Reviewed research article

Avalanches in coastal towns in Iceland

Svanbjörg Helga Haraldsdóttir[1,2,3], Esther Hlíðar Jensen[2],
Leah Tracy[2], and Haraldur Ólafsson[2,3]

[1]*Menntaskólinn í Reykjavík (Reykjavík College), 101 Reykjavík,*

[2]*Veðurstofa Íslands (Icelandic Meteorological Office)*

[3]*Faculty of Science, University of Iceland*

email: svanahh@gmail.com

Abstract — *An overview of all registered avalanches in the vicinity of 13 towns known to be threatened by avalanches is presented graphically, together with information on weather prior to avalanches at specific locations. In N-Vestfirðir (NW-Iceland), Central N-Iceland and in Austfirðir (E-Iceland), large avalanches are generally preceded by heavy precipitation and strong sustained winds from a northerly direction. In such cases, the snow accumulates at the top of the lee slopes. In some cases snow accumulates in gullies when the wind blows parallel to the mountain side and at some locations, snow accumulation is very sensitive to wind direction.*

INTRODUCTION

In January and October 1995, catastrophic avalanches killed a total of 34 people in Súðavík and Flateyri (Figure 1) in N-Vestfirðir, NW-Iceland, (Egilsson, 1995a,b, 1996; Ólafsdóttir, 1996; Haraldsdóttir, 1998a,b). Property loss was enormous and so was the impact on the local society. Since late December 1995, Veðurstofa Íslands (Icelandic Meteorological Office) has been responsible for deciding evacuation of residents in Icelandic towns in case of avalanche hazards (Figure 2), hazard mapping and guiding the work on permanent protection structures against avalanches (Magnússon, 1998). On the basis of records of avalanches and studies of weather related to avalanches, evacuation plans have been made for individual towns. After the catastrophic 1995 avalanches, the need for permanent protection measures was reviewed by Jóhannesson *et al.* (1996). This led to the construction of deflecting and catching avalanche dams and supporting structures in avalanche starting zones. Avalanche dams have already been constructed in five towns, Flateyri, Siglufjörður, Neskaupstaður, Ísafjörður and Seyðisfjörður.

Figure 1. Flateyri after the catastrophic avalanche on 26 October 1995, which caused 20 fatalities. Over 30 houses were hit by the avalanche – *Yfirlitsmynd af Flateyri eftir snjóflóðið mikla 26. október 1995, þar sem 20 manns fórust. Snjóflóðið lenti á rúmlega 30 húsum.*

Most of the avalanche mapping, as well as most studies of weather situations causing avalanches, have only been presented in internal reports, of which many are in Icelandic. In this paper, an overview of the weather related to avalanche hazard, in 15 towns (Figure 2) is presented, together with maps showing the outlines of avalanches in the vicinity of 13 towns. The purpose of this paper is to bring a synthesis of this extensive data collection and research to the international avalanche community. Furthermore, it can be considered as a basis for research e.g. on snowdrift, aiding future selection of sites for monitoring and studies of the phenomena. In the next section of this paper, a brief review of published studies of weather prior to avalanches is presented. This is followed by a short review of work on the geographic settings of avalanches in Iceland, including the most severe events in recent years. The registration of avalanches in Iceland is reviewed in the following section, which includes an overview of avalanches in the towns in question. Plans for evacuation are explained and the relevant weather prior to avalanches in each town is described. The paper concludes with a short summary and a vision for future work.

STUDIES OF WEATHER PRIOR TO AVALANCHES

The climate of Iceland

Iceland's winter climate is characterised by snowfall during strong winds and frequent thaw periods. Considerable snowdrift is frequent and it has a strong effect on avalanche hazard.

An overview of averages and extremes of winter climate from 1961 to 1990 at several weather observation stations (Figure 2) is presented in Table 1. The table reveals that the average winter temperature at sea level is close to 0°C (giving lower mean temperatures at the starting zones of avalanches). The average 7-month precipitation ranges from 335 to more than 950 mm. At 400-800 m a.s.l. above the towns at risk, most of this precipitation falls as snow. These numbers may seem low, but here it should be kept in mind that during strong winds and solid precipitation, the conventional observations give a large underestimation of the true ground precipitation (Friðriksson and Ólafsson, 2005). Furthermore, precipitation in the mountains can be expected to be greater than in the lowland where the weather stations in Table 1 are located (Rögnvaldsson *et al.*, 2004). The mean wind speed is remarkably high at most of these lowland stations and the extreme wind values are far above what is needed for significant snowdrift.

Studies of weather and avalanches

Björnsson (1980) presented statistics on deaths and types of avalanches in Iceland based partly on Jónsson (1957). The Björnsson paper also describes climatic conditions and terrain features for the main areas endangered by avalanches as well as weather prior to both wet and dry avalanches (see also Björnsson, 1979).

In recently published avalanche history reports (Veðurstofa Íslands, 1997–2004), some information about weather related to avalanches is included, and these reports have been the background for several studies of avalanche weather.

Two catastrophic avalanches fell in Neskaupstaður on 20 December 1974, causing 12 fatalities. Guttormsson (1975a,b) registered information about the avalanches and the preceding weather, and avalanche maps were published in Haraldsdóttir (1997). Egilsson (1995a,b, 1996) described the avalanches that struck the towns Súðavík and Flateyri, in January and October 1995, killing 14 and 20 people, respectively. More detailed studies of the Flateyri avalanche, including an analysis of the preceding weather conditions, is given in Haraldsdóttir (1998a,b). A weather analysis of the Súðavík avalanche is found in Ólafsdóttir (1996). All the above studies underline the importance of heavy snowfall and transport of snow in strong winds. Jóhannesson and Jónsson (1996) studied weather conditions prior to avalanches in Vestfirðir (Figure 2). Jónsson (1998) found that dry avalanches in Vestfirðir and Austfirðir were predominantly associated with northerly and mainly north-easterly winds, and that registered dry avalanches are twice as common in Vestfirðir than in Austfirðir. Jónsson attributed this difference in frequency to the winter climate being warmer in Austfirðir than in Vestfirðir.

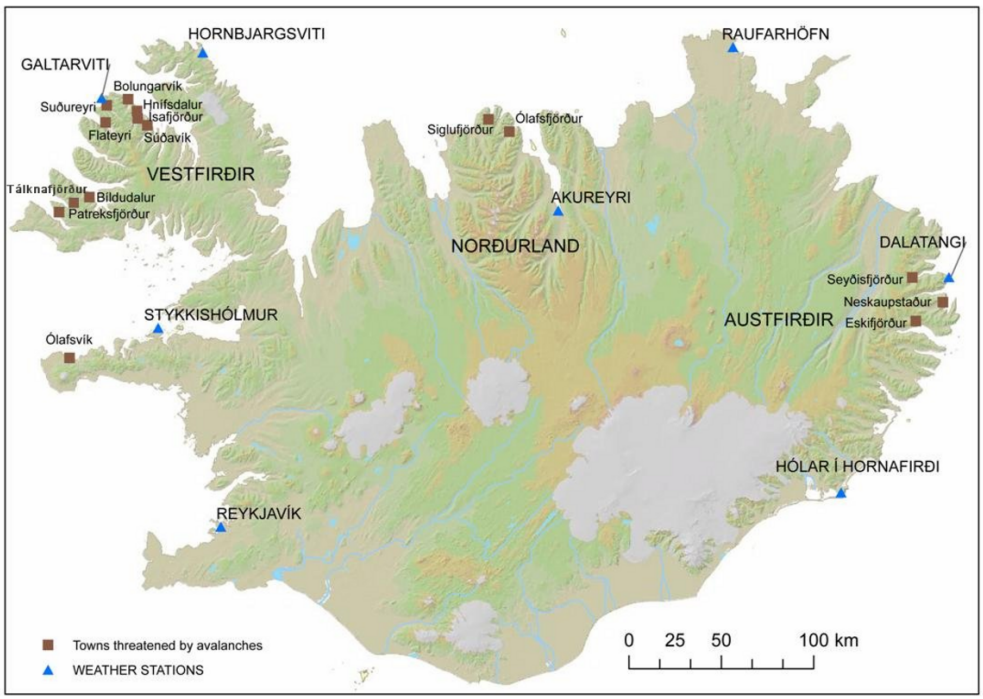

Figure 2. Towns in Iceland threatened by avalanches and selected weather stations from which data is shown in Table 1. *– Þéttbýli á Íslandi þar sem hætta er á snjóflóðum. Gögn frá veðurstöðvunum sem merktar eru með þríhyrningum eru í 1. töflu.*

Table 1: Winter values of key climate parameters (October to April) from selected weather stations, 1961–1990. Winds in 10 minute averages. All stations are close to sea level. *– Helstu þættir veðurfars á nokkrum veðurstöðvum, 1. október –30. apríl. 1961–1990. Vindhraði byggir á 10 mín. meðaltölum.*

Weather observation station	**Avg. T** (°C)	**Average precipitation** (mm)	**Max. snow depth** (cm)	**Avg. wind** speed (m/s)	**Max. wind** speed (m/s)
Reykjavík	1.2	524	43	6.4	39.6
Stykkishólmur	0.4	480	70	6.9	35.0
Galtarviti	0.3	876	140	6.3	39.1
Hornbjargsviti	-0.5	694	218	6.8	39.1
Akureyri	-0.4	335	160	4.2	34.4
Raufarhöfn	-0.9	487	205	6.6	36.0
Dalatangi	1.3	859	220	5.9	43.7
Hólar í Hornafirði	1.6	956	60	5.7	35

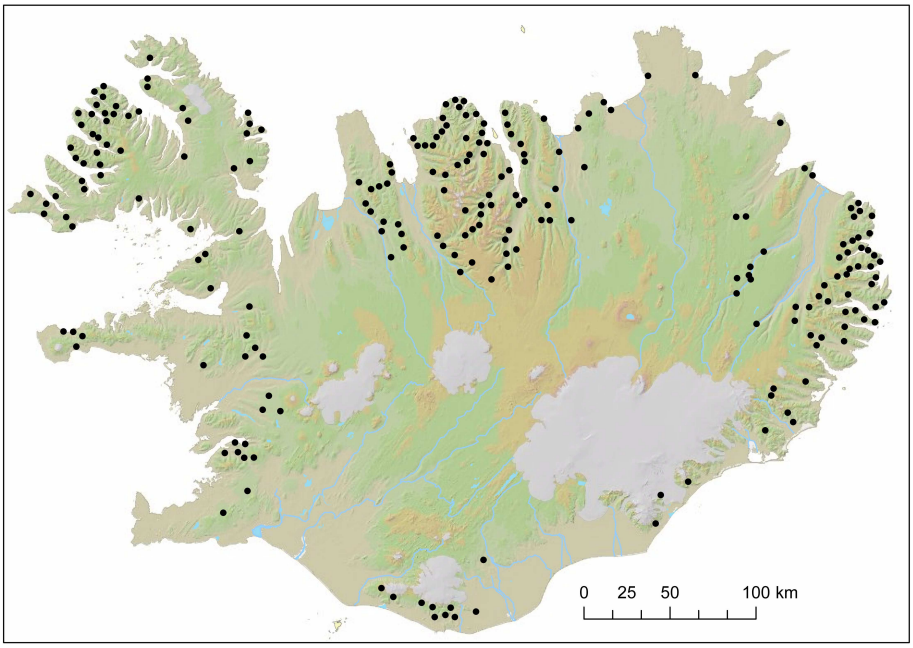

Figure 3. Avalanches known to have caused fatalities or damage 1600–1980. (From Björnsson, 1980.) – *Kortið sýnir staði þar sem snjóflóð hafa valdið dauðsföllum eða eyðileggingu á árunum 1600-1980.*

Table 2: Number of avalanches and registered outlines of avalanches in the Icelandic Meterological Office database in the vicinity of the towns threatened by avalanches. By 31 July 2003, a total of 2072 snow avalanches were registered in the database. – *Yfirlit yfir fjölda skráðra snjóflóða í gagnagrunni Veðurstofu Íslands fram til 31. júlí 2003.*

Location	**Town and the closest surroundings**	**Rural area close town**	**Outlines in the GI-system**
Ólafsvík	11	-	7
Patreksfjörður	19	4	21
Bíldudalur	20	9	4
Flateyri	129	231	172
Ísafjörður	192	29	203
Hnífsdalur	76	-	70
Súðavík	24	7	21
Bolungarvík	30	108	95
Siglufjörður	140	220	126
Ólafsfjörður	3	54	45
Seyðisfjörður	83	54	95
Neskaupstaður	151	14	128
Eskifjörður	27	22	6

Weather related to avalanches at Neskaupstaður (Ólafsson, 1998), showed connections between precipitation, maximum wind speed and the occurrence of large avalanches. A prerequisite for avalanches with a long run-out was either a high value of accumulated precipitation over 5 days or moderate precipitation, but strong winds from the north-east. Studies for Siglufjörður (Björnsson, 2001), Seyðisfjörður (Karlsdóttir, 2003) and for the northern part of Vestfirðir (Björnsson, 2002) also revealed a connection between high wind speeds and avalanches. Prior to the avalanches in Seyðisfjörður, a high amount of precipitation was also observed. Much precipitation was usually observed before the largest avalanches in the northern part of Vestfirðir, as well as in Siglufjörður. Strong winds as well as heavy precipitation are the most important parameters to consider when attempting to predict regional avalanche hazard with the help of sophisticated numerical modeling of the snowpack (Haraldsdóttir *et al.*, 2004).

