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Forsmark site investigation

Snow depth, ground frost and ice cover during the winter 2004/2005

Niklas Heneryd, Svensk Kärnbränslehantering AB

June 2005

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

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Keywords: Snow depth, Snow water content, Ground frost penetration depth, Ice cover, AP PF 400-04-119.

Abstract

During the winter of 2004/2005 a set of meteorological parameters, snow depth, ground frost penetration depth and ice cover, have been measured and observed. It is the third consecutive year that these measurements and observations have been performed. In addition to these parameters the water content of the snow was calculated from the weight of a snow sample at each measurement.

The first snow of the season fell in late November and lay for about one week. This was followed by a warmer period with rainfall and melting. A persistent snow cover was established in late January. At one station the snow cover lasted until the second week of April. The ground frost depth was very shallow at all stations compared to previous years. The deepest recorded ground frost level was at Storskäret where the ground frost penetration depth was 27 cm at its most.

The period of ice cover was 143 days in Lake Eckarfjärden, and in the sea bay at SFR the ice cover was broken up into two periods due to warm weather and hard wind. In total, the sea bay at SFR was ice-covered for 95 days.

Sammanfattning

Under vintern 2004/2005 har de meterologiska parametrarna snödjup, tjäldjup och istäcke mätts och observerats. Det är tredje året i rad som dessa parametrar har registrerats. Under denna aktivitet har även snöns vatteninnehåll beräknats utifrån vikten på en bestämd volym snö.

Säsongens första snö föll i slutet på november och låg i ungefär en vecka. Därefter följde en varmare period med regn och snösmältning. Ett varaktigt snötäcke etablerades först i slutet på januari. Vid en av mätstationerna låg snön kvar till andra veckan i april. Tjäldjupet var mycket litet på alla mätstationer. Det största uppmätta tjäldjupet var vid Storskäret där tjälen var 27 cm som djupast.

Istäcket varade 143 dagar i Eckarfjärden, och i havsviken vid SFR låg isen i två omgångar med en mellanliggande isfri period orsakad av varmare väder och hårda vindar. Totalt var havsviken vid SFR istäckt i 95 dagar.

Contents

1 Introduction

This document reports the data gained in "Registration of snow depth, ground frost penetration depth 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 400-04-119. Similar studies were performed during the winters of 2002/2003 /1/ and 2003/2004 /2/ and this activity is in large parts carried out in the same way.

The activity comprised measurements and registrations of certain weather parameters in the Forsmark area in winter. Four parameters; snow depth, snow weight, ground frost penetration depth and duration of ice cover was measured and registered in the field. 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 November 2004 until early April 2005.

