CHALMERS
UNIVERSITY OF TECHNOLOGY

Evaluation of the Most Socioeconomically Favourable Road Alignment

A Case Study of Road 56

Master of Science Thesis in the Master Degree Programme Infrastructural and Environmental Engineering

REBECCA GREK
CECILIA NORBERG

Department of Civil and Environmental Engineering
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2014
Master's Thesis 2014:96

MASTER’S THESIS 2014:96

Evaluation of the Most Socioeconomically Favourable Road Alignment

A Case Study of Road 56

Master of Science Thesis in the Master’s Programme Infrastructure and Environmental Engineering

REBECCA GREK
CECILIA NORBERG

Department of Civil and Environmental Engineering
Division of GeoEngineering
Road and Traffic Research Group
CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden 2014

Evaluation of the Most Socioeconomically Favourable Road Alignment
A Case Study of Road 56

Master of Science Thesis in the Master's Programme Infrastructure and Environmental Engineering

REBECCA GREK
CECILIA NORBERG

Examensarbete / Institutionen för bygg- och miljöteknik,
Chalmers tekniska högskola 2014:96

Department of Civil and Environmental Engineering
Division of GeoEngineering
Road and Traffic Research Group
Chalmers University of Technology
SE-412 96 Göteborg
Sweden
Telephone: + 46 (0)31-7721000

Cover: Visualization of alignments generated by Trimble Quantm on a satellite photo (Trimble, 2011)

Chalmers reproservice / Department of Civil and Environmental Engineering
Göteborg, Sweden 2014

Evaluation of the Most Socioeconomically Favourable Road Alignment
A Case Study of Road 56

Master of Science Thesis in the Master's Programme Infrastructure and Environmental Engineering
REBECCA GREK
CECILIA NORBERG
Department of Civil and Environmental Engineering
Division of GeoEngineering
Road and Traffic Research Group
Chalmers University of Technology

ABSTRACT

The construction of a new road is a process of several years and requires large investments. It is therefore of great importance that the project becomes profitable in a socioeconomic perspective. At the moment (May 2014) a part of the Swedish national road 56 is under investigation for a planned reconstruction. The consultant company WSP has produced several corridors for the part passing the settlement Äs, and the Swedish Transport Administration will make a choice of corridor at the end of May 2014. This thesis investigates two of the corridors in order to find the most socioeconomically favourable alignment and speed limit. Appropriate placement of overtaking fields has also been decided. In addition, the usability of the software Trimble Quantm (version 7.1.0.121 desktop edition) as a road planning tool has been evaluated.

The evaluation of the socioeconomic effectiveness of the alignments has been performed using the road planning software Trimble Quantm and a socioeconomic analysis. Trimble Quantm has been used in order to find alternative alignments. Three speed limits have been investigated, 80 km/h, 100 km/h and 110 km/h, resulting in six scenarios and a total of 150 alignments. These have been evaluated with a cost-benefit analysis, which considers costs for the road authority, road user and community. The analysis gave a net benefit cost ratio for each alignment. The most beneficial alignment from each scenario was selected for further evaluation. The cost-benefit analysis only considers effects which can be valued with monetary values. Intrusion into sensitive areas and fulfilment of project goals has therefore been evaluated separately.

According to the cost-benefit analysis and the non-monetary valued parameters, an alignment within corridor four should be selected. The alignment with the highest net benefit cost ratio can be found in the scenario with speed limit 100 km/h. The overtaking fields are placed between section 1/100 and 3/900. Trimble Quantm has proven not to manage large constrains well and might therefore not be suitable to use for detailed design. It is probably more useful when finding or comparing alternative corridors and can be a practical tool in an early stage of the planning process.

Keywords: alignment, cost-benefit analysis, Road 56, road design, socioeconomically favourable, transport economy, Trimble Quantm

Utvärdering av den samhällsekonomiskt mest fördelaktiga vägsträckningen
En fallstudie av väg 56

Examensarbete inom Infrastructure and Environmental Engineering
REBECCA GREK
CECILIA NORBERG
Institutionen för bygg- och miljöteknik
Avdelningen för geologi och geoteknik
Väg och trafik
Chalmers tekniska högskola

SAMMANFATTNING

En vägbyggnation är ett stort projekt som tar lång tid och kräver stora investeringar. Det är således av stor vikt att en samhällsekonomiskt fördelaktig lösning väljs. För tillfället (maj 2014), är en del av landsväg 56 under utredning för en kommande rekonstruktion. Konsultföretaget WSP har tagit fram flera korridorer för den del av vägen som passerar samhället Äs och Trafikverket förväntas ta ett beslut om korridor i slutet av maj 2014. Det här examensarbetet har utförts som en utvärdering av två av korridorerna med syftet att finna den samhällsekonomiskt mest fördelaktiga linjeföringen och hastighetsstandard. Lämplig placering av omkörningsfält har också hittas. Dessutom har användbarheten av optimeringsverktyget Trimble Quantm (version 7.1.0.121 desktop edition) utvärderats.

Utvärderingen av olika linjeföringars samhällsekonomiska nytta har utförts med hjälp av vägplaneringsprogrammet Trimble Quantm tillsammans med en samhällsekonomisk analys. Trimble Quantm har använts för att finna alternativa linjeföringar. Tre hastigheter har utvärderats; 80 km/h, 100 km/h och 110 km/h, vilket resulterat i sex scenarion och 150 olika linjeföringar. Dessa har utvärderats med en kostnads-nyttoanalys. Analysen tar hänsyn till kostnader för väghållare, väganvändare och icke-användare. Nettonuvärdeskvoten har beräknats för varje väglinje. Den mest fördelaktiga inom varje scenario har valts ut för vidare utvärdering. Kostnads-nyttoanalysen inkluderar endast effekter med monetära värden. Intrång i känsliga områden och uppfyllande av projektmålen har därför utvärderas separat.

Enligt kostnads-nyttoanalysen och utvärderingen av parametrar utan monetära värden ska en väglinje inom korridor fyra väljas. Väglinjen med den största nettonuvärdeskvoten hittas i scenariot med hastighetsstandard 100 km/h. Omkörningsfälten har placerats mellan sektion 1/100 och 3/900. Trimble Quantm har visat sig inte klara av stora begränsningar väl och lämpar sig därför inte för detaljprojektering. Programmet är förmodligen mer lämpat för att finna eller jämföra olika korridorer och kan vara ett praktiskt verktyg i ett tidigt skede i projektet.

Nyckelord: samhällsekonomisk analys, samhällsekonomiskt fördelaktig, transportekonomi, Trimble Quantm, väg 56, väg design, väglinje

Contents

Preface

This Master thesis is written by Rebecca Grek and Cecilia Norberg. The work has been supervised by Jan Englund and Gunnar Lannér at Chalmers University of Technology. The thesis was performed between January and May 2014.

The authors would like to thank their supervisors Jan Englund and Gunnar Lannér for guidance. Thanks are also given to Anders Markstedt for the idea, Karolina Wettermark for supervision regarding the project of road 56 and Christian Lundberg for assistance with Trimble Quantm.

Notations

AADT-DIM – Dimensional annual average daily traffic

ASEK – An authority group led by the Swedish Transport Administration; a working group for socioeconomic profitability and analysis methods within transportation (Arbetsgruppen för samhällsekonomiska kalkyl- och analysmetoder inom transportområdet)

CBA – Cost-benefit analysis

DTM – Digital Terrain Model

FoU – Investments in research and development

GDB – Gross domestic product, referred to in Sweden as BNP

IRR – Internal rate of return

mSEK – Million Swedish crowns

NPV – Net Present Value

PV – Present Value

SEK – Swedish currency

SKL – Sweden's municipalities and county councils

VAT – value-added tax

WSP – Consultant Company

1 Introduction

In this first chapter, a background to the thesis is given. This includes some information about why socioeconomic evaluations are important in infrastructural investments and an introduction to the case study. It also presents the aim, scope and method of the thesis.

1.1 Background

Building a new or making a large reconstruction of a road is a long process of several years and requires large investments. A new or reconstructed road provides the society with welfare. It can be the possibility to travel to a certain place or e.g. improvement of travel time, vehicle operating costs, safety and environment (Johansson, 2004). The overall goal for transport policy in Sweden is to provide citizens and businesses with a transportation system that is socioeconomically effective and sustainable (Trafikverket, 2012a). When choosing which measures to apply, socioeconomic effectiveness is a criterion with substantial importance.

Road 56, between Norrköping and Gävle, is a Swedish national road. The road is an option to the 40 kilometre longer European road E4, passing through the capital Stockholm. Plans regarding some kind of reconstruction of the road have existed since the 1990s (WSP, 2013). At the moment, the part between Bie and Stora Sundy is under investigation. Road 56 is currently passing through the settlement Äs, where several households are situated near the road with driveways connected to it. As the stretch is frequently trafficked by heavy vehicles, the inhabitants are subjected to emissions and safety risks. The reconstruction is planned in order to increase the traffic safety, mobility and accessibility, and to improve the living conditions for the inhabitants of Äs. As a first step, a suitable corridor has to be chosen. Several alternative corridors are being investigated (see Figure 1) and corridor alternative four is considered as the most socioeconomically favourable. There are however objections to a road within this corridor, mainly due to the crossing of natural and cultural values. Further steps in the planning process are to decide a suitable road alignment within the corridor, speed limit and placement of overtaking fields. For the society, it is important that an alignment which contributes to welfare is designed. A road planner can however only investigate a limited number of alignments. Therefore a software program like Trimble Quantm, a planning tool which analyses millions of alternative alignments, can be used (Trimble, 2011). Thus, several alternatives can be investigated before a choice is made.

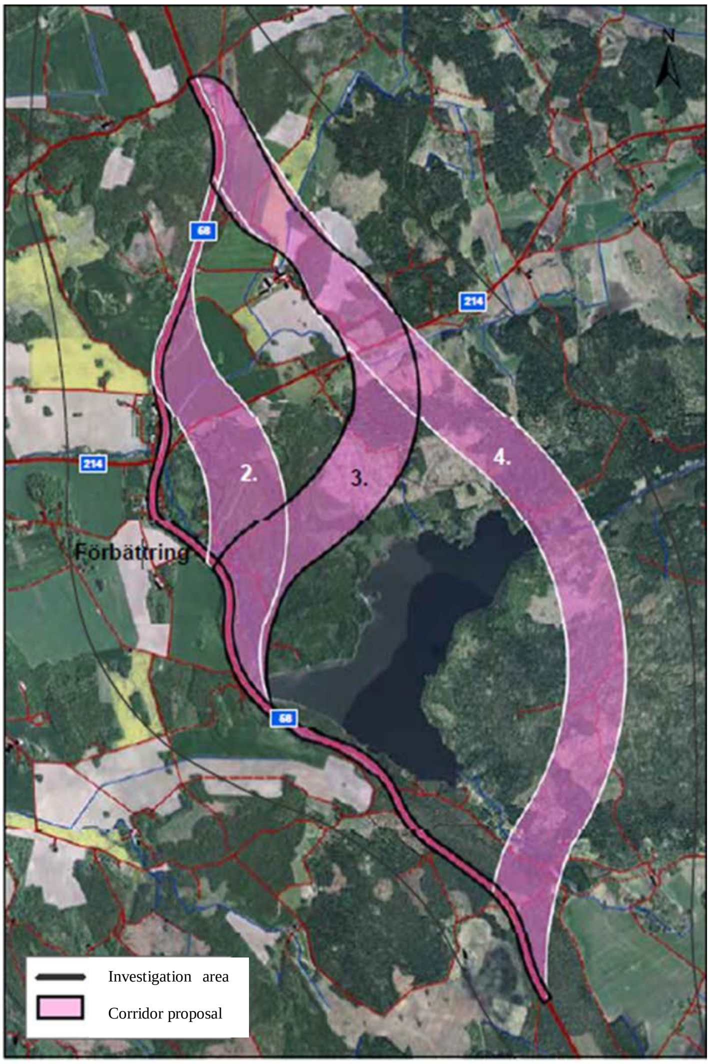

Figure 1 Alternative corridors for road 56, passing Äs [Taken from (WSP, 2013)]

1.2 Aim

The aim of this thesis is to evaluate different road alignments within corridor number two and four, for road 56 between Bie and Stora Sundby, in socioeconomic values. By application of different geometric road standards, the most socioeconomically effective alternative should be found. Suitable placement of overtaking fields should also be determined. The thesis should also evaluate the usability of the software Trimble Quantm as a tool in road planning and design.

1.3 Scope

The thesis only includes a stretch between Bie and Stora Sundby, passing Äs, of road 56. No other alternative corridor, than corridor number two and four, will be evaluated. These corridors are considered to be the two most favourable[1]. Road alignments will be found using the software tool Trimble Quantm. No other program will be used in order

[1] Karolina Wettermark project manager for the project at WSP, interviewed 2014-03-27

to receive a result. The socioeconomic evaluation will be done with a cost-benefit analysis. It will only include differences between different alignments and corridors. Focus lies on road authority costs, road user costs, community costs and effects on natural, cultural and landscape values.

The literature survey includes the road planning process, road design, and socio and transport economy since these are considered relevant for the thesis. A case study will be performed in order to provide information about the project of the reconstruction of road 56. In addition to overall information about the project, detailed information about corridor two and four will be presented.

1.4 Method

This is a comparative study of road alignments for road 56 in order to find the most socioeconomically beneficial solution. In a comparative study at least two different cases are studied with similar methods (Bryman, 2008). In this thesis the software program Timble Quantm will be used in order to obtain different road alignments which will be compared in the cost-benefit analysis. Program version 7.1.0.121 desktop edition is used. It should be noted that a new version of the software is available. To meet the aim given in Chapter 1.2, the thesis will include three different phases: literature survey (including a case study), investigation of different road alignments using Trimble Quantm and evaluation of the result with a cost-benefit analysis. The different phases and their location in time are visualized in Figure 2.

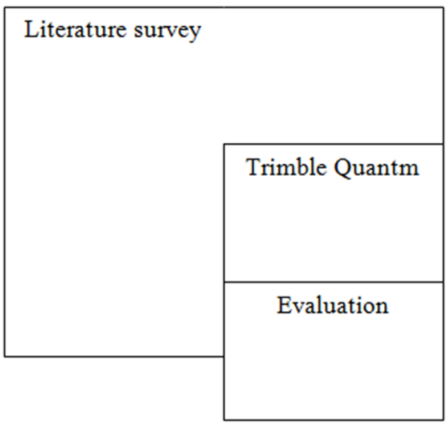

Figure 2 The three phases of the thesis

1.4.1 Literature survey

This part of the thesis is authored partly in order to be the foundation and background of the investigation conducted (Bryman, 2008). It is also functioning as a framework for which the road planning process, road design, and socio and transport economy can be understood and the provided result interpreted. The chapter about the road planning process will shortly describe the planning process which is used in Sweden since 2013. The chapter about road design will include information of the road structure, geometric design and aspects as speed, overtaking fields and medians. The economy is mainly focused on transport economy and how measures can be evaluated in order to receive the most socioeconomically favourable alternative. The survey is based on literature on the subjects as well as reports mainly from the Swedish Transport Administration. Since the road is going to be designed for Swedish standard, it is judged suitable to base the study mainly on Swedish literature.

A case study is a comprehensive and intensive analysis of a specific case (Bryman, 2008). The case study's focus in this thesis is road alignments within corridor two and four, on road 56. The Swedish Transport Administration was, at the beginning of 2014, investigating various alternatives for a reconstruction of a part of road 56. Thus, material regarding the case study is mainly provided from the Swedish Transport Administration and the consultant company WSP. The fundamental basis is the road plan produced in the end of year 2013. Specific project related information is obtained by an interview with Karolina Wettermark, project manager at WSP.

1.4.2 Trimble Quantm

Trimble Quantm is a software program developed by the company Trimble (Trimble, 2014). The software is a road and railway planning tool that investigates and analyses possible corridors or alignments (Trimble, 2011). It considers all feasible alternatives; millions of alternatives are investigated, and presents 25 alignments for evaluation. Trimble Quantm integrates engineering, environmental, social and economic factors in the analysis. In this thesis the program will be used in order to evaluate how different speed limits will affect the construction cost for different alignments. The program is claimed to lead to more rapid decisions and lower construction and operating costs. The software should also minimize the road's environmental and social impact. Factors, in road design, which are considered and analysed simultaneously in the software, are more specifically (Trimble, 2013):

- Design standard
- Terrain
- Geological and hydrogeological data
- Environmental areas
- Cost information

The program does not have a widespread use in Sweden, but it has been used with positive results globally. Trimble Quantm is claimed to be ideal for both small and large projects (Trimble, 2013). Its benefits are, among other, reduced planning time which delivers a finished road faster, simplifies consideration to added constrains from stakeholders during the planning process, reduce the investor risk and consider land values. In the end, Trimble Quantm should provide value for the project owner, project team and the community.

A lot of information needs to be set to the software in order to receive a result. The accuracy of the result provided by Trimble Quantm depends on the accuracy of the input data. The needed input data includes a digital terrain model (DTM), construction costs, material parameters and geometric parameters. Information regarding how the model is set up is provided in Chapter 6.1. There are also costs which are not included in Trimble Quantm that needs to be considered. These are fixed costs (e.g. planning costs), maintenance costs, road user costs and community costs, and will be considered with a cost-benefit analysis. The fixed costs for each corridor are provided from the basis calculation performed by WSP (WSP, 2014). Such costs are mainly interesting

when comparing alignments in different corridors. All input data (both to Trimble Quantm and the cost-benefit analysis) is presented in Appendix 1.
Placement of overtaking fields cannot be suggested by Trimble Quantm. Therefore the placement of these have to be suggested based on literature. Cost estimations for different placements can however be evaluated with Trimble Quantm.

1.4.3 Evaluation

The software program Trimble Quantm will provide 25 different road alignments within corridor two and 25 alignments within corridor four for each geometric standard. These have to be evaluated in order to judge which alternative will provide the greatest socioeconomic efficiency. This will be done through a cost-benefit analysis performed in two steps. First, the most socioeconomic alternative has to be found for each scenario. Thereafter a comparison between different corridors and speed limits will be done. This procedure is necessary due to the magnitude of alignments provided by Timble Quantm (a total of 150 alignments).

There are several factors that can be considered during evaluation of different road alignments in order to find the most socioeconomically favourable alternative. However, since only one corridor is investigated at a time, it is likely that there is none or a very small difference between some factors for the different road alignments. Thus, these factors will be excluded from the analysis. That is, only differences between the alignments and corridors will be considered. The software program Trimble Quantm will only consider construction costs. The cost-benefit analysis will consider other relevant socioeconomic factors:

- Fixed planning and construction costs
- Maintenance costs
- Travel time costs
- Traffic accident costs
- Vehicle operating costs
- Emission costs
- Noise costs
- Intrusion in sensitive areas
- Barrier effect
- Risks
- Disturbance during the construction
- Fulfilment of the specific project goals

In addition, a sensitivity analysis will be made. This, in order to evaluate the robustness of the cost-benefit analysis, which factors the result from the CBA is sensitive to and make sure representative values are used. This will be done by increasing or removing some costs from the analysis and see how the result is affected.

2 The process of road planning

The planning process of a new road construction is an extensive process. It involves many authorities such as the Swedish Transport Administration, county administrative boards, municipalities, public transportation, interest groups, regional and cooperative bodies, the public and property owners (Trafikverket, 2013). In 2013, a new planning process was adapted by the Swedish Transport Administration (Trafikverket, 2012). The purpose of the new process is to obtain a coherent process instead of the previously applied stages[2]. With the new process the opportunities for interaction with local government planning would increase.

The process starts with a measure study (Trafikverket, 2013). When a deficiency is detected in the transport system, potential measures are investigated. The measure study should answer why a road project is needed. The study is performed with a four stage principal.

1. *Reconsideration:* the first stage should investigate if the requirements of transportation can be reduced or replaced with other modes of transport.
2. *Optimization*: the second stage should investigate however the road network could be used more efficiently.
3. *Reconstruction*: the third stage should investigate if it is possible to solve the problems through improvements or minor reconstructions of the road.
4. *New construction:* the fourth stage should investigate however new investments or major reconstructions are required.

It is primarily strived to solve the problem through measures of stage one and two. But if it is not sufficient, stage three and four are applied.

Further on in the process, the planning takes place during which a road plan is developed (Trafikverket, 2013). The planning should answer where and how the road should be built. The required time for the planning is depending on the size of the project, amount of pre-investigations, alternative routes, budget and the stakeholders' opinions. An environmental impact assessment is developed during the planning and is included in the road plan. When the road plan is approved, there is a time for appeal before the plan becomes final. The planning process ends with a construction document. This document includes technical descriptions and requirements regarding the function of the road and serves as a basis for the construction work.

[2] The planning process was earlier divided into prestudy, road investigation, road plan and construction documentation.

3 Road design

When designing a new road, it is necessary to decide the thickness of the different layers in the road structure, horizontal respectively vertical alignment and cross sections. This chapter will describe these aspects in order to provide an understanding of the different parts in road design. The design of the Swedish national road network is conformed to guidelines stated in the document *"Vägar och Gators utformning"* (Trafikverket, 2013a). The guidelines are developed by the Swedish Transport Administration and Sweden's municipalities and county councils (SKL). The guidelines are determined on basis of socioeconomics, transport policy goals and environmental and architectural objectives. They are obligatory on the national road network but optional on municipal roads.

Traffic safety should also be a design criterion (Odgen, 1996). A road with high design standard (geometric standard) is generally safer than a road with lower standard. This is due to that potential sources of conflicts have been designed out. There are several different factors that should be considered from a safety perspective. However, only speed, medians and overtaking fields are considered to be relevant for this thesis and will be described later in this chapter.

3.1 Road structure

The road structure is the part of the road which is constructed in order to carry the traffic load (Granhage, 2009). A road is built of rock material, either crushed rock, natural gravel or till. Natural gravel is a finite resource and an important water source. Hence, crushed rock is from a socioeconomic perspective more suitable. During the construction of the road structure, cuts and banks are needed where the earth or rock masses are too high respectively too low, see Figure 3.

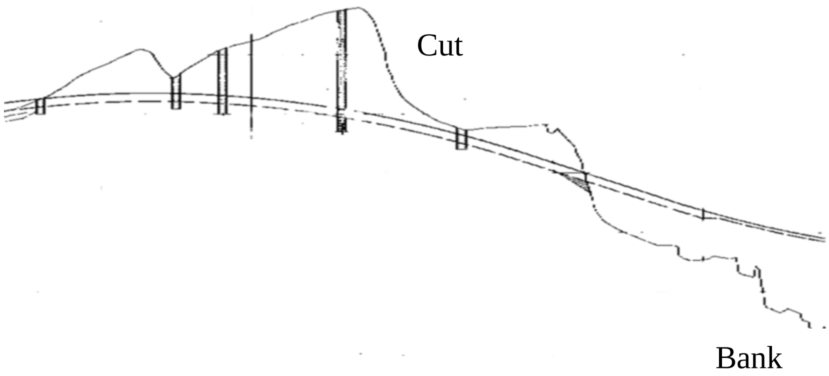

Figure 3 Illustration of cuts respectively banks during road construction [Taken from (Granhage, 2009)]

The road structure consists of several different layers with different properties, demands and purposes. The layers' thicknesses are determined in order to meet requirements regarding traffic load and frost heave, where the thickest structure is dimensional (Granhage, 2009). Thus, the thickness of the structure varies with traffic load, climate and ground material. The traffic load is calculated in terms of equivalent standard axles (ESALs) during the road's technical life length. This means that all traffic is recalculated to a standard axel, which in Sweden is a truck axel of 100 kN. ESALs are used since it is the heavy traffic, such as trucks, that deteriorate the road. Deterioration from passenger vehicles is assumed negligible due to their small contribution. The load surface of an ESAL is presented in Figure 4 below.

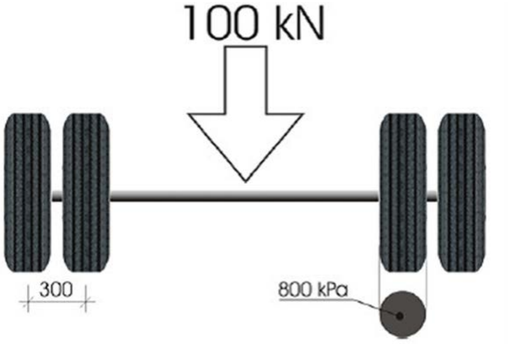

Figure 4 A Swedish equivalent standard axel [Taken from (Granhage, 2009)]

The ground situated under the road structure is called subgrade (Granhage, 2009). It is the subgrade's properties, such as strength and heave susceptibility, that decide the thickness of the road structure. A road constructed on rock does not have to be as thick as one constructed on e.g. clay. Ground reinforcements can be necessary if the bearing capacity is insufficient. Directly upon the subgrade is an embankment. At the top of the embankment lies the terrace surface, see Figure 5. Occasionally, a material, e.g. geotextile or a fibre cloth is added to the terrace surface in order to keep the materials over and under the terrace separated.

On top of the terrace surface the superstructure is constructed which is the top layers in the road structure (Granhage, 2009). It can take different appearances and consists of several layers. The layers that can be included will be presented below and an example is presented in Figure 5. The purpose of the superstructure is to distribute the traffic load in order to protect the underlying layers and to reduce abrasion. As the load is distributed down in the structure, so are the demands on the layers[3]. The permeability of the superstructure should however increase down in the structure since a water collection would affect the bearing capacity negatively.

[3] The different demands are not within the scope of this thesis, but can be found in VVTK Väg, VV Publ 2008:78.

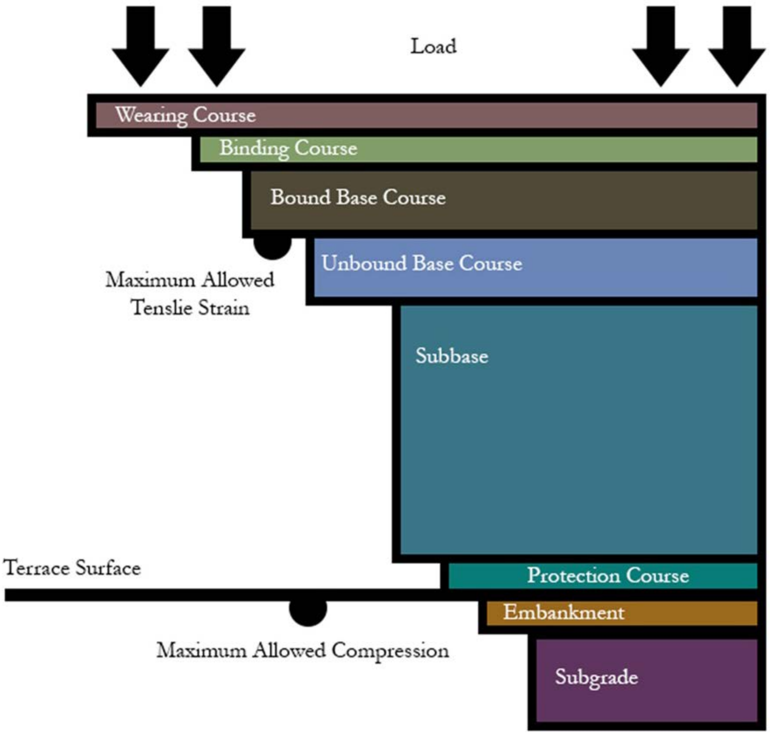

Figure 5 Example of road structure [Inspired by (Granhage, 2009)]

The superstructure's top layer is the wearing course. In this layer the rock material is normally mixed with either bitumen or concrete in order to create a layer with good bearing capacity, friction, evenness, optic qualities and resistance to abrasion and deformation. On high volume roads, or roads with a lot of heavy traffic, a binding course should be constructed beneath the wearing course. This, in order to reduce cracking and rutting due to the traffic load. The layer should be stable, stiff, durable and water resistant. It can also be applied as a transmission layer if there is a big difference in rock size between the wearing course and underlying base course. The purpose of the base course is to distribute the traffic load. On high volume roads it can be divided into two layers where the upper is stabilized with bitumen or cement and the lower layer is compacted stone material. Underneath the base course is the subbase. It should also distribute the load but the demands on this layer are lower and the material is therefore not as expensive. If the subgrade material is sensitive to frost heave, the superstructure should be thick enough to prevent frost from reaching the subgrade. In order to increase the thickness a protection course is constructed between the terrace surface and the subbase.

There are two main design criteria which have to be fulfilled by the superstructure, see Figure 5 (Huang, 2010). The first criterion is the tensile strain at the bottom of the bound base course. If this is higher than the structures capacity, cracks will form through which water can enter the structure, thus decreasing the life length of the road. The second criterion is the compressive strain at the terrace surface. A high compressive strain here indicates that relocation of material and deflection will take place.

3.2 Geometry of the road

The alignment of a road consists of both a horizontal element and a vertical element which together define the position of the road (Sektionen Utformning av vägar och gator, 2004). The road's alignment is adjusted to the required road standard and the conditions of the adjacent terrain. The design of the road is important since the road’s orientation through the terrain and the surrounding landscape form an environment which affects the road user performance. The design and the interaction between the horizontal and vertical alignment should create a good visual guidance where clear indications regarding driving behaviour are given.

The geometric design of a road is determined based on a socioeconomic perspective (Sektionen Utformning av vägar och gator, 2004). Consideration is taken to the design speed, traffic (AADT-DIM), environment and the construction and maintenance costs. The design speed is one of the major variables in the geometric design of the alignment. The speed will influence the stopping distance, sight during overtaking and other recommendations for the alignment elements.

The geometric design of a road is determined on basis of three perspectives. These are horizontal alignment, vertical alignment and cross section. These three perspectives are adjusted to provide a suitable road design.

3.2.1 Horizontal alignment

The horizontal alignment is a geometric description of the road in the horizontal plane. The alignment is described by straight lines, arcs, clothoids and polygons (Sektionen Utformning av vägar och gator, 2004). The position of the road is determined by the type of geometric element, its start and end coordinates and tangential directions. Figure 6 gives an example of a drawing of the horizontal alignment.

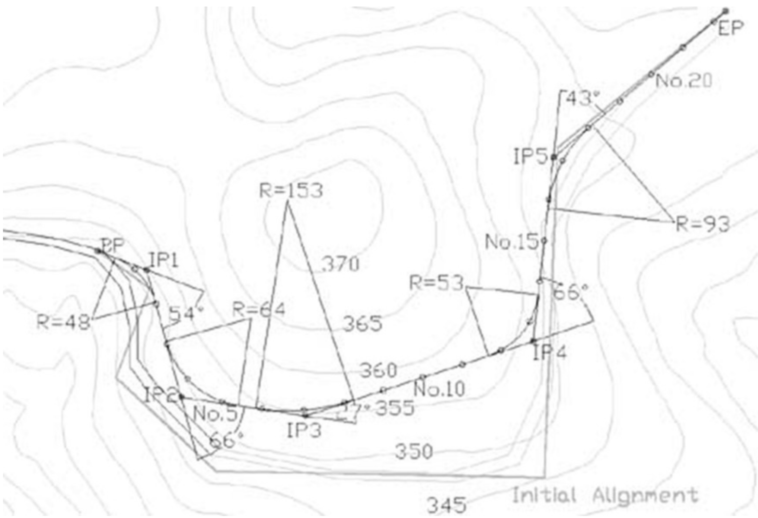

Figure 6 Example of horizontal alignment [Taken from (Aruga, et al., 2005)]

The horizontal curves are drawn using arcs (Sektionen Utformning av vägar och gator, 2004). The radius and the length of the arcs are determined by factors of safety, mobility, driving dynamics, sight distance, visual guidance, orientation through the terrain, aesthetics, construction costs and intrusion into the environment. To achieve a suitable sight distance and visual guidance, long arcs and large radii are desired. This is needed in order for the vehicle to be able to stop before reaching an appeared obstacle. The size of the radius should be adjusted to fit the scale of the surrounding terrain as well as the vertical variations.

In order to obtain a smooth alignment between arcs with different radii or between arcs and straight lines, a transition curve is applied (Sektionen Utformning av vägar och gator, 2004). This will improve the driving dynamics and allow the driver to perform the vehicle in a safe and comfortable manner. The width of the road, design speed and arc radius affect the requirement of transition curves. These curves can be described by clothoids. Alternative transition curves are egg-lines, which are located between two arcs with same bending direction and S-curves, which are a combination of two clothoids located between two arcs with opposite bending directions.

If there are buildings in the surroundings of the road alignment the distance to these should be as large as possible (Sektionen Utformning av vägar och gator, 2004). The negative impacts on the building environment, considering noise and pollution, should be minimized. The required distance is depending on the type of the intermediate terrain.

3.2.2 Vertical alignment

The vertical alignment describes the road's vertical variation along the stretch. The geometry is described by straight lines with varying inclination, and concave and convex arcs (Sektionen Utformning av vägar och gator, 2004). Figure 7 shows an example where both the horizontal and the vertical alignment are outlined.

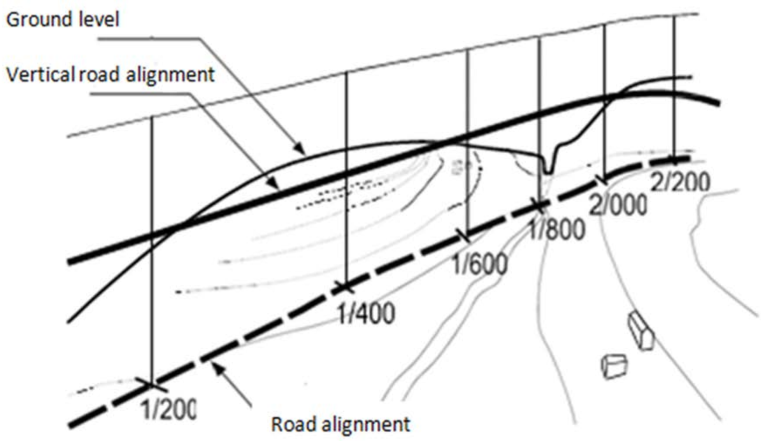

Figure 7 An example of both horizontal and vertical alignment [Inspired by (Sektionen Utformning av vägar och gator, 2004)]

The inclination of the straight lines is designed with regards to safety, travel time, capacity, effects of the vehicle, driving dynamics, adjustment to the terrain and aesthetics (Sektionen Utformning av vägar och gator, 2004). The inclination of the straight lines is described in percent relative to the horizontal plane. An inclination which exceeds one percent will impose a reduction in traffic safety which will continue to decrease as the inclination increases. On rural roads the inclination should not be steeper than that a heavy truck can start in an uphill slope.

The design of the arcs is determined by factors such as safety, driving dynamics, visual guidance, orientation through the terrain, aesthetics and overtaking sight (Sektionen Utformning av vägar och gator, 2004). Long arcs are preferable since it improves the sight conditions. The size of the radius depends mostly on the scale of the terrain and the horizontal geometry. A too large or small radius might not fit into the landscape and reduce the visual guidance. Too small radius would also impair the driving comfort.

3.2.3 Cross section

The cross section describes the road at a certain position (Sektionen Utformning av vägar och gator, 2004). It shows the width of the road and all of its components such as driving fields, shoulders and roadsides. It also shows the crossfall of the road and can include some building technical information regarding the design.

Generally, the width of the driving fields is between three and four meters. This is Swedish recommendation according to (Sektionen Utformning av vägar och gator, 2004). At a 1+1 roads, the shoulders are recommended to be at least 0,25 meters.

The crossfall is the inclination of the road surface crosswise (Sektionen Utformning av vägar och gator, 2004). It is measured in percent relative to the horizontal plane and could either be one sided or two sided, see Figure 8. The inclination of the crossfall is determined by water runoff and driving comfort (Sektionen Utformning av vägar och gator, 2004). The crossfall will drain the road and thereby reduce the risk of hydroplaning. A crossfall of 2,5 percent is recommended and the resultant of the crossfall and the vertical alignment's inclination should be at least 0,5 percent (Trafikverket, 2012b).

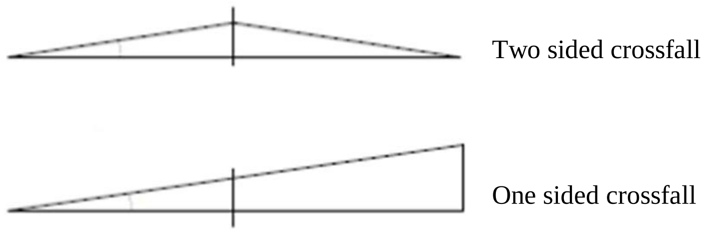

Figure 8 Illustration of one and two sided crossfall [Inspired by (Alm, 2000)]

For straight alignments, the crossfall is generally one sided at roads with one-directional traffic, and two sided at roads with bidirectional traffic (Trafikverket, 2012b). In horizontal curves the crossfall is generally one sided. At horizontal curves, the skewing also reduces the centrifugal force on the vehicle, thus reducing the risk of driving off the road (Sektionen Utformning av vägar och gator, 2004).

The inclination is levelled between two types of crossfall (Sektionen Utformning av vägar och gator, 2004). This is achieved on a stretch where the crossfalls' inclinations are merging. The length of the stretch is determined by the reference speed, size of the rotation and the resultant of the skewing. If there is a transition curve at the stretch, the levelling stretch should be of the same length.

3.3 Speed management

Speed limiting and traffic calming[4] are two ways of managing speed (Odgen, 1996). From a traffic safety perspective, high speeds should be avoided due to the increased accident rate and severity. The energy to be dissipated in an accident is proportional to the square of the impact speed. Thus, small differences in speed might cause large differences in the severity of an accident. From a safety perspective, no other factor is as significant as speed (Trafikverket, 2011a). A total of 25 lives could be spared each year if the average speed was lowered with 1 km/h. (Lay, 1986) presents four factors, contributing to greater hazard at high speeds. Both the driver and other road users have less time to react, the vehicle becomes less stable and the severity of a potential collision increases. High speeds are however necessary in a mobility perspective.

The risk of being involved in an accident related to travelling speed has a U-shaped distribution (Odgen, 1996). The smallest risks eventuate at speeds near the traffic's average speed, or slightly above, see Figure 9. The accident risk increases rapidly for speeds significantly above or below the average speed. Therefore, it can be questioned whether a road should have a speed limit not all vehicles, such as trucks, can or are allowed to keep.

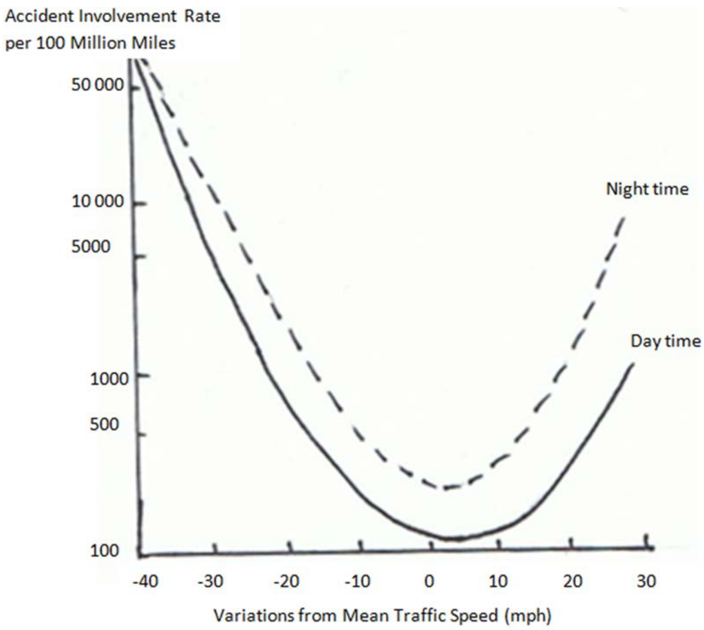

Figure 9 Accident risk in relation to speed [Inspired by (Odgen, 1996)]

[4] Traffic calming measures are not studied or described further within this thesis.

In Sweden, the Transport Agency sets guidelines for the country's base speed limits[5] (VTT Technical Research Center of Finland, 2013). The Swedish Transport Administration can however relinquish from the base speed if justified. When setting a speed limit there are several factors to be considered (Odgen, 1996). It is for example important to establish a balance between safety, mobility and accessibility. The set speed limit should also meet the drivers' expectations; the speed limit can thus be self-enforcing. (Odgen, 1996) presents a table, developed by (Jarvis & Hooban, 1988), of criteria and factors which should be considered when setting speed limits, see Table 1. The Swedish Transport Administration emphasizes that it is the road's standard from a traffic safety perspective which decides the speed limit (Trafikverket, 2011a). The side area, distance to solid objects, and whether a median is present, are three factors included. The criteria for traffic safety are based on the human body's ability to withstand a collision.

Table 1 Factors to consider when setting the speed limit [Taken from (Odgen, 1996), Table 13.1 page 339]

Criterion	Factors
Road environment	Road classification Undivided or divided road Number of lanes and lane widths Presence of footpaths/sidewalks Clearance to roadside obstacles Vertical and horizontal alignment
Abutting development	Number and density of abutting developments Type and extent of traffic generated Land use (schools, houses, apartments, shops, etcetera)
Road users and their movements	Car, trucks, busses, bicyclists & pedestrians, parked vehicles, peak hour traffic, recreational traffic
Existing speeds	Average speed 85 percentile speeds
Accident history	To give an indication of speed related safety problems
Adjacent speed zones	To be consistent Minimum lengths for buffer zones are specified
Other factors	Intersections, schools, pedestrian crossings, road alignment

3.4 Medians

In order to separate traffic with opposite directions, medians can be constructed between the lanes (Odgen, 1996). This gives a beneficial effect since collision with opposing traffic is prevented. Medians can take the appearance of a spacing of varying size between the lanes or by a physical barrier. According to a British study, performed by (Walker & Lines, 1991), roads where medians were applied had an accident rate[6] of two-thirds compared to undivided roads. The efficiency does however differ between

---

[5] Base speed limits; Urban area: 50 km/h, Outside urban area: 70 km/h, Freeway: 110 km/h

[6] Based on vehicle kilometer

different types of medians (Odgen, 1996). Some studies have showed that narrow medians with physical barriers overall have a higher accident frequency, although with lower severity. Two British studies (1980) and (1988)[7] have investigated the efficiency of physical barriers on rural roads. The first showed a 15 percent reduction of fatalities and a 14 percent increase in non-injury accidents. The latter showed a reduction of 57 percent for fatal accidents and a total accident reduction of 29 percent.

Sweden is in the front in Europe when it comes to traffic safety (Statistiska Centralbyrån, 2013). The goal is, since 1997, that no one should die or be seriously injured in traffic. This is an ethical approach used in road planning and maintenance, which also works as guiding principles for developing a safe road transport environment (Trafikverket, 2012c). The government decided in 2009 that the number of fatal traffic accidents should be decreased with 50 percent from year 2007 to 2020. Since then, the Swedish Transport Administration has, among other, worked towards the goal that 75 percent of all national roads with a speed limit of 80 km/h or higher should be separated from meeting traffic (Trafikverket, 2012d). If this goal is reached, it is believed to save 50 lives per year (Trafikverket, 2013b).

3.5 Overtaking fields

There are limited opportunities for overtaking slow-moving vehicles on a 1+1 road, especially if the traffic flow is high or physical barriers are present (Odgen, 1996). The result is queues and accidents during the overtaking opportunity. For roads with high traffic flow or limited sight due to hilly terrain, overtaking fields can be constructed in order to improve traffic operations and reduce delays caused by poor overtaking opportunities.

The construction of overtaking fields increases the traffic safety of the road (Odgen, 1996). Studies have shown that the accident rate has decreased with 25 to 38 percent and reduced the fatal accidents with 29 percent[8]. The size of the reduction depends on the vehicle's location in relation to the overtaking field. After the overtaking field, which has enabled overtaking, the accident rate has decreased further compared to prior the overtaking field.

Depending on the placement, overtaking fields can be called gradient fields (Sektionen Utformning av vägar och gator, 2004). The difference is that a gradient field is an extra field, placed to the left, at ascents, while an overtaking field is an extra field, with limited length, on relatively levelled ground. Both types have similar advantages by improving the mobility. Overtaking fields are however less effective since the heavy vehicles have higher speeds on level ground than in an ascent. Whether a gradient or overtaking field should be constructed is decided by factors as comfort, safety and mobility, as well as investment and maintenance cost. The placement of an overtaking field has to be analysed for each case. Wisely placed overtaking fields on ten percent of the road length, can during moderate traffic provide much of the benefits as a four lane

---

[7] (Johnsson, 1980) respectively (Simpson & Brown, 1988)

[8] Note that these figures only apply to the construction of overtaking fields and not a combination with physical barriers.

road (Odgen, 1996). In order to be efficient the length of an overtaking field should be between 1 000 and 2 500 meters.[9]

3.5.1 Gradient fields

By facilitating overtaking in ascents the mobility will improve (Sektionen Utformning av vägar och gator, 2004). This, since queues are prevented and resolved. The size of this effect depends on the length and inclination of the ascent, percentage of heavy vehicles and their performance, and the risk of queues in the beginning of the ascent. A gradient field should be considered if the distance exceeds 400 meters, for which a truck with trailer's speed drops below 65 km/h until it reaches 60 km/h, see Figure 10. This is usually the case for an ascent with an average inclination of three percent or higher. Gradient fields might also be favourable at ascents with a smaller inclination e.g. if the speed prior the hill is low e.g. due to roundabout. Hence, the placement of the field depends on the appearance of the ascent and the speed prior to the hill. The length of the field should be able to liquidate the queues arising with a possibility of ten percent during the design hour.

