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Title: Monitoring of groundwater quality in the Norwegian-Finnish border area with Russia. (Status Report 2003)			
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Summary: <p>The Pasvik groundwater-monitoring project started with the establishment of three monitoring stations in Skjellbekken, Svanvik and Karpdalen at the end of September 2003. Skjellbekken station is about 30 km Southwest of Nikel, Svanvik is about 7 km west of Nikel while the Karpdalen is about 25km NNE of Nikel. All three wells are established in quaternary deposits and are equipped with PEH casing suitable for groundwater chemistry monitoring. A total of three samples were collected from each station between October and December 2003. The samples were analysed for cation concentrations by inductively coupled plasma-atomic emission spectrometry (ICP-AES: Si, Fe, Ti, Ti, Mg, Ca, Na, K, Mn, P, Cu, Zn, V, Ba, Sr, Ag, Sc, Y), heavy metals and trace elements by inductively coupled plasma-mass spectrometry (ICP-MS: Al, B, Be, Cd, Co, Cr, Li, Mo, Ni, Pb, Rb, La, Ce, Zr), anions by ion chromatography (IC: Br, Cl, F, NO₃, NO₂, PO₄, SO₄), alkalinity, pH, turbidity and colour. The analysis results can be considered reliable since the ionic charge balance is below 5% for all analyses. The data set is still too small to make any meaningful interpretations and conclusions from the analytical results. However, it can be noted that for most ions and elements, there is not much variation in concentrations with time, but highest concentrations are measured in the Karpdalen well. High values of alkalinity and electrical conductivity are also measured in the Karpdalen well. A comparison of field measurements and laboratory measurements showed comparable EC measurements, indicating no changes in the dissolved substance from the time the samples were collected to the time they were analysed. Two of the pH measurements showed substantial differences between field and laboratory measurements. Otherwise the rest of the measurements are quite comparable. These differences could be due to a number of factors ranging from the sampling procedure to performance of the pH probe or human error.</p>			
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Pollution	Monitoring	Chemical analysis	
Collaboration	Water sample	Report	

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1. INTRODUCTION

Copper-nickel ore smelting at Nickel and Zapolyarniy in the Kola Peninsula of Northwest Russia is the main source of environmental pollution in the border area between Norway, Russia and Finland. Previous studies have not focused on the potential contamination of groundwater from airborne pollution. Focus has been put on soils, air, surface water and vegetation, all of which have shown to be affected by the emissions. Indirect pollution/contamination of groundwater may occur from leaching of these surfaces media. For example, data on snowmelt contribution to groundwater in this area suggests a possible nickel contamination (NGU unpublished data).

It is in this light that the Geological Survey of Norway (NGU) proposed a Norwegian – Finnish collaborative project to monitor groundwater quality in this vulnerable area. Following an agreement between NGU and Fylkesmannen in Finnmark, this project was started on the Norwegian side during the third quarter of 2003.

2. COLLABORATION

The Pasvik project is a collaborative project between Norway and Finland. Contact has been established with our Finnish counterparts from Lapland Regional Environmental Centre (LREC). Long term monitoring background data on groundwater quality from the Nellim station and other groundwater monitoring stations in Finland where needed, will be obtained from LREC for integration with groundwater quality data from the Norwegian side through this cooperation. Details for LREC staff with whom contact has been established, as well as for NGU staff involved in the implementation of this project, are given in Appendix 1. So far no meetings have been held between the collaborating institutions, but it is expected that the formal establishment of the Interreg project will result in such meetings in 2004.

3. FIELDWORK

Groundwater monitoring wells were established and monitored in Skjellbekken area only during the previous studies in the mid-1990s. In order to extend the groundwater-monitoring network in the study area, NGU proposed another two monitoring stations, one in the Svanvik area and one in Karpdalen, in addition to the one in Skjellbekken. The stations were located in the same geological setting i.e. Quaternary deposits and at various distances from the smelters. Fieldwork was carried out in the study area between 24 September and 3 October 2003 in order to establish the two new monitoring wells, check the condition of the existing wells for monitoring purposes, identify and train a local assistant in groundwater sampling and collect the first round of groundwater samples from the 3 monitoring stations.

