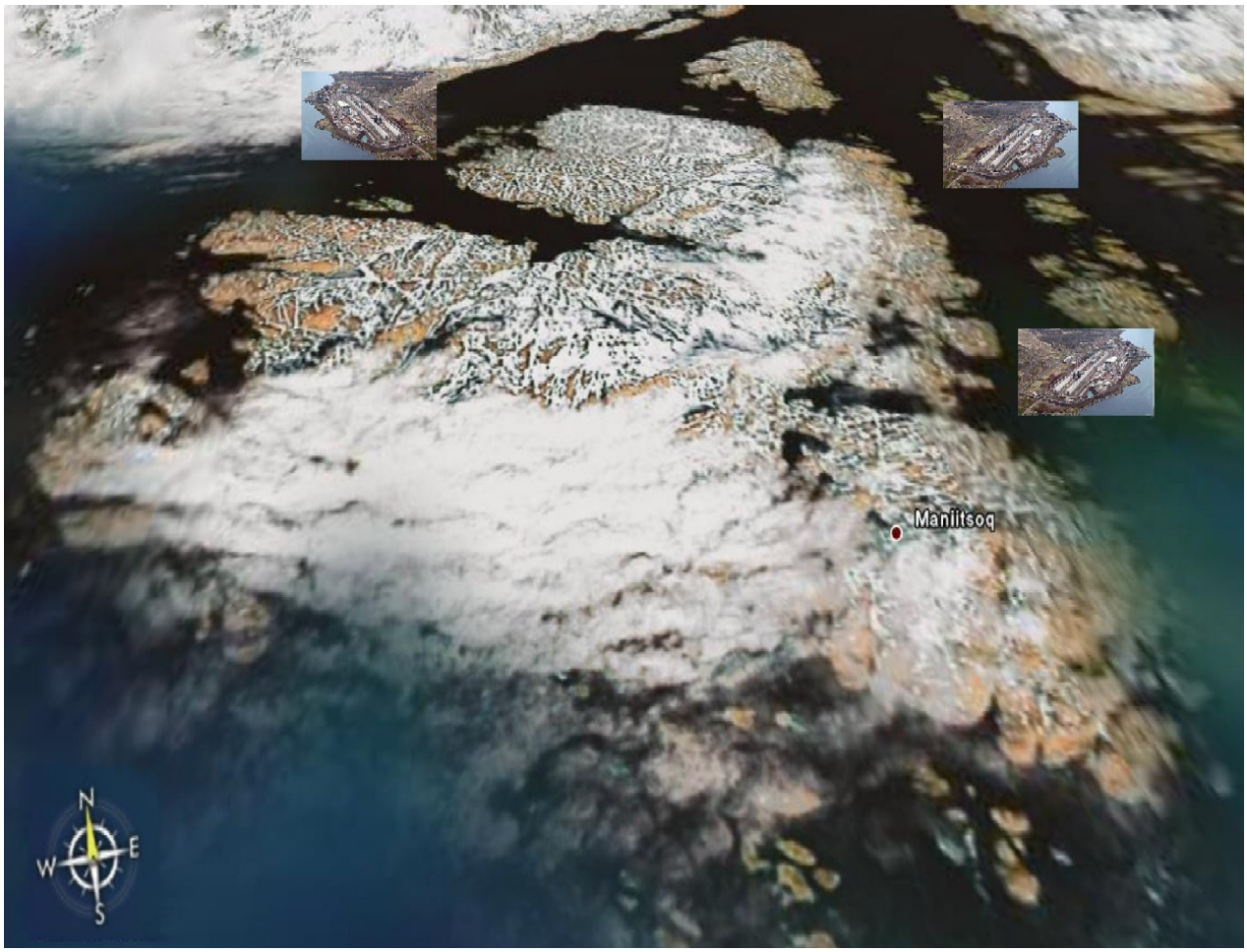
The Municipality of Maniitsoq



Aluminum Smelting Works on the Island of Maniitsoq

Proposals for Locations

Proposals for Location of Aluminum Smelting Works on the Island of Maniitsoq

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Appendixes:

1 BACKGROUND

By request the municipality of Maniitsoq has made proposals for possible locations for an aluminum smelting works. The requirement is an area of 120 hectares (or 1500 by 800 m) that may be extended and must facilitate a harbor or quay with minimum water depths of 16 meters.

The municipality of Maniitsoq has made three proposals that all meet theses requirements for a location of an aluminum smelting works. The three locations (A, B, and C) are indicated in appendix 2.

