INTEGRATED MONITORING AT LITLA-SKARD, ICELAND
PROJECT OVERVIEW 1996-2004

Albert S. Sigurðsson, Sigurður H. Magnússon, Jóhanna M. Thorlacius, Hreinn Hjartarson, Páll Jónsson, Bjarni D. Sigurðsson, Borgþór Magnússon and Hlynur Óskarsson

UST
Umhverfisstofnun

ICELANDIC INSTITUTES PARTICIPATING IN THE IM MONITORING PROJECT

Institute of Natural History

Hydrological Service of the National Energy Authority

Meteorological Office

Environment and Food Agency

Agricultural University of Iceland

The Iceland Forest Service

Scientific Institute, University of Iceland

SUMMARY

In 1996 several Icelandic agencies established a research project in a small catchment area at Litla-Skard in the western part of Iceland. The project is a part of a European network of stations with integrated monitoring and follows common guidelines available for the network. A detailed site description was made for the area with studies of vegetation, soils and animal life. The main focus of the monitoring is on hydrology, chemical properties of precipitation, groundwater and surface water, as well as measurements of weather parameters.

Results from Litla-Skard indicate that the study area is a good background monitoring station. The flora and fauna are typical for Icelandic rural areas. There are no significant local sources of anthropogenic pollution. Oceanic parameters are clearly visible in the precipitation data and result in clear input fluxes of mineral salts from sea in runoff stream from the area. The groundwater and soil component is insignificant for most chemical parameters.

SAMANTEKT

Árið 1996 hófu nokkrar íslenskar stofnanir samstarf um rannsóknir og vöktun á litlu vatnasviði ofan við Litla-Skarð í Borgarfirði. Verkefnið er hluti af samevrópsku neti mælistöðva þar sem stunduð er samþætt vöktun á ýmsum vistkerfisþáttum og fylgja rannsóknir evrópskum leiðbeiningum um verkefnið. Nákvæm staðarlýsing var gerð fyrir Litla-Skarð þar sem lýst var gróðurfari, jarðvegi og dýralífi á svæðinu. Þeir þættir sem vaktaðir með reglubundnum hætti eru eru vatnafar, efnafræði úrkomu, grunnvatns og yfirborðsvatns, auk veðurfars.

Niðurstöður mælinga sýna að Litla-Skarð gefi góða mynd af efnamælingum á ósnortnu svæði. Tegundasamsetning á svæðinu er ekki ólík því sem finnst annarstaðar á landinu. Það eru engar mengunaruppsprettur í nágrenni svæðisins. Áhrifa hafsins gætir nokkuð í efnafræði úrkomu og má sjá augljós áhrif sjávarseltu í afrennsli frá svæðinu. Áhrif jarðvegs og grunnvatns á efnafræði vatnsins virðast vera lítil.

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1. INTRODUCTION

A European Integrated Monitoring (IM) programme was initiated in the early 1980's in order to measure the impact of air pollution on ecosystems. This is accomplished by long-term monitoring of the main physical, chemical and biological processes in natural catchment areas under limited human influences (Pylvänäinen 1993).

Initially the main aim of the project was to determine and predict the state of ecosystems and their changes in a long-term perspective with respect to regional variation and the impact of air pollutants especially nitrogen, sulphur and ozone and the effects on biota (ICP IM Programme Centre 1998). This information was intended as a base for emission control. In the last decade a greater emphasis has also been put on the effects of climate change and how this affects biodiversity (Manual for Integrated Monitoring 1998). An important part of the project has always been to provide scientific and statistically reliable data that can be used in modelling work.

The Litla-Skard catchment area in the westarn part of Iceland, was specially selected for Integrated Monitoring (IM station IS01) in Iceland and the monitoring programme has been done according to standards set by an IM project manual. At the first stages of the project basic information about the site was collected. The boundaries of the catchment area were determined and the vegetation and soil mapped. Regular measurements at the site initiated in late 1996 and have focused on runoff hydrology and water chemistry. Litla-Skard is one of the sites of the SCANNET network of Scandinavian and North European Terrestrial Field Bases (www.scannet.nu) founded in 2001 (Callaghan et. al. 2004).

Integrated monitoring at Litla-Skard is funded by the Ministry for the Environment and has been carried out by the following institutes: Institute of Natural History, Hydrological Service of the National Energy Authority, Meteorological Office, Environment and Food Agency, Agricultural University of Iceland and the Iceland Forest Service.

This report gives an overview of the integrated monitoring activity at Litla-Skard. It shows monitoring data collected from 1996 to the end of 2004. The report provides information on the dynamics and seasonal variation in the data that may be used to detect trends in the measured variables. An account of other research activity and data from Litla-Skard is also given.

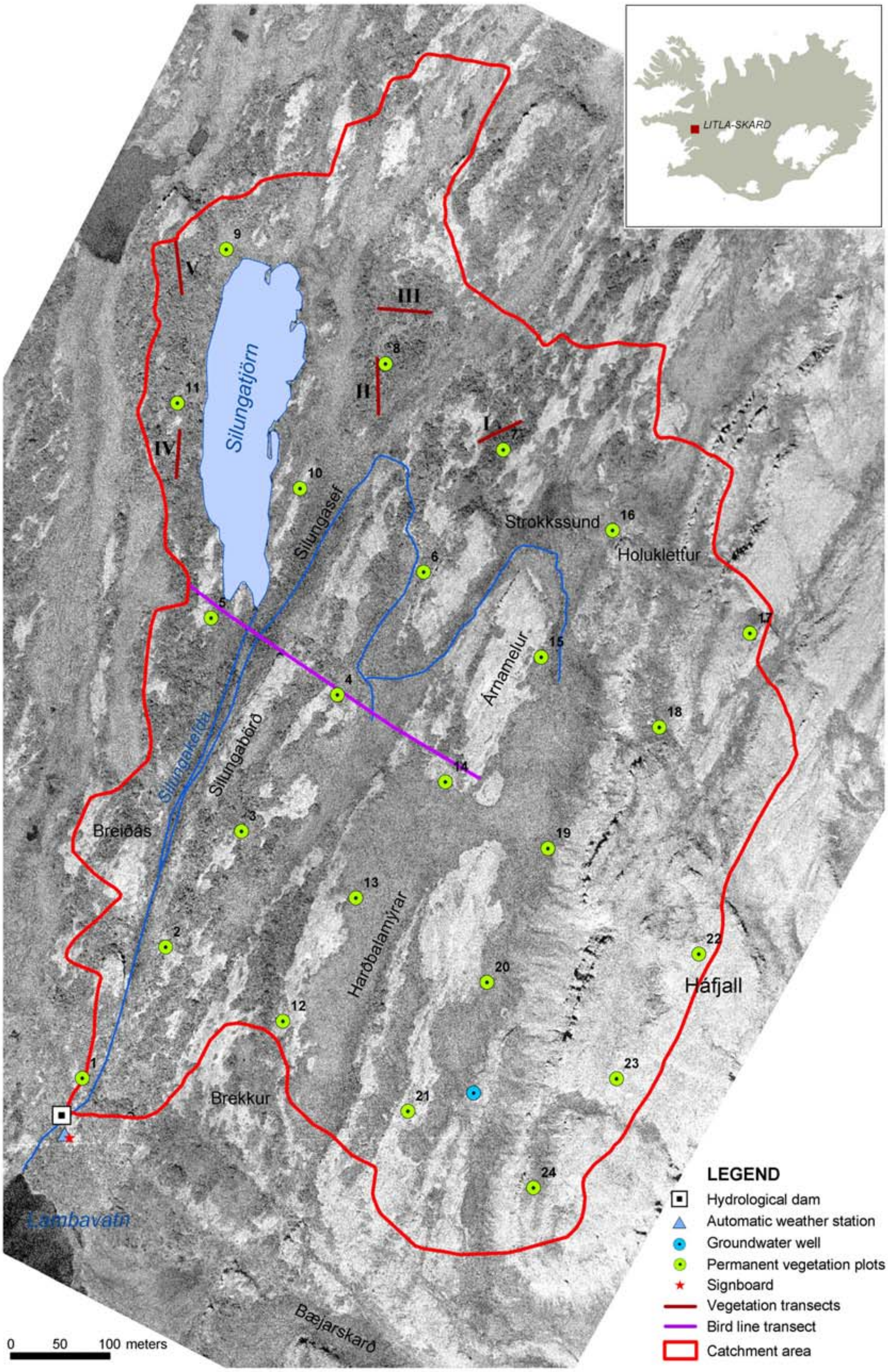


Fig. 2.1 Litla-Skard is situated in the western part of Iceland. An aerial photograph of the catchment area in Litla-Skard (August 14, 1985) showing the main IM stations and position of the 24 permanent vegetation plots. The location of the transects from the ICEWOOD project where plants and invertebrates were sampled and density of nesting birds determined in 2004 is also shown.

Fig. 2.2 An autumn view of the Litla-Skard catchment area in the foreground.

2. SITE DESCRIPTION

2.1. Geography and landscape

Litla-Skard is in the lowlands of the western part of Iceland (21 37 53 W; 64 43 34 N), about 30 km from the coastline (Fig. 2.1). The landscape in this area is rugged with a moderate relief. In between ridges with birch scrubland and heathland there are depressions with mire vegetation, small lakes and streams. The catchment area at Litla-Skard is hydrologically isolated and 55.5 ha in size. It is north-westerly sloping and within the elevation of 115–229m a.s.l. It is a part of an old farmland, now owned by the Iceland Forest Service.

2.2 Air and climate

The climate in, Litla-Skard is similar to many other lowland sites in Iceland and can be described as an oceanic, low arctic cold temperate (Einarsson 1976). Based on data from the nearest weather stations the average annual precipitation is about 740 mm and the mean annual temperature 3.1 °C, July 10.8 °C and January -1.8 °C (data from the Icelandic Meteorological Office). The growing period for vegetation is about 104 days (temp >5 °C).

Ground level ozone, which can be a stress factor for vegetation, has been monitored at Hvanneyri, some 12 km away from Litla-Skard, by the Environment and Food Agency. Preliminary results suggest that the monthly average from July – August 2004 for ozone is around 54 μg/m3, which is the background level for Iceland.

2.3 Bedrock and soils

The bedrock of the area is dense and consists of basic and intermediate lavas of the upper Tertiary (Jóhannesson 1994). In 1996 the soil within the catchment area was mapped according to a classification system developed by Arnalds (Annex 2). That system is based on the FAO soil classification system and the classification of Icelandic soils described by

Jóhannesson (1960). There are main soil types. In vegetated areas there are Andosol (29%) and Histosol (31%) but soils in low areas of vegetation cover are Leptosol (30%) and Vitrisol (6%). Open water is about 4% of the total area.

During the soil mapping, the topsoil (0–10 cm) of the main units were sampled for analysis of pH and carbon content (Table 1.1). The lowest pH was found in Histosol (4.6–5.5) but the highest in Vitrisol (6.2–6.7). The carbon content was lowest in Vitrisol (0.1%–2.5%) but highest values were found in Histosol (17.7%–24.6%).

Table 1.1 Soil pH and total carbon content in topsoil (0-10 cm) in Andosol, Histosol and Vitrisol at Litla-Skard. Each sample is a composite of five subsamples. pH was measured in water and carbon is a percentage of dry matter content (from Magnusson and Arnalds 1997). See also Annex 2

	pH	Carbon %
Andosol, A1	5.3	7.8
Andosol, A2	5,6	9,9
Andosol, A3	5.7	7.9
Histosol, H1	5,5	14,6
Histosol, H1	4.6	24.6
Histosol, H2	5.0	17.7
Vitrisol, L2	6.7	2.5
Vitrisol, L3	6.2	0.1

In a recent project (ICEWOOD) the soil chemistry was also measured in 2004 in samples from Litla-Skard in topsoil (0–10 cm) and mineral soil (10–30 cm) under mountain birch (*Betula pubescens*) within five vegetation transects (Fig. 2.3). Nitrogen concentrations varied between 0.5% and 0.8% in topsoil and between 0.3% and 0.6% in mineral soil (Figure 2.3a). The carbon concentrations varied between 8.9% and 15.6% in topsoil and between 3.9% and 10.2% in mineral soil (Figure 2.3b). The average C/N ratio was 18.2 in topsoil and 15.2 in mineral soil (Figure 2.3c). On average, the topsoil contained 44% more nitrogen and 70% more carbon than the mineral soil and its C/N ratio was 20% higher. Soil acidity of all samples ranged between 5.5 and 6.1 (Figure 2.3d).

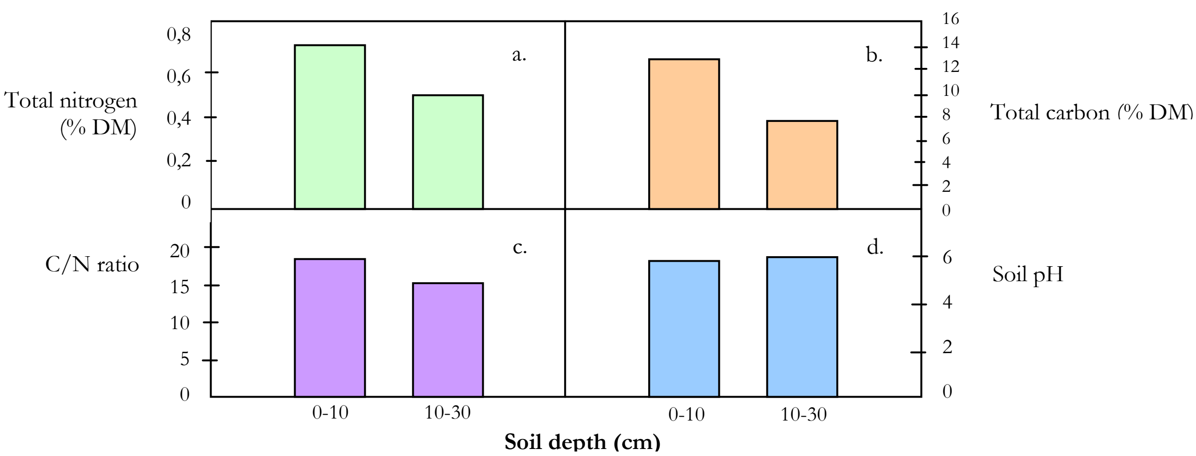


Figure 2.3 Soil chemistry in topsoil (0-10 cm) and mineral soil (10-30 cm) within birch shrub areas in the Litla-Skard catchment area. a) total nitrogen and b) total carbon as a percentage of dry matter, c) the C/N ratio and d) soil pH measured in water. All values are means ± standard error of n = 3-5.

The high C:N ratio and pH in the soil in Litla-Skard are typical for Icelandic Andosol (Arnalds et al. 1995) and are similar to values reported from other birch woodlands in Iceland (Sigurdardottir 2000; Sigurdsson et al. 2005).

2.4 Vegetation

In 1996 the vegetation within the catchment area was mapped (Magnusson and Arnalds 1997), Annex 3). In connection with the mapping an inventory of plants was carried out, using circular 100 m^2 permanent sample plot network distributed at 150m intervals over the area (Fig. 2.1). A total of 24 plots were established In the plots the cover of each vascular plant species was estimated visually and classified into three cover classes (>1%, 1–25%, >25%) as well as the total cover of bryophytes, lichens and of bare ground. In order to get information on the height of the birch, each plot was divided into four equal parts and the height of the tallest birch tree in each part measured.

Fig. 2.4 Plant inventory and vegetation mapping.

Within the catchment area are four main classes; freely drained land (67%), wetland 28%), a transitional zone between these two classes (1%) and open water (4%). Within the freely drained land Betula shrubland (28%) and sparely vegetated land (15%) was largest in area. Of the wetland the sloping fen was the most extensive (23%) (Annex 3). According to the inventory of vascular plants in the permanent plots the most common species were *Empetrum nigrum*, *Vaccinium uliginosum*, *Thalictrum alpinum*, *Galium normanii*, *Festuca vivipara, Bistorta vivipara* and *Betula pubescens*. The average maximum height of birch trees was 1.38m (0.35–2.8m).

2.5 Flora and fauna

A total of 262 species of plants and animals have been recorded within the catchment area in Litla-Skard (Table 2.2). It is, however, likely that the actual number of species in the area is much higher as intensive sampling has not been carried out for all these groups in the different habitats. However, the number of vascular plants, birds, mammals and fish is probably not far from reality as as these groups are already well covered within most habitats in the area. For species lists see Annex 4 – Annex 6.

2.6 Human activities

In the past most of the Litla-Skard area was used as wide, open ranges for grazing livestock, namely sheep. Today the influence from farming is low and the site has not been grazed since 1985. Some 2-3 kilometers south of the site there are summer cabins and 7 km to the north-east there is a hotel and a school complex with several hundred residents.

A road is situated about 1,5 km east of the catchment area. Between the area and the road there is a 180 m high mountain. Also, the road traffic is not very high (Table 2.3), but is significantly higher in summer than in winter. Traffic pollution is very low or negligible as it cannot be carried directly from the road to the catchment area.

Table 2.2 Overview of recorded richness of flora and fauna in Litla-Skard.

		Number of species
	Vascular plants	101
Flora	Mosses	19
	Lichens	4
Fauna	Birds	22
	Mammals	3
	Fish	2
	Insects	77
	Arachnids	22
	Gastropods	7
	Annelids	5
		262

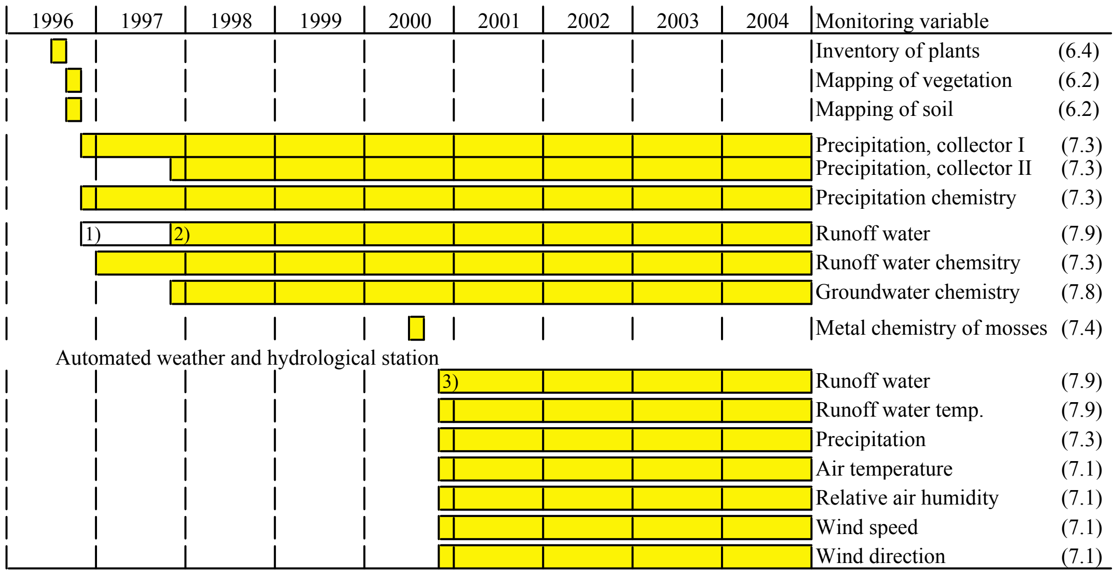
Table 2.3 Road traffic on the road in the vicinity of Litla-Skard (Road Authority 2005).

	Average Daily Traffic, whole year	Average Daily Traffic, summer	Average Daily Traffic, winter
2000	1071	1815	562
2001	1174	1930	616
2002	1229	1994	686
2003	1254	2029	681
Yearly average	1182	1942	636

3. MONITORING AT LITLA-SKARD – METHODS

3.1. Monitoring activities at Litla-Skard

The methods used follow the descriptions outlined in the Manual for Integrated Monitoring program phase 1993–1996. (Pylvänäinen 1993). The integrated monitoring started at Litla-Skard in 1996. Since then several parameters have been monitored (Fig. 3.1, Table 3.1).



1) First data logger. 2-3) Additional data loggers installed.

Fig. 3.1. Overview of the IM-sampling carried out in Litla-Skard. Numbers within parenthesis refer to the different programmes in the Manual for Integrated Monitoring.

All chemical analyses have been carried out by Centre for Chemical Analysis at Keldnaholt in Reykjavik. The chemical analyses were performed according to the description given in the Manual for Integrated Monitoring, with some minor adjustments (Annex 8). The main deviation from the descriptions is regarding filtering of samples. No filtering of samples was performed on samples until beginning of year 2004. This is very important to interpret metal levels, especially Fe and Al. From 2004 water samples have been filtered prior to Spectrophotometric analysis if turbidity and/or colour was noticed. After filtration, the samples are preserved with HNO3 and cooled until analysis is made. Details concerning monitoring practises are outlined below.

3.2. Monitoring of weather parameters

At the end of November 2000 an automated weather and hydrological station was established at the research site. Since then there has been a continuous recording of the precipitation (tipping bucket precipitation gauge), air temperature, relative air humidity, wind speed and wind direction. The automated sampling is run in cooperation between the Icelandic Meteorological Office and the National Energy Authority.

Values for the weather parameters are measured by frequency of 1Hz and is recorded every 10 minutes and with an hourly transmission by cellular phone to the Meteorological Office where the values are stored in a database. The values recorded are 10 minutes averages of wind speed and wind direction together with the highest gust (1s) observed over the last 10 minutes. For temperature the last 1 min average is recorded together with the maximum and mininum 1 min average last 10 min. For humidity the last 1 min average is recorded.

Table 3.1 A list of parameters measured in accordance with the IM programme at Litla-Skard.

Parameter	Running water (RW)	Ground-water (GW)	Precipitation (PC, AM)	Unit	IM code
Calcium	x	x	x	mg/l	CA
Magnesium	x	x	x	mg/l	MG
Potassium	x	x	x	mg/l	K
Sodium	x	x	x	mg/l	NA
Total sulphur	x	x	x	mg/l	STOT
Aluminium	x	x	x	mg/l	AL
Iron	x	x	x	mg/l	FE
Manganese	x	x	x	mg/l	MN
Nitrate as nitrogen	x	x	x	mg/l	NO3N
Ammonium as nitrogen	x	x	x	mg/l	NH4N
pH	x	x	x		PH
Conductivity	x	x	x	microS/cm	COND
Total organic carbon	x			mg C/l	TOC
Alcalinity	x			mmol/l	ALK
Stream flow	x			L/(s*km2)	Q
Precipitation			x	mm	PREC
Temperature	x	x	x	°C	AIR
Wind speed			x	m/s	WIV
Wind direction			x	NSAV	WID

3.3. Monitoring of precipitation chemistry

In September 1996 one precipitation collector (I) was set up near the outlet of the catchment area. The collector is a white 15 l open plastic container with a bag (45 x 60 cm) of polyethylene and polyamid inside and with a polyethylene funnel on top, holding the plastic bag in place. The container fits into a frame of stainless steel with a 40 cm wide ring to reduce contamination from bird droppings (Fig. 3.2). During winter a snow collector is used. This is the same equipment except a funnel with a wider bottom (15 cm) is used. For data sampling we used CR10x measure module from Campbell Sci. Despite these precautions occasional contamination from birds was found. Therefore the existing equipment on the collector was improved with bird deterring "crowns" and an additional collector set up (precipitation collector II). Later, inner "crowns" were added on both collectors.

The collectors have been sampled monthly and the amount of precipitation measured and analysed for the following: Ca, Mg, K, Na, Cl, pH, specific conductivity, NH_4 and NO_3. In addition S has been analysed in samples taken from November 1997.

Fig 3.2 Precipitation collectors with bird deterring "crowns".

3.4. Monitoring of stream water hydrology and chemistry

In June 1996 a 60° triangular sharp crested weir dam was established at the runoff outlet of the catchment area in order to measure the runoff (Fig. 3.3). During the first winter there were some water flow disturbances due to ice formation on the dam. Therefore a 2.6 m wide isolated roof was built over the dam in order to reduce disturbance by ice (Fig. 3.4) (Magnússon et.al. 1999).

From January 1997 stream water samples have been taken once a month for analysis of Ca, Mg, K, Na, Cl, P, S, Al, Fe, Mn, pH, specific conductivity, total alkalinity, NH_4 and NO_3.

Fig 3.3 The dam in 1996

Fig 3.4 The dam in 2002

At the end of October 1996 devises for automatic recording of the runoff were set up. They did not function properly. In November 1997 the Hydrological Service of the National Energy Authority in Iceland started continuous recording of the water level in the pool behind the weir. From that time a continuous record of runoff is available. The measuring device is a pressure transducer connected to a datalogger recording the instantaneous water level once every hour. At the end of November 2000 when automated weather and hydrological station was established a new pressure transducer was set up in the pool behind the dam. These devices together with an automatic weather station with a tipping bucket precipitation gauge, were connected to a multiple channel, programmable data logger. Since then there has been a continuous recording of the following environmental parameters:

- Water level, from which the runoff is calculated
- Electrical conductivity of the stream water
- Running water temperature
- Precipitation
- Air temperature
- Relative air humidity
- Wind speed
- Wind direction

The data is available on the internet at the site www.ust.is/litla_skard.

The pressure transducer is checked every month during the monthly sampling of chemical data by measuring the water level with a meter stick from a bench mark with a given height. This is very important and gives more secure water level data.

3.5. Monitoring of groundwater chemistry

Groundwater at Litla-Skard is sampled from a well (Fig. 3.5). In order to make the sampling more easy, especially during wintertime, the soil above the well was dug up and a 150 cm long and 100 mm wide polypropylene-plastic pipe put in a vertical position over the well.

From that pipe the water is led about 20 m downslope through 4 cm wide black polyethylene-plastic pipe were it is sampled. The water has been sampled monthly, starting in November 1997 and has been analysed for the following parameters: Ca, Mg, K, Na, S, Al, Fe, Mn, pH, specific conductivity and NO_3.

Fig. 3.5 Photos showing the groundwater well (left) and the accompanying overflow runoff (right).

3.6. Heavy metals in mosses

As a part of an international survey on atmospheric heavy metal deposition the moss species *Hylocomium splendens* has been sampled in Iceland at five years interval, starting in 1990 (Rühling et al. 1992, Rühling and Steinnes 1998, Harmens et al. 2004. In Litla-Skard one composite moss sample has been taken within the catchment area at each sampling occasion. Compared to other sites in Iceland the concentration of heavy metals in Litla-Skard is low, especially for the years 1990 and 2000 (Table 3.2). However, it should be noted that values of some heavy metals are generally higher in Iceland than in the other Nordic countries, especially iron and vanadium but also chromium, nickel and copper (Rühling et al. 1992, Rühling and Steinnes 1998). The values are particularly high within the volcanically active zone crossing the country in the southwest–northeast direction and are probably due to high volcanic ash and soil dust in this area (Fig. 3.6). The concentration of lead and zinc is on the other hand significantly lower in Iceland than in the other Nordic countries. Therefore the heavy metal values from Litla-Skard indicate low human influence at the site.

Table 3.2 Minimum, maximum and medium concentration of heavy metals (µg/g) in *Hylocomium* moss in Iceland in 1990, 1995 and 2000 compared to the concentration in moss at Litla-Skard. Number of samples is denoted with n.

