APPENDIX J PHYSICAL ENVIRONMENT IMPACT ASSESSMENT

J DETAILED AIR QUALITY METHODOLOGY

J.1 PHYSICAL RESOURCES AND RECEPTORS

A physical resource is determined to be:

- a 'human receptor' within:
  - 250 m of the boundary of the site; and/or
  - 50 m of the route(s) used by construction vehicles on the public highway, up to 250 m from the site entrance(s).
- an 'ecological receptor' within:
  - 50 m of the boundary of the site; and/or
  - 50 m of the route(s) used by construction vehicles on the public highway, up to 250 m from the site entrance(s)

The nearest sensitive human and environmental receptors which may be impacted by construction activities are:

- The closest dwellings, including schools, shopping centres, hospitals, and churches, rivers, forests and agricultural lands which are located within 2 km of the site.

The baseline study has shown the airshed[63] in the Project area is not degraded for both SO_2, NO_x, NO_2 and PM_{10} against IFC standards. The potential human receptors are of moderate sensitivity.

J.1.1 CONSTRUCTION DUST

Construction activities can lead to emissions of dust. The process for the air quality assessment for construction dust impacts is based on the methodology shown in Figure J-1.

In lieu of international guidance the Institute of Air Quality Management (IAQM) guidelines [64] have been adopted and adapted for this project. Following the guidelines high-risk assessments must be carried out in areas where human receptors are located within 250 m of the site's boundary. These assessments are crucial to evaluate the potential impacts on air quality and the health risks posed to nearby residents. The IAQM emphasizes the importance of identifying and managing risks to ensure that any significant adverse effects on the local population are minimized. This process involves detailed monitoring and analysis of pollutant levels, as well as the implementation of appropriate mitigation measures to protect public health and maintain compliance with air quality standards.

J.1.2 CONSTRUCTION TRAFFIC

Project construction can generate traffic on nearby roads and thereby associated combustion emissions and dust level raising. The process for the air quality assessment for traffic-related

[63] Airshed is a geographical area that often shares the same air because of topography, meteorology, and/or climate. The air is generally confined or channeled, with all parts of the area therefore being subject to similar conditions of air pollution.

[64] IAQM (2024) Assessment of dust from demolition and construction V2.2

impacts associated with the construction phase of the project is based on the methodology as shown in the infographic in Figure J-2.

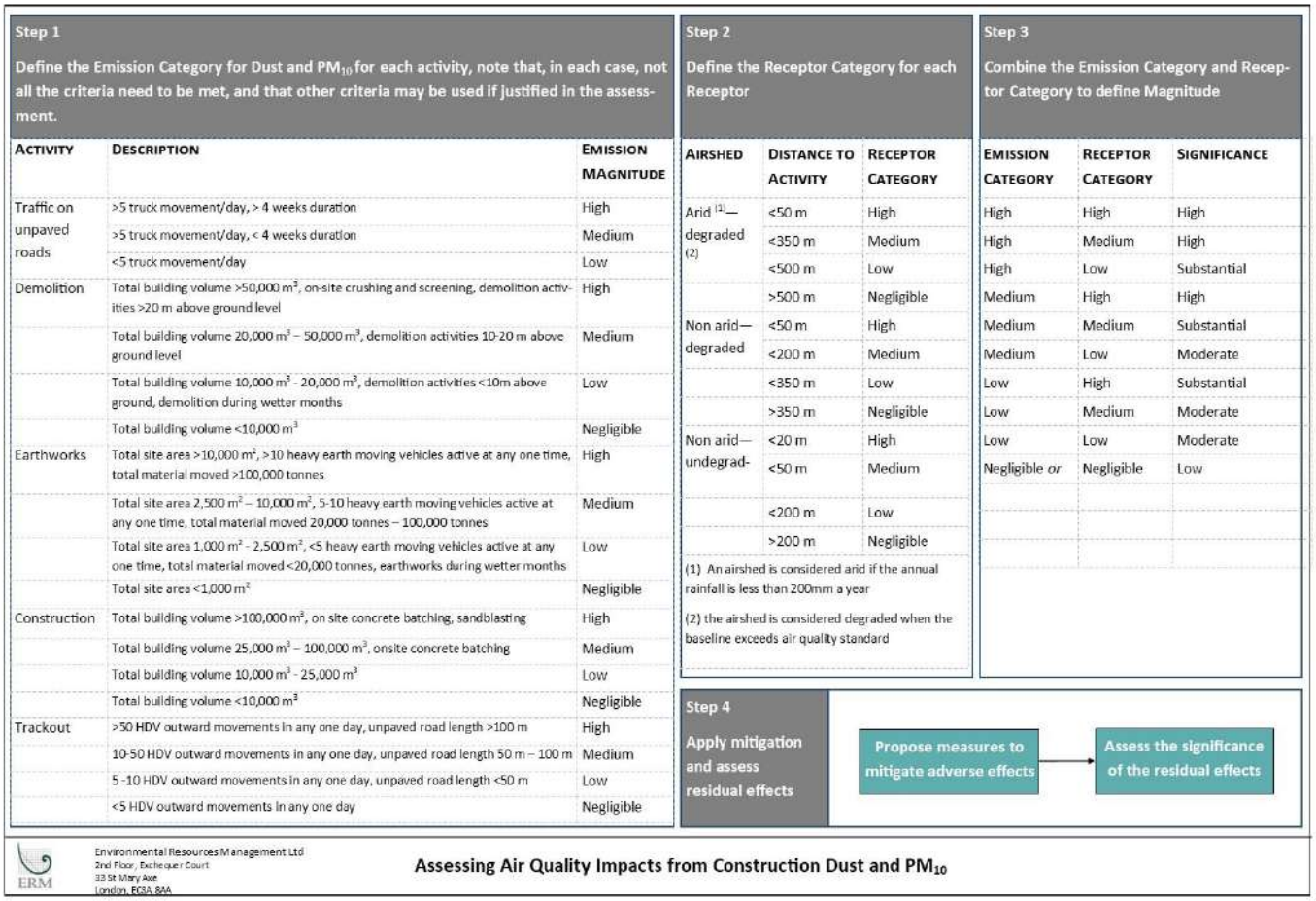
The World Bank and the national Bhutan regulations do not provide prescriptive methodologies for assessing road traffic. Instead, a screening method has been used based upon the UK Highways Agency Design Manual for Roads and Bridges (DMRB) [65] and IFC Toll Road guidelines adapted for the traffic fleet likely to be in place in Bhutan. DMRB is a semi-quantitative method that utilises traffic emission factors, and a dispersion factor derived from ADMS-Roads model for a typical road to estimate roadside concentrations at increments away from the roadside. This approach provided a set of traffic screening criteria corresponding to thresholds for Minor, Moderate and Major Impacts. These screening thresholds can be used in the future to identify the potential for significant impacts to arise.

J.1.3 OPERATIONAL TRAFFIC

The methodology used to assess the impacts of construction traffic has been similarly applied to evaluate the impacts during the operational phase of the Project. This approach ensures a consistent and comprehensive analysis of potential air quality effects associated with ongoing traffic once the project becomes operational.

UK Highways Agency (2008) Design Manual for Roads and Bridges: http://www.standardsforhighways.co.uk/dmrb/vol11/section3/11s3p01.pdf

FIGURE J-1 INFOGRAPHIC FOR AIR QUALITY ASSESSMENT OF DUST



Step 1

Define the Emission Category for Dust and PM_{10} for each activity, note that, in each case, not all the criteria need to be met, and that other criteria may be used if justified in the assessment.