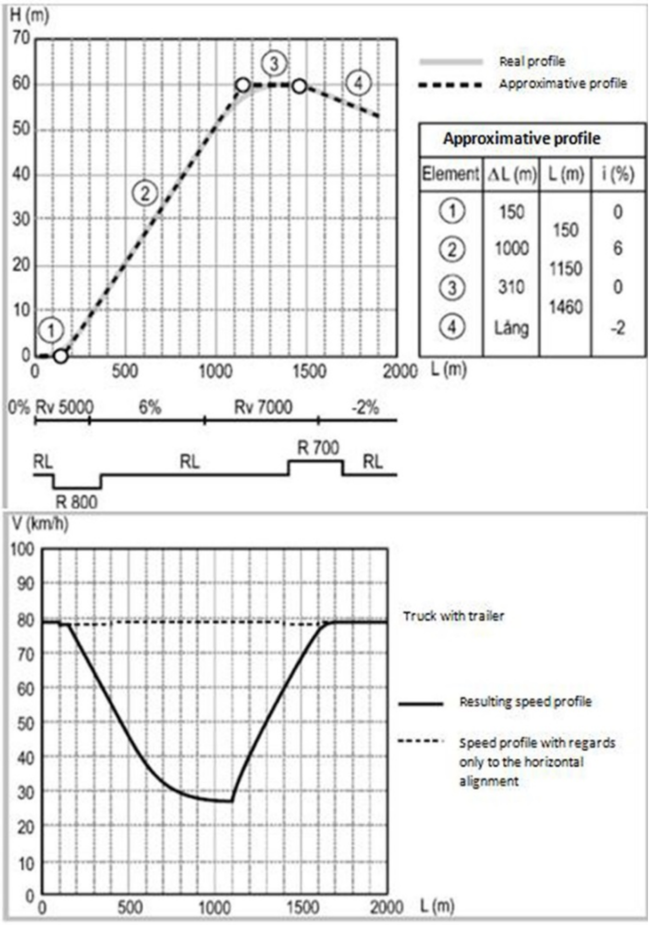

Figure 10 The upper diagram shows the road alignment and the bottom shows the speed a truck with trailer travel with. The distance between when the trucks speed decrease below 65 km/h to when it exceeds 60 km/h indicate whether a gradient field is needed [Inspired by (Sektionen Utformning av vägar och gator, 2004)].

[9] Karolina Wettermark, Project manager for road 56 at WSP. Interview 2014-03-27

3.5.2 Choice of cross section

Which cross section to use for an overtaking or gradient field depends on several factors (Sektionen Utformning av vägar och gator, 2004). It partly depends on whether it is a new road construction or a rebuilding, the presence of pedestrians, bicyclists and slow-moving vehicles and the mobility for heavy vehicles. In addition, the width of the overtaking field should be the same as the width of the driving fields. New rural roads which are free from opposing traffic should be 14 meters wide and can have the type section showed in Figure 11, which allows pedestrians and bicycles to use to the road (Sektionen Utformning av vägar och gator, 2004). The main motives for this type section are:

- Increased standard for vulnerable road users[10] by having a wider shoulder (one meter instead of 0,75 meters)
- Improve the possibilities to overtake slow-moving vehicles and minimize the risks for blockage due to truck breakdowns on stretches where an overtaking field is absent
- Allow wider transports
- Improve accessibility for emergency vehicles
- Minimize the risk of collisions with the physical barrier

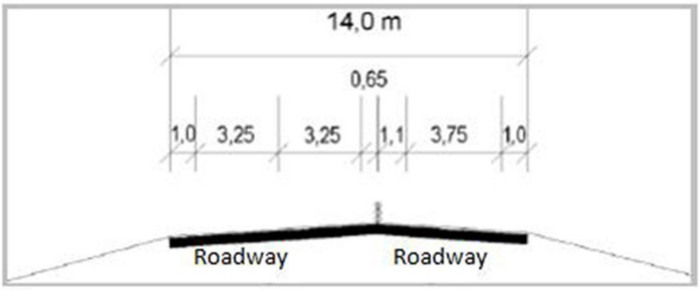

Figure 11Type section for a rural road free from opposite traffic, if new construction [Inspired by (Sektionen Utformning av vägar och gator, 2004)]

[10] Pedestrians, bicyclists and motorcyclists

4 Economy

In this chapter the concept of socioeconomics and its application within transport economy is presented. First, some general information about socioeconomics is presented. Thereafter, delimitation to infrastructure is made and information regarding cost-benefit analysis and transport economy is presented.

4.1 Socioeconomics

Economy is a Greek word, meaning husbandry (Hammarlund, 1981). Since resources are limited, husbandry has to be applied in all operations. Companies, organizations and private persons take economic decisions with regards to their specific operation (Bångman, 2012). Socioeconomics on the other hand is husbandry with the society's (e.g. a country or region) resources (Hammarlund, 1981).

The available resources, or factors of production, are constituted by natural resources, human resources and real capital (Anderson, et al., 1978). Examples of natural resources are earth, forest, air and water. Human resources can be workforce, knowledge, technology and ideas. Corporation between these two factors results in real capital, which is factories, buildings, transportation etcetera. Factors of production can also be divided into primary and secondary recourses (Hammarlund, 1981). Natural and human recourses are counted as primary recourses, while real capital is considered to be secondary resources.

4.1.1 The socioeconomic zodiac

Simplified, the society is composed by the public sector, companies and individuals. These are all included in the socioeconomic zodiac, see Figure 12 (Holmström, 2007). The individuals and the public sector are provided with goods, services and jobs from the companies. Individuals and the public sector provide the companies with workforce, capital and resources. The individuals providing workforce is repaid with salary which they can buy goods and services for. The public sector receives income taxes from both companies and individuals. These can be invested in e.g. infrastructure, health care and education. Some of the tax money goes back to the companies and individuals directly as financial support. In order for the zodiac and the cash flow that arise to work properly, banks and other credit institutions are necessary. They make it possible to borrow money in order to pay for goods, services and other investments.

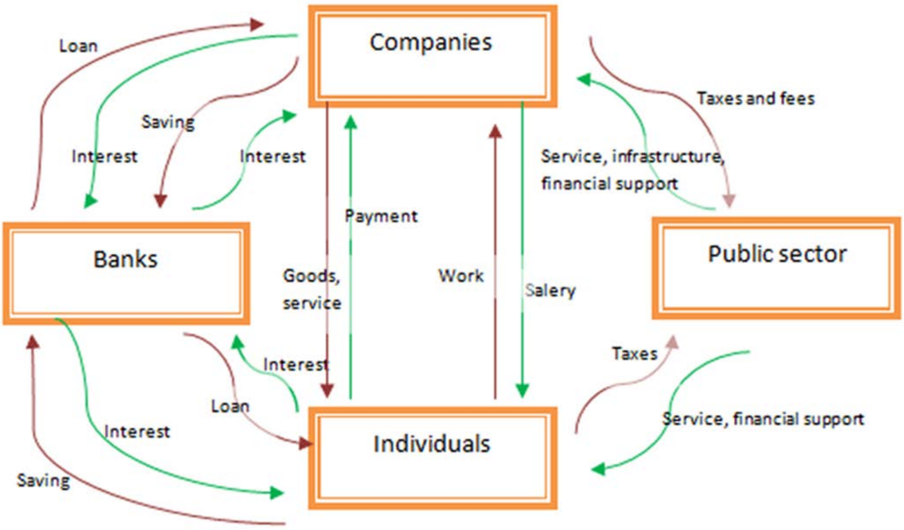

Figure 12 The socioeconomic zodiac [Inspired by (Holmström, 2007)]

4.1.2 Infrastructure and socioeconomics

A well working transport system is essential. Around 13,5 million travels are done on a daily basis in Sweden (Statens offentliga utredningar, 2009). Additionally, goods of a value of roughly six billion SEK are transported in order to accommodate the needs of companies and households.

The different types of benefits, which can be obtained from a new road, will be described in Chapter 4.3. There are several papers that conclude that investments in infrastructure are necessary in order to receive a growing economy (Hesselborn, 1992). A new or improved road can increase the availability to an area or country. This will indirectly influence the production ability by increasing the labour market (Johansson, 1992). Thus, a larger volume can be produced with a certain amount of recourses (Anderson, et al., 1992). This creates an improved efficiency within the production, which in turn adds a higher value. Since the added value is the base for compensation to the work force and capital, the income development in the society depends on the production development in the private and public sector.

During the early 1990s, several researches indicated a strong connection between investments in infrastructure and the productivity of the private sector (Anderson, et al., 1992). It has been shown that the lack of infrastructural investments since the 1960s in USA could explain three quarters of the country's decreasing economy. In Sweden, the GDP growth per capita between the 1960s and 1980s decreased with almost 50 percent. According to (Aschauer, 1989), public investments are necessary components in the private production process. Future sacrifices within private consumption and leisure will be necessary without adequate investments in infrastructure. Swedish studies performed in the early 1990s, show that roads, airports and FoU are important factors for the regional economic development. A more recent discussion of the lack of Swedish infrastructural investments' effect on the socioeconomics can be found in (Mellwing, 2011). The article emphasizes that long term investments are required in order to prevent the development of Swedish companies to fall behind in the competition.

A strong connection between infrastructural investments and economic growth has however been questioned (Anderstig & Mattsson, 1992). It has been emphasized that the production function model used by Aschauer has serious flaws and highly overestimates the increased productivity efficiency caused by infrastructural investments. According to (Anderstig & Mattsson, 1992) only direct profits from a road construction should be considered since there is no standard model for how the indirect effects should be quantified.

4.1.3 Socioeconomic analysis

A socioeconomic analysis can be described as an evaluation of socioeconomic effectiveness or a socioeconomic profitability calculation (Bångman, 2012). Socioeconomic profitability calculations have been performed for road investments since the late 1960s (Nilsson, et al., 2009). At the Swedish Transport Administration, this evaluation is made by performing a cost-benefit analysis, a CBA. Simplified, a profitability calculation is an assembly and summation of a project’s costs and benefits. It shows the net changes of the project’s total assets. There is a difference between e.g. business economics and a socioeconomic profitability calculation. A company calculates the net value for the economic effects for the company. Socioeconomic profitability calculations, however, calculate the total net value of all citizens’ economic effects. A socioeconomic analysis should consider all positive and negative utility and resource effects, direct as well as indirect, generated from a certain alternative (Bångman, 2012). These can also be described as primary and secondary effects. The primary effects affect individuals, companies and organizations directly. Secondary effects are a consequence of the primary effects. This can be e.g. changes in price, production or consumption.

4.1.3.1 Socioeconomic effectiveness

The purpose with socioeconomic profitability assessments is to assess whether a certain measure is beneficial for the society (Bångman, 2012). It can also be used in order to compare different alternatives and see which measure that would result in the biggest benefit. A socioeconomically effective project implies that the project eventuates in a benefit to the society (Hammarlund, 1981). The content, division and realization of this, so called welfare, are up to the elected representatives to decide.

In a socioeconomically effective project, the society’s resources, such as time, natural resources, workforce etcetera should result in the largest possible value from the citizens’ perspective, today and in the future (Bångman, 2012). In order to assess socioeconomic effectiveness the Kaldor/Hicks criterion can be used. According to the Kaldor/Hicks criterion, welfare will be contributed to the society if those who gain on a measure can compensate those who lose on it. That is, if the positive effects exceed the negative. This criterion can however be criticized since the distribution of welfare is not taken into account. Therefore, it might be preferred to use Little’s criterion. According to (Little, 1950), a measure should fulfil the Kaldor/Hicks criterion and have an acceptable distribution of welfare, which is a politic question. These distributional effects consider whether the benefit or disadvantage is more than marginal for e.g. a region or national group (Nordlöf, 2008).

4.2 Cost-benefit analysis

In a cost-benefit analysis (CBA), a project's costs and benefits are presented in monetary terms in order to evaluate whether the project results in a value for the society and in order to compare numerous options (Williams, 2008). The CBA also includes methods to evaluate not market-priced resources and benefits (Bångman, 2012). A socioeconomic analysis includes the effects on all citizens, not just specific operations' effects. Therefore, when performing a CBA, consideration should be taken to all effects to all individuals and organizations in the society. This is however not applicable in reality since all effects cannot be included in the analysis. A CBA may be implemented in two ways, giving the same result; the welfare model and the classic calculation model.

In the welfare model consideration is taken to a measure's effect (e.g. financial assets and cash flows) on different social categories or different groups of citizens (Bångman, 2012). The most common approach is to divide the society into consumers, producers and public sector, although it is possible to implement a more fine division. Then the sum of the producers' and consumers' surpluses[11] as well as budgetary effects[12] is calculated. Application of this model enables visualization of distributional effects.

The classic calculation model is applied if the changes of real resources are calculated by summation of the real incomes and costs, and no consideration is taken to who produce respectively consume (Bångman, 2012). In this model the interest lies in the value of the production and consumption. Thus, no consideration is taken to cash flows in conjunction with production. Furthermore, the net effect of money transfer is set to zero. This is due to that the gain and loss is equal and consequently not affecting the net result. A certain measure's effects are identified by evaluating which resources are created respectively consumed. Effects with and without market-price should be included, as well as both direct and indirect effects. Indirect effects, as changed income or production, are however not considered. This is due to that financial transactions and income effects are not considered in the classic model

4.2.1 How to perform a cost-benefit analysis

A CBA is normally performed in six steps (Bångman, 2012) (Nilsson, et al., 2009):

1. Define the measure
2. Identify and quantify the relevant effects
3. Monetary valuation
4. Discounting to present value
5. Calculate net present value or net benefit cost ratio
6. Sensitivity analysis

Firstly, it is necessary to define the alternatives (Bångman, 2012). The main option as well as all other alternatives should be described in detail. The reference alternative

[11] The producer's surplus is the marginal cost, i.e. the income minus the variable cost. The net benefit for the consumers is their surplus. It is the difference between the actual price and what they are willing to pay.

[12] Budgetary effects are cash flows of incomes from taxes and other expenses.

should also be described in order to receive the outcome if no measure is taken. When the measure is well defined, the relevant effects, both direct and indirect, have to be identified. Only effects which would occur if the project is implemented should be included in the analysis (Williams, 2008). Effects that would occur even if nothing would be done should be excluded. Additionally, the analysis should account the costs and benefits for all members in the society. This is however difficult to execute. Caution has to be taken in order to only include an effect once in the analysis (Bångman, 2012). Due to that effects can be described and presented in several different ways there is a risk that effects are considered twice in the analysis. The effects have to be quantified, e.g. how much time the new road saves for the road users. Quantifying the effects can be problematic since there are uncertainties of the extent of the effects (Nilsson, et al., 2009). The consequences of the original alternative have to be investigated as well, what the effects will be if no measure is taken. It is also necessary to decide which time period the calculations are valid for in this, second, step. This is usually set to the projects economic life length.

As mentioned earlier, not all effects have a market-price (Bångman, 2012). It is necessary to estimate these effects in SEK, so called monetary valuation. This is done with shadow prices, which should correspond to the value the resource would have on a free competition market. In some cases it is not possible to estimate all effects through monetary valuation (Bångman, 2012). The best practice is then to describe the effect and attempt to state whether it has a positive or negative effect on the socioeconomic profitability and the size of the influence. How not market-priced resources can be valuated to monetary terms is described in Chapter 4.2.1.1.

A large part of the costs and incomes for a new road occurs in the future (Bångman, 2012). It is required to recalculate these to a present value (PV), through which comparison with costs and incomes occurring today are possible. When calculating the present value, time is a critical factor (Williams, 2008). An income today is valued higher than an income in the future (Nilsson, et al., 2009). There are two reasons for this (Williams, 2008). If the money was put in the bank a return would be provided. Furthermore, humans are impatient and prefer benefits today ahead of benefits in the future. Thus, the present value depends on how far into the future the transaction will be and the size of the interest. A long time frame and high interest rate gives a low present value. The discount rate represents the society’s demand on revenue but its size can also depend on future uncertainties. The PV for a single payment is calculated by dividing the cost (C) or income (B) occurring year t with $(1+s)^t$, where s is the social discount rate (see Equation 1 below). If a payment occurs during several years, a uniform series should be used and the PV is calculated with Equation 2.

$$Single\ payment: PV(B\ or\ C) = \sum_{i=0}^{n} \frac{(B\ or\ C)_i}{(1+s)^t}\ (Eq\ 1)$$

$$Uniform\ series: PV(B\ or\ C) = (B\ or\ C)_{year\ 1} \times \frac{(1+s)^t - 1}{s \times (1+s)^t}\ (Eq\ 2)$$

There are several alternative methods in order to evaluate whether a project is socioeconomically profitable (Williams, 2008). The most common approach is to calculate the net present value (NPV) by subtracting PV(C) from PV(B), see Equation 3 below. A NPV above zero indicates that the measure will be profitable. Another option is the benefit/cost ratio, which indicates a profitable project if the ratio of PV(B) and PV(C) is above one, see Equation 4. It is also possible to calculate the internal rate of return (IRR). In this method PV(C) is set equal to PV(B) and the equation is solved for the discount rate, see Equation 5. If the calculated discount rate is larger than the social discount rate, the project is profitable. The method also gives the interest needed for a profitable project. (Williams, 2008) states that NPV is the most appropriate method for evaluation of socioeconomic profitability. It is also possible to compare different alternatives or measures by setting the NPV in relation to the investment cost (Bångman, 2012). This will result in a net benefit cost ratio, see Equation 6. The higher value, the more profitable is the alternative.

$$Net\ present\ value, NPV = PV(B) - PV(C) (Eq\ 3)$$

$$\frac{Benefit}{Cost} ratio = \frac{PV(\mathrm{B})}{PV(C)}\ (Eq\ 4)$$

$$Internal\ rate\ of\ return, IRR = \sum_{\mathrm{t=0}}^{\mathrm{t=n}} \frac{\mathrm{B_t}}{(1+\mathrm{i})^{\mathrm{t}}} = \sum_{\mathrm{t=0}}^{\mathrm{t=n}} \frac{\mathrm{C_t}}{(1+\mathrm{i})^{\mathrm{t}}}\ (Eq\ 5)$$

$$Net\ benefit\ cost\ ratio\ = \frac{PV(B) - PV(C)}{PV(C)}\ (Eq\ 6)$$

Due to uncertainties in the input data, a sensitivity analysis should be performed (Bångman, 2012). The main uncertainties are usually the prognosis of future effects and the monetary valuation. (Williams, 2008, page 69) writes “ CBA reports are only as good as the sensitivity analysis surrounding them; if a report does not include some allowance for uncertainty, then its recommendation can become very fragile for the decision maker”.

4.2.1.1 Valuation of not market-priced resources

There are several different methods to set a market price on individuals’ valuation of a resource (Bångman, 2012). The overall purpose of these methods is to measure how much an individual is willing to pay for a certain resource. According to (Bångman, 2012), there are two main methods based on the models “Revealed Preference” and “Stated Preference”. These two models are complementary (Pearce, 2002). The difference is that in revealed preference the consumers’ behaviour is observed, while the stated preference is performed with surveys. Thus, in revealed preference the consumers’ actual economic behaviour is received and stated preference reveals what the consumers’ think they are willing to pay for a certain resource. It is possible to value resources from political decisions if no other method is applicable (Bångman, 2012). To use this approach does have disadvantages and should not be used if a value can be received in another way. The main disadvantage is that the basic principle of economic welfare, that the individuals are the best to judge how they value different resources, is broken.

(Williams, 2008) claims that there are four principles to evaluate a resource’s market value, namely averted costs, human capital, implicit valuation and explicit valuation.

Williams use the example of a traffic accident in order to explain the first two principles. Averted costs is a partially valuation of a benefit. Considering a traffic accident, it can be the cost for emergency vehicles to travel to the accident site, i.e. the personals wages and cost of equipment. The principle of human capital is based on time saving. Time can quite easily be given a value, namely a person's market wage. The benefit if no accident occur can thus be valued based on the time an individual saves when no delays. In explicit valuation, the individuals are asked what they are prepared to pay for a certain resource, whereas in implicit valuation their actual behaviour is used. The two last principles have a clear resemblance to stated respectively revealed preference and is most likely the same models with various names.

4.2.2 Limitations and uncertainties of socioeconomic profitability calculations

It should be noted that a socioeconomic profitability analysis does not give a comprehensive and accurate representation of the reality (Bångman, 2012). Idealized relationships are to some extent used in the economic theory. It cannot be certain that all options are known to the people, which do not always act rationally. Effects might not be possible to value, or have large uncertainties in its valuation. In addition, there are always uncertainties involved when it comes to prognosis of the future development. Due to this there are also uncertainties in the resultant values of the profitability calculations.

4.3 Transport economy

The transportation costs can be classified by their source (Sinha & Labi, 2011). The three classifications are costs for the road authority, costs for the road user, and community or nonuser costs, see Figure 13. The costs for the road authority include capital costs and operation and maintenance costs. The road user costs comprise expenses which arise for a person who uses the road such as travel time costs, traffic safety costs and vehicle operating costs. The costs for community or nonuser refer to the costs for the community as a whole. These costs will also affect people who are not using the road, e.g. air pollutions, noise and other environmental impacts. These costs can be of both monetary and nonmonetary values.

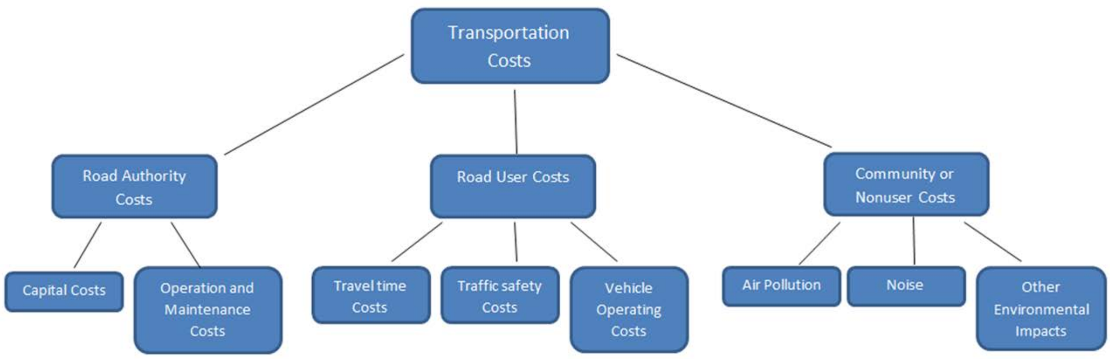

Figure 13 Scheme over components of transportation costs [Inspired by (Sinha & Labi, 2011)]

The classifications of costs are connected. A high standard of the road results in higher capital costs for the road authority but results in lower costs for the road users and the community. The correlation is visualized in Figure 14. The sum of the costs for the authority, road user and community makes a total cost for the road (Johansson, 2004). From a societal point of view it is desirable to minimize the total cost. In a road project, the most socioeconomically effective solution is where the sum of the cost for the road authority, road user and community is at its minimum.

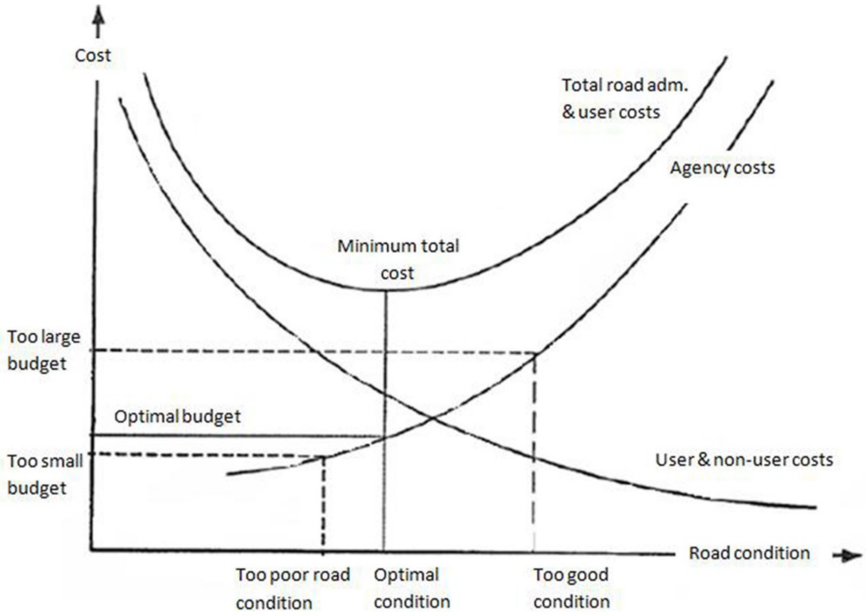

Figure 14 Socioeconomically optimum for a new road [Inspired by (OCED, 1994)]

Since a new road construction or the improvement of a road implies a reduction of road user and community costs, it is logical to refer to these as benefits in a socioeconomic context (Sinha & Labi, 2011). Road user and community benefits will however be referred to as costs throughout this chapter. Figure 15 illustrates the distribution of the costs and benefits incurring during the life time of a road. The costs for a road project can be evaluated by performing a CBA. The performance of a CBA was described in Chapter 4.2 and the creation of the CBA performed in this thesis is described in Chapter 6.2.

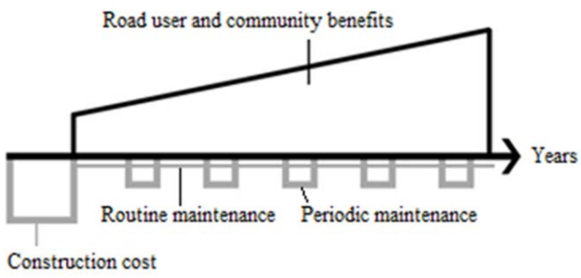

Figure 15 Distribution of costs and benefits during a road's life time[13]

[13] Interview with Gunnar Lannér, Lector at Chalmers University of Technology, 2014-04-24

4.3.1 Costs for road authority

The road authority is responsible for the construction and the maintenance of the road. Already in the planning phase it is important to set the standards for the road in order to ensure that the road will meet the requirements. This, since the construction will set the preconditions for the quality of the road during the operational time. The quality will affect the lifetime of the road, required maintenance and road user costs. For instance, if not enough investment is put during the construction phase, it might cause both a higher demand of maintenance and worse driving conditions for the road user. Investment in a good quality road might result in high construction costs, but the road will probably last longer and demand less maintenance. A well performed evaluation of the respective type of costs might reduce the total costs for the society. The road authority costs comprise capital costs, operating costs and maintenance costs (Sinha & Labi, 2011).

4.3.1.1 Capital costs

The capital costs incurred by the road authority comprise (Sinha & Labi, 2011):

- advance planning
- preliminary engineering
- final design
- right-of-way acquisition and preparation
- construction

The *advance planning* comprises the cost of labour-hours required by the road agency or consultants (Sinha & Labi, 2011). The planning work consists of route and location studies, traffic surveys, environmental impact assessments and public hearings. Only the planning work performed after the decision of investment should be taken into account. The previous costs are referred to as “sunk-costs” and are thus not included in the socioeconomic analysis (Trafikverket, 2012e). The sunk-costs are excluded due to that only costs which are recoverable should be included. In other words, recoverable costs would return to the society if the investment is rejected. Sunk-cost incurs through the road plan at the most.

The geodetic and geotechnical investigations are referred to as *preliminary engineering costs* (Sinha & Labi, 2011). The preparation of plans, drawings, technical specifications and bid documents, are referred to as *final design costs*. The final design costs are often of the order ten to 20 percent of the total construction costs.

The *right-of-way acquisition costs* include the purchase price, legal costs, title acquisition and administrative costs (Sinha & Labi, 2011). Negotiation, condemnation and settlement are such administration costs. The *right-of-way preparation costs* refer to costs that arise in connection with relocation or demolition of structures and relocation of utilities. In case of a new alignment or widening of an already existing road, land area is claimed at the stretch where the road is going to be constructed. The cost of the claim is depended on if there are any natural or cultural values connected to it, if there are any sensitive areas or if other constructions, such as residents, exist that needs to be torn down.

The costs for the *construction* could be estimated by comparison between similar projects (Sinha & Labi, 2011). However, the cost can only be a rough estimation during the planning stage. This is due to that each project is unique with variations of both preconditions on site and properties of the planned road. Construction work in ground is generally unpredictable since the ground properties are connected to a large amount of uncertainties and even carefully performed cost estimations would easily change due to unforeseen obstacles.

A road construction requires that masses need to be transported (Granhage, 2009). This includes both materials that have to be removed from a cut and material that will be added to a bank. The transport of material represents a major part of the construction costs. An example is the Swedish project Västerleden, where the mass transports constitute approximately 28 percent of the total costs (Kungliga Tekniska Högskolan, n.d.). Due to its large contribution to the construction costs, masses need to be coordinated efficiently. The high cost is due to that masses are heavy and energy intensive to move. It is therefore important to reduce the mass transports, for instance to reuse excavation material as landfill material and keep the mass transport distance to a minimum[14]. Mass-diagrams and mass-profiles are useful tools to optimize the management of masses, see Figure 16. With the diagram and profile, the volume of mass that a combination of equipment and trucks could transport, can be determined. To make this process as resource efficient as possible, machines with appropriate capacity should be used.

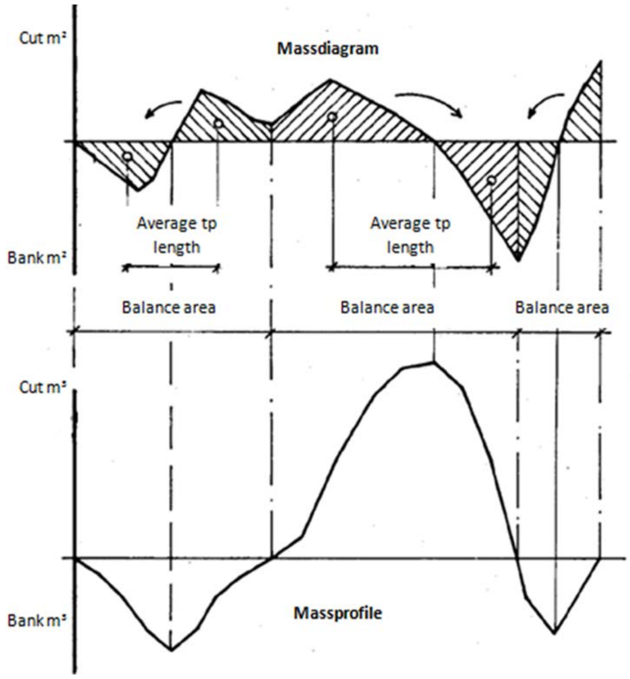

Figure 16 Example of mass-diagram and mass-profile [Inspired by (Granhage, 2009)]

[14] Bo Löfgren, Project Manager at Civil Design Management and Development, WSP. Lecture: Urban Development 2014-01-27

4.3.1.2 Operation and maintenance costs

During the operational life time of a road, costs for operations and maintenance arise (Sinha & Labi, 2011). The operating costs could be utility charges such as street lightning or traffic signals while the maintenance costs refer to costs spent in order to keep the road in a good physical condition.

In Sweden, the Swedish Transport Administration is responsible for the maintenance of the national road network (Trafikverket, 2011b). Municipal and private roads are maintained by either the municipality or private managers. The purpose of the operation and maintenance is to make sure that the road is safe and accessible during the whole year (Sinha & Labi, 2011).

Maintenance is divided into periodic maintenance and routine maintenance, see Figure 15 (Trafikverket, 2011b). The periodic maintenance is referred to road work such as new paving. This is performed at regular intervals when the life time of the material has passed. It includes tasks which are performed in order to maintain the road in a more long term perspective, such as paving, bridges and tunnels. Routine maintenance is performed on a regular basis. The major tasks of the routine maintenance are; snowploughing and sanding or salting, maintenance of the road construction and rest stops, smaller reparation works on the roads, cleaning the road sides from vegetation and exchanges of damaged road signs.

The timing of the periodic maintenance is of importance in order to minimize the costs (Huang, 2010). This is due to that the deterioration is proceeding exponentially. There is no linear correspondence between the level of damage and time. In other words, a delayed maintenance work might have a large effect on how far the deterioration has proceeded. Figure 17 illustrates the relation between time and quality of the road. The curve corresponding to the deterioration of the road if no maintenance is made shows that at a certain point the reduction in quality of the road impairs rapidly.

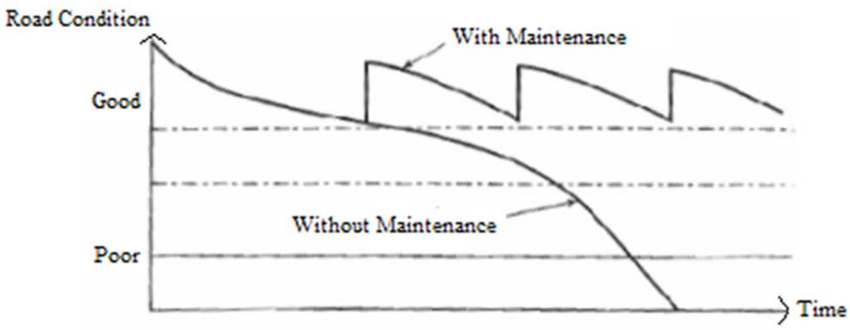

Figure 17 Evolution of the road condition with and without treatment [Inspired by (Huang, 2010)]

The annual costs for maintenance of the Swedish national road network are estimated to 8 billion SEK (Trafikverket, 2011b). Out of this 8 billion, one half of it is spent on paving, one fourth is spent on winter maintenance and one fourth is spent on cleaning and maintenance of rest areas and lightning. The management of the maintenance is divided into 120 regions. There are approximately 700 to 1000 kilometres of road in each region. The Swedish Transport Administration is procuring the maintenance and the currently largest Swedish contractors are NCC, Peab, Skanska and Svevia. The work is continuously monitored by the Swedish Transport Administration to make sure that it meets the requirements. Safety and accessibility are functioning as parameters when evaluating the profitability of the maintenance work. Surveys focusing on these parameters are handed out to road users to give an indication of the satisfaction of the maintenance.

4.3.2 The costs for road users

The road user costs include travel time costs, traffic safety costs and vehicle operating costs (Sinha & Labi, 2011). In CBAs, these parameters are included due to the possibility to evaluate them in monetary values (Johansson, 2004). Impacts on comfort or social life are not included in conventional models.

The condition of the road, both in terms of construction design and condition of the pavement, will have an influence on the driving performance and the associated costs (Sinha & Labi, 2011). Poor road conditions will force the driver to decrease the speed and thereby increase the travel time. A poorly planned design of a road might also lead to increased travel time due to queues or accidents. Furthermore, irregular driving is causing higher fuel consumption and a more frequent need for vehicle service.

4.3.2.1 Travel time costs

New road projects or reconstructions should aim to reduce travel time, either by increased speed limit or by decreased waiting or transfer times (Sinha & Labi, 2011). Since the time a person has is limited, it is considered to be a resource with an economic value (Bångman, 2012). The travel time does not have an intrinsic monetary value itself, but can rather be seen as necessary time to reach a destination (Trafikverket, 2012e). This is considered as lost time which could be used to perform other activities, such as increased working hours or spare time. A time value would thereby be defined as the monetary value of goods, services or utilities that can be produced within a time interval (Sinha & Labi, 2011).

According to (Trafikverket, 2012e) the estimation of the unit value comprises three parts. Firstly, consideration is taken to the benefit that would be obtained if the travel time was used to other activities. Secondly, consideration is taken to the comfort and how productive one can be during the journey. The benefit of productivity is valued by comparing it to the benefit of being at the destination. A higher importance of arriving to the destination will hence result in a higher unit value. The third part is the marginal benefit of money. Studies have shown that there is a correlation between the marginal benefit and income. A higher income is tending to result in a lower marginal benefit.

The unit value is individual and depends on the purpose of the trip and whether it is during business hours or private (Trafikverket, 2012e). Other factors could also be taken into account, such as vehicle type and if any delays are occurring or waiting time of some sort. The unit values will differ due to that they are based on the individual's valuation of the time sacrificed and convenience. The unit values are obtained by a time value study where data is collected and put together. There are values developed by ASEK for private and business travelling, transports of goods and professional traffic. An example of unit values of travel time is shown in Table 2.

The costs of the travel time are calculated by multiplying the unit value of time with the total vehicle-hours of traveling (Sinha & Labi, 2011). The travel time impacts are assessed as a comparison between the existing situation and the improvement scenario. The savings in travel time are thus multiplied with the established unit value and results in an estimated travel time cost.

Table 2 Example of unit values of travel time [Inspired by (Trafikverket, 2012e)]

	Transport time	Interval, [min]						Connection time	Exchange time
		<10-	11-30	31-60	61-120	121-480	>480		
Long distances									
Car	145	-	-	-	-	-	-	-	-
Bus	52	27	27	27	13	13	11	71	131
Regional/Local									
Car, work	117	-	-	-	-	-	-	-	-
Car, otherwise	78	-	-	-	-	-	-	-	-
Bus, work	71	80	66	32	20	9	9	71	178
Bus, otherwise	44	51	42	20	12	7	7	44	111

4.3.2.2 Traffic safety costs

The traffic safety costs are borne by individuals, insurance companies and the government (Sinha & Labi, 2011). They include preventative costs and retrospective costs (Sinha & Labi, 2011). The preventative costs occur in conjunction with the construction and maintenance of the road thus ends up as a part of road authority costs. The retrospective costs are a part of the road user costs and include fatality, injury and vehicle damage. Damage to railings or adjoining property are part of road authority respectively community costs.

Retrospective costs that arise due to a traffic accident can be divided into direct, indirect and intangible costs (MSB, 2009). Direct costs are expenses used in order to manage the consequences of an accident, i.e. medical expenses, reparation costs, expenses in order to manage the situation at site and administrative costs for personal injuries and property damage. The indirect costs represent the expenses as a result of lost production due to injuries or death. Intangible costs are the loss of a life or deteriorating health (Bångman, 2012). These costs are usually not included due to the impossibility to value a life. For this reason an indirect valuation, called the value of a statistic life, is used in order to analyse how much an individual is willing to pay to reduce the risk of a traffic accident with fatal outcome.

The accident costs are calculated by multiplying the unit accident cost with an estimated accident rate (Sinha & Labi, 2011). The accident rate before and after the improvement of the road are used in the cost estimation. In Sweden, 2005, the total costs for road related accidents was 20,9 billion SEK (MSB, 2011). Out of this, 58 percent consisted of direct costs and 42 percent of indirect costs.

4.3.2.3 Vehicle operating costs

The expenses that the road user has in order to use a vehicle are referred to as vehicle costs. The costs can be divided into fixed and variable costs (VTPI, 2013). Fixed costs are not affected by mileage and include purchase, insurance, registration and taxes. Variable costs are those factors that are mileage dependent. This includes:

- fuel
- tires
- service
- depreciation

Parking and toll fees can also be included here. The variable costs are also referred to as vehicle operating costs, which are typically used in economic evaluation of projects (Sinha & Labi, 2011). The components of vehicle operating costs are mainly affected by vehicle type, fuel type, speed, longitudinal grade, horizontal curvatures, road surface condition and speed changes.

Fuel is one of the main components of the operating costs (Sinha & Labi, 2011). For highway vehicles the fuel can make up 50 to 75 percent of the operating costs. Fuel costs vary with fuel efficiency and fuel price. Large vehicles are generally more costly due to the higher fuel consumption. The consumption also increases at very high and low speeds, steep uphill grades and curves. For instance, at speeds above 90 km/h and below 30 km/h the fuel consumption increases (VTPI, 2013). This is also the case under stop-and-go conditions, why vehicle operating costs are higher in urban areas than on highways. Uphill grades demands increased fuel consumption and are thereby increasing the vehicle costs (Sinha & Labi, 2011). The downhill grades might instead reduce the vehicle costs; however it causes increased wearing on the breaks. In horizontal curvature higher fuel consumption is required in order to counter the centrifugal force on the vehicle.

The wearing of *tires* is affected by the road surface condition, longitudinal grade, curvature and speed changes (Sinha & Labi, 2011). The roughness of the road surface causes wear of the tires due to higher rolling resistance. Also in horizontal curvature the wearing of tires increases due to the centrifugal force which the vehicle is subjected to.

Vehicle operating requires *service* in order to function properly (Sinha & Labi, 2011). Batteries, alternators, fuel pumps, air pump, tire rim and other parts need replacements or replenishment with certain intervals. The deterioration is influenced mainly by the road surface condition and curvature. Speed, speed changes and longitudinal grade also cause some deterioration. The *depreciation* of the vehicle comprises both a mileage dependent component and a time dependent. The rate of the mileage dependent depreciation is affected by longitudinal grade, curvature, road surface condition and speed.

In Sweden the vehicle operating costs are evaluated based on market prices (Trafikverket, 2012e). Average costs for the different factors are in many cases based on data provided from Statistic Sweden. Table 3 gives an example of average costs for different factors according to the price level in year 2010.

Table 3 Average vehicle costs and parameters according to the price level in 2010 [Inspired by (Trafikverket, 2012e)]

Vehicle Costs and Parameters	
Purchase price of car, [SEK]	194 000
Tires, [SEK/tire]	780
Salary costs, [SEK/hour]	168
Yearly driving distance, [km]	13 000
Utilization, [hour/year]	8 760
Depreciation, {SEK/hour]	0,64
Capital costs, [SEK/hour]	1,11
Component deterioration, {SEK/km]	0,16
Petrol price including fuel taxes and VAT, [SEK/litre]	12,6

4.3.3 Community and nonuser costs

The community and nonuser costs refer to impacts such as air pollution, noise and other environmental impacts (Sinha & Labi, 2011). Like user costs, the community costs are often referred to as benefits. There is no universal way of estimating these impacts in monetary values. As a consequence, the community costs are generally not included in economic analyses. These impacts should however be included as descriptions (Bångman, 2012). Intrusions in natural and cultural environments are examples of such impacts. In order to include these impacts a valuation of each separate case would be necessary. Noise effects are also excluded from the calculations if the investment does not involve noise measures specifically. Set values are also lacking for contamination of water streams and are therefore excluded from the calculation if their presence cannot be motivated.

4.3.3.1 Air pollutions

The traffic releases substances which give damage on both the environment and personal health (Bångman, 2012). Air pollutions can cause mild transverse problems as well as standing health issues (Trafikverket, 2012f). Pollutions have shown to be a contributing factor of the development of asthma, allergy and cardiovascular diseases. Cancerogenic substances are also released through traffic. The environmental effects are e.g. acidification, eutrophication and release of greenhouse gases. Hence, a decrease of air pollutions released from traffic is beneficial in both an environmental and health perspective.

4.3.3.2 Noise

Noise causes negative effects in the form of stress, irritation and medical problems such as sleeping disorders and high blood pressure (Bångman, 2012). The risk of cardiovascular diseases can also increase (Trafikverket, 2013c). The socioeconomic cost of noise depend on the number of individuals that experience disturbance due to it.

4.3.3.3 Other environmental impacts

The other environmental impacts also affect the surroundings of the road in different ways. The impacts are depended on the type of area. Some of them are for instance impacts on water sources or other ecosystems, visual impacts in the landscape picture, land use and social and cultural impacts.

5 Case study

Road 56 is a national road situated between Norrköping and Gävle, see Figure 18. The road makes an alternative to the road E4 for road users travelling north, respectively south, passing Stockholm (WSP, 2013). A large part of the stretch is planned to be reconstructed as a national road separated from meeting traffic. This is decided as a part of a national goal that all roads with speed limits over 80 km/h should be separated from meeting traffic. The exception is roads with volumes lower than 2 000 AADT. A part of the road, reaching from Bie to Stora Sundby is currently under investigation.

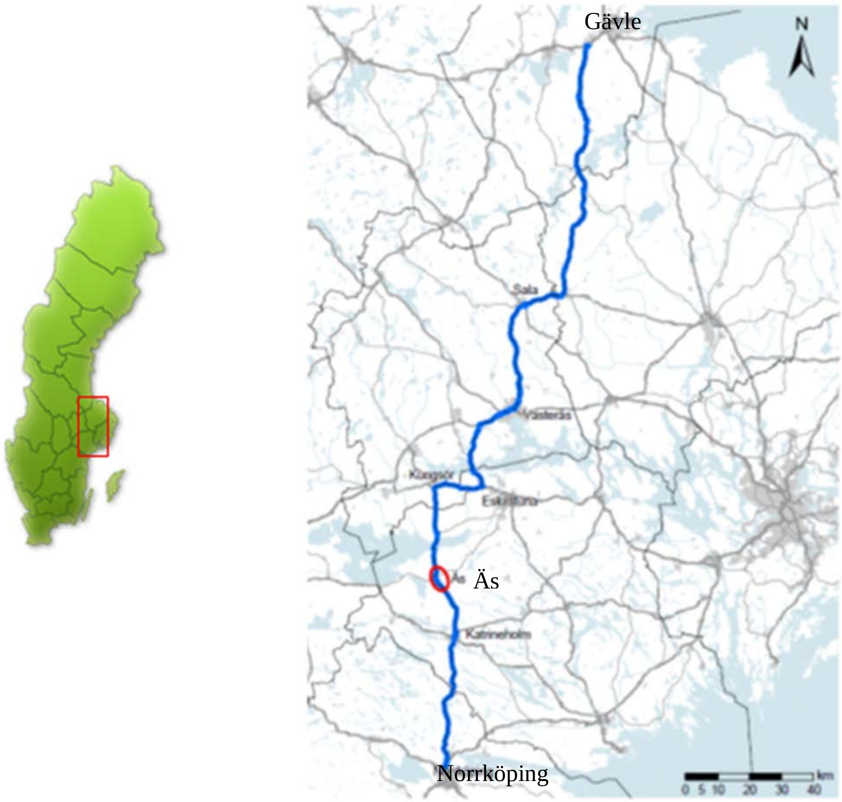

Figure 18 Location of road 56 [Taken from (WSP, 2013)]

5.1 Current situation

The 23 kilometre long stretch passes through the settlement Äs which has approximately 40 households (WSP, 2013). Through Äs, the road is surrounded by residents and several driveways are connected to the road. The speed limit through Äs is decreased from 90 km/h to 50 km/h, and is set to 70 km/h over Hjälmaresund. The road width is 7,5 and 9 meters on the south respectively north side. In year 2011, the traffic density was 4 000 AADT of which 20 percent was heavy vehicles. Between year 2010 and 2050 the increase of passenger cars is estimated to 1,3 percent and 0,4 percent for trucks.

The landscape at the stretch is characterized by open agricultural land and woodland areas (WSP, 2013), see Figure 20. On the west side of the road there is an open landscape with agricultural farming. Julita Gård, which is a popular tourist attraction during summertime, is also situated on the west side of the road. The east side is dominated by forestry. There is a wooded area with rock outcrops in the south-east and mosaic landscape with field islets and smaller woodlots in the north-east. The lake Aspen is also situated on the east side and the esker Köpingsåsen reaches in a north-south direction along the current road 56. The water source of Mo is situated south of Äs and is restricted area. The locations are presented in Figure 43 in Appendix 2.