GEOGRAPHICAL SETTING

Several coastal towns are endangered by avalanches in Iceland (Figure 2). Fishing is the economic foundation for these towns, which were established in the late 1800's. Above the towns are steep 400–800 m high mountains. As the towns grew bigger in the late 1900's, they gradually expanded towards the mountain slopes and today there are many houses that are located within presently-defined avalanche hazard zones. The slopes of the mountains in the starting zones of avalanches are typically 30–40°. The mountain tops are either relatively sharp peaks or flat with relatively extensive fetch for blowing snow. Both types exist in most parts of the country, but the peak form is more common in Austfirðir, E-Iceland, and the plateau form in Vestfirðir, NW-Iceland. Many starting zones are in gullies or bowls, while others are on more open slopes.

Previous awareness of the potential hazard depended mainly on people's experience of avalanches. During the late 1800's there were cold winters. In Neskaupstaður in the 1890's (translated to English): "avalanches struck every winter down to the ocean" (unpublished memoirs of Pálmason, as referred to by Haraldsdóttir (1997). At that time, there were few houses in the present location of Neskaupstaður, where in 1885 three lives were lost. During the same year, an avalanche took the lives of 24 people in Seyðisfjörður. During most of the 20th century the climate was warmer and there are no registered major catastrophic avalanches in the Neskaupstaður area until 1974, when 12 fatalities occurred. More than half a century without any significant avalanche activity in vicinity of the inhabited area had resulted in carelessness in planning new residential areas.

The present avalanche hazard zones extend down to the ocean in many towns, enclosing industrial as well as inhabited areas. Several farms and many roads are threatened by avalanches, but this overview concerns only towns and their immediate surroundings.

Figure 3 shows an overview of avalanche accidents in Iceland. The incidents are mostly clustered in Vestfirðir, NW-Iceland, in central N-Iceland and in Austfirðir, E-Iceland with some scatter elsewhere. As Björnsson (1980) points out, the data is discontinuous. Records are inaccurate up to the year 1800, but after 1800 reports on damage from avalanches are quite complete.

Most of the fatal, catastrophic avalanches during the last 30 years striking towns or farms in Iceland have been dry slab avalanches. Examples include Neskaupstaður on 20 December 1974, causing 12 casualties, an avalanche striking approximately 40 summer cottages close to Ísafjörður on 5 April 1994 killing one person, Súðavík on 16 January 1995 causing 14 casualties, a farmhouse in Reykhólasveit on 18 January 1995 killing one person, Flateyri on 26 October 1995 causing 20 casualties and the most recent one destroying a farm in Ólafsfjörður on 13 January 2004 killing the farmer.

Slush flows killed four people in Patreksfjörður on 22 January 1983. Assessments of the avalanche hazard at several locations, as well as recommendations for actions to be taken, were made after the Neskaupstaður 1974 avalanches (Quervain, 1975), and also after the Patreksfjörður 1983 slush flows (Hestnes, 1985). Besides dry slab avalanches, slush flows cause a major threat to several towns. Powder avalanches on the other hand are rare, due to prevailing strong

winds, causing new snow to be wind packed immediately. It has been shown that the snowpack in Iceland has generally higher densities than the snowpack in the Alps (Jóhannesson *et al.*, 1998), but close to the values found in the western part of Norway. The densities are high due to wind packing, interchanging periods of melting and freezing throughout the winter. Salinity could also be of importance in some places, close to the coast.

Most avalanche accidents occur during or shortly after strong winds and heavy snowfall. In many countries the residential areas have already been permanently protected, e.g. in the Alps. Increasing mountaineering during the winter has led to increased numbers of avalanches triggered by skiers or other traffic. Two fatal avalanches in 1998 and 1999, when slabs broke on weak layers during fine weather, were triggered by traffic, one by a snow-scooter and the other by a tractor. One person was killed in each accident.

REGISTRATION AND MAPPING OF AVALANCHES

Jónsson (1957) conducted pioneering work on recording the avalanche history of Iceland, including the available information about avalanches causing damage or fatalities from 1118 to 1957. A report on avalanches from 1958 to 1971 with maps locating the avalanches was published by Jónsson and Rist (1972). The previously mentioned analysis of Björnsson (1980) is partly based on these reports. Sigvaldason co-ordinated a new edition of Jónsson's work (Jónsson *et al.*, 1992), based on previous work and more recent registrations (Rist, 1975; Jónsson, 1981, 1983a, 1983b, 1984; Eyþórsdóttir, 1985; Ágústsson, 1987; Magnússon, 1988, 1989, 1991, 1992). Since 1990, information on avalanches has been collected at Veðurstofa Íslands and published in reports. Jóhannesson and Arnalds (2001) presented an up to date overview of avalanches, as well as information about the costs of avalanche damage and protection measures.

In recent years, intensive work has been invested in registering avalanches in the vicinity of the towns presented in Figure 2. Reports for each town have been published (Veðurstofa Íslands, 1997–2004). The Public Roads Administration has also registered avalanches on roads for many years. The avalanche history provides necessary background information for hazard assessment (Arnalds *et al.*, 2004), permanent protection measures (Jóhannesson *et al.*, 1996), as well as evacuation plans (Veðurstofa Íslands, 1997), avalanche forecasting, and developing and testing avalanche models (Jóhannesson *et al.*, 2001–2002).

Table 2 gives an overview of known avalanches in 13 coastal towns and their immediate surroundings up to 31 July 2003. The data is from the avalanche database of Veðurstofa Íslands. The surroundings of these towns and outlines of registered avalanches are shown in Figures A1-A13. The maps are made using a digitally based Geographic Information System (GIS). It is necessary to keep in mind that knowledge regarding avalanches other than those which occurred during the most recent decades, is limited in some of the towns.

Evacuation in case of avalanche hazard

Evacuation plans for 15 towns endangered by avalanches have been made at Veðurstofa Íslands (Figure 2). They are: Ólafsvík, Patreksfjörður, Bíldudalur, Tálknafjörður, Suðureyri, Flateyri, Súðavík, Ísafjörður, Hnífsdalur, Bolungarvík, Siglufjörður, Ólafsfjörður, Seyðisfjörður, Neskaupstaður and Eskifjörður (Veðurstofa Íslands, 1997).

Dry slab avalanches are the primary hazard in most of the towns, but some areas are threatened by wet avalanches as well. There is a minor threat of dry avalanches affecting Suðureyri and Tálknafjörður, where there is more prominent hazard due to wet avalanches and landslides. Evacuation plans due to slush flow and landslide hazard are mostly organised locally, in each case in cooperation with Veðurstofa Íslands. Hazard zoning and hazard maps of the towns have been made or are in preparation at Veðurstofa Íslands. In addition, Þingeyri, NW-Iceland, and Fáskrúðsfjörður, E-Iceland, are (in 2004) considered for hazard mapping due to landslide risk.

Evacuation levels are defined according to avalanche paths, run-out of known avalanches and the results of avalanche modeling (Jóhannesson *et al.*,

2001-2002). There are three main evacuation levels (Magnússon, 1996):

Evacuation level 1: An area where avalanches have occurred following moderate snow accumulation. The extent of the evacuation area may be smaller than indicated by the avalanche history, where extreme conditions are included. Frequent evacuation of homes can be expected.

Evacuation level 2: An area which is predominantly determined by known avalanches and topographic conditions that are similar to known avalanche paths. Avalanche hazard is associated with heavy accumulation of snow. The area will be evacuated during impending weather conditions which are known to impose a serious threat of avalanches.

Evacuation level 3: An area which is considered threatened by catastrophic avalanches that need not be included in the known avalanche history, but are considered possible; meteorological conditions with extreme snow accumulation and extreme winds. Areas threatened during extremely rare meteorological conditions are included.

Evacuation level 2 1/2: In Neskaupstaður, level 3 reaches down to the ocean in an extensive part of the town. Furthermore, the starting zones of the various avalanche paths have similar aspects resulting in avalanche hazard a large area at the same time. To be able to evacuate smaller parts of the town, an intermediate level between levels 2 and 3 was defined.

Although permanent avalanche protection has been constructed in some towns, level 3 evacuation plans are still in effect, as the risk can never be eliminated completely.

Where the hazard is mainly due to wet avalanches or slush flows, evacuation is usually not predefined, but partly based on a subjective evaluation of the situation on each occation.

WEATHER LEADING TO AVALANCHES IN THE TOWNS AT RISK

A general description of weather related to avalanches for each town is given in the evacuation plans (Veðurstofa Íslands, 1997). The weather description is based on the studies mentioned previously in this paper, as well as unpublished studies relating local conditions and particular weather characteristics. Details on avalanche paths and weather characteristics prior to avalanches in individual towns are summarized in Tables 3–17. The evacuation levels are included to show the scale of the danger in the zone below the relevant source area. A short overview is given for each town.

Ólafsvík

The two known avalanche events in Ólafsvík (Figure A1) occurred when relatively large amounts of snow had accumulated during winds from S and SE.

Patreksfjörður

The most severe avalanche hazard in Patreksfjörður (Figure A2), especially at Vatneyri, seems to be related to intense snowfall and/or snowdrift in easterly wind directions, i.e. from 60° to 130°. This is associated with frontal zones moving slowly northwards over the area. Intensive rain and/or melting can cause serious slush flow danger.

Bíldudalur

During most winters there is not much snow accumulation on the slopes above Bíldudalur (Figure A3). Although rare, avalanche hazard may develop along the mountainside above the town, during intense snowfall and persistent westerly winds. Wet avalanches, slush flows, landslides and water floods are more likely than dry avalanches. Intensive rain or sudden thawing can create a severe avalanche danger in Bíldudalur.

Tálknafjörður

The town is mainly threatened by slush and water flows, caused by intense rain or thawing. Evacuations due to risk from dry avalanches were not considered necessary and there are only a few recent mapped avalanches. Predefined evacuation plans are designed with respect to flooding along two gullies.

Northern part of Vestfirðir: Suðureyri, Flateyri, Súðavík, Ísafjörður, Hnífsdalur and Bolungarvík

The most severe avalanche hazard in Northern-Vestfirðir (Figures A4-A8) is related to snowfall with strong winds from northerly directions, mainly N and

NE. Heavy snowfall and persistent strong winds may result in enormous snow accumulation in many of the starting zones of avalanches in N-Vestfirðir. Intensive snowfall during winds from SE can cause avalanche hazard on slopes facing north in parts of Ísafjörður and Hnífsdalur. In all of the towns in N-Vestfirðir there is frequently a serious threat of dry avalanches, with the exception of Suðureyri.

Siglufjörður

The most severe avalanche hazard in Siglufjörður (Figure A9) is related to heavy snowfall with strong winds from northerly directions. Some of the avalanches with the longest run-outs (from Skollaskál, Ytra-Strengsgil and Jörundargil) have been preceded by persistent snowfall during moderate winds and cold weather followed by strong winds leading to very rapid snow accumulation in the starting zones.

Ólafsfjörður

Avalanches with long run-out zones are uncommon along the mountainside above the town (Figure A10). The main dry avalanche threat is considered to be associated with snowfall during easterly winds. Additionally, the town is threatened by mudflows.

Seyðisfjörður

Analysis of weather related to avalanches in Seyðisfjörður (Figure A11) is more complicated than in most of the other towns in Iceland. Hazard may arise in some of the avalanche source areas in most wind conditions during snowfall or sleet, but the most common circumstances are associated with snowfall during winds from NE or E.