Activity	Description	Emission Magnitude
Traffic on unpaved roads	>5 truck movement/day, > 4 weeks duration	High
	>5 truck movement/day, < 4 weeks duration	Medium
	<5 truck movement/day	Low
Demolition	Total building volume >50,000 m^3, on-site crushing and screening, demolition activities >20 m above ground level	High
	Total building volume 20,000 m^3 – 50,000 m^3, demolition activities 10-20 m above ground level	Medium
	Total building volume 10,000 m^3 - 20,000 m^3, demolition activities <10m above ground, demolition during wetter months	Low
	Total building volume <10,000 m^3	Negligible
Earthworks	Total site area >10,000 m^2, >10 heavy earth moving vehicles active at any one time, total material moved >100,000 tonnes	High
	Total site area 2,500 m^2 – 10,000 m^2, 5-10 heavy earth moving vehicles active at any one time, total material moved 20,000 tonnes – 100,000 tonnes	Medium
	Total site area 1,000 m^2 - 2,500 m^2, <5 heavy earth moving vehicles active at any one time, total material moved <20,000 tonnes, earthworks during wetter months	Low
	Total site area <1,000 m^2	Negligible
Construction	Total building volume >100,000 m^3, on site concrete batching, sandblasting	High
	Total building volume 25,000 m^3 – 100,000 m^3, onsite concrete batching	Medium
	Total building volume 10,000 m^3 - 25,000 m^3	Low
	Total building volume <10,000 m^3	Negligible
Trackout	>50 HDV outward movements in any one day, unpaved road length >100 m	High
	10-50 HDV outward movements in any one day, unpaved road length 50 m – 100 m	Medium
	5 -10 HDV outward movements in any one day, unpaved road length <50 m	Low
	<5 HDV outward movements in any one day	Negligible

Step 2

Define the Receptor Category for each Receptor

Airshed	Distance to Activity	Receptor Category
Arid [1]— degraded [2]	<50 m	High
	<350 m	Medium
	<500 m	Low
	>500 m	Negligible
Non arid— degraded	<50 m	High
	<200 m	Medium
	<350 m	Low
	>350 m	Negligible
Non arid— undegrad-	<20 m	High
	<50 m	Medium
	<200 m	Low
	>200 m	Negligible

(1) An airshed is considered arid if the annual rainfall is less than 200mm a year

(2) the airshed is considered degraded when the baseline exceeds air quality standard

Step 3

Combine the Emission Category and Receptor Category to define Magnitude

Emission Category	Receptor Category	Significance
High	High	High
High	Medium	High
High	Low	Substantial
Medium	High	High
Medium	Medium	Substantial
Medium	Low	Moderate
Low	High	Substantial
Low	Medium	Moderate
Low	Low	Moderate
Negligible *or*	Negligible	Low

Step 4

Apply mitigation and assess residual effects

Propose measures to mitigate adverse effects → **Assess the significance of the residual effects**

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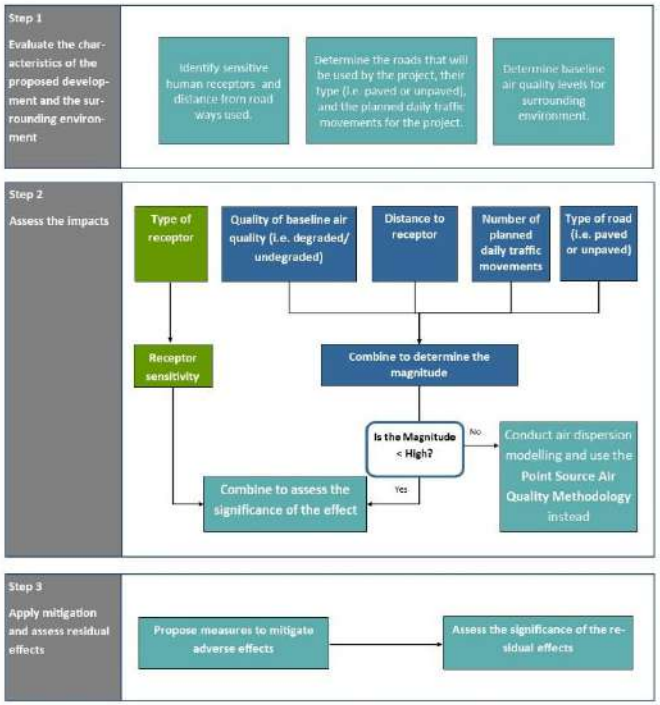
Assessing Air Quality Impacts from Construction Dust and PM_{10}

FIGURE J-2 TRAFFIC INFOGRAPHIC FOR AIR QUALITY ASSESSMENT

Overview

The IFC are not prescriptive in determining the threshold of road traffic which may result in significant impacts. The only guidance provided is that operators of fleets with greater than 120 Heavy Goods Vehicles should consider using lower emission vehicles. This methodology is therefore based upon the UK Highways Agency Design Manual for Roads and Bridges assuming Euro 3 or equivalent fleet .

The methodology is based upon the calculated increases in vehicles needed to trigger the significance thresholds, based upon the interpretation of the IFCs significance criteria.



Receptor Sensitivity

Note that this methodology applies only to human receptors (i.e. not ecological receptors). The table below provides receptor sensitivity with respects to human health.

Sensitivity	Description
Low	N/A
Moderate	N/A
Substantial	General population
High	Particularly vulnerable individuals, e.g. a hospital with intensive care ward

Magnitude of Change

The magnitude of the impacts to air quality from project traffic are determined using the combination of factors illustrated to the left. The first step in this process is identifying the relative level of traffic.

Road Type	Type of Traffic	Annual Average Daily Traffic (AADT), e.g. number of traffic movements	Level of Project Traffic (Relative to the Baseline Air Quality)	
			Undegraded Airshed	Degraded Airshed
Paved Roads	Heavy Duty Vehicles (HDV)	<440	Low	Low
		<1000	Low	Moderate
		<3200	Low	Substantial
		<15000	Moderate	High
		>15000	High	High
	Light Duty Vehicles (LDV)	<7600	Low	Low
		<17000	Low	Moderate
		<55000	Moderate	Substantial
		<250000	Substantial	High
		>250000	High	High

This methodology applies to road traffic exhaust emissions. Emissions of dust arising from the use of unpaved roads by vehicles is assessed separately .

The magnitude can then be determined using the matrix below.

Level of Project Traffic	Distance of Receptor to Road				
	>100m	<100m	<50m	<20m	<5m
High	Low	Low	Substantial	High	High
Substantial	Low	Moderate	Moderate	Substantial	High
Moderate	Low	Low	Low	Low	Moderate
Low	Low	Low	Low	Low	Low

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Assessing Air Quality Impacts from Road Traffic

J.2 DETAILED NOISE IMPACT METHODOLOGY

To evaluate the impact of noise effects during the construction and operation phases, it is necessary to establish criteria at which some significant adverse effect may be experienced.

As noted in Chapter 3, The Royal Government of Bhutan provides criteria[66] for external noise. These criteria are generally in-line with the World Bank Group (WB) Environmental, Health, and Safety (EHS) Guidelines[67] (hereafter referred to as the EHS Guidelines). The criteria are presented in ***Table J-1.***

TABLE J-1 NATIONAL AND INTERNATIONAL GUIDELINES FOR EXTERNAL NOISE

	Environmental Standards 2020[b]		**EHS Guidelines[c]**	
Parameter	Day (0600-2200hrs)	Night (2200-0600hrs)	Day (0700-2200hrs)	Night (2200-0700hrs)
Industrial area	75 dB	65 dB	70 dB	70 dB
Mixed area	65 dB	55 dB	-	-
Sensitive area[a]	55 dB	45 dB	55 dB	45 dB

Source:
Royal Government of Bhutan; WB
Note:
[a] Also referred to as "Residential; institutional; educational" in the EHS Guidelines
[b] Values stated as "maximum" and A-weighted
[c] Values stated as $L_{Aeq,T}$
[d] EHS Guidelines also state that noise levels also should not result in a maximum increase in background noise levels of 3 dB at the nearest receptor

Construction noise impact magnitude is often judged by the exceedance of absolute noise thresholds, given that predicted noise emissions are typically well above baseline noise levels. In the absence of specific national/international guidance on construction noise, it is considered best practice to adopt thresholds based on the guidance given in BS 5228[68] to represent the point at which a 'Medium' magnitude noise impact would occur. The following criteria apply at 1m from the façades of sensitive receptors and take into account reflection effects[69]. Specific details on construction operating times were not available at the time of the assessment, and therefore it has been assumed for the purpose of the assessment that no construction activities will be largely conducted outside of 0700-1900hrs. Instances where activities proceed into the night (e.g., for particularly large concrete pours) it is assumed that these instances are isolated and very short in duration, thus unlikely to lead to a significant impact. This will be confirmed in due course as part of the final ESIA submission.

