TRAFIKVERKET
SWEDISH TRANSPORT ADMINISTRATION

Environmental Product Declaration for

the railway infrastructure on the Bothnia Line

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En EPD® (Environmental Product Declaration; miljövarudeklaration) är ett oberoende verifierat och registrerat dokument som ger transparent och jämförbar information om produkters miljöpåverkan i ett livscykelperspektiv.

Introduction

This environmental product declaration (EPD) describes, from a lifecycle perspective, the total environmental impact of railway infrastructure on the Bothnia Line.

Within the International EPD system based on ISO standard 14025, this EPD was drawn up in accordance with Product Category Rules (PCR) 2013:19 for Railways (see www.environdec.com for further information about the EPD system).

The aim of this EPD is that it should provide transport buyers, stakeholders and decision makers with objective and reliable information on the environmental impact of railway infrastructure.

This EPD was developed by Trafikverket (the Swedish Transport Administration). It has been certified by Bureau Veritas Certification AB and the certification is valid for three years (after which it can be prolonged).

Botniabanan AB has been responsible for the financing, detailed planning and building of the Bothnia Line. After completion, ownership of the infrastructure has been transferred to Trafikverket. Trafikverket has an implemented management system in accordance with the Swedish government's regulation (SFS 2009:907) on environmental management in state agencies. One focus area for Trafikverket's environmental work is to reduce climate gas emissions from construction, operation and maintenance of infrastructure and Trafikverket has therefore developed a tool for carbon footprint calculations for infrastructure projects (*Klimatkalkyl*, available at www.trafikverket.se). Inventory data for this EPD has been included in Klimatkalkyl, and the results for Global Warming and Energy Resources in this EPD is comparable to results in Klimatkalkyl for corresponding infrastructure parts.

This EPD sets out the environmental performance of the entire infrastructure on the Bothnia Line. The environmental impact of transport services is not included in the declared environmental performance, but is described in a transport scenario. The following EPDs are also available for other Bothnia Line systems:

- EPD for railway tunnels on the Bothnia Line.
- EPD for railway track foundations on the Bothnia Line.
- EPD for railway bridges on the Bothnia Line.
- EPD for railway track on the Bothnia Line.
- EPD for power, signalling and telecom systems on the Bothnia Line.

As this EPD is based on data relating to Bothnia Line infrastructure, the results might not be representative of other railway infrastructure. In order to decide if the results can be representative for other railway lines, the most important areas that should be checked to be comparable with the Bothnia Line are:

• Railway functionality (type of traffic,axle load, etc.).
• Topography (e.g. impact on share of bridges and tunnels).
• Mix of electricity for construction, operation and maintenance.
• Origin of materials (mainly steel and concrete).

Comparison towards previous EPD

This EPD is an updated version of the original EPD from 2010. The reason for the update is that the PCR has been revised. In the revision, the declared unit was changed:

Old declared unit: *1 km railway (main line) over a calculation period of 60 years*

New declared unit: *1 km railway (main line) and year*

Inventory data for LCA-calculations have not been changed, but the change of declared unit gives results in other units compared to previous EPD. The declared environmental performance in this EPD is therefore not comparable to previous EPD since it is presented in other units.

The revised PCR does not allow development of EPDs for transport services why previous EPDs for passenger and freight transport on the Bothnia Line are no longer valid. The infrastructure's contribution to environmental impact from railway transport services is instead presented under *Transport scenario* in this EPD.

Facts about the infrastructure of the Bothnia Line

The Bothnia Line is a new Swedish railway running from Nyland (north of Kramfors) to Umeå. It is routed via Örnsköldsvik and comprises 190 km of new single track railway with 22 sidings (each 1 km long) and 7 travel centres/stations. The latter have good connections for pedestrians, cyclists, local and regional bus traffic and private vehicles. There is a large freight terminal in Umeå and a smaller container terminal in Örnsköldsvik.

The line has 90 railway bridges (total length of 11 km) and 16 tunnels (25 km of main railway tunnels and 16 km of service and access tunnels). Designed for combined passenger and heavy freight traffic, the Bothnia Line offers maximum speeds of 250 km/h for passenger trains and 120 km/h for freight trains with a maximum axle load of 25 tonnes. The groundbreaking for the project took place on 14 August 1999 and the railway is operational since autumn 2010.

