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Sustainability analysis of remediation and reclamation of Maurliden mine using the SCORE method

ACEX30

RESHMA SREEKUMARY

DEPARTMENT OF ARCHITECTURE AND CIVIL ENGINEERING

CHALMERS UNIVERSITY OF TECHNOLOGY

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Sustainability analysis of remediation and reclamation of Legacy Mines

The Maurliden case study using the SCORE Method

RESHMA SREEKUMARY

Department of Architecture and Civil Engineering

Division of Infrastructure and Environmental Engineering

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RESHMA SREEKUMARY

Supervisor: Jenny Norrman, Architecture and Civil engineering (Chalmers)

Examiner: Lars Rosen, Architecture and Civil engineering (Chalmers)

Master's Thesis 2022

Department of Architecture and Civil engineering

Division of Infrastructure and Environmental Engineering

Chalmers University of Technology

SE-412 96. Gothenburg

Telephone +46 31 772 1000

Cover: Maurliden mine open pit.

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RESHMA SREEKUMARY

Department of Architecture and Civil Engineering
Division of Geology and Geotechnics
Chalmers university of technology

ABSTRACT

Mines in several years of functioning produce a large quantity of waste materials containing contaminants that are harmful to different ecosystems. The study aims to analyse two suggested remediation alternatives by Boliden AB for the Maurliden mine location in the central part of the Skellefteå field in Norsjö from a sustainability perspective. Maurliden is an open pit mine in a sulphide deposit with zinc being the primary mined metal along with gold, silver, copper, and lead. The mine is currently subject to remediation measures with fewer activities going on like the treatment of wastewater from the mine at the facility. This sustainability study to compare remediation measures is made by implementing the SCORE method, a multi-criteria analysis method for evaluating and comparing the sustainability performance of remediation alternatives in the environmental, social, and economic domains.

In the SCORE analysis, two alternatives have been studied. These two alternatives have been compared to a reference alternative representing no action, i.e., that the site remains in its current state. Remediation alternative 1 is where the open pit is backfilled with the waste rock from the mine site and the left-over waste rock is moved to the north of the mine site and qualified covered. Remediation alternative 2 is where the open pit is backfilled with a paste mixture of mine tailings from the Boliden area, water, and cement, and all waste rock from the site is moved up north and qualified covered. Both measures are associated with positive and negative social and environmental effects, but alternative 2 predominantly showed a higher positive sustainability score as compared to alternative 1. The remediation alternatives are generally associated with positive local environmental effects, both because of the implementation of the alternative and the reduction of the source contamination. The secondary effects, due to the emission to air, use of non-renewable natural resources, and production of non-recyclable waste differ between the measures where lesser emissions take place in alternative 1 and less virgin materials are used in alternative 2. The study comprises the quantitative and qualitative assessment of environmental and social domains and the qualitative assessment of the economic domain. Therefore, from environmental and social points of view, alternative 2 is the best remediation measure but from an economic point of view, due to insufficient data, it is difficult to comprehend which alternative that is the best. A sensitivity analysis showed that if the social or environmental domain is weighted lower/higher, the ranking of the alternative remains the same. Only when the social criterion, local acceptance is included in the scenario 3, the ranking of the alternatives changed. This explains that the opinions of the local population strongly influence the ranking of the alternatives. The main recommendation based on the results of the SCORE analysis is that alternative 2 is the most

sustainable measure. However, it should be emphasized that before a final decision on which the alternative that is the most suitable is made, it is important to assess which is the most sustainable alternative in terms of the economic domain too.

Keywords. **SCORE, Sustainable remediation, mine closure, source contamination, qualified cover, waste rock, tailings.**

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List of acronyms

Below is the list of acronyms that have been used throughout this thesis listed in alphabetical order:

WRD	Waste rock deposit
MLV	Most likely value
NPV	Net present value
PV	Present value
AMD	Acid mine drainage
SCORE	Sustainable Choice of Remediation
MCM	Mine closure model
MCDA	Multi-criteria decision analysis
MCA	Multi-criteria analysis
ICMM	International council of mining and metals

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1. Introduction

1.1. Background

Mining metals, such as iron, copper, zinc, and gold, produce vast amounts of residual rock with low metal content which acts as a source of pollution to groundwater aquifers and surface water. Mines with several years of production result in waste sites that must be remediated and managed to reduce risks to humans and ecosystems. Large volumes of waste make it impossible to remove all of them; therefore, different measures to reduce the leakage of contaminants, or in other ways, protect sensitive recipients, must be implemented sustainably. Mine closure, the final phase in mining is rated among the top operating risks in mining (www.icmm.com). Boliden AB is a major mining company with several mines in central and northern Sweden and internationally. In addition to mines in operation, they are also responsible for closed legacy mines (Boliden summary report, 2018). Legacy mines are sites that are operated and closed way before modern era mining practices and environmental regulations came into action (Braun, 2021). Wastes generated from legacy mines remain a significant issue to the communities, industry, and government. The closure and remediation practice should focus on protecting public, ensuring environmental health and safety, and establishing a better post-mining or closure land-use option for the long term. To avoid problems in the future, industries should also focus on reducing the volume of tailings and other waste generated at the site. Industries should also focus on a circular economy by extracting valuable materials from the tailings produced at the site (globaltailingsreview.org [GTR], 2020).

Boliden aims to identify suitable remediation measures from a sustainability perspective considering the environmental, social, and economic performance of measures that are technically possible to implement. SCORE (Sustainable Choice of Remediation) (Rosén et al, 2015) is a multi-criteria analysis method for evaluating and comparing the sustainability performance of remediation alternatives. Still, it has not previously been applied to remediation alternatives at mining waste sites. The purpose of this master thesis project is to apply the SCORE method developed at Chalmers on Boliden's Maurliden mine situated in the central part of the Skellefteå field in Norsjö municipality, Västerbotten country.

1.2. Aim and objectives

This study aims to test and (potentially) adapt the SCORE method for evaluating remediation alternatives for handling mine waste from a sustainability perspective. This is achieved by analysing and comparing two remediation alternatives for the mine waste at Maurliden using the SCORE tool and discussing the applicability of the key criteria currently included in SCORE.

2. Sustainable remediation of mines

2.1. Closure of mines in general

Mine pollution is one of the global environmental concerns and requires a sustainable approach to address the complexity of mining-specific problems. The ecological effects of mining are not just limited to the recent area of extraction but also the legacy of abandoned mines (Byrne et al.2012). The contamination that originates from the mine is mainly due to the mine tailing deposits which act as a source of acid mine drainage (AMD). These mine areas are not suitable for vegetation due to their harsh soil conditions. These contaminants degrade the plants and prevent the plants from rooting (Karaca et al., 2017). Conventional remediation technologies like chemical precipitation that neutralize the acid mine drainage in mines would cost more for heavy metal contamination due to high chemical and energy use. Heavy metal contamination in mine waste can be treated by methods that include pump and treat, in-situ flushing, soil washing, electrokinetic remediation, permeable reactive barriers, vitrification, stabilization, solidification, and monitored natural attenuation. Various mining exploitations include open pit mines, underground mining, in-situ leach mining, and heap leaching. The effect from mining operations depends on the type of exploitation (Karaca et al., 2017).

Open pit mines cause a very serious effect on the environment in every process like deforestation, removal of the topsoil, and exposure of the rocks and minerals to the atmosphere (Karaca et al., 2017). The environmental issues with mine sites are mainly due to the tailing deposits, weathering, and acid mine drainage followed by the effect on the soil, groundwater, and surface water. The mine tailings consist of minerals, rocks, and low-grade ores that contain low metal concentrations but enough to contaminate the water and soil ecosystem. Other effects include wind and water erosion and hindrance to plant growth due to the destruction of minerals in the soil and soil structure, and possibilities of reaction of minerals present in the tailings deposit with external agents like oxygen. These effects stay as a long-term environmental issue hence there is a need for frequent monitoring and restoration (Karaca et al., 2017).

Heavy metal contamination is recognized as the most contaminant type in the world. Mine tailings contamination is due to the low pH and high metal content. The areas affected by mine tailings, therefore, do not have good vegetation. Hence restoration of the mine tailings should focus on reducing the heavy metal content and balancing the pH to restore the vegetation at the place (Karaca et al., 2017).

Immediate remediation and restoration of the mines are essential if there is a risk to public health or sensitive ecosystems. Further, it is to be decided if the remediation technology is for mine drainage, mine waste, or both.

The mine waste can be excavated and transported to reduce its exposure to the atmosphere, but this isn’t always feasible hence technologies can be used to immobilize the metal and reduce its bioavailability. The immobilization can be done using physical or engineered barriers. Mine water (surface runoff and groundwater) is also a concern during the remediation of mine sites. Wells and

water bodies are affected; in special cases, a wastewater treatment plant can be set up as a solution (Karaca et al., 2017).

Phyto capping is a remediation technique that is multifunctional and helps in solving various problems associated with acid mine drainage. It provides erosion control, and landscape rehabilitation, and enhances the soil properties for revegetation. Vegetative capping is a technology for soil remediation that decreases the mobility and availability of contaminants in the subsoil and is a good solution for the restoration of large areas with heavy metal contamination (Karaca et al., 2017).

Mine closure is the final phase of a mining cycle that includes the ceasing of mine activities and the completion of the reclamation of the site. Reclamation of a mine site is the process of modifying the mined land to a fully ecologically functioning land (Kabir et al.,2015). In the past, mines were closed without proper planning, and this led to various social issues such as the loss of jobs by the local people, moving out of local people leading to damage to their community bondage, and environmental issues like degradation of the soil quality and releasing of acid water are problems that arise due to improper planning of closure of mine (Kabir et al.,2015).

Some of the shortcomings found due to the immediate unplanned closure of mines are inadequate social effect assessment, community consultation, close monitoring post-closure of mines, and inadequate analysis of alternative options (Kabir et al.,2015). The mine closure planning aims to make sure the reclamation and decommissioning of the site is achieved and make sure a productive and sustainable post mining use of the site is available for use to the stakeholders, to ensure public safety and health, to eradicate any environmental damage, to conserve the cultural heritage and to reduce the socio-economic effects. (Kabir et al.,2015).

While technical and environmental aspects are mostly considered in the mine closure, it lacks consideration of social and economic aspects such as sustaining the growth of the mining region after the mine closure (Syahrir et al.,2021). The social aspects of the mine closure that arise at the end of the project consist of socio-economic, political, cultural, and institutional effects and to mitigate these effects proper planning and management processes are required (Bainton et al.,2018).

Some engineering management tools for the closure of mines widely used are Life cycle assessment, to determine between the alternatives which has the least environmental effects, multi-criteria decision analysis (MCDA) allows to combine environmental, social, and economic aspects of mine closure and Risk evaluations, a comparison of risk level and risk criteria that will be defined (Krzemien et al.,2016).

2.2. SCORE

Sustainable choice of remediation, by Rosen, et al, (2015) is developed for evaluating the environmental, social, and economic sustainability of site remediation using MCDA. SCORE combines a linear additive function to rank the alternatives with a non-compensatory approach. The performance of remediation alternatives in three sustainability domains: environmental, social, and economic is

assessed. A reference alternative is used as a base for the comparison with each alternative. SCORE can provide a transparent assessment of sustainability by identifying the most sustainable or least sustainable alternative but the most sustainable alternative from the analysis is only relative to the ones analysed. Moreover, there might be other better options that are not considered in the assessment. A detailed description of SCORE is given below.

2.3. Other methods adopted for sustainable remediation of mine

Closure of mines should be carefully planned as it deals with uncertainties of future conditions and events related to environmental issues, long-term regulatory needs, and stakeholder demands (Fourie and Brent, 2005). According to the International council on mining and metals (ICMM) at (www.icmm.com,) a successful closure is when the land is rehabilitated to a sustainable living condition and is achieved only by careful and monitored (Darling et al.2011). ICMM has developed principles for planning and closure of mines with good practice guidelines. Successful closure planning is a complex task to minimize the effects on the stakeholders, the environment, and the mining company in the long term. One such method for the sustainable closure of the mines is the mine closure model (MCM)(Fourie and Brent, 2005) as seen in figure 1.

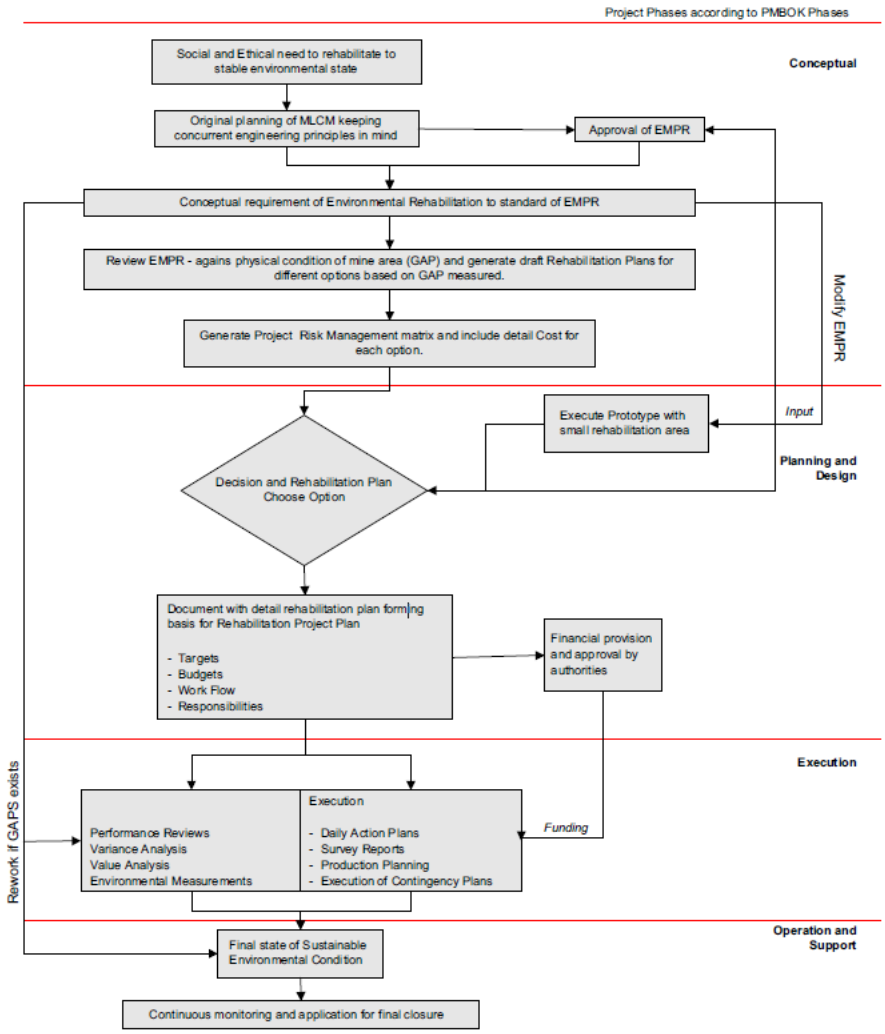


Figure 1 Derived mine closure model (Fourie and Brent, 2005).

This model is structured based on project management principles like detail design, testing, execution, control, and completion along with risk management and together with concurrent engineering principles is used to propose the closure of mines and help the governing body from an excessive economic burden (Fourie and Brent, 2005). As discussed in the chapter closure of mines in general, the majority of planned or unplanned mine closure practices focusses on the environmental and social aspects of sustainability and some of the environment management tools for mine closure widely used are Life cycle assessment, multi-criteria dimension analysis and risk evaluations (Krzemien et al.,2016). No method has described or considered the three sustainability domains in the assessment of the remediations in mine closure. This makes SCORE the most effective method in the sustainability assessment of mine closure practices.

3. Case study

3.1. General information of the site

The study site Maurliden is an open pit mine located in Norsjö, Skellefteå, Sweden, see figure 2. The mine is a sulphide deposit with zinc being the primarily mined metal along with gold, silver, copper, and lead. The deposits at the mine site were found in the mid-1940s by the Geological Survey of Sweden (SGU). The Maurliden area covers an area of approximately 8 by 6 km (Boliden summary report, 2018). The bedrock mostly consists of volcanic rocks that belong to the Skellefteå group, a sequence of volcanic rocks in the Skellefteå field. Apart from the mine workings, the land type covered is mainly coniferous forests. The geology of the Maurliden area can be divided into two stratigraphy units: Quaternary sediments deposited unconformably on the top of the Precambrian volcanic rhyolites. The sediments consist of poorly sorted glacial till with a dominating grain size distribution ranging from sandy silts to silty sands. The thickness of the till ranges from a few to ten meters with the discontinuous level of gravel present at the bottom of the unit in contact with the rhyolite bedrock (Boliden closure report, 2021).

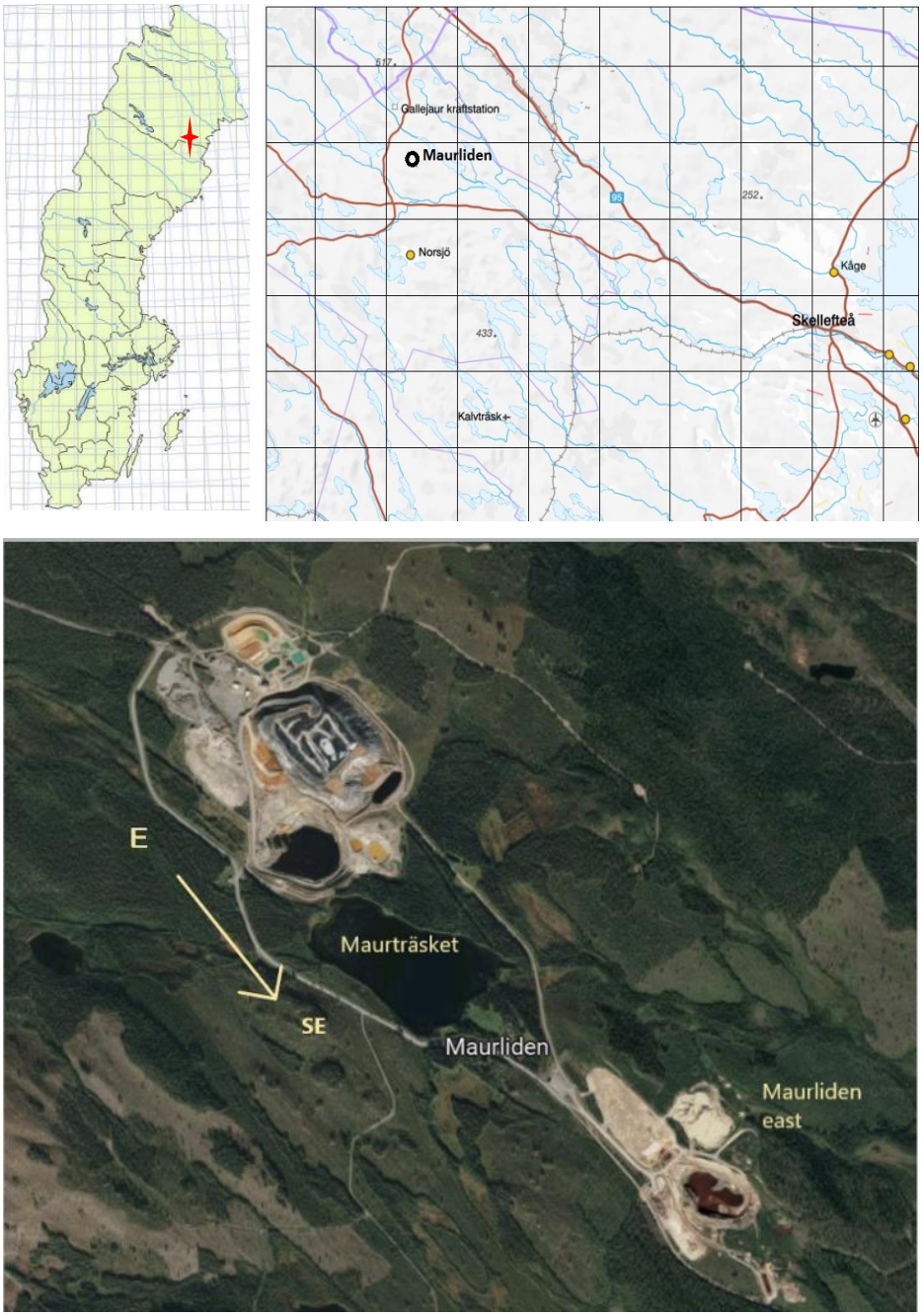


Figure 2 Maurliden mine (Boliden closure report ,2021, p.3).

The glacial till and the underlying bedrock also represent the two hydrogeologic units in the Maurliden site. Glacial till overlaying variable fractured bedrock represents the uppermost hydrogeologic unit of the Maurliden area. The depth to the groundwater level in the till is relatively small (<10m below ground). The low permeability of the bedrock compared to the till and the shallow water table together creates groundwater flow largely oriented in an E-SE direction as shown in figure 2. Annual evapotranspiration of 355 mm for 1981 -2010 is recorded, and due to its high latitude and cold climate, the evapotranspiration measured is higher from May to September but negligible in winter. SMHI

estimates an average total annual precipitation for the period 1981-2010 as 651mm for the Maurbäcken catchment. Therefore, the recharge is calculated as 296mm. The snowmelt contributes most recharge as the meltwater overwhelmingly exceeds the evapotranspiration (Boliden closure report, 2021).

3.2. Remediation alternatives at Maurliden Site

3.2.1. Reference alternative

The reference alternative is the present situation at the Maurliden site i.e., the open pit filled with water. There is a water treatment plant facility located north of the open pit and adjacent to the treatment plant are sedimentation basins. The sedimentation basins are built with mesa lime at the bottom and sides. In addition to the maintenance of the excavated open pit and waste rock deposit, Maurliden mine also handles the purification of water from Maurliden Östra's(east) open pit in the form of leachate from the waste rock deposit. The facility also disposes of the sludge that arises from the water treatment process at the site (Boliden closure report, 2021). The units can be seen in figure 3.

Figure 3 The main components of the Maurliden site (google maps).

3.2.2. Alternative 1

Alternative 1 is shown in figure 4, the open pit is backfilled with waste rock and the resulting concave mass is qualified covered. Due to the dissolution of the metals from the waste rock in the pit, lime is added as buffering material to raise the pH value of water to keep it slightly alkaline (Boliden closure

report, 2021). The extra waste rock that will not fit in the open pit is moved to the new location to the north of the mine site and qualified covered. The qualified covering is a mix of bentonite and till to prevent rainwater drainage from entering the backfill (Boliden closure report, 2021).

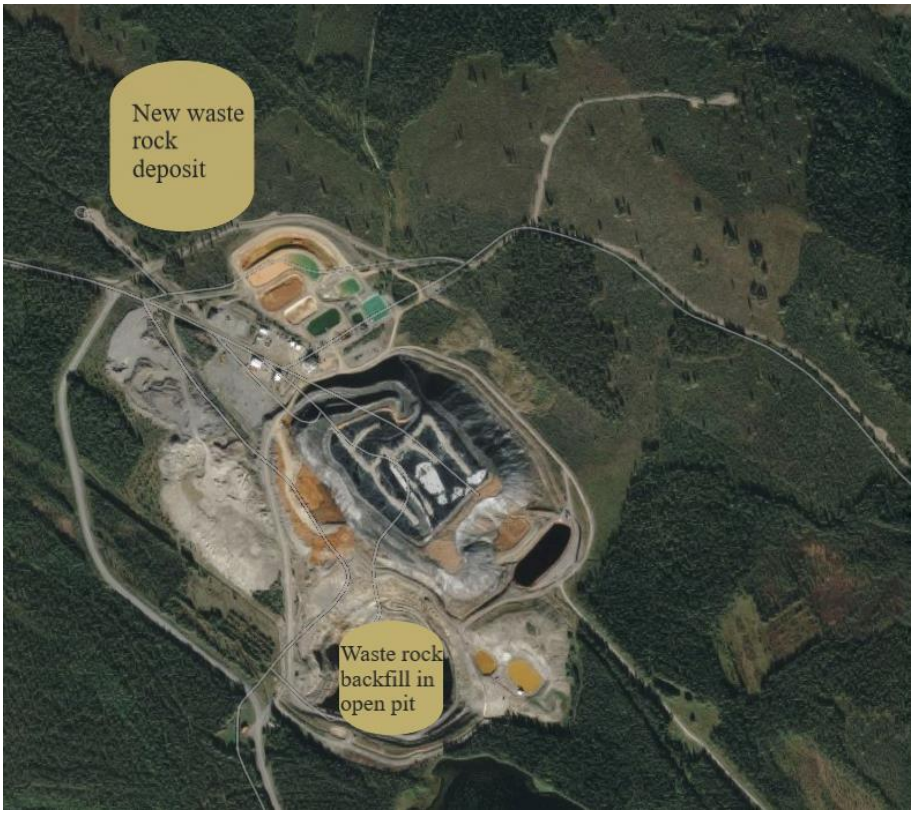


Figure 4 The main components of remediation alternative 1 (google maps).

3.2.3. Alternative 2

Alternative 2 is shown in figure 5, the open pit is backfilled with a paste which is a mixture of tailings, water, and cement and the surface is later covered with till. The waste rock is moved to a new location to the north of the mine site and qualified covered (Maurliden closure report, 2021). The new location of waste rock deposit is situated to the north of mine site close to the Skellefteälven river. In alternative 2, the paste filling restricts the mass transport of contaminants from and into the pit (Maurliden closure report, 2021).Tailings used in the paste are at present stored at the Boliden urban area and cement is an additional material brought from an external source for the remediation process.

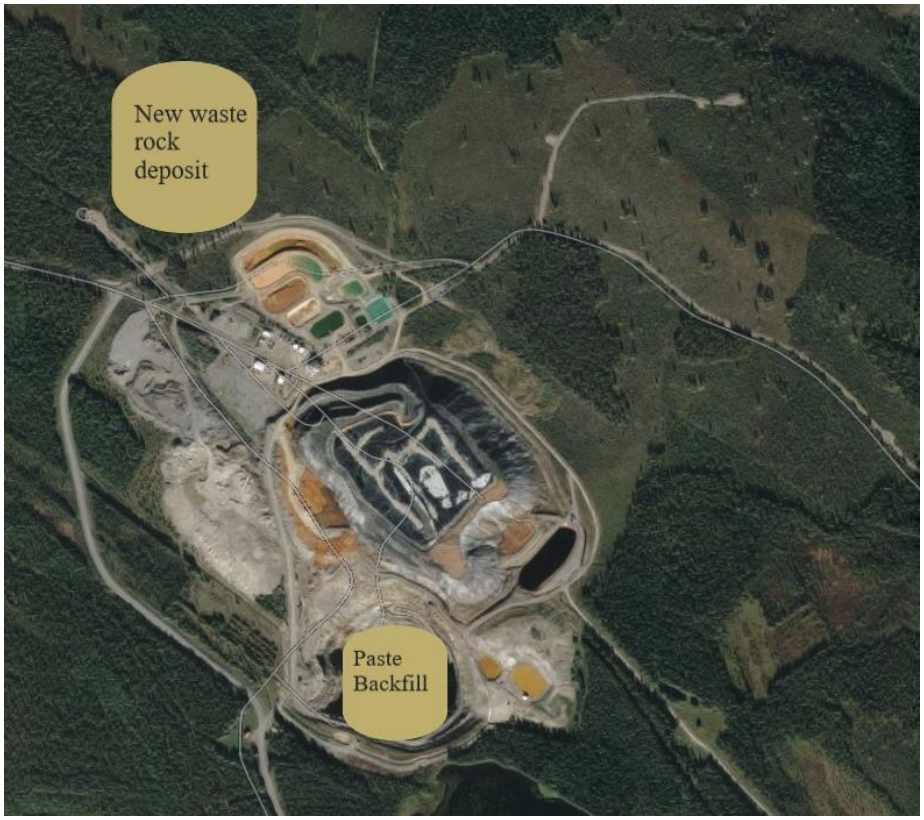


Figure 5 The main components of remediation Alternative 2 (google maps).

4. Methodology

4.1. General SCORE methodology

4.1.1. SCORE framework and conceptual model

SCORE is focused on providing support to decision-making by comparing a set of remediation alternatives with a reference alternative. The SCORE decision support framework is shown in figure 6. SCORE combines semi-quantitative scores in the environmental and social domains with a quantitative cost-benefit analysis in the economic domain, and the alternatives are ranked using a linear additive model (Rosén et al., 2015).

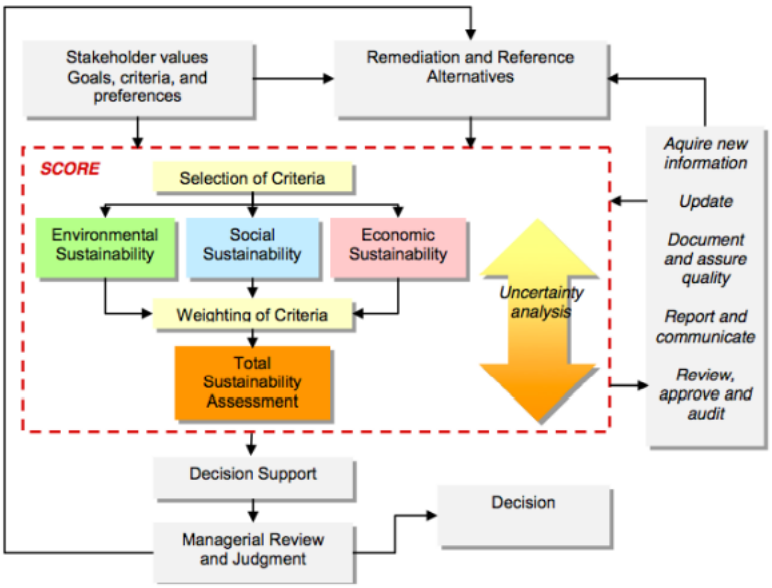


Figure 6 Structure and key criteria of SCORE, in Rosén et al. (2015).

The conceptual model of SCORE is shown in Figure 7. SCORE distinguishes the activity against the stressor, locations, receptors, and their long- and short-term effects. The stressors are categorised as the change in source contamination and remedial action itself. The effects due to the remedial action and the change in source contamination are considered both on-site and off-site. The recipients are the ecosystems, natural resources, and humans and these are further classified into environmental, social, and economic domains.

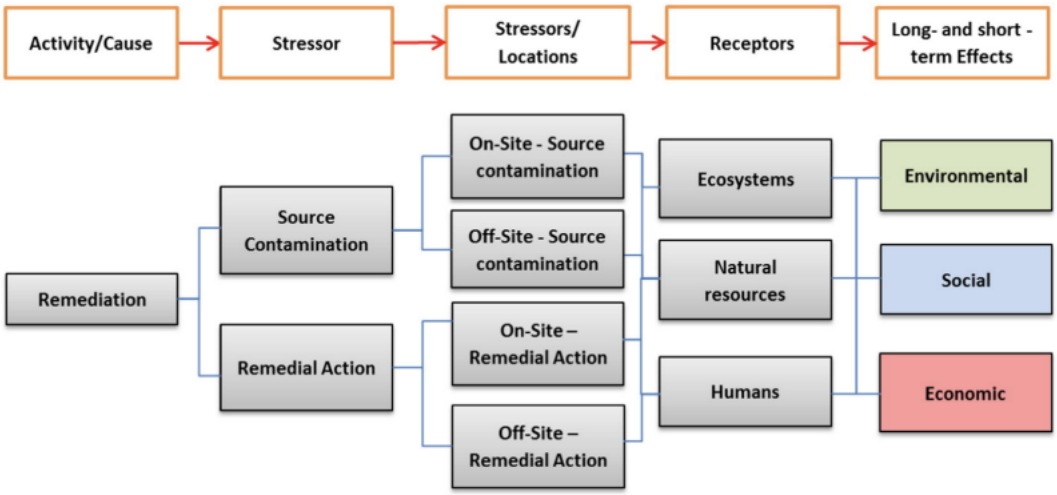


Figure 7 Conceptual model of SCORE, in Rosén et al. (2015).

4.1.2. Key criteria in SCORE

Each alternative is evaluated with respect to a reference alternative and each alternative is assessed in environmental, social, and economic domains. Scoring represents the effects of each criterion in the environmental and social domain. Each criterion and sub-criterion in the environmental and social domain are weighted with respect to their relative importance. In the economic domain costs and benefits relative to the reference alternative are estimated and summed to a net present value representing the economic profitability to society of the alternatives. The three different domains are weighted to produce a total sustainability index. The purpose of SCORE is to be a tool for the sustainability assessment of remediation alternatives and provide a basis and guidance to long-term sustainability development (Rosén et al., 2015). The key criteria in the environmental, social domains are shown in figure 8.

Figure 8 SCORE is divided into three sustainability domains: Environmental, Social and Economic.

The steps in SCORE methodology are as follows:

4.1.2.1. Selection of criteria

Criteria are selected as per the SCORE method shown in figure 8, and they are selected independently of each other to avoid the risks of double counting. The environmental domain consists of eight key criteria and the social domain consists of six key criteria. The description of the environmental domain and social domain are tabulated in table 1 and table 2 respectively.

Table 1 List of the key criteria for the environmental domain and their description from Rosén et al., (2015)

Key criteria	**Description**
E1. Soil	Ecotoxicological risk due to the soil contamination (reflects the effects on the soil ecosystems due to the change in source contamination and/or to effects of the remedial action) and soil function component (considers the effects of the remedial action on soil's capability of providing good pre-conditions for organisms, considering factors such as soil texture, pH, organic content, availability of nitrogen and carbon, and water retention capacity).
E2. Flora & Fauna	Physical effects from the remedial action on e.g., trees, birds, and mammal habitats.
E3. Groundwater	Effects on groundwater quality and ecotoxicological risks in the discharge zone e.g., wetland areas potentially affected by the source contamination and/or the remedial action.

E4. Surface water	Effects on surface water quality and ecotoxicological risks in the water zone of surface water bodies and streams potentially affected by the source contamination and/or remedial action.
E5. Sediments	Effects on ecotoxicological risks for organisms in sediments potentially affected by the source contamination and/or remedial action.
E6. Air	Total emissions to air, including greenhouse gases, acidifying substances, and particulate matter, due to the remedial action.
E7. Non-Renewable natural resources	Total use of non-renewable natural resources, such as fossil fuels, virgin soil and rock material for backfilling, and occupation of new land for disposal, due to the remedial action.
E8. Waste	Total production of non-recyclable waste due to the remedial action.

All criteria listed have sub-criteria that specifies the on-site and off-site effects due to the remedial action and the source contamination.

Table 2 List of the key criteria for the social domain and their description from Rosén et al., (2015).

Key criteria	**Description**
S1. Local environment quality and amenity	Effects on e.g., recreational values, noise or/and the accessibility of the area
S2. Cultural heritage	Effects on cultural heritage items due to destruction, preservation, or restoration, but not with regard to the increased access to those items that can be expected from a change in SC and subsequent change in land-use (this is scored in S1)
S3. Health and safety	Effects on human health and safety due to exposure and spreading of contaminants in soil, dust, air, water, and due to accidental risks (e.g., traffic).
S4. Equity	Effects on vulnerable groups in society.
S5. Local participation	Effects on how the local community is affected with regard to local job opportunities or other local activities. This criterion does not relate to the participation of the local community in the remediation decision process
S6. Local acceptance	Effects with regard to the acceptance of the remediation alternative by the local community. It should be noted that the local acceptance of activities can be improved by open information, dialogue and/or participation processes carried out appropriately.

4.1.2.2. Assessment of environmental, economic, and social effects

The effects in the environmental and social domains are scored on a scale between -10 to +10 where negative values indicate a negative effect and the positive value indicates a positive effect both with respect to a reference alternative. The score values indicate -10 to -6: very negative, -5 to -1: negative, 0 being no effect, +1 to +5: positive, and +6 to +10: very positive. In the economic domain, the effects

are assessed in terms of socio-economic costs and benefits that can be expected to arise according to the method described in Söderqvist et al. (2015).

4.1.3. Weighting

In this step weighting between domains and criteria is done to indicate the priority of one over the other. The weights represent the relative importance of criteria and domains perceived by those involved in the SCORE analysis. Preferable, all stakeholders should be involved in the SCORE analysis. However, the weights can also reflect importance given by the problem owner to the criteria and domains. In the latter case the SCORE analysis provides a transparent display of the preferences of the problem owner that can be reviewed by other stakeholders and the responsible authority. The weights are set according to a scale of 0 to 25. For a criterion not being relevant a weight of 0 is given, and 25 for a criterion of the highest significance. Based on the weights assigned, the percentage weight for each criterion is calculated (Rosén et al., 2015).

4.1.4. Cost-benefit analysis

Cost-benefit analysis is a well-defined technique to evaluate the economic consequences for society. The economic domain includes one key criterion i.e., societal profitability, which is obtained by performing a cost-benefit analysis (CBA). The cost and benefit items are shown in table 3. A preliminary assessment of the importance of each economic item to prioritize the ones to be monetized is done and is succeeded by the CBA.

Table 3 List of the key criteria for the economic domain and their description from Rosén et al., (2015).

Main items of cost and benefits	**Sub items of cost and benefits**
B1. Increased property value on-site	
B2. Improved health	B2a. Reduced acute health risks.
	B2b. Reduced non-acute health risks.
	B2c. Other types of improved health, e.g., reduced anxiety
B3. Increased provision of ecosystem services	B3a. Increased recreational opportunities on-site.
	B3b. Increased recreational opportunities in the surroundings.
	B3c. Increased provision of other ecosystem services.
B4. Other positive externalities than B2 and B3	
C1. Remediation costs	C1a. Design of remedial actions.

	C1b. Project management.
	C1c. Capital costs.
	C1d. Remedial action.
	C1e. Monitoring.
	C1f. Project risks.
C2. Impaired health due to remedial action	C2a. Increased health risks on-site.
	C2b. Increased health risks from transports activities.
	C2c. Increased health risks at disposal sites.
	C2d. Other types of impaired health, e.g., increased anxiety.
C3. Decreased provision of ecosystem services due to remedial action	C3a. Decreased provision of ecosystem services on-site.
	C3b. Decreased provision of ecosystem services in the surroundings.
	C3c. Decreased provision of ecosystem services at disposal sites
C4. Other negative externalities than C2 and C3	

4.1.5. Uncertainty analysis

Uncertainties that can influence the results can be of various types. The uncertainty that arises due to lack of knowledge is called epistemic uncertainty and uncertainty due to natural variability is called aleatory uncertainty. Uncertainty analysis was implemented in SCORE to study the sensitivity of a model and to analyse the dependencies on various parameters. In SCORE the uncertainty analysis follows a Monto-Carlo simulation approach. Beta and lognormal distributions are assigned to represent the uncertainty. Input is the Most likely value (MLV) of the present value (PV) of each benefit and cost and uncertainty level is assigned as low, medium, and high (Söderqvist, et al., 2015).

4.2. Working process

For the practical application of SCORE, an excel based computer tool was developed and used to access the sustainability of the remediation alternatives in the case study (Volchko et al,2014). A semi

quantitative approach using scorings is used for the environmental and social domain, whereas a qualitative assessment of the economic domain was performed. The working process is shown in figure 9.

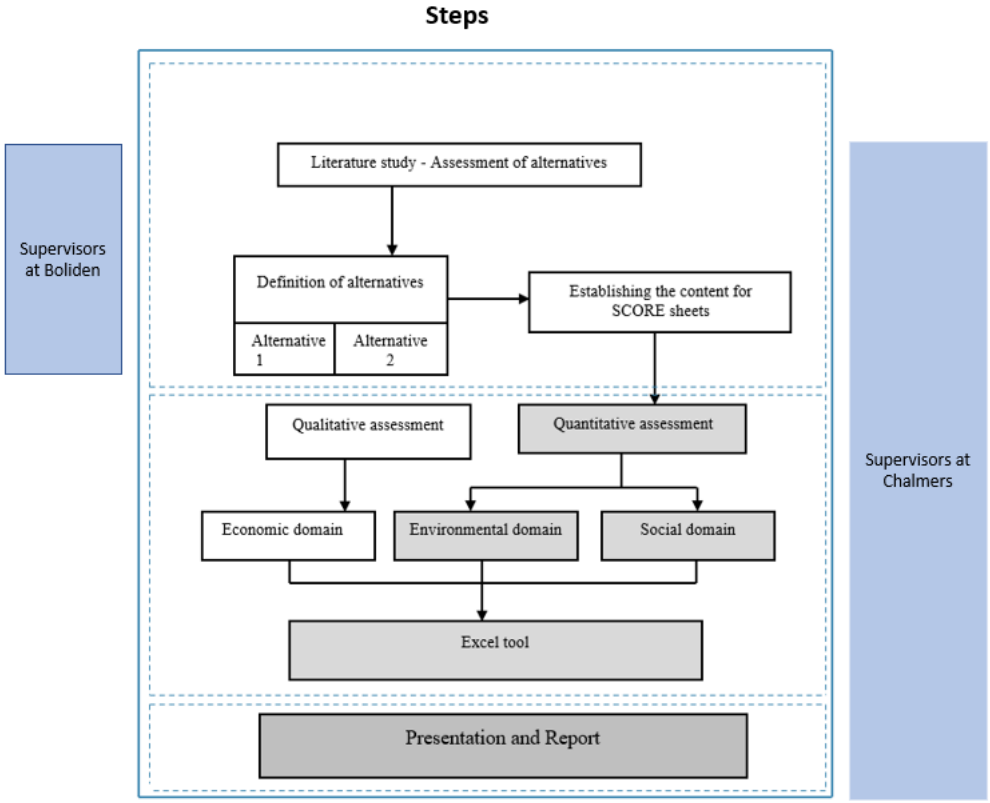


Figure 9 Working process of the SCORE tool.

4.2.1. Environmental domain

The quantitative and qualitative assessment of the environmental domain for Maurliden was done. The key criteria assigned are shown in figure 10.