- 70 dB $L_{Aeq,12h}$ at during the day (0700-1900hrs) for residential properties in rural, suburban and urban areas away from main road traffic;

[66] Environmental Standards, 2020. National Environment Commission; Royal Government of Bhutan. 2020
[67] Environmental, Health and Safety (EHS) Guidelines – General EHS Guidelines: Introduction. World Bank Group; International Finance Corporation. 2007
[68] BS 5228-1:2009+A1:2014. The British Standards Institution 2014
[69] Sound can be amplified as it reflects from nearby surfaces. Sound measured within close proximity to a reflective surface is typically expected to be up to 3 dB higher than when in free-field conditions.

- 65 dB $L_{Aeq,12h}$ during the day (0700-1900hrs) for hospitals and educational buildings.

The impact magnitudes of the construction noise are presented in Table J-2, based on the above thresholds.

TABLE J-2 MAGNITUDE OF CONSTRUCTION NOISE EFFECTS

Description[a,b]	**Residential properties in rural, suburban and urban areas, dB $L_{Aeq,12h}$**	**Hospitals and educational buildings, dB L_{Aeq12h}**	**Magnitude of predicted impact**
5 or more below the criteria	<65	<60	Negligible
> 5 below, up to the criteria	≥65 to <70	≥60 to <65	Low
Up to 5 dB above the criteria	≥70 to <75	≥65 to <70	Medium
> 5 above the criteria	≥75	≥70	High

Note:
[a] Criteria for residential properties in rural, suburban and urban areas away from main road traffic is 70 dB $L_{Aeq,12h}$.
[b] Criteria for hospitals and educational buildings is 65 dB $L_{Aeq,12h}$.

For the assessment of operation road traffic noise, the thresholds in the EHS Guidelines are regarded as 'preferred noise levels', above which, in general terms noise is likely to cause some disturbance.

An alternative WB and IFC guidance document relating to toll roads[70] (hereafter referred to as the WB Toll Roads Guidance) has also been considered, which provides a specific noise impact example of 70 dB L_{A10} as being the upper road traffic noise limit for residential land use in the USA. L_{A10} levels are usually a few decibels higher than L_{Aeq} levels for road traffic noise so the value can be broadly converted to 65 dB $L_{Aeq,T}$ (the difference is typically 3-5 dB), which in other countries, similar levels are used to indicate that mitigation is required. Thus, noise levels above this precautionary level of 65 dB $L_{Aeq,T}$ during the day can be considered high and will, in general, warrant consideration of further mitigation where practicable, noting there are no national requirements to mitigate at that level.

The EHS Guidelines also require that the baseline noise levels must increase for an impact to be predicted. The noise survey results suggest that baseline noise levels fluctuate between 52-60 dB throughout the day. Baseline noise levels are expected to be increased for most affected receptors so therefore impacts can be derived based on absolute thresholds, as shown in Table J-3 below.

[70] Environmental, Health, and Safety Guidelines – Toll Roads. World Bank Group; International Finance Corporation. 2007

TABLE J-3 MAGNITUDE OF OPERATION NOISE EFFECTS

Absolute thresholds during the day, dB $L_{Aeq,16h}$	**Absolute thresholds during the night, dB $L_{Aeq,8h}$[a]**	**Magnitude of predicted impact**
≤55	≤45	Negligible
>55 to <60	>45 to <50	Low
≥60 to <65	≥50 to <55	Medium
≥65	≥55	High

Note:
[a] Night-time threshold derived on the basis that the EHS guidelines night-time thresholds are 10 dB lower than during the day.

When assessing the significance of an impact for the noise assessment, the process is slightly different to most other topics in this ESIA. The significance of an impact is derived from the impact magnitude, along with professional judgement on other factors such as:

- The duration of the noise event;
- The time when it occurs;
- The characteristics of the noise (e.g., whether the noise is tonal or impulsive); and
- The estimated sensitivity of the receptor.

For example, if the noise effect is loud, but very brief, broadband (without audible tones) and happens during times when residential properties are likely less noise sensitive then the significance may be downgraded.

The overall significance of the noise impact will be derived using the matrix in Chapter 5. Where the significance of an impact warrants an amendment based on the contextual considerations mentioned above, clear justification will be provided.

J.2.1 CONSTRUCTION NOISE CALCULATION DETAILS

1. Introduction

This appendix presents the construction plant information used to inform the construction noise impact assessment. This information was omitted from the main text for clarity.

Sound power levels for plant items and activities have been extracted from Annex C of BS5228 unless otherwise stated.

Details of the plant 'percentage on time' were not available at the time of the assessment so it has been assumed that each plant item / activity operates of the 50% of the time. It should be noted however that this is still considered conservative for some activities.

Based on the successful implementation of the noise control mitigation and management measures described above, it is envisaged that a reduction in the overall noise from construction plant teams of approximately 3 dB is achievable from the noise data provided in BS 5228.

2.0 Road construction

TABLE J-4 SITE PREPARATION, LAND CLEARANCE AND EARTHWORKS

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Crane, mobile (diesel)	1	C3.30	50	3 dB	92
Excavator/loader, wheeled/tracked	1	C5.35			102
Lorry	1	C9.25			104
				Total	106

TABLE J-5 ROAD SURFACING AND RETAINING WALLS

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Air compressor, air flow > 10m3/min and <= 30m3/min	2	C5.5	50	3 dB	90
Asphalt paver	2	C5.31			102
Crane, mobile (diesel)	2	C3.30			95
Dump truck	2	C1.11			105
Excavator/loader, wheeled/tracked	2	C5.35			99
Generator, silenced, 75 dB(A) at 7 m	2	Project team			98

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Lorry	2	C9.25			107
Paint line marker	2	C4.76			86
Roller, vibratory	2	C5.20			100
Water pump, submersible (electric)	2	C2.45			90
				Total	111

TABLE J-6 CONSTRUCTION OF CULVERTS, DRAINAGE AND WATER MANAGEMENT STRUCTURES

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Crane, mobile (diesel)	1	C3.30	50	3 dB	92
Excavator/loader, wheeled/tracked	1	C5.35			96
Lorry	1	C9.25			104
Concrete lorry mixer	1	C4.20			102
Poker, vibratory, hand-held	2	C4.33			103
Generator, silenced, 75 dB(A) at 7 m	1	Project team			95
Saw, circular, wood	1	C4.70			113
				Total	114

TABLE J-7 SLOPE WORKS FOR EXISTING ROAD WIDENING

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Breaker, hand-held	4	C5.3	50	3 dB	110
Breaker, excavator mounted (hydraulic)	1	C5.2			105
Compactor, vibratory	1	C2.42			100
Drilling rig	1	C6.35			108

