

Forsmark site investigation

Snow depth, ground frost and ice cover during the winter 2003/2004

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June 2004

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Abstract

During the winter of 2003/2004, snow depth, snow weight, ground frost penetration depth and ice cover were determined from field observations. The snow parameters and ground frost were measured at three stations and the ice cover was observed at two locations. It is the second consecutive year that these measurements and observations have been performed (with exception of the snow weight). The water content of the snow was calculated from the weight of snow cores of known volumes.

The first snow of the season fell in late October and a lasting snow cover was established in the middle of December. At one station the snow cover lasted until the middle of April. The maximum snow depth and snow water content, registered at a measurement station located in a forest glade, were approximately 40 cm and 100 mm, respectively.

Due to the relatively early snow and large thickness of the snow cover, the ground frost was very shallow compared to the previous year. The only station with substantial ground frost was the station located in open land where the maximum depth of the ground frost was 46 cm.

The period of ice cover at the stations observed were 117 days in Lake Eckarfjärden and 120 days at a sea bay at SFR.

Sammanfattning

Under vintern 2003/2004 bestämdes snödjup, snöns vikt, tjäldjup och istäcke vid fältobservationer. Snöparametrarna och tjäldjupet har mätts på tre stationer och istäcket vid två stationer. Det är andra året i rad som dessa parametrar har registrerats (med undantag av snöns vikt). Snöns vatteninnehåll beräknades utifrån vikten på en snökärna som stansades ut med en cylinder.

Säsongens första snö föll redan i slutet på oktober medan ett varaktigt snötäcke etablerades i mitten på december. Vid en av mätstationerna låg snön kvar till i mitten på april. De högsta värdena för snödjup och snöns vatteninnehåll, uppmätta vid en station i en skogsglänta, var ca 40 cm respektive 100 mm.

Som en följd av det tidiga snöfallet och dess tjocklek var tjälen i området grundare än föregående år. Den enda stationen med betydande tjäle var belägen på jordbruksmark. Där var det maximala tjäldjupet 46 cm.

Istäcket vid de stationer som observerades varade 117 dagar i Eckarfjärden och 120 dagar vid havsviken vid SFR.

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1 Introduction

This document reports the data gained in "Registration of snow depth, depth of frost in the ground and time for ice cover/ice break-up", which is one of the activities performed within the site investigation at Forsmark. The work was carried out in accordance with activity plan SKB PF 400-04-34. A similar study was performed during the winter of 2002/2003 /1/ and this activity is in large parts carried out in the same way.

The activity comprised measurements and registrations of four parameters: snow depth, snow weight, depth of ground frost and duration of ice. The water content of the snow was calculated using the results from the snow weight measurements. The map in Figure 1-1 below shows the positions for the measurements. The activity was performed from late October 2003 until mid April 2004.