2 CONSIDERATIONS

All three proposals presuppose the below mentioned factors:

1. Central location of the plant in relation to the hydropower plant that supply electricity.
2. Location on the island of Maniitsoq rather than on the mainland.
3. Location within a short distance from a town environment and accessible by road.
4. Good sailing conditions for large ships and a quay on location with a water depth of approx. 20 meters.
5. Year round ice free harbor (or ice that does not obstruct free sailing).
6. Good communication lines.
7. Reasonable costs of development and leveling of construction sites.

2.1 LOCATION IN RELATION TO HYDROPOWER PLANTS

Electricity for a smelting works in Greenland could be supplied from a number of hydropower plants (see sections 2.1.1 – 2.1.5). Location of the aluminum smelting works on the island of Maniitsoq will be central in relation to electricity supply from the below mentioned hydropower plants. Information about the power plants is from Nukissiorfiit, the Greenlandic energy supply company.

The locations of the hydropower plants are indicated in appendix 1. Supply lines are also indicated in appendix 1. The locations of the icecaps are adjusted in accordance with Google Earth.

2.1.1 Hydropower Plant at Evighedsfjorden

It is assumed that a hydropower plant at the fiord Evighedsfjorden will supply power to the smelting works at any location in any of the municipalities.

The hydropower plant at Evighedsfjorden will have a potential capacity of 2500 GWh/a; the largest potential in Greenland. This plant will probably produce the cheapest power. The plant may generate up to 3170 GWh/a if water from the catchments area A can be utilized.

The hydropower plant will take in water from the lake Tasersiaq.

2.1.2 Hydropower Plant at Majorqaq

A hydropower plant at the source of the river Majorqaq with water from Søndre Isortup isua is estimated to produce 1000 GWh/a. This plant could be a second power supplier for the smelting works.

If the potential 3170 GWh/a of the plant at Evighedsfjorden is reached, then together the plants at Evighedsfjorden and at Majorqaq will produce enough power to supply the smelting works on the island of Maniitsoq.

2.1.3 Hydropower Plant at Fiskefjorden

A hydropower plant in the fiord Fiskefjorden taking in water from the lake Tasersuaq has a potential capacity of 500 GWh/a. This could be a third supplier for the smelting works.

2.1.4 Hydropower Plant at Ujarassuit Nunaat

It is estimated that a hydropower plant in the fiord Godthåbsfjorden at Ujarassuit Nunaat taking in water from the lake Imarsuup Isua will have a capacity of 1480 GWh/a.
Together with a plant at Evighedsfjorden, a plant at Ujarassuit Nunaat could supply the smelting works with sufficient power.

2.1.5 Hydropower Plant at Umiiviit

It is estimated that a hydropower plant at Umiiviit in the fiord Sønderstrømfjord (Kangerlussuaq) has a potential output of 900 GWh/a. The plant would take in water from the lake Tasersuaq.

At maximum capacities a plant at Umiiviit and at Evighedsfjorden could supply the smelting works with sufficient power. However, Nukissiorfiit (energy supply company) expresses certain reservations as regards a plant at Umiiviit, as the Tasersuaq is shallow.

2.2 LOCATION ON THE ISLAND OF MANIITSOQ OR ON THE MAINLAND

The fiords Kangia, Søndre Isortoq and Kangerdluarssuk offer central and convenient locations in relation to the above mentioned hydropower plants.

There are reasonably level areas at the landward ends of all three fiords. However, the permafrost in the subsoil in these areas will thaw due to the heat of the constructions (there might be ice lenses in the subsoil). All three fiords are shallow at the mouths of the rivers that run into the fiords. In winter it is colder in the fiords than along the coastline, and ice in the fiords may be quite thick.

For these reasons it is not recommended that the smelting works be located in the fiords.

At the mouth of the fiords it should be possible to find a location with fairly level ground and adequate water depths for a quay. However, this location will be at a fair distance from a town and from infrastructure and communication lines. A location on the island of Maniitsoq is therefore preferable.

2.3 LOCATION ON THE ISLAND OF MANIITSOQ

A location close to town is preferable for a number of reasons:

- Staff and their families will enjoy the social and cultural life of an established society rather than a newly established community around the aluminum smelting works.
- Families of staff will be able to seek jobs in the town and there are schools, day care institutions and recreational activities.
- It is to be expected that staff would not wish to live isolated in a "mining society" away from their families.
- Construction costs will be considerably less as some infrastructure exists already.
- Road access will greatly enhance regular transportation rather than transportation by boat. Even if sailing conditions around Maniitsoq are fair compared to other towns, as it is possible to sail in lee of the archipelago. However, weather conditions may hinder transportation by boat.