Technical Data

- Minimum radius of curvature: 3200 m
- Maximum gradient: 10 ‰

- Track gauge: 1435 mm
- Power-supply voltage: 15 kV, 16 2/3 Hz, AT-system
- Track: ballasted concrete sleepers, UIC 60 rail (continuous welded)
- Signalling system: ERTMS level 2
- Maximum axle load: 25 tonnes (30 ton on bridges)

Location of the Bothnia Line

Environmental performance

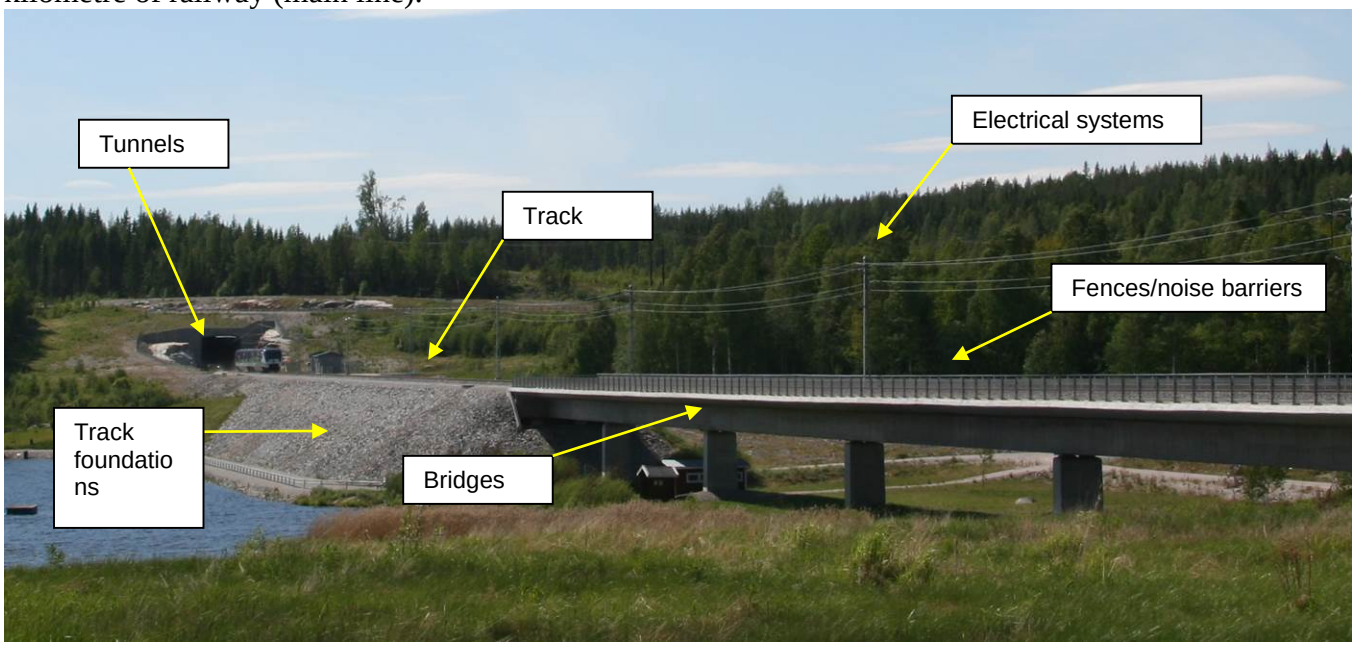
Resource use and emissions

The environmental performance section of the declaration is based on a lifecycle assessment (LCA) carried out by WSP in 2014. The LCA was largely based on ecoinvent-data for materials and processes, and implemented in the software SimaPro. Inventory data was collected from the LCA for the Bothnia Line made by IVL Swedish Environmental Research Institute in 2009. An overview of system boundaries and included processes is given in the text, figures and tables below.

Extraction and production of raw materials, transport of materials and manufacturing of products were included in the LCA calculations. The data in respect of processes and quantities of materials was collected from the building of the Bothnia Line. As regards steel for rails, specific data for material production was used. For other materials, selected generic data was used according to the calculation rules in PCR 2013:19. The electricity used in construction processes and for production of materials was calculated as the average electricity mix for the countries hosting the processes.

Calculation of the environmental impact of building railway tunnels, bridges and track foundations was based on data from three selected “typical” contracts for each of the three structures. As regards soil and rock excavation quantities, fuel and electricity consumption, etc., specific data was collected from these contracts and used as a basis for calculating the environmental impact of the entire Bothnia Line.