3.1 Monitoring wells

Out of the 3 stations in Skjellbekken area, station 43 of the Kola Project was chosen for groundwater monitoring and samples will be collected from the deepest well, which is about 12.2m below the surface. It is located at UTM coordinates 596584; 7697488 in zone 35. The well was drilled in Quaternary deposits where sand and fine sand overlay coarse grained deposits. Station 42 was considered too shallow, while station 44 has a 3 m layer

of silt, which may hinder flow of water to the groundwater zone. The well was pumped clean and fitted with a small electric pump, which was left in the well for collection of samples. For the purposes of this project this will be referred to as 'Well 1' (Figure 1).

Following hydrogeological investigations using test drilling at several locations, two groundwater-monitoring wells were drilled in the Quaternary deposits in Svanvik ('Well 2') and Karpdalen ('Well 3') areas, respectively (Figure 1).

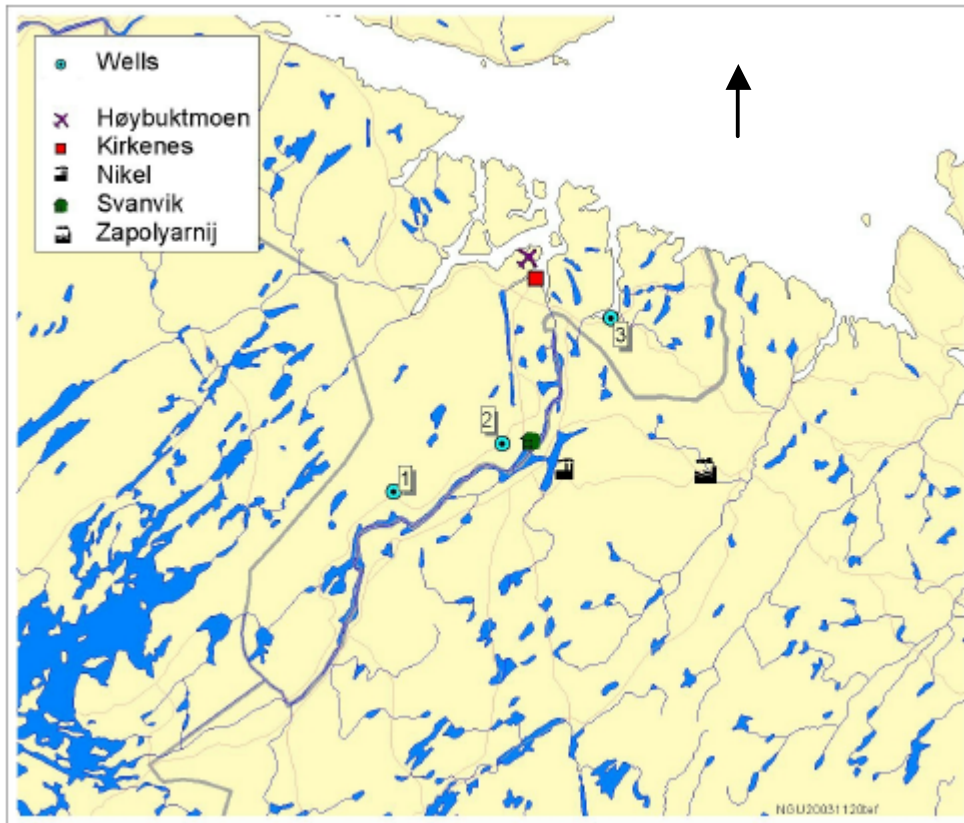


Figure 1 – Location of established groundwater monitoring wells in Norway and location of nickel-copper ore smelters in Russia

