# P-06-127

# Oskarshamn site investigation

# Hydro chemical monitoring programme for core drilled boreholes 2005

## Summary of analyses from water sampling

Pia Wacker, Geosigma AB

September 2006

**Svensk Kärnbränslehantering AB**
Swedish Nuclear Fuel
and Waste Management Co
Box 5864
SE-102 40 Stockholm Sweden
Tel 08-459 84 00
+46 8 459 84 00
Fax 08-661 57 19
+46 8 661 57 19

ISSN 1651-4416
SKB P-06-127

# Oskarshamn site investigation

# Hydro chemical monitoring programme for core drilled boreholes 2005

## Summary of analyses from water sampling

Pia Wacker, Geosigma AB

September 2006

*Keywords:* Groundwater, Borehole, Chemical analyses, Isotope determinations, AP PS 400-05-091.

# Abstract

This report summarises water sampling from five sections in permanent installed core-drilled boreholes, KAV01:3, KSH01A:4, KSH01A:7 KSH02:1 and KSH02:4, within the site investigation programme at Oskarshamn. This is the first water sampling performed in the monitoring programme and is planned to be repeated twice every year. The objective is to determine the groundwater composition in the sections instrumented for this purpose.

The results from this activity include groundwater chemistry data in accordance with SKB class 3 chemistry from one section in KAV01 (section 3; 391–434 m), two sections in KSH01A (section 4 and 7; 535–572 and 238–277 m) and two sections in KSH02 (section 1 and 4; 955–963 and 411–439 m). The data were obtained during November 2005.

All analytical data from the activity are stored in the SICADA database.

# Sammanfattning

Denna rapport sammanfattar vattenprovtagning från fem sektioner i de permanent installerade kärnborrhålen KAV01:3, KSH01A:4, KSH01A:7 KSH02:1 och KSH02:4 inom platsundersökningen i Oskarshamn. Denna mätning är den första som genomförts i moniteringsprogrammet, framöver är provtagningen planerad att utföras två gånger per år. Syftet är att bestämma grundvattensammansättningen i samtliga för ändamålet instrumenterade borrhålssektioner.

Resultaten från denna aktivitet inkluderar vattenkemidata enligt SKB kemiklass 3 från en sektion i KAV01 (sektion 3; 391–434 m), två sektioner i KSH01A (sektion 4 och 7; 535–572 och 238–277 m) och två sektioner i KSH02 (sektion 1 och 4; 955–963 och 411–439 m). Proverna är tagna under november 2005.

Alla resultat från vattenanalyserna finns i databasen SICADA.

# Contents

# 1 Introduction

This document reports data collected within the Hydro chemical monitoring programme for core drilled boreholes 2005, which is one of the activities performed within the site investigation at Oskarshamn. The work was carried out in accordance with activity plan AP PS 400-05-091. Controlling documents for performing this activity are listed in Table 1-1. The activity plan and method description are SKB internal controlling documents. The field work was performed during November 2005 and is reported in the database SICADA, traceable using the activity plan number.

The activity includes water sampling from one section in KAV01 (section 3; 391–434 m), two sections in KSH01A (section 4 and 7; 535–572 and 238–277 m) and two sections in KSH02 (section 1 and 4; 955–963 and 411–439 m) according to SKB chemistry class 3 including options of the isotopes deuterium, tritium and O–18. Determination of density and field measurements of pH and temperature were also performed. Archive samples were stored in a freezer. A map showing the investigation site at Oskarshamn including the boreholes KAV01, KSH01A and KSH02 is presented in Figure 1-1.

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

| **Activity plan** | **Number** | **Version** |
|---|---|---|
| Hydrokemiskt moniteringsprogram för kärnborrhål 2005 | AP PS 400-05-091 | 1.0 |
| **Method description** | **Number** | **Version** |
| System för hydrologisk och meterologisk datainsamling | SKB MD 368.010 | 1.0 (2004-05-26) |

***Figure 1-1.*** *Overview of the Oskarshamn site investigation are, including the boreholes KAV01, KSH01A and KSH02.*

# 2 Objective and scope

This report summarises the results from the SKB chemistry class 3 water samples collected within the Hydro chemical monitoring programme for core drilled boreholes 2005, one section in KAV01 and two sections in KSH01A and KSH02 respectively.

According to the general programme for the site investigation area, the core drilled boreholes are monitored. The water sampling is performed in circulation sections that are sealed off using permanently installed packers. The monitoring programme will last at least until the decision about a future repository is made. This activity will present the only water sampling according to Hydro chemical monitoring programme for core drilled boreholes 2005, the first year.

# 3 Equipment

## 3.1 Description of equipment

The water sampling is performed in borehole sections with permanently installed packers. The pump equipment used for the water sampling is schematically presented in Figure 3-1.

