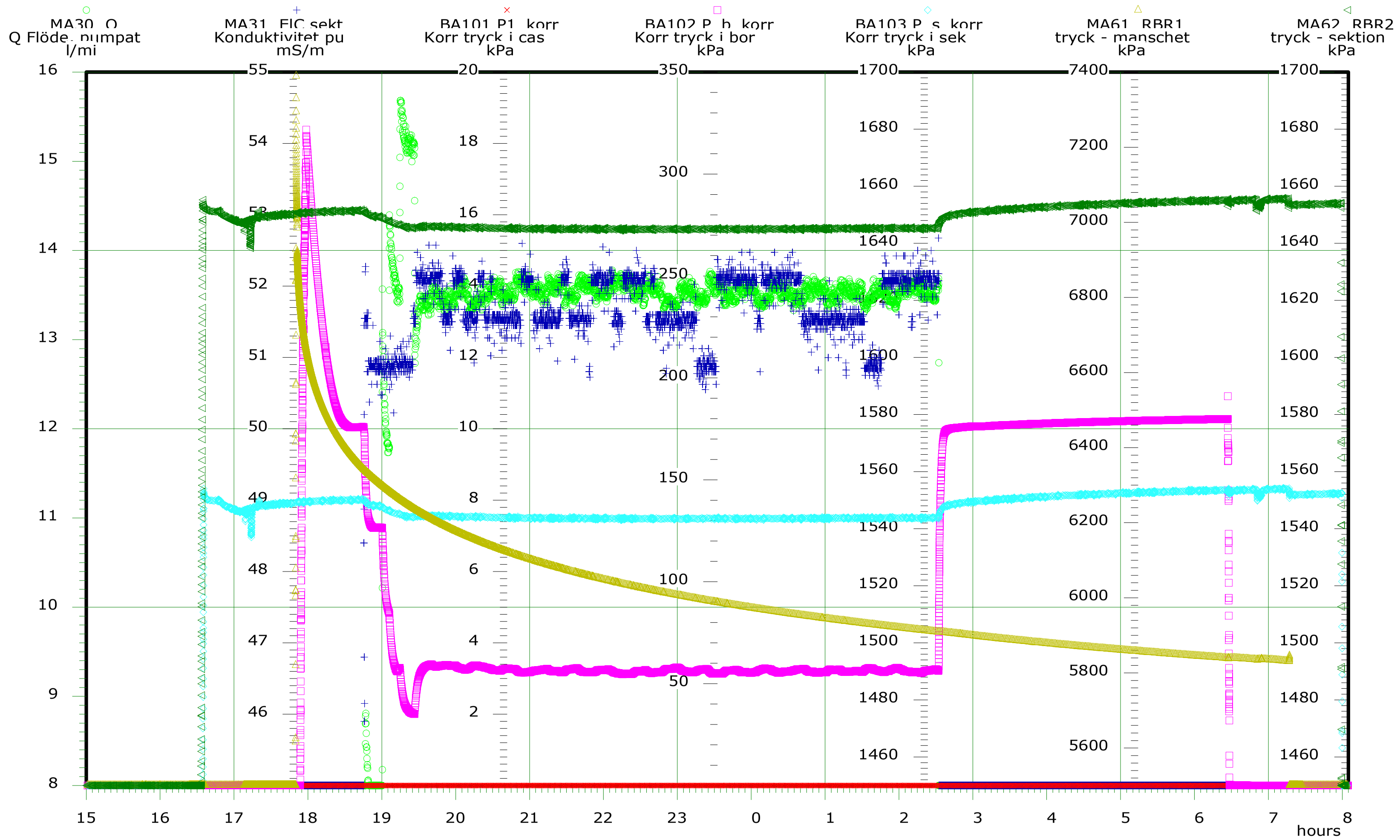
INTERVAL: All readings

STOP :05/04/12 08:14:59

PLOT TIME :05/04/27 12:36:17
PLOT FILE :P_Pumptest
Adjusted for DST

DMS1 PO

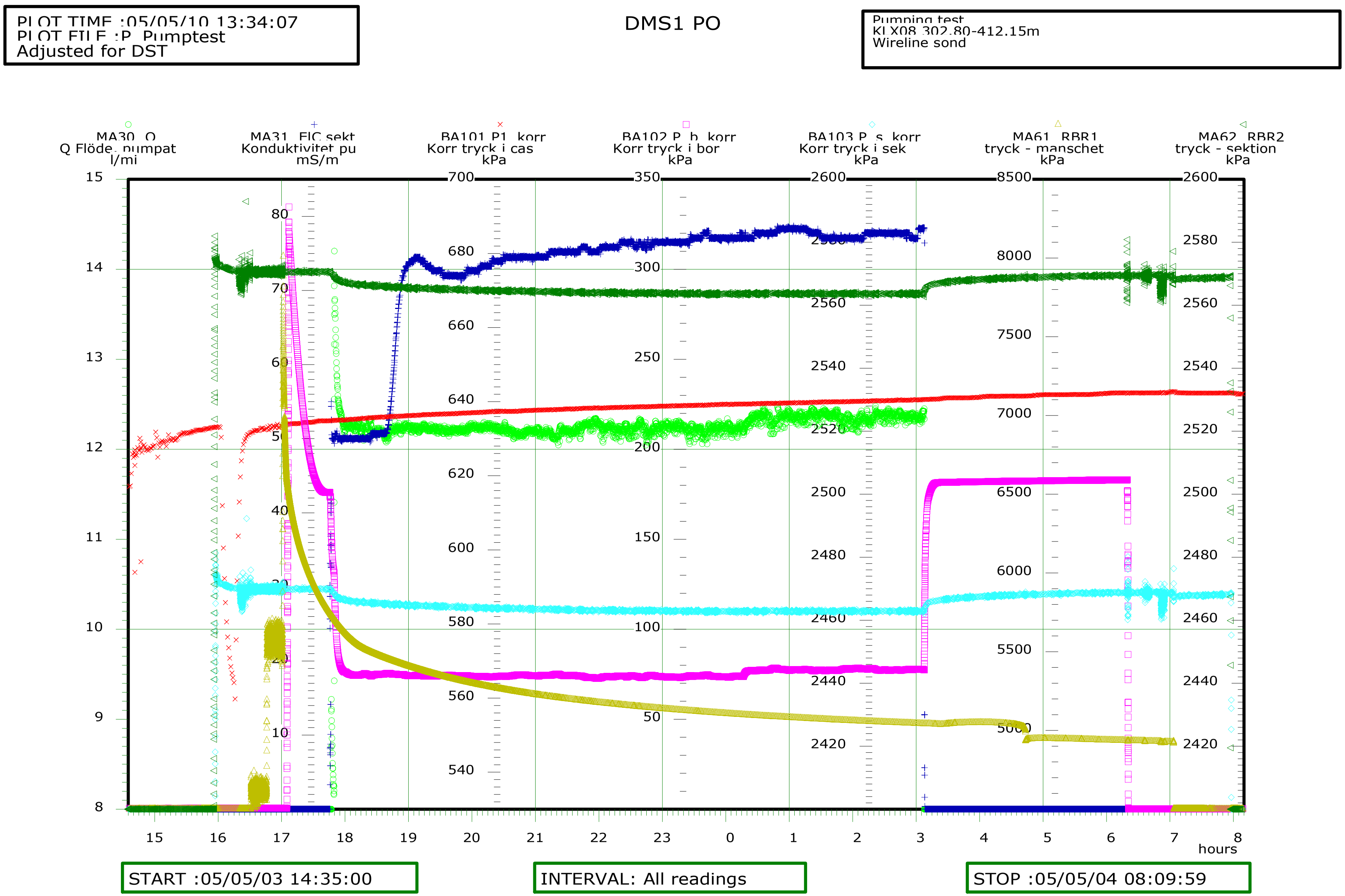
Pumping test
KLX08 197.50-303.86m
Wireline sond

