Annexe 9.A

Etude de modélisation du bruit

Cette annexe (en anglais) présente le modèle et les hypothèses utilisés puis les résultats des modélisations de bruit réalisées dans le cadre de l'Etude d'Impact Social et Environnemental du projet de Chemin de Fer de Boké.

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9-A.1 INTRODUCTION

This annex presents the Noise Modeling Study that supported the assessment of the impacts of the Project (see *Chapter 3* for the Project description) on the acoustic environment.

Noise measurements were performed in the Project area as part of the baseline field survey in September-October 2016 (see *Chapter 6*).

A modeling approach was then used to estimate quantitatively existing and expected future noise levels and potential impacts to the receptors settled along the railway.

The resulting noise levels were compared to applicable criteria to assess for and identify impacted areas.

9-A.2 MODEL ASSUMPTIONS

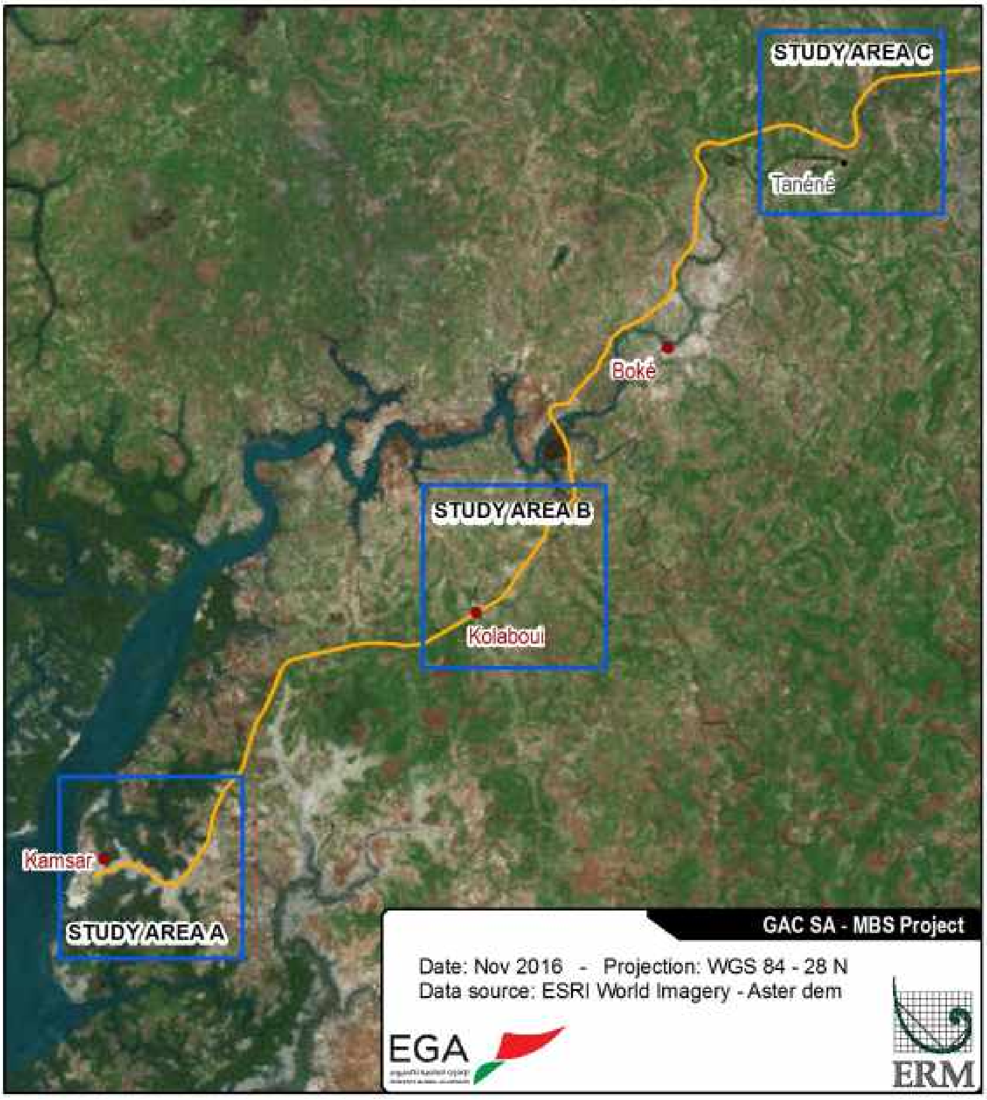
9-A.2.1 Study areas

For the purpose of this study, settlements located along the railway and considered representative of the three types of zones identified in *Chapter 5* were identified and studied:

- the urban area of Kamsar (Study Area A);
- the semi-urban area of Kolaboui, close to N22 road (Study Area B); and
- the rural area of Tanéné, far from N22 road (Study Area C).

Their locations are shown in *Figure 9-A.1.*

Figure 9-A.1 Study Areas



9-A.2.2 *Background noise levels*

A noise monitoring campaign was performed in the study areas to monitor the existing acoustic climate conditions.

This campaign resulted in existing high ambient noise levels at the main settlements along the existing railway, as a consequence of the noise associated to:

- village's activities;
- the rail traffic both during the daytime and night-time; and
- the road traffic contribution, where the existing railway is close to the N22 road, resulting in a significant increase of the ambient noise levels.

9-A.2.3 *Model and Assumptions*

A comparison between the noise contribution of the existing traffic and the Project's was carried out.

The analysis was based on modeling studies, taking into account the current rail traffic volumes on the existing railway (Scenario 1) and the future expansion scenarios (Scenario 2 and Scenario 3).

Noise levels were calculated using the *SoundPLAN v7.4* noise prediction software, in accordance with the used international standard ISO 9613-2 [1].

The parameters reported in *Table 9-A.1* were used as input of the modeling simulations.

The railway was modelled as a linear source, configured with rail traffic volumes associated to each Scenario; the emission levels associated to the transit of the trains were based on the monitoring data described in *Chapter 7*.

As background sound levels unrelated to rail traffic vary along the rail route, the assessment only considered the sound levels solely attributable to rail traffic.

Table 9-A.1 Project design data used in the definition of the noise modelling scenarios

Parameter	Description
Train composition	2 locomotives + 120 carts
Rail traffic volumes	Scenario 1 (Current Traffic): 10 trains' movements per day Scenario 2 (Traffic in 2020): 30 trains' movements per day Scenario 3 (Traffic in 2028): 40 trains' movements per day
Railway operations	24 hours. It is assumed that the number of trips per day is equally distributed throughout the day (e.g. the same time interval between train is considered both for night time and day time).
Average speed	20 km/h in Study Area A (Kamsar) 50 km/h in Study Area B (Kolaboui) 60 km/h in Study Area C (Tanéné)

9-A.2.4 *Sources of noise emissions*

Railway traffic generates noise mainly due to:

- Rolling noise, the vibrations induced by the small roughness on the wheel and rail surfaces. When the wheel is rolling on the rail the small

[1] International organisation for Standardisation (ISO), (1996); International Standard 9613-2: Acoustics – Attenuation of Sound During Propagation Outdoors – Part 2: General Method of Calculation.

unevenness of both wheel and rail cause forces on both of them. These forces excite vibrations throughout the whole system which in turn radiates sound.

- Curve squeal, that is the intense tonal noise that can set in when a rail vehicle traverses a curve or switch. The process starts with either lateral creeping in the contact patch between rail and wheel or rubbing of the flange of the wheel against the rail. When the stick-slip process at the patch or the flange becomes unstable (i.e. when there is a feedback that leads to instability), the wheel will radiate the tonal noise.

- Aerodynamic sources, that are closely related to airflow around the train and the optimisation for a low air resistance. Where the airflow is turbulent, sound will be emitted, and at high speeds the contribution can be substantial. The sound power emitted by the aeroacoustic sources is strongly dependent on the train speed.

- Secondary sources, that are noisy machinery on the train such as cooling fans and power transmissions.

9-A.2.5 Acoustic Descriptor

Noise from traffic on a rail changes as traffic flows change during the day and also fluctuates within shorter time periods as trains pass the receptor's site.

Noise often fluctuates over time because of the characteristics of the source (e.g., traffic volumes, train speed). In order to compare situations with different traffic noise levels a noise metric providing a single estimate of the overall rail traffic noise level was selected: the equivalent sound level $L_{Aeq,T}$ over a time period.

$L_{Aeq,T}$ is the "average" of the fluctuating noise levels over a time period (T). It is the constant noise level that would produce the same amount of sound energy as the fluctuating noise level.

9-A.2.6 Assesment criteria

The assessment methodology and criteria for noise impacts are presented in *Chapters 5* and *8* of this report. *Table 9-A.2* presents the thresholds used in *Section 8-A.3* to assess impact magnitude based on the modelling results.

Table 9-A.2 Increase above the background and impact magnitude

Increase above background	Impact magnitude	Comment
0 – 3 dB	Negligible	Changes in environmental noise of less than 3dB are often not noticeable to a community
3 – 5 dB	Small	A change of 3dB to 5dB is barely perceptible
5 – 10 dB	Medium	A change of 5dB to 10dB is clearly perceptible
> 10 dB	High	A change of 10dB is often judges as subjectively twice as loud so may have additional significance

9-A.3 MODELLING RESULTS

9-A.3.1 *Increase above the background traffic noise*

The modeling studies were performed to compare the noise levels due to the current rail traffic volumes on the existing railway (Scenario 1) and the future expansion scenarios (Scenario 2 and Scenario 3).

The predicted increase in existing traffic noise at monitored receptors is summarised in *Table 9-A.3* for Scenario 2 (traffic noise in 2020) and *Table 9-A.4* for Scenario 3 (traffic noise in 2028) respectively.

In both tables, the predicted impact magnitude is then assessed based on the criteria presented in *Table 9-A.2*

The noise contours maps reported in *Figure 9-A.2, Figure 9-A.3* and *Figure 9-A.4* show the predicted noise levels for the Existing and Future Noise Traffic Scenarios over the three study areas considered in the model simulations.

9-A.3.2 *Assessment of single train contribution*

Additional analyses were performed to assess the temporary disturbance generated by a single event (the transit of a train/two trains simultaneously).

Based on the available monitored data (see *Chapter 6*) it can be estimated that a single-event train pass-by (lasting approx 90 seconds) will generate a noise emission level of about LAeq = 83 - 85 dB(A) at a distance of 5 m from the centreline of the rail, depending on several parameters (e.g., type of train (full or empty), average speed, etc.).

The temporary noise level increases of about 3 dB if considering the simultaneous transit of two trains, resulting in a noise emission level of about 88 dB(A) at a distance of 5 m.