The LCA calculations are based on the technical life times of all included components and results in a yearly contribution to all impact categories. All construction, reinvestment, operation and maintenance processes are included in that. All results are presented in the declared unit per kilometre of railway (main line) and year. As a complement, the impact from the construction phase is presented separately per kilometre of railway (main line).



All processes and elements needed to construct, operate and maintain

the railway infrastructure have been included in the LCA. The figure shows some of the most important structural elements.

Overview of processes and elements included in the LCA for the different infrastructure subsystems.

Infrastructure construction						**Infrastructure operation**	**Infr e mai**
Railway Substructure	**Track**	**Power supply system**	**Signalling and telecom systems**	**Station installations**	**Other installations**		
Tunnels	Rail	Catenary system	Balises	Railway stations/travel centers	Noise barriers	Rail grinding	Rei dete to li com and ns
Bridges	Concrete sleepers	Catenary posts	Interlocking system	Freight terminals	Fences	Switch heating	
Track foundations	Ballast	Cables	Radio towers		Wildlife culverts	Illumination of tunnels and depots	
Deforestation	Switches and drivers	Substations	Cables			Frost protection for firefighting water in tunnels	
Service roads	Rail grinding	Transformers	UPS systems			Operation of railway stations and freight terminals	
Ducting (cable ducts and manholes)		UPS systems	Service buildings			Operation of electrical and electronic systems	
Drainage and surface water piping		Service buildings					

Processes and system elements that were excluded from the LCA as, under the rules in PCR 2013:19, they make a negligible contribution to environmental impact categories (<1 %). For processes excluded by default, see 2013:19.

- Platform equipment
- Train heating posts
- Shunting towers
- Waste handling processes
- Train control centre

Annual environmental impact of 1 km railway infrastructure (main line) on the Bothnia Line. All construction, reinvestment, operation and maintenance activities are included for the railway infrastructure. Impact from construction phase is presented separately per km (not annually). Note that transport service is not included.

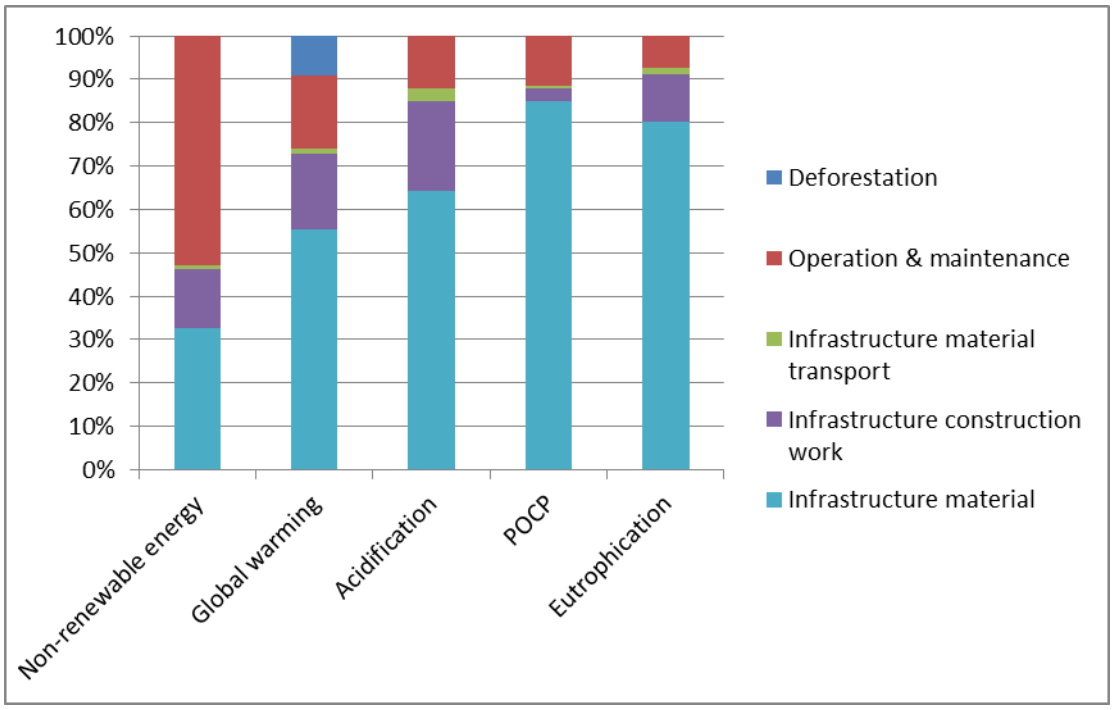
		Declared unit per km and year			
Impact category	**Unit**	**Construction & reinvestment**	**Operation & Maintenance**	**Total**	**Construction per km**
Use of resources					
Non-renewable materials	kg	1 817 149	1 045	1 818 194	217 663 860
Renewable materials	kg	25	0,020	25	1 252
Non-renewable energy	MJ	346 535	388 543	735 078	26 123 222
Renewable energy	MJ	19 733	104 169	123 902	1 446 308
Secondary materials	kg	54 802	0	54 802	4 307 267
Secondary energy	MJ	80 804	219 907	300 711	8 816 702
Water, total	kg	197 662	1 026 412	1 224 074	16 031 655
Water, direct	kg	33 450	0	33 450	4 014 036
Land use	m2	2 841	398	3 240	132 323
Potential environmental impacts					
Global warming	kg CO_2-eq.	27 641	5 549	33 189	2 266 631
Acidification	kg SO_2-eq.	123	17	140	8 485
POCP (Photochemical oxidant formation)	kg C_2H_4-eq.	6,4	0,84	7,2	372
Eutrophication	kg PO_4^{3-}-eq.	59	4,6	64	3 593
Waste and outflows					
Output of materials for recycling	kg	314 345	0	314 345	38 950 848
Waste, hazardous	kg	1,8	0,17	2,0	106
Waste, excess soil	kg	507 121	0	507 121	62 875 955
Waste, other	kg	3 992	762	4 754	243 405

