P-04-281

Oskarshamn site investigation

Water sampling in KSH02A

Summary of water sampling analysis in connection with Pipe String System (PSS) and Single Well Injection Withdrawal (SWIW) measurements

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June 2004

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Keywords: Groundwater, Borehole, Chemical analyses, Isotope determinations.

This report concerns a study which was conducted for SKB. The conclusions and viewpoints presented in the report are those of the authors and do not necessarily coincide with those of the client.

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Abstract

Water sampling in the core drilled borehole KSH02A within the site investigation at Oskarshamn was performed during pumping with Pipe String System (PSS) in two sections and using the equipment for Single Well Injection Withdrawal (SWIW) tests in one section.

The results from the chemistry activity contain groundwater chemistry data, SKB chemistry class 5, from three borehole sections: 419.0–424.0 m (PSS), 575.0–580.0 m (PSS) and 957.2–958.2 m (SWIW). The data were obtained during September 2003–February 2004.

Most of the analysis results from the water samples have been reported at the time of preparing this manuscript. The missing results include the determination of isotopes $\delta^{13}C$, $\delta^{37}Cl$ and ^{14}C (pmC) for all sections as well as the control analysis of uranium isotopes from section 575.0–580.0 m.

Sammanfattning

Vattenprovtagning i kärnborrhål KSH02A inom platsundersökningen i Oskarshamn, har utförts vid pumpning med Pipe String System (PSS) i två sektioner samt med Single Well Injection Withdrawal (SWIW) i en sektion.

Resultaten från denna aktivitet inkluderar vattenkemidata, SKB kemiklass 5, från de tre borrhålssektionerna 419,0–424,0 m (PSS), 575,0–580,0 m (PSS) och 957,2–958,2 m (SWIW). Proverna är tagna under perioden september 2003 till februari 2004.

De flesta analysresultaten från vattenproverna är rapporterade vid skrivandet av denna rapport. De analysresultat som saknas är isotoperna $\delta^{13}C$, $\delta^{37}Cl$ och ^{14}C (pmC), alla sektioner, såsom kontrollanalys av uran isotoper från sektion 575,0–580,0 m.

Contents

1 Introduction

This document summarises the results gained from water sampling, a sub-activity during pumping with the Pipe String System (PSS) in two sections and Single Well Injection Withdrawal (SWIW) in one section, in the core drilled borehole KSH02A within the site investigation at Oskarshamn. The work was conducted in accordance with activity plan SKB PS 400-03-043 (PSS) and SKB PS 400-03-073 (SWIW). Controlling documents for performance of the water sampling activities are listed in Table 1-1. Both activity plans and method descriptions are SKB's internal controlling documents. The data were obtained during September 2003–February 2004 and are reported in SICADA in the field note no listed in Table 1-2. A map showing the investigation site and the location of the borehole KSH02A is shown in Figure 1-1.

The report presents groundwater chemistry data from the following three borehole sections:

- 419.0–424.0 m (PSS)
- 575.0–580.0 m (PSS)
- 957.2–958.2 m (SWIW)

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

Activity plan	Number	Version
Test pumping and Hydraulic Injection Tests in Borehole KSH02.	AP PS 400-03-043	1.0
Grundvattenflödesmätningaroch SWIW-tester med utspädningssond samt kemiprovtagning I borrhål KSH02.	AP PS 400-03-073	1.0
Method descriptions	**Number**	**Version**
Metodbeskrivning för hydrauliska injektionstester.	SKB MD 323.001	1.0
Metodbeskrivning för provtagning under pumptester i kärnborrhål.	SKB MD 430.018	1.0
Utspädningssond med SWIW-test utrustning.	SKB MD 353.003-095	manuscript

Table 1-2. Data references.

Subactivity	Database	Identity number
Water sampling in section 419.0–424.0 m.	SICADA	Field note 128
Water sampling in section 575.0–580.0 m.	SICADA	Field note 131
Water sampling in section 957.2–958.2 m.	SICADA	Field note 233

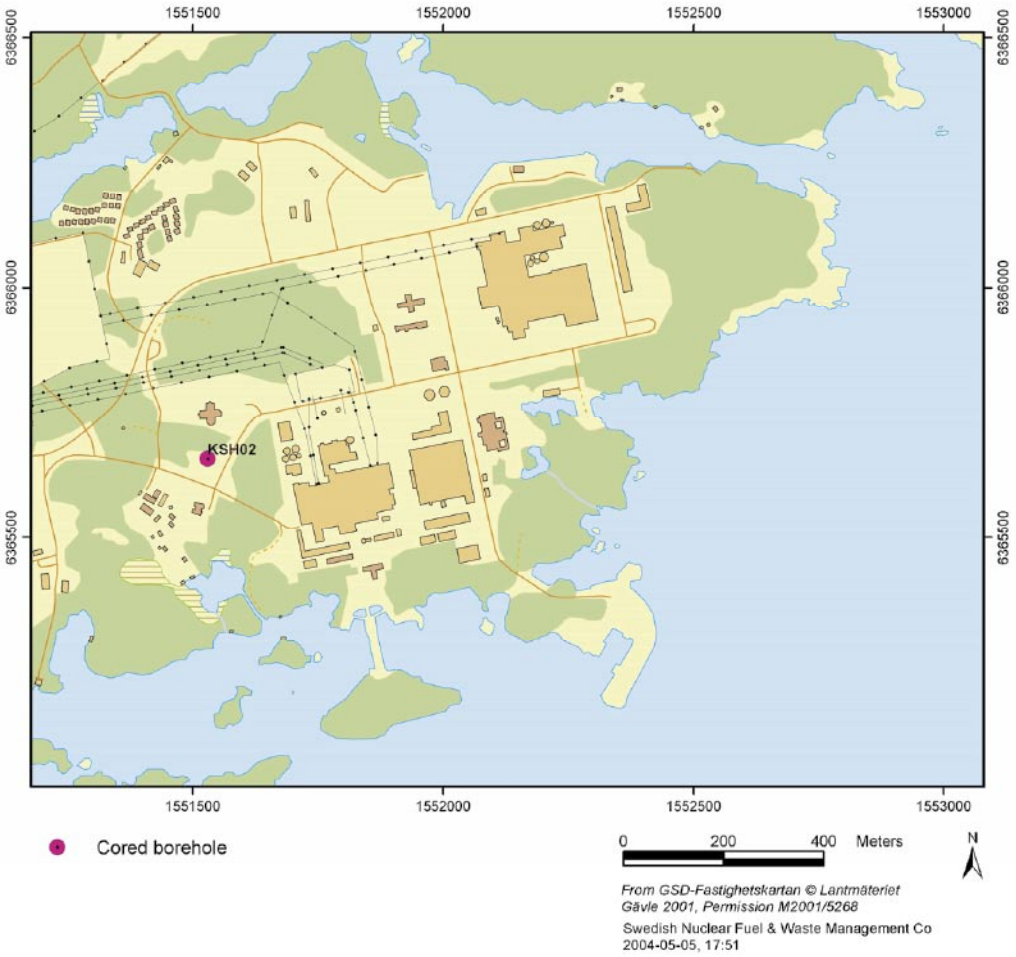

Figure 1-1. *The location of the core drilled borehole KSH02A within the Oskarshamn investigation area.*

2 Objective and scope

This report summarises the results from the SKB chemistry class 5 water samples collected during pumping tests with PSS in two sections and in connection with a SWIW test in one section, in borehole KSH02A.

The water sampling is primarily performed as a complement and to increase the quantity of chemical data in the borehole.

3 Equipment

3.1 Pipe string system (PSS)

The SKB pipe string system (PSS) consists of a measurement container with downhole equipment. The system is normally used for hydraulic pumping tests but in this case it was used for pumping and chemical sampling. The equipment is described in SKB MD 345.100-124 (Pipe String System, SKB internal controlling document).

