Invest in Iceland Agency
Energy Marketing

DYSNES

A Preliminary Site Study for a Primary Aluminum Plant in Eyjafjördur

Prepared by

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1. INTRODUCTION

Over the last few years the Invest in Iceland Agency-Energy Marketing (IIA) has conducted studies on potential industrial sites at various locations in Iceland. One of those sites is Dysnes in Eyjafjördur, a long deep fjord in northern Iceland. Dysnes is located on the west coast of Eyjafjördur, in the Arnarneshreppur District, 18 km north of Akureyri, the largest town in Iceland outside the Reykjavík capital area. The Commerce and Tourism Office of the Eyjafjördur Area (AFE) has taken an active part in studies at Dysnes, and in some cases, consulting companies and various institutions have been assigned to assist in preparing data.

The Dysnes location is a “greenfield site” in the sense that virtually no site preparation has taken place. It is located in a thinly populated rural area, in the centre of the developed Eyjafjördur Region, where all necessary infrastructure can be established at short notice.

Mapping and extensive studies have been carried out at the site over the last two decades in order to investigate the technical, environmental and economic premises for major industry.

On February 15, 2002, agreements were signed between IIA and Atlantsál regarding pre-feasibility studies for a 360,000 tpy aluminium smelter located at Dysnes or Húsavik.

This report is a preliminary study for locating a 180,000 tpy primary aluminium smelter at Dysnes, based on a plant layout and further information from Atlantsál, matched with local conditions at the site. An extension of up to 360,000 tpy is discussed but not studied in detail.

The Master Plan for Arnarneshreppur District provides for an approx. 120 ha industrial site at the coast, easily sufficient for the first stage. The extension from 180,000 to 360,000 tpy calls for revision of land use in the Master Plan for Arnarneshreppur District or changes in the layout.

This report was made up for the IIA by Almenna verkfræðistofan and Verkfræðistofa Nordurlands Consulting Engineers and Electrical Consulting Engineers Rafhönnun, with assistance from the Icelandic Meteorological Office and the Icelandic Institute of Natural History, Akureyri.

2. THE EYJAFJÖRDUR AREA

2.1 General

Eyjafjördur is a long, deep fjord in the northern part of Iceland. At the south end of the fjord is Akureyri, the capital of northern Iceland, and along its shore are the fishing villages of Ólafsfjördur, Dalvík and Grenivík. In the fjord are two islands, Hrólfssker and Hrísey, helping to protect the fjord against the ocean waves and securing superior harbour conditions in the inner part of the fjord.

At the head of Eyjafjördur is a long, deep valley, known for centuries as one of the most prosperous agricultural areas in Iceland. Eyjafjördur and the Eyjafjördur Valley are surrounded by mountain ridges which contribute to the relatively calm and mild weather, that is typical at the area.

The population of the region is about 21,000 living in nine communities as follows:

	Inhabitants (2002)	
Akureyri	15,840	
Arnarneshreppur	183	(location of Dysnes)
Dalvíkurbyggð	2,040	
Eyjafjarðarsveit	974	
Grýtubakkahreppur	392	
Hríseyjarhreppur	186	
Hörgárbyggð	370	
Ólafsfjörður	1,041	
Svalbarðsstrandarhreppur	380	
Total	**21,406**	

The main sources of employment in the region are agriculture, fishing and various industries and a rapidly growing service sector.

2.2 Akureyri

Akureyri with its developed infrastructure and 15,840 inhabitants is the capital city of northern Iceland. Akureyri was established as a trading post many centuries ago due to favourable harbour conditions and its strategic location.

Over the last century, Akureyri developed into an industrial, trading and service centre with a rapidly growing fishing industry. Today, Akureyri is the administrative and transport centre for the region, and its role as an educational centre is fast growing. Akureyri has one of the country's leading universities, which together with two colleges offers a wide range of higher education. The Akureyri hospital is the second largest hospital in Iceland with a staff of 650.

The local economy is supported by a growing commercial and service sector, in which over 20 percent of the local working population is employed. Other major economic activities are fishing and various industries. Akureyri contains some of the most modern fish-processing plants in the country, and the Slippstöðin shipyard is one of the area's key enterprises. In terms of variety of services and shopping,

Fig 1: Akureyri, the capital city in northern Iceland. (Photo: Oddur Sigurðsson)

composition of industries, culture and trade, Akureyri ranks second only to the capital city Reykjavík.

The Akureyri harbour, with its deep and calm waters, is an important export/import harbour and home for a fleet of fishing vessels. The Icelandic container shipping lines operate efficient cargo handling services at the port and trucking services to and from Akureyri.

The Akureyri airport has a single 2000 m runway. There are a number of scheduled flights between Akureyri and Reykjavík every day.

Most buildings in Akureyri are heated with geothermal water.

Akureyri, with its mild climate, clean environment and high standard of living, is appreciated by local people as a good place to live, work and play.

2.3 Arnarneshreppur Community

Arnarneshreppur, the community where Dysnes is located, is on the west coast of Eyjafjördur, extending north from the mouth of the river Hörgá. Arnarneshreppur, with its 183 inhabitants, is a rather thinly populated rural area where agriculture is the main economic activity. The farms are mainly located in a row along the hillside, and the lowland is flat and marshy in part. On the coast is the old fishing village Hjalteyri, where there was a lively herring industry early in the last century. Now a growing halibut hatching industry is located at Hjalteyri.

2.4 Other communities in the region

The rest of the Eyjafjördur area consists of fishing villages, rural areas or communites with mixed sources of employment. The fishing villages traditionally have a harbour, a fish processing plant and basic daily services. The rural areas are predominantly agricultural, some of them numbering among the most prosperous agricultural areas in Iceland.

All of these communities are relatively small and rely heavily on Akureyri as their trading and service center.

3. DYSNES LOCATION

The Dysnes industial site is located on a lowland area in the Arnarneshreppur District on the west coast of Eyjafjördur, north of the river Hörgá. (See fig 2).

The distance by road from Dysnes to various locations in the Eyjafjördur area is as follows:

Akureyri	18 km
Akureyri airport	22 km
Hjalteyri	5 km
Hauganes	18 km
Árskógssandur	19 km
Dalvík	28 km
Ólafsfjörður	46 km
Grenivík	59 km

The distance from Dysnes to Reykjavík by road is 389 km. The flying time Akureyri – Reykjavík is 45 minutes

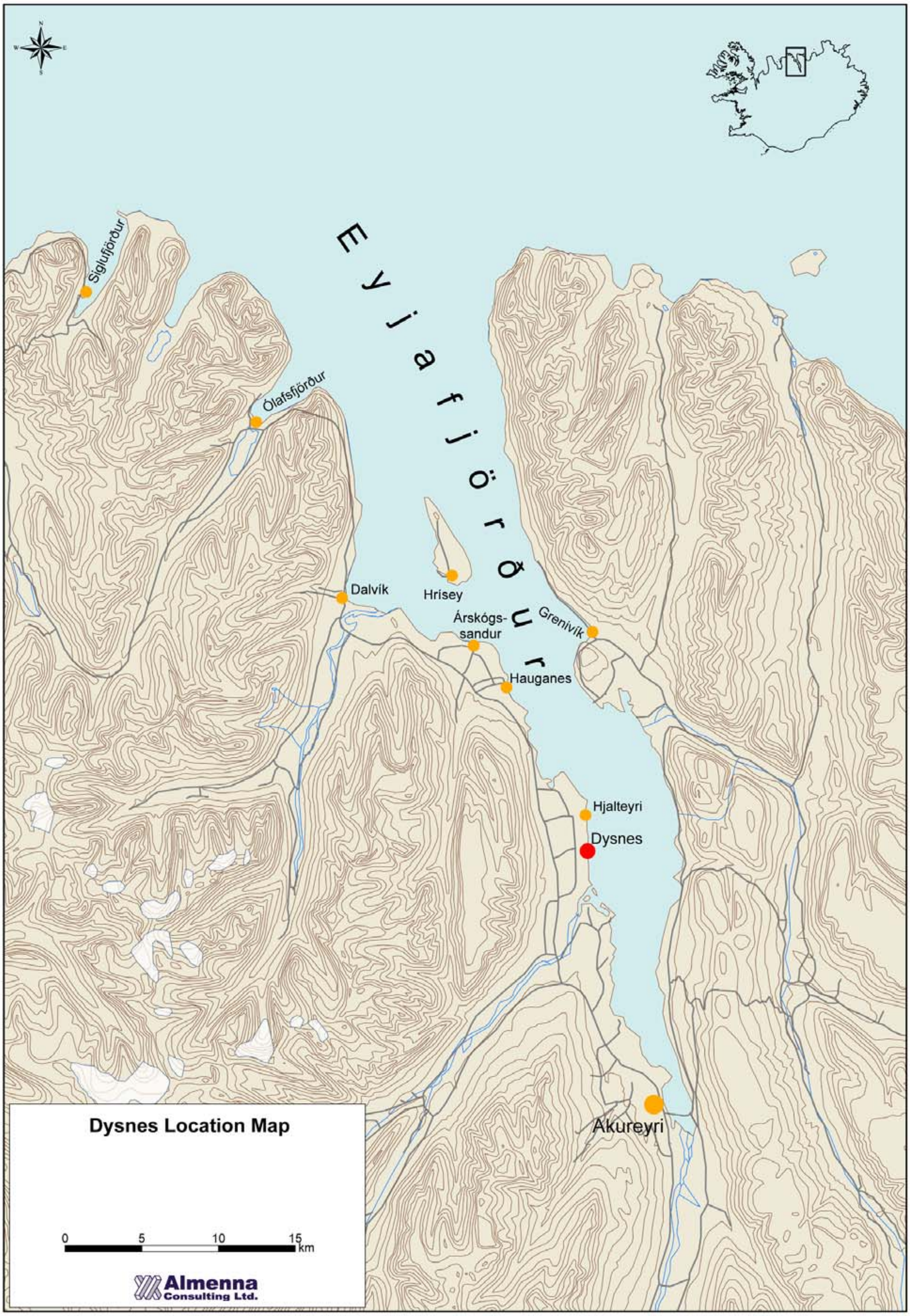

Fig 2: Dysnes location map.

