Norges geologiske undersøkelse
7491 TRONDHEIM
Tlf. 73 90 40 00
Telefaks 73 92 16 20

RAPPORT

Rapport nr.: 2003.071 | ISSN 0800-3416 | Gradering: Open

Tittel:
Hydrogeological studies in connection with production of bottled water, Best Kjøttprodukter AS, Utleirveien 140, Trondheim.

Forfatter:
Atle Dagestad

Oppdragsgiver:
Best kjøttprodukter AS

Fylke:
Sør-Trøndelag

Kommune:
Trondheim

Kartblad (M=1:250.000)
Trondheim

Kartbladnr. og -navn (M=1:50.000)
1621 IV Trondheim

Forekomstens navn og koordinater:

Sidetall: 31 Pris: 150,-
Kartbilag:

Feltarbeid utført:
2000-2001

Rapportdato:
25.04.2002

Prosjektnr.:
271200

Ansvarlig:

Sammendrag:

NGU has conducted a hydrogeological assessment of a groundwater well, which Best Kjøttprodukter AS is considering for the production of bottled water. This report forms the basis for approval by the local Food Control Authority to use the well for the production of bottled water. The hydrogeological assessment of the groundwater well is based on geological- and environmental mapping of the area, as well as test pumping of the well with an extraction rate of 1 l/s during a period of one whole year. In conjunction with the test pumping, monthly water samples were extracted for microbiological-, chemical- and physical analyses. The results show that the groundwater has a good and stable quality that meets all microbiological- and esthetic requirements of the *Directive for extraction and production of natural mineral- and spring water* and the *Directive for water supply and drinking water*. The geological mapping demonstrates the bedrock well to be well protected from surface water and potential contamination in the vicinity of the well area. To further protect the well from potential contamination, protection zones have been established around the wells where restrictions of activities have been imposed. Based on all studies conducted, NGU assesses this groundwater well to be well suited for the production of bottled water.

Emneord: Hydrogeology	Groundwater quality	Groundwater source
Sampling	Bedrock well	Test pumping

TABLE OF CONTENTS

FIGURES

APPENDICES

1. INTRODUCTION

Best Kjøttprodukter AS is planning the production and sale of bottled, natural water to be extracted from a bedrock well. NGU was contracted to carry out a hydrogeological survey and an environmental assessment of the well's catchment area. These investigations are aimed at documenting the bacteriological- and chemical quality of the groundwater, as well as the protection of water quality in the production well. This report forms the basis for approval by the Food Control Authority to use the well for the production of bottled water.

2. SURVEY AREA

The actual bedrock well has been drilled within the industrial site of Best Kjøttprodukter AS located at Utleirvegen 140, about 8 km south of Trondheim town centre. The production well is one of three wells that have been drilled behind the factory building. Figure 3 shows a detailed map, where the production well is referred to as well 1. The well area is situated under a steep bedrock slope that has been excavated in a ridge stretching about 1 km eastward from the industrial site. This ridge reaches 270 m over sea level and is flanked by small valleys toward both the north and south.

Figure 1: General map showing the survey area.

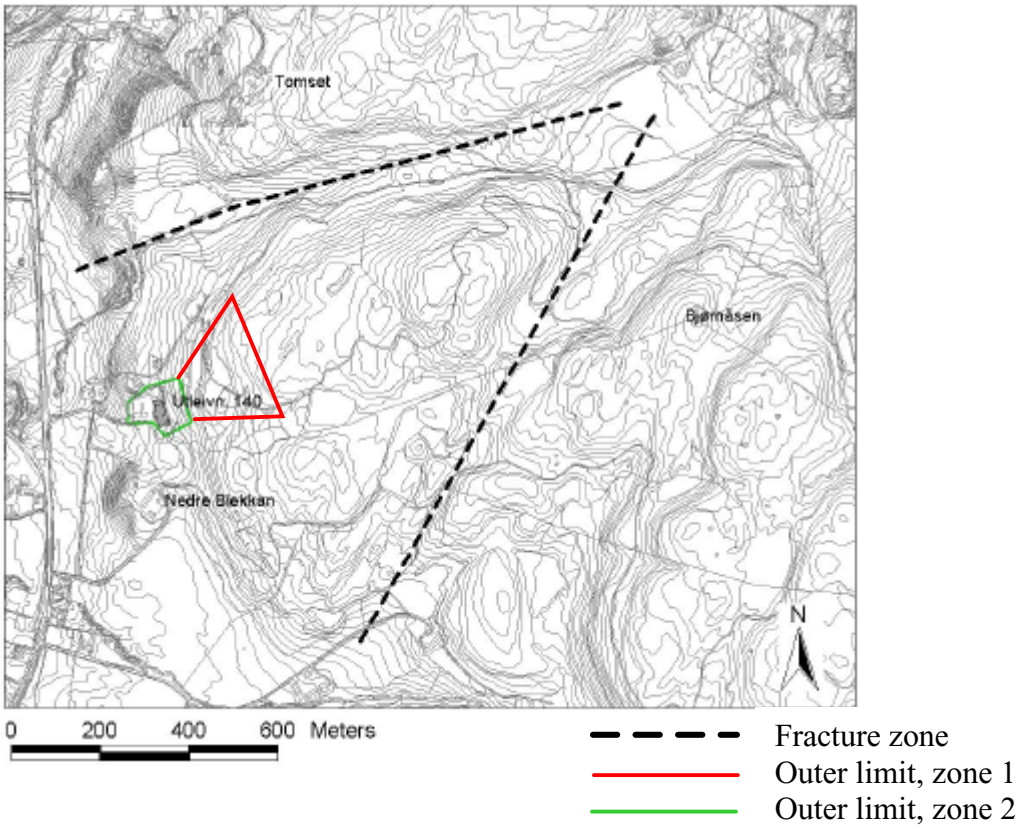


Figure 2: Map over the survey area showing major fracture zones and outer limits of protection zones around the well.

