Appendix 1 Narva-Mustajoe LCA calculation sheets

1a Starting point

	Structure	Materials	Processes for the construction
Alt 1	Old road and mining waste stabilised with OSA Q1 and composite cement	Mining waste, oil shale ash and composite cement	*Grinding of old road*, mixing of osa and cement, spreading of the mining waste and ground road material on the road, wetting the material, spreading the binders, mixing the whole structure and compacting the structure.
Alt 2	Old road and mining waste stabilised with OSA Q2 and composite cement	Mining waste, oil shale ash and composite cement	*Grinding of old road*, mixing of osa and cement, spreading of the mining waste and ground road material on the road, wetting the material, spreading the binders, mixing the whole structure and compacting the structure.
Alt 3	Old road and mining waste stabilised with composite cement	Mining waste and composite cement	*Grinding of old road*, spreading of the mining waste and ground road material on the road, wetting the material, spreading the binders, mixing the whole structure and compacting the structure.
Alt 4	Cold in place complex recycling	Cement, bitumen, crushed stone	*Grinding of old road*, spreading of crushed stone, wetting the material, spreading the binders, mixing the whole structure and compacting the structure.

OSA = oil shale ash
Q1 = better quality oil shale ash
Q2 = lower quality oil shale ash

	Material	Amount [m^2] / (1 kilometre)	Amount [m^3]	Amount [%]	Amount [ton/FU]	Other information	Reference:
Alt 1	Mining waste aggregate (Aidu) 0–32 mm	9500	1520		3002	16 cm to 25 cm stabilisation, density 1,975	Material report, Ramboll expertise
	Layer stabilisation	9500	2375		4631	Thickness 25 cm, Density 1,95 mining waste + old paving	
	Oil shale fly ash EF BL3, w = 20 %			6	278		
	Composite cement			3	139		
Alt 2	Mining waste aggregate (Aidu) 0–32 mm	9500	1520		3002	16 cm to 25 cm stabilisation, density 1,975	Material report, Ramboll expertise
	Layer stabilisation	9500	2375		4631	Thickness 25 cm, Density 1,95 mining waste + old	
	Oil shale fly ash CYCL			5	232		
	Composite cement			5	232		
Alt 3	Mining waste aggregate (Aidu) 0–32 mm	9500	1520		3002	16 cm to 25 cm stabilisation, density 1,975	Material report, Ramboll expertise
	Layer stabilisation	9500	2375		4631	Thickness 25 cm, Density 1,95 mining waste + old	
	Composite cement			6	278		
Alt 4	Cold in place complex recycling	9500	1425		2779	Thickness 15 cm, body material average density 1950 kg/m3	Material report, Ramboll expertise
	Bitumen			1	28	Density 1900 kg/m3	
	Composite cement			2,5	69		
	Crushed stone	9500	2945		6185	Density 2100 kg/m3, thickness 31 cm (according to the Material Rport the aggregate layer MWA 160/260 mm and MAC 100/100 mm -> the averge is 310 mm.	

1b Material production

	Material	Amount used [tonnes/FU]	Emissions per ton [g/ton]									Energy consumption [MJ/ton]	Use of natural resources [g/ton]
			CO_2	NOx	PM	SO_2	CO	VOC	CH_4	HC	N_2O		
Alt 1	Composite cement	139	623628	1794	263,1	1791						5825	1151000
	Oil shale ash	278	No emissions from the oil shale ash as it is not a product, instead it is a by-product from the burning of the oil shale for energy.										
	Mining waste	3002	365	3,28	0,13	0,18	0,39		0,0002	0,236	0,0074	5,09	125
	SUM	4877											
Alt 2	Composite cement	232	623628	1794	263,1	1791						5825	1151000
	Oil shale ash	232	No emissions from the oil shale ash as it is not a product, instead it is a by-product from the burning of the oil shale for energy.										
	Mining waste	3002	365	3,28	0,13	0,18	0,39		0,0002	0,236	0,0074	5,09	125
	SUM	4923											
Alt 3	Composite cement	278	623628	1794	263,1	1791						5825	1151000
	Mining waste	3002	365	3,28	0,13	0,18	0,39		0,0002	0,236	0,0074	5,09	125
	SUM	4738											
Alt 4	Composite cement	69,5	623628	1794	263,1	1791						5825	1151000
	Bitumen	27,8	255669	1207		993	1057	410	764	68		510	1095010
	Crushed stone	6185	1 800	2,10	1,20	1,30	1,10	0,30	1,1			34	1010000
	SUM	7740											

Emissions total [kg/FU]											Reference:
CO_2	NOx	PM	SO_2	CO	VOC	CH_4	HC	N_2O	Energy consumption [MJ/FU]	Use of natural resources [kg/FU]	
86 645	249	37	249	0	0	0	0		809 261	159 917	[8]
No emissions from the oil shale ash as it is not a product, instead it is a by-product from the burning of the oil shale for energy.											
1 097	10	0,4	0,5	1,2	0,0000	0,001	0,7	0,02	15 278	375	[10]
87 743	**259**	**37**	**249**	**1,2**	**0,7**	**0,001**	**0,7**	**0,02**	**824 539**	**160 292**	
144 409	415	61	415	0	0	0	0	0	1348768	266 528	[8]
No emissions from the oil shale ash as it is not a product, instead it is a by-product from the burning of the oil shale for energy.											
1 097	10	0,4	0,5	1,2	0,0	0,0	0,7	0,02	15 278	375	[10]
145 506	**425**	**61**	**415**	**1,2**	**0,7**	**0,001**	**0,7**	**0,02**	**1 364 046**	**266 904**	
173 291	499	73	498	0	0	0	0		1 618 522	319 834	[8]
1 097	10	0,4	0,5	1,2	0	0,001	0,7	0,02	15 278	375	[10]
174 388	**508**	**73**	**498**	**1**	**1**	**0**	**0,7**	**0,0**	**1 633 799**	**320 209**	
43 323	125	18	124	0	0	0	0	0	404 630	79 959	[8]
7 104	34	0	28	29	11	21	2	0	14 172	30 428	[11]
11 132	13	7	8	7	2	7	0	0	210 273	6 246 345	[10]
61 559	**171**	**26**	**160**	**36**	**13**	**28**	**2**	**0,0**	**629 075**	**6 356 731**	

1c Material transportation

Alternative	Material	Destination	Total mass [tonnes/FU]	Vehicle	Distance [km]	Number of loads	Total km*	fuel consumption** [l/km]	total fuel consumption [l/ FU]
Alt 1	Composite cement	to site	139	tank truck (40t)	100	3,5	695	0,42	292
	Oil shale ash	to site	278	tank truck (40t)	8,5	6,9	118	0,42	50
	(Oil shale ash)	(to landfill)	278	tank truck (40t)	-5	6,9	-69	0,42	-29
	Mining waste	to site	3 002	truck (19 t)	77	158	24 332	0,31	7 543
	SUM		**3 763**				**25 075**		**7 855**
Alt 2	Composite cement	to site	232	tank truck (40t)	100	6	1 158	0,42	486
	Oil shale ash	to site	232	tank truck (40t)	8,5	6	98	0,42	41
	(Oil shale ash)	(to landfill)	232	tank truck (40t)	-5	5,8	-58	0,42	-24
	Mining waste	to site	3 002	truck (19 t)	77	158	24 332	0,31	7 543
	SUM		**3 763**				**25 530**		**8 046**
Alt 3	Composite cement	to site	278	tank truck (40t)	100	7	1 389	0,42	584
	Mining waste	to site	3 002	truck (19 t)	77	158	24 332	0,31	7 543
	Oil shale ash	to landfill	278	tank truck (40t)	5	6,9	69	0,42	29
	SUM		**3 624**				**25 791**		**8 156**
Alt 4	Composite cement	to site	69	tank truck (40t)	100	2	347	0,42	146
	Ground road structure	to final storage	1 642	truck (19 t)	5	86	1 728	0,31	536
	Bitumen	to site	28	tank truck (40t)	44	1	61	0,42	26
	Crushed stone	to site	6 185	truck (19 t)	77	326	50 127	0,31	15 539
	Oil shale ash	to landfill	278	tank truck (40t)	5	6,9	69	0,42	29
	SUM		**8 268**				**52 333**		**16 276**

Emissions [g/km]								Energy consumption [MJ/km]	Depletion of natural resources [kg/l]	Total emissions [kg / FU]								Energy consumption [MJ/FU]	Depletion of natural resources [kg/FU]	Reference:
CO_2	NOx	PM	SO_2	CO	VOC + HC	CH_4	N_2O			CO_2	NOx	PM	SO_2	CO	VOC + HC	CH_4	N_2O			
1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16	720	5	0,1	0,005	0,1	0,1	0,01	0,02	10 420	338	
1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16	122	1	0,01	0,001	0,02	0,01	0,001	0,004	1 771	58	
1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16	-72	-1	-0,01	-0,0005	-0,01	-0,01	-0,001	-0,002	-1 042	-34	[5], [6]
774,5	5,75	0,063	0,0053	0,195	0,115	0,007	0,033	11,5	1,16	18 845	140	1,5	0,1	4,7	2,8	0,2	0,8	279 818	8 750	
										19 615	**146**	**1,6**	**0,13**	**4,9**	**2,9**	**0,2**	**0,8**	**290 968**	**9 112**	
1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16	1 199	8,9	0,1	0,008	0,2	0,1	0,01	0,04	17 367	564	
1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16	102	0,8	0,007	0,001	0,02	0,01	0,001	0,003	1 476	48	
1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16	-60	-0,4	-0,004	-0,0004	-0,01	-0,01	-0,001	-0,002	-868	-28	[5], [6]
774,5	5,75	0,063	0,0053	0,195	0,115	0,007	0,033	11,5	1,16	18 845	140	1,5	0,1	4,7	2,8	0,17	0,8	279 818	8 750	
										20 087	**149**	**1,6**	**0,14**	**5,0**	**2,9**	**0,2**	**0,8**	**297 793**	**9 334**	
1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16	1 439	11	0,1	0,01	0,3	0,1	0,01	0,04	20 841	677	
774,5	5,75	0,063	0,0053	0,195	0,115	0,007	0,033	11,5	1,16	18 845	140	1,5	0,13	4,7	2,8	0,17	0,8	279 818	8 750	[5], [6]
1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16	72	1	0,01	0,0005	0,01	0,01	0,001	0,002	1 042	34	
										20 356	**151**	**1,6**	**0,1**	**5,1**	**2,9**	**0,2**	**0,8**	**301 701**	**9 461**	
1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16	360	3	0,026	0,002	0,1	0,03	0,003	0,011	5 210	169	
774,5	5,75	0,063	0,0053	0,195	0,115	0,007	0,033	11,5	1,16	1 338	10	0,1	0,01	0,3	0,2	0,01	0,1	19 872	621	
1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16	63	0	0,005	0,0004	0,01	0,01	0,001	0,002	917	30	[5], [6]
774,5	5,75	0,063	0,0053	0,195	0,115	0,007	0,033	11,5	1,16	38 823	288	3,2	0,26	9,8	5,8	0,4	1,7	576 461	18 026	
1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16	72	1	0,005	0,0005	0,01	0,01	0,001	0,002	1 042	34	
										40 657	**302**	**3,3**	**0,3**	**10,2**	**6,0**	**0,4**	**1,7**	**603 502**	**18 880**	