Specification of resources making the largest contributions to the different resource use categories

Resource use category	**%**
Non-renewable materials	
Rock, gravel	64%
Soil	36%
Other	1%
Renewable materials	
Wood	100%
Non-renewable energy	
Fossil	50%
Nuclear	50%
Renewable energy	
Hydropower	97%
Biomass	2%

Wind, solar, geothermal	1%

Dominance analysis



Emission impact categories and the relative contributions (in %) made by the process groups relevant to the Bothnia Line's railway infrastructure. The process groups include all activities during the lifetime of the infrastructure. For example, "Infrastructure material" covers all materials used during construction, maintenance and reinvestment.

Upstream processes

Infrastructure material = Emissions from raw material acquisition and production of materials such as steel, concrete etc.

Infrastructure material transport = Emissions from vehicles (e.g.trucks and trains) used for transporting infrastructure material (e.g. sleepers and cables) from suppliers to the construction site.

Core processes

Infrastructure construction work = Emissions from machines (excavators, trucks, drilling, rigs, etc) used in constructing the infrastructure,. This includes also transportation of excavated soil and rock.

Deforestation = Net emissions of CO_2 resulting from forest land being permanently changed to railway land.

Downstream processes

Operation & maintenance = Emissions from production of electricity used for operation of the infrastructure,(e.g. tunnel illumination and swith heating) and from use of fuels for maintenance work (e.g. rail grinding).

Transport scenario

The contribution from railway infrastructure to the total environmental impact for railway transport services is presented here in a transport scenario. The

infrastructure's environmental impact is allocated to passenger and freight transport services according to rules in PCR 2013:19. The transport scenario is based on Trafikverket's traffic forecast "Basprognos 2020" for the Bothnia Line (developed using calculation methods common for the transport sector). This forecast should be seen as a "medium" scenario. Forecast traffic volumes do not use the Bothnia Line's maximum capacity. In 2014, the traffic on the Bothnia Line is still in an initial phase and the volumes have not reached the levels in Basprognos 2020. However, development statistics from Trafikverket and train operators show that Basprognos 2020 still is a relevant scenario.

Traffic forecast (based on Trafikverket's "Basprognos 2020") for the Bothnia Line year 2020.

Train type	**No of trains per day**	**Annual transport in passenger km (pkm) and tonne km (tkm)**
Passenger	28	343800000 pkm
Freight	21	506400000 tkm

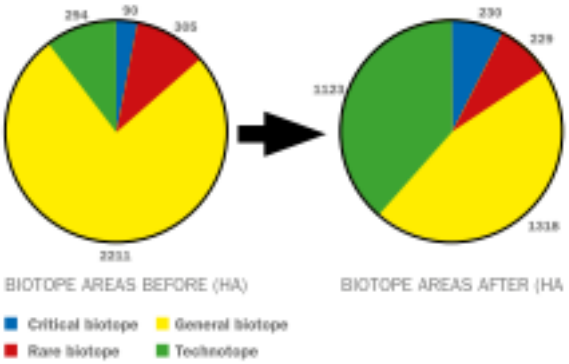
Environmental impact for passenger and freight transports on the Bothnia Line. LCA-data for construction, operation and maintenance of vehicles have been collected from a lifecycle assessment (LCA) carried out by IVL Swedish Environmental Research Institute in 2009.