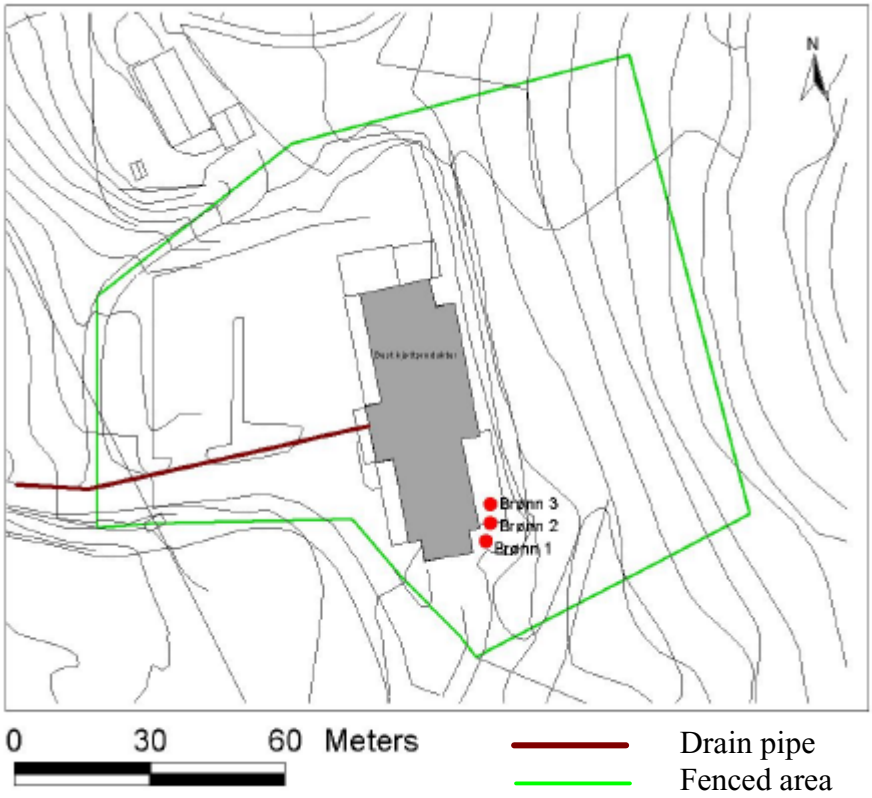


Figure 3: Detailed map over the industrial plot showing established wells.

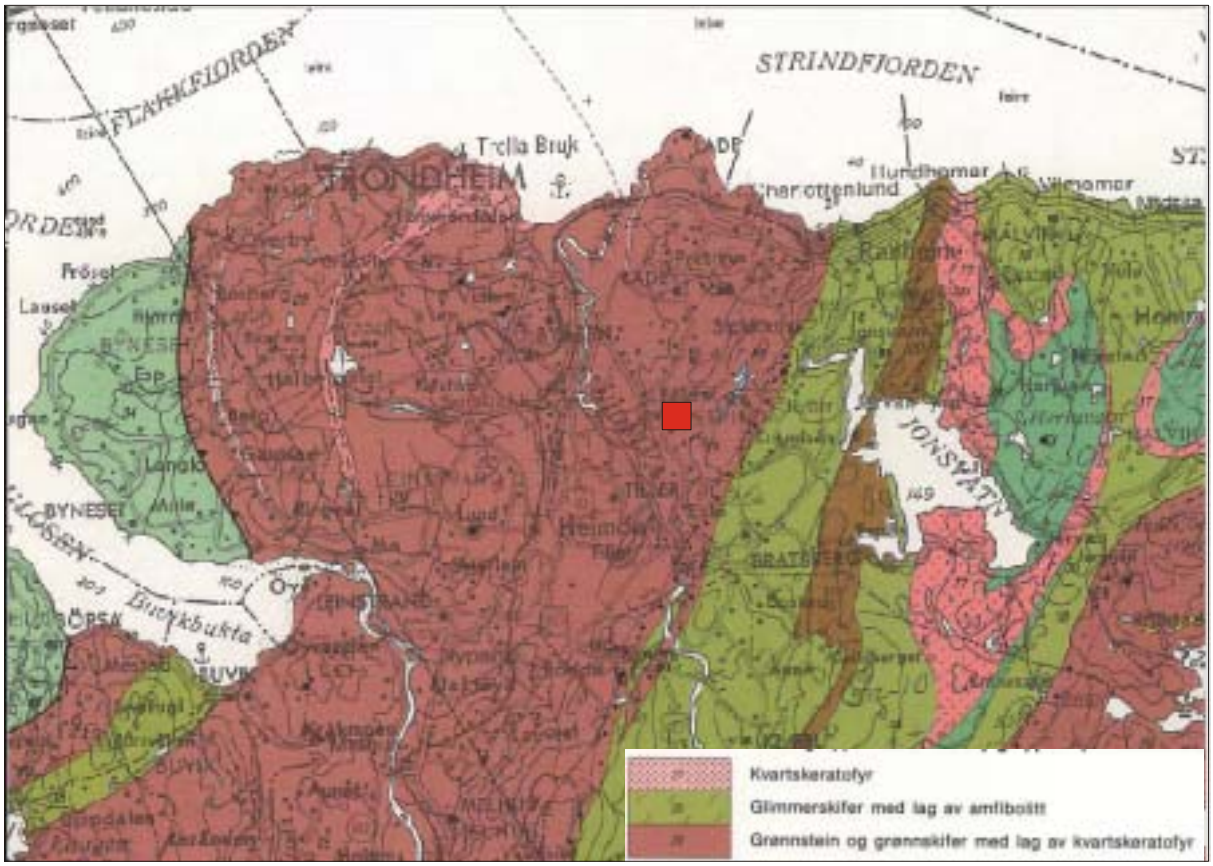


Figure 4: Map showing bedrock geology in the Trondheim area and the survey area, which is located in a zone of greenstone and greenschist. (Source: NGU bedrock geology database www.ngu.no)

3. GEOLOGICAL AND HYDROGEOLOCAL CONDITIONS

The bedrock geology in the survey area (Figure 4) is dominated by greenstone. The minor valleys north and south of the industrial site (Figure 2) are assumed to originate from fracture zones in the bedrock. These lineaments and valleys constitute the outer limits of the catchment area in question. The bedrock exposures behind the factory building show a moderate near-surface fracturing of the bedrock. No major water-bearing fractures or fracture zones have been registered in the vicinity of the wells. This is consistent with the fact that no water bearing fractures were registered in the top 50 meters during the drilling of the wells.
Tracer tests have not been carried out to map the infiltration or hydraulic-flow pattern in the catchment area. However, based on the topography and the geological observations, it is expected that infiltration of precipitation as well as the formation and flow of groundwater towards the well occurs in the sloping area to the east of the well.

4. LAND USE AROUND WELL AREA

Activities in the vicinity of the well area are all related to those of Best Kjøttprodukter AS. This includes substantial motorised transport to and from the factory building, which mainly takes place on the NW side of the building where loading areas and storage space are situated. Transport occurs on asphalt-covered surfaces with the surface runoff collected by sewer. The drain pipe from the site leading to the main sewer is shown in Figure 3. Previously, a pumping station connected to a buried storage tank for diesel fuel was buried about 30 meters west of the well area. The tank and pumping station have now been removed.

The catchment area above the wells contains forested areas where the only activities are related to small-scale forestry. A forrestry road runs across the ridge slope crossing the catchment area, but there is little traffic restricted to forestry activity. Land use regulations east of the industrial area are designated outdoor activities and there are no plans to change the land use.