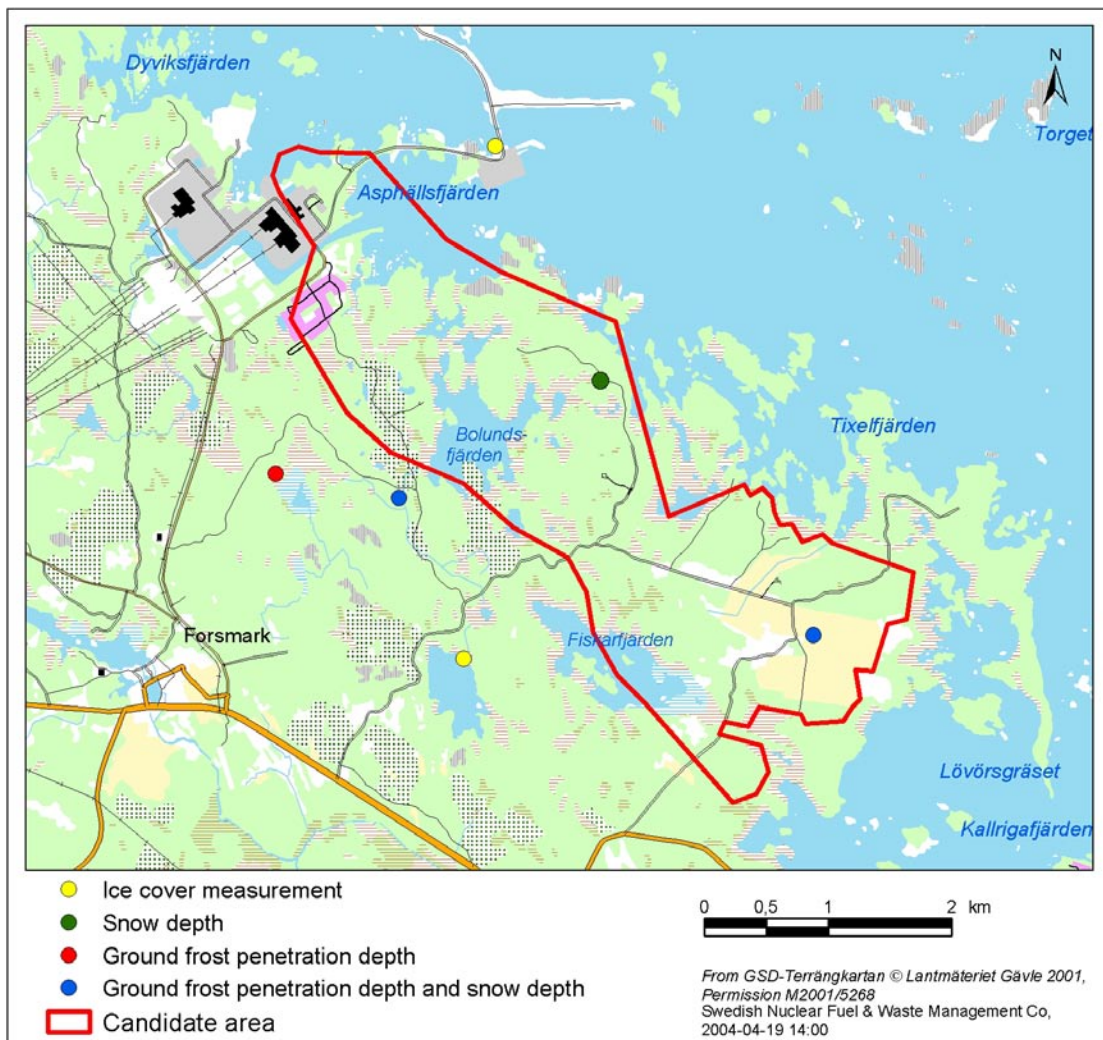


Figure 1-1. Locations of measurements and registration of snow depth, snow weight, ground frost, and ice cover.

In Table 1-1 controlling documents for performing this activity are listed. The activity plan is SKB's internal controlling document.

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

Activity plan	Number	Version
Registration of snow depth, depth of frost in the ground and time for ice cover/ice break up	AP PF 400-04-34	1.0
Other controlling documents	Number	Version
SMHI, Handbok för observatörer	SMHI internal document	N/A

The data from this activity is store in the SICADA database with Field Note No. Forsmark 309.

Table 1-2. Data references.

Subactivity	Database	Identity number
Snow depth and water content	SICADA	Field Note No. Forsmark 309
Ground frost penetration depth	SICADA	Field Note No. Forsmark 309
Ice cover	SICADA	Field Note No. Forsmark 309

2 Objective and scope

This activity was conducted in order to obtain site specific data on snow, ground frost and ice cover which in combination with other meteorological data will be used in hydrological and ecological modelling. The activity started at the first snowfall of the season in late October 2003 and was completed when all the snow had melted away in mid April. The snow weight, however, was only measured between January 16 and mid April.

The following parameters were measured:

- Snow depth at three locations.
- Snow weight at three locations (January-April).
- Depth of ground frost at three locations.
- Time for ice-coverage and ice-break up respectively at two locations.

The snow weight was used to calculate the water content of the snow.

3 Equipment

3.1 Description of equipment

3.1.1 Snow depth

The snow depth was measured according to SMHI's Handbook for observers (In Swedish: SMHI's handbook för observatörer) /2/. Between October 29 and January 16 the snow depth was measured with a measuring stick graded in centimetres. From January 16 until April 15 a transparent plastic tube, with 50 mm inner diameter, graded in centimetres was used for the snow depth measurement, see Figure 3-1.

3.1.2 Snow weight

The snow weight was measured by taking a snow sample with a transparent plastic tube with an inner diameter of 50 mm. The tube was the same one that was used to measure the snow depth. A spatula was used to keep the sample in the tube so it could be transferred to a plastic bag. To measure the weight, a spring scale was used. The spring scale could measure up to 200 g and was graded with 2 g increments. The equipment used to take snow samples and measure the snow weight is shown in Figure 3-1.



Figure 3-1. Equipment used to measure snow depth and snow weight.

3.1.3 Depth of ground frost

The depth of the ground frost was measured according to SMHI's handbook for observers /2/. The measurements were made with the same measuring devices as during the winter of 2002/2003 /1/. The measuring device comprises a protective tube with a disc, a protective hood, and a measurement tube. The whole measuring device is about 1.5 m long and is installed in the ground. The measurement tube contains a solution consisting of methylene blue and distilled water. The measurement tube is installed inside the protective tube. When the water freezes, the methylene blue crystallizes and turns white and the boundary between the blue colour and the white colour shows the depth of ground frost, see Figure 3-2 below. The measurement tube is graded in centimetres.

3.1.4 Ice cover

The observations of ice-coverage and ice-break up respectively were performed by visual inspections.



Figure 3-2. Measurement tube for determination of ground frost depth.

4 Execution

This activity consisted of four different items:

1. Measurements of snow depth, snow weight and determination of snow water content.
2. Measurements of ground frost depth.
3. Observations of ice cover.
4. Documentation.

4.1 General

Measurements of snow depth and depth of ground frost were made once a week between October 29 and April 15, 2004. The measurements of snow weight started on January 16. Ice conditions were observed with varying regularity depending on temperature and weather conditions. Each object for measurements/observations has a specific ID-code according to Table 4-1. The snow depth and snow weight objects as well as the objects where ice conditions were observed were registered as surfaces (AFM-numbers) while the objects for ground frost measurements were registered as points (PFM-numbers).

Table 4-1. ID-code numbers for the objects of this activity.

Parameter	ID-code	X	Y	Type of location	
Snow depth and water content	AFM000071			Open land	
	1	6697419	1634872		
	2	6697413	1634869		
	3	6697412	1634874		
Depth and water content	4	6697416	1634877	Forest glade	
	AFM000072				
	1	6698528	1631524		
	2	6698524	1631527		
Depth and water content	3	6698529	1631527	Forest glade	
	4	6698534	1631523		
	AFM001172				
	1	6699475	1633157		
Ground frost	2	6699468	1633157	Open land	
	3	6699473	1633160		Forest glade
	4	6699480	1633160		
	PFM002458	6697418	1634874		Wetland
PFM002459	6698528	1631528			
PFM002460	6698726	1630528			
Ice cover	AFM000010	6697230	1632050	Lake	
	AFM000075	6701371	1632303	Sea bay	

4.2 Execution of measurements and observation

4.2.1 Measurements of snow depth, snow weight and determination of water content

Snow depth is in this case defined as the thickness of the snow cover from the snow surface to the ground. The site should have a fairly smooth ground surface and the snow should not fall in drifts or be able to blow away. From the beginning of the activity there were two sample stations, one in open land at Storskäret and one in a forest glade southwest of Lake Bolundsfjärden. From January 16 a third measurement station in a forest glade close to Jungfruholm was added to the activity, see Figure 1-1. The measurement stations were approximately 4x4 m and marked with poles.