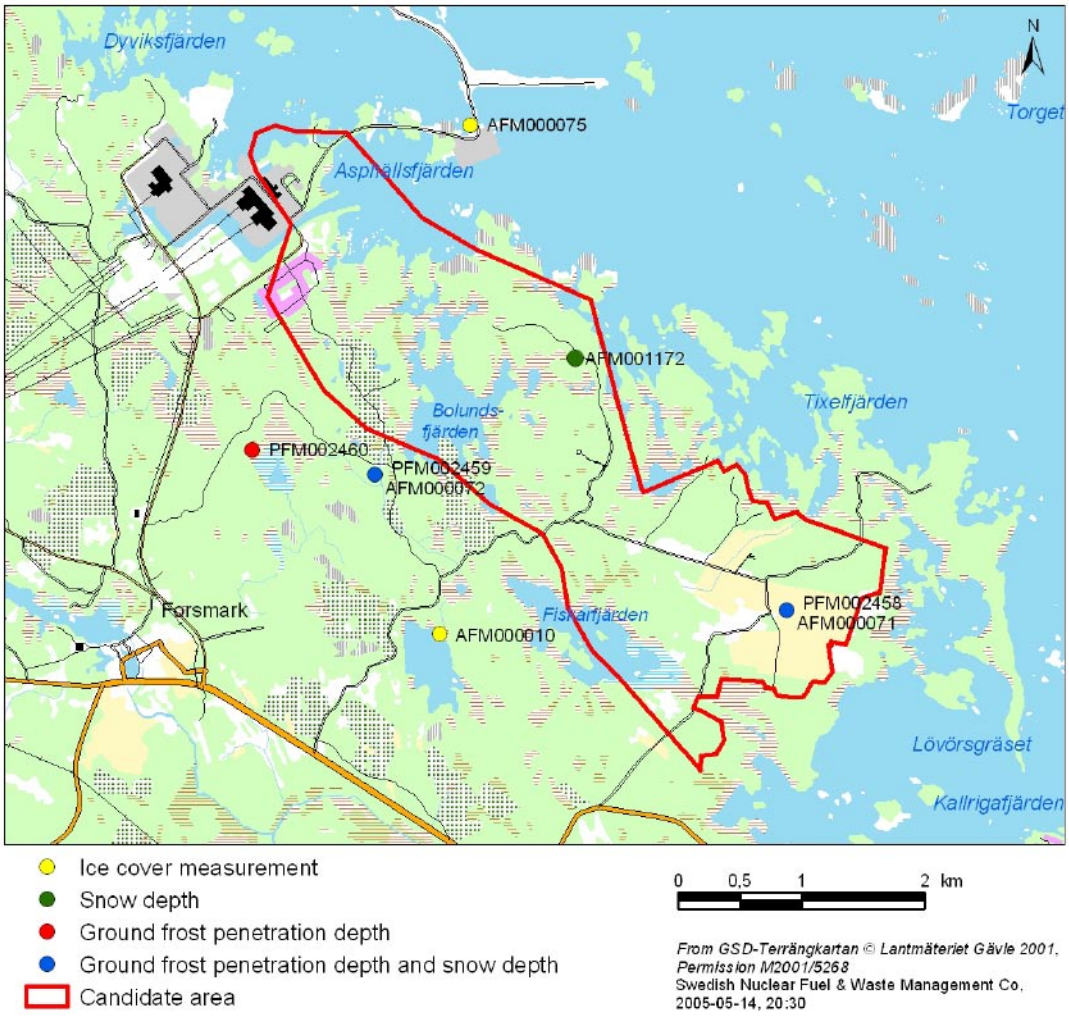

Figure 1-1. *Locations of measurements and registration of meteorological winter parameters.*

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

The data from this activity are stored in the SICADA database and are traceable by the activity plan number.

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

Activity plan	**Number**	**Version**
Registration of snow depth, ground frost penetration depth and time for ice cover/ice break up	AP PF 400-04-119	1.0
Other controlling documents	**Number**	**Version**
SMHI, Handbok för observatörer	SMHI internal document	N/A

2 Objective and scope

This activity was conducted in order to obtain data about the local climate which, in combination with other meteorological data, will be used in hydrological and ecological model calculations. The activity started at the first snowfall of the season in late November 2004 and was completed when all the snow had melted away in early April 2005.

The following parameters were measured:

- Snow depth at three locations.
- Snow weight at three locations.
- Depth of ground frost at three locations.
- Time for ice-coverage and ice-breakup 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) /3/. A transparent plastic tube graded in centimetres, with 5 cm inner diameter, 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 the transparent plastic tube mentioned above. 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 scale was used. The 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 /3/. The measurements were made with the same measuring devices as were used during the winter of previous years /1/, /2/. The measuring device comprises a protective tube with a disc and 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 liquid 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-breakup 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 water content.
2. Measurements of ground frost depth.
3. Observations of ice freeze-up and ice break-up.
4. Documentation.

4.1 General

Measurements of snow depth, snow weight and depth of ground frost were made once a week between November 24 and April 14. 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			Ploughed arable land
	1	6697419	1634872	
	2	6697413	1634869	
	3	6697412	1634874	
	4	6697416	1634877	
Depth and water content	AFM000072			Forest glade
	1	6698528	1631524	
	2	6698524	1631527	
	3	6698529	1631527	
	4	6698534	1631523	
Depth and water content	AFM001172			Forest glade
	1	6699475	1633157	
	2	6699468	1633157	
	3	6699473	1633160	
	4	6699480	1633160	
Ground frost	PFM002458	6697418	1634874	Ploughed arable land
	PFM002459	6698528	1631528	Forest glade
	PFM002460	6698726	1630528	Wetland
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. There were three sample stations, one in an open field at Storskäret, one in a forest glade southwest of Lake Bolundsfjärden and one in a forest glade close to Jungfruholm. The sample stations were approximately 4×4 m and marked with poles.

Measurements were made once a week, starting at the first snowfall of the season, which was November 24, and continued until the snow was completely melted in spring, which was April 14. The measurements were made even if no new snow had been falling, since packing, melting and evaporation should be considered as well. Between December 8 and January 25 there was a period with warmer weather, melting and rainfall which made the snow melt away. A more persistent snow cover was established in late January.

The snow depth was measured at 6 points within each sample station and the average depth of the station was calculated. The depth was measured with a transparent plastic tube which also was used to take snow samples for water content determination. The tube was pressed down through the snow layer 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 plastic tube at Storskäret, AFM000071.*

The snow weight was measured at all three sample stations. At each sample 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 weighed more than 200 g the sample was divided in two subsamples that were weighed separately. In these cases the weight of the bag was subtracted for each measurement. The average snow weight of the station was then calculated. In cases of hard wind, the body of the person performing the measurement and natural objects in the vicinity was used to block the wind to avoid incorrect readings on the scale.

On the basis of average snow depth and snow weight the water content was determined with the following calculations:

Inner diameter of plastic tube: 50 mm
Inner area of the plastic tube (πr^2): 19.635 cm^2
Water density: 1 g/cm^3
Water content of the snow in mm: snow weight (g)/19.635 (cm^3) × 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 and topography. The soil types at the three stations were clayey till at PFM002458, Storskäret, sandy till at PFM002459, the forest glade, and gyttja clay (0.7 m) underlain by sandy till at PFM002560, Gällsboträsket.

The measurement is 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 with registration of snow depth.