5. DESIGN OF WELL AND WELL TOP

The design of the wells is shown in Appendix 1. Well 1 is 72 meters deep while both well 2 and 3 are 120 meters deep. A great difference in water yield from the wells exists. Well 1 yields 3600 l/s, while well 2 and 3 yield 300 l/s and 100 l/s, respectively. Only well 1 is considered for bottled-water production and is the only well that has been test pumped. The sketch of the wells shows that the wells were established with a 3-meter long ODEX steel casing and a 12-meter long inner casing of plastic. The plastic casing is, at the end, provided with a 15 cm wide packing (Aqua-seal) that will swell in contact with water and thus provide a good sealing between the casing and the bedrock wall. The top of the well is secured with a watertight well top, where the inner casing and the pipe leading to the pump are connected in a watertight manner. A construction, covering the well top and connecting it to the production facilities, is under consideration. By designing the well and well top in this manner, surface water and near-surface groundwater are prevented from entering the well, which is important in order to secure the bacteriological quality of the groundwater.

6. ANALYTIC STUDIES

During late autumn of 2000, a hydrogeological survey was conducted to study the conditions of runoff and infiltration in the well area. In November-December (2000) a quality-testing program was initiated, including monthly sampling of the water for bacteriological-, chemical- and physical analyses. During this period, about 1 l/s was extracted continuously from well 1.

The bacteriological analyses were carried out by The Food Control Authority in Trondheim, while the chemical- and physical analyses were conducted by NGU's laboratory. In addition to the bacteriological-, chemical- and physical analyses, the temperature of the groundwater was monitored using an automatic temperature logger placed at the end of the extraction pipe.

7. RESULTS

7.1 Bacteriological analysis

The results from the bacteriological analysis, presented in appendix 2, show that the groundwater has a satisfactory low content of bacteria. However, two water samples contain a bacterial content exceeding the acceptable level. The first water sample, collected on 27.11.2000, contained a HPC (heterotrophic plate count at 22^{o}C) of 900. The high level may be due to the well not having been pumped for a sufficiently long time following the drilling and/or well construction. This is consistent with the fact that subsequent water samples have shown a low and, in some cases, sinking HPC level during the test period.

The second water sample with an unacceptable high HPC level, collected on 06.03.2001,contained 3 fecal streptococci. This result is difficult to explain because the sample contained otherwise low levels of other bacteria. Normally, such a bacterial count

would indicate leakage of contaminated surface water and, thus, have a high level of other bacteria and HPC. However, the well owner mentioned that the pump had been taken out for repair and had been reinstalled prior to the collection of this water sample. This was done without disinfecting the pump prior to reinstallation, thus providing a possible explanation for the observed bacterial contamination of the water sample. Because such an operation should then also result in high HPC levels, the absence of such levels is still difficult to explain in this particular sample.

7.2 Chemical analyses

The results of the chemical analyses are presented in the tables in Appendices 3 to 16. The contents of dissolved elements and compounds all lie below the maximum allowable concentration of the Norwegian *Directive for water supply and drinking water* (1). In addition to the standard chemical analyses, the content of radon in the groundwater was monitored in the field on 22.03.2002,showing a low level of radon in the groundwater ([Ra]< 100 Bq/l).

7.3 Physical parameters

Measurements of turbidity and colour (Tables in Appendices 16 to 20) show that all water samples have values below the maximum allowable concentration of the Norwegian *Directive for water supply and drinking water* (1). Results from the continuous monitoring of temperature of the extracted groundwater are presented graphically in Figure 5. This graph shows an almost constant temperature (7,7-7,8 ^{o}C) throughout the one-year period of test pumping.

8. ASSESSMENT OF THE WATER ANALYSES

Based on the results of the surveys conducted, the quality of the groundwater from the production well appears good and stable, satisfying all microbiological- and esthetic requirements of the Norwegian *Directive for water supply and drinking water* (1) and the *Directive for extraction and production of natural mineral- and spring water* (2). The latter Directive would classify this groundwater as water with a low mineral content. The chemical analyses show that the groundwater's content of calcium, sodium, magnesium, potassium, silica, sulphate and several other compounds at minor levels, result from contact with the weathered bedrock.

The stable microbiological- and chemical composition of the groundwater, as well as its near-constant temperature, indicate that the groundwater from this well has had a long residence time in the sub-surface without being affected by surface water or near-surface groundwater. These observations indicate that the well is properly protected from potential contamination in the vicinity of the well.

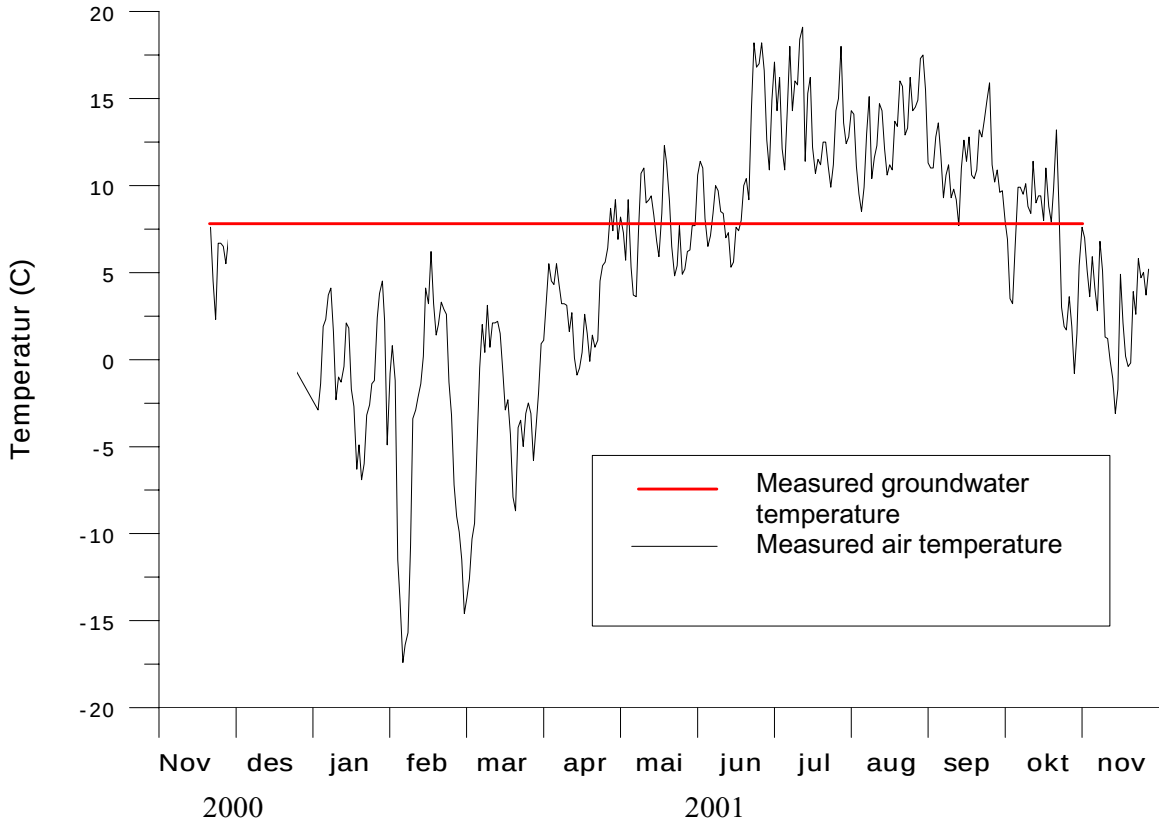


Figure 5: Summary of temperatures measured in extracted groundwater (red line) and atmosphere temperatures (black line) recorded at Voll meteorological station, Trondheim.

