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Oskarshamn site investigation

Core drilling of short boreholes KLX11B, KLX11C, KLX11D, KLX11E and KLX11F for discrete fracture network investigation (DFN)

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December 2006

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Keywords: Core drilling, Discrete fracture network (DFN) investigation, Hydraulic responses.

Abstract

The short cored boreholes KLX11B, KLX11C, KLX11D, KLX11E and KLX11F were drilled to gain information of structural geological properties, mainly frequency and orientation of fractures in the shallow bedrock from ground surface to ca 100 m depth.

The boreholes will provide input to the statistical modelling of fractures (discrete fracture network model or DFN model.

The boreholes were drilled to planned length at 100 to 120 m.

Hydraulic responses from flushing with nitrogen gas could be seen in the closely located observation boreholes.

Sammanfattning

De korta kärnborrhålen KLX11B, KLX11C, KLX11D, KLX11E och KLX11F borrades för att ge information om strukturgeologiska egenskaper, främst frekvens och orientering på sprickor i det ytnära berget från markytan och ner till ca 100 meters djup. Borrhålen kommer att ge underlag för den statistiska modelleringen av sprickor (discrete fracture network model eller DFN-modell).

De fem korta kärnborrhålen borrades till planerad längd på 100 till 120 meter.

Hydrauliska responser från kvävgasblåsning kunde ses i närliggande observationshål.

Contents

1 Introduction

SKB performs site investigations in order to evaluate the feasibility of locating a deep repository for spent nuclear fuel in Oskarshamn municipality, Sweden /1/.

Drilling of the short cored boreholes KLX11B, KLX11C, KLX11D, KLX11E and KLX11F was made to provide further data for the DFN-model, especially in the uppermost 100 m interval in order to provide a link between field observations and observations in cored boreholes /2/.

The location of the boreholes, KLX11B, KLX11C, KLX11D, KLX11E and KLX11F, is shown in Figure 1-1 together with the deep cored boreholes KLX11A and KL20A. The short boreholes KLX11C-F were drilled with a dip of 60 degrees in a boxlike pattern around the centrally located, vertical borehole KLX11B. KLX11A is steeply dipping to the east. KLX20A was drilled towards the west at the same time as drilling was performed in KLX11B-F.

The decision to perform the drilling is given in SKB id 1050811, internal document.

The Regional Authority was informed by letter on 2006-02-17, SKB id 1050723, internal document.

The drilling and all related on-site operations were performed according to a specific Activity Plan (AP PS-05-075). Reference is given in the activity plan to procedures in the SKB Method Description for Core Drilling (SKB MD 620.003, Version 1.0) and relevant method instructions for handling of chemicals, surveying and evaluation of cuttings. Method descriptions and activity plans are SKB internal documents.

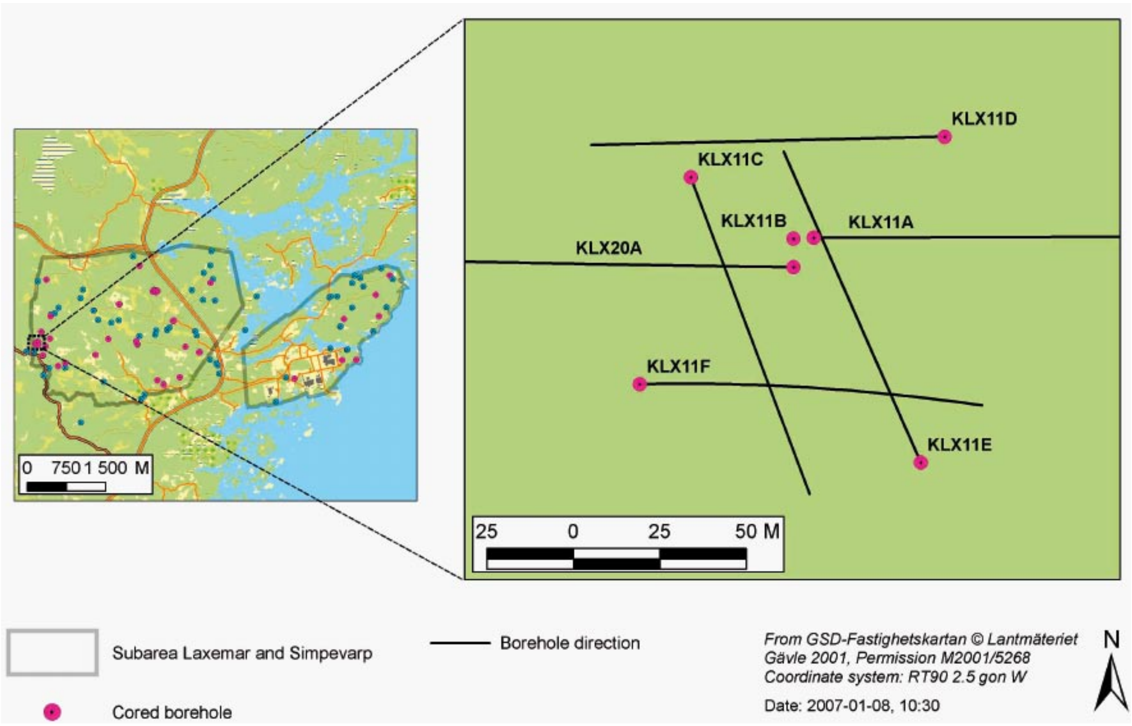


Figure 1-1. *Location of the short cored boreholes KLX11B, KLX11C, KLX11D, KLX11E and KLX11F in the Laxemar subarea. The location of the deep cored boreholes KLX11A and KLX20A is also shown.*

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

Activity plan	ID Number	Version
Kärnborrning av KLX11B–F	AP PS 400-06-020	1.0
Method descriptions	**ID Number**	**Version**
Metodbeskrivning för kärnborrning	SKB MD 620.003	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 spolvattenhantering	SKB MD 620.007	1.0
Metodbeskrivning för krökningsmätning av hammar- och kärnborrhål	SKB MD 224.001	1.0
Instruktion för utsättning och ansättning av hammar- och kärnborrhål	SKB MD 600.002	1.0
Instruktion för hantering och provtagning av borrkärna	SKB MD 143.007	1.0
Instruktion för miljökontroll av ytnära grundvatten och mark vid borrning och pumpning i berg	SKB MD 300.003	2.0

All data were stored in the SICADA database for Oskarshamn.

2 Objective and scope

This report will describe the drilling of the five short cored boreholes, KLX11B, KLX11C, KLX11D, KLX11E and KLX11F and the measurements of hydraulic responses performed as part of the drilling activity.

3 Equipment

In this chapter the drilling equipment and the equipment used for measurements and sampling is described.

3.1 Drilling equipment

Drilling of the short cored boreholes KLX11B, KLX11C, KLX11D, KLX11E and KLX11F was made with a trackmounted, self-propelled Geomachines GM200 drilling machine supplied with accessories.

Figure 3-1. *The Geomachines GM200 drill rig at KLX11F.*

The main core drilling was done with N-size, i.e. giving a borehole of 76 mm diameter. The core barrel was of the type AC Corac N3/50, a triple-tube wireline equipment which gives a core diameter of 50.2 mm. The rods were of type NT.

Reaming of the borehole wall in order to place a casing was made with HQ equipment. The HQ bit gives a borehole diameter of 96 mm.

Drilling through overburden was only done in KLX11B. This was made by casing drilling with dimension HV, giving a hole of 117 mm diameter.

3.2 Equipment for measurements and sampling

Measurements of drill penetration rate, flushing and return water flow and flushing water pressure was not done during the drilling activity.

Hydraulic responses in observation boreholes were measured with Mini-Troll pressure loggers.

4 Execution

Drilling and borehole completion were made by contractor Drillcon AB.

The work was performed in accordance with SKB MD 610.003, Version 1.0 (Method Description for Percussion Drilling, SKB internal document) and consisted of:

- preparations,
- drilling through overburden,
- core drilling in hard rock and casing grouting,
- borehole completion and deviation measurements,
- hydraulic responses,
- data handling,
- environmental control.

An overview of the time schedule for core drilling of boreholes KLX11B–F is given in Figure 4-1.

4.1 Preparations

The preparation stage included the contractor's functional control of his equipment. The machinery and chemicals used have to comply with SKB MD 600.006, Version 1.0 (Method Instruction for Chemical Products and Materials, SKB internal document).

The equipment was cleaned in accordance with SKB MD 600.004, Version 1.0 (Method Instruction for Cleaning Borehole Equipment and certain Ground-based Equipment, SKB internal document).

4.2 Drilling through overburden

Drilling through unconsolidated overburden was only done in KLX11B. Drilling in this borehole was done from the surface to 1.21 m below reference level (TOC) by casing drilling with HV equipment which gives a 117 mm diameter hole. A temporary casing was left in the borehole in order to stabilise the overburden for subsequent core drilling in rock.

ID	Aktivitet	Start	Finish
1	**First activity starts**	**Tue 06-03-14**	**Fri 06-04-28**
2	Core drilling KLX11F	Tue 06-03-14	Fri 06-03-17
3	Core drilling KLX11C	Thu 06-03-30	Wed 06-04-05
4	Core drilling KLX11D	Thu 06-04-06	Thu 06-04-13
5	Core drilling KLX11E	Thu 06-04-13	Fri 06-04-21
6	Core drilling KLX11B	Sat 06-04-22	Fri 06-04-28

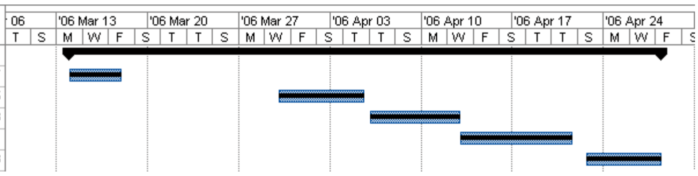


Figure 4-1. *Overview of the time schedule for core drilling of boreholes KLX11B-F.*

4.3 Core drilling in hard rock and gap injection

Core drilling in boreholes KLX11C-F was started with the N-size equipment directly on the bedrock surface. Drilling with N-size was done to lengths as given in Table 4-1. Reaming was then done to a 96 mm diameter with HQ equipment, followed by casing installation.

In order to prevent surface water and shallow groundwater to infiltrate into deeper parts of the borehole, the annular space between the borehole wall and the casing was grouted with cement, see Figure 4-2.

Table 4-1. Drilled length with dimension N and HQ at the time for gap injection in boreholes KLX11B–F.