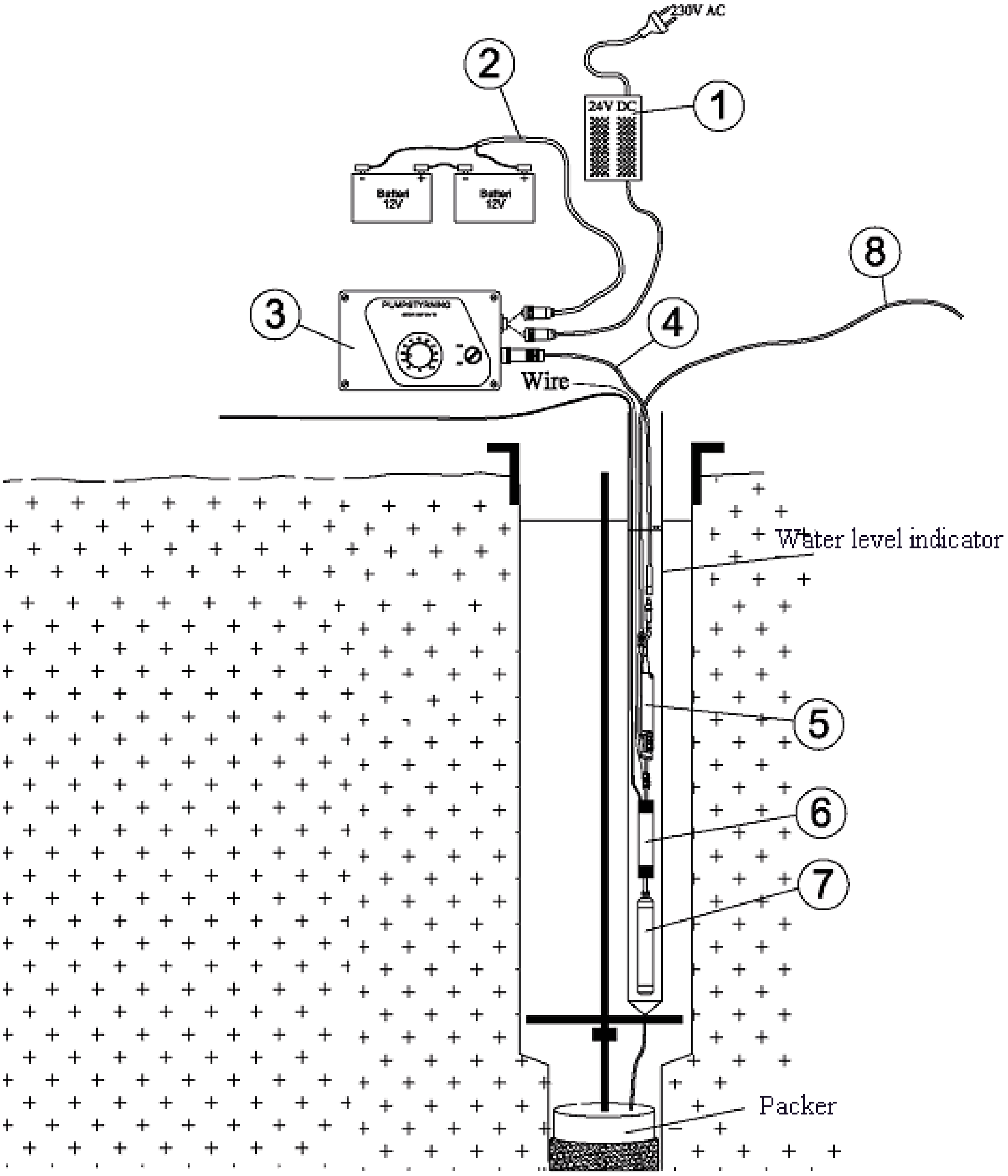

***Figure 3-1.*** *Schematic drawing of the equipment used for water sampling; 1. Battery eliminator 2. Battery cable 3. Pump control GEOPUMP UV 45 4. Pump Cable 5. GEOPUMP UV 45 6. Mini packer 7. Filter holder with filter 8. Pump tube, polyamide 8/6 mm.*

# 4 Execution

## 4.1 General

The water sampling was performed using five identical equipment set-ups, one in each borehole section, a schematic drawing is shown in Figure 3-1. The water volume in the pipe plus the volume in the section should preferably be converted five times, but at least three times before the water sample is taken. The pumping volume is controlled by the down-hole pump. The drawdown is not allowed to exceed 20 m.

All of the pumped water is collected in a tank and emptied onto the rinse plate at Simpevarp.

The activity was performed in accordance with the activity plan AP PS 400-05-091 and following the method description SKB MD 368.010 (System för hydrologisk och metrologisk datainsamling. Vattenprovtagning och utspädningsmätning i observationshål, SKB internal controlling document).

## 4.2 Preparations

The function of each pump was checked using a bucket. The pipes were cleaned, particles were wiped off, before installation in the borehole.

## 4.3 Execution of field work

The water sampling was performed in five sections listed in Table 4-1. The samples were taken after conversion of water in each section, at least three times. For a detailed description see method description SKB MD 368.010 (System för hydrologisk och metrologisk datainsamling. Vattenprovtagning och utspädningsmätning i observationshål, SKB internal controlling document).

The logging interval for water level measurements in the borehole sections was changed to log each 5 minute (2005-11-11) in order to determine the maximal drawdown during the sampling period.