2.4 NAVIGATION

The sea depths around the island of Maniitsoq make it possible to navigate large ships both north and south of the island, as well as east of the island. There are good approaches all three locations. It is possible to sail in lee of the archipelago as the depth of water is adequate.

The below circumstances apply to all three proposals, locations A, B, and C:

- Adequaate water depths close to land (see appendix 8).
- Costs of quay construction with minimum water depths of 16 m may be kept comparatively low.
- The quay will be leeward to the heavy storms which are south-west or south south-west.
- Waves are fairly small, likely always less than 1 meter.

2.5 ICE CONDITIONS

All harbors in central West Greenland may freeze in winter and hinder navigation. However, the harbor and the sea around the island of Maniitsoq is navigable by ships year round because of the water depths; even when the harbors of Sisimiut and Nuuk may freeze as happened in the winter of 1982-83. The ice has not closed around the island of Maniitsoq since 1993.

It is estimated that ice will not cause problems for the big ships plying to and from the smelting works. Icebergs are a rare sight around Maniitsoq. Year-round navigation is thus possible to, from, and around the island of Maniitsoq.

2.6 SERVICE/CONNECTION

There are regular flight and ferry connections to and from Maniitsoq.

There are daily flight connections to and from Maniitsoq to the rest of Greenland and by Kangerlussuaq to the rest of the world. The runway is an 800 meter STOL runway (Short Take Off and Landing). It is possible to extend the runway.

From spring till late fall, the ferry calls weekly at Maniitsoq. Freight ships call weekly at Maniitsoq year round.

2.7 SMELTING WORKS LOCATIONS

In principle the smelting works may be founded on rock or soil. Rock is preferable as it offers secure foundation. However, the leveling and development of the construction site are costly as it is necessary to blast rock.

Areas of soil are generally relatively level. However, if there is permafrost, the foundation has to be specially constructed.. The technique is very costly, and building on permafrost cannot be recommended.

There is no permafrost on the island of Maniitsoq or in the towns south of Maniitsoq. But there is permafrost in towns north of Maniitsoq and there is permafrost on the mainland.

The proposed locations or sites on the island of Maniitsoq are all rock sites and it is necessary to blast rock to prepare the sites for construction, but the foundation will be solid.

3 ELECTRICAL POWER LINES

Span, wind, and ice-up risk are factors that need be considered in dimensioning the electrical power lines. To erect electrical lines across the ice caps is not considered a possibility.

3.1 SPAN

There will be a span of approximately 2.7 km as the electrical power line crosses over the fiord Evighedsfjorden (see appendix 1). Across the fiord Maniitsup Sermillia there will be a span of 1.6 km. From the mainland to the island of Maniitsoq it is possible to lay down a sea cable or put up an overhead electrical line.

The longest span of the overhead electrical line would be 800 meters; pylons may be placed on islands and rocks.

3.2 WIND SPEED

In Greenland wind speed is fairly high. In Sisimiut and Maniitsoq the code design wind speed is 45 m/sec., while code design wind speed in Nuuk is 50 m/sec. Wind speed increases with altitude. Therefore, electrical power lines should not cross over high mountains when this could be avoided. Electrical power lines to Maniitsoq may be kept at an altitude of less than 600 m. AMSL (except from Umiivit) (see appendix 1).

3.3 ICE-UP

In the Maniitsoq area ice-up of electrical power lines are rare, probably due to the dry climate. It is estimated that the most severe ice-up over a ten year period was 5 cm/diameter. It is estimated that spans across water will have a higher risk of ice-up than spans across land. An estimate of the risk of ice-up on the mainland is not available. However, the ice-up risk is likely to be less than on the island of Maniitsoq.

4 CLIMATE CONDITIONS

4.1 CLIMATE

The climate data are from the period 1961–1965. Data have been collected methodical in the period 1992–2003, but these data are not yet analyzed.

4.1.1 Temperature

Air temperature (year average)	- 0.4^{o}	C
Warmest month (August) (average)	+ 7.7^{o}	C
Coldest month (March) (average)	- 7.8^{o}	C

4.1.2 Rain and Snowfall

Average yearly rain and snowfall is approx. 720 mm. There is least rain/snowfall in the winter months of December, January, and February; approx. 30 mm average.
Rainfall is most heavy in the months of July, August, and September. The average for the month of September is approx. 150 mm.

4.1.3 Snowfall

The average snowcover in the period November through April is 60 cm.