9. POTENTIAL SOURCES OF CONTAMINATION

Because the well is located within an industrial site where traffic, drainage pipes and other activities may cause contamination, there is a certain vulnerability of the groundwater quality. However, the geological setting in the well area is favourable from a contamination point of view. The bedrock is generally little fractured and drilling of the well showed the first water-bearing fracture observed at a depth of 57 meters. This indicates little hydraulic communication between the surface in the well area and the fracture zone from which the groundwater originates. It can therefore be concluded that the bedrock zone above the well's production horizon provides good protection of the groundwater against surface water infiltrating directly from surface.

10. PROTECTION OF THE GROUNDWATER SOURCE

Despite the good protection provided by the bedrock in the area surrounding the well, certain protective measures need to be implemented around the well. This involves establishing protection zones around the well that put restrictions on the land use. Here a division into three zones is proposed, where the outer limit of each zone is shown in Figure 3.

Zone 0: This zone includes the planned construction over the well within the production facilities. The room where the well is situated must be locked to prevent unauthorised access. Only activities that are connected to maintenance and control of the production well are

permitted within this zone. It is not permitted within this zone to store chemicals or carry out any activities that may cause contamination of the well.

Zone 1: This zone includes the fenced off industrial site. Outdoor storage of substantial quantities of chemicals is not permitted and neither is refuelling of vehicles permitted within this zone. Special attention must be paid to activities that are potentially contaminating (transport, construction work etc.) In cases of chemical contamination (for example oil leakage), immediate action must be taken to prevent infiltration and the contaminants must be collected and removed from the area. The well owner must therefore establish an action plan for such scenarios.

Zone 2: This zone includes parts of the ridge behind the well area. There are currently no activities in this area that pose a threat to the quality of the groundwater in the well. However, major changes in land use are not allowed (larger road construction, housing estates) before a more detailed hydrogeological investigation has been conducted.

11. CONCLUSIONS

The conducted investigations have shown that the groundwater from the production well at Utleirveien 140 has a good and stable quality meeting all microbiological- and esthetic requirements of the *Directive for water supply and drinking water* and of the *Directive for extraction and production of natural mineral- and spring water*.

The investigations also indicate that the well is well protected from surface water in the vicinity of the well area. However, unforeseen circumstances linked to activities at the industrial site pose a potential risk for contamination of the groundwater quality. To reduce this risk, protection zones have been established which further restrict specific activities within the industrial site.

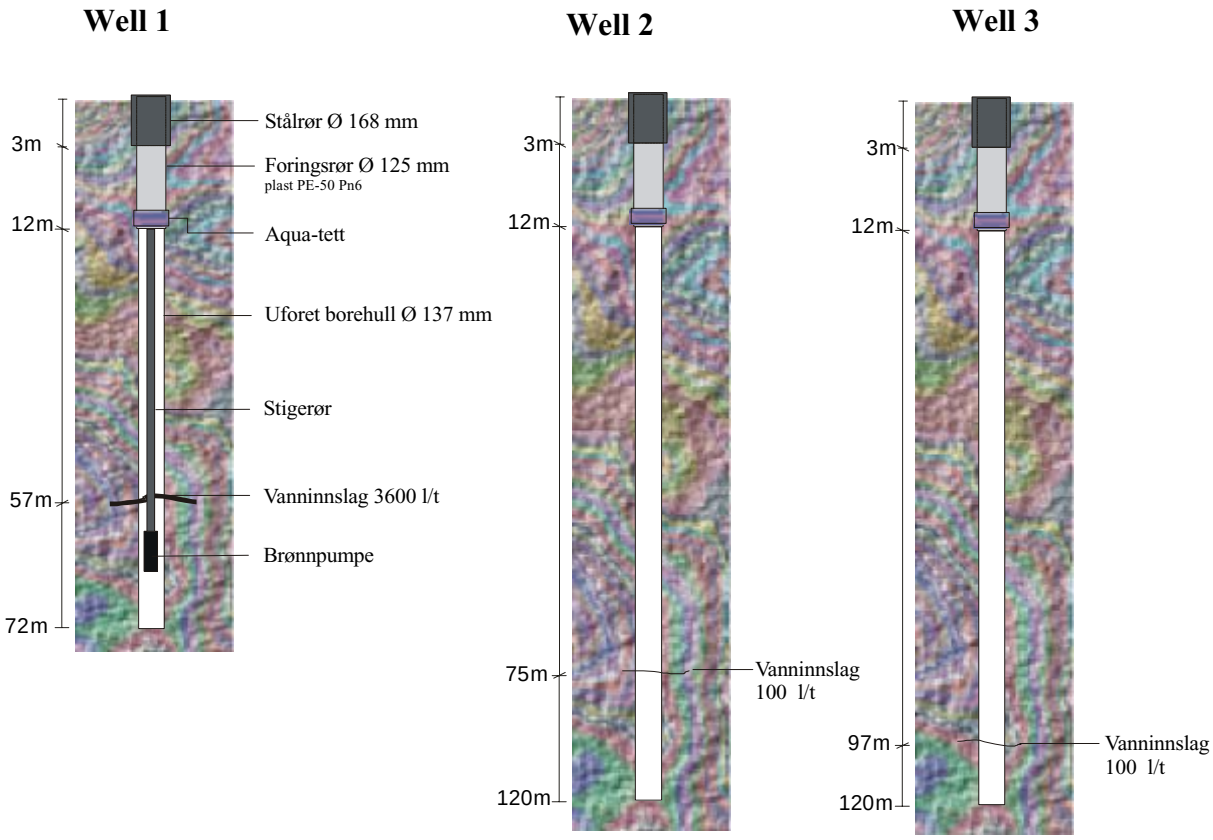
NGU concludes, based on the hydrogeological investigation and chemical analyses, that the groundwater well at Utleirveien 140 is suitable for the production of bottled water, provided that protective measures are carried out in practice. The water analyses reported here represent the quality of groundwater extracted from the well at a rate of 1 l/s. An increase in the extraction rate, or the establishment of new production wells in the same area, may have a negative effect on the groundwater quality. New water analyses must be conducted to document the water quality if the water extraction rate were to be increased.