**Table 4-1. Volume in pipe and sections and the desired minimum conversion volume.**

| | **KAV01:3** | **KSH02:4** | **KSH02:1** | **KSH01A:7** | **KSH01A:4** |
|---|---|---|---|---|---|
| Volume, pipe+section (L) | 35.8 | 39.3 | 61.6 | 37.7 | 47.9 |
| Volume x 3 (L) | 107.5 | 117.8 | 184.9 | 113.1 | 143.8 |

The following parameters for each borehole section during the field work are listed in Table 4-2:

- Converted water volume.
- Volume of water sample.
- Drawdown, maximum, during pumping.
- Temperature of water sample measured in the field.
- pH of water sample measured in the field.
- Pump effect, maximum, during pumping.
- Flow during maximum pump effect.
- Date of water sampling.

Pumping was performed twice in KSH02:4, KSH02:1 and KSH01A:4.

The events during the field work are listed in Table 4-3 to 4-7.

After the water sampling, the pumps were left in the borehole sections for Groundwater flow measurements.

**Table 4-2. Sampling conditions.**

| | KAV01:3 | KSH02:4 | KSH02:1 | KSH01A:7 | KSH01A:4 |
|---|---|---|---|---|---|
| Pumped,converted water volume (L) | 227.3 | 265.5 + 470.4 | 259.3 + 243.2 | 232.7 | 102.6 + 165.5 |
| Water sample, volume (L) | 4.6 | 4.6 + 4.6 | 4.6 + 4.6 | 5.0 | 4.6 + 4.6 |
| Maximum drawdown (m.a.s.l.)* | 0.2 | 2.2 and 3.0 | 6.9 and ~5.5 | 0.7 | 6.6 and 12.4 |
| Temperature$_{field}$ | 9.8 | 8.8 | 7.1 | 8.1 | 10.9 |
| pH$_{field}$ | 7.5 | 7.3 | 8.1 | 7.6 | 7.3 |
| Maximum pump effect (%) | 80 | 40 and 50 | 40 and 40 | 40 | 40 and 65 |
| Maximum flow (mL/min) | 570 | 250 and 294 | 260 and ~166 | 280 | 230 and 430 |
| Water sampling date | 2005-11-15 | 2005-11-15<br>2005-11-18 | 2005-11-15<br>2005-11-18 | 2005-11-15 | 2005-11-15<br>2005-11-18 |

* (m.a.s.l.) metre above see level.

**Table 4-3. Events in KAV01, 391–434 m, section 3.**

| Date | Events Improvement/deviation | SKB sample no. |
|---|---|---|
| 2005-11-11 | Deflation of packer. | |
| 2005-11-14 | Installation of pump. | |
| 2005-11-15 | Start of pump. | |
| | Water sampling: SKB class 3. T$_{field}$ = 9.8°C, pH$_{field}$ = 7.48 | 10611 |
| | Stop of pump. | |

### Table 4-4. Events in KSH01A, 238–277 m, section 7.

| Date | Events<br>Improvement/deviation | SKB sample no. |
|---|---|---|
| 2005-11-10 | Deflation of packer. | |
| 2005-11-11 | Installation of pump. | |
| 2005-11-14 | Start of pump. | |
| 2005-11-15 | Water sampling: SKB class 3. $T_{field}$ = 8.1°C, $pH_{field}$ = 7.55 | 10615 |
| | Stop of pump. | |

### Table 4-5. Events in KSH01A, 532–572 m, section 4.

| Date | Events<br>Improvement/deviation | SKB sample no. |
|---|---|---|
| 2005-11-10 | Deflation of packer. | |
| 2005-11-11 | Installation of pump. | |
| 2005-11-15 | Start of pump. | |
| | Water sampling: SKB class 3 (pH, electric conductivity, $HCO_3^-$, $Cl^-$, $SO_4^{2-}$,$Br^-$, $F^-$ and density) $T_{field}$ = 7.5°C, $pH_{field}$ = 6.99 | 10614 |
| | Converted volume, not enough. | |
| 2005-11-18 | Start of pump. | |
| | Water sampling: SKB class 3.<br>$T_{field}$ = 10.9°C, $pH_{field}$ = 7.25 | 10635 |
| | Stop of pump. | |

### Table 4-6. Events in KSH02, 411–439 m, section 4.

| Date | Events<br>Improvement/deviation | SKB sample no. |
|---|---|---|
| 2005-11-10 | Deflation of packer. | |
| 2005-11-11 | Installation of pump. | |
| 2005-11-14 | Start of pump. | |
| 2005-11-15 | Water sampling: SKB class 3. The sample was discarded due to the presence of a smell and an oily film on top of the sample portions. | 10613 |
| | Stop of pump. | |
| 2005-11-17 | Deflation of packer, filter and tube were exchanged. | |
| 2005-11-17 | Start of pump. | |
| | Reduced smell. | |
| 2005-11-18 | Water sampling: SKB class 3.<br>$T_{field}$ = 8.8°C, $pH_{field}$ = 7.31 | 10634 |
| | Stop of pump. | |