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Excavator/loader, wheeled/tracked	1	C5.35			96
Generator, silenced, 75 dB(A) at 7 m	1	Project Team			95
Grout mixer	1	C4.19			93
Grout pump	1	C4.18			97
Lorry	1	C9.25			104
				Total	114

3. Bridge Construction

TABLE J-8 PILING WORKS

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Air compressor, air flow > 10m3/min and <= 30m3/min	1	C5.5	50	3 dB	87
Breaker, hand-held, mass <= 10kg	1	C5.3			104
Concrete lorry mixer	1	C4.20			102
Crane, mobile (diesel)	1	C3.30			92
Excavator/loader, wheeled/tracked	1	C5.35			96
Generator, silenced, 75 dB(A) at 7 m	1	Project team			95
Lorry	1	C9.25			104
Piling, large diameter bored, grab and chisel	1	C3.14			105
Water pump, submersible (electric)	1	C2.45			87
				Total	110

TABLE J-9 CONSTRUCTION OF PILING CAPS AND PIERS

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Air compressor, air flow > 10m3/min and <= 30m3/min	1	C5.5	50	3 dB	87
Breaker, hand-held, mass <= 10kg	1	C5.3			104
Concrete lorry mixer	1	C4.20			102
Concrete pump, lorry mounted	1	C4.18			97
Crane, mobile (diesel)	1	C3.30			92
Excavator/loader, wheeled/tracked	1	C5.35			96
Lorry	1	C9.25			104
Poker, vibratory, hand-held	2	C4.33			103
Generator, silenced, 75 dB(A) at 7 m	1	Project team			95
Saw, circular, wood	2	C4.70			116
				Total	117

TABLE J-10 CONSTRUCTION OF SUPERSTRUCTURES

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Concrete lorry mixer	1	C4.20	50	3 dB	102
Concrete mixer (petrol)	1	C4.20			102
Concrete pump, lorry mounted	1	C4.18			97
Crane, mobile (diesel)	1	C3.30			92
Generator, silenced, 75 dB(A) at 7 m	1	Project team			95
Lorry	1	C9.25			104
Poker, vibratory, hand-held	1	C4.33			100
Saw, circular, wood	1	C4.70			113

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Travelling formwork / falsework (for in-situ box only)	2	C5.37			98
				Total	115

4.0 Miscellaneous Works

TABLE J-11 RIVER TRAINING WORKS AND LANDSCAPE WORKS

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Crane, mobile (diesel)	1	C3.30	50	3 dB	92
Excavator/loader, wheeled/tracked	1	C5.35			96
Generator, silenced, 75 dB(A) at 7 m	1	Project team			95
Lorry	1	C9.25			104
				Total	105

TABLE J-12 TREE FELLING

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Breaker, hand-held	1	C5.3	50	3 dB	104
Crane, mobile (diesel)	1	C3.30			92
Excavator/loader, wheeled/tracked	1	C5.35			96
Lorry	1	C9.25			104
Saw, circular, wood	1	C4.70			113
				Total	114

TABLE J-13 CONSTRUCTION OF CONCRETE BATCHING PLANT

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Air compressor, air flow > 10m3/min and <= 30m3/min	1	C5.5	50	3 dB	87
Breaker, hand-held	1	C5.3			104
Concrete lorry mixer	1	C4.20			102
Crane, mobile (diesel)	1	C3.30			92
Dump truck	1	C1.11			102
Excavator/loader, wheeled/tracked	1	C5.35			96
Generator, silenced, 75 dB(A) at 7 m	1	Project team			95
Poker, vibratory, hand-held	1	C4.33			100
				Total	109

J.2.2 OPERATION NOISE CALCULATION DETAILS

1.0 Introduction

This appendix presents the road traffic data used for the noise modelling, as well as calculation settings. This information was omitted from the main text for clarity.

2.0 Calculation Settings and Assumptions

Road traffic noise emissions were assumed to be propagating across a flat ground with mixed absorption (G=0.5). No buildings have been included in the noise model so therefore it is appropriate to assume a reflection order of 1.

Grid and receiver heights were set to 1.5m above ground.

Road traffic noise emissions were calculated in accordance with the methodology set out in CoRTN, based on hourly traffic flows and composition presented in the tables below.

CoRTN calculates road traffic noise emissions as L_{A10} values, so the following approximate relationship was used to derive $L_{Aeq,T}$ daytime and night-time values: $L_{Aeq,T} \approx L_{A10} - 3$ dB.

No traffic flow data was provided for the segment of existing road that will be widened as part of the Project. It was therefore assumed that road traffic flows and composition along this road is the same as Segment 6.

Road traffic was assumed to be flowing consistently at 60 km/h.

3.0 Traffic flow data

FIGURE J-3 ROAD TRAFFIC FLOW SEGMENTS

Source: Arup

TABLE J-14 YEAR 2035 TRAFFIC (SCENARIO 1)

Vehicle type	Time	Hourly traffic count per segment (see Figure J-3)					
		1	2	3	4	5	6
Car and LGV	0000	97	111	121	27	1	15
	0100	55	62	68	15	1	8
	0200	66	74	82	18	1	10
	0300	64	72	79	18	1	10
	0400	158	179	196	44	2	24
	0500	409	464	509	115	4	61
	0600	1042	1181	1296	292	10	156

Vehicle type	Time	Hourly traffic count per segment (see Figure J-3)					
		1	2	3	4	5	6
	0700	2251	2552	2800	630	22	337
	0800	2254	2556	2804	631	22	338
	0900	1799	2039	2238	504	18	269
	1000	1568	1778	1951	439	16	235
	1100	1489	1688	1852	417	15	223
	1200	1613	1828	2006	452	16	242
	1300	1627	1844	2024	456	16	244
	1400	1880	2132	2339	527	19	282
	1500	2063	2339	2566	578	21	309
	1600	2394	2714	2978	671	24	359
	1700	2391	2710	2974	670	24	358
	1800	1655	1877	2059	464	17	248
	1900	948	1075	1179	266	9	142
	2000	753	854	937	211	8	113
	2100	615	697	765	172	6	92
	2200	436	494	542	122	4	65
	2300	229	259	284	64	2	34
HGV	0000	5	8	6	1	0	1
	0100	3	5	3	1	0	0
	0200	3	5	4	1	0	0
	0300	3	5	4	1	0	0
	0400	8	13	10	2	0	1
	0500	20	34	25	6	0	3
	0600	50	87	63	14	1	8
	0700	109	188	136	31	1	16
	0800	109	189	136	31	1	16
	0900	87	151	108	24	1	13
	1000	76	131	95	21	1	11
	1100	72	125	90	20	1	11
	1200	78	135	97	22	1	12

Vehicle type	Time	Hourly traffic count per segment (see Figure J-3)					
		1	2	3	4	5	6
	1300	79	136	98	22	1	12
	1400	91	157	113	26	1	14
	1500	100	173	124	28	1	15
	1600	116	200	144	32	1	17
	1700	116	200	144	32	1	17
	1800	80	139	100	22	1	12
	1900	46	79	57	13	0	7
	2000	36	63	45	10	0	5
	2100	30	51	37	8	0	4
	2200	21	36	26	6	0	3
	2300	11	19	14	3	0	2

Source: Arup

TABLE J-15 YEAR 2053 TRAFFIC (SCENARIO 2)

Vehicle type	Time	Hourly traffic count per segment (see Figure J-3)					
		1	**2**	**3**	**4**	**5**	**6**
Car and LGV	0000	150	163	186	42	1	22
	0100	84	92	105	24	1	13
	0200	101	110	125	28	1	15
	0300	98	107	122	27	1	15
	0400	242	264	302	68	2	36
	0500	629	684	783	176	6	94
	0600	1602	1741	1993	449	16	240
	0700	3459	3760	4304	969	34	518
	0800	3465	3766	4310	970	35	519
	0900	2765	3005	3439	774	28	414
	1000	2411	2620	2999	675	24	361
	1100	2288	2487	2846	641	23	343
	1200	2479	2694	3084	694	25	371
	1300	2501	2718	3111	700	25	375