5.1.1 Problem identification

The stretch is frequently used for transporting goods (WSP, 2013). Due to the large amount of trucks, queues are forming behind them. The low speed limit through Äs is limiting the mobility further. Due to the traffic, many of the residents are also affected by pollution. The current design of the road is unfavourable regarding traffic safety. This is due to the presence of pedestrians, residents near the road, the amount of heavy vehicles and passing through traffic. Through Äs, there is a side walk on the western side of the road but no safe passages are available at present. Outside Äs, there is a narrow shoulder for pedestrians.

Road 56, between Bie and Stora Sundby, has had five traffic accidents with bodily injuries in the past ten years (WSP, 2013). One of these had fatal outcome and two caused severe respectively mild injuries. The fatal injury was a head on collision. Traffic accidents with fatal outcome are most commonly caused by single-car-accidents, followed by head on collisions (Svenska kommunförbundet, 1999).

5.2 The planning process

Road 56 as a whole has been under investigation since the 1990's. In 2010 and 2011 a prestudy for the stretch between Bie and Stora Sundby was developed. The prestudy was evaluating the possibilities of reconstructing the road into a separated national road. The part of the stretch which passes Äs was evaluated regarding different corridors for a new road construction, while the rest of the stretch, north and south of Äs, can be reconstructed at the current position. In the end of May 2014, a corridor should be selected. A specific stretch within the corridor and certain standards are also to be determined.

5.2.1 Goals

The project is founded on specific goals which investments are intended to realize (WSP, 2013). These are defined as transport policy objectives which include goals of mobility, safety, environment and health. The goals have been specified into more concrete goals for the specific project. The overall transport political goal is to ensure an economically efficient and sustainable transport system for citizens and businesses throughout the country (WSP, 2013). Apart from the overall goal two main transport political goals are formulated; one concerning the mobility and the other is concerning safety, environment and health. The mobility will contribute to give people access to the road network and to the development for the whole country. The second goal is to design a transport system where no one is killed or seriously injured and which contributes to improved environment and health.

14 goals are also formulated for this specific project:

1. The number of deaths and serious injuries should decrease.
2. It should be possible for pedestrians and bicyclists to safely stay in the area.
3. The mobility for traffic between Norrköping and Gävle should be improved.
4. Travel time savings for through traffic at Äs.
5. The noise levels for residents along the stretch and through Äs should decrease.
6. Preserve the large scale mansion landscape around Äs and contribute to that the current land use can continue.
7. Avoiding interference with tree avenues in the countryside as well as provide prerequisites for preservation of the oaks at Äs.
8. Consideration should be taken to the well-defined landscape forms e.g. the esker, the fault-steep north-east of Äs, the ancient castle and the field islets.
9. Avoid impacts on the water protection zone and in and outlets of Lake Aspen.
10. Consideration should be taken to the accessibility of the small-scale historically shaped road network and outdoor recreation in the area.
11. The opportunities to pursue both local and regional public transport should be maintained.
12. The project should contribute to regional development.
13. Future maintenance and operating costs should be minimized.
14. The project should be economically beneficial.

5.3 Current suggestion for the design of the new road construction

The current suggestion for the new road is a 1+1 road with a physical barrier and overtaking fields (WSP, 2013). The road is suggested to be nine to ten meters wide and consist of two lanes, one in each direction. The driving fields for the new road is suggested to be 3,5 meters, giving a total section of ten meters. North of Äs, where the current road alignment will be used, a width of 3,25 meters is suggested. This will allow the total section to fit into the nine meters width of the current road. The road sides will have an inclination of 1:4 and ditches. The low inclination will imply that in case of driving off the road, the risk of tumbling over is small. No fixed obstacles are allowed in the safety zones at the road sides. The total area for the road and road sides would be approximately 30 meters. Where limited space prohibits the road sides to be designed as required, side railing should be placed at the road sides. The standard of the new construction should be high. A somewhat lower standard would however be acceptable where the old alignment is used. The speed limit is suggested to be 100 km/h and the number of intersections should be minimized due to traffic safety. The intersections are also suggested to be levelled three-way crossings. The road’s life length has been set to 40 years.

5.4 Alternative corridors

Several different corridors have been developed for the reconstruction of the part of road 56 passing Äs. In February 2014 it was considered that either corridor two or four will be chosen. According to (WSP, 2013) corridor four is most socioeconomically beneficial. There is however objections towards its intrusion into the natural interest Hälleforsgången, the farm Segerhultsgården and the swamp forests. Below follows a description of the two corridors, as well as a description of their environmental effects and factors that will be considered in the CBA. Appendix 2 presents figures of sensitive areas and a map with specific locations.

5.4.1 Corridor alternative two

Corridor two is approximately 7,5 kilometres long (WSP, 2013). Most of the stretch involves a reconstruction of the current alignment and only about 2,6 kilometres new road will be constructed. An eventual alignment will part from the current road after approximately 3,5 kilometres. It turns east, south of Äs, after passing the lake Aspen, see Figure 19, thus passing east of the settlement. The corridor aligns with the current road by Grindstugan in the north, and follows the current road the remaining 1,4 kilometres. The road through Äs will remain as a local street through smaller adjustments. The traffic safety will increase due to the wider road, separation from meeting traffic, safer roadsides and improved design of the alignment and intersections. The yearly decrease of people killed or seriously injured in traffic is estimated to 0,22 lives.

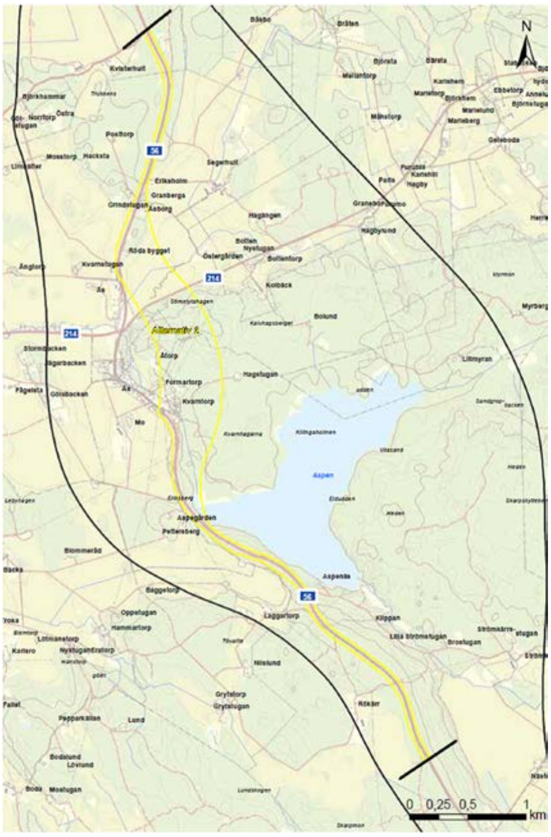

Figure 19 The propagation of corridor two is shown with yellow lines. [Taken from (WSP, 2013)]

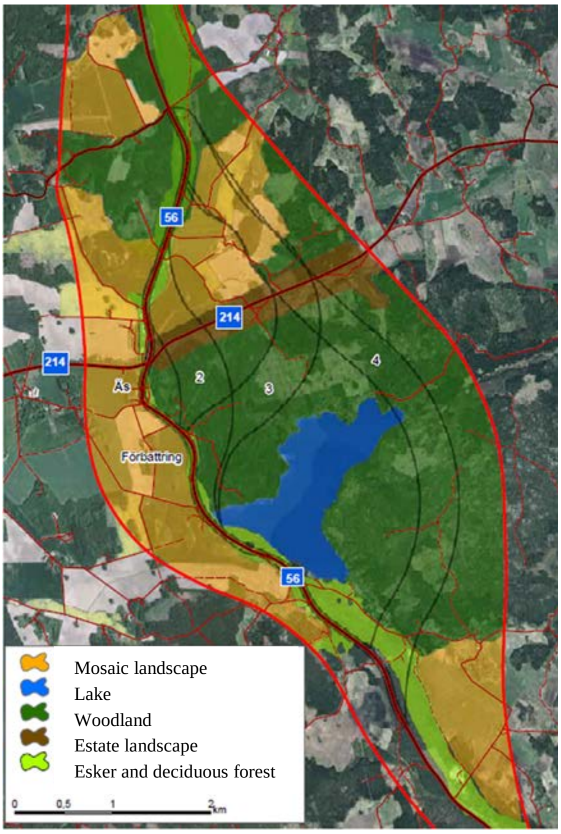

Figure 20 Division of landscape for the investigated area [Taken from (WSP, 2013)]

As seen in Figure 20, the landscape within corridor two is dominated by woodland and a mosaic landscape in the south respectively north part. The landscape where the current alignment needs reconstruction is dominated by the propagation of the esker and a mosaic landscape. The configuration of the parts which follows the current alignment will result in smaller intrusions in the surrounding terrain. After the corridor turns to the east, through the esker, a marsh landscape with alternating areas of open water and trees will be crossed. Backfilling and high banks will have a negative impact on this area. Here is also Lake Aspen’s outlet, an area with watercourse, rushing water and remains from a mill and dams. The watercourse, together with the road to the bathing area, should be crossed with a large bridge. Where the corridor passes through the wood east of Äs, large cuts are expected. Especially in the transition to the lower laying agricultural land, where the road will be a bank construction. After passing the agricultural land the corridor align with the current road again.

5.4.2 Corridor alternative four

The length of corridor four is 7,2 kilometres (WSP, 2013). This means a reduction of 0,4 kilometres of road compared to the current alignment. The new corridor separates from the current alignment south of Lake Aspen and continues on the eastern side of it; see Figure 21. North-west of Segerhult the corridor connects to the current alignment again. The old road passing through Äs will remain with some adjustments. The yearly decrease of people killed or seriously injured in traffic is estimated to 0,22 lives.

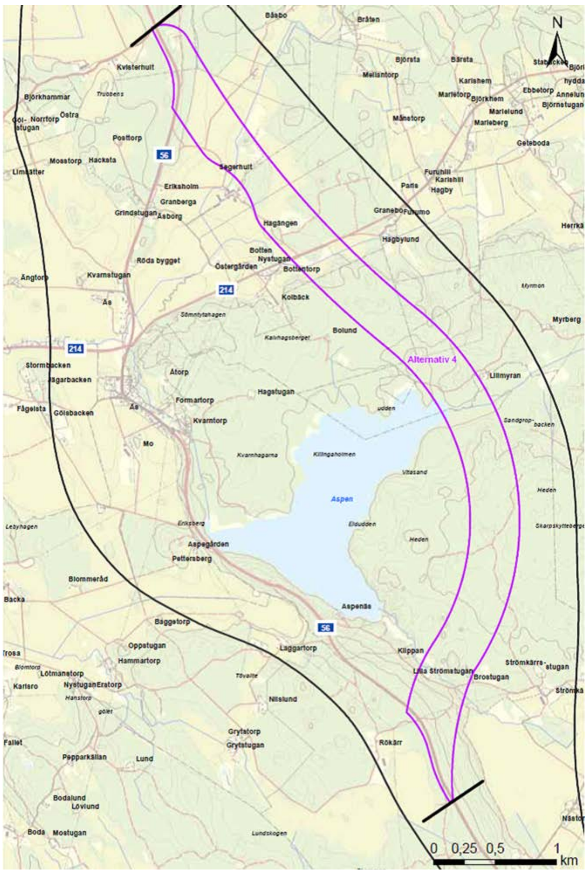

Figure 21 Propagation of corridor four is located within the pink lines [Taken from (WSP, 2013)]

Corridor four is initially turning slightly to the east, crossing the esker and continues over a smaller ravine (WSP, 2013). At the ravine there is a stream which leads to an inlet of Aspen. The cut through the esker and the passage over the stream will require that the masses are handled carefully. The landscape in the area of the corridor is dominated by woodland and is somewhat hilly, see Figure 20. Therefore large-scale cuts and fills are required. In the woodland several crofts and remnants are found. On the east side of Aspen there is lowland and the road will need to be built on an embankment where the ground conditions are marshy. Nearby the lake, the management of masses should be handled carefully, especially regarding cuts and slopes, in order to avoid landslides. The corridor passes road 214 and is thereafter continuing through the mosaic landscape north-east of Äs. The mosaic landscape is somewhat hilly with field islets which will need to be cut through.

5.4.3 Geological description

Simplified, the mosaic landscape lies on clay and silt, and the woodland on till. The geology of the area can be seen in Figure 22. The esker is propagating along the current road's east side. The area east of the esker and south of road 214 is dominated by till and rock outcrops. Areas of peat can also be found here, especially by the watercourse east of Lake Aspen where peat layers of five meters have been found. North of road 214 the geological formation is mainly clay and silt. These layers are commonly between five to eight meters deep. Deeper layers can however be expected locally.

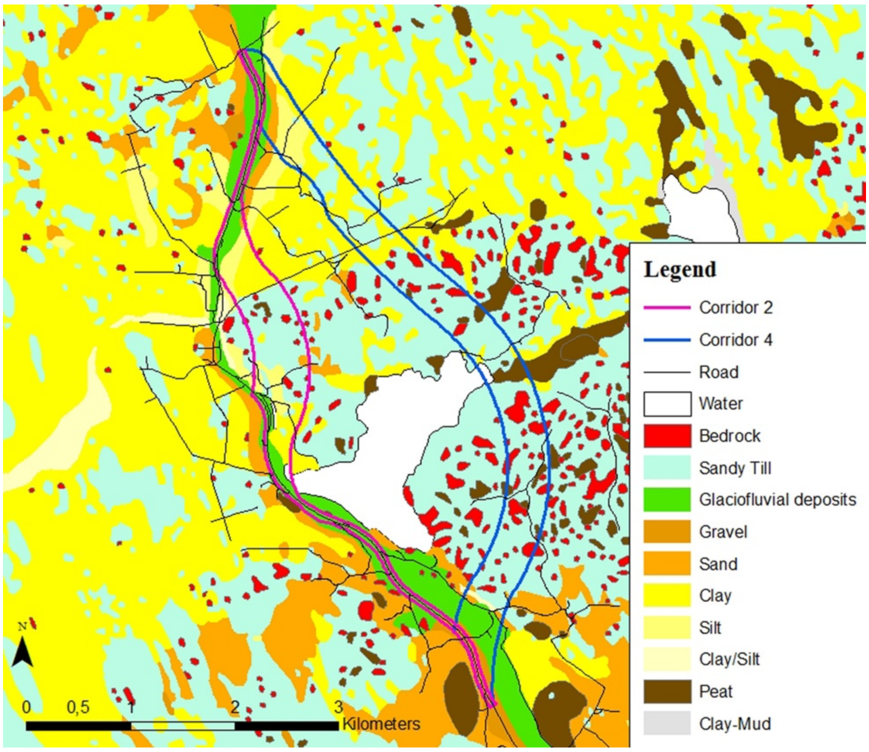

Figure 22 Geological conditions for the area [Own visualization with data from the property map]

5.4.4 Environmental effects

An environmental description has been made for the investigated area (WSP, 2013). This chapter will summarize the consequences an eventual road within corridor two and four will have on the environment. It is within these corridors different road alignments will be investigated. The consequences for the environmental effects are divided into five main categories; environment, health and security, husbandry of resources, environmental impact during construction and risks. A minor presentation of each category is presented in this segment, and a summary is presented in Table 4 in the end of the chapter.

5.4.4.1 Environment

East of the present road 56, the landscape is characterized mainly by hilly woodland in the south and mosaic landscape in the north (WSP, 2013). The effects on the environment are valuated with regards to the natural and cultural environment, recreation and the landscape picture.

Natural environment

Preserving the natural environment is essential for biological diversity, which is the base for biological development and ecological balance (WSP, 2013). This is practically done by safe guarding of certain environments (e.g. fens, wetlands and deciduous forests) and thus protects the species living there. Such environments are called biotopes and could be lost due to the construction of a road. This, both due to that it claims area and fragments the landscape, which affects the animals' movement patterns.

A road construction within *corridor two* would cause significant effects on the natural environment (WSP, 2013). The location of the values can be seen in Appendix 3. Along the current road, from Bie to Äs, there is an esker called Köpingsåsen. The esker is one of the largest eskers in Södermanland and corridor two is initially stretching parallel to it and separates from it when the corridor turns east.

Aspen is a lake with nutrient-poor and clear water (WSP, 2013). The inlets are mainly situated in woodland areas but also within the esker. There is a shoreline protection zone founded in connection to the lake. This aims to both preserve public recreation and biological valuable water and land areas. Generally the shoreline protection zone reaches 100 meters from the shoreline. The current alignment of road 56, within corridor two, is tangent to the protection area. Since the current road alignment is already affecting the protection area the consequences are considered as small. West of Aspen there is a marshland, through which the corridor passes. A bridge construction over this area will reduce the impact and the consequences are considered as moderate.

Within the corridor there is also a sand pine forest which is considered as a key habitat with high natural values (WSP, 2013). The habitat will be affected by a road construction and the consequences are considered as significant. South-east of Kvarntorp there is also a swamp forest. Two valuable trees exist within corridor two; these are situated in the northern part.

A road construction within *corridor four* would cause large impacts on the natural environment (WSP, 2013). One of the major impacts consists of the cut through Hälleforsgången, which is the largest diabase dyke in Sweden and its preservation is of national interest. Part of the dyke is situated south of road 214 and the corridor will pass the western end of it. A road construction would have to cut the dyke. However, since it intersects the end of the dyke it would not completely intersect it; the consequences are considered as large. At the beginning of corridor four there will be a cut through the esker which will affect its character. The consequences are considered as large.

North-east of Lake Aspen there is a mire. The corridor intersects the western part of the mire which will affect the hydraulic conditions (WSP, 2013). The areal would decrease and some drainage is likely to occur. The consequences are considered as moderate.

In the woodland east of the lake there are a lot of wild animals (WSP, 2013). There are for instance hare, foxes, badgers, wild boar, roe deer, deer and elk. Due to the small extent of buildings and roads in the area, the consequences for the wildlife might be large. Between Segerhult and road 56 there is an avenue with oaks. Part of it is situated within the corridor. The road should be aligned east of it; otherwise the consequences would be large. Three small swamp forests are also situated within the corridor and might be intersected by the road. The severity of the consequences is difficult to estimate.

Cultural environment

Traces, produced by humans, in the landscape which tells the historically stages and procedures which resulted in today's landscape, are considered to be a part of the cultural environment (WSP, 2013). Part of the area of investigation is intersecting an area of national interest, Julitabygden, which is an estate landscape from the Middle Ages. The location of the values can be seen in Appendix 3.

Several objects connected to Julitabygden are listed as national interest (WSP, 2013). These are; the manor houses' main buildings and land plots, the long avenue systems and the relation between the centrally located seat farms and the peripheral leasehold farms and crofts. The municipality's cultural program has also stated that the road network's original alignments and character should be preserved. Pasture fields and grassland, deciduous trees and the openness of the landscape should also be preserved, as well as the old mill Julita kvarn and the cultivation area of Julita adjacent to Aspen. Some archaeological findings have been found within the area of investigation and it is likely that more objects are to be found.

Corridor two would cause large impacts on the cultural environment (WSP, 2013). At the beginning of the corridor, the area of Julita Kvarn is situated. The corridor continues over the agricultural area connected to the country house of Äs. The passage through the area might cause fragmentation of the landscape and produce residual areas between the old and the new road alignment.

It is likely to find archaeological objects in the area around the country house of Äs and at the site where Aspån intersects another stream on its way to Öljaren (WSP, 2013). Along the esker and on the marshland at the west side of Aspen, further findings of ancient roads are likely. Within the forest area in the corridor it is likely to find settlements from the Stone Age, tombs, cairns, and objects for hunting and forestry. Within the agricultural area it is likely to find settlements from the Bronze Age and Iron Age.

The effects on the cultural environment within *corridor four* are considered as moderate (WSP, 2013). The corridor intersects a croft landscape south of Aspen and agricultural landscape at Segerhult. The area south of Aspen is characterized by crofts and smaller roads. A new, larger road might break the connection between the crofts. At the agricultural landscape at Segerhult, the new road might cause a fragmentation of the landscape. Near Segerhult the corridor is situated at the border of Julitabygden. East of Segerhult an archaeological object has been found (WSP, 2013). It is likely to find other objects, such as sacrifice findings, in the area. In the woodland, the new road is likely to affect Stone Age settlements.

Outdoor recreation

An area needs to be attractive and accessible in order to be interesting for outdoor recreation. The accessibility to the small road network is essential in the agricultural area (WSP, 2013). The woodland is of great importance considering recreation, walkabouts and berry and mushroom picking. Lake Aspen is of importance for fishing and swimming. The position of the road and the possibilities of passing it might influence the accessibility. Especially if a new road is built in an unbuilt area, movement patterns might be obstructed. Median barriers and wildlife fences hinder passage of the road. Road embankments and cuts through the landscape complicate the passing of the road further.

Corridor two impairs the settlement’s connection with the recreational area in the woodland (WSP, 2013). Additionally, the bathing area by Aspen is foreclosed and it is of importance that an overpass is constructed. The corridor is considered to have large consequences to the outdoor recreation. Corridor four does not affect the recreation possibilities to a large extent. This is most likely due to its location, away from any densely populated area. The consequences to recreation from corridor four is considered to be small.

Landscape

A new road might give new character to the landscape. This is due to that the landscape picture is fragmented by the road or that visual lines are disturbed. The extent of the impact depends on the alignment’s adjustment to the terrain. The open agricultural landscape and the filed islets compose a characteristic landscape picture in the area. The esker, Hälleforsgången and a fault-steep located in an east-west direction with the northern steep at road 214 are also important features in the landscape. The inlets and outlets of Aspen are also characteristic with ravines and large differences in altitude. Corridor two will have a large impact on the landscape, especially by the outlet of Aspen and in the transition between wood and agricultural land where the fault-steep is located. The consequences of corridor four is moderate, the main stretch is through woodland and the alignment can be adjusted to the terrain.

5.4.4.2 *Health and security*

It is of importance that a new road does not lead to worsening health or lacking security for the individuals in the society. The factors included in the evaluation of these aspects are noise and barrier effects.

Noise

The pollution in terms of noise is caused by engines, exhaust, wind and tires (WSP, 2013). It varies with the amount of traffic, type of vehicle, speed, driving manner and the road condition. The level of noise is dependent on the distance from the source to the receiver. According to the government, a new road or reconstruction of a road should cause maximum 30 dBA equivalent level[15] indoors in residences and a maximum level of 45 dBA no more than five times per night. The maximum equivalent level outdoors at a residence is 55 dBA. These values are guidance only and not legally binding. A road within corridor two will cause equivalent levels over 55 dBA for ten houses. The disturbance is considered to be significant. In case of a new road construction within corridor four, there are three houses for which the noise levels are exceeded. The noise disturbance is considered to be insignificant. Since the exact alignment is not determined, the number of houses is only estimation.

Barrier effects

The road construction as well as the traffic can impose a barrier for pedestrians and bicyclists (WSP, 2013). The impression of decreased safety and accessibility lead to certain movement patterns. A median barrier is increasing the barrier effect. The consequence due to barrier effect is considered to be large for both corridors. Corridor two will impose a barrier for the recreation area east of Äs. In corridor four, a road would be a barrier for outdoor life on the east side of Aspen as well as for the wild life in the area. Safe overpasses for pedestrians and bicyclists are needed in both corridors.

5.4.4.3 *Husbandry of land, water and other resources*

The resources the earth provides are finite and have to be used with a sustainable approach. It is thus necessary that the land devoted to agriculture and forestry is kept as much as possible (WSP, 2013). This category also includes surface water, groundwater and mass management. Water is a must for the survival of the earth's inhabitants and sources have to be protected. A lot of masses are used and transported during a road construction. It is essential that the management of these are as resource effective as possible.

Agriculture

According to the Swedish Environmental Code, agriculture is an economy of national importance (WSP, 2013). Due to this, agricultural land may be claimed only to meet important societal interest and if no other area of land could be claimed. The amount of land that needs to be claimed depends on the alignment, width of the road and where the

[15] Equivalent level is a value for the measured overall noise level for a specific time.

overtaking fields are placed. North of road 214 there are agricultural land which parts of need to be claimed. The land consolidation might be negatively affected by a new road and there are risks that land with low production are subjected to afforestation. Due to fragmentation, some lots may also be difficult to farm. The consequences to the agriculture due to a new road are considered to be significant for both corridors.

Forestry

The forestry is also an economy of national importance according to the Swedish Environmental Code (WSP, 2013). Woodland of importance should be protected from measures that would complicate forestry. The land consolidation along the esker and the accessibility will be impaired. The major part of both corridors passes through woodland south of road 214. Although corridor four claims more woodland the consequences are considered to be equivalent for the two alternatives and regarded as small.

Surface water and groundwater

The water source of Mo is situated on the esker, south of Äs and on the west side of road 56 (WSP, 2013). The possibilities of withdrawal from the groundwater aquifer within the esker are considered as good. The protection zone is intersected by the current road alignment for 400 meters along with a watershed. There are two recipients, one on each side of the road, Lake Aspen to the east and Lake Öljaren to the west. The water source is considered to have hydraulic contact with Aspen. The esker leaks water into a stream which flows from Aspen in a north-west direction towards Äs. The geology at the esker is composed by glacial sediments and sand. This is permeable material and the infiltration of surface water proceeds quickly. An accident with leakage would therefore pose a risk to the water source. The municipality of Katrineholm developed in 2012 a suggestion for a safety plan for the water source. The largest risk was judged to be traffic accidents nearby the water source.

The surface water and the groundwater might be altered due to a road construction regarding both quality and water level (WSP, 2013). The stormwater from the road is polluted by exhaust, tires and road surface. The pollutions might affect ecological systems and humans. Increased traffic causes an increase of pollutions in the storm water which eventually end up in a recipient or reach the groundwater. A wider road results in a slight increase of stormwater. Altered water levels might cause settlements and landslides. The consequences could be decreased by implementing grass covered ditches which will prolong the infiltration of stormwater. Ditches will be constructed on both sides of the road where it passes the esker. Some of the glacial material will be replaced with less permeable material.

Regarding corridor two, the risks of groundwater contamination due to e.g. a traffic accident remain since it passes through the water protection zone (WSP, 2013). In addition, the corridor cuts the esker and crosses the marshland west of Aspen. The consequences of a road within this corridor are considered to be large. Corridor four is not situated within the protection zone of the water source and will offload the road through Äs from traffic. However, a cut through the esker and the closeness to the lake Aspen might pose a risk to the water source. The consequences are considered as small.

Management of masses

Cuts and embankments result in relocation of masses. A balance between cut material and required fill material is desired. The topography for a new construction within corridor two implies large cut volumes (WSP, 2013). The cuts are expected to consist of reusable rock and a significant surplus is expected. For corridor four, the volume of masses is expected to be large with a surplus of masses. The material is assumed to be composed by bedrock material which can be used in the road construction.

5.4.4.4 Environmental impact during construction

Disturbance will arise during the construction of the new road (WSP, 2013). Hence, measures in order to minimize these have to be applied. It can for instance be physical measures or application of resource efficient methods. The disturbance can be e.g. noise and parking of work vehicles. Corridor two is situated closest to Äs and is mostly a reconstruction of the current alignment. Hence, significant disturbances are expected during construction. Since corridor four lies outside densely populated areas the disturbance due to construction is considered to be small.

5.4.4.5 Risks

Some risks have been evaluated for the corridors, namely vulnerability regarding flooding and traffic accidents involving hazardous goods (WSP, 2013). The basis of the assessment is geotechnical assessments, map studies, nature inventories and calculations of accident risks. The overall risks related to the two corridors differ. The risks regarding corridor two is considered to be large, whereas the risks related to corridor four is insignificant.

Vulnerability and robustness

The county board, and others, are responsible for monitoring and support vulnerability in the communication systems (WSP, 2013). The finalized road should be robust and flexible in order to meet the requirements which might vary during its lifetime. Flooding and the risk of shut down are two of the vulnerabilities of the road.

Flooding occurs mostly in lowlands and often in conjunction with heavy rain or snow melting (WSP, 2013). Lake Aspen only have smaller inlets and the outlet Aspån is regulated. No greater flooding has occurred either in Aspen or in Aspån. Corridor two passes through the marsh west of Aspen. If this corridor is selected, a bridge alternative will be developed which will decrease the risk of flooding. Corridor four passes through a mire on the east side of Aspen. The risk of flooding is considered as small, however the risk varies with the position of the road.

A shut down of the road would at present have significant effects (WSP, 2013). This is due to that no other roads exist nearby on which the traffic could be diverted to. The new road would enable improved possibilities of diverting traffic in case of an accident.

Accidents with hazardous goods

Hazardous goods are flammable, explosive, toxic or corrosive goods (WSP, 2013). The most common type is flammable fluids. In case of an accident, the goods are posing a risk to humans and to the environment. Fluids are primary affecting the direct environment but the extent could be increased if spread to water streams or groundwater. Road 56 is currently a recommended road for transporting hazardous goods. In September 2006, 33 000 tons of hazardous goods were transported on the stretch. The largest risks are currently subjected to humans and the groundwater source Mo. Implementation of a new road results in a decreased accident risk due to improved road standard. Additionally, a new road will remove the hazardous goods passing through Äs. Considering corridor two, the passage through the water protection area remains. This problem does not exist for corridor four which passes outside the protection zone.

Table 4 Consequences of a road within corridor two and four [Inspired by (WSP, 2013)]

Interest\corridor	Corridor two	Corridor four
Natural environment	Significant	Large: National interest, esker
Cultural environment	Large: Kvarntortp, agricultural land at country house of Äs	Moderate
Recreation	Significant	Small
Landscape	Large: Level differences	Moderate
Noise	Significant	Insignificant
Barrier effect	Large	Large
Agriculture	Significant	Significant
Forestry	Small	Small
Surface and groundwater	Large: Water protection zone	Small: not through water source
Mass-management	Significant	Large: surplus
Implementation	Significant	Small
Risks	Large: Hazardous goods	Insignificant

6 Creation of the computer model and the socioeconomic analysis

In order to perform the simulations in Trimble Quantm, a model has to be set up. The procedure for this is described in Chapter 6.1. Data is also needed in order to perform the socioeconomic analysis. The creation of the CBA follows the classic model described in Chapter 4.2. The procedure for the creation of the CBA is described in Chapter 6.2.

6.1 Setting up the model in Trimble Quantm

The different road alignments were found using Trimble Quantm (version 7.1.0.121 desktop edition). A model was set up by images of geographic information and relevant input data regarding geometric and cost parameters were applied. A complete list of input data is found in Appendix 1. The subchapters below describe each step of setting up the model in Trimble Quantm.

6.1.1 Digital terrain model

The first step in creating the model was to add a digital terrain model (DTM). The DTM is the basis of the model and simulations cannot be made without it. Through the DTM, Trimble Quantm can find alternative alignments and do mass and cost calculations. The DTM was provided from Christian Lundberg, GIS-developer at WSP. The DTM is constructed from laser data and has a resolution of 2x2. It was imported to Trimble Quantm where it was stored in raster format.

6.1.2 Data from property map

Existing objects, such as lakes, rivers, road network and buildings were applied onto the terrain model which visualizes their location and extent over the investigated area. The information was imported into Trimble Quantm as shapefiles, provided from WSP. For each type of object, a crossing type was chosen. This gives the program information of how crossing of the object should proceed. Since the road connections are taken into account in the basis calculation (WSP, 2014), they were excluded from the model. The set crossing types are presented in Table 5.

Table 5 Feature and crossing type used in Trimble Quantm for data from property map

Feature	Crossing type
Lake (Water)	Bridge
Rivers	Bridge or culvert
Houses	Avoid areas with high priority

6.1.3 Corridors

In order to delimit the investigated area, two different cases were constructed; one with corridor two and another with corridor four. The corridors’ locations were given by a shapefile, provided by WSP. Extraneous area was thereafter excluded from the analysis by drawing two avoid zones around respective corridor. Trimble Quantm then tries to avoid entering the area. It turned out that the usage of avoid zones was not sufficient in order for the alignments to stay within the corridors. Therefore, the areas created around the corridors were given an area cost of 1 000 000 000 SEK/m^2 in order to make Trimble Quantm provide alignments within the corridors. In addition, the borders of the corridors had to be adjusted in order to avoid crossing Lake Aspen, the valuable trees and Julita Kvarn, and trespassing of the corridor borders at certain locations.

6.1.4 Geometric parameters

The geometric parameters constrain the alignments to meet the Swedish criteria regarding road design. The geometric parameters include horizontal and vertical alignment and cross section. The input data was obtained from the document "Vägar och gators utformning" (Trafikverket, 2012b). Some of the data are depending on reference speed. The geometric values were set for three different reference speeds; 80 km/h, 100 km/h and 110 km/h. The choice of speed limits was based on the suggested speed limit of 100 km/h. New roads are not designed for speed limits of 90 km/h and this limit has therefore been excluded.

In Trimble Quantm, a setting which tells the program how to design the road with regards to the terrain can be made. A range between zero and one can be chosen, where zero corresponds to that the terrain has the highest priority and one corresponds to that the geometric design of the road has the highest priority. In order to avoid too large cuts or fills, Trimble Quantm was set to follow the terrain as much as possible, thus set to zero.

6.1.5 Costs and other parameters

The input data for the cost parameters are rough estimations or standard values. It is very difficult to provide exact numbers for a project in such an early stage. The data has been provided from various sources. The currency used in Trimble Quantm is US dollar. Thus, all values have been converted to SEK and the exchange course was set to 6.38 SEK per US dollar.

For data regarding cost parameters, e.g. pavement construction and mass transportation, default values in Trimble Quantm have been used. The exception is the construction cost of bridges, tunnels and retaining walls. The unit construction cost for bridges were provided by the basis calculation performed by WSP (WSP, 2014). Information regarding limiting abutment slope was provided by Oscarsson[16]. According to Swedish standard the maximum slope is 1:1,7 and slope of 1:2 was chosen in order to be on the safe side. No tunnels are planned in the construction. In order to prevent Trimble Quantm to propose tunnel constructions, the tunnels were given a high construction cost.

Costs and other values regarding retaining walls have been provided by Kullingsjö[17]. The cost of wall will however differ between different types and amount of reinforcement. It is assumed that a wall with at least one anchoring level is used. It is also assumed that Trimble Quantm considers the total length of the wall and not just the

[16] Jonas Oscarsson, Bridge Engineer at WSP. Interview 2017-03-05
[17] Anders Kullingsjö, Geotechnical Engineer at Skanska. Interview 2014-03-26

excavation depth when calculating wall costs. For this type of wall, Kullingsjö estimated the cost to be between 1 000 and 1 500 SEK/m^2.

Through studies of the geological map three different ground conditions, dominated by till, peat and clay, have been identified. The different ground conditions were set in Trimble Quantm by creating zones with local default values. The ground conditions will influence the thickness of the road's superstructure. The thickness of the superstructure has been estimated through the Swedish table method with regards to traffic load and heave. Geological information, such as different materials' compaction factor and usability in a road construction have been estimated based on Trimble Quantm's default values together with Johansson[18].

6.1.6 Sensitive areas

Within the area of investigation there are several sensitive areas which require specific attention. WSP has defined the sensitive areas and divided them into four categories; natural valuable areas, cultural valuable areas, valuable landscape picture and areas with geotechnical issues. During the production of the corridors, the areas were considered and avoided as much as possible[19]. Some intrusion into the areas is however inevitable and the extent of the intrusion must be compared when choosing alignment. In order to make the program present the area of intrusion for each alignment, an area cost of zero SEK was applied to each sensitive area. No additional cost was set to the area since these have been taken into account in the basis calculation (e.g. ground reinforcement), or does not exist.

The sensitive areas have been given a level of sensitivity for intrusion, see Table 6. The areas are also visualised in Figure 44 in Appendix 2. The levels are estimated or obtained from WSP. The values can be used for evaluating or comparing the intrusion into different areas. Level one corresponds to the highest level of severity and three to the lowest.

[18] Lars O Johansson, Geotechnical Engineer at WSP. Interview 2014-03-27
[19] Karolina Wettermark, Project manager for road 56 at WSP. Interview 2014-03-27

Table 6 Sensitivity level for the areas considered in this thesis

Sensitive area	Sensitivity level
Within corridor two	
Natural values by Aspen	2
Swamp forest	2
Valuable trees	3
Cultural environment	3
Julita Kvarn	1
Landscape picture	2
Within corridor four	
Hälleforsgången	2
Swamp forests	2
Oak alley	3
Cultural environment	3
Croft landscape	3
Landscape picture	2 and 3

6.1.6.1 Natural valuable areas

Within corridor two, the naturally valuable areas included in Trimble Quantm are the marshland west of Aspen, the swamp forest, the pine forest and two valuable trees. Within corridor four the naturally valuable areas include Hälleforsgången, the oak alley and three swamp forests. Since the swamp forests and the two valuable trees were not included in the predefined sensitive areas, these have been drawn into Trimble Quantm by hand.

6.1.6.2 Cultural valuable areas

The culturally valuable areas include Julita Kvarn and agricultural landscape at the country house of Äs within corridor two, and the croft landscape and the agricultural landscape at Segerhult within corridor four.

6.1.6.3 Valuable landscape picture

The valuable areas regarding the landscape picture consist of Julitabygden and the agricultural area connected to the country house of Äs within corridor two, and the agricultural landscape by Segerhultsgården within corridor four.

6.1.6.4 Areas with geotechnical issues

Specific geotechnical difficult areas are found at Julita Kvarn and at the northern part of corridor two. Within corridor four, problematic areas are found at the mire east of Aspen, at the bogs and by a clayey area at Segerhultsgården. Construction costs for ground reinforcement are taken into account with data from the basis calculation and are therefore excluded from the simulations in Trimble Quantm.

6.1.7 Overtaking fields

As stated in (WSP, 2013) the new road 56 should be a 1+1 road with a part being 2+1 to enable overtaking. According to Wettermark[20], an overtaking field should be at least 1000 meters long. The percentage of overtaking fields of a road is generally between 15 and 40 percent (WSP, 2013). Two overtaking fields, each 1,4 kilometres long, are designed in this thesis, one in each direction. The length was suggested by a preinvestigation made by WSP. Two overtaking fields with the suggested length would constitute 12 percent of the total stretch from Bie to Stora Sundby. Since the percentage of overtaking fields is referred to the entire stretch from Bie to Stora Sundby, none or longer fields could be placed within the corridors. No more than two fields are however investigated within the corridors.

The placement of the fields was determined based on the literature survey and with regards to intersections and topography. It is favourable to place overtaking fields in ascents since this is where heavy vehicles will lose speed and decrease the mobility on the road. Within corridor two, one overtaking field is suggested at the northern part of the corridor. This field will be placed on the east side of the current road, resulting in an uphill gradient for traffic travelling north. The other field, in the opposite direction, is suggested south-west of Lake Aspen, west of the current road. This position also results in an uphill gradient. An investigation of corridor four resulted in a suggested placement of the overtaking fields shortly after the southern inlet of Lake Aspen and continues over the eastern inlet. The two fields are placed in sequel, where the southernmost is placed on the east side and the northernmost on the west side. This area constitutes of hilly woodland with the highest point positioned at the junction between the overtaking fields. In this way there will be uphill gradients in both directions. The positions of the overtaking fields are presented in Figure 23.

[20] Karolina Wettermark, Project manager for road 56 at WSP. Interview 2014-03-27

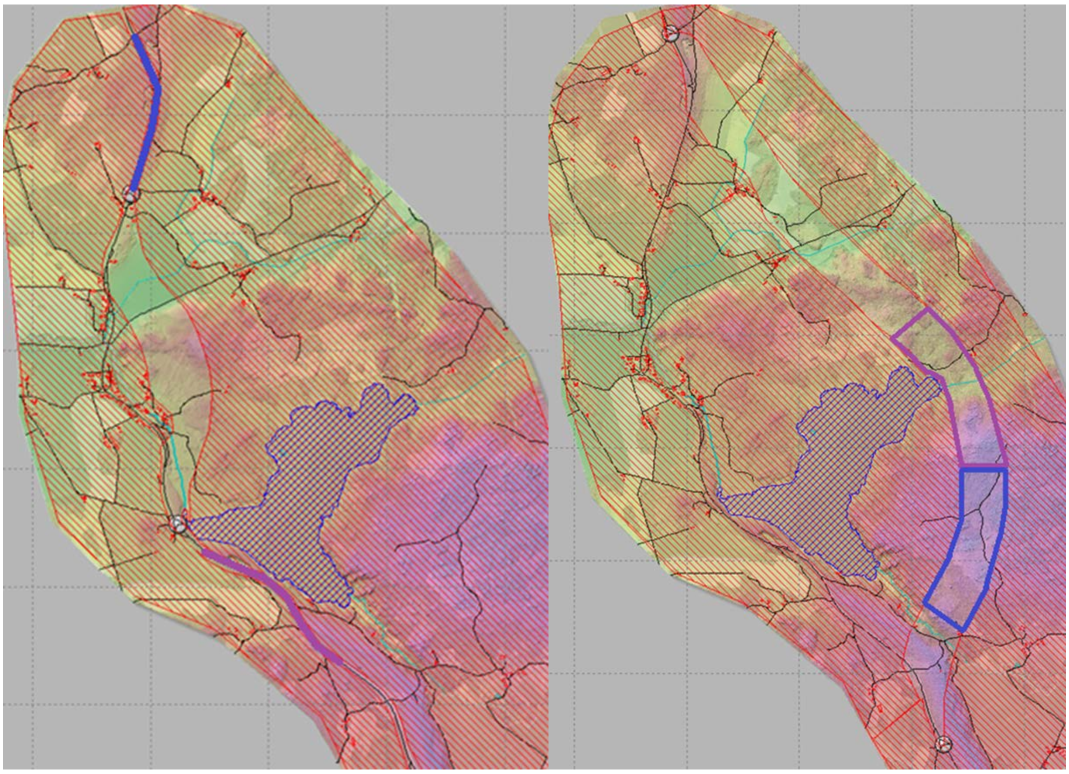

Figure 23 Placement of overtaking fields in corridor two and four. The left picture shows the placement of overtaking fields in corridor two. The right picture shows the placement in corridor four. The blue represent an overtaking field on the east side for traffic travelling north. The purple represent an overtaking field on the west side for traffic travelling south.

6.2 Creation of the cost-benefit analysis

All costs for a road project are not considered through Trimble Quantm. Trimble Quantm will only take account to construction costs. Costs for e.g. project planning, maintenance and road user costs have been considered with a CBA. Maintenance costs, road user costs and community costs decrease when a new road is constructed and are therefore considered as benefits in the CBA.

6.2.1 Input data for project costs

The investment in a road project comprises more than the construction cost. WSP has made an early basis calculation for project costs for both corridors (WSP, 2014). These costs are fixed and do not vary between different alignments within a corridor. There is however a difference between the two corridors. The basis calculation includes preliminary costs for:

- Project administration
- Investigation and planning
- Engineering design
- Right-of-way acquisition (woodland and agricultural land)
- Environmental measurements (noise measures, wild life passages, decontamination compensation measures and conformation measures)
- Transfer and termination
- Connections to existing road network

- Archaeological fieldwork
- Measures for electricity and telecommuting cables
- Temporary road structures
- Demolition of bituminous layers
- Drainage shaft
- Wildlife fences
- Median barrier
- Road side barrier
- Barrier openings
- Termination of road side barriers
- Stormwater reservoir
- Infiltration retarding ditches
- Road signs
- Ground reinforcement

The alignments within corridor two require that a part of the road needs to be reconstructed, both north and south of Äs. The cross section of the road north of Äs is decided to be nine meters in order to fit into the current cross section. South of Äs, the road will be reconstructed and widened from 7,5 meters to ten meters. A widening to 13,5 meters are also required for the overtaking fields, one north of Äs and one south of Äs. Only the wearing course and the binding course are replaced where the reconstruction takes place. At the widening, base courses and a subbase need to be constructed as well. The cost of reconstruction has been calculated using the data in the basis calculation (WSP, 2014). This, since a division in different layers and their respective costs were given here. The costs for the different layers are given per square meter. The costs were therefore multiplied with the width and the length of the road. The cost for the subbase was given in cubic meters and therefore multiplied with the width and length of the road, and the thickness of the layer. The data for the calculation is found in Appendix 1, Table 34.

6.2.2 Input data for maintenance costs

Maintenance costs have to be included in the CBA in order to be able to evaluate which alignment is most socioeconomically beneficial. Data regarding maintenance costs has been received from the Swedish Transport Administration (Trafikverket, 2012g). A yearly cost per meter is calculated with Equation 7 presented in Appendix 1. The values of the parameters depend on type of road. Thus, values for both meeting separated 1+1 road and 2+1 were used.

6.2.3 Input data for road user costs

The costs for the road user were also taken into account through the CBA. These costs were provided from the Swedish Transport Administration (Trafikverket, 2012g). The road user costs included in the CBA are vehicle operating costs and travel time costs. The accidents costs will not differ between corridor two and corridor four and is therefore not included in the analysis.

The vehicle operating costs include fuel, tires, service and depreciation. All operating costs are based on standard values for passenger cars. The fuel cost was chosen according to a prognosis for year 2020 made by the Swedish Transport Administration. The cost for tires was calculated based on 2014 market price of tires from (Michelin, 2012) and (Trafikverket, 2012g). According to the company, the Michelin tires have a 20 percent longer lifetime than regular tires. Therefore, 80 percent of the lifetime of Michelin tires was used when calculating the amount of tires required during one year. The amount of tires was then multiplied with the unit cost per tire obtained from the Swedish Transport Administration. The service cost was calculated based on estimations made by (Instant Interactive Information Europe Ab, 2009). Since all units are SEK/km, the values were multiplied by road length, AADT and 365 (days per year). This makes the costs comparable in the CBA.

The travel time costs were calculated by multiplying the travel time with a time unit value, AADT and 365. The time unit value used comprises national and regional trips as well as business and private hours. Since there was no value available for 2010, the value for 2006 with an addition of six percent was used. This increase corresponds to the median value of the increase for the partial costs.

