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Oskarshamn site investigation

Core drilling of short boreholes KLX09B, KLX09C, KLX09D, KLX09E and KLX09F for discrete fracture network investigation (DFN)

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January 2007

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

Abstract

The short cored boreholes KLX09B, KLX09C, KLX09D, KLX09E and KLX09F 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. Borehole KLX09F was however prolonged to ca 150 m.

Hydraulic responses, both from drilling and from nitrogen gas lifting could be seen in the closely located observation boreholes.

Sammanfattning

De korta kärnborrhålen KLX09B, KLX09C, KLX09D, KLX09E och KLX09F 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 meter 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. Borrhål KLX09F förlängdes dock till ca 150 m.

Hydrauliska responser, både från borrning och 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 KLX09B, KLX09C, KLX09D, KLX09E and KLX09F was made to provide further data for the DFN-model, especially in the uppermost 100 metre interval in order to provide a link between field observations and observations in cored boreholes /2/.

The location of the boreholes, KLX09B, KLX09C, KLX09D, KLX09E and KLX09F, is shown in Figure 1-1 together with the deep cored borehole KLX09. The short boreholes KLX09C–F were drilled with a dip of 60 degrees and emplaced in a box-like geometry around the centrally located, vertical borehole KLX09B. KLX09 (the deep borehole) is dipping steeply to the west and is located very close to KLX09B.

The decision to perform the drilling is given in SKB id 1045353, internal document.

The Regional Authority was informed by letter on 2005-10-21, SKB id 1045412, 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.

All data were stored in the SICADA database for Oskarshamn.

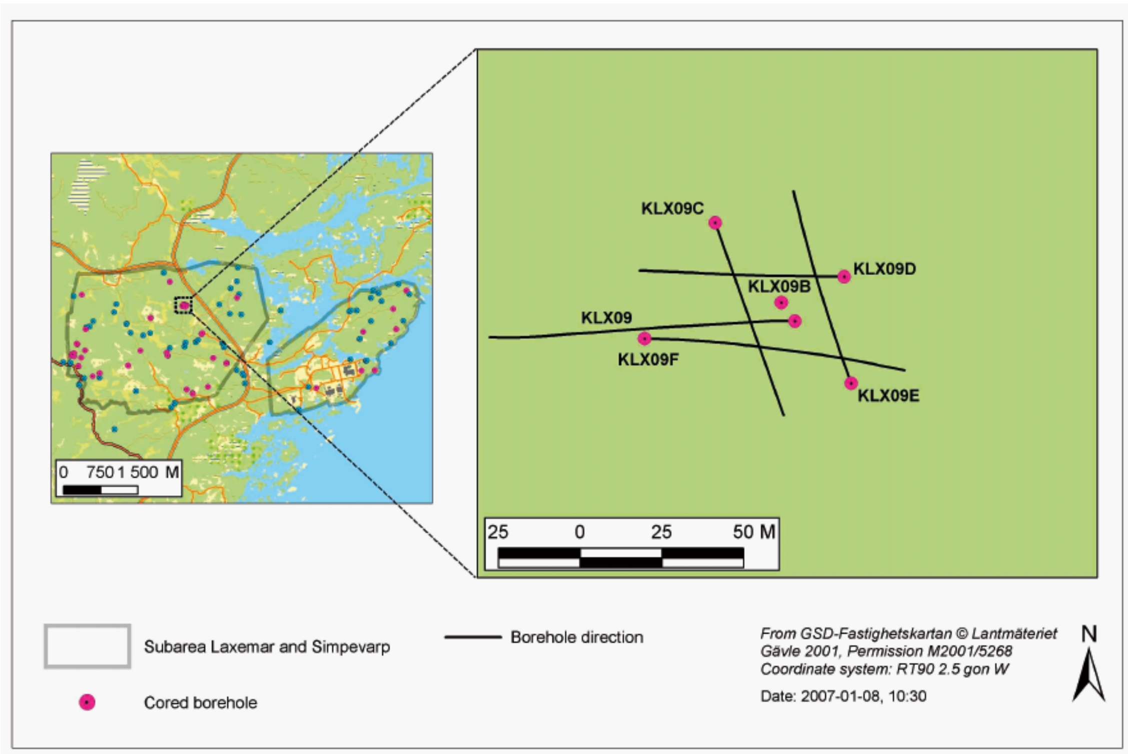


***Figure 1-1.** Location of the short cored boreholes KLX09B, KLX09C, KLX09D, KLX09E and KLX09F in the Laxemar subarea. The location of the deep cored borehole KLX09 is also shown.*

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

Activity plan	ID Number	Version
Kärnborrning av KLX09B–F	AP PS 400-05-075	1.0*
Method descriptions	**ID Number**	**Version**
Metodbeskrivning för kärnborrning	SKB MD 620.003	1.0
Metodbeskrivning för registrering och provtagning av spolvattenparametrar samt borrkax under kärnborrning	SKB MD 640.001	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 utsättning och inmätning av borrhål	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

* One amendment to the activity plan exists.

2 Objective and scope

This report will describe the drilling of the five short cored boreholes, KLX09B, KLX09C, KLX09D, KLX09E and KLX09F 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 KLX09B, KLX09C, KLX09D, KLX09E and KLX09F was made with a trackmounted, self-propelled Geomachines GM200 drilling machine supplied with accessories.

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 KLX09B. This was made by casing drilling with dimension HV, giving a hole of 116 mm diameter.

Figure 3-1. *The Geomachines GM200 drill rig at KLX09E.*

3.2 Equipment for measurements and sampling

Measurements of drill penetration rate, flushing water flow and flushing water pressure was intended to be provided by the drilling contractor. The equipment malfunctioned and the above mentioned three parameters could not be monitored during drilling. This has been reported as a nonconformity.

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 KLX09B–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 KLX09B. Drilling in this borehole was done from the surface to 2.48 m metres below reference level (TOC) by casing drilling with HV equipment which gives a 116 mm diameter hole. A temporary casing was left in the borehole in order to stabilise the overburden for subsequent core drilling in rock.

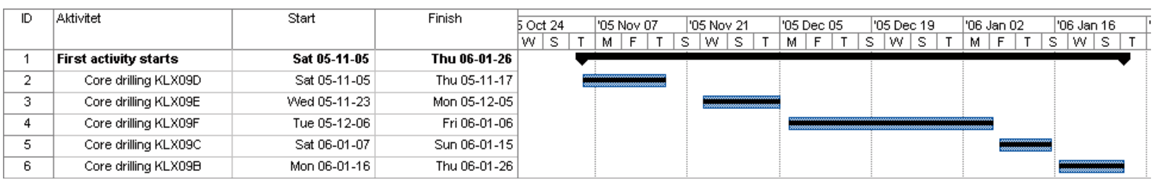


Figure 4-1. Overview of the time schedule for core drilling of boreholes KLX09B–F.

4.3 Core drilling in hard rock and casing grouting

Core drilling in boreholes KLX09C–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 installation of casing.

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.

In the typical case, drilling was commenced with N-size drilling to a depth of ca 10 metres. 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.

Table 4-1. Drilled length with dimension N and HQ at the time for gap injection in boreholes KLX09B–F.

Borehole	Size N (length m)	Size HQ (length m)	Comment
KLX09B	11.14	10.74	Predrilled to 2.48 m through gravel fill.
KLX09C	10.50	9.00	Drilling started in bedrock with N-size
KLX09D	11.19	9.75	Drilling started in bedrock with N-size
KLX09E	9.00	9.00	Drilling started in bedrock with N-size
KLX09F	10.36	9.00	Drilling started in bedrock with N-size