The PSS equipment is designed for flow rates from 5 L/min to 30–40 L/min. In order to pump at lower flow rates (down to 1 L/min), it is necessary to re-circulate pumped water.

3.1.1 Measurement container

The PSS is primarily designed for pumping and injection tests in packed-off borehole sections. All equipment needed to perform the tests is located in a steel container. The container is placed on pallets in order to get a suitable working level in relation to the borehole casing. The container is divided into a data-room and a workshop compartment, see Figure 3-1.

The hoisting rig is of a hydraulically chain-feed type. The jaws, holding the pipe string, is opened hydraulically and closed mechanically using springs. The rig is equipped with a load transmitter, maximum 22 kN, and a limiting value for the load may be adjusted.

Water filled pressure vessels operate the packers and the test valve. Expansion and release of packers as well as opening and closing of the test valve is done by magnetic valves controlled by the software in the data acquisition system.

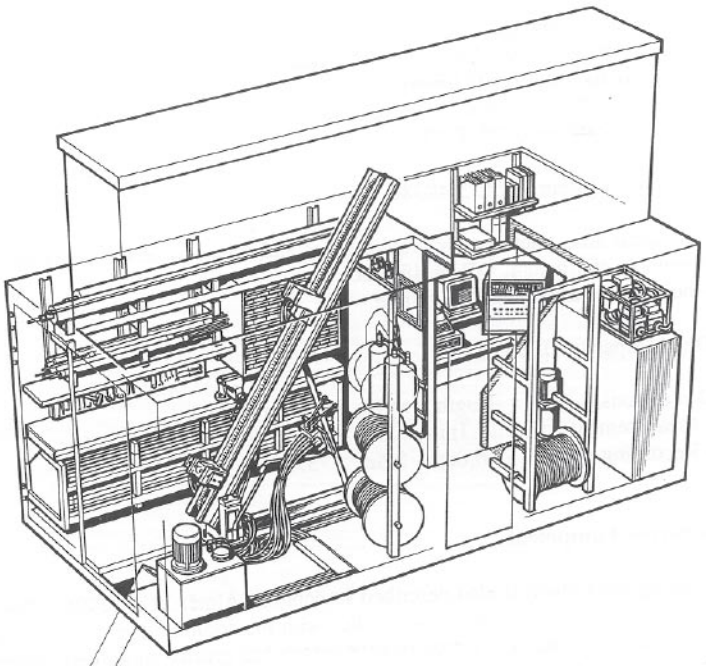

Figure 3-1. *Outline of the PSS container with equipment.*

The injection system consists of a tank, a pump and a flow meter unit at the surface. The injection flow rate may be manually or automatically controlled. At small flow rates, a water filled pressure vessel connected to a nitrogen gas regulator is used instead of the pump.

3.1.2 Downhole equipment

A schematic drawing of the downhole equipment is shown in Figure 3-2. The pipe string consists of aluminium pipes with an inner diameter of 21 mm and of 3 m length, connected by stainless steel taps sealed with double o-rings. The length of the test section is constructed from 5 m pipe lengths which can be adjusted to investigate 5, 20 or 100 m borehole sections; this conforms to available lengths of electric cable. Pressure is measured above (P_a), within (P) and below the test section (P_b), which is isolated by two packers. The groundwater temperature in the test section is also measured. The hydraulic connection between the pipe string and the test section can be closed or opened by a test valve operated by the measurement system.

At the lower end of the borehole equipment, a level indicator (caliper type) gives a signal when the reference length marks along the borehole are passed.

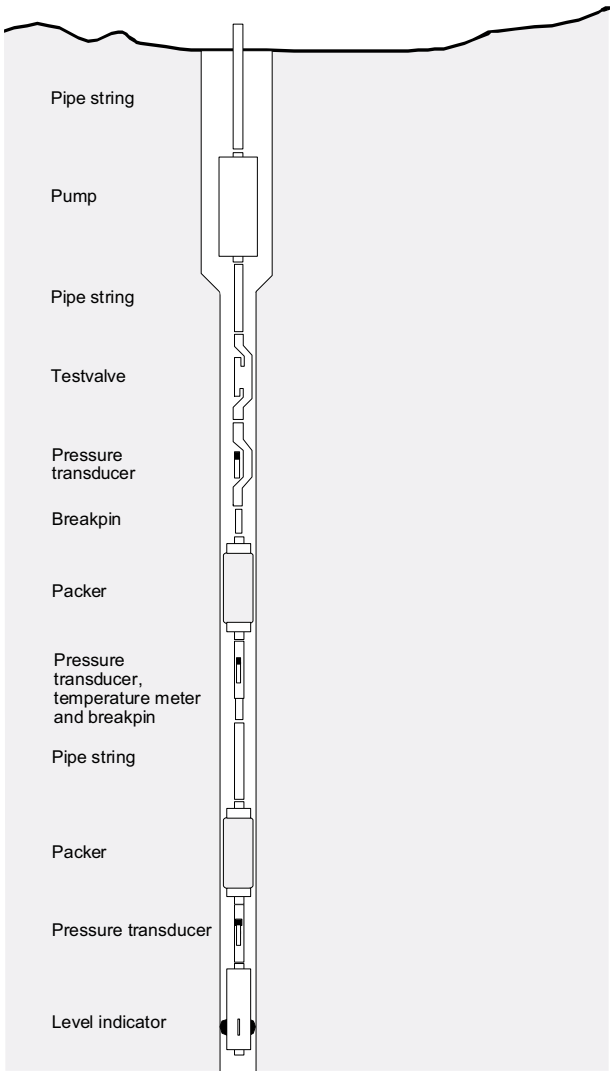

Figure 3-2. *Schematic drawing of the downhole equipment in the PSS system.*

3.2 Single Well Injection Withdrawal (SWIW)

The SWIW-test equipment is a complement to the dilution probe. The system is normally used to investigate transport characteristics but in this case it was used to pump water for chemical sampling. The major components of the equipment include a polyamide tube (constituting a hydraulic connection between the SWIW-test equipment and the dilution probe), hosedrum fore the polyamide tube, tank (capacity 300 L) for storage of groundwater under nitrogen gas atmosphere, control system for injection of tracer/ groundwater and finally injection pumps for tracer/groundwater. To be able to perform SWIW tests, the equipment must be connected to the dilution probe. The equipment is described in SKB MD 353.003-095 ("Utspädningssond med SWIW-test utrustning", manuscript, SKB internal controlling document). A schematic drawing of equipment (connected to the dilution probe) is shown in Figure 3-3.

The SWIW-test equipment is designed for measurements in a borehole length interval of 300 to 700 m.