Vehicle type	Time	Hourly traffic count per segment (see Figure J-3)					
		1	2	3	4	5	6
	1400	2890	3142	3595	809	29	433
	1500	3171	3447	3944	888	32	475
	1600	3680	4000	4578	1031	37	551
	1700	3675	3994	4571	1029	37	550
	1800	2544	2766	3165	713	25	381
	1900	1457	1584	1813	408	15	218
	2000	1158	1258	1440	324	12	173
	2100	945	1027	1176	265	9	142
	2200	670	728	834	188	7	100
	2300	351	382	437	98	4	53
HGV	0000	9	13	12	3	0	1
	0100	5	7	7	1	0	1
	0200	6	9	8	2	0	1
	0300	6	8	8	2	0	1
	0400	15	21	19	4	0	2
	0500	39	54	49	11	0	6
	0600	100	136	124	28	1	15
	0700	215	295	268	60	2	32
	0800	216	295	268	60	2	32
	0900	172	236	214	48	2	26
	1000	150	205	187	42	1	22
	1100	142	195	177	40	1	21
	1200	154	211	192	43	2	23
	1300	156	213	194	44	2	23
	1400	180	246	224	50	2	27
	1500	197	270	246	55	2	30
	1600	229	313	285	64	2	34
	1700	229	313	285	64	2	34
	1800	158	217	197	44	2	24
	1900	91	124	113	25	1	14

Vehicle type	Time	Hourly traffic count per segment (see Figure J-3)					
		1	2	3	4	5	6
	2000	72	99	90	20	1	11
	2100	59	81	73	16	1	9
	2200	42	57	52	12	0	6
	2300	22	30	27	6	0	3

Source: Arup

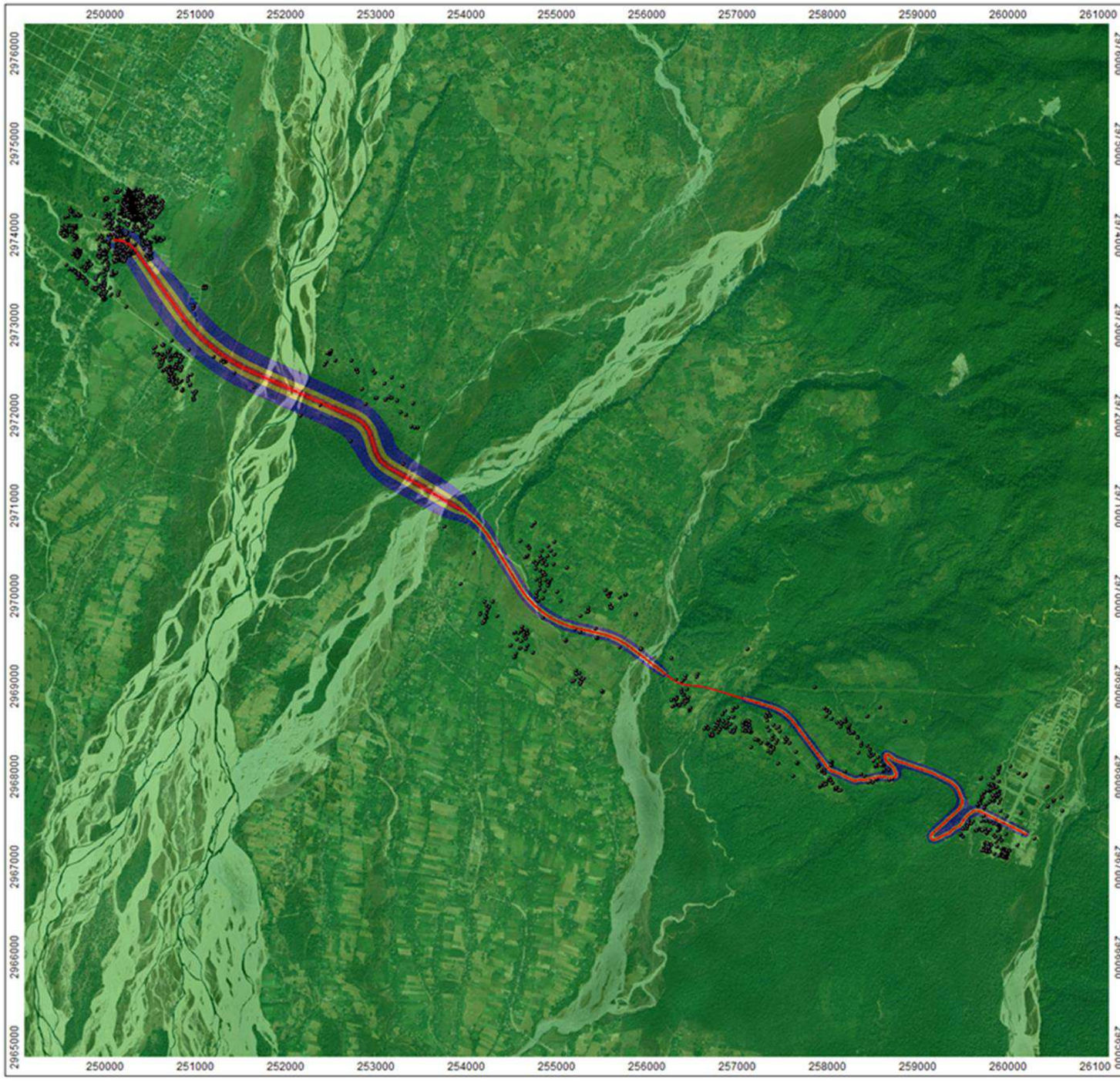
TABLE J-16 CAPACITY TRAFFIC (SCENARIO 3)

Vehicle type	Time	Hourly traffic count per segment (see Figure J-3)					
		1	2	3	4	5	6
Car and LGV	0000	232	232	232	116	116	116
	0100	131	131	131	65	65	65
	0200	156	156	156	78	78	78
	0300	152	152	152	76	76	76
	0400	375	375	375	188	188	188
	0500	973	973	973	487	487	487
	0600	2478	2478	2478	1239	1239	1239
	0700	5352	5352	5352	2676	2676	2676
	0800	5360	5360	5360	2680	2680	2680
	0900	4277	4277	4277	2139	2139	2139
	1000	3729	3729	3729	1865	1865	1865
	1100	3540	3540	3540	1770	1770	1770
	1200	3835	3835	3835	1917	1917	1917
	1300	3868	3868	3868	1934	1934	1934
	1400	4471	4471	4471	2235	2235	2235
	1500	4905	4905	4905	2452	2452	2452
	1600	5693	5693	5693	2846	2846	2846
	1700	5684	5684	5684	2842	2842	2842
	1800	3936	3936	3936	1968	1968	1968
	1900	2254	2254	2254	1127	1127	1127
	2000	1791	1791	1791	895	895	895

Vehicle type	Time	Hourly traffic count per segment (see Figure J-3)					
		1	2	3	4	5	6
	2100	1462	1462	1462	731	731	731
	2200	1037	1037	1037	518	518	518
	2300	544	544	544	272	272	272
HGV	0000	20	20	20	10	10	10
	0100	11	11	11	6	6	6
	0200	14	14	14	7	7	7
	0300	13	13	13	7	7	7
	0400	33	33	33	16	16	16
	0500	85	85	85	42	42	42
	0600	216	216	216	108	108	108
	0700	466	466	466	233	233	233
	0800	467	467	467	233	233	233
	0900	372	372	372	186	186	186
	1000	325	325	325	162	162	162
	1100	308	308	308	154	154	154
	1200	334	334	334	167	167	167
	1300	337	337	337	168	168	168
	1400	389	389	389	195	195	195
	1500	427	427	427	214	214	214
	1600	496	496	496	248	248	248
	1700	495	495	495	247	247	247
	1800	343	343	343	171	171	171
	1900	196	196	196	98	98	98
	2000	156	156	156	78	78	78
	2100	127	127	127	64	64	64
	2200	90	90	90	45	45	45
	2300	47	47	47	24	24	24