Table 9-A.3 Predicted increase in rail traffic noise in 2020 (Scenario 2)

Study Area	Receptor	Approx. distance from the rail track [m]	Existing Traffic Noise Scenario 1 L_{Aeq} [dB(A)]	Traffic Noise in 2020 Scenario 2 L_{Aeq} [dB(A)]	Increase above Scenario 1 [dB(A)]	Impact Magnitude
Area A (Kamsar)	B01	100	58.2	60.4	2.2	Negligible
	B02	20	65.3	70.0	4.7	Small
	B03	50	58.4	62.9	4.5	Small
	B04	20	65.1	69.8	4.7	Small
	B05	20	65.0	69.7	4.7	Small
	B06	20	64.7	69.4	4.7	Small
Area B (Kolaboui)	B07	5	74.0	78.8	4.8	Small
Area C (Tanéné)	B09	5	74.3	79.1	4.8	Small

Table 9-A.4 Predicted increase in rail traffic noise in 2028 (Scenario 3)

Study Area	Receptor	Approx. distance from the rail track [m]	Existing Traffic Noise Scenario 1 L_{Aeq} [dB(A)]	Traffic Noise in 2028 Scenario 3 L_{Aeq} [dB(A)]	Increase above Scenario 1 [dB(A)]	Impact Magnitude
Area A (Kamsar)	B01	100	58.2	61.2	3.0	Small
	B02	20	65.3	71.3	6.0	Medium
	B03	50	58.4	64.1	5.7	Medium
	B04	20	65.1	71.1	6.0	Medium
	B05	20	65.0	71.0	6.0	Medium
	B06	20	64.7	70.7	6.0	Medium
Area B (Kolaboui)	B07	5	74.0	80.1	6.1	Medium
Area C (Tanéné)	B09	5	74.3	80.4	6.1	Medium

Figure 9-A.2 Predicted noise levels for Existing and Future Noise Traffic Scenario within Study Area A (Kamsar)

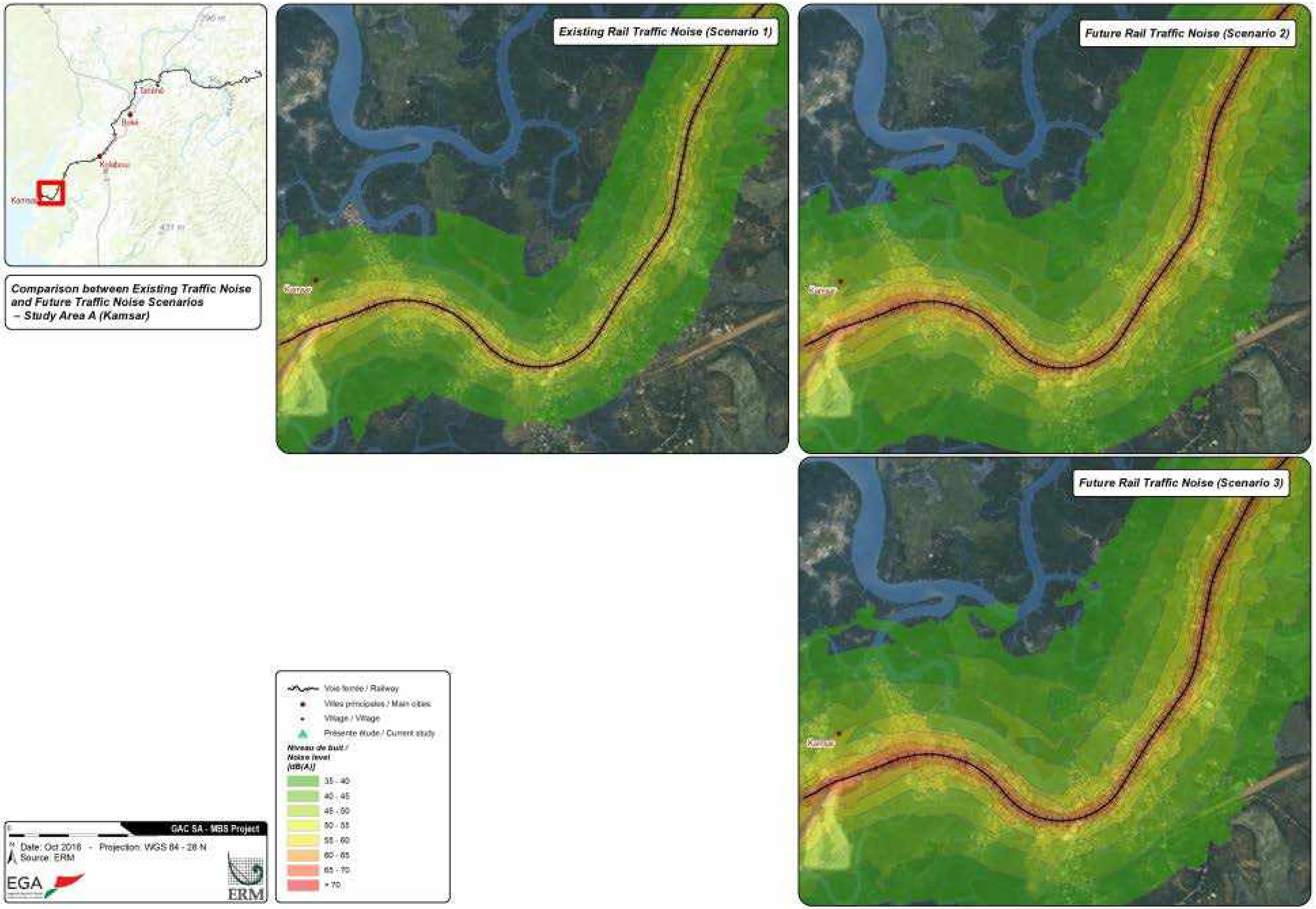


Figure 9-A.3 Predicted noise levels for Existing and Future Noise Traffic Scenario within Study Area B (Kolaboui)

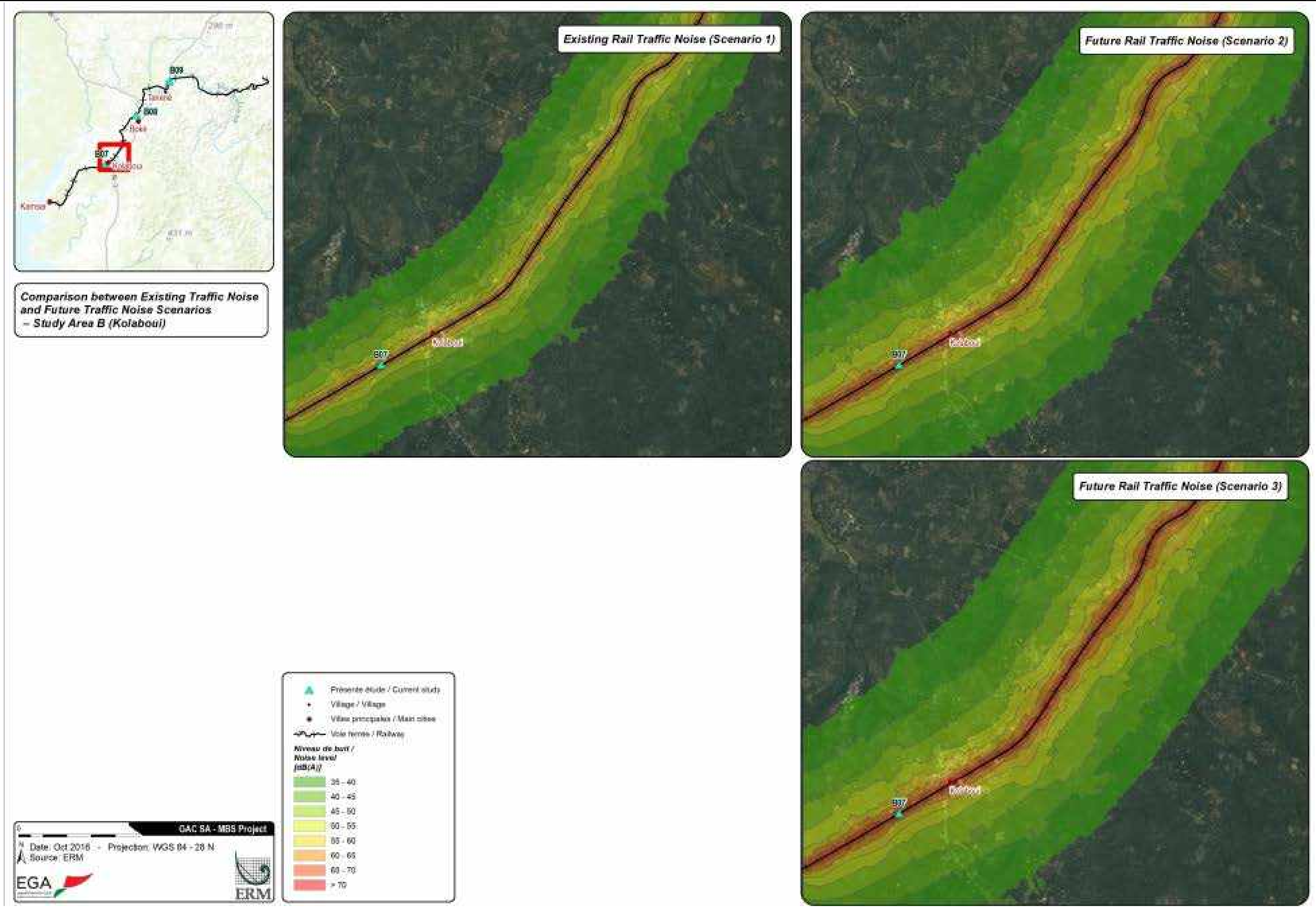
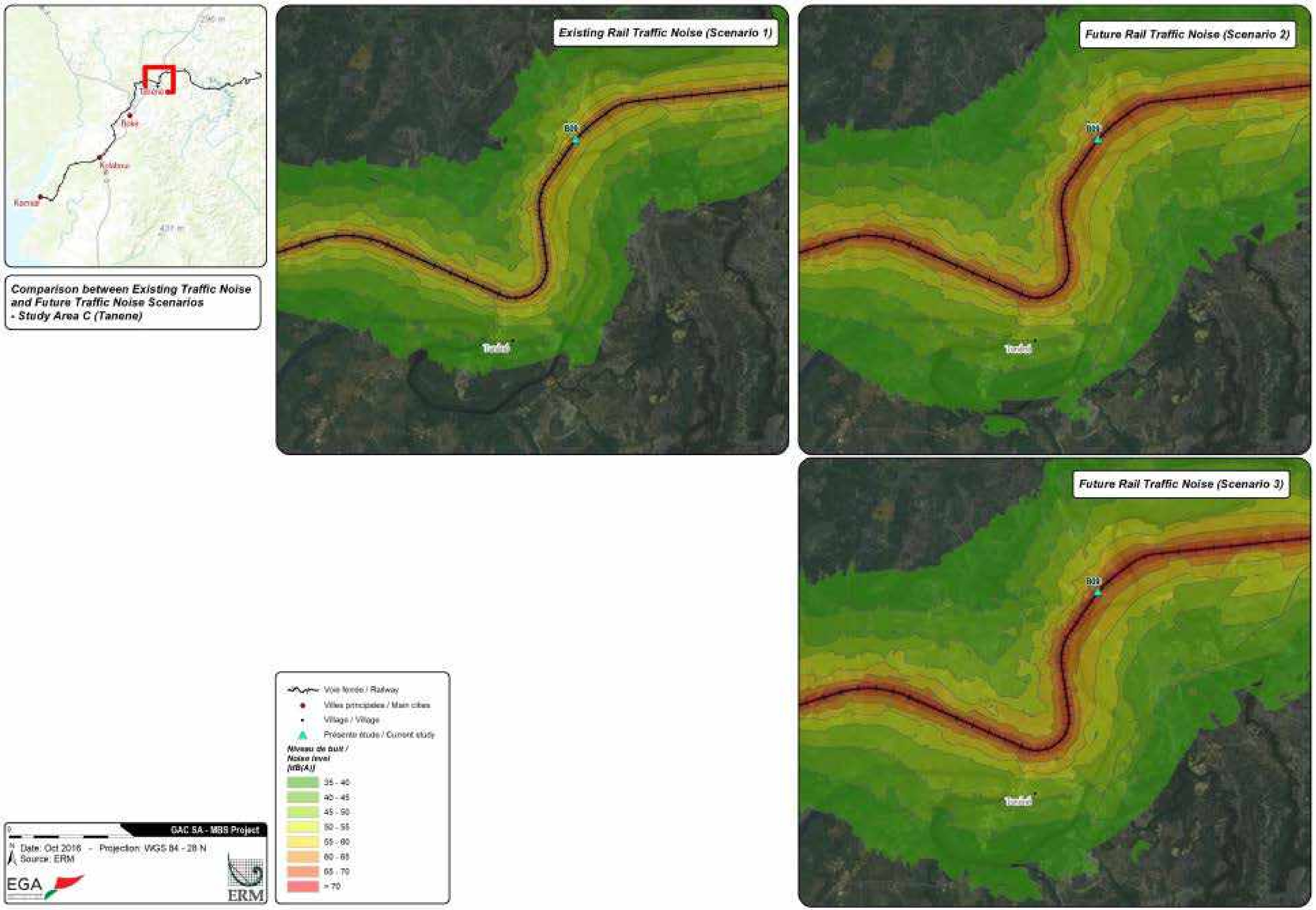


