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Hydrogeochemical groundwater monitoring

Results from water sampling in the Forsmark area 2023

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Abstract

The present report documents the hydrogeochemical monitoring of deep groundwaters in the Forsmark area including The Spent Fuel Repository as well as The Final Repository for Short-lived Radioactive Waste. The sampling performed during the 2023 campaign included 39 borehole sections within the monitoring program.

Sampling was conducted in series of three samples collected on three different occasions during continuous pumping i.e. varying the purged volume prior to sampling. Most of the standpipes connected to the sections were cleaned before the sampling campaign, with some exceptions.

Many different parameters were analysed during the sampling in 2023. Measured values for a large group of major and minor constituents as well as trace elements and isotopes are presented in the appendices. The relative charge balance is within the acceptable limits for all samples except for two in the same series. For the third and final sample, the relative charge balance is acceptable. As observed in previous sampling campaigns, rather high pH values were also recorded in a couple of the monitored borehole sections in 2023. The agreement between pH measured in the field and in the lab is generally good compared to the results from previous years, while for the electrical conductivity (EC) values the agreement is very good. According to the chloride concentrations, the groundwater composition in the sampled sections has generally been stable from year to year and no significant changes have been observed during latter years.

Sammanfattning

Denna rapport dokumenterar hydrokemisk övervakning av djupt grundvatten inom Forsmarksområdet där Projekt Kärnbränsleförvaret samt Projekt SFR-Utbyggnad ingår. Provtagningen som utförts under 2023 inkluderade 39 borrhålssektioner inom övervakningsprogrammet.

Provtagningen gjordes i serier med tre prov, tagna vid tre olika tillfällen under tiden som kontinuerlig pumpning pågick, det vill säga de omsatta volymerna innan provuttaget varierades. Med några undantag spolades de flesta vattenståndsrör som är kopplade till sektionerna innan provtagningskampanjen påbörjades.

Många olika parametrar analyserades under provtagningen 2023. Uppmätta värden för huvudkomponenter, mindre förekommande ämnen, spårämnen och isotoper presenteras i rapportens bilagor. Jonbalansen ligger inom acceptabla gränser för samtliga prov, förutom för två i samma serie. För det tredje och sista provet stämmer jonbalansen. Som observerats under tidigare mätkampanjer förekom relativt höga uppmätta pH-värden i ett par borrhålssektioner även under 2023. Överenstämmelsen mellan pH uppmätt i fält och på laboratorium är relativt bra jämfört med tidigare år, medan den för elektrisk konduktivitet (EC) är mycket bra. Med hänsyn till kloridkoncentrationerna har grundvattensammansättningarna i de provtagna sektionerna generellt varit stabila från år till år och inga signifikanta förändringar har observerats under senare år.

Contents

1 Introduktion

1.1 General

This report includes results from hydrogeochemical groundwater monitoring in boreholes included in The Spent Fuel Repository as well as The Final Repository for Short-lived Radioactive Waste in the Forsmark area during the year of 2023. The long-term hydrogeochemical monitoring programme for percussion-drilled and core-drilled boreholes aims at delivering long time series of data that will provide a baseline in order to facilitate evaluation of possible future impacts on the groundwater situation from the construction and the operation of the two facilities. The extent of natural variations is important information in order to identify possible future changes in water composition. Since the two study sites overlap, each project benefits from the increased amount of information about the hydrogeochemical conditions.

The controlling documents for the hydrogeochemical monitoring activities are listed in Table 1-1. Both activity plans and method descriptions are SKB´s internal controlling documents. Original data from the reported activities are stored in the primary database Sicada. Data are traceable in Sicada by the activity plan number (AP SFK-23-015). Only data in the database are accepted for further interpretation and modelling. The data presented in this report are regarded as copies of the original data. Data in the database may be revised, if needed. However, such revision of the database will not necessarily result in a revision of this report.

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

Activity plan	**Number**	**Version**
Hydrogeokemisk övervakning i hammar- och kärnborrhål 2023	AP SFK 23-015	1.0
Method descriptions	**Number**	**Version**
Metodbeskrivning för hydrogeokemisk provtagning i ytborrhål med fasta manschettinstallationer	SKB MD 425.001	3.0
Metodbeskrivning för hydrokemisk provtagning i tunnelborrhål med fasta manschettinstallationer	SKB MD 425.002	2.0
Mätsystembeskrivning (MSB) – Handhavandedel; System för hydrologisk och meteorologisk datainsamling.Vattenprovtagning och utspädningsmätning i observationshål.	SKB MD 368.010	2.0
Provtagning och provhantering	SKBdoc id 1063531	17.0
Kvalitetsparametrar för kemianalyser – SKB:s kemiklasser, aktuella detektions-, rapporteringsgränser samt mätosäkerheter	SKBdoc id 1494275	2.0
Provtagningstyper och felkällor	SKBdoc id 1072751	6.0

The field work carried out during the 2023 campaign was planned and performed by Rejlers, except for the tunnel boreholes which were carried out by SKB. SKB determined which borehole sections were to be sampled and managed the laboratory analyses of the samples obtained, either by analysis or by distribution of samples to external laboratories. For more detailed information of the division of tasks, see Activity Plan AP SFK 23-015.

1.2 Background

The monitoring program for groundwater has been on-going since 2005 (SKB 2005) and was initiated during the site investigations for a final repository of spent nuclear fuel (SKB 2001). The program was continued after the completion of the site investigation in 2007. The current monitoring program is developed from the program in R-07-34 (SKB 2007) and since 2012 boreholes drilled during the site investigations for the SFR extension (SKB 2008) are incorporated in the monitoring program for the Forsmark area. During the years, the program has been modified concerning sampling techniques and analytical protocol.

1.3 Boreholes and borehole sections

A total of 39 borehole sections, representing 17 core drilled boreholes and 10 percussion drilled boreholes from the surface and 2 core drilled boreholes from the tunnel, were included in 2023 in the hydrogeochemical monitoring program of groundwater in the bedrock, see Figure 1-1 and Table 1-2.

Figure 1-1. *General overview of the Forsmark area and the boreholes included in the hydrogeochemical monitoring program for deep groundwater 2023. The (telescopic) cored boreholes and the percussion boreholes within the monitoring program are marked with orange and blue filled circles, respectively.*

Table 1-2. Borehole sections included in the monitoring programme 2023 for percussion- and core-drilled boreholes, corresponding transmissivity values and comments on sections and sampling.

Borehole: section no.	Secup (mbl) [1]	Seclow (mbl) [1]	Elevation secmid (m.b.s.l) [2]	Transmissivity (m^2/s)	Comments
KFM01A:5	109.0	130.0	115.6	1.0 E-7 [3]	
KFM01D:2	429.0	438.0	342.8	2.0 E-7 [3]	
KFM01D:4	311.0	321.0	252.3	8.0 E-7 [3]	
KFM02A:3	490.0	518.0	494.8	2.1 E-6 [3]	Section of interest for the Uranium project
KFM02A:5	411.0	442.0	417.6	2.5 E-6 [3]	
KFM02B:2	491.0	506.0	483.6	3.0 E-5 [3]	
KFM02B:4	410.0	431.0	406.9	2.0 E-5 [3]	
KFM03A:1	969.5	994.5	969.0	5.5 E-7 [3]	Suspected leakage to section KFM03A:2
KFM03A:4	633.5	650.0	630.9	2.4 E-6 [3]	Section of interest for the Uranium project
KFM04A:4	230.0	245.0	199.7	2.0 E-6 [3]	
KFM06A:3	738.0	748.0	622.6	1.2 E-7 [3]	
KFM06A:5	341.0	362.0	298.4	3.5 E-6 [3]	
KFM06C:3	647.0	666.0	526.9	5.3 E-8 [3]	
KFM06C:5	531.0	540.0	434.7	1.1 E-6 [3]	
KFM07A:2	962.0	972.0	795.0	5.0 E-7 [3]	
KFM08A:2	684.0	694.0	550.4	1.0 E-6 [3]	
KFM08A:6	265.0	280.0	227.6	2.0 E-6 [3]	
KFM08D:2	825.0	835.0	662.4	2.4 E-8 [3]	[5]
KFM08D:4	660.0	680.0	537.9	2.0 E-7 [3]	[5]
KFM10A:2	430.0	440.0	299.7	3.0 E-5 [3]	Zone A2
KFM11A:2	690.0	710.0	593.6	7.6 E-7	Section through Singö zone. Not sampled 2022 [6]
KFM11A:4	446.0	456.0	389.4	4.4 E-8	Section through Singö zone. Not sampled 2022 [6]
KFM12A:3	270.0	280.0	226.6	1.0 E-6 [3]	
HFM01:2	33.5	45.5	36.8	4.0 E-5 [4]	
HFM02:2	38.0	48.0	39.7	5.9 E-4 [4]	
HFM04:2	57.9	65.9	57.6	7.9 E-5 [4]	
HFM13:1	159.0	173.0	139.6	2.9 E-4 [4]	
HFM15:1	85.0	95.0	60.5	1.0 E-4 [4]	
HFM16:2	54.0	67.0	57.0	3.5 E-4 [4]	
HFM21:3	22.0	32.0	18.6	4.0 E-5 [4]	
HFM27:2	46.0	58.0	45.4	4.0 E-5 [4]	
HFM32:3	26.0	31.0	27.2	2.3 E-4 [4]	
HFM33:2	121.0	137.5	101.8	4.7 E-4	
KFR101:1	279.5	341.8	240.0	5.8 E-6 [3]	Section in bottom of borehole. Extremly low salinity. No dummy in section.
KFR104:1	333.0	454.6	306.3	6.5 E-8 [3]	Section in bottom of borehole. Extremly low salinity. No dummy in section.
KFR106:1	260.0	300.1	260.9	1.0 E-5 [3]	Section of interest for the Uranium project. No dummy in section.
KFR106:2	143.0	259.0	187.1	3.3 E-5 [3]	Section of interest for the Uranium project. No dummy in section.
KFR01:1	44.65	62.3	94.1	-	Tunnel borehole
KFR105:1	265.0	306.8	153.4	6.1 E-8 [3]	Tunnel borehole.

[1] mbl = metres borehole length
[2] m.b.s.l. = metres below sea level [RH2000 = the national levelling system]
[3] From differential flow logging or from injection tests
[4] From flow logging
[5] Equipment lifted and reinstalled in 2013-2014. PEEK (PolyEtherEtherKetone) equipment was installed.
[6] Equipment lifted and reinstalled in 2021-2022. No changes in equipment.

In order to evaluate the results of groundwater analyses and observed trends in the groundwater chemistry, it is important to have information about previous investigations in each borehole and to understand the implications of these activities on the groundwater chemistry. Investigations likely to affect subsequent water sampling include hydraulic pumping and injection tests, tracer tests, SWIW tests (*Single Well Injection and Withdrawal-tests*) and tracer dilution tests.

Activities in the area during the year 2023 can be found in SKB´s database Sicada. During the sampling campaign the drilling of boreholes KFR91 (2023-05-04 – 2023-07-05) and KFR90 (2023-08-18 – 2023-09-20) were conducted. Impact on the water pressure in some of the KFR-sections could be seen which indicates that the drilling activities potentially could have impacted the samples collected from the KFR-boreholes.

Early activities in the area for The Spent Fuel Repository that may have affected, for example, the Uranine or trace metal concentrations are presented in (Nilsson ed. 2010). Since 2008 Amino-G acid has been used as tracer instead of Uranine for dilution tests, except in boreholes HFM15 and KFM05A where Uranine was used in the dilution tests performed in 2013 (Wass 2014).

2 Equipment

2.1 Installations in surface boreholes

The monitored boreholes are divided into sections sealed off by inflated rubber packers. The groundwater pressure is measured on-line in standpipes, hydraulically connected to each section and transmitted to HMS (*Hydro Monitoring System*), i.e. SKB´s hard- and software system for processing and interim storage of hydrological, hydrogeological and meteorological data. Most of the sampled sections are so-called circulation sections and are also hydraulically connected to wider standpipes that the pump fits into. The fixed equipment (packers, tubing, standpipes etc.) remains in the borehole from year to year. An overview of the installation equipment is seen in Figure 2-1.

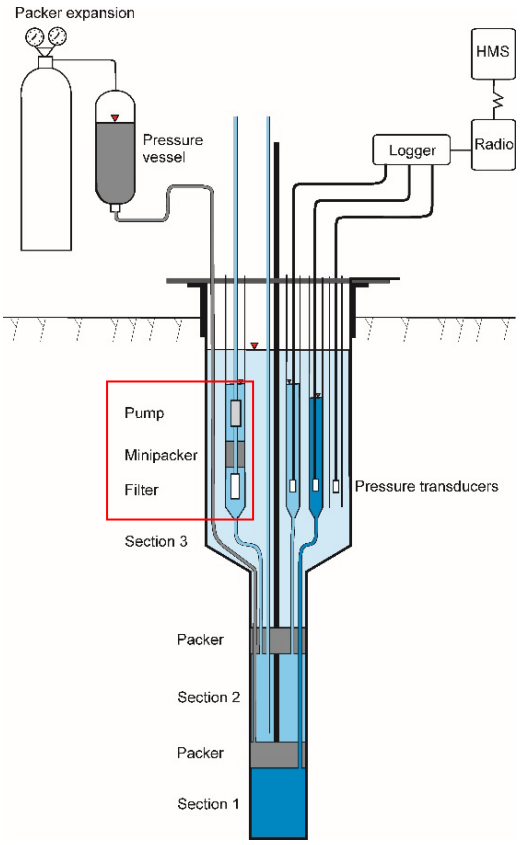

Figure 2-1. *Installations in a surface borehole test section with connected standpipes and monitoring equipment. The installation is permanent in the borehole, except for the pump and filter (marked with the red box), which are used in the standpipe at the pumping/sampling occasions.*

2.2 Installations in tunnel boreholes

KFR01 and KFR105 are tunnel boreholes, and the installations in the boreholes differ from the surface drilled boreholes in some aspects, see Figure 2-2. For instance, there are no standpipes and the pressure gauges are placed outside the borehole in a separate steel locker and are connected to the borehole sections through plastic tubes.

In tunnel boreholes, no pumping equipment is needed due to the pressure gradient. Water flows out of the section when the valve on the tube is opened.

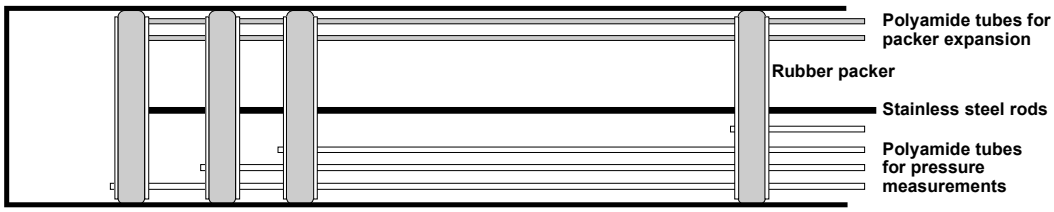

Figure 2-2. *Example of instrumentation in a tunnel borehole with hydraulic packers. The packed-off sections have hydraulic connection to the pressure transducers in the tunnel via polyamide bypass tubes through the packers.*

2.3 Cleaning equipment for standpipes

The cleaning is conducted using a specially designed nozzle combined with a pressure washer, Figure 2-3. The nozzle is designed to direct the water jet upwards in the standpipe to flush any flakes out of the standpipe. In order to lift the litter out of the standpipe more efficiently, a tube delivering nitrogen gas is mounted just above the nozzle to achieve a gas-lift pumping effect in the standpipe. A more detailed description of the cleaning equipment can be found in SKB MD 425.001.

Figure 2-3. *Cleaning equipment used to clean the standpipes prior to pumping and sampling.*

2.4 Sampling equipment

Several identical pumping equipment set-ups (GEOPUMP UV45) were used to retrieve the water samples from the sampled sections, Figure 2-4. The sampling equipment is identical to what was used in previous campaigns and is further described in (Lindquist et al. 2011). When using this equipment, a mini-packer is expanded in the standpipe above the inlet to the filter and pump so that only water from the section and lowest part of the standpipe is pumped. In some sections, dissolved gas is released as pressure decreases. The gas accumulates under the mini-packer and causes pump stops. To avoid such problems, a special evacuation tube is used in some of the borehole sections, allowing the gas to evacuate. For more information about what pumping techniques were used in what sections, see Table 3-1.

Figure 2-4. *The pumping equipment (GEOPUMP UV-45) used for pumping in wide standpipes. The equipment consists of a filter and a pump connected to the mini-packer. The small diameter plastic hose is used for expanding the packer and the plastic hose connected to the pump is the pumping hose (enclosed picture right lower corner).*

In KFM08D the borehole equipment was lifted and then reinstalled during 2013-2014 due to problems with corrosion. The upper part of the installation was replaced by equipment in the material PEEK. Because of this, no mini-packers are used in the standpipes. To allow pumping directly from the section (and avoid contaminating water from the standpipe) a special docking unit was used, see Figure 2-5, similar to the one used in a few sections in 2015 (Lindquist and Ragvald 2015). The unit is working together with the normal pump (GEOPUMP UV45) but instead of expanding the mini-packer in the standpipe, the docking unit docks on and tightens around the top of the tube leading directly to the section (located at the bottom of the standpipe).

Figure 2-5. *The docking unit, which is used together with the pump (GEOPUMP UV-45). Instead of using the mini-packer to isolate the lower part of the standpipe with the pump, the unit is tightly fitted to the tube in the bottom of the standpipe. The photo shows the docking unit used in normally equipped boreholes. The one used in KFM08D is modified to match with the special equipment in PEEK but is very similar to the one in the photo.*

In the borehole sections lacking wide standpipes, sampling was performed in the standpipes for pressure measurements. Due to the smaller diameter of these standpipes, the sections were pumped using gas-lift pumping (with nitrogen). The function of this pump is briefly described in (Lindquist and Nilsson 2013) and the sampling equipment is also further described by (Sandström et al. 2011). Figure 2-6 shows a photo of the equipment. The sampling conditions caused by gas-lift pumping are different from the conventional pumping generally used in the hydrogeochemical monitoring programme. The more effective (intermittent) pump action might affect the borehole walls (microbe coating, mineral particles etc.), and thus might have an impact on the water composition. Especially, constituents such as hydrogen sulphide, TOC, DOC and trace metals may be affected.

Figure 2-6. *The equipment used for gas-lift pumping. To the left, the tubing lowered down the standpipe (the narrower tube for sample water and the wider for gas) on a bobbin to simplify the lowering. To the upper right the control unit for the pumping/gas supply and lower right the end of the gas-lift pump.*

3 Performance

3.1 General

The sampling campaign 2023 included 39 borehole sections. Monitored boreholes, borehole sections and pumping technique at each sampling location are presented in Table 3-1. See Appendix 1 for more sampling information.

Table 3-1. Borehole sections and pumping technique within the monitoring program 2023.

Borehole: section no.	Secup (mbl) [1)]	Seclow (mbl) [1)]	Comments	Used pumping technique [2)]
KFM01A:5	109.0	130.0	Gas evacuation	A
KFM01D:2	429.0	438.0		A
KFM01D:4	311.0	321.0		A
KFM02A:3	490.0	518.0		A
KFM02A:5	411.0	442.0		A
KFM02B:2	491.0	506.0		A
KFM02B:4	410.0	431.0		A
KFM03A:1	969.5	994.5	Gas evacuation	A
KFM03A:4	633.5	650.0		A
KFM04A:4	230.0	245.0		A
KFM06A:3	738.0	748.0	Gas evacuation	A
KFM06A:5	341.0	362.0	Gas evacuation	A
KFM06C:3	647.0	666.0	Gas evacuation	A
KFM06C:5	531.0	540.0	Gas evacuation	A
KFM07A:2	962.0	972.0	Gas evacuation	A
KFM08A:2	684.0	694.0		A
KFM08A:6	265.0	280.0		A
KFM08D:2	825.0	835.0	Gas evacuation	B
KFM08D:4	660.0	680.0	Gas evacuation	B
KFM10A:2	430.0	440.0		A
KFM11A:2	690.0	710.0	Gas evacuation	A
KFM11A:4	446.0	456.0	Gas evacuation	A
KFM12A:3	270.0	280.0	Gas evacuation	A
HFM01:2	33.5	45.5		A
HFM02:2	38.0	48.0		A
HFM04:2	57.9	65.9		A
HFM13:1	159.0	173.0		A
HFM15:1	85.0	95.0		A
HFM16:2	54.0	67.0		A
HFM21:3	22.0	32.0		A
HFM27:2	46.0	58.0		A
HFM32:3	26.0	31.0		A
HFM33:2	121.0	137.5		A

Borehole: section no.	Secup (mbl) [1)]	Seclow (mbl) [1)]	Comments	Used pumping technique [2)]
KFR101:1	279.5	341.8		C
KFR104:1	333.0	454.6		C
KFR106:1	260.0	300.1		C
KFR106:2	143.0	259.0		C
KFR01:1	44.65	62.3		D
KFR105:1	265.0	306.8		D

[1)] mbl = metres borehole length
[2)] A= UV45 pump, B= docking unit, C= nitrogen lifting pump (in standpipe for pressure measurements), D= valve opening (no pump)

3.2 Cleaning of standpipes

A special cleaning procedure was performed in most of the standpipes connected to the borehole sections prior to the sampling campaign in 2023, described in Section 2.3. Some sections were not cleaned for different reasons:

- HFM32:3 since the location of the borehole makes it difficult to transport the cleaning equipment,
- KFR106:1 and KFR106:2 because of the location,
- KFM08D due to risk of damage on borehole equipment (PEEK),
- KFR105:1 and KFR01:1 (tunnel boreholes) are not connected to standpipes, so no cleaning is needed.

After cleaning, the water in the standpipes was evacuated with gas (mammoth pumping) so that the standpipe filled up from underneath with section water. This was done to remove cleaning water from the standpipe and avoid cleaning water in the samples. The mammoth pumping was done twice in each standpipe. The groundwater in the standpipes and the borehole sections was then allowed to settle for a period of at least four weeks before the pumping and sample collection started.

3.3 Water sample treatment and analyses

The constituents included in the different SKB chemistry classes are listed in Table 3-2. Sample treatment (filtration, conservation, storage etc.) of samples, for analyses performed by SKB as well as for analyses performed by external laboratories, generally follow standard procedures. An overview of sample treatment and analysis routines/methods for major and minor constituents, organic carbon, trace metals and isotopes are given in *"Kvalitetsparametrar för kemianalyser – SKB:s kemiklasser, aktuella detektions-, rapporteringsgränser samt mätosäkerheter"*, see Table 1-1. The routines are applicable independently of sampling method or sampling object. See Appendix 2 for the results of the water composition for all the sampled boreholes and sections.

Table 3-2. Constituents analysed within the sampling series in the monitoring programme of deep groundwater in Forsmark, 2023, required volumes, pre-treatment and storage prior to analysis.

Constituent	Bottle[1)]/Volume	Preparation	Comment
pH_F, EC_F, temperature	-	-	On-line measurement in the field
pH_L, EC_L, alkalinity	500 mL	-	Analysis within 24h
Cl^-, SO_4^{2-}, Br^-, F^-	250 mL	Filtered with 0.4 µm filter	-
Major constituents (Na, K, Ca, Mg, Si, S^- tot, Li, Sr Fe, Mn) SO_4-S	Acid washed, 60 mL	Filtered with 0.4 µm filter, conserved with 1 mL HNO_3.	Suprapure acid is used for conservation
δ^2H, $\delta^{18}O$	100 mL	-	-
Uranine	60 mL, dark bottle	-	-
HS^-	2x120 mL glass Winkler bottles	Conserved with 0.5 mL 1M ZnAc and 0.5 mL 1M NaOH in the field. Bottle volume exchanged 2 times	-
TOC	2x100 mL	-	Stored in freezer
DOC	2x100 mL	Filtered with 0.4 µm filter.	Stored in freezer
Archive	2x250 mL	Filtered with 0.4 µm filter	Stored in freezer
Archive	3x60 mL	Filtered with 0.4 µm filter, conserved with 1 mL HNO_3.	Suprapure acid is used for conservation Stored in freezer
Archive	1000 mL	-	Stored in freezer
Density	100 mL	-	-
^3H	500 mL	Bottle volume exchanged 3 times	-
Br^- / I^-	100 mL	-	-
Fe (+II), Fe-tot	250 mL plastic Winkler bottles	Filtered with 0.4 µm filter. Conserved with 2.5 mL HCl	Analysis within 20 h Suprapure acid is used for conservation
NH_4-N, NO_2, NO_3, NO_2+NO_3, PO_4, AcPO_4	250 mL	Filtered with 0.4 µm filter	Do not store sample together with bottles containing HNO_3
Al, As, B, Ba, Cd, Cs, Cr, Co, Hg, Ni, V, Rb, Sb, Zr, Se, Nb, Pd, Ag, Sn, Cu, Mo, Pb, Zn (U, Th)	60 mL	Filtered with 0.4 µm filter	U and Th only included for samples in sections KFM02A:3, KFM03A:4, KFR106:1 and KFR106:2
U/Th-isotopes	1000 mL	-	Last sample in KFM02A:3, KFM03A:4, KFR106:1, KFR106:2

Constituent	Bottle[1)]/Volume	Preparation	Comment
^{34}S in SO_4	1000 mL	-	Last sample in KFM02A:3, KFM03A:1, KFM07A:2, KFM08A:2, KFM08A:6, KFM08D:4, KFM12A:3, HFM13:1, HFM15:1, HFM16:2
^{18}O in SO_4	1000 mL	-	Last sample in KFM02A:3, KFM03A:1, KFM07A:2, KFM08A:2, KFM08A:6, KFM08D:4, KFM12A:3, HFM13:1, HFM15:1, HFM16:2

Constituents determined in the different SKB chemistry classes:
Class II+: Constituents in green cells are included in class II+
Class III+: Constituents in green and purple cells are included in class III+
Class III++: Constituents in green, purple and turquoise cells are included in class III++
Class III+++: Constituents in green, purple and orange cells are included in class III+++
Class III++++: Constituents in green, purple, turquoise and orange cells are included in class III++++

[1)] Plastic bottles are used if nothing else is mentioned.

3.4 Water sampling in series and field measurements

3.4.1 General

Sampling in series was performed in all sampled borehole sections. During earlier sampling campaigns in 2011-2022, generally each series consisted of three samples distributed with respect to pumped or purged "plug-flow volumes" (also including the volume of the tube connecting to the section). The term "plug-flow volume" refers to the theoretical volume that needs to be withdrawn in order to remove the exchangeable water present in the borehole section and achieve samples constituting close to 100% formation water (water originating directly from water bearing fractures in the surrounding rock). As the theoretical plug-flow volume may be underestimated due to laminar flow effects, 100% formation water is assumed at minimum 1.5 times the calculated plug-flow volume. The plug-flow volume varies from section to section, depending on the distribution of water-yielding fractures along the section and their hydraulic transmissivities. This concept is further described in (Nilsson ed. 2010) and (Lindquist et al. 2011). With some exceptions 1.5, 3 and 5 plug-flow volumes were removed before sampling in 2011-2023. Corresponding plug flow volumes for each borehole section are listed in Appendix 3.

In general, adequate water volumes according to the plug flow calculations were removed. However, in KFR101:1 and KFR01:1 the volumes removed before some of the samples were slightly less than 100 % of the plug flow volumes. In KFR101:1 the pumped flow (nitrogen lifting) was somewhat lower than expected and in KFR01:1 the first sample was taken somewhat earlier than intended for practical reasons. The volumes and percent formation water for each of these borehole sections are presented separately in Appendix 3.

The sampling procedure for the campaign in 2023 is described in section 3.4.2.

In order to rule out factors in the sampling procedure that could affect for example the sulphide concentrations, the discharge flow rate from each borehole section was set to the same flow rate as used during previous years. In sections with low hydraulic transmissivity, where a low flow rate must be used, all three samples in the series could not be collected during the working hours of a day. The collected samples and the removed water volumes prior to each sample are presented in Appendix 1. The discrepancy between actually removed volumes and those prescribed is partly due to practical reasons (i.e., sampling could not be performed in the middle of the night). The total removed volumes were calculated from the readings in the field protocols, where date, time and flow rates for the discharge periods and sampling occasions were noted.

Sample portions intended for analysis of major constituents and trace metals (by ICP technique), DOC, anions, iron (by spectrometry) and nutrient salts were filtered on-line in the field. Disposable 0.4 µm filters were fitted directly to the 8/6 mm polyamide-tube leading the pumped water from the borehole section. In sections with very low flow, syringe filtration was performed to mitigate the risk of a pump stop due to the resistance in the 0.4 µm filters. During the entire sampling, laboratory gloves were used to minimize the risk of contaminating the samples.

In addition to sampling of groundwater, field measurements of temperature, electrical conductivity (EC) and pH were conducted. The water from the borehole was led into a glass beaker on the ground surface with probes and electrodes as well as a temperature sensor for measurements of field pH (pH_F), field electrical conductivity (EC_F) and groundwater temperature. Measurements were conducted on flowing water. The results are given in Chapter 4 and raw data in Appendix 2.

The pumped water was, where needed, collected in tanks to prevent saline water from affecting the surroundings of the boreholes. The water was then discharged to the Baltic Sea.

The pressure in the borehole sections is continuously monitored by HMS, also during sampling. Pressure diagrams for each borehole and sampling occasion are given in Appendix 4. Possible short-circuiting, indicated by pressure responses in one or more sections other than the sampled ones, can be observed in several boreholes, see Appendix 4. However, observation of pressure propagation does not necessarily mean that water is transported between the sections. In the boreholes sampled from the small diameter standpipes where gas-lift pumping was used, the pressure transducers had to be lifted and the pressure in the pumped section could not be monitored during pumping.

3.4.2 Sampling in 2023

In 2023, each series consisted of three samples. Sampling was conducted in 39 borehole sections included in the monitoring program. HFM19 was omitted due to deflated borehole packers and KFR102A was omitted due to uninstalled borehole equipment.

During the 2023 campaign, mainly 1.5, 3 and 5 plug-flow volumes were planned to be removed before sampling. In some borehole sections no flow logging has been made and plug-flow volumes can therefore not be calculated. For these sections, other pump or purge volumes are used according to Table 3-3. Collected samples and chemistry classes are listed in Table 3-4.

Generally, sampling was carried out successfully except for a pump stop in KFM06A:5 (before the last sample). In the sections where a pump stop occurred, the pumped volume prior to the next sample was measured from the new pump start, but the total pumped volume includes all pumping periods. For this and for more comments on nonconformities, see Section 3.5.

Interruption of pumping also occurred in KFM01D:2, but after sampling of the third sample in the series.

Table 3-3. Sections where planned pumped or purged volumes in sampling campaign in 2023 differ from normally used 1.5, 3 and 5 plug flow volumes.

Borehole: section no.	Sample 1	Sample 2	Sample 3
HFM33:2	3 sv [1)]	5 sv	7 sv
KFM06A:3	3 pf [2)]	5 pf	7 pf
KFM06C:3	115 L [3)]	215 L	315 L
KFM06C:5	1.5 sv	3 sv	5 sv
KFM11A:2	300 L	450 L	600 L
KFM12A:3	3 sv	5 sv	7 sv
KFR01:1	3 sv	5 sv	7 sv

[1)] sv= Section volumes including the volume of the plastic hoses. Corresponding volume in litre for each section are found in Appendix 3
[2)] pf= plug flow volumes. Corresponding volume in litre for each section are found in Appendix 3.
[3)] L= Litre

Table 3-4. Collected samples and analyses performed within the monitoring program 2023.

Borehole: section no.	Sample No in series	Chemistry class*		
		Sample 1	Sample 2	Sample 3
KFM01A:5	113258-113260	II+	II+	III+
KFM01D:2	113264-113266	II+	II+	III+
KFM01D:4	113261-113263	II+	II+	III+
KFM02A:3	113270-113272	II+	II+	III++++
KFM02A:5	113267-113269	II+	II+	III+
KFM02B:2	113276-113278	II+	II+	III+
KFM02B:4	113273-113275	II+	II+	III+
KFM03A:1	113282-113284	II+	II+	III+++
KFM03A:4	113279-113281	II+	II+	III++
KFM04A:4	113285-113287	II+	II+	III+
KFM06A:3	113291-113293	II+	II+	III+
KFM06A:5	113288-113290	II+	II+	III+
KFM06C:3	113297-113299	II+	II+	III+
KFM06C:5	113294-113296	II+	II+	III+
KFM07A:2	113300-113302	II+	II+	III+++
KFM08A:2	113306-113308	II+	II+	III+++
KFM08A:6	113303-113305	II+	II+	III+++
KFM08D:2	113312-113314	II+	II+	III+
KFM08D:4	113309-113311	II+	II+	III+++
KFM10A:2	113315-113317	II+	II+	III+
KFM11A:2	113321-113323	II+	II+	III+
KFM11A:4	113318-113320	II+	II+	III+
KFM12A:3	113324-113326	II+	II+	III+++
HFM01:2	113327-113329	II+	II+	III+
HFM02:2	113330-113332	II+	II+	III+
HFM04:2	113333-113335	II+	II+	III+
HFM13:1	113336-113338	II+	II+	III+++
HFM15:1	113339-113341	II+	II+	III+++
HFM16:2	113342-113344	II+	II+	III+++
HFM21:3	113345-113347	II+	II+	III+
HFM27:2	113348-113350	II+	II+	III+
HFM32:3	113351-113353	II+	II+	III+
HFM33:2	113354-113356	II+	II+	III+
KFR101:1	113357-113359	II+	II+	III+
KFR104:1	113360-113362	II+	II+	III+
KFR106:1	113372-113374	II+	II+	III++
KFR106:2	113369-113371	II+	II+	III++
KFR01:1	113363, 113365	II+	II+	III+
KFR105:1	113366-113367	II+	II+	III+

* See Table 3-2 for more information about the chemistry classes and colour coding

3.5 Nonconformities

The hydrogeochemical monitoring of deep groundwater has been conducted according to the SKB internal controlling document AP SFK SFK-23-015 with the following nonconformities.

Sampling:

- Sample 2 in KFR01:1 (sample nr 113364) could not be collected due to reduced accessibility in the tunnel.
- Some bottles in sample 3 in KFM03A:1 (sample nr 113284) and sample 3 in KFM01D:2 (sample nr 113266) were incorrectly collected from a plastic container instead of sampled directly from the pumping hose. The potentially affected bottles are: uranine, deuterium, iron (II, III), major constituents and archive.
- A new pH, EC and temperature meter were used for the first time during the 2023 campaign. Some troubles with the new equipment forced the old pH, EC and temperature meter to be used for some samples.
- Errors while measuring EC and temperature in field occurred during sample 2 and 3 in KFM01A:5 (sample nr 113259 and 113260), sample 2 in KFM03A:1 (sample nr 113283) and sample 1 in KFM08D:4 (sample nr 113309).

Pumping procedures:

- Interruption of pumping occurred in KFM06A:5 (between sample 2 and sample 3) due to a timer switch problem. The pump was re-started, and the last sample was collected one day later.
- After all of the three samples had been collected in KFM01D:2, the pumping continued since gas sampling was to be performed within another project. However, before the gas sampling was completed, the pump stopped unexpectedly but was later restarted and the sampling could be finished.
- For sample 1 and 3 in KFR101:1 and sample 1 in KFR01:1 the pumped or purged volumes before sampling were smaller than planned (see Appendix 1).

Analyses:

- In 35 of the samples, the dissolved organic carbon was higher than the total organic carbon. Most often the difference is relatively small but in some samples the difference is significant.
- The relative charge balance criteria (± 5 %) were not met for two samples (first and second sample in KFM03A:1).

4 Results

4.1 Water analysis and measurements

The results from analyses and field measurements are presented in Appendix 2. The first table includes the major constituents Na, K, Ca, Mg, HCO_3^-, Cl^-, SO_4^{2-}, SO_4-S, Br^-, F^-, Si, Fe, Mn, Li and Sr as well as minor constituents like HS^-, NO_2^-, NO_3^-, NH_4^+, PO_4^{3-}, TOC and DOC from all sampled boreholes. Furthermore, this table contains laboratory data and field measurement data on pH, electrical conductivity (EC) and the water temperature recorded in the field.

The relative charge balance (RCB) provides an indication of the quality and uncertainty of the analyses of major constituents and, the charge balance errors were calculated for all samples. Relative errors within ± 5% are considered acceptable.

$$rel.error(\%) = 100 \times \frac{\sum cation(equivalents) - \sum anion(equivalents)}{\sum cation(equivalents) + \sum anion(equivalents)}$$

The relative charge balances were for all samples, except for two samples (first and second sample in KFM03A:1) within the acceptable limit of ± 5%.

Trace elements and the isotopes δ^2H and $\delta^{18}O$ were determined in all samples during the 2023 campaign and ^3H was determined in the last sample in each series (see Appendix 2). $\delta^{34}S$ in SO_4^{2-} and $\delta^{18}O$ in SO_4^{2-} were analysed in the last sample in HFM13:1, HFM15:1, HFM16:1, KFM02A:3, KFM03A:1, KFM07A:2, KFM08A:2, KFM08A;6 and KFM08D:4. In 2019 (Föhlinger 2021) and 2020 (Olofsson 2022a) analyses of Ag, As, B, Nb, Rb, Zr, Sb, Cs and Nd were added in some sections. From 2021 (Olofsson 2022b, Olofsson, 2023) these elements were determined in the last sample in each series in all borehole sections which was also true for the 2023 campaign.

Furthermore, the uranium and thorium element concentrations were not analysed during the 2023 campaign while the isotopes (^{238}U, ^{235}U, ^{234}U, ^{232}Th and ^{230}Th) were determined in the last sample from sections KFM02A:3, KFM03A:4, KFR106:1 and KFR106:2 (see Appendix 2).

The laboratory measurements and field measurements of pH and EC are compared in Figure 4-1 and Figure 4-2, respectively.

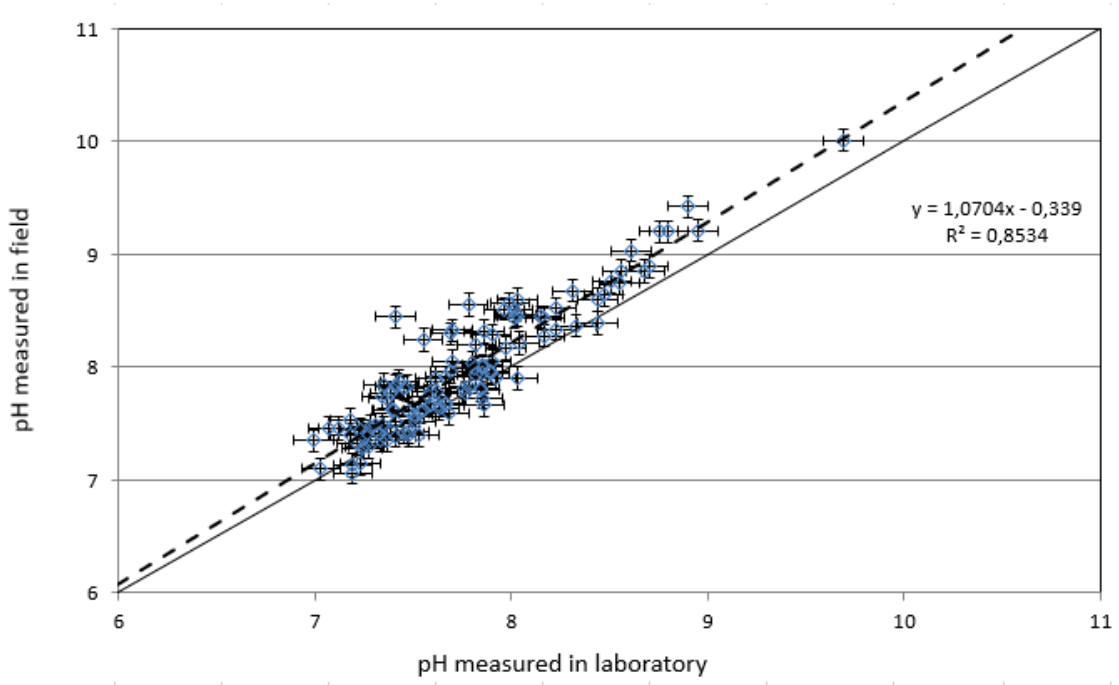

Figure 4-1. *Comparison between laboratory measurements and field measurements of pH. The laboratory measurements are performed at 25 °C and the field measurements are performed at the actual water temperature. The dashed line is the linear fit.*

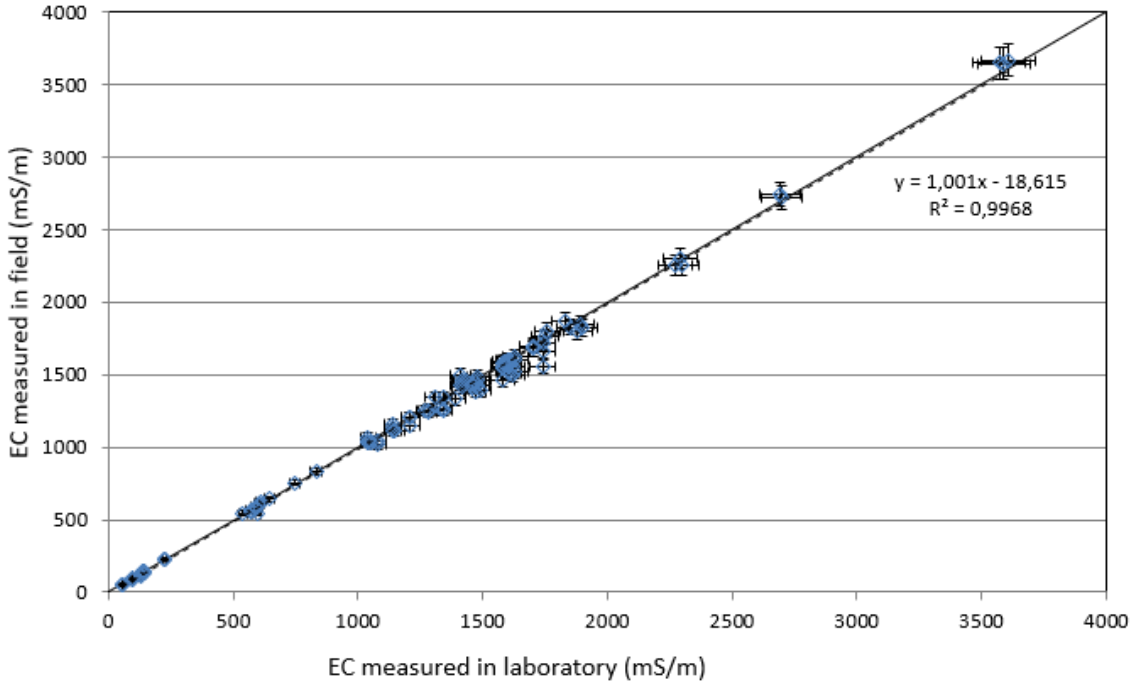

Figure 4-2. *Comparison between laboratory measurements and field measurements of EC. All values are corrected to the conductivity at 25 °C. The dashed line is the linear fit.*

The agreement between the field and laboratory measured pH values is generally good. There are some samples where the compared pH values deviate more than others, which may be due to temperature and pressure differences and/or time delay. For some of these, the field value differs compared to other pH-measurements in the same section and mistakes during field measurement is the most plausible reason.