1d Construction

				Emissions per l [g/l]									
		Fuel consumption [l/h]	Fuel consumption [l/FU]	CO_2	NOx	PM	SO_2	CO	VOC + HC	CH_4	N_2O	Energy consumption [MJ/h]	Depletion of natural resources [kg/l]
Alt 1	**Base coarse stabilisation**												
	*Spreading of mining waste with tractor	16,7	491	2624	19	0,9	0,017	7,3	2,1	0,15	0,071	671	1,16
	*Spreading of cement with tractor (spreading vessel attached)	18,7	15,0	2624	19	0,9	0,017	7,3	2,1	0,15	0,071	671	1,16
	*Spreading of OSA with tractor (spreading vessel attached)	18,7	15,0	2624	19	0,9	0,017	7,3	2,1	0,15	0,071	671	1,16
	SUM		**520**										
Alt 2	**Base coarse stabilisation**												
	*Spreading of mining waste with tractor	16,7	491	2624	19	0,9	0,017	7,3	2,1	0,15	0,071	671	1,16
	*Spreading of cement with tractor (spreading vessel attached)	18,7	15,0	2624	19	0,9	0,017	7,3	2,1	0,15	0,071	671	1,16
	*Spreading of OSA with tractor (spreading vessel attached)	18,7	15,0	2624	19	0,9	0,017	7,3	2,1	0,15	0,071	671	1,16
	SUM		**520**										
Alt 3	**Base coarse stabilisation**												
	*Spreading of mining waste with tractor	16,7	491	2624	19	0,9	0,017	7,3	2,1	0,15	0,071	671	1,16
	*Spreading of cement with tractor (spreading vessel attached)	18,7	15,0	2624	19	0,9	0,017	7,3	2,1	0,15	0,071	671	1,16
	SUM		**505**										
Alt 4	Excavating the old ground road structure	31,5	1206	2607	18,0	0,70	0,02	6,30	1,70	0,15	0,07	1595	1,16
	Spreading of crushed stone	16,7	1093	2624	19	0,9	0,017	7,3	2,1	0,15	0,071	671	1,16
	*Spreading of cement with tractor (spreading vessel attached)	18,7	15,0	2624	19	0,9	0,017	7,3	2,1	0,15	0,071	671	1,16
	SUM		**2314**										

Emissions [kg/FU]								Energy consumption [MJ/FU]	Depletion of natural resources [kg/FU]	Reference:
CO_2	NOx	PM	SO_2	CO	VOC + HC	CH_4	N_2O			
1 287	9,32	0,44	0,01	3,58	1,03	0,07	0,03	19 709	569	[5], [6]
39	0,28	0,01	0,0003	0,11	0,03	0,002	0,001	537	17	
39	0,28	0,01	0,0003	0,11	0,03	0,002	0,001	537	17	
1 672	**12**	**0,55**	**0,01**	**4,6**	**1,3**	**0,10**	**0,05**	**25 017**	**740**	
1 287	50	0,02	0,000	0,0001	0,02	0,0003	0,00001	19 709	569	[5], [6]
39	0,3	0,01	0,000	0,1	0,03	0,002	0,001	537	17	
39	0,3	0,01	0,000	0,1	0,03	0,002	0,001	537	17	
1 672	**52**	**0,13**	**0,003**	**0,98**	**0,3**	**0,02**	**0,01**	**25 017**	**740**	
1 287	9,3	0,44	0,01	3,58	1,03	0,07	0,03	19 709	569	[5], [6]
39	0,28	0,01	0,0003	0,11	0,03	0,00	0,00	537	17	
1 633	**12**	**0,54**	**0,01**	**4,5**	**1,3**	**0,09**	**0,04**	**24 481**	**723**	
3 145	22	0,84	0,02	7,60	2,05	0,18	0,09	61 083	1 399	[5], [6]
2 868	21	0,98	0,02	7,98	2,30	0,16	0,08	43 913	1 268	
39	0,28	0,01	0,00	0,11	0,03	0,00	0,00	537	17	
6 052	**43**	**1,84**	**0,04**	**16**	**4,4**	**0,35**	**0,16**	**105 533**	**2 684**	

1e Final results

Narva-Mustajoe Life Cycle Analysis		Emissions total [kg/FU]								Energy consumption [MJ/FU]	Depletion of natural resources [kg/FU]	Global warming potential [kg CO_2 eqv/FU]
		CO_2	NOx	PM	SO_2	CO	VOC + HC	CH_4	N_2O			
ALT 1	Material production	87 743	259	37	249	1,2	0,71	0,001	0,02	824 539	160 292	87 749
	Material transportation	19 615	146	1,6	0,13	4,9	2,9	0,2	0,8	290 968	9 112	19 866
	Construction	1 672	12	0,55	0,01	4,6	1,3	0,096	0,05	25 017	740	1 689
		109 030	**417**	**39**	**250**	**11**	**4,9**	**0,27**	**0,89**	**1 140 524**	**170 144**	**109 304**
ALT 2	Material production	145 506	425	61	415	1,2	0,71	0,001	0,02	1 364 046	266 904	145 513
	Material transportation	20 087	149	1,6	0,14	5,0	2,9	0,2	0,8	297 793	9 334	20 342
	Construction	1 672	52	0,13	0,003	0,98	0,278	0,02	0,01	25 017	740	1 676
		167 265	**627**	**63**	**415**	**7,2**	**3,9**	**0,20**	**0,87**	**1 686 856**	**276 978**	**167 531**
ALT 3	Material production	174 388	508	73	498	1,2	0,71	0,001	0,02	1 633 799	320 209	174 394
	Material transportation	20 356	151	1,6	0,1	5,1	2,9	0,18	0,85	301 701	9 461	20 614
	Construction	1 633	12	0,54	0,01	4,5	1,3	0,09	0,04	24 481	723	1 649
		196 377	**671**	**76**	**498**	**11**	**4,9**	**0,28**	**0,91**	**1 959 981**	**330 393**	**196 658**
ALT 4	Material production	61 559	171	26	160	36	13	28	0,00	629 075	6 356 731	62 344
	Material transportation	40 657	302	3,3	0,28	10	6,0	0,37	1,7	603 502	18 880	41 181
	Construction	6 052	43	1,8	0,04	16	4,4	0,35	0,16	105 533	2 684	6 111
		108 268	**516**	**31**	**160**	**62**	**24**	**29**	**1,9**	**1 338 110**	**6 378 296**	**109 636**

Appendix 2 Simuna-Vaiatu LCA calculation sheets

2a Starting point

	Alternative strcutures	Materials for the structure	Processes for the construction
Alt 1	First mass stabilisation with OSA (EF CFB) and cement (1-3 m deep peat material) and base course stabilisation on top of it with OSA (EF CFB)	Oil shale ash, composite cement	Removal of the old road layers and top soil to the sides of the road. First mass stabilisation with OSA (EF CFB) and cement and base course stabilisation with OSA (EF CFB) on top of mass stabilisation.
Alt 2	First mass stabilisation with OSA (EF CFB) and cement (1-3 m deep peat material) and then complex stabi on top of it	Oil shale ash, composite cement	Removal of the old road layers and top soil to the sides of the road. First mass stabilisation with OSA (EF CFB) and cement and then complex stabilisation on top of mass stabilisation.
Alt 3	First mass stabilisation with cement (1-3 deep peat material) and then complex stabilisation on top of it	Cement, bitumen	Removal of the old road layers and top soil to the sides of the road. First mass stabilisation with cement and then complex stabilisation on top of mass stabilisation.
Alt 4	Replacing the peat layer with crushed stone, and complex stabilisation on top of it	Crushed stone, bitumen, cement	Removal of the peat layer. Filling with crushed stone. Complex stabilisation on top of crushed stone.

	Material	Amount [m^2] / 1 kilometre	Amount [m^3]	Amount [%]	Amount [t/1 kilometer]	Other information	Reference:
Alt 1	**Layer stabilisation**	9 200	1 840		3 588	Thickness 20 cm, width 9,2 meters, density 1950 kg/m3	Material report, Ramboll expertise
	*Oil shale fly ash EF CFB			9	323		
	Load material, sand, first 80 cm	9 200	7 360		13 248	Thickness 80 cm, density 1800 kg/m3	
	*sand, excavated 30 cm off	9 200	2 760		4 968	Thickness 80 cm, density 1800 kg/m3	
	*gravel sand 30 cm and medium sand 20 cm, left on place	9 200	4 600		8 280	Thickness 50 cm, density 1800 kg/m3	
	Mass stabilisation	9 200	18 400		35 880	Thickness average 2,0 m, density 1950 kg/m3	
	*Oil shale fly ash EF CFB			20	7 176		
	*Composite cement			6	2 153		
	Water			30	2 896	30 %	
Alt 2	**Complex stabilisation**	9 200	1 840		3 588	Complex stabilisation depth 20 cm, density 1950 kg/m3	Material report, Ramboll expertise
	*Bitumen			1	36		
	*Composite cement			2,5	90		
	Load material, sand, first 80 cm	9 200	7 360		13 248	Thickness 80 cm, density 1800 kg/m3	
	*sand, excavated 30 cm off	9 200	2 760		4 968	Thickness 80 cm, density 1800 kg/m3	
	*gravel sand 30 cm and medium sand 20 cm, left on place	9 200	4 600		8 280	Thickness 50 cm, density 1800 kg/m3	
	Mass stabilisation	9 200	18 400		35 880	Thickness average 2,0 m, density 1950 kg/m3	
	*Oil shale fly ash EF CFB			20	7 176		
	*Composite cement			6	2 153		
	Water			30	2 799	30 %	
Alt 3	**Complex stabilisation**	9 200	1 840		3 588	Thickness 20 cm, body material average density 1950 kg/m3	Material report, Ramboll expertise
	*Bitumen			1	36	Density 1900 kg/m3	
	*Composite cement			2,5	90		
	Load material, sand, first 80 cm	9 200	7 360		13 248	Thickness 80 cm, density 1800 kg/m3	
	*sand, excavated 30 cm off	9 200	2 760		4 968	Thickness 80 cm, density 1800 kg/m3	
	*gravel sand 30 cm and medium sand 20 cm, left on place	9 200	4 600		8 280	Thickness 50 cm, density1800 kg/m3	
	Mass stabilisation	9 200	18 400		35 880	Thickness average 2,0 m, density 1950 kg/m3	
	*Composite cement			9	3 229		
	Water			30	969	30 %	
Alt 4	Peat layer	9 200	18 400		20 240	Thickness 2 m, density 1100 kg/m3 (average)	Material report, Ramboll expertise
	Complex stabilisation	9 200	1 840		3 588	Thickness 20 cm, body material average density 1950 kg/m3	
	*Bitumen			1	36		
	*Composite cement			2,5	90		
	Water			30	27	30 %	
	Gravel sand 30 cm and medium sand 20 cm	9 200	4 600		8 280	Thickness 50 cm, density 1800 kg/m3	
	Rock material for replacing the peat, 2 m	9 200	18 400		40 480	Thickness 2 m, density 2200 kg/m3	