4.2.3 Observations of ice cover

Observations of ice freeze-up/ice break-up 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 for the sea and approximately once a week for the lake. The time for the first ice freeze-up, 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 freeze-ups 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 measurements and observations in the activity were made by SKB. The measurements and observations were noted in field protocols and then transferred to Excel-files. The primary data of this activity are registered in SICADA and are traceable by the Activity Plan number, AP PF 400-04-119. Only primary data registered in SICADA should be used for model calculations and other assessments of the site.

4.4 Nonconformities

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

At Storskäret (PFM002458) the measurement device could not be found when the activity started. Later, bits and pieces of the device were found, and it was concluded that it had been damaged during ploughing. New devices were ordered and a new device was installed at PFM002458 on December 20. On December 21 the ground frost depth was 18 cm which probably means that ground frost had been established while the measurement device was missing.

At the forest glade (PFM002459) a leakage was discovered on February 2 and the measurement device was replaced by a new one. This did probably not affect the measurements.

At Gällsboträsket (PFM002460) a leakage was discovered on November 24 and the measurement device was removed. New measurement devices were ordered and a new one was installed on December 20. This did probably not affect the measurements because ground frost did not appear at this station until March.

5 Results

5.1 Snow depth and water content

Snow depth was measured at three stations (AFM000071, AFM000072 and AFM001172) for the whole season. The snow weight was measured at these three stations to calculate the water content in 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 November, and at the forest glade (AFM000072) the ground was covered for about seven weeks before the snow melted away. A persistent snow cover was established in late January and lasted until early April in the forest glade and about a week shorter at the two other stations. The snow cover is thickest in the forest glade and thinnest on the open field at Storskäret. This station is exposed to wind which transports the snow and affects the snow cover. Furthermore, the station is situated in the open entailing that the melting is more rapid and that the wind transports the water vapour away.

The snow weight was measured to calculate the water content of the snow. The results are presented in Figures 5-2a–c below.

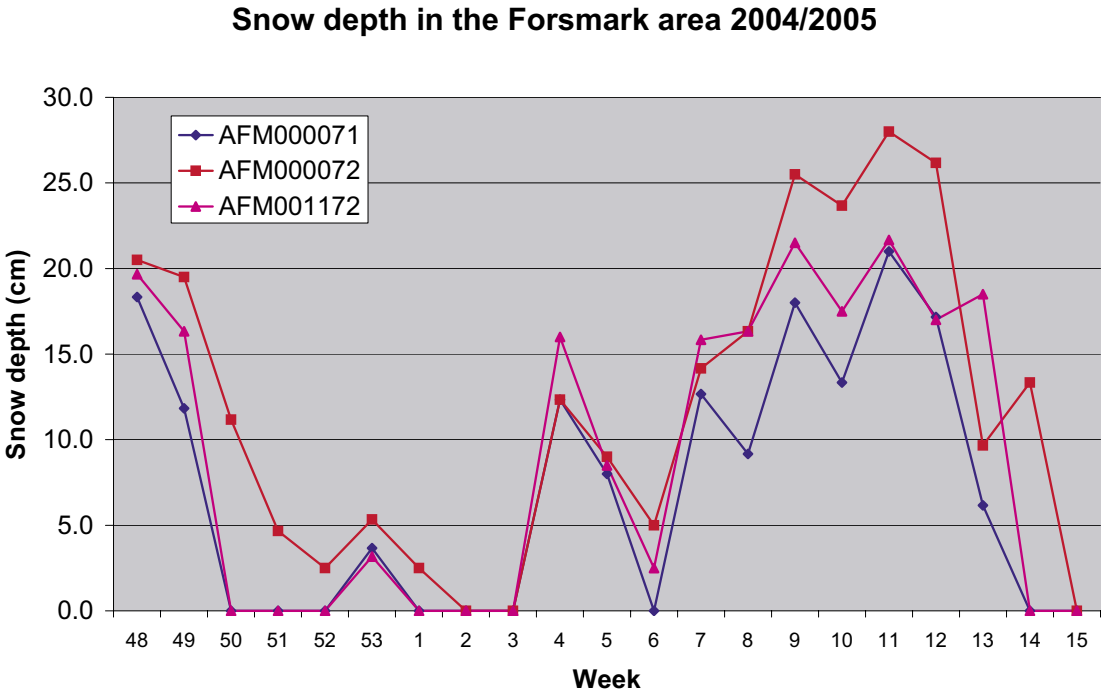

Figure 5-1. *Average snow depth during the winter 2004/2005 at three stations in the Forsmark area.*