References:

1. Directive for water supply and drinking water. 1995. Directive no. 68. Ministry of Social Affairs and Health.
2. Directive for extraction and production of natural mineral- and spring water. 1998. Ministry of Health.

Appendices

Design of bedrock wells at Best kjøttprodukter AS



Appendix 2

Bacteriological analyses of groundwater from well 1

Parameter	Metode	27.11.2000	09.01.2001	12.02.2001	06.03.2001	18.04.2001	08.05.2001	05.06.2001
Kimtall ved 22 °C	NS-6222	**900**	11	16	17	4	3	19
Kimtall ved 36 °C 2d.	NS-6222	0	1	1	0	0	0	0
Koliforme bakt., MF	NS-4788	0	0	0	0	0	0	0
Temotol.kolif. Bakt.,MF	NS-4792	0	0	0	0	0	0	0
Fekale strept. MF	NS-4793	0	0	0	**3**	0	0	0
Sulfittred. Colostr. MF	ISO-6461	0	0	0	0	0	0	0
Escherichia coli	API	0	0	0	0	0	0	0
Persumtivt E.coli MF	NS-4792	0	0	0	0	0	0	0
Pseudomonas Aeriginosa	NS-4798	0	0	0	0	0	0	0

Parameter	Metode	03.07.2001	10.07.2001	06.08.2001	04.09.2001	02.10.2001	05.11.2001
Kimtall ved 22 °C	NS-6222	0	3	2	2	0	5
Kimtall ved 36 °C 2d.	NS-6222	0	0	0	0	0	2
Koliforme bakt., MF	NS-4788	0	0	0	0	0	0
Temotol.kolif. Bakt.,MF	NS-4792	0	0	0	0	0	0
Fekale strept. MF	NS-4793	0	0	0	0	0	0
Sulfittred. Colostr. MF	ISO-6461	0	0	0	0	0	0
Escherichia coli	API	0	0	0	0	0	0
Persumtivt E.coli MF	NS-4792	0	0	0	0	0	0
Pseudomonas Aeriginosa	NS-4798	0	0	0	0	0	0

NGU
Norges geologiske undersøkelse
7491 TRONDHEIM
Tlf.: 73 90 40 00
Telefaks: 73 92 16 20

NORSK AKKREDITERING
Nr. P020

INSTRUMENT TYPE : **DIONEX IONEKROMATOGRAF 120 DX**

NEDRE BESTEMMELSES GRENSE :

F^-	Cl^-	NO_2^-*	Br^-	NO_3^-	PO_4^{3-}	SO_4^{2-}
0.05 mg/l	0.1 mg/l	0.05 mg/l	0.1 mg/l	0.05 mg/l	0.2 mg/l	0.1 mg/l

(1 mg/l = 1 ppm)

ANALYSEUSIKKERHET : ± 10 rel. % for alle ionene

*) NGU-lab er ikke akkrediter for NO_2^-

PRESISJON : Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.

ANTALL PRØVER: 12

ANMERKNINGER: Ingen

Rapporten må ikke gjengis i utdrag uten skriftlig godkjenning fra NGU-Lab.

Bente Kjøsnes
OPERATØR

NGU
Norges geologiske undersøkelse

7491 TRONDHEIM
Tlf.: 73 90 40 00
Telefaks: 73 92 16 20

NORSK AKKREDITERING
Nr. P020

Oppdr.nr.	Prøve id.	Prøvetatt	F^- [mg/l]	Cl^- [mg/l]	NO_2^- [mg/l]	Br^- [mg/l]	NO_3^- [mg/l]	PO_4^{3-} [mg/l]	SO_4^{2-} [mg/l]
1-515/00	Prøvenummer: 1	04.12 2000	0.05	9.39	< 0.05	< 0.1	0.61	< 0.2	26.2
1-002/01	Prøvenummer: 2	03.01 2001	0.09	9.17	< 0.05	< 0.1	1.31	< 0.2	25.5
1-068/01	Prøvenummer: 3	12.02 2001	< 0.05	9.41	< 0.05	< 0.1	1.39	< 0.2	27
1-100/01	Prøvenummer: 4	06.03 2001	< 0.05	9.53	< 0.05	< 0.1	0.91	< 0.2	29
1-154/01	Prøvenummer: 5	18.04 2001	0.06	10.3	< 0.05	< 0.1	1.28	< 0.2	30
1-182/01	Prøvenummer: 6	08.05 2001	0.06	10.4	< 0.05	< 0.1	1.2	< 0.2	29.8
1-215/01	Prøvenummer: 7	05.06 2001	< 0.05	10.7	< 0.05	< 0.1	0.98	< 0.2	29.4
1-267/01	Prøvenummer: 8	03.07 2001	< 0.05	11.1	< 0.05	< 0.1	1.28	< 0.2	30.2
1-313/01	Prøvenummer: 9	07.08 2001	0.06	11.1	< 0.05	< 0.1	2.1	< 0.2	30.7
1-348/01	Prøvenummer: 10	04.09 2001	0.06	10.9	< 0.05	< 0.1	1.62	< 0.2	30.8
1-398/01	Prøvenummer: 11	02.10 2001	0.06	10.8	< 0.05	< 0.1	2.99	< 0.2	30.1
1-452/01	Prøvenummer: 12	05.11 2001	< 0.05	11.3	< 0.05	< 0.1	2.77	< 0.2	30.5

NGU
Norges geologiske undersøkelse

7491 TRONDHEIM
Tlf.: 73 90 40 00
Telefaks: 73 92 16 20

NORSK AKKREDITERING
Nr. P020

INSTRUMENT TYPE : **Thermo Jarrell Ash ICP 61**

NEDRE BESTEMMELSESGRENSER VANNANALYSER

(For vannprøver som tynnes, blir deteksjonsgrensene automatisk omregnet)

Si mg/l	Al mg/l	Fe mg/l	Ti mg/l	Mg mg/l	Ca mg/l	Na mg/l	K mg/l	Mn mg/l	P mg/l	Cu mg/l	Zn mg/l	Pb mg/l	Ni mg/l	Co mg/l
0.02	0.02	0.01	0.005	0.05	0.02	0.05	0.5	0.001	0.1	0.005	0.002	0.05	0.02	0.01

V mg/l	Mo mg/l	Cd mg/l	Cr mg/l	Ba mg/l	Sr mg/l	Zr mg/l	Ag mg/l	B mg/l	Be mg/l	Li mg/l	Sc mg/l	Ce mg/l	La mg/l	Y ppb
0.005	0.01	0.005	0.01	0.002	0.001	0.005	0.01	0.02	0.001	0.005	0.001	0.05	0.01	0.001