4. THE DYSNES INDUSTRIAL SITE

4.1 Geology

The bedrock in Arnarneshreppur District and at the Dysnes site consists of basalt rock layers, inclining approx. 4° to the South. The bedrock at the industrial site is covered by loose layers. These layers are mainly glacial moraine covered by organic soil, humus or peat. It is likely that fissures, like faults and dikes, can be found in many places in the bedrock. It is impossible to locate such fissures with any certainty through visual inspection of the industrial site, since the bedrock is covered by overburden and only exposed at the coast and in the Pálmholtslækur Creek. The exact location of two fissures mentioned in a research report by the National Energy Authority in 1983 is therefore very uncertain. The thickness of the moraine varies considerably from a very thin layer to as much as 2 or 3 meters at the industrial site. North of the site at Bakkaás and Arnarnesnafir the moraine is dozens of meters thick.

The moraine is dense and hard, probably due to the load from the glaciers in the last glacial period. The water content of the moraine can be considerable, but ground water seapage through it is very slow. Exposed to the air, moraine can become saturated with water and totally lose its bearing capacity. This is well known and must be considered during construction.

Some sand and gravel can be found in the area, mainly close to the river Hörgá. Those formations are ancient gravel terraces, formed at the end of the last glacial period, when the sea level was higher than it is today. At that time, the edge of the glacier in Hörgárdalur Valley was at the mouth of the valley, and glacial rivers formed thick deltas on the coast. The remnants of those deltas are Lónsmelar, the gravel terraces south of the river Hörgá. Considerable gravel material is also found north of the river Hörgá, and thin terraces can be found, for example at the farms Gilsbakki and Sjávarbakki approx. 20 m.a.s.l., in the center of the industrial site. Some other formations from the last glacial period are to be found in the area. On the hillside, south of the farm Hvammur, there are two alluvium terraces, Reidholt and Selás, formed when the glacier was close to the hillside. The material is most likely moraine but possibly also some coarse gravel deposits from a glacial river.

The humus and peat soil on top of the moraine in the area is of varying thickness. In Pálmholtsmýri, a wetland west of the industrial site, the thickness of the peat can even exceed 10 m.

4.2 Site conditions

The planned industrial area according to the Master plan of Arnarneshreppur is on a lowland area between the road to Hjalteyri and the coast. The total area is 120 ha, 1800 m long and 675 m wide. The area is mainly flat but partly leaning toward the sea. The Pálmholtslækur Brook runs through the site, and must be diverted if long buildings are to be erected at the site.

Arnarneshreppur is a rural area where agriculture and some fishing are the main industries. Agriculture has been declining rapidly in the vicinity of the site, and only few farms are left.

In 1983, site investigations were conducted north of Pálmholtslækur Brook by drilling holes with a cobra drill and digging some test holes. In 1990, the site south of Pálmholtslækur also was investigated by digging a net of test holes. The depth to bedrock is normally 2-3.5 m and a maximum 6-7 m at the deepest spots. The bedrock consists of basalt layers inclining slightly SW. The overburden is divided into two layers. On top of the bedrock is normally a 1-3 m thick layer of rather fine moraine or deposits of sand and gravel. On top of that is a layer of humus or peat 1-2 m thick. The geotechnical properties of the moraine and sand layers have not yet been investigated.

4.3 Site Preparation – Stage 1, Capacity 180,000 tpy

The site has been evaluated for a new aluminum smelter with a capacity of 180,000 tpy in two potrooms and an anode plant according to a layout submitted by Altantsál. The two potrooms are located parallel to the Hjalteyri Road, and they cross the Pálmholtslækur Brook, which must be relocated. (See drawing nr. 804.00 M 01).

The cost estimate assumes that organic materials and moraine from the pot room area will be excavated and dumped west of the site, forming an earth barrier to protect the site against melting snow and spring floods. Excavated rock would be compacted as fill on the site. It is further assumed that the load bearing capacity of the moraine is sufficient for light buildings, roads and park areas, but that potrooms would be founded on rock.

In the following estimates, it is assumed that the whole lot is paved with 5cm asphalt with a coarse base layer and sufficient load bearing capacity for daily traffic. A complete sewer system and gutters is foreseen. Earthwork and backfill for the various buildings are also included in the cost estimate.

Due to the slope towards the sea, two alternatives were studied for site preparation: alternative 1 with the site on split level, and alternative 2, a lower site but on one level.

The following apply to all cost estimates in this report:

Prices are estimated contractor prices, price level March 2003.

Building Cost Index 285.5

US Dollar Cost indications are based on the exchange rate of March 10, 2003 at 76.61 ISK.

A. Alternative 1 – Site on split level

Upper level with potrooms, casthouse, laboratory, pot maintenance and electrode plant at the upper level approx. 20 m.a.s.l. Auxiliary buildings on a lower level approx. 17 m.a.s.l. Potrooms founded on bedrock, other buildings founded on moraine, gravel deposits or compacted fill.

		Quantity		Unit Price ISK	ISK x 1000	USD x 1000
1.	Excavation loose, transport to dike	950,000 m^3	@	310	294,500	3,844
2.	Excavation moraine, transport 2 km	250,000 m^3	@	390	97,500	1,273
3.	Excavation rock, transport within site	250,000 m^3	@	1,000	250,000	3,263
4.	Leveling and compaction blasted rock	300,000 m^3	@	110	33,000	431
5.	Fill compacted	350,000 m^3	@	420	147,000	1,919
	Earth work	**Subtotal excl. VAT**			**822,000**	**10,730**
6.	Sewer system (12-24")	11,000 m	@	35,000	385,000	5,025
7.	Gutters	400 pcs	@	29,000	11,600	151
8.	Base – Subbase Coarse	60,000 m^3	@	1,300	78,000	1,018
9.	5 cm Asphalt Pavement	200,000 m^2	@	1,000	200,000	2,611
10.	Fencing 2.5 m	3,400 m	@	10,500	35,700	466
11.	Slope grading and protection	34,000 m^2	@	410	13,940	182
12.	Leveling of dike and dump areas, seeding	100,000 m^2	@	120	12,000	157
	General Site Preparation	**Subtotal excl. VAT**			**1,558,240**	**20,340**
13.	Access road (7.5 m + shoulders)	3,500 m	@	23,000	80,500	1,051
14.	Harbour road	500 m	@	32,000	16,000	209
15.	Steel culvert ø 2000	15 m	@	26,000	390	5
16.	Water supply			LS	125,000	1,631
		Total excl. VAT			**1,780,130**	**23,236**
		VAT 24.5%			**436,132**	**5,693**
		Total incl. VAT			**2,216,261**	**28,929**

B. Alternative 2 – Site on one level

Elevation of the site 18 m.a.s. All buildings on same level.

		Quantity		Unit Price ISK	ISK x 1000	USD x 1000
1.	Excavation loose, transport to dike	900,000 m^3	@	310	279,000	3,642
2.	Excavation moraine, transport 2 km	500,000 m^3	@	390	195,000	2,545
3.	Excavation rock, transport within site	550,000 m^3	@	1,000	550,000	7,179
4.	Leveling and compaction blasted rock	400,000 m^3	@	110	44,000	574
5.	Compacted fill	50,000 m^3	@	420	21,000	274
	Earth work	**Subtotal excl. VAT**			**1,089,000**	**14,214**
6.	Sewer system (12-24")	11,000	@	41,500	456,500	5,959
7.	Gutters	400 pcs	@	29,000	11,600	151

8.	Base and subbase coarse	$60,000\ m^3$	@	1,300	78,000	1,018
9.	5 cm asphalt pavement	$200,000\ m^2$	@	1,000	200,000	2,611
10.	Fencing 2.5 m	3,400 m	@	10,500	35,700	466
11.	Slope grading and protection (humus and grass)	$34,000\ m^2$	@	410	13,940	182
12.	Leveling of dike and dump areas, seeding	$100,000\ m^2$	@	120	12,000	157
	General Site Preparation	**Subtotal excl. VAT**			**1,896,740**	**24,758**
13.	Access road	3,500 m	@	23,000	80,500	1,051
14.	Harbour road	500 m	@	32,000	16,000	209
15.	Steel culvert ø 2000	15 m	@	26,000	390	5
16.	Water supply			LS	125,000	1,631
		Total excl. VAT			**2,118,630**	**27,654**
		VAT 24.5%			**519,064**	**6,775**
		Total incl. VAT			**2,637,694**	**34,429**

Elevation of the site has not been optimized
Possible future extension is not included.

This comparison indicates that Alternative 1, site on split level, is lower in cost than totally level site. All further discussion in this report will be based on Alternative 1.

4.4 Site Preparation – Stage 2, Extension from 180,000 to 360,000 tpy

A possible extension with two extra potrooms increasing capacity from 180,000 tpy to 360,000 tpy seems to be best located west of the Hjalteyri Road as shown on drawing 804.00 M 01. This extension is outside the present industrial area of the Master Plan of Arnarneshreppur, which in that case would have to be revised. The site preparation for the extension has therefore not been studied in detail.