4.1.4 Wind

Appendix 9 shows wind roses that indicate the dominant wind directions. The predominant wind direction is east, but the wind directions vary over the seasons. Most typical summer wind directions are south and west, whereas the most typical direction in winter is east.

5 INFRASTRUCTURE

5.1 HOUSING AND NEW SUBURB

To accommodate new residents more houses should be built. The area northeast of the town of Maniitsoq, the direction of the proposed locations, is suitable for development. The area is indicated in appendix 2.

There are other areas that could be developed as well as only a small percentage of the island is developed. The inhabitants of Maniitsoq wish to live close to the sea, with a view and close to the anchorage of their boat. Most inhabitants in Maniitsoq have a small boat. The area northeast of the town of Maniitsoq is reasonably level and offers a nice view over the archipelago. There is a natural harbor for small and large boats.

5.2 WATER SUPPLY

The waterworks of Maniitsoq supplies 500 m3 water daily. When the fish processing factory was working, the waterworks supplied 2500 m3 water daily. Thus, the water works could easily supply water for both the aluminum smelting works and a new suburb. The reservoir capacity may also be increased.

Depending on the location of the smelting works, there are lakes further north on the island of Maniitsoq which may supply the smelting works with fresh water.

5.3 ROAD CONNECTION AND BRIDGE ACROSS ATAA

All three proposals include a bridge across the bay Ataa. A bridge with a free height of 15-20 m AMSL across the bay would allow for free entering by boat to the bay and the natural harbor of Ataa. The terrain is also ideal for a 15-20 m tall bridge.

An alternative is to construct the road at the foot of the mountain Pattefjeld. However, the cost of this alternative is estimated to be the same as the bridge as the terrain is very steep.

The road to Ataa will connect the present town area with the proposed new neighborhood at Ataa (see appendix 2).

5.4 TEMPORARY WORKERS' CAMP

For proposals A or B, a temporary workers' camp may be established in the area for a new neighborhood. This makes use of the planned infrastructure connecting the Ataa area with the present-day town. It would also be possible to set up a temporary workers' camp between location A and B.

For location C it might be practical to set up a temporary workers' camp close to the construction site

6 DESCRIPTIONS OF THE LOCATIONS

Locations A, B, and C have been proposed based on knowledge of the terrain and inspection of the sites.

The map material used to illustrate the sites is a digital map of the area, it is a first draft. The scale of the map is 1:20,000. Based on the digital map, digital models of the terrain have been made. Mass calculation has been made from the model. However, more detailed maps are needed for final decision-making.

6.1 LOCATION A

Location A is a site just 5 km north of the town of Maniitsoq, on the eastern coast of the island. The site is 1.5 km north of the entrance to the bay Ataa.

Any air pollution will be carried away from the town (see appendix 9 (wind roses)).

6.1.1 Coordinates and Dimensions

Location A is indicated in appendix 2. The site is 1500 by 800 m, a total of 120 hectares. The coordinates of the center of the site are 65o27.6' N; 52o53.3' W. The site may be extended north. Adjusting the dimensions of the site to the terrain may reduce leveling costs.

6.1.2 General Description of the Location

The site is rock (mainly gneiss), but there are pockets of soil. The site offers solid foundation.
Location A is the most hilly of the three locations, but it has the shortest length of road construction from the town of Maniitsoq. To prepare the site, rock needs to be blasted and a small bay needs to be filled up. The elevation is 18.65 m AMSL. Adjusting the dimensions of the site to the terrain will reduce leveling costs.

At the north corner of the site, a quay may be constructed. There are adequate water depths approx. 65 m from land. The quay may be constructed closer to land after minor leveling of the seafloor (see appendix 8).

6.1.3 Infrastructure

Total road distance from the town of Maniitsoq to location A is 3.9 km. Most of the access road construction is regular, perhaps apart from the bridge across the Ataa bay.

Fresh water may be supplied from the town's water reservoir or from a lake approx. 1 km west of the northwestern corner of the site. A 3.4 km. water main may be laid out from the town reservoir, across the bridge, to the smelting works.

Telecommunication lines may easily be provided by an expansion of the present network.

6.1.4 Estimate of Road and Bridge Constructions and Leveling in mill. DKK

(DKK million)

Site	Access road	Bridge	Leveling	Total
800*1500 m	31	51	326	408
Adjusted to terrain(1,200,000 m^2)	31	51	277	359

6.2 LOCATION B

Location B is a site 8 km north of the town of Maniitsoq, on the northeastern corner of the island of Maniitsoq.