As previously observed in some of the monitored boreholes belonging to The Spent Fuel Repository, see e.g. (Ragvald 2016) and (Ragvald 2018), some high pH values were also recorded in 2023, although no pH values above 10 have been measured in the laboratory. During earlier campaigns, especially in 2019, there were several samples with pH values above 10. Diagrams of pH values during the years in sections with elevated pH values are presented in Appendix 5. The issue with elevated pH values is discussed in (Nilsson and Sandberg 2016). The earlier increase seems to have ceased or at least been less obvious and the measured pH values seem to have stabilized during the last years of sampling. An interesting result was seen 2023 in KFM11A:2 where the pH-value seems to have returned to lower levels after re-installation of the borehole equipment in 2022.

The agreement between the EC values from field and lab is very good. The dispersion between different years is small.

In the comparison between the laboratory and field measurements for both EC and pH, no outliers have been removed.

For the borehole sections for which no cleaning of the standpipes was performed prior to the sampling campaigns, the water compositions generally also seem to have been quite stable through the sampling series.

4.2 Chloride

Graphs showing chloride concentrations in collected samples from hydrogeochemical monitoring 2023 together with data from hydrogeochemical monitoring earlier years are presented in Appendix 6.

When the chloride trends are analysed, it can be observed that in KFM01D:2, KFM01D:4, KFM06A:3, KFM06C:3, KFM06C:5 and KFM12A:3 there appears to be an increasing trend in chloride concentrations, however within the analytical uncertainty of the results from recent years. In KFM08D:2 and KFM08D:4, higher chloride concentrations have been measured since the measurements continued in 2015, after re-installation in 2014.

In KFM08A:6, HFM01:2, HFM02:2, HFM15:1, KFR102A:5 and KFR104:1 there have been decreasing trends since the measurements started, which now seem to have levelled out during the latter years. In HFM27:2 there is an ongoing decreasing trend in chloride concentration.

The chloride concentration measured 2023 in KFM11A:2 was lower than it had been since 2007-2008. The borehole equipment was re-installed in 2022.

Within each sample series (increasing plug flow volumes), the chloride concentrations were generally stable in 2023. The exceptions are KFR106:1 where the chloride concentrations increased with pumped volumes. For KFR106:1, also sodium, calcium, magnesium, iron, lithium and sulphate concentrations increased, which has also been the case during earlier campaigns. In the same section, bicarbonate had a decreasing trend.

In 2016, the chloride concentrations were lower in KFR106:1. The lower chloride concentrations were thought to be due to smaller pumping volumes (Ragvald 2018). The values during last years in KFR106:1 vary from year to year. When comparing chloride concentrations and pumping volumes for 2014-2023, there is an indication that they might be correlated.

Altogether, the results indicate that a longer pumping period for KFR106:1 could result in a more stable water composition.

5 Summary and discussions

A total of 39 borehole sections included in the monitoring program were sampled during the 2023 campaign. Sampling was conducted in series of three samples collected on three different occasions during continuous pumping i.e. varying of the purged volume prior to sampling. With large enough purging prior to sampling, the contribution from influenced section water present in the borehole section decreased with more representative groundwater samples as a result.

Many different parameters were analysed during the sampling in 2023 including measured values for a large group of major and minor constituents as well as trace elements and isotopes. The relative charge balance was within the acceptable limits for all analysed samples, except for two of them (first and second sample in the series). As observed in previous sampling campaigns for The Spent Nuclear Fuel Repository, high pH values were recorded in some of the monitored borehole sections also in 2023 although no pH values above 10 were measured in the laboratory. The agreement between the pH-values measured in the field and in the lab were generally good and significantly better compared with the 2022 campaign. The agreement between the EC-values measured in the field and in the lab were very good and almost spot on the 1:1 proportional line.

According to the analysed chloride concentrations, the groundwater compositions in the sampled sections are generally stable, although some increasing and decreasing trends (compared with 2009, when sampling series were introduced) can be discerned in some sections during the last years of sampling.

During the campaign with three samples in series, only one interruption of pumping occurred. Gas evacuation tubes were used in the same sections as previous years, which probably helped avoiding additional pump stops.

References

SKB's (Svensk Kärnbränslehantering AB) publications can be found at www.skb.com/publications. SKBdoc documents will be submitted upon request to document@skb.se.

Föhlinger S, 2021. Hydrochemical groundwater monitoring. Results from water sampling in the Forsmark area 2017-2019. SKB P-20-31, Svensk Kärnbränslehantering AB.

Lindquist A, Nilsson A-C, 2013. Hydrochemical groundwater monitoring. Results from water sampling at the SFR-site, spring and autumn 2012. SKBdoc1413843 ver 1.0, Svensk Kärnbränslehantering AB.

Lindquist A, Ragvald J, 2015. Hydrochemical groundwater monitoring. Results from water sampling in the Forsmark area 2014. SKBdoc 1420576 ver 1.0, Svensk Kärnbränslehantering AB.

Lindquist A, Nilsson K, Jönsson S, 2011. Hydrochemical monitoring of groundwaters. Results from water sampling in the Forsmark area, spring and autumn 2010. SKBdoc1334697 ver 1.0, Svensk Kärnbränslehantering AB.

Nilsson A-C, Sandberg B, 2016. Elevated pH values in groundwater. Observations from SKB investigations 1976–2014 and possible causes. SKB R-16-04, Svensk Kärnbränslehantering AB.

Nilsson A-C (ed), Berg C, Harrström J, Jönsson S, Thur P, Borgiel M, Qvarfordt S, 2010. Forsmark site investigation. Hydrochemical monitoring of groundwaters and surface waters. Results from water sampling in the Forsmark area, January-December 2009. SKB P-10-40, Svensk Kärnbränslehantering AB.

Olofsson J, 2022a. Hydrogeochemical groundwater monitoring. Results from water sampling in the Forsmark area 2020. SKB P-21-17, Svensk Kärnbränslehantering AB.

Olofsson J, 2022b. Hydrogeochemical groundwater monitoring. Results from water sampling in the Forsmark area 2021. SKB P-22-12, Svensk Kärnbränslehantering AB.

Olofsson J, 2023. Hydrogeochemical groundwater monitoring. Results from water sampling in the Forsmark area 2022. SKB P-23-10, Svensk Kärnbränslehantering AB.

Ragvald J, 2016. Hydrochemical groundwater monitoring. Results from water sampling in the Forsmark area 2015. SKBdoc1542091 ver 1.0, Svensk Kärnbränslehantering AB.

Ragvald J, 2018. Hydrochemical groundwater monitoring. Results from water sampling in the Forsmark area 2016. SKB P-18-11, Svensk Kärnbränslehantering AB.

Sandström B, Nilsson K, Tullborg E-L, 2011. Site investigation SFR. Fracture mineralogy including identification of uranium phases and hydrochemical characterisation of groundwater in borehole KFR106. SKB P-11-41, Svensk Kärnbränslehantering AB.

SKB, 2001. Site investigations. Investigation methods and general execution programme. SKB TR-01-29. Svensk Kärnbränslehantering AB.

SKB, 2005. Forsmark site investigation. Programme for further investigations of geosphere and biosphere. SKB R-05-14, Svensk Kärnbränslehantering AB.

SKB, 2007. Forsmark site investigation. Programme for long-term observations of geosphere and biosphere after completed site investigations. SKB R-07-34, Svensk Kärnbränslehantering AB.

SKB, 2008. Geovetenskapligt undersökningsprogram för utbyggnad av SFR. SKB R-08-67, Svensk Kärnbränslehantering AB. (In Swedish.)

Wass E, 2014. Groundwater flow measurements in permanently installed boreholes, test campaign no. 9, 2013. SKBdoc 1384642 ver 2.0, Svensk Kärnbränslehantering AB.

Appendix 1 - Sampling information for 2023

Table A1-1 Sampling information for 2023

Idcode: section	Tube volume	Section volume	Length of pumping period	Medium flow rate[1)]	Planned removed volume[2)]	Pumped volume[3)]	Sampling date	Sample no.	Responses observed in other sections in the borehole (if yes, se Appendix 4) /Comments
	[L]	[L]		[mL/min]	[L]	[L]			
KFM01A:5	1.4	18	1 day 17 h 24 min	168		428	-	-	Yes
					140	129	2023-05-23	113258	
					279	390	2023-05-24	113259	
					465	427	2023-05-24	113260	
KFM01D:2	3.3	24.5	2 days 13 h 19 min	80		259	-	-	Yes
					24	39	2023-05-29	113264	
					48	62	2023-05-29	113265	
					80	140	2023-05-30	113266	
KFM01D:4	9	12.3	0 days 9 h 19 min	233		130	-	-	Yes
					27	29	2023-06-01	113261	
					54	57	2023-06-01	113262	
					90	96	2023-06-01	113263	
KFM02A:3	14.1	33.4	2 days 8 h 10 min	145		488	-	-	No
					63	63	2023-05-09	113270	
					126	245	2023-05-10	113271	
					210	280	2023-05-10	113272	
KFM02A:5	11.9	31.8	3 days 4 h 58 min	208		958	-	-	No. However, a response was seen in KFM02B:4
					273	288	2023-05-09	113267	from pumping in KFM02A:5 and vice versa.
					546	612	2023-05-10	113268	
					910	944	2023-05-11	113269	
KFM02B:2	12.8	15	1 day 5 h 16 min	318		559	-	-	No
					90	93	2023-05-11	113276	
					180	197	2023-05-11	113277	
					300	536	2023-05-12	113278	

Idcode: section	Tube volume	Section volume	Length of pumping period	Medium flow rate[1)]	Planned removed volume[2)]	Pumped volume[3)]	Sampling date	Sample no.	Responses observed in other sections in the borehole (if yes, se Appendix 4) /Comments
	[L]	[L]		[mL/min]	[L]	[L]			
KFM02B:4	10.5	21	1 day 7 h 25 min	519		979	-	-	Yes. A response was also seen in KFM02A:5
					287	325	2023-05-11	113273	from pumping in KFM02B:4 and vice versa.
					573	863	2023-05-12	113274	
					955	963	2023-05-12	113275	
KFM03A:1	27.7	31.5	4 days 17 h 29 min	58		397	-	-	Yes
					119	116	2023-05-22	113282	
					237	284	2023-05-24	113283	
					395	385	2023-05-25	113284	
KFM03A:4	18.2	18.6	1 day 7 h 4 min	193		360	-	-	No
					44	55	2023-05-09	113279	
					87	108	2023-05-09	113280	
					145	349	2023-05-10	113281	
KFM04A:4	6.8	18.7	1 day 9 h 4 min	245		487	-	-	No
					24	42	2023-05-31	113285	
					48	67	2023-05-31	113286	
					80	102	2023-05-31	113287	
KFM06A:3	21.1	13.6	3 days 0 h 2 min	63		274	-	-	Yes
					84	89	2023-05-03	113291	
					140	179	2023-05-04	113292	
					196	265	2023-05-05	113293	
KFM06A:5	9.9	22.4	3 days 6 h 42 min	157		655	-	-	Yes
					39	39	2023-05-03	113288	
					78	76	2023-05-03	113289	
					130	223	2023-05-05	113290	

Idcode: section	Tube volume	Section volume	Length of pumping period	Medium flow rate[1)]	Planned removed volume[2)]	Pumped volume[3)]	Sampling date	Sample no.	Responses observed in other sections in the borehole (if yes, se Appendix 4) /Comments
	[L]	[L]		[mL/min]	[L]	[L]			
KFM06C:3	18.5	23.5	11 days 5 h 45 min	22		364	-	-	Yes
					115	132	2023-05-08	113297	
					215	271	2023-05-12	113298	
					315	357	2023-05-15	113299	
KFM06C:5	15.3	11.1	1 day 8 h 21 min	147		285	-	-	Yes
					42	47	2023-05-04	113294	
					84	94	2023-05-04	113295	
					140	278	2023-05-05	113296	
KFM07A:2	27.4	13.9	1 day 9 h 37 min	93		188	-	-	Yes
					57	56	2023-06-07	113300	
					114	144	2023-06-08	113301	
					190	178	2023-06-08	113302	
KFM08A:2	19.6	13.9	1 day 9 h 7 min	305		606	-	-	No
					33	48	2023-05-30	113306	
					66	69	2023-05-30	113307	
					110	127	2023-05-30	113308	
KFM08A:6	7.7	16.3	3 days 6 h 37 min	283		1334	-	-	Yes
					389	443	2023-05-29	113303	
					777	850	2023-05-30	113304	
					1295	1322	2023-05-31	113305	
KFM08D:2	n/a	n/a	4 days 3 h 29 min	31		185	-	-	Yes
					50	51	2023-05-30	113312	
					99	111	2023-06-01	113313	
					165	169	2023-06-02	113314	

Idcode: section	Tube volume	Section volume	Length of pumping period	Medium flow rate[1)]	Planned removed volume[2)]	Pumped volume[3)]	Sampling date	Sample no.	Responses observed in other sections in the borehole (if yes, se Appendix 4) /Comments
	[L]	[L]		[mL/min]	[L]	[L]			
KFM08D:4	18.9	22	7 days 1 h 58 min	123		1252	-	-	Yes
					353	363	2023-05-24	113309	
					705	675	2023-05-26	113310	
					1175	1237	2023-05-29	113311	
KFM10A:2	12.4	13.9	2 days 12 h 13 min	198		715	-	-	No
					188	196	2023-05-09	113315	
					375	428	2023-05-10	113316	
					625	705	2023-05-11	113317	
KFM11A:2	19.8	25.2	2 days 8 h 16 min	180		608	-	-	Yes
					300	296	2023-06-12	113321	
					450	547	2023-06-13	113322	
					600	600	2023-06-13	113323	
KFM11A:4	12.9	12.3	0 days 8 h 13 min	229		113	-	-	Yes
					32	29	2023-06-07	113318	
					63	59	2023-06-07	113319	
					105	104	2023-06-07	113320	
KFM12A:3	7.9	13.6	0 days 11 h 27 min	248		170	-	-	Yes
					69	68	2023-06-12	113325	
					115	114	2023-06-12	113324	
					161	160	2023-06-12	113326	
HFM01:2	1.5	36.5	4 days 4 h 53 min	287		1735	-	-	Yes
					459	548	2023-05-22	113327	
					918	999	2023-05-23	113328	
					1530	1723	2023-05-25	113329	

Idcode: section	Tube volume	Section volume	Length of pumping period	Medium flow rate[1)]	Planned removed volume[2)]	Pumped volume[3)]	Sampling date	Sample no.	Responses observed in other sections in the borehole (if yes, se Appendix 4) /Comments
	[L]	[L]		[mL/min]	[L]	[L]			
HFM02:2	1.6	31.3	2 days 22 h 40 min	292		1237	-	-	No
					357	364	2023-05-15	113330	
					714	809	2023-05-16	113331	
					1190	1227	2023-05-17	113332	
HFM04:2	2.2	26.1	1 day 15 h 1 min	286		669	-	-	No
					155	203	2023-05-08	113333	
					309	315	2023-05-08	113334	
					515	656	2023-05-09	113335	
HFM13:1	5	45.6	8 days 14 h 33 min	219		2716	-	-	No
					773	812	2023-05-23	113336	
					1545	1700	2023-05-26	113337	
					2575	2705	2023-05-29	113338	
HFM15:1	2.9	31.8	2 days 14 h 30 min	191		718	-	-	No
					174	171	2023-05-15	113339	
					348	430	2023-05-16	113340	
					580	708	2023-05-17	113341	
HFM16:2	2	39	3 days 1 h 2 min	1049		4599	-	-	No
					1260	1292	2023-05-03	113342	
					2520	3029	2023-05-04	113343	
					4200	4564	2023-05-05	113344	
HFM21:3	1.5	30.8	2 days 10 h 39 min	227		799	-	-	Yes
					201	212	2023-06-07	113345	
					402	485	2023-06-08	113346	
					670	790	2023-06-09	113347	

Idcode: section	Tube volume	Section volume	Length of pumping period	Medium flow rate[1)]	Planned removed volume[2)]	Pumped volume[3)]	Sampling date	Sample no.	Responses observed in other sections in the borehole (if yes, se Appendix 4) /Comments
	[L]	[L]		[mL/min]	[L]	[L]			
HFM27:2	2	36.5	4 days 2 h 12 min	203		1195	-	-	No
					333	325	2023-05-22	113348	
					666	649	2023-05-23	113349	
					1110	1184	2023-05-25	113350	
HFM32:3	1.4	18	0 days 8 h 23 min	339		170	-	-	No
					44	43	2023-05-16	113351	
					87	89	2023-05-16	113352	
					145	159	2023-05-16	113353	
HFM33:2	n/a	n/a	1 day 10 h 8 min	314		643	-	-	No
					154	164	2023-06-19	113354	
					257	268	2023-06-19	113355	
					360	627	2023-06-20	113356	
KFR101:1	3.5	80.1	1 day 17 h 53 min	120		302	-	-	No
					110	82	2023-06-08	113357	
					219	259	2023-06-09	113358	
					365	296	2023-06-09	113359	
KFR104:1	9.4	199	4 days 11 h 40 min	54		348	-	-	No, but smaller responses may be hidden due to
					90	99	2023-06-13	113360	disturbances from the drilling of borehole KFR91.
					180	186	2023-06-14	113361	
					300	338	2023-06-16	113362	
KFR106:1	7.4	174	0 days 11 h 5 min	134		89	-	-	No
					24	24	2023-06-20	113372	
					48	48	2023-06-20	113373	
					80	80	2023-06-20	113374	

Idcode: section	Tube volume	Section volume	Length of pumping period	Medium flow rate[1)]	Planned removed volume[2)]	Pumped volume[3)]	Sampling date	Sample no.	Responses observed in other sections in the borehole (if yes, se Appendix 4) /Comments
	[L]	[L]		[mL/min]	[L]	[L]			
KFR106:2	4.0	490	1 day 8 h 35 min	147		287	-	-	No
					83	86	2023-06-20	113369	
					165	237	2023-06-21	113370	
					275	279	2023-06-21	113371	
KFR01:1	0.8	39.6	1 day 5 h 13 min	348		609	-	-	No
					121	97	2023-09-04	113363	
					283	598	2023-09-05	113365	
KFR105:1	13.3	179	4 days 0 h 31 min	588		3407	-	-	No, but smaller responses may be hidden due to
					1044	998	2023-09-05	113366	disturbances from the drilling of borehole KFR90.
					2088	2600	2023-09-07	113367	
					3480	3399	2023-09-08	113368	

1) The pumping period may contain pump stops. Medium flow rate and pumped volume is calculated from periods of actual pumping.
2) The first sample is planned to be collected after 1.5 plug flow, the second after 3 and third and last sample in each series after 5 plug flow volumes.
3) Pump stop has occurred causing restart of pumping during the pumping period for some sections. Volume written by each sample number represent volume pumped since restart in those cases, but total pumped volume include all pumping.

Appendix 2 - Water composition 2023

Table A2-1. Water composition – 2023

Id code	Secup	Seclow	Section	Sample	Sampling	RCB	Na	K	Ca	Mg	HCO_3^-	Cl^-	SO_4^{2-}	SO_4-S	Br^-	F^-	Si	Fe	Fe-tot	Fe(II)	Mn	Li
	m	m	no.	no.	date	%	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
HFM01	33.50	45.50	2	113327	2023-05-22	0.35	428	13.6	44.6	13.8	475	372	170	60	1.3	2.6	6.00	0.335	-	-	0.075	0.014
HFM01	33.50	45.50	2	113328	2023-05-23	-0.58	427	13.6	44.5	13.8	482	381	171	60	1.3	2.6	6.01	0.335	-	-	0.075	0.014
HFM01	33.50	45.50	2	113329	2023-05-25	-0.93	419	14.2	44.2	15.7	480	377	171	62	1.3	2.5	6.58	0.332	0.35	0.35	0.084	0.014
HFM02	38.00	48.00	2	113330	2023-05-15	-0.22	255	11.3	35.6	11.2	446	193	62	20.5	0.77	2.0	6.21	0.269	-	-	0.070	0.012
HFM02	38.00	48.00	2	113331	2023-05-16	-0.21	251	11.5	35.8	11.3	447	187	61	20.5	0.76	2.0	6.33	0.293	-	-	0.072	0.012
HFM02	38.00	48.00	2	113332	2023-05-17	0.31	252	11.4	36.0	11.2	449	183	61	20.3	0.75	2.0	6.32	0.308	0.30	0.29	0.073	0.012
HFM04	58.00	66.00	2	113333	2023-05-08	1.60	177	7.26	30.6	7.99	411	73.0	40	13.8	0.28	1.9	6.80	0.390	-	-	0.081	0.011
HFM04	58.00	66.00	2	113334	2023-05-08	0.10	177	7.09	29.2	7.69	425	73.0	40	13.3	0.28	1.9	6.59	0.368	-	-	0.078	0.010
HFM04	58.00	66.00	2	113335	2023-05-09	-1.11	172	6.92	28.5	7.43	422	74.0	40	13.2	0.29	1.9	6.48	0.452	0.37	0.36	0.086	0.010
HFM13	159.00	173.00	1	113336	2023-05-23	-0.78	1720	22.8	1120	191	129	4900	425	144	19.8	1.3	6.93	3.62	-	-	2.10	<0.08
HFM13	159.00	173.00	1	113337	2023-05-26	0.38	1740	25.0	1130	218	134	4880	425	155	19.7	1.3	7.94	3.80	-	-	2.26	0.059
HFM13	159.00	173.00	1	113338	2023-05-29	1.43	1760	25.3	1120	220	136	4790	426	156	19.8	1.3	8.06	3.58	3.40	3.40	2.38	0.059
HFM15	85.00	95.00	1	113339	2023-05-15	-2.27	40.7	5.52	68.4	7.01	332	12.8	16.4	5.54	<0.2	0.75	6.37	1.01	-	-	0.179	<0.004
HFM15	85.00	95.00	1	113340	2023-05-16	-1.32	40.8	5.42	69.5	6.81	329	11.9	16.4	5.52	<0.2	0.75	6.36	1.02	-	-	0.174	<0.004
HFM15	85.00	95.00	1	113341	2023-05-17	-1.76	42.1	5.35	67.8	6.70	329	13.6	16.8	5.56	<0.2	0.76	6.33	1.38	1.01	0.99	0.201	<0.004
HFM16	54.00	67.00	2	113342	2023-05-03	-0.95	256	7.18	31.2	7.55	465	152	79	27.5	0.59	2.5	6.32	0.365	-	-	0.072	0.012
HFM16	54.00	67.00	2	113343	2023-05-04	1.30	271	7.19	30.5	7.34	463	148	83	29.4	0.58	2.6	6.60	0.418	-	-	0.075	0.012
HFM16	54.00	67.00	2	113344	2023-05-05	2.05	275	7.35	31.0	7.41	464	146	84	30.2	0.58	2.6	6.70	0.385	0.39	0.37	0.076	0.013
HFM21	22.00	32.00	3	113345	2023-06-07	-2.06	239	13.8	50.8	16.2	489	166	109	39.3	0.61	1.6	8.00	0.690	-	-	0.146	0.016
HFM21	22.00	32.00	3	113346	2023-06-08	-2.03	240	13.9	50.4	15.9	492	164	109	39.3	0.60	1.6	7.93	0.672	-	-	0.140	0.016
HFM21	22.00	32.00	3	113347	2023-06-09	-2.52	238	13.7	49.2	15.7	492	165	111	38.7	0.60	1.7	7.95	0.552	0.62	0.60	0.146	0.016
HFM27	46.00	58.00	2	113348	2023-05-22	-0.99	889	28.1	270	74.5	307	1770	249	81.8	6.2	1.6	5.81	1.77	-	-	0.487	<0.04
HFM27	46.00	58.00	2	113349	2023-05-23	-1.35	866	27.4	261	72.6	309	1730	242	79.5	6.0	1.7	5.75	1.74	-	-	0.472	<0.04
HFM27	46.00	58.00	2	113350	2023-05-25	1.25	913	30.7	263	87.6	312	1730	241	86.0	6.0	1.7	6.59	1.61	1.65	1.56	0.519	0.032
HFM32	26.00	31.00	3	113351	2023-05-16	-3.30	1800	64.2	431	156	197	3930	373	126	13.8	1.4	5.35	4.40	-	-	0.771	0.064
HFM32	26.00	31.00	3	113352	2023-05-16	-3.49	1800	63.5	429	155	199	3940	371	125	13.7	1.4	5.26	4.47	-	-	0.774	0.063
HFM32	26.00	31.00	3	113353	2023-05-16	-4.26	1770	63.6	426	155	195	3960	374	125	13.8	1.5	5.24	4.88	4.70	4.70	0.890	0.063

Table A2-1. Water composition – 2023, continued

Id code	Secup	Seclow	Section	Sample	Sampling	RCB	Na	K	Ca	Mg	HCO_3^-	Cl^-	SO_4^{2-}	SO_4-S	Br^-	F^-	Si	Fe	Fe-tot	Fe(II)	Mn	Li
	m	m	no.	no.	date	%	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
HFM33	121.00	137.50	2	113354	2023-06-19	-1.92	2080	38.5	790	213	134	5060	436	148	17.2	1.2	6.90	3.39	-	-	1.63	0.064
HFM33	121.00	137.50	2	113355	2023-06-19	-1.24	2080	38.5	812	214	132	5030	439	148	17.4	1.3	6.95	3.28	-	-	1.63	0.064
HFM33	121.00	137.50	2	113356	2023-06-20	-0.97	2150	38.3	790	210	135	5060	439	148	17.3	1.3	6.78	3.22	3.10	2.94	1.71	0.058
KFM01A	109.00	130.00	5	113258	2023-05-23	-0.67	1610	18.1	686	98.1	60.4	3850	212	73.7	16.1	1.5	8.16	0.218	-	-	0.496	<0.04
KFM01A	109.00	130.00	5	113259	2023-05-24	-0.89	1600	18.4	681	98.1	62.1	3840	217	74.8	15.9	1.5	8.32	0.333	-	-	0.508	<0.04
KFM01A	109.00	130.00	5	113260	2023-05-24	0.08	1600	19.9	692	114	62.2	3820	217	79.4	15.9	1.5	9.38	0.338	0.33	0.26	0.593	0.042
KFM01D	429.00	438.00	2	113264	2023-05-29	0.77	1720	9.46	1460	23.7	15.4	5160	77	27.1	33.0	1.3	12.2	<0.1	-	-	0.081	0.034
KFM01D	429.00	438.00	2	113265	2023-05-29	1.22	1730	9.21	1490	24.0	13.9	5180	80	27.3	33.0	1.3	12.1	<0.1	-	-	0.083	0.035
KFM01D	429.00	438.00	2	113266	2023-05-30	0.63	1720	9.05	1460	23.3	14.0	5170	80	28.3	34.0	1.3	11.5	0.008	<0.03	<0.03	0.088	0.034
KFM01D	311.00	321.00	4	113261	2023-06-01	-0.42	1610	9.53	1280	27.8	10.5	4810	73	25.6	31.0	1.6	10.5	0.172	-	-	0.171	0.029
KFM01D	311.00	321.00	4	113262	2023-06-01	0.70	1650	10.9	1240	41.3	12.4	4700	111	40.2	28.0	1.6	11.9	0.316	-	-	0.214	0.034
KFM01D	311.00	321.00	4	113263	2023-06-01	0.97	1670	12.1	1140	48.4	13.8	4540	127	45.8	27.0	1.5	12.4	0.368	0.37	0.36	0.262	0.036
KFM02A	490.00	518.00	3	113270	2023-05-09	-2.25	2180	40.0	915	226	126	5490	487	168	19.6	1.5	7.13	0.355	-	-	1.71	0.052
KFM02A	490.00	518.00	3	113271	2023-05-10	-2.50	2170	38.7	930	224	126	5520	495	170	19.6	1.5	6.60	1.63	-	-	1.94	0.055
KFM02A	490.00	518.00	3	113272	2023-05-10	-3.92	2150	37.6	896	219	124	5590	497	166	19.8	1.5	6.34	1.72	1.71	1.65	2.35	0.054
KFM02A	411.00	442.00	5	113267	2023-05-09	-2.90	1900	23.3	1140	190	94.0	5480	420	145	21.0	1.4	6.99	0.617	-	-	1.61	0.548
KFM02A	411.00	442.00	5	113268	2023-05-10	0.04	2020	24.7	1210	201	94.5	5470	424	153	21.0	1.4	7.47	0.906	-	-	2.76	0.528
KFM02A	411.00	442.00	5	113269	2023-05-11	-1.21	1990	24.1	1160	196	93.8	5470	426	151	21.0	1.4	7.32	0.721	0.71	0.67	2.02	0.471
KFM02B	491.00	506.00	2	113276	2023-05-11	-2.46	2230	40.7	885	228	123	5540	505	172	19.5	1.6	8.29	3.26	-	-	1.83	0.059
KFM02B	491.00	506.00	2	113277	2023-05-11	-2.60	2230	40.1	881	229	121	5550	506	173	19.5	1.6	8.16	3.73	-	-	1.88	0.059
KFM02B	491.00	506.00	2	113278	2023-05-12	-2.54	2200	39.8	882	227	122	5500	507	171	19.2	1.6	7.84	4.32	4.30	4.20	2.38	0.059
KFM02B	410.00	431.00	4	113273	2023-05-11	-3.53	1980	25.0	1060	201	101	5550	446	151	21.0	1.5	8.28	1.71	-	-	1.78	0.083
KFM02B	410.00	431.00	4	113274	2023-05-12	-3.02	2000	25.4	1050	200	102	5500	447	151	20.0	1.5	8.16	1.82	-	-	1.81	0.087
KFM02B	410.00	431.00	4	113275	2023-05-12	-3.00	1980	25.9	1080	203	103	5530	446	153	20.0	1.5	8.22	1.98	1.91	1.89	2.25	0.088
KFM03A	969.50	994.50	1	113282	2023-05-22	-7.68	2040	7.60	3220	6.72	7.5	10300	49	14.2	94.0	1.4	4.76	<0.1	-	-	0.025	0.026
KFM03A	969.50	994.50	1	113283	2023-05-24	-9.00	2000	7.55	3170	6.75	6.1	10400	51	14.2	95.0	1.5	4.20	<0.1	-	-	0.025	0.024
KFM03A	969.50	994.50	1	113284	2023-05-25	0.44	2310	8.63	3870	8.68	5.9	10300	51	16.8	95.0	1.5	5.29	0.032	0.03	<0.03	0.029	0.028
KFM03A	633.50	650.00	4	113279	2023-05-09	-2.22	1830	16.7	1470	51.70	18.3	5690	188	62.7	34.0	1.6	6.52	0.417	-	-	0.300	0.033
KFM03A	633.50	650.00	4	113280	2023-05-09	-2.98	1810	16.1	1480	50.60	16.9	5760	189	63.9	34.0	1.6	6.28	0.412	-	-	0.288	0.035
KFM03A	633.50	650.00	4	113281	2023-05-10	0.51	1940	16.5	1580	52.70	15.5	5730	192	69.8	33.0	1.7	6.36	0.381	0.40	0.39	0.295	0.041

Table A2-1. Water composition – 2023, continued

Id code	Secup	Seclow	Section	Sample	Sampling	RCB	Na	K	Ca	Mg	HCO_3^-	Cl^-	SO_4^{2-}	SO_4-S	Br^-	F^-	Si	Fe	Fe-tot	Fe(II)	Mn	Li
	m	m	no.	no.	date	%	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
KFM04A	230.00	245.00	4	113285	2023-05-31	1.02	1990	28.5	1490	270	105	5930	490	180	26.0	1.1	7.53	2.29	-	-	2.88	0.063
KFM04A	230.00	245.00	4	113286	2023-05-31	1.82	2060	29.0	1490	271	106	5930	491	182	27.0	1.1	7.54	2.18	-	-	2.88	0.065
KFM04A	230.00	245.00	4	113287	2023-05-31	-1.14	1940	27.4	1400	253	105	5940	490	171	27.0	1.1	7.12	1.95	1.89	1.88	2.87	0.058
KFM06A	738.00	748.00	3	113291	2023-05-03	-2.98	1820	8.80	2090	14.2	9.7	6880	91	30.9	50.0	1.4	6.32	<0.1	-	-	0.159	0.041
KFM06A	738.00	748.00	3	113292	2023-05-04	-1.85	1840	8.33	2160	13.0	8.9	6880	91	31.0	50.0	1.5	6.12	<0.1	-	-	0.148	0.041
KFM06A	738.00	748.00	3	113293	2023-05-05	-1.41	1880	8.78	2180	13.2	7.8	6920	90	31.4	50.0	1.5	6.13	0.086	0.09	0.08	0.165	0.043
KFM06A	341.00	362.00	5	113288	2023-05-03	-2.17	1460	13.7	1230	39.7	29.1	4660	101	35.5	29.0	1.2	5.54	0.158	-	-	0.211	0.054
KFM06A	341.00	362.00	5	113289	2023-05-03	-2.50	1450	11.2	1230	36.9	28.3	4670	98	33.4	30.0	1.2	5.49	0.304	-	-	0.232	0.053
KFM06A	341.00	362.00	5	113290	2023-05-05	-3.21	1410	8.68	1220	34.8	24.9	4650	95	31.9	30.0	1.3	4.73	0.425	0.41	0.35	0.259	0.053
KFM06C	647.00	666.00	3	113297	2023-05-08	-1.53	1530	6.93	1810	17.8	15.7	5730	63	23.3	44.0	1.3	3.97	0.203	-	-	0.062	0.044
KFM06C	647.00	666.00	3	113298	2023-05-12	-1.50	1520	6.12	1790	14.3	13.5	5670	64	21.0	43.0	1.3	4.01	<0.1	-	-	0.064	0.040
KFM06C	647.00	666.00	3	113299	2023-05-15	-2.07	1500	6.14	1800	13.9	12.5	5720	64	21.2	44.0	1.4	3.95	0.023	<0.03	<0.03	0.084	0.039
KFM06C	531.00	540.00	5	113294	2023-05-04	-3.02	1670	15.3	1210	78.6	40.1	5060	251	83.2	26.0	1.0	4.80	0.206	-	-	0.497	0.045
KFM06C	531.00	540.00	5	113295	2023-05-04	-1.94	1710	14.4	1240	78.6	44.3	5060	252	84.7	26.0	1.0	4.98	0.263	-	-	0.568	0.047
KFM06C	531.00	540.00	5	113296	2023-05-05	-0.80	1780	13.7	1250	79.6	46.7	5070	254	84.5	26.0	1.1	4.94	0.336	0.32	0.31	0.736	0.049
KFM07A	962.00	972.00	2	113300	2023-06-07	0.17	3090	11.5	5660	17.4	12.2	14700	97	34.1	131.0	1.5	3.74	<0.2	-	-	<0.03	0.076
KFM07A	962.00	972.00	2	113301	2023-06-08	-0.79	3020	11.4	5670	18.9	10.5	14900	97	34.1	131.0	1.5	3.97	<0.2	-	-	0.039	0.074
KFM07A	962.00	972.00	2	113302	2023-06-08	-1.21	2950	11.1	5440	18.4	9.9	14500	97	32.9	130.0	1.5	3.79	0.044	0.03	<0.03	0.049	0.070
KFM08A	684.00	694.00	2	113306	2023-05-30	-0.93	1720	10.8	2000	10.2	12.6	6280	75	24.9	49.0	1.4	5.88	<0.1	-	-	0.064	0.021
KFM08A	684.00	694.00	2	113307	2023-05-30	-0.53	1740	10.9	2000	10.3	11.8	6260	74	25.2	49.0	1.4	6.14	<0.1	-	-	0.075	<0.02
KFM08A	684.00	694.00	2	113308	2023-05-30	0.11	1740	11.1	2050	10.5	10.5	6270	74	25.2	49.0	1.4	6.52	0.048	0.05	0.05	0.099	<0.02
KFM08A	265.00	280.00	6	113303	2023-05-29	1.95	1350	15.0	921	70.4	56.9	3580	204	74.9	16.7	1.3	8.16	1.2000	-	-	0.657	0.040
KFM08A	265.00	280.00	6	113304	2023-05-30	-0.07	1290	14.6	890	69.5	55.8	3590	204	73.1	16.8	1.3	7.82	1.21	-	-	0.650	0.037
KFM08A	265.00	280.00	6	113305	2023-05-31	0.42	1300	14.6	905	70.7	54.7	3600	203	73.1	16.8	1.3	7.69	1.18	1.13	1.11	0.682	0.037
KFM08D	825.00	835.00	2	113312	2023-05-30	-0.50	2180	4.74	2900	2.69	13.4	8470	135	47.3	68.0	1.4	4.26	<0.1	-	-	<0.02	0.029
KFM08D	825.00	835.00	2	113313	2023-06-01	-1.37	2220	5.22	2960	2.20	24.5	8790	131	45.7	69.0	1.4	4.44	<0.1	-	-	<0.02	0.028
KFM08D	825.00	835.00	2	113314	2023-06-02	-0.15	2200	4.86	3000	2.75	13.0	8620	134	47.1	69.0	1.4	4.50	<0.004	<0.03	<0.03	0.0070	0.029
KFM08D	660.00	680.00	4	113309	2023-05-24	-0.46	1810	7.37	2170	7.96	7.8	6660	69	23.5	51.0	1.4	6.40	<0.1	-	-	0.079	0.024
KFM08D	660.00	680.00	4	113310	2023-05-26	-1.79	1820	7.04	2100	7.44	6.7	6730	68	22.4	52.0	1.4	5.80	<0.1	-	-	0.078	0.024
KFM08D	660.00	680.00	4	113311	2023-05-29	-0.59	1820	6.70	2180	6.97	6.7	6710	66	22.3	52.0	1.5	5.48	0.041	0.04	0.04	0.080	0.024

Table A2-1. Water composition – 2023, continued

Id code	Secup	Seclow	Section	Sample	Sampling	RCB	Na	K	Ca	Mg	HCO_3^-	Cl^-	SO_4^{2-}	SO_4-S	Br^-	F^-	Si	Fe	Fe-tot	Fe(II)	Mn	Li
	m	m	no.	no.	date	%	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
KFM10A	430.00	440.00	2	113315	2023-05-09	-3.09	2070	30.6	1080	205	94.0	5610	568	194	19.5	1.4	7.36	2.44	-	-	1.22	0.067
KFM10A	430.00	440.00	2	113316	2023-05-10	-2.76	2090	30.9	1090	207	100	5620	570	196	19.5	1.4	7.23	2.71	-	-	1.32	0.066
KFM10A	430.00	440.00	2	113317	2023-05-11	-3.13	2080	30.6	1090	206	99.2	5650	571	196	19.5	1.4	7.12	2.89	2.89	2.85	1.62	0.066
KFM11A	690.00	710.00	2	113321	2023-06-12	1.56	1950	12.3	1810	75.1	28.3	6090	172	60.6	39.0	1.2	6.37	1.35	-	-	0.508	0.046
KFM11A	690.00	710.00	2	113322	2023-06-13	0.92	1930	12.9	1930	65.4	23.7	6330	163	57.9	42.0	1.3	6.25	1.24	-	-	0.478	0.050
KFM11A	690.00	710.00	2	113323	2023-06-13	0.39	1910	12.8	1920	63.2	23.0	6350	160	56.3	42.0	1.3	6.09	1.24	1.19	1.19	0.499	0.049
KFM11A	446.00	456.00	4	113318	2023-06-07	1.73	1480	4.95	1640	22.4	9.2	4880	243	87.6	23.0	1.3	4.38	<0.2	-	-	0.082	0.049
KFM11A	446.00	456.00	4	113319	2023-06-07	3.24	1550	5.00	1680	22.1	6.7	4890	244	90.9	23.0	1.3	4.30	<0.2	-	-	0.077	0.052
KFM11A	446.00	456.00	4	113320	2023-06-07	1.83	1480	4.71	1660	21.1	6.1	4900	246	88.9	23.0	1.3	4.12	0.080	0.07	0.07	0.079	0.051
KFM12A	270.00	280.00	3	113325	2023-06-12	1.44	1060	6.12	1340	37.5	29.6	3940	63	21.5	27.0	1.4	4.06	<0.2	-	-	0.436	0.046
KFM12A	270.00	280.00	3	113324	2023-06-12	1.89	1080	6.12	1360	38.0	30.6	3970	62	21.3	27.0	0.93	3.96	<0.2	-	-	0.455	0.047
KFM12A	270.00	280.00	3	113326	2023-06-12	1.55	1100	6.84	1320	38.7	31.6	3960	63	21.7	27.0	0.91	4.03	0.129	0.14	0.13	0.481	0.046
KFR01	44.65	62.30	1	113363	2023-09-04	1.09	1550	10.3	578	120	103	3350	343	127	11.5	1.3	4.61	0.450	-	-	0.659	0.064
KFR01	44.65	62.30	1	113365	2023-09-05	1.08	1500	9.67	614	121	104	3340	339	127	11.3	1.3	4.62	0.429	0.47	0.44	0.699	0.061
KFR101	279.50	341.76	1	113357	2023-06-08	2.15	823	5.08	410	28.8	36.5	1940	40	14.8	10.7	0.95	5.36	0.046	-	-	0.200	0.032
KFR101	279.50	341.76	1	113358	2023-06-09	2.10	809	4.91	411	32.6	53.7	1920	43	16.2	10.4	1.5	6.05	0.208	-	-	0.400	0.032
KFR101	279.50	341.76	1	113359	2023-06-09	3.23	820	4.97	422	33.3	54.7	1910	44	16.5	10.3	1.7	6.15	0.233	0.21	0.21	0.463	0.033
KFR104	333.00	454.57	1	113360	2023-06-13	2.00	750	3.40	396	5.16	19.3	1760	37	12.6	10.1	1.7	4.91	<0.02	-	-	0.011	0.019
KFR104	333.00	454.57	1	113361	2023-06-14	2.15	788	3.59	427	7.09	20.8	1860	47	16.4	10.2	1.6	4.89	<0.02	-	-	0.015	0.022
KFR104	333.00	454.57	1	113362	2023-06-16	2.63	786	3.51	421	7.05	17.4	1830	46	16.6	10.1	1.6	4.77	<0.002	<0.03	<0.03	0.019	0.021
KFR105	265.00	306.80	1	113366	2023-09-05	2.60	1430	7.18	771	103	82.0	3440	252	88.2	12.0	1.3	4.90	0.752	-	-	1.53	0.061
KFR105	265.00	306.80	1	113367	2023-09-07	0.71	1400	6.96	719	101	82.7	3430	253	92.2	12.0	1.3	4.90	0.694	-	-	1.44	0.068
KFR105	265.00	306.80	1	113368	2023-09-08	1.84	1380	6.84	777	103	83.0	3420	256	93.8	12.1	1.3	4.97	0.658	0.72	0.70	1.48	0.066