Year		n		Cd	Cr	Cu	Fe	Hg	Ni	Pb	V	Zn
1990	Iceland	106	Min	0.00	0.42	2.74	452		0.60	0.00	2.12	9.71
	Iceland	106	Max	2.22	24.23	57.55	15923		25.38	13.89	60.02	43.62
	Iceland	106	Med	0.41	2.33	8.42	3187		2.59	1.88	12.15	18.24
	L-Skard	1		0.11	0.89	3.99	1267		1.16	1.48	4.29	15.89
1995	Iceland	110	Min	0.01	0.26	3.18	594	0.06*	0.65	0.20	0.87	7.38
	Iceland	110	Max	0.83	11.87	32.80	18600	0.18*	24.10	45.79	48.20	91.50
	Iceland	110	Med	0.22	2.36	8.09	2877	0.00*	2.96	0.99	11.30	17.15
	L-Skard	1		0.36	5.43	12.50	6630	0.06	6.23	1.91	17.10	54.20
2000	Iceland	124	Min	0.02	0.48	3.64	1008	0.00	1.06	0.39	2.94	11.39
	Iceland	124	Max	0.50	12.71	35.81	19215	0.16	33.30	45.71	34.67	246.02
	Iceland	124	Med	0.05	2.61	8.36	4073	0.04	3.32	1.47	11.95	27.72
	L-Skard	1		0.06	1.16	5.13	1880	0.01	1.70	0.99	5.60	23.70

* Based on 30 samples.

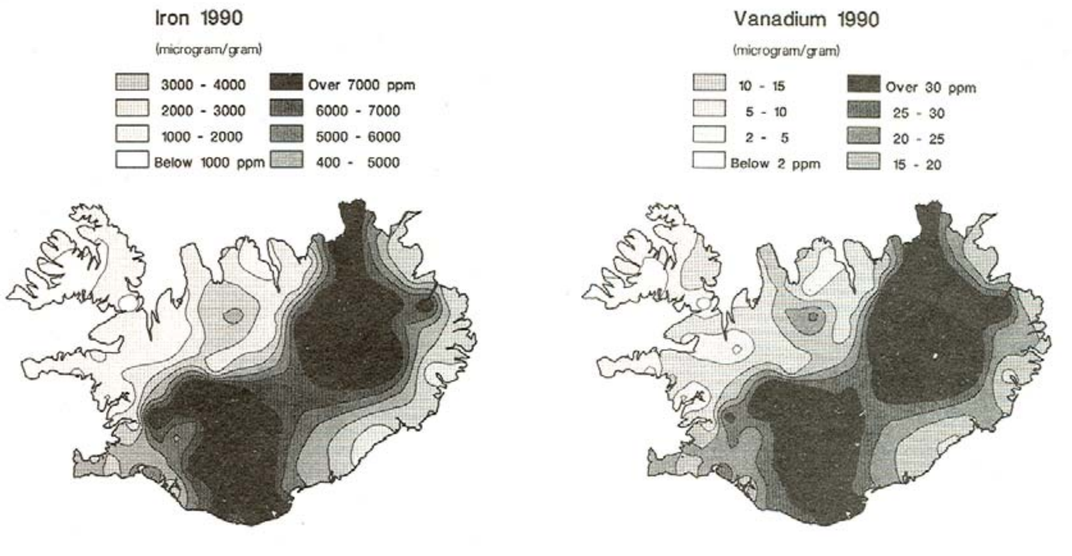


Fig 3.6 Concentration of iron (Fe) and vanadium (V) in moss in Iceland (from Rühling et al. 1992).

3.7. Data handling

All water samples for chemical analysis are collected monthly and brought to the Centre for Chemical Analysis at Keldnaholt in Reykjavik.

The automatic data logger is equipped with a telephone and the data are automatically collected once every day and sent to the office of the Hydrological Service and the weather data to the Icelandic Meteorological Office, where they are stored in a database. The data logger measures each parameter every 5 seconds and then a running average over one minute is calculated. This average value is stored in the data logger at the end of each hour. In addition to that, for the air temperature and the water level, the value of the highest and the lowest one minute average occurring during the particular hour, together with hourly average is stored in the data logger.

The purpose of the triangular weir is to be able to calculate the discharge and runoff using a formula for triangular sharp crested weir. The formula is of the following type:

$$Q = C \cdot \tan(\theta/2) \cdot (W - W_0)^{2,5}$$

Q is the discharge in L/s, θ is the angle the sides of the weir make at the vertex, W is the water level, W_0 is a parameter representing the water level at which the discharge is zero and C is a scaling parameter depending on friction, the acceleration of gravity and the units used.

For the particular weir at the Litla-Skard station the angle θ is 60° and the local water level scale is set to 100 cm at the vertex. In order to determine the two parameters C and W_0 a series of six discharge measurements have been made at different water levels at the station and these data fitted to a curve of the form in the equation above. The result can be seen in Figure 3.7 and the rating curve formula is:

$$Q = 0{,}006597 \cdot (W - 99{,}4)^{2,5}$$

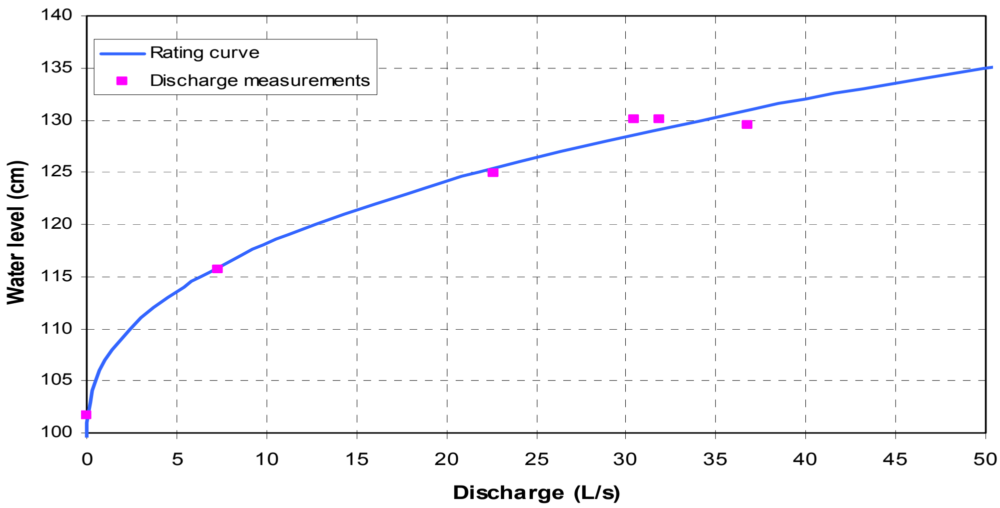


Figure 3.7 Rating curve for the triangular weir.

The water level W is measured in cm. As can be seen from the Figure 3.7 there is a good fit for the three lowest discharge measurements but there is a greater spread for the higher measurements although the curve fits reasonably well also for the higher discharges. This implies that there is good reason to believe that the discharge and runoff are fairly accurately determined from the water level data.

All collected raw data is sent to the Environment and Food Agency where all Icelandic IM monitoring data is stored, processed and forwarded to the ECE Integrated Monitoring project databank in Helsinki.

For the purposes of this report all data records were carefully looked over and any polluted or suspicious data records have been left out of graphs and tables, unless otherwise noted.

4. RESULTS AND DISCUSSION

4.1. Meteorology

AIR TEMPERATURE.

Temperature measurements were made at 2m height above ground with PT100 platinum sensor. Table 1 shows the monthly average temperatures. In tables 2 and 3 the extreme temperatures are shown, maximum and mininum respectively. Data for May 2001 and April–August 2004 are missing. The mean annual temperatures for 2002 and 2003 are 4.3 and 5.1°C respectively.

Table 4.1 Average monthly temperature, °C

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	-0.1	-2.2	-3.5	1.0		8.0	9.7	10.2	8.4	5.1	-0.2	1.0
2002	-0.4	-5.1	-1.6	2.8	5.8	10.4	10.3	9.9	8.9	4.3	3.3	3.1
2003	-0.4	1.1	2.2	5.2	5.9	11.1	12.3	12.6	7.2	4.0	1.3	-1.5
2004	-2.1	0.1	2.9						8.4	2.9	-0.5	-2.9

Table 4.2 Maximum temperature of the month, °C

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	9.8	7.3	4.1	9.6		19.7	17.0	17.9	15.9	13.5	11.1	11.7
2002	10.4	7.7	9.1	12.8	18.3	21.8	19.6	17.6	20.2	17.6	11.6	11.9
2003	7.9	12.2	11.0	14.6	16.9	20.2	25.3	20.8	17.4	15.6	11.8	7.8
2004	8.5	9.5	10.1						16.2	11.6	10.9	7.1

Table 4.3 Minimum temperature of the month, °C

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	-12.0	-14.7	-17.2	-10.4		-1	0.0	1.8	-0.9	-7.7	-16.1	-15.2
2002	-15.6	-16.4	-16.1	-6.5	-5.8	1.0	0.0	0.0	-0.1	-10.1	-10.1	-7.6
2003	-12.1	-13.4	-14.2	-5.3	-8.2	3.7	5.4	3.7	-5.7	-8.1	-12.1	-16.4
2004	-14.7	-17.3	-8.5						-2.3	-9.2	-19.8	-18.5

HUMIDITY

Humidity measurements are made at the site. In Table 4.4 average monthly relative humidity is shown and also yearly mean. The highest humidity is in the autumn and early winter but the driest months are May and June.

Table 4.4 Average monthly relative humidity, %

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YEAR
83	83	82	79	73	76	80	83	85	83	85	87	82

WIND MEASUREMENTS.

At Litla-Skard wind is measured in a mast 10m above ground. Data is collected for 10 min average wind speeds, wind direction and maximum gust.

Table 4.5 Average monthly wind speed, maximum 10 min average of wind speed and maximum monthly gust, m/s.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YEAR
Mean	5.1	5.5	5.0	4.7	4.3	3.6	3.2	3.2	3.7	4.0	4.4	4.2	4.2
Max	22.6	23.9	16.9	17.2	13	16.5	10.8	10.8	17.8	14.8	19.8	18.1	23.9
Gust	30.4	33.5	23.1	23.9	18.5	25.7	16.8	15.7	26.3	21.5	26.7	27.5	33.5

During these four years the highest wind speed has been in February and the lowest wind speed in July and August. The main axis of the wind flow is along the valley. Comparison with the windrose from Ás í Melasveit (see Annex 1) which is sited in more open landscape, demonstrates clearly how affected by landscape the wind climate of Litla-Skard is almost all the easterly component turns into the northeasterly direction of the valley. The highest wind speed turns out to be in the low frequency north and south directions.

PRECIPITATION

Monthly sampling of precipitation for chemical analysis is a part of the measuring programme. The quantity of precipitation for each sampling period is recorded but the periods are variable in length as weather and holidays make it impossible to measure on exactly a monthly basis. In table 6 we have the result of the monthly measurements. March 2001 was exceptionally dry in the southwestern part of Iceland. Normally there is a great variation in precipitation between years and the spring months are usually the driest time of the year. The months June and January are the driest while September and November are on average the wettest.

Table 4.6 Monthly precipitation, mm.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YEAR
2001	46	76	7	18	92	49	85	40	88	75	162	78	817
2002	56	29	57	84	27	32	82	151	151	35	37	56	797
2003	45	73	85	54	16	57	60	78	126	57	39	162	852
2004	43	73	83	56	112	32	64	23	122	98	197	92	995

4.2. Precipitation chemistry

Sampling and chemical analysis of precipitation has been done in accordance with the IM programme manual. Particular emphasis is on quantifying acidifying compounds and nutrients.

At Litla-Skard, monthly precipitation data has been collected since November 1996. Because of contamination from bird droppings an additional sampler was set up in October 1997. The problem persisted until both samplers were redesigned in May 2003.

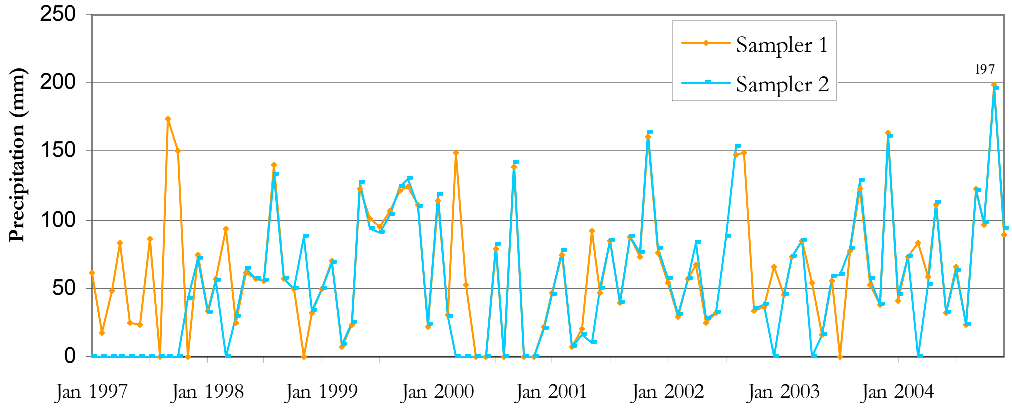
Major components have been analysed in all samples as well as aluminium and manganese from Jan 2001. The series[1] are presented in Table 4.7 and in Figures 4.1 - 4.15. Unfortunately trace element results in 2004 could not be included due to suspected data error.

Table 4.7 A summary of precipitation chemistry results.

			Cl	**Na**	**Mg**	**Ca**	**K**	**S(tot)**	**NO3-N**	**NH4-N**	**Cond**	**Al**	**Mn**
	mm	pH	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µS/cm	µg/l	µg/l
Maximum	197.1	7.00	29.7	25.76	1.99	1.65	1.42	3.06	0.91	0.40	110.9	564	22.7
Average	71.5	5.20	6.6	3.80	0.48	0.23	0.20	0.47	0.07	0.06	28.8	121	3.7
Median	62.5	5.18	3.9	2.52	0.34	0.19	0.14	0.38	0.05	0.04	20.4	65	2.5
Minimum	4.0	4.05	0.2	0.08	0.01	0.01	0.01	0.01	0.01	0.01	1.6	1	0.8

[1]Omitting the first two samples (as a pilot experiment) for easier annual presentation.

Precipitation amount appears inconsistent in Figure 4.1, showing measurements from both samplers including rejects but Figure 4.2 shows the best estimate: average where possible, leaks are excluded and measurements from a nearby station (Stafholtsey) when both samplers proved unreliable[2]. Precipitation amount is usually greatest in late autumn and is about 70mm on the average (see Tables 4.6 and 4.7).



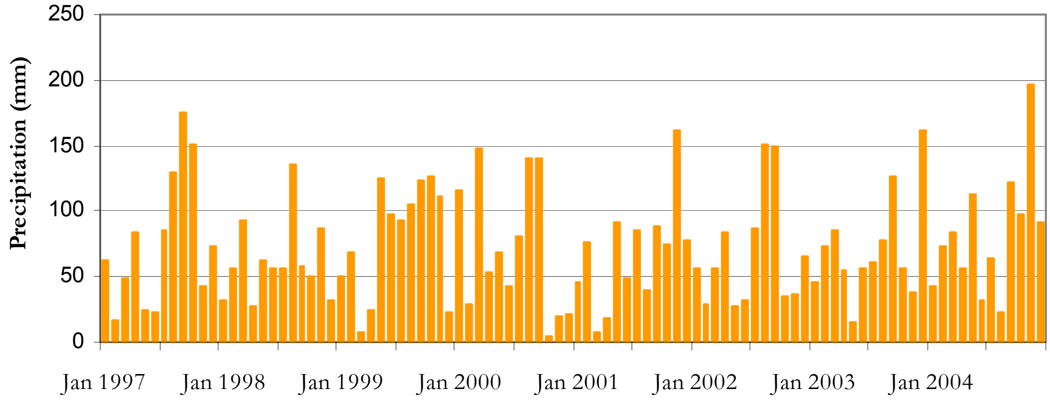


Figure 4.1-4.2 Precipitation amount, data from both samplers (upper) and best estimate (lower).

Measurements of monthly pH in precipitation samples are not reliable because dry deposition can alter pH as well as carbon dioxide in air, especially when measured after storage. This is reflected in Figure 4.3 but a clearer picture is given in Figure 4.4 presenting all samples relative to pH 5.6 which is the pH of precipitation in equilibrium with atmosphere. Three marked samples are probably contaminated, possibly with soil dust although parallel sample from the other sampler seems unaffected. pH values ranging from 5.6 - 4.0 may reflect the effect of sulphate or other acidifying components in precipitation. Apparent lowering of pH values during the first two or perhaps three years is illusionary and can only be contributed to a change in the measuring technique (Annex 8).

[2]April 1997 and May, June, August, October, November 2000.

Chloride and sodium in precipitation, as well as magnesium, stem from sea-spray. These elements inter-correlate (Figures 4.5 - 4.7) and show consistent summer lows and winter peaks indicating winter storms which absorb much sea-spray over the ocean, to be carried far inland and deposited there, dissolved in rain, sleet or snow.

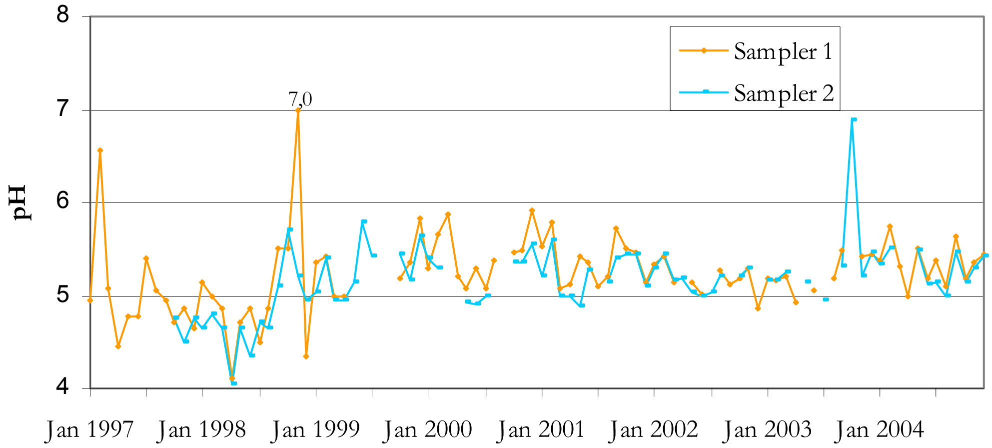


Figure 4.3 pH of precipitation – overview of the monitoring period 1997-2004.

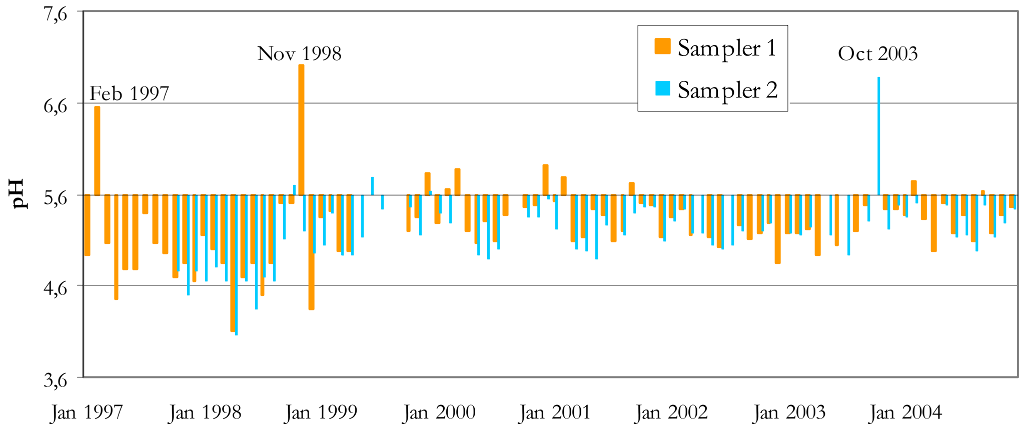


Figure 4.4 pH of precipitation relative to pH 5.6 – overview of the monitoring period 1997-2004.

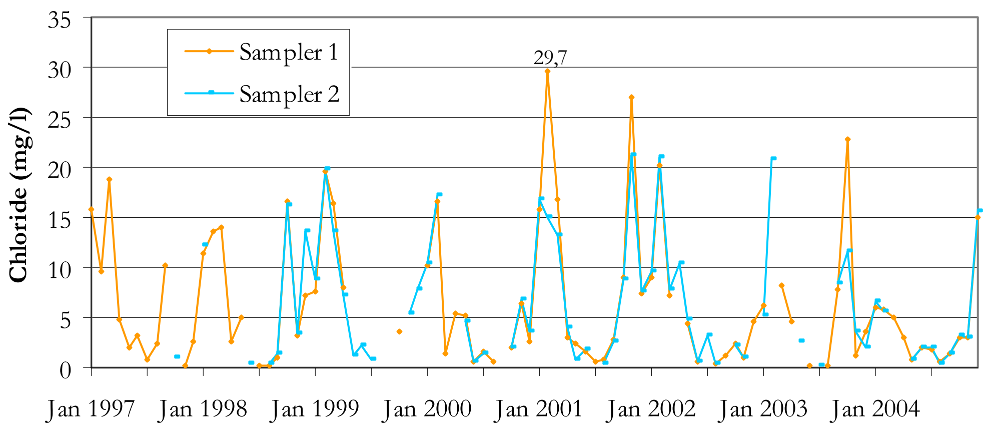


Figure 4.5 Chloride (Cl) in precipitation – overview of the monitoring period 1997-2004.

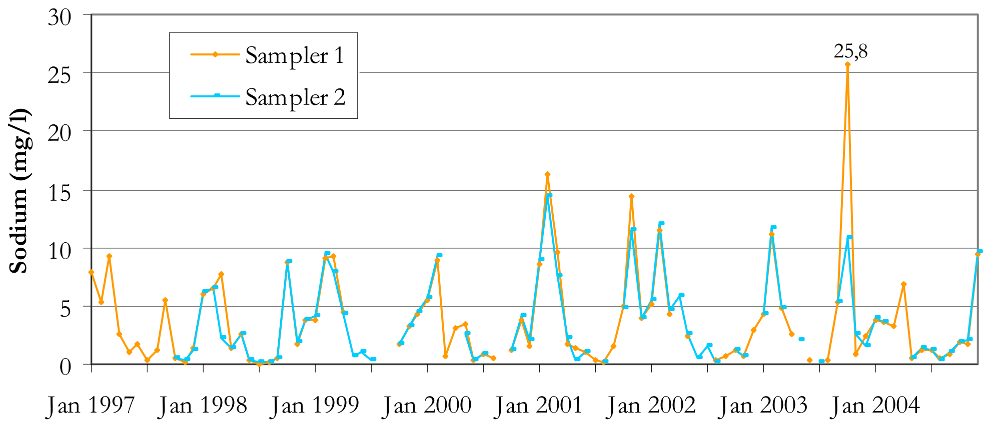


Figure 4.6 Sodium (Na) in precipitation – overview of the monitoring period 1997-2004.

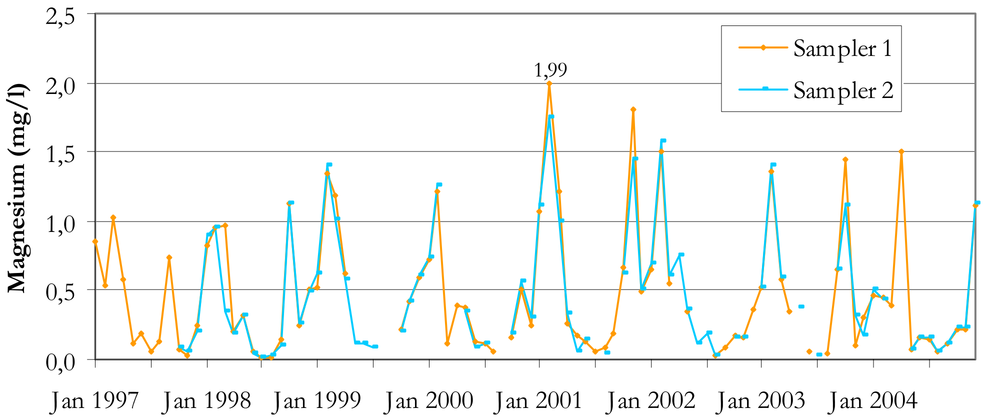


Figure 4.7 Magnesium (Mg) in precipitation – overview of the monitoring period 1997-2004.

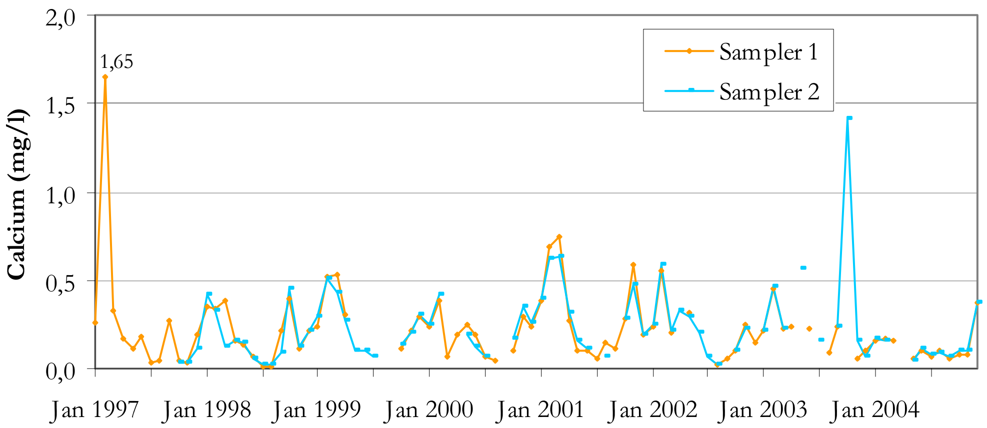


Figure 4.8 Calcium (Ca) in precipitation – overview of the monitoring period 1997-2004.

Calcium (Figure 4.8) correlates with these elements to a lesser extent which can be explained by the fact that it can originate from both the sea and from rock- or soil dust. The highest calcium peaks, in early 1997 and late 2003, are the same as those marked in Figure 4.4.

Potassium and sulphur show erratic variability which is hard to interpret, sometimes seeming to follow calcium and sometimes the sea elements, while the nitrogen does neither (Fig. 4.9

and 4.10). Sulphur may be partly derived from the low temperature geothermal fields in Reykholtsdalur, 15 km southeast of Litla-Skard.

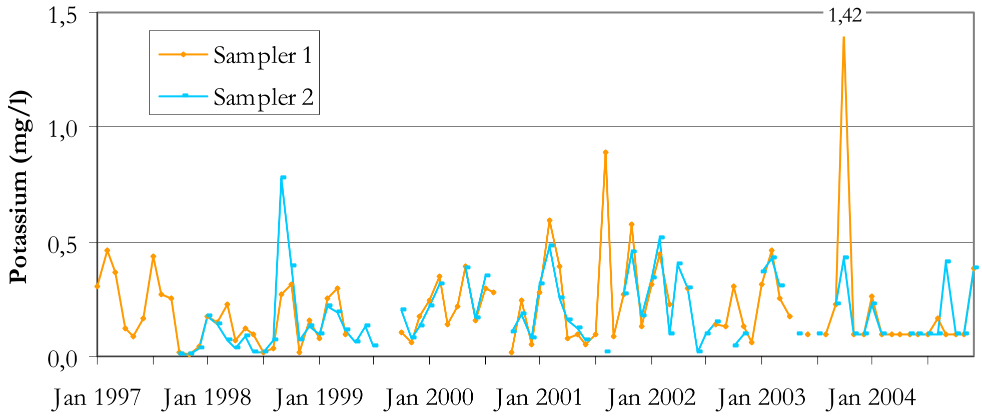


Figure 4.9 Potassium (K) in precipitation – overview of the monitoring period 1997-2004.