A rough estimate would be:

		Quantity		Unit Price ISK	ISK x 1000	USD x 1000
1.	Excavation loose, transport 2 km	$250,000\ m^3$	@	310	77,500	1,011
2.	Excavation moraine, transport 2 km	$275,000\ m^3$	@	390	107,250	1,400
3.	Excavation rock, transport 2 km	$280,000\ m^3$	@	1,000	280,000	3,655
4.	Leveling and compaction blasted rock	-----	@	-----	------	------
5.	Compacted fill	$32,000\ m^3$	@	420	13,440	175
	Earth work	**Subtotal excl. VAT**			**478,190**	**6,241**
6.	Sewer system (12-24")	3,000 m	@	35,000	105,000	1,370
7.	Gutters	200 pcs	@	29,000	5,800	76

8.	Base and subbase coarse	23,000 m^3	@	1,300	29,900	390
9.	5 cm asphalt pavement	90,000 m^2	@	1,000	90,000	1,175
10.	Fencing 2.5 m	1,300 m	@	10,500	13,650	178
11.	Slope grading and protection (humus and grass)	3,000 m^2	@	410	1,230	16
12.	Leveling of dike and dump areas, seeding	100,000 m^2	@	120	12,000	157
	General Site Preparation Stage 2	**Subtotal excl. VAT**			**735,770**	**9,603**
		VAT 24.5%			**180,264**	**2,353**
		Total incl. VAT			**916,034**	**11,956**

5. THE PÁLMHOLTSLÆKUR BROOK

Two small streams, the Reistará Brook and the Hvammslækur Brook come from the mountain side west of Dysnes. At main road 813, Reistará Brook changes its name to Pálmholtslækur Brook, which flows through the lowland into the sea. On the lowland, the Hvammslækur Brook joins the Pálmholtslækur Brook, which then flows through the industrial site.

The total catchment area of the two brooks is 18.48 km^2 at the sea. The average flow of Pálmholtslækur Brook at the site is estimatedet at 0.5 – 0.7 m^3/S. The maximum floods in the two brooks have been estimated at 100, 500 and 1000 years respectively as follows:

Estimated max flow

	Q_{100}	Q_{500}	Q_{1000}
	m^3/S	m^3/S	m^3/S
Reistará at main road 813	32	41	45
Hvammslækur at main road 813	8	10	11
Pálmholtslækur at unification	35	44	48
Hvammslækur at unification	8	12	13
Both brooks after unification	43	56	61
Pálmholtslækur at lower end	47	61	67

There are plans to divert Pálmholtslækur Brook to the north around the industrial site by excavating a ditch from the unification of Hvammslækur and Pálmholtslækur Brooks through the lowlands north of the site and down to the sea. The ditch has been predesigned to master a maximum 1000 years flow. The bottom of the ditch is 2 m wide with a slope of 1:3 in loose materials and 3:1 in rock.

At the uppermost part of the ditch, from station 0-80 on the lowland, big floods would flow over the borders. In this part, a dike on the lower bank is planned in order to avoid water flowing uncontrolled towards the site.

The ditch runs mainly through peatland with thick moraine underneath. The last 300 m of the ditch are excavated in solid rock, up to 3 m deep. In this part of the ditch, some erosion will certainly take place due to the steeper grade and higher water velocity. However the rock at the lower end will surely protect the bottom.

In the upper parts of the ditch, some erosion will also take place, both at the bottom and in the slopes on both sides. The erosion in the peatland can certainly be prevented to a large extent by seeding grass on the banks at both sides.

The cost estimate for the relocation of Pálmholtslækur Brook is as follows:

	Quantity	Unit Price ISK	ISK x 1000	USD x 1000
Excavation loose	59,000 m^3 @	350	20,650	270
Excavation moraine	29,000 m^3 @	430	12,470	162
Excavation rock	4,000 m^3 @	1,150	4,600	60
	Total excl. VAT		**37,720**	**492**
	VAT 24.5%		**9,241**	**121**
	Total incl. VAT		**46,961**	**613**

According to these figures, the relocation of Pálmholtslækur brook is a minor issue in the total preparation.

6. HARBOUR

Eyjafjördur is a long, deep fjord, where harbour conditions are favorable, especially in the inner part of the fjord. Ocean waves hardly reach south of the island Hrísey so waves in the inner part are mainly limited to wind waves across the fjord.

Studies for a new harbour at Dysnes started in 1982, when a survey of the seabed was made by the Icelandic Maritime Administration. The same year, seismic refraction research was done by the Ocean Research Institute to investigate the thickness of the sediment layers in the seabed and the depth of the bedrock.

In the summer of 1999, the sediment layers were further investigated by drilling three test holes and taking samples from the soft layers. The samples were tested by the Icelandic Building Research Institute. The sediment layers consist mainly of organic, average plastic silt with some silicate aggregates, but the lowest 1 m layer on top of the bedrock is a dense sandy sediment.

Based on the information above, a harbour project serving a possible aluminum plant at Dysnes has been predesigned and evaluated. The facilities are designed for 60,000 DWT ore carriers (Panamax) at the outside of the pier, and 10-11,000 DWT freighters on the inside, intended for export of products. It is estimated that export will take place either by 6-8,000 DWT ships coming twice a week, or by 10-11,000 DWT ships once a week. Those criteria are used to determine the length of the berth and the storage area on the pier. Thus the length of the pier has been set at 260 m, and the width at 42 m, allowing space for unloading equipment, cranes and storage for export. Depth at the outer berth is –14 m, but –11 m on the inside. The pier is made of sheet piling backfilled with gravel and connected across the pier by anker rods. Because of the soft sediment layers, a trench with stable materials is provided for the sheet piling. On top of the sheet piling, a concrete edge beam is provided, and 50 t and 100 t pollards and fenders are foreseen. The deck of the pier is paved with 6 cm asphalt.

		ISK x 1000	**USD x 1000**
Cost estimate:			
1.	Move in	13,000	170
2.	Earth work incl. 6cm asphalt	296,500	3,870
3.	Sheet piling	316,000	4,125
4.	Concrete work incl. pollards and fenders	176,000	2,297
5.	Miscellaneous, el., lighting, water etc	12,000	157
	Total excl. VAT	**813,500**	**10,619**
	VAT 24.5%	**199,308**	**2,601**
	Total incl. VAT	**1,012,808**	**13,220**

7. CONSTRUCTION MATERIALS

In 1990, the Akureyri Museum of Natural History made a report on possible construction materials in the vicinity of Dysnes. It is stressed in the report that only availability is studied, ownership and environmental aspects are not considered.

The bedrock in the lowlands is mainly covered with thick sediments and humus. Most of the sediment is moraine or deposits from glacial rivers from the last glacial period. At the mouth of the river Hörgá and in the sea off the river mouth, there are young gravel deposits that the river has transported a long way from the Öxnardalur and Hörgárdalur Valleys. Those materials have mainly eroded from layers related to an old central volcano, resulting in mixed aggregates which should be further studied before use as concrete aggregates.

The closest known major deposits of suitable fill materials on land are on the hillside between the farms Hvammur and Ytra Brekkukot approx. 4 km away from Dysnes. There are large quantities of material here and it is very likely that coarse base material, fill material and possibly concrete aggregates can be excavated here.

The farm Möðruvellir is located on a big plain at the mouth of the Hörgárdalur Valley. The plain is a large deposit from rivers in the last glacial period. There are substantial quantities of sand, gravel and stones here. For many reasons it must be considered rather unlikely that it will be possible to excavate construction materials from the Möðruvellir plain.

There are other possibilities to excavate gravel and fill materials from areas in the vicinity, such as Neskotshóll, Spónsgerði or Björg, all 6-8 km away from Dysnes.

The most economic way of obtaining gravel and fill material may be to pump it up from the deposit in the sea at the mouth of the river Hörgá. It is very close to the site, and is considered an easy operation by experienced operators of pumping ships. Another possibility is pumping materials from the Fnjóská deposits, if material obtaining at Hörgá does not prove to be feasible.

Concrete aggregates in the area have been taken mainly at Lónsmelar or Bjargarnáma, both close to the river Hörgá. Material quality, land ownership and environmental aspects should be considered early enough to find feasible deposits of concrete aggregates and fill materials.

8. POWER SUPPLY

Landsvirkjun, the National Power Company, produces around 85% of Iceland's electricity, a total of 8,028 GWh/year, and it owns and operates the national power grid. Landsvirkjun's Power System is seen in Figure 3. The major share of production comes from the southern rim of the central highland. As indicated, the transmission lines are mainly 132 kV except the 220 kV lines between power intensive industry, located in the southwest part of the country and power stations in the southern highlands.

Figure 3. Landsvirkjun`s power system year 2001 (source: Landsvirkjun).

There is currently no surplus in the power system to meet the power requirements of new power intensive industry. It will therefore be necessary to harness one or more of the potential energy resources to supply the new aluminum smelter located at Dysnes. According to Orkustofnun, the National Energy Authority, only 10-15% of technically feasible hydropower has been harnessed, and only a fraction of the geothermal potential available for electricity production.

There are several potential energy resources, both hydropower and geothermal resources, relatively close to Dysnes, that could supply power to the project. The high-temperature geothermal fields at Krafla and Theistareykir are less than 100 km east of Dysnes, and potential hydropower resources are approximately 110 km to the south or southwest.

The existing power grid in northern Iceland does not meet the requirements of new power intensive industry, with regard to transmission capacity, voltage level etc. It will be necessary to reinforce/rebuild the appropriate power grid lines in the northern part of the country.

The common procedure for Landsvirkjun is to deliver the power to the customer's switchyard. Other power intensive industries in Iceland therefore own and operate the switchyard, or the main step down substation for the smelter.