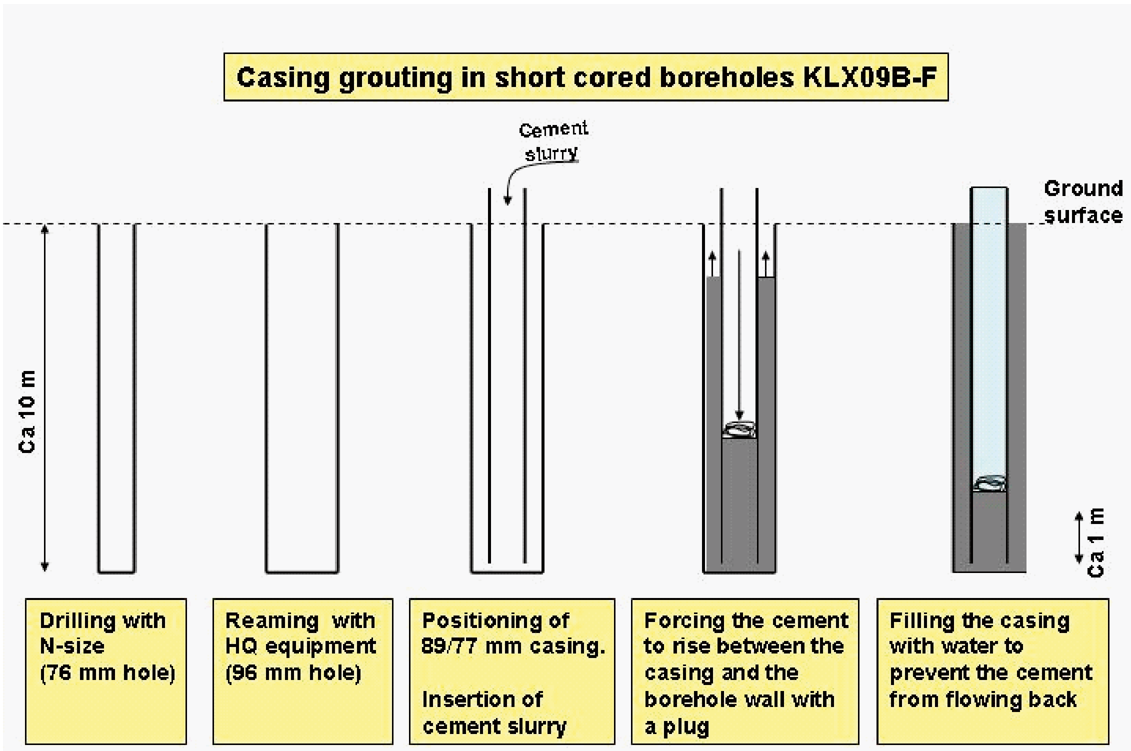


Figure 4-2. Casing installation and grouting.

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 made to remove the concrete inside the casing. Core drilling in rock could then be resumed to planned length.

In KLX09B the temporary casing from drilling through the overburden was removed after the emplacement of the 89/77 mm casing but before the casing grouting.

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, see Table 5-4.

The flushing water for the drilling of KLX09B–F was supplied from HLX10. 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 the amount of drill cuttings returned were made, see also section 4.8.

Figure 4-3. *Drilling equipment at the site for KLX09C.*

A pressure logger for measuring hydraulic responses during drilling of KLX09B–F were emplaced in KLX09 (the centrally located deep cored borehole) during the entire drilling period. Pressure loggers were installed in the short boreholes KLX09B–F as the drilling in each borehole was completed. All loggers were installed in open holes i.e. no packers were utilized.

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 not made in boreholes KLX09B–F.

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.

The times and dates for flushing of the boreholes KLX09B–F with nitrogen gas for rinsing of water and cuttings are given in Table 4-2.

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 KLX09 (the centrally located deep borehole) during the entire time of drilling of boreholes KLX09B–F. Pressure loggers were also installed in the short boreholes KLX09B–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: 30s

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

Table 4-2. Nitrogen gas flushing.

Borehole	From (m)	To (m)	Date	Time for flushing with nitrogen gas
KLX09B	10.74	100.22	060128	10.30–11.50
KLX09C	9.00	120.05	060116	13.30–15.10
KLX09D	9.75	121.02	051118	Time has not been noted*
KLX09D	9.75	121.02	060208	13.00–15.30
KLX09E	9.00	120.00	051206	Time has not been noted*
KLX09F	9.00	152.30	060109	9.30–13.30

* See section 5.7 “Nonconformities”.

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, SSM000218 and SSM000219. The location of the monitoring wells in relation to boreholes KLX09B–F is shown in Figure 4-5.

As already noted in section 4.4, no measurements of the volume of return water was made during drilling. The amounts released from drilling of KLX09B–F do, however, not exceed the consumption of water as given in Table 5-4.

Figure 4-4. *Downloading data from logger in KLX09D.*

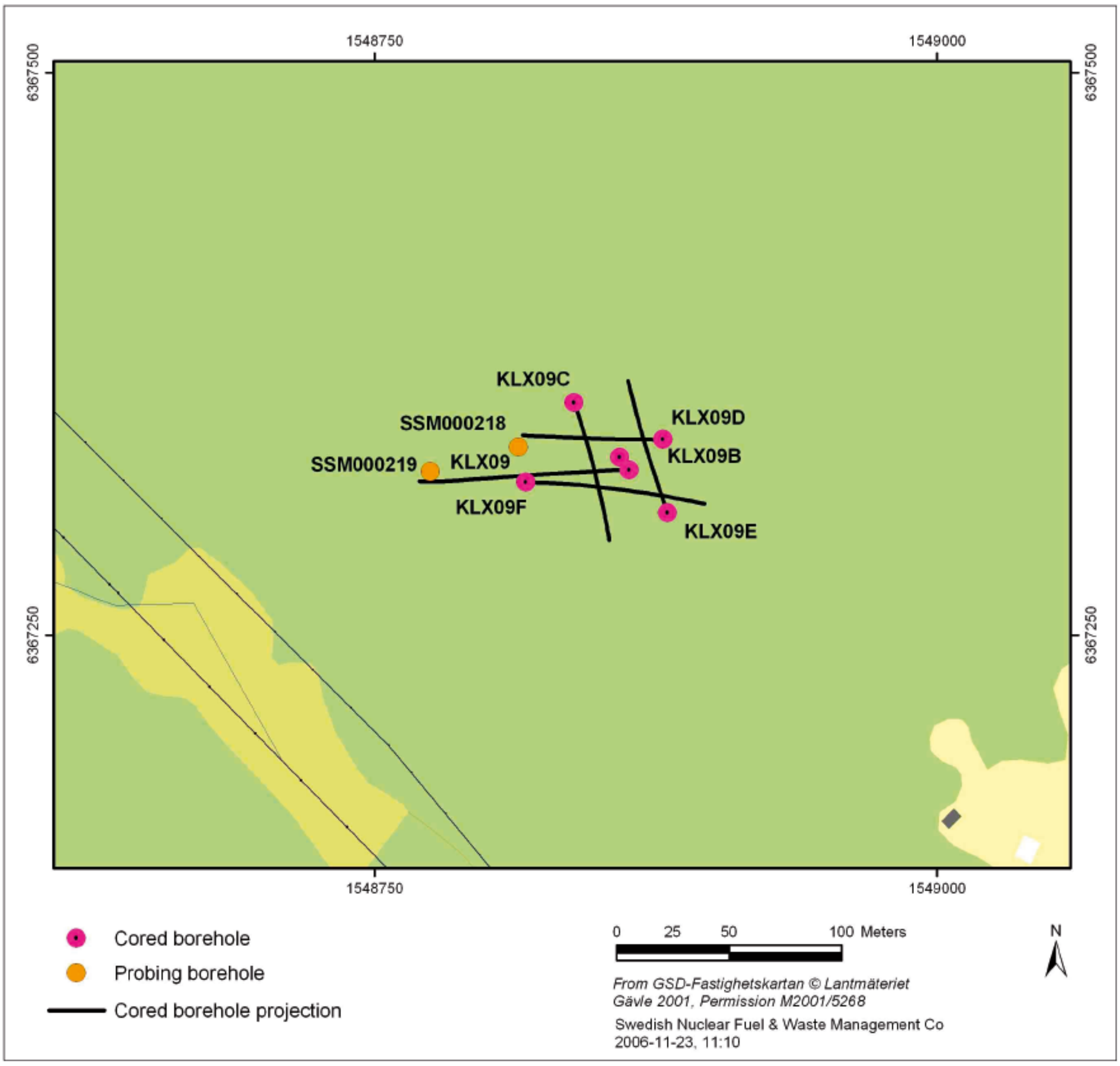


Figure 4-5. *The location of the environmental monitoring wells, SSM000218 and SSM000219 in relation to boreholes KLX09B–F and the deep cored borehole KLX09.*

5 Results

Boreholes KLX09B, KLX09C, KLX09D, KLX09E and KLX09F 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 designed to penetrate as many potential fracture planes as possible and to provide a link between surface observations in outcrops and depth information, see Figure 1-1.

Borehole KLX09F was drilled to 152 m instead of the originally planned length of 120 m. The reason was to reach a possible minor deformation zone that was noted during drilling of KLX09D.

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.

5.2 Drilling progress and water consumption

Drilling progress for boreholes KLX09B–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 KLX09B–F is summarized in Table 5-4.

Table 5-1. Geometric and technical data for borehole KLX09B, KLX09C and KLX09D.