**Table 4-7. Events in KSH02, 955–963 m, section 1.**

| Date | Events<br>Improvement/deviation | SKB sample no. |
|---|---|---|
| 2005-11-10 | Deflation of packer. | |
| 2005-11-11 | Installation of pump. | |
| 2005-11-14 | Start of pump. | |
| 2005-11-15 | Water sampling: SKB class 3. The sample was discarded due to the presence of a smell and an oily film on top of the sample portions. | 10612 |
| | Stop of pump. | |
| 2005-11-17 | Deflation of packer, filter and tube were exchanged. | |
| 2005-11-17 | Start of pump. | |
| | Reduced smell. | |
| 2005-11-18 | Water sampling: SKB class 3.<br>Tfield= 7.1°C, pHfield=8.08 | 10633 |
| | Stop of pump. | |

## 4.4 Handling of water analytical data

The following routines for quality control and data management are generally applied for hydrogeochemical analytical 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.

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

- General 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.

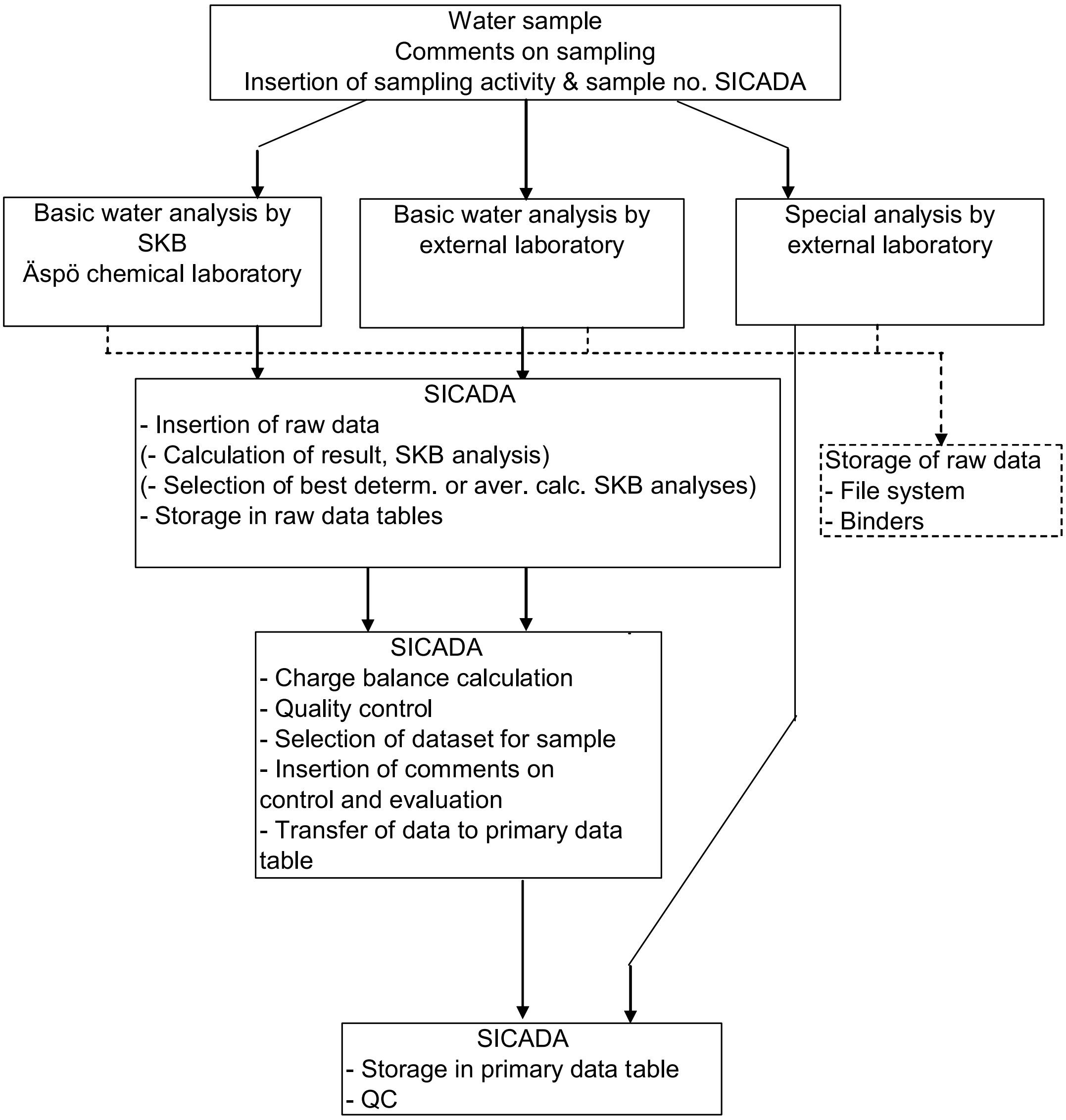

***Figure 4-1.*** *Overview of data management for hydrogeochemical data.*

## 4.5 Water sampling, sample treatment and analyses

The pumped water from the borehole section is conveyed from the pipe into the sample bottles. The sampling bottles consist of one 5 litre plastic can, one acid washed plastic bottle for main components and a bottle for tritium. Filtration was performed at the Äspö laboratory before portioning into sample bottles. A water sample is defined as groundwater collected during one day and consists of several sample portions, labelled with the same sample number.