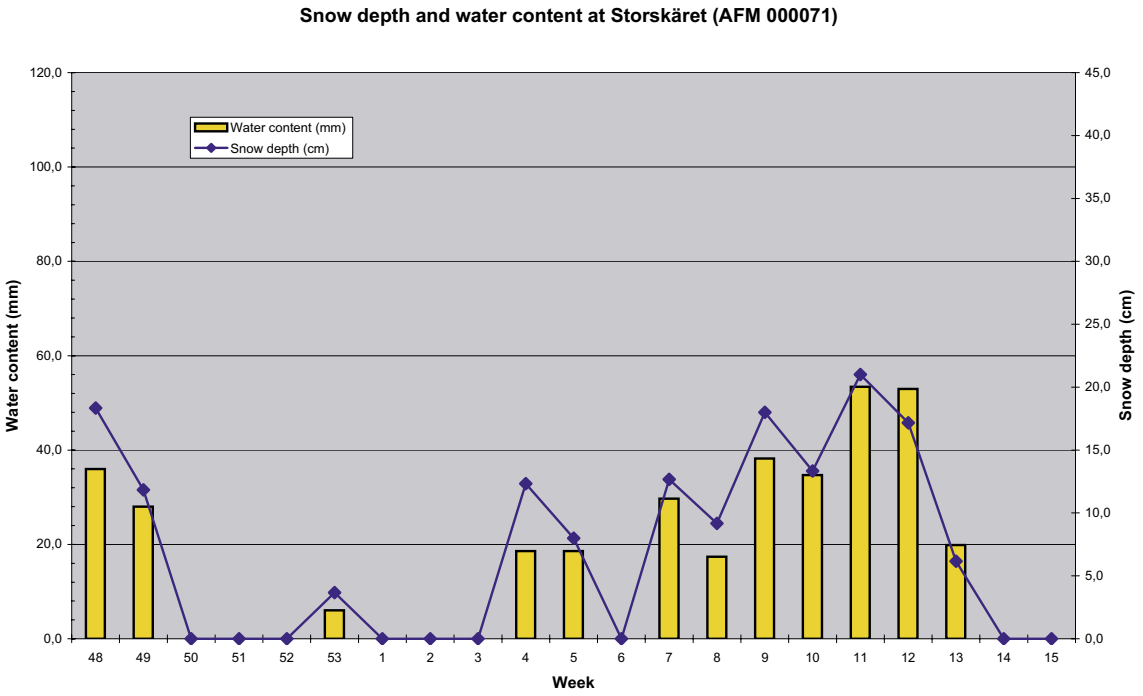

Figure 5-2a. *Snow depth and water content at Storskäret (AFM000071).*

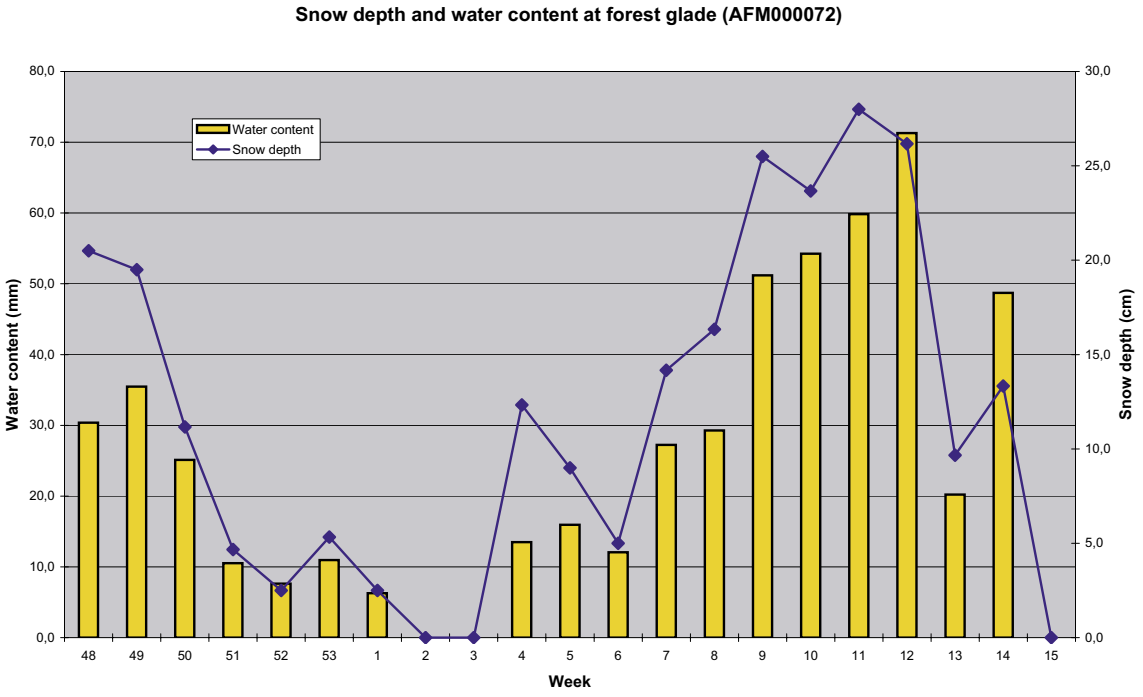

Figure 5-2b. *Snow depth and water content at the forest glade (AFM000072).*

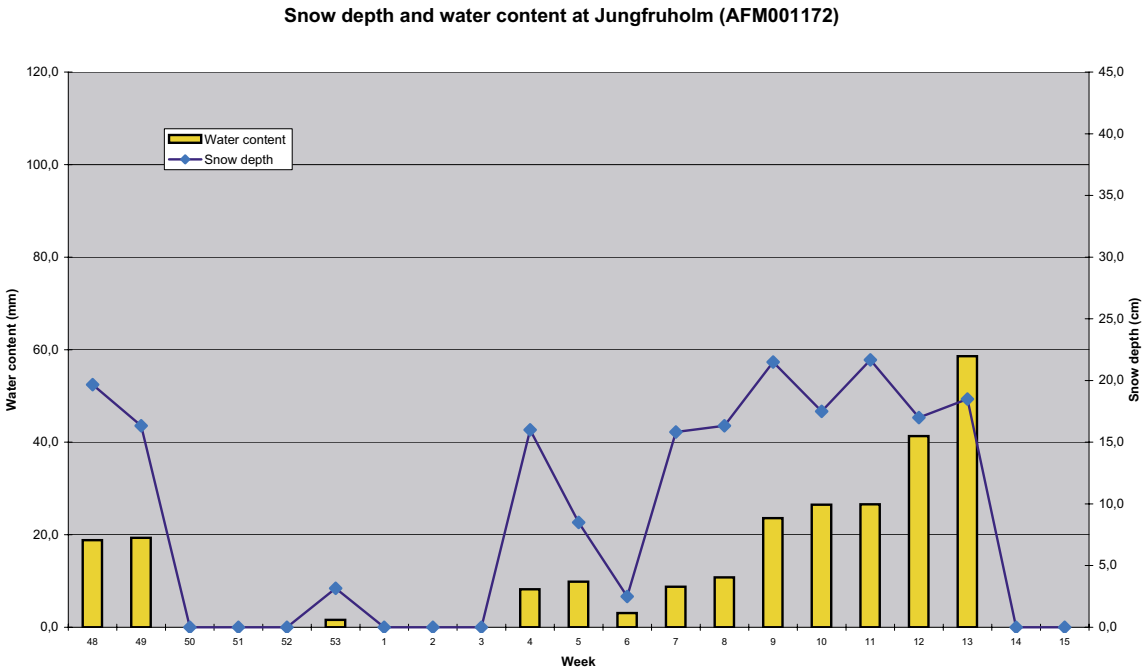

Figure 5-2c. *Snow depth and water content at Jungfruholm (AFM001172).*

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.

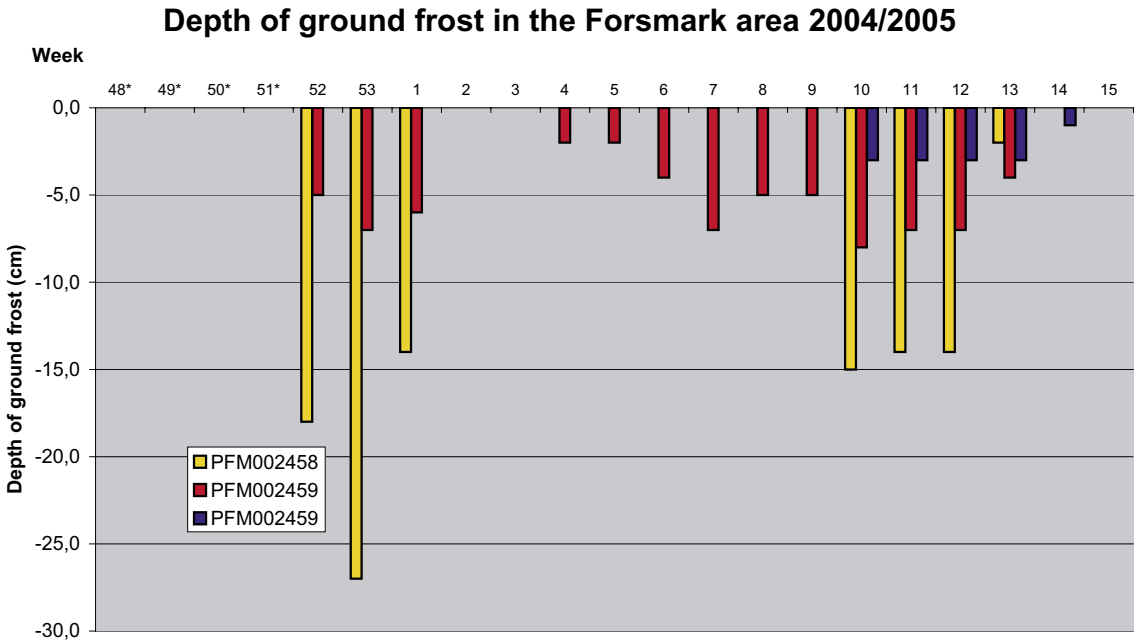

Figure 5-3. *Ground frost penetration depth at three stations in the Forsmark area during the winter 2004/2005. Weeks with * indicate that no measurements have been made due to problems with the measurement devices.*

At the wetland (PFM002460) there was almost no ground frost at all. At the few occasions when ground frost existed, the penetration depth was very small, 3 cm or less. At the forest glade (PFM002459) the ground frost depth reached 8 cm at its most, and at the open field (PFM002458) maximum 27 cm. Compared to the two previous years measurements of ground frost /1/, /2/, the penetration depth is smaller at the open field at Storskäret, about the same at the wetland station but a bit larger at the forest station.