Although often warm, winds from SE may bring snow to the mountains above Seyðisfjörður. During intense snow or sleet and moderate winds from E, snow can accumulate on both sides of the fjord, causing wet avalanche hazard. Threat by wet avalanches and slush flows mainly occurs on the south side of town below Strandartindur. The town is also threatened by debris flows and an area of large mass-creep.

Neskaupstaður

Avalanche hazard can arise along the entire mountainside at Neskaupstaður (Figure A12) in snowfall during winds between N and E. The most frequent circumstances creating avalanche hazard is intense snowfall, sometimes during calm weather in the town but strong winds in the mountains and out on the open sea. Temperature at sea level is often slightly above freezing during snow accumulation preceding the most severe avalanche events. North-easterly winds can lead to accumulation of snow on parts of the mountains above the town as well as erosion of snow from other parts. During avalanche weather, temperatures usually drop as one gets farther away from the coast, and consequently, the limits of snow and rain tend to be at a lower level inland than at the coast. Intensive wet snow accumulation sometimes occurs during ESE- and SE-winds.

Most of the largest avalanches since 1885 seem to have been dry avalanches, triggered after several days of NE-winds with snowfall on top of hard snow surface in the mountains, and temperatures just below 0°C in the lowland. Debris-flow hazard is also present, especially from the Urðarbotn area.

Eskifjörður

The main threat in Eskifjörður is due to slush flows, debris flows and flooding (Figure A13), which is most likely to occur during intense precipitation. Monitoring is necessary if snow has accumulated in gullies.

SUMMARY

An overview of the outlines of recorded avalanches in the vicinity of all major towns in Iceland that are endangered by avalanches has been presented graphically, together with a short description of the relevant elements of the weather prior to the avalanches. The overview is based on avalanche records, which have been reliable during decades in some towns, whereas in other towns there was no record until after 1995, except for avalanches causing fatalities and/or damage to property.

The main characteristics of the weather prior to avalanches is heavy precipitation and strong winds. The most severe avalanche hazard is generally also associated with strong winds in the mountains and heavy precipitation during the days preceding a catastrophic avalanche. Avalanche hazard in N-Vestfirðir,

in the central part of Northern Iceland and Austfirðir is predominantly associated with winds from north-east or north. In most cases, the avalanches occur on south-facing slopes, which are the lee slopes during northerly winds. This is, however, not always the case, as e.g. in Siglufjörður, where the snow accumulates in gullies when the wind blows along the mountain slope. In some of the towns, avalanche hazard occurs during both northerly and southerly wind directions in different parts of the town. There is, in some cases, a relatively small difference between wind directions which cause accumulation in an avalanche starting zone and wind directions that erode the snow from the mountainside. The critical conditions depend on the aspect and form of the starting zones as well as the fetch for snowdrift.

FUTURE WORK

Avalanche chronology and recording is a continual and essential process. With the present effort of registration of avalanches, a good database will continue to improve. At present, the main emphasis is only on mapping for towns where the information is valuable for hazard mapping. Improved digital information on the topography will gradually make it possible to create maps of all the available geographic avalanche information in Iceland. This will provide important background for hazard mapping for farms and outdoor activities.

During the next years, the construction of permanent avalanche protections will continue in most of the towns. In spite of these protection measures, there will always be a remaining risk. Avalanche warnings and evacuations of residential areas will therefore continue to be necessary.

Acknowledgements

This work would not have been possible without the intensive work of employees at the avalanche section at Veðurstofa Íslands forming the background for this paper. We are grateful to Tómas Jóhannesson, Magnús Tumi Guðmundsson, Helgi Björnsson, and two anonymous reviewers for comments on the scientific aspect of the paper and Amy Clifton, Barði Þorkelsson and Matthew Roberts for their editing contributions.

ÁGRIP

Í grein þessari er gefið yfirlit yfir skráð snjóflóð og snjóflóðaveður á 13 þéttbýlisstöðum á Íslandi. Dregin eru kort sem sýna útlínur á annað þúsund skráðra snjóflóða fram til ársins 2003. Algengasti undanfari mikilla snjóflóða er hvass vindur og mikil úrkoma. Á norðanverðum Vestfjörðum, Mið-Norðurlandi og Austfjörðum falla flóð oftast í norðlægum vindi en þá safnast snjór hlémegin fjallanna í upptakasvæði sem vísa móti suðri. Í undantekningartilfellum safnast umtalsverður snjór í hlíðar samsíða vindátt og sums staðar getur lítil vindáttarbreyting valdið mikilli breytingu á snjósöfnun.

REFERENCES

Ágústsson, K. 1987. Snjóflóð á Íslandi veturna (Snow avalanches in Iceland) 1984/85 og 1985/86. *Jökull*, 37, 91–98.

Arnalds, Þ., K. Jónasson and S. Sigurðsson 2004. Avalanche hazard zoning in Iceland based on individual risk. *Ann. Glac.*, 38, 285–290.

Björnsson, H. 1979. Snjóflóð og snjóflóðavarnir. *Náttúrufræðingurinn*, 49, 4, 257–277.

Björnsson, H. 1980. Avalanche activity in Iceland, climatic conditions, and terrain features. *J. Glaciol.*, 26(94), 13–23.

Björnsson, H. 2001. Veður í aðdraganda snjóflóðahrina á Siglufirði. Veðurstofa Íslands - Greinargerð, 01018, Reykjavík, 22 pp. (Icelandic Meteorological Office - Report: Weather related to avalanche cycles at Siglufjörður.)

Björnsson, H. 2002. Veður í aðdraganda snjóflóðahrina á norðanverðum Vestfjörðum. *Veðurstofa Íslands* - Greinargerð, 02019, Reykjavík, 75 pp. (Icelandic Meteorological Office - Report: Weather related to avalanche cycles in the northern part of Vestfirðir.)

Egilsson, J. G. 1995a. Snjóflóðið á Súðavík. Aðdragandi og orsök. *Fréttarit Landsbjargar*, 1-95, 17–19.

Egilsson, J. G. 1995b. Snjóflóðið á Flateyri. Aðdragandi og orsök. *Fréttarit Landsbjargar*, 5-95, 20–23.

Egilsson, J. G. 1996. Two destructive avalanches in Iceland. In: *ISSW'96. Proceedings of the International*

Snow Science Workshop, Banff, Canada. The Canadian Avalanche Association, Revelstoke, BC, Canada, 264–267.

Eyþórsdóttir, K. G. 1985. Snjóflóð á Íslandi veturinn 1983-1984. *Jökull*, 35, 121–126.

Friðriksson, R. F. and H. Ólafsson 2005. Estimating errors in wintertime precipitation observations by comparison with snow observations. Proceedings of the Int. Conf. Alpine Meteorol., *J. Croatian Meteorol. Soc.* 40, 695–697.

Guttormsson, H. 1975a. Snjóflóðin í Neskaupstað. *Árbók Slysavarnafélags Íslands.* (The avalanches at Neskaupstaður.)

Guttormsson, H. 1975b. Snjóflóðin í Neskaupstað. *Sveitarstjórnarmál*, 1, 3–6. (The avalanches at Neskaupstaður.)

Haraldsdóttir, S. H. 1997. Snjóflóðasaga Neskaupstaðar. *Rit Veðurstofu Íslands*, VÍ-R97002, Reykjavík, 214 pp. (Icelandic Meteorological Office - Research Report: The avalanche history of Neskaupstaður.)

Haraldsdóttir, S. H. 1998a. Snjóflóð úr Skollahvilft - Snjóflóðahrinan í október 1995. *Rit Veðurstofu Íslands*, VÍ-R98003, Reykjavík, 56 pp. (Icelandic Meteorological Office - Research Report: The avalanche at Skollahvilft - The avalanche cycle in October 1995.)

Haraldsdóttir, S. H. 1998b. The avalanche at Flateyri, Iceland, October 26th 1995 and the avalanche history. In: E. Hestnes (editor), *Proceedings of 25 Years of Snow Avalanche Research, Voss, Norway, May 12-16, 1998. Norwegian Geotechnical Institute*, 203, Oslo, 122–127.

Haraldsdóttir, S. H., H. Ólafsson, Y. Durand, G. Giraud, and L. Merindol 2004. A system for prediction of avalanche hazard in the windy climate of Iceland. *Ann. Glaciology*, 38, 319–324.

Hestnes, E. 1985. Skredfare I arealbruksammenheng. Studietur i Island 30.07-05.08.84. *Norges Geotekniske Institutt*, Oslo, Norway. Tech. Rep. 58030-3.

Jóhannesson, T. and T. Jónsson 1996. Weather in Vestfirðir before and during several avalanche cycles in the period 1949 to 1995. *Veðurstofa Íslands* - Greinargerð, VÍ-G98013, Reykjavík. (Icelandic Meteorological Office - Report.)

Jóhannesson, T., K. Lied, S. Margreth and F. Sandersen 1996. Þörf fyrir snjóflóðavarnarvirki á Íslandi. Yfirlit og mat á kostnaði / An overview of the need for avalanche protection measures in Iceland. *Rit Veðurstofu Íslands*, VÍ-R96003/04, Reykjavík. (Icelandic Meteorological Office - Research Reports.)

Jóhannesson, T., J. O. Larsen and J. Hopf 1998. Pilot Project in Siglufjörður. Interpretation of observations from the winter 1996/97 and comparison with similar observations from other countries. *Veðurstofa Íslands - Greinargerð*, VÍ-G98033, Reykjavík, 25 pp. (Icelandic Meteorological Office - Report.)

Jóhannesson, T. and Þ. Arnalds 2001. Accidents and economic damage due to snow avalanches and landslides in Iceland. *Jökull*, 50, 81–94.

Jóhannesson, T., Þ. Arnalds and L. Tracy 2001-2002. Results of the 2D avalanche model SAMOS for Bolungarvík and Neskaupstaður, Eskifjörður, Ísafjörður and Hnífsdalur, Seyðisfjörður, Siglufjörður. *Veðurstofa Íslands - Greinargerð*, 01011, 02013, 02018, 02008 and 01019, Reykjavík. (Icelandic Meteorological Office - Reports.)

Jónsson, H. H. 1981. Snjóflóðaannáll áranna 1975-1980. (Snow avalanches 1975-1980). *Jökull*, 31, 47–58.

Jónsson, H. H. 1983a. Snjóflóð á Íslandi veturinn 1980-81. (Snow avalanches in Iceland 1980-81). *Jökull*, 33, 149–152.

Jónsson, H. H. 1983b. Snjóflóð á Íslandi veturinn 1981-82. (Snow avalanches in Iceland 1981-82). *Jökull*, 33, 153-154.

Jónsson, H. H. 1984. Snjóflóð á Íslandi veturinn 1982-83. (Snow avalanches in Iceland 1982-83). *Jökull*, 34, 159–164.

Jónsson, Ó. 1957. Skriðuföll og snjóflóð, I-II. Akureyri, Norðri. (Landslides and avalanches, I-II.)

Jónsson, Ó. and S. Rist 1972. Snjóflóð og snjóflóðahætta á Íslandi. *Jökull*, 21, 24–44.

Jónsson, Ó., S. Rist, H. G. Pétursson and J. Sigvaldason 1992. *Skriðuföll og snjóflóð*, I-III. Reykjavík, Bókaútgáfan Skjaldborg. (Landslides and avalanches, I-III.)

Jónsson, T. 1998. Hlutfallslíkur snjóflóðaátta á Vestfjörðum og á Austfjörðum. *Veðurstofa Íslands - Greinargerð*, VÍ-G98013, Reykjavík. (Icelandic Meteorological Office - Report: Probable wind directions related to avalanches in Vestfirðir and Austfirðir.)

Karlsdóttir, S. 2003. Veður í aðdraganda snjóflóðahrina á Seyðisfirði. *Veðurstofa Íslands - Greinargerð*, 02006, Reykjavík, 32 pp. (Icelandic Meteorological Office - Report: Weather related to avalanche cycles at Seyðisfjörður.)

Magnússon, M. M. 1988. Snjóflóð á Íslandi veturinn 1986/87. *Jökull*, 38, 98–102.

Magnússon, M. M. 1989. Snjóflóð á Íslandi veturinn 1987/88. *Jökull*, 39, 114–117.

Magnússon, M. M. 1991. Snjóflóð á Íslandi veturinn 1988/89. *Jökull*, 41, 99–102.

Magnússon, M. M. 1992. Snjóflóð á Íslandi veturinn 1989-1990. *Jökull*, 42, 97–101.