2b Material production

	Materials	Amount used [tonnes/FU]	Emissions per ton [g/ton]									Energy consumption [MJ/ton]	Use of natural resources [g/ton]
			CO_2	NOx	PM	SO_2	CO	VOC	CH_4	HC	N_2O		
Alt 1	**Layer stabilisation**												
	OSA EF CFB	323	No emissions from the oil shale ash as it is not a product, instead it is a by-product from the burning of the oil shale for energy.										
	Sand for load material	13 248	1 800	2,1	1,2	1,3	1,1	0,3	1,1			34	1010000
	Mass stabilisation												
	OSA EF CFB	7 176	No emissions from the oil shale ash as it is not a product, instead it is a by-product from the burning of the oil shale for energy.										
	Composite cement	2 153	623 628	1794	263,1	1791						5825	1151000
	SUM	**32 670**											
Alt 2	**Complex stabilisation**												
	Bitumen	36	255 669	1207		993	1057	410	764	68		510	1095010
	Composite cement	90	623 628	1794	263,1	1791						5825	1151000
	Sand for load material	13 248	1 800	2,1	1,2	1,3	1,1	0,3	1,1			34	1010000
	Mass stabilisation												
	OSA EF CFB	7 176	No emissions from the oil shale ash as it is not a product, instead it is a by-product from the burning of the oil shale for energy.										
	Composite cement	2 153	623 628	1794	263,1	1791						5825	1151000
	SUM	**32 473**											
Alt 3	**Complex stabilisation**												
	Bitumen	36	255 669	1207		993	1057	410	764	68		510	1095010
	Composite cement	90	623 628	1794	263,1	1791						5825	1151000
	Sand for load material	13 248	1 800	2,1	1,2	1,3	1,1	0,3	1,1			34	1010000
	Mass stabilisation												
	Composite cement	3 229	623 628	1794	263,1	1791						5825	1151000
	SUM	**23 061**											
Alt 4	Gravel and medium sand	8 280	1 800	2,1	1,2	1,3	1,1	0,3	1,1			34	1010000
	Rock material 2 m	40 480	1 800	2,1	1,2	1,3	1,1	0,3	1,1			34	1010000
	Complex stabilisation												
	Bitumen	36	255 669	1207		993	1057	410	764	68		510	1095010
	Composite cement	90	623 628	1794	263,1	1791						5825	1151000
	SUM	**48 886**											

continuing…

Emissions total [kg/FU]											Reference:
CO_2	**NOx**	**PM**	**SO_2**	**CO**	**VOC**	**CH_4**	**HC**	**N_2O**	**Energy consumption [MJ/FU]**	**Use of natural resources [kg/FU]**	
No emissions from the oil shale ash as it is not a product, instead it is a by-product from the burning of the oil shale for energy.											
23 846	28	16	17	14,6	4,0	14,6			450 432	13 380 480	
											[8], [10]
No emissions from the oil shale ash as it is not a product, instead it is a by-product from the burning of the oil shale for energy.											
1 342 546	3862	566	3856						12 539 285	2 477 873	
1 366 393	**3 890**	**582**	**3 873**	**15**	**4**	**15**	**0**	**0**	**12 989 717**	**15 858 353**	
9 173	43		36	38	15	27	2,4		18 299	39 289	
55 939	161	24	161						522 470	103 245	
23 846	28	16	17	15	4,0	15			450 432	13 380 480	
											[8], [10]
No emissions from the oil shale ash as it is not a product, instead it is a by-product from the burning of the oil shale for energy.											
1 342 546	3862	566	3856						12 539 285	2 477 873	
1 431 506	**4 094**	**606**	**4 069**	**52**	**19**	**42**	**2**	**0**	**13 530 486**	**16 000 886**	
9 173	43	0	36	38	15	27	2		18 299	39 289	
55 939	161	24	161						522 470	103 245	
23 846	28	16	17	15	4	15			450 432	13 380 480	[8], [10]
2 013 820	5 793	850	5 783						18 808 927	3 716 809	
2 102 779	**6 025**	**889**	**5 997**	**52**	**19**	**42**	**2**	**0**	**19 800 128**	**17 239 823**	
14 904	17	9,9	11	9,1	2,5	9,1			281 520	8 362 800	
72 864	85	49	53	45	12	45			1 376 320	40 884 800	
9 173	43	0	36	38	15	27	2,4		18 299	39 289	[8], [10], [11]
55 939	161	24	161						522 470	103 245	
152 881	**307**	**82**	**260**	**92**	**29**	**81**	**2,4**	**0**	**2 198 609**	**49 390 134**	

2c Material transportation

	Material	Destination	Total mass [ton/FU]	Vehicle	Distance [km]	Total fuel consumption [l/FU]	Emissions [g/km]								Energy consumption [MJ/km]	Depletion of natural resources [kg/l]
							CO_2	NOx	PM	SO_2	CO	VOC + HC	CH_4	N_2O		
Alt 1	**Layer stabilisation**															
	OSA EF CFB	to site	323	tank truck (40t)	155	1051	1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16
	(OSA EF CFB)	(to landfill)	323	tank truck (40t)	-5	-34	1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16
	Load material, sand, first 80 cm	to site	13248	truck (19 t)	30	12969	774,5	5,8	0,063	0,0053	0,195	0,115	0,007	0,033	11,5	1,16
	Load material, sand, 30 cm excavated off	to temporary storage	4968	truck (19 t)	3	486	774,5	5,8	0,063	0,0053	0,195	0,115	0,007	0,033	11,5	1,16
	Water															
	Mass stabilisation															
	OSA EF CFB	to site	7176	tank truck (40t)	155	23358	1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16
	(OSA EF CFB)	(to landfill)	7176	tank truck (40t)	-5	-753	1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16
	Composite cement	to site	2153	tank truck (40t)	80	3617	1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16
	Water	to site	2896	tank truck (40t)	3	182	1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16
	SUM					**48 982**										
Alt 2	**Complex stabilisation**															
	Bitumen	to site	36	tank truck (40t)	135	75	1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16
	Composite cement	to site	90	tank truck (40t)	70	132	1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16
	Load material, sand, first 80 cm	to site	13248	truck (19 t)	30	12969	774,5	5,8	0,063	0,0053	0,195	0,115	0,007	0,033	11,5	1,16
	Load material, sand, 30 cm excavated off	to temporary storage	4968	truck (19 t)	3	486	774,5	5,8	0,063	0,0053	0,195	0,115	0,007	0,033	11,5	1,16
	Mass stabilisation															
	OSA EF CFB	to site	7176	tank truck (40t)	155	23358	1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16
	(OSA EF CFB)	(to landfill)	7176	tank truck (40t)	-5	-753	1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16
	Composite cement	to site	2153	tank truck (40t)	70	3165	1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16
	Water	to site	2799	tank truck (40t)	3	176	1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16
	SUM					**47 713**										
Alt 3	Gravel and medium sand	to site	13248	truck (19 t)	30	12969	774,5	5,8	0,063	0,0053	0,195	0,115	0,007	0,033	11,5	1,16
	Complex stabilisation															
	Bitumen	to site	36	tank truck (40t)	135	102	1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16
	Composite cement	to site	89,7	tank truck (40t)	70	132	1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16
	Stone material	to site	13248	truck (19 t)	30	12969	774,5	5,75	0,063	0,0053	0,195	0,115	0,007	0,033	11,5	1,16
	Mass stabilisation															
	Composite cement	to site	3229	tank truck (40t)	80	5425	1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16
	OSA	to landfill	3229	tank truck (40t)	5	339	1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16
	Water	to site	969	tank truck (40t)	3	61	1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16
	SUM					**31 997**										
Alt 4	Peat	off site	20240	truck (19 t)	3	1981	774,5	5,8	0,063	0,0053	0,195	0,115	0,007	0,033	11,5	1,16
	Gravel and medium sand	to site	8280	truck (19 t)	30	8106	774,5	5,8	0,063	0,0053	0,195	0,115	0,007	0,033	11,5	1,16
	OSA	to landfill	7176	tank truck (40t)	5	1586	1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	11,5	1,16
	Complex stabilisation															
	Bitumen	to site	35,88	tank truck (40t)	135	102	1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16
	Composite cement	to site	89,7	tank truck (40t)	70	132	1036	7,7	0,074	0,0071	0,21	0,09	0,009	0,0305	15	1,16
	Stone material	to site	40480	truck (19 t)	30	39628	774,5	5,8	0,063	0,0053	0,195	0,115	0,007	0,033	11,5	1,16
	SUM					**51 535**										

Total emissions [kg / FU]								Energy consumption [MJ/FU]	Depletion of natural resources [kg/FU]	Reference:
CO_2	NOx	PM	SO_2	CO	VOC + HC	CH_4	N_2O			
2 593	19	0,19	0,02	0,53	0,23	0,02	0,08	37 539	1 219	
-84	-0,62	-0,006	-0,0006	-0,02	-0,007	-0,0007	-0,002	-1 211	-39	
32 402	241	2,6	0,2	8,2	4,8	0,3	1,4	481 112	15 044	
1 215	9,0	0,1	0,01	0,3	0,2	0,01	0,1	18 042	564	
										[5]
57 616	428	4,1	0,39	12	5,0	0,50	1,7	834 210	27 095	
-1 859	-13,8	-0,13	-0,01	-0,38	-0,16	-0,02	-0,05	-26 910	-874	
8 921	66	0,6	0,06	1,8	0,78	0,08	0,26	129 168	4 195	
450	3,3	0,03	0,003	0,09	0,04	0,004	0,01	6 515	212	
101 255	**752**	**7,6**	**0,69**	**22**	**11**	**0,89**	**3,4**	**1 779 159**	**56 819**	
251	1,9	0,02	0,002	0,05	0,02	0,002	0,01	3 633	87	
325	2,4	0,02	0,002	0,07	0,03	0,003	0,01	4 709	153	
32 402	241	2,6	0,22	8,2	4,8	0,3	1,4	481 112	15 044	
1 215	9,0	0,10	0,01	0,31	0,18	0,01	0,05	18 042	564	
										[5]
57 616	428	4,1	0,39	12	5,0	0,50	1,7	834 210	27 095	
-1 859	-14	-0,13	-0,01	-0,38	-0,16	-0,02	-0,05	-26 910	-874	
7 806	58	0,56	0,05	1,6	0,68	0,07	0,23	113 022	3 671	
435	3,2	0,03	0,003	0,09	0,04	0,004	0,01	6 297	205	
98 192	**730**	**7,3**	**0,67**	**22**	**11**	**0,86**	**3,3**	**1 734 809**	**45 945**	
32 402	241	2,6	0,2	8,2	4,8	0,3	1,4	481 112	15 044	
251	1,9	0,02	0,002	0,05	0,02	0,002	0,007	3 633	118	
325	2,4	0,02	0,002	0,07	0,03	0,003	0,010	4 709	153	
32 402	241	2,6	0,22	8,2	4,8	0,29	1,4	481 112	15 044	
										[5]
13 382	99	0,96	0,09	2,71	1,16	0,12	0,39	193 752	6 293	
836	6,2	0,06	0,006	0,17	0,07	0,007	0,02	12 110	393	
151	1,1	0,01	0,001	0,03	0,01	0,001	0,004	2 180	71	
79 749	**592**	**6,3**	**0,5**	**19**	**10,9**	**0,7**	**3,2**	**1 178 606**	**37 116**	
4 950	37	0,4	0,0	1,2	0,7	0,0	0,2	73 503	2 298	
20 251	150	1,6	0,1	5,1	3,0	0,2	0,9	300 695	9 403	
3 913	29	0,28	0,03	0,79	0,34	0,03	0,12	43 434	1 840	
251	1,9	0,018	0,002	0,051	0,022	0,002	0,007	3 633	118	[5]
325	2,4	0,023	0,002	0,066	0,028	0,003	0,010	4 709	153	
99 006	735	8,1	0,7	24,9	14,7	0,9	4,2	1 470 063	45 968	
128 696	**955**	**10**	**0,9**	**32**	**19**	**1,2**	**5,4**	**1 896 037**	**59 780**	