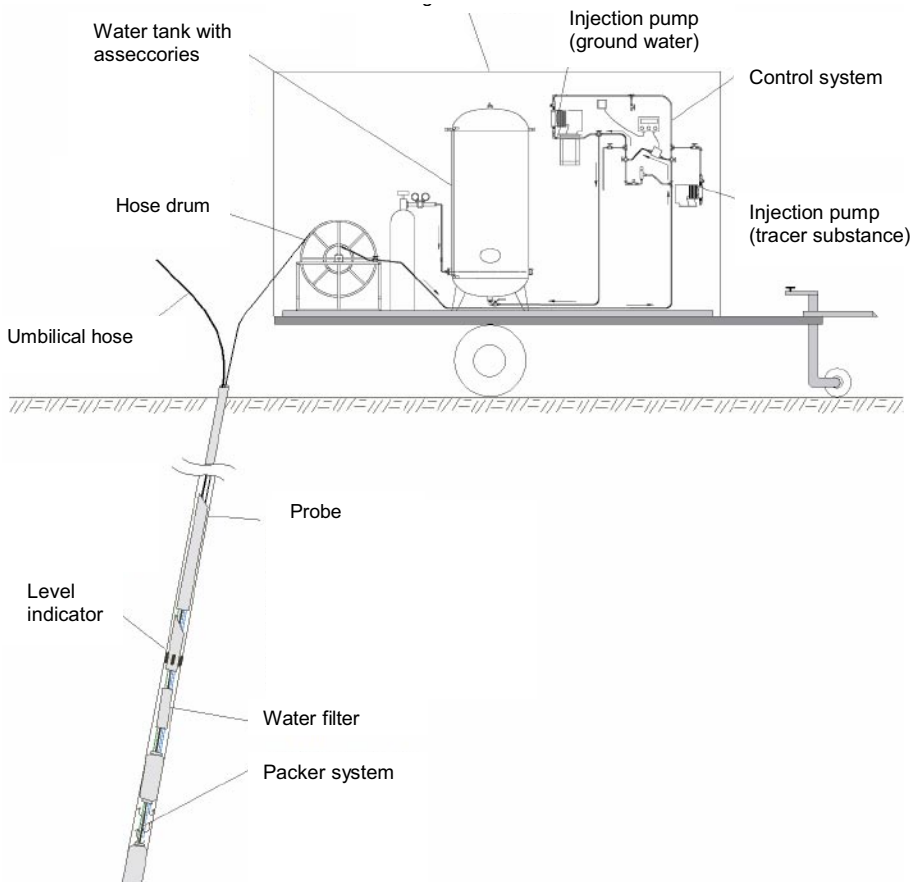

Figure 3-3. *SWIW-test equipment connected to the dilution probe.*

4 Performance

4.1 General

The pumping and water sampling in section 419.0–424.0 m and 575.0–580.0 m was conducted as a sub-activity in connection to the performance of injection tests in the borehole KSH02A using the PSS system. The activity was performed in accordance with the Activity Plan AP PS 400-03-043 (SKB internal controlling document) and following the method describtion SKB MD 430.018 (Metodbeskrivning för provtagning under pumptester i kärnborrhål, SKB internal controlling document). The samples from section 957.2–958.2 m was collected in connection to SWIW-tests in the borehole in accordance with the Activity Plan AP PS 400-03-073 (SKB internal controlling document) and SKB MD 353.003-095 (“Utspädningssond med SWIW-test utrustning”, manuscript, SKB internal controlling document).

4.2 Performance in section 419.0–424.0 (PSS)

The pumping in the section was performed as a constant head (drawdown) test /1/. The main purpose of the pumping in the section was chemistry sampling. Samples for uranine analysis were collected each day until an acceptable level of remaining flushing water content was reached, as decided by the activity leader/SKB. Thereafter, SKB chemistry class 5 samples were collected.

Two SKB chemistry class 5 samples from this section were collected approximately 30 minutes apart. The first sample collected was analysed for all parameters included in a class 5 sample. The second sample was collected as a control sample but, however, not analysed for iodine, nutrient salts, trace elements and stable and radioactive isotopes, and no archive samples were stored in freezer.

Water samples collected during the pumping period is listed in Table 4-1.

Table 4-1. Sampling performed in section 419.0–424.0 in KSH02A.

Date and time	Sampling activity	SKB no
2003-09-02 13:25	Water sampling: Uranine	5805
2003-09-03 09:00	Water sampling: Uranine	5806
2003-09-04 07:15	Water sampling: Uranine	5807
2003-09-05 07:40	Water sampling: Uranine	5809
2003-09-05 12:15	Water sampling: SKB class 5	5810
2003-09-05 12:40	Water sampling: SKB class 5 (control sample)	5811

4.3 Performance in section 575.0–580.0 (PSS)

The pumping in the section was performed as a constant head (drawdown) test /1/. The main purpose of the pumping in the section was chemistry sampling. Samples for uranine analysis were collected each day until an acceptable level of remaining flushing water content was reached, as decided by the activity leader/SKB. Thereafter, a final SKB chemistry class 5 samples was collected.

Two SKB chemistry class 5 samples were collected approximately 30 minutes apart. The first sample collected was analysed for all parameters included in a class 5 sample. The second class 5 sample was collected as a control sample but, however, not analysed for iodine, trace elements, radioactive isotopes (except uranium isotopes) and the stable isotopes $\delta^{13}C$, $^{87}Sr/^{86}Sr$, $^{10}B/^{11}B$, and no archive samples were stored in freezer.

Water samples collected during the pumping period is listed in Table 4-2.

Table 4-2. Samplings performed in section 575.0–580.0 in KSH02A.

Date and time	Sampling activity	SKB no
2003-09-09 22:47	Water sampling: Uranine	5812
2003-09-10 09:15	Water sampling: Uranine	5813
2003-09-11 07:43	Water sampling: Uranine	5814
2003-09-12 07:45	Water sampling: Uranine	5815
2003-09-15 07:28	Water sampling: Uranine	5855
2003-09-15 07:35	Water sampling: SKB class 5	5856
2003-09-15 08:10	Water sampling: SKB class 5 (control sample)	5857

4.4 Performance in section 957.2–958.2 (SWIW)

The sampling in section 957.2–958.5 was performed in connection to SWIW-tests with the dilution probe in KSH02A /2/. Water samples were collected each day after start of pumping in order to check the remaining content of flushing water in the section. When the content was at an acceptably low level, as decided by the activity leader/SKB, two SKB chemistry class 5 samples were collected. The two class 5 samples were collected about one hour apart. The first of the two samples were analysed for all parameters included in a class 5 sample. The second collected sample was collected as an control sample but analysed only for uranine, pH, conductivity, HCO_3^-, Cl^-, SO_4^{2-}, Br^-, F^-, Fe-tot, Fe(+II), HS^- and NH_4^+. Samples collected for the other parameters are stored in the freezer at SKB.

Water samples collected during the pumping period is listed in Table 4-3.

Table 4-3. Sampling performed in section 957.2–958.2 during SWIW-tests in KSH02A.

Date and time	Sampling activity	SKB no
2004-02-10 07:55	Water sampling: SKB class 1	7111
2004-02-11 08:30	Water sampling: SKB class 1	7112
2004-02-11 10:40	Water sampling: SKB class 5	7113
2003-02-11 11:45	Water sampling: SKB class 5 (control sample)	7114

4.5 Water sample treatment and analyses

An overview of sample treatment and analysis routines of major constituents, minor anions, trace metals and isotopes is given in Appendix 1. The routines are applicable independently of sampling method or sampling object.

4.6 Handling of water analysis data

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

Some of the constituents are determined by more than one method and/or laboratory. All analytical results are stored in the SICADA database. The applied hierarchy path "Hydrochemistry/Hydrochemical investigation/Analyses/Water in 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 the 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.
- Calculation of charge balance errors, equation (1). Relative errors within ± 5% are considered acceptable.

$$\text{Relative error } (\%) = 100 \times \frac{\sum \text{cations}(\text{equivalents}) - \sum \text{anions}(\text{equivalents})}{\sum \text{cations}(\text{equivalents}) + \sum \text{anions}(\text{equivalents})} \quad (1)$$

- General expert judgement of plausibility based on earlier results and experience.

All results from special analyses of trace metals and isotopes are inserted directly into primary data tables. In 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.

An overview of the data management is given in Figure 4-1.