Figure 9-A.4 Predicted noise levels for Existing and Future Noise Traffic Scenario within Study Area C (Tanéné)



Annexe 9.B

Etude de modélisation de la qualité de l'air

Cette annexe (en anglais) présente le modèle et les hypothèses utilisés puis les résultats des modélisations de qualité de l'air réalisées dans le cadre de l'Etude d'Impact Social et Environnemental du projet de Chemin de Fer de Boké.

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9-B.1 *INTRODUCTION*

This annex presents the Atmospheric Dispersion Modeling Study (ADMS) that supported the assessment of the impacts on air quality generated by the Project (see *Chapter 3* for the Project description). It considers impacts on human health and vegetation due to emissions to air of airborne gaseous pollutants and airborne dust.

Atmospheric emissions during the ore transport by train mainly consists of locomotives exhaust gases and dust due to wind erosion from open rail cars.

The key pollutants of interest for the assessment are:

- oxides of nitrogen (NO_2 and NO_x) from locomotives exhausts. The assessment considers nitrogen dioxide (NO_2), which is of concern for its impact on health, and total oxides of nitrogen (NO_x), which are of concern because of their impacts on vegetation (and therefore on supported fauna)[1].

- sulphur dioxide (SO_2) from locomotives exhausts. SO_2 is of concern because of its potential impacts on health and vegetation[(2)].

- particulate matter (PM) from locomotives exhausts and wind erosion from open railcars. The assessment considers impacts of particles of diameter less than 2.5 microns in diameter ($PM_{2.5}$) and particles of diameter between 2.5 and 10 microns (PM_{10})[3].

Other pollutants such as metals, volatile organic compounds and polycyclic aromatic hydrocarbons (PAHs) are excluded from the assessment, as these are usually only significant when coal or heavy fuel oil are used– this is not applicable as the Project will not be using these compounds.

Locomotives' exhaust gases include also carbon monoxide, however with good maintenance and operating procedures in place emissions of carbon monoxide are expected to produce negligible impacts on air quality.

([1]) NO_x includes NO_2 plus nitrous oxide NO and nitrogen oxide (N_2O) which convert to NO_2 over time in the atmosphere.

([2]) In urban areas SO_2 can also be of concern because of corrosion of materials (building materials, monuments, *etc.*), however this is not judged likely to be an issue given in the rural setting of the Project location.

[3] PM2.5 and PM_{10} are of concern because of their potential impact on health as the size means these particles are small enough to be inhaled into the lungs. Larger particles are removed in the upper respiratory tract.

9-B.2 *MODELING ASSUMPTIONS*

9-B.2.1 *Model and General Assumptions*

Changes in air quality induced by the Project operation were predicted using the CALMET-CALPUFF modeling system, a state of the art model developed by the US EPA and recognized by the IFC. The CALMET-CALPUFF modeling system is capable of representing meteorology varying in space and time along with complex array of emission sources.

It is particularly suitable in the context of complex topography, such as that of the area of influence. The railway sources were characterized using the new "road source" module available in CALPUFF (Version 7).

The model used data on emissions associated with the rail traffic and local meteorology to predict changes in air quality arising from the Project emissions. An overview of the representation of the emission sources in the ADMS performed for the railway traffic is presented in *Section 8-B.3*.

The CALPUFF dispersion model uses meteorological data produced by the meteorological pre-processor CALMET to calculate dispersion. One full year of meteorological hourly sequential data (8,760 hour) was taken into account in the model.

- The model estimated the project contribution in terms of induced ground level concentrations both in the short term (e.g. hourly, daily averages) and long term (e.g. annual concentrations).

- A constant emission rate was assumed 24 hours seven day per week (operational hours) equivalent to the traffic figures and emissions of each scenario. This approach is due to the fact that the number of trips per day is equally distributed throughout the day (e.g. the same time interval between trains is considered both for night time and day time).

- Emissions from other traffic are not included in the model as the size of vehicles, the numbers and distances travelled, and the resulting emissions are not known. However, the baseline undertaken for the project will capture these impacts.

- The model does not account for photochemical reactions of the pollutants which in reality takes place and would reduce macro pollutants concentrations in the atmosphere. Thus results are overestimating the likely actual contribution of the sources. The approach again is on the safe side of assumptions and gives a conservative picture maximising pollutants modelled concentration values over the sampling domain.

- NO to NO_2 conversion rate of 80% has been used for short term, whilst a 75% conversion rate has been used for long term.

9-B.2.2 Study Areas

For the purpose of this study, settlements located along the railway and considered representative of the three types of zones identified in *Chapter 5* were identified and studied:

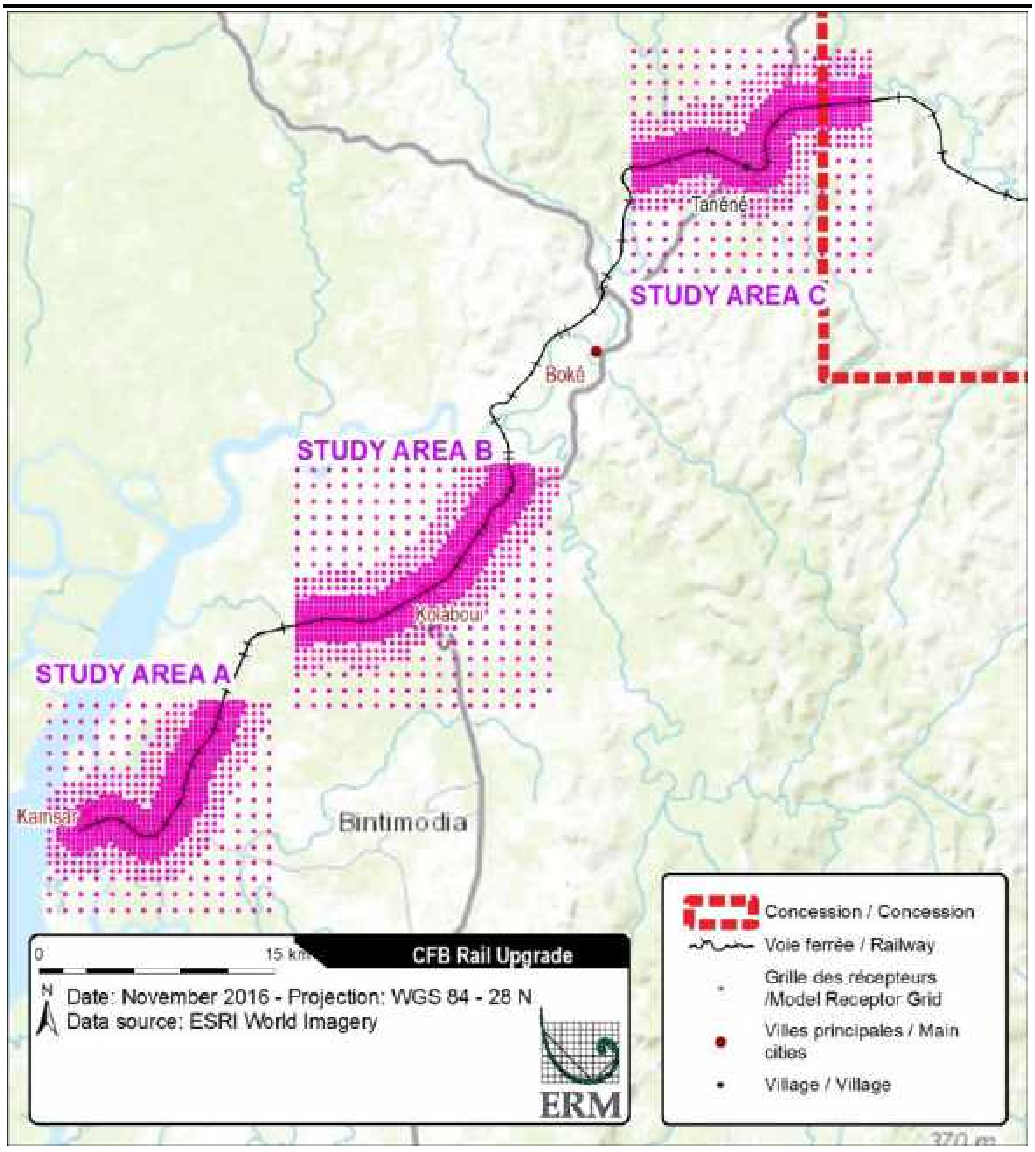
- Urban area of Kamsar - Study Area A;
- Semi-urban area of Kolaboui, close to N22 road - Study Area B; and
- Rural area of Tanéné, far from N22 road - Study Area C.