Measurements were made once a week, starting at the first snowfall of the season, which was on October 29, and continued until the snow melt was completed in spring, which was on April 15. The measurements were made even if no new snow had been falling, since packing, melting and evaporation should be considered as well.

The snow depth was measured at 6 points within each measurement station and the average snow depth of the station was calculated. Between October 29 and January 16, the depth was measured with a graded stick, which was vertically pressed through the snow cover until the ground was hit. The depth was measured to the nearest centimetre. Between January 16 and April 15, the depth was measured with a transparent plastic tube which was also used to take snow samples for water content determination. The tube was pressed down through the snow cover until it hit the ground, and the depth was measured to the nearest centimetre, see Figure 4-1.



Figure 4-1. Measurement of snow depth with a plastic tube at Storskäret, AFM000071.

The snow weight was measured at all three measurement stations between January 16 and April 15. At each station 6 snow samples were taken with the plastic tube and transferred to a plastic bag for measurement of the weight of each sample. The weight of the bag, approximately 4 g, was subtracted. If the sample weight exceeded 200 g, the sample was divided into sub samples that were weighted separately. The average snow weight at the station was then calculated.

From the average snow weight the water content was calculated based on the following data:

Inner diameter of plastic tube: 50 mm

Bottom area of the plastic tube (πr^2): 19,635 cm²

Water density: 1 g/cm³

Water content of the snow in mm: snow weight (g)/19,635 (cm²) x 10

4.2.2 Measurements of ground frost penetration depth

For measurements of the ground frost penetration depth, the equipment described in Section 3.1.3 was used. The measurements were carried out on three sites representative for the local conditions considering soil characteristics, topography and land use. The soil types at the three stations were clayey till at PFM002458 (open land at Storskäret), sandy till at PFM002459 (forest glade), and gyttja clay (0.7 m) underlain by sandy till at PFM002560 (Gällsboträsket).

The measurements were made by observing the uncoloured part of the solution, i. e. the frozen part, which indicates the border between ice and water. The measurement tube is graded in centimetres and the ground level value, which is set for each measurement point, is subtracted from the value that is observed.

The measurements were performed once a week in connection to registration of snow depth.

4.2.3 Observations of ice cover

Observations of ice cover were made for a sea bay near SFR and for one of the lakes in the area, Lake Eckarfjärden.

The ice conditions were observed every morning during working days at the sea bay and approximately once a week at the lake. The time for the first ice cover, which is important to register, is defined as the first occasion during the season when a lasting ice cover is established, i. e. there are no occasional ice break-ups until spring. The last ice break-up is defined as the time when the ice cover from the winter season finally breaks up and no occasional ice coverages occur. Short periods in early autumn with only thin ice cover were neglected, as well as ice remains during spring.

4.3 Data handling

All activities were performed by the staff appointed in the activity plan (AP PF 400-03-34) except for the measurements and observations during the period March 3 – March 24 which were made by the Forsmark Site ecologist. The measurements and observations were noted in field protocols and then transferred to Excel-files. The field note (FN) of the primary data of this activity registered in SICADA is “Forsmark 309”. Only primary data registered in SICADA should be used for modelling and other assessments of the site.

4.4 Nonconformities

There were two nonconformities in the execution of this activity, both concerning the measuring devices for measurement of ground frost penetration depth.

The first occasion appeared on February 19 at PFM002459 where the solution leaked out of the measuring device when lifted out of the protective tube. The measuring tube was removed, refilled, and reinstalled on February 25. The measurement device was checked on February 26 and the solution was frozen down to the ground level just as it was when the leakage occurred. The incident did probably not affect the measurements.

The second occasion occurred on March 4 at PFM002458 where the measurement tube was frozen to the protective tube. To get it out, ethanol was poured down the protective tube. The location was visited every day but the measurement tube did not come loose until March 11. When removing the measurement tube it was observed that the protective tube was broken at ground level, which made it possible for water to flow down between the two tubes and freeze. The prevailing conditions made removal and reparation of the measuring devices impossible. The measurements after the reinstallation could therefore be incorrect due to ethanol inside the protective tube. This nonconformity is reported in report PF-04-02 (SKB’s internal controlling document).

5 Results

The primary data from this activity are registered in the SICADA database. Field Note No. Forsmark 309.

5.1 Snow depth and water content

Snow depth was measured at two stations (AFM000071, AFM000072) for the entire season. In January 2004 a third station (AFM001172) was added to the activity. The snow weight was measured at these three stations between January and April to calculate the water content of the snow.

The average snow depth at the three stations is presented in Figure 5-1. The complete set of primary data is presented in Appendix 1.

The first snow fell in late October and at the forest glade AFM000072 the ground was snow covered for about two weeks before the snow melted away. A lasting snow cover was established in mid December 2003 and lasted until early April 2004 at the forest glade AFM000072 and a couple of weeks shorter at the other two stations. The snow cover was thickest at the forest glade AFM000072 and thinnest at the open land at Storskåret (AFM000071). This latter station is also more exposed to wind than the other stations.

The snow weight was measured to calculate the water content of the snow. This was made from January 16 until the activity was completed in April. The water content of the snow is presented in Figures 5-2a-c below.