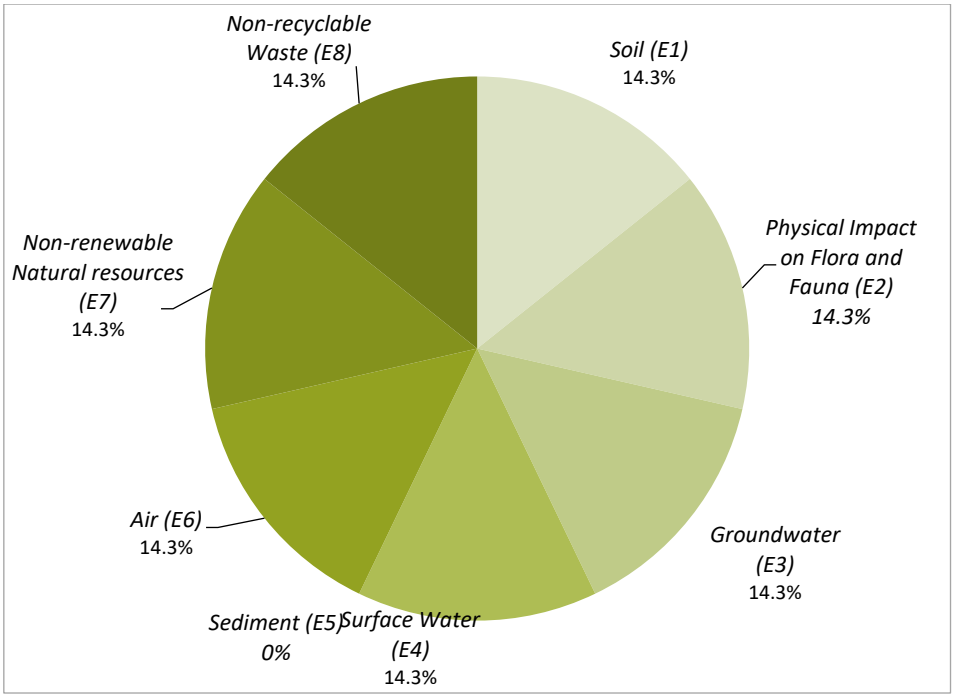


Figure 10 Weighting of the key criteria in the environmental domain.

In the environmental domain, key criteria included are soil, flora and fauna, groundwater, surface water, air, non-renewable natural resources, and waste. A weight of 14.3 % is assigned to each key criterion except sediment considering all the key criteria are of equal importance. Sediment is not considered relevant in the assessment as it is not affected by the remedial action. All the criteria in environmental domain are weighted equally except the criteria sediment.

Table 4 Environmental domain assessment (NR- Not relevant, L, M & H mean low, medium, and high value in the uncertainty assessment).

Key criteria	Sub-criteria	Alternative 1			Alternative 2		
		L	M	H	L	M	H
E1. Soil	Ecotoxicological risk RA On-site	NR	NR	NR	NR	NR	NR
	Ecotoxicological risk SC On-site	**-4**	**-2**	**0**	**-6**	**-3**	**0**
	Soil functions RA On-site	**5**	**8**	**10**	**5**	**8**	**10**
E2. Flora and Fauna	**Flora and Fauna RA On-site**	**-2**	**1**	**2**	**-4**	**-1**	**2**
E3. Groundwater	RA On-site	NR	NR	NR	NR	NR	NR
	RA Off-site	NR	NR	NR	NR	NR	NR
	SC On-site	**1**	**3**	**6**	**1**	**5**	**8**
	SC Off-site	**-6**	**-4**	**-1**	**-8**	**-6**	**-1**
E4. Surface water	RA On-site	NR	NR	NR	NR	NR	NR

	RA Off-site	NR	NR	NR	NR	NR	NR
	SC On-site	**1**	**2**	**5**	**1**	**5**	**8**
	SC Off-site	NR	NR	NR	NR	NR	NR
E5. Sediment	RA On-site	NR	NR	NR	NR	NR	NR
E6. Air	**Air RA Off-site**	**-5**	**-3**	**-1**	**-8**	**-4**	**-2**
E7. Non-renewable natural resources	**Natural resources RA Off-site**	**-5**	**-4**	**-3**	**-7**	**-3**	**-2**
E8. Waste	**Waste RA Off-site**	**2**	**5**	**6**	**7**	**8**	**9**

E1- Soil

The soil criterion considers soil down to 0.5m depth at the site. The Maurliden mine site does not contain any soil but waste rock deposit from the mining activities that are excavated and deposited near the open pit.

The sub-criterion 'Ecotoxicological risk SC on-site' is scored quantifying the negative effects on soil from the remedial action, since a previous undisturbed location is damaged due to the new waste rock deposit. Alternative 2 is assigned a higher negative score as compared to alternative 1 because a larger area is used for the waste rock deposit that causes more disturbance.

The sub-criterion 'Soil functions RA on-site' is scored quantifying the positive effects due to the restoration of the soil layer at the site that will allow the soil ecosystem to grow in time. Both the alternatives are scored equally since the transformation of the area is same in both cases.

E2- Flora, and fauna

SCORE in its present form does not allow the division into on-site and off-site. Scoring of the key criteria is done by combining the negative effects on flora and fauna due to the remedial action off-site and positive effects on-site due to the revegetation. A larger area is used for the new WRD deposit in the case of alternative 2, hence slightly less positive score is assigned as it takes longer time to revegetate this area.

E3- Ground water

Groundwater is present on-site and off-site.

The sub-criterion' Groundwater SC on-site' was scored by quantifying the reduction of the negative effects from the contamination on GW due to the remedial action. Both alternatives involve the reduction of contaminants. The groundwater isn't heavily polluted in the reference situation and since it is unsure of what will happen in the future with the efficiency of the water treatment plant, there is an uncertainty in the scores assigned to the sub-criterion.

The sub-criterion ‘Groundwater SC off-site’ was scored by quantifying the negative effects of the contamination off-site due to the remedial action. Both alternatives involve damage to the previously undisturbed location for the storage of waste rock deposits. Alternative 1 is scored less negative as it involves less area of relocation as compared to alternative 2 with more volume of WRD relocated.

E4 -Surface water

Surface water is present on-site and off-site.

The sub-criterion ‘Surface water SC on-site’ was scored by quantifying the positive effects of the remedial action. Both alternatives improve the surface water condition at the site. The wastewater treatment plant facility ensures no surface water is contaminated at the site at present. Since it’s uncertain what will happen in the future with the efficiency of the wastewater treatment plant or in the efficiency of lime in the neutralization of WRD in alternative 1 or the efficiency of the paste refill in alternative 2, it is difficult to score the criterion without uncertainty. Alternative 2 is scored higher positive score than alternative 1 since the paste refill is considered to be more stable and creates a plug that allows no from the pit as compared to waste rock refill.

The sub-criterion ‘Surface water SC off-site’ was not scored as there is no threat to the SW off-site at present and after the remedial action. The movement of WRD to the new location up north will not lead to an effect on the environmental quality standards of Skellefteälven river due to the river’s high-water flow and the dilution that is obtained (Boliden closure report,2021).

E5-Sediments

Polluted sediments are present in lake Mauträsket in the Maurbäcken catchment in its natural state before the mining activities. The mining activities are concluded, and the two alternatives are not assumed to change this situation. Hence this criterion is not included.

E6- Air

The criteria air does not differentiate between the area of the Maurliden.

The main activities having emissions in the air are the transport of materials within the site and into the site. Movement of WRD within the site and to the new locations, transport of tailings, bentonites, till, lime, and cement cause emissions into the air. More transportation of materials is involved in alternative 2 as compared to alternative 1 hence alternative 2 is scored more negative.

E7- Non-renewable natural resources

The criteria for non-renewable natural resources do not differentiate between the area of the Maurliden. This key criterion is assessed based on the amount of non-renewable natural resources used at the mine site. Both the alternatives are scored negative as materials like lime, bentonite, and cement are

transported from external for the remediation process. The volume of materials used in alternative 2 is higher as compared to alternative 1. Hence alternative 2 is given the lowest possible score of -7. There is an uncertainty in the volume of materials used for the remedial action, hence, the highest possible score of -2 is assigned. The materials that are used for remedial action are shown in table 5. The alternatives are scored differently, with alternative 2 having a more negative value than alternative 1 since more virgin materials are used in alternative 2.

Table 5 List of materials used in the remediation alternatives 1 and 2 (Boliden closure report, 2021).

Material	Source	Remedial action	
		Alternative 1	Alternative 2
Mesa lime	External	✓	✓
Slaked lime	External	✓	✓
Bentonite	External	✓	✓
Cement	External	✗	✓
Tailings	Internal (From another mine unit Kankberg, within the Boliden area)	✗	✓
Till	Internal	✓	✓

E8- Waste

The waste rock and tailings are two waste materials generated at the site. WRD is backfilled into the open pit in alternative 1 and tailings are used to create the paste for the backfill in alternative 2. Both alternatives create a new waste site to the north of the mine. Since all WRDs are reused in the case of alternative 1, positive scores are assigned. Since WRD and tailings are reused in alternative 2 and this further free up the space in Boliden urban area, higher positive scores are assigned to alternative 2 than alternative 1.

4.2.2. Social domain

The quantitative and qualitative assessment of the social domain for Maurliden was done. The Key criteria assigned are as shown in figure 11.

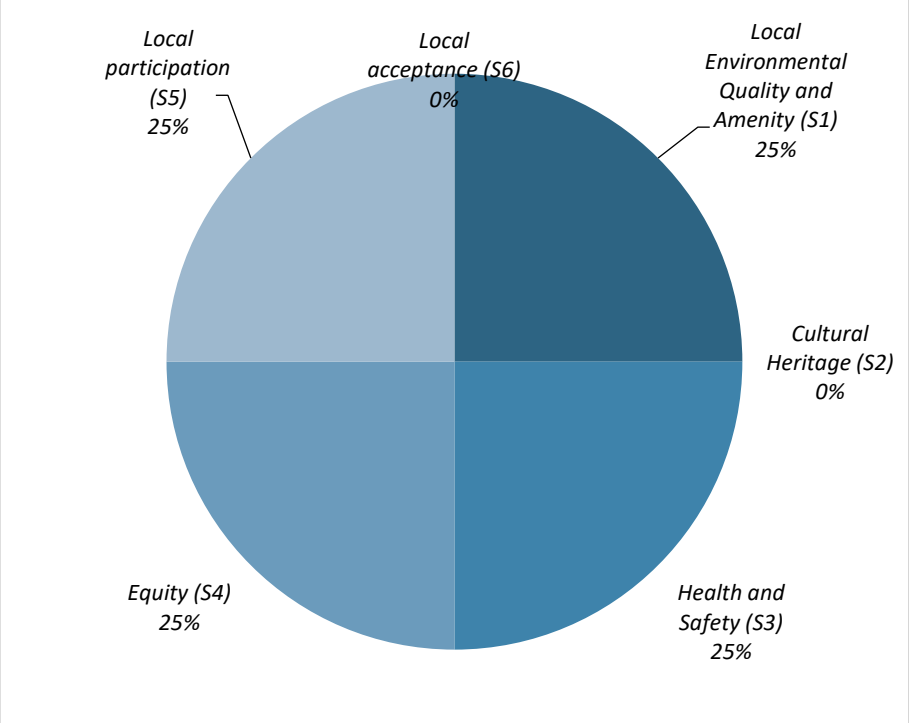


Figure 11 Weighting of the key criteria in the social domain.

In the social domain, the key criteria included are local environmental quality and amenity, health and safety, equity, and local participation. Weight of 25% is assigned to each key criterion except local acceptance considering all the key criteria is of equal importance. All the criteria in social domain are weighted equal except for cultural heritage and local acceptance. The criterion of local acceptance should be assessed based on the local community's opinion and since no workshops are conducted between the stakeholders, this criterion is not assessed initially but considered as a special scenario in the analysis. The study also includes a scenario to find the influence of local acceptance and its potential to change the outcome of the analysis.

Table 6 Social domain assessment (NR- Not relevant, L, M & H mean low, medium, and high value in the uncertainty assessment).

Key criteria	Sub-criteria	Alternative 1			Alternative 2		
		L	M	H	L	M	H
S1. Local environmental quality and amenity	**RA On-site**	**-4**	**-1**	**0**	**-2**	**-1**	**0**
	RA Off-site	**-3**	**-2**	**-1**	**-6**	**-3**	**-1**
	SC On-site	**4**	**5**	**7**	**7**	**8**	**9**
	SC Off-site	NR	NR	NR	NR	NR	NR
S2. Cultural Heritage	RA On-site	NR	NR	NR	NR	NR	NR
S3. Health and Safety	RA On-site	NR	NR	NR	NR	NR	NR
	RA Off-site	NR	NR	NR	NR	NR	NR
	SC On-site	**1**	**2**	**3**	**1**	**2**	**3**

	SC Off-site	NR	NR	NR	NR	NR	NR
S4. Equity	**RA On-site**	**-7**	**-3**	**-1**	**-3**	**-2**	**-1**
	RA Off-site	**-5**	**-2**	**-1**	**-5**	**-2**	**-1**
	SC On-site	**2**	**4**	**7**	**2**	**4**	**7**
	SC Off-site	NR	NR	NR	NR	NR	NR
S5. Local participation	RA On-site	NR	NR	NR	NR	NR	NR
	RA Off-site	NR	NR	NR	NR	NR	NR
	SC On-site	**2**	**6**	**9**	**2**	**6**	**9**
	SC Off-site	**-4**	**-2**	**-1**	**-6**	**-3**	**-1**
S6. Local acceptance	RA On-site	NR	NR	NR	NR	NR	NR
	RA Off-site	NR	NR	NR	NR	NR	NR
	SC On-site	NR	NR	NR	NR	NR	NR
	SC Off-site*	**-10**	**0**	**10**	**-10**	**-5**	**-1**

* only considered relevant in scenario 3.

S1- Local environment quality and amenity (LEQ)

There are no surrounding residents near the mine site. At present, there is a functioning wastewater treatment facility at the site for the treatment of leachate from the WRD. The treatment plant will be needed for a longer time in the case of alternative 1 due to the backfilling of WRD into the pit leading to leachate water that needed to be treated. This reduces the accessibility to the site but since the site did not have a particular recreational value in the present situation, less negative scores are assigned to the sub-criterion “RA On-site”.

The sub-criterion “RA off-site” was scored quantifying the negative effects from the remedial action off-site as the area becomes inaccessible due to the deposition of WRD to the north of the mine site. Alternative 2 is assigned the lowest possible score of -6 as more area is destroyed compared to alternative 1. The alternatives are scored differently as more area is destroyed and is inaccessible by alternative 2 as compared to alternative 1, hence alternative 2 is assigned a more negative value.

The sub-criterion “SC On-site” was scored quantifying the positive effects from the removal of the source contamination as the site will regenerate its natural vegetation over the period of time and the area will be available for assessable for recreational purposes. Alternative 2 scored higher positive than alternative 1 as the site will be accessible earlier. The alternatives are scored differently as the accessibility after the implementation of remedial action is possible earlier in the case of alternative 2, hence alternative 2 is assigned a more positive value.

S2- Cultural heritage

At the site only the treatment plant is present, and no buildings or monuments of cultural heritage were present at the site, therefore it was decided not to consider this criterion in the analysis.

S3- Health and safety

This criterion is relevant on-site with respect to source contamination. The health and accident risks with the open pit and the open storage of waste rock are reduced by the remedial action of backfilling the open pit. As the openly deposited waste rock is removed from its location in the both the remediation alternatives, both are assigned equal positive scores.

S4- Equity

This criterion is relevant on and off-site with respect to remedial action and on-site with respect to change in source contamination. With respect to the remedial action on-site, the area will not be accessible for a long time due to the treatment of leachate from the WRD. Alternative 1 takes longer time for the leachate treatment and this reduced the accessibility, hence alternative 1 is score more negative than alternative 2. With respect to the remedial action off-site, the new location previously undisturbed will be inaccessible for a long time as the WRD will be moved to the north and the vegetation will take time to regrow. Since the inaccessibility to the site remains the same for alternative 1 and 2, they are assigned equal weights.

The sub-criterion “SC On-site” was scored quantifying the positive effects from the removal of the source contamination. Backfilling of open pit action improves the condition of the mine site for future generations, so they do not need to pay for it in the future. Hence positive and equal scores are assigned to both alternatives.

S5- Local participation

This criterion is relevant on and off-site for change in source contamination.

The sub-criterion “SC On-site” was scored quantifying the positive effects from the removal of source contamination. The removal of the contamination after the remedial action revegetates the location making it available to local population. The availability of local jobs and accessibility to the site are possible at the same time in both alternatives, hence they are scored the same.

The sub-criterion “SC Off-site” was scored quantifying the negative effects after the remedial action. The remedial action involves the transportation of WRD to the new location up north. Thus, the area will be inaccessible for the traditional reindeer herding for Sami people. The local job opportunities will also no longer be available after the completion of remedial action. Hence negative scores are assigned to both the alternatives. Alternative 2 is assigned a more negative score as compared to alternative 1 since more area of land is inaccessible after the remedial action.

S6- Local acceptance

This criterion is usually scored by conducting workshops with the local representatives. However, a workshop was not conducted, and this criterion was not included in the initial analysis but as a separate scenario to study its influence in changing the outcome of the analysis. In the analysis, various scores were tested to study the potential of the criteria to change the ranking order.

4.2.3. Economic domain

The benefits and costs are identified for the alternative 1 and 2 and are tabulated as a very important [X], somewhat important[(X)], and not relevant (NR) in table 7 and 8 respectively. Only a qualitative assessment is done in economic domain. Due to the lack of data on actual costs and benefits related to the implementation of remedial actions, no monetization of benefits and costs were made in the study.

Table 7 Qualitative assessment of benefits in the Maurliden site, to each alternative. X= important, (X)= somewhat important, NR= not relevant.

Benefits: Qualitative assessment			
Useful items	**Qualitative assessment of the significance of benefits (stated as X for very important, (X) for somewhat important, and NR for Not relevant)**		
B.1 Increased property value		**Alternative 1**	**Alternative 2**
		X	X
	The property is likely to have an effect on the future sales value as there will be a need to pay for the water treatment facility. Hence this criterion is considered important.		
B.2 Improved health			
B.2a Reduction in acute health risks		**Alternative 1**	**Alternative 2**
		NR	NR
	There are no issues related to any acute health risks like poisoning at the mine site. So, the criterion is insignificant.		
B.2b Reduction in non-acute health risks		**Alternative 1**	**Alternative 2**
		(X)	(X)
	The non-acute health risks like the leakage from the waste rock deposit are already treated with the wastewater treatment facility and since there are no residents living in the vicinity of the site, the sub-criteria are considered somewhat important.		
B.2c Other types of improved health like reduced anxiety		**Alternative 1**	**Alternative 2**
		(X)	(X)
	Other health issues might arise. Could be considered somewhat important		
B.3 Increased provision of ecosystem services			
		Alternative 1	**Alternative 2**

B.3a Increased recreational opportunities on-site		X	X
	Increased recreational opportunity due to the remedial action is considered very important. Both alternatives improve the vegetation at the mine site.		
B.3b Increased recreational opportunities in the surroundings		**Alternative 1**	**Alternative 2**
		X	X
	The new waste site will be improved after the remediation. Vegetation regrows and the place will be once again available to the local population. Hence is considered important in the analysis.		
B.3c other environmental improvements including increased access to other ecosystem services		**Alternative 1**	**Alternative 2**
		X	X
	The water treatment plant at the mine site improves the water quality at the mine site that discharges from the pit and the WRD. This improves the water ecosystems and is considered important.		
B.4		**Alternative 1**	**Alternative 2**
		NR	X
	The tailings reused as a backfill into the open pit save space for a new work facility for tailings at the Boliden urban area.		

Table 8 Qualitative assessment of cost in the Maurliden site, to each alternative. X= important, (X)= somewhat important, NR= not relevant.

Costs: Qualitative assessment			
Useful items	**Qualitative assessment of the significance of costs (stated as X for very important, (X) for somewhat important, and NR for Not relevant)**		
C.1 Remediation costs			
C.1a Design of remedial actions		**Alternative 1**	**Alternative 2**
		X	X
		The cost associated with the design of remedial action is very important. This consists of implementation costs and site investigation costs.	
C.1b Project management		**Alternative 1**	**Alternative 2**
		NR	NR
	The costs that are associated with project management and technical support. These costs are not the same as remedial designs cost and are not considered relevant		
C.1c Capital costs		**Alternative 1**	**Alternative 2**
		NR	NR
	The costs associated with the interest paid on loans financing the remediation techniques. This cost is not considered relevant in the study.		
C.1.d Remedial action and materials cost		**Alternative 1**	**Alternative 2**
		X	X
	The cost of remedial action associated with the transport and disposal of materials is considered important. More transportation of materials takes place in Alt 2. Both the alternatives need treatment of water and the cost for Alternative 1 probably be higher than 2 due to the long-term running of the water treatment plant. The cost associated with the use of lime in the backfill in the case of Alternative 1. Additionally, the cost associated with the use of geo tubes and sludge dredging taking place at the site comes under the criterion.		
C.1e Monitoring		**Alternative 1**	**Alternative 2**
		X	(X)
	Costs associated with the design and implementation of the monitory programs at the mine site. Longer monitoring will be needed in the case of Alternative 1, so is given higher importance. The costs can be during the remedial action, monitoring due to termination of the remedial action, and post- remediation monitoring		
C.1f Project risks		**Alternative 1**	**Alternative 2**
		X	X
	Uncertainties may arise at the site like the reopening of a closed mine due to improper planning in closure. In such instances, additional costs		

	may arise which is considered important under the category of project risks costs		
C.2 Impaired health due to remedial action			
C.2a Increased health risks on-site		**Alternative 1**	**Alternative 2**
		NR	NR
	This criterion deals with health issues that might arise from the remediation implementations at the mine site and is mostly related to the workers. But since the workers are equipped with protective equipment, this health risk is not considered relevant.		
C.2b Increased health risk from transport activities		**Alternative 1**	**Alternative 2**
		(X)	(X)
	Health risks associated with the transport of the contaminants outside the site area along the route of residential areas. This criterion is somewhat important as there are few residents living along the route.		
C.2c Increased health risks at disposal sites		**Alternative 1**	**Alternative 2**
		NR	NR
C.2d Other types of impaired health		**Alternative 1**	**Alternative 2**
		(X)	(X)
	Another type of impaired heath associated with public worry about the spreading of a contaminant if not properly handled can be considered somewhat important.		
C.3 Decreased provision of ecosystem services due to remedial actions			
C.3a Decreased provision of ecosystem services on-site		**Alternative 1**	**Alternative 2**
		NR	NR
	Ecosystem services on-site were already low before the remediation activities since it is a mine site. So, the cost is considered not relevant.		
C.3b Decreased provision of ecosystem services to surroundings		**Alternative 1**	**Alternative 2**
		X	X
	This criterion accounts for the cost associated with emissions from the transport of the materials as well as the resources that are used to implement the remedial action. Hence is classified as a very important		
C.3c Decreased provision of ecosystem services at disposal sites		**Alternative 1**	**Alternative 2**
		NR	NR
C.4 Other negative externalities		There are no costs related to other negative externalities other than C2 and C1	
C.4		**Alternative 1**	**Alternative 2**
		NR	NR

5. Results

The results of the SCORE analysis is shown by using four different scenarios:

- Base Scenario: Environmental (50%) and social (50%) domains have equal weights, and the local acceptance criterion is not included.
- Scenario 1: Environmental 70%, social 30%, and the local acceptance criterion is not included.
- Scenario 2: Environmental 30%, social 70% and the local acceptance criterion is not included.
- Scenario 3: Environmental (50%) and social (50%) domains have equal weights with the local acceptance criterion included.

5.1. Base scenario

In the base scenario, the environmental (50%) and social domain (50%) were given equal importance and the local acceptance criterion was not included. The results obtained are seen in figure 12. Alternative 2 receives the highest total score in the analysis. Alternative 1 receives a less positive total sustainability score. Alternative 2 scored the best in both the environmental and social domains, whereas alternative 1 scored lesser than alternative 2 in both social and environmental domain. The normalized total sustainability score with uncertainty levels for the base scenario shows a high certainty that alternative 2 will have a positive total score (0.44) and alternative 1 has a slightly lesser positive total score (0.32) with a high uncertainty. This is because alternative 2 performs best in both environmental and social sustainability scores.

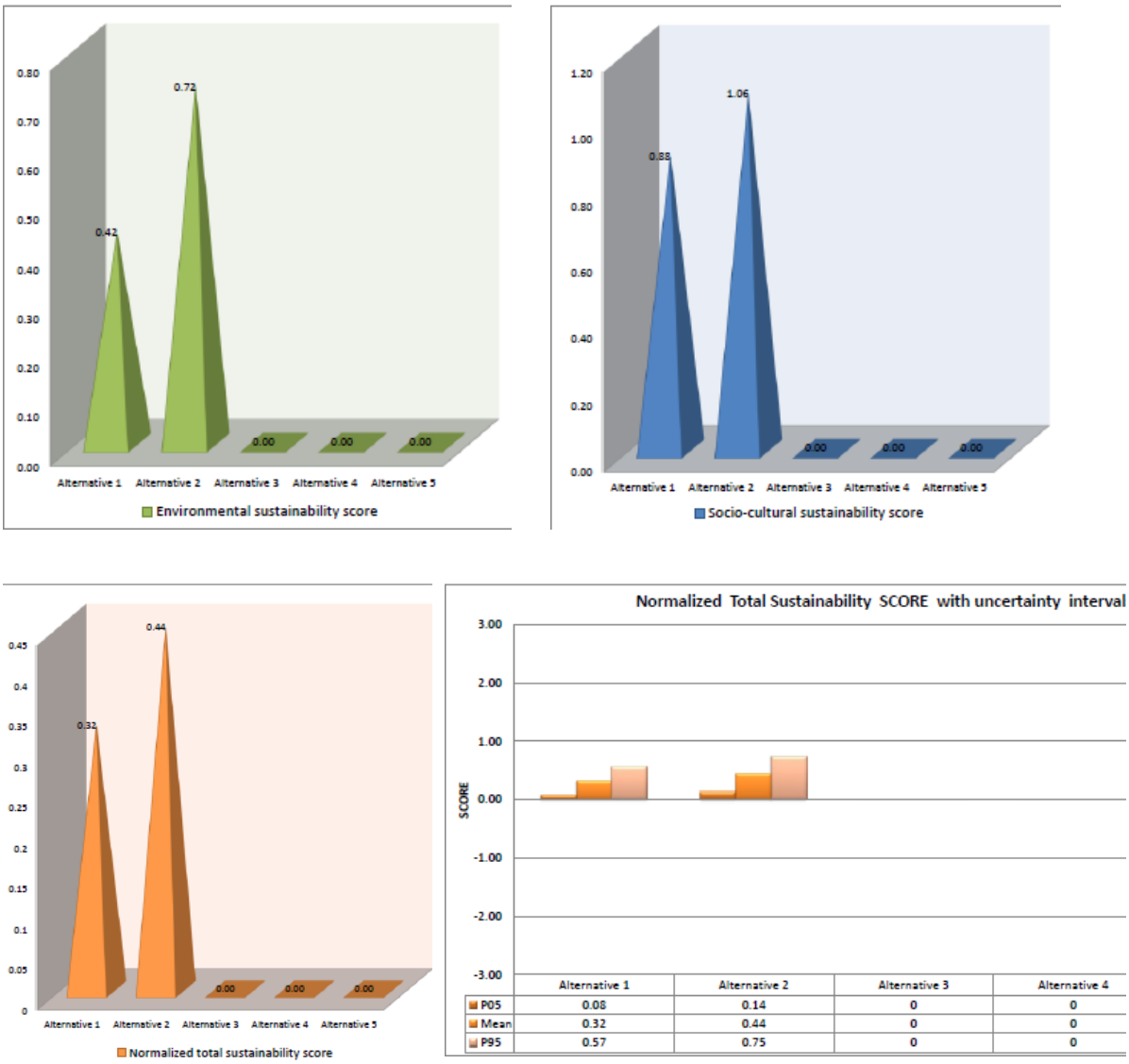


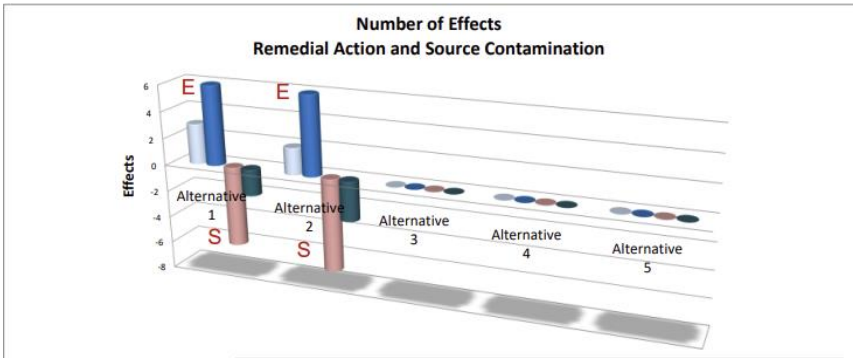
Figure 12 Sustainability score for base scenario.

The SCORE method makes it possible to identify where to improve the score of each alternative. Figure 13 shows the environmental and social effects of the remediation alternatives.

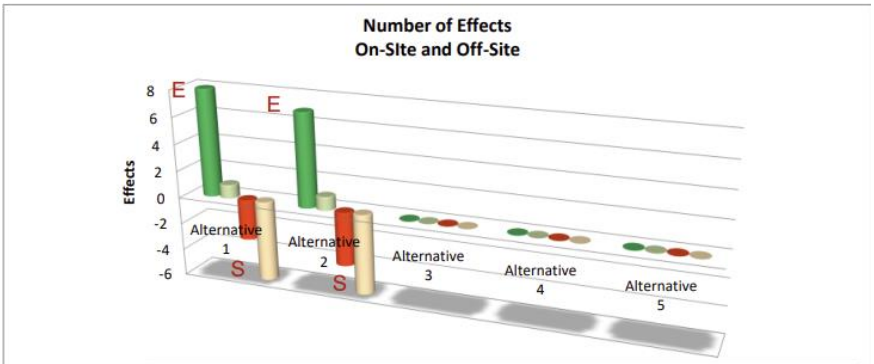
The following observations are made:

- Both alternatives have positive environmental effects in the implementation of remedial action as well as in the reduction of effects of contamination.
- Both alternatives have negative social effects in the implementation of the remedial action as well as in the reduction of effects of contamination.
- The environmental effects are more positive on-site than off-site for both alternatives.
- The social effects are negative in both on-site and off-site for both alternatives.

The reason could be that the site in its initial state had environmental issues which would be improved during and after the remedial action and since the site initially does not have many social criteria that are affected due to its remote location and the relocation of WRD, and destruction of a new area reduced the accessibility to the location.



	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Remedial Action Positive	3	2	0	0	0
Source Contamination Positive	6	6	0	0	0
Remedial Action Negative	-6	-7	0	0	0
Source Contamination Negative	-2	-3	0	0	0



	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
On-Site Positive	8	7	0	0	0
Off-Site Positive	1	1	0	0	0
On Site Negative	-3	-4	0	0	0
Off-Site Negative	-6	-6	0	0	0

Figure 13 Environmental and social effects of the remediation alternatives.

Figure 14 shows alternative 2 has the highest probability of being the most sustainable, almost 70%, and alternative 1 with the least probability, close to 30%. The uncertainties in result can be understood by the sensitivity analysis.

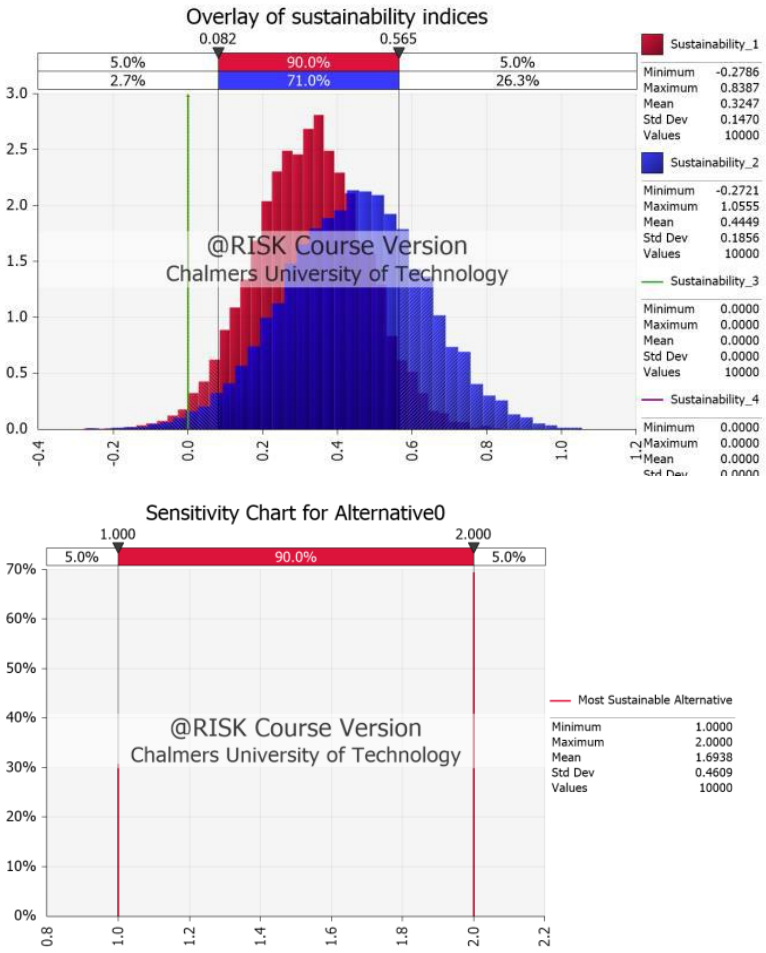


Figure 14 Probability of each alternative to be the most sustainable.

How the different parameters contribute to the variance in the results is shown in figure 15. For Alternative 1, the scoring of the effect on local participation on-site has the greatest influence as the effect on location participation on-site has a high uncertainty in the assessment, it is uncertain how many will be given job opportunities as the place is a remote location, see appendix I.S5. To reduce the uncertainty in the analysis, it would be good to make a better estimate of how the local population's access to the place is affected along with the opportunities for local jobs. For alternative 2, the scoring of the effect on surface water has the greatest influence. This is due to the uncertainty in the scores assigned. The wastewater treatment facility at the site treats the leachate from the pit and WRD but it's uncertain what can happen in the future regarding the efficiency of the treatment plant, or the efficiency of the paste backfill. To reduce the uncertainty in the analysis, it is good to make a better estimate of how surface water is affected by alternative 2.

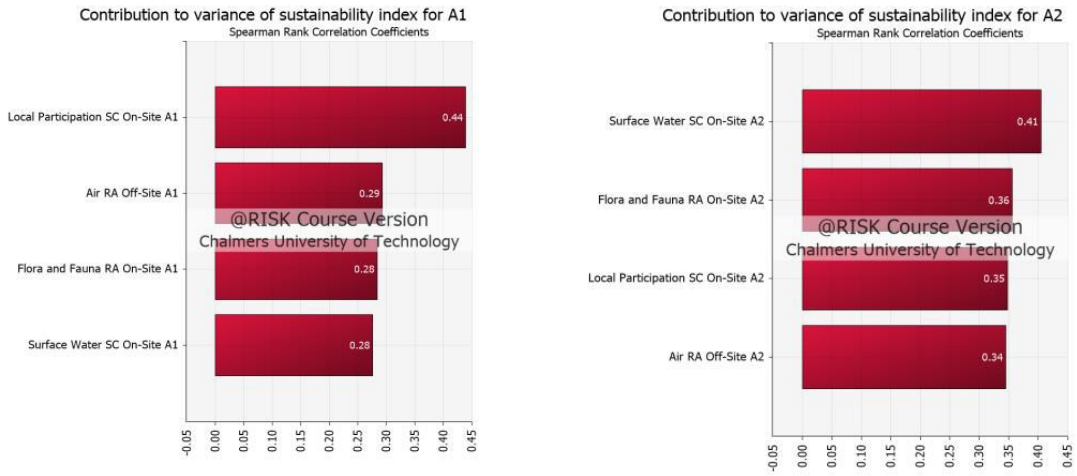


Figure 15 Sensitivity analysis for each alternative in the base scenario.

5.2. Scenario 1

In scenario 1, the environmental domain was considered more important (70%) than the social domain (30%) by not including the local acceptance criterion. Scoring and weighting within each domain were the same as the base scenario and the results obtained are seen in figure 16. Alternatives 1 and 2 had positive total sustainability scores of 0.28 and 0.41 respectively. The resulting normalised total sustainability score had the same ranking as the base scenario. The uncertainty intervals show certainty that alternative 2 will have a positive total score. This is because Alternative 2 has a strong performance in both the social and environmental domains.

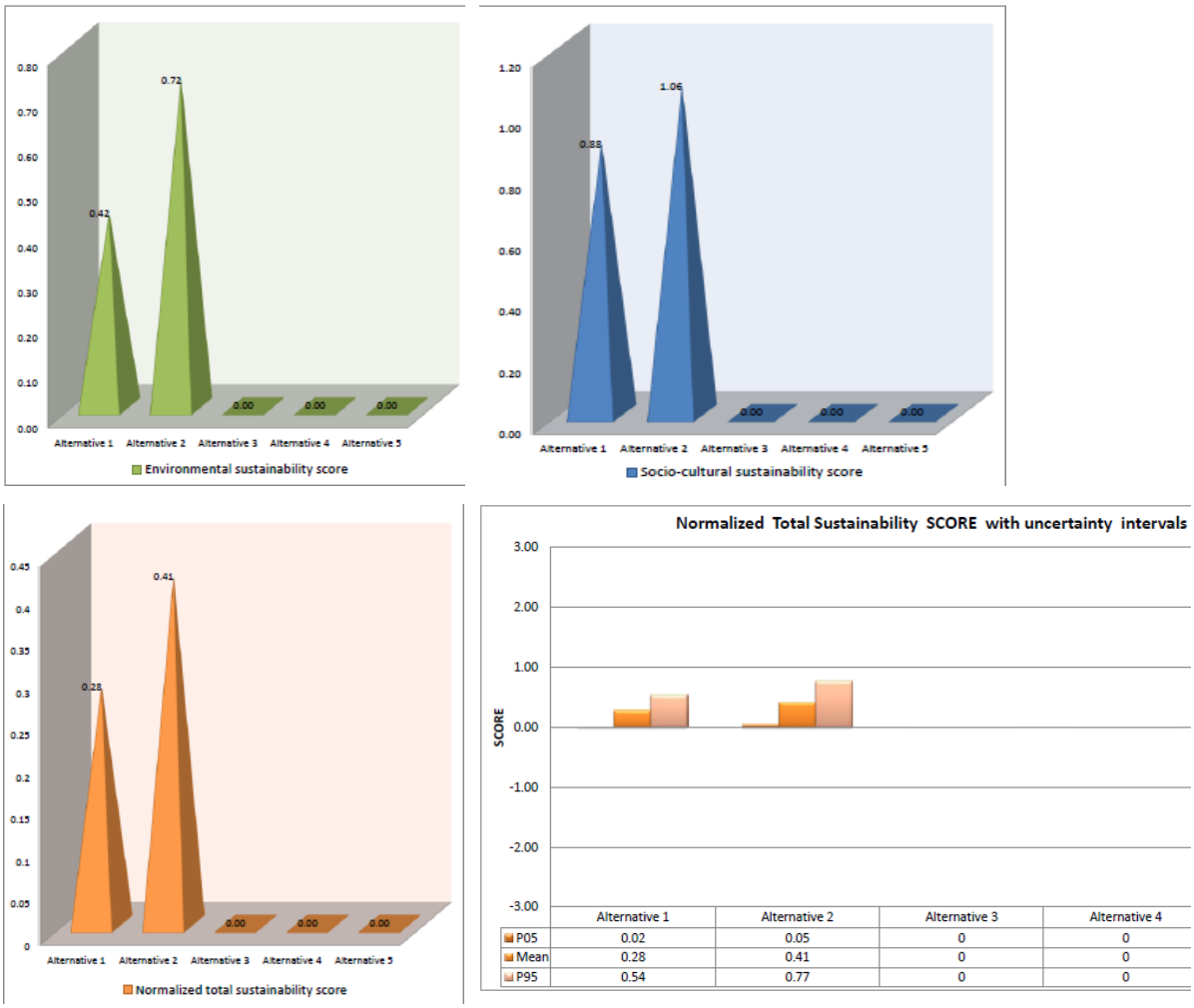


Figure 16 Sustainability score for scenario 1.

Due to the higher weight assigned to the environmental domain in scenario 1, the criteria in the environmental domain have the greatest influence on the uncertainties for both the alternatives as shown in figure 17.

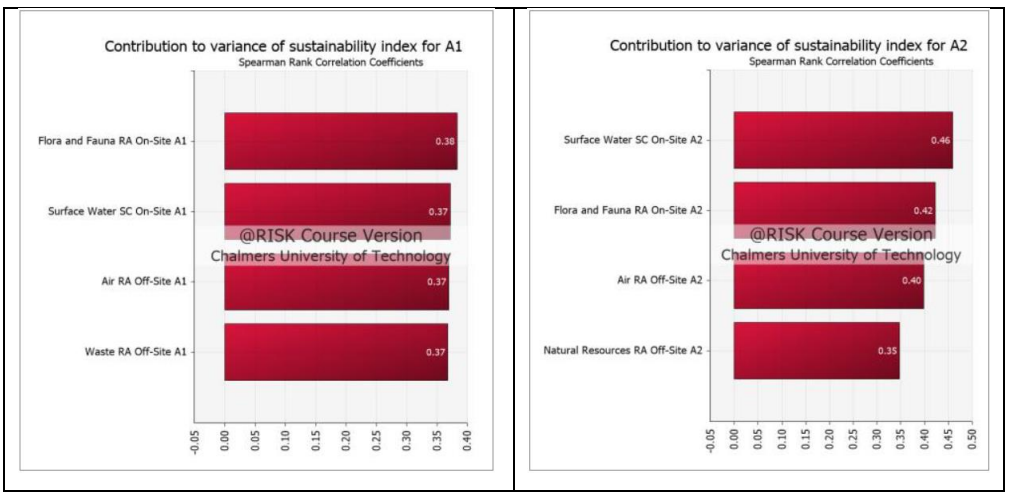


Figure 17 Sensitivity analysis for each alternative in scenario 1.