Parameter	KLX09B		KLX09C		KLX09D	
Drilling period	From 2006-01-16 to 2006-01-26		From 2006-01-07 to 2006-01-15		From 2005-11-05 to 2005-11-17	
Borehole inclination (starting point) (0 to–90)	–89.54°		–58.72°		–59.62°	
Borehole azimuth (0–360)	21.25°		160.39°		270.15°	
Borehole length	100.22 m		120.05 m		121.02 m	
Soil depth	2.48 m (gravel fill)		0 m		0 m	
Starting point coordinates (system RT90/RHB70)	Northing: 6367329.07 m Easting: 1548859.01 m Elevation: 23.62 m.a.s.l.		Northing: 6367353.43 m Easting: 1548838.82 m Elevation: 23.75 m.a.s.l.		Northing: 6367336.99 m Easting: 1548878.22 m Elevation: 23.10 m.a.s.l.	
Borehole diameter (interval) (diameter mm)	0.3–2.48 m 0.3–10.74 m 10.74–100.22 m	116 mm 96 mm 75.7 mm	0.3–9.00 m 9.00–120.05 m	96 mm 75.7 mm	0.3–9.75 m 9.75–121.02 m	96 mm 75.8 mm
Casing diameter (interval) (diameter mm)	0–10.74 m	$Ø_o$ = 89 $Ø_i$ = 77	0–9.00 m	$Ø_o$ = 89 $Ø_i$ = 77	0–9.75 m	$Ø_o$ = 89 $Ø_i$ = 77

Table 5-2. Geometric and technical data for boreholes KLX09E and KLX09F.

Parameter	KLX09E		KLX09F	
Drilling period	From 2005-11-23 to 2005-12-05		From 2005-12-06 to 2006-01-06	
Borehole inclination (starting point) (0 to–90)	–59.93°		–59.14°	
Borehole azimuth (0–360)	338.90°		90.67°	
Borehole length	120.00 m		152.30 m	
Soil depth	0 m		0 m	
Starting point coordinates (system RT90/RHB70)	Northing: 6367304.45 m Easting: 1548880.37 m Elevation: 22.16 m.a.s.l.		Northing: 6367318.02 m Easting: 1548817.27 m Elevation: 19.57 m.a.s.l.	
Borehole diameter (interval) (diameter mm)	0.3–9.00 m 9.00–120.00 m	96 mm 75.8 mm	0.3–9.00 m 9.00–152.30 m	96 mm 75.7 mm
Casing diameter (interval) (diameter mm)	0–9.00 m	$Ø_o$ = 89 $Ø_i$ = 77	0 –9.00 m	$Ø_o$ = 89 $Ø_i$ = 77

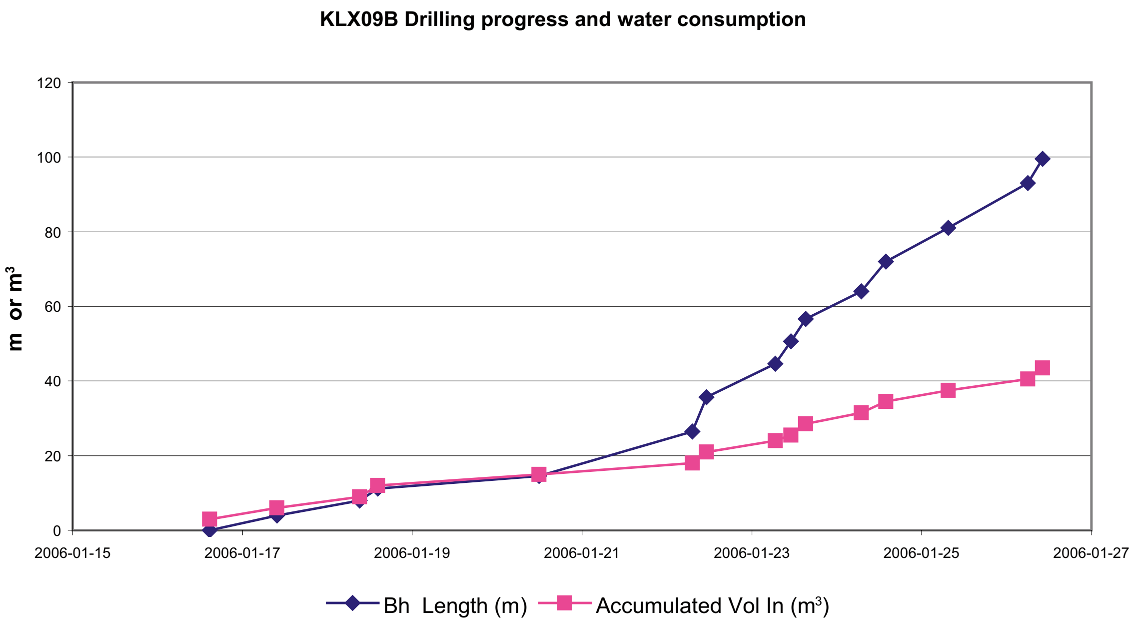


Figure 5-1. *Drilling progress expressed as borehole length vs time and accumulated water consumption vs time in KLX09B.*

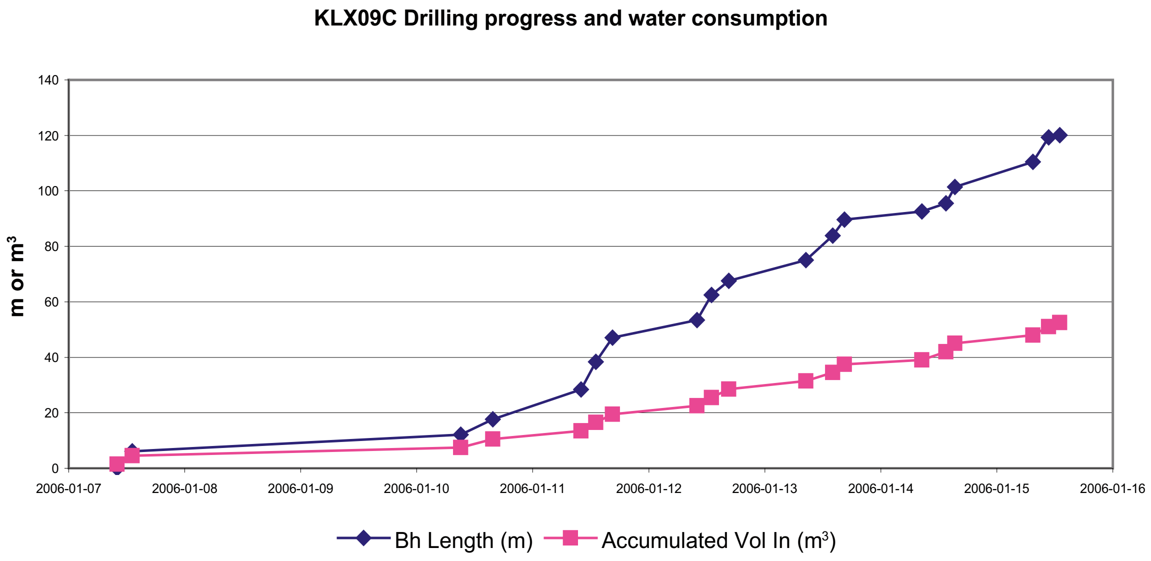


Figure 5-2. *Drilling progress expressed as borehole length vs time and accumulated water consumption vs time in KLX09C.*

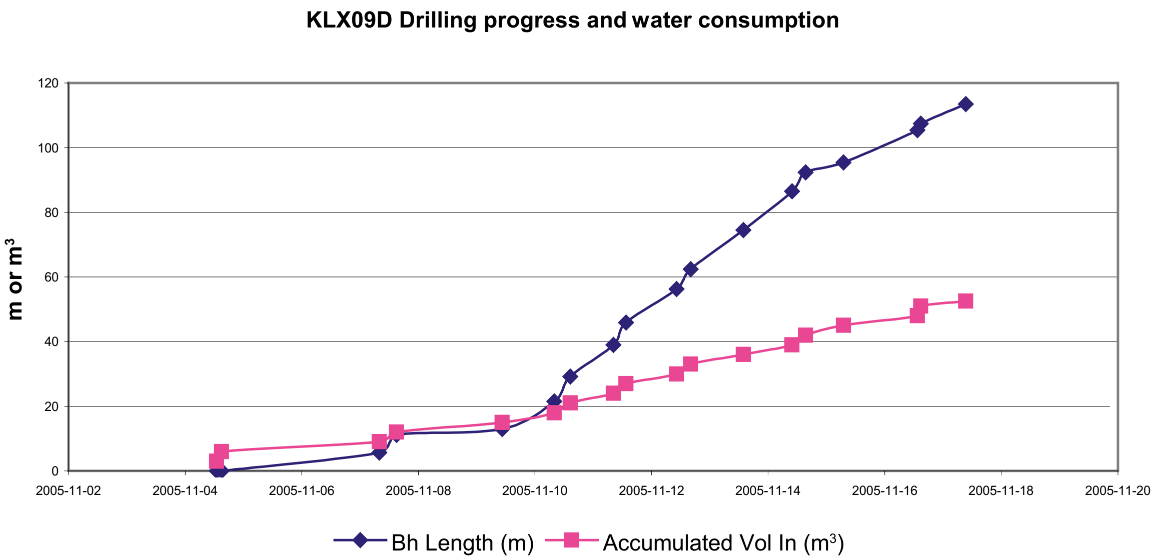


Figure 5-3. *Drilling progress expressed as borehole length vs time and accumulated water consumption vs time in KLX09D.*