A pre-feasibility study has been made related to new power intensive industry located in the northern part of the country. The study is based on a 360,000 tpy smelter located at Dysnes or Húsavík east of Eyjafjördur. Figure 4 shows possible modifications of the power system and transmission lines in order to meet requirements from new power intensive industry.

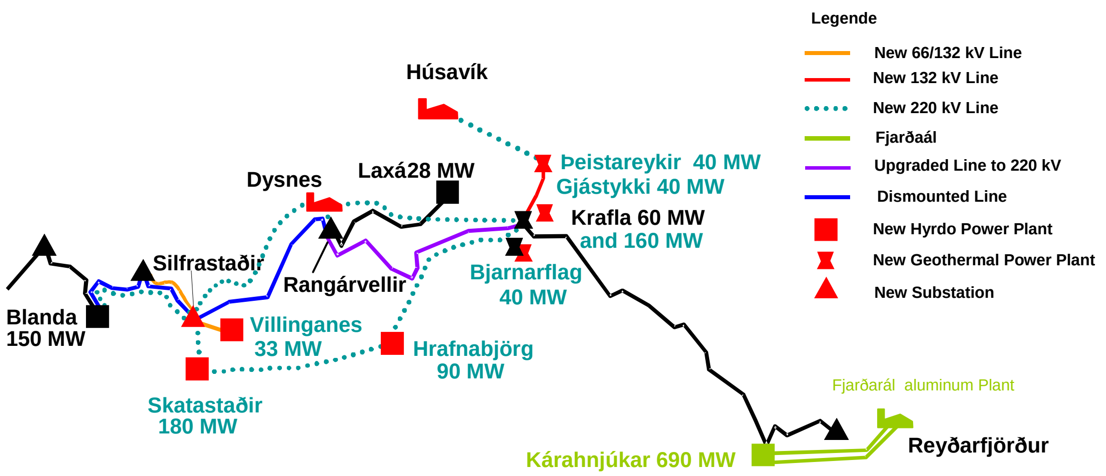

Figure 4. Possible future power system in Northern Iceland to serve power intensive industry at Dysnes and Húsavík (Source: Landsvirkjun)

As indicated in figure 4, power will be supplied by hydropower and geothermal power plants in the vicinity of both industry sites. It is assumed that considerable modification will be made to the power grid, e.g. new 220 kV transmission lines will be installed instead of 132 kV and new power transformers wil be required.

Taking only the smelter into consideration, the first stage of 180,000 tpy would need two independent 220 kV transmission lines (to meet the n-1 power delivery security). The second stage, extension up to 360,000 tpy, would require a third power line.

The power stations and transmission lines are currently at feasibility or pre-feasibility stage.

9. WATER SUPPLY

Potential water supply has been studied by both the National Energy Authority (1981-84) and the Akureyri Museum of Natural History.

The most promising source for both potable and industrial water is the area around the Hörgá river, 3-5 km away from Dysnes.

The Akureyri municipal waterworks obtain their potable water from boreholes in deposits around the Hörgá River south of the school Þelamerkurskóli in Hörgárdalur Valley. It would probably be possible to get potable water for the industrial plant at Dysnes from the Akureyri water works via special pipe from the Akureyri water main at Moldhaugnaháls, 7-8 km from the site.

How the water would be supplied depends on the demand and criteria for industrial water. If surface water is adequate, industrial water could be taken directly from the river Hörgá 3-5 km away from the site. If industrial water has to be clean and almost meet the same criteria as potable water, it should be possible to establish a separate water supply from the huge deposits around the river Hörgá. A contract with the Akureyri waterworks for industrial water should also be considered.

The cost estimate allows for the plant´s own water supply with a capacity of 50 l/sec.

10. SUMMARY OF COST

The result of the cost estimates for site preparation and various facilities, discussed in this report, can be summarized as follows:

A Stage 1 – 180,000 tpy	**ISK x 1000**	**USD x 1000**
Site Preparation Stage 1 (180,000 tpy)		
Earth work	822,000	10,730
Finishing incl. pavement	736,240	9,610
Access road	80,500	1,051
Harbour road incl. culvert	16,390	214
Water Supply	125,000	1,631
Relocation Pálmholtslækur Brook	37,720	492
Harbour	813,500	10,619
Total Stage 1 excl. VAT	**2,631,350**	**34,347**
VAT 24.5%	**664,680**	**8,415**
Total Stage 1 incl. VAT	**3,276,030**	**42,762**

B. Stage 2 – Extension 180,000 – 360,000 tpy		
Site Preparation Stage 2, Extension 180,000 – 360,000 tpy		
Earth work	478,190	6,241
Finishing incl. pavement	257,580	3,362
Rough Estimate excl. VAT	**735,770**	**9,603**
VAT 24.5%	**180,264**	**2,353**
Total Stage 2 incl. VAT	**916,034**	**11,956**

A + B Stage 1 and Stage 2		
Site Preparation and facilities Stage 1	2,631,350	34,347
Site Preparation Stage 2	735,770	9,603
Total excl. VAT	**3,367,120**	**43,950**
VAT 24.5%	**824,944**	**10,768**
Total incl. VAT	**4,192,064**	**54,718**

11. GENERAL CONDITIONS

11.1 Weather conditions

Iceland enjoys a much milder climate than its name and location adjacent to the Arctic Circle would imply. This mild climate stems from the Gulf Stream and attendant warm ocean currents from the Gulf of Mexico. A branch of the warm Gulf Stream flows along the southern and western coast of Iceland, meeting the cold East Greenland Polar Current curving south-eastwards round the north and east coast. This brings mild Atlantic air in contact with colder Arctic air, resulting in a climate that is marked by frequent changes and storms. Furthermore this leads to more rainfall in the southern and western part than in the northern part of the island.

The climate in the Eyjafjördur area is dryer and more stable than in the southern part of Iceland, as can by seen from the following average figures for the years 1961-1990

	Temperature °C		Precipitation mm/year	Wind Velocity m/sec
	Jan	July		
Reykjavík	-0.5	10.6	798.8	11.4
Akureyri	-2.2	10.5	489.5	7.9

Since the weather in Akureyri is cooler and calmer than in Reykjavík during the winter, its also means that more precipitation falls as snow. The snow depth can be quite substantial calling for mechanical clearing of roads and industrial sites. Snow storms also are well known in the Eyjafjördur area as in most parts of Iceland, but they usually do not last very long.

11.2 Earthquakes

General

Iceland is a volcanic island, located on the crest of the Atlantic ridge which also happens to be the plate boundary between two of the major plates that form the earths crust (lithosphere), i.e. the North-American and Eurasian Plates. Between the two plates, a volcanic zone runs at a slant through Iceland heading NE from the Reykjanes peninsula in the southwest towards lake Mývatn and Axarfjörður in the north. The volcanic zone is characterized by young formations and active geothermal areas with volcanic activity and movement of the earth´s as crust. The movements result in earthquakes that are most intensiv at their origin (epicenters), fading out with distance.

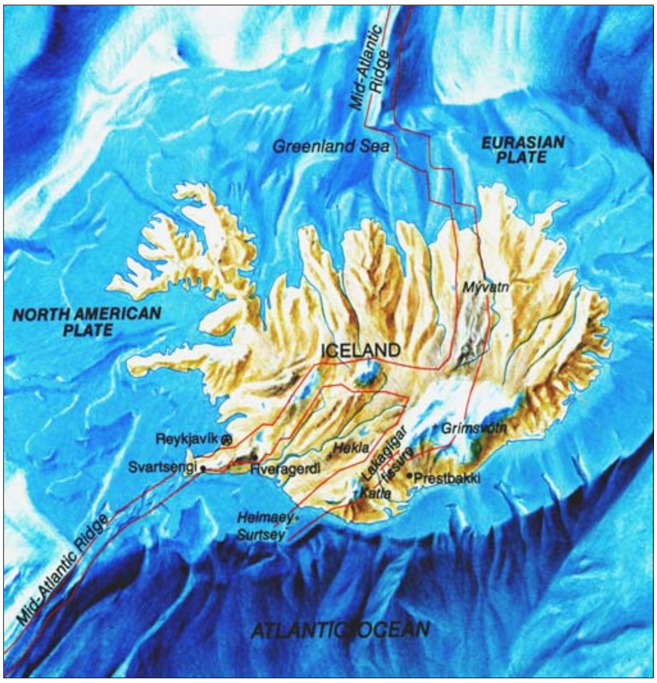

Fig 5: Plate boundaries and volcanic zone through Iceland (source: National Geographic).

The intensity of earthquakes is measured in grades on the Richter scale. Earthquake waves are both horizontal and vertical, and the acceleration of the movement is measured in cm/sec^2.

There are two major earthquake zones in Iceland. One is in the southern part of Iceland, reaching from the Reykjanes Penisula east to Rangárvellir and Hekla, east of the river Þjórsá. These earthquakes do not affect the Dysnes site. The other major earthquake zone lies north of the coast of Iceland generally known as the Tjörnes Fracture Zone, owing its existence to a displacement of the plate bondary. It is an extensive approx. 80 km wide main zone devided into two belts, heading WNW from the villages of Húsavík and Kópasker respectivly, passing north of the mouth

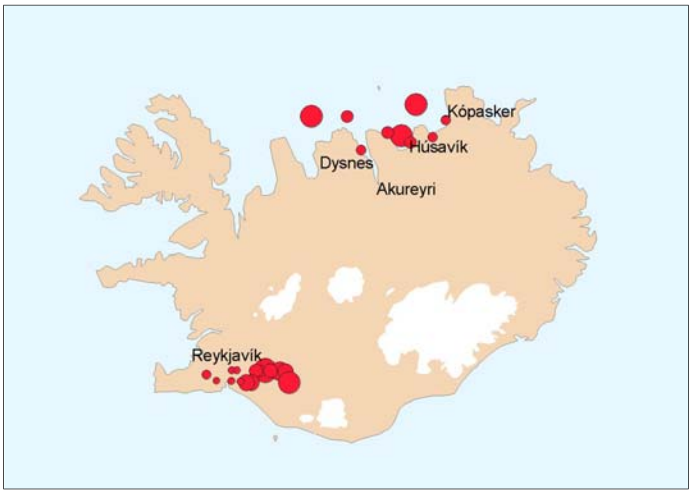

Fig 6: Origins of major earthquakes in Iceland since 1700. (Source: Páll Halldórsson 2002.)

of Eyjafjörður (see fig 7). In 1872 there was a series of earthquakes in this zone of magnitudes up to 6-7.