5.3. Scenario 2

In scenario 2, the social domain was considered more important (70%) than the environmental domain (30%) by not including the local acceptance criterion. Scoring and weighting within each domain were the same as the base scenario and the results obtained are seen in figure 18. Alternatives 1 and 2 had positive total sustainability scores of 0.37 and 0.48 respectively. The resulting normalised total sustainability score had the same ranking as the base scenario. Alternative 2 has a positive total score in scenario 2.

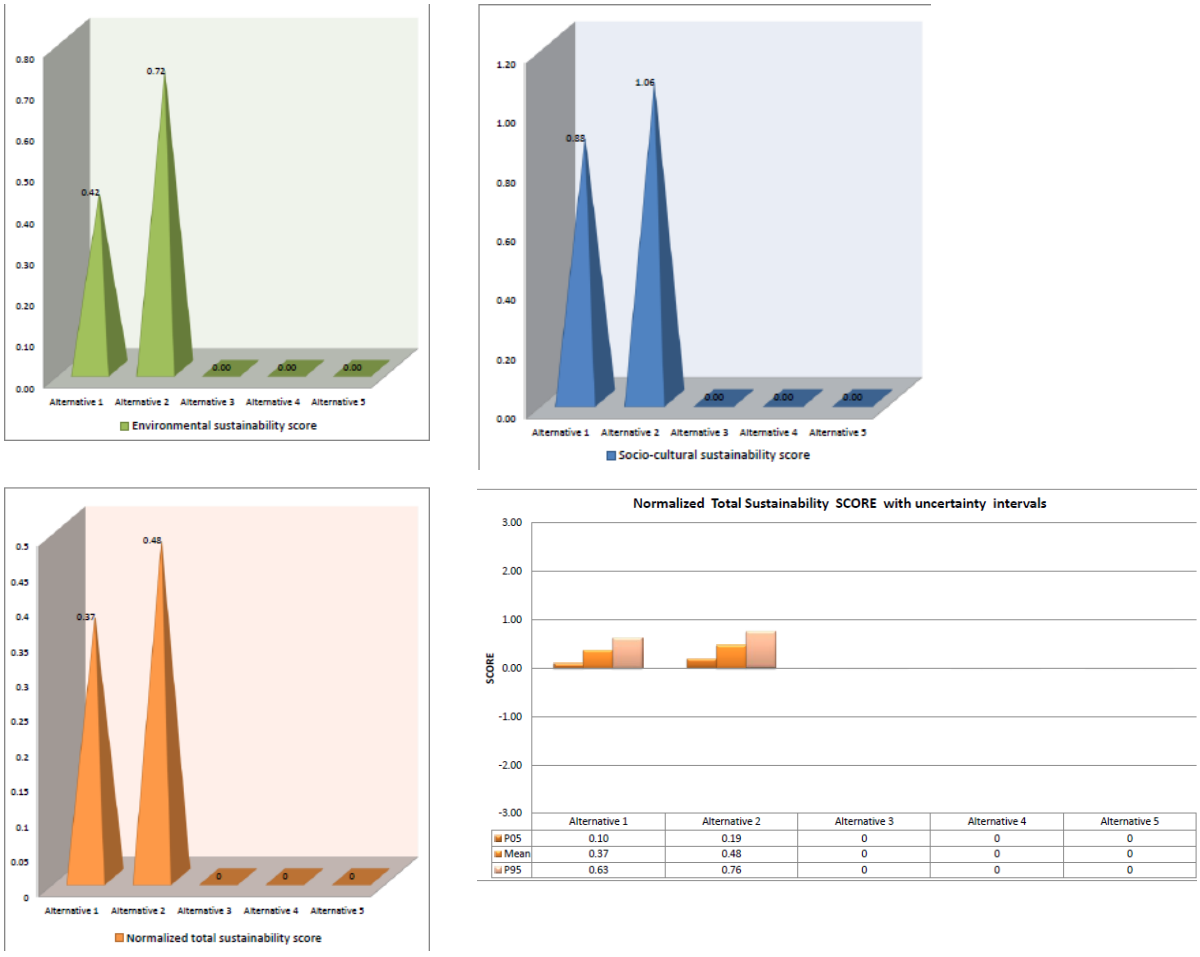


Figure 18 Sustainability score for scenario 2.

Due to the higher weight assigned to the social domain in scenario 2, the criteria in the social domain have the greatest influence on the uncertainties for both the alternatives as shown in figure 19.

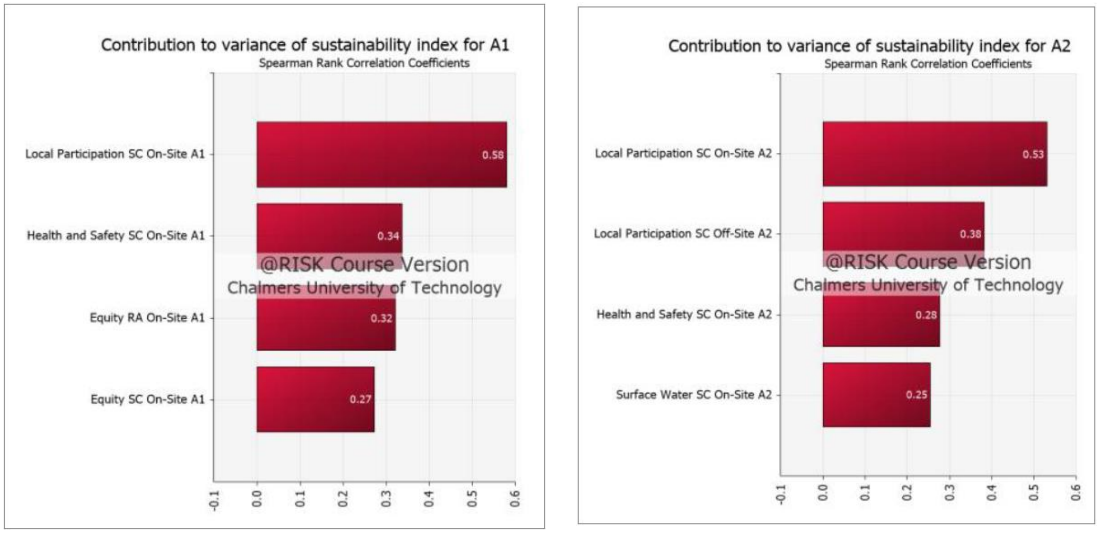


Figure 19 Sensitivity analysis for each alternative in scenario 2.

5.4. Scenario 3

In the base scenario, the environmental (50%) and social domain (50%) were given equal importance and the local acceptance criterion was included. In scenario 3, influence of local acceptance and its potential to change the outcome of the analysis is studied. Scoring and weighting within each domain were the same as the base scenario and the results obtained are seen in figure 20.

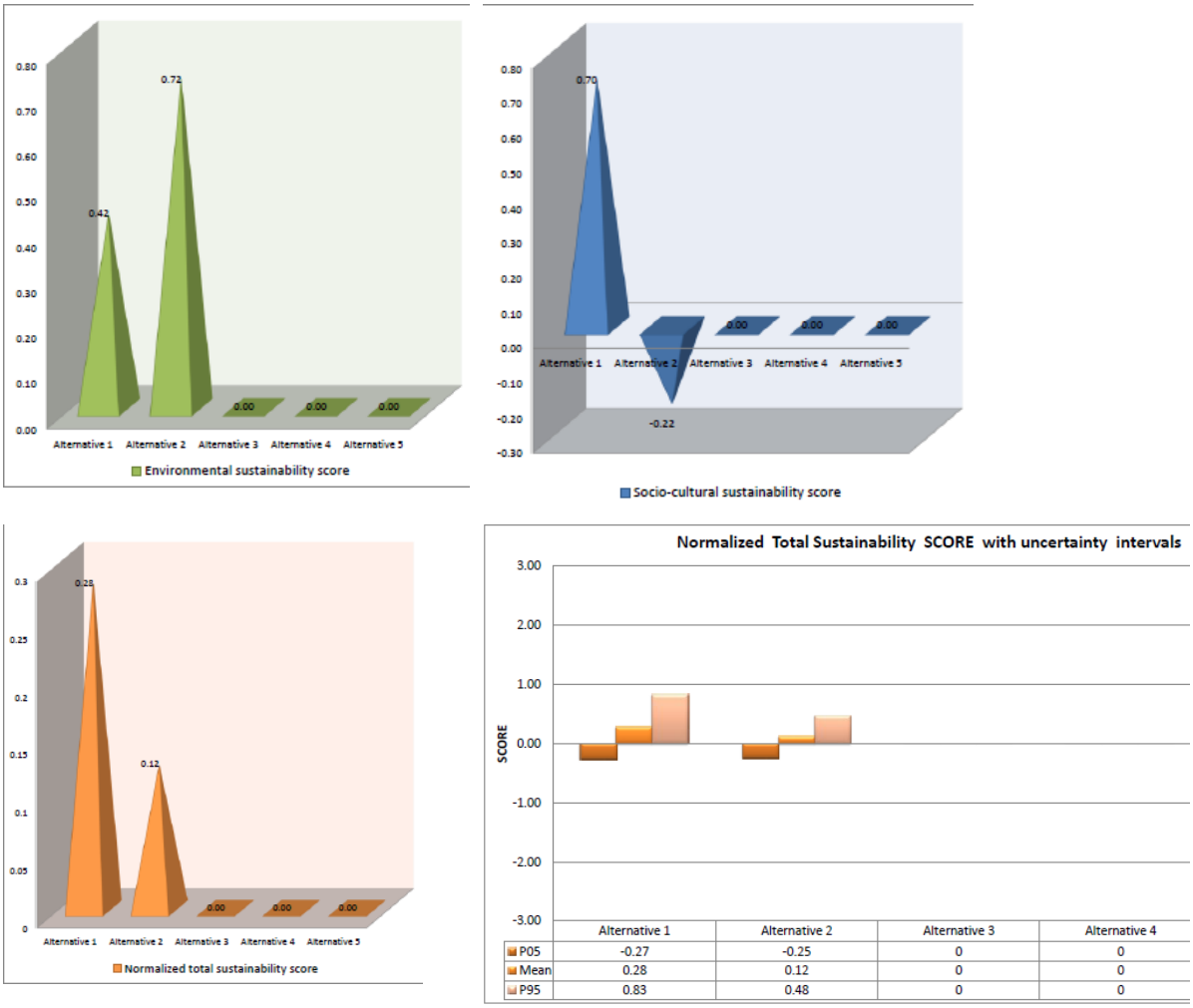


Figure 20 Sustainability score for scenario 3.

The results indicate a change in the ranking of the alternatives. When an input score of extreme values i.e., a score of -10 is assigned to the local acceptance criterion, alternative 1 ranked highest in the normalised total sustainability score. This explains if the local community strongly prefers alternative 1, then the ranking of the alternative shifts.

6. Discussion

Four scenarios were analysed in the study. Alternatives 1 and 2 resulted in positive total normalised sustainable scores in the base scenario and scenarios 1 and 2. The scenarios considered in the study are based on the weights assigned to each domain. Scenario 3 analysed the influence of the local acceptance criterion and its potential to switch the ranking in the study. Alternative 2 ranked best in the base scenario and scenarios 1 and 2. In scenario 3, when weights were distributed equally between environmental (50%) and social domain (50%) and local acceptance criterion were include, the ranking of the alternatives switched resulting in alternative 1 ranking at the top. This explains that the opinions of the local community have a strong influence and can change the result of the analysis in the SCORE method if the environmental domain is not weighted very high.

The SCORE method in its current form does not allow the division of on-site and off-site for some key criteria in the study. Flora and fauna, a key criterion in the environmental domain do not allow the division of on-site and off-site in the study. Since the area in mining is much larger as compared to most other types of contaminated sites, the scores were assigned by combining both on-site and off-site. On-site, the vegetation improves from the remedial action for both the alternatives as compared to the present situation of the mine site. Off-site, a new area is destroyed which was previously accessible. So, the positive scores from on-site are combined with negative scores from off-site in the analysis.

The waste criterion from the environmental domain in the SCORE tool in its present form states that maximum positive effects are not expected to occur in general at contaminated sites. But for the mine closure, the scoring tool is adapted to fit maximum positive effects as maximum positive scores are assigned if all the soil masses are reused at the site. Alternatives 1 and 2 contributed to the reduction of the mine's wastes deposited at the site. Hence both alternatives are assigned positive scores. Additionally, alternative 2 has a strong positive effect than alternative 1 due to the reuse of the tailings in filling the open pit and thus saving up space for a new work facility for tailings at Boliden. So, the scoring tool was adjusted to fit the waste criterion in mine closure.

In the analysis of Maurliden, a remote location, social criteria are found to be less important in the SCORE analysis. In Appendix III, the sensitivity analysis results shows that environmental criteria have a greater impact in the base scenario and scenarios 1 and 3. However, when more weight is given to the social domain in scenario 2, the results are affected by the social criteria.

7. Conclusions and recommendations

The main conclusion and recommendations based on this study are:

- Alternative 2 has the highest ranking in all scenarios except scenario 3. The normalised total score with uncertainty intervals indicates that alternative 2 has the highest positive sustainability.
- Only when the local acceptance criterion was included and given an extremely negative scoring in the analysis, was alternative 1 ranked highest.
- Both results for alternatives 1 and 2 are more sensitive to the criteria in the environmental domain. This is due to the uncertainties in the scores assigned to the key criteria as flora and fauna, surface water on-site, and air.
- The features that generate the positive effects in alternative 2 are the improvement in the quality of environmental standards on-site during and after the remedial action. The paste refill method ensures better sealing of the open pit as compared to the WRD refill.
- This study does not include quantitative analysis of the economic domain due to the unavailability of the data. It is important to assess the economic domain rather with a cost benefit analysis to analyse the sustainability of the measure from an economic point of view.
- No other available method considers all three sustainability domains in assessment for remediations in mine closure. This makes SCORE, an effective method for mine closure practices.

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Appendices

Appendix I.

SCORE: Form for scoring and weighting the environmental effects of remedial action

Brief description of reference options and action options:

Reference	**Alt 1**	**Alt 2**
Present situation: The open pit is currently partially filled with water	The open pit is backfilled with waste rock and resulting concave mass is qualified covered. The extra waste rock that will not fit in the pit is transferred to the north of the mine site and qualified covered. The tailings are transported to the Boliden urban area.	The open pit is backfilled with paste (mixture of tailings, water & cement/slag) and the surface is covered with till. The current waste rock deposit (WRD) is moved to the north of the water divide of the river Skellefteälven and covered.

Explanation and abbreviations for categories of effects. Effects may occur on-site or off-site as a result of the remedial action or changes in the source contamination:

	On-site	**Off-site**
The remedial action	**I.** Effects that arise on-site as a result of the remedial action itself (often during remedial action).	**II.** Effects that arise off-site as a result of the remedial action itself (often during remedial action).
Changes in the source contamination	**III.** Effects that arise on-site as a result of changes in the source contamination (often after the measure has been implemented).	**IV.** Effects that arise off-site as a result of changes in the source contamination (often after the measure has been implemented).

The explanation for assigning scores when assessing effect:

Point: Scale from - 10 to +10	**(+10 p)** Very positive effect in relation to the reference alternative. **(+5 p)** Positive effect in relation to the reference alternative. **(0 p)** No effect in relation to the reference alternative. **(-5 p)** Negative effect in relation to the reference alternative. **(-10 p)** Very negative effect in relation to the reference alternative.
Uncertainty: 3 values are specified	Lowest possible score (L), most likely score (ML), and highest possible score(H)

The explanation for assigning weights to the criteria:

Weights: 0-25	For each sub-criterion, a weight of 0-25 is given in relation to how important the criterion is considered to be. A pie chart is used to adjust the ratio of the weights until it matches the group's perception

E1 – Soil

Here, effects on the soil environment on-site are assessed: the effects of the contamination on the soil ecosystem and other effects on ecological soil functions		
	Effects due to contamination	*Other types of effects*
As a result of remedial action (during remedial action)	**E1A-I**	**E1B-I**
Due to a change in source contamination (after remedial action)	**E1A-III**	**E1B-III**

Reference: Only the upper soil layer of 0.5m is considered in the assessment of effects on soil and at this depth at the mine site, only waste rock is available. Hence the mine site at present does not contain any natural soil material. At the new WRD location to the north of the mine there are only natural soil layers.	
Worst case:	Maximum negative effects on the soil environment if there is serious damage to an area without previous risks to the soil environment and with very good ecological soil functions (-10 p)
Best case:	Maximum positive effects on the soil environment if there is a transformation of an area with very high risks to the soil environment and no functioning ecological soil functions into an area without risks to the soil environment and with very good ecological soil functions (+10 p)

E1A-III. Weighting and scoring of **effects due to contamination** (normally the usual soil environmental risks) that arise **off-site as a result of changes in the source contamination** (after remedial action):

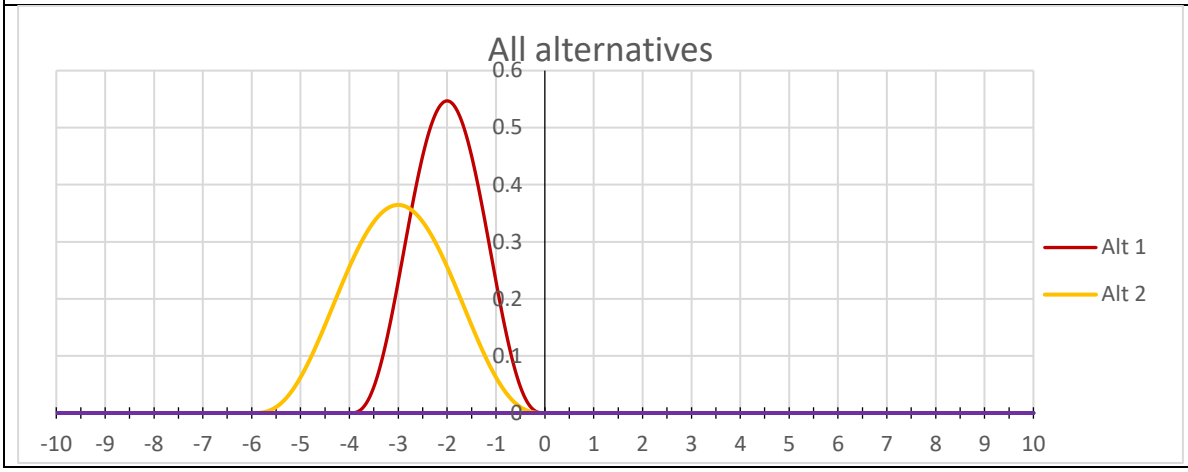
Weight: 1	Motivation and discussion: Both assessed indicators are considered equally important.	
Point:	**Alt 1**	**Alt 2**
Lowest possible score:	-4	-6
Most likely score	-2	-3
Highest possible score:	0	0

Motivation and discussion:

Off-site: new location of WRD & Skellefteälven river catchment

- Both Alternative 1 and 2 involves qualified covering of waste rock in the new location to the north of the mine site. Since the new area, previously undisturbed, is damaged due to the waste rock deposit, negative scores are assigned to both alternatives.
- Qualified covering is a mix of bentonite and till to prevent the rainwater drainage from entering the backfill (Maurliden closure report, 2019).
- Lower score is assigned to Alternative 2 than 1 since a larger area is used for the deposit of the waste rock.

- Lowest possible score of -6 is assigned to Alternative 2 since a new soil layer will be constructed on the top of the qualified cover



E1B-I. Weighting and scoring of **other types of effects** (normally the ecological soil function) that occur **on-site as a result of the remedial action** (during remedial action):

Weight: 1	Motivation and discussion: Both assessed indicators are considered equally important.	
Point:	**Alt 1**	**Alt 2**
Lowest possible score:	5	5
Most likely score	8	8
Highest possible score:	10	10

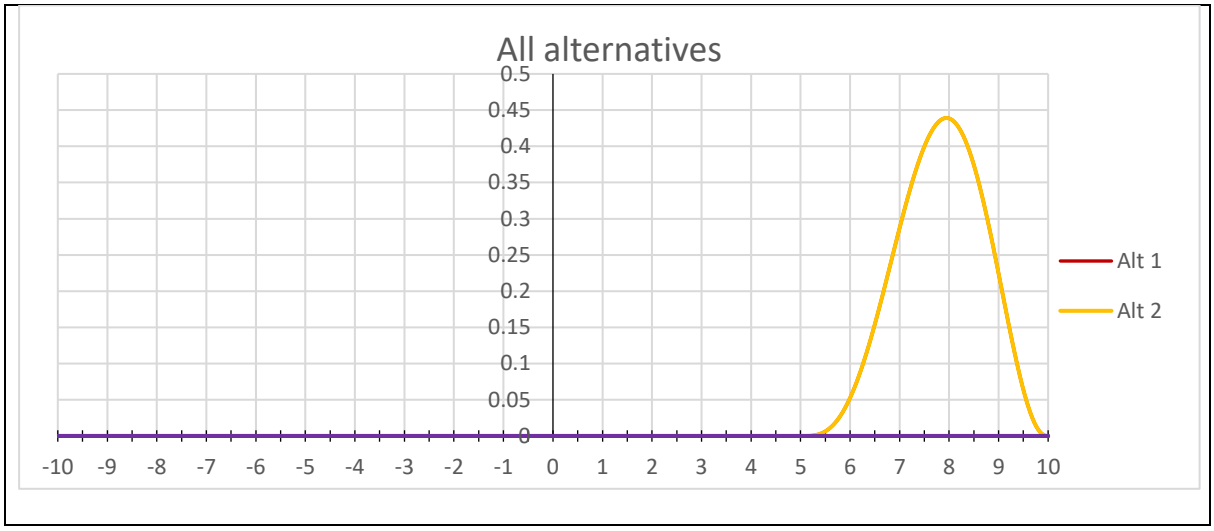
Motivation and discussion:

On-site: The entire mine site, Maurträsket lake, new WRD location up north & Skellefteälven river basin.

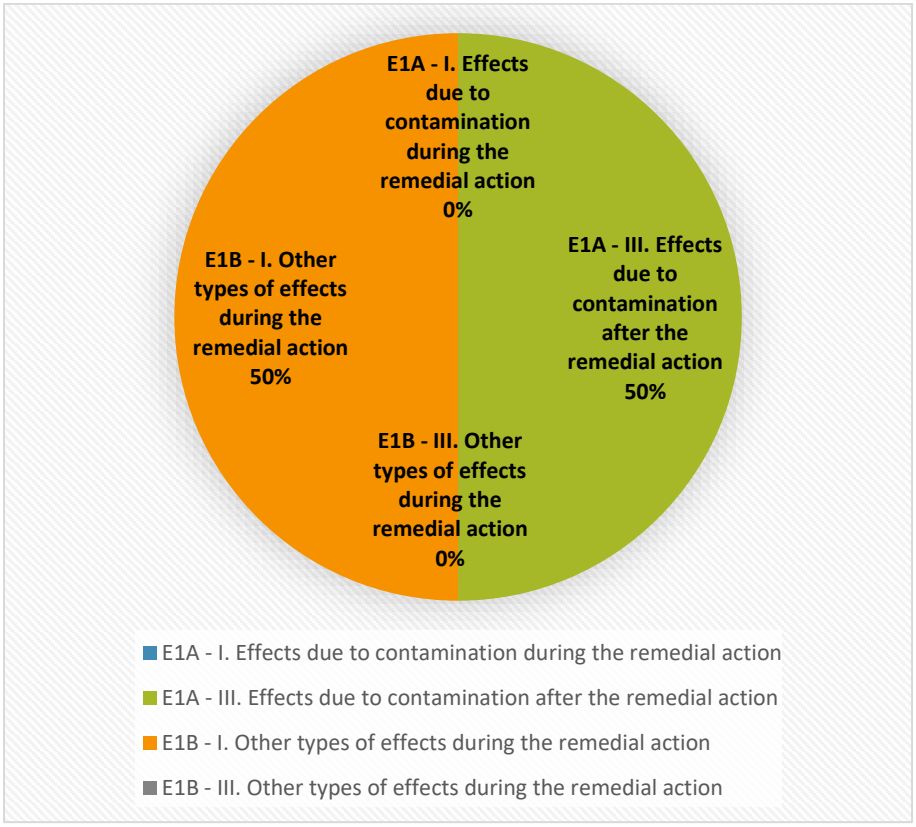
- Alternative 1 involves backfilling of the open pit with WRD and qualified covering. This remedial action will allow the soil ecosystem to re-establish compared to the present situation in which only a pile of waste rocks exists at the site. The most likely score of 8 is assigned as there is no contaminated soil at the site in the reference alternative.

- Alternative 2 involves backfilling the open pit with paste. This remedial action will allow the soil ecosystem to re-establish in time and has a positive effect on the mine site as compared to the present situation at the site.

- Equal scores are assigned to both the alternatives since transformation of the area is the same in both the cases and highest possible score 10 is given since the soil restored as compared to the present situation.



The figure below shows the selected weighting for the two included key criterion of soil. Both were given equal importance because the soil ecosystem is dependent on both good soil condition and low contamination levels.



E2 – Flora, and fauna

Here, physical effects on valuable flora and fauna are assessed		
	On-site	*Off-site*
As a result of remedial action (during remedial action)	**I**	II

Due to a change in source contamination (after remedial action)	III	IV

Reference: There is no flora or fauna located at the mine site. But there is flora and fauna at the new WRD location which is undisturbed in the present situation.	
Worst case:	Maximum negative effects if a prosperous and valuable flora and fauna are eliminated as a result of the measure (-10 p)
Best case:	Maximum positive effects if an area with a total lack of valuable flora and fauna is transformed into an area with prosperous and valuable flora and fauna as a result of the measure (+10 p)

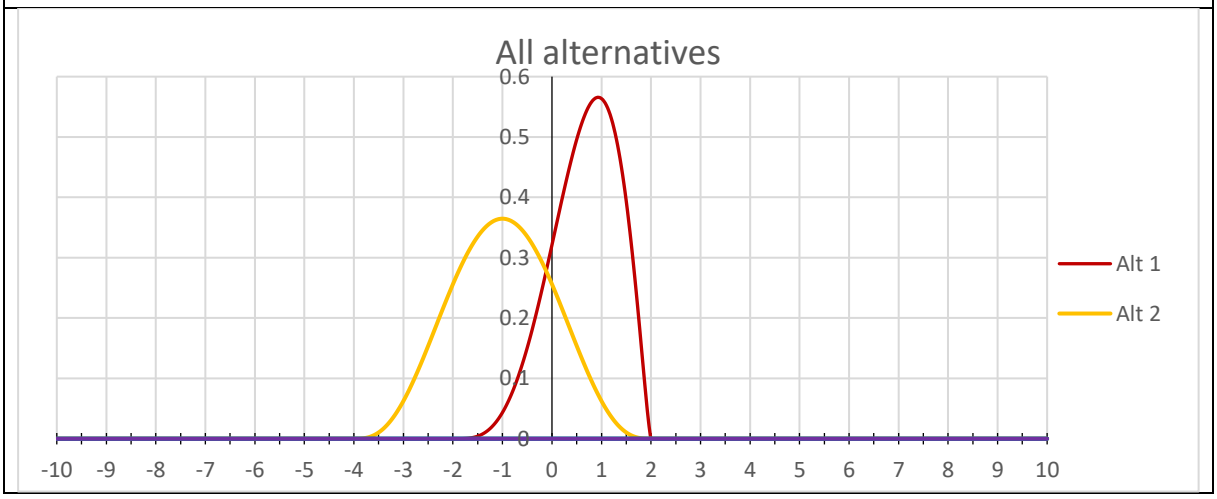
E2-I. Scoring of effects that occur **on-site as a result of the remedial action** (during remedial action):

Point:	**Alt 1**	**Alt 2**
Lowest possible score:	-2	-4
Most likely score	1	-1
Highest possible score:	2	2

Motivation and discussion:

On-site: Entire mine site, Maurträsket lake, new WRD location up north & Skellefteälven river basin.

- There is no valuable flora & fauna at the mine site before the remedial action. Nature is re-established in a long time at the mine site in both the alternatives 1 and 2, but since the flora and fauna at the new WRD location is destroyed, negative scores are assigned to both the alternatives. A larger area is used for the new WRD deposit in the case of alternative 2, hence slightly less positive score is assigned as it takes longer time to revegetate this area.



E 3 - Groundwater

Here, effects on groundwater are assessed		
	On-site	*Off-site*

As a result of remedial action (during remedial action)	**I**	**II**
Due to a change in source contamination (after remedial action)	**III**	**IV**

Reference:

- Groundwater is present both on-site and off-site in the area. There are two different catchment areas. The Maurbäcken river catchment is on-site, and the Skellefteälven river catchment area is off-site. The Maurliden mine is in the Maurbäcken catchment and the groundwater in the Maurliden mine discharges into Maurträsket lake in the Maurbäcken catchment area. The groundwater in the new WRD location discharges into the Skellefteälven river.
- There are no large aquifers in the area thus groundwater is mainly a transportation medium.
- The glacial till and the underlying bedrock represent the two hydrogeologic units in the Maurliden site. Glacial till overlaying variable fractured bedrock represents the uppermost hydrogeologic unit of the Maurliden area. (Boliden closure report, 2021).
- Groundwater in the new location to the north of the mine site is not polluted in the present situation.
- Dissolved metals are generated from the natural oxidation of the sulphide minerals present in the waste rock deposit and constitute leachate discharge from the deposit. The waste treatment plant located to the north of the open pit is active and receive polluted water from the open mine pit by pumping. The facility treats the polluted water from the pit and the polluted leachate reducing the amount of pollutants reaching the groundwater (Boliden closure report,2019). Consequently, only minor leaching to to the groundwater is expected today.
- Both the alternatives assume continuous pumping and treating of the water that is leached out from the open pit and waste rock deposit. There is a water treatment facility located at the north of the open pit that collects and treats the leachate from the waste rock deposit and the open pit.

Worst case:	Maximum negative effects if unaffected groundwater is damaged very severely by contamination or by physical effect (-10 p)
Best case:	**As a result of action (I + II):** Maximum positive effects are not expected to occur. Negative effects are minimized if no disturbance occurs during the implementation of the measure (0 p) **Due to source contamination (III + IV):** Maximum positive effects if very heavily polluted or otherwise disturbed groundwater is restored to its natural state (+10 p)

E3-III. Weighting and scoring of effects occurring **on-site due to changes in source contamination** (after remedial action):

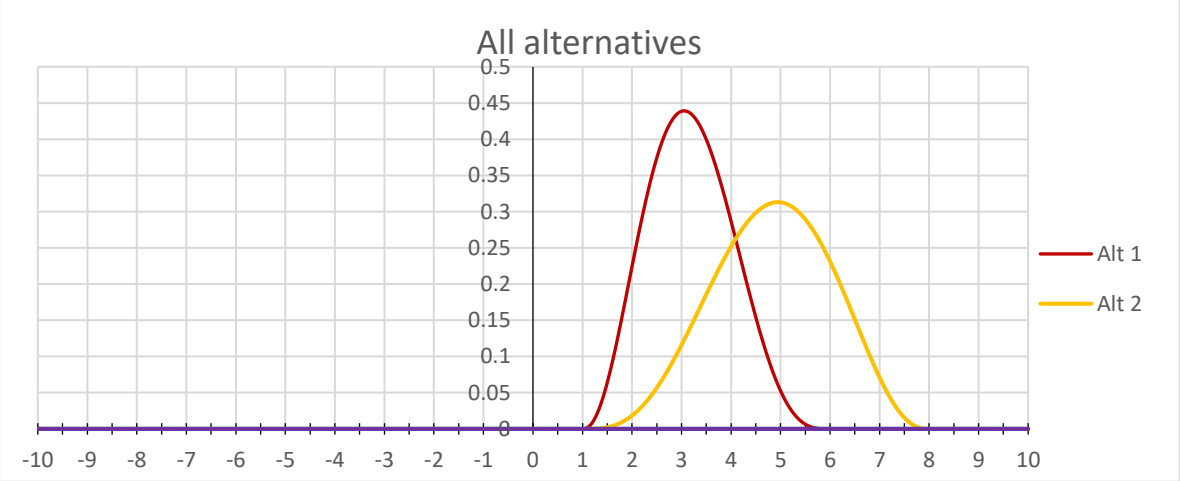
Weights: 1	Motivation and discussion: Both assessed indicators are equally weighted as the groundwater on-site and off-site are of equal importance.	
Point:	**Alt 1**	**Alt 2**
Lowest possible score:	1	1
Most likely score	3	5
Highest possible score:	6	8

Motivation and discussion:

On-site: The entire mine area and the Maurträsket lake

- Alternative 1 involves backfilling the open pit with the waste rock deposit and qualified covering. The backfill will be mixed with lime as a buffering material to raise the pH to precipitate metals. The backfill is then qualified covered. This remedial action improves the water quality with concentrations of pollutants reducing over time as compared to the reference situation. The remaining waste rock deposit after backfilling is moved to the north of mine site and qualified covered. Most likely score of 3 is assigned as the groundwater isn't heavily polluted in the reference condition.

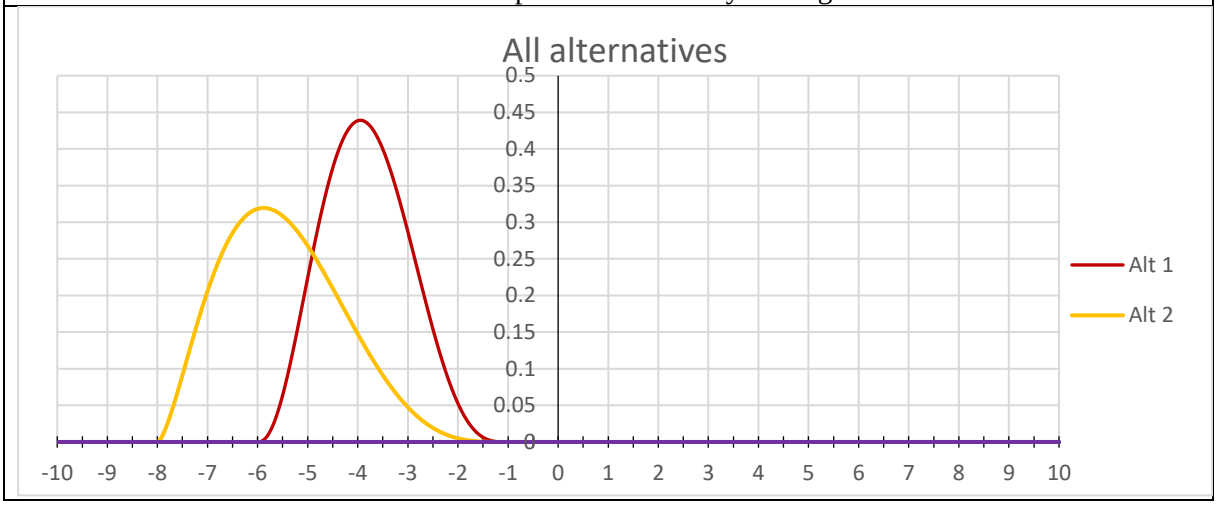
- Alternative 2 involves moving the entire WRD to the north of Skellefteälven river qualified covered and backfilling the pit with paste. There is little leaching in the reference condition, water treatment plant located at the mine site treats the leachate water and will be further reduced due to the remedial action 2. The most likely score of 5 is assigned to Alternative 2 as the paste method is more stable and creates a cement plug that restricts the water from the pit from reaching the GW.

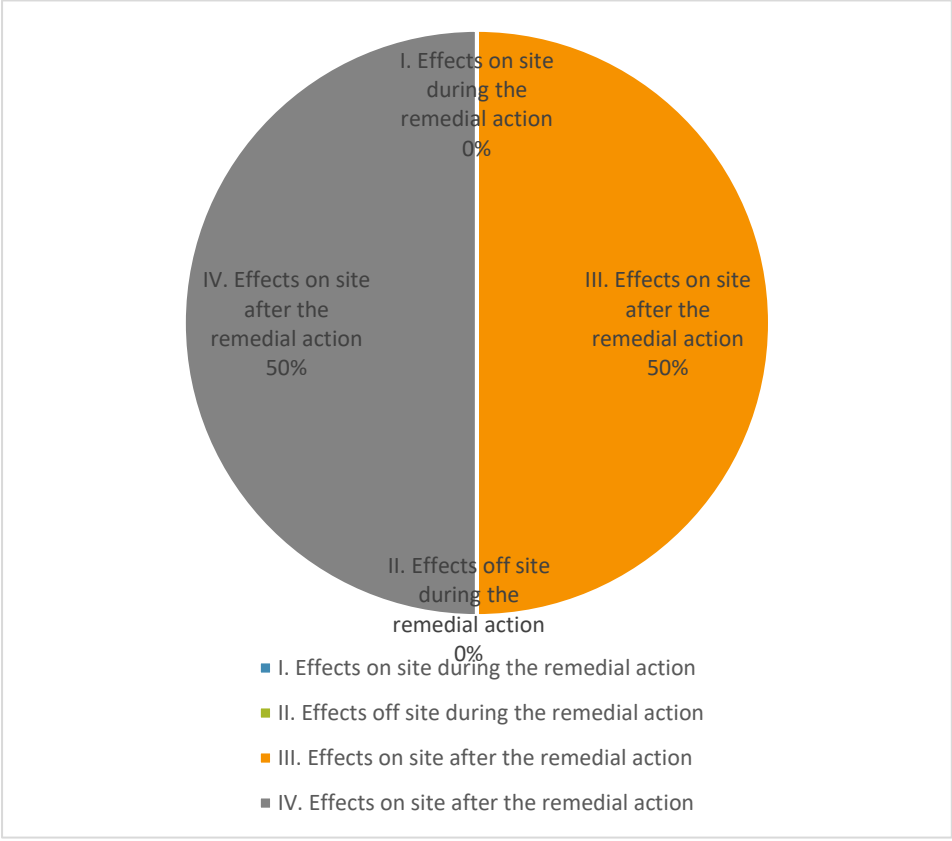


E3-IV. Weighting and scoring of effects that occur **off-site as a result of changes in the source contamination** (after remedial action):

Weight: 1	Motivation and discussion: Both assessed indicators are equally weighted as the groundwater on-site and off-site are of equal importance.	
Point:	**Alt 1**	**Alt 2**
Lowest possible score:	-6	-8
Most likely score	-4	-6
Highest possible score:	-1	-1
Motivation and discussion: Off-site: New deposit location north of the mine site situated in the Skellefteälven river catchment		

- The groundwater flow at the new location was previously undisturbed and with the relocation of the WRD in both the alternatives will have an effect on the quality of groundwater.
- There will be a negative effect on the quality of the groundwater, and alternative 2 is more negative as compared to alternative 1. There is an uncertainty in the scoring of both the alternatives as it is difficult to comprehend how badly is the groundwater affected.





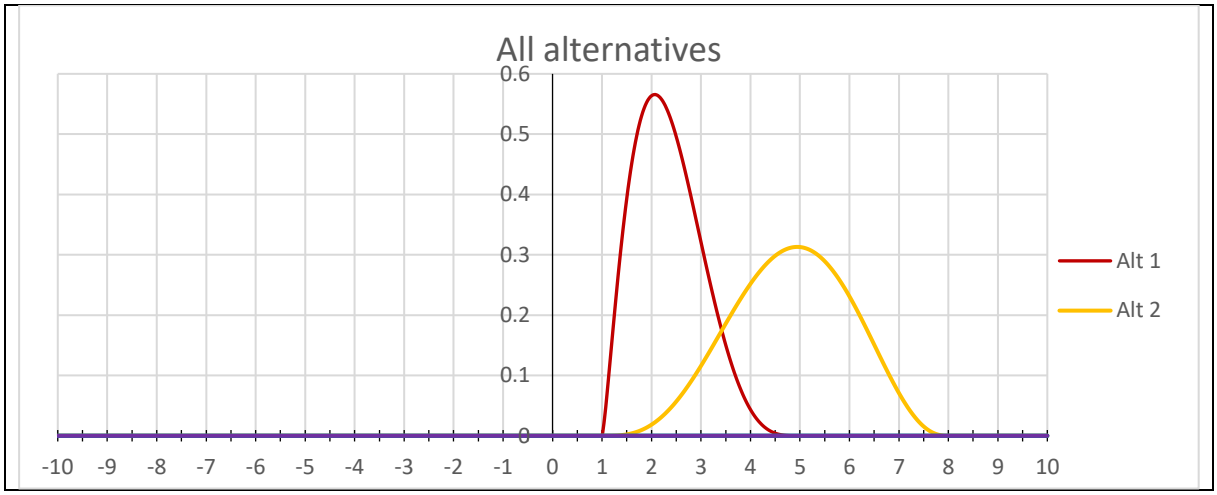
E 4 - Surface water

Here, effects on surface water are assessed		
	On-site	*Off-site*
As a result of remedial action (during remedial action)	**I**	**II**
Due to a change in source contamination (after remedial action)	**III**	**IV**

Reference:	
	• The glacial till and the underlying bedrock represent the two hydrogeologic units in the Maurliden site. Glacial till overlaying variable fractured bedrock represents the uppermost hydrogeologic unit of the Maurliden area. • The oxidized sulphide minerals present in the waste rock deposit and along the pit wall constitute the major source of pollutants. A wastewater treatment plant located at the mine site is active and treats the wastewater collected through the ditches around the open pit. • The surface water sources are the Maurträsket lake located to the southeast of the open pit and the Skellefteälven river basin located to the north of mine site.
Worst case:	Maximum adverse effects if unaffected surface water is severely damaged by contamination or by physical effect (-10 p)
Best case:	**As a result of action (I + II):** Maximum positive effects are not expected to occur. Negative effects are minimized if no disturbance occurs during the implementation of the measure (0 p) **Due to source contamination (III + IV):** Maximum positive effects if a very heavily polluted or otherwise disturbed surface water is restored to its natural state (+10 p)

E4-III. Weighting and scoring of effects occurring **on-site as a result of changes in source contamination** (after remedial action):

Weights: 1	Motivation and discussion: Only effects on-site due to change in source contamination is relevant.	
Point:	**Alt 1**	**Alt 2**
Lowest possible score:	1	1
Most likely score	2	5
Highest possible score:	5	8
Motivation and discussion: • Both the remedial action reduces the contaminants reaching the Maurträsket lake compared the present situation at the site. The paste refill is the most stable and creates a plug that allows no flow from the pit. Hence the Alternative 2 is assigned a higher score than Alternative 1. It is also uncertain how effective the waste rock fill is in preventing the the pollutants in reaching in surface water, so a lowest possible score of 1 and highest possible score of 7 is assigned to the Alternative 1.		