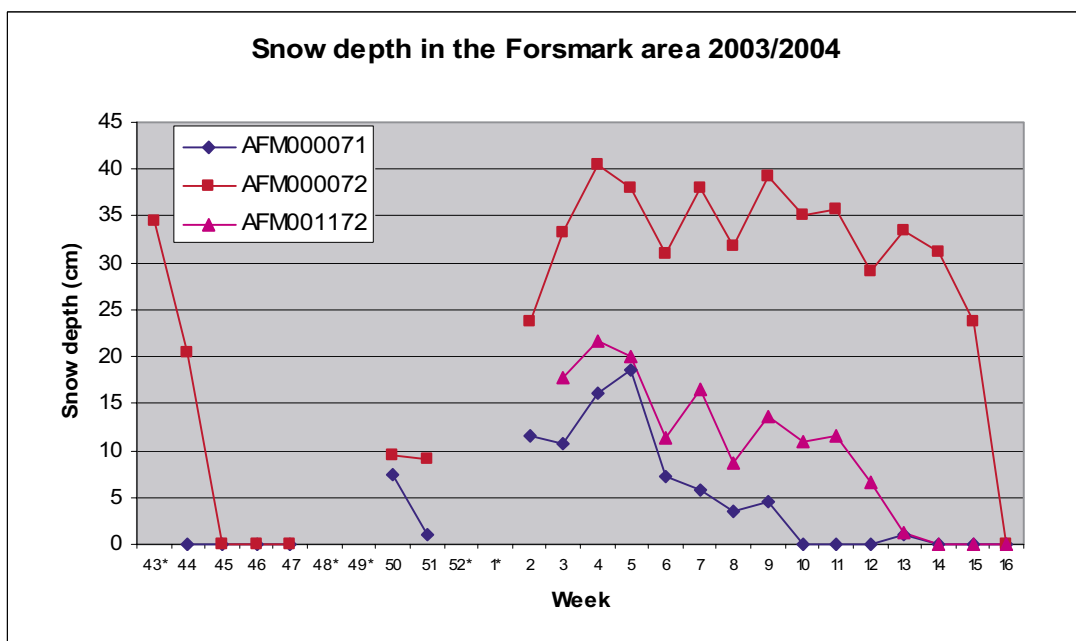


Figure 5-1. Average snow depth during the winter 2003/2004 at three stations in the Forsmark area. Weeks with * indicate that no measurements were made.

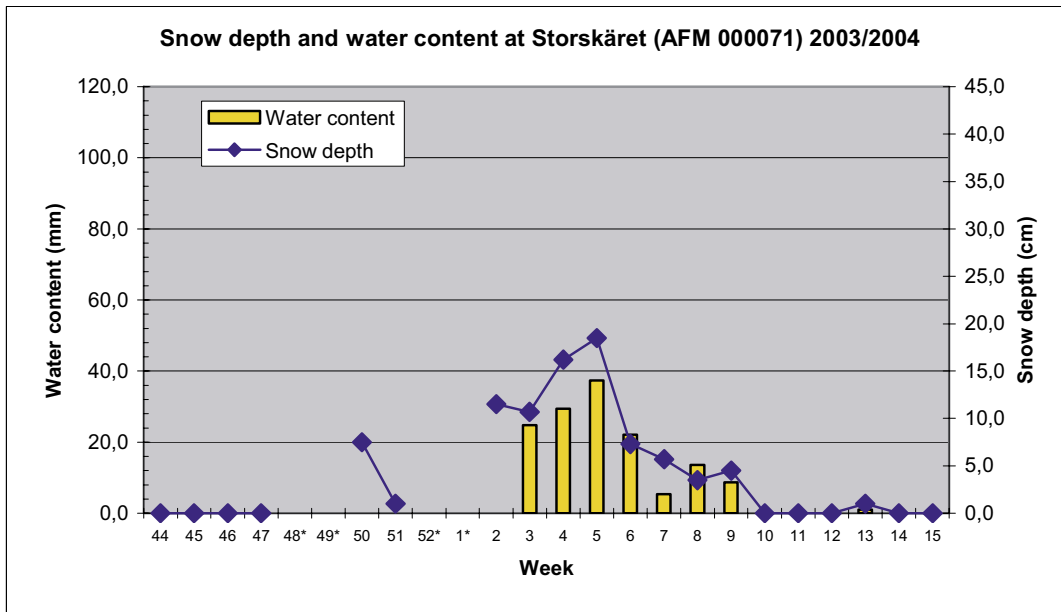


Figure 5-2a. Snow depth and water content at Storskäret (AFM000071). Weeks with * indicate that no measurements were made.

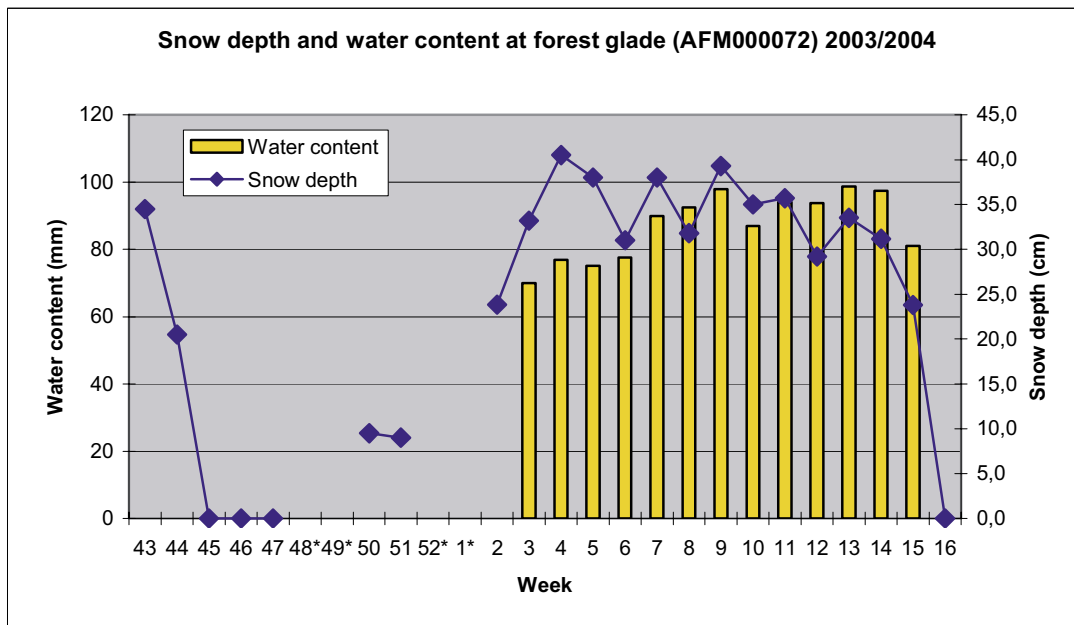


Figure 5-2b. Snow depth and water content at the forest glade (AFM000072). Weeks with * indicate that no measurements were made.