6.2.4 Input data for community costs

Some community costs are included in the CBA, namely noise and emissions. As mentioned in Chapter 5.4.4.2, ten houses will be subjected to noise levels above the limit if a road is constructed in corridor two, and three houses if a road is constructed in corridor four. The costs for noise are given per person and year (Trafikverket, 2012g). The average number of persons per household was set to two, based on statistics from Statistics Sweden (Statistiska Centralbyrån, 2013a).

The emissions considered are nitrogen oxides (NO_X), volatile organic compounds (VOC), particles, sulphur dioxide (SO_2) and carbon dioxide (CO_2). The values are given in grams/km (Trafikverket, 2012g). By multiplication with the cost of each type of emission, in unit SEK/kg, an emission cost per kilometre was obtained.

7 Result

In this chapter the results obtained from Trimble Quantm and the CBA are presented. Firstly, the results from the six simulations performed in Trimble Quantm will be presented. Due to the magnitude of information given from the simulations, only a summary of each simulation will be presented. The result of the CBA will be presented in Chapter 7.2, followed by more detailed information about the most socioeconomically favourable alignment in each scenario.

7.1 Results obtained from Trimble Quantm

Six simulations have been performed with the software Trimble Quantm, one simulation for each corridor and the speed limits 80 km/h, 100 km/h and 110 km/h. The result provided 150 alignments. This segment will present data regarding costs and quantities for each alignment. The result is presented separately for each scenario.

7.1.1 Results for corridor alternative two

Below, the results of 75 suggested alignments within corridor two are presented. For each speed limit, a visualization of the area shows the localization of the alignments, see Figure 24 to 26. Their respective lengths, quantities and construction costs are presented in Table 7 to 12. Note that costs and quantities presented for the corridor do not include the reconstruction of the present road.

7.1.1.1 80 km/h

The results for speed limit 80 km/h within corridor two are presented below. The 25 horizontal alignments are visualised in Figure 24. As seen, the position of the horizontal alignments is very similar and only minor differences are noticeable. All alignments pass close to Äs. The alignments tangent the altered corridor line, resulting in intrusions on the border of the cultural area of Julita Kvarn. The valuable trees are avoided and the shoreline protection zone is not impaired.

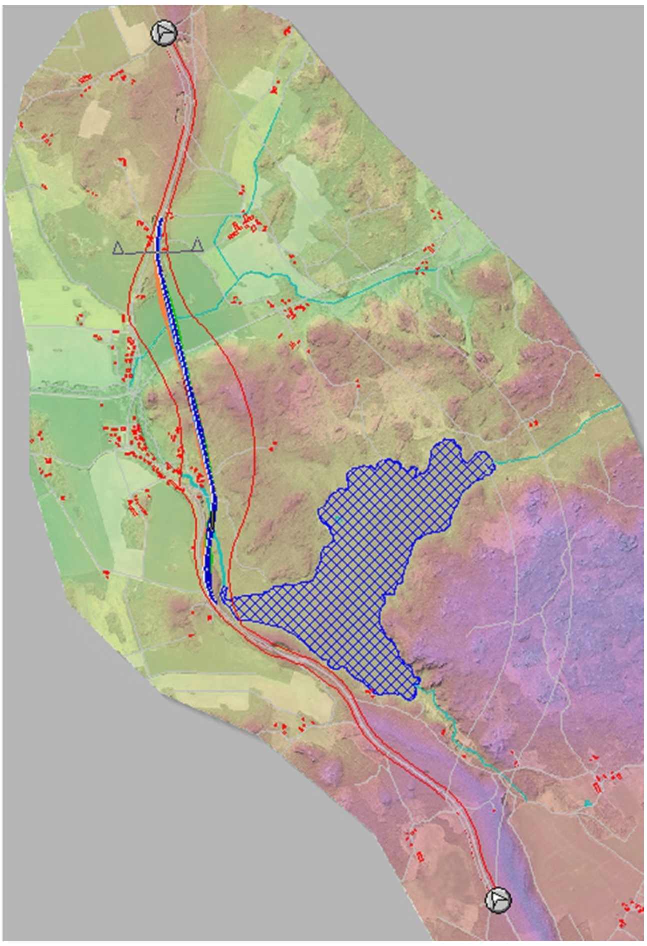

Figure 24 The result provided from Trimble Quantm for corridor two with a speed limit of 80 km/h.

Table 7 below presents the length and cost data for each alignment. The quantities of masses and constructions are presented in Table 8. This data is given as a part of the result of a simulation in Trimble Quantm. The length of the alignments varies between 2 867 and 2 896 meters, where alignment 15 is the shortest one and alignment 10 the longest. To this, the length of the road which will be reconstructed should be added, resulting in a total road length between 7 367 and 7 396 meters. There is generally a surplus of masses. Only six alignments have mass deficit and needs to import (borrow) construction masses. The construction cost of the alignments varies between 79,179 mSEK for alignment 1 and 163,427 mSEK for alignment 9. The average construction cost is 116,555 mSEK.

Table 7 The different construction costs given by Trimble Quantm for each alignment.

Summary of costs for corridor two, 80 km/h											
Alignment name	Length [m]	Fill [SEK]	Cut [SEK]	Borrow [SEK]	Dump [SEK]	Paving [SEK]	Mass Haul [SEK]	Wall [SEK]	Culvert [SEK]	Bridge [SEK]	Construction Cost [SEK]
1	2 872	1 762 094	8 491 252	11 236 544	105 981	24 005 344	333 266	-	46 159	33 198 880	79 179 520
2	2 869	1 276 880	43 541 608	-	1 506 718	23 430 748	817 203	30 134	44 691	55 352 748	126 000 731
3	2 871	1 002 351	34 986 512	-	1 315 186	23 686 124	651 209	23 878	48 011	45 329 240	107 042 510
4	2 879	1 225 805	36 454 924	-	1 187 498	23 877 656	626 310	-	45 712	39 774 812	103 192 717
5	2 887	287 936	83 635 640	-	4 686 150	24 133 032	1 845 092	41 754	31 347	34 731 136	149 392 087
6	2 873	804 434	61 481 772	-	2 911 286	23 558 436	1 308 802	-	32 050	51 841 328	141 938 108
7	2 872	836 356	75 335 920	-	3 658 261	23 430 748	1 570 562	17 557	42 137	55 544 280	160 435 822
8	2 872	970 429	35 241 888	-	1 404 568	23 430 748	670 362	3 020	44 499	54 841 996	116 607 510
9	2 873	1 321 571	79 166 560	-	3 345 426	23 494 592	1 583 331	-	56 630	54 458 932	163 427 041
10	2 896	2 885 749	10 023 508	20 493 924	153 864	24 133 032	670 362	-	75 336	37 795 648	96 231 423
11	2 876	1 053 426	56 565 784	-	2 464 378	23 877 656	1 072 579	-	45 968	40 732 472	125 812 263
12	2 867	605 241	34 348 072	-	1 621 638	23 366 904	702 284	-	29 432	55 608 124	116 281 695
13	2 870	887 432	14 109 524	-	198 555	23 494 592	173 656	-	29 560	52 032 860	90 926 178
14	2 873	695 900	26 750 636	-	1 257 727	23 558 436	536 928	-	35 880	50 564 448	103 399 955
15	2 867	932 122	41 243 224	-	1 794 016	23 494 592	823 588	-	41 371	52 032 860	120 361 773
16	2 873	619 287	50 436 760	-	2 560 144	23 430 748	1 098 117	-	38 306	55 288 904	133 472 266
17	2 868	1 998 317	30 836 652	1 238 574	259 845	23 622 280	526 713	-	62 567	46 159 212	104 704 160
18	2 872	1 142 808	22 856 152	-	473 084	23 558 436	297 513	-	45 521	50 309 072	98 682 585
19	2 872	772 512	13 662 616	-	261 760	23 558 436	184 509	-	27 134	49 542 944	88 009 912
20	2 874	1 506 718	52 671 300	-	1 774 863	23 558 436	919 354	-	54 395	51 202 888	131 687 954
21	2 869	2 502 685	30 517 432	5 841 726	274 529	23 430 748	589 280	-	64 482	55 735 812	118 956 695
22	2 877	2 975 130	19 344 732	15 641 780	236 861	23 430 748	715 053	-	68 952	57 651 132	120 064 388
23	2 870	1 168 345	21 898 492	-	413 071	23 494 592	339 012	-	42 712	52 288 236	99 644 459
24	2 870	1 372 646	21 451 584	360 080	227 285	23 430 748	308 367	7 087	49 990	55 608 124	102 815 910
25	2 871	1 002 351	31 538 936	-	1 117 270	23 366 904	579 065	-	47 117	57 970 352	115 621 995

Table 8 Quantities of the parameters included in Trimble Quantm for each alignment.

Summary of quantities for corridor two, 80 km/h									
Alignment name	Fill [m3]	Cut [m3]	Borrow [m3]	Dump [m3]	Paving [m3]	Mass Haul [m3 km]	Wall [m2]	Culvert [m]	Bridge [m]
1	176 000	62 300	123 000	11 100	14 100	109 000	-	45	112
2	127 000	274 000	-	157 000	13 800	267 000	24	43	186
3	100 000	230 000	-	137 000	14 000	212 000	19	47	152
4	122 000	238 000	-	124 000	14 100	204 000	-	44	133
5	28 700	495 000	-	490 000	14 200	601 000	34	29	117
6	80 500	367 000	-	304 000	13 900	427 000	-	30	174
7	83 200	443 000	-	382 000	13 800	513 000	14	41	186
8	96 700	236 000	-	146 000	13 800	219 000	2	43	184
9	132 000	457 000	-	349 000	13 800	516 000	-	56	183
10	288 000	78 400	225 000	16 100	14 200	220 000	-	75	127
11	105 000	348 000	-	258 000	14 100	350 000	-	45	137
12	60 400	222 000	-	170 000	13 800	229 000	-	27	187
13	88 700	108 000	-	20 700	13 800	56 600	-	28	175
14	69 100	198 000	-	132 000	13 900	175 000	-	34	170
15	92 800	271 000	-	187 000	13 800	269 000	-	40	175
16	61 800	316 000	-	267 000	13 800	359 000	-	37	186
17	199 000	207 000	13 600	27 100	13 900	172 000	-	62	155
18	114 000	159 000	-	49 400	13 900	97 100	-	44	169
19	77 200	103 000	-	27 300	13 900	60 300	-	25	166
20	150 000	322 000	-	185 000	13 900	301 000	-	53	172
21	250 000	209 000	64 000	28 700	13 800	192 000	-	64	187
22	297 000	148 000	171 000	24 800	13 800	233 000	-	69	194
23	117 000	156 000	-	43 100	13 800	111 000	-	41	176
24	137 000	154 000	3 950	23 700	13 800	101 000	6	49	187
25	99 900	210 000	-	116 000	13 700	189 000	-	46	195

7.1.1.2 100 km/h

The results for speed limit 100 km/h within corridor two are presented below. Some variations in horizontal alignment can be found, but these are generally small, see Figure 25. All, but one, alignments pass on the west side of the corridor. The general alignment position passes close to Äs and intrudes the border of the cultural area Julita Kvarn. Crossing of Lake Aspen and the valuable trees are avoided, and the shoreline protection zone is not impaired.

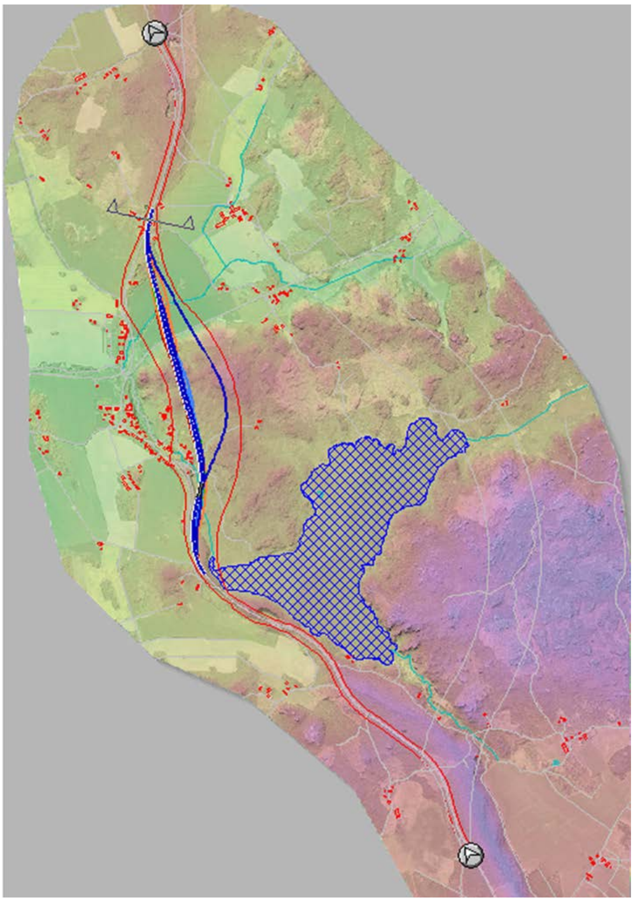

Figure 25 The result provided from Trimble Quantm for corridor two with a speed limit of 100 km/h.

The cost data and quantities of masses and constructions are presented in Table 9 respectively Table 10 below. The data was given by the software Trimble Quantm. The length of the new construction part of the road varies between 2 870 and 3 009 meters. If this is added to the length of the road that will be reconstructed, the total length varies between 7 370 and 7 509 meters. Alignment 11 is the shortest one and alignment 25 the longest. Only seven alignments need to import (borrow) masses which indicate that there generally are a surplus of masses. The construction cost, given by Trimble Quantm, varies between 43,305 and 117,520 mSEK. These costs correspond to alignment 25 and 15. The average construction cost for all 25 alignments is 116,725 mSEK.

Table 9 The different construction costs given by Trimble Quantm for each alignment.

Summary of costs for corridor two, 100 km/h											
Alignment name	Length [m]	Fill [SEK]	Cut [SEK]	Borrow [SEK]	Dump [SEK]	Paving [SEK]	Mass Haul [SEK]	Wall [SEK]	Culvert [SEK]	Bridge [SEK]	Construction Cost [SEK]
1	2 885	650 760	47 531 000	-	2 430 780	24 116 400	918 720	-	34 388	34 005 400	75 682 048
2	2 888	2 386 120	8 676 800	16 970 800	116 754	23 606 000	484 242	-	63 800	52 060 800	52 304 516
3	2 882	4 121 480	6 188 600	34 133 000	49 892	23 669 800	835 780	-	79 750	49 764 000	69 078 302
4	2 881	1 658 800	23 669 800	2 328 700	262 856	23 861 200	299 222	4 153	55 570	41 852 800	52 140 301
5	2 888	1 103 740	19 331 400	-	399 388	23 542 200	291 566	49 828	28 327	54 549 000	44 746 449
6	2 882	1 205 820	36 493 600	-	1 135 640	23 733 600	669 900	-	34 771	46 255 000	63 273 331
7	2 886	617 584	55 633 600	-	3 004 980	24 244 000	1 212 200	-	29 539	28 901 400	84 741 903
8	2 884	982 520	24 563 000	-	886 820	23 861 200	389 180	-	40 513	44 213 400	50 723 233
9	2 887	1 059 080	17 991 600	-	399 388	23 542 200	284 548	-	29 093	53 911 000	43 305 909
10	2 884	669 900	47 531 000	-	2 449 920	23 669 800	982 520	-	43 193	51 805 600	75 346 333
11	2 870	3 138 960	22 776 600	15 694 800	242 440	23 287 000	695 420	28 965	74 008	60 737 600	65 938 193
12	2 876	386 628	69 542 000	-	3 955 600	23 542 200	1 524 820	-	39 173	52 060 800	98 990 421
13	2 882	2 966 700	50 721 000	720 940	279 444	23 669 800	676 280	-	76 560	50 465 800	79 110 724
14	2 885	1 154 780	20 033 200	-	530 816	23 733 600	270 512	-	39 620	49 062 200	45 762 528
15	2 888	266 684	86 768 000	-	4 976 400	23 542 200	1 933 140	-	34 324	55 569 800	117 520 748
16	2 874	1 741 740	16 460 400	6 022 720	228 404	23 542 200	370 678	-	57 994	51 614 200	48 424 136
17	2 879	1 078 220	32 219 000	-	1 193 060	23 669 800	528 264	-	58 951	48 615 600	58 747 295
18	2 887	950 620	47 084 400	-	2 111 780	23 606 000	937 860	7 465	45 745	54 676 600	74 743 869
19	2 884	733 700	65 714 000	-	3 445 200	23 797 400	1 346 180	-	51 933	44 596 200	95 088 413
20	2 884	597 168	27 561 600	-	1 441 880	23 797 400	525 074	-	37 833	44 979 000	53 960 955
21	2 885	569 096	40 130 200	-	2 054 360	23 733 600	874 060	-	31 134	48 488 000	67 392 450
22	2 885	570 372	62 396 400	-	3 209 140	23 606 000	1 390 840	-	33 878	53 592 000	91 206 630
23	2 886	2 717 880	42 809 800	1 646 040	355 366	23 797 400	657 140	-	77 836	45 680 800	72 061 462
24	2 888	571 648	49 445 000	-	2 641 320	23 733 600	1 059 080	19 523	41 917	49 445 000	77 512 087
25	3 009	861 300	17 417 400	-	451 066	24 626 800	287 738	-	30 752	49 827 800	43 675 056

Table 10 Quantities of the parameters included in Trimble Quantm for each alignment.

Summary of quantities for corridor two, 100 km/h									
Alignment name	Fill [m3]	Cut [m3]	Borrow [m3]	Dump [m3]	Paving [m3]	Mass Haul [m3 km]	Wall [m2]	Culvert [m]	Bridge [m]
1	65 200	309 000	-	254 000	14 200	301 000	-	33	114
2	238 000	63 200	186 000	12 200	13 900	158 000	-	65	175
3	411 000	41 200	374 000	5 210	14 000	272 000	-	80	167
4	166 000	164 000	25 500	27 500	14 100	97 700	3	55	141
5	110 000	151 000	-	41 700	13 900	95 100	40	26	183
6	120 000	230 000	-	118 000	14 000	219 000	-	33	156
7	61 700	363 000	-	314 000	14 300	396 000	-	28	97
8	97 900	188 000	-	92 400	14 000	127 000	-	39	149
9	105 000	147 000	-	41 700	13 900	92 900	-	27	181
10	66 700	313 000	-	256 000	13 900	320 000	-	42	174
11	313 000	163 000	172 000	25 300	13 700	227 000	23	74	204
12	38 600	434 000	-	413 000	13 900	498 000	-	38	175
13	296 000	303 000	7 870	29 200	13 900	220 000	-	77	169
14	115 000	171 000	-	55 500	14 000	88 300	-	38	165
15	26 600	523 000	-	520 000	13 900	631 000	-	33	187
16	174 000	130 000	66 000	23 800	13 900	121 000	-	57	173
17	108 000	227 000	-	125 000	14 000	173 000	-	58	163
18	94 600	305 000	-	221 000	13 900	306 000	6	44	184
19	73 200	417 000	-	360 000	14 000	440 000	-	51	150
20	59 600	208 000	-	151 000	14 000	172 000	-	36	151
21	56 800	263 000	-	215 000	14 000	285 000	-	29	163
22	56 900	375 000	-	335 000	13 900	455 000	-	32	180
23	271 000	281 000	18 000	37 100	14 000	215 000	-	78	154
24	57 000	322 000	-	276 000	14 000	346 000	16	40	166
25	86 100	131 000	-	47 100	14 500	93 900	-	29	167

7.1.1.3 110 km/h

The results for speed limit 110 km/h within corridor two are presented below. Even though most of the alignments pass on the corridor's west side, a distinct variation in the horizontal alignments' position is visible, see Figure 26. The alignments leave the shoreline unimpaired. The valuable trees are also avoided. The alignments intrude the border of the cultural area Julita Kvarn and several alignments pass close to Äs.

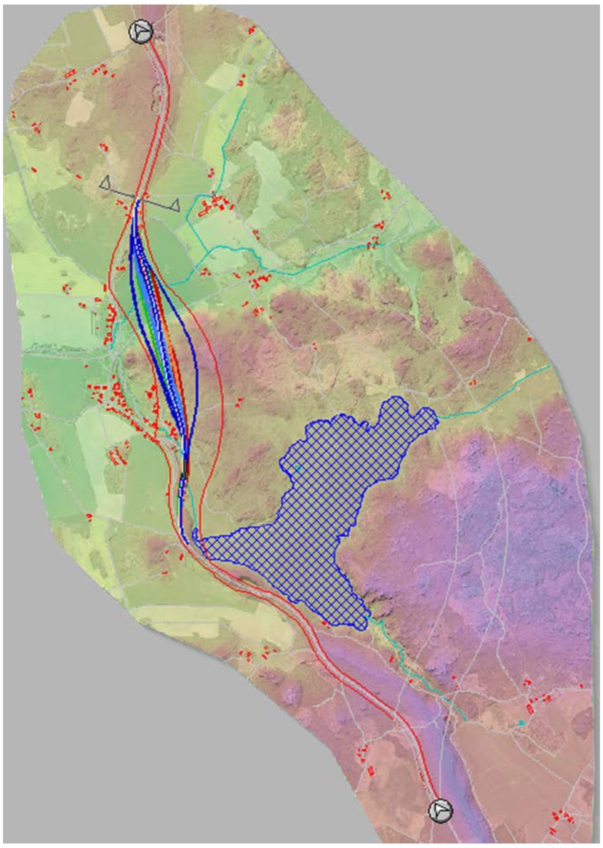

Figure 26 The result provided from Trimble Quantm for corridor two with a speed limit of 110 km/h

The data regarding costs and masses, received from Trimble Quantm, for all alignments within corridor two with speed limit 110 km/h, is presented in Table 11 and 12 below. The length of the new road construction varies between 2 867 meters for alignment 17, and 2 940 meters for alignment 24. This results in a total length between 7 367 and 7 440 meters for all the alignments. There is generally a surplus of masses and only four alignments need to import (borrow) masses. The construction cost given by Trimble Quantm varies between 87,577 mSEK for alignment 24 and 168,264 mSEK for alignment 25. The average construction cost for all 25 alignments is 127,466 mSEK.

Table 11 The different construction costs given by Trimble Quantm for each alignment.

Summary of costs for corridor two, 110 km/h											
Alignment name	Length [m]	Fill [SEK]	Cut [SEK]	Borrow [SEK]	Dump [SEK]	Paving [SEK]	Mass Haul [SEK]	Wall [SEK]	Culvert [SEK]	Bridge [SEK]	Construction Cost [SEK]
1	2 868	1 181 114	40 285 564	-	1 398 184	23 366 904	721 437	5 867	53 054	41 690 132	108 702 256
2	2 874	1 481 181	51 011 356	-	1 666 328	23 303 060	970 429	-	45 202	45 201 552	123 679 108
3	2 882	409 878	50 053 696	-	2 777 214	23 366 904	1 085 348	-	39 966	46 733 808	124 466 815
4	2 872	900 200	34 731 136	-	1 404 568	22 728 464	651 209	5 101	48 585	69 589 960	130 059 224
5	2 880	734 206	40 349 408	-	1 889 782	23 175 372	817 203	-	44 882	53 309 740	120 320 594
6	2 871	1 513 103	30 645 120	-	605 880	22 792 308	430 947	3 071	53 246	66 397 760	122 441 434
7	2 872	1 174 730	35 944 172	-	1 142 808	23 239 216	644 824	-	44 818	48 010 688	110 201 256
8	2 877	759 744	37 476 428	-	1 698 250	22 919 996	746 975	-	46 415	61 545 616	125 193 423
9	2 879	785 281	37 859 492	-	1 723 788	22 919 996	772 512	-	44 946	62 439 432	126 545 448
10	2 880	715 053	46 159 212	-	2 196 234	22 792 308	951 276	-	42 201	68 951 520	141 807 803
11	2 868	861 894	50 564 448	-	2 323 922	23 047 684	1 027 888	-	38 179	53 948 180	131 812 195
12	2 875	1 142 808	38 370 244	-	1 353 493	22 983 840	651 209	-	59 950	59 438 764	124 000 307
13	2 880	152 587	49 287 568	-	3 185 816	22 856 152	1 110 886	-	31 220	65 759 320	142 383 548
14	2 893	1 883 398	14 364 900	9 129 692	209 408	22 919 996	363 911	-	67 675	67 036 200	115 975 180
15	2 877	1 596 100	34 284 228	-	651 209	22 856 152	483 299	-	62 631	65 759 320	125 692 939
16	2 893	1 832 323	6 895 152	12 577 268	127 050	22 792 308	400 940	-	63 716	74 059 040	118 747 797
17	2 867	2 285 615	38 434 088	549 697	252 822	22 600 776	467 977	-	68 313	70 866 840	135 526 128
18	2 873	657 593	35 561 108	-	1 615 253	22 664 620	753 359	18 196	29 368	72 782 160	134 081 657
19	2 877	1 334 340	42 775 480	-	1 340 724	23 239 216	810 819	2 209	38 498	48 521 440	118 062 725
20	2 869	1 123 654	20 685 456	-	338 373	22 983 840	280 275	-	46 351	57 842 664	103 300 614
21	2 870	555 443	48 329 908	-	2 540 991	22 536 932	1 015 120	38 945	36 200	75 974 360	151 027 898
22	2 873	1 117 270	43 158 544	-	1 685 482	22 919 996	785 281	-	49 607	62 056 368	131 772 548
23	2 876	2 336 690	94 489 120	-	3 166 662	23 430 748	1 679 097	-	68 313	39 838 656	165 009 287
24	2 940	1 717 404	12 960 332	8 172 032	188 978	24 005 344	320 497	-	54 970	40 157 876	87 577 432
25	2 868	683 131	90 658 480	-	4 564 846	23 239 216	1 979 164	-	23 175	47 116 872	168 264 884

Table 12 Quantities of the parameters included in Trimble Quantm for each alignment.

Summary of quantities for corridor two, 110 km/h									
Alignment name	Fill [m3]	Cut [m3]	Borrow [m3]	Dump [m3]	Paving [m3]	Mass Haul [m3 km]	Wall [m2]	Culvert [m]	Bridge [m]
1	118 000	254 000	-	146 000	13 700	235 000	5	52	119
2	148 000	307 000	-	174 000	13 700	316 000	-	44	129
3	40 900	319 000	-	290 000	13 700	353 000	-	38	133
4	89 500	229 000	-	147 000	13 400	213 000	4	47	198
5	73 000	261 000	-	197 000	13 600	266 000	-	44	152
6	151 000	209 000	-	63 200	13 400	141 000	2	52	190
7	117 000	228 000	-	119 000	13 700	211 000	-	43	137
8	76 000	245 000	-	177 000	13 500	245 000	-	45	176
9	78 300	250 000	-	180 000	13 500	252 000	-	44	178
10	71 500	289 000	-	229 000	13 400	310 000	-	41	197
11	86 000	316 000	-	242 000	13 600	336 000	-	37	154
12	114 000	247 000	-	142 000	13 500	212 000	-	59	170
13	15 200	340 000	-	333 000	13 500	363 000	-	29	187
14	188 000	108 000	100 000	21 900	13 500	119 000	-	67	192
15	159 000	219 000	-	68 000	13 400	158 000	-	62	188
16	182 000	58 000	138 000	13 300	13 400	131 000	-	63	211
17	228 000	238 000	6 020	26 400	13 300	153 000	-	68	202
18	65 400	225 000	-	168 000	13 300	246 000	15	27	207
19	133 000	261 000	-	140 000	13 700	265 000	2	37	139
20	112 000	144 000	-	35 400	13 500	91 500	-	45	165
21	55 400	310 000	-	266 000	13 300	332 000	31	34	217
22	111 000	278 000	-	176 000	13 500	255 000	-	48	177
23	233 000	534 000	-	331 000	13 800	549 000	-	68	114
24	172 000	101 000	89 300	19 800	14 100	105 000	-	54	115
25	68 000	516 000	-	477 000	13 700	646 000	-	21	135

7.1.2 Result for corridor alternative four

Below, the results of 75 suggested alignments within corridor four are presented. For each speed limit, a visualization of the area shows the localization of the alignments, see Figure 27 to 29. Their respective lengths, quantities and construction costs are presented in Table 13 to 18.

7.1.2.1 80 km/h

The results for speed limit 80 km/h within corridor four are presented below. As Figure 27 shows, all 25 alignments are located at a horizontally similar position. The alignments pass close to the east border of the corridor in the southernmost respectively northernmost part. In the middle of the stretch, the alignments tangent the western border of the corridor, and is passing approximately 30 meters from the shoreline of Lake Aspen. The national interest Hälleforsgången and one of the southern swamp forests is crossed by all alignments. At Segerhult the alignments are stretching along the eastern side of the corridor, leaving some space to the farm on the west side.

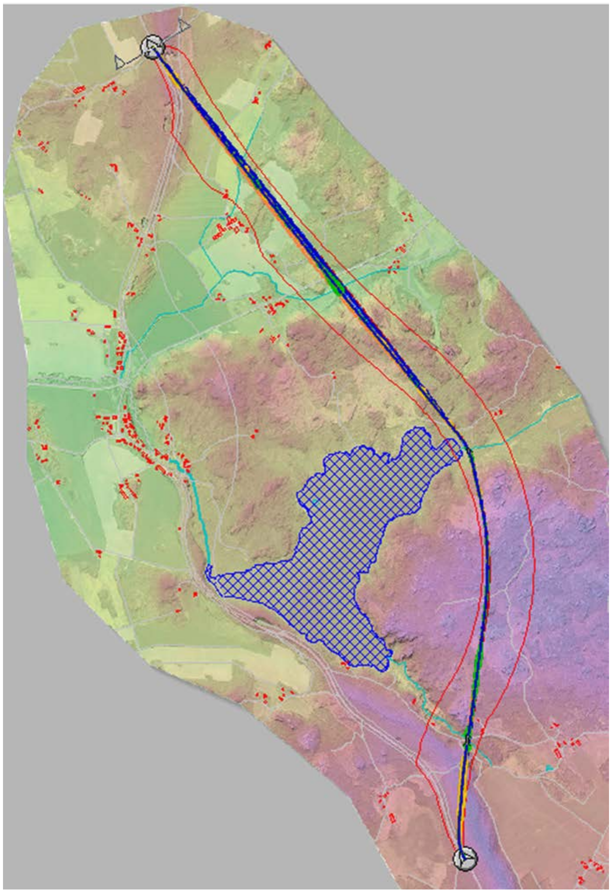

Figure 27 The result provided from Trimble Quantm for corridor four with a speed limit of 80 km/h

The road lengths, costs and quantities for the road constructions are presented in Table 13 and Table 14. The data is provided by Trimble Quantm. The length of the alignments varies between 7 194 and 7 202 meters. Alignment number 20 is the shortest one and alignments number 16 and 25 are the longest. There are some variations of the mass management, where only a few alignments have a mass deficit and need to import construction masses. The construction cost varies between 114,678 and 183,480 mSEK, which correspond to alignment number 18 and 25. The average construction cost is 140,982 mSEK.

Table 13 The different construction costs given by Trimble Quantm for each alignment.

Summary of costs for corridor four, 80 km/h											
Alignment name	Length [m]	Fill [SEK]	Cut [SEK]	Borrow [SEK]	Dump [SEK]	Paving [SEK]	Mass Haul [SEK]	Wall [SEK]	Culvert [SEK]	Bridge [SEK]	Construction Cost [SEK]
1	7 197	3 677 414	77 251 240	-	1 506 718	61 162 552	3 160 278	-	183 871	18 897 824	165 839 898
2	7 198	2 924 055	54 905 840	-	1 238 574	61 034 864	1 551 409	-	176 848	24 069 188	145 900 778
3	7 196	2 483 532	45 137 708	-	1 155 576	61 034 864	1 251 342	-	179 402	23 686 124	134 928 548
4	7 196	1 251 342	71 505 280	-	4 105 169	61 354 084	2 432 456	-	123 219	13 407 240	154 178 791
5	7 197	2 234 540	39 008 684	-	1 130 039	61 098 708	1 570 562	-	168 548	22 409 244	127 620 325
6	7 200	2 623 988	45 137 708	670 362	734 206	61 162 552	1 723 788	-	135 349	20 876 988	133 064 942
7	7 196	2 911 286	56 246 564	-	1 468 412	60 971 020	1 513 103	-	134 711	26 814 480	150 059 576
8	7 196	2 113 236	36 901 832	-	759 744	61 034 864	1 206 652	-	125 773	24 963 004	127 105 104
9	7 198	1 960 011	28 474 424	2 732 523	1 021 504	61 162 552	1 155 576	-	122 580	19 344 732	115 973 903
10	7 197	2 196 234	69 589 960	-	3 224 122	61 098 708	1 640 791	-	141 095	22 536 932	160 427 842
11	7 197	2 138 774	43 860 828	-	1 436 490	61 162 552	919 354	-	126 411	20 302 392	129 946 801
12	7 198	2 304 768	52 160 548	-	1 659 944	61 162 552	1 168 345	-	90 658	19 536 264	138 083 080
13	7 196	2 100 468	35 178 044	317 943	1 225 805	61 034 864	1 130 039	-	128 965	24 963 004	126 079 131
14	7 195	2 368 612	41 243 224	271 975	1 027 888	61 162 552	1 366 262	-	148 757	18 004 008	125 593 278
15	7 199	1 359 877	75 335 920	-	4 137 091	61 226 396	1 902 551	-	117 473	18 195 540	162 274 849
16	7 202	1 640 791	92 573 800	-	5 535 275	61 290 240	1 921 704	-	162 802	15 131 028	178 255 640
17	7 197	2 579 298	45 967 680	-	1 008 735	61 034 864	1 519 487	-	156 418	25 026 848	137 293 330
18	7 197	1 794 016	29 112 864	791 666	919 354	61 162 552	912 969	-	129 603	19 855 484	114 678 508
19	7 198	2 457 994	41 881 664	-	925 738	61 162 552	1 206 652	-	115 558	17 812 476	125 562 633
20	7 194	2 489 916	46 414 588	-	1 015 120	61 098 708	1 462 028	-	150 033	21 515 428	134 145 821
21	7 199	1 991 933	37 093 364	-	964 044	60 971 020	1 015 120	-	123 857	26 686 792	128 846 130
22	7 199	2 126 005	42 839 324	-	1 653 560	60 907 176	1 474 796	-	132 157	29 112 864	138 245 882
23	7 197	1 340 724	84 912 520	-	5 120 289	61 290 240	1 730 172	-	127 050	15 769 468	170 290 463
24	7 196	2 081 314	33 581 944	989 582	855 510	61 226 396	1 417 337	-	121 942	16 407 908	116 681 933
25	7 202	3 102 818	86 189 400	-	3 594 417	61 034 864	2 381 381	-	171 740	27 006 012	183 480 633

Table 14 Quantities of the parameters included in Trimble Quantm for each alignment.

Summary of quantities for corridor four, 80 km/h									
Alignment name	Fill [m3]	Cut [m3]	Borrow [m3]	Dump [m3]	Paving [m3]	Mass Haul [m3 km]	Wall [m2]	Culvert [m]	Bridge [m]
1	366 000	510 000	-	158 000	36 000	1 030 000	-	182	63
2	291 000	417 000	-	129 000	36 000	507 000	-	175	81
3	247 000	368 000	-	121 000	36 000	407 000	-	177	80
4	124 000	548 000	-	428 000	36 100	794 000	-	119	45
5	222 000	344 000	-	118 000	36 000	513 000	-	166	75
6	262 000	326 000	7 320	76 900	36 000	562 000	-	132	70
7	290 000	441 000	-	153 000	35 900	494 000	-	131	90
8	210 000	288 000	-	79 000	35 900	393 000	-	121	84
9	195 000	279 000	29 900	107 000	36 000	377 000	-	118	65
10	219 000	554 000	-	336 000	36 000	536 000	-	137	76
11	213 000	364 000	-	150 000	36 000	301 000	-	122	68
12	229 000	400 000	-	173 000	36 000	380 000	-	85	65
13	209 000	341 000	3 480	128 000	35 900	369 000	-	125	84
14	236 000	342 000	2 980	108 000	36 000	445 000	-	145	60
15	135 000	560 000	-	432 000	36 000	622 000	-	113	61
16	163 000	740 000	-	578 000	36 100	627 000	-	160	51
17	257 000	361 000	-	106 000	35 900	496 000	-	153	84
18	179 000	271 000	8 660	96 000	36 000	298 000	-	125	67
19	245 000	342 000	-	96 800	36 000	395 000	-	110	60
20	248 000	351 000	-	106 000	36 000	476 000	-	147	72
21	198 000	299 000	-	101 000	35 900	331 000	-	119	90
22	212 000	390 000	-	172 000	35 900	481 000	-	128	98
23	134 000	664 000	-	534 000	36 100	564 000	-	122	53
24	207 000	288 000	10 900	89 300	36 100	463 000	-	118	55
25	309 000	682 000	-	375 000	35 900	778 000	-	170	91

7.1.2.2 100 km/h

The results for speed limit 100 km/h within corridor four are presented below. As Figure 28 shows, the resulting alignments have a similar position. The alignments start at the eastern border of the corridor and proceeds towards the western side as it approaches the lake. At the end of the corridor, the alignments pass close to the eastern border of the corridor again. Hälleforsgången is intersected by all alignments and one of the southern swamp forests is crossed. The alignments pass Lake Aspen approximately 30 meter from the shoreline and Segerhultsgården is avoided since the alignments are positioned on the eastern part of the corridor at this site. The belonging land is however crossed.

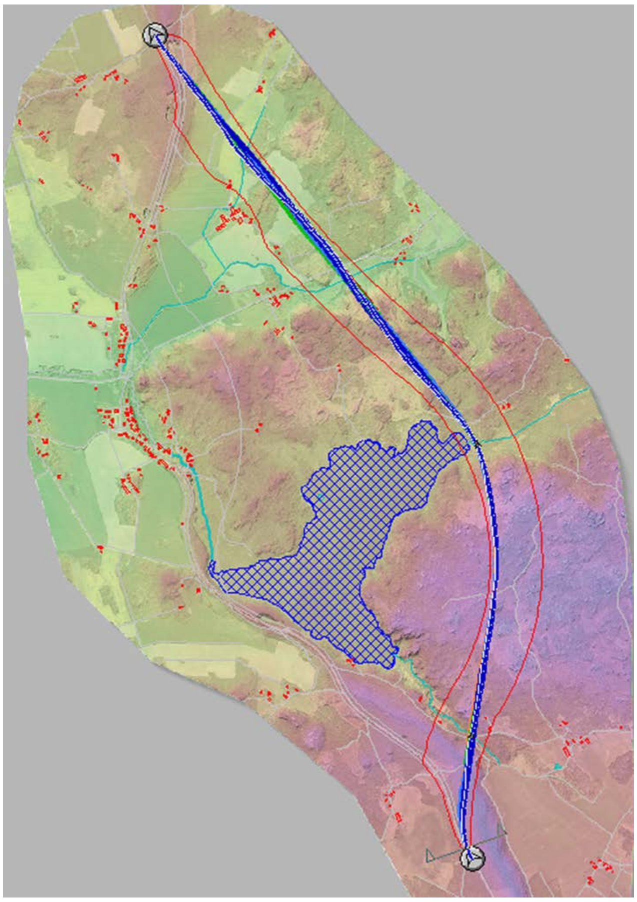

Figure 28 The result provided from Trimble Quantm for corridor four with a speed limit of 100 km/h

Table 15 and Table 16 present the road lengths, costs and quantities for the road constructions. The data was obtained from Trimble Quantm. The length of the alignments varies between 7 210 and 7 231 meters, which correspond to alignment number 2 and 24. Most of the alignments show a surplus of reusable masses and only nine alignments need to import construction masses. The construction cost varies from 135,454 mSEK to 298,231 mSEK, corresponding to alignment number 18 and 11. The average construction cost is 176,452 mSEK.

Table 15 The different construction costs given by Trimble Quantm for each alignment.

Summary of costs for corridor four, 100 km/h											
Alignment name	Length [m]	Fill [SEK]	Cut [SEK]	Borrow [SEK]	Dump [SEK]	Paving [SEK]	Mass Haul [SEK]	Wall [SEK]	Culvert [SEK]	Bridge [SEK]	Construction Cost [SEK]
1	7 215	4 507 386	79 805 000	414 348	817 203	61 354 084	5 081 982	-	188 978	19 791 640	171 960 622
2	7 210	2 764 445	57 459 600	-	1 653 560	61 162 552	1 570 562	-	139 818	24 196 876	148 947 414
3	7 219	4 826 606	26 686 792	29 623 616	609 710	61 162 552	1 698 250	-	184 509	27 133 700	151 925 736
4	7 217	2 017 470	40 732 472	-	1 525 872	61 034 864	1 136 423	-	104 704	31 666 624	138 218 429
5	7 213	2 509 069	40 285 564	670 362	1 027 888	61 034 864	1 379 030	56 374	144 926	28 346 736	135 454 814
6	7 216	3 192 200	43 860 828	6 026 874	893 816	61 034 864	1 276 880	-	148 118	29 432 084	145 865 664
7	7 217	3 485 882	40 477 096	10 087 352	919 354	61 098 708	1 685 482	-	165 994	28 091 360	146 011 228
8	7 222	3 862 562	76 612 800	-	1 327 955	61 162 552	3 000 668	-	169 187	27 452 920	173 588 644
9	7 217	3 817 871	82 997 200	-	2 177 080	61 034 864	2 936 824	-	174 933	29 176 708	182 315 480
10	7 214	2 502 685	105 342 600	-	4 647 843	61 034 864	4 264 779	-	157 695	28 793 644	206 744 110
11	7 225	2 368 612	194 724 200	-	9 768 132	61 290 240	6 639 776	248 992	144 287	23 047 684	298 231 923
12	7 212	3 230 506	91 296 920	-	3 019 821	61 162 552	2 924 055	-	194 724	25 218 380	187 046 959
13	7 219	2 917 671	38 689 464	5 848 110	906 585	61 034 864	1 238 574	-	127 050	30 964 340	141 726 657
14	7 211	3 709 336	91 935 360	-	2 451 610	61 417 928	4 252 010	-	185 786	16 280 220	180 232 250
15	7 211	2 547 376	49 542 944	-	1 570 562	60 843 332	1 410 952	97 043	143 649	34 922 668	151 078 526
16	7 208	2 362 228	111 088 560	-	5 235 208	61 226 396	3 396 501	-	106 619	22 409 244	205 824 756
17	7 214	6 831 308	118 749 840	1 296 033	1 072 579	61 290 240	8 172 032	-	234 307	20 685 456	218 331 796
18	7 217	3 824 256	100 873 520	-	3 083 665	61 354 084	3 447 576	361 357	210 685	17 812 476	190 967 619
19	7 213	3 932 790	30 708 964	19 408 576	925 738	60 971 020	1 800 401	-	148 757	31 411 248	149 307 494
20	7 212	2 445 225	100 873 520	-	4 456 311	61 290 240	3 364 579	-	153 226	19 280 888	191 863 989
21	7 214	4 998 985	90 020 040	-	1 098 117	61 481 772	5 228 824	-	205 578	12 130 360	175 163 675
22	7 216	3 626 339	49 159 880	6 958 996	1 053 426	61 354 084	2 113 236	-	146 841	19 408 576	143 821 379
23	7 212	2 030 239	102 788 840	-	5 037 292	61 481 772	2 687 832	-	121 942	13 917 992	188 065 909
24	7 231	1 206 652	134 072 400	-	7 788 968	61 354 084	5 592 734	-	89 382	22 409 244	232 513 464
25	7 226	3 505 036	137 903 040	-	5 516 122	61 098 708	5 152 211	-	130 242	33 581 944	246 887 302

Table 16 Quantities of the parameters included in Trimble Quantm for each alignment.

Summary of quantities for corridor four, 100 km/h								
Alignment name	Fill [m3]	Cut [m3]	Borrow [m3]	Dump [m3]	Paving [m3]	Mass Haul [m3 km]	Wall [m2]	Culvert [m]	Bridge [m]
1	449 000	513 000	4 540	85 200	36 100	1 660 000	-	188	67
2	276 000	446 000	-	173 000	36 000	512 000	-	136	81
3	481 000	221 000	324 000	63 700	36 000	554 000	-	182	91
4	201 000	365 000	-	159 000	35 900	372 000	-	99	106
5	250 000	353 000	7 370	107 000	36 000	449 000	45	142	95
6	319 000	345 000	66 000	93 300	36 000	417 000	-	145	99
7	348 000	334 000	111 000	96 300	36 000	549 000	-	163	94
8	385 000	510 000	-	139 000	36 000	980 000	-	167	92
9	380 000	597 000	-	228 000	36 000	958 000	-	173	98
10	250 000	717 000	-	486 000	35 900	1 390 000	-	155	97
11	236 000	1 210 000	-	1 020 000	36 100	2 170 000	200	141	77
12	322 000	623 000	-	315 000	36 000	954 000	-	193	85
13	291 000	323 000	64 100	94 700	35 900	404 000	-	123	104
14	370 000	608 000	-	256 000	36 100	1 390 000	-	184	55
15	254 000	420 000	-	164 000	35 800	460 000	78	140	117
16	236 000	764 000	-	546 000	36 000	1 110 000	-	101	75
17	683 000	754 000	14 200	112 000	36 100	2 660 000	-	234	70
18	381 000	686 000	-	322 000	36 100	1 120 000	290	210	60
19	392 000	281 000	212 000	96 800	35 900	587 000	-	145	106
20	244 000	692 000	-	465 000	36 100	1 100 000	-	150	65
21	499 000	596 000	-	114 000	36 200	1 710 000	-	205	41
22	362 000	395 000	76 500	110 000	36 100	690 000	-	143	65
23	202 000	712 000	-	526 000	36 200	878 000	-	118	47
24	120 000	913 000	-	816 000	36 100	1 820 000	-	84	75
25	350 000	897 000	-	576 000	36 000	1 680 000	-	126	113

7.1.2.3 110 km/h

The results for speed limit 110 km/h within corridor four is presented below. The resulting alignments have a similar position, see Figure 29. A horizontal variation is however noticeable in the south respectively north part of the stretch. The part of the alignments passing the eastern shore of Lake Aspen varies less. The alignments start at the eastern border of the corridor and passes Lake Aspen on the west side of the corridor, approximately 30 meters from the shoreline. The alignments are proceeding toward the eastern border at the end of the stretch. Hälleforsgången is intersected by all alignments and one of the southern swamp forests is crossed. Segerhultsgården is avoided since the alignments are positioned further east. The belonging area of Segerhultsgården is however crossed.