An overview of sample treatment and analysis methods is given in Appendix 1. The routines are applicable independently of sampling method or type of sampling object. One sample (10634) was sent for control analysis of main components to a control laboratory.

## 4.6 Nonconformities

Nonconformities during the activity:

- No extra sample for analysis of $Br^-$, from the deepest section in each borehole, was sent for analysis.
- Missing data of Uranine, converted to drill water content, from KAV01:3 and KSH01A:7.
- In KSH01A:4, not enough water was converted before the first sample was taken therefore, a second sample was taken.
- In each of the borehole sections KSH02:4 and KSH02:1 the first samples were discarded due to an oily film on the top of the sample portions, therefore, a second sample was taken in each section.

# 5 Results

The results obtained within this activity are water chemistry data from borehole sections KAV01:3, KSH01A:7, KSH01A:4, KSH02:4 and KSH02:1. The second sampling occasion in KSH01A:4 are denoted KSH01A:4:2. The results from the chemical analysis are presented below. The results are stored in the SICADA data base and are traceable by the activity plan number and sample number. It is the data in the data base that will be used for further interpretation (modelling).

## 5.1 Basic water analyses

The basic water analyses include Na, K, Ca, Mg, Si, Li, S, Sr, $SO_4^{2-}$, $Cl^-$, $HCO_3^-$, $Br^-$ and $F^-$. Furthermore, measurements are made of pH, electrical conductivity, drill water content and density. The basic water analysis data and relative charge balance errors are compiled in Appendix 2, Table A2-1.

The charge balance error gives 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, for KSH01A:7.

The drill water content in the samples collected during the pumping/measurement periods in the borehole sections are compiled in Appendix 2, Table A2-1.

Values of pH from laboratory and field analyses are compared in Figure 5-1.

Sulphate ($SO_4^{2-}$) analysed using ion chromatography (IC) is compared with sulphate determined as total sulphur using inductively coupled plasma atomic emission spectrometry (ICP-AES) in Figure 5-2.

The chloride concentrations are plotted versus the corresponding electric conductivity values in Figure 5-3. 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.