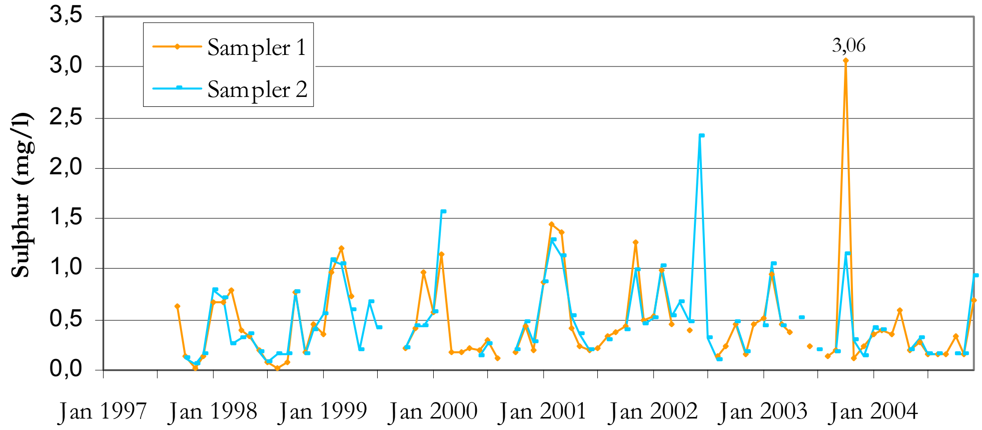


Figure 4.10 Sulphur (total S) in precipitation – overview of the monitoring period 1997-2004.

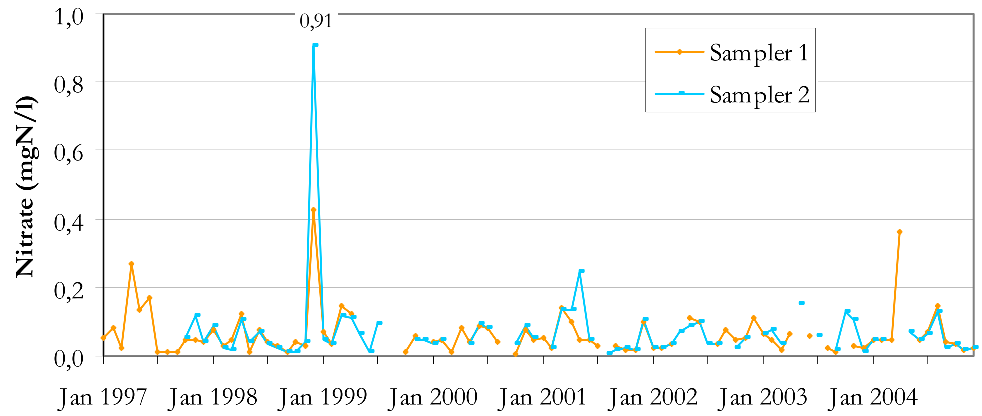


Figure 4.11 Nitrate in precipitation – overview of the monitoring period 1997-2004.

Iron measurements were unreliable and rejected. It is considered unlikely that elements measured in precipitation at Litla-Skard other than nitrate and ammonia (Figures 4.11 and 4.12), might have undergone long-range transport, e.g. from Scandinavia.

Conductivity (Figure 4.13) reflect the quantity of ions in each sample and the conductivity trend echoes clearly those ions which are of highest concentration, namely Na and Cl.

Aluminium and manganese results are only recently available from Litla-Skard (Figures 4.14 and 4.15). Al and Mn trends show only slight resemblance to calcium. Al is an important component of rock, soil and clay whereas Mn substitutes for iron in crystal lattices.

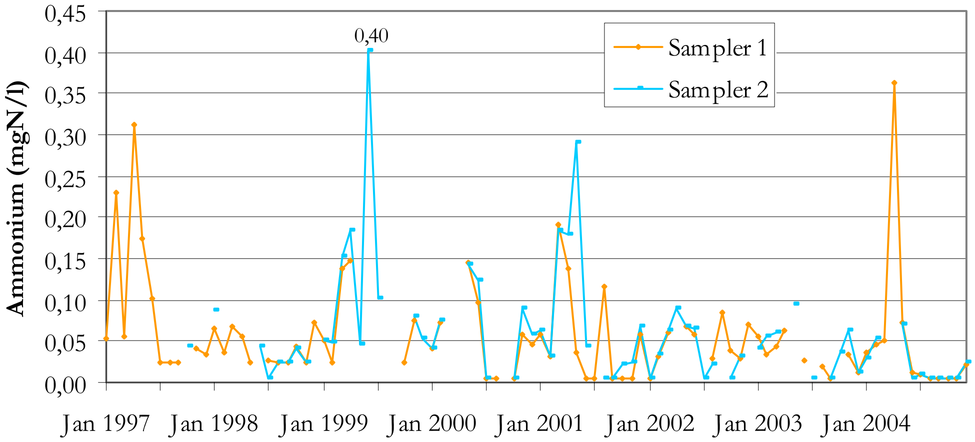


Figure 4.12 Ammonium in precipitation – overview of the monitoring period 1997-2004.

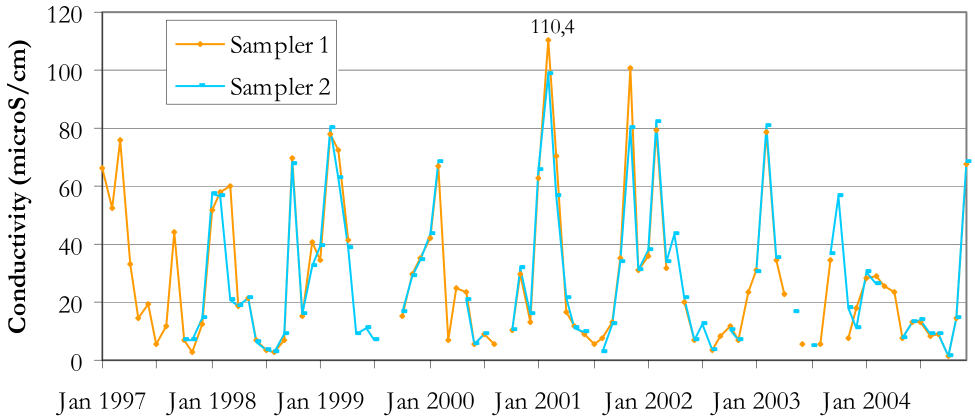


Figure 4.13 Conductivity in precipitation – overview of the monitoring period 1997-2004.

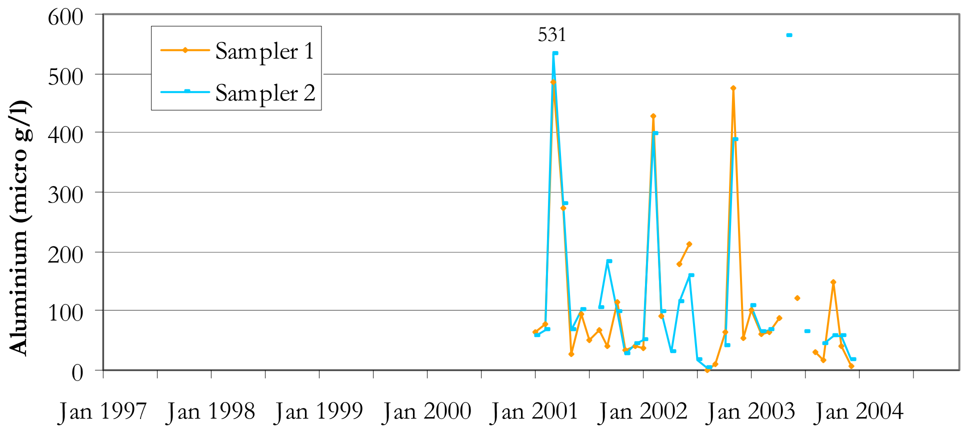


Figure 4.14 Aluminium in precipitation – overview of the monitoring period 2001-2004.

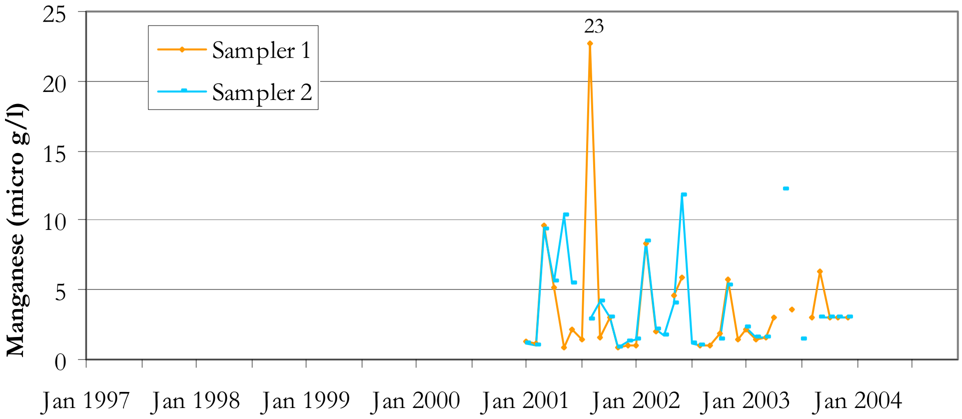


Figure 4.15 Manganese in precipitation – overview of the monitoring period 2001-2004.

4.3. Groundwater chemistry

Groundwater is defined as subsurface water, which occurs in the water saturated zone of bedrock and ground layers. Groundwater is not a major factor in the hydrology of the Litla-Skard catchment area. This assumption can be derived in at least two ways. Firstly the bedrock is among the oldest found in Iceland, from the upper Tertiary, which is not suspect to strong fluxes of chemicals to groundwater, especially in the moderate climate at Litla-Skard. Secondly there is a clear relationship between air temperature and stream water temperature (Fig. 4.16), suggesting that the amount of groundwater, which is normally colder than air in summer months, is not sufficient to balance temperatures of runoff from the catchment area.

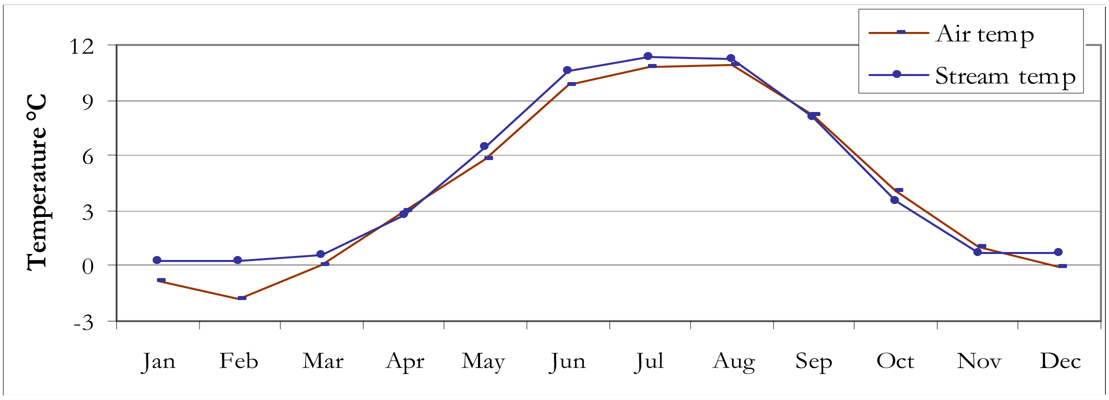


Figure 4.16 Comparison of air temperature and tempereature in runoff stream.

4.4 Monitoring of stream runoff hydrology

Runoff measurements started at Litla-Skard in October 1996 when a triangular sharp crested weir dam was established at the runoff outlet of the research area in order to measure the stream runoff.

The runoff (or specific discharge) is calculated from the discharge data by dividing the discharge by the area of the watershed, which in the case of Litla-Skard is exactly 0.555 km^2, and this gives the runoff in L/(s·km^2). However, it is also possible to convert this unit to mm/time and thereby compare the runoff directly to the precipitation data. The tables below give the results for the monthly runoff, first the monthly average and then the highest and the lowest instantaneous discharge in the particular month.

Table 4.8 The average runoff for each month during the measuring period Nov 1997 - Dec 2004.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1997											31.5	34.5	
1998	5.28	10.3	32.9	20.9	26.8	2.66	10.8	24.4	14.2	15.4	16.6	24.7	17.2
1999	11.2	31.8	1.15	37.9	47.4	27	19	15.5	34.1	40.9	43	2.82	25.8
2000	86.2	5.32	56.3	24.4	34.5	4.16	19.1	11.2	32.3	16.8	1.17	0.82	24.6
2001	24	31.2	0.76	22.7	34	9.25	12.1	2.53	22.2	23.4	73.1	37.2	24.2
2002	48.1	0.04	13.4	70.6	9.7	3.82	11.7	43.3	51.7	12.2	9.88	31.3	25.6
2003	9.69	57.8	53.4	53.7	1.4	1.18	1.46	12	47.8	28.4	19.3	67.7	29.2
2004	9.01	66.6	48.1	46.7	30.6	4.63	1.38	1.77	30.3	34.8	81.1	16.8	30.7
Average	27.64	29.01	29.43	39.56	26.34	7.53	10.79	15.81	33.23	24.56	34.88	25.91	25.33

Table 4.9 The maximum instantaneous runoff for each month during the measuring period Nov 1997 - Dec 2004, together with the date of occurrence.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Date
1997											186	854		
1998	28.8	196	591	61.6	56.6	8.11	83.8	312	110	52.1	149	167	591	1998.03.20
1999	261	274	47.6	398	299	125	96.4	72.1	133	261	216	8.11	398	1999.04.07
2000	854	13.4	431	167	312	35.7	125	47.6	238	96.4	6.7	9.68	854	2000.01.16
2001	176	384	9.68	117	110	39.5	52.1	6.7	72.1	83.8	737	447	737	2001.11.09
2002	205	0.54	353	312	28.8	20.2	61.6	353	149	39.5	43.4	110	353	2002.03.25
2003	61.6	286	186	238	5.44	6.7	9.68	43.4	125	96.4	83.8	611	611	2003.12.16
2004	43.4	497	414	326	205	28.8	6.7	9.68	96.4	216	414	52.1	497	2004.02.12

Table 4.10 The minimum instantaneous runoff for each month during the measuring period Nov 1997 - Dec 2004, together with the date of occurrence

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Date
1997											6.7	2.58		
1998	0.88	0.04	0.13	6.7	8.11	0.29	0.29	0.54	1.89	2.58	0.13	1.33	0.04	1998.02.16
1999	0.04	0.54	0.13	0.13	9.68	6.7	1.89	0.88	8.11	6.7	4.34	1.33	0.04	1999.01.21
2000	2.58	2.58	2.58	2.58	2.58	0.54	0.88	0.88	4.34	4.34	0.04	0.13	0.04	2000.11.28
2001	0	0.13	0	0.04	8.11	2.58	2.58	0.29	1.89	4.34	8.11	1.33	0	2001.03.08
2002	0	0	0	9.68	3.39	0.29	0	6.7	15.4	0.13	0.04	4.34	0	2002.07.09
2003	0.88	1.89	5.44	2.58	0.29	0.13	0	0.88	6.7	9.68	1.89	1.89	0	2003.07.20
2004	0.88	0.13	1.33	4.34	4.34	0.88	0.04	0	0.29	0.88	4.34	1.33	0	2004.08.22

The average monthly runoff is also shown in Figure 4.17, and it is apparent that there is a great variation in the runoff as might be expected from such a small watershed. The highest monthly runoff is 86.2 L/(s·km^2) in January 2000 and the lowest monthly runoff is 0.04

L/(s·km^2), measured in February 2002. This corresponds to a cumulated monthly runoff of 231 mm and 0.1 mm, respectively.

The variation in daily runoff is much greater, where the maximum daily discharge of 611 L/(s·km^2) occurred on January 17, 2000, and a minimum daily discharge of 0 L/(s·km^2) has occurred several times during the period from November 1997 to December 2004, the first time on January 4, 2001. The maximum value corresponds to a cumulated runoff of 53 mm for January 17, 2000. This event was caused by both increasing precipitation and more importantly increasing temperature which results in a very sudden melting of snow on the ground.

It is interesting to compare the monthly values of precipitation and runoff measured in the same unit as is done in Figure 4.18 which shows average monthly values from 1998 to 2004.

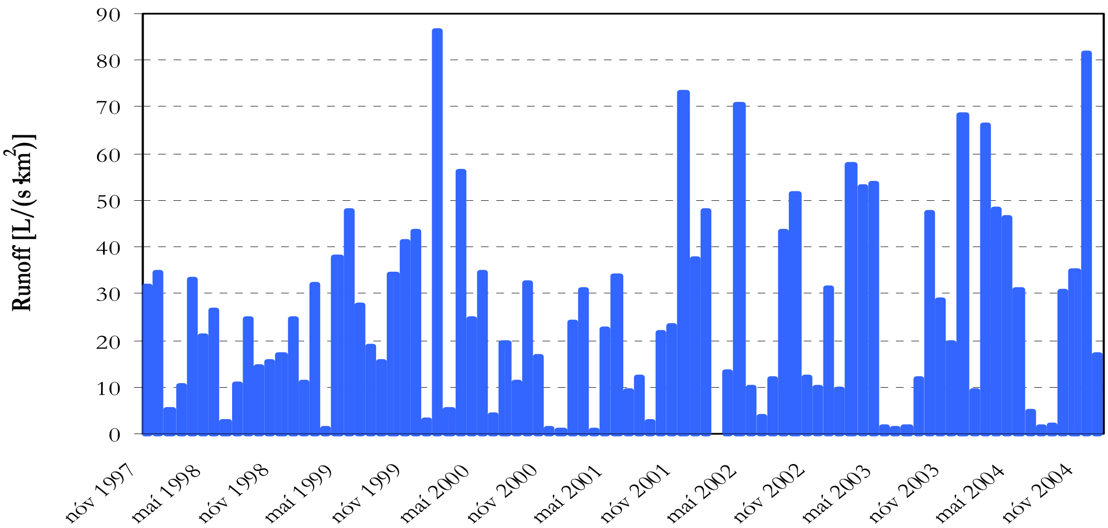


Figure 4.17 The average runoff for each month in the measuring period Nov 1997 - Dec 2004.

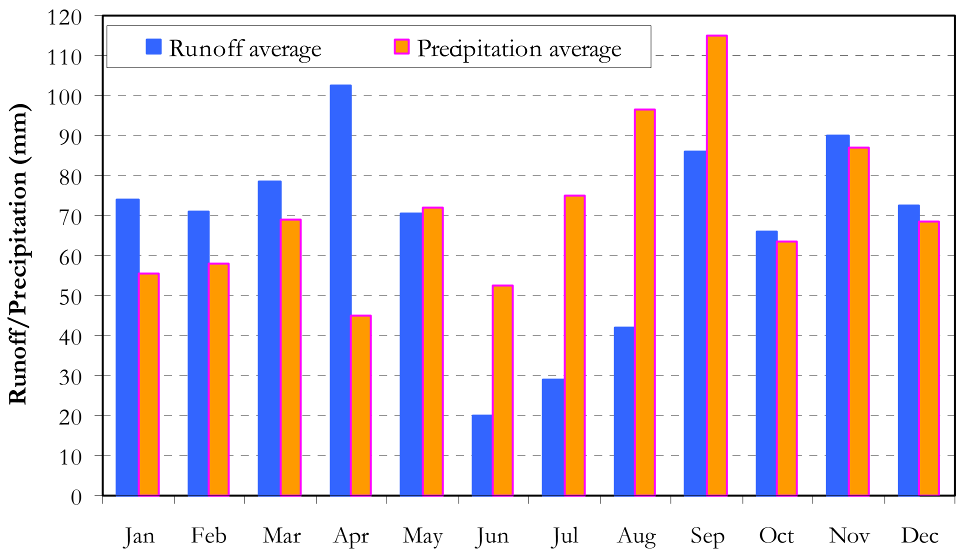


Figure 4.18 Comparison between runoff averages and precipitation averages 1998-2004, where each column represents the average over all the years for the particular month.

It is apparent that the runoff and precipitation are not distributed in the same manner throughout the year. Runoff is higher during the winter months due to occasional snow melting and more direct runoff from frozen ground. Also the precipitation is not as accurately measured during these periods since some of it may not enter the precipitation gauges due to wind. In the summer period on the other hand we see that the precipitation is greater than the runoff because infiltration, evaporation and transpiration is much greater than in the winter. Some of the water penetrates into the ground water and appears later as runoff.

The total annual runoff and precipitation compare quite well with each other as can be seen in Figure 4.19. This is to be expected since all seasonal variations are not highlighted.

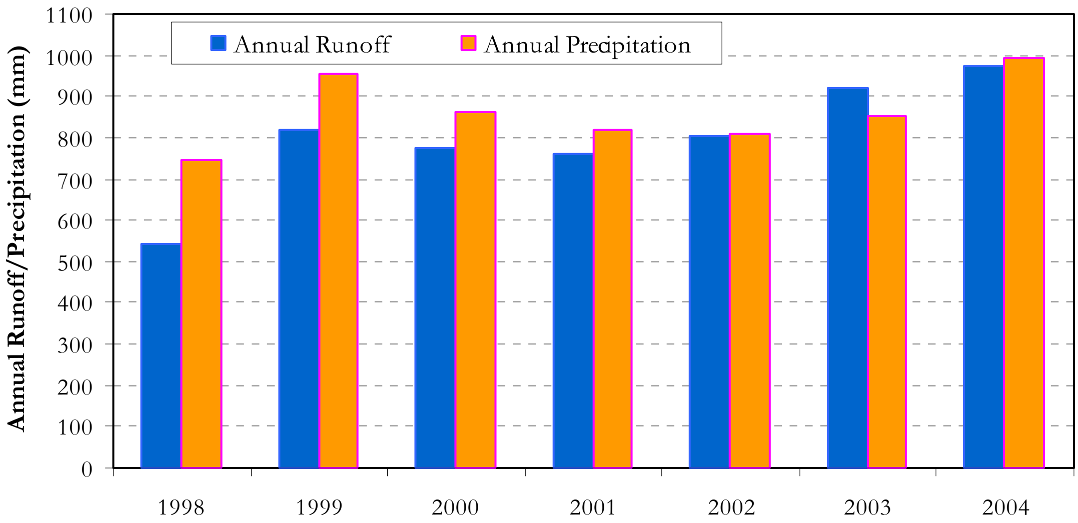


Figure 4.19 Comparison of the total annual runoff and the total annual precipitation for the years 1998-2004.

There seems to be a better agreement between total runoff and precipitation in the period 2001 - 2004 than in the period 1998 - 2000. This may be difficult to explain but one reason might be that the water level and thus the runoff is measured more accurately with the programmable data recorder that was installed in November 2000. It is also possible that the precipitation measurements are more precise in the latter period, although it is the rainwater sampling gauges that are used for the precipitation but not the tipping bucket precipitation gauge. Only in the year 2003 we see that the runoff is greater than the precipitation and this may show some inaccuracy in the data.

4.5. Chemical properties of running water

Runoff is the main output of chemicals from the catchment area. Monthly averages of runoff and precipitation shown in Figure 4.20, illustrate that snowmelt at Litla-Skard occurs in April each year, as runoff increases while precipitation does not. The figure also shows a clear uptake of water by vegetation during the summer months, where the amount of runoff is generally lower than that of precipitation. Other seasonal trends can be seen from figures in Annex 7.

In order to see an eventual seasonal variation in the monthly runoff. Figure 4.20 shows the monthly runoff plotted for each year separately together with the average over the years. This figure shows relatively clearly that the maximum runoff is due to snow melting in early spring and also a relatively high runoff in the autumn and winter periods, where as the summer months June, July and August are much drier.

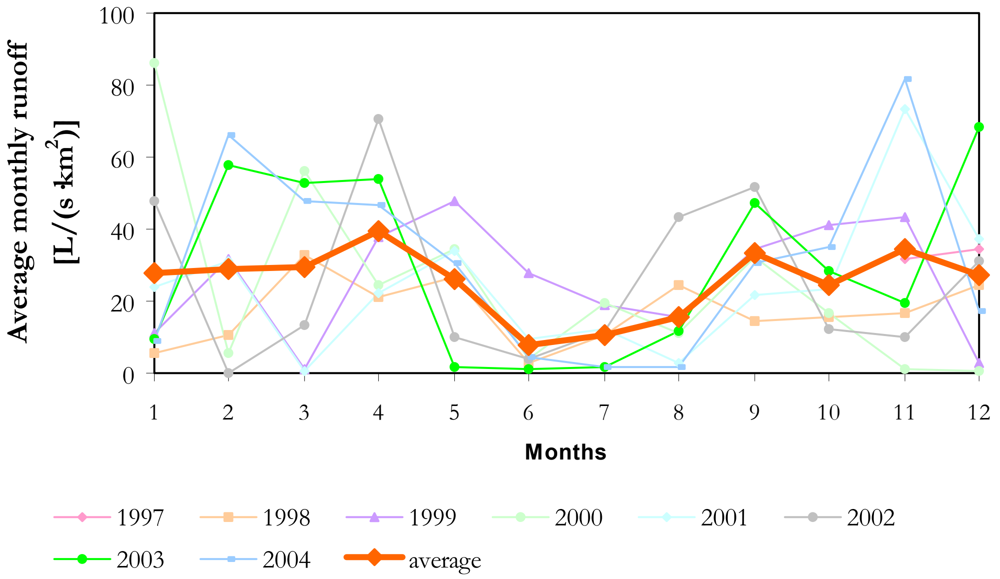


Figure 4.20 The average runoff for each month in the period Nov 1997 - Dec 2004, together with the average for each month taken over all the years.

With decreased runoff in summer, conductivity is increased. It is interesting to observe the relationship between the runoff on one hand and the electrical conductivity on the other hand. Figures 4.21 and 4.22 show the average daily runoff for the years 2000-2004 together with the conductivity. It is apparent that the usual pattern is that the conductivity decreases as the runoff increases and this is due to the fact that the water in the pool is diluted by fresh running water entering the pool at a high rate. This is especially obvious in July-August although there are also many other events showing the same pattern. As mentioned earlier there was a complete drought in the area in July 2002 and it is apparent from the figure that the conductivity increased during that period, probably because of evaporation of the water in the pool. Figure 4.23 on the other hand shows a clear correlation between conductivity and the amount of mineral salts found in the stream.