Figure 9-B.1 shows the distribution of the above mentioned areas along with the model receptor grid.

The latter extends from the railway out to 6-7 km. The receptor spacing varied with distance from the railway centreline, as shown below:

- Along lines parallel to the railroad centerline:
  - 150 meters at a distance that ranges from 20 to 30 meters from the railroad centreline;
  - 200 meters at a distance of 100 meters from the railroad centerline;
  - 300 meters at a distance of 200 meters from the railroad centerline;
- In a Cartesian grid with increasing spacing:
  - 300 meters from 200 to 1500 meters from the railroad centerline;
  - 500 meters from 1500 meters to 3000 meters from the railroad centreline; and
  - 1000 meters from 3000 to the edge of the study area.

Figure 9-B.1 Study Areas and Model receptor grid



9-B.2.3 *Air quality assessment criteria*

Air quality assessment criteria derived from WHO standards and the IFC EHS guideline

The magnitude of impacts on air quality is evaluated by reference to applicable air quality standards.

Guinean standard NG 09-01-011: 2012 / CNQ: 2004 sets the regulatory limits for air quality. The limits set are identical or slightly less restrictive than the World Health Organization (WHO) standards. Therefore, the WHO Air Quality Standards have been selected.

These standards establish Interim Targets and guideline values for protection of human health:

- the guideline values are aspirational and are intended to confer a maximum degree of protection; and

- the Interim Targets are set at points to allow the staged achievement of air quality standards.

For the purpose of this assessment, WHO Interim Target 1 has been used to derive the assessment criteria (considered to represent concentrations in ambient air above which health effects can reasonably be expected to occur). The standards are set out in *Table 9-B.1*.

Table 9-B.1 Air quality standards for the protection of human health

Pollutant	**Averaging period**	**Air quality standard (µg/m³)**
		Interim Target 1
PM_{10}	24 hour mean	150
	Annual mean	70
$PM_{2.5}$	24 hour mean	75
	Annual mean	35
NO_2	1 hour mean	200
	Annual mean	40
SO_2	24 hour mean	125
	10 minute mean	500

Reference to European Union air quality standards for further analysis of results

With regard to the NO_2 hourly standard, to better evaluate the magnitude of impacts, the European Air Quality Standard (AQS) was applied. The European Directive 2008/50/EC on Ambient Air Quality sets as the AQS for NO_2 short-term concentration (1-hour average) a limit value of 200µg/m³, not to be exceeded more than 18 times a calendar year (named Rank 18). The comparison of the predicted NO_2 concentrations to this standard allows more accurate assessment of the impact on human health related to short-term scenarios.

For the protection of vegetation, the assessment has referred to European Union Standards as there are no equivalent standards from IFC or WHO. These are set out in *Table 9-B.2*.

Table 9-B.2 Air quality standards for the protection of vegetation

Pollutant	**Averaging period**	**Air quality standard (µg/m³)**
NO_x	Annual mean	30
SO_2	Annual mean	20

The assessment methodology and criteria for impacts on air quality are presented in *Chapters 5* and *8* of this report. *Table 9-B.3* presents the thresholds used in *Section 8-B.3* to rank impact magnitude based on the modelling results.

Table 9-B.3 Thresholds used to assess the magnitude of impacts on air quality

PEC as % of AQS	Magnitude
<25%	Negligible
25-50%	Low
50-75%	Medium
>75% (1)	Large

9-B.2.4 Rail traffic Scenarios

Impacts on air quality from air traffic have been assessed for three traffic scenarios, detailed in *Table 9-B.5*, along with key project design data and emission estimation methods and inputs.

Model outputs for each scenario enabled to evaluate the significance of impacts in accordance with the impact assessment methodology presented in *Chapter 5*.

Table 9-B.4 Project design data used in the definition of the air quality modeling scenarios

Parameter	Description
Rail traffic volumes	• Scenario 1 (Current Traffic): 10 trains' movements per day (5 empty + 5 full) transporting 16Mtpa. *Train type: Existing trains.* • Scenario 2 (Future Traffic in 2020): 30 trains' movements per day (15 empty + 15 full) transporting 51 Mtpa. *Train type: 10 existing trains + 20 trains future trains.* • Scenario 3 (Future Traffic in 2028): 40 trains' movements per day transporting (20 empty + 20 full) 70 Mtpa. *Train type: 10 existing trains + 30 future trains.*
Railway operations	• 24 hours. • It is assumed that the number of trips per day is equally distributed throughout the day (e.g. the same time interval between trains is considered both for night time and day time).
Train composition	• Existing trains consist of 3 locomotives (EMD SD 40s, installed power of 6714 kW) + 120 railcars. • Future trains consist of 2 locomotives (SD70ACS, installed power of 6714 kW) + 120 railcars. • Power load (for both existing and future trains): 64% loaded trains and 52% for empty trains, 58% on average.
Average speed	• 20 km/h in Study Area A (Kamsar). • 50 km/h in Study Area B (Kolaboui). • 60 km/h in Study Area C (Tanéné).
Sulphur Content	• 0.35%

Parameter	Description
Exhaust Emission estimation *(see Section 8-B.2.5)*	• Exiting trains equipped with locomotives compliant with TIER 0, Emission Factors for Locomotives for general line-haul operation (US EPA 2009b). • Future trains equipped with locomotives compliant with TIER II, Emission Factors for Locomotives for general line-haul operation (US EPA 2009b).
Dust Emission estimation *(see Section 8-B.2.5)*	• Dust emissions estimated with the NPi[1] methodology. • Ore Silt Content = 10%. • Single railcar open area= 5 x 10 m^2.
Safety zone	• The study considered a safety zone around the railway itself of 20 m on each side; hence no receptors have been considered within a buffer of 40 m centered on the railway.

9-B.2.5 *Estimation of Atmospheric Emissions*

9-B.2.5.1 *Exhaust Emissions*

Exhaust emissions from locomotives have been estimated on the basis of USEPA emissions standards for locomotives, set for line haul operations (given in grams per brake horsepower-hour). These emission factors are summarised in the following *Table 9-B.5.*

The calculation of exhaust emissions took into account the following input data already introduced in *Table 9-B.4*:

- the locomotives nominal power (for a single train, the same nominal power was assumed for existing trains and future trains equal to 6714 kW);
- the average power load (58%);
- TIER 0 emission factors for existing trains; and
- TIER II emissions for future trains.

Table 9-B.5 ***US EPA Line haul Emission Factors for Locomotives (g/bhp-hr)***

	PM10	HC	NOx	CO
UNCONTROLLED	0.32	0.48	13	1.28
TIER 0	0.32	0.48	8.6	1.28
TIER 1	0.2	0.3	7.2	1.28
TIER 1+	0.32	0.47	6.7	1.28
TIER2	0.2	0.29	6.7	1.28
TIER 2+ & TIER 3	0.18	0.26	4.95	1.28
TIER 4	0.08	0.13	4.95	1.28

+ *Indicates that these are the revised standards in 40 cfr part 1033*

The assumption of a constant power load over the entire route is very conservative for urban areas where speed is limited. In the Kamsar area the

[1] National Pollutant Inventory (NPi) Emission Estimation Technique Manual for Mining, Version 3.1, January 2012.

power load would be only about 15 to 16%. The low speed of the train in this area would however imply a longer duration of presence and at constant power load, higher emissions per km.

9-B.2.5.2 Emissions due to wind erosion

The approach set out in NPi[1] was used to estimate the emissions of PM_{10}. The following NPi emission equation for the calculation of wind erosion from stockpiles has been used to estimate wind erosion from open railcars.

$$EF_{TSP} = 1.9 \times \left(s/1.5 \right) \times 365 \times \left(365 - p/235 \right) \times \left(f(\%)/15 \right) \quad \text{kg/ha/yr}$$

Where:

- EF_{TSP} is the emission rate in kg/ha/yr;
- s = silt content % by weight, taken to be 10%;
- p = number of days when precipitation is greater than 0.25mm. This data was extracted from the performed CALMET model run.
- f(%) = percentage of time wind speed is greater than 5.4 m/s at the mean height of the stockpile or conveyor. This data was assumed equal to 100% since railcars will be moving at least at 20 km/h, hence wind on exposed ore will always have a speed greater than 5.4 m/s.

The calculation of the emission rate in grams per second took into account the hectares of exposed surface; the latter for one single train were calculated multiplying the area of a single railcar (5 x 10 m2) by the number of railcars (120).

On the basis of NPi, the PM_{10} emissions are taken to be 50% of the TSP emissions. PM25 emissions have been derived from PM10 based on the particle size and distribution reported in the Lighty, Veranth and Sarofim (2000) [2] which sets particle size distribution for several sources of emissions based upon several references.

9-B.3 MODELING RESULTS

The present Section provides an overview of numerical results and related impacts for all pollutants and averaging periods.

[1] National Pollutant Inventory (NPi) Emission Estimation Technique Manual for Mining, Version 3.1, January 2012.

(2) Lighty J. Veranth J. Sarofim A (2000) Combustion aerosols: factors governing their size and composition and implications to human health Journal of the Air and Waste Management Association 50

While comparing results obtained for different areas and scenarios the following conclusions can be drawn:

- The most critical results are obtained for the Kamsar area (Area A), followed by Kolaboui (Area B) and Tanéné (Area C). This pattern is attributable to the different train speed in these areas. Low train speed (such as 20 km/h at Kamsar) implies a longer permanence period of the train in a given stretch of railway, hence higher emissions per km; whereas, at higher speed the transit time and related emissions per km decreases.

- For each area, predicted concentrations increases passing from Scenario 1 to Scenario 2 and 3, as expected.

9-B.3.1 *Nitrogen dioxide (NO_2)*

Impacts for NO_2 long-term concentrations

The following table presents maximum concentration predicted by the model in comparison with IFC AQS, for NO_2 long-term (annual) concentrations.