Id code	Secup m	Seclow m	Section no.	Sample no.	Sampling date	RCB %	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	Fe-tot mg/L	Fe(II) mg/L	Mn mg/L	Li mg/L
KFR106	260.00	300.13	1	113372	2023-06-20	-1.81	860	9.04	410	45.7	114	2160	60	20.4	10.4	1.8	4.68	<0.1	-	-	0.177	0.038
KFR106	260.00	300.13	1	113373	2023-06-20	-0.97	987	9.45	505	59.3	108	2510	98	33.2	11.3	1.7	5.02	0.121	-	-	0.278	0.042
KFR106	260.00	300.13	1	113374	2023-06-20	2.71	1130	8.86	608	67.4	88.7	2710	127	45.8	11.9	1.6	5.22	0.466	0.44	0.43	0.392	0.045
KFR106	143.00	259.00	2	113369	2023-06-20	-2.40	1660	14.3	748	165	109	4290	319	108	14.9	1.4	5.66	0.874	-	-	1.04	0.059
KFR106	143.00	259.00	2	113370	2023-06-21	-4.68	1590	13.4	720	158	108	4320	323	103	15.1	1.4	5.35	0.926	-	-	1.01	0.056
KFR106	143.00	259.00	2	113371	2023-06-21	-1.66	1720	13.9	749	164	106	4320	324	108	15.1	1.4	5.46	1.10	1.04	1.02	1.16	0.054

RCB % = Rel. charge balance error %
- = Not analysed
< "value" = value below reporting limit

Table A2-2. Water composition – 2023

Id code	Secup	Seclow	Sec	Sample	Sampling	Sr	I^-	pH_L	pH_F	TOC	DOC	HS^-	Uranine	EC_L	EC_F	NO_2-N	NO_3-N	NO_2-N+ NO_3-N	NH_4-N	Density
	m	m	no.	no.	Date	mg/L	mg/L			mg/L	mg/L	mg/L	µg/L	mS/m	mS/m	mg/L	mg/L	mg/L	mg/L	g/mL
HFM01	33.50	45.50	2	113327	2023-05-22	0.288	-	7.85	7.94	10.3*	10.5*	0.042	2.1	223	226	-	-	-	-	-
HFM01	33.50	45.50	2	113328	2023-05-23	0.290	-	7.89	7.96	10.7	10.6	0.046	1.8	223	224	-	-	-	-	-
HFM01	33.50	45.50	2	113329	2023-05-25	0.292	0.0107	7.90	8.05	10.4	10.4	0.045	1.7	224	227	<0.0002	<0.0003	<0.0003	0.692	0.9980
HFM02	38.00	48.00	2	113330	2023-05-15	0.261	-	7.84	7.80	11.2	11.1	0.035	1.7	139	140	-	-	-	-	-
HFM02	38.00	48.00	2	113331	2023-05-16	0.262	-	7.76	7.82	11.3*	11.4*	0.035	1.7	137	136	-	-	-	-	-
HFM02	38.00	48.00	2	113332	2023-05-17	0.260	0.0113	7.84	7.82	11.7	11.7	0.032	2.1	137	131	<0.0002	0.0044	0.0045	0.453	0.9975
HFM04	58.00	66.00	2	113333	2023-05-08	0.255	-	7.69	7.96	10.6*	10.8*	0.052	1.5	94	93	-	-	-	-	-
HFM04	58.00	66.00	2	113334	2023-05-08	0.247	-	7.78	7.82	10.6	10.6	0.047	1.5	94	93	-	-	-	-	-
HFM04	58.00	66.00	2	113335	2023-05-09	0.237	0.0217	7.77	7.77	10.4	10.4	0.052	1.6	94	90	<0.0002	<0.0003	<0.0003	0.525	0.9973
HFM13	159.00	173.00	1	113336	2023-05-23	11.8	-	7.07	7.46	2.1	2.0	0.029	0.6	1430	1459	-	-	-	-	-
HFM13	159.00	173.00	1	113337	2023-05-26	11.6	-	7.34	7.49	2.2*	2.4*	0.028	0.6	1420	1442	-	-	-	-	-
HFM13	159.00	173.00	1	113338	2023-05-29	11.7	0.0534	7.40	7.62	1.8*	2.0*	0.032	0.7	1420	1414	<0.0002	0.015	0.015	1.42	1.0034
HFM15	85.00	95.00	1	113339	2023-05-15	0.278	-	7.19	7.06	8.9*	9.0*	0.094	1.1	57	57	-	-	-	-	-
HFM15	85.00	95.00	1	113340	2023-05-16	0.271	-	7.03	7.10	9.0*	9.1*	0.088	1.1	57	56	-	-	-	-	-
HFM15	85.00	95.00	1	113341	2023-05-17	0.267	0.0057	7.19	7.13	9.1	9.1	0.091	1.1	57	56	<0.0002	0.0004	0.0005	0.242	0.9972
HFM16	54.00	67.00	2	113342	2023-05-03	0.280	-	7.85	8.02	14.7	14.7	0.126	2.6	133	124	-	-	-	-	-
HFM16	54.00	67.00	2	113343	2023-05-04	0.278	-	7.92	7.90	14.1	14.1	0.064	2.4	132	120	-	-	-	-	-
HFM16	54.00	67.00	2	113344	2023-05-05	0.281	0.0102	8.03	7.91	13.9*	14.1*	0.060	2.4	133	114	<0.0002	0.0004	0.0004	0.667	0.9976
HFM21	22.00	32.00	3	113345	2023-06-07	0.290	-	7.63	7.63	8.6*	8.7*	0.044	1.7	145	139	-	-	-	-	-
HFM21	22.00	32.00	3	113346	2023-06-08	0.283	-	7.63	7.67	8.7*	8.8*	0.038	1.7	145	143	-	-	-	-	-
HFM21	22.00	32.00	3	113347	2023-06-09	0.279	0.0109	7.68	7.59	8.9	8.9	0.037	1.7	145	140	<0.0002	<0.0005	<0.0005	0.419	0.9977
HFM27	46.00	58.00	2	113348	2023-05-22	1.88	-	7.51	7.51	5.8*	6.1*	0.028	1.6	609	619	-	-	-	-	-
HFM27	46.00	58.00	2	113349	2023-05-23	1.82	-	7.54	7.60	6.0	6.0	0.025	1.5	604	607	-	-	-	-	-
HFM27	46.00	58.00	2	113350	2023-05-25	1.96	0.0228	7.59	7.67	6.0*	6.1*	0.026	1.5	603	602	<0.0002	0.0003	0.0005	1.30	0.9995
HFM32	26.00	31.00	3	113351	2023-05-16	3.16	-	7.21	7.32	3.3	3.3	0.095	<0.5	1210	1206	-	-	-	-	-
HFM32	26.00	31.00	3	113352	2023-05-16	3.13	-	7.24	7.29	3.5	3.5	0.055	0.5	1210	1206	-	-	-	-	-
HFM32	26.00	31.00	3	113353	2023-05-16	3.12	0.0526	7.23	7.15	3.2*	3.4*	0.033	<0.5	1210	1151	<0.0002	<0.0003	<0.0003	2.16	1.0021
HFM33	121.00	137.50	2	113354	2023-06-19	6.83	-	7.12	7.46	1.7*	1.8*	0.040	<0.5	1490	1388	-	-	-	-	-
HFM33	121.00	137.50	2	113355	2023-06-19	7.05	-	7.26	7.41	1.7	1.7	0.033	<0.5	1480	1483	-	-	-	-	-
HFM33	121.00	137.50	2	113356	2023-06-20	6.58	0.0399	7.41	7.39	1.7	1.7	0.029	<0.5	1480	1463	<0.0002	<0.0003	<0.0003	2.39	1.0035

Table A2-2. Water composition – 2023, continued

Id code	Secup	Seclow	Sec	Sample	Sampling	Sr	I^-	pH_L	pH_F	TOC	DOC	HS^-	Uranine	EC_L	EC_F	NO_2-N	NO_3-N	NO_2-N+ NO_3-N	NH_4-N	Density
	m	m	no.	no.	Date	mg/L	mg/L			mg/L	mg/L	mg/L	µg/L	mS/m	mS/m	mg/L	mg/L	mg/L	mg/L	g/mL
KFM01A	109.00	130.00	5	113258	2023-05-23	6.06	-	7.85	8.00	1.8	1.8	0.301	23	1140	1155	-	-	-	-	-
KFM01A	109.00	130.00	5	113259	2023-05-24	5.96	-	7.82	7.94	1.7	1.8	0.169	28	1140	-	-	-	-	-	-
KFM01A	109.00	130.00	5	113260	2023-05-24	6.01	0.0650	7.85	8.00	1.7	1.7	0.168	26	1140	-	<0.0002	0.0022	0.0022	0.779	1.0017
KFM01D	429.00	438.00	2	113264	2023-05-29	17.4	-	8.01	8.44	2.2	1.9	1.907	10.9	1460	1436	-	-	-	-	-
KFM01D	429.00	438.00	2	113265	2023-05-29	17.5	-	8.01	8.51	2.1*	2.3*	1.912	10.5	1470	1454	-	-	-	-	-
KFM01D	429.00	438.00	2	113266	2023-05-30	17.5	0.165	7.82	8.20	2.1	1.6	2.997	11.5	1480	1432	<0.0002	0.0022	0.0022	0.166	1.0033
KFM01D	311.00	321.00	4	113261	2023-06-01	14.5	-	7.90	8.28	1.1	1.1	0.354	3.0	1390	1330	-	-	-	-	-
KFM01D	311.00	321.00	4	113262	2023-06-01	13.7	-	8.17	8.28	1.3*	1.4*	0.187	8.0	1340	1346	-	-	-	-	-
KFM01D	311.00	321.00	4	113263	2023-06-01	12.8	0.127	7.55	8.24	1.6	1.5	0.149	11.2	1310	1343	<0.0002	<0.0005	<0.0005	0.328	1.0026
KFM02A	490.00	518.00	3	113270	2023-05-09	8.62	-	7.28	7.48	2.3	2.2	0.917	6.7	1600	1517	-	-	-	-	-
KFM02A	490.00	518.00	3	113271	2023-05-10	8.61	-	7.27	7.29	1.6	1.5	0.089	6.3	1600	1602	-	-	-	-	-
KFM02A	490.00	518.00	3	113272	2023-05-10	8.42	0.0957	7.25	7.29	1.7*	1.9*	0.085	6.2	1610	1575	<0.0002	0.0020	0.0020	2.60	1.0041
KFM02A	411.00	442.00	5	113267	2023-05-09	12.2	-	7.32	7.42	1.3	1.3	0.196	34	1580	1462	-	-	-	-	-
KFM02A	411.00	442.00	5	113268	2023-05-10	12.7	-	7.23	7.45	1.2	1.2	0.144	31	1580	1546	-	-	-	-	-
KFM02A	411.00	442.00	5	113269	2023-05-11	12.4	0.140	7.32	7.42	1.2	1.2	0.123	27	1580	1550	<0.0002	0.0037	0.0038	1.69	1.0040
KFM02B	491.00	506.00	2	113276	2023-05-11	8.06	-	7.41	7.52	1.8*	1.9*	0.100	1.5	1620	1557	-	-	-	-	-
KFM02B	491.00	506.00	2	113277	2023-05-11	8.10	-	7.31	7.49	1.5	1.4	0.081	1.7	1610	1582	-	-	-	-	-
KFM02B	491.00	506.00	2	113278	2023-05-12	8.07	0.535	7.35	7.47	1.5*	1.7*	0.076	1.9	1610	1605	<0.0002	0.0005	0.0005	2.70	1.0040
KFM02B	410.00	431.00	4	113273	2023-05-11	10.9	-	7.39	7.62	1.3	1.2	0.119	3.3	1590	1574	-	-	-	-	-
KFM02B	410.00	431.00	4	113274	2023-05-12	10.9	-	7.50	7.58	1.3	1.3	0.077	3.6	1590	1587	-	-	-	-	-
KFM02B	410.00	431.00	4	113275	2023-05-12	11.1	0.104	7.48	7.60	1.3*	1.4*	0.088	3.5	1580	1583	<0.0002	0.0007	0.0007	1.94	1.0040
KFM03A	969.50	994.50	1	113282	2023-05-22	38.2	-	7.69	8.30	0.8	0.8	0.216	<0.5	2690	2744	-	-	-	-	-
KFM03A	969.50	994.50	1	113283	2023-05-24	37.6	-	7.86	8.32	0.5	0.5	0.123	<0.5	2700	-	-	-	-	-	-
KFM03A	969.50	994.50	1	113284	2023-05-25	43.9	0.363	8.02	8.47	0.9	0.9	0.104	<0.5	2700	2722	<0.0002	0.0011	0.0011	0.018	1.0095
KFM03A	633.50	650.00	4	113279	2023-05-09	18.3	-	7.34	7.74	1.0*	1.2*	0.185	2.6	1620	1497	-	-	-	-	-
KFM03A	633.50	650.00	4	113280	2023-05-09	18.2	-	7.37	7.73	0.8	0.7	0.123	2.4	1610	1514	-	-	-	-	-
KFM03A	633.50	650.00	4	113281	2023-05-10	19.5	0.125	7.42	7.85	0.8	0.8	0.101	2.1	1610	1590	<0.0003	0.0016	0.0015	0.155	1.0040
KFM04A	230.00	245.00	4	113285	2023-05-31	16.1	-	7.37	7.35	1.3	1.3	0.089	2.8	1700	1681	-	-	-	-	-
KFM04A	230.00	245.00	4	113286	2023-05-31	16.1	-	7.33	7.35	1.3	1.2	0.075	2.6	1700	1697	-	-	-	-	-
KFM04A	230.00	245.00	4	113287	2023-05-31	15.2	0.0829	6.99	7.35	1.6	1.6	0.059	2.5	1700	1695	<0.0002	0.0012	0.0011	1.49	1.0048

Table A2-2. Water composition – 2023, continued

Id code	Secup	Seclow	Sec	Sample	Sampling	Sr	I^-	pH_L	pH_F	TOC	DOC	HS^-	Uranine	EC_L	EC_F	NO_2-N	NO_3-N	NO_2-N+ NO_3-N	NH_4-N	Density
	m	m	no.	no.	Date	mg/L	mg/L			mg/L	mg/L	mg/L	µg/L	mS/m	mS/m	mg/L	mg/L	mg/L	mg/L	g/mL
KFM06A	738.00	748.00	3	113291	2023-05-03	25.9	-	8.03	8.60	0.9	0.9	0.185	21	1880	1800	-	-	-	-	-
KFM06A	738.00	748.00	3	113292	2023-05-04	26.1	-	7.78	8.55	0.8	0.8	0.179	19	1890	1847	-	-	-	-	-
KFM06A	738.00	748.00	3	113293	2023-05-05	27.1	0.220	8.03	8.46	0.9	0.8	0.216	19	1900	1824	<0.0002	0.0013	0.0013	0.124	1.0055
KFM06A	341.00	362.00	5	113288	2023-05-03	15.5	-	8.15	8.45	1.6	1.6	0.478	15	1330	1261	-	-	-	-	-
KFM06A	341.00	362.00	5	113289	2023-05-03	15.5	-	7.70	8.33	1.3	1.3	0.226	13.9	1340	1268	-	-	-	-	-
KFM06A	341.00	362.00	5	113290	2023-05-05	15.4	0.147	7.89	7.94	1.0	1.0	0.125	12.8	1340	1257	<0.0002	<0.0003	<0.0003	0.142	1.0026
KFM06C	647.00	666.00	3	113297	2023-05-08	22.4	-	8.70	8.89	0.9	0.9	0.349	8.7	1590	1582	-	-	-	-	-
KFM06C	647.00	666.00	3	113298	2023-05-12	22.3	-	8.55	8.75	0.9*	1.0*	0.208	7.3	1590	1582	-	-	-	-	-
KFM06C	647.00	666.00	3	113299	2023-05-15	22.1	0.204	8.44	8.39	0.8*	0.9*	0.264	8.1	1590	1595	<0.0002	0.0018	0.0018	0.081	1.0038
KFM06C	531.00	540.00	5	113294	2023-05-04	14.0	-	7.80	8.04	1.5	1.5	0.263	41	1460	1413	-	-	-	-	-
KFM06C	531.00	540.00	5	113295	2023-05-04	14.4	-	7.61	7.90	1.4	1.4	0.179	39	1470	1413	-	-	-	-	-
KFM06C	531.00	540.00	5	113296	2023-05-05	14.6	0.113	7.66	7.67	1.3	1.3	0.125	40	1470	1384	<0.0002	<0.0003	<0.0003	0.413	1.0033
KFM07A	962.00	972.00	2	113300	2023-06-07	67.4	-	8.95	9.21	1.3*	1.4*	0.231	1.2	3610	3666	-	-	-	-	-
KFM07A	962.00	972.00	2	113301	2023-06-08	66.6	-	8.80	9.20	1.2	1.2	0.277	1.1	3590	3644	-	-	-	-	-
KFM07A	962.00	972.00	2	113302	2023-06-08	63.8	0.660	8.61	9.04	1.3	1.3	0.311	1.1	3570	3650	<0.0002	0.0017	0.0017	0.010	1.0142
KFM08A	684.00	694.00	2	113306	2023-05-30	24.1	-	8.68	8.85	0.6*	0.8*	0.089	9.5	1750	1760	-	-	-	-	-
KFM08A	684.00	694.00	2	113307	2023-05-30	24.1	-	8.56	8.85	0.6	0.6	0.070	9.6	1740	1718	-	-	-	-	-
KFM08A	684.00	694.00	2	113308	2023-05-30	24.3	0.257	8.31	8.68	0.5	0.5	0.053	9.9	1740	1666	<0.0002	<0.0005	<0.0005	0.065	1.0047
KFM08A	265.00	280.00	6	113303	2023-05-29	10.8	-	7.66	7.91	1.1*	1.3*	0.096	4.8	1080	1016	-	-	-	-	-
KFM08A	265.00	280.00	6	113304	2023-05-30	10.6	-	7.62	7.78	1.5	1.5	0.082	5.0	1080	1044	-	-	-	-	-
KFM08A	265.00	280.00	6	113305	2023-05-31	10.6	0.100	7.35	7.84	1.2	1.2	0.079	5.0	1080	1048	<0.0002	<0.0005	<0.0005	0.316	1.0015
KFM08D	825.00	835.00	2	113312	2023-05-30	32.0	-	8.75	9.20	1.0	1.2*	<0.019	0.6	2270	2254	-	-	-	-	-
KFM08D	825.00	835.00	2	113313	2023-06-01	32.6	-	9.69	10.01	0.7*	0.9*	0.021	0.7	2300	2257	-	-	-	-	-
KFM08D	825.00	835.00	2	113314	2023-06-02	32.5	0.268	8.90	9.43	0.7	0.5	<0.019	0.7	2290	2297	<0.0002	0.0013	0.0014	0.021	1.0076
KFM08D	660.00	680.00	4	113309	2023-05-24	25.2	-	8.33	8.37	0.7*	0.8*	0.069	22	1840	-	-	-	-	-	-
KFM08D	660.00	680.00	4	113310	2023-05-26	25.2	-	8.23	8.52	0.4	0.4	0.043	17	1830	1873	-	-	-	-	-
KFM08D	660.00	680.00	4	113311	2023-05-29	25.5	0.224	8.23		0.6	0.5	0.023	18	1850	1829	<0.0002	0.0011	0.0011	0.060	1.0051
KFM10A	430.00	440.00	2	113315	2023-05-09	11.3	-	7.47	7.83	1.9*	2.0*	0.144	0.9	1630	1517	-	-	-	-	-
KFM10A	430.00	440.00	2	113316	2023-05-10	11.4	-	7.45	7.81	1.8	1.7	0.127	0.8	1630	1627	-	-	-	-	-
KFM10A	430.00	440.00	2	113317	2023-05-11	11.4	0.0388	7.38	7.77	1.6	1.5	0.118	0.8	1630	1603	<0.0002	<0.0003	<0.0003	1.29	1.0043

Table A2-2. Water composition – 2023, continued

Id code	Secup	Seclow	Sec	Sample	Sampling	Sr	I^-	pH_L	pH_F	TOC	DOC	HS^-	Uranine	EC_L	EC_F	NO_2-N	NO_3-N	NO_2-N+ NO_3-N	NH_4-N	Density
	m	m	no.	no.	Date	mg/L	mg/L			mg/L	mg/L	mg/L	µg/L	mS/m	mS/m	mg/L	mg/L	mg/L	mg/L	g/mL
KFM11A	690.00	710.00	2	113321	2023-06-12	23.3	-	7.59	7.78	0.9	0.9	0.270	<0.5	1700	1680	-	-	-	-	-
KFM11A	690.00	710.00	2	113322	2023-06-13	24.8	-	7.58	7.74	0.6	0.6	0.206	<0.5	1740	1561	-	-	-	-	-
KFM11A	690.00	710.00	2	113323	2023-06-13	24.9	0.189	7.43	7.87	0.6	0.6	0.184	<0.5	1760	1803	<0.0002	0.0042	0.0043	0.489	1.0047
KFM11A	446.00	456.00	4	113318	2023-06-07	22.4	-	7.41	8.44	1.1	1.1	0.360	1.6	1410	1431	-	-	-	-	-
KFM11A	446.00	456.00	4	113319	2023-06-07	23.4	-	7.96	8.52	0.7	0.7	0.143	1.6	1410	1498	-	-	-	-	-
KFM11A	446.00	456.00	4	113320	2023-06-07	22.7	0.142	7.99	8.56	0.6	0.6	0.100	1.7	1420	1457	<0.0002	<0.0005	<0.0005	0.028	1.0031
KFM12A	270.00	280.00	3	113325	2023-06-12	20.0	-	7.70	8.05	0.7	0.7	0.160	1.1	1140	1131	-	-	-	-	-
KFM12A	270.00	280.00	3	113324	2023-06-12	20.0	-	7.81	7.99	0.7	0.7	0.156	1.1	1150	1114	-	-	-	-	-
KFM12A	270.00	280.00	3	113326	2023-06-12	19.9	0.151	7.41	7.83	0.6*	0.7*	0.095	1.2	1140	1111	<0.0002	0.0019	0.0020	0.042	1.0018
KFR01	44.65	62.30	1	113363	2023-09-04	8.40	-	7.18	7.54	1.4	1.4	-0.019	<0.5	1050	1026	-	-	-	-	-
KFR01	44.65	62.30	1			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
KFR01	44.65	62.30	1	113365	2023-09-05	9.06	0.0323	7.48	7.43	1.4	1.4	-0.019	<0.5	1050	1035	<0.0002	<0.0003	<0.0003	0.231	1.0014
KFR101	279.50	341.76	1	113357	2023-06-08	6.50	-	8.51	8.76	1.1	1.1	1.301	<0.5	591	590	-	-	-	-	-
KFR101	279.50	341.76	1	113358	2023-06-09	6.40	-	8.04	8.22	0.8	0.7	0.331	<0.5	593	573	-	-	-	-	-
KFR101	279.50	341.76	1	113359	2023-06-09	6.48	0.159	7.97	8.17	0.7	0.7	0.277	<0.5	595	548	<0.0002	<0.0005	<0.0005	0.046	0.9992
KFR104	333.00	454.57	1	113360	2023-06-13	6.59	-	8.47	8.64	0.7	0.7	0.965	0.7	539	547	-	-	-	-	-
KFR104	333.00	454.57	1	113361	2023-06-14	7.04	-	8.44	8.60	0.5*	0.6*	0.718	1.0	573	555	-	-	-	-	-
KFR104	333.00	454.57	1	113362	2023-06-16	6.92	0.118	8.17	8.44	0.5*	0.6*	0.383	1.0	568	565	<0.0002	0.0021	0.0021	0.007	0.9991
KFR105	265.00	306.80	1	113366	2023-09-05	12.4	-	7.45	7.42	0.9	0.9	<0.019	<0.5	1040	1034	-	-	-	-	-
KFR105	265.00	306.80	1	113367	2023-09-07	11.0	-	7.51	7.57	0.9	0.8	<0.019	<0.5	1040	1070	-	-	-	-	-
KFR105	265.00	306.80	1	113368	2023-09-08	12.0	0.0422	7.55	7.62	0.9	0.8	<0.019	<0.5	1040	1042	<0.0002	<0.0003	<0.0003	0.012	1.0014
KFR106	260.00	300.13	1	113372	2023-06-20	6.52	-	7.85	7.73	3.9	3.4	3.399	0.6	645	643	-	-	-	-	-
KFR106	260.00	300.13	1	113373	2023-06-20	7.83	-	7.86	7.67	2.9	2.9	1.719	0.8	747	757	-	-	-	-	-
KFR106	260.00	300.13	1	113374	2023-06-20	9.32	0.0970	7.66	7.67	2.6	2.6	1.310	1.0	833	834	<0.0002	<0.0030	0.0033	0.087	1.0003
KFR106	143.00	259.00	2	113369	2023-06-20	9.33	-	7.53	7.40	1.7*	1.8*	0.734	0.6	1270	1253	-	-	-	-	-
KFR106	143.00	259.00	2	113370	2023-06-21	9.00	-	7.48	7.40	1.3*	1.4*	0.636	0.6	1280	1257	-	-	-	-	-
KFR106	143.00	259.00	2	113371	2023-06-21	9.29	0.0457	7.18	7.40	1.3	1.3	0.410	0.6	1280	1243	<0.0002	<0.0003	<0.0030	0.204	1.0024

pH_L; EC_L = Laboratory measurements of pH and EC
pH_F; EC_F = Field measurements of pH and EC
* possibly affected sample (DOC > TOC)

- = Not analysed
< "value" = value below reporting limit

Table A2-3. Water composition – 2023

Id code	Secup	Seclow	Section	Sample	Sampling	PO_4-P	PO_4-P[1]	Temp_F
	m	m	no.	no.	Date	mg/L	mg/L	
HFM01	33.50	45.50	2	113327	2023-05-22	-	-	10.7
HFM01	33.50	45.50	2	113328	2023-05-23	-	-	11.9
HFM01	33.50	45.50	2	113329	2023-05-25	0.059	0.080	8.6
HFM02	38.00	48.00	2	113330	2023-05-15	-	-	11.9
HFM02	38.00	48.00	2	113331	2023-05-16	-	-	9.3
HFM02	38.00	48.00	2	113332	2023-05-17	0.031	0.041	7.1
HFM04	58.00	66.00	2	113333	2023-05-08	-	-	8.5
HFM04	58.00	66.00	2	113334	2023-05-08	-	-	8.4
HFM04	58.00	66.00	2	113335	2023-05-09	0.013	0.019	12.6
HFM13	159.00	173.00	1	113336	2023-05-23	-	-	14.1
HFM13	159.00	173.00	1	113337	2023-05-26	-	-	12.7
HFM13	159.00	173.00	1	113338	2023-05-29	<0.001	0.001	8.5
HFM15	85.00	95.00	1	113339	2023-05-15	-	-	13.0
HFM15	85.00	95.00	1	113340	2023-05-16	-	-	9.4
HFM15	85.00	95.00	1	113341	2023-05-17	0.001	0.006	7.2
HFM16	54.00	67.00	2	113342	2023-05-03	-	-	6.7
HFM16	54.00	67.00	2	113343	2023-05-04	-	-	6.6
HFM16	54.00	67.00	2	113344	2023-05-05	0.060	0.074	6.8
HFM21	22.00	32.00	3	113345	2023-06-07	-	-	11.2
HFM21	22.00	32.00	3	113346	2023-06-08	-	-	11.2
HFM21	22.00	32.00	3	113347	2023-06-09	0.009	0.019	13.6
HFM27	46.00	58.00	2	113348	2023-05-22	-	-	18.8
HFM27	46.00	58.00	2	113349	2023-05-23	-	-	15.0
HFM27	46.00	58.00	2	113350	2023-05-25	<0.001	0.014	10.0
HFM32	26.00	31.00	3	113351	2023-05-16	-	-	10.0
HFM32	26.00	31.00	3	113352	2023-05-16	-	-	10.6
HFM32	26.00	31.00	3	113353	2023-05-16	<0.001	0.008	10.5
HFM33	121.00	137.50	2	113354	2023-06-19	-	-	12.9
HFM33	121.00	137.50	2	113355	2023-06-19	-	-	14.8
HFM33	121.00	137.50	2	113356	2023-06-20	<0.001	0.002	11.4

Table A2-3. Water composition – 2023, continued

Id code	Secup	Seclow	Section	Sample	Sampling	PO_4-P	PO_4-P[1]	Temp_F
	m	m	no.	no.	Date	mg/L	mg/L	
KFM01A	109.00	130.00	5	113258	2023-05-23	-	-	14.6
KFM01A	109.00	130.00	5	113259	2023-05-24	-	-	16.6
KFM01A	109.00	130.00	5	113260	2023-05-24	<0.001	0.001	25.0
KFM01D	429.00	438.00	2	113264	2023-05-29	-	-	10.2
KFM01D	429.00	438.00	2	113265	2023-05-29	-	-	10.4
KFM01D	429.00	438.00	2	113266	2023-05-30	0.001	0.001	10.8
KFM01D	311.00	321.00	4	113261	2023-06-01	-	-	10.6
KFM01D	311.00	321.00	4	113262	2023-06-01	-	-	10.1
KFM01D	311.00	321.00	4	113263	2023-06-01	0.001	0.00	9.1
KFM02A	490.00	518.00	3	113270	2023-05-09	-	-	17.0
KFM02A	490.00	518.00	3	113271	2023-05-10	-	-	12.3
KFM02A	490.00	518.00	3	113272	2023-05-10	<0.001	<0.001	14.8
KFM02A	411.00	442.00	5	113267	2023-05-09	-	-	12.5
KFM02A	411.00	442.00	5	113268	2023-05-10	-	-	13.5
KFM02A	411.00	442.00	5	113269	2023-05-11	<0.001	<0.001	14.7
KFM02B	491.00	506.00	2	113276	2023-05-11	-	-	13.9
KFM02B	491.00	506.00	2	113277	2023-05-11	-	-	15.4
KFM02B	491.00	506.00	2	113278	2023-05-12	<0.001	<0.001	11.8
KFM02B	410.00	431.00	4	113273	2023-05-11	-	-	10.7
KFM02B	410.00	431.00	4	113274	2023-05-12	-	-	8.7
KFM02B	410.00	431.00	4	113275	2023-05-12	<0.001	<0.001	10.0
KFM03A	969.50	994.50	1	113282	2023-05-22	-	-	15.8
KFM03A	969.50	994.50	1	113283	2023-05-24	-	-	13.4
KFM03A	969.50	994.50	1	113284	2023-05-25	<0.001	0.002	14.3
KFM03A	633.50	650.00	4	113279	2023-05-09	-	-	12.8
KFM03A	633.50	650.00	4	113280	2023-05-09	-	-	15.7
KFM03A	633.50	650.00	4	113281	2023-05-10	<0.001	<0.001	13.8
KFM04A	230.00	245.00	4	113285	2023-05-31	-	-	11.6
KFM04A	230.00	245.00	4	113286	2023-05-31	-	-	11.6
KFM04A	230.00	245.00	4	113287	2023-05-31	<0.001	<0.001	11.2

Table A2-3. Water composition – 2023, continued

Id code	Secup	Seclow	Section	Sample	Sampling	PO_4-P	PO_4-P[1]	Temp_F
	m	m	no.	no.	Date	mg/L	mg/L	
KFM06A	738.00	748.00	3	113291	2023-05-03	-	-	9.2
KFM06A	738.00	748.00	3	113292	2023-05-04	-	-	5.0
KFM06A	738.00	748.00	3	113293	2023-05-05	<0.001	0.001	6.6
KFM06A	341.00	362.00	5	113288	2023-05-03	-	-	7.8
KFM06A	341.00	362.00	5	113289	2023-05-03	-	-	8.5
KFM06A	341.00	362.00	5	113290	2023-05-05	<0.001	<0.001	6.3
KFM06C	647.00	666.00	3	113297	2023-05-08	-	-	15.6
KFM06C	647.00	666.00	3	113298	2023-05-12	-	-	19.8
KFM06C	647.00	666.00	3	113299	2023-05-15	0.001	0.001	20.4
KFM06C	531.00	540.00	5	113294	2023-05-04	-	-	8.2
KFM06C	531.00	540.00	5	113295	2023-05-04	-	-	6.5
KFM06C	531.00	540.00	5	113296	2023-05-05	<0.001	<0.001	8.0
KFM07A	962.00	972.00	2	113300	2023-06-07	-	-	19.9
KFM07A	962.00	972.00	2	113301	2023-06-08	-	-	12.2
KFM07A	962.00	972.00	2	113302	2023-06-08	<0.001	0.002	18.5
KFM08A	684.00	694.00	2	113306	2023-05-30	-	-	9.3
KFM08A	684.00	694.00	2	113307	2023-05-30	-	-	10.1
KFM08A	684.00	694.00	2	113308	2023-05-30	<0.001	0.001	11.4
KFM08A	265.00	280.00	6	113303	2023-05-29	-	-	8.5
KFM08A	265.00	280.00	6	113304	2023-05-30	-	-	9.9
KFM08A	265.00	280.00	6	113305	2023-05-31	<0.001	0.001	12.5
KFM08D	825.00	835.00	2	113312	2023-05-30	-	-	15.6
KFM08D	825.00	835.00	2	113313	2023-06-01	-	-	13.6
KFM08D	825.00	835.00	2	113314	2023-06-02	0.001	0.001	15.2
KFM08D	660.00	680.00	4	113309	2023-05-24	-	-	22.1
KFM08D	660.00	680.00	4	113310	2023-05-26	-	-	12.7
KFM08D	660.00	680.00	4	113311	2023-05-29	<0.001	0.001	-
KFM10A	430.00	440.00	2	113315	2023-05-09	-	-	13.0
KFM10A	430.00	440.00	2	113316	2023-05-10	-	-	10.2
KFM10A	430.00	440.00	2	113317	2023-05-11	<0.001	0.003	10.8

Table A2-3. Water composition – 2023, continued

Id code	Secup	Seclow	Section	Sample	Sampling	PO_4-P	PO_4-P[1]	Temp_F
	m	m	no.	no.	Date	mg/L	mg/L	
KFM11A	690.00	710.00	2	113321	2023-06-12	-	-	17.3
KFM11A	690.00	710.00	2	113322	2023-06-13	-	-	15.5
KFM11A	690.00	710.00	2	113323	2023-06-13	<0.001	<0.001	11.8
KFM11A	446.00	456.00	4	113318	2023-06-07	-	-	11.8
KFM11A	446.00	456.00	4	113319	2023-06-07	-	-	11.3
KFM11A	446.00	456.00	4	113320	2023-06-07	<0.001	<0.001	10.5
KFM12A	270.00	280.00	3	113325	2023-06-12	-	-	10.6
KFM12A	270.00	280.00	3	113324	2023-06-12	-	-	13.2
KFM12A	270.00	280.00	3	113326	2023-06-12	<0.001	<0.001	16.3
KFR01	44.65	62.30	1	113363	2023-09-04	-	-	9.9
KFR01	44.65	62.30	1	113365	2023-09-05	<0.001	<0.001	9.8
KFR101	279.50	341.76	1	113357	2023-06-08	-	-	11.2
KFR101	279.50	341.76	1	113358	2023-06-09	-	-	11.7
KFR101	279.50	341.76	1	113359	2023-06-09	<0.001	0.001	11.5
KFR104	333.00	454.57	1	113360	2023-06-13	-	-	22.6
KFR104	333.00	454.57	1	113361	2023-06-14	-	-	19.1
KFR104	333.00	454.57	1	113362	2023-06-16	0.002	0.002	20.9
KFR105	265.00	306.80	1	113366	2023-09-05	-	-	9.7
KFR105	265.00	306.80	1	113367	2023-09-07	-	-	10.0
KFR105	265.00	306.80	1	113368	2023-09-08	<0.001	<0.001	9.8
KFR106	260.00	300.13	1	113372	2023-06-20	-	-	15.0
KFR106	260.00	300.13	1	113373	2023-06-20	-	-	12.7
KFR106	260.00	300.13	1	113374	2023-06-20	<0.001	0.001	10.4
KFR106	143.00	259.00	2	113369	2023-06-20	-	-	16.9
KFR106	143.00	259.00	2	113370	2023-06-21	-	-	16.0
KFR106	143.00	259.00	2	113371	2023-06-21	<0.001	0.001	17.2

PO4-P[1] = P after hydrolysis
- = Not analysed
< "value" = value below reporting limit

Table A2-4. Trace elements – 2023

Id code	Secup	Seclow	Section	Sample	Sampling	Ag	Al	As	B	Ba	Cd	Cr	Cu	Co	Hg	Ni	Mo	Nb
	m	m	no.	no.	date	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
HFM01	33.50	45.50	2	113329	2023-05-25	<0.05	5.92	0.220	413	22.0	<0.01	0.398	<0.1	0.049	<0.002	0.232	11.4	0.022
HFM02	38.00	48.00	2	113332	2023-05-17	<0.05	3.58	0.090	238	29.8	0.009	0.413	0.12	0.035	<0.002	0.142	8.11	0.298
HFM04	57.90	65.90	2	113335	2023-05-09	<0.05	4.51	0.127	194	44.4	<0.002	0.573	<0.1	0.035	<0.002	0.350	3.40	0.675
HFM13	159.00	175.60	1	113338	2023-05-29	<0.3	3.23	<0.5	572	76.6	<0.02	0.334	<0.2	<0.02	<0.002	<0.2	3.72	0.013
HFM15	85.00	99.50	1	113341	2023-05-17	<0.05	16.0	0.208	49	34.2	0.004	0.412	0.15	0.023	<0.002	0.163	9.90	0.310
HFM16	54.00	67.00	2	113344	2023-05-05	<0.05	5.68	0.490	330	27.4	0.021	1.04	<0.1	0.050	<0.002	0.323	25.9	0.023
HFM21	22.00	32.00	3	113347	2023-06-09	<0.05	4.76	0.129	223	40.8	<0.006	0.695	<0.1	0.048	<0.002	0.399	8.35	0.028
HFM27	46.00	58.00	2	113350	2023-05-25	<0.3	5.57	<0.5	387	34.5	<0.02	0.421	0.369	<0.02	<0.002	0.558	10.0	0.017
HFM32	26.00	31.00	3	113353	2023-05-16	<0.3	3.75	1.44	590	73.9	0.021	0.316	<0.2	0.036	<0.002	<0.2	13.0	0.114
HFM33	121.00	137.50	2	113356	2023-06-20	<0.5	3.69	<0.5	599	81.7	<0.05	2.18	<0.5	<0.05	<0.002	<0.5	4.55	<0.01
KFM01A	109.00	130.00	5	113260	2023-05-24	<0.3	3.39	<0.5	794	101	<0.02	0.308	<0.2	<0.02	<0.002	<0.2	28.0	0.008
KFM01D	429.00	438.00	2	113266	2023-05-30	<0.5	1.93	0.921	665	702	<0.05	0.320	<0.5	<0.05	<0.002	0.731	0.19	0.014
KFM01D	311.00	321.00	4	113263	2023-06-01	<0.3	3.85	<0.5	696	474	<0.02	0.411	<0.2	<0.02	<0.002	<0.2	6.00	0.013
KFM02A	490.00	518.00	3	113272	2023-05-10	<0.5	4.20	<0.5	572	102	<0.05	0.381	<0.5	0.149	<0.002	<0.5	80.7	0.110
KFM02A	411.00	442.00	5	113269	2023-05-11	<0.5	5.82	<0.5	658	91.9	<0.05	0.546	<0.5	0.079	<0.002	<0.5	14.6	0.110
KFM02B	491.00	506.00	2	113278	2023-05-12	<0.5	3.06	<0.5	588	112	<0.05	0.291	<0.5	0.099	<0.002	<0.5	6.49	0.091
KFM02B	410.00	431.00	4	113275	2023-05-12	<0.5	3.58	<0.5	632	105	<0.05	0.407	<0.5	0.057	<0.002	<0.5	7.08	0.124
KFM03A	969.50	994.50	1	113284	2023-05-25	<0.5	20.4	<0.5	918	1080	0.052	0.312	<0.5	<0.05	<0.002	<0.5	9.64	0.032
KFM03A	633.50	650.00	4	113281	2023-05-10	<0.5	5.65	<0.5	1050	183	<0.05	<0.1	<0.5	<0.05	<0.002	<0.5	27.2	0.138
KFM04A	230.00	245.00	4	113287	2023-05-31	<0.5	3.30	<0.5	577	114	<0.05	0.894	<0.5	2.50	<0.002	0.667	87.4	0.014
KFM06A	738.00	748.00	3	113293	2023-05-05	<0.5	4.82	<0.5	746	437	0.309	0.289	<0.5	<0.05	<0.002	<0.5	314	0.024
KFM06A	341.00	362.00	5	113290	2023-05-05	<0.3	3.00	7.59	896	258	0.172	0.238	<0.2	0.224	<0.002	<0.2	164	0.014
KFM06C	647.00	666.00	3	113299	2023-05-15	<0.5	3.39	1.04	876	453	0.059	0.271	<0.5	<0.05	<0.002	<0.5	31.3	0.190
KFM06C	531.00	540.00	5	113296	2023-05-05	<0.5	2.95	<0.5	971	119	<0.05	0.253	<0.5	<0.05	<0.002	<0.5	50.4	0.014
KFM07A	962.00	972.00	2	113302	2023-06-08	<0.5	8.63	<0.5	716	620	0.084	0.940	0.703	<0.05	<0.002	1.00	6.50	0.053
KFM08A	684.00	694.00	2	113308	2023-05-30	<0.5	1.68	2.99	724	384	<0.05	0.460	<0.5	<0.05	<0.002	<0.5	34.6	0.020
KFM08A	265.00	280.00	6	113305	2023-05-31	<0.3	3.57	<0.5	946	384	<0.02	0.224	<0.2	<0.02	<0.002	0.223	9.28	0.010
KFM08D	825.00	835.00	2	113314	2023-06-02	<0.5	2.73	<0.5	724	247	<0.05	0.296	<0.5	<0.05	<0.002	3.40	37.6	0.025
KFM08D	660.00	680.00	4	113311	2023-05-29	<0.5	3.04	0.710	697	579	<0.05	0.422	<0.5	<0.05	<0.002	0.799	34.4	0.022
KFM10A	430.00	440.00	2	113317	2023-05-11	<0.5	2.58	<0.5	670	83.1	<0.05	0.366	<0.5	<0.05	<0.002	<0.5	3.02	0.105