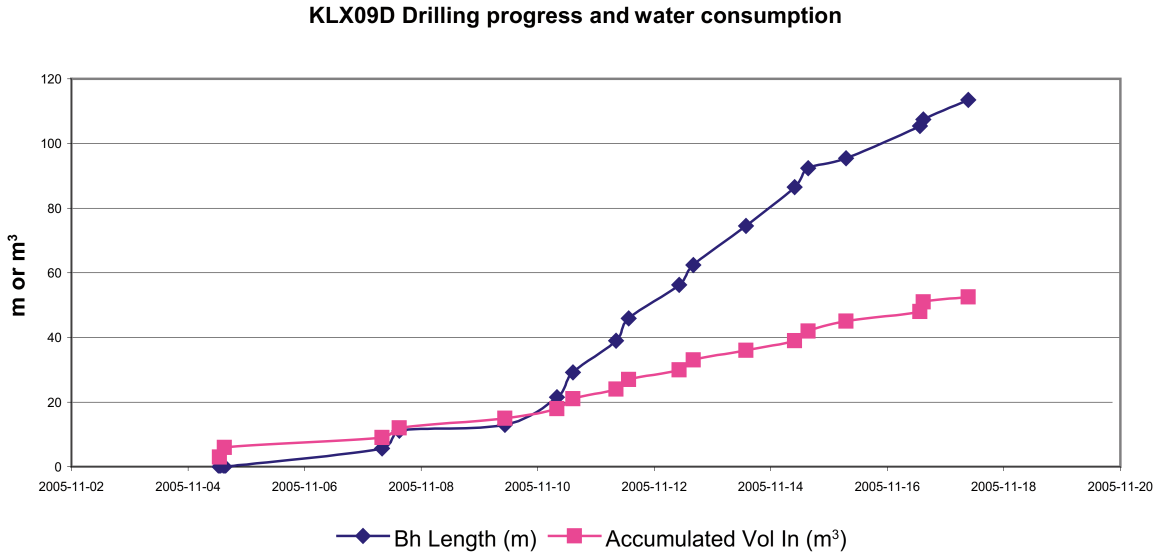


Figure 5-4. *Drilling progress expressed as borehole length vs time and accumulated water consumption vs time in KLX09E.*

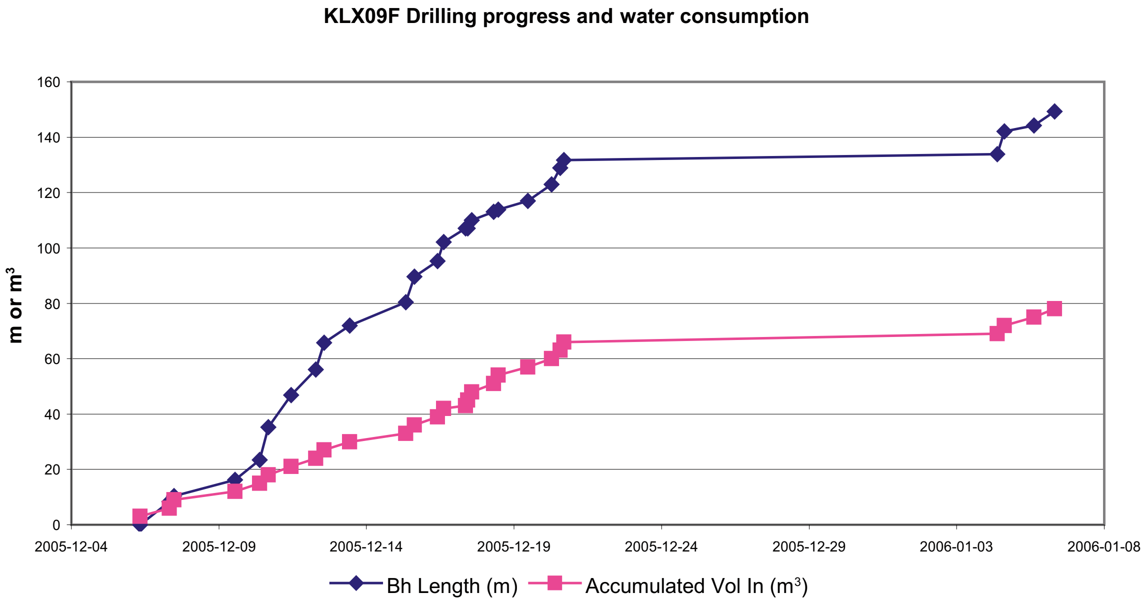


Figure 5-5. *Drilling progress expressed as borehole length vs time and accumulated water consumption vs time in KLX09F.*

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

Borehole	Observed levels of reduced water pressure during drilling
KLX09B	None
KLX09C	Loss of return water in KLX09C at 117 m (15/1)
KLX09D	None
KLX09E	Water pressure reduced in KLX09E at 115 m (4/12)
KLX09F	Loss of return water in KLX09F at 113 m (17/12)

Table 5-4. Amount of water consumed during drilling of KLX09B–F.

	Accumulated volume water (m^3)*	Drilled length (m)	Water consumption (m^3/drilled metre)
KLX09B	43.50	100.22	0.43
KLX09C	52.50	120.05	0.44
KLX09D	52.50	121.02	0.43
KLX09E	73.50	120.00	0.61
KLX09F	78.00	152.30	0.51

* 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 KLX09B–F, can 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.

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 Table 4-2, are therefore important as they can be correlated to hydraulic responses in near-by boreholes.

Hydraulic responses are shown in Figure 5-6 for observation hole KLX09 and in Figure 5-7 for observation holes KLX09B–F.

A summary of the hydraulic responses from water losses during drilling and flushing with nitrogen gas are given in Table 5-5.

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/.

Table 5-5. Summary of the hydraulic responses in KLX09B–F.

Event	Observation borehole KLX09	KLX09D	KLX09E	KLX09F	KLX09C	KLX09B
Nitrogen gas flushing in KLX09D (18/11)	N	N/A	N/A	N/A	N/A	N/A
Water pressure reduced in KLX09E at 115 m (4/12)	Y	Y	N/A	N/A	N/A	N/A
Nitrogen gas flushing in KLX09E (6/12)	?	Y	N/A	N/A	N/A	N/A
Loss of return water in KLX09F at 113 m (17/12)	Y	Y	Y	N/A	N/A	N/A
Nitrogen gas flushing in KLX09F (9/1)	Y	Y	Y	N/A	N/A	N/A
Loss of return water in KLX09C at 117 m (15/1)	Y	Y	Y	Y	N/A	N/A
Nitrogen gas flushing in KLX09C (16/1)	Y	Y	Y	Y	N/A	N/A
Nitrogen gas flushing in KLX09B (28/1)	N	?	?	?	?	N/A

LEGEND

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

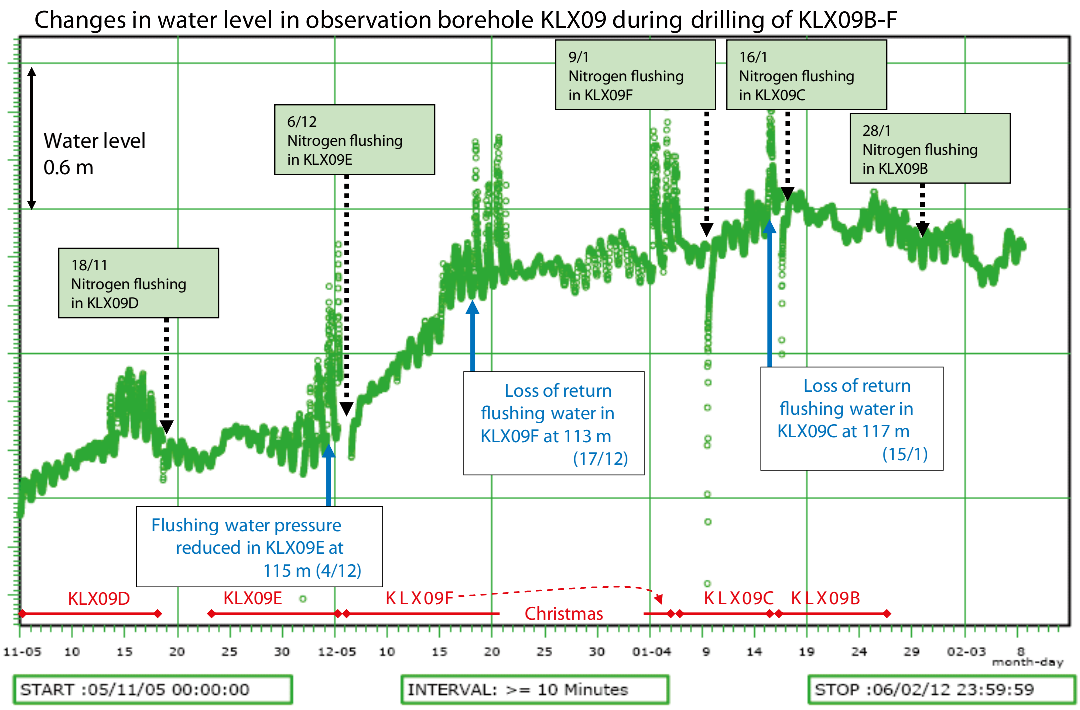


Figure 5-6. Hydraulic responses in KLX09 (green curve) during drilling of KLX09B–F. The times for drilling of boreholes KLX09B–F are given with red lines in the bottom of the figure. Hydraulic responses seen as slight increases of water level in KLX09 can be related to observed loss of return water or reduced water pressure during drilling (blue arrows). Water level drawdowns are clearly related to nitrogen gas flushing as shown with dotted arrows. 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 KLX09 can be given The relative fluctuations are however correct and given in height of water column, see scale bar at top left corner.