The deposits at Well 2 consist of glacial-fluvial sediments (fine sand to sand) overlying esker sediments (gravel), while at Well 3 marine sediments (fine sand and clay) overlay coarse sediments (Figure 2). However, Quaternary deposits in the southern part of the Karpdalen were inaccessible with the drilling rig, thus investigations were limited to the northern parts. Well 2 was drilled to 12.50 m at UTM coordinates (615006; 7707999 in zone 35). The well in Karpdalen (Well 3) was drilled to 11.85 m at UTM coordinates (399657; 7730782 in zone 36). Each well was cased with white PEH tubing and 1 m of screen installed through the monitored interval. The annulus was sealed with bentonite. The design of the wells is shown in Figure 2. Both wells were purged or pumped clean before equipping each of them with a small electric pump and hose for groundwater sampling. The pumps and hose were left in the wells to minimise contamination.

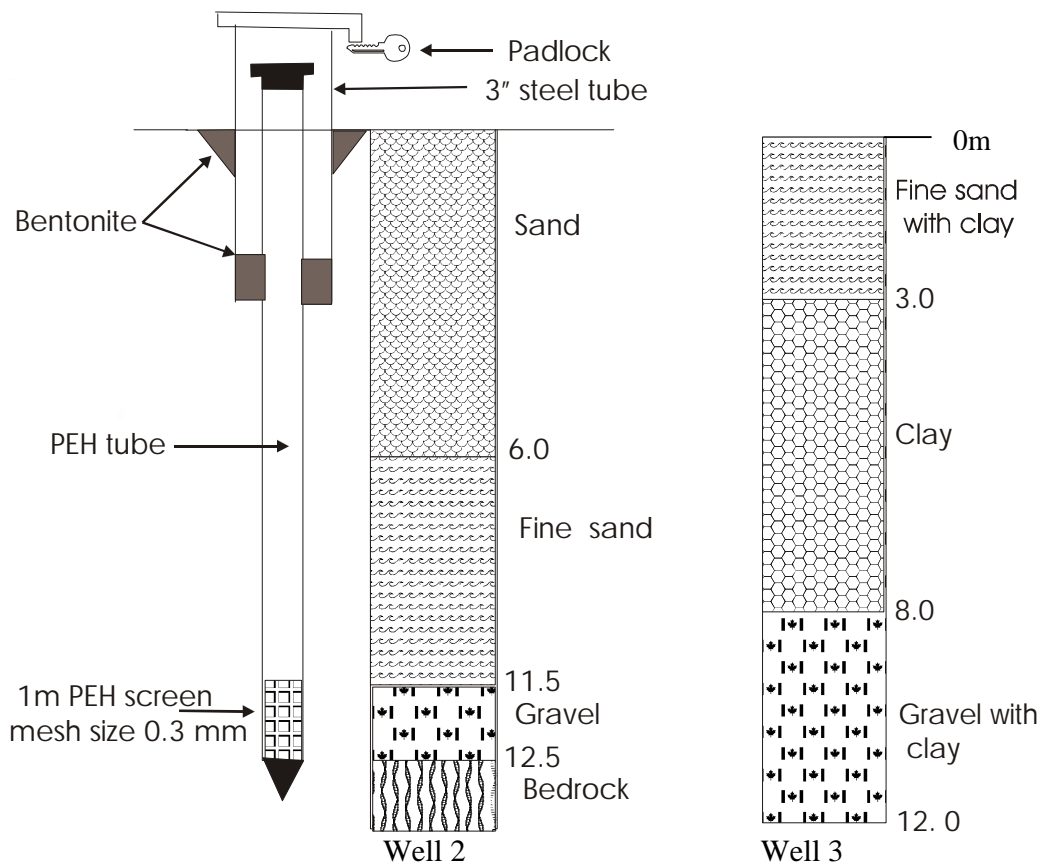


Figure 2: Well design and geological logs

Sediment samples were collected at Well 2 in Svanvik every 3 m during drilling. These were sent to NGU laboratory for grain size analysis from which hydraulic parameters (e.g. hydraulic conductivity) will be estimated. Results of grain size analysis of sediments from Well 1 carried out during the Kola Project will be used in this project. Sediment sampling at Well 3 was impossible because of the high clay and water content, which resulted in muddy material.