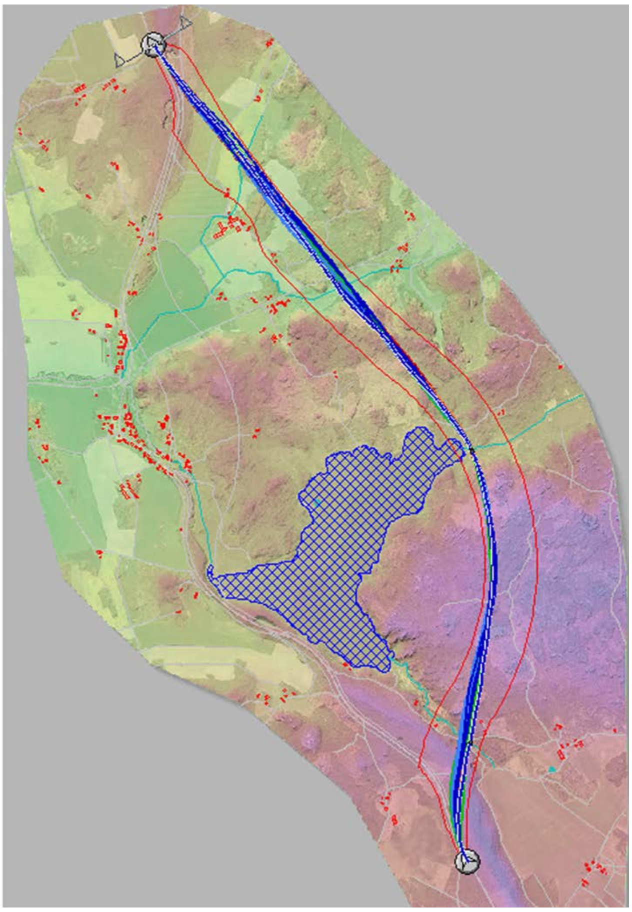

Figure 29 The result provided from Trimble Quantm for corridor four with a speed limit of 110 km/h

The road lengths, costs and quantities for the road constructions are presented in Table 17 and Table 18. The data is given from Trimble Quantm. The length of the alignments varies between 7 219 and 7 247 meters. Alignment number 13 has the shortest length and alignments number 21 and 24 have the longest. Most alignments show a surplus of reusable masses, only seven alignments need to import construction masses. Alignment number 19 has the lowest construction cost which is 162,714 mSEK and alignment number 13 has the highest which is 415,416 mSEK. The average construction cost is 259,208 mSEK.

Table 17 The different construction costs given by Trimble Quantm for each alignment.

Summary of costs for corridor four, 110 km/h											
Alignment name	Length [m]	Fill [SEK]	Cut [SEK]	Borrow [SEK]	Dump [SEK]	Paving [SEK]	Mass Haul [SEK]	Wall [SEK]	Culvert [SEK]	Bridge [SEK]	Construction Cost [SEK]
1	7 235	4 252 010	157 056 240	-	5 605 503	59 247 232	5 369 280	-	215 154	23 430 748	255 176 168
2	7 227	1 487 565	314 112 480	-	17 237 880	59 438 764	10 278 884	-	97 681	11 938 828	414 592 083
3	7 236	3 926 406	228 561 520	-	9 831 976	59 247 232	7 597 436	-	181 955	25 218 380	334 564 905
4	7 240	1 704 635	243 245 640	-	13 024 176	59 566 452	7 405 904	-	118 111	14 684 120	339 749 038
5	7 228	4 137 091	105 342 600	-	3 204 969	59 311 076	3 594 417	-	158 333	19 153 200	194 901 686
6	7 232	4 628 690	116 196 080	-	3 173 047	59 311 076	4 092 400	-	247 715	20 557 768	208 206 776
7	7 232	7 086 684	133 433 960	-	1 698 250	59 183 388	7 278 216	-	261 760	26 686 792	235 629 051
8	7 240	1 583 331	265 591 040	-	14 428 744	59 438 764	10 023 508	-	104 704	17 557 100	368 727 191
9	7 236	3 051 743	271 337 000	-	13 024 176	59 502 608	8 108 188	-	188 340	15 258 716	370 470 771
10	7 237	2 528 222	114 919 200	-	5 158 595	59 119 544	2 681 448	-	132 796	30 836 652	215 376 457
11	7 241	6 199 252	144 287 440	-	3 109 203	59 374 920	4 992 601	-	197 278	21 962 336	240 123 030
12	7 227	3 192 200	95 127 560	-	3 536 958	58 864 168	3 766 796	-	143 011	36 582 612	201 213 304
13	7 219	612 264	310 920 280	-	18 195 540	59 374 920	12 449 580	-	74 059	13 790 304	415 416 947
14	7 231	5 528 890	81 081 880	8 682 784	1 053 426	59 119 544	5 177 748	-	242 607	28 538 268	189 425 148
15	7 240	10 406 572	57 523 444	67 036 200	676 746	59 374 920	6 831 308	-	269 422	21 706 960	223 825 572
16	7 228	1 640 791	207 493 000	-	11 491 920	59 055 700	8 299 720	-	101 512	29 815 148	317 897 791
17	7 236	8 044 344	70 866 840	37 157 208	925 738	58 864 168	4 047 710	-	237 500	42 264 728	222 408 235
18	7 234	3 313 504	75 974 360	-	2 215 387	59 119 544	2 547 376	-	167 910	27 899 828	171 237 908
19	7 232	3 862 562	51 841 328	7 788 968	804 434	58 928 012	1 966 395	-	173 656	37 348 740	162 714 095
20	7 220	1 794 016	126 411 120	-	6 448 244	59 055 700	4 149 860	-	122 580	26 814 480	224 796 001
21	7 247	10 534 260	30 134 368	83 635 640	893 816	58 991 856	6 831 308	-	236 223	40 349 408	231 606 879
22	7 244	5 350 127	82 358 760	6 512 088	1 181 114	58 864 168	2 579 298	-	121 304	44 180 048	201 146 906
23	7 236	5 171 364	55 288 904	18 259 384	919 354	58 800 324	2 119 621	-	178 125	44 243 892	184 980 967
24	7 247	4 801 069	254 099 120	-	10 534 260	59 694 140	7 725 124	-	141 095	10 215 040	347 209 848
25	7 230	6 384 400	120 665 160	-	1 551 409	59 502 608	7 214 372	-	229 838	13 279 552	208 827 340

Table 18 Quantities of the parameters included in Trimble Quantm for each alignment.

Summary of quantities for corridor four, 110 km/h									
Alignment name	Fill [m3]	Cut [m3]	Borrow [m3]	Dump [m3]	Paving [m3]	Mass Haul [m3 km]	Wall [m2]	Culvert [m]	Bridge [m]
1	424 000	970 000	-	585 000	34 900	1 750 000	-	215	70
2	149 000	1 860 000	-	1 800 000	35 000	3 360 000	-	92	38
3	392 000	1 350 000	-	1 020 000	34 900	2 490 000	-	180	76
4	170 000	1 460 000	-	1 360 000	35 100	2 410 000	-	113	46
5	413 000	731 000	-	335 000	34 900	1 170 000	-	155	58
6	462 000	771 000	-	332 000	34 900	1 340 000	-	248	60
7	706 000	854 000	-	177 000	34 900	2 380 000	-	263	80
8	158 000	1 590 000	-	1 510 000	35 000	3 270 000	-	99	54
9	304 000	1 590 000	-	1 360 000	35 000	2 640 000	-	187	48
10	252 000	769 000	-	538 000	34 800	875 000	-	128	92
11	618 000	909 000	-	325 000	35 000	1 630 000	-	196	66
12	318 000	674 000	-	369 000	34 700	1 230 000	-	140	107
13	61 000	1 880 000	-	1 900 000	35 000	4 060 000	-	67	42
14	551 000	553 000	94 800	110 000	34 800	1 690 000	-	243	85
15	1 040 000	362 000	731 000	70 600	35 000	2 230 000	-	271	66
16	164 000	1 320 000	-	1 200 000	34 800	2 710 000	-	96	87
17	804 000	482 000	407 000	96 500	34 700	1 320 000	-	238	124
18	330 000	552 000	-	231 000	34 800	831 000	-	166	82
19	385 000	379 000	85 000	84 000	34 700	642 000	-	171	110
20	179 000	827 000	-	674 000	34 800	1 350 000	-	118	79
21	1 050 000	228 000	919 000	93 200	34 700	2 230 000	-	237	121
22	534 000	574 000	71 200	123 000	34 700	841 000	-	117	131
23	516 000	406 000	200 000	95 800	34 600	691 000	-	176	129
24	479 000	1 510 000	-	1 100 000	35 200	2 510 000	-	137	32
25	640 000	776 000	-	162 000	35 000	2 350 000	-	230	40

7.2 Cost-benefit analysis

The CBA includes the construction cost received from Trimble Quantm, fixed costs within a corridor, maintenance costs, road user costs and community costs. The three latter are referred to as benefits and are obtained by a comparison with the current situation. A summarized table of the CBA is presented in Table 19. The net benefit cost ratio is presented for each alignment, the highest values are the most socioeconomically favourable. The highest net benefit cost ratio for each scenario is highlighted with a dark green colour. All data used in the CBA is presented in Appendix 4. Most alignments have a negative net benefit cost ratio, which means that they are not socioeconomically beneficial.

Table 19 Net benefit cost ratio for all the alignments in each scenario

	Corridor two			**Corridor four**		
Alignment	80 km/h	100 km/h	110 km/h	80 km/h	100 km/h	110 km/h
1	-0,15	-0,32	-0,30	-0,36	-0,20	-0,20
2	-0,37	-0,30	-0,37	-0,30	0,07	-0,46
3	-0,30	-0,36	-0,38	-0,26	0,23	-0,36
4	-0,29	-0,24	-0,39	-0,33	0,17	-0,37
5	-0,46	-0,28	-0,36	-0,23	0,17	-0,01
6	-0,43	-0,32	-0,36	-0,26	0,16	-0,06
7	-0,47	-0,34	-0,31	-0,31	-0,05	-0,14
8	-0,34	-0,25	-0,37	-0,23	0,24	-0,41
9	-0,48	-0,27	-0,38	-0,18	0,09	-0,41
10	-0,27	-0,39	-0,43	-0,35	0,08	-0,08
11	-0,38	-0,37	-0,39	-0,24	0,37	-0,16
12	-0,33	-0,45	-0,37	-0,27	0,26	-0,03
13	-0,21	-0,39	-0,43	-0,23	0,27	-0,46
14	-0,28	-0,25	-0,36	-0,22	0,03	0,01
15	-0,35	-0,52	-0,38	-0,35	0,01	-0,11
16	-0,40	-0,27	-0,37	-0,40	-0,22	-0,33
17	-0,28	-0,31	-0,40	-0,27	0,22	-0,11
18	-0,26	-0,40	-0,40	-0,18	0,10	0,09
19	-0,20	-0,43	-0,35	-0,23	0,13	0,13
20	-0,39	-0,27	-0,28	-0,26	0,24	-0,10
21	-0,34	-0,35	-0,45	-0,24	0,18	-0,14
22	-0,36	-0,44	-0,39	-0,28	0,17	-0,04
23	-0,26	-0,36	-0,49	-0,37	-0,12	0,03
24	-0,28	-0,39	-0,29	-0,19	-0,14	-0,38
25	-0,33	-0,40	-0,49	-0,41	-0,30	-0,06

7.3 The most socioeconomically favourable alignments

The CBA gives the calculated net benefit cost ratio for each corridor and speed limit. Based on the result presented in Table 19 above, one alignment for each scenario has been selected for further evaluation. These six alignments are described in Chapter 7.3.1 and 7.3.2. In Table 20, a summarized CBA for the selected alignments are presented.

Table 20 Data from CBA for the six most beneficial alignments. The table is a summary of the CBA performed for all 150 alignments which can be found in Appendix 4

Comparison between the most socioeconomically beneficial alignments	**Corridor two**			**Corridor four**		
	80 km/h	100 km/h	110 km/h	80 km/h	100 km/h	110 km/h
Aligmment number	1	4	20	18	11	19
Length [km]	7,372	7,381	7,369	7,197	7,213	7,232
Construction cost						
Total construction cost [SEK]	129 863 938	144 677 519	153 985 032	177 599 871	188 403 553	225 635 458
Construction cost per meter [SEK]	17 616	19 601	20 896	24 677	26 120	31 200
Road user, community and maintenance costs						
Fuel cost [SEK]	275 214 661	275 550 653	275 102 664	268 681 486	269 278 805	269 988 121
Tire cost [SEK]	23 393 246	23 421 806	23 383 726	22 837 926	22 888 698	22 948 990
Service cost [SEK]	53 963 659	54 029 540	53 941 699	52 682 644	52 799 766	52 938 847
Loss in value [SEK]	172 683 709	172 894 527	172 613 436	168 584 462	168 959 250	169 404 311
Time cost [SEK]	589 890 248	590 610 407	589 650 195	575 887 156	461 733 951	462 950 220
Maintenance cost [SEK]	18 670 003	18 698 836	18 660 392	14 905 757	14 957 015	15 017 884
Emissions [SEK]	166 939 277	167 143 083	166 871 342	162 976 394	163 338 715	163 768 971
Noise [SEK]	1 462 290	1 462 290	1 462 290	438 687	438 687	438 687
Benefit						
Total benefit	110 878 776	109 284 729	111 410 125	146 101 356	258 700 982	255 639 838
Result of cost-benefit analysis						
Net benefit cost ratio	-0,15	-0,24	-0,28	-0,18	0,37	0,13

As stated in Chapter 6.1.6, the intrusion into sensitive areas is evaluated with regards to quantity. The absence of monetary values implies that the intrusion is not included in the net benefit cost ratio and is therefore evaluated separately. The six most beneficial alignments' intrusions into sensitive areas are presented in Table 21. The intruded sensitive areas correspond to the naturally valuable environment by Aspen and cultural values at Julita Kvarn in corridor two, culturally valuable environment and the landscape picture in the north part of each corridor, and Hälleforsgången, the swamp forests and the croft landscape in corridor four. The smallest intrusion is caused by alignment number four (corridor two, 100 km/h). The largest intrusion is caused by alignment number 19 (corridor four, 110 km/h).

Table 21 Intrusion into sensitive areas for the six most favourable alignments

Intrusion in sensitive areas	**Corridor**	**two**		**Corridor**	**four**	
	80 km/h	100 km/h	110 km/h	80 km/h	100 km/h	110 km/h
Alignment number	1	4	20	18	11	19
Nature by Aspen [m²]	11 300	10 000	8 090	-	-	-
Hälleforsgången [m²]	-	-	-	12 300	15 800	16 900
Swamp forest [m²]	-	-	-	1 610	1 700	1 380
Cultural value Julita Kvarn [m²]	150	495	1 030	-	-	-
Cultural valuable environment [m²]	23 300	19 500	25 100	37 700	36 100	46 200
Croft landscape [m²]	-	-	-	36 900	42 800	41 600
Landscape picture [m²]	35 600	37 000	36 000	25 700	29 600	38 300
Total intrusion [m^2]	**70 350**	**66 995**	**70 220**	**114 210**	**126 000**	**144 380**

7.3.1 Presentation of the most profitable alignments within corridor two

The most favourable alignment for each speed limit, according to the net benefit cost ratio in the CBA, is presented below. Detailed information is provided regarding horizontal and vertical alignment together with construction costs and intrusion into sensitive areas.

7.3.1.1 80 km/h

In corridor two, with speed limit 80 km/h, alignment number one gave the highest net benefit cost ratio and is thus the most socioeconomically favourable. The horizontal alignment is visualized in Figure 30. Its position follows the general position of all 25 alignments in the scenario. Alignment number one has the lowest construction cost for this scenario, with a total construction cost of 129,863 mSEK. The alignment is 7 372 meters long, where 2 872 meters is a new construction. Table 21 above shows that the alignment passes through several sensitive areas. The total amount of intrusion in such areas is 70 350 m^2, where the intrusion into the landscape picture in the north part of the corridor is the largest component.

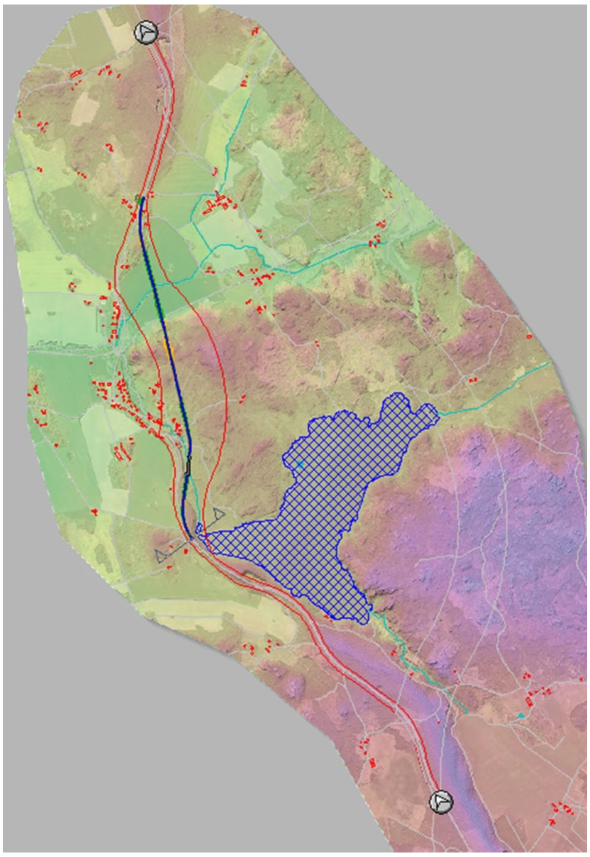

Figure 30 Alignment number one is the most socioeconomically beneficial alignment for corridor two with speed limit 80 km/h.

Figure 31 shows the vertical alignment for alignment one. The new construction begins on an embankment and crosses the wetland by the outlet of Aspen with a large bridge in section 0/500. The construction transcends from embankment to cut in section 1/200. Where the terrain changes from woodland to agricultural land, at section 1/800, back filling and large embankments are needed. The road is built on embankment until section 2/500 where it transcends to cut, which is the main construction the remaining part of the new road. There is a large mass deficit. Thus, import of masses is needed, which can be seen in Table 8. Trimble Quantm could not meet the geometric standard regarding horizontal radius and avoidance of buildings at one location. The violation regarding horizontal radius can be found where the alignment separates from the existing road. The crossing of a building occurs approximately at section 2/600.

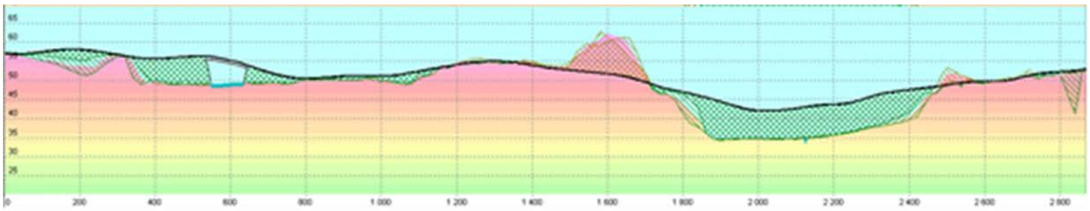

Figure 31 Profile for alignment one

7.3.1.2 100 km/h

In corridor two, with a speed limit of 100 km/h, alignment number four has the highest net benefit cost ratio. It is thus the most socioeconomically favourable alignment in this scenario. The position of the horizontal alignment can be seen in Figure 32. It follows the general position of the scenario's all 25 alignments. The alignment is 7 381 meters long, where 2 881 meters is a new construction. The total construction cost for the alignment is 144,677 mSEK. This is the second lowest construction cost for the scenario. The alignment passes through several sensitive areas. The total amount of intrusion is 66 995 m^2, where the intrusion into the landscape picture in the northern part of the corridor is the largest component.

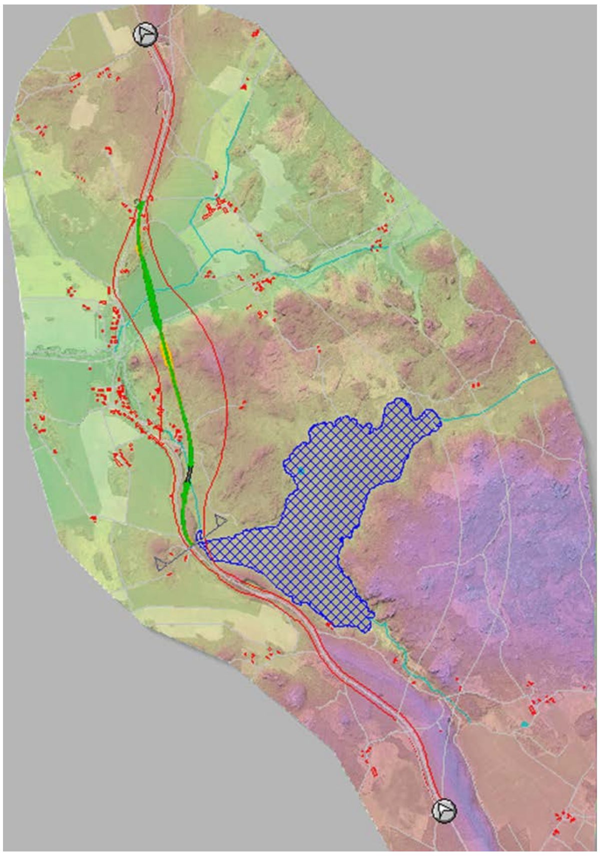

Figure 32 Alignment number four is the most socioeconomically beneficial alignment for corridor two with speed limit 100 km/h.

The vertical alignment can be seen in Figure 33. The new road construction begins on an embankment and crosses the outlet of Aspen with a large bridge at section 0/500. Embankments are the main construction type until section 1/200 where the construction transcends to a cut. The cut continues until the transition from woodland to agricultural land in section 1/800. Large back fillings are needed on the low-lying agricultural land, which means large embankments. In section 2/400 the road is constructed as cut again, which is the main construction type of the remaining construction. Mass-balance is almost achieved; only a small mass deficit is present, which can be seen in Table 10. At one location Trimble Quantm could not meet the geometric standard regarding horizontal radius and avoidance of buildings. The violation of horizontal radius can be found where the alignment separates from the existing road. The crossing of a building occurs approximately at section 2/600.

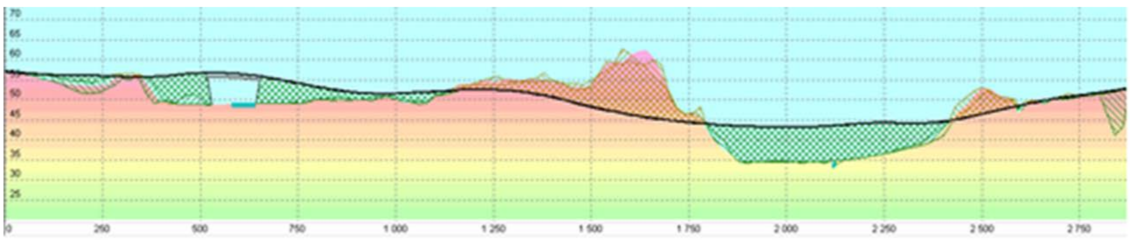

Figure 33 Profile for alignment number four.

7.3.1.3 110 km/h

Alignment number 20 has the highest net benefit cost ratio when the speed limit is set to 110 km/h in corridor two. It is therefore the most socioeconomically beneficial alignment for this scenario. The position of the horizontal alignment is shown in Figure 34. Its location is slightly to the east of the general alignment for the scenario. The alignment is 7 369 meters long, where 2 869 meters is a new construction. Alignment 20 has a total construction cost of 153,985 mSEK, which is the second lowest construction cost for this scenario. The alignment passes through several sensitive areas. The total intrusion is 70 220 m^2, where the intrusion into the landscape picture in the north part of the corridor is the largest component.

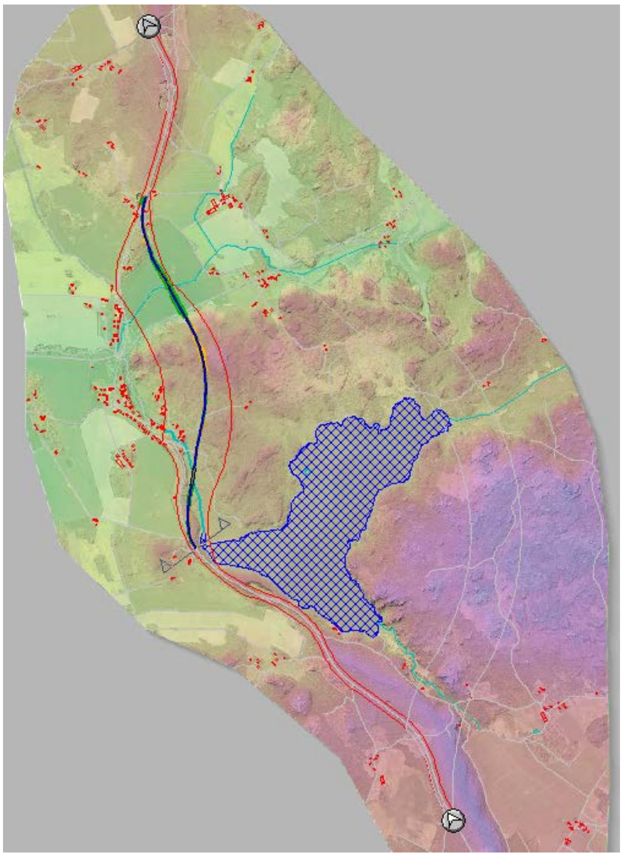

Figure 34 Alignment number 20 is the most socioeconomically beneficial alignment for corridor two with speed limit 110 km/h.

The vertical alignment is shown in Figure 35. The new construction begins in a cut and follows the natural terrain more or less the first kilometre. Thereafter there is an embankment for around 100 meters before the construction transcends to a cut. A bridge is situated at the outlet of Lake Aspen. At section 1/800 large back fillings are needed. This means that an embankment is needed on the agricultural lowland which is located here. In section 2/500 the construction transcends to cut again, which it the main construction for the rest of the new construction. Mass-balance is almost achieved for the construction. A small surplus of masses might be present, which can be seen in Table 12. The alignment has warnings of not met geometric standard for horizontal radius as well as avoidance of buildings and bridge height. The set minimum radius is exceeded where the alignment separate and aligns with the existing road, as well as in section 2/500. The warning of the crossing of a building occurs approximately at section 2/600 and the bridge height at section 0/500 is too low.

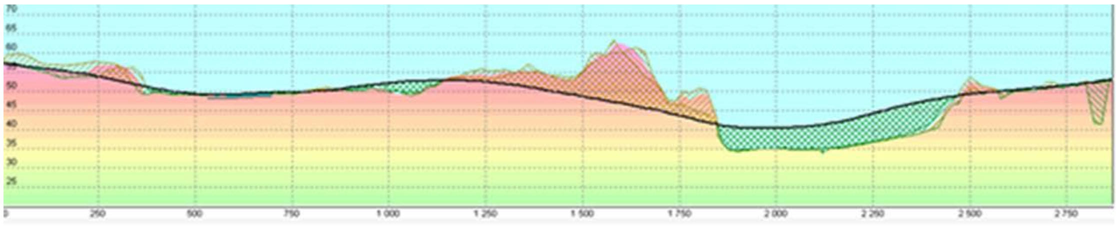

Figure 35 Profile for alignment number 20.

7.3.2 Presentation of the most profitable alignments within corridor four

The most favourable alignment for each speed limit, according to the net benefit cost ratio, is presented below. Detailed information is provided regarding horizontal and vertical alignment together with construction costs and intrusion into sensitive areas.

7.3.2.1 80 km/h

In corridor four, with speed limit 80 km/h, alignment 18 has the highest net benefit cost ratio. It is therefore the most socioeconomically favourable alignment for this scenario. The horizontal alignment can be seen in Figure 36. It follows the general position for all alignments within this scenario. The length of the alignment is 7 197 metres and the total construction cost is 177,599 mSEK. Out of the 25 alignments which Trimble Quantm presented, alignment 18 has the lowest construction cost. The intrusion into sensitive areas is 114 210 m^2, where intrusion into cultural valuable environment is the largest component.

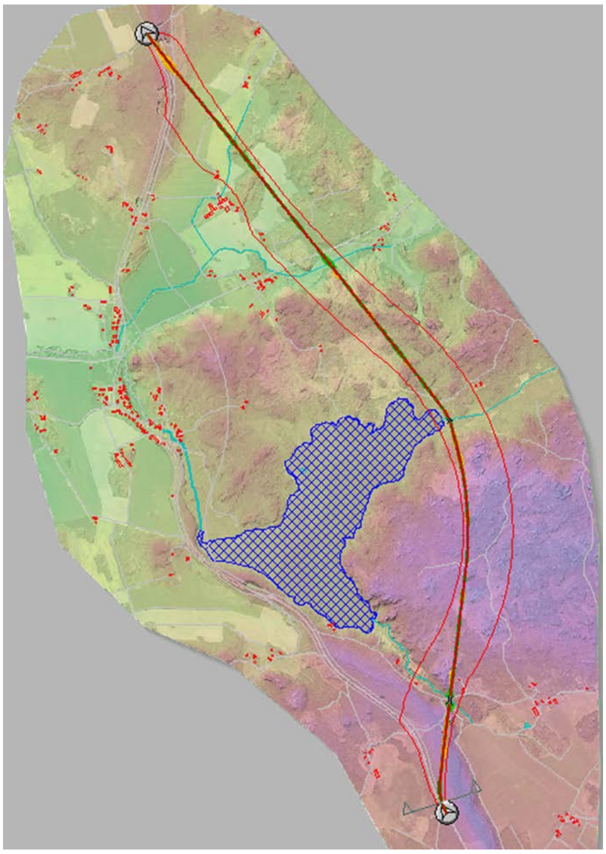

Figure 36 Alignment number 18 is the most socioeconomically beneficial alignment for corridor four with speed limit 80 km/h.

Figure 37 shows the vertical alignment. The new road construction separates from the existing road at the beginning of the corridor and cuts through the esker. After crossing the southern inlet of Lake Aspen with a bridge in section 0/900, the road construction alters between a cut and bank throughout the alignment. The eastern inlet to Aspen is crossed with a bridge at section 3/200 and the two northernmost water streams are crossed with culverts at section 4/800 and 6/080. The passage over Hälleforsgången lies approximately in section 4/250 to 4/750. Although cuts are necessary, the passage is mainly constructed as an embankment. According to Table 14 there is a mass deficit for the construction. It is thus necessary to import construction material. Trimble Quantm could not meet the geometric standard regarding horizontal radius at one location, which is where the alignment separates from the existing road.

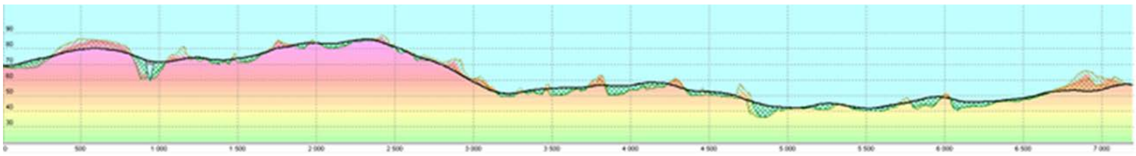

Figure 37 Profile for alignment 18

7.3.2.2 100 km/h

In corridor four, with speed limit 100 km/h, alignment number 11 has the highest net benefit cost ratio. It is thus considered to be the most beneficial alignment for this scenario. The horizontal alignment is shown in Figure 38. It follows the general position of all the alignments for the scenario. Alignment 11 has a length of 7 213 meters. The total construction cost is 188,403 mSEK which is the lowest cost of the 25 resulting alignments. The intrusion into sensitive areas is 126 000 m^2 where the intrusion into the croft landscape is the largest component.

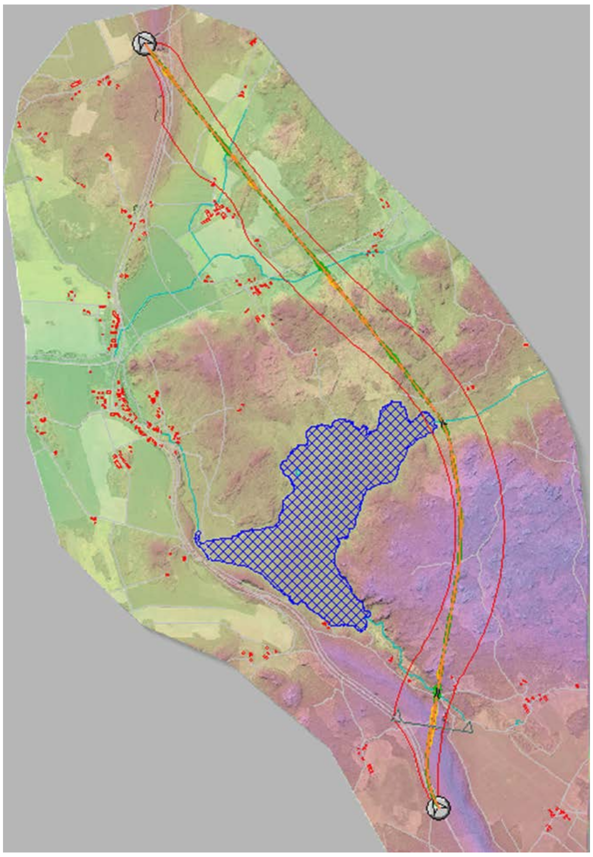

Figure 38 Alignment number 11 is the most socioeconomically beneficial alignment for corridor four with speed limit 100 km/h

The vertical alignment of alignment 11 is shown in Figure 39. The road construction cuts through the esker and crosses the southern inlet of Lake Aspen with a bridge in section 0/950. Throughout the stretch, the road construction alters between cuts and embankments. The passage over Hälleforsgången (section 4/250 to 4/750) is mainly constructed as a cut. Lake Aspen's eastern inlet is crossed with a bridge at section 3/200. The two northernmost water streams are crossed with culverts at section 4/850 and 6/100. Table 16 indicates a mass surplus for the construction. No warnings regarding unmet geometric standard exists for the alignment.

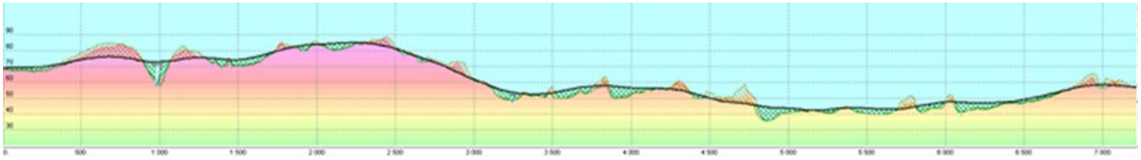

Figure 39 Profile for alignment 11

7.3.2.3 110 km/h

The alignment with the highest net benefit cost ratio, for speed limit 110 km/h within corridor four, is alignment number 19. It is therefore considered to be the most socioeconomically beneficial alignment in this scenario. The horizontal alignment can be seen in Figure 40, and follows the general alignment for the scenario. The length of the alignment is 7 232 metres. The total construction cost of alignment 19 is 225,635 mSEK, which is the lowest cost in the scenario. The intrusion into sensitive areas is 144 380 m^2, where the largest part constitutes of intrusion into cultural landscape north of road 214.

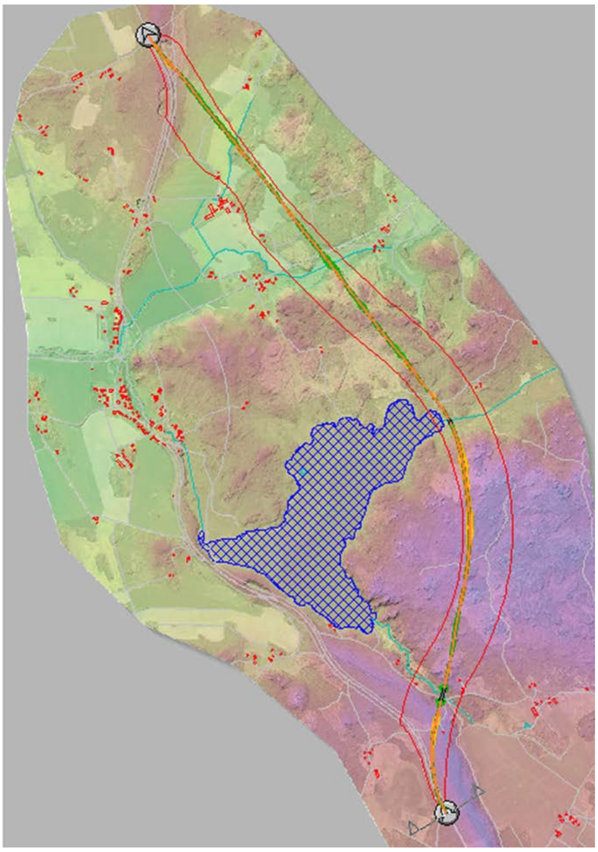

Figure 40 Alignment number 19 is the most socioeconomically beneficial alignment for corridor four with speed limit 110 km/h

The vertical alignment for alignment 19 can be seen in Figure 41. After cutting through the esker in the beginning of the corridor, the road crosses the southern inlet of Lake Aspen at section 0/950 with a bridge. Another bridge is constructed at section 3/200 at Aspen's eastern inlet. Two culverts, at section 4/850 and 6/100, is constructed in order to cross the two northernmost water streams. Hälleforsgången is situated approximately at section 4/250 to 4/750. The passage of the dyke is mainly constructed as an embankment. According to Table 18 there is a mass deficit for the construction. It is thus necessary to import construction masses. Trimble Quantm could not meet the geometric standard regarding horizontal radius at one location, which is where the alignment separates from the existing road.

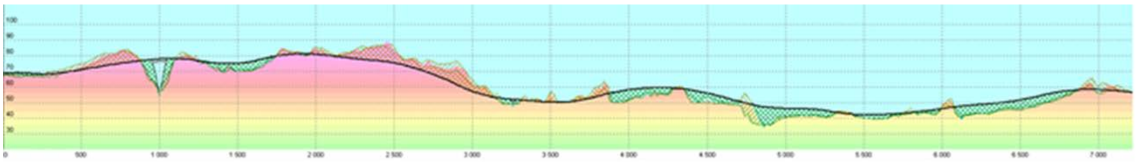

Figure 41 Profile for alignment 19

8 Analysis

Trimble Quantm produced 25 alignments for each corridor and speed limit, resulting in 150 alignments. The six most socioeconomically beneficial alignments according to the net benefit cost ratio are presented in Chapter 7.3 earlier in this thesis. The advantage of the selected alignments against the other 144 alignments are analysed in Chapter 8.1. In order to evaluate the CBA's sensitivity to variations in costs and benefits, a sensitivity analysis has been performed. The result of the sensitivity analysis is presented in Chapter 8.2. In order to determine which alignment is the most favourable, a comparison of the six most beneficial alignments are performed in Chapter 8.3. This includes an analysis of the alignments' intrusion into sensitive areas.

8.1 Selection of the six most favourable alignments

150 alignments were suggested by Trimble Quantm. Out of these, six alignments were selected based on their net benefit cost ratio. The data of the selected alignments should however be evaluated regarding their relation to the other alignments. The alignments' positions, construction costs, benefits and net benefit cost ratios are analysed below.

8.1.1 Horizontal and vertical alignment

Three different speed limits have been investigated for corridor two and four. Within corridor two, some differences in horizontal alignment can be found in the different scenarios. Even though a clear general alignment is present, the variation in horizontal position increases with increased speed limit (compare Figure 24 to 26 in Chapter 7.1). In corridor four, all the 75 alignments have a very similar horizontal position. It is thus not possible to see any clear differences between the different speed limits. Somewhat larger variations are however noticeable for speed limit 110 km/h. Since Trimble Quantm analyses millions of different alternatives it could be concluded that the suggested orientation is the most favourable. Regarding the vertical alignment, only one alignment in each scenario has been investigated. It is therefore difficult to evaluate any differences between the different speed limits. If consideration is only taken to the six most favourable alignments there is a risk that an unrepresentative comparison is conducted. The vertical alignment will therefore be omitted from this analysis.

8.1.2 Construction costs, benefits and net benefit cost ratio

The construction cost for the six most socioeconomically favourable alignments can be put in relation to the costs for all alignments provided by Trimble Quantm. The six alignments are either the least or second least expensive alignment in their respective scenario. This indicates that the construction cost is an important factor to consider when evaluating which alternative to select. The total benefit for the alignments can also be compared to all alignments in each scenario. The benefit of the selected alignments is generally not among the best in their respective scenario. As seen in Table 22 some of the most favourable alignments have a low rank and a quite large difference to the alignment with the highest benefit. Different alignments would thus be received if regards was taken to construction cost or benefit singly. These factors alone cannot say which solution is the most beneficial.

Table 22 Benefit for the different scenarios

Scenario	Benefit of most favourable alignment	Rank	Highest benefit for scenario
Corridor 2			
80 km/h	110 878 776	13	111 764 358
100 km/h	109 284 729	5	111 233 009
110 km/h	111 410 125	5	111 764 358
Corridor 4			
80 km/h	146 101 356	12	146 632 705
100 km/h	258 700 982	3	259 184 320
110 km/h	255 639 838	10	257 734 305

Since neither construction cost nor benefit can be used singly, the net benefit cost ratio has been calculated for all the alignments. It is with the basis of this value, the six most beneficial alignments have been selected. Table 23 shows the variance of the net benefit cost ratio between different alignments within a scenario, as well as the average ratio. As seen, there is a span in which the net benefit cost ratio lies for every scenario. When determining which corridor to proceed with, it might be beneficial to evaluate the average net benefit cost ratio for each scenario. The average value for all the scenarios within a corridor is -0,36 for corridor two and -0,13 for corridor four. According to this, corridor four is the most beneficial.

Table 23 The variance of the net benefit cost ratio within each scenario.

	Net benefit cost ratio			
Scenario	**Highest**	**Lowest**	**Variance**	**Average**
Corridor 2				
80 km/h	-0,15	-0,48	0,34	-0,33
100 km/h	-0,24	-0,52	0,27	-0,35
110 km/h	-0,28	-0,49	0,21	-0,38
Corridor 4				
80 km/h	-0,18	-0,41	0,23	-0,28
100 km/h	0,37	-0,30	0,67	0,09
110 km/h	0,13	-0,46	0,60	-0,17

8.2 Sensitivity analysis

There are several different aspects to consider when determining which alignment is most socioeconomically favourable. A sensitivity analysis of the result has been performed in order to evaluate the robustness of the result and to find which parameters are critical. The net benefit cost ratio has been calculated for four different situations:

- Without any alternations (origin CBA)
- Altered construction costs
- Without the benefit of lower community costs
- Without the construction cost of bridges

8.2.1 Construction costs

The CBA's result is independent of changes in the construction cost. The total construction cost, as well as only the cost received from Trimble Quantm, have been increased and decreased with 30 percent. This gave no alternations of which alignment was most beneficial between and within different scenarios. No such difference can be expected since the relation between the alignments withstand. It is however interesting to investigate how much the cost in one scenario has to increase in order for another scenario to become the most beneficial. This has been done for the scenario with the highest net benefit cost ratio within each corridor. According to Table 20, this is alignment one (corridor two, 80 km/h) and alignment 11 (corridor four, 100 km/h), where alignment 11 is the most beneficial. In order for alignment number one to become more beneficial than alignment 11 the total construction cost for alignment 11 has to increase with 61 percent. This corresponds to a cost increase of 114,926 mSEK and gives alignment 11 a net benefit cost ratio of -0,15. Similar calculations have been performed in order to investigate which cost increase is needed in order for the second best scenario to become the most beneficial. According to Table 20, this is alignment 19 (corridor four, 110 km/h). In order for alignment 19 to become more beneficial than alignment 11, the total construction cost has to increase with 21 percent. This correspond to 39,564 mSEK and gives alignment 11 a net benefit cost ratio of 0,13.

8.2.2 Community costs

Within a corridor and speed limit, the CBA is not sensitive to whether community costs are included or not. Differences do however arise when comparing alignments in different corridors and speed limits. Alignment 11 (corridor four, 100 km/h) is nevertheless still the most beneficial. Worth mentioning is that the noise cost is 1,023 mSEK more expensive in corridor two than in corridor four. In addition, the average cost of emissions for the top three alignments are 3,630 mSEK more in corridor two compared to corridor four.

When the community costs are excluded from the CBA the value of the net benefit cost ratio decreases and there is an alternation in the order of the most beneficial scenario, see Table 24. Note that this difference only applies for corridor four. Since the cost of noise disturbance does not alter within a corridor, this alternation depends on the cost of emissions. If the road user, maintenance and community costs in Table 20 are compared, it is clear that there are differences between the alternatives.

As above, it is interesting to investigate how much the total construction cost has to increase in order to receive an alternation of the most socioeconomically beneficial corridor. This has been done for alignment one (corridor two, 80 km/h) and alignment 11 (corridor four, 100 km/h). The total construction cost for alignment number 11 has to be increased with 81 percent, corresponding to 152,606 mSEK, in order for alignment number one, to become more beneficial. Alignment number 11 will then have a net benefit cost ratio of – 0,32.

Table 24 The net benefit cost ratio without community cost for the six selected alignments.