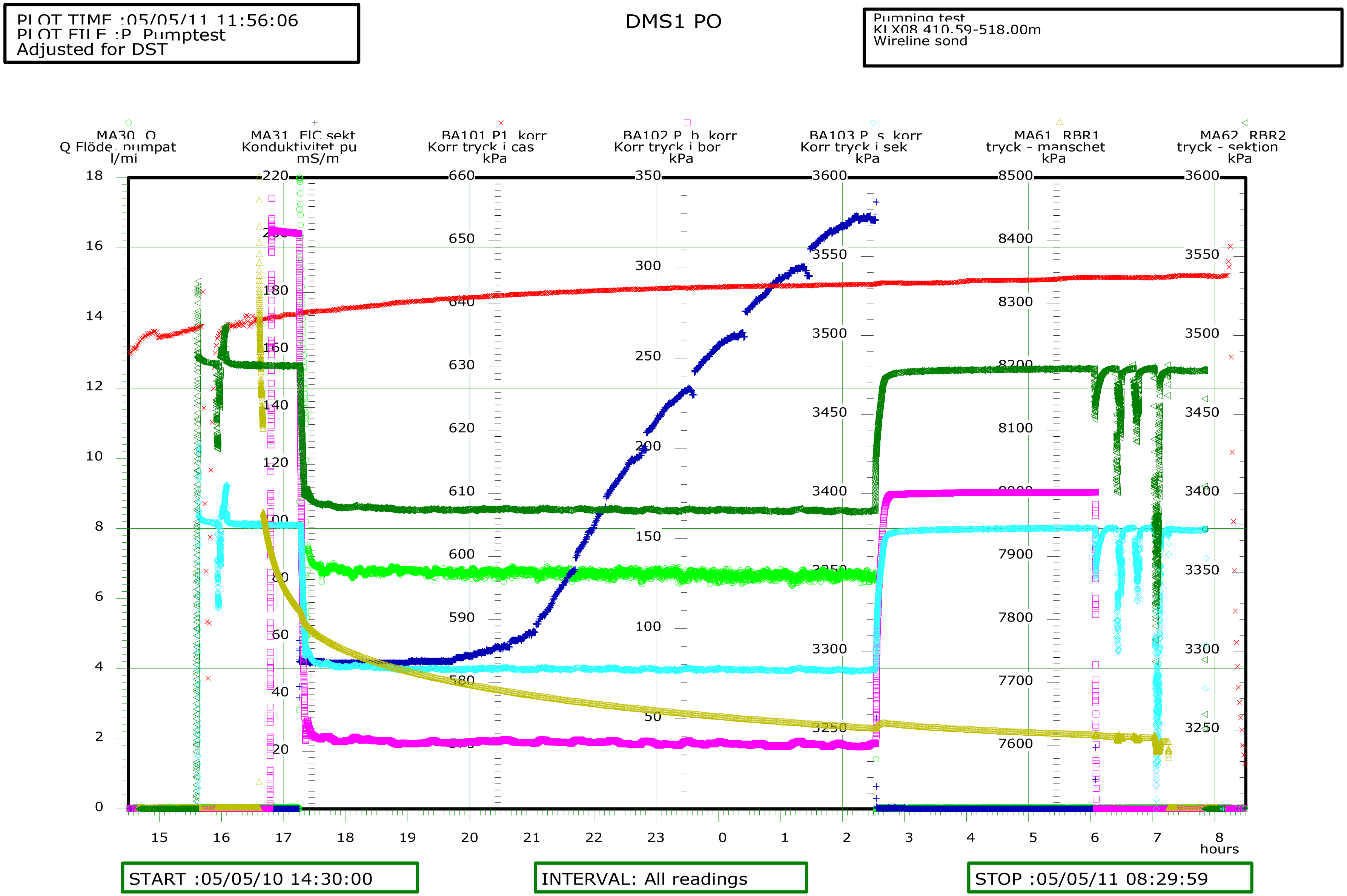


START :05/04/19 15:00:00

INTERVAL: All readings

STOP :05/04/20 08:04:59


PLOT TIME :05/05/10 13:34:07
PLOT FILE :P_Pumptest
Adjusted for DST
DMS1 PO
Pumping test
KLX08 302.80-412.15m
Wireline sond
MA30 Q
Q Flöde, pumpat
l/mi
MA31 EIC sekt
Konduktivitet pu
mS/m
BA101 P1 korr
Korr tryck i cas
kPa
BA102 P_b korr
Korr tryck i bor
kPa
BA103 P_s korr
Korr tryck i sek
kPa
MA61 RBR1
tryck - manschet
kPa
MA62 RBR2
tryck - sektion
kPa
hours
START :05/05/03 14:35:00
INTERVAL: All readings
STOP :05/05/04 08:09:59

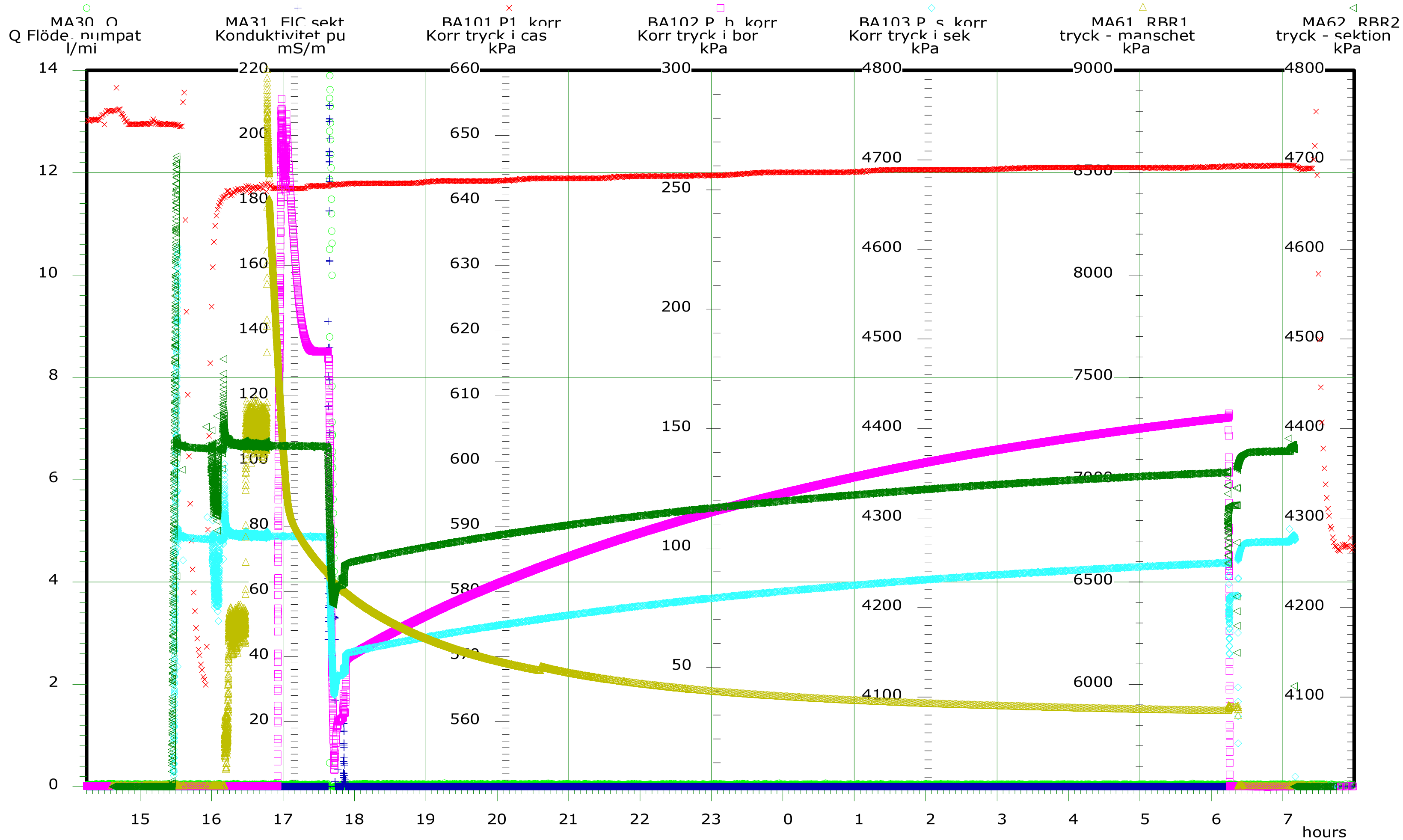


PLOT TIME :05/05/11 11:56:06
PLOT FILE :P_Pumptest
Adjusted for DST
DMS1 PO
Pumping test
KLX08 410.59-518.00m
Wireline sond
MA30 Q
Q Flöde, pumpat
l/mi
MA31 EC sekt
Konduktivitet pu
mS/m
BA101 P1 korr
Korr tryck i cas
kPa
BA102 P_b korr
Korr tryck i bor
kPa
BA103 P_s korr
Korr tryck i sek
kPa
MA61 RBR1
tryck - manschet
kPa
MA62 RBR2
tryck - sektion
kPa
hours
START :05/05/10 14:30:00
INTERVAL: All readings
STOP :05/05/11 08:29:59