Magnússon, M. M. 1996. Preparedness of the Icelandic Meteorological Office in response to potential avalanche danger. In: *Proceedings of the ISSW'96. International Snow Science Workshop*, Banff, Canada. The Canadian Avalanche Association, Revelstoke, BC, Canada, 53–59.

Magnússon M. M. 1998. The buildup of the avalanche section of the Icelandic Meteorological Office. In *Proceedings of the International Snow Science Workshop 1998*, 132–139.

Male, D. H. 1980. The Seasonal Snowcover. *Dynamics of Snow and Ice Masses*, 305–395.

Ólafsdóttir, U. 1996. Lavinen i Suðavik den 16. Januari 1995. *Polarfront*, 23(89), 12–15.

Ólafsson, H. 1998. Veður fyrir snjóflóðahrinur í Neskaupstað 1974-1995. *Veðurstofa Íslands - Greinargerð*, VÍ-G98015, Reykjavík, 19 pp. (Icelandic Meteorological Office - Report: Weather related to avalanche cycles at Neskaupstaður 1974-1995.)

De Quervain, M. R. 1975. Avalanche Problems of Iceland. Analysis and recommendations for further action. *Eidgenössisches Institut für Schnee und Lawineforschung*, Weissfluhjoch-Davos, CH. Tech. Rep., G75.51.

Rist, S. 1975. Snjóflóðaannáll áranna 1972 til 1975. (Snow avalanches in Iceland 1972-1975). *Jökull*, 25, 47–71.

Rögnvaldsson, Ó., P. Crochet and H. Ólafsson 2004. Mapping of precipitation in Iceland using numerical simulations and statistical modelling. *Meteorol. Zeitschrift*, 13(3), 209–219.

Veðurstofa Íslands 1997. Greinargerðir um snjóflóðaaðstæður vegna rýmingarkorta fyrir Bíldudal, Bolungarvík, Eskifjörð, Flateyri, Ísafjörð og Hnífsdal ásamt Suðureyri, Neskaupstað, Ólafsfjörð, Ólafsvík, Patreksfjörð, Seyðisfjörð, Siglufjörð, Súðavík og Tálknafjörð. *Veðurstofa Íslands - Greinargerð*. VÍ-G97010, VÍ-G96004, VÍ-G97011, VÍ-G96005, VÍ-G96006, VÍ-G96007, VÍ-G97012, VÍ-G97013, VÍ-G96008, VÍ-G96010, VÍ-G96009, VÍ-G96011, VÍ-G97014. (Icelandic Meteorological Office - Reports: Descriptions of the avalanche situation in 15 towns in Iceland in connection with evacuation maps.) (http://www.vedur.is/snjoflod/rymingar.)

Veðurstofa Íslands 1997-2004. Snjóflóðasaga Bíldudals, Bolungarvíkur, Eskifjarðar, Flateyrar og Önundarfjarðar, Ísafjarðar og Hnífsdals, Neskaupstaðar, Ólafsfjarðar, Ólafsvíkur, Patreksfjarðar, Seyðisfjarðar, Siglufjarðar, Súðavíkur. *Veðurstofa Íslands - Greinargerð*: 03001, 02037, 02012, 02036, 03011, VÍ-R97002, 04015, 03005, 03002, 02009, 01016, 03004. (Icelandic Meteorological Office - Reports: The avalanche history for 13 towns in Iceland in 12 reports including maps.)
(http://www.vedur.is/snjoflod/haettumat/annalar.)

Appendix

The Appendix includes Figures A1 to A13 showing the surroundings of 13 towns. Outlines of avalanches, as well as the evacuation plans are presented. The towns are divided into evacuation areas, formed by vertical lines depending on avalanche paths and horizontal lines showing evacuation levels (1-3), as presented in Tables 3-5 and 8-17. The correlation between the figures and tables is shown in the heading of each table.

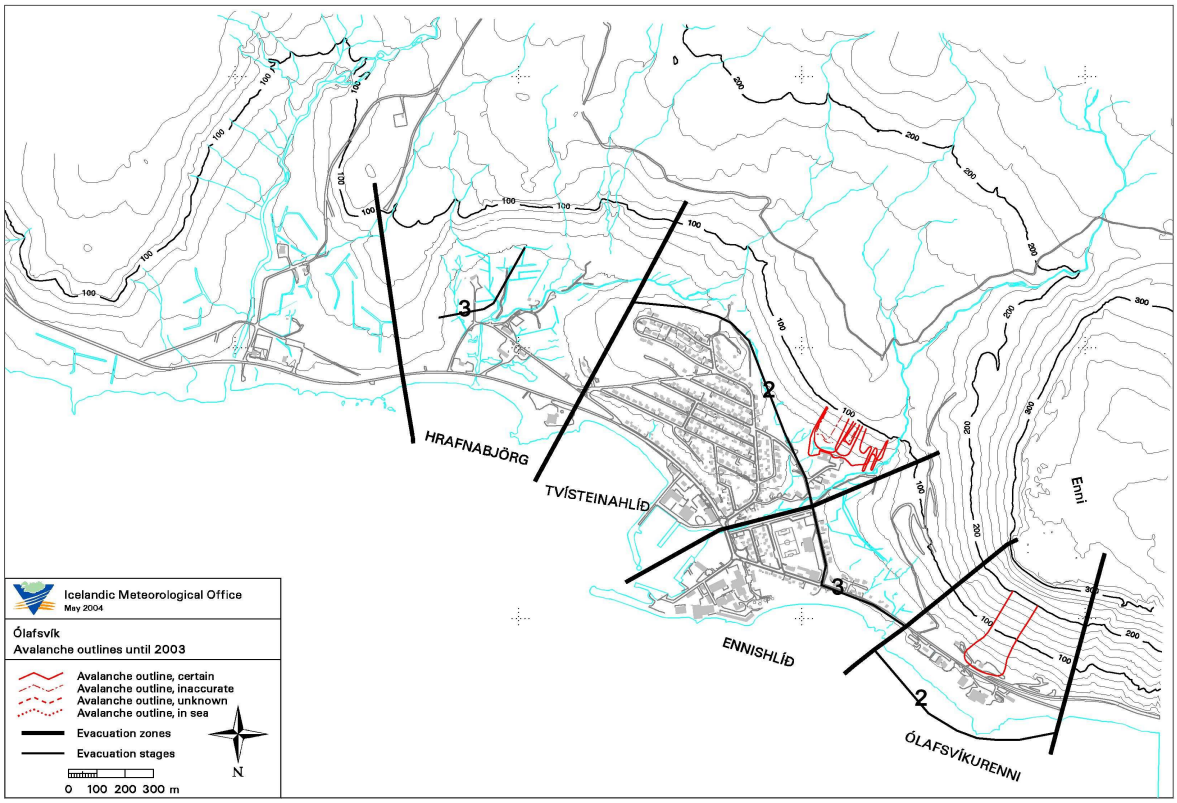

Figure A1 and Table 3: Avalanche weather and paths in Ólafsvík, W-Iceland. – *Yfirlit yfir snjóflóð, rýmingarsvæði og snjóflóðaveður í Ólafsvík.*

Evacuation areas	**Avalanche weather and wind directions for snowdrift accumulation**	**Avalanche paths and notification**
Snowdrift accumulation in southerly and westerly winds (S,W).		
Ólafsvíkurenni	Southerly winds and snowfall.	Steep mountainside, cliffs at the top and steep gravel beds downhill. Evacuation level 2.
Ennishlíð	Snowfall in westerly winds or calm weather.	Open slope without defined avalanche paths. Two cup-formed bowls are located below the cliffs close to the top. Evacuation level 3.
Tvísteinahlíð	Snowfall in southerly winds.	A low slope without defined paths. A relatively large fetch south of the slope. Old supporting structures at the top of the hill. Evacuation level 2.
Hrafnabjörg	(Southerly winds.)	A low slope without defined paths. Low cliffs at its top, gravel bed down slope. Evacuation level 3.

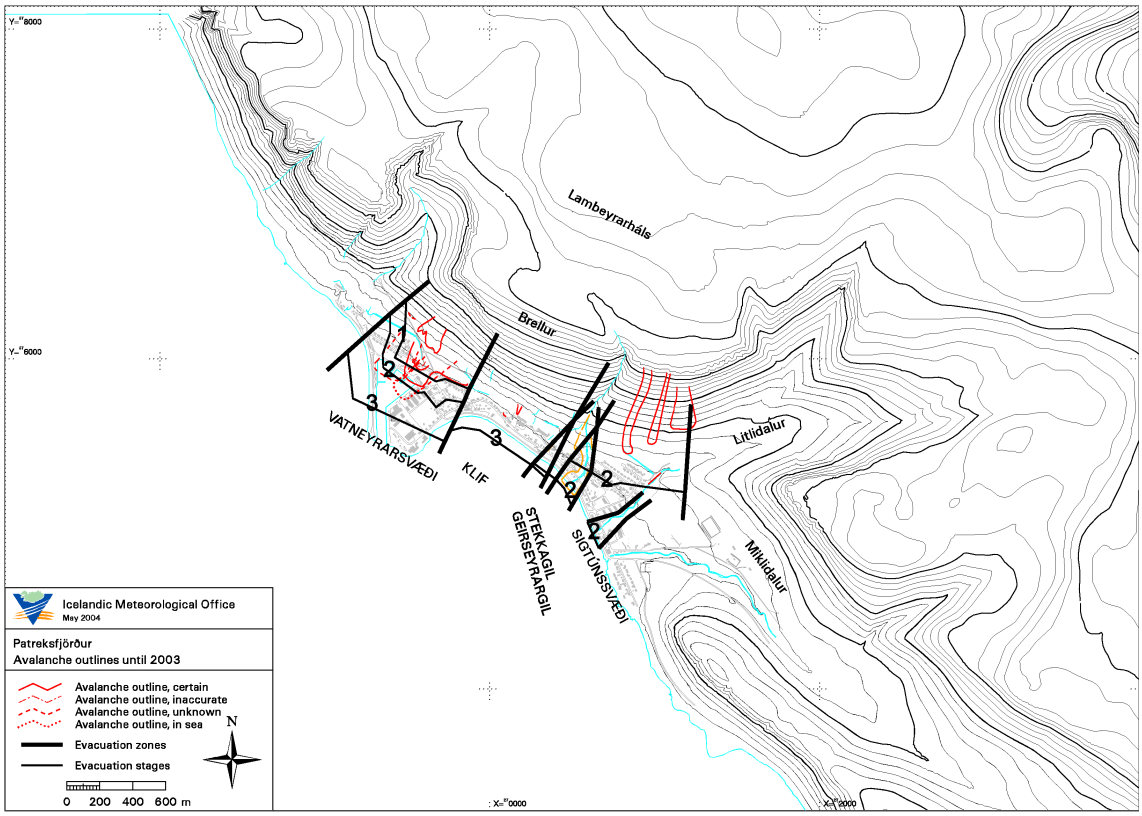

Figure A2 and Table 4: Avalanche weather and paths in Patreksfjörður, S-Vestfirðir. – *Yfirlit yfir snjóflóð, rýmingarsvæði og snjóflóðaveður á Patreksfirði.*

Evacuation zone	**Avalanche weather and wind directions for snowdrift accumulation**	**Avalanche paths and notification**
Snowdrift accumulation in winds from NW-NE-SE. Rain and melting		
Vatneyrarsvæði	Winds from NE-SE with intense snowfall and/or snowdrift. Accumulation to the fetch in many wind directions, especially from W. Afterwards the hazard can become enormous in strong winds from NE-SE.	The starting zone is bowl shaped, surrounded by cliffs. A very large fetch NE of the town. Evacuation levels 1-3.
Klif	Most severe hazard in winds from N-NE from the mountain edge or during intense snowfall. Erosion of snow from the mountainside in most types of weather.	The edge is convex, with few gullies or cuts. Evacuation level 3.
Stekkagil/ Geirseyrargil	intense rain, melting. Snow accumulation in winds from NE-E along the mountainside, and from the mountain top in winds from N-NE.	The gully is deep, wider at the top, with debris fan down slope. Slush flows. Part of the zone is shared by Sigtúnssvæði. Evacuation level 2.
Sigtúnssvæði	Snow accumulation in winds from NW-N from the mountain top or intense snowfall. During winds from NE erosion occurs from the mountainside (into Stekkagil).	The edge at the top of the hillside is convex, with two shallow gullies. Slush flow and landslides from Litladalsá. Part of the zone is shared by the Stekkagil area. Evacuation level 2.