(1 mg/l = 1 ppm)

ANALYSEUSIKKERHET : ± 20 rel. % for K, Pb, Cd, Li, Ce
± 10 rel. % for Si, Al, Na, Mo, Cr, Zr, Ag, B og La
± 5 rel. % for Fe, Ti, Mg, Ca, Mn, P, Cu, Zn, Ni, Co, V, Ba, Sr, Be, Sc, Y

PRESISJON : **Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.**

ANTALL PRØVER: 12
ANMERKNINGER:

Baard Søberg
OPERATØR

NGU
Norges geologiske undersøkelse

7491 TRONDHEIM
Tlf.: 73 90 40 00
Telefaks: 73 92 16 20

NORSK AKKREDITERING
Nr. P020

Oppdr.nr.	Prøve id.	Prøvetatt	Si [mg/l]	Al [mg/l]	Fe [mg/l]	Ti [mg/l]	Mg [mg/l]	Ca [mg/l]	Na [mg/l]	K [mg/l]	Mn [mg/l]	P [mg/l]	Cu [mg/l]	Zn [mg/l]	Pb [mg/l]
1-515/00	Prøvenummer: 1	04.12 2000	3.58	<0.02	<0.01	<0.005	7.02	41.8	26.9	5.4	0.0136	<0.1	0.00688	0.0192	<0.05
1-002/01	Prøvenummer: 2	03.01 2001	3.19	<0.02	<0.01	<0.005	6.89	40.4	29.2	5.23	0.0104	<0.1	<0.005	0.0156	<0.05
1-068/01	Prøvenummer: 3	12.02 2001	3.23	<0.02	<0.01	<0.005	6.71	38.2	31.7	5.23	0.0110	<0.1	<0.005	0.00659	<0.05
1-100/01	Prøvenummer: 4	06.03 2001	3	<0.02	<0.01	<0.005	6.82	38.6	32.6	5.44	0.0107	<0.1	<0.005	0.00504	<0.05
1-154/01	Prøvenummer: 5	18.04 2001	2.69	<0.02	<0.01	<0.005	6.96	38.7	32.7	5.41	0.0118	<0.1	<0.005	0.0071	<0.05
1-182/01	Prøvenummer: 6	08.05 2001	3.23	<0.02	<0.01	<0.005	6.85	39.6	30.8	5.4	0.0115	<0.1	<0.005	0.00386	<0.05
1-215/01	Prøvenummer: 7	05.06 2001	2.89	<0.02	<0.01	<0.005	6.72	39	30	5.17	0.0114	<0.1	<0.005	0.0275	<0.05
1-267/01	Prøvenummer: 8	03.07 2001	3.03	<0.02	0.0125	<0.005	6.75	38.8	29.7	4.91	0.0113	<0.1	<0.005	0.00667	<0.05
1-313/01	Prøvenummer: 9	07.08 2001	3.48	<0.02	<0.01	<0.005	7.4	43.2	29.9	5.25	0.00934	<0.1	<0.005	0.00751	<0.05
1-348/01	Prøvenummer: 10	04.09 2001	3.25	<0.02	<0.01	<0.005	7.58	44.9	29.9	5.27	0.0109	<0.1	<0.005	0.00649	<0.05
1-398/01	Prøvenummer: 11	02.10 2001	3.2	<0.02	<0.01	<0.005	7.6	44.6	30	5.88	0.00904	<0.1	<0.005	0.0124	<0.05
1-452/01	Prøvenummer: 12	05.11 2001	3.42	<0.02	<0.01	<0.005	7.53	45.3	29.6	5.55	0.00965	<0.1	<0.005	0.00776	<0.05

NGU
Norges geologiske undersøkelse

7491 TRONDHEIM
Tlf.: 73 90 40 00
Telefaks: 73 92 16 20

NORSK AKKREDITERING
Nr. P020

Prøve id.	Prøvetatt	Ni [mg/l]	Co [mg/l]	V [mg/l]	Mo [mg/l]	Cd [mg/l]	Cr [mg/l]	Ba [mg/l]	Sr [mg/l]	Zr [mg/l]	Ag [mg/l]	B [mg/l]
Prøvenummer: 1	04.12 2000	<0.02	<0.01	<0.005	<0.01	<0.005	<0.01	0.0517	0.234	<0.005	<0.01	0.0213
Prøvenummer: 2	03.01 2001	<0.02	<0.01	<0.005	<0.01	<0.005	<0.01	0.057	0.233	<0.005	<0.01	<0.02
Prøvenummer: 3	12.02 2001	<0.02	<0.01	<0.005	<0.01	<0.005	<0.01	0.0170	0.222	<0.005	<0.01	0.0267
Prøvenummer: 4	06.03 2001	<0.02	<0.01	<0.005	<0.01	<0.005	<0.01	0.0174	0.227	<0.005	<0.01	0.021
Prøvenummer: 5	18.04 2001	<0.02	<0.01	<0.005	<0.01	<0.005	<0.01	0.0246	0.239	<0.005	<0.01	0.0206
Prøvenummer: 6	08.05 2001	<0.02	<0.01	<0.005	<0.01	<0.005	<0.01	0.0168	0.235	<0.005	<0.01	0.032
Prøvenummer: 7	05.06 2001	<0.02	<0.01	<0.005	<0.01	<0.005	<0.01	0.0174	0.226	<0.005	<0.01	<0.02
Prøvenummer: 8	03.07 2001	<0.02	<0.01	<0.005	<0.01	<0.005	<0.01	0.0173	0.232	<0.005	<0.01	<0.02
Prøvenummer: 9	07.08 2001	<0.02	<0.01	<0.005	<0.01	<0.005	<0.01	0.0191	0.255	<0.005	<0.01	<0.02
Prøvenummer: 10	04.09 2001	<0.02	<0.01	<0.005	<0.01	<0.005	<0.01	0.0202	0.258	<0.005	<0.01	0.0222
Prøvenummer: 11	02.10 2001	<0.02	<0.01	<0.005	<0.01	<0.005	<0.01	0.0208	0.255	<0.005	<0.01	<0.02
Prøvenummer: 12	05.11 2001	<0.02	<0.01	<0.005	<0.01	<0.005	<0.01	0.0197	0.262	<0.005	<0.01	0.0215