PLOT TIME :05/05/24 09:38:23
PLOT FILE :P_Pumptest
Adjusted for DST

DMS1 PO

Pumping test
KLX08 516.73-613.37m
Wireline sond



START :05/05/17 14:15:00

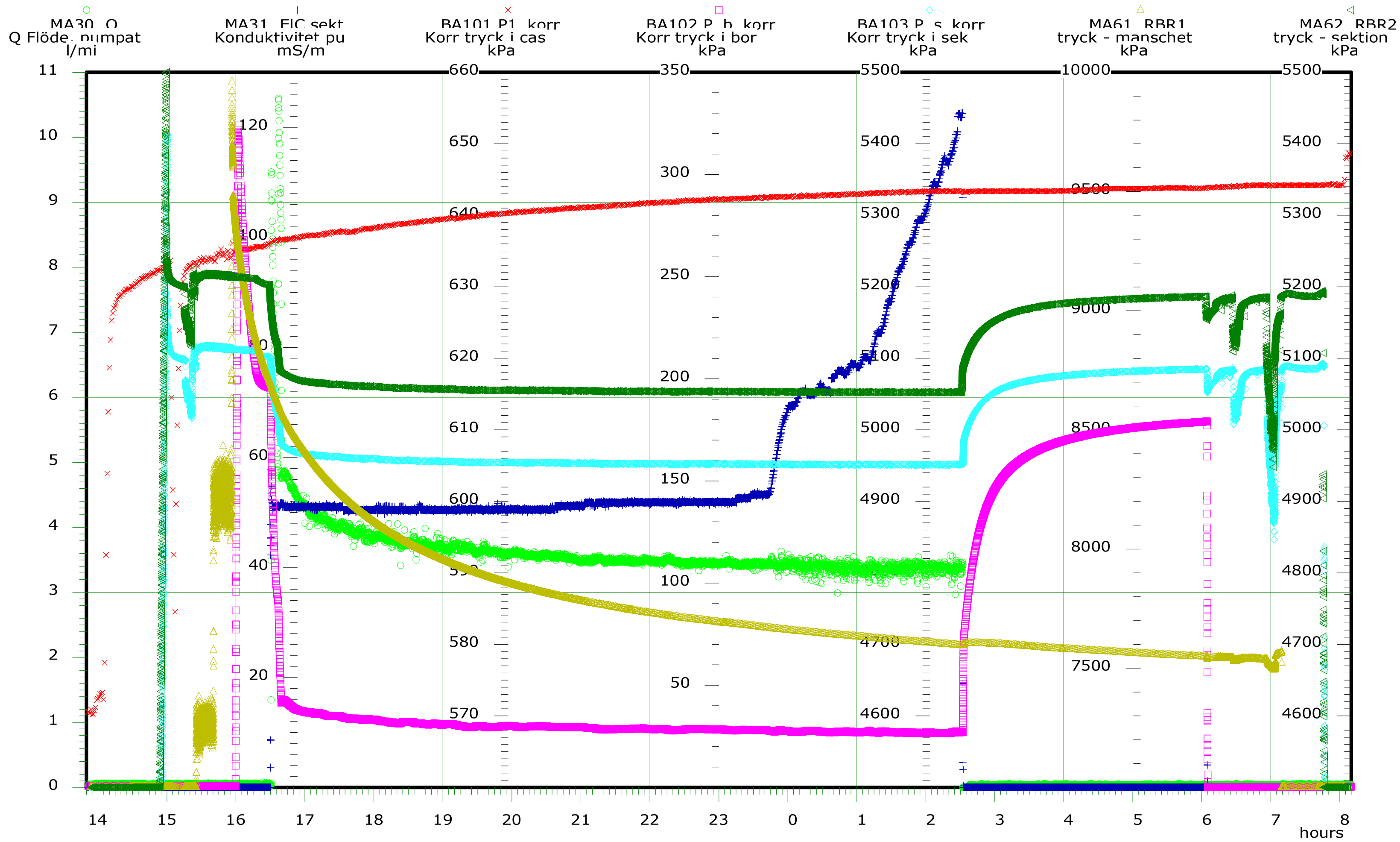
INTERVAL: All readings

STOP :05/05/18 07:59:59

PLOT TIME :05/05/31 10:29:01
PLOT FILE :P_Pumptest
Adjusted for DST

DMS1 PO

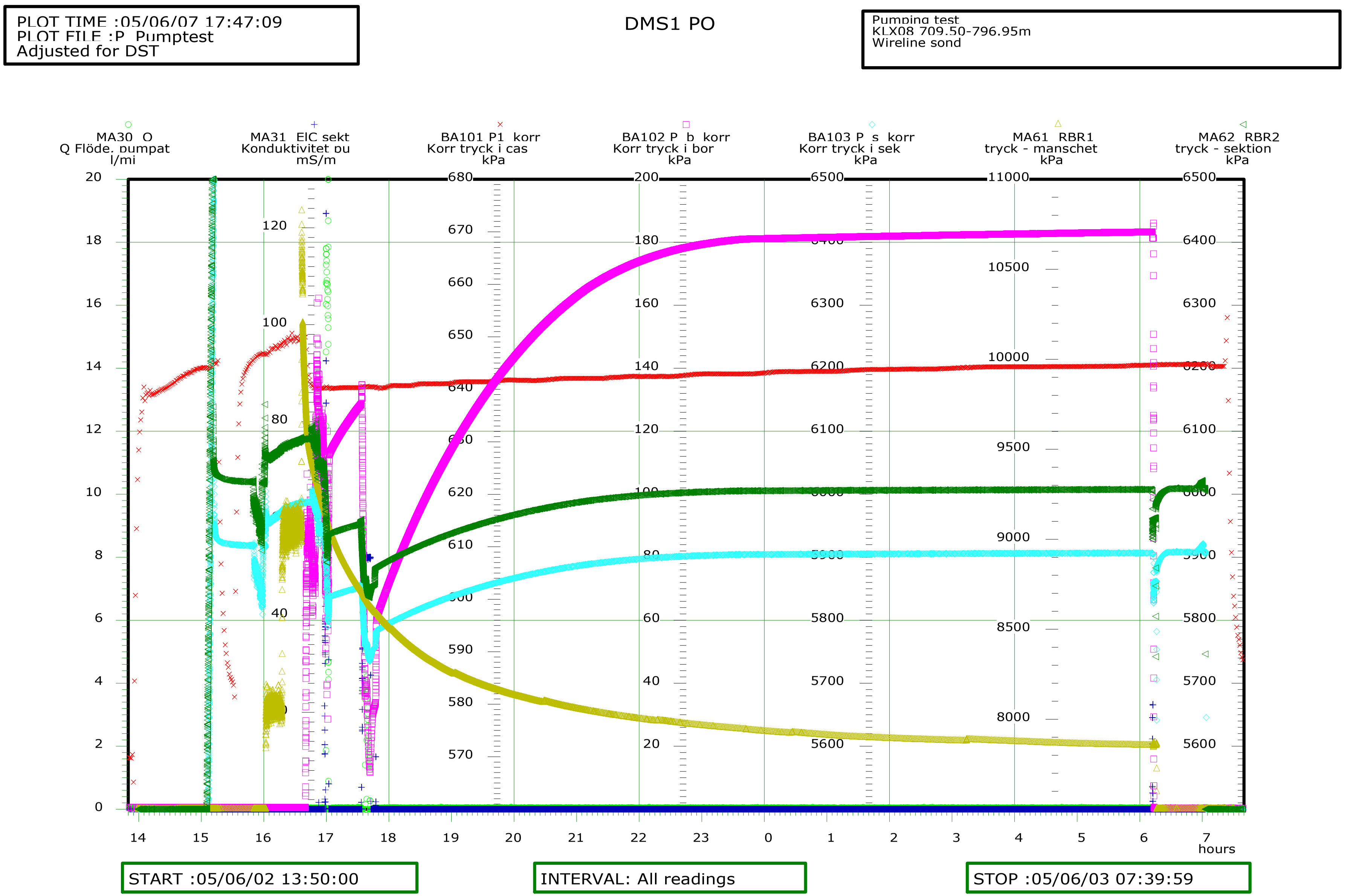
Pumping test
KLX08 612.00-713.00m
Wireline sond



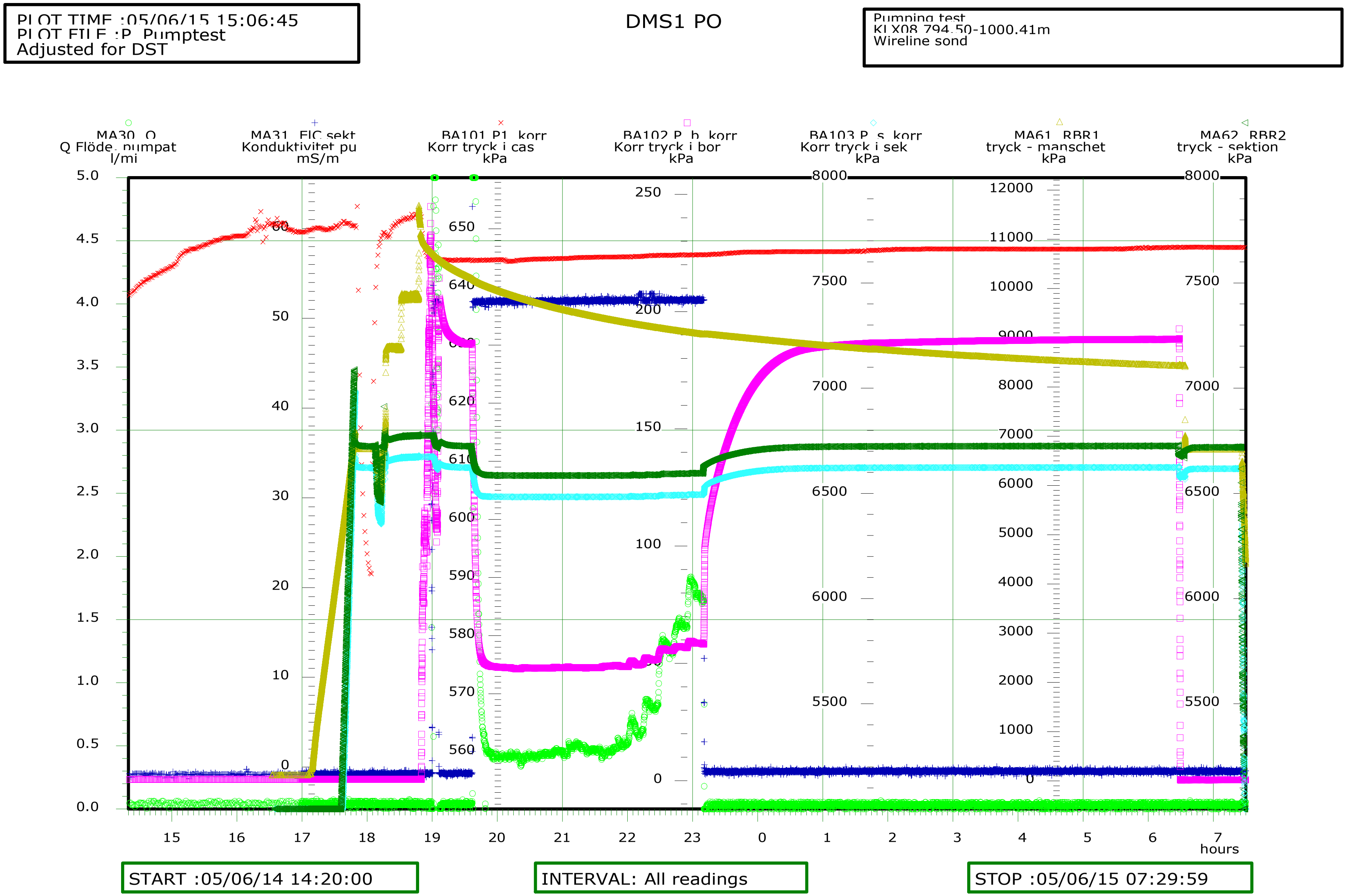
START :05/05/27 13:50:00

INTERVAL: All readings

STOP :05/05/28 08:09:59



PLOT TIME :05/06/07 17:47:09
PLOT FILE :P_Pumptest
Adjusted for DST
DMS1 PO
Pumping test
KLX08 709.50-796.95m
Wireline sond
MA30 Q
Q Flöde, pumpat
l/mi
MA31 EIC sekt
Konduktivitet pu
mS/m
BA101 P1 korr
Korr tryck i cas
kPa
BA102 P b korr
Korr tryck i bor
kPa
BA103 P s korr
Korr tryck i sek
kPa
MA61 RBR1
tryck - manschet
kPa
MA62 RBR2
tryck - sektion
kPa
hours
START :05/06/02 13:50:00
INTERVAL: All readings
STOP :05/06/03 07:39:59