2d Construction

		Fuel consumption [l/h]	Capacity [m^2/h]	Capacity [h/m^3]	Volume [m^3/h]	[l/m^3]	m^3/FU	Time [h/FU]	Fuel consumption [l/FU]
Alt 1	**Layer stabilisation**								
	*Road grader	44	11875					0,8	35
	*Spreading of OSA with tractor (spreading vessel attached)	19	11500					0,8	15
	*The rotary mixer used in stabilisation work	44	11875					0,8	35
	*Road grader	44	11875					0,8	35
	Spreading of gravel and medium sand with excavator	32		0,022	45	0,693	4 600	101	3 188
	Mass stabilisation	30			120		18 400	153	4 600
	SUM								**7 909**
Alt 2	**Complex stabilisation**								
	Bitumen	27,2	11500					0,8	22
	*Spreading of cement with tractor (spreading vessel attached)	19	11500					0,8	15
	Spreading of gravel and medium sand with excavator	32		0,022	45	0,693	4 600	101	3 188
	Mass stabilisation	30			120		18 400	153	4 600
	SUM								**7 825**
Alt 3	**Complex stabilisation**								
	Bitumen	27,2	11500					0,8	22
	*Spreading of cement with tractor (spreading vessel attached)	19	11500					0,8	15
	Spreading of gravel and medium sand with excavator	31,5		0,022	45	0,693	7 360	162	5 100
	Spreading of crushed stone 1 m	31,5	*433*	0,022	45	0,693	2 760	61	1 913
	Excavating of crushed stone 0,5 m	31,5		0,013	77	0,41	4 600	60	1 884
	Mass stabilisation	30			120		18 400	153	4 600
	SUM								**13 534**
Alt 4	Excavating the peat layer	31,5		0,007	77	0,22	18 400	129	4 057
	Complex stabilisation								
	Bitumen	27,2	11500					0,8	22
	*Spreading of cement with tractor (spreading vessel attached)	19	11500					0,8	15
	Spreading of crushed stone 2 m	31,5	11500	0,022	45	0,693	18 400	405	12 751
	SUM								**16 845**

Emissions per l [g/l]										Emissions [kg/FU]								Energy consumption [MJ/FU]	Depletion of natural resources [kg/FU]	Reference:
CO_2	NOx	PM	SO_2	CO	VOC + HC	CH_4	N_2O	Energy consumption [MJ/h]	Depletion of natural resources [kg/l]	CO_2	NOx	PM	SO_2	CO	VOC + HC	CH_4	N_2O			
2 607	25	1,2	0,017	7,6	2,6	0,15	0,07	1639	1,16	92	0,89	0,04	0,001	0,27	0,09	0,01	0,003	1 311	41	
2 624	19	0,9	0,017	7,3	2,1	0,15	0,071	671	1,16	40	0,29	0,01	0,0003	0,11	0,03	0,002	0,001	537	18	
2 607	25	1,2	0,017	5,4	2,6	0,15	0,072	1639	1,16	92	0,89	0,04	0,001	0,19	0,09	0,01	0,003	1 311	41	
2 607	25	1,2	0,017	7,6	2,6	0,15	0,07	1639	1,16	92	0,89	0,04	0,001	0,27	0,09	0,01	0,003	1 311	41	[5], [12]
2 607	18	0,7	0,017	6,3	1,7	0,15	0,071	1144	1,16	8 311	57	2,2	0,05	20	5,4	0,48	0,23	115 773	3 698	
									1,16	11 070	76	3,0	0,07	27	7,2	0,64	0,30	154 135	5 336	
										19 697	**137**	**5,3**	**0,13**	**48**	**13**	**1,1**	**0,54**	**274 379**	**9 175**	
2 607	17	0,7	0,017	6,5	1,7	0,15	0,072	979	1,16	57	0,37	0,02	0,00	0,14	0,04	0,00	0,00	783	25	
2 624	19	0,9	0,017	7,3	2,1	0,15	0,071	671	1,16	40	0,29	0,01	0,00	0,11	0,03	0,00	0,00	537	18	
2 607	18	0,7	0,017	6,3	1,7	0,15	0,071	1144	1,16	8 311	57	2,2	0,05	20,08	5,42	0,48	0,23	115 773	3 698	[5], [12]
									1,16	11 070	76	3,0	0,07	27	7,2	0,64	0,30	154 135	5 336	
										19 477	**134**	**5,2**	**0,13**	**47**	**13**	**1,1**	**0,53**	**271 228**	**9 077**	
2 607	17	0,7	0,017	6,5	1,7	0,15	0,072	979	1,16	57	0,37	0,02	0,0004	0,14	0,04	0,003	0,002	783	25	
2 624	19	0,9	0,017	7,3	2,1	0,15	0,071	671	1,16	40	0,29	0,01	0,0003	0,11	0,03	0,002	0,001	18	18	
2 607	18	0,7	0,017	6,3	1,7	0,15	0,071	1144	1,16	13 297	92	3,6	0,09	32	8,7	0,77	0,36	5 917	5 917	
2 607	22	1,3	0,017	7	3	0,15	0,1	148,5	1,16	4 986	42	2,5	0,03	13	5,9	0,29	0,13	2 219	2 219	[5], [12]
2 607	18	0,7	0,017	6,3	1,7	0,15	0,071	1144	1,16	4 911	34	1,3	0,03	12	3,2	0,28	0,13	68 411	2 185	
									1,16	11 070	76	3	0,07	27	7,2	0,64	0,30	154 135	5 336	
										34 360	**245**	**10**	**0,22**	**84**	**25**	**2,0**	**0,93**	**231 483**	**15 699**	
2 607	18	0,7	0,017	6,3	1,7	0,15	0,071	1144	1,16	10 577	73	2,8	0,07	26	6,9	0,61	0,29	147 347	4706	
2 607	17	0,7	0,017	6,5	1,7	0,15	0,072	979	1,16	57	0,37	0,02	0,00	0,14	0,04	0,00	0,00	783	25	
2 624	19	0,9	0,017	7,3	2,1	0,15	0,071	671	1,16	40	0,29	0,01	0,00	0,11	0,03	0,00	0,00	537	18	[5], [12]
2 607	18	0,7	0,017	6,3	1,7	0,15	0,071	1144	1,16	33 242	229,52	8,93	0,22	80,33	21,68	1,91	0,91	463 091	14791	
										43 916	**303**	**12**	**0,29**	**106**	**29**	**2,5**	**1,2**	**611 758**	**19 541**	

2d Final results

Simuna-Vaiatu Life Cycle Analysis		Emissions total [kg/FU]								Energy consumption [MJ/FU]	Use of natural resources [kg/FU]	Global warming potential [kg CO_2 eqv / FU]
		CO_2	NOx	PM	SO_2	CO	VOC + HC	CH_4	N_2O			
ALT 1	Material production	1 366 393	3 890	582	3 873	15	4,0	15	0	12 989 717	15 858 353	1 366 801
	Material transportation	101 255	752	7,6	0,69	22	11	0,89	3,4	1 779 159	56 819	102 300
	Construction	19 697	137	5,3	0,13	48	13	1,1	0,54	274 379	9 175	19 889
		1 487 345	**4 779**	**595**	**3 874**	**84**	**28**	**17**	**4,0**	**15 043 255**	**15 924 346**	**1 488 989**
ALT 2	Material production	1 431 506	4 094	606	4 069	52	21	42	0	13 530 486	16 000 886	1 432 681
	Material transportation	98 192	730	7,3	0,67	22	11	0,86	3,3	1 734 809	45 945	99 209
	Construction	19 477	134	5,2	0,13	47	13	1,1	0,53	271 228	9 077	19 666
		1 549 174	**4 958**	**618**	**4 070**	**121**	**44**	**44**	**3,9**	**15 536 523**	**16 055 908**	**1 551 557**
ALT 3	Material production	2 102 779	6 025	889	5 997	52	21	42	0	19 800 128	17 239 823	2 103 954
	Material transportation	79 749	592	6,3	0,54	19	11	0,72	3,2	1 178 606	37 116	80 722
	Construction	34 360	245	10	0,22	84	25	2,0	0,93	231 483	15 699	34 693
		2 216 888	**6 862**	**906**	**5 998**	**156**	**57**	**45**	**4,1**	**21 210 218**	**17 292 639**	**2 219 370**
ALT 4	Material production	152 881	307	82	260	92	32	81	0	2 198 609	49 390 134	155 150
	Material transportation	128 696	955	10	0,87	32	19	1,2	5,4	1 896 037	59 780	130 345
	Construction	43 916	303	12	0,29	106	29	2,5	1,2	611 758	19 541	44 343
		325 493	**1 565**	**104**	**261**	**230**	**79**	**85**	**6,6**	**4 706 404**	**49 469 455**	**329 838**

Appendix 3 Narva-Mustajoe LCC calculation sheets

3a Material amounts and measurements

Structures that are included in the calculations:	Alt1 Layer stabilisation with OSA Q1 and cement	Alt2 Layer stabilisation with binder OSA Q2 and cement	Alt3 Layer stabilisation with cement	Alt4 Complex stabilisation (with bitumen and cement)
Pavement				
Mass	Height 9 cm, width 900 cm			
Pavement thickness [mm]	90	90	90	90
Surface area				
* surface area [m^2] of the stabilisation	9500	9500	9500	9500
* surface area [m^2] pavement	9000	9000	9000	9000
Other structure layers	**Stabilised layer 25 cm: binder (OSA EF BL3 OBT 6 % + cement 3 %) + crushed asphalt 9 cm + mining waste 16 cm**	**Stabilised layer 25 cm: binder (OSA CYCL 5 % + cement 5 %)+ crushed asphalt 9 cm + mining waste 16 cm**	**Stabilised layer 25 cm: binder (cement 6 %)+ crushed asphalt 9 cm + mining waste 16 cm**	**Stabilised layer 15 cm: binder (bitumen 1 % + cement 2,5 %) + crushed rock 15 cm**
Thickness of the mining waste (m)	**0,16**	**0,16**	**0,16**	
Thickness of the crushed aggregate (m)				**0,31**
The amount of mining waste MWA (Aidu 77km) / crushed aggregate (77 km) needed amount (m3rtr) in the structure (per 1 road-km)	**1520**	**1520**	**1520**	
The amount of needed crushed aggregate (m3rtr) in the structure, (per 1 tiekm)				**2945**
The amount of needed crushed aggregate (previous mass in the structure) tons (per 1 tiekm)				**6185**
Wet density of stabilised aggregate [kg/m^3]	1975	1975	1975	1975
Water content of stabilised aggregate [%]	4,5	4,5	4,5	4,5
Dry density of stabilised aggregate [kg/m^3]	1886	1886	1886	1886
Stabiloitavaa runkoainetta tyoyksilla [m^3/km]	2375	2375	2375	1425
Total dry mass of stabilised aggregate [t/km]	4479	4479	4479	2687
Total mass of stabilised aggregate [t/km]	**4631**	**4631**	**4631**	**2779**
OSA amount in binder mixture [%]	6,0	5,0	0	0
OSA, dry [t/km]	269	224	0	0
OSA, dry [t/km]	278	232		
Bitumen (%)	0	0	0	1
Bitumen (t/km)	0	0	0	27
Bitumen (t/km)	0	0	0	28
Cement amount in binder mixture [%]	3,0	5,0	6,0	2,5
Cement, dry [t/km]	134	224	269	67
Cement, dry [t/km]	139	232	278	69
Target water content of the binder mixture [%]	30	30	30	30
Extra water for mixing [m^3/km]	17	17	17	10
Total mass of the binder mixture (t/km)	420	465	285	104