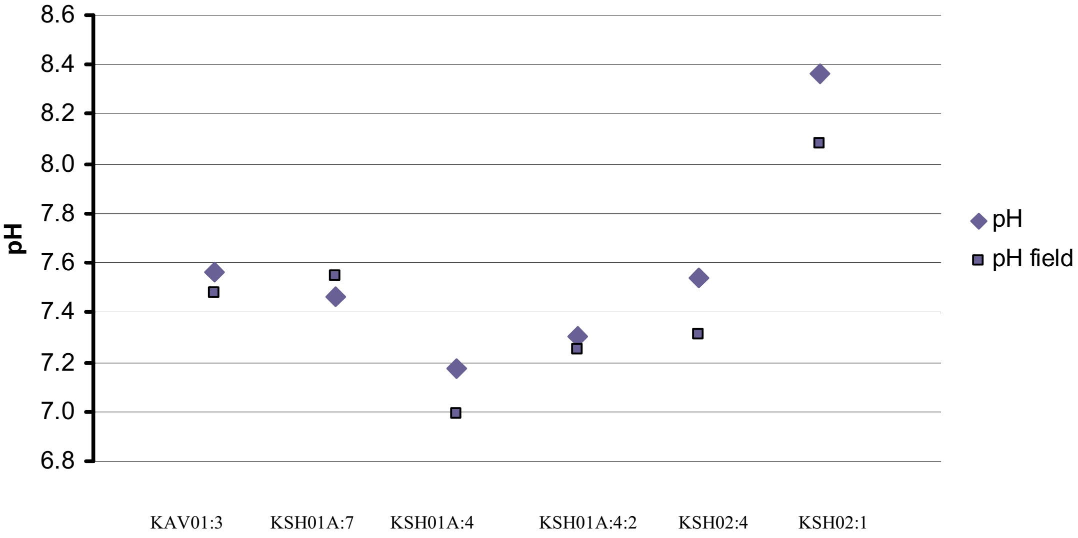

***Figure 5-1.** pH from laboratory and field analyses.*

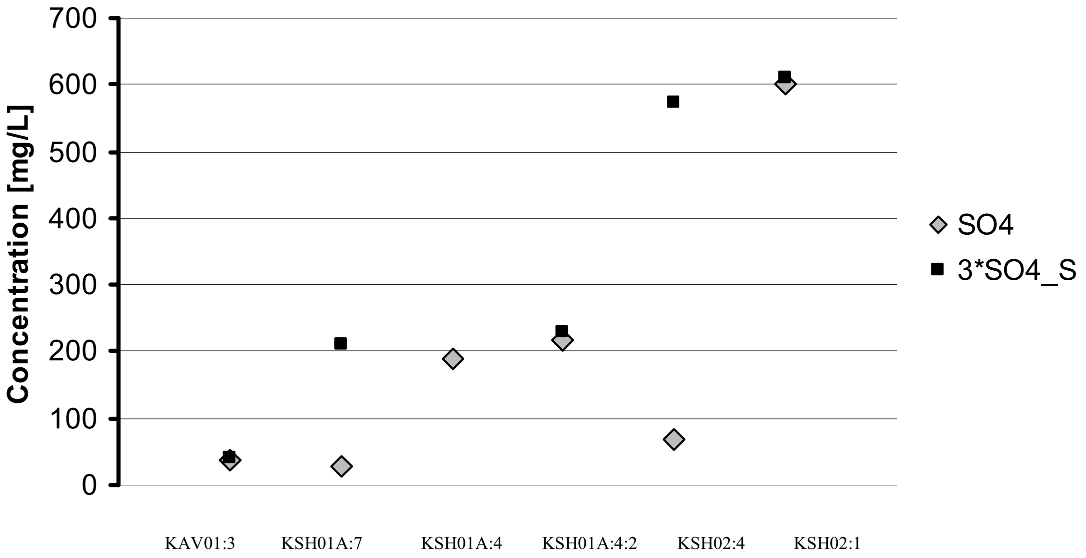

*Figure 5-2. Sulphate ($SO_4$ by IC) data compared to sulphate calculated from total sulphur ($3\times SO_4$-S by ICP) data from samples collected in the investigated sections.*

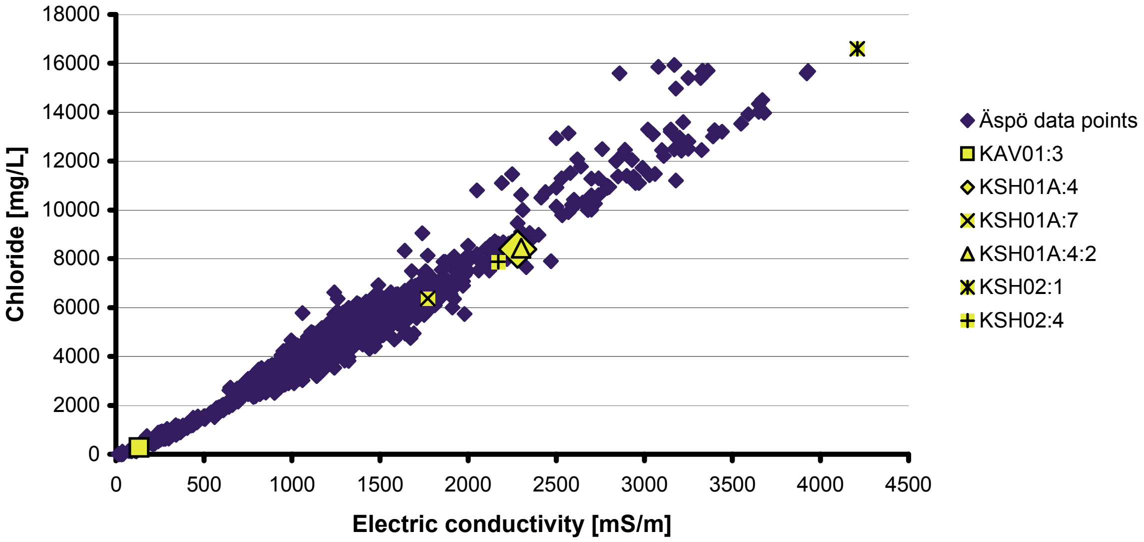

***Figure 5-3.** Chloride concentration versus electrical conductivity. Data from earlier investigations at the Äspö Hard Rock Laboratory are used to show the overall trend.*

## 5.2 Stable and radioactive isotopes

The isotope determinations include the stable isotopes $\delta^{2}H$, and $\delta^{18}O$ as well as the radioactive isotope $^{3}H$ (TU). The isotope data are compiled in Appendix 2, Table A2-2.

The $^{3}H$ and $\delta^{18}O$ results from the investigated sections are presented in Figure 5-4. The $^{3}H$ content was below the detection (BD) limit (0.8 Tritium Units (TU)) in KSH02A, section KSH02:4 and KSH02:1.