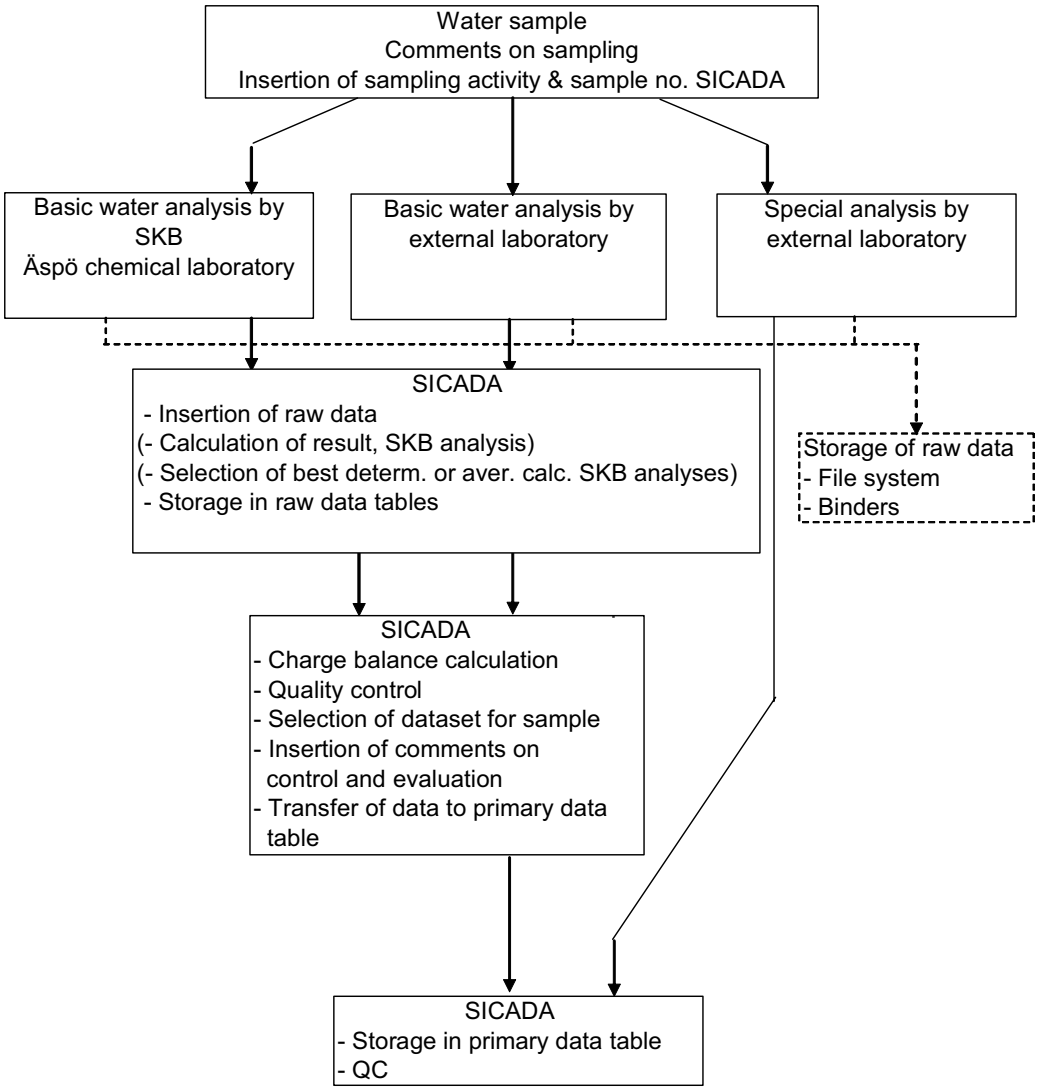

Figure 4-1. *Overview of data management for hydrogeochemical data.*

4.7 Nonconformities

The sampling of water was conducted according to the Activity Plan AP PS 400-03-043 during the pumping tests with PSS.

The water sampling in connection to SWIW-test was conducted according to the Activity Plan AP PS 400-03-073.

No deviation reports were written regarding the chemical water sampling in KSH02A.

5 Results of water analysis

The results from the chemical analysis are presented below. The original results are stored in the primary data base SICADA in field note no Simpevarp 128, 131 and 233 for section 419.0–424.0 m, 575.0–580.0 and 957.2–958.2 m respectively.

5.1 Basic water analyses

The basic water analyses include the major constituents Na, K, Ca, Mg, S, SO_4^{2-}, Cl^-, Si and HCO_3^- as well as the minor constituents Fe, Li, Mn, DOC, Br, F, HS^- and NH_4^+. Furthermore, there are measurements of pH, electric conductivity and flushing water content in each sample. The basic water analysis data and relative charge balance errors are compiled in Appendix 2, Table A2-1.

The charge balance error give an indication of the quality and uncertainty of the analyses of major constituents. The charge balance error exceeds the acceptable level of ± 5% in one case, SKB no 5811 from section 419.0–424.0 m.

The flushing water content in the samples in the borehole sections during the measurements are presented in Figures 5-1 and 5-2.

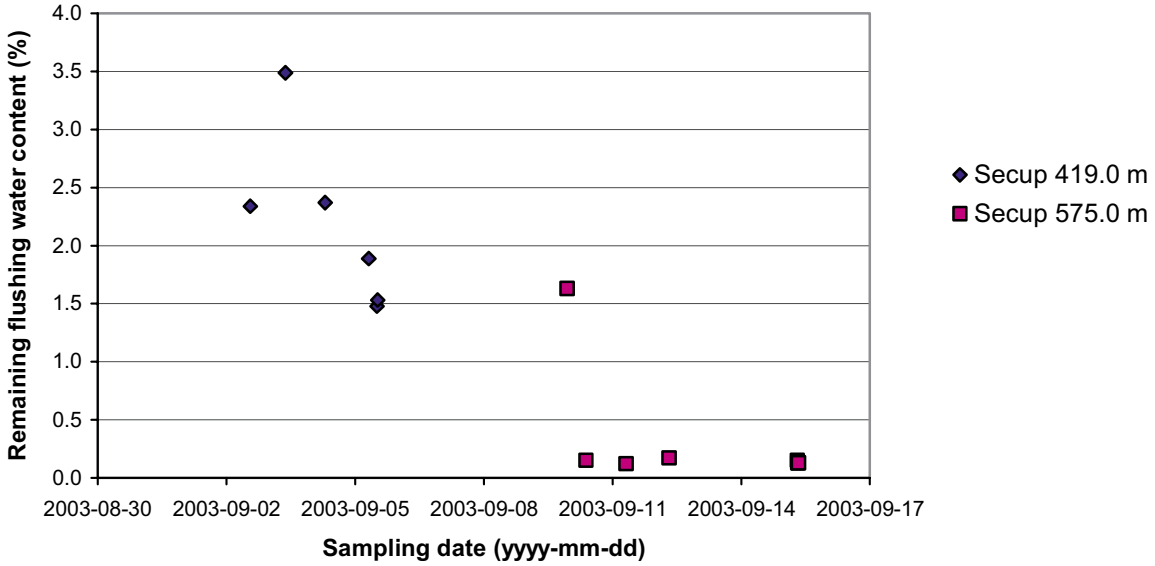

Figure 5-1. *Flushing water content in samples collected in the two sections sampled using the PSS equipment in KSH02A.*