4. GROUNDWATER SAMPLING

The first groundwater samples were taken soon after establishment of the monitoring wells (first week of October). A sample from each well includes three sub samples: 1) 500 ml of unfiltered, unacidified water for analysis of physical parameters, 2) 100 ml filtered but unacidified water for analysis of anions, and 3) 100 ml of filtered water, acidified with 1 ml super-pure (65%) nitric acid for cation and metal analysis. Sample bottles were pre-acidified in order to reduce field errors and the risk of moving around with toxic acid. Physical parameters, such as water level, EC, temperature and pH, were also measured in the field.

A local assistant was identified and trained in groundwater sampling procedures in order to reduce operations costs. Groundwater samples were collected in the first week of every month until the end of the year according to the 2003 groundwater sampling programme. A total of 3 samples were collected from each station during 2003.

5. CHEMICAL ANALYSIS

All samples were analysed at NGU laboratory for cation concentrations by inductively coupled plasma-atomic emission spectrometry (ICP-AES: Si, Fe, Ti, Mg, Ca, Na, K, Mn, P, Cu, Zn, V, Ba, Sr, Ag, Sc, Y), heavy metals and trace elements by inductively coupled plasma-mass spectrometry (ICP-MS: Al, B, Be, Cd, Co, Cr, Li, Mo, Ni, Pb, Rb, La, Ce, Zr), anions by ion chromatography (IC: Br, Cl, F, NO₃, NO₂, PO₄, SO₄), alkalinity, pH, turbidity and colour.

5.1 Comparison of laboratory data and field data

EC and pH were measured both in the field and in the laboratory. EC measurements are particularly useful as a control on analysis and conservation of samples (Appelo & Postma, 1996). Figures 3 and 4 show a comparison of field measurements and laboratory measurements.