5.3 Ice cover

Ice conditions observed in the Forsmark area during the winter 2004/2005 are shown in Table 5-1. Lake Eckarfjärden was selected as representative for the lakes in the area concerning ice cover. When the ice froze and broke up, the conditions in other lakes in the area were controlled and no larger deviations were observed.

At the sea bay at SFR the ice broke up on January 13 due to warm weather and hard wind and then refroze at January 27.

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)	2004-11-18	2005-04-09	143
Sea bay at SFR (AFM000075)	2004-12-21	2005-01-13	95
	2005-01-27	2005-04-07	

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. Svensk Kärnbränslehantering AB.

/2/ **Heneryd, N, 2004.** Forsmark site investigation. Snow depth, ground frost and ice cover during the winter 2003/2004. SKB P-04-137. Svensk Kärnbränslehantering AB.

/3/ **SMHI.** Handbok för observatörer. Internal document.

Appendix 1

Primary data from snow depth and snow weight measurements during the winter 2004/2005

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 coverage degree 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 A1-1. Snow depth, snow weight and water content at Storskäret (AFM000071) during the winter 2004/2005.

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)
2004-11-24	17.0	76.00	18.0	72.00	23.0	86.00	26.0	88.00	10.0	36.00	16.0	66.00	18.3	S	70.67	36.0
2004-12-02	12.0	58.00	11.0	50.00	11.0	56.00	12.0	48.00	13.0	60.00	12.0	58.00	11.8	S	55.00	28.0
2004-12-08	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
2004-12-16	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
2004-12-21	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
2004-12-28	2.0	10.00	5.0	14.00	3.0	10.00	3.0	12.00	4.0	12.00	5.0	13.00	3.7	S	11.83	6.0
2005-01-04	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
2005-01-12	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
2005-01-17	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
2005-01-25	27.0	70.00	16.0	56.00	6.0	21.00	7.0	21.00	12.0	35.00	6.0	16.00	12.3	S	36.50	18.6
2005-02-02	16.0	84.00	8.0	34.00	4.0	16.00	5.0	16.00	10.0	44.00	5.0	25.00	8.0	S	36.50	18.6
2005-02-08	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
2005-02-16	8.0	36.00	5.0	17.00	33.0	171.00	13.0	56.00	11.0	42.00	6.0	28.00	12.7	S	58.33	29.7
2005-02-22	18.0	66.00	3.0	2.00	17.0	75.00	8.0	31.00	5.0	12.00	4.0	19.00	9.2	S	34.17	17.4
2005-03-02	24.0	106.00	36.0	155.00	13.0	57.00	11.0	42.00	7.0	19.00	17.0	71.00	18.0	S	75.00	38.2
2005-03-09	23.0	136.00	17.0	96.00	6.0	17.00	14.0	67.00	9.0	45.00	11.0	48.00	13.3	S	68.17	34.7
2005-03-16	30.0	177.00	17.0	58.00	14.0	61.00	26.0	132.00	24.0	129.00	15.0	72.00	21.0	S	104.83	53.4
2005-03-23	30.0	225.00	15.0	86.00	17.0	98.00	18.0	93.00	12.0	69.00	11.0	53.00	17.2	S	104.00	53.0
2005-03-30	6.0	40.00	7.0	46.00	8.0	50.00	6.0	42.00	5.0	26.00	5.0	30.00	6.2	BS	39.00	19.9
2005-04-06	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
2005-04-14	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 A1-2. Snow depth, snow weight and water content at the forest glade (AFM000072) during the winter 2004/2005.