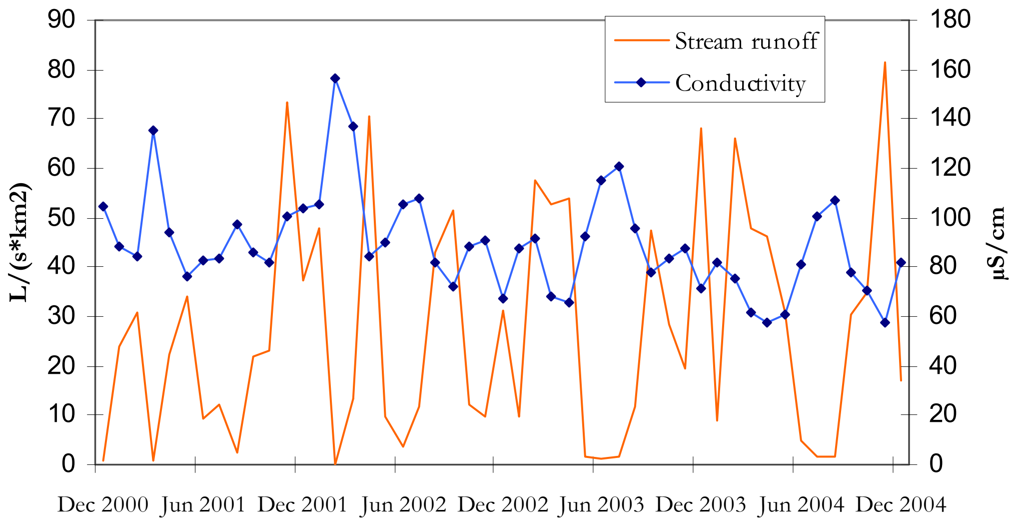


Figure 4.21 Comparing stream runoff and conductivity for the years 2000-2004.

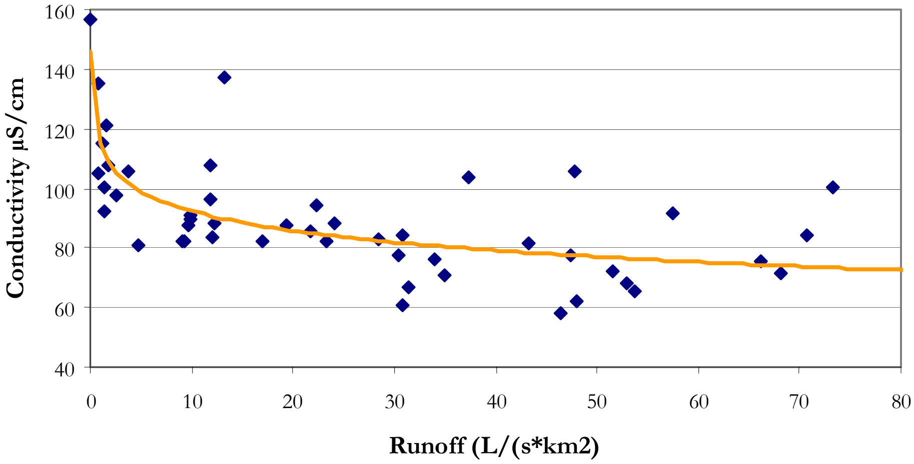


Figure 4.22 Conductivity increases as runoff decreases, data from 2000-2004.

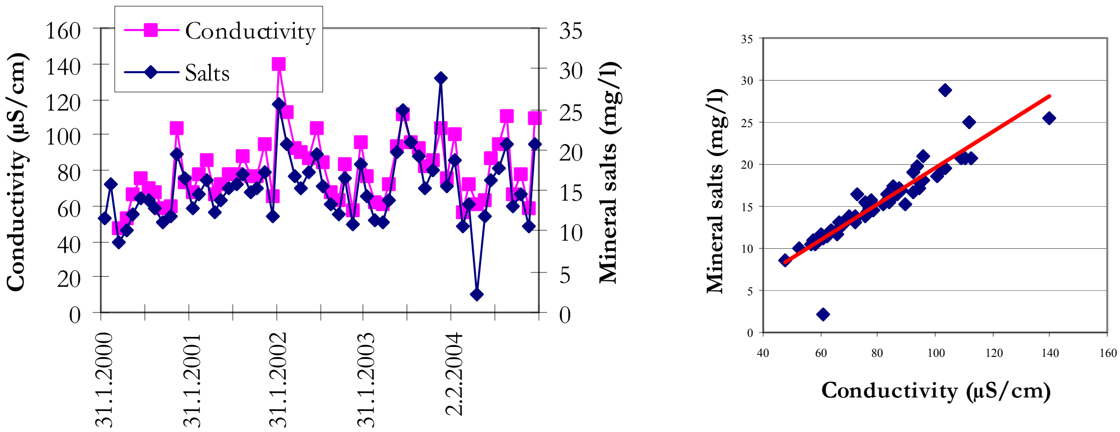


Figure 4.23 Running water conductivity and total amount of mineral salts (Ca, K, Mg and Na) from 2000-2004.

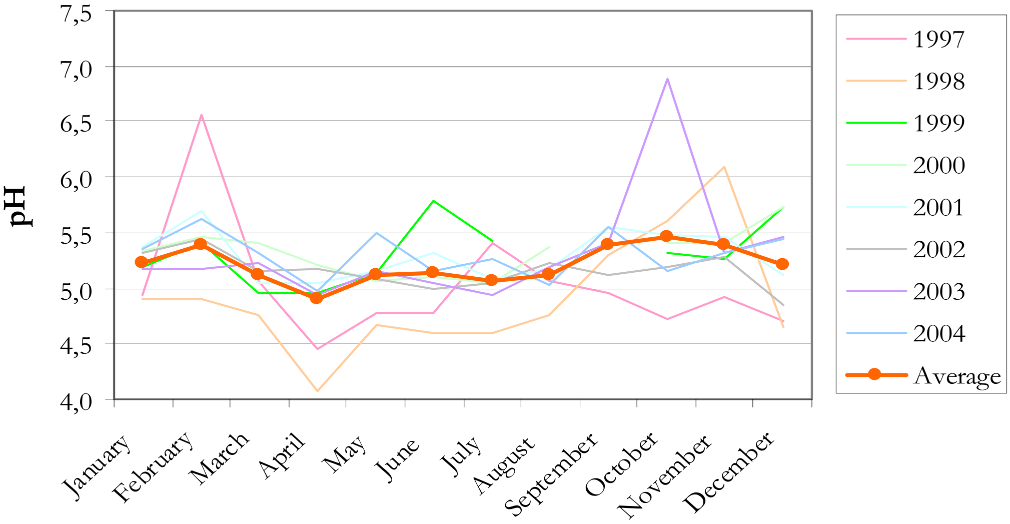


Figure 4.24 Seasonal trends of pH of precipitation – monthly averages from both samplers.

Figure 4.24 shows how pH in precipitation has mild seasonal variations while Figure 4.25 shows how pH is higher in groundwater and stream water than in precipitation. The concentration range of the elements in precipitation is best seen in Table 4.7 where the minimum and maximum values of these monthly samples are given, and the average and the median. The overall picture is as expected with Cl and Na averaging a few milligrams per litre while Mg, S, Ca and K concentration is usually just under 0.5 mg/l and N around 0.05 mg/l. Al is in fact of comparable concentration range to nitrogen but it is traditionally expressed in ppb (or micrograms per litre) for better comparison with other trace elements, such as Mn, present in few ppb only.

Calcium and magnesium in stream water are mainly originated from soils within the catchment area, as there are clearly lower levels of these in precipitation (Fig. 4.26 and 4.27).

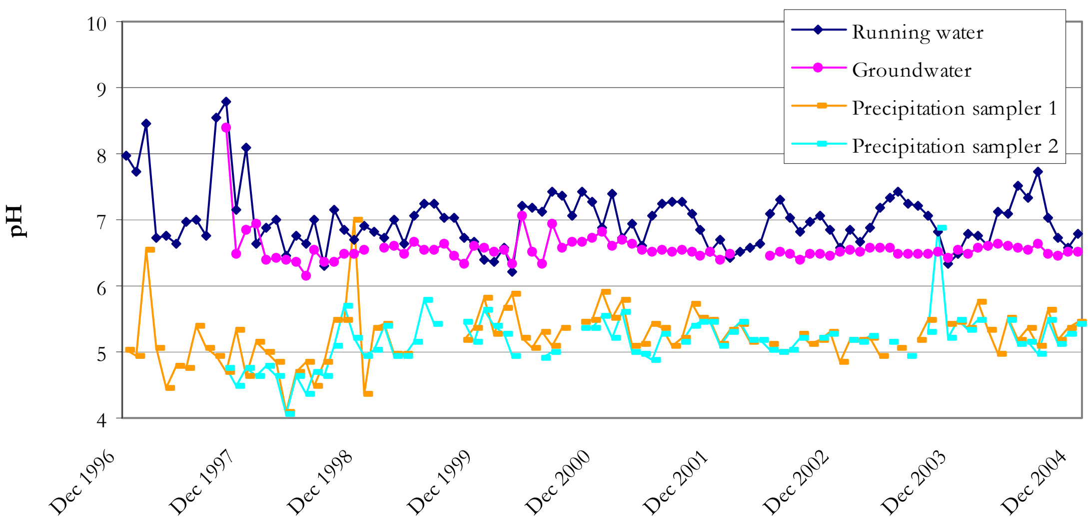


Figure 4.25 pH measured in precipitation, groundwater and running water.

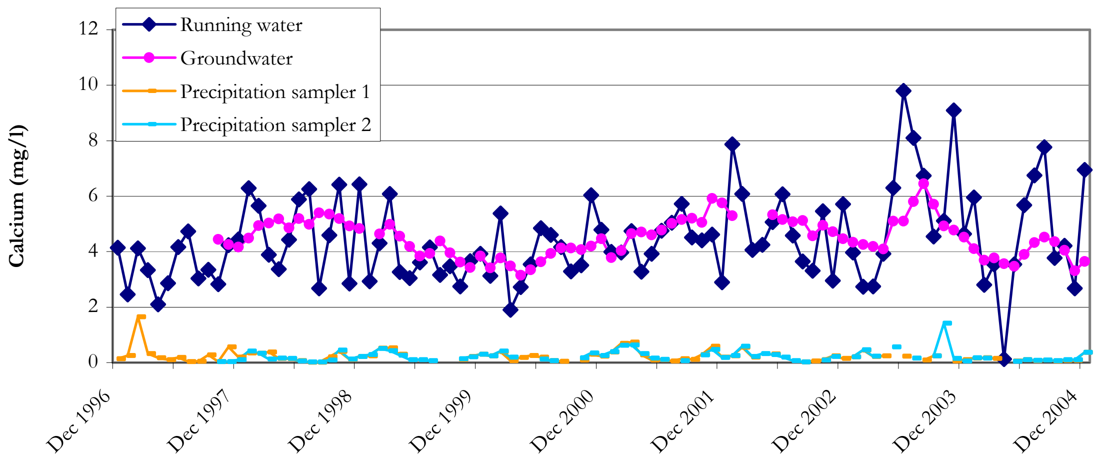


Figure 4.26 Amounts of calcium (Ca) found in precipitation, groundwater and running water.

Heavy metals in running water are derived from the dissolution of basalts (Gislason et.al. 1996). This is in accordance with findings at Litla-Skard, where iron (Fe) and manganese (Mn) are mainly found in groundwater and running water, but not in precipitation (Fig. 4.28 and 4.29). From figures in Annex 7 it is apparent that monthly averages do not give a conclusive hint of what may be the source of these metals, but since samples for chemical analysis are not filtered the high peaks may be due to silt or dust particles in the samples, affecting the monthly averages.

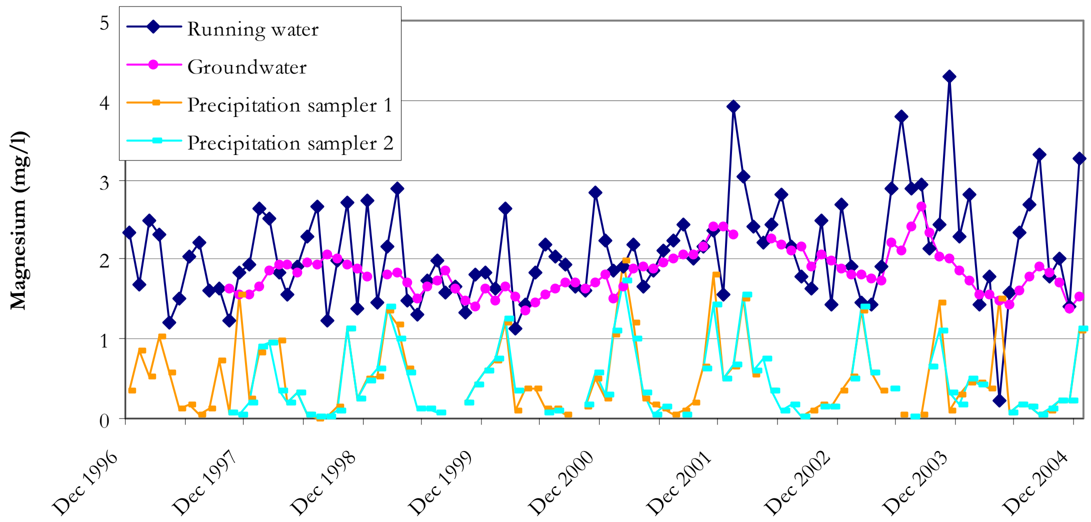


Figure 4.27 Amounts of magnesium (Mg) found in precipitation, groundwater and running water.

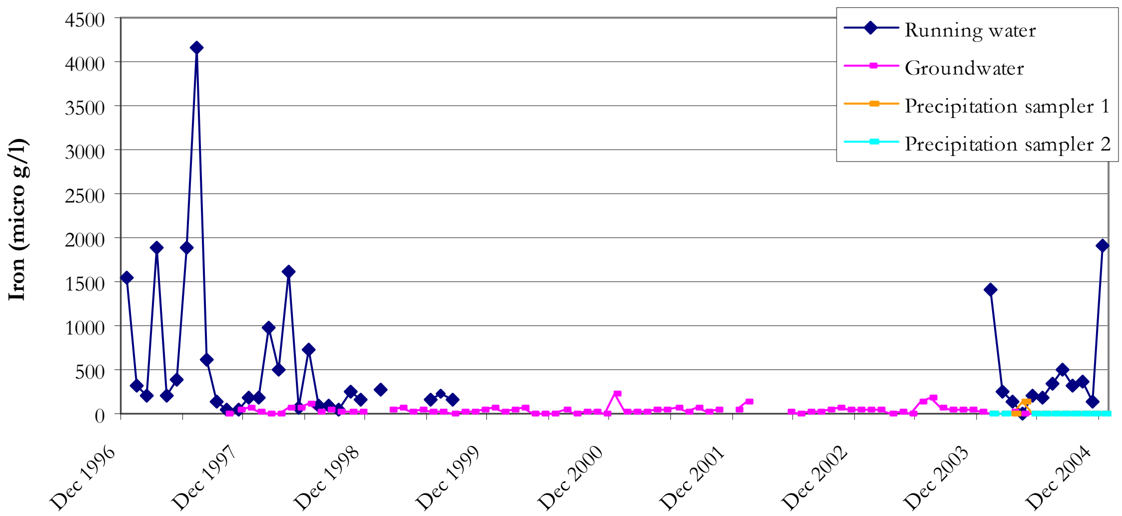


Figure 4.28 Amounts of iron (Fe) found in precipitation, groundwater and running water.

Aluminium (Al) is harder to interpret (Fig. 4.30). On several occasions there have been a high influx of Al in the precipitation. The source of this airborn aluminum is not known. One possibility is the aluminium factory in Hvalfjordur, some 50 km south of Litla-Skard.

Chloride (Cl) and sodium (Na) originate mostly from sea spray via wind and precipitation (Sigurdsson & Einarsson 1988). In Litla-Skard however it is apparent from Figures 4.31 and 4.32 how influxes of these salts in precipitation over the catchment area are gradually moved from the soils in the groundwater and the running water.

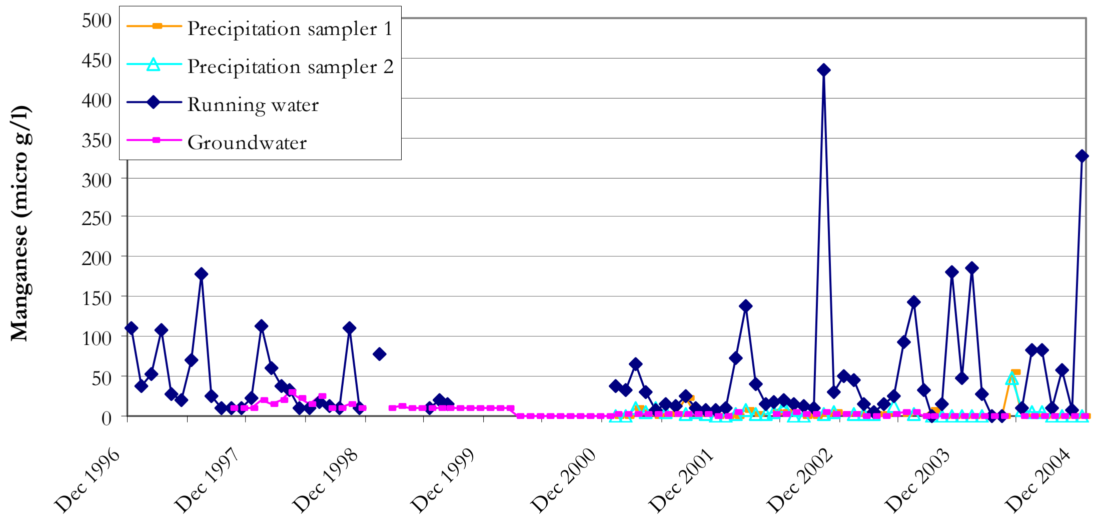


Figure 4.29 Amounts of manganese (Mn) found in precipitation, groundwater and running water.

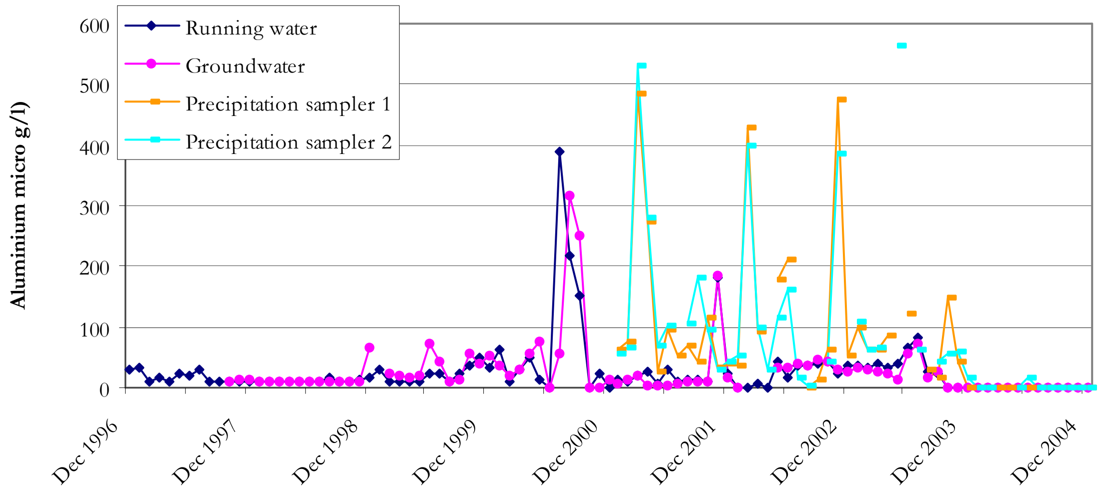


Figure 4.30 Amounts of aluminium (Al) found in precipitation, groundwater and running water.

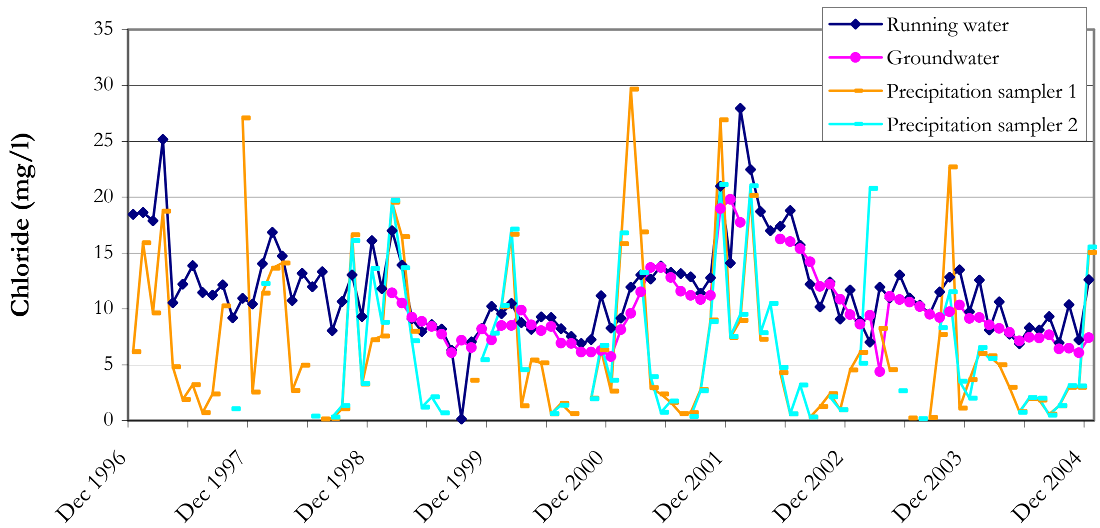


Figure 4.31 Amounts of chloride (Cl) found in precipitation, groundwater and running water.

Earlier studies of water chemistry have shown that an insignificant portion of chloride present in groundwater and running water is due to local weathering (Gislason et.al 1996).

Nitrate and ammonium concentrations in Icelandic precipitation are said to be independent from other chemical parameters and position in Iceland (Gislason, et.al. 1996). Thus nitrate and ammonium may be long-range transport parameters. Figures 4.33 and 4.34 show clearly how these substances are mainly measured in precipitation.

Sulphur (Fig. 4.35) seems to have arrived in the catchment area via precipitation, but is on average transported in similar amounts via the runoff stream.

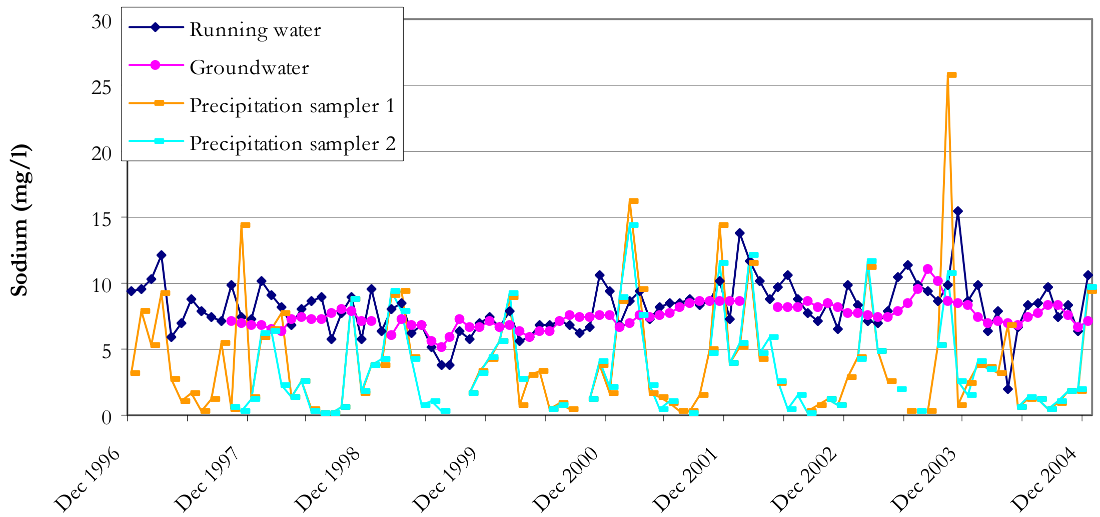


Figure 4.32 Amounts of sodium (Na) found in precipitation, groundwater and running water.

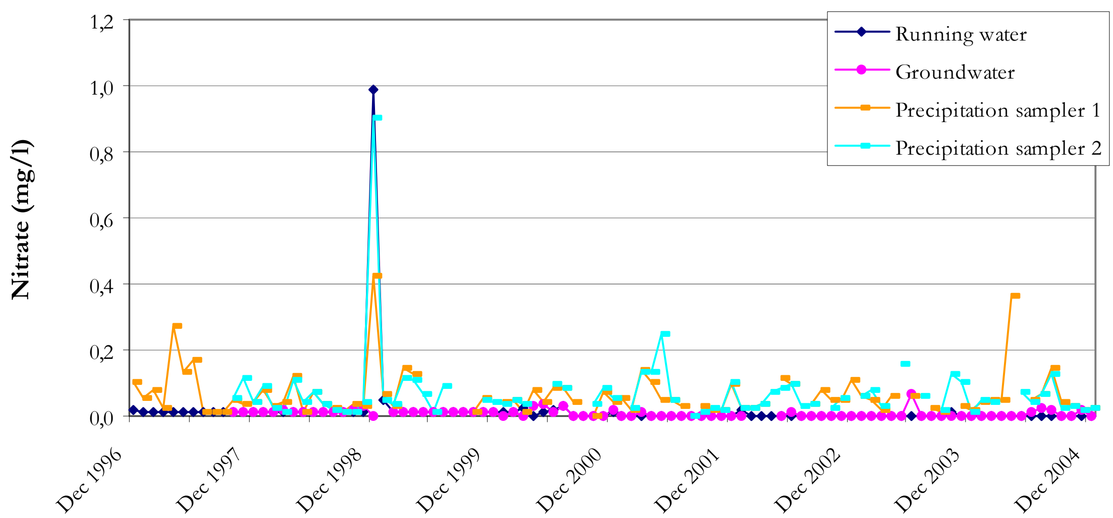


Figure 4.33 Nitrate in running water, groundwater and precipitation from 1996-2004.

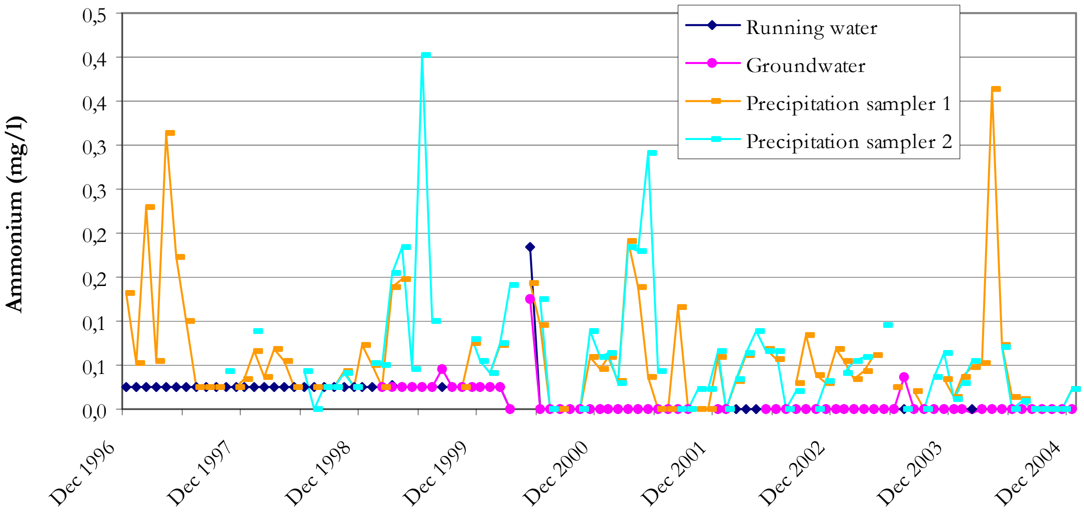


Figure 4.34 Ammonium in running water, groundwater and precipitation from 1996-2004.