3b Calculated material costs

		Alt1 Layer stabilisation with OSA Q1 and cement		Alt2 Layer stabilisation with binder OSA Q2 and cement		Alt3 Layer stabilisation with cement		Alt4 Complex stabilisation (with bitumen and cement)	
Crushed rock	Total need [t/road-km]	0		0		0		6 185	
	Unit price [€/t]	13,50		13,50		13,50		13,50	
	Price in the crushing plant [€]	**0**		**0**		**0**		**83 491**	
	Transportation distance [km]	77		77		77		77	
	Transportation cost [€/t-km]	**0,06**		**0,06**		**0,06**		**0,06**	
	Transportations [€/t-km]	**0**		**0**		**0**		**28 572**	
	Transportations on site [€/road-km]		**0**		**0**		**0**		**112 063**
Mining waste	Estimated need [t]	3 002		3 002		3 002		0	
	*unit price [€/t]	**3,20**		**3,20**		**3,20**		**3,20**	
	*price [€]	**9 606**		**9 606**		**9 606**		**0**	
	*transportation distance [km]	***77***		***77***		***77***		***77***	
	*transportation cost [€/t-km]	**0,06**		**0,06**		**0,06**		**0,06**	
	*transportations [€]	**13 869**		**13 869**		**13 869**		**0**	
	Transportations on site [€/road-km]	23 476	**23 476**	23 476	**23 476**	23 476	**23 476**	0	**0**
Binder components	**Cement [t/road-km]**	139		232		278		69	
	*unit price [€/t]	87,75		87,75		87,75		87,75	
	*price [€]	**12 197**		**20 358**		**24 395**		**6 055**	
	*transportation distance [km]	100		100		100		100	
	*transportation cost [€/t-km]	0,1254		0,1254		0,1254		0,1254	
	*transportations [€]	**1 743**		**2 909**		**3 486**		**865**	
	***costs in mixing site [€/road-km]**		**13 940**		**23 267**		**27 881**		**6 920**
	OSA [t/road-km]	278		232		0		0	
	*unit price [€/t]	8,00		8,00		8,00		8,00	
	*price [€]	**2 224**		**1 856**		**0**		**0**	
	*transportation distance [km]	8,5		8,5		8,5		8,5	
	*transportation cost [€/t-km]	0,1254		0,1254		0,1254		0,1254	
	*transportations[€]	**296**		**247**		**0**		**0**	
	***costs in mixing site [€/road-km]**		**2 520**		**2 103**		**0**		**0**

The benefit obtained from avoiding the landfilling	**OSA [t/road-km]**	278		232		0		0	
	*unit price [€/t]	50,00		50,00		50,00		50,00	
	*price [€]	**-13 900**		**-11 600**		**0**		**0**	
	*transportation distance [km]	5,0		5,0		5,0		5,0	
	*transportation cost [€/t-km]	0,1254		0,1254		0,1254		0,1254	
	*transportations [€]	**-174**		**-145**		**0**		**0**	
	***costs in mixing site [€/road-km]**		**-14 074**		**-11 745**		**0**		**0**
Bitumen	**Bitumen [t/road-km]**	0		0		0		27	
	*unit price [€/t]	430,00		430,00		430,00		430,00	
	*price [€]	**0**		**0**		**0**		**11 556**	
	*transportation distance [km]	44		44		44		44	
	*transportation cost [€/t-km]	0,1254		0,1254		0,1254		0,1254	
	*transportations [€]	**0**		**0**		**0**		**148**	
	***costs in mixing site [€/road-km]**		**0**		**0**		**0**		**11 704**
Water	**water [m3/road-km]**	67		67		67		67	
	*unit price [€/t]	0,00		0,00		0,00		0,00	
	*price [€]	**0**		**0**		**0**		**0**	
	*transportation distance [km]	3		3		3		3	
	*transportation cost [€/t-km]	0,13		0,13		0,13		0,13	
	*transportations [€]	**25**		**25**		**25**		**25**	
	***costs in mixing site [€/road-km]**		25		25		25		**25**
Landfilling costs from general overhaul	**Total mass [t/road-km]**	0		0		0		0	
No landfilling in any of the alternatives	*unit price [€/t]	50,00		50,00		50,00		50,00	
	*price [€]	**0**		**0**		**0**		**0**	
	*transportation distance [km]	5,0		5,0		5,0		5,0	
	*transportation cost [€/t-km]	0,13		0,13		0,13		0,13	
	*transportations [€]	**0**		**0**		**0**		**0**	
	***costs in mixing site [€/road-km]**		**0**		**0**		**0**		**0**
	Material costs on site [€/tie-km] in initial stage	**39 961**		**48 871**		**51 381**		**130 712**	
		Alt1 Layer stabilisation with OSA Q1 and cement		**Alt2 Layer stabilisation with binder OSA Q2 and cement**		**Alt3 Layer stabilisation with cement**		**Alt4 Complex stabilisation (with bitumen and cement)**	
	Road length [m] = FU	1 000		1 000		1 000		1 000	
	Material costs on site [€/tie-km] and landfilling of OSA taken into account	**25 887**		**37 126**		**51 381**		**130 712**	
		Alt1 Layer stabilisation with OSA Q1 and cement		**Alt2 Layer stabilisation with binder OSA Q2 and cement**		**Alt3 Layer stabilisation with cement**		**Alt4 Complex stabilisation (with bitumen and cement)**	
	Road length [m] = FU	1 000		1 000		1 000		1 000	

3c Calculated work costs

Structures included in the calculation:		**Alt1 Layer stabilisation with OSA Q1 and cement**		**Alt2 Layer stabilisation with binder OSA Q2 and cement**		**Alt3 Layer stabilisation with cement**		**Alt4 Complex stabilisation (with bitumen and cement)**	
Paving (new)		AC 12 surf 4 cm + AC 32 base 5 cm; width 9,00 m							
AC 12, 4 cm, bitumen 5,6 %	Unit price [€/m^2]	*9,03*		*9,03*		*9,03*		*9,03*	
AC 32, 5 cm, bitumen 4,0 %	Unit price [€/m^2]	*8,09*		*8,09*		*8,09*		*8,09*	
	Surface area to be paved [m^2]	9 000		9 000		9 000		9 000	
	New pavement [€]		**154 080**		**154 080**		**154 080**		**154 080**
	Pavement [€/tie-m]	*154,08*		*154,08*		*154,08*		*154,08*	
	Length of FU [m]	1 000		1 000		1 000		1 000	
Work stages	structure; m3-rtr/FU	2 375		2 375		2 375		1 425	
	structure-theor-aggeregate_m2;/	9 500		9 500		9 500		9 500	
	structure-theor-surf_m2;/FU	9 000		9 000		9 000		9 000	
Milling of the pavement and transport to the storage (distance 8,5 km), and pile dumping	unit price; €/m2-rtr	0	0	0	0	0	0	1,2	10 800
Milling of the pavement	unit price; €/m2-rtr	0,79	7 110	0,79	7 110	0,79	7 110		
Spreading of the mining waste	unit price; €/m3-rtr	2,40	22 800	2,4	22 800	2,4	22 800		
Spreading of the crushed rock	unit price; €/m3-rtr							2,40	22 800
Stabilisation (including the spreading of the binders, mixing, wetting, compacting)	unit price; €/m3-rtr	26	61 750	22	52 250	16	38 000	33	47 500
Adding the water	unit price; €/m3-rtr		0	0	0	0	0	0	0
			91 660		**82 160**		**67 910**		**81 100**
	Costs [€/road-km]	**245 740**		**236 240**		**221 990**		**235 180**	

		Alt1 Layer stabilisation with OSA Q1 and cement		**Alt2 Layer stabilisation with binder OSA Q2 and cement**		**Alt3 Layer stabilisation with cement**		**Alt4 Complex stabilisation (with bitumen and cement)**	
General overhaul									
NEW pavement (REM)									
AC 12, 4 cm, bitumen 5,6 %	Unit price [€/m^2]	*9,03*		*9,03*		*9,03*		*9,03*	
AC 32, 5 cm, bitumen 4,0 %	Unit price [€/m^2]	*8,09*		*8,09*		*8,09*		*8,09*	
Milling of the surface and transportation to the storage (distance 8,5 km)	Unit price [€/m^2]	*1,20*		*1,20*		*1,20*		*1,20*	
	Surface area to be paved [m^2]	9 000		9 000		9 000		9 000	
	New pavement [€]		**164 880**		**164 880**		**164 880**		**164 880**
	Pavement [€/tie-m]	*164,88*		*164,88*		*164,88*		*164,88*	
	Length of the FU [m]	1 000		1 000		1 000		1 000	
Stabilisation									
Work stages	structure-theor-m3; m3-rtr/FU	2 375		2 375		2 375		1 425	
	structure-theor-m2-pavement	9 000		9 000		9 000		9 000	
	unit price; €/m3-rtr		0		0		0		0
Stabilisation	unit price; €/m3-rtr	26	61 750	22	52 250	16	38 000	33	47 500
Milling of the surface and immeadiate use in the old structure	unit price; €/m3-rtr	0,79	7 110	0,79	7 110	0,79	7 110	0,79	7 110
Adding water	unit price; €/m3-rtr		0	0	0	0	0	0	0
			68 860		**59 360**		**45 110**		**54 610**
	Costs [€/road-km]	**233 740**		**224 240**		**209 990**		**219 490**	

3d Maintenance scenarios

Structure alternative			Alt1 Layer stabilisation with OSA Q1 and cement	Alt2 Layer stabilisation with binder OSA Q2 and cement	Alt3 Layer stabilisation with cement	Alt4 Complex stabilisation (with bitumen and cement)
Paving			AC	AC	AC	AC
Patching (UREM) (assumption 50 % * 40 % of the REM price)		**Maintenance cycles (a)**	8	8	8	8
			30 816	**30 816**	**30 816**	**30 816**
Re-paving (as REM)		**Maintenance cycles (a)**	8	8	8	8
			154 080	**154 080**	**154 080**	**154 080**
Need of general overhaul	**Scenario 1**	**Action cycles (a)**	32	28	24	20
		Action	Milling of the old surface and mixing it into lowe ash stabilised layer into 200-300 mm depth. New stabilisation (ash + cement) and paving.	Milling of the old surface and mixing it into lowe ash stabilised layer into 200-300 mm depth. New stabilisation (ash + cement) and paving.	Milling of the old surface and mixing it into lowe ash stabilised layer into 200-300 mm depth. New stabilisation (cement) and paving.	Milling of the old surface and mixing it into lowe ash stabilised layer into 200-300 mm depth. New stabilisation (ash + cement) and paving.
		€/FU	**259 627**	**261 366**	**261 371**	**350 202**
	Scenario 2	**Action cycles (a)**	36	32	28	24
		Action	Milling of the old surface and mixing it into lowe ash stabilised layer into 200-300 mm depth. New stabilisation (ash + cement) and paving.	Milling of the old surface and mixing it into lowe ash stabilised layer into 200-300 mm depth. New stabilisation (ash + cement) and paving.	Milling of the old surface and mixing it into lowe ash stabilised layer into 200-300 mm depth. New stabilisation (cement) and paving.	Milling of the old surface and mixing it into lowe ash stabilised layer into 200-300 mm depth. New stabilisation (ash + cement) and paving.
		€/FU	**259 627**	**261 366**	**261 371**	**350 202**
	Scenario 3	**Action cycles (a)**	40	36	32	28
		Action	Milling of the old surface and mixing it into lowe ash stabilised layer into 200-300 mm depth. New stabilisation (ash + cement) and paving.	Milling of the old surface and mixing it into lowe ash stabilised layer into 200-300 mm depth. New stabilisation (ash + cement) and paving.	Milling of the old surface and mixing it into lowe ash stabilised layer into 200-300 mm depth. New stabilisation (cement) and paving.	Milling of the old surface and mixing it into lowe ash stabilised layer into 200-300 mm depth. New stabilisation (ash + cement) and paving.
		€/FU	**259 627**	**261 366**	**261 371**	**350 202**