E 5 - Sediment

Here, effects on sediment in surface watercourses are assessed		
	On-site	*Off-site*
As a result of remedial action (during remedial action)	**I**	**II**
Due to a change in source contamination (after remedial action)	**III**	**IV**

Reference:	
Polluted sediments are present in lake Maurträsket in Maurbäcken catchment. The investigation analysis of metal contents on sediments from Maurträsket showed an elevated level of metal contents in a group of organisms living in the water. But the contamination is not from the mining activity but is in its natural state and the mining has been concluded. The two alternatives are not assumed to change this situation. Hence this criterion is not analysed.	
Worst case:	Maximum adverse effects if unaffected sediments are severely damaged by contamination or by physical effect (-10 p)
Best case:	**As a result of action (I + II):** Maximum positive effects are not expected to occur. Negative effects are minimized if no disturbance occurs during the implementation of the measure (0 p) **Due to source contamination (III + IV):** Maximum positive effects if very heavily polluted or otherwise disturbed sediment is restored to its natural state (+10 p)

E6 - Air

Here, effects on air are assessed as a result of different types of emissions: VOCs, particles (PM_{10}), NO_X, SO_X and greenhouse gases		
	On-site	*Off-site*
As a result of remedial action (during remedial action)	**I**	**II**
Due to a change in source contamination (after remedial action)	**III**	**IV**

Reference: The mining is completed in 2019 and wastewater treatment is the only activity at the mine site at present. Hence the reference alternative does not generate any greenhouse gases, NO_X or SO_X.	
Worst case:	**As a result of measure (II):** Maximum negative effects if the air emissions are matched by the air emissions caused by excavation, and long-distance transportation & disposal of the tailings/building materials (-10)
Best case:	**As a result of measure (II):** Maximum positive effects are not expected to occur. Negative effects are minimized if no air emissions occur during the implementation of the measure (0 p)

E6-I. Weighting and scoring of effects that occur **on-site as a result of the remedial action** (during remedial action):

Weight:	Motivation and discussion:	
Point:	**Alt 1**	**Alt 2**
Lowest possible score:	-5	-8
Most likely score	-3	-4
Highest possible score:	-1	-2

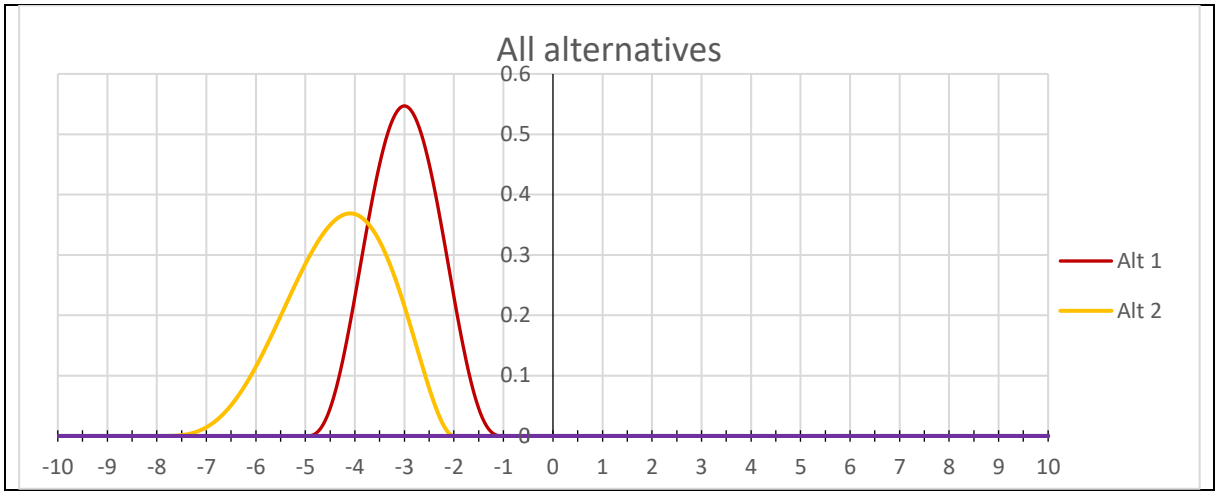
Motivation and discussion:

- The criterion air does not differentiate between the areas of the Maurliden mine site since the emissions to air will spread regionally and globally.

- Alternative 1 involves the disposal of the waste rock from its present location by tipping/dumping it into the open pit over the edge with the help of a conveyor belt. Bentonite and till are transported to the site to cover an open pit filled with WRD and to the new location to the north of mine site where the rest of the WRD is deposited. (Boliden closure report, 2021). Lime is transported to the mine site for filling in the open pit. This transportation will contribute to the emissions into the air. So, a most likely score of -4 is assigned.

- The total area for qualified covering in Alt 1 may amount to 80,000-100,000m2 approximately with a depth of 0.5m. Hence an approximate amount of 50,000 m3 of Bentonite and till will need to be transported.

- Alternative 2 involves the transportation and disposal of the waste rock from its present location to the north of the mine site and qualified covered with a mix of bentonite and till. The cover is one or more layers each of 0.5m thickness. The movement of WRD to its new location and transportation of bentonite, till, cement, and tailing to the site causes emissions to the air compared to the reference situation. Most likely score of -4 is assigned.



E7 - Non-renewable natural resources

Here, effects with regard to non-renewable natural resources, e.g., virgin backfill material, fossil fuel, and other things such as peat		
	On-site	*Off-site*
As a result of remedial action (during remedial action)	**I**	**II**
Due to a change in source contamination (after remedial action)	**III**	**IV**

Reference: Since there are no ongoing activities at the mine site, there is no use of any non-renewable natural resources in the reference situation.	
Worst case:	**As a result of measure (II):** Maximum negative effects if backfilling takes place only with virgin masses, for example rock, sand, and gravel materials, and only fossil energy is used for handling masses and transports (-10 p)
Best case:	**As a result of measure (II):** Maximum positive effects if there is a large surplus of masses that can be recycled or if there is a large production of valuable materials or substances that replace the use of virgin masses/materials in society (+10 p)

E7-II. Scoring of effects that occur **off-site as a result of remedial action** (during remedial action):

Point:	**Alt 1**	**Alt 2**
Lowest possible score:	-5	-7
Most likely score	-4	-3
Highest possible score:	-3	-2

Motivation and discussion:

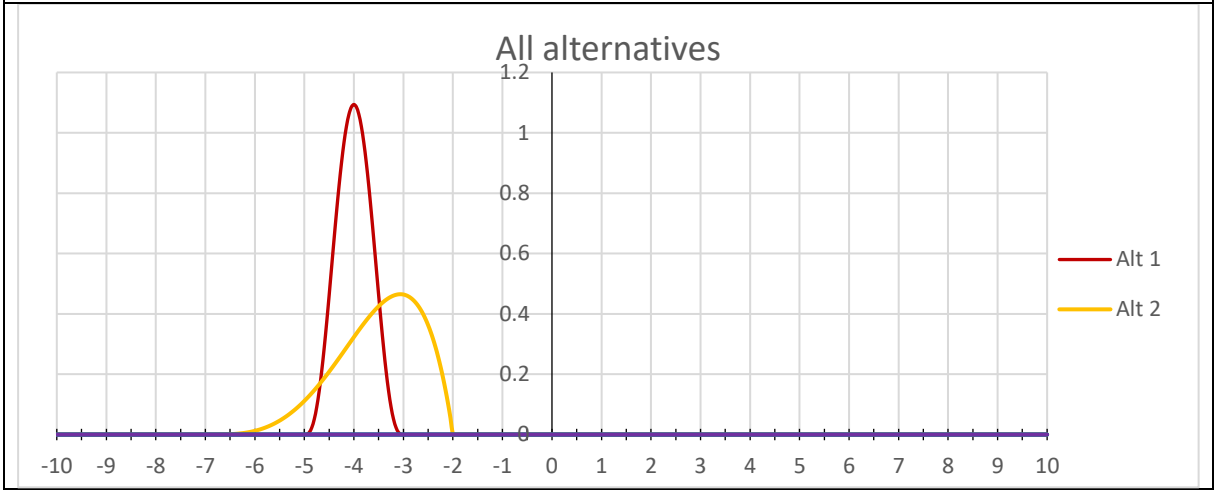
- The criterion non-renewable natural resources do not differentiate between the areas of the Maurliden mine site.
- Alternative 1 involves the use of Bentonite and till for qualified covering (one or more layers each of 0.5m thickness) the WRD into the open pit & at the north of mine site. Till is

transported to the site due to insufficient till storage. Bentonite & Lime are also transported to the site.

- The total area for qualified covering in Alt 1 may amount to 80,000-100,000m2 approximately with a thickness of 0.5m. Hence an approximate amount of 50,000 m3 of Bentonite and till will be needed.

- For a 40-ton truck, approximately 440 trips will be needed for the transportation of the materials

- Alternative 2 involves the use of Bentonite and till for qualified covering the WRD to the north of the mine site. Also uses cement in making the paste for backfilling the open pit. bentonite is transported from the Boliden urban area. Cement from another site is used in making the paste. Since fewer virgin materials are used in Alt 2 as compared to Alt 1, a most likely score of -3 is assigned.



E8 –Waste

Here, effects are assessed with regard to the production of non-recyclable or reusable waste		
	On-site	*Off-site*
As a result of remedial action (during remedial action)	I	**II**
Due to a change in source contamination (after remedial action)	III	IV

Reference:

Tailings from the mine have been moved and is stored at the Boliden site. Only waste rock is stored at the mine site and is not re-used for any purposes in the reference situation.

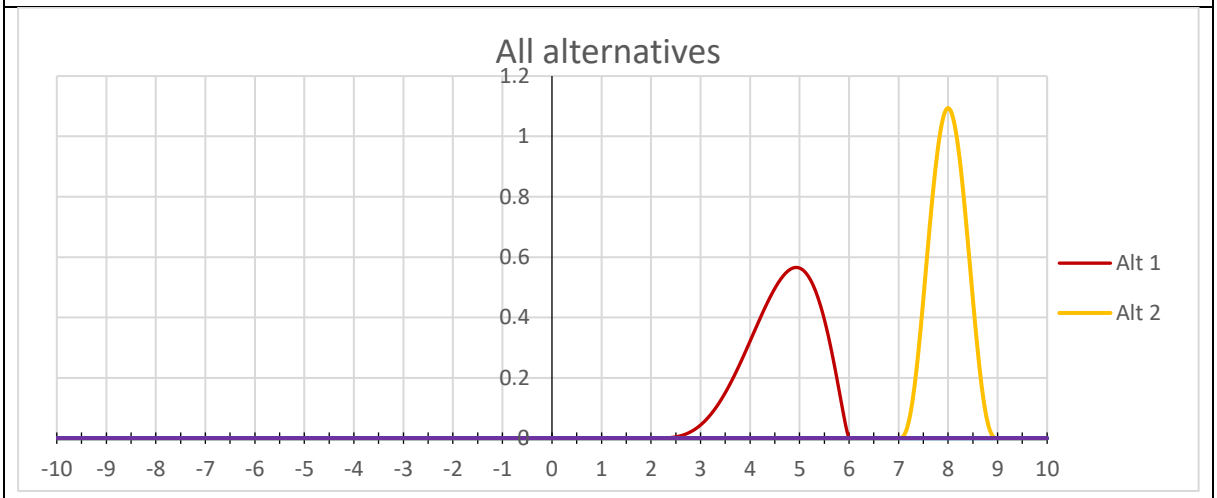
Worst case:	**As a result of measure (II):** Maximum negative effects if all soil masses on-site are excavated and disposed of as waste without treatment (-10 p)
Best case:	**As a result of measure (II):** Maximum positive effects if all the soil masses on-site are reused. (10 p)

E8-II. Scoring of effects that occur **off-site as a result of remedial action** (during remedial action):

Point:	**Alt 1**	**Alt 2**
Lowest possible score:	2	7
Most likely score	5	8
Highest possible score:	6	9

Motivation and discussion:

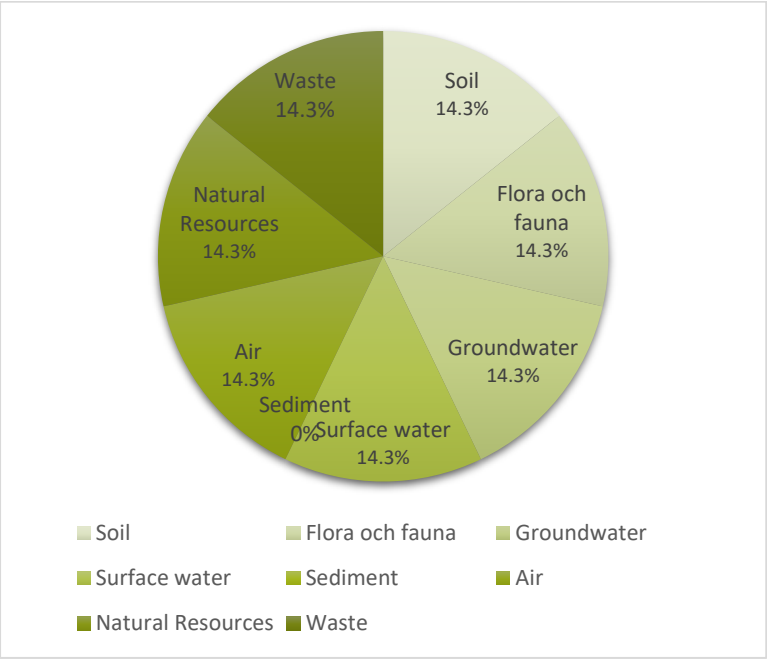
- The criterion waste does not differentiate between the areas of the Maurliden mine site.
- The two waste materials in waste criterion are tailings and waste rock stored at the mine site. Both alternatives imply creating a new waste site and alternative 1 have somewhat smaller space and alternative 2 has a larger space.
- Alternative 1 uses the waste rock as backfill for an open pit and the remaining waste rock moved up north. tailings are stored at the Boliden urban area.
- Alternative 2 used the tailings for the paste to refill the open pit and the waste rock is moved up north to the new location. Use of tailings in alternative 2 will save space for a new work at Boliden urban area hence the highest possible score of 9 is assigned.



The weighting of environmental criteria

All the criterion in environmental domain is weighted equally except the criteria sediment. It is difficult to weigh them based on their importance. For Maurliden all the criteria are considered equally important.

	Key criteria	weight	weight (%)
E1	Soil	1	14.3%
E2	Flora and fauna	1	14.3%
E3	Groundwater	1	14.3%
E4	Surface water	1	14.3%
E5	Sediment	0	0%
E6	Air	1	14.3%
E7	Natural Resources	1	14.3%
E8	Waste	1	14.3%



SCORE: Form for scoring and weighting the social effects of remedial action

Brief description of reference options and action options:

Reference	Alt 1	Alt 2
Present situation: The open pit is currently partially filled with water.	The open pit is backfilled with waste rock and resulting concave mass is qualified covered. The extra waste rock that will not fit in the pit is transferred to the north of the mine site and qualified covered. The tailings are transported to the Boliden urban area.	The open pit is backfilled with paste (mixture of tailings, water & cement/slag) and the surface is covered with till. The current waste rock deposit (WRD) is moved to the north of the water divide of the river Skellefteälven and covered.

Explanation and abbreviations for categories of effects. Effects may occur on-site or off-site as a result of the remedial action or changes in the source contamination:

	On-site	Off-site
The remedial action	**I.** Effects that arise on-site as a result of the remedial action itself (often during remedial action).	**II.** Effects that arise off-site as a result of the remedial action itself (often during remedial action).
Changes in the source contamination	**III.** Effects that arise on-site as a result of changes in the source contamination (often after the measure has been implemented).	**IV.** Effects that arise off-site as a result of changes in the source contamination (often after the measure has been implemented).

The explanation for assigning scores when assessing the effect.

Point: Scale from - 10 to +10	**(+10 p)** Very positive effect in relation to the reference alternative. **(+5 p)** Positive effect in relation to the reference alternative. **(0 p)** No effect in relation to the reference alternative. **(-5 p)** Negative effect in relation to the reference alternative. **(-10 p)** Very negative effect in relation to the reference alternative.
Uncertainty: 3 values are specified	Lowest possible score, most probable score, and highest possible score

The explanation for assigning weights to the criteria.

Weights: 0-25	For each criterion, a weight of 0-25 is stated in relation to how important the criterion is considered to be. A pie chart is used to adjust the ratio of the weights until it matches the group's perception

S1 - Local environmental quality and amenity (LEQ)

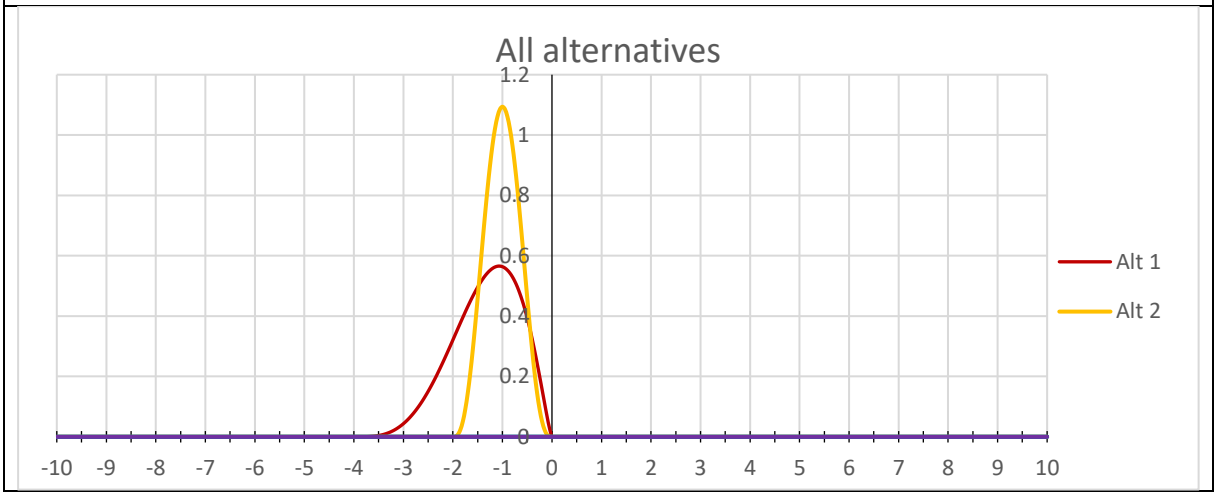
Here, effects on the quality of the local environment, recreational opportunities, and physical disturbances, including noise, are assessed.		
	On-site	*Off-site*
As a result of remedial action (during remedial action)	**I**	**II**
Due to change in source pollution (after remedial action)	**III**	**IV**

Reference:	
• There are no households located around or near the mine. The nearest built-up property in the immediate area is the Önusstugan located 1.5 km south of the mine site (Boliden closure report,2019). Currently, only the wastewater treatment plant and the workers office are located at the mine site. No activities are going on at the mine site hence there are no disturbances related to noise affecting the local environment.	
Worst case:	**As a result of remedial action (I + II):** Maximum negative effects if excavation work and transport seriously disturb several households, cause major problems with accessibility, and/or cause major damage to properties (-10p) **Due to source pollution (III + IV):** Maximum negative effects if the area does not become accessible, i.e., it is fenced and signposted as a dangerous area, and that it appears as untreated (-10p)
Best case:	**As a result of remedial action (I + II):** Maximum positive effects are not expected to occur. Negative effects are minimized if no disturbances occur at all, i.e., no effect at all relative to the reference alternative (0p) **As a result of source pollution (III + IV):** Maximum positive effects if the area is experienced as very pleasant and becomes a highly valued nature or walking area (+ 10p)

S1-I. Weighting and scoring of effects that occur **on-site as a result of the remedial action** (during remedial action):

Weight: 1	Motivation and discussion: The site in its present form does not have many social effects due to its remote location. During the remedial action, accessibility to the site was reduced. After the remedial action, the natural habitat improves. All the assessed indicators are equally weighted as they are equally important.	
Point:	**Alt 1**	**Alt 2**
Lowest possible score:	-4	-2
Most likely score	-1	-1
Highest possible score:	0	0
Motivation and discussion: On-site: entire mine area & Maurträsket lake		

Both Alternative 1 and 2 involved relocation of WRD to the north of mine site and qualified covering. As the new location which was previously undisturbed loses its natural habitat and is not accessible, negative scores are assigned to both the alternatives. Most likely score of -1 is assigned. The water treatment plant located at the mine site to treat the leachate from the WRD is needed for a longer time in the case of Alternative 1. Hence slightly higher negative score of -4 is assigned to Alternative 1.



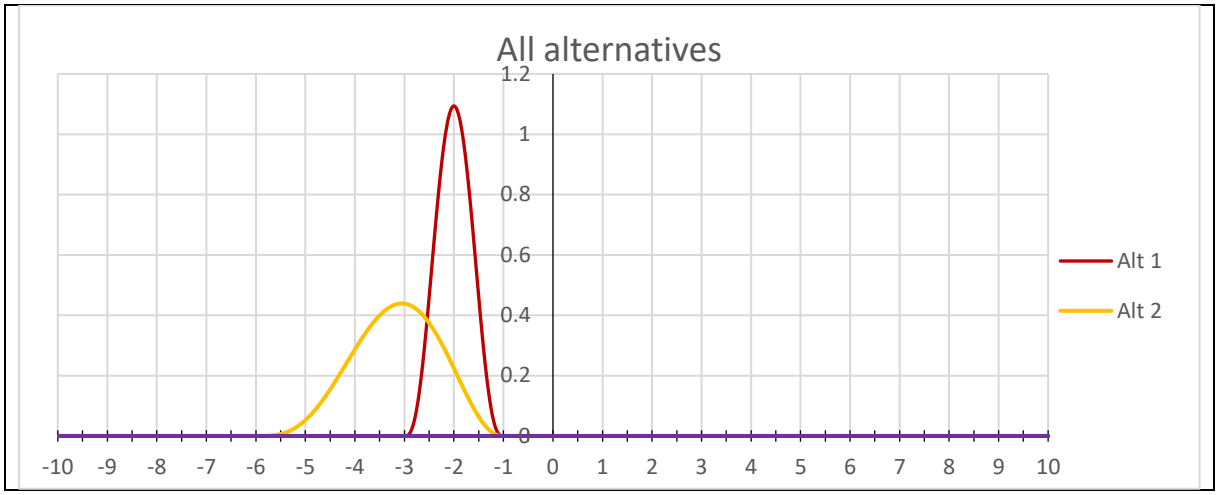
S1-II. Weighting and scoring of effects that occur **off-site as a result of the remedial action** (during remedial action):

Weight: 1	Motivation and discussion: The site in its present form does not have many social effects due to its remote location. During the remedial action, accessibility to the site reduced. After the remedial action, the natural habitat improves. All the assessed indicators are equally weighted as they are equally important.	
Point:	**Alt 1**	**Alt 2**
Lowest possible score:	-3	-6
Most likely score	-2	-3
Highest possible score:	-1	-1

Motivation and discussion:

Off-site: New location of WRD & Skellefteälven river catchment

Both alternative 1 and 2 involves the relocation of WRD to the north of mine site which was previously undisturbed. Hence the new location will be damaged and reduces the accessibility to the site due to the remedial action. Hence negative scores are assigned and since more area will be destroyed in the case of alternative 2, the lowest possible score of -6 is assigned.



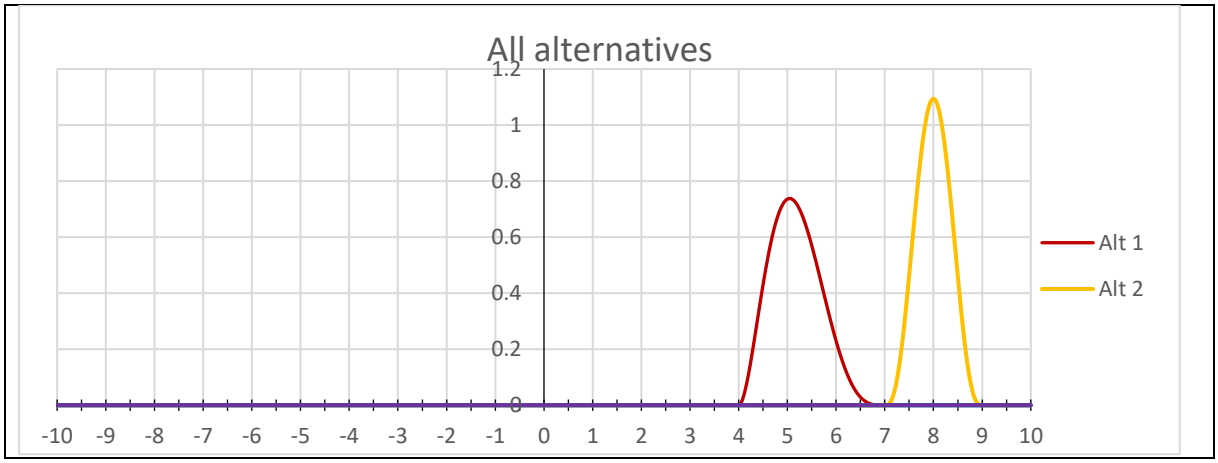
S1-III. Weighting and scoring of effects that occur **on-site as a result of changes in source pollution** (after remedial action):

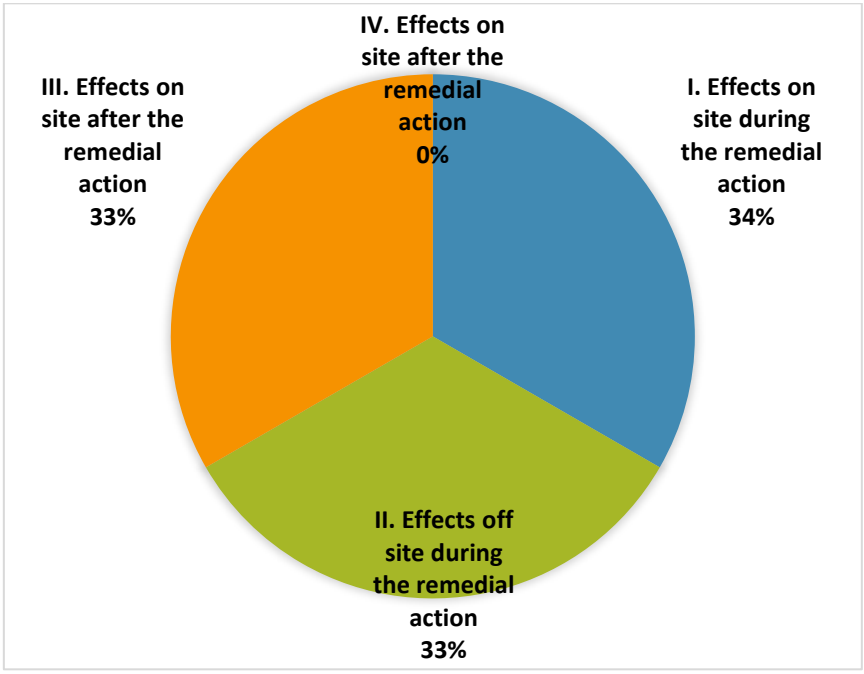
Weights: 1	Motivation and discussion: The site in its present form does not have much social effects due to its remote location. During the remedial action, accessibility to the site reduced. After the remedial action, the natural habitat improves. All the assessed indicators are equally weighted as they are equally important.	
Point:	**Alt 1**	**Alt 2**
Lowest possible score:	4	7
Most likely score	5	8
Highest possible score:	7	9

Motivation and discussion:

On-site: entire mine area & Maurträsket lake

- The remedial action will improve the vegetation of the area. The fences will be removed in the future once the remediation will be completed. The Alternative 1 will have a longer time to restore the vegetation than Alternative 2 as backfilling the pit with WRD will have leachate to treat at the water treatment plant. Hence access to the area will be earlier possible in the case of Alternative 2.





S2 - Cultural heritage

Here, effects on cultural heritage such as buildings, structures, monuments, and landscapes are assessed: they are destroyed, preserved, or restored during the remedial action		
	On-site	*Off-site*
As a result of remedial action (during remedial action)	I	II
Due to change in source pollution (after remedial action)	III	IV

Reference:	
• There are no buildings, structures, or monuments that are culturally important at the mine site. This criterion is not included in the analysis.	
Worst case:	**As a result of remedial action (I + II):** Maximum negative effects on buildings, foundations, and quays are culturally and historically very valuable, and all are destroyed by the measure (-10p)

Best case:	**As a result of remedial action (I + II):** Maximum positive effects if buildings, foundations, and quays are culturally very valuable but very dilapidated, and that they are restored through the measure (+ 10p)

S3 - Health and safety

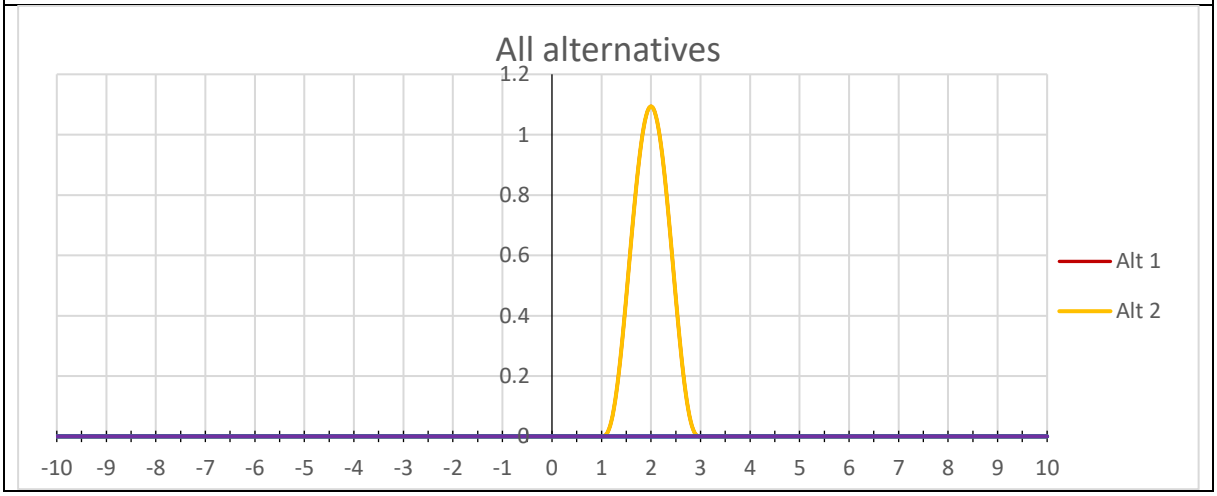
Here, effects on health and safety are assessed as a result of contamination and accident risks		
	On-site	*Off-site*
As a result of remedial action (during remedial action)	I	II
Due to change in source pollution (after remedial action)	**III**	IV

Reference: • At present, there are risks due to the big container lime where the incoming water from the pit is mixed with lime to achieve a pH of 9.5 -10 and is discharged into sedimentation ponds (Boliden closure report, 2021). This water contains metal contents and is polluted and poses a risk to health and safety. • There is also the open pit with a risk of falling into it during the transportation of the materials.	
Worst case:	**As a result of remedial action (I + II):** Maximum negative effects if workers, residents, or visitors are exposed to completely unacceptable health and accident risks due to the measure (-10 p) **Due to source pollution (III + IV):** Maximum negative effects if much higher health or accident risks remain than before the measure (-10 p)
Best case:	**As a result of remedial action (I + II):** Maximum positive effects are not expected to occur. Negative effects are minimized if the remedial action is carried out without any risks to workers or residents (0 p) **Due to source pollution (III + IV):** Maximum positive effects if the health or accident risks are high from the beginning and the area has many visitors, and the risks are reduced to acceptable levels (+10 p)

S3-III. Weighting and scoring of effects that occur **on-site as a result of changes in source pollution** (after remedial action):

Weights: 1	Motivation and discussion:	
Point:	**Alt 1**	**Alt 2**
Lowest possible score:	1	1
Most likely score	2	2
Highest possible score:	3	3
Motivation and discussion: • The health and accident risks associated with the open pit and the open storage of the waste rock are reduced from the remedial actions as compared to the reference site conditions. • Backfilling the open pit in both alternatives will reduce the risk of falling into the pit.		

- In both Alt 1 and Alt 2, the open pit is qualified covered, and the openly deposited waste rock is removed from its location. So equal positive scores are assigned to both the alternatives.



S4 - Equity

Here, effects on weak groups in society are assessed, for example with regard to economic conditions, ethnicity, gender, future generations		
	On-site	*Off-site*
As a result of remedial action (during remedial action)	**I**	**II**
Due to change in source pollution (after remedial action)	**III**	**IV**

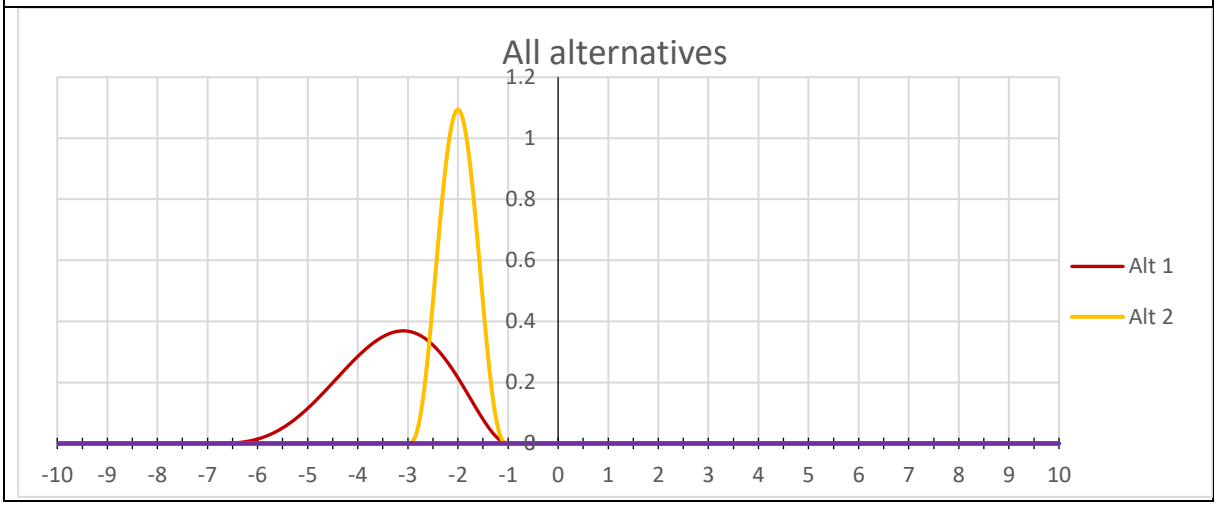
Reference:

- There are no weaker groups present at the mine site at present. Sami people used to practice reindeer herding in Maurliden before the mine activities started (Boliden closure report,2019). Once the mining started, they were compensated for the land.

Worst case:	**As a result of remedial action (I + II):** Maximum negative effects if a vulnerable group is affected very negatively, e.g., by destroying an important meeting place during the operation. (-10 p) **Due to source pollution (III + IV):** Maximum negative effects if you leave existing environmental debts to future generations (0 p).
Best case:	**As a result of remedial action (I + II):** Maximum positive effects if vulnerable groups benefit to a very high degree during the implementation of the measure (+10 p). **As a result of source pollution (III + IV):** Maximum positive effects if a large environmental debt is eliminated or if any vulnerable group who previously did not have access to the area now receives it (+10 p).

S4-I. Weighting and scoring of effects that occur **on-site as a result of the remedial action** (during remedial action):

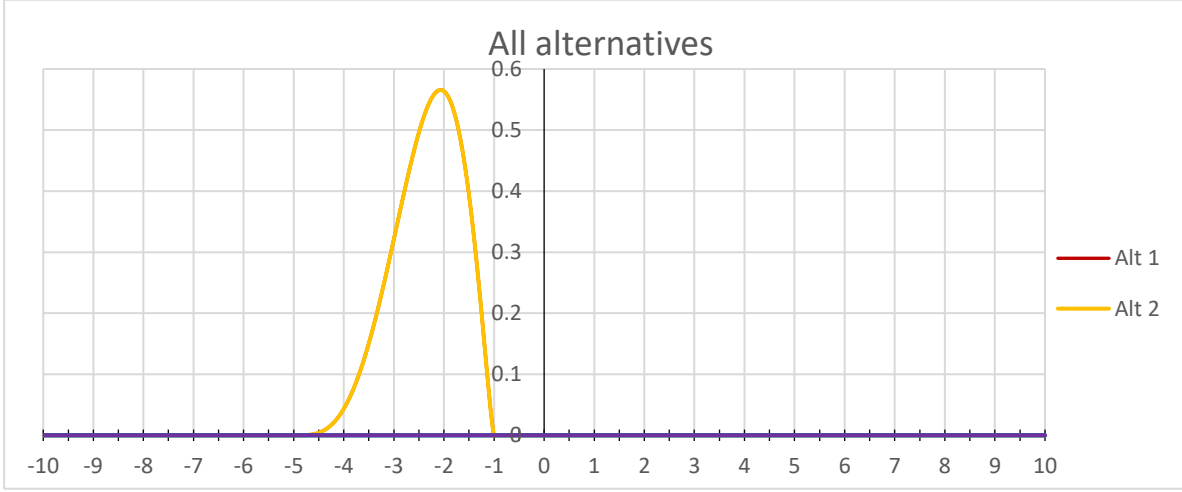
Weight: 1	Motivation and discussion: The accessibility to the site is considered important, hence it is weighted equally with other indicators in equity criterion.	
Point:	**Alt 1**	**Alt 2**
Lowest possible score:	-7	-3
Most likely score	-3	-2
Highest possible score:	-1	-1
Motivation and discussion: On-site: entire mine area & Maurträsket lake The remedial action is taking longer time in alternative 1 for the treatment of leachate, hence the site will not be assessable for a longer period. Hence negative scores are assigned to both the alternatives.		



S4-II. Weighting and scoring of effects that occur **off-site as a result of the remedial action** (during remedial action):

Weight: 1	Motivation and discussion: The accessibility to the site is considered important, hence it is weighted equally with other indicators in equity criterion.	
Point:	**Alt 1**	**Alt 2**
Lowest possible score:	-5	-5
Most likely score	-2	-2
Highest possible score:	-1	-1
Motivation and discussion: Off-site: New location of WRD & Skellefteälven river catchment		

Both the remedial action involves destroying a new location up north of mine site. Equal negative scores are assigned to both the alternatives as the new location will not be accessible for traditional reindeer herding.



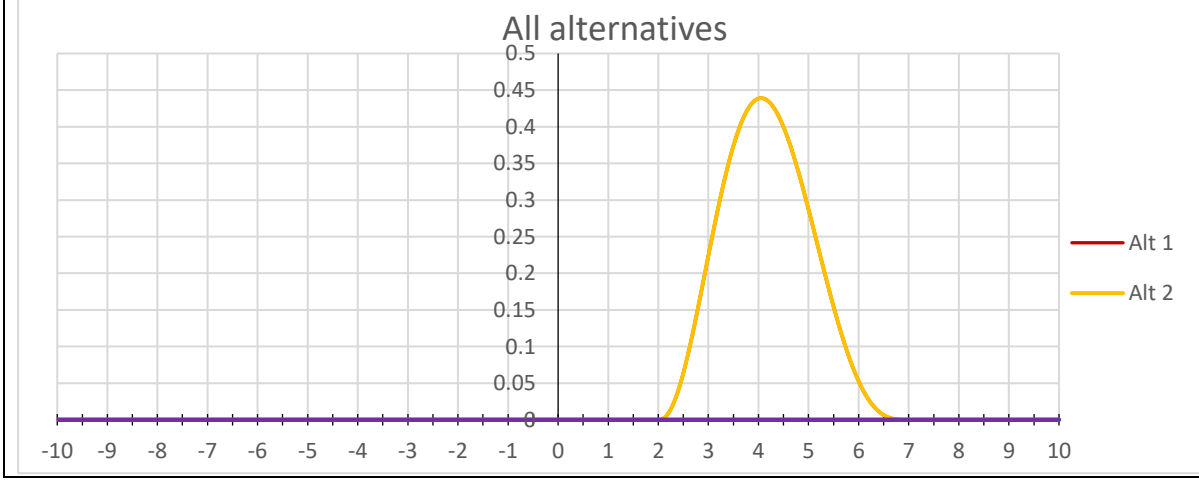
S4-III. Weighting and scoring of effects that occur **on-site as a result of changes in the source pollution** (after remedial action):

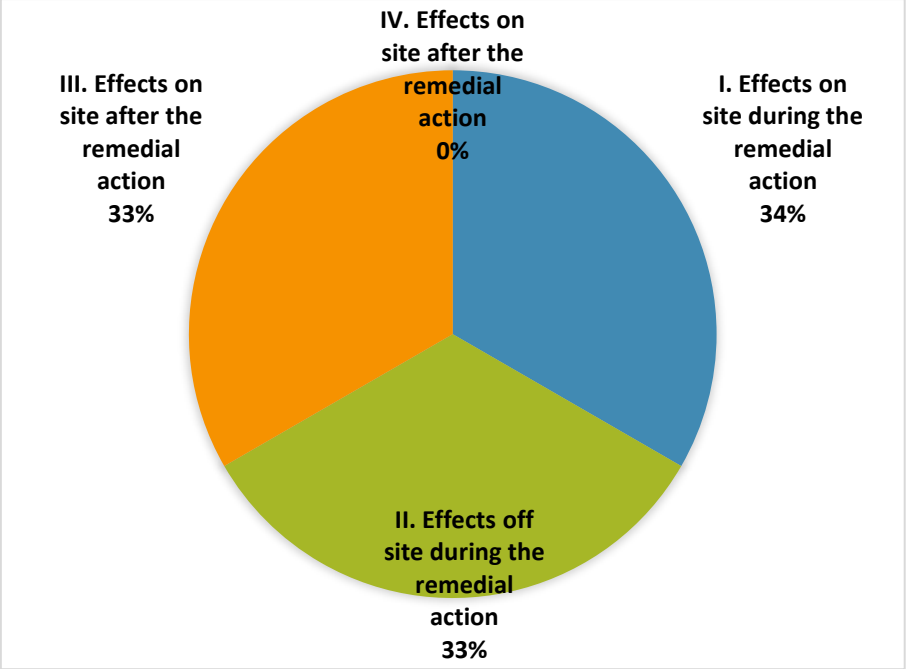
Weight: 1	Motivation and discussion: Environmental debt is an important aspect, hence is weighted equally with other indicators in equity criterion.	
Point:	**Alt 1**	**Alt 2**
Lowest possible score:	2	2
Most likely score	4	4
Highest possible score:	7	7

Motivation and discussion:

On-site: entire mine area & Maurträsket lake

The remedial action improves the condition of the mine site for future generations, so they do no need to pay for it in the future. Hence positive scores are assigned to both the alternatives.