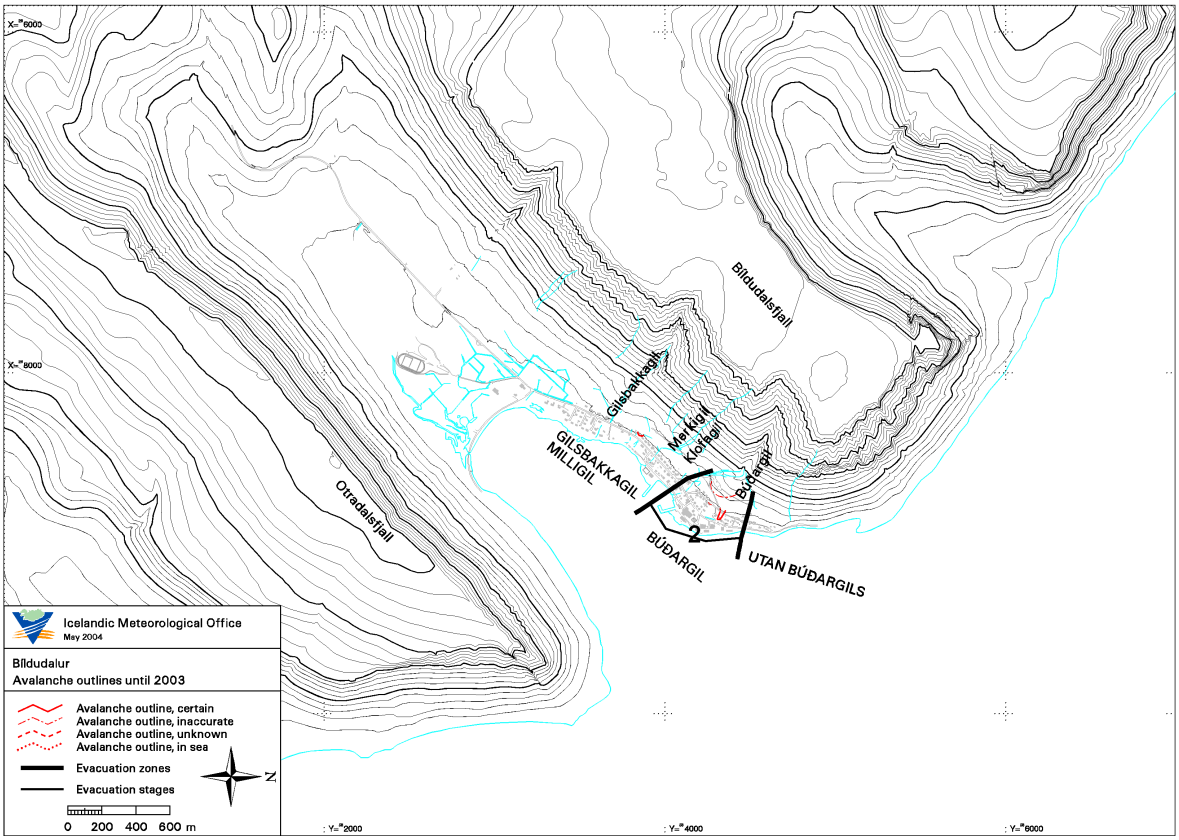

Figure A3 and Table 5: Avalanche weather and paths in Bíldudalur, S-Vestfirðir. – *Yfirlit yfir snjóflóð, rýmingarsvæði og snjóflóðaveður í Bíldudal.*

Evacuation areas	**Avalanche weather and wind directions for snowdrift accumulation**	**Avalanche paths and notification**
Snowdrift accumulation in westerly winds. Rain and melting.		
Gilsbakkagil Milligil	Westerly winds with snowfall. Rain and melting.	Gilsbakkagil is 400-500 m wide and very rough at the top, narrows farther downhill and curves down to a debris fan. Evacuation due to mud and slush flow hazard (defined in each case). Large fetch.
Búðargil	Snowdrift from a large fetch in westerly winds. intense rain or melting afterwards can create severe hazard.	The gully is 400-500 m wide at the top and narrows down to a debris fan. Endangered by mud and slush flows, water flooding and wet avalanches. Evacuation planned in each occasion due to mud and slush flows. Evacuation level 2.
North of Búðargil		Open slope without defined paths. Cliffs at the top and debris fans farther downhill. No evacuation.

Table 6: Avalanche weather and paths in Tálknafjörður, S-Vestfirðir. – *Yfirlit yfir rýmingarsvæði, snjóflóðaveður og farvegi á Tálknafirði.*

Evacuation areas	**Avalanche weather and wind directions for snowdrift accumulation**	**Avalanche paths and notification**
Probably snowdrift accumulation in winds from E, SE and SW. Rain and melting. No history of avalanches before 2003.		
Tungufellssvæði	Rain and melting.	Slush flows. Evacuation due to slush flow hazard or water flooding. Evacuation level 2.
Geitársvæði	intense rain or melting after accumulation in a bowl formed starting zone uphill. Snow accumulation can probably occur during E and SE winds as well as breeze from SW.	Evacuation especially due to slush flow hazard, but also in case of dry avalanche hazard from the bowl between Innra- and Ytra-Geitárhorn. Evacuation level 2.

Table 7: Avalanche weather and paths in Suðureyri, N-Vestfirðir. – *Yfirlit yfir rýmingarsvæði, snjóflóðaveður og farvegi á Suðureyri.*

Evacuation areas	**Avalanche weather and wind directions for snowdrift accumulation**	**Avalanche paths and notification**
Rain and melting. No history of avalanches.		
SE-part of the town	Avalanche hazard in enormous snowfall. intense rain or intense melting can cause slush flow and landslide hazard.	Locally defined evacuation due to slush flows or landslides. North facing slope. Sea-flooding in town due to avalanches at Norðureyri on the other side of the fjord.

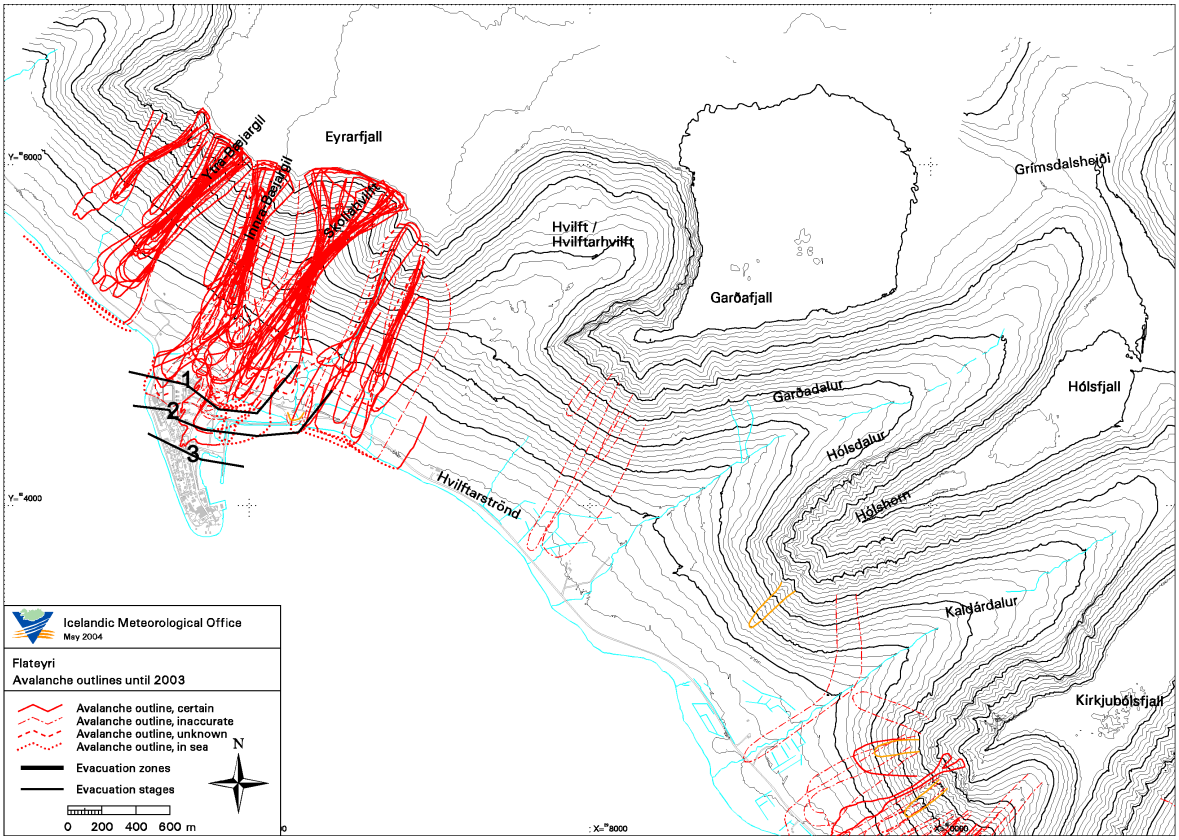

Figure A4 and Table 8: Avalanche weather and paths in Flateyri, N-Vestfirðir. – *Yfirlit yfir snjóflóð, rýmingarsvæði og snjóflóðaveður á Flateyri.*

Evacuation areas	**Avalanche weather and wind directions for snowdrift accumulation**	**Avalanche paths and notification**
Snowdrift accumulation in winds from NW-ENE.		
Innra-Bæjargil	Accumulation in winds from northerly directions, from the top of the mountain in winds from NW to NE and from the side in more westerly winds. Little accumulation in more easterly directions.	A gully, 250 m wide at the top, narrowing downhill. The opening of the gully is at 200 m a.s.l. with a gravel fan below. A large fetch for snowdrift. Protections with an avalanche dam. Evacuation 1997, levels 1-3. At present level 3.
Skollahvilft	Snowfall and snowdrift in northerly winds. Accumulation from the mountain top in winds from NW-ENE, and from the side in more easterly winds. Little accumulation in more westerly winds.	A gully or a bowl, 700 m wide at its top, the gully opening at 180 m a.s.l., where the width is 20–30 m. Farther downhill a mud fan. Relatively large fetch. Protections with an avalanche dam. Evacuation 1997, levels 1-3. At present level 3.

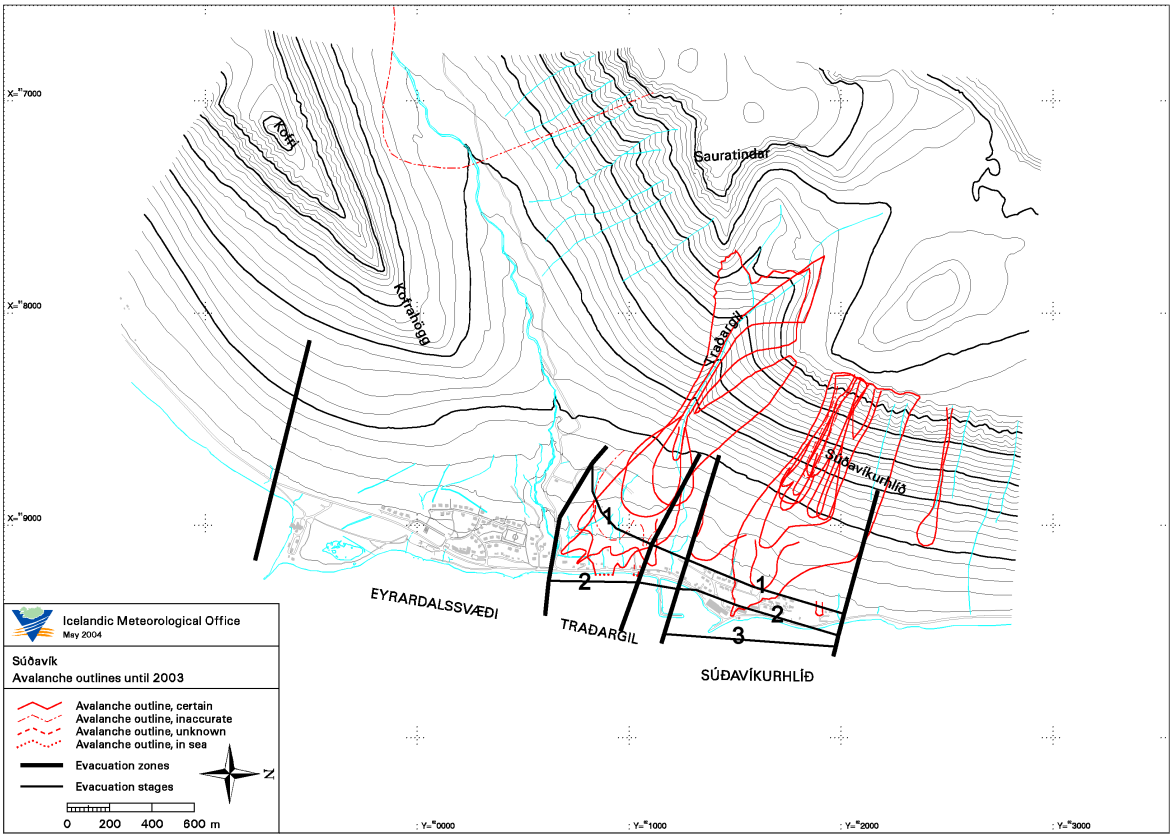

Figure A5 and Table 9: Avalanche weather and paths in Súðavík, N-Vestfirðir. – *Yfirlit yfir snjóflóð, rýmingarsvæði og snjóflóðaveður í Súðavík.*