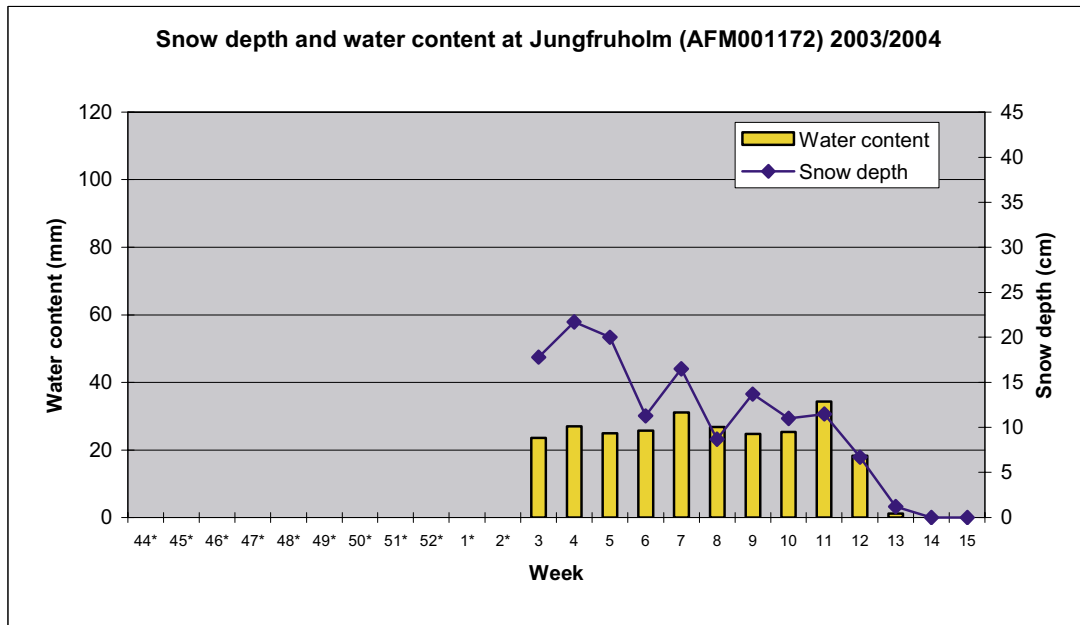


Figure 5-2c. Snow depth and water content at Jungfruholm (AFM001172). Weeks with * indicate that no measurements were made.

5.2 Depth of ground frost penetration

The depth of ground frost penetration was measured at three stations, an open field at Storskäret (PFM002458), a forest glade (PFM002459) and a wetland at Gällsboträsket (PFM002460). The results are presented in Figure 5-3 below. The complete sets of primary data are presented in Appendix 2.

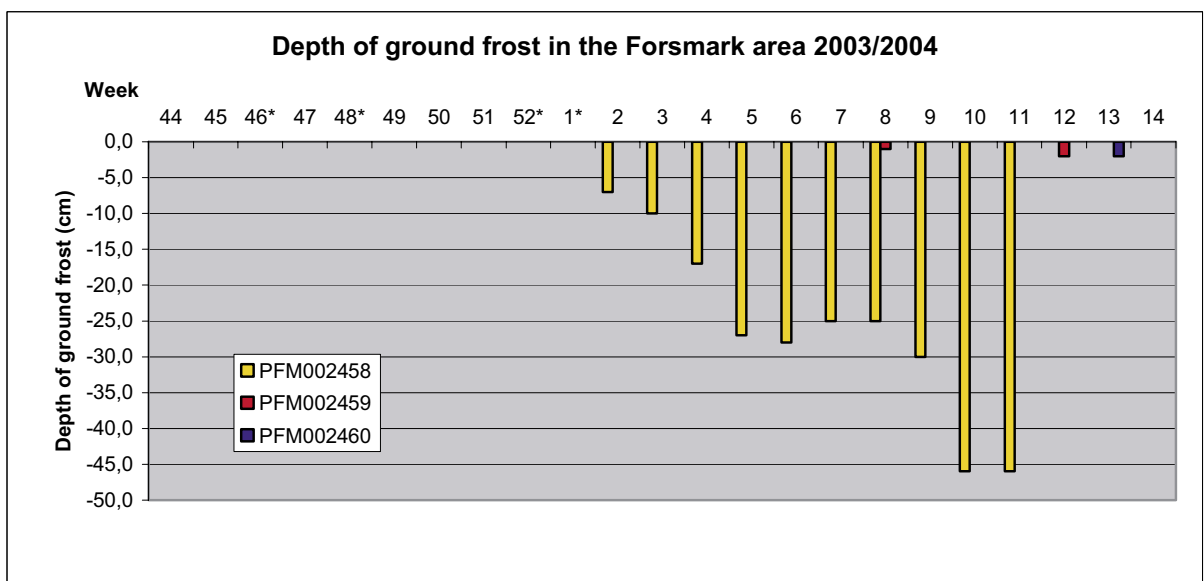


Figure 5-3. Ground frost penetration depth at three stations in the Forsmark area during the winter 2003/2004. Weeks with * indicate that no measurements were made.