Source: Arup

Annex A – Operation Noise Modelling results



Project: Gelephu road and Bridge ESIA
Project-No. 0743906

Map
1

Year 2035
Result number 105
Calculation in 1.5 m above ground

Project engineer: ROO
Created: 15/11/2024
Processed with SoundPLAN 9.1, Update 08/10/2024

LAeq,16h (Daytime)
in dB(A)

- < 55
- >= 55
- >= 60
- >= 65

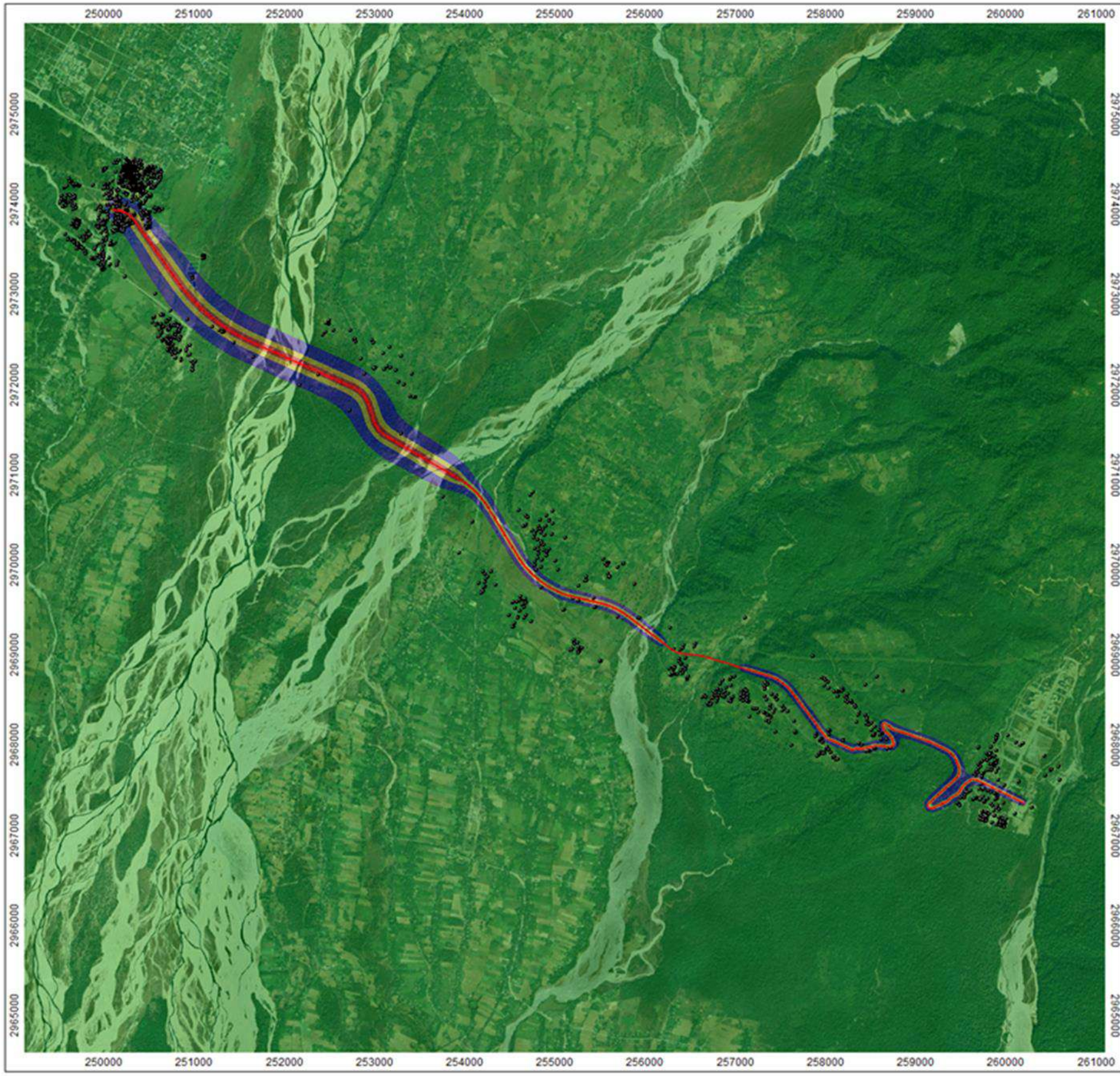
Signs and symbols

- Road axis
- Emission line
- Point receiver
- Surface

N

Length scale 1:42859
0 350 700 1400 2100 2800 m

ERM



Project: Gelephu road and Bridge ESIA
Project-No. 0743906

Map
1

Year 2035
Result number 105
Calculation in 1.5 m above ground

Project engineer: ROO
Created: 15/11/2024
Processed with SoundPLAN 9.1, Update 08/10/2024

LAeq,8h (Night)
in dB(A)

