VEÐURSTOFA ÍSLANDS

Report
01010

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Hazard zoning for Neskaupstaður
Technical report

VÍ-ÚR05
Reykjavík
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Contents

1 Introduction

This report is an assessment of avalanche hazard in Neskaupstaður and part of the final report for the project *Pilot Hazard Zoning for Ísafjörður, Siglufjörður and Neskaupstaður* (Tilraunahættumat fyrir Ísafjörð, Siglufjörð og Neskaupstað). In 1999 it was decided to make the pilot hazard maps a basis for the final hazard maps of the three communities.

General information about the project, and necessary background information for this report are included in a separate report (Thorsteinn Arnalds *et al.*, 2001). Among other things, it contains a short description of Icelandic and Austrian hazard zoning regulations and a discussion of uncertainty in the hazard evaluation.

The investigated area reaches from Stóralækjargil in the east to Gunnólfsskarð in the west and covers the present settlement and industrial areas in Neskaupstaður. Detailed investigation was performed in the eastern part of the area from Miðstrandarskarð to Stóralækjargil, which is the area of the main settlement and referred to as the *outer area*. Detailed investigation was also done for Gunnólfsskarð to Ytri-Sultarbotnagjá which is above the area where the main industrial activity is concentrated. This area is referred to as the *inner area*. The area between the two already mentioned areas is considered briefly. The hazard situation there is quite clear and also this area is not as important as the outer and inner areas. This area is referred to as the *middle area*.

The report is split into five main sections. The first part is general and contains an overview of topographic and climatic conditions, a summarised avalanche chronicle, a review of previous hazard maps and discussion of debris flow hazard. The next three sections deal with each of the three above mentioned areas (inner, middle and outer). The inner and outer area are split into subareas defined by the main gullies above the settlement. For each of the subareas we describe:

Topographic conditions: Physical characteristics of the starting zone, track, and runout area.

Assessment: Discussion of avalanche conditions and qualitative hazard analysis.

For the middle area a brief discussion is given. For each of the three main areas we then give:

Model estimates: Model results that are the basis of the hazard zoning. For explanations of technical concepts and notation, refer to Appendix A.

Conclusion: Hazard evaluation and a proposed hazard zoning.

Due to the similar aspect of the starting areas and rather homogeneous possibilities for snow accumulation only a general description is given about climatic conditions, wherein the differences between areas are also mentioned. Explicit descriptions of climatic conditions for each starting area are therefore not included in the sections describing the topographic conditions of each area.

The topographic descriptions in Sections 3.1–3.4 and 5.1–5.9 are detailed and similar to each other, but the main results can be found in sections 3.5, 3.6, 4.2, 4.3, 5.10 and 5.11.

Figure 1. *The outer part of Neskaupstaður in the spring of 1999, viewed from air towards north. (Photo: Oddur Sigurðsson).*

2 General

2.1 Topographic description

Neskaupstaður is located on the north side of the fjord Norðfjörður which is oriented from east to west from the bay Norðfjarðarflói. Map 1 (and Figure 1 of the general report) shows an overview of the area. South of Norðfjörður are the fjords Hellisfjörður and Viðfjörður. A south to southeast facing mountain rises above the settlement of Neskaupstaður up to between 700 and 900 m a.s.l. The top of the mountain ridge is a sharp edge with the fjord Mjóifjörður on the other side. Figure 1 shows the outer part of Neskaupstaður.

A little to the west of the industrial area in the innermost part of the fjord above the farm Þrastalundur there is a large bowl below the mountain pass Gunnólfsskarð, which is a 50–100 m depression in the mountain ridge. The upper part of the bowl has gentle slope and is covered with loose material. The bowl becomes steeper below about 620 m a.s.l. and there are some cliffs down to about 520 m a.s.l. Below that the slope is rather even and covered with talus. The cliffs become more distinctive towards the east reaching from about 580 to 720 m a.s.l. in the Brynjólfsbotnagjá gully and in a small gully between Brynjólfsbotnagjá and Gunnólfsskarð. Below the cliffs the slope is rather even and covered with loose material, except for a trace of a cliffbelt that can be seen around 350 m a.s.l. In the next two gullies, Innri- and Ytri-Sultarbotnagjá the cliffs reach from about 400–450 m a.s.l. and up to the top, at about 900 m a.s.l., where the mountain reaches its highest peak. There are large shelves around 450–500 m a.s.l. in both the gullies where boulders have accumulated, especially in the eastern gully. Below the shelves there are small cliffs and further down the slope is interrupted by several small gullies, and a rather large gully below Ytri-Sultarbotnagjá.

Between the new industrial area and the main settlement the lowland is very narrow. The summit east of Ytri-Sultarbotnagjá forms a flat area called Fláar. Rock faces cut by many shallow gullies characterize the uppermost part of the hillside just east of Ytri-Sultarbotnagjá. The most distinctive two gullies reach down to the lowland where they transform to streambeds. Further to the east, below the highest part of the summit Fláar, three gullies called Bræðslugjár are most distinctive in a cliff belt at about 200–350 m a.s.l. Above that the gullies separate from each other and become deeper and more irregular. Near the top the gullies split into smaller gullies which are carved in cliffs. Below the three Bræðslugjár gullies there is an alluvial fan that is covered with vegetation and marked by three streambeds. East of Bræðslugjár there are two small gullies carved into the cliff belts extending almost from the top of the mountain. A ridge with a small gully in its lower part is located east of the small gullies. A small debris cone has accumulated below the gullies.

The mountainside in the outer part can be divided into three characteristic elevation sections. The main starting areas for snow avalanches are in the highest part. This area is formed by small cliffbelts but mostly covered with weathered rock. The area is interrupted by deep bowls and gullies. The average inclination in the starting area is mostly between 32° and 38°.

The second section of the mountainside is a formation of cliffbelts located between 400 and 550 m a.s.l. in the eastern part and between 350 and 500 m a.s.l in the western part. The area is interrupted by deep gullies below the bowls in the upper area. The inclination in the area is on average around 40°. Due to the higher inclination there is less loose material on the surface in the area and the cliffbelts are therefore more visible.

In the third section below the cliffs a high amount of weathered debris has accumulated in debris cones that partly overlap and are interrupted by several small gullies and streambeds. The slope is gentle and there is a long distance along the path with an inclination between 20° and 10°. In the western part of the hillside the runout area (with an inclination less than 10°) is short and in some places starts at the shoreline. In the eastern part the runout area is longer and extends a distance of several hundred meters away from the mountain.

The main gullies are from west to east: Miðstrandargil/Klofagil, Innra-/Ytra-Tröllagil, Urðarbotn/Sniðgil, Drangaskarð/Skágil, Nesgil, Bakkagil and Stóralækjargil.

The first settlement in the area where the village Neskaupstaður is now located was the farm

Nes which was settled around the year 1000. It was standing on the ness below the gully Nesgil. Two other farms were established a few hundred years later. They were Bakki, which was beneath Bakkagil, and Naustahvammur, which was west of the current settlement where the industrial area is now located. An avalanche hit Naustahvammur in the year 1885. One farmhouse, Þiljuvellir, was built above the current settlement and beneath the gully Drangagil. An avalanche hit that farmhouse in 1894. In the last two decades of the nineteenth century some other houses were built and a small village started to form. Most of these houses were by the sea in the area from the gully Miðstrandargil in the west to Nesgil in the east. In the first three decades of the twentieth century the village grew fast and people started to build houses closer to the mountain. In those times many houses were built beneath Tröllagil and towards east to the area beneath Drangagil. In the next decades the settlement became denser. In the sixties the houses by the uppermost streets beneath Drangagil, Blómsturvellir and Víðimýri, were built. Most of the houses by the uppermost street in the western part of the town, Urðarteigur, were also built around this time. In the seventies and eighties two new areas were settled in the eastern part of town, "Bakkarnir" and "Mýrarnar". Building years and names of houses in Neskaupstaður have been documented in detail by Harpa Grímsdóttir (1997).

2.1.1 General notes

The characteristic cliffbelts in the mountain between about 400 and 500 m a.s.l. mark the limit between the starting area and the track. A bowl is often to be found in the upper part of the mountain that is transformed into a deep narrow gully by the cliffbelt. The cliffs are considered the lower limit of the starting areas and therefore areas with inclination between 30° and 55° below the cliffs are not considered to be a part of the potential starting area.

Areas of starting zones are measured in the plane of the mountain and snowdepths are measured perpendicular to the slope.

Snow accumulation in the starting area is classified as follows:

high:	deep extensive gully/bowl and situated on the lee side against common wind directions with precipitation falling as snow
medium:	shallow depressions and narrow gullies
low:	steep, unconfined/straight or convex areas or areas where snow is blown away by prevailing wind directions.

The potential spreading of an avalanche is classified as follows:

high:	the avalanche follows a confined track that terminates in a debris cone and the runout area is convex
medium:	the track is confined and the runout area is slightly convex or unconfined
low:	the avalanche follows an unconfined track with no distinctive debris cone below and the runout area is unconfined or concave

2.2 Chronicle

Maps 2 and 3 show recorded avalanches in Neskaupstaður.

The avalanche chronicle of Neskaupstaður dates back to 1885 when an avalanche, probably coming from Ytri-Sultarbotnagjá, hit two farmhouses near Naustahvammur, killing three persons and causing extensive damage. In 1894 avalanches are recorded from Tröllagil and Drangagil. A few more avalanches are recorded until 1974, but before that time no systematic records were kept on avalanches and therefore only avalanches that caused damages, injuries or deaths were recorded. Before 1900 it is likely that damage causing avalanches were the only ones to be recorded, and between 1900 and 1974 major avalanches falling close to the settlement may be recorded. During that time the easternmost part of the present settlement had not been established. Large avalanches may therefore have fallen in the outermost part of the present settlement in the period without being recorded.

In December 1974 long avalanches fell from most of the gullies above Neskaupstaður. Two avalanches, from Bræðslugjár and Miðstrandarskarð, that fell within a few minutes interval of each other, killed in total 12 people. The avalanche from Bræðslugjár hit a fish factory, killed 5 people and caused severe oil pollution in the sea. The avalanche from Miðstrandarskarð hit a workshop, concrete production facilities and the domestic house Mánahús. Several cars were caught in the avalanche. It killed 7 people.

In 1990 an avalanche starting in Gunnólfsskarð hit the farmhouse Þrastalundur.

After the accidents in 1974 systematic recording of avalanches was started. The naturalist Hjörleifur Guttormsson measured and recorded information on the avalanches which fell in February 1974 and in the winter of 1974–75. He also collected some information on older avalanches. After this there has been a snow observer responsible for monitoring the avalanche situation, participating in decision about evacuation of buildings and collecting data about fallen avalanches. The observer was at first employed by the community, but since 1995 he has been employed and supervised by the IMO.

An avalanche chronicle for Neskaupstaður was compiled at the IMO by Svanbjörg Helga Haraldsdóttir (1997).

2.3 Previous hazard assessments

After the accidents in December 1974 the town's council consulted the Norwegian Geotechnical Institute (NGI). Experts from the NGI came to Neskaupstaður in the autumn of 1975 (Neskaupstaður town council, 1976). The Norwegian experts analysed the avalanche situation in Neskaupstaður (NGI, 1975a), and proposed protection measures against avalanches (NGI, 1975b). In 1975 the Icelandic Civil Defence hired M. R. de Quervain from the Swiss Avalanche Institute (SLF) to assess the avalanche hazard in Siglufjörður, Seyðisfjörður and Neskaupstaður. He described and analysed the avalanche situation in Neskaupstaður and several villages in Iceland (SLF, 1975).

The first laws concerning avalanches and debris flows were issued in 1985. The §2 of the laws states: "Hazard assessment shall be performed in communities where avalanches and debris flows have fallen into the settlement or close to it. The hazard assessment shall both cover settled areas, as well as areas that are due to be planned. The hazard assessment shall be taken into consideration in the entire planning process and shall be attached to planning proposals." In §3 of the laws the Icelandic Civil Defence is made accountable for specifying further guidelines and regulations on hazard zoning, classification of hazard zones and the construction of defence structures. It was also given the role to supervise the preparation of hazard maps.

In regulation 247/1988 on hazard zoning it was specified that a particular physical model should be used for hazard zoning and guidelines on how to apply it were given. The model was developed by Þorsteinn Jóhannesson at Verkfræðistofa Siglufjarðar sf. (VS, 1986). In the next few years hazard zoning was done in several villages by independent consultants, supervised by the Icelandic Civil Defense.

Árni Jónsson studied the avalanche hazard in Neskaupstaður and proposed possible protection measures in his thesis at the Royal Institute of Technology in Stockholm (Árni Jónsson, 1987).

Árni Jónsson at Hnit hf. (Hnit, 1992) prepared a hazard map for Neskaupstaður based on the regulation from 1988. Based on his proposal the first official hazard map for Neskaupstaður was approved by the Minister of Social Affairs in October 1992, see Map 4. According to the hazard map all the land below Ytri-Sultarbotnagjá and all gullies east to and including Ytra-Tröllagil was considered to be a hazard zone (red). Below Urðarbotn, Drangagil, Nesgil and Bakkagil up to 5 rows of houses were in the hazard zone. The areas between Tröllagil and Urðarbotn, between Sniðgil and Drangagil, between Skágil and east of Bakkagil were considered mostly to be safe (green).

The community of Neskaupstaður hired Verkfræðistofa Sigurðar Thoroddsen (VST) to propose avalanche protection measures for Neskaupstaður. The planned defences were laid out in accordance to the hazard map of 1992 and the work was concluded with a report in 1995 (VST, 1995).

In 1996 the Icelandic Meteorological Office made plans for emergency evacuations of several communities in Iceland. The plans included a division of the community into subareas and description of under which conditions each subarea should be evacuated. Such a plan was made for Neskaupstaður (IMO, 1996) and revised in 1997. According to the plans most of the settled area in Neskaupstaður is a part of evacuation zones that need to be evacuated under extreme conditions.

A catching dam, breaking mounds and supporting structures are under construction in and below Drangagil. They were designed by Verkfræðistofa Sigurðar Thoroddsen (VST, 1998b). As a part of their design a protection plan was made for the whole of Neskaupstaður based on a preliminary hazard assessment (VST, 1998a). During the design a meeting was held with the participation of experts from Norway, Switzerland and Austria to discuss the avalanche situation in Neskaupstaður (Tómas Jóhannesson and Sigurður Kiernan, 1997).

2.4 Climatic conditions

After the catastrophic avalanches in 1974, meteorological observations in Neskaupstaður were started, using a climatic station with observations 3 times a day. Since then the most important meteorological parameters such as temperature, precipitation, snowcover, windspeed and wind direction have been observed. An automatic station was installed in Neskaupstaður in 1997. Other automatic weather stations in the area are Gagnheiði (started in 1994), Dalatangi (from 1994) and two stations operated by the Icelandic Public Roads Administration in Fjarðarheiði (from 1995) and Oddsskarð (from 1995). The automatic weather stations record temperature, humidity and wind. Furthermore, the automatic station in Neskaupstaður records precipitation. The stations operated by the Roads Administration are not entirely comparable to those operated by the IMO. Synoptical observations have been carried out at Dalatangi since 1938.

Appendix C.1 shows the maximum and minimum temperature, average wind speed, maximum wind speed and the maximum gust in 1996–2000 for Gagnheiði, Fjarðarheiði and Oddsskarð, the average temperature, maximum and minimum temperature, average precipitation and maximum daily precipitation in 1976–2000 for the manual observations in Neskaupstaður. Strong gusts are observed in Gagnheiði, Oddsskarð and Fjarðarheiði. Gagnheiði is located at about 949 m a.s.l. and the wind speed measurements are technically difficult and different types of equipment are used there than in the other stations. Windspeed, the gust in particular, is probably overestimated there when winds are strong. The vertical movement of air may also influence the windspeed measurements at Gagnheiði.

The annual precipitation in Neskaupstaður is among the highest observed in the lowland in Iceland and varies greatly in magnitude from year to year. The maximum was observed in 1997, 2183 mm and the minimum in 1983, 1382 mm. The automatic precipitation observations have given annual values of 1750 mm in 1998, 1300 mm in 1999 and 1850 mm in 2000. These values are consistently lower than the manual observations that gave 1822 mm in 1999 and 2166 mm in 2000.

Snow depth observations are sparse and not suitable for analysis. Appendix C.2 shows average and maximum snow depths for some months where observations are consistent. A snow depth of more than 1 m has been recorded several times and the maximum observed depth was 1.4 m in March 2000.

Present weather is given in Neskaupstaður and Dalatangi whenever an observation is made, but precipitation is measured once or twice a day. The automatic weather stations do not have a present weather recorder. The synoptic station in Dalatangi is utilised to analyse the wind directions when there is precipitation because the proximity of the mountains in Neskaupstaður makes wind directions there ill suited for this purpose.

Appendix C.3 shows plots of the frequency of wind directions for Dalatangi, Gagnheiði, Oddsskarð and Fjarðarheiði with some extra constraints aimed at finding the most probable wind directions when there is precipitation at low temperatures.

Winds from NNW, N og NA are dominant when precipitation is recorded and temperature is below 1°. These are also the main wind directions at Dalatangi when it is snowing. The northeasterly winds are furthermore strongest. Looking at observations from the montain stations Gagnheiði, Oddsskarð and Fjarðarheiði we see that winds between N og NE are most common and also that there often are northwesterly winds at Oddsskarð and east-southeasterly at Fjarðarheiði. The wind directions are highly affected by the local landscape, although this influence is the least at Gagnheiði. The frequencies of winds at Gagnheiði are similar during the winter as in the whole year. Common wind directions other than NNE are WSW and E. Snow accumulation in the area is most likely in north and northeasterly winds.

All the starting areas in the outer part of the settlement in Neskaupstaður from Miðstrandarskarð face towards south. The potential for snow accumulation in the starting areas is therefore highest in northerly winds. Snow can also accumulate in the big gullies in northeasterly winds though it would probably lead to less snow accumulation than in northerly winds. The most intense accumulation can be expected in the upper part of the big bowls and gullies. The areas between the gullies and to some extent the Urðarbotn area are less favourable for high snow accumulation. In northeasterly and easterly winds, snow will be blown away from the areas between the gullies. Heavy snow accumulation in these areas is not very likely during northerly winds because they are slightly convex, conical, and much narrower near the top than lower down. They are also considerably steeper than the gullies. The least favorable areas for snow accumulaton are the areas between Innra- and Ytra-Tröllagil, Sniðgil and Drangagil, Drangagil and Skágil, Skágil and Nesgil, and Nesgil and Bakkagil. Between Klofagil and Innra-Tröllagil, and Bakkagil and Stóralækjargil, some amount of snow can accumulate in shallow depressions. The area below Urðarbotn is also formed as two shallow depressions where snow accumulation is more likely though heavy snow accumulation in the depressions is not as likely as in the big bowls and gullies.

Avalanche cycles in Neskaupstaður since 1974 have been analysed by Haraldur Ólafsson (1998). He finds that most of the avalanches occur after a period of heavy precipitation and wind between north and east. The wind may be strong, but this does not seem to be a necessary condition, even for some of the greatest avalanches. There is no clear connection between the runout index (of the longest observed avalanche of each cycle) and wind direction, nor is there any obvious relationshhip between the temperature and the runout index. Somewhat more clear positive correlation can be found between the runout index on one hand and the precipitation and the maximum wind speed. All the avalanches with runout index 13 or greater are found in the upper right corner in a scatter diagram showing wind speed and precipitation. The fact that extremes in precipitation and wind speed do not go together in the analysed period suggests that meteorological conditions are possible that can lead to even greater avalanches than in 1974.

2.5 Snow depth measurements in starting areas

Regular monitoring of snow depth in the mountain above Neskaupstaður was initiated in the fall of 1993 with the installation of 26 stakes in Nesgil, Drangagil and Tröllagil. The stakes were 3 m high and placed in the elevation range from about 200 m a.s.l. to about 700 m a.s.l. The number of stakes was increased to 36 in the autumn of 1995, with the installation of 10 additional stakes in Miðstrandargil and Bræðslugjár. At the same time the height of some of the existing stakes was increased from 300 to 400 cm. Several stakes have been lost in avalanches or due to other causes during the period of the measurements leading to some gaps in the snow depth time-series. The measurements are described by Guðmundur Helgi Sigfússon and Tómas Jóhannesson (1997), Sigurður Kiernan *et al.* (1998), Sigurður Kiernan and Tómas Jóhannesson (1998) and Sigurður Kiernan, *et al.* (1999).

The maximum vertical snow depth measured at the uppermost stakes in the starting zones is typically in the range 2 m to more than 4 m. The highest snow depths were reached in the winter 1994/1995 and the second highest in the winter 1998/1999. The stakes are all located on relatively unconfined terrain and much higher snow depths may be expected to have occurred in the gullies that are located near the middle of several of the starting zones. Appendix C.4 shows the measured snow depth at stake `nedr05` at 568 m a.s.l. in Drangagil for the winters since the start of the measurements in the winter 1993/1994, except for the winter 1995/96 when there was little snow in the mountain and no measurements were made. The arrows above a part of the curve for 1994/1995 indicate that the 3 m high stake was buried below snow surface during this period. Return period analysis of snow depth at lowland stations indicates that the winters 1994/1995 and 1998/1999 had relatively much snow fall on a decadal time scale (see figure of snow depths measured the at meteorological stations Neskaupstaður, Dalatangi and Seyðisfjörður in the report by Guðmundur Helgi Sigfússon and Tómas Jóhannesson, 1997), so one may expect the highest recorded snow depths in the starting zones during the admittedly short measurement period to correspond to a return period of several decades.

Some stakes were located in the elevation range 100 to 200 m a.s.l. from Stóralækjargil to Brynjólfsbotnagjá for a few year period after the catastrophic avalanches of 1974. They were mainly used for accurate description of avalanche outlines and no useful snow depth data from these stakes exist.

Lowland snow depth has been monitored regularly at the meteorological station in Neskaupstaður since the winter of 1981–82, in nearby Seyðisfjörður since 1980–81 and in Dalatangi since the winter of 1964–65. These records are shown in a figure in the report by Guðmundur Helgi Sigfússon and Tómas Jóhannesson (1997). The maximum measured snow depth for the stations is 140, 128 and 90 cm, respectively The 50 year snow depth has been estimated for each of these stations and found to be 133, 108 and 87 cm, respectively (Kristján Jónasson and Trausti Jónsson, 1997).

2.6 Debris flow hazard and rockfall

The current Icelandic regulation on hazard zoning requires the same criteria to be used for debris flow/rockfall hazard zoning and for avalanche hazard zoning, i.e. individual risk. Furthermore the combined risk should be presented on one map. Therefore it is expected that debris flow hazard zoning is done in synchronization with avalanche hazard zoning.

A debris flow chronicle for Neskaupstaður has been compiled and a geological study has been conducted to evaluate the debris flow activity and potential (Halldór G. Pétursson and Þorsteinn Sæmundsson, 1999; Þorsteinn Sæmundsson and Halldór G. Pétursson, 1999).

Although debris flows have caused property damage in Neskaupstaður and may impose some threat to the local population, the debris flow hazard must be considered to be insignificant compared with the avalanche hazard. It is therefore concluded that taking debris flows specifically into account will not significantly alter the hazard zoning, which is presented here. In spite of this it may be feasible or even advisable to take actions to prevent property damage due to debris flows at some locations in the village.

3 From Gunnólfsskarð to Ytri-Sultarbotnagjá

The innermost part of Neskaupstaður, below the gullies Gunnólfsskarð, Brynjólfsbotnagjá, Innri- and Ytri-Sultarbotnagjá is an industrial area. The farm Naustahvammur was located in the easternmost part of this area. It was an annex from Nes and it is expected that it existed for about 700 years. The first domestic house was probably located in a similar area as the present domestic houses in Naustahvammur. Some houses may have been located closer to the mountain, and one was probably located above the upper road. A building named Vindheimur was built in 1908 to the west of Naustahvammur and beside it to the west was the house Slétta in 1916–1923. Other houses in the area are industrial buildings, built after 1975. The outermost farm in Norðfjarðarsveit is Þrastalundur, which is below Gunnólfsskarð. It was built in 1940.

3.1 Gunnólfsskarð

3.1.1 Topographic description

Figure 2 shows the mountain pass Gunnólfsskarð which is a depression in the main mountainridge. It can be seen on Maps 1 and 5 and a logitudinal section (`nein01ba`) is shown in Drawing 1. Below the gully is the farm Þrastalundur which was hit by an avalanche in 1990. The gully is to the west of the present industrial area.

Starting zone

The starting zone above Gunnólfsskarð is a large symmetric bowl about 50 m deep. It is about 300 m wide and ranges from 620 to 440 m a.s.l. The 9.1 ha area is oriented S to SE and inclines 33°–42°. The surface is composed of weathered rock and interrupted by some small cliff belts. Snow accumulation is medium. The bowl extends above the starting zone up to about 800 m a.s.l. but the inclination there is too low to allow avalanche release.

Track

The 150 m wide track through Gunnólfsskarð ranges from 440 to 75 m a.s.l. It is mostly an open slope cut by a small gully with a brook running through it. It inclines approximately: 29° at 450–400 m a.s.l., 21° at 400–350 m a.s.l., 31° at 350–300 m a.s.l., 21° at 300–200 m a.s.l., 14° at 200–100 m a.s.l., and 11° at 100–75 m a.s.l. The surface is composed of weathered talus that is partly covered with vegetation. The degree of confinement is 2.

Runout area

The altitude of the runout area ranges from 75–5 m a.s.l. The zone is over 650 m long and inclines 7° on average. The area has a medium avalanche spreading potential. Only the farm Þrastalundur

Figure 2. *The inner part of Neskaupstaður. Gunnólfsskarð, Brynjólfsbotnagjá, Innri- and Ytri-Sultarbotnagjá and finally Bræðslugjár. In the runout area is the farm Þrastalundur furthest to the left. The blue house is a freezing plant and the other houses various industrial buildings. (Photo: Harpa Grímsdóttir).*

is located in the area. It is built in 1940 and since 1987 people have only lived there during the summer.

3.1.2 Chronicle

Several avalanches are recorded from Gunnólfsskarð. The largest one fell in 1990 and damaged the farm Þrastalundur. The oldest known avalanches are from 1914 and 1920. Information about these is not detailed, but they were probably not very large. In 1978 two young hikers were killed by an avalanche when they were passing through the gully on their way to Mjóifjörður. Recorded avalanches from the gully are shown on Map 2 and listed in the following table:

Number Time *Runout index*	**Description**
1109 Around 1914	An avalanche started in the wall of the gully and stopped slightly below the rock faces. More exact descriptions do not exist.
1108 Around 1920	An avalanche fell from the gullies east of Gunnólfsskarð down Kúabotnar. The avalanche stopped near a utility pole on the debris cone almost directly below the gully.
1055 26.3.1978 *≪11*	An avalanche fell over the slope west of the gully. It started at 550 m a.s.l. and stopped around 400 m a.s.l. The avalanche was probably triggered by two young men who died in the avalanche.
1096 29.3.1981	Some small avalanches fell from the mountain above the Þrastalundur farm.
149 27.2.1990 *16.4*	A dry slab avalanche fell from Gunnólfsskarð and stopped 150 m from the road below. It was around 120 m wide with a thickness of 0.8–1.2 m. The avalanche divided into two tongues around 60 m a.s.l. One of the tongues was 50 m wide and fell to the west, but an 80 m wide tongue which fell towards west hit the farm Þrastalundur and damaged part of the house, a machine storage hut, some other sheds, cars and farm machines. The avalanche also toppled some utility poles.
1010 11.3.1995 *12.5*	An avalanche fell from Gunnólfsskarð and fell as one slab from the west side of the gully to the middle of the gully and followed the gully down. The main part of the avalanche stopped at the end of the gully, but a thin tongue flowed further down and spread considerably. The 180 m wide tongue stopped about 150 m a.s.l.
1014 11.3.1995 *11.6*	A small avalanche released in a narrow stream bed east of the main gully. It stopped 180 m a.s.l. and the deposition was about 30 m wide.

3.1.3 Assessment

Above the main starting area there is a large but rather flat bowl. In the eastern part the inclination in some parts of it is up to and around 30°. According to Guðmundur H. Sigfússon the avalanche in 1990 started below this bowl. The lower area is the most favorable starting area and therefore the area above it is not further considered here. The bowl above the starting area will probably reduce snow accumulation. The information available on the avalanche in 1990 indicates that it was a very dry and even a powder avalanche to some extent. This is surprising taking into account that the slope is not very high, steep or terraced and considering that powder avalanches are uncommon in Iceland.

3.2 Brynjólfsbotnagjá

3.2.1 Topographic description

Figure 2 shows the gully Brynjólfsbotnagjá. It can be seen on Maps 1 and 5 and a longitudinal section (`neat13aa`) is shown in Drawing 2.

The gully is above the innermost part of the industrial area.

Starting zone

There are two starting zones in Brynjólfsbotnagjá. The higher starting zone is about a 250 m wide area of even mountainside that ranges from 860 to 780 m a.s.l. The 2.3 ha area inclines 35°–40°. The other starting area is a 50 m deep gully that is 160 m wide and ranges from 775 to 580 m a.s.l. The 4.1 ha area inclines 34°–50°. Both areas are oriented S to SE. The surface of the lower starting area is composed of weathered rock, bare rock, and cliff belts. The snow accumulation is medium.

Track

The 90 m wide track through Brynjólfsbotnagjá ranges from 580 to 75 m a.s.l. It is a 25 m deep gully until 500 m a.s.l. where it becomes an even mountainside. The track inclines approximately: 34° at 580–500 m a.s.l., 30° at 500–300 m a.s.l., 22° at 300–200 m a.s.l., 16° at 200–100 m a.s.l., and 11° at 100–75 m a.s.l. The surface is composed of cliffs in the upper part and weathered talus and rocks in the lower part. The degree of confinement is 2.8.

Runout area

The altitude of the runout area ranges from 75–5 m a.s.l. At 75–50 m a.s.l., the zone inclines 9° for 120 m and at 50–5 m a.s.l., the inclination decreases to 6° for 600 m. The area is unconfined with medium avalanche spreading potential.

3.2.2 Chronicle

Only a few avalanches are recorded from Brynjólfsbotnagjá, and all of them are small. The recorded avalanches from the gully are shown on Map 2 and listed in the following table:

Number Time *Runout index*	**Description**
1121 15/16.2.1975 *< 11*	A small avalanche fell over the rocky debris inside of the town fence west of Innri-Sultarbotnagjá.
1054 22/23.1.1977 *< 11*	A small avalanche fell from Brynjólfsbotnagjá and stopped around 260 m a.s.l.
1208 21.3.1997	A small avalanche fell from Brynjólfsbotnagjá. It stopped just below the opening of the gully.

3.2.3 Assessment

The starting area is not uniform, in the lower part it is a deep gully and an open slope divided into two separate areas in the upper part. Large avalanches are not recorded from the gully and they are considered unlikely due to the shapes and sizes of the starting areas.

3.3 Innri-Sultarbotnagjá

3.3.1 Topographic description

Figure 2 shows the gully Innri-Sultarbotnagjá. It can be seen on Maps 1 and 5 and a longitudinal section (`neat14aa`) is shown in Drawing 3. The gully is above the industrial area.

Starting zone

The starting zone above Innri-Sultarbotnagjá is a deep gully combined with an even slope on the eastern side and a bowl above the gully. It is 300 m wide and ranges from 920 to 600 m a.s.l. The 13.9 ha area is oriented S to SE. It mostly inclines 34°–40° and is even steeper in the gully. The surface is composed of bare rocks and weathered rock densely interrupted by high cliff belts especially in the lower part of the starting area. Snow accumulation is high.

Track

The 240 m wide track through Innri-Sultarbotnagjá ranges from 600 to 75 m a.s.l. A 70 m wide shelf that inclines 16° is located between 450 and 425 m a.s.l. Below the shelf, the track consists of small debris cones interrupted by several shallow gullies. The track inclines approximately: 32° at 600–500 m a.s.l., 34° at 500–400 m a.s.l., 27° at 400–300 m a.s.l., 23° at 300–200 m a.s.l., 15° at 200–100 m a.s.l., and 12° at 100–75 m a.s.l. The surface is composed of weathered debris and rocks interrupted by cliffs. The degree of confinement is 1.3.

Runout area

The altitude of the runout area ranges from 75 m a.s.l. to sea level. At 75–50 m a.s.l., the path inclines 9° for 150 m. At 50–25 m a.s.l., it inclines 8° for 180 m. From 25 m a.s.l. to sea level, the inclination is 4° to the sea. The even area has a low avalanche spreading potential.

3.3.2 Chronicle

The largest avalanche recorded from Innri-Sultarbotnagjá fell in 1936. It damaged some fences and killed sheep in a sheep shed. Two other avalanches are recorded but they are much smaller. The recorded avalanches from the gully are shown on Map 2 and listed in the following table:

Number Time *Runout index*	**Description**
150 Feb/Mar 1936 *16.7*	An avalanche stopped at 10 m a.s.l. by a small tarn just west of Vindheimar. Some sheep were killed when the avalanche hit a sheep shed and some fences were damaged. It is uncertain whether the avalanche came from Brynjólfsbotnagjá or Innri-Sultarbotnagjá. In a field investigation Innri-Sultarbotnagjá was deemed to be much more likely.
152 20/21.12.1974 *11.6*	An avalanche fell from Innri-Sultarbotnagjá and stopped around 150 m a.s.l., about 850 m from the sea. The deposition was around 150 m wide at its widest.
156 4.11.1981 *11.2*	A dry loose avalanche fell from Innri-Sultarbotnagjá and stopped about 150 m a.s.l. The avalanche ran on bare ground and collected some rock and debris along the way.