Evacuation areas	**Avalanche weather and wind directions for snowdrift accumulation**	**Avalanche paths and notification**
Snowdrift accumulation in winds from NW-NE.		
Súðavíkurhlíð	Most intense snow accumulation during winds from N-NW. NE-wind erodes snow from the mountainside.	Shallow paths in cliffs on top of the mountainside with loose debris or gravel farther downhill. A ridge on top of the mountain causes local snow accumulation. Winter residence is now prohibited within this zone. Permanent homes have been built elsewhere. Evacuation 1997, levels 1-3.
Traðargil	Accumulations from a relatively large fetch on the top of Súðavíkurfjall in winds from NW-NE. Accumulation in the starting zone from the side in winds from NE.	The starting zone is on an open mountainside with a defined gully farther down and below it a gravel fan. The homes have been moved. Winter residence prohibited. Evacuation 1997, levels 1-2.
Eyrardalssvæði (the "New Súðavík")	Accumulation in Sauratindar from the mountain top in winds from NE, but from the side along Sauradalur in winds from NW (considered unlikely).	The starting zone in S-Sauratindar and/or in the mountainside at Kofrahögg, mostly on open hillsides.

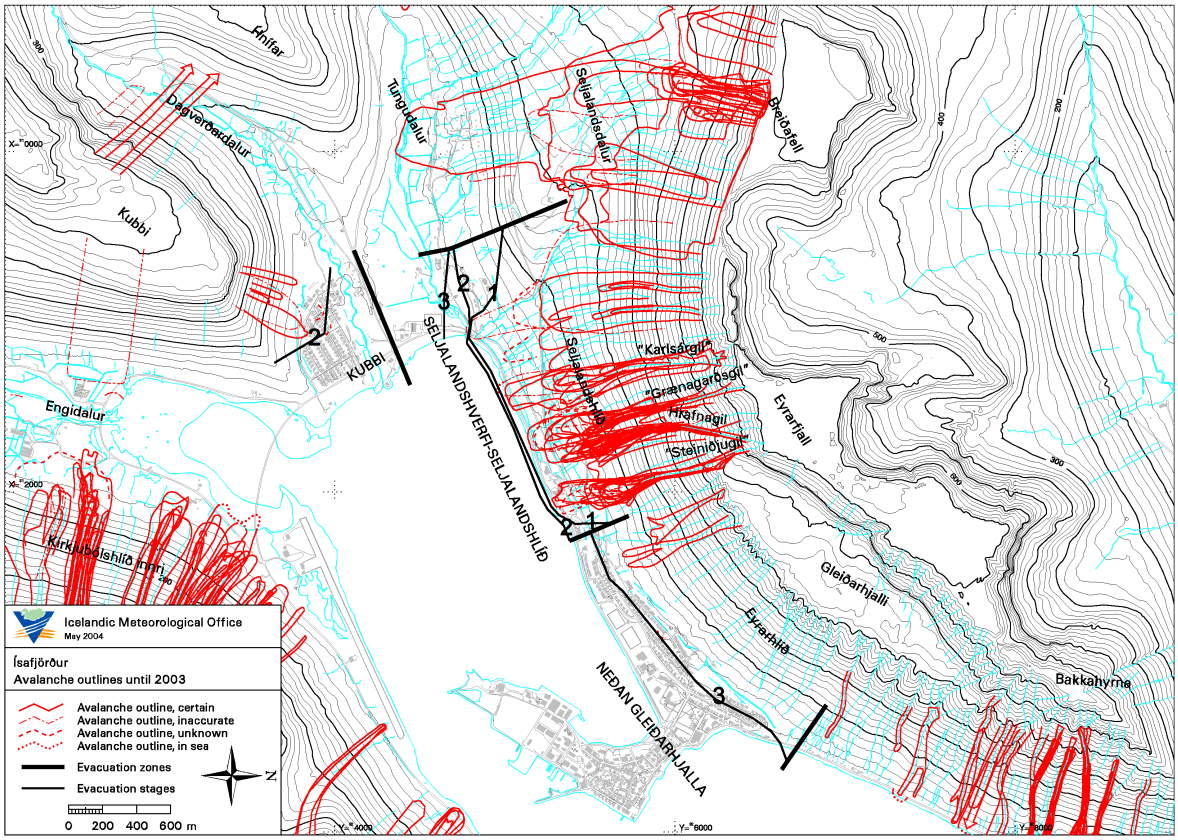

Figure A6 and Table 10: Avalanche weather and paths in Ísafjörður, N-Vestfirðir. – *Yfirlit yfir snjóflóð, rýmingarsvæði og snjóflóðaveður á Ísafirði.*

Evacuation areas	**Avalanche weather and wind directions for snowdrift accumulation**	**Avalanche paths and notification**
Snowdrift accumulation in winds from NW-NE, SW and SSE		
Kubbi	Snow accumulation from the mountain top in winds from SW. Known avalanches in SSE-storm with intense snowfall (unusual weather).	Flat or concave mountainside without defined avalanche paths. Evacuation level 2.
Seljalandshlíð, Seljalandshverfi	Snow accumulation from the mountain top of Eyrarfjall in winds from NW to NE (a relatively large fetch). During winds from N-NE snowdrift from the top of Eyrarfjall and Gleiðarhjalli into Seljalandshlíð, snow accumulates from the sides to the gullies.	In the eastern part of the area the avalanche paths are in gullies with flat gravelfans downhill. In the western side above Seljalandshverfi the paths are on an open mountainside, where Seljalandsmúli affects the run-out of the avalanches. Dam completed 2004. Evacuation in 1997, levels 1-3. At present level 3.
Neðan Gleiðarhjalla (Eyrarhlíð-Eyrarfjall) (below Gleiðarhjalli)	Generally little snow accumulation. Possibly snow accumulation in strong winds from NW-N.	Shallow gullies in cliffs at the mountainside with gravel below. A ca. 400 m wide shelf above cliffs on the mountain. Evacuation of homes only during exceptional circumstances. Evacuation level 3.

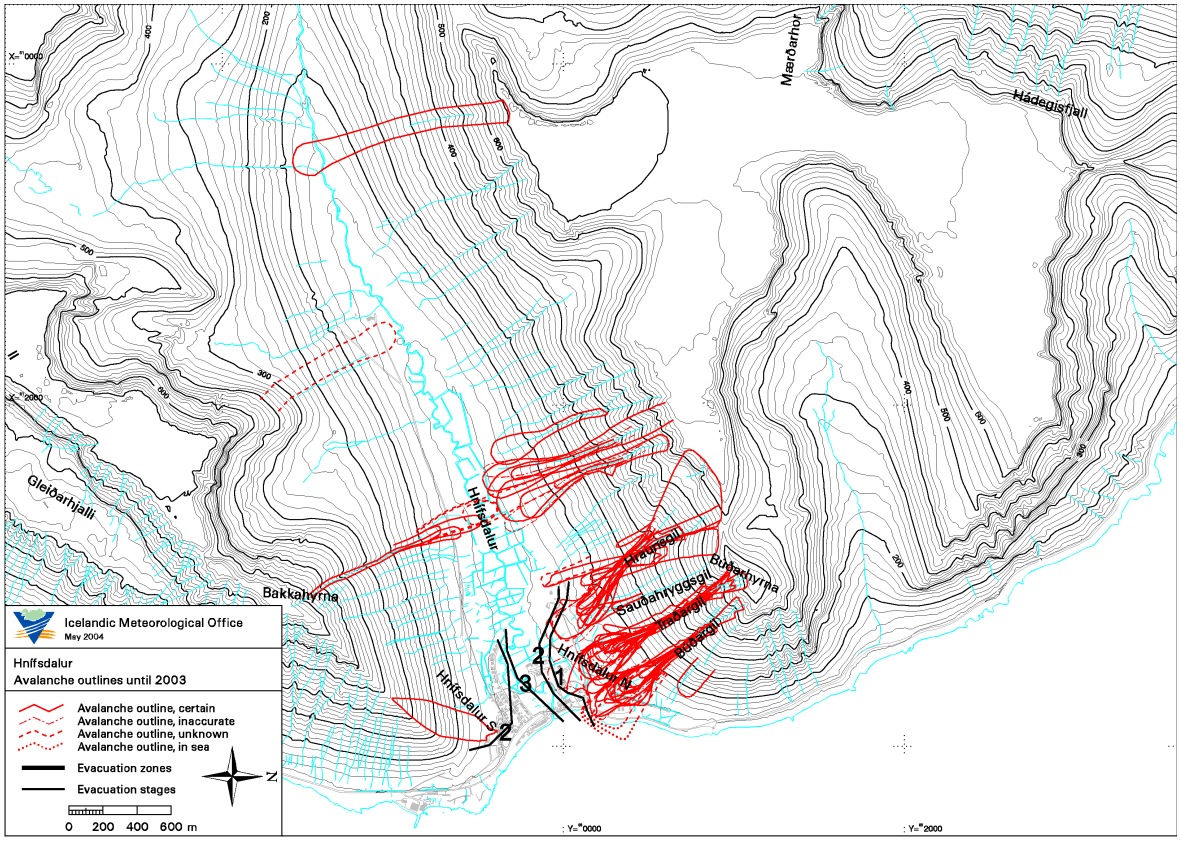

Figure A7 and Table 11: Avalanche weather and paths in Hnífsdalur, N-Vestfirðir. – *Yfirlit yfir snjóflóð, rýmingarsvæði og snjóflóðaveður í Hnífsdal.*

Evacuation areas	**Avalanche weather and wind directions for snowdrift accumulation**	**Avalanche paths and notification**
Snowdrift accumulation in winds from SE, NW-NE		
Hnífsdalur, S (Bakkahyrna)	Snow accumulation in strong winds from SE, when snow is transported from Eyrarhlíð over the mountain shoulder. Snow accumulation is not anticipated during SW-winds.	Avalanche paths on an open, flat mountainside. Evacuation level 2.
Hnífsdalur, N (Búðarfjall - Búðarhyrna)	Snow accumulation from the mountain top in winds from NW-N from Seljadalur. The gullies get filled from the side in winds from NE, when snow accumulates in the lower parts of the gullies. Large avalanches seem to be associated with snow accumulating in the upper parts of the gullies.	The paths are mostly defined to three gullies: Búðargil, Traðargil, Hraunsgil. Permanent homes have been moved as winter residence is prohibited. Evacuation 1997, levels 1-3. At present evacuation levels 2-3.