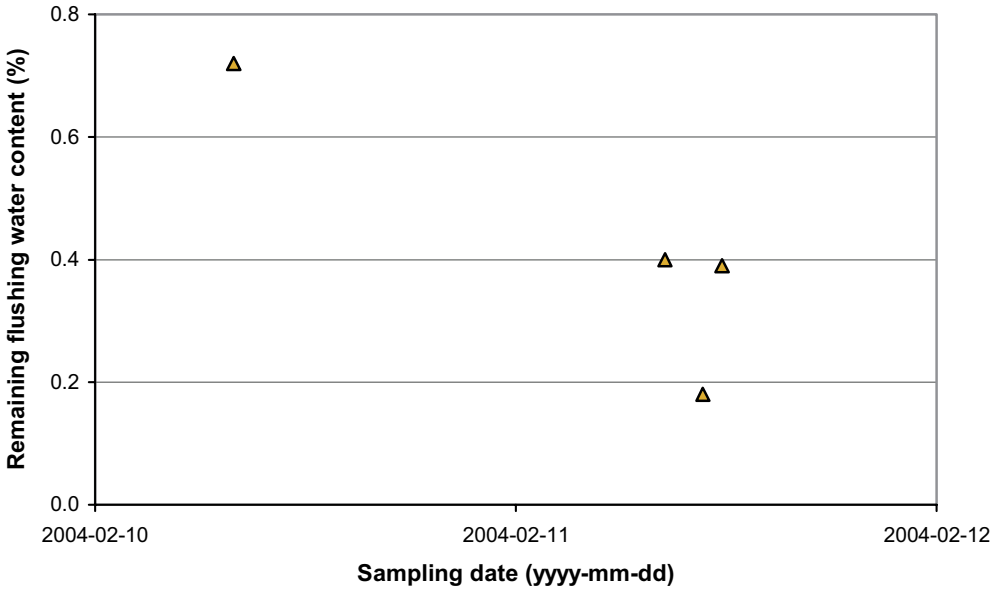

Figure 5-2. *Flushing water content in samples collected in section 957.2–958.2 m sections sampled using the SWIW equipment in KSH02A.*

The iron concentrations determined by ICP-AES (total Fe) and by spectrophotometry (Fe(+II) and Fe-tot) are compared in Figure 5-3.

Sulphate analysed by ion chromatography (IC) is compared to sulphate determined as total sulphur by ICP-AES in Figure 5-4. As shown, there is a satisfactory agreement.

The chloride concentrations are plotted versus the corresponding electric conductivity values in Figure 5-5. The plot gives an approximate indication that the values are reasonable. The data from the borehole sections agree well with earlier data from the Äspö Hard Rock Laboratory.

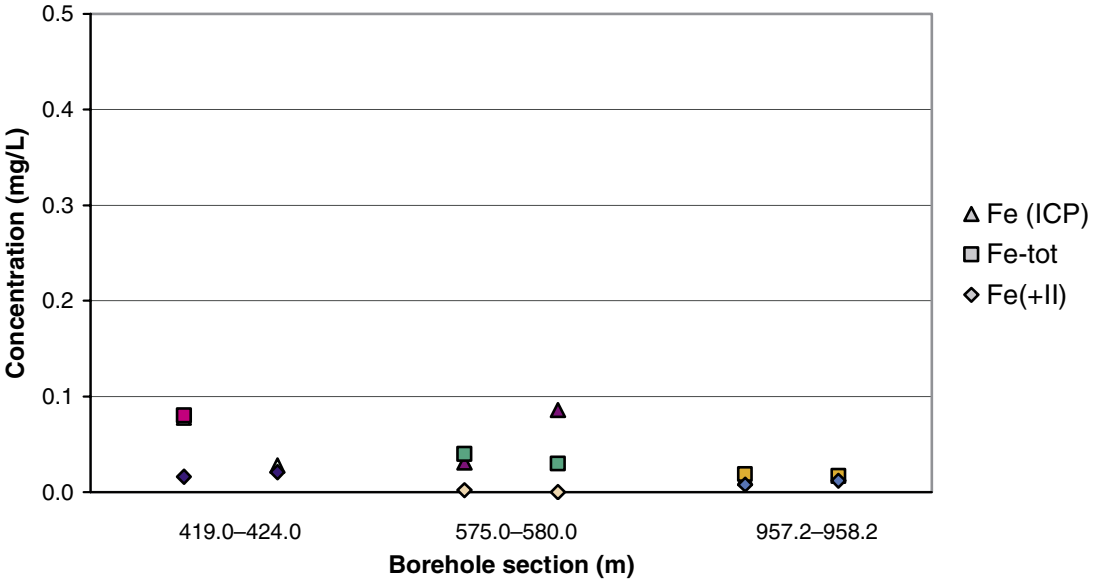

Figure 5-3. *Comparison of iron concentrations in the three borehole sections obtained by ICP-AES and spectrophotometry, respectively.*

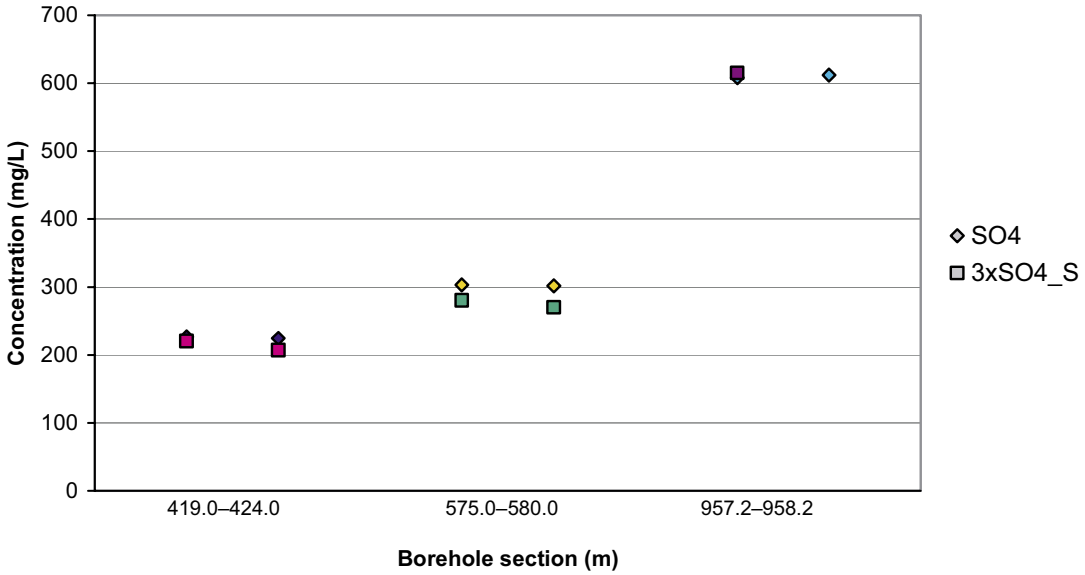

Figure 5-4. *Sulphate (SO_4 by IC) compared to sulphate calculated from total sulphur ($3 \times SO_4$–S by ICP).*

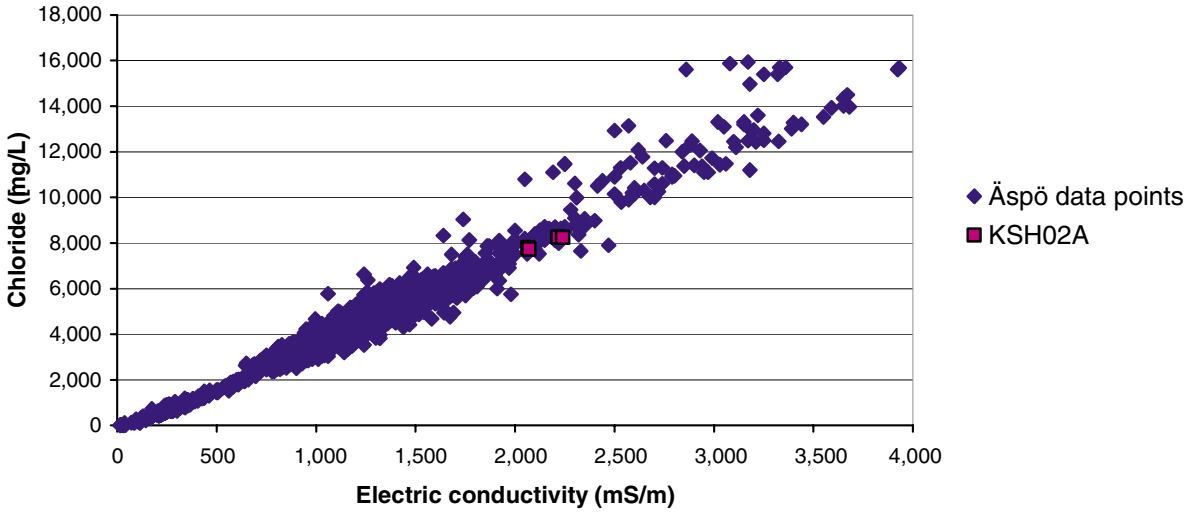

Figure 5-5. *Chloride concentration versus electric conductivity. Data from earlier investigations at the Äspö Hard Rock Laboratory are used to show the trend. Data from KSH02A are consistent with earlier values.*