3e Current values of maintenance scenarios

Current value of the actions / scenario 1										
Year	Alternative / actions				**Year**	D(ir)	**Alternative / actions**			
	Alt1	**Alt2**	**Alt3**	**Alt4**			**Alt1**	**Alt2**	**Alt3**	**Alt4**
0	0	0	0	0	0	1,000				
1	0	0	0	0	1	0,962				
2	0	0	0	0	2	0,925				
3	0	0	0	0	3	0,889				
4	26 342	26 342	26 342	26 342	4	0,855	30 816	30 816	30 816	30 816
5	0	0	0	0	5	0,822				
6	0	0	0	0	6	0,790				
7	0	0	0	0	7	0,760				
8	112 585	112 585	112 585	112 585	8	0,731	154 080	154 080	154 080	154 080
9	0	0	0	0	9	0,703				
10	0	0	0	0	10	0,676				
11	0	0	0	0	11	0,650				
12	19 248	19 248	19 248	19 248	12	0,625	30 816	30 816	30 816	30 816
13	0	0	0	0	13	0,601				
14	0	0	0	0	14	0,577				
15	0	0	0	0	15	0,555				
16	82 265	82 265	82 265	82 265	16	0,534	154 080	154 080	154 080	154 080
17	0	0	0	0	17	0,513				
18	0	0	0	0	18	0,494				
19	0	0	0	0	19	0,475				
20	14 064	14 064	14 064	159 828	20	0,456	30 816	30 816	30 816	350 202
21	0	0	0	0	21	0,439				
22	0	0	0	0	22	0,422				
23	0	0	0	0	23	0,406				
24	60 110	60 110	101 967	12 022	24	0,390	154 080	154 080	261 371	30 816
25	0	0	0	0	25	0,375				
26	0	0	0	0	26	0,361				
27	0	0	0	0	27	0,347				
28	10 276	87 160	10 276	51 382	28	0,333	30 816	261 366	30 816	154 080
29	0	0	0	0	29	0,321				
30	0	0	0	0	30	0,308				
31	0	0	0	0	31	0,296				
32	74 009	8 784	43 922	8 784	32	0,285	259 627	30 816	154 080	30 816
33	0	0	0	0	33	0,274				
34	0	0	0	0	34	0,264				
35	0	0	0	0	35	0,253				
36	7 509	37 544	7 509	37 544	36	0,244	30 816	154 080	30 816	154 080
37	0	0	0	0	37	0,234				
38	0	0	0	0	38	0,225				
39	0	0	0	0	39	0,217				
40	32 093	6 419	32 093	6 419	40	0,208	154 080	30 816	154 080	30 816
41	0	0	0	0	41					
Current value	**438 500**	**454 520**	**450 269**	**516 418**						

Current value of actions / scenario 2

Year	Alternative / actions				Year	D(ir)	Alternative / actions			
	Alt1	Alt2	Alt3	Alt4			Alt1	Alt2	Alt3	Alt4
0	0	0	0	0	0	1,000				
1	0	0	0	0	1	0,962				
2	0	0	0	0	2	0,925				
3	0	0	0	0	3	0,889				
4	26 342	26 342	26 342	26 342	4	0,855	30 816	30 816	30 816	30 816
5	0	0	0	0	5	0,822				
6	0	0	0	0	6	0,790				
7	0	0	0	0	7	0,760				
8	112 585	112 585	112 585	112 585	8	0,731	154 080	154 080	154 080	154 080
9	0	0	0	0	9	0,703				
10	0	0	0	0	10	0,676				
11	0	0	0	0	11	0,650				
12	19 248	19 248	19 248	19 248	12	0,625	30 816	30 816	30 816	30 816
13	0	0	0	0	13	0,601				
14	0	0	0	0	14	0,577				
15	0	0	0	0	15	0,555				
16	82 265	82 265	82 265	82 265	16	0,534	154 080	154 080	154 080	154 080
17	0	0	0	0	17	0,513				
18	0	0	0	0	18	0,494				
19	0	0	0	0	19	0,475				
20	14 064	14 064	14 064	14 064	20	0,456	30 816	30 816	30 816	30 816
21	0	0	0	0	21	0,439				
22	0	0	0	0	22	0,422				
23	0	0	0	0	23	0,406				
24	60 110	60 110	60 110	136 622	24	0,390	154 080	154 080	154 080	350 202
25	0	0	0	0	25	0,375				
26	0	0	0	0	26	0,361				
27	0	0	0	0	27	0,347				
28	10 276	10 276	87 161	10 276	28	0,333	30 816	30 816	261 371	30 816
29	0	0	0	0	29	0,321				
30	0	0	0	0	30	0,308				
31	0	0	0	0	31	0,296				
32	43 922	74 504	8 784	43 922	32	0,285	154 080	261 366	30 816	154 080
33	0	0	0	0	33	0,274				
34	0	0	0	0	34	0,264				
35	0	0	0	0	35	0,253				
36	63 263	7 509	37 544	7 509	36	0,244	259 627	30 816	154 080	30 816
37	0	0	0	0	37	0,234				
38	0	0	0	0	38	0,225				
39	0	0	0	0	39	0,217				
40	6 419	32 093	6 419	32 093	40	0,208	30 816	154 080	30 816	154 080
41	0	0	0	0	41					
Nykyarvo	**438 492**	**438 995**	**454 521**	**484 924**						

Current value of actions / scenario 3

Year	Alternative / actions				Year	D(ir)	Alternative / actions			
	Alt1	Alt2	Alt3	Alt4			Alt1	Alt2	Alt3	Alt4
0	0	0	0	0	0	1,000				
1	0	0	0	0	1	0,962				
2	0	0	0	0	2	0,925				
3	0	0	0	0	3	0,889				
4	26 342	26 342	26 342	26 342	4	0,855	30 816	30 816	30 816	30 816
5	0	0	0	0	5	0,822				
6	0	0	0	0	6	0,790				
7	0	0	0	0	7	0,760				
8	112 585	112 585	112 585	112 585	8	0,731	154 080	154 080	154 080	154 080
9	0	0	0	0	9	0,703				
10	0	0	0	0	10	0,676				
11	0	0	0	0	11	0,650				
12	19 248	19 248	19 248	19 248	12	0,625	30 816	30 816	30 816	30 816
13	0	0	0	0	13	0,601				
14	0	0	0	0	14	0,577				
15	0	0	0	0	15	0,555				
16	82 265	82 265	82 265	82 265	16	0,534	154 080	154 080	154 080	154 080
17	0	0	0	0	17	0,513				
18	0	0	0	0	18	0,494				
19	0	0	0	0	19	0,475				
20	14 064	14 064	14 064	14 064	20	0,456	30 816	30 816	30 816	30 816
21	0	0	0	0	21	0,439				
22	0	0	0	0	22	0,422				
23	0	0	0	0	23	0,406				
24	60 110	60 110	60 110	60 110	24	0,390	154 080	154 080	154 080	154 080
25	0	0	0	0	25	0,375				
26	0	0	0	0	26	0,361				
27	0	0	0	0	27	0,347				
28	10 276	10 276	10 276	116 785	28	0,333	30 816	30 816	30 816	350 202
29	0	0	0	0	29	0,321				
30	0	0	0	0	30	0,308				
31	0	0	0	0	31	0,296				
32	43 922	43 922	74 506	8 784	32	0,285	154 080	154 080	261 371	30 816
33	0	0	0	0	33	0,274				
34	0	0	0	0	34	0,264				
35	0	0	0	0	35	0,253				
36	7 509	63 687	7 509	37 544	36	0,244	30 816	261 366	30 816	154 080
37	0	0	0	0	37	0,234				
38	0	0	0	0	38	0,225				
39	0	0	0	0	39	0,217				
40	54 077	6 419	32 093	6 419	40	0,208	259 627	30 816	154 080	30 816
41	0	0	0	0	41					
Current value	**430 397**	**438 916**	**438 997**	**484 145**						

3f LCC calculation final results

Construction and maintenance scenario 1

		Alt1	Alt2	Alt3	Alt4
Construction costs, year 0	R_N	**271 627**	**273 366**	**273 371**	**365 892**
Current value of maintenance costs	KP_N	438 500	454 520	450 269	516 418
Current value of depriciation value	$-J_N$	190 139	191 356	191 360	256 125
Current value of the costs	K_N	519 988	536 529	532 281	626 186
Annual cost	$c*K_N$	26 272	27 107	26 893	31 637

annuity factor = c $[i*(1+i)^n]/[(1+i)^n-1]$	0,051	0,051	0,051	0,051

Construction and maintenance scenario 2

		Alt1	Alt2	Alt3	Alt4
Construction costs, year 0	R_N	**271 627**	**273 366**	**273 371**	**365 892**
Current value of maintenance costs	KP_N	438 492	438 995	454 521	484 924
Current value of depriciation value	$-J_N$	190 139	191 356	191 360	256 125
Current value of the costs	K_N	519 980	521 005	536 533	594 692
Annual cost	$c*K_N$	26 271	26 323	27 108	30 046

annuity factor = c $[i*(1+i)^n]/[(1+i)^n-1]$	0,051	0,051	0,051	0,051

Construction and maintenance scenario 1

		Alt1	Alt2	Alt3	Alt4
Construction costs, year 0	R_N	**271 627**	**273 366**	**273 371**	**365 892**
Current value of maintenance costs	KP_N	430 397	438 916	438 997	484 145
Current value of depriciation value	$-J_N$	190 139	191 356	191 360	256 125
Current value of the costs	K_N	511 885	520 926	521 008	593 912
Annual cost	$c*K_N$	25 862	26 319	26 323	30 007

annuity factor = c $[i*(1+i)^n]/[(1+i)^n-1]$	0,051	0,051	0,051	0,051

Interest 4 %				
Present value	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 4**
Scenario 1	519 988	536 529	532 281	626 186
Scenario 2	519 980	521 005	536 533	594 692
Scenario 3	511 885	520 926	521 008	593 912
Annual cost	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 4**
Scenario 1	26 272	27 107	26 893	31 637
Scenario 2	26 271	26 323	27 108	30 046
Scenario 3	25 862	26 319	26 323	30 007

Appendix 4 Simuna-Vaiatu LCC calculation sheets

4a Material amounts and measurements

Structures that are included in the calculations:	Alt 1 Top: Base course stabilisation with OSA (EF CFB). Bottom: Mass stabilisation with OSA (EF CFB) and cement	Alt 2 Top: Complex stabilisation with bitumen and cement. Bottom: Mass stabilisation with OSA (EF CFB) and cement.	Alt 3 Top: Complex stabilisation with bitumen and cement. Bottom: Mass stabilisation with cement.	Alt 4 Top: Complex stabilisation with bitumen and cement. Bottom: Mass exchange from peat to crushed stone.
Pavement				
Mass	Height 9 cm, width 900 cm			
Thickness of the pavement [mm]	90	90	90	90
Surface area				
* surface area [m^2] pavement	9000	9000	9000	9000
* surface area [m^2] base course stabilisation	9200		9200	9200
* surface area [m2] mass stabilisation	9200	9200	9200	
*surface area [m2] complex stabilisation		9200	9200	9200
*surface are [m2] of other structures	9200	9200	9200	9200
Other structural layers	**Base course stabilisation 20 cm with EF CFB 9 % / Mass stabilisation 2 m with EF CFB % + cement 6 %**	**Complex stabilisation with bitumen 1 % and cement 2,5 % / Mass stabilisation 2 m with EF CFB 20 % + cement 6 %**	**Complex stabilisation with bitumen 1 % and cement 2,5 % / Mass stabilisation 2 m with cement 9 %**	**Complex stabilisation with bitumen 1 % and cement 2,5 % / Crushed rock 2 m**
thickness of the natural aggregates (sand/crushed rock) (m)	**0,8**	**0,8**	**0,8**	**2,5**
The amount of needed sand aggregates (m3rtr) in the structure, (per 1 road km), density 1,8 ton/m3	**14720**	**14720**	**14720**	**4600**
The amount of needed crushed rock aggregater (m3rtr) in the structure, (per 1 road km), density 2,2 ton/m3				**18400**
The amount of needed natural aggregates (previous mass in the structure) tons, (per 1 road km)	**26496**	**26496**	**26496**	**48760**
The wet density of the aggregate to be layer stabilised [kg/m^3]	1950			
The wet density of the aggregate to be mass stabilised [kg/m^3]	1100	1100	1100	
The wet density of the aggregate to be complex stabilised [kg/m^3]		1950	1950	1950
The water content of the aggregate to be layer stabilised [%]	4,5			
The water content of the aggregate to be mass stabilised [%]	550	550	550	
The water content of the aggregate to be complex stabilised [%]		4,5	4,5	4,5
The dry density of the aggregate to be layer stabilised [kg/m^3]	1866			
The dry density of the aggregate to be mass stabilised [kg/m^3]	169,2	169,2	169,2	
The dry density of the aggregate to be complex stabilised [kg/m^3]		1866	1866	1866
The dry density of the aggregate to be stabilised [kg/m^3]	1950	0	0	
Stabiloitavaa runkoainetta_tyoyksilla [m^3/km]	20240	20240	20240	1840
Total mass of stabilised aggregate [t/km]	**41194**	**41194**	**41194**	**3433**
OSA in base course stabilisation [%]	9,0	0	0	0
OSA in base course stabilisation, dry [t/km]	323	0	0	0
OSA in mass stabilisation [%]	20	20	0	0
OSA in mass stabilisation, dry [t/km]	7176	7176	0	0
Bitumen (%)	0	1	1	1
Bitumen (t/km)	0	36	36	36
Cement in base course stabilisation [%]	0,0	0	0	0
Cement in base course stabilisation, dry [t/km]	0	0	0	0
Cement in mass stabilisation [%]	6	6	9	0
Cement in mass stabilisation, dry [t/km]	2153	2153	3229	0
Cement in complex stabilisation [%]		2,5	2,5	2,5
Cement in complex stabilisation, dry [t/km]		90	90	90
Target water content of the binder mixture [%]	30	30	30	30
Extra water for mixing [m^3/km]	2896	2799	969	27
Total mass of the binder mixture [t/km]	9652	9455	3355	126
Total mass of OSA [t/km]	7499	7176	0	0
Total mass of cement [t/km]	2153	2243	3319	90
Total mass of bitumen [t/km]	0	36	36	36