- < 45
- >= 45
- >= 50
- >= 55

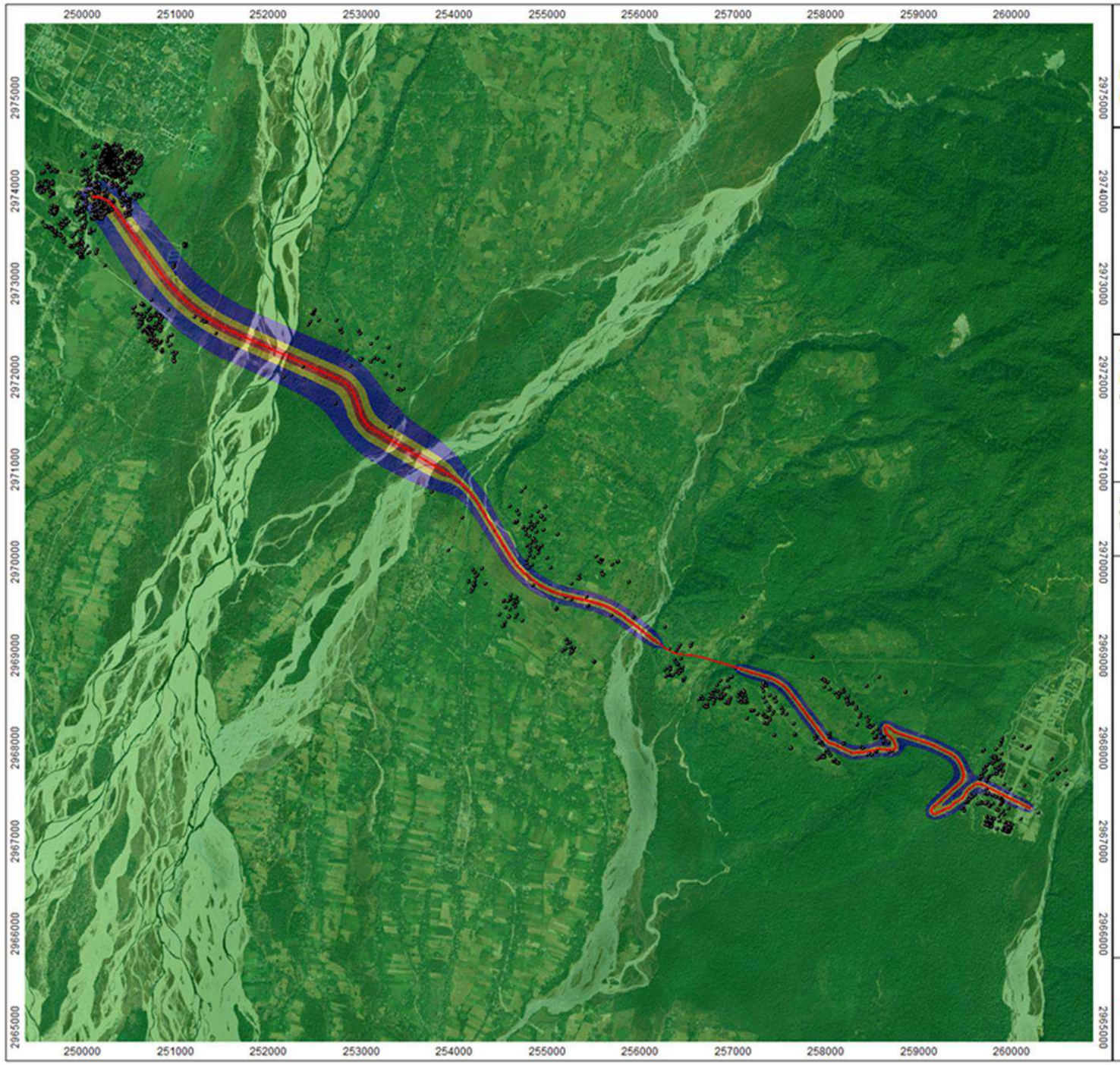
Signs and symbols

- Road axis
- Emission line
- Point receiver
- Surface

N

Length scale 1:42784
0 350 700 1400 2100 2800 m

ERM



Project: Gelephu road and Bridge ESIA
Project-No. 0743906

Map
1

Year 2053
Result number 103
Calculation in 1.5 m above ground

Project engineer: ROO
Created: 15/11/2024
Processed with SoundPLAN 9.1, Update 08/10/2024

LAeq,16h (Daytime)
in dB(A)

- < 55
- >= 55
- >= 60
- >= 65

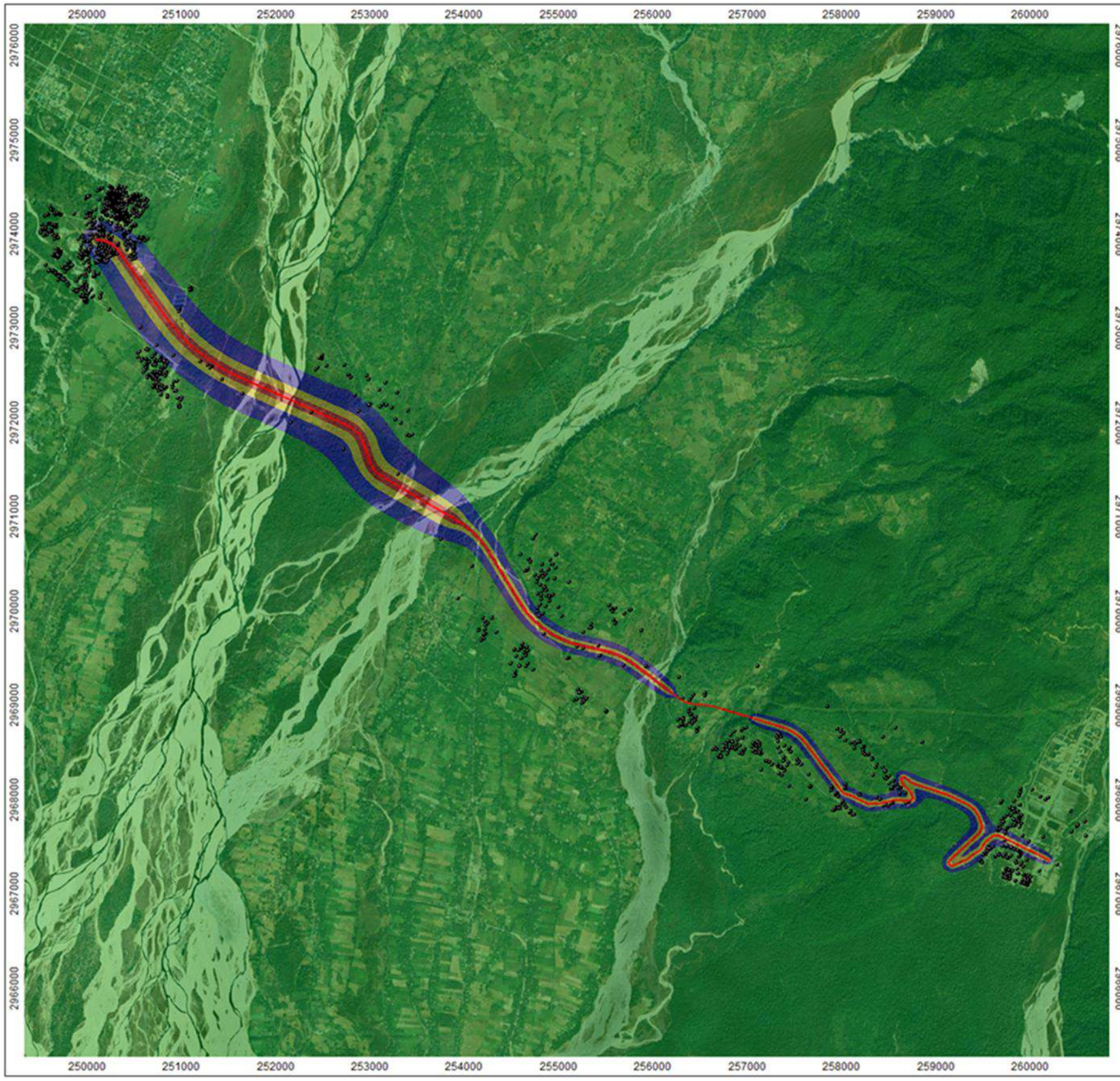
Signs and symbols

- Road axis
- Emission line
- Point receiver
- Surface

N

Length scale 1:41060
0 350 700 1400 2100 2800 m

ERM



Project: Gelephu road and Bridge ESIA
Project-No. 0743906

Map
1

Year 2053
Result number 103
Calculation in 1.5 m above ground

Project engineer: ROO
Created: 15/11/2024
Processed with SoundPLAN 9.1, Update 08/10/2024

LAeq,8h (Night)
in dB(A)