Table A2-4. Trace elements – 2023, continued

Id code	Secup	Seclow	Section	Sample	Sampling	Ag	Al	As	B	Ba	Cd	Cr	Cu	Co	Hg	Ni	Mo	Nb
	m	m	no.	no.	date	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
KFM11A	690.00	710.00	2	113323	2023-06-13	0.826	4.59	<0.5	780	257	<0.05	0.512	<0.5	<0.05	<0.002	<0.5	17.5	0.018
KFM11A	446.00	456.00	4	113320	2023-06-07	<0.3	5.68	<0.5	971	104	<0.02	0.725	0.271	0.024	<0.002	0.534	15.0	0.012
KFM12A	270.00	280.00	3	113326	2023-06-12	<0.3	3.45	1.64	798	535	0.031	0.244	<0.2	0.095	<0.002	0.203	9.56	0.014
KFR01	44.65	62.30	1	113365	2023-09-05	<0.3	3.97	<0.5	730	54.1	0.102	0.249	<0.2	<0.02	<0.002	<0.2	4.36	0.018
KFR101	279.50	341.76	1	113359	2023-06-09	<0.3	5.47	<0.5	1010	618	<0.02	0.302	<0.2	<0.02	<0.002	0.290	3.76	0.006
KFR104	333.00	454.57	1	113362	2023-06-16	<0.3	0.516	<0.5	930	264	0.041	<0.04	<0.2	<0.02	<0.002	<0.2	12.5	0.005
KFR105	265.00	306.80	1	113368	2023-09-08	<0.3	6.18	<0.5	885	112	<0.02	0.179	0.637	<0.02	<0.002	<0.2	2.40	0.017
KFR106	260.00	300.13	1	113374	2023-06-20	<0.3	7.82	<0.5	799	371	<0.02	1.230	0.210	<0.02	<0.002	0.487	5.90	<0.005
KFR106	143.00	259.00	2	113371	2023-06-21	<0.3	4.23	<0.5	754	86.5	<0.02	0.566	<0.2	0.027	<0.002	0.462	6.05	<0.005

Table A2-4. Trace elements – 2023, continued

Id code	Secup	Seclow	Section	Sample	Sampling	U	Th	Rb	Zr	Sb	Cs	Pb	Pd	Se	Sn	V	Zn
	m	m	no.	no.	date	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
HFM01	33.50	45.50	2	113329	2023-05-25	-	-	7.18	7.89	0.018	0.207	0.051	0.039	<0.3	<0.05	1.77	<0.2
HFM02	38.00	48.00	2	113332	2023-05-17	-	-	6.17	76.2	0.013	0.190	0.019	0.456	<0.3	<0.05	1.12	0.408
HFM04	57.90	65.90	2	113335	2023-05-09	-	-	8.44	68.6	0.017	0.251	0.013	0.449	<0.3	<0.05	1.02	<0.2
HFM13	159.00	175.60	1	113338	2023-05-29	-	-	48.6	0.352	0.101	1.91	<0.1	<0.005	<2	<0.3	0.470	<0.8
HFM15	85.00	99.50	1	113341	2023-05-17	-	-	6.64	146	0.034	59.3	0.023	<0.9	<0.3	<0.05	0.998	3.57
HFM16	54.00	67.00	2	113344	2023-05-05	-	-	5.94	6.49	0.046	0.066	0.020	0.053	<0.3	<0.05	1.84	2.35
HFM21	22.00	32.00	3	113347	2023-06-09	-	-	8.84	4.89	0.017	0.154	0.023	<0.01	<0.3	<0.05	1.10	1.03
HFM27	46.00	58.00	2	113350	2023-05-25	-	-	20.3	2.45	<0.1	0.921	<0.1	0.018	<2	<0.3	0.520	<0.8
HFM32	26.00	31.00	3	113353	2023-05-16	-	-	39.8	5.92	<0.1	0.986	<0.1	<0.07	<2	<0.3	0.260	<0.8
HFM33	121.00	137.50	2	113356	2023-06-20	-	-	56.7	<0.2	<0.1	1.82	<0.3	<0.01	<2	<0.5	0.502	<2
KFM01A	109.00	130.00	5	113260	2023-05-24	-	-	52.9	<0.1	<0.1	0.843	<0.1	<0.005	<2	<0.3	0.286	<0.8
KFM01D	429.00	438.00	2	113266	2023-05-30	-	-	41.9	<0.2	<0.1	2.83	<0.3	<0.01	<2	<0.5	0.395	2.28
KFM01D	311.00	321.00	4	113263	2023-06-01	-	-	42.3	<0.1	0.102	0.517	<0.1	<0.005	<2	<0.3	0.210	1.03
KFM02A	490.00	518.00	3	113272	2023-05-10	145	<0.2	65.9	0.325	<0.1	1.75	<0.3	0.193	<2	<0.5	0.205	<2
KFM02A	411.00	442.00	5	113269	2023-05-11	-	-	385	<0.2	<0.1	98.1	<0.3	<0.05	<2	<0.5	0.292	<2
KFM02B	491.00	506.00	2	113278	2023-05-12	-	-	61.1	0.763	<0.1	1.75	<0.3	<0.03	<2	<0.5	0.286	<2
KFM02B	410.00	431.00	4	113275	2023-05-12	-	-	70.7	<0.2	<0.1	4.00	<0.3	<0.03	<2	<0.5	0.291	<2
KFM03A	969.50	994.50	1	113284	2023-05-25	-	-	34.0	<0.2	0.324	0.691	<0.3	<0.01	<2	<0.5	0.467	4.55
KFM03A	633.50	650.00	4	113281	2023-05-10	17.2	<0.2	39.8	<0.2	<0.1	2.60	<0.3	<0.1	<2	<0.5	0.251	2.43
KFM04A	230.00	245.00	4	113287	2023-05-31	-	-	43.2	<0.2	0.154	1.57	<0.3	<0.02	<2	<0.5	0.180	3.92
KFM06A	738.00	748.00	3	113293	2023-05-05	-	-	27.2	<0.2	<0.1	0.514	<0.3	0.059	<2	<0.5	0.373	<2
KFM06A	341.00	362.00	5	113290	2023-05-05	-	-	21.4	<0.1	1.59	0.229	<0.1	0.037	<2	<0.3	0.320	<0.8
KFM06C	647.00	666.00	3	113299	2023-05-15	-	-	15.1	<0.2	0.277	0.378	<0.3	<0.1	<2	<0.5	0.390	<2
KFM06C	531.00	540.00	5	113296	2023-05-05	-	-	29.7	<0.2	<0.1	0.741	<0.3	0.030	<2	<0.5	0.318	<2
KFM07A	962.00	972.00	2	113302	2023-06-08	-	-	41.8	<0.2	0.390	0.745	<0.3	<0.01	<2	<0.5	0.428	16.8
KFM08A	684.00	694.00	2	113308	2023-05-30	-	-	28.4	<0.2	0.188	0.470	<0.3	<0.01	3.93	<0.5	0.358	<2
KFM08A	265.00	280.00	6	113305	2023-05-31	-	-	31.8	<0.1	<0.1	0.268	<0.1	0.008	<2	<0.3	0.226	1.89
KFM08D	825.00	835.00	2	113314	2023-06-02	-	-	16.6	<0.2	0.558	0.338	<0.3	<0.01	<2	<0.5	0.162	4.17
KFM08D	660.00	680.00	4	113311	2023-05-29	-	-	17.8	<0.2	0.222	0.243	<0.3	<0.01	<2	<0.5	0.323	2.82
KFM10A	430.00	440.00	2	113317	2023-05-11	-	-	63.6	2.44	<0.1	0.978	<0.3	0.087	<2	<0.5	0.279	<2

Table A2-4. Trace elements – 2023, continued

Id code	Secup	Seclow	Section	Sample	Sampling	U	Th	Rb	Zr	Sb	Cs	Pb	Pd	Se	Sn	V	Zn
	m	m	no.	no.	date	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
KFM11A	690.00	710.00	2	113323	2023-06-13	-	-	20.7	<0.2	0.222	3.06	<0.3	<0.01	<2	<0.5	0.357	<2
KFM11A	446.00	456.00	4	113320	2023-06-07	-	-	12.7	<0.1	0.111	0.292	0.156	<0.005	<2	<0.3	0.388	7.54
KFM12A	270.00	280.00	3	113326	2023-06-12	-	-	13.6	<0.1	0.222	0.660	<0.1	<0.005	<2	<0.3	0.114	<0.8
KFR01	44.65	62.30	1	113365	2023-09-05	-	-	14.2	<0.1	<0.1	0.390	<0.1	0.0350	<2	<0.3	0.294	2.55
KFR101	279.50	341.76	1	113359	2023-06-09	-	-	11.7	<0.1	<0.1	0.276	<0.1	<0.005	<2	<0.3	0.376	1.04
KFR104	333.00	454.57	1	113362	2023-06-16	-	-	7.74	<0.1	<0.1	0.162	<0.1	<0.005	<2	<0.3	<0.03	1.32
KFR105	265.00	306.80	1	113368	2023-09-08	-	-	13.0	<0.1	<0.1	0.360	<0.1	0.0220	<2	<0.3	0.425	16.8
KFR106	260.00	300.13	1	113374	2023-06-20	9.5	<0.02	16.1	<0.1	<0.1	0.378	<0.1	<0.005	<2	<0.3	0.246	1.37
KFR106	143.00	259.00	2	113371	2023-06-21	25.4	<0.02	27.4	<0.1	<0.1	0.728	<0.1	<0.005	<2	<0.3	0.272	1.46

- = Not analysed
< "value" = result less than reporting limit

Table A2-5. H-, O- and S-isotopes I – 2023

Id code	Secup	Seclow	Section	Sample	Sampling	$\delta^{2}H$	^{3}H	$\delta^{18}O$	$\delta^{34}S\text{-}SO_4$	$\delta^{18}O\text{-}SO_4$
	m	m	no.	no.	date	‰ dev SMOW	TU	‰ dev SMOW	‰ dev CDT	‰ dev SMOW
HFM01	33.50	45.50	2	113327	2023-05-22	-75.9	-	-10.23	-	-
HFM01	33.50	45.50	2	113328	2023-05-23	-76.0	-	-10.27	-	-
HFM01	33.50	45.50	2	113329	2023-05-25	-75.8	1.8	-10.25	-	-
HFM02	38.00	48.00	2	113330	2023-05-15	-82.1	-	-11.4	-	-
HFM02	38.00	48.00	2	113331	2023-05-16	-81.9	-	-11.39	-	-
HFM02	38.00	48.00	2	113332	2023-05-17	-81.8	5.0	-11.38	-	-
HFM04	58.00	66.00	2	113333	2023-05-08	-82.4	-	-11.5	-	-
HFM04	58.00	66.00	2	113334	2023-05-08	-82.5	-	-11.52	-	-
HFM04	58.00	66.00	2	113335	2023-05-09	-82.6	3.7	-11.54	-	-
HFM13	159.00	173.00	1	113336	2023-05-23	-71.8	-	-9.51	-	-
HFM13	159.00	173.00	1	113337	2023-05-26	-71.6	-	-9.55	-	-
HFM13	159.00	173.00	1	113338	2023-05-29	-71.6	5.2	-9.54	26.9	9.6
HFM15	85.00	95.00	1	113339	2023-05-15	-89.0	-	-12.5	-	-
HFM15	85.00	95.00	1	113340	2023-05-16	-89.2	-	-12.51	-	-
HFM15	85.00	95.00	1	113341	2023-05-17	-88.9	8.5	-12.49	14.91	-1.4
HFM16	54.00	67.00	2	113342	2023-05-03	-81.0	-	-11.19	-	-
HFM16	54.00	67.00	2	113343	2023-05-04	-80.8	-	-11.13	-	-
HFM16	54.00	67.00	2	113344	2023-05-05	-80.5	1.9	-11.12	15.93	1.3
HFM21	22.00	32.00	3	113345	2023-06-07	-81.9	-	-11.26	-	-
HFM21	22.00	32.00	3	113346	2023-06-08	-81.4	-	-11.21	-	-
HFM21	22.00	32.00	3	113347	2023-06-09	-81.4	5.6	-11.19	-	-
HFM27	46.00	58.00	2	113348	2023-05-22	-74.3	-	-10.13	-	-
HFM27	46.00	58.00	2	113349	2023-05-23	-74.7	-	-10.2	-	-
HFM27	46.00	58.00	2	113350	2023-05-25	-74.8	5.2	-10.23	-	-
HFM32	26.00	31.00	3	113351	2023-05-16	-65.9	-	-8.55	-	-
HFM32	26.00	31.00	3	113352	2023-05-16	-65.7	-	-8.59	-	-
HFM32	26.00	31.00	3	113353	2023-05-16	-65.9	<0.8	-8.57	-	-
HFM33	121.00	137.50	2	113354	2023-06-19	-65.4	-	-8.61	-	-
HFM33	121.00	137.50	2	113355	2023-06-19	-66.0	-	-8.7	-	-
HFM33	121.00	137.50	2	113356	2023-06-20	-65.8	1.7	-8.66	-	-

Table A2-5. H-, O- and S-isotopes I – 2023, continued

Id code	Secup	Seclow	Section	Sample	Sampling	$\delta^{2}H$	^{3}H	$\delta^{18}O$	$\delta^{34}S\text{-}SO_4$	$\delta^{18}O\text{-}SO_4$
	m	m	no.	no.	date	‰ dev SMOW	TU	‰ dev SMOW	‰ dev CDT	‰ dev SMOW
KFM01A	109.00	130.00	5	113258	2023-05-23	-89.8	-	-11.91	-	-
KFM01A	109.00	130.00	5	113259	2023-05-24	-89.8	-	-11.98	-	-
KFM01A	109.00	130.00	5	113260	2023-05-24	-90	<0.8	-11.99	-	-
KFM01D	429.00	438.00	2	113264	2023-05-29	-73.5	-	-10.72	-	-
KFM01D	429.00	438.00	2	113265	2023-05-29	-73.4	-	-10.72	-	-
KFM01D	429.00	438.00	2	113266	2023-05-30	-73.1	<0.8	-10.74	-	-
KFM01D	311.00	321.00	4	113261	2023-06-01	-78.1	-	-11.28	-	-
KFM01D	311.00	321.00	4	113262	2023-06-01	-76.8	-	-11.03	-	-
KFM01D	311.00	321.00	4	113263	2023-06-01	-76	<0.8	-10.84	-	-
KFM02A	490.00	518.00	3	113270	2023-05-09	-66.2	-	-8.75	-	-
KFM02A	490.00	518.00	3	113271	2023-05-10	-66.2	-	-8.74	-	-
KFM02A	490.00	518.00	3	113272	2023-05-10	-66.1	<0.8	-8.73	25.42	9.6
KFM02A	411.00	442.00	5	113267	2023-05-09	-76	-	-10.06	-	-
KFM02A	411.00	442.00	5	113268	2023-05-10	-75.9	-	-10.08	-	-
KFM02A	411.00	442.00	5	113269	2023-05-11	-75.4	<0.8	-9.99	-	-
KFM02B	491.00	506.00	2	113276	2023-05-11	-64.6	-	-8.48	-	-
KFM02B	491.00	506.00	2	113277	2023-05-11	-64.6	-	-8.48	-	-
KFM02B	491.00	506.00	2	113278	2023-05-12	-64.6	<0.8	-8.44	-	-
KFM02B	410.00	431.00	4	113273	2023-05-11	-71.4	-	-9.45	-	-
KFM02B	410.00	431.00	4	113274	2023-05-12	-71.5	-	-9.45	-	-
KFM02B	410.00	431.00	4	113275	2023-05-12	-71.5	<0.8	-9.39	-	-
KFM03A	969.50	994.50	1	113282	2023-05-22	-96.2	-	-13.63	-	-
KFM03A	969.50	994.50	1	113283	2023-05-24	-95.8	-	-13.6	-	-
KFM03A	969.50	994.50	1	113284	2023-05-25	-95.7	<0.8	-13.58	31.37	1.1
KFM03A	633.50	650.00	4	113279	2023-05-09	-84.5	-	-11.62	-	-
KFM03A	633.50	650.00	4	113280	2023-05-09	-84.4	-	-11.64	-	-
KFM03A	633.50	650.00	4	113281	2023-05-10	-84.2	<0.8	-11.62	-	-
KFM04A	230.00	245.00	4	113285	2023-05-31	-69.5	-	-9.13	-	-
KFM04A	230.00	245.00	4	113286	2023-05-31	-69.6	-	-9.14	-	-
KFM04A	230.00	245.00	4	113287	2023-05-31	-69.4	<0.8	-9.06	-	-

Table A2-5. H-, O- and S-isotopes I – 2023, continued

Id code	Secup	Seclow	Section	Sample	Sampling	$\delta^{2}H$	^{3}H	$\delta^{18}O$	$\delta^{34}S\text{-}SO_4$	$\delta^{18}O\text{-}SO_4$
	m	m	no.	no.	date	‰ dev SMOW	TU	‰ dev SMOW	‰ dev CDT	‰ dev SMOW
KFM06A	738.00	748.00	3	113291	2023-05-03	-81.5	-	-11.82	-	-
KFM06A	738.00	748.00	3	113292	2023-05-04	-81.8	-	-11.86	-	-
KFM06A	738.00	748.00	3	113293	2023-05-05	-81.8	<0.8	-11.85	-	-
KFM06A	341.00	362.00	5	113288	2023-05-03	-88.7	-	-12.16	-	-
KFM06A	341.00	362.00	5	113289	2023-05-03	-88.9	-	-12.21	-	-
KFM06A	341.00	362.00	5	113290	2023-05-05	-89.3	<0.8	-12.26	-	-
KFM06C	647.00	666.00	3	113297	2023-05-08	-93.6	-	-12.9	-	-
KFM06C	647.00	666.00	3	113298	2023-05-12	-93.6	-	-12.89	-	-
KFM06C	647.00	666.00	3	113299	2023-05-15	-93.7	<0.8	-12.87	-	-
KFM06C	531.00	540.00	5	113294	2023-05-04	-82	-	-11.18	-	-
KFM06C	531.00	540.00	5	113295	2023-05-04	-82.1	-	-11.19	-	-
KFM06C	531.00	540.00	5	113296	2023-05-05	-82.1	1.2	-11.21	-	-
KFM07A	962.00	972.00	2	113300	2023-06-07	-87.1	-	-12.64	-	-
KFM07A	962.00	972.00	2	113301	2023-06-08	-87.8	-	-13.54	-	-
KFM07A	962.00	972.00	2	113302	2023-06-08	-88	<0.8	-13.05	24.3	5.9
KFM08A	684.00	694.00	2	113306	2023-05-30	-90.9	-	-12.97	-	-
KFM08A	684.00	694.00	2	113307	2023-05-30	-90.5	-	-12.92	-	-
KFM08A	684.00	694.00	2	113308	2023-05-30	-90	<0.8	-12.74	26.39	10.7
KFM08A	265.00	280.00	6	113303	2023-05-29	-100.6	-	-13.48	-	-
KFM08A	265.00	280.00	6	113304	2023-05-30	-100.6	-	-13.46	-	-
KFM08A	265.00	280.00	6	113305	2023-05-31	-100.7	<0.8	-13.48	29.11	8.8
KFM08D	825.00	835.00	2	113312	2023-05-30	-80.3	-	-11.66	-	-
KFM08D	825.00	835.00	2	113313	2023-06-01	-80.3	-	-11.75	-	-
KFM08D	825.00	835.00	2	113314	2023-06-02	-80.4	<0.8	-12.03	-	-
KFM08D	660.00	680.00	4	113309	2023-05-24	-83.7	-	-12.08	-	-
KFM08D	660.00	680.00	4	113310	2023-05-26	-83.5	-	-11.94	-	-
KFM08D	660.00	680.00	4	113311		-83.9	<0.8	-12.08	28.77	9.9
KFM10A	430.00	440.00	2	113315	2023-05-09	-64.5	-	-8.55	-	-
KFM10A	430.00	440.00	2	113316	2023-05-10	-64.4	-	-8.49	-	-
KFM10A	430.00	440.00	2	113317	2023-05-11	-64.5	<0.8	-8.5	-	-

Table A2-5. H-, O- and S-isotopes I – 2023, continued

Id code	Secup	Seclow	Section	Sample	Sampling	$\delta^{2}H$	^{3}H	$\delta^{18}O$	$\delta^{34}S\text{-}SO_4$	$\delta^{18}O\text{-}SO_4$
	m	m	no.	no.	date	‰ dev SMOW	TU	‰ dev SMOW	‰ dev CDT	‰ dev SMOW
KFM11A	690.00	710.00	2	113321	2023-06-12	-84.3	-	-11.5	-	-
KFM11A	690.00	710.00	2	113322	2023-06-13	-84.8	-	-11.6	-	-
KFM11A	690.00	710.00	2	113323	2023-06-13	-84.9	5.9	-11.61	-	-
KFM11A	446.00	456.00	4	113318	2023-06-07	-90.8	-	-12.31	-	-
KFM11A	446.00	456.00	4	113319	2023-06-07	-91.2	-	-12.36	-	-
KFM11A	446.00	456.00	4	113320	2023-06-07	-91	<0.8	-12.32	-	-
KFM12A	270.00	280.00	3	113325	2023-06-12	-112.3	-	-15.17	-	-
KFM12A	270.00	280.00	3	113324	2023-06-12	-112.6	-	-15.18	-	-
KFM12A	270.00	280.00	3	113326	2023-06-12	-112.6	<0.8	-15.18	32.74	5.1
KFR01	44.65	62.30	1	113363	2023-09-04	-	-	-	-	-
KFR01	44.65	62.30	1	113365	2023-09-05	-	-	-	-	-
KFR101	279.50	341.76	1	113357	2023-06-08	-112.2	-	-15.2	-	-
KFR101	279.50	341.76	1	113358	2023-06-09	-112.3	-	-15.2	-	-
KFR101	279.50	341.76	1	113359	2023-06-09	-112.5	<0.8	-15.21	-	-
KFR104	333.00	454.57	1	113360	2023-06-13	-107.8	-	-14.45	-	-
KFR104	333.00	454.57	1	113361	2023-06-14	-108	-	-14.46	-	-
KFR104	333.00	454.57	1	113362	2023-06-16	-108.1	<0.8	-14.5	-	-
KFR105	265.00	306.80	1	113366	2023-09-05	-	-	-	-	-
KFR105	265.00	306.80	1	113367	2023-09-07	-	-	-	-	-
KFR105	265.00	306.80	1	113368	2023-09-08	-	2.1	-	-	-
KFR106	260.00	300.13	1	113372	2023-06-20	-117.8	-	-15.87	-	-
KFR106	260.00	300.13	1	113373	2023-06-20	-113.3	-	-15.18	-	-
KFR106	260.00	300.13	1	113374	2023-06-20	-112.1	1.0	-15.04	-	-
KFR106	143.00	259.00	2	113369	2023-06-20	-83.4	-	-11.03	-	-
KFR106	143.00	259.00	2	113370	2023-06-21	-83.6	-	-11.1	-	-
KFR106	143.00	259.00	2	113371	2023-06-21	-83.5	-	-11.1	-	-

- = Not analysed
< "value" = result less than reporting limit

Table A2-6. Uranium and thorium isotopes – 2023

Id code	Secup	Seclow	Section	Sample	Sampling	^{238}U	^{235}U	^{234}U	^{232}Th	^{230}Th
	m	m	no.	no.	date	mBq/kg	mBq/kg	mBq/kg	mBq/kg	mBq/kg
KFM02A	490.00	518.00	3	113272	2023-05-10	1760	82	3480	<1	12
KFM03A	633.50	650.00	4	113281	2023-05-10	208	10	313	<1	<4
KFR106	260.00	300.10	1	113374	2023-06-20	115	5	2490	<1	<4
KFR106	143.00	259.00	2	113371	2023-06-21	287	13	877	<1	<4

Appendix 3 - Plug flow volumes

Table A3-1. Plug flow volumes

Borehole Idcode: section	Plug flow volume [L]
KFM01A:5	93
KFM01D:2	16
KFM01D:4	18
KFM02A:3	42
KFM02A:5	182
KFM02B:2	60
KFM02B:4	191
KFM03A:1	79
KFM03A:4	29
KFM04A:4	16
KFM06A:3	28
KFM06A:5	26
KFM06C:3 [2)]	43
KFM06C:5 [2)]	28
KFM07A:2	38
KFM08A:2	22
KFM08A:6	259
KFM08D:2	33
KFM08D:4	235
KFM10A:2	125
KFM11A:2 [2)]	46
KFM11A:4	21
KFM12A:3 [2)]	23
HFM01:2	306
HFM02:2	238
HFM04:2	103
HFM13:1	515
HFM15:1	116
HFM16:2	840
HFM19:1	203
HFM21:3	134
HFM27:2	222
HFM32:3	29
HFM33:2 [2)]	51
KFR101:1 [1)]	73
KFR102A:2 [1)]	194
KFR102A:5	52
KFR104:1 [1)]	60
KFR105:1 [1)]	696
KFR106:1	16
KFR106:2 [1)]	55
KFR01:1 [2)]	40
KFR02:2	42
KFR02:3	87
KFR02:4	86

[1)] Used plug flow volumes smaller than 100% formation waters, se Table A3-2.
[2)] Section volume

Table A3-2. Plug flow volumes special

Idcode:section	Used plug flow volume [L]	Percent formation water [%]	Volume needed for 100 % formation water [L]
KFR101:1	73	99.0	17881
KFR102A:2	194	99.9	986
KFR104:1	60	83.0	491
KFR105:1	696	98.6	2433
KFR106:2	55	89.4	1450

Appendix 4 - Pressure registration during pumping and sampling, HMS system

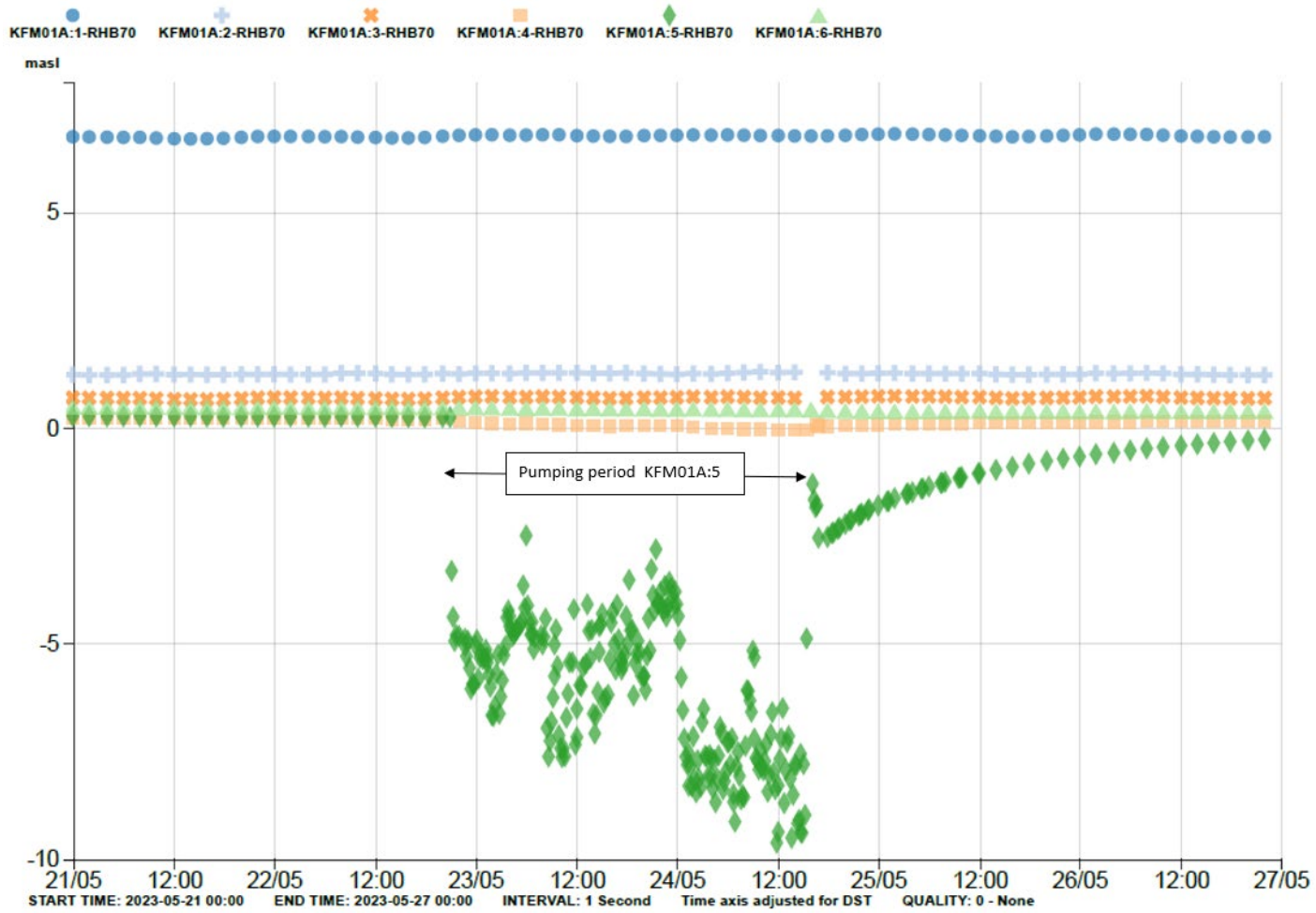

Figure A4-1. *Pumping and drawdown in KFM01A:5 (dark green) in May 2023. A small response was observed in section 4 (pale orange).*

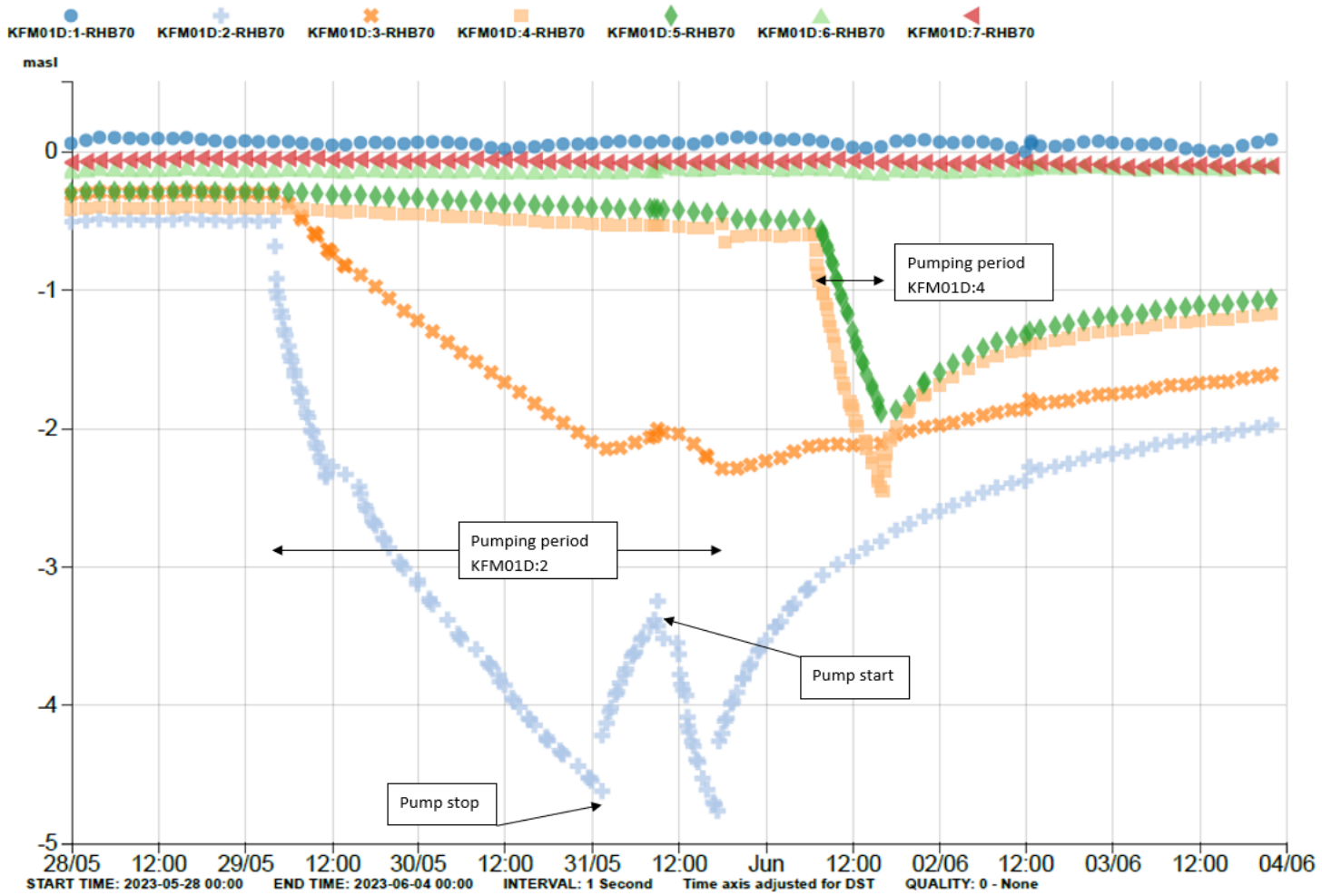

Figure A4-2*. Pumping and drawdown in KFM01D:2 (pale blue) in May 2023 and KFM01D:4 (pale orange) in June 2023. Sections 3 (dark orange), 4 and 5 (dark green) were affected by the pumping in KFM01D:2. Sections 3 and 5 were affected by the pumping in KFM01D:4. A pump stop occurred during the pumping period for KFM01D:2, although after sample collection of the third sample in the series.*

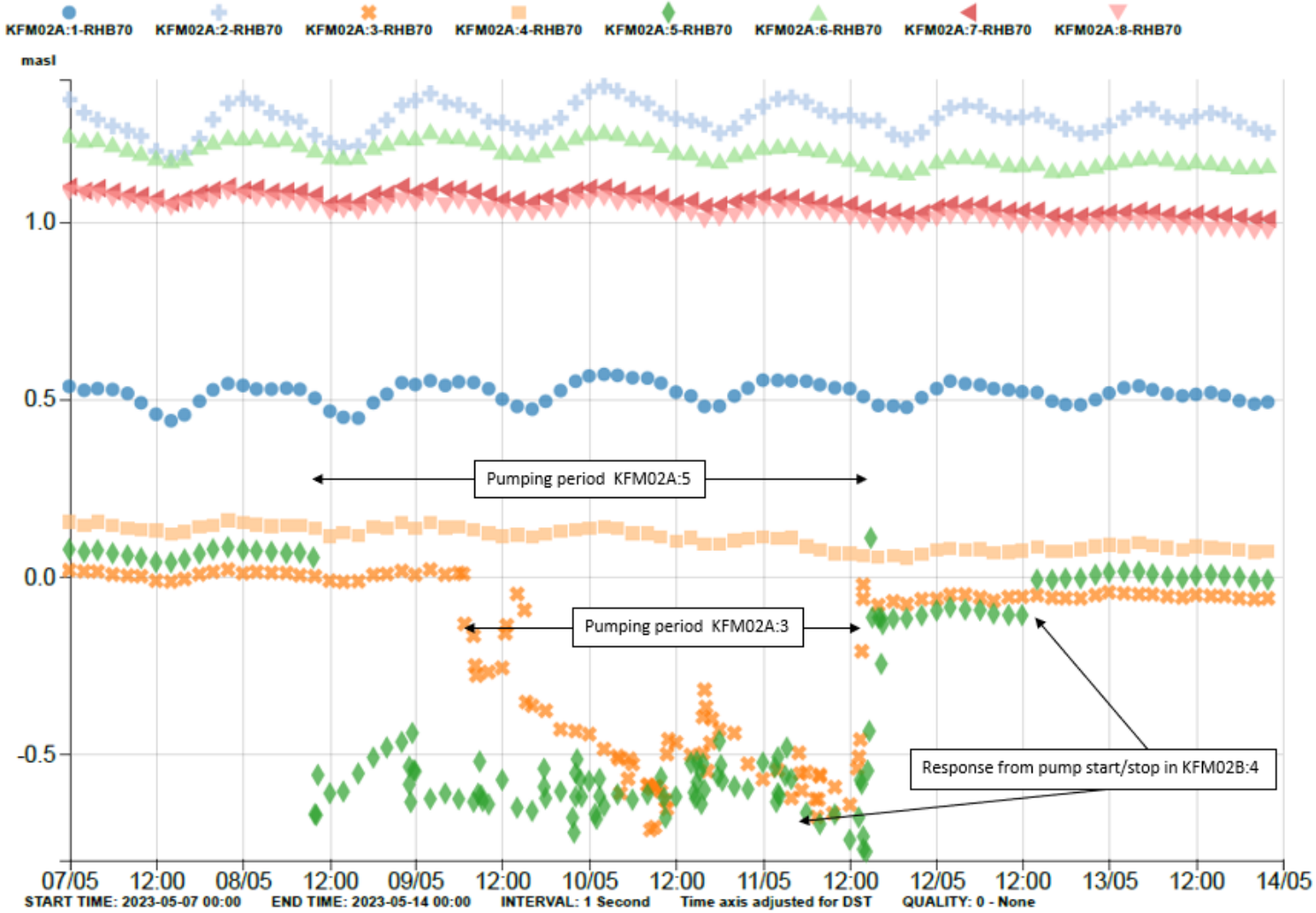

Figure A4-3. *Pumping and drawdown in KFM02A:3 (dark orange) and KFM02A:5 (dark green) in May 2023. No other sections in the borehole were affected. However, in KFM02A:5 there was a response from the pumping in KFM02B:4 and vice versa (see also Figure A4-4).*

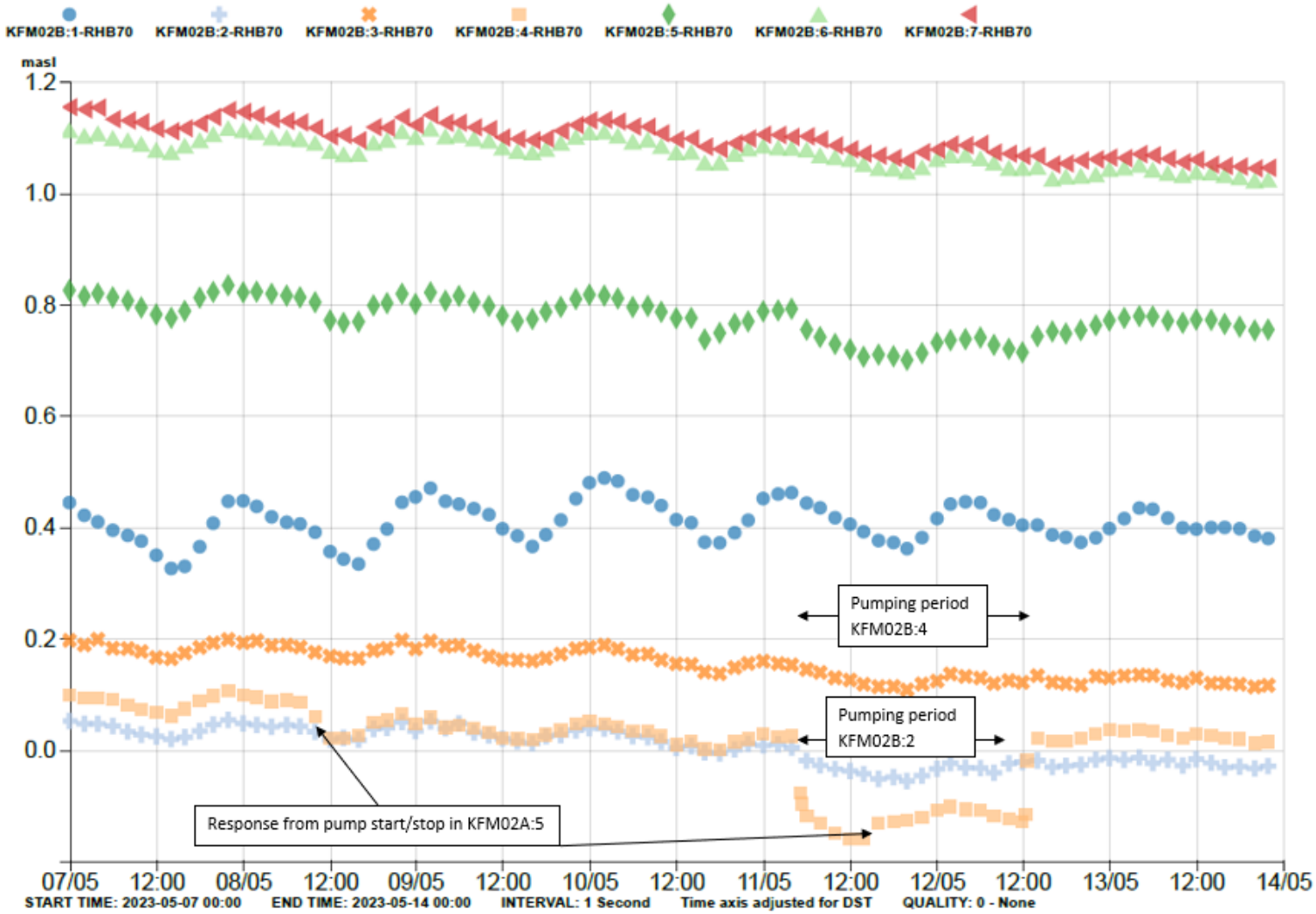

Figure A4-4. *Pumping and drawdown in KFM02B:2 (pale blue) and KFM02B:4 (pale orange) in May 2023. The pumping in KFM02B:4 caused a small response in section 5 (dark green). In KFM02B:4 there was a response from the pumping in KFM02A:5 and vice versa (see also Figure A4-3).*