Table 9-B.6 NO_2 annual concentrations – Magnitude of impacts for human health based on IFC AQS- Scenario 1, Scenario 2 and Scenario 3

Pollutant	Averaging Period	Study Area	Project Contribution [µg/m3]	IFC AQS [µg/m3]	% AQS	Magnitude
Scenario 1						
NO_2	Calendar year	Kamsar (Study Area A)	18.44	40	46%	Low
		Kolaboui (Study Area B)	12.8	40	32%	Low
		Tanéné (Study Area C)	9.37	40	23%	Negligible
Scenario 2						
NO_2	Calendar year	Kamsar (Study Area A)	39.68	40	99%	Large
		Kolaboui (Study Area B)	27.6	40	69%	Medium
		Tanéné (Study Area C)	20.17	40	50%	Low
Scenario 3						
NO_2	Calendar year	Kamsar (Study Area A)	50.29	40	126%	Large
		Kolaboui (Study Area B)	35.04	40	88%	Large
		Tanéné (Study Area C)	25.5	40	64%	Medium

Figure 9-B.2 Impact magnitude for NO_2 Annual concentrations compared to IFC Standards, Area A – Scenario 1, Scenario 2, Scenario 3

Figure 9-B.3 Impact magnitude for NO_2 Annual concentrations compared to IFC Standards, Area B – Scenario 1, Scenario 2, Scenario 3

Figure 9-B.4 Impact magnitude for NO_2 Annual concentrations compared to IFC Standards, Area C – Scenario 1, Scenario 2, Scenario 3

Impacts for NO_2 short-term concentrations

The following table presents maximum concentration predicted by the model in comparison with IFC AQS, for NO_2 short-term (1-h) concentrations. Numerical results presented correspond to the worst hour predicted by the model over the temporal domain (8760 hours).

Table 9-B.7 NO_2 -1h concentrations maxima –Magnitude of impacts for human health based on IFC AQS- Scenario 1, Scenario 2 and Scenario 3

Pollutant	Averaging Period	Study Area	Project Contribution [µg/m3]	IFC AQS [µg/m3]	% AQS	Magnitude
Scenario 1						
NO_2	1h	Kamsar (Study Area A)	604.00	200	302%	Large
		Kolaboui (Study Area B)	286.02	200	143%	Large
		Tanéné (Study Area C)	242.83	200	121%	Large
Scenario 2						
NO_2	1h	Kamsar (Study Area A)	1300.00	200	650%	Large
		Kolaboui (Study Area B)	615.28	200	308%	Large
		Tanéné (Study Area C)	522.36	200	261%	Large
Scenario 3						
NO_2	1h	Kamsar (Study Area A)	1648.00	200	824%	Large
		Kolaboui (Study Area B)	779.91	200	390%	Large
		Tanéné (Study Area C)	662.13	200	331%	Large

Figure 9-B.5 Impact magnitude for NO_2 hourly concentrations compared to IFC AQS Area A – Scenario 1, Scenario 2, Scenario 3

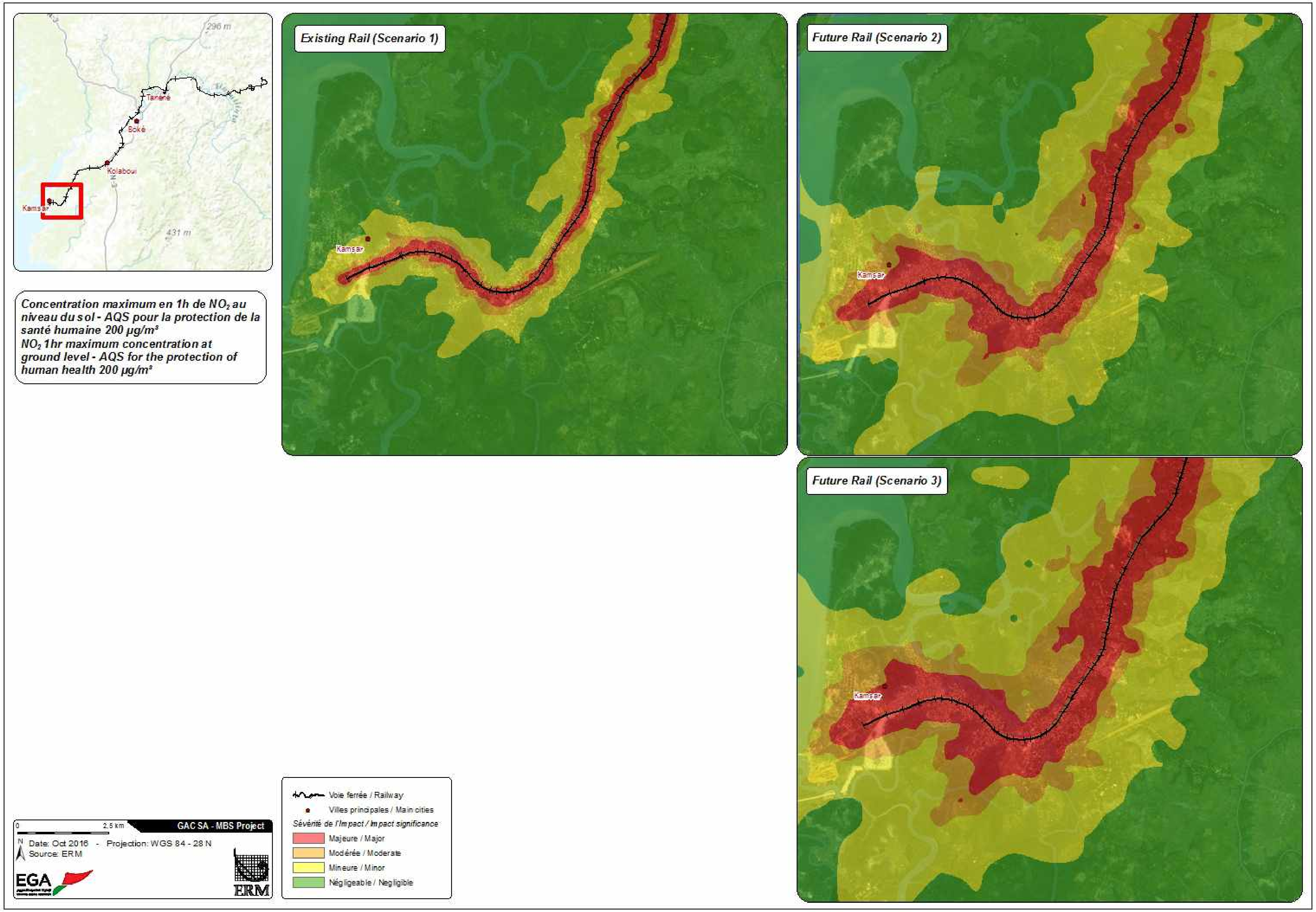


Figure 9-B.6 Impact magnitude for NO_2 hourly concentrations compared to IFC AQS Area B – Scenario 1, Scenario 2, Scenario 3

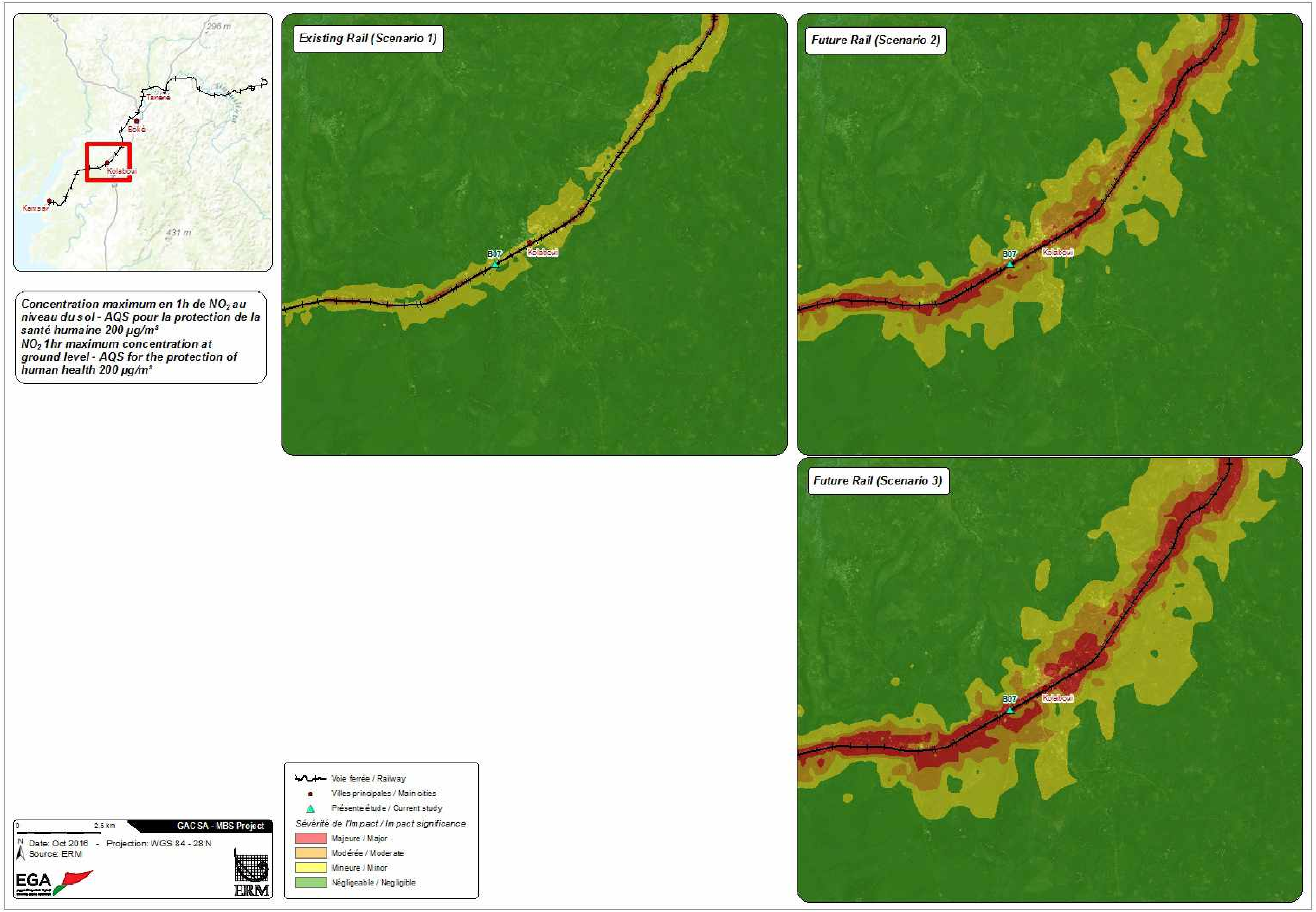
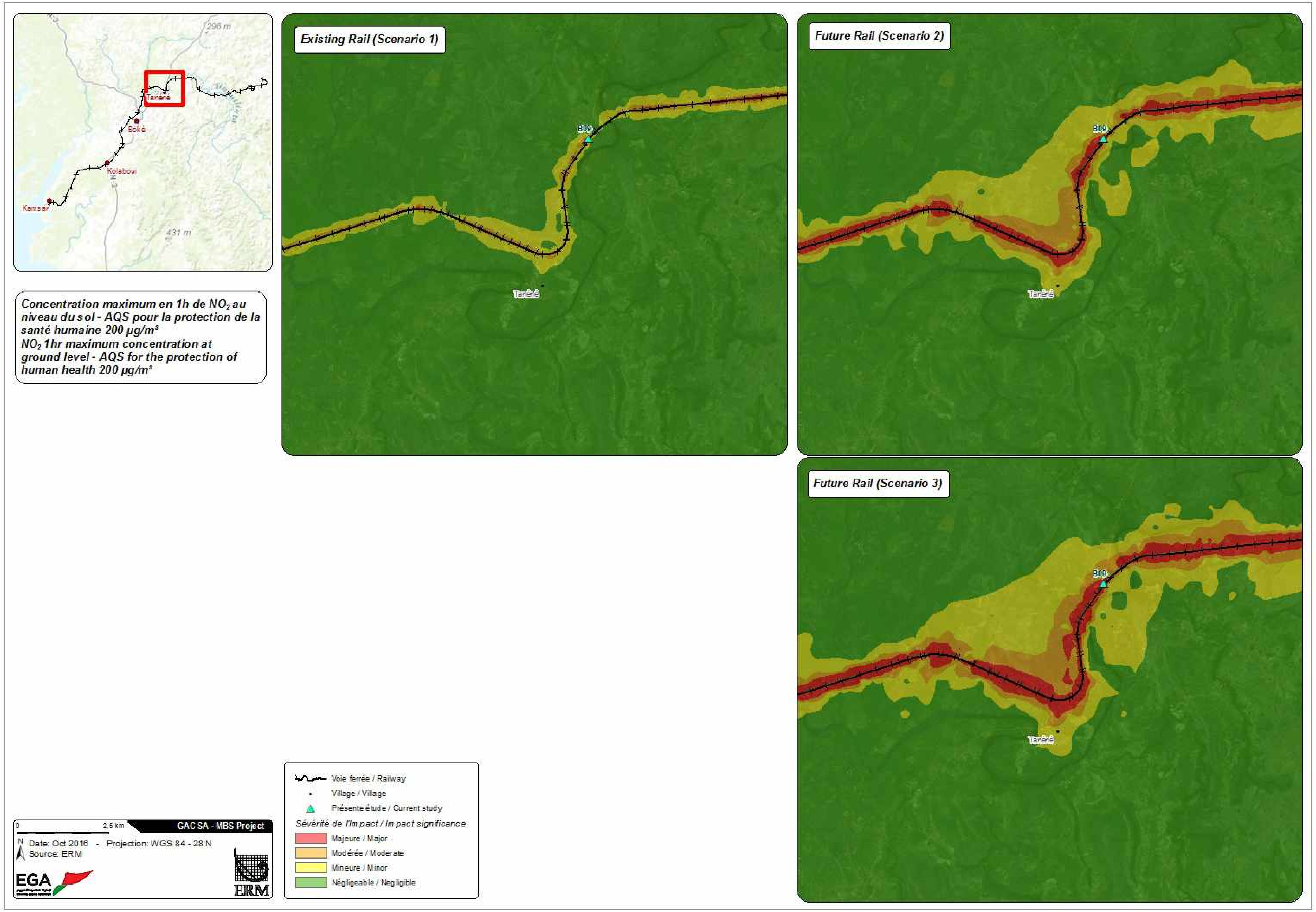