At the forest glade (PFM002459) and the wetland (PFM002460) there were almost no ground frost at all. At the few occasions when ground frost existed, the penetration depth was very small, 2 cm or less. At the open field, however, the ground frost penetrated to a maximum depth of 46 cm. An explanation to these differences is most probably the presence of the snow cover and its thickness. Both at the forest glade and at the wetland the snow cover was significantly thicker than in the open field. Another reason to the differences could be the different soil types of the stations. Compared to last years' measurements of ground frost /1/, the ground frost depth is smaller at all stations. This is probably explained by the fact that a relatively thick, lasting snow cover was established early in the season.

5.3 Ice cover

Ice conditions observed in the Forsmark area during the winter 2003/2004 are shown in Table 5-1. Lake Eckarfjärden was selected as representative for the lakes in the area concerning ice cover. When the ice cover was established and broke up, the conditions in other lakes in the area were controlled and no large deviations were observed.

Table 5-1. Time for ice freeze-up and ice break-up in Lake Eckarfjärden and in a bay of the Baltic sea at SFR, Forsmark.

Station	Date for ice freeze-up	Date for ice break-up	Period with ice cover (days)
Lake Eckarfjärden (AFM000010)	2003-12-12	2004-04-06	117
Sea bay at SFR (AFM000075)	2003-12-17	2004-04-13	120

6 References

- /1/ Aquilonius K, Karlsson S, 2003. Forsmark site investigation. Snow depth, frost in ground and ice cover during the winter 2002/2003. SKB P-03-117.
- /2/ SMHI. Handbok för observatörer. Internal document.

Appendix 1

Primary data from snow depth and snow weight measurements during the winter 2003/2004.

The data collected during the snow depth and snow weight measurements are presented below as individual measurements as well as calculated average snow depth, snow weight, and water content. At each measurement a visual estimate of the degree of coverage was made according to the following scale: S=completely or almost completely covered ground, SB=more than half of the ground snow covered but not completely, BS=more than half of the ground free of snow but not completely, B=the ground completely or almost completely free of snow.

Table 1. Snow depth, snow weight, and water content at Storskåret (AFM000071) during the winter 2003/2004.

Date	Point 1, depth (cm)	Point 1, weight (g)	Point 2, depth (cm)	Point 2, weight (g)	Point 3, depth (cm)	Point 3, weight (g)	Point 4, depth (cm)	Point 4, weight (g)	Point 5, depth (cm)	Point 5, weight (g)	Point 6, depth (cm)	Point 6, weight (g)	Average snow depth (cm)	Snow coverage	Average snow weight (g)	Water content (mm)
2003-10-29	0,0		0,0		0,0		0,0		0,0		0,0		0,0	B		
2003-11-06	0,0		0,0		0,0		0,0		0,0		0,0		0,0	B		
2003-11-12	0,0		0,0		0,0		0,0		0,0		0,0		0,0	B		
2003-11-21	0,0		0,0		0,0		0,0		0,0		0,0		0,0	B		
2003-12-08	9,0		7,0		7,0		8,0		9,0		5,0		7,5	SB		
2003-12-16	1,0		0,0		2,0		1,0		1,0		1,0		1,0	SB		
2004-01-07	11,0		13,0		9,0		11,0		14,0		11,0		11,5	S		
2004-01-16	8,0	56,00	11,0	64,00	11,0	36,00	12,0	36,00	9,0	62,00	13,0	38,00	10,7	S	48,67	24,8
2004-01-21	14,0	50,00	17,0	54,00	15,0	52,00	15,0	72,00	19,0	66,00	17,0	52,00	16,2	S	57,67	29,4
2004-01-28	17,0	56,00	16,0	64,00	20,0	76,00	22,0	98,00	18,0	72,00	18,0	74,00	18,5	S	73,33	37,3
2004-02-05	9,0	64,00	5,0	34,00	5,0	30,00	6,0	42,00	13,0	52,00	6,0	38,00	7,3	SB	43,33	22,1
2004-02-11	6,0	8,00	6,0	8,00	5,0	14,00	5,0	8,00	6,0	14,00	6,0	12,00	5,7	S	10,67	5,4
2004-02-19	7,0	52,00	2,0	20,00	2,0	16,00	5,0	30,00	2,0	20,00	3,0	22,00	3,5	BS	26,67	13,6
2004-02-26	3,0	10,00	4,0	8,00	1,0	2,00	4,0	10,00	9,0	60,00	6,0	12,00	4,5	SB	17,00	8,7
2004-03-04	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	B	0,00	0,0
2004-03-11	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	B	0,00	0,0
2004-03-19	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	B	0,00	0,0
2004-03-24	1,0	2,00	1,0	2,00	1,0	2,00	1,0	2,00	1,0	2,00	1,0	2,00	1,0	SB	2,00	1,0
2004-04-01	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	B	0,00	0,0
2004-04-06	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	B	0,00	0,0

Table 2. Snow depth, snow weight and water content at forest glade AFM000072 during the winter 2003/2004.