The origins of earthquakes in northern Iceland are not entirely limited to this major zone. A third belt is indicated running through Dalvík to the mouth of Skagafjörður. The best known earthquake in this area was that near Dalvík in 1934, approx. 25 km. north of Dysnes.

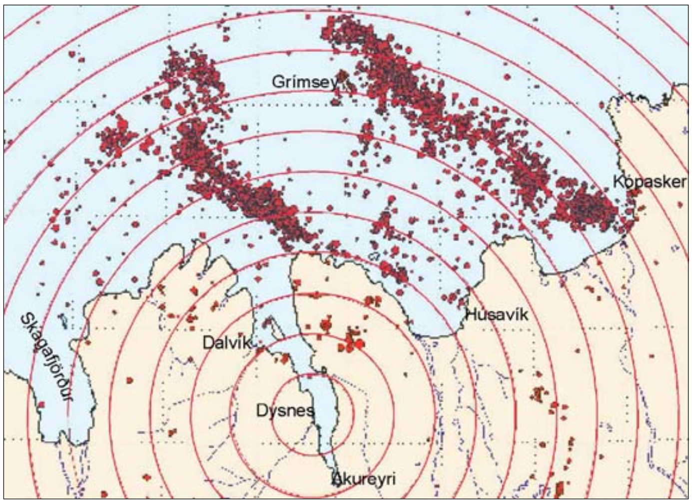

Fig 7: Origin of recorded erthquakes at the northern cost of Iceland. Distance rings from Dysnes with a 10 km intervall. (Source: Páll Halldórsson 2003).

Dysnes is well outside the epicenter areas of major earthquakes. However, the nearest earthquake zone, the Dalvík area is not far away. Earthquakes of up to 6.5 on Richter scale can be expected there, and would cause considerable acceleration at Dysnes.

Earthquake Design Criteria

All major structures in Iceland are designed according to an Earthquake Building Code.

The old Earthquake Building Code IST 13, which is still valid (March 2003) is being replaced by Eurocode 8, combined with an appendix (National Document) valid for Iceland. Eurocode 8, combined with the Icelandic "National Document", hereinafter called the New Earthquake Building Code, applied as of July 2002.

In the New Earthquake Building Code, the country is divided into 6 regions with different design loads for earthquake impact. The design acceleration varies from 0-0.4 g (g = the earths acceleration 9.81 m/sec^2) as shown in Fig 4.

The design acceleration at Dynes is 0.2 g. In comparison, the design acceleration at the following locations is as follows:

Reykjavík	0.1 – 0.3 g
Akureyri	0.1
Dalvík	0.4
Húsavík	0.4
Keflavík	0.3
Straumsvík	0.3

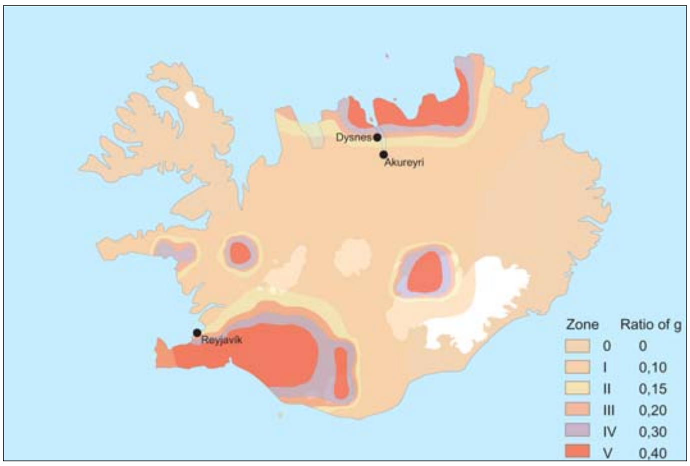

Fig 8: Earthquake zones according to the new earthquake building code.

The earthquake impact at Dysnes, according to the Eurocode 8 and the relevant

National Document for design provisions for earthquake resistance of structures in Iceland is rather modest on an Icelandic scale. The aluminum smelter at Straumsvík, where the design acceleration is 0.3 g, has been in operation since 1969, without any problems due to earthquakes. The hydro power stations of the National Power Company that are located in southwest Iceland where the design acceleration is 0.4 withstood a severe earthquake in year 2000 without any damage.

Damage to modern structures that are professionally designed according to the relevant Earthquake Building Codes is almost unknown in Iceland.

11.3 Sea ice

General

Both the Polar regions and the sea around them are more or less covered with ice. Wind and ocean currents constantly break up the ice fields and carry drift ice away until it melts in warmer waters.

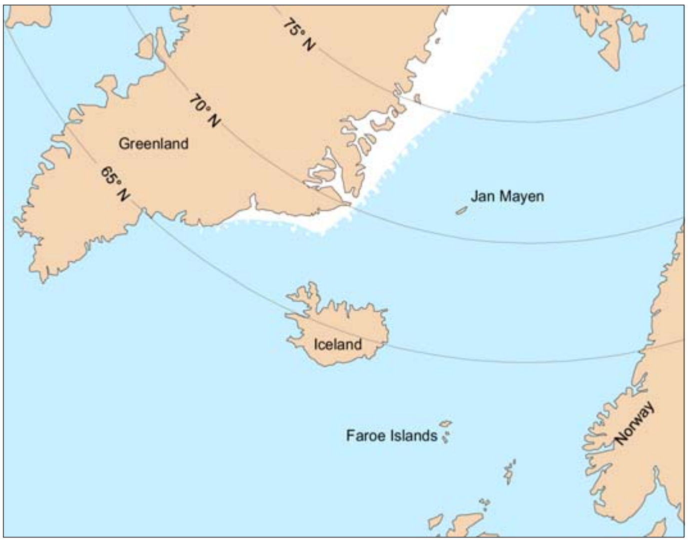

Fig 9: Median ice edge boundaries October 1. 1972-1982. (End of summer)

Iceland is located close to the East-Greenland current, the main ocean current from the Arctic Ocean. Far north in this stream, between Greenland and Svalbard, a great deal of drift ice constantly flows to the south, so the east coast of Greenland is very seldom ice free south to Scoresbysund or the 71°N latitude. In this area, also new ice is added that has been created in the sea off the East-Greenland coast as well as icebergs which have broken away from the glaciers in Greenland.

However, it should be noted that in recent years, the minimum seasonal ice extent in the fall has only reached south to approximately 75°N latitude. This is most likely due to global warming.

In the autumn, the spreading of the ice off East-Greenland increases, and new ice is formed. Later in the winter, the sea ice edge is normally midway between Iceland and Greenland. The spreading of the ice off Greenland culminates in May, when continuous ice fields reach along the whole east coast and around the southern tip of Greenland.

Sea ice in Icelandic waters has been observed and recorded for centuries in the Icelandic sagas, annals and diaries. In recent times it has been described by scientists and investigated more or less systematically by reconnaissance flights and observation records. In cooperation with the Icelandic Coast Guard, the Icelandic Meteorological Office (IMO) is in charge of sea ice monitoring in Icelandic waters, cooperating also with institutions abroad, that are responsible for the Artic regions. In Fig.9 and Fig.10 the median ice edge boundaries at the end of winter (June 1) and end of summer (October 1) for eleven years (1972-1982) are shown.

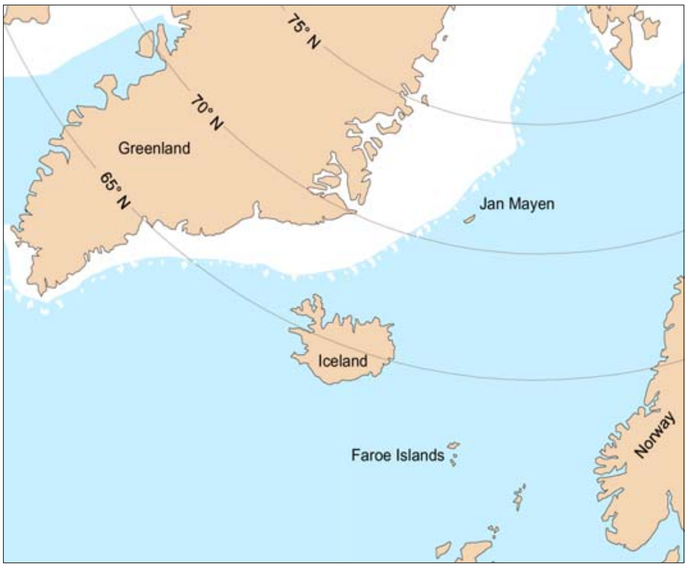

Fig 10: Median ice edge boundaries on June 1. 1972-1982. (End of winter)

Sea ice off the coast of Iceland

Although the edge of the drift ice is normally found in deep waters off the coast, keeping the sailing routes around Iceland clear of ice, exceptions to that situation are well known. Prevailing southwest- and westerly winds in the Denmark strait (the channel between Iceland and Greenland) can move the ice fields towards the coast, especially the Westfjords and Hornstrandir. Prolonged westerly winds can move the sea ice further to the East into the Icelandic sea north of Melrakkaslétta. If these westerly winds are followed by strong or prolonged northerly winds, there is a danger that sea ice will drift onto the sailing routes north of Iceland and even onto the north coast and in extreme cases, onto the east coast.