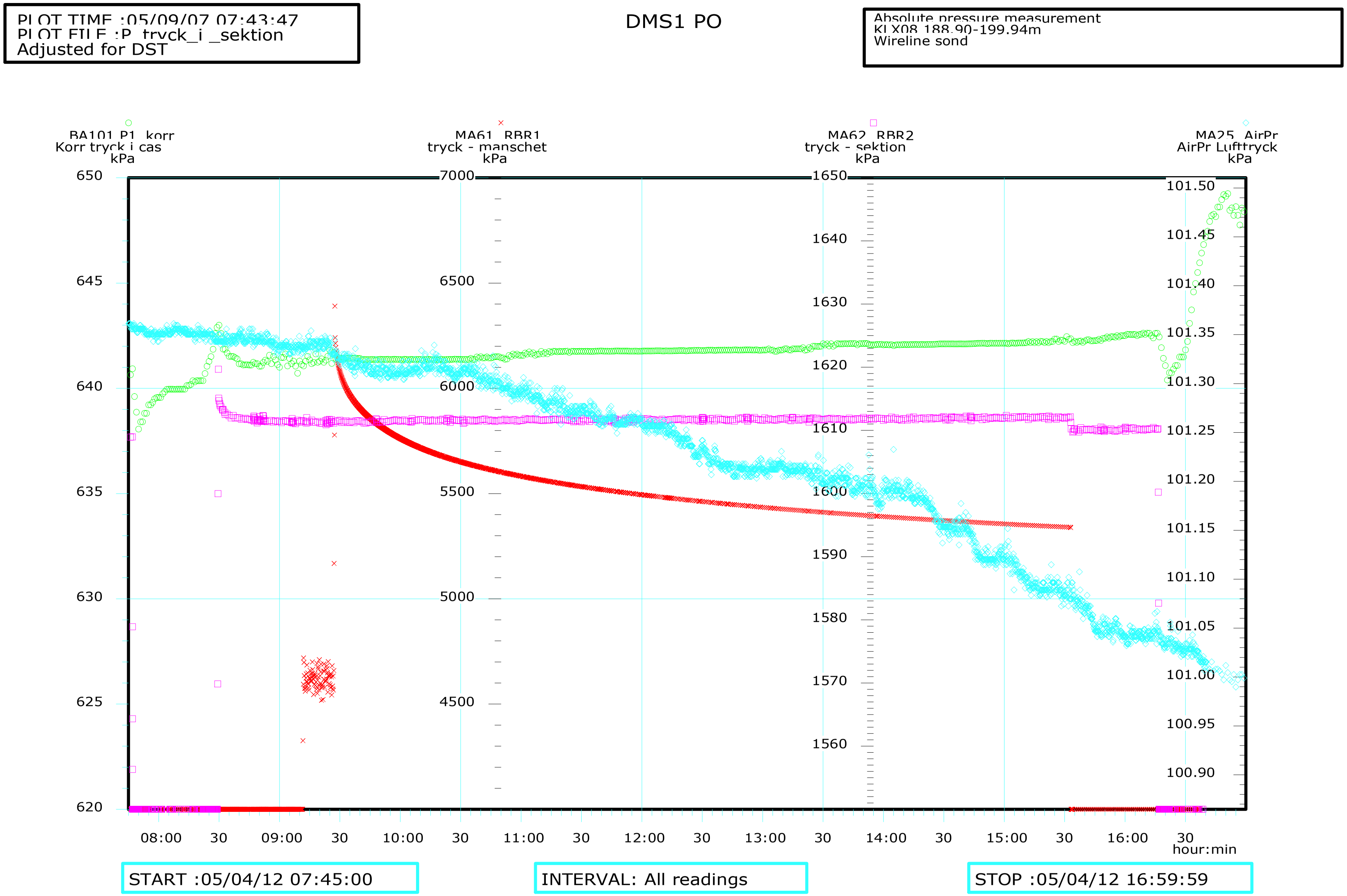

PLOT TIME :05/06/15 15:06:45
PLOT FILE :P_Pumptest
Adjusted for DST
DMS1 PO
Pumping test
KLX08 794.50-1000.41m
Wireline sond
MA30 Q
Q Flöde, pumpat
l/mi
MA31 EC sekt
Konduktivitet pu
mS/m
BA101 P1 korr
Korr tryck i cas
kPa
BA102 P_b korr
Korr tryck i bor
kPa
BA103 P_s korr
Korr tryck i sek
kPa
MA61 RBR1
tryck - manschet
kPa
MA62 RBR2
tryck - sektion
kPa
hours
START :05/06/14 14:20:00
INTERVAL: All readings
STOP :05/06/15 07:29:59