5.2 Trace elements (rare earth metals and others)

The analyses of trace and rare earth metals include U, Th, As, Sc, Cd, Hg, V, Rb, Y, Zr, In, Sb, Cs, Ba, La, Hf, Tl, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb and Lu. Commonly occurring metals, such as Cu, Zn, Pb and Mo are not included in the analysis programme due to contamination considerations. The trace element data are compiled in Appendix 2, Table A2-3.

5.3 Stable and radioactive isotopes

The isotope determinations include the stable isotopes δD, $\delta^{18}O$, $^{10}B/^{11}B$, $\delta^{34}S$, $\delta^{13}C$, $\delta^{37}Cl$ and $^{87}Sr/^{86}Sr$ as well as the radioactive isotopes Tr (TU), ^{14}C (pmC), ^{238}U, ^{235}U, ^{234}U, ^{232}Th, ^{230}Th, ^{226}Ra and ^{222}Rn. The isotope data are compiled in Appendix 2, Table A2-2 and Table A2-4. Determinations for $\delta^{13}C$ and C^{14} (pmC) are yet to be reported from the laboratory at the time of preparing this report.

The tritium and $\delta^{18}O$ results from sections 419.0–424.0 m, 575.0–580.0 m and 957.2–958.2 m are presented in Figure 5-6. The tritium content was below the detection limit (0.8 Tritium Units, 0.4±0.4 Tritium Units) in all samples. The $\delta^{18}O$ ratios are approximately the same in the samples from the two sections sampled during PSS pumping i.e. section 419.0–424.0 and 575.0–580.0 m and slightly higher in section 957.2–958.2 samples during the SWIW-measurements.

A comparison between re-calculated uranium and thorium isotope determinations and ICP-analyses of the elements is given in Table 5-1. The isotopes uranium-238 and thorium-232 are converted to element concentrations. All thorium determinations were below the detection level. Generally, values of the same order of magnitude from the different methods indicate a satisfactory agreement.

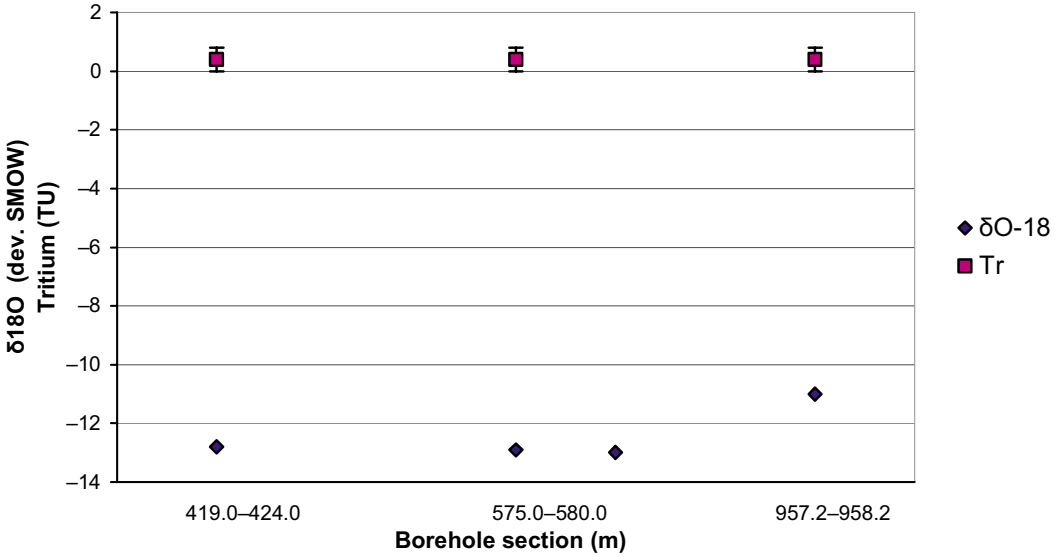

Figure 5-6. *Tritium and $\delta^{18}O$ data from samples collected in three sections in the core drilled borehole KSH02A.*

Table 5-1. Comparison of isotope determinations (^{238}U and ^{232}Th) and ICP- analyses of the elements uranium and thorium[(1)].

Borehole section (m)	Sample no	Date	U (µg/L)	U (µg/L) [(2)]	Th (µg/L)	Th[(3)] (µg/L)
419.0–424.0	5810	2003-09-05	0.571	< 4	< 0.2	< 12.7
575.0–580.0	5856	2003-09-15	0.095	< 4	< 0.2	< 12.7
957.2–958.2	7113	2004-02-11	< 0.01	< 4	< 0.4	< 12.7

(1) The following expressions are applicable to convert activity to concentration, for uranium-238 and thorium-232: 1 ppm U = 12.4 Bq/kg^{238}U and 1 ppm Th = 3.93 Bq/kg^{232}Th
(2) recalculated from ^{238}U (mBq/L)
(3) recalculated from ^{232}Th (mBq/L)

6 Summary

This report summarises the results obtained from the chemical sampling in three sections in KSH02A during September 2003–February 2004.

The data set is not complete. Some results from the chemical sampling in KSH02A are still to be received from consulted laboratories at the time of preparing this report. The missing results include the determination of isotopes $\delta^{13}C$, $\delta^{37}Cl$ and ^{14}C (pmC) for all sections as well as the control analysis of uranium isotopes from section 575.0–580.0 m.

The control sample from section 419.0–424.0 m, SKB:no 5811, had a charge balance error that exceeded the acceptable level of ± 5%. This was probably due to a low concentration of calcium. The difference in concentration between the two samples in the section was approximately 1,000 mg/L.

7 References

/1/ **Ludvigsson J-E, Levén J, Källgården J, 2004.** Oskarshamn site investigation. Single-hole injection tests in borehole KSH02. SKB P-04-XX (in progress). Svensk Kärnbränslehantering AB.

/2/ **Gustafsson E, Gröhn S, Lindgren D, Segerbäck D, 2004.** Oskarshamn site investigation. Ground water flow measurements and SWIW tests with borehole probe dilution equipment in borehole KSH02. SKB P-04-XX (in progress). Svensk Kärnbränslehantering AB.

Appendix 1

Sampling and analysis methods

Table A1-1. Sample handling routines and analysis methods.