NGU
Norges geologiske undersøkelse

7491 TRONDHEIM
Tlf.: 73 90 40 00
Telefaks: 73 92 16 20

NORSK AKKREDITERING
Nr. P020

Prøve id.	Prøvetatt	Be [mg/l]	Li [mg/l]	Sc [mg/l]	Ce [mg/l]	La [mg/l]	Y [mg/l]
Prøvenummer: 1	04.12 2000	<0.001	<0.005	<0.001	<0.05	<0.01	<0.001
Prøvenummer: 2	03.01 2001	<0.001	<0.005	<0.001	<0.05	<0.01	<0.001
Prøvenummer: 3	12.02 2001	<0.001	<0.005	<0.001	<0.05	<0.01	<0.001
Prøvenummer: 4	06.03 2001	<0.001	<0.005	<0.001	<0.05	<0.01	<0.001
Prøvenummer: 5	18.04 2001	<0.001	<0.005	<0.001	<0.05	<0.01	<0.001
Prøvenummer: 6	08.05 2001	<0.001	<0.005	<0.001	<0.05	<0.01	<0.001
Prøvenummer: 7	05.06 2001	<0.001	<0.005	<0.001	<0.05	<0.01	<0.001
Prøvenummer: 8	03.07 2001	<0.001	<0.005	<0.001	<0.05	<0.01	<0.001
Prøvenummer: 9	07.08 2001	<0.001	<0.005	<0.001	<0.05	<0.01	<0.001
Prøvenummer: 10	04.09 2001	<0.001	<0.005	<0.001	<0.05	<0.01	<0.001
Prøvenummer: 11	02.10 2001	<0.001	<0.005	<0.001	<0.05	<0.01	<0.001
Prøvenummer: 12	05.11 2001	<0.001	<0.005	<0.001	<0.05	<0.01	<0.001

NGU
Norges geologiske undersøkelse

7491 TRONDHEIM
Tlf.: 73 90 40 00
Telefaks: 73 92 16 20

NORSK AKKREDITERING
Nr. P020

UTFØRES ETTER NORSK STANDARD - NS-ISO 7888

INSTRUMENT TYPE : **Radiometer Titralab 94 / CDM 210 Conductivity meter**

NEDRE BESTEMMELSES GRENSE : **0.07 mS m^{-1}**

ANALYSEUSIKKERHET :

Måleområde / mS m^{-1}	Usikkerhet
0.07 - 0.2	± 3 % rel
> 2.0	± 1 % rel

PRESISJON : **Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.**

ANTALL PRØVER: 12

ANMERKNINGER:
1. Elektrisk konduktivitet ved 25° C er beregnet ved automatiske temperaturkompensasjon. Temperatur verdier oppgitt i tabellen tilsvarer prøvetemperatur under måling.
   Resultat angis mS/m (1mS/m=10 µS/cm) med tre gjeldende siffer
2. Resultater mindre enn 1 mS/m kan bli påvirket av atmosfærisk karbondioksyd og ammoniakk

Tomm Berg
OPERATØR

NGU
Norges geologiske undersøkelse

7491 TRONDHEIM
Tlf.: 73 90 40 00
Telefaks: 73 92 16 20

Analysedato	Oppdr.nr.	Prøve id.	Prøvetatt	Ledn.-evne mS/m	Temp. °C
07.12.2000	1-515/00	Prøvenummer: 1	04.12 2000	37.5	22.6
05.01.2001	1-002/01	Prøvenummer: 2	03.01 2001	37.4	22.0
13.02.2001	1-068/01	Prøvenummer: 3	12.02 2001	37.5	22.3
08.03.2001	1-100/01	Prøvenummer: 4	06.03 2001	37.8	22.6
04.05.2001	1-154/01	Prøvenummer: 5	18.04 2001	38.1	22.4
16.05.2001	1-182/01	Prøvenummer: 6	08.05 2001	37.9	23.2
08.06.2001	1-215/01	Prøvenummer: 7	05.06 2001	38.2	21.8
05.07.2001	1-267/01	Prøvenummer: 8	03.07 2001	38.5	23.2
22.08.2001	1-313/01	Prøvenummer: 9	07.08 2001	39.1	22.4
13.09.2001	1-348/01	Prøvenummer: 10	04.09 2001	39.7	21.9
11.10.2001	1-398/01	Prøvenummer: 11	02.10 2001	39.9	22.3
09.11.2001	1-452/01	Prøvenummer: 12	05.11 2001	40.4	22.1

NGU
Norges geologiske undersøkelse
7491 TRONDHEIM
Tlf.: 73 90 40 00
Telefaks: 73 92 16 20

NORSK AKKREDITERING
Nr. P020

pH: UTFØRES ETTER NORSK STANDARD -NS 4720
ALKALITET: UTFØRES ETTER NGU-SD 3.7B (følger tidligere NS 4754)

INSTRUMENT TYPE : Radiometer Titralab 94 / Glasselektrode pHC 2701-8 "Red Rod"

PARAMETER	NEDRE BESTEMMELSES GRENSE	ANALYSEUSIKKERHET		
		Måleområde	Usikkerhet	
pH	-	-	+ 0.05 pH units	
			p-alkalitet	t-alkalitet
Alkalitet	0.04 mmol l -1	0.04 - 0.2 mmol l^{-1}	± 0.02 mmol l^{-1}	± 0.04 mmol l^{-1}
		0.2 - 2.0 mmol l^{-1}	± 5.0 % rel.	± 4.0 % rel.
		> 2.0 mmol l^{-1}	± 4.3 % rel.	± 1.0 % rel.

PRESISJON : **Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.**
ANTALL PRØVER: 12
ANMERKNINGER: Ingen
Rapporten må ikke gjengis i utdrag uten skriftlig godkjenning fra NGU-Lab.

Tomm Berg
OPERATØR

NGU
Norges geologiske undersøkelse

7491 TRONDHEIM
Tlf.: 73 90 40 00
Telefaks: 73 92 16 20

NORSK AKKREI
Nr. P02(

Analysedato	Oppdr.nr.	Prøve id.	Prøvetatt	pH pH	t-alkalitet mmol/l
07.12.2000	1-515/00	Prøvenummer: 1	04.12 2000	8.09	3.18
05.01.2001	1-002/01	Prøvenummer: 2	03.01 2001	8.10	3.16
13.02.2001	1-068/01	Prøvenummer: 3	12.02 2001	8.11	3.15
08.03.2001	1-100/01	Prøvenummer: 4	06.03 2001	8.16	3.15
04.05.2001	1-154/01	Prøvenummer: 5	18.04 2001	8.14	3.17
16.05.2001	1-182/01	Prøvenummer: 6	08.05 2001	8.25	3.17
08.06.2001	1-215/01	Prøvenummer: 7	05.06 2001	8.14	3.17
05.07.2001	1-267/01	Prøvenummer: 8	03.07 2001	8.13	3.20
22.08.2001	1-313/01	Prøvenummer: 9	07.08 2001	8.14	3.38
13.09.2001	1-348/01	Prøvenummer: 10	04.09 2001	8.13	3.29
11.10.2001	1-398/01	Prøvenummer: 11	02.10 2001	8.03	3.21
09.11.2001	1-452/01	Prøvenummer: 12	05.11 2001	7.96	3.25

NGU
Norges geologiske undersøkelse

7491 TRONDHEIM
Tlf.: 73 90 40 00
Telefaks: 73 92 16 20

NORSK AKKREDITERING
Nr. P020

INSTRUMENT TYPE : **Perkin Elmer SIMAA 6000**

NEDRE BESTEMMELSES GRENSE :

Cd µg/l	Pb µg/l	As µg/l	Se µg/l	Sn µg/l
0.02	0.2	3	1	2

(For analyser med tynningsfaktor som avviker fra 100, blir deteksjonsgrensen automatisk omregnet)
(1 µg/l = 1 ppb)

ANALYSEUSIKKERHET : ± 20 rel. % for As og Sn.
± 10 rel. % for Cd, Pb og Se.