Impact category	**Unit**	**Vehicles (production & maintenance)**	**Train operation**	**Infrastructure**	**Total**
Passenger transport					
Non-renewable energy	MJ/pkm	0,038	0,00062	0,12	0,16
Renewabe energy	MJ/pkm	0	0,33	0,021	0,35
Global warming	kg CO2-eq./pkm	0,0021	0,000079	0,0056	0,0077
Freight transport					
Non-renewable energy	MJ/tkm	0,0040	0,00033	0,18	0,19
Renewabe energy	MJ/tkm	0,00032	0,17	0,031	0,20
Global warming	kg CO2-eq./tkm	0,00018	0,000042	0,0082	0,0084

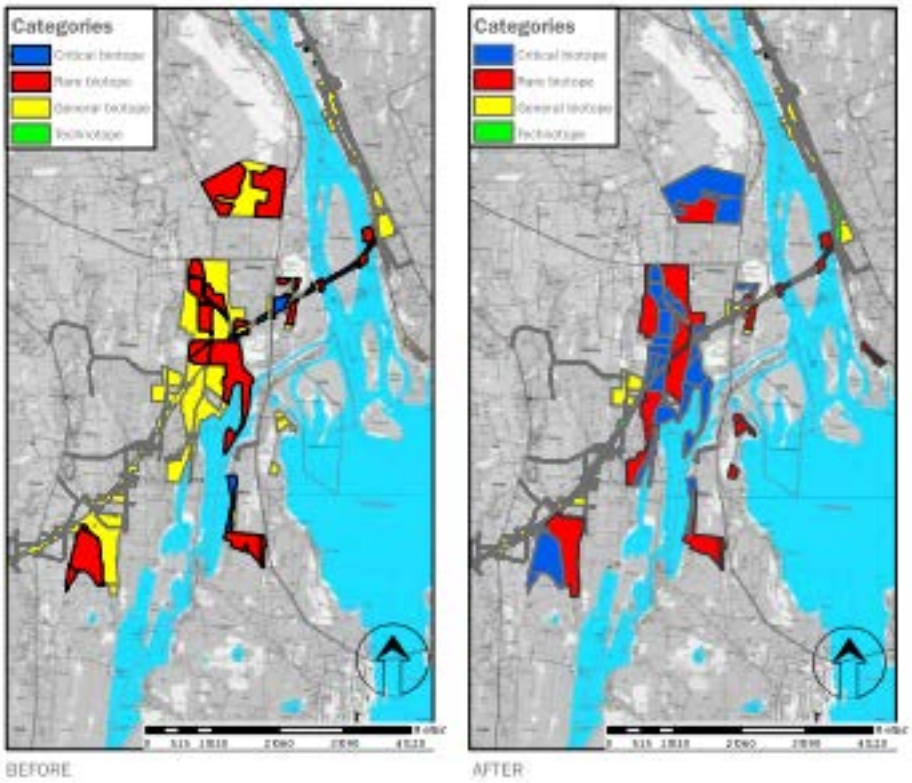
Land use and impact on biodiversity

The Biotope Method®(developed by Vattenfall) was used to quantify the impact that land use in building the railway infrastructure has had on biodiversity. All land areas that have been affected by the building of the railway have been placed in one of the following categories: critical biotope, rare biotope, general biotope and technotope.

The figures and table below shows the identified changes in the above-mentioned categories.

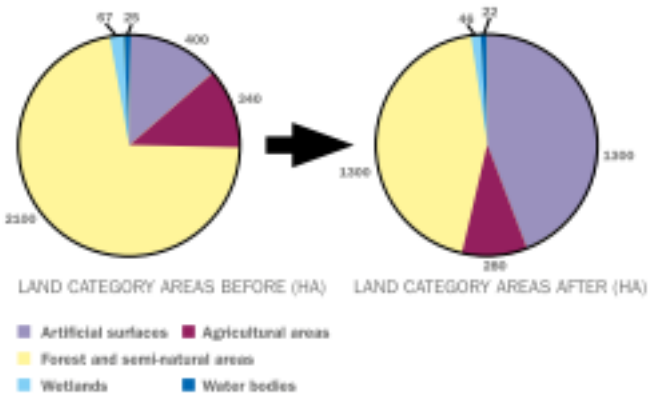


Biotope category	Change per kilometre railway (m^2/km)
Critical biotope	+ 7 700
Rare biotope	-4 000
General biotope	-49 000
Technotope	+45 000



The maps show changes in biotope categories in the area close to Umeå where compensatory measures have been taken. Said measures are largely responsible for the increase in critical biotope area after the building of the railway.