Borehole	Diameter 76 mm Size N (length m)	Diameter 96 mm Size HQ (length m)	Comment
KLX11B	2.54	2.54	Predrilled to 1.21 m through gravel fill
KLX11C	3.95	2.00	Drilling started in bedrock with N-size
KLX11D	2.40	2.00	Drilling started in bedrock with N
KLX11E	2.68	2.00	Drilling started in bedrock with N
KLX11F	2.89	2.00	Drilling started in bedrock with N

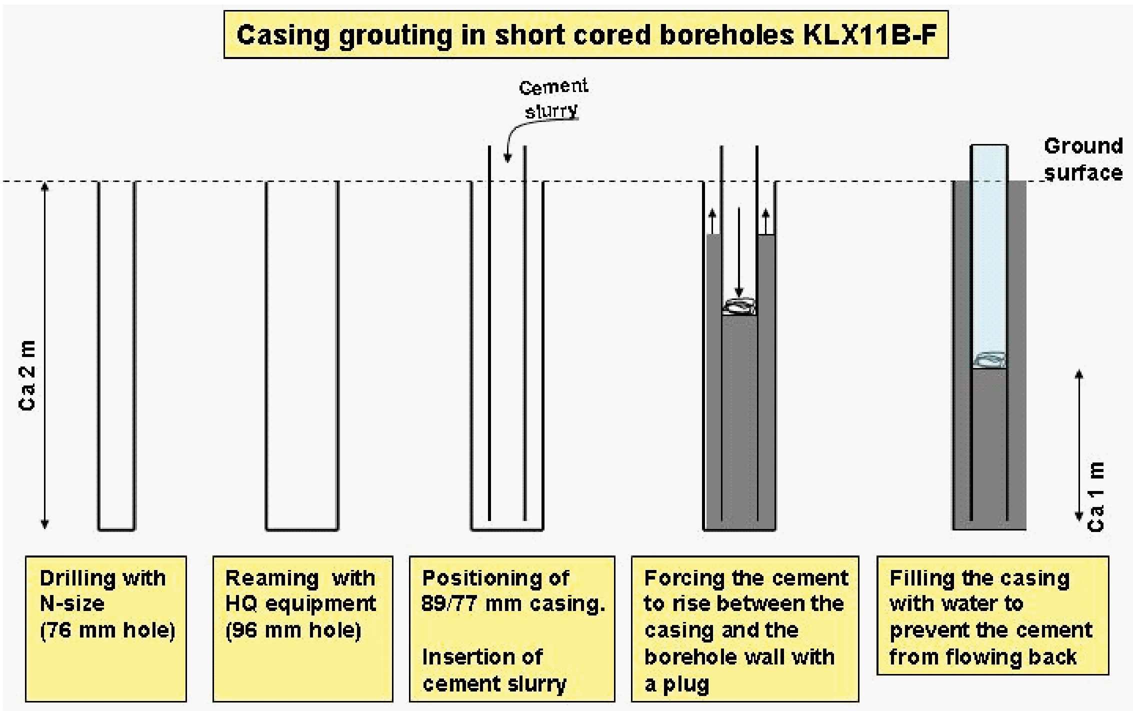


Figure 4-2. Casing installation and grouting.

In the typical case, drilling commenced with N-size drilling to a depth of ca 2 m. The borehole was then reamed to a diameter of 96 mm. The stainless steel casing was emplaced and cement slurry for casing grouting was entered into the casing. A plug of paper was placed on top of the slurry. The plug, and hence the cement slurry, is forced down the borehole making the slurry rise on the outside of the casing thus filling the annular space between casing and borehole wall. The casing was then filled with water to provide buoyancy i.e. preventing the cement from flowing back.

The concrete was allowed to harden. No data is available on possible reductions in the water level in the casing during the time of concrete hardening, see also Section 5-7 "Nonconformities".

Drilling with N-size was then made to remove the concrete inside the casing. Core drilling in rock could then be resumed to planned length.

In KLX11B the temporary casing from drilling through the overburden was removed after the emplacement of the 89/77 mm casing but before the casing grouting.

Figure 4-3. *Drillers carrying the core barrel at the site for KLX11C.*

4.4 Sampling, flushing water handling and deviation measurements

No sampling or measurements were done during drilling.

Observations of water loss or reductions in flushing water pressure during drilling were noted by the drill crew.

The flushing water for the drilling of KLX11B–F was supplied from HLX28. The water was transported to the drill site in water tanks. A uranine tracer was added by the SKB drill coordinators who also kept track on the number of water tanks consumed i.e. the amount of water consumed during drilling. No measurements of the return water volumes or estimates of amounts of drill cuttings returned were made, see also Section 4.8.

Deviation measurements were not made as part of the drilling activity. According to the activity plan measurements with the Maxibor method should have been done. Deviation measurements were instead performed as part of a separate activity /3/.

Reaming of depth reference slots was made in boreholes KLX11B–F. The positions of the reamed slots and the dates for reaming are given in Table 4-2.

4.5 Borehole completion

When the drilling was completed the hole was rinsed from drill cuttings and water by flushing with high pressure nitrogen gas.

A summary record of all the nitrogen gas flushings performed in boreholes KLX11B–F is given in Table 4-3. Each of the rows in Table 4-3 can represent one or more individual gas flushings.

A record of the starting time for each individual nitrogen gas flushing used for evaluation of hydraulic responses is given in Table 4-4.

Table 4-2. Position and reaming dates of depth reference slots in KLX11B–F.

Borehole	Start date	Stop date	Reference slot position (m)	
KLX11B	2006-04-28 14:30	2006-04-28 17:30	50.00	80.00
KLX11C	2006-05-03 09:45	2006-05-03 14:30	47.00	98.00
KLX11D	2006-04-13 13:00	2006-04-13 18:00	50.00	100.00
KLX11E	2006-04-21 16:00	2006-04-21 18:30	50.00	100.00
KLX11F	2006-05-03 14:43	2006-05-04 07:30	50.00	101.00

Table 4-3. Nitrogen gas flushing.

Start date	Stop date	Borehole	Secup (m)	Seclow (m)
2006-05-08 15:37	2006-05-08 17:38	KLX11C	2.00	120.15
2006-05-09 08:22	2006-05-09 09:32	KLX11F	2.00	120.05
2006-05-09 10:20	2006-05-09 11:00	KLX11E	2.00	121.30
2006-05-09 11:15	2006-05-09 14:05	KLX11D	2.00	120.35
2006-05-09 15:53	2006-05-09 16:34	KLX11B	2.54	100.20
2006-05-12 15:09	2006-05-12 16:32	KLX11D	2.00	120.35
2006-05-13 14:10	2006-05-13 14:34	KLX11D	2.00	120.35
2006-05-13 14:49	2006-05-13 15:10	KLX11C	2.00	120.15
2006-05-13 15:24	2006-05-13 15:34	KLX11B	2.54	100.20

*The times are given in local time i.e. in daylight savings time.

Table 4-4. Starting times for individual nitrogen gas flushings in boreholes KLX11B–F.

Borehole	Date	Time for start of nitrogen gas flushing in local time i.e. with daylights savings time	Time for start of nitrogen gas flushing in Swedish Normal Time i.e. without daylights savings time
KLX11C	2006-05-08	15:37	14:37
KLX11C	2006-05-08	16:10	15:10
KLX11C	2006-05-08	16:47	15:47
KLX11C	2006-05-08	17:31	16:31
KLX11F	2006-05-09	08:22	07:22
KLX11F	2006-05-09	09:02	08:02
KLX11F	2006-05-09	09:28	08:28
KLX11E	2006-05-09	10:20	09:20
KLX11E	2006-05-09	10:57	09:57
KLX11D	2006-05-09	11:15	10:15
KLX11D	2006-05-09	14:02	13:02
KLX11B	2006-05-09	15:53	14:53
KLX11B	2006-05-09	16:31	15:31

The boreholes were secured by mounting of lockable steel caps on the casing.

All equipment was removed, the sites cleaned and joint inspections were made by representatives from SKB and the contractor to ensure that the sites had been restored to a satisfactory level.

4.6 Monitoring of hydraulic responses

Pressure loggers were installed in KLX11A (the centrally located deep borehole) during the entire time of drilling of boreholes KLX11B–F. Pressure loggers were also installed in the short boreholes KLX11B–F as they were completed. All logger installations referred to in this report were emplaced in open holes i.e. no packers were used.

The logger installations were:

Log time:10 seconds

The log time is the interval between data savings regardless of pressure changes.

4.7 Data handling

Data collected by the drillers and drill site personnel 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.

4.8 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 release of water was made between the two environmental monitoring wells, SSM000236 and SSM000237. The location of the monitoring wells in relation to boreholes KLX11A-F is shown in Figure 4-4.

As already noted in Section 4.4, no measurements of the volume of return water released was made during drilling of KLX11B–F. The amounts cannot however exceed the amount given in Table 5-4.

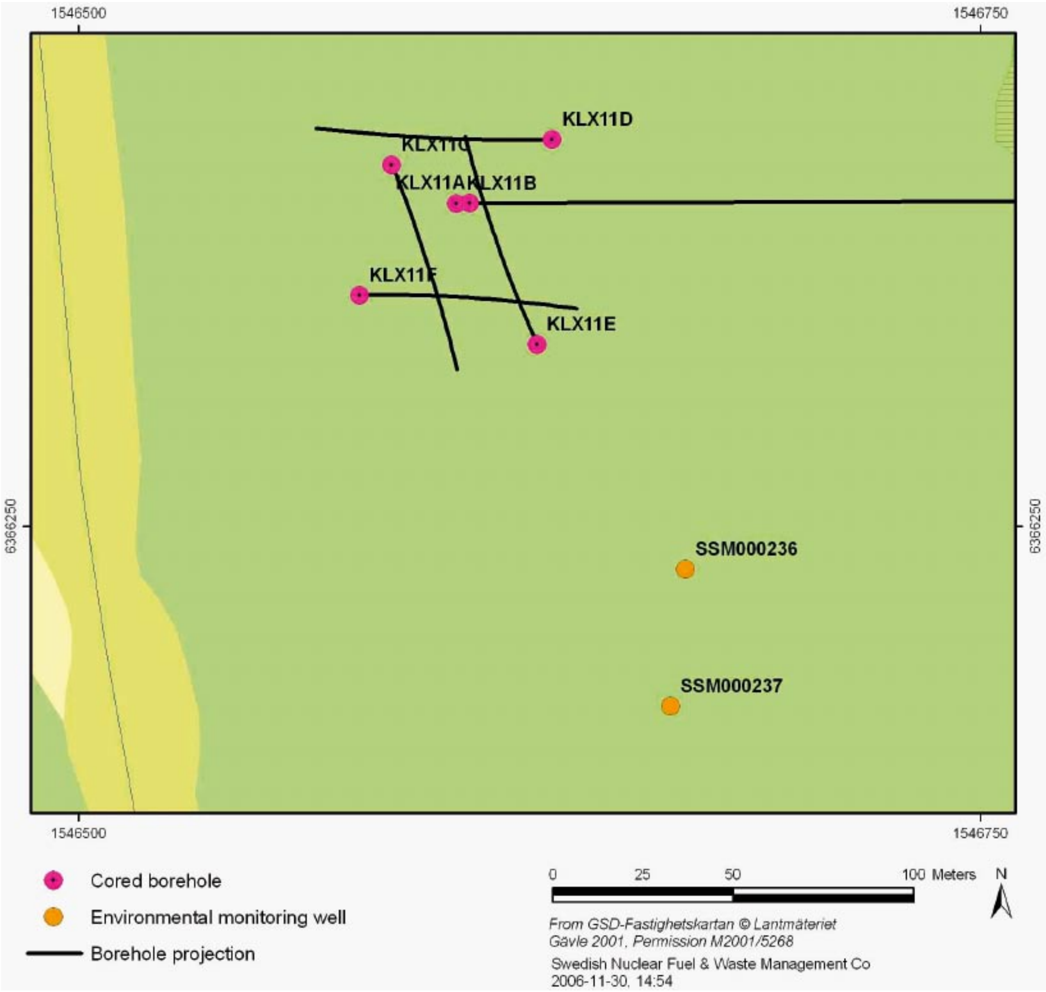


Figure 4-4. *The location of the environmental monitoring wells, SSM000236 and SSM000237 in relation to boreholes KLX11A-F.*