Date	Point 1, depth (cm)	Point 1, weight (g)	Point 2, depth (cm)	Point 2, weight (g)	Point 3, depth (cm)	Point 3, weight (g)	Point 4, depth (cm)	Point 4, weight (g)	Point 5, depth (cm)	Point 5, weight (g)	Point 6, depth (cm)	Point 6, weight (g)	Average snow depth (cm)	Snow coverage	Average snow weight (g)	Water content (mm)
2003-10-23	38,0		33,0		36,0		31,0		34,0		35,0		34,5	S		
2003-10-29	20,0		17,0		22,0		24,0		20,0		20,0		20,5	S		
2003-11-06	0,0		0,0		0,0		0,0		0,0		0,0		0,0	B		
2003-11-12	0,0		0,0		0,0		0,0		0,0		0,0		0,0	B		
2003-11-21	0,0		0,0		0,0		0,0		0,0		0,0		0,0	B		
2003-12-08	10,0		11,0		7,0		10,0		10,0		9,0		9,5	S		
2003-12-16	10,0		9,0		8,0		9,0		10,0		8,0		9,0	S		
2004-01-07	23,0		25,0		24,0		23,0		22,0		26,0		23,8	S		
2004-01-16	34,0	152,00	35,0	130,00	34,0	124,00	30,0	152,00	33,0	126,00	33,0	140,00	33,2	S	137,33	69,9
2004-01-21	35,0	124,00	39,0	174,00	40,0	146,00	43,0	156,00	40,0	144,00	46,0	162,00	40,5	S	151,00	76,9
2004-01-28	32,0	136,00	42,0	154,00	40,0	146,00	40,0	160,00	38,0	144,00	36,0	144,00	38,0	S	147,33	75,0
2004-02-05	29,0	132,00	31,0	160,00	35,0	164,00	29,0	150,00	30,0	150,00	32,0	158,00	31,0	S	152,33	77,6
2004-02-11	38,0	178,00	38,0	194,00	42,0	202,00	41,0	186,00	33,0	164,00	36,0	136,00	38,0	S	176,67	90,0
2004-02-19	32,0	186,00	34,0	200,00	30,0	160,00	32,0	178,00	32,0	194,00	31,0	172,00	31,8	S	181,67	92,5
2004-02-26	42,0	210,00	38,0	188,00	38,0	182,00	38,0	190,00	41,0	194,00	39,0	190,00	39,3	S	192,33	98,0
2004-03-04	45,0	198,00	37,0	184,00	34,0	192,00	34,0	132,00	25,0	126,00	35,0	192,00	35,0	S	170,67	86,9
2004-03-11	37,0	188,00	37,0	190,00	38,0	194,00	37,0	214,00	38,0	186,00	27,0	136,00	35,7	S	184,67	94,0
2004-03-19	28,0	166,00	31,0	202,00	30,0	208,00	28,0	178,00	28,0	136,00	30,0	214,00	29,2	S	184,00	93,7
2004-03-24	34,0	180,00	32,0	194,00	32,0	188,00	29,0	178,00	37,0	222,00	37,0	200,00	33,5	S	193,67	98,6
2004-04-01	32,0	190,00	35,0	216,00	35,0	220,00	29,0	176,00	31,0	178,00	25,0	168,00	31,2	S	191,33	97,4
2004-04-06	27,0	188,00	25,0	172,00	28,0	194,00	20,0	110,00	21,0	146,00	22,0	144,00	23,8	S	159,00	81,0
2004-04-15	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	B	0,00	0,0

Table 3. Snow depth, snow weight and water content at Jungfruholm (AFM001172) during the winter 2003/2004.

Date	Point 1, depth (cm)	Point 1, weight (g)	Point 2, depth (cm)	Point 2, weight (g)	Point 3, depth (cm)	Point 3, weight (g)	Point 4, depth (cm)	Point 4, weight (g)	Point 5, depth (cm)	Point 5, weight (g)	Point 6, depth (cm)	Point 6, weight (g)	Average snow depth (cm)	Snow coverage	Average snow weight (g)	Water content (mm)
2004-01-16	17,0	34,00	18,0	46,00	18,0	52,00	16,0	50,00	17,0	48,00	21,0	48,00	17,8	S	46,33	23,6
2004-01-21	20,0	46,00	21,0	72,00	21,0	56,00	19,0	52,00	23,0	52,00	26,0	40,00	21,7	S	53,00	27,0
2004-01-28	20,0	50,00	20,0	58,00	22,0	48,00	19,0	58,00	19,0	46,00	20,0	34,00	20,0	S	49,00	25,0
2004-02-05	11,0	42,00	13,0	52,00	12,0	62,00	13,0	58,00	10,0	48,00	9,0	40,00	11,3	S	50,33	25,6
2004-02-11	20,0	58,00	16,0	58,00	17,0	72,00	18,0	60,00	14,0	58,00	14,0	60,00	16,5	S	61,00	31,1
2004-02-19	8,0	46,00	11,0	76,00	9,0	56,00	8,0	46,00	8,0	46,00	8,0	46,00	8,7	SB	52,67	26,8
2004-02-26	13,0	50,00	14,0	44,00	10,0	38,00	20,0	78,00	12,0	40,00	13,0	42,00	13,7	S	48,67	24,8
2004-03-04	9,0	42,00	6,0	36,00	13,0	64,00	13,0	38,00	18,0	90,00	7,0	28,00	11,0	S	49,67	25,3
2004-03-11	8,0	56,00	8,0	68,00	10,0	62,00	15,0	100,00	13,0	54,00	15,0	64,00	11,5	S	67,33	34,3
2004-03-19	7,0	36,00	8,0	56,00	7,0	38,00	8,0	46,00	4,0	16,00	6,0	24,00	6,7	BS	36,00	18,3
2004-03-24	1,0	2,00	1,0	2,00	1,0	2,00	1,0	2,00	1,0	2,00	2,0	4,00	1,2	SB	2,33	1,2
2004-04-01	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	B	0,00	0,0
2004-04-06	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	0,00	0,0	B	0,00	0,0

Appendix 2

Primary data from measurements of ground frost penetration depth during the winter 2003/2004.

The data collected during the measurements of ground frost are presented below. As a part of the measuring device is above the ground level, the ground frost penetration depth is calculated by first subtracting the distance with which the device rises above the ground level and then calculate how deep below this point the ground frost reaches. The ground level for each measurement point is presented in the corresponding datatable. The upper registration is the level of the upper border of the ground frost read from the device, whereas the lower registration is the lower border. The upper and lower level of ground frost are calculated using the level of the ground surface and the upper and lower registration, respectively. From these two levels the distribution of ground frost is calculated.