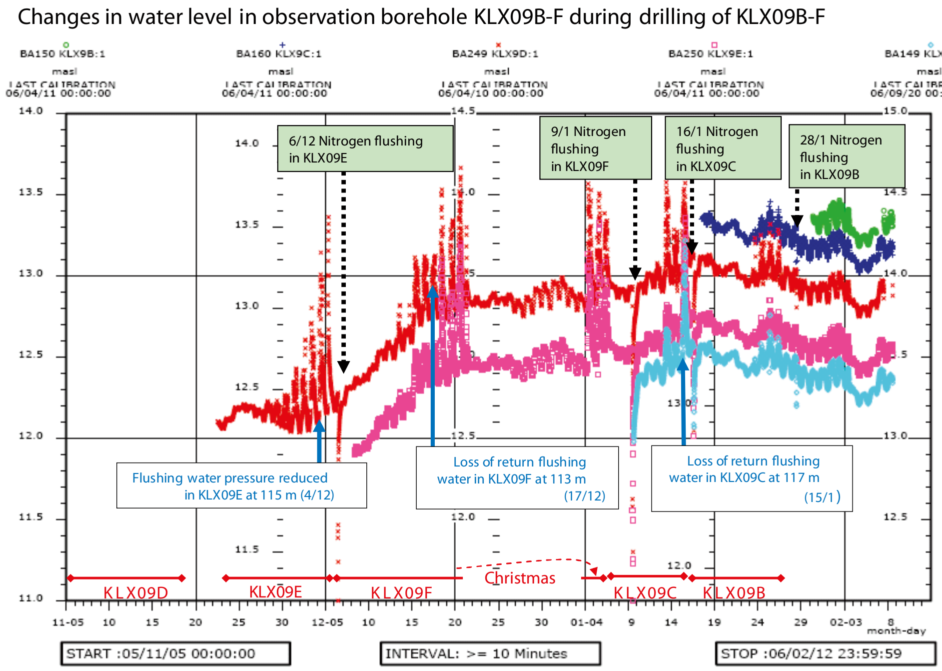


Figure 5-7. *Hydraulic responses in observation boreholes KLX09B (green curve), KLX09C (dark blue curve), KLX09D (red curve), KLX09E (purple curve) and KLX09F (light blue curve) during drilling of KLX09B–F. The times for drilling of boreholes KLX09B–F are given with red lines in the bottom of the figure. Hydraulic responses seen as slight increases of water level in observation boreholes can be related to observed loss of return water or reduced water pressure during drilling (blue arrows). Water level drawdowns are clearly related to nitrogen gas flushing as shown with dotted arrows. The water levels in the observation boreholes are given in metres above sea level "m.a.s.l.".*

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 KLX09B–F and is given in Table 5-6.

Table 5-6. Composition of cement paste in KLX09B–F.

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

5.7 Nonconformities

Deviation measurements in KLX09B–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/.

Borehole KLX09F was extended to152 metres instead of the planned length of 120 in order to reach what was interpreted as a minor deformation zone in accordance with an amendment to the activity plan.

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.

The automatic registration of drill penetration rate, flushing water flow and flushing water pressure as specified in the Activity Plan did not function during the drilling. This has been reported as a formal nonconformity.

No measurements of the return water volumes were made.

The times for nitrogen gas flushing in boreholes KLX09D (051118) and KLX09E (051206) has not been noted by the SKB drill coordinators.

An accident occured while drilling KLX09D when a driller injured a finger. This has been reported as an injury. The formal handling of the issue was done by the contractor, Drillcon AB.

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.

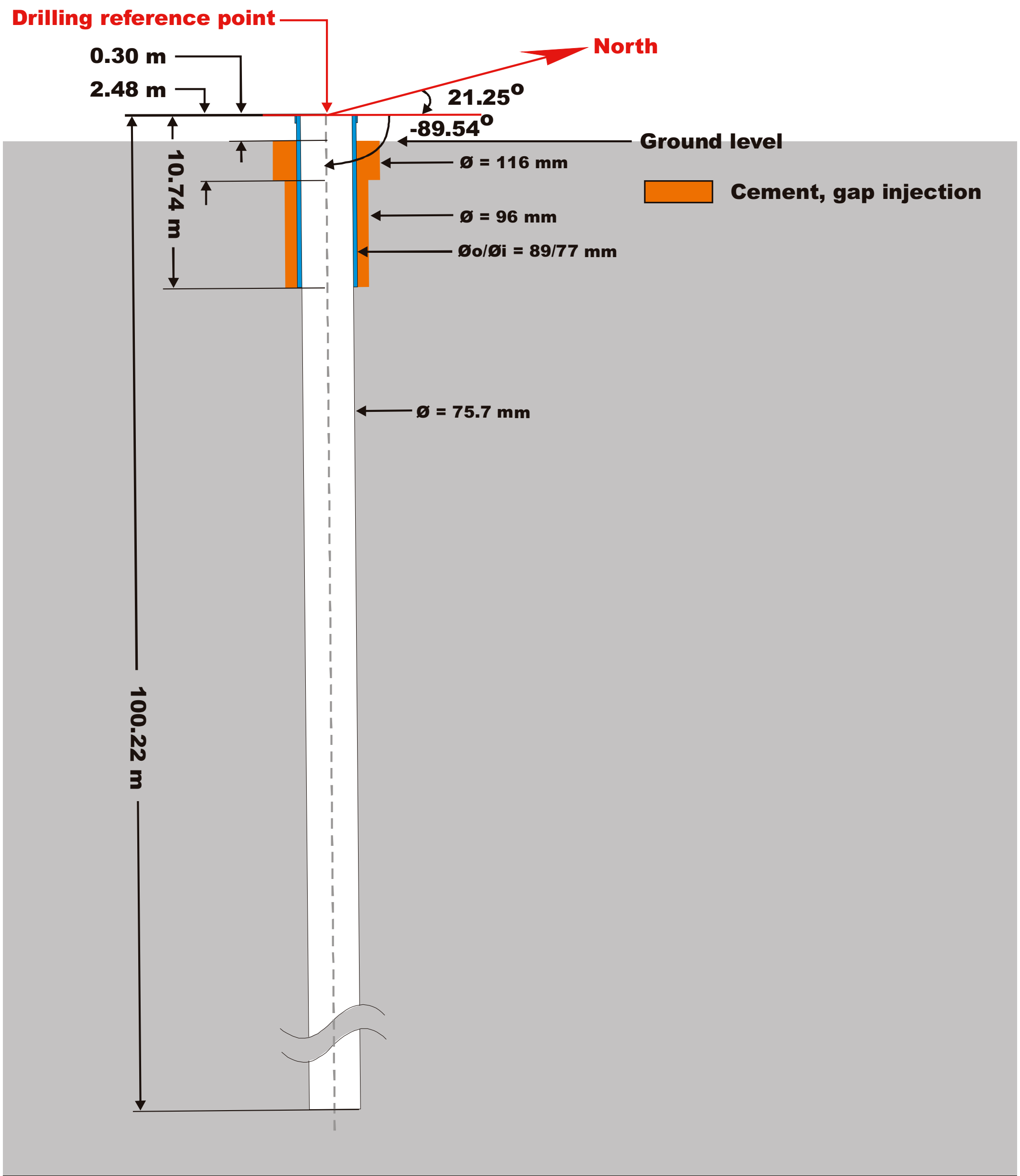
/3/ **Gustafsson J and Gustafsson C, 2006.** Oskarshamn site investigation. RAMAC, BIPS and deviation logging in boreholes KLX09B, KLX09C, KLX09D, KLX09E, KLX09F and KLX09G. SKB P-06-99, Svensk Kärnbränslehantering AB.