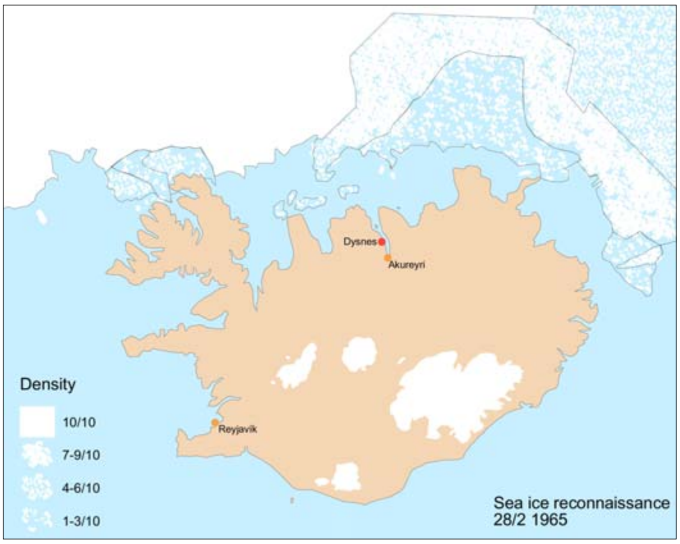

Fig 11: Extreme ice conditions off Iceland in February 1965.

Hence the area of Iceland where sea ice can reach the coast extends from the Westfjords to the east along the northern coast, around Melrakkaslétta and Langanes, and south along the east coast, south to the Eastfjords. The maximum distribution of the ice, if any, normally occurs in March and April. The main ice area is Hornstrandir in the Westfjords, where the ice spreads widest in March and where disturbance due to ice in shipping waters is most frequent. Off the north coast, there are definitely fewer days with ice, although disturbance at Melrakkaslétta in the northeast is well known.

It is the experience of the Icelandic people through the centuries, that sea ice off the coast varies immensely from one year to another. There can be long periods when practically no ice is recorded in Icelandic waters. At other times, sea ice has been a frequent and unwelcome guest off the coast. Variation in sea ice occurrence off the coast of Iceland is an excellent indicator of weather and climate fluctuations.

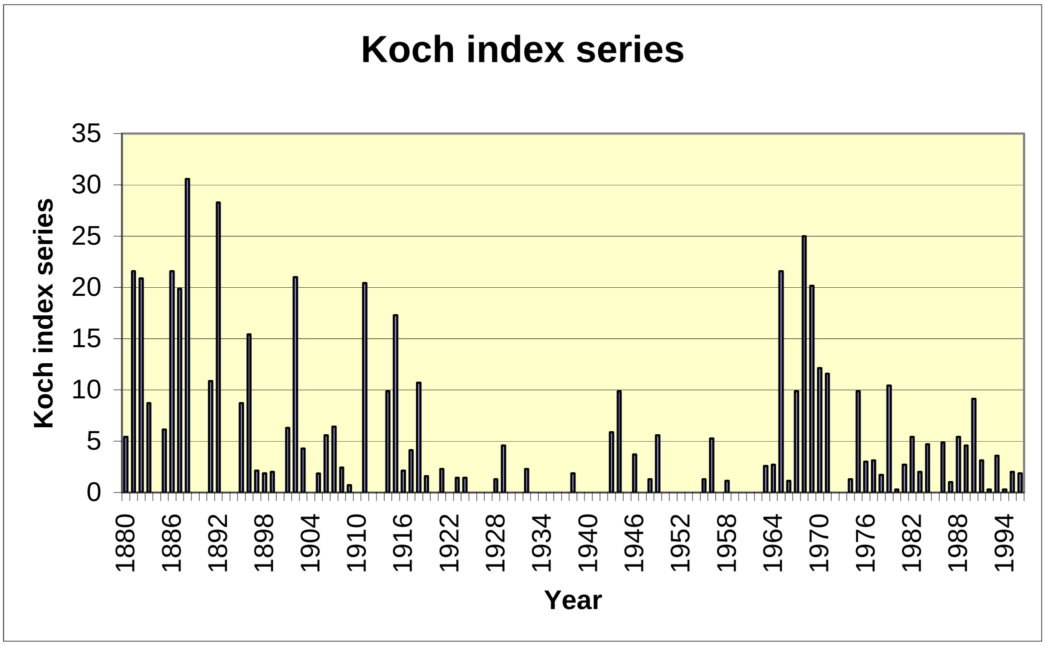

Fig 12: Changes in sea ice conditions off the coast at Iceland have been recorded for a long time according to a special sea ice index, the Koch-index which is a multiplication of weeks with sea ice and number of specified sections of the coast.

As can be seen from the so-called Koch index in Fig 12, the period from 1880 to 1920 was a period when sea ice was frequently seen off the coast of Iceland. Then there was a long, practically ice free period from 1920-1964. A new sea ice period was experienced from 1965-1971, when the ice was frequent and widespread. Since then, with the exception of 1979, sea ice off the coast of Iceland has been very moderate if there has been any at all.

Effect of sea ice on sea transport

The Icelandic Meteorologic Office keeps systematic records of "ice days" off the coast of Iceland. An "ice day" is a day when sea ice is recorded within 12 nautical miles of the coast. In these records, the coast is divided into 10 sections. See Fig.13.

For sea transport to and from Eyjafjörður and the entire north coast during sea ice periods, the conditions on the west route at Hornstrandir, and especially the east route across Melrakkaslétta are crucial. Annex 1 showns the "ice days" at three different locations for the period 1964-2001, including the last sea ice period from 1965-1971. These three locations are Hornstrandir (the west route), the north-east coast (around Eyjafjörður) and Melrakkaslétta (the east route).

The table in Annex 1 shows, that during a period of 37 years from 1964-2001 there were 3 years at Hornstrandir (the west route) and 3 years at Melrakkaslétta (the east route) when dense ice was recorded for more than 10 days. A conclusion from scanning the table could be that there were 4-5 years during this period of 37 years with considerable navigational disturbance due to sea ice.

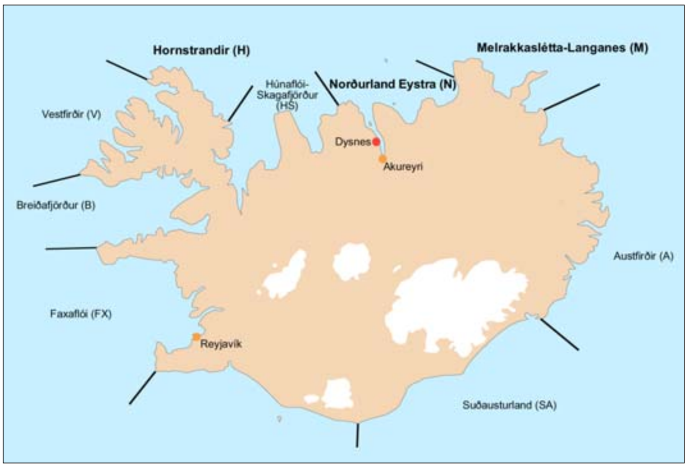

Fig 13: Sections of the coast of Iceland as basis for ice records.

It should be stressed that sailing along the west route can be easy even though the east route is closed and vice versa. Both routes along the north coast have been closed simultaneously in severe ice years only for a short time, 10 to 15 days at the longest during the heavy sea ice period 1965-1971. Even in the extreme sea ice year of 1968, it was possible to navigate with caution to Akureyri either via the western passage around Hornstrandir or the eastern passage around Melrakkaslétta, except for a few days in April and May.

Fig 14: Melting sea ice in June 1982 in the Greenland Sea, 71°N. (Photo: Thor Jakobsson).

According to the experience of centuries and modern analysis of available data, sea ice off the coast of Iceland is a very irregular occurrence. If, however, the above mentioned 37 years from 1964-2001 are typical for longer periods, the conclusion might be that one should expect some disturbance due to sea ice off the northern coast of Iceland every 8 to 10 years, for a few days at a time. The conditions when the ice threatens the sailing routes is well known and can be forecast a few days ahead. High tech reconnaissance and modern information technology have totally changed possibilities to cope with sea ice and made it into a team work between seafarers and those who monitor the ice in Icelandic waters. Consequently, occasional temporary disturbances of the northern sailing routes due to sea ice are not considered a hindrance to locating energy intensive industry in northern Iceland.

11.4 Infrastructure

Road connection: The Dysnes site is only 3 km away from the main paved road system in Iceland. These 3 km of road must be rebuilt simultaneously with the site preparation.

The main road system in the Eyjafjörður area consists of paved public roads, kept open year round by the Public Road Administration, with the occational exception of a few hours under extreme weather conditions.

Reykjavík is 390 km away via a main road. The road is mainly on lowland and open year round. Disturbance in road traffic can accur under extreme snow or weather conditions, especially on the two or three elevated sections of the road. This disturbance normally does not last long.

Connection by air: The Akureyri airport is the main air traffic centre in northern Iceland and an auxiliary airport for international flights. There are 4-7 scheduled flights a day by Air Iceland between Akureyri and Reykjavík, starting early in the morning and running till late in the evening. Flying time is 45 minutes. There is also commuter air traffic from Akureyri to the small airports or landing strips in north and northeast Iceland.