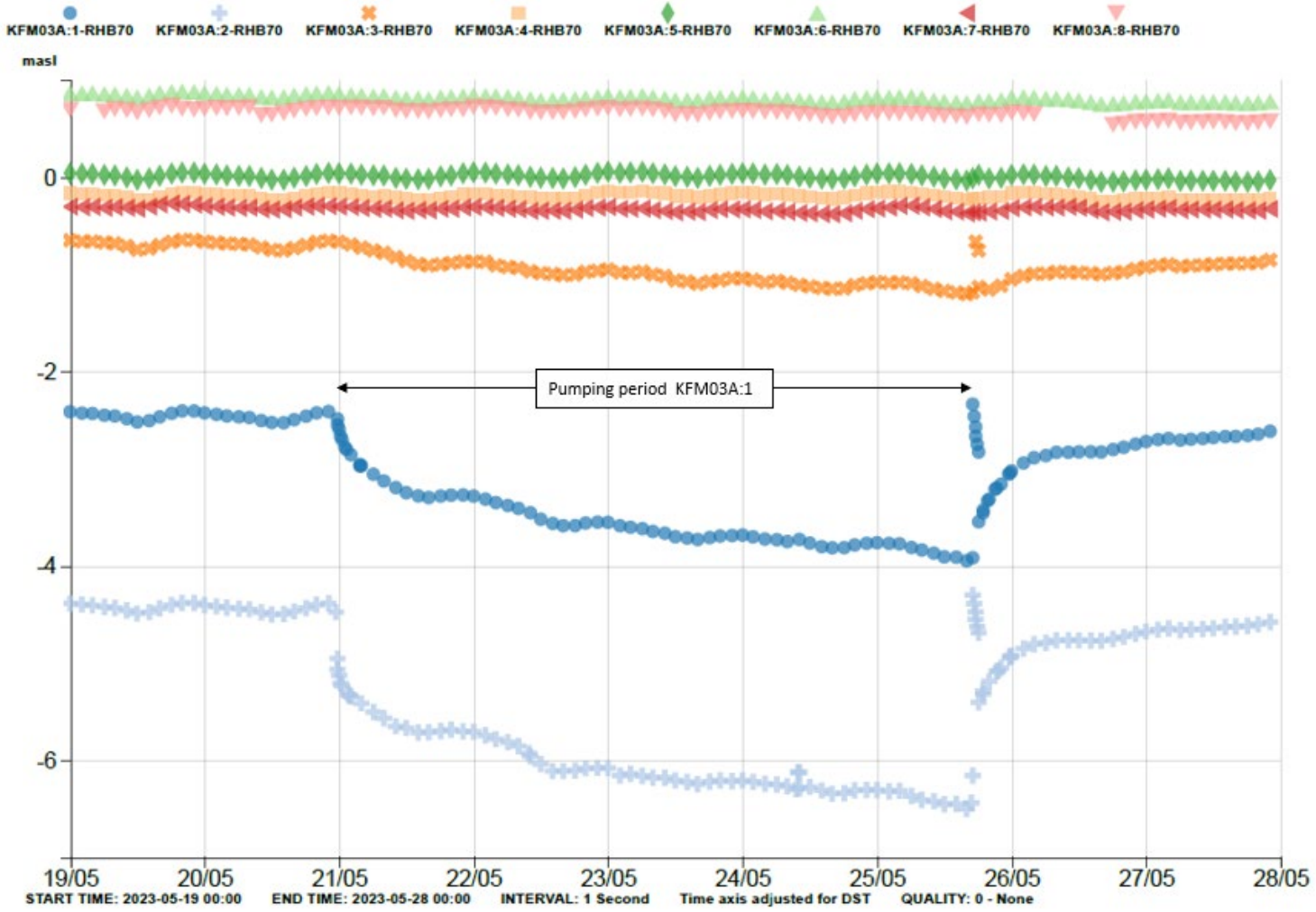

Figure A4-5. *Pumping and drawdown in KFM03A:1 (dark blue) in May 2023. The pressure response observed in section 2 (pale blue) during pumping may be caused by a leaking connection in the equipment between the sections rather than a connected fracture system. A response to the pumping in KFM03A:1 was also seen in section 3 (dark orange).*

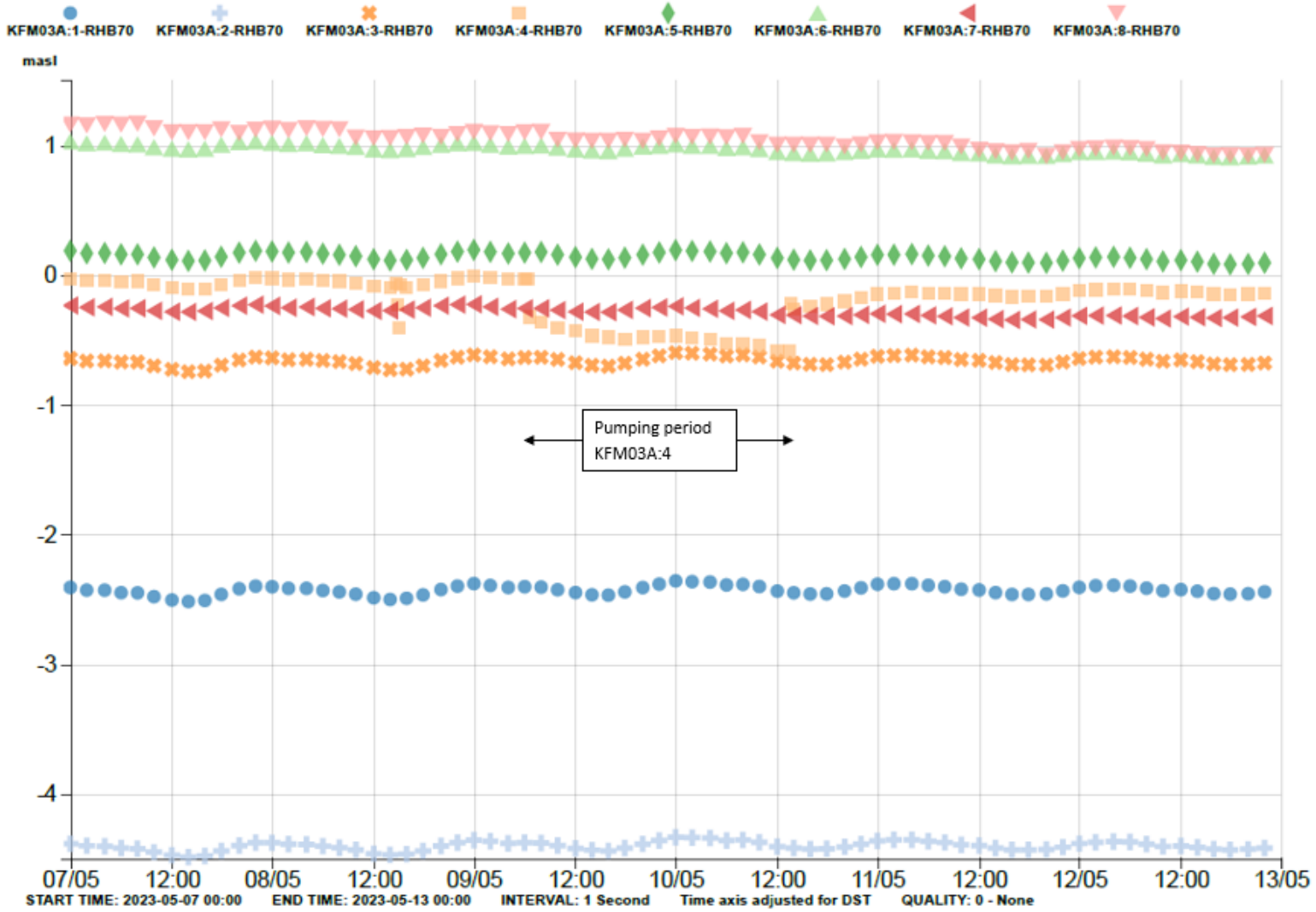

Figure A4-6. *Pumping and drawdown in KFM03A:4 (pale orange) in May 2023. No other sections in the borehole were affected.*

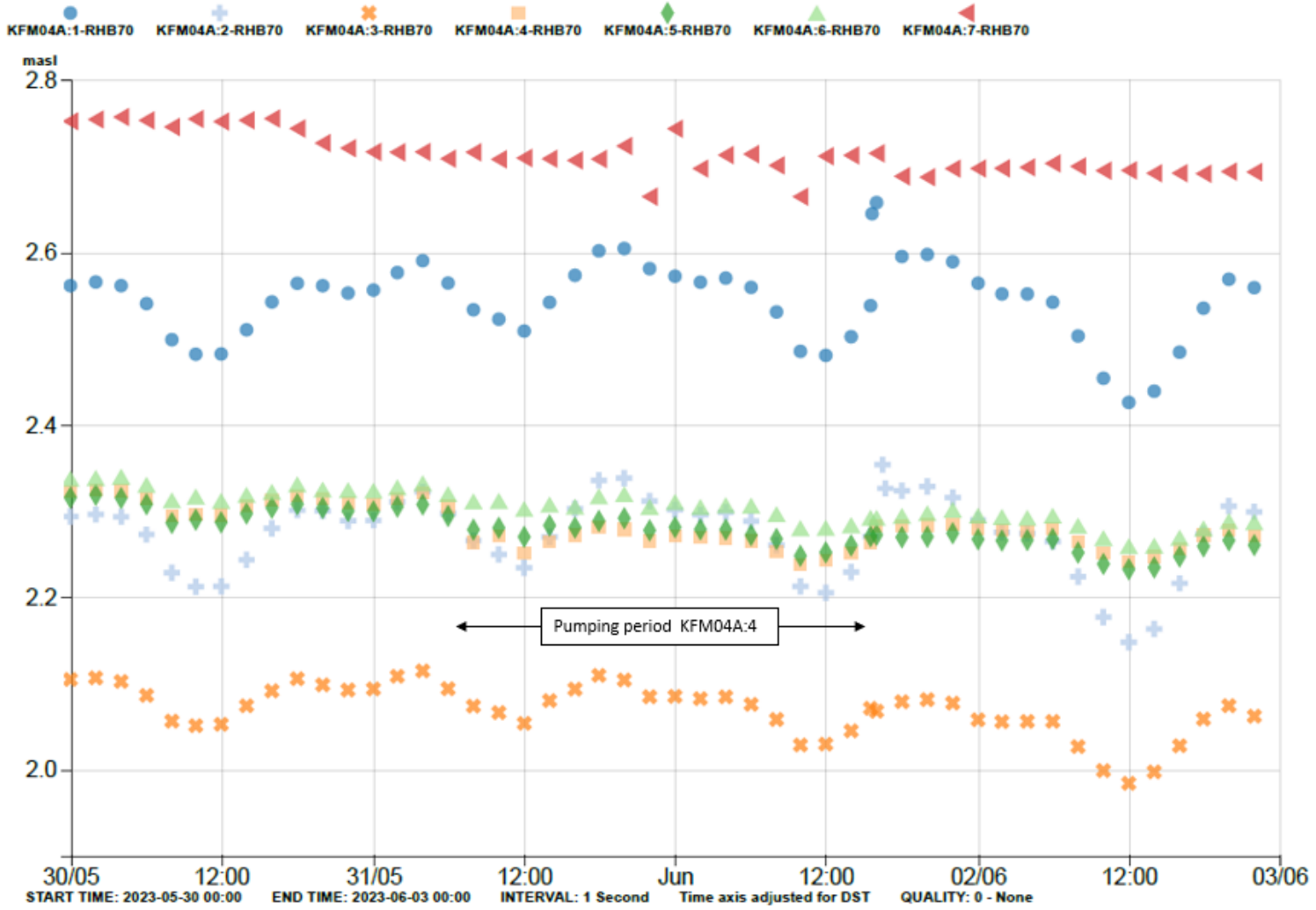

Figure A4-7. *Pumping in KFM04A:4 (pale orange) in May-June 2023. A slight drawdown can be seen in the pumped section but not in any of the other sections.*

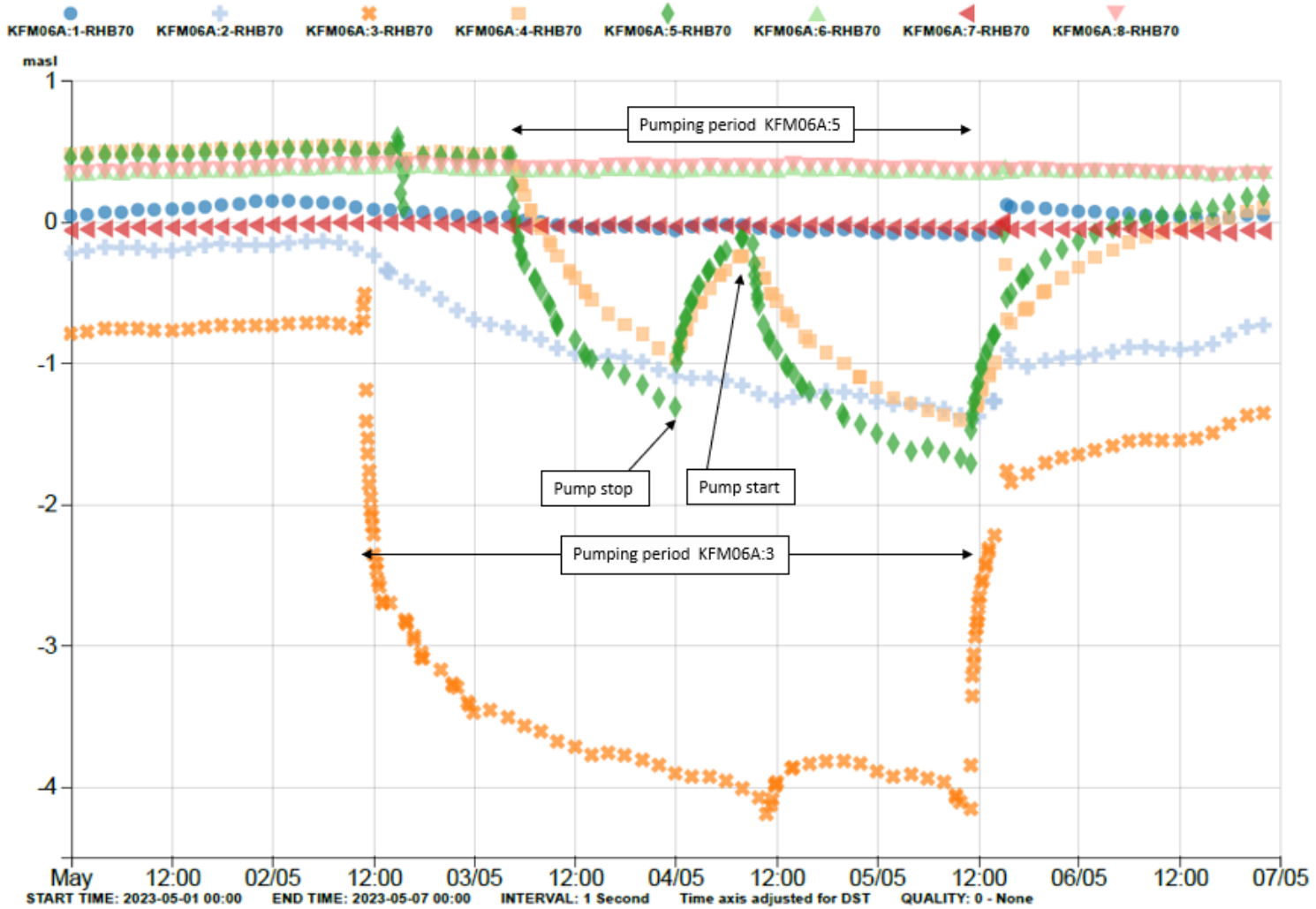

Figure A4-8. *Pumping and drawdown in KFM06A:3 (dark orange) and KFM06A:5 (dark green) in May 2023. Section 1 (dark blue) and section 2 (pale blue) were affected by the pumping in KFM06A:3. Section 4 (pale orange) was affected by the pumping in section KFM06A:5. During the pumping period for KFM06A:5 a pump stop occurred.*

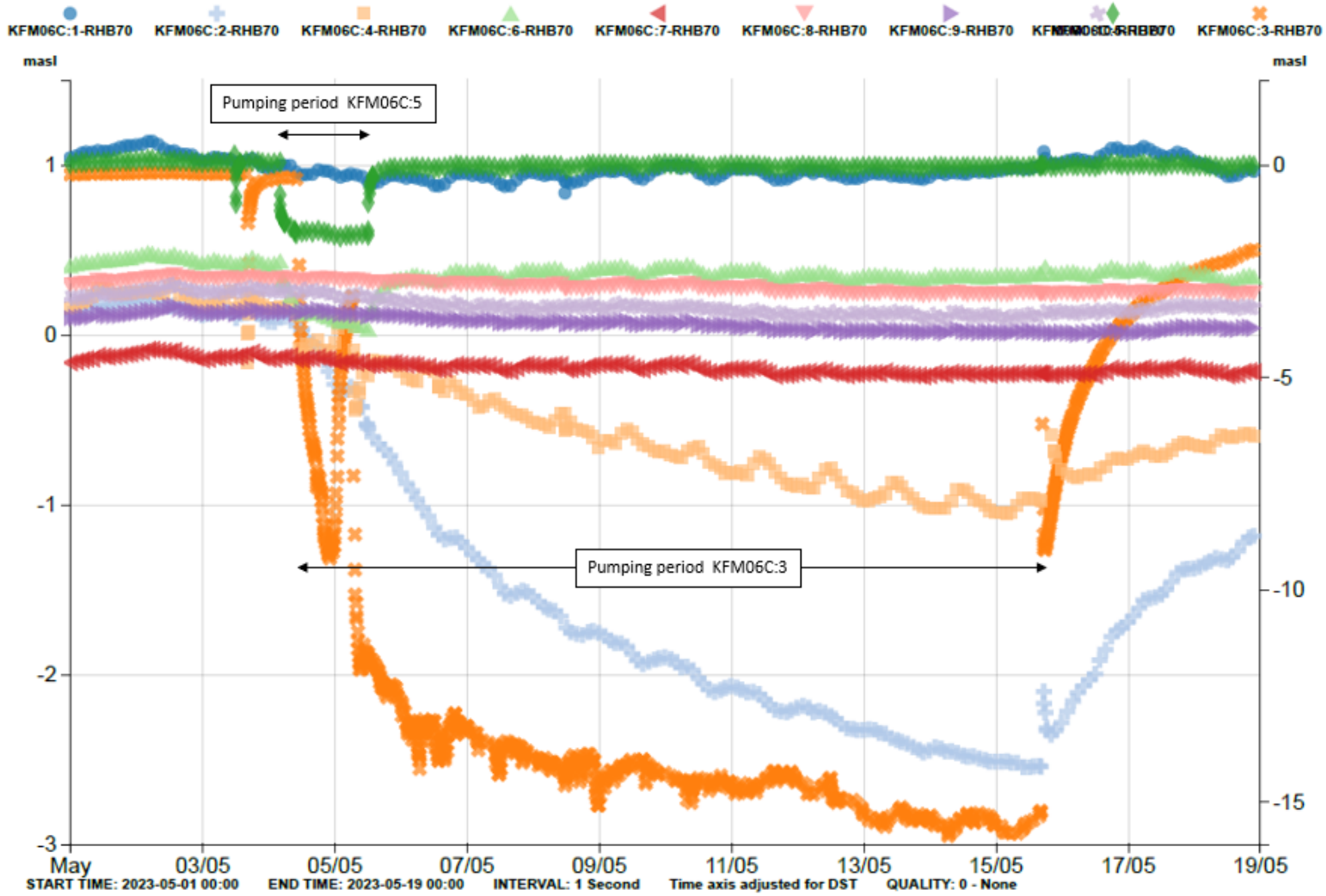

Figure A4-9. *Pumping and drawdown in KFM06C:3 (dark orange) and KFM06C:5 (dark green) in May 2023. Sections 2 (pale blue) and 4 (pale orange) were affected by the pumping in section KFM06C:3. The pumping in section KFM06C:5 caused a response in section 6 (pale green).*

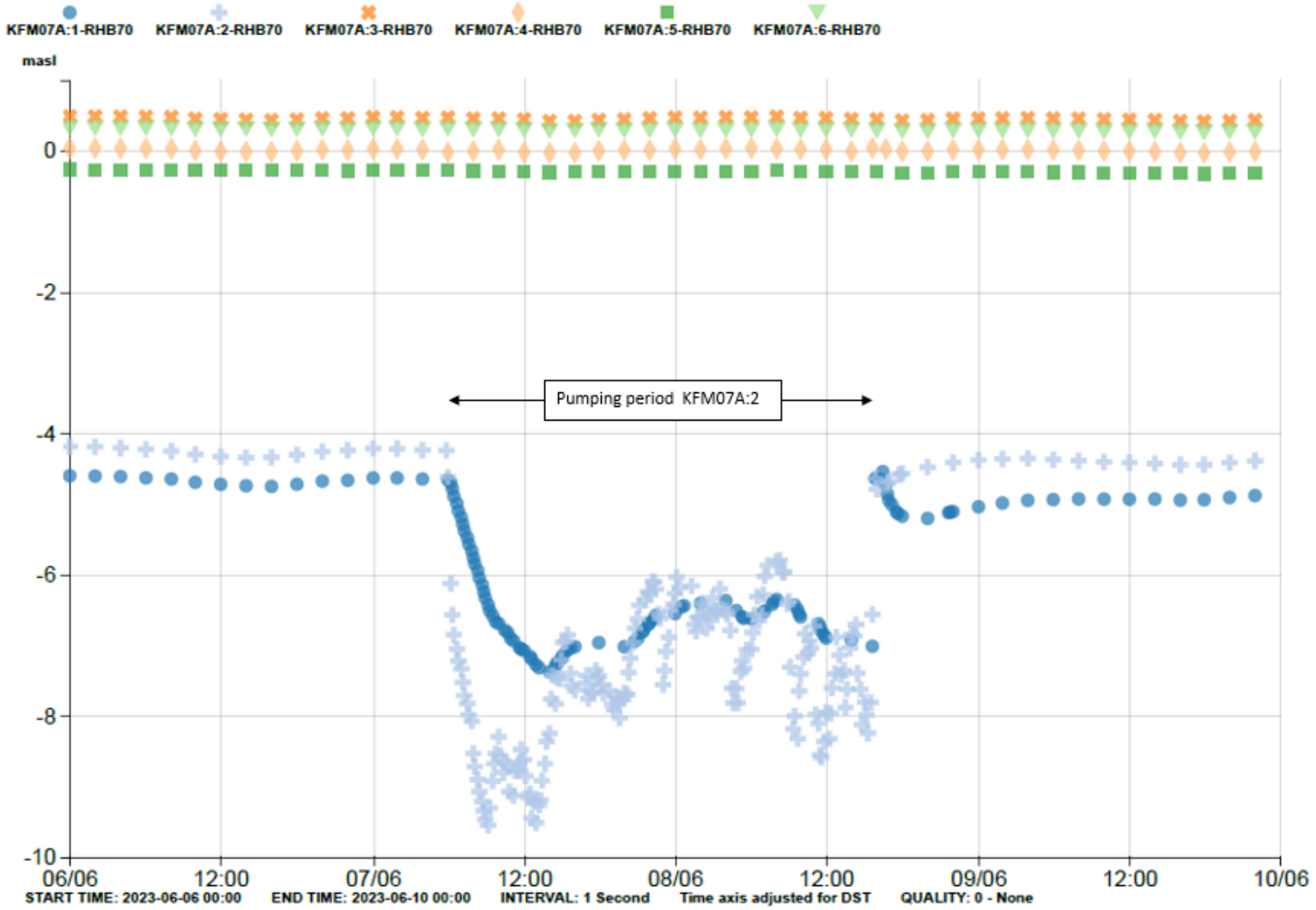

Figure A4-10. *Pumping and drawdown in KFM07A:2 (pale blue) in June 2023. The pumping caused a response in section 1 (dark blue).*

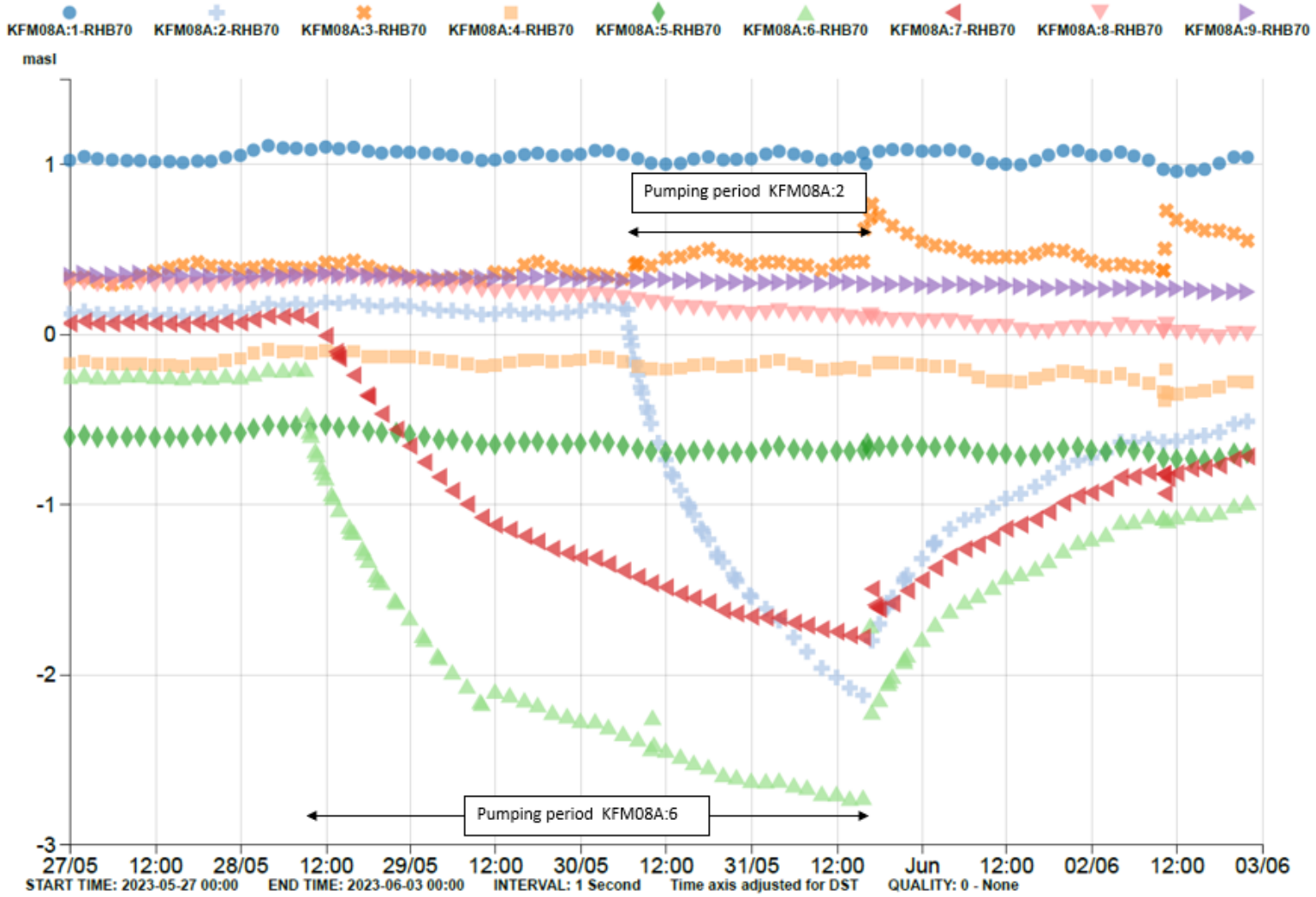

Figure A4-11. *Pumping and drawdown in KFM08A:2 (pale blue) and KFM08A:6 (pale green) in May 2023. The pumping in KFM08A:6 caused responses in section 7 (red) and section 8 (pink).*

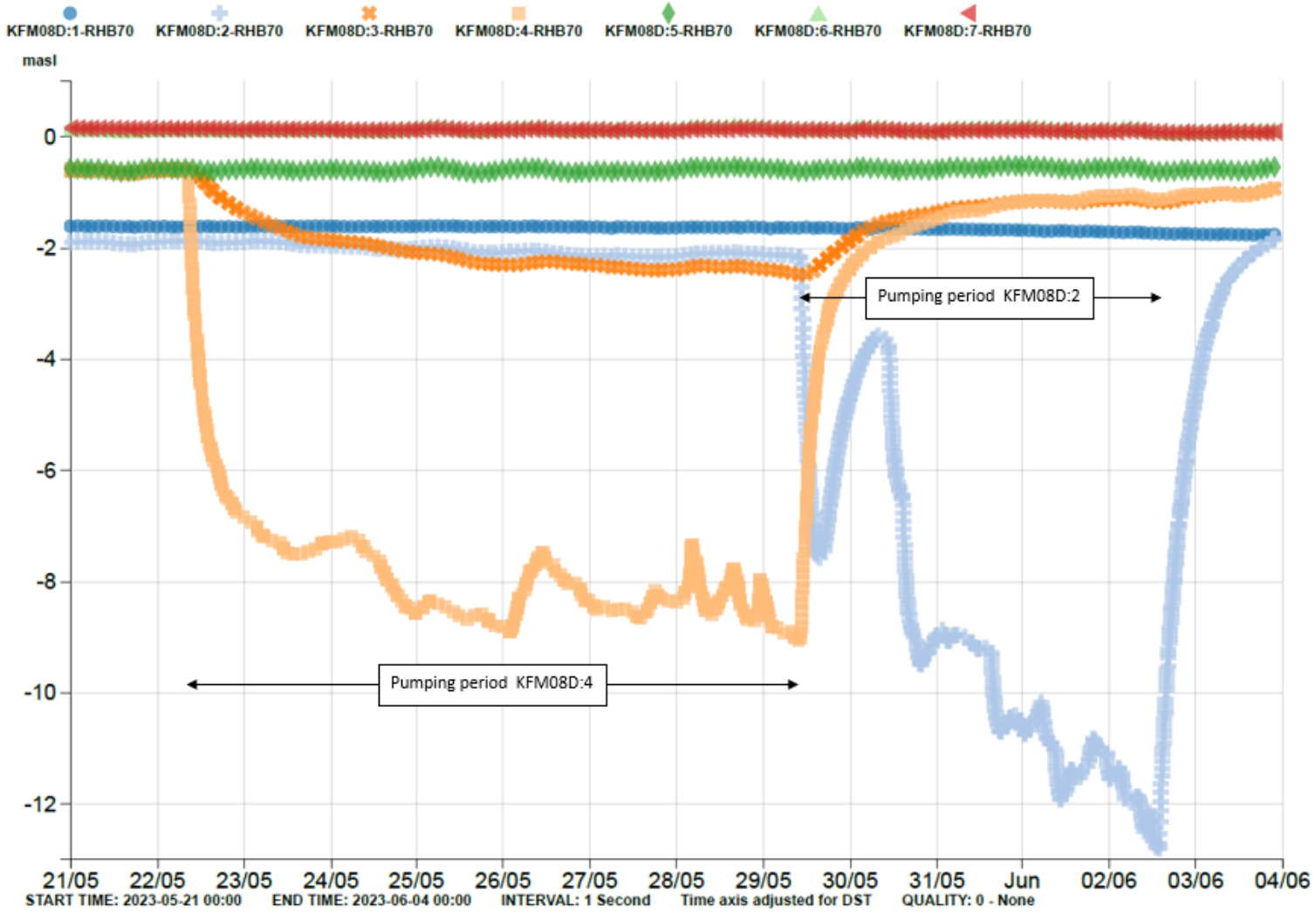

Figure A4-12. *Pumping and drawdown in KFM08D:2 (pale blue) and KFM08D:4 (pale orange) in May and June 2023. Pumping in KFM08D:2 caused a small response in section 1 (dark blue). The pumping in section KFM08D:4 affected section 2 and section 3 (dark orange).*

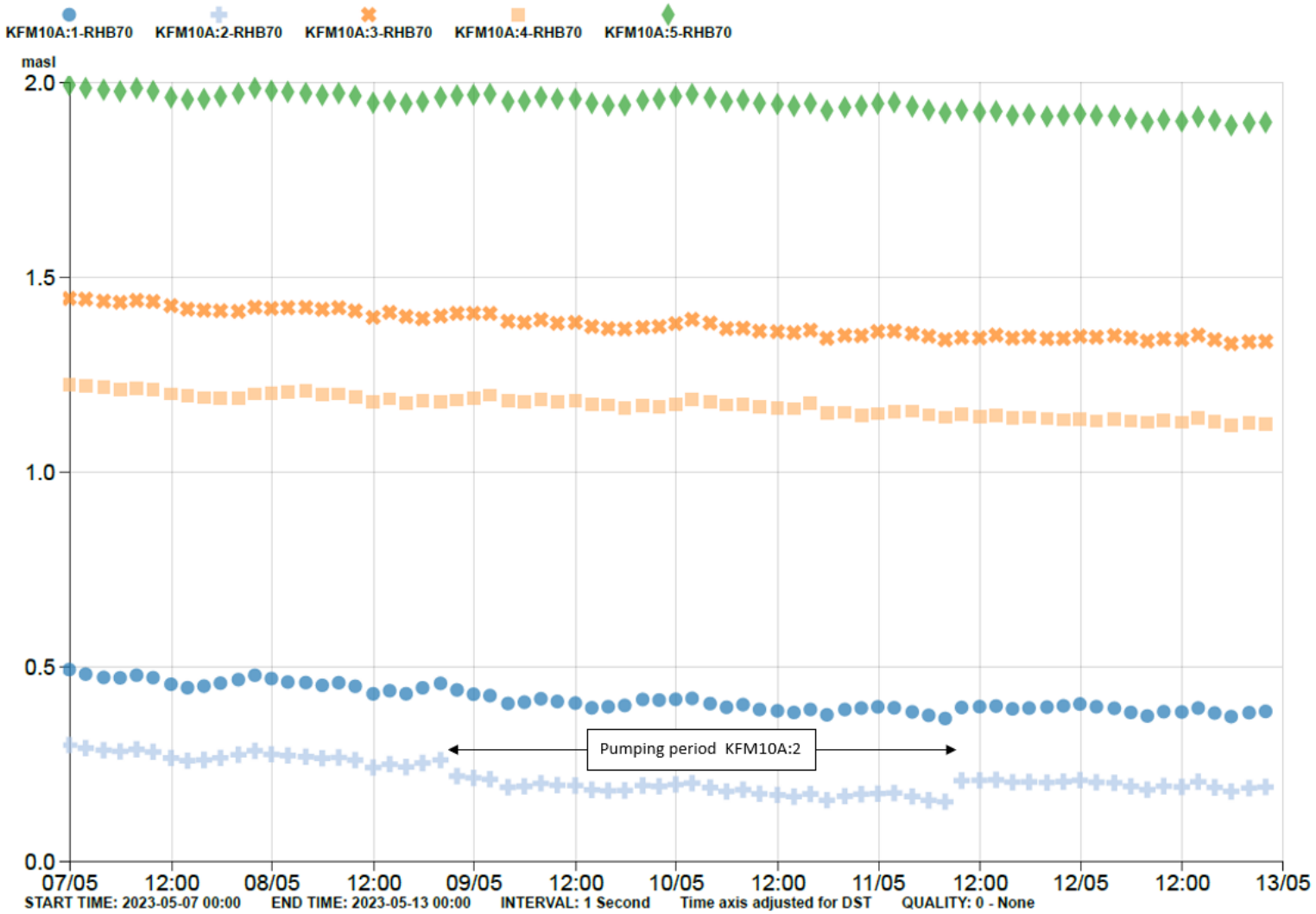

Figure A4-13. *Pumping and drawdown in KFM10A:2 (pale blue) in May 2023. No other sections were significantly affected by the pumping.*

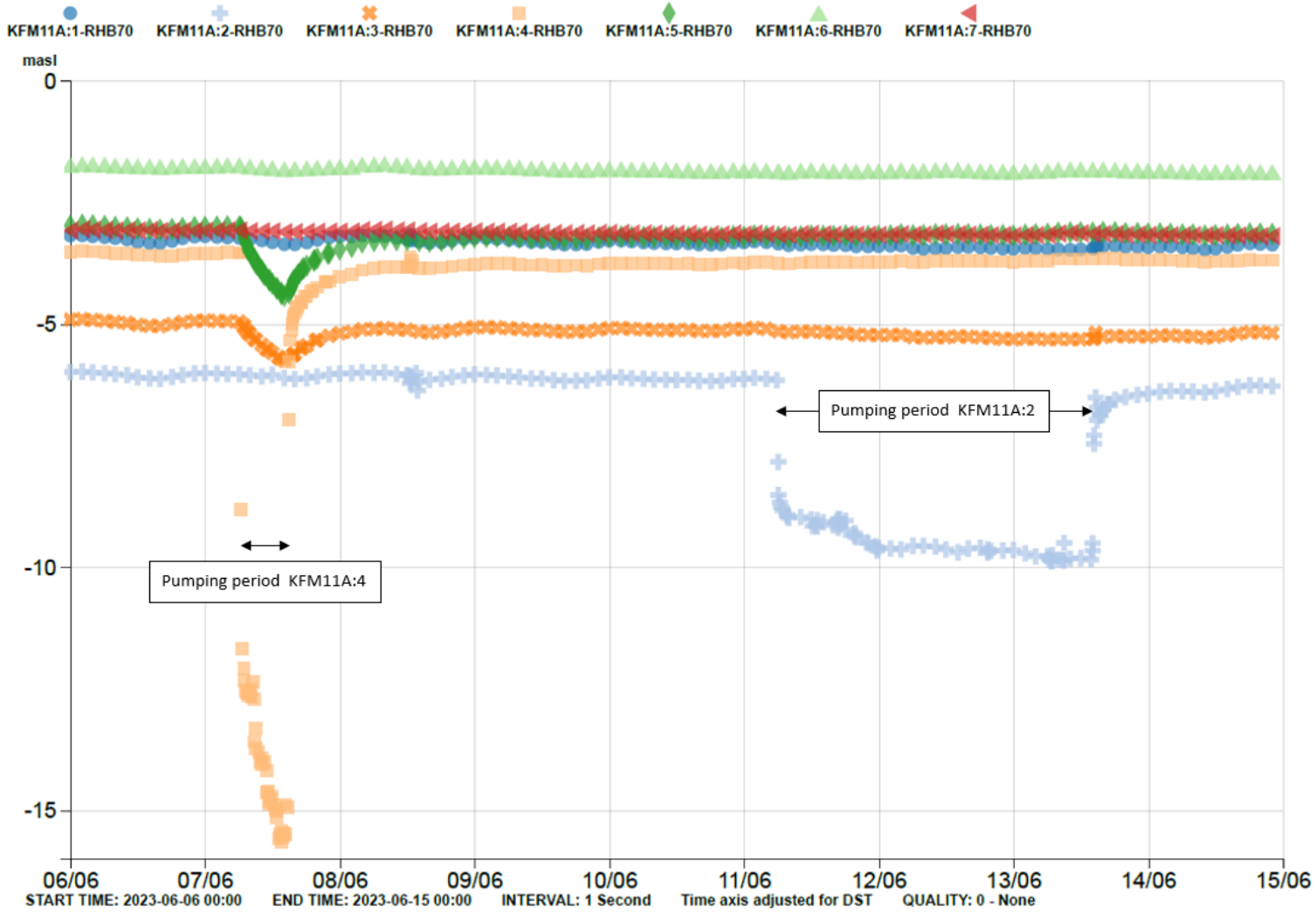

Figure A4-14. *Pumping and drawdown in KFM11A:2 (pale blue) and KFM11A:4 (pale orange) in June 2023. Section 3 (dark orange) was affected during pumping in KFM11A:2. The pumping in section KFM11A:4 affected the surrounding sections 3 and 5 (dark green).*

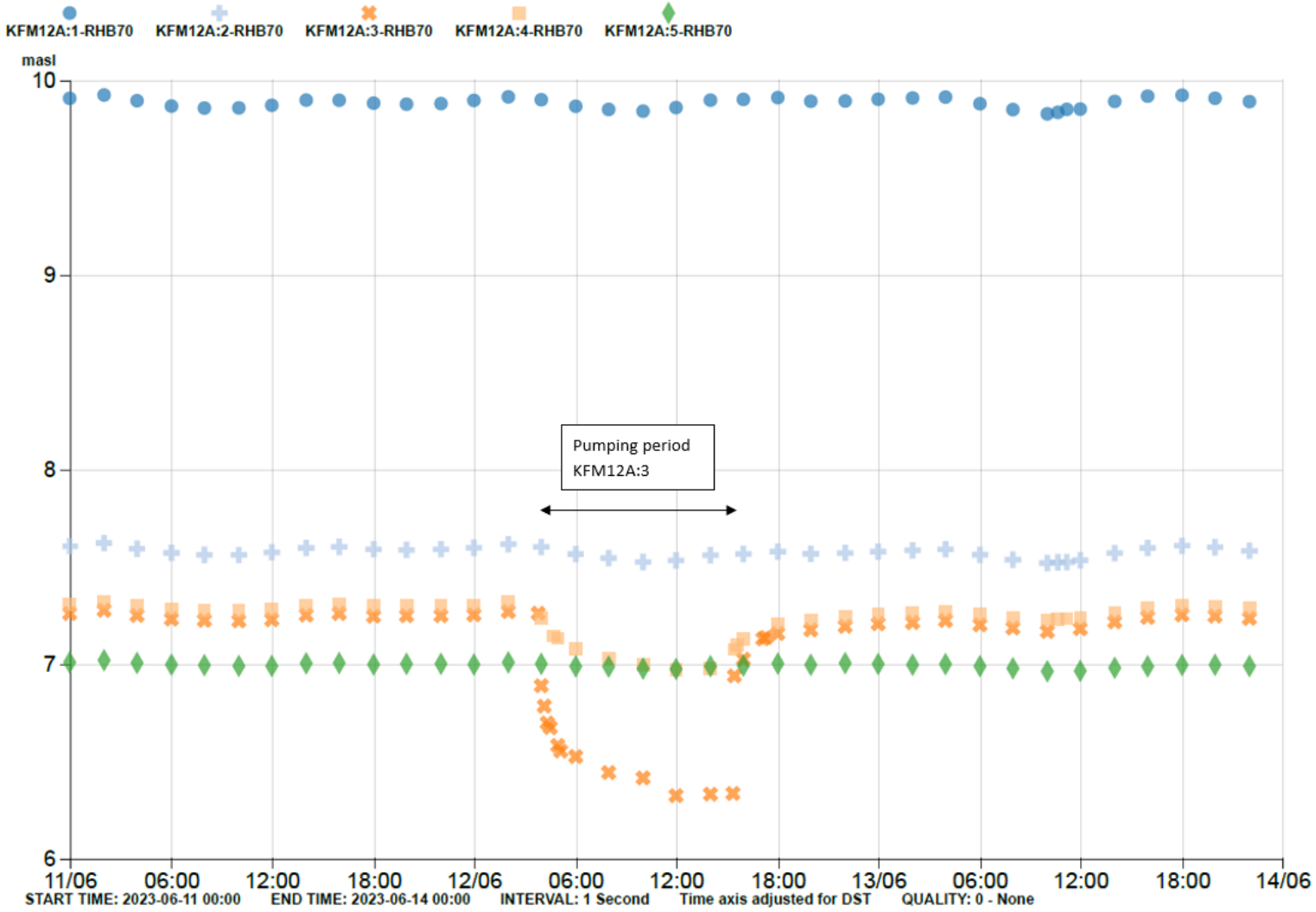

***Figure A4-15**. Pumping and drawdown in KFM12A:3 (dark orange) in June 2023. The pumping caused a response in section 4 (pale orange).*