Constituent group	Constituent/ element	Sample container (material)	Volume (mL)	Filtering	Preparation/ Conservation*	Analysis method	Laboratory***	Analysis within - or delivery time to lab.
Anions 1	HCO3 pH(lab) cond (lab)	Plastic	250	Yes	No	Titration Pot. meas, Cond. meas	Äspö:s chemistry lab. AnalyCen	The same day – maximum 24 hours
Anions 2	Cl, SO4, Br-, F-, I-	Plastic	100	Yes	No	Titration (Cl-) IC (Cl-, SO4, Br-, F-) ISE (F-)	Äspö:s chemistry lab. AnalyCen	Not critical (month)
	Br, I	Plastic	100	Yes	No	ICP MS	Paavo Ristola OY Analytica AB	Not critical (month)
Cations, Si and S according to SKB class 4 and 5	Na, K, Ca, Mg, S(tot), Si(tot), Fe, Mn, Li, Sr	Plastic (Acid washed)	100	Yes (immediately)	Yes (1mL HNO3)	ICP-AES ICP-MS	Analytica AB AnalyCen	Not critical (month)
Fe(II), Fe(tot)	Fe(II), Fe(tot)	Plastic (Acid washed)	500	Yes	Yes (5 mL HCl)	Spectrophotometry Ferro-zine method	Äspö:s chemistry lab.	As soon as possible the same day
Hydrogen sulphide	HS-	Glass (Winkler)	About 120×2	No	Ev 1 mL 1 M NaOH+ 1 mL 1M ZnAc	Spectrophotometry	Äspö:s chemistry lab. AnalyCen	Immediately or, if conserved, a few days
Nutrient salts	NO2, NO3+NO2, NH4, PO4	Plastic	250	No	No	Spectrophotometry	Äspö:s chemistry lab. AnalyCen	Maximum 24 hours
Environmental metals	Al, As, Ba, B, Cd, Co, Cr, Cu, Hg, Mo, Ni, P, Pb, V, Zn	Plastic	100	Yes	Yes (1 mL HNO3)	ICP-AES ICP-MS	Analytica AB AnalyCen	Not critical (month)
Lantanoids, U, Th, and others.	Sc, Rb, Y, Zr, I, Sb, Cs, La, Hf, Tl, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, U, Th	Plastic	100	Yes	Yes (1 mL HNO3)	ICP-AES ICP-MS	Analytica AB AnalyCen	Not critical (month)

Component group	Component/ element	Sample container (material)	Volume (mL)	Filtering	Preparation/ Conservation*	Analysis method	Laboratory**	Analysis within - or delivery time to lab.
Dissolved organic Carbon, dissolved inorganic Carbon	DOC, DIC	Plastic	250 25	Yes	Frozen, transported in isolated bag	UV oxidation, IR Carbon analysator Shimadzu TOC5000	Paavo Ristola OY Dept. of System ecology, SU	Short transportation time.
Total organic Carbon	TOC	Plastic	250 25	No	Frozen, transported in isolated bag	UV oxidation, IR Carbon analysator Shimadzu TOC5000	Paavo Ristola OY Dept. of System ecology, SU	Short transportation time
Environmental isotopes	∂2H, ∂18O	Plastic	100	No	- -	MS	IFE	Not critical (month)
Tritium,	3H (enhanced.)	Plastic (dry bottle)	500	No	-	LSC	Univ. of Waterloo	Not critical (month)
Chlorine-37	∂37Cl	Plastic	100	No	-	ICP MS		
Carbon isotopes	∂13C, pmC (14C)	Glass (brown)	100×2	No	-	(A)MS	Univ. of Waterloo The Ångström laboratory, Uppsala	A few days
Sulphur isotopes	∂34S	Plastic	500 –1,000	Yes	-	Combustion, ICP MS	IFE	No limit
Strontium-isotopes	87Sr/86Sr	Plastic	100	Yes	-	TIMS	IFE	Days or Week
Uranium and Thorium isotopes	234U, 235U, 238U, 232 Th, 230Th,	Plastic	50	No	-	Chemical separat. Alfa/ gamma spectrometry	IFE Analytica AB	No limit
Boron isotopes	10B/11B	Plastic	100	Yes	Yes (1 mL HNO3)	ICP – MS	Analytica AB	No limit
Radon and Radium isotopes	222Rn, 226Ra	Plastic	500	No	No	EDA, RD-200	IFE	Immediate transport
Archive samples with acid	-	Plastic (washed in acid)	100×2	Yes	Yes (1 mL HNO3)	-	-	Storage in freezer
Archive samples without acid	-	Plastic	250×2	Yes	No	-	-	Storage in freezer

* Suprapur acid is used for conservation of samples.
** Full name and address is given in Table A1-2.

Abbreviations and definitions

IC	Ion chromatograph
ISE	Ion selective electrode
ICP-AES	Inductively Coupled Plasma Atomic Emission Spectrometry
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
INAA	Instrumental Neutron Activation Analysis
MS	Mass Spectrometry
LSC	Liquid Scintillation Counting
(A)MS	(Accelerator) Mass Spectrometry
GC	Gas Chromatography

Table A1-2. Participant laboratories.

Äspö water chemical laboratory (SKB)
Inainööritoimisto Paavo Ristola Oy Teollisuus-ja Voimalaitoskemia Rajantorpantie 8, C-talo 01600 Vantaa FINLAND
Dept. of System ecology Stockholm University 10691 Stockholm
Analytica AB Aurorum 10 977 75 Luleå
Environmental Isotope Laboratory Dep. Of earth sciences University of Waterloo Waterloo, Ontario N2L 3G1 CANADA
Institutt for energiteknik (IFE) Insituttveien 18 P.O Box 40 2027 Kjeller NORGE
AnalyCen Nordic AB Box 905 531 19 Lidköping
The Ångström laboratory Box 534 Se-751 21 Uppsala

Appendix 2

Table A2-1. Water Composition.

Idcode	Secup m	Seclow m	Sample no	Sampling date and time	Charge Bal %	Na mg/L	K mg/L	Ca mg/L	Mg mg/L	HCO_3^- mg/L	Cl^- mg/L	SO_4^{2-} mg/L	SO_4-S mg/L	Br^- mg/l	F^- mg/L	Si mg/L	Fe mg/L
KSH02A	419.00	424.00	5805	2003/09/02 13:25		–	–	–	–	–	–	–	–	–	–	–	–
KSH02A	419.00	424.00	5806	2003/09/03 09:00		–	–	–	–	–	–	–	–	–	–	–	–
KSH02A	419.00	424.00	5807	2003/09/04 07:15		–	–	–	–	–	–	–	–	–	–	–	–
KSH02A	419.00	424.00	5809	2003/09/05 07:40		–	–	–	–	–	–	–	–	–	–	–	–
KSH02A	419.00	424.00	5810	2003/09/05 12:15	–1.4	3,100	9.81	1,710	11.1	5	7,803.2	226.74	73.5	59.1	1.27	3.9	0.078
KSH02A	419.00	424.00	5811	2003/09/05 12:40	–13.3	3,100	11	730	9.7	8	7,733.2	224.35	69	59.3	1.32	3.3	0.028
KSH02A	575.00	580.00	5812	9/9/03 22:47		–	–	–	–	–	–	–	–	–	–	–	–
KSH02A	575.00	580.00	5813	9/10/03 9:15		–	–	–	–	–	–	–	–	–	–	–	–
KSH02A	575.00	580.00	5814	9/11/03 7:43		–	–	–	–	–	–	–	–	–	–	–	–
KSH02A	575.00	580.00	5815	9/12/03 7:45		–	–	–	–	–	–	–	–	–	–	–	–
KSH02A	575.00	580.00	5855	9/15/03 7:28		–	–	–	–	–	–	–	–	–	–	–	–
KSH02A	575.00	580.00	5856	2003/09/15 07:35	–1.7	3,310	10.2	1,790	7.3	6	8,262.3	303.21	93.4	67.16	1.22	3.9	0.031
KSH02A	575.00	580.00	5857	2003/09/15 08:10	–4.9	3,400	16	1,400	7.2	6	8,245.5	301.58	90	66.75	1.17	3.4	0.086
KSH02A	957.20	958.20	7111	2004/02/10 07:55		–	–	–	–	–	–	–	–	–	–	–	–
KSH02A	957.20	958.20	7112	2004/02/11 08:30		–	–	–	–	–	–	–	–	–	–	–	–
KSH02A	957.20	958.20	7113	2004/02/11 10:40	–4.6	4,630	14.5	4,930	4.8	7	16,800	608	205	139	< 0.2	4.3	0.015
KSH02A	957.20	958.20	7114	2004/02/11 11:45		xxx	xxx	xxx	xxx	7	16,800	612	xxx	140	< 0.2	xxx	xxx

– = Not analysed.
A = Results will be reported later.
x = No result due to sampling problems.
xx = No result due to analysis problems.
xxx = Sample stored in freezer.
< ”value” = result less than detection limit.