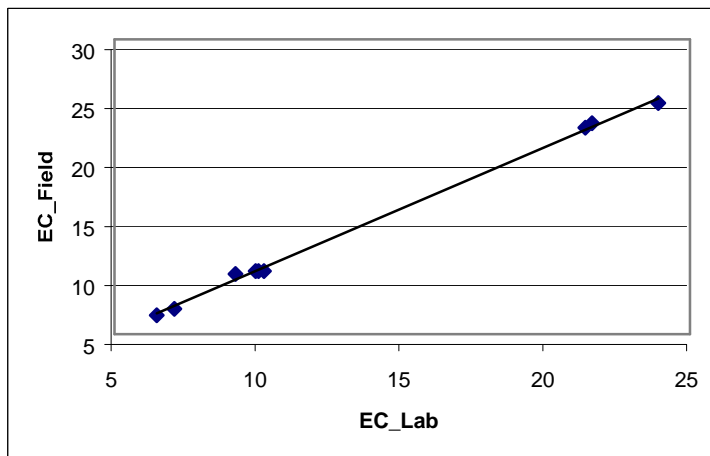


Figure 3: Comparison of EC measurements

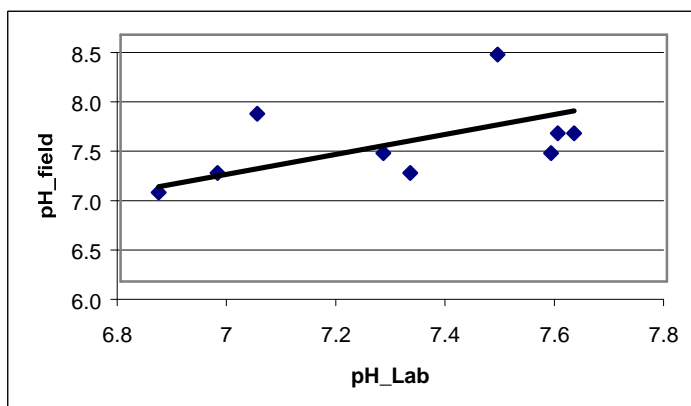


Figure 4: Comparison of pH measurements

Figure 3 shows clearly that EC measurements in the laboratory and in the field are close to each other, meaning there was no major changes in the dissolved substance from the time samples were collected to the time they were analysed. However, Figure 4 shows that there is a substantial difference in the pH measurements resulting from two measurements from Svanvik and Skjellbekken respectively. The differences in these two measurements could be due to a number of factors ranging from sampling procedure to performance of electrode or simply human error.

The accuracy of chemical analysis can be estimated from charge balance of major ions, which was calculated to be below 5% for all analyses. Therefore the analyses are regarded as reliable.

5.2 Analysis of Results

Except for ICP-MS results for December samples, all chemical analysis results of the 3 sets of samples collected in 2003 have been received and are shown in Appendix 2. The dataset is still too small to make any meaningful interpretation and conclusions from the results. However, it can be noted that for most ions and elements, there is not much variation in concentration levels with time, but highest concentrations are being measured at well 3 in Karpdalen compared to the other wells (Appendix 3). ICP-AES results for the December samples have been used for trace elements whose concentrations are above detection limit of this method, otherwise the December measurement is not shown on the graphs. High values of alkalinity and electrical conductivity were also measured at well 3. The high turbidity and colour values at well 3 can be explained in terms of the aquifer formation which is clayey-gravel. Figures 5 and 6 show that the waters in all wells are becoming clearer and less turbid with time.

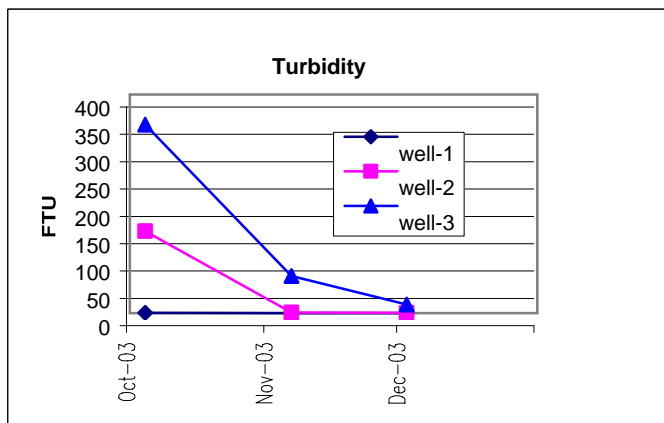


Figure 5: Turbidity of groundwater in the monitoring wells

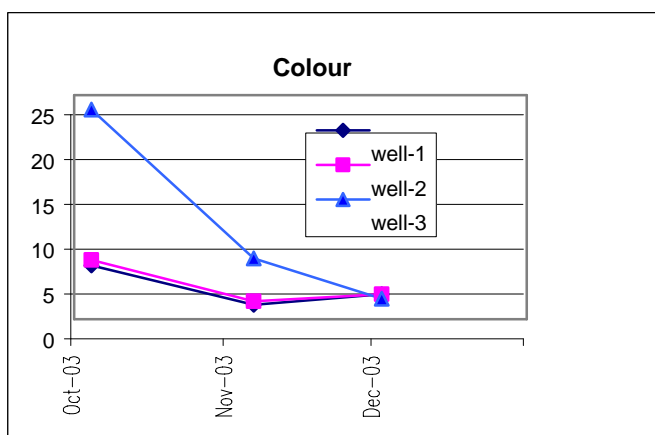


Figure 6: Colour of groundwater in the monitoring wells

It must be noted that for interpretation and presentation purposes, half the detection limit value was used where parameter values were below detection limit.

6. FINANCIAL STATUS

The financial status of the project in terms of money used as at the end of year 2003 is given in Table 1 below.