5 Results

Boreholes KLX11B, KLX11C, KLX11D, KLX11E and KLX11F were drilled to gain information of structural geological properties, mainly frequency and orientation of fracture sets as input to the statistical modelling of fractures (discrete fracture network model or DFN model, and hydraulic properties in the shallow bedrock in the Laxemar subarea. The five boreholes were emplaced in a pattern to provide a link between surface observations in outcrops and depth information, see Figure 1-1.

5.1 Borehole technical summary

Geometric and technical data from the boreholes are presented in Tables 5-1 and 5-2.

Technical drawings of the boreholes are given in Appendix 1.

Table 5-1. Geometric and technical data for borehole KLX11B, KLX11C and KLX11D.

Parameter	KLX11B		KLX11C		KLX11D	
Drilling period	From 2006-04-22 to 2006-04-28		From 2006-03-30 to 2006-04-05		From 2006-04-06 to 2006-04-13	
Borehole inclination (starting point) (0 to –90)	–89.87°		–60.52°		–59.00°	
Borehole azimuth (0–360)	136.16°		159.34°		268.70°	
Borehole length	100.20 m		120.15 m		120.35 m	
Soil depth	1.21 m		0 m		0 m	
Starting point coordinates (system RT90/RHB70)	Northing: 6366339.51 m Easting: 1546604.89 m Elevation: 27.27 m.a.s.l.		Northing: 6366350.26 m Easting: 1546586.89 m Elevation: 27.19 m.a.s.l.		Northing: 6366357.37 m Easting: 1546631.42 m Elevation: 25.57 m.a.s.l.	
Borehole diameter (interval) (diameter mm)	0.3–1.21 m 0.3–2.54 m 2.54–100.22 m	117 mm 96 mm 75.7 mm	0.3–2.00 m 2.00–120.15 m	96 mm 75.7 mm	0.3–2.00 m 2.00–120.35 m	96 mm 75.7 mm
Casing diameter (interval) (diameter mm)	0–2.54 m	$Ø_o$ = 89 $Ø_i$ = 77	0–2.00 m	$Ø_o$ = 89 $Ø_i$ = 77	0–2.00 m	$Ø_o$ = 89 $Ø_i$ = 77

Table 5-2. Geometric and technical data for boreholes KLX11E and KLX11F.

Parameter	KLX11E		KLX11F	
Drilling period	From 2006-04-13 to 2006-04-21		From 2006-03-14 to 2006-03-17	
Borehole inclination (starting point) (0 to –90)	–60.65°		–60.98°	
Borehole azimuth (0–360)	336.17°		888.61°	
Borehole length	121.30 m		120.05 m	
Soil depth	0 m		0 m	
Starting point coordinates (system RT90/RHB70)	Northing: 6366300.39 m Easting: 1546627.23 m Elevation: 22.65 m.a.s.l.		Northing: 6366314.09 m Easting: 1546577.96 m Elevation: 24.47 m.a.s.l.	
Borehole diameter (interval) (diameter mm)	0.3–2.00 m 2.00–121.30 m	96 mm 75.7 mm	0.3–2.00 m 2.00–120.05 m	96 mm 75.7 mm
Casing diameter (interval) (diameter mm)	0–2.00 m	$Ø_o$ = 89 $Ø_i$ = 77	0–2.00 m	$Ø_o$ = 89 $Ø_i$ = 77

5.2 Drilling progress and water consumption

Drilling progress for boreholes KLX11B–F, expressed as borehole length versus time, is given in Figures 5-1 through 5-5. The figures also show the accumulated volume of water consumed during drilling.

Observations by the driller of variations in flushing water flow or pressure are summarized in Table 5-3.

The amount of flushing water consumed during drilling of boreholes KLX11B–F is summarized in Table 5-4.

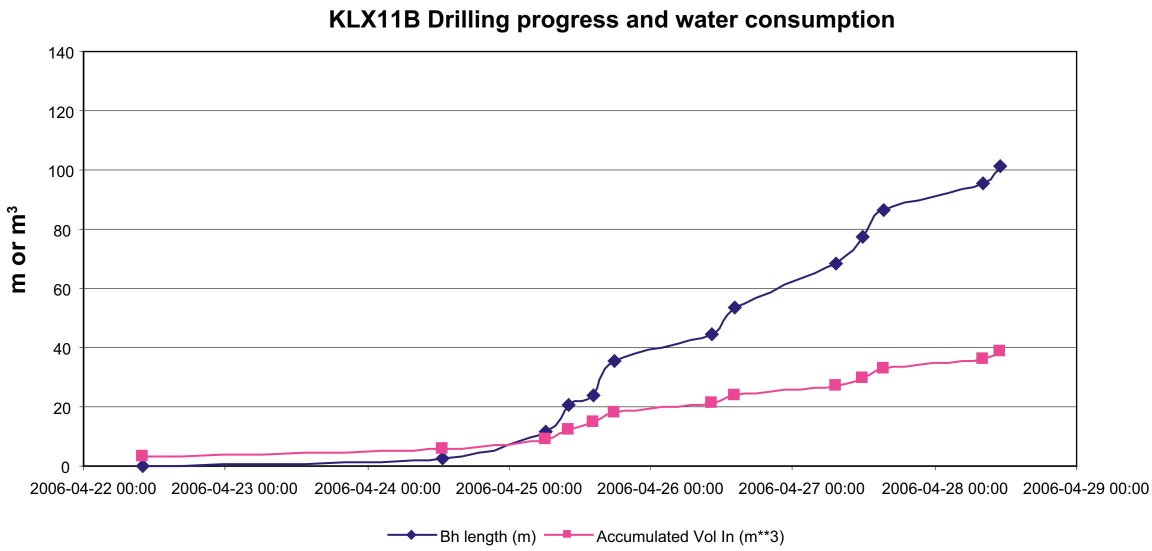


Figure 5-1. *Drilling progress expressed as borehole length vs time and accumulated water consumption vs time in KLX11B.*

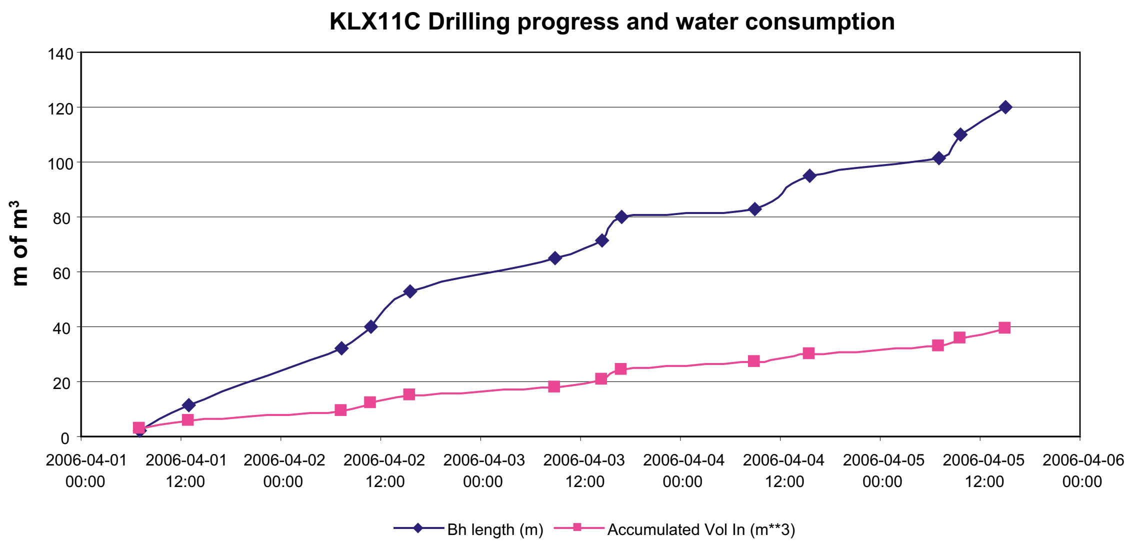


Figure 5-2. *Drilling progress expressed as borehole length vs time and accumulated water consumption vs time in KLX11C.*

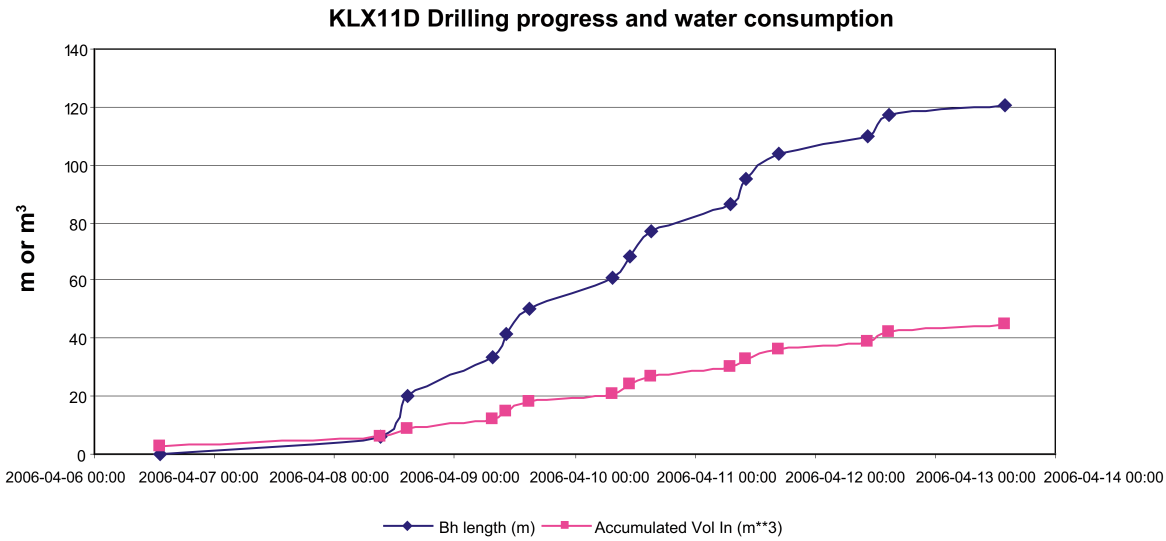


Figure 5-3. *Drilling progress expressed as borehole length vs time and accumulated water consumption vs time in KLX11D.*