In the figures and table below, land use is also described in terms of utilisation of land categories as per CORINE land cover classes.



Land category	Change per kilometre railway (m^2/km)
Artificial surfaces	+49 000
Agricultural areas	-3 200
Forest and semi-natural areas	-44 000
Wetlands	-1 100
Water bodies	-160

The Bothnia Line passes through a Natura 2000 site south of Umeå. Within that site, the following areas have been used as railway land:

- 7 hectares of classifiedbiotopes according to the Council Directive 92/43 EEC of May 1992 on the conservation of natural habitats and of wild fauna and flora.
- 6 hectares of land protected according to the Council Directive 79/409/EEC of April 1979 on the conservation of wild birds.

Overview of compensatory measures that have been adopted in order to compensate for the encroachment into the Nature 2000 site.

Affected areas		**Compensatory measures**	
Land type (pSCI category)	**Area (ha)**	**Land type**	**Area (ha)**
Primary forest of landupheaval coast (9030*)	6	Forestland as nature reserve, partly with nature conservation management	194
Transition mires and quaking bogs (7140)	1	Wetland as nature reserve	37
Valuable staging sites for birds	6	Valuable staging sites for birds as nature reserve	297

Water management

All construction activities with potential impact on water flows, groundwater level and water quality have been tried according to the Swedish Environmental Code for approximately 200 separate objects. The conditions in the permits for these objects have been followed up in monitoring programs, documented in an extensive GIS-based database and reported annually to the authorities.

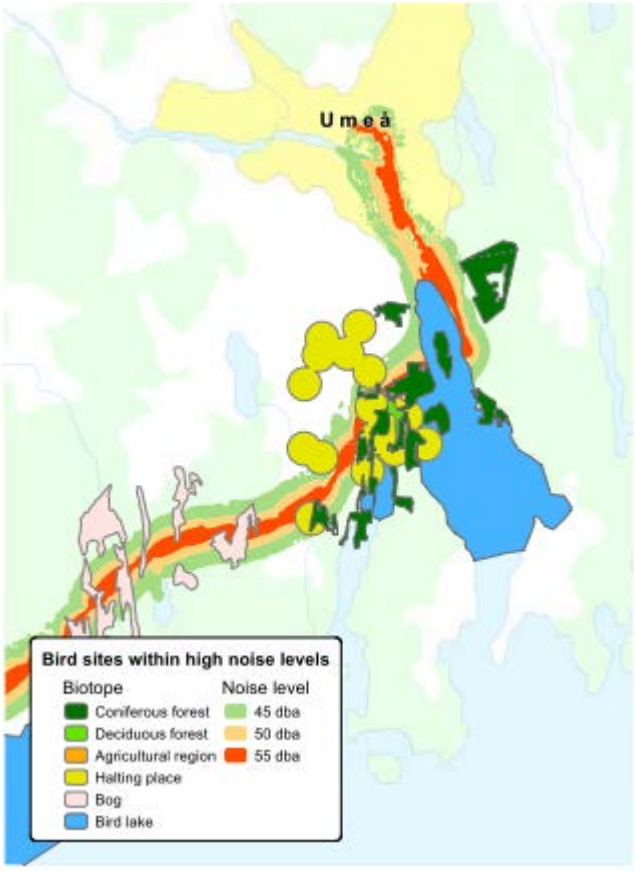
Guidelines for crossings of watercourses were developed in the project, including i.e. requirements for avoidance of flow changes and placement of culverts to avoid barriers for fish migration. Compliance with the requirements were regularly controlled in audits and 96% of 111 watercourse crossings were approved.

Noise

In the parts based on the LCA study, this EPD for the Bothnia Line's infrastructure does not include the transport services carried out on the infrastructure. However, as indirect environmental impact such as noise from railway traffic is a very important railway-connected issue, it is described in this EPD.