S5 – Local participation

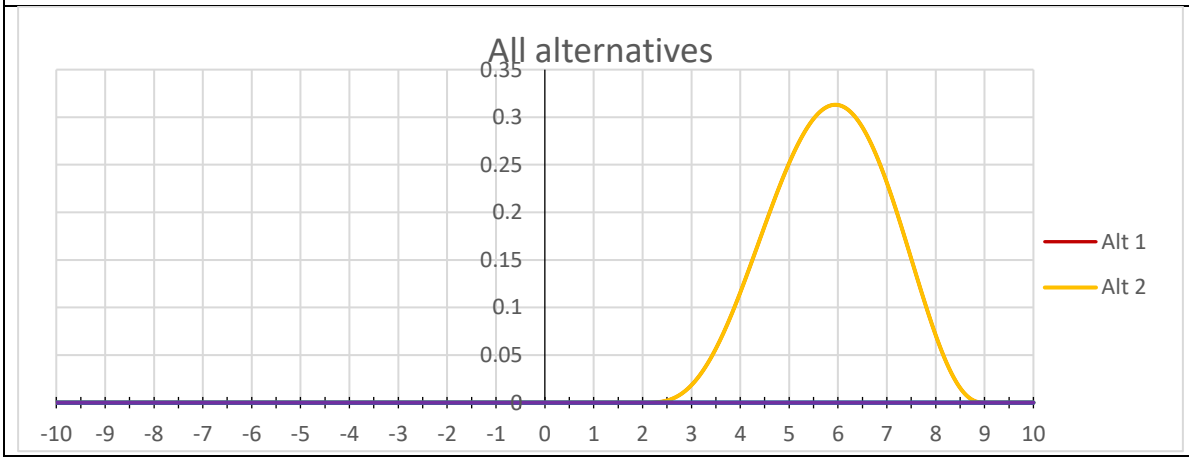
Here, local effects on jobs and the local population's access to places to meet and get involved are assessed		
	On-site	*Off-site*
As a result of remedial action (during remedial action)	I	II
Due to change in source pollution (after remedial action)	**III**	**IV**

Reference: There are few workers at the mine site at present, but the place is currently not suitable for recreational purposes.	
Worst case:	**As a result of remedial action (I + II):** Maximum negative effects if local jobs are made impossible and the local population loses access to the place (-10 p) **Due to source pollution (III + IV):** Maximum negative effects if local jobs are permanently impossible or relocated, or if the local population permanently loses access to the place (-10 p)
Best case:	**As a result of remedial action (I + II):** Maximum positive effects if many local jobs are created through the after-treatment (+10 p) **As a result of source pollution (III + IV):** Maximum positive effects if opportunities are created for many jobs, and/or important meeting places are made possible (+10 p).

S5-III. Weighting and scoring of effects occurring **on-site as a result of changes in source pollution** (after remedial action):

Weight: 1	Motivation and discussion:

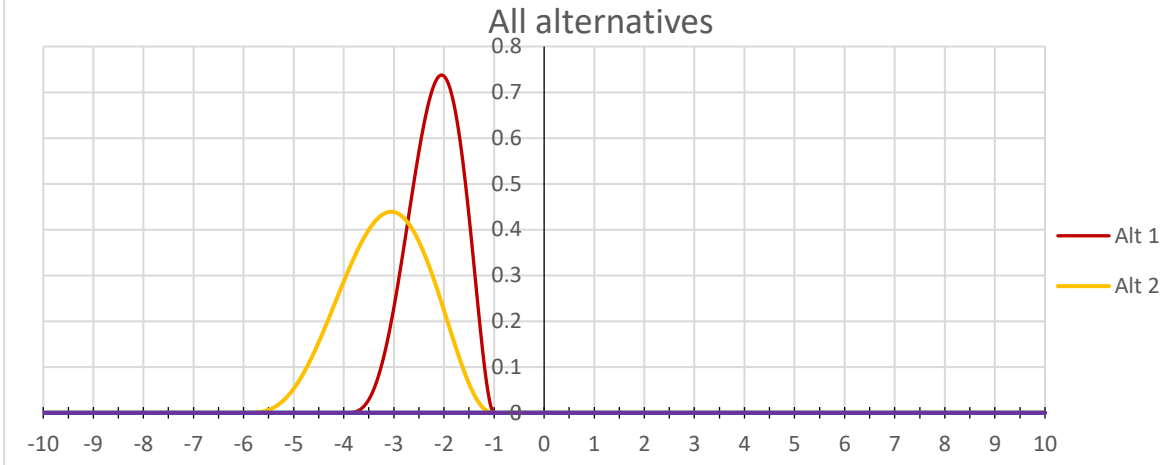
	Both assessed indicators are equally weighted as the availability of local jobs and accessibility to the site are both equally important in local participation criterion.	
Point:	**Alt 1**	**Alt 2**
Lowest possible score:	2	2
Most likely score	6	6
Highest possible score:	9	9
Motivation and discussion: On-site: entire mine area & Maurträsket lake • After the implementation of remedial action 1 and 2, the mine site will be restored, and vegetation regrows naturally. s compared to the present situation on-site, the environmental quality standards improve well, and the site will be available as a meeting place. Hence equal positive scores are assigned to both the alternatives.		

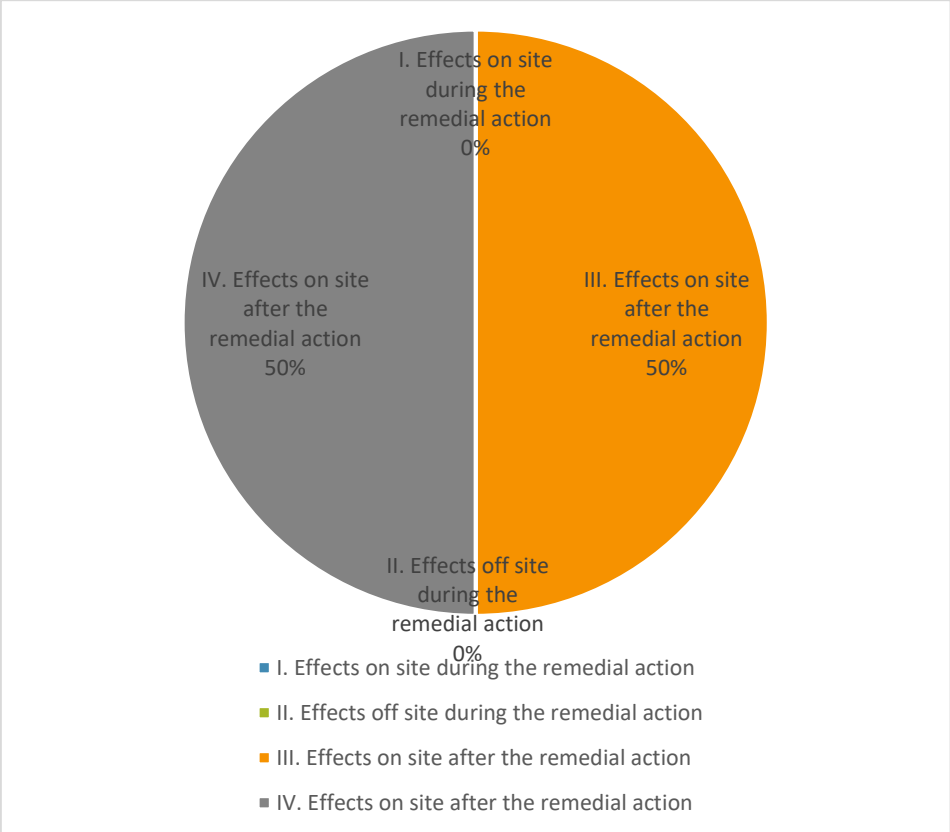


S5-IV. Weighting and scoring of effects occurring **off-site as a result of changes in source pollution** (after remedial action):

Weight: 1	Motivation and discussion: Both assessed indicators are equally weighted as the availability of local jobs and accessibility to the site are both equally important in local participation criterion.	
Point:	**Alt 1**	**Alt 2**
Lowest possible score:	-4	-6
Most likely score	-2	-3
Highest possible score:	-1	-1
Motivation and discussion: On-site: entire mine area & Maurträsket lake • After the implementation of alternatives 1 and 2, the new location of WRD which was previously undisturbed loses its vegetation and the local population loses access to the site. Since its uncertain how the job opportunities are affected due to the sites remote location		

there is an uncertainty in the scores assigned to both the alternatives. Since larger area of land become in accessible in alternative 2, lowest possible score of -6 is assigned.





S6 - Local acceptance

Criterion S6 Local acceptance is scored by asking the local population directly about their views on different alternatives. Below is an opportunity to comment on what you think about the local acceptance and which groups are important to ask about this.

Here, the local population is asked about their views on the various alternative measures		
	On-site	*Off-site*
As a result of remedial action (during remedial action)	I	II

Due to change in source pollution (after remedial action)	III	**IV**

Reference: *What do the locals think about the area today?* This criterion in general is analysed based on workshops conducted between the locals and the mining company. Boliden conducts meetings with Sami people to write their evaluation chart regarding the activities at the mine site.	
Worst case:	**As a result of remedial action (I + II):** Maximum negative effects if the implementation of the measure is not accepted at all by the local population (-10 p). **Due to source pollution (III + IV):** Maximum negative effects if the result of the measure is not accepted at all by the local population but instead is considered a sharp deterioration (-10 p).
Best case:	**As a result of remedial action (I + II):** Maximum positive effects if the implementation of the measure is considered very positive by the local population (+10 p) **Due to source pollution (III + IV):** Maximum positive effects if the result of the measure is well accepted by the local population and is considered a sharp improvement (-10 p)

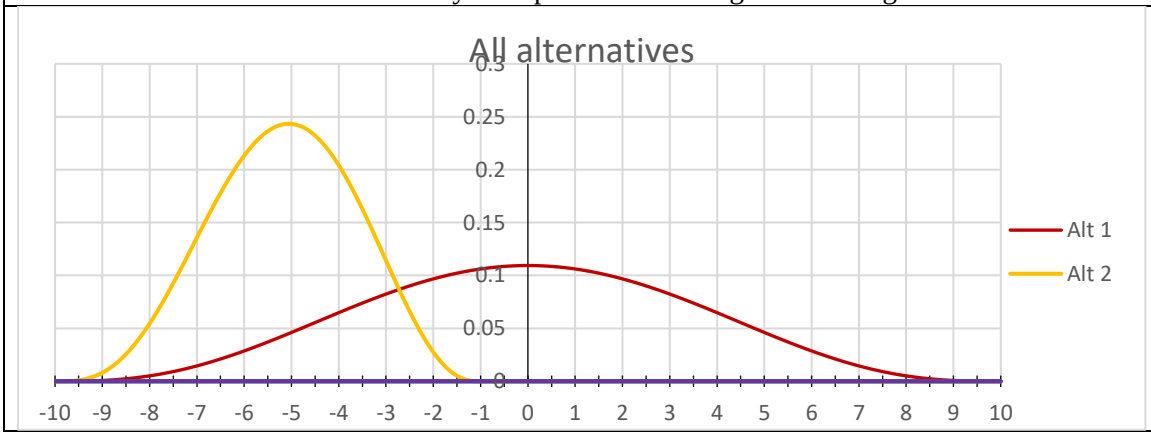
S6-IV. Weighting and scoring of effects that occur **off-site as a result of changes in the source pollution** (after remedial action):

Weight:	Motivation and discussion:	
Point:	**Alt 1**	**Alt 2**
Lowest possible score:	-10	-10
Most likely score	0	-5
Highest possible score:	10	-1

Motivation and discussion:

Off-site: New location of WRD & Skellefteälven river catchment

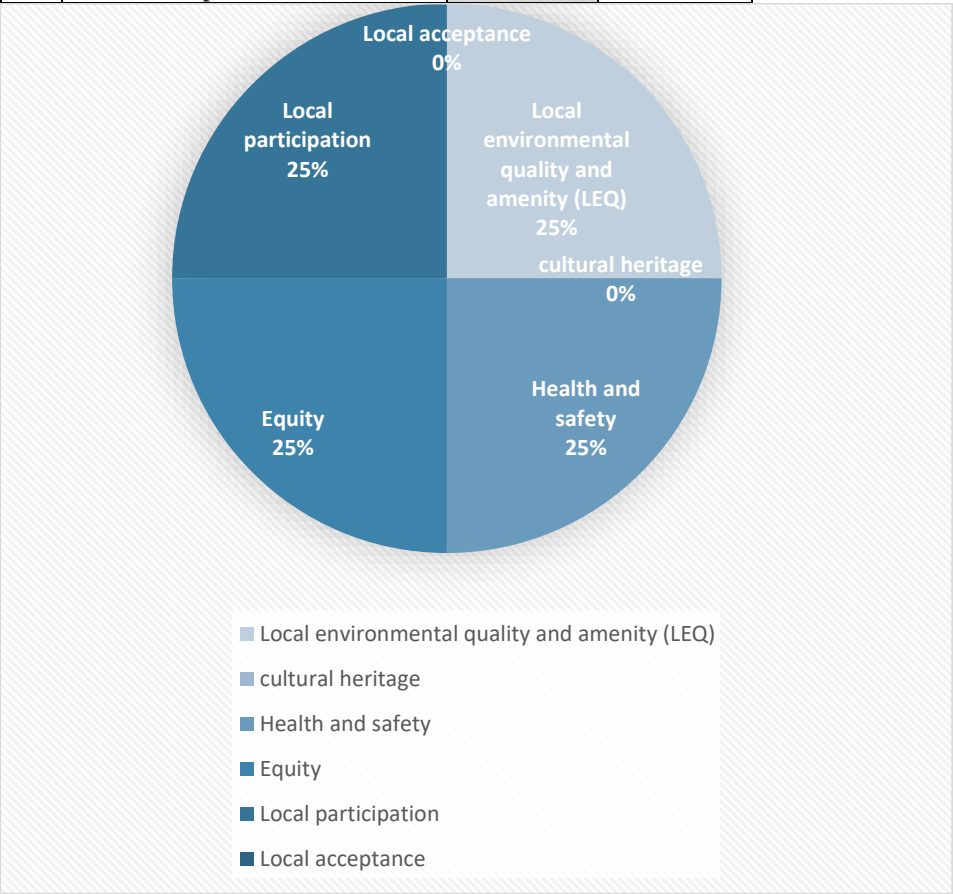
- No workshops were conducted hence the criterion is included in the initial analysis, but it is included in scenario 3 to analyse its potential to change the ranking of the alternative.



The weighting of social criteria

All the criterion in social domain is weighted equal except for cultural heritage and local acceptance. It is difficult to weigh them based on their importance. For Maurliden all the criteria are considered equally important.

	Key criteria	weight	weight (%)
S1	Local environmental quality and amenity (LEQ)	1	25%
S2	cultural heritage	0	0%
S3	Health and Safety	1	25%
S4	Equity	1	25%
S5	Local participation	1	25%
S6	Local acceptance	0	0%



Appendix II.

Table A 1 Weight distribution in the SCORE analysis for the base scenario with alternatives 1 and 2.

Environmental domain 50%				
E1 Soil	14.3%	Weight	Weight (%)	Total weight (%)
E1A-I	E1A - I. Effects due to contamination during the remedial action	0	0%	
E1A-III	E1A - III. Effects due to contamination after the remedial action	1	50%	7%
E1B-I	E1B - I. Other types of effects during the remedial action	1	50%	7%
E1B-III	E1B - III. Other types of effects during the remedial action	0	0%	
E2 Flora and Fauna	14.3%			
E6-I	I. Effects on-site during the remedial action	1	100%	14.3%
E6-II	II. Effects off-site during the remedial action	0	0%	
E6-III	III. Effects on-site after the remedial action	0	0%	
E6-IV	IV. Effects on-site after the remedial action	0	0%	
E3 Groundwater	14.3%			
E3-I	I. Effects on-site during the remedial action	0	0%	
E3-II	II. Effects off-site during the remedial action	0	0%	
E3-III	III. Effects on-site after the remedial action	1	50%	7%
E3-IV	IV. Effects on-site after the remedial action	1	50%	7%
E4 Surface water				
E4-I	I. Effects on-site during the remedial action	0	0%	
E4-II	II. Effects off-site during the remedial action	0	0%	
E4-III	III. Effects on-site after the remedial action	1	100%	14.3%
E4-IV	IV. Effects on-site after the remedial action	0	0%	

E6 Air	14.3%			
E6-I	I. Effects on-site during the remedial action	1	100%	14.3%
E6-II	II. Effects off-site during the remedial action	0	0%	
E6-III	III. Effects on-site after the remedial action	0	0%	
E6-IV	IV. Effects on-site after the remedial action	0	0%	
E7 Non-renewable natural resources	14.3%			
E7-I	I. Effects on-site during the remedial action	0	0%	
E7-II	II. Effects off-site during the remedial action	1	100%	14.3%
E7-III	III. Effects on-site after the remedial action	0	0%	
E7-IV	IV. Effects on-site after the remedial action	0	0%	
E8 Waste	14.3%			
E8-I	I. Effects on-site during the remedial action	0	0%	
E8-II	II. Effects off-site during the remedial action	1	100%	14.3%
E8-III	III. Effects on-site after the remedial action	0	0%	
E8-IV	IV. Effects on-site after the remedial action	0	0%	
Social domain 50%				
S1 Local environmental quality and amenity (LEQ)	25%	Weight	Weight (%)	Total weight (%)
E1A-I	E1A - I. Effects due to contamination during the remedial action	1	33%	8%
E1A-III	E1A - III. Effects due to contamination after the remedial action	1	33%	8%
E1B-I	E1B - I. Other types of effects during the remedial action	1	33%	8%
E1B-III	E1B - III. Other types of effects during the remedial action	0	0%	0%
S3 Health and safety	25%			

E3-I	I. Effects on-site during the remedial action	0	0%	0%
E3-II	II. Effects off-site during the remedial action	0	0%	0%
E3-III	III. Effects on-site after the remedial action	1	100%	25%
E3-IV	IV. Effects on-site after the remedial action	0	0%	0%
S4 Equity	25%			
E6-I	I. Effects on-site during the remedial action	1	33%	8%
E6-II	II. Effects off-site during the remedial action	1	33%	8%
E6-III	III. Effects on-site after the remedial action	1	33%	8%
E6-IV	IV. Effects on-site after the remedial action	0	0%	0%
S5 Local participation	25%			
E7-I	I. Effects on-site during the remedial action	0	0%	0%
E7-II	II. Effects off-site during the remedial action	0	0%	0%
E7-III	III. Effects on-site after the remedial action	1	50%	13%
E7-IV	IV. Effects on-site after the remedial action	1	50%	13%
S6 Local acceptance	0%			
E8-I	I. Effects on-site during the remedial action	0	0%	0%
E8-II	II. Effects off-site during the remedial action	0	0%	0%
E8-III	III. Effects on-site after the remedial action	0	0%	0%
E8-IV	IV. Effects on-site after the remedial action	0	0%	0%

Appendix III.

Results of SCORE© Sustainability Assessment

The sustainability assessment for:

Maurliden , Gothenburg, Sweden

performed by

RS

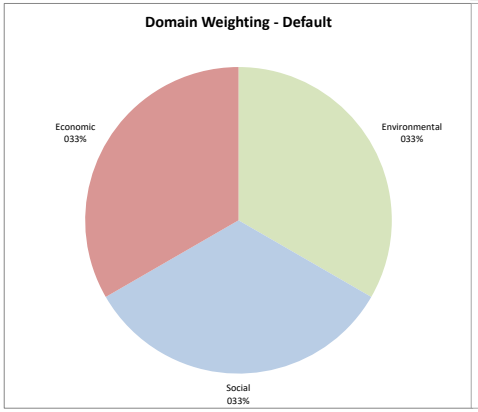
resulted in the results presented on the following pages.

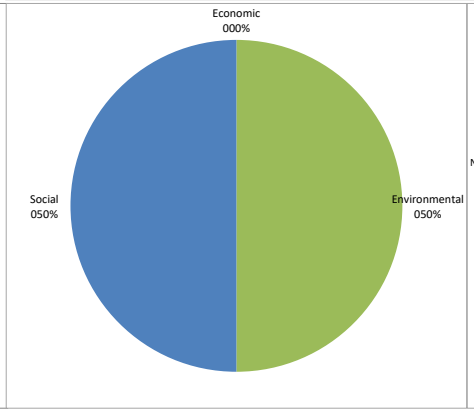
Scorings for the Environmental domain	Weight (within domain)	Alternative 1			Alternative 2			Alternative 3			Alternative 4			Alternative 5		
Soil (E1)	14%	**E1A1**	*Risk On*	*Functions On*	**E1A2**	*Risk On*	*Functions On*	**E1A3**	*Risk On*	*Functions On*	**E1A4**	*Risk On*	*Functions On*	**E1A5**	*Risk On*	*Functions On*
		RA	0	8	*RA*	0	8	*RA*	0	0	*RA*	0	0	*RA*	0	0
		SC	-2	Not relevant	*SC*	-3	Not relevant	*SC*	0	Not relevant	*SC*	0	Not relevant	*SC*	0	Not relevant
Physical Impact on Flora and fauna (E2)	14%	*E2A1*	*On*	*Off*	*E2A2*	*On*	*Off*	*E2A3*	*On*	*Off*	*E2A4*	*On*	*Off*	*E2A5*	*On*	*Off*
		RA	1	Not relevant	*RA*	-1	Not relevant	*RA*	0	Not relevant	*RA*	0	Not relevant	*RA*	0	Not relevant
		SC	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant
Groundwater (E3)	14%	**E2A1**	*On*	*Off*	**E2A2**	*On*	*Off*	**E2A3**	*On*	*Off*	**E2A4**	*On*	*Off*	**E2A5**	*On*	*Off*
		RA	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0
		SC	3	-4	*SC*	5	-6	*SC*	0	0	*SC*	0	0	*SC*	0	0
Surface Water (E4)	14%	**E3A1**	*On*	*Off*	**E3A2**	*On*	*Off*	**E3A3**	*On*	*Off*	**E3A4**	*On*	*Off*	**E3A5**	*On*	*Off*
		RA	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0
		SC	2	0	*SC*	5	0	*SC*	0	0	*SC*	0	0	*SC*	0	0
Sediment (E5)	0%	**E4A1**	*On*	*Off*	**E4A2**	*On*	*Off*	**E4A3**	*On*	*Off*	**E4A4**	*On*	*Off*	**E4A5**	*On*	*Off*
		RA	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0
		SC	0	0	*SC*	0	0	*SC*	0	0	*SC*	0	0	*SC*	0	0
Air (E6)	14%	**E5A1**	*On*	*Off*	**E5A2**	*On*	*Off*	**E5A3**	*On*	*Off*	**E5A4**	*On*	*Off*	**E5A5**	*On*	*Off*
		RA	Not relevant	-3	*RA*	Not relevant	-4	*RA*	Not relevant	0	*RA*	Not relevant	0	*RA*	Not relevant	0
		SC	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant
Non-renewable Natural Resources (E7)	14%	**E6A1**	*On*	*Off*	**E6A2**	*On*	*Off*	**E6A3**	*On*	*Off*	**E6A4**	*On*	*Off*	**E6A5**	*On*	*Off*
		RA	Not relevant	-4	*RA*	Not relevant	-3	*RA*	Not relevant	0	*RA*	Not relevant	0	*RA*	Not relevant	0
		SC	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant
Non-recyclable Waste Generation (E8)	14%	**E7A1**	*On*	*Off*	**E7A2**	*On*	*Off*	**E7A3**	*On*	*Off*	**E7A4**	*On*	*Off*	**E7A5**	*On*	*Off*
		RA	Not relevant	5	*RA*	Not relevant	8	*RA*	Not relevant	0	*RA*	Not relevant	0	*RA*	Not relevant	0
		SC	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant
WEIGTHED SCORE Environmental domain, *E*		**0.42**			**0.72**			**Not evaluated**			**Not evaluated**			**Not evaluated**		

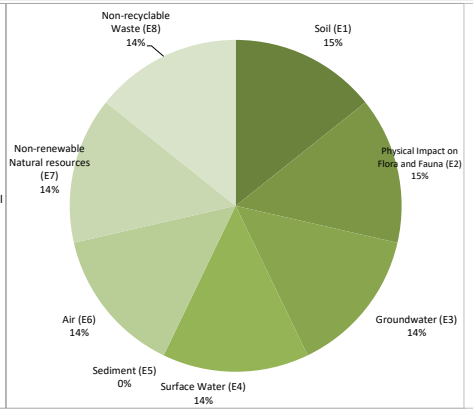
Scorings for the Socio-cultural domain	Weight (within domain)	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Local Environmental Quality and Amenity (S1)	25%	S1A1 / On / Off RA: -1 / -2 SC: 5 / 0	S1A2 / On / Off RA: -1 / -3 SC: 8 / 0	S1A3 / On / Off RA: 0 / 0 SC: 0 / 0	S1A4 / On / Off RA: 0 / 0 SC: 0 / 0	S1A5 / On / Off RA: 0 / 0 SC: 0 / 0
Cultural Heritage (S2)	0%	S2A1 / On / Off RA: 0 / 0 SC: Not relevant / Not relevant	S2A2 / On / Off RA: 0 / 0 SC: Not relevant / Not relevant	S2A3 / On / Off RA: 0 / 0 SC: Not relevant / Not relevant	S2A4 / On / Off RA: 0 / 0 SC: Not relevant / Not relevant	S2A5 / On / Off RA: 0 / 0 SC: Not relevant / Not relevant
Health and Safety (S3)	25%	S3A1 / On / Off RA: 0 / 0 SC: 2 / 0	S3A2 / On / Off RA: 0 / 0 SC: 2 / 0	S3A3 / On / Off RA: 0 / 0 SC: 0 / 0	S3A4 / On / Off RA: 0 / 0 SC: 0 / 0	S3A5 / On / Off RA: 0 / 0 SC: 0 / 0
Equity (S4)	25%	S4A1 / On / Off RA: -3 / -2 SC: 4 / 0	S4A2 / On / Off RA: -2 / -2 SC: 4 / 0	S4A3 / On / Off RA: 0 / 0 SC: 0 / 0	S4A4 / On / Off RA: 0 / 0 SC: 0 / 0	S4A5 / On / Off RA: 0 / 0 SC: 0 / 0
Local participation (S5)	25%	S5A1 / On / Off RA: 0 / 0 SC: 6 / -2	S5A2 / On / Off RA: 0 / 0 SC: 6 / -3	S5A3 / On / Off RA: 0 / 0 SC: 0 / 0	S5A4 / On / Off RA: 0 / 0 SC: 0 / 0	S5A5 / On / Off RA: 0 / 0 SC: 0 / 0
Local Acceptance (S6)	0%	S6A1 / On / Off RA: 0 / 0 SC: 0 / 0	S6A2 / On / Off RA: 0 / 0 SC: 0 / 0	S6A3 / On / Off RA: 0 / 0 SC: 0 / 0	S6A4 / On / Off RA: 0 / 0 SC: 0 / 0	S6A5 / On / Off RA: 0 / 0 SC: 0 / 0
WEIGHTED SCORE Social domain, *S*		**0.88**	**1.06**	**Not evaluated**	**Not evaluated**	**Not evaluated**
NET PRESENT VALUE, Economic domain, Φ (MSEK)		**-100.01**	**-100.01**	**Not evaluated**	**Not evaluated**	**Not evaluated**
Note: Non quantified items were not considered!						
Normalized Sustainability SCORE, *H (-100 to +100)*		**0**	**0**	**Not evaluated**	**Not evaluated**	**Not evaluated**
Strong sustainability on Domain Level?		**NO**	**NO**	**Not evaluated**	**Not evaluated**	**Not evaluated**
Strong sustainability on Key Criteria Level?		**NO**	**NO**	**Not evaluated**	**Not evaluated**	**Not evaluated**

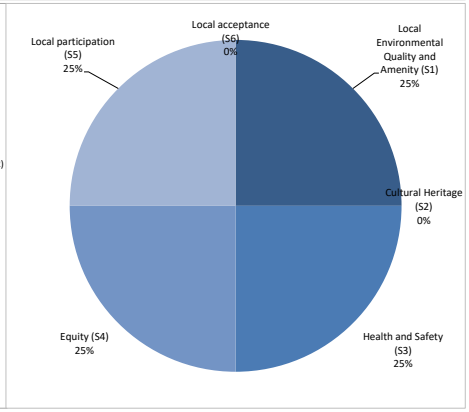
Weighting Summary

User Weights



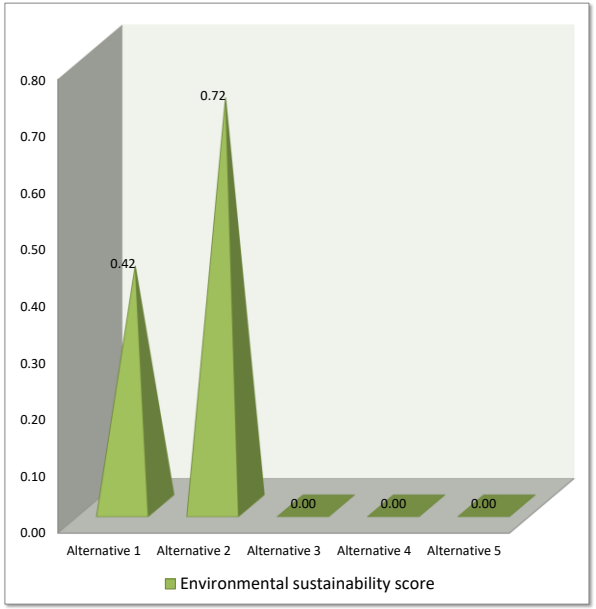


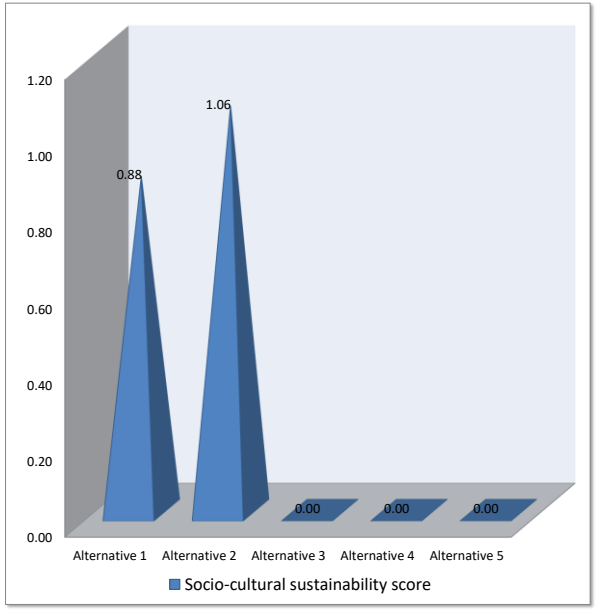


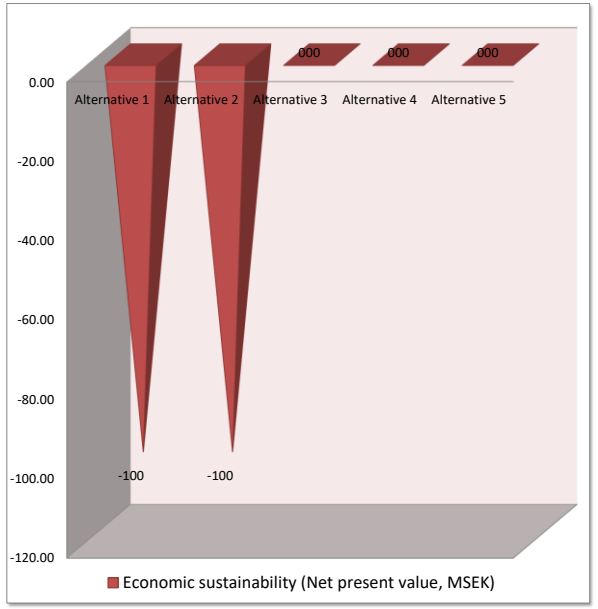


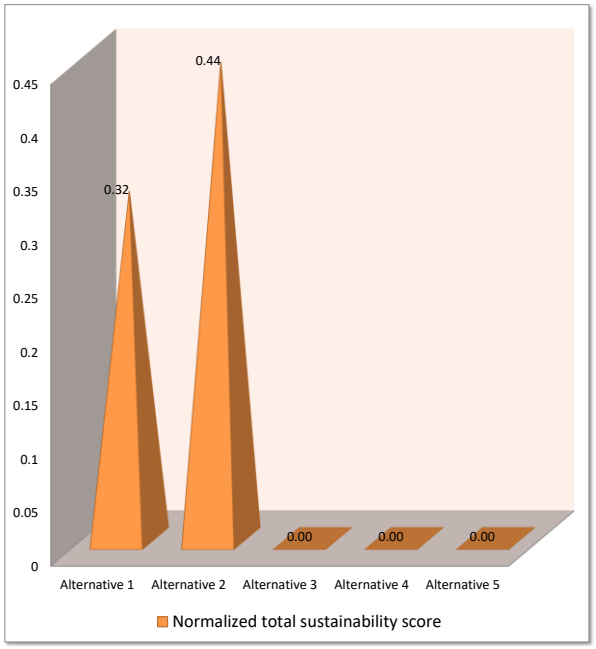
Note: Domains are not equally weighted!

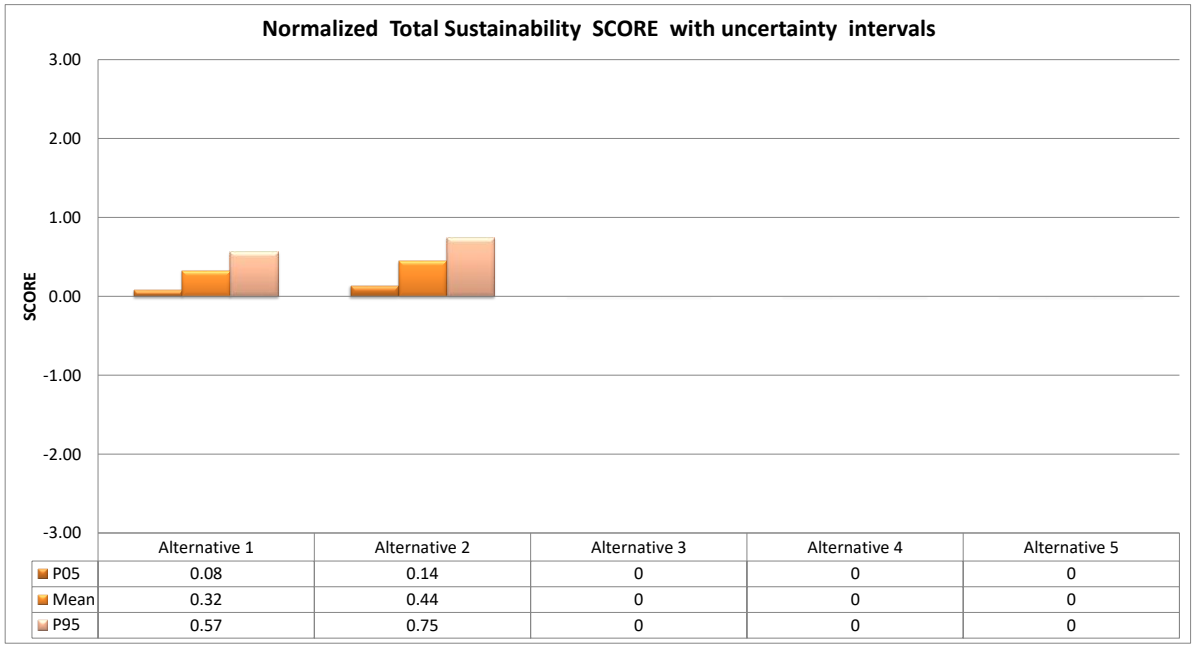
Results - Sustainability Scores





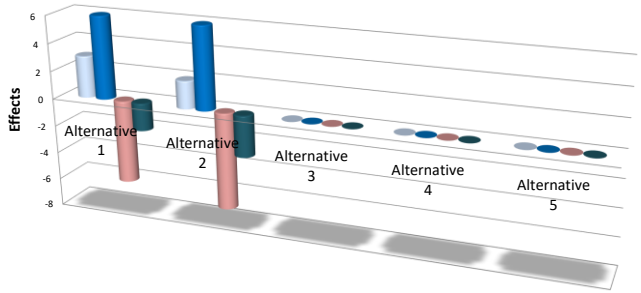




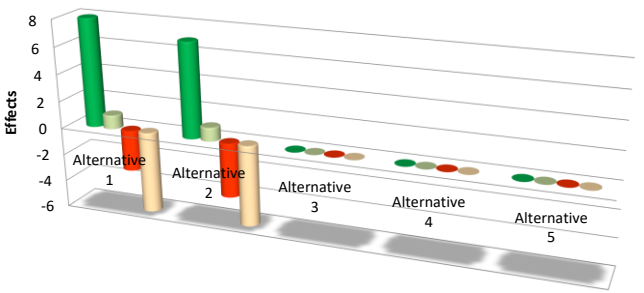


	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
P05	0.08	0.14	0	0	0
Mean	0.32	0.44	0	0	0
P95	0.57	0.75	0	0	0

Ecological and Social Effects of Remediation Alternatives



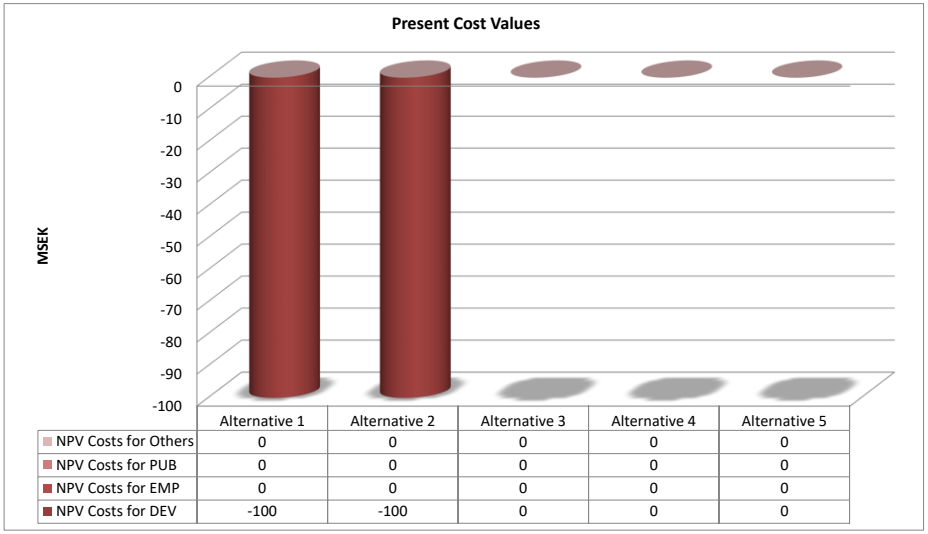
	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Remedial Action Positive	3	2	0	0	0
Source Contamination Positive	6	6	0	0	0
Remedial Action Negative	-6	-7	0	0	0
Source Contamination Negative	-2	-3	0	0	0



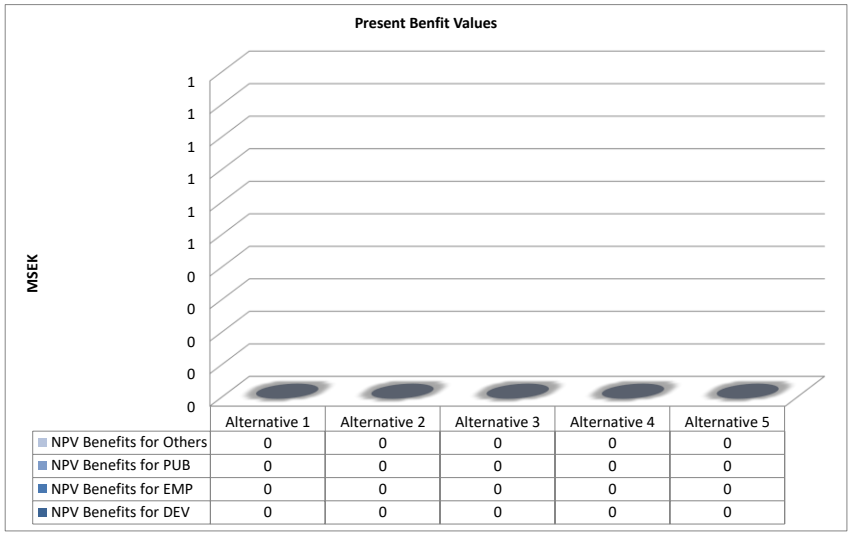
	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
On-Site Positive	8	7	0	0	0
Off-Site Positive	1	1	0	0	0
On Site Negative	-3	-4	0	0	0
Off-Site Negative	-6	-6	0	0	0