/4/ **Mattsson K-J and Dahlin P, 2006.** Oskarshamn site investigation. Boremap mapping of core drilled boreholes KLX09B–KLX09F. SKB P-06-239, Svensk Kärnbränslehantering AB.

Technical data cored boreholes KLX09B, KLX09C, KLX09D, KLX09E and KLX09F

Technical data

Borehole KLX09B



Drilling reference point

Northing: 6367329.07 (m), RT90 2,5 gon V 0:-15

Easting: 1548859.01 (m), RT90 2,5 gon V0:-15

Elevation: 23.62 (m), RHB 70

Drilling period

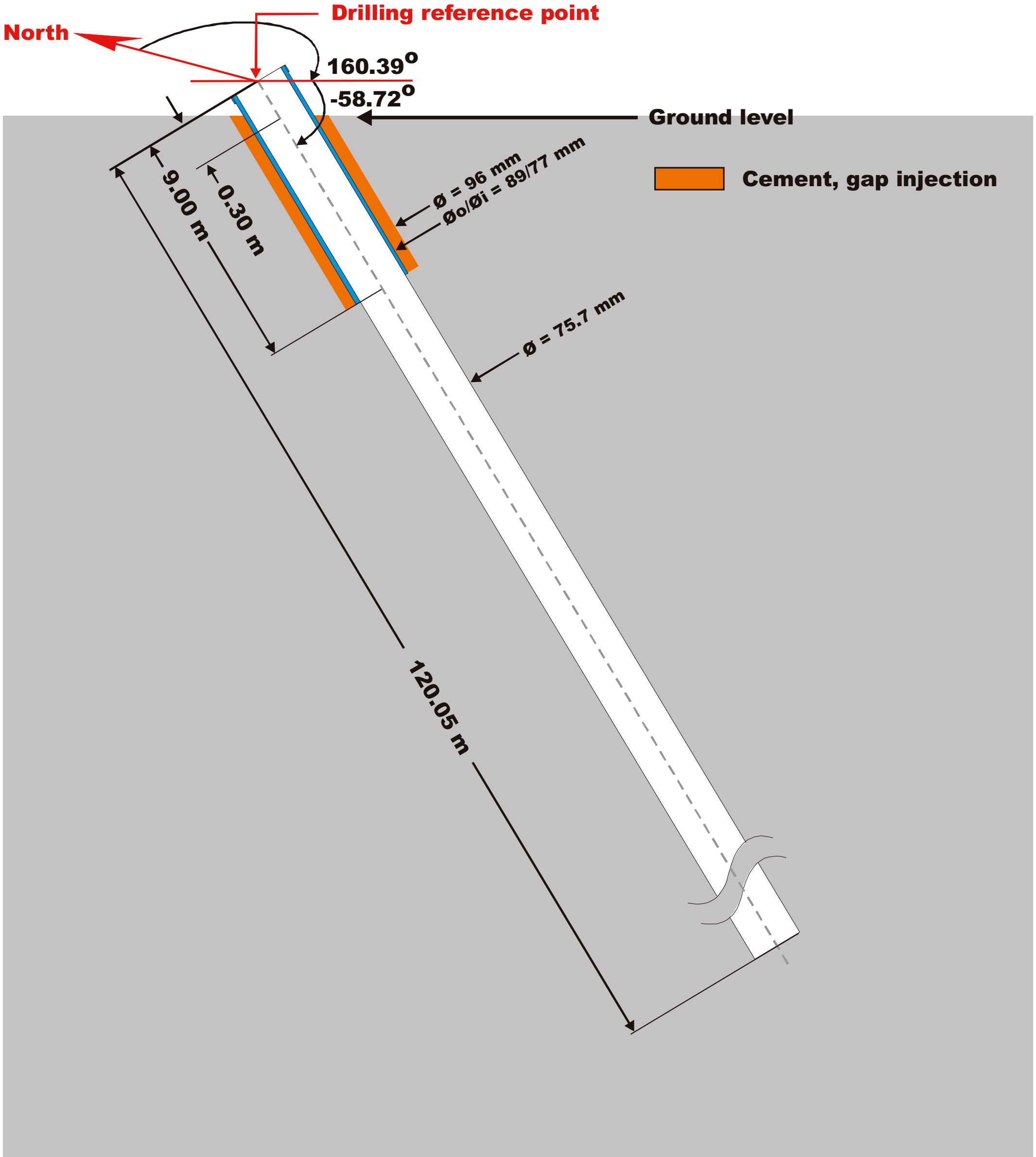
Drilling start date: 2006-01-16

Drilling stop date: 2006-01-26

Ver 2006-11-23

Technical data

Borehole KLX09C



Drilling reference point

Northing: 6367353.43 (m), RT90 2,5 gon V 0:-15

Easting: 1548838.82 (m), RT90 2,5 gon V0:-15

Elevation: 23.75 (m), RHB 70

Drilling period

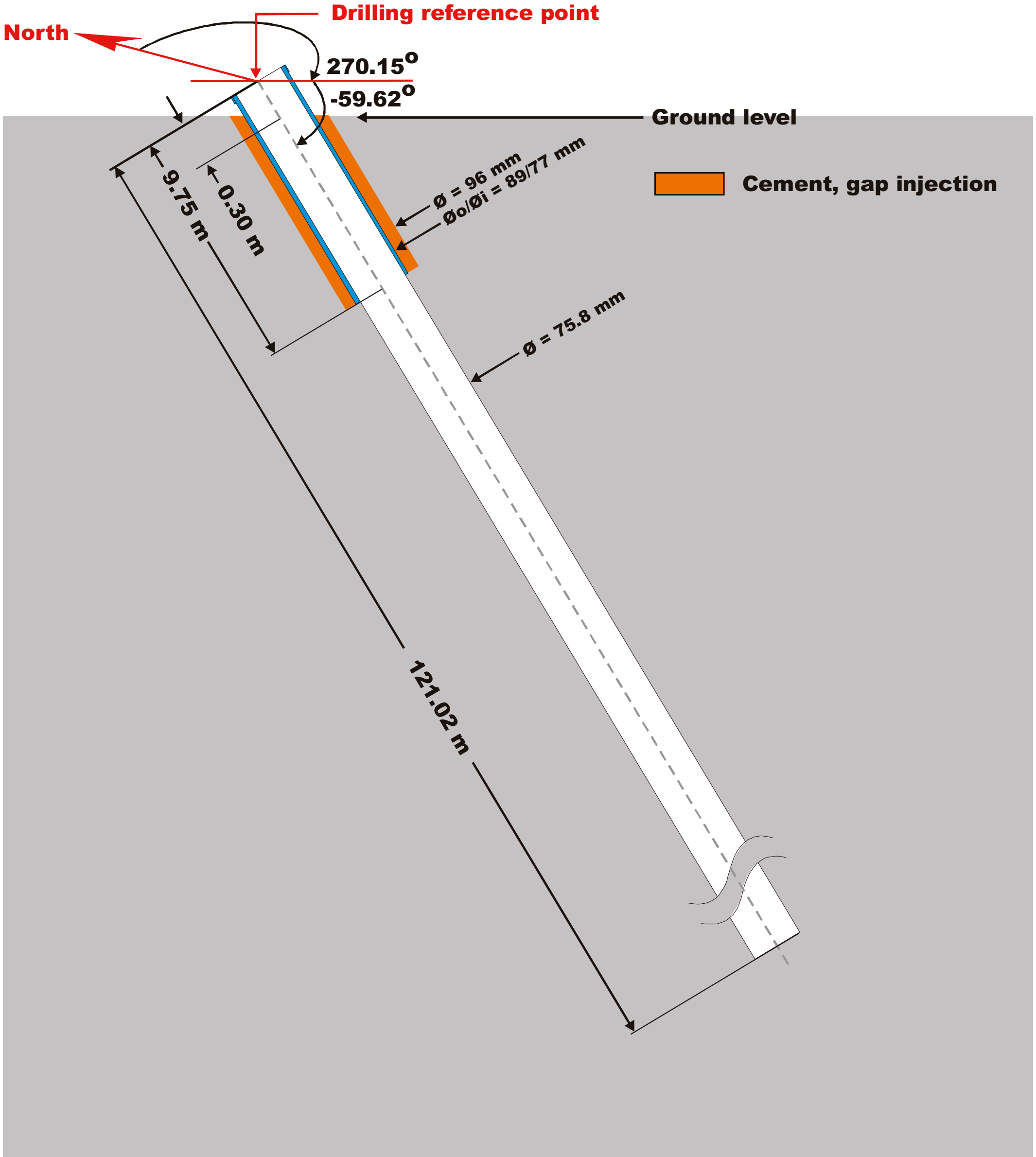
Drilling start date: 2006-01-07

