Nord Stream
The new gas supply route for Europe

Section 6

Alternatives and route optimisation

6 Alternatives and route optimisation

This chapter describes the alternatives within the Finnish exclusive economic zone (EEZ) that have been assessed in this environmental impact assessment (EIA) report (Chapter 6.1). In addition to feasible route alternatives, one alternative that have been excluded during the EIA process is also described (Chapter 6.2.). In addition, the process of optimising the pipeline routing in the Finnish section is explained (Chapter 6.3).

6.1 Description of alternatives within the Finnish EEZ

The Finnish national environmental assessment concerns the sections of the Nord Stream project alternatives that are located within the Finnish EEZ. The Nord Stream project consists of two pipelines:

- A south-east pipeline, closer to the coasts of Estonia and Poland
- A north-west pipeline, closer to the coasts of Finland and Sweden

There are two main route alternatives and one sub-alternative studied in the national EIA. In addition, a so-called ‘0-alternative’ (non-implementation of the project) is assessed.

The alternatives assessed within the Finnish EEZ (see Figure 6.1):

- 0-Alternative: Non-implementation of the Nord Stream pipeline. The natural gas pipeline from Russia to Germany will not be constructed.
- Alternative 1: Route C14. The natural gas pipeline system comprises two parallel pipelines from Vyborg, Russia, through the Baltic Sea to Greifswald in Germany. The sections within the Finnish EEZ are 372.5 km for the southeast pipeline and 372.7 km for the north-west pipeline.
- Alternative 2: Route C16. The only difference between Alternatives 1 and 2 is that Alternative 2 deviates slightly to the south for some 40 km in the vicinity of Kalbådagrund shallow. The length of Alternative 2 is 374.3 km for the southeast pipeline and 375.3 km for the north-west pipeline.
- Sub-alternative 1a/2a: This sub-alternative is a localised southerly 2.9 km deviation of the southeast pipeline and a 1.7 km diversion of the north-west pipeline. It is situated near the border of the Finnish and Russian EEZs.

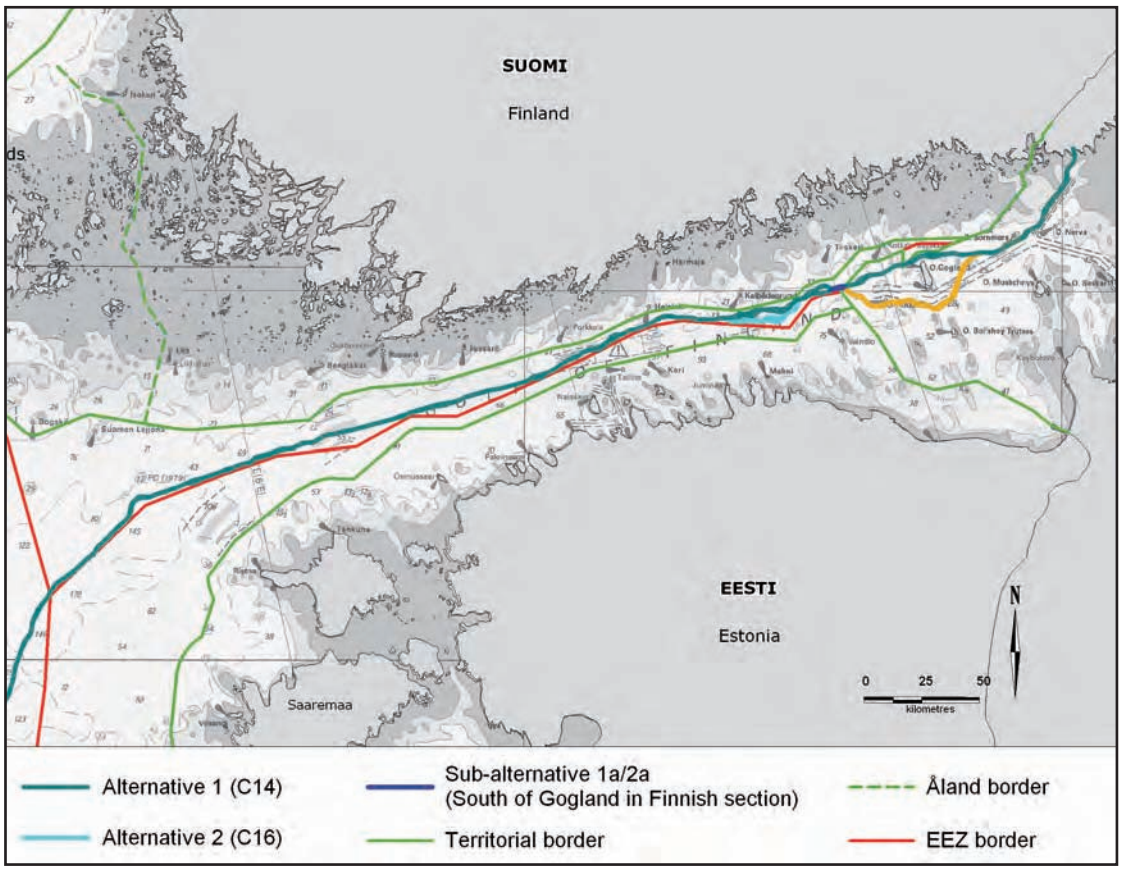

Figure 6.1. The three route Alternatives (1, 2, 1a/2a) in the Finnish EEZ. For details of the alternative routes see Atlas Map PR-1b-F.

