

## **Forsmark site investigation**

# **Snow depth, snow water content and ice cover during the winter 2009/2010**

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Geosigma AB

November 2010

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*Keywords:* Snow depth, Snow water content, Ice cover, AP PF 400-09-004.

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## Abstract

During the winter of 2009/2010 snow depth and ice cover have been measured and observed. This type of measurements started in the winter 2002/2003 and has been ongoing since then. In addition to these parameters the water content of the snow was, at each measurement occasion, calculated from the weight of a snow sample.

Measurements and observations were conducted on a regular basis from December 2009 until the end of April 2010.

A persistent snow cover was established in the middle of December 2009 and remained until the end of April 2010 at the station with longest snow cover duration. This winter the largest snow depths have been measured at all three locations since the measurements started in the winter of 2002/2003.

The period of ice cover was 139 days in Lake Eckarfjärden, whereas the sea bay at SFR was ice-covered for 126 days.

## Sammanfattning

Under vintern 2009/2010 har de meteorologiska parametrarna snödjup och istäcke mätts och observerats. Denna typ av mätningar påbörjades vintern 2002/2003 och har pågått sedan dess. Under denna aktivitet har även snöns vatteninnehåll beräknats utifrån vikten på en bestämd volym snö.

Regelbundna mätningar och observationer har gjorts från december 2009 till slutet av april 2010.

Vintern 2009/2010 fanns ett bestående snötäcke från mitten av december 2009 till slutet av april 2010 vid den station som hade längst kvarliggande snötäcke. Denna vinter har de största snödjupen uppmätts vid alla tre mätstationerna sedan mätningarna startade vintern 2002/2003.

Istäcket varade 139 dagar i Eckarfjärden och 126 dagar i havsviken vid SFR.

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# 1 Introduction

This document reports data obtained from snow measurements and ice cover observations during the winter of 2009/2010. These are activities performed within the site investigation at Forsmark. The work was carried out in accordance with activity plan AP PF 400-09-004. Similar studies have been performed since the winter of 2002/2003, /1/-/7/.

The three parameters, snow depth, snow weight and duration of ice cover, were measured and registered in the field. The water content of the snow was calculated using results from snow weight measurements. The map in Figure 1-1 shows the positions of the measurements. The activity was performed from the beginning of December 2009 until the end of April 2010.

Controlling documents for performing this activity are listed in Table 1-1. The activity plan is an SKB internal controlling document.

Original data from the reported activity are stored in the primary database Sicada. Data are traceable in Sicada by the Activity Plan number (SKB AP PF 400-09-004). Only data in databases are accepted for further interpretation and modelling. The data presented in this report are regarded as copies of the original data. Data in the databases may be revised, if needed. Such revisions will not necessarily result in a revision of the corresponding P-report, although the normal procedure is that major revisions entail a revision of the P-report. Minor revisions are normally presented as supplements, available at [www.skb.se](http://www.skb.se).

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

<b>Activity plan</b>	<b>Number</b>	<b>Version</b>
Platsundersökning Forsmark: Registrering av snödjup/-vatteninnehåll och tider för isläggning/islossning, säsongen 2009-2010	AP PF 400-09-004	1.0
<b>Other controlling documents</b>	<b>Number</b>	<b>Version</b>
SMHI, Handbok för observatörer	SMHI internal document	N/A



Figure 1-1. Locations of measurements and observation of meteorological winter parameters.

## 2 Objective and scope

This activity was conducted in order to obtain data about the local climate that, in combination with other meteorological data, will be used in hydrological and ecological modelling. The activity started in December 2009 and was completed when all snow had melted at the end of April 2010.

The following parameters were measured:

- snow depth at three locations,
- snow weight at three locations,
- time for ice freeze-up and ice break-up 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 handbok för observatörer). A transparent plastic tube graded in centimetres, with 5 centimetres inner diameter, was used for the snow depth measurements, see Figure 3-1.

#### 3.1.2 Snow weight

The snow weight was measured by collecting 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 can measure up to 200 g and is graded with 2 g increments. The equipment used for collection of snow samples and snow weight measurement is shown in Figure 3-1.

#### 3.1.3 Ice cover

The observations of ice freeze-up and ice break-up were performed by visual inspection.