Drilling stop date: 2006-01-15

Ver 2006-11-23

Technical data

Borehole KLX09D



Drilling reference point

Northing: 6367336.99 (m), RT90 2,5 gon V 0:-15

Easting: 1548878.22 (m), RT90 2,5 gon V0:-15

Elevation: 23.10 (m), RHB 70

Drilling period

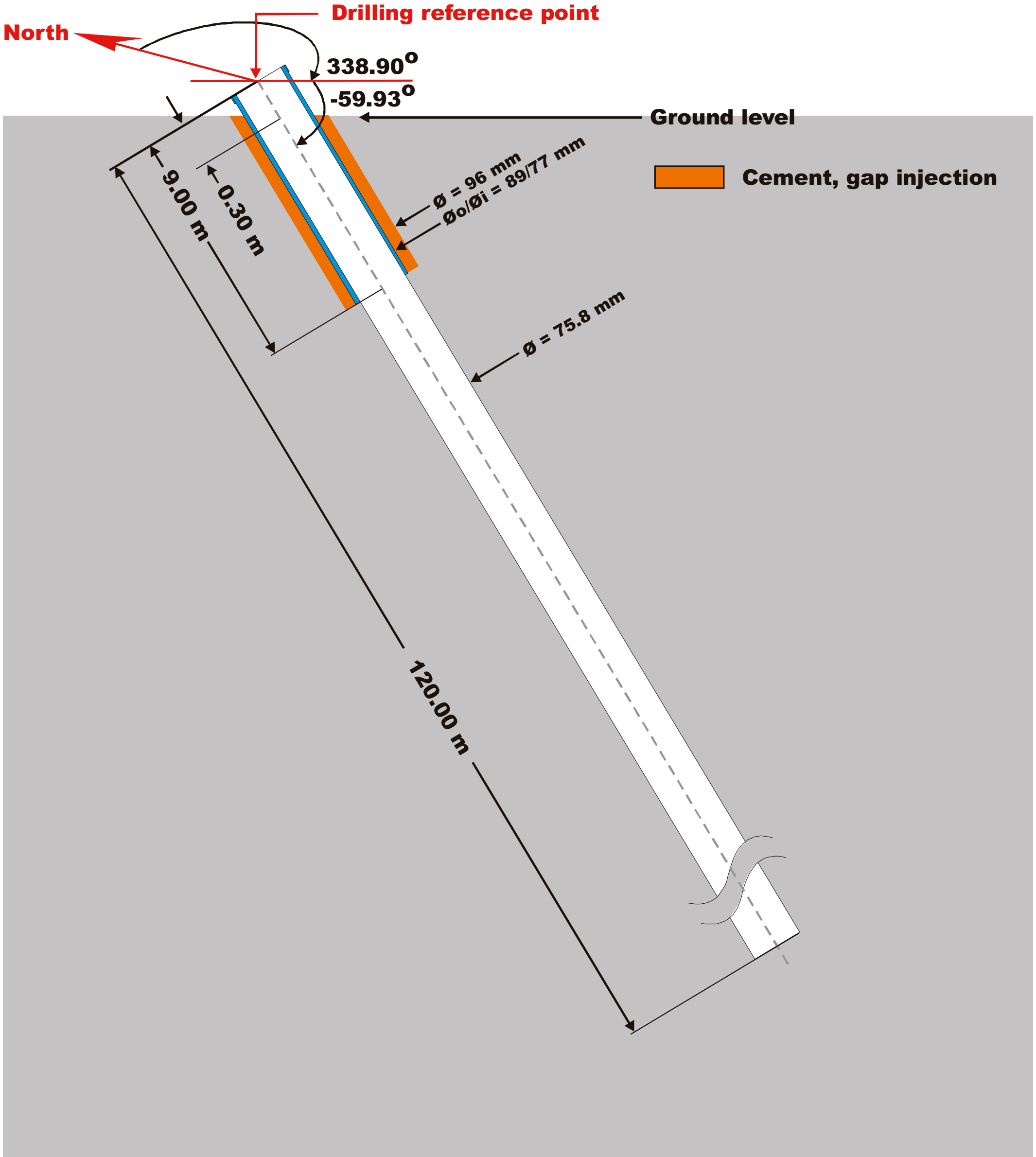
Drilling start date: 2005-11-05

Drilling stop date: 2005-11-17

Ver 2006-11-23

Technical data

Borehole KLX09E



Drilling reference point

Northing: 6367304.45 (m), RT90 2,5 gon V 0:-15

Easting: 1548880.37 (m), RT90 2,5 gon V0:-15

Elevation: 22.16 (m), RHB 70

Drilling period

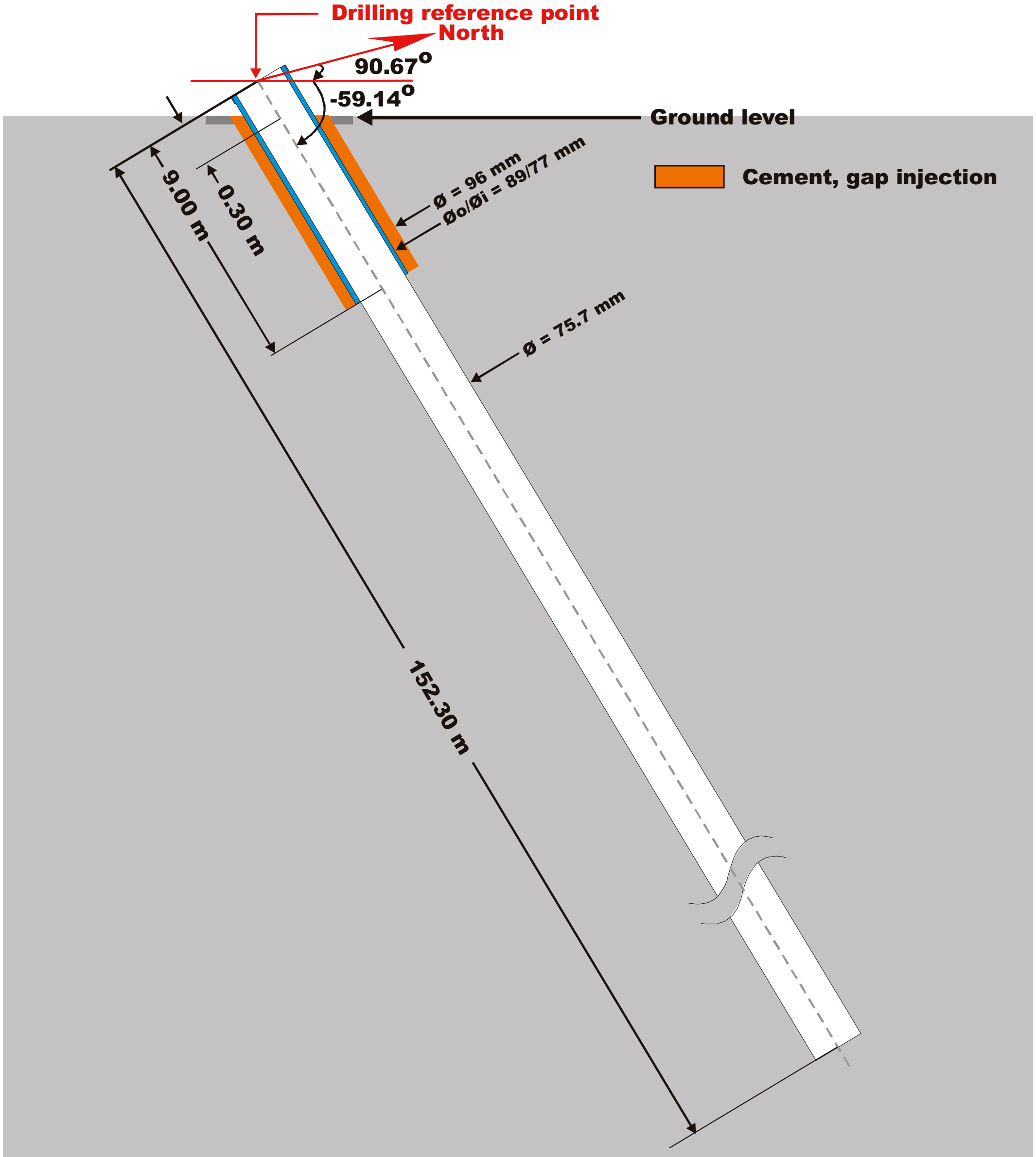
Drilling start date: 2005-11-23

Drilling stop date: 2005-12-05

Ver 2006-11-23

Technical data

Borehole KLX09F



Drilling reference point

Northing: 6367318.02 (m), RT90 2,5 gon V 0:-15

Easting: 1548817.27 (m), RT90 2,5 gon V0:-15