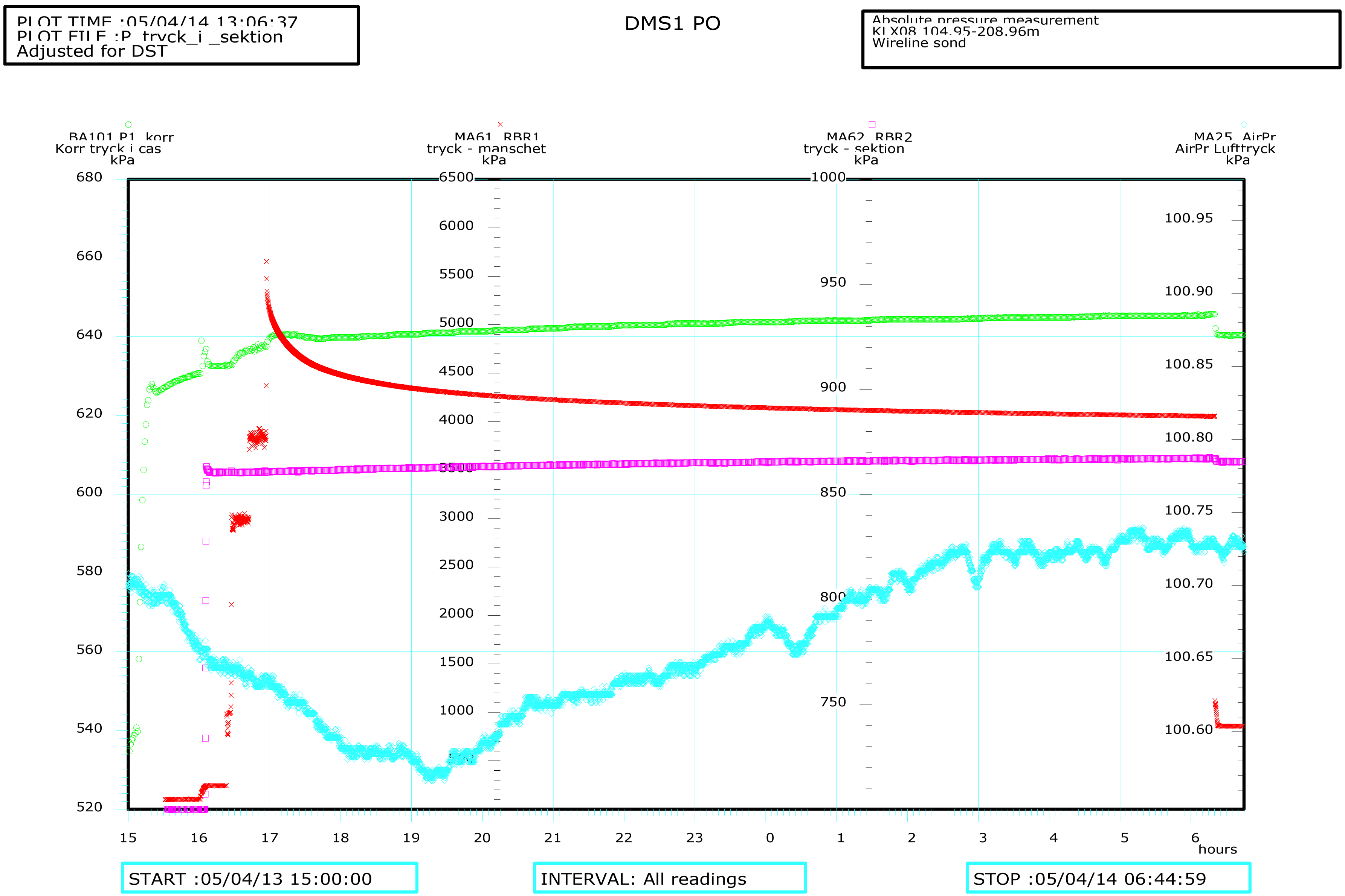
Appendix 6

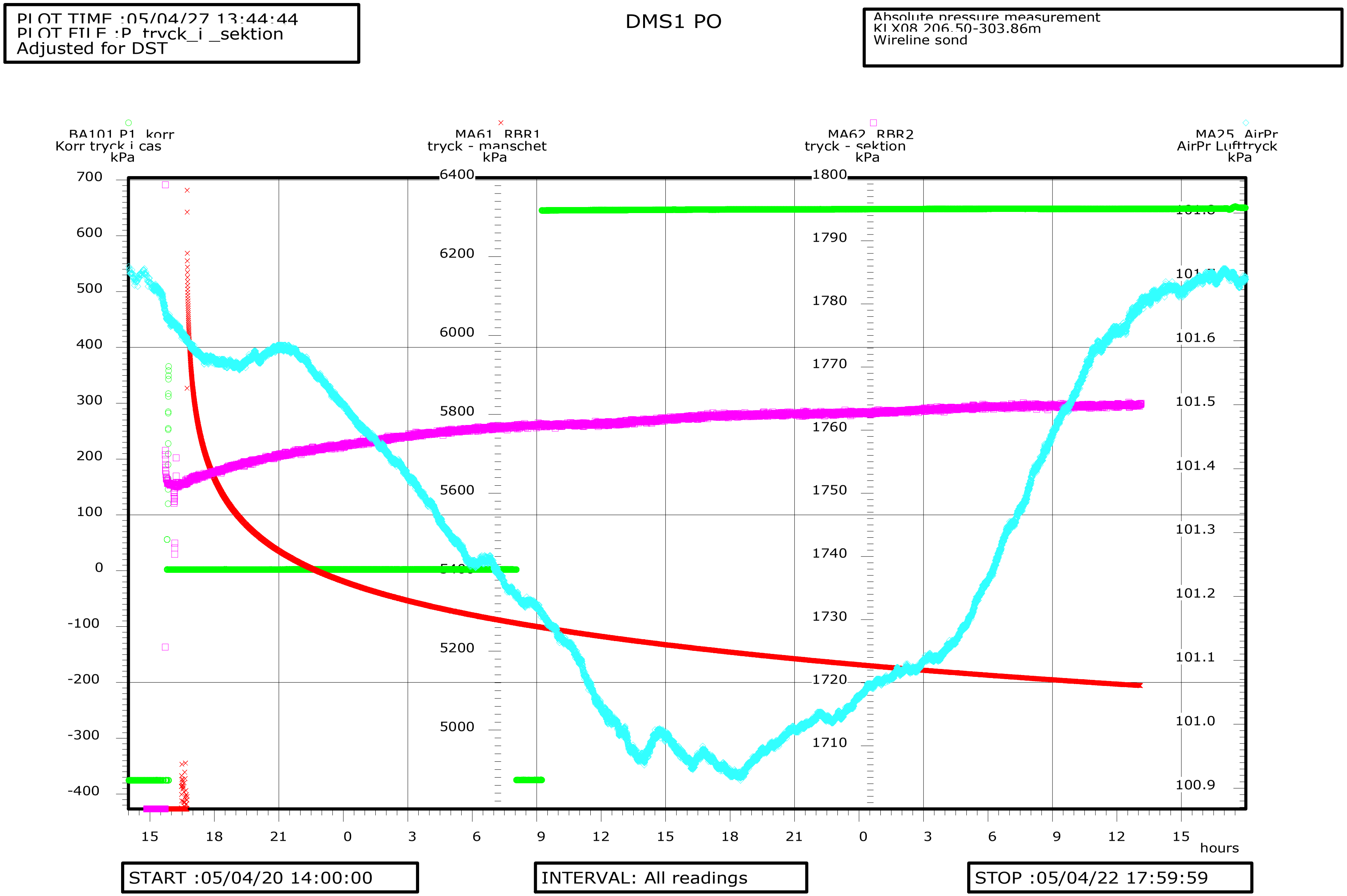
Absolute pressure measurement

Description of the parameters in the enclosed plots

Channel	Parameter	Unit	Description
BA101	Pressure	kPa	Pressure of the water column in the telescopic section subtracted with the ambient air pressure.
MA61	Pressure – packer	kPa	Inflation pressure in packer
MA62	Pressure – section	kPa	Pressure of the water column in the test section ie at depth in the borehole. Not corrected for ambient air pressure
MA25	Air pressure	kPa	


PLOT TIME :05/09/07 07:43:47
PLOT FILE :P_tryck_i _sektion
Adjusted for DST
DMS1 PO
Absolute pressure measurement
KLX08 188.90-199.94m
Wireline sond
BA101 P1 korr
Korr tryck i cas
kPa
MA61 RBR1
tryck - manschet
kPa
MA62 RBR2
tryck - sektion
kPa
MA25 AirPr
AirPr Lufttryck
kPa
650
645
640
635
630
625
620
7000
6500
6000
5500
5000
4500
1650
1640
1630
1620
1610
1600
1590
1580
1570
1560
101.50
101.45
101.40
101.35
101.30
101.25
101.20
101.15
101.10
101.05
101.00
100.95
100.90
08:00
30
09:00
30
10:00
30
11:00
30
12:00
30
13:00
30
14:00
30
15:00
30
16:00
30
hour:min
START :05/04/12 07:45:00
INTERVAL: All readings
STOP :05/04/12 16:59:59


PLOT TIME :05/04/14 13:06:37
PLOT FILE :P_tryck_i _sektion
Adjusted for DST
DMS1 PO
Absolute pressure measurement
KLX08 104.95-208.96m
Wireline sond
BA101 P1 korr
Korr tryck i cas
kPa
MA61 RBR1
tryck - manschet
kPa
MA62 RBR2
tryck - sektion
kPa
MA25 AirPr
AirPr Lufttryck
kPa
680
660
640
620
600
580
560
540
520
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
950
900
850
800
750
100.95
100.90
100.85
100.80
100.75
100.70
100.65
100.60
15
16
17
18
19
20
21
22
23
0
1
2
3
4
5
6
hours
START :05/04/13 15:00:00
INTERVAL: All readings
STOP :05/04/14 06:44:59

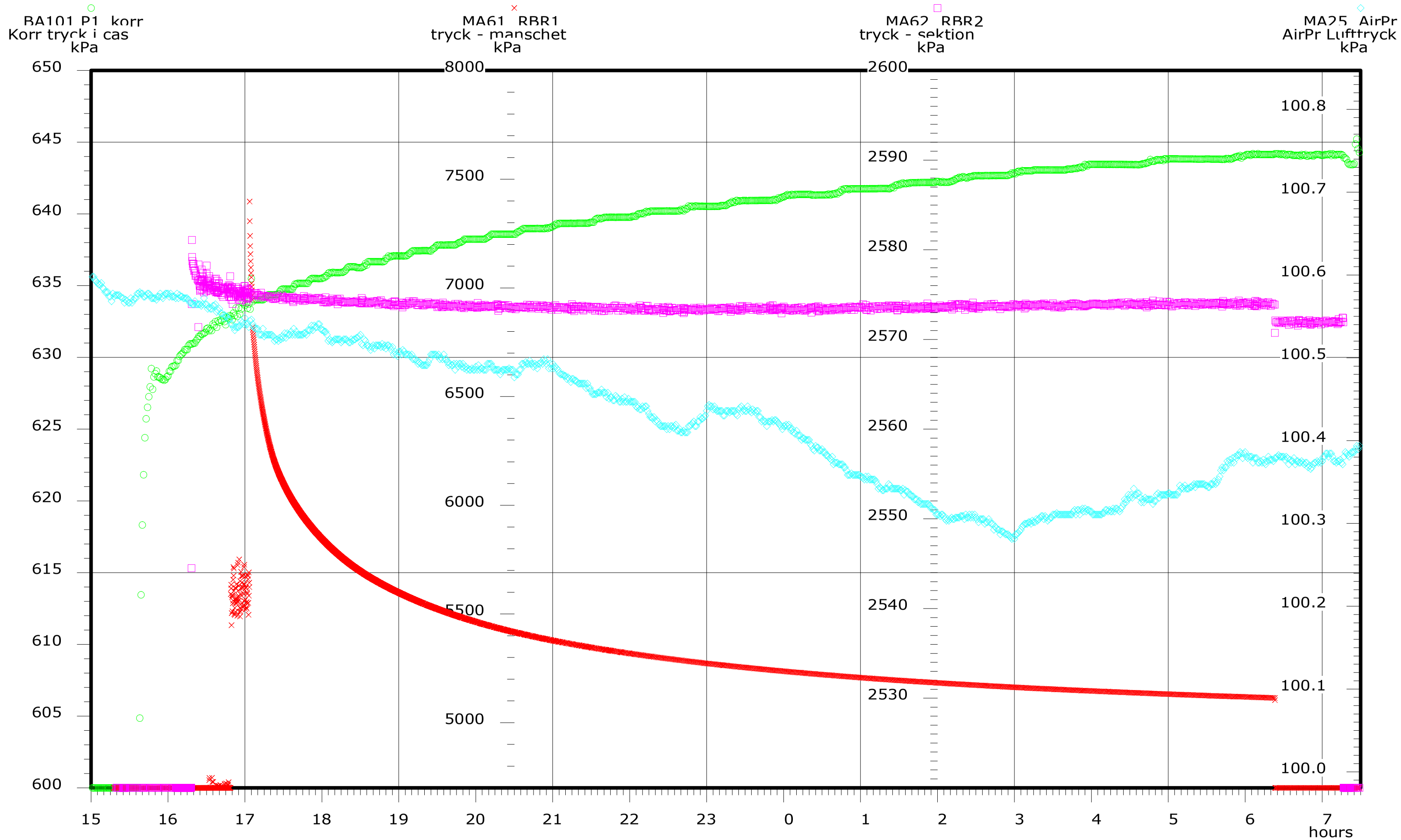


PLOT TIME :05/04/27 13:44:44
PLOT FILE :P_tryck_i _sektion
Adjusted for DST
DMS1 PO
Absolute pressure measurement
KLX08 206.50-303.86m
Wireline sond
BA101 P1 korr
Korr tryck i cas
kPa
MA61 RBR1
tryck - manschet
kPa
MA62 RBR2
tryck - sektion
kPa
MA25 AirPr
AirPr Lufttryck
kPa
700
600
500
400
300
200
100
0
-100
-200
-300
-400
6400
6200
6000
5800
5600
5200
5000
1800
1790
1780
1770
1760
1750
1740
1730
1720
1710
101.6
101.5
101.4
101.3
101.2
101.1
101.0
100.9
15
18
21
0
3
6
9
12
15
18
21
0
3
6
9
12
15
hours
START :05/04/20 14:00:00
INTERVAL: All readings
STOP :05/04/22 17:59:59