The alternatives are described in greater detail in the following sections.

6.1.1 Alternative 0 (non-implementation)

The 0-alternative means that the natural gas pipeline from Russia to Germany will not be constructed. A broader presentation of the energy policy arguments related to the 0-alternative is presented in the Espoo Report /5/.

6.1.2 Alternative 1 (C14)

Alternative 1 runs from the border of the Russian and Finnish EEZs to the border of the Finnish and Swedish EEZs (see figure 6.2). The length of this route alternative is approximately 370 km. It does not enter into the Finnish territorial waters. The route runs close to the border of the Estonian EEZ. This route alternative has code number C14 (see Chapter 6.3 for a detailed explanation of these code numbers).

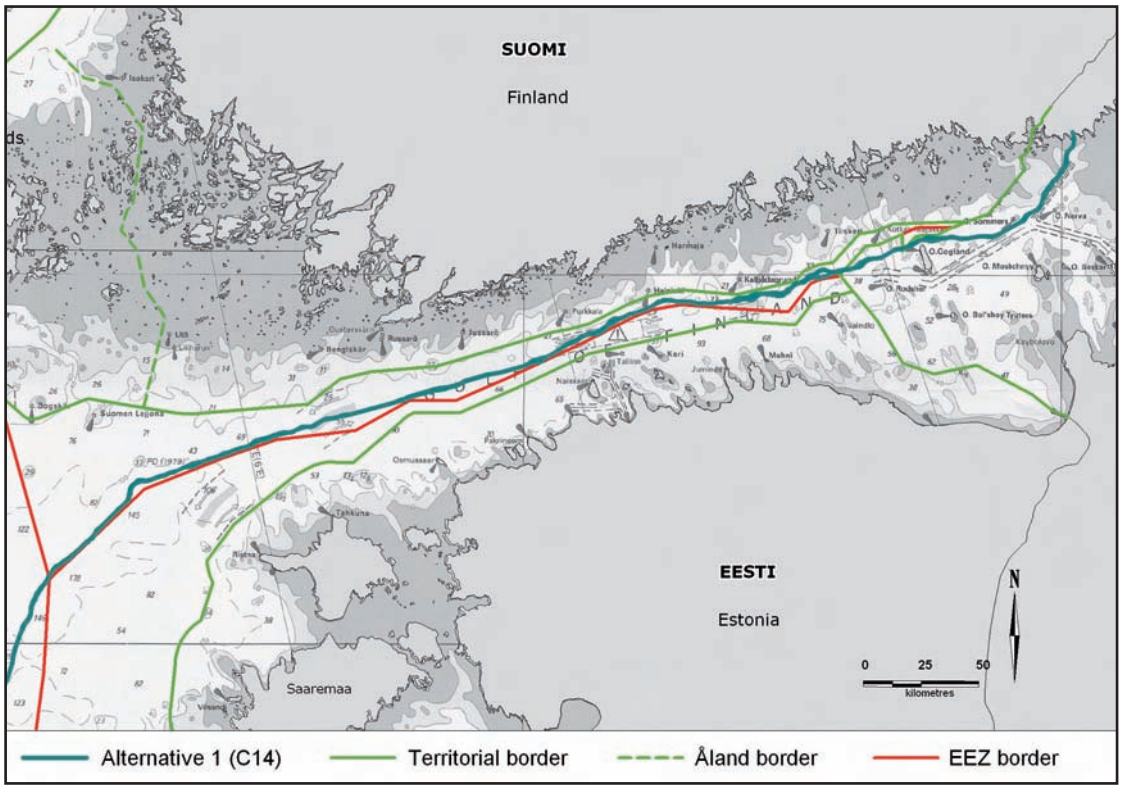

Figure 6.2. Route Alternative 1 (C14).

6.1.3 Alternative 2 (C16)

During the EIA process the Finnish authorities asked Nord Stream AG to investigate an alternative pipeline route further south of Alternative 1 in the area of Kalbådagrund, which is situated east of Helsinki and south of Porvoo and Loviisa. This request was based on the view that geological conditions south of Kalbådagrund are more favourable, i.e., that the seabed is more even than along route C14.