Economic effects of Remediation Alternatives

Distributional Analysis

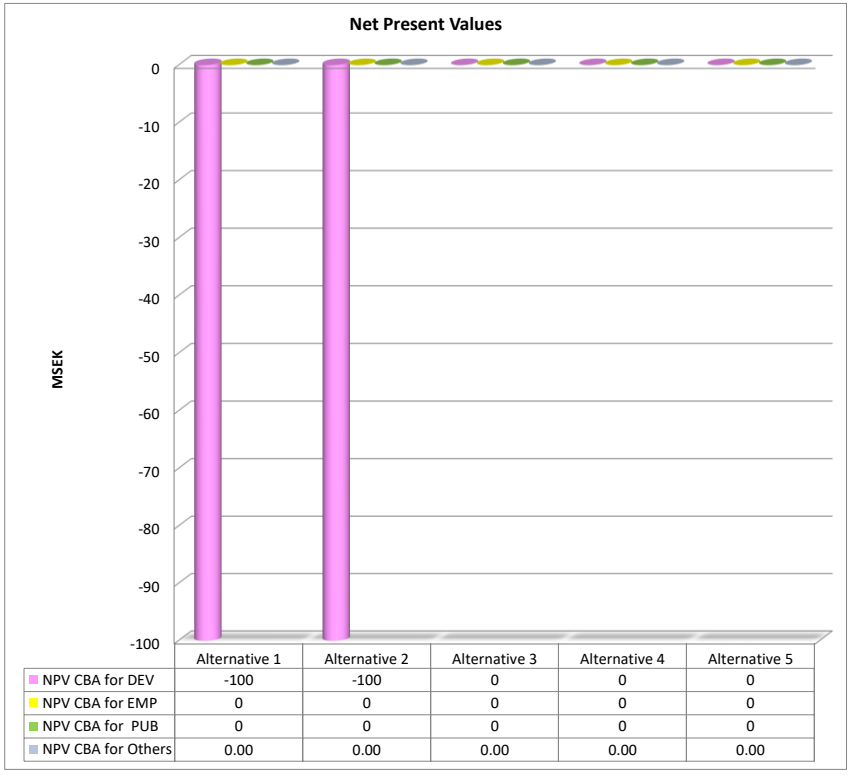


	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
NPV Costs for Others	0	0	0	0	0
NPV Costs for PUB	0	0	0	0	0
NPV Costs for EMP	0	0	0	0	0
NPV Costs for DEV	-100	-100	0	0	0



	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
NPV Benefits for Others	0	0	0	0	0
NPV Benefits for PUB	0	0	0	0	0
NPV Benefits for EMP	0	0	0	0	0
NPV Benefits for DEV	0	0	0	0	0

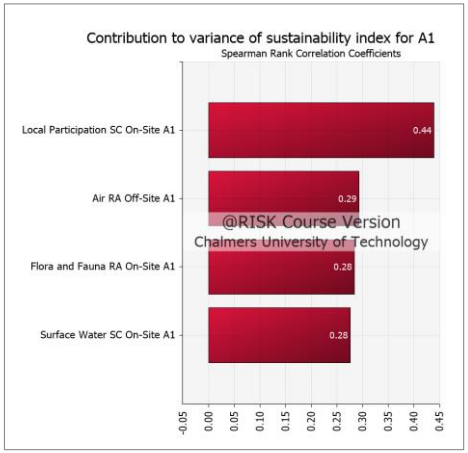
Benefit item	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
B1. Increased property value on site	NR	NR			
B2a. Reduced acute health risks	nr	nr			
B2b. Reduced non-acute health risks	nr	nr			
B2c. Other types of improved health, e.g. reduced anxiety	nr	nr			
B3a. Increased recreational opportunities on site	nr	nr			
B3b. Increased recreational opportunities in the surroundings	nr	nr			
B3c. Increased provision of other ecosystem services	nr	nr			
B4. Other positive externalities	nr	nr			
Cost item					
C1a. Costs for investigations and design of remedial actions	100	100			
C1b. Costs for contracting	nr	nr			
C1c. Capital costs due to allocation of funds to the remedial action	nr	nr			
C1d. Costs for the remedial action, including transport and disposal of contaminated soil minus possible revenues of reuse of contaminants and/or soil	nr	nr			
C1e. Costs for design and implementation of monitoring programs including sampling, analysis and data processing	nr	nr			
C1fa. Project risks	#REF!	nr			
C2a. Increased health risks due to the remedial action on site	nr	nr			
C2b. Increased health risks due to transports to and from the remediation site, e.g. transports of contaminated soil	nr	nr			
C2c. Increased health risks at disposal sites	nr	nr			
C2d. Other types of impaired health due to the remedial action, e.g. increased anxiety	nr	nr			
C3a. Decreased provision of ecosystem services on site due to remedial action, e.g. reduced recreational opportunities	nr	nr			
C3b. Decreased provision of ecosystem services outside the site due to the remedial action, e.g. environmental effects due to transports of contaminated soil	nr	nr			
C3c. Decreased provision of ecosystem services due to environmental effects at the disposal site	nr	nr			
C4. Other negative externalities	nr	nr			

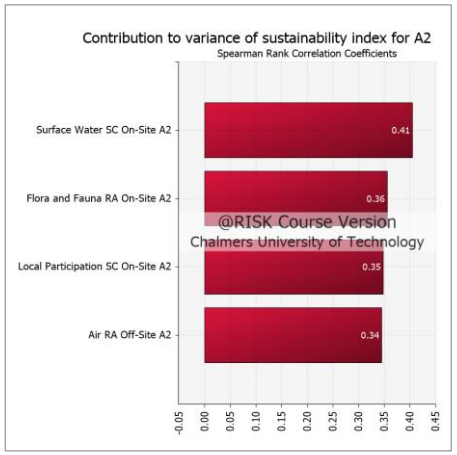


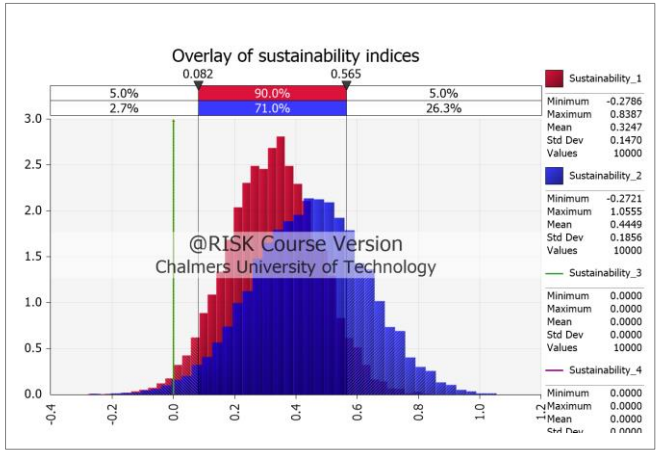
	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
NPV CBA for DEV	-100	-100	0	0	0
NPV CBA for EMP	0	0	0	0	0
NPV CBA for PUB	0	0	0	0	0
NPV CBA for Others	0.00	0.00	0.00	0.00	0.00

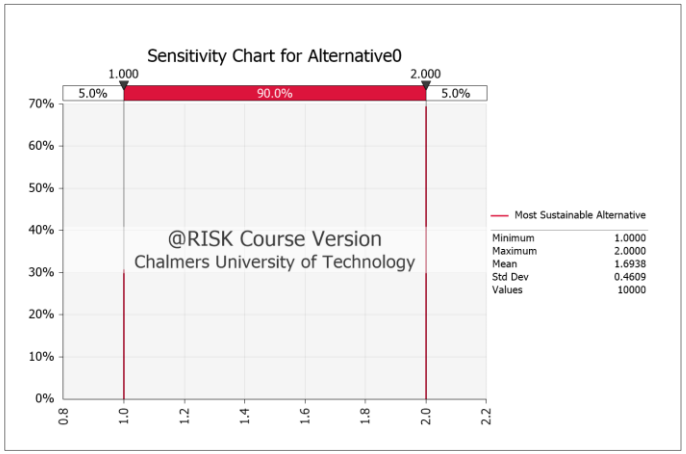
Uncertainty Analysis

Sensitivity analysis









Comments / Motivation Summary

Environmental Domain

Selection / Weighting:

		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
E1: Soil						
Ecotoxicological risk SC On-site	**Scoring:**	No effects on ecotoxicological risk levels.	No effects on ecotoxicological risk levels.			
Ecotoxicological risk RA On-site	**Scoring:**	Reduced contaminant concentrations and contaminat mass in the soil.	Reduced contaminant concentrations and contaminat mass in the soil.			
Soil Functions RA On-site	**Scoring:**	Improvement of soil quality, from Very Poor to Moderate/Good according to the Soil Quality Indicator Assessment.	Improvement of soil quality, from Very Poor to Moderate/Good according to the Soil Quality Indicator Assessment.			
E2: Physical Impact on Flora and Fauna						
Flora and Fauna RA On-site	**Scoring:**	No physical disturbances on any species with protection value.	No physical disturbances on any species with protection value.			
E3: Groundwater						
Groundwater RA On-Site	**Scoring:**	The remediation will have a small but insignificant effect on contaminant concentration in groundwater.	The remediation will have a small but insignificant effect on contaminant concentration in groundwater.			
Groundwater RA Off-Site	**Scoring:**					
Not relevant						
Groundwater SC On-Site	**Scoring:**	Leakage of contaminants to the groundwater is largely eliminated by the remedial action.	Leakage of contaminants to the groundwater is largely eliminated by the remedial action.			
Groundwater SC Off-Site	**Scoring:**					
Not relevant						

E4: Surface Water

Surface Water RA On-Site	**Scoring:**					
Not relevant						
Surface Water RA Off-Site	**Scoring:**	The remediation will have a small effect on contaminant concentrations in groundwater.	The remediation will have a small effect on contaminant concentrations in groundwater.			
Surface Water SC On-Site	**Scoring:**					
Not relevant						
Surface Water SC Off-Site	**Scoring:**	The effect on the concentration in surface water is neglible. Decreased polluted runoff.	The effect on the concentration in surface water is neglible. Decreased polluted runoff.			

E5: Sediment

Sediment RA On-Site	**Scoring:**					
Not relevant						
Sediment RA Off-Site	**Scoring:**	The remedial action will have a neglible effect on contaminant concentrations in the sediments.	The remedial action will have a neglible effect on contaminant concentrations in the sediments.			
Sediment SC On-Site	**Scoring:**					
Sediment SC Off-Site	**Scoring:**	The effect on the concentration in the sediment is neglible. Decreased polluted runoff.	The effect on the concentration in the sediment is neglible. Decreased polluted runoff.			
Not relevant						

E6: Air

Air RA Off-Site	**Scoring:**	Extensive increase in green house gas (GHG) emissions due to extensive transportation of excavated soil to a landfill. The emissions are larger 85% of the maximum alternative (complete excavation of all contaminated soil above generic guideline values).	Increase in green house gas (GHG) emissions due to extensive transportation of excavated soil to a landfill. The emissions are ca 85% of the maximum alternative (complete excavation of all contaminated soil above generic guideline values).			

E7: Non-renewable Natural Resources

Non-renewable Natural Resources RA Off-Site	**Scoring:**	Fossile fuel will be used for excavation and transportation of contaminated soil. The amount of fussil fuel is ca 85% of the maximum alternative. The amount of backfilling material is 85% of the maximum alternative.	Fossile fuel will be used for excavation, transportation and soil washing of contaminated soil. The amount of fussil fuel is ca 150% of the maximum alternative. The amount of backfilling material is 15% of the maximum alternative.			

E8: Non-recyclable Waste Generation

Non-recyclable Waste Genration RA Off-Site	**Scoring:**	The amount of produced waste is 70% of the maximum alternative.	The amount of produced waste is ca15% of the maximum alternative.			

Socio-cultural Domain

Selection / Weighting:

		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
S1: Local Environmental Quality and Amenity						
Local Environmental Quality and Amenity RA On-Site	**Scoring:**					
Not relevant						
Local Environmental Quality and Amenity RA Off-Site	**Scoring:**	There are some negative effects off-site due to heavy transports.	There are some negative effects off-site due to heavy transports but less transport than alt 1.			
Local Environmental Quality and Amenity SC On-Site	**Scoring:**	There is a large positive effect on the local environmental quality and amenities on the site.	There is a large positive effect on the local environmental quality and amenities on the site.			
Local Environmental Quality and Amenity SC Off-Site	**Scoring:**	There are some positive effects, for the sourrounding as well .	There are some positive effects, for the sourrounding as well .			
S2: Cultural Heritage						
Cultural heritage RA On-Site	**Scoring:**					
Not relevant						
Cultural heritage RA Off-Site	**Scoring:**					
Not relevant						
S3: Health and Safety						
Health and Safety RA On-Site	**Scoring:**	The workers on-site are exposed to contaminated material.	The workers on-site are exposed to contaminated material.			
Health and Safety RA Off-Site	**Scoring:**	The heavy traffic will be a safety risk for neigbours. There will also be some dusting.	There is cinsiderably less traffic than in alt1. Dust will be prevented at the sieve.			
Health and Safety SC On-Site	**Scoring:**	Since the reference alternative is considering a fenced area, i.e. no workers, there is no effect on-site as a result of the remediation alternative.	Since the reference alternative is considering a fenced area, i.e. no workers, there is no effect on-site as a result of the remediation alternative.			
Health and Safety SC Off-Site	**Scoring:**	Neighbours will be less exposed to contamination spreading from the site.	Neighbours will be less exposed to contamination spreading from the site.			

S4: Equity

Equity RA On-Site	Scoring:					
Not relevant						
Equity RA Off-Site	Scoring:	Neighbours are affected somewhat negatively by the remedial action but are able to influence the decision to some extent, e.g. when transports will take place etc.	Neighbours are affected somewhat negatively by the remedial action but are able to influence the decision to some extent, e.g. when transports will take place etc.			
Equity SC On-Site	Scoring:	The future environmental cost is reduced to a very large extent/eliminated.	The future environmental cost is reduced to a very large extent/eliminated.			
Equity SC Off-Site	Scoring:	The future environmental cost is reduced to a very large extent/eliminated.	The future environmental cost is reduced to a very large extent/eliminated.			

S5: Local Participation

Local participation RA On-Site	Scoring:	The remedial action does not affect job opportunities etc on site.	The remedial action does not affect job opportunities etc on site.			
Local participation RA Off-Site	Scoring:	Due to the remedial action there are some positive effects off-site, such as an increased use of services.	Due to the remedial action there are some positive effects off-site, such as an increased use of services.			
Local participation SC On-Site	Scoring:	The future landuse will affect local job opportunities positively.	The future landuse will affect local job opportunities positively.			
Local participation SC Off-Site	Scoring:	An increased number of workers at the site which uses shops and services in the vicinity, will lead to increased local job opportunities in the surrounding.	An increased number of workers at the site which uses shops and services in the vicinity, will lead to increased local job opportunities in the surrounding.			

S6: Local Acceptance

Local acceptance RA On-Site	Scoring:					
Not relevant						
Local acceptance RA Off-Site	Scoring:	Neighbours are worried about heavy transports through the area but want something to be done.	This alternative results in smaller amounts of transport than in alt 1 and is viewed as very positive by neighbours.			
Local acceptance SC On-Site	Scoring:					
Not relevant						
Local acceptance SC Off-Site	Scoring:	Neighbours are very positive to the reduction of source contamination.	Neighbours are very positive to the reduction of source contamination.			

Results of SCORE© Sustainability Assessment

The sustainability assessment for:

Maurliden , Gothenburg, Sweden

performed by

RS

resulted in the results presented on the following pages.

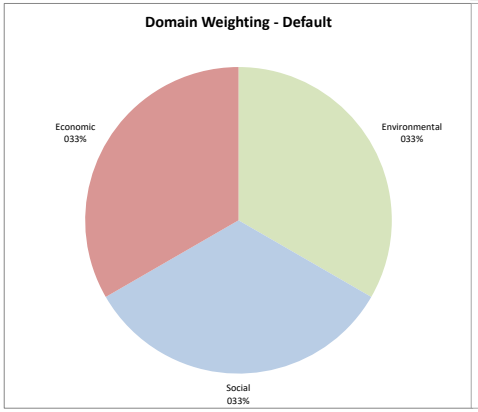
Scorings for the Environmental domain	Weight (within domain)	Alternative 1			Alternative 2			Alternative 3			Alternative 4			Alternative 5		
Soil (E1)	14%	**E1A1**	*Risk On*	*Functions On*	**E1A2**	*Risk On*	*Functions On*	**E1A3**	*Risk On*	*Functions On*	**E1A4**	*Risk On*	*Functions On*	**E1A5**	*Risk On*	*Functions On*
		RA	0	8	*RA*	0	8	*RA*	0	0	*RA*	0	0	*RA*	0	0
		SC	-2	Not relevant	*SC*	-3	Not relevant	*SC*	0	Not relevant	*SC*	0	Not relevant	*SC*	0	Not relevant
Physical Impact on Flora and fauna (E2)	14%	*E2A1*	*On*	*Off*	*E2A2*	*On*	*Off*	*E2A3*	*On*	*Off*	*E2A4*	*On*	*Off*	*E2A5*	*On*	*Off*
		RA	1	Not relevant	*RA*	-1	Not relevant	*RA*	0	Not relevant	*RA*	0	Not relevant	*RA*	0	Not relevant
		SC	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant
Groundwater (E3)	14%	**E2A1**	*On*	*Off*	**E2A2**	*On*	*Off*	**E2A3**	*On*	*Off*	**E2A4**	*On*	*Off*	**E2A5**	*On*	*Off*
		RA	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0
		SC	3	-4	*SC*	5	-6	*SC*	0	0	*SC*	0	0	*SC*	0	0
Surface Water (E4)	14%	**E3A1**	*On*	*Off*	**E3A2**	*On*	*Off*	**E3A3**	*On*	*Off*	**E3A4**	*On*	*Off*	**E3A5**	*On*	*Off*
		RA	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0
		SC	2	0	*SC*	5	0	*SC*	0	0	*SC*	0	0	*SC*	0	0
Sediment (E5)	0%	**E4A1**	*On*	*Off*	**E4A2**	*On*	*Off*	**E4A3**	*On*	*Off*	**E4A4**	*On*	*Off*	**E4A5**	*On*	*Off*
		RA	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0
		SC	0	0	*SC*	0	0	*SC*	0	0	*SC*	0	0	*SC*	0	0
Air (E6)	14%	**E5A1**	*On*	*Off*	**E5A2**	*On*	*Off*	**E5A3**	*On*	*Off*	**E5A4**	*On*	*Off*	**E5A5**	*On*	*Off*
		RA	Not relevant	-3	*RA*	Not relevant	-4	*RA*	Not relevant	0	*RA*	Not relevant	0	*RA*	Not relevant	0
		SC	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant
Non-renewable Natural Resources (E7)	14%	**E6A1**	*On*	*Off*	**E6A2**	*On*	*Off*	**E6A3**	*On*	*Off*	**E6A4**	*On*	*Off*	**E6A5**	*On*	*Off*
		RA	Not relevant	-4	*RA*	Not relevant	-3	*RA*	Not relevant	0	*RA*	Not relevant	0	*RA*	Not relevant	0
		SC	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant
Non-recyclable Waste Generation (E8)	14%	**E7A1**	*On*	*Off*	**E7A2**	*On*	*Off*	**E7A3**	*On*	*Off*	**E7A4**	*On*	*Off*	**E7A5**	*On*	*Off*
		RA	Not relevant	5	*RA*	Not relevant	8	*RA*	Not relevant	0	*RA*	Not relevant	0	*RA*	Not relevant	0
		SC	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant
WEIGTHED SCORE Environmental domain, *E*		**0.4**			**0.7**			**Not evaluated**			**Not evaluated**			**Not evaluated**		

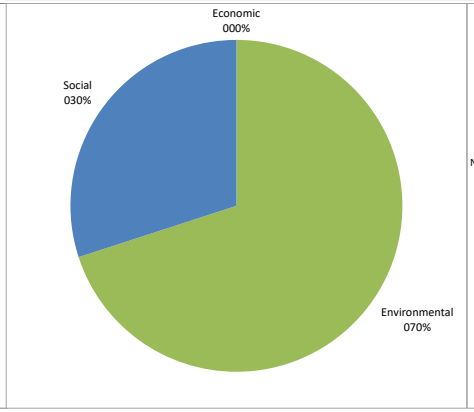
Scorings for the Socio-cultural domain	Weight (within domain)	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Local Environmental Quality and Amenity (S1)	25%	S1A1 / On / Off RA: -1 / -2 SC: 5 / 0	S1A2 / On / Off RA: -1 / -3 SC: 8 / 0	S1A3 / On / Off RA: 0 / 0 SC: 0 / 0	S1A4 / On / Off RA: 0 / 0 SC: 0 / 0	S1A5 / On / Off RA: 0 / 0 SC: 0 / 0
Cultural Heritage (S2)	0%	S2A1 / On / Off RA: 0 / 0 SC: Not relevant / Not relevant	S2A2 / On / Off RA: 0 / 0 SC: Not relevant / Not relevant	S2A3 / On / Off RA: 0 / 0 SC: Not relevant / Not relevant	S2A4 / On / Off RA: 0 / 0 SC: Not relevant / Not relevant	S2A5 / On / Off RA: 0 / 0 SC: Not relevant / Not relevant
Health and Safety (S3)	25%	S3A1 / On / Off RA: 0 / 0 SC: 2 / 0	S3A2 / On / Off RA: 0 / 0 SC: 2 / 0	S3A3 / On / Off RA: 0 / 0 SC: 0 / 0	S3A4 / On / Off RA: 0 / 0 SC: 0 / 0	S3A5 / On / Off RA: 0 / 0 SC: 0 / 0
Equity (S4)	25%	S4A1 / On / Off RA: -3 / -2 SC: 4 / 0	S4A2 / On / Off RA: -2 / -2 SC: 4 / 0	S4A3 / On / Off RA: 0 / 0 SC: 0 / 0	S4A4 / On / Off RA: 0 / 0 SC: 0 / 0	S4A5 / On / Off RA: 0 / 0 SC: 0 / 0
Local participation (S5)	25%	S5A1 / On / Off RA: 0 / 0 SC: 6 / -2	S5A2 / On / Off RA: 0 / 0 SC: 6 / -3	S5A3 / On / Off RA: 0 / 0 SC: 0 / 0	S5A4 / On / Off RA: 0 / 0 SC: 0 / 0	S5A5 / On / Off RA: 0 / 0 SC: 0 / 0
Local Acceptance (S6)	0%	S6A1 / On / Off RA: 0 / 0 SC: 0 / 0	S6A2 / On / Off RA: 0 / 0 SC: 0 / 0	S6A3 / On / Off RA: 0 / 0 SC: 0 / 0	S6A4 / On / Off RA: 0 / 0 SC: 0 / 0	S6A5 / On / Off RA: 0 / 0 SC: 0 / 0
WEIGHTED SCORE Social domain, *S*		**0.9**	**1.1**	**Not evaluated**	**Not evaluated**	**Not evaluated**
NET PRESENT VALUE, Economic domain, Φ (MSEK)		**-100.01**	**-100.01**	**Not evaluated**	**Not evaluated**	**Not evaluated**
Normalized Sustainability SCORE, *H (-100 to +100)*		**0**	**0**	**Not evaluated**	**Not evaluated**	**Not evaluated**
Strong sustainability on Domain Level?		**NO**	**NO**	**Not evaluated**	**Not evaluated**	**Not evaluated**
Strong sustainability on Key Criteria Level?		**NO**	**NO**	**Not evaluated**	**Not evaluated**	**Not evaluated**

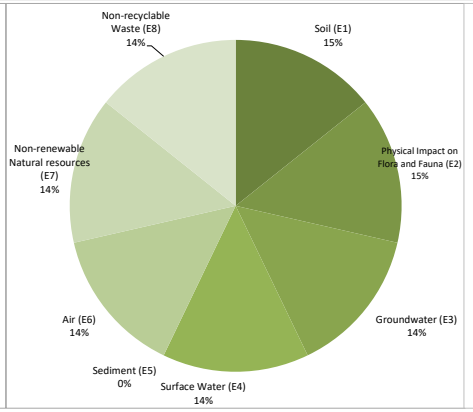
Note: Non quantified items were not considered!

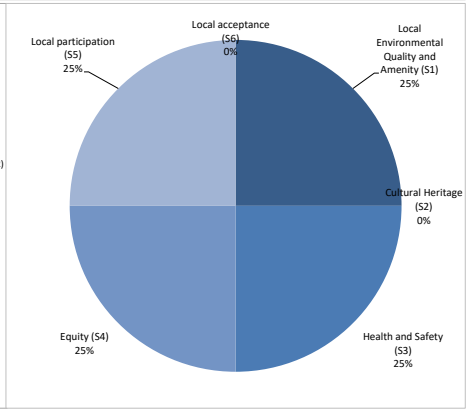
Weighting Summary

User Weights



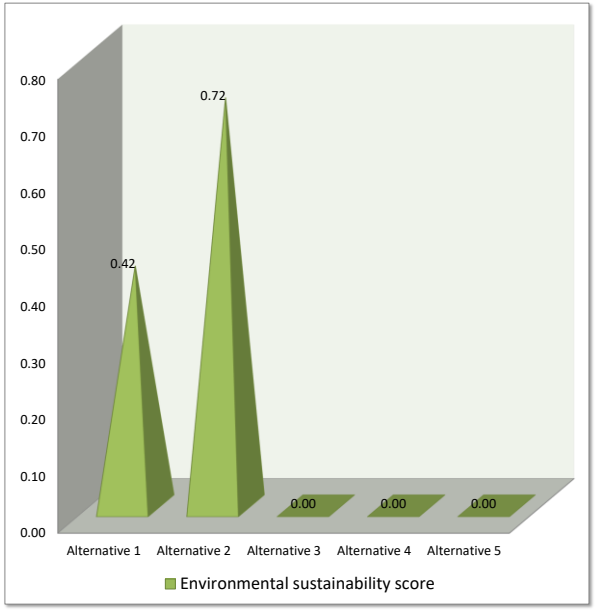


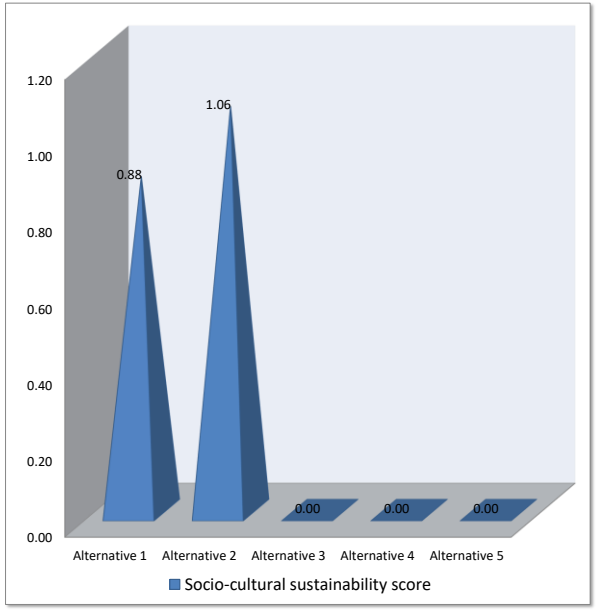


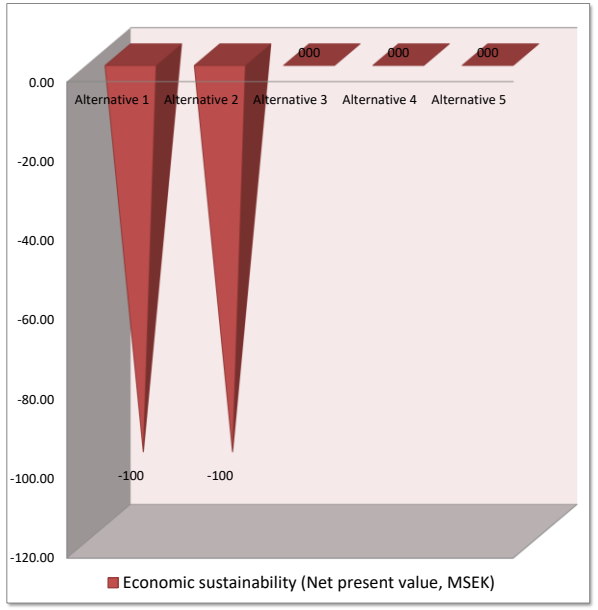


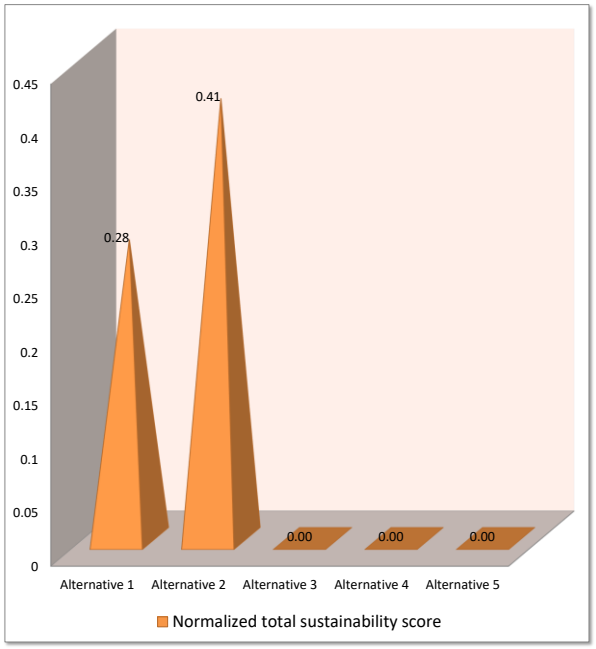
Note: Domains are not equally weighted!

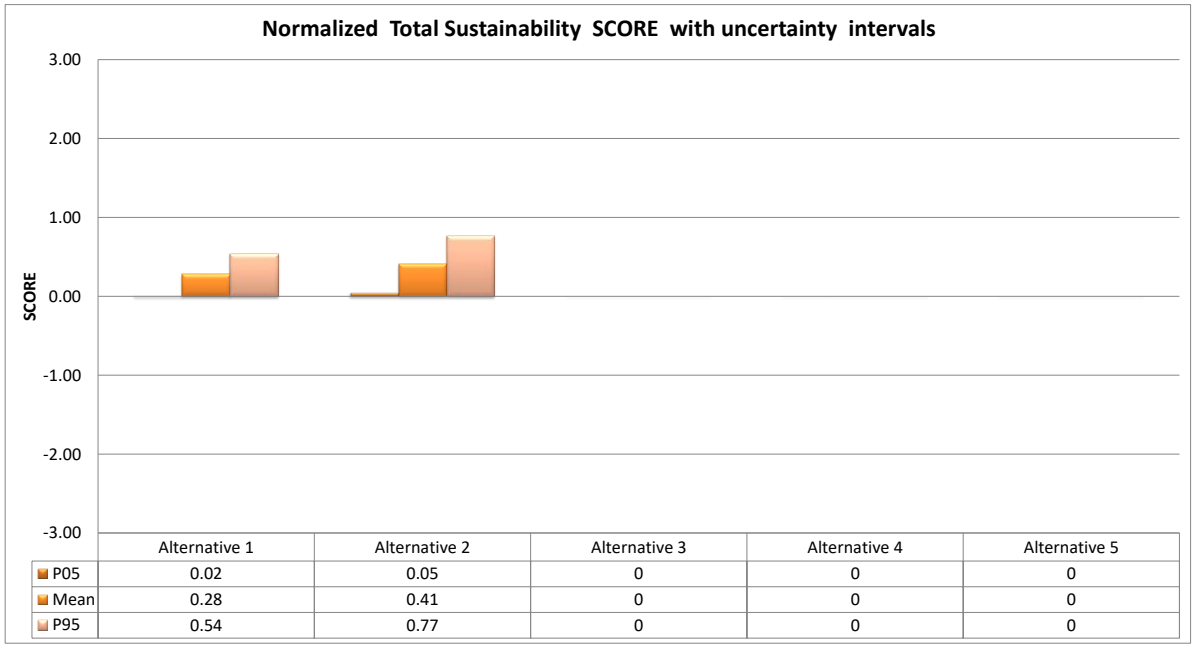
Results - Sustainability Scores





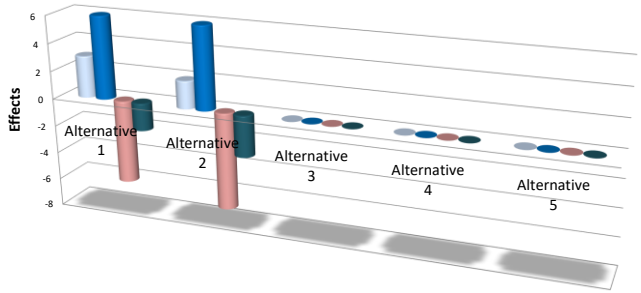




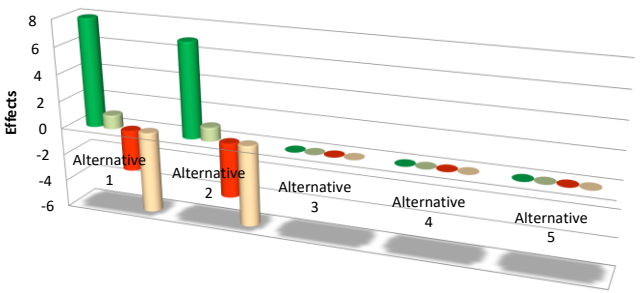


	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
P05	0.02	0.05	0	0	0
Mean	0.28	0.41	0	0	0
P95	0.54	0.77	0	0	0

Ecological and Social Effects of Remediation Alternatives



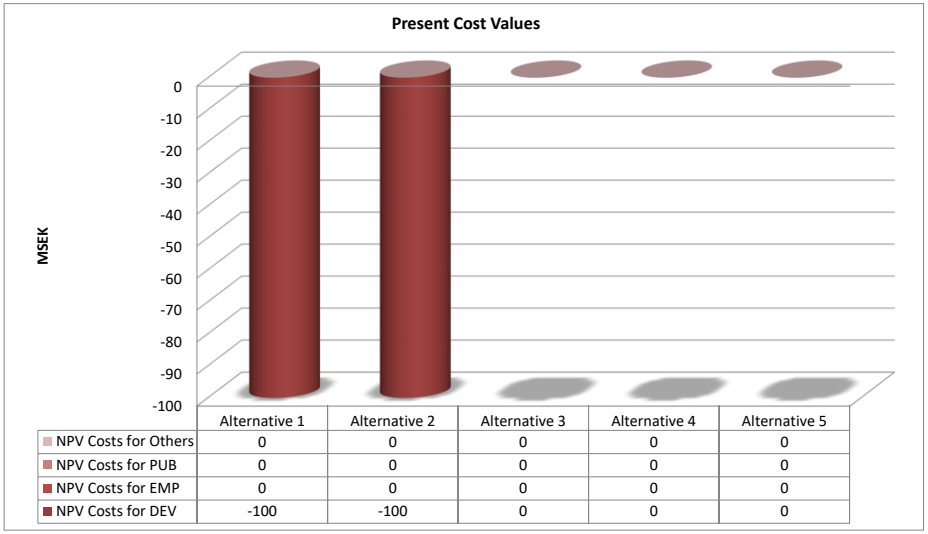
	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Remedial Action Positive	3	2	0	0	0
Source Contamination Positive	6	6	0	0	0
Remedial Action Negative	-6	-7	0	0	0
Source Contamination Negative	-2	-3	0	0	0



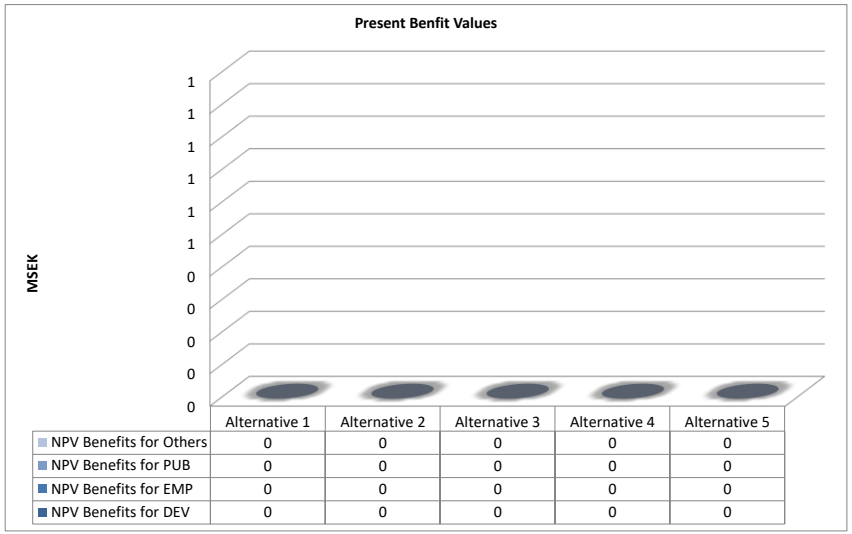
	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
On-Site Positive	8	7	0	0	0
Off-Site Positive	1	1	0	0	0
On Site Negative	-3	-4	0	0	0
Off-Site Negative	-6	-6	0	0	0

Economic effects of Remediation Alternatives

Distributional Analysis

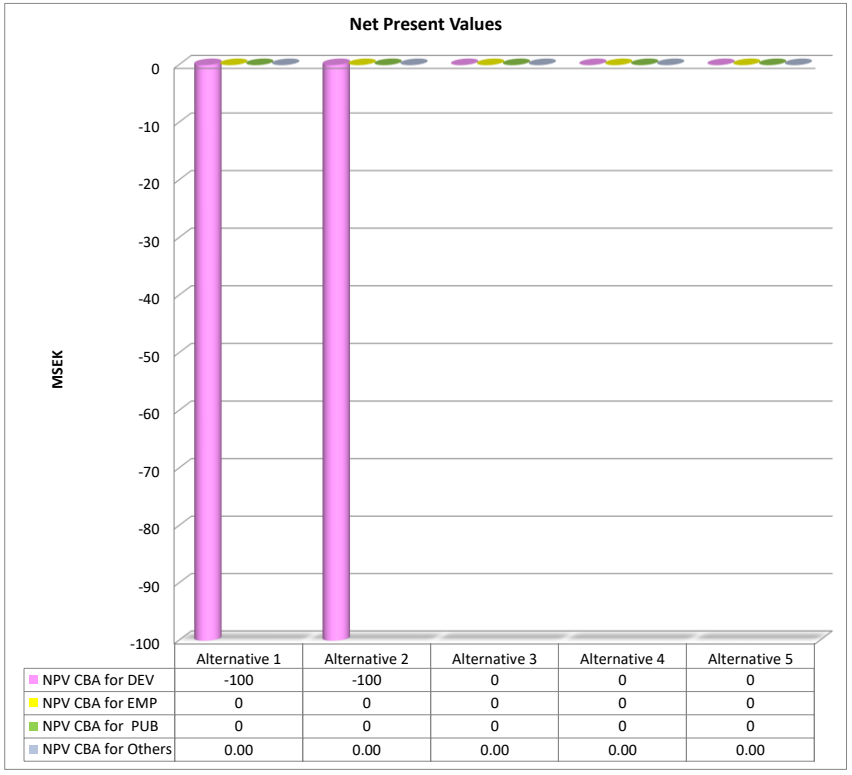


	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
NPV Costs for Others	0	0	0	0	0
NPV Costs for PUB	0	0	0	0	0
NPV Costs for EMP	0	0	0	0	0
NPV Costs for DEV	-100	-100	0	0	0



	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
NPV Benefits for Others	0	0	0	0	0
NPV Benefits for PUB	0	0	0	0	0
NPV Benefits for EMP	0	0	0	0	0
NPV Benefits for DEV	0	0	0	0	0

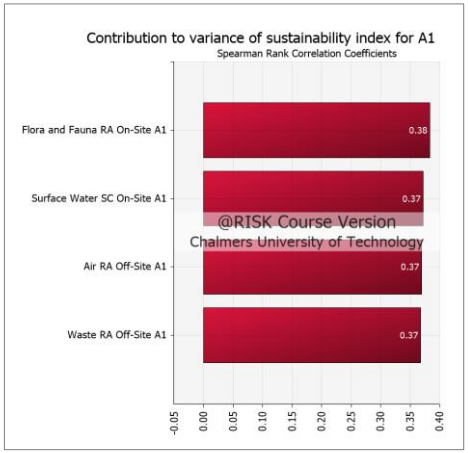
Benefit item	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
B1. Increased property value on site	NR	NR			
B2a. Reduced acute health risks	nr	nr			
B2b. Reduced non-acute health risks	nr	nr			
B2c. Other types of improved health, e.g. reduced anxiety	nr	nr			
B3a. Increased recreational opportunities on site	nr	nr			
B3b. Increased recreational opportunities in the surroundings	nr	nr			
B3c. Increased provision of other ecosystem services	nr	nr			
B4. Other positive externalities	nr	nr			
Cost item					
C1a. Costs for investigations and design of remedial actions	100	100			
C1b. Costs for contracting	nr	nr			
C1c. Capital costs due to allocation of funds to the remedial action	nr	nr			
C1d. Costs for the remedial action, including transport and disposal of contaminated soil minus possible revenues of reuse of contaminants and/or soil	nr	nr			
C1e. Costs for design and implementation of monitoring programs including sampling, analysis and data processing	nr	nr			
C1fa. Project risks	#REF!	nr			
C2a. Increased health risks due to the remedial action on site	nr	nr			
C2b. Increased health risks due to transports to and from the remediation site, e.g. transports of contaminated soil	nr	nr			
C2c. Increased health risks at disposal sites	nr	nr			
C2d. Other types of impaired health due to the remedial action, e.g. increased anxiety	nr	nr			
C3a. Decreased provision of ecosystem services on site due to remedial action, e.g. reduced recreational opportunities	nr	nr			
C3b. Decreased provision of ecosystem services outside the site due to the remedial action, e.g. environmental effects due to transports of contaminated soil	nr	nr			
C3c. Decreased provision of ecosystem services due to environmental effects at the disposal site	nr	nr			
C4. Other negative externalities	nr	nr			

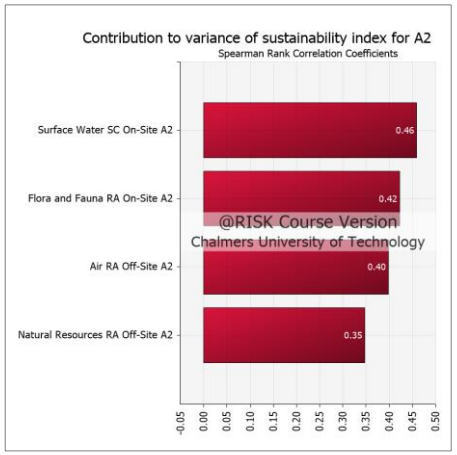


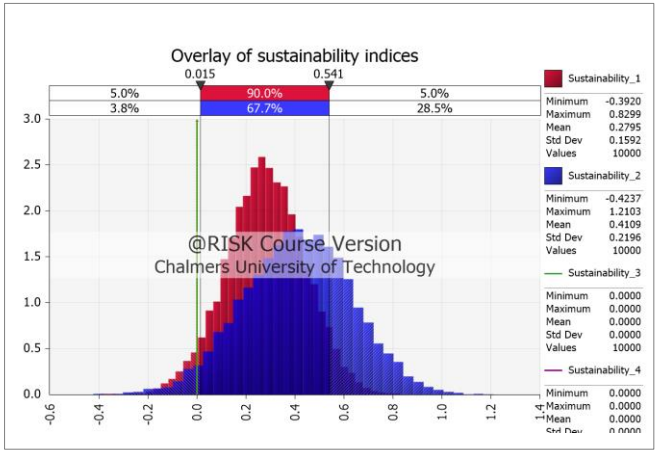
	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
NPV CBA for DEV	-100	-100	0	0	0
NPV CBA for EMP	0	0	0	0	0
NPV CBA for PUB	0	0	0	0	0
NPV CBA for Others	0.00	0.00	0.00	0.00	0.00

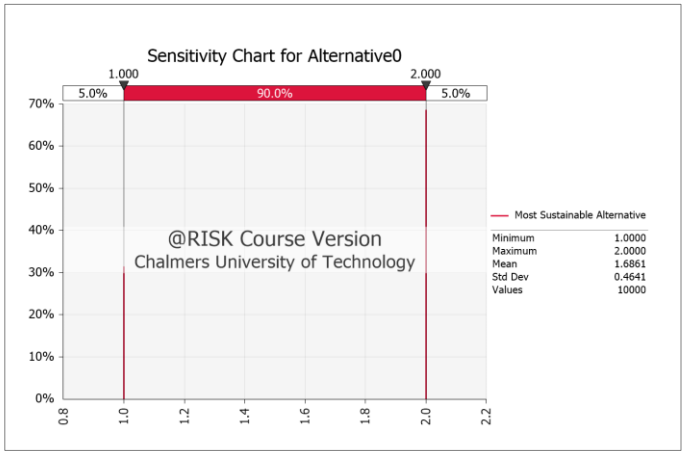
Uncertainty Analysis

Sensitivity analysis









Comments / Motivation Summary

Environmental Domain

Selection / Weighting:

		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
E1: Soil						
Ecotoxicological risk SC On-site	**Scoring:**	No effects on ecotoxicological risk levels.	No effects on ecotoxicological risk levels.			
Ecotoxicological risk RA On-site	**Scoring:**	Reduced contaminant concentrations and contaminat mass in the soil.	Reduced contaminant concentrations and contaminat mass in the soil.			
Soil Functions RA On-site	**Scoring:**	Improvement of soil quality, from Very Poor to Moderate/Good according to the Soil Quality Indicator Assessment.	Improvement of soil quality, from Very Poor to Moderate/Good according to the Soil Quality Indicator Assessment.			
E2: Physical Impact on Flora and Fauna						
Flora and Fauna RA On-site	**Scoring:**	No physical disturbances on any species with protection value.	No physical disturbances on any species with protection value.			
E3: Groundwater						
Groundwater RA On-Site	**Scoring:**	The remediation will have a small but insignificant effect on contaminant concentration in groundwater.	The remediation will have a small but insignificant effect on contaminant concentration in groundwater.			
Groundwater RA Off-Site	**Scoring:**					
Not relevant						
Groundwater SC On-Site	**Scoring:**	Leakage of contaminants to the groundwater is largely eliminated by the remedial action.	Leakage of contaminants to the groundwater is largely eliminated by the remedial action.			
Groundwater SC Off-Site	**Scoring:**					
Not relevant						

E4: Surface Water

Surface Water RA On-Site	**Scoring:**					
Not relevant						
Surface Water RA Off-Site	**Scoring:**	The remediation will have a small effect on contaminant concentrations in groundwater.	The remediation will have a small effect on contaminant concentrations in groundwater.			
Surface Water SC On-Site	**Scoring:**					
Not relevant						
Surface Water SC Off-Site	**Scoring:**	The effect on the concentration in surface water is neglible. Decreased polluted runoff.	The effect on the concentration in surface water is neglible. Decreased polluted runoff.			