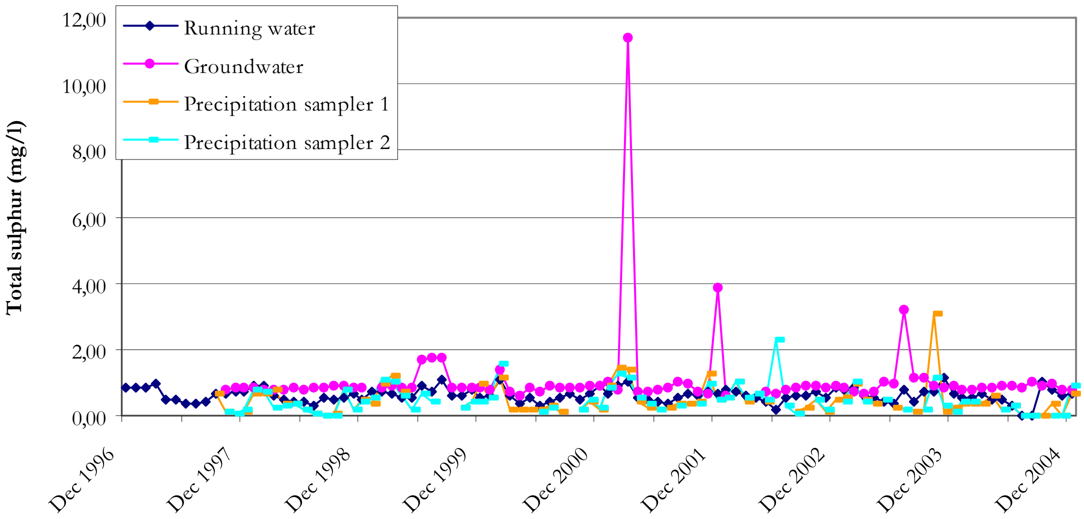


Figure 4.35 Total sulphur in running water, groundwater and precipitation from 1996-2004.

5. CONCLUSIONS

The climate of Litla-Skard is highly modulated by the landscape. The rather narrow valley canalizes the wind and as seen by the windroses, Annex 1, the station is slightly affected by seabreeze during summer. The temperature and precipitation is similar to other sites in the vicinity.

The flora and fauna in the catchment area are typical for the southwestern lowlands of Iceland which have been protected from grazing during the last decades The biota at Litla-Skard are undergoing a slow change after cessation of grazing in the 1980's. The most important change is an increase in cover of birch and willow shrub.

The hydrology and hydrochemistry is typical for Icelandic waters not affected by glacial meltwater. Relationship between physical parameters of precipitation, groundwater and running water is quite similar, leading to the conclusion that groundwater storage is not a major factor within the Litla-Skard catchment area.

The source of chloride, sodium, nitrate and ammonium is clearly not within the catchment Chloride and sodium are of course abundant in the ocean, only some 20-40 km away and are brought inland by storms. Nitrate and ammonium are believed to be transported from even further away, from the European or North American continent.

Calcium, magnesium, iron and manganese are mainly found in groundwater and running water, so they must originate from the soil and bedrock within the catchment area.

Aluminium has been found in higher quantities than average in some precipitation samples in the years 2002-2003. Reasons for this are unknown, but may lead to a suspicion of some local contamination, perhaps from instruments. Iron and manganese also show some high peak values, leading to suspicion of some dust particle contamination in the samples, since the samples are not filtered prior to chemical analysis.

Sulphur enters the Litla-Skard area from outside sources and is found in highest quantities in groundwater during mid summer but is absorbed by plants, since mid summer values of sulphur in running waters are the lowest of the year. High peak values for sulphur in winter 2001 may be due to a wind-transportation from hot springs in nearby areas.

To evaluate the quality of Litla-Skard as a background monitoring station, it is necessary to compare the results with measurements from other sites within Iceland. Irafoss is an EMEP station in southeast Iceland and comparison has been made between precipitation values from there to those of Litla-Skard (Figure 5.1). In every case the Irafoss averages, based on daily samples, are higher than the Litla-Skard monthly values, often twice as high or more. Conductivity values also differ between the monitoring stations, where Irafoss has an average value of 54 μS/cm while Litla-Skard has an average of 29 μS/cm. These differences could be methodical since daily samples at Irafoss may provide more extreme values than monthly samples at Litla-Skard. Irafoss is within the volcanic zone of Iceland and is probably more affected by soil and volcanic dust than the Litla-Skard area. This comparison indicates that Litla-Skard is a very good background station for Iceland.

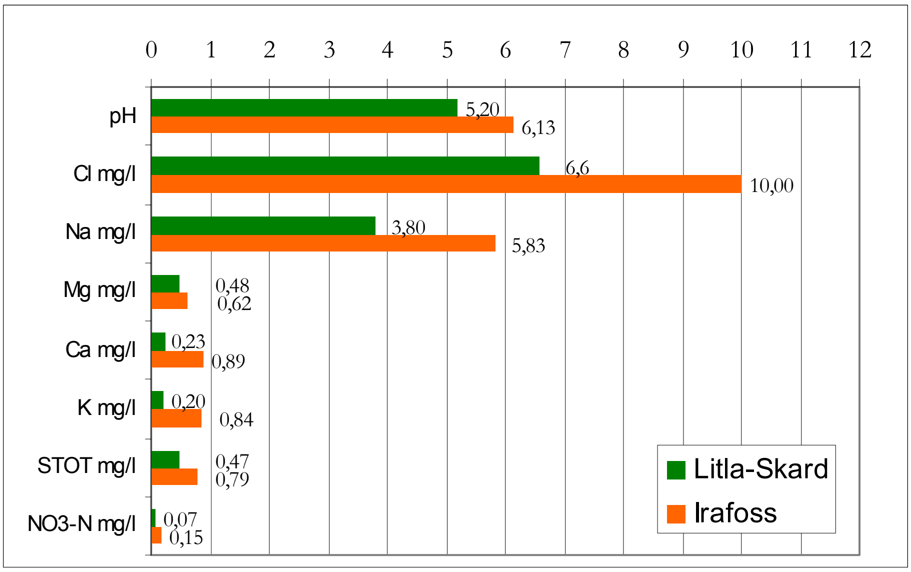


Figure 5.1 A comparison average precipitation chemistry values from Irafoss, an EMEP station in southeast Iceland, and the Litla-Skard averages.

The results from the first nine years of monitoring at Litla-Skard did not reveal any obvious anthropogenic effects on the ecosystem at the site which may be considered relatively unpolluted. The participating agencies have hopes for monitoring more parameters at Litla-Skard in the future.

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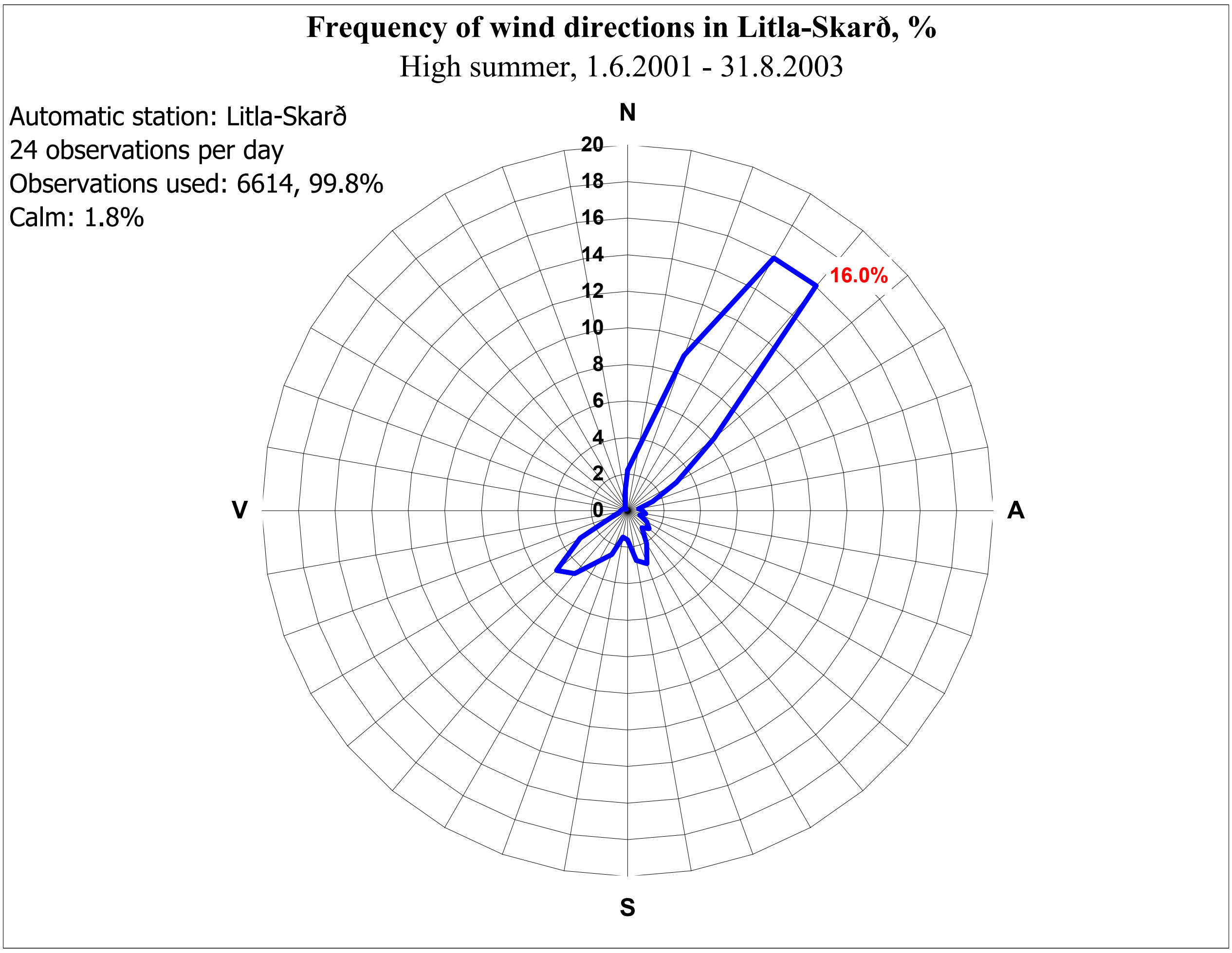
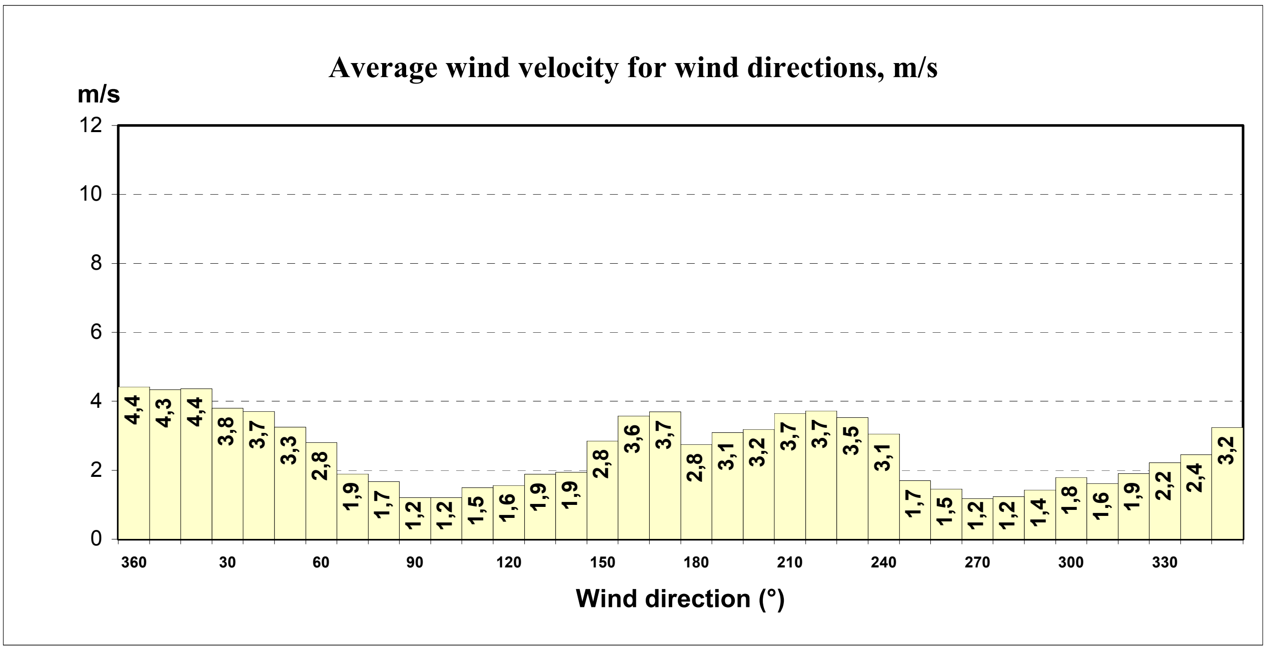
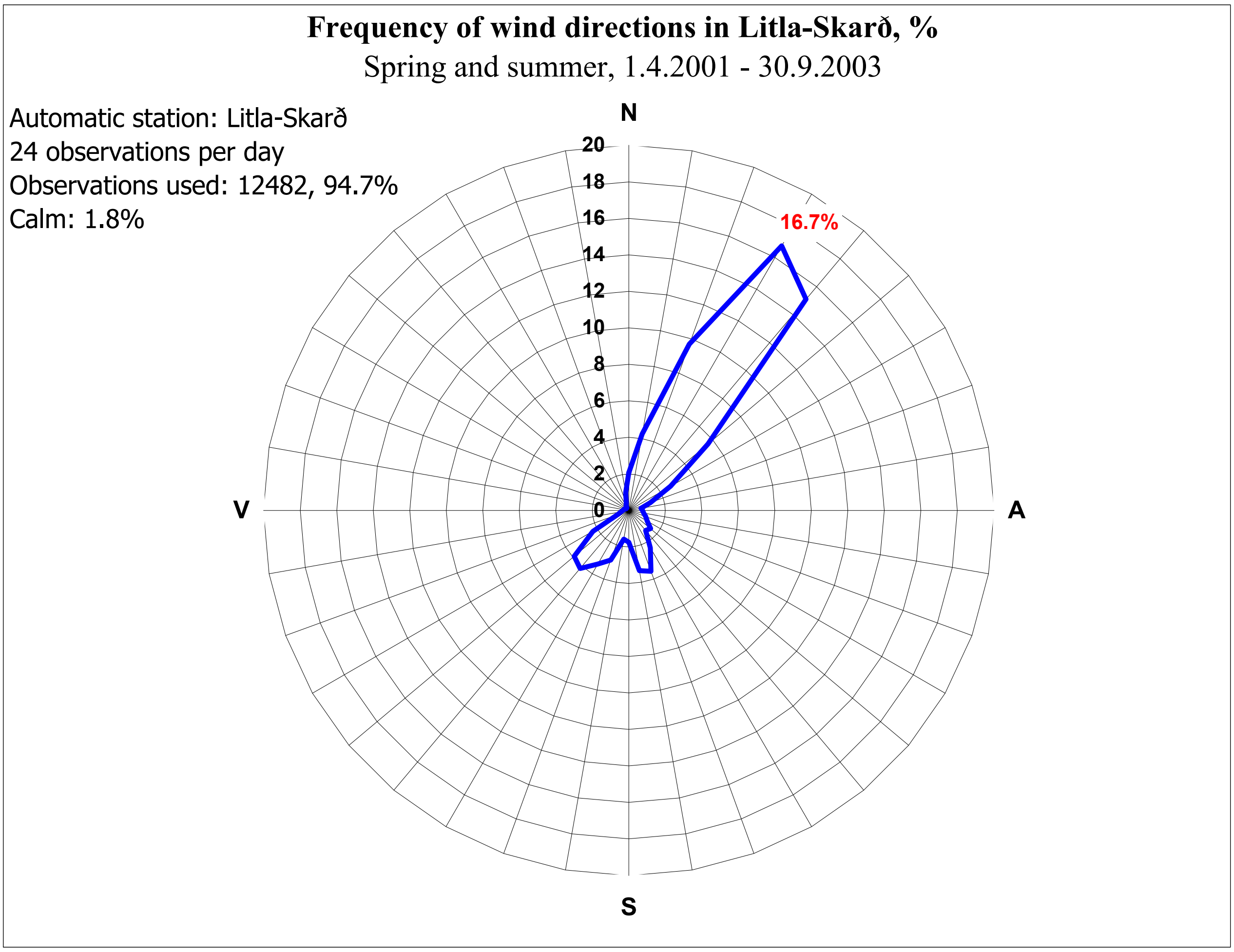
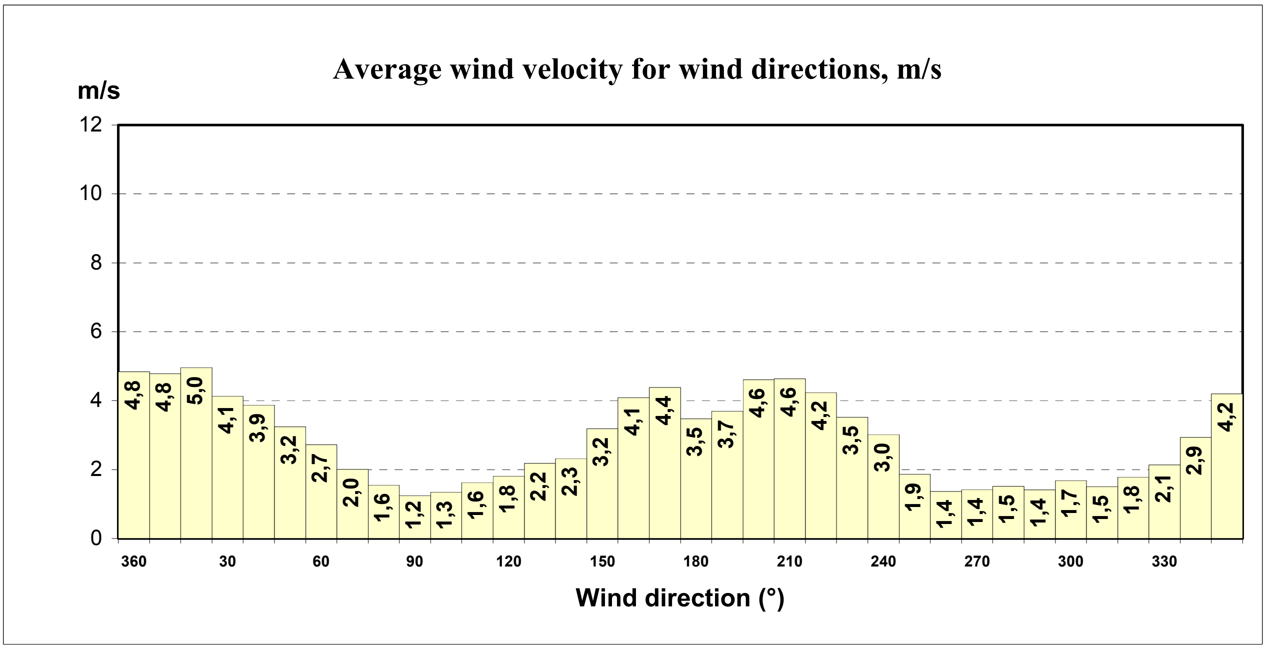
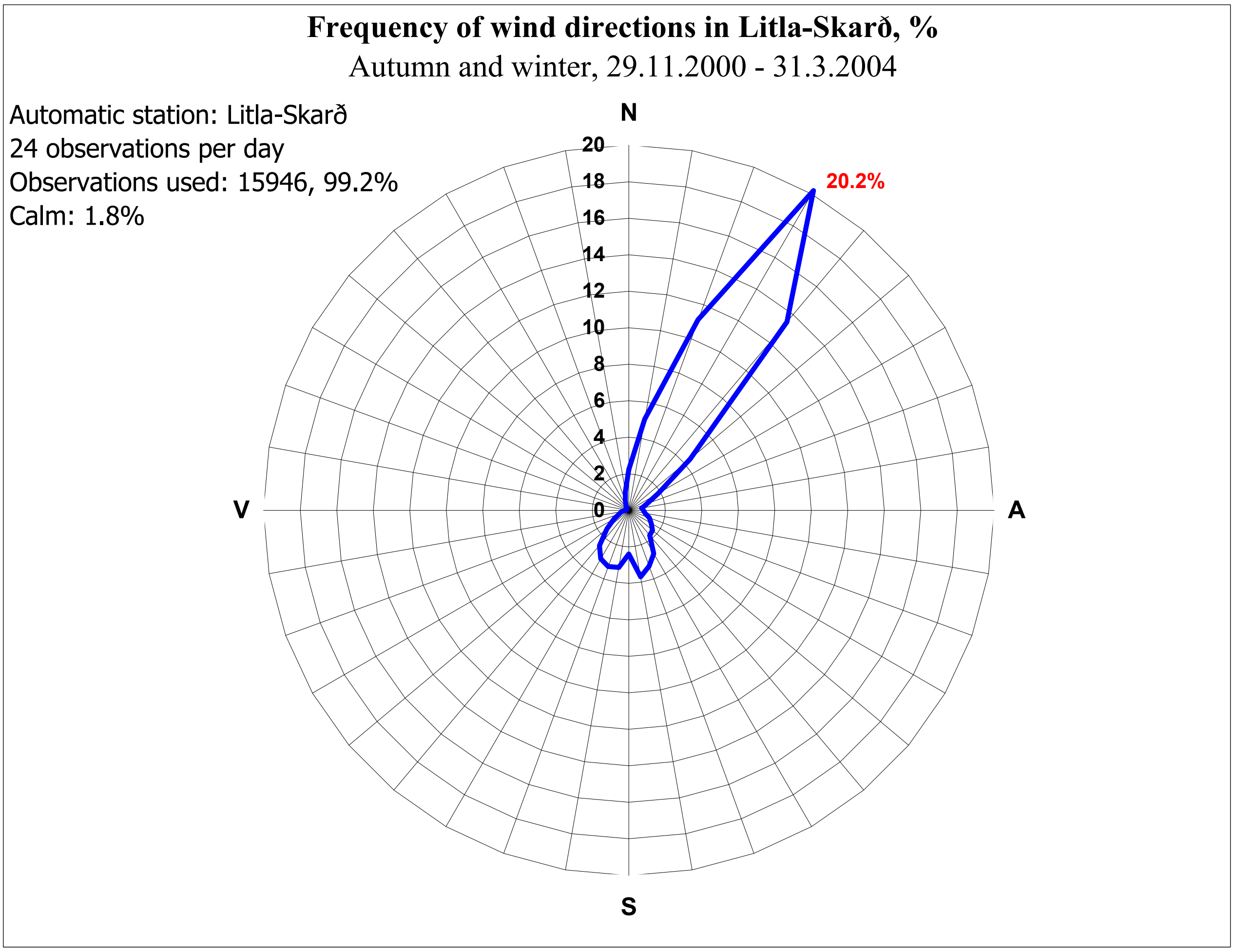
ANNEX 1 Windroses from Litla-Skard

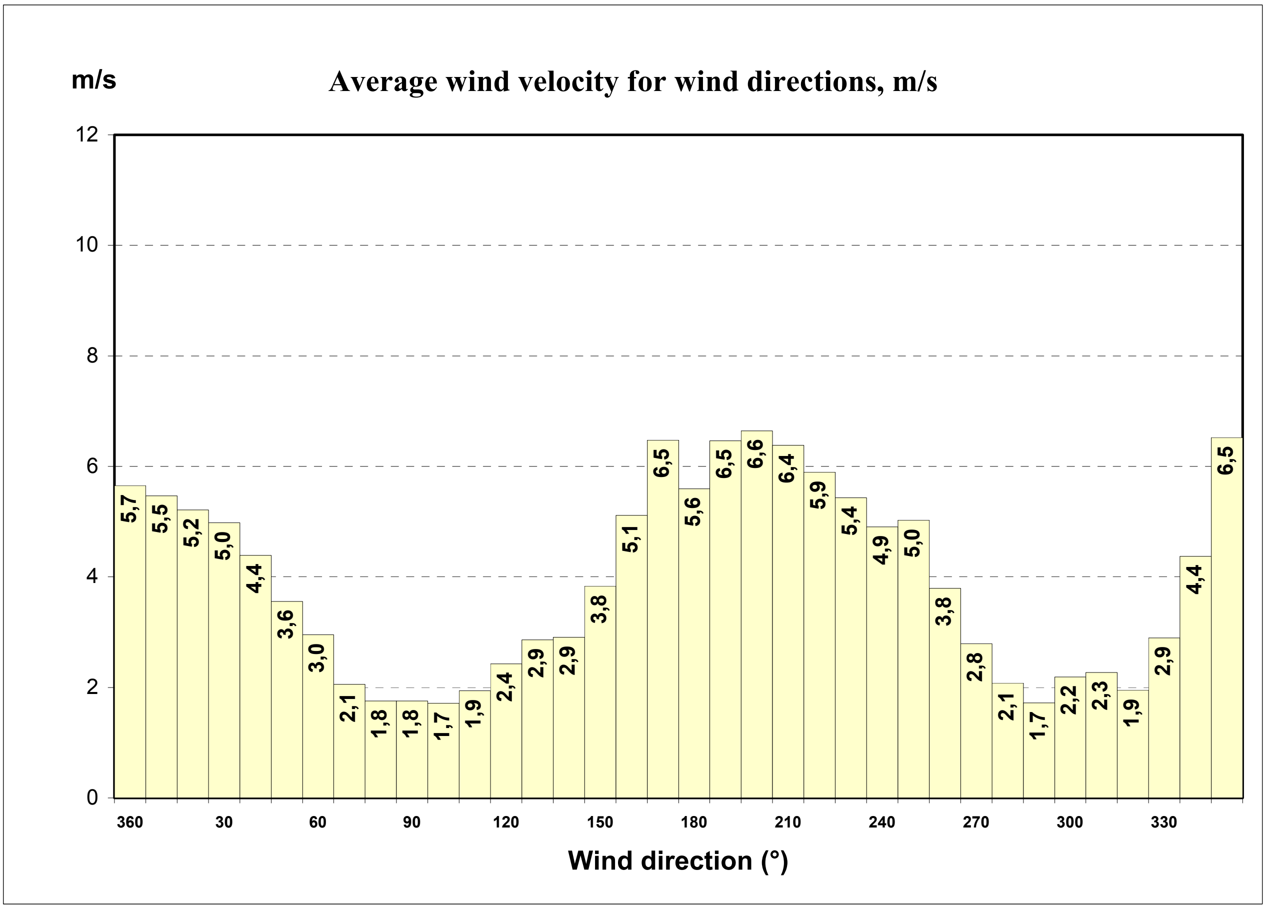




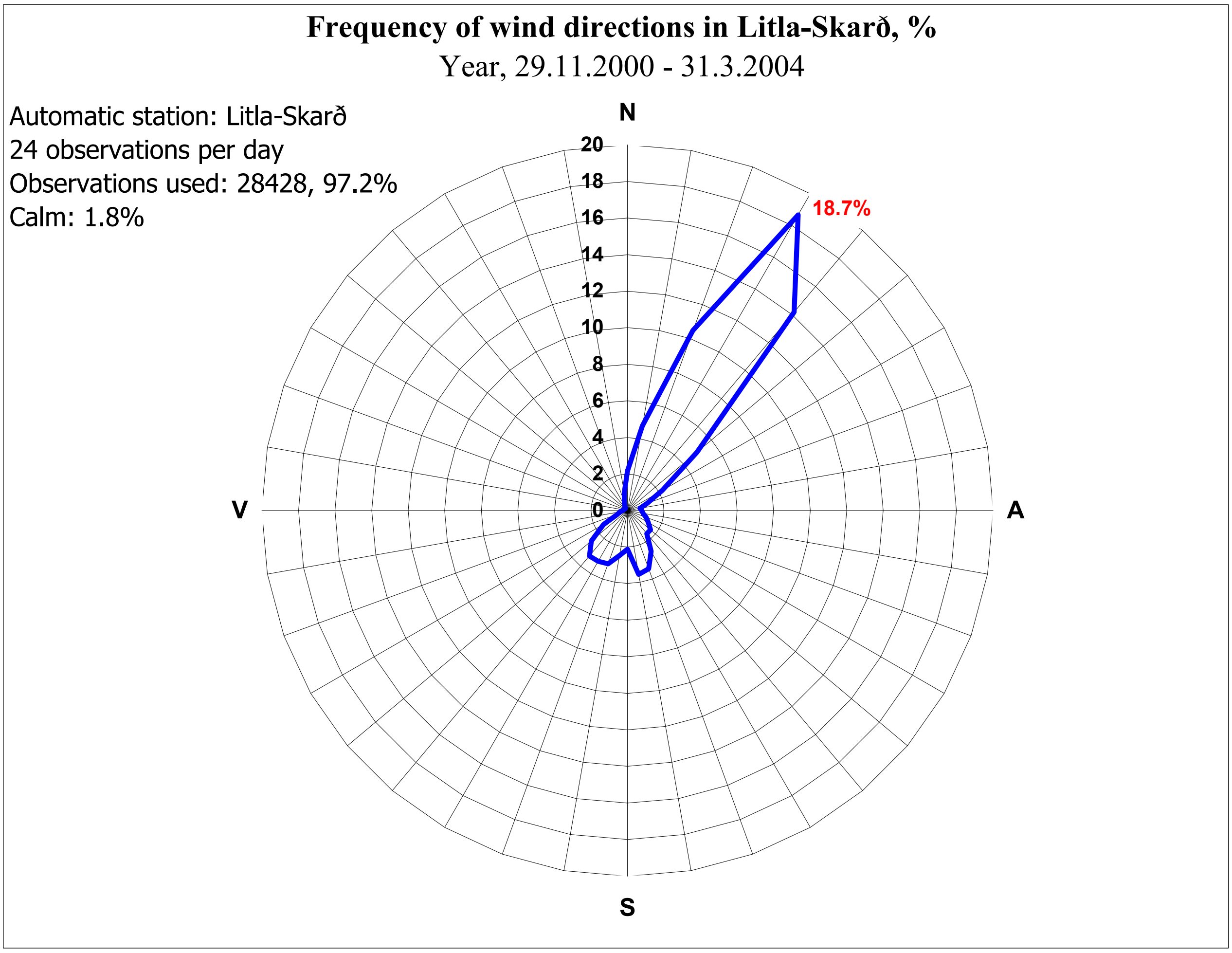

Frequency of wind directions in Litla-Skarð, %
Spring and summer, 1.4.2001 - 30.9.2003
Automatic station: Litla-Skarð
24 observations per day
Observations used: 12482, 94.7%
Calm: 1.8%
N
A
S
V
16.7%
0
2
4
6
8
10
12
14
16
18
20