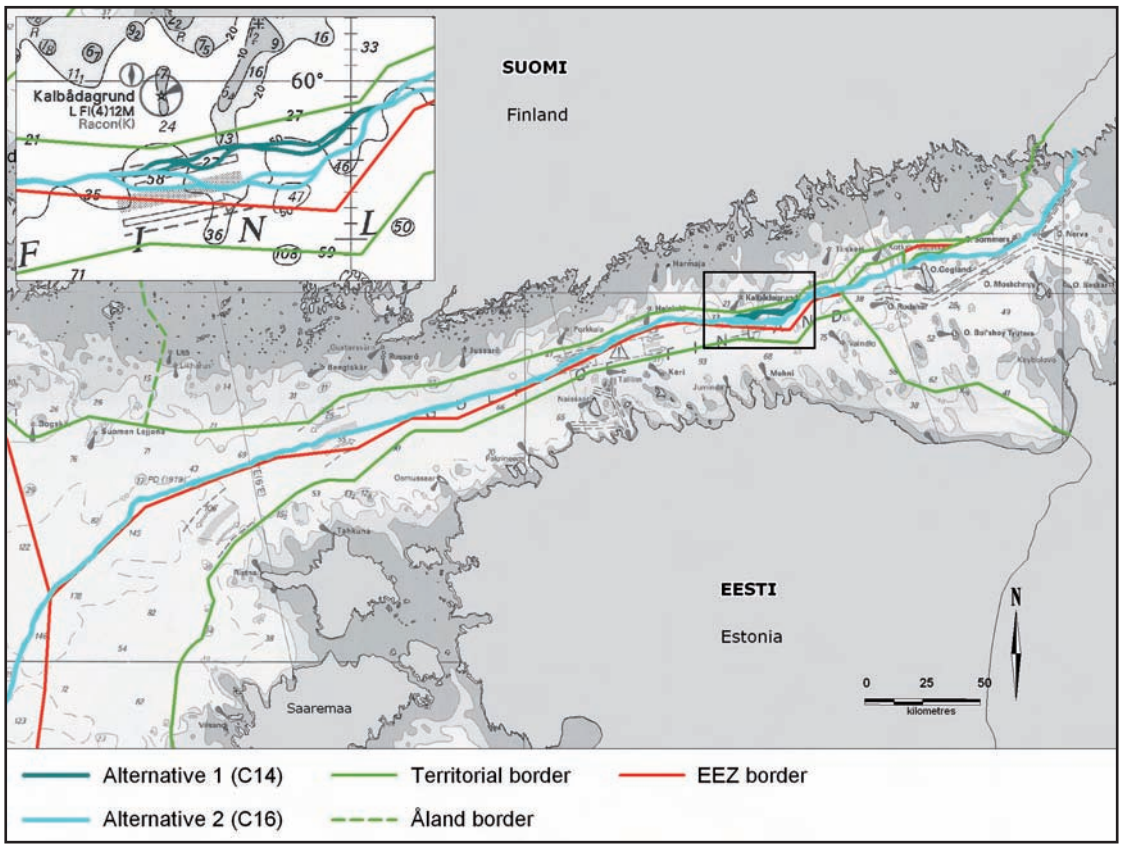

Figure 6.3. Alternative 2 differs from Alternative 1 in the vicinity of Kalbådagrund. For details of the Alternative 2 see Atlas Map PR-1b-F.

Alternative 2 differs from Alternative 1 only in the Kalbådagrund area between KP 140 and KP180 (according to KP numbering for Alternative 1) (see figure 6.3). Alternative 2 has a length of 375 km in the Finnish EEZ and is approximately 2 km longer than Alternative 1. The south-east pipeline route for Alternative 2 is 1.8 km longer than Alternative 1, and the north-west pipeline route for Alternative 2 is 2.6 km longer than Alternative 1.

Table 6.1 shows that seabed interventions works are required in fewer places in Alternative 2 than in Alternative 1(for both the south-east and north-west pipelines). Despite this, Alternative 2 requires a greater volume of gravel for seabed intervention works. Alternative 2 requires some long rock berms to avoid critical freespans and to mitigate the risk of uplifting. For a more detailed description of seabed intervention works please refer to Chapter 3.5.3.

Table 6.1. Properties of Alternative 1 compared with Alternative 2 in Finnish EEZ.

Difference between the routes in whole Finnish EEZ				
	Alternative 1		Alternative 2	
	South-east	North-west	South-east	North-west
Length [km]	372.5	372.7	374.3	375.3
Number of seabed intervention works (the total amount, both static and dynamic)	65	81	63	71
Volume of gravel works [m^3]	82,580	142,030	96,610	150,960

The sections where route Alternatives 1 and 2 differ from each other can be distinguished below (see table 6.2).

Table 6.2. Properties of deviating parts of Alternatives 1 and 2 around Kalbådagrund.

Parts of the routes that differ in area around Kalbådagrund				
	Alternative 1		Alternative 2	
	South-east	North-west	South-east	North-west
Length [km]	38.6	38.3	40.4	40.9
Number of seabed intervention works	16	30	14	19
Volume of gravel works [m^3]	11,980	48,970	26,020	56,610

6.1.4 Sub-alternative 1a/2a (South of Gogland in Finnish section)

Within the Russian EEZ the route C14 runs on the northern side of Gogland Island. During the EIA process, various parties and authorities requested that an alternative route south of Gogland would be investigated and its impacts assessed. As this alternative route is located in Russian waters, the route and its impacts to the Finnish waters are discussed in the Nord Stream Espoo Report /5/.

However, the proposed southern route alternative around Gogland Island creates a small deviation for the pipeline route also in the Finnish EEZ. This deviation for south-east and north-west pipelines, can be considered as a sub-alternative to Alternative 1 (C14) or Alternative 2 (C16).

The distances from the Russian – Finnish EEZ border to the location where the deviated route joins Alternative 1 or Alternative 2 are approximately 3.7 km for the south-east pipeline and 3.5 km for the north-west pipeline. As these distances are relatively small compared with the entire pipeline route in the Finnish section, this sub-alternative is locally assessed and compared with the local section of Alternative 1 or 2.

Routing is illustrated in Figure 6.4, and more properties are presented in Table 6.3.