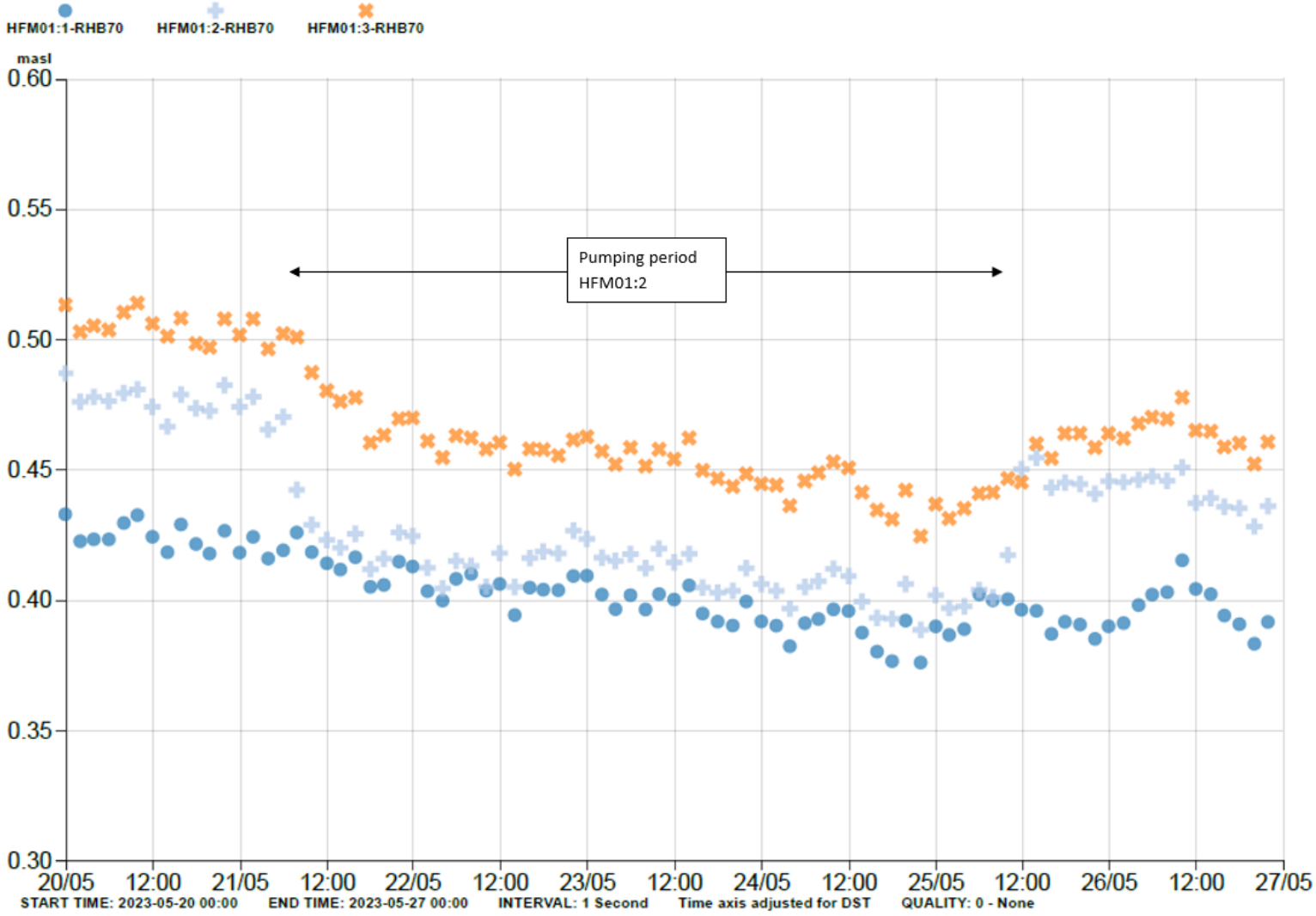

Figure A4-16. *Pumping and drawdown in HFM01:2 (pale blue) in May 2023. Section 3 (dark orange) was affected by the pumping.*

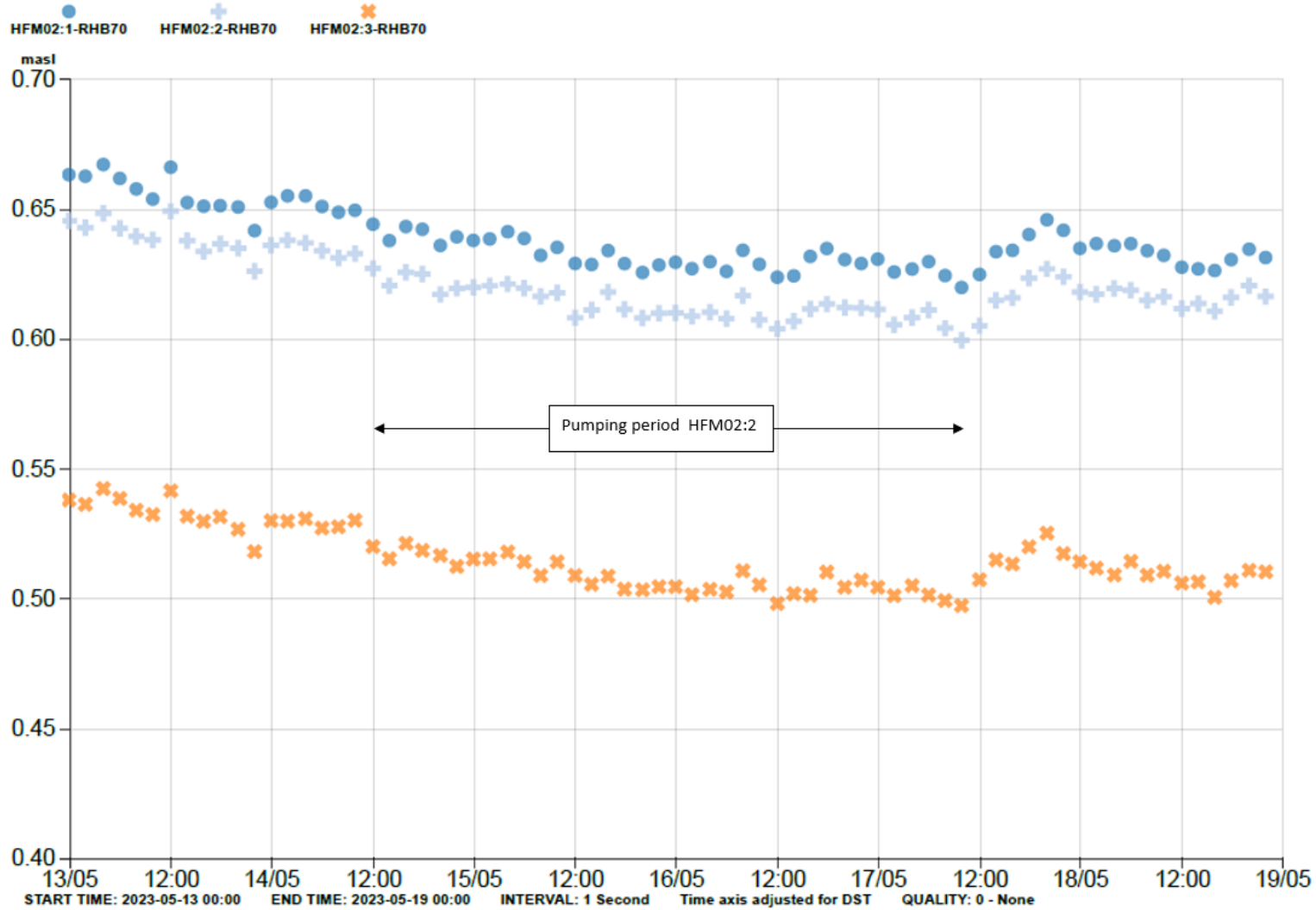

Figure A4-17. *Pumping in HFM02:2 (pale blue) in May 2023. No significant drawdown was observed in any of the borehole sections.*

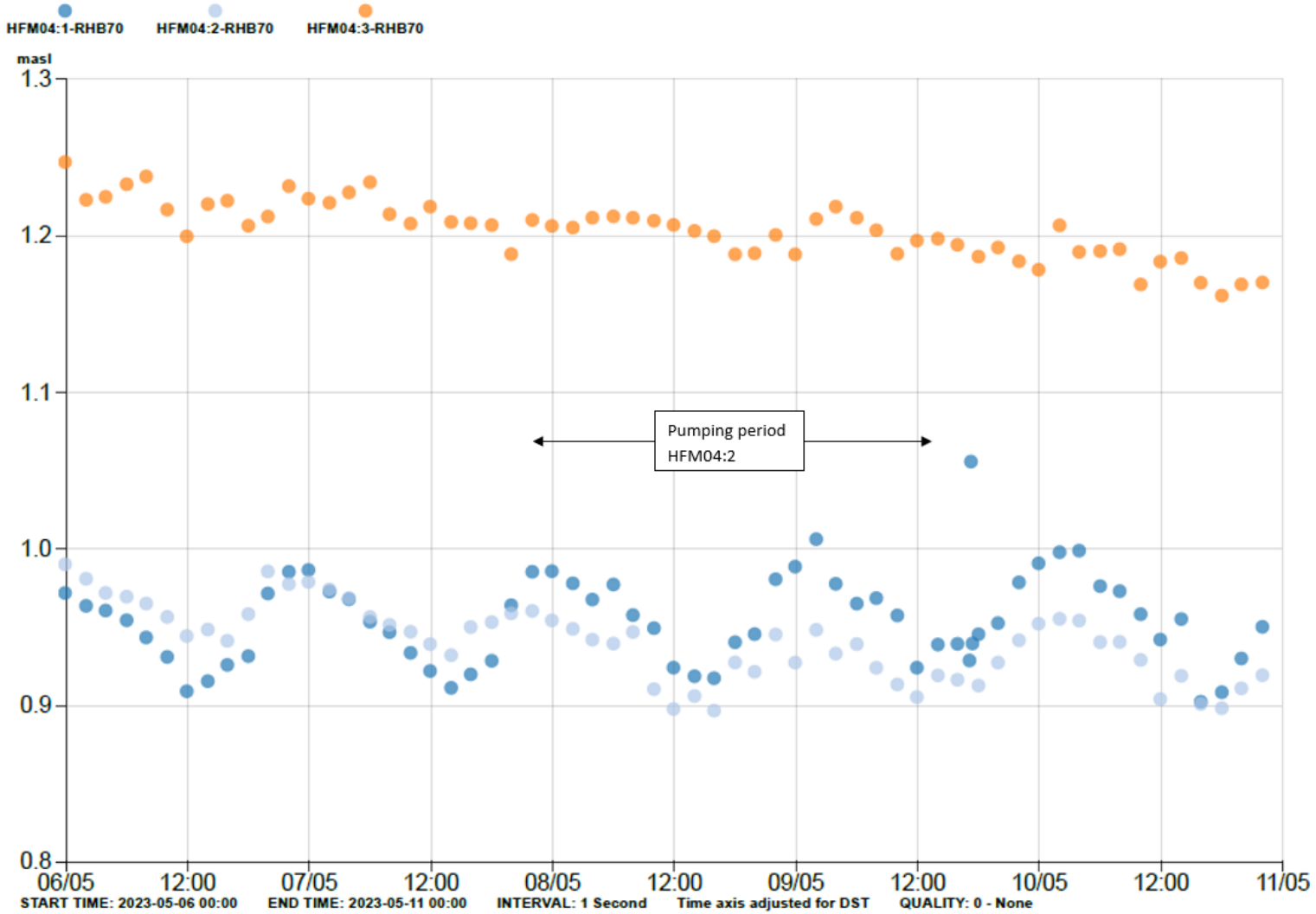

Figure A4-18. *Pumping in HFM04:2 (pale blue) in May 2023. No significant drawdown was observed in any of the borehole sections.*

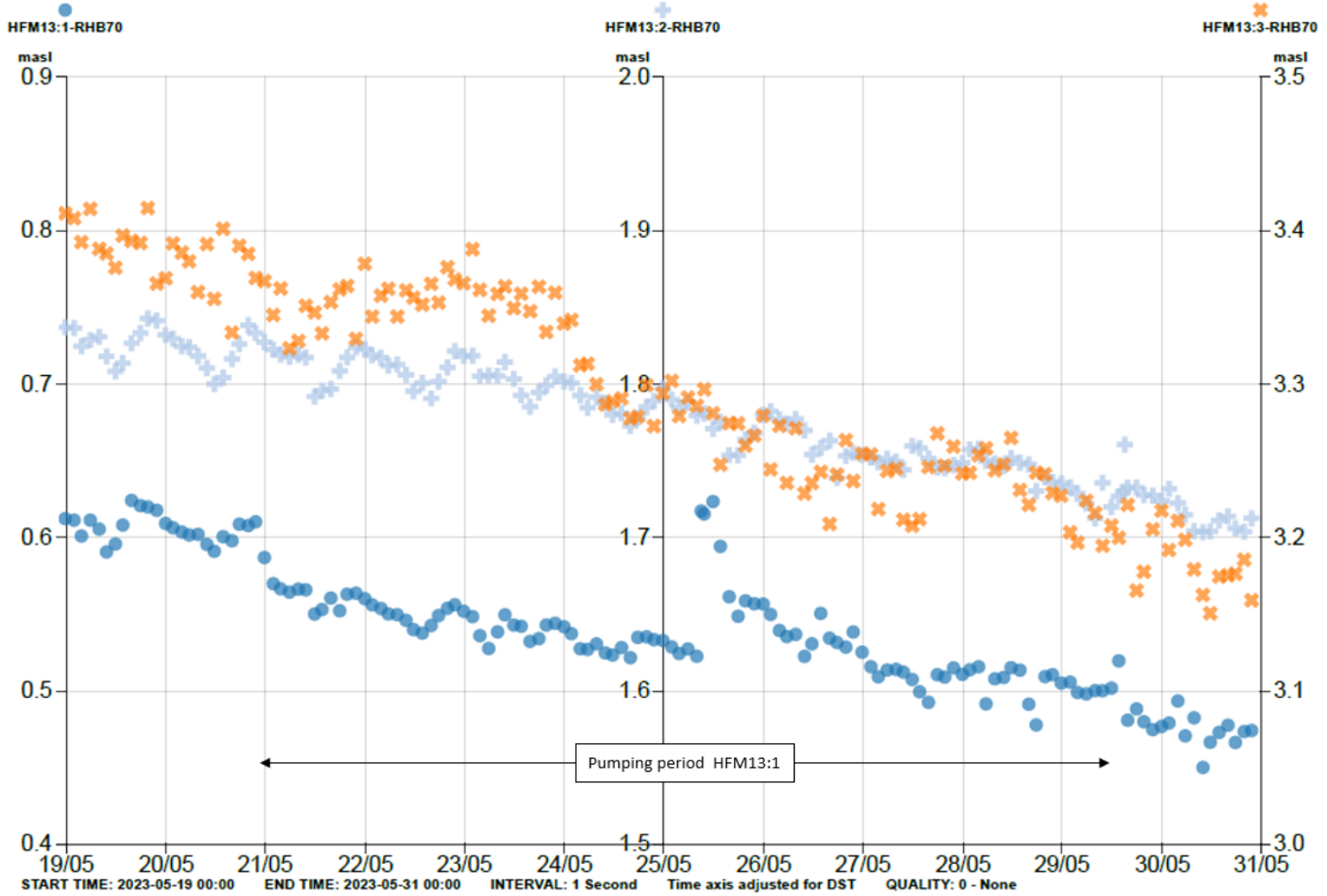

Figure A4-19. *Pumping in HFM13:1 (dark blue) in May 2023. No section was significantly affected by the pumping. Note the different scales for each borehole section.*

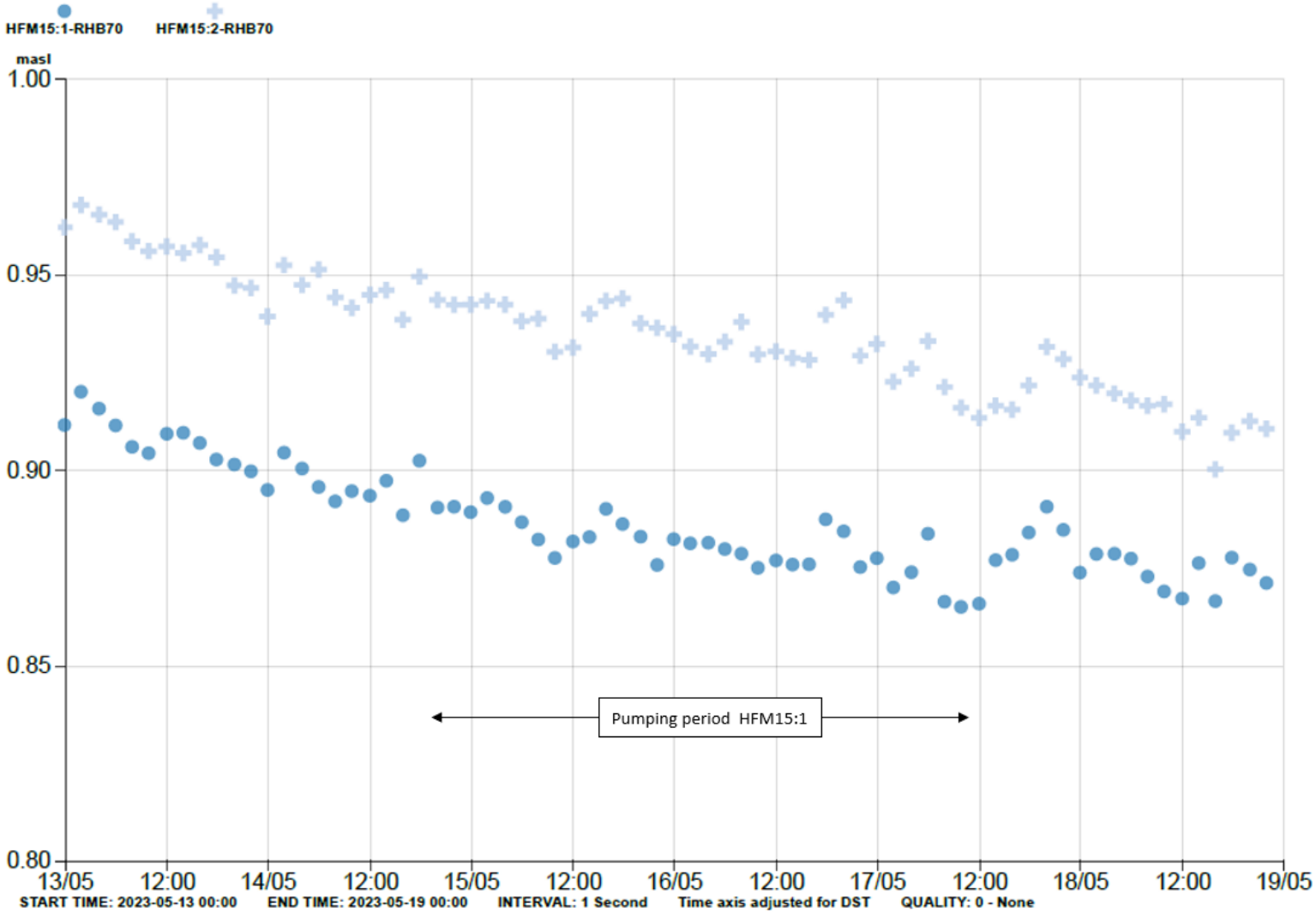

Figure A4-20. *Pumping in HFM15:1 (dark blue) in May 2023. No significant drawdown was observed in any of the borehole sections.*

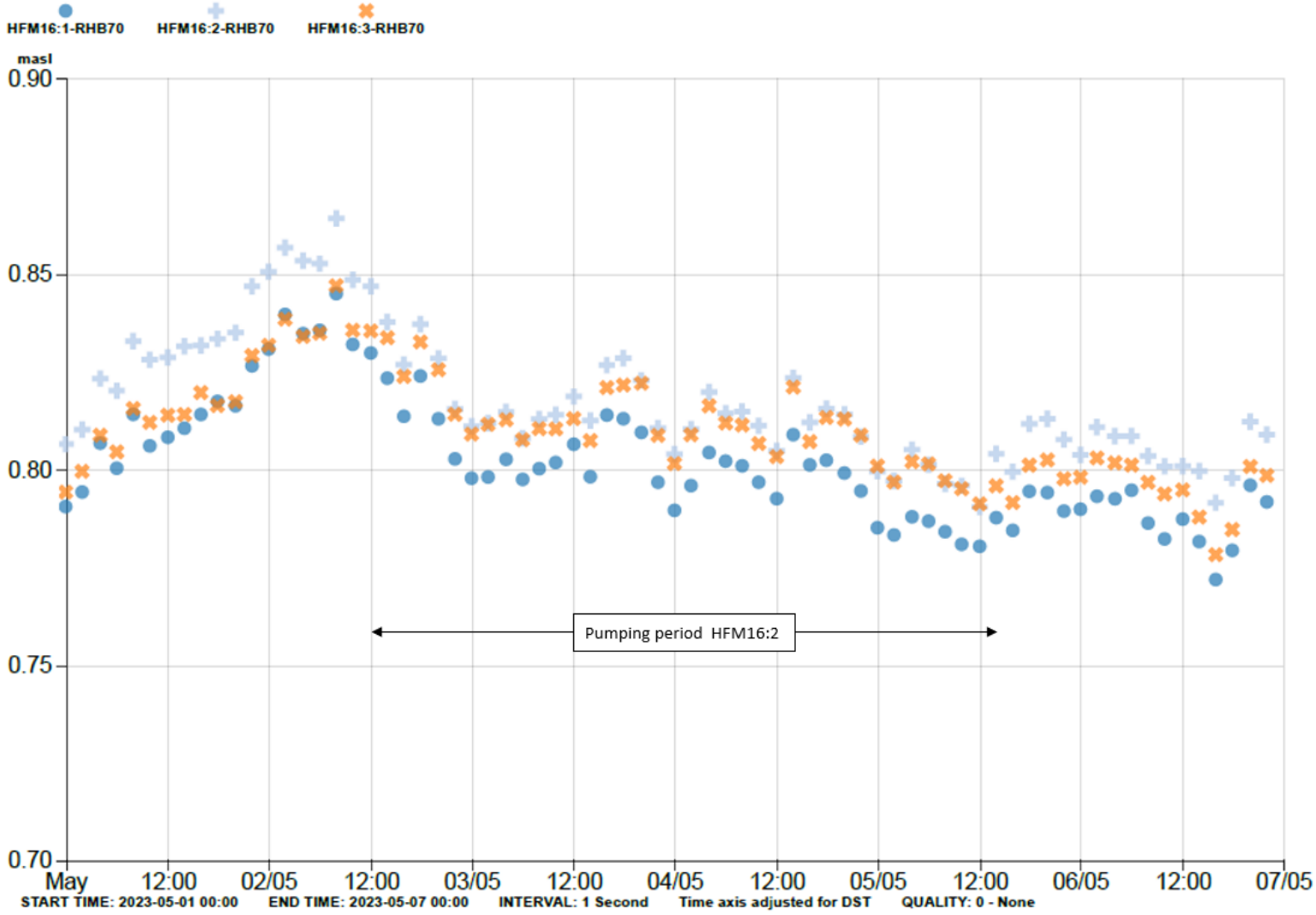

Figure A4-21. *Pumping in HFM16:2 (pale blue) in May 2023. No significant drawdown was observed in any of the borehole sections.*

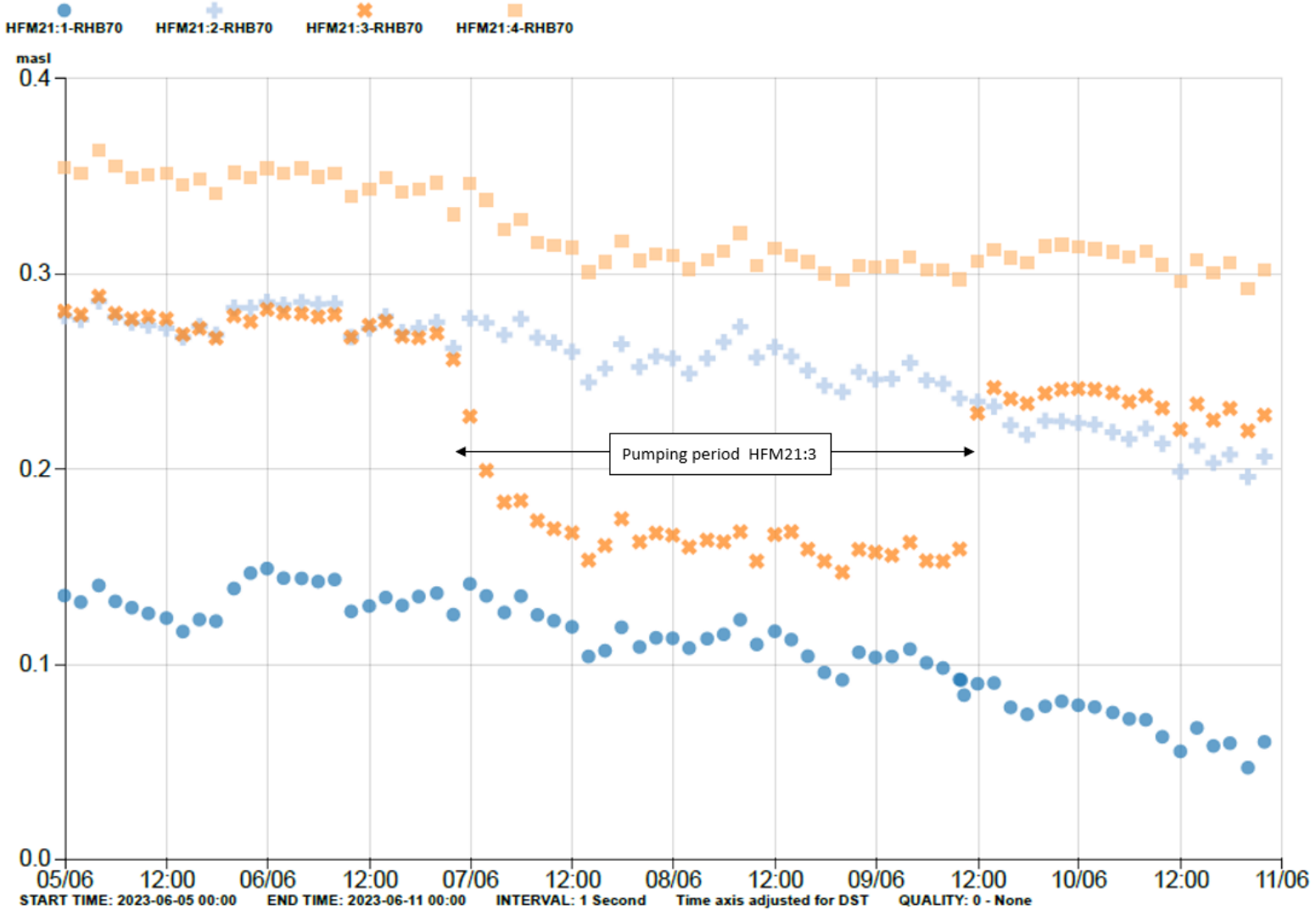

Figure A4-22. *Pumping and drawdown in HFM21:3 (dark orange) in June 2023. A small response was observed in section 4 (pale orange).*

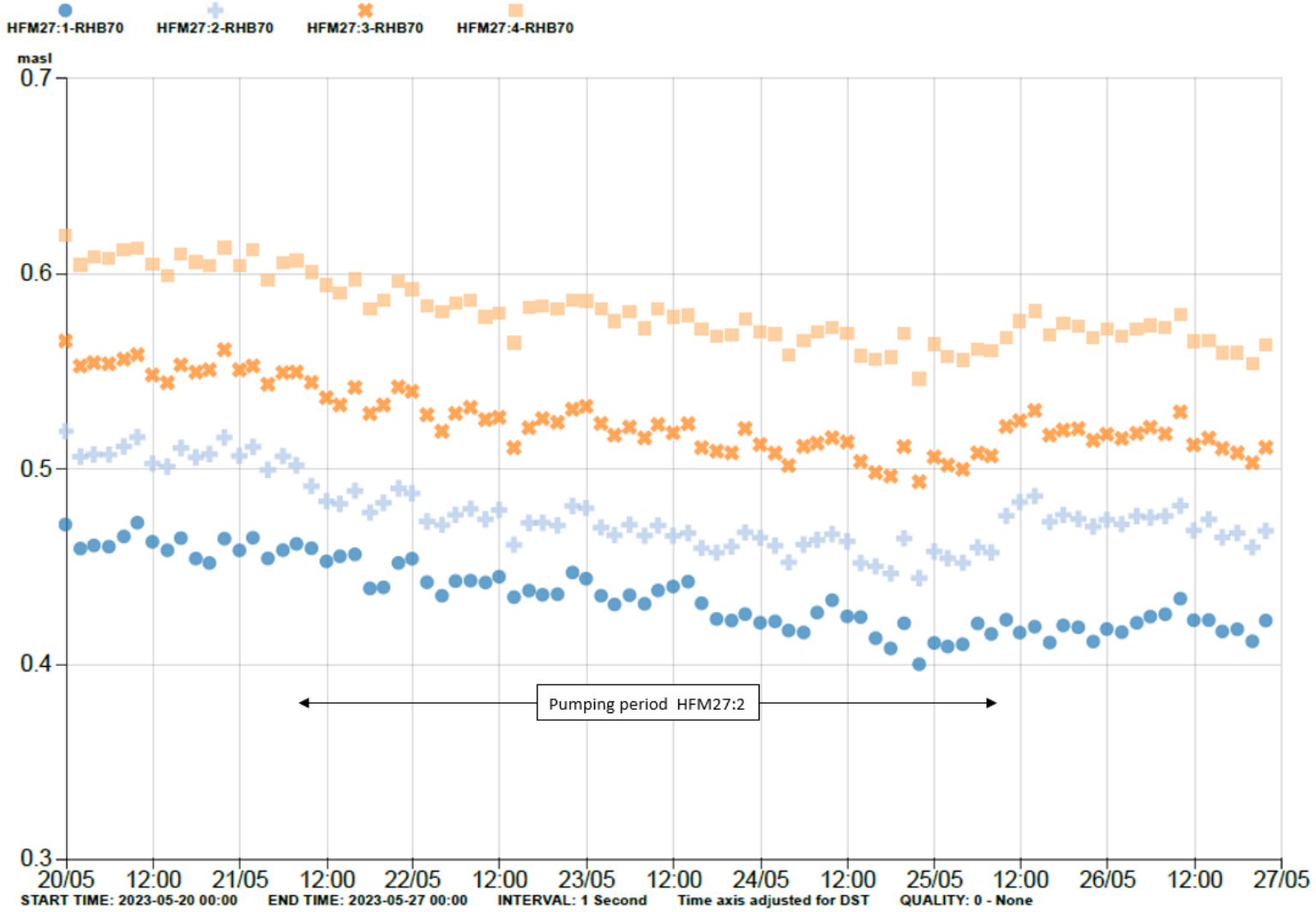

Figure A4-23. *Pumping in HFM27:2 (pale blue) in May 2023. A slight drawdown can be seen in the pumped section but not in any of the other sections.*

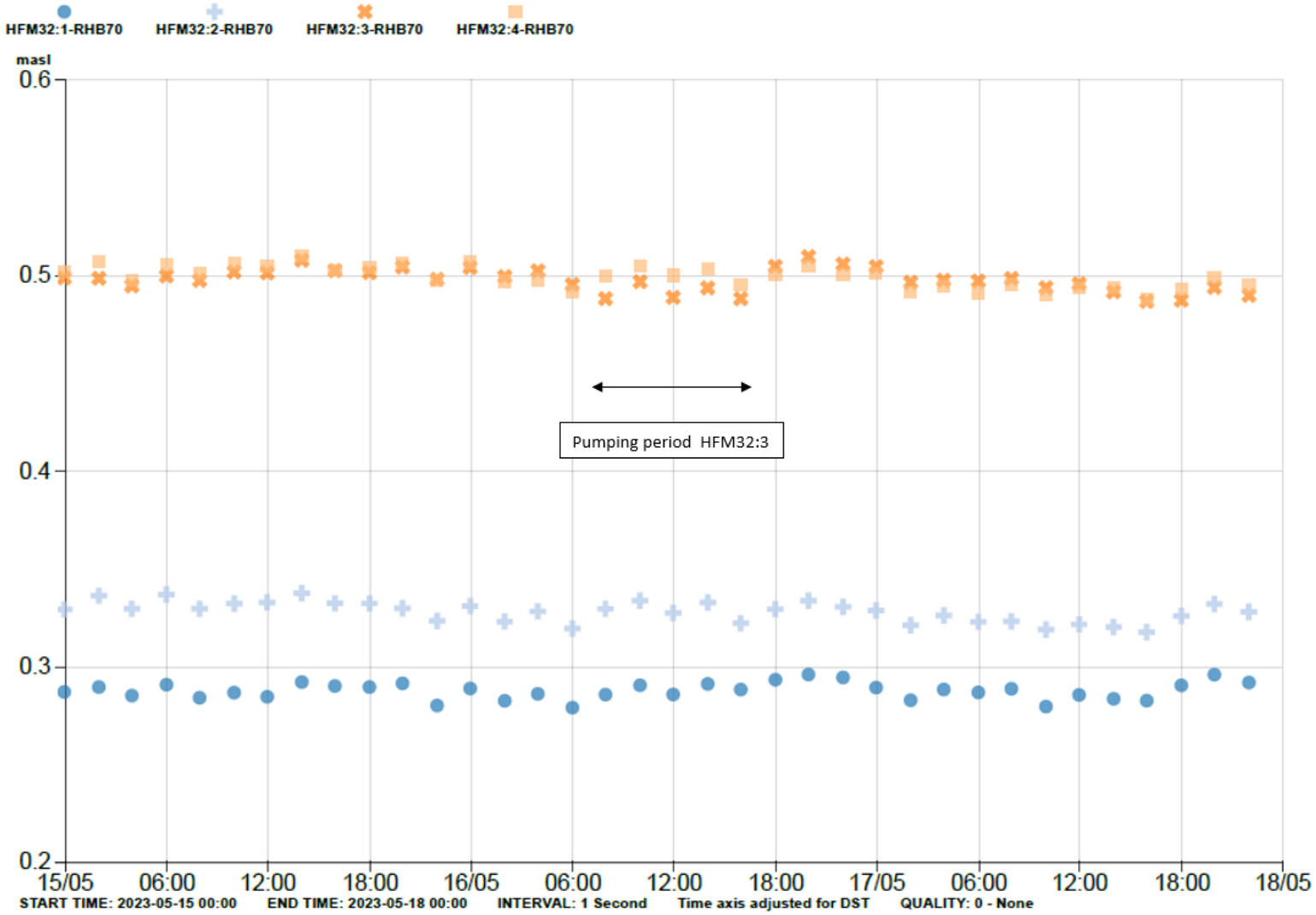

Figure A4-24. *Pumping in HFM32:3 (dark orange) in May 2023. A slight drawdown can be seen in the pumped section but not in any of the other sections.*

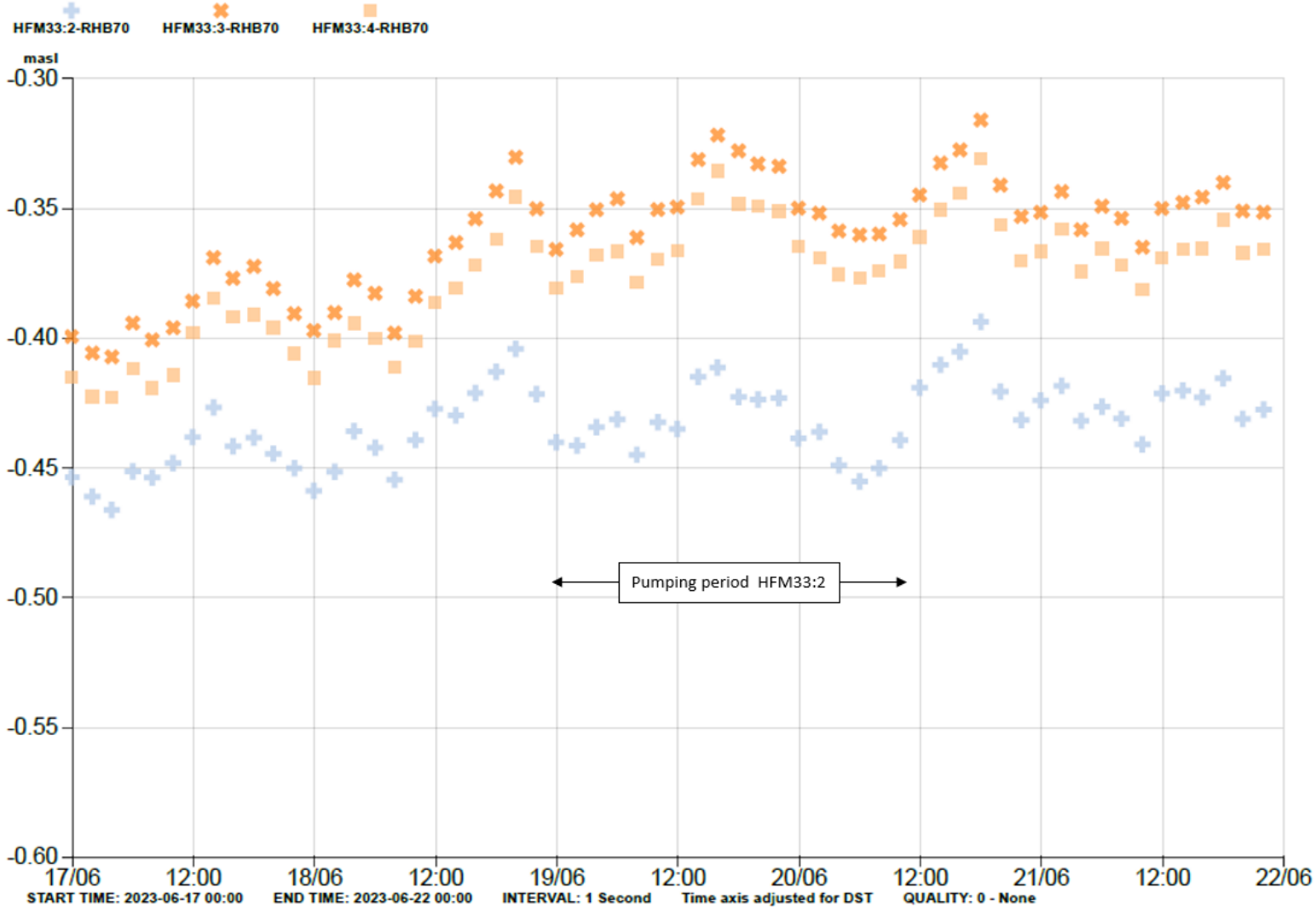

***Figure A4-25**. Pumping in HFM33:2 (pale blue) in June 2023. A slight drawdown can be seen in the pumped section but not in any of the other sections.*

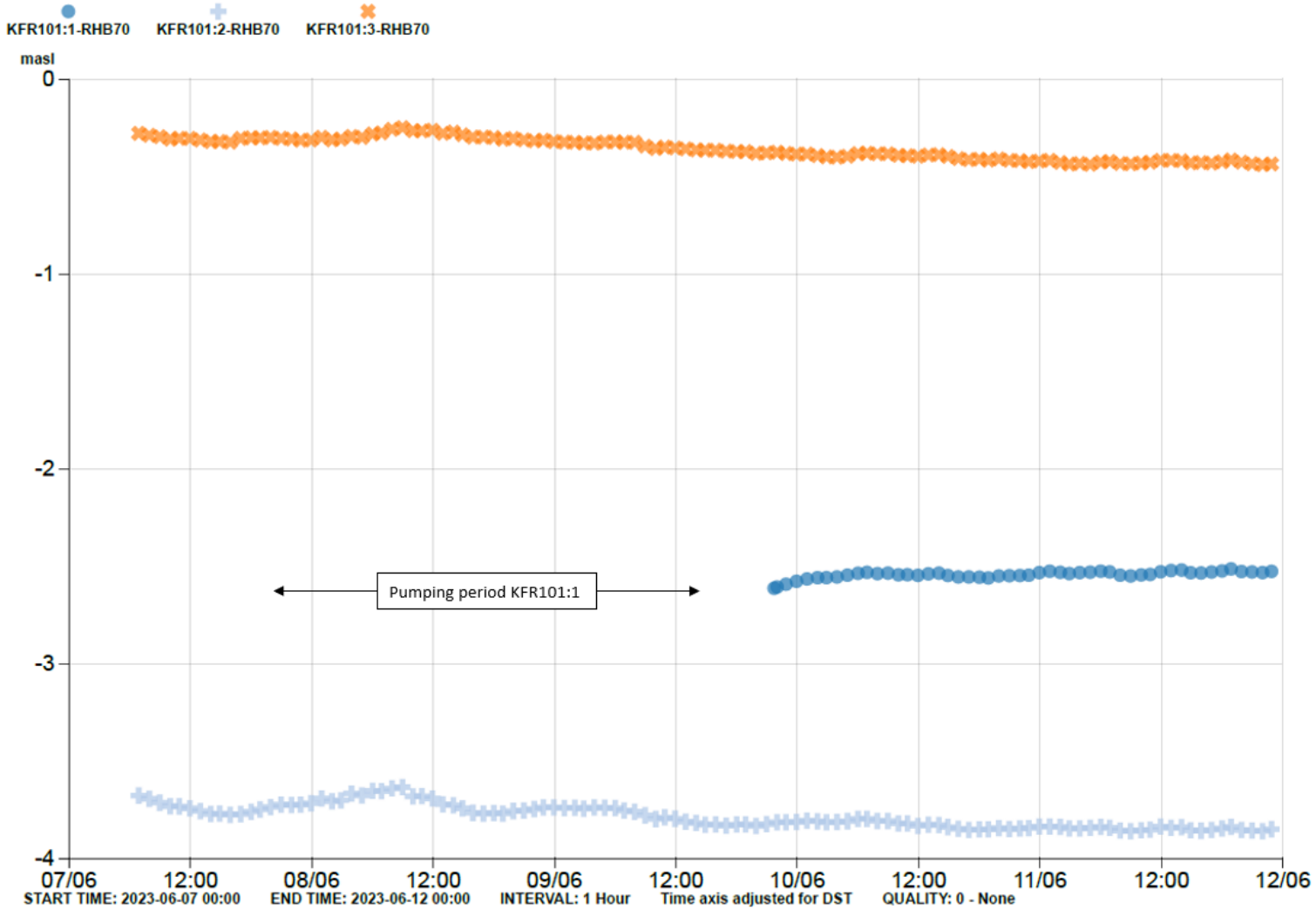

Figure A4-26. *Pumping in KFR101:1 in June 2023. The pressure transducer in KFR101:1 was removed during the pumping. No response was noted in any other section.*