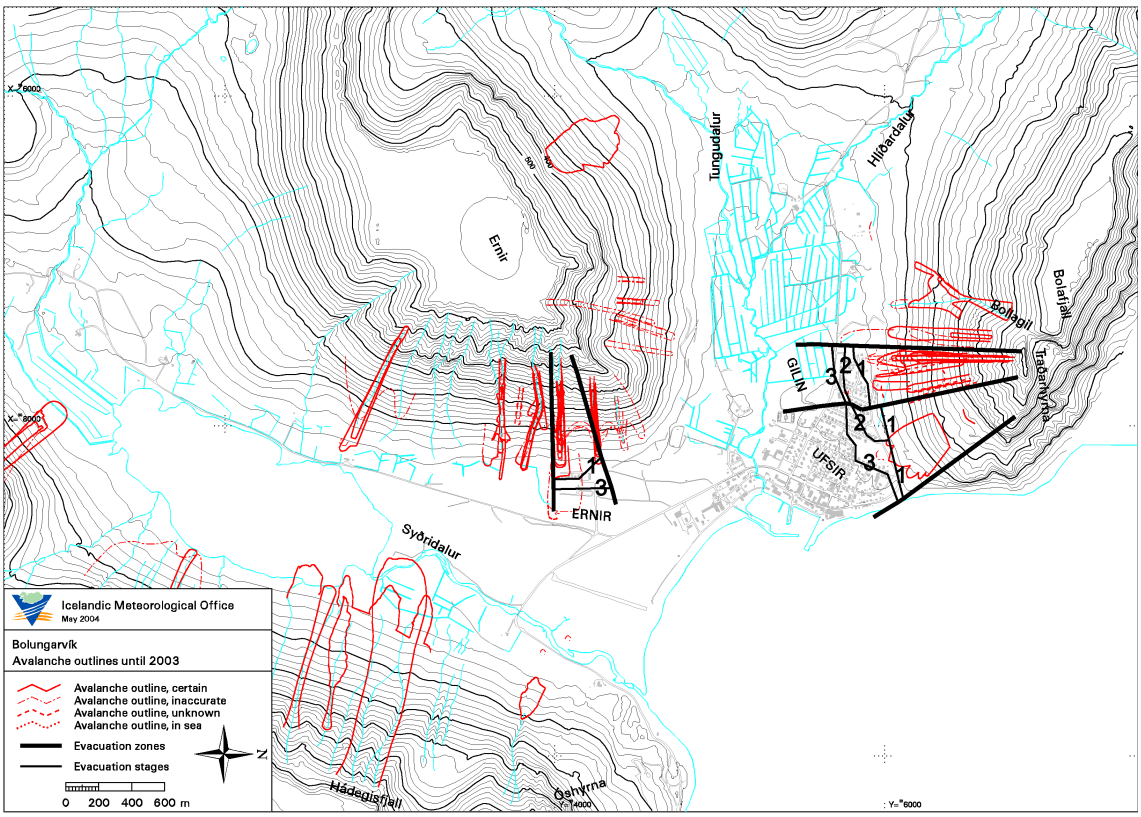

Figure A8 and Table 12: Avalanche weather and paths in Bolungavík, N-Vestfirðir. – *Yfirlit yfir snjóflóð, rýmingarsvæði og snjóflóðaveður í Bolungarvík.*

Evacuation areas	**Avalanche weather and wind directions for snow-drift accumulation**	**Avalanche paths and notification**
Snowdrift accumulation in winds from NW-NE		
Gilin	Possibly accumulation from the mountain top in winds from N-NW. Small fetch.	Usually erosion from the mountainside in winds from NE. Shallow gullies, not much potential accumulation. The snow accumulates in Bollagil in winds from NW from the mountain top. Evacuation levels 1-3.
Ufsir	In winds from N-NW snow is transported from the edge of the mountain to the mountainside. No fetch. An intense snowfall in calm weather or breeze from NW-NE. Snow eroded in winds from NE.	An open mountainside. A small shelf along parts of the hillside. Evacuation levels 1-3.
Ernir (Horse stalls)	Snow accumulation from the mountain above in winds from NW, which is not common. Snowdrift can accumulate in the gully from the side in winds from NE.	The avalanche path is in two uphill gullies merging farther downhill into a well defined gully. Evacuation levels 1 and 3.
“Sheep-houses and fishrails at Minni-Hlíð”		The responsibility of the civil guard.

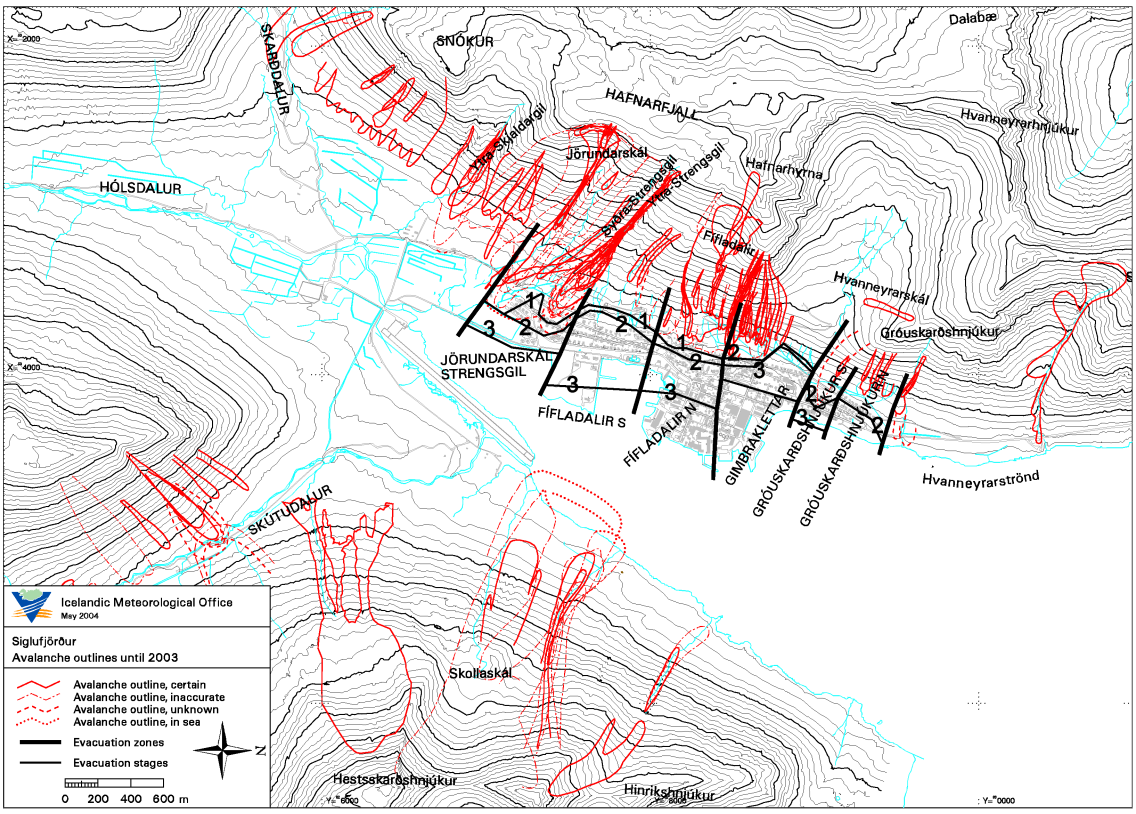

Figure A9 and Table 13: Avalanche weather and paths in Siglufjörður, N-Iceland. – *Yfirlit yfir snjóflóð, rýmingarsvæði og snjóflóðaveður á Siglufirði.*

Evacuation areas	**Avalanche weather and wind directions for snow-drift accumulation**	**Avalanche paths and notification**
	Snowdrift accumulation in northerly winds. NW-NE, NW-SW breeze	
Jörundarskál - Strengsgil	Northerly winds. Hazard due to snowdrift from the mountains in winds from NW-N. Breeze from NW-SW in the mountains can lead to snow accumulation.	A wide gully from Jörundarskál, narrows downhill. Syðra- and Ytra-Strengsgil are well defined gullies down slope. Partly protected with an avalanche dam. Evacuation 1997, levels 1-3, at present level 3.
Fífladalasvæði syðra (southern part)	Possibly snow accumulation in the upper part of the area during strong winds from NW.	From Ytra-Strengsgil to Fífladalagil. Two gullies are in this area. Evacuation levels 1-3. No houses on 1.
Fífladalasvæði nyrðra (northern part)	Strong winds from NW can lead to evacuation at level 3. Snow accumulates in northerly winds at the downhill part of the slope, and in the upper part in winds from N-NW simultaneous with snowdrift from the mountains.	The upper part is a bowl, and shallow gullies further downhill. Evacuation levels 1-3.
Gimbraklettar to Hvanneyrará (Hvanneyrarskál)	Accumulation if wind blows into the fjord along the mountainside. A long lasting sleet can lead to a level 1 evacuation.	A slope with gullies. Evacuation levels 1-2.
Gróuskarðshnjúkur, syðri hluti (southern part)	Winds from NE.	Evacuation levels 2-3.

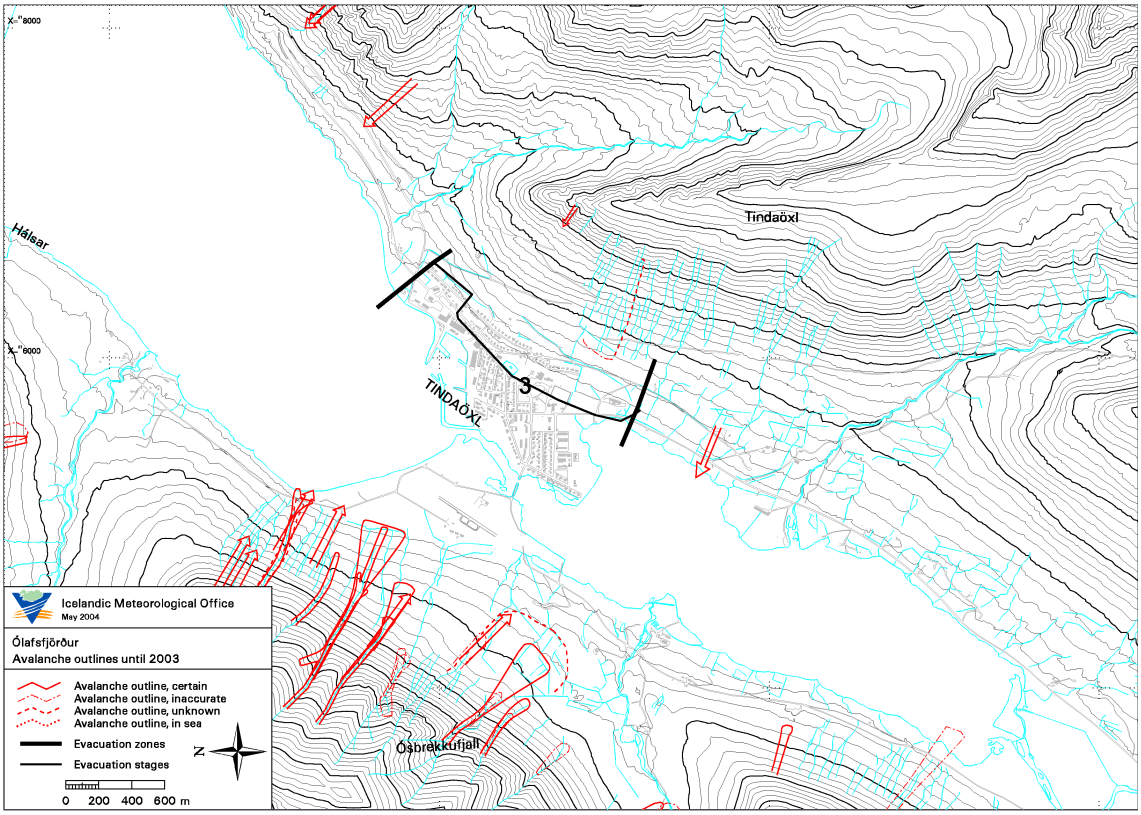

Figure A10 and Table 14: Avalanche weather and paths in Ólafsfjörður, N-Iceland. – *Yfirlit yfir snjóflóð, rýmingarsvæði og snjóflóðaveður á Ólafsfirði.*

Evacuation areas	**Avalanche weather and wind directions for snowdrift accumulation**	**Avalanche paths and notification**
Snowdrift accumulation in northerly winds.		
Tindaöxl	Erosion from the mountainside in northerly winds, which is also the main snowfall wind direction.	Snow avalanches are rare. Mudflows can occur. Evacuation level 3.
(Horse stalls)		The responsibility of the civil guard.