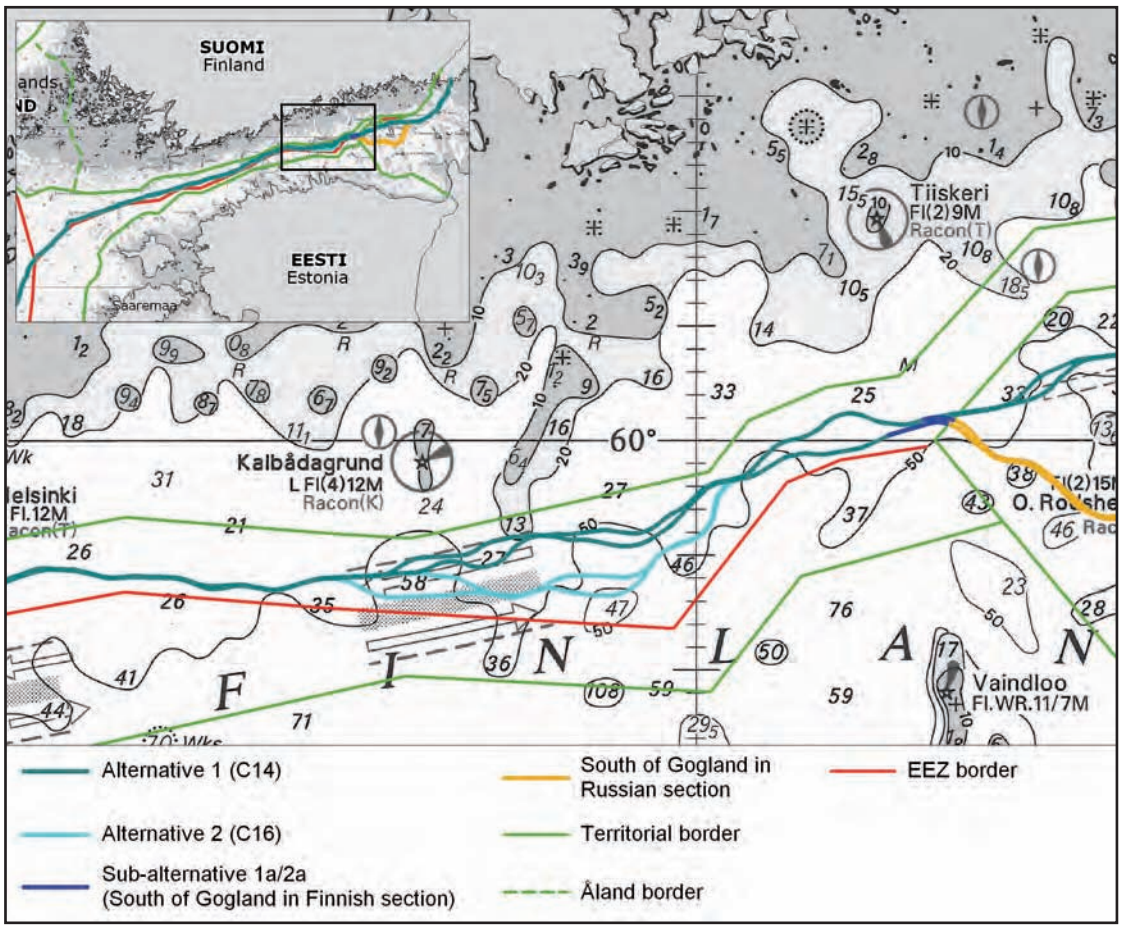

Figure 6.4. Sub-alternative 1a/2a (South of Gogland in Finnish section). For details of the Alternative 1a/2a see Atlas Map PR-1b-F.

Table 6.3. Properties of Alternatives 1 and 2 compared with sub-alternative 1a/2a in Finnish EEZ.

	Alternative 1/2 – locally		Subalternative 1a/2a	
	South-east	North-west	South-east	North-west
Length [m]	4,337	3,850	2,881	1,746
Number of seabed intervention works	0	0	1	1
Volume of gravel works [m^3]	0	0	3,420	34

6.2 Non-assessed route within Estonian and Finnish EEZ

During the EIA procedure a route alternative further south, partly through Estonian waters, was also considered. However, for reasons that will be explained in this chapter, this alternative was excluded from further technical design and environmental impact assessment.

The pipeline routes in the Gulf of Finland run through Russian and Finnish waters. The uneven topography of the Gulf of Finland seabed prompted Nord Stream's predecessor, North Transgas, to apply to the Estonian government in 1998 for a permit to carry out seabed surveys for alternative pipeline routes within the Estonian EEZ. The purpose of the surveys was to identify alternative routes in the Gulf of Finland with geological and environmental conditions less problematic to pipeline construction. However, permission for the survey was not granted, and the potential route alternatives through the Estonian EEZ were abandoned. Subsequent investigations therefore focused on a pipeline route within the Finnish EEZ.

However, since the original survey application in 1998 a number of alternative pipeline route options in Estonian waters have consequently been considered because of the substantially uneven seabed in the Gulf of Finland. Desk studies indicated that the seabed was less rugged further south of the proposed pipeline routes within the Finnish EEZ. A more even seabed would require fewer seabed intervention works. For this reason, the Finnish authorities formally requested during the EIA scoping phase that Nord Stream AG investigate potential route alternatives further south in the Gulf of Finland. In response, Nord Stream AG applied for survey permits in both Finland and Estonia in order to perform the assessment of more southerly pipeline routes within the Finnish and Estonian EEZs.

A survey permit application for the section of the route within the Finnish EEZ was submitted to the Ministry of Trade and Industry in June 2007. The survey permit was granted in August 2007. A proposal for an optimised route in the Gulf of Finland was submitted to the Estonian authorities together with a survey application. The Estonian Ministry of Foreign Affairs rejected the survey permit application for the section in the Estonian EEZ in a letter dated 26 September 2007. For this reason, the Estonian route alternative was excluded from further technical design and from the environmental impact assessment.