PLOT TIME :05/05/10 14:24:25
PLOT FILE :P_tryck_i _sektion
Adjusted for DST

DMS1 PO

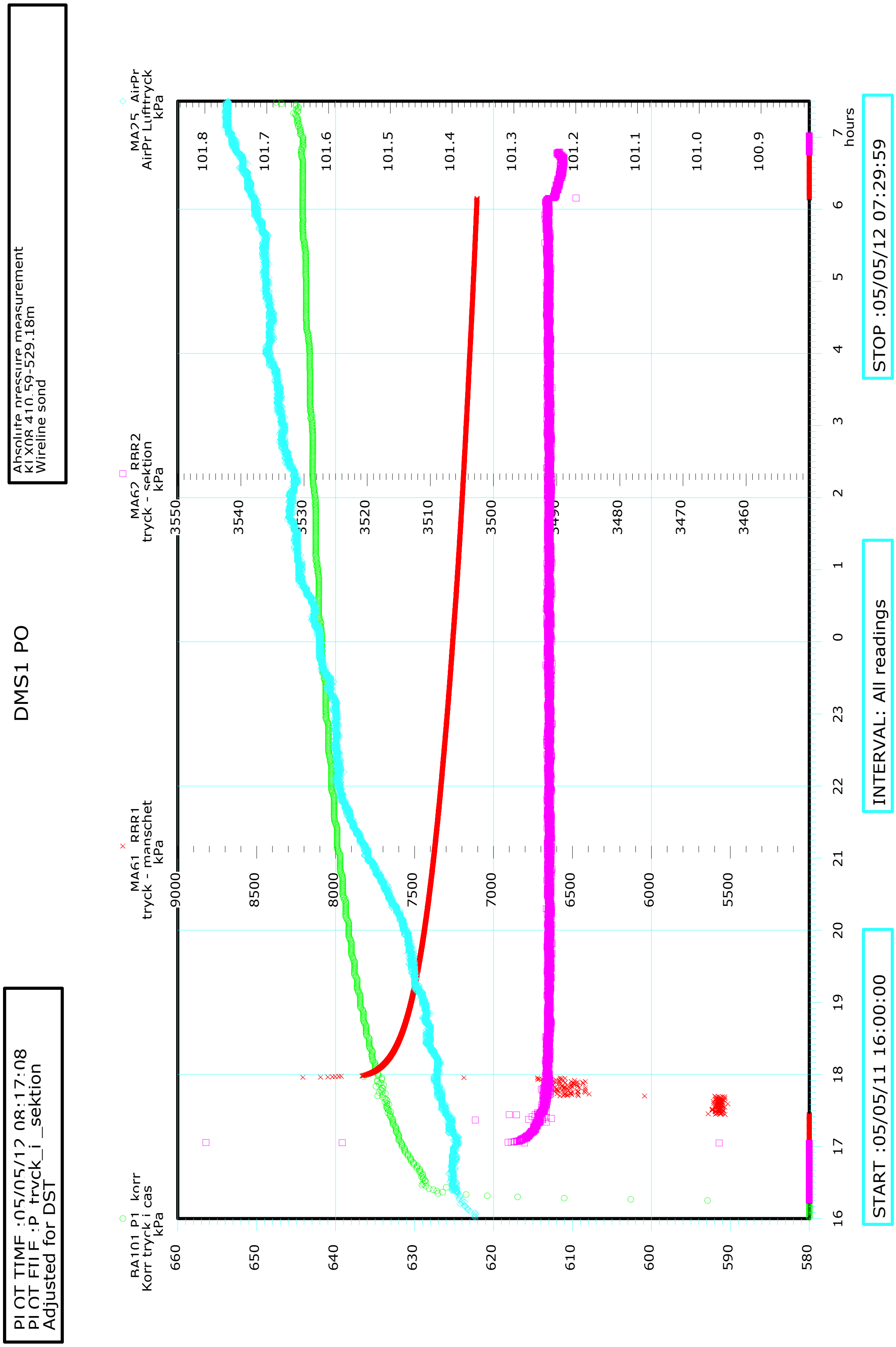
Absolute pressure measurement
KLX08 302.80-424.40m
Wireline sond

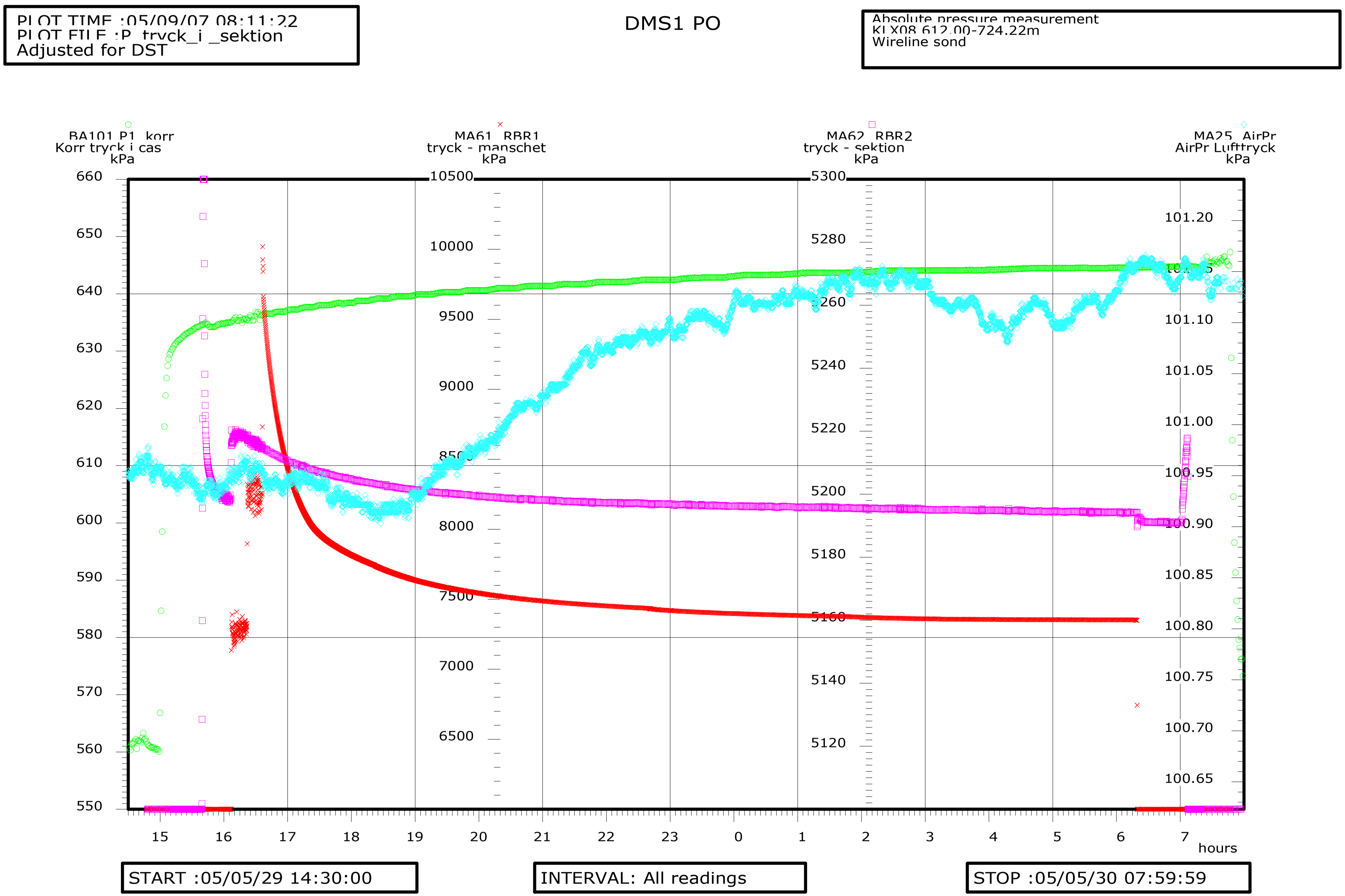


START :05/05/04 15:00:00

INTERVAL: All readings

STOP :05/05/05 07:29:59


PLOT TIME :05/05/12 08:17:08
PLOT FILE :P_tryck_i_sektion
Adjusted for DST
DMS1 PO
Absolute pressure measurement
KLX08 410.59-529.18m
Wireline sond
RA101 P1_korr
Korr tryck i cas
kPa
MA61 RBR1
tryck - manschet
kPa
MA62 RBR2
tryck - sektion
kPa
MA25 AirPr
AirPr Lufttryck
kPa
hours
START :05/05/11 16:00:00
INTERVAL: All readings
STOP :05/05/12 07:29:59


PLOT TIME :05/09/07 08:11:22
PLOT FILE :P_tryck_i _sektion
Adjusted for DST
DMS1 PO
Absolute pressure measurement
KLX08 612.00-724.22m
Wireline sond
BA101 P1 korr
Korr tryck i cas
kPa
MA61 RBR1
tryck - manschet
kPa
MA62 RBR2
tryck - sektion
kPa
MA25 AirPr
AirPr Lufttryck
kPa
660
650
640
630
620
610
600
590
580
570
560
550
10500
10000
9500
9000
8500
8000
7500
7000
6500
5300
5280
5260
5240
5220
5200
5180
5160
5140
5120
101.20
101.15
101.10
101.05
101.00
100.95
100.90
100.85
100.80
100.75
100.70
100.65
15
16
17
18
19
20
21
22
23
0
1
2
3
4
5
6
7
hours
START :05/05/29 14:30:00
INTERVAL: All readings
STOP :05/05/30 07:59:59

Appendix 7

Results from flushing, S, and returning, R, water from the drilling of KLX08

(Samples in bold italics are analysed at the drillsite.)

Borehole	Date and time	Bh length (m)	Sample No	Uranine content (mg/L)	Drill water content (%)	Electrical Conductivity measured at lab (mS/m)
KLX08	2005/04/07 13:05:00	109.85	S1	0.17200		54.70
KLX08	2005/04/07 13:05:00	109.85	R1	0.00560	3.1	51.00
KLX08	2005/04/07 15:45:00	121.07	S2	0.16530		53.80
KLX08	2005/04/07 15:45:00	121.07	R2	0.01320	7.4	55.80
KLX08	2005/04/08 06:35:00	125.20	S3	0.19590		53.10
KLX08	2005/04/08 06:35:00	125.20	R3	0.16380	91.5	54.50
KLX08	2005/04/08 13:45:00	148.67	S4	0.16950		52.70
KLX08	2005/04/08 13:45:00	148.67	R4	0.14220	79.5	56.30
KLX08	2005/04/08 17:15:00	153.96	S5	0.18900		53.00
KLX08	2005/04/08 17:15:00	153.96	R5	0.15090	84.3	52.60
KLX08	2005/04/09 08:00:00	156.26	S6	0.16240		52.80
KLX08	2005/04/09 08:00:00	156.26	R6	0.11280	63.0	53.80
KLX08	2005/04/09 13:05:00	162.85	S7	0.16900		53.00
KLX08	2005/04/09 13:05:00	162.85	R7	0.09660	54.0	50.90
KLX08	2005/04/09 16:05:00	174.09	S8	0.18310		53.40
KLX08	2005/04/09 16:05:00	174.09	R8	0.05040	28.2	50.80
KLX08	2005/04/10 09:00:00	178.97	S9	0.18710		53.30
KLX08	2005/04/10 09:00:00	178.97	R9	0.02000	11.2	50.00
KLX08	2005/04/10 14:13:00	186.63	S10	0.03470		53.70
KLX08	2005/04/10 14:13:00	186.63	R10	0.00950	5.3	49.30
KLX08	2005/04/11 06:45:00	195.21	S11	0.20580		53.70
KLX08	2005/04/11 06:45:00	195.21	R11	0.02400	13.4	49.40
KLX08	2005/04/13 13:27:00	202.96	S12	0.20810		53.00
KLX08	2005/04/13 13:27:00	202.96	R12	0.01360	7.6	49.20
KLX08	2005/04/14 07:50:00	209.38	S13	0.21630		52.90
KLX08	2005/04/14 07:50:00	209.38	R13	0.02080	11.6	48.90
KLX08	2005/04/14 11:18:00	218.16	S14	***0.18010***		
KLX08	2005/04/14 11:18:00	218.16	R14	0.02140	12.0	48.80
KLX08	2005/04/14 16:15:00	229.96	S15	***0.20240***		
KLX08	2005/04/14 16:15:00	229.96	R15	0.02100	11.7	48.40
KLX08	2005/04/15 06:31:00	237.18	S16	0.22850		52.30
KLX08	2005/04/15 06:31:00	237.18	R16	0.01380	7.7	49.30
KLX08	2005/04/15 10:38:00	250.62	S17	***0.16760***		
KLX08	2005/04/15 10:38:00	250.62	R17	0.02530	14.2	49.80
KLX08	2005/04/15 16:33:00	260.85	S18	***0.18980***		
KLX08	2005/04/15 16:33:00	260.85	R18	0.01120	6.3	47.10
KLX08	2005/04/16 08:50:00	263.37	S19	0.17590		52.40
KLX08	2005/04/16 08:50:00	263.37	R19	0.03380	19.0	50.80
KLX08	2005/04/16 16:44:00	264.55	S20	***0.18730***		