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

## 4 Execution

This activity consisted of the following items:

1. measurements of snow depth, snow weight and determination of water content,
2. observations of ice freeze-up and ice break-up,
3. documentation.

### 4.1 General

Measurements of snow depth and snow weight were made once a week between December 18, 2009 and April 30, 2010. Ice conditions were observed with varying frequency depending on temperature and weather situation. Each object for measurements/observations has a specific ID-code according to Table 4-1 (cf. positions in Figure 1-1). The snow depth and snow weight objects as well as the objects where ice conditions were observed were registered as surfaces (AFM-numbers).

**Table 4-1. ID-code numbers and coordinates for the objects of this activity. Coordinate system RT 90 2,5 gon V 0:-15.**

Parameter	ID-code	X	Y	Type of location
<b>Snow</b>				
Depth and water content	AFM000071			Ploughed arable land
	1	6697419	1634872	
	2	6697413	1634869	
	3	6697412	1634874	
Depth and water content	4	6697416	1634877	
	AFM000072			Forest glade
	1	6698528	1631524	
	2	6698524	1631527	
3	6698529	1631527		
Depth and water content	4	6698534	1631523	
	AFM001172			Forest glade
	1	6699475	1633157	
	2	6699468	1633157	
3	6699473	1633160		
Ice cover	4	6699480	1633160	
	AFM000010	6697230	1632050	Lake
	AFM000075	6701371	1632303	Sea bay

## 4.2 Execution of measurements and observations

### 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 4x4 m and marked with poles.

Measurements were made once a week, starting on December 18, 2009, and continuing until the snow was completely melted in the spring, which was on April 30, 2010. 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 sample station and the average snow depth at each station was calculated. The depth was measured with a transparent plastic tube, which also was used to collect 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.

The snow weight was measured at all three sample stations. At each station, 6 snow samples were collected with the plastic tube and transferred to a plastic bag for weight measurements. The weight of the bag, approximately 4 g, was subtracted. If the sample weighed more than 200 g, the sample was divided into two subsamples that were weighed separately. 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 in order to avoid incorrect readings of the scale.



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

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

Inner diameter of plastic tube: 50 mm.

Inner area of the plastic tube ( $\pi^2$ ): 19.635 cm<sup>2</sup>.

Water density: 1 g/cm<sup>3</sup>.

Water content of the snow in mm: snow weight (g)/19.635 (cm<sup>3</sup>) × 10.

#### **4.2.2 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.

It is important to register the times of the first ice freeze-up and the last ice break-up. The time of the first ice freeze-up is defined as the first occasion during the season when a lasting ice cover is established. The last ice break-up is defined as the time when the ice cover from the winter season finally breaks up in spring. Very short periods in early autumn and late spring with only thin ice cover are neglected, as well as ice remains during the spring.

### **4.3 Data handling**

The measurements and observations were documented in field notes and then transferred to Excel-files. The primary data of this activity are registered in Sicada and are traceable by the Activity Plan number, SKB PF 400-09-004. Only primary data registered in Sicada should be used for model calculations and other assessments of the site.

### **4.4 Nonconformities**

The activity was conducted without nonconformities.