3.3.3 Assessment

The starting area is large and steep with high probability of snow accumulation but the surface is interrupted by high cliffbelts. It is difficult to evaluate the probability of large avalanches but this is the most probable starting area for the avalanche in 1936 which almost went to the shoreline.

We must therefore conclude that the starting area is favorable for large avalanches in spite of the high roughness.

3.4 Ytri-Sultarbotnagjá

3.4.1 Topographic description

Figure 2 shows the gully Ytri-Sultarbotnagjá. It can be seen on Maps 1 and 5 and longitudinal sections (`neat15aa` and `neat15ba`) are shown in Drawings 4 and 5. The gully is above the industrial area.

Starting zone

There are two separate starting zones in Ytri-Sultarbotnagjá. The western one is a deep gully combined with an even mountainside in its western part. The 200 m wide area ranges from 840 to 600 m a.s.l. and it is 7.9 ha. The eastern starting area is a 50 m deep gully, reaching from 760 down to 600 m a.s.l. The width of the eastern area is about 100 m and it is 2.3 ha. The areas incline 35°–45° and are oriented S to SE. The surface is composed of mostly cliffbelts and weathered rock. Snow accumulation is high.

Track

The 170 m wide track through Ytri-Sultarbotnagjá ranges from 600 to 75 m a.s.l. The track is a deep gully from 600 to 200 m a.s.l. that terminates in a debris cone. The track inclines approximately: 45° at 600–500 m a.s.l., 38° at 500–400 m a.s.l., and 28° at 400–300 m a.s.l., 23° at 3000—200 m a.s.l., 15° at 200–100 m a.s.l., and 11° at 100–60 m a.s.l. The surface is composed of bare rock and cliff belts in the upper part and weathered debris in most of the area. The degree of confinement is 1.2.

Runout area

The altitude of the runout zone ranges from 60 m a.s.l. to sea level. From 60 to 25 m a.s.l., the path inclines 9° for 200 m. From 25 m a.s.l. to sea level, it inclines 7° for 230 m into the sea. The even area has a medium avalanche spreading potential.

3.4.2 Chronicle

In 1885 an avalanche fell from Ytri-Sultarbotnagjá down to the sea. It hit two farms and killed three people. Nine other avalanches are recorded from the gully. Four of them reached the runout index 13, but the others are smaller. The recorded avalanches from the gully are shown on Map 2 and listed in the following table:

Number Time *Runout index*	**Description**
153 26.2.1885 *>15.7*	An avalanche hit two farmhouses in Naustahvammur and ran into the sea. A woman and two children were killed in one of the houses, but all four people at the other farm were rescued out of the snow. The avalanche touched two other farms, but caused little damage there. The avalanche width was estimated 240 m. According to personal accounts, the avalanche divided into two tongues, and the eastern tongue reached the sea.
154 4.2.1974 *13.6*	An avalanche fell from Ytri-Sultarbotnagjá. The deposition was about 160 m wide and stopped around 60 m a.s.l.
155 20/21.12.1974 *13.4*	A dry slab avalanche fell from Ytri-Sultarbotnagjá and stopped 70–80 m a.s.l. around 500 m from the sea. The 160 m wide tongue damaged some fences.
1058 27.4.1977 *<11*	A dry slab avalanche fell from Ytri-Sultarbotnagjá and stopped 70–80 m a.s.l. around 500 m from the sea. The 160 m wide tongue damaged some fences.
1053 3.3.1978 *<11*	A small avalanche fell from Ytri-Sultarbotnagjá and stopped around 210 m a.s.l. In town, it was raining and sleeting with thick slush on the roads.
1076 20.3.1981 *12.9*	A loose dry avalanche fell from Ytri-Sultarbotnagjá. The 80 m wide deposition was about 1 m deep and stopped around 70 m a.s.l.
1077 4.11.1981 *11.0*	A loose wet avalanche fell from Ytri-Sultarbotnagjá. It ran over bare ground collecting rocky debris and stopped around 130 m a.s.l.
1202 27.2.1990	A dry slab avalanche fell from Ytri-Sultarbotnagjá, and reached all the way down to a power line which is just above the saltfish factory of SVN.
1209 21.3.1997	A small avalanche came from Ytri-Sultarbotnagjá and stopped just below the mouth of the gully.

3.4.3 Assessment

The delimitation of the starting area is not easy, it is divided into two gullies. We have considered the inner gully to be the most likely starting area. The starting area is rather large and steep with high probability of snow accumulation but with very rough and interrupted surface due to high cliffbelts. It is difficult to evaluate the probability of large avalanches but the inner starting area is the most probable starting area of the avalanche in 1885 which almost reached the shoreline. As for Innri-Sultarbotnagjá, we therefore conclude that the starting area is favorable for large avalanches in spite of its high roughness.

3.5 Model estimates

Map 5 shows the results of model calculations and the profiles used for the calculations. The profiles `nein01ba` (Gunnólfsskarð), `neat13aa` (Brynjólfsbotnagjá), `neat14aa` (Innri-Sultarbotnagjá), `neat15ab` and `neat15ba` (Ytri-Sultarbotnagjá), and the results of the calculations are also shown in Drawings 1–5. The runout was calculated using runout indices and the α/β-model. The risk estimation methods of RiskEst (*Estimation of avalanche risk*, Kristján Jónasson *et al.*, 1999) were applied. For explanation of notation see Appendix A.

The farm Þrastalundur is standing closest to the mountain of the buildings in the area, and an avalanche with runout just over $r = 15$ in profile `neat12aa` will reach the buildings. The tip of the 1990 avalanche had runout index 16.5. In profile `neat13aa` the α-point is located close to the road and there the runout measured by runout indices is about 16.5. The uppermost houses in the area are just below the road. In profile `neat14aa` an avalanche with $r = 16$ would reach the road. About 75 m above the road there is a horse shed. The runout of the 1936 avalanche is $r = 16.7$ or close to α. In profiles `neat15ba` and `neat15ab` an avalanche with $r = 16$ or a runout angle a little higher than α will run into the sea as the avalanche in 1885 did.

In the four gullies in total there are three avalanches with runout $r \geq 16$ recorded since 1885. It is quite possible that large avalanches with runout index ≥ 14 have fallen during that period in the area without being observed. To estimate the frequency of avalanches by the methods of RiskEst one might therefore decrease the observation time from more than 115 years down to say 100 years. The estimated frequency then becomes $F_{13} = 0.11$, or 11 avalanches pr. century down to or longer than $r = 13$, in each gully. Only Ytri-Sultarbotnagjá, which is closest to the settlement of the gullies, has avalanches with $13 \geq r \geq 16$ recorded. In the past about 30 years that systematic records have been kept there are three such avalanches. This implies frequency of about $F_{13} = 0.1$, which is in good accordance to the previous result. The fact that no medium sized avalanches are recorded from the other three gullies is a little bit puzzling. It should be kept in mind though that the observation period is quite short and it is also possible that such avalanches went unnoticed in the past 30 years.

The Austrian avalanche model SAMOS was applied to evaluate the direction of avalanches from the starting areas and the possible extents of avalanches. The findings are described by Tómas Jóhannesson *et al.* (2001).

3.6 Conclusion

There is an indication that there is more snow accumulation in the inner part of the mountain above Neskaupstaður, than in the outer part. This together with the frequency implied by the number of large avalanches is considered sufficient to attach a slightly higher frequency to the inner area than to the residential area further to the east (see section 5.11).

There is an indication from the avalanche chronicle and the topographic conditions that Brynjólfsbotnagjá is less hazardous than the other three gullies. It is, however, considered not to be feasible to attach a lower frequency to that gully than the others. The delineation of the areas that are affected by each of the gullies is also difficult and therefore the proposed risk lines are more or less straight. The lines are based on calculations using $F_{13} = 0.1$. The two dimensional model calculations seem to confirm this, since the runout areas of Innri-Sultarbotnagjá and Brynjólfsbotnagjá partly coincide according to the model.

This part of the mountain is a typical avalanche path with recorded avalanches. However since the delineation of the affected areas is difficult the uncertainty is considered to be low to medium ($\frac{1}{2}$–1).

The hazard zoning proposal is shown on Map 7.

4 Bræðslugjár and surroundings

Detailed field investigations were not carried out for thise area. The area can be seen in Figure 2 and in Maps 1 and 5. The main avalanche paths in the area are the three gullies Bræðslugjár, sometimes referred to as Bræðslugjá I, II, and III, counting from west to east. There are numerous recorded avalanches from these three and a few other gullies to the west and east of Bræðslugjár. The largest of the avalanches was one of the catastrohic avalanches in 1974 that hit the freezing plant and killed 5 persons. Old sources claim that in the last part of the nineteenth century avalanches fell down to the sea almost every year in the area. It is thus apparent that the area is very hazardous. Therefore a detailed investigation was not performed.

4.1 Chronicle

4.1.1 Between Ytri-Sultarbotnagjá and Bræðslugjár

Six avalanches are recorded in the area. They are shown on Map 2 and listed in the following table.

Number Time *Runout index*	**Description**
1073 20.12.1974 *13.9*	A dry slab avalanche is recorded from Breiðajaðarsgil. It stopped at 35 m a.s.l, 270 m from the sea. The deposition was about 100 m wide.
1114 14.1.1975 *10.9*	An avalanche started in the opening of a gully above the lowest rockfaces in the second gully east of Ytri-Sultarbotnagjá. It fell down to the foot of the mountain. The path was 30–60 m wide and widened a little downhill.
1117 2.2.1975 *< 11*	A small, wet avalanche fell just east of Ytri-Sultarbotnar. It probably started by a cornice collapsing at the top.
1051 22/23.1.1977 *10.6*	A small avalanche fell east of Ytri-Sultarbotnagjá and stopped at about 110 m a.s.l.
1052 3.3.1978 *10.7*	A small avalanche fell east of Ytri-Sultarbotnagjá and stopped at about 120 m a.s.l.
1064 22/23.5.1979 *< 11*	A small avalanche fell in the next gully west of Bræðslugjár and stopped at about 160 m a.s.l.

4.1.2 Bræðslugjár

A total of 26 avalanches are recorded from Bræðslugjár. They are shown on Map 2 and listed in the following table.

Number Time *Runout index*	**Description**
158 Jan/Feb 1936 *>15.1*	An avalanche fell from Bræðslugjár, probably the two easternmost. The avalanche split above the house Hruni and fell down to the sea on both sides of the house. The western tongue was thicker and went down to the sea between Hruni and the house Bjarg. The deposition was estimated to have been about 250 m wide.
1110 Around 1940 *12.3*	An avalanche fell above the houses Skálholt and Hruni. The avalanche damaged a fence. It stopped about 300 m above Skálholt.
165 4.2.1974 *12.9*	A wet avalanche came from Bræðslugjá III and stopped at about 40 m a.s.l.
162 20.12.1974 *>15.3*	A large avalanche fell, probably from all three Bræðslugjár. The avalanche went down to the sea. The deposition was 410 m where it was widest and the average thickness was estimated about 1.5 m. The volume of the avalanche was estimated 600 000 $m^3 \pm 10\%$. It was a dry slab-avalanche. Five persons were killed and bacalao-factory, oil tanks and other buildings were damaged or destroyed. Crude oil polluted the sea.
1113 10.1.1975 *$\ll$11*	Some small avalanches fell down where the rock-faces are steepest in Bræðslugjá I, but they stopped at a little under 250 m a.s.l.
1123 10.1.1975 *$\ll$11*	Some small avalanches fell where the rock-faces are steepest in Bræðslugjá II, but they stopped at a little above 300 m a.s.l.
1115 31.1.1975 *<11*	A wet avalanche fell in Bræðslugjá I, and a short way down the rocky debris below the mouth of the gully.
1119 Feb 1975 *<11*	An avalanche fell from Bræðslugjá I, a few days before the 13 February 1975. It stopped at about 130–140 m a.s.l.
1120 15/16.2.1975 *<11*	A small avalanche fell from Bræðslugjá, but it did not reach the bottom of the rocky debris (about 120–140 m a.s.l.). It was some tens of meters wide where it was widest.

Number Time *Runout index*	**Description**
1057 6.1.1976 *< 11*	A small avalanche fell from Bræðslugjá I which stopped at about 120 m a.s.l.. The tongue was about 60 m wide.
1050 12.10.1977 *< 11*	A small avalanche fell from Bræðslugjá I and stopped at about 110 m a.s.l.
1056 3.3.1978 *10.6*	A small avalanche fell from Bræðslugjá I and stopped at about 110 m a.s.l.
1065 17.4.1979 *≪ 11*	A small avalanche came from Bræðslugjá I and stopped at about 210 m a.s.l.
1068 20.5.1979 *≪ 11*	A small avalanche fell from Bræðslugjá III. It stopped at about 250 m a.s.l. and the tongue was about 20 m wide.
1069 20.5.1979 *≪ 11*	A small avalanche came from Bræðslugjá II and stopped at about 170 m a.s.l. The tongue was about 20 m wide.
1063 22/23.5.1979 *< 11*	An avalanche fell from all three Bræðslugjár. The depostion was split into two parts. One part was 100 m wide and the other 30 m. The maximum width was 220 m and it stopped at about 115 m a.s.l.
160 20.3.1981 *11.7*	A dry, loose avalanche came from Bræðslugjá I. The tongue was about 80 m wide and it stopped at about 70 m a.s.l. The avalance was about 1 m thick.
159 4.11.1981 *12.3*	Small avalanches fell both from Bræðslugjá I and II. The snow was sliding on bare soil and the avalanche picked up some rocks and debris. The avalanche from Bræðslugjá II was larger, and just below the gully the snow accumulated in a thick mass that was several meters thick. Part of the mass reached further down and the deposition ended at about 60 m a.s.l.
166 1/2.3.1982 *10.9*	An avalanche came down from Bræðslugjá I and stopped at 100 m a.s.l. The deposition was 200 m wide.
1097 15.4.1988 *≪ 11*	Some very small avalanches fell from the gullies above the freezing plant (SVN).
1083 21.3.1989 *11.2*	A small avalanche fell from the hillside just west of Bræðslugjá I and stopped at 80 m a.s.l. The tongue was about 20 m wide.

Number Time *Runout index*	Description
1084 21.3.1989 *11.7*	A small avalanche fell from Bræðslugjá I. The tongue was about 30 m wide and stopped at 70 m a.s.l.
1011 22.3.1994 < 11	A small avalanche fell from Bræðslugjá II and stopped at 120 m a.s.l.
1012 22.3.1994 < 11	A small avalanche started in Bræðslugjá III and stopped at 120 m a.s.l.
1013 22.3.1994 < 11	A thin avalanche fell from Bræðslugjá I and stopped at 120 m a.s.l.
1009 18.3.1995 < 11	A small avalanche fell from Bræðslugjá I and stopped at about 130 m a.s.l. The tongue was about 100 m wide. It seemed like that the avalanche had overrun another, older avalanche.

4.1.3 Between Bræðslugjár and Miðstrandarskarð

Nine avalanches are recorded from the slope between Bræðslugjár and Miðstrandarskarð. They are shown on Map 2 and listed in the following table.

Number Time *Runout index*	Description
161 4.2.1974 *12.7*	A wet avalanche fell east of Bræðslugjár and stopped at about 40 m a.s.l. The depostion was about 100 m wide.
1046 27.4.1977 $\ll 11$	A small avalanche fell from the first gully west of Miðstrandargil and stopped at about 180 m a.s.l.
1047 27.4.1977 $\ll 11$	A small avalanche fell from the third gully east of Bræðslugjár and stopped at about 180 m a.s.l.
1048 27.4.1977 $\ll 11$	A small avalanche fell from the second gully east of Bræðslugjár and stopped at about 180 m a.s.l.
1049 27.4.1977 $\ll 11$	An avalanche fell above some oil-tanks owned by BP, in the next gully east of Bræðslugjár. It stopped at about 150 m a.s.l. and the deposition was about 110 m wide.

Number Time *Runout index*	**Description**
1044 3.3.1978 *< 11*	An avalanche fell from the second gully east of Bræðslugjár and stopped at about 100 m a.s.l.
1062 22/23.3.1979 *≪ 11*	A small avalanche fell from the second gully east of Bræðslugjár and stopped at about 140 m a.s.l. The deposition was close to 20 m wide.
167 9/10.1.1983 *≪ 11*	A small avalanche fell west of Miðstrandargil in the third gully east of Bræðslugjár. It stopped at about 150 m a.s.l. and the deposition about 30 m wide.
1085 21.3.1989 *12.7*	An avalanche fell from the first gully west of Miðstrandargil, and stopped at 35 m a.s.l.

4.2 Model estimates

Maps 5 and 6 show the results of model calculations and the profiles used for those calculations. The profiles `neat05aa`, `neat06aa`, `neat07aa`, `neat08aa`, and `neat09aa`, and the results of the calculations for them are also shown in Drawings 6–10. To reach the shoreline an avalanche must have a runout index of about 14–15 and with the α/β-model the shoreline measures to be around α. The avalanche chronicle and comparison to the areas to the east and west indicates that the base avalanche frequency may be about $F_{13} = 0.05$–0.1 per year. Using a freqency of that order gives an annual risk at the shoreline of about 10–$30 \cdot 10^{-3}$.

4.3 Conclusion

The risk in all of the area is considered to be more than $3 \cdot 10^{-4}$ and therefore the entire area is in the category C hazard zone. The uncertainty of the assessment that all the area is in the category C hazard zone is low since the boundary of the category C hazard zone is well beyond the shoreline. No conceivable reinterpretations of the data or changes in hazard zoning methods are likely to change this assessment. The uncertainty of the risk estimate as such is low ($\frac{1}{2}$) directly below the gullies, but somewhat higher between them.

Figure 3. *The westernmost part of the residential area. Miðstrandarskarð and Klofagil to the left and Innra- and Ytra Tröllagil to the right. (Photo: Harpa Grímsdóttir).*

5 From Miðstrandargil to Stóralækjargil

The area is the residential area of Neskaupstaður. The city center is located around the middle of the area, where there is a city hall and various services.

5.1 Miðstrandargil/Klofagil

5.1.1 Topographic description

Figure 3 shows Miðstrandarskarð and Klofagil. They can also be seen on Maps 1 and 6 and longitudinal sections (`neib15aa` and `neib16aa`) are shown in Drawings 11 and 12. The area below the gullies is immediately to the west of the residential area. Cliffs top the mountain and mostly loose deposits with minor cliff belts characterize the mountainside down to the sea. Miðstrandarskarð is a mountain pass and below it is the bowl Miðstrandargil. Klofagil is a gully to the east of Miðstrandargil starting parallel to Miðstrandargil but curving toward east in the upper part.

Starting zone

The starting zone in Miðstrandargil is a bowl that ranges from 500 to 700 m a.s.l. with a maximum width of 350 m. The area is 11.6 ha and the aspect is SSE to S. The surface is comprised of weathered rocks interrupted by cliffs. Snow accumulation in this area is high and the inclination ranges between 34° and 41°.

The Klofagil starting zone ranges from 500 to 700 m a.s.l. with a maximum width of 190 m. It is a 4.7 ha combination of a gully and mountainside that is oriented S to SW. The inclination ranges from 34° to 38°. The surface is composed of weathered rocks interrupted by cliffs. Snow accumulation in this area is high.

Track

The track through Miðstrandargil ranges from 500 to about 25 m a.s.l. It is 250 m wide with an average inclination of 25°. Specifically, the inclination is approximately: 28° at 500–400 m a.s.l., 35° at 400–300 m a.s.l., 33° at 300–200 m a.s.l., 25° at 200–100 m a.s.l., and 14° at 100–25 m a.s.l. The track encompasses the mountainside and is interrupted by small gullies. The track surface is composed of weathered rock and some vegetation interrupted by cliffs. The degree of confinement for this track is 1.4.

The Klofagil track ranges from 500 to 24 m a.s.l. with a width of 60 m. The inclination is approximately: 34° at 500–400 m a.s.l., 29° at 400–300 m a.s.l., 30° at 300–200 m a.s.l., 25° at 200–125 m a.s.l., 18° at 125–25 m a.s.l., and 12° at 75–25 m a.s.l. The surface is composed of weathered rock and some vegetation interrupted by cliffs. The degree of confinement is 3.2.

Runout area

The runout area ranges from 25 m a.s.l. to sea level. The runout area is 170 m long with an 8° average inclination down to the sea. The runout area is even and the avalanche spreading potential in this area is medium. There are few houses in the area. The houses Skuld and Mánahús were both destroyed by an avalanche in 1974. Skuld had been standing there since 1913.

5.1.2 Chronicle

Sixteen avalanches are recorded from Miðstrandargil. In 1936 an avalanche fell down to the house Skuld, without touching it. In December 1974 a large avalanche from Miðstrandargil caused extensive damage and killed seven people. Other recorded avalanches are smaller. The recorded avalanches from the gully are shown on Map 3 and listed in the following table:

Number Time *Runout index*	**Description**
168 Jan 1936 *14.2*	An avalanche fell, probably from Miðstrandargil. It divided into two tongues that flowed along either side of the house Skuld. The avalanche stopped at 5–10 m a.s.l., and the estimated width of the deposition was 80 m. It was probably a dry slab avalanche.
172 4.2.1974 *10.7*	A wet slab avalanche fell from Klofagil and stopped at approximately 75 m a.s.l. The tongue was 100–200 m wide.
169 20.12.1974 *>14.6*	A large dry slab avalanche fell from Miðstrandargil. The avalanche was 1700 m long on land and went around 400 m out onto the sea. The volume of the tongue on land was 190,000 m^3 $\pm 15\%$. The volume of the snow that flowed into the sea was estimated to have been about 20,000 m^3. The average snowdepth of the deposition on land was 1.25 m though the snow was as deep as 3 m deep in parts of the depostion. Seven people were killed and buildings sustained massive damage.
1112 10.1.1975 *≪11*	A small avalanche fell in cleft of Miðstrandargil. It started on the western wall of Miðstrandargil and fell to the bottom of the cleft at around 550 m a.s.l.
1118 3.2.1975 *≪11*	A wet avalanche fell from Klofagil down to the second rock face at 220–240 m a.s.l.
1045 22/23.1.1977 *9.9*	A small avalanche fell from Klofagil and stopped at around 100 m a.s.l. The tongue was approximately 30 m wide.
1059 27.4.1977 *10.1*	An avalanche fell from Klofagil and stopped at 100–120 m a.s.l. The tongue was 30–50 m wide.
1037 3.3.1978 *10.4*	An avalanche fell from Miðstrandargil. The tongue was narrow and stopped around 70 m a.s.l.
1043 3.3.1978 *≪11*	A small avalanche fell from Klofagil directly above the concrete production facility and stopped at around 170 m a.s.l.
1061 22/23.5.1979 *10.2*	An avalanche fell from Klofagil and stopped around 100 m a.s.l. The tongue was about 60 m wide.
1090 15.4.1979 *≪11*	A small avalanche fell from Miðstrandargil and stopped about 440 m a.s.l.

Number Time *Runout index*	**Description**
1066 17.4.1979 *< 11*	A small and narrow avalanche fell from Klofagil and stopped around 170 m a.s.l.
1067 20.5.1979 *< 11*	A small avalanche fell from Klofagil and stopped at about 150 m a.s.l. The tongue was approximately 20 m wide.
170 29.3.1981 *11.0*	A wet slab-avalanche fell from Miðstrandargil and/or Klofagil and stopped in a quarry 80 m a.s.l. The tongue was 150–200 m wide. The snow was rapidly melting in the sunshine.
179 1/2.3.1982 *10.6*	A loose dry avalanche fell from Miðstrandargil and/or Klofagil and stopped in a quarry just below 100 m a.s.l. It was 100 m wide.
1082 21.3.1989 *10.6*	An avalanche fell from Klofagil, and stopped about 85 m a.s.l. and the tongue was approximately 60 m wide.
1207 21.3.1997 *13.4*	A slab avalanche released in Miðstrandargil, probably about 100 m below the top of the mountain. A 25–30 cm thick layer of new snow slid on old, hard snow. The tongue was about 160 m wide at its widest. The tongue stopped about 200 m below the widest part of the avalanche, and just reached the concrete production facility.

5.1.3 Assessment

Miðstrandargil is one of the largest starting areas and has a recorded avalanche of about 200,000 m^3. The estimated starting area is 10 ha. If entrainment is not considered, the volume of the largest recorded avalanches and the size of the starting area corresponds to an average snowdepth (perpendicular to the slope) of 2 m. The avalanche path below Miðstrandargil has almost no runout area and large avalanches going into the sea such as in 1974 can be expected. Klofagil has a track and runout area that partly coincides with Miðstrandargil. Although smaller avalanches are expected from Klofagil than Miðstrandargil, the slope down to the shoreline is so steep that avalanches from Klofagil can be hazardous for the settlement below the gully.

5.2 Between Klofagil and Innra-Tröllagil

5.2.1 Topographic description

The area can be seen in Figure 3 and on Maps 1 and 6 and a longitudinal section (`neib17aa`) is shown in Drawing 13.

Starting zone

This area encompasses two starting zones. The upper starting zone is 600–540 m a.s.l. with a maximum width of 100 m. It is a small and even depression with an average inclination of 42° and an area of 0.8 ha. The lower starting zone is 500–370 m a.s.l. with a maximum width of 220 m. It is a small depression that is about 15 m deep. The inclination is approximately 36° over the 4.7 ha area. Both areas are oriented to S and are composed of weathered rocks interrupted by cliffs. Snow accumulation in these areas is low.

Track

The track between Klofagil and Innra-Tröllagil is 200 m wide and ranges from 370 to 20 m a.s.l. The even mountainside inclines approximately: 31° at 370–200 m a.s.l., 23° at 200–100 m a.s.l., and 14° at 100–20 m a.s.l. The surface is composed of weathered rock and vegetation interrupted by cliffs. The degree of confinement in the highest part of the track is 0.5 and below 200 m a.s.l., the degree of confinement rises to 1.0.

Runout area

The altitude of the runout area ranges from 20 m a.s.l. to sea level. It is 150 m long at a 7° inclination. The even runout area has a low avalanche spreading potential. The runout area is settled with about three rows of houses. The houses closest to the sea were built mostly in the beginning of the twentieth century, except for Strönd, built 1886. The uppermost houses were built in the second half of the twentieth century.

5.2.2 Chronicle

Three avalanches are recorded in the area, one of them reaching the runout index 13. None of them reached the settlement. The avalanches are shown on Map 3 and listed in the following table:

Number Time *Runout index*	**Description**
1072 4.2.1974 *10.4*	An avalanche fell above Urðarteigur and stopped around 80 m a.s.l.
177 28.12.1974 *12.9*	A large wet avalanche fell from above Urðarteigur and stopped at 30 m a.s.l., 200 m from the sea. The path was 1300 m long and the tongue was a maximum 70 m wide. Some fences were slightly damaged.
1042 3.3.1978 *<11*	A small avalanche fell from the second gully west of Innra-Tröllagil and stopped at about 110 m a.s.l.

5.2.3 Assessment

The starting area consists of two small depressions between and slightly above the cliffbelts at 350 and 500 m a.s.l. High snow accumulation in the area is not expected so large avalanches are considered unlikely. Due to the absence of a runout area, such small avalanches can reach the settlement.

5.3 Innra- and Ytra-Tröllagil

5.3.1 Topographic description

Innra- and Ytra-Tröllagil are two adjacent bowls or gullies that go to the top of the mountain above the eastern part of the residential area. The area can be seen in Figure 3 and on Maps 1 and 6 and longitudinal sections (`neib18aa` and `neib19aa`) are shown in Drawings 14 and 15.

Starting zone

The starting zone in Innra-Tröllagil ranges from 680 m to 380 m a.s.l with a maximum width of 250 m. It is a bowl in the upper part and a gully in the lower part. It is oriented SSE to SSW. The area is 9.2 ha and inclines at 38°. The surface is composed of weathered rock interrupted by cliffs. Snow accumulation in this area is high.

The starting zone above Ytra-Tröllagil ranges from 700 to 400 m a.s.l. with a maximum width of 190 m. It is a 15 m deep gully that is oriented SSE to SSW. The area is 7.0 ha and inclines 34°–38°. The surface is composed of weathered debris interrupted by cliffs. Snow accumulation in this area is high.

East of Ytra-Tröllagil there is a shallow depression. It is considered to be about an 80 m wide starting area reaching from 340 to 440 m a.s.l. The average inclination of the 1.3 ha area is about 36°. Snow accumulation is low.

Track

The track in Innra-Tröllagil is 80 m wide and ranges from 380 to 30 m a.s.l. The track is a 20 m deep gully between 380 and 200 m a.s.l. Below 200 m a.s.l., the track is a slightly convex debris cone. The inclination of this track is approximately 29° at 380–300 m a.s.l., 27° at 300–200 m a.s.l., 24° at 200–150 m a.s.l., 19° at 150–100 m a.s.l., 15° at 100–50 m a.s.l., and 12° at 50–30 m a.s.l. The surface is composed of weathered rock and vegetation in some parts. The degree of confinement is 3.1.

The track in Ytra-Tröllagil is 100 m wide and ranges from 400 to 30 m a.s.l. The track is a 20 m deep gully between 400 and 180 m a.s.l. Below 180 m a.s.l., the track becomes a slightly convex debris cone. The inclination of this track is approximately 31° at 400–300 m a.s.l., 26° at 300–200 m a.s.l., 23° at 200–100 m a.s.l., and 13° at 100–30 m a.s.l. The surface is composed of weathered debris partly covered by vegetation and isolated rocks. The degree of confinement is 1.7.

Runout area

The altitude of the runout area in Innra-Tröllagil ranges from 30 m a.s.l. to sea level. It is 200 m long and inclines at 8°. The slightly convex runout area has a high avalanche spreading potential.

The altitude of the runout area in Ytra–Tröllagil ranges from 30 m a.s.l. to sea level. It is 270 m long and inclines at 7°. The even runout area has a low avalanche spreading potential.

The area below Tröllagil has been settled for more than a century. The oldest house in the area, Bjarnarborg, was built in 1880–1890 and was initially a sheep shed for the farm Ormsstaðir. In 1890 it became a domestic house. The house Strönd was built by the sea in the western part of the area in 1886 and Gamla-Tröllanes a little to the east in 1896. In the first three decades of the twentieth century a cluster of houses was built in the area along the coastline and towards the mountain below Ytra-Tröllagil and between the two gullies. Most of the uppermost houses by the road Urðarteigur were built in the 1960's and 1970's.

5.3.2 Chronicle

Seven avalanches are recorded from the two gullies, Innra- Tröllagil and Ytra-Tröllagil. It is not always clear in which gully the avalanches released. In 1894 there are records of a large avalanche from one of the gullies down to the sea. It didn't do much damage. Other recorded avalanches are smaller. The recorded avalanches from the gullies are shown on Map 3 and listed in the following table:

Number Time *Runout index*	**Description**
173 1894 >14.8	In his memoirs, Ingvar Pálmason writes, "... 1894 a great avalanche fell from Tröllagil and some part of it went over the huts at Bjarnarborg but it didn't do much damage to them because the main tongue was more to the east and went all the way to the sea. The tongue was so thick where the sea dispersed the front of it at the seashore that it was estimated about 6 m thick."
175 Mar 1920 *13.5*	An avalanche fell from Innra-Tröllagil during wet March weather. It stopped at around 30 m a.s.l., and the tongue was estimated at 120 m wide.
180 4.2.1974 *12.3*	An avalanche fell from Ytra-Tröllagil and stopped at approximately 55 m a.s.l.
176 20/21.12.1974 $\ll 11$	A small dry slab avalanche fell from Innra-Tröllagil. It stopped 500–600 m from the sea at 150–200 m a.s.l. The tongue was about 35 m wide.

Number Time *Runout index*	Description
181 27.12.1974 *13.3*	A large wet slab avalanche fell from Ytra-Tröllagil and stopped 30 m a.s.l. around 190 m from the sea. The tongue was 210 m at its widest. Some fences were slightly damaged.
178 1/2.3.1982 *12.4*	An avalanche released, either in Innra-Tröllagil or from both Innra-Tröllagil and Ytra-Tröllagil. It stopped about 150 m from town at 60 m a.s.l.
1205 21.3.1997 *12.9*	An avalanche started in the lower part of the gully Innra-Tröllagil, or at 280–300 m a.s.l. The tongue stopped 93 m away from the house Urðarteigur 12, and headed towards the center of the house. It was approximately 25 m wide and 1.5–2 m thick.

5.3.3 Assessment

The gullies are considered as two separate starting areas that are large but not the largest in the outer part of Neskaupstaður. The size of the starting area, the lack of a runout area, and the recorded history of avalanches all indicate that avalanches down to the sea are to be expected.

5.4 Urðarbotn and Sniðgil

Urðarbotn is the name of a shelf in the mountain at about 600 m a.s.l. Above the shelf there are about 20 m high cliffs and above the cliffs there is a slightly concave area. The shelf is probably formed by a rockslide and the rocks in the shelf are creeping down (Árni Hjartarson, 2000). Below the shelf there are two shallow depressions and to the east of those is a small gully called Sniðgil. The area can be seen in Figure 3 and on Maps 1 and 6 and longitudinal sections (`neib22aa` and `neib22ba`) are shown in Drawings 16 and 17.