4b Calculated material costs

		Alt 1 Top: Base course stabilisation with OSA (EF CFB). Bottom: Mass stabilisation with OSA (EF CFB) and cement		Alt 2 Top: Complex stabilisation with bitumen and cement. Bottom: Mass stabilisation with OSA (EF CFB) and cement.		Alt 3 Top: Complex stabilisation with bitumen and cement. Bottom: Mass stabilisation with cement.		Alt 4 Top: Complex stabilisation with bitumen and cement. Bottom: Mass exchange from peat to crushed stone.	
Crushed rock sand	Total need [t/road-km]	26 496		26 496		26 496		48 760	
	Unit price [€/t]	13,50		13,50		13,50		13,50	
	Price in the crushing plant [€]	**357 696**		**357 696**		**357 696**		**658 260**	
	Transportation distance [km]	30		30		30		30	
	Transportation cost [€/t-km]	**0,06**		**0,06**		**0,06**		**0,06**	
	Transportations [€/t-km]	**47 693**		**47 693**		**47 693**		**87 768**	
	Cost on site [€/tie-km]		**405 389**		**405 389**		**405 389**		**746 028**
Crushed rock sand to the temporary storage (part of the loading embankment is excavated out). This price is only for the transportation to the temporary storage. The price of crushes rock/sand already taken into account in the previous rows.	Total need [t/road-km]	4 968		4 968		4 968		0	
	Unit price [€/t]	0,00		0,00		0,00		0,00	
	Price in the crushing plant [€]	**0**		**0**		**0**		**0**	
	Transportation distance [km]	3		3		3			
	Transportation cost [€/t-km]	**0,06**		**0,06**		**0,06**			
	Transportations [€/t-km]	**894**		**894**		**894**		**0**	
	Cost on site [€/tie-km]	894	**894**	894	**894**	894	**894**	0	**0**
Binder components	**Cement [t/tie-km]**	2 153		2 243		3 319		90	
	*unit price [€/t]	87,75		87,75		87,75		87,75	
	*price [€]	**188 926**		**196 823**		**291 242**		**7 898**	
	*transportation distance[km]	55		55		55		55	
	*transportation price [€/t-km]	0,1254		0,1254		0,1254		0,1254	
	*transportations [€]	**14 849**		**15 470**		**22 891**		**621**	
	***Costs on site [€/road-km]**		**203 775**		**212 293**		**314 133**		**8 518**
	OSA [t/tie-km]	7 499		7 176		0		0	
	*unit price [€/t]	16,39		16,39		16,39		16,39	
	*price [€]	**122 909**		**117 615**		**0**		**0**	
	*transportation distance[km]	155,0		155,0		155,0		155,0	
	*transportation price [€/t-km]	0,1254		0,1254		0,1254		0,1254	
	*transportations [€]	**145 758**		**139 480**		**0**		**0**	
	***Costs on site [€/road-km]**		**268 667**		**257 095**		**0**		**0**
Benefit from avoiding the land filling of OSA	**OSA [t/road km]**	7 499		7 176		0		0	
	*unit price [€/t]	50,00		50,00		50,00		50,00	
	*price [€]	**-374 950**		**-358 800**		**0**		**0**	
	*transportation distance[km]	5,0		5,0		5,0		5,0	
	*transportation price [€/t-km]	0,13		0,13		0,13		0,13	
	*transportations [€]	**-4 702**		**-4 499**		**0**		**0**	
	***Costs on site [€/road-km]**		**-379 652**		**-363 299**		**0**		**0**
Bitumen	**Bitumen [t/road-km]**	0		36		36		36	
	*unit price [€/t]	430,00		430,00		430,00		430,00	
	*price [€]	**0**		**15 480**		**15 480**		**15 480**	
	*transportation distance[km]	0		135		135		135	
	*transportation price [€/t-km]	1,30		1,30		1,30		1,30	
	*transportations [€]	**0**		**6 318**		**6 318**		**6 318**	
	***Costs on site [€/road-km]**		**0**		**21 798**		**21 798**		**21 798**
Water	**Water [m³/road km]**	2 896		2 799		969		27	
	*unit price [€/t]	0,00		0,00		0,00		0,00	
	*price [€]	**0**		**0**		**0**		**0**	
	*transportation distance[km]	3		3		3		3	
	*transportation price [€/t-km]	0,13		0,13		0,13		0,13	
	*transportations [€]	**1 089**		**1 053**		**364**		**10**	
	***Costs on site [€/road-km]**		1 089		1 053		364		**10**
Landfilling cost from the renovation	**Mass of total material [t/tie-km]**	0		0		0		0	
No landfilling in any of the alternatives	*unit price [€/t]	50,00		50,00		50,00		50,00	
	*price [€]	**0**		**0**		**0**		**0**	
	*transportation distance[km]	5,0		5,0		5,0		5,0	
	*transportation price [€/t-km]	0,13		0,13		0,13		0,13	
	*transportations [€]	**0**		**0**		**0**		**0**	
	***Costs on site [€/road-km]**		**0**		**0**		**0**		**0**
	Material costs on site [€/road km] in initial stage	**500 162**		**535 222**		**742 579**		**776 354**	

4c Calculated work costs

Structures included in the calculation:		**Alt 1 Top: Base course stabilisation with OSA (EF CFB). Bottom: Mass stabilisation with OSA (EF CFB) and cement**		**Alt 2 Top: Complex stabilisation with bitumen and cement. Bottom: Mass stabilisation with OSA (EF CFB) and cement.**		**Alt 3 Top: Complex stabilisation with bitumen and cement. Bottom: Mass stabilisation with cement.**		**Alt 4 Top: Complex stabilisation with bitumen and cement. Bottom: Mass exchange from peat to crushed stone.**	
Pavement (new pavement)		AC 12 surf 4 cm + AC 32 base 5 cm; vast. lev. 9,00 m ja 9,00 m							
AC 12, 4 cm, bitumen 5,6 %	Unit price [€/m^2]	9,03		9,03		9,03		9,03	
AC 32, 5 cm, bitumen 4,0 %	Unit price [€/m^2]	8,09		8,09		8,09		8,09	
	Surface area to be paved [m^2]	9 000		9 000		9 000		9 000	
	New pavement [€]		**154 080**		**154 080**		**154 080**		**154 080**
	Pavement [€/tie-m]	154,08		154,08		154,08		154,08	
	Length of FU [m]	1 000		1 000		1 000		1 000	
Work stages	structure; m3-rtr/FU	20 240		20 240		20 240		1 840	
	structure-theor-aggeregate_m2;/	9 200		9 200		9 200		9 200	
	structure-theor-surf_m2;/FU	9 000		9 000		9 000		9 000	
Milling of the pavement	unit price; €/m2-rtr	0,79	7 110	0,79	7 110	0,79	7 110	0,79	7 110
			7 110		**7 110**		**7 110**		**7 110**
	Costs [€/FU]	**161 190**		**161 190**		**161 190**		**161 190**	
		Alt 1 Top: Base course stabilisation with OSA (EF CFB). Bottom: Mass stabilisation with OSA (EF CFB) and cement		Alt 2 Top: Complex stabilisation with bitumen and cement. Bottom: Mass stabilisation with OSA (EF CFB) and cement.		Alt 3 Top: Complex stabilisation with bitumen and cement. Bottom: Mass stabilisation with cement.		Alt 4 Top: Complex stabilisation with bitumen and cement. Bottom: Mass exchange from peat to crushed stone.	
NEW Pavement (REM)									
AC 12, 4 cm, bitumen 5,6 %	Unit price [€/m^2]	*9,03*		*9,03*		*9,03*		*9,03*	
AC 32, 5 cm, bitumen 4,0 %	Unit price [€/m^2]	*8,09*		*8,09*		*8,09*		*8,09*	
Milling of the pavement	Unit price [€/m^2]	*1,20*		*1,20*		*1,20*		*1,20*	
	Surface area to be paved [m^2]	9 000		9 000		9 000		9 000	
	New pavement [€]		**164 880**		**164 880**		**164 880**		**164 880**
	Pavement [€/tie-m]	*164,88*		*164,88*		*164,88*		*164,88*	
	Length of the FU [m]	1 000		1 000		1 000		1 000	
Layer / complex stabilisation									
Work stages	structure-m^3; m^3-rtr/FU	1 840		1 840		1 840		1 840	
	structure-m^2-pavement	9 000		9 000		9 000		9 000	
	unit price; €/m^3-rtr		0		0		0		0
Stabilisation	unit price; €/m^3-rtr	26	47 840	33	60 720	33	60 720	33	60 720
Milling of the pavement and immediate use in the old structure	unit price; €/m^3-rtr	0,79	7 110	0,79	7 110	0,79	7 110	0,79	7 110
Mass stabilisation									
Work stages	structure-m^3; m^3-rtr/FU	18 400		18 400		18 400			
	structure-m^2-pavement	9 200		9 200		9 200			
	unit price; €/m^3-rtr								
	unit price; €/m^3-rtr	10	184000	10	184000	10	184000		
Spreading the crushed rock									
	structure-m^3; m^3-rtr/FU	7 360		7 360		7 360		23 000	
	structure-m^2-pavement	9 200		9 200		9 200		9 200	
	unit price; €/m^3-rtr	8		8		8		8	
	unit price; €/m^3-rtr		58880		58880		58880		184000
Excavating part of the loading embankment	structure-m^3; m^3-rtr/FU	2 760		2760		2760			
	structure-m^2-pavement	9 200		9200		9200			
	unit price; €/m^3-rtr	8		8		8			
	unit price; €/m^3-rtr		22080		22080		22080		
Adding of water	unit price; €/m^3-rtr		0	0	0	0	0	0	0
			484 790		**497 670**		**497 670**		**416 710**
	Costs [€/FU]	**649 670**		**662 550**		**662 550**		**581 590**	