Any air pollution will be carried away from the town, across land and out over sea (see appendix 9 (wind roses)).

6.2.1 Coordinates and Dimensions

Location B is indicated in appendix 2. The site is 1714 by 700 m, a total of 120 hectares. The coordinates of the center of the site are 65°29,7' N, 52°52,9' W. Adjusting the dimensions of the site to the terrain will reduce leveling costs.

6.2.2 General Description of the Location

The site is rock (mainly gneiss), but there are pockets of soil. The site offers solid foundation.
Location B is less hilly than A, but it is necessary to level the terrain, blasting rock and filling up. The elevation is 36.6 m AMSL. Blasting may be reduced if the site dimensions are adjusted to the terrain.

At the southeastern corner a quay may be constructed. There are adequate water depths approx. 35 m from land (see appendix 8).

6.2.3 Infrastructure

The access road will run through fairly plane terrain. Total road distance from the town of Maniitsoq to location B is approx. 7.9 km. Most of the access road construction is regular, perhaps apart from the bridge across the Ataa bay.

Fresh water may be supplied from the town's water reservoir or from a lake approx. 1 km west of the northwestern corner of location A. A 7.5 km water main may be laid out from the town reservoir, across the bridge, to the smelting works.

The present telecommunication network may be expanded and provide for the smelting works, or own central may be established and connected to the present radio link.

6.2.4 Estimate of Road and Bridge Constructions and Leveling in mill. DKK

(DKK million)

Site	Access road	Bridge	Leveling	Total
700*1714 m	63	51	285	399
Adjusted to terrain(1,200,000 m^2)	63	51	242	357

6.3 LOCATION C

Location C is a site 9 km northwest of the town of Maniitsoq, at the fiord Kangerluk on the nortern coast of the island of Maniitsoq.

Wind will carry any air pollution out over the sea (see appendix 9 (wind roses)).

6.3.1 Coordinates and Dimensions

Location C is indicated in appendix 2. The site is 1500 by 800 m, a total of 120 hectares. The coordinates of the center of the site are 65o29.9' N; 52o59.9' W. The site may be expanded north, south, and eastward.

6.3.2 General Description of the Location

The site is rock (mainly gneiss), but there are pockets of soil. The site offers solid foundation.
Location C offers the most level terrain of the three proposals. However it is necessary to level the terrain, blasting rock and filling up. The elevation is 26.15 m AMSL. The leveling may be reduced if the site is moved toward the northwest. Site C offers the best possibilities for expansion.

At the southwestern corner of the site a quay may be constructed. There are adequate water depths approx. 50 m from land (see appendix 8).

6.3.3 Infrastructure

The total distance of access road is approx. 11 km. The road is sited from location A toward the northwest through hilly terrain.

Fresh water may be supplied from the lake approx. 1 km west of the northwestern corner of location A (water main of 3.6 km) or from the lake east of location C (water main of approx. 2.5 km).

The present telecommunication network may be expanded and provide for the smelting works. However, it is not possible to link on to the present radio link because of high mountains.

6.3.4 Estimate of Road and Bridge Constructions and Leveling in mill. DKK

(DKK million)

Site	Access road	Bridge	Leveling	Total
800 * 1500 m	83	51	234	373
Adjusted to terrain(1,200,000 m^2)	83	51	216	355

7 SOCIAL CONDITIONS

7.1 THE PEOPLE

Most citizens of Maniitsoq are Inuit; however, 6–8 % are "immigrants", mainly from Denmark. There are many mixed marriages. Most children of mixed marriages see themselves as Greenlanders.

The citizens of Maniitsoq are used to meeting new people and different cultures. There are many residents from outside Maniitsoq and a number of citizens work on big trawlers with an international crew.

The Swedish company Minelco Ltd. was welcomed when the company opened the olivine mine in the fiord Fiskefjorden in 2005. Today about 50 staff work at the mine, most are from the municipality of Maniitsoq.

7.2 DEVELOPMENT OF GREENLAND

The citizens of Maniitsoq are positive towards the prospect of an aluminum smelting works on the island of Maniitsoq.

Developments in Greenland have in recent years mainly been concentrated around the towns of Nuuk and Sisimiut. An aluminum smelting works on the island of Maniitsoq would attract and boost development in Maniitsoq, following the positive trend that started with the opening of the olivine mine.

7.2.1 Spin-offs

Presently the municipality of Maniitsoq is the region in Greenland where prospecting for minerals and gems is conducted most intensively. Continuous development of Maniitsoq is expected to support these activities and prepare the ground for further mining developments that will benefit Greenland.