Borehole	Date and time	Bh length (m)	Sample No	Uranine content (mg/L)	Drill water content (%)	Electrical Conductivity measured at lab (mS/m)
KLX08	2005/04/16 16:44:00	264.55	R20	0.03730	21.0	50.80
KLX08	2005/04/17 10:02:00	266.63	S21	0.17070		52.70
KLX08	2005/04/17 10:02:00	266.63	R21	0.02090	11.7	50.70
KLX08	2005/04/17 16:38:00	275.70	S22	***0.19360***		
KLX08	2005/04/17 16:38:00	275.70	R22	0.03630	20.4	50.90
KLX08	2005/04/18 09:50:00	280.76	S23	0.25920		53.80
KLX08	2005/04/18 09:50:00	280.76	R23	0.01380	7.5	49.30
KLX08	2005/04/19 08:17:00	295.59	S24	0.22340		53.90
KLX08	2005/04/19 08:17:00	295.59	R24	0.01430	7.8	49.60
KLX08	2005/04/19 14:15:00	302.28	S25	0.20600		53.50
KLX08	2005/04/19 14:15:00	302.28	R25	0.02050	11.1	50.20
KLX08	2005/04/23 09:44:00	304.88	S26	0.19330		53.40
KLX08	2005/04/23 09:44:00	304.88	R26	0.01890	10.1	51.00
KLX08	2005/04/23 17:04:00	312.42	S27	0.17620		53.50
KLX08	2005/04/23 17:04:00	312.42	R27	0.02840	15.3	49.80
KLX08	2005/04/24 10:46:00	316.53	S28	0.19930		53.80
KLX08	2005/04/24 10:46:00	316.53	R28	0.01820	9.8	49.80
KLX08	2005/04/25 15:19:00	320.61	S29	0.21460		54.00
KLX08	2005/04/25 15:19:00	320.61	R29	0.03110	16.5	51.80
KLX08	2005/04/26 07:45:00	328.09	S30	0.19590		53.80
KLX08	2005/04/26 07:45:00	328.09	R30	0.03340	17.8	51.40
KLX08	2005/04/26 16:57:00	329.72	S31	0.20080		52.80
KLX08	2005/04/26 16:57:00	329.72	R31	0.02110	11.2	50.20
KLX08	2005/04/27 06:50:00	332.49	S32	0.18740		52.20
KLX08	2005/04/27 06:50:00	332.49	R32	0.01280	6.8	50.20
KLX08	2005/04/27 10:37:00	345.18	S33	0.19550		52.90
KLX08	2005/04/27 10:37:00	345.18	R33	0.00740	4.0	49.60
KLX08	2005/04/28 14:38:00	349.99	S34	0.20070		53.60
KLX08	2005/04/28 14:38:00	349.99	R34	0.00360	1.9	50.30
KLX08	2005/04/29 09:55:00	351.08	S35	0.19580		53.50
KLX08	2005/04/29 09:55:00	351.08	R35	0.01090	5.8	49.90
KLX08	2005/04/29 14:02:00	358.98	S36	0.19340		53.40
KLX08	2005/04/29 14:02:00	358.98	R36	0.05400	28.3	50.70
KLX08	2005/04/30 07:59:00	362.11	S37	0.20330		53.60
KLX08	2005/04/29 07:59:00	362.11	R37	0.05550	29.1	49.90
KLX08	2005/04/30 10:45:00	368.44	S38	***0.18000***		
KLX08	2005/04/30 10:45:00	368.44	R38	0.01630	8.5	49.90
KLX08	2005/05/01 07:52:00	374.49	S39	0.18510		53.00
KLX08	2005/05/01 07:52:00	374.49	R39	0.01320	6.9	50.10
KLX08	2005/05/01 12:40:00	381.10	S40	***0.31660***		
KLX08	2005/05/01 12:40:00	381.10	R40	0.02140	11.2	50.00
KLX08	2005/05/02 09:35:00	387.52	S41	0.22460		53.00
KLX08	2005/05/02 09:35:00	387.52	R41	0.01020	5.4	50.00
KLX08	2005/05/02 16:12:00	400.08	S42	0.21960		52.50
KLX08	2005/05/02 16:12:00	400.08	R42	0.02860	15.0	49.30
KLX08	2005/05/03 07:42:00	406.32	S43	0.18220		52.90
KLX08	2005/05/03 07:42:00	406.32	R43	0.02130	11.2	50.20

Borehole	Date and time	Bh length (m)	Sample No	Uranine content (mg/L)	Drill water content (%)	Electrical Conductivity measured at lab (mS/m)
KLX08	2005/05/04 14:35:00	422.57	S44	0.16590		53.10
KLX08	2005/05/04 14:35:00	422.57	R44	0.00660	3.5	49.70
KLX08	2005/05/05 08:32:00	425.92	S45	0.14360		52.30
KLX08	2005/05/05 08:35:00	425.92	R45	0.00430	2.3	49.50
KLX08	2005/05/05 15:05:00	437.14	S46	0.17990		52.80
KLX08	2005/05/05 15:05:00	437.14	R46	0.01850	9.8	50.20
KLX08	2005/05/06 07:40:00	446.38	S47	0.14530		53.30
KLX08	2005/05/06 07:40:00	446.38	R47	0.01760	9.4	50.30
KLX08	2005/05/06 14:37:00	461.87	S48	***0.28930***		
KLX08	2005/05/06 14:37:00	461.87	R48	0.01750	9.3	50.70
KLX08	2005/05/06 17:25:00	469.74	S49	***0.28200***		
KLX08	2005/05/06 17:25:00	469.74	R49	0.01120	5.9	50.80
KLX08	2005/05/07 09:27:00	475.95	S50	0.16790		53.30
KLX08	2005/05/07 09:27:00	475.95	R50	0.01350	7.2	50.70
KLX08	2005/05/07 15:19:00	483.66	S51	***0.32680***		
KLX08	2005/05/07 15:19:00	483.66	R51	0.01770	9.4	50.90
KLX08	2005/05/08 10:34:00	484.27	S52	0.22500		53.80
KLX08	2005/05/08 10:34:00	484.27	R52	0.01550	8.2	51.10
KLX08	2005/05/08 16:25:00	496.78	S53	***0.18470***		
KLX08	2005/05/08 16:25:00	496.78	R53	0.01570	8.4	50.10
KLX08	2005/05/09 06:37:00	501.76	S54	0.16870		54.00
KLX08	2005/05/09 06:37:00	501.76	R54	0.00660	3.5	50.80
KLX08	2005/05/09 10:25:00	509.79	S55	***0.01550***		
KLX08	2005/05/09 10:25:00	509.79	R55	0.01140	6.1	50.70
KLX08	2005/05/10 08:41:00	515.68	S56	0.20740		54.10
KLX08	2005/05/10 08:41:00	515.68	R56	0.00570	3.0	50.60
KLX08	2005/05/11 09:40:00	520.53	S57	0.18660		53.90
KLX08	2005/05/11 09:40:00	520.53	R57	0.00640	3.4	50.90
KLX08	2005/05/11 13:35:00	526.27	S58	***0.17730***		
KLX08	2005/05/11 13:35:00	526.27	R58	0.03560	18.9	52.20
KLX08	2005/05/12 09:40:00	533.24	S59	0.17870		53.90
KLX08	2005/05/12 09:40:00	533.24	R59	0.00830	4.4	50.50
KLX08	2005/05/12 13:15:00	539.11	S60			
KLX08	2005/05/12 13:15:00	539.11	R60	0.00870	4.6	49.80
KLX08	2005/05/12 16:23:00	547.45	S61			
KLX08	2005/05/12 16:23:00	547.45	R61	0.01930	10.3	50.40
KLX08	2005/05/13 11:15:00	547.45	S62	0.20680		53.70
KLX08	2005/05/13 11:15:00	547.45	R62	0.01170	6.2	52.20
KLX08	2005/05/13 15:36:00	554.44	S63			
KLX08	2005/05/13 15:36:00	554.44	R63	0.02270	12.1	50.90
KLX08	2005/05/14 10:18:00	556.48	S64	0.17820		53.70
KLX08	2005/05/14 10:18:00	556.48	R64	0.00940	5.0	50.50
KLX08	2005/05/14 14:31:00	560.39	S65			
KLX08	2005/05/14 14:31:00	560.39	R65	0.01340	7.1	50.40
KLX08	2005/05/15 07:01:00	569.57	S66	0.19250		53.60
KLX08	2005/05/15 07:01:00	569.57	R66	0.01160	6.1	50.60
KLX08	2005/05/15 11:03:00	578.60	S67			