Average wind velocity for wind directions, m/s
m/s
0
2
4
6
8
10
12
4,8
4,8
5,0
4,1
3,9
3,2
2,7
2,0
1,6
1,2
1,3
1,6
1,8
2,2
2,3
3,2
4,1
4,4
3,5
3,7
4,6
4,6
4,2
3,5
3,0
1,9
1,4
1,4
1,5
1,4
1,7
1,5
1,8
2,1
2,9
4,2
360
30
60
90
120
150
180
210
240
270
300
330
Wind direction (°)

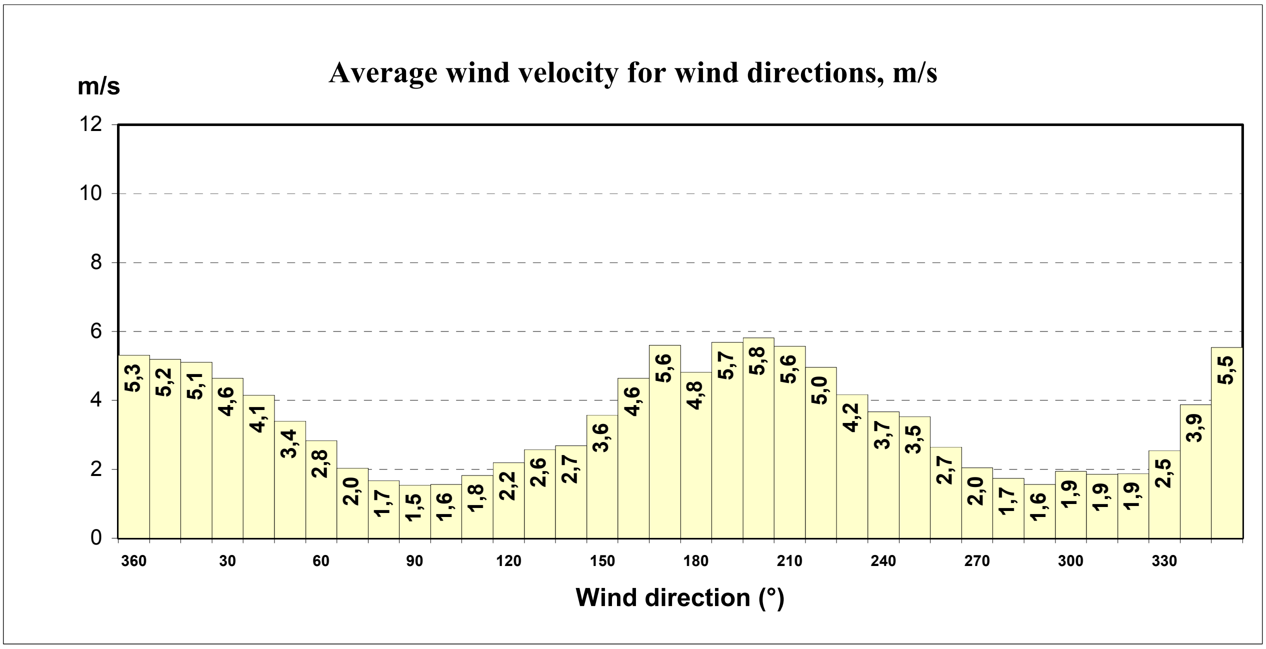

Frequency of wind directions in Litla-Skarð, %
Autumn and winter, 29.11.2000 - 31.3.2004
Automatic station: Litla-Skarð
24 observations per day
Observations used: 15946, 99.2%
Calm: 1.8%
N
A
S
V
20.2%
0
2
4
6
8
10
12
14
16
18
20


Average wind velocity for wind directions, m/s
m/s
0
2
4
6
8
10
12
5,7
5,5
5,2
5,0
4,4
3,6
3,0
2,1
1,8
1,8
1,7
1,9
2,4
2,9
2,9
3,8
5,1
6,5
5,6
6,5
6,6
6,4
5,9
5,4
4,9
5,0
3,8
2,8
2,1
1,7
2,2
2,3
1,9
2,9
4,4
6,5
360
30
60
90
120
150
180
210
240
270
300
330
Wind direction (°)

-



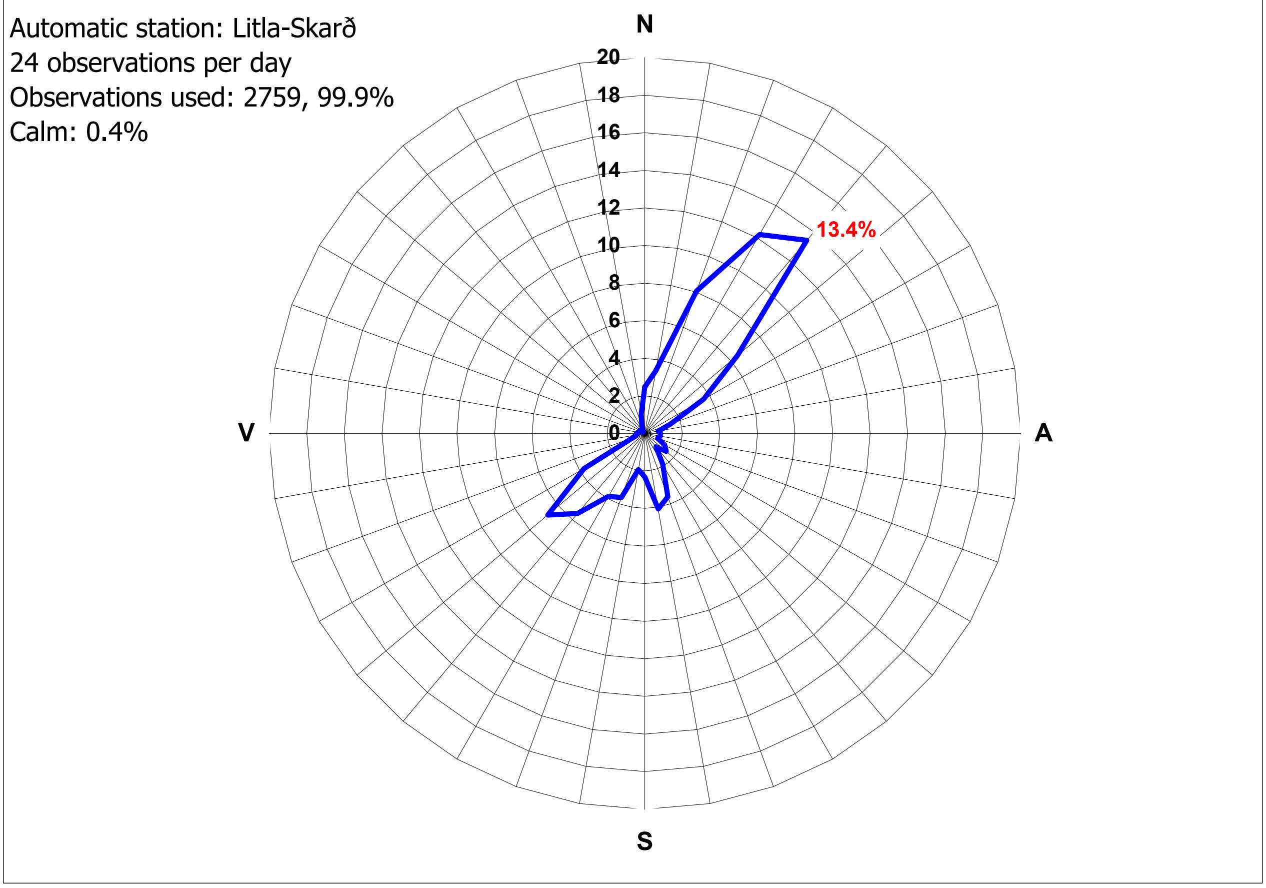
Frequency of wind directions in Litla-Skarð, %
Year, 29.11.2000 - 31.3.2004
Automatic station: Litla-Skarð
24 observations per day
Observations used: 28428, 97.2%
Calm: 1.8%
N
A
S
V
18.7%



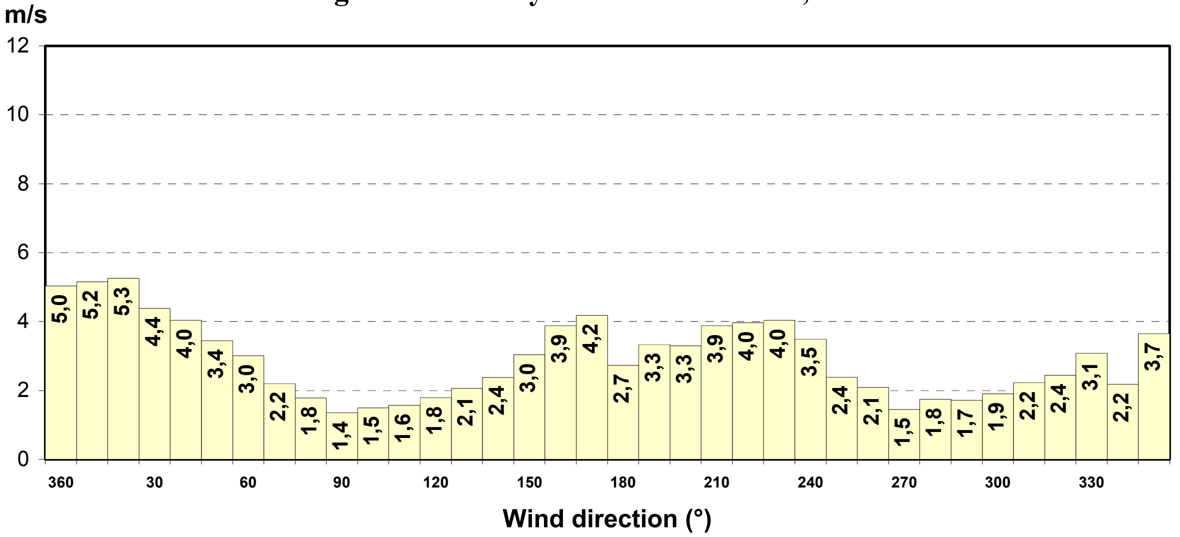
Average wind velocity for wind directions, m/s
m/s
Wind direction (°)
5,3
5,2
5,1
4,6
4,1
3,4
2,8
2,0
1,7
1,5
1,6
1,8
2,2
2,6
2,7
3,6
4,6
5,6
4,8
5,7
5,8
5,6
5,0
4,2
3,7
3,5
2,7
2,0
1,7
1,6
1,9
1,9
1,9
2,5
3,9
5,5

Frequency of wind directions in Litla-Skarð, %

High summer, 1.6.2001 - 31.8.2003, day hours 09 - 18 GMT



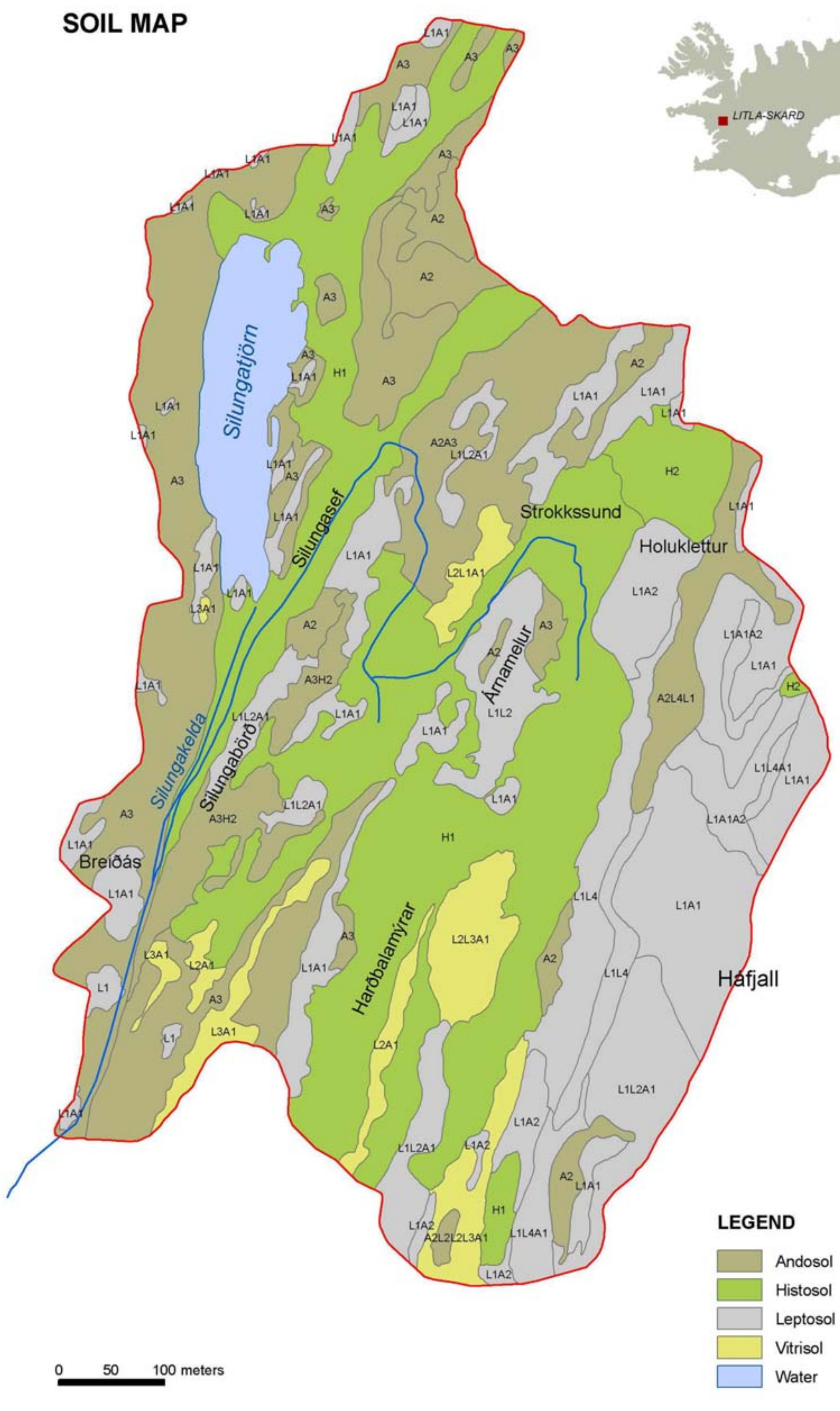
Average wind velocity for wind directions, m/s



ANNEX 2 Soil map of the catchment area in Litla-Skard modified from Magnusson and Arnalds (1997). The main soil types are Andosol, Histosol, Leptosol and Vitrisol. These four types are then further divided into subgroups as depicted in the table below.

Soils of vegetated areas		
	Andosol	
	A1	Shallow Andosol, 5-15 cm. The vegetation often dominated by mosses.
	A2	10-50 cm thick Andosol.
	A3	20-100 cm thick Andosol, often with gley features.
	Histosol	
	H1	>60 cm thick organic soil, rich in organic matter.
	H2	Organic soil lower in organic matter.
Soils with very low vegetation cover		
	Leptosol	
	L1	Rock surface, sometimes with mosses growing on top.
	L4	Scree slopes.
	Vitrisol	
	L2	Lag-gravel areas, often with mosses.
	L2-L3	Vitrisol-Andosol complex.

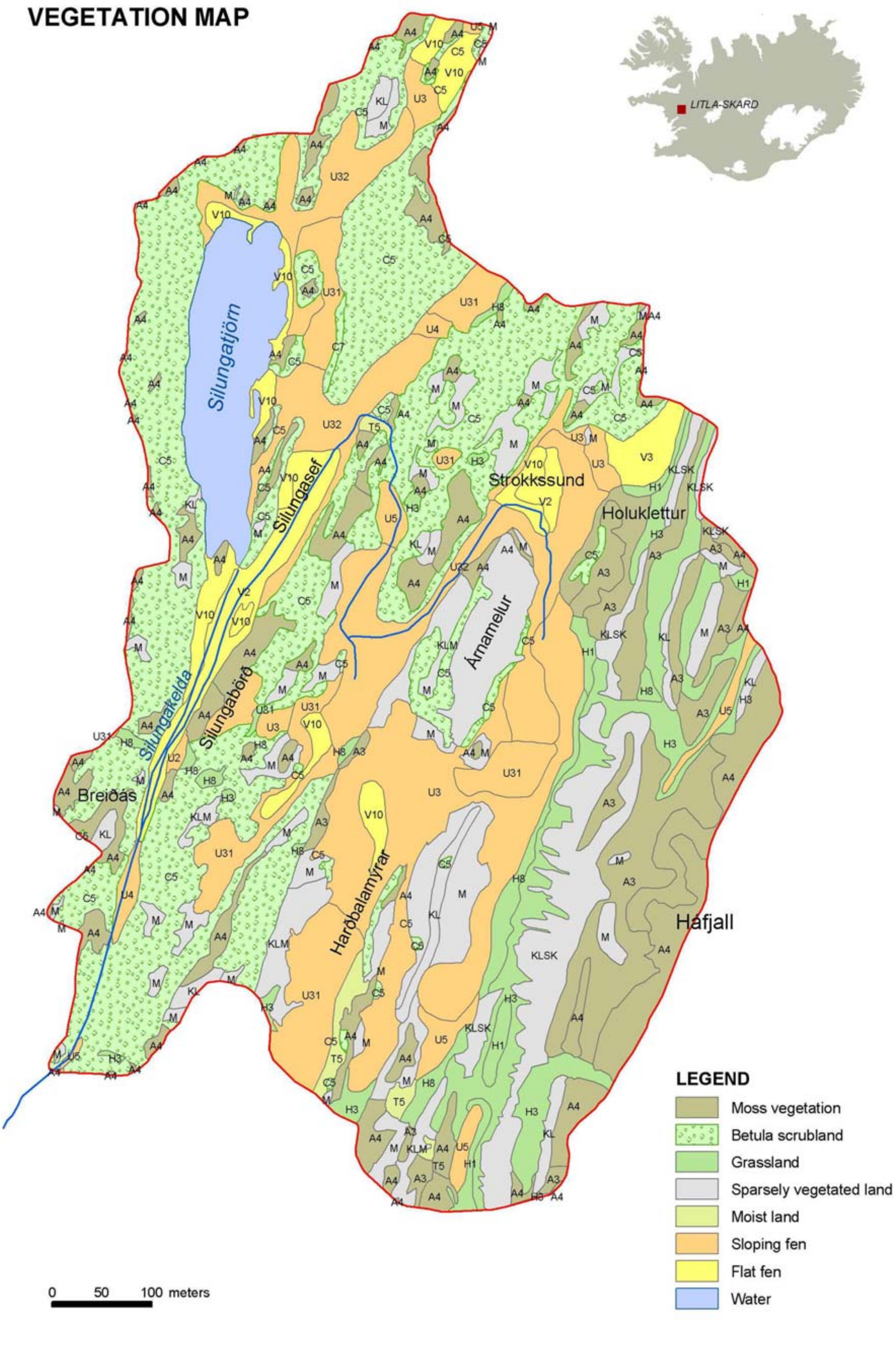
Soil types	**Size ha**	**%**
Andosol		
A2	2.1	
A2A3	2.5	
A2L2	0.1	
A2L4L1	1.2	
A3	9.1	
A3H2	1.4	
	16.3	**29.4**
Histosol		
H1	16.1	
H2	1.0	
	17.1	**31.0**
Leptosol		
L1	0.2	
L1A1	7.6	
L1A1A2	0.9	
L1A2	1.4	
L1L2	1.0	
L1L2A1	2.9	
L1L4	1.9	
L1L4A1	0.6	
	16.5	**29.7**
Vitrisol		
L2A1	0.5	
L2L1A1	0.4	
L2L3A1	1.7	
L3A1	0.6	
	3.1	**5.6**
Open water	**2.4**	**4.2**
Total	55.4	100.0


SOIL MAP
LITLA-SKARD
Silungatjörn
Silungasef
Silungakelda
Silungabörð
Strokkssund
Holuklettur
Árnamelur
Breiðás
Harðbalamýrar
Háfjall
LEGEND
Andosol
Histosol
Leptosol
Vitrisol
Water
0 50 100 meters

ANNEX 3 Vegetation map of the catchment area in Litla-Skard (Magnusson and Arnalds 1997). The vegetation was mapped in 1996 in the scale of 1:5000 on a black/white air photo (August 14, 1985) using the community classes established by Steindórsson (1980). Size of the different plant communities found within the catchment area is given below.

Class	Size ha	%
Freely drained land		
Moss vegetation		
A3 Racomitrium heath with Carex bigelowii and dwarf shrubs	3.8	
A4 Racomitrium heath with dwarf shrubs	5.7	
	9.5	**17.1**
Betula scrubland		
C5 Betula pubescens with dwarf shrubs	15.0	
C7 Betula pubescens with Salix phylicifolia	0,1	
	15.1	**27.2**
Grassland		
H1 Grassland	0.5	
H3 Grassland with dwarf shrubs	3.0	
*H10 Deschamsia caespitosa and Agrostis capillaris**	0.7	
	4.2	**7.5**
Sparsely vegetated land		
Kl Exposed rock	0.8	
Kl/M Exposed rock, gravel flats	1.6	
Kl/Sk Exposed rock, screes	2.5	
M Gravel flats	3.6	
	8.5	**15.3**
Transitional zone between freely drained land and wetland		
Moist land	0.3	
T5 Graminae–Carex		
	0.3	**0.6**
Wetland		
Sloping fen		
U2 Carex nigra – Salix callicarpaea	>0.0	
U3 Carex nigra – Betula nana	4.3	
U4 Carex nigra – Eriophorum angustifolium	0.2	
U5 Carex nigra	0.7	
*U31 Eriophorum angustifolium – Betula nana – Carex nigra**	2.9	
*U32 Carex nigra – Carex rostrata – Betula nana**	4.5	
	12.5	**22.6**
Flat fen		
V2 Carex rostrata	1.2	
V3 Eriophorum angustifolium	0.4	
*V10 Eriophorum angustifolium – Carex chordorrhiza**	1.4	
	3.0	**5.4**
Open water	2.4	
	2.4	**4.2**
Total	**55.5**	**100.0**

* Vegetation classes not defined by Steindórsson (1980).


VEGETATION MAP
LITLA-SKARD
Silungatjörn
Silungasef
Silungakelda
Silungabörð
Breiðás
Strokkssund
Holuklettur
Árnamelur
Harðbalamýrar
Háfjall
LEGEND
Moss vegetation
Betula scrubland
Grassland
Sparsely vegetated land
Moist land
Sloping fen
Flat fen
Water
0 50 100 meters

ANNEX 4 Plant species found within the catchment area in Litla-Skard. Data on vascular plants are based on vegetation survey carried out in 1996 within the 24 (100 m^2) circular IM permanent study plots (Magnusson and Arnalds 1997) and on information from five (2 x 50 m) transects analysed in 2004 in the ICEWOOD project (Fig. 2.1). Data on mosses and lichens are also from the five ICEWOOD vegetation transects.