5.4.1 Topographic description

Starting zone

The area by Urðarbotn has 2 starting zones. The altitude of the eastern starting zone ranges from 600 to 400 m a.s.l. with a maximum width of 150 m. It is a shallow bowl that is about 20 m deep. This 5.0 ha area is below Urðarbotn. The western starting zone ranges from 730 to 400 m a.s.l. with a maximum width of 200 m. It is a shallow bowl and an even mountainside that covers 8.0 ha. The surface of both areas is composed of weathered debris interrupted by cliffs. Snow accumulation is low.

The Sniðgil starting zone is a 20 m deep gully that ranges in elevation from 600 to 400 m a.s.l. with a maximum width of 120 m. This 3.9 ha area inclines at 38° and is oriented S to SW. The

Figure 4. *The center of Neskaupstaður. Urðarbotn and Sniðgil to the left and Drangaskarð and Skágil to the right. (Photo: Harpa Grímsdóttir).*

surface is composed of weathered debris interrupted by cliffs. Snow accumulation is medium.

Track

The track below Urðarbotn is 100 m wide and ranges from 400 to 40 m a.s.l. The even mountainside inclines approximately: 37° at 400–300 m a.s.l., 23° at 300–200 m a.s.l., 18° at 200–100 m a.s.l., and 11° at 100–40 m a.s.l. The surface is composed of weathered talus covered with vegetation. The degree of confinement is 1.5.

The track through Sniðgil starting area is 90 m wide and ranges from 400 to 40 m a.s.l. The even mountainside inclines approximately 30° at 430–300 m a.s.l., 23° at 300–200 m a.s.l., 18° at 200–100 m a.s.l., and 11° at 100–40 m a.s.l. The surface is composed of weathered talus covered with vegetation. The degree of confinement is 1.3.

Runout area

The altitude of the runout area below Urðarbotn and Sniðgil ranges from 40 m a.s.l. to sea level. It is 340 m long and inclines 7° on average. The even runout area has a low avalanche spreading potential.

The area is densely settled. The upper part of the settlement is mostly domestic houses, the uppermost (Blómsturvellir) were built in and after the 1960's. Lower down the houses are mostly built in the 1940's but some are older, the oldest one built in 1910. By the street closest to the sea (Hafnarbraut) is the town center of Neskaupstaður. There a dense settlement had formed early in the twentieth century.

5.4.2 Chronicle

No great, massive avalanches are recorded from the Urðarbotn area, but three avalanches are recorded down to below 100 m a.s.l. All af them fell in the year 1974 and a narrow one extended close to the uppermost houses. Other recorded avalanches are very small and with runout indices much lower than 13. The recorded avalanches from the area are shown on Map 3 and listed in the following table:

Number Time *Runout index*	**Description**
183 4.2.1974 *12.0*	An avalanche fell down the western depression below Urðarbotn and stopped at about 85 m a.s.l.
182 27/28.12.1974 *13.7*	A wet avalanche fell down the western depression below Urðarbotn. The deposition was a maximum 70 m wide and stopped 45 m a.s.l. Some trees were slightly damaged.
184 28.12.1974 *12.9*	A wet avalanche started in the eastern depression below Urðarbotn, or in Sniðgil. It stopped 430 m from the sea at around 65 m a.s.l. The tongue had a 70 m wide maximum.
1036 22.3.1977 *≪11*	A small avalanche fell from Urðarbotn/Sniðgil and stopped about 240 m a.s.l.
1035 27.4.1977 *≪11*	A small avalanche fell from Urðarbotn and Sniðgil and stopped around 290 m a.s.l. The width of the tongue was an estimated 30 m.
1034 3.3.1978 *<11*	A small avalanche fell from Urðarbotn and Sniðgil and stopped at approximately 210 m a.s.l.
1007 11.3.1995 *≪11*	A small narrow avalanche started below some rock faces in front of Urðarbotn. The avalanche stopped 50–100 m below the lowest rock faces, in a stream bed.
1212 21.3.1997	A small avalanche fell in Urðarbotn and stopped just below the opening of the gully.

Figure 5. *Drangaskarð and Skágil furthest to the left, then Nesgil, and Bakkagil to the right. (Photo: Harpa Grímsdóttir).*

5.4.3 Assessment

Small avalanches can be expected from some areas such as the area above the Urðarbotn shelf and the area west of Urðarbotn. Larger avalanches can start around 600 m a.s.l. and below that where there are three depressions. The potential size of avalanches is estimated at 10–100,000 m^3. Due to the small size of the potential starting areas and the low probability of snow accumulation, the area is considered relatively less hazardous than the areas below the large gullies. The runout zone, however, is very small so that even small avalanches threaten the houses.

5.5 Drangagil/Skágil

5.5.1 Topographic description

The area can be seen in Figures 3 and 4 and on Maps 1 and 6 and longitudinal sections (`neib23aa` and `neib24aa`) are shown in Drawings 18 and 19. The mountain pass Drangaskarð derives its name from a rectangular rock formation in the middle of the pass. Below the pass there is a bowl/gully referred to as Drangagil. To the east of it there is a smaller gully, Skágil.

Starting zone

The starting zone in Drangagil is split into two subareas that can be expected to release avalanche at the same time. The western part is 120 m wide shallow depression that ranges from 610 to 400 m a.s.l. Its area is 4.3 ha. The eastern part is a 50 m deep gully which is 330 m wide at its maximum, ranges from 660 to 400 m a.s.l. and is 11.3 ha. The total potential starting area is thus 15.6 ha. The area is oriented SE to SW. It inclines 34°–38°. The surface is composed of weathered debris and rock with only a few cliffs. Snow accumulation is high in the gully and medium in the depression.

The starting zone in Skágil ranges from 740 to 400 m a.s.l with a width of 150 m. It is a 15 m deep gully that is oriented SSE to SSW. The 4 ha area inclines 34°–40°. The surface is composed of weathered rock with a few cliffs. Snow accumulation is high.

Track

The track through Drangagil is a deep, cliffy, and narrow gully from 400 to 280 m a.s.l. on the western side. Cliffbelts border the area on the eastern side. From 280 to 70 m a.s.l., the track is even and slightly convex. The altitude of the track ranges from 400 to 70 m a.s.l. with an inclination of approximately: 33° at 400–300 m a.s.l., 22° at 300–200 m a.s.l., 16° at 200–100 m a.s.l., and 13° at 100–70 m a.s.l. The track is 250 m wide, with 70 m of that value being the width of the gully. The surface is composed of weathered debris covered with vegetation. The degree of confinement is 1.6 but the confinement in the gully is higher.

The track through Skágil is a deep, and narrow gully from 400 to 320 m a.s.l. Below 320 m a.s.l., the track becomes a slightly convex debris cone. The altitude of the track ranges from 500 to 70 m a.s.l. with an inclination of approximately: 31° at 400–300 m a.s.l., 23° at 300–200 m a.s.l., 7° at 200–150 m a.s.l., and 14° at 150–70 m a.s.l. The track is 70 m wide with a degree of confinement of 2.1. The surface is composed of weathered debris and bare cliffs in the upper part.

Runout area

The altitude of the runout area ranges from 70 m a.s.l. to sea level. From 70 to 50 m a.s.l., the runout area inclines a little less than 10°. Below 50 m a.s.l., the average inclination decreases to 7° down to the sea. The even area has a medium avalanche spreading potential.

The farmhouse Þiljuvellir was located a little above the present settlement. It was built in 1860 and destroyed by an avalanche in 1894. After that it was rebuilt a little closer to the coast, where the house Þiljuvellir 12 is presently located. The oldest house by the sea was built before 1890. Around the turn of the nineteenth century a few houses were built in the area and around 1920 a dense settlement had formed from the sea and up to Þiljuvellir. In the street closest to the sea there are some services and community buildings, such as a church, a bank, shops and offices. Closer to the mountain there are mainly domestic houses.

5.5.2 Chronicle

A large avalanche fell from Drangagil in 1894 hitting the farm Þiljuvellir. In 1974 medium sized avalanches were released in the gully, both in February and December. The recorded avalanches in the area are shown on Map 3 and listed in the following table:

Number Time *Runout index*	**Description**
186 24.1.1894 *15.8*	An avalanche hit the farm Þiljuvellir. The people in the farm were not injured and dug themselves out through a window. Two men were saved from a snow tunnel in a stream bed by Þiljuvellir. Some stables were damaged and 30 sheep were killed as well as one horse. Records from that time say that the avalanche probably started at Rósubotn below the cliffs at the top of Drangaskarð. According to some records the avalanche fell through Kvíbólsgil and to sea, but according to other records it didn't go that far. The stopping point is estimated to have been at 15 m a.s.l. in the avalanche chronicle by the IMO.
187 4.2.1974 *13.4*	An avalanche fell from Drangagil and stopped about 70 m a.s.l.
188 20.12.1974 *14.2*	A dry slab avalanche started at 600 m a.s.l. in Drangagil. The width of the starting zone was about 400 m. The length of the path was around 1550 m, and the volume of the tongue was an estimated 265,000 $m^3 \pm 20\%$. The tongue was a maximum 230 m wide and the average snowdepth was estimated at 1.5 m. The tip of the tongue was 50 m a.s.l. The avalanche severed an underground telephone cable and damaged a ski lift and some fences.
1071 20.12.1974 *13.5*	A dry avalanche fell from Skágil and joined an avalanche from Drangagil that fell the same day. It started at 650 m a.s.l. and the starting zone was 150 m wide. The path was 1600 m long and the deposition volume was estimated at 170,000 $m^3 \pm 20\%$. The tongue stopped at 70 m a.s.l. about 470 m from the sea. The tongue was around 100 m wide at its widest with an average snowdepth of 1.5 m. The avalanche damaged 340 m of fences surrounding a small forest and some trees.
189 20/21.12.1974 *$\simeq$ 12.5*	The location of this avalanche is uncertain. It is recorded in Drangagil and stopped at a little over 100 m a.s.l.
192 20/21.12.1974 *$\simeq$ 12*	An avalanche fell from Skágil and stopped at about 130 m a.s.l. The tongue was approximately 40 m wide.

Number Time *Runout index*	**Description**
1039 6.1.1976 *12.4*	An avalanche fell from Skágil and stopped at around 110 m a.s.l. The deposition was about 50 m wide.
1041 22/23.1.1977 *≪11*	A small avalanche fell from Skágil and stopped at approximately 250 m a.s.l. The tongue was about 50 m wide.
1033 6.3.1977 *<11*	A small avalanche released in Drangagil and stopped about 240 m a.s.l. The tongue was around 60 m wide.
1032 3.3.1978 *<11*	A small avalanche fell from Drangagil and stopped at around 200 m a.s.l. The deposition was 130 m wide at 230 m elevation.
1060 15.4.1979 *≪11*	A small avalanche fell from Skágil and stopped at about 250 m a.s.l.
190 6.2.1981 *≪11*	A small avalanche fell from Drangagil. It stopped around 250 m a.s.l. and the tongue was approximately 40 m wide.
191 1/2.3.1982 *11.0*	A small dry slab avalanche fell from Drangagil and stopped slightly below the opening of the gully at 170 m a.s.l. It was probably triggered by a cornice collapse.
1074 9/10.1.1983 *≪11*	A loose wet avalanche fell in Skágil. It was about 100 m long and stopped at around 300 m a.s.l. The tongue was about 10 m wide.
1006 11.3.1985 *≪11*	An avalanche came from Skágil below the uppermost rock faces at a little under 600 m a.s.l.
1094 15.1.1995	A small avalanche started at the bottom of Drangagil and turned east about 150 m.
1206 21.3.1997 *11.8*	A small avalanche fell from Drangagil. It stopped just below the mouth of the gully, but the tongue was quite wide where it stopped. A narrow and thin part of the avalanche turned east out of the main flow, and stopped approximately 50 m below and 50–100 m east of the upper part of a skilift which used to be there.

5.5.3 Assessment

Drangagil is the largest starting area above the settlement. An avalanche of about 250,000 m^3 that stopped above the uppermost houses was recorded from Drangagil in 1974. Another avalanche fell in 1894 and stopped about 100 m from the shoreline. The large starting area and the avalanche history show that most of the houses in this area must be considered to be endangered by avalanches. Skágil is a smaller starting area with a track and runout zone that partly coincides with that of Drangagil. Smaller avalanches are expected from Skágil than from Drangagil. Below Drangagil/Skágil, the runout area starts 450 m from the shoreline and is larger than further to the west.

5.5.4 Defence structures

A catching dam and two rows with a total of 13 breaking mounds have been built to provide protection against avalanches in the runout area below Drangagil. The catching dam is 17 m high and the mounds are 10 m high. The sides facing the mountain are almost vertical. Supporting structures are also to be built in parts of the starting area to reduce the potential size of avalanches that could hit the defence structures in the runout area. The design of the protection measures aims to reduce the risk to people below $0.5 \cdot 10^{-4}$ per year in all the houses below the dam (VST, 1998).

5.6 Nesgil

5.6.1 Topographic description

The Y-shaped bowl Nesgil is below the distinctive 800 m high summit Skarðstindur. The area can be seen in Figures 5 and 6 and on Maps 1 and 6. A longitudinal section (`neib25aa`) is shown in Drawing 20.

Starting zone

The Nesgil starting zone ranges from 780 to 500 m a.s.l. with a width of about 350 m. It is a large symmetric bowl that is around 25 m deep and faces SSE to SSW. The 12.9 ha area inclines 34°–40°. The surface is composed of weathered rock with a few cliffs. Snow accumulation is high.

Track

The 100 m wide track through Nesgil ranges from 500–75 m a.s.l. It is a cliffy 20 m deep gully at 500–350 m a.s.l. The mountainside is even between 350 and 150 m a.s.l., and below that, the track is a slightly concave debris cone. The track inclines approximately: 40° at 500–400 m a.s.l., 30° at 400–300 m a.s.l., 23° at 300–200 m a.s.l., and 14° at 100–75 m a.s.l. The surface is composed of weathered debris with bare cliffs in the upper part. The degree of confinement is 3.5.

Runout area

The altitude of the runout zone ranges from 70 m a.s.l. to sea level. At 70–50 m a.s.l., the zone is 110 m long and inclines about 10°. Below 50 m a.s.l., the runout zone is 380 m long and inclines 7°. The area is even and the avalanche spreading potential is high.

Nesgil derives its name from a small promontory called Nes where the farm Nes was standing. It is believed to have been built when the fjord was first settled in the tenth century. Presently there are workshops, a shipyard and a few old domestic houses on the promontory. The primary school, first built in 1930, is located above Nes. A gymnasium is located above the primary school and to the east there is a hospital and a home for the elderly. Above the hospital there are domestic houses built mostly in the second half of the twentieth century, the oldest one in 1947.

5.6.2 Chronicle

There are several avalanches recorded from Nesgil. The longest on fell in 1974 and stopped about 50 m from the uppermost houses. The recorded avalanches in the area are shown on Map 3 and listed in the following table:

Number Time *Runout index*	**Description**
193 Feb 1966 *14.6*	An avalanche fell from Nesgil. The avalanche was probably dry. It stopped around 60 m a.s.l., and the deposition was about 120 m wide.
194 4.2.1974 *13.1*	An avalanche, probably a wet slab, came from Nesgil. It stopped around 95 m a.s.l. and the tongue was about 70 m wide.
195 19.12.1974 *15.2*	A dry avalanche started around 700 m a.s.l. in Nesgil damaging 365 m of fence around the small forest park. It buried a hectare of trees and damaged water pipes. The width of the starting zone was about 275 m. The path was 1950 m long and the 210 m wide tongue was estimated at 270,000 m^3 $\pm 12\%$ in volume. The tip of the tongue was 50 m a.s.l. and 410 m from the sea.
1040 1977/1978 *$\ll 11$*	A small avalanche fell over the hillside west of Nesgil in 1977–1978. The tongue was 40–60 m wide.
1091 1/2.3.1982	A very small avalanche fell in Nesgil.
1079 21.3.1989 *13.4*	An avalanche fell from Nesgil and stopped around 90 m a.s.l. The tongue was 50–60 m wide.
1004 1.3.1995 *11.8*	An avalanche started from two locations in Nesgil and combined into a 65–80 m wide tongue that stopped about 110 m a.s.l. The tongue was 0.2–0.25 m thick.
1005 2/3.3.1995 *$\ll 11$*	A small avalanche fell in Nesgil. The two arms were 45 and 60 m wide at the starting point. At 410 m a.s.l., the tip of the tongue was about 30 m wide.

Figure 6. *The easternmost part of the settlement in Neskaupstaður. Nesgil to the left, then Bakkagil. Uxavogslækjargil can be seen as two scars in the lower part of the mountain, and finally Stóralækjargil to the right. (Photo: Harpa Grímsdóttir).*

5.6.3 Assessment

Nesgil is one of the largest starting areas in Neskaupstaður where high snow accumulation can occur. An avalanche of almost 300,000 m^3 is recorded. This corresponds to an average slope-perpendicular snowdepth in the defined starting area of about 3 m. The beginning of the runout area is 600 m from the shoreline so the area is not as hazardous as Drangagil.

5.7 Bakkagil

5.7.1 Topographic description

Bakkagil is a gully adjacent and east of Nesgil. The area can be seen in Figures 5 and 6 and on Maps 1 and 6. A longitudinal section (`neib26aa`) is shown in Drawing 21.

Starting zone

The starting zone in Bakkagil is a 35 m deep gully that ranges from 725 to 500 m a.s.l. The 200 m wide zone is oriented SSE to SSW and is 7.8 ha. The inclination is 32°–40°. The surface is composed of weathered rock interrupted by cliffs. Snow accumulation is high.

Track

The 110 m wide track through Bakkagil ranges from 500 to 75 m a.s.l. At 500–330 m a.s.l., the track is a cliffy 35 m deep gully. Below 330 m a.s.l., the track becomes a small gully on an even slope. The track inclines approximately: 40° at 500–400 m a.s.l., 28° at 400–300 m a.s.l., 22° at 300–200 m a.s.l., 18° at 200–150 m a.s.l., and 12° at 150–75 m a.s.l. The surface is composed of weathered debris with bare cliffs in the upper part. The degree of confinement is 2.0.

Runout area

The altitude of the runout zone ranges from 75 m a.s.l. to sea level. At 75–50 m a.s.l., the inclini-nation is 6° for 230 m. At 50–25 m a.s.l., the runout zone inclines 5° for 350 m. Below 25 m a.s.l., there is a low bank where the slope steepens and inclines 24° for 60 m before it reaches the ocean. The area is slightly convex with a high avalanche spreading potential.

Parts of the housing areas Mýrar and Bakkar are in the runout area for Bakkagil. Almost all the houses in the area were built in the 1970's. The annex Bakki stood above the present street Bakkavegur. Bakki is believed to have been built around 1300 and in 1907 all of it had been abandoned. Houses built around 1930 are located by the coast.

5.7.2 Chronicle

In 1974 an avalanche was released in Bakkagil and stopped approximately where the house Valsmýri 6 is currently located. Three medium sized avalanches are also recorded from the gully. The recorded avalanches in the area are shown on Map 3 and listed in the following table:

Number Time *Runout index*	**Description**
196 Feb/Mar 1966 *14.3*	An avalanche, probably dry, fell in Bakkagil. It stopped around 70 m a.s.l. and the deposition was approximately 130 m wide.
197 4.2.1974 *13.3*	An avalanche fell from Bakkagil and stopped around 95 m a.s.l. The tongue was about 60 m wide.
198 19/20.12.1974 *16.4*	A dry slab avalanche started at 700 m a.s.l. in Bakkagil. The fracture was 150 m wide. The path was 2050 m long and the tongue volume was estimated at 390,000 $m^3 \pm 12\%$. The tip of the 200 m wide tongue was 40 m a.s.l. about 250 m from the sea. The avalanche slightly damaged fences and dislocated water pipes.
1092 1/2.3.1982	A very small avalanche fell in Bakkagil.

Number Time *Runout index*	**Description**
1078 21.3.1989 *13.7*	An avalanche fell from Bakkagil and stopped about 85 m a.s.l. The tongue was 60–80 m wide.
1003 2/3.3.1995 $\ll$ *11*	A small avalanche released in Bakkagil. It appeared to have started around 590 m a.s.l. as two arms that joined. The avalanche stopped just below the mouth of the gully about 210 m a.s.l. The tongue was 30–40 m wide and less than 0.5 m thick.

5.7.3 Assessment

The starting area is separated from Nesgil by a low and wide mountainridge. It is not possible to rule out that an avalanche might fall from both gullies at the same time. The volume of the December 1974 avalanche is recorded to have been 390,000 m^3 with a deposition area of 280,000 m^2. According to a map by Hjörleifur Guttormsson, the maximum width of the tounge was approximately 200 m. This indicates that the depostion length was 1400 m which means that it should have extended far up into the track, which does not seem plausible. The runout area starts 600 m from the shoreline so the hazard in this area is similar to the hazard below Nesgil.

5.8 Uxavogslækjargil

5.8.1 Topographic description

Uxavogslækjargil are small gullies in the middle elevational part of the slope east of Bakkagil. The area can be seen in Figure 6 and on Maps 1 and 6 a longitudinal section (`neib27aa`) is shown in Drawing 22.

Starting zone

The starting zone in Uxavogslækjargil is a very shallow depression that ranges from 540 to 340 m a.s.l. The 190 m wide area is 5.6 ha, and inclines 39° and is oriented S. The surface is composed of weathered rock interrupted by many belts of cliffs. Snow accumulation is low.

Track

The 150 m wide track through Uxavogslækjargil ranges from 340 to 110 m a.s.l. The track consists of two small gullies on an even slope that inclines approximately: 25° at 340–250 m a.s.l., 24° at 250–175 m a.s.l., and 13° at 175–110 m a.s.l. The surface is composed of weathered debris with cliff belts in the upper part. The degree of confinement is 1.3.

Runout area

The altitude of the runout zone ranges from 110 m to 20 m a.s.l. The distance from the end of the track to the shoreline is about 800 m. The runout area is slightly convex and inclines on average 4°. The avalanche spreading potential is medium. The lowest part of the area is densely settled with houses built in 1973–1989.

5.8.2 Chronicle

Three avalanches are recorded from the Uxavogslækjargil area. All of them are small. The recorded avalanches in the area are shown on Map 3 and listed in the following table:

Number Time *Runout index*	**Description**
199 19–21.12.1974 *12.2*	A dry slab avalanche fell near to Uxavogslækjargil. The deposition stopped 105–110 m a.s.l. It was approximately 40 m wide.
1081 21.3.1989 *13.4*	An avalanche fell west of Uxavogslækjargil. It stopped around 90 m a.s.l.
1002 2/3.3.1995 *11.4*	A small avalanche fell down a ridge between two shallow gullies and stopped about 100 m a.s.l. The 20 m wide deposition was on average 0.4 m thick.

5.8.3 Assessment

The starting area is small and not favorable for high snow accumulation. Some small avalanches are recorded, but large avalanches are very unlikely.

5.9 Stóralækjargil

5.9.1 Topographic description

Stóralækjargil is a large bowl/gully at above the outskirts of the settlement. The area can be seen in Figure 6 and on Maps 1 and 6. A longitudinal section (`neib28aa`) is shown in Drawing 23.

Starting zone

The starting zone in Stóralækjargil is a large symmetric bowl about 40 m deep. It is 350 m wide at its widest and ranges from 740 m to 400 m a.s.l. The 18.0 ha area is oriented SSW to SSE and inclines 32°–40°. The surface is composed of weathered rock interrupted by some small cliff belts. Snow accumulation is high.

Track

The 150 m wide track through Stóralækjargil ranges from 400 to 100 m a.s.l. The track consists of a 20 m deep gully at 400–300 m a.s.l. and a slightly convex slope with a small gully below 300 m a.s.l. The track inclines approximately: 25° at 400–300 m a.s.l., 24° at 300–200 m a.s.l., 20° at 200–150 m a.s.l., and 12° at 150–100 m a.s.l. The surface consists of weathered debris with bare cliffs in the upper part. The degree of confinement is 2.3.

Runout

The altitude of the runout area ranges from 100 m a.s.l. to sea level. At 100–75 m a.s.l., the zone inclines 9° for 150 m. At 75–50 m a.s.l., the zone inclines 12° for 120 m. At 50–25 m a.s.l., the zone inclines 5° for 300 m. At 25–0 m a.s.l., the zone inclines 29° for 45 m before reaching the sea. The runout zone is a flat convex debris cone with high avalanche spreading potential.

The runout area is on the outskirt of the settlement in Neskaupstaður.

5.9.2 Chronicle

There is information on an avalanche from Stóralækjargil in 1956 that may have been large. In addition two medium sized avalanches are recorded, but it should be noted that since very little settlement has been in the area records are probably incomplete. The recorded avalanches in the area are shown on Map 3 and listed in the following table:

Number Time *Runout index*	**Description**
1124 Mar 1956	An avalanche seems to have fallen from Stóralækjargil. Accounts of this avalanche are in a letter written by Níels Ingvarsson in 1975. The letter mentions that, "The south edge of the avalanche formed a steep face probably 2–3 times the height of a man ... The south edge of the tongue was a little above the hill at Selhraun. The tongue wasn't very wide..."
200 19–21.12.1974 *13.0*	A dry slab avalanche came from Stóralækjargil and it stopped around 100 m a.s.l. The tongue was approximately 50 m wide.
1116 2.2.1975 *≪11*	A thin and light avalanche fell in Stóralækjargil and stopped just below the opening of the gully.

Number Time *Runout index*	**Description**
1038 20.2.1977 $\ll$*11*	A small avalanche fell in Stóralækjargil and stopped around 340 m a.s.l.
1093 1/2.3.1982	A very small avalanche came from Stóralækjargil.
1001 2/3.3.1995 *13.1*	An avalanche fell from Stóralækjargil. The main tongue width was 20–30 m and the depth was a maximum 1.2 m. The 110 m wide deposition stopped around 100 m a.s.l.

5.9.3 Assessment

The starting area is the largest one in the outer part of Neskaupstaður. Very large avalanches are possible. The only houses in this area are 600 m from the β-line and not in the most likely direction of the avalanches from the gully. The hazard in the area is low.

5.10 Model estimates

Map 6 shows the results of model calculations and the profiles used for the calculations. The profiles `neib15aa` (Miðstrandargil), `neib16aa` (Klofagil), `neib17aa` (between Klofagil and Innra-Tröllagil), `neib18aa` (Innra-Tröllagil), `neib19aa` (Ytra-Tröllagil) `neib22aa` (Urðarbotn), `neib22ba` (Sniðgil), `neib23aa` (Drangagil), `neib24aa` (Skágil), `neib25aa` (Nesgil), `neib26aa` (Bakkagil), `neib27aa` (Uxavoglækjargil) and `neib28aa` (Stóralækjargil), and the results of the calculations are also shown in Drawings 11–23. The runout was calculated using runout indices and the α/β-model. The risk estimation methods of RiskEst (*Estimation of avalanche risk*, Kristján Jónasson *et al.*, 1999) were applied. For explanation of notation see Appendix A.

Below Miðstrandarskarð, Tröllagil and the area between these gullies an avalanche with $r = 14.5$ will reach the sea. The β-point is close to the sea and an avalanche with runout angle $\alpha + \sigma$ would reach the sea. Below Urðarbotn the runout area becomes a little wider and an avalanche with $r = 15.5$ or a runout angle a little higher than α will reach the sea. In the area from Klofagil and east towards Sniðgil the uppermost houses are around runout index 13–13.5. An avalanche from Drangagil/Skágil needs to be about $r = 14.5$ or $\alpha + \sigma$ to reach the houses and avalanche with $r = 16.5$ or with a runout angle slightly lower than α to run into the sea. Below Nesgil, Bakkagil and Uxavogslækjargil the runout area is larger above the houses and avalanches need to have about $r = 16$ to reach the houses and $r = 17$–17.5 to run into the sea. The α/β-model shows more difference in runout between profiles `neib25aa`–`neib27aa` than runout indices. This is due to the rather decisive movement of the β-point as we go further to the east. An avalanche with runout angle α will run well into the settlement in profile `neib25aa` but an avalanche with runout $\alpha - \sigma$

is needed to reach the uppermost houses in profile `neib27aa`.

Table 17 shows "long" recorded avalanches in the area from Bræðslugjár to Bakkagil. An estimate of the frequency is discussed in RiskEst. It is assumed there that the frequency in all the gullies is similar and the result is a pooled frequency estimate of $F_{13} = 0.05$, or 5 avalanches per century from each gully with $r \geq 13$. It can be seen from Table 17 that the omission of Bræðslugjár from the estimation will not change the estimate greatly.

Calculations were carried out using the Swiss one-dimensional model (Bartelt *et al.*, 1997; Christen *et al.*, 1999) for Miðstrandarskarð, Innra-Tröllagil, Drangagil and Bakkagil.

The Austrian two-dimensional model SAMOS was applied to evaluate possible directions and extents of avalanches released from the starting zones in the area. The results are described by Tómas Jóhannesson *et al.* (2001).

5.11 Conclusion

It is clear that the hazard imposed by the main avalanche paths is not uniform. How to distinguish between more and less hazardous areas is however not clear. It is proposed to use a "standard" frequency for most of the main starting areas, and a subjectively determined reduced frequency for one of the main starting areas and the smaller starting areas. For the main starting areas except for Urðarbotn there is little indication from the avalanche chronicle that the avalanche activity is different between the main gullies. Although the sizes of the starting areas differ they can be considered to be more or less equally hazardous. A frequency of $F_{13} = 0.05$ was used for these gullies, i.e. Miðstrandargil/Klofagil, Tröllagil, Drangagil/Skágil, Nesgil, Bakkagil and Stóralækjargil. There are no major avalanches recorded from Stóralækjargil with certainty, but there has hardly been any settlement in the area and it is one of the largest starting areas, with similar snow accumulation potential as the other areas. Therefore the same frequency is attached to it as the other main gullies.

There is both indication from the avalanche history and topography that Urðarbotn/Sniðgil is less hazardous than the other main areas. In the risk calculations the estimated frequency in Urðarbotn was reduced to a fifth of the estimated frequency in the other gullies, i.e. $F_{13} = 0.01$. An argument could be made that the frequency should then be increased in the other gullies, since by doing this the frequency estimate becomes slightly biased. Such a correction will however have an insignificant effect.

Uxavogslækjargil is a small starting area rather low down in the mountain with unfavorable snow accumulation potential. All the avalanches recorded in the area are also small. Ten times lower frequency than in the main gullies was used in the risk calculation, i.e. $F_{13} = 0.005$.

Between Klofagil and Innra-Tröllagil there is a starting area of similar size as Uxavogslækjargil, with small avalanches recorded. Risk calculations were done there using $F_{13} = 0.005$.

Between Sniðgil and Drangagil there is a convex area, where no starting areas have been defined. To assist in the delineation of hazard zones in the area risk calculation was done using frequency that was one thirtieth of the "standard" frequency, i.e. $F_{13} = 0.0017$.

Table 17. *Long recorded avalanches from 7 gullies in Neskaupstaður.*

Gully	No.	Date	Runout index	Maximum width (m)	Into sea
Bræðslugjár	158	Jan./Feb. 1936	15.1	130	Yes
	1110	around 1940	12.3	?	
	161	4.2.1974	12.7	100	
	165	4.2.1974	12.9	220	
	162	20.12.1974	15.3	415	Yes
	159	4.11.1981	12.3	?	
Miðstrandarskarð/Klofagil	168	Jan. 1936	14.2	130	
	169	20.12.1974	14.6	270	Yes
	1088	21.3.1989	12.7	60	
	1207	21.3.1997	13.4	140	
Ytra- and Innra Tröllagil	173	Jan. 1894	14.8	?	Yes
	175	March 1920	13.5	140	
	180	4.2.1974	12.3	?	
	181	27.12.1974	13.3	190	
	1205	21.3.1997	12.9	100	
Urðarbotn/Sniðgil	183	4.2.1974	12.0	?	
	182	27/28.12.1974	13.7	60	
	184	28.12.1974	12.9	60	
Drangaskarð/Skágil	186	24.1.1894	15.8	390	
	187	4.2.1974	13.4	220	
	188	20.12.1974	14.2	390	
	1071	20.12.1974	13.5	?	
	189	20/21.12.1974	12.4	40	
Nesgil	193	Feb. 1966	14.6	120	
	194	4.2.1974	13.1	90	
	195	19.12.1974	15.2	180	
	1079	21.3.1989	13.4	130	
Bakkagil	196	Feb. 1966	14.3	150	
	197	4.2.1974	13.3	70	
	198	20.12.1974	16.4	260	
	1078	21.3.1989	13.7	100	

The areas threatened by each starting area were estimated subjectively and using the results of the two dimensional SAMOS model estimates.

The areas below the main gullies are typical avalanche paths with known avalanches, so the uncertainty is considered low ($\frac{1}{2}$), but between the gullies the uncertainty is somewhat greater or medium to high (1–2).

5.12 Defence structures

Uncertainties are unavoidable in avalanche hazard zoning. The uncertainty is even greater for areas protected by defence structures than for areas where no such measures have been taken. Therefore it is not advisable to increase the risk that the uncertainty imposes by increasing the number of inhabitants in a protected area or by increasing the total risk by other means.