Borehole	Date and time	Bh length (m)	Sample No	Uranine content (mg/L)	Drill water content (%)	Electrical Conductivity measured at lab (mS/m)
KLX08	2005/05/15 11:03:00	578.60	R67	0.01930	10.2	50.00
KLX08	2005/05/15 15:15:00	586.23	S68			
KLX08	2005/05/15 15:15:00	586.23	R68	0.01180	6.3	50.50
KLX08	2005/05/16 07:55:00	593.27	S69	0.17110		54.00
KLX08	2005/05/16 07:55:00	593.27	R69	0.01410	7.5	50.90
KLX08	2005/05/16 13:37:00	604.63	S70	0.18690		53.90
KLX08	2005/05/16 13:37:00	604.63	R70	0.00970	5.2	50.80
KLX08	2005/05/17 07:03:00	612.42	S71	0.17590		54.50
KLX08	2005/05/17 07:03:00	612.42	R71	0.00890	4.7	50.80
KLX08	2005/05/19 08:00:00	616.76	S72	0.17960		53.60
KLX08	2005/05/19 08:00:00	616.76	R72	0.00210	1.0	50.70
KLX08	2005/05/19 14:18:00	625.00	S73	***0.23900***		
KLX08	2005/05/19 14:18:00	625.00	R73	0.01600	8.0	50.60
KLX08	2005/05/19 17:09:00	631.81	S74	***0.23210***		
KLX08	2005/05/19 17:09:00	631.81	R74	0.00610	3.1	50.10
KLX08	2005/05/20 13:15:00	643.16	S75	0.09762		53.30
KLX08	2005/05/20 13:15:00	643.16	R75	0.01070	5.4	52.30
KLX08	2005/05/21 09:27:00	643.30	S76	0.10680		54.20
KLX08	2005/05/21 09:27:00	643.30	R76	0.00200	1.0	51.60
KLX08	2005/05/22 07:42:00	649.55	S77	0.18700		53.20
KLX08	2005/05/22 07:42:00	649.55	R77	0.00260	1.3	50.70
KLX08	2005/05/22 14:15:00	652.07	S78	***0.24200***		
KLX08	2005/05/22 14:15:00	652.07	R78	0.00600	3.0	50.20
KLX08	2005/05/23 06:58:00	655.40	S79	0.18930		53.30
KLX08	2005/05/23 06:58:00	655.40	R79	0.00470	2.4	50.30
KLX08	2005/05/23 11:07:00	659.55	S80	***0.22450***		
KLX08	2005/05/23 11:07:00	659.55	R80	0.00420	2.1	50.70
KLX08	2005/05/24 07:00:00	661.47	S81	0.17620		53.90
KLX08	2005/05/24 07:00:00	661.47	R81	0.00170	0.8	50.70
KLX08	2005/05/24 16:05:00	667.99	S82	***0.18530***		
KLX08	2005/05/24 16:05:00	667.99	R82	0.00490	2.5	52.60
KLX08	2005/05/25 08:31:00	670.94	S83	0.16190		54.30
KLX08	2005/05/25 08:31:00	670.94	R83	0.00500	2.5	50.70
KLX08	2005/05/26 06:24:00	677.31	S84	0.16120		54.50
KLX08	2005/05/26 06:24:00	677.31	R84	0.00310	1.6	51.80
KLX08	2005/05/26 10:41:00	686.90	S85	***0.23750***		
KLX08	2005/05/26 10:41:00	686.90	R85	0.00480	2.4	50.60
KLX08	2005/05/26 15:56:00	695.21	S86	***0.25250***		
KLX08	2005/05/26 15:56:00	695.21	R86	0.01310	6.6	50.90
KLX08	2005/05/27 06:59:00	701.21	S87	0.16620		54.50
KLX08	2005/05/27 06:59:00	701.21	R87	0.01000	5.2	51.80
KLX08	2005/05/27 12:25:00	710.50	S88	***0.19150***		
KLX08	2005/05/27 12:25:00	710.50	R88	0.00900	4.7	52.30
KLX08	2005/05/29 09:12:00	715.11	S89	0.16990		55.00
KLX08	2005/05/29 09:12:00	715.11	R89	0.01480	7.7	51.10
KLX08	2005/05/29 13:15:00	721.65	S90	***0.17280***		
KLX08	2005/05/29 13:15:00	721.65	R90	0.00520	2.7	51.60

Borehole	Date and time	Bh length (m)	Sample No	Uranine content (mg/L)	Drill water content (%)	Electrical Conductivity measured at lab (mS/m)
KLX08	2005/05/30 09:55:00	728.66	S91	0.14700		55.40
KLX08	2005/05/30 09:55:00	728.66	R91	0.00160	0.8	51.50
KLX08	2005/05/30 16:45:00	739.85	S92	0.16810		53.30
KLX08	2005/05/30 16:45:00	739.85	R92	0.01120	5.8	51.40
KLX08	2005/05/31 12:25:00	752.37	S93	0.17210		55.00
KLX08	2005/05/31 12:25:00	752.37	R93	0.00550	2.9	52.30
KLX08	2005/05/31 15:15:00	758.53	S94	0.12470		54.10
KLX08	2005/05/31 15:15:00	758.53	R94	0.00560	2.9	50.90
KLX08	2005/06/01 09:51:00	769.94	S95	0.12530		55.50
KLX08	2005/06/01 09:51:00	769.94	R95	0.01520	7.9	50.50
KLX08	2005/06/01 16:46:00	783.84	S96	0.18490		55.20
KLX08	2005/06/01 16:46:00	783.84	R96	0.00370	1.9	51.60
KLX08	2005/06/02 07:56:00	788.95	S97	0.10780		55.00
KLX08	2005/06/02 07:56:00	788.95	R97	0.00400	2.1	51.60
KLX08	2005/06/04 12:47:00	801.41	S98	0.17320		54.70
KLX08	2005/06/04 12:47:00	801.41	R98	0.00260	1.4	51.50
KLX08	2005/06/04 17:14:00	810.52	S99	0.18240		54.40
KLX08	2005/06/04 17:14:00	810.52	R99	0.00470	2.5	52.10
KLX08	2005/06/05 07:13:00	812.16	S100	0.18030		53.90
KLX08	2005/06/05 07:13:00	812.16	R100	0.00750	3.9	51.20
KLX08	2005/06/05 16:47:00	827.55	S101	0.17340		54.10
KLX08	2005/06/05 16:47:00	827.55	R101	0.01940	10.1	52.80
KLX08	2005/06/06 06:18:00	828.01	S102	0.17780		54.50
KLX08	2005/06/06 06:18:00	828.01	R102	0.00340	1.8	51.30
KLX08	2005/06/06 17:49:00	836.16	S103	0.20040		54.00
KLX08	2005/06/06 17:49:00	836.16	R103	0.00580	3.0	51.40
KLX08	2005/06/06 22:40:00	842.03	S104	0.25060		54.40
KLX08	2005/06/06 22:40:00	842.03	R104	0.03510	18.3	52.10
KLX08	2005/06/07 03:26:00	851.22	S105	0.15450		54.80
KLX08	2005/06/07 03:26:00	851.22	R105	0.02070	10.8	51.90
KLX08	2005/06/07 06:25:00	854.72	S106	0.17940		54.10
KLX08	2005/06/07 06:25:00	854.72	R106	0.00480	2.5	51.20
KLX08	2005/06/07 16:12:00	861.19	S107	0.19390		54.20
KLX08	2005/06/07 16:12:00	861.19	R107	0.00470	2.4	51.60
KLX08	2005/06/07 19:59:00	866.48	S108	0.30550		53.90
KLX08	2005/06/07 19:59:00	866.48	R108	0.01650	8.6	52.20
KLX08	2005/06/07 23:48:00	873.82	S109	0.16850		54.40
KLX08	2005/06/07 23:48:00	873.82	R109	0.00660	3.4	53.70
KLX08	2005/06/08 07:01:00	884.04	S110	0.16660		54.20
KLX08	2005/06/08 07:01:00	884.04	R110	0.00700	3.6	53.30
KLX08	2005/06/08 10:13:00	888.95	S111	0.17750		53.80
KLX08	2005/06/08 10:13:00	888.95	R111	0.00600	3.1	51.10
KLX08	2005/06/08 14:24:00	893.14	S112	0.16520		55.50
KLX08	2005/06/08 14:24:00	893.14	R112	0.01060	5.5	51.50
KLX08	2005/06/10 03:02:00	899.34	S113	0.18380		54.90
KLX08	2005/06/10 03:12:00	899.34	R113	0.00570	2.9	51.20
KLX08	2005/06/10 06:38:00	902.71	S114	0.20200		54.90

Borehole	Date and time	Bh length (m)	Sample No	Uranine content (mg/L)	Drill water content (%)	Electrical Conductivity measured at lab (mS/m)
KLX08	2005/06/10 06:38:00	902.71	R114	0.00460	2.4	51.30
KLX08	2005/06/10 14:31:00	914.13	S115	0.20820		55.60
KLX08	2005/06/10 14:31:00	914.13	R115	0.02480	12.9	51.10
KLX08	2005/06/10 18:52:00	922.80	S116	0.17000		55.60
KLX08	2005/06/10 18:52:00	922.80	R116	0.00630	3.3	52.60
KLX08	2005/06/11 01:25:00	932.06	S117	0.18570		54.40
KLX08	2005/06/11 01:25:00	932.06	R117	0.01550	8.1	51.20
KLX08	2005/06/11 06:21:00	938.32	S118	0.19060		55.50
KLX08	2005/06/11 06:21:00	938.32	R118	0.00820	4.3	51.10
KLX08	2005/06/11 09:46:00	944.85	S119	0.19600		55.40
KLX08	2005/06/11 09:45:00	944.85	R119	0.00470	2.4	51.60
KLX08	2005/06/11 14:30:00	950.76	S120	0.19040		55.40
KLX08	2005/06/11 14:30:00	950.76	R120	0.00500	2.6	51.20
KLX08	2005/06/11 09:03:00	958.42	S121	0.18520		54.40
KLX08	2005/06/11 19:03:00	958.42	R121	0.00310	1.6	52.60
KLX08	2005/06/11 23:48:00	965.00	S122	0.19460		55.60
KLX08	2005/06/11 23:48:00	965.00	R122	0.02040	10.6	50.80
KLX08	2005/06/12 08:16:00	973.98	S123	0.19850		54.60
KLX08	2005/06/12 08:16:00	973.98	R123	0.00210	1.1	52.00
KLX08	2005/06/12 14:40:00	983.69	S124	0.18290		55.90
KLX08	2005/06/12 14:40:00	983.69	R124	0.00500	2.6	51.20
KLX08	2005/06/13 13:04:00	998.10	S125	0.21120		53.00
KLX08	2005/06/13 13:04:00	998.10	R125	0.01430	7.4	52.20