PRESISJON : **Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.**

ANTALL PRØVER: 2

ANMERKNINGER: Ingen

Rapporten må ikke gjengis i utdrag uten skriftlig godkjenning fra NGU-Lab.

Ferdig analysert Dato 18. mar. 2002 Frank Berge
OPERATØR

NGU
Norges geologiske undersøkelse
7491 TRONDHEIM
Tlf.: 73 90 40 00
Telefaks: 73 92 16 20

NORSK AKKREDITERING Nr. P020

Oppdr.nr.	Prøve id.	Prøvetatt	As µg/L	Cd µg/L
1-313/01	Prøvenummer: 9	07.08 2001	< 3	0.04
1-452/01	Prøvenummer: 12	05.11 2001	< 3	< 0.02

NGU
Norges geologiske undersøkelse

7491 TRONDHEIM
Tlf.: 73 90 40 00
Telefaks: 73 92 16 20

NORSK AKKREDITERING
Nr. P020

INSTRUMENT TYPE : **CETAC M-6000A Hg Analyzer**

NEDRE BESTEMMELSES GRENSE : **0.01** **µg/l**
(1 µg/l = 1 ppb)

ANALYSEUSIKKERHET : ± 10 rel. %

PRESISJON : **Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.**

ANTALL PRØVER: 2

ANMERKNINGER: Prøve 9 tidligere oppdragsnr. 2001.0313 - Prøve 12 tidligere oppdragsnr. 2001.0452

Ferdig analysert	13. mar. 2002	Frank Berge
	Dato	OPERATØR

NGU
Norges geologiske undersøkelse

7491 TRONDHEIM
Tlf.: 73 90 40 00
Telefaks: 73 92 16 20

NORSK AKKREDITERING
Nr. P020

Oppdr.nr.	Prøve id.	Prøvetatt	Hg [µg/l]
1-313/01	Prøvenummer: 9	07.08 2001	< 0.01
1-452/01	Prøvenummer: 12	05.11 2001	< 0.01

NGU
Norges geologiske undersøkelse

7491 TRONDHEIM
Tlf.: 73 90 40 00
Telefaks: 73 92 16 20

NORSK AKKREDITERING
Nr. P020

METODE

Vannet filtreres gjennom et membranfilter med porestørrelse 0.45mm. Absorbansen måles ved 410nm.
Resultatene er oppgitt uten benevning som konsentrasjon av platina (mg/l Pt) i en referanseløsning med samme absorbans.
(Metoden tilsvarer tidligere Norsk Standard - NS 4787. 1 utg. 1988)

INSTRUMENT TYPE : **SHIMADZU UV-1201 Spektrofotometer**

NEDRE BESTEMMELSES GRENSE : **1.4**

ANALYSEUSIKKERHET : ± 7.5 % rel.

PRESISJON : Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram).
Disse kan forevises om ønskelig.

ANTALL PRØVER: 12

ANMERKNINGER: Ingen

Bente Kjøsnes
OPERATØR

NGU
Norges geologiske undersøkelse

7491 TRONDHEIM
Tlf.: 73 90 40 00
Telefaks: 73 92 16 20

NORSK AKKREDITERING
Nr. P020

Oppdr.nr.	Prøve id.	Prøvetatt	Fargetall -
1-515/00	Prøvenummer: 1	04.12 2000	< 1.4
1-002/01	Prøvenummer: 2	03.01 2001	2
1-068/01	Prøvenummer: 3	12.02 2001	3.3
1-100/01	Prøvenummer: 4	06.03 2001	2.4
1-154/01	Prøvenummer: 5	18.04 2001	< 1.4
1-182/01	Prøvenummer: 6	08.05 2001	1.9
1-215/01	Prøvenummer: 7	05.06 2001	2
1-267/01	Prøvenummer: 8	03.07 2001	< 1.4
1-313/01	Prøvenummer: 9	07.08 2001	< 1.4
1-348/01	Prøvenummer: 10	04.09 2001	1.1
1-398/01	Prøvenummer: 11	02.10 2001	< 1.4
1-452/01	Prøvenummer: 12	05.11 2001	< 1.4

NGU
Norges geologiske undersøkelse
7491 TRONDHEIM
Tlf.: 73 90 40 00
Telefaks: 73 92 16 20

NORSK AKKREDITERING
Nr. P020

UTFØRES ETTER TIDLIGERE NORSK STANDARD - NS 4723 (2 utg. 1989).

INSTRUMENT TYPE : **Hach 2100 A Turbidimeter**

NEDRE BESTEMMELSES GRENSE : **0.05 FTU**

ANALYSEUSIKKERHET

Måleområde / FTU	Usikkerhet
0.05 - 1.0	± 0.04 FTU
1.0 - 10	± 0.4 FTU
10 - 100	± 4 FTU
100 - 1000	± 40 FTU

PRESISJON : Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.

ANTALL PRØVER: 12

ANMERKNINGER: Ingen

Rapporten må ikke gjengis i utdrag uten skriftlig godkjenning fra NGU-Lab.

Bente Kjøsnes
OPERATØR

NGU
Norges geologiske undersøkelse
7491 TRONDHEIM
Tlf.: 73 90 40 00
Telefaks: 73 92 16 20

Oppdr.nr.	Prøve id.	Prøvetatt	Turbiditet FTU
1-515/00	Prøvenummer: 1	04.12 2000	0.13
1-002/01	Prøvenummer: 2	03.01 2001	0.12
1-068/01	Prøvenummer: 3	12.02 2001	0.09
1-100/01	Prøvenummer: 4	06.03 2001	0.13
1-154/01	Prøvenummer: 5	18.04 2001	0.1
1-182/01	Prøvenummer: 6	08.05 2001	0.14
1-215/01	Prøvenummer: 7	05.06 2001	0.13
1-267/01	Prøvenummer: 8	03.07 2001	0.12
1-313/01	Prøvenummer: 9	07.08 2001	0.08
1-348/01	Prøvenummer: 10	04.09 2001	0.12
1-398/01	Prøvenummer: 11	02.10 2001	0.1
1-452/01	Prøvenummer: 12	05.11 2001	0.09