## 5 Results

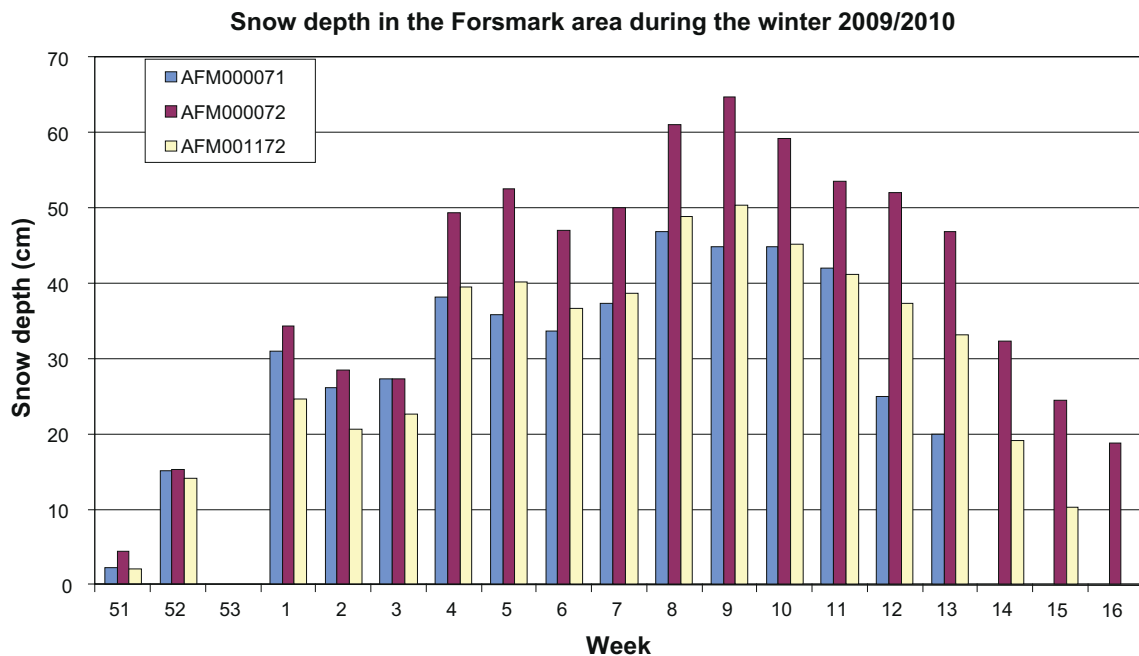
### 5.1 Snow depth and water content

Snow depth was measured at three stations (AFM000071, AFM000072 and AFM001172) during the winter of 2009/2010.

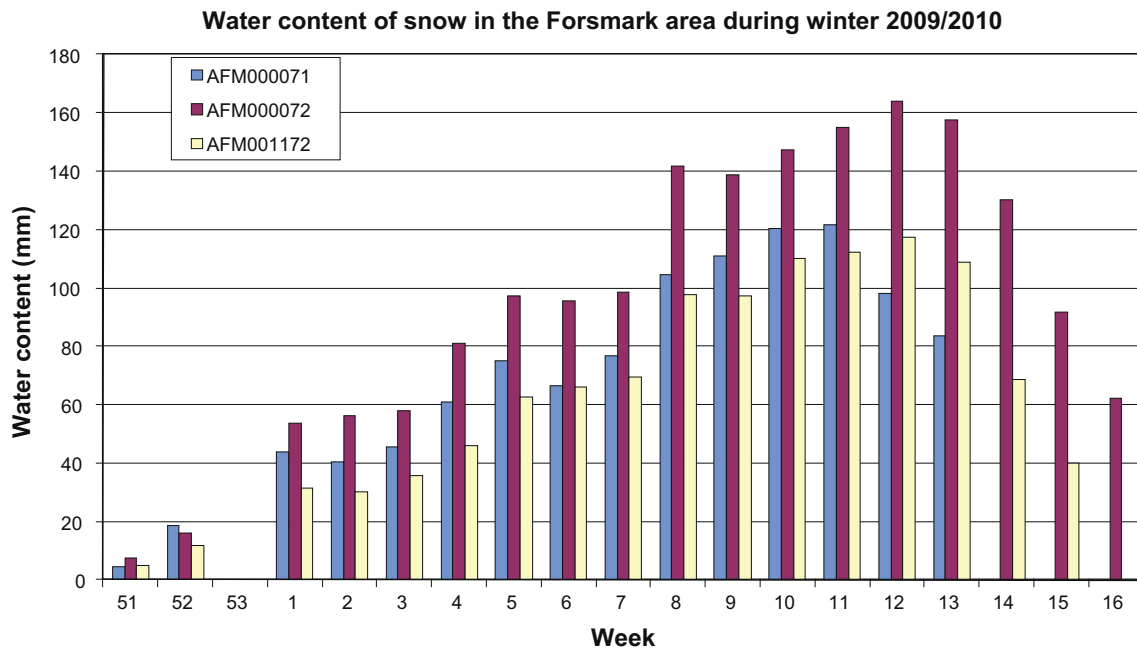
The average snow depth at the three stations is presented in Figure 5-1. The complete set of primary data is presented in Appendix 1.

No measurements were performed in week number 53 due to Christmas holidays. No persistent snow cover was established before week number 51 and after week number 16. This winter the largest snow depths have been measured at all three locations since the measurements started in the winter of 2002/2003.

The snow weight was measured to calculate the water content of the snow. The results are presented in Figure 5-2.