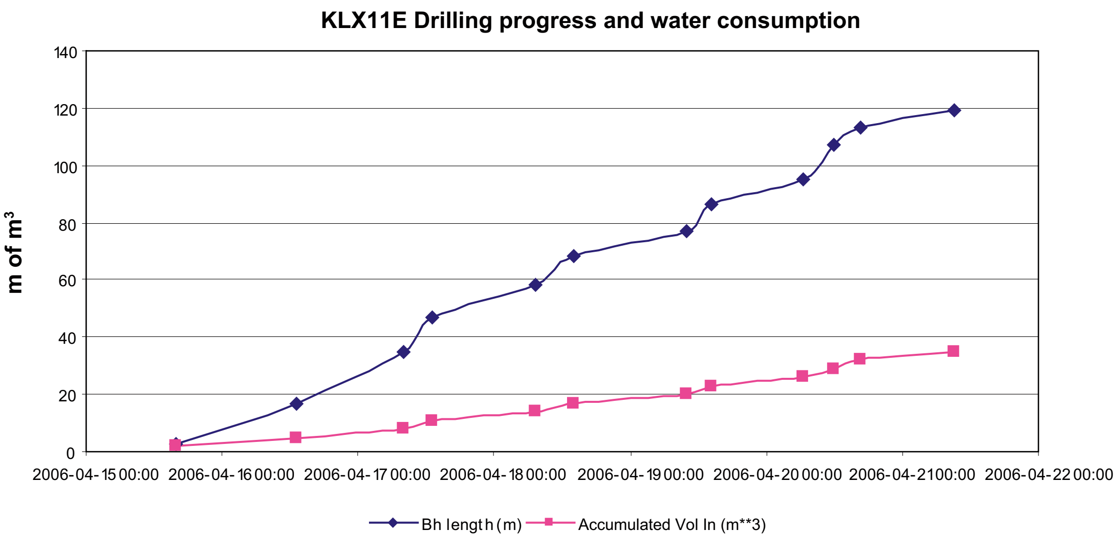


Figure 5-4. *Drilling progress expressed as borehole length vs time and accumulated water consumption vs time in KLX11E.*

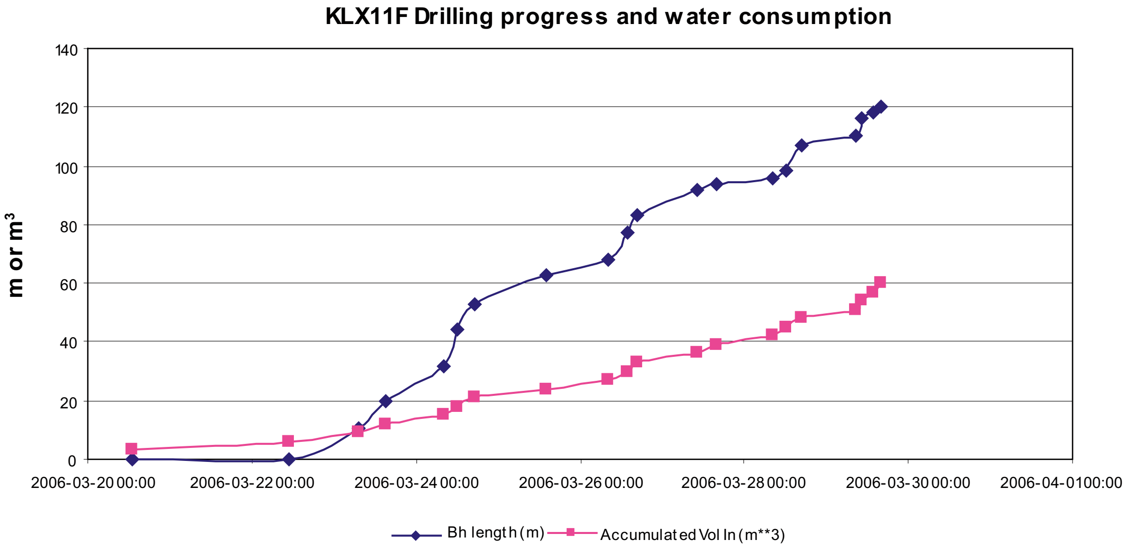


Figure 5-5. *Drilling progress expressed as borehole length vs time and accumulated water consumption vs time in KLX11F.*

Table 5-3. Observed levels of reduced water pressure during drilling.

Borehole	Observed levels of reduced water pressure during drilling (metres drilled length)
KLX11B	None
KLX11C	Loss of return water at 8.40 m
KLX11D	None
KLX11E	None
KLX11F	None

Table 5-4. Amount of water consumed during drilling of KLX11B–F.

	Accumulated volume water (m^3)*	Drilled length (m)	Water consumption (m^3/drilled metre)
KLX11B	39.00	101.20	0.39
KLX11C	39.00	120.15	0.32
KLX11D	45.00	120.35	0.37
KLX11E	35.00	119.40	0.29
KLX11F	60.00	120.05	0.50

*The amount is estimated based on counts of water tanks consumed. The inaccuracy of the estimate is therefore +/–3 m^3.

5.3 Hydraulic responses

Hydraulic responses in near-by boreholes during core drilling, as performed in KLX11B–F, mainly occur for two reasons:

- An increase in water level in the observation borehole as a response to injection of water in the borehole being drilled. Injections of water into the bedrock formation can be noted during drilling as a significant loss of return water or reduction in flushing water pressure.
- A drawdown (and recovery) of the water table in the observation borehole as a response to the flushing of another borehole with nitrogen gas.

The variations in water levels during drilling of KLX11B–F are dominated by air-lift pumping in KLX20A. An example of the water level readings in KLX11F, the first of the five short boreholes KLX11B–F to be drilled, is given in Figure 5-6.

Flushing with nitrogen gas gives a strong drawdown of the water table in the borehole being flushed. The dates and times for the nitrogen flushing, see Tables 4-3 and 4-4, are therefore important as they can be correlated to hydraulic responses in near-by boreholes.

Hydraulic responses are shown in Figure 5-7 for observation boreholes KLX11A-F and in Figure 5-8 for observation hole KLX11B. A summary of hydraulic responses from flushing with nitrogen gas in boreholes KLX11B–F is given in Table 5-5.

A peculiar type of response was noted in KLX11B from nitrogen gas flushing in KLX11C, see Figure 5-9. A slight increase of the water table in KLX11B was noted for the three flushings at the times 15:10, 15:47 and 16:31 (Swedish Normal Time). The first flushing at 14:37 however created a distinct drawdown in KLX11B.

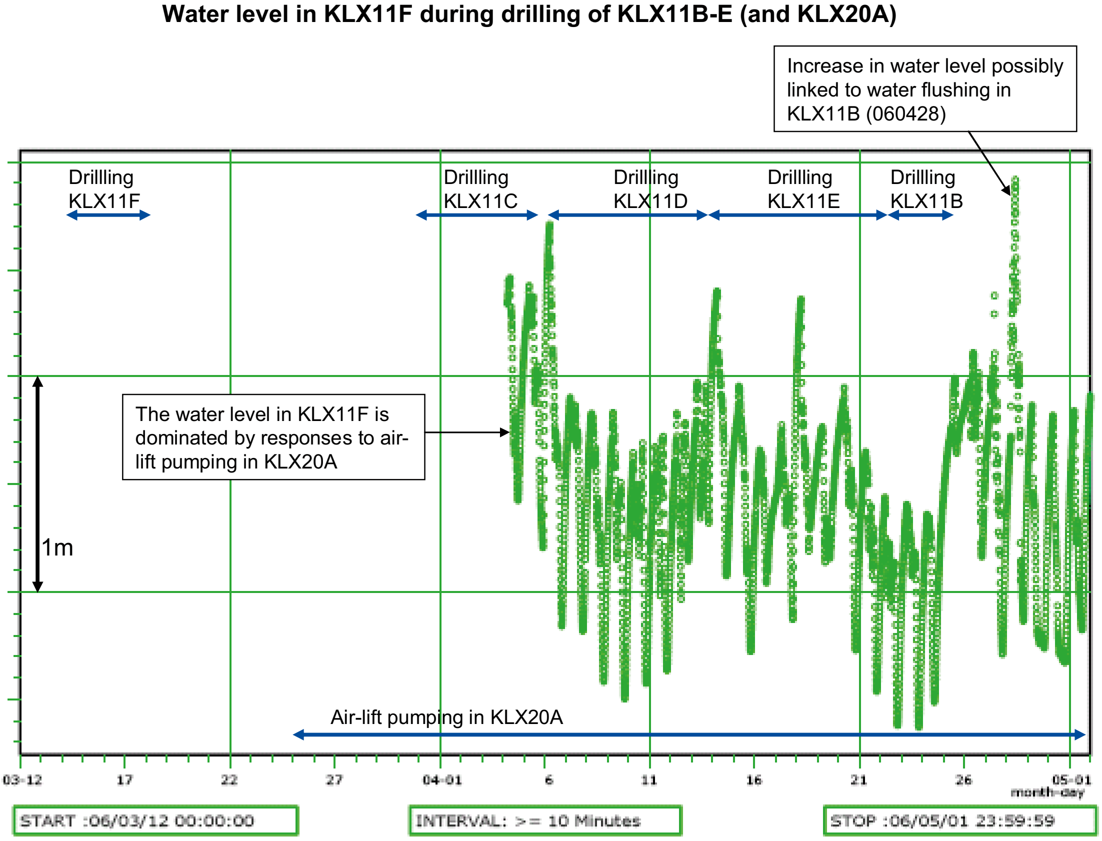


Figure 5-6. *Water level in KLX11F (green curve) during drilling of KLX11B-E. The times for drilling of boreholes KLX11B-E are given with blue lines along the top of the figure. The time when air-lift pumping was done during drilling in KLX20A is indicated with a blue line in the bottom of the figure. The variation of the water level in KLX11F is dominated by responses to air-lift pumping in KLX20A. A possible response in KLX11F to water flushing in KLX11B on April 28 is however indicated on the right hand side of the figure. No manual readings of the position of the logger (pressure transducer) in relation to the water table were available. As a result no absolute scale for the water level in KLX11F can be given. The relative fluctuations are however correct and given in height of water column, see scale bar on the left side. Times are in Swedish Normal Time.*