A number of different methods have been used to quantify the noise disturbance that traffic on the Bothnia Line causes for animals and people. All assessments were based on noise levels calculated for the traffic forecast in Basprognos 2020. The calculation model (topography, placement of noise barriers, etc.) was specific to the Bothnia Line.

The assessment of noise impact on animals used a method developed jointly by Ekologigruppen AB and SLU (Swedish University of Agricultural Sciences) with birds as indicator species. Sensitive bird biotopes were identified as per the method and the areas affected by different disturbance levels in these biotopes were calculated. The relationship between disturbance levels and noise levels is based on scientific research and is described in the method.



Example of sensitive bird biotopes disturbed by noise from traffic on the

Bothnia Line. The map shows a selected area close to Umeå.

Noise impact on people was assessed by calculating:

1. Outdoor recreational areas within 2 km of the railway and affected by different disturbance levels.
2. Number of people affected by different (outdoor) disturbance levels in residential areas.

For the outdoor recreational areas, the relationship between disturbance and noise levels was mapped out using the same method as that used for bird biotopes. For the residential areas, the calculated relationship between disturbance and noise levels was based on other studies.

Noise disturbance from traffic on the Bothnia Line on selected sensitive bird biotopes. Total affected area is presented as well as affected area for 1 km of railway infrastructure (main line).

Disturbance level in sensitive bird biotopes	**Affected area (ha)**	**% of total area sensitive bird biotopes**	**Affected area per km railway (ha/km)**
>50% disturbance (≥55 dBA_{eq})	909	8 %	5.0
50% disturbance (50-55 dBA_{eq})	1241	11 %	6.8
20% disturbance (45-50 dBA_{eq})	1832	17 %	10
Total disturbance (sum of affected areas)	**3982**	**36 %**	22

Noise disturbance from traffic on the Bothnia Line on outdoor recreational areas. Total affected area is presented as well as affected area for 1 km of railway infrastructure (main line).

Disturbance level for recreational areas	**Affected area (ha)**	**% of total recreational areas within 2 km from railway**	**Affected area per km railway (ha/km)**
>50% disturbance (≥55 dBA_{eq})	665	6 %	3.6
50% disturbance (50-55 dBA_{eq})	905	8 %	4.9
20% disturbance (45-50 dBA_{eq})	1514	13 %	8.3
Total disturbance (sum of affected areas)	**3084**	**27%**	17

Noise disturbance from traffic on the Bothnia Line on residential areas. Total number of affected persons is presented as well as number of affected persons for 1 km of railway infrastructure (main line).

Disturbance level in residential areas	Number of persons affected	Number of persons per km railway
Affected (>55 dB Leq)	1728	9.4
Heavily affected (>65 dBA_{eq})	598	3.3

Risk related issues

Risk assessments were carried out within the framework of the railway plans for the Bothnia Line and high safety requirements were imposed throughout building. The railway is crossing-free and has ERTMS, a new radio-based signalling system that makes the risk of collisions between trains and other trains or road traffic very low. Other risk-reducing measures include: emergency exits and firefighting water in tunnels; fencing; dimensioning of water culverts to minimise risk of/from erosion; and, where the railway passes larger water sources, ground water protection.

To reduce the risk of animal accidents, the measures below have also been implemented.

Risk reducing measure	Amount	Comment
Cable manhole evacuation pipes for amphibians, reptiles and rodents	574	Makes it possible for animals to escape from cable manholes if they fall down and get trapped.
Small game passages near watercourses culverts	24	Separate, dry, concrete culverts that makes it easier for small game to pass the railway
Isolated lines for auxiliary power	Along the entire railway	Reduces risk for bird collisions and electrocution
Auxiliary power in cable on the ground	2 km	Reduces risk of collisions in bird rich areas
Luminous tags on carrier cable	500	Reduces risk of collision inn bird rich areas
Insulatedtransformers	80	Reduces risk for bird electrocution
Vertical plastic bars on cantilever	100	Reduces risk for bird electrocution
Pointed cones on top of catenary posts	600	Prevents birds of prey using the posts as observation points (reduces the risk of bird collisions with trains)

Recycling declaration

The main infrastructure elements that are relevant as regards waste management and recycling are track, power, signalling and telecom equipment. For older signalling systems, Trafikverket has listed strategic components that should be returned to Trafikverket Material Service for revision when they are replaced. For other materials, there is currently no general national strategy for recycling materials that are replaced during maintenance. Such materials often become the property of the contractor. Trafikverket's environmental strategy contains the following prioritised goals for the future:

- Development, from an environmental perspective, of long-term reutilisation plans for strategic materials.