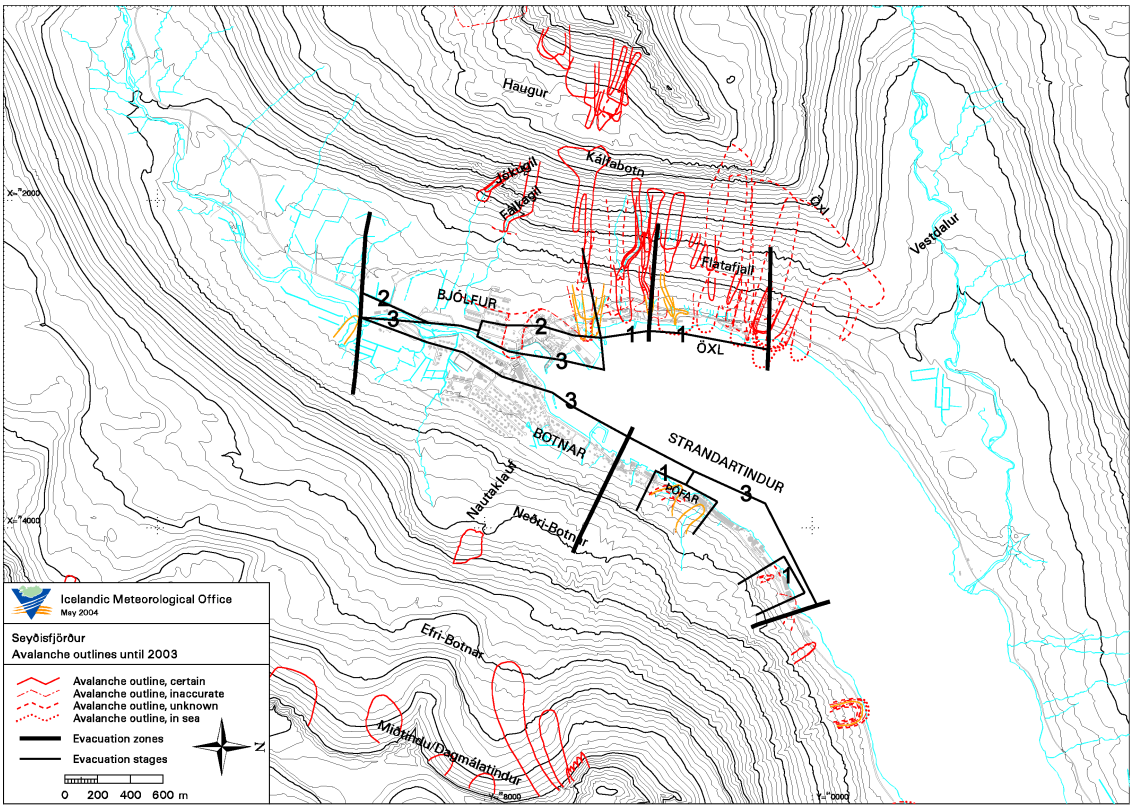

Figure A11 and Table 15: Avalanche weather and paths in Seyðisfjörður, E-Iceland. – *Yfirlit yfir snjóflóð, rýmingarsvæði og snjóflóðaveður á Seyðisfirði.*

Evacuation areas	**Avalanche weather and wind directions for snowdrift accumulation**	**Avalanche paths and notification**
Snowdrift accumulation in winds from SE, E, NE, W. Rain and melting		
Strandartindur - Fjarðarströnd	Snowdrift in winds from SE and E.	Wet avalanches from several gullies. Small as well as deep gullies. Hazard due to mud and slush flows. Evacuation levels 1 and 3.
Botnar	intense, continuous snowfall in winds from S-SE, not common. Intense rain and intense melting.	East of Búðará to the west of houses in the town. Several gullies and streams in the area. Slush flows possible from Hádegisá. Evacuation level 3.
Bjólfur	Winds from NE in the whole area. Accumulation to Kálfabotn from Haugar in winds from W. Accumulation to the side of Haugar in winds from NE as well as in winds from W and E in case of already much accumulated snow.	Several gullies. Kálfabotn is a big bowl-formed starting zone. The larger avalanches from the top part of Bjólfur do not follow gullies. Evacuation levels 1-3.
Öxl	Snowdrift over the ridge (shoulder) in winds from NW. Intensive accumulation in winds from N (from Vestdalur) during snowfall.	The area is limited between a ridge between Seyðisfjörður and Vestdalur, to Krókhryggur. Deep gullies in the northern part of the area, open mountainside towards the southern side. Dam under construction 2004. Evacuation level 1.

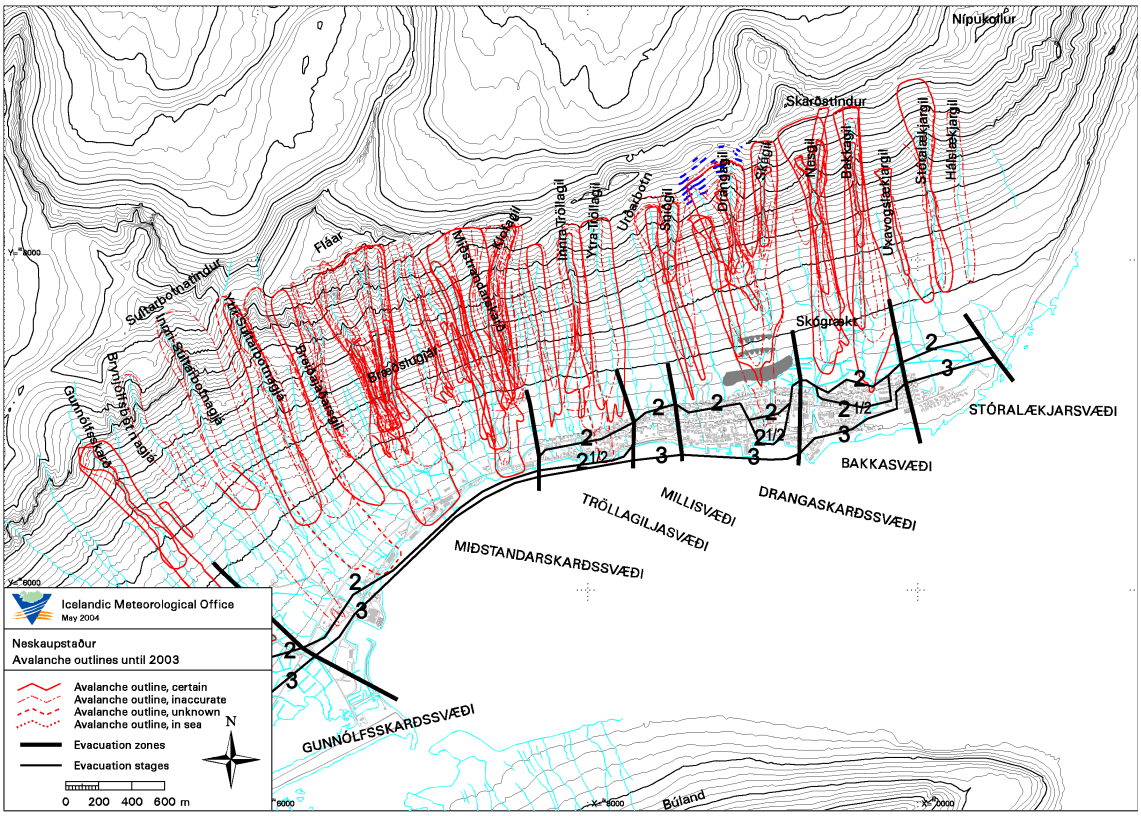

Figure A12 and Table 16: Avalanche weather and paths in Neskaupstaður, E-Iceland. – *Yfirlit yfir snjóflóð, rýmingarsvæði og snjóflóðaveður í Neskaupstað.*

Evacuation areas	**Avalanche weather and wind directions for snowdrift accumulation**	**Avalanche paths and notification**
Snowdrift accumulation in winds from NE-E, N		
Stóralækjarsvæði	Winds from NE-E simultaneous with snowfall.	Three main gullies. Wet avalanches. Evacuation levels 2 and 3.
Bakkasvæði	Winds from NE-E simultaneous with snowfall.	Two main gullies. Evacuation levels 2, 2,5 and 3.
Drangaskarðs-svæði	Winds from NE-E simultaneous with snowfall.	Much snow accumulation possible at Drangaskarð and Skágil. Debris flow hazard below Urðarbotnar. Protections with an avalanche catching dam and supporting structures. Evacuation 1997, levels 2, 2,5 and 3. At present evacuation level 3.
Millisvæði	Winds from NE-E simultaneous with snowfall.	Not well defined paths. Evacuation levels 2 and 3.
Tröllagil	Winds from NE-E simultaneous with snowfall.	Innra- and Ytra-Tröllagil. Huge accumulation possible in Innra-Tröllagil. A catching dam will shortly be constructed. Evacuation levels 2 and 2,5.
Miðstrandarskarðs-svæði	Winds from NE-E simultaneous with snowfall.	Mostly in several gullies. Evacuation levels 2 and 3.
Gunnólfsskarðs-svæði	Winds from NE-E simultaneous with snowfall. Snowdrift in strong winds from N.	Evacuation levels 2 and 3.

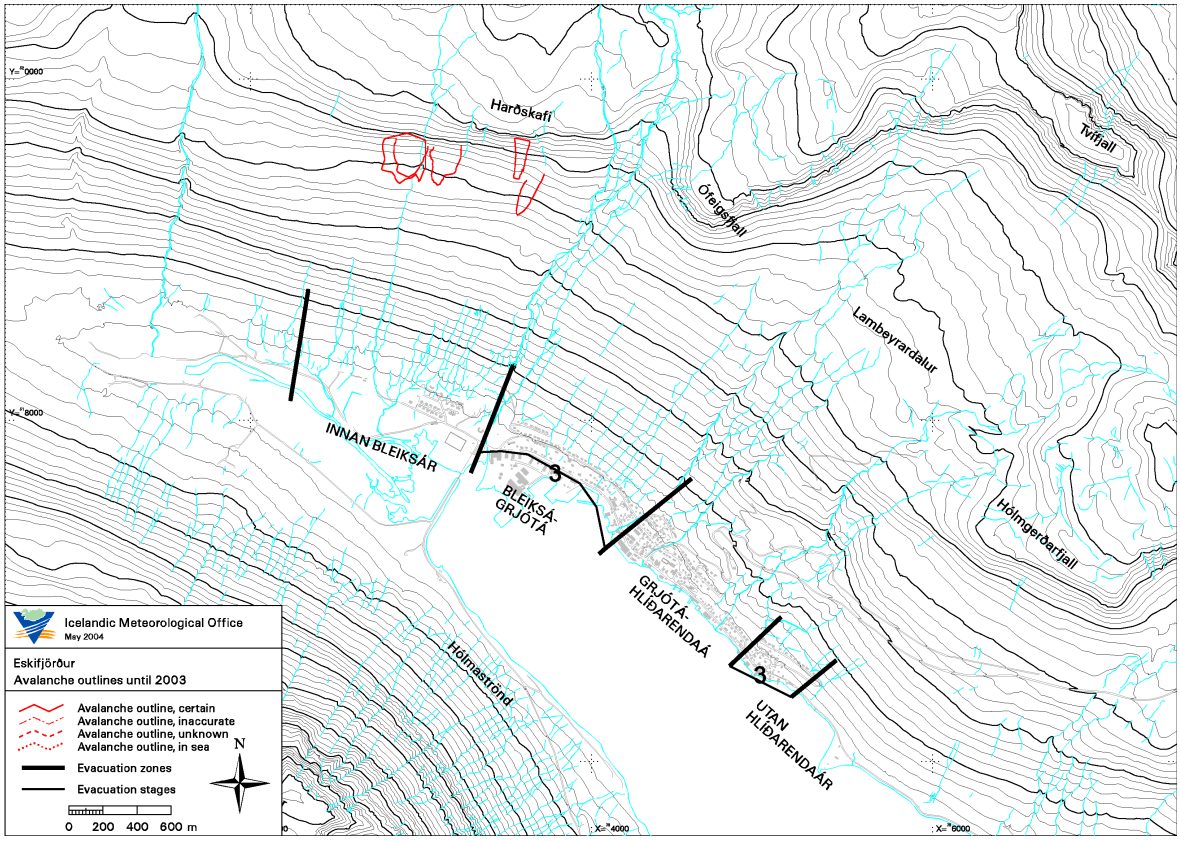

Figure A13 and Table 17: Avalanche weather and paths in Eskifjörður, E-Iceland. – *Yfirlit yfir snjóflóð, rýmingarsvæði og snjóflóðaveður á Eskifirði.*

Evacuation	**Avalanche weather and wind directions for snowdrift accumulation**	**Avalanche paths and notification**
Snowdrift accumulation in winds from W. Rain and melting		
Innan Bleiksár (west of Bleiksá)	Winds from W with snowfall. Large fetch. Rain and intense melting.	The slope is barely steep enough to trigger avalanches.
Bleiksá - Grjótá		Known floods and wet avalanches. Open mountainside without defined avalanche paths. The slope is steep enough for dry avalanches to fall. Evacuation level 3.
Grjótá - Hlíðarendaá		Uneven landscape, cut by a curving stream, a “shelf” on the hillside. Known slush flow when a snow-ice dam broke.
Utan Hlíðarendaár (east of Hlíðarendaá)		A relatively flat mountainside without avalanche paths. Evacuation level 3.