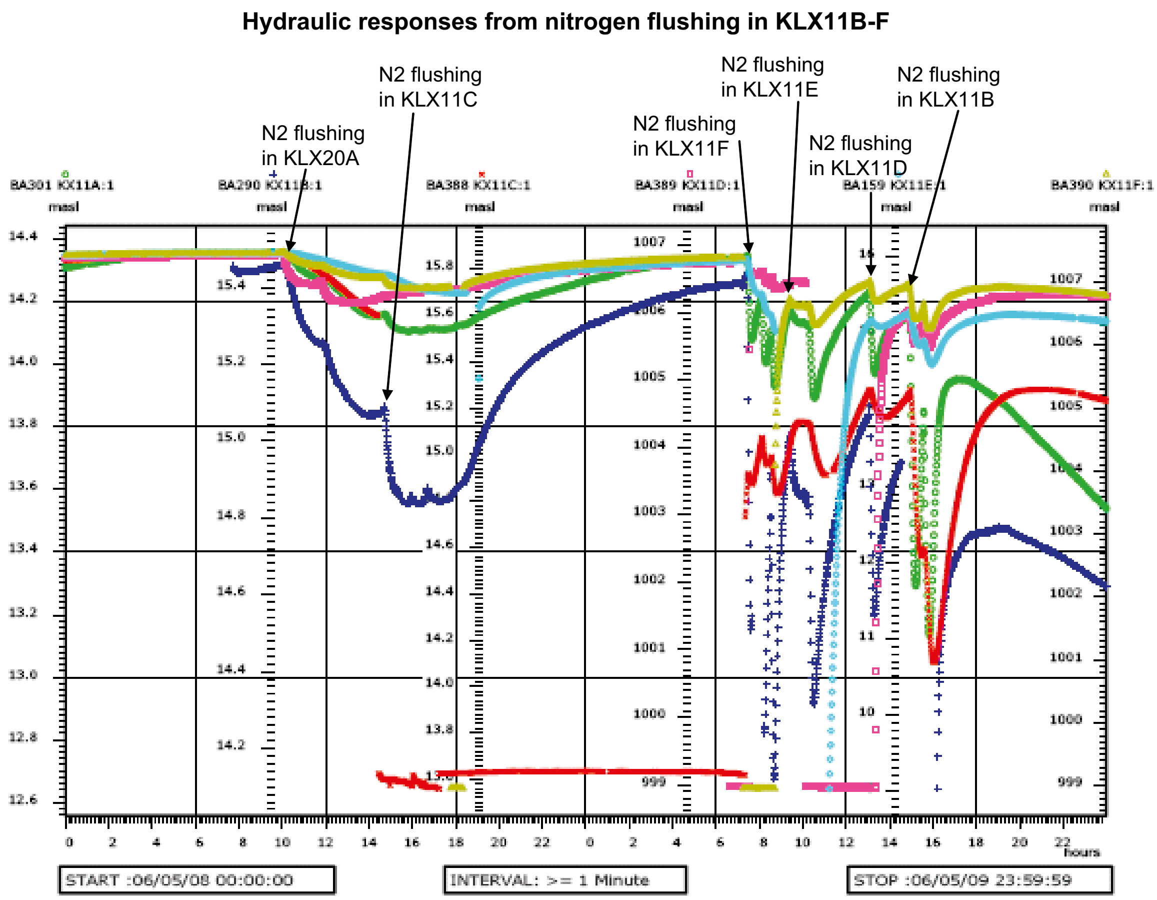


Figure 5-7. Hydraulic responses in observation boreholes KLX11A (green curve) KLX11B (dark blue curve), KLX11C (red curve), KLX11D (purple curve), KLX11E (light blue curve) and KLX11F (light brown curve) from nitrogen flushing in KLX11B-F. Water level drawdowns are clearly related to nitrogen gas flushing as shown with the arrows. The water levels for observation boreholes KLX11A, KLX11B, KLX11C and KLX11E are given in metres above sea level "m.a.s.l.". No manual readings of the position of the logger (pressure transducer) in relation to the water table were available for KLX11D and KLX11F. The reference level was set to 1,000 m in order to distinguish data from the two boreholes from the rest. The relative fluctuations are however correct and given in height of water column. Times are in Swedish Normal Time.

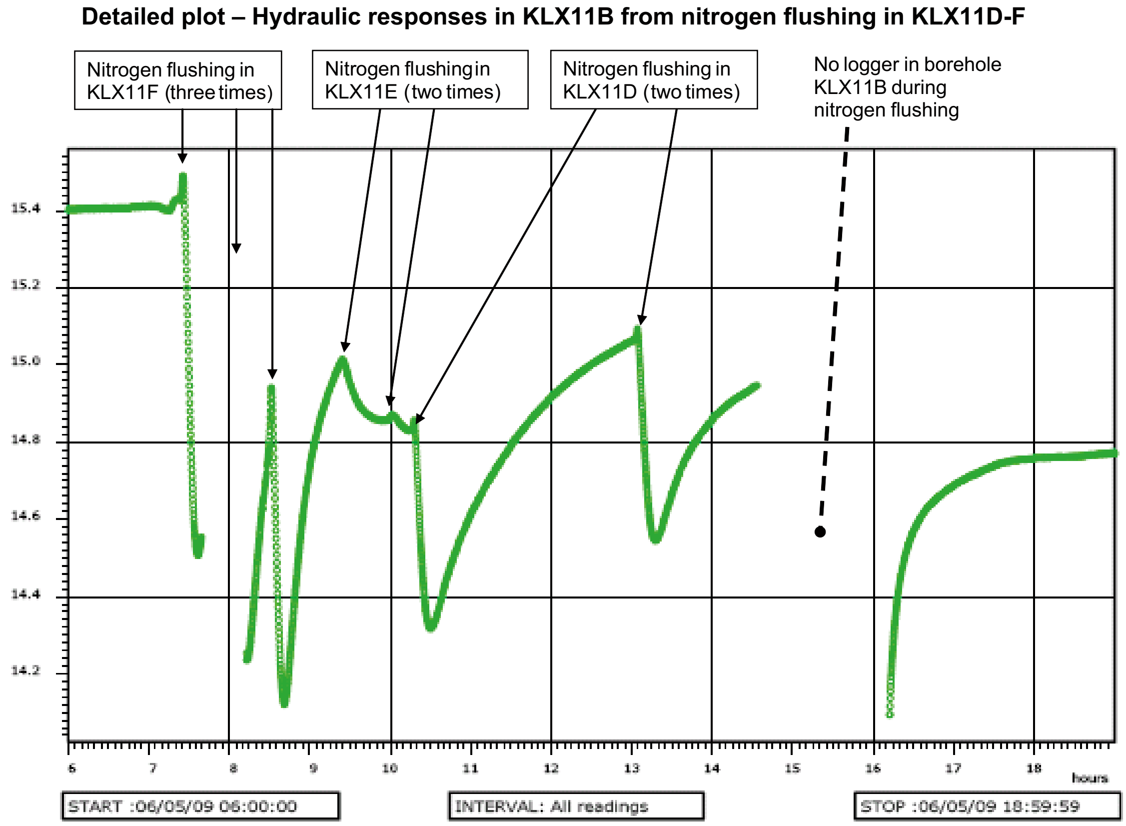


Figure 5-8. *Detailed plot of the hydraulic responses in observation boreholes KL11B (green curve) during May 9, 2006. Water level drawdowns are clearly related to nitrogen gas flushing as shown with arrows. The water levels in the observation boreholes are given in metres above sea level "m.a.s.l.". Times are in Swedish Normal Time.*

Table 5-5. Summary of the hydraulic responses in KLX11B-F.

Event	Observation borehole KLX11A	KLX11B	KLX11C	KLX11D	KLX11E	KLX11F
Nitrogen gas flushing in KLX11C 060508 15:30-17:30	Yes	Yes	N/A	?*	?	Yes
Nitrogen gas flushing in KLX11F 060509 8:20-9:30	Yes	Yes	Yes	?	Yes	N/A
Nitrogen gas flushing in KLX11E 060509 10:20-11:00	Yes	Yes	No	No	N/A	?
Nitrogen gas flushing in KLX11D 060509 11:15-14:00	Yes	Yes	Yes	N/A	Yes**	Yes
Nitrogen gas flushing in KLX11B 060509 15:50-16:30	Yes	N/A	Yes	Yes	Yes	Yes

LEGEND

No response	N
Yes- response noted in observation borehole	Y
Possible response in observation borehole	?
Data not available	N/A

* Weak reduction in recovery trend
** Data is only available from the second nitrogen flushing

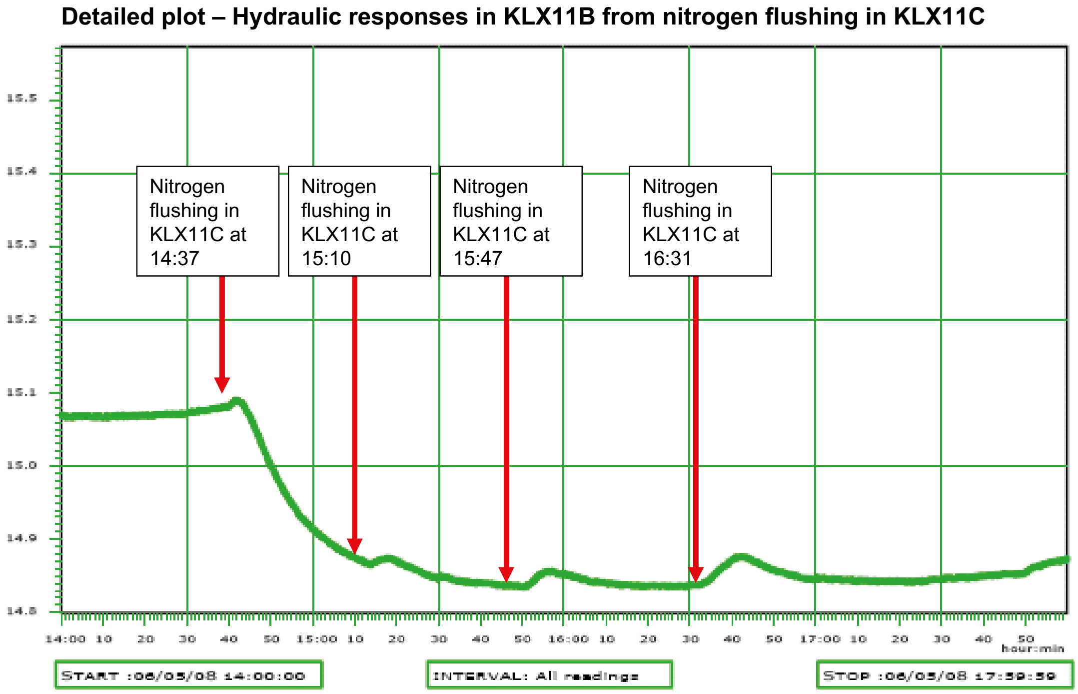


Figure 5-9. Detail from May 8, 2006 showing hydraulic response in KLX11B from nitrogen flushing in KLX11C. The three increases in water level that occcur shortly after nitrogen flushing are indicated with red arrows. Times are in Swedish Normal Time.