The excluded route is identified in Figure 6.5.

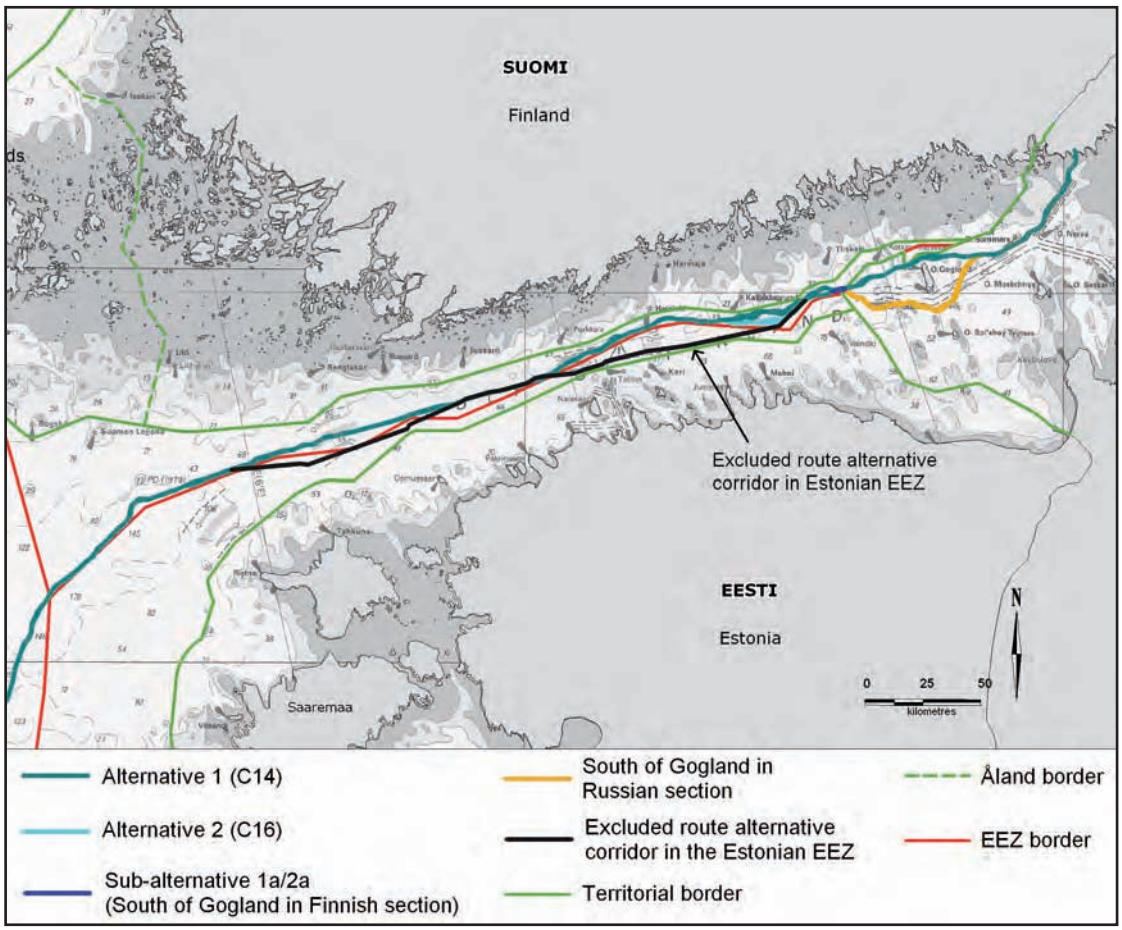

Figure 6.5. Excluded route alternative corridor in the Estonian EEZ.

6.3 Route optimisation process

The selection of the route Alternatives 1 (C14) and 2 (C16) is a result of continuous evaluation of different possibilities of re-routing the pipelines with regard to seabed, length of the route, needed intervention works and so on. The objective of this process has been to find the best possible route in a way that it minimises the environmental impacts and the overall cost of the project while respecting the applicable codes and standards. By optimising the route so that critical seabed conditions, munitions, environmentally sensitive areas and shipwrecks can be avoided and by minimising the need of gravel supports (seabed intervention works), impacts to the environment can be minimised.

This chapter describes the optimisation process in each design phase of the project: feasibility study, conceptual design and detailed design. The most relevant route optimisations are described, including an explanation of the criteria used in that phase. For a more detailed description of applied methodologies, criteria and assumptions, reference is made to /321-329/.

6.3.1 Feasibility study

In 1998, a feasibility study to consider various route options was performed by a company called North Transgas (NTG) (see chapter 2). The study focused mainly on combined gas delivery to Finland, Sweden and Germany and consisted of different combinations of onshore and offshore segments. The study confirmed the feasibility of the project.

After evaluation of the routes and establishing the technical feasibility of all routes, NTG concluded in 1999 that a route option completely through the Baltic Sea proved to be most advantageous. This route consists of an onshore section in Finland and an offshore section through the Baltic Sea to Germany. With regard to sustainability, a rough, preliminary comparison of potential environmental impacts showed that onshore solution would probably result in more impacts on the environment. In addition, the geographical circumstances clearly favour an offshore solution. Onshore routes via Scandinavia or via a Baltic-Polish corridor would have led to complicated lake and river crossings and pass through other environmentally sensitive areas. The Finnish onshore part was replaced in the next project phase by a complete offshore solution through the Gulf of Finland. The feasibility study is presented in more detail in chapter 2.