- < 45
- >= 45
- >= 50
- >= 55

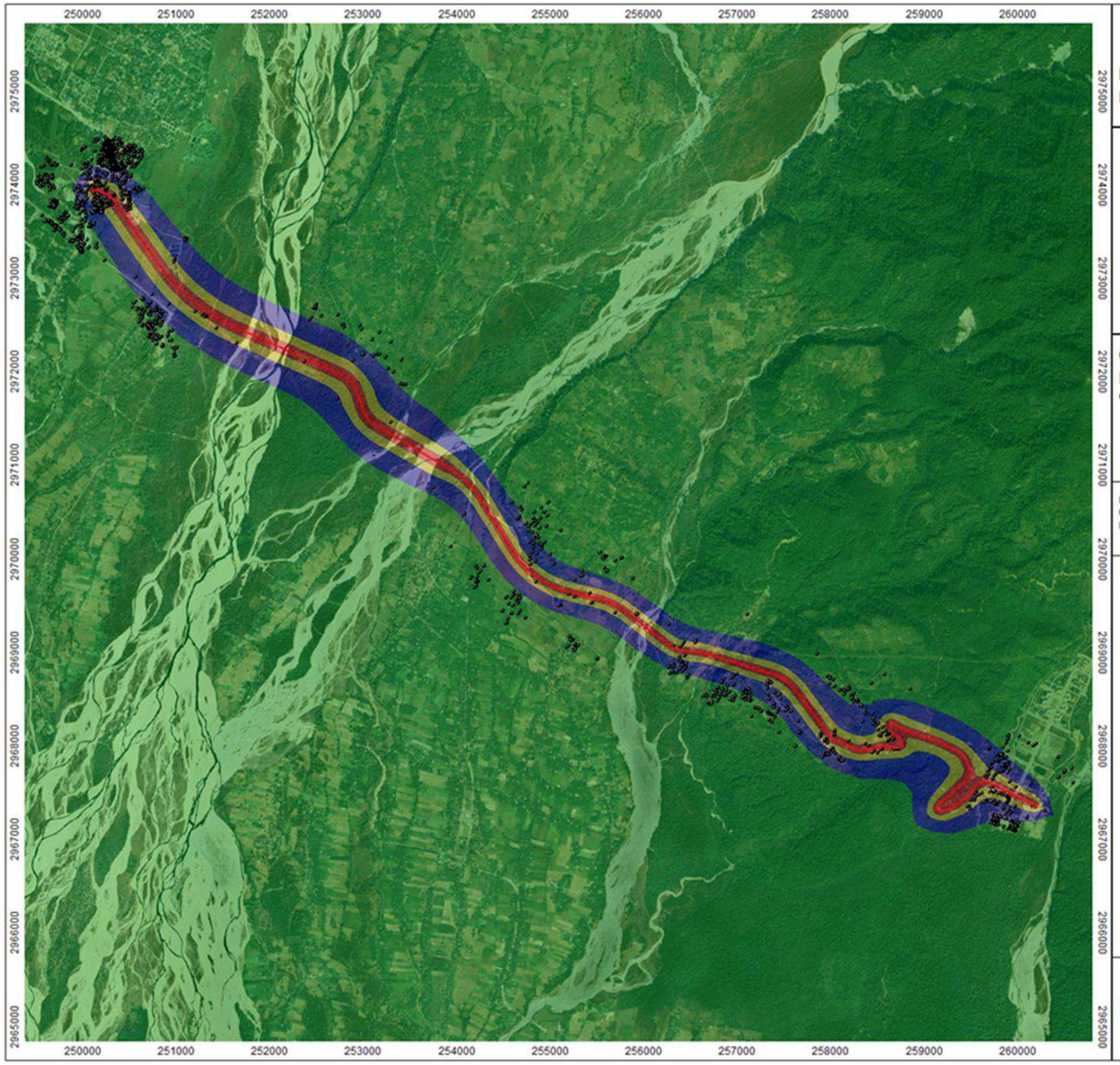
Signs and symbols

- Road axis
- Emission line
- Point receiver
- Surface

N

Length scale 1:41060
0 350 700 1400 2100 2800 m

ERM



Project: Gelephu road and Bridge ESIA
Project-No. 0743906

Map
1

Capacity
Result number 101
Calculation in 1.5 m above ground

Project engineer: ROO
Created: 15/11/2024
Processed with SoundPLAN 9.1, Update 08/10/2024

LAeq,16h (Daytime)
in dB(A)

- < 55
- >= 55
- >= 60
- >= 65

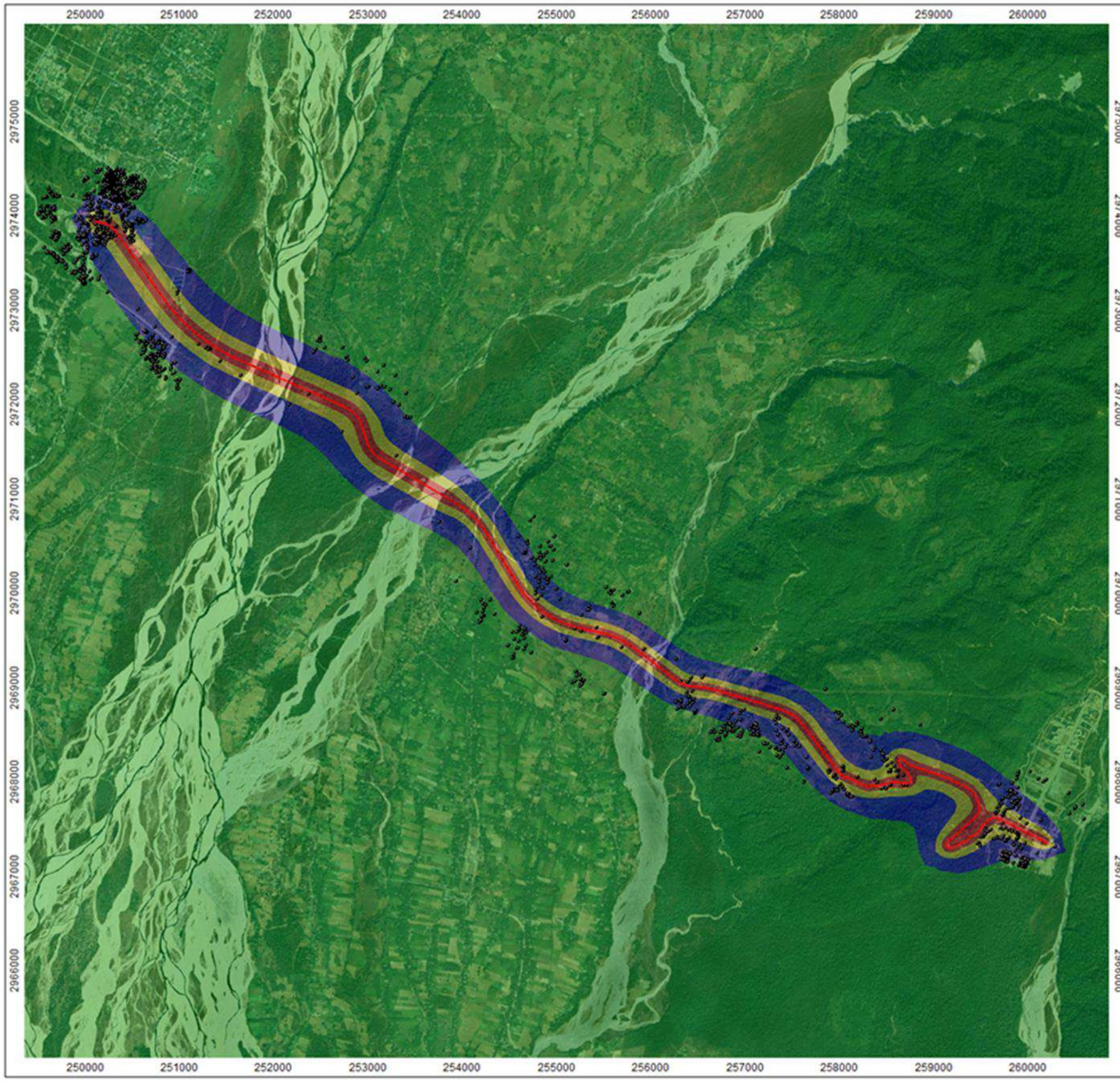
Signs and symbols

- Road axis
- Emission line
- Point receiver
- Surface

N

Length scale 1:40771
0 350 700 1400 2100 2800 m

ERM



Project: Gelephu road and Bridge ESIA
Project-No. 0743906

Map
1

Capacity
Result number 101
Calculation in 1.5 m above ground

Project engineer: ROO
Created: 15/11/2024
Processed with SoundPLAN 9.1, Update 08/10/2024

LAeq,8h (Night)
in dB(A)

- < 45
- >= 45
- >= 50
- >= 55

Signs and symbols

- Road axis
- Emission line
- Point receiver
- Surface

N

Length scale 1:41060
0 350 700 1400 2100 2800 m

ERM