Scenario	Net benefit cost ratio without community costs	Rank without community costs	Net benefit cost ratio with community costs	Rank with community costs
Corridor 2				
80 km/h	-0,32	3	-0,15	3
100 km/h	-0,40	5	-0,24	5
110 km/h	-0,43	6	-0,28	6
Corridor 4				
80 km/h	-0,33	4	-0,18	2
100 km/h	0,23	1	0,37	1
110 km/h	0,01	2	0,13	4

8.2.3 Construction costs for bridges

The analysis is sensitive to the cost of bridges within and between scenarios. The net benefit cost ratios without the bridge costs are shown in Table 25. It should be noted that in the scenarios of corridor two, speed limit 100 km/h and 110 km/h, alignment number four respectively 20 is no longer the most beneficial. Alignment number seven respectively 23 are the alignments with the highest net benefit cost ratio in these scenarios without bridge costs, and their ratios are presented in Table 25. An alignment within corridor four is most beneficial when the cost of bridge constructions is excluded. This is quite interesting since the average bridge length in corridor two is more than twice the length of bridges within corridor four. With a pricing of 35 000 SEK/m^2 the average construction cost decrease is 44 percent within corridor two, due to the exclusion of bridges. For alignments within corridor four the average cost decrease is only 14 percent.

Table 25 Net benefit cost ratios without the construction cost of bridges

Net benefit cost ratio without bridge costs		
Scenario	**Ratio**	**Rank**
Corridor 2		
80 km/h	0,32	4
100 km/h	0,36	2
110 km/h	0,22	5
Corridor 4		
80 km/h	-0,07	6
100 km/h	0,59	1
110 km/h	0,36	2

There is a risk that the amount of bridges is incorrect. Since Trimble Quantm would provide an entirely different result if a simulation with altered bridge cost or width of water streams was made, new simulations have not been possible to perform. The bridge cost for the alignments in corridor four has however been increased in order to see when an alignment in corridor two becomes the most beneficial. When considering the net benefit cost ratio without any alternations the scenario with speed limit 80 km/h and 100 km/h have been investigated in corridor two respectively four since these have the highest ratios. In order for the maximum net benefit cost ratio to pass from corridor four to corridor two, the bridge cost for the alignments within corridor four has to increase with 500 percent.

8.2.4 Average net benefit cost ratios for the scenarios

If no consideration is taken to a specific alignment, the average value of the net benefit cost ratio for all 25 alignments can be used in order to compare the different scenarios. The result of such comparison is shown in Table 26. As seen, the most favourable corridor and speed limit does not vary with the different calculations. Corridor four, with a speed limit of 100 km/h, is the most beneficial in all situations.

Table 26 Average values for the corridors for two of the sensitivity analysis scenarios. The most beneficial corridor and speed limit for each scenario is marked with bold text.

Average net benefit cost ratios			
Scenario	**With no alternations**	**Without community costs**	**Without bridge costs**
Corridor 2			
80 km/h	-0,33	-0,47	0,11
100 km/h	-0,35	-0,48	0,09
110 km/h	-0,38	-0,51	0,02
Corridor 4			
80 km/h	-0,28	-0,42	-0,19
100 km/h	**0,09**	**-0,03**	**0,22**
110 km/h	-0,17	-0,26	-017

An evaluation of the size of the cost increase has also been performed in order to receive an alternation of the most favourable scenario regarding average ratios. This has only been done for the most beneficial scenarios within each corridor. In the scenario of corridor four, speed limit 100 km/h, the total construction cost has to increase with more than 62 percent in order for the average net benefit cost ratio to be lower than in corridor two, speed limit 80 km/h. If the community costs are excluded from the CBA, the total construction cost has to increase with 81 percent, in order for corridor two to become more beneficial. The construction costs for bridges can increase more than 600 percent before the average net benefit cost ratio in corridor four, speed limit 100 km/h, is lower than in corridor two, speed limit 80 km/h. If the average net benefit cost ratio without community costs are considered, the construction cost of bridges can increase with more than 800 percent without any alternations in which corridor is the most beneficial.

8.3 Comparison of the six most socioeconomic favourable alignments

Through the net benefit cost ratio six alignments have been selected, one for each scenario. These have been presented in Chapter 7.3 and will be compared in order to determine which is the most socioeconomically favourable. All six alignments are visualized in Figure 42 below. As seen, there are only small alternations in horizontal position within a corridor. The exception is alignment number 20 (corridor two, 110 km/h), which is positioned further to the east compared to the two other alignments in the corridor.

In the results received from Trimble Quantm, warnings about unmet geometric standard are given. Such information is provided for the most beneficial alignment within each scenario in Chapter 7.3. Overall, the alignments within corridor four had fewer warnings than corridor two, and alignment 11 (corridor four, 100 km/h) had none. Most warnings did apply for the separation from the existing road. In corridor two, all alignments had warnings regarding crossing of buildings at the same section, 2/600. In alignment 20 (corridor two, 110 km/h), the required bridge height was violated. The bridge is nearly at ground level which is unlikely in reality.

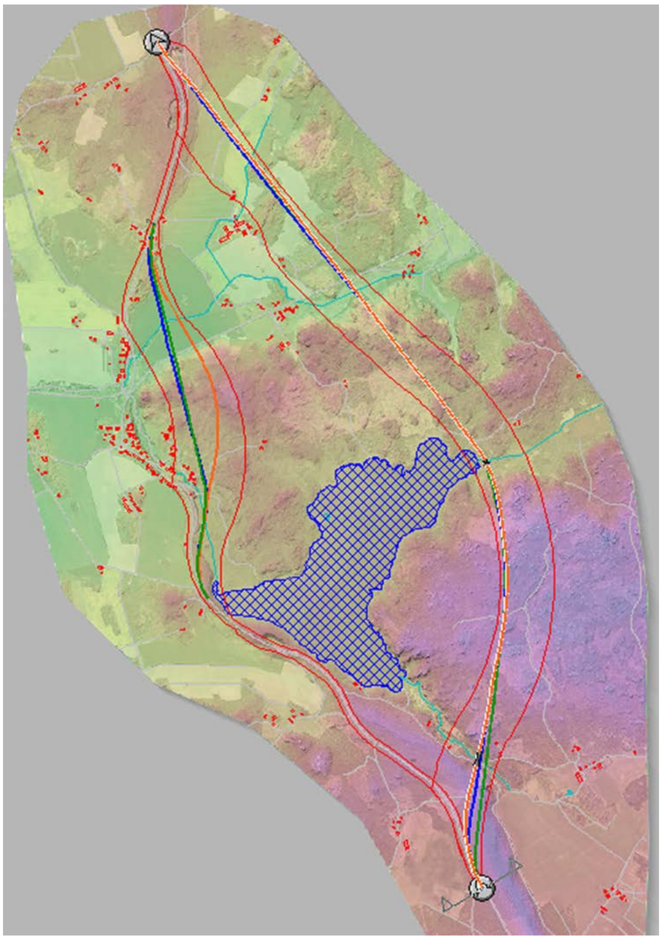

Figure 42 The six most socioeconomic favourable alignments. The green lines correspond to speed limit 80 km/h, the blue lines 100 km/h and the orange lines 110km/h.

8.3.1 Socioeconomic evaluation

The CBA was used in order to select one alignment in each scenario. The CBA produced values for costs, benefits and net benefit cost ratios for each alignment. In this segment a comparison of these will be conducted. A summary of these values can be found in Table 27 below.

If consideration only is taken to the construction cost, an alignment within corridor two should be chosen. Even though the alignments within corridor two are longer than in corridor four, most of the stretch is a reconstruction resulting in lower construction costs. In both corridors, the construction costs increase with increased speed limit and road standard, see Table 27. The alignments within corridor four have larger benefits than those in corridor two. This is most likely due to two reasons. Firstly, the alignments in corridor two are longer, causing higher road user, maintenance and emission costs. Secondly, more houses are situated close to the road in corridor two resulting in higher costs due to noise disturbance. The road user, maintenance and community costs for the six alignments can be seen in Table 20 in Chapter 7.3 earlier in this thesis.

As mentioned earlier, it is not suitable to singly consider construction costs or benefits when determining which alignment is most socioeconomically favourable. In this thesis the net benefit cost ratio has been used in order to put the investment cost of an alternative in relation to the benefit. According to this parameter, alignment number 11 (corridor four, 100 km/h) is the most beneficial. The ranking of the six alignments can be seen in Table 27.

Table 27 Comparison of construction cost, benefit and net benefit cost ration for the six most socioeconomically favourable alignments.

Construction cost, benefit and net benefit cost ratio						
Scenario	**Total construction cost**	**Rank**	**Total benefit**	**Rank**	**Net benefit cost ratio**	**Rank**
Corridor 2						
80 km/h	129 863 938	1	110 878 776	5	-0,15	3
100 km/h	144 677 519	2	109 284 729	6	-0,24	5
110 km/h	153 985 032	3	111 410 125	4	-0,28	6
Corridor 4						
80 km/h	177 599 871	4	146 101 356	3	-0,18	4
100 km/h	188 403 553	5	258 700 982	1	0,37	1
110 km/h	225 635 458	6	255 639 838	2	0,13	2

8.3.2 Intrusion into sensitive areas

Since the intrusion into sensitive areas is not included with monetary values in the CBA, it is interesting to calculate what the intrusion should be valuated to, in order to make corridor two a more beneficial option than corridor four. The evaluation is performed with regards to the net benefit cost ratios. A percentage increase is added to the total construction cost for alignment 11 (corridor four, 100 km/h) until the net benefit cost ratio exceeds the ratio for alignment one (corridor two, 80 km/h). A cost per square meter is obtained by dividing the cost with the additional area of intrusion caused by alignment 11. The area of intrusion is calculated as the difference between the intrusion of the alignment one and 11. The intrusion caused by alignment one is thus evaluated to zero SEK. The alignments' intrusions are shown in Table 21.

Table 28 presents the result of the calculations. In order for alignment one to become more favourable than alignment 11, the additional intrusion of 55 650 m^2 has to be valuated to 114,926 mSEK. This results in a cost of 2 065 SEK/m^2. If the community costs are excluded from the calculations in the CBA, alignment eleven's additional intrusion has to be valued to 152,606 mSEK. This corresponds to a cost of 2 742 SEK/m^2.

Table 28 Evaluation of the intrusion caused by alignment 11 (corridor 4, 100 km/h), with and without community costs.

Evaluation of intrusion into sensitive areas	With community costs	Without community costs
Percentage increase [%]	61	81
Evaluation of intrusion [SEK]	114 926 167	152 606 878
Additional area of intrusion [m2]	55 650	55 650
Cost per m^2 [SEK]	2 065	2 742

In order to take consideration to the sensitivity levels mentioned in Chapter 6.1.6, a calculation with different cost increase corresponding to the different sensitivity levels has been conducted. Table 6 shows the sensitivity levels for the areas. If areas with sensitivity level one, two and three were given a unit cost of six, three respectively one SEK/m^2; corridor two is no longer the most beneficial regarding intrusion. Table 29 shows the result of such calculation. According to the calculations alignment 18 (corridor four, 80 km/h) should be selected. Whether this valuation is representative or not cannot be answered in this thesis. The purpose of the calculation is to show what the different sensitivity levels have to be valued to, in order to receive an alternation in which corridor is the most beneficial with regards to intrusion into sensitive areas. The average intrusion cost for corridor two respectively four is 163 973 SEK and 161 323 SEK.

Table 29 The cost of the total intrusion if the different sensitivity levels are given unit values

Intrusion in sensitive areas	Corridor	two		Corridor	four	
	80 km/h	100 km/h	110 km/h	80 km/h	100 km/h	110 km/h
Alignment number	1	4	20	18	11	19
Nature by Aspen (sensitivity level 2) [SEK]	33 900	30 000	24 270	-	-	-
Hälleforsgången (2) [SEK]	-	-	-	36 900	47 400	50 700
Swamp forest (2) [SEK]	-	-	-	4 830	5 100	4 140
Cultural value Julita Kvarn (1) [SEK]	900	2 970	6 180	-	-	-
Cultural valuable environment (3) [SEK]	23 300	19 500	25 100	37 700	36 100	46 200
Croft landscape (3) [SEK]	-	-	-	36 900	42 800	41 600
Landscape picture (2 and 3) [SEK]	106 800	111 000	108 000	25 700	29 600	38 300
Total cost of intrusion [SEK]	**164 900**	**163 470**	**163 550**	**142 030**	**161 000**	**180 940**

9 Discussion

In order to obtain the most socioeconomically favourable road alignment, the result and analysis have to be viewed together with parameters lacking monetary values. Such parameters will be taken into account in the end of this chapter. First, the construction of the model in Trimble Quantm will be discussed. Thereafter, the usability of Trimble Quantm is evaluated. The creation of the CBA is also discussed.

9.1 Trimble Quantm

It has been strived to use as project specific input data to Trimble Quantm as possible. In order to obtain an accurate model, the input data needs to be relevant and of right proportions. The accuracy of the result will reflect the relevance of the input data. Exact numbers are however not possible to estimate at this early stage. The values used in this thesis are not intended to be more than estimations. Since a road construction project comprises a lot of uncertainties there will always be deviations from the estimated numbers.

9.1.1 Road structure

The road structure's thickness is set as input data in Trimble Quantm. The thickness of the superstructure has been designed for two geologies, till and clay. Peat was omitted due to the small size of the area, the fact that it is likely to be excavated and that a bridge is planned at this location. The design is based on the Swedish Table Method, where either traffic load or heave susceptibility is the dimensioning factor. This approach is in agreement with (Granhage, 2009). A thickness of the road structure was given in the basis calculation (WSP, 2014). This document did however lack a division regarding geology and an own estimation was therefore used in Trimble Quantm. Worth mentioning is that the road structures received by the Swedish Table Method are not as thick as the one given in the basis calculation.

The simplification to only use two types of geology, as well as the lack of consideration to the thickness given in the basis calculation, leads to uncertainties in the result. Both corridors, and all the alignments within them, do however have the same prerequisites and this factor should therefore not have a significant impact on which alignment is the most beneficial.

9.1.2 Geometry of the road

The geometric parameters are bound to criteria stated in "Vägar och gators utformning". The program aims to meet the requirements and makes a warning when those are violated. In order to obtain a more beneficial alignment, a deviation from the geometric criteria might be justified and it is up to the road planner to decide however it is reasonable. Warnings were received for all alignments but alignment 11 (corridor four, 100 km/h). As mentioned in Chapter 8.3 most of the warnings were related to the separation from the current road alignment. The direction of the start node might not be beneficial regarding the geometric standard. However, if that is the case it can be considered that alignment 11 also should have violated the geometric standard at this point. The warnings can also origin from the setting which makes Trimble Quantm prioritize the terrain ahead of the geometric standard. The alignments in corridor two cross a house in the end of the corridor. Why this building is crossed cannot be answered. It can be considered to be a negative aspect of Trimble Quantm since buildings were given a high avoidance priority. It can however be that other options required several buildings to be crossed.

9.1.3 Overtaking fields

As stated in Chapter 6.1.7, the overtaking fields should constitute 15 to 40 percent of the total road length from Bie to Stora Sundby (WSP, 2013). This implies that no overtaking fields are bound to be positioned within the corridors. The length of the overtaking fields within the corridors could also be longer. The fields were however included in the analysis in order to cover the additional costs that the widening of the road would imply. The overtaking fields are strategically placed at ascents, and functioning as gradient fields (Sektionen Utformning av vägar och gator, 2004). This is particularly favourable due to the large amount of heavy vehicles which are using the road.

The placement of overtaking fields was made before running the program in order to find suitable road alignments. Trimble Quantm could be used for the purpose of finding the most socioeconomically beneficial placement; it would however require that each placement was set manually and the program would thereafter suggest road alignments. A comparison between different placements would thereafter be necessary. By estimating a beneficial placement on beforehand, the number of simulations could be limited. The most socioeconomic placement of overtaking fields is thus not determined; instead, the overtaking field is included as a feature in the model. The suggested placement was determined with basis of the literature survey and by process of elimination. It was strived to avoid intersections with other roads and sensitive areas, especially with regards to the national interests Hälleforsgången and Julitabygden.

9.1.4 Cost parameters

Most of the input data for the cost parameters are default values, hence not corresponding to the area or the project. The values are considered to be sufficiently close to the actual costs and therefore used as input values. The costs have also been used as a means of avoidance. Features are avoided by adding a higher cost which makes the program present other, less expensive alternatives. Additional costs were applied to tunnels and the corridors. Very high costs could be applied since it led to that those were rejected from the analysis.

9.2 Evaluation of the usage of Trimble Quantm

For this thesis Trimble Quantm version 7.1.0.121 desktop edition was used. This is not the newest version and some improvements of the software might have been made. The favourable qualities of the program are that it is user friendly and easy to learn. The program is structured similarly to ArcGIS and previous knowledge of this program is advantageous when using Trimble Quantm. As claimed in (Trimble, 2013), the program has proved to work fast and time consuming planning work could hence be performed more efficiently. Since a large number of alignments are evaluated, alignments with lower construction costs could be found. Trimble Quantm could thereby provide more cost optimized suggestions. The program is also flexible, many different preconditions and restrictions can be put into the program and thereby obtain a desired result. The result provides detailed information of the alignments. Both output data and geographic visualizations are presented. This enables readily available information which can be used for evaluation. The evaluations can be performed for a single alignment or as a comparison between several. Alignments from different scenarios can also be opened in one scenario in order to compare the alignments positions and data side by side.

9.2.1 Perceived problems

Some issues with the program have however occurred during the simulations. For corridor two, Trimble Quantm presented a profile map with bridges constructed underground, beneath a water stream. The deep cuts on both sides of the stream as well as the road construction beneath it seemed unreasonable. The problem did however disappear when the case was closed and then opened again.

Very large cuts and banks were created when the setting of whether the program should prioritize the terrain or the geometry was set to the recommended value of 0,5. In order to obtain a more realistic result the setting was changed to zero, which means that the terrain have the highest priority. It is probably this setting that causes some alignments to have a mass deficit, even though large surpluses are predicted in the road plan (WSP, 2013). This creates an unfortunate uncertainty to the result. It can be considered that unrealistically large cuts and fills should not be possible to obtain with optimization software.

The program was prone to trespass the produced avoid zones. The corridors were first delimited by avoid zones, but as the program suggested alignments outside the borders, an area cost were added to the area outside the corridors. Still, the alignments were slightly trespassing the borders. By moving the borders inwards at the site where the trespassing occurred, a slight trespassing were possible without crossing the border of the actual corridor. In corridor two, the position of the corridor border had to be altered in order to avoid passage over Julita Kvarn and the valuable trees. In corridor four, Trimble Quantm tended to cross the lake Aspen even if a high area cost was added to the lake. In this case, a way station (which is a point the alignments have to pass through) was implemented but it did not do any difference. Therefore, the borders of the corridor were moved inwards to avoid the lake.

9.2.2 Usability of Trimble Quantm

In this thesis, the software program Trimble Quantm and a CBA have been used in order to find the most socioeconomically favourable alignment. This was done by letting Trimble Quantm find possible alignments and then evaluate them with a CBA. Since Trimble Quantm provided very small differences within a corridor, it might be more appropriate to use this method when evaluating different corridors, using average values for each simulation. Another possibility is to use the software in an even earlier stage and let Trimble Quantm find possible corridors. For these purposes, the software is considered to be a functional tool.

In order to receive an as accurate result as possible from Trimble Quantm, reliable and somewhat site specific data is necessary. This can be time consuming at first, but when a library of different data has been created the program will generate results rapidly. Some typical geology, geometry and cost data can be created, saved and used several times. This procedure would generate possible corridors or alignments rapidly.

It can be discussed whether it was accurate to move the corridor borders in order to avoid certain areas. Since the corridor passes through the area, it should be allowed to be crossed by a planned road. It is however advantageous to avoid certain areas if possible. This might be more difficult to do using software as Trimble Quantm. It is however possible to avoid areas by the means of high costs or as avoid zones, and the program should be able to consider such restrictions. This was nevertheless a problem during the simulations performed for this thesis. It might be that the implementation of a corridor was too strict for the program and is consequently not an appropriate tool to use for the final design of the alignment. Trimble Quantm can however be a beneficial tool when estimating construction costs and, as mentioned, when finding optimal corridors.

If the software is used in order to find alternative corridors it might be easier to consider sensitive areas and generate possible corridors with regards to these. To use it in order to find alignments under the restriction of specific corridors is, based on the experience from this thesis, not optimal. This might have changed in the new version of the software. Trimble Quantm did however present a typical road alignment for each corridor which could be processed further. Alignments created in Trimble Quantm can be edited by hand and are transferable to CAD and GIS programs. Hence, it is possible to further process a selected alignment. This has not been done in this thesis and this function can therefore not be evaluated.

9.3 Cost-benefit analysis

The classification of transportation costs presented by (Sinha & Labi, 2011) has been used in this thesis. The costs have been divided into costs for the road authority, road user and the community. The costs for the road user, the community and maintenance are likely to decrease due to a new road and are therefore referred to as benefits. The size of the benefit has been calculated by a comparison with the current situation. This segment will discuss the CBA and its input data.

9.3.1 Costs for road authority

A large part of the investment cost for the road authority is given by the result from Trimble Quantm, thus depending on the input data to the software. Costs such as advance planning, preliminary engineering, final design, as well as construction costs for wildlife fences and median barriers, were not received from Trimble Quantm. These have been taken from the basis calculation (WSP, 2014). It is important to consider that all costs only are early estimations. There are uncertainties in the costs for the road authority and thus in the result of the CBA. A large error will occur if the input data to Trimble Quantm is not representative and the cost estimations in the basis calculation are far from the actual outcome.

In order to evaluate the CBA's sensitivity to cost alternations a sensitivity analysis has been performed. It shows that the total construction cost, in corridor four, has to increase 61 percent in order for corridor two to become the most beneficial. If the community costs are excluded from the CBA the construction cost has to increase with 81 percent, to achieve the same result. This shows that there is some margin, regarding the construction cost, before an alternation in the result of the most socioeconomically favourable corridor occurs. It should be noted that this analysis only considers differences between the two corridors. The scenario with the second highest net benefit cost ratio can be found in corridor four, with speed limit 110 km/h. The difference between alignments within one corridor is however small. The total construction cost has to increase with 21 percent in order for alignment 19 (corridor four, 110 km/h) to become more favourable than alignment 11 (corridor four, 100 km/h). However, it is not likely that large cost errors between the alignments within a corridor exist.

The sensitivity analysis showed that the net benefit cost ratio is sensitive to the construction cost of bridges. But due to the large difference in bridge costs between the two corridors, the net benefit cost ratio without bridge costs are not a representative measurement. Due to this, the needed percentage of increased bridge cost in order for an alignment within corridor two to become the most beneficial was calculated. This indicated a large margin for bridge costs as the bridge cost can be increased with 500 percent before any alternation in which corridor is the most socioeconomically favourable. The influence of construction cost for bridges is thus not considered to be substantial for the result.

The costs for maintenance lie on the road authority (Sinha & Labi, 2011). In the CBA the maintenance costs have been considered as a benefit. This, since they are likely to decrease due to the construction of a new road. The maintenance cost per meter road has been calculated with data from the Swedish Transport Administration (Trafikverket, 2012g). As all other costs, this is only estimation and might not represent the reality. The data used to calculate the maintenance cost is however considered to be reliable and any error is probably not significant to the result of the CBA.

9.3.2 Costs for the road user

The road user costs included in the analysis are vehicle operating costs and time costs. Traffic safety costs are not included in the analysis. It should be noted that the costs used only applies for passenger cars. Trucks are excluded from the analysis. This will impose an error in the CBA, but since the same prerequisites apply for all alternatives the relation between alignments should not be affected substantially.

The fixed cost for a vehicle does not depend on mileage and will therefore not vary between the alternatives (VTPI, 2013). Such costs are therefore excluded from the CBA. Consequently, only costs regarding fuel, tires, service and depreciation are considered. These components are affected by fuel type, speed, curvatures etcetera (Sinha & Labi, 2011). The costs used in the CBA are however estimated with consideration to mileage only. This approach, as well as the usage of general values from the Swedish Transport Administration, is considered to be viable in this early analysis. Most of the input data regarding vehicle operating costs was obtained from the Swedish Transport Administration. The usage of other sources for estimation of tire and service cost is not considered to have a large effect on the result. This, since the cost per kilometre is unchanged between different alignments and the costs should not be so far from reality that the result from the CBA depends on it.

The unit value of time depends on the purpose of the trip (local/regional) and whether it is during business or private hours (Trafikverket, 2012e). Factors as vehicle type and delays can also be taken into account. Due to lack of data regarding division of travellers' purpose, one unit value for time has been used. As for vehicle operating costs, the margin of error due to the use of this value is not considered to have a large influence of the result of the CBA.

The accident costs are calculated by multiplying the unit accident cost with an estimated accident rate (Sinha & Labi, 2011). The benefit of a safer road has been excluded since no difference is expected between corridor two and four (WSP, 2013).It might however be a minor difference between alignments and corridors. The improvement from the current situation was given in number of lives saved per year. Thus, it would be necessary to estimate the value of a lost life in order to include the parameter in the analysis. To do this can be considered as impossible (Bångman, 2012). There is a risk that other differences in traffic safety costs are present between alignments, such as medical expenses and reparation costs, and thus missing in the analysis. These differences are however considered to be negligible and it is likely that their presence in the analysis would cause a greater uncertainty than their absence.

9.3.3 Community costs

The community costs included in the CBA are noise and emissions. Noise costs are normally not included in the CBA, if the investment does not involve noise measures specifically (Bångman, 2012). This is in agreement with (Sinha & Labi, 2011) who states that community costs usually are excluded from the CBA. The difference between the numbers of houses with equivalent levels above 55 dBA for corridor two and four was however considered to be substantial and have therefore been included in the analysis. Regarding emissions, only nitrogen oxides (NO_X), volatile organic compounds (VOC), particles, sulphur dioxide (SO_2) and carbon dioxide (CO_2) are considered. This is due to that these are the major emissions from traffic and have been given unit values by the Swedish Transport Administration. Corridor two passes just outside Äs and emissions might have a larger health impact here than in corridor four.

The valuation of the emissions and the amount of exhaust might however change during the lifetime of the road. As the climate is changing, harder requirements are put on the nations to limit the emissions. It is therefore likely that the cost for emissions will increase in the future, this as a means to limit the emissions. At the same time, the car fleet is changing and more environmentally friendly vehicles are promoted. There is a possibility that electric cars and hybrids will be more common. The yearly increase in traffic might therefore not necessarily imply that the emissions will increase at the same rate. Improved technique of the vehicles could pose a braking effect to the increase of emissions.

In the sensitivity analysis the influence of the community costs has been evaluated. It shows that the presence of community costs has an influence on the net benefit cost ratio. The ranking of the scenarios' maximum net benefit cost ratio is also affected by the community costs. It does however not have any impact on which scenario is the most beneficial. It should be noted that the number of houses which are subjected to high noise levels only are estimation. This cost can increase and decrease in both corridors. It might be more appropriate to exclude the community cost from the analysis and thus follow (Bångman, 2012) and (Sinha & Labi, 2011) recommendation. It is likely that a more reliable result will be obtained if these factors are omitted in the CBA. The costs do nevertheless fall on the community and not on any governmental institution. This can motivate their inclusion in the CBA, especially since their presence do not affect which scenario is the most socioeconomically favourable.

9.4 The most favourable alignment

From the CBA, six alignments were selected which generated the highest net benefit cost ratio in their scenario. The selected alignments would thus generate the highest benefit for each spent SEK. The net benefit cost ratio is however not giving information of how high the initial investment is, but rather indicates its relation to the benefits during the lifetime of the road. By selecting alignments based on the result from the CBA, only parameters with monetary values are taken into account. Intrusion into sensitive areas and other community costs need to be considered separately. An alignment with a high net benefit cost ratio might be less advantageous if analysed in a wider perspective.

9.4.1 Community costs without monetary values

In a CBA, identified effects have to be quantified and evaluated through monetary valuation (Bångman, 2012).This can be done for a large part of the effects related to the construction of a new road, but far from all. Consequently, some effects cannot be considered through the analysis. The recommendation is to describe these effects and state their size and influence (Bångman, 2012). Thus, it is not possible to solely rely on the result obtained from the CBA. This is a large uncertainty in the analysis since it can be difficult to decide how influential the described effects should be. Effects like these might not be critical within a corridor but are substantial in a comparison between the two corridors.

Intrusion into sensitive areas is usually not included in a CBA (Bångman, 2012). This, since a valuation would be necessary for each separate area, and no general valuation can be done. In this thesis, the areas are taken into account by measuring the amount of intrusion. There are no additional costs added due to the intrusion. Instead, intrusion is considered by a subjective valuation. Besides the intrusion into sensitive areas, there are other effects or potential risks which require consideration. The additional parameters which are mentioned in Chapter 5.4.4 are the water source Mo, emissions, barrier effects and disturbance during construction.

9.4.1.1 Intrusion into sensitive areas

All alignments within the corridors pass through sensitive areas. The areas were given a sensitivity level, see Chapter 6.1.6. These levels are used in order to evaluate the intrusions. Within corridor two, the largest intrusions were made into the naturally valuable area by Aspen and the landscape picture. These are both valued with severity level two. Within corridor four, the largest intrusions were made into cultural environment and the croft landscape, both having severity level three. As shown in Table 21 the least intrusion was caused by corridor two and speed limit 100 km/h. The largest intrusion was caused by corridor four and speed limit 110 km/h. It is difficult to determine how large influence the different sensitivity levels should be given. The analysis showed that areas with sensitivity level two and one have to be given unit costs that are three and six times higher than sensitivity level three in order for corridor four to become more beneficial regarding intrusion into sensitive areas. If this is representative cannot be answered in this thesis.

Calculations of how much the additional intrusion for the alignments in corridor four, compared to corridor two, have to be valuated to, have also been conducted. These shows that a unit value of 2 065 and 2 742 SEK/m^2 have to be implemented in order for corridor two to receive a higher net benefit cost ratio, with respectively without community costs included in the CBA. These unit costs are quite high and it can be questioned whether it is reasonable to have such a high value of the intrusions. The additional intrusion caused by the alignments in corridor four might therefore not be crucial to the determination of which alignment in the most beneficial.

9.4.1.2 The water source Mo

Corridor two is intersecting the water protection zone and its position is posing a risk to the water source. The large amount of heavy vehicles with hazardous goods is increasing the risks in case of a traffic accident. An alignment within corridor four would imply that the heavy vehicles would not have to cross the protection zone, hence reduce the risks. Both corridors are however passing close to Lake Aspen and there is a risk that hazardous goods could spread with the water systems. The crossing of the esker will also affect the groundwater. Since corridor two will not make a large cut through the esker, the consequences are considered to be moderate. Corridor four is causing a larger cut through the esker and will therefore affect the hydraulic conditions to a larger extent.

9.4.1.3 Emissions

The CBA include emissions caused within each corridor. The cost is calculated as a cost per kilometre for respective type of emission. The geographical position of the corridors and closeness to surrounding buildings is not considered in the analysis. There are however a difference of the effects of the emissions due to the surrounding environment. The geographical position differs between the corridors, where corridor two passes outside, yet close to Äs. The pollutions from corridor two would thereby affect the inhabitants to a larger extent than pollutions from corridor four. Corridor two is also intersecting the water protection zone, which might be affected by emissions. Corridor four is to a large extent passing through woodland with rich wildlife. The area is unbuilt and the emissions would not affect people as much as in corridor two. Pollution of the environment might occur and since the corridor passes close to Lake Aspen, there is a risk of pollutions being spread by the water systems. The difference between the original road alignment and both corridors are however implying an improvement regarding emissions for the inhabitants of Äs.

9.4.1.4 *Barrier effects*

A road construction could cause a barrier effect to several users of the environment. For corridor two, a road would be situated between Äs and Lake Aspen. Äs will thus be separated from the lake. A recreational area for swimming and fishing attracts the inhabitants to visit the site, why a safe passage is required. The road would cross the area with a bridge which enables people to reach the lake. Corridor four is passing through land areas which are unbuilt. Even though the environment is used for berry and mushroom picking, is it likely that a road within this corridor will not affect the area's inhabitants to as large extent as corridor two. A road within corridor four will however have a large effect on the wildlife and its movement patterns.

9.4.1.5 *Sensitivity to shutdowns and disturbance during construction*

Road 56 is currently sensitive to shutdowns. This, since there are no suitable alternative route to use in case road 56 would temporarily shut down. A new road construction would increase the opportunities of choosing an alternative route since the current road through Äs will remain. A large part of corridor two consists of a reconstruction of the current road alignment. The road's sensitivity to interruptions is hence larger for corridor two than for corridor four, which would use less of the current road. The disturbance during construction would also be larger for a road construction within corridor two. Since a part of the current road is used, the construction work will affect the existing traffic. The construction of a road within corridor four would have the advantage that the construction could be performed with less interference with existing traffic. It should be noted that only a part of the stretch between Bie and Stora Sundby is evaluated in this thesis and traffic disturbances due to reconstruction is likely before and after passing Äs.

9.4.2 The corridors fulfilment of the project specific goals

In Chapter 5.2.1, 14 goals are presented which has been developed for the reconstruction of road 56. Whether corridor two and four meet the goals is discussed below.

According to (WSP, 2013), both corridor two and four imply an improvement of traffic safety. The accident rate is equal for both corridors, the estimated number of lives saved each year are estimated to 0,22. The first goal is thereby fulfilled regardless choice of corridor. The transfer of heavy vehicles and through traffic through Äs will improve the safety for pedestrians and bicyclists in the settlement. Safe crossings at the new construction are not yet designed, but it is not judged as likely that there would be large differences between the corridors regarding safety for pedestrians and bicyclists.

Due to the new alignment outside Äs, higher speed limit can be applied on the stretch. The mobility between Norrköping and Gävle would thereby be improved, especially with overtaking fields implemented. Time savings are achieved both due to the higher speed limit and the somewhat shorter stretch. Project goal three and four are hence fulfilled by both corridors.

As stated in Chapter 5.4.4.2, reductions of noise levels for the inhabitants of Äs are achieved when much of the traffic is moved away from the settlement. Some disturbance will however still occur. If a road is constructed within corridor two, ten houses are estimated to be subjected to higher noise levels than accepted, and three houses if constructed within corridor four. Goal number five is thus fulfilled by both corridors, but to a larger extent by corridor four.

Goal number six is to preserve the mansion landscape around Äs. Corridor two is intersecting the cultural valuable environment and the landscape picture around the country house of Äs. As shown in Table 21, the largest intrusion by corridor two is made into valuable landscape. Corridor four is positioned further east and does not intersect the mansion landscape, thus meeting goal number six.

When setting up the model in Trimble Quantm, the valuable trees in corridor two had to be drawn and added manually, see Chapter 6.1.6.1. There is thus some uncertainty regarding the accuracy of the position of the trees. According to the estimated position in this thesis, all alignments within corridor two avoid the valuable trees. The oak alley in corridor four was predefined, the position is thus regarded as accurate. The alignments within corridor four are not causing interference with the trees. Both corridors can thus be regarded as fulfilling goal number seven. The uncertainty is however larger in corridor two.

Goal number eight states that consideration should be taken to the esker, fault-steep, ancient castle and field islets. The esker is affected by both corridors. Corridor four is however causing a larger impact since it cuts through the esker to a larger extent than corridor two. The fault-steep is affected by corridor two at the transition from woodland to the agricultural lowland. The ancient castle and the field islets have not been taken into account in this thesis. The ancient castle is situated outside of corridor two and the filed islets are neglected due to lack of information of their exact positions.

The protection zone of Mo water source is intersected by corridor two. The protection zone is already affected by the current road. Since a part of corridor two follow the current alignment, the impact on the water source is not improved. Corridor four implies that heavy traffic is moved away from the protection zone, thus reducing the negative impacts on it. Corridor two crosses the outlet of Lake Aspen. It is however crossed by a bridge to avoid negative impacts. Bridges are also constructed at the southern and eastern inlets of Lake Aspen which are crossed by corridor four. At the eastern inlet, there is however a mire which might be affected by the road construction.

Goal number ten states that consideration should be taken to the historical road network and the recreation in the area. Corridor two is affecting the availability to the lake for the inhabitants of Äs. The barrier effect that the road would impose is reduced by the construction of the bridge which would allow the inhabitants to reach the lake without crossing the road. Corridor four will cause a barrier effect to wildlife and users of the forest. The impact is however smaller than in corridor two. The historical road network would be affected in corridor four, especially in the croft landscape.

Goals number 11 and 12 states that the local and regional public transport should be maintained and that the project should lead to regional development. These subjects have not been included in this thesis and are thus also excluded from the discussion.

The average maintenance cost for corridor two during the road's life length is 18,695 mSEK. The average cost for corridor four is 14,967 mSEK. The maintenance costs for alignments within corridor four are thus lower than in corridor two.

Goal number 14 states that the project should be beneficial. The results of the net benefit cost ratio for the alignments within both corridors have shown that only corridor four has alignments that are socioeconomically beneficial.

9.4.3 Socioeconomic evaluation

The CBA provided the relation between cost and benefit for each alignment, the net benefit cost ratio. The CBA was then evaluated with a sensitivity analysis in Chapter 8.2, in order to see which aspects the result of the analysis is sensitive to. According to the net benefit cost ratio, an alignment within corridor four should be selected. This result is in accordance with the suggested corridor made by WSP (WSP, 2013).

If consideration is taken to the community costs without monetary values, corridor four might be more favourable as well. It will remove hazardous goods from entering the water protection zone of Mo; it is located further from Äs and will not create a direct barrier to the recreational area just outside Äs. The disturbance during the construction of the road is also likely to be smaller, since a shorter stretch needs to be reconstructed. As stated in Chapter 6.1.3, the alignments within corridor four tended to cross Lake Aspen. The lake was avoided by moving the border of the corridor from the lake. A distance of 30 meters from the shoreline was determined, hence not fulfilling the general, required distance of 100 meters for shoreline protection zones. An exemption is however likely to be given and 30 meters was judged to be sufficient. This distance should leave the lake intact and to move the corridor 100 meters inwards would alter the appearance of the corridor to a too large extent.

9.4.4 Selection of speed limit

The CBA conducted in Chapter 7.2 indicates that a geometric standard, corresponding to a speed limit of 100 km/h should be selected. A low speed limit could however be beneficial from a traffic safety perspective. Higher speeds cause both increased accident rate and severity, and no other factor is as significant as the speed (Odgen, 1996) (Trafikverket, 2011a). In addition, most vehicles using the road are allowed to travel with a speed of 80 km/h. According to (Odgen, 1996) the risk of being involved in a traffic accident increases when travelling at speeds above or below the traffic's average speed. It can nevertheless be questioned how large influence a speed limit of 100 km/h would have from this perspective. Most of the traffic can keep a speed limit of 100 km/h and the traffic's average speed will probably be close to this. Heavy trucks, which are restricted to a speed limit of 80 km/h can for simplicity be said to travel 10mph[21] slower than the average speed. According to Figure 9, the increased traffic accident rate should not be substantial.

When considering speed, the mobility has to be considered as well. Higher speed limits increase the mobility for the travellers and decrease the travel time. The travel time has

[21] 10 mph ~ 16 km/h

been considered in the CBA. But with a speed limit above 80 km/h, heavy trucks will impose a reduction of the mobility on a 1+1 road. Since the traffic lanes are separated from meeting traffic by a barrier, overtaking of slow-moving vehicles are not possible. Overtaking fields are thus crucial, especially is ascents where the trucks' speed decrease. There is a risk that queues are formed behind the trucks, resulting in narrow distances between cars and consequently increased accident risk. This might be solved by constructing overtaking fields on a longer part of the road, allowing the queues to dissipate.

In Table 1, several criteria are stated which should influence the design speed limit. The presence of pedestrians and bicyclists advocates a lower speed limit. The amount of heavy vehicles and hazardous goods would also imply that a lower speed limit should be set. However, another criterion states that the speed limit should be consistent. Since the adjoining parts of road 56 are likely to have a speed limit of 100 km/h, the same speed limit should also be set in the corridors. Additionally, corridor four, which is considered most favourable, passes through unbuilt area and interference with abutting developments is small. A higher speed limit could thus be applied.

10 Conclusion

The input data used in this thesis has to a large extent been the software Trimble Quantm's default values and early cost estimations from the basis calculation. This creates uncertainties in the result. The data is however considered to be sufficiently accurate to use in this early stage in the planning process. In addition, all scenarios have the same prerequisites and minor errors in the in data should not affect the result to a large extent. The robustness of the cost-benefit analysis is also shown with the result of the sensitivity analysis. This showed that the variation of the construction cost has some margin before the most socioeconomic favourable corridor alters.

In this thesis, Trimble Quantm has not managed large constrains well. It is therefore considered to be a more useful tool in an earlier stage in the planning process. In this thesis, the uncertainties in the input data and the deficiencies of the software are considered to be too large in order to receive a detailed design of the road's alignment. It is probably more suitable to use when finding corridors or for comparison between different corridors. To use Trimble Quantm together with a CBA in order to evaluate different options, considering corridors and speed limits, have proven to be useable. This application can be recommended for further use in other projects.

The result of this thesis indicates that an alignment within corridor four is most socioeconomically favourable and should therefore be selected. Corridor four has the highest average net benefit cost ratio, and conducts the alignments with the highest ratios. It is also more favourable regarding Mo water source, less emission in Äs due to the larger distance to the settlement, created barrier effects for the inhabitants, and disturbance during the construction. Both corridors are fulfilling most of the goals set for the project. Corridor four does however meet the goals to a slightly larger extent. The additional intrusion into sensitive areas in corridor four has to be valuated to a high cost before corridor two becomes more favourable, which might not be realistic.

The community costs are not recommended to be included in the CBA. This thesis has presented reasons to include as well as exclude the community costs. Although a more reliable result might be obtained if the community costs are excluded, the result does not depend on whether these costs are included or not.

Alignment 11 (corridor four, 100 km/h) is considered to be the most socioeconomically favourable and should therefore be implemented. A speed limit of 100 km/h should not imply a safety risk due to slower moving vehicles, such as heavy trucks. Together with the overtaking fields, placed in section 1/100 to 3/900, both mobility and safety should be sufficient.

References

Alm, L.-O., 2000. *Course Compendium: Road and Street Design.* Göteborg: Chalmers University of Technology.

Anderson, A. M., Hegeland, H., Mattsson, B. & Ohlsson, O., 1978. *Grundkurs i samhällsekonomi.* s.l.:Akademiförlaget.

Anderson, A. M., Holmberg, I. & Ohlsson, O., 1992. Vägsystemet, produktivitet och inkomster, modellskattningar. In: *Infrastruktur och samhällsekonomi.* Stockholm: Transportforskningsberedningen.

Anderstig, C. & Mattsson, L.-G., 1992. Från ruttval till regional utveckling - Flerdimensionell konsekvensbeskrivning av transportinvesteringar. In: *Infrastruktur och samhällsekonomi.* Stockholm: Transportforskningsberedningen.

Aruga, K., Sessions, J., Abdullah, A. & Chung, W., 2005. Simultaneous Optimization of Horizontal and Vertical Alignments of Forest Roads Using Tabu Search. *International Journal of Forest Engineering,* 16(2).

Aschauer, D. A., 1989. Is public expenditure productive?. *Journal of Monetary Economics,* pp. 177-200.

Bryman, A., 2008. *Social Research Methods.* Third edition ed. Oxford: Oxford University Press.

Bångman, G., 2012. *Introduktion till samhällsekonomisk analys 2012:220,* s.l.: Trafikverket.

Granhage, L., 2009. *Kompendium i vägbyggnad.* Göteborg: Chalmers University of Technology.

Hammarlund, Y., 1981. *Samhällsekonomi och byggande.* Lund: Studentlitteratur.

Hesselborn, P.-O., 1992. *Infrastruktur och samhällsekonomi.* Stockholm: Transportforskningsberedningen.

Holmström, N., 2007. *Företagsekonomi - från begrepp till beslut.* 5th edition ed. Stockholm: Bonnier Utbildning.

Huang, Y. H., 2010. *Pavement analysis and design.* Second edition ed. s.l.:Pearson.

Instant Interactive Information Europe Ab, 2009. *Bilen.* [Online] Available at: http://www.iii.se/privatekonomi/steg2/2-15_Bilen.shtml [Accessed 14 03 2014].

Jarvis, J. & Hooban, C., 1988. *Vlimits: An Expert System for Speed Zone Determination,* Melbourne, Australia: Australian Road Research Board.

Johansson, B., 1992. Samhällsekonomi, infrastruktur och transporter. In: *Infrastruktur och samhällsekonomi.* Stockholm: Transportforskningsberedningen.

Johansson, S., 2004. *Socio-Economic Impacts of road conditions on low volume roads,* s.l.: Roadex II Northern Periphery.

Johnsson, H. D., 1980. *Cross-over accidents on all-purpose dual carrageways,* Crowthorne, UK: Transport and Road Research Laboratory.

Kungliga Tekniska Högskolan, n.d. *Vägbank.* [Online] Available at: http://intra.kth.se/polopoly_fs/1.370702!/Menu/general/column-content/attachment/Bilaga%20Studie%201.pdf
[Accessed 10 03 2014].

Lay, M. G., 1986. *Handbook of Road Technology.* Second edition ed. London: Gordon and Breach.

Little, I. M. D., 1950. *A Critique of Welfare Economics.* Oxford: Clarendon Press.

Mellwing, D., 2011. *svensktnaringsliv.se.* [Online] Available at: http://www.svensktnaringsliv.se/fragor/naringslivet_2020/eftersatt-infrastruktur-hotar-tillvaxten_126618.html
[Accessed 22 01 2014].

Michelin, 2012. *Varför välja Michelin.* [Online] Available at: http://www.michelin.se/dack/dackskola/varfor-michelin-dack/dacket-som-haller
[Accessed 14 03 2014].

MSB, 2009. *Samhällets kostnader för vägtrafikolyckor,* Karlstad: Myndigheten för samhällskydd och beredskap.

MSB, 2011. *Samhällets kostnader för olyckor,* Karlstad: Myndigheten för samhällsskydd och beredskap.

Nilsson, J.-E.et al., 2009. *Infrastrukturpolitik på samhällsekonomisk grund,* s.l.: VTI.

Nordlöf, P., 2008. *Samhällsekonomi - Vad är alternativet?.* [Online] Available at: http://vianordica2008.vegagerdin.is/vetenskapligt_webb/Tisdag/Session4_sal3A/Nordlof.pdf
[Accessed 07 04 2014].

OCED, 1994. *Road maintenance and rehabilitation: funding and allocation strategies,* Paris: Organisation for Economic Co-operation and Development.

Odgen, K., 1996. *Safer Roads - A Guide to Road Safety Engineering.* Melbourne, Australia: Avebury Technical.