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)
2004-11-24	18.0	60.00	21.0	66.00	22.0	52.00	21.0	56.00	21.0	64.00	20.0	60.00	20.5	S	59.67	30.4
2004-12-02	18.0	70.00	21.0	72.00	16.0	60.00	22.0	64.00	20.0	76.00	20.0	76.00	19.5	S	69.67	35.5
2004-12-08	11.0	46.00	10.0	46.00	12.0	48.00	13.0	56.00	11.0	54.00	10.0	46.00	11.2	SB	49.33	25.1
2004-12-16	5.0	25.00	4.0	19.00	8.0	26.00	3.0	16.00	5.0	20.00	3.0	18.00	4.7	SB	20.67	10.5
2004-12-21	2.0	13.00	4.0	21.00	2.0	15.00	4.0	14.00	1.0	14.00	2.0	13.00	2.5	BS	15.00	7.6
2004-12-28	5.0	22.00	6.0	33.00	7.0	20.00	6.0	17.00	4.0	19.00	4.0	18.00	5.3	S	21.50	10.9
2005-01-04	2.0	2.00	5.0	32.00	3.0	12.00	2.0	11.00	1.0	6.00	2.0	11.00	2.5	SB	12.33	6.3
2005-01-12	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
2005-01-17	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
2005-01-25	13.0	28.00	10.0	24.00	14.0	26.00	12.0	28.00	12.0	27.00	13.0	26.00	12.3	S	26.50	13.5
2005-02-02	8.0	29.00	10.0	35.00	9.0	31.00	9.0	25.00	10.0	35.00	8.0	33.00	9.0	S	31.33	16.0
2005-02-08	3.0	18.00	5.0	28.00	6.0	25.00	6.0	24.00	5.0	26.00	5.0	21.00	5.0	S	23.67	12.1
2005-02-16	13.0	47.00	15.0	55.00	15.0	59.00	13.0	49.00	15.0	55.00	14.0	56.00	14.2	S	53.50	27.2
2005-02-22	18.0	70.00	16.0	62.00	14.0	32.00	15.0	53.00	17.0	63.00	18.0	65.00	16.3	S	57.50	29.3
2005-03-02	27.0	113.00	25.0	99.00	26.0	97.00	23.0	86.00	25.0	116.00	27.0	92.00	25.5	S	100.50	51.2
2005-03-09	21.0	83.00	22.0	102.00	24.0	108.00	22.0	121.00	26.0	101.00	27.0	124.00	23.7	S	106.50	54.2
2005-03-16	30.0	127.00	27.0	95.00	28.0	120.00	29.0	124.00	27.0	118.00	27.0	121.00	28.0	S	117.50	59.8
2005-03-23	25.0	131.00	25.0	133.00	26.0	140.00	28.0	154.00	25.0	132.00	28.0	150.00	26.2	S	140.00	71.3
2005-03-30	7.0	26.00	11.0	38.00	10.0	46.00	10.0	48.00	10.0	38.00	10.0	42.00	9.7	SB	39.67	20.2
2005-04-06	16.0	117.00	15.0	109.00	13.0	88.00	14.0	106.00	12.0	86.00	10.0	68.00	13.3	S	95.67	48.7
2005-04-14	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 A1-3. Snow depth, snow weight and water content at Jungfruholm (AFM001172) during the winter 2004/2005.

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)
2004-11-25	17.0	32.00	17.0	42.00	20.0	40.00	24.0	38.00	20.0	34.00	20.0	36.00	19.7	S	37.00	18.8
2004-12-02	16.0	32.00	17.0	40.00	16.0	36.00	15.0	40.00	16.0	38.00	18.0	42.00	16.3	S	38.00	19.4
2004-12-08	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
2004-12-16	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
2004-12-21	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
2004-12-28	2.0	2.00	5.0	3.00	4.0	4.00	3.0	4.00	2.0	3.00	3.0	3.00	3.2	S	3.17	1.6
2005-01-04	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
2005-01-12	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
2005-01-17	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
2005-01-25	17.0	17.00	13.0	17.00	12.0	13.00	19.0	17.00	17.0	18.00	18.0	15.00	16.0	S	16.17	8.2
2005-02-02	6.0	14.00	8.0	18.00	12.0	23.00	8.0	18.00	12.0	26.00	5.0	17.00	8.5	S	19.33	9.8
2005-02-08	5.0	13.00	1.0	6.00	0.0	0.00	3.0	7.00	0.0	0.00	6.0	10.00	2.5	SB	6.00	3.1
2005-02-16	17.0	14.00	20.0	15.00	19.0	18.00	11.0	18.00	15.0	20.00	13.0	18.00	15.8	S	17.17	8.7
2005-02-22	20.0	15.00	18.0	17.00	16.0	31.00	16.0	20.00	11.0	26.00	17.0	18.00	16.3	S	21.17	10.8
2005-03-02	25.0	45.00	18.0	46.00	19.0	55.00	25.0	44.00	18.0	35.00	24.0	53.00	21.5	S	46.33	23.6
2005-03-09	11.0	55.00	18.0	59.00	16.0	47.00	19.0	60.00	21.0	46.00	20.0	45.00	17.5	S	52.00	26.5
2005-03-16	23.0	40.00	19.0	42.00	20.0	45.00	24.0	48.00	25.0	72.00	19.0	66.00	21.7	S	52.17	26.6
2005-03-23	15.0	69.00	19.0	88.00	16.0	67.00	15.0	70.00	19.0	98.00	18.0	95.00	17.0	S	81.17	41.3
2005-03-30	18.0	102.00	20.0	118.00	17.0	120.00	17.0	100.00	21.0	142.00	18.0	108.00	18.5	S	115.00	58.6
2005-04-06	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
2005-04-14	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 calculating how deep below this point the ground frost reaches. The ground level for each measurement point is presented in the corresponding data table. The upper registration is the level of the upper limit of the ground frost, read from the device, whereas the lower registration is the lower limit. The upper and lower levels 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 A2-1. Ground frost penetration depth at Storskäret (PFM002458) during the winter 2004/2005.