The results of these investigations were never implemented because Fortum Oil and Gas Oy shifted its focus towards the power sector, establishing nuclear power plants in Finland and buying Swedish utilities.

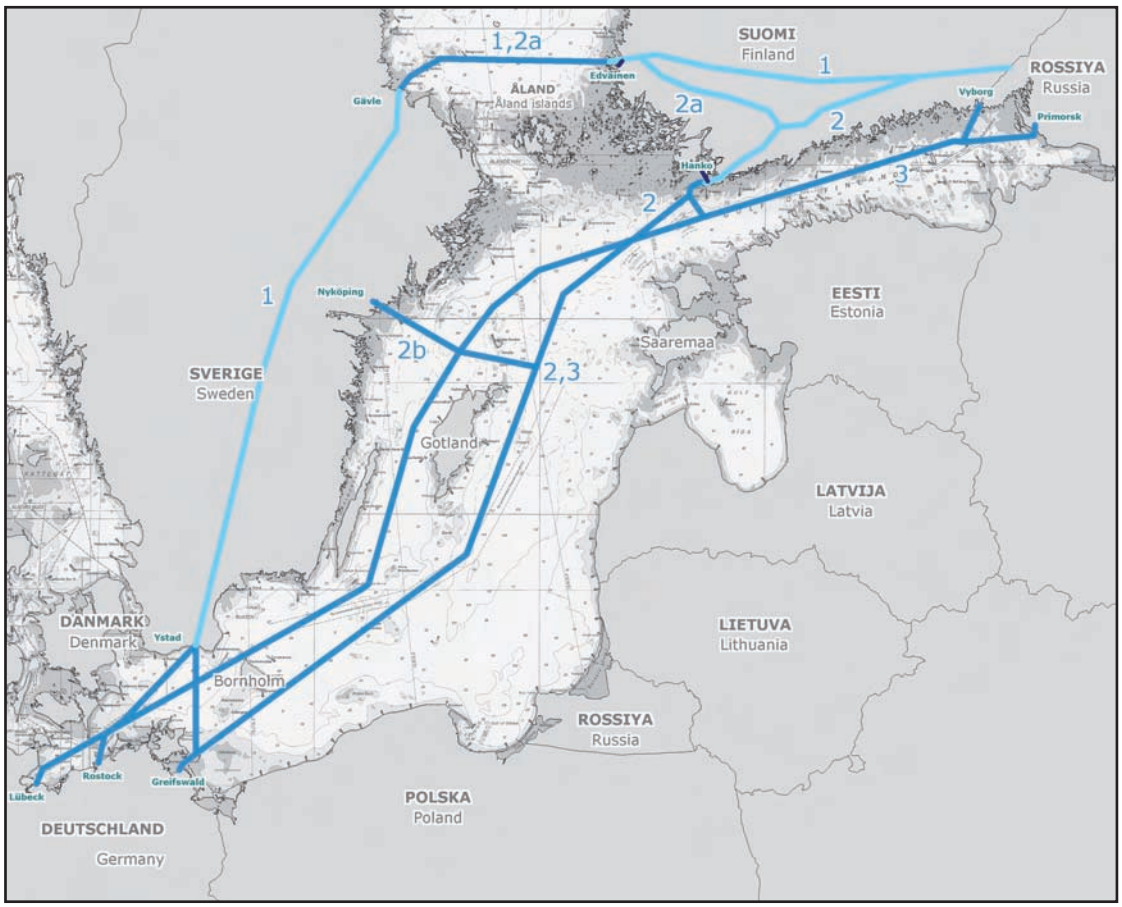

Figure 6.6. Route option during feasibility study in 1998.

6.3.2 Conceptual engineering design

In 2004, a conceptual design for offshore pipelines was produced by NEGP (North European Gas Pipeline). A centre line for a route corridor was developed for the Baltic Sea (so called Route B1). This centre line was used as a reference line to define the survey corridor around it for the 2005 detailed geophysical survey. Therefore it has a different code number than the route optimisations in the detailed design. For more information see chapter 2.1.

The route selection in this conceptual phase was based on a number of principles and requirements, such as:

- route length
- number of curves
- required intervention works (minimising impacts to the environment from intervention works)
- crossing of existing pipelines / cables
- crossing of fishing areas / shipping channels (minimising impacts to the environment)
- crossing of restricted areas (military areas, Natura 2000 areas, other nature protection areas, cultural heritage) (minimising impacts to the environment)

6.3.3 Detailed design phase

For clear reference and order, code numbering has been used throughout the entire technical design of route optimisation process. According to the numbering system, each pipeline route is given a general code number in this way: CX.Y, where X is a progressive number starting from 1, while Y is always limited between 0 and 9, for example C4.1. The letter C is a label defined by PeterGaz during the previous design phase. This is a simple label for the route and was also used in the detailed design phase for route identification.

Optimisation the route is carried out as follows:

- The relevant pipeline configuration, taken during its lifetime (i.e. pipeline laid on the seabed in empty, flooded and operating conditions) are analysed for the defined route (i.e., Route C9.9)
- Rerouting is applied if this route does not satisfy the general principles (reduction of overstress of the pipeline or long freespans) or if further optimisation is possible
- Consequently, a new route is defined and a different code number is applied (i.e., Route C10.0)
- The process continues until the best route is found.