	IM permanent vegetation plots, 1–24																								ICEWOODS transects				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	I	II	III	IV	V
Vascular plants																													
Agrostis capillaris	x		x		x	x	x	x		x	x	x						x							x	x	x	x	x
Agrostis stolonifera		x								x	x	x	x	x		x					x	x							
Agrostis vinealis	x			x							x	x		x	x	x	x			x	x	x	x						
Alchemilla alpina	x					x	x								x		x	x			x	x	x	x	x				
Alchemilla vulgaris	x																	x											
Anthoxanthum odoratum	x					x	x	x			x	x			x	x		x						x	x	x	x	x	x
Arctostaphylos uva-ursi	x					x	x																						
Arenaria norvegica		x																											
Armeria maritima		x															x	x			x	x	x						
Bartsia alpina				x									x																
Betula nana		x	x	x		x			x			x	x	x		x			x	x									
Betula pubescens	x	x	x	x	x	x	x	x		x	x	x		x	x			x							x	x	x	x	x
Bistorta vivipara	x	x	x	x		x						x	x	x	x	x	x	x	x	x	x	x	x	x	x			x	
Botrychium lunaria																					x								
Calamagrostis stricta																x													
Cardamine nymanii					x					x						x			x										
Cardaminopsis petraea															x		x					x	x						
Carex bigelowii		x				x	x	x		x		x					x	x			x			x	x				
Carex capillaris		x																			x								
Carex chordorrhiza									x				x	x		x			x	x									
Carex curta																			x										
Carex livida									x				x	x					x										
Carex nigra	x		x	x	x				x	x			x	x		x			x	x	x								
Carex norvegica														x							x								
Carex panicea	x																												
Carex rariflora				x					x	x			x	x		x			x	x									
Carex rostrata				x	x				x	x						x													
Carex saxatilis		x											x						x										
Carex vaginata				x												x			x	x	x				x	x	x	x	x
Cerastium alpinum		x															x				x	x	x	x					
Cerastium fontanum		x				x	x											x											
Coeloglossum viride		x																											
Deschampsia alpina		x										x					x				x	x							
Deschampsia caespitosa		x	x			x		x		x				x				x							x			x	
Deschampsia flexuosa	x		x		x	x	x	x		x	x	x		x	x	x	x	x			x			x	x	x	x	x	x
Dryas octopetala	x	x				x	x								x		x	x			x	x	x	x					
Empetrum nigrum	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Equisetum arvense										x				x		x	x	x						x					
Equisetum palustre	x	x	x	x	x	x			x	x			x	x		x			x	x	x								
Equisetum pratense						x					x	x						x						x	x	x	x		
Erigeron borealis	x																	x											
Eriophorum angustifolium		x	x	x					x	x			x	x		x			x	x									
Euphrasia frigida															x			x			x	x		x					
Festuca richardsonii		x	x	x		x								x		x	x		x	x	x			x	x		x		
Festuca vivipara	x	x	x			x	x	x		x	x	x		x	x	x	x		x	x	x	x	x	x	x	x			x
Galium boreale	x				x					x								x									x	x	
Galium normanii		x	x	x	x	x	x	x		x	x	x		x	x	x	x	x	x	x	x	x	x	x	x				
Galium verum	x					x												x								x			
Geranium sylvaticum	x																	x							x		x	x	
Geum rivale																		x											
Gymnocarpium dryopteris						x																							x
Hierochloe odorata																												x	x
Hieracium spp.	x	x			x	x	x	x			x	x						x						x		x	x	x	x

Juncus alpinus																x													
Juncus biglumis		x										x									x			x					
Juncus trifidus	x	x				x						x			x		x	x			x	x	x	x	x				
Juncus triglumis		x		x								x				x					x								
Kobresia myosuroides																					x			x					
Koenigia islandica		x								x		x				x	x				x	x		x					
Leontodon autumnalis	x		x		x	x	x	x			x				x			x								x	x	x	
Listera cordata						x					x															x			x
Luzula multiflora	x		x		x	x	x	x				x		x	x	x		x	x	x	x			x	x	x	x	x	x
Luzula spicata		x								x		x			x		x	x			x	x	x	x					
Lycopodium selago		x															x												
Menyanthes trifoliata										x			x	x		x			x										
Nardus stricta	x									x								x											
Oxyria digyna		x													x		x						x						
Pinguicula vulgaris		x							x	x							x	x			x								
Plantago maritima	x											x									x	x	x						
Poa glauca								x			x	x			x		x	x			x	x	x	x					
Potentilla crantzii	x	x	x	x		x									x					x	x	x	x	x					
Potentilla palustris																x			x										
Pyrola minor						x	x					x						x											
Ranunculus acris																										x	x		x
Rhinanthus minor																		x			x								
Rubus saxatilis					x	x		x		x															x		x	x	
Rumex acetosa		x				x											x	x						x					
Sagina nodosa		x										x				x					x								
Sagina saginoides																						x							
Salix callicarpaea		x	x	x			x							x		x	x			x									
Salix herbacea		x	x	x								x	x	x		x	x		x	x	x	x	x	x	x				
Salix lanata			x			x								x		x		x	x	x					x				
Salix phylicifolia			x	x	x	x		x		x	x			x		x			x	x								x	x
Saxifraga caespitosa																					x	x							
Saxifraga oppositifolia																							x						
Sedum villosum		x								x		x				x					x	x							
Selaginella selaginoides	x																	x			x			x					
Silene acaulis		x													x		x	x			x	x	x						
Silene uniflora																					x								
Spergula arvensis																					x								
Taraxacum spp	x		x		x	x	x	x		x	x	x		x	x		x	x							x	x	x	x	x
Thalictrum alpinum	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x
Thymus praecox	x	x	x				x			x		x			x		x	x			x	x	x	x	x				
Toifeldia pusilla		x											x																
Trichophorum caespitosum		x		x					x	x				x		x				x									
Triglochin palustre		x		x												x													
Trisetum spicatum	x	x													x								x						
Vaccinium myrtillus	x				x	x	x	x		x	x	x			x										x	x	x	x	x
Vaccinium uliginosum	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Veronica officinalis	x						x											x											
Viola palustris																		x											
Mosses																													
Barbilophozia barbata																										x			
Barbilophozia hatcheri																									x				
Dicranum scoparium																									x	x			
Hylocomium splendens																									x	x	x	x	x
Plagiochila porelloides																									x				
Pleurozium schreberi																									x	x	x	x	
Pogonatum urnigerum																									x				
Polytrichum alpinum																									x				
Ptilidium ciliare																									x	x		x	
Racomitrium ericoides																									x				
Racomitrium fasciculare																												x	

ANNEX 5 Birds, mammals and fish species found within the catchment area at Litla-Skard. Bird data was obtained by monthly anecdotal observations from 2000 – 2004 and from the ICEWOOD project where breeding pairs were counted on June 6, 2004 along a 350 m long and 200 m wide linear transect (Fig. 2.1). Mammals and fish data is based on anectodal observations 1997–2004.

BIRDS

Common name	Latin name		Total number of birds found within the catchment area in monthly observation periods from 2000 to 2004													Breeding pairs observed along the bird transect
			J	F	M	A	M	J	J	A	S	O	N	D	Total	
Waterbirds																
Great northern diver	*Gavia immer*								1		2				3	
Whooper swan	*Cygnus cygnus*					3	5	4		9	4				25	
Greylag goose	*Anser anser*	(x)				2	11								13	
Red-breasted merganser	*Mergus serrator*	x				1									1	
Raptor																
Merlin	*Falco columbarius*						1	2	3	1	2				9	
Grouse																
Ptarmigan	*Lagopus muta*	x		1	4	5	2	1	1	9	1	9	15	19	67	
Waders																
Golden plover	*Pluvialis apricaria*	x				+	7		5	26					38+	2
Common snipe	*Gallinago gallinago*	x				13+	2	13	5	7	1				41+	3
Black-tailed godwit	*Limosa limosa*	(x)					3								3	
Whimbrel	*Numenius phaeopus*	x					7	11	8+	2					28+	
Redshank	*Tringa totanus*	x				3	4								7	
Skuas, gulls, terns																
Arctic skua	*Stercorarius parasiticus*						2	1							3	
Black-headed gull	*Larus ridibundus*							2							2	
Great black-backed gull	*Larus marinus*							2							2	
Arctic tern	*Sterna paradisaea*						1	1	1						3	
Passerines																
Meadow pipit	*Anthus pratensis*	x				+	25	26	11	19	7				88+	4
Wren	*Troglodytes troglodytes*	x								1				1	2	1
Wheatear	*Oenanthe oenanthe*								1						1	
Redwing	*Turdus iliacus*	x			1	16+	33	33	2+	31	98	3			217+	3
Raven	*Corvus corax*		2	2			1			4	2	1	3	2	17	
Redpoll	*Carduelis flammaea*											12	27		39	
Snow bunting	*Plectrophenax nivalis*			1	5		15						22	11	54	
			2	4	10	43+	119	96	38+	109	117	25	67	33	663+	

[x] probably breeding within the area.

MAMMALS AND FISH

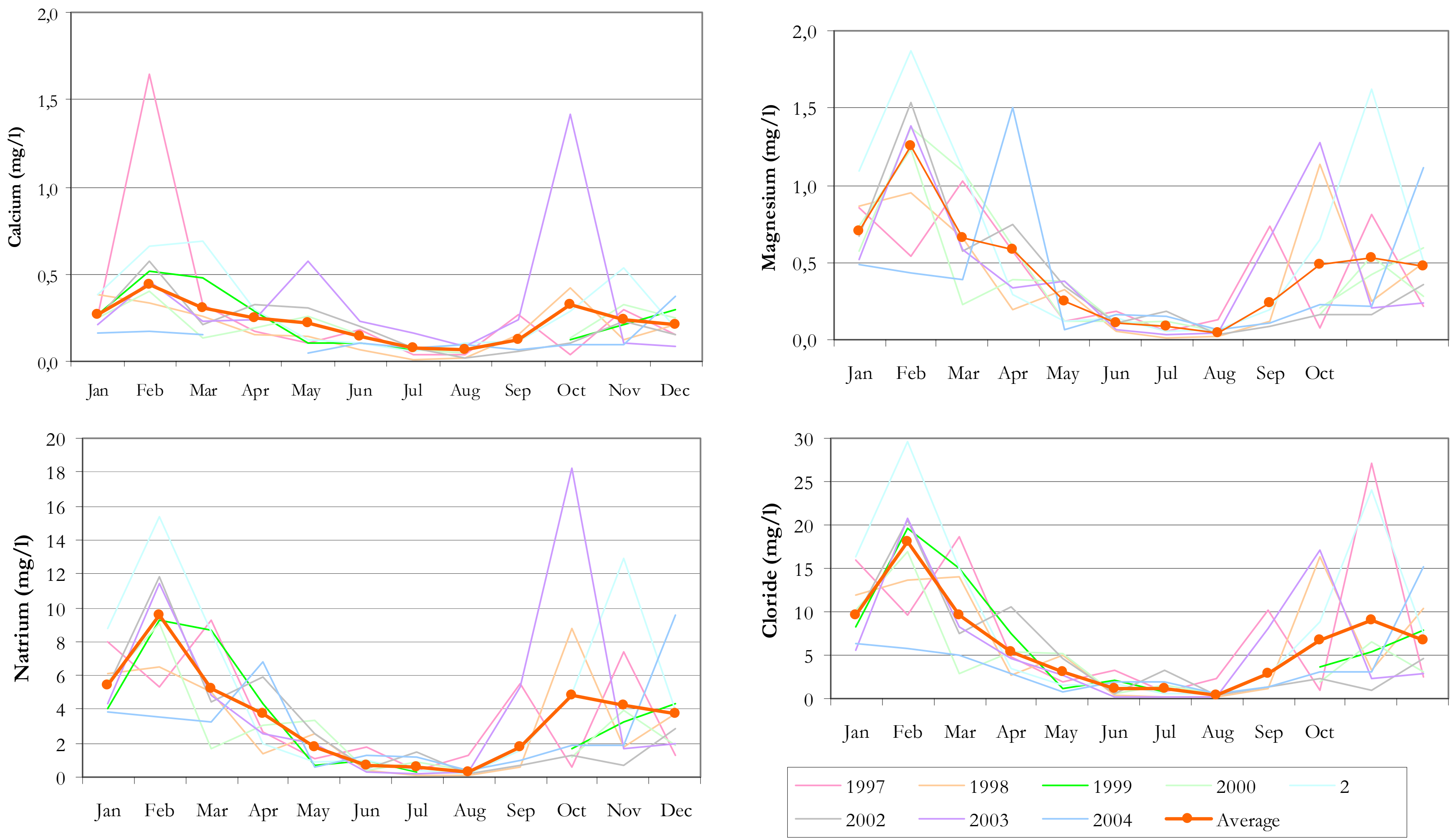
Common name	Latin name	Comments
Arctic fox	*Alopex lagopus*	Fox tracks repatedly observed during winter
American mink	*Mustela vison*	Mink tracks several times observed along streems during winter
Wood mouse	*Apodemus sylvaticus*	Mouse holes observed at fews places in autumn
Three-spined stickleback	*Gasterosteus aculeatus*	Very common, found in streems, wetland and in the lake Silungatjörn
Brown trout	*Salmo trutta*	Observed several times in the streem near the outlet of the catchment area

ANNEX 6 Terrestrial invertebrates (arthropods, gastropods and annelids) within the catchment area in Litla-Skard. Arthropods and gastropods were sampled in pitfall traps (diameter 7.2 cm) from 15 June to 8 August 2004 on the five ICEWOOD transects in the Betula scrubland (Fig. 2.1). The numbers shows sum of individuals trapped in three traps within each transect. For analysis of annelids soil samples were taken at three points within each transect.

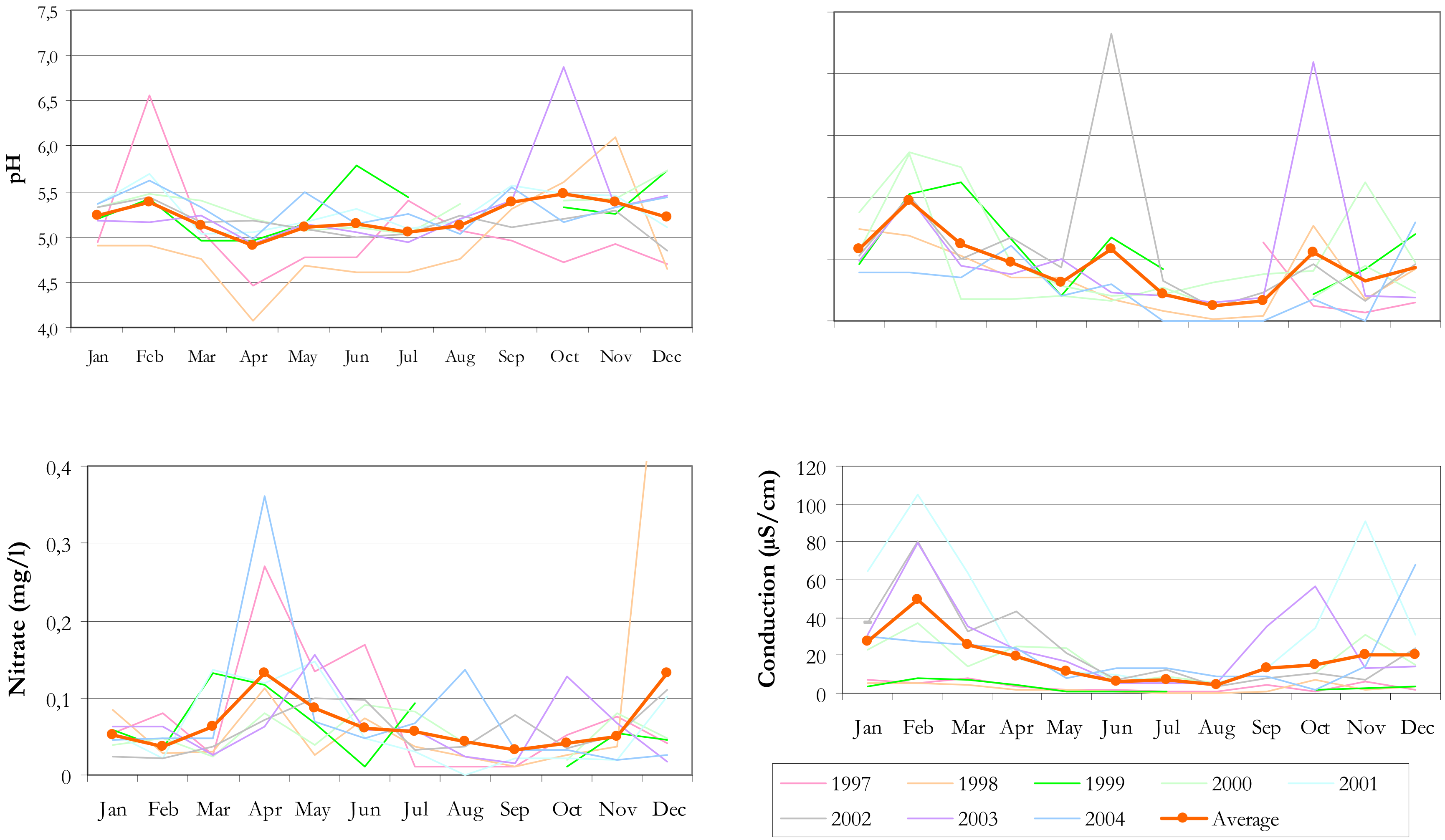
Taxa	Transects I	II	III	IV	V
INSECTA					
Hemiptera					
Javesella pellucida			3		
Arctorthezia cataphracta	12	29		5	9
Coccoidea indet.		2			
Aphidina indet.	3	6	2	13	7
Thysanoptera					
Thysanoptera indet.			1		
Trichoptera					
Limnephilus sparsus	1				
Neuroptera					
Wesmaelius betulina				1	
Lepidoptera					
Epinotia solandriana		1	1		
Diarsia mendica		2	1		1
Coleoptera					
Nebria rufescens				1	
Calathus melanocephalus	15	15	14	31	8
Patrobus septentrionis	33	64	85	67	40
Stenichnus collaris			2		
Lesteva longoelytrata	1			1	
Stenus impressus	3	4	11	4	6
Quedius boops		1			
Quedius fulvicollis	1	2	2	4	5
Atheta islandica		3	8		
Sipalia circellaris		1			
Oxypoda islandica	1	4	3	2	
Oxypoda soror				1	
Hypnoidus riparius	1	1	11	3	
Otiorhynchus arcticus				1	
Otiorhynchus nodosus	3	1	1	2	
Hymenoptera					
Pimpla arctica					1
Pimpla flavicoxis	1		1	1	1
Phygadeuon cylindraceus		1			
Phygadeuon thricops	3	2	1	1	
Cremnodes atricapillus					1
Gelis agilis					1
Gelis ruficornis		1			
Nepiera collector					1
Stenomacrus affinator		3		1	
Cratichneumon rufifrons	1	2	2	2	
Homotherus magus	1	4		5	1
Dacnusa sp.			1		
Microctonus intricatus	1	1			
Monoctonus caricis			2		2
Alloxysta sp.				1	
Pteromalidae		2		2	1
Aphelinidae sp. A				2	
Mymaridae sp. B		1			
Cinetus sp.		1	1		
Pantoclis trisulcata	1	1	1	1	
Zygota norvegica	5	4	1		5
Basalys parva	16	11	6	19	9
Trimorus ovata	3	1		1	
Trimorus pedestris	24	76	41	46	24
Telenomus nitidulus	7				4
Lagynodes pallidus	2	6	6	2	
Bombus jonellus	1				
Diptera					
Ormosia hederae		1	3		2
Brevicornu kingi				1	
Sciaridae	27	21	28	54	24

Taxa	Transects I	II	III	IV	V
Diptera (continued)					
Cecidomyiidae		2			
Psychodidae					1
Dilophus femoratus		2	1		
Dolichopus plumipes	1	2	1		
Megaselia giraudii		1		1	
Megaselia humeralis	1				
Megaselia sordida			2	4	
Triphleba renidens	1		3	2	2
Crumomya nitida	1		1		
Pterenis fenestralis	1				
Spelobia pseudosetaria			1	1	
Spelobia rufilabris	2	1	1		
Scathophaga furcata					1
Pegomya fulgens	1				
Pegomya notabilis	1			1	
Botanophila profuga	15	7	20	25	16
Lasiomma picipes	1				
Thricops cunctans	3		3	4	
Trichops longipes			1		
Helina annosa	1			1	
Spilogona contractifrons		1	1	4	
Fannia postica	3	1	3	3	3
Ornithomyia chloropus	1				
ARACHNIDA					
Araneae					
Haplodrassus signifer	2	1		1	
Gnaphosa lapponum		2	1	1	
Pardosa palustris		1			1
Pardosa hyperborea	2	6	4	2	
Pardosa sphagnicola	37	58	53	37	43
Xysticus cristatus		1	2		
Ceratinella brevipes		1			
Walckenaeria clavicornis			2	1	1
Walckenaeria cuspidata		3	1		1
Walckenaeria nudipalpis				1	2
Gonatium rubens	2	14	10	13	6
Mecynargus morulus	2				
Diplocentria bidentata	1	1	8	5	
Latithorax faustus	2	1		1	
Leptorhoptrum robustum	14	11	20	15	4
Hilaira frigida	1	1	2		
Bolyphantes index		1			
Lepthyphantes complicatus	20	3			1
Lepthyphantes mengei	12	8	8	8	5
Lepthyphantes zimmermanni	6	10			2
Hypselistes jacksoni		1			
Opiliones					
Mitopus morio	24	40	30	46	35
GASTROPODA					
Vitrina pellucida			1		2
Nesovitrea hammonis			1	1	
Arionidae	6		1	1	9
Limacidae	2	8	9	2	1
Vertigo modesta	1				
Euconulus fulvus	5	1			4
Columella aspera	2	2	2		1
ANNELIDA					
Allolobophora rosea	x		x		
Dendrobena octaedra			x	x	x
Dendrobena rubida	x	x	x	x	x
Lumbricus rubellus	x	x	x	x	x
Octolasion cyaneum					x

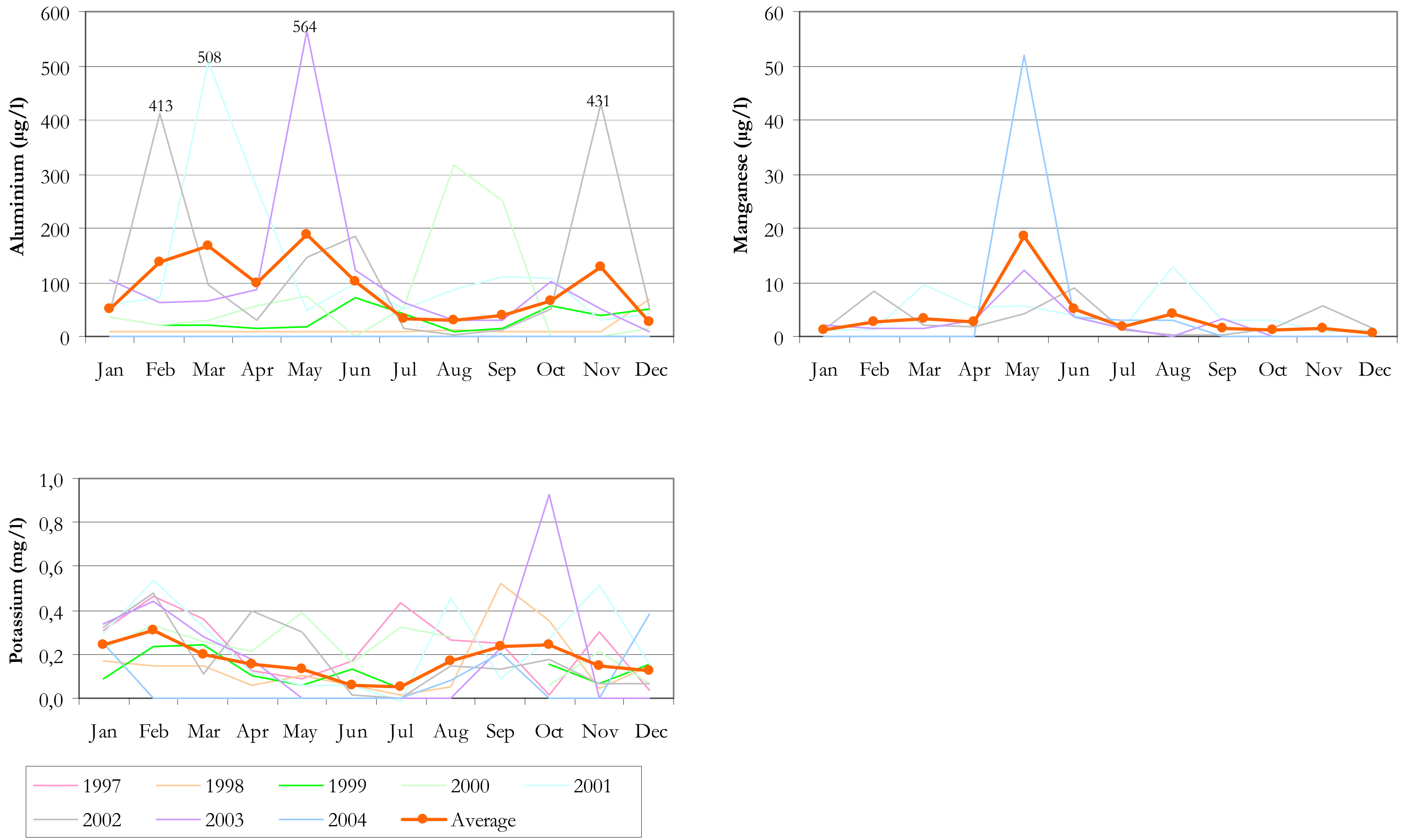
APPENDIX 7 Monthly averages for chemical compounds in precipitation, groundwater and stream runoff.



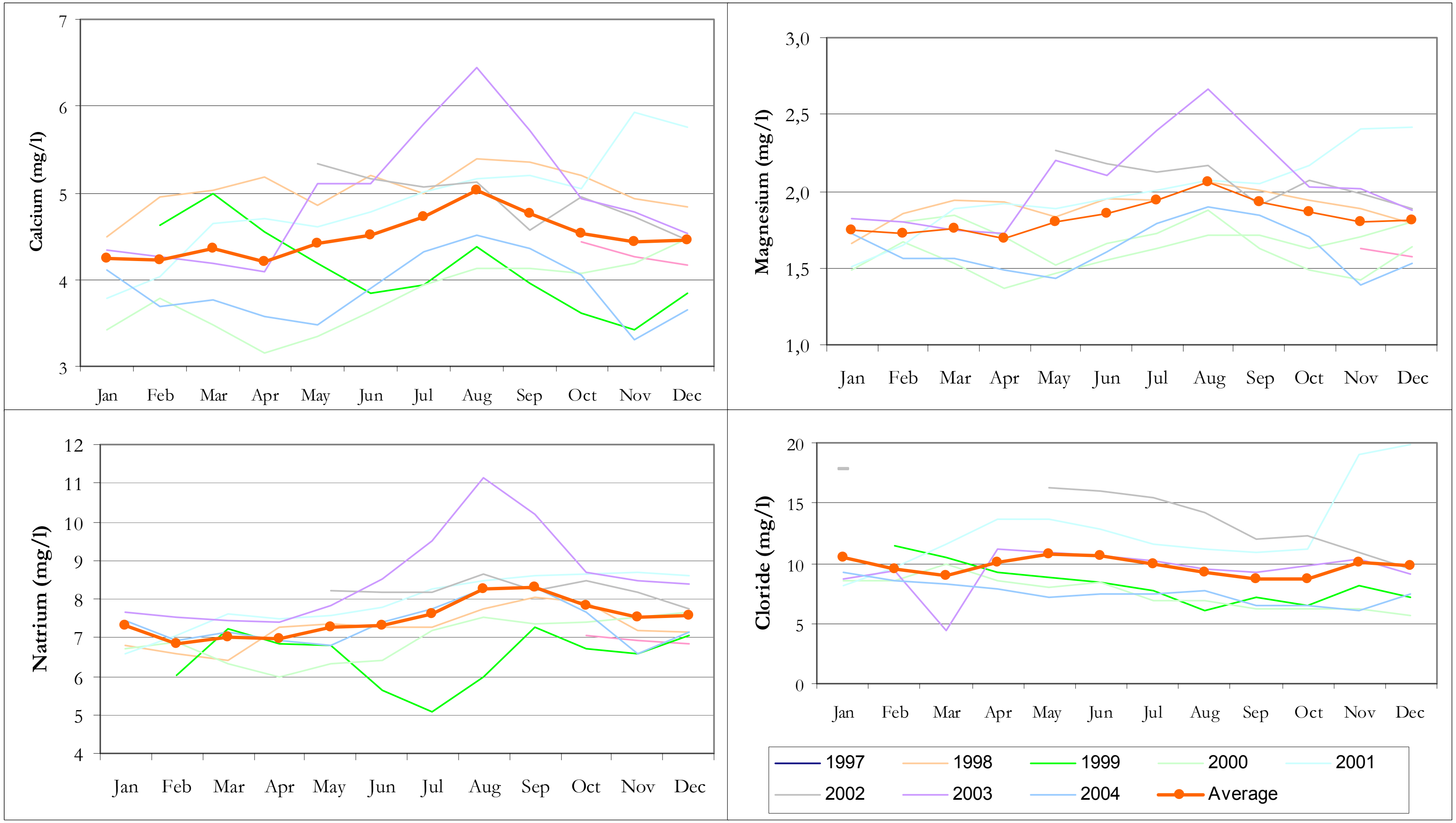
Monthly averages for chemical compounds in precipitation, calcium, magnesium and natrium.