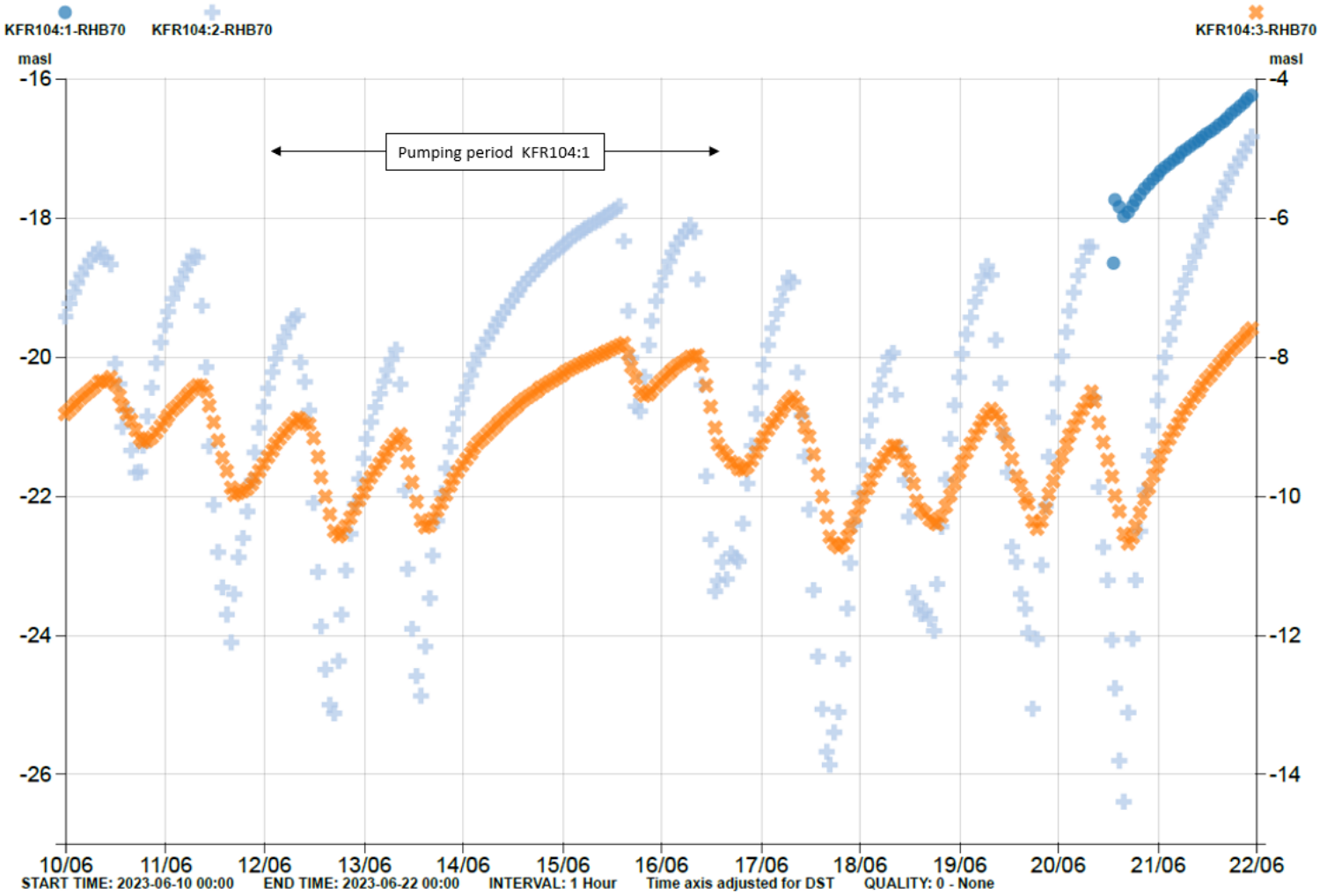

Figure A4-27. *Pumping in KFR104:1 (dark blue) in June 2023. The pressure transducer in KFR104:1 was removed during the pumping. Due to the disturbances from the ongoing drilling of borehole KFR91 in the SFR-tunnel, no possible impact from the pumping can be seen in the other sections. Note the different scales for the borehole sections.*

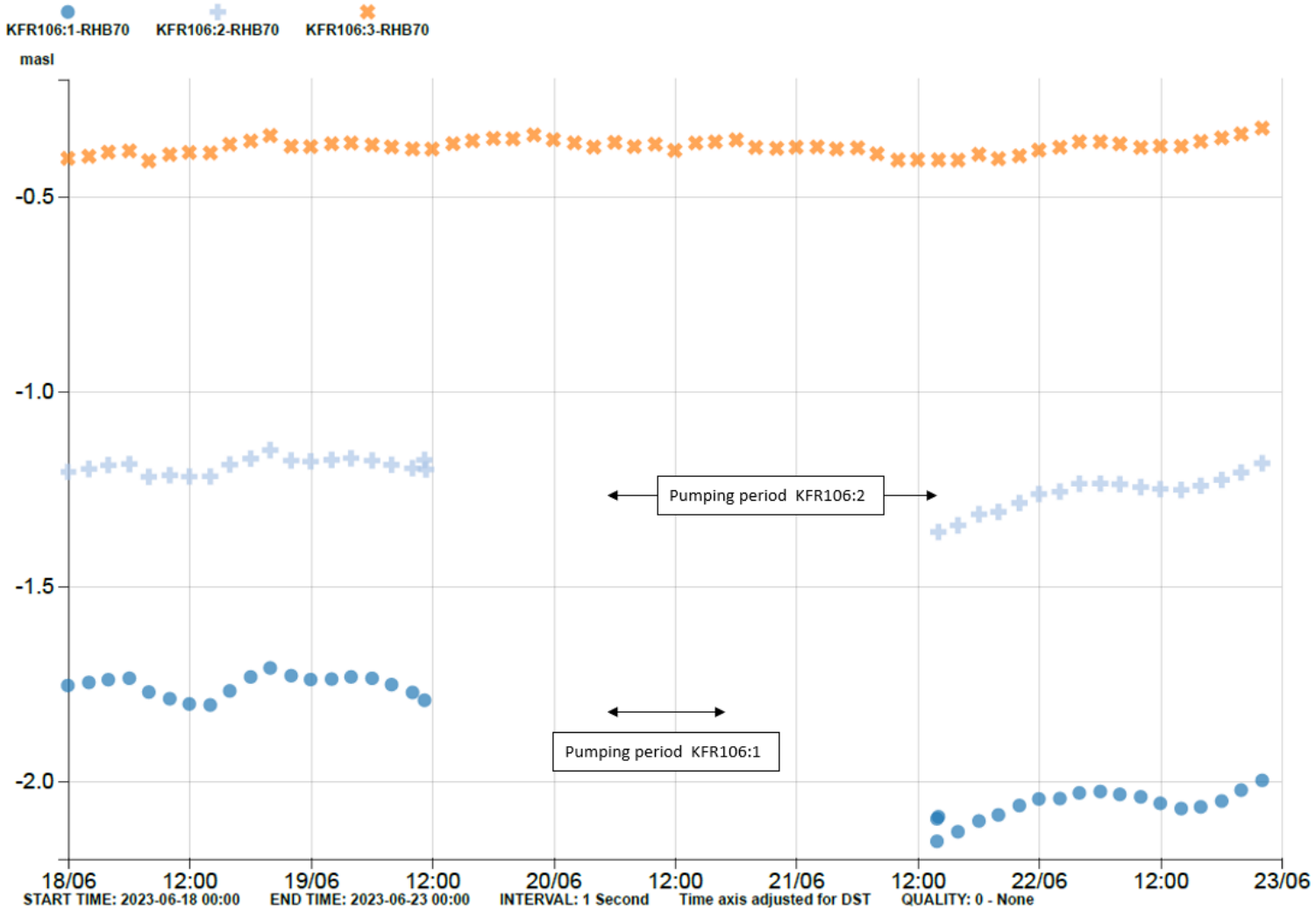

Figure A4-28. *Pumping in KFR106:1 (dark blue) and KFR106:2 (pale blue) in June 2023. The pressure transducers in the pumped sections were removed during the pumping. Section 3 (dark orange) was not affected.*

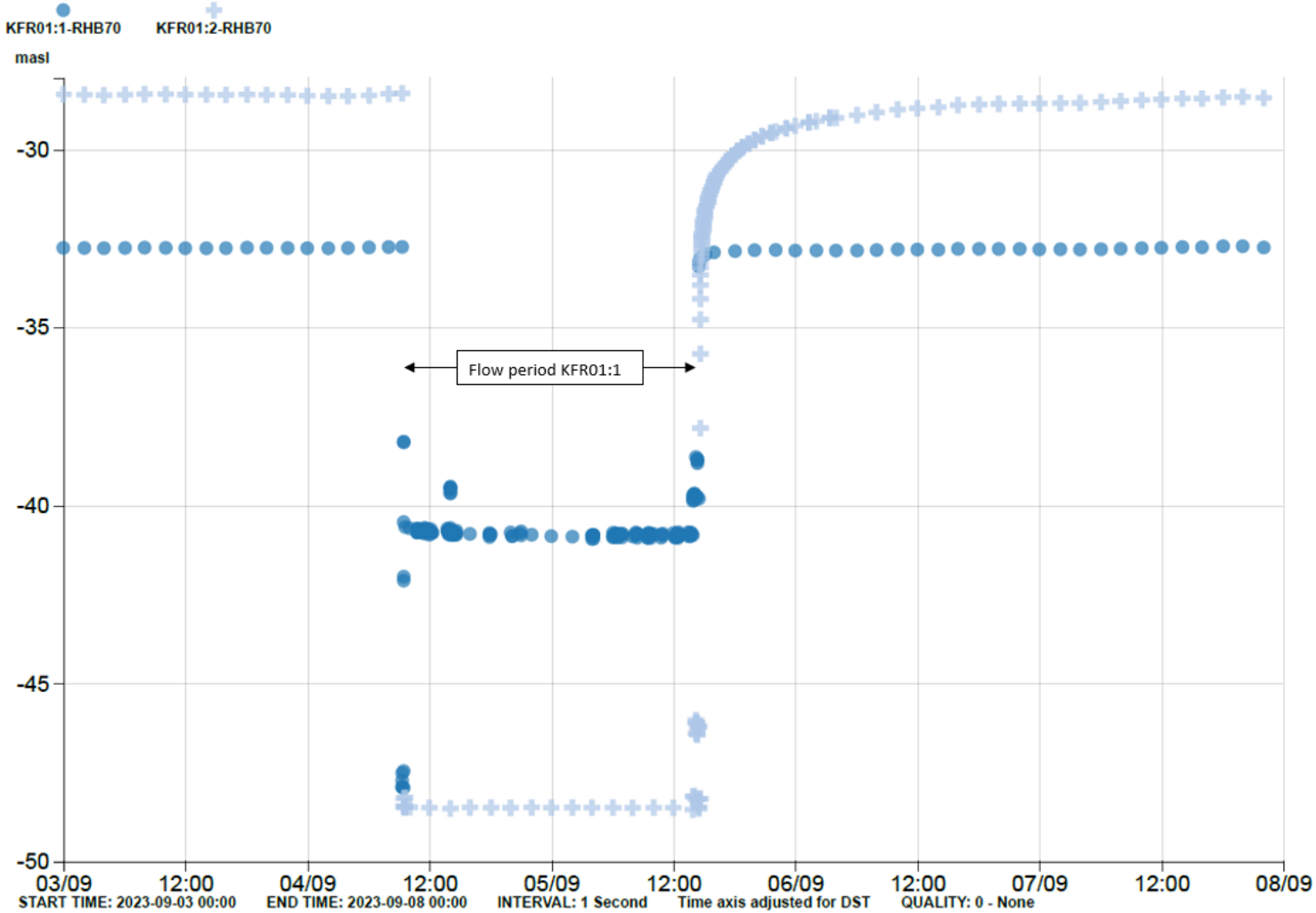

Figure A4-29. *Flow period in KFR01:1 (dark blue) in September 2023. KFR01:2 (pale blue) was opened at the same time for sampling within another project.*

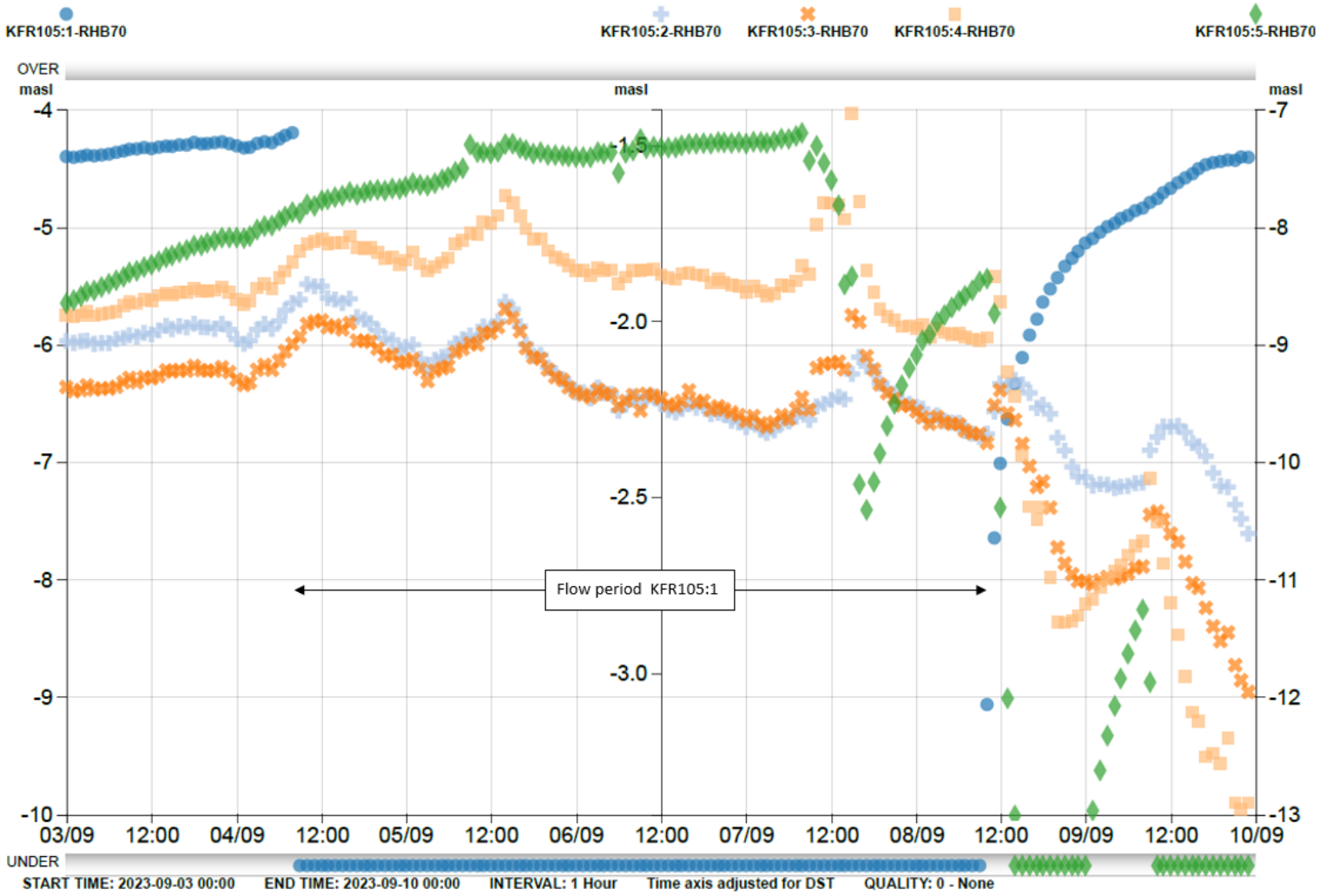

Figure A4-30. *Flow period in KFR105:1 in September 2023. Due to the disturbances from the ongoing drilling of borehole KFR90 in the SFR-tunnel, no possible impact from the pumping can be seen in the other sections. Note the different scales for the borehole sections.*

Appendix 5 - pH trends in some of the core drilled boreholes

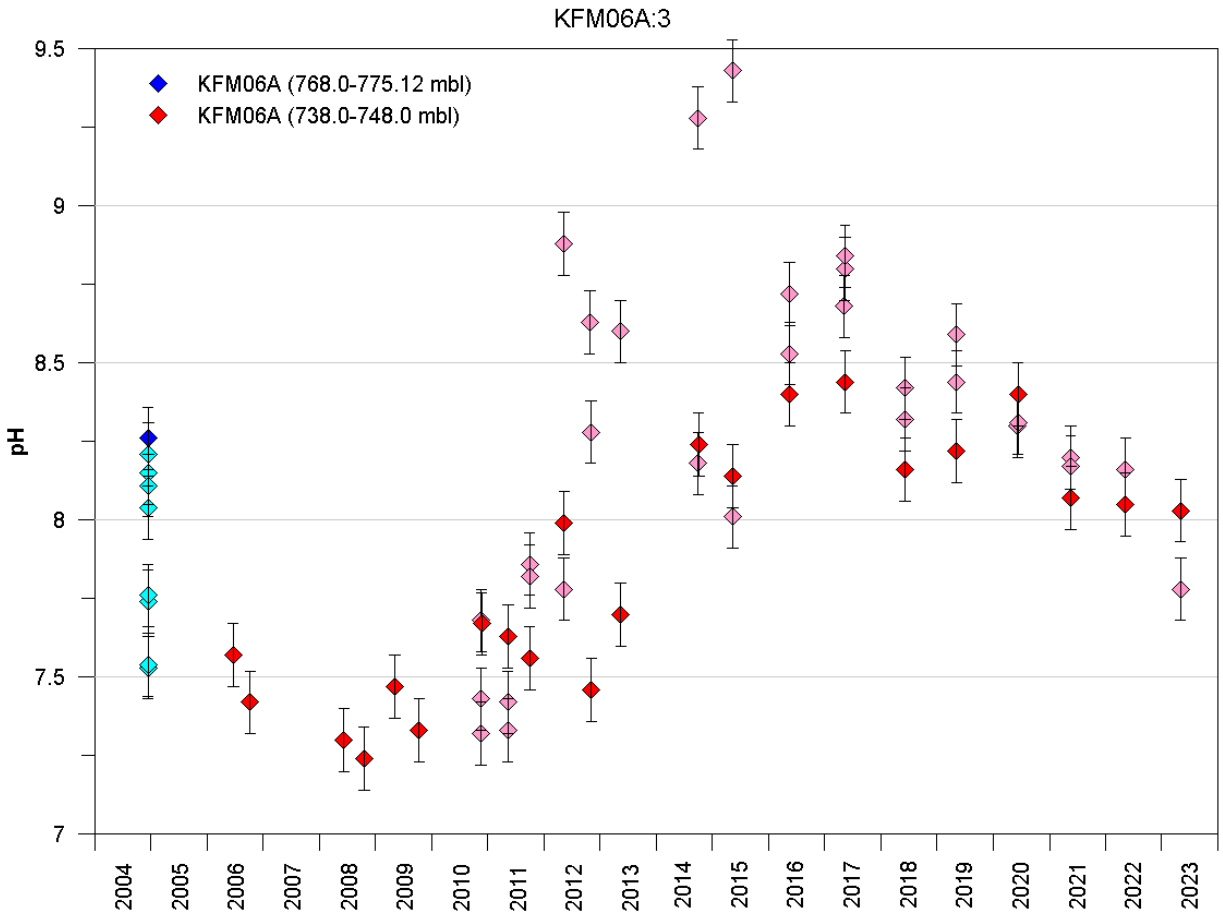

Figure A5-1. *Comparison between initial pH-values from complete chemical characterisation during PLU (Forsmark site investigation; blue diamonds) and later measurements in the ongoing monitoring programme (red diamonds) for KFM06A:3. The last sample in the series (or the only sample if no series) is marked with a darker red colour. All the presented pH-values are measured in the laboratory at 25°C, except those from 2013 which are from field measurements.*

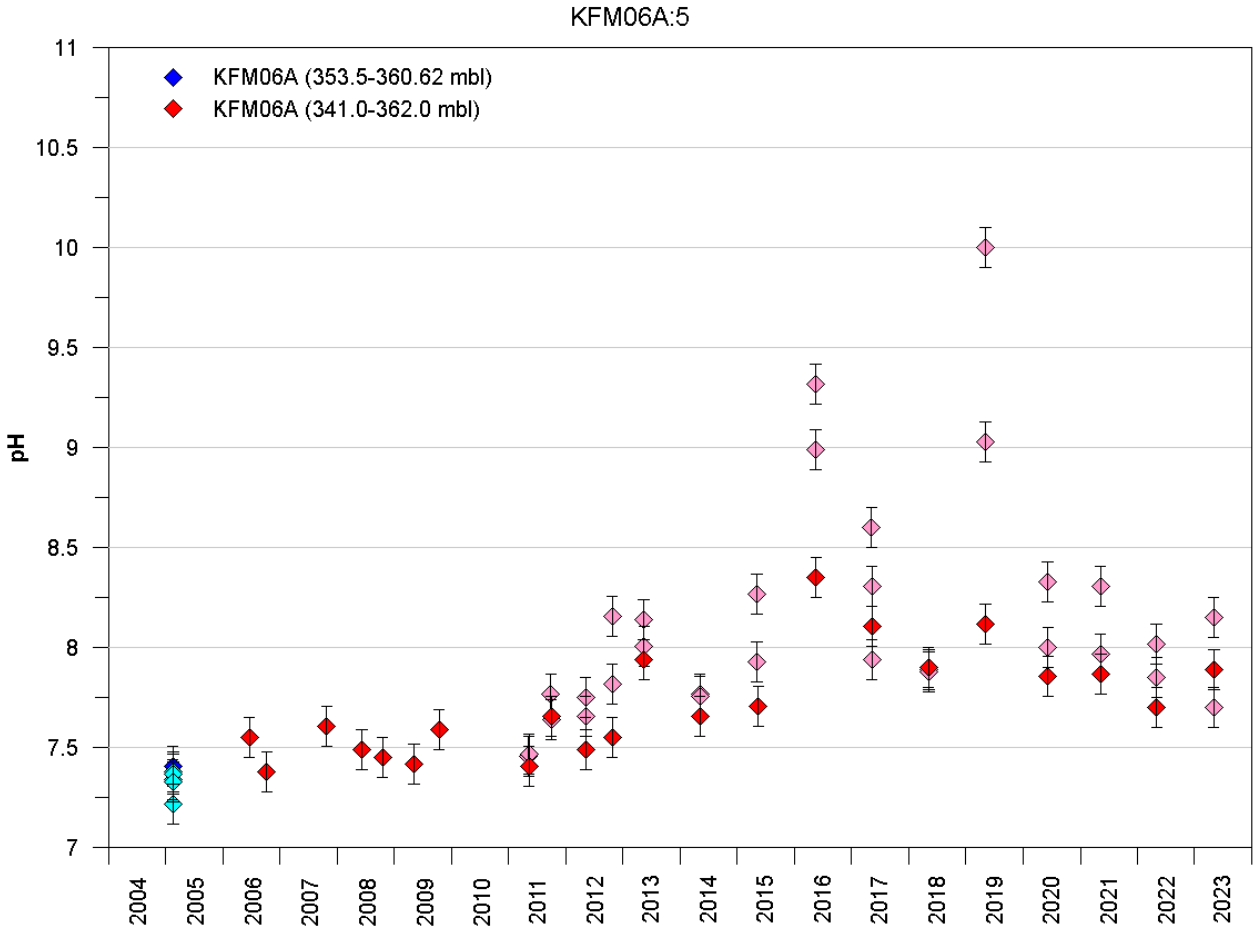

Figure A5-2. *Comparison between initial pH-values from complete chemical characterisation during PLU (blue diamonds) and later measurements in the ongoing monitoring programme (red diamonds) for KFM06A:5. The last sample in the series (or the only sample if no series) is marked with a darker red colour. All the presented pH-values are measured in the laboratory at 25°C, except those from 2013 which are from field measurements.*

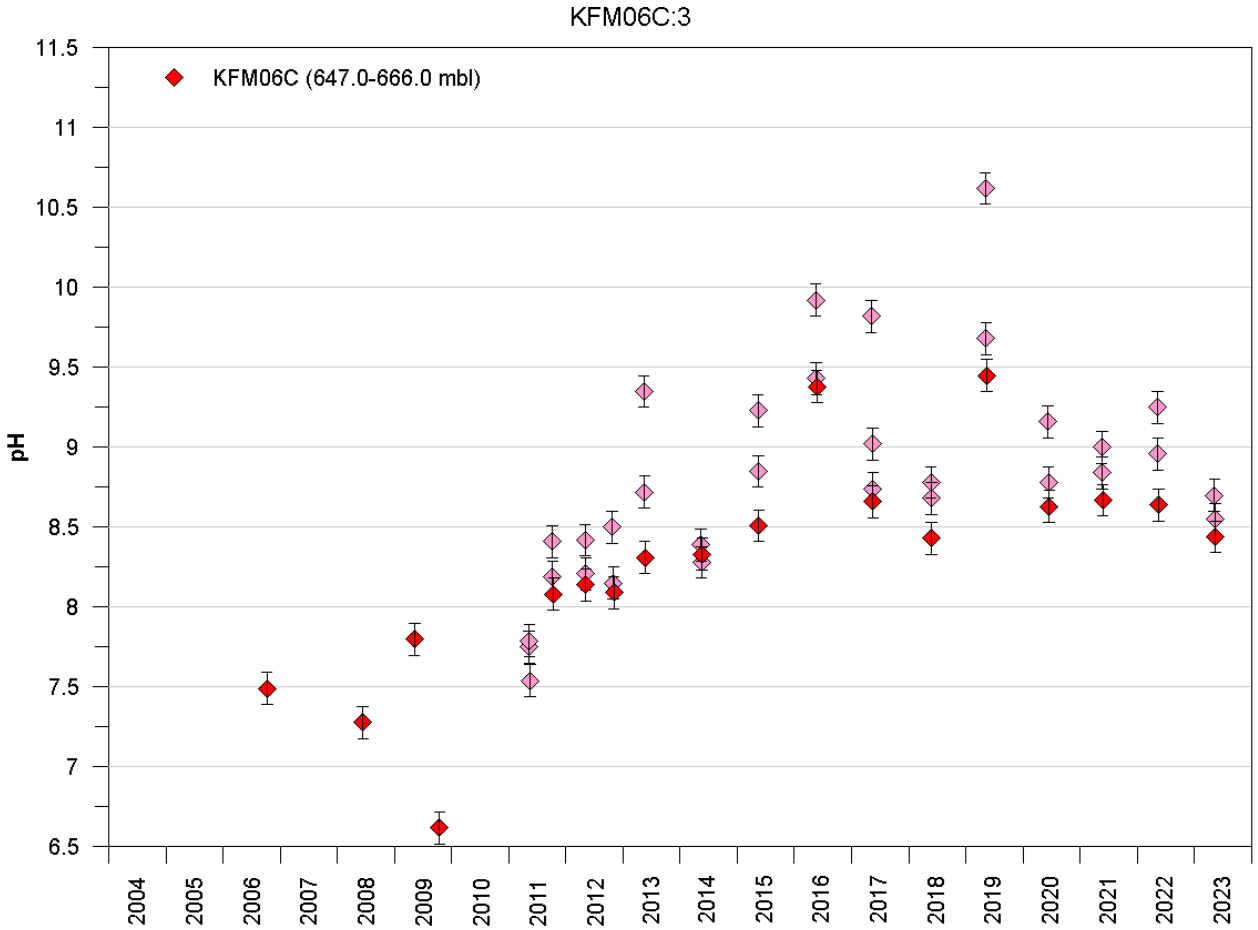

Figure A5-3. *Measurements of pH-values from the ongoing monitoring programme (red diamonds) for KFM06C:3. The last sample in the series (or the only sample if no series) is marked with a darker red colour. All the presented pH-values are measured in the laboratory at 25°C, except those from 2013 and the last sample from 2015 which are from field measurements.*

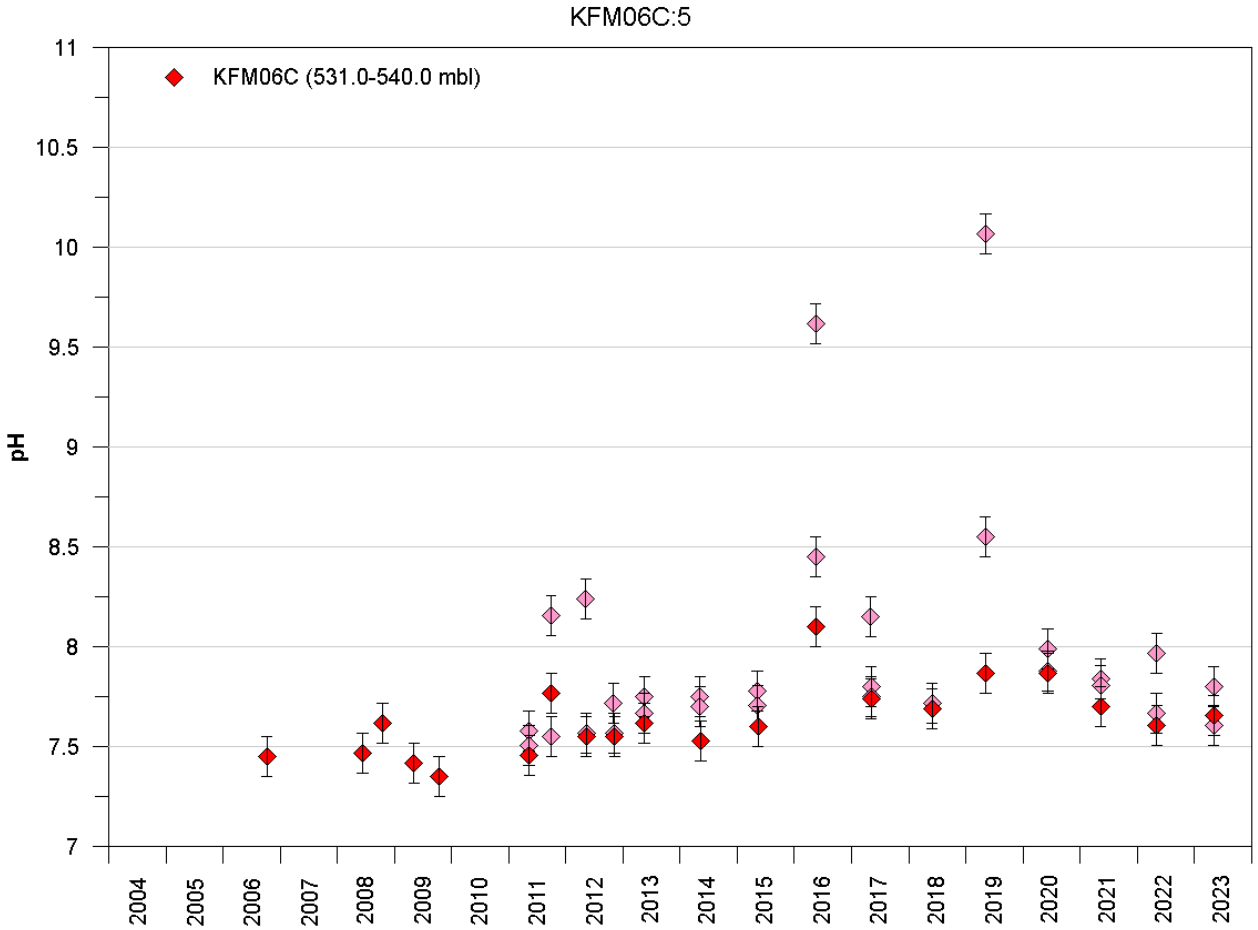

Figure A5-4. *Measurements of pH-values from the ongoing monitoring programme (red diamonds) for KFM06C:5. The last sample in the series (or the only sample if no series) is marked with a darker red colour. All the presented pH-values are measured in the laboratory at 25°C, except those from 2013 which are from field measurements.*

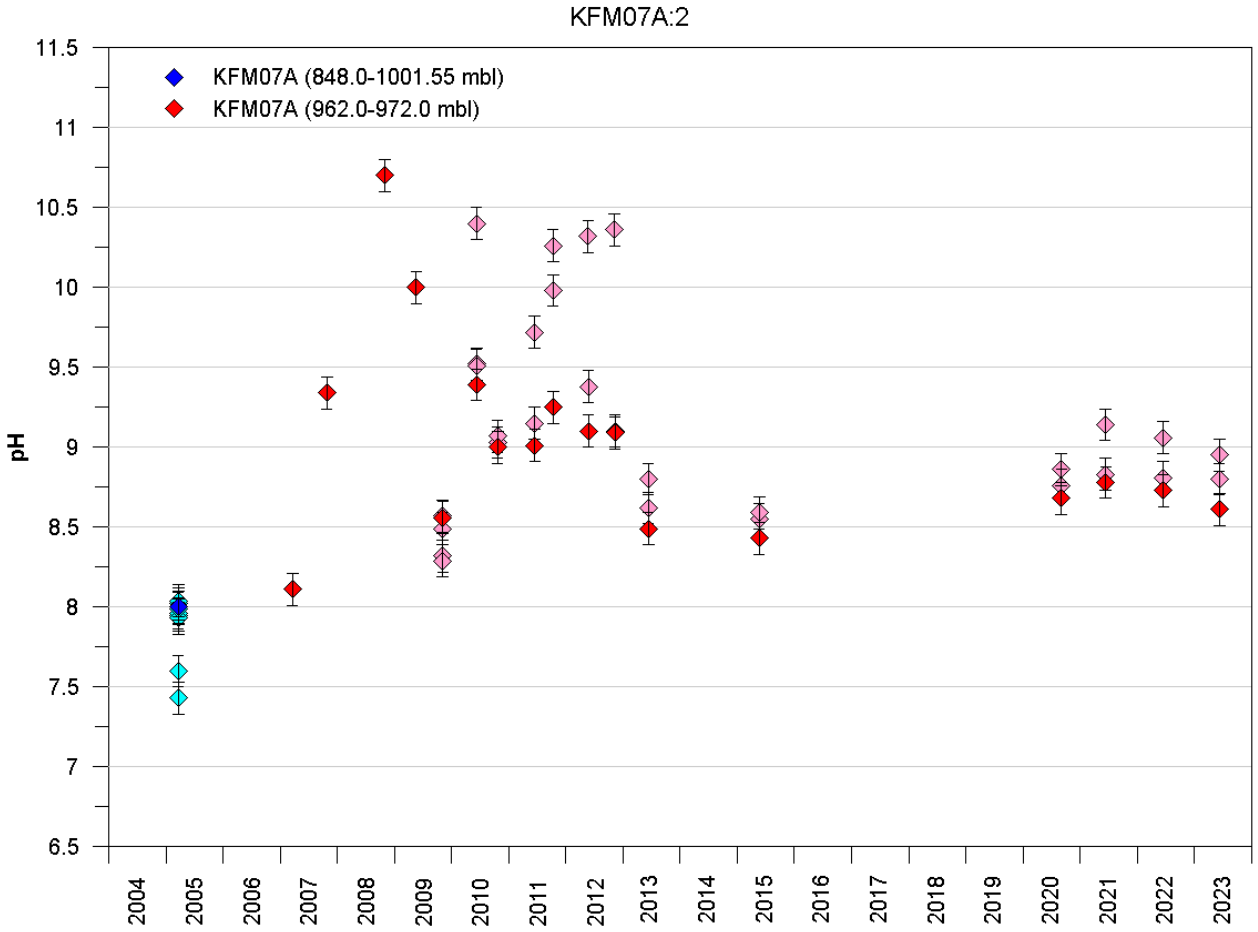

Figure A5-5. *Comparison between initial pH-values from complete chemical characterisation during PLU (blue diamonds) and later measurements in the ongoing monitoring programme (red diamonds) for KFM07A:2. The last sample in the series (or the only sample if no series) is marked with a darker red colour. All the presented pH-values are measured in the laboratory at 25°C, except those from 2013 which are from field measurements. No sampling was made in 2017 due to CCC (Complete Chemical Characterisation) measurements or in 2018-2019 due to lifted borehole equipment.*

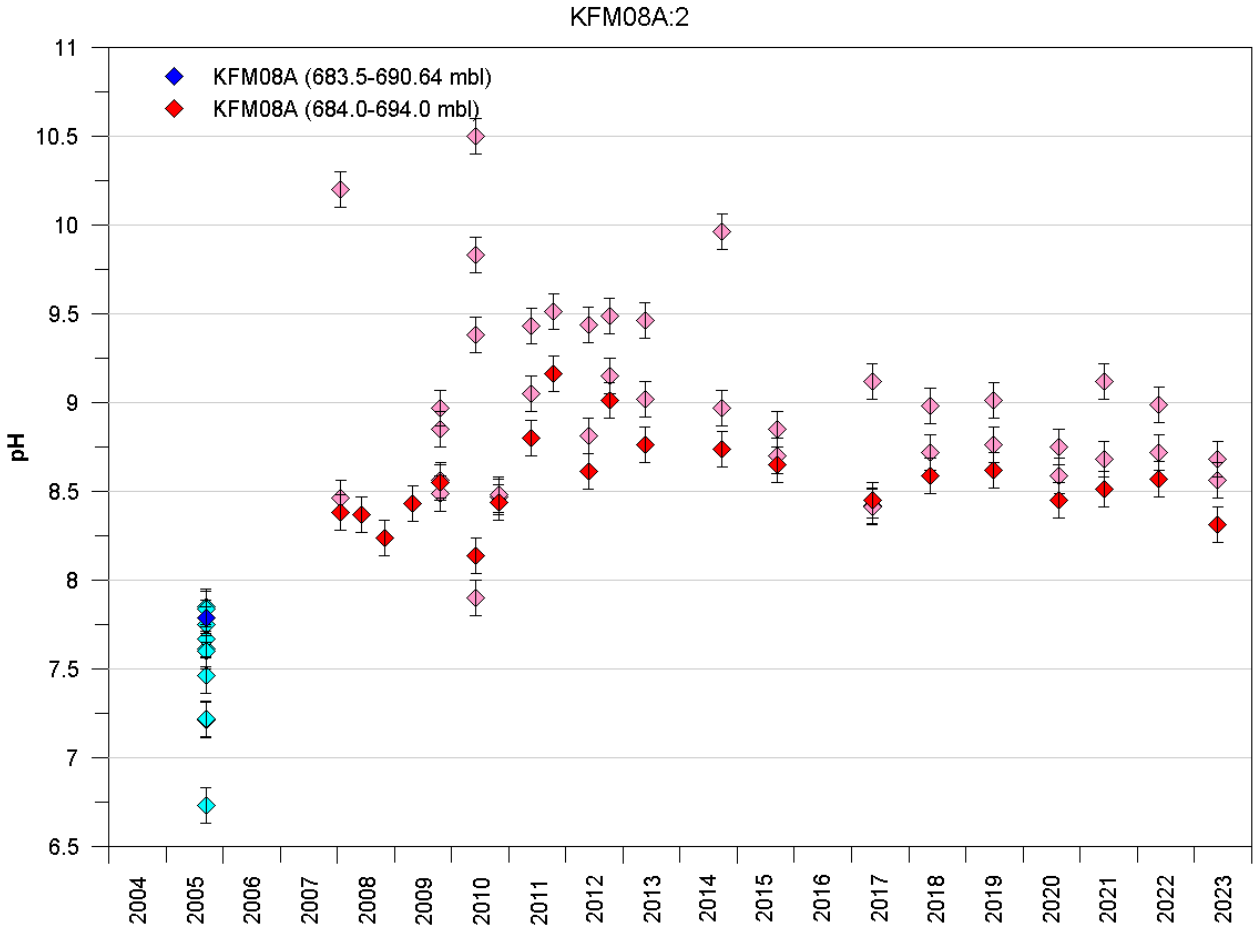

Figure A5-6. *Comparison between initial pH-values from complete chemical characterisation during PLU (blue diamonds) and later measurements in the ongoing monitoring programme (red diamonds) for KFM08A:2. The last sample in the series (or the only sample if no series) is marked with a darker red colour. All the presented pH-values are measured in the laboratory at 25°C, except those from 2013 which are from field measurements.*

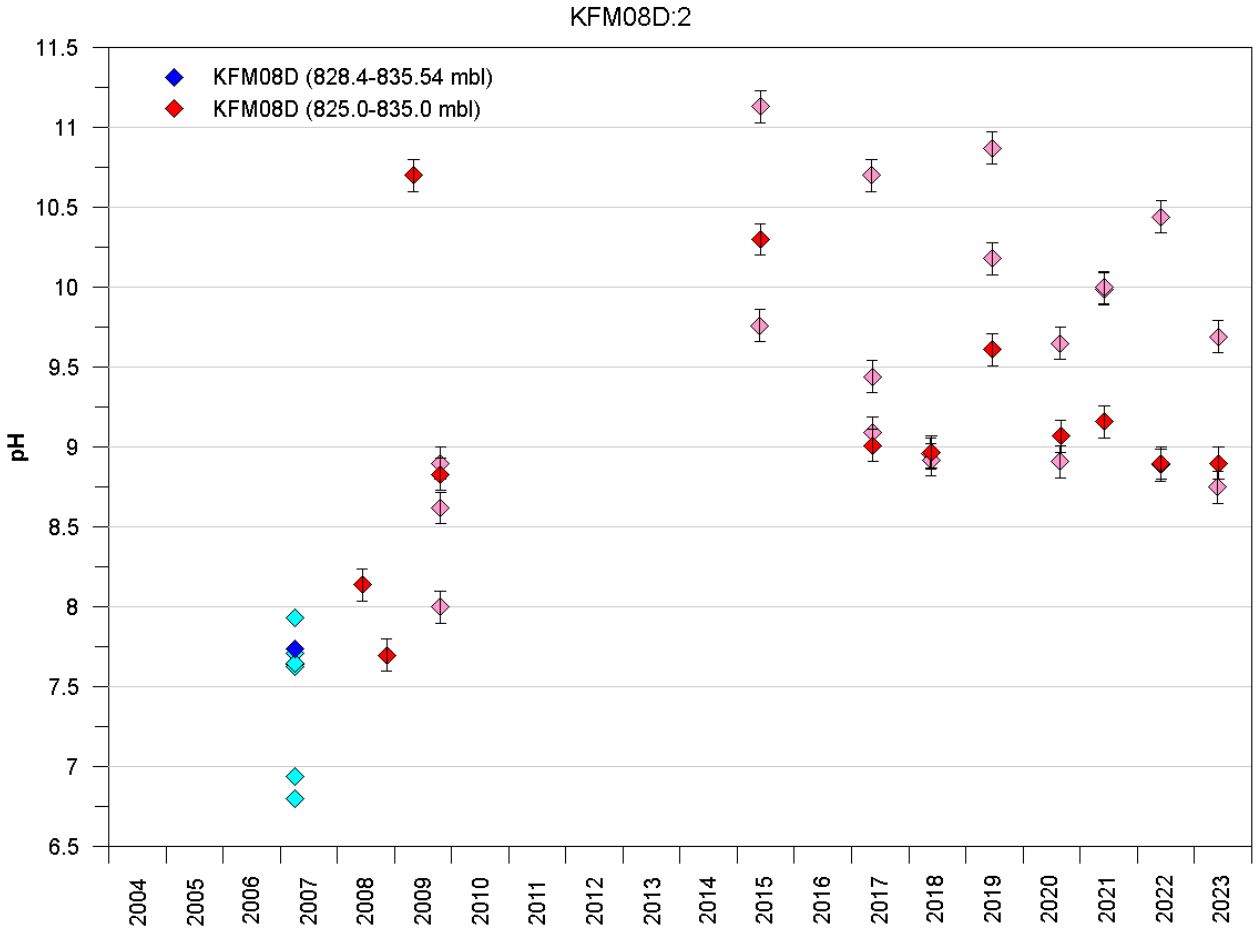

Figure A5-7. *Comparison between initial pH-values from complete chemical characterisation during PLU (blue diamonds) and later measurements in the ongoing monitoring programme (red diamonds) for KFM08D:2. The last sample in the series (or the only sample if no series) is marked with a darker red colour. All the presented pH-values are measured in the laboratory at 25°C. This section has been omitted from the monitoring program for many years due to corrosion problems. After reinstallation of borehole equipment it was sampled again from 2015 and onwards.*