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
2004-11-24							Measurement device missing
2004-12-02							Measurement device missing
2004-12-08							Measurement device missing
2004-12-16							Measurement device missing
2004-12-21	45.0	10.0	63.0	0.0	18.0	18.0	New measurement device installed
2004-12-28	45.0	5.0	72.0	0.0	27.0	27.0	
2005-01-04	45.0	14.0	59.0	0.0	14.0	14.0	
2005-01-12	45.0	0.0	0.0	0.0	0.0	0.0	No ground frost
2005-01-17	45.0	0.0	0.0	0.0	0.0	0.0	No ground frost
2005-01-25	45.0	19.0	37.0	0.0	0.0	0.0	No ground frost
2005-02-02	45.0	18.0	37.0	0.0	0.0	0.0	No ground frost
2005-02-08	45.0	0.0	0.0	0.0	0.0	0.0	No ground frost
2005-02-16	45.0	22.0	41.0	0.0	0.0	0.0	No ground frost
2005-02-22	45.0	22.0	42.0	0.0	0.0	0.0	No ground frost
2005-03-02	45.0	5.0	43.0	0.0	0.0	0.0	No ground frost
2005-03-09	45.0	5.0	60.0	0.0	15.0	15.0	
2005-03-16	45.0	5.0	59.0	0.0	14.0	14.0	
2005-03-23	45.0	5.0	59.0	0.0	14.0	14.0	
2005-03-30	45.0	5.0	47.0	0.0	2.0	2.0	
2005-04-06	45.0	0.0	0.0	0.0	0.0	0.0	No ground frost
2005-04-14	45.0	0.0	0.0	0.0	0.0	0.0	No ground frost

Table A2-2. Ground frost penetration depth at the forest glade (PFM002459) during the winter 2004/2005.

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
2004-11-24	40.0	20.0	39.0				No ground frost
2004-12-02	40.0	20.0	37.0				No ground frost
2004-12-08	40.0						No ground frost
2004-12-16	40.0						No ground frost
2004-12-21	40.0	20.0	45.0	0.0	5.0	5.0	
2004-12-28	40.0	10.0	47.0	0.0	7.0	7.0	
2005-01-04	40.0	22.0	46.0	0.0	6.0	6.0	
2005-01-12	40.0	0.0	0.0	0.0	0.0	0.0	No ground frost
2005-01-17	40.0	0.0	0.0	0.0	0.0	0.0	No ground frost
2005-01-25	40.0	23.0	42.0	0.0	2.0	2.0	
2005-02-02	40.0	22.0	42.0	0.0	2.0	2.0	New measurement device installed
2005-02-08	40.0	8.0	44.0	0.0	4.0	4.0	
2005-02-16	40.0	8.0	47.0	0.0	7.0	7.0	
2005-02-22	40.0	8.0	45.0	0.0	5.0	5.0	
2005-03-02	40.0	8.0	45.0	0.0	5.0	5.0	
2005-03-09	40.0	10.0	48.0	0.0	8.0	8.0	
2005-03-16	40.0	10.0	47.0	0.0	7.0	7.0	
2005-03-23	40.0	13.0	47.0	0.0	7.0	7.0	
2005-03-30	40.0	17.0	44.0	0.0	4.0	4.0	
2005-04-06	40.0	0.0	0.0	0.0	0.0	0.0	No ground frost
2005-04-14	40.0	0.0	0.0	0.0	0.0	0.0	No ground frost

Table A2-3. Ground frost penetration depth at Gällsboträsket (PFM002460) during the winter 2004/2005.

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
2004-11-25	38.0						Measurement device was removed due to leakage
2004-12-02							Measurement device missing
2004-12-08							Measurement device missing
2004-12-16							Measurement device missing
2004-12-21	42.0	20.0	39.0	0.0	0.0	0.0	New measurement device installed
2004-12-28	42.0	10.0	36.0	0.0	0.0	0.0	No ground frost
2005-01-04	42.0	21.0	39.0	0.0	0.0	0.0	No ground frost
2005-01-12	42.0	27.0	41.0	0.0	0.0	0.0	No ground frost
2005-01-17	42.0	33.0	40.0	0.0	0.0	0.0	No ground frost
2005-01-25	42.0	15.0	38.0	0.0	0.0	0.0	No ground frost
2005-02-02	42.0	15.0	37.0	0.0	0.0	0.0	No ground frost
2005-02-08	42.0	15.0	38.0	0.0	0.0	0.0	No ground frost
2005-02-16	42.0	15.0	42.0	0.0	0.0	0.0	No ground frost
2005-02-22	42.0	15.0	41.0	0.0	0.0	0.0	No ground frost
2005-03-02	42.0	15.0	41.0	0.0	0.0	0.0	No ground frost
2005-03-09	42.0	5.0	45.0	0.0	3.0	3.0	
2005-03-16	42.0	5.0	45.0	0.0	3.0	3.0	
2005-03-23	42.0	5.0	45.0	0.0	3.0	3.0	
2005-03-30	42.0	10.0	45.0	0.0	3.0	3.0	
2005-04-06	42.0	33.0	43.0	0.0	1.0	1.0	
2005-04-14	42.0	0.0	0.0	0.0	0.0	0.0	No ground frost