Table 1. Ground frost penetration depth at Storskåret (PFM002458) during the winter 2003/2004.

Date	Ground surface (cm)	Upper reg. (cm)	Lower reg. (cm)	Upper level of ground frost (cm)	Lower level of ground frost (cm)	Ground frost distribution (cm)	Comments
2003-10-29	40	0,0	0,0	0,0	0,0	0,0	No frost
2003-11-06	40	0,0	0,0	0,0	0,0	0,0	No frost
2003-11-21	40	0,0	0,0	0,0	0,0	0,0	No frost
2003-12-08	40	0,0	0,0	0,0	0,0	0,0	No frost
2003-12-16	40	0,0	0,0	0,0	0,0	0,0	No frost
2004-01-07	40	25,0	47,0	0,0	7,0	7,0	
2004-01-16	40	22,0	50,0	0,0	10,0	10,0	
2004-01-21	40	22,0	57,0	0,0	17,0	17,0	
2004-01-28	40	22,0	67,0	0,0	27,0	27,0	
2004-02-05	40	22,0	68,0	0,0	28,0	28,0	
2004-02-11	40	22,0	65,0	0,0	25,0	25,0	
2004-02-19	40	21,0	65,0	0,0	25,0	25,0	
2004-02-26	40	21,0	70,0	0,0	30,0	30,0	
2004-03-04	40						Measurement tube stuck
2004-03-09	40	0,0	86,0	0,0	46,0	46,0	
2004-03-11	40	0,0	85,0	0,0	45,0	45,0	Protective tube broken
2004-03-19	40	0,0	0,0	0,0	0,0	0,0	Likely incorrect
2004-03-24	40	0,0	13,0	0,0	0,0	0,0	Likely incorrect
2004-04-01	40	0,0	0,0	0,0	0,0	0,0	No frost

Table 2. Ground frost penetration depth at forest glade (PFM002459) during the winter 2003/2004.

Date	Ground surface (cm)	Upper reg. (cm)	Lower reg. (cm)	Upper level of ground frost (cm)	Lower level of ground frost (cm)	Ground frost distribution (cm)	Comments
2003-10-23	40	0,0	0,0	0,0	0,0	0,0	No frost
2003-10-29	40	0,0	0,0	0,0	0,0	0,0	No frost
2003-11-06	40	0,0	0,0	0,0	0,0	0,0	No frost
2003-11-21	40	0,0	0,0	0,0	0,0	0,0	No frost
2003-12-08	40	20,0	38,0	0,0	0,0	0,0	No frost
2003-12-16	40	19,0	40,0	0,0	0,0	0,0	No frost
2004-01-07	40	19,0	40,0	0,0	0,0	0,0	No frost
2004-01-16	40	19,0	39,0	0,0	0,0	0,0	No frost
2004-01-21	40	19,0	39,0	0,0	0,0	0,0	No frost
2004-01-28	40	20,0	39,0	0,0	0,0	0,0	No frost
2004-02-05	40	19,0	37,0	0,0	0,0	0,0	No frost
2004-02-11	40	18,0	41,0	0,0	1,0	1,0	No frost
2004-02-19	40	18,0	37,0	0,0	0,0	0,0	Leakage from measurement tube
2004-02-26	40	15,0	40,0	0,0	0,0	0,0	Measurement tube reinstalled feb. 25
2004-03-04	40	0,0	40,0	0,0	0,0	0,0	No frost
2004-03-11	40	0,0	42,0	0,0	2,0	2,0	No frost
2004-03-19	40	0,0	17,0	0,0	0,0	0,0	No frost
2004-03-24	40	0,0	17,0	0,0	0,0	0,0	No frost
2004-04-01	40	0,0	0,0	0,0	0,0	0,0	No frost

Table 3. Ground frost penetration depth at Gällsboträsket (PFM002460) during the winter 2003/2004.

Date	Ground surface (cm)	Upper reg. (cm)	Lower reg. (cm)	Upper level of ground frost (cm)	Lower level of ground frost (cm)	Ground frost distribution (cm)	Comments
2003-10-23	38	0,0	0,0	0,0	0,0	0,0	No frost
2003-10-29	38	0,0	0,0	0,0	0,0	0,0	No frost
2003-11-06	38	0,0	0,0	0,0	0,0	0,0	No frost
2003-11-21	38	0,0	0,0	0,0	0,0	0,0	No frost
2003-12-08	38	0,0	0,0	0,0	0,0	0,0	No frost
2003-12-16	38	0,0	0,0	0,0	0,0	0,0	No frost
2004-01-07	38	20,0	38,0	0,0	0,0	0,0	No frost
2004-01-16	38	18,0	32,0	0,0	0,0	0,0	No frost
2004-01-21	38	18,0	35,0	0,0	0,0	0,0	No frost
2004-01-28	38	15,0	32,0	0,0	0,0	0,0	No frost
2004-02-05	38	10,0	32,0	0,0	0,0	0,0	No frost
2004-02-11	38	29,0	34,0	0,0	0,0	0,0	No frost
2004-02-19	38	29,0	34,0	0,0	0,0	0,0	No frost
2004-02-26	38	30,0	35,0	0,0	0,0	0,0	No frost
2004-03-04	38	0,0	37,0	0,0	0,0	0,0	No frost
2004-03-11	38	0,0	38,0	0,0	0,0	0,0	No frost
2004-03-19	38	0,0	40,0	0,0	2,0	2,0	No frost
2004-03-24	38	0,0	33,0	0,0	0,0	0,0	No frost
2004-04-01	38	0,0	0,0	0,0	0,0	0,0	No frost