5.4 Geological results

No preliminary mapping of the cores was done as part of the drilling activity. A highly simplified summary of the geological results obtained in separate activity, Boremap mapping is given in Appendix 2. A complete account of the geological results from the Boremap mapping is given in /4/.

5.5 Hydrogeochemical results

No water samples were taken during the activity.

5.6 Consumption of oil and chemicals

The consumption of cement paste for grouting of the casings was 40 litres per borehole. The composition of the paste was the same for boreholes KLX111B-F and is given in Table 5-6.

Table 5-6. Composition of cement paste in KLX11B–F.

Component	Amount
Low alkali cement	25 kg
Silica	10.7 kg
Water	28 litres
Salt	1 kg

5.7 Nonconformities

Deviation measurements in KLX11B–F were not made as part of the drilling activity. Deviation measurements were however made with the Flexit method as part of a separate activity /3/.

The method employed for testing the water tightness of the concrete gap injection does not correspond to the method described in MD 620.003 (Metodbeskrivning för kärnborrning v1.0), SKB internal document. The method used during drilling of KLX09B-F tests the tightness of the casing rather than the gap injection itself. Also no data is provided on the amount of water lost, i.e. reduction in water level in the casing, during the time for concrete hardening, see Figure 4-2.

6 References

/1/ **SKB, 2001.** Geovetenskapligt program för platsundersökning vid Simpevarp. SKB R-01-44, Svensk Kärnbränslehantering AB.

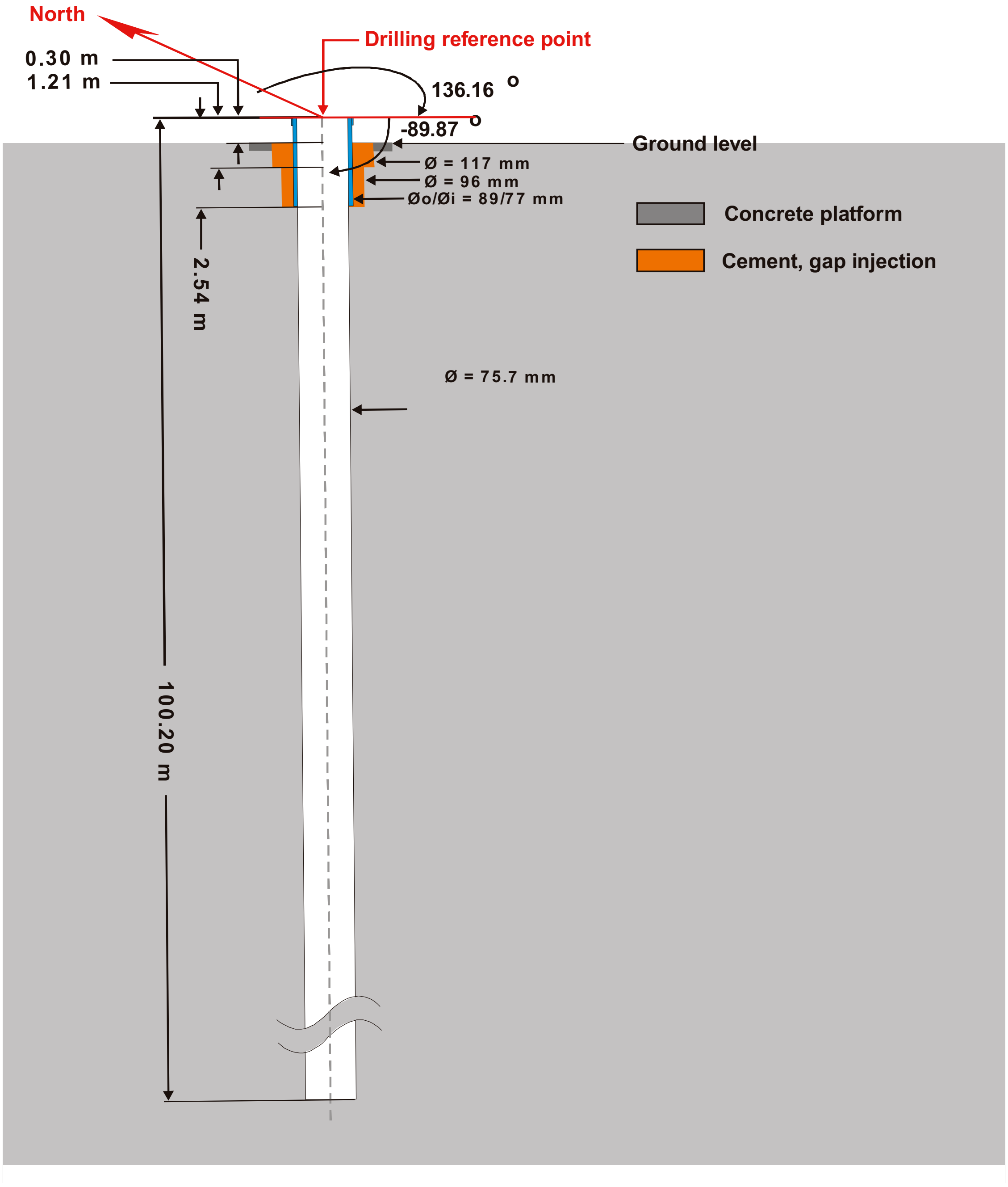
/2/ **SKB, 2005.** Program för fortsatta undersökningar av berggrund, mark, vatten och miljö inom delområde Laxemar. SKB R-05-37, Svensk Kärnbränslehantering AB.

/3/ **Gustafsson J, Gustafsson C, 2006.** Oskarshamn site investigation. RAMAC, BIPS and deviation logging in boreholes KLX11B, KLX11C, KLX11D, KLX11E, KLX11F, KLX18A, KLX20A, HLX38 and HLX40 and BIPS and deviation logging in KLX19A. SKB P-06-159, Svensk Kärnbränslehantering AB.

/4/ **Mattsson K-J, Rauséus G, Eklund S, Ehrenborg J, 2006.** Oskarshamn site investigation. Boremap mapping of core drilled DFN boreholes KLX11B–KLX11F. SKB P-06-244 (in prep), Svensk Kärnbränslehantering AB.