4d Maintenance scenarios

Structure alternative			Alt 1 Top: Base course stabilisation with OSA (EF CFB). Bottom: Mass stabilisation with OSA (EF CFB) and cement	Alt 2 Top: Complex stabilisation with bitumen and cement. Bottom: Mass stabilisation with OSA (EF CFB) and cement.	Alt 3 Top: Complex stabilisation with bitumen and cement. Bottom: Mass stabilisation with cement.	Alt 4 Top: Complex stabilisation with bitumen and cement. Bottom: Mass exchange from peat to crushed stone.
Pavement			AC	AC	AC	AC
Patching (UREM) (assumption 50 % * 40 % of the REM price)	**Maintenance intervalles (a)**		6	6	6	6
			30 816	**30 816**	**30 816**	**30 816**
Re-newing the pavement (REM)	**Cycles for maintenance (a)**		10	10	10	10
			154 080	**154 080**	**154 080**	**154 080**
Need for renovation	***Scenario 1***	**Action cycles / a**	25	25	25	25
		Action	Re-newing the structure. New pavement.	Re-newing the structure. New pavement.	Re-newing the structure. New pavement.	Re-newing the structure. New pavement.
		€/FU	**1 149 832**	**1 197 772**	**1 405 129**	**1 357 944**
	Scenario 2	**Action cycles / a**	30	28	28	28
		Action	Re-newing the structure. New pavement.	Re-newing the structure. New pavement.	Re-newing the structure. New pavement.	Re-newing the structure. New pavement.
		€/FU	**1 149 832**	**1 197 772**	**1 405 129**	**1 357 944**
	Scenario 3	**Action cycles / a**	35	31	31	31
		Action	Re-newing the structure. New pavement.	Re-newing the structure. New pavement.	Re-newing the structure. New pavement.	Re-newing the structure. New pavement.
		€/FU	**1 149 832**	**1 197 772**	**1 405 129**	**1 357 944**

4e Current values of maintenance scenarios

Current value of the actions / scenario 1

Year	Alternatives / actions				Year	D(ir)	Alternatives / actions			
	Alt1	**Alt2**	**Alt3**	**Alt4**			**Alt1**	**Alt2**	**Alt3**	**Alt4**
0	0	0	0	0	0	1,000				
1	0	0	0	0	1	0,962				
2	0	0	0	0	2	0,925				
3	0	0	0	0	3	0,889				
4	0	0	0	0	4	0,855				
5	0	0	0	0	5	0,822				
6	24 354	24 354	24 354	24 354	6	0,790	30 816	30 816	30 816	30 816
7	0	0	0	0	7	0,760				
8	0	0	0	0	8	0,731				
9	0	0	0	0	9	0,703				
10	104 091	104 091	104 091	104 091	10	0,676	154 080	154 080	154 080	154 080
11	0	0	0	0	11	0,650				
12	0	0	0	0	12	0,625				
13	0	0	0	0	13	0,601				
14	0	0	0	0	14	0,577				
15	0	0	0	0	15	0,555				
16	16 453	16 453	16 453	16 453	16	0,534	30 816	30 816	30 816	30 816
17	0	0	0	0	17	0,513				
18	76 058	76 058	76 058	76 058	18	0,494	154 080	154 080	154 080	154 080
19	0	0	0	0	19	0,475				
20	0	0	0	0	20	0,456				
21	0	0	0	0	21	0,439				
22	0	0	0	0	22	0,422				
23	0	0	0	0	23	0,406				
24	0	0	0	0	24	0,390				
25	431 321	449 305	527 087	509 388	25	0,375	1 149 832	1 197 772	1 405 129	1 357 944
26	55 575	55 575	55 575	55 575	26	0,361	154 080	154 080	154 080	154 080
27	0	0	0	0	27	0,347				
28	0	0	0	0	28	0,333				
29	0	0	0	0	29	0,321				
30	0	0	0	0	30	0,308				
31	0	0	0	0	31	0,296				
32	0	0	0	0	32	0,285				
33	0	0	0	0	33	0,274				
34	40 608	40 608	40 608	40 608	34	0,264	154 080	154 080	154 080	154 080
35	0	0	0	0	35	0,253				
36	7 509	7 509	7 509	7 509	36	0,244	30 816	30 816	30 816	30 816
37	0	0	0	0	37	0,234				
38	0	0	0	0	38	0,225				
39	0	0	0	0	39	0,217				
40	0	0	0	0	40	0,208				
41	0	0	0	0	41					
Current value	**755 970**	**773 953**	**851 736**	**834 036**						

Current value of the actions, scenario 2

Year	Alternatives / actions				Year	D(ir)	Alternatives / actions			
	Alt1	Alt2	Alt3	Alt4			Alt1	Alt2	Alt3	Alt4
0	0	0	0	0	0	1,000				
1	0	0	0	0	1	0,962				
2	0	0	0	0	2	0,925				
3	0	0	0	0	3	0,889				
4	0	0	0	0	4	0,855				
5	0	0	0	0	5	0,822				
6	24 354	24 354	24 354	24 354	6	0,790	30 816	30 816	30 816	30 816
7	0	0	0	0	7	0,760				
8	0	0	0	0	8	0,731				
9	0	0	0	0	9	0,703				
10	104 091	104 091	104 091	104 091	10	0,676	154 080	154 080	154 080	154 080
11	0	0	0	0	11	0,650				
12	0	0	0	0	12	0,625				
13	0	0	0	0	13	0,601				
14	0	0	0	0	14	0,577				
15	0	0	0	0	15	0,555				
16	16 453	16 453	16 453	16 453	16	0,534	30 816	30 816	30 816	30 816
17	0	0	0	0	17	0,513				
18	76 058	76 058	76 058	76 058	18	0,494	154 080	154 080	154 080	154 080
19	0	0	0	0	19	0,475				
20	0	0	0	0	20	0,456				
21	0	0	0	0	21	0,439				
22	0	0	0	0	22	0,422				
23	0	0	0	0	23	0,406				
24	0	0	0	0	24	0,390				
25	0	0	0	0	25	0,375				
26	55 575	55 575	55 575	55 575	26	0,361	154 080	154 080	154 080	154 080
27	0	0	0	0	27	0,347				
28	0	399 430	468 579	452 844	28	0,333		1 197 772	1 405 129	1 357 944
29	0	0	0	0	29	0,321				
30	354 515	0	0	0	30	0,308	1 149 832			
31	0	0	0	0	31	0,296				
32	0	0	0	0	32	0,285				
33	0	0	0	0	33	0,274				
34	40 608	40 608	40 608	40 608	34	0,264	154 080	154 080	154 080	154 080
35	0	0	0	0	35	0,253				
36	7 509	7 509	7 509	7 509	36	0,244	30 816	30 816	30 816	30 816
37	0	0	0	0	37	0,234				
38	0	0	0	0	38	0,225				
39	0	0	0	0	39	0,217				
40	0	0	0	0	40	0,208				
41	0	0	0	0	41					
Current value	**679 163**	**724 078**	**793 227**	**777 492**						

Current value of the actions, scenario 3

Year	Alternatives / actions				Year	D(ir)	Alternatives / actions			
	Alt1	Alt2	Alt3	Alt4			Alt1	Alt2	Alt3	Alt4
0	0	0	0	0	0	1,000				
1	0	0	0	0	1	0,962				
2	0	0	0	0	2	0,925				
3	0	0	0	0	3	0,889				
4	0	0	0	0	4	0,855				
5	0	0	0	0	5	0,822				
6	24 354	24 354	24 354	24 354	6	0,790	30 816	30 816	30 816	30 816
7	0	0	0	0	7	0,760				
8	0	0	0	0	8	0,731				
9	0	0	0	0	9	0,703				
10	104 091	104 091	104 091	104 091	10	0,676	154 080	154 080	154 080	154 080
11	0	0	0	0	11	0,650				
12	0	0	0	0	12	0,625				
13	0	0	0	0	13	0,601				
14	0	0	0	0	14	0,577				
15	0	0	0	0	15	0,555				
16	16 453	16 453	16 453	16 453	16	0,534	30 816	30 816	30 816	30 816
17	0	0	0	0	17	0,513				
18	76 058	76 058	76 058	76 058	18	0,494	154 080	154 080	154 080	154 080
19	0	0	0	0	19	0,475				
20	14 064	14 064	14 064	14 064	20	0,456	30 816	30 816	30 816	30 816
21	0	0	0	0	21	0,439				
22	0	0	0	0	22	0,422				
23	0	0	0	0	23	0,406				
24	0	0	0	0	24	0,390				
25	0	0	0	0	25	0,375				
26	55 575	55 575	55 575	55 575	26	0,361	154 080	154 080	154 080	154 080
27	0	0	0	0	27	0,347				
28	0	0	0	0	28	0,333				
29	0	0	0	0	29	0,321				
30	0	0	0	0	30	0,308				
31	0	355 092	416 565	402 577	31	0,296		1 197 772	1 405 129	1 357 944
32	0	0	0	0	32	0,285				
33	0	0	0	0	33	0,274				
34	40 608	40 608	40 608	40 608	34	0,264	154 080	154 080	154 080	154 080
35	291 385	0	0	0	35	0,253	1 149 832			
36	7 509	7 509	7 509	7 509	36	0,244	30 816	30 816	30 816	30 816
37	0	0	0	0	37	0,234				
38	0	0	0	0	38	0,225				
39	0	0	0	0	39	0,217				
40	0	0	0	0	40	0,208				
41	0	0	0	0	41					
Current value	**630 098**	**693 804**	**755 277**	**741 289**						

4f LCC calculation final results

Construction and maintenance scenario 1

		Alt1	Alt2	Alt3	Alt4
Construction costs, year 0	R_N	**770 180**	**834 473**	**1 405 129**	**1 357 944**
Current value of maintenance costs	KP_N	755 970	773 953	851 736	834 036
Current value of depreciation value	$-J_N$	539 126	584 131	983 590	950 561
Current value of the costs	K_N	987 024	1 024 295	1 273 275	1 241 419
Annual cost	$c*K_N$	49 868	51 751	64 330	62 721
Differences vs. Alt1 (annual costs)	%				

annuity factor = c $[i*(1+i)^n]/[(1+i)^n-1]$	0,051	0,051	0,051	0,051

Construction and maintenance scenario 2

		Alt1	Alt2	Alt3	Alt4
Construction costs, year 0	R_N	**770 180**	**834 473**	**1 405 129**	**1 357 944**
Current value of maintenance costs	KP_N	679 163	724 078	793 227	777 492
Current value of depreciation value	$-J_N$	539 126	584 131	983 590	950 561
Current value of the costs	K_N	910 217	974 420	1 214 766	1 184 876
Annual cost	$c*K_N$	45 987	49 231	61 374	59 864
Differences vs. Alt1 (annual costs)	%				

annuity factor = c $[i*(1+i)^n]/[(1+i)^n-1]$	0,051	0,051	0,051	0,051

Construction and maintenance scenario 3

		Alt1	Alt2	Alt3	Alt4
Construction costs, year 0	R_N	**770 180**	**834 473**	**1 405 129**	**1 357 944**
Current value of maintenance costs	KP_N	630 098	693 804	755 277	741 289
Current value of depreciation value	$-J_N$	539 126	584 131	983 590	950 561
Current value of the costs	K_N	861 152	944 146	1 176 816	1 148 672
Annual cost	$c*K_N$	43 508	47 702	59 457	58 035
Differences vs. Alt1 (annual costs)	%				

annuity factor = c $[i*(1+i)^n]/[(1+i)^n-1]$	0,051	0,051	0,051	0,051

Interest 4 %				
Current value	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 4**
Scenario 1	987 024	1 024 295	1 273 275	1 241 419
Scenario 2	910 217	974 420	1 214 766	1 184 876
Scenario 3	861 152	944 146	1 176 816	1 148 672
Annual cost	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 4**
Scenario 1	49 868	51 751	64 330	62 721
Scenario 2	45 987	49 231	61 374	59 864
Scenario 3	43 508	47 702	59 457	58 035