Cont.

Fe-tot mg/L	FeII mg/L	Mn mg/L	Li mg/L	Sr mg/L	I^- mg/L	pH	DOC mg/L	TOC mg/L	HS^- mg/L	Drill_water %	ElCond mS/m	NO_2N mg/L	NO_3N mg/L	NO_2NO_3N mg/L	NH_4N mg/L	PO_4P mg/L
–	–	–	–	–	–	–	–	–	–	2.34	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	3.49	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	2.37	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	1.89	–	–	–	–	–	–
0.080	0.016	0.13	0.366	26.7	0.327	6.83	< 1	1	xx	1.48	2,065	< 0.002	< 0.01	< 0.01	0.015	< 0.005
0.064	0.021	0.09	0.380	28	–	7.87	–	–	0.03	1.53	2,070	–	–	–	0.015	–
–	–	–	–	–	–	–	–	–	–	1.63	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	0.15	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	0.12	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	0.17	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	0.15	–	–	–	–	–	–
0.04	0.002	0.14	0.359	28.9	0.353	8.13	< 1	< 1	–	0.13	2,216	< 0.002	< 0.01	< 0.01	0.005	< 0.005
0.03	< 0.005	0.11	0.470	27	–	8.07	0.5	0.4	< 0.02	0.13	2,240	< 0.002	< 0.01	< 0.01	0.008	< 0.005
–	–	–	–	–	–	–	–	–	–	0.72	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	0.40	–	–	–	–	–	–
0.019	0.008	0.06	0.864	88.2	0.404	8.42	A	A	0.02	0.18	4,140	< 0.002	< 0.01	< 0.01	0.003	0.001
0.017	0.012	xxx	xxx	xxx	xxx	8.41	xxx	xxx	0.03	0.39	4,090	xxx	xxx	xxx	0,003	xxx

– = Not analysed.
A = Results will be reported later.
x = No result due to sampling problems.
xx = No result due to analysis problems.
xxx = Sample stored in freezer.
< ”value” = result less than detection limit.

Table A2-2. Isotopes I (H-, O-, B-, S-, Cl- and C-isotopes).

Idcode	Secup m	Seclow m	Sample no	Sampling date	δ^2H dev SMOW	^{3}H TU	δ^{18}O dev SMOW	^{10}B/^{11}B no unit	δ^{34}S dev CDT	δ^{13}C dev PDB	^{87}Sr/^{86}Sr no unit	^{14}C pmC	δ^{37}Cl dev SMOC
KSH02A	419.00	424.00	5810	2003/09/05 12:15	–93.8	< 0.8	–12.8	0.2291	17.7	A	0.715376	A	A
KSH02A	419.00	424.00	5811	2003/09/05 12:40	–	–	–	–	–	–	–	–	–
KSH02A	575.00	580.00	5856	2003/09/15 07:35	–93.4	< 0.8	–12.9	0.2278	17.1	A	0.715307	A	A
KSH02A	575.00	580.00	5857	2003/09/15 08:10	–91.3	–	–12.99	–	16.6	–	–	–	–
KSH02A	957.20	958.20	7113	2004/02/11 10:40	–73.0	< 0.8	–11.0	0.2376	15.3	A	0.715930	A	A
KSH02A	957.20	958.20	7114	2004/02/11 11:45	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

– = Not analysed
A = results will be reported later
x = No result due to sampling problems
xx = No result due to analytical problems
xxx = Sample stored in freezer
< ”value” = result less than detection limit

Table A2-3. Trace elements.

Idcode	Secup m	Seclow m	Sample no	Sampling date	U ug/L	Th ug/L	As ug/L	Sc ug/L	Cd ug/L	Hg ug/L	V ug/L	Rb ug/L	Y ug/L	Zr ug/L	In ug/L	Sb ug/L
KSH02A	419.00	424.00	5810	2003/09/05 12:15	0.571	< 0.2	< 2	< 0.5	–	–	–	22.6	0.261	< 0.25	< 0.5	0.295
KSH02A	419.00	424.00	5811	2003/09/05 12:40	–	–	–	–	–	–	–	–	–	–	–	–
KSH02A	575.00	580.00	5856	2003/09/15 07:35	0.095	< 0.2	< 2	< 0.5	–	–	–	25	0.274	< 0.25	< 0.5	x
KSH02A	575.00	580.00	5857	2003/09/15 08:10	–	–	–	–	–	–	–	–	–	–	–	–
KSH02A	957.20	958.20	7113	2004/02/11 10:40	< 0.01	< 0.4	< 4	< 1	0.1	< 0.002	< 0.1	62.9	0.949	< 0.5	< 1	x
KSH02A	957.20	958.20	7114	2004/02/11 11:45	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

– = Not analysed
A = Results will be reported later
x = No result due to sampling problems
xx = No result due to analysis problems
xxx = Sample stored in freezer
< ”value” = result less than detection limit

Cont.

Cs ug/L	Ba ug/L	La ug/L	Hf ug/L	Tl ug/L	Ce ug/L	Pr ug/L	Nd ug/L	Sm ug/L	Eu ug/L	Gd ug/L	Tb ug/L	Dy ug/L	Ho ug/L	Er ug/L	Tm ug/L	Yb ug/L	Lu ug/L
2.41	**–**	**< 0.05**	**< 0.05**	**< 0.3**	**< 0.05**	**<0.05**	**< 0.05**	**< 0.05**	**< 0.05**	**< 0.05**	**< 0.05**	**< 0.05**	**< 0.05**	**< 0.05**	**< 0.05**	**< 0.05**	**< 0.05**
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2.5	–	< 0.05	< 0.05	< 0.3	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
5.03	124	0.31	–0.1	< 0.5	< 0.1	<0.1	<0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

– = Not analysed
A = Results will be reported later
x = No result due to sampling problems
xx = No result due to analysis problems
xxx = Sample stored in freezer
< ”value” = result less than detection limit

Table A2-4. Isotopes II (U-, Th, Ra- and Rn-isotopes).

Idcode	Secup m	Seclow m	Sample no	Sampling date	^{238}U mBq/L	^{235}U mBq/L	^{234}U mBq/L	^{232}Th mBq/L	^{230}Th mBq/L	^{226}Ra Bq/L	^{222}Rn Bq/L
KSH02A	419.00	424.00	5810	2003/09/05 12:15	< 50	< 50	< 50	< 50	< 50	–	–
KSH02A	419.00	424.00	5811	2003/09/05 12:40	–	–	–	–	–	–	–
KSH02A	575.00	580.00	5856	2003/09/15 07:35	< 50	< 50	< 50	< 50	< 50	–	–
KSH02A	575.00	580.00	5857	2003/09/15 08:10	A	A	A	–	–	–	–
KSH02A	957.20	958.20	7113	2004/02/11 10:40	< 50	< 50	< 50	< 50	< 50	5.6	913
KSH02A	957.20	958.20	7114	2004/02/11 11:45	xxx	xxx	xxx	xxx	xxx	xxx	xxx

– = Not analysed
A = Results will be reported later
x = No result due to sampling problems
xx = No result due to analysis problems
xxx = Sample stored in freezer
< ”value” = result less than detection limit