*Figure 5-1. Average snow depth during the winter 2009/2010 at three stations in the Forsmark area.*



*Figure 5-2. Snow water content during the winter 2009/2010 at three stations in the Forsmark area.*

## 5.2 Ice cover

Ice conditions observed in the Forsmark area during the winter 2009/2010 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 checked and no major 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)	2009-12-02	2010-04-19	139
Sea bay at SFR (AFM000075)	2009-12-18	2010-04-23	126

## 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/ **Heneryd N, 2005.** Forsmark site investigation. Snow depth, ground frost and ice cover during the winter 2004/2005. SKB P-05-134, Svensk Kärnbränslehantering AB.
- /4/ **Heneryd N, 2006.** Forsmark site investigation. Snow depth, ground frost and ice cover during the winter 2005/2006. SKB P-06-97, Svensk Kärnbränslehantering AB.
- /5/ **Heneryd N, 2007.** Forsmark site investigation. Snow depth, snow water content and ice cover during the winter 2006/2007. SKB P-07-81, Svensk Kärnbränslehantering AB.
- /6/ **Nyberg G, Wass E, 2008.** Forsmark site investigation. Snow depth, snow water content and ice cover during the winter 2007/2008. SKB P-08-92, Svensk Kärnbränslehantering AB.
- /7/ **Nyberg G, Wass E, 2009.** Forsmark site investigation. Snow depth, snow water content and ice cover during the winter 2008/2009. SKB P-09-70, Svensk Kärnbränslehantering AB.

### **Primary data from snow depth and snow weight measurements during the winter 2009/2010.**

The data collected during the snow depth and snow weight measurements are presented below as individual measurements as well as calculated averages of snow depth, snow weight and water content.

For each measurement, a visual estimate of the degree of coverage was made according to the following scale:

S = completely or almost completely snow-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 A-1. Snow depth, snow weight and water content at Storskäret (AFM000071) during the winter 2009/2010.**

Date	Depth (cm)						Weight (g)						Snow coverage	Average snow depth (cm)	Average snow weight (g)	Water content (mm)
	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6				
2009-12-18	2	2	2	3	2	3	9	8	9	11	7	11	SB	2.3	9.2	4.7
2009-12-23	15	15	14	15	16	16	35	37	34	35	38	39	S	15.2	36.3	18.5
2010-01-08	30	31	33	31	29	32	95	80	95	75	78	95	S	31.0	86.3	44.0
2010-01-15	27	26	27	26	26	25	107	73	93	60	75	66	S	26.2	79.0	40.2
2010-01-22	26	25	28	28	29	28	100	75	110	75	83	95	S	27.3	89.7	45.7
2010-01-29	39	38	37	38	39	38	130	132	142	90	108	117	S	38.2	119.8	61.0
2010-02-05	38	34	37	35	35	36	170	110	162	135	143	165	S	35.8	147.5	75.1
2010-02-12	33	32	34	35	35	33	145	130	152	125	132	100	S	33.7	130.7	66.5
2010-02-19	37	37	40	36	37	37	145	170	180	120	142	145	S	37.3	150.3	76.6
2010-03-01	47	46	47	48	49	44	205	205	205	207	210	200	S	46.8	205.3	104.6
2010-03-05	43	42	47	47	47	43	208	217	230	225	235	190	S	44.8	217.5	110.8
2010-03-12	42	48	47	42	47	43	222	270	250	195	262	220	S	44.8	236.5	120.4
2010-03-19	42	43	42	42	45	38	220	245	255	252	265	195	S	42.0	238.7	121.6
2010-03-26	28	26	25	25	24	22	235	210	185	185	165	175	S	25.0	192.5	98.0
2010-03-31	23	21	17	19	19	21	200	170	135	145	150	185	S	20.0	164.2	83.6
2010-04-09	–	–	–	–	–	–	–	–	–	–	–	–	B	–	–	–