There are no scheduled flights between Akureyri and Keflavík International Airport. International passengers must travel 50 km by car between Keflavík and Reykjavík for connecting flights Reykjavík-Akureyri.

Power line: The main electricity substation for the Eyjafjördur area is located at Rangárvellir close to Akureyri. From this substation, a power line runs through Arnarneshreppur north to Dalvík. The line is designed for 130 kV but operates on 66 kV. The power line is only 2 km from the Dysnes site, and is, with a preliminary connection, easily sufficient for a construction period for major industry at Dysnes. Power for operation of the aluminium smelter is discussed in a special chapter.

Telecommunications: Telecommunications are developed in the Eyjafjördur area as elsewhere in Iceland. The connection point for a new major telephone customer would most likely be at Hjalteyri, 5 km north of Dysnes or at Björg in the Hörgárdalur Valley. There is a fibre optic cable along the hillside behind the row of farms in Arnarneshreppur district. A fibre optic connection to the site would be approx. 3-4 km long. A microwave connection from stations across the fjord is also possible. Links to the telephone system and the Internet could be provided right from the start of construction.

Harbours: The ports at Akureyri and Dalvík, a township 28 km north of the site are the main cargo handling ports in the Eyjafjördur area. The draft at Akureyri is 8.2 m and 7.5 m at Dalvík. The port at Akureyri, 18 km from the site, would most likely by used for imports during the construction period, until own harbour facilities at Dysnes were finished.

Geothermal resources: Several low temperature geothermal systems are known in the Eyjafjördur region. They are normally linked to fractures in the otherwise low-permeability bedrock, and their capacitity is rather limited compared to many geothermal systems located in the Icelandic volcanic zone.

Since the late seventies, most of the houses in Akureyri have been heated with geothermal water that comes mainly from the geothermal system at Laugaland and Ytri Tjarnir, 12 km south of Akureyri. The villages of Dalvík, Ólafsfjördur, Hrísey and Árskógsströnd are also heated with geothermal water from local geothermal systems.

Recently a new geothermal field was located close to Hjalteyri, approx. 5 km north of the Dysnes site. Initial tests indicate that average production from this system could be 85 l/sec of 85-87 °C hot water. A hot water pipeline from Hjalteyri to Akureyri is under construction.

Board and lodging: The nearest hotels and restaurants are in Akureyri. During the construction period, a canteen certainly must be operated. The local workforce will return home at night. Barracks will be essential for other construction workers.

Other services: Like most enterprise in the Eyjafjördur area, an aluminium smelter at Dysnes would rely heavily on services from Akureyri, only 18 km away.

Akureyri is a developed community with a traditional industrial background. Akureyri has machine and electrical shops, lawyers, consulting engineers, high level health care and schools, a swimming pool, sports hall, ski lifts, a golf course, a cinema, theatre and practically every other facility needed for modern life.

11.5 Workforce

The population of the Eyjafjördur area is about 21,500. Most of the inhabitants, almost 16,000, live in Akureyri, 18 km south of the site. The rest live in fishing villages or rural areas around the fjord, within 30-40 minutes commuting distance from Dysnes. It is therefore likely that the daily labour force will come from the whole Eyjafjördur Area.

The area, especially Akureyri, is known for its manufacturing base with large firms, and almost 22% of the labour force is engaged in manufacturing. Ship building in Akureyri and fish processing plants around the fjord are key industries. Fish processing, where most workers are women, is considered to match well with heavy industry, where the workforce is predominantly male.

11.6 Environment

Eyjafjördur is a deep fjord, about 55-60 km long running S-N. The outer part of the fjord is about 10 km wide, and the inner part near Dysnes is 6 km from coast to coast. On both sides of the fjord are mountain ridges, 1000-1200 m high. The lowland along the fjord is found mainly on the west coast, and is 2-3 km wide. South of the head of the fjord is the Eyjafjördur Valley, over 40 km long. Due to the mild climate and rich vegetation, the Eyjafjördur area, especially the valley south of

Akureyri, is known as one of the most prosperous agricultural areas in Iceland. North of the river Hörgá, the topography changes and conditions differ from the valley. The area around the industrial site is a declining farming area, and within the area affected, the level of farming activity is negligible.

Extensive environmental research has been carried out in Eyjafjördur over the last two decades. A report on the natural history and archeological relics on the west coast of Eyjafjördur was issued 1982, as a background study for possible heavy industry. A group of experts from the Icelandic Meteorological Institute and the University of Iceland evaluated the earthquake risk in 1984. An automatic weather station was erected close to the Dysnes site to collect data for dispersion modelling. Temperature gauges were installed at various elevations on the mountain side across the fjord, and an automatic temperature recording device was installed in an airplane operating from the Akureyri airport, to study possible inversion in the fjord. Air dispersion calculations for possible air pollution from a proposed 200,000 tpy aluminium smelter at Dysnes were carried out for fluorides, sulfure and dust on the basis of these meteorological records. These calculations show a dilution zone extending some 1 km to the north and 1 km to the south of the plant, where air quality guidelines might be exceeded. A group of experts from the Agricultural Research Institute in Reykjavík issued a report on the influence of air pollution from an aluminium smelter at Dysnes on vegetation and livestock in Eyjafjördur in 1985.

The Ocean Research Institute in Reykjavík measured ocean currents along the shore in Arnarneshreppur over a period of time to evaluate the impact of waste from the plant, and the Icelandic Meteorological Institute issued a report on sea ice conditions in the sailing routes off the north coast of Iceland in 2002.

These reports and others are available from the Invest in Iceland Agency or the relevant research institutions.

12. REFERENCE LIST

12.1	Consideration regarding geology of major industrial site of Dysnes	*Halldór G. Pétursson, Icelandic Institute of Natural History Akureyri*	*February 2003*
12.2	Sea Ice Hazard with regard to sea transport out of Northern – Iceland	*Icelandic Meteorological Office*	*January 2002*
12.3	Earthquake activity at Eyjafjördur – Extract from a report –	*Páll Halldórsson*	*2002*
12.4	Akureyri – industry opportunities	*The Commerce and Tourism Office of Eyjafjördur , Invest in Iceland Agency Energy Marketing*	*2002*
12.5	Dysnes – Report on an industrial site in Eyjafjördur, Northern Iceland suitable for large aluminum smelter	*Invest in Iceland Agency Energy Marketing*	*August 2000*
12.6	Sea ice incidents in Icelandic waters and their monitoring	*Þór Jakobsson Icelandic Meteorological Office*	*2000*
12.7	Harbour at Dysnes in Eyjafjördur – Investigation of loose soil material	*Almenna Consulting Engineers*	*January* 2000
12.8	Continued location studies for major industries in Eyjafjördur	*MIL, Eyjafjördur regional committee, Institute of regional development*	*June 1998*
12.9	Demonstration of improved energy extraction from a fractured geothermal reservoir	*National Energy Authority*	*1998*
12.10	Construction material in the vicinity of Dysnes	*The Akureyri Museum of Natural history*	*1990*
12.11	Water supply for major industry at Dysnes	*The Akureyri Museum of Natural History*	*1990*
12.12	Thickness of overburden at Dysnes	*The Akureyri Museum of Natural History*	*June 1990*
12.13	Comparison between 2 different locations for Atlantal stand – alone aluminum smelter	*Almenna Consulting Engineers*	*February 1990*
12.14.	Geologic preinvestigation of possible industrial site at Dysnes in Arnarneshreppur District	*National Energy Authority*	*March 1983*

13. LIST OF RESEARCH REPORTS

1.	Almenna verkfræðistofan (Almenna Consulting Engineers):	Industrial Sites at Dysnes and Árskógsströnd. Prel. Engineering report	*In English May 1990*
2.	Almenna verkfræðistofan (Almenna Consulting Engineers):	Industrial Sites at Dysnes and Árskógarströnd. Rev. engineering report	*In English June 1990*
3.	Almenna verkfræðistofan (Almenna Consulting Engineers):	Comparison between 2 different locations for stand-alone aluminium smelter	*In English 1990*
4.	Búnaðarsamband Eyjafjarðar og Iðntæknistofnun Íslands (Agricultural Association of Eyjafjördur and Technological Institut of Iceland):	Background investigation of fluor in Eyjafjördur	*In Icelandic 1984*
5.	Byggðastofnun (Institut of regional development):	Inpact of power –intensive industries on population and environment	*In English 1990*
6.	Byggðastofnun (Institut of regional development):	Inpact of power –intensive industries on population and labour market	*In Icelandic 1990*
7.	Viðræðunefnd um orkufrekan iðnað (Commission of Goverment of Iceland and Swiss Aluminium Ltd):	Proposed aluminium smelter in Northern Iceland. Project study	*In English 1972*
8.	Framkvæmdastofnun ríkisins, byggðadeild (Economic development institute, department of regional development):	Research of the impact of aluminium industries on environment and society	*In Icelandic July 1983*
9.	Framkvæmdastofnun ríkisins, byggðadeild (Economic development institute, department of regional development):	Study of economic and social impact of an aluminium smelter	*In Icelandic 1985*
10.	Framkvæmdastofnun ríkisins, byggðadeild (Economic development institute, department of regional development):	Research of the impact of aluminium industry on society and economic activity	*In Icelandic 1983*
11.		Report on environmental impact of aluminium smelters. Comparison of Eyjafjördur, Keilisnes and Reyðarfjördur regarding location	*In Icelandic Oct. 1990*
12.	Hafrannsóknastofnun (Marine research institute):	Hörgárgrunn – Hjalteyri – Depth to bedrock. Report on seismic refractions survey in June 1982	*In Icelandic June 1982*
13.	Hafrannsóknastofnun (Marine research institute):	Survey of ocean currents at Dysnes in Eyjafjördur July – October 1983	*In Icelandic Oct. 1984*
14.	Náttúrugripasafnið á Akureyri (Museum of natural history, Akureyri):	West coast of Eyjafjördur – Nature and relics	*In Icelandic 1982*
15.	Hörður Þormar:	Measurement of fluor in samples from Eyjafjördur	*In Icelandic 1984*
16.	Háskólinn á Akureyri (The University at Akureyri):	Public opinions regarding power intensive industry in Eyjafjördur	*In Icelandic Nov. 1997*
17.	Iðnaðarráðuneytið (The Ministry of Industry):	A new aluminium smelter in Iceland	*In Norwegian 1978*
18.	Iðnaðarráðuneytið-Staðarvalsnefnd um iðnrekstur. (The Ministry of Industry, Localizing committee for power intensive industry):	Status report on location of an aluminium smelter	*In Icelandic July 1982*
19.	Iðnaðarráðuneytið-Staðarvalsnefnd um iðnrekstur. (The Ministry of Industry, Localizing committee for power intensive industry):	Selection of sites for power intensive industry – Preselection	*In Icelandic 1983*
20.	Iðnaðarráðuneytið-Staðarvalsnefnd um iðnrekstur (The Ministry of Industry, Localizing Committee for power intensive industry):	Evaluation of earth quake risk: Dysnes, Geldinganes, Helguvík, Vatnsleysuvík, Vogastapi and Þorlákshöfn.	*In Icelandic Sept. 1983*
21.	Iðnaðarráðuneytið-Staðarvalsnefnd um iðnrekstur (The Ministry of Industry, Localizing committee for power intensive industry):	Selection of sites for aluminium smelters. (Final report)	*In Icelandic July 1986*
22.	Iðnaðarráðuneytið (The Ministry of Industry):	Atlantsál. Report on selection of sites	*In Icelandic Sept. 1990*