Figure 9-B.7 Impact magnitude for NO_2 hourly concentrations compared to IFC AQS Area C – Scenario 1, Scenario 2, Scenario 3



European Union "Rank" approach for short term concentrations

Impacts arising from induced concentrations of NO_2 in the short term (1 hour) have been also assessed on the base of the EU AQS set on NO_2 hourly concentrations by the *European Directive 2008/50/EC on Ambient Air Quality*[1]. The EU AQS is numerically equal to the IFC limit, but it allows 18 hourly exceedances of the limit per year. Therefore the assessment against the EU AQS excluded the 18 highest hourly values and mapped the 99.8° percentile of hourly concentrations.

The following table presents the 99.8° percentile of hourly concentrations predicted by the model in comparison with EU AQS. Numerical results presented correspond to the worst hour predicted by the model over the temporal domain (8760 hours).

Table 9-B.8 NO_2 -99.8° Percentile of 1h concentrations–Magnitude of impacts for human health based on EU AQS (Rank 18) - Scenario 1, Scenario 2 and Scenario 3

Pollutant	Averaging Period	Study Area	Project Contribution [µg/m3]	IFC AQS [µg/m3]	% AQS	Magnitude
Scenario 1						
NO_2	99.8° Percentile of hourly concentrations(1)	Kamsar (Study Area A)	322.50	200	161%	Large
		Kolaboui (Study Area B)	150.00	200	75%	Medium
		Tanéné (Study Area C)	143.32	200	72%	Medium
Scenario 2						
NO_2	99.8° Percentile of hourly concentrations(1)	Kamsar (Study Area A)	693.78	200	347%	Large
		Kolaboui (Study Area B)	323.59	200	162%	Large
		Tanéné (Study Area C)	308.30	200	154%	Large
Scenario 3						
NO_2	99.8° Percentile of hourly concentrations(1)	Kamsar (Study Area A)	879.42	200	440%	Large
		Kolaboui (Study Area B)	410.18	200	205%	Large
		Tanéné (Study Area C)	390.79	200	195%	Large

1-It corresponds to the limit set on hourly concentrations not be exceeded more than 18 times per calendar year

[1] *European Directive 2008/50/EC on Ambient Air Quality* sets as AQS for NO_2 short-term concentration (1-hour average) a limit value of 200 µg/m³, not to be exceeded more than 18 times per calendar year (named Rank 18).

Figure 9-B.8 Impact magnitude for NO_2 hourly concentrations compared to EU AQS (Rank 18) Area A – Scenario 1, Scenario 2, Scenario 3

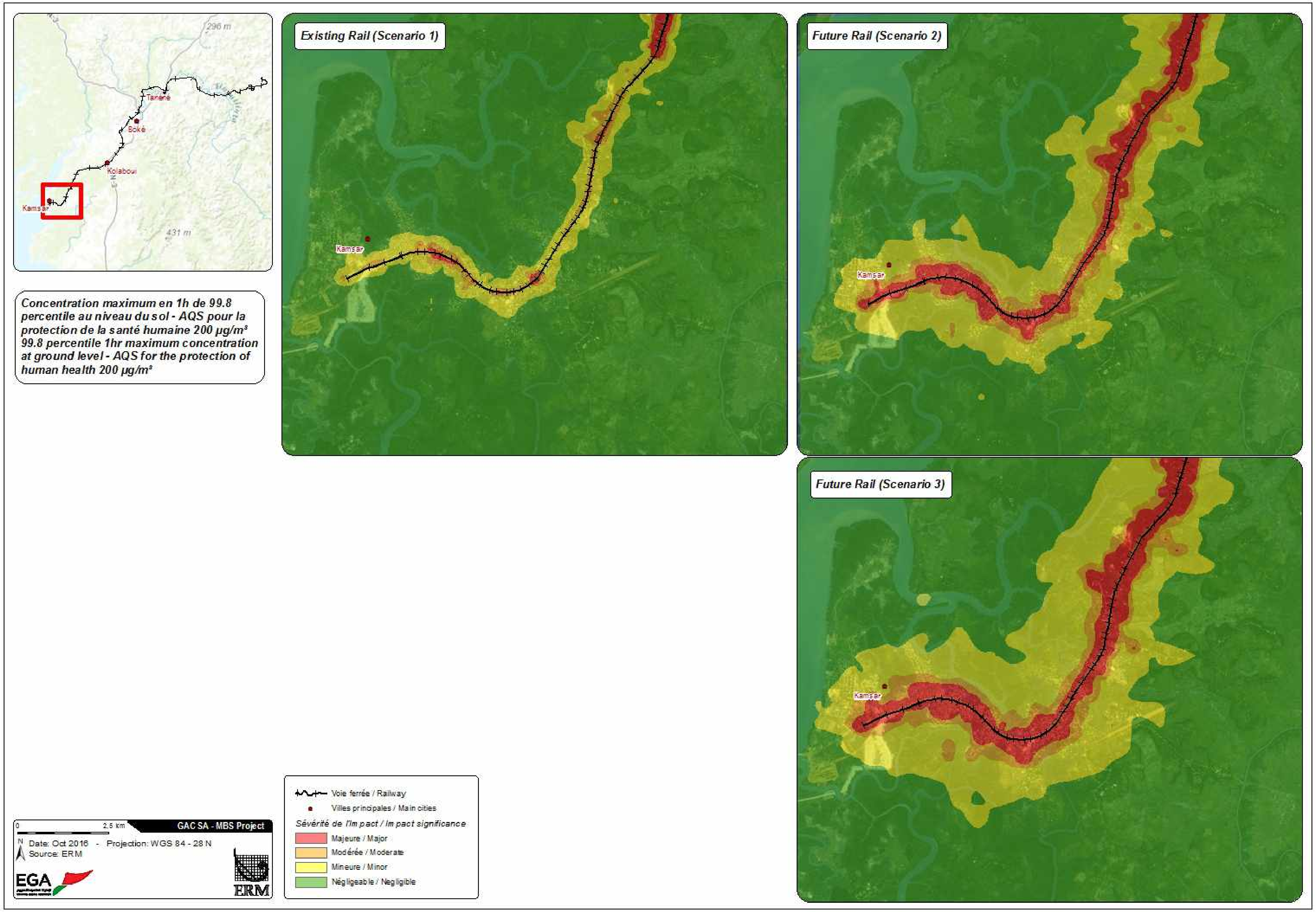


Figure 9-B.9 Impact magnitude for NO_2 hourly concentrations compared to EU AQS (Rank 18) Area B – Scenario 1, Scenario 2, Scenario 3