It should be noted that some code numbers refer to only a certain section of the pipeline route. For example, Route C9.4 concerns local rerouting of the south-east pipeline in order to avoid local critical slopes along the seabed profile between kilometre position (KP) 381 and KP 390. The south-east pipeline runs closest to Estonia and Poland; the north-west pipeline runs closest to Finland and Sweden. The remaining Finnish pipeline route (from KP 123 to KP 381 and from KP 390 to KP 495) has code number C9.1.

The detailed design phase started with the latest optimised route from the conceptual design phase, which was assigned the code number 3.2. The Route C3.2 alignment was used as a basis for the detailed design phase. Several opportunities for optimisation were identified during the conceptual study to potentially further reduce the level of required intervention. These were considered in the updated routes C4.0 East and C4.0 West, which formed the reference alignments for the 2006 detailed seabed survey by remotely operated vehicle (ROV). The width of the corridor investigated during this 2006 survey was approximately 200–250 m.

The C4.0 routes formed the basis of the detailed technical design phase. In this phase, further optimisation was performed through the definition of the seabed intervention work (IW), according to the following criteria:

- Minimising the number and dimension of intervention works required
- Keeping the two pipelines a reasonable distance from one another (preferably 100 m, locally reduced where required due to uneven seabed)
- Minimising the number of curves
- Positioning the curves in areas pf even seabed and checking their stability
- Avoiding undesired pipeline interference with seabed obstacles during pipelay
- Minimising interaction with shipping routes.

The following route optimisations relevant to the detailed seabed intervention design are summarised in Figure 6.7 and described thereafter:

- C4.0 routes
- C9.1 routes
- C10.3 routes
- C14 / C16 routes

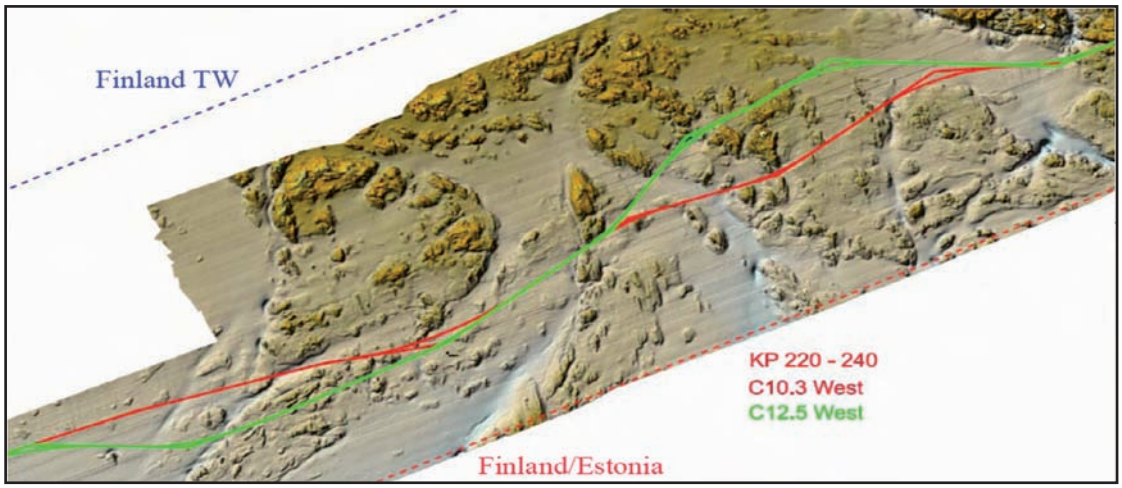

Figure 6.7. Example of route optimisation of the north-west pipeline from C10.3 to C12.5 between KP 220 and KP 240. For other examples of route optimisation and alignments, see the Atlas, maps PR-4a, PR-4b, PR-4c, PR-7a and PR-7b.

6.3.3.1 Routes C4.0

The C4.0 routes are the routes defined in the conceptual phase. To estimate the required gravel volumes for sea-bed intervention works at the start of the project, prior to any detail design activity, gravel volumes from similar projects on an uneven seabed were applied. These values are to be considered the upper limit of gravel volume.

6.3.3.2 Routes C9.1

Optimisation of the C4.0 routes to the C9.1 routes aimed to reduce the overall amount of seabed intervention works and gravel volumes. A further improvement of this route (only for the East Pipeline) is route C9.4, where local rerouting between approximately KP 381 and KP 390 was performed to avoid critical slopes along the seabed profile.

Due to some critical seabed intervention works in terms of the height of the intervention works, for example high gravel berms, and geotechnical stability, a decision was taken to extend the investigation corridor in some locations (called “recommended / suggested areas” in the following) in order to minimise the gravel works. The required gravel amounts are presented in Table 6.4. The amounts are based on experience from pipeline construction projects in areas with similar seabed conditions.

6.3.3.3 Routes C10.3

The C10.3 routes were the result of the route optimisation process in order to provide an engineering solution for the intervention works to be presented to the Finnish authorities. The rerouting activity was performed within the 'base corridor'. No possible other alternatives were considered because survey data was only available for the base case corridor, not for the recommended suggested areas.

Table 6.4 shows that the required rock volume for route C10.3 is higher than that for route C9.1. This is because the amount of gravel for route C10.3 was determined with exact calculations based on the available survey data, while C9.1 is estimated on the basis of experience with similar projects.

6.3.3.4 Routes C14

The C14 routes were defined with the additional benefit of new survey data. The rerouting activity was performed within the recommended / suggested areas as well as within the 'base corridor'.

Optimisation from route C10.3 to route C14 significantly reduced the number of intervention works and the amount of gravel required.