Map 9 shows the proposed hazard zones after the completion of the defence structures for the Drangagil area. The hazard lines do not necessarily represent risk in a formal sense but are intended to reflect both the increased safety provided by the defence structures and the unavoidable uncertainty about their effectiveness. The boundary of the C hazard zones is located just above the uppermost houses in the area. This can be interpreted as a statement that in spite of the defence structures it is not advisable to build houses closer to the mountain than already has been done. No category B hazard zone is delineated but the category C hazard zone is delineated down to about where the category C hazard zone ended before.

6 Conclusion

The results presented in this report indicate that almost all of the residences in Neskaupstaður are in a hazard zone according to the Icelandic regulation on hazard zoning. Only a few houses are outside of the hazard zone and about a half of the residences are located in the category C hazard zone. This makes the avalanche situation in Neskaupstaður unique. Emergency evacuations are for example difficult since it is nearly impossible to find "safe" areas where people can stay when they have to abandon their houses. Even though a large proportion of the town is in a hazard zone before defence measures have been taken, the magnitude of the risk varies considerably within the community. The highest risk is probably in the old industrial area and in the neighbouring areas. This was the site of the avalanche accidents in 1974. In the residential area the greatest risk is below Tröllagil and Drangagil. In those two areas there is dense settlement close to the mountain below known avalanche paths. When the density of the settlement is taken into account, Drangagil probably contributed more to the total risk before the construction of the defence structures in that area. The protection measures that have been taken have thus reduced the total risk in Neskaupstaður considerably.

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Þórðarson.)

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VST. 1998b. Neskaupstaður. *Avalanche defence appraisal. Drangagil area.* VST, Proj. 97.202. (Authors Flosi Sigurðsson, Gunnar Guðni Tómasson and François Rapin).

A Technical concepts and notation

α-angle: The slope of the line of sight from the stopping position of an avalanche to the top of the starting zone (see Figure 7).

β-angle: The slope of the line of sight from the location in the avalanche path where the inclination to the top of the starting zone is 10° (see Figure 7).

α/β-model: A topographical model used to predict avalanche runout or to transfer avalanches between paths. The model uses the β-angle to predict the α-angle of the longest recorded avalanche. The model was first derived by Lied and Bakkehøi (1980). The version of the model used in this project was derived by Tómas Jóhannesson (1998a, 1998b) using data on 45 Icelandic avalanches. The formula of the model is

$$\alpha = 0.85 \cdot \beta, \qquad \sigma = 2.2°$$

where σ is standard deviation of the residuals from the model. It is customary to denote an avalanche with an α-angle $n\sigma$ lower than the predicted α- value as an avalanche with runout of $\alpha - n\sigma$ and conversely $\alpha + n\sigma$ if the α-angle is higher than given by the above equation. Note that as the α-angle is lower as the runout is longer, and therefore $\alpha - \sigma$ corresponds to an avalanche with a longer runout distance than α.

$F_{r_0}(F_{13})$: The expected frequency of avalanches with a runout index greater or equal than r_0. The value F_{13} is most often used, i.e. the frequency at the runout index $r_0 = 13$.

PCM-model: A one-dimensional physical model used to simulate the flow of avalanches. The model has two parameters, μ a Coulomb friction coefficient and, M/D an inverse drag coefficient. It was developed by Perla *et al.* (1980).

Runout index: The runout measured in hectometers of an avalanche that has been *transferred* (Sven Sigurðsson *et al.*, 1997) to the *standard path* making use of some transfer method. The runout index is in this report referred to as the runout index obtained by using the PCM-model with parameters lying on a predefined parameter axis. An avalanche that has a runout index of r_0 is referred to as an avalanche with $r = r_0$. The method was developed by Kristján Jónasson *et al.* (1999).

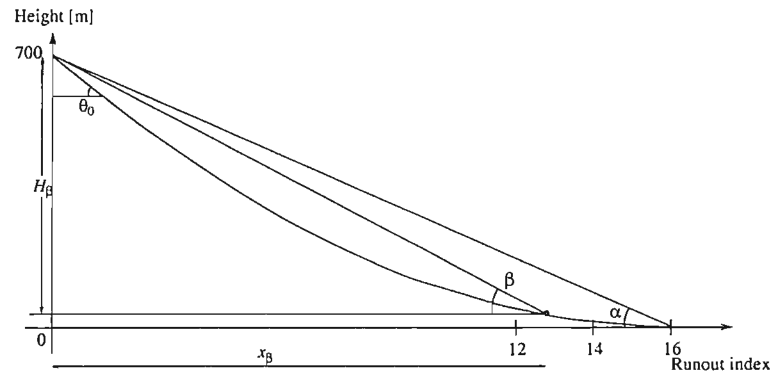


Figure 7. *The standard path. The α-angle is the expected α-angle of an avalanche according to the α/β-model.*

B Maps

Map 1. An overview of Neskaupstaður and the boundary of the investigated area (A3, 1:25 000).

Map 2. Recorded avalanches in the inner part of the investigated area (A3, 1:10 000).

Map 3. Recorded avalanches in the outer part of the investigated area (A3, 1:10 000).

Map 4. The hazard map for Neskaupstaður issued in 1992 and revoked in 1997. (A3, 1:15 000).

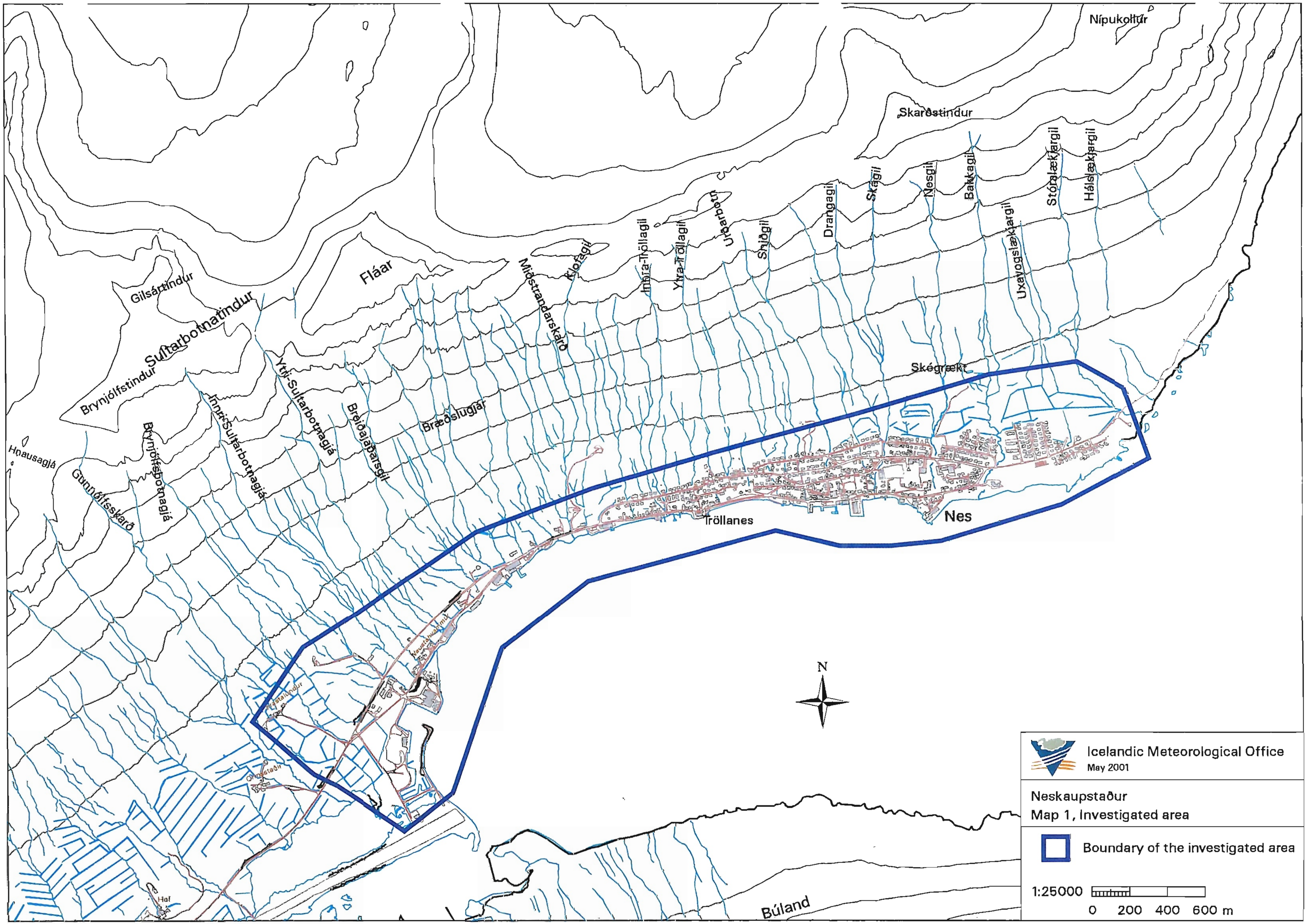
Map 5. Results of model estimates for the outer part of the investigated area. (A3, 1:10 000).

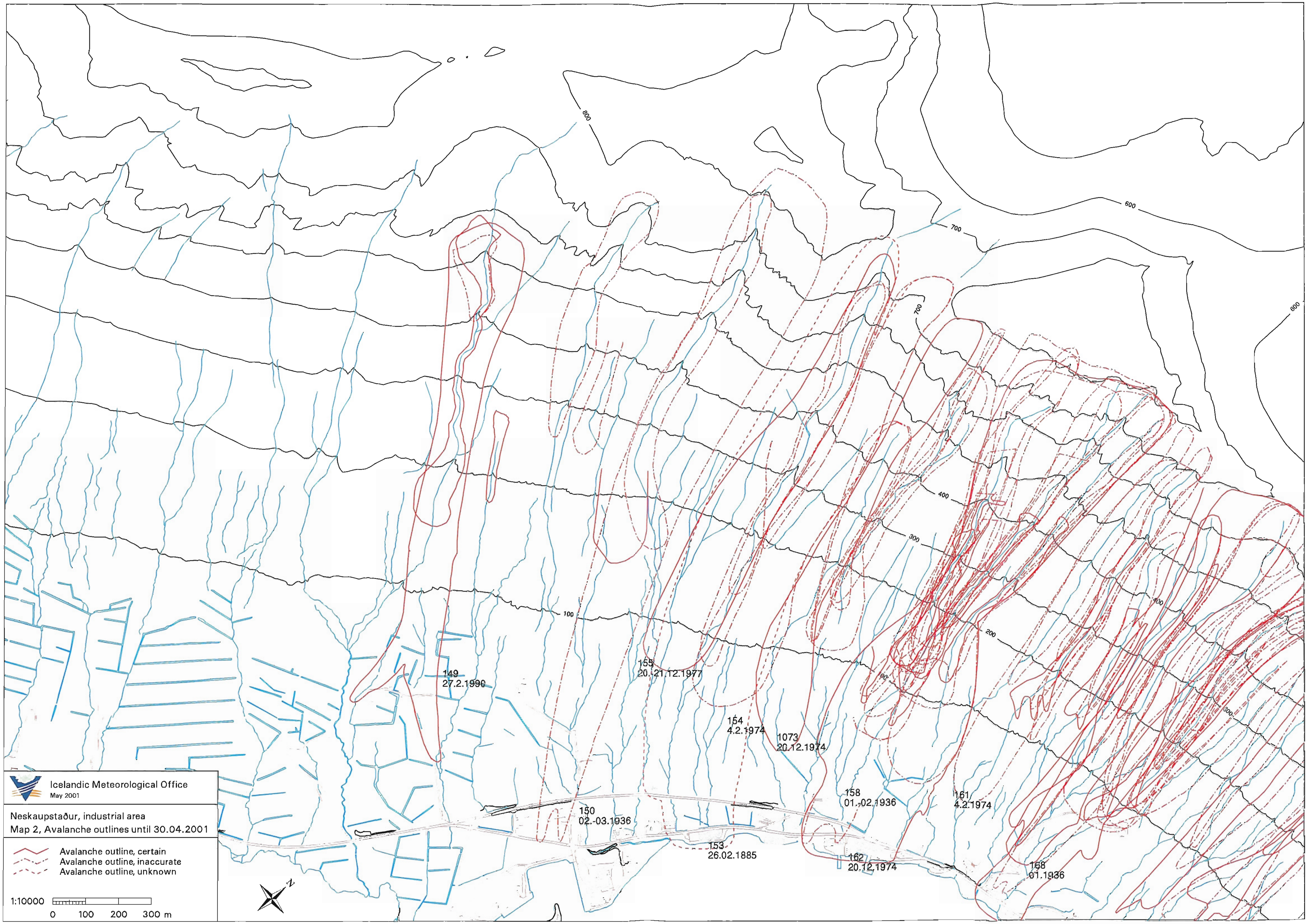
Map 6. Results of model estimates for the inner part of the investigated area. A3, 1:10 000).

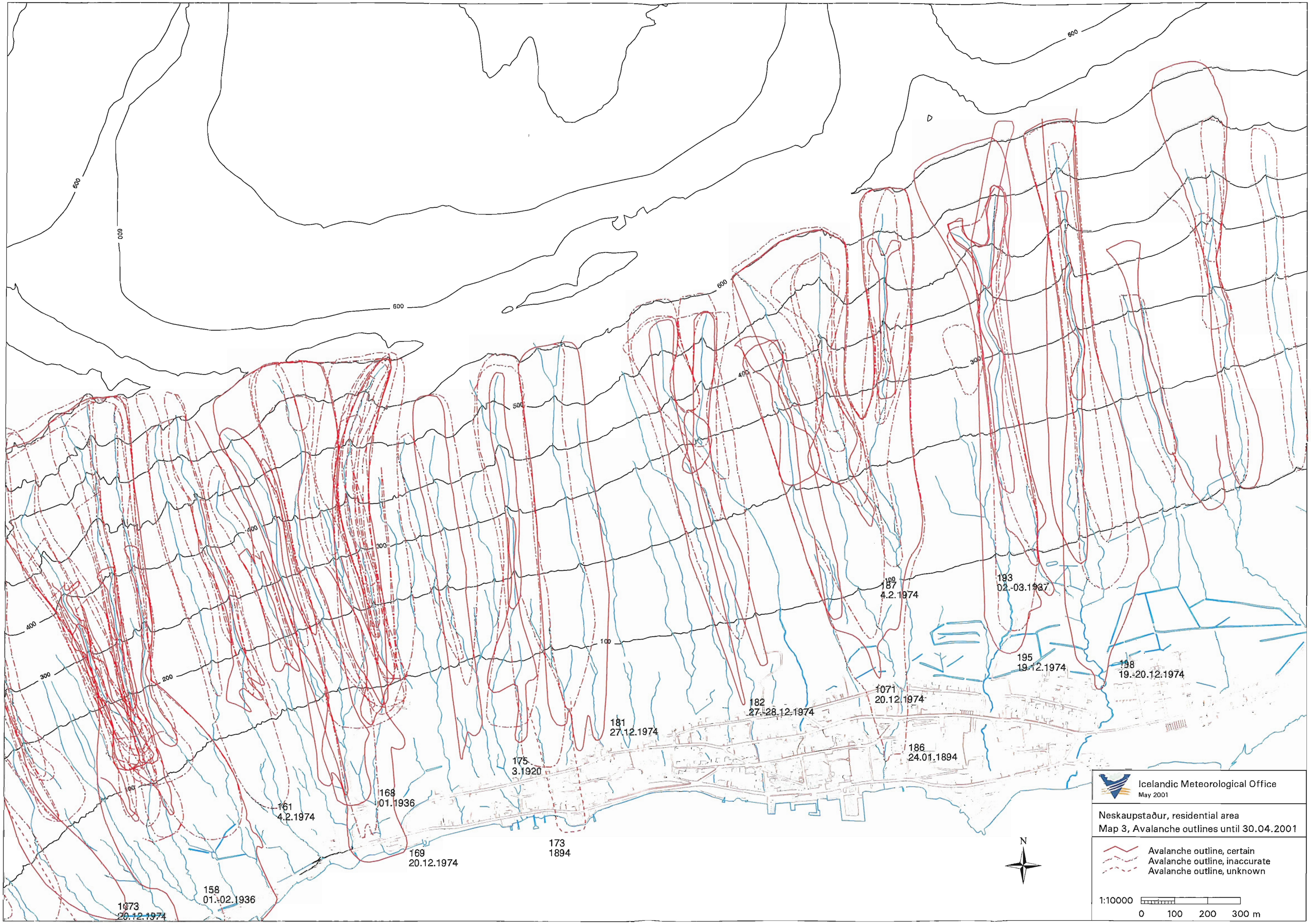
Map 7. Proposed hazard zoning for the inner part of the investigated area. A3, 1:7 500).

Map 8. Proposed hazard zoning for the outer part of the investigated area. A3, 1:7 500).

Map 9. Proposed hazard zoning below Drangagil, before and after protection measures have been taken. A4, 1:5 000).


Núpukollur
Skarðstindur
Gilsártindur
Sultarbotnatindur
Brynjólfstindur
Fláar
Miðstrandarskarð
Klofagil
Innra-Tröllagil
Ytra-Tröllagil
Urðarbotn
Sniógil
Drangagil
Skágil
Nesgil
Bakkagil
Uxavogslækjargil
Stóralækjargil
Hálslækjargil
Skógrækt
Hnausagjá
Gunnólfsskarð
Brynjólfsbotnagjá
Innri-Sultarbotnagjá
Ytri-Sultarbotnagjá
Breiðabliðarsgil
Bræðslugjár
Tröllanes
Nes
Búland
N
Icelandic Meteorological Office
May 2001
Neskaupstaður
Map 1, Investigated area
Boundary of the investigated area
1:25000
0 200 400 600 m


800
700
600
700
600
400
300
100
200
400
100
300
149
27.2.1990
155
20.-21.12.1977
154
4.2.1974
1073
20.12.1974
158
01.-02.1936
161
4.2.1974
150
02.-03.1936
153
26.02.1885
162
20.12.1974
168
01.1936
N
Icelandic Meteorological Office
May 2001
Neskaupstaður, industrial area
Map 2, Avalanche outlines until 30.04.2001
Avalanche outline, certain
Avalanche outline, inaccurate
Avalanche outline, unknown
1:10000
0 100 200 300 m



Icelandic Meteorological Office
May 2001
Neskaupstaður, residential area
Map 3, Avalanche outlines until 30.04.2001
Avalanche outline, certain
Avalanche outline, inaccurate
Avalanche outline, unknown
1:10000
0 100 200 300 m
N
158
01.-02.1936
161
4.2.1974
168
01.1936
169
20.12.1974
173
1894
175
3.1920
181
27.12.1974
182
27.-28.12.1974
186
24.01.1894
1071
20.12.1974
187
4.2.1974
193
02.-03.1937
195
19.12.1974
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19.-20.12.1974
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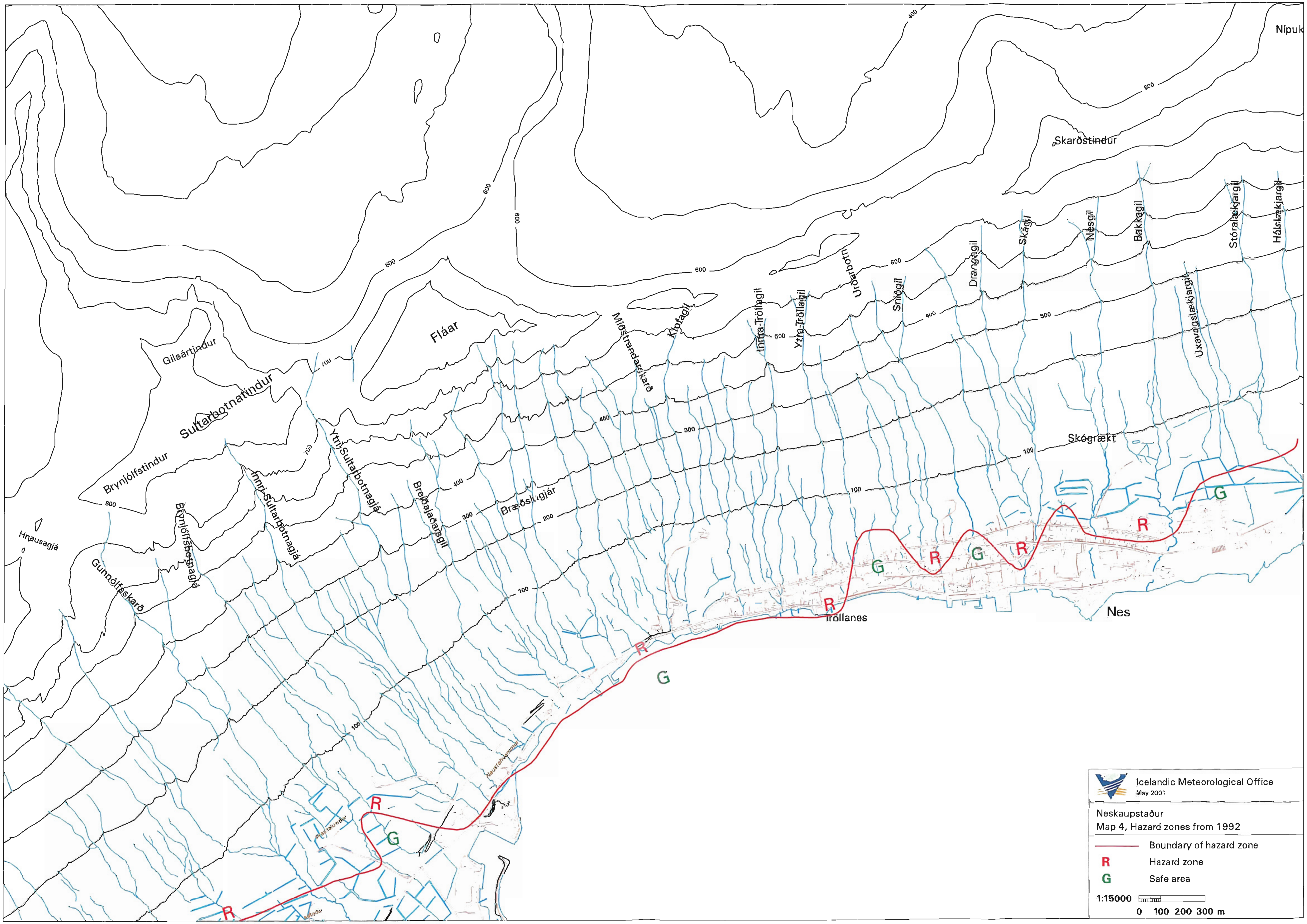
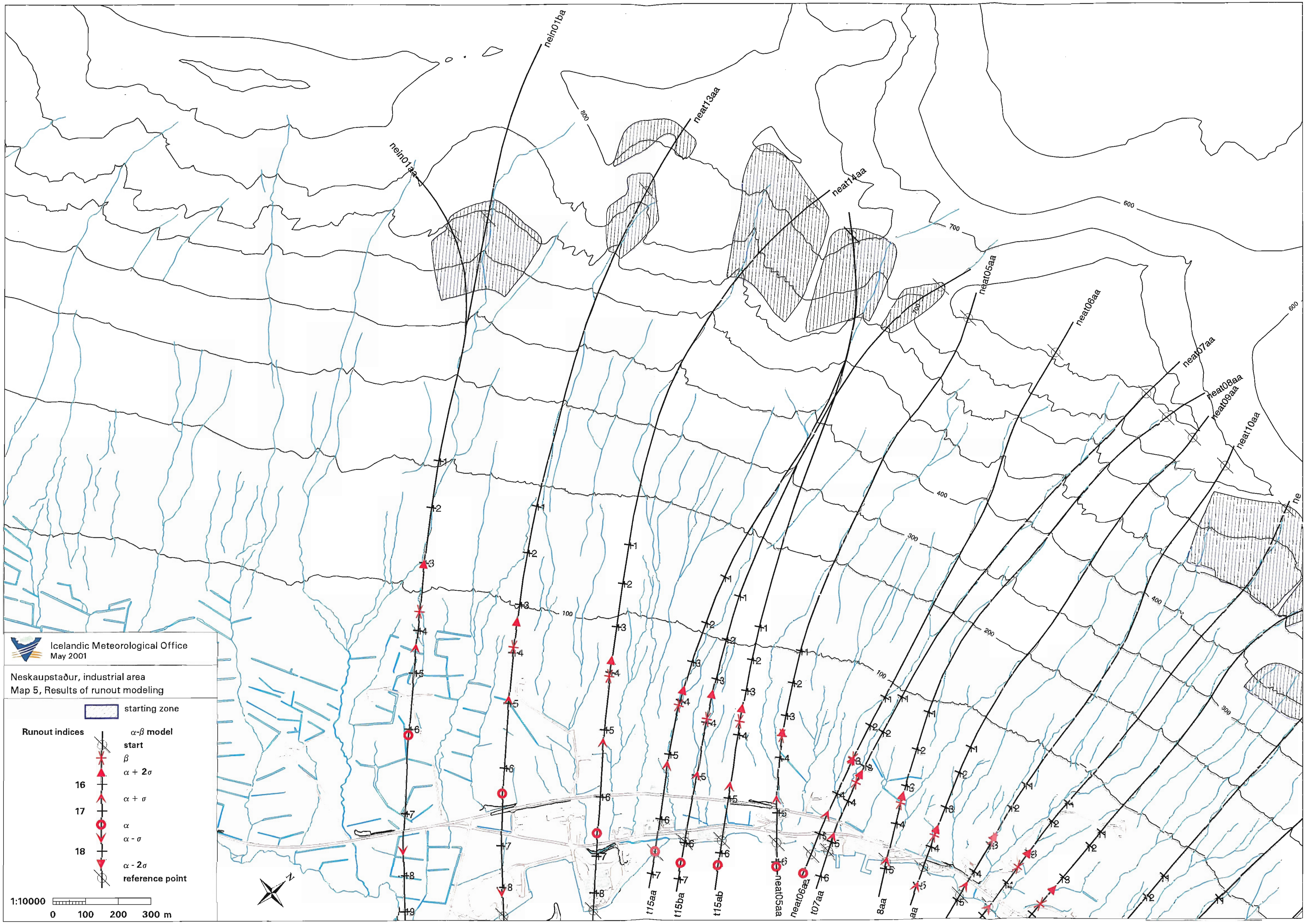
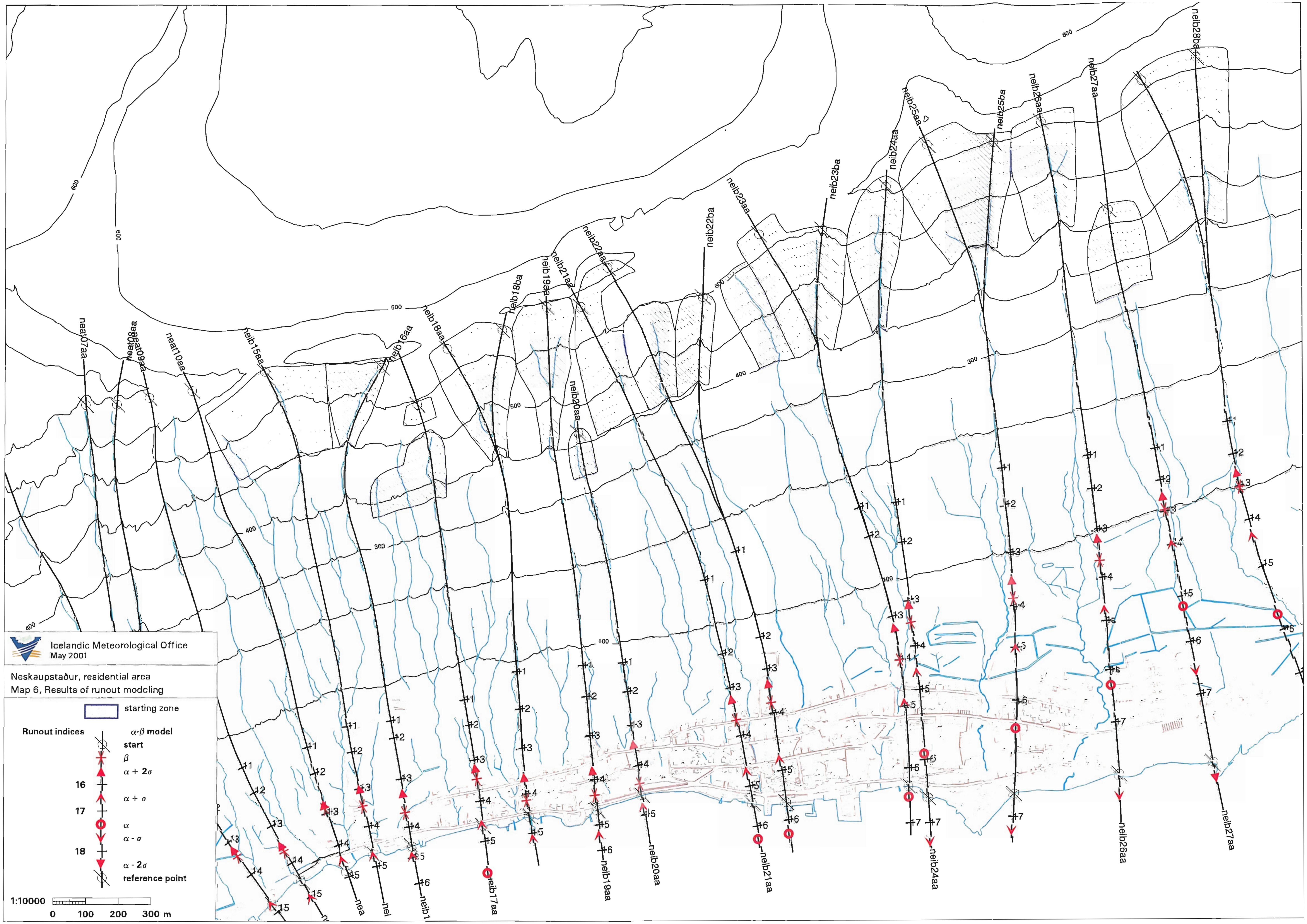
500
400
300
200
100



Icelandic Meteorological Office
May 2001
Neskaupstaður
Map 4, Hazard zones from 1992
Boundary of hazard zone
R Hazard zone
G Safe area
1:15000
0 100 200 300 m
Skarðstindur
Fláar
Gilsártindur
Sultarbotnatindur
Brynjólfstindur
Hnausagjá
Gunnólfsskarð
Brynjólfsbotnagjá
Innri-Sultarbotnagjá
Ytri-Sultarbotnagjá
Bræðslugjár
Miðstrandarskarð
Klofagil
Innra-Tröllagil
Ytra-Tröllagil
Urðarbotn
Snjógil
Drangagil
Skágil
Nesgil
Bakkagil
Stóralækjargil
Hálslækjargil
Uxavogslækjargil
Skógrækt
Tröllanes
Nes



Icelandic Meteorological Office
May 2001
Neskaupstaður, industrial area
Map 5, Results of runout modeling
starting zone
Runout indices
α-β model
start
β
α + 2σ
16
α + σ
17
α
α - σ
18
α - 2σ
reference point
1:10000
0 100 200 300 m
nein01ba
nein01aa
neat13aa
neat14aa
neat05aa
neat06aa
neat07aa
neat08aa
neat09aa
neat10aa
t15aa
t15ba
t15ab
neat05aa
neat06aa
t07aa
800
700
600
400
300
200
100