23.	Iðnþróunarfélag Eyjafjarðar (Commerce and Tourism Office of Eyjafjördur):	Atlantal Aluminium Smelter – A summary report of Eyjafjördur	*In English July 1990*
24.	Magnús Jónsson:	Report on wind from the sea and dispersion of odors and smoke from the herring factories in Eyjafjördur	*In Icelandic 1984*
25.	Markaðsskrifstofa Iðnaðarráðuneytisins og Landsvirkjunar (The Marketing Unit of the Ministry of Industry and the National Power Company):	Drift Ice in the Icelandic Coastal Waters	*In English Jan. 1993*
26.	Markaðsskrifstofa Iðnaðarráðuneytisins og Landsvirkjunar (The Marketing Unit of the Ministry of Industry and the National Power Company):	Possible location of a new aluminium smelter	*In Icelandic 1989*
27.	Markaðsskrifstofa Iðnaðarráðuneytisins og Landsvirkjunar (The Marketing Unit of the Ministry of Industry and the National Power Company):	Report on four industrial sites in Iceland suitable for large aluminium smelters	*In English March 1996*
28.	Markaðsskrifstofa Iðnaðarráðuneytisins og Landsvirkjunar (The Marketing Unit of the Ministry of Industry and the National Power Company):	Atlantsál – Report on selection of site	*In Icelandic 1990*
29.	Mecmo Trepp, Consulting Engineer:	Atlantal, site selection study for a 200,000 tpy aluminium smelter in Iceland	*In English 1990*
30.	Náttúrufræðistofnun Norðurlands. (The Institute of Natural History, Akureyri):	Water supply for power intensiv industry at Dysnes	*In Icelandic 1990*
31.	Norsk – Hydro:	Aluminium Project Iceland. Investigation of possible location	*In Norwegian 1975*
32.	Norsk institute for luftforskning (NILU) (The Norwegian institute for atmospheric research):	Model calculations for a planned aluminium smelter north of Akureyri, Iceland	*In Norwegian Nov. 1985*
33.	Norsk institute for luftforskning (NILU) (The Norwegian institute for atmospheric research):	Model calculations for a planned aluminium smelter at Eyjafjördur, Iceland	*In English June 1990*
34.	Orkustofnun (National Energy Authority):	Ground water and springs between Akureyri and Dalvík	*In Icelandic Sept. 1980*
35.	Orkustofnun (National Energy Authority):	Land use in Eyjafjördur, industrial sites	*In Icelandic 1981*
36.	Orkustofnun (National Energy Authority):	Geologic preinvestigation of a possible industrial site at Dysnes in Arnarneshreppur	*In Icelandic 1983*
37.	Rannsóknastofnun byggingariðnaðarins (The Building Research Institute):	Material Deposits in Eyjafjördur and on Reykjanes	*In Icelandic 1982*
38.	Rannsóknastofnun landbúnaðarins (The agricultural research institute):	Evaluation of the impact of air pollution on vegetation and livestock in Eyjafjördur	*In Icelandic Des. 1984*
39.	Rannsóknastofnun landbúnaðarins (The agricultural research institute):	Impact of air pollution from an aluminium smelter at Dysnes in Eyjafjördur on vegetation and livestock.	*In Icelandic 1985*
40.	Stenstadsvold, Kjell:	Influence on population and labour market from location of an aluminium smelter in Iceland	*In Norwegian 1975*
41.	Stóriðjunefnd (Committee for power intensive industry):	Comparison of location of an aluminium smelter in North and South Iceland	*In Icelandic 1964*
42.	Vatnaskil Consulting Engineers:	Air pollution calculations for Eyjafjördur and Keilisnes	*In English June 1990*
43.	Vatnaskil Consulting Engineers:	Calculation of air pollution in Eyjafjördur	*In Icelandic Nov 1994*
44.	Vatnaskil Consulting Engineers:	Calculations of air pollution in Eyjafjördur – Annexes	*In Icelandic Nov. 1994*
45.	Vatnaskil Consulting Engineers:	Calculations of air pollution in Eyjafjördur	*In Icelandic May 1997*
46.	Veiðimálastofnun (Institute of Fresh Water Fisheries):	Study of Hörgá river and Öxnadalsá river	*In Icelandic 1976*

47. Veðurstofa Íslands (Icelandic Meteorological Office):	Air temperature recording in Eyjafjördur. (Start summer 1983, and October 1985)	
48. Verkfræðistofnun Háskóla Íslands (Engineering Institute of the University of Iceland):	Dysnes, measurements of atmospheric turbulence at Dysnes	*In English 1990*
49. Virkir hf. Consulting Engineers:	Preinvestigation of geographic conditions for location of power intensive industry in Northern Iceland	*In Icelandic 1977*

14. ANNEXES

14.1 Annex 1 – Sea Ice days

Sea Ice observed off the west-, north- and northeast Coast of Iceland

NUMBER OF SEA ICE DAYS 1964 - 2001									
"ICEYEAR"	HORNSTRANDIR *) (The West Route)			NORÐURLAND EYSTRA *) (The Northeast Coast)			MELRAKKASLÉTTA *) (The East Route)		
	Traces of ice	**Scattered ice**	**Dense ice**	**Traces of ice**	**Scattered ice**	**Dense ice**	**Traces of ice**	**Scattered ice**	**Dense ice**
1964-1965	33	47	25	41	34	2	39	51	8
1965-1966	17	0	0	1	0	0	3	0	0
1966-1967	19	21	0	8	5	1	18	8	2
1967-1968	29	51	55	25	45	19	14	22	37
1968-1969	14	66	26	16	44	0	11	41	30
1969-1970	6	38	2	10	25	9	9	20	1
1970-1971	14	44	4	2	14	0	0	1	0
1971-1972	6	0	0	3	0	0	0	0	0
1972-1973	0	0	0	7	0	0	1	0	0
1973-1974	8	1	0	5	0	0	2	0	0
1974-1975	31	18	0	6	0	0	4	0	0
1975-1976	12	5	3	6	0	0	2	0	0
1976-1977	17	5	0	23	1	0	10	3	0
1977-1978	21	1	0	0	0	0	0	0	0
1978-1979	5	24	7	23	13	15	8	14	38
1979-1980	0	0	0	0	0	0	0	0	0
1980-1981	9	0	0	0	0	0	1	0	0
1981-1982	8	3	0	3	0	0	2	0	0
1982-1983	8	2	0	1	0	0	0	0	0
1983-1984	22	5	0	17	4	0	0	0	0
1984-1985	0	0	0	0	0	0	0	0	0
1985-1986	11	9	5	8	0	0	1	0	0
1986-1987	8	2	0	2	0	0	0	0	0
1987-1988	19	8	2	13	3	1	15	6	1
1988-1989	12	10	2	3	0	0	0	0	0
1989-1990	18	22	9	0	0	0	0	0	0
1990-1991	19	2	0	0	0	0	0	0	0
1991-1992	9	0	0	0	0	0	0	0	0
1992-1993	21	4	0	0	0	0	0	0	0
1993-1994	6	0	0	5	0	0	0	0	0
1994-1995	7	2	0	0	0	0	0	0	0
1995-1996	10	2	1	1	0	0	0	0	0
1996-1997	19	5	3	1	0	0	3	0	0
1997-1998	16	8	0	0	0	0	2	3	0
1998-1999	7	1	0	0	0	0	0	0	0
1999-2000	10	0	0	0	0	0	0	0	0
2000-2001	2	0	0	4	0	0	0	0	0

*) *See also* *Fig 13 for details*

Traces of ice: Single or very scattered floes.
Scattered ice: Navigation possible, ice in question is scattered, mainly floes in groups, strips or both.
Dense sea ice: Navigation difficult or closed.

14.2 Annex 2-11, Drawings