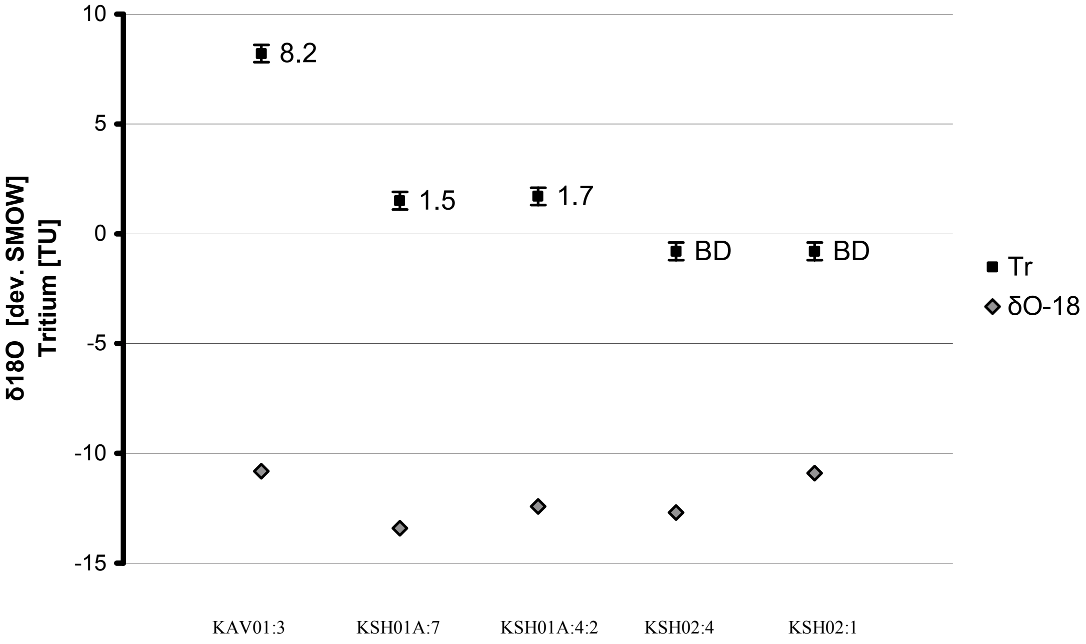

***Figure 5-4.*** *$^{3}H$ and $\delta^{18}O$ data from samples collected in the investigated sections.*

# 6 Summary

- Comparison of the results from different laboratories and/or methods showed agreement in most cases.
- The charge balance error exceeds the acceptable level of ± 5% in one case, for KSH01A:7.
- General judgement of plausibility based on earlier results and experience indicated reasonable values, in most cases.

# Appendix 1

## Sampling and analytical methods

**Table A1-1. Sample handling routines and analytical methods. SKB class 3 chemistry.**

| Analysis | Sample container (material) | Preparation | SKB label | Analysis method | Comment |
|---|---|---|---|---|---|
| pH, conductivity, alkalinity | 250 ml plastic | – | Green | Titration<br>Pot. meas,<br>Cond. meas | Analysed within 24 hours. |
| Anions ($F^-$, $Br^-$, $Cl^-$, $SO_4^{2-}$) | 250 ml plastic | Filtering in connection with analysis | Green | Titration ($Cl^-$)<br>IC ($Cl^-$, $SO_4^{2-}$, $Br^-$, $F^-$)<br>ISE ($F^-$) | |
| Uranine | 100 ml brown glass | – | Green | | |
| Density | 250 ml | – | Green | Pycnometer | |
| Cations: Na, K, Ca, Mg, Si, Li, Sr and S | Analytica's 100 ml acid washed | 1 ml $HNO_3$ suprapur, filtering membrane filter | Red | ICP-AES<br>ICP-MS | |
| Archive samples | 2 × 250 ml plastic | Filtering Pallfilter | Green | | Stored in a freezer. |
| Deuterium, O–18 | 100 ml square plastic | – | Green | MS | |
| Tritium | 500 ml dried plastic | – | Green | LSC | Flooded at least once. |

**Table A1-2. Reporting limits and measurement uncertainties.**

| Component | Method | Detection limit | Reporting limit or range | Unit | Measurement uncertainty[2] | "Total" uncertainty[3] |
|---|---|---|---|---|---|---|
| $HCO_3$ | Alkalinity titration | 0.2 | 1 | mg/L | 4% | <10% |
| $Cl^-$ | Mohr titration | 5 | 70 | mg/L | 5% | <10% |
| $Cl^-$ | IC | 0.2 | 0.5 |  | 6% | 10% |
| $SO_4$ | IC | 0.2 | 0.5 | mg/L | 6% | 15% |
| $Br^-$ | IC | 0.2 | 0.7 | mg/L | 9% | 20% |
| $Br^-$ | ICP | – | 0.001–0.010[1] |  | 15% |  |
| $F^-$ | IC | 0.2 | 0.6 | mg/L | 10% | 20% |
| $F^-$ | Potentiometry | – | – |  | – | – |
| Na | ICP | – | 0.1 | mg/L | 4% | 10% |
| K | ICP | – | 0.4 | mg/L | 6% | 15% |
| Ca | ICP | – | 0.1 | mg/L | 4% | 10% |
| Mg | ICP | – | 0.09 | mg/L | 4% | 10% |
| S(tot) | ICP | – | 0.160 | mg/L | 10% | 15% |
| Si(tot) | ICP | – | 0.03 | mg/L | 4% | 15% |
| Sr | ICP | – | 0.002 | mg/L | 4% | 15% |
| Li | ICP | – | 0.2–2[1] | µg/L | 10% | 20% |
| $\delta^2H$ | MS | – | 2 | ‰ SMOW[4] | 1.0‰ | – |
| $\delta^{18}O$ | MS | – | 0.1 | ‰ SMOW[4] | 0.2‰ | – |
| $^3H$ | LSC | – | 0.8 or 0.1 | TU[5] | 0.8 or 0.1 TU | – |
| Density | Pycnometer | – | – | g/mL | 0.15% | – |