Icelandic Meteorological Office
May 2001
Neskaupstaður, residential area
Map 6, Results of runout modeling
starting zone
Runout indices
α-β model
start
β
α + 2σ
16
α + σ
17
α
α - σ
18
α - 2σ
reference point
1:10000
0 100 200 300 m
neat07aa
neat10aa
neib15aa
neib16aa
neib17aa
neib18aa
neib18ba
neib19aa
neib20aa
neib21aa
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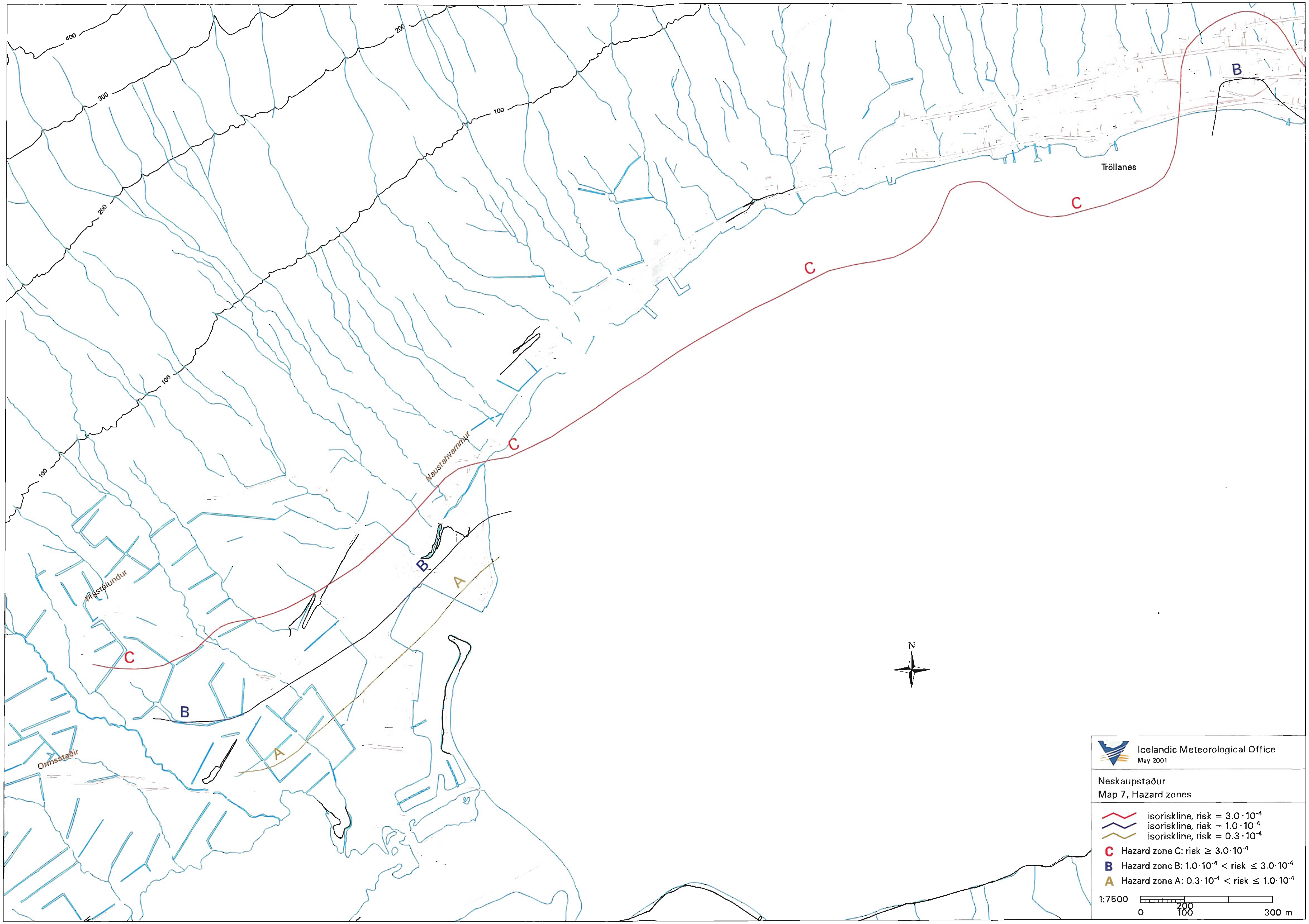
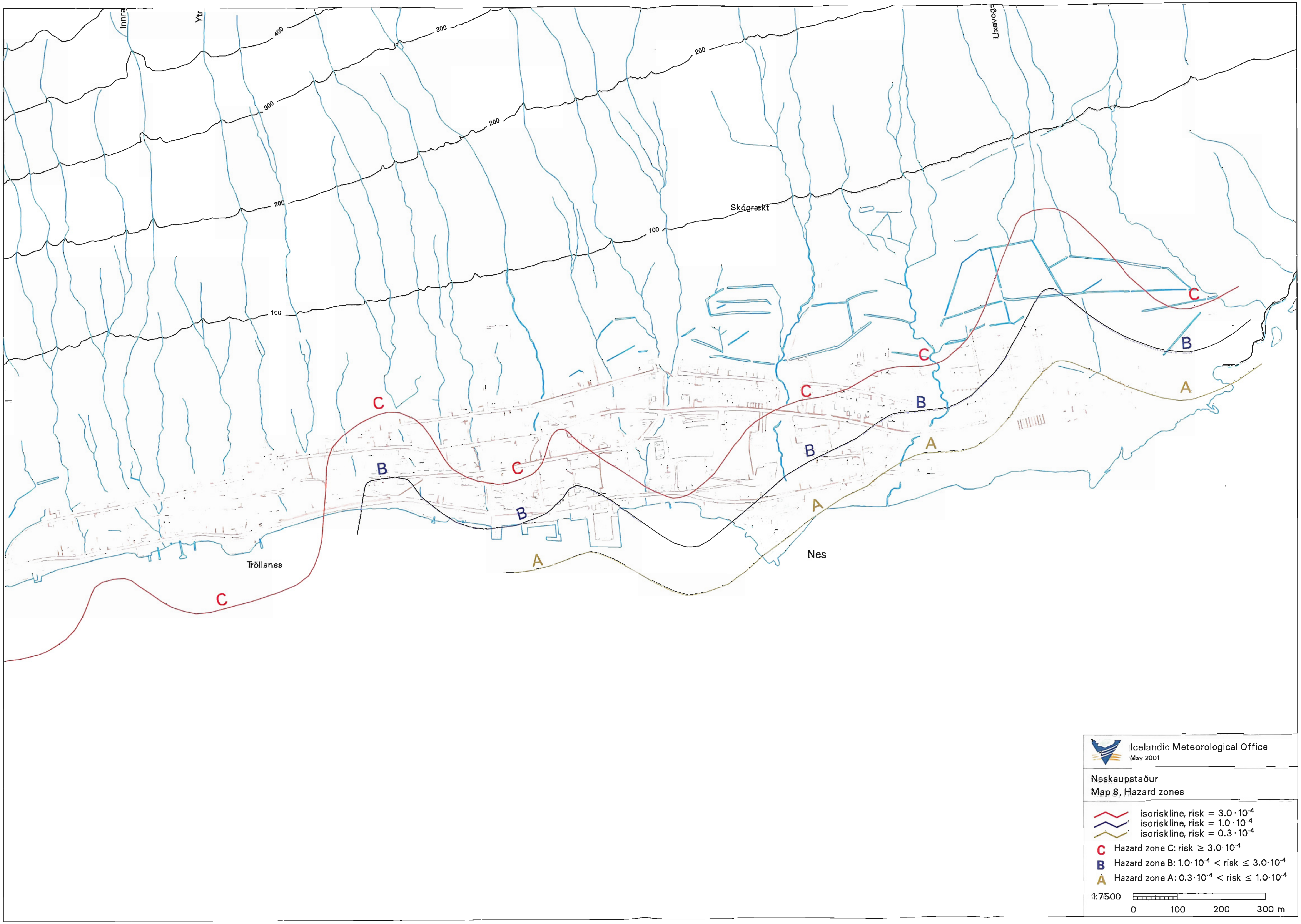
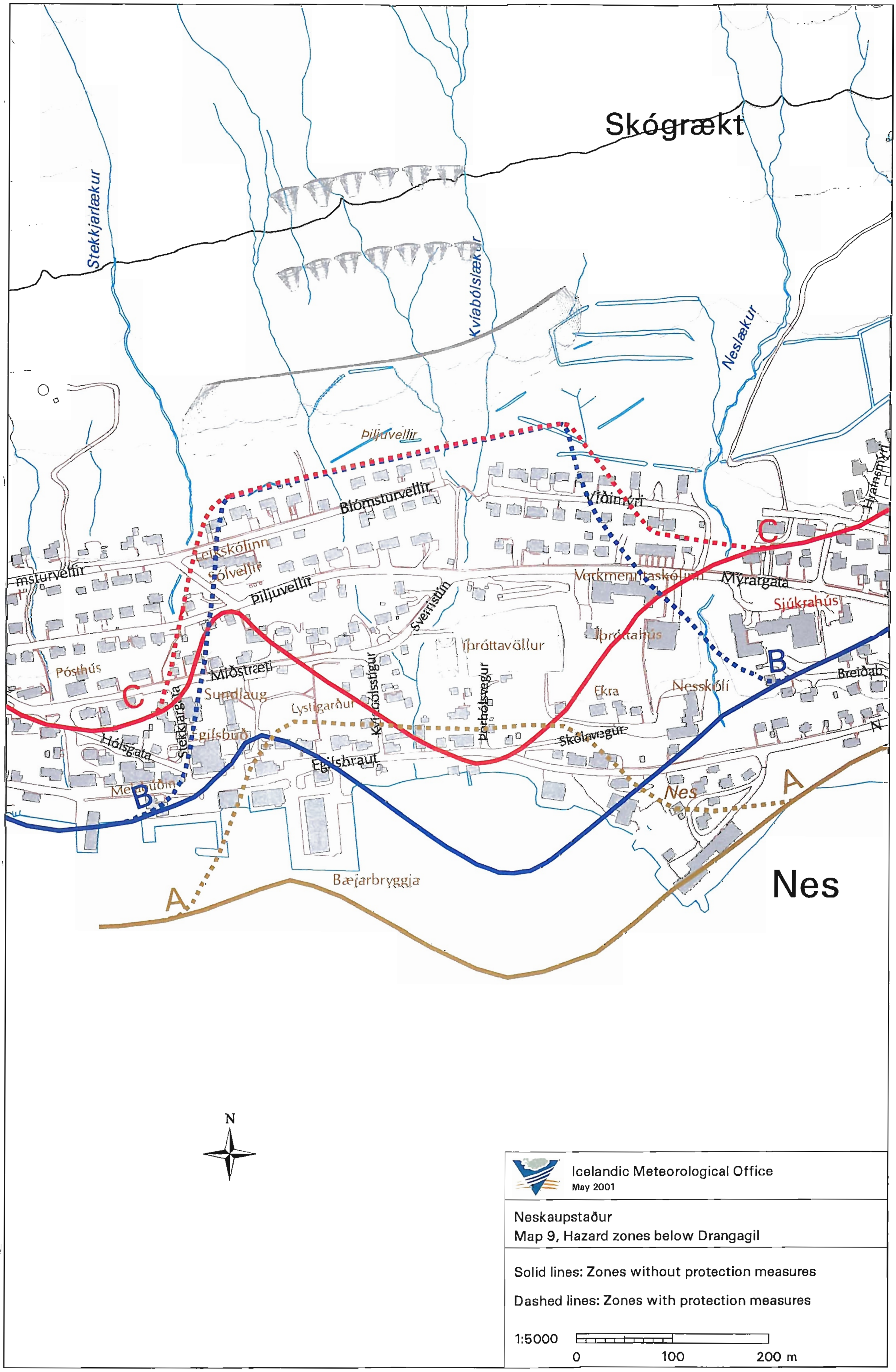
neib26aa
neib27aa
neib28ba



400
300
200
100
200
100
100
200
100
Tröllanes
Naustahvammur
Þrastalundur
Ormsstaðir
C
C
C
C
C
B
B
B
A
A
N
Icelandic Meteorological Office
May 2001
Neskaupstaður
Map 7, Hazard zones
isoriskline, risk = $3.0 \cdot 10^{-4}$
isoriskline, risk = $1.0 \cdot 10^{-4}$
isoriskline, risk = $0.3 \cdot 10^{-4}$
C Hazard zone C: risk $\geq 3.0 \cdot 10^{-4}$
B Hazard zone B: $1.0 \cdot 10^{-4}$ < risk $\leq 3.0 \cdot 10^{-4}$
A Hazard zone A: $0.3 \cdot 10^{-4}$ < risk $\leq 1.0 \cdot 10^{-4}$
1:7500
0
100
200
300 m


Innra
Ytr
Uxavogs
400
300
200
100
Skógrækt
Tröllanes
Nes
Icelandic Meteorological Office
May 2001
Neskaupstaður
Map 8, Hazard zones
isoriskline, risk = $3.0 \cdot 10^{-4}$
isoriskline, risk = $1.0 \cdot 10^{-4}$
isoriskline, risk = $0.3 \cdot 10^{-4}$
C Hazard zone C: risk $\geq 3.0 \cdot 10^{-4}$
B Hazard zone B: $1.0 \cdot 10^{-4}$ < risk $\leq 3.0 \cdot 10^{-4}$
A Hazard zone A: $0.3 \cdot 10^{-4}$ < risk $\leq 1.0 \cdot 10^{-4}$
1:7500
0 100 200 300 m



Icelandic Meteorological Office
May 2001

Neskaupstaður
Map 9, Hazard zones below Drangagil

Solid lines: Zones without protection measures

Dashed lines: Zones with protection measures

1:5000 0 100 200 m

C Climatic data

C.1 Summary statistics

Gagnheiði 949 m a.s.l. (1996–2000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
avg(t)	-5.1	-7.6	-6.9	-5.1	-1.0	1.3	5.3	5.3	2.3	-2.4	-4.9	-5.9	-2.0
max(tx)	7.3	6.9	9.4	10.3	11.7	15.8	17.8	19.6	12.9	9.4	12.1	9.3	19.6
min(tn)	-19.2	-22.7	-23.9	-16.1	-12.8	-9.4	-3.4	-3.3	-7.8	-15.1	-16.5	-21.1	-23.9
avg(f)	11.4	12.0	11.8	9.1	8.0	6.5	6.2	6.7	9.9	10.0	10.3	10.5	9.3
max(fx)	54.2	48.1	43.3	34.4	30.2	33.6	24.6	26.2	43.2	44.8	53.8	44.0	54.2
max(fg)	67.3	65.9	58.7	40.4	37.4	37.3	29.8	32.7	47.4	59.6	70.4	54.6	70.4

Oddsskarð 520 m a.s.l. (1996-2000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
avg(t)	-1.2	-3.7	-3.0	-1.6	2.3	4.7	8.4	8.5	5.7	1.3	-1.1	-2.3	1.5
max(tx)	12.6	9.9	14.5	11.6	15.1	18.2	21.6	21.3	17.0	12.7	15.9	10.3	21.6
min(tn)	-15.0	-18.5	-18.5	-12.3	-8.5	-5.5	0.4	0.5	-4.3	-11.0	-12.8	-16.3	-18.5
avg(f)	6.1	6.8	6.2	4.5	3.8	3.6	3.1	3.3	4.8	5.4	5.1	5.1	4.8
max(fx)	38.2	33.1	39.8	19.2	21.9	23.6	19.5	16.7	25.2	28.0	27.5	26.6	39.8
max(fg)	55.4	42.4	62.0	42.4	37.2	48.7	32.1	31.5	44.2	45.3	41.6	49.7	62.0

Fjarðarheiði 600 m a.s.l. (1996–2000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
avg(t)	-3.0	-5.4	-4.8	-2.9	1.0	3.9	8.3	8.2	5.6	0.3	-2.7	-3.6	0.3
max(tx)	10.0	7.8	9.5	8.4	14.4	18.8	20.7	22.2	16.2	10.4	13.8	12.0	22.2
min(tn)	-19.6	-20.3	-23.9	-19.4	-12.9	-6.5	-1.3	-0.2	-4.8	-13.1	-18.2	-19.3	-23.9
avg(f)	8.5	9.0	8.1	6.4	5.8	4.9	4.8	4.9	6.6	6.6	6.8	6.9	6.6
max(fx)	37.7	29.9	28.2	21.7	20.9	18.6	18.4	20.5	29.9	26.7	29.8	30.8	37.7
max(fg)	46.7	41.8	41.5	32.0	28.2	27.1	22.9	27.7	38.1	34.8	40.2	39.4	46.7

Neskaupstaður 60 m a.s.l. (1998–2000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
avg(t)	0.8	-0.7	-0.8	0.3	6.1	7.1	9.7	10.3	7.7	4.7	2.4	0.6	4.0
max(tx)	17.0	12.8	15.6	13.9	20.4	23.5	25.5	21.9	17.9	15.2	20.8	12.1	25.5
min(tn)	-11.9	-14.3	-14.4	-9.3	-2.1	-1.4	0.0	3.0	-0.7	-4.6	-10.5	-13.1	-14.4
avg(f)	4.4	4.5	4.2	2.6	2.6	2.6	2.1	2.3	3.2	3.7	3.7	4.1	3.3
max(fx)	26.8	25.1	21.9	13.8	11.8	15.5	12.8	11.0	18.1	17.6	15.3	18.5	26.8
max(fg)	47.8	48.7	43.8	28.3	32.1	29.6	28.3	19.8	28.2	39.6	33.2	43.1	48.7

Neskaupstaður (manual observations, 1976–2000)

avg(·)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
t	0.0	0.2	0.6	1.8	4.8	7.9	10.0	9.8	7.2	4.1	1.7	0.4	4.1
tx	16.0	13.3	14.0	20.1	21.2	24.7	27.4	25.2	24.5	21.7	20.2	14.3	27.4
tn	-15.6	-12.8	-16.6	-11.9	-7.1	-2.6	0.6	1.1	-4.1	-8.8	-10.8	-14.0	-15.4
r	205.3	154.6	182.6	96.6	84.4	74.5	81.8	106.9	188.8	275.5	199.7	180.9	1820.9
rmax	115.6	59.4	115.4	103.8	88.1	98.4	186.1	96.3	125.2	154.4	185.9	105.0	186.1

t: temperature (°C), **tx**: maximum temperature (°C), **tn**: minimum temperature (°C), **f**: wind speed (m/s), **fg**: gust speed (m/s), **r**: precipitation (mm), **rmax**: maximum precipitation in one day (mm), **avg**: average

C.2 Snowdepth in Neskaupstaður

Average snow depth (cm)

The average snow depth is calculated for days that the ground is fully covered with snow.

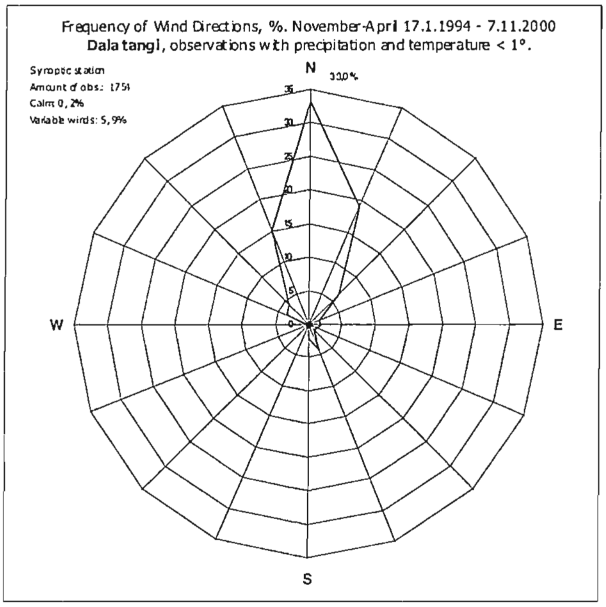
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1975–1976					24	2		
1985–1986		15	27	19		10		
1986–1987		27	21	17	25	13		
1987–1988				27	37			
1988–1989			15	21	11	40	26	4
1989–1990			17		23	91	49	
1990–1991				13			15	
1991–1992			19	23				
1993–1994						25	12	
1994–1995			42					
1996–1997	16							
1997–1998			6				28	
1999–2000		17	28		78			
2000–2001				42				

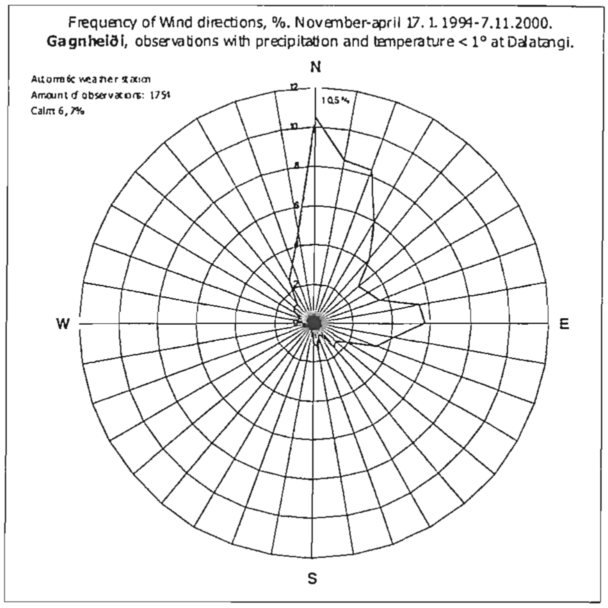
Maximum snow depth (cm)

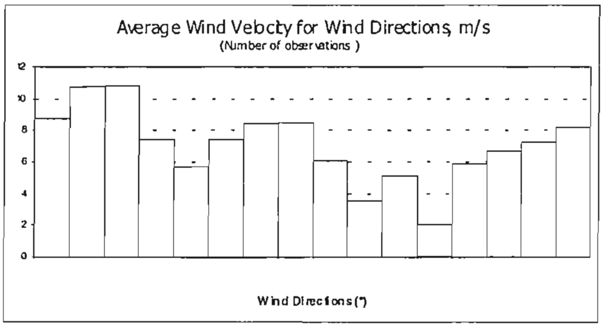
Measured at 9 am.

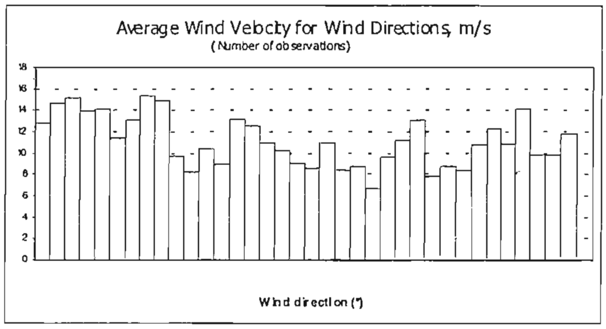
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1975–1976		20	25	48	34	3		
1981–1882	45							
1982–1983				23	20			
1983–1984	6		22		32			
1985–1986		20	50	36		13		
1986–1987	2	27	28	17	31	15	3	2
1987–1988				33	45	24		
1988–1989			25	30	27	60	40	6
1989–1990			23	40	82	109	70	10
1990–1991				15		10	16	
1991–1992			19	25		15		
1992–1993				100				27
1993–1994			20	25		40	14	
1994–1995			49	50	22	100	25	
1996–1997	17	40	50	84	42	52		
1997–1998			6			36	34	5
1998–1999			7	32				
1999–2000		17	38	70	120	140		
2000–2001			20	60				

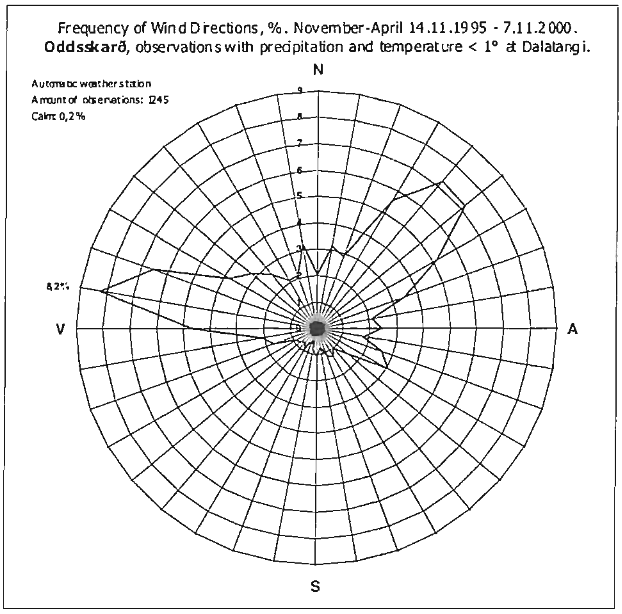
C.2 Wind roses

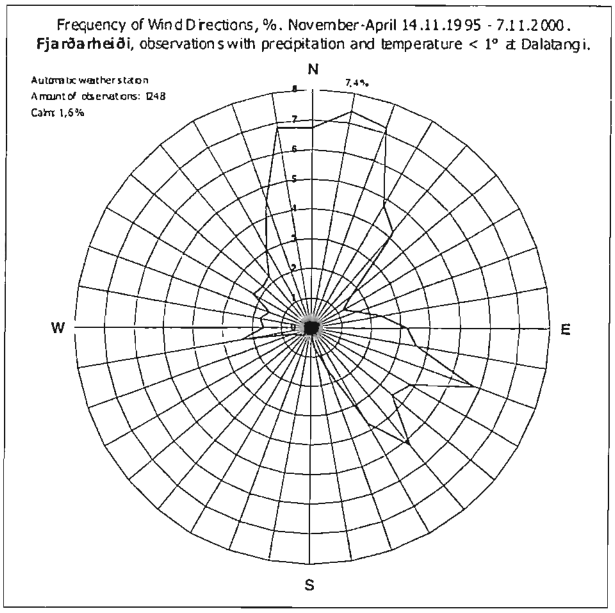


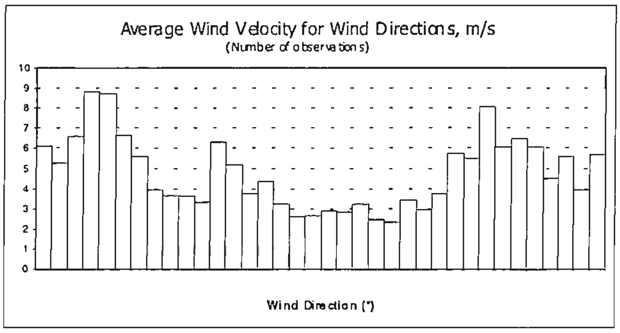


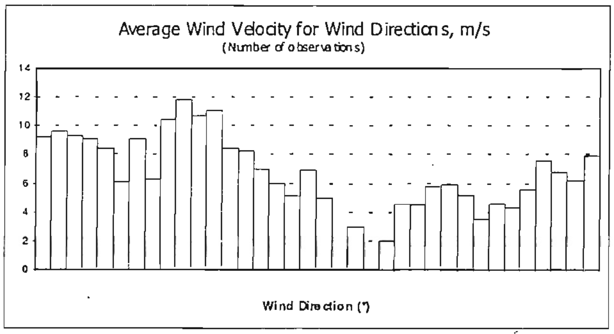






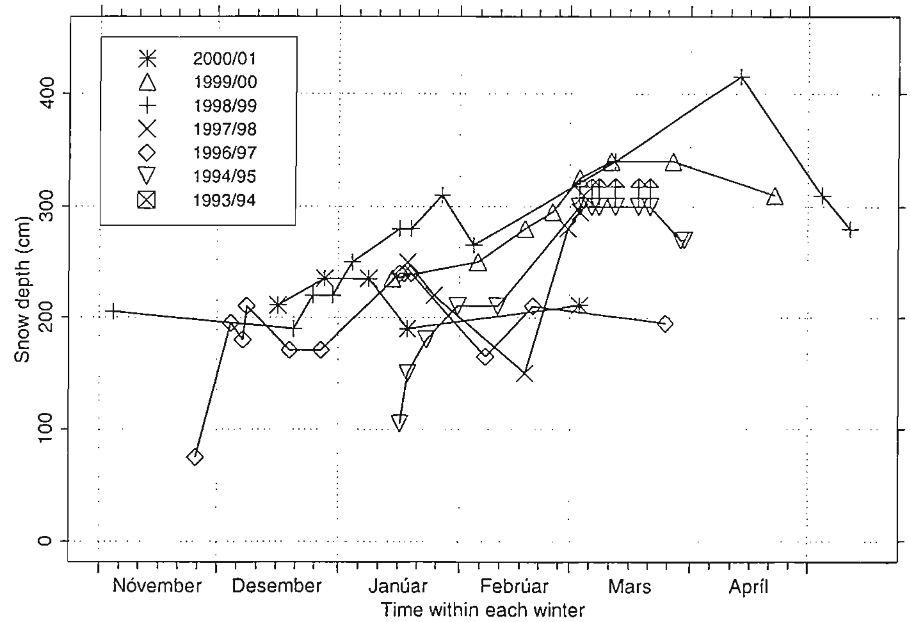






C.4 Snow depth measurements in starting areas

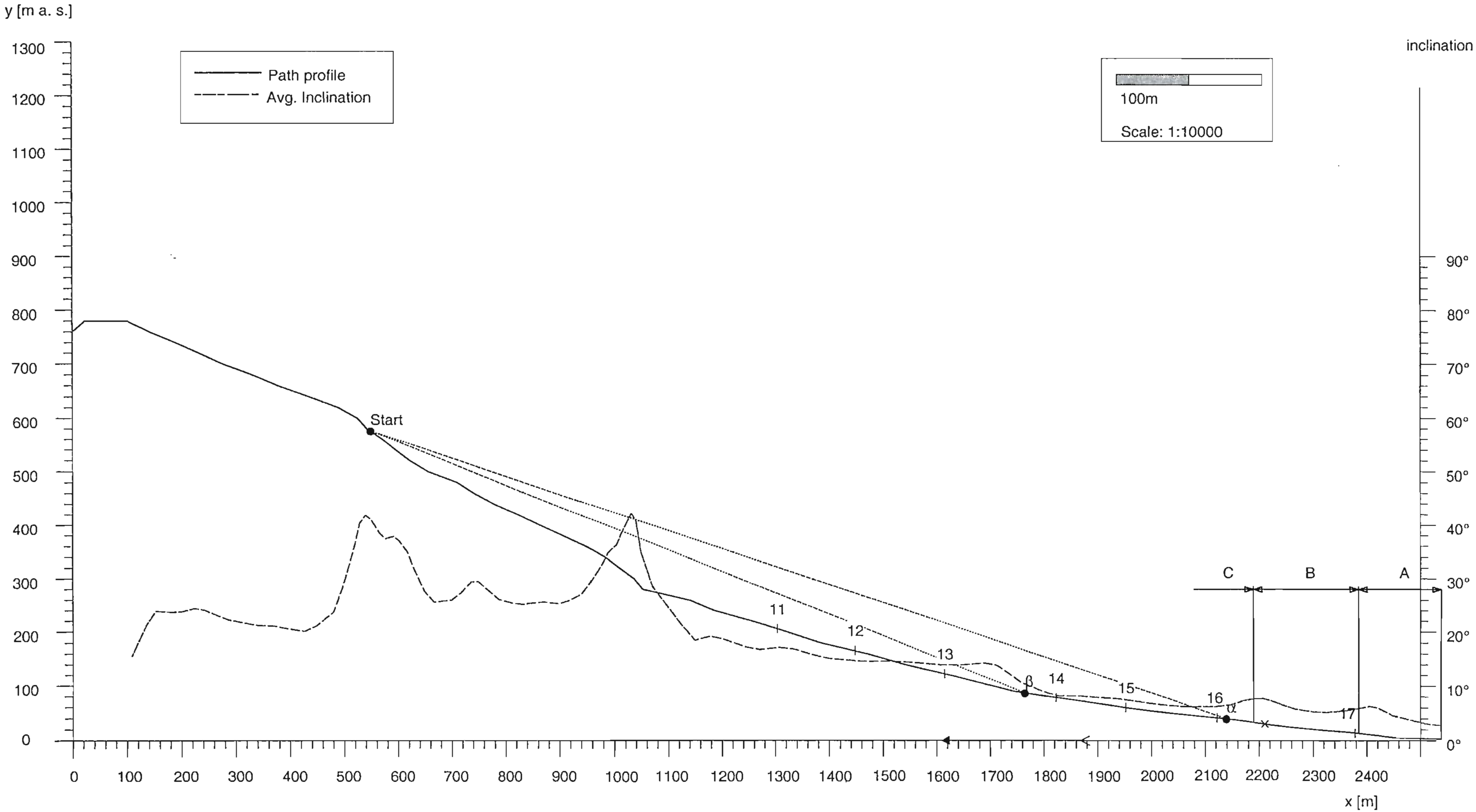
Snow depth at stake nedr05 at 568 m a.s.l. in Drangagil



D Profile drawings

Drawing no.	Profile ID	Avalanche path
1	nein01ba	Gunnólfsskarð
2	neat13aa	Brynjólfsbotnagjá
3	neat14aa	Innri-Sultarbotnagjá
4	neat15aa	Ytri-Sultarbotnagjá
6	neat05aa	Breiðajaðarsgil
7	neat06aa	Bræðslugjá I
8	neat07aa	Bræðslugjá II
9	neat08aa	Bræðslugjá III
10	neat09aa	Between Bræðslugjár and Miðstrandarskarð
11	neib15aa	Miðstrandarskarð
12	neib16aa	Klofagil
13	neib17aa	Between Klofagil and Innra-Tröllagil
14	neib18aa	Innra-Tröllagil
15	neib19aa	Ytra-Tröllagil
16	neib22aa	Urðarbotn
17	neib22ba	Sniðgil
18	neib23aa	Drangagil
19	neib24aa	Skágil
20	neib25aa	Nesgil
21	neib26aa	Bakkagil
22	neib27aa	Uxavogslækjargil
23	neib28aa	Stóralækjargil

nein01ba



ICELANDIC METEOROLOGICAL OFFICE

Hazard evaluation
Runout model and hazard zones

Gunnólfsskarð

Hazard evaluation
Runout models and hazard zones

Hazard zones
C : Risk more than 3·10-4
B : Risk between 3·10-4 and 1·10-4
A : Risk less than 0.3·10-4
According to July 2001 hazard zone regulations.

α/β-model
β: Angle from the start to where the slope is 10°.
α: Angle from runout to the start. α = 0.85β.