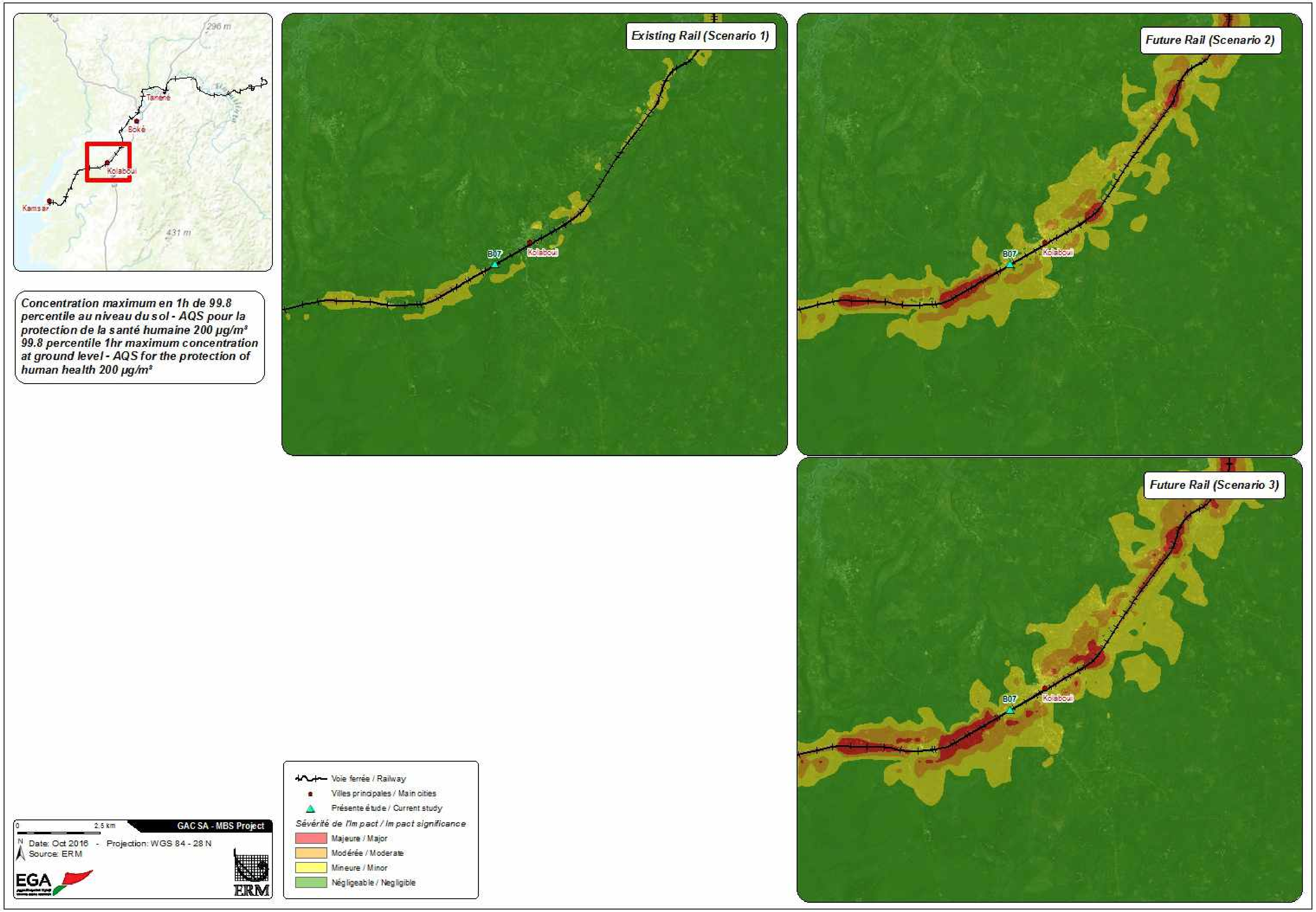
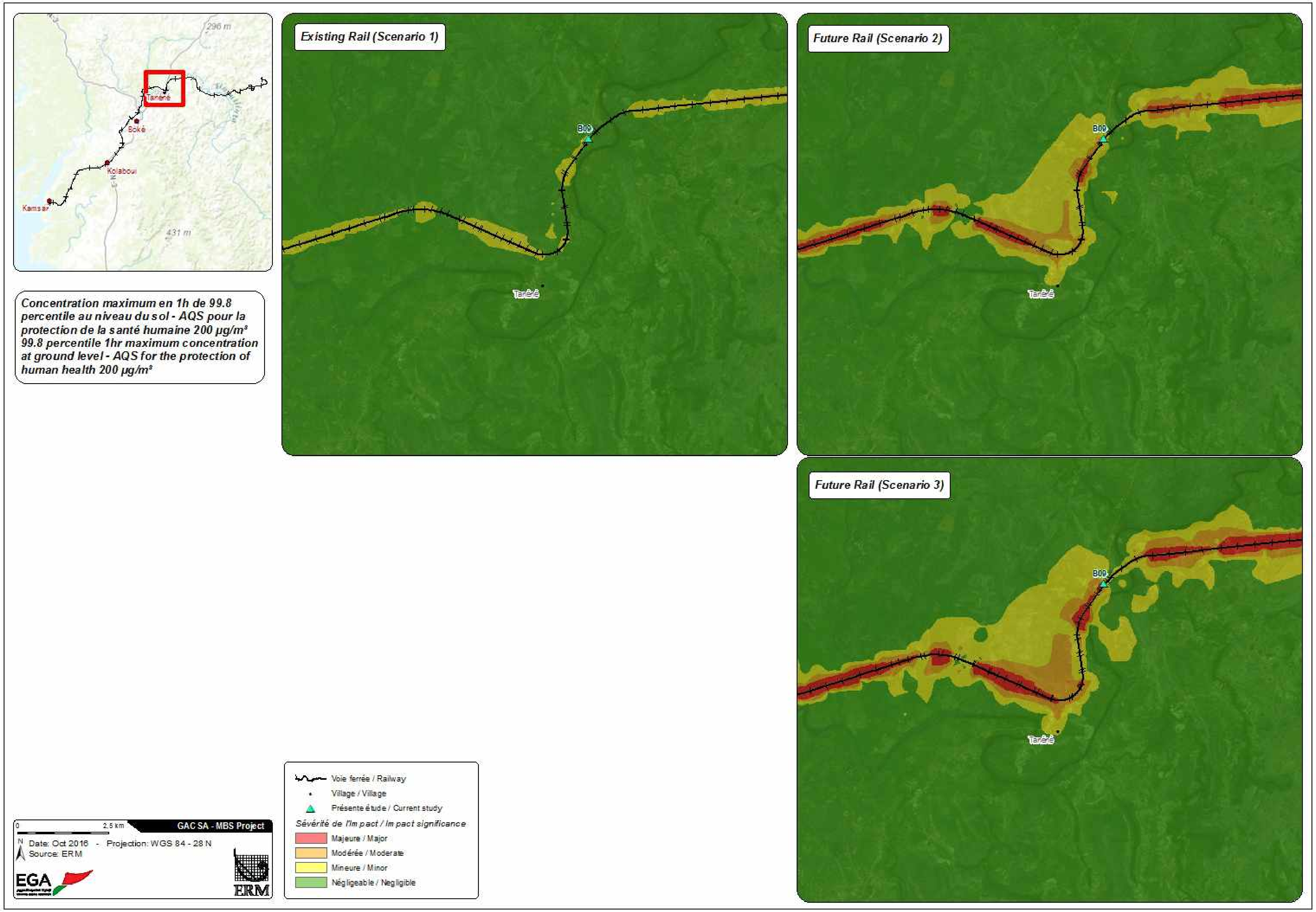


Figure 9-B.10 Impact magnitude for NO_2 hourly concentrations compared to EU AQS (Rank 18) Area C – Scenario 1, Scenario 2, Scenario 3



9-B.3.2 Particulate matter (PM10 and PM2.5)

PM10 emissions during rail operation are primarily produced by the wind erosion from open railcars carrying ore. Minor PM10 emissions are also caused by the locomotives' exhaust gases. PM25 emissions have been derived from PM10 emissions on the base of particle size distribution reported by *Veranth and Sarofim (2000)* [1] for both wind erosion and diesel trucks emissions.

Impacts for PM10 and PM2.5 long-term concentrations

Table 9-B.9 presents maximum concentration predicted by the model in comparison with IFC AQS, for PM10 and PM2.5 long-term (annual) concentrations.

PM_{10} and $PM_{2.5}$ long-term concentrations generate only negligible impacts for all areas and tested scenarios.

(1) Lighty J. Veranth J. Sarofim A (2000) Combustion aerosols: factors governing their size and composition and implications to human health Journal of the Air and Waste Management Association 50

Table 9-B.9 PM_{10} and $PM_{2.5}$ annual concentrations –Magnitude of impacts for human health - Scenario 1, Scenario 2 and Scenario 3

Pollutant	Averaging Period	Study Area	Project Contribution [µg/m3]	IFC AQS [µg/m3]	% AQS	Magnitude
Scenario 1						
PM10	Calendar year	Kamsar (Study Area A)	1.51	70	2%	Negligible
		Kolaboui (Study Area B)	1.05	70	2%	Negligible
		Tanéné (Study Area C)	0.77	70	1%	Negligible
PM25	Calendar year	Kamsar (Study Area A)	0.51	35	1%	Negligible
		Kolaboui (Study Area B)	0.36	35	1%	Negligible
		Tanéné (Study Area C)	0.26	35	1%	Negligible
Scenario 2						
PM10	Calendar year	Kamsar (Study Area A)	7.23	70	10%	Negligible
		Kolaboui (Study Area B)	5.05	70	7%	Negligible
		Tanéné (Study Area C)	3.70	70	5%	Negligible
PM25	Calendar year	Kamsar (Study Area A)	1.36	35	4%	Negligible
		Kolaboui (Study Area B)	0.95	35	3%	Negligible
		Tanéné (Study Area C)	0.70	35	2%	Negligible
Scenario 3						
PM10	Calendar year	Kamsar (Study Area A)	11.85	70	17%	Negligible
		Kolaboui (Study Area B)	8.27	70	12%	Negligible
		Tanéné (Study Area C)	6.07	70	9%	Negligible
PM25	Calendar year	Kamsar (Study Area A)	2.16	35	6%	Negligible
		Kolaboui (Study Area B)	1.50	35	4%	Negligible
		Tanéné (Study Area C)	1.10	35	3%	Negligible

Impacts for PM10 and PM2.5 short-term concentrations

Table 9-B.10 presents maximum concentration predicted by the model in comparison with IFC AQS, for PM10 and PM2.5 short-term (24h) concentrations.