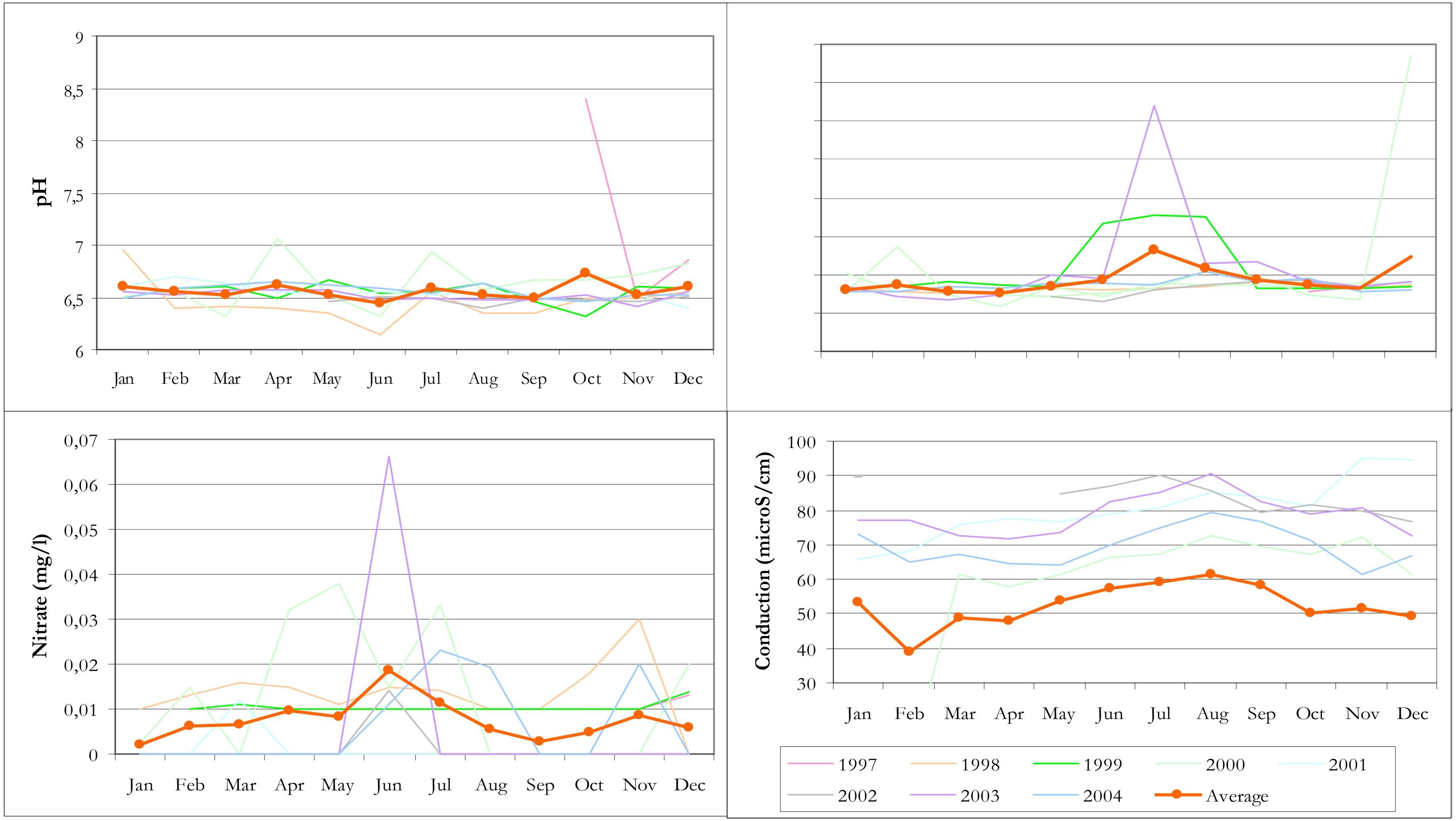
Monthly averages for pH, conduction, sulphur and nitrate in precipitation.



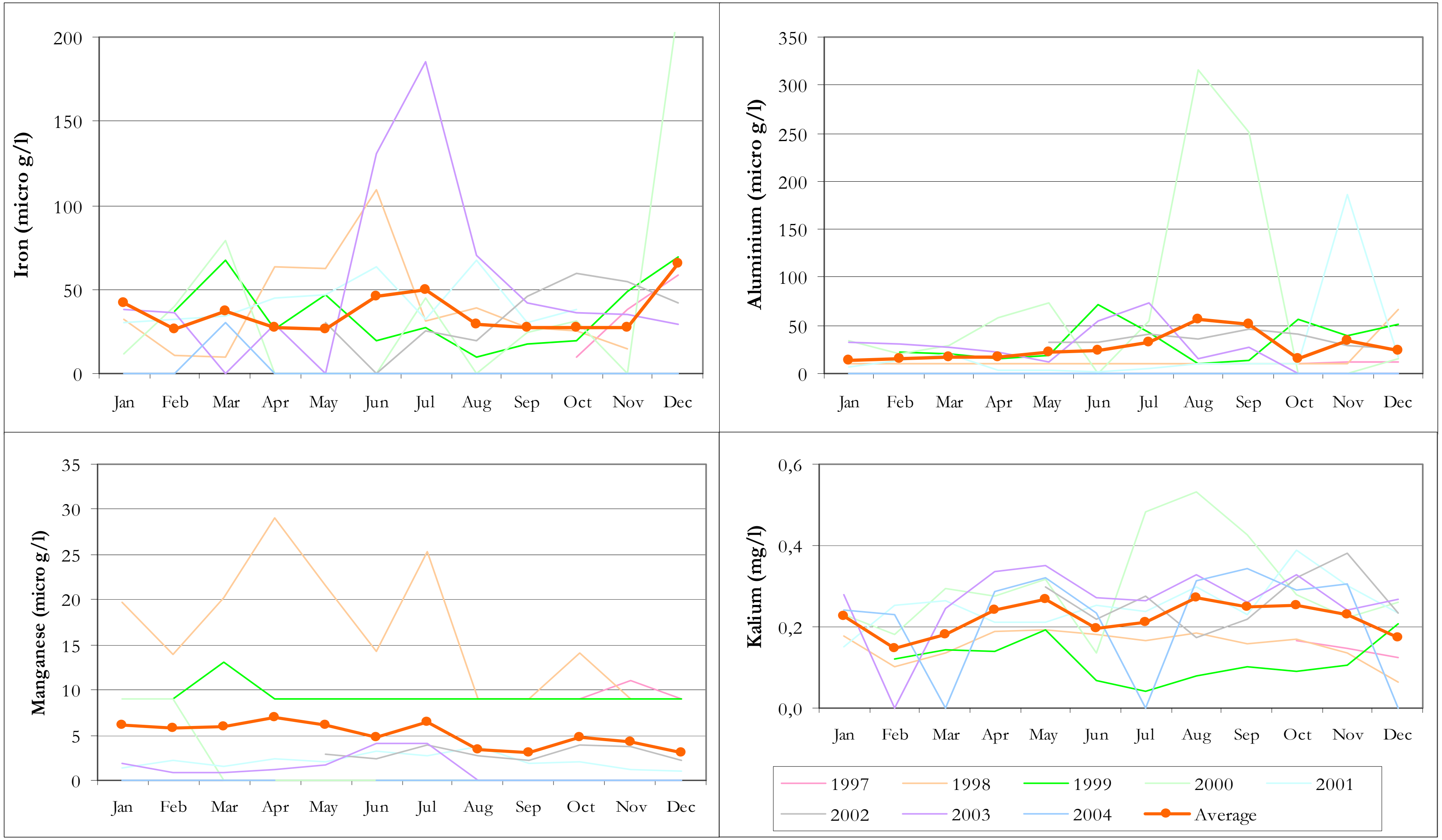
Monthly averages for aluminium, manganese and potassium in groundwater.



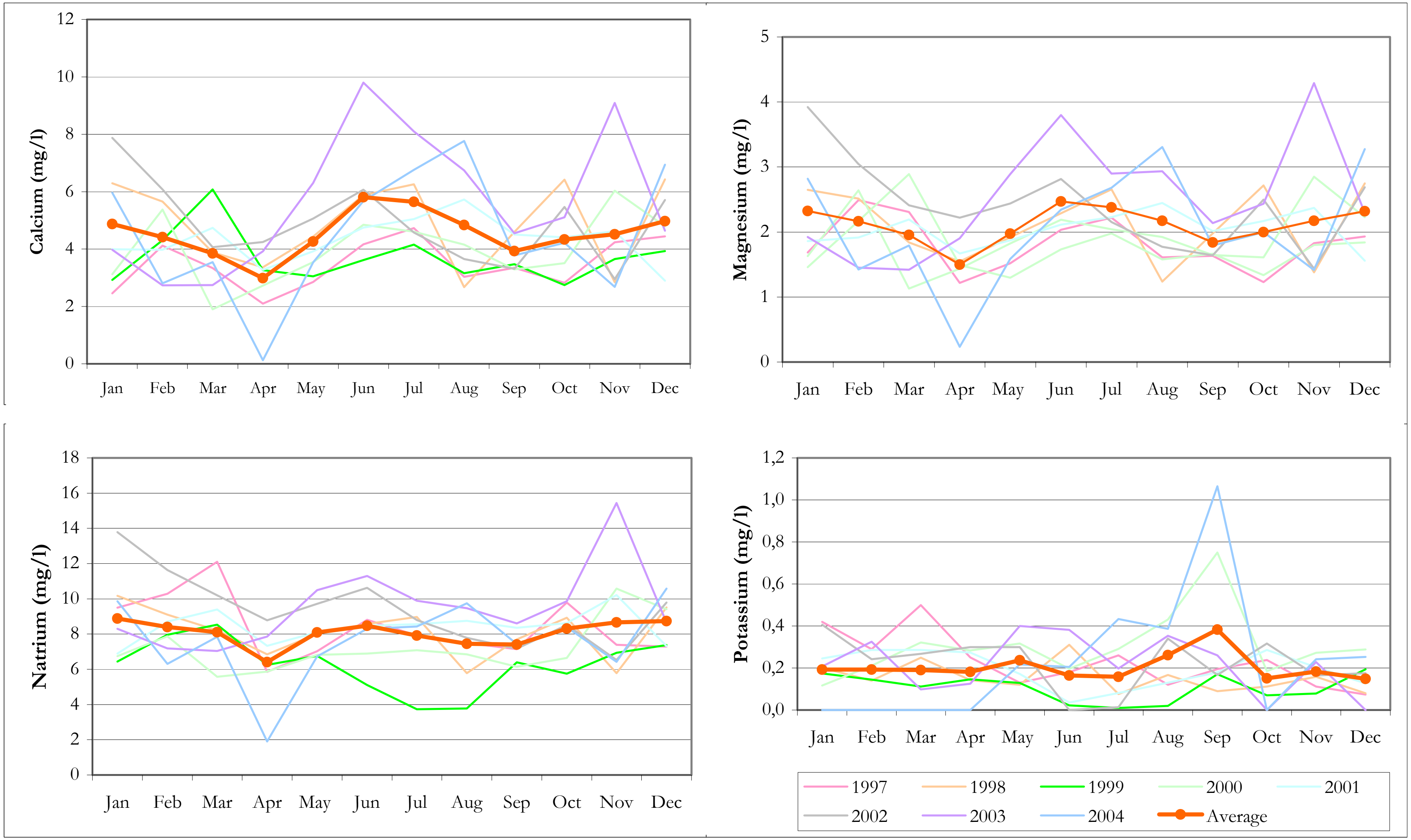
Monthly averages for chemical compounds in groundwater, calcium, magnesium and natrium seem to have yearly peaks in August, while Cl has a gentler seasonal distribution.



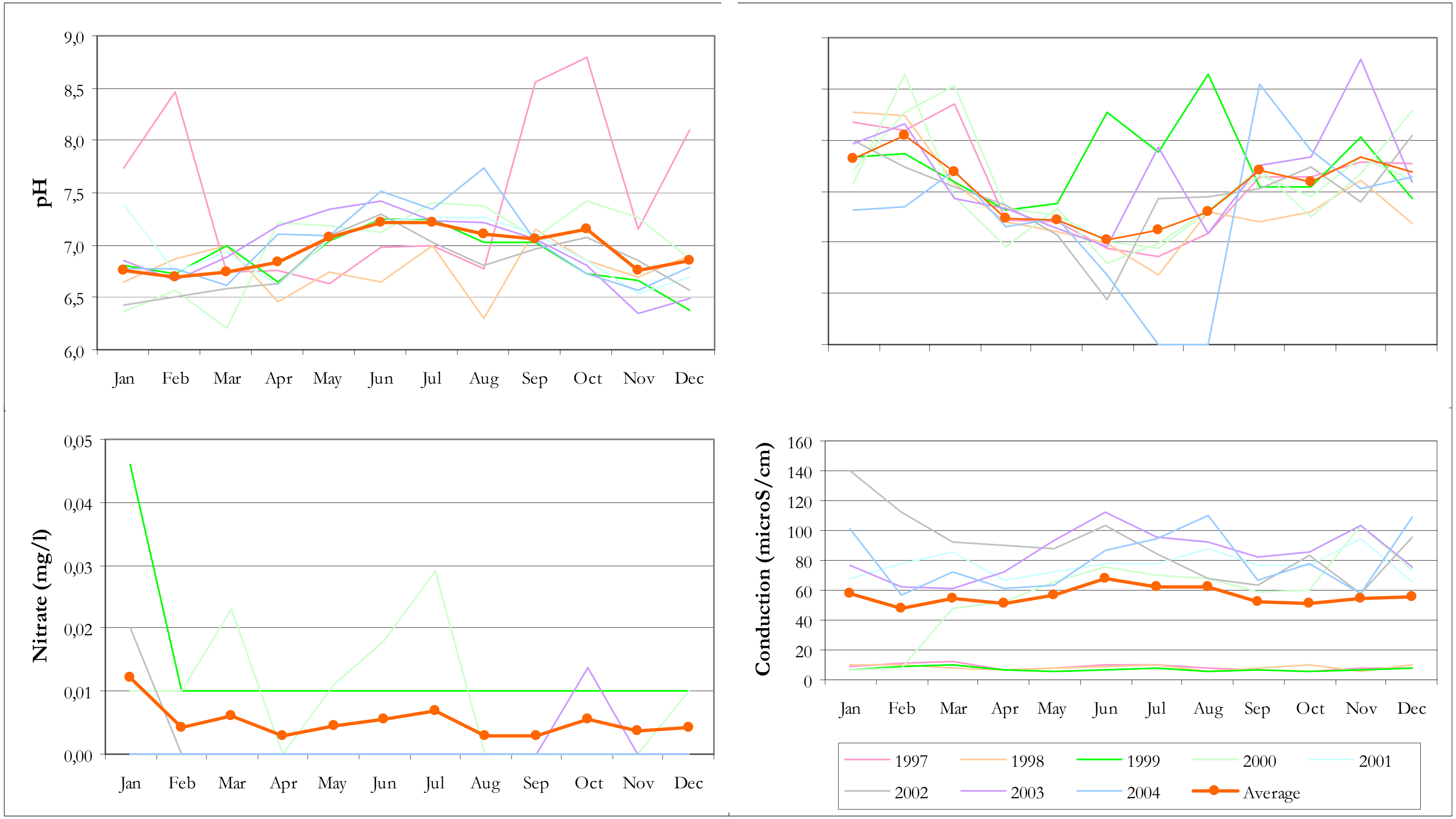
Monthly averages for pH, conduction, sulphur and nitrate in groundwater.



Monthly averages for iron, aluminium, manganese and potassium in groundwater.

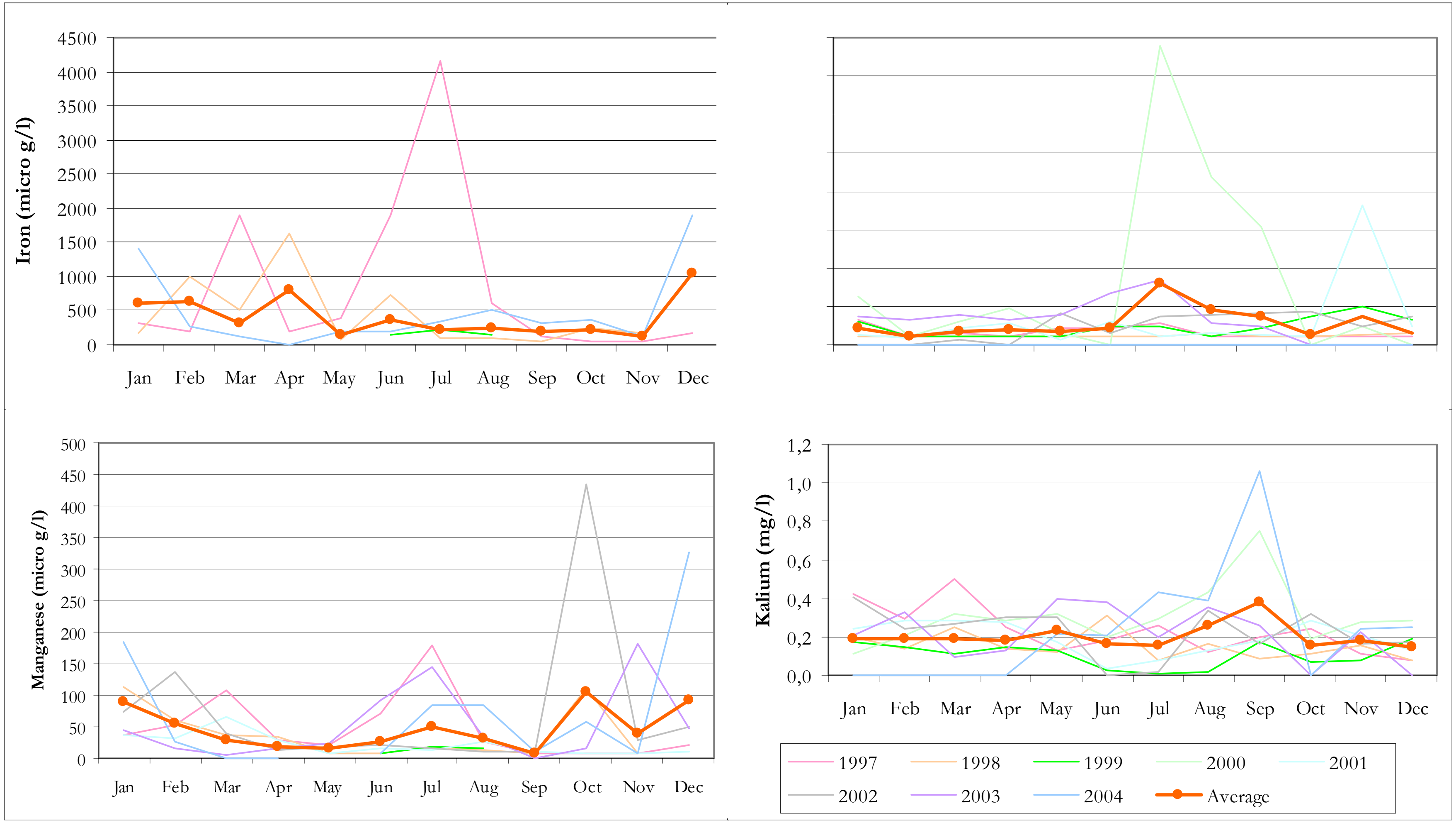


Monthly averages for calcium, magnesium, natrium and cloride in stream runoff. All but cloride show a clear spring-summer trend, where spring floods cause lower concentrations than summer "low water flow" periods.

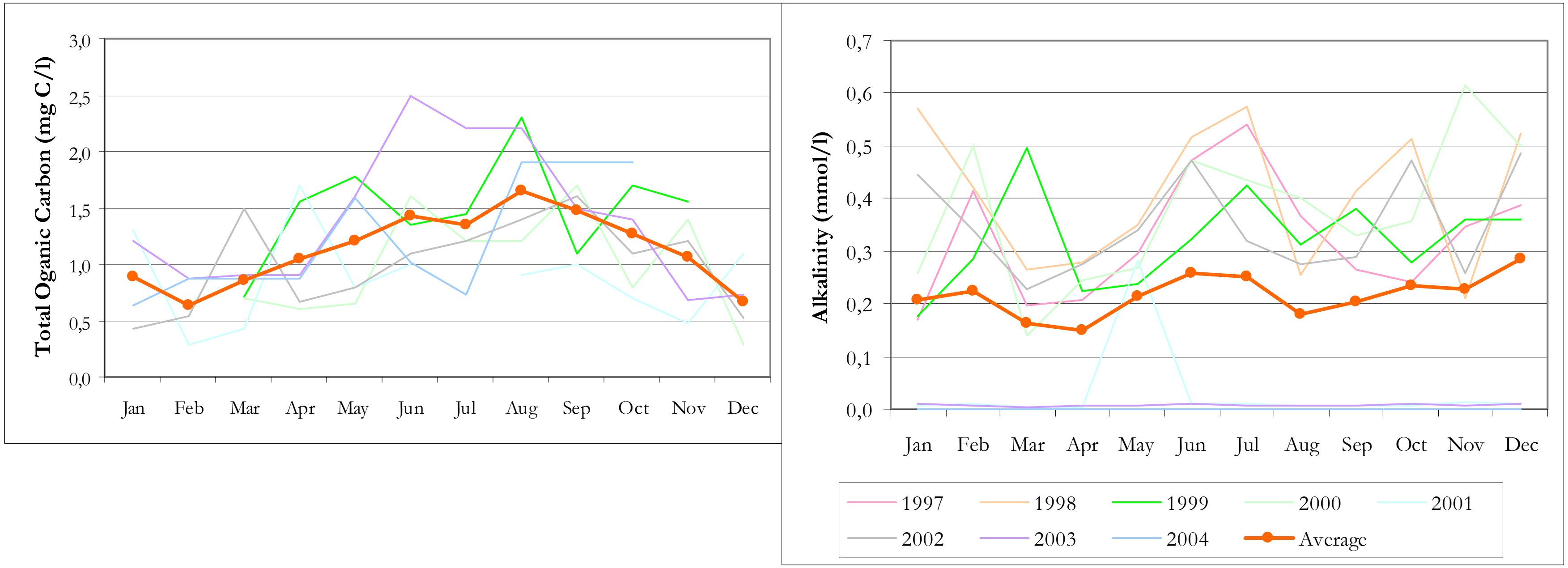


Monthly averages for pH, conduction, sulphur, nitrate and conductivity in stream runoff. Yearly trends are clearly affected by single measurements, possibly due to clay or dust particles in the samples. pH and Conductivity are slightly higher in summer, whild sulphur averages are lower during summer. Nitrate does not show a clear seasonal trend.

-



Monthly averages for iron, aluminium, manganese and kalium in stream runoff.



Monthly averages for carbon and alkanlinity in runoff water. Carbon is slowly increasing during the growing season. Alkalinity is lowest in spring.

ANNEX 8 Chemical analyses and methods performed on samples from Litla Skarð 1997 – 2004.

Parameter	Methods	Instrument	Remarks
pH	Potientometric , Calibrated with pH4 and pH7 buffers Non Stirring	Orion model 920 A	Instrument change 1999 Measured on day of arrival or next morning
Conductivity		Cole Parmer Conductivity meter 1481 - 60 Automatic Temperature control	Instrument change 1999 Measured on day of arrival or next morning
Total Alkalinity	Standard Methods for the examination of Water and Wastewater. 2320 B 4d Low Alkalinity method. Titrated to end points pH 4,5 and pH 4,3	Metrohm KF Titrator Processor	Almost always on same day of arrival.
NO3N (Nitrate)	Tecator Application note ASN 143-01/90 FIA (Flow injection analysis) spectrophotometric determination after reduction of NO3 to NO2	FIAlab 3500	Instrument change 2002 Before: Tecator Aquatec After: FIAlab 3500
NH4N (Ammonium)	Tecator Application note ASN 140-01/90 Gas diffusion. FIA spectrophotometric determination after liberation of NH3 over a gasdiffusion membrane into an indicator stream.	FIAlab 3500	Instrument change 2002 Before: Tecator Aquatec After: FIAlab 3500
Chloride	Tecator Application note ASN 63-03/83 Mercury Thiocyanate method FIA spectrophotometric determination.	FIAlab 3500	Instrument change 2002 Before: Tecator Aquatec After: FIAlab 3500
DOC (Dissolved Organic Carbon)	Samples sent to: Prof. Siegel & Partner GMBH Umweltanalytik und Beratung Method : DIN EN 1484		Discontinued year end 1999. After discussion revealed that TOC was desired.
TOC (Total Organic Carbon)	Samples sent to NIVA (Norwegian institute for water analysis). Peroxodisulfate method	Phoenix 8000 instrument	Analyses began in beginning of year 2000
Ca, Mg, K, Na,S	ICP (Inductively coupled plasma)	Spectral Solutions,Spectroflame	
Total P	ICP (Inductively coupled plasma)	Spectral Solutions , Spectroflame	Analyzed with ICP until year end 2002 Discontinued because of low sensitivity

Total P	Tecator Application note ASN 147-01/90 Peroxodisulfate digestion in autoclave. FIA spectrophotometric determination Reduction of P to Phosphomolybdenum blue with Stannous Chloride after reaction with Ammonium molybdate in H2SO4 medium	FIAlab 3500	Anlalyses by this method began in the beginning of year 2003
Total Aluminium	ICP ICP TOFMS (Inductively coupled plasma time of flight mass spectrometer)	Spectral Solutions, Spectroflame LECO Renaissance TOFMS Spectrometer	Analysis through 2002 on ICP After that either with ICP or ICP TOFMS based on availability of ICP TOFMS which has been out of order many times. ICP TOFMS preferred, because of lower detection limits.
Fe and Mn	ICP ICP TOFMS	Spectral Solutions , Spectroflame LECO Renaissance TOFMS Spectrometer	Analysis through 2002 on ICP After that either with ICP or ICP TOFMS based on availability of ICP TOFMS which has been out of order many times. ICP TOFMS preferred, because of lower detection limits.