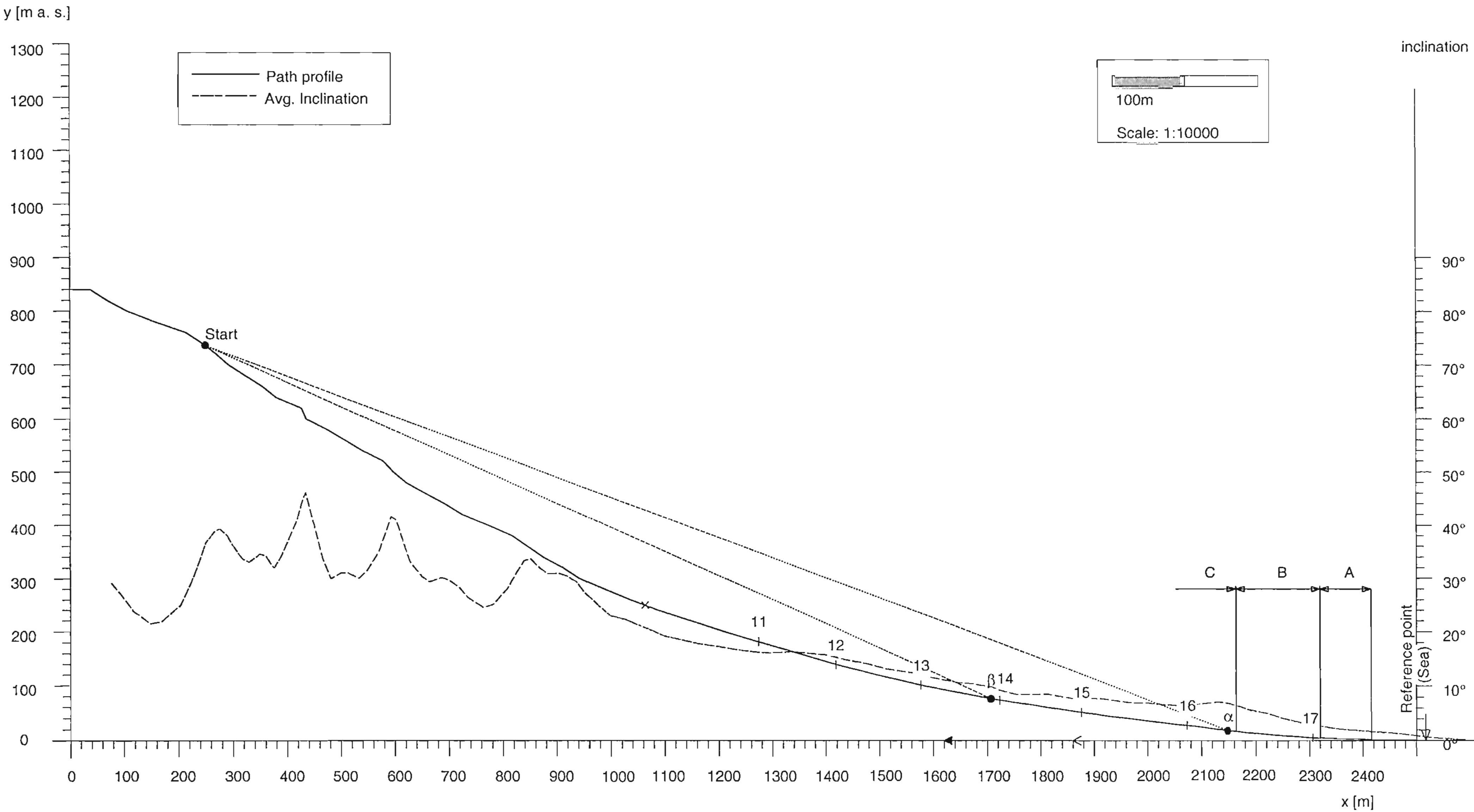
< : α + σ
◄ : α + 2σ
> : α - σ
► : α - 2σ
σ=2.2°

Runout Indices
11, 12, ...17
See VÍ-R99001-ÚR01

Longest avalanche runout: ×

Profile: nein01ba
Drawn by: LT
Date: 7.5.2001
Drawing: 1

neat13aa



ICELANDIC METEOROLOGICAL OFFICE

Hazard evaluation
Runout model and hazard zones

Brynjólfsbotnagjá

Hazard evaluation
Runout models and hazard zones

Hazard zones
C : Risk more than 3·10-4
B : Risk between 3·10-4 and 1·10-4
A : Risk less than 0.3·10-4
According to July 2001 hazard zone regulations.

α/β-model
β: Angle from the start to where the slope is 10°.
α: Angle from runout to the start. α = 0.85β.

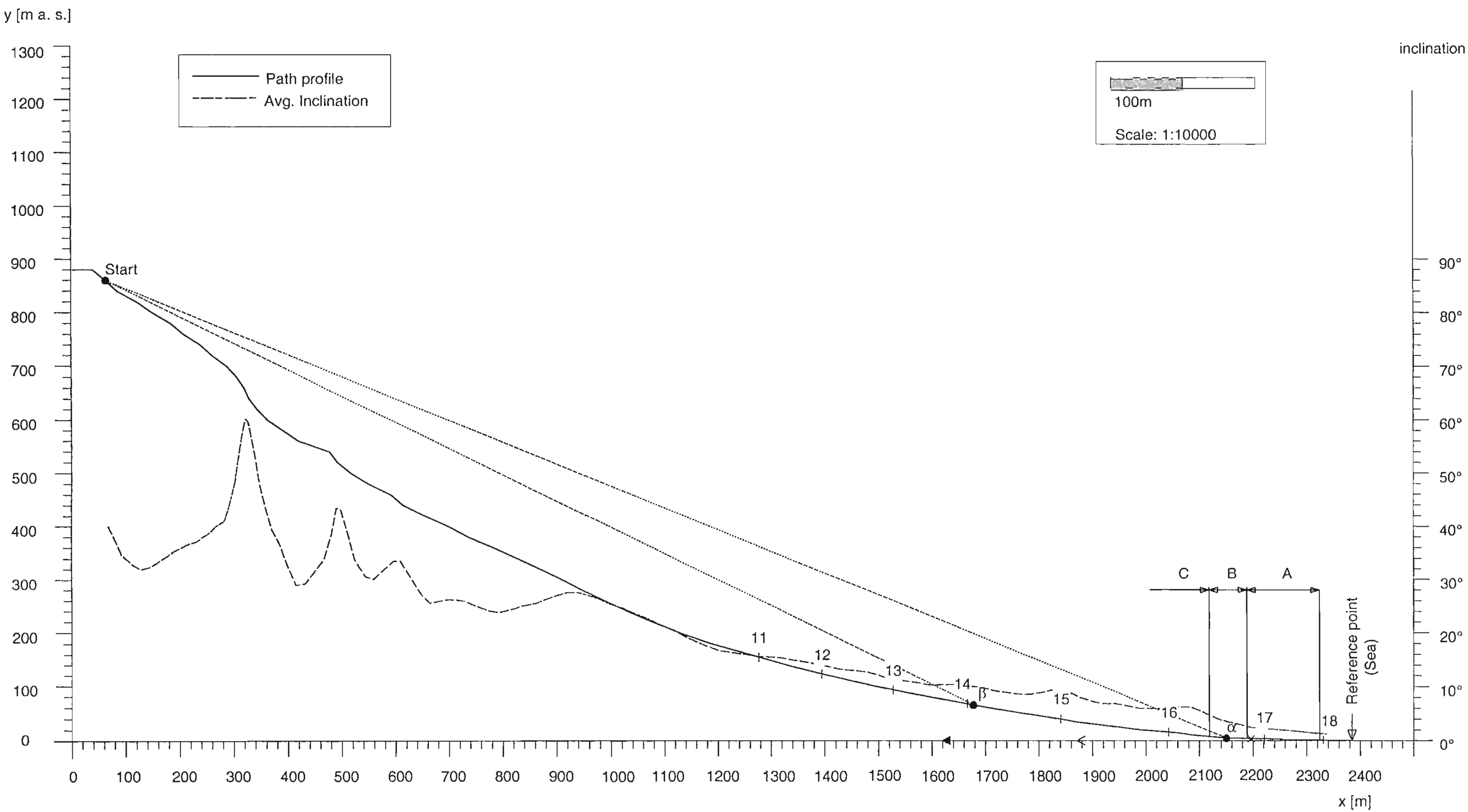
< : α + σ
◄ : α + 2σ
> : α - σ
► : α - 2σ
σ=2.2°

Runout indices
11, 12, ...17
See VÍ-R99001-ÚR01

Longest avalanche runout: ×

Profile: neat13aa
Drawn by: LT
Date: 7.5.2001
Drawing: 2

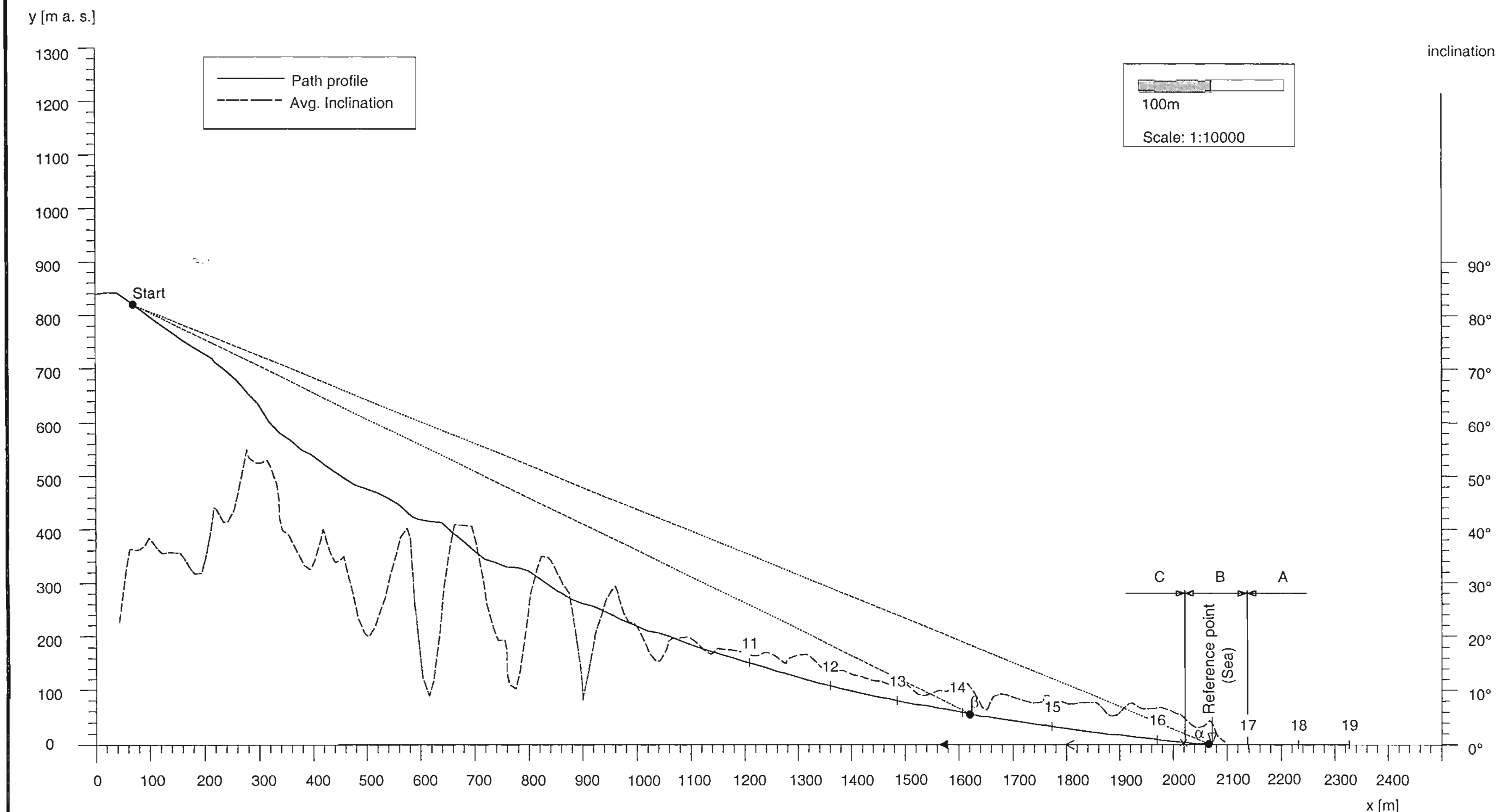
neat14aa



ICELANDIC METEOROLOGICAL OFFICE

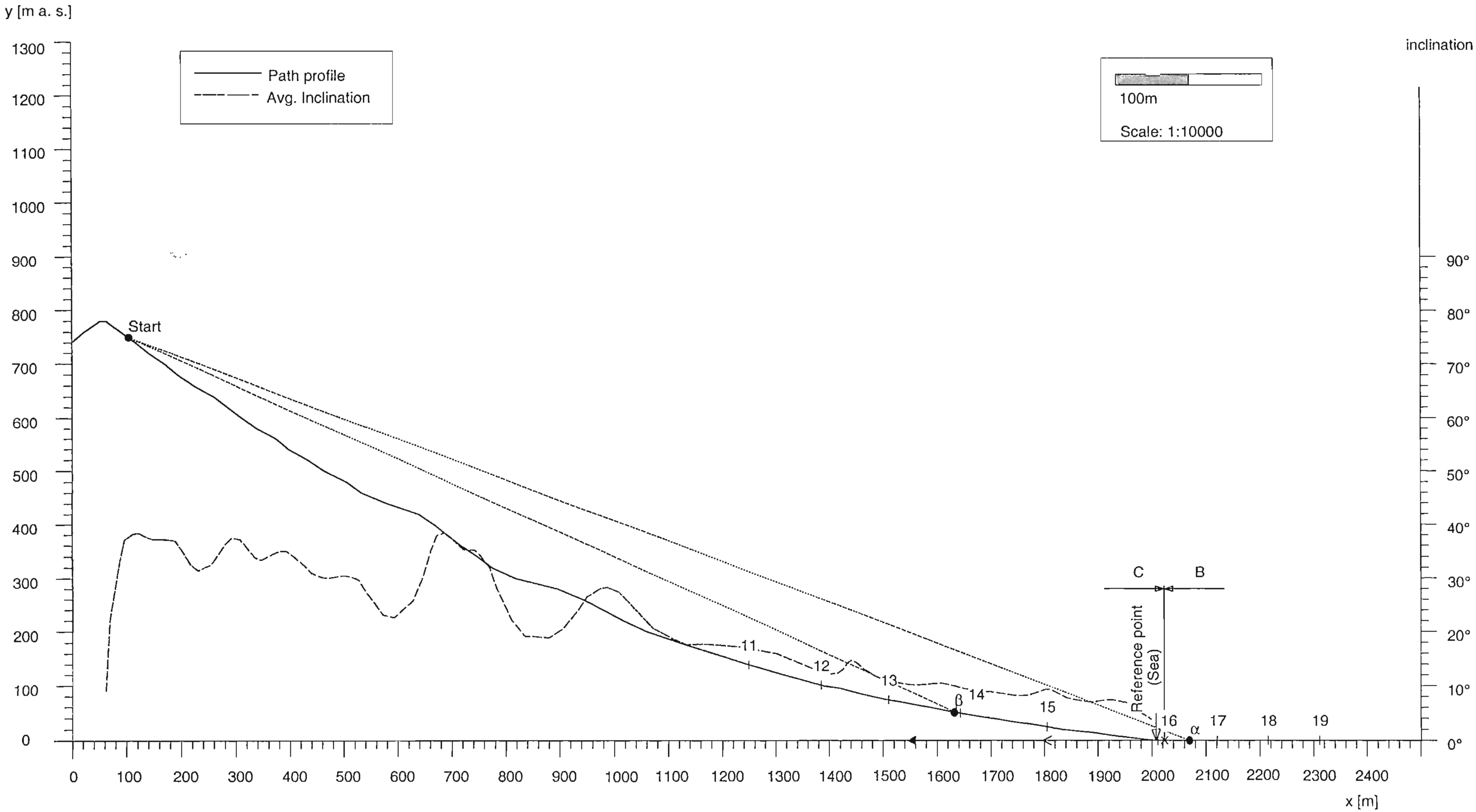
Hazard evaluation Runout model and hazard zones Innri-Sultarbotnagjá Hazard evaluation Runout models and hazard zones	**Hazard zones** C : Risk more than 3·10-4 B : Risk between 3·10-4 and 1·10-4 A : Risk less than 0.3·10-4 According to July 2001 hazard zone regulations.	**α/β-model** β: Angle from the start to where the slope is 10°. α: Angle from runout to the start. α = 0.85β. < : α + σ ; > : α - σ ◄ : α + 2σ ; ► : α - 2σ σ=2.2°	**Runout Indices** 11, 12, ...18 See VÍ-R99001-ÚR01 **Longest avalanche runout:** × *Tongue of avalanche to the west of profile*	Profile: neat14aa Drawn by: LT Date: 7.5.2001 Drawing: 3	

neat15aa



ICELANDIC METEOROLOGICAL OFFICE	**Hazard evaluation** Runout model and hazard zones Ytri-Sultarbotnagjá Hazard evaluation Runout models and hazard zones	**Hazard zones** C : Risk more than 3·10-4 B : Risk between 3·10-4 and 1·10-4 A : Risk less than 0.3·10-4 According to July 2001 hazard zone regulations.	**α/β-model** β: Angle from the start to where the slope is 10°. α: Angle from runout to the start. α = 0.85β. < : α + σ ◂ : α + 2σ > : α - σ ▸ : α - 2σ σ=2.2°	**Runout Indices** 11, 12, ...19 See VÍ-R99001-ÚR01 **Longest avalanche runout:** ×	**Profile:** neat15aa **Drawn by:** LT **Date:** 7.5.2001 **Drawing:** 4

neat15ba



ICELANDIC METEOROLOGICAL OFFICE

Hazard evaluation
Runout model and hazard zones

Ytri-Sultarbotnagjá

Hazard evaluation
Runout models and hazard zones

Hazard zones
C : Risk more than 3·10-4
B : Risk between 3·10-4 and 1·10-4
A : Risk less than 0.3·10-4
According to July 2001 hazard zone regulations.

α/β-model
β: Angle from the start to where the slope is 10°.
α: Angle from runout to the start. $\alpha = 0.85\beta$.

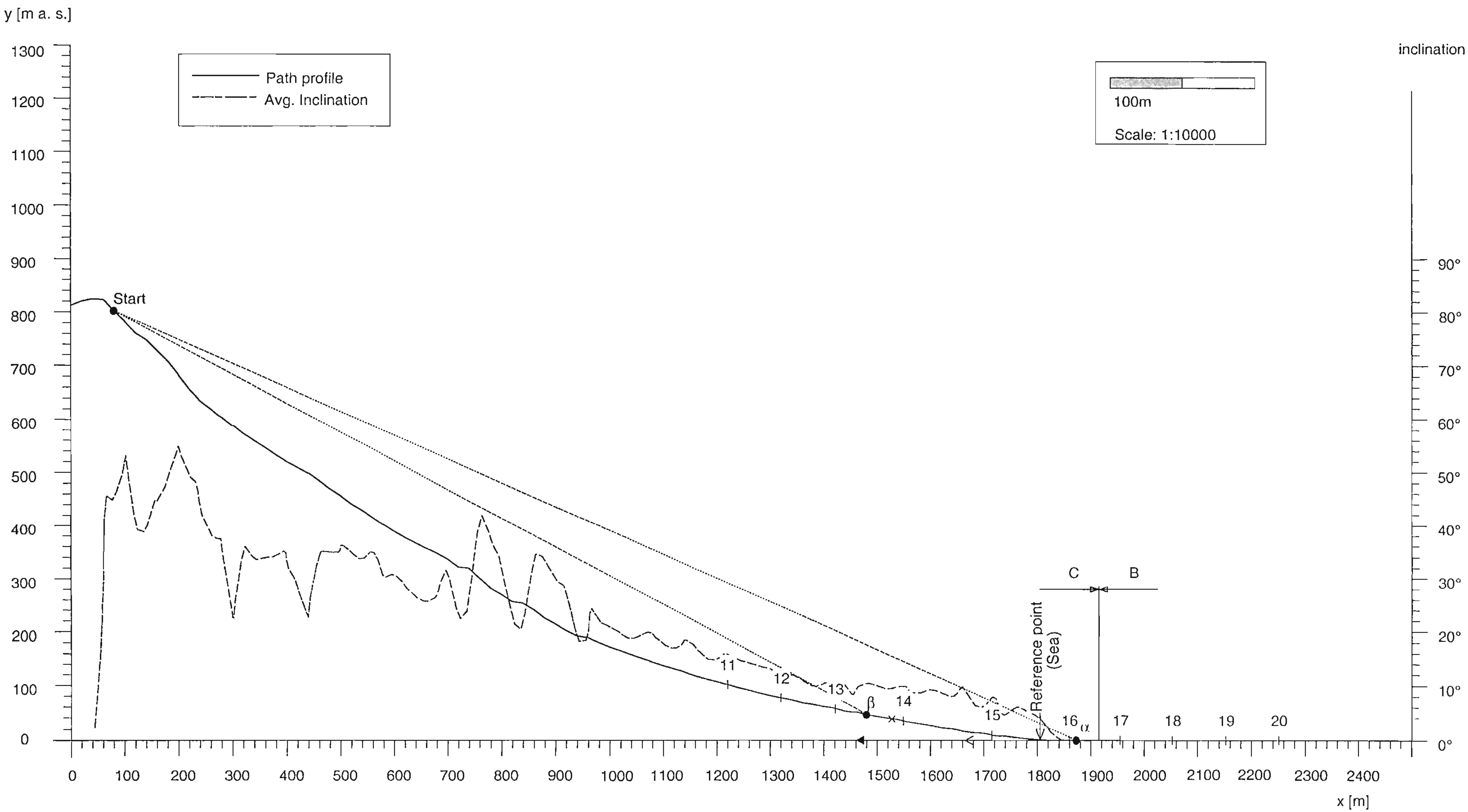
< : α + σ > : α - σ
◂ : α + 2σ ▸ : α - 2σ
σ=2.2°

Runout indices
11, 12, ...19
See VÍ-R99001-ÚR01

Longest avalanche runout: ×

Profile: neat15ba
Drawn by: LT
Date: 7.5.2001
Drawing: 5

neat05aa



ICELANDIC METEOROLOGICAL OFFICE

Hazard evaluation
Runout model and hazard zones

Breiðajaðarsgil

Hazard evaluation
Runout models and hazard zones

Hazard zones
C : Risk more than 3·10-4
B : Risk between 3·10-4 and 1·10-4
A : Risk less than 0.3·10-4
According to July 2001 hazard zone regulations.

α/β-model
β: Angle from the start to where the slope is 10°.
α: Angle from runout to the start. $\alpha = 0.85\beta$.

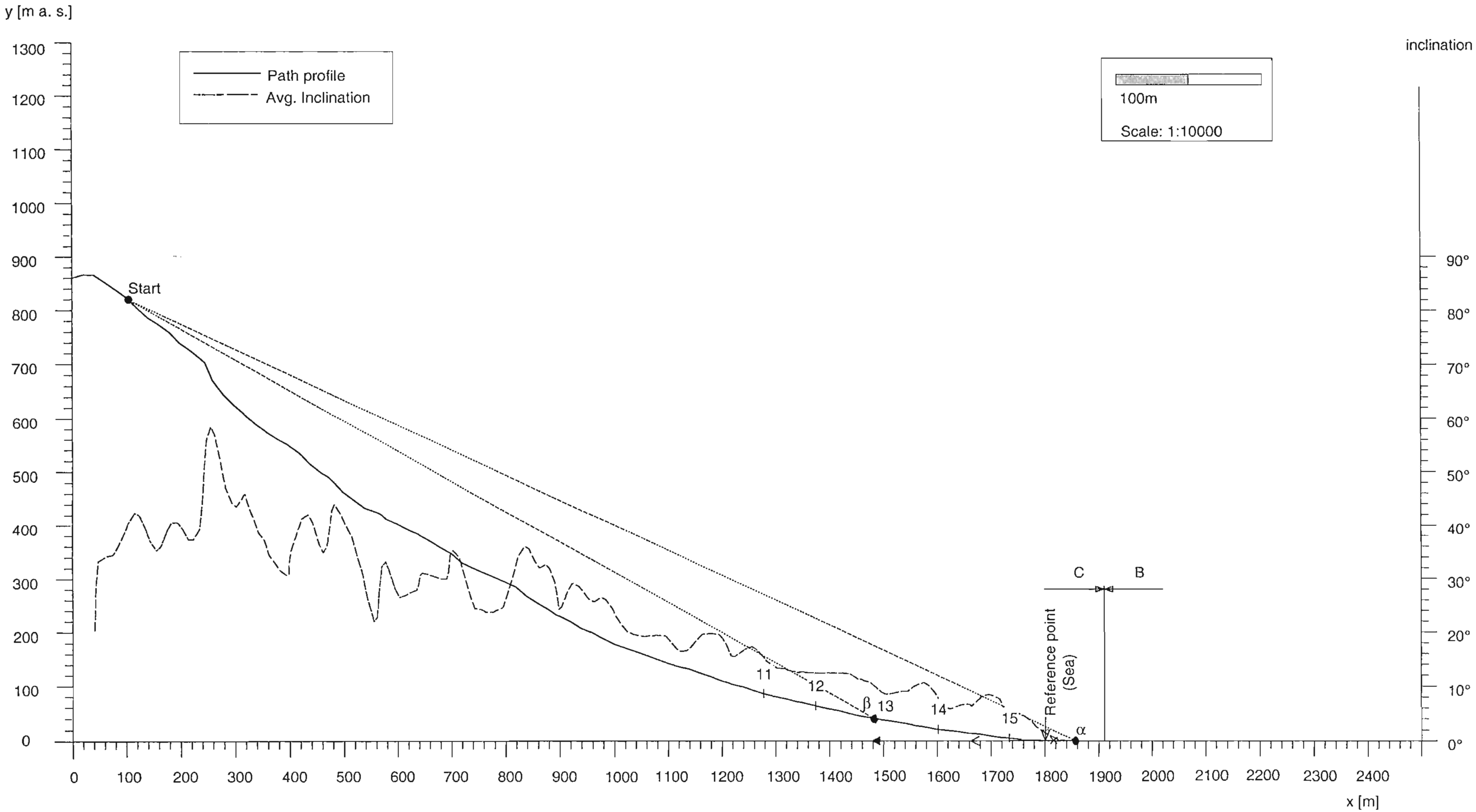
< : α + σ > : α - σ
◄ : α + 2σ ► : α - 2σ
σ=2.2°

Runout indices
11, 12, ...20
See VÍ-R99001-ÚR01

Longest avalanche runout: ×

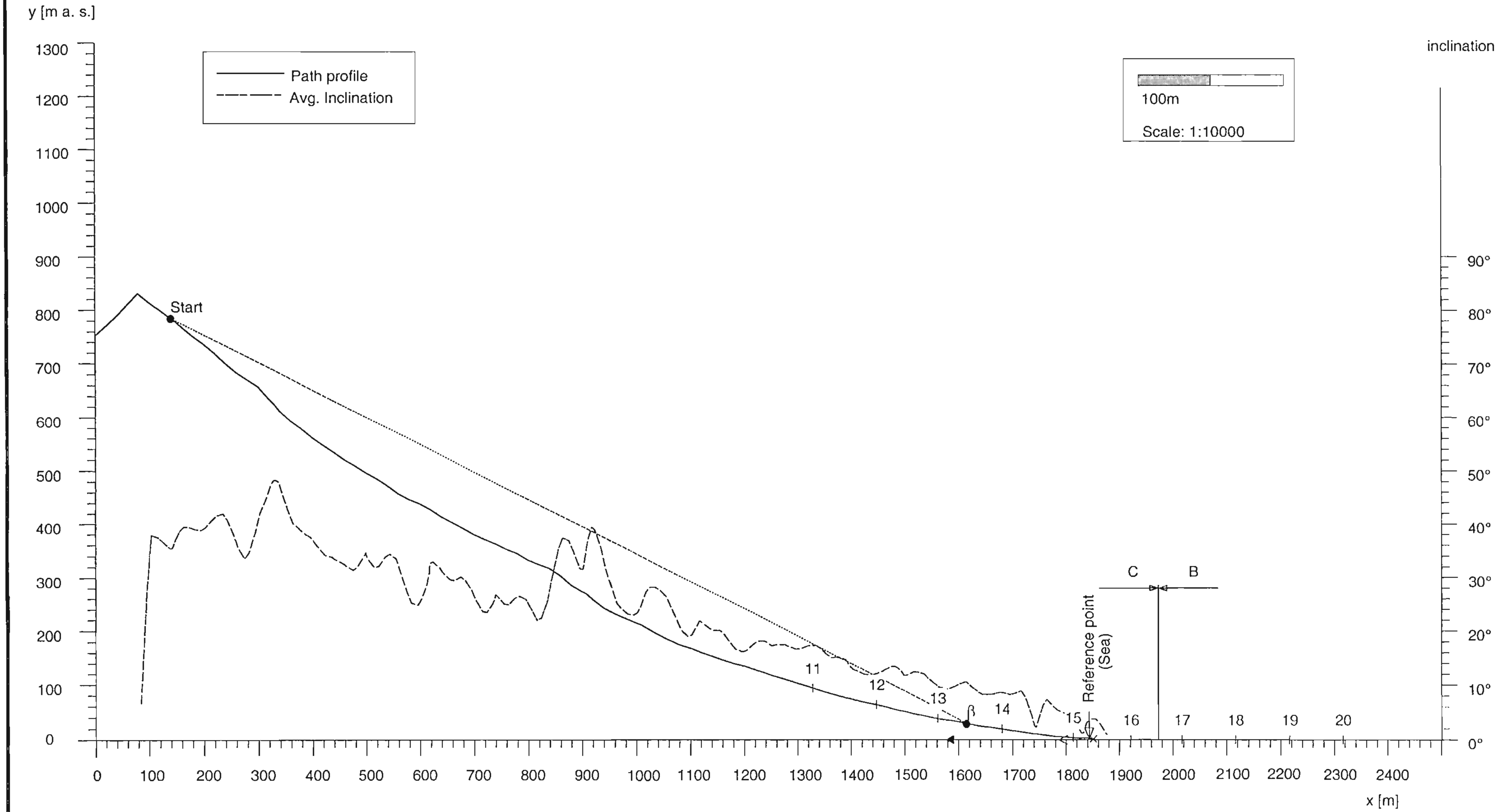
Profile: neat05aa
Drawn by: LT
Date: 7.5.2001
Drawing: 6

neat06aa



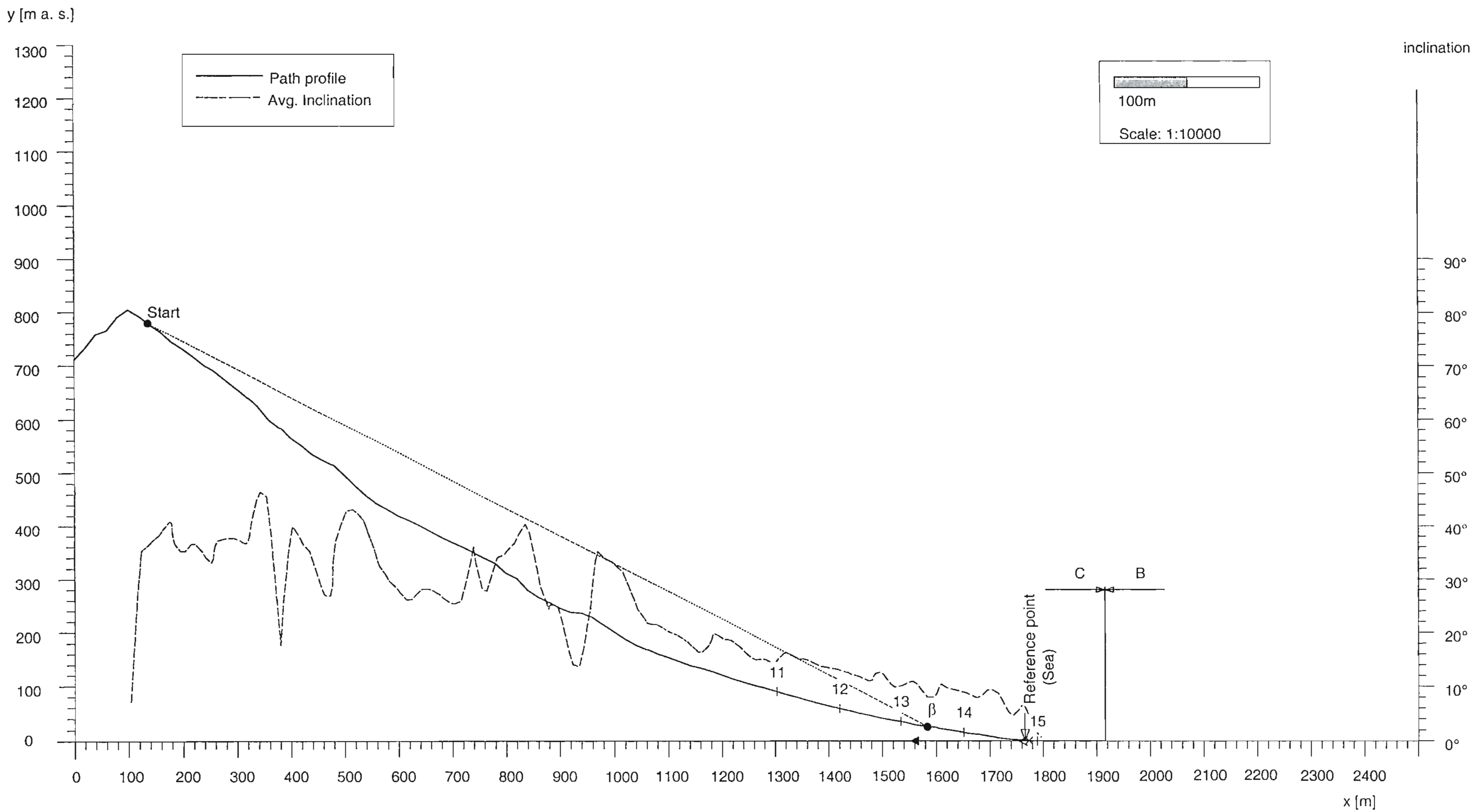
ICELANDIC METEOROLOGICAL OFFICE	**Hazard evaluation** Runout model and hazard zones Bræðslugjá I Hazard evaluation Runout models and hazard zones	**Hazard zones** C : Risk more than 3·10-4 B : Risk between 3·10-4 and 1·10-4 A : Risk less than 0.3·10-4 According to July 2001 hazard zone regulations.	**α/β-model** β: Angle from the start to where the slope is 10°. α: Angle from runout to the start. $\alpha = 0.85\beta$. < : α + σ > : α - σ ◄ : α + 2σ ► : α - 2σ σ=2.2°	**Runout Indices** 11, 12, ...15 See VÍ-R99001-ÚR01 **Longest avalanche runout:** ×	**Profile:** neat06aa **Drawn by:** LT **Date:** 7.5.2001 **Drawing:** 7

neat07aa



ICELANDIC METEOROLOGICAL OFFICE	**Hazard evaluation** Runout model and hazard zones Bræðslugjá II Hazard evaluation Runout models and hazard zones	**Hazard zones** C : Risk more than 3·10-4 B : Risk between 3·10-4 and 1·10-4 A : Risk less than 0.3·10-4 According to July 2001 hazard zone regulations.	**α/β-model** β: Angle from the start to where the slope is 10°. α: Angle from runout to the start. α = 0.85β. < : α + σ > : α - σ ◄ : α + 2σ ► : α - 2σ σ=2.2°	**Runout indices** 11, 12, ...20 See VÍ-R99001-ÚR01 **Longest avalanche runout:** ×	**Profile:** neat07aa **Drawn by:** LT **Date:** 7.5.2001 **Drawing:** 8

neat08aa



ICELANDIC METEOROLOGICAL OFFICE

Hazard evaluation
Runout model and hazard zones

Bræðslugjá III

Hazard evaluation
Runout models and hazard zones

Hazard zones
C : Risk more than 3·10-4
B : Risk between 3·10-4 and 1·10-4
A : Risk less than 0.3·10-4
According to July 2001 hazard zone regulations.