**Table A-2. Snow depth, snow weight and water content at the forest glade (AFM000072) during the winter 2009/2010.**

Date	Depth (cm)						Weight (g)						Snow coverage	Average snow depth (cm)	Average snow weight (g)	Water content (mm)
	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6				
2009-12-18	4	5	5	5	4	4	14	17	16	16	13	13	S	4.5	14.8	7.6
2009-12-23	17	15	13	17	16	14	34	31	28	35	32	30	S	15.3	31.7	16.1
2010-01-08	30	33	37	35	38	33	105	88	112	108	120	100	S	34.3	105.5	53.7
2010-01-15	27	27	26	30	30	31	107	110	103	115	114	115	S	28.5	110.7	56.4
2010-01-22	28	26	26	30	28	26	112	107	112	127	118	108	S	27.3	114.0	58.1
2010-01-29	50	48	50	50	49	49	170	150	152	165	162	155	S	49.3	159.0	81.0
2010-02-05	53	52	52	53	52	53	188	190	185	190	192	200	S	52.5	190.8	97.2
2010-02-12	48	49	45	47	45	48	175	210	168	195	175	205	S	47.0	188.0	95.7
2010-02-19	50	49	51	50	48	52	190	188	178	206	185	215	S	50.0	193.7	98.6
2010-03-01	60	60	59	62	64	61	285	255	260	280	290	300	S	61.0	278.3	141.8
2010-03-05	64	65	62	66	69	62	265	265	255	280	295	275	S	64.7	272.5	138.8
2010-03-12	60	59	55	59	59	63	300	255	285	290	285	320	S	59.2	289.2	147.3
2010-03-19	54	55	50	56	53	53	305	315	295	300	305	305	S	53.5	304.2	154.9
2010-03-26	51	52	49	53	53	54	315	300	297	338	345	335	S	52.0	321.7	163.8
2010-03-31	45	46	48	46	47	49	305	305	310	305	305	325	S	46.8	309.2	157.5
2010-04-09	32	33	28	35	32	34	250	250	218	285	248	285	S	32.3	256.0	130.4
2010-04-16	20	22	27	25	26	27	157	160	200	185	187	190	S	24.5	179.8	91.6
2010-04-23	17	21	16	25	17	17	127	130	107	145	115	110	S	18.8	122.3	62.3
2010-04-30	–	–	–	–	–	–	–	–	–	–	–	–	B	–	–	–

**Table A-3. Snow depth, snow weight and water content at Jungfruholm (AFM001172) during the winter 2009/2010.**

Date	Depth (cm)						Weight (g)						Snow coverage	Average snow depth (cm)	Average snow weight (g)	Water content (mm)
	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6				
2009-12-18	3	2	2	2	2	2	13	9	10	9	8	9	S	2.2	9.7	4.9
2009-12-23	16	16	14	14	12	13	25	27	23	23	20	22	S	14.2	23.3	11.9
2010-01-08	25	26	25	23	26	23	62	38	65	68	71	65	S	24.7	61.5	31.3
2010-01-15	22	22	19	19	22	20	77	55	47	51	60	63	S	20.7	58.8	30.0
2010-01-22	25	23	25	23	17	23	67	82	60	83	58	72	S	22.7	70.3	35.8
2010-01-29	39	40	40	38	37	43	85	90	92	85	92	98	S	39.5	90.3	46.0
2010-02-05	40	39	40	43	41	38	115	117	130	145	112	120	S	40.2	123.2	62.7
2010-02-12	37	39	35	39	36	34	113	150	118	130	137	128	S	36.7	129.3	65.9
2010-02-19	38	37	40	44	35	38	130	110	155	158	118	150	S	38.7	136.8	69.7
2010-03-01	49	47	50	51	49	47	200	175	215	207	185	170	S	48.8	192.0	97.8
2010-03-05	52	49	52	51	53	45	205	185	210	177	210	160	S	50.3	191.2	97.4
2010-03-12	48	45	45	45	48	40	235	225	205	200	250	180	S	45.2	215.8	109.9
2010-03-19	42	43	42	42	41	37	230	260	225	225	220	160	S	41.2	220.0	112.0
2010-03-26	40	39	37	38	39	31	242	240	232	240	235	195	S	37.3	230.7	117.5
2010-03-31	35	36	31	35	33	29	235	265	190	240	200	150	S	33.2	213.3	108.6
2010-04-09	20	21	19	23	22	10	135	160	137	165	150	63	S	19.2	135.0	68.8
2010-04-16	9	11	8	12	12	10	65	90	57	95	95	70	S	10.3	78.7	40.1
2010-04-23	–	–	–	–	–	–	–	–	–	–	–	–	B	–	–	–