Table 6.4 presents the number of intervention works and the gravel volumes for both the south-east pipeline and the north-west pipeline. It should be noted that the gravel volumes in this table include only those required for static (pre- and post-lay) stability and not for dynamic stability. For this reason, the values for C14 do not match those reported in other sections. This is done in order to be able to compare the optimisations, as the intervention works for dynamic stability have been determined for C14 only.

6.3.3.5 Routes C16

The C16 routes are to the same as the C14 route, with the exception of a 40 km section in the Kalbådagrund area. In this section, route optimisation was carried out according to a different numbering system: "Kalb_x", where x is a progressing number. C16 corresponds to "C14 + Kalb_3 East" for the south-east pipeline and "Kalb_6 West" for the north-west pipeline.

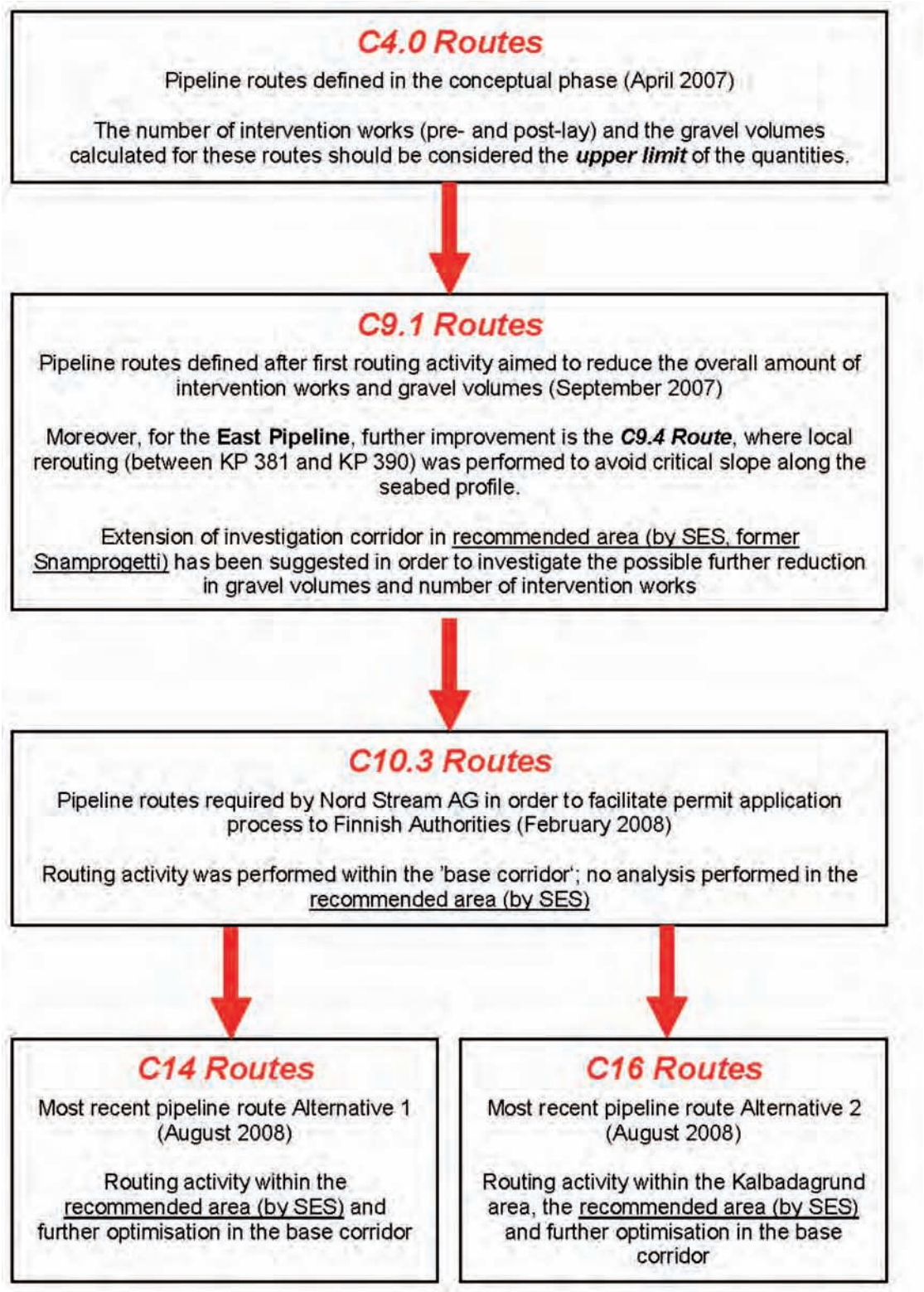

Figure 6.8. Schematic description of the most relevant optimisation steps.

Table 6.4. Amount of intervention works (IWs) and special foundations in different phases of optimisation in the Finnish EEZ. The reported amount concerns only the IWs required for mitigating excessive stress in static conditions and not for the dynamic ones.

	East Pipeline			West Pipeline		
	IWs [nr]	Total gravel volume [m³]	Special foundations [nr]	IWs [nr]	Total volume of gravel [m³]	Special foundations [nr]
C4.0	183	431,120	24	n.a.	n.a.	n.a.
C9.1 (incl C9.4)	119	157,340	17	101	115,020	10
C10.3	95	196,650	10	116	198,900	18
C14 (Alternative 1)	65	82,574	0	81	142,033	0
C16 (Alternative 2)	63	96,612	0	71	150,969	0