Pearce, D., 2002. An Intellectual History of Environmental Economics. *Annual Review of Energy and the Environment,* Volume 27, pp. 57-81.

Sektionen Utformning av vägar och gator, 2004. *Vägar och gators utformning: Linjeföring,* Borlänge: Vägverket.

Simpson, D. & Brown, M., 1988. A review of recent Department of Transport accident-based studies. *Journal of the Institution of Highways and Transportation,* Volume 35(2), pp. 26-28.

Sinha, K. C. & Labi, S., 2011. *Transportation Decision Making : Principles of Project Evaluation and Programming,* s.l.: Wiley.

Statens offentliga utredningar, 2009. *Effektiva transporter och samhällsbyggande - en ny struktur för sjö, luft, väg och järnväg,* s.l.: Näringsdepartementet.

Statistiska Centralbyrån, 2013a. *Personer och hushåll samt personer per hushåll 31 december 2012,* Stockholm: Statistiska Centralbyrån.

Statistiska Centralbyrån, 2013. *Transporter och kommunikationer,* s.l.: Statistiska Centralbyrån.

Svenska kommunförbundet, 1999. *Olycksboken,* Stockholm: Svenska kommunförbundet.

Trafikverket, 2011a. *Kunskapsbank Hastighet,* s.l.: Trafikverket.

Trafikverket, 2011b. *Om Drift och Underhåll.* [Online] Available at: http://www.trafikverket.se/Foretag/Bygga-och-underhalla/Vag/Drift-och-underhall/Om-drift-och-underhall/
[Accessed 24 01 2014].

Trafikverket, 2012a. *trafikverket.se.* [Online] Available at: http://www.trafikverket.se/Foretag/Planera-och-utreda/Planerings--och-analysmetoder/Samhallsekonomisk-analys-och-trafikanalys/
[Accessed 22 01 2014].

Trafikverket, 2012b. *Krav för vägar och gators utformning,* s.l.: Trafikverket.

Trafikverket, 2012c. *Tillsammans för nollvisionen,* Borlänge: Trafikverket.

Trafikverket, 2012d. *Analys av säkerhetsutvecklingen 2012,* s.l.: Trafikverket.

Trafikverket, 2012e. *Samhällsekonomiska principer och kalkylvärden för transportsektorn: ASEK 5,* s.l.: Trafikverket.

Trafikverket, 2012f. *Handbok för vägtrafikens luftföroreningar,* s.l.: Trafikverket.

Trafikverket, 2012g. *Samhällsekonomiska analyser i transportsektorn,* s.l.: Trafikverket.

Trafikverket, 2012. *Ny planeringsprocess för vägar och järnvägar,* s.l.: s.n.

Trafikverket, 2013a. *Vägar och gators utformning, VGU.* [Online] Available at: http://www.trafikverket.se/Foretag/Bygga-och-

underhalla/Vag/Utformning-av-vagar-och-gator/
[Accessed 08 02 2014].

Trafikverket, 2013b. *Säkra statligavägar*. [Online]
Available at: http://www.trafikverket.se/Foretag/Trafikera-och-transportera/Trafikera-vag/Sakerhet-pa-vag/Tillsammans-for-Nollvisionen/Prioriterade-insatsomraden1/Sakra-statliga-vagar/
[Accessed 23 01 2014].

Trafikverket, 2013c. *trafikverket.se.* [Online]
Available at: http://www.trafikverket.se/Privat/Miljo-och-halsa/Halsa/Buller-och-vibrationer/Halsopaverkan/
[Accessed 25 01 2014].

Trafikverket, 2013. *Från planering till byggande.* [Online]
Available at: http://www.trafikverket.se/Privat/Vagar-och-jarnvagar/Fran-planering-till-byggande/
[Accessed 24 04 2014].

Trimble, 2010. *User Guide Quantm Desktop, version 7.0.* s.l.:Trimble.

Trimble, 2011. *Trimble Alignment Planning Solution.* s.l.:Trimble.

Trimble, 2013. *Trimble Alignment Planning Solution: Road Alignment.* [Online]
Available at: http://www.trimble.com/alignment/road-alignment.aspx
[Accessed 06 02 2014].

Trimble, 2014. *About Trimbe: At a glance.* [Online]
Available at: http://www.trimble.com/Corporate/About_at_Glance.aspx
[Accessed 06 02 2014].

Walker, C. & Lines, C., 1991. *Accident Reductions from Trunk Road Imporvements,* Crowthorne, UK: Transport Research Laboratory.

Williams, B., 2008. Cost-benefit analysis. *Economic & Labour Market Review,* 2(12), pp. 67-70.

WSP, 2013. *Samrådshandling: Väg 56 delen förbi Äs,* Örebro: Trafikverket.

WSP, 2014. *TDOK 2011:192 Underlagskalkyl.* s.l.:Trafikverket.

VTPI, 2013. *Transportation Cost and Benefit Analysis II - Vehicle Costs,* s.l.: Victoria Transport Policy Institute.

VTT Technical Research Center of Finland, 2013. *Hastighetsbegränsing i de nordiska länderna.* [Online]
Available at: http://www.nvfnorden.org/library/Files/Utskott-och-tema/Trafiksakerhet/Seminarier/NTF_Bergen_2013/20%20Hastighetsbegr%C3%A4nsning%20Riikka%20Rajamaki.pdf
[Accessed 27 01 2014].

List of figures and tables

Appendix 1

In this Appendix the input data to Trimble Quantm and the cost-benefit analysis are presented. Various calculations used in order to receive the result are also presented.

Geometric parameters

The geometric parameters are mainly obtained from (Trafikverket, 2012b) and are presented in Table 30.

Table 30 Input data for geometric parameters in Trimble Quantm

Horizontal Alignment					Comment	Source
Velocity [km/h]		110	100	80	The different velocities included in the analysis	
Minimum horizontal radius[m]		900	700	400		Trafikverket 2012b
Super elevation [%]	4	-	-	-	Superelevation to minimun radius	Trafikverket 2012b
Stiffness	0,5	-	-	-	The alignments adamptment to the terrain	Trimble 2010
Transition type	Clothoid	-	-	-	Chlotoid is common in Sweden	
Length conversion	Linear	-	-	-		
Transition length		72	64	52	The transition length varies lineraly with the ratio of the radius at a point of specified the minimum horizontal radius	Trimble 2010
Minimum striaght		-	-	-	No straights are needed between two curves	
Back to back curves allowed	Yes				Curves can be back to back	
Vertical alignment						
Max gradient downhill [%]	-6	-	-	-		Trafikverket 2012b
Max gradient uphill [%]	6	-	-	-		Trafikverket 2012b
Sustained limits	6	-	-	-	Not a demand in Sweden and is therfore set to the maximum gradient	
Sight distance	0	192	160	107		Trafikverket 2012b
Eye level [m]	1,1	-	-	-		Trafikverket 2012b
Object level [m]	0,35	-	-	-		Trafikverket 2012b
Vertical curve type	Circular	-	-	-		
Minimum radius: convex [m]		9 000	6 000	3 000		Trafikverket 2012b
Minimum radius. concave [m]		5 500	4 500	2 500		Trafikverket 2012b
Straights: vertical minimum	0	-	-	-	No straights are needed between two curves	
Straights: back to back	Yes	-	-	-	Curves can be back to back	
Cross section						
Right side [m]	4,25	-	-	-		
Left side [m]	4,25	-	-	-		
Thickness (south of road 214) [mm]	545	-	-	-		Swedish table method
Thickness (north of road 214) [mm]	700	-	-	-		Swedish table method
Slope [%]	2,5	-	-	-	For pavement and shoulder	Trafikverket 2012b
Shoulder [m]	0,75	-	-	-		
Ditch width[m]	5	-	-	-		
Ditch depth[m]	1,5	-	-	-		

Cost parameters

In Table 31 and 32 the cost parameters used in Trimble Quantm are presented. Due to lack of data, Trimble Quantm's default values were used (Trimble, 2010), with the exception of bridge, tunnel and retaining wall costs.

Table 31 The different construction costs parameters in Trimble Quantm

Pavement and masstransport	Value	Comment	Source
Cost of pavement [SEK/m3]	1 689	Cost of placing and compacting one cubicmeter of material to a specific thickness	Trimble 2010
Haul [SEK/m3/km]	3	Transportation cost of ine cubic meter usuble material along the alignment	Trimble 2010
Dump [SEK/m3]	10	Cost of removal unusable or excess material	Trimble 2010
Borrow [SEK/m3]	91	Material purchasing cost and cost of transportation to construction site	Trimble 2010
Rate [SEK/m3]	10	Cost of placement and compaction	Trimble 2010
The fills maximum slope [%]	55		Trimble 2010
Step width [m]	6		Trimble 2010
Step height [m]	2		Trimble 2010
Culvert			
Construction cost [SEK/m]	958		Trimble 2010
Cost of portals [SEK]	1 596		Trimble 2010
Diamater [m]	1		Trimble 2010
Minimum cover [m]	0,75		Trimble 2010
Bridge			
Slope of abutment [%]	50		Jonas Oscarsson 2014
Construction cost [SEK/m2]	35 000		WSP 2014
Tunnel		In order to prevent construction of tunnels a large construction cost was set	
Construction cost [SEK/m]	318 683 000- 637 366 000	Cost per meter depend on length of tunnel	Own valuation
Cost of portal [SEK]	2 039 570 000		Own valuation

Table 32 Material parameters

Geology and Geotechnics					Comment	Source
Wall [SEK/m2]	1250				Cost of wall. Usually varies between 1000-1500 SEK/m2, average value is used.	Anders Kullingsjö, 2014
Slope	200				Allowed slope if no wall is used.	Anders Kullingsjö, 2014
Material	Clay	Till	Peat	Broken rock		
Reuse of material [%]	50	75	0	100	Percentage of material that can be used in the construction.	Trimble 2010, Lars O Johansson 2014
Compaction factor	0,9	0,95	1,5	1,1		Trimble 2010, Lars O Johansson 2014
Material cost [SEK/m3]	75/76	75/76	145/180	204/223	The cost of schakt and fill of the material for corridor two/corridor four.	Trafikverket 2014
Friction angle	30/24	34/28	30/24	45/38	Characteristic/design value	Lars O Johansson 2014
Maximum slope of material [%]	44	54	44	78	Design friction angle in percent.	
Thickness of layers [m]	6,5	3	5	Infinity	Expected thickness of layers in the area.	WSP 2013, SGU

Costs not included in Trimble Quantm

As mentioned, there are several costs related to a road investment which are not included in the calculations in Trimble Quantm. There are differences regarding these costs between the two corridors. In this calculation eventual differences between alignments within a corridor are neglected. It should be noted that the costs presented in Table 33 are early estimations.

Table 33 Cost parameters which are not included in Trimble Quantm [Source: (WSP, 2014)]

Project costs	Corridor 2	Corridor 4	Comment
Project administrative costs	7 000 000	9 000 000	
Investigation and planning	1 721 429	1 780 612	
Engineering design	900 000	11 000 000	
Land redemption	5 152 163	8 793 894	Cost of claimed woodland and agriculture
Environmental measures	8 498 367	6 273 265	Costs for noise measures, wild life passages, decontamination compensation measures and conformation measures
Transfer and termination	400 000	400 000	
Measures on the local road network and costs of junctions	3 927 551	3 658 164	
Archaeology/fieldwork	4 000 000	4 795 918	
Measures for electricity and telecommuting cables	1 500 000	750 000	
Temporary road structures	5 000 000	2 000 000	
Demolition of bituminous layers, 0-250 mm	164 500	35 000	
Drainage shaft	800 000	620 000	Costs for archaeological fieldwork
Wildlife fences	2 648 571	2 144 082	
Median barrier	4 392 000	4 200 000	
Road side barrier	504 000	984 000	
Barrier openings	120 000	160 000	
Termination of road side barriers	160 000	240 000	
Stormwater reservoir	1 010 204	1 010 204	
Infiltration retarding ditches	1 041 633	400 000	
Road signs	1 200 000	900 000	
KC-columns	544 000	800 000	
Reconstruction cost	17 453 375	0	
Vertical drains	0	67 500	
Bank piling	0	2 824 316	
Pressure bank/overloading	0	84 408	
Sum	**68 137 793**	**62 921 363**	

Since corridor two to a large part is a reconstruction, the cost for this have to be included in the CBA. Data regarding both structure and the layers costs have been taken from the basis calculation (WSP, 2014). The calculation is presented in Table 34.

Table 34 The costs for the reconstruction of the existing road

Layer	**Cost [SEK]**		
Wearing course, 50 mm [m2]	100		
Binding course 50 mm [m2]	100		
Bound base course 60 mm [m2]	120		
Unbound base course [m2]	40		
Subbase 550 mm [m3]	285		
New wearing and binding course	**Length [m]**	**Width [m]**	**Cost [SEK]**
North of Äs	1 400	9	4 340 000
South of Äs	3 100	7	2 520 000
Widening	**Length [m]**	**Width [m]**	**Cost [SEK]**
From 7 to ten meters	1 700	3	2 635 425
From 7 to 13,5 meters	1 400	6,5	4 702 425
From 9 to 13,5 meters	1 400	4,5	3 255 525
Sum			**17 453 375**

Maintenance cost calculation

The yearly maintenance cost per meter was calculated with Equation 7 for a meeting separated 1+1 road as well as 2+1 road. It is assumed that 2,8 kilometres of the road will have an overtaking field. This is based on the recommendation that an overtaking field should be between 1000 and 2500 meters. Equation 7 takes winter, coating and other maintenance into account (see index w-winter, c-coating and o-other). The values of the equation's different parameters and the result of the calculation are presented in Table 35.

$$K = (k_0^w \times k_1^w + k_0^c + k_1^c \times AADT^{k2c} + k_0^o + k_1^o \times AADT^{k2o}) \times SF \times PS \times K_{road} \quad (Eq\ 7)$$

Where
K – Maintenance cost [SEK/m/year]
K_{road}– Road construction type, depend on when the road is constructed
k_0^w – Cost SEK/m for winter maintenance
k_1^w– correction factor for number of lanes affecting the number of crossings and amount of road salt
k_0^c – Fixed cost (due to ageing, climate etc.) for coating maintenance.
k_1^c – Coefficient that gives the variable cost (due to studded tires, heavy traffic etc.) for coating when multiplied with $AADT^{k2c}$
k2c – The cost's dependence on AADT (1 means proportionality and 0.5 means proportionality to the square root)
k_0^o – Fixed costs which is not winter or coating maintenance (e.g. illumination, mowers bridge and tunnel)
k_1^o – coefficient that gives variable costs (e.g. road sign maintenance, bridge and tunnel) for other measures when multiplied with $AADT^{k2o}$
k2o - The cost's dependence on AADT (1 means proportionality and 0.5 means proportionality to the square root)
SF – Tax factor
PS – Production support

Table 35 Value of the parameters in Equation 7 in order to calculate the maintenance cost

Parameter	2+1	1+1	Comment
K_0^w	34,5	34,5	(2000<AADT<8000)
K_1^w	1,7	1	SEK/m for winter maintenance
k_0^c	18,38	13,78	Fixed cost for coating maintenance
k_1^c	0,2	0,13	Variable costs for coating
k2c	0,7	0,7	The cost's dependence on AADT
k_0^o	25,27	0,69	Fixed cost for other maintenance
k_1^o	0,69	0,4	Variable costs for other maintenance
k2o	0,5	0,5	The cost's dependence on AADT
AADT	4 000	4 000	Daily average traffic
K_{road}	1,3	1,3	Not yet built road
SF	1,3	1,3	Tax factor
PS	1,06	1,06	Production support
K	292,67	161,86	Yearly maintenance cost per meter

The total maintenance cost for an alignment was then calculated with Equation 8, where the length of the alignment is expressed in meters.

$$Cost_{maintenance} = (Length\ of\ alignment - 2800) \times K_{1+1} + 2800 \times K_{2+1}\ (Eq\ 8)$$

Road user and community costs

Table 36 presents the input data used in the CBA regarding vehicle operating, time, noise and emission costs.

Table 36 Input data for road user and community costs

Input data: road user costs		Price level year	Source
Fuel [SEK/vkm]	1,02	2010	Trafikverket, 2012g
Tires [SEK/tire]	780	2010	Trafikverket, 2012g
Tires [SEK/vkm]	0,0867	2012	Michelin, 2012
Service [SEK/vkm]	0,2	2009	Instant Interactive Information Europe AB, 2009
Depreciation [SEK/vkm]	0,64	2010	Trafikverket, 2012g
Travel time costs [SEK/h]	175	2010	Trafikverket, 2012g
Input data: community costs			
Noise [SEK/person/year]	3 694	2010	Trafikverket, 2012g
Noise [SEK/year] Corridor two	73 880	2010	Trafikverket, 2012g
Noise [SEK/year] Corridor four	22 164	2010	Trafikverket, 2012g

Emissions:			
NOX [gram/km]	0,29	2010	Trafikverket, 2012g
VOC [gram/km]	0,22	2010	Trafikverket, 2012g
Particles [gram/km]	0,0039	2010	Trafikverket, 2012g
SO2 [gram/km]	0,0004	2010	Trafikverket, 2012g
CO2 [gram/km]	350	2010	Trafikverket, 2012g
NOX [SEK/kg]	80	2010	Trafikverket, 2012g
VOC [SEK/kg]	40	2010	Trafikverket, 2012g
Particles [SEK/kg]	180	1997	Trafikverket, 2012g
SO2 [SEK/kg]	27	2010	Trafikverket, 2012g
CO2 [SEK/kg]	1,45	2010	Trafikverket, 2012g
NOX [SEK/km]	0,023	2010	Trafikverket, 2012g
VOC [SEK/km]	0,088	2010	Trafikverket, 2012g
Particles [SEK/km]	0,0007	1997	Trafikverket, 2012g
SO2 [SEK/km]	0,00001	2010	Trafikverket, 2012g
CO2 [SEK/km]	0,507	2010	Trafikverket, 2012g

The current situation

Table 37 shows the calculations of the current situation. The road user, maintenance and community costs for the current situation have been calculated in order to be able to calculate the benefit of a new road. The benefit of a new road is received by subtracting the costs for the new road from the current situation.

Table 37 Costs for road user and community in the current situation

Current situation				Total cost
Length [km]	4	3	0,7	
Speed limit [km/h]	90	70	50	
Travel time [h]	0,0444	0,0429	0,014	
Fuel cost [SEK]	149 329 713	111 997 285	26 132 700	287 459 698
Tire cost [SEK]	12 693 026	9 519 769	2 221 279	24 434 074
Service cost [SEK]	29 280 336	21 960 252	5 124 059	56 364 647
Loss in value [SEK]	93 697 075	70 272 806	16 396 988	180 366 869
Time cost [SEK]	284 507 264	274 346 290	89 619 788	648 473 342
Maintanence cost [SEK]	12 814 453	9 610 840	2 242 529	24 667 822
Emissions [SEK]	90 580 183	67 935 137	15 851 532	174 366 852
Noise [SEK]	5 264 244	5 849 161	5 849 161	16 962 566
Total cost				1 413 095 870
Total cost without community costs				1 221 766 452

Discounting

Costs regarding maintenance, travel time, vehicle operating, noise and emissions occur during the road's whole lifetime and have to be discounted to a present value. Due to traffic increase (1,3 percent per year) the costs for time, vehicle operating and emissions will increase throughout the years. The traffic is assumed to increase exponentially; the traffic year t can be calculated with Equation 9. The discounted total cost per kilometre or hour during the roads lifetime can then be calculated with Equation 10. The discount rate s is set to 0,04 in accordance with the Swedish Transport Administration. The result of the calculations is presented in Table 38. The total cost for time, vehicle operating and emissions can then be used during evaluation of the alignments in the CBA by multiplying the total cost per kilometre or hour with the alignments length respectively travel time.

$$Traffic_{year\ t} = AADT_{year\ 1} \times 1{,}013^{t-1}\ (Eq\ 9)$$

$$Total\ cost = \sum_{t=0}^{39} \frac{Traffic_{yeat\ t} \times \frac{Cost}{km\ or\ h}}{(1+s)^t}\ (Eq\ 10)$$

Table 38 Results from calculation of total traffic and total cost per kilometre or hour for vehicle operating costs, time and emissions.

Year	Discount factor	AADT for year t	Total traffic year t	Fuel cost [total SEK/km]	Tire cost [total SEK/km]	Service cost [total SEK/km]	Loss of value [total SEK/km]	Time cost [total SEK/h]	Emissions [total SEK/km]
1	1,00	4 000	1 460 000	1 489 200	126 582	292 000	934 400	255 354 000	903 317
2	1,04	4 052	1 478 980	1 450 538	123 296	284 419	910 142	248 724 617	879 865
3	1,08	4 105	1 498 207	1 412 880	120 095	277 035	886 513	242 267 344	857 022
4	1,12	4 158	1 517 683	1 376 199	116 977	269 843	863 498	235 977 711	834 773
5	1,17	4 212	1 537 413	1 340 471	113 940	262 837	841 080	229 851 366	813 101
6	1,22	4 267	1 557 400	1 305 670	110 982	256 014	819 244	223 884 071	791 992
7	1,27	4 322	1 577 646	1 271 773	108 101	249 367	797 975	218 071 696	771 430
8	1,32	4 379	1 598 155	1 238 756	105 294	242 893	777 259	212 410 219	751 403
9	1,37	4 435	1 618 931	1 206 596	102 561	236 587	757 080	206 895 723	731 895
10	1,42	4 493	1 639 977	1 175 271	99 898	230 445	737 425	201 524 392	712 894
11	1,48	4 551	1 661 297	1 144 759	97 305	224 463	718 280	196 292 509	694 386
12	1,54	4 611	1 682 894	1 115 039	94 778	218 635	699 633	191 196 453	676 359
13	1,60	4 671	1 704 772	1 086 091	92 318	212 959	681 469	186 232 699	658 800
14	1,67	4 731	1 726 934	1 057 895	89 921	207 430	663 777	181 397 812	641 696
15	1,73	4 793	1 749 384	1 030 430	87 587	202 045	646 544	176 688 446	625 037
16	1,80	4 855	1 772 126	1 003 678	85 313	196 800	629 759	172 101 342	608 810
17	1,87	4 918	1 795 163	977 621	83 098	191 690	613 410	167 633 326	593 004
18	1,95	4 982	1 818 501	952 241	80 940	186 714	597 484	163 281 307	577 609
19	2,03	5 047	1 842 141	927 519	78 839	181 867	581 973	159 042 273	562 613
20	2,11	5 113	1 866 089	903 439	76 792	177 145	566 864	154 913 291	548 007
21	2,19	5 179	1 890 348	879 985	74 799	172 546	552 147	150 891 504	533 780
22	2,28	5 246	1 914 923	857 139	72 857	168 066	537 813	146 974 128	519 922
23	2,37	5 315	1 939 817	834 886	70 965	163 703	523 850	143 158 454	506 424
24	2,46	5 384	1 965 034	813 211	69 123	159 453	510 250	139 441 840	493 277
25	2,56	5 454	1 990 580	792 099	67 328	155 314	497 003	135 821 715	480 470
26	2,67	5 525	2 016 457	771 535	65 580	151 281	484 100	132 295 575	467 997
27	2,77	5 596	2 042 671	751 505	63 878	147 354	471 532	128 860 978	455 847
28	2,88	5 669	2 069 226	731 995	62 220	143 528	459 291	125 515 549	444 012
29	3,00	5 743	2 096 126	712 991	60 604	139 802	447 367	122 256 972	432 485
30	3,12	5 817	2 123 375	694 481	59 031	136 173	435 753	119 082 993	421 257
31	3,24	5 893	2 150 979	676 451	57 498	132 637	424 440	115 991 415	410 320
32	3,37	5 970	2 178 942	658 889	56 006	129 194	413 421	112 980 100	399 668
33	3,51	6 047	2 207 268	641 783	54 552	125 840	402 688	110 046 962	389 292
34	3,65	6 126	2 235 963	625 122	53 135	122 573	392 233	107 189 974	379 185
35	3,79	6 206	2 265 030	608 893	51 756	119 391	382 050	104 407 157	369 341
36	3,95	6 286	2 294 476	593 085	50 412	116 291	372 132	101 696 587	359 752
37	4,10	6 368	2 324 304	577 687	49 103	113 272	362 470	99 056 387	350 413
38	4,27	6 451	2 354 520	562 690	47 829	110 331	353 060	96 484 731	341 315
39	4,44	6 535	2 385 128	548 081	46 587	107 467	343 894	93 979 839	332 454
40	4,62	6 620	2 416 135	533 852	45 377	104 677	334 966	91 539 978	323 823
Totalt:		**208 123**	**75 964 993**	**37 332 428**	**3 173 256**	**7 320 084**	**23 424 269**	**6 401 413 434**	**22 645 046**

Maintenance and noise costs are considered to be fixed throughout the roads lifetime, i.e. not change from one year to another. The present value of the cost is then calculated as a uniform series (instead of single series used above). The total cost (per meter in the case of maintenance) is calculated by multiplying the cost year one with the discount factor, see Equation 11.

$$Total\ cost = Cost_{year\ 1} \times \frac{(1+s)^t - 1}{s \times (1+s)^t}\ (Eq\ 11)$$

Appendix 2

In this appendix, figures regarding the area around Äs are presented. Figure 43 shows some of the locations presented in the report. Figure 44 presents sensitive areas, which have to be taken into consideration when choosing the most socioeconomically favourable road alignment.

Figure 43 Locations of interest in the investigated area [Taken from (WSP, 2013)]

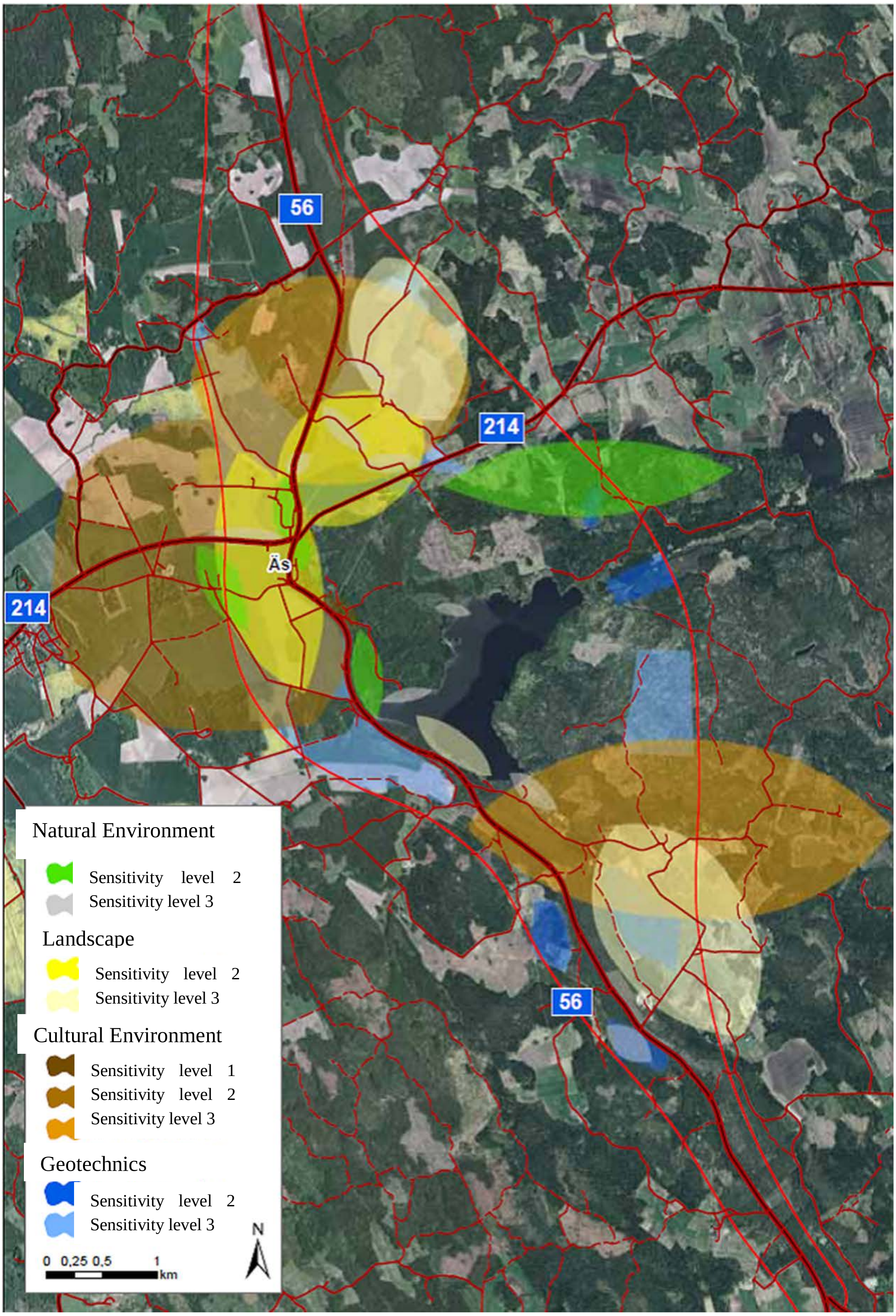

Figure 44 Sensitive areas regarding natural environment, landscape, cultural environment and geotechnics [Taken from (WSP, 2013)]

Appendix 3

In this appendix the location of objects considered in the evaluation of natural and cultural environment can be seen in Figure 45 respectively Figure 46.

Figure 45 Location of naturally valuable environment [Inspired by (WSP, 2013)]

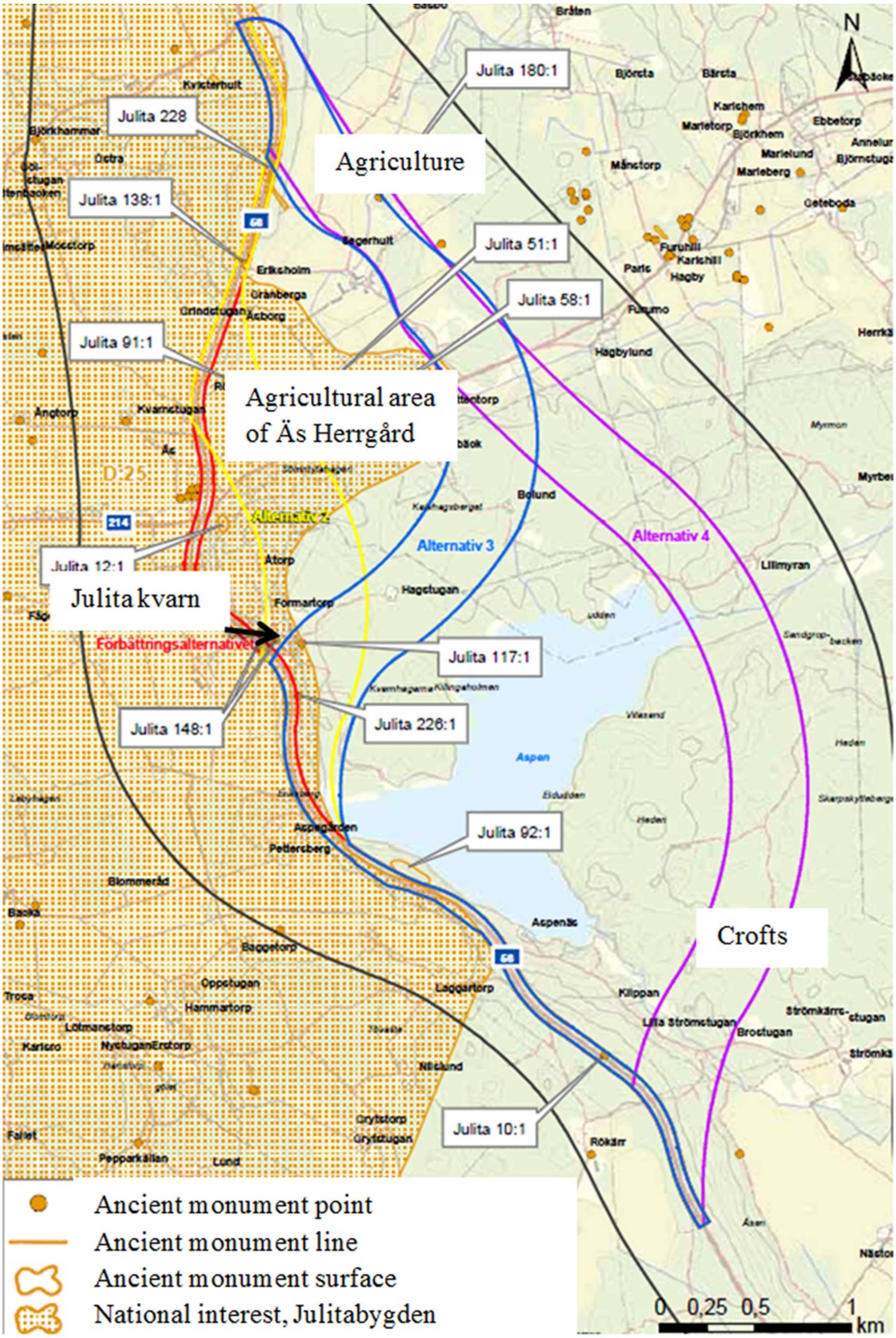

Figure 46 Location of culturally valuable environment [Inspired by (WSP, 2013)]

Appendix 4

Tables 39 to 44 below show the CBA calculus. There is one table for each scenario. The most socioeconomically favourable alignment for each scenario is highlighted. The highest net benefit cost ratios are made bold. The result of the sensitivity analysis, regarding net benefit cost ratio without community costs and bridge costs, for all 150 alignments are also presented.

Table 39 Corridor alternative two, 80 km/h

Alignment	1	2	3	4	5	6	7	8	9	10	11	12	13
Data from Trimble Quantm													
Construction cost [SEK]	79 179 520	126 000 731	107 042 510	103 192 717	149 392 087	141 938 108	160 435 822	116 607 510	163 427 041	96 231 423	125 812 263	116 281 695	90 926 178
Bridge cost [SEK]	45 980 640	70 647 983	61 713 270	63 417 905	114 660 951	90 096 780	104 891 542	61 765 514	108 968 109	58 435 775	85 079 791	60 673 571	38 893 318
Length [km]	2,872	2,869	2,871	2,879	2,887	2,873	2,872	2,872	2,873	2,896	2,876	2,867	2,870
Data from basis calculation													
Project administative costs	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000
Investigation and planning	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429
Engineering design	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000
Land redemption	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163
Environmental measures	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367
Transfer and termination	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000
Measures on the local road network and costs of junctions	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551
Archeology/fieldwork	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000
Measures for electricity and telecommuting cables	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000
Temporary road structures	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000
Demolition of bituminous layers, 0-250 mm	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500
Drainage shaft	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000
Wildlife fences	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571
Median barrier	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000
Road side barrier	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000
Barrier openings	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000
Termination of road side barriers	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000
Stormwater reservoir	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204
Infiltration retarding ditches	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633
Road signs	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000
KC-columns	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000
Reconstruction cost	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375
Total cost													
Total Construction cost	129 863 938	176 685 149	157 726 928	153 877 135	200 076 505	192 622 526	211 120 240	167 291 928	214 111 459	146 915 841	176 496 681	166 966 113	141 610 596
Total construction cost without bridge	83 883 298	106 037 166	96 013 658	90 459 230	85 415 554	102 525 746	106 228 698	105 526 414	105 143 350	88 480 066	91 416 890	106 292 542	102 717 278
Road user, maintenance and community costs													
Travel time [h]	0,0922	0,0921	0,0921	0,0922	0,0923	0,0922	0,0922	0,0922	0,0922	0,0925	0,0922	0,0921	0,0921
Fuel cost [SEK]	275 214 661	275 102 664	275 177 329	275 475 988	275 774 648	275 251 994	275 214 661	275 214 661	275 251 994	276 110 639	275 363 991	275 027 999	275 139 996
Tire cost [SEK]	23 393 246	23 383 726	23 390 073	23 415 459	23 440 845	23 396 419	23 393 246	23 393 246	23 396 419	23 469 404	23 405 939	23 377 380	23 386 900
Service cost [SEK]	53 963 659	53 941 699	53 956 339	54 014 900	54 073 460	53 970 979	53 963 659	53 963 659	53 970 979	54 139 341	53 992 939	53 927 059	53 949 019
Loss in value [SEK]	172 683 709	172 613 436	172 660 285	172 847 679	173 035 073	172 707 133	172 683 709	172 683 709	172 707 133	173 245 891	172 777 406	172 566 588	172 636 860
Time cost [SEK]	589 890 248	589 650 195	589 810 230	590 450 372	591 090 513	589 970 266	589 890 248	589 890 248	589 970 266	591 810 672	590 210 319	589 490 160	589 730 213
Maintanence cost [SEK]	18 670 003	18 660 392	18 666 800	18 692 428	18 718 057	18 673 207	18 670 003	18 670 003	18 673 207	18 746 890	18 682 818	18 653 985	18 663 596
Emissions [SEK]	166 939 277	166 871 342	166 916 632	167 097 793	167 278 953	166 961 922	166 939 277	166 939 277	166 961 922	167 482 759	167 029 858	166 826 052	166 893 987
Noise [SEK]	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290
Benefit													
Total benefit	110 878 776	111 410 125	111 055 892	109 638 961	108 222 030	110 701 660	110 878 776	110 878 776	110 701 660	106 627 983	110 170 310	111 764 358	111 233 009
Benefit without community costs	87 950 925	88 414 339	88 105 397	86 869 626	85 633 856	87 796 454	87 950 925	87 950 925	87 796 454	84 243 614	87 333 040	88 723 282	88 259 868
Socioeconomic evaluation													
Net present value (NPV)	- 18 985 162	- 65 275 024	- 46 671 036	- 44 238 174	- 91 854 475	- 81 920 867	- 100 241 464	- 56 413 152	- 103 409 800	- 40 287 858	- 66 326 371	- 55 201 755	- 30 377 587
Cost benefit ratio	0,85	0,63	0,70	0,71	0,54	0,57	0,53	0,66	0,52	0,73	0,62	0,67	0,79
Net benefit cost ratio	**-0,15**	-0,37	-0,30	-0,29	-0,46	-0,43	-0,47	-0,34	-0,48	-0,27	-0,38	-0,33	-0,21
Net benefit cost ratio without community costs	**-0,32**	-0,50	-0,44	-0,44	-0,57	-0,54	-0,58	-0,47	-0,59	-0,43	-0,51	-0,47	-0,38
Net benefit cost ratio without bridge	**0,32**	0,05	0,16	0,21	0,27	0,08	0,04	0,05	0,05	0,21	0,21	0,05	0,08

Alignment	14	15	16	17	18	19	20	21	22	23	24	25
Data from Trimble Quantm												
Construction cost [SEK]	103 399 955	120 361 773	133 472 266	104 704 160	98 682 585	88 009 912	131 687 954	118 956 695	120 064 388	99 644 459	102 815 910	115 621 995
Bridge cost [SEK]	52 835 507	68 328 913	78 183 362	58 544 948	48 373 513	38 466 968	80 485 066	63 220 883	62 413 256	47 356 223	47 207 786	57 651 643
Length [km]	2,873	2,867	2,873	2,868	2,872	2,872	2,874	2,869	2,877	2,870	2,870	2,871
Data from basis calculation												
Project administative costs	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000
Investigation and planning	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429
Engineering design	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000
Land redemption	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163
Environmental measures	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367
Transfer and termination	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000
Measures on the local road network and costs of junctions	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551
Archeology/fieldwork	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000
Measures for electricity and telecommuting cables	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000
Temporary road structures	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000
Demolition of bituminous layers, 0-250 mm	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500
Drainage shaft	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000
Wildlife fences	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571
Median barrier	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000
Road side barrier	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000
Barrier openings	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000
Termination of road side barriers	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000
Stormwater reservoir	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204
Infiltration retarding ditches	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633
Road signs	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000
KC-columns	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000
Reconstruction cost	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375
Total cost												
Total Construction cost	154 084 373	171 046 191	184 156 684	155 388 578	149 367 003	138 694 330	182 372 372	169 641 113	170 748 806	150 328 877	153 500 328	166 306 413
Total construction cost without bridge	101 248 866	102 717 278	105 973 322	96 843 630	100 993 490	100 227 362	101 887 306	106 420 230	108 335 550	102 972 654	106 292 542	108 654 770
Road user, maintenance and community costs												
Travel time [h]	0,0922	0,0921	0,0922	0,0921	0,0922	0,0922	0,0922	0,0921	0,0922	0,0921	0,0921	0,0921
Fuel cost [SEK]	275 251 994	275 027 999	275 251 994	275 065 331	275 214 661	275 214 661	275 289 326	275 102 664	275 401 323	275 139 996	275 139 996	275 177 329
Tire cost [SEK]	23 396 419	23 377 380	23 396 419	23 380 553	23 393 246	23 393 246	23 399 593	23 383 726	23 409 112	23 386 900	23 386 900	23 390 073
Service cost [SEK]	53 970 979	53 927 059	53 970 979	53 934 379	53 963 659	53 963 659	53 978 299	53 941 699	54 000 259	53 949 019	53 949 019	53 956 339
Loss in value [SEK]	172 707 133	172 566 588	172 707 133	172 590 012	172 683 709	172 683 709	172 730 557	172 613 436	172 800 830	172 636 860	172 636 860	172 660 285
Time cost [SEK]	589 970 266	589 490 160	589 970 266	589 570 177	589 890 248	589 890 248	590 050 283	589 650 195	590 290 336	589 730 213	589 730 213	589 810 230
Maintanence cost [SEK]	18 673 207	18 653 985	18 673 207	18 657 189	18 670 003	18 670 003	18 676 410	18 660 392	18 686 021	18 663 596	18 663 596	18 666 800
Emissions [SEK]	166 961 922	166 826 052	166 961 922	166 848 697	166 939 277	166 939 277	166 984 568	166 871 342	167 052 503	166 893 987	166 893 987	166 916 632
Noise [SEK]	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290
Benefit												
Total benefit	110 701 660	111 764 358	110 701 660	111 587 241	110 878 776	110 878 776	110 524 543	111 410 125	109 993 194	111 233 009	111 233 009	111 055 892
Benefit without community costs	87 796 454	88 723 282	87 796 454	88 568 811	87 950 925	87 950 925	87 641 983	88 414 339	87 178 569	88 259 868	88 259 868	88 105 397
Socioeconomic evaluation												
Net present value (NPV)	- 43 382 713	- 59 281 834	- 73 455 025	- 43 801 337	- 38 488 228	- 27 815 554	- 71 847 829	- 58 230 988	- 60 755 612	- 39 095 869	- 42 267 319	- 55 250 521
Cost benefit ratio	0,72	0,65	0,60	0,72	0,74	0,80	0,61	0,66	0,64	0,74	0,72	0,67
Net benefit cost ratio	-0,28	-0,35	-0,40	-0,28	-0,26	-0,20	-0,39	-0,34	-0,36	-0,26	-0,28	-0,33
Net benefit cost ratio without community costs	-0,43	-0,48	-0,52	-0,43	-0,41	-0,37	-0,52	-0,48	-0,49	-0,41	-0,43	-0,47
Net benefit cost ratio without bridge	0,09	0,09	0,04	0,15	0,10	0,11	0,08	0,05	0,02	0,08	0,05	0,02

Table 40 Corridor alternative two, 100 km/h

Alignment	1	2	3	4	5	6	7	8	9	10	11	12	13
Data from Trimble Quantm													
Construction cost [SEK]	109 687 448	104 365 316	118 842 302	93 993 101	99 295 449	109 528 331	113 643 303	94 936 633	97 216 909	127 151 933	126 675 793	151 051 221	129 576 524
Bridge cost [SEK]	75 682 048	52 304 516	69 078 302	52 140 301	44 746 449	63 273 331	84 741 903	50 723 233	43 305 909	75 346 333	65 938 193	98 990 421	79 110 724
Length [km]	2,885	2,888	2,882	2,881	2,888	2,882	2,886	2,884	2,887	2,884	2,87	2,876	2,882
Data from basis calculation													
Project administative costs	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000
Investigation and planning	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429
Engineering design	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000
Land redemption	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163
Environmental measures	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367
Transfer and termination	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000
Measures on the local road network and costs of junctions	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551
Archeology/fieldwork	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000
Measures for electricity and telecommuting cables	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000
Temporary road structures	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000
Demolition of bituminous layers, 0-250 mm	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500
Drainage shaft	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000
Wildlife fences	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571
Median barrier	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000
Road side barrier	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000
Barrier openings	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000
Termination of road side barriers	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000
Stormwater reservoir	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204
Infiltration retarding ditches	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633
Road signs	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000
KC-columns	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000
Reconstruction cost	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375
Total cost													
Total Construction cost	160 371 866	155 049 734	169 526 720	144 677 519	149 979 867	160 212 749	164 327 721	145 621 051	147 901 327	177 836 351	177 360 211	201 735 639	180 260 942
Total construction cost without bridge	84 689 818	102 745 218	100 448 418	92 537 218	105 233 418	96 939 418	79 585 818	94 897 818	104 595 418	102 490 018	111 422 018	102 745 218	101 150 218
Road user, maintenance and community costs													
Travel time [h]	0,0923	0,0924	0,0923	0,0923	0,0924	0,0923	0,0923	0,0923	0,0923	0,0923	0,0921	0,0922	0,0923
Fuel cost [SEK]	275 699 983	275 811 980	275 587 985	275 550 653	275 811 980	275 587 985	275 737 315	275 662 650	275 774 648	275 662 650	275 139 996	275 363 991	275 587 985
Tire cost [SEK]	23 434 499	23 444 018	23 424 979	23 421 806	23 444 018	23 424 979	23 437 672	23 431 325	23 440 845	23 431 325	23 386 900	23 405 939	23 424 979
Service cost [SEK]	54 058 820	54 080 780	54 036 860	54 029 540	54 080 780	54 036 860	54 066 140	54 051 500	54 073 460	54 051 500	53 949 019	53 992 939	54 036 860
Loss in value [SEK]	172 988 224	173 058 497	172 917 952	172 894 527	173 058 497	172 917 952	173 011 649	172 964 800	173 035 073	172 964 800	172 636 860	172 777 406	172 917 952
Time cost [SEK]	590 930 478	591 170 531	590 690 425	590 610 407	591 170 531	590 690 425	591 010 495	590 850 460	591 090 513	590 850 460	589 730 213	590 210 319	590 690 425
Maintanence cost [SEK]	18 711 650	18 721 261	18 702 039	18 698 836	18 721 261	18 702 039	18 714 854	18 708 446	18 718 057	18 708 446	18 663 596	18 682 818	18 702 039
Emissions [SEK]	167 233 663	167 301 598	167 165 728	167 143 083	167 301 598	167 165 728	167 256 308	167 211 018	167 278 953	167 211 018	166 893 987	167 029 858	167 165 728
Noise [SEK]	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290
Benefit													
Total benefit	108 576 263	108 044 914	109 107 612	109 284 729	108 044 914	109 107 612	108 399 147	108 753 380	108 222 030	108 753 380	111 233 009	110 170 310	109 107 612
Benefit without community costs	85 942 798	85 479 384	86 406 212	86 560 684	85 479 384	86 406 212	85 788 327	86 097 270	85 633 856	86 097 270	88 259 868	87 333 040	86 406 212
Socioeconomic evaluation													
Net present value (NPV)	- 51 795 603	- 47 004 820	- 60 419 107	- 35 392 791	- 41 934 953	- 51 105 137	- 55 928 575	- 36 867 671	- 39 679 296	- 69 082 971	- 66 127 203	- 91 565 329	- 71 153 330
Cost benefit ratio	0,68	0,70	0,64	0,76	0,72	0,68	0,66	0,75	0,73	0,61	0,63	0,55	0,61
Net benefit cost ratio	-0,32	-0,30	-0,36	**-0,24**	-0,28	-0,32	-0,34	-0,25	-0,27	-0,39	-0,37	-0,45	-0,39
Net benefit cost ratio without community costs	-0,46	-0,45	-0,49	**-0,40**	-0,43	-0,46	-0,48	-0,41	-0,42	-0,52	-0,50	-0,57	-0,52
Net benefit cost ratio without bridge	0,28	0,05	0,09	0,18	0,03	0,13	**0,36**	0,15	0,03	0,06	0,00	0,07	0,08