Table 1: Project expenditure for 2003

	EURO	NOK
Project personell	23 443	197 416
External personell	12 770	107 539
Administrative costs	1 811	15 250
Material cost	1 157	9 746
Investments	1 990	16 760
Travelling	5 089	42 854
Total spend	46 260	389 565

EURO 1 = NOK 8,421 (as at 01.01.2004)

7. REFERENCES

Appelo, C.A.J. & Postma, D. (1996): Geochemistry of groundwater and pollution, A. A.Balkema, Rotterdam, The Netherlands.

8. NORWEGIAN SUMMARY

Overvåkning av grunnvannskvalitet i de norsk-finske grenseområdene mot Russland. Statusrapport - 2003.

Kobber-nikkel smelteverkene ved Nickel og Zapoljarnij på Kolahalvøya i Nordvest-Russland er hovedkilden til miljøforurensning i grensetraktene mellom Norge, Finland og Russland. I de ulike kartleggings-/overvåkningsprosjektene som har vært utført i området, har grunnvannskvaliteten fått relativt liten oppmerksomhet, selv om påvist luftbåren forurensning i jord, overflatevann og vegetasjon vil kunne infiltrere ned til grunnvannet.

Norges geologiske undersøkelse (NGU) foreslo derfor et norsk-finsk prosjekt for å overvåke grunnvannskvaliteten i dette sårbare området. Etter avtale med Fylkesmannen i Finnmark startet prosjektet på norsk side i 3. kvartal 2003.

To nye stasjoner for grunnvannsovervåkning er blitt etablert i henholdsvis Svanvik og Karpdalen i tillegg til at en tidligere NGU-stasjon ved Skjellbekken er reaktivert (se figur 1). Arbeidet pågikk mellom 24. september og 3. oktober og omfattet hydrogeologisk kartlegging og valg av lokaliteter, bestemmelse av prøvedyp, nedsetting og klargjøring av overvåkningsbrønner, prøvetaking av sedimenter for kornfordelingsanalyse, opplæring av lokalt mannskap fra Svanhovd Miljøsenler for grunnvannsprøvetaking samt første prøvetakingsrunde.

Brønnene består av hvite polyeten rør med filteråpning over 1 meters lengde. Toppen er forseglet med bentonitt og hver brønn er permanent utrustet med en liten elektrisk pumpe og egen slange for å begrense mulig forurensning dersom utstyret hadde måttet flyttes rundt.

Grunnvannsnivå, elektrisk ledningsevne, pH og temperatur ble målt i felt. Tre prøveflasker ble fylt med vann fra hver stasjon for analyse av henholdsvis fysikalske parametre, kationer og anioner ved NGU-lab.

Den lokale assistenten gjennomførte andre og tredje prøvetakingsrunde i første uke av november og desember måned i 2003. Resultatene av vannanalysene foreligger (appendix 2 og 3) og nye prøver vil bli samlet inn hver femte uke i 2004.

Kontakt er etablert mellom Lapland Regional Environmental Centre (LREC) og NGU. Langtids bakgrunnsverdier på grunnvannskvalitet fra Nellim-stasjonen i Finland vil være av stor verdi for vurderingen av måleverdiene på norsk side.

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Appendix 2: Chemical analysis results of the parameters determined in groundwater during 2003 (concentrations in mg/l, EC in mS/m, pH in pH units, alkalinity in mmol/l)