E5: Sediment

Sediment RA On-Site	**Scoring:**					
Not relevant						
Sediment RA Off-Site	**Scoring:**	The remedial action will have a neglible effect on contaminant concentrations in the sediments.	The remedial action will have a neglible effect on contaminant concentrations in the sediments.			
Sediment SC On-Site	**Scoring:**					
Sediment SC Off-Site	**Scoring:**	The effect on the concentration in the sediment is neglible. Decreased polluted runoff.	The effect on the concentration in the sediment is neglible. Decreased polluted runoff.			
Not relevant						

E6: Air

Air RA Off-Site	**Scoring:**	Extensive increase in green house gas (GHG) emissions due to extensive transportation of excavated soil to a landfill. The emissions are larger 85% of the maximum alternative (complete excavation of all contaminated soil above generic guideline values).	Increase in green house gas (GHG) emissions due to extensive transportation of excavated soil to a landfill. The emissions are ca 85% of the maximum alternative (complete excavation of all contaminated soil above generic guideline values).			

E7: Non-renewable Natural Resources

Non-renewable Natural Resources RA Off-Site	**Scoring:**	Fossile fuel will be used for excavation and transportation of contaminated soil. The amount of fussil fuel is ca 85% of the maximum alternative. The amount of backfilling material is 85% of the maximum alternative.	Fossile fuel will be used for excavation, transportation and soil washing of contaminated soil. The amount of fussil fuel is ca 150% of the maximum alternative. The amount of backfilling material is 15% of the maximum alternative.			

E8: Non-recyclable Waste Generation

Non-recyclable Waste Genration RA Off-Site	**Scoring:**	The amount of produced waste is 70% of the maximum alternative.	The amount of produced waste is ca15% of the maximum alternative.			

Socio-cultural Domain

Selection / Weighting:

		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
S1: Local Environmental Quality and Amenity						
Local Environmental Quality and Amenity RA On-Site	**Scoring:**					
Not relevant						
Local Environmental Quality and Amenity RA Off-Site	**Scoring:**	There are some negative effects off-site due to heavy transports.	There are some negative effects off-site due to heavy transports but less transport than alt 1.			
Local Environmental Quality and Amenity SC On-Site	**Scoring:**	There is a large positive effect on the local environmental quality and amenities on the site.	There is a large positive effect on the local environmental quality and amenities on the site.			
Local Environmental Quality and Amenity SC Off-Site	**Scoring:**	There are some positive effects, for the sourrounding as well .	There are some positive effects, for the sourrounding as well .			
S2: Cultural Heritage						
Cultural heritage RA On-Site	**Scoring:**					
Not relevant						
Cultural heritage RA Off-Site	**Scoring:**					
Not relevant						
S3: Health and Safety						
Health and Safety RA On-Site	**Scoring:**	The workers on-site are exposed to contaminated material.	The workers on-site are exposed to contaminated material.			
Health and Safety RA Off-Site	**Scoring:**	The heavy traffic will be a safety risk for neigbours. There will also be some dusting.	There is cinsiderably less traffic than in alt1. Dust will be prevented at the sieve.			
Health and Safety SC On-Site	**Scoring:**	Since the reference alternative is considering a fenced area, i.e. no workers, there is no effect on-site as a result of the remediation alternative.	Since the reference alternative is considering a fenced area, i.e. no workers, there is no effect on-site as a result of the remediation alternative.			
Health and Safety SC Off-Site	**Scoring:**	Neighbours will be less exposed to contamination spreading from the site.	Neighbours will be less exposed to contamination spreading from the site.			

S4: Equity

Equity RA On-Site	**Scoring:**					
Not relevant						
Equity RA Off-Site	**Scoring:**	Neighbours are affected somewhat negatively by the remedial action but are able to influence the decision to some extent, e.g. when transports will take place etc.	Neighbours are affected somewhat negatively by the remedial action but are able to influence the decision to some extent, e.g. when transports will take place etc.			
Equity SC On-Site	**Scoring:**	The future environmental cost is reduced to a very large extent/eliminated.	The future environmental cost is reduced to a very large extent/eliminated.			
Equity SC Off-Site	**Scoring:**	The future environmental cost is reduced to a very large extent/eliminated.	The future environmental cost is reduced to a very large extent/eliminated.			

S5: Local Participation

Local participation RA On-Site	**Scoring:**	The remedial action does not affect job opportunities etc on site.	The remedial action does not affect job opportunities etc on site.			
Local participation RA Off-Site	**Scoring:**	Due to the remedial action there are some positive effects off-site, such as an increased use of services.	Due to the remedial action there are some positive effects off-site, such as an increased use of services.			
Local participation SC On-Site	**Scoring:**	The future landuse will affect local job opportunities positively.	The future landuse will affect local job opportunities positively.			
Local participation SC Off-Site	**Scoring:**	An increased number of workers at the site which uses shops and services in the vicinity, will lead to increased local job opportunities in the surrounding.	An increased number of workers at the site which uses shops and services in the vicinity, will lead to increased local job opportunities in the surrounding.			

S6: Local Acceptance

Local acceptance RA On-Site	**Scoring:**					
Not relevant						
Local acceptance RA Off-Site	**Scoring:**	Neighbours are worried about heavy transports through the area but want something to be done.	This alternative results in smaller amounts of transport than in alt 1 and is viewed as very positive by neighbours.			
Local acceptance SC On-Site	**Scoring:**					
Not relevant						
Local acceptance SC Off-Site	**Scoring:**	Neighbours are very positive to the reduction of source contamination.	Neighbours are very positive to the reduction of source contamination.			

Results of SCORE© Sustainability Assessment

The sustainability assessment for:

Maurliden , Gothenburg, Sweden

performed by

RS

resulted in the results presented on the following pages.

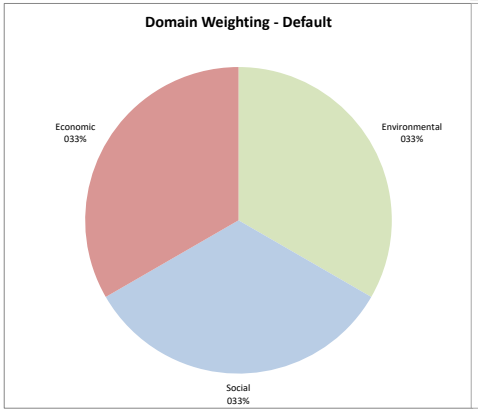
Scorings for the Environmental domain	Weight (within domain)	Alternative 1			Alternative 2			Alternative 3			Alternative 4			Alternative 5		
Soil (E1)	14%	**E1A1**	*Risk On*	*Functions On*	**E1A2**	*Risk On*	*Functions On*	**E1A3**	*Risk On*	*Functions On*	**E1A4**	*Risk On*	*Functions On*	**E1A5**	*Risk On*	*Functions On*
		RA	0	8	*RA*	0	8	*RA*	0	0	*RA*	0	0	*RA*	0	0
		SC	-2	Not relevant	*SC*	-3	Not relevant	*SC*	0	Not relevant	*SC*	0	Not relevant	*SC*	0	Not relevant
Physical Impact on Flora and fauna (E2)	14%	*E2A1*	*On*	*Off*	*E2A2*	*On*	*Off*	*E2A3*	*On*	*Off*	*E2A4*	*On*	*Off*	*E2A5*	*On*	*Off*
		RA	1	Not relevant	*RA*	-1	Not relevant	*RA*	0	Not relevant	*RA*	0	Not relevant	*RA*	0	Not relevant
		SC	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant
Groundwater (E3)	14%	**E2A1**	*On*	*Off*	**E2A2**	*On*	*Off*	**E2A3**	*On*	*Off*	**E2A4**	*On*	*Off*	**E2A5**	*On*	*Off*
		RA	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0
		SC	3	-4	*SC*	5	-6	*SC*	0	0	*SC*	0	0	*SC*	0	0
Surface Water (E4)	14%	**E3A1**	*On*	*Off*	**E3A2**	*On*	*Off*	**E3A3**	*On*	*Off*	**E3A4**	*On*	*Off*	**E3A5**	*On*	*Off*
		RA	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0
		SC	2	0	*SC*	5	0	*SC*	0	0	*SC*	0	0	*SC*	0	0
Sediment (E5)	0%	**E4A1**	*On*	*Off*	**E4A2**	*On*	*Off*	**E4A3**	*On*	*Off*	**E4A4**	*On*	*Off*	**E4A5**	*On*	*Off*
		RA	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0
		SC	0	0	*SC*	0	0	*SC*	0	0	*SC*	0	0	*SC*	0	0
Air (E6)	14%	**E5A1**	*On*	*Off*	**E5A2**	*On*	*Off*	**E5A3**	*On*	*Off*	**E5A4**	*On*	*Off*	**E5A5**	*On*	*Off*
		RA	Not relevant	-3	*RA*	Not relevant	-4	*RA*	Not relevant	0	*RA*	Not relevant	0	*RA*	Not relevant	0
		SC	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant
Non-renewable Natural Resources (E7)	14%	**E6A1**	*On*	*Off*	**E6A2**	*On*	*Off*	**E6A3**	*On*	*Off*	**E6A4**	*On*	*Off*	**E6A5**	*On*	*Off*
		RA	Not relevant	-4	*RA*	Not relevant	-3	*RA*	Not relevant	0	*RA*	Not relevant	0	*RA*	Not relevant	0
		SC	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant
Non-recyclable Waste Generation (E8)	14%	**E7A1**	*On*	*Off*	**E7A2**	*On*	*Off*	**E7A3**	*On*	*Off*	**E7A4**	*On*	*Off*	**E7A5**	*On*	*Off*
		RA	Not relevant	5	*RA*	Not relevant	8	*RA*	Not relevant	0	*RA*	Not relevant	0	*RA*	Not relevant	0
		SC	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant
WEIGTHED SCORE Environmental domain, *E*		**0.4**			**0.7**			**Not evaluated**			**Not evaluated**			**Not evaluated**		

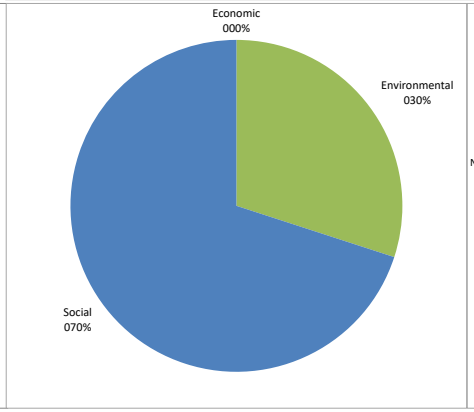
Scorings for the Socio-cultural domain	Weight (within domain)	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Local Environmental Quality and Amenity (S1)	25%	S1A1 / On / Off RA: -1 / -2 SC: 5 / 0	S1A2 / On / Off RA: -1 / -3 SC: 8 / 0	S1A3 / On / Off RA: 0 / 0 SC: 0 / 0	S1A4 / On / Off RA: 0 / 0 SC: 0 / 0	S1A5 / On / Off RA: 0 / 0 SC: 0 / 0
Cultural Heritage (S2)	0%	S2A1 / On / Off RA: 0 / 0 SC: Not relevant / Not relevant	S2A2 / On / Off RA: 0 / 0 SC: Not relevant / Not relevant	S2A3 / On / Off RA: 0 / 0 SC: Not relevant / Not relevant	S2A4 / On / Off RA: 0 / 0 SC: Not relevant / Not relevant	S2A5 / On / Off RA: 0 / 0 SC: Not relevant / Not relevant
Health and Safety (S3)	25%	S3A1 / On / Off RA: 0 / 0 SC: 2 / 0	S3A2 / On / Off RA: 0 / 0 SC: 2 / 0	S3A3 / On / Off RA: 0 / 0 SC: 0 / 0	S3A4 / On / Off RA: 0 / 0 SC: 0 / 0	S3A5 / On / Off RA: 0 / 0 SC: 0 / 0
Equity (S4)	25%	S4A1 / On / Off RA: -3 / -2 SC: 4 / 0	S4A2 / On / Off RA: -2 / -2 SC: 4 / 0	S4A3 / On / Off RA: 0 / 0 SC: 0 / 0	S4A4 / On / Off RA: 0 / 0 SC: 0 / 0	S4A5 / On / Off RA: 0 / 0 SC: 0 / 0
Local participation (S5)	25%	S5A1 / On / Off RA: 0 / 0 SC: 6 / -2	S5A2 / On / Off RA: 0 / 0 SC: 6 / -3	S5A3 / On / Off RA: 0 / 0 SC: 0 / 0	S5A4 / On / Off RA: 0 / 0 SC: 0 / 0	S5A5 / On / Off RA: 0 / 0 SC: 0 / 0
Local Acceptance (S6)	0%	S6A1 / On / Off RA: 0 / 0 SC: 0 / 0	S6A2 / On / Off RA: 0 / 0 SC: 0 / 0	S6A3 / On / Off RA: 0 / 0 SC: 0 / 0	S6A4 / On / Off RA: 0 / 0 SC: 0 / 0	S6A5 / On / Off RA: 0 / 0 SC: 0 / 0
WEIGHTED SCORE Social domain, *S*		**0.9**	**1.1**	**Not evaluated**	**Not evaluated**	**Not evaluated**
NET PRESENT VALUE, Economic domain, Φ (MSEK)		**-100.01**	**-100.01**	**Not evaluated**	**Not evaluated**	**Not evaluated**
Normalized Sustainability SCORE, *H (-100 to +100)*		**0**	**0**	**Not evaluated**	**Not evaluated**	**Not evaluated**
Strong sustainability on Domain Level?		**NO**	**NO**	**Not evaluated**	**Not evaluated**	**Not evaluated**
Strong sustainability on Key Criteria Level?		**NO**	**NO**	**Not evaluated**	**Not evaluated**	**Not evaluated**

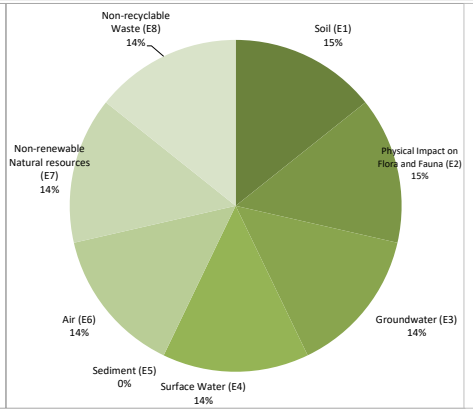
Note: Non quantified items were not considered!

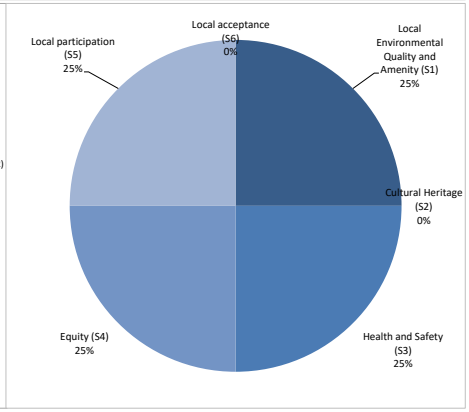
Weighting Summary

User Weights



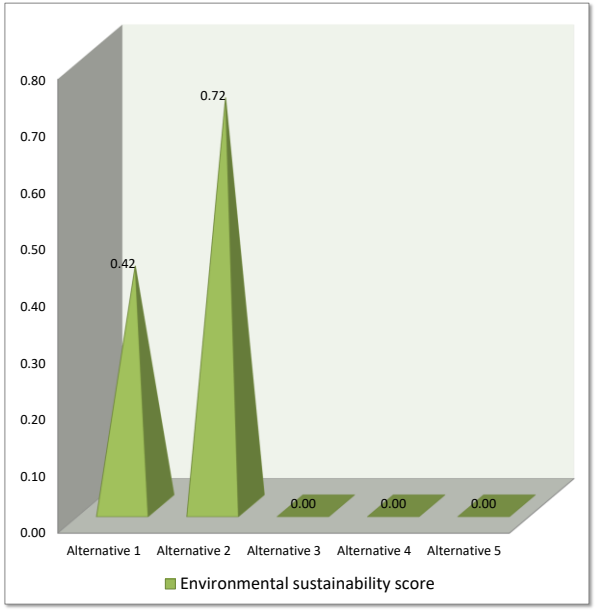


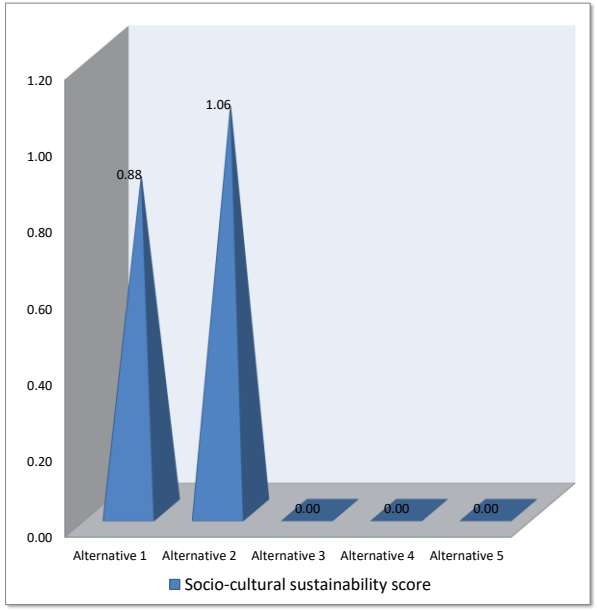


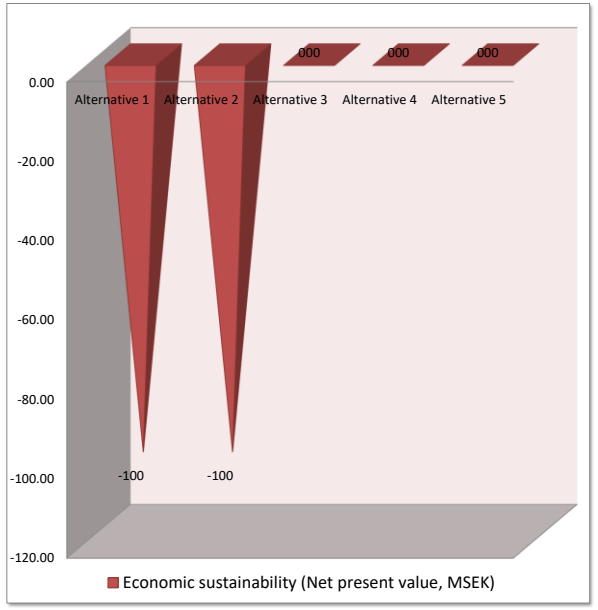


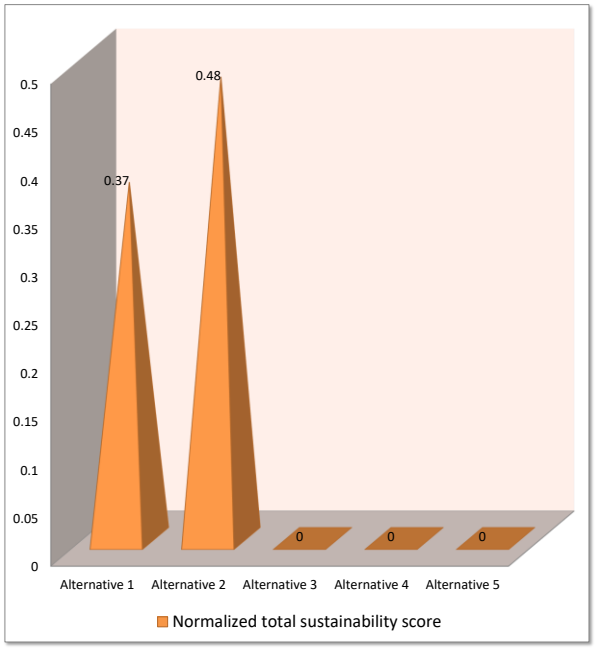
Note: Domains are not equally weighted!

Results - Sustainability Scores

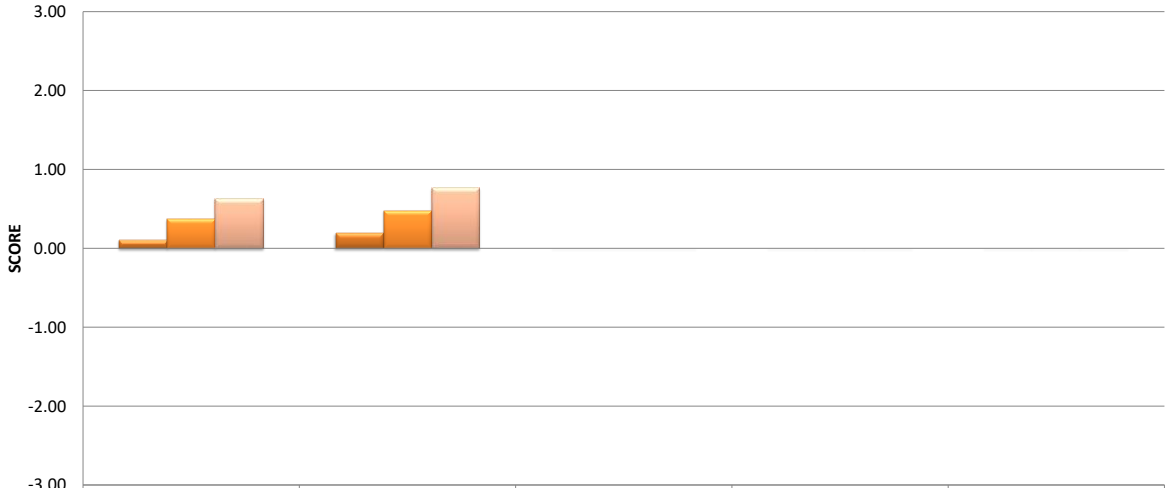






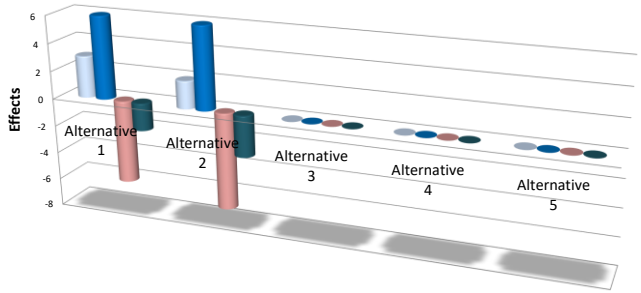


Normalized Total Sustainability SCORE with uncertainty intervals

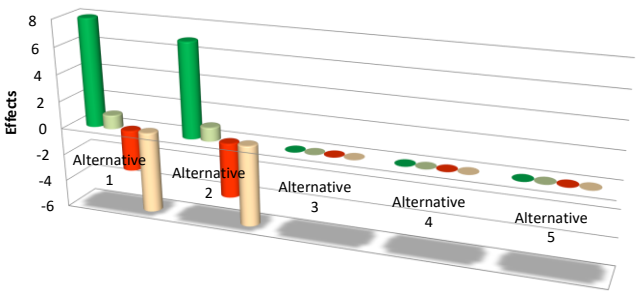


	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
P05	0.10	0.19	0	0	0
Mean	0.37	0.48	0	0	0
P95	0.63	0.76	0	0	0

Ecological and Social Effects of Remediation Alternatives



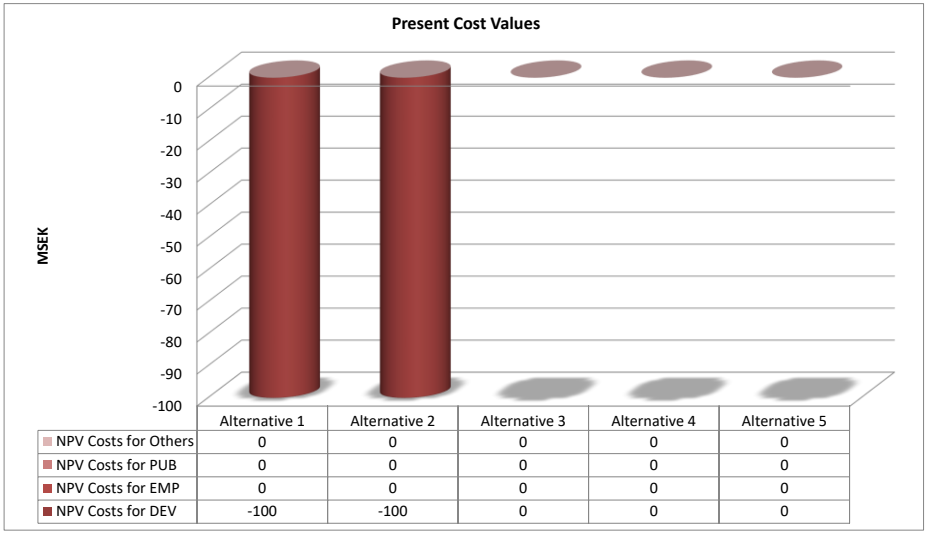
	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Remedial Action Positive	3	2	0	0	0
Source Contamination Positive	6	6	0	0	0
Remedial Action Negative	-6	-7	0	0	0
Source Contamination Negative	-2	-3	0	0	0



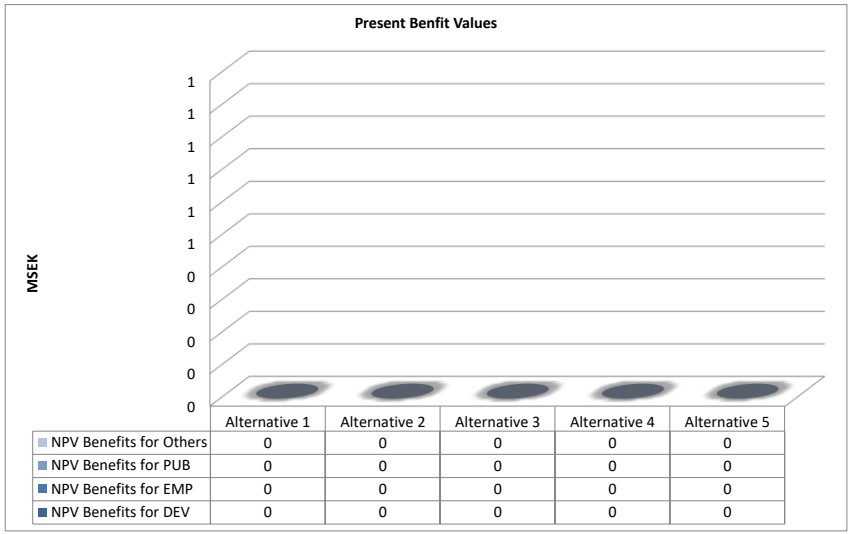
	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
On-Site Positive	8	7	0	0	0
Off-Site Positive	1	1	0	0	0
On Site Negative	-3	-4	0	0	0
Off-Site Negative	-6	-6	0	0	0

Economic effects of Remediation Alternatives

Distributional Analysis

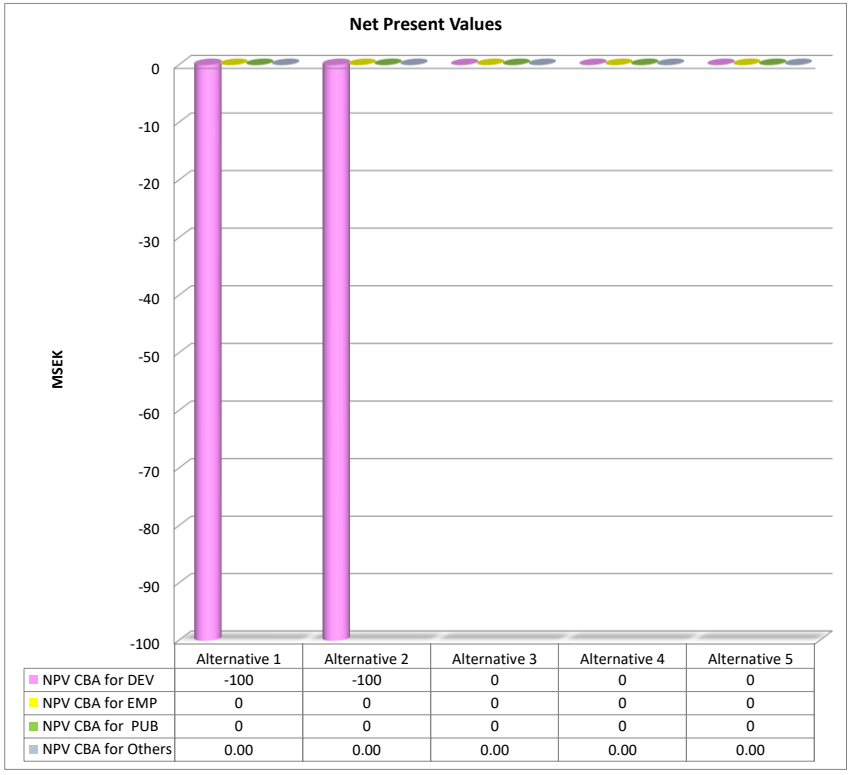


	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
NPV Costs for Others	0	0	0	0	0
NPV Costs for PUB	0	0	0	0	0
NPV Costs for EMP	0	0	0	0	0
NPV Costs for DEV	-100	-100	0	0	0



	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
NPV Benefits for Others	0	0	0	0	0
NPV Benefits for PUB	0	0	0	0	0
NPV Benefits for EMP	0	0	0	0	0
NPV Benefits for DEV	0	0	0	0	0

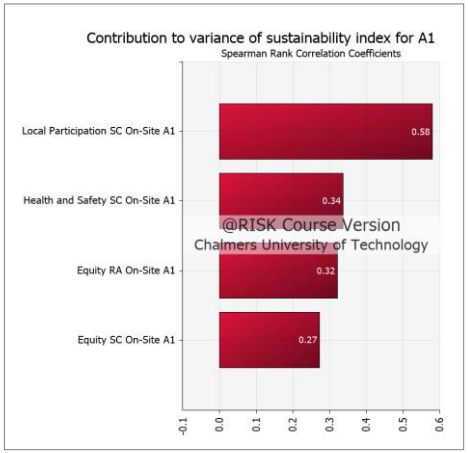
Benefit item	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
B1. Increased property value on site	NR	NR			
B2a. Reduced acute health risks	nr	nr			
B2b. Reduced non-acute health risks	nr	nr			
B2c. Other types of improved health, e.g. reduced anxiety	nr	nr			
B3a. Increased recreational opportunities on site	nr	nr			
B3b. Increased recreational opportunities in the surroundings	nr	nr			
B3c. Increased provision of other ecosystem services	nr	nr			
B4. Other positive externalities	nr	nr			
Cost item					
C1a. Costs for investigations and design of remedial actions	100	100			
C1b. Costs for contracting	nr	nr			
C1c. Capital costs due to allocation of funds to the remedial action	nr	nr			
C1d. Costs for the remedial action, including transport and disposal of contaminated soil minus possible revenues of reuse of contaminants and/or soil	nr	nr			
C1e. Costs for design and implementation of monitoring programs including sampling, analysis and data processing	nr	nr			
C1fa. Project risks	#REF!	nr			
C2a. Increased health risks due to the remedial action on site	nr	nr			
C2b. Increased health risks due to transports to and from the remediation site, e.g. transports of contaminated soil	nr	nr			
C2c. Increased health risks at disposal sites	nr	nr			
C2d. Other types of impaired health due to the remedial action, e.g. increased anxiety	nr	nr			
C3a. Decreased provision of ecosystem services on site due to remedial action, e.g. reduced recreational opportunities	nr	nr			
C3b. Decreased provision of ecosystem services outside the site due to the remedial action, e.g. environmental effects due to transports of contaminated soil	nr	nr			
C3c. Decreased provision of ecosystem services due to environmental effects at the disposal site	nr	nr			
C4. Other negative externalities	nr	nr			

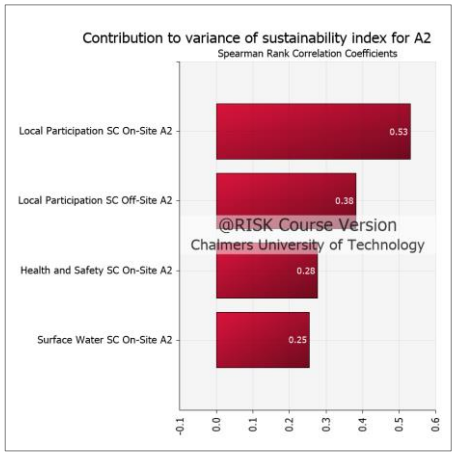


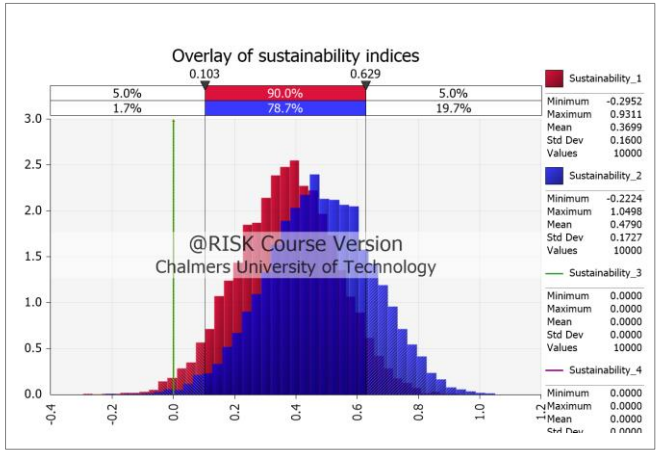
	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
NPV CBA for DEV	-100	-100	0	0	0
NPV CBA for EMP	0	0	0	0	0
NPV CBA for PUB	0	0	0	0	0
NPV CBA for Others	0.00	0.00	0.00	0.00	0.00

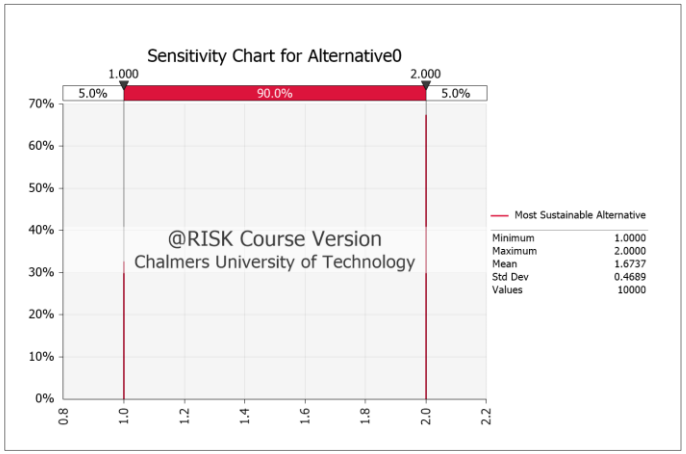
Uncertainty Analysis

Sensitivity analysis









Comments / Motivation Summary

Environmental Domain

Selection / Weighting:

		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
E1: Soil						
Ecotoxicological risk SC On-site	**Scoring:**	No effects on ecotoxicological risk levels.	No effects on ecotoxicological risk levels.			
Ecotoxicological risk RA On-site	**Scoring:**	Reduced contaminant concentrations and contaminat mass in the soil.	Reduced contaminant concentrations and contaminat mass in the soil.			
Soil Functions RA On-site	**Scoring:**	Improvement of soil quality, from Very Poor to Moderate/Good according to the Soil Quality Indicator Assessment.	Improvement of soil quality, from Very Poor to Moderate/Good according to the Soil Quality Indicator Assessment.			
E2: Physical Impact on Flora and Fauna						
Flora and Fauna RA On-site	**Scoring:**	No physical disturbances on any species with protection value.	No physical disturbances on any species with protection value.			
E3: Groundwater						
Groundwater RA On-Site	**Scoring:**	The remediation will have a small but insignificant effect on contaminant concentration in groundwater.	The remediation will have a small but insignificant effect on contaminant concentration in groundwater.			
Groundwater RA Off-Site	**Scoring:**					
Not relevant						
Groundwater SC On-Site	**Scoring:**	Leakage of contaminants to the groundwater is largely eliminated by the remedial action.	Leakage of contaminants to the groundwater is largely eliminated by the remedial action.			
Groundwater SC Off-Site	**Scoring:**					
Not relevant						

E4: Surface Water

Surface Water RA On-Site	**Scoring:**					
Not relevant						
Surface Water RA Off-Site	**Scoring:**	The remediation will have a small effect on contaminant concentrations in groundwater.	The remediation will have a small effect on contaminant concentrations in groundwater.			
Surface Water SC On-Site	**Scoring:**					
Not relevant						
Surface Water SC Off-Site	**Scoring:**	The effect on the concentration in surface water is neglible. Decreased polluted runoff.	The effect on the concentration in surface water is neglible. Decreased polluted runoff.			

E5: Sediment

Sediment RA On-Site	**Scoring:**					
Not relevant						
Sediment RA Off-Site	**Scoring:**	The remedial action will have a neglible effect on contaminant concentrations in the sediments.	The remedial action will have a neglible effect on contaminant concentrations in the sediments.			
Sediment SC On-Site	**Scoring:**					
Sediment SC Off-Site	**Scoring:**	The effect on the concentration in the sediment is neglible. Decreased polluted runoff.	The effect on the concentration in the sediment is neglible. Decreased polluted runoff.			
Not relevant						

E6: Air

Air RA Off-Site	**Scoring:**	Extensive increase in green house gas (GHG) emissions due to extensive transportation of excavated soil to a landfill. The emissions are larger 85% of the maximum alternative (complete excavation of all contaminated soil above generic guideline values).	Increase in green house gas (GHG) emissions due to extensive transportation of excavated soil to a landfill. The emissions are ca 85% of the maximum alternative (complete excavation of all contaminated soil above generic guideline values).			