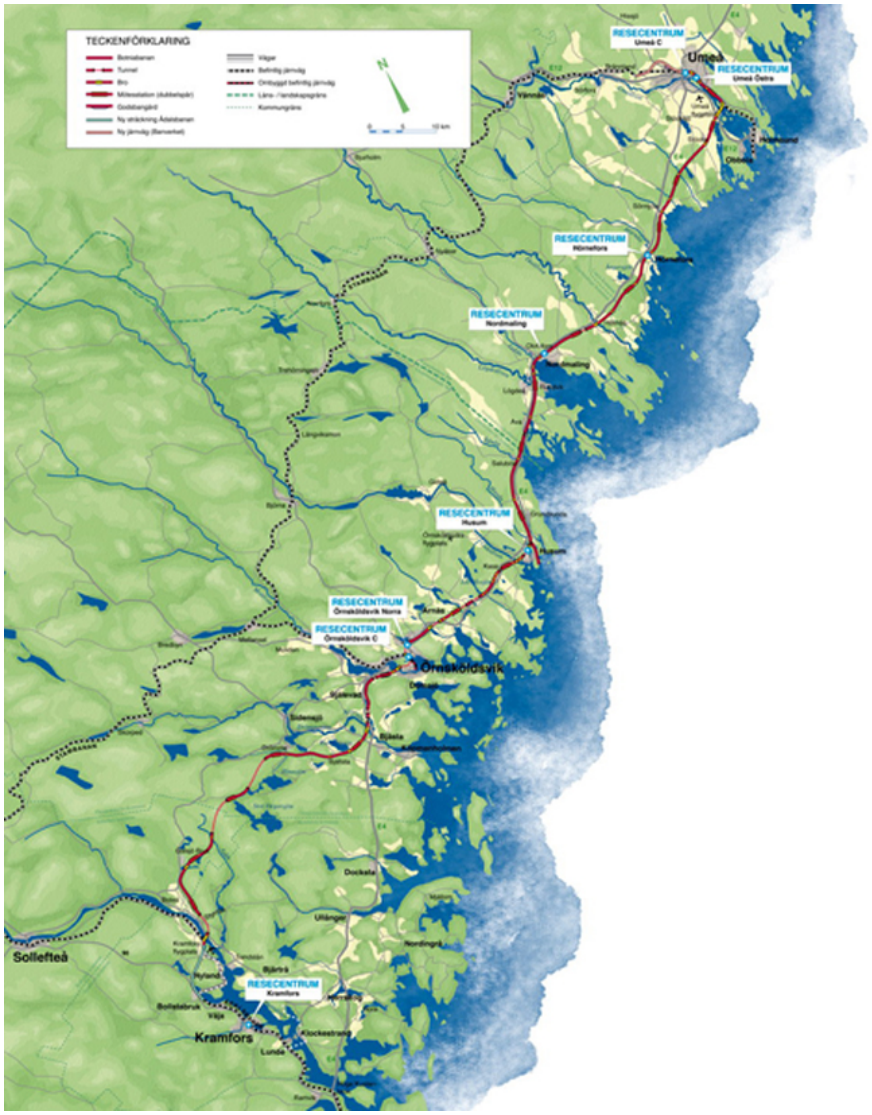
- Development of environmentally sound and effective management procedures for prioritised categories of waste.

Management of materials and substances

Throughout the construction of the Bothnia Line, all contractors have, as regards any chemical products and potentially environmental harmful materials they use, been required to obtain the approval of Trafikverket's Chemicals Board. Another requirement has been that PVCs and certain other materials (a number of specified harmful substances included therein) must not be used before the contractor has made an environmental risk assessment and Botniabanan AB has agreed with the use. If the use of any of these substances could not be avoided, the location of the components containing the substances has been documented by the contractor.

The satisfaction of these requirements has been checked in audits of all major contractors.

Hazardous waste generated in all contracts for the building of the Bothnia Line has been collected in environmental stations supplied by Botniabanan AB and managed by companies accredited for management of hazardous waste.



Route and travel centres/stations on the Bothnia Line (tunnels and bridges also shown)

EPDs from different programmes may not be comparable.

See www.trafikverket.se for more information on the EPD and background material.

PCR review was conducted by the Technical Committee (TC) of the International EPD Consortium (IEC). **See www.environdec.com for more information and contact for IEC.**
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SWEDEN

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