α/β-model
β: Angle from the start to where the slope is 10°.
α: Angle from runout to the start. α = 0.85β.

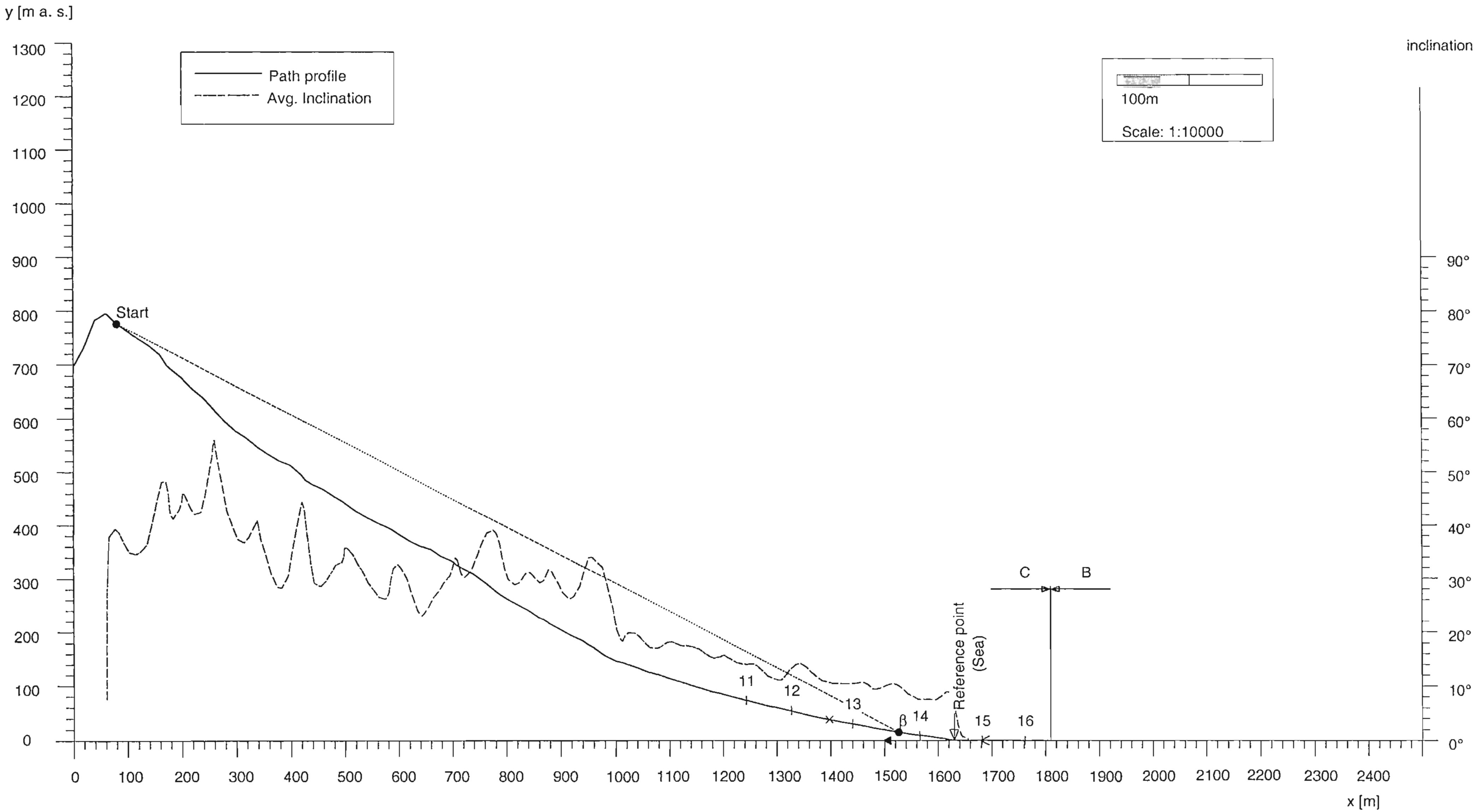
< : α + σ
◂ : α + 2σ
> : α - σ
▸ : α - 2σ
σ=2.2°

Runout indices
11, 12, ...15
See VÍ-R99001-ÚR01

Longest avalanche runout: ×

Profile: neat08aa
Drawn by: LT
Date: 7.5.2001
Drawing: 9

neat09aa



ICELANDIC METEOROLOGICAL OFFICE

Hazard evaluation
Runout model and hazard zones

Between Bræðslugjár and Miðstrandarskarð

Hazard evaluation
Runout models and hazard zones

Hazard zones
C : Risk more than 3·10-4
B : Risk between 3·10-4 and 1·10-4
A : Risk less than 0.3·10-4
According to July 2001 hazard zone regulations.

α/β-model
β: Angle from the start to where the slope is 10°.
α: Angle from runout to the start. α = 0.85β.

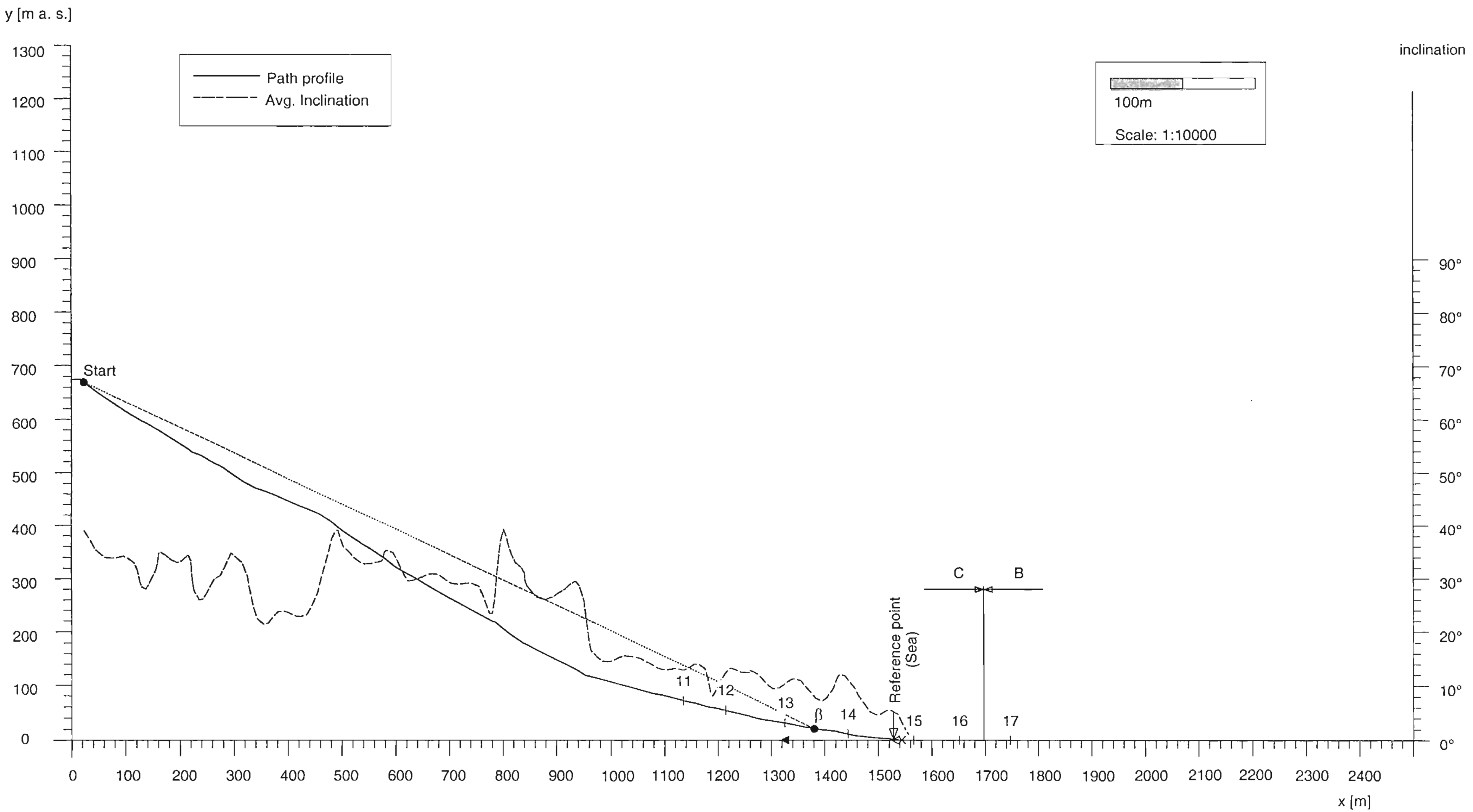
< : α + σ   > : α - σ
◄ : α + 2σ   ► : α - 2σ   σ=2.2°

Runout indices
11, 12, ...16
See VÍ-R99001-ÚR01

Longest avalanche runout: ×

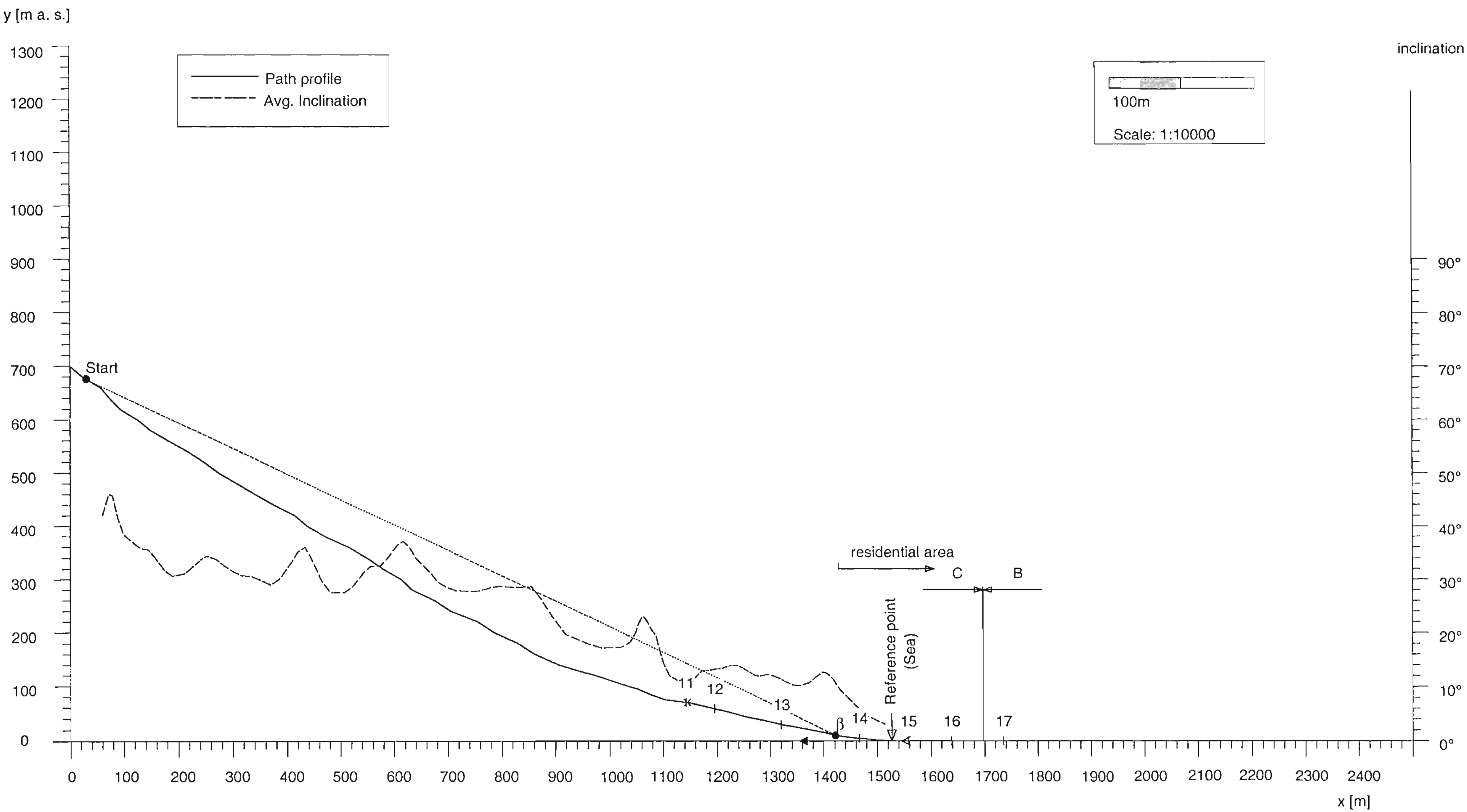
Profile: neat09aa
Drawn by: LT
Date: 7.5.2001
Drawing: 10

neib15aa



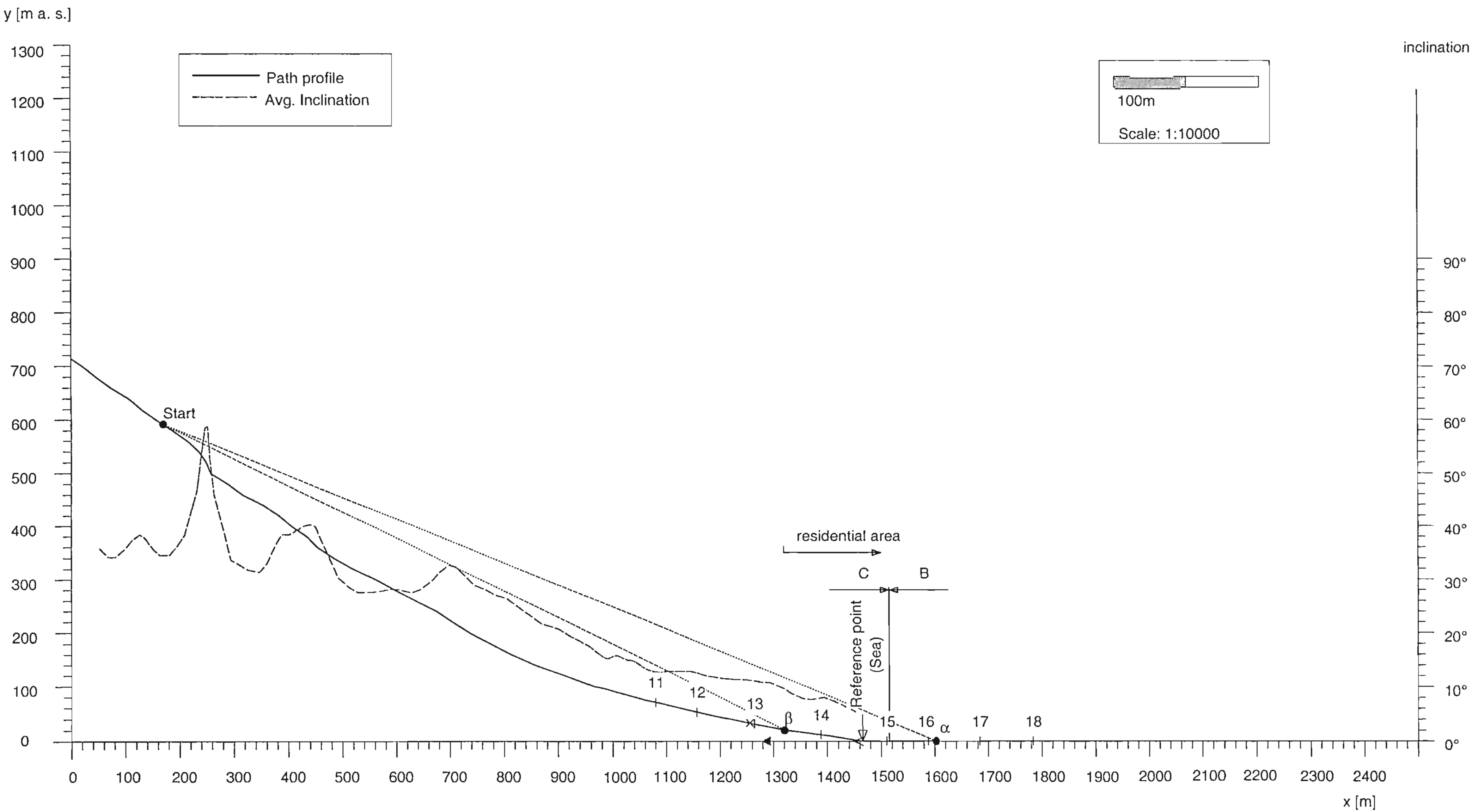
ICELANDIC METEOROLOGICAL OFFICE	**Hazard evaluation** Runout model and hazard zones Miðstrandarskarð Hazard evaluation Runout models and hazard zones	**Hazard zones** C : Risk more than 3·10-4 B : Risk between 3·10-4 and 1·10-4 A : Risk less than 0.3·10-4 According to July 2001 hazard zone regulations.	**α/β-model** β: Angle from the start to where the slope is 10°. α: Angle from runout to the start. α = 0.85β. < : α + σ > : α - σ ◄ : α + 2σ ► : α - 2σ σ=2.2°	**Runout Indices** 11, 12, ...17 See VÍ-R99001-ÚR01 **Longest avalanche runout:** ×	**Profile:** neib15aa **Drawn by:** LT **Date:** 7.5.2001 **Drawing:** 11

neib16aa



ICELANDIC METEOROLOGICAL OFFICE	**Hazard evaluation** Runout model and hazard zones Klofagil Hazard evaluation Runout models and hazard zones	**Hazard zones** C : Risk more than 3·10-4 B : Risk between 3·10-4 and 1·10-4 A : Risk less than 0.3·10-4 According to July 2001 hazard zone regulations.	**α/β-model** β: Angle from the start to where the slope is 10°. α: Angle from runout to the start. α = 0.85β. < : α + σ > : α - σ ◂ : α + 2σ ▸ : α - 2σ σ=2.2°	**Runout indices** 11, 12, ...17 See VÍ-R99001-ÚR01 **Longest avalanche runout:** ×	**Profile:** neib16aa **Drawn by:** LT **Date:** 7.5.2001 **Drawing:** 12

neib17aa



ICELANDIC METEOROLOGICAL OFFICE

Hazard evaluation
Runout model and hazard zones

Between Klofagil and Innra-Tröllagil

Hazard evaluation
Runout models and hazard zones

Hazard zones
C : Risk more than 3·10-4
B : Risk between 3·10-4 and 1·10-4
A : Risk less than 0.3·10-4
According to July 2001 hazard zone regulations.

α/β-model
β: Angle from the start to where the slope is 10°.
α: Angle from runout to the start. α = 0.85β.

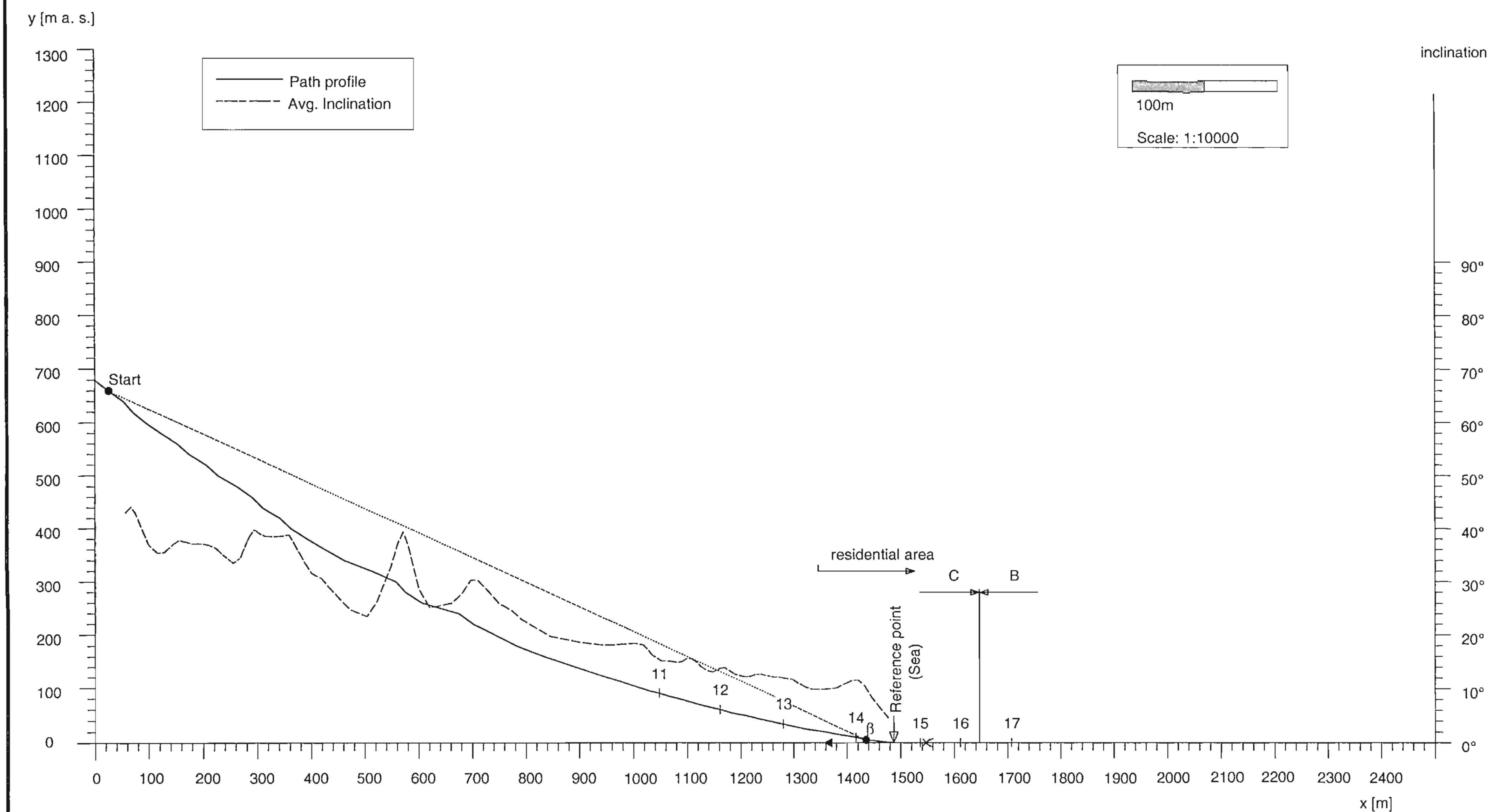
< : α + σ   > : α - σ
◄ : α + 2σ   ► : α - 2σ   σ=2.2°

Runout indices
11, 12, ...18
See VI-R99001-ÚR01

Longest avalanche runout: ×

Profile: neib17aa
Drawn by: I T
Date: 7.5.2001
Drawing: 13

neib18aa



ICELANDIC METEOROLOGICAL OFFICE

Hazard evaluation
Runout model and hazard zones

Innra-Tröllagil

Hazard evaluation
Runout models and hazard zones

Hazard zones
C : Risk more than 3·10-4
B : Risk between 3·10-4 and 1·10-4
A : Risk less than 0.3·10-4
According to July 2001 hazard zone regulations.

α/β-model
β: Angle from the start to where the slope is 10°.
α: Angle from runout to the start. α = 0.85β.

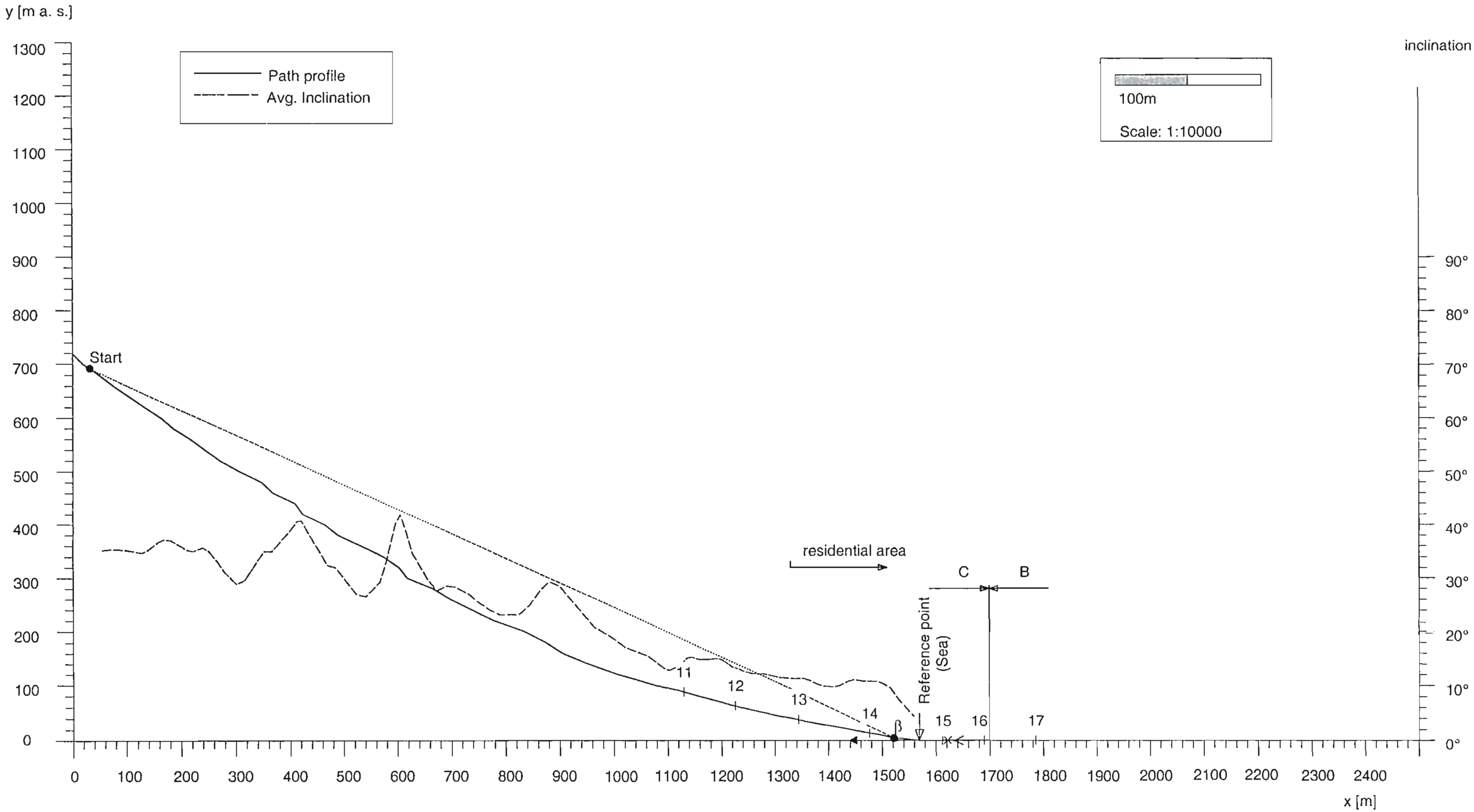
< : α + σ > : α - σ
◄ : α + 2σ ► : α - 2σ
σ=2.2°

Runout Indices
11, 12, ...17
See VÍ-R99001-ÚR01

Longest avalanche runout: ×
Tongue of avalanche to the east of profile

Profile: neib18aa
Drawn by: LT
Date: 7.5.2001
Drawing: 14

neib19aa



ICELANDIC METEOROLOGICAL OFFICE

Hazard evaluation
Runout model and hazard zones

Ytra-Tröllagil

Hazard evaluation
Runout models and hazard zones

Hazard zones
C : Risk more than 3·10-4
B : Risk between 3·10-4 and 1·10-4
A : Risk less than 0.3·10-4
According to July 2001 hazard zone regulations.

α/β-model
β: Angle from the start to where the slope is 10°.
α: Angle from runout to the start. α = 0.85β.

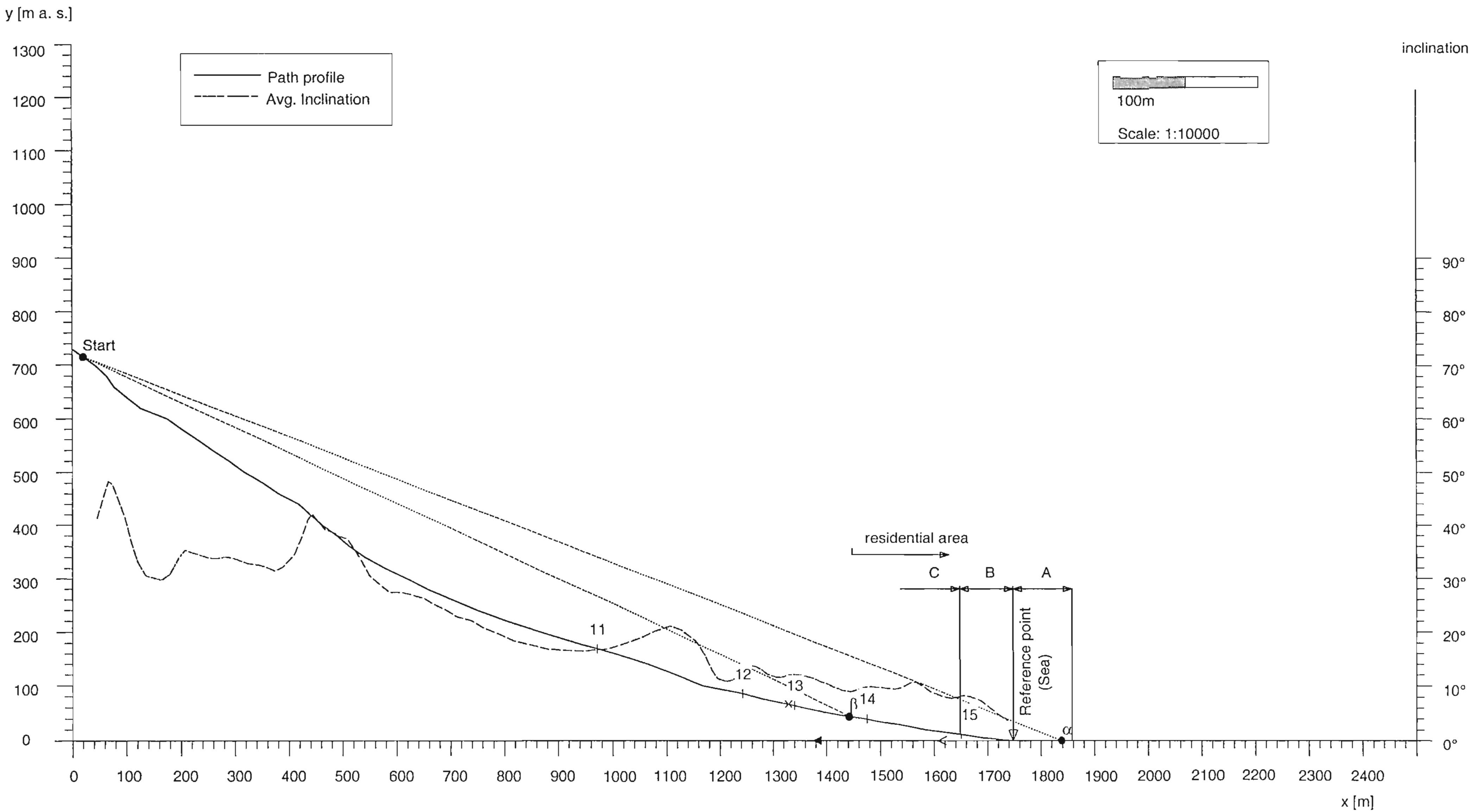
< : α + σ
◄ : α + 2σ
> : α - σ
► : α - 2σ
σ=2.2°

Runout indices
11, 12, ...17
See VÍ-R99001-ÚR01

Longest avalanche runout: ×
Tongue of avalanche to the west of profile

Profile: neib19aa
Drawn by: LT
Date: 7.5.2001
Drawing: 15

neib22aa



ICELANDIC METEOROLOGICAL OFFICE

Hazard evaluation
Runout model and hazard zones

Urðarbotn

Hazard evaluation
Runout models and hazard zones

Hazard zones
C : Risk more than 3·10-4
B : Risk between 3·10-4 and 1·10-4
A : Risk less than 0.3·10-4
According to July 2001 hazard zone regulations.