Alignment	14	15	16	17	18	19	20	21	22	23	24	25
Data from Trimble Quantm												
Construction cost [SEK]	94 824 728	173 090 548	100 038 336	107 362 895	129 420 469	139 684 613	98 939 955	115 880 450	144 798 630	117 742 262	126 957 087	93 502 856
Bridge cost [SEK]	45 762 528	117 520 748	48 424 136	58 747 295	74 743 869	95 088 413	53 960 955	67 392 450	91 206 630	72 061 462	77 512 087	43 675 056
Length [km]	2,885	2,888	2,874	2,879	2,887	2,884	2,884	2,885	2,885	2,886	2,888	3,009
Data from basis calculation												
Project administative costs	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000
Investigation and planning	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429
Engineering design	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000
Land redemption	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163
Environmental measures	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367
Transfer and termination	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000
Measures on the local road network and costs of junctions	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551
Archeology/fieldwork	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000
Measures for electricity and telecommuting cables	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000
Temporary road structures	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000
Demolition of bituminous layers, 0-250 mm	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500
Drainage shaft	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000
Wildlife fences	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571
Median barrier	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000
Road side barrier	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000
Barrier openings	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000
Termination of road side barriers	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000
Stormwater reservoir	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204
Infiltration retarding ditches	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633
Road signs	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000
KC-columns	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000
Reconstruction cost	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375
Total cost												
Total Construction cost	145 509 146	223 774 966	150 722 754	158 047 313	180 104 887	190 369 031	149 624 373	166 564 868	195 483 048	168 426 680	177 641 505	144 187 274
Total construction cost without bridge	99 746 618	106 254 218	102 298 618	99 300 018	105 361 018	95 280 618	95 663 418	99 172 418	104 276 418	96 365 218	100 129 418	100 512 218
Road user, maintenance and community costs												
Travel time [h]	0,0923	0,0924	0,0922	0,0922	0,0923	0,0923	0,0923	0,0923	0,0923	0,0923	0,0924	0,0939
Fuel cost [SEK]	275 699 983	275 811 980	275 289 326	275 475 988	275 774 648	275 662 650	275 662 650	275 699 983	275 699 983	275 737 315	275 811 980	280 329 204
Tire cost [SEK]	23 434 499	23 444 018	23 399 593	23 415 459	23 440 845	23 431 325	23 431 325	23 434 499	23 434 499	23 437 672	23 444 018	23 827 982
Service cost [SEK]	54 058 820	54 080 780	53 978 299	54 014 900	54 073 460	54 051 500	54 051 500	54 058 820	54 058 820	54 066 140	54 080 780	54 966 511
Loss in value [SEK]	172 988 224	173 058 497	172 730 557	172 847 679	173 035 073	172 964 800	172 964 800	172 988 224	172 988 224	173 011 649	173 058 497	175 892 834
Time cost [SEK]	590 930 478	591 170 531	590 050 283	590 450 372	591 090 513	590 850 460	590 850 460	590 930 478	590 930 478	591 010 495	591 170 531	600 852 668
Maintanence cost [SEK]	18 711 650	18 721 261	18 676 410	18 692 428	18 718 057	18 708 446	18 708 446	18 711 650	18 711 650	18 714 854	18 721 261	19 108 898
Emissions [SEK]	167 233 663	167 301 598	166 984 568	167 097 793	167 278 953	167 211 018	167 211 018	167 233 663	167 233 663	167 256 308	167 301 598	170 041 649
Noise [SEK]	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290
Benefit												
Total benefit	108 576 263	108 044 914	110 524 543	109 638 961	108 222 030	108 753 380	108 753 380	108 576 263	108 576 263	108 399 147	108 044 914	86 613 834
Benefit without community costs	85 942 798	85 479 384	87 641 983	86 869 626	85 633 856	86 097 270	86 097 270	85 942 798	85 942 798	85 788 327	85 479 384	66 788 355
Socioeconomic evaluation												
Net present value (NPV)	- 36 932 883	- 115 730 052	- 40 198 211	- 48 408 352	- 71 882 857	- 81 615 652	- 40 870 994	- 57 988 605	- 86 906 785	- 60 027 533	- 69 596 591	- 57 573 440
Cost benefit ratio	0,75	0,48	0,73	0,69	0,60	0,57	0,73	0,65	0,56	0,64	0,61	0,60
Net benefit cost ratio	-0,25	-0,52	-0,27	-0,31	-0,40	-0,43	-0,27	-0,35	-0,44	-0,36	-0,39	-0,40
Net benefit cost ratio without community costs	-0,41	-0,62	-0,42	-0,45	-0,52	-0,55	-0,42	-0,48	-0,56	-0,49	-0,52	-0,54
Net benefit cost ratio without bridge	0,09	0,02	0,08	0,10	0,03	0,14	0,14	0,09	0,04	0,12	0,08	-0,14

Table 41 Corridor alternative two, 110 km/h

Alignment	1	2	3	4	5	6	7	8	9	10	11	12	13
Data from Trimble Quantm													
Construction cost [SEK]	108 702 256	123 679 108	124 466 815	130 059 224	120 320 594	122 441 434	110 201 256	125 193 423	126 545 448	141 807 803	131 812 195	124 000 307	142 383 548
Bridge cost [SEK]	67 012 124	78 477 556	77 733 007	60 469 264	67 010 854	56 043 674	62 190 568	63 647 807	64 106 016	72 856 283	77 864 015	64 561 543	76 624 228
Length [km]	2,868	2,874	2,882	2,872	2,88	2,871	2,872	2,877	2,879	2,88	2,868	2,875	2,88
Data from basis calculation													
Project administative costs	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000
Investigation and planning	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429
Engineering design	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000
Land redemption	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163
Environmental measures	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367
Transfer and temination	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000
Measures on the local road network and costs of junctions	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551
Archeology/fieldwork	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000
Measures for electricity and telecommuting cables	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000
Temporary road structures	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000
Demolition of bituminous layers, 0-250 mm	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500
Drainage shaft	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000
Wildlife fences	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571
Median barrier	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000
Road side barrier	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000
Barrier openings	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000
Temination of road side barriers	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000
Stormwater reservoir	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204
Infiltration retarding ditches	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633
Road signs	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000
KC-columns	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000
Reconstruction cost	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375
Total cost													
Total Construction cost	159 386 674	174 363 526	175 151 233	180 743 642	171 005 012	173 125 852	160 885 674	175 877 841	177 229 866	192 492 221	182 496 613	174 684 725	193 067 966
Total construction cost without bridge	92 374 550	95 885 970	97 418 226	120 274 378	103 994 158	117 082 178	98 695 106	112 230 034	113 123 850	119 635 938	104 632 598	110 123 182	116 443 738
Road user, maintenance and community costs													
Travel time [h]	0,0921	0,0922	0,0923	0,0922	0,0923	0,0921	0,0922	0,0922	0,0922	0,0923	0,0921	0,0922	0,0923
Fuel cost [SEK]	275 065 331	275 289 326	275 587 985	275 214 661	275 513 321	275 177 329	275 214 661	275 401 323	275 475 988	275 513 321	275 065 331	275 326 658	275 513 321
Tire cost [SEK]	23 380 553	23 399 593	23 424 979	23 393 246	23 418 632	23 390 073	23 393 246	23 409 112	23 415 459	23 418 632	23 380 553	23 402 766	23 418 632
Service cost [SEK]	53 934 379	53 978 299	54 036 860	53 963 659	54 022 220	53 956 339	53 963 659	54 000 259	54 014 900	54 022 220	53 934 379	53 985 619	54 022 220
Loss in value [SEK]	172 590 012	172 730 557	172 917 952	172 683 709	172 871 103	172 660 285	172 683 709	172 800 830	172 847 679	172 871 103	172 590 012	172 753 982	172 871 103
Time cost [SEK]	589 570 177	590 050 283	590 690 425	589 890 248	590 530 389	589 810 230	589 890 248	590 290 336	590 450 372	590 530 389	589 570 177	590 130 301	590 530 389
Maintanence cost [SEK]	18 657 189	18 676 410	18 702 039	18 670 003	18 695 632	18 666 800	18 670 003	18 686 021	18 692 428	18 695 632	18 657 189	18 679 614	18 695 632
Emissions [SEK]	166 848 697	166 984 568	167 165 728	166 939 277	167 120 438	166 916 632	166 939 277	167 052 503	167 097 793	167 120 438	166 848 697	167 007 213	167 120 438
Noise [SEK]	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290
Benefit													
Total benefit	111 587 241	110 524 543	109 107 612	110 878 776	109 461 845	111 055 892	110 878 776	109 993 194	109 638 961	109 461 845	111 587 241	110 347 427	109 461 845
Benefit without community costs	88 568 811	87 641 983	86 406 212	87 950 925	86 715 155	88 105 397	87 950 925	87 178 569	86 869 626	86 715 155	88 568 811	87 487 511	86 715 155
Socioeconomic evaluation													
Net present value (NPV)	- 47 799 433	- 63 838 982	- 66 043 621	- 69 864 866	- 61 543 167	- 62 069 960	- 50 006 898	- 65 884 647	- 67 590 904	- 83 030 376	- 70 909 371	- 64 337 298	- 83 606 121
Cost benefit ratio	0,70	0,63	0,62	0,61	0,64	0,64	0,69	0,63	0,62	0,57	0,61	0,63	0,57
Net benefit cost ratio	-0,30	-0,37	-0,38	-0,39	-0,36	-0,36	-0,31	-0,37	-0,38	-0,43	-0,39	-0,37	-0,43
Net benefit cost ratio without community costs	-0,44	-0,50	-0,51	-0,51	-0,49	-0,49	-0,45	-0,50	-0,51	-0,55	-0,51	-0,50	-0,55
Net benefit cost ratio without bridge	0,21	0,15	0,12	-0,08	0,05	-0,05	0,12	-0,02	-0,03	-0,09	0,07	0,00	-0,06

Alignment	14	15	16	17	18	19	20	21	22	23	24	25
Data from Trimble Quantm												
Construction cost [SEK]	115 975 180	125 692 939	118 747 797	135 526 128	134 081 657	118 062 725	103 300 614	151 027 898	131 772 548	165 009 287	87 577 432	168 264 884
Bridge cost [SEK]	48 938 980	59 933 619	44 688 757	64 659 288	61 299 497	69 541 285	45 457 950	75 053 538	69 716 180	125 170 631	47 419 556	121 148 012
Length [km]	2,893	2,877	2,893	2,867	2,873	2,877	2,869	2,870	2,873	2,876	2,940	2,868
Data from basis calculation												
Project administative costs	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000	7 000 000
Investigation and planning	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429	1 721 429
Engineering design	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000
Land redemption	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163	5 152 163
Environmental measures	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367	8 498 367
Transfer and termination	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000
Measures on the local road network and costs of junctions	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551	3 927 551
Archeology/fieldwork	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000	4 000 000
Measures for electricity and telecommuting cables	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000
Temporary road structures	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000	5 000 000
Demolition of bituminous layers, 0-250 mm	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500	164 500
Drainage shaft	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000
Wildlife fences	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571	2 648 571
Median barrier	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000	4 392 000
Road side barrier	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000	504 000
Barrier openings	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000	120 000
Termination of road side barriers	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000
Stormwater reservoir	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204
Infiltration retarding ditches	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633	1 041 633
Road signs	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000
KC-columns	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000	544 000
Reconstruction cost	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375	17 453 375
Total cost												
Total Construction cost	166 659 598	176 377 357	169 432 215	186 210 546	184 766 075	168 747 143	153 985 032	201 712 316	182 456 966	215 693 705	138 261 850	218 949 302
Total construction cost without bridge	117 720 618	116 443 738	124 743 458	121 551 258	123 466 578	99 205 858	108 527 082	126 658 778	112 740 786	90 523 074	90 842 294	97 801 290
Road user, maintenance and community costs												
Travel time [h]	0,0924	0,0922	0,0924	0,0921	0,0922	0,0922	0,0921	0,0921	0,0922	0,0922	0,0930	0,0921
Fuel cost [SEK]	275 998 642	275 401 323	275 998 642	275 027 999	275 251 994	275 401 323	275 102 664	275 139 996	275 251 994	275 363 991	277 753 266	275 065 331
Tire cost [SEK]	23 459 885	23 409 112	23 459 885	23 377 380	23 396 419	23 409 112	23 383 726	23 386 900	23 396 419	23 405 939	23 609 028	23 380 553
Service cost [SEK]	54 117 381	54 000 259	54 117 381	53 927 059	53 970 979	54 000 259	53 941 699	53 949 019	53 970 979	53 992 939	54 461 425	53 934 379
Loss in value [SEK]	173 175 619	172 800 830	173 175 619	172 566 588	172 707 133	172 800 830	172 613 436	172 636 860	172 707 133	172 777 406	174 276 559	172 590 012
Time cost [SEK]	591 570 619	590 290 336	591 570 619	589 490 160	589 970 266	590 290 336	589 650 195	589 730 213	589 970 266	590 210 319	595 331 449	589 570 177
Maintanence cost [SEK]	18 737 279	18 686 021	18 737 279	18 653 985	18 673 207	18 686 021	18 660 392	18 663 596	18 673 207	18 682 818	18 887 849	18 657 189
Emissions [SEK]	167 414 823	167 052 503	167 414 823	166 826 052	166 961 922	167 052 503	166 871 342	166 893 987	166 961 922	167 029 858	168 479 141	166 848 697
Noise [SEK]	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290	1 462 290
Benefit												
Total benefit	107 159 332	109 993 194	107 159 332	111 764 358	110 701 660	109 993 194	111 410 125	111 233 009	110 701 660	110 170 310	98 834 863	111 587 241
Benefit without community costs	84 707 028	87 178 569	84 707 028	88 723 282	87 796 454	87 178 569	88 414 339	88 259 868	87 796 454	87 333 040	77 446 876	88 568 811
Socioeconomic evaluation												
Net present value (NPV)	- 59 500 266	- 66 384 163	- 62 272 883	- 74 446 188	- 74 064 416	- 58 753 949	- 42 574 907	- 90 479 307	- 71 755 306	- 105 523 395	- 39 426 987	- 107 362 061
Cost benefit ratio	0,64	0,62	0,63	0,60	0,60	0,65	0,72	0,55	0,61	0,51	0,71	0,51
Net benefit cost ratio	-0,36	-0,38	-0,37	-0,40	-0,40	-0,35	**-0,28**	-0,45	-0,39	-0,49	-0,29	-0,49
Net benefit cost ratio without community costs	-0,49	-0,51	-0,50	-0,52	-0,52	-0,48	**-0,43**	-0,56	-0,52	-0,60	-0,44	-0,60
Net benefit cost ratio without bridge	-0,09	-0,06	-0,14	-0,08	-0,10	0,11	0,03	-0,12	-0,02	**0,22**	0,09	0,14

Table 42 Corridor alternative four, 80 km/h

Alignment	1	2	3	4	5	6	7	8	9	10	11	12	13
Data from Trimble Quantm													
Construction cost [SEK]	165 839 898	145 900 778	134 928 548	154 178 791	127 620 325	133 064 942	150 059 576	127 105 104	115 973 903	160 427 842	129 946 801	138 083 080	126 079 131
Construction cost without bridge	146 942 074	121 831 590	111 242 424	140 771 551	105 211 081	112 187 954	123 245 096	102 142 100	96 629 171	137 890 910	109 644 409	118 546 816	101 116 127
Length [km]	7,197	7,198	7,196	7,196	7,197	7,2	7,196	7,196	7,198	7,197	7,197	7,198	7,196
Data from the basis calculation													
Project administative costs	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000
Investigation and planning	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612
Engineering design	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000
Land redemption	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894
Environmental measures	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265
Transfer and termination	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000
Measures on the local road network and costs of junctions	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164
Archeology/fieldwork	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918
Measures for electricity and telecommuting cables	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000
Temporary road structures	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000
Demolition of bituminous layers, 0-250 mm	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000
Drainage shaft	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000
Wildlife fences	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082
Median barrier	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000
Road side barrier	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000
Barrier openings	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000
Termination of road side barriers	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000
Stormwater reservoir	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204
Infiltration retarding ditches	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000
Road signs	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000
Vertical drains	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500
bank piling	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316
pressure bank/overloading	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408
Lime-cement columns	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000
Total cost													
Total construction cost	228 761 261	208 822 141	197 849 911	217 100 154	190 541 688	195 986 305	212 980 939	190 026 467	178 895 266	223 349 205	192 868 164	201 004 443	189 000 494
Total construction cost without bridge (SEK)	209 863 437	184 752 953	174 163 787	203 692 914	168 132 444	175 109 317	186 166 459	165 063 463	159 550 534	200 812 273	172 565 772	181 468 179	164 037 490
Road user, maintenance and community costs													
Travel time [h]	0,08996	0,08998	0,08995	0,08995	0,08996	0,09000	0,08995	0,08995	0,08998	0,08996	0,08996	0,08998	0,08995
Fuel cost [SEK]	268 681 486	268 718 819	268 644 154	268 644 154	268 681 486	268 793 483	268 644 154	268 644 154	268 718 819	268 681 486	268 681 486	268 718 819	268 644 154
Tire cost [SEK]	22 837 926	22 841 100	22 834 753	22 834 753	22 837 926	22 847 446	22 834 753	22 834 753	22 841 100	22 837 926	22 837 926	22 841 100	22 834 753
Service cost [SEK]	52 682 644	52 689 964	52 675 324	52 675 324	52 682 644	52 704 605	52 675 324	52 675 324	52 689 964	52 682 644	52 682 644	52 689 964	52 675 324
Loss in value [SEK]	168 584 462	168 607 886	168 561 038	168 561 038	168 584 462	168 654 735	168 561 038	168 561 038	168 607 886	168 584 462	168 584 462	168 607 886	168 561 038
Time cost [SEK]	575 887 156	575 967 174	575 807 138	575 807 138	575 887 156	576 127 209	575 807 138	575 807 138	575 967 174	575 887 156	575 887 156	575 967 174	575 807 138
Maintanence cost [SEK]	14 905 757	14 908 961	14 902 554	14 902 554	14 905 757	14 915 368	14 902 554	14 902 554	14 908 961	14 905 757	14 905 757	14 908 961	14 902 554
Emissions [SEK]	162 976 394	162 999 039	162 953 749	162 953 749	162 976 394	163 044 330	162 953 749	162 953 749	162 999 039	162 976 394	162 976 394	162 999 039	162 953 749
Noise [SEK]	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687
Benefit													
Total benefit	146 101 356	145 924 240	146 278 472	146 278 472	146 101 356	145 570 007	146 278 472	146 278 472	145 924 240	146 101 356	146 101 356	145 924 240	146 278 472
Benefit without community costs	118 187 020	118 032 548	118 341 491	118 341 491	118 187 020	117 723 606	118 341 491	118 341 491	118 032 548	118 187 020	118 187 020	118 032 548	118 341 491
Socioeconomic evaluation													
Net present value	- 82 659 904	- 62 897 901	- 51 571 439	- 70 821 682	- 44 440 332	- 50 416 298	- 66 702 467	- 43 747 995	- 32 971 026	- 77 247 849	- 46 766 808	- 55 080 203	- 42 722 022
Cost benefit ratio	0,64	0,70	0,74	0,67	0,77	0,74	0,69	0,77	0,82	0,65	0,76	0,73	0,77
Net benefit cost ratio	-0,36	-0,30	-0,26	-0,33	-0,23	-0,26	-0,31	-0,23	-0,18	-0,35	-0,24	-0,27	-0,23
Net benefit cost ratio without community costs	-0,48	-0,43	-0,40	-0,45	-0,38	-0,40	-0,44	-0,38	-0,34	-0,47	-0,39	-0,41	-0,37
Net benefit cost ratio without bridge	-0,30	-0,21	-0,16	-0,28	-0,13	-0,17	-0,21	-0,11	-0,09	-0,27	-0,15	-0,20	-0,11

Alignment	14	15	16	17	18	19	20	21	22	23	24	25
Data from Trimble Quantm												
Construction cost [SEK]	125 593 278	162 274 849	178 255 640	137 293 330	114 678 508	125 562 633	134 145 821	128 846 130	138 245 882	170 290 463	116 681 933	183 480 633
Construction cost without bridge	107 589 270	144 079 309	163 124 612	112 266 482	94 823 024	107 750 157	112 630 393	102 159 338	109 133 018	154 520 995	100 274 025	156 474 621
Length [km]	7,195	7,199	7,202	7,197	7,197	7,198	7,194	7,199	7,199	7,197	7,196	7,202
Data from the basis calculation												
Project administative costs	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000
Investigation and planning	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612
Engineering design	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000
Land redemption	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894
Environmental measures	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265
Transfer and termination	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000
Measures on the local road network and costs of junctions	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164
Archeology/fieldwork	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918
Measures for electricity and telecommuting cables	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000
Temporary road structures	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000
Demolition of bituminous layers, 0-250 mm	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000
Drainage shaft	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000
Wildlife fences	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082
Median barrier	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000
Road side barrier	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000
Barrier openings	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000
Termination of road side barriers	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000
Stormwater reservoir	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204
Infiltration retarding ditches	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000
Road signs	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000
Vertical drains	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500
bank piling	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316
pressure bank/overloading	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408
Lime-cement columns	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000
Total cost												
Total construction cost	188 514 641	225 196 212	241 177 003	200 214 693	177 599 871	188 483 996	197 067 184	191 767 493	201 167 245	233 211 826	179 603 296	246 401 996
Total construction cost without bridge (SEK)	170 510 633	207 000 672	226 045 975	175 187 845	157 744 387	170 671 520	175 551 756	165 080 701	172 054 381	217 442 358	163 195 388	219 395 984
Road user, maintenance and community costs												
Travel time [h]	0,08994	0,08999	0,09003	0,08996	0,08996	0,08998	0,08993	0,08999	0,08999	0,08996	0,08995	0,09003
Fuel cost [SEK]	268 606 821	268 756 151	268 868 148	268 681 486	268 681 486	268 718 819	268 569 489	268 756 151	268 756 151	268 681 486	268 644 154	268 868 148
Tire cost [SEK]	22 831 580	22 844 273	22 853 793	22 837 926	22 837 926	22 841 100	22 828 407	22 844 273	22 844 273	22 837 926	22 834 753	22 853 793
Service cost [SEK]	52 668 004	52 697 285	52 719 245	52 682 644	52 682 644	52 689 964	52 660 684	52 697 285	52 697 285	52 682 644	52 675 324	52 719 245
Loss in value [SEK]	168 537 613	168 631 310	168 701 583	168 584 462	168 584 462	168 607 886	168 514 189	168 631 310	168 631 310	168 584 462	168 561 038	168 701 583
Time cost [SEK]	575 727 121	576 047 191	576 287 244	575 887 156	575 887 156	575 967 174	575 647 103	576 047 191	576 047 191	575 887 156	575 807 138	576 287 244
Maintanence cost [SEK]	14 899 350	14 912 165	14 921 776	14 905 757	14 905 757	14 908 961	14 896 147	14 912 165	14 912 165	14 905 757	14 902 554	14 921 776
Emissions [SEK]	162 931 104	163 021 685	163 089 620	162 976 394	162 976 394	162 999 039	162 908 459	163 021 685	163 021 685	162 976 394	162 953 749	163 089 620
Noise [SEK]	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687
Benefit												
Total benefit	146 455 589	145 747 123	145 215 774	146 101 356	146 101 356	145 924 240	146 632 705	145 747 123	145 747 123	146 101 356	146 278 472	145 215 774
Benefit without community costs	118 495 962	117 878 077	117 414 663	118 187 020	118 187 020	118 032 548	118 650 433	117 878 077	117 878 077	118 187 020	118 341 491	117 414 663
Socioeconomic evaluation												
Net present value	- 42 059 053	- 79 449 088	- 95 961 229	- 54 113 337	- 31 498 515	- 42 559 757	- 50 434 478	- 46 020 370	- 55 420 122	- 87 110 470	- 33 324 823	- 101 186 222
Cost benefit ratio	0,78	0,65	0,60	0,73	0,82	0,77	0,74	0,76	0,72	0,63	0,81	0,59
Net benefit cost ratio	-0,22	-0,35	-0,40	-0,27	**-0,18**	-0,23	-0,26	-0,24	-0,28	-0,37	-0,19	-0,41
Net benefit cost ratio without community costs	-0,37	-0,48	-0,51	-0,41	**-0,33**	-0,37	-0,40	-0,39	-0,41	-0,49	-0,34	-0,52
Net benefit cost ratio without bridge	-0,14	-0,30	-0,36	-0,17	**-0,07**	-0,14	-0,16	-0,12	-0,15	-0,33	-0,10	-0,34

Table 43Corridor alternative four, 100 km/h

Alignment	1	2	3	4	5	6	7	8	9	10	11	12	13
Data from Trimble Quantm													
Construction cost [SEK]	256 297 907	176 949 392	146 475 374	158 456 339	156 987 927	160 349 952	207 795 621	144 406 190	174 896 169	175 389 683	125 482 190	141 379 984	139 778 138
Construction cost without bridge	239 443 091	152 433 296	117 617 886	141 729 211	127 747 375	130 470 960	183 343 369	115 037 950	159 765 141	156 491 859	99 433 838	111 628 680	108 877 642
Length [km]	7,224	7,224	7,218	7,214	7,216	7,214	7,22	7,219	7,216	7,223	7,213	7,22	7,22
Data from the basis calculation													
Project administative costs	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000
Investigation and planning	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612
Engineering design	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000
Land redemption	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894
Environmental measures	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265
Transfer and termination	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000
Measures on the local road network and costs of junctions	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164
Archeology/fieldwork	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918
Measures for electricity and telecommuting cables	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000
Temporary road structures	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000
Demolition of bituminous layers, 0-250 mm	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000
Drainage shaft	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000
Wildlife fences	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082
Median barrier	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000
Road side barrier	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000
Barrier openings	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000
Termination of road side barriers	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000
Stormwater reservoir	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204
Infiltration retarding ditches	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000
Road signs	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000
Vertical drains	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500
bank piling	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316
pressure bank/overloading	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408
Lime-cement columns	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000
Total cost													
Total construction cost	319 219 270	239 870 755	209 396 737	221 377 702	219 909 290	223 271 315	270 716 984	207 327 553	237 817 532	238 311 046	188 403 553	204 301 347	202 699 501
Total construction cost without bridge (SEK)	302 364 454	215 354 659	180 539 249	204 650 574	190 668 738	193 392 323	246 264 732	177 959 313	222 686 504	219 413 222	162 355 201	174 550 043	171 799 005
Road user, maintenance and community costs	0	0	0	0	0	0	0	0	0	0	0	0	0
Travel time [h]	269689461,8	269689461,8	269465467,2	269316137,5	269390802,3	269316137,5	269540132	269502799,6	269390802,3	269652129,3	269278805,1	269540132	269540132
Fuel cost [SEK]	22 923 604	22 923 604	22 904 565	22 891 872	22 898 218	22 891 872	22 910 911	22 907 738	22 898 218	22 920 431	22 888 698	22 910 911	22 910 911
Tire cost [SEK]	52 880 287	52 880 287	52 836 366	52 807 086	52 821 726	52 807 086	52 851 006	52 843 686	52 821 726	52 872 967	52 799 766	52 851 006	52 851 006
Service cost [SEK]	169 216 917	169 216 917	169 076 372	168 982 674	169 029 523	168 982 674	169 123 220	169 099 796	169 029 523	169 193 493	168 959 250	169 123 220	169 123 220
Loss in value [SEK]	462 438 106	462 438 106	462 054 022	461 797 965	461 925 993	461 797 965	462 182 050	462 118 036	461 925 993	462 374 092	461 733 951	462 182 050	462 182 050
Time cost [SEK]	14 992 255	14 992 255	14 973 033	14 960 219	14 966 626	14 960 219	14 979 441	14 976 237	14 966 626	14 989 051	14 957 015	14 979 441	14 979 441
Maintanence cost [SEK]	163 587 811	163 587 811	163 451 940	163 361 360	163 406 650	163 361 360	163 497 230	163 474 585	163 406 650	163 565 166	163 338 715	163 497 230	163 497 230
Emissions [SEK]	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687
Noise [SEK]													
Benefit	256 928 741	256 928 741	257 895 418	258 539 869	258 217 643	258 539 869	257 573 192	257 734 305	258 217 643	257 089 854	258 700 982	257 573 192	257 573 192
Total benefit	229 625 821	229 625 821	230 456 627	231 010 498	230 733 563	231 010 498	230 179 692	230 318 159	230 733 563	229 764 288	231 148 966	230 179 692	230 179 692
Benefit without community costs													
Socioeconomic evaluation	- 62 290 530	17 057 986	48 498 681	37 162 167	38 308 354	35 268 554	- 13 143 791	50 406 752	20 400 112	18 778 808	70 297 429	53 271 845	54 873 691
Net present value	1	1	1	1	1	1	1	1	1	1	1	1	1
Cost benefit ratio	-0,20	0,07	0,23	0,17	0,17	0,16	-0,05	0,24	0,09	0,08	0,37	0,26	0,27
Net benefit cost ratio	-0,28	-0,04	0,10	0,04	0,05	0,03	-0,15	0,11	-0,03	-0,04	**0,23**	0,13	0,14
Net benefit cost ratio without community costs	-0,15	0,19	0,43	0,26	0,35	0,34	0,05	0,45	0,16	0,17	**0,59**	0,48	0,50
Net benefit cost ratio without bridge	-0,16	0,19	0,42	0,26	0,35	0,33	0,04	0,44	0,15	0,16	**0,58**	0,47	0,49

Alignment	14	15	16	17	18	19	20	21	22	23	24	25
Data from Trimble Quantm												
Construction cost [SEK]	187 686 037	192 376 018	266 037 948	147 644 358	172 642 476	166 225 515	144 845 437	157 339 069	158 622 333	230 572 606	238 821 889	304 171 331
Construction cost without bridge	166 936 737	176 287 330	251 481 516	116 935 394	151 254 736	146 178 499	115 604 885	139 207 373	121 145 905	210 780 966	224 712 365	289 614 899
Length [km]	7,215	7,213	7,220	7,219	7,213	7,214	7,219	7,210	7,216	7,214	7,215	7,216
Data from the basis calculation												
Project administative costs	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000
Investigation and planning	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612
Engineering design	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000
Land redemption	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894
Environmental measures	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265
Transfer and termination	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000
Measures on the local road network and costs of junctions	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164
Archeology/fieldwork	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918
Measures for electricity and telecommuting cables	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000
Temporary road structures	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000
Demolition of bituminous layers, 0-250 mm	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000
Drainage shaft	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000
Wildlife fences	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082
Median barrier	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000
Road side barrier	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000
Barrier openings	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000
Termination of road side barriers	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000
Stormwater reservoir	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204
Infiltration retarding ditches	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000
Road signs	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000
Vertical drains	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500
bank piling	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316
pressure bank/overloading	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408
Lime-cement columns	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000
Total cost												
Total construction cost	250 607 400	255 297 381	328 959 311	210 565 721	235 563 839	229 146 878	207 766 800	220 260 432	221 543 696	293 493 969	301 743 252	367 092 694
Total construction cost without bridge (SEK)	229 858 100	239 208 693	314 402 879	179 856 757	214 176 099	209 099 862	178 526 248	202 128 736	184 067 268	273 702 329	287 633 728	352 536 262
Road user, maintenance and community costs	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07
Travel time [h]	269353469,9066	269278805,0501	269540132,0479	269502799,6197	269278805,0501	269316137,4784	269502799,6197	269166807,7653	269390802,3349	269316137,4784	269353469,9066	269390802,3349
Fuel cost [SEK]	22 895 045	22 888 698	22 910 911	22 907 738	22 888 698	22 891 872	22 907 738	22 879 179	22 898 218	22 891 872	22 895 045	22 898 218
Tire cost [SEK]	52 814 406	52 799 766	52 851 006	52 843 686	52 799 766	52 807 086	52 843 686	52 777 805	52 821 726	52 807 086	52 814 406	52 821 726
Service cost [SEK]	169 006 099	168 959 250	169 123 220	169 099 796	168 959 250	168 982 674	169 099 796	168 888 977	169 029 523	168 982 674	169 006 099	169 029 523
Loss in value [SEK]	461 861 979	461 733 951	462 182 050	462 118 036	461 733 951	461 797 965	462 118 036	461 541 909	461 925 993	461 797 965	461 861 979	461 925 993
Time cost [SEK]	14 963 423	14 957 015	14 979 441	14 976 237	14 957 015	14 960 219	14 976 237	14 947 404	14 966 626	14 960 219	14 963 423	14 966 626
Maintanence cost [SEK]	163 384 005	163 338 715	163 497 230	163 474 585	163 338 715	163 361 360	163 474 585	163 270 780	163 406 650	163 361 360	163 384 005	163 406 650
Emissions [SEK]	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687
Noise [SEK]												
Benefit	258 378 756	258 700 982	257 573 192	257 734 305	258 700 982	258 539 869	257 734 305	259 184 320	258 217 643	258 539 869	258 378 756	258 217 643
Total benefit	230 872 031	231 148 966	230 179 692	230 318 159	231 148 966	231 010 498	230 318 159	231 564 370	230 733 563	231 010 498	230 872 031	230 733 563
Benefit without community costs												
Socioeconomic evaluation	7 771 356	3 403 601	- 71 386 119	47 168 584	23 137 143	29 392 991	49 967 505	38 923 889	36 673 947	- 34 954 100	- 43 364 496	- 108 875 050
Net present value	1	1	1	1	1	1	1	1	1	1	1	1
Cost benefit ratio	0,03	0,01	-0,22	0,22	0,10	0,13	0,24	0,18	0,17	-0,12	-0,14	-0,30
Net benefit cost ratio	-0,08	-0,09	-0,30	0,09	-0,02	0,01	0,11	0,05	0,04	-0,21	-0,23	-0,37
Net benefit cost ratio without community costs	0,12	0,08	-0,18	0,43	0,21	0,24	0,44	0,28	0,40	-0,06	-0,10	-0,27
Net benefit cost ratio without bridge	0,12	0,08	-0,19	0,42	0,20	0,23	0,44	0,27	0,39	-0,06	-0,11	-0,27

Table 44 Corridor alternative four, 110 km/h

Alignment	1	2	3	4	5	6	7	8	9	10	11	12	13
Data from Trimble Quantm													
Construction cost [SEK]	255 176 168	414 592 083	334 564 905	339 749 038	194 901 686	208 206 776	235 629 051	368 727 191	370 470 771	215 376 457	240 123 030	201 213 304	415 416 947
Construction cost without bridge	231 745 420	402 653 255	309 346 525	325 064 918	175 748 486	187 649 008	208 942 259	351 170 091	355 212 055	184 539 805	218 160 694	164 630 692	401 626 643
Length [km]	7,235	7,227	7,236	7,24	7,228	7,232	7,232	7,24	7,236	7,237	7,241	7,227	7,219
Data from the basis calculation													
Project administative costs	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000
Investigation and planning	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612
Engineering design	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000
Land redemption	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894
Environmental measures	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265
Transfer and termination	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000
Measures on the local road network and costs of junctions	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164
Archeology/fieldwork	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918
Measures for electricity and telecommuting cables	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000
Temporary road structures	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000
Demolition of bituminous layers, 0-250 mm	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000
Drainage shaft	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000
Wildlife fences	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082
Median barrier	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000
Road side barrier	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000
Barrier openings	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000
Termination of road side barriers	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000
Stormwater reservoir	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204
Infiltration retarding ditches	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000
Road signs	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000
Vertical drains	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500
bank piling	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316
pressure bank/overloading	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408
Lime-cement columns	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000
Total cost													
Total construction cost	318 097 531	477 513 446	397 486 268	402 670 401	257 823 049	271 128 139	298 550 414	431 648 554	433 392 134	278 297 820	303 044 393	264 134 667	478 338 310
Total construction cost without bridge (SEK)	294 666 783	465 574 618	372 267 888	387 986 281	238 669 849	250 570 371	271 863 622	414 091 454	418 133 418	247 461 168	281 082 057	227 552 055	464 548 006
Road user, maintenance and community costs													
Travel time [h]	0,07235	0,07227	0,07236	0,0724	0,07228	0,07232	0,07232	0,0724	0,07236	0,07237	0,07241	0,07227	0,07219
Fuel cost [SEK]	270 100 118	269 801 459	270 137 451	270 286 781	269 838 791	269 988 121	269 988 121	270 286 781	270 137 451	270 174 783	270 324 113	269 801 459	269 502 800
Tire cost [SEK]	22 958 510	22 933 124	22 961 683	22 974 376	22 936 297	22 948 990	22 948 990	22 974 376	22 961 683	22 964 857	22 977 550	22 933 124	22 907 738
Service cost [SEK]	52 960 808	52 902 247	52 968 128	52 997 408	52 909 567	52 938 847	52 938 847	52 997 408	52 968 128	52 975 448	53 004 728	52 902 247	52 843 686
Loss in value [SEK]	169 474 584	169 287 190	169 498 008	169 591 705	169 310 614	169 404 311	169 404 311	169 591 705	169 498 008	169 521 433	169 615 130	169 287 190	169 099 796
Time cost [SEK]	463 142 262	462 630 149	463 206 276	463 462 333	462 694 163	462 950 220	462 950 220	463 462 333	463 206 276	463 270 290	463 526 347	462 630 149	462 118 036
Maintanence cost [SEK]	15 027 495	15 001 866	15 030 698	15 043 513	15 005 070	15 017 884	15 017 884	15 043 513	15 030 698	15 033 902	15 046 716	15 001 866	14 976 237
Emissions [SEK]	163 836 906	163 655 746	163 859 551	163 950 131	163 678 391	163 768 971	163 768 971	163 950 131	163 859 551	163 882 196	163 972 776	163 655 746	163 474 585
Noise [SEK]	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687
Benefit													
Total benefit	255 156 500	256 445 402	254 995 387	254 350 936	256 284 290	255 639 838	255 639 838	254 350 936	254 995 387	254 834 274	254 189 823	256 445 402	257 734 305
Benefit without community costs	228 102 675	229 210 417	227 964 207	227 410 336	229 071 949	228 518 078	228 518 078	227 410 336	227 964 207	227 825 739	227 271 868	229 210 417	230 318 159
Socioeconomic evaluation													
Net present value	- 62 941 032	- 221 068 043	- 142 490 882	- 148 319 466	- 1 538 760	- 15 488 301	- 42 910 576	- 177 297 619	- 178 396 747	- 23 463 546	- 48 854 570	- 7 689 265	- 220 604 005
Cost benefit ratio	0,80	0,54	0,64	0,63	0,99	0,94	0,86	0,59	0,59	0,92	0,84	0,97	0,54
Net benefit cost ratio	-0,20	-0,46	-0,36	-0,37	-0,01	-0,06	-0,14	-0,41	-0,41	-0,08	-0,16	-0,03	-0,46
Net benefit cost ratio without community costs	-0,28	-0,52	-0,43	-0,44	-0,11	-0,16	-0,23	-0,47	-0,47	-0,18	-0,25	-0,13	-0,52
Net benefit cost ratio without bridge	-0,13	-0,45	-0,32	-0,34	0,07	0,02	-0,06	-0,39	-0,39	0,03	-0,10	0,13	-0,45

Alignment	14	15	16	17	18	19	20	21	22	23	24	25
Data from Trimble Quantm												
Construction cost [SEK]	189 425 148	223 825 572	317 897 791	222 408 235	171 237 908	162 714 095	224 796 001	231 606 879	201 146 906	184 980 967	347 209 848	208 827 340
Construction cost without bridge	160 886 880	202 118 612	288 082 643	180 143 507	143 338 080	125 365 355	197 981 521	191 257 471	156 966 858	140 737 075	336 994 808	195 547 788
Length [km]	7,231	7,240	7,228	7,236	7,234	7,232	7,220	7,247	7,244	7,236	7,247	7,230
Data from the basis calculation												
Project administative costs	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000	9 000 000
Investigation and planning	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612	1 780 612
Engineering design	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000	11 000 000
Land redemption	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894	8 793 894
Environmental measures	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265	6 273 265
Transfer and termination	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000
Measures on the local road network and costs of junctions	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164	3 658 164
Archeology/fieldwork	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918	4 795 918
Measures for electricity and telecommuting cables	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000	750 000
Temporary road structures	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000
Demolition of bituminous layers, 0-250 mm	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000	35 000
Drainage shaft	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000	620 000
Wildlife fences	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082	2 144 082
Median barrier	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000	4 200 000
Road side barrier	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000	984 000
Barrier openings	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000	160 000
Termination of road side barriers	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000	240 000
Stormwater reservoir	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204	1 010 204
Infiltration retarding ditches	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000	400 000
Road signs	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000	900 000
Vertical drains	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500	67 500
bank piling	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316	2 824 316
pressure bank/overloading	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408	84 408
Lime-cement columns	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000	800 000
Total cost												
Total construction cost	252 346 511	286 746 935	380 819 154	285 329 598	234 159 271	225 635 458	287 717 364	294 528 242	264 068 269	247 902 330	410 131 211	271 748 703
Total construction cost without bridge (SEK)	223 808 243	265 039 975	351 004 006	243 064 870	206 259 443	188 286 718	260 902 884	254 178 834	219 888 221	203 658 438	399 916 171	258 469 151
Road user, maintenance and community costs												
Travel time [h]	0,07231	0,07240	0,07228	0,07236	0,07234	0,07232	0,07220	0,07247	0,07244	0,07236	0,07247	0,07230
Fuel cost [SEK]	269 950 789	270 286 781	269 838 791	270 137 451	270 062 786	269 988 121	269 540 132	270 548 108	270 436 110	270 137 451	270 548 108	269 913 456
Tire cost [SEK]	22 945 817	22 974 376	22 936 297	22 961 683	22 955 337	22 948 990	22 910 911	22 996 589	22 987 069	22 961 683	22 996 589	22 942 644
Service cost [SEK]	52 931 527	52 997 408	52 909 567	52 968 128	52 953 487	52 938 847	52 851 006	53 048 649	53 026 688	52 968 128	53 048 649	52 924 207
Loss in value [SEK]	169 380 887	169 591 705	169 310 614	169 498 008	169 451 160	169 404 311	169 123 220	169 755 675	169 685 403	169 498 008	169 755 675	169 357 463
Time cost [SEK]	462 886 205	463 462 333	462 694 163	463 206 276	463 078 248	462 950 220	462 182 050	463 910 432	463 718 389	463 206 276	463 910 432	462 822 191
Maintanence cost [SEK]	15 014 680	15 043 513	15 005 070	15 030 698	15 024 291	15 017 884	14 979 441	15 065 938	15 056 327	15 030 698	15 065 938	15 011 477
Emissions [SEK]	163 746 326	163 950 131	163 678 391	163 859 551	163 814 261	163 768 971	163 497 230	164 108 647	164 040 712	163 859 551	164 108 647	163 723 681
Noise [SEK]	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687	438 687
Benefit												
Total benefit	255 800 951	254 350 936	256 284 290	254 995 387	255 317 613	255 639 838	257 573 192	253 223 146	253 706 484	254 995 387	253 223 146	255 962 064
Benefit without community costs	228 656 546	227 410 336	229 071 949	227 964 207	228 241 143	228 518 078	230 179 692	226 441 061	226 856 465	227 964 207	226 441 061	228 795 014
Socioeconomic evaluation												
Net present value	3 454 440	-32 396 000	-124 534 864	-30 334 211	21 158 342	30 004 380	-30 144 172	-41 305 096	-10 361 785	7 093 057	-156 908 065	-15 786 639
Cost benefit ratio	1,01	0,89	0,67	0,89	1,09	1,13	0,90	0,86	0,96	1,03	0,62	0,94
Net benefit cost ratio	0,01	-0,11	-0,33	-0,11	0,09	**0,13**	-0,10	-0,14	-0,04	0,03	-0,38	-0,06
Net benefit cost ratio without community costs	-0,09	-0,21	-0,40	-0,20	-0,03	**0,01**	-0,20	-0,23	-0,14	-0,08	-0,45	-0,16
Net benefit cost ratio without bridge	0,14	-0,04	-0,27	0,05	0,24	**0,36**	-0,01	0,00	0,15	0,25	-0,37	-0,01