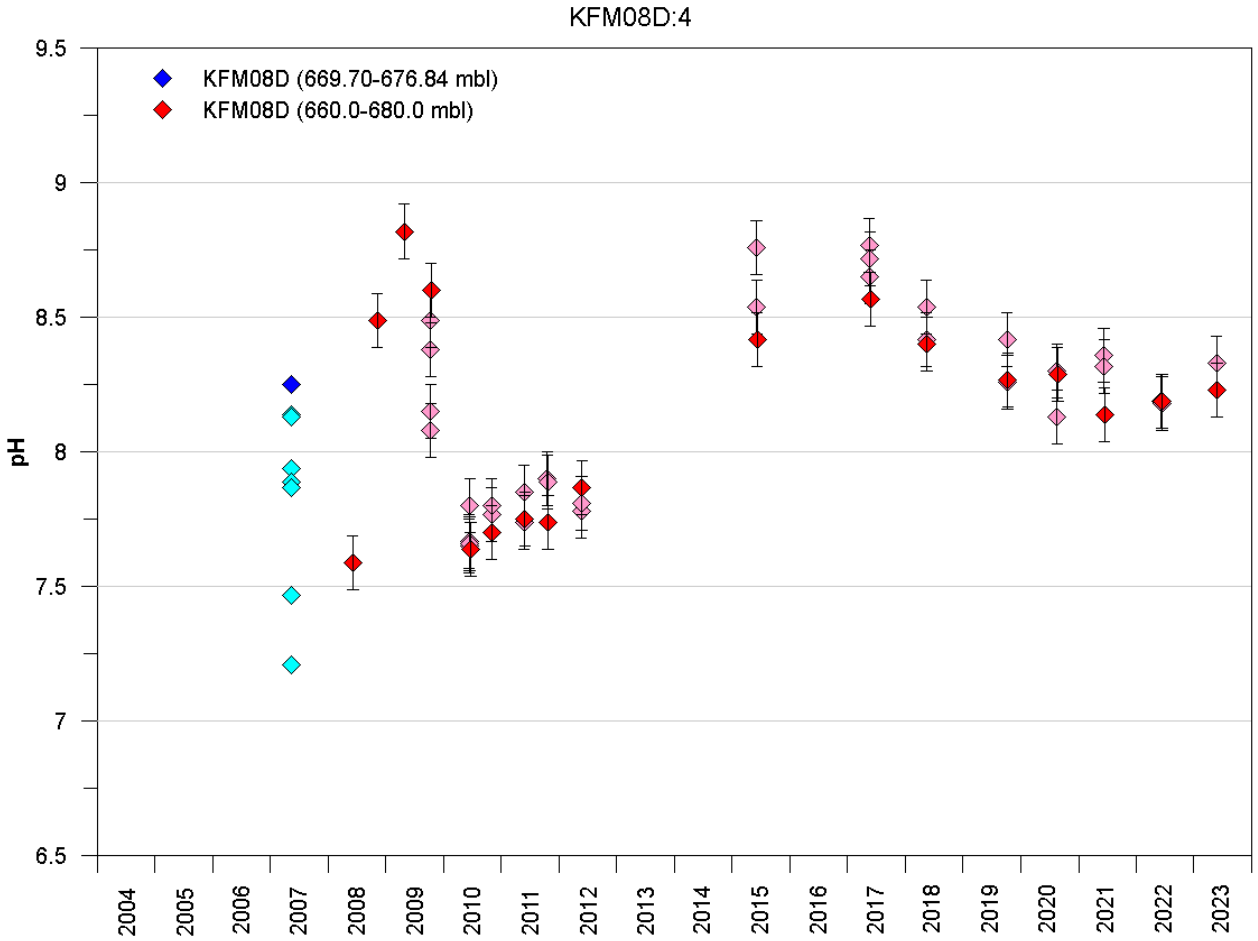

Figure A5-8. *Comparison between initial pH-values from complete chemical characterisation during PLU (blue diamonds) and later measurements in the ongoing monitoring programme (red diamonds) for KFM08D:4. The last sample in the series (or the only sample if no series) is marked with a darker red colour. All the presented pH-values are measured in the laboratory at 25°C. This section has been omitted from the monitoring program for 2013-2014 due to corrosion problems. After reinstallation of borehole equipment it was sampled again from 2015 and onwards.*

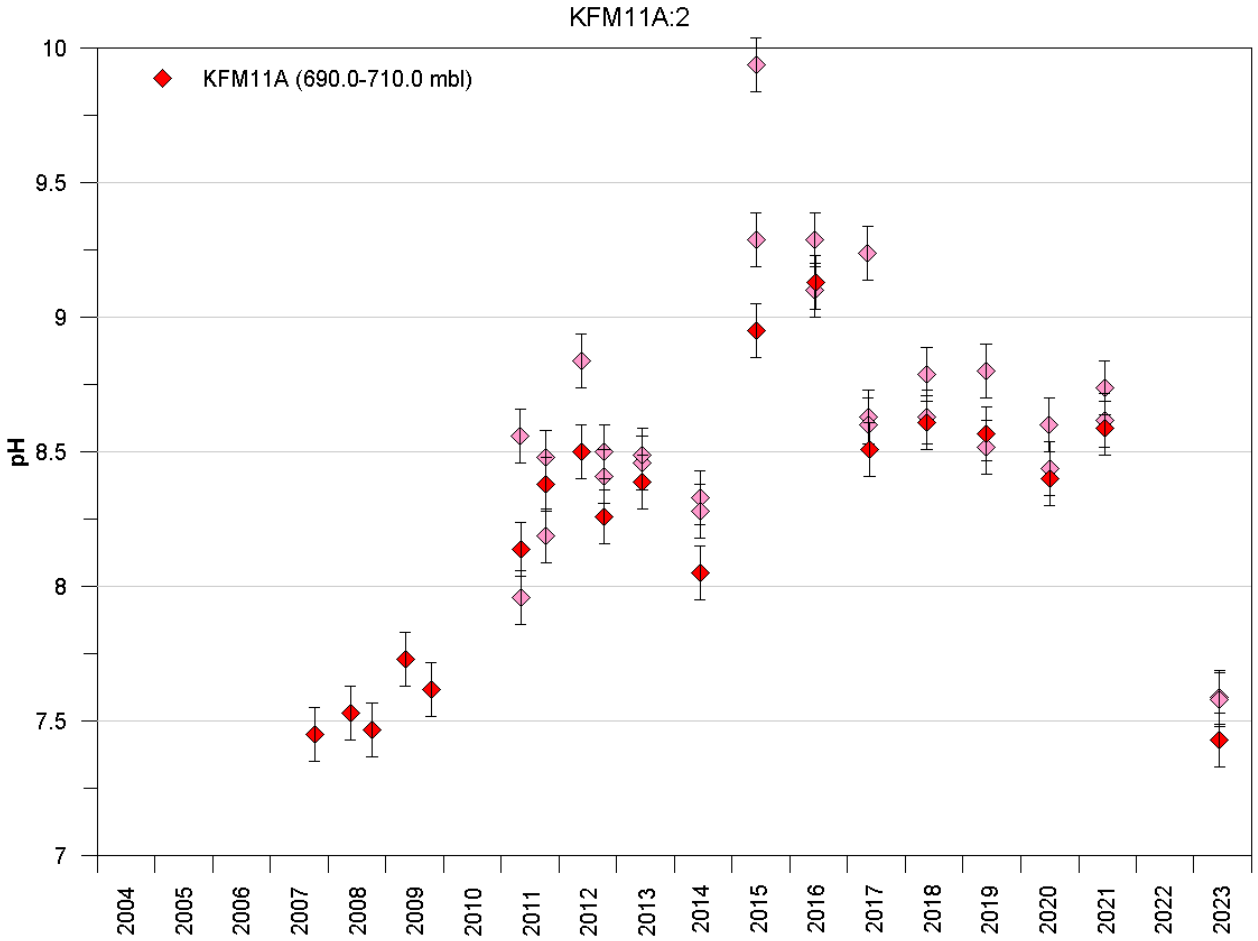

Figure A5-9. *Measurements of pH-values from the ongoing monitoring programme (red diamonds) for KFM11A:2. The last sample in the series (or the only sample if no series) is marked with a darker red colour. All the presented pH-values are measured in the laboratory at 25°C, except those from 2013 which are from field measurements. After re-installation of the borehole equipment, the pH value seems to have returned to earlier levels.*

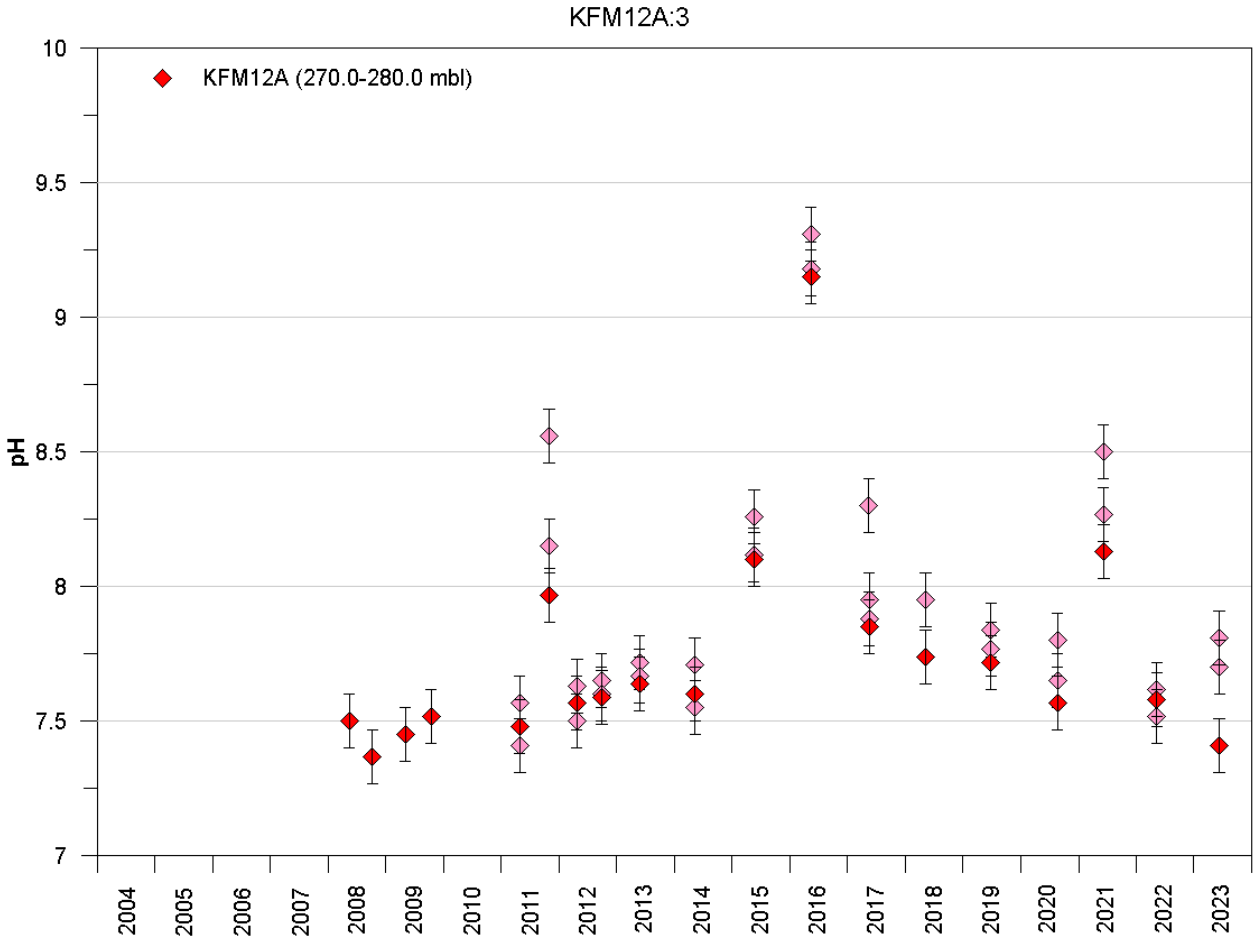

Figure A5-10. *Measurements of pH-values from the ongoing monitoring programme (red diamonds) for KFM12A:3. The last sample in the series (or the only sample if no series) is marked with a darker red colour. All the presented pH-values are measured in the laboratory at 25°C, except those from 2013 and 2015 which are from field measurements.*

Appendix 6 - Chloride trends in core- and percussion-drilled boreholes

Figure A6-1 to Figure A6-7 present chloride concentrations in collected samples from hydrogeochemical monitoring 2023 together with data from hydrogeochemical monitoring earlier years. The analytical uncertainty (± 5%) is shown as error bars in the diagrams. For some of the core drilled boreholes, data from the initial complete chemical characterisation (CCC) in corresponding borehole sections (Lindquist et al. 2011; SKB Database Sicada) are also presented. The CCC data are shown as dots on the y-axes (not corresponding to date on the x-axis). In the cases of sample series (after October 2009 and onwards), the value from the last sample in the series is presented in the diagrams. For boreholes included in the SFR Extension Project, the hydrogeochemical monitoring program started in 2012, but the diagrams of chloride concentrations (Figure A6-6 f) and Figure A6-7) also include data from earlier studies. Results from HFM19:1 (Figure A6-5 f)) and KFR102A:2 and :5 (Figure A6-7 a) and b)), not sampled during the last years campaigns, are also included in the presentation.

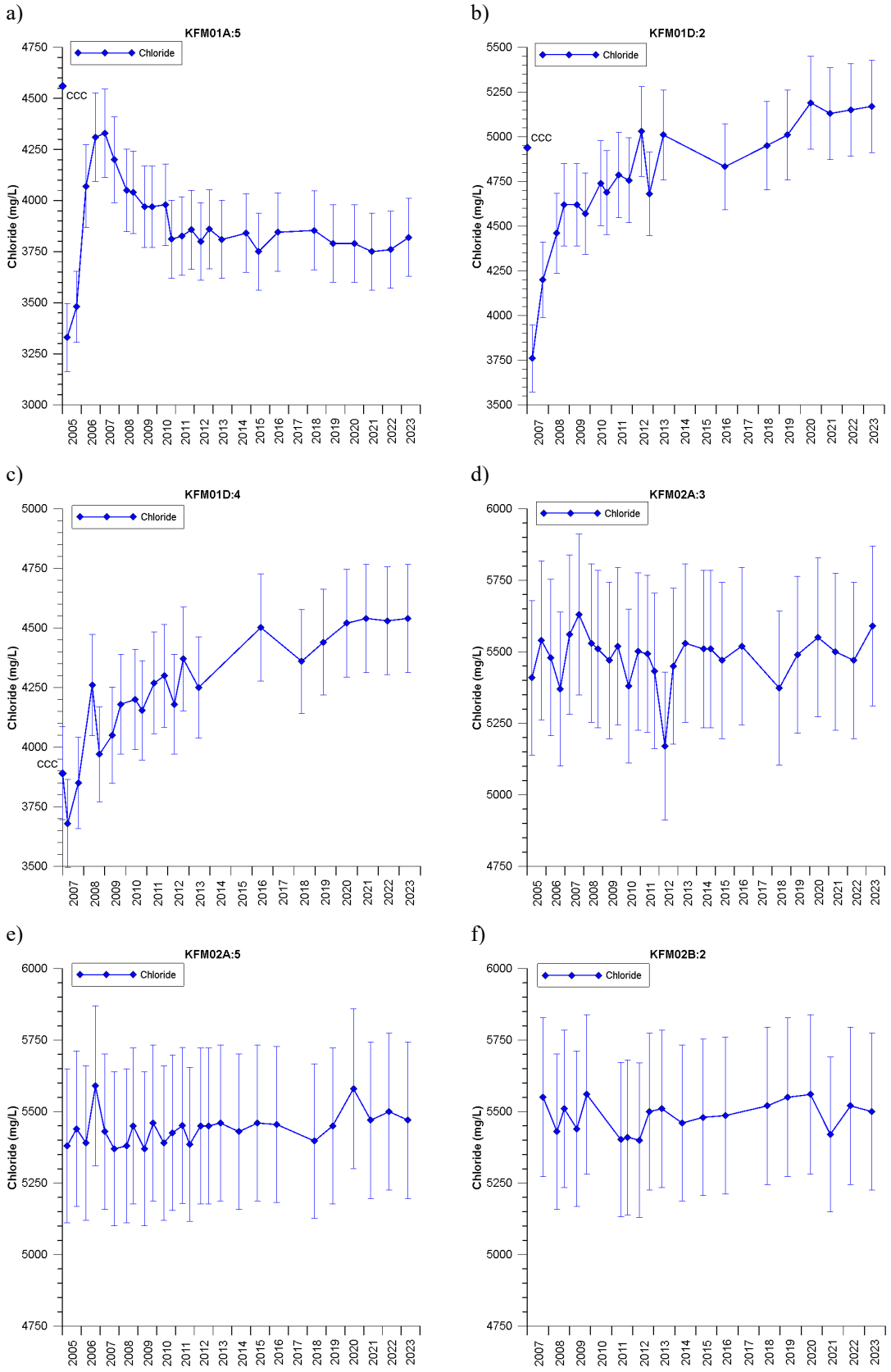

Figure A6-1. *Chloride concentrations in collected samples from hydrogeochemical monitoring 2005 to 2023 and from the initial complete chemical characterisation (CCC). The data points for CCC are placed on the y-axes with no correlation to date on x-axis.*

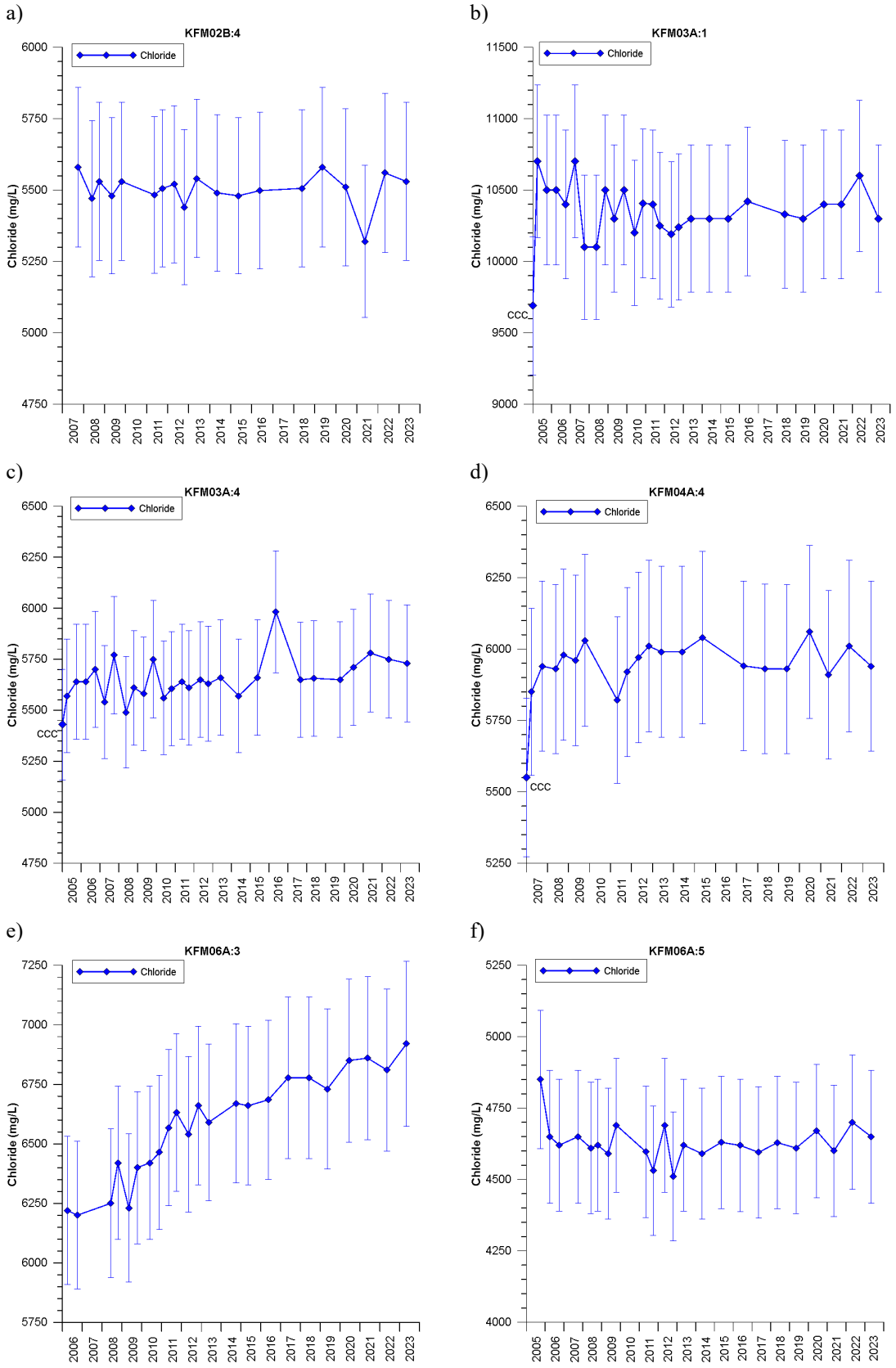

Figure A6-2. *Chloride concentrations in collected samples from hydrogeochemical monitoring 2005 to 2023 and from the initial complete chemical characterisation (CCC). The points for CCC are placed on the y-axes with no correlation to date on x-axis.*

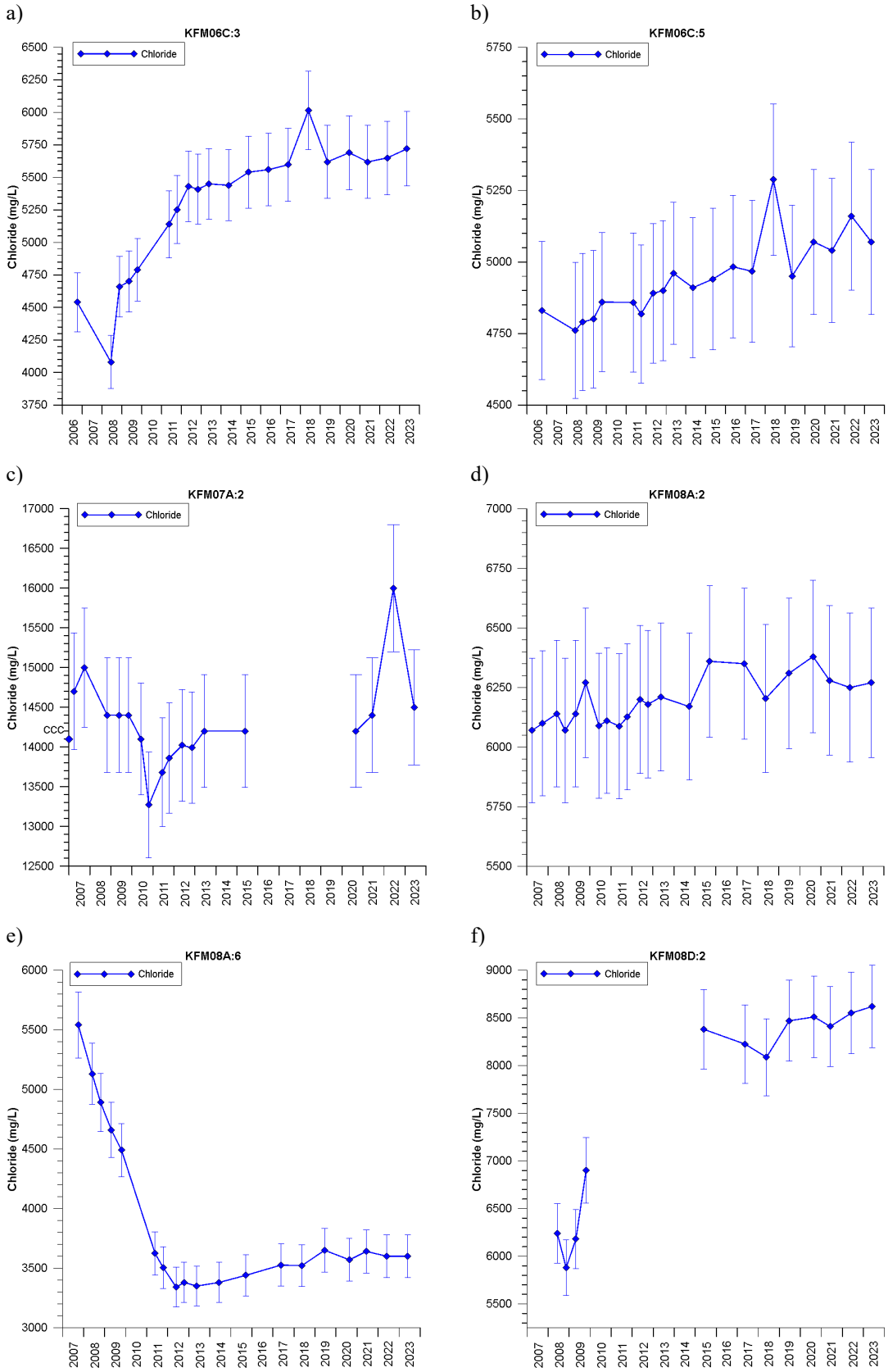

Figure A6-3. *Chloride concentrations in collected samples from hydrogeochemical monitoring 2006 to 2023 and from the initial complete chemical characterisation (CCC). The points for CCC are placed on the y-axes with no correlation to date on x-axis.*

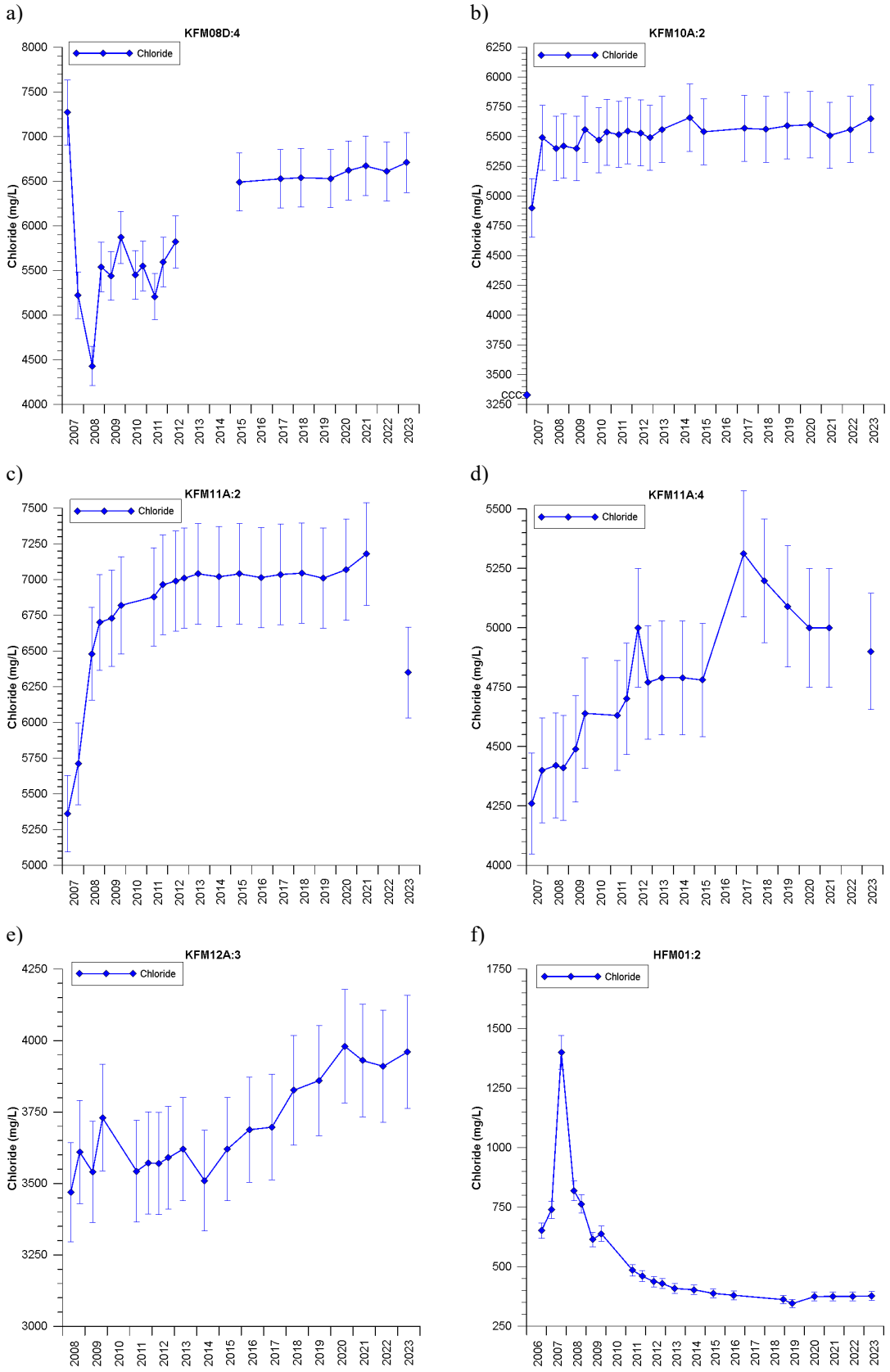

Figure A6-4. *Chloride concentrations in collected samples from hydrogeochemical monitoring 2006 to 2023 and from the initial complete chemical characterisation (CCC). The points for CCC are placed on the y-axes with no correlation to date on x-axis.*

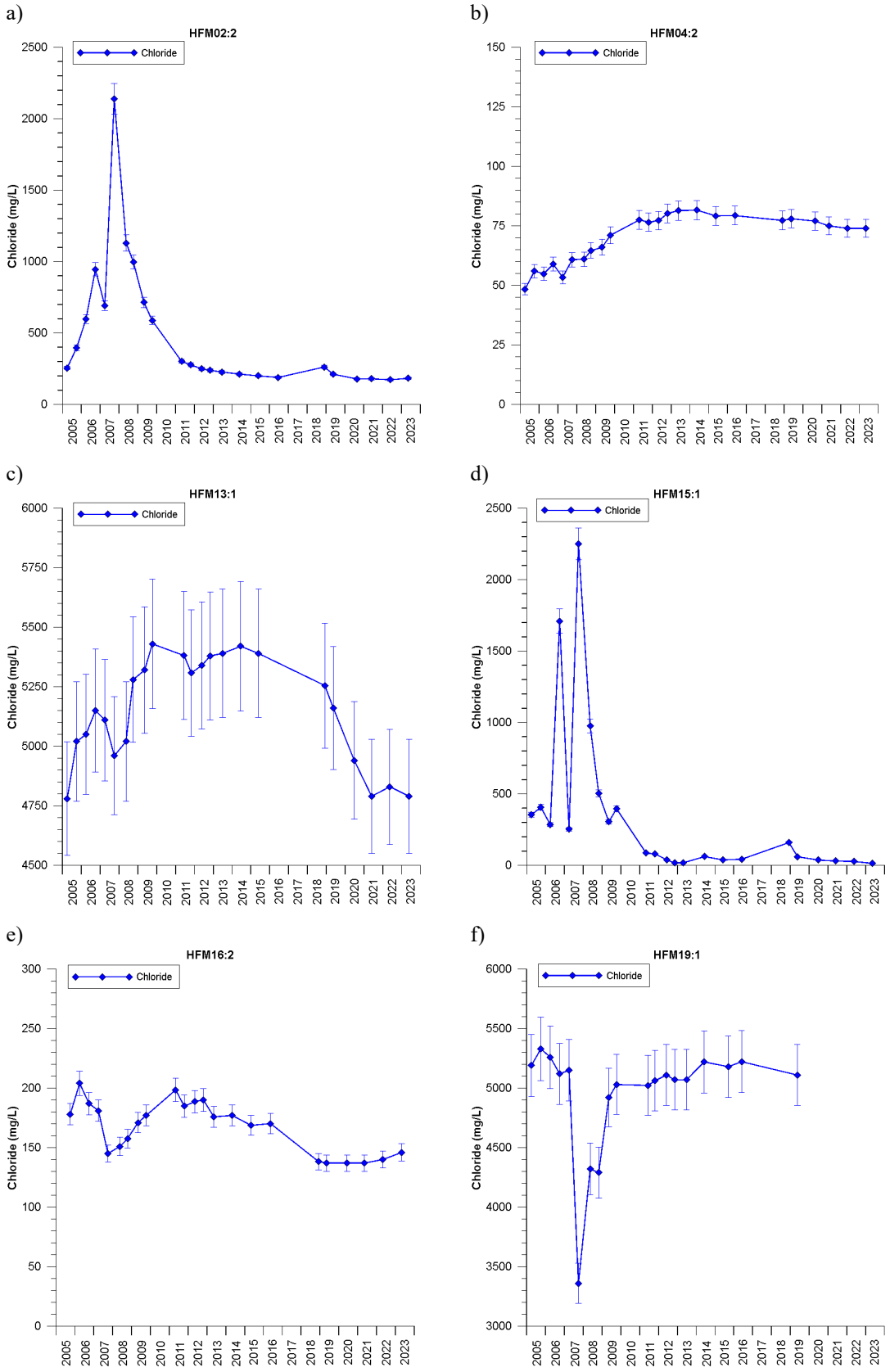

Figure A6-5. *Chloride concentrations in collected samples from hydrogeochemical monitoring 2005 to 2023.*

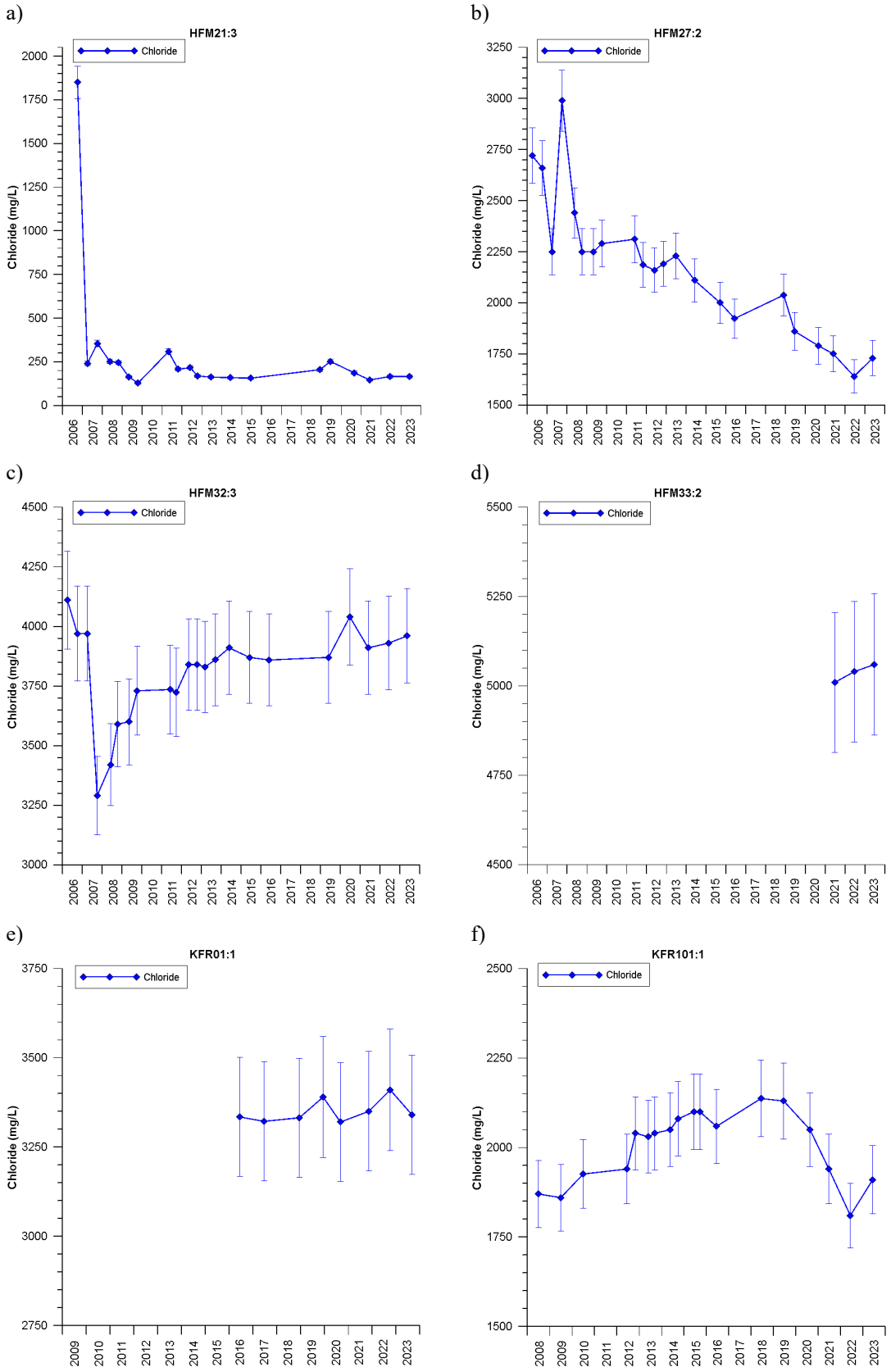

Figure A6-6. *Chloride concentrations in collected samples from hydrogeochemical monitoring 2006 to 2023.*

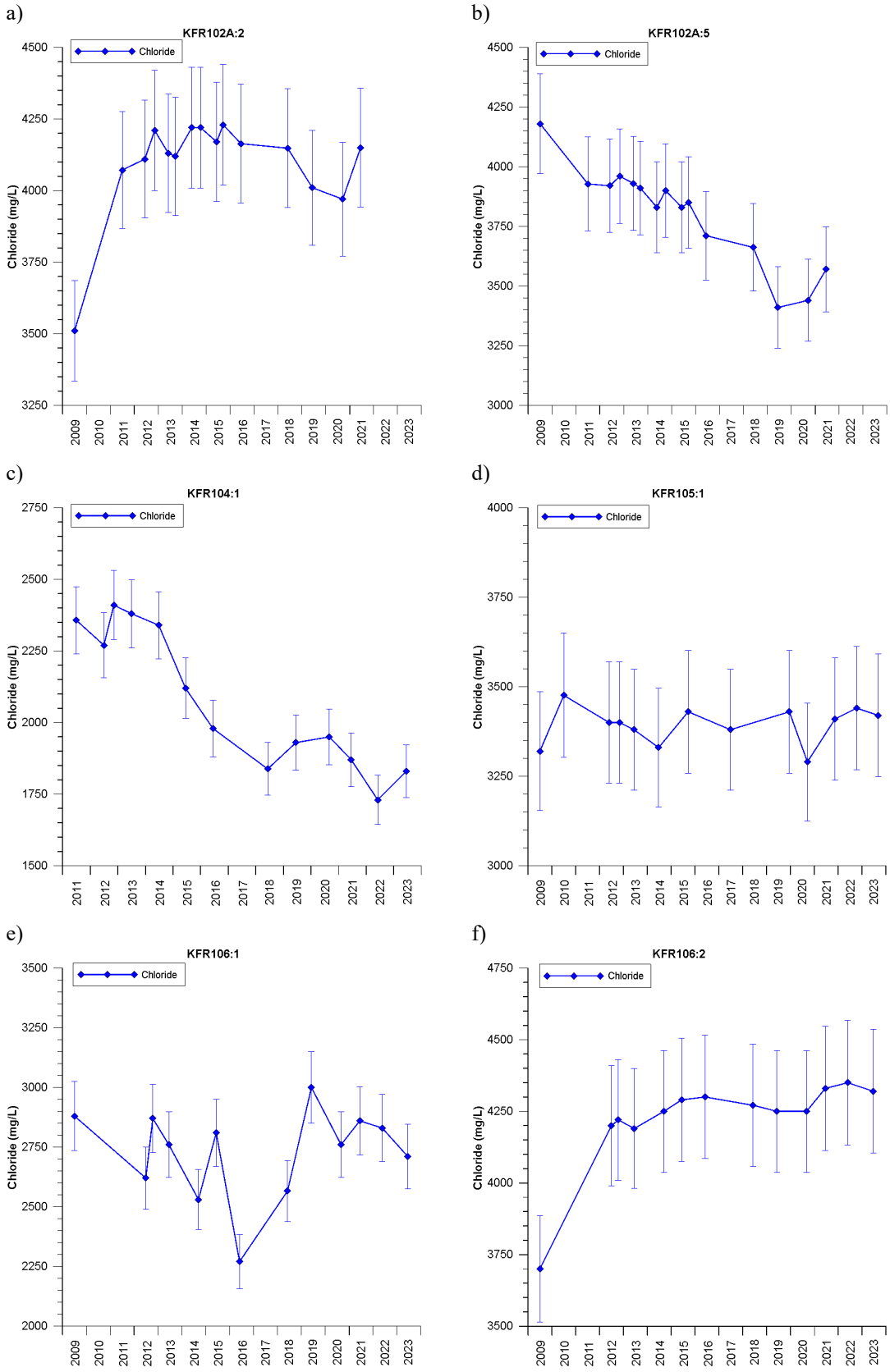

Figure A6-7. *Chloride concentrations in collected samples from hydrogeochemical monitoring 2009 to 2023.*