Technical data

Borehole KLX11B



Drilling reference point

Northing: 6366339.51 (m), RT90 2,5 gon V 0:-15

Easting: 1546604.89 (m), RT90 2,5 gon V0:-15

Elevation: 27.27 (m), RHB 70

Drilling period

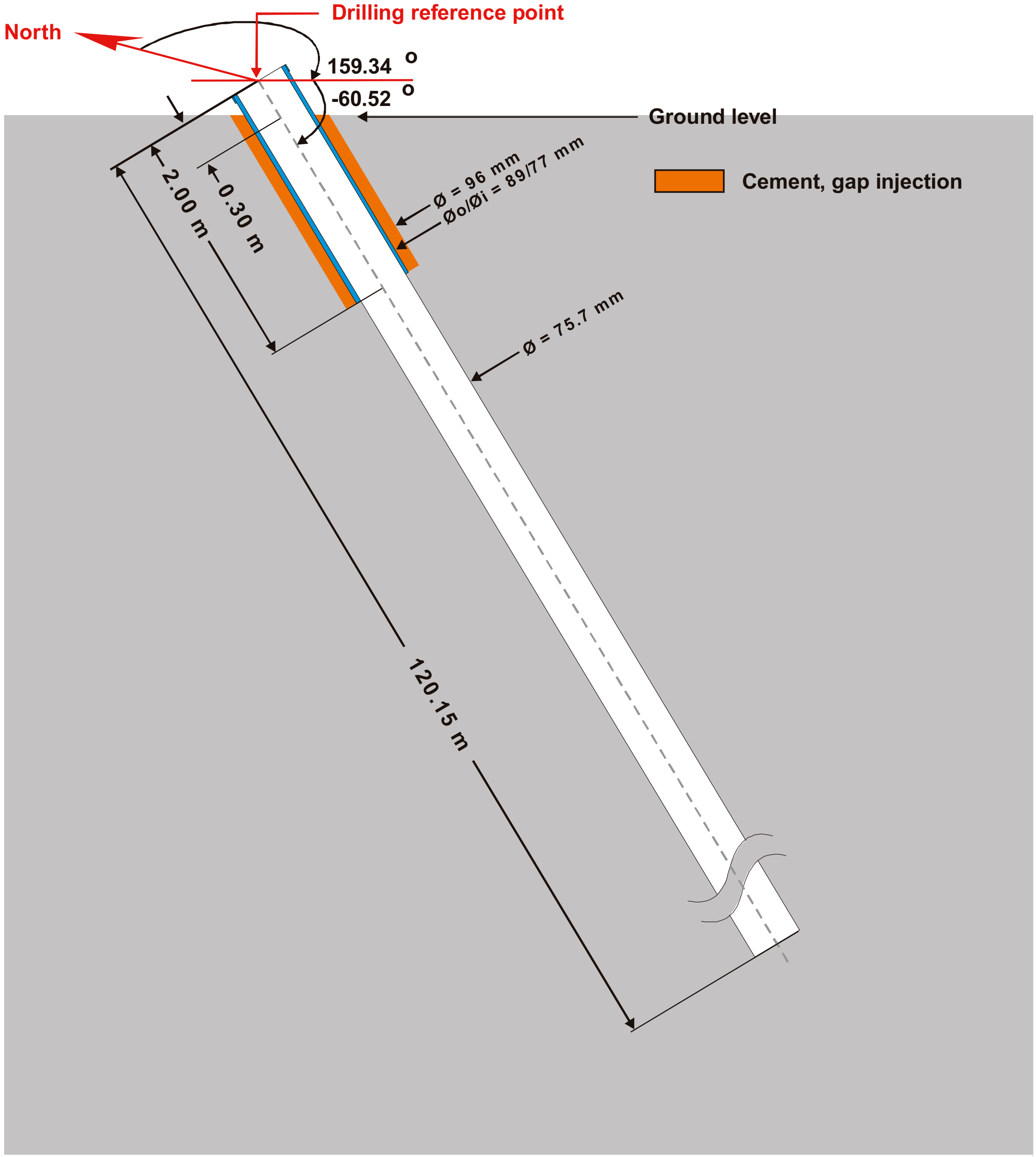
Drilling start date: 2006-04-22

Drilling stop date: 2006-04-28

Rev 2006-11-30

Technical data

Borehole KLX11C



Drilling reference point

Northing: 6366350.26(m), RT90 2,5 gon V 0:-15

Easting: 1546586.89(m), RT90 2,5 gon V0:-15

Elevation: 27.19(m), RHB 70

Drilling period

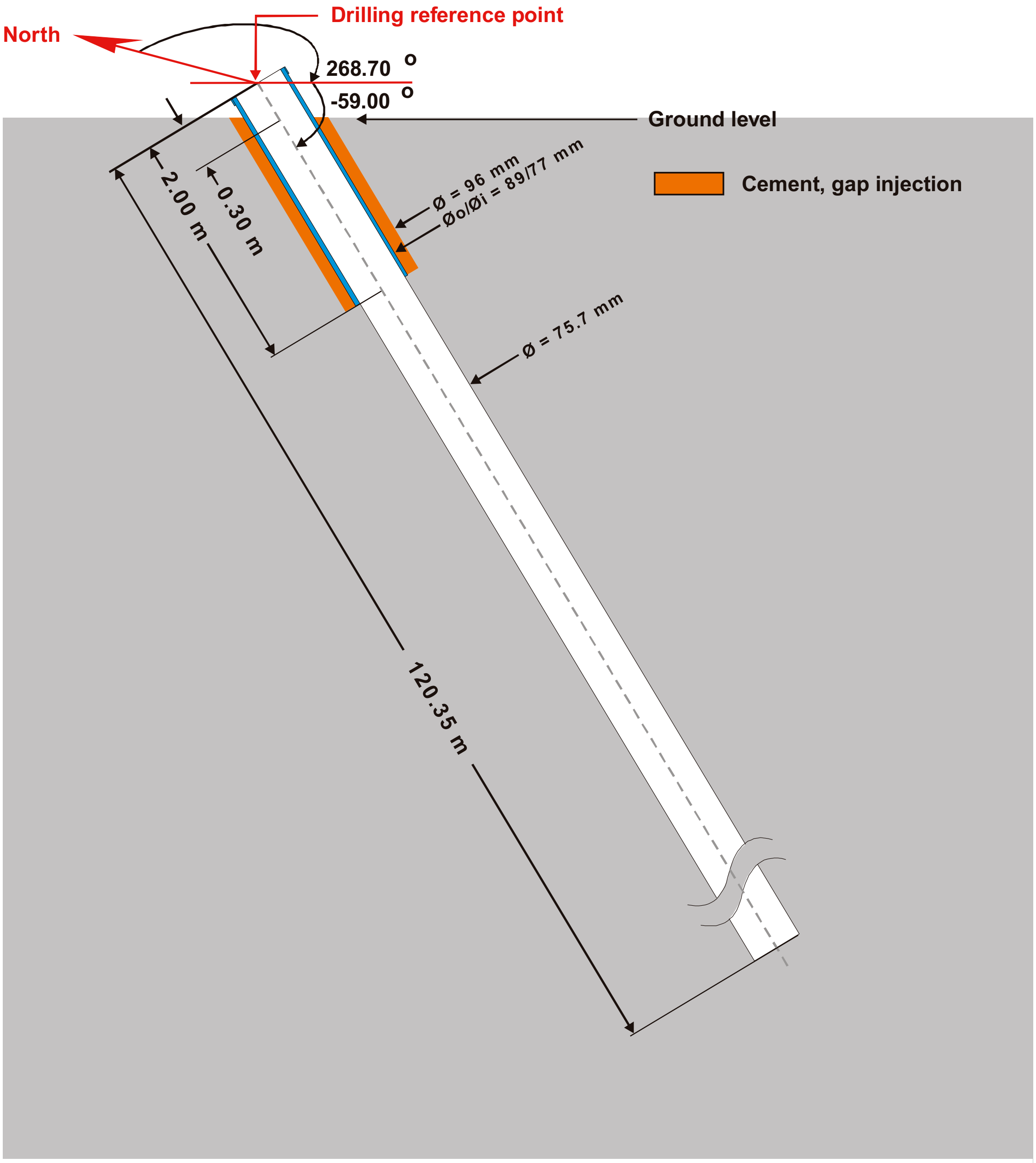
Drilling start date: 2006-03-30

Drilling stop date: 2006-04-05

Rev 2006-11-30

Technical data

Borehole KLX11D



Drilling reference point

Northing: 6366357.37 (m), RT90 2,5 gon V 0:-15

Easting: 1546631.42 (m), RT90 2,5 gon V0:-15

Elevation: 25.57 (m), RHB 70

Drilling period

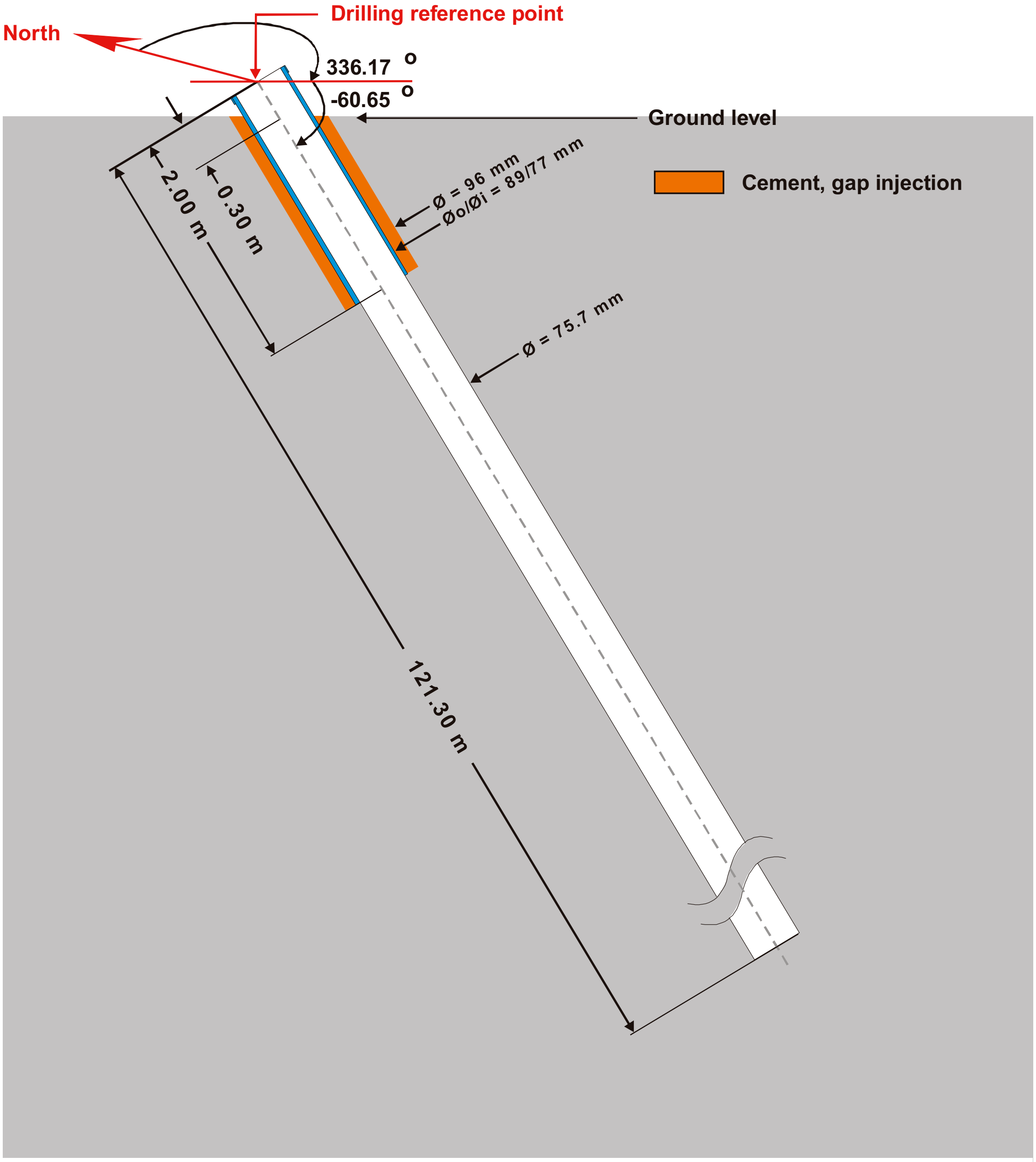
Drilling start date: 2006-04-06

Drilling stop date: 2006-04-13

Rev 2006-11-30

Technical data

Borehole KLX11E



Drilling reference point

Northing: 6366300.39(m), RT90 2,5 gon V 0:-15