Elevation: 19.57 (m), RHB 70

Drilling period

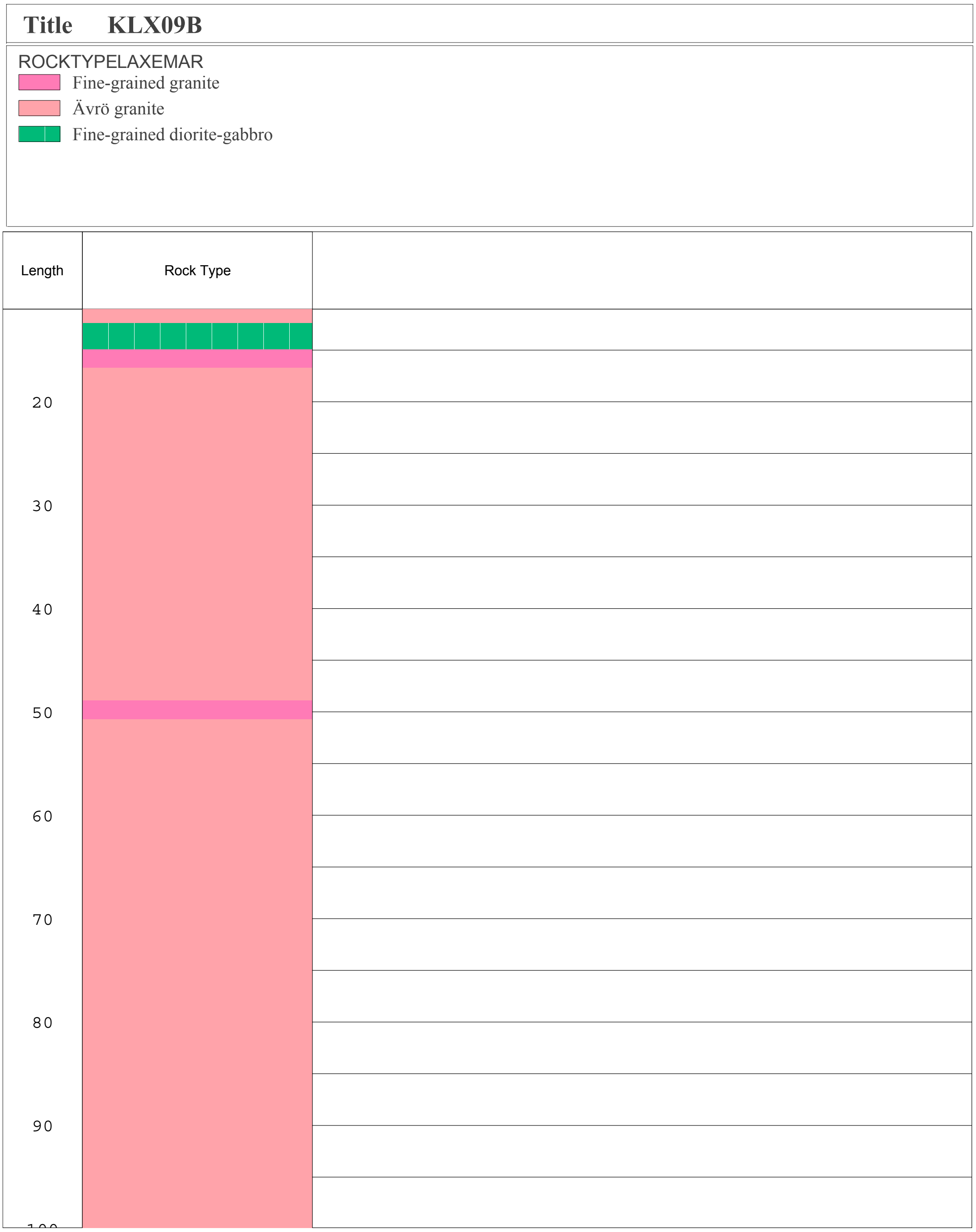
Drilling start date: 2005-12-06

Drilling stop date: 2006-01-06

Ver 2006-11-23

Appendix 2

Wellcad plots – Rock types in boreholes KLX09B, KLX09C, KLX09D, KLX09E and KLX09F



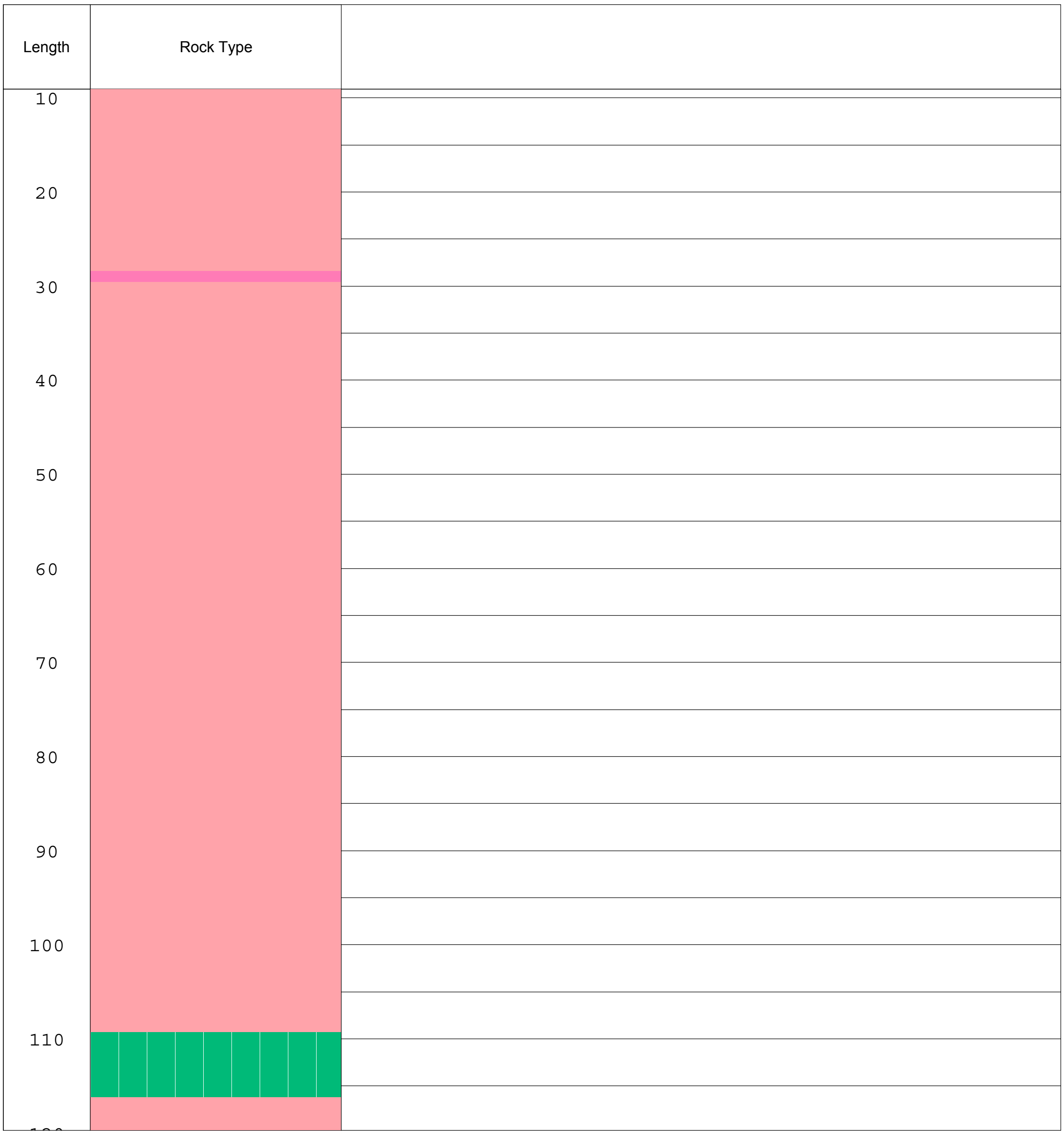

Title KLX09C
ROCKTYPELAXEMAR
Fine-grained granite
Ävrö granite
Length
Rock Type
10
20
30
40
50
60
70
80
90
100
110


Title KLX09D
ROCKTYPELAXEMAR
Fine-grained granite
Ävrö granite
Fine-grained diorite-gabbro
Length
Rock Type
20
30
40
50
60
70
80
90
100
110
120

Title KLX09E

ROCKTYPELAXEMAR

- Fine-grained granite
- Ävrö granite
- Fine-grained diorite-gabbro




Title KLX09F
ROCKTYPELAXEMAR
Fine-grained granite
Granite
Ävrö granite
Fine-grained diorite-gabbro
Length
Rock Type
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150