1. Reporting limits at salinity ≤ 0.4% (520 mS/m) and ≤ 3.5% (3,810 mS/m) respectively.
2. Measurement uncertainty reported by consulted laboratory, generally 95% confidence interval.
3. Estimated total uncertainty by experience (includes effects of sampling and sample handling).
4. Per mill deviation[6] from SMOW (Standard Mean Oceanic Water).
5. TU=Tritium Units, where one TU corresponds to a Tritium/hydrogen ratio of $10^{-18}$ (1 Bq/L Tritium = 8.45 TU).
6. Isotopes are often reported as per mill deviation from a standard. The deviation is calculated as:

$\delta^y I = 1{,}000 \times (K_{sample} - K_{standard})/K_{standard}$, where K= the isotope ratio and $^yI$ = $^2H$ or $^{18}O$.

# Appendix 2

## Groundwater chemistry data

**Table A2-1. Water composition.**

| Idcode | Secup m | Seclow m | Sample no. | Sampling date and time | pH field | Temperature field degree Celcius | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KAV01 | 391.00 | 434.00 | 10611 | 2005/11/15 15:24:00 | 7.48 | 9.8 | –1.35 | 163 | 3.94 | 80.3 | 8.7 | 228 | 269 | 38 |
| KSH01A | 238.00 | 277.00 | 10615 | 2005/11/15 16:26:00 | 7.55 | 8.1 | 10.01 | 2,790 | 12.00 | 2,010 | 42.9 | 21 | 6,380 | 27 |
| KSH01A | 532.00 | 572.00 | 10614 | 2005/11/15 16:26:00 | 6.99 | 7.5 | – | – | – | – | – | 39 | 8,390 | 188 |
| KSH01A | 532.00 | 572.00 | 10635 | 2005/11/18 14:35:00 | 7.25 | 10.9 | –2.64 | 2,840 | 11.50 | 2,070 | 42.2 | 22 | 8,440 | 216 |
| KSH02 | 411.00 | 439.00 | 10634 | 2005/11/18 14:05:00 | 7.31 | 8.8 | –3.69 | 2,960 | 11.50 | 1,780 | 12.9 | 96 | 7,880 | 68 |
| KSH02 | 955.00 | 963.00 | 10633 | 2005/11/18 14:05:00 | 8.08 | 7.1 | –0.66 | 4,910 | 14.80 | 5,200 | 5.7 | 7 | 16,600 | 602 |

| Idcode | Secup m | Seclow m | Sample no. | $SO_4$-S mg/L | $Br^-$ mg/l | $F^-$ mg/L | Si mg/L | Fe mg/L | Mn mg/L | Li mg/L | Sr mg/L | pH | Drill_water % | ElCond mS/m | Density g/mL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KAV01 | 391.00 | 434.00 | 10611 | 13.3 | 1.3 | 2.26 | 6.83 | 0.390 | 0.5350 | 0.057 | 0.94 | 7.56 | – | 131 | 0.9971 |
| KSH01A | 238.00 | 277.00 | 10615 | 70.6 | 32.2 | 1.14 | 6.34 | 0.762 | 0.5640 | 0.567 | 34.60 | 7.46 | – | 1,770 | 1.0040 |
| KSH01A | 532.00 | 572.00 | 10614 | – | 57.8 | 1.48 | – | – | – | – | – | 7.17 | – | 2,280 | 1.0067 |
| KSH01A | 532.00 | 572.00 | 10635 | 76.9 | 58.3 | 1.46 | 5.73 | 0.452 | 0.4610 | 0.576 | 35.90 | 7.30 | 12.50 | 2,300 | 1.0066 |
| KSH02 | 411.00 | 439.00 | 10634 | 191.0 | 52.7 | 1.41 | 9.85 | <0.04 | 0.1390 | 0.363 | 30.10 | 7.54 | 16.20 | 2,170 | 1.0055 |
| KSH02 | 955.00 | 963.00 | 10633 | 203.0 | 114.0 | 1.43 | 5.46 | <0.10 | 0.0706 | 0.850 | 96.30 | 8.36 | 0.62 | 4,210 | 1.0172 |

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

| Idcode | Secup m | Seclow m | Sample no | Sampling date and time | $\delta^{2}H$ dev SMOW | $^{3}H$ TU | $\delta^{18}O$ dev SMOW |
|---|---|---|---|---|---|---|---|
| KAV01 | 391.00 | 434.00 | 10611 | 2005/11/15 15:24:00 | –78.3 | 8.2 | –10.8 |
| KSH01A | 238.00 | 277.00 | 10615 | 2005/11/15 16:26:00 | –99.8 | 1.5 | –13.4 |
| KSH01A | 535.00 | 572.00 | 10635 | 2005/11/18 14:35:00 | –89.7 | 1.7 | –12.4 |
| KSH02 | 411.00 | 439.00 | 10634 | 2005/11/18 14:05:00 | –92.8 | <0.8 | –12.7 |
| KSH02 | 955.00 | 963.00 | 10633 | 2005/11/18 14:05:00 | –78.0 | <0.8 | –10.9 |