Element/ parameter	Detection limit	Well 1- Skjellbekken			Well 2- Svanvik			Well 3 - Karpdalen		
		Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec
F	0.05	<0.05	<0.05	< 0.05	<0.05	<0.05	< 0.05	0.25	0.24	0.26
Cl	0.1	2.57	2.61	2.68	5	5.4	5.20	11.1	10.6	10.9
NO2	0.05	<0.05	<0.05	< 0.05	<0.05	<0.05	< 0.05	<0.05	<0.05	< 0.05
Br	0.1	<0.1	<0.1	< 0.1	<0.1	<0.1	< 0.1	<0.1	<0.1	< 0.1
NO3	0.05	0.11	<0.05	< 0.05	0.32	0.38	0.37	0.2	0.23	0.15
PO4	0.2	<0.2	<0.2	< 0.2	<0.2	<0.2	< 0.2	<0.2	<0.2	< 0.2
SO4	0.1		9.86	10.1	6.48	15.4	8.81	12.4	13.6	15.0
Si	0.02	3.9	4.01	4.11	4.6	4.67	4.84	5.45	5.85	5.82
Al	0.002	0.00998	0.0098	<0.02	0.0503	0.0938	<0.02	0.21	0.0374	0.034
Fe	0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	0.25	0.611	1.22
Ti	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0138	<0.005	<0.005
Mg	0.05	1.45	1.51	1.47	1.19	1.36	1.22	7.14	6.67	6.35
Ca	0.02	14.1	13.3	12.6	6.21	7.28	5.98	24.2	21.1	19.6
Na	0.05	2.81	2.68	2.67	3.94	8.37	4.93	12.4	11.8	11.4
K	0.5	2.9	2.63	2.68	0.7	0.68	<0.5	4.3	3.52	3.57
Mn	0.001	0.01	0.0094	0.0087	0.002	0.0032	0.0021	0.1	0.0899	0.0797
P	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Cu	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Zn	0.002	0.293	0.328	0.329	0.319	0.325	0.350	0.299	0.324	0.331
Pb	0.00005	0.00009	<0.00005	<0.05	0.000088	<0.00005	<0.05	0.000084	<0.00005	<0.05
Ni	0.0002	0.000555	0.00044	<0.02	0.00197	0.00175	<0.02	0.00181	0.00191	<0.02
Co	0.00002	0.000256	0.00029	<0.01	0.000321	0.00038	<0.01	0.000473	0.00053	<0.01
V	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Mo	0.00006	0.00123	0.00125	<0.01	0.00105	0.00159	<0.01	0.00409	0.00381	<0.01
Cd	0.00003	<0.00003	0.00005	<0.005	<0.00003	0.00005	<0.005	<0.00003	0.00005	<0.005
Cr	0.0001	0.000462	0.00044	<0.01	0.000695	0.00061	<0.01	0.000975	0.00058	<0.01
Ba	0.002	0.041	0.0439	0.0427	0.028	0.0288	0.0272	0.053	0.0453	0.0446
Sr	0.001	0.031	0.0289	0.0285	0.018	0.0222	0.0183	0.11	0.0975	0.0936
Zr	0.00005	0.000173	<0.00005	<0.005	0.00005	0.00014	<0.005	0.000239	0.00009	<0.005
Ag	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
B	0.005	<0.005	<0.005	<0.02	<0.005	0.00511	<0.02	0.0207	0.0201	<0.02
Be	0.00001	0.000018	0.00003	<0.001	0.000003	0.00003	<0.001	0.000007	0.00003	<0.001
Li	0.0005	0.00111	0.00096	<0.005	0.000546	0.00056	<0.005	0.00328	0.00292	<0.005
Sc	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ce	0.00001	0.00007	0.00003	<0.05	0.000396	0.00007	<0.05	0.000731	0.00013	<0.05
La	0.0001	0.000075	0.00003	<0.01	0.000314	0.00027	<0.01	0.000338	0.00007	<0.01
Y	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
PH (lab)		7.49	7.63	7.59	6.87	7.05	6.98	7.6	7.33	7.28
EC (lab)	0.07	10.2	10	9.91	6.47	9.21	7.08	23.9	21.6	21.4
Alkalinity	0.04	0.71	0.71	0.69	0.32	0.38	0.33	1.87	1.61	1.57
Turbidity	0.05	0.32	0.12	0.13	150	1.1	0.32	345	68	16
Colour	1.4	6	1.6	2.8	6.6	2	2.8	23.4	6.8	2.3

Appendix 3: Groundwater parameter measurements