E7: Non-renewable Natural Resources

Non-renewable Natural Resources RA Off-Site	**Scoring:**	Fossile fuel will be used for excavation and transportation of contaminated soil. The amount of fussil fuel is ca 85% of the maximum alternative. The amount of backfilling material is 85% of the maximum alternative.	Fossile fuel will be used for excavation, transportation and soil washing of contaminated soil. The amount of fussil fuel is ca 150% of the maximum alternative. The amount of backfilling material is 15% of the maximum alternative.			

E8: Non-recyclable Waste Generation

Non-recyclable Waste Genration RA Off-Site	**Scoring:**	The amount of produced waste is 70% of the maximum alternative.	The amount of produced waste is ca15% of the maximum alternative.			

Socio-cultural Domain

Selection / Weighting:

		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
S1: Local Environmental Quality and Amenity						
Local Environmental Quality and Amenity RA On-Site	**Scoring:**					
Not relevant						
Local Environmental Quality and Amenity RA Off-Site	**Scoring:**	There are some negative effects off-site due to heavy transports.	There are some negative effects off-site due to heavy transports but less transport than alt 1.			
Local Environmental Quality and Amenity SC On-Site	**Scoring:**	There is a large positive effect on the local environmental quality and amenities on the site.	There is a large positive effect on the local environmental quality and amenities on the site.			
Local Environmental Quality and Amenity SC Off-Site	**Scoring:**	There are some positive effects, for the sourrounding as well .	There are some positive effects, for the sourrounding as well .			
S2: Cultural Heritage						
Cultural heritage RA On-Site	**Scoring:**					
Not relevant						
Cultural heritage RA Off-Site	**Scoring:**					
Not relevant						
S3: Health and Safety						
Health and Safety RA On-Site	**Scoring:**	The workers on-site are exposed to contaminated material.	The workers on-site are exposed to contaminated material.			
Health and Safety RA Off-Site	**Scoring:**	The heavy traffic will be a safety risk for neigbours. There will also be some dusting.	There is cinsiderably less traffic than in alt1. Dust will be prevented at the sieve.			
Health and Safety SC On-Site	**Scoring:**	Since the reference alternative is considering a fenced area, i.e. no workers, there is no effect on-site as a result of the remediation alternative.	Since the reference alternative is considering a fenced area, i.e. no workers, there is no effect on-site as a result of the remediation alternative.			
Health and Safety SC Off-Site	**Scoring:**	Neighbours will be less exposed to contamination spreading from the site.	Neighbours will be less exposed to contamination spreading from the site.			

S4: Equity

Equity RA On-Site	**Scoring:**					
Not relevant						
Equity RA Off-Site	**Scoring:**	Neighbours are affected somewhat negatively by the remedial action but are able to influence the decision to some extent, e.g. when transports will take place etc.	Neighbours are affected somewhat negatively by the remedial action but are able to influence the decision to some extent, e.g. when transports will take place etc.			
Equity SC On-Site	**Scoring:**	The future environmental cost is reduced to a very large extent/eliminated.	The future environmental cost is reduced to a very large extent/eliminated.			
Equity SC Off-Site	**Scoring:**	The future environmental cost is reduced to a very large extent/eliminated.	The future environmental cost is reduced to a very large extent/eliminated.			

S5: Local Participation

Local participation RA On-Site	**Scoring:**	The remedial action does not affect job opportunities etc on site.	The remedial action does not affect job opportunities etc on site.			
Local participation RA Off-Site	**Scoring:**	Due to the remedial action there are some positive effects off-site, such as an increased use of services.	Due to the remedial action there are some positive effects off-site, such as an increased use of services.			
Local participation SC On-Site	**Scoring:**	The future landuse will affect local job opportunities positively.	The future landuse will affect local job opportunities positively.			
Local participation SC Off-Site	**Scoring:**	An increased number of workers at the site which uses shops and services in the vicinity, will lead to increased local job opportunities in the surrounding.	An increased number of workers at the site which uses shops and services in the vicinity, will lead to increased local job opportunities in the surrounding.			

S6: Local Acceptance

Local acceptance RA On-Site	**Scoring:**					
Not relevant						
Local acceptance RA Off-Site	**Scoring:**	Neighbours are worried about heavy transports through the area but want something to be done.	This alternative results in smaller amounts of transport than in alt 1 and is viewed as very positive by neighbours.			
Local acceptance SC On-Site	**Scoring:**					
Not relevant						
Local acceptance SC Off-Site	**Scoring:**	Neighbours are very positive to the reduction of source contamination.	Neighbours are very positive to the reduction of source contamination.			

Results of SCORE© Sustainability Assessment

The sustainability assessment for:

Maurliden , Gothenburg, Sweden

performed by

RS

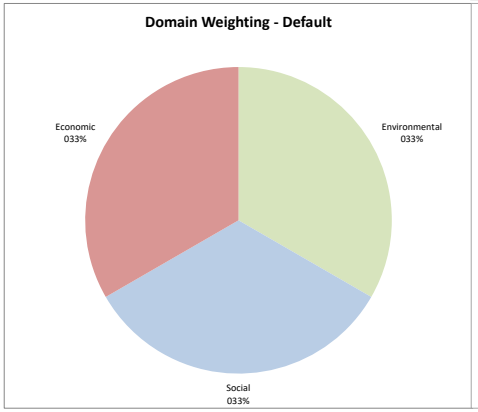
resulted in the results presented on the following pages.

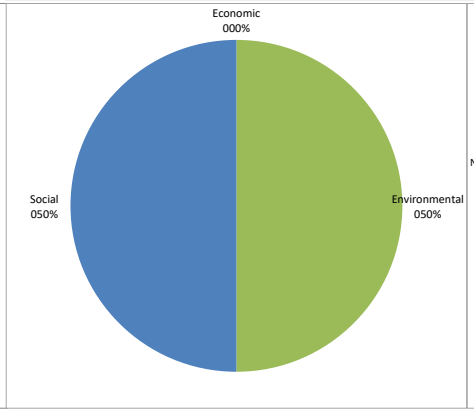
Scorings for the Environmental domain	Weight (within domain)	Alternative 1			Alternative 2			Alternative 3			Alternative 4			Alternative 5		
Soil (E1)	14%	**E1A1**	*Risk On*	*Functions On*	**E1A2**	*Risk On*	*Functions On*	**E1A3**	*Risk On*	*Functions On*	**E1A4**	*Risk On*	*Functions On*	**E1A5**	*Risk On*	*Functions On*
		RA	0	8	*RA*	0	8	*RA*	0	0	*RA*	0	0	*RA*	0	0
		SC	-2	Not relevant	*SC*	-3	Not relevant	*SC*	0	Not relevant	*SC*	0	Not relevant	*SC*	0	Not relevant
Physical Impact on Flora and fauna (E2)	14%	*E2A1*	*On*	*Off*	*E2A2*	*On*	*Off*	*E2A3*	*On*	*Off*	*E2A4*	*On*	*Off*	*E2A5*	*On*	*Off*
		RA	1	Not relevant	*RA*	-1	Not relevant	*RA*	0	Not relevant	*RA*	0	Not relevant	*RA*	0	Not relevant
		SC	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant
Groundwater (E3)	14%	**E2A1**	*On*	*Off*	**E2A2**	*On*	*Off*	**E2A3**	*On*	*Off*	**E2A4**	*On*	*Off*	**E2A5**	*On*	*Off*
		RA	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0
		SC	3	-4	*SC*	5	-6	*SC*	0	0	*SC*	0	0	*SC*	0	0
Surface Water (E4)	14%	**E3A1**	*On*	*Off*	**E3A2**	*On*	*Off*	**E3A3**	*On*	*Off*	**E3A4**	*On*	*Off*	**E3A5**	*On*	*Off*
		RA	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0
		SC	2	0	*SC*	5	0	*SC*	0	0	*SC*	0	0	*SC*	0	0
Sediment (E5)	0%	**E4A1**	*On*	*Off*	**E4A2**	*On*	*Off*	**E4A3**	*On*	*Off*	**E4A4**	*On*	*Off*	**E4A5**	*On*	*Off*
		RA	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0	*RA*	0	0
		SC	0	0	*SC*	0	0	*SC*	0	0	*SC*	0	0	*SC*	0	0
Air (E6)	14%	**E5A1**	*On*	*Off*	**E5A2**	*On*	*Off*	**E5A3**	*On*	*Off*	**E5A4**	*On*	*Off*	**E5A5**	*On*	*Off*
		RA	Not relevant	-3	*RA*	Not relevant	-4	*RA*	Not relevant	0	*RA*	Not relevant	0	*RA*	Not relevant	0
		SC	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant
Non-renewable Natural Resources (E7)	14%	**E6A1**	*On*	*Off*	**E6A2**	*On*	*Off*	**E6A3**	*On*	*Off*	**E6A4**	*On*	*Off*	**E6A5**	*On*	*Off*
		RA	Not relevant	-4	*RA*	Not relevant	-3	*RA*	Not relevant	0	*RA*	Not relevant	0	*RA*	Not relevant	0
		SC	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant
Non-recyclable Waste Generation (E8)	14%	**E7A1**	*On*	*Off*	**E7A2**	*On*	*Off*	**E7A3**	*On*	*Off*	**E7A4**	*On*	*Off*	**E7A5**	*On*	*Off*
		RA	Not relevant	5	*RA*	Not relevant	8	*RA*	Not relevant	0	*RA*	Not relevant	0	*RA*	Not relevant	0
		SC	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant	*SC*	Not relevant	Not relevant
WEIGTHED SCORE Environmental domain, *E*		**0.42**			**0.72**			**Not evaluated**			**Not evaluated**			**Not evaluated**		

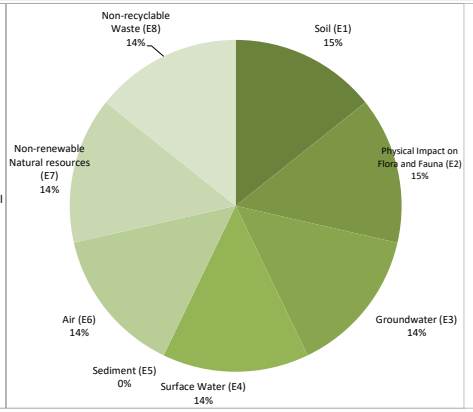
Scorings for the Socio-cultural domain	Weight (within domain)	Alternative 1		Alternative 2		Alternative 3		Alternative 4		Alternative 5	
		S1A1	On / Off	S1A2	On / Off	S1A3	On / Off	S1A4	On / Off	S1A5	On / Off
Local Environmental Quality and Amenity (S1)	20%	RA	-1 / -2	RA	-1 / -3	RA	0 / 0	RA	0 / 0	RA	0 / 0
		SC	5 / 0	SC	8 / 0	SC	0 / 0	SC	0 / 0	SC	0 / 0
		S2A1	On / Off	S2A2	On / Off	S2A3	On / Off	S2A4	On / Off	S2A5	On / Off
Cultural Heritage (S2)	0%	RA	0 / 0	RA	0 / 0	RA	0 / 0	RA	0 / 0	RA	0 / 0
		SC	Not relevant / Not relevant	SC	Not relevant / Not relevant	SC	Not relevant / Not relevant	SC	Not relevant / Not relevant	SC	Not relevant / Not relevant
		S3A1	On / Off	S3A2	On / Off	S3A3	On / Off	S3A4	On / Off	S3A5	On / Off
Health and Safety (S3)	20%	RA	0 / 0	RA	0 / 0	RA	0 / 0	RA	0 / 0	RA	0 / 0
		SC	2 / 0	SC	2 / 0	SC	0 / 0	SC	0 / 0	SC	0 / 0
		S4A1	On / Off	S4A2	On / Off	S4A3	On / Off	S4A4	On / Off	S4A5	On / Off
Equity (S4)	20%	RA	-3 / -2	RA	-2 / -2	RA	0 / 0	RA	0 / 0	RA	0 / 0
		SC	4 / 0	SC	4 / 0	SC	0 / 0	SC	0 / 0	SC	0 / 0
		S5A1	On / Off	S5A2	On / Off	S5A3	On / Off	S5A4	On / Off	S5A5	On / Off
Local participation (S5)	20%	RA	0 / 0	RA	0 / 0	RA	0 / 0	RA	0 / 0	RA	0 / 0
		SC	6 / -2	SC	6 / -3	SC	0 / 0	SC	0 / 0	SC	0 / 0
		S6A1	On / Off	S6A2	On / Off	S6A3	On / Off	S6A4	On / Off	S6A5	On / Off
Local Acceptance (S6)	20%	RA	0 / 0	RA	0 / 0	RA	0 / 0	RA	0 / 0	RA	0 / 0
		SC	0 / 0	SC	0 / -5	SC	0 / 0	SC	0 / 0	SC	0 / 0
WEIGHTED SCORE Social domain, *S*		**0.70**		**-0.22**		**Not evaluated**		**Not evaluated**		**Not evaluated**	
NET PRESENT VALUE, Economic domain, Φ (MSEK)		**-100.01**		**-100.01**		**Not evaluated**		**Not evaluated**		**Not evaluated**	
Note: Non quantified items were not considered!											
Normalized Sustainability SCORE, *H (-100 to +100)*		**0**		**0**		**Not evaluated**		**Not evaluated**		**Not evaluated**	
Strong sustainability on Domain Level?		**NO**		**NO**		**Not evaluated**		**Not evaluated**		**Not evaluated**	
Strong sustainability on Key Criteria Level?		**NO**		**NO**		**Not evaluated**		**Not evaluated**		**Not evaluated**	

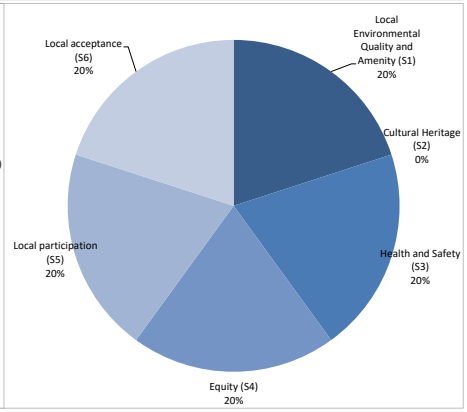
Weighting Summary

User Weights



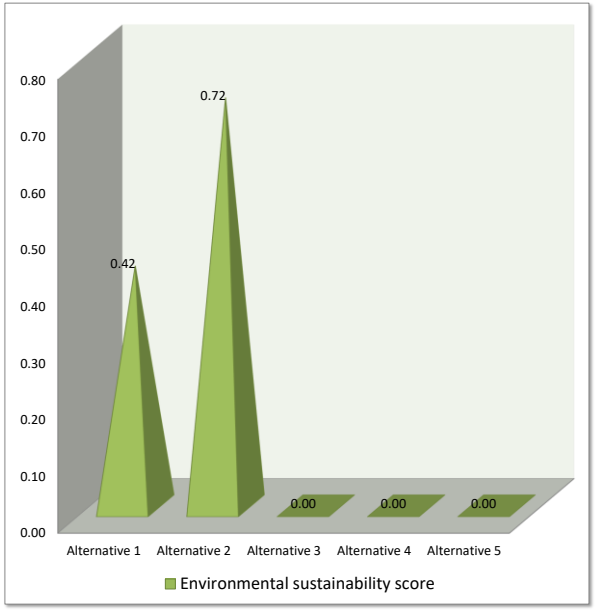


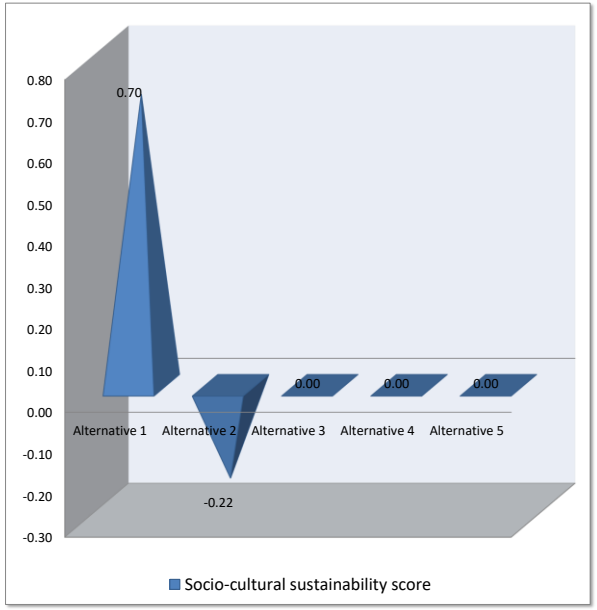


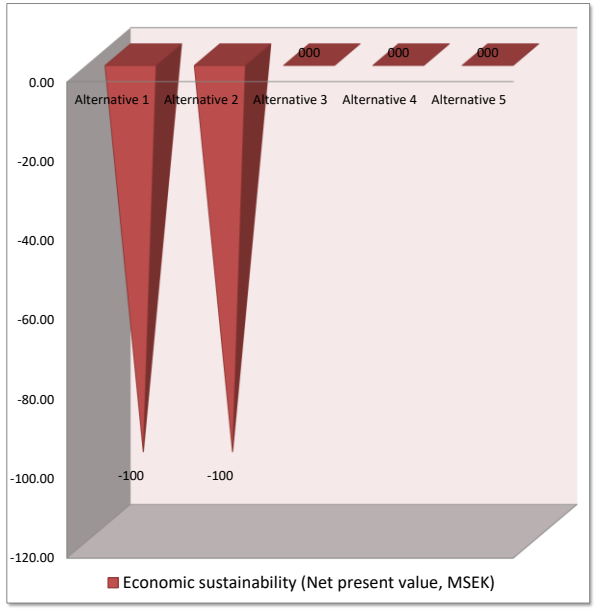


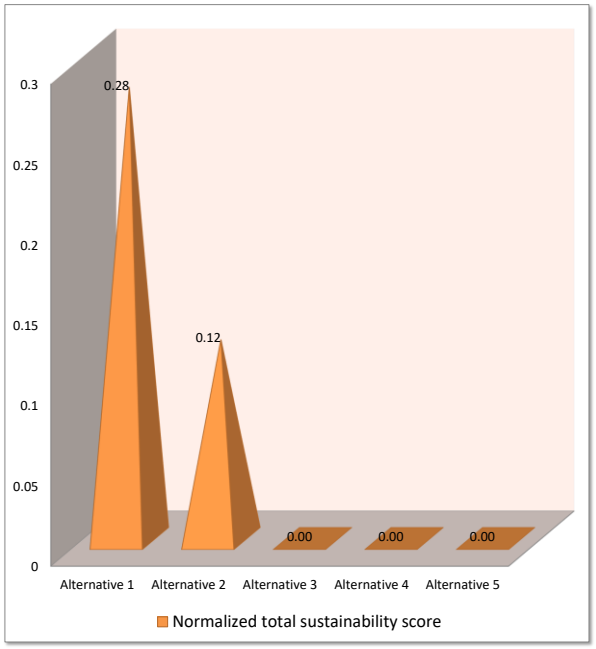
Note: Domains are not equally weighted!

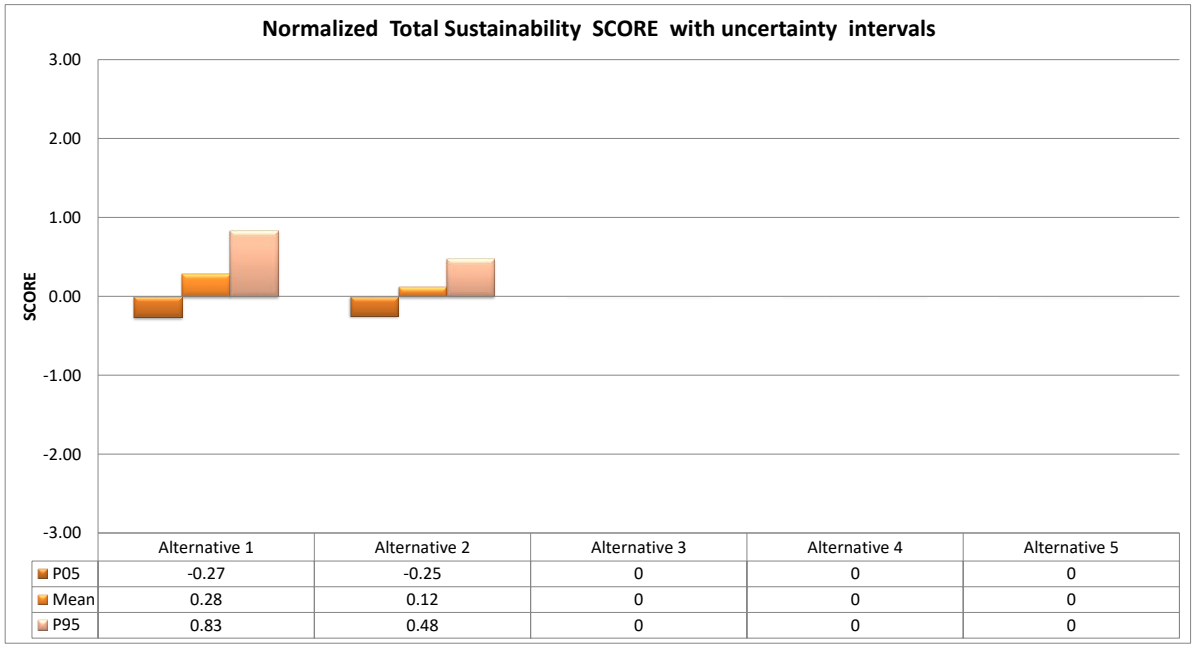
Results - Sustainability Scores





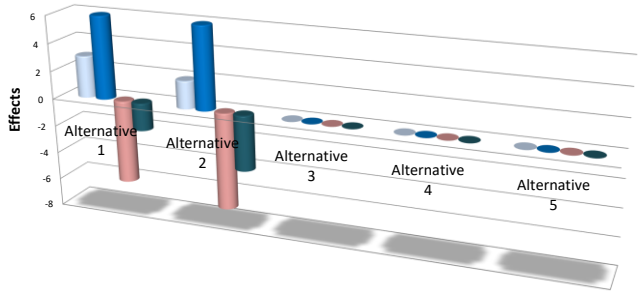




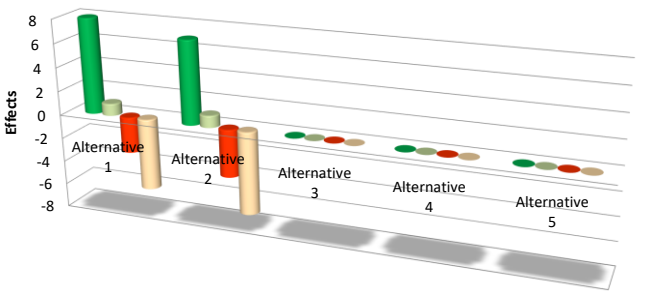


	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
P05	-0.27	-0.25	0	0	0
Mean	0.28	0.12	0	0	0
P95	0.83	0.48	0	0	0

Ecological and Social Effects of Remediation Alternatives



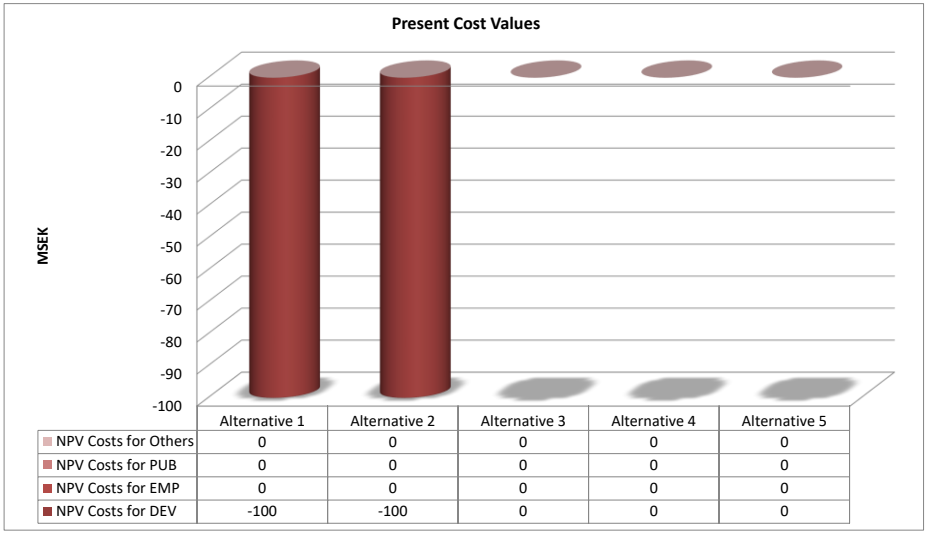
	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Remedial Action Positive	3	2	0	0	0
Source Contamination Positive	6	6	0	0	0
Remedial Action Negative	-6	-7	0	0	0
Source Contamination Negative	-2	-4	0	0	0



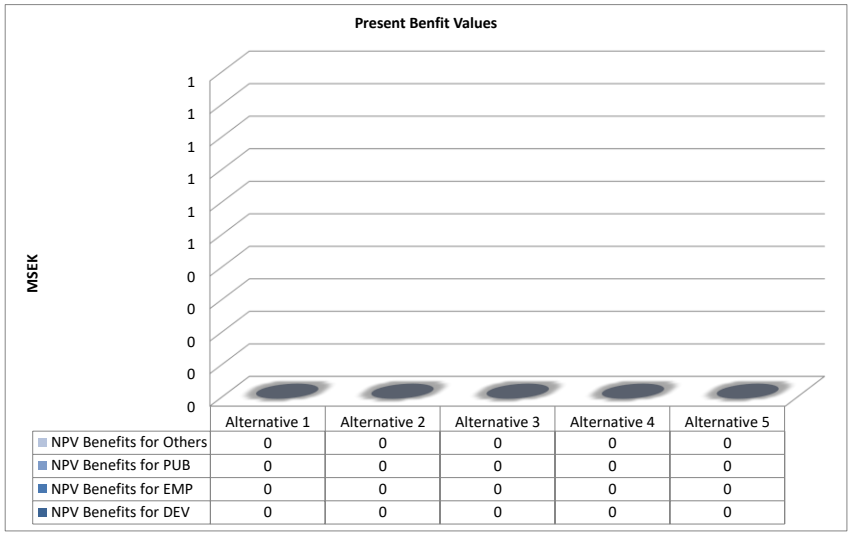
	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
On-Site Positive	8	7	0	0	0
Off-Site Positive	1	1	0	0	0
On Site Negative	-3	-4	0	0	0
Off-Site Negative	-6	-7	0	0	0

Economic effects of Remediation Alternatives

Distributional Analysis

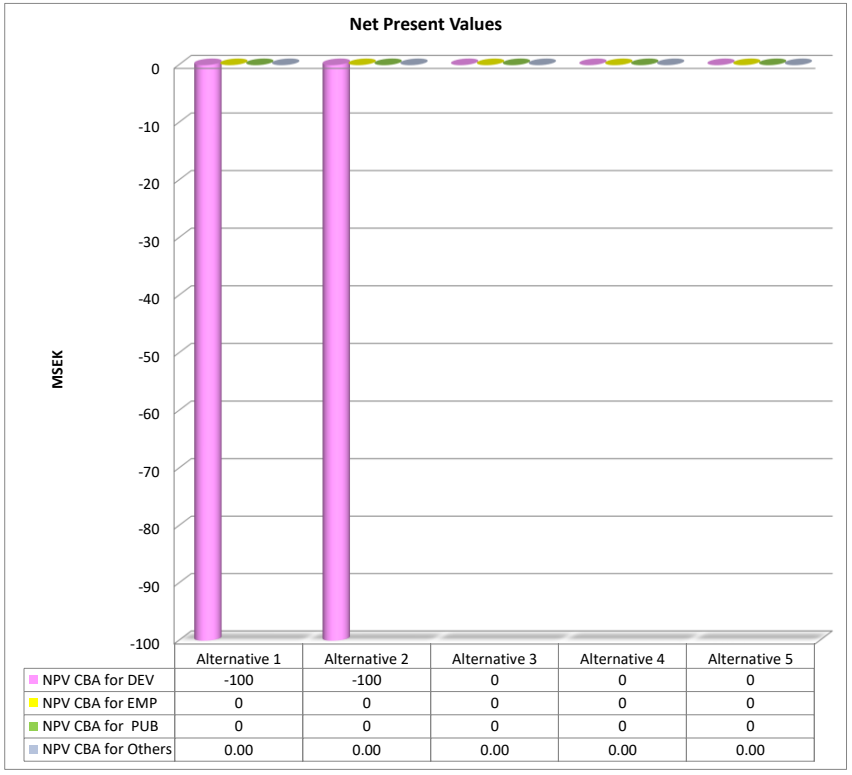


	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
NPV Costs for Others	0	0	0	0	0
NPV Costs for PUB	0	0	0	0	0
NPV Costs for EMP	0	0	0	0	0
NPV Costs for DEV	-100	-100	0	0	0



	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
NPV Benefits for Others	0	0	0	0	0
NPV Benefits for PUB	0	0	0	0	0
NPV Benefits for EMP	0	0	0	0	0
NPV Benefits for DEV	0	0	0	0	0

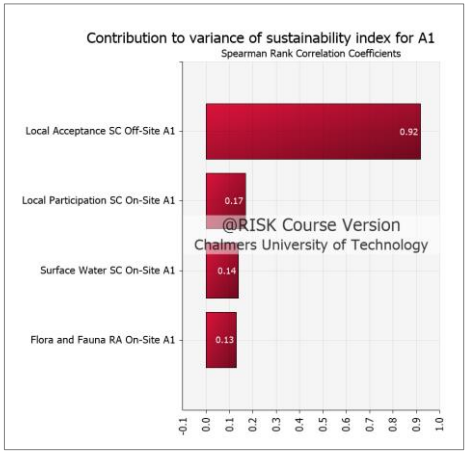
Benefit item	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
B1. Increased property value on site	NR	NR			
B2a. Reduced acute health risks	nr	nr			
B2b. Reduced non-acute health risks	nr	nr			
B2c. Other types of improved health, e.g. reduced anxiety	nr	nr			
B3a. Increased recreational opportunities on site	nr	nr			
B3b. Increased recreational opportunities in the surroundings	nr	nr			
B3c. Increased provision of other ecosystem services	nr	nr			
B4. Other positive externalities	nr	nr			
Cost item					
C1a. Costs for investigations and design of remedial actions	100	100			
C1b. Costs for contracting	nr	nr			
C1c. Capital costs due to allocation of funds to the remedial action	nr	nr			
C1d. Costs for the remedial action, including transport and disposal of contaminated soil minus possible revenues of reuse of contaminants and/or soil	nr	nr			
C1e. Costs for design and implementation of monitoring programs including sampling, analysis and data processing	nr	nr			
C1fa. Project risks	#REF!	nr			
C2a. Increased health risks due to the remedial action on site	nr	nr			
C2b. Increased health risks due to transports to and from the remediation site, e.g. transports of contaminated soil	nr	nr			
C2c. Increased health risks at disposal sites	nr	nr			
C2d. Other types of impaired health due to the remedial action, e.g. increased anxiety	nr	nr			
C3a. Decreased provision of ecosystem services on site due to remedial action, e.g. reduced recreational opportunities	nr	nr			
C3b. Decreased provision of ecosystem services outside the site due to the remedial action, e.g. environmental effects due to transports of contaminated soil	nr	nr			
C3c. Decreased provision of ecosystem services due to environmental effects at the disposal site	nr	nr			
C4. Other negative externalities	nr	nr			

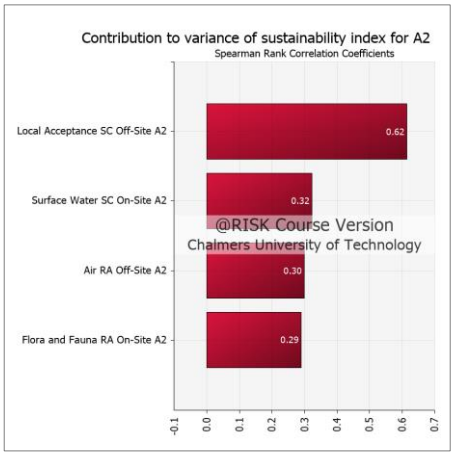


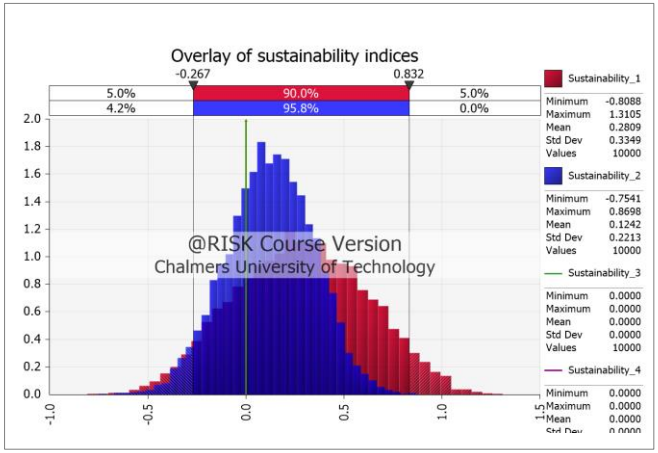
	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
NPV CBA for DEV	-100	-100	0	0	0
NPV CBA for EMP	0	0	0	0	0
NPV CBA for PUB	0	0	0	0	0
NPV CBA for Others	0.00	0.00	0.00	0.00	0.00

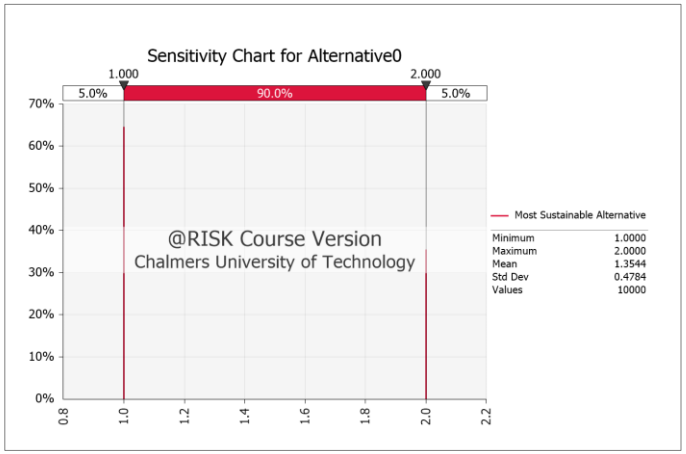
Uncertainty Analysis

Sensitivity analysis









Comments / Motivation Summary

Environmental Domain

Selection / Weighting:

		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
E1: Soil						
Ecotoxicological risk SC On-site	**Scoring:**	No effects on ecotoxicological risk levels.	No effects on ecotoxicological risk levels.			
Ecotoxicological risk RA On-site	**Scoring:**	Reduced contaminant concentrations and contaminat mass in the soil.	Reduced contaminant concentrations and contaminat mass in the soil.			
Soil Functions RA On-site	**Scoring:**	Improvement of soil quality, from Very Poor to Moderate/Good according to the Soil Quality Indicator Assessment.	Improvement of soil quality, from Very Poor to Moderate/Good according to the Soil Quality Indicator Assessment.			
E2: Physical Impact on Flora and Fauna						
Flora and Fauna RA On-site	**Scoring:**	No physical disturbances on any species with protection value.	No physical disturbances on any species with protection value.			
E3: Groundwater						
Groundwater RA On-Site	**Scoring:**	The remediation will have a small but insignificant effect on contaminant concentration in groundwater.	The remediation will have a small but insignificant effect on contaminant concentration in groundwater.			
Groundwater RA Off-Site	**Scoring:**					
Not relevant						
Groundwater SC On-Site	**Scoring:**	Leakage of contaminants to the groundwater is largely eliminated by the remedial action.	Leakage of contaminants to the groundwater is largely eliminated by the remedial action.			
Groundwater SC Off-Site	**Scoring:**					
Not relevant						

E4: Surface Water

Surface Water RA On-Site	**Scoring:**					
Not relevant						
Surface Water RA Off-Site	**Scoring:**	The remediation will have a small effect on contaminant concentrations in groundwater.	The remediation will have a small effect on contaminant concentrations in groundwater.			
Surface Water SC On-Site	**Scoring:**					
Not relevant						
Surface Water SC Off-Site	**Scoring:**	The effect on the concentration in surface water is neglible. Decreased polluted runoff.	The effect on the concentration in surface water is neglible. Decreased polluted runoff.			

E5: Sediment

Sediment RA On-Site	**Scoring:**					
Not relevant						
Sediment RA Off-Site	**Scoring:**	The remedial action will have a neglible effect on contaminant concentrations in the sediments.	The remedial action will have a neglible effect on contaminant concentrations in the sediments.			
Sediment SC On-Site	**Scoring:**					
Sediment SC Off-Site	**Scoring:**	The effect on the concentration in the sediment is neglible. Decreased polluted runoff.	The effect on the concentration in the sediment is neglible. Decreased polluted runoff.			
Not relevant						

E6: Air

Air RA Off-Site	**Scoring:**	Extensive increase in green house gas (GHG) emissions due to extensive transportation of excavated soil to a landfill. The emissions are larger 85% of the maximum alternative (complete excavation of all contaminated soil above generic guideline values).	Increase in green house gas (GHG) emissions due to extensive transportation of excavated soil to a landfill. The emissions are ca 85% of the maximum alternative (complete excavation of all contaminated soil above generic guideline values).			

E7: Non-renewable Natural Resources

Non-renewable Natural Resources RA Off-Site	**Scoring:**	Fossile fuel will be used for excavation and transportation of contaminated soil. The amount of fussil fuel is ca 85% of the maximum alternative. The amount of backfilling material is 85% of the maximum alternative.	Fossile fuel will be used for excavation, transportation and soil washing of contaminated soil. The amount of fussil fuel is ca 150% of the maximum alternative. The amount of backfilling material is 15% of the maximum alternative.			

E8: Non-recyclable Waste Generation

Non-recyclable Waste Genration RA Off-Site	**Scoring:**	The amount of produced waste is 70% of the maximum alternative.	The amount of produced waste is ca15% of the maximum alternative.			

Socio-cultural Domain

Selection / Weighting:

		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
S1: Local Environmental Quality and Amenity						
Local Environmental Quality and Amenity RA On-Site	**Scoring:**					
Not relevant						
Local Environmental Quality and Amenity RA Off-Site	**Scoring:**	There are some negative effects off-site due to heavy transports.	There are some negative effects off-site due to heavy transports but less transport than alt 1.			
Local Environmental Quality and Amenity SC On-Site	**Scoring:**	There is a large positive effect on the local environmental quality and amenities on the site.	There is a large positive effect on the local environmental quality and amenities on the site.			
Local Environmental Quality and Amenity SC Off-Site	**Scoring:**	There are some positive effects, for the sourrounding as well .	There are some positive effects, for the sourrounding as well .			
S2: Cultural Heritage						
Cultural heritage RA On-Site	**Scoring:**					
Not relevant						
Cultural heritage RA Off-Site	**Scoring:**					
Not relevant						
S3: Health and Safety						
Health and Safety RA On-Site	**Scoring:**	The workers on-site are exposed to contaminated material.	The workers on-site are exposed to contaminated material.			
Health and Safety RA Off-Site	**Scoring:**	The heavy traffic will be a safety risk for neigbours. There will also be some dusting.	There is cinsiderably less traffic than in alt1. Dust will be prevented at the sieve.			
Health and Safety SC On-Site	**Scoring:**	Since the reference alternative is considering a fenced area, i.e. no workers, there is no effect on-site as a result of the remediation alternative.	Since the reference alternative is considering a fenced area, i.e. no workers, there is no effect on-site as a result of the remediation alternative.			
Health and Safety SC Off-Site	**Scoring:**	Neighbours will be less exposed to contamination spreading from the site.	Neighbours will be less exposed to contamination spreading from the site.			

S4: Equity

Equity RA On-Site	**Scoring:**					
Not relevant						
Equity RA Off-Site	**Scoring:**	Neighbours are affected somewhat negatively by the remedial action but are able to influence the decision to some extent, e.g. when transports will take place etc.	Neighbours are affected somewhat negatively by the remedial action but are able to influence the decision to some extent, e.g. when transports will take place etc.			
Equity SC On-Site	**Scoring:**	The future environmental cost is reduced to a very large extent/eliminated.	The future environmental cost is reduced to a very large extent/eliminated.			
Equity SC Off-Site	**Scoring:**	The future environmental cost is reduced to a very large extent/eliminated.	The future environmental cost is reduced to a very large extent/eliminated.			

S5: Local Participation

Local participation RA On-Site	**Scoring:**	The remedial action does not affect job opportunities etc on site.	The remedial action does not affect job opportunities etc on site.			
Local participation RA Off-Site	**Scoring:**	Due to the remedial action there are some positive effects off-site, such as an increased use of services.	Due to the remedial action there are some positive effects off-site, such as an increased use of services.			
Local participation SC On-Site	**Scoring:**	The future landuse will affect local job opportunities positively.	The future landuse will affect local job opportunities positively.			
Local participation SC Off-Site	**Scoring:**	An increased number of workers at the site which uses shops and services in the vicinity, will lead to increased local job opportunities in the surrounding.	An increased number of workers at the site which uses shops and services in the vicinity, will lead to increased local job opportunities in the surrounding.			

S6: Local Acceptance

Local acceptance RA On-Site	**Scoring:**					
Not relevant						
Local acceptance RA Off-Site	**Scoring:**	Neighbours are worried about heavy transports through the area but want something to be done.	This alternative results in smaller amounts of transport than in alt 1 and is viewed as very positive by neighbours.			
Local acceptance SC On-Site	**Scoring:**					
Not relevant						
Local acceptance SC Off-Site	**Scoring:**	Neighbours are very positive to the reduction of source contamination.	Neighbours are very positive to the reduction of source contamination.			