Table 9-B.10 PM_{10} and $PM_{2.5}$ short-term (daily) concentrations –Magnitude of impacts for human health - Scenario 1, Scenario 2 and Scenario 3

Pollutant	Averaging Period	Study Area	Project Contribution [µg/m3]	IFC AQS [µg/m3]	% AQS	Magnitude
Scenario 1						
PM10	24-h	Kamsar (Study Area A)	7.74	150	5%	Negligible
		Kolaboui (Study Area B)	3.39	150	2%	Negligible
		Tanéné (Study Area C)	3.11	150	2%	Negligible
PM25	24-h	Kamsar (Study Area A)	2.63	75	4%	Negligible
		Kolaboui (Study Area B)	1.14	75	2%	Negligible
		Tanéné (Study Area C)	1.05	75	1%	Negligible
Scenario 2						
PM10	24-h	Kamsar (Study Area A)	37.07	150	25%	Negligible
		Kolaboui (Study Area B)	16.23	150	11%	Negligible
		Tanéné (Study Area C)	14.88	150	10%	Negligible
PM25	24-h	Kamsar (Study Area A)	7.01	75	9%	Negligible
		Kolaboui (Study Area B)	3.05	75	4%	Negligible
		Tanéné (Study Area C)	2.79	75	4%	Negligible
Scenario 3						
PM10	24-h	Kamsar (Study Area A)	60.70	150	40%	Low
		Kolaboui (Study Area B)	26.58	150	18%	Negligible
		Tanéné (Study Area C)	24.37	150	16%	Negligible
PM25	24-h	Kamsar (Study Area A)	11.15	75	15%	Negligible
		Kolaboui (Study Area B)	4.84	75	6%	Negligible
		Tanéné (Study Area C)	4.44	75	6%	Negligible

9-B.3.3 Sulfur dioxide (SO_2)

Impacts for SO_2 short-term concentrations

Table 9-B.11 presents maximum concentration predicted by the model in comparison with IFC AQS, for SO_2 short-term (24h) concentrations.

Table 9-B.11 SO_2 -24h concentrations maxima –Magnitude of impacts for human health based on IFC AQS - Scenario 1, Scenario 2 and Scenario 3

Pollutant	Averaging Period	Study Area	Project Contribution [µg/m3]	IFC AQS [µg/m3]	% AQS	Magnitude
Scenario 1						
SO_2	24h	Kamsar (Study Area A)	29.87	125	24%	Negligible
		Kolaboui (Study Area B)	13.031	125	10%	Negligible
		Tanéné (Study Area C)	11.77	125	9%	Negligible
Scenario 2						
SO_2	24h	Kamsar (Study Area A)	89.61	125	72%	Medium
		Kolaboui (Study Area B)	39.09	125	31%	Low
		Tanéné (Study Area C)	35.31	125	28%	Low
Scenario 3						
SO_2	24h	Kamsar (Study Area A)	119.485	125	96%	Large
		Kolaboui (Study Area B)	52.12	125	42%	Low
		Tanéné (Study Area C)	47.08	125	38%	Low

Figure 9-B.11 Impact magnitude for SO_2 24h concentrations compared to IFC AQS Area A – Scenario 1, Scenario 2, Scenario 3

9-B.3.4 *NOx and SO_2 Impacts on vegetation*

Impacts on vegetation might arise from the NOx and SO_2 emissions released due to rail operation. The concentration predicted by the ADMS were compared against applicable limits set for the protection of vegetation by the *European Directive 2008/50/EC on Ambient Air Quality*[1] on long term concentrations of NOx and $SO_{2.}$ The assessment therefore took into account predicted long term concentrations for these pollutants.

*Table 9-B.12*and *Table 9-B.13* presents maximum concentration predicted by the model in comparison with EU AQS, for NO_x and SO_2 long-term (annual) concentrations respectively

Table 9-B.12 *NO_x annual concentrations – Magnitude of impacts for vegetation based on EU AQS- Scenario 1, Scenario 2 and Scenario 3*

Pollutant	Averaging Period	Study Area	Project Contribution [µg/m3]	IFC AQS [µg/m3]	% AQS	Magnitude
Scenario 1						
NO_x	Calendar year	Kamsar (Study Area A)	24.59	30	82%	Large
		Kolaboui (Study Area B)	17.13	30	57%	Medium
		Tanéné (Study Area C)	12.50	30	42%	Low
Scenario 2						
NO_x	Calendar year	Kamsar (Study Area A)	52.90	30	176%	Large
		Kolaboui (Study Area B)	36.80	30	123%	Large
		Tanéné (Study Area C)	26.80	30	89%	Large
Scenario 3						
NO_x	Calendar year	Kamsar (Study Area A)	67.06	30	224%	Large
		Kolaboui (Study Area B)	46.70	30	156%	Large
		Tanéné (Study Area C)	34.09	30	114%	Large

[1] *European Directive 2008/50/EC on Ambient Air Quality* sets as AQS for NO_2 short-term concentration (1-hour average) a limit value of 200 µg/m³, not to be exceeded more than 18 times per calendar year (named Rank 18).

Table 9-B.13 SO_2 annual concentrations – Magnitude of impacts for vegetation based on EU AQS- Scenario 1, Scenario 2 and Scenario 3

Pollutant	Averaging Period	Study Area	Project Contribution [µg/m3]	IFC AQS [µg/m3]	% AQS	Magnitude
Scenario 1						
SO_2	Calendar year	Kamsar (Study Area A)	5.76	20	29%	Low
		Kolaboui (Study Area B)	4.01	20	20%	Negligible
		Tanéné (Study Area C)	2.92	20	15%	Negligible
Scenario 2						
SO_2	Calendar year	Kamsar (Study Area A)	17.28	20	86%	Large
		Kolaboui (Study Area B)	12.04	20	60%	Medium
		Tanéné (Study Area C)	8.78	20	44%	Low
Scenario 3						
SO_2	Calendar year	Kamsar (Study Area A)	23.04	20	115%	Large
		Kolaboui (Study Area B)	16.05	20	80%	Large
		Tanéné (Study Area C)	11.71	20	59%	Medium

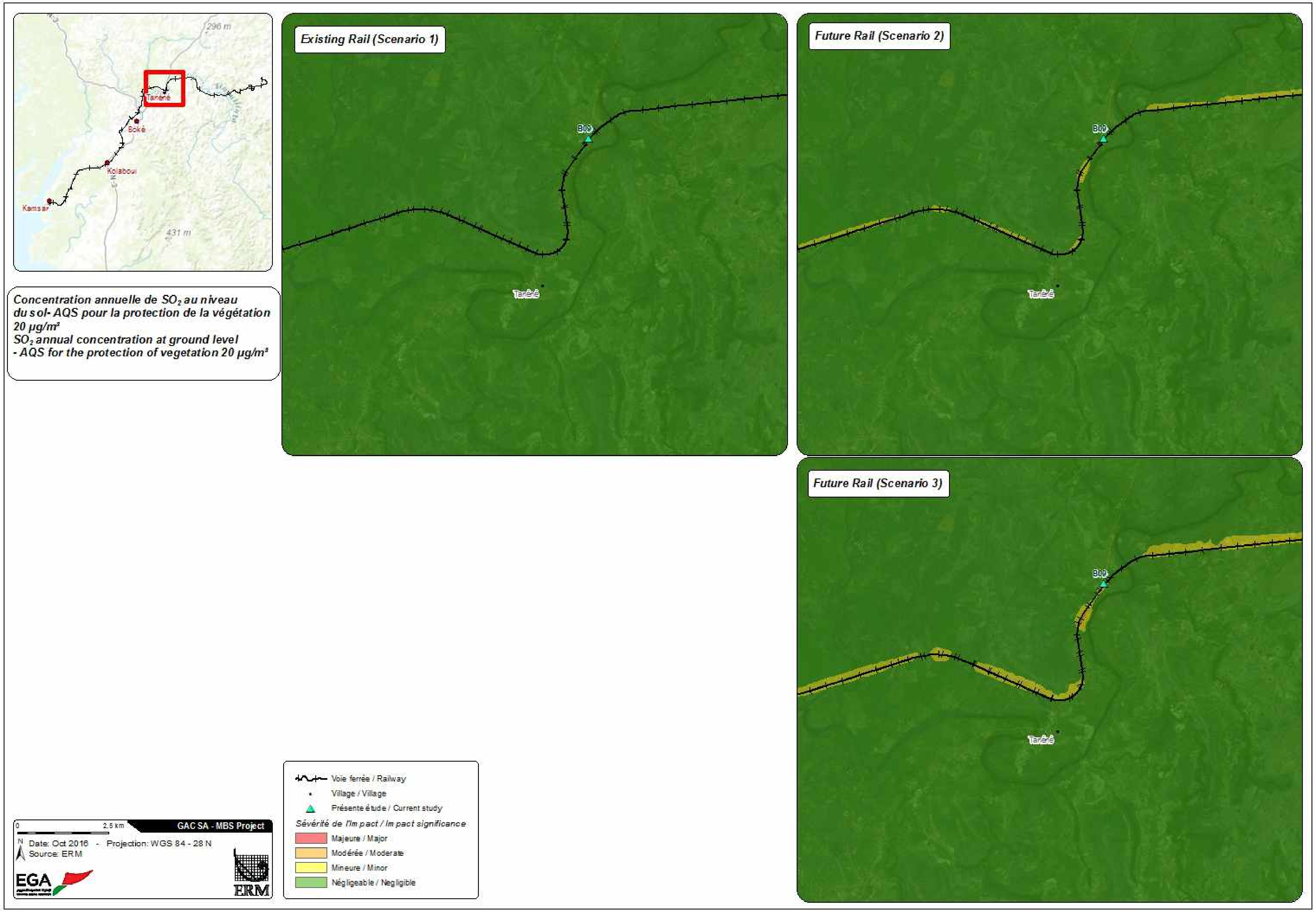
Figure 9-B.12 Impact magnitude for NO_x Annual concentrations compared to EU Standards for the protection of vegetation, Area A – Scenario 1, Scenario 2, Scenario 3

Figure 9-B.13 Impact magnitude for NO_x Annual concentrations compared to EU Standards for the protection of vegetation, Area B – Scenario 1, Scenario 2, Scenario 3

Figure 9-B.14 Impact magnitude for NO_x Annual concentrations compared to EU Standards for the protection of vegetation , Area C – Scenario 1, Scenario 2, Scenario 3

Figure 9-B.15 Impact magnitude for SO_2 Annual concentrations compared to EU Standards for the protection of vegetation, Area A – Scenario 1, Scenario 2, Scenario 3

Figure 9-B.16 Impact magnitude for SO_2 Annual concentrations compared to EU Standards for the protection of vegetation, Area B – Scenario 1, Scenario 2, Scenario 3



Existing Rail (Scenario 1)
Future Rail (Scenario 2)
Future Rail (Scenario 3)
Concentration annuelle de SO2 au niveau du sol- AQS pour la protection de la végétation 20 µg/m³
SO2 annual concentration at ground level - AQS for the protection of vegetation 20 µg/m³
Tanéné
Boké
Kolaboui
Kamsar
296 m
431 m
Voie ferrée / Railway
Village / Village
Présente étude / Current study
Sévérité de l'Impact / Impact significance
Majeure / Major
Modérée / Moderate
Mineure / Minor
Négligeable / Negligible
GAC SA - MBS Project
Date: Oct 2016 - Projection: WGS 84 - 28 N
Source: ERM
2,5 km
EGA
ERM