Easting: 1546627.23(m), RT90 2,5 gon V0:-15

Elevation: 22.65(m), RHB 70

Drilling period

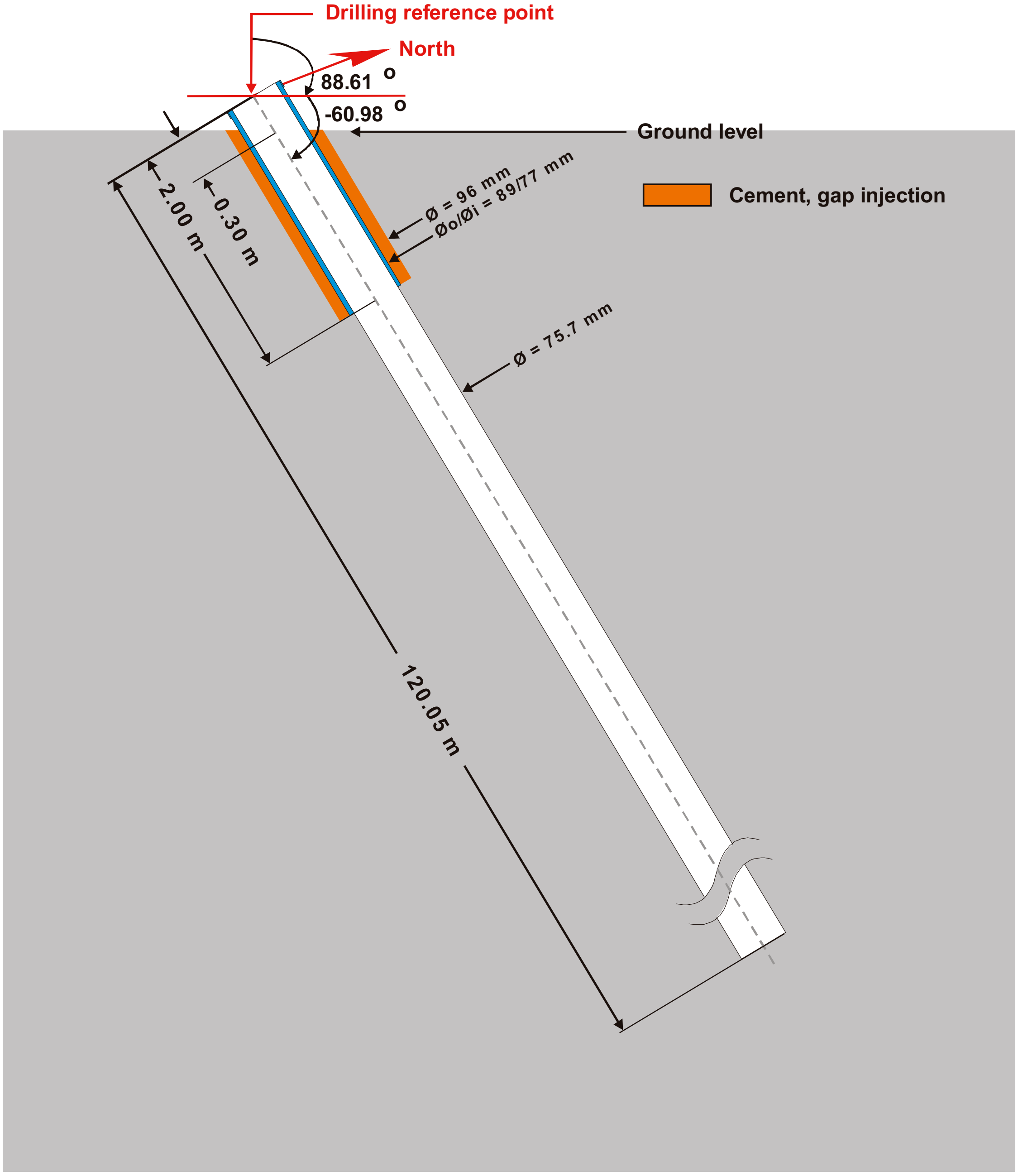
Drilling start date: 2006-04-13

Drilling stop date: 2006-04-21

Rev 2006-11-30

Technical data

Borehole KLX11F



Drilling reference point

Northing: 6366314.09 (m), RT90 2,5 gon V 0:-15

Easting: 1546577.96 (m), RT90 2,5 gon V0:-15

Elevation: 24.47 (m), RHB 70

Drilling period

Drilling start date: 2006-03-14

Drilling stop date: 2006-03-17

Rev 2006-11-30

Appendix 2


Title KLX11B
ROCKTYPELAXEMAR
Fine-grained granite
Quartz monzodiorite
Length
Rock Type
10
20
30
40
50
60
70
80
90

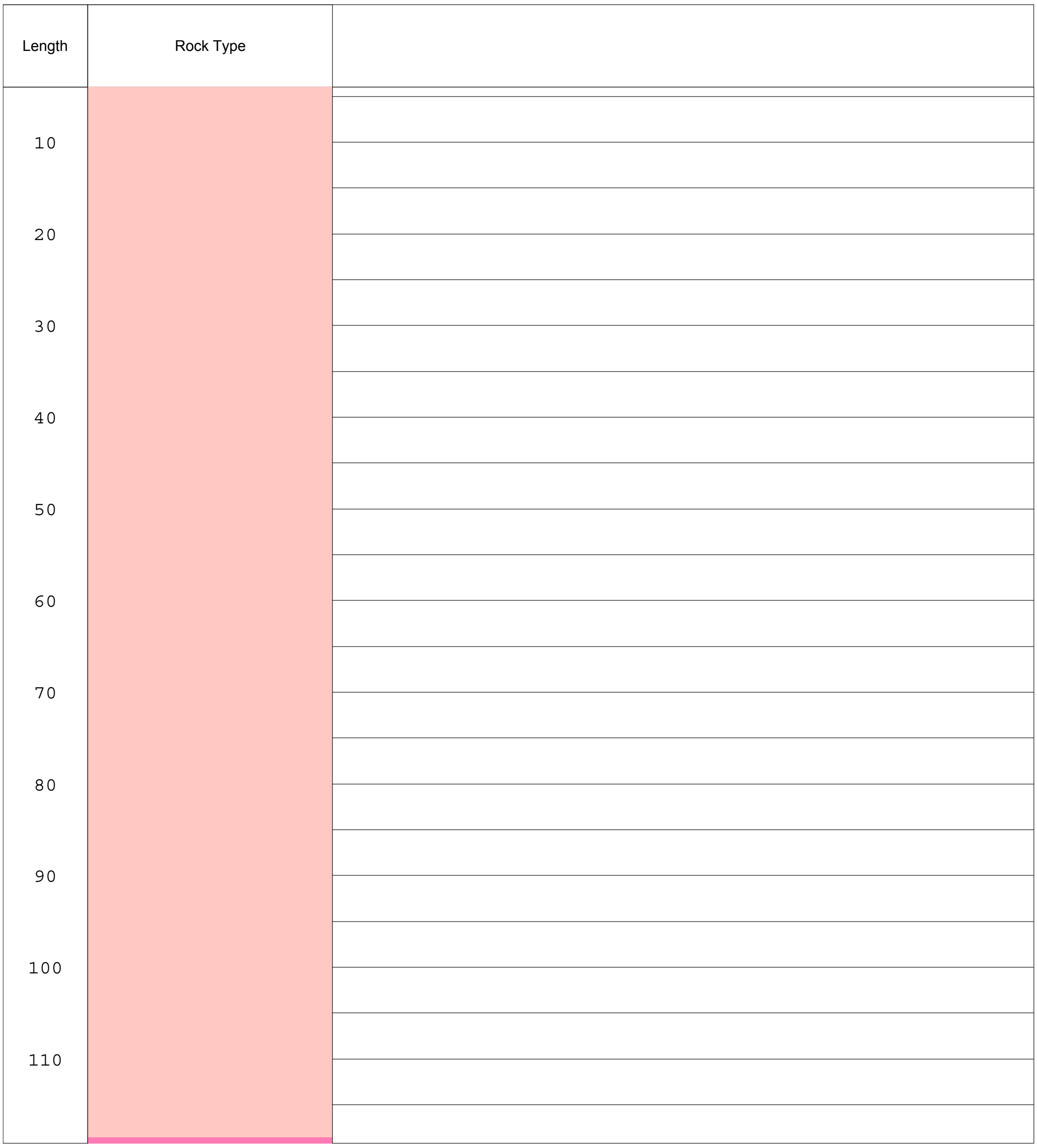

Title KLX11C
ROCKTYPELAXEMAR
Ävrö granite
Quartz monzodiorite
Length
Rock Type
10
20
30
40
50
60
70
80
90
100
110

Page 1

Title KLX11D

ROCKTYPELAXEMAR

- Fine-grained granite
- Quartz monzodiorite

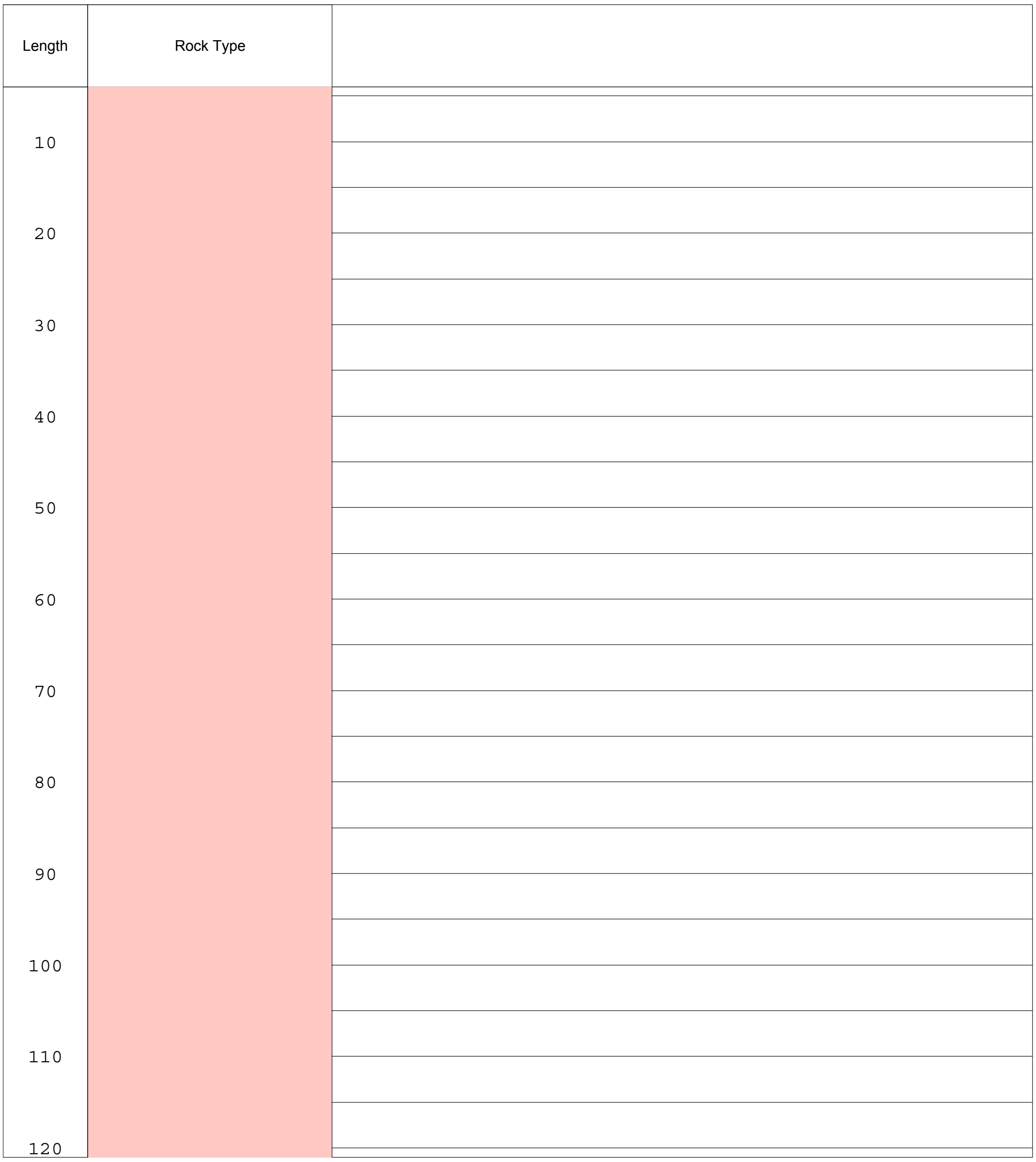


Page 1

Title KLX11E

ROCKTYPELAXEMAR

Quartz monzodiorite



Page 1

Title KLX11F
ROCKTYPELAXEMAR
Fine-grained granite
Quartz monzodiorite
Length
Rock Type
10
20
30
40
50
60
70
80
90
100
110

Page 1