α/β-model
β: Angle from the start to where the slope is 10°.
α: Angle from runout to the start. $\alpha = 0.85\beta$.

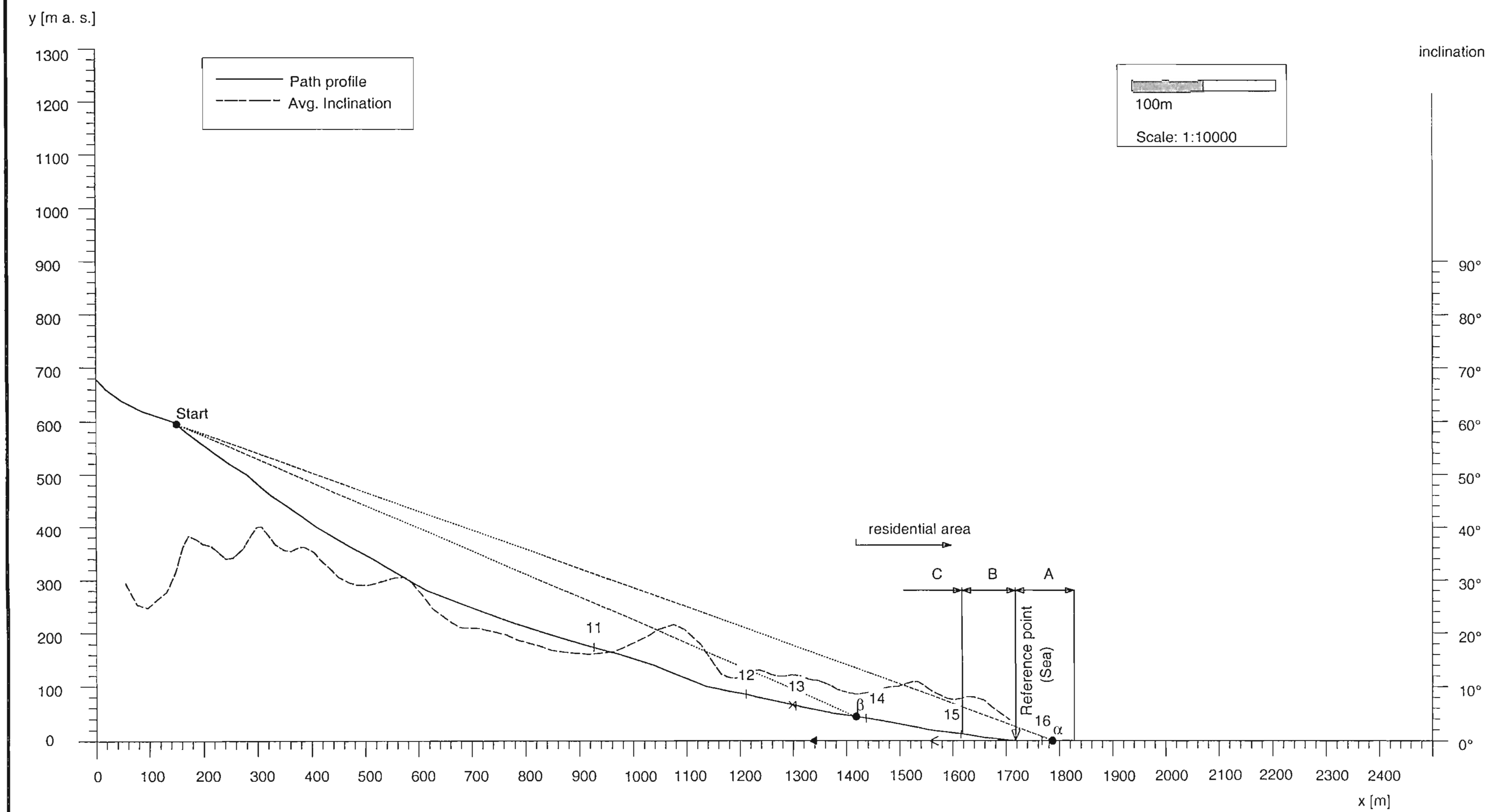
< : $\alpha + \sigma$ > : $\alpha - \sigma$
◄ : $\alpha + 2\sigma$ ► : $\alpha - 2\sigma$
$\sigma = 2.2°$

Runout indices
11, 12, ...15
See VÍ-R99001-ÚR01

Longest avalanche runout: ×

Profile: neib22aa
Drawn by: LT
Date: 7.5.2001
Drawing: 16

neib22ba



ICELANDIC METEOROLOGICAL OFFICE

Hazard evaluation
Runout model and hazard zones

Sniðgil

Hazard evaluation
Runout models and hazard zones

Hazard zones
C : Risk more than 3·10-4
B : Risk between 3·10-4 and 1·10-4
A : Risk less than 0.3·10-4
According to July 2001 hazard zone regulations.

α/β-model
β: Angle from the start to where the slope is 10°.
α: Angle from runout to the start. $\alpha = 0.85\beta$.

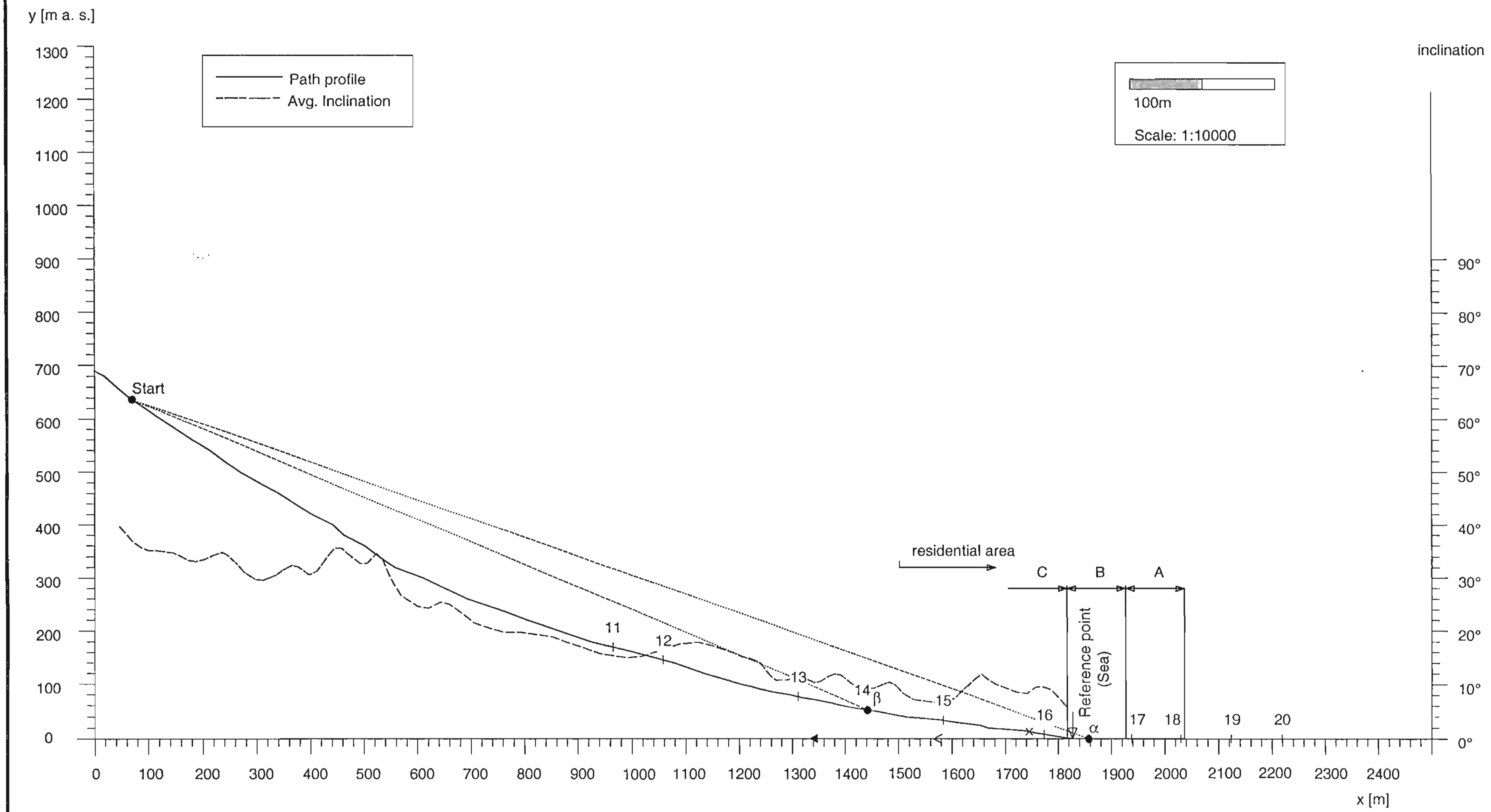
< : α + σ
◄ : α + 2σ
> : α - σ
► : α - 2σ
σ=2.2°

Runout indices
11, 12, ...16
See VÍ-R99001-ÚR01

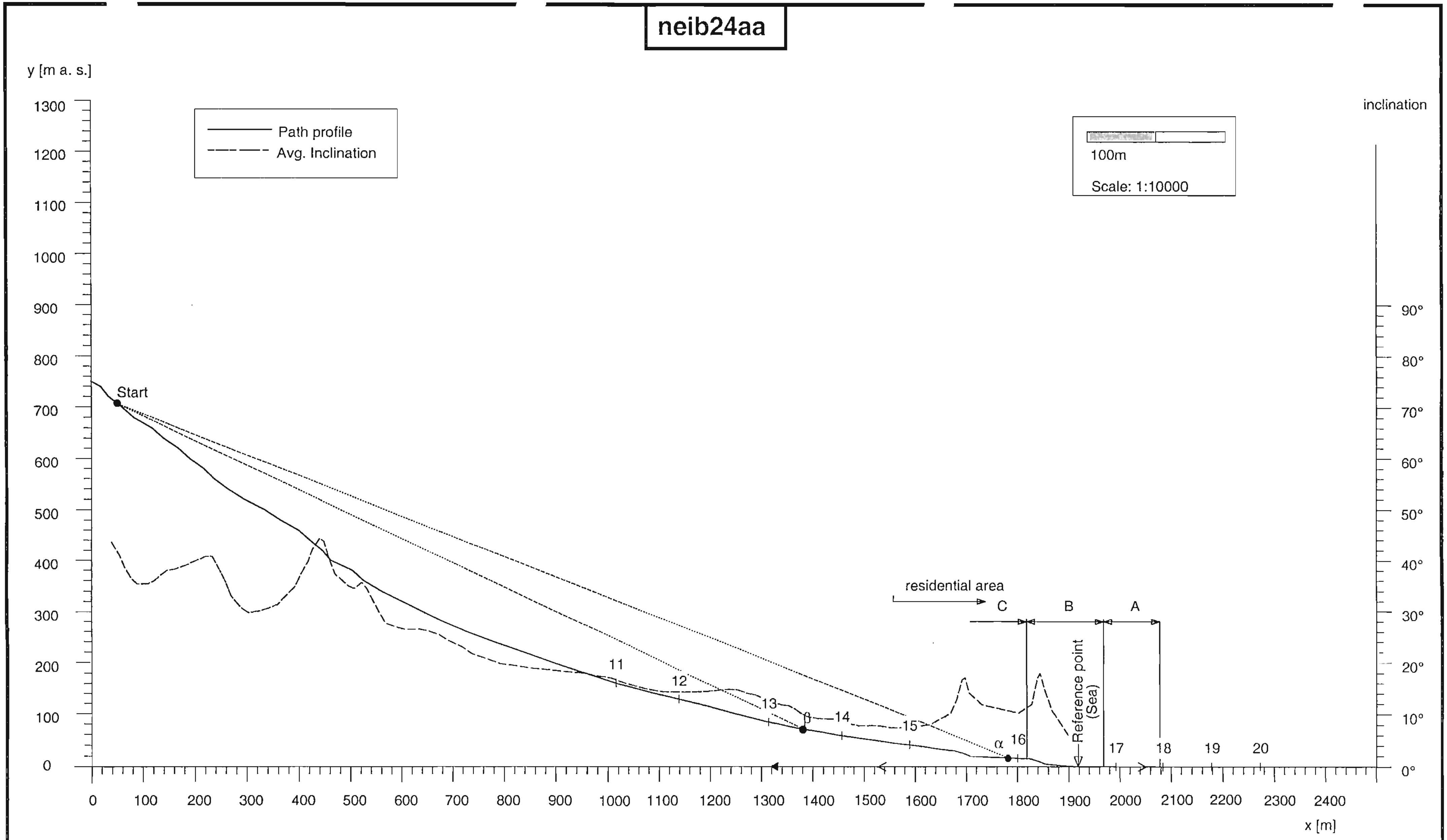
Longest avalanche runout: ×

Profile: neib22ba
Drawn by: LT
Date: 7.5.2001
Drawing: 17

neib23aa

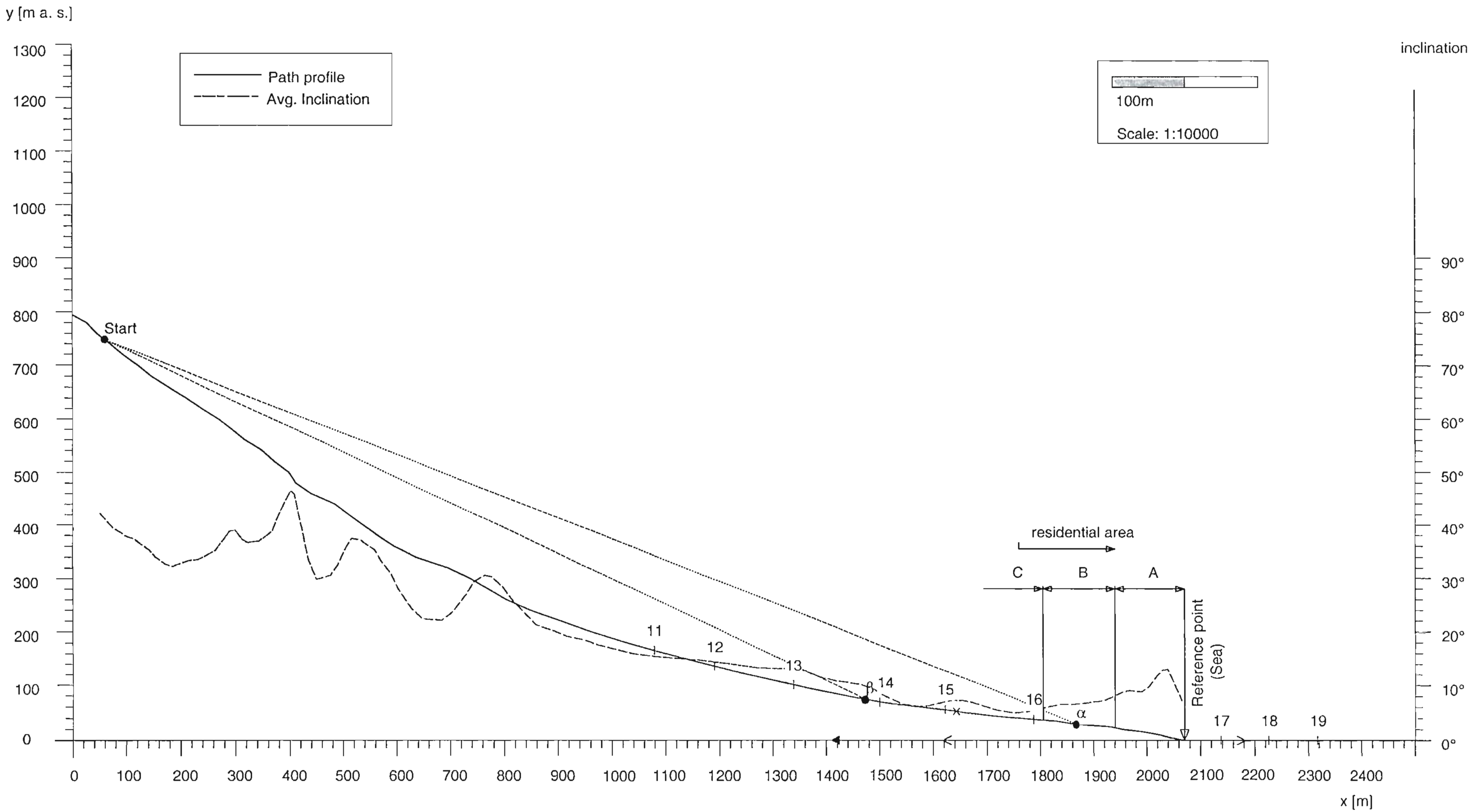


ICELANDIC METEOROLOGICAL OFFICE	**Hazard evaluation** Runout model and hazard zones Drangagil Hazard evaluation Runout models and hazard zones	**Hazard zones** C : Risk more than 3·10-4 B : Risk between 3·10-4 and 1·10-4 A : Risk less than 0.3·10-4 According to July 2001 hazard zone regulations.	**α/β-model** β: Angle from the start to where the slope is 10°. α: Angle from runout to the start. α = 0.85β. < : α + σ > : α - σ ◀ : α + 2σ ▶ : α - 2σ σ=2.2°	**Runout Indices** 11, 12, ...20 See VÍ-R99001-ÚR01 **Longest avalanche runout:** ×	**Profile:** neib23aa **Drawn by:** LT **Date:** 7.5.2001 **Drawing:** 18



ICELANDIC METEOROLOGICAL OFFICE	**Hazard evaluation** Runout model and hazard zones Skágil Hazard evaluation Runout models and hazard zones	**Hazard zones** C : Risk more than 3·10-4 B : Risk between 3·10-4 and 1·10-4 A : Risk less than 0.3·10-4 According to July 2001 hazard zone regulations.	**α/β-model** β: Angle from the start to where the slope is 10°. α: Angle from runout to the start. α = 0.85β. < : α + σ > : α - σ ◄ : α + 2σ ► : α - 2σ σ=2.2°	**Runout indices** 11, 12, ...20 See VÍ-R99001-ÚR01	Profile: neib24aa Drawn by: LT Date: 7.5.2001 Drawing: 19

neib25aa



ICELANDIC METEOROLOGICAL OFFICE

Hazard evaluation
Runout model and hazard zones

Nesgil

Hazard evaluation
Runout models and hazard zones

Hazard zones
C : Risk more than $3 \cdot 10^{-4}$
B : Risk between $3 \cdot 10^{-4}$ and $1 \cdot 10^{-4}$
A : Risk less than $0.3 \cdot 10^{-4}$
According to July 2001 hazard zone regulations.

α/β-model
β: Angle from the start to where the slope is 10°.
α: Angle from runout to the start. $\alpha = 0.85\beta$.

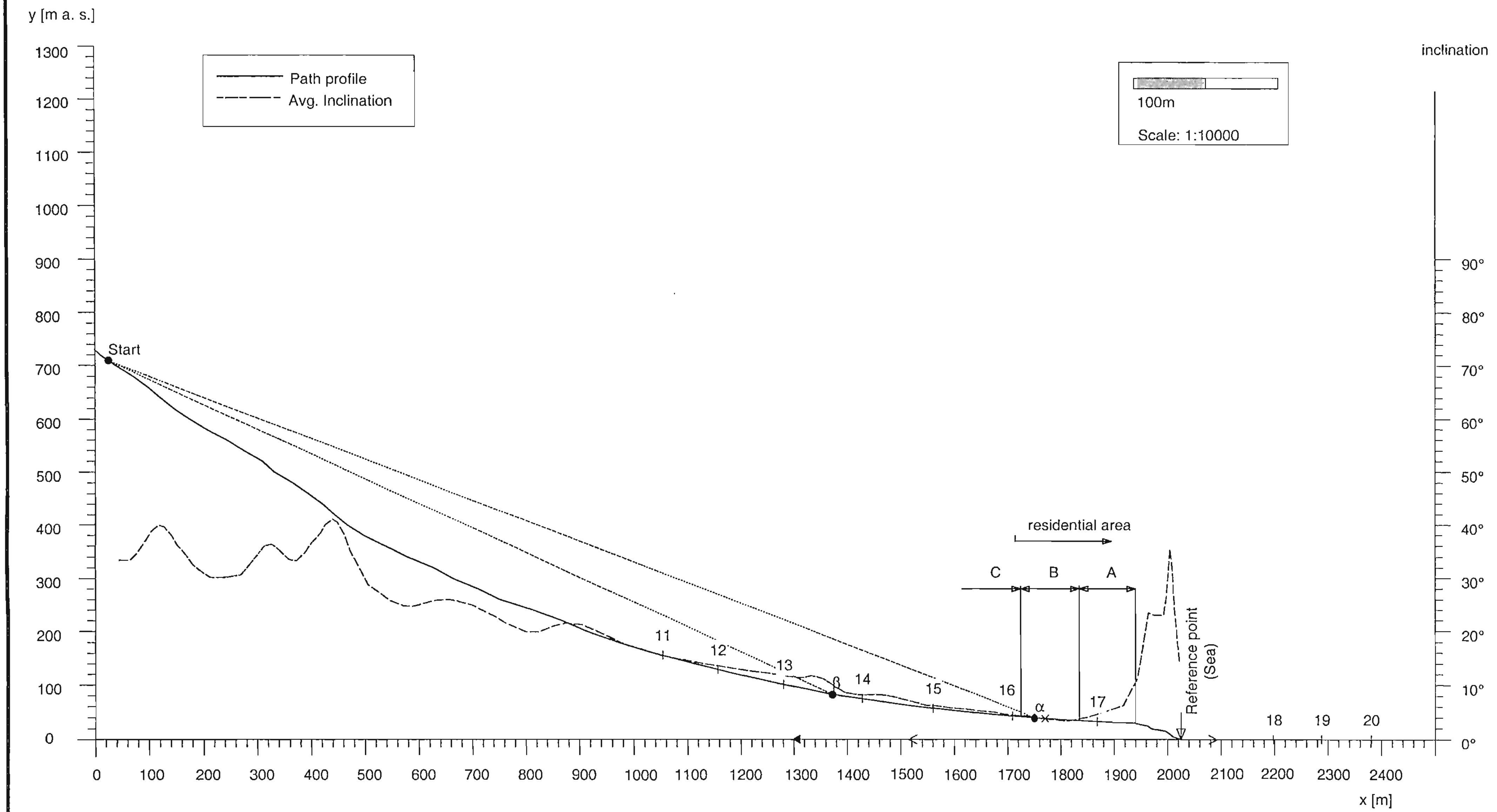
< : $\alpha + \sigma$ > : $\alpha - \sigma$
◄ : $\alpha + 2\sigma$ ► : $\alpha - 2\sigma$
$\sigma = 2.2°$

Runout Indices
11, 12, ...19
See VÍ-R99001-ÚR01

Longest avalanche runout: ×

Profile: neib25aa
Drawn by: LT
Date: 7.5.2001
Drawing: 20

neib26aa



ICELANDIC METEOROLOGICAL OFFICE

Hazard evaluation
Runout model and hazard zones

Bakkagil

Hazard evaluation
Runout models and hazard zones

Hazard zones
C : Risk more than 3·10-4
B : Risk between 3·10-4 and 1·10-4
A : Risk less than 0.3·10-4
According to July 2001 hazard zone regulations.

α/β-model
β: Angle from the start to where the slope is 10°.
α: Angle from runout to the start. α = 0.85β.

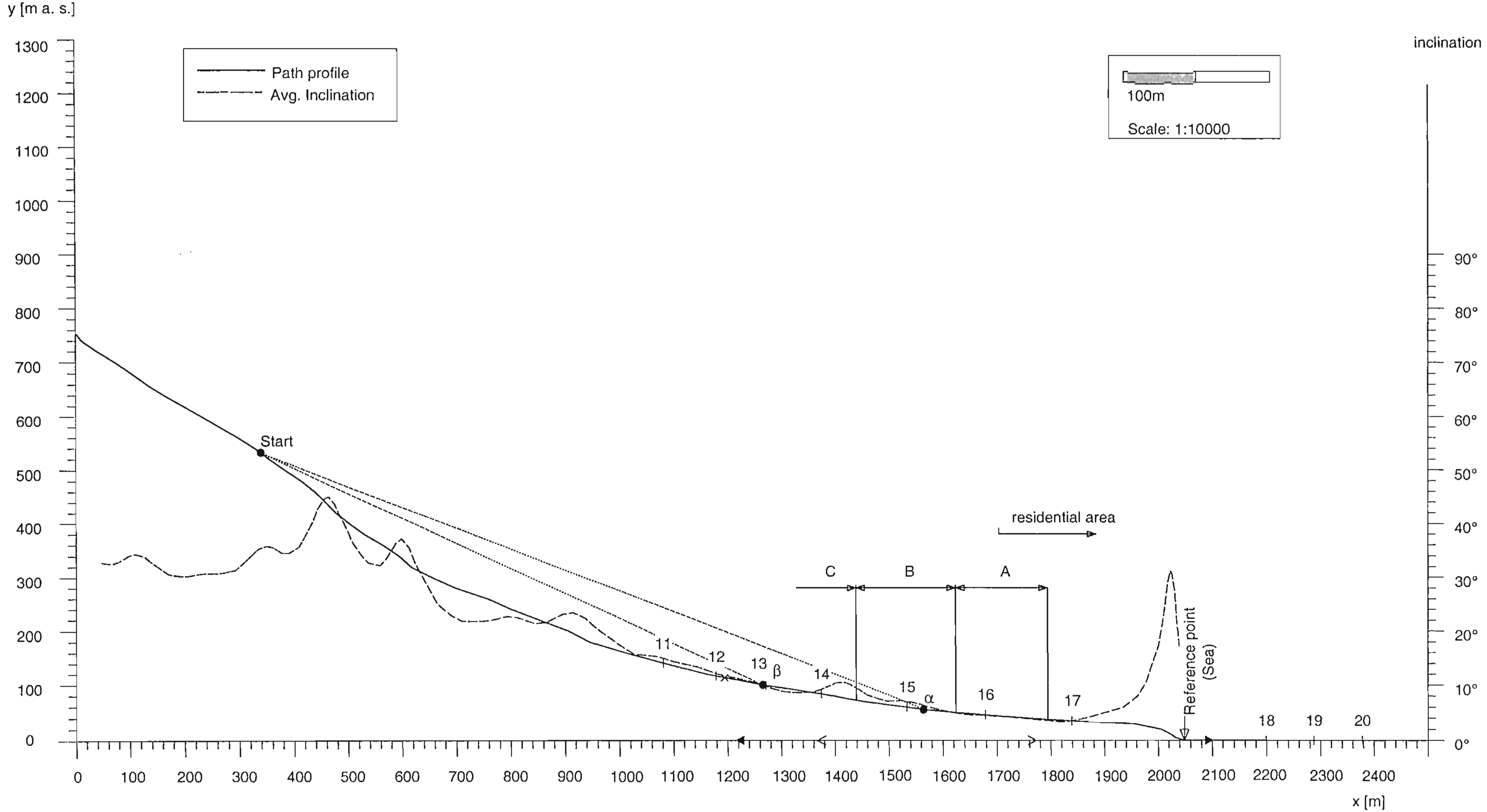
< : α + σ
◄ : α + 2σ
> : α - σ
► : α - 2σ
σ=2.2°

Runout indices
11, 12, ...20
See VÍ-R99001-ÚR01

Longest avalanche runout: ×

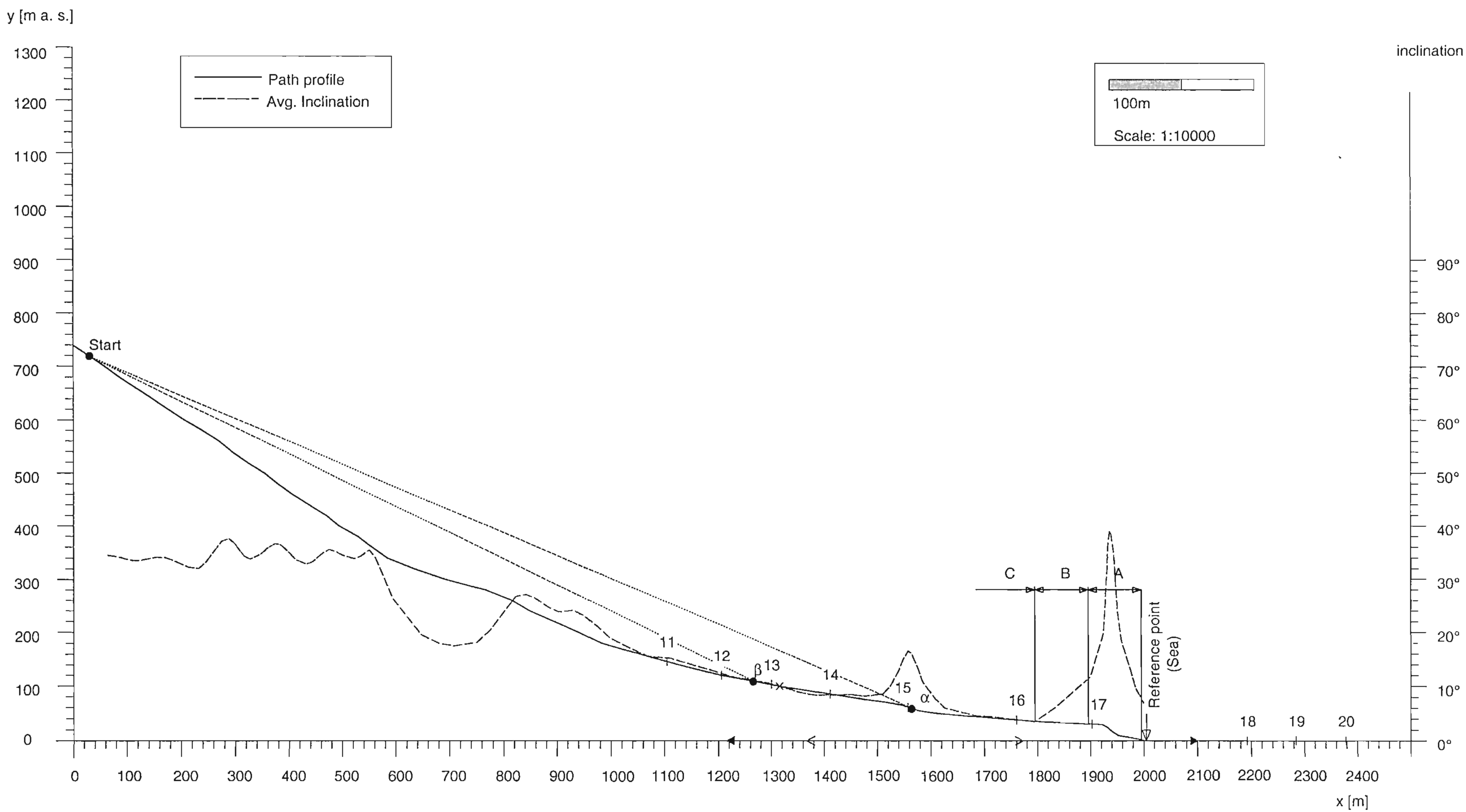
Profile: neib26aa
Drawn by: LT
Date: 7.5.2001
Drawing: 21

neib27aa



ICELANDIC METEOROLOGICAL OFFICE	**Hazard evaluation** Runout model and hazard zones Uxavogslækjargil Hazard evaluation Runout models and hazard zones	**Hazard zones** C : Risk more than 3·10-4 B : Risk between 3·10-4 and 1·10-4 A : Risk less than 0.3·10-4 According to July 2001 hazard zone regulations.	**α/β-model** β: Angle from the start to where the slope is 10°. α: Angle from runout to the start. α = 0.85β. < : α + σ > : α - σ ◄ : α + 2σ ► : α - 2σ σ=2.2°	**Runout Indices** 11, 12, ...20 See VÍ-R99001-ÚR01 Longest avalanche runout: ×	**Profile:** neib27aa **Drawn by:** LT **Date:** 7.5.2001 **Drawing:** 22

neib28aa



ICELANDIC METEOROLOGICAL OFFICE

Hazard evaluation
Runout model and hazard zones

Stóralækjargil

Hazard evaluation
Runout models and hazard zones

Hazard zones
C : Risk more than 3·10-4
B : Risk between 3·10-4 and 1·10-4
A : Risk less than 0.3·10-4
According to July 2001 hazard zone regulations.

α/β-model
β: Angle from the start to where the slope is 10°.
α: Angle from runout to the start. α = 0.85β.

< : α + σ
◄ : α + 2σ
> : α - σ
► : α - 2σ
σ=2.2°

Runout indices
11, 12, ...20
See VÍ-R99001-ÚR01

Longest avalanche runout: ×

Profile: neib28aa
Drawn by: LT
Date: 7.5.2001
Drawing: 23